European Commission

EU-funded research on the Carbon Cycle

Presented at the 9th International Carbon Dioxide Conference (ICDC9)

Beijing, China
3 > 7 June 2013

Research and Innovation

EUROPEAN COMMISSION

Directorate-General for Research and Innovation
Directorate I - Environment
Unit I.4 — Climate Change & Natural Hazards

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2013 Directorate-General for Research and Innovation

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EUROPE'S FRAMEWORK PROGRAMMES FOR RESEARCH

The Framework Programmes for Research (FP) represent the European Union's (EU) main instrument for funding research in Europe. With a budget allocation of over €50 billion for the period 2007-2013, the Seventh Framework Programme (FP7) is one of the largest research programmes in the world. Funded through the contributions from 27 EU Member States and 14 associated countries[1], its scope extends well beyond these countries, both in terms of subject matter and participation.

The EU's FPs allocate grants and fellowships for specific research activities. Activities receiving FP7 funding must demonstrate a European added value. This may take different forms: the European added value of an initiative may rest in that it tackles research challenges too complex or costly to be led by a single (European) country, or it may be that it raises competition between scientists in fundamental research across Europe. For many actions, the key added value is trans-nationality. For instance, collaborative research projects must include participants from different European countries.

The EU is a major funder of carbon cycle research. Over the last decade, EU grants in this field have amounted to over € 120 million. Funding to carbon cycle research has been allocated across four FP7 Specific Programmes: Cooperation (collaborative research projects), Capacities (infrastructures for research), People (career development and mobility for researchers) and Ideas (frontier research).

A large proportion of the available funding has been provided under the Cooperation Specific Programme and in particular within the 'Environment (including climate change)' Programme.

This booklet presents a selection of key research projects on carbon cycle that have received FP7 funding.

[1]Switzerland, Israel, Norway, Iceland, Liechtenstein, Turkey, Croatia, the Former Yugoslav Republic of Macedonia, Serbia, Albania, Montenegro, Bosnia&Herzegovina, Faroe Islands, Republic of Moldova.

PROSPECTS BEYOND 2014: HORIZON 2020

In 2011, the European Commission proposed a new financial instrument to fund research and innovation in Europe from 2014 to 2020. This is the Horizon 2020: The EU Framework Programme for Research and Innovation.
Horizon 2020 will be the key instrument to implement the EU's Innovation Union, one of seven Europe 2020 Strategy flagship initiatives aimed at securing Europe's global competitiveness.
For the first time, a single EU instrument will integrate support to research and to innovation. It will do so by providing seamless and coherent funding throughout the innovation cycle, from fundamental research to the commercialisation of new ideas.
Horizon 2020 will comprise the following three pillars:

- Excellent science, which will aim at raising the level of excellence in Europe's science base;

- Industrial leadership to turn Europe into a more attractive place for business and investment in Research and Development; and

- Societal challenges of major concern to Europeans (such as health and wellbeing, food security and sustainable agriculture, climate change and resource efficiency, clean and efficient energy, green transport, inclusive societies)

This new programme and in particular the societal challenges pillar will operate through annual calls for proposals and emphasise funding for projects and initiatives that address specified challenges as opposed to prescribing specific research topics as has been the case hitherto. In many cases, this will mean more multidisciplinary, multi-actor actions that bring together and integrate different competences across Europe and beyond.

Despite this change in approach, the societal challenges and key enabling technologies identified for Horizon 2020 will provide a measure of continuity with FP7 thematic areas. They will closely map EU policy goals in such areas as agriculture, energy, climate change, transport and security.

CARBO-Extreme

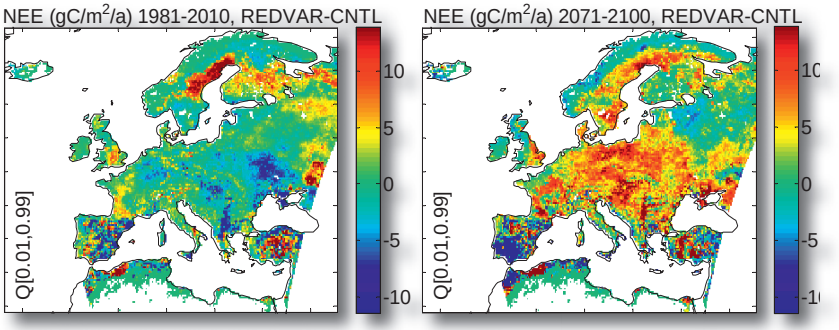
THE TERRESTRIAL CARBON CYCLE

under climate variability and extremes a Pan European synthesis

CARBO-Extreme analyses the impact of climate extremes on the terrestrial carbon cycle. Multiple evidence indicates water-cycle extremes (in particular droughts) being a dominant threat to the carbon cycle in large parts of Europe. Climate extremes have the most diverse, largest, and longest-lasting effects in forests.

One of the major unknowns in climate research is the reaction of the terrestrial carbon cycle to climate variability and extremes, which may alter the response to gradual changes like rising temperature and CO2 concentration. CARBO-Extreme aims to 1) advance the understanding of effects of climate variability and extremes on the terrestrial European carbon cycle based on long-term carbon observations, ecosystem manipulation experiments and a comprehensive model-data integration framework, 2) project the European terrestrial carbon cycle at the end of the century, and 3) analyze the vulnerability of the carbon cycle. Specific regional effects include the impacts of warmer and wetter winters and longer growing seasons in Northern Europe, of hotter and drier summers in Central and Southern Europe, as well as the overall more variable climate in the temperate zone. Multiple evidence indicates that water-cycle extremes, in particular droughts, are a dominant threat to carbon cycle related ecosystem services. Taken together, climate extremes appear to have the largest, most diverse and longest-lasting consequences for carbon cycling in forests compared to other land-cover types.

Ecosystem manipulation experiments with "rainout-shelters" at Stubai, Austria (copyright by Michael Bahn, University of Innsbruck, Austria)



Differences of decadal average of annual Net Ecosystem Exchange (NEE) between two JSBACH simulation experiments, one forced by a climate dataset with reduced variability and extreme events (REDVAR) and the control climate data. Shown are results for a recent period (1981-2010, left-hand side) and a period in future (2071-2100, right-hand side). (copyright by Christian Beer, Max-Planck-Institute for Biogeochemistry Jena, Germany)

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CARBOCHANGE

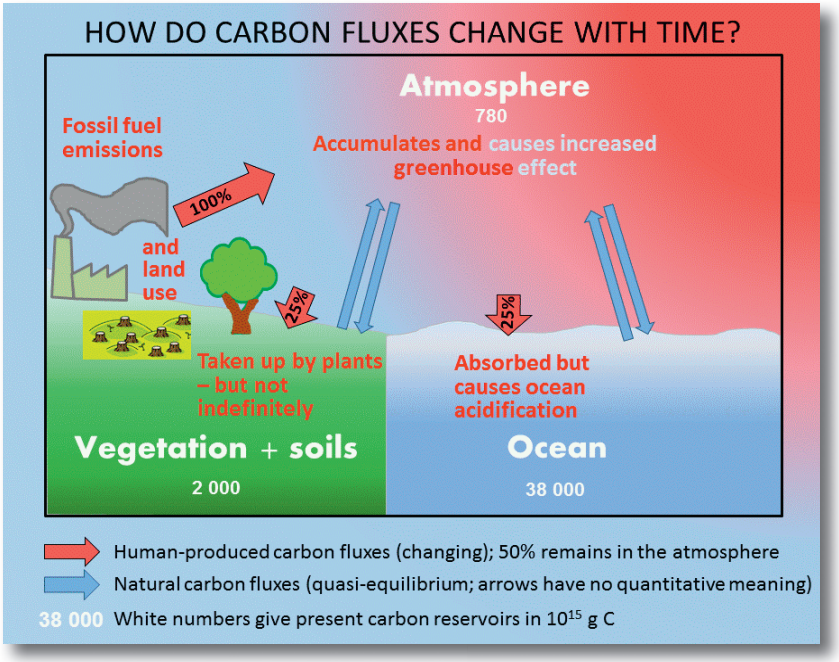
CHANGES IN CARBON UPTAKE

and Emissions by Oceans in a Changing Climate

CARBOCHANGE aims at quantifying the ocean's role in the uptake of human-produced carbon dioxide in the past, at present, and in the future. By contributing to international assessments, CARBOCHANGE contributes to science-based management of CO2 emission reductions.

CARBOCHANGE aims at quantifying the ocean's role in the uptake of human-produced carbon dioxide, and at investigating how large this uptake rate has been in the past, how it is changing at present, and how it will evolve in the future. Carbon dioxide in the surface ocean has to pass through the bottleneck of oceanic mixing on its way to the deep ocean. Climate change feedbacks and biogeochemical processes further modify the oceanic absorption of carbon dioxide. CARBOCHANGE employs cutting-edge measurement and modelling techniques to observe the ongoing carbon dioxide uptake by the oceans, to understand the underlying processes, and to predict future changes in uptake. The project places special emphasis on a systematic combination of ocean carbon observations and ocean models through advanced model performance assessments and data assimilation methods.

CARBOCHANGE results contribute to international assessments such as the Global Carbon Budget 2011 and 2012, and the IPPC 5th Assessment Report. CARBOCHANGE thus provides science-based guardrails for political decisions on mitigation actions in order to control and alleviate the impact of carbon dioxide emissions and climate change.



Carbon dioxide from fossil fuel burning and land use changes is the main driver for human-induced climate change. Currently, the ocean takes up about 25 % of the annually emitted CO2 but this rate is changing.

CARBOCHANGE surface observation network.

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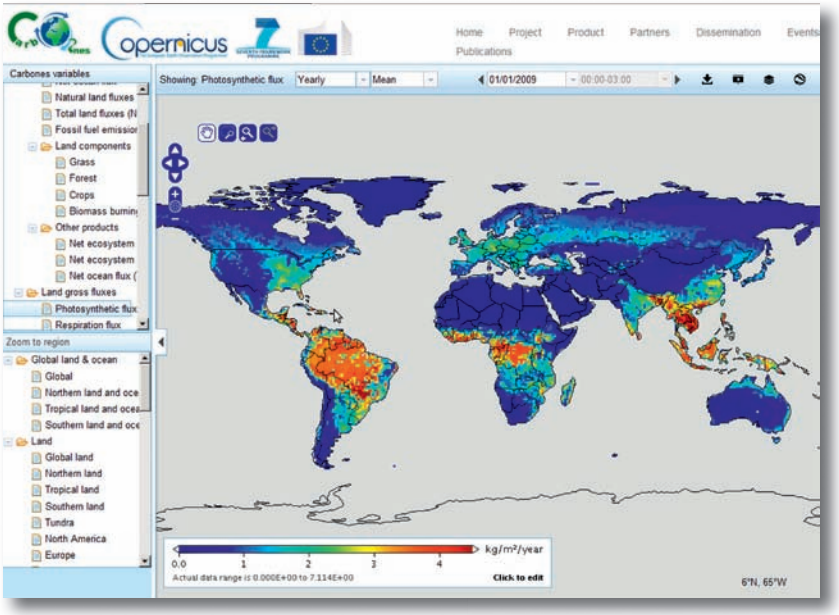
CARBONES

20-YEAR RE-ANALYSIS OF CARBON FLUXES

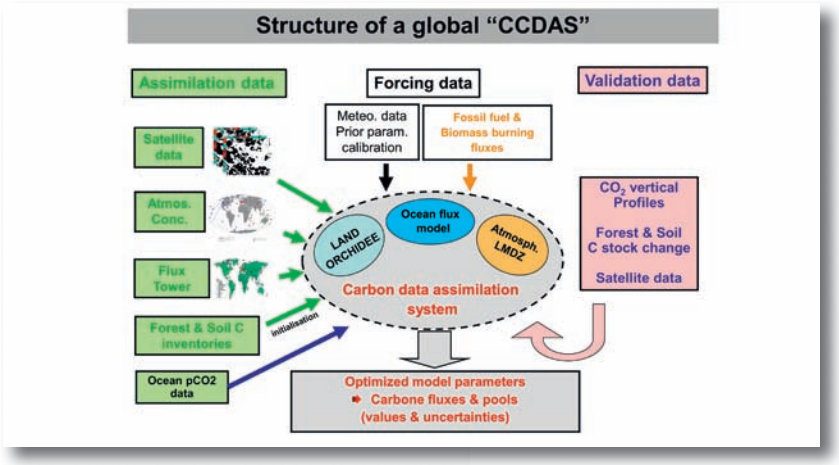
and pools over Europe and the Globe

CARBONES is an information system that provides calibrated state-of-the-art 20 year-long global reanalysis of space and time variations of carbon fluxes and stocks at 1°resolution.

CARBONES is a global information system that provides comprehensive information on the spatial and temporal distribution of carbon fluxes and pools over the Globe. The aim is to deliver state-of-the-art information on the history of the carbon cycle, based on a carbon cycle data assimilation system (CCDAS) using available observations of the terrestrial and oceanic carbon-cycles: ocean surface CO2 partial pressure, atmospheric CO2 concentrations, remotely-sensed vegetation properties and in situ ecological data. The main CARBONES product is a calibrated 20 year-long reanalysis of space and time variations of carbon fluxes (3 hourly) and stocks at 1°resolution. This reanalysis includes the surface-atmosphere CO2 fluxes (net and gross fluxes), leaf area and biomass stocks in various categories of land ecosystems. The service may serve as a benchmark for core services carbon products and provides a baseline for predicting future responses of the carbon-cycle. The CARBONES data products and diagnostics are publically available through a web interface. Dissemination material and interactive visualisation tools give scientists and public organisations a general view of the living carbon cycle and allow visualisation and downloading of the CARBONES products as well as their comparison against



Demonstration of the CARBONES portal displaying the Carbon Photosynthetic flux averaged for year 2009.



Schematic presentation of the CARBONES global information system. Long-term observations of the terrestrial and oceanic carbon-cycles are divided into: assimilation, forcing and validation data.

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COMBINE

COMPREHENSIVE MODELLING

of the Earth System for Better Climate Prediction and Projection

The COMBINE project comprises component workpackages which aim to bring together latest understanding and modelling in carbon cycle, aerosol, cryosphere and stratosphere into new and improved Earth System Models. Improved initialisation techniques will also be developed and both near-term and long-term projections made with the new ESMs and feedback analyses performed to examine the role of the new components.

The European integrating project COMBINE brings together research groups to advance Earth system models (ESMs) for more accurate climate projections and for reduced uncertainty in the prediction of climate and climate change in the next decades. COMBINE will contribute to better assessments of changes in the physical climate system and of their impacts in the societal and economic system. The proposed work will strengthen the scientific base for environmental policies of the EU for the climate negotiations, and will provide input to the IPCC/AR5 process. We aim to more fully represent the carbon cycle in ESMs including representation of the nitrogen cycle, permafrost and natural sources of methane such as from fire and wetlands. We will consider the nitrogen cycle both in its capacity to moderate the carbon cycle (e.g. through limitation of vegetation growth) and its role in emissions of nitrous oxide - a greenhouse gas in its own right. Climate-carbon cycle feedback analysis of CMIP5 ESMs, to which COMBINE forms a contribution, shows that model-spread in ocean carbon response to changing CO2 and climate has reduced since C4MIP but there remains a very large model spread in the response of land-carbon. sions and climate change.

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GEOCARBON

TOWARD AN OPERATIONAL

Global Carbon Observing System

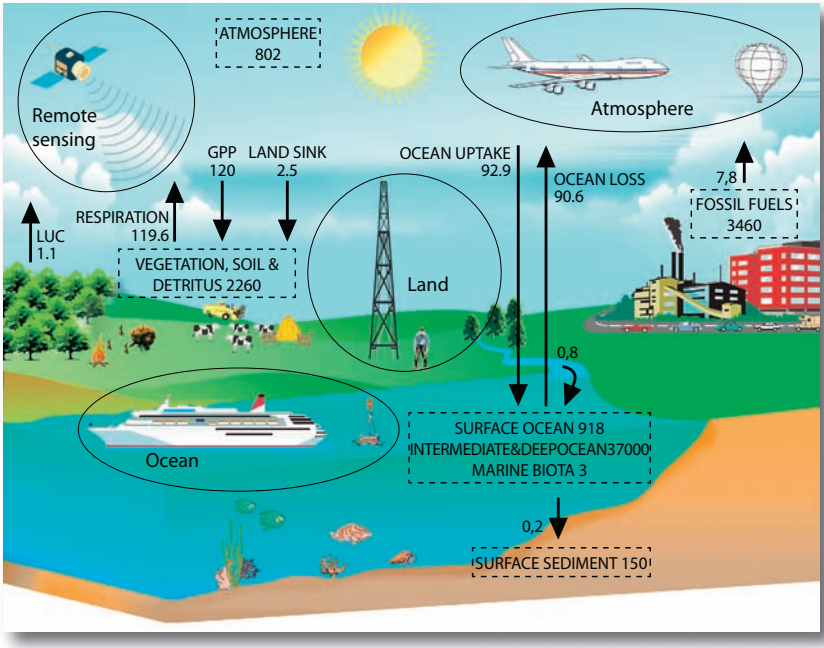
GEOCARBON aims at designing a coordinated Global Carbon Observation and Analysis System, addressing the climate targets of the Group on Earth Observations (GEO) toward building a Global Earth Observation System of Systems (GEOSS) for carbon.

Project's objectives are:

1. Provide a harmonized set of global carbon (CO2 and CH4) data and information, integrating the land, ocean, atmosphere and human dimension
2. Develop improved Carbon Cycle Data Assimilation Systems (CCDAS)
3. Provide improved regional carbon budgets of Amazon and Central Africa
4. Provide annual estimates of carbon sources and sinks for the globe and for large ocean and land regions
5. Define the specifications for an operational Global Carbon Observing System
6. Provide an economic assessment of the value of an enhanced Global Carbon Observing System
7. Strengthen the effectiveness of the global Carbon Community participation in the GEO system and link with EC, decision makers and stakeholders.

The provision of improved and coordinated global carbon data, that will be incorporated into the improved CCDAS and integrated with other available information, will lead to new carbon balance estimates, from regional to global level, with a focus on tropics and a reduced uncertainty. The scientific results will be then turned into policy relevant information, including the requirements for an optimal operational carbon observing system and the assessment of its economic value.

A picture from of the top of the new observation (under development) site in Kogyae Ghana - in the foreground dry forest, in the background savanna.



The global carbon cycle and its observing systems.

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GHG-Europe

GREENHOUSE GAS MANAGEMENT

in European land use systems

Improved quantitative understanding of the biogeochemical responses and the greenhouse gas balance in managed terrestrial ecosystems to changes in natural and anthropogenic drivers.

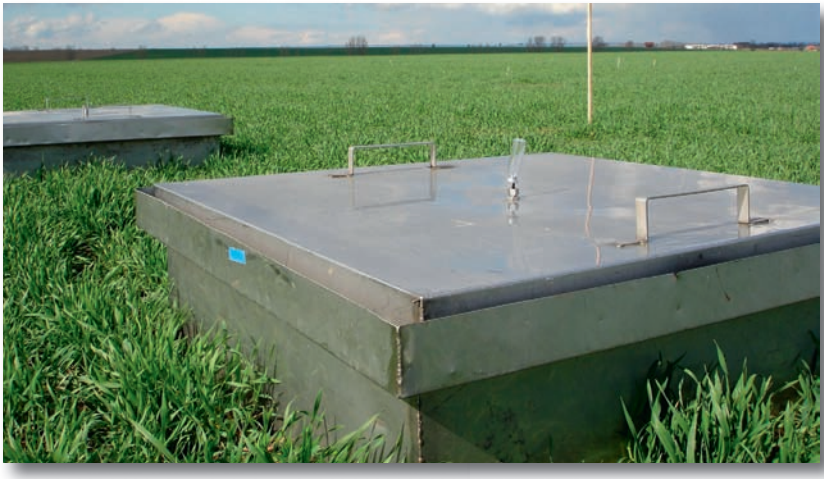
GHG-Europe aims to improve our understanding and capacity for predicting the European terrestrial carbon and greenhouse gas (GHG) budget by applying a systematic, comprehensive and integrative approach. GHG-Europe quantifies the annual to decadal variability of the carbon and GHG budgets of terrestrial ecosystems via data-model integration, diagnostic and predictive modelling. Ultimately, the scientific challenge is to determine how, and to what degree, the carbon cycle and GHG emissions in terrestrial ecosystems can be managed.

An important finding for forests was that the stimulatory effect of nitrogen deposition in most European forests does not stem from increased photosynthesis, but from increased carbon allocation to wood. This could increase forest vulnerability to extreme events.

Although afforestation is thought to sequester carbon it turned out that afforested grasslands accumulate labile soil organic carbon but the stable fractions are depleted. This makes the soil carbon pool more vulnerable to future disturbance and loss.

Croplands are the largest N_2O source in Europe. Sensitivity analyses with models showed that there is some scope for mitigation by changes in the timing and forms of fertilizer applications.

Eddy-Covariance grassland site, The Netherlands



Chamber measurements (N_2O, CH_4) at farmland site, Germany

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GREENCYCLESII

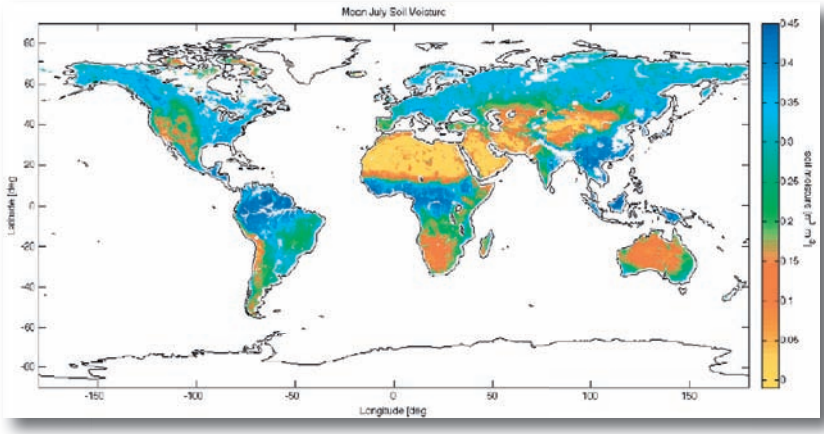
ANTICIPATING CLIMATE CHANGE

and biospheric feedbacks within the Earth system to 2200

GCII is working to produce, compile, and use key global datasets and diverse modelling approaches to improve understanding of the behaviour of the coupled climate-biogeochemical system.

The overall science objective of GREENCYCLESII (GCII) is to substantially improve current understanding of the impacts of climate-biogeochemistry feedbacks on the evolution of the Earth system over the next two centuries. Earth System Models (ESMs) are key tools for understanding and predicting Earth system behaviour, particularly with respect to the potential impacts of rising concentrations of anthropogenic greenhouse gases (GHGs). GCII is working to improve substantially the predictive capability of ESMs through linked data and modelling activities. Research projects are broadly classed into data and model benchmarking, marine processes, terrestrial processes, high latitude feedbacks, and coupled modelling. Methods we are using consist of data compilation and processing to produce benchmark standards, model development and testing, and data production through the analysis of ice core samples, remote sensing data, and in situ measurements of marine carbon (C) transport. Constraints from global-scale datasets and improved process understanding are being integrated into a wide range of ESMs to enable rigorous uncertainty analysis of the range of possible future Earth system states.

"Above the Canopy": View from above the Rainforest canopy from the tower at Cristalino Lodge, Alta Floresta, Mato Grosso, Brazil.



Global map of retrieved volumetric surface soil moisture for a mean July month - the soil moisture data has been created using an innovative neural network based retrieval algorithm that exploits the synergy of microwave, infrared and visible satellite observations to create a global and long-term soil moisture product.

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ICOS

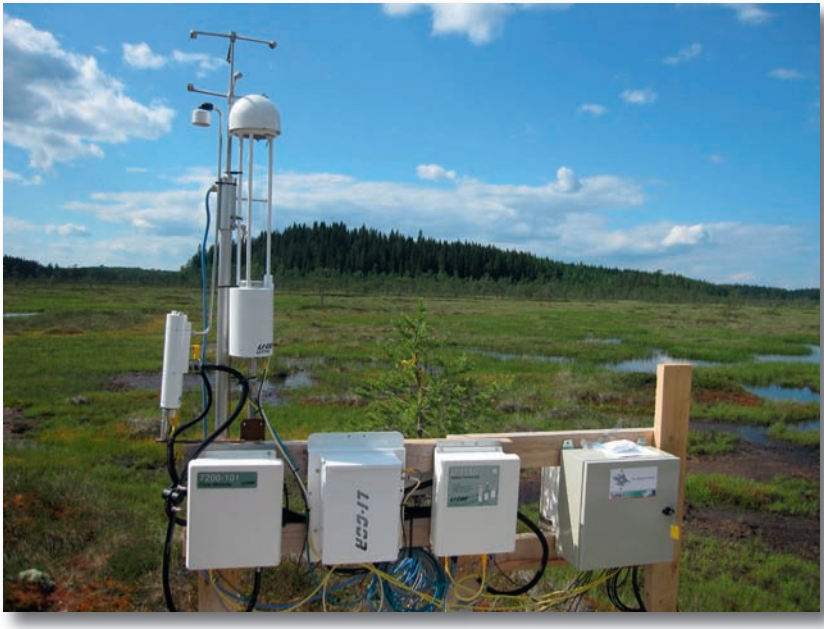
INTEGRATED CARBON OBSERVATION SYSTEM

The mission of ICOS RI is to enable research to understand the greenhouse gases budgets and perturbations. ICOS RI provides the long-term observations required to understand the present state and predict future behavior of the global carbon cycle and greenhouse gas emissions.

The first objective of ICOS RI is to provide effective access to a single and coherent data set to facilitate research into multi-scale analysis of GHG emissions, sinks and the processes that determine them. ICOS RI aims to establish a template for the future development of similar integrated and operative GHG observation networks beyond Europe.

The second objective is to provide information, which is profound for research and understanding of regional budgets of greenhouse gas sources and sinks, their human and natural drivers, and the controlling mechanisms. ICOS will permit to detect changes in regional greenhouse gas fluxes, early warning of negative developments and the response of natural fluxes to extreme climate events, to reduce uncertainties in Earth System models.

Even though the ICOS RI station network is designed to monitor biospheric and oceanic fluxes rather than anthropogenic emissions, ICOS RI will provide independent data to help improve emission inventories, for monitoring the applications of international conventions like the Kyoto protocol. Linking research, education and innovation promotes technological development related to greenhouse gases.



Tall tower for measurements of the atmospheric concentrations of greenhouse gases.

Flux tower set-up for measurements of the greenhouse gas exchange rates over wetland.

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InGOS

INTEGRATED NON CO2

Greenhouse gas Observing System

Non CO2 greenhouse gas measurements over Europe and the source attribution calculations based on inverse modelling.

The increase in atmospheric greenhouse gases (GHGs) are causing significant changes in Earth's radiation balance. At present, the non-CO2 GHGs (NCGHG) contribute about 37% (0.97 Wm-2) of the global anthropogenic radiative forcing of all long-lived GHGs. For gas species like methane (CH4) and nitrous oxide (N2O), there is still substantial uncertainty in the emission levels from different source systems. Manmade NCHGH's like halocarbons and SF6, are very potent greenhouse gasses in terms of their global warming potential. Some species show decreasing concentration levels, other components are increasing. InGOS keeps track of these changes.

With the development of common quality control and quality assurance procedures InGOS aims to further integrate the existing European facilities for monitoring of NCGHGs in the atmosphere, at ecosystem flux sites and over the ocean. Also, new measurement techniques and instrumentation are explored, thus giving these observations an operational, long-term monitoring perspective.

The atmospheric measurements of greenhouse gasses can be used for so called 'top-down' emission estimates that provide independent values on national or regional scales.

Methane flux measurement intercomparison Campaign at Cabauw the Netherlands in summer 2012. Comparison of state of the art methane measurement systems.

Cabauw tall tower, one of the supersites in the InGOS measurement network.

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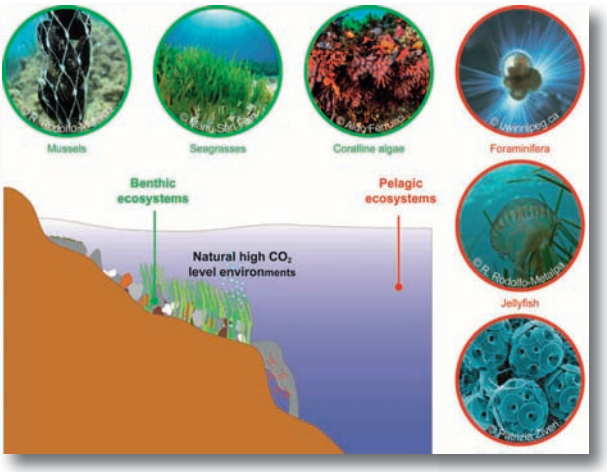
MedSeA

MEDITERRANEAN SEA ACIDIFICATION

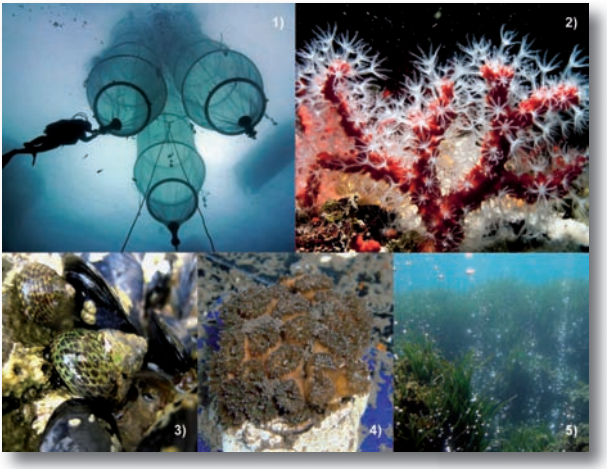
in a changing climate

Impacts of Mediterranean Sea acidification and warming on its ecosystems and socio-economy.

MedSeA is assessing the chemical, climatic, ecological, biological, and economical changes of the Mediterranean Sea driven by increases in CO2 and other greenhouse gases (OA and ocean warming). The emphasis is on the combined impacts of these pressures on endemic calcifying species and related biogeochemical processes, in order to detect changes in calcification, fitness, productivity, biodiversity and food web functioning. Our findings suggest that the degree of OA and warming expected over the next 100 years may have major consequences for the biodiversity and biogeochemistry of endemic and keystone species Mediterranean coastal ecosystems such as coralline algae. Other habitats such as sea grass meadows are expected to suffer from elevated seawater temperature and invasion by non-indigenous algae species, which benefit from increased pCO2 and elevated temperature. A central goal is to provide science-based projections of Mediterranean acidification under the influence of climate change as well as associated economic impacts. Projections are being based on new observations of chemical conditions as well as new observational and experimental data on the responses of key organisms and ecosystems to OA and warming, which will be fed into existing ocean models that have been improved to account for the Mediterranean fine-scale features. These scientific advances will allow us to provide the best advice to policymakers who must develop regional strategies for adaptation and mitigation.



MedSeA targets the study of key habitat-forming species of coralline algae, seagrass, corals and vermetids that are endemic to the Mediterranean as well as the commercially important species that these habitats support. MedSeA combines laboratory, mesocosm and volcanic CO2 vents to examine the long-term effects of elevated CO2 on the structure and function of benthic communities.



A view from below of 3 MedSeA mesocosms deployed in June-July 2012 off Corsica (1). The MedSeA mesocosm experiments are testing how elevated CO2 conditions (ocean acidification) will affect marine planktic life in Mediterranean oligotrophic waters. Several endemic benthic organisms (2-4) are also study to know how a warmer and more acidic Mediterranean Sea will affect them. Natural CO2 degassing (5) are used in MedSeA as natural laboratories for studying the impact of changing seawater carbonate chemistry on

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PAGE21

CHANGING PERMAFROST IN

the Arctic and its Global Effects in the 21st Century

The EU FP7 project PAGE21 has started in November 2011 for the duration of 48 months. It aims to understand and quantify the vulnerability of permafrost environments to a changing global climate, and to investigate the feedback mechanisms associated with increasing greenhouse gas emissions from permafrost zones.

PAGE21 aims to understand and quantify the vulnerability of permafrost environments to a changing global climate, and to investigate the feedback mechanisms associated with increasing greenhouse gas emissions from permafrost zones. This research makes use of a unique set of Arctic permafrost investigations performed at stations that span the full range of Arctic bioclimatic zones. The PAGE21 consortium signed a Memorandum of understandings with the Canadian permafrost research project «ADAPT – Arctic Development and Adaptation to Permafrost in Transition» and the Japanese GRENE-TEA «Green Network of Excellence - Terrestrial Ecosystem of the Arctic». Both MoUs aim to build synergies in climate change and permafrost research and work towards standardization of methods, protocols and instrumentation at the circum-Arctic level. One of the highlights is that PAGE21, together with Global Terrestrial Network for Permafrost (GTN-P), will create a data information system for permafrost data encompassing data archiving, distribution, and visualisation. The system will be compatible with international standards and builds on existing initiatives in permafrost data management, allowing a maximum top-down and bottom-up data flow to eventually become a one-stop shop for all permafrost data.

Abisko Station.

Spasskaya pad expedition 2012 Sample of permanently frozen mineral.

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Presented at the Presented at the 9th International Carbon Dioxide Conference (ICDC9), this publication offers a selection of key FP7 projects in the area of the Carbon Cycle research.

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http://ec.europa.eu/research/horizon2020

For more information on FP7, see:
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