SEVENTH FRAMEWORK PROGRAMME

THEME [ENV.2010.1.1.3-1]
[Changes in carbon uptake and emissions by oceans in a changing climate]

Grant agreement for: Collaborative project*

Annex I - "Description of Work"

Project acronym: CARBOCHANGE

Project full title: " Changes in carbon uptake and emissions by oceans in a changing climate "

Grant agreement no: 264879

Version date: 2014-01-09

Table of Contents

Part A

Workplan Tables

A1:
Project summary

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

One form per project

General information			
Project title [3]	Changes in carbon uptake and emissions by oceans in a changing climate		
Starting date [4]	01/03/2011		
Duration in months [5]	48		
Call (part) identifier [6]	FP7-ENV-2010		
Activity code(s) most relevant to your topic [7]	ENV.2010.1.1.3-1: Changes in carbon uptake and emissions by oceans in a changing climate		

Abstract [9]

CARBOCHANGE will provide the best possible process-based quantification of net ocean carbon uptake under changing climate conditions using past and present ocean carbon cycle changes for a better prediction of future ocean carbon uptake. We will improve the quantitative understanding of key biogeochemical and physical processes through a combination of observations and models. We will upscale new process understanding to large-scale integrative feedbacks of the ocean carbon cycle to climate change and rising carbon dioxide concentrations. We will quantify the vulnerability of the ocean carbon sources and sinks in a probabilistic sense using cutting edge coupled Earth system models under a spectrum of emission scenarios including climate stabilisation scenarios as required for the 5th IPCC assessment report. The drivers for the vulnerabilities will be identified. The most actual observations of the changing ocean carbon sink will be systematically integrated with the newest ocean carbon models, a coupled land-ocean model, an Earth system model of intermediate complexity, and fully fledged Earth system models through a spectrum of data assimilation methods as well as advanced performance assessment tools. Results will be optimal process descriptions and most realistic error margins for future ocean carbon uptake quantifications with models under the presently available observational evidence. The project will deliver calibrated future evolutions of ocean pH and carbonate saturation as required by the research community on ocean acidification in the EU project EPOCA and further projects in this field. The time history of atmosphere-ocean carbon fluxes past, present, and future will be synthesised globally as well as regionally for the transcontinental RECCAP project. Observations and model results will merge into GEOSS/GEO through links with the European coordination action COCOS and will prepare the marine branch of the European Research Infrastructure ICOS.

A2:
List of Beneficiaries

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

List of Beneficiaries

No	Name	Short name	Country	Project entry month[10]	Project exit month
1	UNIVERSITETET I BERGEN	UiB	Norway	1	48
2	VITUSLAB V/JORGEN BENDTSEN	VITUS	Denmark	1	48
3	INSTITUT FRANCAIS DE RECHERCHE POUR L'EXPLOITATION DE LA MER	IFREMER	France	1	48
4	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	CEA	France	1	48
5	UNIVERSITE PIERRE ET MARIE CURIE - PARIS 6	UPMC	France	1	48
6	ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG	AWI	Germany	1	48
8	MAX PLANCK GESELLSCHAFT ZUR FOERDERUNG DER WISSENSCHAFTEN E.V.	MPG	Germany	1	48
9	UNIVERSITAET BREMEN	UniHB	Germany	1	48
10	HAFRANNSOKNASTOFNUNIN	MRI-UI	Iceland	1	48
11	NATIONAL UNIVERSITY OF IRELAND, GALWAY	NUIG	Ireland	1	48
12	INSTITUT NATIONAL DE RECHERCHE HALIEUTIQUE	INRH	Morocco	1	48
13	STICHTING KONINKLIJK NEDERLANDS INSTITUUT VOOR ZEEONDERZOEK (NIOZ)	NIOZ	Netherlands	1	48
14	STIFTELSEN NANSEN SENTER FOR MILJOOG FJERNMALING	NERSC	Norway	1	48
15	UNI RESEARCH AS	UNIRESEARCH	Norway	1	48
16	AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	CSIC	Spain	1	48
17	UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA	ULPGC	Spain	1	48
18	GOETEBORGS UNIVERSITET	UGOT	Sweden	1	48
19	EIDGENOESSISCHE TECHNISCHE HOCHSCHULE ZURICH	ETH Zürich	Switzerland	1	48
20	UNIVERSITAET BERN	UBERN	Switzerland	1	48

A2:
List of Beneficiaries

No	Name	Short name	Country	Project entry month[10]	Project exit month
21	MET OFFICE	MetO	United Kingdom	1	48
22	NATURAL ENVIRONMENT RESEARCH COUNCIL	NERC	United Kingdom	1	48
23	PLYMOUTH MARINE LABORATORY	PML	United Kingdom	1	48
24	UNIVERSITY OF BRISTOL	UNIVBRIS	United Kingdom	1	48
25	UNIVERSITY OF EAST ANGLIA	UEA	United Kingdom	1	48
26	COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH	CSIR	South Africa	1	48
27	TRUSTEES OF PRINCETON UNIVERSITY	PU-AOS	United States	1	48
28	DALHOUSIE UNIVERSITY	DU	Canada	1	48
29	HELMHOLTZ ZENTRUM FUR OZEANFORSCHUNG KIEL	GEOMAR	Germany	11	48
30	CLIMMOD ENGINEERING SARL	CLIMMOD	France	14	48
31	THE UNIVERSITY OF EXETER	UNEXE	United Kingdom	29	48

A3:
Budget Breakdown

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

One Form per Project

Participant number in this project [11]	Participant short name	Fund. % [12]	Ind. costs [13]	Estimated eligible costs (whole duration of the project)					Requested EU contribution
				RTD / Innovation (A)	Demonstration (B)	Management (C)	Other (D)	Total A+B+C+D	
1	UiB	75.0	T	555,096.00	0.00	301,598.08	84,992.00	941,686.08	733,542.00
2	VITUS	75.0	T	35,536.00	0.00	0.00	0.00	35,536.00	26,652.00
3	IFREMER	75.0	A	305,002.00	0.00	0.00	0.00	305,002.00	67,200.00
4	CEA	75.0	A	549,312.00	0.00	2,100.00	0.00	551,412.00	414,084.00
5	UPMC	75.0	T	756,768.00	0.00	0.00	0.00	756,768.00	567,576.00
6	AWI	75.0	S	535,216.00	0.00	0.00	8,400.00	543,616.00	409,812.00
8	MPG	75.0	S	199,416.00	0.00	0.00	0.00	199,416.00	149,562.00
9	UniHB	75.0	T	208,480.00	0.00	2,560.00	0.00	211,040.00	158,280.00
10	MRI-UI	75.0	T	104,608.00	0.00	0.00	0.00	104,608.00	78,456.00
11	NUIG	75.0	T	110,880.00	0.00	0.00	0.00	110,880.00	83,160.00
12	INRH	75.0	F	74,400.00	0.00	0.00	6,000.00	80,400.00	61,292.00
13	NIOZ	75.0	A	253,333.00	0.00	0.00	0.00	253,333.00	189,999.00
14	NERSC	75.0	S	373,890.00	0.00	0.00	0.00	373,890.00	280,417.00
15	UNIRESEARCH	75.0	T	573,710.08	0.00	0.00	12,960.00	586,670.08	438,381.00
16	CSIC	75.0	A	458,199.00	0.00	0.00	0.00	458,199.00	343,649.00
17	ULPGC	75.0	T	437,968.00	0.00	0.00	6,400.00	444,368.00	332,476.00
18	UGOT	75.0	T	158,400.00	0.00	0.00	0.00	158,400.00	118,800.00
19	ETH Zürich	75.0	T	278,612.80	0.00	0.00	0.00	278,612.80	208,959.00
20	UBERN	75.0	T	548,640.00	0.00	0.00	8,320.00	556,960.00	419,800.00
21	MetO	50.0	A	198,800.00	0.00	0.00	0.00	198,800.00	99,400.00
22	NERC	75.0	A	195,561.00	0.00	0.00	0.00	195,561.00	146,670.00

A3:
Budget Breakdown

Participant number in this project [11]	Participant short name	Fund. % [12]	Ind. costs [13]	Estimated eligible costs (whole duration of the project)					Requested EU contribution
				RTD / Innovation (A)	Demonstration (B)	Management (C)	Other (D)	Total A+B+C+D	
23	PML	75.0	A	128,932.00	0.00	0.00	0.00	128,932.00	96,699.00
24	UNIVBRIS	75.0	T	191,800.00	0.00	0.00	0.00	191,800.00	143,850.00
25	UEA	75.0	T	731,883.20	0.00	4,800.00	13,953.60	750,636.80	565,865.00
26	CSIR	75.0	S	0.00	0.00	0.00	0.00	0.00	0.00
27	PU-AOS	75.0	A	0.00	0.00	0.00	0.00	0.00	0.00
28	DU	75.0	F	0.00	0.00	0.00	0.00	0.00	0.00
29	GEOMAR	75.0	T	892,256.00	0.00	0.00	0.00	892,256.00	669,192.00
30	CLIMMOD	75.0	T	39,956.80	0.00	0.00	0.00	39,956.80	29,967.00
31	UNEXE	75.0	T	208,221.44	0.00	0.00	0.00	208,221.44	156,166.00
Total				9,104,877.32	0.00	311,058.08	141,025.60	9,556,961.00	6,989,906.00

Note that the budget mentioned in this table is the total budget requested by the Beneficiary and associated Third Parties.

*** The following funding schemes are distinguished**

Collaborative Project (if a distinction is made in the call please state which type of Collaborative project is referred to: (i) Small of medium-scale focused research project, (ii) Large-scale integrating project, (iii) Project targeted to special groups such as SMEs and other smaller actors), Network of Excellence, Coordination Action, Support Action.

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project, and it cannot be changed. The project number **should appear on each page of the grant agreement preparation documents** to prevent errors during its handling.

2. Project acronym

Use the project acronym as indicated in the submitted proposal. It cannot be changed, unless agreed during the negotiations. The same acronym **should appear on each page of the grant agreement preparation documents** to prevent errors during its handling.

3. Project title

Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date

Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry info force of the Grant Agreement (NB : entry into force = signature by the Commission). Please note that if a fixed starting date is used, you will be required to provide a detailed justification on a separate note.

5. Duration

Insert the duration of the project in full months.

6. Call (part) identifier

The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Activity code

Select the activity code from the drop-down menu.

8. Free keywords

Use the free keywords from your original proposal; changes and additions are possible.

9. Abstract

10. The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

11. The number allocated by the Consortium to the participant for this project.

12. Include the funding % for RTD/Innovation – either 50% or 75%

13. Indirect cost model
A: Actual Costs
S: Actual Costs Simplified Method
T: Transitional Flat rate
F :Flat Rate

Workplan Tables

Project number

264879

Project title

CARBOCHANGE—Changes in carbon uptake and emissions by oceans in a changing climate

Call (part) identifier

FP7-ENV-2010

Funding scheme

Collaborative project

WT1
List of work packages

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

LIST OF WORK PACKAGES (WP)

WP Number [53]	WP Title	Type of activity [54]	Lead beneficiary number [55]	Person-months [56]	Start month [57]	End month [58]
WP 1	Biochemical processes and feedbacks	RTD	17	70.51	1	48
WP 2	Physical processes and feedbacks	RTD	29	93.31	1	48
WP 3	Future scenarios under different emission curves and vulnerability analysis	RTD	4	76.00	1	42
WP 4	Surface observing system	RTD	31	156.72	1	48
WP 5	Deep ocean, time series, choke points	RTD	16	165.92	1	48
WP 6	Systematic model calibration using observational data	RTD	14	93.50	1	36
WP 7	Data-model and model-model comparison	RTD	29	125.51	1	36
WP 8	Global synthesis and outreach to policy makers	RTD	25	52.02	1	48
WP 9	Data and information management	RTD	1	36.01	1	48
WP 10	Management of the project	MGT	1	18.00	1	48
			Total	887.50		

WT2:
List of Deliverables

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

List of Deliverables - to be submitted for review to EC

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D1.1	D1.1 Sensitivity of air-sea CO2 fluxes and atmospheric CO2	1	1	8.00	R	PP	24
D1.2	D1.2 Calibration and assessment of particle export and remineralisation	1	29	8.00	R	PP	24
D1.3	D1.3 Estimation of remineralisation and oxygen consumption rates	1	9	8.00	R	PP	36
D1.4	D1.4 Validation of ocean ecosystem models	1	19	7.51	R	PP	36
D1.5	D1.5 Qantification of biological processes (part 1)	1	6	8.00	R	PP	36
D1.6	D1.6 Qantification of biological processes (part 2)	1	6	8.00	R	PP	48
D1.7	D1.7 Biogeochemistry in Atlantic related to African upwelling (part 1)	1	19	8.00	R	PP	24
D1.8	D1.8 Biogeochemistry in Atlantic related to African upwelling (part 2)	1	19	8.00	R	PP	48
D1.9	D1.9 Report on carbon flux	1	16	3.50	R	PP	24

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
	through Strait of Gibraltar (part 1)						
D1.10	D1.10 Report on carbon flux through Strait of Gibraltar (part 2)	1	16	3.50	R	PP	48
D2.1	D2.1 Workshop of modelling and observational groups	2	29	2.01	O	PP	3
D2.2	D2.2 Report on the feedback of physical processes (part 1)	2	18	12.00	R	PU	24
D2.3	D2.3 Report on the feedback of physical processes (part 2)	2	18	10.30	R	PU	40
D2.4	D2.4 Deepwater production and atmospheric CO2	2	1	11.00	R	PU	48
D2.5	D2.5 Report on physical processes in the Atlantic	2	3	24.00	R	PU	36
D2.6	D2.6 Session on impact of changes in the Southern Ocean	2	19	12.00	O	PP	36
D2.7	D2.7 Report on impact of Southern Ocean wind-stress	2	19	12.00	R	PU	40
D2.8	D2.8 Report on Southern Ocean eddy impacts	2	5	10.00	R	PU	40
D3.1	D3.1 Simulations of carbon sources and sinks	3	4	30.00	R	RE	6
D3.2	D3.2 Report on vulnerability of carbon sources and sinks	3	21	10.00	R	RE	12

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D3.3	D3.3 Report on feasibility of mitigation scenarios	3	21	8.00	R	RE	24
D3.4	D3.4 Mechanisms that contribute to carbon source/sink changes	3	4	8.00	R	RE	18
D3.5	D3.5 Probabilistic carbon sources and sink assessment for the 21st century	3	20	5.00	R	RE	42
D3.6	D3.6 Long-term simulations	3	20	10.00	R	RE	36
D3.7	D3.7 Assessment of detection	3	4	5.00	R	RE	42
D4.1	D4.1 Network set up	4	25	10.00	R	PU	12
D4.2	D4.2 Report on Co-ordination (part 1)	4	25	2.00	R	PU	12
D4.3	D4.3 Report on Co-ordination (part 2)	4	25	2.00	R	PU	24
D4.4	D4.4 Report on Co-ordination (part 3)	4	31	2.00	R	PU	36
D4.5	D4.5 Report on Co-ordination (part 4)	4	31	2.00	R	PU	48
D4.6	D4.6 Delivery of Atlantic data (part 1)	4	25	10.00	R	PP	12
D4.7	D4.7 Delivery of Atlantic data (part 2)	4	1	10.00	R	PP	24
D4.8	D4.8 Delivery of Atlantic data (part 3)	4	31	10.00	R	PP	36

Deliverable Number [61]	Deliverable Title	WP number [53]	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D4.9	D4.9 Delivery of Atlantic data (part 4)	4	31	10.00	R	PP	48
D4.10	D4.10 Delivery of Southern Ocean data (part 1)	4	25	10.00	R	PP	12
D4.11	D4.11 Delivery of Southern Ocean data (part 2)	4	25	10.00	R	PP	24
D4.12	D4.12 Delivery of Southern Ocean data (part 3)	4	31	10.00	R	PP	36
D4.13	D4.13 Delivery of Southern Ocean data (part 4)	4	1	10.00	R	PP	48
D4.14	D4.14 Delivery of atmospheric data (part 1)	4	25	9.00	R	PU	12
D4.15	D4.15 Delivery of atmospheric data (part 2)	4	1	9.00	R	PU	24
D4.16	D4.16 Delivery of atmospheric data (part 3)	4	25	8.00	R	PU	36
D4.17	D4.17 Delivery of atmospheric data (part 4)	4	25	8.00	R	PU	48
D4.18	D4.18 Seasonal to interannual variability (part 1)	4	25	5.00	R	PU	24
D4.19	D4.19 Seasonal to interannual variability (part 2)	4	31	5.00	R	PU	48
D4.20	D4.20 Report on the effect of high frequency variability	4	5	5.00	R	PU	48
D4.21	D4.21 Report on climatology	4	31	5.00	R	PU	48

Deliverable Number [61]	Deliverable Title	WP number [53]	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
	of seasonal sea surface pH						
D4.22	D4.22 Assessment of air-sea fluxes by atmospheric observations	4	4	4.71	R	PU	48
D5.1	D5.1 Submission of quality controlled data (part 1)	5	29	11.00	R	PP	18
D5.2	D5.2 Submission of quality controlled data (part 2)	5	29	11.00	R	PP	30
D5.3	D5.3 Submission of quality controlled data (part 3)	5	29	11.00	R	PP	42
D5.4	D5.4 Submission of quality controlled data (part 4)	5	29	11.00	R	PP	48
D5.5	D5.5 Collection of section data (part 1)	5	16	16.00	R	PP	18
D5.6	D5.6 Collection of section data (part 2)	5	16	15.00	R	PP	30
D5.7	D5.7 Collection of section data (part 3)	5	16	15.00	R	PP	42
D5.8	D5.8 Collection of section data (part 4)	5	16	15.00	R	PP	48
D5.9	D5.9 Regional carbon inventories	5	16	10.00	R	PU	40
D5.10	D5.10 Variability of the carbon cycle from time series	5	29	10.00	R	PU	40
D5.11	D5.11 Trends in ocean acidification	5	17	10.00	R	PU	36

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D5.12	D5.12 Publication on deep storage variability	5	25	10.00	O	PU	46
D5.13	D5.13 Atlantic synthesis papers	5	25	10.00	O	PU	46
D5.14	D5.14 Constraints for climate/ocean circulation models	5	6	10.90	R	PU	46
D6.1	D6.1 Calibrated version of MICOM-HAMOCC	6	14	11.00	R	PU	24
D6.2	D6.2 Report on constrained CaCO3 dissolution fluxes (Bern3D)	6	20	19.00	R	PU	30
D6.3	D6.3 Report on calibrated versions of MITBOGCM	6	24	34.00	R	PU	36
D6.4	D6.4 Report on assimilation (MICOM-HAMOCC)	6	14	6.00	R	PU	36
D6.5	D6.5 Report on parameter optimisation (PISCES)	6	30	23.50	R	PU	36
D7.1	D7.1 Report on first comparions	7	4	40.00	R	PU	12
D7.2	D7.2 Workshop on new metrics	7	19	10.00	O	PU	12
D7.3	D7.3 Evaluation with C-14	7	29	15.00	R	PU	24
D7.4	D7.4 Workshop on methods to weigh models	7	20	10.00	O	PU	24
D7.5	D7.5 Report on metrics	7	4	25.00	R	PU	30

Deliverable Number [61]	Deliverable Title	WP number [53]	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D7.6	D7.6 Report on Detection-Attribution	7	25	10.50	R	PU	36
D7.7	D7.7 Session on weighted optimal estimates	7	20	15.00	O	PU	36
D8.1	D8.1 Annual estimates of oceanic CO2 sinks (part 1)	8	25	4.00	R	PP	8
D8.2	D8.2 Annual estimates of oceanic CO2 sinks (part 2)	8	25	4.00	R	PP	20
D8.3	D8.3 Annual estimates of oceanic CO2 sinks (part 3)	8	25	4.00	R	PP	32
D8.4	D8.4 Annual estimates of oceanic CO2 sinks (part 4)	8	25	4.00	R	PP	44
D8.5	D8.5 SOCAT update no. 1	8	25	4.00	R	PP	20
D8.6	D8.6 SOCAT update no. 2	8	25	4.00	R	PP	44
D8.7	D8.7 Unified CARINA-GLODAP dataset	8	15	6.00	O	RE	24
D8.8	D8.8 Atlas of carbonate variables	8	6	6.00	O	PP	36
D8.9	D8.9 Atlas for near present conditions	8	25	6.00	O	PP	36
D8.10	D8.10 Report on vulnerability	8	4	5.00	R	PU	36
D8.11	D8.11 Summarising outreach paper	8	25	5.00	O	PU	48
D9.1	D9.1 Data management implementation plan	9	1	0.20	O	RE	1

Delive-rable Number [61]	Deliverable Title	WP number [53]	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D9.2	D9.2 First version of CARBOCHANGE data portal	9	9	4.00	O	RE	3
D9.3	D9.3 Update of the SOCAT input database	9	1	6.00	O	RE	12
D9.4	D9.4 First update of model output database	9	4	3.00	O	RE	12
D9.5	D9.5 Databases of observational data and selected model data (part 1)	9	1	4.45	O	RE	6
D9.6	D9.6 Databases of observational data and selected model data (part 2)	9	1	4.45	O	RE	12
D9.7	D9.7 Databases of observational data and selected model data (part 3)	9	1	4.45	O	RE	24
D9.8	D9.8 Databases of observational data and selected model data (part 4)	9	1	4.45	O	RE	36
D9.9	D9.9 Ocean Data View optimisation	9	6	5.00	O	RE	18
D10.1	D10.1 Kick-off meeting	10	1	1.00	O	PU	1
D10.2	D10.2 Project website	10	1	1.00	O	PU	1
D10.3	D10.3 Annual project meetings (part 1)	10	1	1.50	O	PU	12
D10.4	D10.4 Annual project meetings (part 2)	10	1	3.00	O	PU	24
D10.5	D10.5 Annual project meetings (part 3)	10	1	3.00	O	PU	36

Deliverable Number [61]	Deliverable Title	WP number [53]	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D10.6	D10.6 Annual project meetings (part 4)	10	1	3.00	O	PU	48
D10.7	D10.7 First outreach paper to policy makers	10	1	3.00	R	PU	24
D10.8	D10.8 Second outreach paper to policy makers	10	1	2.50	R	PU	36
			Total	887.43			

WT3:
Work package description

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

One form per Work Package

Work package number [53]	WP1	Type of activity [54]	RTD
Work package title	Biochemical processes and feedbacks		
Start month	1		
End month	48		
Lead beneficiary number [55]	17		

Objectives

• To quantitatively assess the magnitude of the feedbacks on the ocean uptake of CO2 by changes in vertical fluxes of organic carbon, testing new model parameterizations and producing model output that will be used in model-model intercomparison
• To assess the role of lateral fluxes of carbon into the open ocean for variations in air-sea carbon fluxes, integrating models and observations

Description of work and role of partners

Description of work
Task 1.1 - Sensitivity of atmospheric carbon to changes in organic matter remineralisation rates and sinking, potential stoichiometry changes as a consequence of changes in CO2 partial pressure: Changes in the vertical flux attenuation of carbon fluxes are among the stronger feedbacks that had been considered in CARBOOCEAN. Further mechanisms that will be investigated here are: a) changes in the remineralisation of organic matter through the temperature dependence of bacterial activity, b) changes in sinking speeds through changes in ballasting (e.g. through changes in dust deposition or production of calcium carbonate), and c) variable stoichiometry in both production and consumption. A major aim is to quantify the sensitivity of the global carbon flux to these mechanisms better, by also taking into account the interaction between the different feedbacks .
Partners: ETHZürich (remineralisation feedback), CEA(LSCE) (sensitivity of air-sea CO2 fluxes to changes in organic matter remineralisation depth), UniHB (CFC estimation of remineralisation rates), GEOMAR (calibration of export with TMM and monthly oxygen fields), MPG + VitusLab (temperature dependence on remineralisation), AWI (C:N:Si stoichiometry in export).
Task 1.2 - Sensitivity of oceanic CO2 and air-sea CO2 fluxes to changes in vertical carbon flux through changes in plankton community structure: The role of primary and secondary producers for export strength shall be investigated using several sets of observational data (in situ microscopy and flow cytometry counts, HPLC pigments or satellite observations) and results from multiple ocean ecosystem models containing at least two plankton functional types (PFTs).
Partners: ETHZürich, AWI (both: Model runs several phytoplankton types, generation of datasets for validation)
Task 1.3 - Role of organic and inorganic export of carbon from continental margins to the Atlantic Ocean: The continental margins supply organic carbon (OC) and nutrients to the open ocean, which can lead to downstream productivity and respiration changes that influence the air-sea CO2 balance of the open ocean substantially. The roles of the offshore transport of OC and nutrients on the carbon cycle in the North-West African margin and the Mediterranean outflow will be considered. To this end, combined experimental studies taking advantage of the substantial number of satellite data sets available for the continental margins, and using state-of-the-art coupled high resolution physical / biogeochemical / ecological models configured for the Atlantic and regional models for the North-West African Margin will be applied. The integration of models and observations will lead to better understanding of the feedback strength between offshore transport and open ocean carbon in the Subtropical Atlantic.
Partners: ETHZürich (modelling shelf-open-ocean transfer), ULPGC-INRH (North-West African Margin), CSIC (Mediterranean outflow), CSIR (Atlantic sector of Southern Ocean)

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
2	VITUS	2.00
4	CEA	6.00
6	AWI	9.00
8	MPG	3.50
9	UniHB	6.00
12	INRH	2.00
16	CSIC	5.00
17	ULPGC	10.00
19	ETH Zürich	18.00
26	CSIR	0.01
29	GEOMAR	9.00
	Total	70.51

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D1.1	D1.1 Sensitivity of air-sea CO2 fluxes and atmospheric CO2	1	8.00	R	PP	24
D1.2	D1.2 Calibration and assessment of particle export and remineralisation	29	8.00	R	PP	24
D1.3	D1.3 Estimation of remineralisation and oxygen consumption rates	9	8.00	R	PP	36
D1.4	D1.4 Validation of ocean ecosystem models	19	7.51	R	PP	36
D1.5	D1.5 Qantification of biological processes (part 1)	6	8.00	R	PP	36
D1.6	D1.6 Qantification of biological processes (part 2)	6	8.00	R	PP	48
D1.7	D1.7 Biogeochemistry in Atlantic related to African upwelling (part 1)	19	8.00	R	PP	24
D1.8	D1.8 Biogeochemistry in Atlantic related to African upwelling (part 2)	19	8.00	R	PP	48
D1.9	D1.9 Report on carbon flux through Strait of Gibraltar (part 1)	16	3.50	R	PP	24
D1.10	D1.10 Report on carbon flux through Strait of Gibraltar (part 2)	16	3.50	R	PP	48
		Total	70.51			

Description of deliverables

D1.1) D1.1 Sensitivity of air-sea CO2 fluxes and atmospheric CO2: Global and regional sensitivity of air-sea CO2 fluxes and atmospheric CO2 to changes in organic matter remineralisation depth over different time-scales, output for model intercomparison (WP7) (UiB, ETHZürich, CEA, MPG, VitusLab) [month 24]

D1.2) D1.2 Calibration and assessment of particle export and remineralisation: Calibration and assessment of particle export and remineralisation model parameterisations against observed oxygen distributions (GEOMAR) [month 24]

D1.3) D1.3 Estimation of remineralisation and oxygen consumption rates: Estimation of remineralisation and oxygen consumption rates in the tropical and South Atlantic using CFC data and changes with respect to historical data (UniHB) [month 36]

D1.4) D1.4 Validation of ocean ecosystem models: Validation of ocean ecosystem models containing more than two plankton functional types (PFTs) using observational data, output for model-model intercomparison (ETHZürich, AWI) [month 36]

D1.5) D1.5 Qantification of biological processes (part 1): Quantification of the relation between the biological pump and changes in community composition and quantification of the effect on the vertical distribution of dissolved inorganic carbon and atmospheric CO2 from model runs (AWI, ETHZürich) [month 36]

D1.6) D1.6 Qantification of biological processes (part 2): Quantification of the relation between the biological pump and changes in community composition and quantification of the effect on the vertical distribution of dissolved inorganic carbon and atmospheric CO2 from model runs (AWI, ETHZürich) [month 48]

D1.7) D1.7 Biogeochemistry in Atlantic related to African upwelling (part 1): Report on biogeochemical processes and changes affecting the carbon sources and sinks in the Atlantic originating from the African upwelling to quantify and define the time variations from seasonal to decadal timescales. (ETHZürich, ULPGC, INRH) [month 24]

D1.8) D1.8 Biogeochemistry in Atlantic related to African upwelling (part 2): Report on biogeochemical processes and changes affecting the carbon sources and sinks in the Atlantic originating from the African upwelling to quantify and define the time variations from seasonal to decadal timescales. (ETHZürich, ULPGC, INRH) [month 48]

D1.9) D1.9 Report on carbon flux through Strait of Gibraltar (part 1): Report on the impact of processes affecting the magnitude and variability of CO2 outflow through the Strait of Gibraltar in the North Atlantic Ocean. (CSIC, INRH) [month 24]

D1.10) D1.10 Report on carbon flux through Strait of Gibraltar (part 2): Report on the impact of processes affecting the magnitude and variability of CO2 outflow through the Strait of Gibraltar in the North Atlantic Ocean. (CSIC, INRH) [month 48]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS11	M1.1 Organic matter remineralisation data delivered to WP 7	19	24	
MS12	M1.2 First series of reports on biological pump, time variations and CO2 outflow submitted	17	24	
MS13	M1.3 Plankton model data submitted to WP7 for model-model intercomparison	6	36	

WT3:
Work package description

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

One form per Work Package

Work package number [53]	WP2	Type of activity [54]	RTD
Work package title	Physical processes and feedbacks		
Start month	1		
End month	48		
Lead beneficiary number [55]	29		

Objectives

• To quantitatively assess the feedback on the oceanic uptake of CO_2 by changes in physical processes in the North Atlantic Ocean, including the Arctic Ocean and Nordic Seas, and the Southern Ocean.
• To assess the representation of small-scale processes involved in the feedbacks (e.g. eddies) in carbon-climate models and guide development of improved subgrid-scale parameterisations.

Description of work and role of partners

T2.1 – Sea ice cover and deep water formation: Quantify the impact of changes in Arctic sea ice cover and deep-water formation on oceanic CO_2 uptake in the Arctic. Observational process studies will be combined with regional process models. (UGOT, NERSC)
T2.2 – Variability of deep-water formation: Assess the impact of changes in deep-water formation, overflow to the North Atlantic, and the meridional overturning on CO_2 uptake in the Atlantic Ocean. Identify dominant modes of variability from observed changes in hydrographic and biogeochemical properties in the North Atlantic and the Nordic Seas (WP1, WP4, WP5). Identify mechanisms driving observed and possible future changes by performing sensitivity experiments with forced ocean models. (UiB, ULPGC, IFREMER)
T2.3 – Variability in air-sea CO_2 flux: Assess the relative importance of the major processes that drive interannual to decadal variability in air-sea CO_2 fluxes in the Atlantic. Provide (WP7) and archive (WP9) high-resolution global coupled biogeochemical-physical model simulation forced by atmospheric reanalysis fields over the last 50 years. Analyse modes of variability and identify mechanisms driving these both in historical observations and in the model simulation. (CEA/LSCE, IFREMER)
T2.4 – Eddies, Southern Ocean: Quantify the impact of Southern Ocean wind-stress changes on the CO_2 uptake of the eddying ocean. Run coupled biogeochemical-physical eddy-resolving Southern-Ocean models and quantify the role of eddies in moderating the response of CO_2 uptake to wind-stress changes. Joint analysis of observational data provided from SOCAT (WP8) CARIOCA buoys and ARGO floats to assess impact of eddies on the uptake and transport of CO_2. (ETH, GEOMAR, UPMC, CSIR)

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	UiB	6.00
3	IFREMER	24.00
4	CEA	10.00
5	UPMC	11.00
14	NERSC	4.30
17	ULPGC	6.00
18	UGOT	10.00
19	ETH Zürich	12.00

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
26	CSIR	0.01
29	GEOMAR	10.00
	Total	93.31

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D2.1	D2.1 Workshop of modelling and observational groups	29	2.01	O	PP	3
D2.2	D2.2 Report on the feedback of physical processes (part 1)	18	12.00	R	PU	24
D2.3	D2.3 Report on the feedback of physical processes (part 2)	18	10.30	R	PU	40
D2.4	D2.4 Deepwater production and atmospheric CO2	1	11.00	R	PU	48
D2.5	D2.5 Report on physical processes in the Atlantic	3	24.00	R	PU	36
D2.6	D2.6 Session on impact of changes in the Southern Ocean	19	12.00	O	PP	36
D2.7	D2.7 Report on impact of Southern Ocean wind-stress	19	12.00	R	PU	40
D2.8	D2.8 Report on Southern Ocean eddy impacts	5	10.00	R	PU	40
		Total	93.31			

Description of deliverables

D2.1) D2.1 Workshop of modelling and observational groups: Joint Workshop of modelling and observational groups to prioritize process studies (GEOMAR). [month 3]

D2.2) D2.2 Report on the feedback of physical processes (part 1): Reports on the feedback of physical processes (e.g. ice coverage, brine formation, shelf-basin water exchange, vertical mixing and pycnocline depth) on carbon fluxes in the Arctic Ocean (UGOT, NERSC) [month 24]

D2.3) D2.3 Report on the feedback of physical processes (part 2): Reports on the feedback of physical processes (e.g. ice coverage, brine formation, shelf-basin water exchange, vertical mixing and pycnocline depth) on carbon fluxes in the Arctic Ocean (UGOT, NERSC) [month 40]

D2.4) D2.4 Deepwater production and atmospheric CO2: Report on interaction between deepwater production and atmospheric CO2 (UiB, ULPGC) [month 48]

D2.5) D2.5 Report on physical processes in the Atlantic: Report on physical processes that govern observed sea surface and interior CO2 trends in the Atlantic (IFREMER, CEA/LSCE) [month 36]

D2.6) D2.6 Session on impact of changes in the Southern Ocean: Joint session on impact of changes in the Southern Ocean on air-sea CO2 fluxes, 3rd annual meeting (month 36, O, PP), (ETHZürich, GEOMAR, UPMC). [month 36]

D2.7) D2.7 Report on impact of Southern Ocean wind-stress: Report on impact of Southern Ocean wind-stress changes on CO_2 uptake in eddy-resolving models (ETHZürich, GEOMAR) [month 40]

D2.8) D2.8 Report on Southern Ocean eddy impacts: Report on Southern Ocean eddy impacts diagnosed from combined analysis of CARIOCA buoys and ARGO floats (UPMC) [month 40]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS21	M2.1 Archived output of high-res. (1/4 deg) glob. coupl. biogeochem.-phys. model simul., last 50 yr	4	18	

WT3:
Work package description

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

One form per Work Package

Work package number [53]	WP3	Type of activity [54]	RTD
Work package title	Future scenarios under different emission curves and vulnerability analysis		
Start month	1		
End month	42		
Lead beneficiary number [55]	4		

Objectives

• To assess the vulnerability of oceanic carbon sources or sinks with respect to future emission scenarios and associated climate change projections, on different time-scales (from multi-decadal to multi-centennial) through the use of earth system models of variable complexity (ESMs and EMICs).
• To identify the processes responsible for the simulated future changes in carbon sources and sinks and develop methods to determine the probability density distributions of their future evolution.

Description of work and role of partners

Task 3.1 – Vulnerability of sources and sinks: Simulations of the evolution of oceanic sources and sinks of CO2 under different IPCC-AR5 scenarios over the next 100 yrs, with at least 5 ESMs (IPSL-CM5, NorESM/BCCR, MPIM, HadCM3-HadGEM, NCAR-CCSM) and 1 EMIC (Bern3D). The scenarios will be chosen from the IPCC Radiative Concentration Pathways scenarios (RCPs). Different mitigation options (with a focus on green scenarios) will be investigated. Both coupled and uncoupled simulations will be performed to evaluate climate-carbon feedbacks. Output will be provided to WP9 and used in WP7 for model intercomparisons and evaluations (LSCE, MPG, MetO, UiB, UBern).
Task 3.2 - Probabilistic distribution of vulnerability: Simulations with Monte-Carlo type parameter variations / Ensemble simulations to determine probability density distributions of the future evolution of CO2, climate and carbon sources and sinks for a range of scenarios and 2 models of different complexity (Bern3D and HadCM3) (MetO, UBern).
Task 3.3 - Stabilization: Long-term simulations (to 2500) using same or fast versions of ESMs (IPSL-CM5, HadCM3) or EMICs (Bern3D) will be performed to investigate long-term changes in the climate-carbon system (stabilization scenarios – collapse of THC – Greenland melting). Output will be provided to WP9, used in WP7 for model intercomparisons (UBern, MetO, CEA/LSCE).
Task 3.4 – Detectability: Analysis of ESMs (IPSLCM5, NorESM/BCCR, MPG, HadCM3, NCAR-CCSM) simulated decadal variability of CO2 fluxes in global warming and control simulations will be carried out to assess when climate change impact is unambiguously separable from decadal variability. Forced ocean only simulations (hindcast simulations, 1950-2010, WP7) will be used to compare simulated decadal trends in both coupled and forced simulations with the observed ones. Results from this task will be combined with those from Task 7.5 of WP7 using detection-attribution methods. (LSCE).

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	UiB	10.00
4	CEA	17.00
8	MPG	11.00
20	UBERN	16.00
21	MetO	22.00

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
	Total	76.00

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D3.1	D3.1 Simulations of carbon sources and sinks	4	30.00	R	RE	6
D3.2	D3.2 Report on vulnerability of carbon sources and sinks	21	10.00	R	RE	12
D3.3	D3.3 Report on feasibility of mitigation scenarios	21	8.00	R	RE	24
D3.4	D3.4 Mechanisms that contribute to carbon source/sink changes	4	8.00	R	RE	18
D3.5	D3.5 Probabilistic carbon sources and sink assessment for the 21st century	20	5.00	R	RE	42
D3.6	D3.6 Long-term simulations	20	10.00	R	RE	36
D3.7	D3.7 Assessment of detection	4	5.00	R	RE	42
		Total	76.00			

Description of deliverables

D3.1) D3.1 Simulations of carbon sources and sinks: Simulations of carbon sources and sinks under IPCC AR5 scenarios (1860-2100) with ESMs and EMICs (month 6, all partners) [month 6]

D3.2) D3.2 Report on vulnerability of carbon sources and sinks: Report on vulnerability of carbon sources and sinks as a function of model and scenario (month 12, MetO leads, all partners) [month 12]

D3.3) D3.3 Report on feasibility of mitigation scenarios: Report on feasibility of different green scenarios / mitigation options (month 24, MetO leads, all partners) [month 24]

D3.4) D3.4 Mechanisms that contribute to carbon source/sink changes: Report on mechanisms that contribute to simulated changes in carbon sources and sinks (month 18, LSCE and ETHZürich leads, all partners) [month 18]

D3.5) D3.5 Probabilistic carbon sources and sink assessment for the 21st century: Probabilistic carbon sources and sink assessment for the 21st century from a range of sensitivity simulations (Bern 3D and HadCM3) including different parameterisations and an optimally-tuned model version (month 42, UBern and MetO leads) [month 42]

D3.6) D3.6 Long-term simulations: Long-term simulations (to 2500) using same or fast versions of ESMs (IPSL-CM, HadCM3) or EMICS (Bern3D) to investigate long-term changes in the climate-carbon system (month 36, UBern leads, LSCE, MetO) [month 36]

D3.7) D3.7 Assessment of detection: Assessment of when climate impact on carbon fluxes is detectable in the future, for different models and different scenarios (month 42, LSCE leads, all partners). [month 42]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS31	M3.1 Simulations of carbon sources and sinks under IPCC AR5 scenarios (1860-2100) with ESMs & EMICs	4	6	
MS32	M3.2 Long-term simulations performed (2100 to 2500) with a subset of ESMs and EMICs	20	36	
MS33	M3.3 Ensemble simulations / Monte-Carlo simulations with Bern3D / HadCM3 performed	21	42	

WT3:
Work package description

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

One form per Work Package

Work package number [53]	WP4	Type of activity [54]	RTD
Work package title	Surface observing system		
Start month	1		
End month	48		
Lead beneficiary number [55]	31		

Objectives

• Set up and evaluate a network of observations to track trends in atmosphere-ocean carbon fluxes in critical regions, and changes in both the natural carbon cycle and the trends due to the penetration of anthropogenic carbon in the ocean. The evaluation will include assessment of the accuracy and precision of analyses, evaluation of the data intercalibration methods and documentation, and standardization where agreed best practice is identified, of the techniques being used by the partners.
• In the North and Tropical Atlantic, support and build on the prototype CARBOOCEAN network: Improve its efficiency of operation by a more co-ordinated approach. Improvements that need to be made are: better co-ordination to avoid data gaps due to the uncertainties of the shipping industry, more traceability in calibration, more accurate atmospheric measurements to be useable in inversion models, and useful in-water oxygen measurements. A co-ordination unit will be initiated to provide this extra level of support.
• In the Southern ocean use repeated transects of research vessels to enable a decadal picture to be built up in the Atlantic and Indian sectors. These large-scale / long-term investigations will be complemented by smaller-scale studies based on drifters' measurements, characterising the variability under-sampled by ship observations.
• In the atmosphere we will undertake high-precision atmospheric observations of CO2 and oxygen / nitrogen to enable us to test the use of regional patterns of atmospheric potential oxygen as an independent method of observing air-sea carbon fluxes over the North Atlantic.

Description of work and role of partners

Task 4.1: Set up and evaluate an observational network for estimates of the air-sea flux of CO2 (UPMC, GEOMAR, NUIG, UNIRESEARCH, ULPGC, NERC, PML, UEA,).
Task 4.2: Co-ordinate the Atlantic/Southern Ocean observational network, trace gas calibrations, improve sea surface oxygen data, and improve atmospheric measurements on VOS. (UEA, UNEXE).
Task 4.3: Collect surface water CO2 and associated data in the Atlantic. As part of the observing network, 9 ships will be equipped with pCO2 equipment as Voluntary Observing Ships (VOS); additionally, there will be 2 PIRATA moorings in the Tropical Atlantic, equipped with pCO2 sensors. (UPMC, AWI, GEOMAR, NUIG, UNIRESEARCH, ULPGC, NERC, UEA, UNEXE).
Task 4.4: Collect surface water CO2 and associated data in the Southern Ocean, from 3 research vessels: Marion Dufresnes/OISO cruises in the Indian Ocean, FS Polarstern and RRS James Clark Cross in the Atlantic section of the Southern Ocean (UPMC, AWI, PML, CSIR).
Task 4.5: Collect CO2 and O2/N2 data in the atmosphere at Mace Head, Ireland, and Ivittuut, Southern Greenland. (CEA/LSCE), NUIG, UEA).
Task 4.6: Estimate seasonal to interannual variability of the air-sea flux of CO2 on a yearly basis (UPMC, AWI, GEOMAR, NUIG, UNIRESEARCH, ULPGC, NERC, PML, UEA, UNEXE).
Task 4.7: Create a climatology of seasonal sea surface pH for the Atlantic and the Atlantic section of the Southern Ocean (UPMC, GEOMAR, NUIG, UNIRESEARCH, ULPGC, NERC, PML, UNEXE).
Task 4.8: Estimate the effect of high frequency variability as sampled by CARIOCA instruments onto ship based air-sea CO2 flux estimates (UPMC)
Task 4.9: Collaborate with WP8 with quality controlled data (CEA /LSCE, UPMC, AWI, GEOMAR, NUIG, UNIRESEARCH, ULPGC, NERC, PML, UNEXE).
Task 4.10: Assess CO2 air-sea fluxes by atmospheric observations, and compare with in-water techniques (CEA/LSCE, GEOMAR, NUIG, UEA).

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
4	CEA	1.00
5	UPMC	35.00
6	AWI	7.00
11	NUIG	5.00
15	UNIRESEARCH	12.00
17	ULPGC	30.00
22	NERC	7.70
23	PML	8.00
25	UEA	24.20
26	CSIR	0.01
28	DU	0.01
29	GEOMAR	8.00
31	UNEXE	18.80
	Total	156.72

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D4.1	D4.1 Network set up	25	10.00	R	PU	12
D4.2	D4.2 Report on Co-ordination (part 1)	25	2.00	R	PU	12
D4.3	D4.3 Report on Co-ordination (part 2)	25	2.00	R	PU	24
D4.4	D4.4 Report on Co-ordination (part 3)	31	2.00	R	PU	36
D4.5	D4.5 Report on Co-ordination (part 4)	31	2.00	R	PU	48
D4.6	D4.6 Delivery of Atlantic data (part 1)	25	10.00	R	PP	12
D4.7	D4.7 Delivery of Atlantic data (part 2)	1	10.00	R	PP	24
D4.8	D4.8 Delivery of Atlantic data (part 3)	31	10.00	R	PP	36
D4.9	D4.9 Delivery of Atlantic data (part 4)	31	10.00	R	PP	48
D4.10	D4.10 Delivery of Southern Ocean data (part 1)	25	10.00	R	PP	12
D4.11	D4.11 Delivery of Southern Ocean data (part 2)	25	10.00	R	PP	24
D4.12	D4.12 Delivery of Southern Ocean data (part 3)	31	10.00	R	PP	36
D4.13	D4.13 Delivery of Southern Ocean data (part 4)	1	10.00	R	PP	48

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D4.14	D4.14 Delivery of atmospheric data (part 1)	25	9.00	R	PU	12
D4.15	D4.15 Delivery of atmospheric data (part 2)	1	9.00	R	PU	24
D4.16	D4.16 Delivery of atmospheric data (part 3)	25	8.00	R	PU	36
D4.17	D4.17 Delivery of atmospheric data (part 4)	25	8.00	R	PU	48
D4.18	D4.18 Seasonal to interannual variability (part 1)	25	5.00	R	PU	24
D4.19	D4.19 Seasonal to interannual variability (part 2)	31	5.00	R	PU	48
D4.20	D4.20 Report on the effect of high frequency variability	5	5.00	R	PU	48
D4.21	D4.21 Report on climatology of seasonal sea surface pH	31	5.00	R	PU	48
D4.22	D4.22 Assessment of air-sea fluxes by atmospheric observations	4	4.71	R	PU	48
		Total	156.71			

Description of deliverables

D4.1) D4.1 Network set up: Observational network set up (12, UEA with all participating partners), (R, PU). [month 12]

D4.2) D4.2 Report on Co-ordination (part 1): Reports on Co-ordination of observational network (12,24,36,48, UEA), (R, PU). [month 12]

D4.3) D4.3 Report on Co-ordination (part 2): Reports on Co-ordination of observational network (12,24,36,48, UEA), (R, PU). [month 24]

D4.4) D4.4 Report on Co-ordination (part 3): Reports on Co-ordination of observational network (12,24,36,48, UNEXE, UEA), (R, PU). [month 36]

D4.5) D4.5 Report on Co-ordination (part 4): Reports on Co-ordination of observational network (12,24,36,48, UNEXE, UEA), (R, PU). [month 48]

D4.6) D4.6 Delivery of Atlantic data (part 1): Delivery of CO2 and related parameters in the Atlantic to WP9 (12,24,36,48, UEA, GEOMAR, UNIRESEARCH, ULPGC, UPMC), (R, PP). [month 12]

D4.7) D4.7 Delivery of Atlantic data (part 2): Delivery of CO2 and related parameters in the Atlantic to WP9 (12,24,36,48, UEA, GEOMAR, UNIRESEARCH, ULPGC, UPMC), (R, PP). [month 24]

D4.8) D4.8 Delivery of Atlantic data (part 3): Delivery of CO2 and related parameters in the Atlantic to WP9 (12,24,36,48, UEA, UNEXE, GEOMAR, UNIRESEARCH, ULPGC, UPMC), (R, PP). [month 36]

D4.9) D4.9 Delivery of Atlantic data (part 4): Delivery of CO2 and related parameters in the Atlantic to WP9 (12,24,36,48, UNEXE, UEA, GEOMAR, UNIRESEARCH, ULPGC, UPMC), (R, PP). [month 48]

D4.10) D4.10 Delivery of Southern Ocean data (part 1): Delivery of CO2 and related parameters in the Southern Ocean to WP9 (12,24,36,48, UEA, UPMC, PML), (R, PP). [month 12]

D4.11) D4.11 Delivery of Southern Ocean data (part 2): Delivery of CO2 and related parameters in the Southern Ocean to WP9 (12,24,36,48, UEA, UPMC, PML), (R, PP). [month 24]

D4.12) D4.12 Delivery of Southern Ocean data (part 3): Delivery of CO2 and related parameters in the Southern Ocean to WP9 (12,24,36,48, UNEXE, UEA, UPMC, PML), (R, PP). [month 36]

D4.13) D4.13 Delivery of Southern Ocean data (part 4): Delivery of CO2 and related parameters in the Southern Ocean to WP9 (12,24,36,48, UEA, UPMC, PML), (R, PP). [month 48]

D4.14) D4.14 Delivery of atmospheric data (part 1): Delivery of atmospheric CO2 and O2/N2 to WP9 (12,24,36,48, UEA with NUIG, CEA/LSCE) (R, PU). [month 12]

D4.15) D4.15 Delivery of atmospheric data (part 2): Delivery of atmospheric CO2 and O2/N2 to WP9 (12,24,36,48, UEA with NUIG, CEA/LSCE) (R, PU). [month 24]

D4.16) D4.16 Delivery of atmospheric data (part 3): Delivery of atmospheric CO2 and O2/N2 to WP9 (12,24,36,48, UEA with NUIG, CEA/LSCE) (R, PU). [month 36]

D4.17) D4.17 Delivery of atmospheric data (part 4): Delivery of atmospheric CO2 and O2/N2 to WP9 (12,24,36,48, UEA with NUIG, CEA/LSCE) (R, PU). [month 48]

D4.18) D4.18 Seasonal to interannual variability (part 1): Report on seasonal to interannual variability of the air-sea flux of CO2 (24, 48, UEA, AWI, GEOMAR, NERC, PML, UNIRESEARCH, ULPGC, UPMC), (R, PU)). [month 24]

D4.19) D4.19 Seasonal to interannual variability (part 2): Report on seasonal to interannual variability of the air-sea flux of CO2 (24, 48, UNEXE, UEA, AWI, GEOMAR, NERC, PML, UNIRESEARCH, ULPGC, UPMC), (R, PU)). [month 48]

D4.20) D4.20 Report on the effect of high frequency variability: Report on the effect of high frequency variability as observed by CARIOCA instruments onto ship based air-sea CO2 flux estimates (UPMC), (R, PU)) [month 48]

D4.21) D4.21 Report on climatology of seasonal sea surface pH: Report on climatology of seasonal sea surface pH for the Atlantic and the Atlantic section of the Southern Ocean (48, UNEXE, UEA, GEOMAR, NERC, PML, UNIRESEARCH, ULPGC, UPMC), (R, PU)). [month 48]

D4.22) D4.22 Assessment of air-sea fluxes by atmospheric observations: Assessment of air-sea fluxes by atmospheric observations, comparison with in-water techniques (48, CEA/LSCE), UEA, NUIG, UPMC), (R, PU) [month 48]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS41	M4.1 Observational network set up	25	12	
MS42	M4.2 Quality-controlled data delivered to WP 9	25	12	
MS43	M4.3 Quality-controlled data delivered to WP 9	25	24	
MS44	M4.4 Quality-controlled data delivered to WP 9	31	36	
MS45	M4.5 Quality-controlled data delivered to WP 9	31	48	
MS46	M4.6 Climatology of seasonal sea surface pH for the Atlantic and the Atl. section of the South. Oc.	31	24	

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

One form per Work Package

Work package number [53]	WP5	Type of activity [54]	RTD
Work package title	Deep ocean, time series, choke points		
Start month	1		
End month	48		
Lead beneficiary number [55]	16		

Objectives

• Coordinate and conduct time-series and deep section measurements of the vertical structure of ocean carbon. New and existing high-frequency observations (<seasonal) at time series stations and lower-frequency (multi-annual/decadal) hydrographic sections will be used to estimate the variability of (regional budgets of) natural and anthropogenic CO2 and resolve internal ocean processes affecting the variability of oceanic CO2 parameters.
• Evaluate the carbon storage and its vulnerability in the interior ocean with respect to anthropogenic changes, oceanic circulation and biogeochemical processes, linked to model outputs and skills.

Description of work and role of partners

Because circulation and biological changes can vary in response to local or regional climate forcing whose timescales are not yet fully understood, it is critical to determine changes in natural and anthropogenic carbon inventories and ocean acidification and how they interact with changing ocean circulation patterns and biogeochemical cycles. For this it is essential to resolve the sub-surface vertical structure of ocean carbon. Repeat hydrographic sections with carbon and ancillary quantities at defined choke points across the Atlantic Ocean basin provides an effective approach to accurately quantify changes in the world oceans. This includes both decadal-scale repeats and repeat sections with a frequency of 2-3 years in key regions for water mass formation. As a second prong of this work package, time series stations at choking points are necessary for high frequency processes and mechanisms, and are complementary to deep sections.

The approach is to implement repeat sections and ocean time-series stations within the Atlantic Ocean and natural adjacent regions of the Arctic Seas and Southern Ocean. We will carry out repeat sections that will contribute to the long-term observation, i.e. those that have a long history, those at critical sites and those that have a good chance to be continued after the project. Hydrographic sections provide information on changing carbon inventories and can be used for estimating large-scale transports of carbon within the ocean and serve as a benchmark for testing prognostic and predictive models. Time series stations will provide information on seasonal variations of the carbon cycle in the upper layers and will serve as focal points for process studies and high-frequency data sets. In addition to tracing the increase of anthropogenic CO2 and acidification in the upper ocean, time series stations and repeat sections permit to quantify the downward spreading of the acidifying seawater. Apart from carbon system measurements, also a suite of auxiliary data will be collected including temperature and salinity, nutrients, oxygen, transient tracers, optionally isotopes like 13C and 14C. For carbon measurements, community-wide recognized certified reference material, obtained from Prof. A. Dickson (Scripps Institution of Oceanography), will be used to make data intercomparable; this will also be done for other measured quantities, as far as internationally recognized standards are available. Moreover, all collected data will be compared with the data from the synthesis projects GLODAP and CARINA (in which many CarboChange investigators have been heavily involved), which ensures internal consistency of all relevant data, both present and historic.
Task 5.1: Collect oceanic time series data at the 7 predefined time series (Irminger and Iceland Seas, GIFT, ESTOC, TENATSO, PIRATA, PAP) in the Atlantic Ocean and the Nordic Seas in coordination with OceanSites (GEOMAR, AWI, ULPGC, CSIC, MRI-UI, UPMC, NERC)
Description of work
Because circulation and biological changes can vary in response to local or regional climate forcing whose timescales are not yet fully understood, it is critical to determine changes in natural and anthropogenic carbon

inventories and ocean acidification and how they interact with changing ocean circulation patterns and biogeochemical cycles. For this it is essential to resolve the sub-surface vertical structure of ocean carbon. Repeat hydrographic sections with carbon and ancillary quantities at defined choke points across the Atlantic Ocean basin provides an effective approach to accurately quantify changes in the world oceans. This includes both decadal-scale repeats and repeat sections with a frequency of 2-3 years in key regions for water mass formation. As a second prong of this work package, time series stations at choking points are necessary for high frequency processes and mechanisms, and are complementary to deep sections.

The approach is to implement repeat sections and ocean time-series stations within the Atlantic Ocean and natural adjacent regions of the Arctic Seas and Southern Ocean. We will carry out repeat sections that will contribute to the long-term observation, i.e. those that have a long history, those at critical sites and those that have a good chance to be continued after the project. Hydrographic sections provide information on changing carbon inventories and can be used for estimating large-scale transports of carbon within the ocean and serve as a benchmark for testing prognostic and predictive models. Time series stations will provide information on seasonal variations of the carbon cycle in the upper layers and will serve as focal points for process studies and high-frequency data sets. In addition to tracing the increase of anthropogenic CO2 and acidification in the upper ocean, time series stations and repeat sections permit to quantify the downward spreading of the acidifying seawater. Apart from carbon system measurements, also a suite of auxiliary data will be collected including temperature and salinity, nutrients, oxygen, transient tracers, optionally isotopes like 13C and 14C. For carbon measurements, community-wide recognized certified reference material, obtained from Prof. A. Dickson (Scripps Institution of Oceanography), will be used to make data intercomparable; this will also be done for other measured quantities, as far as internationally recognized standards are available. Moreover, all collected data will be compared with the data from the synthesis projects GLODAP and CARINA (in which many CarboChange investigators have been heavily involved), which ensures internal consistency of all relevant data, both present and historic.

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Task 5.2: Collect CO2 and associated data along 10 predefined sections (75ºN, Arctic, Greenland, OVIDE, Subpolar Atlantic, MOC2 at 8ºN, 24ºN, 28ºN-14-12ºW, Southern Ocean Prime Meridian and Weddell Sea, FICARAM South Atlantic, all West Atlantic) in the Atlantic Ocean and adjacent regions (CSIC, AWI, UNIRESEARCH, UGOT, UniHB, UEA, NIOZ, INRH, UPMC)
Task 5.3: Assess the variability of natural and anthropogenic carbon storage and the factors affecting this in critical regions and at choke points: 75ºN, Greenland, 8ºN, Irminger, Iceland, Labrador, Strait of Gibraltar, Drake Passage, Prime Meridian and Weddell Sea (UniHB, UGOT, UNIRESEARCH, MRI-UI, CSIC, NIOZ, UEA, AWI).
Task 5.4: Assess regional carbon inventories and decadal and interannual changes in these for testing the prognostic and predictive models, in collaboration with Task 8.3 (CSIC, UNIRESEARCH, AWI, UniHB, NIOZ, UEA)
Task 5.5: Determine natural variability of the carbon cycle in the upper ocean using high frequency data from time series stations (GEOMAR, CSIC, ULPGC, MRI-UI, UPMC)
Task 5.6: Assess trends on ocean acidification using data from time series and repeat sections and generate synergies with international projects addressing this topic (ULPGC, CSIC, AWI, MRI-UI, GEOMAR, UEA)
Task 5.7: Contribute quality controlled data to Task 8.3 (AWI, all partners)
Task 5.8: Set first steps to provide a link between the uptake of CO2 from the atmosphere with the deep-water increase of CO2, in collaboration with WP4 (UEA, CSIC, GEOMAR, AWI, UNIRESEARCH, UPMC, NERC)

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
5	UPMC	7.00
6	AWI	27.00
9	UniHB	7.00
10	MRI-UI	7.00
12	INRH	5.00

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
13	NIOZ	18.00
15	UNIRESEARCH	8.00
16	CSIC	37.00
17	ULPGC	15.00
18	UGOT	3.00
22	NERC	3.40
25	UEA	4.50
27	PU-AOS	0.01
28	DU	0.01
29	GEOMAR	24.00
	Total	165.92

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D5.1	D5.1 Submission of quality controlled data (part 1)	29	11.00	R	PP	18
D5.2	D5.2 Submission of quality controlled data (part 2)	29	11.00	R	PP	30
D5.3	D5.3 Submission of quality controlled data (part 3)	29	11.00	R	PP	42
D5.4	D5.4 Submission of quality controlled data (part 4)	29	11.00	R	PP	48
D5.5	D5.5 Collection of section data (part 1)	16	16.00	R	PP	18
D5.6	D5.6 Collection of section data (part 2)	16	15.00	R	PP	30
D5.7	D5.7 Collection of section data (part 3)	16	15.00	R	PP	42
D5.8	D5.8 Collection of section data (part 4)	16	15.00	R	PP	48
D5.9	D5.9 Regional carbon inventories	16	10.00	R	PU	40
D5.10	D5.10 Variability of the carbon cycle from time series	29	10.00	R	PU	40
D5.11	D5.11 Trends in ocean acidification	17	10.00	R	PU	36
D5.12	D5.12 Publication on deep storage variability	25	10.00	O	PU	46

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D5.13	D5.13 Atlantic synthesis papers	25	10.00	O	PU	46
D5.14	D5.14 Constraints for climate/ocean circulation models	6	10.90	R	PU	46
		Total	165.90			

Description of deliverables

D5.1) D5.1 Submission of quality controlled data (part 1): Submission of quality controlled data to WP9 (GEOMAR, ULPGC, CSIC, MRI-UI, UPMC, NERC) (month 18, 30, 42, 48) (R, PP) [month 18]

D5.2) D5.2 Submission of quality controlled data (part 2): Submission of quality controlled data to WP9 (GEOMAR, ULPGC, CSIC, MRI-UI, UPMC, NERC) (month 18, 30, 42, 48) (R, PP) [month 30]

D5.3) D5.3 Submission of quality controlled data (part 3): Submission of quality controlled data to WP9 (GEOMAR, ULPGC, CSIC, MRI-UI, UPMC, NERC) (month 18, 30, 42, 48) (R, PP) [month 42]

D5.4) D5.4 Submission of quality controlled data (part 4): Submission of quality controlled data to WP9 (GEOMAR, ULPGC, CSIC, MRI-UI, UPMC, NERC) (month 18, 30, 42, 48) (R, PP) [month 48]

D5.5) D5.5 Collection of section data (part 1): Collection of carbon data for 9 sections and submission to WP9 (month 12, 24, 36, 48) and submission of quality controlled data from time series and deep sections to data centre (CSIC, AWI, UNIRESEARCH, UGOT, UniHB, NIOZ, INRH, UEA) (month 18, 30, 42, 48) (R, PP) [month 18]

D5.6) D5.6 Collection of section data (part 2): Collection of carbon data for 9 sections and submission to WP9 (month 12, 24, 36, 48) and submission of quality controlled data from time series and deep sections to data centre (CSIC, AWI, UNIRESEARCH, UGOT, UniHB, NIOZ, INRH, UEA) (month 18, 30, 42, 48) (R, PP) [month 30]

D5.7) D5.7 Collection of section data (part 3): Collection of carbon data for 9 sections and submission to WP9 (month 12, 24, 36, 48) and submission of quality controlled data from time series and deep sections to data centre (CSIC, AWI, UNIRESEARCH, UGOT, UniHB, NIOZ, INRH, UEA) (month 18, 30, 42, 48) (R, PP) [month 42]

D5.8) D5.8 Collection of section data (part 4): Collection of carbon data for 9 sections and submission to WP9 (month 12, 24, 36, 48) and submission of quality controlled data from time series and deep sections to data centre (CSIC, AWI, UNIRESEARCH, UGOT, UniHB, NIOZ, INRH, UEA) (month 18, 30, 42, 48) (R, PP) [month 48]

D5.9) D5.9 Regional carbon inventories: Report on regional carbon inventories and their decadal changes (CSIC, UNIRESEARCH, AWI, UniHB, NIOZ, UEA) (month 40) (R, PU) [month 40]

D5.10) D5.10 Variability of the carbon cycle from time series: Report on the variability of the carbon cycle in the upper ocean using data from time series stations (GEOMAR, CSIC, ULPGC, MRI-UI, UPMC) (month 40) [month 40]

D5.11) D5.11 Trends in ocean acidification: Report on trends in ocean acidification in different regions of the Atlantic Ocean (ULPGC, CSIC, AWI, MRI-UI, GEOMAR, UEA) (month 36) (R, PU) [month 36]

D5.12) D5.12 Publication on deep storage variability: Publication in the peer-reviewed international literature on the regional and basin-wide variability of deep carbon storage (UEA, CSIC, AWI, UniHB, UNIRESEARCH, UGOT, MRI-UI, NIOZ, INRH) (month 46) (O, PU) [month 46]

D5.13) D5.13 Atlantic synthesis papers: Synthesis papers for the Atlantic Ocean and for adjacent regions (in collaboration with WP8) [month 46]

D5.14) D5.14 Constraints for climate/ocean circulation models: With the deep section and time series network, deliver constraints for climate/ocean circulation models (all Tasks) in connection with the model-data-comparison group (WP7) (all partners) (month 46) [month 46]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS51	M5.1 Quality-controlled data submitted to WP 9	6	18	
MS52	M5.2 Quality-controlled data submitted to WP 9	6	30	
MS53	M5.3 Quality-controlled data submitted to WP 9	6	42	
MS54	M5.4 Quality-controlled data submitted to WP 9	6	48	
MS55	M5.5 Synthesis paper for Atlantic ocean and adjacent regions submitted	6	48	

WT3:
Work package description

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

One form per Work Package

Work package number [53]	WP6	Type of activity [54]	RTD
Work package title	Systematic model calibration using observational data		
Start month	1		
End month	36		
Lead beneficiary number [55]	14		

Objectives

• To integrate the ocean carbon models with observations available from WP4 (surface), WP5 (interior, time series) and WP8 (synthesis) and calibrate the biogeochemical parameters for accurate reconstruction of carbon and related tracers on different time scales. Advanced stand-alone models and a coupled terrestrial-ocean model will be used over decadal time scales, EMICs over centennial time scales and stationary transport matrices for millennial time scales. The validation metrics defined in WP7 at Mo 12 will be implemented in each of the 3D models used in WP6 to demonstrate the benefits of calibration.
• To provide the calibrated models for reconstructions (hindcasts) for the synthesised assessment in WP8 and for synthesis activities beyond the IPCC AR5 time frame.,

Description of work and role of partners

Task 6.1 - Calibration of biogeochemical parameters in a stand alone isopycnic ocean on interannual time scale: An EnKF system is set up around the coupled MICOM-HAMOCC model and applied for calibration of the main physical and biological parameters with focus on interannual variability over a recent four-year period using observations from WP4. The calibrated model is then integrated within the Earth system model NorESM for climate projections. (NERSC, UiB)
Task 6.2 - Calibration of biogeochemical process parameters in a stand alone ocean and simultaneously with terrestrial biosphere model on decadal time scale: Build and operate a variational assimilation system around the BGC version of the MITgcm (MITBOGCM) to systematically calibrate the biogeochemical process parameters using a range of oceanic observations plus a system that can calibrate the ocean model simultaneously with the terrestrial biosphere model BETHY by using observed atmospheric concentrations (in addition to the oceanic observations). The calibrated ocean model can be used for long simulations within the MITEMIC(UNIVBRIS, UiB, AWI).
Task 6.3 - EMIC calibration for improved predictability and constrained biogeochemical fluxes: An EnKF System is set up around the Bern3D model and applied for calibration of physical and biogeochemical process parameters (further used in WP3) and to constrain fluxes of potential alkalinity and carbon. Use of temperature, salinity, CFCs, radiocarbon, carbon, nutrient and alkalinity data (UBern).
Task 6.4 - Calibration of process parameters in a set of stand alone biogeochemical models for circulation fields from a range of IPCC models on millennial time scale: To speed up the simulation, the circulations (including those from MIT, NCAR, NEMO, GFDL) will be approximated by transport matrices resulting in a seasonally cycling stationary solution that is fit will be fit to measured alkalinity, nutrient and oxygen distributions and estimated pre-industrial dissolved inorganic carbon (GEOMAR).
Task 6.5 - Calibration of biogeochemical process parameters in a one dimensional version of a stand alone model: Variational calibration of the PISCES biogeochemistry model with biogeochemical observations from individual sites and satellite products (CLIMMOD).

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
4	CEA	6.00
6	AWI	15.00

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
14	NERSC	17.00
20	UBERN	19.00
24	UNIVBRIS	19.00
29	GEOMAR	16.00
30	CLIMMOD	1.50
	Total	93.50

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D6.1	D6.1 Calibrated version of MICOM-HAMOCC	14	11.00	R	PU	24
D6.2	D6.2 Report on constrained CaCO3 dissolution fluxes (Bern3D)	20	19.00	R	PU	30
D6.3	D6.3 Report on calibrated versions of MITBOGCM	24	34.00	R	PU	36
D6.4	D6.4 Report on assimilation (MICOM-HAMOCC)	14	6.00	R	PU	36
D6.5	D6.5 Report on parameter optimisation (PISCES)	30	23.50	R	PU	36
		Total	93.50			

Description of deliverables

D6.1) D6.1 Calibrated version of MICOM-HAMOCC: Calibrated version of stand alone MICOM-HAMOCC after 5-years assimilation run for WP3 (month 24, P, PU), (NERSC) [month 24]

D6.2) D6.2 Report on constrained CaCO3 dissolution fluxes (Bern3D): Report on constrained CaCO3 dissolution fluxes and implications for carbon sources and sinks as simulated by Bern3D model (month 30, R, PU), (UBern) [month 30]

D6.3) D6.3 Report on calibrated versions of MITBOGCM: Report on calibrated versions of MITBOGCM stand alone and with terrestrial biosphere (month 36, R, PU), (UNIVBRIS) [month 36]

D6.4) D6.4 Report on assimilation (MICOM-HAMOCC): Report on assimilation vs. control run MICOM-HAMOCC (month 36, R, PU), (NERSC) [month 36]

D6.5) D6.5 Report on parameter optimisation (PISCES): Report on optimised parameter values for the PISCES model (month 36; R), (PU) [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS61	M6.1 EnKF Assimilation implemented in MICOM-HAMOCC	14	12	
MS62	M6.2 EnKF system around Bern3D model implemented	20	12	
MS63	M6.3 Systems for calibration of MITBOGCM stand alone and with terrestrial biosphere implemented	24	28	

WT3:
Work package description

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

One form per Work Package

Work package number [53]	WP7	Type of activity [54]	RTD
Work package title	Data-model and model-model comparison		
Start month	1		
End month	36		
Lead beneficiary number [55]	29		

Objectives

• To compare data-based estimates concerning ocean carbon and related tracers to simulated results from ocean carbon cycle models, both in forced mode (50-year hindcasts) and in coupled mode (part of Earth System Models).
• To develop regional data metrics and use them to evaluate and weigh these models to provide optimal estimates for the changing ocean carbon sink (preindustrial through modern to 2100 and beyond) and carbon-climate feedbacks.

Description of work and role of partners

Task 7.1 – Global comparison and evaluation: Compare models, including those focused on interannual-to-decadal variability (forced hindcast models in WP2, WP8) and those focused on future change (Earth System Models in WP3) using their output in the project archive (WP9), to one another and to the most up-to-date relevant ocean carbon-related data. Data references will include time series and global databases for surface pCO2 (SOCAT) and derived air-sea CO2 fluxes, interior ocean DIC and alkalinity (GLODAP and CARINA), O2, nutrients, CFCs, radiocarbon, temperature, and salinity. Model intercomparison will be extended to also include the international group of IPCC AR5 Earth System Models (CMIP5) and the international group of forced ocean models making hindcast simulations as part of the Marine Ecosystem Model Intercomparison project (MAREMIP) (LSCE, GEOMAR, UBern, ETHZürich, UEA, UPMC, UiB, NERSC, MetO, MPG, AWI).
Task 7.2 – Performance indices: Develop quantitative data-based performance indices (metrics) to assess model skill; combine these metrics to provide a weighted-mean "best" assessment for projected changes (UBern, ETHZurich, CEA/LSCE, UPMC, GEOMAR).
Task 7.3 – Links across timescales: Assess correlations between performance indices on different time scales (mean state, seasonal variability, and interannual-to-decadal variability) across the model spectrum to assess how useful it is to use them to weigh future projections (CEA/LSCE).
Task 7.4 – Feedbacks: Assess carbon-climate feedbacks at the regional scale across the range of Earth system models, constrain feedbacks with data, and quantify how these carbon-climate feedbacks compare with cloud feedbacks (UBern, CEA/LSCE).
Task 7.5 – Attribution: Quantify contribution of climate change to recent changes in observed carbon-cycle variables using fingerprints of climate change and climate variability from the forced hindcast model outputs and detection-attribution methods Results from this task will be combined with those from Task 3.4 of WP3 using Earth system models. (UEA)
Task 7.6 – Deep-ocean evaluation: Apply efficient Transport Matrix Method (TMM) to bypass intensive computational resources needed to evaluate the natural mean state. Use TMM to evaluate the mean state for natural radiocarbon, DIC, and alkalinity (GEOMAR)

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	UiB	1.00
4	CEA	24.00

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
5	UPMC	21.00
6	AWI	2.00
8	MPG	1.00
14	NERSC	0.50
19	ETH Zürich	18.00
20	UBERN	21.00
21	MetO	2.00
25	UEA	14.00
26	CSIR	0.01
29	GEOMAR	21.00
	Total	125.51

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D7.1	D7.1 Report on first comparions	4	40.00	R	PU	12
D7.2	D7.2 Workshop on new metrics	19	10.00	O	PU	12
D7.3	D7.3 Evaluation with C-14	29	15.00	R	PU	24
D7.4	D7.4 Workshop on methods to weigh models	20	10.00	O	PU	24
D7.5	D7.5 Report on metrics	4	25.00	R	PU	30
D7.6	D7.6 Report on Detection-Attribution	25	10.50	R	PU	36
D7.7	D7.7 Session on weighted optimal estimates	20	15.00	O	PU	36
		Total	125.50			

Description of deliverables

D7.1) D7.1 Report on first comparions: Report on 1st model-model & model-data comparisons (month 12, CEA/LSCE leads, all partners contribute) (R, PU) [month 12]

D7.2) D7.2 Workshop on new metrics: Workshop on new metrics and data-model evaluation (month 12, ETHZürich leads; all partners contribute) (O, PU) [month 12]

D7.3) D7.3 Evaluation with C-14: Presentation on deep-ocean evaluation of forced models with natural C-14 (month 24, GEOMAR, CEA/LSCE) (R, PU) [month 24]

D7.4) D7.4 Workshop on methods to weigh models: Workshop on methods to weigh models and constrain feedbacks (month 24, UBern leads; all partners contribute) (O, PU) [month 24]

D7.5) D7.5 Report on metrics: Report on “Metrics across time scales” (month 30, CEA/LSCE leads, all partners contribute) [month 30]

D7.6) D7.6 Report on Detection-Attribution: Report on Detection-Attribution of fingerprints of climate change on observed ocean carbon cycle (month 36, UEA) [month 36]

D7.7) D7.7 Session on weighted optimal estimates: Session on weighted optimal estimates and feedbacks at 3rd annual meeting (month 36, UBern, ETHZürich, CEA/LSCE lead; other partners contribute) [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS71	M7.1 Protocol distributed to model groups to make 1-timestep dye simulations for TMM evaluations	29	6	
MS72	M7.2 Model output fr. interann. variability simulations (forced ocean-model hindcasts) subm. to WP9	6	12	
MS73	M7.3 Model output fr. future climate-change simulations (ESMs und. IPCC AR5 scenarios) subm. to WP9	4	12	
MS74	M7.4 Output from dye simulations in set of forced ocean models made available to GEOMAR	29	12	
MS75	M7.5 Detection-attribution analysis of patterns underway with existing model output completed	25	18	
MS76	M7.6 Begin analysis of cross-timescale, data metric-correlations	4	18	
MS77	M7.7 Results from TMM simulations for natural C14 made available to WP9 for archiving	29	18	
MS78	M7.8 Output from models with data assimilation submitted to WP9 archive	1	24	

WT3:
Work package description

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

One form per Work Package

Work package number [53]	WP8	Type of activity [54]	RTD
Work package title	Global synthesis and outreach to policy makers		
Start month	1		
End month	48		
Lead beneficiary number [55]	25		

Objectives

• Produce high level synthesized products on an annual basis that provide key information on the uptake of CO2 by the ocean at the regional and global level and on the regional drivers of change.
• Synthesize information on the state of the ocean carbon cycle.
• Synthesize information on the vulnerability of the oceanic CO2 sink.

Description of work and role of partners

WP8 will synthesize the information produced within CARBOCHANGE, combine it with existing data and provide synthesis products that can be used in international assessments such at the 5th IPCC Assessment Report and by the annual CO2 budgets of the Global Carbon Project. We will produce four types of products: (Task 1) annual CO2 budgets for the global and regional ocean, (Task 2) biennial updates of surface ocean fCO2 observations, (Task 3) global atlas of key carbonate variables for the oceans, (Task 4) synthesis reports and papers in outreach journals.

Task 8.1 - Prepare annual releases of air-sea CO2 fluxes for the global ocean and by basin: These releases will be based on the average of several model simulations forced by increasing atmospheric CO2 and changes in climate (3 from CARBOCHANGE groups plus at least 2 from US groups). The releases will include an estimate of additional uncertainty caused by model spread, and of the confidence level based on the model spread and on the observed regional air-sea CO2 fluxes (in co-ordination with Task 2 and WP4). The releases will include associated press material, pictures, and a web summary for a lay audience. (UEA, UiB, LSCE)
Task 8.2 – Release of the Surface ocean CO2 atlas: Second level quality control and release of the Surface Ocean CO2 Atlas (SOCAT) and of a gridded product every two years (in co-ordination with Task 1 and WP4 and WP9). The work will be carried out according to approved SOCAT routines (see SOCAT cookbook and SOCAT input database documentation on http://www.socat.info/). Analyse observations to validate the model estimates and provide a confidence level based on the terminology developed by the IPCC. (UEA, UPCM)
Task 8.3 - Merge the GLODAP and CARINA datasets into a unified, consistent dataset: This task requires reassessing the adjustments applied to the GLODAP dataset in the Atlantic and Southern Oceans to ensure full compatibility with the CARINA dataset. Further expand this global database by inclusion of new data from the post CARINA era (after 2004), quality controlled using tools developed during CARBOOCEAN (Tanhua, T., et al., 2010. Quality controll procedures and methods of the CARINA database, Earth System Science Data, 2, 35-49). Create a 3-dimensional (3D) atlas of ocean DIC, TA, pH and CaCO3 saturation. The database and atlas will serve to assess ocean carbon cycle variability and to evaluate the performance of ocean models in collaboration with WP5 and WP6 . Extend and apply the AWI global adjoint model for the quantification of monthly CO2 air-sea fluxes, carbon export fluxes and 3D carbon transport in the water column by assimilation of the SOCAT fCO2 data, the merged and expanded GLODAP-CARINA water column data, other data from the World Ocean Database, and remote sensing data (SeaWiFS and MODIS chlorophyll). (UNIRESEARCH, GEOMAR, AWI, PU-AOS)
Task 8.4 – Report on vulnerability of the oceanic CO2 sink: Write a report on the vulnerability of the oceanic CO2 sink in collaboration with WP3, and at least three outreach papers on topics centered around high latitude CO2 fluxes, monitoring surface ocean CO2 in the long-term, and the oceanic CO2 sink and climate change. (LSCE, UGOT, UEA, UiB)

WT3:
Work package description

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	UiB	7.00
4	CEA	3.00
5	UPMC	3.00
6	AWI	11.00
15	UNIRESEARCH	8.00
18	UGOT	1.00
25	UEA	16.00
27	PU-AOS	0.01
28	DU	0.01
29	GEOMAR	3.00
	Total	52.02

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D8.1	D8.1 Annual estimates of oceanic CO2 sinks (part 1)	25	4.00	R	PP	8
D8.2	D8.2 Annual estimates of oceanic CO2 sinks (part 2)	25	4.00	R	PP	20
D8.3	D8.3 Annual estimates of oceanic CO2 sinks (part 3)	25	4.00	R	PP	32
D8.4	D8.4 Annual estimates of oceanic CO2 sinks (part 4)	25	4.00	R	PP	44
D8.5	D8.5 SOCAT update no. 1	25	4.00	R	PP	20
D8.6	D8.6 SOCAT update no. 2	25	4.00	R	PP	44
D8.7	D8.7 Unified CARINA-GLODAP dataset	15	6.00	O	RE	24
D8.8	D8.8 Atlas of carbonate variables	6	6.00	O	PP	36
D8.9	D8.9 Atlas for near present conditions	25	6.00	O	PP	36
D8.10	D8.10 Report on vulnerability	4	5.00	R	PU	36
D8.11	D8.11 Summarising outreach paper	25	5.00	O	PU	48
		Total	52.00			

Description of deliverables

D8.1) D8.1 Annual estimates of oceanic CO2 sinks (part 1): Annual estimates of the global and regional oceanic CO2 sinks including the uncertainty, driving processes, and confidence level from observations (months 8, 20, 32, 44) [month 8]

D8.2) D8.2 Annual estimates of oceanic CO2 sinks (part 2): Annual estimates of the global and regional oceanic CO2 sinks including the uncertainty, driving processes, and confidence level from observations (months 8, 20, 32, 44) [month 20]

D8.3) D8.3 Annual estimates of oceanic CO2 sinks (part 3): Annual estimates of the global and regional oceanic CO2 sinks including the uncertainty, driving processes, and confidence level from observations (months 8, 20, 32, 44) [month 32]

D8.4) D8.4 Annual estimates of oceanic CO2 sinks (part 4): Annual estimates of the global and regional oceanic CO2 sinks including the uncertainty, driving processes, and confidence level from observations (months 8, 20, 32, 44) [month 44]

D8.5) D8.5 SOCAT update no. 1: Biennial releases of the SOCAT updated database and gridded product (months 20 and 44) [month 20]

D8.6) D8.6 SOCAT update no. 2: Biennial releases of the SOCAT updated database and gridded product (months 20 and 44) [month 44]

D8.7) D8.7 Unified CARINA-GLODAP dataset: Unified and fully consistent CARINA and GLODAP dataset, including new available data (month 24) [month 24]

D8.8) D8.8 Atlas of carbonate variables: Atlas of carbonate variables for 3D fields of annual mean DIC, TA, pH and CaCO3 saturation states in the water column (month 36) [month 36]

D8.9) D8.9 Atlas for near present conditions: Atlas for near present conditions for monthly air-sea CO2 fluxes, carbon transports and sinking flux of particulate organic carbon (POC) and CaCO3 (month 36) [month 36]

D8.10) D8.10 Report on vulnerability: Report on the vulnerability of the oceanic CO2 sink (month 36) [month 36]

D8.11) D8.11 Summarising outreach paper: Summarising outreach paper on oceanic CO2 fluxes (months 48) [month 48]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS81	M8.1 SOCAT updated database released	15	20	
MS82	M8.2 SOCAT updated database released	15	44	
MS83	M8.3 CARINA and GLODAP dataset unified and updated	29	24	
MS84	M8.4 Atlas for carbonate variables for near-present conditions released	29	36	

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

One form per Work Package

Work package number [53]	WP9	Type of activity [54]	RTD
Work package title	Data and information management		
Start month	1		
End month	48		
Lead beneficiary number [55]	1		

Objectives

Providing
• continuous data management
• continues data management for model output
• continuous information management
• continuous technical and organizational data management infrastructure for observational data
• software for efficient use with large datasets
• yearly updates for the SOCAT (Surface Ocean CO2 Atlas) input database

Description of work and role of partners

Task 9.1 - Observational data management implies (UiB):
- data actions: rescue; acquisition; harmonization; assimilation; formatting; processing; archival; integration; quality control; attribution to PI; documentation; sharing; online access; long term preservation; synthesis; dissemination; visualization. Providing existing multidisciplinary data sets (e.g., WOCE, GLODAP, CARINA, etc.)
- management components: networking among the scientific and database partners; according to international standards and protocols (ISO, SOAP, WSDL, XML); structuring and organizing data flow between and among core themes, WPs, data centers, etc.; data exchange between national (eg NFR funded Merclim and CarbonHeat; DFG funded SOPRAN PHASE II) and EC funded projects (eg EU FP7 IP EPOCA) according to intellectual property rights as stated in the CARBOCHANGE data policy; timely data exchange and collaboration with international partners/projects is strongly encouraged; feeding metadata and data streams into international programs (eg. GEO, GEOSS and GMES; NASA's GCMD) as encouraged by FP7 COCOS; providing access (according to intellectual property rights) to all CARBOCHANGE data (observed and modelled data) while elaborating a comprehensive short term (data rescue) and long term (data preservation) data management plan; providing an appropriate data policy with respect to ESF and ICSU/CODATA "Good scientific practice in research" 1,2, the WIPO copyright treaty 3, and the DOE-NIH Guidelines for Sharing Data and Resources 4 organizing and participating to regular data and information management meetings.
Task 9.2- Model output data management comprises (CEA/LSCE):
- expand model-output archive used in the CARBOOCEAN & EPOCA projects (4 ESM) to accommodate new and updated ESMs and hindcast simulations with forced ocean models (from WPs 2, 3, 8, 9) following OCMIP4, C4MIP, and CMIP5.
Task 9.3 - Information management (UiB):
- sophisticated communication modules to guarantee efficient and smooth flow of information: creating a project name Information Service Center (UiB, WDC-MARE); supplying a pivotal communication platform (communication server, document server, electronic mailing lists, web sites, data portal, etc.); providing access to the international alliance WDC/ICSU (WDC Cluster) ; developing and maintaining the central www based project portal to all stakeholders; elaborate user interfaces scalable for different stakeholders;
develop and maintain links to groups with complementary/overlapping scientific interest/issues and/or institutional overlap: FP7 EPOCA, COCOS; ICOS; SCOR/IGBP IMBER, SOLAS; UNESCO-IOC IOCCP; GCP; LOICZ; national ocean acidification projects; etc.
Task 9.4 - Technical and organizational data management infrastructure for observational data comprises (UniHB):

- data storage and access; hardware and services for long term archival, distribution, citable publication via DOI (Digital Object Identifier); establishing a metadata and data information system (data portal); retrieval via data warehouse and data portal technology
Task 9.5- Assistance in creating datasets and software optimization comprises (AWI):
- assist in the creation of surface ocean and water column carbon datasets that will be used for model assimilation and validation. Provide enhanced versions of the enhancement the Ocean data View (ODV) Software
Task 9.6 - Updates of the SOCAT input database comprises (UiB):
- acquisition, harmonization, recalculation, formatting, documentation, primary quality control and inclusion of public underway data on a global scale; updating of already existing cruises; merging new and updated cruises with older versions of the SOCAT input database on a yearly basis; joint dissemination of SOCAT in collaboration with WP8 after performed secondary QC (see WP8 Task 2)

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	UiB	18.00
4	CEA	9.00
6	AWI	5.00
9	UniHB	4.00
27	PU-AOS	0.01
	Total	36.01

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D9.1	D9.1 Data management implementation plan	1	0.20	O	RE	1
D9.2	D9.2 First version of CARBOCHANGE data portal	9	4.00	O	RE	3
D9.3	D9.3 Update of the SOCAT input database	1	6.00	O	RE	12
D9.4	D9.4 First update of model output database	4	3.00	O	RE	12
D9.5	D9.5 Databases of observational data and selected model data (part 1)	1	4.45	O	RE	6
D9.6	D9.6 Databases of observational data and selected model data (part 2)	1	4.45	O	RE	12
D9.7	D9.7 Databases of observational data and selected model data (part 3)	1	4.45	O	RE	24
D9.8	D9.8 Databases of observational data and selected model data (part 4)	1	4.45	O	RE	36
D9.9	D9.9 Ocean Data View optimisation	6	5.00	O	RE	18
		Total	36.00			

Description of deliverables

D9.1) D9.1 Data management implementation plan: Data and information management implementation plan (short/long term); data policy; presented during kick-off meeting (UiB; Month 1) (O, RE) [month 1]

D9.2) D9.2 First version of CARBOCHANGE data portal: First version of CARBOCHANGE data portal ("web services" via standard interfaces linking all metadata and data inventories engaged) (UniHB; Month 3) (O, RE) [month 3]

D9.3) D9.3 Update of the SOCAT input database: Update of the SOCAT input database (UiB; Month 12) (O, RE) [month 12]

D9.4) D9.4 First update of model output database: First update of model output database made available to partners (CEA/LSCE; Month 12) (O, RE) [month 12]

D9.5) D9.5 Databases of observational data and selected model data (part 1): Databases of observational data; databases of selected model data (UiB; LSCE, continuously updated, Month 6, 12, 24, 36) (O, RE) [month 6]

D9.6) D9.6 Databases of observational data and selected model data (part 2): Databases of observational data; databases of selected model data (UiB; LSCE, continuously updated, Month 6, 12, 24, 36) (O, RE) [month 12]

D9.7) D9.7 Databases of observational data and selected model data (part 3): Databases of observational data; databases of selected model data (UiB; LSCE, continuously updated, Month 6, 12, 24, 36) (O, RE) [month 24]

D9.8) D9.8 Databases of observational data and selected model data (part 4): Databases of observational data; databases of selected model data (UiB; LSCE, continuously updated, Month 6, 12, 24, 36) (O, RE) [month 36]

D9.9) D9.9 Ocean Data View optimisation: Ocean Data View Software optimised for large data products (AWI; continuously updated, Month 18) (O, RE) [month 18]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS91	M9.1 Data management in full operation	1	3	
MS92	M9.2 Data exchange between observational scientists and modellers runs smoothly	1	12	
MS93	M9.3 Project’s data sets readily accessible	1	12	

WT3:
Work package description

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

One form per Work Package

Work package number [53]	WP10	Type of activity [54]	MGT
Work package title	Management of the project		
Start month	1		
End month	48		
Lead beneficiary number [55]	1		

Objectives

• Efficient scientific project management.
• ☐Efficient administrative/financial project management.
• ☐Provide the contact between the project consortium and the European Commission
• Review and assessment of project results
• Communication internally in the consortium, with the scientific community, the general public, and policy makers

Description of work and role of partners

WP10 is dedicated to all managerial aspects of the project (details are also described in section 2.1 of this proposal). This includes the scientific management and the administrative/financial management. A considerable part of the management person effort is dedicated to producing the scientific as well as financial periodic reports (the person effort has been included in the delivery of annual meetings).
Task 10.1: Internal communication within the consortium (including the scientific steering committee, the executive board, and the international advisory board),
Task 10.2: Communication between the European Commission and the coordinator as well as the consortium through email, phone, fax, and mail.
Task 10.3: Survey of project tasks and deadlines, timely notification of partners on upcoming deadlines (deliverables, milestones, project meetings, reporting), updating of important project lists and archives (deliverables, publications, partner lists and addresses, email-lists).
Task 10.4: General coordination, supervision, accomplishment and submission of periodic reports (scientific and financial parts).
Task 10.5: Solution of problems through addressing corresponding panels.
Task 10.6: General project dissemination/outreach to the scientific community and the general public, press contacts, in collaboration with outreach activities of WP 8 and the panel for Outreach to policy makers and training (see B2.1)
Task 10.7: Design, maintenance, and continuous updating of the project homepage on the internet.

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
1	UiB	18.00
	Total	18.00

List of deliverables

Delive-rable Number [61]	Deliverable Title	Lead benefi-ciary number	Estimated indicative person-months	Nature [62]	Dissemi-nation level [63]	Delivery date [64]
D10.1	D10.1 Kick-off meeting	1	1.00	O	PU	1
D10.2	D10.2 Project website	1	1.00	O	PU	1
D10.3	D10.3 Annual project meetings (part 1)	1	1.50	O	PU	12
D10.4	D10.4 Annual project meetings (part 2)	1	3.00	O	PU	24
D10.5	D10.5 Annual project meetings (part 3)	1	3.00	O	PU	36
D10.6	D10.6 Annual project meetings (part 4)	1	3.00	O	PU	48
D10.7	D10.7 First outreach paper to policy makers	1	3.00	R	PU	24
D10.8	D10.8 Second outreach paper to policy makers	1	2.50	R	PU	36
		Total	18.00			

Description of deliverables

D10.1) D10.1 Kick-off meeting: Organisation of kick-off meeting [month 1]

D10.2) D10.2 Project website: First version of project website [month 1]

D10.3) D10.3 Annual project meetings (part 1): Organisation of annual project meetings [month 12]

D10.4) D10.4 Annual project meetings (part 2): Organisation of annual project meetings [month 24]

D10.5) D10.5 Annual project meetings (part 3): Organisation of annual project meetings [month 36]

D10.6) D10.6 Annual project meetings (part 4): Organisation of annual project meetings [month 48]

D10.7) D10.7 First outreach paper to policy makers: First outreach paper to policy makers and dialogue event at Brussels (or annual meeting) [month 24]

D10.8) D10.8 Second outreach paper to policy makers: Second outreach paper to policy makers and dialogue event at Brussels (or annual meeting) [month 36]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead benefi-ciary number	Delivery date from Annex I [60]	Comments
MS101	M10.1 First reporting period accomplished and documented	1	19	
MS102	M10.2 Second reporting period accomplished and documented	1	37	

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS103	M10.3 Third reporting period accomplished and documented	1	48	Month 49

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

List and Schedule of Milestones

Milestone number [59]	Milestone name	WP number [53]	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS11	M1.1 Organic matter remineralisation data delivered to WP 7	WP1	19	24	
MS12	M1.2 First series of reports on biological pump, time variations and CO2 outflow submitted	WP1	17	24	
MS13	M1.3 Plankton model data submitted to WP7 for model-model intercomparison	WP1	6	36	
MS21	M2.1 Archived output of high-res. (1/4 deg) glob. coupl. biogeochem.-phys. model simul., last 50 yr	WP2	4	18	
MS31	M3.1 Simulations of carbon sources and sinks under IPCC AR5 scenarios (1860-2100) with ESMs & EMICs	WP3	4	6	
MS32	M3.2 Long-term simulations performed (2100 to 2500) with a subset of ESMs and EMICs	WP3	20	36	
MS33	M3.3 Ensemble simulations / Monte-Carlo simulations with Bern3D / HadCM3 performed	WP3	21	42	
MS41	M4.1 Observational network set up	WP4	25	12	
MS42	M4.2 Quality-controlled data delivered to WP 9	WP4	25	12	
MS43	M4.3 Quality-controlled data delivered to WP 9	WP4	25	24	

Milestone number [59]	Milestone name	WP number [53]	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS44	M4.4 Quality-controlled data delivered to WP 9	WP4	31	36	
MS45	M4.5 Quality-controlled data delivered to WP 9	WP4	31	48	
MS46	M4.6 Climatology of seasonal sea surface pH for the Atlantic and the Atl. section of the South. Oc.	WP4	31	24	
MS51	M5.1 Quality-controlled data submitted to WP 9	WP5	6	18	
MS52	M5.2 Quality-controlled data submitted to WP 9	WP5	6	30	
MS53	M5.3 Quality-controlled data submitted to WP 9	WP5	6	42	
MS54	M5.4 Quality-controlled data submitted to WP 9	WP5	6	48	
MS55	M5.5 Synthesis paper for Atlantic ocean and adjacent regions submitted	WP5	6	48	
MS61	M6.1 EnKF Assimilation implemented in MICOM-HAMOCC	WP6	14	12	
MS62	M6.2 EnKF system around Bern3D model implemented	WP6	20	12	
MS63	M6.3 Systems for calibration of MITBOGCM stand alone and with terrestrial biosphere implemented	WP6	24	28	
MS71	M7.1 Protocol distributed to model	WP7	29	6	

Milestone number [59]	Milestone name	WP number [53]	Lead beneficiary number	Delivery date from Annex I [60]	Comments
	groups to make 1-timestep dye simulations for TMM evaluations				
MS72	M7.2 Model output fr. interann. variability simulations (forced ocean-model hindcasts) subm. to WP9	WP7	6	12	
MS73	M7.3 Model output fr. future climate-change simulations (ESMs und. IPCC AR5 scenarios) subm. to WP9	WP7	4	12	
MS74	M7.4 Output from dye simulations in set of forced ocean models made available to GEOMAR	WP7	29	12	
MS75	M7.5 Detection-attribution analysis of patterns underway with existing model output completed	WP7	25	18	
MS76	M7.6 Begin analysis of cross-timescale, data metric-correlations	WP7	4	18	
MS77	M7.7 Results from TMM simulations for natural C14 made available to WP9 for archiving	WP7	29	18	
MS78	M7.8 Output from models with data assimilation submitted to WP9 archive	WP7	1	24	
MS81	M8.1 SOCAT updated database released	WP8	15	20	
MS82	M8.2 SOCAT updated database released	WP8	15	44	

Milestone number [59]	Milestone name	WP number [53]	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS83	M8.3 CARINA and GLODAP dataset unified and updated	WP8	29	24	
MS84	M8.4 Atlas for carbonate variables for near-present conditions released	WP8	29	36	
MS91	M9.1 Data management in full operation	WP9	1	3	
MS92	M9.2 Data exchange between observational scientists and modellers runs smoothly	WP9	1	12	
MS93	M9.3 Project's data sets readily accessible	WP9	1	12	
MS101	M10.1 First reporting period accomplished and documented	WP10	1	19	
MS102	M10.2 Second reporting period accomplished and documented	WP10	1	37	
MS103	M10.3 Third reporting period accomplished and documented	WP10	1	48	Month 49

WT5:
Tentative schedule of Project Reviews

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

Tentative schedule of Project Reviews

Review number [65]	Tentative timing	Planned venue of review	Comments, if any
RV 1	18	remote	
RV 2	36	remote	

WT6:
Project Effort by Beneficiary and Work Package

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

Indicative efforts (man-months) per Beneficiary per Work Package

Beneficiary number and short-name	WP 1	WP 2	WP 3	WP 4	WP 5	WP 6	WP 7	WP 8	WP 9	WP 10	Total per Beneficiary
1 - UiB	0.00	6.00	10.00	0.00	0.00	0.00	1.00	7.00	18.00	18.00	60.00
2 - VITUS	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
3 - IFREMER	0.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00
4 - CEA	6.00	10.00	17.00	1.00	0.00	6.00	24.00	3.00	9.00	0.00	76.00
5 - UPMC	0.00	11.00	0.00	35.00	7.00	0.00	21.00	3.00	0.00	0.00	77.00
6 - AWI	9.00	0.00	0.00	7.00	27.00	15.00	2.00	11.00	5.00	0.00	76.00
8 - MPG	3.50	0.00	11.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	15.50
9 - UniHB	6.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	4.00	0.00	17.00
10 - MRI-UI	0.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	7.00
11 - NUIG	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00
12 - INRH	2.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	7.00
13 - NIOZ	0.00	0.00	0.00	0.00	18.00	0.00	0.00	0.00	0.00	0.00	18.00
14 - NERSC	0.00	4.30	0.00	0.00	0.00	17.00	0.50	0.00	0.00	0.00	21.80
15 - UNIRESEARCH	0.00	0.00	0.00	12.00	8.00	0.00	0.00	8.00	0.00	0.00	28.00
16 - CSIC	5.00	0.00	0.00	0.00	37.00	0.00	0.00	0.00	0.00	0.00	42.00
17 - ULPGC	10.00	6.00	0.00	30.00	15.00	0.00	0.00	0.00	0.00	0.00	61.00
18 - UGOT	0.00	10.00	0.00	0.00	3.00	0.00	0.00	1.00	0.00	0.00	14.00
19 - ETH Zürich	18.00	12.00	0.00	0.00	0.00	0.00	18.00	0.00	0.00	0.00	48.00
20 - UBERN	0.00	0.00	16.00	0.00	0.00	19.00	21.00	0.00	0.00	0.00	56.00
21 - MetO	0.00	0.00	22.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	24.00
22 - NERC	0.00	0.00	0.00	7.70	3.40	0.00	0.00	0.00	0.00	0.00	11.10
23 - PML	0.00	0.00	0.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00

WT6:
Project Effort by Beneficiary and Work Package

Beneficiary number and short-name	WP 1	WP 2	WP 3	WP 4	WP 5	WP 6	WP 7	WP 8	WP 9	WP 10	Total per Beneficiary
24 - UNIVBRIS	0.00	0.00	0.00	0.00	0.00	19.00	0.00	0.00	0.00	0.00	19.00
25 - UEA	0.00	0.00	0.00	24.20	4.50	0.00	14.00	16.00	0.00	0.00	58.70
26 - CSIR	0.01	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.04
27 - PU-AOS	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.03
28 - DU	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.03
29 - GEOMAR	9.00	10.00	0.00	8.00	24.00	16.00	21.00	3.00	0.00	0.00	91.00
30 - CLIMMOD	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	1.50
31 - UNEXE	0.00	0.00	0.00	18.80	0.00	0.00	0.00	0.00	0.00	0.00	18.80
Total	70.51	93.31	76.00	156.72	165.92	93.50	125.51	52.02	36.01	18.00	887.50

WT7:
Project Effort by Activity type per Beneficiary

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

Indicative efforts per Activity Type per Beneficiary

Activity type	Part. 1 UiB	Part. 2 VITUS	Part. 3 IFREMER	Part. 4 CEA	Part. 5 UPMC	Part. 6 AWI	Part. 8 MPG	Part. 9 UniHB	Part. 10 MRI-UI	Part. 11 NUIG	Part. 12 INRH	Part. 13 NIOZ	Part. 14 NERSC	Part. 15 UNIRESE
1. RTD/Innovation activities														
WP 1	0.00	2.00	0.00	6.00	0.00	9.00	3.50	6.00	0.00	0.00	2.00	0.00	0.00	0.00
WP 2	6.00	0.00	24.00	10.00	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.30	0.00
WP 3	10.00	0.00	0.00	17.00	0.00	0.00	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WP 4	0.00	0.00	0.00	1.00	35.00	7.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	12.00
WP 5	0.00	0.00	0.00	0.00	7.00	27.00	0.00	7.00	7.00	0.00	5.00	18.00	0.00	8.00
WP 6	0.00	0.00	0.00	6.00	0.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	17.00	0.00
WP 7	1.00	0.00	0.00	24.00	21.00	2.00	1.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00
WP 8	7.00	0.00	0.00	3.00	3.00	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00
WP 9	18.00	0.00	0.00	9.00	0.00	5.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Research	42.00	2.00	24.00	76.00	77.00	76.00	15.50	17.00	7.00	5.00	7.00	18.00	21.80	28.00
2. Demonstration activities														
Total Demo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Consortium Management activities														
WP 10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Management	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Other activities														
Total other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	60.00	2.00	24.00	76.00	77.00	76.00	15.50	17.00	7.00	5.00	7.00	18.00	21.80	28.00

WT7:
Project Effort by Activity type per Beneficiary

WT7:
Project Effort by Activity type per Beneficiary

Activity type	Part. 16 CSIC	Part. 17 ULPGC	Part. 18 UGOT	Part. 19 ETH Zür	Part. 20 UBERN	Part. 21 MetO	Part. 22 NERC	Part. 23 PML	Part. 24 UNIVBRI	Part. 25 UEA	Part. 26 CSIR	Part. 27 PU-AOS	Part. 28 DU	Part. 29 GEOMAR
1. RTD/Innovation activities														
WP 1	5.00	10.00	0.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	9.00
WP 2	0.00	6.00	10.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	10.00
WP 3	0.00	0.00	0.00	0.00	16.00	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WP 4	0.00	30.00	0.00	0.00	0.00	0.00	7.70	8.00	0.00	24.20	0.01	0.00	0.01	8.00
WP 5	37.00	15.00	3.00	0.00	0.00	0.00	3.40	0.00	0.00	4.50	0.00	0.01	0.01	24.00
WP 6	0.00	0.00	0.00	0.00	19.00	0.00	0.00	0.00	19.00	0.00	0.00	0.00	0.00	16.00
WP 7	0.00	0.00	0.00	18.00	21.00	2.00	0.00	0.00	0.00	14.00	0.01	0.00	0.00	21.00
WP 8	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	16.00	0.00	0.01	0.01	3.00
WP 9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Total Research	42.00	61.00	14.00	48.00	56.00	24.00	11.10	8.00	19.00	58.70	0.04	0.03	0.03	91.00
2. Demonstration activities														
Total Demo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Consortium Management activities														
WP 10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Management	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Other activities														
Total other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	42.00	61.00	14.00	48.00	56.00	24.00	11.10	8.00	19.00	58.70	0.04	0.03	0.03	91.00

WT7:
Project Effort by Activity type per Beneficiary

Activity type	Part. 30 CLIMMOD	Part. 31 UNEXE	Total
1. RTD/Innovation activities			
WP 1	0.00	0.00	70.51
WP 2	0.00	0.00	93.31
WP 3	0.00	0.00	76.00
WP 4	0.00	18.80	156.72
WP 5	0.00	0.00	165.92
WP 6	1.50	0.00	93.50
WP 7	0.00	0.00	125.51
WP 8	0.00	0.00	52.02
WP 9	0.00	0.00	36.01
Total Research	1.50	18.80	869.50
2. Demonstration activities			
Total Demo	0.00	0.00	0.00
3. Consortium Management activities			
WP 10	0.00	0.00	18.00
Total Management	0.00	0.00	18.00
4. Other activities			
Total other	0.00	0.00	0.00
Total	1.50	18.80	887.50

WT8:
Project Effort and costs

Project Number [1]	264879	Project Acronym [2]	CARBOCHANGE

Project efforts and costs

Beneficiary number	Beneficiary short name	Estimated eligible costs (whole duration of the project)						Requested EU contribution (€)
		Effort (PM)	Personnel costs (€)	Subcontracting (€)	Other Direct costs (€)	Indirect costs OR lump sum, flat-rate or scale-of-unit (€)	Total costs	
1	UiB	60.00	427,598.80	0.00	160,955.00	353,132.28	941,686.08	733,542.00
2	VITUS	2.00	14,560.00	0.00	7,650.00	13,326.00	35,536.00	26,652.00
3	IFREMER	24.00	175,118.00	0.00	12,000.00	117,884.00	305,002.00	67,200.00
4	CEA	76.00	326,176.00	2,100.00	18,788.00	204,348.00	551,412.00	414,084.00
5	UPMC	77.00	337,880.00	0.00	135,100.00	283,788.00	756,768.00	567,576.00
6	AWI	76.00	215,958.00	0.00	145,972.00	181,686.00	543,616.00	409,812.00
8	MPG	15.50	79,189.00	0.00	9,362.00	110,865.00	199,416.00	149,562.00
9	UniHB	17.00	100,200.00	0.00	31,700.00	79,140.00	211,040.00	158,280.00
10	MRI-UI	7.00	25,480.00	0.00	39,900.00	39,228.00	104,608.00	78,456.00
11	NUIG	5.00	54,800.00	0.00	14,500.00	41,580.00	110,880.00	83,160.00
12	INRH	7.00	34,000.00	0.00	33,000.00	13,400.00	80,400.00	61,292.00
13	NIOZ	18.00	72,000.00	0.00	125,893.00	55,440.00	253,333.00	189,999.00
14	NERSC	21.80	164,249.00	0.00	19,000.00	190,641.00	373,890.00	280,417.00
15	UNIRESEARC	28.00	226,800.00	6,000.00	136,118.80	217,751.28	586,670.08	438,381.00
16	CSIC	42.00	163,361.00	0.00	69,400.00	225,438.00	458,199.00	343,649.00
17	ULPGC	61.00	186,770.00	0.00	90,960.00	166,638.00	444,368.00	332,476.00
18	UGOT	14.00	78,000.00	0.00	21,000.00	59,400.00	158,400.00	118,800.00
19	ETH Zürich	48.00	169,333.00	0.00	4,800.00	104,479.80	278,612.80	208,959.00
20	UBERN	56.00	341,200.00	0.00	6,900.00	208,860.00	556,960.00	419,800.00
21	MetO	24.00	108,000.00	0.00	14,000.00	76,800.00	198,800.00	99,400.00
22	NERC	11.10	68,303.00	0.00	52,125.00	75,133.00	195,561.00	146,670.00

WT8:
Project Effort and costs

Beneficiary number	Beneficiary short name	Estimated eligible costs (whole duration of the project)						Requested EU contribution (€)
		Effort (PM)	Personnel costs (€)	Subcontracting (€)	Other Direct costs (€)	Indirect costs OR lump sum, flat-rate or scale-of-unit (€)	Total costs	
23	PML	8.00	31,701.00	0.00	52,956.00	44,275.00	128,932.00	96,699.00
24	UNIVBRIS	19.00	85,166.00	10,000.00	28,459.00	68,175.00	191,800.00	143,850.00
25	UEA	58.70	348,226.00	0.00	120,922.00	281,488.80	750,636.80	565,865.00
26	CSIR	0.04	0.00	0.00	0.00	0.00	0.00	0.00
27	PU-AOS	0.03	0.00	0.00	0.00	0.00	0.00	0.00
28	DU	0.03	0.00	0.00	0.00	0.00	0.00	0.00
29	GEOMAR	91.00	382,160.00	0.00	175,500.00	334,596.00	892,256.00	669,192.00
30	CLIMMOD	1.50	24,973.00	0.00	0.00	14,983.80	39,956.80	29,967.00
31	UNEXE	18.80	113,692.40	0.00	16,446.00	78,083.04	208,221.44	156,166.00
Total		887.50	4,354,894.20	18,100.00	1,543,406.80	3,640,560.00	9,556,961.00	6,989,906.00

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

2. Project acronym

Use the project acronym as given in the submitted proposal. It cannot be changed unless agreed so during the negotiations. The same acronym **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

53. Work Package number

Work package number: WP1, WP2, WP3, ..., WPn

54. Type of activity

For all FP7 projects each work package must relate to one (and only one) of the following possible types of activity (only if applicable for the chosen funding scheme – must correspond to the GPF Form Ax.v):

• **RTD/INNO =** Research and technological development including scientific coordination - applicable for Collaborative Projects and Networks of Excellence

• **DEM =** Demonstration - applicable for collaborative projects and Research for the Benefit of Specific Groups

• **MGT =** Management of the consortium - applicable for all funding schemes

• **OTHER =** Other specific activities, applicable for all funding schemes

• **COORD =** Coordination activities – applicable only for CAs

• **SUPP =** Support activities – applicable only for SAs

55. Lead beneficiary number

Number of the beneficiary leading the work in this work package.

56. Person-months per work package

The total number of person-months allocated to each work package.

57. Start month

Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

58. End month

Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

59. Milestone number

Milestone number:MS1, MS2, …, MSn

60. Delivery date for Milestone

Month in which the milestone will be achieved. Month 1 marking the start date of the project, and all delivery dates being relative to this start date.

61. Deliverable number

Deliverable numbers in order of delivery dates: D1 – Dn

62. Nature

Please indicate the nature of the deliverable using one of the following codes

R = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other

63. Dissemination level

Please indicate the dissemination level using one of the following codes:

• **PU =** Public

• **PP =** Restricted to other programme participants (including the Commission Services)

• **RE =** Restricted to a group specified by the consortium (including the Commission Services)

• **CO =** Confidential, only for members of the consortium (including the Commission Services)

• **Restreint UE =** Classified with the classification level "Restreint UE" according to Commission Decision 2001/844 and amendments

• **Confidentiel UE =** Classified with the mention of the classification level "Confidentiel UE" according to Commission Decision 2001/844 and amendments

• **Secret UE =** Classified with the mention of the classification level "Secret UE" according to Commission Decision 2001/844 and amendments

64. Delivery date for Deliverable

Month in which the deliverables will be available. Month 1 marking the start date of the project, and all delivery dates being relative to this start date

65. Review number

Review number: RV1, RV2, ..., RVn

66. Tentative timing of reviews

Month after which the review will take place. Month 1 marking the start date of the project, and all delivery dates being relative to this start date.

67. Person-months per Deliverable

The total number of person-month allocated to each deliverable.

Table of Contents

Description of Work

B1. Concept and objectives, progress beyond state-of-the-art, S/T methodology and work plan

The *FP7 Cooperation Work Programme 2010: Environment (including climate change)* places **special emphasis on carbon uptake by the oceans under future climate** in its *Sub-Activity 6.1.1 Pressures on environment and climate*. **CARBOCHANGE** addresses the key specific topic *ENV.2010.1.1.3-1 Changes in carbon uptake and emissions by oceans in a changing climate* under this activity.

B.1.1 Concept and project objectives

Overall goal and mission: **CARBOCHANGE will provide the best possible process-based quantification of net ocean carbon uptake under changing climate conditions using past and present ocean carbon cycle changes for a better prediction of future ocean carbon uptake. We will improve the quantitative understanding of key biogeochemical processes (particle flux, ecosystem community structure, lateral advection) and physical processes (overturning circulation, ice cover, mixing) through a combination of observations and models. We will upscale new process understanding to large-scale integrative feedbacks of the ocean carbon cycle to climate change and rising carbon dioxide concentrations. We will quantify the vulnerability of the ocean carbon sources and sinks in a probabilistic sense using cutting edge coupled Earth system models under a variety of emission scenarios including climate stabilisation scenarios as required for the 5th IPCC assessment report. The drivers for the vulnerabilities will be identified. The most actual observations of the changing ocean carbon sink will be systematically integrated with the newest ocean carbon models, a coupled land-ocean model, an Earth system model of intermediate complexity, and fully fledged Earth system models through a spectrum of data assimilation methods as well as advanced performance assessment tools. Results will be optimal process descriptions and most realistic error margins for future ocean carbon uptake quantifications with models under the presently available observational evidence. The project will deliver calibrated future evolutions of ocean pH and carbonate saturation as required by the research community on ocean acidification in the EU project EPOCA and further projects in this field. The time history of atmosphere-ocean carbon fluxes past, present, and future will be synthesised globally as well as regionally for the transcontinental RECCAP project. Observations and model results will merge into GEOSS/GEO through links with the European coordination action COCOS and will prepare the marine branch of the European Research Infrastructure ICOS. Results of the project will be summarised and forwarded to policy makers working on climate change mitigation through specifically targeted outreach papers.**

B.1.1.1 Background - main ideas

Carbon dioxide (CO_2) emissions from fossil fuel combustion, land use, and cement manufacturing are the **main agent of a human-induced climate change** through their impact on the Earth's radiation budget (IPCC, 2007, chapter 2). CO_2 emissions in principle are manageable by human societies.
The **ocean has a pivotal role in regulating the atmospheric CO_2 concentration.** There are indicators for some decrease in the fraction of human-produced CO_2 emissions to the atmosphere taken up by the oceans over the past two centuries:

Time interval	*Fraction of annual CO_2 emissions (fossil fuel plus net land biosphere) taken up by the ocean on average*	*Reference*
1800-1994	42 +/- 7 %	Sabine et al. (2004)
1980-2005	37 +/- 7%	IPCC (2007), ch. 5

In the long term, the land biosphere has a limited capacity to absorb more CO_2 by comparison to the oceans because land vegetation is a comparatively small reservoir. It is expected therefore that **the ocean will play the leading role for buffering anthropogenic CO_2 emissions**. It is essential for climate mitigation and adaptation strategies, to observe the changing oceanic anthropogenic CO_2 uptake, to explain the underlying mechanisms, and to correctly predict its future evolution. The present project plan addresses these challenges.

European research, in particular the EU FP6 *Integrated Project* CARBOOCEAN, has resulted in a new view on the operation of the ocean carbon buffering: The **uptake rate of anthropogenic CO_2 can vary substantially over time and over basin-wide domains** of the **Atlantic Ocean** and the **Southern Ocean** (Watson et al., 2009; Le Quéré et al., 2007). Ultimately, the ocean as a whole will take up the majority of human-produced CO_2 emissions. But the oceanic CO_2 buffering cannot prevent a temporary build-up of anthropogenic CO_2 in the atmosphere due to the slowness of oceanic processes (Bolin and Eriksson, 1959). During the **coming decades a steep rise in atmospheric CO_2** is expected (Raupach et al., 2007) unless a fundamental change in carbon emission policies will occur. At the recent COP15 conference there was no binding international treaty reached, but there were significant steps taken toward the reduction of greenhouse gas emissions (see for the "Copenhagen Accord" here: http://unfccc.int/2860.php and here: http://en.cop15.dk/). It is vital to know exactly, how much CO_2 the ocean will be able to buffer in a certain time interval. A **best possible quantification of the evolution of oceanic CO_2 uptake** and the **related process-based understanding,** i.e. answers to the questions: **how much, how quickly, and why -** are the overall goals of the present CARBOCHANGE project plan. The plan responds fully to the European research requirements as outlined in the recent EU publication *Integrated assessment of the European and North Atlantic Carbon Balance - key results, policy implications for post 2012 and research needs* (Schulze, Heinze, et al., 2009). CARBOCHANGE exploits the results of the CARBOOCEAN FP6 *Integrated Project* and focuses now specifically on **future changes in ocean carbon uptake** as required for *Sub-Activity 6.1.1 Pressures on environment and climate* of *FP7 Cooperation Work Programme 2010: Environment (including climate change)*. It links to other EU projects in the field, in particular the EU FP7 Coordination Action COCOS (Coordination Action Carbon Observing System) and the European FP7 Project on Ocean Acidification EPOCA.

The main ideas shaping this planned project work are:

1. Novel ocean observing programmes have shown that ocean carbon sources and sinks are much more variable at regional scale than previously thought. This is particularly the case for CO_2 uptake critical deep water production areas of the **Southern Ocean** and **North Atlantic**, with the possibility of an approaching saturation of regional carbon sinks (Watson et al., 2009; Le Quéré et al., 2009; Metzl, 2009). We have **observational evidence for vulnerable ocean carbon sources and sinks undergoing significant changes** which cannot as yet be fully explained.
2. With progressing climate change and increasing CO_2 concentrations in the atmosphere and the ocean, the airborne fraction of incremental CO_2 emissions has shown a tendency to increase with time, while there is mounting evidence that the oceanic carbon sink has become somewhat less efficient relative to newly added CO_2 emissions (Le Quéré et al., 2009). In other words, **the ocean sink is undergoing changes of global scope**.
3. In the future climate projections of the 4^{th} IPCC assessment report (IPCC, 2007) mostly coupled climate models forced by prescribed CO_2 concentrations have been used. However, the oceanic carbon cycle climate feedback can have a significantly enhancing effect on climate change (Friedlingstein et al., 2006; Crueger et al., 2008). Therefore, **interactive carbon cycle climate models (Earth system models) forced by CO_2 emissions have to be used in the future projections for the 5^{th} IPCC assessment report**. We can and will provide these models and projections.
4. The carbon cycle climate feedback strength varies largely between the different Earth system models (Friedlingstein et al., 2006; Tjiputra et al., accepted for publication). **Evidence for key biogeochemical and physical processes from observations** and their differential representation in the various models will allow **an improved process-based parameterisation of ocean carbon feedbacks** to climate change (e.g. Wohlers et al., 2009; Lenton et al., 2009).
5. Methods for an **improved integration of observations on the changing ocean carbon cycle with prognostic ocean models and coupled Earth system mod**els have evolved. Sequential and variational **data assimilation** methods (e.g. Gerber et al., 2009; Tjiputra and Winguth, 2008) are available to systematically calibrate model parameters of process parameterisations with respect to observations. We can improve the models systematically by combining the qualitative process knowledge with the quantitative information from the real world in order to **calibrate the models with respect to the mean state and their ability to reproduce dynamically changes in the ocean carbon system** due to changing climate and rising CO_2 concentrations.

6. Due to the immense computational costs, the oceanic components of Earth system models cannot be integrated into equilibrium repeatedly in order to achieve a best possible spin-off start status for future climate scenarios. New **transport matrix methods** (Khatiwala, 2007) provide a tool for **calibration of the pre-industrial state for the global 3-D ocean** (including the slow parts of the system), which will significantly improve also the ocean carbon change behaviour of models used in future scenarios.
7. The evidence for vulnerable carbon sources and sinks needs to be explained and extrapolated to future conditions with appropriate models and analysis methods. We will employ **Monte-Carlo simulations** and **detection methods** for changing ocean carbon feedbacks to produce probabilistic projections on the vulnerabilities of the carbon sink and means to detect these vulnerabilities as early as possible.
8. Scientists assessing the changes in the ocean carbon cycling and those assessing ocean acidification impacts need to work hand in hand. We will provide the observational and modelling framework for impact researchers. Such a framework cannot be provided by these communities independently. We will produce **three-dimensional time series of ocean pH and carbonate saturation which are vitally needed by ocean acidification researchers** to strategically plan their experiments and to find early detection methods on occurring environmental and ecosystem change.
9. Major international assessments such as the **5th IPCC assessment report** of Working Group I, the **RECCAP (REgional Carbon Cycle Assessment and Processes)** programme of the Global Carbon Project, and the assessments **SOCAT** as well as **DeCChange** by SOLAS-IMBER working groups need input from organised communities with highest quality observational data and modelling products on the changing ocean carbon source/sink distributions. We will provide this input as expected from Europe through a consortium which is already involved in these assessments. The results from these assessments will provide **vital information for policy makers on climate change mitigation**. We will in addition inform policy makers directly on the new knowledge about the changing oceanic carbon sink so that policy makers can optimally tailor their decisions to the best available knowledge on carbon flows within the Earth system.
10. CARBOCHANGE will also synergistically work with the emerging **European Research Infrastructure ICOS** (Integrated Carbon Observing System; see: http://www.icos-infrastructure.eu) in order to establish a functioning long-term observing capability in Europe to watch the evolution of carbon sources and sinks on land and in the ocean and their vulnerabilities. The key members of the ocean component to ICOS participate in CARBOCHANGE. This project also aims at bridging the gap between the previous FP6 *Integrated Project* CARBOOCEAN and the operational start of ICOS. The European ocean carbon data streams will feed into the global observing system **GEOSS under the Group on Earth Observations (GEO)**, and into the related European **GMES** (Global Monitoring for Environment and Security) programme.

B.1.1.2 S&T objectives

The scientific and technological objectives of the project fully relate to all elements addressed by the call. These elements are *highlighted* below, to make the link between the project's objectives and the call clear. We further cross reference the specific sub-goals already here to the project's **Work Packages** (WP1-WP10), which have these sub-goals as respective WP objectives.

Objective 1 – Process understanding:
We aim at a quantification of the *key physical, chemical and biogeochemical processes* controlling net air-sea exchange of CO_2 in key regions of European interest. We will further identify, quantify, and explain the *feedback mechanisms associated to atmospheric CO_2 and resulting climate change* related to these processes.
The **sub-goals** for a better understanding of biogeochemical process and feedbacks are (**WP1**):
1. To quantitatively assess the magnitude of biological feedbacks on the ocean uptake of CO_2 by changes in vertical fluxes of organic carbon, testing as well as validating new model parameterizations and producing model output that will be used in model-model intercomparison.
2. To assess the role of lateral fluxes of carbon into the open ocean for variations in air-sea carbon fluxes, integrating models and observations
Delivery: We will provide a process identification of biological carbon cycling, improved process parameterisations for interactive carbon cycle climate models, upscaling of observational evidence to the large scale using models in order to quantify the impact on the atmospheric CO_2 concentration.
The **sub-goals** for a better understanding of physical process and feedbacks are (**WP2**):

1. To quantitatively assess the feedback on the oceanic uptake of CO_2 by changes in physical processes in the North Atlantic Ocean, including the Arctic Ocean and Nordic Seas, and the Southern Ocean.
2. To assess the representation of small-scale processes involved in the feedbacks (e.g. eddies) in carbon-climate models and guide development of improved subgrid-scale parameterisations

Delivery: We will provide new quantifications on the impact of climate induced changes in ice cover and ocean overturning from model sensitivity studies as well as from field data. The critical question of relevant model resolution will be answered through systematic experiments with ocean general circulation models.

Objective 2 – Future scenarios and vulnerability analysis:
We will achieve an assessment of *the vulnerability of marine carbon sources and sinks* with respect to *future emission scenarios* and *associated climate change scenarios* using coupled Earth system models through pursuing the following **sub-goals** (**WP 3**):

1. To assess the vulnerability of oceanic carbon sources or sinks with respect to future emission scenarios and associated climate change projections, on different time-scales (from multi-decadal to multi-centennial) through the use of Earth system models of variable complexity (ESMs and EMICs).
2. To identify the processes responsible for the simulated future changes in carbon sources and sinks and develop methods to determine the probability density distributions of their future evolution.

Delivery: We will carry out coordinated runs with several Earth system models (ESMs and EMICs) and analyse the results for a spectrum of possible IPCC emission pathways as established for the 5th IPCC assessment report including mitigation/stabilisation scenarios. We will address the short term (100 years) and long term (500 years) impact of CO_2 emissions on the ocean carbon sink evolution. A study on the detectability of human-induced variability of the ocean carbon sink will be carried out.

Objective 3 – Observing systems of the changing ocean carbon sink for integration with models
We will set up a network of observations which constrains the *magnitude and distribution of carbon sources and sinks under present and past climate change conditions* linking surface observations with time-series of subsurface ocean properties as well as interior ocean transports in key locations. We will use the combined network to detect and explain changes in the natural carbon cycle and the inventory of anthropogenic carbon in the ocean for *integration of these observations and state-of-the art models*. The goal is further, to perform a critical evaluation of the measurement network design in order to develop a long-term, sustained and efficient carbon observing system under climate change that can be carried forward and sustained in *synergy with international research projects* and specifically the evolving *European Integrated Carbon Observing System ICOS* (a European Research Infrastructure). The field data will provide the information on progressing *ocean acidification* both at the surface and in the ocean interior which is essential for – and cannot be provided by - scientists investigating the impact of ocean acidification on marine ecosystems.
Specific **sub-goals** for the surface observing system are (**WP4**):

1. Set up and evaluate a **network of observations** to track trends in atmosphere-ocean carbon fluxes in critical regions, and changes in both the natural carbon cycle and the trends due to the penetration of anthropogenic carbon in the ocean.
2. In the **North and Tropical Atlantic**, support and build on the prototype CARBOOCEAN network: Improve its efficiency of operation by a more co-ordinated approach. Improvements that need to be made are: better co-ordination to avoid data gaps due to the uncertainties of the shipping industry, more traceability in calibration, more accurate atmospheric measurements to be useable in inversion models, and useful in-water oxygen measurements. A coordination unit will be initiated to provide this extra level of support.
3. In the **Southern Ocean** use repeated transects of research vessels to enable a decadal picture to be built up in the Atlantic and Indian sectors. These large-scale / long-term investigations will be complemented by smaller-scale studies based on drifters' measurements, characterising the variability under-sampled by ship observations.
4. In the **atmosphere** we will undertake high-precision atmospheric observations of CO_2 and oxygen / nitrogen to enable us to test the use of regional patterns of atmospheric potential oxygen as an independent method of observing air-sea carbon fluxes over the North Atlantic.

Delivery: We will provide highest quality field data on pCO_2, DIC, pH, temperature, salinity, and oxygen which allow Atlantic Ocean and Southern Ocean carbon trends to be followed. These data are the pre-requisite for a successful calibration of ocean carbon models.
Specific **sub-goals** for observing the deep ocean (including time series and choke points) are (**WP5**):

1. To coordinate and conduct time-series and deep section measurements of the vertical structure of ocean carbon. New and existing high-frequency observations (<seasonal) at time series stations and lower-frequency (multi-annual/decadal) hydrographic sections will be used to estimate the variability of (regional

budgets of) natural and anthropogenic CO_2 and resolve internal ocean processes affecting the variability of oceanic CO_2 parameters.

2. To evaluate the carbon storage and its vulnerability in the interior ocean with respect to anthropogenic changes, oceanic circulation and biogeochemical processes, linked to model outputs and skills.

Delivery: We will collect and publish highest quality carbon system data on the interior ocean. We will produce an analysis of trends in anthropogenic carbon storage and its vulnerability to climate change. Time series data for calibration of ocean carbon cycle models concerning the seasonal cycle and interannual variability will be provided.

Objective 4 – Integration of observations with models including systematic model calibration

We will establish model systems for projections towards climate stabilization and global synthesis by *calibrating ocean carbon models* and *Earth System Models of intermediate complexity* with respect to observations. We will quantify the magnitude and distribution of carbon sources and sinks in the ocean in the *past* (over the industrial period and the recent past) and *present* by *data-model integration*. We will further determine specific governing carbon system parameters, inventories, and fluxes relevant *for improved quantification of the ocean carbon cycle under ongoing and future climate change* and as input for studies on the impact of large scale *ocean acidification*.

Specific **sub-goals** of the activity on model calibration are (**WP6**):

1. To integrate the ocean carbon models with observations available from WP4 (surface), WP5 (interior, time series) and WP8 (synthesis) and calibrate the biogeochemical parameters for accurate reconstruction of carbon and related tracers on different time scales. Advanced stand-alone models and a coupled terrestrial-ocean model will be used over decadal time scales, EMICs over centennial time scales and stationary transport matrices for millennial time scales.
2. To provide the calibrated models for reconstructions (hindcasts), for climate simulations in WP3, for comparisons in WP7 and for the synthesised assessment in WP8.

Delivery: A series of ocean carbon cycle model systems which will have been systematically calibrated through parameter adjustment with respect to observations on the changing ocean carbon sink will be provided to the community for exploitation in future scenarios, vulnerability analyses and ocean carbon budget compilations.

Specific **sub-goals** of the activity on model-observation/model-model comparison are (**WP7**):

1. To compare data-based estimates concerning ocean carbon and related tracers to simulated results from ocean carbon cycle models, both in forced mode (50-year hindcasts) and in coupled mode (part of Earth System Models).
2. To develop regional data metrics and use them to evaluate and weigh these models to provide optimal estimates for the changing ocean carbon sink (preindustrial through modern to 2100 and beyond) and carbon-climate feedbacks

Delivery: We will achieve a systematic performance assessment of the carbon cycle models with respect to observations using novel skill score metrics. The models' feedback behaviour will be analysed with respect to the models' ability to reproduce the observations.

Objective 5 – Synthesis for scientific assessments, policy makers, and international synergies

We will synthesise the results from observing systems and modelling achieved under objectives 1-4 as input to *relevant policies* and for *enhancing synergies with international projects* on carbon budgets. This work will directly feed into *international assessments* on the progressing climate change and related *climate change mitigation*.

Sub-goals for this synthesis activity (**WP8**, in part also the data-/management **WPs 9** and **10**) are to:

1. Produce high level synthesized products on an annual basis that provide key information on the uptake of CO_2 by the ocean at the regional and global level and on the regional drivers of change.
2. Synthesize information on the state of the ocean carbon cycle.
3. Synthesize information on the vulnerability of the oceanic CO_2 sink.
4. Archive and distribute data and information through advanced data management.
5. Communicate internally in the consortium, with the scientific community, the general public, and policy makers

Delivery: Annual estimates of the global and regional oceanic CO_2 sink including the uncertainty, driving processes, merged and quality checked data sets of highest quality ocean carbon data for the global ocean, global ocean carbon atlas, summary on the vulnerability of the carbon sink to global change. Dissemination of data and information to the world wide community and specifically to policy makers.

B.1.1.3 Concept of the project

The concept of the project is illustrated in Figure 1.1.3. The project builds on previous research projects dealing with marine carbon cycling and in particular the FP6 *Integrated Project* CARBOOCEAN. The proposed project will provide a closure to existing knowledge gaps on the ocean carbon sources and sinks in relation to other international projects, such as the FP7 collaborative project EPOCA (European project on ocean acidification) and the FP7 coordination action COCOS (coordination action carbon observation system). The results will improve policy guidance, integrate carbon observing and prediction systems (such as ICOS), and contribute to a sustainable management of the Earth system.

In order to achieve this high level of integration among the different teams that will collaborate in CARBOCHANGE we structured the project into three interactive **core themes** (CTs) and three **overarching work packages** (WPs) which cut across over all three core themes.**We have placed special emphasis to bring together observing and modelling scientists in each work package and core theme whenever advisable in order to overcome the disparities between the two communities**. The core themes themselves are structured into a series of work packages (WPs).

The **core themes** and the related project objectives from previous section 1.2 are:

CT1 - Key processes and feedbacks, future scenarios, and vulnerabilities (Objectives 1 & 2) (**WPs 1-3**)
CT2 - Observing system of ocean carbon changes (Objective 3) (**WPs 4-5**)
CT3 - Data model integration (Objective 4) (**WPs 6-7**)

The **overarching work packages** (addressing Objective 5) are dedicated to: Global **synthesis** and **outreach to policy makers** (**WP8**), data management (**WP9**), and management of the project (**WP10**).

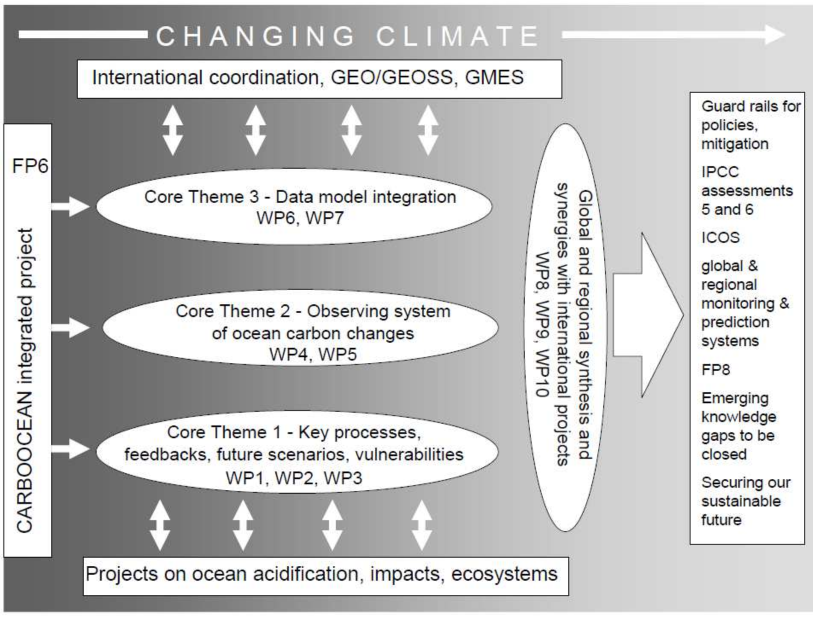

Figure 1.1.3: The concept of CARBOCHANGE.

CT1 - Key processes and feedbacks, future scenarios, and vulnerabilities (WPs 1-3), ***co-lead*** **Marion Gehlen (CEA/LSCE), Nicolas Gruber (ETH Zürich):**
It is the interplay between physical, chemical and biological processes that determine whether a particular ocean region behaves as a net source or sink with respect to atmospheric CO2. CT1 addresses the identification and quantification of key biological and physical processes, as well as their contribution to the feedback between the climate system and the carbon cycle. The CT will deliver an understanding of the observed and model-derived variability in the ocean carbon sink, attribute this variability to physical/ chemical/biological processes and thus strengthen the forecasting skills of numerical models by the development of new process parameterizations. Coupled Earth system models will be used to upscale key feedback processes to the global scale, to determine specific vulnerabilities of the carbon sink, and to predict its influence on the future climate evolution. The coupled model runs will be of high importance to the 5th

assessment report of the Intergovernmental Panel on Climate Change (IPCC). The spectrum of runs will also include stabilisation scenarios on feasible pathways for CO_2 emission reductions.

CT2 - Observing system of ocean carbon changes (WPs 4-5), ***co-lead*** **Andrew Watson (UEA), -Aida Rios (CSIC):**
In CT2, it is planned to combine and critically assess these observational approaches and their data in order to address key scientific questions, identify synergies between different observing platforms and strategies, and establish an efficient and coordinated design for the ocean component of the Integrated Carbon Observing System ICOS. The proposed observing network is global in orientation, being linked to the international community outside Europe. The European contribution will focus primarily on the Atlantic Ocean, including the Arctic Ocean as well as key sectors of the Southern Ocean. Cooperation with related programmes (e.g. projects focussed on European marginal seas) will be established wherever possible to extend the network.

CT3 - Data model integration (WPs 6-7), ***co-lead*** **Fortunat Joos (UBern), Nicolas Metzl (UPMC):**
CT 3 is dedicated to integrate observational data and models by developing and applying frameworks for systematic data assimilation and model-data fusion, by using the most comprehensive data sets, including those compiled in CT2, and by applying the most up-to-date hierarchy of models as well as the most important processes, including those used in and identified by CT1. The time and space scales of CT3 encompass seasonal to centennial and regional to global scales. Regional emphasis will be placed on the Arctic, the North Atlantic, and the Southern Ocean, regions of key importance for the global carbon cycle and where experience of the project team is extensive. Data-model integration will build on (i) assimilation methods, (ii) on model-data intercomparison relying on regional and global skill score metrics, on statistical detection-attribution methods, and on an innovative Transport Matrix Method for model evaluation.

Overarching WPs:
The results from the three core themes are merged in **WP8 on Global synthesis and outreach to policy makers** (co-lead C. Le Quéré, A.Olsen, D. Bakker) so that easily usable numbers and summaries are provided for concrete years. These results will merge directly into decisions on sustainable management as well as into international scientific assessments. **WP9 on Data Management** (co-lead B. Pfeil, R. Schlitzer) will ensure the direct embedding of the new data sets and model results in the international community and ensure long-term archiving, dissemination, and exploitation of results. **WP10 will manage the consortium** (lead: C. Heinze) including its interface with the European Commission.

B.1.2 Progress beyond the state-of-the-art

During the past 10 years, a series of EU funded projects has brought the European Research community on marine carbon cycle research to the very forefront in this field. These projects very specifically targeted to processes (ORFOIS – particle fluxes and carbon cycling end to end; IRONAGES – role of iron in the biological pump), climate modelling (GOSAC – model intercomparison, ENSEMBLES – decadal prediction with coupled models), and observations (CAVASSOO – surface CO_2 from voluntary observing ships, ANIMATE – oceanic time series measurements). The FP6 *Integrated Project* CARBOOCEAN (Marine carbon sources and sinks assessment) bundled the different disciplines and a new European marine carbon cycle network with excellent international network links could be established through this effort. CARBOOCEAN also included process studies on ocean acidification. The impact of ocean acidification is now studied in depth by FP7 project EPOCA, however, this project needs ocean carbon system observations and models from other projects as input to work with. A series of further ongoing FP6 and FP7 projects deal partly with ocean carbon cycling (EUROSITES and TENATSO – ocean time series, COMBINE – development of new Earth system model components and feedback analysis, SESAME and MEECE – ecosystems under climate change).

B.1.2.1 State of the art in research on marine carbon sources and sinks

B.1.2.1.1 Global ocean carbon uptake rates since industrialisation, in the recent past, and in future

The major pathways for carbon exchange between the different Earth system reservoirs are established (see Figure 7.3 in IPCC, 2007; Figure 10.1.1 in Sarmiento and Gruber, 2006). For the global ocean, time averaged ocean carbon uptake bulk numbers have been computed on the basis of observations and through use of models. Integrated over time since the beginning of the industrial revolution until 1994, the ocean has buffered about 42% of these CO_2 emissions (Sabine et al., 2004; IPCC, 2007, chapter 5). The fraction of the net CO_2 emissions taken up by the ocean was reduced to a mean of 37% during 1980 to 2005 (IPCC, 2007, chapter 5).

From decadal to century time scales, the ocean absorbs a fraction of the anthropogenic excess CO_2 in the atmosphere mainly through dissociation of CO_2 into bicarbonate under gradual consumption of the carbonate ions available. During this very well understood inorganic buffering process, the pH value of sea water inevitably sinks (ocean acidification) and with further increasing CO_2 levels, the ocean's buffering ability gets less efficient due to the non-linearity in the buffer system (e.g., Zeebe and Wolf-Gladrow, 2001). The future evolution of ocean carbon uptake depends strongly on the anticipated CO_2 emission scenario (e.g., Maier-Reimer and Hasselmann, 1987), where higher (faster) CO_2 emissions lead to a large build up of CO_2 in the atmosphere as the ocean cannot keep up with buffering the anthropogenic excess CO_2 and transporting it into the interior of the ocean. The coupled climate model future scenarios for the 4th IPCC assessment report (IPCC, 2007; ch. 10) were carried out with models that did not have an interactive carbon cycle. These model runs where unrealistically driven by prescribed CO_2 concentrations (and concentrations of other greenhouse gases) and not by CO_2 emissions into the atmosphere.

B.1.2.1.2 Major findings in the field of marine carbon cycle research during the recent past

Carbon cycle climate feedback using coupled Earth system models: In the past years a growing number of advanced predictive climate models have been developed, so called Earth system models, which include an interactive carbon cycling coupling and further biogeochemical processes. A comprehensive C^4MIP intercomparison of interactive carbon cycle climate models revealed that the carbon cycle climate feedback for both the land vegetation as well as the ocean is positive with time for an IPCC SRES A2 emission scenario (Friedlingstein et al., 2006). However, the model-to-model spread of 3 GtC/yr for the ocean carbon cycle feedback at year 2100 strength is large. While a series of models have confirmed a positive ocean carbon cycle feedback (e.g. Crueger et al., 2008), one study including an isopycnic ocean model revealed only a small feedback due to the compensating effects of changes in the buffer factor and the circulation pattern with climate change (Tjiputra et al., accepted for publication). Sign and amount of the ocean carbon cycle climate feedback depend also on the land carbon cycle components in Earth system models (Friedlingstein et al., 2006). For the coming 5th assessment report of the IPCC a growing number of coupled carbon cycle climate model simulations are required, which then will realistically be forced by greenhouse gas emissions. The scenarios include so-called "Representative Concentration Pathways" (RCPs) (for details, see: http://www.iiasa.ac.at/web-apps/tnt/RcpDb/dsd?Action=htmlpage&page=about) with mitigation scenarios aiming at an effective climate change and greenhouse gas limitation.

Considerable regional ocean carbon sink strength variations: One of the most important findings of the last years is the fact that the ocean carbon sink at regional to basin wide scale is far from being steady or monotonically acting, but undergoes considerable changes. During 2002-2005, the North Atlantic ocean carbon sink had decreased to only half its value for 1995-1996 (Watson et al., 2009; Schuster and Watson, 2007). The Southern Ocean is turning slowly from a source region of atmospheric CO_2 to a sink due to the rising CO_2 partial pressure of the atmosphere. However, a recent stalling or reversal of this trend was deduced both from observations and modelling at least for parts of the Southern Ocean (Metzl, 2009; Le Quéré et al, 2007). It is an alarming signal that the ocean sink decrease is particularly manifested in regions, which have been considered efficient storage areas for anthropogenic carbon. It is yet an open question whether these trends are transient due to natural variability or whether they represent more persistent alterations, e.g. due to a slowing down of the ocean circulation as anticipated for a climatic warming. The detection of the strong temporal variability oceanic sink/source distribution for CO_2 has fundamentally changed our view of the ocean as a reliable constantly working CO_2 sink. It is only from the recent more advanced observing systems for ocean carbon that this new view has been enabled. Attribution of the CO_2 flux variations to specific processes is as yet in its infancy due to the complexity of the interactions. Nevertheless, promising candidates for the changes are a weakening of the North Atlantic sub-polar gyre (Corbière et al., 2007) and an intensification of the Southern Ocean upwelling induced by stratospheric ozone depletion, associated wind stress changes and stronger upward mixing of older water masses carrying high CO_2 signatures (Lenton et al., 2009; Lovenduski et al., 2008).

Physical and biogeochemical feedback processes: Changes in the ocean circulation due to naturally and anthropogenically induced climate change can have a significant impact on changes in ocean carbon uptake, which are coupled to changes in ocean temperature and stratification (e.g. Plattner et al., 2001). Major climatic variability modes alter the CO_2 exchange between ocean and atmosphere, such as the North Atlantic Oscillation (NAO) and El Niño/Southern Oscillation (ENSO) (e.g., Thomas et al., 2008). The impact of a potentially ice free Arctic Ocean on the ocean's carbon budget is not as yet clarified, but may increase the oceanic uptake somewhat due to changes in biological cycling (ACIA, 2005, ch. 9), more efficient gas exchange due to a larger area available, and a series of other processes (Jutterström and Anderson, re-submitted after revisions). Changes in the biological carbon cycling due to climate change, rising CO_2/ocean acidification, and other human-induced drivers such as changes in nitrogen supply to the ocean (Duce et al., 2008) and changing dust deposition under climate change are still not well established, though many indications for potential mechanisms exists. Mesocosm and laboratory studies suggest a slight stimulation of organic carbon production, a decrease in bio-calcification, and a more efficient nutrient utilisation efficiency (stoichiometry change) under high CO_2 conditions (Zondervan et al., 2001; Riebesell et al., 2007). The overall impact on large scale carbon fluxes is not yet well established. While the direct effect of reduced $CaCO_3$ production on atmospheric CO_2 seems to be of minor importance (e.g., Heinze, 2004), secondary effects on particle fluxes may be more important (Klaas and Archer, 2002). The stoichiometry feedback may quantitatively more important, but neither sign nor extent are clarified under real world conditions. Changes in organic carbon particle fluxes due to rising temperature and pCO_2 could potentially have a significant impact on atmospheric CO_2 (Bendtsen et al., 2002; Wohlers et al., 2009).

Observing systems: A series of new developments in ocean carbon cycle observing systems has been made during the recent years. In particular surface ocean CO_2 partial pressure measurements from VOS lines (commercial lines serviced quasi-regularly by volunteering observing ships equipped with autonomous measurement systems) have proven as a cost efficient and rewarding tool. For the North Atlantic, this has resulted in the most precise basin-wide flux estimate available for any ocean part (or continent) with seasonal resolution (Watson et al., 2009). Unfortunately, as yet no sustained funding for these lines is available, though envisaged under the European Research Infrastructure ICOS (Integrated Carbon Observing System, see: http://www.icos-infrastructure.eu/index.php?p=hom). The North Atlantic VOS line observing system has been instrumental in identifying the large interannual CO_2 air-sea flux changes in the North Atlantic domain. Also the deep ocean sections collection with highest quality data has been substantially increased. High quality data syntheses for surface pCO_2 (SOCAT – surface ocean carbon atlas, see: http://ioc3.unesco.org/ioccp/SOCAT.html, most comprehensive surface ocean pCO_2 raw data base; Takahashi et al., 2009, pCO_2 climatology) and the deep ocean (GLODAP, Key et al., 2004; CARINA – Atlantic Ocean data set, see: http://www.carbon-synthesis.org/; e.g., Hoppema et al., 2009) have provided scientists with observational ocean carbon data of unprecedented quality, consistency, and coverage. Also, progress in the field of autonomous measurements has been made to equip floats and buoys with sensors and respective satellite telemetry to enable measurements in areas usually not covered by shipping routes or regular reoccupations through research vessels. Among these new developments, oxygen sensor systems are vital also for constraining the carbon system (as O_2 can be successfully used to discriminate between biologically- induced and physically-induced carbon fluxes in the Earth system). The deep section and surface ocean data have been combined with other oceanic biogeochemical tracers in order to reconstruct the increased load of dissolved inorganic carbon in the ocean due to uptake of human-produced CO_2. A series of different methods has been applied (such as ΔC^*, TrOCA, eMLR; e.g. Lo Monaco et al., 2005; Tanhua et al., 2007). One key result from these measurements are new estimates for northern and southern high latitude water column inventories of the anthropogenically induced carbon increase in the ocean. The unexpectedly high values coincide with the apparent – at least transient – sink strength reductions in large domains of the North Atlantic as well as the Atlantic sector of the Southern Ocean (Vázquez-Rodríguez et al., 2009).

Model developments and combinations of models with observational data: In Europe as well as world wide, climate research centres have developed new Earth system models or upgraded older systems. Existing and emerging hindcasts as well as future scenarios reveal the potential of these systems to provide internally consistent simulations of key features of the real climate system (e.g. Cox et al., 2000; Fung et al., 2005; Doney et al., 2006; Mikolajewicz et al., 2007; Tjiputra et al., accepted). These models are very demanding concerning supercomputing infrastructure for carrying out future scenarios. Therefore, also very coarse resolution Earth system models of intermediate complexity (EMICs) have been developed for scenarios exceeding ca. 500 years periods (e.g. Lenton et al., 2006; Müller et al., 2006; Brovkin et al., 2007). These models have a poor resolution, are thus not suited for simulations with regional significance, but are useful

for answering first order questions on long time scales (e.g. Plattner et al., 2008). New developments include a coupled physical-biogeochemical ocean general circulation model with isopycnic coordinates available (Assmann et al., accepted; Tjiputra et al., accepted).
In order to achieve optimal model predictions, the free model parameters need to be adjusted so that real world observations are reproduced in the best way without violating the model dynamics. Data assimilation methods originally developed for physical climate and Earth system component models are gradually also adopted for ocean carbon cycle models: the adjoint method (e.g. Tjiputra and Winguth, 2008) and the Ensemble Kàlman Filter (e.g. Gerber et al., 2009). Neural network techniques have been successfully employed for intelligently interpolating the VOS line surface ocean pCO_2 data in order arrive at basin-wide flux estimates (Telszewski et al., 2009). Inverse approaches under steady state assumptions have very successfully pursued for CO_2 fluxes (e.g. Mikaloff Fletcher et al., 2006; Gruber et al., 2009) and biogeochemical questions such as the fate of sinking particulate matter in the ocean (e.g. Usbeck et al., 2003).

B.1.2.2 Advance beyond the state of the art

CARBOCHANGE will close major emerging knowledge gaps which so far limit an accurate quantification of the ocean carbon sources and sinks. While for past decades only averaged changes in the ocean uptake strength for CO_2 could be deduced, and in general high variability could be identified for limited ocean basins, we proceed here to a more advanced level of quantification. We relate our description of the progress beyond the state-of-the-art to the same headings as in the previous section.

Carbon cycle climate feedback using coupled Earth system models: From the major climate research centres in Europe, we will employ their state-of-the-art Earth system models for the new IPCC emissions scenarios and RCPs (Radiation Concentration Pathway scenarios) which are of relevance for the IPCC 5^{th} assessment report. The models are forced by CO_2 emissions, and the atmospheric CO_2 concentration is thus a prognostic variable in contrast to the bulk of coupled climate models as used in IPCC AR4 (WP3). This approach is advantageous for feedback quantifications and does not cause additional uncertainties in terms of ocean carbon sink analyses as the atmospheric CO_2 and climate evolution that forces the model ocean is know from the simulation itself. By using emission scenarios, we will explicitly exploit the strength of coupled Earth System Models to provide insights on ocean carbon sinks in the context of natural and anthropogenically forced variability of the entire Earth System, including interactions among atmosphere , ocean, sea ice and land. As an important step beyond previous scenario computations we will rigorously compare the Earth system models against observations and also intercompare the models (WP7). We will use new skill-score metrics with respect to observations in order to establish a valid and objective reality check for the models for the time period when reliable data are available. This is a decisive progress beyond the state-of-the-art and will render a more realistic view on the models' ability to reproduce climatic variations for both physical and biogeochemical variables simultaneously. We will carry out novel analyses concerning the vulnerabilities of the ocean carbon sink to climate change and emission pathways, taking also into account the probability density function for such vulnerabilities using Monte-Carlo ensemble simulations (WP3). A series of longer "stabilisation scenarios" will be carried out in order to quantify the long-term effect of specific emission scenarios, with special emphasis on holding climate change and atmospheric CO_2 concentration at bay (WP3).

Considerable regional ocean carbon sink strength variations: Any modelling of the variable ocean carbon sources and sinks will be futile without corresponding observations from the real world. We will, therefore, build on the observations and data syntheses carried out under the successful FP6 *Integrated Project* CARBOOCEAN, and extend these highest accuracy data sets for the most vital oceanic regions North Atlantic Ocean, Tropical Atlantic Ocean, and Southern Ocean (WPs 4 and 5). The new focus on the Tropical Atlantic Ocean was selected because of the huge buffering capacity of the warm surface waters, which then are transported poleward and undergo significant alterations as preconditioned water masses to be transported downward at high latitude deep water production areas. The tropical preconditioning with respect to CO_2 can be decisive for the apparent sink strength changes at higher latitude. These new data sets will be directly used in the model data integration (WPs 6 and 7). Further these data collections serve as test bed operations for the emerging partners of the European Research Infrastructure ICOS (stakeholder's handbook: Ciais et al., 2009, website: http://www.icos-infrastructure.eu/). The new data sets will be essential to answer the question on whether the transient declines in ocean carbon sink strength in the classical high human-produced CO_2 storage areas North Atlantic and Southern Ocean are only transient or whether they reflect a trend which could potentially indicate a dangerous overall decline in ocean carbon uptake capacities which may have been overlooked before. A dedicated detection analysis will be carried out with stand-alone carbon cycle models forced by synoptic (daily re-analyses) atmospheric data in order to determine the threshold beyond which the CO_2 air-sea-fluxes start to show a clear signal which can be attributed to human-induced climate change and not to natural variability (WP3).

Physical and biogeochemical feedback processes: The identification of physical and biological as well as biogeochemical processes which govern the oceanic carbon source/sink distribution plus the appropriate representation and quantification of these processes in Earth system models is a difficult and quasi-persistent challenge for both measuring and modelling scientists. Processes controlling the vertical distribution of dissolved properties and hence air-sea exchange of CO2 are referred to as C pumps (Volk and Hoffert, 1985). Our main objective is to improve the capability of large scale ocean C cycle models to reproduced observed variability of the ocean C cycle and forecast its future evolution rather then the detailed description of marine ecosystems. Accordingly, we select a small number of key processes for the “biological carbon pumps” (WP1) and the “physical carbon pumps” (WP2), synthesise the knowledge available from observational studies, and implement respective formulations in the models. For the biogeochemical processes relevant to the carbon cycle climate model these processes are: Changing remineralisation rates and organic matter sinking speeds as a function of warming and increasing pCO_2 (decreasing seawater pH value), changes in the fate of the vertical particle flux due to changes in ecosystems and their community structures, and the advection of important carbon sources and sinks from continental margin areas (WP1). In WP2, the physical key processes for the carbon cycle climate feedback of changing overturning circulation under climate change and of changes in sea ice cover will be addressed. We will systematically establish whether ocean pCO_2 can be used to monitor changes in the overturning circulation, as small changes in dissolved inorganic carbon due to such circulation changes would map significantly enlarged on the surface ocean pCO_2 pattern. The results from process studies will be significant as input to WP6 on the systematic model calibration for the selection on model parameters, which will be used in the optimisation. All climate models to date have a quite coarse resolution due to the immense computational demand of these models. In order to establish a better knowledge on what we might miss in respective coarse resolution model scenarios on the ocean carbon sink, we will carry out a study on the role of oceanic eddies for air-sea CO_2 fluxes in relation to wind-stress. For this study we choose the Southern Ocean, as one of the key areas for changes in the ocean carbon sink, which is critical to correct parameterisations of the horizontal and vertical mixing processes and has proven in the past to react sensitively to climate change induced alterations of the wind-field (e.g., Toggweiler et al., 2006; Lenton et al., 2009) (WP2). The skill score metrics for performance assessment of model computations with respect to measurements (WP7) will be employed to establish whether the improved process parameterisations indeed result in an improved reproduction of the changing ocean carbon sink.

Observing systems: With respect to the European Research Infrastructure ICOS, which should be the European back bone for marine carbon cycle observations, the European ocean carbon observing systems will be further developed and extended. As an overall appropriate carbon observing system is a huge task, which by no means can be developed or maintained through selected single research projects, we focus here on a series of key elements which deserve a European concerted effort. These elements will significantly contribute to establish improved European monitoring capabilities. For the surface ocean a coordinated effort on combining VOS lines, buoy data and in-situ measurements from research vessels will be enabled, which will deliver cutting edge data on the evolution of air-sea CO_2 fluxes over the North and Tropical Atlantic as well as the Southern Ocean (WP4). Such a new coordinated approach is necessary in order not to loose the momentum on data quality and standardisation as achieved through previous research projects, and to merge European carbon data initiatives into a coherent framework, which is currently not carried out in any other international network. For the deep ocean, both extended deep section data but also data from time series stations or reoccupied stations at important choke points will be collected, analysed and synthesised (WP5). The key question of the vulnerability of the ocean carbon storage process over time with respect to climate change will be addressed jointly by WP 3, WP5, and WP7. The data sets from WP2, WP3, WP4, and WP5 will be systematically exploited by WP6 on model calibration and WP7 on model-observation comparison. In WP8, key work on the synthesis of existing and emerging data sets on ocean carbon cycling will be carried out, which will lead to new cutting edge data products as needed for ground-truthing any serious attempt to simulate and predict the ocean carbon sink over time: a merged 3-D carbon data product of the CARINA and GLODAP data sets, a new release of the SOCAT data set, and new atmospheric data from VOS lines and other vessels carrying automated systems.

Model developments and combinations of models with observational data: We will make an integrated effort on systematically improving ocean carbon models with respect to observations using different methods. As this is a newly emerging field, we pursue such a diverse approach rather than to calibrate only one model system. The experiences obtained from different model concepts and calibration/assimilation procedures will give us the framework at hand to approach systematic calibration of entire coupled Earth system models for the next several years to come. In order to bundle the different approaches we will carry out the following systematic model calibrations (WP6): A calibration of the MICOM biogeochemical ocean model which also used in the Norwegian Earth system model NorESM using the sequential Ensemble Kàlman Filter method, where we will focus on the impact of model physics on the ocean carbon cycle (link to WP2) and selected optimisations of biological pump relevant parameters (link to WP1). We will use the adjoint method as a variational method to optimise systematically the biogeochemical model parameters in the biogeochemistry model of the MITGCM. The optimised ocean biogeochemistry will then be used in the MIT/CCDAS optimal coupled ocean-land-carbon cycle model to determine the impact of improved ocean carbon cycle on terrestrial CO_2 fluxes and vice versa. As the computational demand for data assimilation procedures is huge, we will further use an Earth system model of intermediate complexity (Bern-3D-model) using also the Ensemble Kàlman Filter approach, but with a quantitatively much larger possibility for runs and over longer time periods. A current problem in Earth system modelling is the long integration time which is required for ocean models (physics and biogeochemistry) in order to achieve quasi-equilibrium (ocean turn over time is of the order of 1000 to 2000 years). For testing the models' ability to reproduce a drift free quasi-equilibrium also for the oldest parts of the world ocean's water masses, the time efficient tracer transport matrix method (Khatiwala, 2007; Merlis and Khatiwala, 2008) will be employed for several biogeochemical ocean models and different flow fields in order to calibrate first order governing parameters for optimal pre-industrial start fields of scenarios. Finally, we will pursue the variational calibration of the PISCES biogeochemistry model with biogeochemical observations from individual sites and satellite products in order to also calibrate more complex ecosystem model parameters in the selection of models within this project. For the calibration and integration of the models with data, the newly emerging data from WP2, WP4, and WP5 as well as the methodology for model performance assessment from WP7 will be needed.

Outreach to policy makers:
Recently, a number of promising report products for policy makers have emerged (*IPCC 4th assessment report* – IPCC, 2007; *Integrated assessment of the European and North Atlantic Carbon Balance* - Schulze, Heinze, et al., 2009; policy briefs such as UNESCO-SCOPE-UNEP, 2009; *special report by the German Advisory Council on Global Change* – WBGU, 2006; and The Copenhagen Diagnosis, 2009), on which we will build to provide further direct firsthand information for policy makers on the evolution and significance of the ocean carbon sink. We will compile annual updates on the altering ocean carbon sources and sinks and their drivers on a regional as well as global basis. We will summarise the ocean state with respect to carbon cycling as well as the vulnerability of the ocean sink for human-produced CO_2 for policy makers, decision makers, and other end-users, e.g. the research communities on ocean acidification, environmental agencies such as the European Environmental Agency (EEA), global observing systems, and large international core projects such as IGBP SOLAS, IMBER, GEOTRACES, European FP7 projects such as EPOCA (on ocean acidification) and COMBINE (on new components for Earth system models) and further programmes.

B.1.3 S/T methodology and associated work plan

B.1.3.1 Overall strategy and general description

For this large scale integrating project we pursue a strategy which enables a broad enough scope to tackle the problem of changing ocean carbon sources and sinks from every necessary angle, but at the same time interlinks all components in order to achieve an overall integration among the different components. We place particular emphasis on the integration of modelling and observations and wherever advisable combine modelling and measuring scientists in each work package. The strategy of the work plan follows directly the requirements of the call.

The work on processes and feedbacks is carried out under core theme 1 using three work packages (see Figure 1.3.3) which are dedicated to the identification and quantification of key processes in the fields of biology and biogeochemistry (WP1), quantification of key physical processes (WP2), as well as the realisation of future scenarios including analyses on vulnerabilities and climate stabilisation (WP3). The time line for the work in WP3 is tailored to provide input to the next IPCC report and a first set of scenario runs is completed within the first six months.

For practical reasons, we have assigned the observations - as base line information for all other WPs and CTs - together in one core theme (CT2) and work packages 4 and 5 (see Figure 1.3.3) in order to achieve a best possible coordination of the measurement programme. The observations are then firmly linked with all other components of the project. The observations feed into the process work packages 1 and 2 as foundation for the derivation of key processes on the ocean carbon cycling, into WP3 for an accurate as possible quantification of feedback processes as well as carbon sink vulnerabilities under changing climate and changing CO_2 concentrations using future emission scenarios, into the model calibration and model assessment work packages 6 and 7 as real world reference data, into the synthesis work package 8 for deriving best integrated estimates on ocean-atmosphere carbon exchanges, and of course WP9 on data management, where all data is archived and disseminated.

The integration of models with observations will be systematically pursued under CT3 in WP6 and WP7 (see Figure 1.3.3). WP6 will carry out systematic model calibrations using different approaches with the observations provided through WP4, WP5, WP8, and WP9 as input. In WP7, a rigorous comparison with observations of the models used in WPs 3 and also 6 will be accomplished. WP7 also will develop the skill score metrics (standardised measures for the discrepancy between model results and observations), which will be applied in WP6 for assessing the quality of model results and for systematic calibration of the ocean carbon cycle models and the Earth system models. The results of CT3 are a prerequisite for the improved synthesis on carbon sinks in WP8. This work requires a long-term commitment dedicated to provide updated knowledge on sinks also after the completion of the next IPCC report.

The overarching work packages WP8, WP9, and WP10 cut across all core themes and therefore have no governing core theme. The project coordinator and the deputy coordinator will steer these work packages together with the leaders of the overarching WPs, so that best possible overarching integration of all disciplines and science work will be achieved. WP8 is dedicated to synthesis work on the ocean carbon sources and sinks. It will take care of important synthesis for observational data sets, will provide global and regional air-sea CO_2 flux numbers for separate years, and will transmit all key results of the project to policy makers and other stakeholders of the climate change topic. WP9 will carry out the professional data management which is needed to archive the project's long-term results and disseminate them to the science community and the end users. The data management will also include the management of model results.

Overarching work package 10 on consortium management will achieve a smooth project flow through continuous following-up, review, and assessment of progress in the various WPs and CTs. It will provide support for the outreach to policy makers. WP10 further will coordinate all scientific as well as administrative work, communicate between all governing and executing levels of the project, will organise project meetings, and compile the periodic reports. Following the call for this project, we have placed a somewhat minor emphasis on training aspects, though we expect that a series of PhD students will be trained in CARBOCHANGE. Also we will not explicitly include a training programme for secondary schools (as done under CarboEurope and CARBOOCEAN). This does by no means that we do not think that these aspects are of extreme importance, but we rather see that the training aspects are to a high degree already addressed by running and emerging Initial Training Networks on ocean carbon cycle aspects and outreach projects on general global change issues. We aim at directly linking CARBOCHANGE to these training and outreach projects and to supporting them with any information and action which will be appropriate and helpful.

General description of the work packages

We describe now briefly the **rationale** behind the various work packages (WPs). The objectives, tasks, deliverables, and milestones associated with each WP are given in detail in the WP tables further below.

WORK PACKAGES OF CT1 - Key processes and feedbacks, future scenarios, and vulnerabilities:

WP1 Biogeochemical processes and feedbacks: lead Völker & Gonzalez

Next to physical processes, the surface ocean CO_2 concentration depends on the biological carbon pump. Global warming, ocean deoxygenation, and ocean acidification will affect the rates at which organic matter, opal, and $CaCO_3$ will be remineralised/dissolved as it sinks through the water column, leading to changes in the associated length scales. Recent work by Kwon et al. (2009) showed a surprisingly large sensitivity of atmospheric CO_2 to very modest changes in the remineralisation length scale of organic matter. The export of this organic matter from the surface ocean is the decisive element controlling the efficiency of the biological pump, which is the important quantity controlling the impact of ocean biology on the air-sea partitioning of carbon. It has been hypothesized that plankton community structure is essential in determining the fraction of production that is being exported to depth. However, this is far from well established, particularly since the relationship between the magnitude of carbon export and community structure is poorly understood. The continental margins and high-productivity areas associated with upwelling regions play a major role supplying organic carbon and nutrients to the open ocean that influence the air-sea CO_2 balance, which can lead to downstream productivity and respiration changes. However, very little is known about this potentially important interaction of the coastal and open oceans. We propose to test the high atmospheric CO_2 sensitivity in a comprehensive ocean carbon cycle model and to develop an understanding of what controls this high sensitivity, to study the role of primary and secondary producers for export strength and to investigate the interaction between coastal and open ocean by addressing the roles of the offshore transport of OC and nutrients on the carbon cycle in the Atlantic Ocean.

WP2 Physical processes and feedbacks: lead Anderson & Oschlies

The transport and mixing of water which carries anthropogenic carbon into deeper layers of the ocean is key for governing the speed of CO_2 uptake by the oceans. Up to now the uptake of anthropogenic CO_2 (C^{anthro}) by the oceans has been estimated based on the assumption of a steady state situation where ocean ventilation has occurred under constant conditions when it comes to degree of CO_2 saturation as well as for tracers, e.g. CFCs, used in the calculations. However, we have now reached a state where climate change has impacted the ocean physics that has changed the basis for the calculations of C^{anthro} making it necessary to develop better tools for these estimates. Examples of changes inferred from observations include changes in winter mixed layer depths in high and mid latitudes, changes in wind-induced upwelling in the eddy-controlled Southern Ocean, an area of substantial intermediate water formation, and changes in the sea ice coverage in the Arctic Ocean that, in turn, change the preconditioning of the waters that ventilate the Nordic Seas and contribute to the overflow to the North Atlantic and, eventually, the meridional overturning circulation. Furthermore, changes in seasonality may feed back on the net oceanic carbon uptake. For example, the decreased summer sea ice coverage in the Arctic Ocean promotes a larger than historic sea ice production during the winter season which result in a more intense brine formation that support ocean ventilation and oceanic uptake of atmospheric CO_2. All of the above changes in the physical environment affect the oceanic CO_2 uptake. Processes involved occur on scales smaller than those resolved by current carbon-climate models and therefore require parameterizations adequate for a correct representation of physical feedbacks. Within this WP we propose to use a hierarchy of models: Regional process models of sufficient resolution will be employed to explicitly resolve the relevant processes and to develop improved parameterizations for coarse-resolution models. The improved parameterizations will be used in carbon-climate models to investigate the large-scale impacts of local processes on oceanic CO_2 uptake.

WP3 Future scenarios under different emission curves and vulnerability analysis: lead Bopp & Totterdell

All modelling studies using coupled climate-carbon models (including those undertaken in the framework of EU FP6 *Integrated Project* CARBOOCEAN), have found a positive climate-carbon feedback in the 21st century (e.g. Friedlingstein et al. 2006). The uncertainty in this feedback, assessed by comparing the different models, is large. Nevertheless, these modelling studies point towards the Southern Ocean and the North Atlantic as key regions for explaining the simulated ocean contribution to this positive feedback. But the detailed processes (physics, biological) beyond the simulated response of the ocean carbon flux to climate change remain unclear. How would the simulated ocean response change for different emissions / concentration curves over 2000-2100 (especially for the new IPCC RCP scenarios)? How would the identified positive feedback evolve under longer-term simulations (2000-2300 or 2500)? At the same time, (some) recent observations and ocean-only simulations attest of a slowing down of the net carbon uptake by the ocean, which has been suggested to be caused by climate change and/or climate variability (e.g., Le Quéré et al., 2007; Telszewski et al., 2009). Is climate change already impacting air-sea carbon fluxes? If not, when will this impact be unambiguously separable from decadal variability? We will assess the uncertainty in future ocean uptake due to different model structure by comparing the response of the different models to future changes with an emphasis on mechanisms. Complementary to this, output from WP3 models for the historical period will be assessed with respect to observation-based metrics in WP7 to produce multi-model average projections. We will also assess the uncertainty in future ocean uptake by focusing on the parameter uncertainty. Many models can fit the historical record with roughly similar accuracy (as that is mainly determined by solubility and circulation) but over longer century time-scales the biogeochemical feedbacks will come into play and will give a range of possible uptakes. Techniques are available to explore the probability density function (PDF) of future atmospheric CO_2 and temperature change, and can be used to determine the PDF due to variations in biogeochemical parameters that fit the historical record. This approach is complementary to the calibration in WP6 because for many parameters the optimal value is not precisely determined by historical data but the resulting uncertainty in future predictions is large. The work of WP3 is tailored in such a way, that it contributes directly to the 5^{th} IPCC assessment report.

WORK PACKAGES OF CT2 - Observing system of ocean carbon changes :

WP4: Surface observing system: lead Schuster & Boutin

In the **N. Atlantic and Tropical Atlantic**, we have a prototype of an effective and accurate observing system following CARBOOCEAN, which operated during the period 2005-2008. We will build on this prototype, improving its efficiency and continuity of operation with the aim that it should deliver results as good as in its first year of operation (2005). In subsequent years, there were periods when the performance of the observing system was reduced, due to its vulnerability to data gaps caused by equipment failure or by the uncertainties of the shipping industry. To make the system fully robust, a more co-ordinated approach is required. This will enable rapid response to equipment problems, and to the sometimes rapidly changing routes of commercial vessels. More traceable and more frequent cross-calibration of the observing system is also desirable, as is improved accuracy of atmospheric measurements on the observing vessels, which would potentially enable their use in atmospheric inversions. Useful in-water oxygen measurements should also be possible given improved sharing of expertise and equipment across the network. A co-ordination unit will be initiated to provide this extra level of support.

In the **Southern Ocean** we cannot hope to have the density of coverage possible in the Atlantic. However the repeated transects of research vessels will enable a decadal picture to be built up in the Atlantic, Indian and western Pacific sectors. We will prioritize synthesis of seasonal and decadal trends. No such synthesis presently exists, nor is one planned under CARBOOCEAN We will also undertake studies characterizing the variability captured by drifters in the Southern Ocean, that suggest variability is under-sampled by ship observations. In particular a better understanding of the physics and biology driving the high frequency variability may help to improve the design of monitoring systems.

In the **European coastal** seas, we will encourage similar efforts, while recognizing there is insufficient funding available to fully support them all from this call. Because of these limited funds, observations in coastal seas are not directly supported in this proposal, but we will link with national efforts supporting coastal observations, to provide an international, regional-to-global framework to make a co-ordinated network of disparately funded observing programs.

In **the atmosphere**: we will undertake precision observations of atmospheric CO_2 and oxygen/ nitrogen designed to enable us to test out the use of regional patterns of atmospheric potential oxygen as independent method of observing air-sea carbon fluxes over large regions, and to enable us to integrate our findings with atmospheric and terrestrial studies .

Marine and atmospheric pCO_2 measurements will be calibrated using gases traceable to WMO standards. Marine pCO_2 observations should normally be accurate to within 1 uatm, and special attention will be paid to the determination of equilibtrator and seawater temperatures which have in the past been shown to be significant sources of error. Building on practice established in CarboOcean, we will ensure that all partners are using compatible schemes for the reduction of raw data to obtain pCO_2 values and fluxes. For CARIOCA sensors, a check of the calibration is made by comparing ship and mooring measurements when the instruments are deployed and recovered. In addition, CARIOCA pCO_2 sensor measures optical dye absorbance at three wavelengths, ensuring an internal control of the calibration of the CO_2 sensor (Copin-Montegut et al. 2004).

WP5 Deep ocean, time series, choke points: lead Rios & Hoppema

WP5 will undertake carbon-related measurements on carefully selected **hydrographic sections** where these contribute to closing carbon budgets for the Atlantic Ocean. Priority will be given therefore to observations that enable assessment of the change in the inventory of anthropogenic and natural carbon in critical regions and in transport across choke points. Time series stations at choke points complement the deep sections by allowing an assessment of high frequency processes and mechanisms. Many/most of the sections and time series have been occupied in the past. The formation regions of water masses (in the Labrador Sea, the Irminger Sea, the Iceland Sea, and the Southern Ocean) are considered of particular importance, as they allow an assessment of the interannual and decadal changes in anthropogenic carbon uptake.

The hydrographic sections include 75ºN, a trans-Arctic section, a Greenland-Ireland section, a Greenland-Lisbon section, a Labrador Sea section, and the Prime Meridian (0°W) section in the Weddell Sea. The time series stations are the Irminger station (64.3ºN, 28ºW), the Icelandic station where the changes are rapidly detected (68ºN, 12.66ºW), and the PAP (Porcupine Abyssal Plain) site (49ºN, 16.5ºW). The flow of the lower limb of the Meridional Overturning Circulation (MOC) from the North Atlantic Ocean to the Southern Ocean is a critical transport pathway for natural and anthropogenic carbon. Sections for assessing the changes in anthropogenic carbon inventories and budgets are the sections along 24ºN, 8ºN, and the Prime Meridian (from 52°S to Antarctica) and a north-south section along the western South Atlantic Ocean (from French Guyana to Ushuaia). Complementary data exist on the Drake Passage between South America and the Antarctic Peninsula. Another choke point is the Strait of Gibraltar which is a key site for crucial exchanges of water, salt, and carbon between the North Atlantic Ocean and the Mediterranean Sea.
In addition, one hydrographic section and three time series stations are located in the eastern Atlantic Ocean in order to assess the carbon changes in this important upwelling area where the biochemical processes are affected by natural and anthropogenic carbon changes. The time series stations along this eastern boundary are ESTOC (29ºN, 16ºW) near the Canary Islands, TENATSO (16ºN, 24ºW) near the Cape Verde Islands, and PIRATA (6ºS, 10ºW) situated in the Tropical Atlantic Ocean. The hydrographic section along 28ºN from 12º to 14ºW will be carried out four times per year.

Carbon measurements will be conducted with state of the art methods, e.g., coulometry for DIC and high precision potentiometric titration for alkalinity. Consistency between cruises will be achieved by applying internationally recognized certified reference material, obtained from Prof A. Dickson (Scripps Institution of Oceanography), and performing consistency analysis using the quality controlled data from the GLODAP and CARINA synthesis products. WP5 will advance the synthesis of the subsurface carbon, nutrient and oxygen data bases to the point where these products are available for use in modelling studies, to provide the best possible.

<u>WORK PACKAGES OF CT3 - Data model integration:</u>

WP6 Systematic model calibration using observational data: lead Bertino & Scholze
WP6 will construct and operate a suite of modelling systems that use a range of oceanic observations for systematic calibration of the physical and biogeochemical process parameters (constants used in the process descriptions) of a set of stand alone ocean models and an EMIC, plus a system that can calibrate the ocean model simultaneously with a terrestrial biosphere model by using observed atmospheric carbon dioxide concentrations (in addition to the oceanic observations).The systems will build upon a set of models covering time scales from decadal to millennial (MICOM-HAMOCC, MITgcm, Bern3D model) and apply two different advanced data assimilation methods for calibration: Ensemble Kàlman Filter (EnKF), a sequential method, and the adjoint method, which belongs to the variational methods. Observational constraints will include T, S, concentrations/partial pressures of carbon, nutrients, CFCs, radiocarbon, potential alkalinity, and remotely sensed ocean colour. Data will be provided by CT 2 and existing data bases such as SOCAT, CARINA, or GLODAP. We will closely collaborate with WP9 on data management for the preparation of the best available input data sets for the assimilation procedures. Selection of observations, specification of uncertainties for definition of misfit functions (metrics), and interpretation of the results will be carried out jointly by observationalists and modellers. The WPs main deliverables are (i) consistency checks of multiple data streams and modelling concepts, which -as input to CT2- helps to improve process understanding (ii) calibrated systems to be used in WP8 for global syntheses that combine the information for observations and models in an optimal way and in WP3 for future scenario calculations. The new knowledge obtained will feed into international assessments and into a new class of coupled calibrated Earth system model frameworks to be developed in the coming decade.

WP7 Data-model and model-model comparison: lead Orr & Tanhua
Many work packages of this project rely on models, both Earth System Models and forced ocean models, as fundamental tools to assess ocean carbon sources and sinks. In these Workpackages (WP1-3, WP6, WP8) models will be used to assess the modern mean state and its variability as well as how these conditions have changed in the past and will change during the 21st century and beyond. Models will also be used to diagnose controlling processes and ocean carbon-climate feedbacks. Yet models are biased. They must be evaluated to assess how well they agree with real data so that we can assign some level of confidence to their projections. In WP7 we will use the best observational data sets available of carbon and related tracers to evaluate the accuracy of the simulated mean state, seasonal variability, and interannual variability at the regional and global scale in the relevant models used in this project. Regional analyses will focus primarily on the

Southern Ocean, the North Atlantic Ocean, and the Arctic Ocean. Particular emphasis will be placed on assessing the extent to which models represent observed changes in North Atlantic and Southern Ocean air-sea CO_2 fluxes (CT2). Global and regional data will be used as targets to quantify model-data agreement. With these data constraints, we will assign model performance indices, and these will be used together to provide best "weighted" projections. Simultaneously, we will asses the extent to which skill scores for different time scales (mean states, seasonal variability, and interannual-to-decadal variability) are correlated across models and can or cannot be used to legitimately weigh future projections. We will also use the range of model results in combination with the best estimates to provide statements regarding the precision and accuracy of model projections and to assess consistencies in carbon-climate feedbacks. Furthermore, we will strive to attribute anthropogenic trends in the data based on the consistencies of trends in modelled carbon and related tracers.

OVERARCHING WORK PACKAGES:

WP8 Global synthesis and outreach to policy makers: lead Le Quéré, Olsen & Bakker
WP8 will work with all Work-packages to synthesize the information produced within CARBOCHANGE, both from data collection and modelling, and provide products that can be used by other scientists, students, policy assessments, press agents, and the public.
WP8 will work towards the establishment of *annual* releases of policy-relevant information on the state of the marine carbon cycle. These releases will be based on annual updates of at least five models forced by increasing atmospheric CO_2 concentration and changes in climate, which will provide the mean annual sink and a measure of the additional uncertainty estimated from the model spread (as in Le Quéré et al. 2009). The level of confidence in the model results will be determined using the updates of the Surface Ocean CO_2 Atlas (SOCAT), also released also by WP8.
WP8 will also create a global 3-dimensional Atlas of key carbonate variables. This information is needed by a wide group of people, particularly those working on the impacts of ocean acidification, and to validate ocean models. WP8 will merge the GLODAP and CARINA datasets into a unified, consistent dataset, and use this product and other available data to assess the export of carbon and $CaCO_3$ to the deep ocean, and provide the global distribution of ocean DIC, TA, pH and $CaCO_3$ saturation states. Using existing data, a global adjoint model will be applied to quantify monthly CO_2 air-sea fluxes and carbon export fluxes. This is the first time that such analysis will be done with a monthly resolution, thus allowing exploration of processes driving their seasonal cycles.
The activities of WP8 will be complemented by a report on the vulnerability of the oceanic CO_2 sink and a summarising outreach paper in a suitable journal including high latitude CO_2 fluxes and the response of the oceanic CO_2 sink to climate change. The annual releases of new global as well as regional carbon flux numbers will be accompanied by co-ordinated press releases among CARBOCHANGE partners and with the Global Carbon Project, and will include material for the press, pictures and a summary for a lay audience. The SOCAT and 3-D atlas data products will be accessible through a Live Access Server from PMEL. The model results will be maintained by the UEA and accessible through a web server. Both data and model products will be visible from the web sites of CARBOCHANGE, the Global Carbon Project and IOCCP, which are popular web sites for carbon research.

WP9 Data management: lead Schlitzer & Pfeil
The sharing of data and information among partners of large coordinated projects, such as CARBOCHANGE, strengthens the collaboration between different disciplines and research groups and ultimately leads to an increased scientific output through synergistic effects. The benefit of CARBOCHANGE to the wider scientific community also requires data generated within the project to be freely available and easily accessible. To encourage and promote data and information exchange in a timely and efficient manner, CARBOCHANGE will establish a data policy with binding rules for all project partners. While calling for openness and free flow of data between partners, these rules must also protect the intellectual property rights of the data producers (link to the EU FP7 coordination action COCOS). CARBOCHANGE will also set up a cost-effective centralized data management infrastructure allowing data storage and data flow with minimal effort for individual scientists. Two major types of data will be handled: (1) direct measurements (e.g. water column data, subsurface measurements) and (2) model output. **Direct measurements:** CARBOCHANGE will employ a data manager (half time) at the coordinator's office who will be responsible for archiving data and making the metadata available on the project's website. Technical implementation will use the facilities of WDC-MARE (World Data Center for Marine Environmental Sciences, University of Bremen) for data storage and access. **Model output:** Output from the different

models employed in CT1 and CT3 will be stored and maintained in a common format at LSCE to allow easy access by PIs and to facilitate multiple model comparison and model-data evaluation. Model output differs greatly from observational data in terms of data storage size, logical file structure, and formats. Model output will therefore be maintained separately from observed data. However, efforts must also be made to facilitate comparison of model results to data that is acquired during CARBOCHANGE. A subset of CARBOCHANGE model output will be provided to LSCE (Partner 6) in a common netCDF format following the OCMIP-4 conventions taking advantage of LSCE's previous experience in building, storing, and distributing multi-model output in a common format during the OCMIP-2, -3, and -4 model comparison efforts (see OCMIP-4 archive guidelines at http://www.ipsl.jussieu.fr/OCMIP/phase4/simulations/OCMIP4/HOWTO-OCMIP4.html).

WP10 Management of the project: lead Heinze & project manager to be assigned/hired
WP10 is dedicated to all managerial aspects of the project (for details see section 2.1) and also will address important outreach issues. Management includes the items: Scientific management, administrative/financial management, communication between the European Commission and the coordinator as well as the consortium, internal communication within the consortium (including the scientific steering committee, the executive board, and the international advisory board), general coordination, supervision, accomplishment, and submission of periodic reports, solution of problems through addressing corresponding panels, general project dissemination/outreach to the scientific community and the general public, press contacts, review and assessment of project tasks, timely notification of partners on upcoming deadlines (deliverables, milestones, project meetings, reporting), updating of important project lists and archives (deliverables, publications, partner lists and addresses, email-lists), design, maintenance, and continuous updating of the project homepage on the internet. The scientific project manager will coordinate at least two outreach papers to policy makers together with the consortium. The project manager in concert with the project director (coordinator) and key PIs throughout the consortium (such as the CT leaders) will provide information packages, fact sheets, and press releases whenever appropriate and of promising impact. We will in particular explore most efficient pathways for the channelling of relevant information on the changing ocean carbon sink to policymakers in close collaboration with the scientific officer at the European Commission to ensure maximum impact of the new knowledge created by CARBOCHANGE. We will in particular forward any relevant new results to other projects and programmes for which ocean carbon cycling is of relevance such as projects on ocean acidification, development of Earth system models, carbon capture and storage, renewable and alternative energy production systems, and marine food production. A considerable part of the management person effort is dedicated to producing the scientific as well as financial periodic reports (the person effort has been included in the delivery of annual meetings).

B.1.3.2 Timing of the different WPs and their components

Year	**1**				**2**				**3**				**4**			
start month	**1**	**4**	**7**	**10**	**13**	**16**	**19**	**22**	**25**	**28**	**31**	**34**	**37**	**40**	**43**	**46**
end month	**3**	**6**	**9**	**12**	**15**	**18**	**21**	**24**	**27**	**30**	**33**	**36**	**39**	**42**	**45**	**48**
WP1 Biochemical processes and feedbacks																
1.1. Organic matter remineralisation																
1.2. Vertical carbon flux, role of plankton																
1.3. Carbon export to Atlantic Ocean																
WP2 Physical processes and feedbacks																
2.1. Sea ice cover and deep-water formation																
2.2.Variability deep-water formation																
2.3. Variability in air-sea CO_2 fluxes																
2.4. Eddies, Southern Ocean																
WP3 Future scenarios, vulnerability analysis																
3.1 Vulnerability of sources and sinks																
3.2. Probabilistic distribution of vulnerability																
3.3. Stabilization																
3.4. Detectability																
WP4 Surface observing system																
4.1. Network for estimates of air-sea flux																
4.2. Co-ordinate observational network																
4.3. Surface water CO_2 - Atlantic																
4.4. Surface water CO_2 - Southern Ocean																
4.5. Collect CO_2 and O_2/N_2 data in the atmosphere																
4.6. Variability of the air-sea flux of CO_2																
4.7. Seasonal sea surface pH Atlantic and Southern Ocean																
4.8. Effect of high frequency variability on air-sea flux																
4.9. Collaborate with WP8 with quality controlled data																
4.10. Comparison atmosph. observations -in-water techn.																

WP5 Deep ocean, time series, choke points																
5.1. Collect oceanic time series data																
5.2. Collect CO_2 along 10 predefined sections																
5.3. Variability of carbon storage at choke points																
5.4. Regional carbon inventories and changes																
5.5: Natural variability of carbon cycle in upper ocean																
5.6. Assess trends on ocean acidification																
5.7. Contribute quality controlled data to Task 8.3																
5.8. Link atmospheric to deep water CO_2																
WP 6 Systematic model calibration																
6.1. Calibration in stand alone isopycnic ocean model																
6.2. Calibration of ocean/ terrestrial biosphere model																
6.3. EMIC calibration																
6.4. Calibration of models for circulation fields																
6.5. Calibration of one dimensionial model																
WP7 Data-model, model-model comparison																
7.1 Global comparison																
7.2 Performance indices																
7.3 Links across timescales																
7.4 Feedbacks																
7.5 Attribution																
7.6 Deep-ocean evaluation																
WP8 Global synthesis and outreach to policy makers																
8.1. Prepare annual releases of air-sea CO_2 fluxes																
8.2. Release of the Surface Ocean CO_2 Atlas (SOCAT)																
8.3. Merge the GLODAP and CARINA datasets																
8.4. Report on vulnerability of the oceanic CO_2 sink																

WP9 Data management																
9.1. Observational data management																
9.2. Model output data management																
9.3. Information management																
9.4. Data management infrastructure																
9.5. Assistance in datasets and software optimisation																
9.6. Update of SOCAT input database																
WP10 Project management																
10.1. Internal communication																
10.2. Communication EC, coordinator, consortium																
10.3. Survey of project tasks and deadlines																
10.4. Supervision and submission of reports																
10.5. Addressing panels																
10.6. Dissemination and outreach activities																
10.7. Maintain and update project homepage																

B.1.3.3 Graphical presentation of the components showing their interdependencies (Pert diagram)

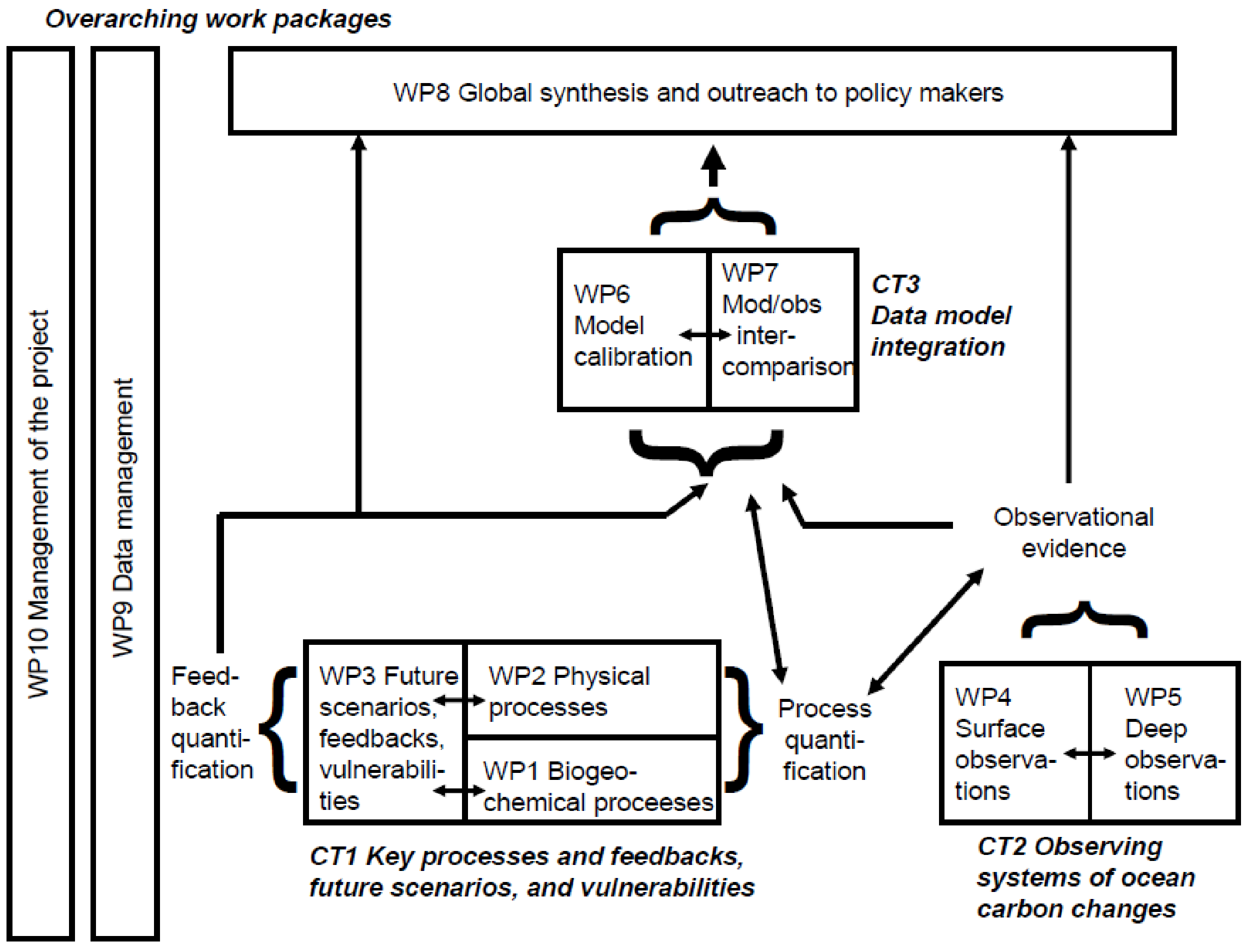

Figure 1.3.3: Overall strategy of the work plan and interdependencies/flowchart of the work packages.

B1.3.4 Description of significant risks, and associated contingency plans

The work in CARBOCHANGE was designed so that the key activities can be kept and carried out as planned – though with a somewhat minor ambition – if one or more tasks can not deliver in time their products and results. For the proposed work we see four risks, which all are balanced by respective preventive measures or contingency plans:

1. *Suitable personnel cannot be hired in time to carry out the work planned:* In order to find suitable personnel for the project tasks, we will announce open positions early and through the most efficient channels (national websites, EU websites, relevant scientific vacancy services such as "Earthworks") which have proven to work well in the past. We will try to attract additional funds from national sources for inviting promising candidates for job interviews in order to assign appropriate candidates with the ambitious tasks.
2. *Shiptime cannot be secured in time and voluntary observing ships are rescheduled:* Usually, shiptime on research vessels has to be booked several years in advance. Planned project work on research vessels, therefore, has to rely on already planned ship expedition time in its earlier phase and that appropriate ship time will be granted by national authorities in the later phase of the project. Also, commercial ships which carry autonomous measurement systems for surface CO_2 and atmospheric CO_2 measurements may be rescheduled or even put out of service by the ship owning company. Such changes usually can be solved by shifting the measurement systems to new ships. Respective additional costs can lead to some delays in putting the systems into operation again. As backbone data sets for data assimilation are available already, the lack of single cruise data sets will not endanger the data-model integration efforts as such, but occasionally will limit their impact for the most recent past. We expect that these potential deficiencies can be diminished by repeat computations towards the project end, if needed.
3. *Complex earth system models are not available as newest cycles due to delays in components taken care of outside of this project:* The complex Earth system models are the products of large research teams involving also personnel outside of CARBOCHANGE. In selected cases it can occur that newest ESM cycles are not available in time for the planned modelling tasks due to work on a component by other groups contributing to the same model, but are not involved in CARBOCHANGE. In order to keep the planned modelling work on track, we can in most cases use an already existing earlier model cycle. We would inform all ESM teams involved in the project early in time, that respective operational model versions will be needed at given points in time, so that the teams can prepare themselves optimally for the start of the project.
4. *Bottlenecks in available supercomputer infrastructure and supercomputer processing time:* CPU time (central processing unit time), huge core memory, and huge archiving space (disc, tape silos) are necessary for carrying out the modelling tasks with advanced Earth system models and higher resolution ocean models. Supercomputers and storage media are expensive infrastructures and have to be booked in advance by the modelling groups through their respective national procedures and agencies. We will reserve the relevant resources for processing and archiving on the national supercomputer facilities as soon as the proposal would become favourably evaluated and contract negotiations would be entered.

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B2. Implementation

B.2.1 Management structure and procedures

The management structure and procedures of CARBOCHANGE are designed to allow fast flow of information and resources between partners, administration, the European commission and the outside world. The management was kept as simple as possible for the sake of efficiency, but at the same time comprehensive enough to address the specific challenges related to the complexity of the project.

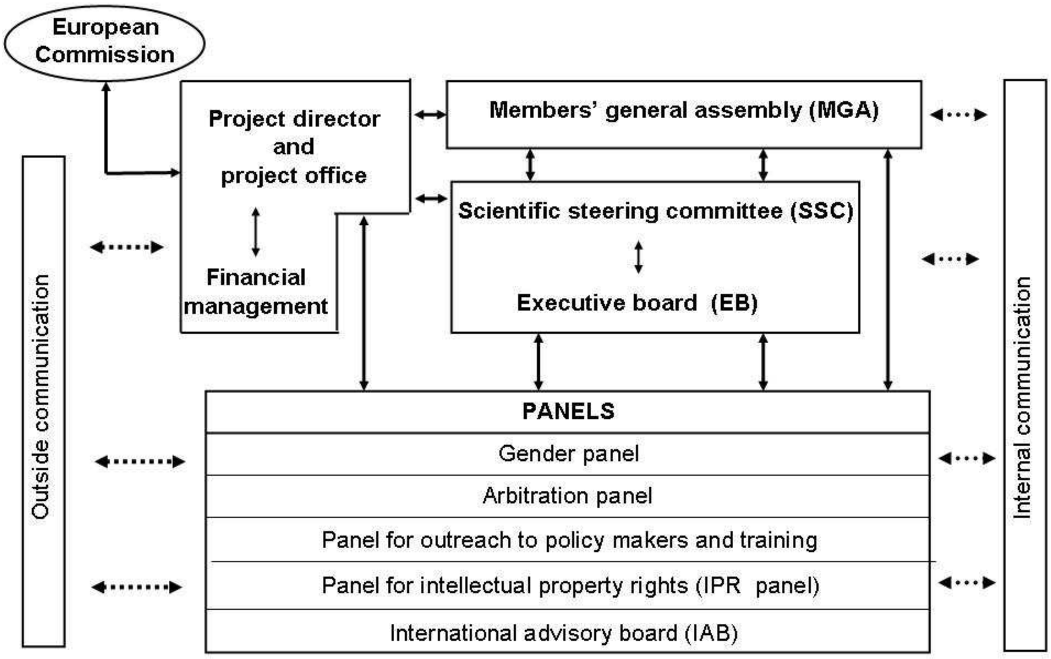

Figure 2.1.1: Management structure of CARBOCHANGE project

The management structure is illustrated in Figure 2.1.1. The main decision making bodies are the **Members' General Assembly (MGA)** and the **Scientific Steering Committee (SSC)** including the Project Director. Executive bodies are the **Project Office** and the **Executive Board (EB).** The **Project Office** includes the **Project Director**, the **Scientific** as well as **Financial/Administrative Project Managers**, and the **Data Manager**. The project office is the interface between the **European Commission** and the **CARBOCHANGE consortium**. A series of 5 dedicated panels deal with **gender issues, arbitration, intellectual property rights,** and **outreach to policy makers** and the general public. The **International Advisory Board** will assist in embedding the project in the global scientific network and will provide input on improving the project work.

B.2.1.1 Management structure

The following section describes the respective decision making and executive bodies as well as the panels and boards: their members, their role in the project, and their specific tasks.

Members' General Assembly (MGA)

Role and tasks: The MGA will be the overall decisive body of the Consortium. At annual meetings, it will give scientific advice to the Steering Committee on the most important issues of the project. If needed, extraordinary meetings will be held. The MGA will be responsible for all major formal decisions regarding project strategy, amendments to the Description of Work, amendments to the Consortium Agreement, decision and allocation of the budget in accordance with the contract, and any change to the Consortium.

Decisions in the MGA need 75% of the votes present at the meeting. The MGA will act upon proposal from the Executive Board and decide on the following issues

- Political and strategic orientation of the project
- Any major change in the scientific plans
- Any major budget reallocation between partners
- Any alteration of the Consortium Agreement
- The acceptance of new Contractors as well as any exclusion of Contractors
- Any premature completion or termination of the project

Members: Each contracting institution will appoint one senior representative to attend the meetings (the **contact PI**), who is authorized to take decisions concerning the project on behalf of the institution. It should be a senior scientific person who knows the field of research and has the necessary experience and qualifications to take decisions on major scientific, administrative and financial issues as well as decisions on the use and exploitation of results. All contracting institutions will also be responsible for the allocation of the necessary administrative, scientific and financial resources to carry out the share of the project contracted to them.

Scientific Steering Committee (SSC)

Role and tasks: The SSC will advise on the overall scientific policy, direction and management of the project to be decided by the MGA. All communication with the MGA will normally be through the Project Office
The responsibilities of the SSC will include:

- Acting on the initiative of the Executive Board (EB) on issues related to fulfilling the scientific objectives
- Assessing scientific progress against the objectives and, when necessary, making recommendations to the EB
- Approving all reports and implementation plans to the European Commission
- Providing advice on any call for and evaluation of new contractors, participants or partners that might be needed to finalize the project's objectives
- Linking with the International Scientific Advisory Panel and approbating any recommendation from this panel
- Giving recommendations to the Executive Board on any scientific aspects it foresees as requiring ethical considerations

Members: The SSC includes the core theme leaders, one representative of the work package leaders (with the others as deputies), and the project director:

Project director	**Christoph Heinze (UiB),** deputy director: Andrew Watson (UNEXE)
Core theme co-leaders CT1	**Marion Gehlen (CEA), Nicolas Gruber (ETHZürich)**
Core theme co-leaders CT2	**Andrew Watson (UNEXE), Aida Rios (CSIC)**
Core theme co-leaders CT3	**Fortunat Joos (UBERN), Nicolas Metzl (UPMC)**
WP 1 lead	**Melchor Gonzales-Davila (ULPGC),** Christoph Völker (AWI)
WP 2 lead	**Andreas Oschlies (GEOMAR),** Leif Anderson (UGOT)
WP 3 lead	**Laurent Bopp (CEA),** Ian Totterdell (MetO)
WP 4 lead	**Ute Schuster (UNEXE),** Jacqueline Boutin (UPMC)
WP 5 lead	**Aida Rios (CSIC),** Mario Hoppema (AWI)
WP 6 lead	**Laurent Bertino (NERSC),** Marko Scholze (UNIVBRIS)
WP 7 lead	**Toste Tanhua (GEOMAR),** Jim Orr (CEA)
WP 8 lead	**Corinne Le Quere**, Dorothee Bakker (UEA), Are Olsen (UNIRESEARCH)
WP 9 lead	**Benjamin Pfeil (UiB),** Reiner Schlitzer (AWI)
WP 10 lead	**Christoph Heinze (UiB)**

Executive Board (EB)

Role and tasks: The Executive Board will implement decisions on executive management, prepare decisions to be approved by the MGA, and ensure that adequate management is in place to monitor the science and perform quality control of deliverables. The EB will also decide on smaller issues which occur on a day-to-day basis and which do not warrant the involvement of a larger group for practical reasons. Major decisions and recommendations will be made with one vote per member of the EB. All communication with other Committees will be through the Project Office.
The responsibility of the EB will include

- Enforcing decisions of the MGA
- Ensuring the preparation of reports and work plan
- Informing the SSC about project progress, any problems and risks encountered and any change in strategy

Members: The EB will include the project director, one representative of the core theme leaders for each theme, and one representative from the overarching work package 8.

Specific tasks of further individuals in decision making positions

Project director and core theme co-leaders will:

- Provide major scientific directions and focal points for the research.
- Make suggestions for replacements of work package leaders if needed.

- Assist the work package leaders in important decisions.
- Report on the fulfilment of the major scientific mission of the project.

Work package co-leaders will:

- Follow-up the work and delivery as planned for the specific work packages.
- Coordinate the tasks in their work packages on a day-to-day basis.
- Observe the timely delivery of results and the linkage with other work packages.
- Report on the progress in the work packages.

In addition to their role as decision-makers in the MGA, Contact PIs (Principal Investigators) will mediate information flow between MGA, SSC members and Project office on one side and the individual researcher on the other side.

Contact PIs will:

- Ensure the information flow from project office and MGA to the institute co-workers
- carry out tasks devoted to them and report to work package leaders.

Further details will be given in the consortium agreement to be provided in case of positive evaluation.

Project office including financial management

The Project Office will be organized at UiB. It will be responsible for the day-to-day management of the project and acts upon decisions taken by the EB, the SSC and the MGA.

Members and their specific tasks: The **project director ("co-ordinator")** will be Christoph Heinze at the University of Bergen (UiB). He has the overall responsibility for the management and delivery of the project as well as its representation to the outside world. He is the contact person to the European Commission for all major decisions. Andrew Watson (University of Exeter, UNEXE) will act as Deputy Coordinator to fill in for the Project Director when under exceptional circumstances he may be absent. The **project manager** assists the project director in all detailed tasks, keeps the communication within the consortium running, helps to coordinate the work between the different work packages and panels, supports in problem solving, plans the project's kick-off and annual meetings, compiles the periodic reports, and ensures that all deliverables as well as milestones are provided in time. The **financial/administrative** manager at the coordinating institution takes care of the correct distribution of funds, coordinates the financial reporting of the consortium, and provides assistance in legal issues. The **data manager** ensures that data created by the project are properly archived and disseminated, that the intellectual property rights are obeyed, that correct meta-data are stored, and that the data sets archived undergo a rigorous quality check.

Gender panel

This panel will be responsible for CARBOCHANGE's gender action plan as described in section 2.1.2 and give advice to the SSC and EB on its implementation. The members will make recommendations on relevant gender issues related to recruitment of CARBOCHANGE staff and monitor how special needs for female researchers are being taken into account in the various training and research activities.

Members: 2 members will be nominated and assigned by the Member General Assembly through email and electronic vote before the kick-off meeting.

Arbitration panel

The purpose of the arbitration panel is to resolve conflicts occurring between partners of the consortium in relation to the project. It may for example become active in conflicts on authorship on publications resulting from the research in CARBOCHANGE. The Arbitration Panel will review the conflicts together with the involved partners and propose solutions. This process will be detailed in the consortium agreement.

Members: 3 members will be nominated and assigned before the kick-off meeting as described above.

Panel for Outreach to Policy Makers and Training

This panel will give advice to the EB and the Project Office on **dissemination activities and outreach** procedures of the project. It will channel the synthesized project results as obtained in WP8 to make them available for international assessments such at the 5th IPCC Assessment Report.

The management of **training** will mostly focus on the training of Master- and Ph.D. students which will become involved in the CARBOCHANGE project. A programme on global change for school teachers and a training network related to air-sea carbon exchange (ITN) will be submitted separately to this proposal. We aim at linking these projects if funded to CARBOCHANGE in order to strengthen the training of young researchers and to continue the outreach to pupils and teachers (as has been very successfully done under the European CarboSchools programme).

Members: 3 members will be nominated and assigned before the kick-off meeting as described above.

IPR (Intellectual Property Rights) Panel

This panel will be responsible for clarifying intellectual property right issues in case of conflicts (such as co-authorship or distribution and release of data by and to the consortium). The IPR panel will also give advice to the EB about all aspects of intellectual property rights. The handling of all data created under CARBOCHANGE will be regulated by a binding data policy to be established also in consultation with the FP7 coordination action COCOS (http://www.cocos-carbon.org/).The **management of Intellectual Property Rights (IPR)** among partners will be regulated by the Consortium Agreement to be developed by the coordinating institution and signed before the start of any eventual project contract with the Commission. This will be done in close collaboration with the responsible dedicated counterparts at all contracting institutions. A more detailed plan for the management of knowledge (intellectual property) acquired in the course of the project is given in chapter B.3.2.2..

Members: 2 members will be nominated and assigned before the kick-off meeting as described above.

International advisory board (IAB)

CARBOCHANGE will establish an International Scientific Advisory Board composed of international distinguished scientists to ensure external evaluation of the project and link to other programmes activities outside Europe. The persons listed below have already been approached and agreed to become members of this panel.

The responsibilities of the IAB will include:

· advising on the project's scientific approach and orientation by liaison with the SSC and the project director

· providing a link to related activities outside Europe

· providing an international perspective of developments in the field of Earth system modelling for climate prediction and climate projection, with focus on the internationally coordinated effort for the 5th assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC)

· making recommendations for new actions and activities in this area

Members:

Maciej Telszewski	Intergovernmental Oceanographic Commission of UNESCO (IOC-IOCCP); Deputy project director
Jean-Pierre Gattuso	Laboratoire d'Océanographie de Villefranche, France; Coordinator of the European Project on Ocean Acidification (EPOCA)
Han Dolman	Free University of Amsterdam, Netherlands; Coordinator of EU FP7 coordination action COCOS
Keith Lindsay	NCAR, Boulder, CO, USA; community liaison of the Biogeochemistry Working Group for the Community Climate System Model (CCSM)
Yasuhiro Yamanaka	Hokkaido University, Japan, liaison to Asian and circum-Pacific commuinities, expert advice in ecosystem modelling and carbon cycle modelling

B.2.1.2 Management procedures

Overall scientific and data management

The organisation and structure of CARBOCHANGE is designed to fulfil the ambitious scientific objectives of the project in accordance to good scientific practice. This will be done through the arrangement and timing of the different work packages and tasks as presented in section 1.3. Monitoring of fulfilment of milestones and deliverables will be done through an effective and transparent communication system as described below. Specific tasks and procedures for **management of the project** are also described in Work Package 10. For the **data management**, which includes also a series of R&D tasks (such as quality checking of data), a separate work package (WP9) was introduced, where the management of observational and model-derived data sets is carried out. A dedicated data policy will be established and agreed on by the MGA which regulates the obligations and rights of all CARBOCHANGE PIs concerning data delivery, sharing, and confidentiality if needed.

Internal communication

The CARBOCHANGE management structure enables a smooth information flow, both vertically (bottom-up and top-down) and horizontally among partners and management bodies (See WP 10, task 10.1.)**. Tools for internal information flow** are the **protected project website, email lists,** and the **project meetings** (see below). The target is to reach maximum transparency for all involved parties and hence increase synergy. In addition to their role as decision-makers in the SSC, the **core theme- and work package leaders** do

mediate information flow between SSC and partner PIs, to ensure that the decisions of the MGA and SSC are followed up in the daily work on the project tasks. **Partner PIs** will **mediate information flow** to their institute's co-workers.

Outside communication

The Project director, supported by the Project Office at UiB, represents the project to towards the general public, end users, and policy makers (WP 10, task 10.6). The project director and the Project Office are also responsible for communication with the European Commission (See WP 10, task 10.2.). This includes the timely delivery of financial and activity reports (see below). The project director, supported by the scientific project manager, further takes responsibility of a seamless functioning of the Panel for outreach to policy makers and for its cooperation with WP8 (Global synthesis and outreach to policy makers).

Reporting – review and assessment

WP leaders collect information on the progress in their WP and send formal reports every 6 months to Core Theme leaders and the Project Office. All formal scientific reports and the final report to the Commission will have to be accepted by the SSC. The scientific project manager coordinates and supervises the reporting (WP 10, task 10.3. and 10.4.)

Project meetings

The project **Kick-off meeting** marks the effective launch of the project. It reinforces the common sense of all partners, and identifies the responsibilities of each in the endeavour.

Annual project meetings of the **MGA** are timed with the preparation of the annual reports. They will involve all the participants, and take place at months 12, 24, 36 and 48 or very soon thereafter. **Scientific Steering Committee, Executive Board meetings and meetings of the different boards and panels** will also be held on these annual meetings. Additional meetings of these management bodies may be convened as required. **Topical working meetings** will be organised by the Work Package leaders as needed for the progress of their tasks. The **Project office management team** will meet semi-monthly.

Management of knowledge: Consortium agreement and IPR

The consortium agreement will spell out and identify pre-existing knowledge and the provisions for intellectual property safeguards. CARBOCHANGE will take due account of the recommendations of the CMIP protocol on the issue of data archiving of climate projections for IPCC AR5, with the goal of making climate predictions and projections, which are made in the CARBOCHANGE project based on the CMIP protocol, accessible to the international research community under the rules to be explained in the CMIP protocol. All those issues will be addressed first during the negotiation phase, as part of the consortium agreement. The appropriate unit of the University of Bergen (Legal affairs) will be involved in the drafting and negotiation of the all important Consortium Agreement, with the Commission and the partners. During the project, the **IPR panel** will be in charge of implementing and monitoring IPR procedures according to the Consortium agreement. A detailed plan for this is given in chapter 3.2.2..

Gender action plan

The Gender Action Plan will be a working document to promote discussion and management of gender issues within the project. It will be implemented and monitored by the **Gender Panel**. Particular goals are: Promote gender equality in recruitment; Promote participation of women in courses, seminars and conferences; Develop avenues for financial support for scientists with children to be able to participate in field work; Promote selection of working hours convenient for mothers; Invite women to scientific and organizing committees.

B.2.2 Beneficiaries - Individual participants

Partner 1: University of Bergen (UiB), Geophysical Institute, Norway
Responsible Scientist: Christoph Heinze

Expertise of the organisation: UiB is the primary academic marine research organisation in Norway with key expertise in physical oceanography, climate research, biogeochemistry, ecology, paleoclimatology and meteorology. UiB has coordinated a series of EU projects in the field of climate research, among others TRACTOR, PACLIVA, CYCLOPS, and currently EU FP6 IP CARBOOCEAN. UiB has participated in IPCC AR4 (coordinating lead author, lead author) and IPCC special report on carbon storage (lead author). The Geophysical Institute of UiB includes the key marine carbon research group in Norway (observation and modelling). UiB and the Geophysical Institute are key participants in the Bjerknes Centre for Climate Research in Bergen, a nationally funded Center of Excellence in research.

Contribution to the project: The University of Bergen will be the co-ordinating institution of the project. UiB will host the project office including the project director, the project manager, and the data manager. UiB will contribute to WP2 (Task 2.1 Variability of deep water formation - study on the role of a change in ocean overturning on anthropogenic CO_2 uptake), WP3 (Task 3.1 Vulnerabilities of sources and sinks - Future scenarios with the Norwegian Earth System model), WP7 (Tasks 7.1 Global comparison - Intercomparison of the MICOM-HAMOCC model and NorESM Earth System Model with other models and observations); WP8 (Tasks 8.1: Annual releases of air-sea CO_2 fluxes, and task 8.4 Report on vulnerability of the oceanic CO_2 sink), WP9 (Task 9.1: Observational data management; Task 9.3 Information management), and will be responsible for WP10 on consortium management. UiB will co-lead WP9 and lead WP10.

Previous experience relevant to the tasks: Our group has comprehensive professional experience in the successful co-ordination of large EU research projects (C. Heinze was co-ordinator of the EU FP6 *Integrated Project* CARBOOCEAN). On the basis of the German HAMOCC model, we have developed the biogeochemical component to the isopycnic ocean model MICOM (K. Assmann) and deliver as well as maintain the biogeochemical modules for the emerging Norwegian Earth system model NorESM (J. Tjiputra, K. Asssmann). We have carried out the data management for the CARBOOCEAN IP (B. Pfeil). We participate in the EU FP7 projects EPOCA (ocean acidification), COMBINE (Earth system modelling), and COCOS (Coordination action on carbon observing systems).

Key personnel and their experience

Name	Relevant experience (keywords)
Christoph Heinze, Professor	Ocean biogeochemical modelling, carbon cycle research, co-ordination
Benjamin Pfeil, Data Man.	Scientific data management, data synthesis, data publication
Karen Assmann, Researcher	Coupled physical-biogeochemical 3-D ocean modelling
Jerry Tjiputra, Researcher	Earth system modelling, carbon cycle modelling, data assimilation
Andrea Volbers, Proj. Man.	Scientific project management

Key publications

Assmann, K.M. Bentsen, J. Segschneider, and C. Heinze, 2009, An isopycnic ocean carbon cycle model, *Geosci. Model Dev. Discuss.*, 2, 1023–1079, accepted for publication in *Geosci. Model Dev.*

Tjiputra, J.F., K. Assmann, M. Bentsen, I. Bethke, O. H. Otterå, C. Sturm, and C. Heinze, 2009, Bergen earth system model (BCM-C): Model description and regional climate-carbon cycle feedbacks assessment, *Geosci. Model Dev. Discuss.*, 2, 845–887, accepted for publication in *Geosci. Model Dev.*

Schulze, E.-D., C. Heinze, J. Gash, A. Volbers, A. Freibauer, and A. Kentarchos, 2009, Integrated assessment of the European and North Atlantic Carbon Balance - key results, policy implications for post 2012 and research needs -, eds., European Commission, Office for Official Publications of the European Communities, Luxembourg, ISBN 978-92-79-07970-2, doi:10.2777/31254, 141 pp.

Watson, A.J., U. Schuster, D.C.E. Bakker, N.R. Bates, A. Corbière, M. González-Dávila, T. Friedrich, J. Hauck, C. Heinze, T. Johannessen, A. Körtzinger, N. Metzl, J. Olafsson, A. Olsen, A. Oschlies, X. A. Padin, B. Pfeil, J. M. Santana-Casiano, T. Steinhoff, M. Telszewski, A.F. Rios, D.W. R. Wallace, and R. Wanninkhof, Accurately tracking the variation in the North Atlantic sink for atmospheric CO_2, 2009, *Science* **326**:1391-1393

Partner 2: VitusLab Copenhagen (VitusLab), Denmark
Responsible Scientist: Jørgen Bendtsen

Expertise of the organisation: VitusLab is a newly established research and consultancy company on ocean and climate dynamics. VitusLab analyse the interplay between physical and biological processes in the ocean by applying numerical ocean circulation models, data analysis and process modelling. VitusLab is involved in the Climate Research Centre in Nuuk, Greenland, with a focus on modelling and analysing the impact from climate change on the oceanographic conditions around Greenland.

Contribution to the project: VitusLab will contribute to WP1, task 1.1 on quantifying the sensitivity of atmospheric carbon to changes in organic matter remineralisation rates and sinking through modelling and analysis of existing experimental data of temperature dependent remineralisation rates obtained during the CARBOOCEAN project. This will contribute to milestone M1.2 on simulating the temperature effects on organic matter remineralisation on $CaCO_3$ redissolution. VitusLab will also contribute to WP8 on “global synthesis and outreach” with analyses of the role of biogeochemical and physical feedback processes on the CO_2 uptake.

Previous experience relevant to the tasks: Jørgen Bendtsen has experience with modelling of physical and biogeochemical processes in ocean circulation models. JB has previously contributed to CARBOOCEAN where the role of temperature dependent biological processes involved in the respiration of dissolved and particulate organic matter was analysed through experimental field work and numerical modelling. JB has experience with global and regional ocean biogeochemical modelling. JB has been involved in recent studies of the interaction between sea ice and DIC.

Key personnel and their experience

Name	Relevant experience (keywords)
Jørgen Bendtsen	Biogeochemical modelling, cycling of dissolved and particulate organic carbon, interaction between sea ice and dissolved inorganic carbon and alkalinity

Key publications

Bendtsen, J., Hilligsøe, K. M., Hansen, J. L. S., Richardson, K. Temperature sensitive remineralisation rates of organic matter in the mesopelagic zone. *submitted*, 2009.Bendtsen, J, Gustafsson, K. E., Söderkvist, J., and Hansen L. S. Ventilation of bottom water in the North Sea – Baltic Sea transition zone, *Journal of Marine Systems* 75, 138-149 doi: 10.1016/j.jmarsys.2008.08.006, 2009.

Rysgaard, S., Bendtsen, J., Pedersen, L. T., Ramløv, H and Glud, R. Increased CO_2 uptake due to sea-ice growth and decay in the Nordic Seas, *Journal of Geophysical Research, 114, C09011, doi:10.1029/2008JC005088*, 2009.

Rysgaard S, R. N. Glud, M. K. Sejr, J. Bendtsen and P. B. Christensen. Sea ice formation and dissolved inorganic carbon transport: A carbon pump in the polar seas, *Journal of Geophysical Research*, 112, C03016, doi:10.1029/2006JC003572, 2007.

Bendtsen, J., Claus Lundsgaard, Mathias Middelboe and David Archer. Influence of bacterial uptake on deep-ocean dissolved organic carbon, *Global Biogeochemical Cycles*, , 16, (4), doi:10.1029/2002GB001947, 2002.

Partner 3: Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), Laboratoire de Physique des Océans, France.
Responsible Scientist: Pascale Lherminier

Expertise of the organisation: Ifremer is a national marine research institute that contributes, through studies and expert assessments, to knowledge about the ocean and its resources, monitoring of marine and coastal zones and the sustainable development of maritime activities. Ifremer has more than 20 years of experience in oceanographic research, (data measurement, data synthesis and modelling of processes in the ocean). Ifremer will represent the Laboratoire de Physique des Océans (LPO), a Joint Research Unit (JRU) with the Centre National de la Recherche Scientifique (CNRS). CNRS is a government funded public organisation that employs a large body of permanent researchers and support staff in joint research units (JRU) with universities, other research organisations and industry. LPO has a long experience in conducting multidisciplinary (physics and biogeochemistry) field experiments to document the general circulation of the Atlantic Ocean and understand the processes that drive its variability.

Contribution to the project: Ifremer will contribute to quantitatively assess the feedback on the oceanic uptake of CO_2 by changes in physical processes in the North Atlantic Ocean by the analysis of a repeat hydrography/biocheochemistry section between Greenland and Portugal. It will participate to WP2 (T2.2 Assess the impact of changes in deep-water formation, overflow to the North Atlantic, and the meridional overturning on CO_2 uptake in the Atlantic Ocean. T2.3 Assess the relative importance of the major processes that drive interannual to decadal variability in air-sea CO_2 fluxes in the Atlantic. Analyse modes of variability and identify mechanisms driving these both in historical observations).

Previous experience relevant to the tasks: Ifremer and LPO have comprehensive professional experience in the successful participation to EU research projects as Gyroscope (FP5) and Mersea (FP6). The group has maintained a repeat hydrography/geochemistry section between Greenland and Portugal every two years since 2002. Combined with other data sets (altimetry and Argo), it was used to monitor the circulation and water mass variability in the subpolar North Atlantic and to understand the relationships between this variability and the atmospheric forcing. The group also participates to the study of the relationships between the ocean variability and the anthropogenic carbon inventories and uptake rates from the atmosphere. Finally, the group is also involved in the deployment of Argo profilers with biochemical sensors, and the analysis of the data.

Key personnel and their experience

Name	Relevant experience (keywords)
Pascale Lherminier	Physical oceanography; circulation and processes; inverse modelling
Virginie Thierry	Physical oceanography; circulation and processes; water mass analysis
Herlé Mercier	Physical oceanography; links to carbon inventory and uptake variability

Key publications

Lherminier P., H. Mercier, C. Gourcuff, M. Alvarez, S. Bacon, C. Kermabon, 2007: Transports across the 2002 Greenland-Portugal OVIDE section and comparison with 1997. *J. Geophys. Res.,* 112(C7), C07003, doi:10.1029/2006JC003716.

Pérez, F. F., M. Vazquez-Rodriguez, E. Louarn, X. A. Padin, H. Mercier, A. Rios, 2008: Temporal trends of the anthropogenic CO_2 storage in the Irminger Sea. *Biogeosciences*, 5,1669-1679.

Rodgers, K. B., R. M. Key, A. Gnanadesikan, J. L. Sarmiento, O. Aumont, L. Bopp, S. C. Doney, J. P. Dunne, D. M. Glover, A. Ishida, M. Ishii, A. R. Jacobson, C. Lo Monaco, E. Maier-Reimer, H. Mercier, N. Metzl, F. F. Perez, A. F. Rios, R. Wanninkhof, P. Wetzel, C. D. Winn, and Y. Yamanaka 2009: Altimetry helps to explain patchy changes in hydrographic carbon measurements.*J. Geophys. Res. Oceans*, 114, C09013, doi:10.1029/2008JC005183.

Thierry, V., E. de Boisséson, H. Mercier 2008: Interannual variability of the Subpolar Mode Water properties over the Reykjanes Ridge during 1990-2006. *J. Geophys. Res.*, 113, C04016, doi:10.1029/2007JC004443

Våge K., Robert S. Pickart, Virginie Thierry, Gilles Reverdin, Craig M. Lee, Brian Petrie, Tom A. Agnew, AmyWong and Mads H. Ribergaard, 2009. Surprising return of deep convection to the subpolar North Atlantic. *Nature Geoscience*, doi: 10.1038/ngeo382.

Partner 4: Commissariat a l'energie atomique, (CEA), Laboratoire des sciences du climat et de l'environnement, France
Responsible Scientist: Marion Gehlen

Expertise of the organisation: LSCE, Laboratoire des Sciences du Climat et de l`Environnement (a JRU of the CEA/CNRS/UVSQ), is one of the leading European research institutions on Earth system modelling. It has both strong atmospheric, as well as oceanographic research teams focusing on global biogeochemical cycles and climate change. LSCE scientists coordinated or participated in several EU funded ocean sciences projects (CARBOOCEAN, EUR-OCEANS, GREENCYCLES, HERMES, ORFOIS, NOCES, IRONAGES, CAVASSOO, NAOC, ESCOBAOcean, OCMIP, MEECE, EPOCA).

Contribution to the project: LSCE will be co-reponsible for the Core Theme 1 on key processes and feedbacks, future scenarios, and vulnerabilities (M. Gehlen) and for two Work Packages on future scenarios under different emission curves and vulnerability analysis (WP3; L. Bopp) and on Model intercomparison (WP7; J. Orr). Latest versions of both NEMO/PISCES and Coupled Earth System Models will be used during the project. LSCE will also contribute to several Work Packages on ocean model data assimilation (WP6; C. Moulin), parameterisation of the remineralisation in the water column (WP1; M. Gehlen), assessment of the interannual-to-decadal variability in air-sea CO_2 fluxes (WP2; L. Bopp and M. Gehlen) and on surface observing system through its continuous monitoring station in Greenland (WP4; M. Delmotte). LSCE will also be involved in overarching Work Packages on global synthesis and synergies with international projects (WP8, WP9).

Previous experience relevant to the tasks: All staff members listed below were already involved in the EU CARBOOCEAN project and are currently participating in other EU projects as MEECE and EPOCA in which the impacts of ocean acidification, climate variability and global warming on marine ecosystems and biogeochemistry are quantified using the NEMO/PISCES model and the key feedbacks to atmospheric CO_2 and climate change are assessed by means of simulations with the IPSL Coupled Earth System Model. LSCE was also in charge of a continuous monitoring station of atmospheric CO_2 in Greenland in the framework of CARBOOCEAN in order to better constrain the role of the Atlantic ocean as a carbon sink.

Key personnel and their experience

Name	Relevant experience (keywords)
Marion GEHLEN	ocean carbon cycle and carbonate geochemistry, impacts of ocean acidification and climate change on marine ecosystems and biogeochemical cycles, feedbacks to atmospheric CO_2
Laurent BOPP	ocean biogeochemical cycles, marine ecosystems and links with climate variability
James ORR	ocean carbon cycle, ocean acidification, ocean circulation and tracers, and numerical modelling.
Marc DELMOTTE	environmental trace elements analysis, isotopes and atmospheric compounds
C. MOULIN	remote sensing, detection of functional phytoplankton groups from space, data assimilation

Key publications

Kane, A., C. Moulin, S. Thiria, L. Bopp, M. Berrada, A. Tagliabue, M. Crépon, O. Aumont and F. Badran, Improving the parameters of a global ocean biogeochemical model using a variational assimilation of in situ data at five time-series stations, *J. Geophys. Res*., submitted.

Schneider B., L. Bopp, M. Gehlen (2008), Assessing the sensitivity of modeled air-sea CO 2 exchange to the remineralization depth of particulate organic and inorganic carbon, *Global Biogeochem. Cycl*es, 22, GB3021, doi:10.1029/2007GB003100.

Gehlen, M., R. Gangstø, B. Schneider, L. Bopp, O. Aumont and C. Ethé (2007), The fate of pelagic $CaCO_3$ production in a high CO_2 ocean: A model study. *Biogeosciences*, 4, 505-519.

Lachkar, Z., J. C. Orr, J.-C. Dutay, P. Delecluse. On the role of mesoscale eddies in the ventilation of Antarctic Intermediate Water, *Deep-Sea Research I*, 56, 909-925, 2009

Lachkar, Z., J. C. Orr, and J.-C. Dutay. Seasonal and mesoscale variability of oceanic transport of anthropogenic CO_2, *Biogeosciences*, 6, 2509-2523, 2009.

Partner 5: University Pierre et Marie Curie (UPMC), Paris, France
Responsible Scientist: Jacqueline Boutin

Expertise of the organisation: The LOCEAN is a new laboratory created in 2005(merging of LODYC and LBCM laboratories). It is a joint laboratory between French CNRS, IRD, Pierre et Marie Curie University (UPMC) and Museum national d'histoire naturelle. It is located inside UPMC. The primary vocation of LOCEAN is the study of the oceanic biogeochemical cycles, in particular the carbon cycle, the study of the dynamical processes governing the oceanic circulation and the comprehension of the mechanisms governing the evolution of the climate system in which the ocean plays a primary part. These problems are tackled both by experimental means (oceanographic campaigns, instrument development, satellite measurements) and by modelling, theoretical and numerical (3-dimension ocean general circulation model). The LOCEAN is actively participating in University teaching and supervision of PhD students. It is one of the world's leading research groups on studying air-sea gas exchange processes, both using in situ observations (from ships and unattended platforms) and satellite data. It has participated to the FP6 CARBOOCEAN project.

Contribution to the project: UPMC will coordinate the Core theme 3 and co-lead WP4. UPMC will contribute to WP2 (Task 2.4: impact of eddies on the uptake and transport of CO_2), WP4 (Task 4.1: Set up and evaluate observational network of the air-sea CO_2 flux; Tasks 4.2 and 4.3: Collect CO_2 in the Atlantic (2 VOS lines) and in the Southern Ocean (OISO line) and associated data (ARGO and satellite data); Task 4.9: Collaborate with WP8 with quality controlled data), WP5 (Task 5.2: Collect oceanic time series at 2 PIRATA sites; Task 5.6: variability of CO_2 in the photic layer using high frequency pCO_2 taken at 2m and 20m depth at a PIRATA mooring (6°S-10°W); Task 5.7: Contribute with QC data to WP8; Task 5.8: first steps towards a link between the uptake of CO_2 from the atmosphere with the deep-water increase of CO_2), WP7 (Task 7.1 Global comparison*:* Compare models to ocean carbon-related data; Task 7.2 Performance indices: Develop quantitative metrics to assess model skill; combine them to provide a weighted-mean "best" assessment for projected changes) and WP8 (Task 8.2: Release of the Surface ocean CO_2 atlas).

Previous experience relevant to the tasks: The teams involved have comprehensive experience in CO_2 measurements: OISO ship line maintained in the Southern Ocean since almost 2 decades; maintenance of 2 VOS lines in the Atlantic; installation of CARIOCA CO_2 autonomous sensors on 2 PIRATA moorings in the tropical Atlantic, deployment of 14 CARIOCA drifters in the Southern Ocean since 2001. Their research covers large scale-decadal to hourly-kilometre variability of pCO_2 and associated air-sea CO_2 fluxes, and variability of CO_2 in the ocean interior. In the frame of the FP6 CARBOOCEAN project, they interpret observed decadal variability with the help of atmosphere-ocean coupled model and develop a new and original methodology for estimating in situ biological production from CARIOCA data. N. Metzl chair of the SOLAS-IMBER Carbon Subgroup 1; N. Metzl & N. Lefèvre PI and/or Co-I of SOCAT and Carina data bases. J. Boutin is strongly involved in satellite projects with focus on synergies between satellite and in situ data (PI on Envisat , Co-I on SMOS).

Key personell and their experience

Name	Relevant experience (keywords)
J. Boutin, Research Director	High-frequency processes from CARIOCA drifters-Satellite data
N. Metzl, Researcher	OISO data-Decadal variability-Data synthesis and model comparison
N. Lefèvre, Researcher	Air-sea CO_2 fluxes from VOS and CARIOCA on PIRATA moorings
C. Lo Monaco, Researcher	Anthropogenic CO_2 in ocean interior

Key publications

Corbière, A., N. Metzl, G. Reverdin, C. Brunet and T. Takahashi, 2007. Interannual and decadal variability of the oceanic carbon sink in the North Atlantic subpolar gyre**.** *Tellus B,* Vol. 59, issue 2, 168-179, DOI: 10.1111/j.1600-0889.2006.00232.

Boutin, J., L. Merlivat, C. Hénocq, N. Martin, and J. B. Sallée, 2008: Air-sea CO_2 flux variability in frontal regions of the Southern Ocean from CARIOCA drifters. *Limnology and Oceanography*, **53,** 2062-2079.

Lefèvre, N., A. Guillot, L. Beaumont, and T. Danguy, Variability of fCO_2 in the Eastern Tropical Atlantic from a moored buoy, Journal of Geophysical Research, 113, C01015, doi:10.1029/2007JC004146, 2008.

Metzl, N., 2009. Decadal increase of oceanic carbon dioxide in the Southern Indian Ocean surface waters (1991-2007). *Deep-Sea Res* II, doi:10.1016/j.dsr2.2008.12.007.

Lenton, A., F. Codron, L. Bopp, N. Metzl, P. Cadule, A. Tagliabue and J. Le Sommer, 2009. Stratospheric ozone depletion reduces ocean carbon uptake and enhances ocean acidification. *Geophys. Res. Let.*,36, L12606.

Partner 6: Alfred Wegener Institute for Polar and Marine Research (AWI), Germany
Responsible Scientist: Christoph Völker

Expertise of the organisation: AWI is Germany's leading institute for polar and marine research, and one of the leading polar institutes in the world. It coordinates polar research in Germany and provides both the necessary equipment and the essential logistic back-up for polar expeditions. Our most important research platform is the research icebreaker "FS Polarstern" - about one quarter of all cruise participants are scientists from abroad. AWI collaborates and has been leading numerous international research programs and maintains close contact with many universities and institutes world-wide. Several scientists from AWI contributed to the recent IPCC reports, also as lead author. Given the major role played by polar regions within the climate system, global change is a focal point.

Contribution to the project: Both observations and modelling will be conducted at AWI by different sub-groups. Work package co-leaders for WP1 (Völker), WP5 (Hoppema) and WP9 (Schlitzer) are based at AWI. Specifically, AWI will contribute to the following WPs and tasks: WP1 (task 1.2: Sensitivity of oceanic CO_2 and air-sea CO_2 fluxes), WP4 (task 4.3: Collect CO_2 and associated data in the Atlantic), WP5 (task 5.1: Collect data at 7 pre-defined time series stations; task 5.2: Collect CO_2 data along 10 predefined sections; task 5.3: Assess the variability of the anthropogenic carbon inventories in critical regions; task 5.4: Assess decadal and inter-annual changes in regional carbon inventories for testing prognostic and predictive models; task 5.6: Trends on ocean acidification; task 5.7: Contribute with QC data to WP8 for the combined synthesis of data with models; task 5.8: Set first steps to provide a link between the uptake of CO_2 from the atmosphere with the deep-water increase of CO_2), WP6 (task 6.2: Calibration of biogeochemical process parameters in a stand-alone ocean model), WP7 (task 7.1: Global comparison), WP8 (task 3: Merge the GLODAP and CARINA datasets; extent and apply the AWI global adjoint model) and WP9 (Task 9.5: Software optimization).

Previous experience relevant to the tasks: Our group has expertise in numerical simulation of the marine carbonate system (see book Zeebe and Wolf-Gladrow, 2001), marine plankton and iron chemistry (various publications by Völker et al.) and in combining observational and process studies with modelling. We have been partner in various EU-projects (MERLIM, CARUSO, GOSAC, IRONAGES, CARBOOCEAN). In CARBOOCEAN we contributed to the numerical study of feedbacks in the Southern Ocean. A major focus is the coupling of the elemental cycles of carbon, silicon and iron in the ocean. We have carried out measurements of CO_2 and ancillary variables in the Southern Ocean since 1992 (Hoppema) and published extensively about it; in CARBOOCEAN Hoppema was leader of the Southern Ocean part of the CARINA data retrieving and quality control effort. We have year-long experience in numerical modelling and inverse techniques, which resulted in many papers on different aspects of biogeochemical cycles; the widely-used software for oceanographic data (Ocean Data View, ODV) was developed and is maintained by Schlitzer.

Key personnel and their experience

Name	Relevant experience (keywords)
Christoph Völker, WP-leader	Marine biogeochemistry modelling, SO physics and biogeochemistry
Mario Hoppema, WP-leader	CO_2 observations; data synthesis CARINA; Southern Oc. carbon cycle
Dieter Wolf-Gladrow, Professor	Marine CO_2 system; global biogeochem. cycles; numerical models
Christine Klaas, Researcher	Plankton ecology; vertical particle flux; sediment traps
Reiner Schlitzer, WP-leader	Inverse modelling of biogeochemical cycles; data visualization

Key publications

Hauck, J., M. Hoppema, R.G.J. Bellerby, C. Völker, D. Wolf-Gladrow, 2009. Data-based estimation of anthropogenic carbon and acidification in the Weddell Sea on a decadal time scale, *J. Geophys. Res.*: in press.
Hoppema, M., 2004. Weddell Sea is a globally significant contributor to deep-sea sequestration of natural carbon dioxide. *Deep-Sea Res. I,* 51: 1169-1177.
Klaas, C., D.E. Archer, 2002. Association of sinking organic matter with various types of mineral ballast in the deep sea: Implications for the rain ratio. *Global Biogeochem. Cycles*, 16(4): 1116, doi:10.1029/2001GB001765.
Schlitzer, R., 2007. Assimilation of radiocarbon and chlorofluorocarbon data to constrain deep and bottom water transports in the world ocean. *J. Phys. Oceanogr.* 37: 259–276.
Ye, Y., C. Völker, D.A. Wolf-Gladrow, 2009. A model of Fe speciation and biogeochemistry at the Tropical Eastern North Atlantic Time-Series Observatory site. *Biogeosciences* 6: 2041-2061.
Zeebe, R.E., D.A. Wolf-Gladrow, 2001. CO_2 in Seawater: Equilibrium, Kinetics, Isotopes. Elsevier, 346 pp.

Partner 8: Max-Planck-Society (MPG), Institute for Meteorology, Germany
Responsible Scientist: Joachim Segschneider

Expertise of the organisation: The Max Planck Institute for Meteorology (MPI-M) (http://www.mpimet.mpg.de) is dedicated to fundamental climate research. The overall mission of the Max Planck Institute for Meteorology is to understand how physical, chemical, and biological processes, as well as human behaviour, contribute to the dynamics of the Earth system, and specifically how they relate to global and regional climate changes. Among the tools used are advanced numerical models that simulate the dynamics of the atmosphere, the ocean, the cryosphere and the biosphere, and their interactions. MPI-M has developed a comprehensive Earth system model (ESM), which is made available to the scientific community in Europe and elsewhere. MPI-M is committed to informing decision-makers and the public on questions related to climate change and global change. Finally, The Max Planck Institute for Meteorology is managing the International Max Planck Research School on Earth System Modelling (IMPRS), which hosts approximately 50 PhD students.

Contribution to the project: MPI-M will contribute to WP1, WP3, and WP7 of the project. In WP1 the change of export of organic matter under changing climate and dust input will be investigated through model studies in Task 1.1 (sensitivity of atmospheric carbon to changes in organic matter remineralisation rates and sinking). In WP3 coupled carbon cycle climate model integrations forced by RCP scenarios will be performed and analyzed as part of Tasks 3.1 (vulnerability of sources and sinks) and 3.4 (detectability) and contribute to the multi model ensemble. A contribution to the inter comparison of these model integrations as part of Task 7.1 (global comparison) in WP7 will be made. Additionally, model output will be provided to WP9.

Previous experience relevant to the tasks: MPI-M is one of the few institutes where all of the components of an Earth System Model have been developed in house. The marine biogeochemistry group in particular has developed the widely used biogeochemistry model HAMOCC (E. Maier-Reimer, K. Six, J. Segschneider). The group has participated in C4MIP (J. Segschneider) and in the EU FP5 projects ORFOIS (Origin and Fate of Organic Matter in the Sea; E. Maier-Reimer, J. Segschneider) and NOCES (Northern Ocean-Atmosphere Carbon Exchange Study; E. Maier-Reimer), and the FP6 project CARBOOCEAN (Marine Carbon Sources and Sinks Assessment, J. Segschneider). We currently participate in the EU FP7 projects EPOCA (Ocean Acidification, E. Maier-Reimer, K. Six) and COMBINE (Earth System Modelling, J. Segschneider). Thus, there is a strong background in biogeochemical model development, performing model simulations of coupled climate-carbon cycle projections, and the evaluation of these experiments.

Key personnel and their experience

Name	Relevant experience (keywords)
Joachim Segschneider, Researcher	Biogeochemical modelling, IPCC AR4 model simulations, PI in COMBINE
Katharina Six, Researcher	Development of the marine biology within HAMOCC
Ernst Maier-Reimer, Researcher	Development of HAMOCC and MPIOM, PI in CARBOOCEAN and EPOCA

Key publications

Maier-Reimer, E., I. Kriest, J. Segschneider, and P. Wetzel, 2005. The HAMburg Ocean Carbon Cycle model HAMOCC5.1 – Technical Description. *Reports on Earth System Science*, 14, 50pp.

Schneider, B., L. Bopp, M. Gehlen, J. Segschneider, T. Fröhlicher, F. Joos, P. Cadule, P. Friedlingstein, S.C. Doney, and M.J. Behrenfeld, 2008. Spatio temporal variability of marine primary production in three coupled climate carbon cycle models. *Biogeosciences*, 5, 597-614.

Six, K.D., and E. Maier Reimer, 1996. Effects of plankton dynamics on seasonal carbon fluxes in an ocean general circulation model. *Global Biogeochem. Cycles*, 10(4), 559-583

Steinacher, M., F. Joos, T.L. Fröhlicher, L. Bopp, P. Cadule, S.C. Doney, M. Gehlen, B. Schneider, and J. Segschneider, 2009. Projected 21st century decrease in marine productivity: a multi model analysis. *Biogeosciences Discuss.*, 6, 7933-7961.

Partner 9: University of Bremen (UniHB), Bremen, Germany
Responsible Scientist: Reiner Steinfeldt

Expertise of the organisation: UniHB is one important academic institution for marine research in Germany. The science center 'the ocean in the earth system' located at UniHB and the graduate school GLOMAR are funded by the German national excellence initiative. The department of oceanography, is specialised in hydrographic and tracer measurements along deep ocean sections. The Centre for Marine Environmental Sciences (MARUM) is a cooperative facility offering a number of technical and scientific services. A major task lies in the maintenance of the scientific information system PANGAEA®, which is a system for acquisition, processing, long term storage, and publication of georeferenced data related to earth science. Essential services supplied by PANGAEA® are project data management and the organisation and implementation of data infrastructures. With its expertise, UniHB has contributed to several national and international oceanographic projects, such as CLIVAR, EUR-OCEANS, CARBOOCEAN, SOPRAN, and the German 'Verbundvorhaben Nordatlantik'.

Contribution to the project: The department of oceanography at the University of Bremen collects and analyses hydrographic, oxygen and transient tracer data. From the age information of the tracers, oxygen consumption/reminerelisation rates can be inferred, which will be done in WP1 (Task 1.1: Sensitivity of atmospheric carbon to changes in organic matter remineralisation rates and sinking). Another application of these data is the calculation of anthropogenic carbon and its spatial-temporal variability, a contribution to WP5 (Task 5.2: Collect CO_2 and associated data along 10 predefined sections; Task 5.3: Assess the variability of carbon inventories in critical regions; Task 5.4: Assess decadal and interannual changes in regional carbon inventories for testing the prognostic and predictive models; Task 5.7: Contribute with QC data to WP8 for the combined synthesis of data with models). UniHB will be responsible for task 5.3. In WP9 UniHB will be responsible for task 9.4 (Technical and organizational data management infrastructure for observational data comprises), organizing data storage and access, providing hardware and services for long term archival, distribution, citable publication, establishment of a data portal and corresponding technology.

Previous experience relevant to the tasks: The department of oceanography at UniHB is one of the leading institutes for the measurements of transient tracers. For several years, these data have been used to investigate the formation of North Atlantic Deep Water (NADW) and its temporal changes. Together with hydrographic and oxygen data, the timescales and dilution for the southward spreading of NADW have been investigated. Another application of CFC data was to infer the Atlantic inventory of Cant, with special focus on the variability in the western North Atlantic. The PANGAEA® group has been engaged in a number of projects supporting spatial data infrastructures (SDI). The group has substantiated knowledge and practical experience on international standards as ISO19xxx and family of standards, OGC web services and Sensor Web Enablement (SWE) concept (incl. SensorML), Open Archives Initiative protocols (OAI-PMH), GRID technologies and data portals.

Key personnel and their experience

Name	Relevant experience (keywords)
Monika Rhein, Professor	Physical Oceanography, hydrographic and tracer measurements
Diepenbroek, Michael, Researcher	Geologist, managing director of WDC-MARE, scientific information systems, exchange protocols, standards
Steinfeldt, Reiner, Researcher	hydrographic and tracer measurements, data quality control, oceanic carbon storage

Key publications

Diepenbroek, M., Grobe, H., Reinke, M., Schindler, U., Schlitzer, R., Sieger, R., Wefer, G. (2002). PANGAEA - an information system for environmental sciences, *Computers & Geosciences*, 28(10)1201-1210, doi:10.1016/S0098-3004(02)00039-0.

Steinfeldt, R., M. Rhein, and M. Walter (2007), NADW transformation at the western boundary between 66°W/20°N and 10°N. *Deep-Sea Res. I*, 54(6), 835-855.

Steinfeldt, R., M. Rhein, J. L. Bullister, and T. Tanhua (2009), Inventory changes in anthropogenic carbon from 1997-2003 in the Atlantic Ocean between 20°S and 65°N. *Global Biogeochem. Cycles*, 23, GB3010, doi:10.1029/2008GB003311.

Partner 10: Hafrannsóknastofnunin - Marine Research Institute and University of Iceland (HAFRO-MRI), Iceland

Responsible Scientist: Jon Olafsson

Expertise of the organisation: The Marine Research Institute (HAFRO-MRI) is a government institute under the auspices of the Ministry of Fisheries. MRI conducts various marine research and provides the Ministry with scientific advice on marine resources and the environment. The institute has around 170 employees, 2 research vessels, 5 branches around Iceland and a mariculture laboratory. One of the main activities of HAFRO-MRI is research on the marine environment around Iceland. HAFRO-MRI was/is a partner in the following related EU projects: ESOP-2, TRACTOR, CARBOOCEAN and EPOCA.

Contribution to the project: We contribute to WP5, in the following tasks:
Tasks 5.1, Collect oceanic time series data at the 7 predefined time series (MIKE, Irminger and Iceland Seas, GIFT, ESTOC, TENATSO, PIRATA, PAP) in the Atlantic Ocean and Nordic Seas in coordination with OceanSites. Task 5.3, Assess factors affecting the variability of the anthropogenic carbon inventories in critical regions (choke points): Arctic, Norwegian, Irminger, Iceland, Labrador, Strait of Gibraltar, Drake passage. Task 5.5, Natural variability of the carbon cycle in the upper layer using high frequency data from time series station data linked with model outputs. Task 5.7, Contribute with QC data to WP8 for the combine synthesis of data with models.

Previous experience relevant to the tasks: We have researched the ocean carbon chemistry at two oceanographically very different locations near Iceland continuously since 1983 (J. Olafsson). Thus created long time series of quality controlled observations (Olafsson et al., 2009b) invaluable for describing rates of change in ocean carbon chemistry (Olafsson et al. 2009a) and for understanding the influences of physical and biological processes on the rate of change. We participate in the EU FP7 project EPOCA.

Key personnel and their experience

Name	**Relevant experience (keywords)**
Jon Olafsson	Professor at UI and scientist at MRI. Ocean carbon system research
Solveig R. Olafsdottir	Scientist. Nutrient chemistry and measurements, data processing
Alice Benoit-Cattin	Researcher. Carbon system measurements, data processing.

Key publication(s)

Nondal, G., Bellerby, R., Olsen, A., Johannessen, T., and Olafsson, J.: Predicting the surface ocean CO_2 system in the northern North Atlantic: Implications for the use of Voluntary Observing Ships., *Limnology and Oceanography: Methods*, 7, 109-118, 2009.

Olafsson, J., Olafsdottir, S. R., Benoit-Cattin, A., Danielsen, M., Arnarson, T. S., and Takahashi, T.: Rate of Iceland Sea acidification from time series measurements, *Biogeosciences*, 6, 2661-2668, 2009a.

Olafsson, J., Olafsdottir, S. R., Benoit-Cattin, A., and Takahashi, T.: The Irminger Sea and the Iceland Sea time series measurements of sea water carbon and nutrient chemistry 1983-2006, *Earth System Science Data Discussions*, 2, 477-492, 2009b.

Partner 11: National University of Ireland, Galway (NUIG)
Responsible Scientist: Brian Ward

Expertise of the organisation: NUIG is the leading institution for marine-related research in Ireland, and ”energy, marine and environment” is one of the underpinning research areas. The Surface Ocean Lower Atmosphere Laboratory (SOLAB) at NUIG focuses on measurements in the upper ocean primarily with the Air-Sea Interaction Profiler (ASIP). It also maintains pCO_2 measurements on the R/V Celtic Explorer. The atmospheric measurements involve eddy covariance measurements of air-sea fluxes from the ship. There is also the Mace Head atmospheric research facility which is a GAW site providing a broad range of traces gas measurements.

Contribution to the project: NUIG will contribute to WP4 (Task 4.1, 4.6, and 4.10). NUIG will collaborate and support the atmospheric measurements of CO_2 and oxygen at Mace Head. NUIG will also provide direct and indirect air-sea CO_2 flux measurements from the R/V Celtic Explorer.

Previous experience relevant to the tasks: Significant funding national, with EU, and internationally with funding for PhD training: FP7 Marie Curie IRG (AIRSEA); SFI development of eddy covariance gas flux sensor; US-NSF funding for quantification of the impact of surfactant and subsurface oceanic turbulence on air-sea gas exchange; development of an ultra-high resolution thermometer for small-scale oceanic studies.

Key personnel and their experience

Name	Relevant experience (keywords)
Brian Ward	Air-sea exchange; upper ocean turbulence; eddy covariance fluxes
Marc Defossez	Physical oceanography
Adrian Callaghan	Wave breaking; image processing
Noel Fitzpatrick	Air-sea fluxes; instrumentation

Key publications

Gentemann, C. L., P. J. Minnett, and B. Ward, Profiles of ocean surface heating (POSH): A new model of upper ocean diurnal warming, *Journal of Geophysical Research*, 114, C07017, doi:10.1029/2008JC004825, 2009.

Ward B., Air-Water Interfacial Laboratory Measurements, In “Transport at the Air Sea Interface -Measurements, Models and Parameterizations”, (eds. Garbe, C.S., Handler, R.A., Jähne, B.), Springer Verlag, 193-203, 2007.

Ward, B., R. Wanninkhof, W. R. McGillis, A. T. Jessup, M. D. DeGrandpre, J. E. Hare, and J.B.Edson, Biases in the air-sea ux of CO_2 resulting from ocean surface temperature gradients, *Journal of Geophysical Research*, 109, C08S08, doi:10.1029/2003JC001800, 2004a.

Ho, D.T., C.J. Zappa, W.R. McGillis, L.F. Bliven, B. Ward, J.W.H. Dacey, P. Schlosser, and M.B.Hendricks, Inuence of rain on air-sea gas exchange: Lessons from a model ocean, *Journal of Geophysical Research*, 109, C08S18, doi:10.1029/2003JC001806, 2004.

Hare, J.E., C.W. Fairall, W.R. McGillis, J.B. Edson, B. Ward, and R. Wanninkhof, Evaluation of the National Oceanic and Atmospheric Administration/Coupled-Ocean Atmospheric Response Experiment (NOAA/COARE) air-sea gas transfer parameterization using GasEx data, *Journal of Geophysical Research*, 109, C08S11, doi:10.1029/2003JC001831, 2004.

Partner 12: Institut National de Recherche Halieutique (INRH, Morocco)
Responsible Scientist: Abdellatif ORBI

Expertise of the organisation: The Institut National de Recherche Halieutique, public body, created by Law n°1.96.98 of July 29, 1996 and endowed with the legal entity and the financial autonomy.
INRH is responsible of the studies and research in the field of marine ecosystems, fisheries and aquaculture. Research is based mainly around the following themes:

- Oceanography and modelling activities;
- Coastal and marine ecosystems;
- Interaction between environment and fisheries;
- Monitoring of the marine biological and chemical pollutants;
- Stock assessment of the fisheries resources;
- Oceanography/fisheries databases, sea mapping of the fishing areas.

Contribution to the project: INRH will carry out cruises between Moroccan coast and the Canary Islands, to quantify Carbon in the North-West African Margin. INRH will be contributing in WP1 and particularly to the task 1.3 that will study the role of organic and inorganic export of carbon from continental margins to the Atlantic Ocean. New observations will be collected that are necessary to be integrated in different coupled models to a better understanding of the feedback strength between offshore transport and open ocean carbon. INRH will be also contributing in WP5 related to collect CO_2 and associated data along the section 28ºN-14-12ºW, in the Atlantic Ocean (Task 5.2).

Previous experience relevant to the tasks: INRH has been involved in many European Union Projects: MEDAR/MEDATLAS, SEA-SEARCH, SEADATANET, CARBOOCEAN, NATFISH, EUROCEAN, SESAME, ECOOP, MYOCEAN, ENCORA., and has ample experience in observation and modelling tasks outlined above.

Key personnel and their experience

Name	Relevant experience (keywords)
Abdellatif Orbi	Physical Oceanographer
Soukaina Zizah	Primary production, Plankton ecology
Makaoui Ahmed	Hydrology, Biochemistry, Upwelling variability
Ettahiri Omar	Ichtyo-plantonologist, Ecology

Key publications

I. E. Huertas, A. F. Ríos, J. García-Lafuente, A. Makaoui, S. Rodríguez-Gálvez, A. Sánchez-Román, A. Orbi, J. Ruíz, and F. F. Pérez. Anthropogenic and natural CO_2 exchange through the Strait of Gibraltar, *Biogeosciences*, 6, 1021-1067, 2009.

Benbrahim S., A. Chafik, R. Chfiri, F. Z. Bouthir, M. Siefeddine et A. Makaoui, 2008. Etude des facteurs influencants la repartition géographique et temporelle de la contamination des côtes atlantiques marocaines par les métaux lourds : cas du mercure, du plomb et du cadmium. *Mar. Life*, 16 (1-2) : 37-47.

Makaoui A. , A. Orbi, K. Hilmi, S. Zizah, J. Larissi and M. Talbi, 2005. L'upwelling de la côte atlantique du Maroc entre 1994 et 1998. *C. R. Geoscience* 337 (2005) 1518-1524.

Lakhdar Idrissi J., Orbi A, Hilmi k., Zidane F., Sarf F., Massik Z .et A. Makaoui, 2004. Organisation et fonctionnement d'un écosystème côtier du maroc: la lagune de Khnifiss. *Revue Sciences de l'Eau*, 17(4), pp 447-462.

SOMOUE L., N. ELKHIATI, A. VAQUER, M. RAMDANI, O. ETTAHIRI, A. MAKAOUI et Am. BERRAHO. (2003). Contribution à l'étude des diatomées dans l'écosystème pélagique côtier au sud de l'atlantique marocain (21°N - 26°30'N). *Journal de Recherche Océanographique*, Vol (28), 1-13.

Partner 13: Netherlands Institute for Sea Research (NIOZ), Netherlands
Responsible Scientist: Hein de Baar

Expertise of the organisation: The Royal Netherlands Institute for Sea Research (Royal NIOZ) is the national institute since 1876. Royal NIOZ is part of the Netherlands Organization for Scientific Research (NWO) and employs 220 people and operates the national ocean research vessel Pelagia. Research on ocean uptake of anthropogenic CO_2 commenced in the 1960's (Postma, 1963), since 1988 under leadership of H. de Baar. Several colleagues now prominent elsewhere in Europe, e.g. Dr. Bakker (UEA), Dr. Bozec (Roscoff), Dr. Buitenhuis (UEA), Dr. Hoppema (AWI) received their training and PhD degree in our group. Moreover in the 2000-2008 era Dr. Thomas and Dr. Zemmelink were key actors in CO_2 research in our group. Currently ms. Astrid Hoogstraten, ms. Lesley Salt and mr. Steven van Heuven are working towards their PhD degree on CO_2 in various marine systems.

Contribution to the project: Work Package 5. Producing deep ocean sections in the West Atlantic Ocean of Dissolved Inorganic Carbon (DIC), Alkalinity and a suite of ancillary parameters (Task 5.2); this includes rigorous quality control (Task 5.7.). This data will be used in conjunction with the previously collected data in the CARINA database (Tanhua et al., 2009; Key et al., 2009), to derive (Task 5.3.) the variability time trend of increase of DIC as result of anthropogenic invasion of CO_2 in the oceans. Moreover time trends of ocean acidification (Task 5.6.) will be derived and assessed.

Previous experience relevant to the tasks: Prof. Hein de Baar received his PhD degree in the WHOI/MIT Joint Program in Oceanography (USA) and after several years research at the University of Cambridge returned to NIOZ in 1987; as off 1992 also senior professor of oceanography at the University of Groningen. Supervisor of 20 completed PhD theses in 1992-2009 period, and another 10 PhD candidates preparing theses to be completed in 2010-2012 period. Author or co-author of more than 200 articles. Major research interests are the ocean carbon cycle and its interaction with the ocean cycle of iron and other bio-essential trace metal elements. Coordinator of preceding EU projects MERLIM, CARUSO, IRONAGES; vice-chair EU CARBOOCEAN 2005-2009.

Key personnel and their experience

Name	Relevant experience (keywords)
Hein de Baar	ocean carbon cycle; accurate measurements of DIC, Alk and other key variables
Lesley Salt	CO_2 system in North Sea and Atlantic (previous MSc Southampton on ocean CO_2 system)
Josje Snoek	senior analyst
Patrick Laan	senior analyst

Key publication(s)

Steven van Heuven, Mario Hoppema, Hans Slagter, Hein de Baar (2009) Direct observation of increasing CO_2 in deep waters of the Southern Ocean in the 1973-2008 era. *Deep-Sea Research*, submitted and in review.

De Baar, H.J.W. and Gerringa, L.J.A. (2009) Effects of ocean acidification on the physical-chemical speciation of nutrients and trace metals. Submitted for publication.

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Partner 14: Nansen Environmental and Remote Sensing Center (NERSC), Norway
Responsible Scientist: Laurent Bertino

Expertise of the organisation: NERSC is a non-profit research centre affiliated with the University of Bergen, with focus on ocean modelling and data assimilation, marine remote sensing, and climate change research. NERSC is a project-based centre with major funding from the European Union research programmes, Norwegian Research Council, the European Space Agency, the Norwegian Space Centre, industry and other governmental and international agencies. Currently the Centre participates in 14 EC funded projects, of which 4 are coordinated by the Centre. The staff comprises 62 persons from 14 countries and includes scientific personnel, Ph.D. candidates, M.Sc. students and administrative/technical personnel.

Contribution to the project: NERSC will be co-leading WP6 Systematic model calibration using observations (in particular Task 6.1: Ensemble Kàlman Filtering and the MICOM-HAMOCC isopycnic physical-biogeochemical global ocean model) and contributing to WP2 (Task 2.1 Sensitivity of carbon uptake to physical parameters) and WP7 (Task 7.1 General comparison)

Previous experience relevant to the tasks: NERSC has a broad expertise in data assimilation and ocean physical and biogeochemical modelling from the introduction of the Ensemble Kàlman Filter in 1994 until the operational TOPAZ system, presently becoming the Arctic Marine Forecasting Center in the FP7 MyOcean project. NERSC has also expertise in ocean carbon modelling and was a partner in the FP6 CARBOOCEAN project. In addition, NERSC has comprehensive expertise in satellite remote sensing including estimation of net primary production using ocean colour satellites.

Key personnel and their experience

Name	Relevant experience (keywords)
Laurent Bertino, Res. Dir.	Data assimilation, ocean modelling,
Johnny Johannessen, Res. Dir.	Remote sensing, mesoscale process understanding, coordinator of FP7 MONARCH-A
Kjetil Lygre, PhD	Ocean Carbon cycle modelling
Ehouarn Simon, PhD	Data assimilation into ocean biogeochemical model, North Atlantic
Annette Samuelsen, PhD	Ocean biogeochemical modelling, North Atlantic
Gisle Nondal, MSc	Ocean biogeochemistry, North Atlantic and Southern Ocean

Key publications

Cummings J., Bertino L**.,** Brasseur P., Fukumori I., Kamachi M., Martin M.J., Mogensen K., Oke P., Testut C. E., Verron J. and Weaver A., (2009) Ocean data assimilation systems for Godae, *Oceanography*. GODAE special issue feature, 22(3), 96-109.

Hernandez F**.,** Bertino L**.,** Brassington G., Chassignet E., Cummings J., Davidson F., Drévillon M., Garric G., Kamachi M., Lellouche J.-M., Mahdon R., Martin M. J., Ratsimandresy A. and Regnier C., (2009) Validation and intercomparison studies within GODAE, *Oceanography*, GODAE Special issue feature, 22(3), 128-143.

Milutinovic S., Behrenfeld M**.** J., Johannessen J. A**.** and Johannessen T., Sensitivity of remote sensing–derived phytoplankton productivity to mixed layer depth: Lessons from the carbon-based productivity model, *Global Biogeochemical Cycles*, Vol. 23, October 2009

Nondal G. N., Bellerby R.G.J, Olsen A., Johannessen T., Olafsson J. and Olafsson J., Optimal evaluation of the surface ocean CO_2 system in the northern North Atlantic using data from voluntary observing ships, *Limnology and oceanography*: methods, Vol. 9, 2009

Samuelsen A., L. Bertino, and C. Hansen (2009) The 2007 North Atlantic spring bloom in operational analysis from the TOPAZ system, *Ocean Sci*., 5, 635-647.

Simon E. and L. Bertino (2009) Application of the Gaussian anamorphosis to assimilation in a 3-D coupled physical-ecosystem model of the North Atlantic with the EnKF: a twin experiment, *Ocean Sci*., 5, 495-510.

Berger, M., E-A. Herland, J. Aschbacher, S. Briggs, J. A. Johannessen, R. Hanssen, J. Moreno, D. Hauglustaine: New possibilities for Science: ESA's operational Sentinel missions, *ESA Bulletin*, 140, 2009

Partner 15: Bjerknes Centre for Climate Research, UniResearch AS, Norway
Responsible Scientist: Truls Johannessen

Expertise of the organisation: Uni Research is a non-profit research company and the University of Bergen's strategic research partner. Uni Research has more than 500 highly-qualified staff from 30 different nations, working in nine departments. The department Uni Bjerknes Centre runs the climate research through the Bjerknes Centre for Climate Research (BCCR), which is a National Centre of Excellence funded by the Research Council of Norway for the period 2003-2012, and the largest scientific climate research centre in Scandinavia. Following a Government decision, the BCCR will become the national centre in Norway for climate research and climate projections. The BCCR is an international leader in high latitude climate research, and a key institution for information on climate change for politicians, industry and the public. The BCCR has a leading research position within climate understanding of the past present and future, in climate modeling and scenarios for future climate changes as well as quantification of climate changes. The BCCR was one of the four modelling groups in Europe that provided model simulations to the IPCC 4^{th} AR. The BCCR leads the Norwegian activities for developing climate models / earth system models (NorESM) in advance of the next IPCC report. At the end of 2008 the BCCR had a total staff of 119 scientists, Postdocs and PhD students. 35% of the total have their employment at Uni Research.

Contribution to the project: Measure the general C-cycle variables and transient tracers using state of the art instrumentation (WP 4 task 4.1, 3, 6, 7, 9and WP 5, task 5.2, 3, 4, 8): responsible for operating the Nuka Arctica line which crosses one of the most important sink regions in the North Atlantic Ocean. A cruise in the Greenland Sea (2013) to study the deepwater formations, C-cycle and transient tracer distribution will be an addition to the time series started in 1992. Uni Research will co-lead WP8 (with UEA) and will specifically be responsible for the CARINA-GLODAP merge and development of the 3D Atlas (task 8.3)

Previous experience relevant to the tasks: Our group has a strong professional profile and has been involved in a series of EU and Norwegian Research Council projects measuring C-cycle variables in the North Atlantic and Greenland Sea. The group has also a long tradition participating in international organizations as JGOFS, SOLAS and IMBER, particularly in SOLAS where we have members belonging to the SSC and participated in writing the science and implementation strategies and later also the Joint Implementation Plan for SOLAS and IMBER on Carbon. We are participating formulating reports on best practises for analytical methods for measurements of carbon relevant variables and procedures for data reduction used by the International community. The latest contribution is the dedication of Dr. Are Olsen in quality assessment of the CARINA and SOCAT database. The most promising results coming out of science produced in IMCORP, CAVASSOO and CARBOOCEAN is the establishment of a VOS network now measuring the heartbeat on the North Atlantic Ocean sources and sinks. This network is planned continued in CARBOCHANGE in WP4.

Key personnel and their experience

Name	Relevant experience (keywords)
Truls Johannessen, Professor	Chem. Oceanography, Global C-cycle, Biogeochemistry, Paleoceanography
Richard Bellerby, Res.	Biogeochemistry and C-cycle
Emil Jeansson, Res.	Transient tracer studies and C-cycle
Are Olsen, Res.	Air Sea gas exchange and C-cycle
Abdirahman M. Omar, Res.	Coastal waters and shallow oceans and C-cycle
Ingunn Skjelvan, Res.	Marine station, moorings and C-cycle

Key publications

Nondal, G., R. G. J. Bellerby, A. Olsen, T. Johannessen, and J. Olafsson. The surface CO_2 system in the northern North Atlantic: an assessment of the optimal variable combination for Voluntary Observing Ships, *Limnol& Oceanogr: Methods*, 7, 109-118, 2009

Omar, A. M., A. Olsen, T. Johannessen, M. Hoppema, H. Thomas, and A. V. Borges. Spatiotemporal variations of fCO_2 in the North Sea, *Ocean Science*, *in press.*

Olsen, A., A. M. Omar, E. Jeansson, L. G. Anderson, and R. G. J. Bellerby. Nordic Seas transit-time distributions and antropogenic CO_2, *Journal of Geophysical Research – Oceans*, *in press*.

Watson, A.J., U. Schuster, D.C.E. Bakker, N.R. Bates, A. Corbière, M. González-Dávila, T. Friedrich, J. Hauck, C. Heinze, T. Johannessen, A. Körtzinger, N. Metzl, J. Olafsson, A. Olsen, A. Oschlies, X. A. Padin, B. Pfeil, J. M. Santana-Casiano, T. Steinhoff, M. Telszewski, A.F. Rios, D.W. R. Wallace, and R. Wanninkhof, Accurately tracking the variation in the North Atlantic sink for atmospheric CO_2, 2009, *Science* 326:1391-139.

Partner 16: Consejo Superior de Investigaciones Científicas (CSIC)
Responsible Scientist: Aida F. Rios

Expertise of the organisation: CSIC is the primary research organisation in Spain affiliated to the Ministry of Science and Innovation. The CSIC undertakes work in practically all branches of knowledge with 126 centres/institutes all around Spain. The *Instituto de Investigaciones Marinas de Vigo (IIM)* has a wide range of oceanographic analytical facilities and a 25 meters long vessel allowing the development of an interdisciplinary research in oceanography. Its Oceanography Department has experience in field-orientated research, both in coastal and open ocean water systems, covering key issues of the chemistry (carbon and nutrients cycling) and biology (microplankton ecology, primary production models) of marine ecosystems. This Department was pioneer in studying CO_2 system in the oceans and it is currently mainly focused on the sequestration of CO_2 by the oceans. IIM has participated in a series of EU projects, among others MORENA, CANIGO, CAVASSOO and currently CARBOOCEAN, where the group worked in anthropogenic carbon uptake in different areas an in the entire Atlantic Ocean. The *Instituto de Ciencias del Mar de Andalucía (ICMAN)* has a topics variety ranging from local, coastal and estuarine ecosystem studies to basin scale ocean dynamics and biogeochemical fluxes. Its Ecology and Coastal Management Department possesses a broad experience in the study of the physical-biological coupling in marine systems of the Gulf of Cádiz, Strait of Gibraltar, and Alborán Sea in collaboration with the Universities of Cádiz and Málaga, using national and EU funding ,e.g.OMEGA, CANIGO, SESAME and CARBOOCEAN. The team was in charge of estimating fluxes of carbon and nutrients through the Strait of Gibraltar.

Contribution to the project: The CSIC will co-lead the WP5, contributing to all its tasks, and being the responsible partner of Task 5.2 Collect CO_2 and associated data along 10 predefined sections and Task 5.4 Assess decadal and interannual changes in regional carbon inventories for testing the prognostic and predictive models. CSIC will also contribute to WP1 in Task 1.3 Role of organic and inorganic export of carbon from continental margins to the Atlantic Ocean. . CSIC´s budget is shared between both ICMAN and IIM: ICMAN would receive 35% of the requested EC contribution (120.277 Euro) while IIM the remaining amount (223.372, 25Euro).

Previous experience relevant to the tasks: Our group has ample professional experience in the successful EU research projects: CANIGO (Canary Islands, Gibraltar and Azores Observation), CAVASSOO (Carbon Variability Studies By Ships Of Opportunity), SESAME (Southern European Seas: Assessing and Modelling Ecosystem Changes) and CARBOOCEAN (Marine carbon sources and sinks assessment), in which the CSIC leaded two WPs, estimating both the Atlantic anthropogenic carbon inventory and the anthropogenic and natural carbon exchange through the Strait of Gibraltar.

Key personnel and their experience

Name	Relevant experience (keywords)
Aida F. Rios, Professor	Oceanographer, carbon cycle, stoichiometry, WP5 co-leader
Fiz F. Perez, Professor	Chemical oceanographer, Carbon cycle, water masses.
Emma Huertas, Researcher	Biochemistry processes in organic material and regeneration
Miguel GilCoto, Researcher	Physical Oceanographer, inverse model of circulation
Anton Velo, HighTech.	Data analysis, software development, QC
Gabriel Navarro, HighTech.	Remote Sensing, data analysis, data synthesis.

Key publication(s)

Perez FF, M. Vazquez-Rodriguez, E Louarn, XA Padin, H Mercier, A F Rios, Temporal variability of anthropogenic CO_2 storage in the Irminger Sea. *Biogeosciences*, 5: 1679-1679, 2008.

Vazquez-Rodriguez, M., Touratier, F., Lo Monaco, C., Waugh, D.W., Padin, X.A., Bellerby, R.G.J., Goyet, C., Metzl, N., Rios, A.F.,Perez, F.F., Anthropogenic carbon distributions in the Atlantic Ocean: data-based estimates from the Arctic to the Antarctic. *Biogeosciences*, 6: 4527-4571, 2009.

Huertas. I.E., A.F. Rios, J.García-Lafuente, A. Makaoui, S. Rodrıiguez-Galvez, A. Sanchez-Roman, A. Orbi, J. Ruiz, F.F. Perez, Anthropogenic and natural CO_2 exchange through the Strait of Gibraltar. *Biogeosciences*, 6: 647-662, 2009.

Padin, X.A, G. Navarro, M. Gilcoto, A.F Rios, F.F. Perez, Estimation of air-sea CO_2 fluxes in the Bay of Biscay based on empirical relationships and remotely sensed observations. *Journal of Marine Systems,*28: 904-914, 2009.

A. Velo, F.F. Perez, P. Brown, T. Tanhua, U. Schuster, R.M. Key, CARINA alkalinity data in the Atlantic Ocean. *Earth Syst. Sci. Data*, 1, 45–61, 2009

Partner 17: University of Las Palmas de Gran Canaria ULPGC, QUIMA group
Responsible Scientist: J. Magdalena Santana Casiano

Expertise of the organisation: The University of Las Palmas de Gran Canaria was established as a full University in 1992 but was before acting as Polytechnic University by 30 years. It now has 21,000 students and nearly 2,500 staff members, and it is at the forefront of teaching and research in Marine Science, Veterinary and Engineer.
The Marine Science study was established as a Faculty in Spain in 1982 in the ULPGC. More than 400 undergraduate students and 30 doctoral students receive teaching class and research at the Faculty every year. The Marine Chemistry group at the University of Las Palmas ULPGC, (QUIMA) was created 14 years ago focusing in the study of the Carbonate system chemistry and in the trace metal speciation processes in seawater with international collaborations with the University of Miami and most of the European Marine centers

Contribution to the project: ULPGC-QUIMA is involved in WP1, WP2, WP4 and WP5. ULPGC will contribute to Task 1.3 (Role of organic and inorganic export of carbon from continental margins to the Atlantic Ocean); Task 2.2 (Assess the impact of changes in deep-water formation, overflow to the North Atlantic, and the meridional overturning on CO_2 uptake in the Atlantic Ocean); Task 4.1 (Set up and evaluate observational network for estimates of the air-sea flux of CO_2); Task 4.3 (Collect CO_2 and associated data in the Atlantic); Task 5.2 (Collect oceanic time series data at the 8 predefined time series); Task 5.6 (Trends on ocean acidification using time series station and repeated sections data to assess the model reliability and generating synergies with international projects addressing this topic (Responsible)). ULPGC (González) acts as co-leader in WP1.

Previous experience relevant to the tasks: The QUIMA group is responsible for the monthly determination of the carbon dioxide system at the European Station for Time-Series at the Ocean in the Canary Islands, ESTOC, from October 1995. The ULPGC-QUIMA has participated in the CANIGO project (1996-1999), collaborated with the ANIMATE project (2001-2004), member of the CARBOOCEAN project contributing with a new VOS (volunteer observing ships) line between UK and South-Africa to the Atlantic Observing System (2005-2009) and EUROSites project in charge of the carbon system study in the ESTOC site and developing a new pH sensor. Member of the French Project POMME 2000-2002 (programme Océan multidisplinaire Mezzo Echelle) studying the carbon dioxide system in the Central Atlantic Ocean and in the GOOD-HOPE project inside the Polar Year 2007 French contribution in the South Atlantic Ocean. A new collaboration with the Shirshov Institute of Oceanology of Moscow has been established studying the carbon system along 59.5ºN.

Key personnel and their experience

Name	Relevant experience (keywords)
J. Magdalena Santana-Casiano, Professor	Chemical Oceanography Research, Marine Biogeochemical Cycles, water column carbon dioxide distribution and processes
Melchor González-Dávila, Professor	Marine Physical-Chemistry, Marine Biogeochemical Cycles, CO_2 flux exchanged at the ocean atmosphere interface, ocean sensors on acidification studies

Key publications

M. González-Dävila, J. M. Santana-Casiano, I.R. Ucha, Seasonal variability of fCO_2 in the Angola-Benguela región.*Prog. Oceanogr.* 83, 124-133 (2009)

J.M. Santana-Casiano, M. González-Dávila and I.R. Ucha. Carbon dioxide fluxes in the Benguela upwelling system during winter and spring. A comparison between 2005 and 2006. *Deep Sea Res*. Vol II, 56, 533 -541 (2009)

U. Schuster, A. J. Watson, N. Bates, A. Corbiere, M. Gonzalez-Davila, N. Metzl, D. Pierrot, M. Santana-Casiano. Trends in North Atlantic sea surface fCO_2 from 1990 to 2006. *Deep Sea Res.* Vol II, 56, 620-629, (2009).

A.J. Watson, U. Schuster, D.C.E. Bakker, N.R. Bates, A. Corbière, M. González-Dávila, T. Friedrich, J. Hauck, C. Heinze, T. Johannessen, A. Körtzinger, N. Metzl, J. Olafsson, A. Olsen, A. Oschlies, X. A. Padin, B. Pfeil, J. M. Santana-Casiano, T. Steinhoff, M. Telszewski, A.F. Rios, D.W. R. Wallace, and R. Wanninkhof, Accurately tracking the variation in the North Atlantic sink for atmospheric CO_2, *Science* (2009)

Partner 18: University of Gothenburg (UGOT), Department of Chemistry and Department of Geosciences, Sweden

Responsible Scientist: Leif G. Anderson

Expertise of the organisation: UGOT is one of the largest Universities in Sweden and has marine research as one of its strategic fields of research, with expertise in system studies of the Baltic Sea region and the Arctic Ocean addressing questions within oceanography, marine chemistry and marine biology. Within the department of chemistry and geosciences of UGOT there is expertise in the marine carbon system and process modelling of the Arctic Ocean physical and biogeochemical system.

Contribution to the project: The University of Gothenburg will contribute to WP2 (Task 2.1 quantify the impact of changes in Arctic sea ice cover and deep-water formation on oceanic CO_2 uptake in the Arctic. Observational process studies will be combined with regional process models), to WP5 (Task 5.2 collect carbon system data in the Arctic Ocean: and Task 5.3 Assess factors affecting the variability of the anthropogenic carbon inventories in the Arctic Ocean) and to WP8 (contribute to outreach paper on high latitude CO_2 fluxes, task 8.4). UGOT will co-lead WP2.

Previous experience relevant to the tasks: Our group has a long experience in Arctic Ocean investigations of physical and chemical oceanography as well as the study of the marine carbon cycle. We have been involved in a number of marine EU projects relevant for this study that include ESOP 1 & 2, TRACTOR, DAMOCLES, CARBOOCEAN and EPOCA. We have used observations as well as models to elucidate water mass formation, mixing and circulation, and used this information together with biogeochemical processes to assess carbon transformation and fluxes. The modelling activity has focused on process understanding and we are at present working with developing a physical – biogeochemical model for the Laptev Sea to investigate how carbon fluxes are impacted by changes in the driving conditions.

Key personnel and their experience

Name	Relevant experience (keywords)
Leif G. Anderson, Professor	Marine chemistry, carbon cycle research, Arctic chemical oceanography
Göran Björk, Professor.	Physical oceanographer, physical and biochemical process modelling

Key publications

Anderson L.G., S. Jutterström, S. Hjalmarsson, I. Wåhlström and I.P. Semiletov, Out-gassing of CO_2 from Siberian Shelf Seas by terrestrial organic matter decomposition, *Geophys. Res. Lett*., 36, L20601, doi:10.1029/2009GL040046, 2009.

Tanhua T., E.P. Jones, E. Jeansson, S. Jutterström, W.M. Smethie Jr., D.W.R. Wallace, L.G. Anderson, Ventilation of the Arctic Ocean: mean ages and inventories of anthropogenic CO_2 and CFC-11, *J. Geophys. Res.,* 114, C01002, doi:10.1029/2008JC004868, 2009.

Björk G., M. Jakobsson, B. Rudels, J. H. Swift, L.G. Anderson, D. A. Darby, J. Backman, B. Coakley, P. Winsor, L. Polyak and M, Edwards, Bathymetry and deep-water exchange across the central Lomonosov Ridge at 88°-89°N, *Deep-Sea Research I,* 54, 1197–1208, 2007.

Björk G. and P. Winsor, The Deep waters of the Eurasian Basin, Arctic Ocean: Geothermal heat flow, mixing and renewal, *Deep Sea Research I*, 53, 1253-1271, 2006.

Jutterström, S., and L.G. Anderson, The saturation of calcite and aragonite in the Arctic Ocean. *Mar. Chem*., 94, 101-110, 2005.

Anderson, L.G., E. Falck, E.P. Jones, S. Jutterström, and J.H. Swift, Enhanced uptake of atmospheric CO_2 during freezing of seawater: a field study in Storfjorden, Svalbard, *J. Geophys. Res*., 109, C06004, doi:10.1029/2003JC002120, 2004.

Björk, G., J. Söderqvist, P. Winsor, A. Nikolopoulos and M. Steele, Return of the cold halocline to the Amundsen Basin of the Arctic Ocean, *Geophys. Res. Lett.,* 29 10.1029, 2002.

Partner 19: Eidgenössische Technische Hochschule Zürich (ETH Zürich), Switzerland
Responsible Scientist: Nicolas Gruber

Expertise of the organisation: The Environmental Physics group at the Swiss Federal Institute of Technology (ETH) Zürich focuses on the study of the interaction of biogeochemical cycles and climate from global to regional scales, with a special emphasis on the cycling of carbon and nitrogen. The group has currently 14 members (1 group leader, 3 senior scientists, 5 post-docs, and 5 Ph.D. students), and is expected to grow by an additional 2 Ph.D. students by the middle of 2010. Prof. Gruber and his group have extensive experience in the analysis of observational data and the modelling of the complex biogeochemical/ecological/physical interactions in the ocean on regional to global scales. A broad palette of models are available, including the Regional Oceanic Modelling System (ROMS) and the Community Climate System Model of the U.S. National Center for Atmospheric Research, plus access to a group-owned computer cluster with more than 300 processors.

Contribution to the project: The Environmental Physics group will contribute to three work packages, i.e. 1, 2, and 7. In addition, its lead scientist, Professor Nicolas Gruber is co-leader of Core Team 1. More specifically, the group will provide its modelling and data interpretation expertise to the project in 4 distinct areas: (i) It will undertake simulations with ROMS of the Canary Current System and the whole Atlantic to assess the impact of coastal ocean-open ocean exchange of organic carbon on the open-ocean air-sea CO_2 balance (WP1, task 1.1); (ii) it will contribute a set of NCAR CCSM simulations to assess the production and fate of sinking organic matter in a warming ocean and lead the interpretation of the role of phytoplankton community structure in governing the export of organic matter (WP1 task 1.2, 3); (iii) it will undertake high-resolution simulations of the Southern Ocean with ROMS with the goal to assess the role of eddies in transporting carbon laterally and in controlling the net air-sea CO_2 balance (WP2, task 2.4); and (iv) it will lead the development and application of novel data-model metrics in order to quantitatively assess the various models with observations (WP7 task 7.1).

Previous experience relevant to the tasks: The responsible scientist has nearly 20 years of experience in ocean carbon cycle research and has led several larger-scale projects in the U.S. Most importantly, he was the PI of the Ocean Inversion project, where 8 modelling groups participated, and whose goal was to estimate the air-sea fluxes of both natural and anthropogenic CO_2 on the basis of ocean interior observations (Gruber et al., 2009). He was also PI of several projects aimed at developing and applying regional models for the U.S. West Coast to assess coastal productivity and carbon cycling (Gruber et al., 2006). Finally, he was PI of a project to assess the interactions between high-latitude climate and the global carbon cycle, especially that of the ocean (Lovenduski et al., 2008). Furthermore, the responsible scientist is a member of the steering committee of IMBER, and he is chair of the IMBER/SOLAS working group on ocean interior carbon cycle.

Key personnel and their experience

Name	Relevant experience (keywords)
Nicolas Gruber	Global biogeochemical cycles, ocean carbon fluxes, model evaluation
Meike Vogt	Ecosystem assessment, metrics
Zouhair Lachkar	Coastal modelling
Matthias Münnich	Southern Ocean modelling

Key publications

Gruber, N., *et al.*, Eddy-resolving simulation of plankton ecosystem dynamics in the California Current System, *Deep-Sea Research I*, 53, doi:10.1016/j.dsr.2006.06.005, 2006.

Gruber, N., *et al.*, Oceanic sources, sinks, and transport of atmospheric CO_2, *Global Biogeochemical Cycles*, 23, GB1005, doi:10.1029/2008GB003349, 2009.

Lovenduski, N.S., N. Gruber, and S. C. Doney, Toward a mechanistic understanding of the decadal trends in the Southern Ocean carbon sink, *Global Biogeochemical Cycles*, 22, GB3016, doi:10.1029/2007GB003139, 2008.

Partner 20: University of Bern (UBERN), Physics Institute Climate and Environmental Physics, Bern, Switzerland
Responsible Scientist: Fortunat Joos

Expertise of the organisation: Climate and Environmental Physics **(**CEP), UBERN, has more than 30 years of experience in modelling biogeochemical cycles, climate, and the Earth System. The overall focus of the Climate and Environmental Physics department (CEP) is to understand the environment, its present and past and its evolution on time scales from decades to one million years. The department currently has a scientific and technical staff of around 60 people. The last progress report provides an overview over the accomplishments of the Division (http://www.climate.unibe.ch/?L1=research). During the three years from 2007 to 2009, 164 papers have been published or are in press or submitted. 9 papers were published in Science and Nature. Members of CEP have been involved in the IPCC Assessments since the First Assessment Report and contributed to IPCC as Co-Chair of Working Group I, as Vice Chair of WGI, and as coordinating lead author, lead author and review editor in various Reports and Technical Papers.

Contribution to the project: UBERN will co-lead core theme 3 and contribute with the NCAR state-of-the-art climate model and with its Bern3D Earth System Model of Intermediate Complexity to the success of the project. Our involvement is to assess vulnerabilities and stabilisation pathways in WP3 (Task 3.1 – *Vulnerability of sources and sinks*, Task 3.2 **-** *Probabilistic distribution of vulnerability*, Task 3.3 – *Stabilization*). In WP6, UBERN will set up an Ensemble Kàlman Filter data assimilation system (Task 6.3 *EMIC calibration for improved predictability and constrained alkalinity fluxes*) for model calibration and inverse analysis of fluxes. In WP7, UBERN will contribute to Task 7.1 – *Global comparison*, Task 7.2 – *Performance indices*, and Task 7.4 – *Feedbacks*

Previous experience relevant to the tasks: Our group has a long-term experience in modelling the carbon-cycle and its coupling with the climate system. UBERN has pioneered reduced form models and Earth System Models of Intermediate Complexity and has gained extensive experience in applying state-of-the-art climate-carbon model. The responsible scientist contributed with his model expertise as PI and WP leader to several FP6 and FP7 projects (CARBOOCEAN, EUR-OCEAN, MARiRON, GAINS-ASIA, NICE, and EPOCA) and was involved as author and Vice Chair in the last three IPCC assessments.

Key personnel and their experience

Name	Relevant experience (keywords)
Fortunat Joos	Head of the Earth System-biogeochemical modelling group, CEP; Affiliate Scientist,NCAR, USA; carbon-climate analysis, scenarios, data assimilation

Key publications (http://www.climate.unibe.ch/~joos/publications.html)

***AOGCM and multi-model analysis**:* T. L. Frölicher, F. Joos, G.-K. Plattner, M. Steinacher, and S. C. Doney. Natural variability and anthropogenic trends in oceanic oxygen in a coupled carbon cycle-climate model ensemble. Global Biogeochemical Cycles , 23, 1-15, doi:10.1.1029/2008GB003316, 2009

Frölicher, T. L., F. Joos, "Reversible and irreversible impacts of greenhouse gas emissions in multi-century projections with a comprehensive climate-carbon model", *Climate Dynamics*, in press, 2009

Steinacher, M., F. Joos, T. L. Frölicher, L. Bopp, P. Cadule, S. C. Doney, M. Gehlen, B. Schneider, J. Segschneider, "Projected 21st century decrease in marine productivity: a multi-model analysis", *Biogeosciences Discuss, 6*, 7933-7981,2009

Steinacher, M. F. Joos, T. L. Frölicher, G.-K. Plattner, and S. C. Doney. Imminent ocean acidification in the Arctic projected with the NCAR global coupled carbon cycle-climate model. Biogeosciences, 6, 515-533, 2009.

***Data assimilation**:* M. Gerber, F. Joos, M. Vazquez-Rodriguez, F. Touratier, and C. Goyet. Regional air-sea fluxes of anthropogenic carbon inferred with an Ensemble Kàlman Filter. Global Biogeochemical Cycles , 23, GB1013, doi:10.1029/2008GB003247, 2009

Gerber, M., F. Joos, "Carbon sources and sinks from an Ensemble Kàlman Filter ocean data assimilation", *Global Biogeochemical Cycles*, submitted, 2009

***Scenarios**:* K. M. Strassmann, F. Joos, and G.-K. Plattner. CO_2 and non-CO_2 radiative forcings in climate projections for twenty-first century mitigation scenarios, *Climate Dynamics, 33/6*, 737-749, 2009

Partner 21: The Met Office (MetO), UK
Responsible Scientist: Ian Totterdell

Expertise of the organisation: The Met Office is the national meteorological service of the United Kingdom, offering a wide range of meteorological, climatological and environmental services to customers in government, commerce and industry. The focus for climatological research at the Met Office is the Hadley Centre for Climate Prediction and Research which, since its creation in 1990, has established a world class reputation for the quality and innovation of its studies on climate variability and on the prediction and detection of anthropogenic climate change. Scientists from the Met Office Hadley Centre have been Coordinating Lead Authors, Lead Authors and Contributing Authors to many chapters in recent IPCC Assessment Reports, and have an excellent publication record, including in Nature and Science. The Met Office Hadley Centre supplies policy-relevant advice on climate science to the UK Government. Ocean carbon cycle research has been carried out at the Hadley Centre for many years, and the ocean biogeochemical model forms an essential part of the recently-developed HadGEM2 Earth System model. The Hadley Centre has contributed to a number of international ocean biogeochemical modelling projects, including OCMIP and CARBOOCEAN.

Contribution to the project: The Met Office will co-lead Work Package 3 and contribute through running model simulations (and analysing of the results of simulations) to tasks in that WP and in WP7. In Task 3.1 of WP3 (Vulnerabilities of sources and sinks) we will use results from the HadGEM2 model forced by a range of scenarios to analyse the strength of feedbacks. In Task 3.2 (Probabilistic distribution of vulnerability) we will use the simpler HadCM3 model and the methodology developed in the "Quantifying Uncertainty in Model Predictions" (QUMP) study to determine the uncertainty in future ocean sources and sinks due to uncertainty in the ocean biogeochemical model. In Task 3.3 (Stabilization) we will use HadCM3 (or HadGEM2 if the opportunity arises) to examine the long-term evolution of the ocean under a stabilization scenario. In WP7 we will apply the data-based and model-intercomparison metrics developed in that WP to our models (Task 7.1 Global Comparison).

Previous experience relevant to the tasks: The Ocean Carbon Cycle Modelling team in the Met Office Hadley Centre has many years of experience in developing, running and analysing ocean biogeochemical models in coupled GCMs. The models have been used to examine climate-carbon feedbacks and how they might change in the future; we were the first group to couple land and ocean carbon-cycle models to an atmosphere-ocean GCM (Cox et al., 2000). The Hadley Centre has also pioneered the use of "perturbed physics" ensembles (now being extended to perturbations in other sub-models) to assess the uncertainty in future climate. The responsible scientist has participated in many EU projects, including GOSAC, NOCES and CARBOOCEAN.

Key personnel and their experience

Name	**Relevant experience (keywords)**
Ian Totterdell	Biogeochemical models; coupled models; feedbacks; future scenarios.
Paul Halloran	Biogeochemical models; coupled models; feedbacks.
Ben Booth	Coupled models; uncertainty analysis.

Key publication(s)

Global biogeochemical models: Cox, P.M., Betts, R.A., Jones, C.D., Spall, S.A. & Totterdell, I.J. (2000) Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. *Nature*, 408, 184-187

Palmer, J.R. & Totterdell, I.J. (2001) Production and export in a global ocean ecosystem model. *Deep-Sea Res. I*, 48, 1169-1198

Ocean carbon-cycle feedbacks: Iglesias-Rodriguez, M.D., Halloran, P.R., Rickaby, R.E.M., Hall, I.R., Colmenero-Hidalgo, E., Gittins, J.R., Green, D.R.H., Tyrrell, T., Gibbs, S.J., von Dassow, P., Rehm, E., Armbrust, E.V. & Boessenkool, K.P. (2008) Phytoplankton calcification in a high-CO_2 world. *Science*, 320, 336-340, doi:10.1126/science.1154122

Model uncertainty: Collins, M., Brierley, C.M., MacVean, M., Booth, B.B.B. & Harris, G.R. (2007) The sensitivity of the rate of transient climate change to ocean physics perturbations. *J. Climate*, 20, 2315-2320, doi:10.1175/JCLI4116.1

Booth, B.B.B., Jones, C.D., Collins, M., Totterdell, I.J., Cox, P.M., Sitch, S., Huntingford, C. & Betts, R. (2009) Global warming uncertainties due to carbon cycle feedbacks exceed those due to CO_2 emissions. *Nature Geoscience* (in revision)

Partner 22: National Oceanography Centre Southampton (NERC) , UK
Responsible Scientist: David Hydes

Expertise of the organisation: National Oceanography Centre Southampton (NOCS) is one of the world's leading centres for oceanographic science and the largest in the UK. It is a joint venture between the Natural Environment Research Council (NERC) and Southampton University with 450 staff and 480 students. and a turnover of about 50 million Euros per annum. There is a wide range of activities from teaching, research, engineering, outreach and operation of NERC's fleet of research ships and key focus on the development of oceanographic observing systems.

Contribution to the project: NOCS will contribute to WPs 4 and 5. In WP4, NOCS will contribute to Task 4.1 setting up the observational network, Task 4.3 the collection of data in the N Atlantic, Task 4.6 estimation seasonal to interannual flux variations, Task 4.9 provide quality controlled data. In WP5, NOCS will contribute to Task 5.2 the collection of data at the PAP time series site.

Previous experience relevant to the tasks: The two ship of opportunity (SOO) underway pCO_2 measurement system operated by NOCS will form part of the network being built up in this project that will develop into the projected ICOS observing system. NOCS is the most experienced group making continuous observations of oxygen and nutrients in conjunction with those of pCO_2. NOCS has operated a SOO system between the UK and Spain since 2002. This system provides valuable data on the important transition between ocean waters and shelf seas and works at a high repeat rate that allows resolution of the interacting forces driving gas exchange. A second system is operated on a global route, which provides data from a range of areas from which little or no data has previously been available. In WP5, NOCS will contribute its expertise from the leadership of the EuroSites project and in particular from the PAP site in the NE Atlantic. This is a key observational site with an observational record starting in the 1980s leading into work within JGOFS and now EuroSites.

Key personnel and their experience

Name	**Relevant experience (keywords)**
Dr David Hydes	Biogeochemical cycle research, SOO measurement of the carbonate system
Dr. Richard Lampitt	Biogeochemical cycle research, carbon cycle, research, co-ordination development of mooring based observing system
Dr. Kate Larkin	Scientific data management, data synthesis,
Susan Hartman	Oceanography and chemical analysis - nutrient and Carbonate system
Mark Hartman	SOO operations and data management
Jon Campbell	SOO and mooring system hard and software development
Maureen Pagnani	Data manager

Key publications

Hartman S E, K E. Larkin, R S. Lampitt, M Lankhorst, D J. Hydes, 2009 Seasonal and inter-annual biogeochemical variations at the Porcupine Abyssal Plain site 2003-2005 associated with winter mixing and surface circulation. DSR II, PAP special issue (paper accepted)

Lampitt, R.S., Salter, I., de Cuevas, B.A., Hartman S., Larkin K.E.., PebodyC.A., 2009. Long-term variability of downward particle flux in the deep Northeast Atlantic: causes and trends. DSR II, PAP special issue (paperaccepted)

Hydes, D. J., Hartman, M. C., Kaiser, J. and Campbell, J. M. (2009) Measurement of dissolved oxygen using optodes in a FerryBox system, *Estuarine Coastal Shelf Science* 83, 485-490.

Hydes, D.J., Hartman, M.C., Bargeron, C.P., Campbell, J.M., Curé, M.S. and Woolf, D. K, (2008) A study of gas exchange during the transition from deep winter mixing to spring bloom (2007) in the Bay of Biscay measured by continuous observation from a ship of opportunity. *Journal of Operational Oceanography* 1(2), 41–50.

Partner 23: Plymouth Marine Laboratory (PML), UK
Responsible Scientist: Nick Hardman-Mountford

Expertise of the organisation: Plymouth Marine Laboratory (PML) is an International Centre of Excellence in Marine Science & Technology and a Collaborative Centre of the UK Natural Environment Research Council (NERC). The research at PML is timely and highly relevant to UK and international societal needs and its research, development and training programmes have at their core the mission to contribute to the issues of global change, pollution and sustainability. As one of the world's first truly multidisciplinary marine research centres, PML delivers research and solutions for national and international marine and coastal programmes. It is an independent, impartial provider of scientific research in the marine environment, with a focus on marine biogeochemistry, especially carbon cycling. The primary purpose of PML is to carry out fundamental and applied research of world-class standard, with core funding coming from UK government and the European framework programmes. PML hosts the GLOBEC International Project Office and has been involved in many EC programs, currently including MEECE and EPOCA. PML hosted the UK Centre for observation of Air-Sea Interactions and fluxes (CASIX) and leads Ocean Carbon Cycle research in the National Centre for Earth Observation (NCEO, PI: Hardman-Mountford), with a focus on the air-sea exchange of CO_2. Much work on direct pCO_2 measurements and air-sea flux research has been undertaken at PML, maintained by senior scientific personnel, supported by technical staff, and enhanced through collaboration with EO and modelling research. It is internationally recognized for its work in this field.

Contribution to the project: PML will undertake work in WP4, contributing to tasks 4.1, 4.4, 4.6 (at no cost to the project) and 4.7 (and associated milestones/deliverables) through analysis of pCO_2 measurements collected in the Southern Ocean and European shelf seas, providing assessments of seasonal to interannual variability in annual flux estimates from these data.

Previous experience relevant to the tasks: PML lead operational pCO_2 observations on UK research vessels (James Clark Ross, James Cook, Discovery, Prince Madog, Plymouth Quest) since 2006 (PI: Hardman-Mountford). The systems are operated on all research cruises and whenever ships are on passage (i.e. in VOS mode), with near-real time supply of data back to PML. In the Southern Ocean, we have built up a substantial time series of pCO_2 observations, over four Southern Ocean seasons (Oct-Apr), covering repeat routes between UK Antarctic bases. In the UK shelf seas, pCO_2 observations have been obtained for three consecutive years at coastal sites in the western Channel and Irish Sea. The PML team have substantial experience in analysis of pCO_2 observations and time series. We have also designed and developed pCO_2 measurement systems in collaboration with a local SME.

Key personnel and their experience

Name	Relevant experience (keywords)
N. Hardman-Mountford	pCO_2 instruments, observations and data analysis, biogeochemistry, time series analysis, air-sea flux estimates, scientific project management
I. Brown	pCO_2 instrument support and data analysis

Key publications

Litt, E.J., Hardman-Mountford, N.J., et al. (Accepted). Variability in seawater pCO_2 at station L4: a comparison of three years observations. *Journal of Plankton Research.*

Litt, E.J., Hardman-Mountford, N.J., et al. (Submitted). Tidal influence on coastal ΔpCO_2 and the implication for integrated seasonal estimates. *Geophysical Research Letters.*

Hardman-Mountford, NJ, et al. (2009). Ocean uptake of carbon dioxide (CO_2). In: Marine Climate Change Impacts Partnership (MCCIP) Annual Report Card 2009 update. Defra. In press.

Turley, Blackford, Hardman-Mountford, et al. (In press). Carbon Uptake, Transport and Storage by Oceans and the Consequences of Change. Harrison & Hester (eds.), Carbon Capture and Storage, IEST **29**. RSC.

Brooks, I.M., et al., incl. Hardman-Mountford, NJ (2009). Physical exchanges at the air-sea interface: UK-SOLAS Field Measurements. *Bull. Amer. Met. Soc.* 90: 629-644.

Brooks, I.M., et al., incl. Hardman-Mountford, NJ (2009). UK-SOLAS field measurements of air-sea exchange: Instrumentation. *Bull. Amer. Met. Soc.* 90: ES9-ES16.

Hardman-Mountford, NJ, et al. (2008). An operational monitoring system to provide indicators of CO_2-related variables in the ocean. *ICES Journal of Marine Science* 65: 1498-1503.

Southward, AJ, O Langmead, NJ Hardman-Mountford, et al. (2005). Long-term oceanographic and ecological research in the western English Channel. *Adv. Mar. Biol.* 47: 1-105.

Partner 24: University of Bristol (UNIVBRIS), Department of Earth Sciences, UK
Responsible Scientist: Marko Scholze

Expertise of the organisation: The University of Bristol is a major research university and one of the most prestigious in the UK. It is continuing to make major investments in biogeochemistry and Earth System Science, including close interaction between model developers and experimental biogeochemists. Earth Sciences also houses the core team of the Natural Environment Research Council programme QUEST (Quantifying and Understanding the Earth System), the UK's flagship programme on Earth System Science. QUEST is developing a new generation of integrated models of the Earth System, and has a strong stakeholder component, responding flexibly to demands from policy makers.

Contribution to the project: The University of Bristol will contribute to WP6 (Task 6.2: Calibration of biogeochemical process parameters in a stand alone ocean, MITGCM, and simultaneously with terrestrial biosphere, BETHY, model on decadal time scale).

Previous experience relevant to the tasks: Our group has comprehensive professional experience in the successful development of data assimilations systems around the terrestrial carbon cycle as well as in Earth system modelling. Both M. Scholze and W. Knorr are members of the Carbon Cycle Data Assimilation System consortium (CCDAS). CCDAS is a highly collaborative project including researcher from various fields and institutions. CCDAS is the first comprehensive terrestrial carbon cycle model-data fusion system worldwide. M. Scholze has developed a first adjoint model-based sensitivity experiment of the carbon cycle package of the MITGCM applying automatic differentiation within a research visit at the Department of Earth, Atmospheric and Planetary Sciences, M.I.T. in summer 2009. We participate in the FP6 projects ENSEMBLES (Earth system modelling), HYMN (atmospheric trace gas composition) and IMECC (Infrastructure for Measurements of the European Carbon Cycle) as well as the FP7 project COMBINE (Earth system modelling).

Key personnel and their experience

Name	Relevant experience (keywords)
Marko Scholze, Advanced Research Fellow	Carbon cycle research, data assimilation, terrestrial and ocean biogeochemical modelling,
Colin Prentice, Professor	Scientific data synthesis, Earth system modelling, carbon cycle modelling,
Wolfgang Knorr, Senior Research Fellow	data assimilation, scientific project management

Key publications

Prentice, I. C., et al., incl. W. Knorr, 2001, The carbon cycle and atmospheric carbon dioxide. In: Climate Change 2001: The Scientific Basis (edited by J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell and C.A. Johnson), Cambridge University Press, Cambridge, pp. 183-237.

Scholze, M., T. Kaminski, P. Rayner, W. Knorr, and R. Giering, 2007, Propagating uncertainty through prognostic CCDAS simulations, *J. Geophys. Res*. 112, doi:10.1029/2007JD008642.

Rayner, P., M. Scholze, W. Knorr, T. Kaminski, R. Giering & H. Widmann, 2005, Two decades of terrestrial Carbon fluxes from a Carbon Cycle Data Assimilation System (CCDAS). *Global Biogeochemical Cycles*, 19:doi:10.1029/2004GB002254

Kaminski, T., W. Knorr, P. Rayner, & M. Heimann, 2002, Assimilating Atmospheric data into a Terrestrial Biosphere Model: A case study of the seasonal cycle, *Global Biogeochemical Cycles*, 16(4):14-1-14-16.

Kaminski, T., R. Giering, M. Scholze, P. Rayner, and W. Knorr, 2003, An example of an automatic differentiation-based modelling system. In V. Kumar, L. Gavrilova, C. J. K. Tan, and P. L'Ecuyer, editors, *Computational Science - ICCSA 2003, International Conference Montreal, Canada, May 2003, Proceedings, Part II*, volume 2668 of *Lecture Notes in Computer Science*, pages 95-104, Berlin, Springer.

Partner 25: University of East Anglia (UEA), Norwich, United Kingdom
Responsible Scientist: Dorothee Bakker

Expertise of the organisation: The School of Environmental Sciences (ENV) at UEA is one of the largest and longest-established academic departments in Europe to focus on the study of the global environment. In the UK's Research Assessment Exercise 2008, 25 % of ENV's research activity was classed as world-leading (4*) and a further 45 % as internationally excellent (3*). The UEA team has participated in several European projects (ORFOIS, Greencycles I and II, CarboEurope, IMECC), including as WP leader (CARBOOCEAN, Eur-Ocean). The team has ample experience in the collection of marine and atmospheric carbon relevant data and in the use of ocean biogeochemistry models. The NEMO-PlankTOM model runs on the UEA cluster. ENV hosts the Carbon Related Atmospheric Measurement (CRAM) Laboratory. UEA scientists have participated in the CARINA synthesis, the IOCCP SSG (Scientific Steering Group of the International Carbon Coordination Project) and in IPCC AR3, AR4 and AR5.

Contribution to the project: The University of East Anglia co-leads WP8 and will contribute to WP4 (Tasks 4.5; Collect atmospheric CO_2 and O_2/N_2 data), WP5 **(**Tasks 5.2-5.4, 5.6-5.8: Identify key repeat sections; Assess the variability of anthropogenic carbon and ocean acidification and their causes; Link air-sea CO_2 uptake with changes in deep carbon inventories), WP7 (Tasks 7.1, 7.5: A global model-data and model-model comparison, as well as the attribution of climate change to changes in carbon-cycle variables) and WP 8 (Lead the outreach activities and Tasks 8.1, 8.2, 8.4: Annual releases of air-sea CO_2 fluxes for the global ocean and by basin, with an estimate of their uncertainty and confidence level; Product releases of SOCAT (Surface Ocean CO_2 Atlas); Develop an extrapolation technique). Until June 2013 UEA has co-led Core Theme 2, has co-led WP4 and has contributed to WP 4 (Tasks 4.1-4.3, 4.6, 4.10; Co-ordinate, and evaluate and Atlantic and Southern Ocean observational network: Seasonal and annual estimates of CO_2 air-sea fluxes).

Previous experience relevant to the tasks: The UEA team has collected surface CO_2 data, has carried out inorganic carbon measurements on deep sections and has made high-precision atmospheric CO_2 and O_2/N_2 measurements. UEA scientists play a key role in SOCAT, and planning of ICOS (Integrated Carbon Observing System) and lead the annual release of the global CO_2 budget by GCP (Global Carbon Project) and MAREMIP (MARine Ecosystem Model Intercomparison Project).

Key personnel and their experience

Name	Relevant experience (keywords)
Dorothee Bakker, Research	Marine biogeochemist, hydrographic sections, SOCAT chair
Corinne Le Quéré, Prof.	Biogeochemical modelling, global carbon budgets, GCP co-chair
Andrew Manning, Research	Atmospheric scientist, leads CRAM laboratory
Erik Buitenhuis, Researcher	Biogeochemical modelling, NEMO-PlankTOM developer

Key publications

Bakker, D.C.E., Hoppema, M., Schröder, M., Geibert, W., Baar, H. J.W. de, 2008. A rapid transition from ice covered CO_2–rich waters to a biologically mediated CO_2 sink in the eastern Weddell Gyre. *Biogeosc.* 5: 1373.

Manning, A.C., and R. F. Keeling, (2006) Global oceanic and land biotic carbon sinks from the Scripps atmospheric oxygen flask sampling network, *Tellus-B* 58B, 95-116. doi:10.1111/j.1600-0889.2006.00175.x.

Le Quéré, C., M.R. Raupach, J.G. Canadell, G. Marland et al., 2009. Trends in the sources and sinks of carbon dioxide. *Nature Geoscience*, 1-6. doi: 10.1038/ngeo689.

Le Quéré, C., Rödenbeck, C., Buitenhuis, E.T., Conway, T.J., Langenfelds, R., Gomez, A., et al., 2007. Saturation of the Southern Ocean CO_2 sink due to recent climate change. *Science* 316, 1735-1738.

Watson, A.J., Schuster, U., Bakker, D.C.E., Bates, N., Corbière, A., González-Dávila M., et al. 2009. Tracking the variable North Atlantic sink for atmospheric CO_2. *Science* 326 (5958), 1391-1393.

Partner 26: Council for Scientific and Industrial Research (CSIR), South Africa
Responsible Scientist: Dr Pedro M.S. Monteiro

Expertise of the organisation: CSIR (www.csir.co.za) is a leading science and engineering Research Council in South Africa with key expertise in the domain of understanding regional climate variability and change through an Earth Systems Science research programme. The ocean climate research focus is on the climate – carbon system in the Southern Ocean (Southern Ocean Carbon and Climate Observatory Programme) which aims, through a long term physics and biogeochemical observational programme, to provide an improved basis to estimate regional (South Atlantic) CO_2 flux estimates, improved understanding of changes in carbon fluxes as a result of adjustments to the carbon – climate system. CSIR has expertise in ocean and upwelling shelf biogeochemistry, large scale climatology, meteorology, ecosystem production. CSIR is the host institution for ACCESS (Africa Centre for Climate and Earth Systems Science) a Centre of Excellence in Earth Systems Science.

Contribution to the project: Our contribution to this project will centre on our long term observation programme in the Atlantic sector of the Southern Ocean which comprises three separate trips with high resolution biogeochemical (pCO_2, TCO_2, TA, O2/Ar, FRRF) and physics (UCTD) underway observations covering 7 months of the year including a process study cruise in the summer (Iron and trace metals, Productivity, phytoplankton species, Chla-HPLC, bio-optics). This contributes to WP1, WP2 and WP4. We will also contribute towards understanding the changing seasonal cycle of carbon fluxes in the Southern Ocean.

Previous experience relevant to the tasks: CSIR has participated in several EU projects in the ocean and coastal biogeochemistry CARBOAFRICA (FP6), SPEAR (FP6) and was scientific coordinator in CATCHMENT2COAST (FP5). We are on the scientific steering committee of the IOC-IOCCP and we coordinate the inter-institutional South African Southern Ocean carbon – climate programme.

Key personnel and their experience

Name	Relevant experience (keywords)
Pedro M.S. Monteiro	Ocean carbon biogeochemistry
Nicolas Fauchereau	Large scale climatology

Key publications

Monteiro, PMS, Schuster, U, Hood, M, Lenton, A, Metzl, N, Olsen, A, Rogers,K, Sabine, C, Takahashi, T, Tilbrook, B, Yoder, J, Wanninkhof, R, Watson, AJ, 2009 A global sea surface carbon observing system: assessment of changing sea surface CO_2 and air-sea CO_2 fluxes. Hall, J., Harrison D.E. and Stammer, D., Eds., Proceedings of the "OceanObs'09: Sustained Ocean Observations and Information for Society" Conference, Venice, Italy, 21-25 September 2009, ESA Publication WPP-306, 2010

Pohl, B, Fauchereau N., Reason, CJC and M. Rouault (2009) Relationships between the Antarctic Oscillation, the Madden-Julian Oscillation and ENSO, and consequences for rainfall analysis. *Journal of Climate*: In Press

Scholes, R.J., Monteiro, P. M.S, Sabine, C. L., and Canadell, J. G.: Systematic long-term observations of the global carbon cycle, *Trends in Ecology and Evolution*, accepted, 2009

Partner 27: Princeton University, Atmospheric and Oceanic Sciences (PU-AOS), US
Responsible Scientist: Robert M. Key

Expertise of the organization: Through collaboration with the NOAA-Geophysical Fluid Dynamics Laboratory, the PU-AOS and one of the leading programs in the U.S. for ocean, atmosphere and earth-system model development and analysis. AOS scientists have participated in the major ocean model intercalibration studies (OCMIP-I, II and III) and have contributed to all of the IPCC reports. Since 1980, PU-AOS has been involved in every large-scale open ocean measurement program aimed at better understanding ocean circulation and the oceanic carbon system (TTO-TAS, TTO-NAS, SAVE, WOCE, JGOFS and CLIVAR). PU has the largest privately held collection of open ocean subsurface carbon data. These data have been used to develop the only subsurface ocean carbon and tracer climatologies. All of the data are openly shared and/or made public as value-added data products including GLODAP and CARINA. With U.S. partners, the GLODAP data were used to produce the first 3-D ocean distribution and inventory for alkalinity, total dissolved inorganic carbon, numerous tracers and anthropogenic CO_2.

Contribution to the project: The PU contributions, wich will not receive any funding from the EU, will be in three broad areas: data collection, management and archive (but specifically excluding measurement); data analysis and synthesis including providing whatever is needed for data-model comparison; and direct interface to similar programs in the U.S. and Pacific Rim countries. These efforts will primarily fall into WP-8, 9 and 5, however, it is likely that independent modelling efforts at PU will lead to the productive exchange of ideas and considerable model comparisons with work products from this project.

Previous experience relevant to the tasks: PU-AOS was the only full-fledged U.S. member of the CARBOOCEAN project. Collaborations developed during that effort will continue in this project. R. Key has extensive experience in large-scale programs and in using the data derived from those programs to investigate the ocean carbon system and global climate change. The data connection has led to productive collaborations with the ocean modelling community.

Key personnel and their experience

Name	Relevant experience (keywords)
Robert M. Key	Creation of ocean carbon and tracer climatologies, interface between the data and modelling communities, ocean ventilation and mixing rates derived from tracer data, global climate change.
Laura Rossi	Grant manager

Key publications

Key, R.M., A. Kozyr, C.L. Sabine, K. Lee, R. Wanninkhof, J. Bullister, R.A. Feely, F. Millero, C. Mordy, T.-H. Peng, A global ocean carbon climatology: Results from Global Data Analysis Project (GLODAP), *Global Biogeochem. Cycles*,18, GB4031,doi:10.1029/2004GB002247, 2004.

Sabine, C.L., J. Bullister, R. Feely, N. Gruber, R. Key, A. Kozyr, K. Lee, F. Millero, T. Ono, T.-H. Peng, B. Tillbrook, D. Wallace, R. Wanninkhof, C.S. Wong, The oceanic sink for anthropogenic CO_2, *Science*, 305, 367-371, 2004.

Key, R.M., T. Tanhua, A. Olsen, M. Hoppema, S. Jutterström, C. Schirnick, S. van Heuven, X. Lin, D. Wallace and L. Mintrop, The CARINA data synthesis project: Introduction and overview,*Earth Sys. Sci. Data*, in press, 2009.

Matsumoto, K. J.L. Sarmiento, R.M. Key, O. Aumont, J.L. Bullister, K. Caldeira, J.-M.Campin, S.C. Doney, H. Drange, J.-C. Dutay, M. Follows, Y. Gao, A. Gnanadesikan, N. Gruber, A. Ishida, F. Joos, K. Lindsay, E. Maier-Reimer, J.C. Marshall, R.J. Matear, P. Monfray, A. Mouchet, R. Najjar, G.-K. Plattner, R. Schlitzer, R. Slater, P.S. Swathi, I.J. Totterdell, M.-F. Weirig, Y. Yamanaka, A. Yool and J.C. Orr, Evaluation of ocean carbon cycle models with data-based metrics, *Geophys. Res. Lett.*, 31, L07303, doi:10.1029/2003GL018970, 2004.

Orr, J.C., Fabry, V.J., Aumont,O., Bopp, L., Doney, S.C., Feely, R.M., Gnanadesikan, A., Gruber, N., Ishida, A., Joos, F., Key, R.M., Lindsay, K., Maier-Reimer, E., Matear, R., Monfray, P., Mouchet, A., Najjar, R.G., Plattner, G.-K., Rodgers, K.B., Sabine, C.L., Sarmiento, J.L., Schlitzer, R., Slater, R.D., Totterdell, I.J., Weirig, M.-F., Yamanaka, Y., and Yool, A., Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms, *Nature*, 437, 681-686, 2005.

Sweeney, C., E. Gloor, A.J. Jacobson, R.M. Key, G. McKinley, J.L. Sarmiento, R. Wanninkhof, Constraining global air-sea gas exchange for CO_2 with recent bomb 14C measurements, *Global Biogeochem. Cycles*, 21, GB2015, doi:10.1029/2006GB002784, 2007.

Partner 28: Dalhousie University
Responsible Scientist: Helmuth Thomas

Expertise of the organisation: Dalhousie University is one of the largest University-based marine research institutions in Canada, with strong expertise on all relevant fields of oceanography. Dalhousie is strongly embedded in national and international research activities. Dr. H. Thomas at Dalhousie has led the core theme 3 in CARBOOCEAN, and in summer 2011 Dr. Wallace, presently in Kiel, Germany will join the Dalhousie team. With a range of expertise that is directly relevant for CARBOCHANGE, Dalhousie has particularly strong expertise in physical and biogeochemical oceanography of the North Atlantic Ocean, the Arctic Ocean and the coastal margins of the NW Atlantic Ocean. Presently there are plans to link Dalhousie University to Federal and Private Sector researchers via a new regional Marine Research Institute which is based at Dalhousie. Once established, this Institute will provide further opportunities for collaborative contributions to CarboChange.

Contribution to the project: Dalhousie University will provide useful links to the North American research community, strengthen ties between Canadian and European research activities, and will provide expertise and data originating from the NW Atlantic Ocean. Together the US partners. Dalhousie's expertise on the Arctic Ocean, the NW Atlantic Ocean including the shallower areas, will directly complement the expertise of the CARBOCHANGE core consortium, and facilitate a comprehensive study and understanding of the northern hemisphere oceanography within the Atlantic sector.

Previous experience relevant to the tasks: All PIs have long-standing experience in observation of processes and patterns of the marine carbon cycle and its anthropogenic perturbation. During the recent years Dalhousie has led responsibly and contributed to Arctic studies, and maintained time series programs at the Scotian Shelf. It is the leading organisation in marine carbon cycle research in Canada, and has made crucial contributions to CARBOOCEAN, in particular to the core themes 3 and 1. With the planned move Dr Wallace to Dalhousie, this expertise will experience a significant strengthening. Dr Wallace has led the core theme 2 in CARBOOCEAN and is co-leading a core theme in CARBOCHANGE. New measurement and modelling programs of relevance to CarboChange will be established at that time.

Key personnel and their experience

Name	Relevant experience (keywords)
Doug Wallace	Marine Biogeochemistry, deep water oceanography.
Helmuth Thomas	Marine Biogeochemistry, Arctic Oceanography and Land-Ocean interaction

Key publication(s)

Körtzinger, A., U. Send, D.W.R. Wallace, J. Karstensen, and M. DeGrandpre (2008). The seasonal cycle of O_2 and pCO_2 in the central Labrador Sea: Atmospheric, biological and physical implications. *Global Biogeochem. Cycles*, 22, GB1014, doi:10.1029/2007GB003029.

Tanhua, T., A. Körtzinger, K. Friis, D.W. Waugh, and D.W.R. Wallace (2007). An estimate of anthropogenic CO_2 inventory from decadal changes in oceanic carbon content. Proc. *Natl. Acad. Sci. USA*, 104, 3037-3042.

Thomas, H., L.-S. Schiettecatte, K. Suykens, Y. J. M. Koné, E. H. Shadwick, F. Prowe, Y. Bozec, H. J. W. de Baar and A. V. Borges (2009). Enhanced ocean carbon storage from anaerobic alkalinity generation in coastal sediments. *Biogeosciences, 6, 267-274, 2009.*

Thomas, H., F. Prowe, I.D. Lima, S.C. Doney, R. Wanninkhof, R.J. Greatbatch, A Corbiere and U. Schuster (2008a). Changes in the North Atlantic Oscillation influence CO2 uptake in the North Atlantic over the past 2 decades. *Global Biogeochem. Cycles*, 22, doi:10.1029/2007GB003167.

Thomas, H., Y. Bozec, K. Elkalay and H.J.W. deBaar (2004a). Enhanced open ocean storage of CO_2 from shelf sea pumping. *Science*, 304, 5673, 1005-1008 (DOI: 10.1126/science.1095491).

Thomas, H., F. Prowe, S. van Heuven, Y. Bozec, H.J.W. deBaar, L.-S. Schiettecatte, K. Suykens, K. Koné, A.V. Borges, I.D. Lima, and S.C. Doney (2007). Rapid decline of the CO_2 buffering capacity in the North Sea and implications for the North Atlantic Ocean. *Global Biogeochemical Cycles, 21, GB4001, doi:10.1029/2006GB002825.*

Partner 29: Helmholtz Zentrum für Ozeanforschung Kiel (GEOMAR) Germany
Responsible Scientist: Arne Körtzinger

Expertise of the organisation: The Helmholtz Centre for Ocean Research Kiel (GEOMAR) is the successor of the Leibniz Institute of Marine Sciences (IFM-GEOMAR). The centre is among the largest non-university research institutions in the field of marine sciences in Germany, with more than 750 scientific and technical staff. Its mandate is the interdisciplinary investigation of all relevant aspects of modern marine sciences, from sea floor geology to marine meteorology, implemented by four major research divisions: Ocean Circulation and Climate Dynamics, Marine Biogeochemistry, Marine Ecology, and Dynamics of the Ocean Floor. GEOMAR has close collaborations with national and international universities and research institutions, as well as with a number of small companies active in marine technology and science. Research is conducted worldwide in all oceans.

Contribution to the project: GEOMAR scientists will contribute to the following WPs: Assessment of different formulations of particle export and remineralisation using global oxygen fields in WP1 (Task 1.1); investigation of the impact of Southern Ocean wind stress changes on air-sea CO_2 fluxes in WP2 (Task 2.4); operation of volunteer observing ship line subpolar North Atlantic in WP4 (Tasks 4.1, 4.3, 4.7, 4.9, 4.10); time-series operation of Cape Verde Ocean Observatory (CVOO) in WP5 (Tasks 5.1, 5.5 , 5.6, 5.7, 5.8), calibration of biogeochemical models with global distributions of biogeochemical tracers based on the Transport Matrix Method in WP6 (Task 6.4); global comparison of the different models using new performance indices and metrics in WP7 (Tasks 7.1, 7.2, 7.6), performance of 2nd level quality control of GLODAP data product to make it fully consistent with CARINA data products in WP8 (Task 8.3). GEOMAR will co-lead WPs 2 and 7.

Previous experience relevant to the tasks: All PIs have long-standing experience in observation and/or modelling of processes and patterns of the marine carbon cycle and its anthropogenic perturbation including the following aspects: development/improvement of methods to measure all parameters of the marine CO_2 system, observation of carbon and ancillary parameters on hydrographic surveys, voluntary observing ships, autonomous long-term moorings, and profiling floats, development and evaluation of methods to estimate the oceanic uptake of anthropogenic CO_2, high-resolution modelling of marine biogeochemical tracer fluxes, data-based calibration and assessment of marine ecosystem models, and investigations of the climate sensitivity of the biological pump. GEOMAR PIs have been strongly involved in the CARBOOCEAN IP (WPs 3, 4, 6, 7, 8, 9, 10, 16, of which WPs 3, 8, 10, and 18 were coordinated from Kiel).

Key personnel and their experience

Name	Relevant experience (keywords)
Arne Körtzinger	Marine carbon cycle, air-sea CO_2 flux, anthropogenic CO_2, new observation approaches
Andreas Oschlies	High-resolution physical and biogeochemical modelling, data-based model assessment

Key publications

Körtzinger, A., U. Send, D.W.R. Wallace, J. Karstensen, and M. DeGrandpre (2008). The seasonal cycle of O2 and pCO2 in the central Labrador Sea: Atmospheric, biological and physical implications. Global Biogeochem. Cycles, 22, GB1014, doi:10.1029/2007GB003029.
Kriest, I. and A. Oschlies (2008). On the treatment of particulate organic matter sinking in large-scale models of marine biogeochemical cycles, Biogeosciences, 5, 55-72.
Oschlies, A., K.G. Schulz, U. Riebesell, and A. Schmittner (2008). Simulated 21st century's increase in oceanic suboxia by CO2-enhanced biological carbon export, Global Biogeochem. Cycles, 22, GB4008, doi:10.1029/2007GB003147.
Tanhua, T., A. Körtzinger, K. Friis, D.W. Waugh, and D.W.R. Wallace (2007). An estimate of anthropogenic CO2 inventory from decadal changes in oceanic carbon content. Proc. Natl. Acad. Sci. USA, 104, 3037-3042.
Riebesell, U., A. Körtzinger, and A. Oschlies (2009). Sensitivities of marine carbon fluxes to ocean change. Proc. Natl. Acad. Sci. USA, 106, 20602-20609.
Watson, A.J., U. Schuster, D.C.E. Bakker, N.R. Bates, A. Corbière, M. González-Dávila, T. Friedrich, J. Hauck, C. Heinze, T. Johannessen, A. Körtzinger, N. Metzl, J. Olafsson, A. Olsen, A. Oschlies, X.A. Padin, B. Pfeil, J.M. Santana-Casiano, T. Steinhoff, M. Telszewski, A.F. Rios, D.W.R. Wallace, and R. Wanninkhof (2009). Tracking the variable North Atlantic sink for atmospheric CO2. Science, 326, 1391-1393.

Partner 30: CLIMMOD ENGINEERING SARL, France
Responsible Scientist: Abdou KANE

Expertise of the organisation: Founded in November 2009, CLIMMOD ENGINEERING is a French SME focused on Climate and Environment science. CLIMMOD is particularly specialized in the development of carbon flux estimation systems (Carbonalys). In partnership with weather and climate laboratories CLIMMOD contributes to the modelling of atmospheric transport and carbon cycle. Major aspects of CLIMMOD's activities are: climate modelling, inversion of greenhouse gas fluxes, data assimilation, model optimization, data processing, development of scientific operational softwares.

Contribution to the project: Calibration of biogeochemical parameters in a one dimensional version of a stand alone model: Variational calibration of the PISCES biogeochemistry model with biogeochemical observations from individual sites and satellite products.

Task 6.5 leads to deliverable 6.5 due month 36: Report on parameter optimisation (PISCES): Report on optimised parameter values for the PISCES model.

Previous experience relevant to the tasks: Our team has a high experience in the development of operational tools for model optimization. Our main product in this field is OptimMod used for the calibration of complex non-linear model. OptimMod will be intensively used in this project. In the framework of the EU FP7 project CARBONES, CLIMMOD has developed a new system (OCVR) to estimate the uptake of CO2 by ocean using satellite measurements.

Key personnel and their experience

Name	Relevant experience (keywords)
Dr Abdou Kane, Scientific Engineer	Data assimilation tools development and model optimization (OptimMod System). Modelling of carbon uptake by ocean (OCVR system)
Dr Thomas Lavaux, Researcher	Inverse Modelling of carbon emission at urban scale. Atmospheric transport modelling. Coupled physical-Inverse
Dr Peter Rayner, Researcher	Expert in the modelling of carbon emission at global scale. Data assimilation tools development.

Partner 31: University of Exeter, United Kingdom
Responsible Scientist: Andrew Watson

Expertise of the organisation: The UNEXE team is based in the College of Life and Environmental Sciences (CLES) at the University of Exeter, within the Geography department. This is one of the most successful Geography departments in the UK, with an excellent reputation for both teaching and research. It continues to recruit world-leading academic staff at the forefront of their fields of research, who are committed to bringing out the very best in their students. In the latest Research Assessment Exercise (2008), the UK government's main measure of quality of universities' research, we ranked 8th in the UK for world-leading research in Geography and Environmental Studies (based on the percentage of research classified as 4*).

The UNEXE team has participated in several European projects (COCOS, ORFOIS, Greencycles), including as co-ordinator (IMCORP, CAVASSOO), Core Theme leader and WP leader (CarboOcean, GEOCARBON). The team has ample experience in the collection of marine carbon relevant data, the synthesis and analysis of large datasets, and in the interpolation techniques used to estimate global fluxes.

Contribution to the project: UNEXE will co-lead Core Theme 2 and WP4. Within WP4, UNEXE will contribute to tasks 4.2 (Co-ordinate the Atlantic/Southern Ocean observational network), 4.3 (Collect surface water CO_2 and associated data in the Atlantic), 4.6 (Estimate seasonal to interannual variability of the air-sea flux of CO_2 on a yearly basis), 4.7 (Create a climatology of seasonal sea surface pH for the Atlantic and the Atlantic section of the Southern Ocean) and 4.9 (Collaborate with WP8 with quality controlled data).

Previous experience relevant to the tasks: The UNEXE team has collected and interpreted surface CO_2 data on an Atlantic Voluntary Observing Ship (VOS) since 2002, has carried out inorganic carbon measurements on deep sections and has made high-precision atmospheric CO_2 and O_2/N_2 measurements. UNEXE scientists play a key role in SOCAT, IOCCP (International Carbon Coordination Project) and planning of ICOS (Integrated Carbon Observing System) and lead the annual release of the global CO_2 budget by GCP (Global Carbon Project) and MAREMIP (MARine Ecosystem Model Intercomparison Project).

Key personnel and their experience

Name	Relevant experience (keywords)
Andrew Watson, Professor	Biogeochemical observations and modelling, co-ordination
Ute Schuster, Researcher	CO_2 data on VOS since 2002, N. Atlantic air-sea CO_2 flux synthesis

Key publications

Le Quéré, C., M.R. Raupach, J.G. Canadell, G. Marland et al. (incl. Schuster and Watson), 2009. Trends in the sources and sinks of carbon dioxide. *Nature Geoscience*, 1-6. doi: 10.1038/ngeo689.
Schuster, U., A. J. Watson, N. Bates, A. Corbière, M. Gonzalez-Davila, N. Metzl, D. Pierrot, M. Santana-Casiano, 2009. Trends in North Atlantic sea surface pCO2 from 1990 to 2006, *Deep-Sea Res. II* 56, 620-629.
Watson, A.J., Schuster, U., Bakker, D.C.E., Bates, N., Corbière, A., González-Dávila M., et al. 2009. Tracking the variable North Atlantic sink for atmospheric CO2. *Science* 326 (5958), 1391-1393.

B.2.3 Consortium as a whole

In order to meet the goal and objectives of CARBOCHANGE as described on chapter 1.1, a **multidisciplinary consortium** of the leading research institutions in fields such as oceanography, biogeochemistry, climate science, modelling, and data management is needed. These institutions not only need the scientific know-how, but also the ability to manage and collaborate in large projects, deliver leading research training, and disseminate results to partners, national and international institutions, the general public, and policy makers. CARBOCHANGE has assembled such a consortium, through careful selection process based on the criteria:

- Scientific excellence within needed fields
- Contribution to relevant previous/existing projects
- Commitment to the integrative approach
- Commitment and excellence in providing advanced research training
- Proven record of delivery of results and dissemination to the scientific community and the general public
- Links to international programmes
- Proven record of outreach and policy impact activities

The CARBOCHANGE IP consortium has a total of 30 partners. They will each have specific functions and contributions to make within the integrated work plan (chapter 1.3) and the management of the project (chapter 2.1).

B.2.3.1. Complementary expertises of the consortium

Partners' roles in CARBOOCEAN and their **complementary expertises** are summarised briefly in Table 2.3.1 below. Partners have been chosen to ensure particular expertise and excellence on marine carbon cycle research regardless of other criteria. These qualifications are complementary in that the varied data collected through different experiments/techniques requires data management to ensure availability, allowing the modellers to apply the data, and finally allowing all stakeholders to use the new knowledge. The contributions of each partner are however unique within their specialty, and **each partner has not only been deemed necessary** to fulfil the objectives of the IP, is considered **crucial** for the advancement of the state of the art of this field.

Also considered necessary for the fulfilment of the IP's objectives as well as those of the ERA are each partner's infrastructural contributions, such as research training, dissemination, organisation and management. These contributions help ensure the use of new knowledge in the future, through delivery of observations and measurements, data management, publication and use of this data in various media (scholarly journals, training programs/courses, general public channels, etc) in Europe and beyond. The partners' collaboration outside of the project with international organisations and other projects are also important for the IP, contributing best practice experience, as well as avenues for dissemination.

The **composition of the consortium is well-balanced in relation to the objectives of the project** (compare chapter 1.1), with close collaboration of experts for process quantification, observation, data analysis and modelling: Several partners perform process investigations and measurements to contribute quality-controlled observational data from different world oceans, while other partners are experts on analysing these data and using them for development and improvement of carbon-climate models.

TABLE 2.3.1

Partner		Principal Investigators	Partners role and contribution
1	University of Bergen; Coordinator (UiB) **Norway**	C. Heinze B. Pfeil K. Assmann J. Tjiputra A. Volbers	<u>Project co-ordination, Lead WP 9 and 10</u> Model experiments on the role of ocean overturning, Earth system model future scenarios, surface and deep ocean carbon measurements
2	VitusLab Copenhagen, Denmark (VitusLab)	J. Bendtsen	Model and analyse temperature dependent remineralisation rates
3	French Research Institute for Exploitation of the Sea (IFREMER) **France**	P. Lherminier V. Thierry H. Mercier	Analysis of a repeated hydrography/biochemistry section between Greenland and Portugal

4	Laboratoire des sciences du climat et de l`environnement (CEA/LSCE) **France**	M. Gehlen L. Bopp J. Orr M. Delmotte C. Moulin	<u>Lead Core Theme 1, Lead WP 3 and 7</u>. NEMO/PISCES model; IPSL coupled Earth System model; in charge of monitoring station for atmospheric CO_2 in Greenland
5	Université Pierre et Marie Curie, Paris (UPMC) **France**	J. Boutin N. Metzl N. Lefèvre C. Lo Monaco	<u>Lead Core Theme 3, Lead WP 3 and 4.</u> Monitoring of air-sea CO_2 fluxes by VOS line observations and PIRATA moorings; Large-scale variability of CO_2
6	Alfred Wegener Institute for Polar and Marine Research (AWI) **Germany**	C. Völker M. Hoppema D. Wolf-Gladrow C. Klaas R. Schlitzer	<u>Lead WP 1 and 9</u> Numerical simulation of the marine carbonate system; CO_2 observations; coupling of carbon, silica and iron cycles; data synthesis
8	Max-Planck-Society, Institute for Meteorology (MPG) **Germany**	J. Segschneider K. Six E. Maier-Reimer	Biogeochemical model development; performing simulations of coupled climate-carbon models HAMOCC model.
9	University of Bremen (UniHB) **Germany**	M. Rhein M. Diepenbroek R. Steinfeld	Collection and analysis of hydrographic, oxygen and transient tracer data; oxygen consumption/remineralisation rates; organizing data storage and access.
10	Hafrannsóknastofnunin – Marine Research Institute and University of Iceland (MRI-UI) **Iceland**	J. Olafsson S. R. Olafsdottir A. Benoit-Cattin	Ocean carbon chemistry observations at locations near Iceland; describe variability of carbon inventories in critical regions.
11	National University of Ireland, Galway (NUIG) **Ireland**	B. Ward M. Defossez A. Callaghan N. Fitzpatrick	Observation of air-sea CO_2 fluxes at Mace Head and from R/V Celtic Explorer.
12	Institut National de Recherche Halieutique, Casablanca (INRH) **Morocco**	O. Abdellatif S. Zizah M. Ahmed E. Omar	Observation of air-sea CO_2 fluxes between Moroccan coast and Canary Islands; role of organic and inorganic export carbon; feedback between offshore transport and open ocean carbon.
13	Netherlands Institute for Sea Research (NIOZ) **Netherlands**	H. de Baar	Producing deep ocean sections in the West Atlantic Ocean of Dissolved Inorganic Carbon (DIC) and Alkalinity; variability time trend of increase of DIC and ocean acidification
14	Nansen Environmental and Remote Sensing Center (NERSC) **Norway**	L. Bertino J. Johannessen K. Lygre E. Simon A. Samuelsen	<u>Lead WP 6</u> Ocean physical and biogeochemical modelling; data assimilation; Ocean carbon modelling; satellite remote sensing
15	Bjerknes Centre for Climate Research, UniResearch AS (UNIRESEARCH) **Norway**	T. Johannessen A. Olsen	<u>Lead WP 8</u> Measure C-cycle variables and transient tracers in the North Atlantic Ocean (Nuka Arctica line); study deepwater formations in Greenland Sea; responsible for the CARINA-GLODAP merge and development of the 3D Atlas.
16	Agencia Estatal Consejo Superior de Investigaciones Cientificas (CSIC) **Spain**	A. F. Rios F.F. Perez E. Huertas M. GilCoto	<u>Lead WP5</u> Collect CO_2 and associated data in the Atlantic; estimate Atlantic anthropogenic carbon inventory; estimate carbon exchange through the Strait of Gibraltar
17	University of Las Palmas de Gran Canaria, QUIMA group (ULPGC) **Spain**	J. M. Santana-Casiano M. González-Dávila	<u>Lead WP1</u> Responsible for CO_2 system at ESTOC-station, Canary Islands; measure surface CO_2 with VOS line between UK and South Africa

18	University of Gothenburg (UGOT) **Sweden**	L. G. Anderson G. Björk	Lead WP2 Marine carbon system and process modelling of the Arctic Ocean physical and biogeochemical system
19	Eidgenössische Technische Hochschule, Zürich (ETH Zürich) **Switzerland**	N. Gruber M. Voigt Z. Lachkar M. Münnich	Lead Core Theme 1 Analysis of observational data; modelling of complex biogeochemical/physical/ecological interactions.
20	University of Bern (UBERN) **Switzerland**	F. Joos	Lead Core Theme 3 Contribute NCAR climate model and Bern3D Earth System Model; assess vulnerability and stabilisation pathways; set up Ensemble Kàlman Filter data assimilation system
21	MetOffice (UK), Hadley Centre for Climate Prediction and Research (MetO) **UK**	I. Totterdell	Lead WP3 Running model simulations (HadGEM2 model, HadCM3 model, QUMP study); running model intercomparisons
22	National Oceanography Centre Southampton, Natural Environment Research Council (NERC) **UK**	D. Hydes R. Lampitt	Contribute to observing system (ICOS) with two ships of opportunity; continuous observation of oxygen, nutrients and pCO_2; running one observation route between UK and Spain; establishing of a new global observation route
23	Plymouth Marine Laboratory (PML) **UK**	N. Hardman-Mountford I. Brown	Time series pCO_2 observations in the Southern Ocean, and the UK shelf sea; analysis of pCO_2 observation and time series
24	University of Bristol (UNIVBRIS) **UK**	M. Scholze C. Prentice W. Knorr	Lead WP 6 Development and application of data assimilation systems for carbon cycle and Earth system modelling;
25	University of East Anglia (UEA) **UK**	C. Le Quéré D. Bakker A. Manning E. Buitenhuis	Co-lead WP 8 Collection and interpretation of surface CO_2 data; inorganic carbon measurements on deep sections; high-precision atmospheric CO_2 and O2/N2 measurements
26	Council for Scientific and Industrial Research (CSIR) **South Africa**	P. Monteira N. Fauchereau	Observations in the Atlantic sector of the Southern ocean collecting biogeochemical and physical data; process study cruise (iron, trace metals, plankton productivity)
27	Princeton University (PU-AOS) **USA**	R. M. Key	Data collection, management and archive; data analysis and synthesis; providing direct interface to similar programs in the US and Pacific Rim countries
28	Dalhousie University, Halifax, **Canada**	H. Thomas D. Wallace	Understanding of the northern hemisphere oceanography within the Atlantic sector incl. Arctic.
29	HELMHOLTZ ZENTRUM FUR OZEANFORSCHUNG KIEL, Germany	A. Körtzinger A. Oschlies T. Tanhua	Lead Core Theme 2, Lead WP 2 and 7 Measure all parameters of the marine CO2 system, high-resolution modelling of marine biogeochemical tracer fluxes; data-based calibration and assessment of marine ecosystem models
30	CLIMMOD Enginneering, France	Dr Abdou Kane, Dr Thomas Dr Peter Rayner,	Report on parameter optimisation (PISCES): Report on optimised parameter values for the PISCES model.
31	University of Exeter (UNEXE), UK	A.Watson U.Schuster	Co-lead Core Theme 2 and WP4. Co-ordinate the Atlantic/Southern Ocean observational network, Create a climatology of seasonal sea surface pH for the Atlantic and the Atlantic section of the Southern Ocean.

B.2.3.2. Geographical origin of the consortium

The CARBOCHANGE consortium is also **well balanced** with respect to its geographical origin. It consists of 30 research groups from 14 nations: Norway (3), Denmark (1), France (4), Germany (4), Iceland (1), Ireland (1), Morocco (1), The Netherlands (1), Spain (2), Sweden (1), Switzerland (2), and United Kingdom (6). Three partners are from outside Europe: South Africa (1), USA (1), and Canada (1).

B.2.3.3 Involvement of partners in relevant international projects

Several CARBOCHANGE partners are involved in international projects with related topics. The CARBOCHANGE consortium aims to create **synergies with relevant international projects** addressing topics which are relevant for the goals and aims of CARBOCHANGE, as for example ocean acidification. The two partners from outside Europe (CSIR, South Africa and PU-AOS, USA) link the CARBOCHANGE consortium with world-wide projects and research networks outside Europe.

CARBOCHANGE-partners participate in the following EU-funded projects of FP7 (compare also chapter 3.1.4):

EPOCA- European Project on Ocean Acidification (Large Scale IP): 13 CARBOCHANGE-partners participate in EPOCA: UiB, IFM-GEOMAR, AWI, CEA/LSCE, PML, MPG, UGOT, INRH, NIOZ, UBERN, ETHZürich, MRI-UI and UNIVBRIS. UBERN is a work package leader.

COMBINE - Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection (Large Scale IP): MPG is leading this project, and 4 other CARBOCHANGE-partners are involved: MetO, UiB, ETHZürich, UNIVBRIS.

COCOS - Coordination action on carbon observing systems: UiB and UEA are partners.

MEECE – Marine Ecosystem Evolution in a Changing Environment. UiB, CEA/LSCE, NERC, and PML are partners.

THOR – Thermohaline Overturning – at Risk? UiB, MPG, CEA/LSCE, UPMC, NIOZ, NERSC, MetO, and NERC are partners

Several other partners are and have been involved in FP6/FP7 projects with ocean- and climate-related topics, as for example IMECC, SESAME, EUROSites, MyOcean, EUR-OCEANS, GO-SHIP. Most partners have already successfully collaborated in FP6 projects, as for example CARBOOCEAN IP.
All project partners of the CARBOCHANGE consortium have **long experience** in the participation in cooperative projects under the framework programmes of the European Union, and have as such shown their motivation and capability to pursue research in Europe-wide projects involving many partners. The partners are generally familiar with the reporting duties towards the European Commission and the existing funding schemes connected with EU projects. CARBOCHANGE partners are thus part of a **strong European and world-wide research network** on global carbon budgets and climate change. Their strong involvement in these European research networks *guarantees synergies with relevant international projects addressing relevant related topics*, as is requested in the Work Programme of this call.

B.2.3.4. Links to international programmes; outreach and policy impact activities of partners

CARBOCHANGE partners play a key role in **several international programmes, committees, advisory boards, COST actions, and recent assessment reports (IPCC)** on global CO_2 budgets and climate change (compare also chapter 3.1.4):

Involvement in international programmes

UiB is a member of the Scientific Steering Committee of the IGBP (International Geosphere Biosphere Program) core project SOLAS (Surface Ocean Lower Atmosphere Study).

Truls Johannessen (UNIRESEARCH) is Chair of the SOLAS-IMBER carbon group, coordinating the work on ocean carbon measurements form the two IGBP core projects SOLAS and IMBER.

UEA scientists play a key role in SOCAT, IOCCP (International Carbon Coordination project), planning of ICOS (Integrated carbon observing system) and lead the annual release of the global CO_2 budget by GCP (Global Carbon Project). Dorothee Bakker (UEA) is chair of the Surface Ocean CO_2 Atlas (SOCAT); member of the Scientific Steering Group of the International Ocean Carbon Coordination Project (SSG of IOCCP); member of the SOLAS-IMBER Carbon Group on Surface Ocean Systems; co-chair, of the COR Working Group 131 'The Legacy of in situ Iron Enrichments: Data Compilation and Modelling'. Corinne Le Quéré (UEA) is member of the International SOLAS Implementation group.

INRH is involved in GFCM, ICAAT, UNEP, IOC, and COPEMED programme from FAO.

Nicolas Metzl (UPMC) is the chair of the SOLAS-IMBER carbon group. UPMC is also involved in PIRATA, a network of moored buoys setup in the tropical Atlantic to monitor physical oceanography parameters; UPMC monitors surface CO_2.

ETHZürich: N. Gruber is a member of the steering committee of IMBER, and he is char of the IMBER/SOLAS working group on ocean interior carbon cycle.

International committees

Melchor González-Dávila (ULPGC) is member of the Steering Scientific Committee of IOCCP (time series stations) CSIR is also a member of the Interantional Steering Committee of IOC-IOCCP.

Aida F. Rios (CSIC) is the chair of the Spanish IGBP Committee and membership of the Spainish Committee of Global Change (CEICAG) and diputy-responsible in the European Alliance of Global Change. UNIVBRIS is involved in the IGBP Analysis, Integration and Modelling of the Earth System (AIMES), Co-chair: Colin Prentice

Corinne Le Quere (UEA): Scientific Steering Committee, European Network of Excellence for Ocean Ecosystems Analysis, Advisory Panel on Ocean CO_2, Intergovernmental Oceanographic Commission and the Scientific Committee on Oceanic Research.

International Advisory Boards

UiB is a member of the Scientific Advisory Committee of the EU FP7 collaborative project MyOCEAN, and member of the International Advisory Board for the FP7 European Infrastructure Project ES-ENES on Earth system modelling.

UBERN is a member of the International Scientific Advisory Board of the UK-NERC programme QUEST.

UGOT is member of the Scientific Advisory Board of the Alfred Wegener Institute for Polar and Marine Research, Germany, and a member of the Arctic Ocean Science Board.

ETHZürich is member of the advisory board of ICOS.

COST (European Cooperation in the field of Scientific and Technical research) actions

UiB is the Norwegian member of the Management Committee of EU COST Action ES0801 "The ocean chemistry of bioactive trace elements and paleoclimate proxies"*;* and the Norwegian member of the Management Committee of EU COST Action ES0805 "Terrabites" on the development of land biosphere components for Earth system models.

J. Magdalena Santana-Casiano (ULPGC) is the Spanish representative of the Cost Action 735, "Tools for Assessing Global Air-Sea Fluxes of Climate and Air Pollution Relevant Gases", and acts as member of the Management Committee of this COST action. Also she is the member of the Working group on the Tools for Assessing Global Air-Sea Fluxes of Climate and Air Pollution Relevant Gases. Group 3, The air-sea fluxes of long-lived climate active gases.

CSIC, UPMC, ETHZürich, UBERN, and NUIG are also members of COST Action 735.

UBERN is a member of the newly established COST action INTIMATE.

Author of assessment reports (IPCC)

UiB, UBERN, INRH, AWI and UEA contributed to the recent IPCC assessment reports:

UiB was *Lead author* for the IPCC Assessment Report no. 4, Working Group I, chapter 7. The Intergovernmental Panel on Climate Change received the *Nobel Peace Prize 2007* jointly together with Al Gore.

UBERN was *lead author* of WG1 paleochapter of AR4, and Technical Summary and Drafting team member of WG1 SPM; *vice chair* of IPCC during the TAR (SPM and TS drafting team); and *lead author* of SAR, carbon cycle chapter.

INRH is a contributing author to IPCC reports (TAR, FAR), and involved in COPEMED programme (FAO).

ULPGC was a contributor to the IPCC 4th report.

Several scientists of AWI contributed to the recent IPCC report, also as lead author.

UEA participated in IPCC AR3 and AR4.

B.2.3.5 Sub-contracting

A sub-contractor to partner 24 (University of Bristol) will be included in order to provide consulting for the use of the Adjoint Model Compiler (AMC) necessary for the data assimilation of the MIT biogeochemical ocean model using the adjoint method. This work will be carried out by the University of Bristol (partner 24). The AMC is the necessary tool to invert the forward MIT model so that it can be optimised with respect to the observations. The costs for this sub-contracting amounts to 10,000 EUR (request 75%).

The partner 4 (CEA) has included 2100 EUR for audit-certificates under sub-contracting for management.

The partner 15 (UNIRESEARCH will be including a subcontract that relates to the maintenance of equipment on the Nuka Arctica line (WP8). The beneficiary has hired a company called Dansk Rørservice to carry out maintenance of equipment that involves the plumbing on board the ship. The estimated cost for this subcontract is Euro 6 000.

B.2.3.6 Third countries

Next to participants from the EU Member States, the Associated Countries or the list of International Cooperation Partner Countries, the consortium includes at no cost one partner each from the Canada and the USA.

B.2.3.7 Additional beneficiaries

We do not foresee to add partners with a budget to the consortium at this stage, as all tasks have so far already been assign to the partners as documented in the work package descriptions. Dalhousie University (Halifax, Canada) has been added as an international no-cost partner.

B.2.3.8 Third parties

Partner 5 “University Pierre et Marie Curie”UPMC introduces two third parties
a. CNRS, Centre National de la Recherche Scientifique, PIC: 999997930
b. IRD, Institut de Recherche pour le développement, PIC: 999513803
which work together in a reserach laboratory called LOCEAN. LOCEAN is a joint research unit (UMR) made by UPMC, CNRS and IRD: this means that the 3 Organizations put personnel and resources in common in the same place, the laboratory LOCEAN that is inside UPMC. in this sense, it is not possible to identify the work in detail task by task that is done by each third party but only the pm (person-months) of the different personnel (please, see below). In practice, all tasks in which UPMC (including CNRS and IRD) are shared by the personnel from the different parties to the percentage as given by their respective person months. For Information, Jacqueline Boutin and Nicolas Metzl are CNRS personnel, Nathalie Lefevre is IRD personnel and all the post-docs are UPMC personnel.
Overview in pm per WP:

WP2	TOTpm 11	UPMC 6, CNRS 5
WP4	TOTpm 35	UPMC 22, CNRS 9, IRD 4
WP5	TOTpm 7	UPMC 6, IRD 1
WP7	TOTpm 21	UPMC 17, CNRS 4
WP8	TOTpm 3	UPMC 2, CNRS 1

B.2.4 Resources to be committed

B.2.4.1 Overall financing plan and cost justification

CARBOCHANGE is planned for the duration of 4 years and **requests a total EU contribution** of 6,989,906.00 € from the EU. This EU request is complemented by partner contributions. Adding the effort from own resources of the partners (2.67 million €) the **total project costs** sum up to 9,566,961 €.(see table 2.4.1 and form A3.2). Data collection by VOS lines and research cruises (see below) as well as computing costs will to a large extend be covered by the **institutes own contributions**.
The budget was planned to receive a balanced distribution between RTD objectives, and to allocate sufficient funding for management and outreach activities. WP 10 is dedicated to overall **project management** tasks, and will receive approx. 3,4% of the total requested budget. **Management of observational and model-derived data** sets will be done in WP9, to which approx. 4% of the total person months will be dedicated. **Global synthesis and outreach to policy makers** will be treated in WP 8, supported by approx. 6% of the

total person months. The remaining approx. 90% of person months are dedicated to pure **RTD activities: Process and feedback quantification, observation, and modelling**. The resource plan was developed by focusing on the highest priority items as mentioned in the Work Programme in order to address changes in ocean carbon uptake and emission and its consequences in an optimal way. The project is exploiting all results from earlier EU FP5 and FP6 research projects on marine carbon cycling so that full use of deliverables derived earlier will be made. Access to research vessels and platforms, high-quality analytical facilities, and high-end supercomputers is ensured. Whenever possible, co-financing from institutional basis money and national funding will be used to support CARBOCHANGE (see below). The cost breakdown (requested EU contribution) per partner is given on page 92 (section 2.4.5).

Table 2.4.1: overall financing plan, cost categories (amounts can differ with budget breakdowns in the Part A due to rounding)

Categories	€ total
RTD/Innovation	9,104,875
Management	321,060.
Other (mainly dissemination)	141,021
TOTAL	**9,566,961**
TOTAL REQUEST FROM EU:	**6,989,906.**

B.2.4.2 Personnel costs

The most important resource in CARBOCHANGE **is skilled top personnel on all levels**. Special emphasis is placed on employment of **young researchers** in terms of capacity building. Hence, the largest fraction of the total costs results from personnel costs, i.e. salaries for post-docs, senior scientists, researchers, Ph.D. students, engineers and technicians. CARBOCHANGE will require funding for 887.5 person months of activity spread between 27 partners over 4 years (compare table 1.3e, summary of staff effort, page 49). The large costs from UEA (Partner 25, UK), GEOMAR (Partner 29, Germany) and UPMC (Partner 5, France) result from their broad field of expertise and consequently the activity in the majority of the work packages. It should be noted that the total effort includes a substantial number of person months contributed by the partners.

B.2.4.3 Other RTD costs

Consumables and durables

Funding is required to cover expenses for working means of the involved scientists, including laptops, computer software and software licenses. Funding is also required for service quantities and consumables of field measurement systems to collect oceanographic data, and for laboratory analysis systems.

Travel and subsistence

Support of travelling and subsistence is needed for attending the annual project meetings and workshops, and to present CARBOCHANGE results on international conferences.

Research cruises and VOS lines

A huge amount of data for the CARBOCHANGE project will be collected by Voluntary Observing Ships (VOS). These commercial ships plying the various oceans and seas of the world are recruited for taking and transmitting oceanographic observations on a no-cost basis. The only costs for the project arise from installation and maintaining of the measuring equipment, and for quality check and processing of the collected data.

For ocean areas where no VOS lines are available, data will be collected by research cruises; these cruises are for example planned by GEOMAR, UNIRESEARCH and CSIR. The costs for these cruises will be covered as own contributions from the institutes. EU support is needed only for transport of scientists and equipment, and for measurement and analysis systems as described above.

Computing costs

The requested budget does not include the substantial costs incurred by the computing and data storage resources consumed for the large amount of simulation years using comprehensive Earth system models. A substantial part of the costs for CPU time on supercomputing facilities will be brought into CARBOCHANGE by the partners and from external sources. Such costs are difficult to anticipate, and hence not quantified here.

Sub-contractors

We include a total of 10,000 EUR for consultancy on the efficient use of the adjoint model compiler AMC for producing the adjoint version of the MIT biogeochemical ocean model. This subcontracting is carried out under partner 24 (University of Bristol). We also include Euro 6000 for a subcontract carried out under partner 15 (UNIRESEARCH) to carry out maintenance of equipment that involves the plumbing on board the Nuka Arctica line.

B.2.4.4. Support of this project by own resources and national funding

In addition to the institutes' own contributions that will be provided for this project, especially for cruise and computing costs (see above), partners in this proposal already could attract national funding for a series of activities which will prepare the work planned in CARBOCHANGE. Further attraction of funds is envisaged and necessary to carry out all CARBOCHANGE tasks in view of the work needed to achieve our ambitious goals. Nevertheless we designed this proposal in a way, that minimum achievements can be reached also without significant outside sources. Already a number of national projects of relevance to the impact of CARBOCHANGE exist, which are presented in detail in chapter 3.1.4.

B3. Impact

B.3.1 Strategic impact

B.3.1.1 Contributions towards the expected impacts listed in the work programme in relation to changing carbon sources and sinks and future ocean carbon uptake under climate change

Significant strengthening of the understanding and quantification of the ocean carbon cycle including its impact and vulnerability to climate change:

CARBOCHANGE will deliver a closure of existing knowledge gaps on ocean carbon cycling with special emphasis on its alteration under climate change and the associated vulnerability of the ocean sink for anthropogenic carbon. The ocean is the climatically relevant Earth system component which is still the least well sampled and least well understood due to its inaccessibility and its spatio-temporal behaviour: As compared to atmospheric motion, the ocean dynamics occur on long time scales and short spatial scales. This even deteriorates the sampling difficulties and requires the thoughtful use of models in order to exploit the observations, use them for the calibration of process representations in models, interpolate between the observations through these models, and predict future carbon cycling under given emission scenarios. Exactly this is the approach used by CARBOCHANGE. The proposed project makes the best possible use of observations, models, and pre-existing process knowledge within the available funding frame to deliver:

1. Improved process quantifications on the ocean carbon cycling and the transfer of these processes through appropriate parameterisations in predictive Earth system climate models;
2. Rigorous integration of ocean carbon observations with ocean climate models through systematic performance assessment, intercomparison, and process calibration through advanced data assimilation procedures.
3. A systematic vulnerability analysis of the ocean carbon sink with respect to driving factors such as climatic change (physical variables temperature, fresh water flux, ice cover etc.) and biogeochemical forcing, in particular rising CO_2 and sinking pH value of seawater.
4. Ocean observations which document the changing ocean carbon sink and which will be merged into a coordinated most efficient ocean carbon monitoring system which will be used and further exploited/extended under the European Research Infrastructure ICOS.

The proposed work will have direct and significant impact on regulating carbon emissions, as the ocean is the key Earth system reservoir for changes in atmospheric CO_2 concentrations next to human produced CO_2 emissions:

1. The land biosphere can react quickly on short-term climatic change through respiration or re-growth of biomass and can buffer a fraction of human produced CO_2 through changes in re-growth kinetics (CO_2 fertilisation). However, the land sink may stall at further increasing CO_2 levels and even may become a source for atmospheric CO_2 once climate change has progressed further.
2. The global ocean will always react as a sink to atmospheric CO_2, with a potential to take up ca. 90% of any human produced CO_2 emissions.
3. However, this buffering capacity becomes effective only on long time scales. On shorter time scales, the change of the ocean carbon sink with time or the “oceanic CO_2 uptake kinetics” determine the temporary retention of CO_2 in the atmosphere and the respective radiative effect on surface temperatures and other climatic variables such as precipitation etc..
4. The efficiency of the oceanic carbon sink depends on the timing of the emissions and the physical as well as biogeochemical processes which may enhance or slow-down the buffering of anthropogenic CO_2.
5. Changes of the ocean carbon sink must be thoroughly observed by appropriate observing systems in order to put any model simulations on the ocean carbon sink on firm grounds.

CARBOCHANGE addresses all these points and will deliver new results which will significantly contribute to all important aspects of the quantification of the carbon sink under past, present, and future conditions.

Improvement of future climate projections:
The proposed work will directly improve future climate projections. It will do this in a measurable and verifiable form through a firm combination of best available models with best available data sets on ocean carbon. The major impact on improved climate projection will be provided through the following results:

1. New process representations in Earth system models for future climate scenarios.

2. Systematic calibrations of ocean carbon models with respect to observations, so that the new models have a calibrated sensitivity, e.g. the models will simulate changes in ocean carbon uptake more accurately than previous models. Further the calibration of model components and Earth system models of intermediate complexity with advanced data assimilation methods will pave the way for a rigorous calibration of fully fledged Earth system models in mid-term future (coming pentads), when the next generation of supercomputers will allow this technologically.
3. Continued new backbone observations of the ocean carbon sources and sinks, provide the necessary reality check and foundation for process representation in the prognostic models. The data base of measurements now will be the necessary legacy to future generations who need highest quality ocean carbon data for comparison with those data once climate change has progressed in order to re-calibrate their models for further improved climate change predictions.
4. Changes in the ocean carbon sink are vulnerable to climate change and can get regionally temporarily saturated. We will deliver an analysis on this gradual saturation for different possible future CO_2 scenarios. We will quantify the impact of mitigation scenarios on the sustainment of the ocean carbon sink and related pH levels in the ocean. We will also provide detection levels for unequivocally available changes in the ocean carbon cycling due to human-induced climate change. This will provide firm grounds for a quantification of the ocean carbon cycle feedback to climatic change.
5. We consider the changes of the ocean carbon sink on the context of the entire Earth system and in particular the land-atmosphere carbon exchange under future climate change. We do this in the model calibration part of the project as well as in the climate projection part.

We will improve the ocean biogeochemical and also the physical components of key European model systems with respect to observations. The Earths system models and coupled biogeochemical-physical ocean models are employed by key European centres of climate research. The work to be carried out will thus immediately be exploited for a better prediction of climatic and global change. The proposed work is complementary to other research work carried out in the European research area and fits this other work perfectly.

Providing a solid foundation for policy actions on climate change mitigation:

Climate change mitigation is defined as the human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2007: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.). CARBOCHANGE provides the quantification of the natural ocean sink to human produced CO_2 as the key long-term sink available in the Earth system.

International treaties and protocol aiming at limiting CO_2 emissions, and hence its impact on the radiation budget and climate, need this accurate as possible quantification on the carbon fluxes in the Earth system for given CO_2 and other greenhouse gas emission scenarios. It is essential to get this knowledge not only for a given time and region, but for many different regions, for the entire globe and – most importantly – as a function of time. The space time distribution of the ocean carbon sink as the most important long-term fossil fuel sink is of complex nature involving different feedback processes and system responses. We will provide quantifications on these fluxes and convert the knowledge into usable information for policy makers. This information on conditional predictions of the ocean carbon sink will be used by policy makers who design and enforce emission limitations as follow-up protocols and agreements to the Kyoto Protocol (United Nations, 1997, Final authentic text of the Kyoto Protocol to the United Nations Framework Convention on Climate Change, FCCC/CP/1997/7/Add.1, 60 p.), which are currently under negotiation and definition (COP15, United Nations Climate Change Conference, Copenhagen Dec 7- Dec 18, 2009, website: http://en.cop15.dk/).

The accurate knowledge of the ocean uptake kinetics with space and time are among other issues important for the following items:
1. Feasible CO_2 emission scenarios have to be defined and agreed on which allow sustained economic and ecological development which can be realised without disrupting democratic systems and causing social conflicts. The knowledge provided by CARBOCHANGE will contribute to finding the appropriate trade-offs between desired reductions of greenhouse gases and practical feasibility, and to find the correct prioritisations of respective policy actions. The proposed work will also help to minimise potentially necessary carbon capture and storage mitigation activities with their associated risks (IPCC, 2005: *IPCC*

Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [Metz, B., O. Davidson, H. C. de Coninck, M. Loos, and L. A. Meyer (eds.)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 442) and to avoid geo-engineering which potentially can cause dangerous environmental alterations (Shepherd, J., et al., 2009, *Geoengineering the climate: science, governance and uncertainty*, RS Policy document 10/09, Issued: September 2009 RS1636, The Royal Society, London, UK, ISBN: 978-0-85403-773-5, 82 pp.).

2. In view of necessary emission reductions, the boundary conditions for the scope and requirements for renewable or environmentally friendly energy production sources will be better defined when the natural carbon sink is well defined.

3. CO_2 fluxes in the Earth system have to be monitored and quantified now and in future in order to check, whether any reductions on CO_2 emissions bring the desired results on carbon uptake kinetics and pH value developments in the ocean.

4. This knowledge is also needed to take further impacts of rising CO_2 into account: The impact of ocean acidification on marine ecosystems, the food web, and marine food production, the gradual dissolution of deep-sea calcium carbonate sediment as environment and paleoclimatic sediment record, and the long-term effect on atmospheric radiation balance beyond the usual IPCC time frame.

5. Factual knowledge on fundamental ocean carbon cycle principles as guidelines for policy actions (such as oceanic turnover rates, gradual sink strength decrease due to the dependency of the ocean buffer factor on temperature changes and rising CO_2 partial pressure, etc.).

6. Annual updates to policy makers so that they can follow together with the scientists the actual trends in the ocean sink in parallel to the ongoing actual CO_2 emissions.

Reinforcement of cooperation and integration of relevant international research programs:

The ocean carbon cycle research community and the world wide carbon cycle community in general need an efficient linkage and networking in order to combine the multitude of national and continent wide research programs for the benefit of a globally as efficient as possible assessment of the evolving carbon cycle changes under changing climate and increasing human-produced greenhouse gas burdens in the atmosphere. CARBOCHANGE will reinforce cooperation between European researchers and international research programs and achieve integration of European ocean carbon cycle research within these programs. These programs and activities are described below.

The European Research Infrastructure ICOS (Integrated Carbon Observing System) - http://www.icos-infrastructure.eu: CARBOCHANGE research bridges previous carbon cycle research projects with the emerging ICOS infrastructure which is in its preparative phase. The proposed work (especially through WPs 4 and 5) serves two purposes with respect to ICOS: (i) It prepares and organises the research community so that ICOS will have an efficient and promising start-up phase. (ii) It continues measurements of the changing ocean carbon sources and sinks under the presently developing climate change pattern, so that no large gap in observational data occurs between previous projects and the operation of ICOS. The bridging function of the CARBOCHANGE work with respect to ICOS was explicitly agreed on with the European Commission on a respective *Experts meeting on 'EU-funded research on carbon cycle and greenhouse gases: Current state-of-the-art, policy implications and future research needs'*, held in Brussels on 5 October 2007.

The key carbon cycle quantification program RECCAP (REgional Carbon Cycle Assessment and Processes) of the Global Carbon Project (GCP) – http://www.globalcarbonproject.org/activities/RECCAP.htm):
As part of the Earth System Science Partnership (ESSP), the Global Carbon Project aims at a best possible quantification of the global carbon cycle and its vulnerabilities to a variety of driving factors. The assessment project RECCAP (please, see also below under input to international assessments) will be a key global assessment on air-ocean and air-land CO_2 fluxes into which CARBOCHANGE will give directly input. The seamless merging of CARBOCHANGE and RECCAP will be achieved through the current GCP chair C. Le Quéré who is also WP8 co-leader.

The core projects SOLAS (Surface Ocean Lower Atmosphere Study) and IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) of the International Exosphere Biosphere Program IGBO (see http://www.solas-int.org/ and http://www.imber.info/): Seamless merging of CARBOCHANGE with these international programs will be achieved through CARBOCHANGE PIs who are already actively involved in these programs (D. Wallace is SOLAS chair, C. Heinze is SSC member of SOLAS, T. Johannessen is chair of the SOLAS-IMBER carbon group). While the more surface ocean related process studies and observations of CARBOCHANGE are of direct interest to SOLAS, the biogeochemical process studies and the deep section data are of vital interest to IMBER. In particular, they will contribute directly to the decadal change in ocean interior carbon (DecCChange) project of the IMBER-SOLAS carbon group that aims to determine the oceanic uptake of anthropogenic CO_2 between the 1990s and the first decade of this millennium based on ocean interior carbon observations. As in the EU FP6 *Integrated Project* CARBOOCEAN, we also aim for an official endorsement of CARBOCHANGE (if funded) by SOLAS and IMBER.

<u>The SCOR core project GEOTRACES (international study of the global marine biogeochemical cycles of trace elements and their isotopes, see http://www.ldeo.columbia.edu/res/pi/geotraces/) and the related European funded COST action ES0801 “The ocean chemistry of bioactive trace elements and paleoclimate proxies” (see http://www.cost.esf.org/domains_actions/essem/Actions/Bioactive_Trace_Elements):</u> CARBOCHANGE work, especially that on biogeochemical processes in WP1 is of relevance to the international trace element project GEOTRACES. Linkage between CARBOCHANGE and GEOTRACES is guaranteed through the COST action ES0801 in which several partner institutes are members of the management committee, so that relevant issues can be brought up also at respective meetings and at COST action working group levels. In particular issues on changing particle fluxes in the ocean are of interest here.

<u>Integration with GEO/GEOSS and GMES:</u> CARBOCHANGE will be the main European supplier of oceanic carbon data to the worldwide collection of climatically relevant carbon cycle observations. The proposed activities will feed their data into the Global Earth Observation System of Systems (GEOSS) under the guiding of the Group on Earth Observations (GEO) (please, see http://www.earthobservations.org/). To this end, CARBOCHANGE will maintain close relationships to the EU FP7 coordination action COCOS (http://www.cocos-carbon.org/), which was established to support and realise the transfer of European data streams into GEOSS. The coordinator of COCOS, Han Dolman, has kindly agreed to become member of the CARBOCHANGE International Advisory Board to ensure its seamless link with COCOS and GEOSS. Several CARBOCHANGE partners are also participants in COCOS and have acted as co-authors for the emerging GEO Carbon Report (a preliminary version of this report, edited and coordinated by R. Dagarville, was presented at the COP15 climate summit at Copenhagen, December 2009).
At the same time links to the European GMES programme (Global Monitoring for Environment and Security) were established, which is the European branch of GEOSS. C. Heinze entered the Scientific Advisory Board of EU FP7 project MyOcean. MyOcean is the implementation project of the GMES Marine Core Service, aiming at deploying the first concerted and integrated pan-European capacity for Ocean Monitoring and Forecasting. CARBOCHANGE will cultivate links with MyOcean and help this project to further the biogeochemical activities, while CARBOCHANGE will benefit from MyOcean through knowledge transfer on operational observing and prediction systems.

<u>Coordinated integration with other ocean carbon cycle projects worldwide through the IOCCP:</u>
<u>IOCCP (see http://www.ioccp.org/):</u> CARBOCHANGE work, especially the data collection and data syntheses, needs careful linkage with international activities already from the planning status. The IOCCP at IOC-UNESCO (Paris) plays a key role in bringing together the different marine efforts on carbon cycle research ensuring standardised procedures so that all ocean carbon data collected are compatible with each other. The director of IOCCP, Dr. Kathy Tedesco, is member of the CARBOCHANGE International Advisor Board. Thus, a proper steering of CARBOCHANGE with respect to IOCCP requirements will be ensured.

<u>Integration with other European efforts on Earth system modelling through ENES (European Network for Earth System modelling, see http://www.enes.org/):</u> The progress to be made in CARBOCHANGE in the field of Earth system modelling will be coordinated with the European network on Earth system science through direct consultation, the link with relevant European infrastructure projects (such as EU FP7 infrastructure project IS-ENES, see http://www.enes.org/The-FP7-Project.435.0.html), through ENES meetings and respective sessions at large international Earth sciences conferences.

<u>Collaboration with the US program OCB and the NCAR modelling community</u>: Traditionally and based on requirements for optimal world wide data coverage and coordination, good relationships between US programs and European projects in the field of ocean carbon cycle research have been developed. We plan to continue further joint coordinated work and exchange representatives to important meetings of the European and US ocean carbon cycle community. We aim especially to further cultivate our links and cooperation with the OCB program (Ocean Carbon & Biogeochemistry - see http://www.us-ocb.org/ - with emphasis on ocean

carbon observations and their interpretation) as well as the NCAR modelling community (CCSM group on Earth system modelling, working group on biogeochemistry, see http://www.ccsm.ucar.edu/ and http://www.ccsm.ucar.edu/working_groups/Biogeo/). CARBOCHANGE aims at sending delegates to the respective OCB (Woods Hole, MA, USA) and NCAR CCSM (Breckenridge, CO, USA) annual meetings for exchange and fostering collaboration.

Collaboration with the Pacific Ocean program PICES (see http://www.pices.int/): The international observational data synthesis program CARINA for the Atlantic was the incentive for the circum-Pacific ocean carbon community to start a similar data synthesis effort for the Pacific Ocean under the name PICES (http://cc-s.pices.jp/table/). PICES is also the name for the organisation PICES itself (The North Pacific Marine Science Organization) which coordinates the Pacific ocean carbon research activities and data collections. Exchange between CARBOCHANGE and PICES will be extremely fruitful for achieving highest quality world wide ocean carbon data sets from measurements, which can be used for the systematic optimisation of ocean carbon models.

CLIVAR (WCRP): Under the international CLIVAR program (see http://www.clivar.org/ and http://www.wmo.ch/pages/prog/wcrp/AP_CLIVAR.html) of the World Climate Research Programme (see http://wcrp.wmo.int/wcrp-index.html), a series of coordinated data collection efforts are under taken (for planned cruises, see http://ioc3.unesco.org/ioccp/Hydrography/New_GlobalMap.html, and for completed cruises, see http://cdiac.esd.ornl.gov/oceans/RepeatSections/repeat_map.html). The data collection efforts of CARBOCHANGE are coordinated with the CLIVAR program and will contribute to its success.

Update of international program GLODAP on ocean carbon and biogeochemistry data: Under CARBOCHANGE an update of the global carbon and biogeochemistry data set GLODAP (Key, R.M., A. Kozyr, C.L. Sabine, K. Lee, R. Wanninkhof, J.L. Bullister, R.A. Feely, F.J. Millero, C. Mordy, and T.-H. Peng, 2004, A global ocean carbon climatology: Results from Global Data Analysis Project (GLODAP), *Global Biogeochemical Cycles*, 18, GB4031) is planned where also cruises that could not be integrated into the CARINA (Atlantic Ocean) and PICES (Pacific Ocean) projects. This work will be done through R.M. Key (Princeton, USA) together with European PIs (http://cdiac.ornl.gov/oceans/glodap/Glodap_home.htm).

Provide input to international assessments including the 5th IPCC report:

The proposed work will significantly contribute to international assessments on climate change and ocean acidification. We will in particular try to make contributions to the planned IPCC 5th assessment report (natural sciences basis, WGI). According to the technical support unit of IPCC WGI, deadline targets for peer reviewed publications to be included in this report are July 2012 (submitted papers) and March 2013 (accepted papers). We expect that a number of important results of this project would also be relevant for the follow-up report to the 5th assessment report. We anticipate input from CARBOCHANGE work in particular to the following chapters of the 5th IPCC assessment report which have been identified at the IPCC AR5 31st IPCC session at Bali, 26-29 September 2009:
Chapter 3: Observations: Ocean, section on: Ocean biogeochemical changes, including ocean acidification.
Chapter 6: Carbon and Other Biogeochemical Cycles, with all its planned sections involving the ocean.
Chapter 9: Evaluation of Climate Models, and specifically the sections on: Assessing model performance (including quantitative measures and their use), new model components and couplings, representation of processes and feedbacks in climate models, simulation of recent and longer term records.
Chapter 10: Detection and Attribution of Climate Change, sections on: Changes in ocean properties, pre-instrumental perspective, implications of attribution for projections.
Chapter 11: Near-term Climate Change: Projections and Predictability, sections on: Predictability of interannual to decadal climate variations and change, projections for the next few decades, atmospheric composition and air quality, quantification of the range of climate change projections.
Chapter 12: Long-term Climate Change: Projections, Commitments and Irreversibility, sections on: Projections for the 21st century, projections beyond the 21st century, forcing, response and climate sensitivity, climate change commitment and inertia, quantification of the range of climate change projections.

The new interactive climate scenarios forced by emissions (not prescribed CO_2 concentrations) performed within CARBOCHANGE and their respective vulnerability analysis will be an important input. But we expect that a series of key publications on data sets, models, processes, feedbacks, and observations of the ocean carbon sink will provide knowledge to the synthesis required in the 5th assessment report of the IPCC. Due to the timeframe for this report, the calibrated models will probably not feed as scenario computations into the report. However, they will have a significant input for subsequent assessment reports where use of models which have systematically been calibrated with measurements through data assimilation are anticipated.

Next to the 5th assessment report of IPCC, CARBOCHANGE will contribute to further international assessments. A key role in this context plays RECCAP (REgional Carbon Cycle Assessment and Processes) of the Global Carbon Project (GCP – http://www.globalcarbonproject.org/activities/RECCAP.htm). RECCAP will deliver a global assessment on air-ocean and air-land CO_2 splitted up into defined regions. The assessment will be carried out on an annual basis and will go back in time as far as it is advisable in view of the observational data coverage. The seamless merging of CARBOCHANGE and RECCAP will be achieved through C. Le Quéré (WP8 co-leader) who is the current GCP chair. The work of WPs 3 (scenario computations including hindcasts with coupled ESMs), WP6 (optimised stand-alone ocean carbon models or coupled ocean-land carbon models, extremely well suited for hindcasts), and WP7 (model intercomparison, comparison of model scenarios with observations including rigorous performance assessment of the models) will merge into RECCAP and give European scientists global visibility.

CARBOCHANGE will further contribute to AMAP, the Arctic Monitoring and Assessment Programme (see http://www.amap.no/), especially concerning the parallel developments of shrinking ice cover, warming, and progressing ocean acidification.

B.3.1.2 Planned steps in order to bring about the expected impacts

Participation in international assessments:
Several CARBOCHANGE participants are already taking part in the IPCC 5th assessment report scenario computations. Nevertheless, the CARBOCHANGE management will explicitly encourage its member PIs to actively act as authors to the IPCC report and further inform any relevant lead authors and coordinating lead authors of IPCC AR5 of WGI about emerging or published manuscripts of relevance to the report. Dissemination will play a major role here.
WP8 will steer the contributions of CARBOCHANGE to the RECCAP project (REgional Carbon Cycle Assessment and Processes) of the Global Carbon Project (through further links with WPs 3, 6, and 7).

Data management, data publication, data dissemination:
CARBOCHANGE places special emphasis on a professional data management for observational and model data. We will whenever applicable publish synthesised data sets in relevant open access journals and make new data sets available to the scientific community as well as policy makers as quickly as possible after the respective data creation. Making data sets quickly available will be key for links with international programmes and international research projects. Through cross participation in other EU projects (such as EPOCA on ocean acidification, COCOS in coordination of observational data streams, and COMBINE on new components for Earth system models and feedback analysis) we will achieve efficient synergies with other research activities in the field.

Outreach and dissemination:
The CARBOCHANGE consortium will disseminate its results through highest level peer reviewed publications to the scientific community and through dedicated outreach papers to policy makers and the general public (see also section 3.2 for details). The management of CARBOCHANGE will ensure, that the information reaches the end users directly to enhance the direct impact of new CARBOCHANGE findings.

B.3.1.3 Statement on why the contribution to these impacts requires a European (rather than a national or local) approach

Ocean carbon cycle research is too demanding to be covered by national research communities alone and needs a concerted effort. This applies also for the joint European impact in this field. Results on the changing ocean carbon sink during the past 5 years were only possible through a coordinated and integrative European effort. On one hand, the necessary measurements are too expensive and logistically complicated to be covered by only one nation, and on the other hand the modelling systems employed need to be looked at in an ensemble approach because at present no model alone can solve all questions concerning future ocean carbon uptake alone. This coordinated carbon sampling approach and the diverse model approach deserve a European effort in order to establish the best reference data sets and the most likely modelling approach. The model diversity is needed in order to cover the uncertainty spectrum, and we are not yet ready for one European Earth system model (which may never be really useful). Coordinated procedures with appropriate standards needed for observations, measurements, and data management, as well as dissemination. As the research effort on the ocean carbon sink is a team effort, the same applies to outreach and dissemination of this international work.

The extremely successful FP6 *Integrated Project* CARBOOCEAN could tackle the fragmentation of the European research area on ocean carbon cycling and could achieve results which only could be reached in a diverse interdisciplinary group of scientists from various institutes and nations. Also in CARBOCHANGE we would like to draw on this rich research community and keep this now well established team going. The carbon cycle research community already has somewhat suffered from the funding gap between CARBOOCEAN and a potential CARBOCHANGE project. CARBOCHANGE will revitalise the resources of the “brain trust” on ocean carbon uptake research mobilised under CARBOOCEAN.

A concerted research effort on the ocean carbon sink is not only necessary on a European level, but on worldwide international level. In order to accomplish this we could successfully invite University of Princeton (USA) and the Council for Scientific and Industrial Research “Ocean Systems and Climate” at Cape Town (South Africa) as contractors into CARBOCHANGE as well as two associate partners: The Earth, Atmospheric and Planetary Sciences department (EAPS) of the Massachusetts Institute of Technology, Cambridge, MA, USA, represented by Prof. Michael Follows and Dr. Patrick Heimbach, and the Pacific Marine Environmental Laboratory (PMEL) of the US National Oceanic and Atmospheric Administration (NOAA), Seattle, WA, USA, represented by Dr. Steven Hankin.

The European and international research effort brings European scientists into a pivotal position in the international research arena on carbon cycling. Through the international links a truly competitive, internationally acknowledged research community is established, maintained, and extended which can speak with a voice that cannot be overheard easily by policy makers. Due to the diverse research group as such, a balanced and objective world view on the ocean carbon sink is developed, which can serve as an international standard as such.

B.3.1.4 Statement on how account is taken of other national or international research activities

CARBOCHANGE is the European link between partner institutes throughout the European research area, US partners, and partners from Africa (Morocco, South Africa). Though the funding framework set by the European Commission for this proposal is highly appreciated, additional funding from other sources, projects, and programmes is necessary to bring out the best of the proposed research effort in CARBOCHANGE. Partners in this proposal already could attract national funding for a series of activities which will prepare the work planned in CARBOCHANGE. Further attraction of funds is envisaged and necessary to carry out all CARBOCHANGE tasks in view of the work needed to achieve our ambitious goals. Nevertheless we designed this proposal in a way, that minimum achievements can be reached also without significant outside sources. Already a number of *national projects* of relevance to the impact of CARBOCHANGE exist, where a *series of examples* is:

Project name and topic	***Funding agency***	***Partners invol.***	***Country***
CarboSeason, optimising the sensitivity of C cycle models	NFR	UiB	Norway
Greenland Climate Research Centre (expected impacts of climate change on Arctic environments and on Greenlandic society)	Danish Government in collaboration with the Commission for Scientific Research in Greenland	VitusLab	Denmark
BIOACID, Biological Impacts of Ocean Acidification	BMBF	GEOMAR, AWI	Germany
SOPRAN (German SOLAS)	BMBF	GEOMAR, AWI, MPG	Germany
SFB 754 "Climate-Biogeochemistry interaction in the Tropical Ocean"	DFG	GEOMAR	Germany
Development of a Greenhouse Gas Ocean-Atmosphere Flux Sensor with MEMS-based Photoacoustic Technology.	Science Foundation Ireland	NUIG	Ireland
Impacts of Increased Atmospheric CO_2 on Ocean Chemistry and Ecosystems	Irish Marine Institute	NUIG	Ireland
Carbon-Heat, carbon and heat transport in the	NFR	UNIRESEARCH	Norway

Nordic Seas and adjacent areas			
Phytoplankton vulnerability to global change: genetic capacity and adaptation strategies (CTM2008-05680-C02/MAR)	Spanish Ministry of Sciences and Innovation	CSIC	Spain
Inter-basin exchange in the changing Mediterranean Sea: Impact on the ecosystems in the vicinity of the Straits connecting the Mediterranean Sea with the adjacent Basins" (CTM2008-04036-E)	Spanish Ministry of Sciences and Innovation (European Network MarinERA)	CSIC	Spain
ANDREX - Antarctic Deep Water Rates of Export	UK's Antarctic Funding Initiative (AFI)	UEA, NOC	United Kingdom
The South Atlantic / Southern Ocean carbon sink: Is it significant, and is it changing?	NERC	UEA	United Kingdom
Transient tracers and Inorganic Carbon in the Oceans 2025 Climate and ocean circulation programme	Strategic Ocean Funding Initiative (SOFI)	UEA	United Kingdom
CCMAP (Climate-carbon modelling, assimilation and prediction) project	QUEST programme	UNIVBRIS	United Kingdom
Southern Ocean Carbon and Climate Observatory	CSIR and national research council	CSIR	South Africa

Internationally the links to a series of *international research activities* will enhance the impact of CARBOCHANGE in a concerted effort. Important *examples for such international projects* are:

Project name and topic	***Funding agency***	***Partners involved***
COCOS, coordination action carbon observing system	EU, FP7	UiB, CEA/LSCE, UEA, AWI, IFM-GEOMAR, UNEXE et al.
EPOCA, European project on ocean acidification	EU, FP7	UiB, CEA/LSCE, AWI, IFM-GEOMAR, NIOZ, MPG, UBERN, ETHZürich, NERC, PML, UNIVBRIS et al.
MONARCH-A (negotiations almost finished), MONitoring and Assessing Regional Climate change in High latitudes and the Arctic	EU, FP7	UiB, NERSC et al.
COMBINE, Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection	EU, FP7	UiB, MPG, MetO, et al.
MEECE, Marine Ecosystem Evolution in a Changing Environment	EU, FP7	UiB, CEA/LSCE, NERC, PML et al.
SESAME, southern europ. Seas: assessing and modelling ecosystem changes,	EU, FP6, Integrated Project	CSIC, UniHB et al.
MyOcean, Implementation of GMES marine core services	EU, FP7	IFM-GEOMAR, NERSC, NERC/NOC et al.
THOR, Thermohaline Overturning – at Risk?	EU, FP7	UiB, MPG, CEA/LSCE, UPMC, NIOZ, NERSC, MetO, NERC
DRAKKAR, The ocean circulation in the North Atlantic and the Nordic seas: Variability, processes and interactions with the global ocean	European collaboration	CEA/LSCE, IFM-GEOMAR, UPMC et al.
SOLAS, Surface Ocean Lower Atmosphere Study	IGBP and multiple	UiB, IFM-GEOMAR, CEA/LSCE, UPMC, AWI, UEA, CSIC et al.
IMBER, Integrated Marine Biogeochemistry and Ecosystem Research	IGBP and multiple	UiB, CEA/LSCE, IFM-GEOMAR, NIOZ, UNIRESEARCH, et al.
ICOS, Integrated Carbon Observing System	EU and multiple	CEA/LSCE, UEA, UiB, UGOT, MRI-UI et al.
GEOTRACES, international study of the global marine biogeochemical cycles of trace elements and their isotopes	SCOR and multiple	CEA/LSCE, UiB, AWI, IFM-GEOMAR
ENES and IS-ENES, European Network for Earth System modelling & infrastructure project	Multiple and EU	CEA/LSCE, MetO, MPG

GLODAP, ocean carbon and biogeochemistry data	NSF and various	PU-AOS, UiB, UEA, AWI, UPMC, et al.
RECCAP, REgional Carbon Cycle Assessment and Processes	Multiple and ESSP	UEA, UBERN, MPG, MetO, UiB et al.
NCAR CCSM, community climate system model	NOAA, NSF and various	UiB, UNIRESEARCH, UBERN

B.3.1.5 Assumptions and external factors that may determine whether the impacts will be achieved

The impact of CARBOCHANGE on policy makers and climate change mitigation will strongly depend on the pathways for delivery to the end users. We plan a number of targeted products to be delivered to policy makers. We will design these deliverables thoroughly and on the highest scientific level (but at the same time completely understandable by informed policy makers) and thus make them ultimately efficient. In order to make the information provided of optimal impact, a direct consultation with European and international policy makers would be the most efficient way to transfer the new knowledge to the political and legislative realm. One of the main tasks of the CARBOOCEAN scientific project manager thus will be to thoroughly and diplomatically explore the optimal pathways for CARBOCHANGE outreach deliverables to reach the policy makers and their teams without getting diluted and un-heard in the vast amount on not relevant climate change information floating around. This direct approach will complement the general dissemination approach pursued in addition.

B.3.2 Plan for the use and dissemination of foreground

B.3.2.1 Measures for the dissemination and/or exploitation of project results

Target groups for dissemination of CARBOCHANGE results: The new results of CARBOCHANGE on the vulnerability of the ocean carbon sink under climate change and the respective implications for climate stabilisation scenarios and relevant policies address first of all policy makers. Also the impact of CARBOCHANGE – namely to provide a solid foundation for policy actions on climate change mitigation – identifies policy makers as relevant primary end users next to the scientific community on climate change (including interdisciplinary groups dealing with climate change impacts, ocean acidification, societal issues associated with climate change such as migration and food production, and energy production). As new policies also require a well informed general public and a multiplication of knowledge through media, we focus here on policy makers, the mass media, and the general public as primary target groups.

Communication means: All WPs will disseminate their results, however, special emphasis and deliverables on outreach will be provided in WPs 8, 9, and 10. A core element of the CARBOCHANGE communication system will be its professionally designed project website including a "who is who" to directly channel respective requests to the appropriate PIs and partners of the project. Information of the project PIs about the EU publication on communications (a. *European Research – a guide to successful communications*, Luxembourg: Office for Official Publications of the European Communities, 2004, ISBN 92-894-7882-9, 48pp.; b. *Communicating Science – a scientist's survival kit*, by Giovanni Carrada, European Commission, Directorate-General for Research, Office for Official Publications of the European Communities, 2006, ISBN 92-79-01947-3, 76pp., see: http://ec.europa.eu/research/science-society/science-communication/index_en.htm) will be forwarded to all project PIs at the start of the project and at the kick-off meeting to facilitate communication with other scientists, policy makers, and the public at large.

In order to distribute new scientific results (data sets, model output, modelling tools, methods, and quantifications) to the **scientific community** we will use the following dissemination means: .

- Publications in peer reviewed journals including highest level transdisciplinary scientific journals.
- Promotion of open access journals.
- Dedicated peer reviewed publications of data sets.
- Newsletters of large international journals.
- Project website including a CARBOCHANGE data portal.
- Use of data bases which allow download of data through public graphical interfaces
- Oral and poster presentations at international conferences dealing with climate change
- Dedicated CARBOCHANGE sessions at international conferences.
- Presentations at annual meetings of national and international projects.

- Dedicated email notification of specifically targeted users (electronic reprints etc.)
- Consequent acknowledgment of the EU funding agency and CARBOCHANGE

In order to inform **policy makers**, we will use the following means of communication:

- Summaries for policy makers of international assessments such as the 5th IPCC report
- Policy briefs (where applicable through large international projects such as SOLAS and GCP).
- Fact sheets about the project on the basic scientific facts about the ocean carbon sink
- Special section on informations for policy makers on the project website.
- Articles in information journals for politicians such as the *Parliament Magazine*.
- Direct communications with the scientific EU officer and specifically targeted EU meetings
- Direct communications with relevant policy makers
- Booths and/or presentations at important policy meetings (such as the post-COP15 meetings).

For communication means for informing the mass **media** and the **general public** at large will aim at:

- Press releases.
- Special sections for press, TV, and broadcasting on the project website, use of open access journals.
- Press kits on website.
- Dedicated oral presentations at local, regional, and national level (such as open house events) ,
- Invitation of press representatives to open sessions of annual CARBOCHANGE meetings.
- Public outreach events at annual CARBOCHANGE meetings.

Increase of the project's impact through these measures: We expect a considerable increase of the project's impact through these measures, as we will target concise but nevertheless comprehensive enough informations to specific end users in order "*to pick them up, where they stand in their respective actual context*". The communication to other scientists, to policy makers, and to the general public will provide the three pillars of (a) new expert knowledge in order to close further knowledge gaps, (b) cutting edge knowledge and background information in order to efficiently design feasible policies on climate change mitigation, and (c) information to the general public who needs to legitimate and execute the measures for climate change mitigation in their daily life.

B.3.2.2 Plans for the management of knowledge (intellectual property) acquired in the course of the project

The management of knowledge in CARBOCHANGE will be regulated in detail through four measures: the consortium agreement (regulating also the use of previous knowledge in the project), the data management, the data policy, and the IPR panel. As our proposed work at this stage does not foresee any patentable knowledge, we expect that we can build on our experience from previous and ongoing European as well as international research projects. Baseline for all management knowledge will be good scientific practice (as described, e.g., at *Guide to Good Practice in Science and Engineering Research*, Office of Science and Technology, EPSRC 2002-2006, Engineering and Physical Sciences Research Council, UK, 5 pp., see: http://www.epsrc.ac.uk/ResearchFunding/GrantHolders/GuideToGoodPracticeInResearch.htm). The *consortium agreement* will regulate all issues on intellectual property rights and their protection including the use of previous knowledge to be exploited by CARBOCHANGE. We will explicitly encourage the use of open access journals for publications in order to make all material including figures easily usable and exploitable by others. The *data management* procedures will ensure a proper handling of all data and their meta information so that the intellectual property rights of scientists are protected, but also relevant data policies are fulfilled in order to maximise the impact and exploitation of observational as well as model output data. The *data policy* will be based on the data policy used previously in projects such as the FP6 *Integrated Projects* CarboEurope-IP and CARBOOCEAN. We will update these policies in particular with new issues emerging from the EU FP7 coordination action COCOS, aiming at an improved interoperability of data sets internationally and at shortening the time interval between data production and public release. The *IPR panel* will monitor the handling of Intellectual Property Rights in the project and will contribute to solving potential cases of conflict before they become an issue.

B4. Ethical Issues

None of the ethical issues listed in the table apply to this proposal.

ETHICAL ISSUES TABLE

	Research on Human Embryo/ Foetus	YES	Page
*	Does the proposed research involve human Embryos?		
*	Does the proposed research involve human Foetal Tissues/ Cells?		
*	Does the proposed research involve human Embryonic Stem Cells (hESCs)?		
*	Does the proposed research on human Embryonic Stem Cells involve cells in culture?		
*	Does the proposed research on Human Embryonic Stem Cells involve the derivation of cells from Embryos?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	
	Research on Humans	**YES**	**Page**
*	Does the proposed research involve children?		
*	Does the proposed research involve patients?		
*	Does the proposed research involve persons not able to give consent?		
*	Does the proposed research involve adult healthy volunteers?		
	Does the proposed research involve Human genetic material?		
	Does the proposed research involve Human biological samples?		
	Does the proposed research involve Human data collection?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	
	Privacy	**YES**	**Page**
	Does the proposed research involve processing of genetic information or personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?		
	Does the proposed research involve tracking the location or observation of people?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	
	Research on Animals	**YES**	**Page**
	Does the proposed research involve research on animals?		
	Are those animals transgenic small laboratory animals?		
	Are those animals transgenic farm animals?		
*	Are those animals non-human primates?		
	Are those animals cloned farm animals?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	
	Research Involving Developing Countries	**YES**	**Page**
	Does the proposed research involve the use of local resources (genetic, animal, plant, etc)?		
	Is the proposed research of benefit to local communities (e.g. capacity building, access to healthcare, education, etc)?		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	
	Dual use	**Yes**	**Page**
	Research having direct military use		
	Research having the potential for terrorist abuse		
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	X	

B5. Consideration of gender aspects

The CARBOCHANGE consortium has identified the integration of gender diversity as a component of its overall organisation, and important in achieving the scientific goals of the project. Thus, gender representation will be considered in recruitment, training, management and scientific work aspects of CARBOCHANGE. Following European Commission guidelines, the planning of this project will adopt specific measures to promote gender equality and the integration of gender issues into the research.

The CARBOCHANGE consortium includes 85 principal investigators, 73 male and 12 female. For 6 of the 27 partners, women are identified as responsible PIs. One woman acts as a core theme leader, and 5 are work packages leaders.

The Gender Panel of CARBOCHANGE will consist of two project members (Chapter 2.1.1.). This panel will be responsible for CARBOCHANGE's gender action plan as described in section 2.1.2 and give advice to the Scientific Steering Committee and the Executive Board on its implementation. The members will make recommendations on relevant gender issues related to recruitment of CARBOCHANGE staff and monitor how special needs for female researchers are being taken into account in the various research, outreach and training activities.

The Gender Action Plan will be a working document to promote discussion and management of gender issues within the project. It will be implemented and monitored by the Gender Panel. Particular goals are:

- promote gender equality in recruitment
- promote participation of women in courses, seminars and conferences
- develop avenues for financial support for scientists with children to be able to participate in field work
- promote selection of working hours convenient for mothers
- invite women to scientific and organizing committees.

Major areas of activity planned by the Gender Panel within CARBOCHANGE are:

- Monitoring gender balance during the whole project period and promoting awareness of the project partners of gender issues at all levels (annually report on gender actions)
- Strengthening the role and participation of women scientists (network of women scientists, special meetings and public web page on gender actions)
- Promoting and supporting methods to reconcile work and private life (e.g. video conferences, family-friendly meeting times, child care programs at meetings)
- Promoting educational activities on gender balance outside the project (e.g. national girls days, student training, school visits) within the participating institutions of CARBOCHANGE.