Addendum to the SOLAS Report to SCOR:
Reporting period: June 2011- June 2012
Version of 10 July 2012 by Dr Emilie Brévière

- National SOLAS networks 2011 annual reports
- 2011/12 SOLAS endorsed projects submission forms
- SOLAS endorsed projects 2011 annual reports
- SOLAS Task Team 2011 annual report
- IGBP/SCOR FTI SOLAS-relevant 2011 annual report
- SCOR WG SOLAS-relevant 2011 annual report
Biogeochemical cycling - Iron in the Antarctic sea ice zone and its role in the past and future climate

Marine phytoplankton play a key role in the global cycling of carbon and sulfur. However, in remote regions like the Southern Ocean and the subarctic Pacific Ocean, primary productivity is effectively limited by the availability of micro-nutrient iron (Fe). Antarctic sea ice hosts high concentration of Fe and organic matter, which triggers ice-edge phytoplankton blooms during austral spring. Given that sea ice formation and retreat affects every year an area of about 14 million km$^2$ in the Southern Ocean and 10 million km$^2$ in the Arctic Ocean, the “frozen ocean” may constitute the dominant source of Fe to polar waters during seasonal melting. Sea ice-bearing Fe may therefore play a key role in drawing down atmospheric carbon dioxide levels in these climatically-important regions. The high Fe concentrations in sea ice may also help sustain the growth of dimethyl sulfide producers, such as phaeocystis. Recent studies carried out by researchers at the Antarctic Climate and Ecosystems CRC (University of Tasmania) in Hobart have shown that micro-nutrients other than iron could co-limit primary production in the Southern Ocean, therefore, we extended our research to the study of other trace elements in sea ice.

Outcome 1:

The first detailed study on the distribution of trace metals other than iron in Antarctic pack ice was achieved during the SIPEX voyage conducted in September/October 2007. This work indicated the studied trace metals are concentrated in Antarctic sea ice, however the levels do not seem limiting or toxic for algal growth in the marginal ice zone. These findings also aid in fingerprinting iron source(s) in the sea ice environment (Lannuzel et al., 2011, van der Merwe et al., 2011a).

Outcome 2:

Field sampling was carried out in land-fast ice off the coast of Australia’s Casey station in Antarctica during austral spring/summer 2009 (van der Merwe et al., 2011b). The fertilization potential of the study site was highlighted. Detailed particulate size fractionation of metals (>10µm, 10µm-2µm, 2µm-0.4µm and 0.4µm-0.2µm) during the melting of sea ice was assessed for the first time in sea ice and under-ice water (Lannuzel et al., in prep).

High precision atmospheric CO$_2$ network to observe the Southern Ocean CO$_2$ sink

One of the main challenges in assessing the Earth’s capacity to mitigate future climate change is to understand how the natural sinks for global CO$_2$ emissions will change over time. Of these sinks, the Southern Ocean currently accounts for about one sixth of the global CO$_2$ emissions. If climate change reduces oceanic circulation transport of CO$_2$ into the deep ocean, the capacity of the Southern Ocean to absorb CO$_2$ would be expected to decrease. Le Quéré et al. (2007, 2008) concluded that the strength of the Southern Ocean CO$_2$ sink is weakening due to increased Southern Ocean zonal winds, a climate change response to growing greenhouse gases and depletion of Antarctic stratospheric ozone. This result has generated considerable debate in the literature, including being questioned as possibly an artefact of data selection and/or calibration biases between the different Southern Ocean observation sites (Law et al., 2008).

This work being carried out by the Centre for Australian Weather and Climate Research (CAWCR) at...
CSIRO Marine and Atmospheric Research Aspendale is aimed at developing both the scientific observation framework and a research tool to more accurately determine the efficiency and temporal behaviour of the Southern Ocean CO$_2$ sink. This tool will provide scientific understanding of and more reliable prediction of global atmospheric CO$_2$ concentrations into the future.

This framework involves atmospheric inversion modelling utilising a high precision Southern Ocean atmospheric observation network combined with state of the art oceanic modelling. Currently, possible instrumental and site biases are being addressed, as well as linking of datasets collected at Baring Head, Macquarie Island, Cape Grim, and Amsterdam Island, to a common derived calibration scale. Calibration hubs are located at CSIRO, Australia and LSCE, France.

Figure 1. Map of Southern Ocean network for atmospheric CO$_2$

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

In addition to the highlights above:

- Australia’s new Ocean-going future research vessel, the *RV Investigator*, is currently being constructed, with completion expected in June 2013. This new vessel can accommodate 40 scientists and will be used by Australian universities, research organisations and international collaborators. The first call for EOI has been made for ship time in 2013-14 and 2014-15. For more information please see
  


Ongoing atmospheric Mercury sampling has begun at Cape Grim Baseline Station as part of the Global Mercury Observation System.

The XXV IUGG General Assembly: Earth on the Edge – Science for a Sustainable Plant was held June-July 2011 in Melbourne. The scientific program comprised of 4758 presentations including 2831 oral and 1926 poster presentations from leading scientists from around the globe. The conference included many oral presentations of strong relevance to SOLAS, in particular in sessions run by the following associations: International Association for the Physical Sciences of the Ocean, the International Association of Cryosphere Sciences and International Association of Meteorology and Atmospheric Sciences.

The Centre for Australian Weather and Climate Research (CAWCR), a joint venture between CSIRO and the Australian Bureau of Meteorology, held its fifth annual workshop in November 2011, exploring the composition of the atmosphere and incorporating the Cape Grim Annual Science Meeting with a particular focus on Chemistry-Climate interactions, Budgets (carbon cycle, fluxes), Emerging tools/opportunities.

3. Human dimensions (outreach, capacity building, public engagement etc)

Media-television program- Iron Wales

Media-newsprint and radio- Iron Wales
Bowie A.R. Whales fertilising the Southern Ocean. Various national and international interviews.

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)

Deep Sea Research Part II Special Edition– The SOLAS Air-Gas Exchange (SAGE) Experiment 2004 (http://www.sciencedirect.com/science?_ob=PublicationURL&_hubEid=1-s2.0-S0967064511X00048&cid=271722&pubType=j&auth=y&acct=C0000522220&version=1&urlVersion=0&userid=1526876&md5=cb9d0fa7c5279b4c0c38c22167d5f)


Deep Sea Research Part II Special Edition– Biogeochemistry of the Australian Sector of the Southern Ocean (http://www.sciencedirect.com/science?_ob=PublicationURL&_hubEid=1-s2.0-S0967064511X00115&cid=271722&pubType=j&auth=y&acct=C0000522220&version=1&urlVersion=0&userid=1526876&md5=0f737f34b5f485d536103693d57f5a5f)


S.H.M Jacquet, P.J. Lam, T. Trull and F. Dehairs, 2011. Carbon export production in the
subantarctic zone and polar front zone south of Tasmania. Deep-Sea Research II, 58(21-22), 2277-2292


Ozone Trends in the MBL:

Phytoplankton modelling: Understanding plankton ecosystem dynamics is essential for correct biogenic transfer of gases between the ocean and atmosphere. These papers are intended to provide a more rigorous basis for the construction of plankton ecosystem models and to provide tools to understand and indeed construct the complex models that are used to predict biogenic gas exchanges.


Ship emissions in Australia:
Goldsworthy, L. and I. E. Galbally, Ship engine exhaust emissions in waters around Australia - an overview, Air Quality and Climate Change, 45(4), 24-32, 2011.

Southern Ocean Gas Exchange Experiment:

Oceanography


Rogers, J. and P. De Deckker, Environmental reconstructions of the upper 500 m of the southern Indian Ocean over the last 40 ka using Radiolarian (Protista) proxies, Quaternary Science Reviews, 30(7-8), 876-886, 2011.

Surface Energy balance measurements over coral reef:


Marine biogeochemical cycling


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

- Joint Australian-French collaboration during the oceanographic fieldwork project KEOPS2 (Kerguelen Ocean and Plateau compared Study), a natural iron fertilisation experiment on the Kerguelen plateau in the Southern Ocean (Australian Pls: Bowie A, Trull T, Armand L.; French Pls: Blain S, Queguiner B)
- Dr Véronique Schoemann and Ing Jeroen de Jong (The Royal Netherlands Institute for Sea Research, The Netherlands): iron isotopes in archived sea ice samples, uptake of iron in algal cells using radioactive technology, iron solubility, cycling of iron in the Southern Ocean. Additional collaboration planned in 2012 during the SIPEX2 voyage.
- Prof Frank Dehairs and Dr Anne-Julie Cavagna (Vrije Universiteit Brussel, Belgium): interactions between iron and the mesopelagic zone during SIPEX2 voyage in Sept/Oct 2012.
- Prof David Thomas, Dr Stathys Papadimitriou, Dr Shazia Aslam and Louiza Norman (Bangor University, United Kingdom): distribution of nutrients and organic matter in East Antarctic sea ice.
- Dr Daniel Cossa (Ifremer, French Research Institute for Exploration of the Sea, France): Study of Mercury in sea ice from Casey Station, Antarctica. Additional collaboration planned in 2012 during the SIPEX2 voyage.
- The 2012 Surface Ocean Aerosol Production (SOAP) study (see section 6 below for details), will involve an international team of scientists from NIWA (NZ), CSIRO (Australia), QUT (Australia), UEF (Finland), UC Irvine (US), U Chapman (US), U Laval (Canada).
- Ian Galbally, a member of the WMO GAW Scientific Advisory Group on Reactive Gases is leading the revision of the measurement guidelines for surface ozone at GAW sites, and in Dec 2011 visited 5 key participating groups including Martin Schultz, Institute of Energy and Climate Research, Forschungszentrum Juelich, Germany, Oksana Tarasova WMO Geneva, Switzerland, Brigitte Buchmann, Christoph Zellweger, Martin Steinbacher EMPA Zurich, Switzerland, Hans-Eckhart Scheel, Karlsruhe Institute of Technology, Garmisch-Partenkirchen, Germany, and Sam Oltmans and Laura Patrick NOAA ESRL, Boulder, Colorado, USA.

6. Goals, priorities and plans for future activities/events
- The Surface Ocean Aerosol Production (SOAP) study scheduled for February 2012 has been endorsed by SOLAS. This study will involve a measurement campaign onboard NIWA’s RV Tangaroa over Chatham Rise which runs from east NZ to the Chatham Islands, to investigate links between surface water biogeochemistry, gaseous aerosol precursors, and production and size distribution of aerosols in the MBL. For more information see http://www.solasint.org/science/researchendorsements/resendprojects/endorsedprojects.html#soap
- University of Wollongong have recently bid successfully for time on the first 3 transit voyages on the Southern Surveyor in 2012, to make measurements of CO₂, CO, CH₄, N₂O and ¹³CO₂ in the atmosphere across the transit path. Uni Wollongong also have a PhD student (Chris Caldow) working with the University of Bremen to develop a method using an equilibrator to also measure the flux of CO₂ from the surface waters.
- SIPEX-2 (Sea Ice Physics and Ecosystems Experiment) will take place in the Antarctic sea-ice zone in September and October 2012 on board RSV Aurora Australis. The international fieldwork will be led from researchers from the Antarctic Climate and Ecosystems CRC in Hobart. A campaign has also been proposed on SIPEX-2 to measure atmospheric reactive halogens and mercury in the polar springtime. Funding dependent, this work will allow the international team lead by University of Melbourne’s Robyn Schofield, to quantitatively link high atmospheric bromine levels to the high deposition of toxic mercury into the biosphere occurring annually with the Antarctic sunrise.

7. Other comments
**SOLAS Belgium**

*compiled by Christiane Lancelot*

**Notes:**

*Reporting Period is January 2011 – December 2011*

*Information will be used for: reporting, fundraising, networking, strategic development & outreach*

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<td>• 43rd International Liege Colloquium on Ocean Dynamics &quot;Tracers of physical and biogeochemical processes, past changes and ongoing anthropogenic impacts&quot;, 2 - 6 May 2011.</td>
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<td>• Set up of a SCOR working group on Biogeochemical Exchange Processes At the Sea-Ice Interfaces (BEPSII)</td>
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- Further development of the 3D MIRO-CO2 model with a module calculating DMS emission in the Southern North Sea.
- Initiation of a year-round (2011-2013) survey of land fast sea ice biogeochemistry in McMurdo Sound, Antarctica: C, S, N and Si fluxes to the atmosphere and/or to the Ocean, quantification and driving processes (YROSIAE [FNRS funding] and BIGSOUTH [BELSPO funding] projects)
- Modelling of gas processes in sea ice and exchanges with the atmosphere and the ocean

7. Other comments
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

Project 1. Turbulent fluxes over the Tropical Atlantic. Coordinator: Jacyra Soares. Air-Sea Interaction Laboratory. Institute of Astronomy, Geophysics and Atmospheric Sciences University of São Paulo, São Paulo, Brazil (jacyra@usp.br).

The local ocean-atmosphere interaction has been investigated through the direct observation of air-sea variables, using a set of slow and fast micrometeorology sensors installed in a 10-meter tower in the Brazilian Archipelago and through atmospheric and oceanic numerical models. The major goals are to characterize observationally and numerically the interaction between the atmosphere and the ocean in micro, meso and macro scales in order to develop, calibrate and verify the parameterization formulae used to indirectly estimate flux from conventional meteorological variables.

An 1 ½ layer oceanic numeric model is coupled to the Topographic Vorticity-mode Mesoscale-Non Hydrostatic (TVM-NH) atmospheric model to study the influence of the sea surface temperature (SST) on the planetary boundary layer of the coastal upwelling area of Cabo Frio (RJ, Brazil). The coupling is tested and then two experiments are performed, the first using just the atmospheric model and the second using the coupled models, to compare the resulting interface fluxes of both experiments. The uncoupled experiment showed smaller values of heat fluxes during all the integration period than the coupled experiment. At last, the mixing ratio vertical profiles of both experiments are compared to observations. It was found that the coupled model results compare better to the observations than when using only the oceanic or the atmospheric models.

The k-ε version using a second-order closure of an one-dimensional oceanic turbulence model, the General Ocean Turbulence Model, is used to investigate the oceanic mixing layer (OML) over the equatorial Atlantic Ocean. Meteorological and oceanographic dataset from the Prediction and Research Moored Array over the Tropical Atlantic Ocean and complementary radiation dataset from the NASA Langley Research Center Atmospheric Science Data Center are used to compute the surface boundary condition and for data assimilation during the simulations. Numerical simulations were performed for two seasons: the first one, when the Inter-tropical Convergence Zone (ITCZ) is over the region, characterized by lower wind velocity and annual extremes of precipitation, and the second season when the wind and the surface heat balance are enhanced. Emphasis was given to the role of the terms of the turbulent kinetic energy equation in the evolution of the OML. Numerical results show that the OML is mainly generated by mechanical turbulence in both seasons and that the thermal production of turbulence is only important on the first 30% of the OML depth at nighttime. During ITCZ season the OML depth estimated, using turbulence criterion is around 5 m at daytime and 10 m at nighttime. During the other season, the OML depth is about 10 m at daytime to around 55 m at nighttime. The turbulent fields simulated in this work show qualitative agreement to observational and numerical studies performed over the equatorial Pacific Ocean.

Project 2. Study of the Atmospheric Boundary Layer in the Region of Brasil-Malvinas Confluence. Coordinator: Marcelo Dourado. Centre for Ocean Studies. Federal University of
A subproject entitled “Coupled Modeling the Ocean and Atmospheric Boundary Layer in upwelling region” was the major activity developed during 2010. Turbulence in the oceanic (OBL) and atmospheric (ABL) boundary layer plays a vital role in the interaction between ocean and atmosphere, by controlling exchanges of heat, momentum and mass at the sea surface. These air-sea exchanges have great importance on determining the weather and the climate. The assessment of air-sea interactions is particularly relevant over the coupled oceanic regions. In the Cabo Frio region (23oS, 42oW), the upwelling has great influence on the primary productivity and in local climate. The coupling between the ABL and OBL has to be understood as a problem of fluid dynamics, where the main difference is the fluid's density. Basic dynamic equations, in which the density is one of the variables, can be applied to both sides of the interface, and in some cases the similarity of the physical processes in the two media, can be notable. For instance, a vertical profile of normalized dissipation rate of the turbulent kinetic energy in the OBL and ABL are very similar when turbulence is kept by thermal convection. Figure 1 indicates the impact of thermal contrast in the upwelling region of Cabo Frio, considering (a) and (c) upwelling and (b) and (d) downwelling conditions.

Figure 1. Diurnal evolution of virtual potential temperature in the ABL and thermal contrast between ABL and OBL.

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

It was made significant progress in the understanding of the PBL interaction between the atmosphere and ocean at tropical regions using modelling technique. Data analysis of FluTuA and other tropical sites are ongoing now.

3. Human dimensions (outreach, capacity building, public engagement etc)
### 4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


### 5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

### 6. Goals, priorities and plans for future activities/events

Main objective of the Solas Brazil is to incorporate new projects and promoting the development of the air-sea interaction in Brazil by involving new research groups.

### 7. Other comments
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

i) Importance of under-ice phytoplankton blooms in the Arctic (Arctic-ICE project: CJ Mundy, V Galindo - PhD candidate, M Levasseur, M Scarratt, M Gosselin)

Significant under-ice phytoplankton blooms were observed near Resolute Bay, Nunavut in both 2010 and 2011, during the Arctic-ICE project. Bloom formation was linked to the demise of the springtime bottom ice algal bloom and surface snow melt, both of which contributed to a deepening of the euphotic zone under the ice (Fig. 1). With a trend towards an earlier melt onset and a thinning Arctic ice cover associated with the relative increase in first-year ice coverage across the Arctic, under-ice phytoplankton blooms are hypothesized to become more prevalent across the Arctic. If this hypothesis holds true, these blooms could represent a major response of the polar marine ecosystem to climate change, the implications of which still need to be determined.

As schematized in figure 1, the under-ice phytoplankton blooms are preceded by the release of ice algae in the water column. Both ice algae and phytoplankton contribute to the increase in particulate dimethylsulfoniopropionate (DMSP) in the water column at that time (Fig. 2). The concentrations of dissolved DMSP (DMSPd) were very high at the bottom of the ice, but less than 10% of the dissolved DMSP lost from the ice during the warming period was found in the water column. This intriguing ‘vanishing’ of DMSPd was also observed in 2010. Bacteria, which are known to use DMSP as a source of carbon and sulfur, could be responsible for the rapid disappearance of the DMSPd released from the ice. The DMSPd consumed by the bacteria could be efficiently converted into DMS, especially if the bacteria use DMSP mostly as a carbon source. This hypothesis will be tested during our field program in 2012. These new observations suggest that ice algae released in the water column and under-ice phytoplankton blooms could be responsible for the high concentrations of dimethylsulfide (DMS) generally measured at the marginal ice zone.
ii) Impact of ash deposition on the North-East Pacific (J Mélançon - PhD candidate, M Levasseur, M Lizotte, L Miller, P Tortell, N Steiner, M Scarratt)

Onboard incubation experiments were conducted on the effect of volcanic ash on the plankton community and its capacity to produce DMS during the June 2011 Line P cruise in the Northeast subarctic Pacific. Results show a strong and rapid response of the community to ash addition, providing additional support the hypothesis that the 2008 Kasatochi eruption was responsible for the unusual large phytoplankton bloom observed in the North Pacific during that year (data presented at the 2011 SOLAS Summer School – poster Mélançon et al.).

iii) Mobility of CO$_2$ in sea ice and impact of ice on CO$_2$ fluxes (L Miller, T Papakyriakou, et al.)

Work conducted in the Canadian Archipelago and the Beaufort Sea on CO$_2$ fluxes and dynamics in sea ice confirmed that CO$_2$ is indeed mobile in sea ice (Papakyriakou and Miller, 2011). The different processes at play are schematised in figure 3 (from Miller et al. 2011).
Members of our research group also show how the presence of sea ice enhances atmospheric CO$_2$ drawdown into undersaturated winter waters that are only partially ice-covered (Else et al. 2011). See figure 4 for a summary.

**Figure 4.** Schematic summarizing the important processes occurring during a wind-driven lead event. The processes highlighted in blue/red are those which likely have a direct effect on air-sea gas exchange. Processes in red are associated with frazil ice formation, and those in blue are associated with the surface cooling.

**iv) Factors controlling the sea-surface microlayer enrichment factors (Wurl, Vagle, Miller, et al.)**

Work focusing on the microlayer generated unexpected results. We found that across oceanographic regimes, the sea-surface microlayer enrichment factors (i.e., the extent to which the microlayer is different from the bulk waters) was actually anticorrelated with both trophic state and organic surfactant concentration – a rather counterintuitive result that had been hinted at in other work (Wurl et al. 2011). We are also currently working on how exopolymeric substances end up in the microlayer through abiotic, as well as biotic processes (Fig. 5).

**Figure 5.** Schematic representation of the different processes leading to the formation of exopolymeric substances and to their accumulation in the microlayer.
v) Relating atmospheric and oceanic DMS levels to particle nucleation events in the Canadian Arctic (Chang, Sjostedt, Pierce, Papakyriakou, Scarratt, Michaud, Levasseur, Leaitch,Abbatt)

Measurements of ocean surface and atmospheric dimethyl sulfide (DMS) and particle size distributions were made in the Canadian Arctic Archipelago during the fall of 2007 and the late summer of 2008 aboard the Canadian Coast Guard Ship Amundsen. Nucleation mode particles were observed during the 2008 cruise, which took place in the eastern Arctic from August to September when the atmosphere and ocean were more photoactive as compared to the October 2007 transit in the Beaufort Sea during which no nucleation/growth events were observed. The observed nucleation periods in 2008 coincided with high atmospheric and ocean surface DMS concentrations, suggesting that the particles originated from marine biogenic sources. An aerosol microphysics box model was used to simulate nucleation given the measured conditions in the marine boundary layer. Although other sources may have contributed, we find that the newly formed particles can be accounted for by a marine biogenic DMS source.

vi) Dimethyl sulfide air-sea fluxes and biogenic sulfur as a source of new aerosols in the Arctic fall (Rempillo, Seguin, Norman, Scarratt, Michaud, Chang, Sjostedt, Abbott, Else, Papakyriakou, Sharma, Grasby, Levasseur)

Dimethyl sulfide (DMS) and its oxidation products, which have been proposed to provide a climate feedback mechanism by affecting aerosol and cloud radiative properties, were measured on board the Canadian Coast Guard ship Amundsen in sampling campaigns in the Arctic in the fall of 2007 and 2008. DMS flux was calculated based on the surface water measurements and yielded 0.1–2.6 mmol m⁻² d⁻¹ along the Northwest Passage in 2007 and 0.2–1.3 mmol m⁻² d⁻¹ along Baffin Bay in 2008. DMS oxidation products, sulfur dioxide (SO₂), methane sulfonic acid (MSA), and sulfate in aerosols were also measured. The amounts of biogenic SO₂ and sulfate were approximated using stable isotope apportionment techniques. Calculating the threshold amount of SO₂ needed for significant new particle formation from the formulation by Pirjola et al. (1999), the study suggests that instances of elevated biogenic SO₂ concentrations (between 8 and 9 September 2008) derived using conservative assumptions may have been sufficient to form new aerosols in clean air conditions in the Arctic region.

vii) DMS Oxidation Pathways and Aerosol Size in the Arctic - Alert (A-L Norman et al.)

MSA and non sea salt sulfate (NSS) in size segregated aerosols generally followed a similar pattern with maximum concentrations in the finest aerosols sampled (<0.49 micrometers in diameter; Fig. 6). It is interesting to note, however, that sea salt sulfate was often at a maximum concentration in the finest aerosol size fraction (F) rather than in larger diameter aerosols (A, B and C in Figure 6) as has been generally found over oceans at lower latitudes.

![Figure 6. Alert - Sulfate and MSA distributions in aerosols for size segregated samples from fall 2007 and 2008.](image-url)
Size bins indicate the range of aerodynamic diameter as follows: F (<0.49 μm), E (0.49-0.95 μm), D (0.95-1.5 μm), C (1-5 μm), B (3-7.2 μm), A (7.2–10 μm).

Evidence that MSA formation (and DMS oxidation pathways) is strongly affected by the presence of existing aerosols in the Arctic environment is demonstrated in Figures 7 and 8. Atmospheric DMS averaged over three days follows a similar pattern to MSA and non sea salt sulfate in the fine aerosol fraction in the fall of 2007 which is surprising given the differences in expected transport and lifetime for gases and aerosols.

![Graph showing temporal distribution of three-day averaged DMS, MSA and nSS in the fine aerosol fraction](image)

Figure 7. Temporal distribution of three-day averaged DMS, MSA and nSS in the fine aerosol showing the correspondence between non sea salt sulfate, and MSA in the fine aerosol size fraction (<0.49 μm diameter), and DMS in air which suggests DMS oxidation pathways (and MSA formation) are strongly influenced by the presence of existing aerosol irrespective of whether the aerosols are of biogenic origin.

![Graphs showing linear correlation between MSA and DMS](image)

Figure 8. [a] MSA from the fine aerosol (<0.49 μm) filter plotted versus the DMS averaged over the 3 day sampling periods give a linear correlation with Spearman rank correlation, rho = 0.88. [b] MSA versus non-sea salt sulfate from the fine aerosol (<0.49 μm) filter measure over a 3 day sampling periods give a linear correlation with Spearman rank correlation, rho = 0.95 for 2007 and rho = 0.90 for 2008.

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

Research projects:

**Arctic-ICE Program** – Arctic-Ice Covered Ecosystem in a rapidly changing environment (Arctic-ICE 2011). Climate warming has induced rapid change on the ice-covered marine ecosystem of the high Arctic. In this project we investigated physical and biological processes controlling the timing of marine primary production and its influence on the drawdown/release of climatically active...
Annual Report for the year 2011:

Biogeochemical Impacts of Asian Dust and Volcanic Ash on the North Pacific Ecosystem and Climate - Onboard incubation experiment were conducted on the effect of volcanic ash on the plankton community and its capacity to produce DMS during the June 2011 Line P cruise in the Northeast subarctic Pacific. Main investigators are J Mélançon (PhD candidate), M Levasseur, M Lizotte, L Miller, P Tortell, N Steiner, M Scarratt. Results show a strong and rapid response of the community to ash addition, providing additional support the hypothesis that the 2008 Kasatochi eruption was responsible for the unusual large phytoplankton bloom observed in the North Pacific during that year.

3. Human dimensions (outreach, capacity building, public engagement etc)

Several MsC and PhD students are trained in the different programs.

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


Annual Report for the year 2011:

116: D00S04, doi:10.1029/2011JD016336

5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

i) Arctic-ICE 2011 was planned in collaboration with a parallel study carried out by the Centre for Ice, Climate and the Environment (ICE) of the Norwegian Polar Institute (NPI). The project include a collaboration between Levasseur and Stefels’s lab (Netherlands).

ii) A number of Canadian SOLAS scientists (Miller, Azetsu-Scott) are participating in the preparation of the upcoming AMAP assessment of Arctic Ocean Acidification.

6. Goals, priorities and plans for future activities/events

To continue tightly coupled physical-biological landfast sea ice based process studies in support of one- and three-dimensional ecosystem model development.

The development of the High Arctic Research Station may offer opportunities to position SOLAS research for better sustained work in the Arctic.

Question of ocean acidification impacts on ecosystem structure and function appears to be something that will not be resolved quickly or easily, possibly facilitating continuing research on air-sea CO₂ exchange feedbacks.

The possibility to study the impacts of ash and other iron sources on the North Pacific biogeochemical cycles and ecosystems in a large, integrated project will be considered during the year.

7. Other comments
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

1.1 Short-term dynamics of oxygen and carbon in productive nearshore shallow seawater systems off Taiwan: observations and modeling.


The diurnal to weekly dynamics of carbon and oxygen in two productive tropical–subtropical nearshore shallow water systems were investigated using a combination of time-series observation and modeling. The two sites, Aodi (121.93°E, 25.06 °N) and Nanwan (120.85°E, 21.91°N), were characterized by limited freshwater input, strong tidal advection and, at Nanwan, upwelling. The diurnal ranges were 96–234 mol kg\(^{-1}\) for dissolved inorganic carbon (DIC), 8.9–42.2 Pa for partial pressure of carbon dioxide (\(p_{\text{CO}_2}\)), and 37–239 mol kg\(^{-1}\) for dissolved oxygen. The diurnal variability increased from spring to neap tidal states at both sites. A model accounting for gas exchange, biological activities, tidal advection, and upwelling was developed to assess the biophysical interactions modulating the biogeochemical dynamics. The strongest driver of the diurnal variability was the net ecosystem production of the benthic-dominated nearshore ecosystem. Tidal advection buffered the accumulation of biological effects and the intensified dispersion lowered the diurnal amplitudes at spring tides.

Tide-induced upwelling at Nanwan increased the surface inorganic carbon, and its decreasing intensity resulted in declines in DIC and \(p_{\text{CO}_2}\) from spring toward neap tide. The maximum community photosynthetic rates at Aodi and Nanwan were 295 and 120 mmol C m\(^{-2}\) h\(^{-1}\), with ecosystem respiratory rates of 122 and 53 mmol C m\(^{-2}\) h\(^{-1}\). The two autotrophic ecosystems were sinks for atmospheric CO\(_2\) during the study period, with the average air–sea fluxes being 20.30 and 20.56 mmol C m\(^{-2}\) d\(^{-1}\) for Aodi and Nanwan.

![Fig. 1](A,C) Modeled carbon fluxes at each 0.25-h time step (CF); (B,D) modelled net daily carbon fluxes (CFDaily). The positive values correspond to the fluxes exported from the nearshore water. The subscripts Gas, Mix, and Bio refer to the fluxes resulted from gas exchange, mixing processes, and biological activities.
Satellite chlorophyll a (Chl a) concentrations and estimated primary production in the coastal seas of China were correlated with Asian dust events during 1998–2008. Dust events were identified using two approaches, i.e., historical record and satellite aerosol index (AI). Severe and very severe dust events correlated well and positively with Chl a concentrations and primary production in the south Yellow Sea and East China Sea, but it was not statistically significant in the Bohai Sea and the north Yellow Sea. In the south Yellow Sea, Chl a concentration and primary production increased and eventually bloomed 1–21 days after the occurrence of the 16 out of 22 dust storms. Granger causality test showed that AI, photosynthetically available radiation (PAR) and sea surface temperature (SST) did Granger cause primary production in the Yellow Sea, suggesting that past values of the above three variables contain statistically meaningful information about current values of primary production. A stepwise multiple linear regression was used to examine the relative importance of the three factors. PAR and SST accounted for most of the variability of primary production in the north Yellow Sea, while AI was not quite as useful. In the south Yellow Sea, PAR and AI accounted for most of the variability of primary production for all storms; in addition, spring algae blooms were due to dust particles transported in the <3 km layer of the atmosphere which passed through the loess plateau and/or megacities, while the higher-level (>5 km) dusts, originated mainly from the Taklimakan Desert, Mongolia, and/or west of Inner Mongolia, had no impact.

Fig. 2 The yearly variations of FDS, annual average Chl a concentration and OPP in the south Yellow Sea and East China Sea.

Fig. 3 Annual variations of bloom frequency and average days with AI ≥ 2.
2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

2.1 Cruises and field experiment on island

2.1.1 A 40-day long and multidisciplinary CHOICE-C (SOLAS endorsed project) cruise was conducted onboard R/V Dongfanghong II on Apr. 29-Jun. 10, 2011, covering the CHOICE-C domains of northern South China Sea, East China Sea and southern Yellow Sea (Fig. 4).

Fig. 4 Map of the China Seas showing the sampling stations in the CHOICE-C spring cruise in 2011
2.1.2 Yellow Sea-East China Sea Cruise: Researchers from Ocean University of China conducted two 3-weeks cruise experiments over Yellow Sea and East China Sea onboard R/V Dongfanghong II, during Mar.17-Apr.10 and Oct. 16-Nov.6, 2011. Fig.5 shows the cruise track during two cruise experiments.

2.1.3 Field observation on Qianliyan Island (within the Yellow Sea): During Apr. 23-May 7, 2011, Ocean University of China conducted 2-weeks field observation on Qianliyan Island which is 64 km away from the inland of Shandong Peninsula. Fig.6 shows the location of sampling instruments.
2.2 Workshops

(1) A Joint International Workshop of OCCOS and CHOICE-C, Apr.3-4, 2011, Xiamen, China.

(2) The 2nd CHOICE-C Scientific Advisory Committee Meeting, Apr.5-6, 2011, Xiamen, China.


(5) Joint 6th Workshop on Asian Dust and Ocean EcoSystem (ADOES) with Asian SOLAS, Oct. 5-9, 2011, Qingdao, China.

3. Human dimensions (outreach, capacity building, public engagement etc)

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


(8) Qi, J.H., H.W. Gao, L.M. Yu, and J.J. Qiao, 2011. Distribution of inorganic nitrogen-containing species in atmospheric particles from an island in the Yellow Sea, Atmospheric Research,
5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

1. As the corresponding member of GEOTRACES, Dr. Minhan Dai hosted the 2012 GEOTRACES SSC Meeting and Date Management Meeting in Xiamen during Sept. 4-8, 2011.

2. Representing SOLAS, Minhan Dai also participated in the PICES 2011 Annual Meeting during Oct. 14-23 in Khabarovsk, Russia.

3. Prof. Huiwang Gao organized the IOC/WESTPAC Side Workshop on Asian Dust and its Impact on Ocean Ecosystem in the Western Pacific (WESTPAS-ADOES) in Busan, Republic of Korea on March 30, 2011. This workshop mainly focus on impacts of Asian dust on biogeochemistry and productivity in marine ecosystem and transport path of Asian dust and its deposition flux to the Western Pacific. Prof. Adina Paytan from University of California, Santa Cruz delivered an invited talk entitled as “Aerosol impacts on marine phytoplankton”. Prof. Xiaohong Yao from Ocean University of China gave an invited talk related to atmospheric chemistry in marine environment. And Prof. Jing Zhang from East China Normal University presented a study on nitrogen deposition from the Yellow and East China seas to NW Pacific Ocean.

6. Goals, priorities and plans for future activities/events

1. Submit the proposal of “Ocean primary productivity and its effect on climate change driven by atmospheric deposition” to the MOST (Ministry of Science and Technology, China).

2. Organize the 7th Workshop on Asian Dust and Ocean EcoSystem (ADOES) during second half of 2012.

7. Other comments
SOLAS China (Taipei)  
compiled by Gwo-Ching Gong

Notes:  
Reporting Period is January 2011 – December 2011  
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

The integrated project of Long-term Observation and Research of the East China Sea (LORECS) is a Taiwanese contribution to the international SOLAS. One of the major goals of LORECS related to SOLAS is to understand the effects of atmospheric forcing on marine biogeochemistry and ecosystem of the East China Sea. We found the events of Asian Dust Storm may not contribute much to the sequestration of atmospheric CO$_2$ in the oligotrophic subtropical northwest Pacific Ocean, although it may enhance biological production, promote the growth of *Synechococcus* and the export of particulate organic carbon (Chou et al., 2011; Chung et al., 2011).

![Graphs showing changes in various parameters over time](image_url)

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)
Ten cruises on board R/V Ocean Researcher I and II were conducted for the East China Sea in the year 2011 under LORECS project. A one-day workshop was organized by Director Gwo-Ching Gong in Keelung, Taiwan to present and discuss recent findings and the next phase of LORECS.

### 3. Human dimensions (outreach, capacity building, public engagement etc)

### 4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


### 5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

We have joined an international program, “A comparative study of natural and anthropogenic factors influencing two river dominated coastal ecosystem (Mississippi and Changjiang): A combined observation and modelling approach”, led by T. S. Bianchi (TAMU).

### 6. Goals, priorities and plans for future activities/events

The LORECS project will end in July 2012. For the next phase of LORECS, we will study the effects of global change (climate change and ocean acidification) on ocean biogeochemistry and ecosystem in the seas surrounding Taiwan in the northwest Pacific (ECOBEST). There are 20 subprojects in the proposal of ECOBEST and have submitted to National Science Council Taiwan in the end of 2011.

### 7. Other comments
SOLAS Denmark/Greenland

compiled by Lise Lotte Sørensen and Mikael Sejr

Notes:

Reporting Period is January 2011 – December 2011

Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

**Air-sea CO\textsubscript{2} fluxes in Arctic coastal areas**

Annual air–sea exchange of CO\textsubscript{2} in Young Sound, NE Greenland was estimated using \textit{pCO}_2 surface-water measurements during summer (2006–2009) and during an ice-covered winter 2008. All surface \textit{pCO}_2 values were below atmospheric levels indicating an uptake of atmospheric CO\textsubscript{2}. The observation that the surface water is under-saturated in \textit{pCO}_2 in both summer and winter implies that Young Sound is a sink for atmospheric CO\textsubscript{2} on an annual scale. The average annual uptake of atmospheric CO\textsubscript{2} was estimated at 2.7 mol CO\textsubscript{2} m\textsuperscript{-2} yr\textsuperscript{-1} or 32 g C m\textsuperscript{-2} yr\textsuperscript{-1} for the study area, which is lower than estimates from the Greenland Sea. However, large uncertainties are associated with the actual flux estimate, most notably related to the choice of gas exchange formulation, and neglecting gas exchange of CO\textsubscript{2} from melt water ponds and polynya areas outside the fjord may potentially underestimate the size of the CO\textsubscript{2} sink.

Formation and melting of sea ice also play a role, the size of which depends on the water masses affected by this annual carbon pump. Moreover, glacial melt-water has been shown to act as a sink of atmospheric CO\textsubscript{2} (Brown, 2002) but whether this process is of importance only locally near glaciers or contributes to lowering \textit{pCO}_2 more widely in Young Sound or along the East Greenland coast is unknown. In any case, a warmer future climate is expected to increase the amounts of melt water, which would act to lower surface-water \textit{pCO}_2 levels. As these main factors identified to cause low surface-water \textit{pCO}_2 levels all respond to warming, it is highly likely that annual air–sea CO\textsubscript{2} exchange in Young Sound, and potentially the East Greenland coastal region, will change in response to global warming, which is expected to increase the open-water period from the present 3 months to 5 months by the end of the century (Rysgaard and Glud, 2007).

![CO2 flux map](image.png)

**2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)**

A new national project ECOCLIM to estimate CO\textsubscript{2} exchange between the atmosphere and the biosphere is initiated. The project has a key focus on air-sea CO\textsubscript{2} exchange in coastal regions. The project is coordinated from the Dep. of Environmental Science, Aarhus University.

Furthermore a new Nordic Centre of Excellence named DEFROST has started in 2011, and a WP
within this project focus on air-sea-ice exchange of CO₂. Activities in DEFROST is coupled to activities in the projects: “Air-sea-ice exchange of CO₂ in the Arctic coastal area”, which is a Nordic Council of Ministry funded project and “ECOCLIM”. As a part of these projects a measurement station for air-sea exchange of CO₂ is established in the Nuuk Basin, Greenland.

3. Human dimensions (outreach, capacity building, public engagement etc)

Two new Ph.D. students started projects related to the oceans uptake of CO2. One project focus on air-sea ice exchange of CO₂ in the Arctic and the other on determining whether Danish coastal water are a sink or source of atmospheric CO₂

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

Many of the activities in the Arctic are part of the Nordic Centres of Excellence, DEFROST and CRAICC and thus has collaboration with researchers from Helsinki University, Lund University, Finnish Meteorological Institute and Stockholm University. Furthermore there is a strong link to Uppsala university through the NMR project; “CO₂ fluxes in the coastal Arctic region”, the Nordic Centre of Excellence SVALI and a planned summer school:

http://ncoe-svali.org/xpdf/course_boundary.pdf

6. Goals, priorities and plans for future activities/events

An experiment to study the air-sea exchange of CO₂ over Arctic waters during ice formation and melting is planned to take place in Young Sound near Zackenberg, Greenland in March 2012.

A thorough study of the CO₂ air-sea exchange processes in costal regions and fjord areas will take place in spring and summer 2012 in Denmark.

An cruise is planned for May 2012 in Greenland which will focus on determining the effect of the biological pump for regulating surface pCO₂ in Greenland coastal waters.

An experiment in Northeast Greenland is planned for March 2012 to investigate the effect of exchange between the sea ice and the atmosphere on aerosol composition in the high Arctic. The experiment is a part of the Nordic Centre of excellence CRAICC and DEFROST and the Danish national project “Short Lived Climate Forcers”.
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

Two meetings for SOLAS in France


Year 2011 was a SOLAS-IGAC joint meeting held in June (29th and 30th) in Paris (web site is: http://www.lisa.upec.fr/SOLAS/2011/). Why a joint SOLAS-IGAC meeting? IGAC (http://igac.jisao.washington.edu/) is an international action which can have a common interest with SOLAS: Atmosphere. IGAC is dedicated to studying the chemical composition of the atmosphere and its impact on climate and air quality. The research conducted in SOLAS extends from the physical transport of matter and energy in ocean, water and air, atmospheric chemistry and photochemistry at the interface of these two systems. SOLAS program covers the study of biogeochemical cycles in the ocean-atmosphere interface, which includes: Emissions and the processes of chemical transformation and deposition of gases and aerosols species, Characterization of exchange between the two reservoirs integrating layer processes in Oceanic and Atmospheric boundary, Study the flux of CO2 and other gases and their radiative link with climate. These themes feed directly on the issues of atmospheric chemistry community in terms of stress sources and sinks of reactive species to short or long life. Improved parameterizations of emissions and deposition of halogenated species, sulfur and nitrogen and aerosols (DMS, marine aerosols, ...) is such a major challenge for both communities to an understanding of the coupled climate pollution in the Earth system. The attendance of the meeting was between 30 and 50 people during the 7 sessions and the guest lecture was given by Alex Baker: “Climatological estimates of atmospheric nutrient deposition to the Atlantic Ocean - problems and potential”. Abstract, extended abstracts and some full text presentations are available on SOLAS-France web pages.

International EUR-OCEANS Conference “Ocean deoxygenation and implications for the marine biogeochemical cycles and ecosystems” (24-26 October 2011, Toulouse):

The International EUR-OCEANS Conference “Ocean deoxygenation and implications for the marine biogeochemical cycles and ecosystems” (24-26 October 2011, Toulouse, France) has been organized by the LEGOS (Véronique GARCON, Aurélien PAULMIER, Boris DEWITTE). This Gordon-like Conference (>90 scientists from 19 different countries) has been supported by EUR-OCEANS, IRD, CNRS-INSU, Académie des Sciences, LEGOS, OMP, the French Embassy in Washington DC (USA), IMBER and SOLAS. The conference brought together biological, biogeochemical and physical oceanographers to discuss the very relevant “hot” topic issue of deoxygenation in the world ocean and its implications for ocean productivity, nutrient cycling, carbon cycling, and marine habitats. In particular, OMZs are key regions in the climatic gases budgets. The conference (3 days) provided a science arena (plenary and posters sessions; round table) where to discuss the state of the art of our knowledge on all topics: description and control mechanisms of the deoxygenation and of the OMZ and hypoxia sites; deoxygenation impacts on the biogeochemical cycles, climatic gases, microbial activity and ecosystems; deoxygenation in the past ocean; inter-comparisons of OMZs systems; efforts towards new parameterizations for addressing regional and global modeling challenges. In perspective, the “ocean deoxygenation” community wishes to keep the ball rolling in maintaining tight
scientific exchanges (e.g. Special Issue, E-lecture), with the idea of international coordination (objective, approach) for observations (e.g. O₂), experiments (e.g. protocols) and modeling efforts (e.g. numerical tools) and inter-comparisons of the major OMZs systems. More details about the conference can be found at: [http://www.eur-oceans.eu/conf-oxygen](http://www.eur-oceans.eu/conf-oxygen). An e-Lectures series from the American Limnology and Oceanography is underway on the deoxygenation topic.

**Research orientation and SOLAS lobbying**

- Two sessions were held at the ASLO Puerto Rico Aquatic Sciences Meeting (“Limnology and Oceanography in a changing world”) during the week of 13-18 February 2011: (1) Session S28 on “Biogeochemical, Ecological and Physical Dynamics of Eastern Boundary Upwelling Systems” with Carol Robinson and Véronique Garçon as chairmen. (2) Session S49, entitled ‘Atmospheric Control of Nutrient Cycling and Production in the Surface Ocean’ was convened by Cecile Guieu, Doug Wallace, Cliff Law and chaired by Cécile Guieu and Julie La Roche. This session was directly related to the Mid Term Strategy initiative and its objective was to discuss new results on key aspects such as the bioavailability of atmospheric inorganic and organic nutrients, impact on marine community structure, future variation of atmospheric nutrient deposition and its impact on carbon and nitrogen fixation at different time scales. The session consisted of 13 oral presentations and was indeed the occasion to learn from recent research from field work to modeling approaches. (more details in SOLAS Special Reports, Issue 11, SOLAS News, 2011).

- Following up the last SOLAS OSC Conference in Barcelona and the COST Action 735 meeting in Toulouse in March 2010, an ESA call entitled Support to Science Element OceanFlux (ESRIN/AO/1- 6668/11/I-AM) on SOLAS Science was launched early this year. Among the 3 themes selected by ESA, Theme 3 was on upwelling. A proposal on this theme was submitted early April and approved in fall with a KickOff starting date as of November 1st, 2011 with the following PIs and co-PIs: Christoph Garbe, Véronique Garçon, André Butz, Boris Dewitte, Aurélien Paulmier, Joël Sudre, Isabelle Dadou and Hussein Yahia.

- A EUR-OCEANS Flagship on Ocean deoxygenation in Eastern Boundary Upwelling Systems has been awarded to IFM-GEOMAR, Kiel, Germany, LEGOS CNRS and IRD, Toulouse and LOCEAN, Paris, France; with IMARPE, IGP, Lima, Peru as co-partners. A two year post-doctorate, between Toulouse, Lima and Kiel, has been recruited and has started on 1 September 2011.

- 5th International Summer School, 29 August-10 September 2011 in Cargese, France (see [http://www.solas-int.org/summerschool/](http://www.solas-int.org/summerschool/)), Director : Véronique Garçon

### 2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

*Here is a list of talks given at the SOLAS-IGAC joint meeting. All details, abstracts and some presentations are on the web site ([http://www.lisa.u-pec.fr/SOLAS/2011/](http://www.lisa.u-pec.fr/SOLAS/2011/)).*

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<th>Speaker</th>
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<tr>
<td>Emilie Journet</td>
<td>A new mineralogical database for atmospheric dust to estimate soluble iron fluxes to surface ocean.</td>
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<tr>
<td>Cécile Guieu</td>
<td>Atmospheric deposition onto oligotrophic marine systems: new insights from mesocosm studies</td>
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<tr>
<td>Alexie Heimburger</td>
<td>Dust deposition over South Ocean measured at Crozet an Kerguelen Island</td>
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<tr>
<td>Rémi Losno</td>
<td>Mercury total deposition at Kerguelen Island</td>
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Many research projects relevant to SOLAS science are running in 2011:

**AMOP project: “Activities of research dedicated to the Minimum of Oxygen in the eastern Pacific”**

The AMOP project “Activities of research dedicated to the Minimum of Oxygen in the eastern Pacific (Peru)” aims to carry out a complete $O_2$ budget taking into account physical (advection/diffusion) and biological ($O_2$ consumption/production through bacteria, phytoplankton and zooplankton) contributions. The transdisciplinary approach is based on: i) a 30-day cruise with two ships in simultaneous (L’Atalante from IFREMER and the Olaya from IMARPE), associated with gliders and Argo floats experiments; ii) a mooring (> 3-yr) coupling water column and sediments; iii) a modeling platform in order to assist the interpretation of our full data set (from in vitro to in situ and satellite observations) at different spatio-temporal scales. AMOP, led by the LEGOS (PI: A. PAULMIER), involves 13 research units in France, 2 Institutes (7 units) in Peru and 6 other countries acting as an international consortium (90 participants). Presently, the AMOP project is approved and labelled by LEFE-CYBER and LEFE-GMMC (INSU), considered as a priority for Fleet (CNFH) and Glider commissions, and submitted to the ANR (01/2012). Contact: Aurélien Paulmier, LEGOS, Toulouse.

**MedSeA: Mediterranean Sea Acidification under changing climate**

The European Mediterranean Sea Acidification in a changing climate (MedSeA) initiative is a project
funded by the European Commission under Framework Program 7 (http://medsea-project.eu/). It involves 16 institutions from 10 countries. MedSeA assesses uncertainties, risks and thresholds related to Mediterranean acidification at organismal, ecosystem and economical scales. It also emphasizes conveying the acquired scientific knowledge to a wider audience of reference users, while suggesting policy measures for adaptation and mitigation that will vary from one region to another.

MedSeA project objectives: i) identify where the impacts of acidification on Mediterranean waters will be more significant taking into account the sequence of causes and effects, from ocean chemistry through marine biology to socio-economic costs, ii) generate new observational and experimental data on Mediterranean organism and ecosystem responses to acidification and fed into existing fine-scale models of the Mediterranean Sea that are modified to better represent key processes, and then used to project future changes. The MedSeA focuses on a selected set of key ecosystem and socio-economic variables that are likely to be affected by both acidification and warming, studying the combination of both effects through ship-based observations, laboratory and mesocosm experiments, physical-biogeochemical-ecosystem modeling, and economical analyses, and iii) provide best estimates and related uncertainties of future changes in Mediterranean Sea pH, CaCO$_3$ saturation states, and other biogeochemical-ecosystem variables, assessing the changes in habitat suitability of relevant ecological and economically-important species.

FLATOCOA: Atmospheric flux of continental origin over the Southern Ocean
The endorsed FLATOCOA project ends its experimental milestone on the deposition fields at Kerguelen and Crozet (South Indian ocean, ~50°S). Numerous elemental analyses were made to calculate and validate deposition data of trace metals, especially micronutrients as Fe, Co, Zn, .... First results show deposition flux do not vary significantly from Crozet to Kerguelen but may exhibit seasonal variability. Average deposition flux over South Indian Southern Ocean is 500 nmol/m$^2$/day of iron, well predicted by models but much larger than those calculated from dry aerosol concentration. The major deposited flux is wet deposition (>90%) and the dry aerosol remaining near ground or sea level is not representative of the scavenged aerosol flying at higher altitude. Next step of the program is to collect aerosols at source regions to measure its chemical properties and especially solubility. A sampling station was set up at Rio Gallegos (Argentina, 51°S 69°W) to collect new emitted aerosol from Patagonia. Contact: Rémi Losno, LISA, Paris.

OCEANS$^{13}$C: observe and model · $^{13}$C variability in the oceans.
This program, funded by LEFE/CYBER (CNRS/INSU) will synthetize and analyze all $^{13}$C data of DIC in the global ocean to provide additional constraints in studies dealing with the oceanic carbon cycle variability and its anthropic component. Web pages are: http://www.locean-ipsl.upmc.fr/OCEANS13C/
MaCloud (Marine Aerosol Cloud Interactions): aims to build on recent advances in marine aerosol formation processes. In addition to coastal iodine-driven nucleation and growth events, it has been recently established that open ocean particle production and growth is quite frequent over the NE Atlantic and appears to be driven by organics. This project aims to better characterize these coastal and open ocean events. Further, aerosol mass spectrometry has revealed unique marine aerosol organic characteristics with effective cloud nucleating properties despite low growth factors. The project aims to characterize the growth factor and CCN activity of varying enrichments of sea-spray aerosol. Particularly, LaMP has contributed to a better quantification of hygroscopic and CCN properties of marine aerosols by using a novel VT-CCN instrument. The VT-CCN instrument was used to infer the ability of marine particles to form cloud droplets, with a focus on their volatile organic fraction during an intensive field campaign at Mace Head, Ireland, in May 2011. During the campaign, open ocean nucleation events and primary organic formation events occurred regularly. The measured marine aerosol hygroscopicity parameter “kappa” was relatively high: average values between 0.5 and 0.7 were defined, depending on the method of analysis and the particle size. The more volatile fraction of the aerosol is typically less CCN-active and tends to hinders aerosol CCN-activation. The dependence of this property on the origin of the organics emitted from the ocean surface (primary during bubble bursting processes or secondary during nucleation) is still to be determined.

Contact: K. Sellegri, (LaMP)

New projects are rising:

Marine Ecosystems Response in the Mediterranean Experiment (MERMEX).

MERMEX is dedicated to study the response of Mediterranean ecosystems and biodiversity to climate changes and anthropogenic pressure. MERMEX aims to deepen the current understanding of the Mediterranean marine ecosystems to better anticipate their upcoming evolution. It will focus on the response of ecosystems to modifications of physico-chemical forcing at various scales, both in time and space, linked to changing environmental conditions and increasing human pressure. It proposes a comprehensive, integrated approach considering the continuum between the coastal
zone and the open sea and its interfaces, including ocean-continent, ocean-atmosphere and water-sediment to precisely describe and model the current state of the Mediterranean ecosystems and the complex interactions existing between the environmental and human factors. MERMeX White Book was published in 2011 in Progress in Oceanography – 95 authors, 130 pages, 630 references.

The MERMeX group, 2011, Marine Ecosystems Responses to climatic and anthropogenic forcing in the Mediterranean, Progress In Oceanography, Volume 91, Issue 2, October 2011, Pages 97-166

The project is divided into several thematic approaches that were grouped into five work packages (WP): 1- Impact of hydrodynamic changes on Mediterranean biogeochemical budgets (WP1), 2- Ecological processes; biogeochemistry and food web interactions (WP2), 3- Land-ocean interactions including extreme events (WP3), 4- Natural and anthropogenic air-sea interactions (WP4), 5- Ecosystem based management (WP5). Each WP is led by 2-3 coordinators and includes several actions that should be funded through different funding agencies [MISTRALS, ANR, FRB, UE...]. In 2011 MERMEX was endorsed by SOLAS as mainly 2 WPs are directly relevant to SOLAS thematics (WP4 and WP2). Among other actions, in 2011, the MERMEX group has been working on setting up a special observation period (SOP) representing an unprecedented intensive effort in the observation in the NWM. This project is currently submitted for fundings. More details on activities in 2011 can be found in the special report (see SOLAS endorsed projects).

VAHINE which will study the fate of newly fixed N by *Trichodesmium* in the pelagic food web in the South West Pacific.

Former SOLAS projects are in their synthesis phase of data interpretation:

**Saharan dust**: more than a simple fertilizer for the clear waters of the Mediterranean Sea.
In the frame of the DUNE project, two original methods (1- reproducing a real atmospheric deposition event necessary for the controlled seeding in seawater and 2-conception of seeding experiments in large clean mesocosms) have been developed, validated and published and can be used in the frame of other projects (for example, the DUNE mesocosms are going to be used in the frame of the MedSea European project on Mediterranean acidification; other projects related to marine biogeochemistry at the atmosphere-ocean interface based on that tool are currently being submitted).

Main results: Chemical and biological changes, along with modification of the dynamic of particles following a dust event have been followed and the multidisciplinary results obtained are bringing new insights regarding the role of atmospheric deposition on oligotrophic ecosystem and carbon export. Among those results, we have shown that the cycles of elements of biogeochemical interest (nutrients, metals) are modified by the atmospheric deposition; that new nutrients introduced are uptake by biota very rapidly; that there is a competition for the new nutrients and that this competition is in favor for heterotrophic bacteria; that among phytoplankton, diazotrophs – although only responsible for few percent of the induced new production - are well stimulated by atmospheric input; that particulate carbon export is in part due to aggregation processes between organic matter and lithogenic particles. All those results indicate that the role of atmospheric deposition on oligotrophic area cannot be seen only like a simple fertilization effect but, induce also a significant export of particulate organic carbon to the deep ocean, through aggregation processes.

Scientific outputs. The DUNE project was officially ending recently (July 2011) and a large number of papers in international journals are already published, others are in preparation and the group decided during a meeting in October 2011 to write a Special Issue devoted to the DUNE project. A series of 14 papers was proposed. In 2011, several oral presentations specific to the DUNE project were done during the ASLO conference in Puerto Rico in Feb. 2011, during the SOLAS-IGAC France joint open meeting in Paris in June 2011 (see details in DUNE web site).

Web site of the project:   [http://www.obs-vlfr.fr/LOV/DUNE/](http://www.obs-vlfr.fr/LOV/DUNE/)

### 3. Human dimensions (outreach, capacity building, public engagement etc)

A short movie made by Alexie Heimburger and Fanny Mazoyer entitled "Qui sème la poussière récolte le phytoplancton", was awarded and available here for downloading or visualization:  [http://www.science.gouv.fr/fr/telesciences/bdd/res/4336/qui-seme-la-poussiere-recolte-le-phytoplancton/](http://www.science.gouv.fr/fr/telesciences/bdd/res/4336/qui-seme-la-poussiere-recolte-le-phytoplancton/)

This movie outreachs a large public to the methods in use to collect and analyze dust in remote oceanic areas.

### 4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)

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<th>Author(s)</th>
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5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

6. Goals, priorities and plans for future activities/events

Joint experiment in 2012:

In order to assess the Mediterranean pelagic ecosystem’s response to ocean acidification, the Laboratoire d’Océanographie de Villefranche (LOV, UPMC; http://www.obs-vlfr.fr/LOV/) will organize two in situ large pelagic mesocosm joint experiments. A first experiment will be conducted in June/July 2012 in Corsica (Stareso station; http://www.stareso.com/; Bay of Calvi). Nine in situ mesocosms (54 m³) will be deployed: i.e. 3 controls and 6 high pCO₂ levels (450, 550, 650, 750, 1000, 1250 μatm), for a period of 1 month. The acidification of the mesocosms will be achieved by addition of various amounts of CO₂ saturated seawater using a diffusing system designed and constructed at LOV. A nutrient (N, P and Si) enrichment will be performed approximately at the middle of the experiment in order to stimulate the production of the community. The nine mesocosms will be sampled on a regular basis using several integrating water samplers. A total of 25 persons, originating from 6 different European countries (Spain, Greece, Italy, UK, Belgium and France) will be involved in the Corsica experiment. An important list of parameters and processes among which primary production, community respiration, bacterial production, calcification, nitrogen fixation etc... will be measured on a regular basis. Contacts: Amélie Sallon (salon@obs-vlfr.fr), Cécile Guieu (guieu@obs-vlfr.fr) and/or Frédéric Gazeau (f.gazeau@obs-vlfr.fr). Web site of the project: http://medsea-project.eu/

South Hemisphere

Dust cycle is only poorly known in the South Hemisphere, and particularly in the Austral subantarctic region. East Patagonia seems to be a major source of dust. Sampling and measurements, including chemical properties, of dust will be performed in Patagonia. Aerosol Lidar measurements will contribute to better know the vertical distribution of aerosol from the Patagonian emission areas.
Upwelling off Peru: AMOP Experiment

A 30-day cruise is planned in December 2012 or early 2013 with two ships in simultaneous (R/V L’Atalante from IFREMER and R/V the Olaya from IMARPE), associated with gliders and Argo floats experiments. A mooring deployment (> 3 yr) will also be performed which will allow to couple water column processes with the sediments. (Contact: aurelien.paulmier@legos.obs-mip.fr)

7. Other comments

Acknowledgements: University Paris7 Denis Diderot and CNRS/INSU to support the join SOLAS-IGAC meeting in june 2011.
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

Iodine containing species in the remote marine boundary layer: A link to oceanic phytoplankton


Iodine containing species have been measured in the particle phase (PM2.5) and the gas phase during a ship campaign between January and February 2007 in the South Atlantic marine boundary layer (MBL). Methyl iodide (CH$_3$I) in the gas phase and soluble iodine species, i.e. iodide, iodate and an unidentified organic iodine species (UOI), in PM2.5 were measured. Temporal variations of gaseous and particulate iodine species were investigated. The exposure of the sampled air masses to phytoplankton along the back-trajectories was studied using a lagrangian transport model and satellite observations of oceanic chlorophyll-a concentration. Significant correlations were found between the concentrations of iodine species and the average chlorophyll exposure along back-trajectories, indicating an emission from phytoplankton in the open ocean. Good correlations were found when the ship approached or crossed the active biological region in the West-southern Atlantic. These results strongly suggest a connection between iodine species and the phytoplankton in the ocean. This study was extended to examine the relation of the iodine measurements to satellite derived phytoplankton distributions. We show that specific phytoplankton species may have impact on different iodine containing species.

The effect of surface films on the air-sea gas exchange in the Baltic Sea


Gas exchange experiments were performed with water from a coastal station in the southwestern Baltic Sea in order to investigate the effect of organic films on the gas transfer velocity. Samples were taken on a weekly basis during January to July in 2007 and 2008. Using a 1.5 L glass vessel, the evasion of oxygen from the sample into an O$_2$-free headspace was recorded with an O$_2$ optode. The transfer velocities were calculated and related to the surface film coverage that was characterized by the reduction of the surface tension with respect to a surfactant-free water sample ($\Delta \sigma$). For the determination of $\Delta \sigma$, surface tension measurements of organic free water samples were performed and an equation was derived that describes $\sigma$ as a function of temperature and salinity. The normalized transfer velocity (Schmidt number=660), $k_{660}$, decreased by 55%–65% at low film densities ($\Delta \sigma<0.3$ mN m$^{-1}$) and remained almost constant at this level despite increasing film coverage ($\Delta \sigma$ up to 10 mN m$^{-1}$). These findings are qualitatively consistent with other studies which, however, report a less drastic film-induced decrease of $k_{660}$. The $\Delta \sigma$ were low in January (0.1–0.2 mN m$^{-1}$) but increased during the development of the spring bloom. This implies a seasonality of the $k_{660}$ which may have a strong effect on gas exchange calculations. It was shown that the annual net CO$_2$ uptake of the Baltic Sea decreases by a factor of two when a seasonal $k_{660}$ amplitude of ±20% is included into the flux calculations.
3. Human dimensions (outreach, capacity building, public engagement etc)

Several newspaper articles, TV features, etc. about SOPRAN activities (such as the mesocosm experiment in Bergen) have been produced.

Brochures which have been produced under leadership of SOPRAN scientists:


4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


5. International interactions and collaborations (including contributions to international assessments)
such as the IPCC, links with observation communities etc)
Plenty

<table>
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<tr>
<th>6. Goals, priorities and plans for future activities/events</th>
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<tr>
<td>SOPRAN Mesocosm experiment at the Finnish research station of Tvärminneis will take place in June-July 2012 (PI Ulf Riebesell, GEOMAR).</td>
</tr>
<tr>
<td>A third phase of SOPRAN (Surface Ocean Processes in the Anthropocene, <a href="http://www.sopran.pangaea.de">www.sopran.pangaea.de</a>) from Feb. 2013 to Jan 2016 is currently in the planing stage.</td>
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<th>7. Other comments</th>
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1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

a. Influence of discharge of monsoonal rivers on the biogeochemistry and carbon dioxide emissions in estuaries and coastal regions of east coast of India

Changes in river discharges alter material loads and the consequent estuarine and coastal biogeochemical process. Evidence for biogeochemical response to variable rainfall over catchment area or changes in river discharges due to dam regulations is sparse; India is the best suited to test the influence of altered discharges, as the monsoon rainfall is annually variable, on estuarine biogeochemistry. Experiments in Godavari estuary over three years revealed that a decrease in precipitation over the Indian subcontinent from 2007 to 2009 resulted in the lowering of its mean annual discharge from 748.63 m$^3$s$^{-1}$ in 2007 to 218.40 m$^3$s$^{-1}$ in 2009. The reduced water discharge, during the peak discharge period, slowed the flushing of the estuary from 1.2 days to 6.3 days. The consequent increase in stability of water column and reduced suspended material load facilitated intense phytoplankton blooms (Chl $\alpha$ 18 $\mu$g l$^{-1}$ in 2007 to 28 $\mu$g l$^{-1}$ in 2009).

Eighteen month long daily monitoring in the tropical Godavari estuarine system revealed a pH decrease by 1.5 units, during peak discharge period, due to high bacterial activity (20.6 ± 7.2 $\mu$MC l$^{-1}$ d$^{-1}$). The strong heterotrophic processes resulted in anomalously high pCO$_2$ of 30,000 $\mu$atm during peak discharge period in the estuary (Figure 1).
An extensive study of 27 estuaries along the east and west coasts of India revealed that the emission of CO\textsubscript{2} to atmosphere to be 4-5 times higher during wet than in dry period. The average pCO\textsubscript{2} ranged between \(\sim 300\) and \(18492\ \mu\text{atm}\), which is within the range found for world estuaries. The mean pCO\textsubscript{2} and particulate organic carbon (POC) showed positive relation with rate of discharge suggesting availability of high quantities of organic matter that led to enhanced oxygen consumption (Fig. 2). The annual CO\textsubscript{2} fluxes from the Indian estuaries amount to 1.92 TgC which is far less than that from the European estuaries.

The pCO\textsubscript{2} levels in the peninsular rivers were an order of magnitude higher (5000-17000 \(\mu\text{atm}\)) than that of atmospheric levels and glacial river Ganges (\(\sim 500 \mu\text{atm}\)). The discharge from the peninsular rivers have a stronger influence in the SW region whereas Ganges river discharge influences in the NW region. Our results suggest that the coastal Bay of Bengal acts as a net source for CO\textsubscript{2} to the atmosphere throughout the year except for a brief winter.


b. Atmospheric disturbances and biological productivity in the Bay of Bengal

Influence of extreme atmospheric events, such as heavy rainfall and cyclone \textit{Sidr}, on phytoplankton biomass in the western Bay of Bengal using both \textit{in situ} time-series observations and satellite derived chlorophyll \(a\) (Chl \(a\)) and sea surface temperature (SST) was studied. Excessive supply of nutrients by the episodic heavy rainfall (234 mm) on 4–5 October 2007 and the subsequent runoff caused an increase in Chl \(a\) abundance by four times in the coastal Bay than before. Similar increase in Chl \(a\), by 3 to 10 times, was observed on the right side of the cyclone \textit{Sidr} track in the central Bay of Bengal after its passage. These two episodic events caused phytoplankton blooms in the western Bay of Bengal that enhanced \(\sim 40\%\) of fishery production.
During October–December 2007 compared to that in the same period in 2006.


c. Atmospheric deposition of nitrogen and iron over the Bay of Bengal

Atmospheric dry-deposition of water soluble inorganic and organic nitrogen ($N_{\text{Inorg}}$ & $N_{\text{Org}}$) to the Bay of Bengal has been studied during the continental outflow (Jan-April) from south and south-east Asia. The analysis of these species has given insight of the relative importance of inorganic versus organic nitrogen in the MABL and their air-sea deposition. The abundance of $\text{NH}_4^+\text{-N}$ (> 90% of $N_{\text{Inorg}}$) dominates the total water soluble nitrogen (> 80%) in the MABL. Nevertheless, contribution of $N_{\text{Org}}$ to $N_{\text{Tot}}$ ($N_{\text{Inorg}}+N_{\text{Org}}$) is significant along coastal regions. A significant linear relationship among $N_{\text{Org}}, \text{NH}_4^+$ and $\text{nss-K}^+$ suggests their common source from biomass burning emissions and fertilizers. A comparison of atmospheric input of soluble N with the riverine supply suggests that both are of comparable magnitude. The dry-deposition flux of nitrogen to the Bay of Bengal ranges from 2 to 165 µmol m$^{-2}$ d$^{-1}$; and can account up to 13% of the Primary Production in the Bay of Bengal (Srinivas et al., 2011a). The fractional solubility of aerosol-Fe (Fe$_{\text{ws}}$ % = Fe$_{\text{ws}}$/Fe$_{\text{Tot}}$ *100; Fe$_{\text{ws}}$ = water-soluble iron; Fe$_{\text{Tot}}$ = total aerosol iron) over the Bay of Bengal is another important issue associated with the continental outflow of pollutants. The high solubility of aerosol-Fe (1.4 to 24 %) over the Bay of Bengal compared to Arabian Sea (0.02 to 0.4 %), is attributable to chemical processing of fine mode alluvial dust during long range transport and combustion products of fossil-fuel and biomass burning emissions. These results have implications to air-sea deposition of micro-nutrients and their impact on the biogeochemistry of surface waters of the Northern Indian Ocean.


2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

3. Human dimensions (outreach, capacity building, public engagement etc)

Four Indian research students participated in SOLAS Summer School. Ms V. P. Vidya was declared as one of the Best Poster winners.

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

Dr. V. V. S. Sarma is the chairman for Indian Ocean sub-group in the preparation of Surface Ocean Carbon Atlas (SOCAT) for the world ocean of IOCCP, UNESCO, Paris, which was released recently.

6. Goals, priorities and plans for future activities/events

Future activity focuses on air-water interactions in Indian estuaries and coastal systems with a sustained time-series approach.

7. Other comments
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

**RV Knorr Bloomcruise**

Participated in the R/V Knorr Bloomcruise in July in collaboration with Scott Miller and Eric Saltzman. This project was funded by the NSF (see [http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0851472](http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0851472)) and participation by NUIG was funded with grants from the Science Foundation Ireland (SFI). The following measurements were conducted by NUIG personnel:

- Upper ocean turbulence with the Air-Sea Interaction Profiler (ASIP)
- Eddy covariance flux measurements of carbon dioxide using two licor gas analysers
- Wave measurements at the bow of the R/V Knorr using a time of flight acoustic device
- Underway pCO2 measurements with a General Oceanics system

Figure above shows measurements of upper ocean turbulence in response to the wind forcing. This deployment captured the crossing of a front, where the wind suddenly dropped from 10 to 4 m/s, and then subsequently ramped up to about 18 m/s. The response of the upper ocean exhibited little time lag with the atmospheric forcing. The dissipation of turbulent kinetic energy (\( \varepsilon \)) is one of the most important parameters for driving air-sea exchange, and our ability to make profiles within the footprint of an eddy covariance flux measurement provides a unique ability to study the \( \varepsilon-k \) (transfer velocity) relationship.

**Air-Sea Iodine Transfer**

This work is the result of an interdisciplinary collaboration between atmospheric physicists at UCC (Dr Sophie Dixneuf, Dr Albert A. Ruth, Laser Spectroscopy Group, Physics Department) and marine botanists of NUI Galway (Udo Nitschke, Dr. Dagmar B. Stengel, Botany and Plant Science, School of Natural Sciences, and Ryan Institute). While the Incoherent-Broadband Cavity-Enhanced absorption Spectroscopy (IBBCEAS) instrument was setup at NUI Galway by the group of Cork (Sophie Dixneuf) the data presented below were measured by the group at Galway (Udo Nitschke).
Although sea-to-air iodine transfer is a key part of the iodine cycle in the global environment, our understanding of the marine sources and mechanisms of the release of elemental iodine into the atmosphere as well as its partitioning into either I\(_2\) or various volatile iodo-carbons is far from complete. In this research time-resolved flux measurements of I\(_2\) emitted by the brown macroalga *Laminaria digitata*, probably the strongest iodine accumulator amongst living organisms, were achieved by applying IBBCEAS [1,2,3] to algal samples freshly collected at Finavarra, Co. Clare, Ireland.

I\(_2\) emission of air-exposed blades of *L. digitata* was investigated as a function of light intensity and temperature. As observed in a previous study [3], the new measurements confirmed the high variability of I\(_2\) release into air. Moreover, investigated irradiances and temperatures did not affect significantly I\(_2\) release into air (Figure 1, \(P\)-values >0.05). Since such environmental factors were in the normal range of conditions occurring in the naturally habitat of this species, these findings could be expected and further research will be required to examine the metabolic function of iodine in *L. digitata*.

![Fig. 1](image.png)

**Fig. 1** Total amount of I\(_2\) emitted from blades (including meristematic area) of *L. digitata* under **A** defined irradiances (at 20°C) and **B** defined temperatures (at 30 µmol photons m\(^{-2}\) s\(^{-1}\)). Data are presented as box plots showing median (black line), 25th and 75th percentile (indicating 50% of the data range), and minimum and maximum (whisker) of \(n = 6\) replicates. Significant effect of irradiance or temperature on I\(_2\) emission was calculated using one-way ANOVA, \(P\)-values are given.

During a biodegradation experiment blades from *L. digitata* were allowed to die off and degrade at 20°C and low irradiances (50 µmol photons m\(^{-2}\) s\(^{-1}\)). I\(_2\) emission into air and I\(^-\) release into seawater was determined after 0, 1, 4 and 29 days of degrading algae. Seawater samples were sent to laboratories of Service Central d’Analyse, CNRS, Solaize (France) and results are still pending. However, preliminary results indicate that major amounts of iodine from degrading *L. digitata* are released into seawater and not into the atmosphere.

Different brown macroalgae, which usually form kelp beds at Irish shores and which are known to retain high amounts of iodine (i.e. *Saccharina latissima*, *L. digitata*, *Saccorhiza polyschides*, *L. hyperborea*: old and new blade) were investigated for their I\(_2\) emission in a controlled environment: 12°C and 30 µmol photons m\(^{-2}\) s\(^{-1}\). Preliminary results are shown in Table 1. These indicate that *L. digitata* was the strongest I\(_2\) emitter amongst the species studied, followed by *L. hyperborea*, but I\(_2\) emission was observed only from newly formed blades. I\(_2\) release into air from other investigated seaweeds or old blades of *L. hyperborea* was below the limit of detection of the IBBCEAS instrument. The results suggest that *Laminaria* species are the main contributors to overall I\(_2\) emission from kelp beds which certainly depends on biomass distribution and tidal levels. Further experiments will be required to confirm such findings.

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

- Participated in the ESA-SOLAS conference held at Frascati in December. Several oral and poster contributions were made (Dr Brian Ward, NUIG)
- Oilwave cruise on the R/V Johan Hjort near the Lofoten Islands in Norway in collaboration with Met.NO (Oslo). The objectives of the cruise were to study the interaction between waves and turbulence at the ocean surface (Dr Brian Ward, NUIG).
- Bloomcruise experiment on the R/V Knorr from Woods Hole to Woods Hole to study air-sea gas exchange (Dr Brian Ward, NUIG).
- Participation in the SOLAS Summer School by PhD student Sebastian Landwehr (Dr Brian Ward, NUIG).
- Travel grant from SFI for Sebastian Landwehr to spend 6 months at Scott Miller’s Laboratory at SUNY, Albany to improve eddy covariance flux techniques, and to participate in the SOAP research cruise (Dr Brian Ward, NUIG).
- Oilwave workshop help in Galway in December to discuss the results from the successful cruise in the Norwegian fjord in April (Dr Brian Ward, NUIG).
- Project funding from Marine Institute “Sea surface alkalinity across the Irish shelf from underway temperature and salinity data collected during the INFOMAR project” €29,985 Feb -Nov 2012 (Dr Rachel Cave, NUIG)
- Experiment conducted at Scripps for controlled wave-breaking and bubbling experiments for identification of organic matter in marine aerosols (Dr Darius Ceburnis, NUIG)

3. Human dimensions (outreach, capacity building, public engagement etc)

- AIRSEA Lab participated in the Sea2Sky outreach event which was funded by the Marie Curie Research Nights (Dr Brian Ward, NUIG)
- AIRSEA lab participated in Galway Science and Technology Festival (Dr Brian Ward, NUIG)

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


Triona McGrath; Caroline Kivimäe; Toste Tanhua; Rachel R Cave; Evin McGovern, Inorganic carbon and pH levels in the Rockall Trough 1991-2010, Submitted to Deep-Sea Research (Dr Rachel Cave, NUIG)

Enowmbi R. Ashu-Ayem, Udo Nitschke, Ciaran Monahan, Jun Chen, Steven B. Darby, Paul D. Smith, Colin D. O’Dowd, Dagmar B. Stengel, Dean S. Venables, Coastal iodine emissions: Part 1. Release of I2 by Laminaria digitata in chamber experiments, SUBMITTED to Environmental Science and Technology (Dr Dean Veneables, UCC)
Ciaran Monahan, Eno Wmbi R. Ashu-Ayem, Udo Nitschke, Steven B. Darby, Paul D. Smith, Dagmar B. Stengel, Dean S. Venables and Colin D. O’Dowd, Coastal Iodine Emissions: Part 2. Particle Formation from Laminaria digitata and I2 in chamber experiments, SUBMITTED to Environmental Science and Technology (Dr Dean Veneables, UCC)

Dixneuf, S., Ruth, A.A., Nitschke, U. and Stengel, D.B. Molecular iodine emission rates of different thallus parts of Laminaria digitata using incoherent broadband cavity-enhanced absorption spectroscopy. 43rd Liège Colloquium on Ocean Dynamics, Liège (Belgium), 2-6 May 2011 (oral).


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)
   - Partner in FP7 project Carbochange and will host second annual meeting in march 2012
   - Participation in the NASA SPURS (Salinity processes in the upper ocean regional study) workshop in February 2012

6. Goals, priorities and plans for future activities/events
   - Participating in the New Zealand SOAP cruise in collaboration with Scott Miller at SUNY. A NUIG student (Sebastian Landwehr) will be responsible for the instrumentation on the R/V Tangaroa.
   - Will participate in the STRASSE/SPURS cruise in collaboration with LOCEAN (Paris) in the sub-tropical North Atlantic to study the processes governing the salinity maximum, and the air-sea exchange of freshwater.
   - Brian Ward will chair a session at Ocean Sciences 2012 in Salt Lake City
   - Participation in the SOLAS OSC in May with 2 students from AIRSEA lab at NUIG
   - NUIG will host the second annual Carbochange meeting in March 2012

7. Other comments
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

i) Responses of marine ecosystem to typhoon passages in the western subtropical North Pacific by Shibano, R., Yamanaka, Y., Okada, N., Chuda, T., Suzuki, S., Niino, H., Toratani, M.

Strong phytoplankton blooms are occasionally observed around a recurvature point of typhoon tracks in the western subtropical Pacific. These are noteworthy events in subtropical regions where both nutrient concentrations and biological production are persistently low. We investigated the response of phytoplankton to typhoon passage using a numerical model with/without biogeochemical processes. The model reproduced the observed patch-like phytoplankton bloom around a recurvature point of Typhoon Keith in 1997. The strong bloom is caused by the typhoon-centered upwelling of nutrient-rich water from below the euphotic layer, which supplies the nutrients required for phytoplankton growth, resulting in higher chlorophyll-a concentrations. Biogeochemical processes then play essential roles in determining the response after the passage of typhoons in subtropical regions.

ii) Population dynamics of phytoplankton, heterotrophic bacteria, and viruses during the spring bloom in the western subarctic Pacific by Suzuki, K., Kuwata, A., Yoshiie, N., Shibata, A., Kawanobe, K. and Saito, H.

An index for diatom bloom development has been established. Bloom-forming diatoms were mainly Thalassiosira and Chaetoceros species. Fucoxanthin can serve as a strong indicator of the diatom carbon biomass. Abundance of heterotrophic bacteria changed little during the spring diatom bloom. Viral abundance increased toward the end of the spring diatom bloom.


Using a single-particle mass spectrometer, the size and chemical composition of individual Fe-containing atmospheric aerosols (Fe aerosols) with diameter from 100 to 1800 nm were characterized during Asian outflow season (spring of 2008) in Okinawa Island, Japan. The results show that anthropogenic sources contribute significant portion of Fe aerosols in Asian outflow. Excluding the vanadium type, relative contribution of the remaining four particle types was constant over the course of study, which remained even when the total concentration of Fe aerosols changed and fraction of the Fe aerosols among atmospheric aerosols decreased significantly by the switch of air mass type into marine type. The observed constant relative abundance reflected the relative source strength of Fe aerosols in Asian outflow, particularly emphasizing the importance of coal combustion source in East Asia.

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)
The science projects, which have been planned to investigate responses of Antarctic marine ecosystems to such global environmental changes as global warming and oceanic acidification, and to study on plankton community structure and environmental parameters, under the six year plan Phase VIII of the Japanese Antarctic Research Expeditions (JARE-52 to -57, 2010/11-2015/16). The marine science cruises were conducted in January by RT/V Umitaka-Maru (Tokyo University of Marine Science and Technology) and in March by Icebreaker Shirase. The intensive study areas were around marginal sea ice zone along 110°E and 140°E in the Antarctic Ocean. On the other hand, shore based observations were conducted around Syowa Station (69°00'S, 39°35'E). Temporal changes in plankton communities and pCO2 under fast ice were investigated.

We postponed the Final Symposium for the W-PASS project in Tsukuba on March to Sapporo on 13 September 2011. We finalized the publication of final report both in Japanese and English version.

Many SOLAS-Japan members have been working on the radioactive material investigation released from the Fukushima Nuclear Power Plants in marine atmosphere and ocean by research vessels and on land. It is important to identify the inputs both from atmosphere and direct discharge of contaminated water to the ocean. SOLAS members are expert for this field.

3. Human dimensions (outreach, capacity building, public engagement etc)

After 5 year W-PASS project, we traced for young scientists involved the project. Seven students continued their PhD study from 37 students for master degree. Eleven scientists obtained PhD have been working as post doc or assistant professor. A new PhD got a job in a private industry. Among 34 post docs working for the W-PASS project, 7 obtained now faculty positions and 22 are keeping their post doc positions. Substantial numbers of young scientist are working in the SOLAS field in Japan, but we see some decrease of PhD candidates for the last 5 years.

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)

See attached file “Top 10 paper”

5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

A SOLAS-Japan research cruise will be carried out coincidentally with the TORERO (Tropical Ocean tRoposphere Exchange of Reactive halogen species and Oxygenated VOC) expedition over the Eastern Equatorial Pacific Ocean in February 2012. We will discuss a joint workshop or session at the AGU SFO meeting in future.

6. Goals, priorities and plans for future activities/events

For W-PASS scientific outcome, the final report in Japanese version will be published by the end of February. The English version planned to be a hard cover book is under editing process. Our expecting publishing date is by the end of March 2012. Unfortunately, the East Japan great earthquake made all publication schedule postponed.

7. Other comments

The person in charge of the National report preparation will take the place from Uematsu to Nojiri from 2012.
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

**Ocean-Atmosphere Interactions Under Moderate to Strong Offshore Winds in the Gulf of Tehuantepec**

Momentum exchange between the atmosphere and ocean, together with the vertical fluxes of heat and moisture, play a fundamental role on weather and climate, and their variability over a wide range of time and space scales. Knowledge on how wind stress varies with environmental parameters is of increasing importance, especially for the modelling of air–sea interaction for ocean current and wave prediction. The Gulf of Tehuantepec air–sea interaction experiment (intOA) took place, under the Programme for the Study of the Gulf of Tehuantepec (PEGoT, Spanish acronym for Programa para el Estudio del Golfo de Tehuantepec). PEGoT is underway aiming for better knowledge of the effect of strong and persistent offshore winds on coastal waters and their natural resources, as well as performing advanced numerical modelling of the wave and surface current fields. One of the goals of the intOA experiment is to improve our knowledge on air–sea interaction processes with particular emphasis on the effect of surface waves on the momentum flux for the characteristic and unique conditions that occur when strong Tehuano winds blow offshore against the Pacific Ocean long period swell. For the field campaign, an air–sea interaction spar (ASIS) buoy was deployed in the Gulf of Tehuantepec to measure surface waves and the momentum flux between the ocean and the atmosphere. High frequency radar systems (phase array type) were in operation from two coastal sites and three acoustic Doppler current profilers were deployed near-shore. Synthetic aperture radar images were also acquired as part of the remote sensing component of the experiment. The present paper provides the main results on the wave and wind fields, addressing the direct calculation of the momentum flux and the drag coefficient, and gives an overview of the intOA experiment. Although the effect of swell has been described in recent studies, this is the first time for the very specific conditions encountered, such as swell persistently opposing offshore winds and locally generated waves, to show a clear evidence of the influence on the wind stress of the significant steepness of swell waves.

Fig. Distribution of friction velocity $u^*$ and spectral peak phase speed for wind-sea encountered during observations in the intOA Experiment, to provide an idea of the range of wave age. Cases for Tehuano events are identified as dark dots, while all the other cases are grey dots. Indication of underdeveloped waves are noticed for these limited-fetch growing conditions as from the characteristic offshore winds measured at the ASIS buoy specific location. The straight line defines $C_{Psea} = 20u^*$ typically for well-developed waves.


**offshore export of total organic carbon along the eastern boundary of the Subtropical North Pacific**

Highest TOC concentrations (470 mM) were observed for waters above the nitracline and associated with both California Current and southern surface waters. The northward advection of tropical waters in the California Undercurrent did not have any discernible impact on TOC distributions. An estimate of the average rate at which TOC in surface waters was exported offshore by Ekman transport in February 2003 was $1.73 \times 10^3$ kg C yr$^{-1}$ for each
The offshore flux estimate is thought to be conservative with respect to the annual mean offshore flux because the offshore Ekman transport and primary production increase in late spring and early summer and the contribution of upwelling filaments has not been considered. Analysis of TOC contributions to pelagic respiration suggested that TOC accounted for 45% of the oxygen decrease in southern oxic waters. In California Current and oxygen minimum zone waters, TOC did not contribute to pelagic respiration.

**Figure.** Station locations along the ship’s track superimposed on satellite (MODIS) chlorophyll estimates (http://seawifs.gsfc.nasa.gov) with the surface circulation overlain. The chlorophyll image is an eight day average from February 19 to 26, 2003. Chlorophyll (mg m\(^{-3}\)) uses a logarithmic scale. The inset shows the Ekman and geostrophic transports for the upper 125 m along the study section. Transport units are kg (s per m of coast)\(^{-1}\).

Recent studies have ranked mangrove forests among the most threatened ecosystems on Earth (Valiela et al. 2001; Alongi 2002; Duke et al. 2007; FAO 2007). In agreement with this view, Mexican governmental agencies have reported that the mangrove area in the nation has been decreasing in the last decades at an annual rate of around 2% (INE 2005). Some large-scale remote-sensing studies in northwest Mexico, however, suggest that mangrove cover in many lagoons, despite common perception, is not being lost. Comparing satellite images, some regional reports have argued that the area covered by mangrove forests has in fact been increasing during the last decades in some lagoons of the Pacific coast of Mexico. A significant increase in mangrove cover has occurred in backwaters of the lagoons during the last 40 years, and especially during the El Niño anomalies of the 1980s and 1990s, while at the same time the mangrove fringe has been receding. The observed change can be attributed to the combined action of the warm surface waters of El Niño events and sea-level rise. Jointly, these two effects are sufficient to flood large areas of previously non-flooded salt flats, dispersing mangrove seedlings inland. The inland expansion of mangroves, however, does not ease conservation concerns, as it is the seaward fringes, and not the inland margins, that provide the most valuable environmental services for fisheries and coastal protection.

Fig. Boca de Santo Domingo in high-resolution images. The top plate shows an aerial photograph taken in 1962, the middle one is a GoogleEarth image from August 2006. The image at the bottom highlights the differences between the two timed photos.


2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

Third Symposium on Carbon in Mexico was held in the premises of the Centre for Research in Sustainable Chemistry, Autonomous University of Mexico State (http://simposiodelcarbono.org/). The symposium aims to bring together specialists in the study of carbon in the different environments of Mexico, in order to learn more about recent advances in research on this subject are underway in the country and thus propose future of research.

First national workshop develop at Centro de investigacion Científica y de Educación Superior de Ensenada Baja California Mexico, about marine biogeochemical cycles: Impacts of global change and ecosystems at regional level in Mexico.

3. Human dimensions (outreach, capacity building, public engagement etc)

Ocean acidification may be causing problems for shellfish producers on the northwest coast, the deep-bay field station manager for the Centre for Shellfish Research at Vancouver Island University. Over the past few years, operations in Washington and Oregon have had difficult getting shellfish larvae to grow. Although it wasn't clear whether this issue extended north to Baja California Mexico, shellfish community now believes it could be the cause of some problems are happening in the Mexican coast as well. For the above, several
fisheries are now requesting collaboration to several institution and results will coming up.

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)
The list below identifies several papers published in 2011 related with biogeochemistry studies.


Hernández-Terrones, Laura; Rebollo-Vieyra, Mario; Merino-Ibarra, Martin; Soto, Melina; Le-Cossec, Adrien; Monroy-Rios, Emilio, (2011). Groundwater Pollution in a Karstic Region (NE Yucatan). Baseline Nutrient Content and Flux to Coastal.- Water, Air, & Soil Pollution. (218), 1:517-528.


María de la Luz Vázquez-Sauceda, G. Aguirre-Guzmán, J. G. Sánchez-Martinez and R. Pérez-Castañeda,


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

Mexican researchers have developed many productive international collaborations, particularly with regard to fieldwork, workshops and samples analysis support. But also a bi-national collaborations but also participation to international assessment:

- UCMEXUS projects. The University of California Institute for Mexico and the United States (UC MEXUS), established in 1980, is an academic research institute dedicated to encouraging, securing, and contributing to binational and Latino research and collaborative academic programs and exchanges.


- The National Data Center Exchange (CEND) is already given an official high in the IODE / IOC / UNESCO.

6. Goals, priorities and plans for future activities/events

The Mexican government goal is to develop a Research Thematic Networks set by CONACYT for group researchers, technologists and entrepreneurs with common interests and willingness to collaborate and contribute their knowledge, skills and abilities to synergistically promote solutions to problems and strategic issues for the development the country. The objective is to promote and strengthen the construction and development of national scientific networks on strategic issues that respond to problems (scientific, technological and social) and seek the linkages between academia, government and society. In the present there are two subnetworks includes the ocean studies with a lot of participation from several institution. However, if this this idea still as a part of the new future government, many work will be coming up.

7. Other comments
SOLAS New Zealand
compiled by Cliff Law

Notes:
Reporting Period is January 2011 – December 2011
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

1. Publication of the SOLAS Air-Sea Gas Exchange Experiment (SAGE), Deep-Sea Research II Special Issue containing 11 papers (detailed in previous report).

2. Secondary organic aerosol in the Southern Pacific Ocean

Marine biologically active regions are known to produce a range of compounds that interact with the atmosphere directly and indirectly affecting particle production, composition, and properties in marine atmosphere. While the CLAW hypothesis (Charlson et al., 1987) suggests the importance of marine biological activity in ultrafine (d<100nm) particles composition and the potential importance of secondary sulphate production, this hypothesis does not take into account the secondary organic fraction in the composition of the ultrafine particles. To date, observations of the presence of a marine origin secondary organic fraction in ultrafine particles have been indicated down to nucleation mode size particles (d<15nm) in Atlantic coastal waters (Vaattovaara et al., 2006), ice edge waters in the Arctic (Vaattovaara et al., ICNAA 2009), and subtropical Pacific Ocean waters (Modini et al., 2009). In spite of the importance of secondary particles to atmospheric radiatively active sizes, the composition of marine produced particles is still uncertain in other marine biologically active locations around the world.

This study of the composition of nucleation (d<15nm) and the lower end of Aitken (20nm<d<60nm) modes particles is focused on particle production at one such region, at the Chatham Rise (New Zealand; latitude 42°S-44°S, longitude 174°E-177°W) during the PreSOAP (Pilot Surface Ocean Particle Production) voyage during the austral summer. The region of the southern Pacific Ocean includes a sub-tropical front characterised by intensive austral summers phytoplankton blooms. The ultrafine particles composition was studied using the UFO-TDMA and the VH-TDMA methods onboard the RV Tangaroa (NIWA, Wellington, New Zealand). Auxiliary data were collected from the ship weather station and marine information observations, SMPS particle distribution measurements, total particles count CPC measurements with 5 nm and 10 nm cut-off sizes, and black carbon measurements. Marine biological activity was established using MODIS satellite data, and supported by a range of in situ parameters including chlorophyll and dissolved DMS. Marine air masses origin was followed with HYSPLIT trajectories.

The TDMA measurements showed nucleation and Aitken mode sized particles including a clearly detectable organic fraction. During intensive solar radiation periods secondary organic contribution is highly probable in those ultrafine particles. Furthermore, the comparison between in situ bubble burst chamber and atmospheric particles composition measurements strongly support a secondary origin of the atmospherically observed ultrafine particles. Comparison with the secondary organic fraction observations on Atlantic, Arctic, and Pacific oceans reveals that although the secondary organic fraction clearly exists in ultrafine particle phase, the properties of the fraction can be dependent on the marine area conditions.

3. Ocean acidification – impact of other anthropogenic gases
   Apart from CO$_2$ other anthropogenic gases have the potential to alter ocean pH and CO$_2$ chemistry, specifically SO$_x$ and NO$_x$ and NH$_3$. We demonstrate using a simple chemical model that in coastal water regions with high atmospheric inputs of these gases, their pH reduction is almost completely canceled out by buffering reactions involving seawater HCO$_3^-$ and CO$_3^{2-}$ ions. However, a consequence of this buffering is a significant decrease in the uptake of anthropogenic CO$_2$ by the atmosphere in these areas.


2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

PreSOAP research voyage, February 2011
The Pre-SOAP voyage was carried out in February 2011 as a pilot study for the 2012 SOAP voyage. Sampling strategy around the productive Chatham Rise region east of New Zealand was informed by ocean colour images, and determined in real time by underway data collection (chl-a, pCO$_2$, pH, DMS, backscatter). Over 11 days three different types of phytoplankton blooms (diatom, dinoflagellate & coccolithophore–dominated), with unique biogeochemical characteristics, were sampled. Surprisingly, the coccolithophore bloom (high underway back-scatter, low pCO$_2$ & high Chl-a) had the lowest DMS signal. A number of instruments, sensors and sampling designs were successfully trialled during PreSOAP. Of particular note were the performance of the in-line sensor suite, real-time output on the ships DAS system, the SCD-GC for measuring atmospheric DMS, the aerosol particle size suite which identified several pulses of new particle formation, the flux catamaran for measurement of CO$_2$ and DMS flux at distance from the ship, new microlayer sampling techniques, and the identification of ultrafine particle formation including an organic fraction in shipboard measurement and bubble burst experiments with detection by TDMA (see above highlight).

NZ Geotraces voyage, June 2011

Continuation of bimonthly Munida/Polaris time-series transect in Sub-Antarctic Water

Aerosol dust and CN sampling on the Transfuture Five Car Carrier, Wellington-Osaka, Japan

Participation in OSO2011 voyage, Dec 2010 / Jan 2011 University of Gothenburg (Sweden) ocean-atmosphere-ice carbon exchange

NZ 5th Annual Workshop on Ocean Acidification, NIWA Wellington; 22/8/11

3. Human dimensions (outreach, capacity building, public engagement etc)


RSNZ Workshop on Geoengineering Feb 2011 - Lectures by P.W. Boyd, C. S. Law and M. Harvey

5th SOLAS summer school in Corsica - P.W. Boyd lecturer

IPCC WG2 Chapter 6 on Ocean Systems, P.W. Boyd Lead Author

### 4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

SOAP (Surface Ocean Aerosol Processes) voyage – February 2012 - QUT, CSIRO (Australia), UEF (Finland), UC Irvine, U. Chapman (USA), NUIG(Ireland), IFM-Geomar (Germany), U. Laval (Canada)

NZ Geotraces voyage – June 2011 – U. S. California, Bigelow (USA), PML (UK), ANU (Australia)

Transfuture Five aerosol sampling - NIES (Japan), UEA (UK)

OSO2011 voyage, Dec 2010 / Jan 2011 University of Gothenburg (Sweden) ocean-atmosphere-ice carbon exchange

6. Goals, priorities and plans for future activities/events
**Annual Report for the year 2011:**

Completion of SOAP voyage, February 2012

Maintain NZ bimonthly Munida/Polaris time-series transect in Sub-Antarctic Water

Maintain Aerosol dust and CN sampling on the *Transfuture Five* Car Carrier, Wellington-Osaka, Japan

| 7. Other comments |
1. Scientific highlight

Carbon budget for the Nordic Seas

In a study recently published in Global Biogeochemical Cycles - and quoted as a 'Research highlight' in the November issue of Nature Geoscience, Emil Jeansson and colleagues at the Bjerknes Centre for Climate Research, University of Bergen, present a carbon budget of the Nordic Seas, the ocean area connecting the North Atlantic with the Arctic Ocean. The authors found that the dominating exchange of carbon takes place across the Greenland-Scotland Ridge. Horizontal transport of carbon in the region is almost two orders of magnitude larger than the uptake from the atmosphere – 12.3 Gt of carbon imported, annually, and 12.5 Gt carbon is exported.

The figure shows the net horizontal transport of total carbon in the different gateways of the Nordic Seas. The 'net' term (in italic) shows the resulting transport, when adding all horizontal in and outflows, where the negative sign means that the budget gives a net transport out of the region. Thus, balancing the budget requires an uptake of CO2 the same amount from the atmosphere. Figure: from Jeansson et al., (2011).

Jeansson and colleagues estimate an annual export of about 0.09 Gt anthropogenic carbon (excess carbon resulting from perturbations of the “natural” carbon cycle), from the Nordic Seas to the deep North Atlantic. This is a crucially important pathway for removing the climatically important CO2 from the atmosphere to the interior ocean and thus moderating the potential global warming of global fossil fuel combustion and land-use change.

Reference

2. Main accomplishments

First public release of Surface Ocean CO2 Atlas (SOCAT)

The Surface Ocean CO2 Atlas (SOCAT) is a global synthesis of surface ocean carbon dioxide (CO2) measurements collected on research vessels, voluntary observing ships and buoys. The first public release of SOCAT (version 1.5) was published in September 2011. This global data set consists of data from 1851 voyages between 1968 and 2007 with approx. 6.3 million recalculated surface water fCO2 (fugacity of CO2) measurements (Figure 1). The following
researchers from the University of Bergen and the Bjerknes Centre for Climate Research contributed to this international effort: Benjamin Pfeil, Are Olsen, Abdirahman Omar, Ingunn Skjelvan Siv Lauvset, Truls Johannessen, Richard Bellerby, Christoph Heinze and Jerry Tjiputra.

The figure shows an overview of SOCAT cruises using Live Access Server (courtesy of NOAA/PMEL)

In 2007, surface water CO₂ data were archived in a wide range of formats at numerous sites around the world, each with its own rules for access, making it virtually impossible to generate a comprehensive data synthesis product. At a meeting in UNESCO headquarters (IOCCP, 2007), the international ocean carbon community decided to initiate the SOCAT to improve access to global surface water CO₂ data. It took four years of hard work by marine carbon scientists around the world to assemble and quality control the first version of SOCAT.

Two SOCAT products are available via http://www.socat.info/ (1) A global data set of recalculated surface water fCO₂ values in a uniform format, which has undergone 2nd level quality control; (2) A global, gridded product of monthly mean surface water fCO₂, with no temporal or spatial interpolation, and individual cruise files with recalculated fCO₂ values.

The methods in SOCAT are transparent and fully documented (Pfeil et al., 2012; Sabine et al., 2012). The products and cruises are citable through their respective Digital Object Identifiers (doi-s). Cruises in SOCAT have an Expocode (a code containing Cruise ID, Year, Month and Day of Cruise), a doi and metadata documentation (e.g. investigator, vessel, methods).

The SOCAT website is maintained at the University of Bergen. It has a large number of visitors (average of 1,000 per month) which demonstrates the intense interest in these carbon synthesis products.

References:

Launch of EU FP7 project CARBOCHANGE

On 8-11 March 2011, 80 scientists from Europe, North America and Africa gathered in Bergen, for the official launch of CARBOCHANGE - Changes in carbon uptake and emissions by oceans in a changing climate – which is a large-scale
integrating collaborative research project of 7 million Euros funded by the EU’s 7th Framework Programme in the period 2011-2015.

The goal of CARBOCHANGE is to quantify the oceanic uptake of human-produced carbon dioxide from the atmosphere. It is coordinated by the Geophysical Institute at the University of Bergen and the Bjerknes Centre for Climate Research, Norway. CARBOCHANGE gathers a consortium of 28 research institutions from Europe, North America (USA and Canada) and Africa (Morocco and South Africa) with outstanding scientific expertise in the field of carbon cycle research.

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. It will provide science-based guardrails for political decisions on mitigation actions in order to control and alleviate the impact of carbon dioxide emissions and climate change. For more info visit: www.carbochange.eu

CARBOCHANGE is endorsed by SOLAS.

Other projects launched in 2011

Several other projects lead by the partners of the Bjerknes Centre for Climate Research started during the 2011. These include:

1. The EU FP7 project Development of global plankton data base and model system for eco-climate early warning (GreenSeas) which is to advance the quantitative knowledge of how planktonic marine ecosystems, including phytoplankton, bacterioplankton and zooplankton, will respond to environmental and climate changes. To achieve this GreenSeas will employ a combination of observation data, numerical simulations and a cross-disciplinary synthesis to develop a high quality, harmonized and standardized plankton and plankton ecology long time-series, data inventory and information service.

2. MONitoring and Assessing Regional Climate change in High latitudes and the Arctic (MONARCH-A) with the objective to generate a dedicated information package tailored to a subset of multidisciplinary Essential Climate Variables and their mutual forcing and feedback mechanisms associated with changes in terrestrial carbon and water fluxes, sea level and ocean circulation and the marine carbon cycle in the high latitude and Arctic regions http://www.nersc.no/project/monarch

3. Human dimensions (outreach, capacity building, public engagement etc)

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)


6. Goals, priorities and plans for future activities/events

7. Other comments
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

SOLAS Perú projects

1. CO₂, Carbonate system an acidification off Perú

At the end of 2009, the Instituto del Mar de Perú (IMARPE) and the State Key Laboratory of Marine Environmental Science from the Xiamen University established a general agreement in order to develop scientific, technical and training cooperation activities particularly in the study of CO₂ and in general the carbonate system in order to explore the ocean acidification in the context of the global change. During 2011 as part of this cooperation, scientist Violeta León from the Instituto del Mar del Perú (IMARPE) participated in a training stage (March-May) under the supervision of Dr. Deli Wang from the Ocean Carbon Group led by Prof. Minhan Dai, supported by the visiting fellowship program of the State Key Laboratory of Marine Environmental Science (Xiamen University). The goal of the stage was to learn the different techniques associated with the carbonate system. Additionally to the capacitación, in 2011, in the frame of the cooperation, we collected samples off Callao (Central Perú) during the monitoring performed by the Chemical Oceanography Unit in order to analyze total CO₂, pH and alkalinity in the Laboratories of the MEL (Xiamen University).

2. N₂O Time Series Measurements off Peru –A Cooperation between SFB 754/IFM GEOMAR and IMARPE.

After the SOLAS workshop “Air-Sea fluxes at the Eastern Boundary Upwelling and OMZ systems” (SOLAS mid-term strategy initiative) on 8-10 November 2010 in Lima (Perú) at the Instituto del Mar del Perú (IMARPE), we established a cooperation between IMARPE and the SFB754/IFM-GEOMAR. The main objective of the cooperation is to investigate the distribution of N₂O in dependence of the oxygen concentration in the OMZ off Perú, in order to understand and predict the role of the OMZs-EBUES in the ocean under climate change. During 2011 we started different activities with the goal of establishing time series measurements off Peru. The sampling activities were initialized during a visit of SFB754/IFM-GEOMAR-staff at IMARPE in May 2011. During this visit the Chemical Oceanography Staff (IMARPE) was introduced to the technique of sampling trace gases. Also a first cruise including N₂O sampling was conducted. A second sampling cruise took place in October 2011, where N₂O was sampled. The samples from both cruises were analyzed at the Biogeochemistry Laboratory of Dr. Hermann Bange, at the IFM-GEOMAR in Kiel, Germany. As a second phase of the training plan, two professionals from IMARPE-Georgina Flores and Michelle Graco, visited the IFM-GEOMAR in November 2011, to be introduced to the N₂O analysis method using the static headspace method and gas chromatography. The first results obtained from May and October 2011, show that most of the water column along the sampled transect was oversaturated with N₂O, indicating N₂O production within the sampled region (see Figure 1). N₂O concentrations found in the water column ranged from 4.7 nmol/kg to 156 nmol/kg. Maximum N₂O concentrations were observed in October coincident with a period characterized by an intense and shallow Oxygen Minimum Zone (OMZ < 25 °M/Kg). We plan to continue during 2012 with the N₂O sampling off Callao.
Figure. Upper panel: Location of the seven stations off Callao associated with an intense Oxygen Minimum Zone (OMZ) off central Peru (12º S). Lower panel: Comparison of O2 and N2O concentrations off Callao in May and in October 2011.

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

See point 1.

3. Human dimensions (outreach, capacity building, public engagement etc)

Participation of the Peruvian student, Maria del Carmen Igarza MSc candidate -Master of Marine Science Cayetano Heredia University, at the SOLAS Summer School (SSS) 2011.

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

In October 2011, several Peruvian scientists from the Instituto del Mar del Perú (IMARPE) and the Instituto Geofísico del Perú (IGP) participate in the international conference "Ocean Deoxygenation and implications for marine biogeochemical cycles and ecosystems" Toulouse (24-26 October 2011; http://www.euroceans.eu/conf-oxygen). France. This Eur-oceans conference was an excellent opportunity to discuss about one of the relevant topics associated with the global climate change, “the ocean loss of oxygen and the “extension of the Oxygen Minimum Zones (OMZs)” that is also one of the focus of the SOLAS OMZs-EBUEs Mid-Term Strategy Initiative.

6. Goals, priorities and plans for future activities/events
### Short and long term goals:

- Establish time series measurements of the carbonate system (total CO2, pH and alkalinity) and N2O off Callao (Central Perú) and at long-term establish the analysis of the carbonate system and of the N2O analysis at IMARPE.

- To participate in national and international efforts to carry out multidisciplinary cruises focus in the SOLAS OMZs-EBUEs Mid-Term Strategy Initiative topics, as the French Initiative AMOP, and also at the SOLAS cruise/ SFB 754-IFM/GEOMAR.

- Build a national network with scientists from different disciplines and institutions from Peru in order to have a local network for communication of SOLAS activities and to coordinate studies in the frame of SOLAS Mid-Term strategy topics associated with the SOLAS.

### 7. Other comments
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

**CO₂ exchange patterns in the Strait of Gibraltar**

Reconstruction of the temporal variability of the air-sea CO₂ exchange in the Strait of Gibraltar from 1997 to 2009 (data gathered in 36 cruises conducted in the area) has allowed to construct the seasonality of the marine source/sink of this important gas in that region of the sea. Contact person: E. Huertas (ICMAN-CSIC).


**Upwelling of CO₂-rich Antarctic waters was more important than the action of marine microorganism to account for the CO₂ increase during the last deglaciation**

Research at the Institut de Ciències del Mar of Barcelona (CSIC) shows that, during the last deglaciation that began nearly 17.000 years ago, the retrait of Antarctic sea ice and the consequent upwelling of CO₂-rich water from the deep was more determinant than the action of planktonic microorganisms for the simultaneous rise of atmospheric CO₂.

The research team is led by Eva Calvo and Carles Pelejero with co-investigators Isabel Cacho (University of Barcelona), Leopoldo D. Pena (University of Columbia) and Graham A. Logan (Geoscience Australia). Contact person: E. Calvo (ICM-CSIC).
La investigación ayuda comprender mejor los mecanismos naturales que determinan la concentración y distribución de CO$_2$ en el planeta, de especial relevancia en el contexto actual de aumento de emisiones y de calentamiento global.

The evolution of phytoplankton, and particularly diatoms and coccolithophores, in the Eastern Equatorial Pacific over the last 40,000 years was investigated for its role in CO$_2$ regulation. Diatoms are known to be more efficient at removing CO$_2$ from seawater and atmosphere because the process of calcification in coccolithophores cause a return of part of the utilized CO$_2$. The study of biomarkers in sediment cores reveals that, at the onset of deglaciation, the upwelling of deep waters around Antarctica and their transport northwards favored the outburst of diatoms over coccolithophores. The associated potential increase in the capacity to remove CO$_2$ was outcompeted by the efflux caused by the increased upwelling.

(Calvo et al. *PNAS* 2011)

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<tr>
<th>2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)</th>
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<tr>
<td><strong>Research Projects:</strong></td>
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<tr>
<td>- The CSIC and the University of Las Palmas de Gran Canarias are partners of CARBOCHANGE (Changes in carbon uptake and emissions by oceans in a changing climate, # 264879) funded by European Commission (7th frame program), 2011-2014.</td>
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<tr>
<td>- The CSIC and the CEAM are partners of INGOS (Integrated non CO$_2$ greenhouse gas observing system) funded by European Commission (7th frame program), 2011-2015.</td>
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<tr>
<td>- ICOS (Integrated Carbon Observation System)-SPAIN funded by the Spanish Ministry of Sciences and Innovation and aimed at establishing the national network of carbon observatories in terrestrial ecosystems, atmosphere and ocean, 2011-2012.</td>
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<tr>
<td>- Contribution of Doñana (NP) wetlands to the regional atmospheric CO$_2$ exchange (049/2010), funded by the Spanish Ministry of Environment, 2011-2013. PI: E. Huertas (ICMAN-CSIC)</td>
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<tr>
<td><strong>Cruises:</strong></td>
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<td>- The Malaspina 2010-11 Expedition, coordinated by C. Duarte (IMEDEA-CSIC), completed its trip around the global oceans (Dec 2010-Jul 2011). SOLAS activities aboard the RV Hespérides and Sarmiento de Gamboa included measurements of O$_2$, CO$_2$, isotopic ratios in CO$_2$ and water vapour, pH, alkalinity, NH$_3$, total volatile carbon, DMS, semivolatile organics, organic pollutants, aerosols, bioaerosols, atmospheric halogens, plankton metabolism, N$_2$ fixation.</td>
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<tr>
<td>- E. Huertas (ICMAN-CSIC) led three oceanographic campaigns at the Strait of Gibraltar on board the RV García del Cid (July and November) and Cornide de Saavedra (August) to sample the GIFT time series to keep tracking carbon fluxes between the North Atlantic and Mediterranean Sea.</td>
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<tr>
<td>- Mooring of the autonomous sensors SAMI-pCO$_2$ and SAMI-pH in the Strait of Gibraltar for</td>
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monitoring temporal variability of CO₂ and ocean acidification in the outflow of Mediterranean water

Mooring of SAMI-pCO₂ in Doñana wetlands to assess spatio-temporal variability of CO₂ in permanent freshwater lagoons.

R. Simó (ICM-CSIC) led the SUMMER cruise (12-23/9/2011) to the Western Mediterranean. Drifters were deployed for a lagrangian study of a surface water patch over two weeks. The effects of the changing underwater light fields on plankton and trace gas dynamics at hourly to weekly timescales were investigated. High temporal and spatial resolution vertical profiles of DMS concentration were obtained for the first time with the use of a yoyo pump coupled to a miniCIMS instrument.

3. Human dimensions (outreach, capacity building, public engagement etc)


Collaborations with the media have been frequent during 2011 as a consequence of the Malaspina 2010-11 Expedition, which has been taken as a good opportunity to tell the society about the functioning of the coupled ocean-atmosphere-climate system.

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

E. Huertas (ICMAN, CSIC) has been elected to the Executive Board of ICOS (Integrating Carbon Observation System) to implement the insertion of the ocean component in the infrastructure

6. Goals, priorities and plans for future activities/events

2012 brings the launch of a new project: ADEPT (Aerosol deposition and ocean plankton dynamics), led by F. Peters (ICM-CSIC). ADEPT addresses the study of the effect of atmospheric aerosol deposition on the dynamics of a marine LNLC (low nutrient low chlorophyll) system, namely the Mediterranean. To achieve its goal, ADEPT uses a multiscale and complementary approach. Relationships between atmospheric deposition and ocean nutrient and plankton dynamics are studied at a coastal scale and at the Mediterranean basin scale. Laboratory experiments focus to understand some of the underlying mechanisms.

7. Other comments
SOLAS Turkey
compiled by Mustafa Kocak and Baris Salihoglu

Notes:
Reporting Period is January 2011 – December 2011
Information will be used for: reporting, fundraising, networking, strategic development & outreach

<table>
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<tr>
<th>1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)</th>
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<tr>
<td><strong>Iron solubility in crustal and anthropogenic aerosols: The Eastern Mediterranean as a case study</strong></td>
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<td>Seguret et al., 2011</td>
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Study presents seawater dissolution experiments for aerosol samples simultaneously collected across the Levantine Basin (LB, Eastern Mediterranean Sea), a marine system influenced by seasonal atmospheric inputs. Two distinct populations exhibited contrasting kinetic profiles, those representative of strong Saharan dust events which had variable iron release profiles with a maximum solubility of 0.94±1.48 % (1 s.d.) whereas those which had a relatively greater anthropogenic influence had consistent profiles (fast release, ≤ 2h, of dissolved iron in seawater followed by removal) with a maximum solubility of 11.5±9.3 % (1 s.d.). First estimates of atmospheric fluxes of soluble iron are represented, ranging from 8.64±10.76 mg m⁻² y⁻¹ for the Northern LB to 6.48±7.78 mg m⁻² y⁻¹ for the Southern LB. Estimates of Fe fluxes to oceanic basins are important for constraining the global iron budget, and dust dissolution kinetic profiles provide information on the mechanisms involved during the release of aerosol Fe in seawater post atmospheric deposition.

**Kinetic dissolution profiles of the two aerosol populations**

All anthropogenically influenced aerosols showed similar dissolution profiles (Fig.1.a) with the maximum dFe concentration occurring after 2h of contact with seawater, followed by a fast decrease. The mean maximum solubility for these aerosols was 11.5±9.3 %. The decrease in solubility after 2h may be a result of:

(i) re-adsorption onto the aerosol particles on the filter (not the filter itself as no adsorption was apparent while equilibrating the blank filter in seawater) and/or

(ii) conversion of dissolved Fe to particulate species and/or organic complexes.

The mean seawater concentrations of released dissolved Fe for each of the equilibration periods (2, 4 and 8 h) were 11.5±9.3 nM; 4.0±3.5 nM; 2.9±3.4 nM, respectively. After 8h, four aerosol samples had dFe concentrations > 2.0 nM. This indicates either (i) equilibrium between dissolved and particulate Fe was not reached after 8h or (ii) equilibrium may have been reached but soluble organic material had also been released, stabilizing higher dFe concentrations. For three of these four aerosol samples, dFe concentrations were not significantly different after 4 and 8h of dissolution, suggesting that equilibrium had been reached and hence the release of soluble organic matter played an important role.
The changes in solubility of crustal aerosol samples with time of seawater equilibration are plotted in Fig. 1b. The overall mean maximum solubility was 0.94±1.48 % for all the samples considered and the maximum was reached at different equilibration times. In contrast to the anthropogenic aerosols, different kinetic trends were observed:

(i) a maximum solubility reached within 2–4 h followed by a decrease,

(ii) an increase in solubility without the attainment of equilibrium during the 8 h study period, and

(iii) no change insolubility with time.

These differences illustrate the contrasting behavior of aerosols from different sources due to their chemical composition and atmospheric aging processes.

**Dry atmospheric fluxes of seawater soluble iron over the Levantine Basin**

The calculated soluble iron fluxes for the two Levantine sub-basins were 8.79±10.23 mgm\(^{-2}\)y\(^{-1}\) for the NLB and 9.01±9.94 mgm\(^{-2}\)y\(^{-1}\) for the SLB. Having calculated the depositional fluxes it is then possible to calculate the atmospheric inputs across the Northern and Southern Basins, assuming the surface areas are 111,000 and 436,000 km\(^2\) respectively (Ludwing and Maybeck,2003). The soluble iron inputs for the two basins ranged from 960±1100 ty\(^{-1}\) for NLB to 3900±4300 ty\(^{-1}\) for SLB. The NLB had lower inputs of soluble iron compared with the SLB, mainly as a result of the larger defined surface area of the SLB. Such a difference between the two basins has also been observed by Koçak et al. (2005).
IMETS METU is granted an infrastructure project by the state funding agency to establish the Center for Marine Ecosystems and Climate Research (CMECLIM). CMECLIM aims to develop and to test analysis systems for the operational synoptic description of the environmental status of the Mediterranean, Marmara and Black Sea coastal waters. ECOCLIM aims to provide knowledge tools that can help authorities and other stakeholders to manage routine tasks, emergency situations and evaluate trends. Within the framework of CMECLIM a new atmospheric sampling site with a tower will be established on the Black Sea coast.

3. Human dimensions (outreach, capacity building, public engagement etc)

Marine Ecosystem Evolution in a Changing Environment (MEECE) Summer School 7-14 September 2011, Ankara, METU campus

Venue: Functioning and Evolution of marine ecosystems

The main objective of this course was to advance the scientific knowledge in a group of young people, with a marine sciences academic background. More specifically, the aims of the summer school are to help the students to:

- Understand the mechanisms, functioning and evolution of marine Ecosystems
- Assess the state of these ecosystems by taking into account their unique environmental drivers and pressures from natural and anthropogenic sources
- Learn innovative ways of integrating predictive models that resolve global change driver, changes in ocean circulation, climate, ocean acidification, pollution, over fishing and alien invasive species into available circulation-biogeochemical models.
- Address non linear combinations of driver impacts in a dynamic environment by using numerical simulation models which include dynamic feedbacks.
- Learn what is ecosystem-based approach to management?

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)
IMS- METU collaborates with Barak Herut (group leader), Ilana Berma-Frank, Michael Krom, Travis Meador, Christos Panagiotopoulos, Eyal Rahav and Nikolaos Mihalopoulos in the framework of mesocosm experiment BioDustMix (MESOAQUA, EC contract no: 228224).

6. Goals, priorities and plans for future activities/events
IMS-METU group is planning to improve laboratory infrastructures and obtain new instruments. The first year’s motto is to have a Central Laboratory and instruments such as moored profiler, profiling floats, gliders and ion chromatography.

7. Other comments
1. Key scientific SOLAS-relevant highlights/findings

1.1 How atmospheric processes alter the bioavailability of Fe and P in dust

Studies at the University of Leeds supported by the UK SOLAS programme have demonstrated that chemical weathering and aging of iron oxide minerals are important controls of iron solubility during acid processes in the atmosphere. In the film of water around aerosol particles pH can be as low as 2, dissolving iron minerals. When the pH is subsequently raised to ~5, as commonly happens during cloud formation, some of the dissolved iron is precipitated as nanoparticles of ferrihydrite (see figure), likely to be bioavailable if deposited to the ocean. It was also found that iron dissolution on dust could be described by a three phase model in which the fastest phase was similar to ferrihydrite (by dissolution rate). Contrary to previous hypotheses, grain size alone was found to have only a minor effect on the Fe solubility in Sahara dust. Additional, preliminary studies provide evidence for the first time that similar acid processes in the atmosphere also increase the solubility – and hence bioavailability – of P in mineral dust.

1.2 First research cruise to investigate ocean acidification effects in shelf seas

Few field-based studies have investigated the biogeochemical effects of natural pH variability, other than at "extreme" environments of CO2 vent sites. The first of a series of three research cruises with that aim took place on RRS Discovery, 6 June –9 July 2011, supported by the UK Ocean Acidification research programme. Led by the University of Southampton, researchers from eight institutions investigated the impacts of changing seawater chemistry on marine organisms, ecosystems, and relevant interactions with the atmosphere (including via DMS). The cruise covered a wide range of environmental conditions around the UK; it involved 60 CTD stations (~1500 sampling bottles), 320 underway sampling points, and 5 bioassay experiments (each ~80 bottles). Analyses of data and samples are in progress, with additional laboratory experiments. Cold-water coral sampling and short-term experiments were also included.

Notes:
- Reporting Period is January – December 2011
- Information will be used for: reporting, fundraising, networking, strategic development & outreach
- This report summarises and outcomes from the NERC-funded UK SOLAS Research Programme (now completed), also from other ongoing SOLAS-relevant programmes and projects, including the UK Ocean Acidification research programme.
Preliminary pH data along the cruise track are shown below (data may be subject to correction). A few weeks earlier, a dramatic coccolithophore bloom had occurred in the NE North Sea, as shown in the satellite image. When that area was sampled, the water was still visibly milky-blue, but very few living coccolithophores were found. For further information, see cruise blog at http://noc.ac.uk/news/rrs-discovery-cruise-366 and the UKOA sea surface consortium website www.surfaceoa.org.uk.

1.3 Added surfactant reduces air-sea gas exchange

During the UK SOLAS Deep Ocean Gas Exchange Experiment (DOGEE) in the North East Atlantic, led by the University of Newcastle, several independent estimates were simultaneously made of gas transfer velocities and air-sea fluxes of CO₂ and DMS¹. A highlight of DOGEE was the first-ever study of the effect of a deliberately released surfactant (oleyl alcohol) on gas transfer velocity \( (k_w) \) in the open ocean, estimated with the \(^3\)He/SF₆ dual tracer technique designed to estimate \( k_w \) on the timescale of hours to days, and from measured sea-to-air fluxes and surface water concentrations of DMS².

Of seven independent \( k_w \) estimates derived from \(^3\)He/SF₆, two were influenced by the surfactant and showed a \( k_w \) suppression of between ~5% and ~55% for wind speeds in the range 7.2–10.7 m s⁻¹ relative to surfactant-free waters². Similarly, \( k_w \) devolved from simultaneous measurements of DMS flux and concentration was also depressed by the surfactant², ranging from ~39% at 5.0 m s⁻¹ to ~24% at 10.8 m s⁻¹ (see figure). Surfactant thus has the potential to measurably suppress air-sea gas exchange rates even at

Transfer velocity \( (k_w) \) as a function of wind speed at 10 m \( (U_{10N}) \) determined from measurement of DMS air-sea fluxes and surface water concentrations. Open circles (with black solid line as linear fit) are estimates unaffected by added surfactant; red and gold circles (with red line) are estimates influenced by surfactant. The relationships of Liss & Merlivat⁵ and Nightingale et al⁶ (dashed and dotted black lines respectively) are added for reference. Reproduced by permission of American Geophysical Union.
moderate to high wind speeds when wave breaking is frequent. This is important because the presence of surfactant could to some degree offset the expected abrupt increase in $k_w$ due to wave-breaking.


1.4 New dataset for air-sea fluxes obtained with wide coverage of conditions and regions

The Waves Aerosol and Gas Exchange Study (WAGES) was developed from the UK-SOLAS HiWASE, SEASAW and DOGEE projects in order to better quantify the effects of sea state and wave breaking on the air-sea exchange of greenhouse gases. In May 2010, the NERC research vessel RRS *James Clark Ross* was equipped with a suite of systems and sensors to provide data on air-sea fluxes of CO$_2$, sea spray aerosol, heat and momentum as well as on sea state and wave-breaking. These sensors have operated continuously since then, sampling a very wide range of conditions and regions (Fig 1). In addition, four WAGES cruises have been successfully completed, with deployment of a novel wave-breaking buoy’ (Fig 2). The most recent Southern Ocean cruise in December 2011 obtained flux and wave-breaking data at wind speeds >15 m s$^{-1}$ in both extreme open-ocean conditions, encountered in Drake Passage, and in short-fetch conditions, off the Falkland Islands. Preliminary results suggest that the number of wave-breaking events depend strongly on fetch (Fig. 3). Underway measurements will continue until at least the end of 2012. WAGES is a joint project between NOC (Margaret Yelland) and the University of Leeds (Ian Brooks). For blog of the most recent WAGES cruise, see [http://frictionvelocity.wordpress.com](http://frictionvelocity.wordpress.com).

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

2.1 Major programmes and projects

- The Final Report for UK SOLAS as a coordinated, NERC-funded programme was posted online in March 2011, at www.nerc.ac.uk/research/programmes/solas/results.asp. Additional information on UK SOLAS research cruises, data inventories and data access is available through the British Oceanographic Data Centre, www.bodc.ac.uk/projects/uk/uksolas.

- The £11m UK Ocean Acidification (UKOA) research programme, co-funded by NERC, Defra and DECC, is now fully underway, contributing to SOLAS research in five main areas:
  - Observations and synthesis to establish variability and trends of oceanic pH
  - Ocean acidification impacts on sea surface biogeochemistry and climate [see Section 1.2]
  - Regional ecosystem and biogeochemical impacts of ocean acidification
  - Abrupt ocean acidification events (focus on Paleocene-Eocene Thermal Maximum)
  - Interactions between CO$_2$, the carbon cycle and climate.

  There are also biologically-focussed components, primarily IMBER-related. For details see www.oceanacidification.org.uk or contact p.williamson@uea.ac.uk (UKOA Science Coordinator).

- The £3.8m OSMOSIS (Ocean Surface Mixing, Ocean Sub-mesoscale Interaction Study) research programme began in 2011. This NERC-funded project addresses the physical processes affecting exchanges across the ocean boundary layer, with participants at Reading, Bangor, NOC, Oxford, Scottish Marine Institute, Southampton and UEA, in partnership with the UK Met Office and the European Centre for Medium Range Weather forecasting. Two research cruises are planned. Contact: Prof Stephen Belcher s.e.belcher@reading.ac.uk.

- The NERC multi-Centre Oceans 2025 programme is now nearing completion; SOLAS-relevant work has mostly been supported through its 'Marine Biogeochemical Cycles' theme, involving PML, NOC and MBA; see www.ocean2025.org.

- WAGES (Waves, Aerosol & Gas Exchange Study), a joint project between NOC and Leeds, has completed ~18 months of direct flux measurements on RRS James Clark Ross using the NOC Autoflux system (for continuous eddy covariance measurements of fluxes of CO$_2$ and sea-spray aerosol), a wave radar, and a whitecap imaging camera. In addition to the autonomous measurements, there are two manned cruises each year with tethered and free-drifting spar buoys [see Section 1.4]. Measurements continue until at least summer 2012; details: http://homepages.see.leeds.ac.uk/~lecimb/WAGES

- The UK GEOTRACES project is now fully underway, funded by NERC and addressing micronutrient cycles and ocean paleoproxies with focus on two Atlantic sections. Participants at Oxford, Bristol, Cambridge, Edinburgh, Imperial College. Manchester, NOC, PML, Plymouth, Southampton and UEA. Details: www.ukgeotraces.com.

- The UK-led, ESA-funded Oceanflux Greenhouse Gases project began in 2011, with partners at University of the Highlands & Islands, PML, NOC and IFREMER; details: http://www.oceanflux-ghg.org

- The SOLAS data integration project provides synthesis and integration of global air-sea gas and
particle fluxes to improve models and assessments of future climate and pollution; contact Shital Rohekar s.rohekar@uea.ac.uk

- UK provides leadership for **COST Action 735** “Tools for assessing global air-sea fluxes of climate and air pollution relevant gases”. Four meetings were held in 2011: on the sea-surface microlayer (25-26 January, Plymouth); sea-ice biogeochemistry (12-14 April, Amsterdam), and preparing the publication **Ocean-Atmosphere Interactions of Gases and Particles** (4-6 May, Brussels; 28 November, Frascati); [www.cost-735.org](http://www.cost-735.org)

- The NERC **National Centre for Atmospheric Science, NCAS** [www.ncas.ac.uk](http://www.ncas.ac.uk) continues to support a wide range of SOLAS-relevant research and sustained observations, the latter including the **Weybourne Atmospheric Observatory** [http://weybourne.uea.ac.uk](http://weybourne.uea.ac.uk) and UK involvement in the **Cape Verde Atmospheric Observatory** (Observatório Atmosferico de Cabo Verde: Humberto Duarte Fonseca; also see Section 5).

2.2 Major fieldwork

There were eight SOLAS-relevant research cruises in 2011, all on NERC research vessels and supported by a range of funding mechanisms. As follows:

- **Discovery 361** (7 Feb - 9 Mar; led by Eric Achterberg) – linking Fe supply and N₂ fixation in (sub-) tropical Atlantic
- **James Clark Ross 254C** (19 Mar – 5 Apr; Ian Brooks) – Waves, Aerosol & Gas Exchange Study (WAGES), in Southern Ocean
- **Discovery 366** (6 Jun -8 Jul; UKOA cruise, led by Eric Achterberg) – upper ocean biogeochemistry and ocean acidification around UK
- **Discovery 369** (9 Aug -16 Sep; Mike Zubkhov) – upper ocean biogeochemistry in tropical Atlantic
- **Discovery 371** (29 Sep – 12 Nov; Glen Tarran) – Atlantic Meridional Transect (AMT) #21; upper ocean biogeochemistry in both North and South Atlantic
- **James Clark Ross 254D** (25 Nov –8 Dec; Margaret Yelland) – Waves, Aerosol & Gas Exchange Study (WAGES), in Southern Ocean
- **Discovery 373** (7 Dec 2011 - 20 Jan 2012; Mark Trimmer) – N₂O formation in Oxygen Minimum Zone (OMZ) in eastern tropical Pacific
- **James Cook 68** (24 Dec 2011 - 27 Jan 2012; Gideon Henderson) – trace nutrient dynamics, including Fe in South Atlantic 40°S transect.

2.3 Other activities

- The UK continued to host the SOLAS nodal office at UEA, with NERC support.
- A national workshop on marine trace gases was held at Plymouth, 24-25 March 2011, supported by NERC’s Strategic Ocean Funding Initiative (SOFI)
- Eight UK-based research students attended the 2011 SOLAS Summer School, with NERC support. There were also three UK-based lecturers.

3. Human dimensions (outreach, capacity building, public engagement etc)

The UK Ocean Acidification programme has been active in this area, with three major outreach activities:

- Production of a short film **Ocean Acidification: Connecting Science, Industry, Policy and Public**, available online at [www.youtube.com/watch?v=BPS8ctW2s](http://www.youtube.com/watch?v=BPS8ctW2s)
- Lead role in production of *Hot, Sour & Breathless – Ocean under Stress* brochure for UNFCCC CoP17; joint publication by PML, Scripps, Oceana, UKOA, EPOCA and MedSeA, online at [www.oceanacidification.org.uk/PDF/ocean_under_stress.pdf](http://www.oceanacidification.org.uk/PDF/ocean_under_stress.pdf)

Public engagement achievements in other SOLAS science areas included David Sproson, a postdoc researchers at Leeds, winning the marine section of the Welcome Trust's 2011 competition “I'm a Scientist Get Me Out Of Here” ([http://marinej11.imascientist.org.uk/profile/davesproson](http://marinej11.imascientist.org.uk/profile/davesproson)).

Capacity building and training included strong UK involvement in the 2011 SOLAS Summer School (see above). Policy-relevant activities are detailed in Section 5 below.
A list of known 2011 SOLAS-UK publications is given here in three groups, based on community-wide input. The 10 papers in bold with UK-based lead authors indicate the range of achievements, without any formal designation that these are the “top 10” in terms of scientific quality or importance. [* Indicates publications already mentioned in Section 1 above].

4.1 Direct linkage to UK SOLAS research programme, peer-reviewed (n = 22)


*Shi ZB, Krom MD, Bonneville S, Baker AR, Bristow C, Drake N, Mann G, Carslaw K, McQuaid JB, Jickells T &
4.2 Other SOLAS-relevant peer-reviewed publications (including those on biogeochemical aspects of ocean acidification, but mostly limited to those with UK first author; n = 15)


4.3 Other high-profile, SOLAS-relevant publications and presentations, not peer-reviewed

Eight oral presentations with UK lead authorship at ASLO Aquatic Sciences Meeting, Puerto Rico, 13-18 February 2011:

- Archer SD, Stephens JA, Stefels J, Hopkins FJ & Kimmance SA. Explanation of the temporal progression of DMS flux from a coastal upwelling system.
Robinson C. Temporal succession in microbial community structure and gene expression during a Lagrangian study in the North West African upwelling.

- Hill PG, Purdie DA & Zubkov MV. High spatial variability of microbial amino acid uptake in an eastern boundary upwelling system, North West Africa.
- Ridgwell, AJ. Ocean acidification: the 'other CO2 problem'??

Four oral presentations with UK lead authorship at AGU Fall meeting, San Francisco, 5-9 December 2011:
- Carpenter LJ, Shaw MD, Partipan P, Plane JMC & Macdonald S. Globally important emissions of iodine from the sea surface
- Jiang Z, Hydes DJ, Hartman SE & Hartman MC. Key controls of surface carbonate system dynamics around the northwest European continental margin.
- Liss PS. How does ocean biology affect cloud properties?

Other oral presentations with UK lead authorship at major international meetings included:

5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

In 2011, the SOLAS-UK research community maintained (and, in many areas, strengthened) its wide range of international linkages. These relate to both science and policy, and include:

- Co-support of Observatório Atmosferico de Cabo Verde: Humberto Duarte Fonseca (Cape Verde Atmospheric Observatory), through the NERC National Centre for Atmospheric Sciences jointly with the Leibniz-Institut für Meereswissenschaften, Germany (IFM-GEOMAR), the Max Planck Institut für Biogeochemie, Germany (MPIB Jena) and the Leibniz-Institut für Troposphärenforschung, Germany (ITF Leipzig), and the Cape Verde National Institute of Meteorology and Geophysics (INMG). Details at http://ncasweb.leeds.ac.uk/capeverde

- UK leadership (Chair: Dorothee Bakker) of the international Surface Ocean CO2 Atlas (SOCAT) project, with online publication of v1.5 in September 2011. Details at www.socat.info

- UK leadership (Chair: Peter Liss) for COST Action 735 “Tools for assessing global air-sea fluxes of climate and air pollution relevant gases” www.cost-735.org; information on 2011 meetings given in Section 2.

- Participation (by Jerry Blackford, Daniela Schmidt, Carol Turley & Stephen Widdicombe) in Intergovernmental Panel on Climate Change workshop (WGIs I & II) on Impacts of Ocean Acidification on Marine Biology and Ecosystems, Okinawa, Japan, 17-19 Jan 2011. Selection of Schmidt and Turley to be Lead Author and Review Editor for Chapters in IPCC 5th AR WGII.

- Participation (by Turley) in the UN Framework Convention on Climate Change Conference of Parties (CoP 17) in Durban, 28 November - 9 December, with Ocean under Stress display and associated publications (jointly between PML, Scripps, Oceana, UKOA, EPOCA and MedSeA); also involvement in UN-Oceans side event (with IOC). Participation (by Carol Turley & Phil Williamson) in preparatory UNFCCC Science Workshop, Bonn, 2-3 June.

- Participation in Convention on Biological Diversity Expert Group meetings on geoengineering, London, 29 June-1 July (Phil Williamson) and ocean acidification, Montreal, 19-20 October (Stephen Widdicombe & Murray Roberts).

- Participation (by Phil Williamson, as SOLAS/IGBP representative) in 43rd Executive Council of Intergovernmental Oceanographic Commission, Paris, 9-11 Jun 2010, for discussion of IOC-SOLAS Scientific Summary for Policy Makers on Ocean Fertilization
Establishment of **US-UK Collaborative Development Award Scheme** (UK support via FCO/ BIS) to support exchange travel for ocean acidification research; 10 awards made, for visits in early 2011.

6. Goals, priorities and plans for future activities/events

SOLAS-UK activities will continue through a range of funding mechanisms, as indicated above (*Section 2*). Although the Oceans 2025 programme ends in March 2012, SOLAS-relevant sustained observations, modelling and technology development will continue to be supported in NERC marine centres (as National Capability). In addition to UKOA, UK GEOTRACES, OSMOSIS and WAGES, two new multi-institution research programmes that include SOLAS-relevant components are under development:

- **Shelf Sea Biogeochemistry**: components to include cycling of N, P, Si and C in shelf waters, the relationship of this cycling to biological processes and air sea exchanges of CO$_2$ and N$_2$O, and shelf sea iron cycling and off-shelf export.
- **Greenhouse Gas Emissions and Feedbacks**: components to include quantification of the North Atlantic carbon sink and its interannual variability.

7. Other comments

The SOLAS-UK research community is extremely active and productive, as indicated above. It is pleased to have made a major contribution to international SOLAS in 2011, and to have benefitted from the work of the SOLAS IPO and the SOLAS SSC.
- 2011/12 SOLAS endorsed projects submission forms
1. Summary

Title of the research project* ADEPT: Aerosol deposition and ocean plankton dynamics
Status* Funded
Is your project part of a larger national/regional programme?
If yes, please give details and outline any relation to other IGBP, SCOR, WCRP or iCACGP projects

2. Contact Information

<table>
<thead>
<tr>
<th>Principal Investigator*</th>
<th>Francesc Peters</th>
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<tbody>
<tr>
<td>Institution (include address)*</td>
<td>Institute of Marine Sciences (ICM, CSIC), Pg. Marítim de la Barceloneta 37-49, 08003 Barcelona, Catalunya, Spain</td>
</tr>
<tr>
<td>Phone*</td>
<td>+34932309598</td>
</tr>
<tr>
<td>Fax</td>
<td>+34932309555</td>
</tr>
<tr>
<td>Email*</td>
<td><a href="mailto:cesc@icm.csic.es">cesc@icm.csic.es</a></td>
</tr>
<tr>
<td>Other Investigators (indicate institution in brackets)</td>
<td>Cèlia Marrasé (ICM), Marta Estrada (ICM), Josep Sánchez (ICM), Laura Arin (ICM), Nixon Bahamón (CEAB, Spain), Cristophe Brunet (Stazione Zoologica Anton Dohrn, Naples, Italy), Óscar Guadayol (U. Hawaii, US), Víctor Martínez-Vicente (PML, UK), Estela Romero (SISYPHE, CNRS-UPMC, France)</td>
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3. Details of the Project

Summary / Abstract of Project* ADEPT addresses the study of the effect of atmospheric aerosol deposition on the dynamics of a marine LNLC (low nutrient low chlorophyll) system, namely the Mediterranean. To achieve its goal, ADEPT will use a multiscale and complementary approach. At the Mediterranean basin scale we will relate satellite chlorophyll data with modeled Saharan dust deposition. At the coastal scale, we will measure deposition directly at 6 locations across the NW Mediterranean and simultaneously sample chemical and biological parameters of the water column. At 3 locations this sampling will be daily. We will analyze relationships between both sets of variables. For such a sampling intensity we will count with the collaboration of non-scientists. In addition we will conduct laboratory experiments with aerosol amendments to seawater in order to study plankton stimulation dynamics, utilization of organic matter by bacteria, and changes in bacterial composition and diversity, all for a better mechanistic understanding of the processes involved.

The bulk input of nutrients to the Mediterranean through atmospheric deposition is equivalent to the land-based input, thus having utmost importance in biogeochemical budgets. However,
contrary to HNLC (high nutrient low chlorophyll) oceanic areas where iron produces a clear stimulation of system production, in the Mediterranean various nutritional elements may show very low concentrations and limit production in temporal succession, which makes it difficult to detect event driven stimulation. Using time series with many events and experimental manipulations, ADEPT aims to evaluate the conditions for the stimulation of plankton owing to deposition in the Mediterranean and the degree of such stimulation.

Key words of project* Aerosol deposition, Mediterranean, events, cross-correlation analyses, coastal time series, experimental manipulation

Relevant SOLAS Activities (tick all that apply)*

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<td>2.1 Air-Sea Interface</td>
<td>3.1 Air-Sea CO₂ Fluxes</td>
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<td>3.3 Air-Sea Flux of N₂O and CH₄</td>
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<td>1.5 Nitrogen cycling</td>
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4. Data

Will new date be collected as part of this project?* Yes ☒ No ☐

Where will this data be reported / archived?* ICM

When will your data be submitted?* 2014

5. Budget

Start date and end date of funding* January 1, 2012 until December 31, 2014

Total funding secured to date* 222640 euro

Total proposed funding* 365078 euro

Sources of funding* Spanish Plan Nacional
6. Submission

Please indicated whether you have contacted your national representative?

Yes ☒ No ☐

If no, are you happy for us to send the details that you submit to your national representative?

Yes ☐ No ☒

If not, please clarify why

If you do not have a national representative, please tick this box ☒

Please email this document with the ‘Subject’ as ‘SOLAS Project Endorsement’ to solas@uea.ac.uk
Submitting your research for SOLAS endorsement (*required fields)

1. Summary

Title of the research project*  bCARBOCHANGE - Changes in carbon uptake and emissions by oceans in a changing climate
Status*  
☑ Funded  
☐ Submitted  
☐ Proposed
Is your project part of a larger national/regional programme? If yes, please give details and outline any relation to other IGBP, SCOR, WCRP or iCACGP projects
CarboChange has further asked for endorsement by IMBER. CarboChange also contributes to the RECCAP project of the Global Carbon Project.

2. Contact Information

<table>
<thead>
<tr>
<th>Principal Investigator*</th>
<th>Christoph Heinze</th>
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<tr>
<td>Institution (include address)*</td>
<td>Geophysical Institute, Allégaten 70, 5007 Bergen, Norway</td>
</tr>
<tr>
<td>Phone*</td>
<td>+47 555 898 44</td>
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<td>Fax</td>
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<td>Email*</td>
<td>555 898 83</td>
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<tr>
<td>Other Investigators (indicate institution in brackets)</td>
<td>Total &gt; 100 scientist from 28 institutions. Contact PIs of project partners:</td>
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<tr>
<td>- Jørgen Bendtsen (Vituslab, Denmark)</td>
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<tr>
<td>- Pascale Lherminier (IFREMER, France)</td>
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<td>- Marion Gehlen (CEA, France)</td>
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<td>- Brian Ward (University of Galway, Ireland)</td>
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<td>- Karim Hilmi (INRH, Morocco)</td>
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<td>- Hein de Baar (NIOZ, Netherlands)</td>
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</table>
### 3. Details of the Project

**Summary / Abstract of Project** CARBOCHANGE - Changes in carbon uptake and emissions by oceans in a changing climate - is a large-scale integrating collaborative research project of 7 million Euros funded by the EU’s 7th Framework Programme in the period 2011-2015 (start 1 March 2011). The goal of CARBOCHANGE is to quantify the oceanic uptake of human-produced carbon dioxide from the atmosphere. It is coordinated by the Geophysical Institute at the University of Bergen and the Bjerknes Centre for Climate Research, Norway. CARBOCHANGE gathers a consortium of 28 research institutions from Europe, North America (USA and Canada) and Africa (Morocco and South Africa) with outstanding scientific expertise in the field of carbon cycle research. Carbon dioxide from fossil fuel burning and land use changes is the main contributor to a human-induced climate change. Currently, the ocean takes up about 25% of the worldwide annually produced carbon dioxide but this rate is subject to continuous change. CARBOCHANGE investigates 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 and biogeochemical processes further modify the oceanic

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Laurent Bertino</td>
<td>NERSC, Norway</td>
</tr>
<tr>
<td>Truls Johannessen</td>
<td>UNIRESEARCH, Norway</td>
</tr>
<tr>
<td>Aida F. Rios</td>
<td>CSIC, Spain</td>
</tr>
<tr>
<td>M. Santana-Casiano</td>
<td>ULPGC, Spain</td>
</tr>
<tr>
<td>Leif Anderson</td>
<td>University of Gothenburg, Sweden</td>
</tr>
<tr>
<td>Nicolas Gruber</td>
<td>ETH Zurich, Switzerland</td>
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<tr>
<td>Fortunat Joost</td>
<td>University of Bern, Switzerland</td>
</tr>
<tr>
<td>Ian Totterdell</td>
<td>MetOffice, UK</td>
</tr>
<tr>
<td>David Hydes</td>
<td>NERC, UK</td>
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<tr>
<td>Nick Hardman-Mountford</td>
<td>PML, UK</td>
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<tr>
<td>Marko Scholze</td>
<td>University of Bristol, UK</td>
</tr>
<tr>
<td>Andrew Watson</td>
<td>UEA, UK</td>
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<tr>
<td>Pedro Monteiro</td>
<td>CSIR, South Africa</td>
</tr>
<tr>
<td>Robert Key</td>
<td>Trustees of Princeton University, USA</td>
</tr>
<tr>
<td>Helmuth Thomas</td>
<td>Dalhousie University, Canada</td>
</tr>
</tbody>
</table>
absorption of carbon dioxide. CARBOCHANGE employs cutting edge measurement and modelling techniques to watch the ongoing carbon dioxide uptake by the oceans, to understand the underlying processes, and to predict changes in uptake to come. 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 will provide science-based guardrails for political decisions on mitigation actions in order to control and alleviate the impact of carbon dioxide emissions and climate change.

Key words of project* carbon cycle - ocean - carbon uptake and emissions - biogeochemical processes - physical processes - feedbacks - observing systems - data model integration - global synthesis

Relevant SOLAS Activities (tick all that apply)*

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<td>1.5 Nitrogen cycling</td>
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</table>

4. Data

Will new date be collected as part of this project?* Yes ☒ No ☐

Where will this data be reported / archived?* Databases will be available through project website: www.carbochange.eu

When will your data be submitted?* continuously during project

5. Budget

Start date and end date of funding* 01/03/2011 until 01/03/2015

Total funding secured to date* 6 989 906,00 €

Total proposed funding* 6 989 906,00 €
6. Submission

Please indicated whether you have contacted your national representative?
Yes ☒ No ☐

If no, are you happy for us to send the details that you submit to your national representative?
Yes ☐ No ☒

If not, please clarify why

If you do not have a national representative, please tick this box ☐

Please email this document with the ‘Subject’ as ‘SOLAS Project Endorsement’ to solas@uea.ac.uk
Submitting your research for SOLAS endorsement (* required fields)

1. Summary

Title of the research project* Mediterranean Sea Acidification in a changing climate
Status* ☒ Funded ☐ Submitted ☐ Proposed
Is your project part of a larger national/regional programme?
If yes, please give details and outline any relation to other IGBP, SCOR, WCRP or iCACGP projects
NO

2. Contact Information

<table>
<thead>
<tr>
<th>Principal Investigator*</th>
<th>Patrizia Ziveri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institution (include address)*</td>
<td>Institut de Ciencia I Tecnologia Ambientals, Universitat Autonoma de Barcelona, Edifici Cn - Campus UAB E-08193 Bellaterra (Cerdanyola), Spain</td>
</tr>
<tr>
<td>Phone*</td>
<td>+34 93586 8485</td>
</tr>
<tr>
<td>Fax</td>
<td>+34 93 581 3331</td>
</tr>
<tr>
<td>Email*</td>
<td><a href="mailto:patrizia.ziveri@uab.cat">patrizia.ziveri@uab.cat</a></td>
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<th>Other Investigators (indicate institution in brackets)</th>
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<tr>
<td>Maoz Fine (BIU), Catherine Goyet (UPDV), Marcello Vichi (CMCC), Jeroen van den Bergh (UAB), Carol Turley (PML) Jim Orr (CEA), Jean-Pierre Gattuso (UPMC), Paulo A.L.D. Nuñes (CIESM), Jelle Bijma (AWI), Jason Hall Spencer (UPM), Nayrah A. Shaltout (NIOF), Neijb Kallel (U. Sfax)</td>
</tr>
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3. Details of the Project

Summary / Abstract of Project*

Increases of atmospheric CO2 and associated decreases in seawater pH and carbonate ion concentration this century and beyond are likely to have wide impacts on marine ecosystems including those of the Mediterranean Sea. Consequences of this process, ocean acidification, threaten the health of the Mediterranean, adding to other anthropogenic pressures, including those from climate change. Yet in comparison to other areas of the world ocean, there has been no concerted effort to study Mediterranean acidification, which is fundamental to the social and economic conditions of more than 400 million people living in Mediterranean countries and another 175 million who visit the region each year.

The MedSeA project addresses ecologic and economic impacts from the combined influences of anthropogenic acidification and warming, while accounting for the unique characteristics of this key region. MedSeA will forecast chemical, climatic, ecological-biological, and socio-economical
changes of the Mediterranean driven by increases in CO2 and other greenhouse gases, while focusing on the combined impacts of acidification and warming on marine shell and skeletal building, productivity, and food webs. We will use an interdisciplinary approach involving biologists, earth scientists, and economists, through observations, experiments, and modelling. These experts will provide science-based projections of Mediterranean acidification under the influence of climate change as well as associated economic impacts.

Projections will be based on new observations of chemical conditions as well as new observational and experimental data on the responses of key organisms and ecosystems to acidification, which will be fed into existing ocean models that have been improved to account for the Mediterranean’s 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.

Key words of project* Mediterranean Sea, ocean acidification, climate change, biogeochemistry, ecosystems, modelling, socio-economic impacts, adaptation strategies

Relevant SOLAS Activities (tick all that apply)*

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4. Data

Will new data be collected as part of this project?* Yes ☒ No ☐

Where will this data be reported / archived?* PANGAEA

When will your data be submitted?* Throughout project

5. Budget
Start date and end date of funding*  01/02/2011 until 31/01/2014
Total funding secured to date*  EUR 3490169.31 (total costs ~EUR6000000)
Total proposed funding*  EUR 3490169.31
Sources of funding*  European Commission

6. Submission

Please indicated whether you have contacted your national representative?
   Yes ☐ No ☒

If no, are you happy for us to send the details that you submit to your national representative?
   Yes ☒ No ☐

If not, please clarify why

If you do not have a national representative, please tick this box ☐

Please email this document with the ‘Subject’ as ‘SOLAS Project Endorsement’ to solas@uea.ac.uk
1. Summary

Title of the research project*  Marine Ecosystems Response in the Mediterranean Experiment (MerMex)  http://mermex.com.univ-mrs.fr/
Status*  ☑Funded  ☑Submitted  □Proposed  
Is your project part of a larger national/regional programme?
If yes, please give details and outline any relation to other IGBP, SCOR, WCRP or iCACGP projects
MerMex is a component of the MISTRALS French national program (Mediterranean Integrated STudies at Regional And Local Scales, http://www.mistrals-home.org/)

2. Contact Information

<table>
<thead>
<tr>
<th>Principal Investigator*</th>
<th>Xavier Durrieu de Madron1, Cécile Guieu2, Richard Sempéré</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institution (include address)*</td>
<td>1 : CEFREM, CNRS-Université de Perpignan, Perpignan, France</td>
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<tr>
<td></td>
<td>2 : LOV, CNRS-Université Pierre et Marie Curie, Villefranche-sur-Mer, France</td>
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<tr>
<td></td>
<td>3 : COM/MIO, CNRS/IRD-Université de la Méditerranée, Marseille, France</td>
</tr>
<tr>
<td>Phone*</td>
<td>33(0)4.93.76.39.95</td>
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<tr>
<td>Fax</td>
<td>33(0)4.93.76.39.92</td>
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<tr>
<td>Email*</td>
<td>1 : <a href="mailto:demadron@univ-perp.fr">demadron@univ-perp.fr</a></td>
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<td>2 : <a href="mailto:guieu@obs-vlfr.fr">guieu@obs-vlfr.fr</a></td>
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<tr>
<td></td>
<td>3 : <a href="mailto:richard.sempere@univmed.fr">richard.sempere@univmed.fr</a></td>
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<td>Other Investigators (indicate institution in brackets)</td>
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3. Details of the Project
Summary / Abstract of Project* The Mediterranean Sea is unique and evolves rapidly, with large interannual to decadal variability and abrupt fluctuations. The semi-enclosed nature of the Mediterranean, together with its smaller inertia compared to large oceans, makes it more sensitive to natural variations in fluxes (between, e.g., the air and sea, freshwater and the sea) and water flows. These natural pressures interact with the trend of increasing human activities in the coastal regions, making the sea even more sensitive. French biogeochemical oceanographers have raised the issue of Mediterranean marine ecosystems response to changes in physical, chemical and socio-economical forcings induced by climate change and by growing anthropogenic pressures. This debate has focused on the current understanding of the effects of key natural and anthropogenic forcings on ecosystems (from coastal zones to open-ocean, from pelagos to benthos) and organisms (from viruses to fishes and mammals). It has further aimed to identify knowledge gaps and to contribute to the emergence of a large integrated research project, the Marine Ecosystems’ Response in the Mediterranean Experiment (MerMex). There are still considerable uncertainties in our understanding of the complex interactions between the different forcings and their impacts on Mediterranean ecosystems. There is therefore a strong need to reach a mechanistic understanding of the relevant processes in order to predict changes in ecosystems. These changes clearly influence the cycles of major biogenic elements, biodiversity, fisheries, invasive species and ultimately have socio-economic impacts. There is a need to develop a comprehensive and holistic approach to address particular questions at the proper spatial and temporal scales. The most relevant issues for the future of marine ecosystems in the Mediterranean are listed here and constitute the main research axes that MERMEX propose to tackle in the next 10 years:

• How would changes in stratification and destratification mechanisms and in the overall thermohaline circulation alter the spatio-temporal distribution of nutrients and their budgets? More specifically, what is the influence of dense water formation on the spatial and temporal variability of biogenic elements, the triggering of planktonic blooms, and the sequestration of biogenic elements, particularly carbon)?

• How would likely changes in nutrient inputs from physical transport, rivers, the atmosphere (including extreme events) and straits affect the nutrient availability in the photic layer of the Mediterranean Sea, the relative abundance of primary producers, and the higher trophic levels?

• What are the typical concentrations of chemical contaminants in the various water masses of the Mediterranean? What are their sources and sinks (e.g., atmosphere versus rivers, especially for organic contaminants) and seasonal variations?

• What is the role of the land-sea boundary (rivers, large cities, groundwater discharge) in the material balance of the Mediterranean Sea (carbon, nutrient, contaminants)?

• Will changes in the frequency or magnitude of extreme events lead to the dispersion or dilution of carbon, nutrients, and pollutants or, in contrast, to their accumulation in specific compartments?
• What will be the impact of changes in light radiation on biogeochemical processes, including primary production, POC-degradation processes, and degradation of DOM and pollutants?

• What is the actual rate of change of both temperature and pH in the Mediterranean Sea? How will these variables evolve and impact the Mediterranean solubility pump? What impacts will they have on the functioning of pelagic and benthic Mediterranean ecosystems?

• Will the functioning of mesopelagic and deep sea Mediterranean ecosystems be strongly affected by changes originating from surface ecosystem production and vertical fluxes or by changes in the hydrodynamics of the intermediate and deep waters?

• As the surface seawater warms, will the planktonic community of the pelagic ecosystem become dominated by nanophytoplankton and jellyfish, as suggested by several recent studies?

*Key words of project* Mediterranean Sea, climate change, anthropogenic pressure, atmosphere-ocean-continent coupled system, land-sea interactions, natural and anthropogenic air-sea interactions, gas fluxes, solar radiation, warming, acidification, hydrodynamics, chemical contaminants, trace elements, groundwater discharges, atmospheric deposition, extreme events, Saharan dust, heat waves, nutrients, stoichiometry, ecological processes, coastal and shelf ecosystems, pelagic realm ecosystems, meso and deep sea pelagic ecosystems, biodiversity, modeling, ecoregionalisation, multidisciplinary research, laboratory and in situ experiments, long-term observations.

Relevant SOLAS Activities *tick all that apply* *

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<td>5. Nitrogen cycling</td>
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4. Data

Will new data be collected as part of this project?* Yes ☒ No ☐

Where will this data be reported / archived?* specific actions within the Mermex project will have their own database but we will ensure a common portal on the MerMex website: http://mermex.com.univ-mrs.fr/
When will your data be submitted?* starting 2012

5. Budget

Start date and end date of funding* 2010 until 2020
Total funding secured to date* 3.1 Meuros for 2011-2013
Total proposed funding* 2.6 M euros/year
Sources of funding* Agence Nationale de la Recherche, European Commission Framework Programme, INSU, Mistrals, Regional programs

6. Submission

Please indicated whether you have contacted your national representative?
    Yes ☒ No ☐

If no, are you happy for us to send the details that you submit to your national representative?
    Yes ☐ No ☐

If not, please clarify why

If you do not have a national representative, please tick this box ☐

Please email this document with the ‘Subject’ as ‘SOLAS Project Endorsement’ to solas@uea.ac.uk
1. Summary

Title of the research project* SOAP (Surface Ocean Aerosol Production)
Status* ☒ Funded ☐ Submitted ☐ Proposed

Is your project part of a larger national/regional programme?
If yes, please give details and outline any relation to other IGBP, SCOR, WCRP or iACGP projects
Contributes to New Zealand MSI (Ministry of Science & Technology) funded research on Ocean-Atmosphere exchange

2. Contact Information

<table>
<thead>
<tr>
<th>Principal Investigator*</th>
<th>Cliff Law</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institution (include address)*</td>
<td>NIWA</td>
</tr>
<tr>
<td>Phone*</td>
<td>+64-43860478</td>
</tr>
<tr>
<td>Fax</td>
<td>+64-43862153</td>
</tr>
<tr>
<td>Email*</td>
<td><a href="mailto:c.law@niwa.co.nz">c.law@niwa.co.nz</a></td>
</tr>
</tbody>
</table>

Other Investigators (indicate institution in brackets)
Mike Harvey, Murray Smith, Carolyn Walker, Kim Currie, Craig Stevens (NIWA, NZ), Eric Saltzman, Tom Bell (UCI, US), Warren de Bruyn (Chapman, US), Scott Miller (SUNY, US), Christa Marandinio (IFM_GEOMAR), Zoran Ristovski (QUT, Australia), Petri Vaatovaarra (UEF, Finland), Sarah Lawson, Melita Keywood (CSIRO, Australia)

3. Details of the Project

Summary / Abstract of Project*

Clouds and their radiative properties are partially influenced by the production of primary aerosols through mechanisms such as the generation of sea salt particles from bubble bursting associated with breaking waves. Theoretical and applied research has indicated that phytoplankton produce a range of compounds that exchange with the atmosphere, and also directly or indirectly influence aerosol via secondary aerosol production in the marine boundary layer. The CLAW hypothesis, which links the release of precursor compounds by phytoplankton and emission of dimethylsulphide to subsequent oxidation to sulphate aerosols and production of cloud condensation nuclei, is well-studied but still remains to be proven. More recently, other secondary aerosol production pathways and precursors associated with phytoplankton have been identified, including via volatile organic hydrocarbons such as isoprene and halocarbons, organic particles and ammonia.
New Zealand has a maritime climate that is dominated by the interaction between oceanic and weather systems. The frontal regions around New Zealand are highly productive, with the Sub-Tropical Front that runs eastwards along the Chatham Rise characterised by intensive phytoplankton blooms. A preliminary survey of this region in February 2011 during the PreSOAP voyage encountered blooms of different phytoplankton groups with differing DMS & CO2 signatures. Surface distributions of both gases were mapped and related to phytoplankton indicators, including chlorophyll & backscatter, and exchange of DMS & CO2 determined using sensors & collectors on the ship and at the sea surface using a free-floating catamaran. Particle production in the MBL was continuously monitored, with additional experiments in a bubble chamber to examine particle formation.

An international team will further determine the production of aerosol precursors by phytoplankton blooms, their subsequent emissions to the atmosphere, and the production and size distribution of aerosols in the overlying marine boundary layer (MBL) during the SOAP voyage in 2012. Initial mapping of phytoplankton blooms around the productive Sub-Tropical Front along the Chatham Rise will be followed by selection of sites for focussed studies. The surface mixed layer and microlayer will be characterised in terms of biological, trace gas and organic composition, to determine how these influence exchange, with the structure of the mixed layer determined by microstructure measurements and SPAR buoy-mounted sensors. Measurements in the MBL will establish the spatial variability in DMS and aerosol concentration and composition, with different approaches used to determine DMS & CO2 exchange for the development of gas exchange parameterisations. Aerosol size spectrum and composition will be related to the potential for aerosol production as determined by onboard experiments, with a focus on establishing the broader role of volatile organic emissions in aerosol production. Sampling will be augmented by measuring aerosol & gas gradients up and downwind of the focus sites. The results will be interpreted in the context of seasonal variation in aerosols recorded at the Baring Head coastal sampling station.

Objectives

Do phytoplankton blooms influence aerosol production in the marine boundary layer?

1. Direct & indirect measurement of DMS, CO2 & aerosol flux;
2. Determination of physical controls on air sea exchange;
3. Determination of biogeochemical influences on DMS & other volatile organics on aerosol flux;
4. Examination of the role of the surface microlayer in influencing DMS & aerosol flux

Key words of project* Aerosols, DMS, phytoplankton, microlayer, flux, volatile organic compounds

Relevant SOLAS Activities (tick all that apply)*
4. Data

Will new data be collected as part of this project?* Yes ☒ No ☐

Where will this data be reported / archived?* Yes

When will your data be submitted?* By 2014

5. Budget

Start date and end date of funding* July 2011 until July 2014

Total funding secured to date* N/A

Total proposed funding* N/A

Sources of funding* NZ MSI, US NSF

6. Submission

Please indicated whether you have contacted your national representative? Yes ☒ No ☐

If no, are you happy for us to send the details that you submit to your national representative? Yes ☐ No ☐

If not, please clarify why
If you do not have a national representative, please tick this box □

Please email this document with the ‘Subject’ as ‘SOLAS Project Endorsement’ to solas@uea.ac.uk
- SOLAS endorsed projects 2011 annual reports
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

In 2011 BIOACID published 23 papers on the impacts of ocean acidification on marine organisms and communities and the impacts of biological responses on biogeochemical cycling (see point 4 below). Much of this work is only marginally relevant to SOLAS. Two research highlights are selected based on the overall importance to marine sciences:

Ocean Acidification effects on commercially important fish species (Frommel et al. 2011)

While it is common knowledge that commercial fish stocks are globally threatened by over-fishing, a new study shows that they may also be vulnerable to ocean acidification. In the past, scientists have primarily focused on calcifying organisms, which are believed to be particularly at risk due to the dissolution of their calcium carbonate structures. A recent study by an international research group led by GEOMAR shows that commercial fish species may also be threatened by increasing acidification. Cod offspring were exposed to three different carbon dioxide concentrations (380, 1800 and 4200 µatm) to examine the influence of ocean acidification. In order to mimic natural conditions for the larvae, the experiment was carried out in large open-air mesocosms in Bergen, Norway. The larval development was monitored for a time span of seven weeks after hatching. Tissue damage with possible lethal consequences was documented in a range of vital organs in the larvae. During this critical stage many structural alterations take place in the larvae, requiring a large amount of energy. As larvae hatch without functional gills, the main site for effective acid-base regulation, the mechanisms to cope with a low pH environment are particularly costly. Therefore, they may not have the energy needed for development, making them more prone to damage. As the larval stage is the bottleneck to recruitment in commercial mass-spawning fish, ocean acidification must be considered as yet another anthropogenic stressor in future stock analysis of already exploited fish.

Fig.1: Cod larvae as reared in the mesocosm experiment (left); Mesocosm facility at Marine Biological Station at Espegrend, Norway (right) Photo source: GEOMAR

A joint SOPRAN/BIOACID mesocosm experiment on ocean acidification was conducted in the Raunefjord in southern Norway. Stationed at the Marine Biological Station of the University of Bergen, 26 scientists from 8 German, Norwegian und UK institutes followed the development of the enclosed plankton community over a 5-week period.

Fig. 1.: Location of the Bergen mesocosm experiment, sketch of a mesocosm, deployment, and view of the nine moored mesocosms in the Raunefjord.

Preliminary results show major changes in plankton community composition and biogeochemical cycling in response to ocean acidification. Some of the surprising community-level responses to ocean acidification include:

- strong CO₂ fertilization effect on picophytoplankton and dinoflagellates
- reduced productivity of diatoms under high CO₂ (probably due to nutrient competition)
- absence of coccolithophores under high CO₂
- reduced abundance of pteropod larvae and juveniles

The fact that some of these responses could not be predicted based on results obtained in laboratory experiments highlights the importance of community-level experiments.

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)
The 2nd Annual Meeting of BIOACID took place on September 26th - 30th, at the University of Bremen, Germany (please see agenda at [http://www.bioacid.de/front_content.php?idart=716&idlang=22](http://www.bioacid.de/front_content.php?idart=716&idlang=22)). The last two days of the meeting were used to discuss the joint proposal of the second phase of BIOACID (2012 – 2015).

A pre-proposal for a BIOACID phase 2 (2012-2015) was prepared and submitted to the German Ministry for Education and Research (BMBF). The proposal is presently under review. A decision about a possible extension of the project is expected for June/July.

### 3. Human dimensions (outreach, capacity building, public engagement etc)

#### Capacity building

BIOACID scientists contributed to preparing the *Guide for best practices in ocean acidification research and data reporting*, an initiative led by the European Project on Ocean Acidification. This guide is intended to provide the rapidly growing community of researchers working on ocean acidification with guidelines and recommendations on best approaches, agreed standards, and minimum requirements for research in this field.

#### Outreach and communication

BIOACID has played an active role in various outreach activities. In 2011 these included:

- producing a brochure and CD describing 8 simple experiments to visualize and explain the process of ocean acidification; this brochure is intended for teachers and school children grade 5-7, the experiments can easily be conducted with the materials available in school; 10,000 copies of the brochure were printed and are being distributed to schools in the framework of school programmes by various BIOACID partners
- working together with school teachers to incorporate aspects of ocean acidification in the natural sciences curricula of local schools
- producing a TV-quality animation visualizing ocean acidification; the animation is without copyright and freely available to all BIOACID partners for use with TV reports, in outreach activities and for institutional purposes; the clip has already been used in a recent TV production and in a GEOMAR film on ocean acidification ([http://www.ifm-geomar.de/index.php?id=6109](http://www.ifm-geomar.de/index.php?id=6109)).
- working together with the International Ocean Acidification Reference User Group (IOA-RUG) to disseminate its various outreach products, including translating the latest brochure *Questions answered* into German; 5000 copies were printed and distributed among BIOACID partner institutes
- presenting public lectures on ocean acidification at various occasions
- giving interviews to newspaper, radio and TV journalists; these have led to various high profile reports on ocean acidification, including leading articles in *Zeit-Wissen* and *GEO*, a 45-minute TV documentary on ocean acidification in the WDR-series *Quarks & Co*, contributions to 90-minute documentary by SPIEGEL TV „Klimawandel: Ist die welt noch zu retten“, a portrait in the NDR-series *DAS!* and various radio reports in Deutschlandradio, NDR 1, WDR, BR, and RBB.

As a regular form of outreach, BIOACID has produced and distributes a flyer and maintains a multifactorial website.
Fig. 2: Examples of BIOACID outreach activities; the German translation of the IOA-RUG brochure Questions answered, the documentary Tipping Point, and the brochure for school teachers and school children describing 8 simple experiments visualizing ocean acidification

**Reference User Group**

The formation of the EPOCA Reference User Group (RUG) has enabled a two way exchange of information between research scientists and the user community. This has ensured that the knowledge is provided in a format and style suitable for the target audience. As the RUG has recently been adopted also by the UKOA programme and BIOACID and to some extent by MedSeA, it has evolved to become the International Ocean Acidification Reference User Group (IOA-RUG) and as such continues is very successful work now representing an even broader community of ocean acidification researchers. Ultimately, a successful program will have an approach that integrates basic science with decision support.

**4. Selection of publications in 2011 (Reports, articles, models, datasets, products, website etc)**

<table>
<thead>
<tr>
<th>Authors</th>
<th>Title</th>
<th>Journal</th>
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<tr>
<td>Büdenbender, J., Riebesell, U., Form, A.</td>
<td>Calcification of the Arctic coralline red algae <em>Lithothamnion glaciale</em> in response to elevated CO₂.</td>
<td>Marine Ecology Progress Series 441, 79-87</td>
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<td>Fabricius, K.E., Langdon, C., Uthicke, S., Humphrey, C., Noonan, S., De’ath, G., Okazaki, R., Muehllehner, N., Glas, M.S. and Lough, J.M.</td>
<td>Losers and winners in coral reefs acclimatized to elevated carbon dioxide concentrations.</td>
<td>NATURE CLIMATE CHANGE; DOI: 10.1038/NCLIMATE1122</td>
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<td>Haynert, K., Schönfeld, J., Riebesell, U, Polovodova, I.</td>
<td>Biometry and dissolution features of the benthic...</td>
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foraminifer Ammonia aomoriensis at high pCO₂, Marine Ecology Progress Series 432, 53-67


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

Assessment and decision support:

Assessment Report (2007) mentions ocean acidification for the first time in an IPCC report. Since then an IPCC WGII/WGI Workshop on Impacts of Ocean Acidification on Marine Biology and Ecosystems was held in Okinawa, Japan 17-19 January 2011, with participation by several BIOACID scientists. The findings of this meeting are in a workshop report. The 5th IPCC Assessment Report due in 2014 will include a more in depth assessment of both ocean climate change and acidification. BIOACID scientists serve as coordinating and lead authors and reviewers of this report.

The IPCC 4th Assessment Report (2007) mentions ocean acidification for the first time in an IPCC report. Since then an IPCC WGII/WGI Workshop on Impacts of Ocean Acidification on Marine Biology and Ecosystems was held in Okinawa, Japan 17-19 January 2011, with participation by several BIOACID scientists. The findings of this meeting are in a workshop report. The 5th IPCC Assessment Report due in 2014 will include a more in depth assessment of both ocean climate change and acidification. BIOACID scientists serve as coordinating and lead authors and reviewers of this report.

International Cooperation

International collaboration provides an opportunity for BIOACID to broaden and strengthen its research portfolio. Since its launch in 2009, BIOACID worked in close collaboration with the European Project on Ocean Acidification (EPOCA). Several of the BIOACID members are also active in EPOCA. A close collaboration has also been established with the UK Ocean Acidification Research Programme (UKOA). The coordinators of EPOCA, UKOA and BIOACID maintain an open information flow between the three programmes and closely work together in various outreach and communication activities. To facilitate this exchange, the coordinators of each project serve as members of the executive board or scientific advisory board of each of the other projects. Cooperation of the three projects encompasses joint training workshops, student exchange, joint experiments and exchange of samples, joint annual meetings and the shared Reference User Group (RUG), a group of key stakeholders interested the knowledge gained in ocean acidification research. In addition, EPOCA and BIOACID use the same data portal at WDC-MARE/PANGEA.

The EPOCA-UKOA-BIOACID partnership has been further broadened to include the recently launched EU-project Mediterranean Sea Acidification in a Changing Climate (MedSeA).
BIOACID partner programmes on ocean acidification.

To further strengthen the international partnership in ocean acidification research the UK funding agencies opened an opportunity for participants in the UKOA programme to seek additional financial support for international research collaborations, in particular with BIOACID. In turn, BIOACID has offered its members additional financial support to establish and/or strengthen active collaboration with UK partners funded through the UKOA Programme. Several BIOACID partners have responded to this offer and will receive funding ear-marked for UKOA-BIOACID collaboration during phase 2 of the BIOACID project.

6. Goals, priorities and plans for future activities/events

The growing evidence of potential biological impacts of ocean acidification affirms that this global change phenomenon may pose a serious threat to marine organisms and ecosystems. Despite a wealth of knowledge on specific effects of acidification and the related changes in seawater chemistry on the physiology of individual marine taxa, many uncertainties still remain. Because the majority of studies are based on single species experiments, little is presently known about possible impacts on natural communities, food webs and ecosystems. Moreover, few studies have addressed possible interacting effects of environmental changes occurring in parallel, such as ocean acidification, warming, and deoxygenation and changes in surface layer stratification and nutrient supply. Almost completely unknown at present is the potential for evolutionary adaptation to ocean acidification. To pave the way for a more encompassing assessment of future biological responses to ocean change and their possible socio-economic consequences phase 2 of BIOACID will

- strengthen the integration within the BIOACID community to allow for more realistic community-level experimentation and field observation
- focus more strongly on interacting affects through multiple stressors
- expand evolutionary biology to assess the potential for adaptation of key taxa
- integrate socio-economic assessments and stakeholder involvement

The overarching focus of BIOACID II will be to address and better understand the chain from biological mechanisms, through individual organism responses, through food web and ecosystem effects, to economic impacts

7. Other comments
Data management

The data management in BIOACID is carried out by the World Data Center for Marine Environmental Sciences WDC-MARE (www.wdc-mare.org) at the University of Bremen. WDC-MARE uses the information system PANGAEA (Publishing Network for Geoscientific & Environmental Data – www.pangaea.de), which is a system for acquisition, processing, long-term storage, and publication of geo-referenced data related to all earth science fields. Specifically, WDC-MARE is responsible for

1. Coordination of data capture, integration and quality control activities for the five BIOACID Themes.
2. Archiving and publishing data sets and data collections online and as offline products (DVD) using persistent Digital Objects Identifiers (DOI).
3. Implementation of the BIOACID data infrastructure
   - enabling a distributed storage of observational and model simulation data within a common networked structure, and
   - establishing a robust and long lasting data network which can be extended by or integrated into ongoing projects and programmes.
4. Maintain the website and data portal for BIOACID.
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

New methodologies developed during DUNE and successfully implemented for the first time.

The project comprised strong risk-taking as it was based on 2 methodological challenges:

1. To be able to reproduce a real atmospheric deposition event necessary for the controlled seeding in seawater. The goal was to produce hundreds of grams of particulate material identical to aerosols depositing at the surface of the ocean. This was achieved by experimental simulation of (i) production of desert aerosols and (ii) chemical aging mimicking their transport in the atmosphere.

2. Conception of seeding experiments in large clean mesocosms. With a list of specifications (such as that those systems should be totally made with plastic material, transportable etc.), the DUNE team worked on the concept of holding structures, enclosure (52 m$^3$), sampling systems, anchoring. Those systems were successfully deployed twice (DUNE1 experiment in 2008 and DUNE2 experiment in 2010) in the preservation area of Scandola in Corsica.

Main results of the project.

The original methods developed and validated during DUNE have been published and can be used in the frame of other projects (for example, the DUNE mesocosms are going to be used in the frame of the MedSea European project on Mediterranean acidification; other projects related to marine biogeochemistry at the atmosphere-ocean interface based on that tool are currently being submitted).

Chemical and biological changes, along with modification of the dynamic of particles following a dust event have been followed and the multidisciplinary results obtained are bringing new insights regarding the role of atmospheric deposition on oligotrophic ecosystem and carbon export. Among those results, we have shown that the cycles of elements of biogeochemical interest (nutrients, metals) are modified by the atmospheric deposition; that new nutrients introduced are uptake by biota very rapidly; that there is a competition for the new nutrients and that this competition is in favor for heterotrophic bacteria; that among phytoplankton, diazotrophs – although only responsible for few percent of the induced new production – are well stimulated by atmospheric input; that particulate carbon export is in part due to aggregation processes between organic matter and lithogenic particles. All those results indicate that the role of atmospheric deposition on oligotrophic area cannot be seen only like a simple fertilization effect but, induce also a significant export of particulate organic carbon to the deep ocean, through aggregation processes.

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)
During this last year 2 workshops were organized in Villefranche sur Mer among the DUNE group: a final workshop event in Avril 2011 (20 people) and a specific meeting in October 2011 dedicated to the final publications of the project during which it was decided to propose a series of 14 papers to constitute a Special Issue to BIOGEOSCIENCE (work in progress).

Several oral presentations specific to the DUNE project were done during the ASLO conference in Puerto Rico in Feb. 2011, during the SOLAS-IGAC France joint open meeting in Paris in June 2011 (see details in DUNE web site).

3. Human dimensions (outreach, capacity building, public engagement etc)

During the course of the project, in addition to several undergrad students, 5 PhD were involved (2 in France, 1 Italie and 2 German) and 4 post-doc were recruited among which 2 have now permanent positions in Research Institute in France.

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


Wagener, T., Guieu C., Leblond N., 2010, Effects of dust deposition on iron cycle in the surface Mediterranean Sea: results from a mesocosm seeding experiment., *Biogeosciences*, 7, 3769-3781, 2010


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

International interactions and collaborations were reinforced and several papers will be proposed for publication in the planned Special Issue. Following the success of the methodology established during DUNE, the DUNE-type large clean mesocosms will be used in the framed of the FP7 MedSea project (9 mesocosms to be deployed in June in Corsica).
6. Goals, priorities and plans for future activities/events

Main goal is to prepare the Special Issue dedicated to the DUNE project (a meeting ‘before submission is scheduled for the end of February.

7. Other comments

The DUNE project a DUst experiment in a low Nutrient, low chlorophyll Ecosystem, is a fundamental research project coordinated by Cécile Guieu at LOV. It was conducted in partnership with the laboratory of LISA (Créteil), LEMAR (Brest), LOCEAN (Paris), and in collaboration with the laboratories LOMIC (Banyuls), IRD/LOBP/COM (Marseille), CEFREM (Perpignan), ERES/ERTI, ENS (Paris) and the Regional Parc of Corsica, Preservation Area of Scandola. DUNE was also conducted in strong collaboration with foreign research institute: the Institut des Régions Arides (IRA), Médenine (Tunisie), IFM-GEOMAR, Kiel (Germany), Station Zoologique-Naples (Italie) and Alfred Wegener Institute, Bremerhaven (Germany).

The project started in nov-2007 and ended in July 2011 (43 months). Funding from ANR (Agence Nationale pour la Recherche) was 500 000 € for a total estimated cost of 1 500 000 € excluding permanent personal costs. Original project bringing together scientists from atmospheric and ocean fields, it was endorsed by the international SOLAS program in Feb 2009, see: [http://solas-int.org/science/researchendorsements/resendprojects/endorsedprojects.html#dune](http://solas-int.org/science/researchendorsements/resendprojects/endorsedprojects.html#dune).

Web site of the project: [http://www.obs-vlfr.fr/LOV/DUNE/](http://www.obs-vlfr.fr/LOV/DUNE/)
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

- The decrease in summer sea ice in the Arctic Ocean could increase the uptake of atmospheric CO\textsubscript{2} thus lowering pH. In the Siberian shelf, the degradation of organic matter has a major impact causing high pCO\textsubscript{2} and low pH levels.
- The key nitrogen fixer *Trichodesmium* will likely be a “winner” of ocean acidification with large implication for the future C and N cycling. It also has an unforeseen role in biogeochemical cycling due to its ability to induce CaC\textsubscript{3}O\textsubscript{3} precipitation.
- New transient simulations up to 2050 demonstrate the accelerated rate of acidification in the California Current System (CCS), particularly in the north. By 2050, the aragonite saturation horizon shoals by 180 m to reach an annual average depth of 40 m.
- A model of the Northwestern European Seas forced with an atmospheric CO\textsubscript{2} of 1000 ppm projects that seawater will become corrosive to aragonite over the entire shelf during winter; in the stratified areas on the shelf, this undersaturation persists throughout the year.
- Global and basin-scale models dramatically underestimate the magnitude, extent, and evolution of ocean acidification in Eastern boundary upwelling systems compared to high resolution regional models.
- Climate change is projected to shift the total abundance and diversity of foraminifera deeper and polewards into waters that have lower and decreasing calcite saturation states.
- A decrease in marine emissions of two major climate-active gases is projected for the end of the 21\textsuperscript{st} century.
- The changes in CaCO\textsubscript{3} production and dissolution induced by ocean acidification provide only a small negative feedback on atmospheric CO\textsubscript{2}.
- A Pinatubo-scale volcanic eruption has a much lower influence on ocean pH than past anthropogenic emissions.
- The volume of supersaturated water providing habitat to calcifying organisms is reduced from preindustrial 40 to 25% in 2100 and to 10% in 2300 for a high 21\textsuperscript{st} century emission commitment scenario.
- The largest simulated pH changes worldwide occur in Arctic surface waters, where hydrogen ion concentration increases by up to 185%. Projected climate change amplifies the decrease in Arctic surface mean saturation and pH by more than 20%, mainly due to freshening and increased carbon uptake in response to sea ice retreat.

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

- The documentary “Tipping Point”, following the EPOCA Svalbard 2010 experiment and other EPOCA work was released in the beginning of the year.
- The book “Ocean Acidification” was released in September 2011 as the first book on the subject, edited by J.-P. Gattuso and L. Hansson and with contributions from many EPOCA scientists.
- EPOCA organized an information event for EU officials and the general public in Brussels, on 9 May 2011. The 1-day event entitled “Ocean acidification – European contribution and perspectives” included presentations by J.-P. Gattuso, U. Riebesell, D. Laffoley, C. Turley, N. Cyr, S. Seitzinger, L. Hansson and F. Gazeau, a screening of the 52’ documentary “Tipping Point”, as well as an exhibition with hands-on chemistry experiments, models of research tools, screenings of short movies and cartoons and a the opportunity to talk to EPOCA scientists.
- The year 2011 was a very productive one for the EPOCA data management. Part of the Svalbard
2010 mesocosm experiment data has been archived: 
http://doi.pangaea.de/10.1594/PANGAEA.769833 and more is expected before the end of the project. 215 data sets are archived from which 88 are EPOCA, combining in a total of 241 studies. All the archived EPOCA data sets are listed here: http://www.epoca-project.eu/index.php/data/data-sets.html. All the EPOCA/EUR-OCEANS data compilation with additional meta data are available here: http://doi.pangaea.de/10.1594/PANGAEA.735138

- The SOLAS-IMBER working group on ocean acidification (SIOA), in which the EPOCA Executive Board are members, continued to strengthen international collaboration outside Europe and put extensive efforts into a proposal for an international coordination office on ocean acidification.

3. Human dimensions (outreach, capacity building, public engagement etc)

EPOCA public day in Brussels (see above), numerous outreach and educational activities at the partner institutes. Several EPOCA scientists contributed to the 52-minute long documentary, "Tipping Point", by Laurence Jourdan. The movie covers several aspects of EPOCA research and in particular the Svalbard 2010 campaign.

During the 2011, EPOCA continued to actively disseminate key research on ocean acidification, in particular via the Reference User Group (RUG). The RUG produced a new guide to policymakers, following the 2 previous guides, called “Acting on evidence” launched at the COP17 conference in Durban in December 2011. All guides are available in several languages at the EPOCA web site: http://www.epoca-project.eu/index.php/what-do-we-do/outreach/rug.html.


4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


Gruber N., 2011. Warming up, turning sour, losing breath: ocean biogeochemistry under global change. Philosophical Transactions of the Royal Society A 369:1980-1996.


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)
Continued links have been established with EU (CARBOOCEAN, MESOAQUA, EUROSITES, ATP, CALMARO and MEECE) and national projects (BIOACID, UK Ocean Acidification Programme, CHOICE-C and US initiatives as part of the FOARAM Act). EPOCA has developed particularly strong interactions with BIOACID, UKOA and the recently launched EU FP7 project MedSea. The EPOCA Executive Board members sit in the SOLAS-IMBER subgroup on ocean acidification. International links have also been continued via the International Scientific Advisory Panel (ISAP) with members from the US and Korea.

Several EPOCA scientists are lead or contributing authors of the IPCC AR5 Report.

6. Goals, priorities and plans for future activities/events

Results from the project will be published in time for consideration in the Fifth Assessment Report of the IPCC and be available for studies of the socio-economic impact of ocean acidification. Results will cover new information on the rate at which ocean acidification proceeds and the hotspots where critical pH values will be reached first; the consequences of ocean acidification in terms of biodiversity, ecological services provided by marine ecosystems, biogeochemical processes and feedbacks on the climate system; the ecosystems which are most vulnerable to ocean acidification. EPOCA will come to an end on 30 April 2012. The final meeting will take place in Saint Jean Cap Ferrat (close to Nice) from 2-6 April 2012.

7. Other comments
Year 2011 have seen the last samples back to the lab from Crozet and Kerguelen Islands. We performed analyses of total deposition by ICP-AES and HR-ICP-MS and have now a database with deposition flux of Li, Na, Rb, Mg, Ca, Sr, Ba, Ti, V, Cr, Mn, Fe, Co, La, Ce, Nd, Sm, Yb, U, Al, P, S, As and Pb (Ni and Zn in progress), for 2 years at Kerguelen and one year at Crozet (Heimburge et al. 2011, ASLO communication). For example, the total deposited iron flux is about 500 nmol/m²/year at Kerguelen, in good agreement with models.

Another result is that there is no large gradient between both stations neither at Kerguelen (30 km distance) nor between Crozet and Kerguelen (1500 km).

The evolution of the project moved our attention to source regions. Because the South Hemisphere is mainly constituted of oceans, the only possible dust sources are East Patagonia, South Africa and Australia. Patagonia is suspected to be the major dust source for the oceanic region ranging between 40°S and 60°S. We begin to investigate the relevant properties of the aerosols emitted from Patagonia, including their chemical composition, the factors controlling their emission and transport, and their bioavailability by looking at their solubility and other ad-hoc assessments. We have instrumented a sampling station in Rio Gallegos (Argentina, 51°37'57.70"S; 69°13'41.64"W) including aerosol sampling, Lidar measurements and meteorological records. This station is situated at the circumpolar atmospheric circulation latitude and may intercept emitted dust as well as locally as transported from the west border (250 km) of this region. In complement and in order to investigate at
a limited cost the spatial (2D) distribution of the atmospheric concentration of trace metals in Patagonia, we collect and analyses lichens harvest in a large area around. Lichens are slow-growing organisms which, over their lifespan, are expected to accumulate and retain high levels of mineral elements present in the atmosphere, but not from the host tree limb or rocks from which they are suspended. It can not be used for temporal studies but it has been shown through large and systematic investigations that the variations in lichens chemical composition are reflecting the variations of local aerosol chemical composition integrated on large time periods (Monna et al., 2006, Monna et al., 2011). In an emission area, lichen chemical composition will reflect the average composition of the emitted aerosol.

FIGURE 2: Atmospheric sampling station set up at Rio Gallegos.

First results will come in the year 2012.


2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

A new project was proposed at the French agency CNRS/INSU through the LEFE/CHAT action: "Dust From Patagonia". Today, we are expecting the answer for the end of January. A positive answer will give 2 years continuity of our investigation in the Patagonian source region (sea section 6).

3. Human dimensions (outreach, capacity building, public engagement etc)
Alexie Heimburger, PhD student working on FLATOCOA made a short movie with Fanny Mazoyer entitled "Qui sème la poussière récolte le phytoplancton", awarded and available here for download or show:
This movie tells a large public the methods in use to collect and analyse dust in remote oceanic areas.

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)
The first publications in journals will be submitted during the year 2012, including dust deposition at Kerguelen and a comparison of dust flux measured at Kerguelen and Crozet and model outputs. Two communications were made in 2011.

Heimburger, A., Losno, R. and Dulac, F, Atmospheric deposition of trace elements over the South Indian ocean: a time series at Kerguelen islands, 2011 ASLO Aquatic Sciences Meeting, San Juan de Porto Rico, 14-18 February 2011.

5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)
We began collaboration with CEILAP (Buenos Aires, Rio Gallegos) in Argentina. CEILAP bring their LIDAR expertise and the facilities of the laboratory installed at Rio Gallegos.

6. Goals, priorities and plans for future activities/events
Experimental work

Next step will be to work on the chemical properties of source aerosols from Patagonia (Rio Gallegos sampling station). This will include sampling but also laboratory experiments with collected aerosols. We will use an aerosol Lidar at Rio Gallegos to help us selecting dust events with a vertical extension large enough for long range transport. The main conclusions we expect of Lidar profile will be information on the continuity of the aerosol layer from ground to higher altitudes. In case of continuity, we will assume that the aerosol layer is homogeneous from ground to its top and extrapolate the measured chemical composition at ground level to the top of the layer.

Location of the new sampling area
Aerosol will be sampled for 2 years, its elemental composition determined and solubility of Fe, Co, Zn... investigated with laboratory experiments.

Aerosol will be produced from soils collected in emission zones using the techniques developed in LISA (Lafon et al., in preparation). This technique allows collecting dust aerosol samples on bulk filters and cascade impactors. This cascade impactor will be useful to obtain the size-resolved elemental composition. This material will be processed as natural samples to determine their mineralogical and chemical properties, including solubility. The various soil samples will be processed in the LISA device in order to study the regional of Patagonian dust.

Model

The coupled LMDz model with a zoom that can go down to 50x50km2 resolution will be used over the region coupled with INCA module (Interactions between Chemistry and Aerosols). Five aerosols components are simulated (sulphate, black carbon, organic carbon, dust and seasalt) and particular emphasis will be put on the analysis of dust fields that include emission, dry and wet deposition fluxes, optical depth, radiative forcing in the SW and LW. We will simulate the distribution of dust over the 2 years of the experiments by nudging the winds of the model to the ones from the ECMWF analysis. To evaluate the model performance, we will compare the LIDAR retrieved profiles of extinction with the vertical profile of dust extinction computed by the model. In addition, we will use the 10x10km MODIS product of optical depth to compare the simulated aerosol optical depth from LMDz-INCA to the ones retrieved from MODIS.

7. Other comments

Aknowledgements: the staff of the IPEV and TAAF for their help at Kerguelen and Crozet, the Argentine military for their hosting at Rio Gallegos.
1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

MERMEX is dedicated to study the response of Mediterranean ecosystems and biodiversity to climate changes and anthropogenic pressure. MERMEX aims to deepen the current understanding of the Mediterranean marine ecosystems to better anticipate their upcoming evolution. It is focusing on the response of ecosystems to modifications of physico-chemical forcing at various scales, both in time and space, linked to changing environmental conditions and increasing human pressure (figure 1). It proposes a comprehensive, integrated approach considering the continuum between the coastal zone and the open sea and its interfaces, including ocean-continent, ocean-atmosphere and water-sediment to precisely describe and model the current state of the Mediterranean ecosystems and the complex interactions existing between the environmental and human factors.

MERMEX White Book was published in 2011 in Progress in Oceanography – 95 authors, 130 pages, 630 references.


The project is divided into several thematic approaches that were grouped into five work packages (WP): 1-Impact of hydrodynamic changes on Mediterranean biogeochemical budgets (WP1), 2-Ecological processes; biogeochemistry and food web interactions (WP2), 3-Land-ocean interactions including extreme events (WP3), 4-Natural and anthropogenic air-sea interactions (WP4), 5-Ecosystem based management (WP5). Each WP is led by 2-3 coordinators and includes several actions currently funded or submitted for fundings through different funding agencies [MISTRALS, ANR, UE...].

![Figure 1. Schematic of the key forcing variables influencing the marine ecosystems’ diversity and functioning, and use of modeling as an integrative tool at the intersection of the different objects considered in MERMEX.](image-url)
2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

The activities of MERMEX deal in part with natural and anthropogenic air-sea interactions (those activities being the WP4 coordinated by Frédéric Gazeau (gazeau@obs-vlfr.fr), LOV/OSU Villefranche/Mer, Karine Desboeufs (Karine.Desboeufs@lisa.univ-paris12.fr), LISA/IPSL Paris and Marc Mallet (Marc.Mallet@aero.obs-mip.fr), LA/OMP Toulouse. Those projects are strongly connected to IGBP-SOLAS programs and operationally connected to CharMex (The Chemistry-Aerosol Mediterranean Experiment; http://charmex.lsce.ipsl.fr) and MOOSE (Mediterranean ocean observing system on environment. http://www.insu.cnrs.fr/co/expeditions-et-campagnes/moose-mediterranean-ocean-observing-system-on-environment

Figure 2. Main MERMEX activities relevant to SOLAS: several actions concern the assessment of gas fluxes (CO2) and acidification and the impacts on ecosystems and biogeochemical cycles and strongly connected with the FP7-MedSea project. A large project on the assessment of fluxes of atmospheric particles to the air-sea interface and their impact on biogeochemical cycles have been recently submitted for funding (Collaboration with CHARMEX). The influence of solar radiations on biogeochemical cycles is studied in MERMEX and includes the potential effect of aerosol and tropospheric ozone attenuation on marine ecosystems.

MERMEX projects related to actions 1, 2 and 3 in figure 2:

• **CALIBORON**: past pH reconstructions in the Mediterranean Sea based on the boron isotopic signature in biogenic carbonates – calibration using Mediterranean mussels and corals (started in 2011)

• **CARBORHONE**: pCO2 and DIC dynamics in the Rhone estuary and the Gulf of Lions (started in 2011)
  - 2 field cruises in spring and fall 2011
  - 2 field cruises planned in summer and winter 2012

• **PHOTOMED**: Metabolic and structural changes of the bacterial community in response to the phototransformations of dissolved and particulate organic matter in Mediterranean Sea

Other relevant projects with strong links with Mermex

• **MedSeA** (EU FP7, started in February 2011): Mediterranean Sea Acidification in a changing climate
• Joint experiment using large pelagic mesocosms in Corsica (summer 2012) and in Crete (summer 2013) – Effects of ocean acidification on planktonic communities in oligotrophic areas.
• Effects of ocean acidification and warming on the development and physiology of the Mediterranean mussel (collaboration with project CALIBORON).
• Effects of ocean acidification and warming on the development of Mediterranean pteropods and foraminifera.

• eFOCE (BNP-Paribas, started in September 2011): European Free-Ocean Carbon dioxide Enrichment experiments
  • Development of benthic experimental systems to study the effects of ocean acidification of benthic communities in the field (Bay of Villefranche, Mediterranean Sea)

• ANR Blanc SAM (Mermex-Charmex, started in 2012): Quantification and determination of marine organic aerosol fluxes as a function of trophic conditions

• Site Frioul: Radiative measurements in the air and in the sea
  • 2011: Installation of the instrumented buoy and first measurements

3. Human dimensions (outreach, capacity building, public engagement etc)
The actions mentioned above represented an activity of 58 man month in 2011, including several PhD students and undergraduate students.

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)
The MERMEX group, 2011, Marine Ecosystems Responses to climatic and anthropogenic forcings in the Mediterranean, Progress In Oceanography, Volume 91, Issue 2, October 2011, Pages 97-166

5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)
As part of the MISTRALS (Mediterranean Integrated STudies at Regional And Local Scales) French program (www.mistrals-home.org), MERMEX was presented during the International MISTRALS Workshop – Malta 30 March to 1st April 2011-, which brought together nearly 200 participants - by invitation - involved in the Mediterranean question, projects holders and potential developers, scientists and policy makers.


6. Goals, priorities and plans for future activities/events
In 2012, the SOLAS-related projects detailed above will be continued and some new one will start. Among those, a proposal was recently submitted to ANR:

ANR FARE (blanc, Mermex-Charmex, submitted in 2012): Study of the relation between atmospheric deposition fluxes and the pool of seawater nutrients - anticipate the future impact of dust deposition on nutrient cycles.

Another action will concern the setting up of a proposal concerning a field cruise entitled PEAcEtIME “ProcEss studies at the Air-sSea Interface: a Mediterranean Experiment” (joint experiment between MERMEX and ChArMEx was discussed in 2011 and planned in 2015. This project will be submitted for presentation at the 2012 OSC to call for international collaboration on that “SOLAS cruise” in the Mediterranean.

7. Other comments
MERMEX is part of the French MISTRALS program initiated in 2008 and internationally launched in Malta meeting in March 2011. MISTRALS is a decennial meta-program for systematic observations and research dedicated to the understanding of the Mediterranean Basin environmental process under the planet global change. Its aim is to anticipate the behavior of this system over a century, from an interdisciplinary analysis conducted over the 2010-2020 decade. The underlined ultimate goal of this meta-program is to predict the evolution of habitable conditions in this large eco-anthropo-system and to propose policies and adaptative measures that would mitigate and optimize them. MISTRALS is bringing together the main French research organizations and is destined to be shared by co-construction and aggregation of new topics and issues with all Mediterranean countries. Indeed, it is now stretching to other countries in Europe and throughout the Mediterranean Basin, according to a bottom-up approach.


Web site MISTRALS: http://www.mistrals-home.org
### 1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

**Secondary organic aerosol in the Southern Pacific Ocean**

Marine biologically active regions are known to produce a range of compounds that interact with the atmosphere directly and indirectly affecting particle production, composition, and properties in marine atmosphere. While the CLAW hypothesis (Charlson et al., 1987) suggests the importance of marine biological activity in ultrafine (d<100nm) particles composition and the potential importance of secondary sulphate production, this hypothesis does not take into account the secondary organic fraction in the composition of the ultrafine particles. To date, observations of the presence of a marine origin secondary organic fraction in ultrafine particles have been indicated down to nucleation mode size particles (d<15nm) in Atlantic coastal waters (Vaattovaara et al., 2006), ice edge waters in the Arctic (Vaattovaara et al., ICNAA 2009), and subtropical Pacific Ocean waters (Modini et al., 2009). In spite of the importance of secondary particles to atmospheric radiatively active sizes, the composition of marine produced particles is still uncertain in other marine biologically active locations around the world.

This study of the composition of nucleation (d<15nm) and the lower end of Aitken (20nm<d<60nm) modes particles is focused on particle production at one such region, at the Chatham Rise (New Zealand; latitude 42°S-44°S, longitude 174°E-177°W) during the PreSOAP (Pilot Surface Ocean Particle Production) voyage during the austral summer. The region of the southern Pacific Ocean includes a sub-tropical front characterised by intensive austral summer phytoplankton blooms. The ultrafine particles composition was studied using the UFO-TDMA and the VH-TDMA methods onboard the RV Tangaroa (NIWA, Wellington, New Zealand). Auxiliary data were collected from the ship weather station and marine information observations, SMPS particle distribution measurements, total particles count CPC measurements with 5 nm and 10 nm cut-off sizes, and black carbon measurements. Marine biological activity was established using MODIS satellite data, and supported by a range of *in situ* parameters including chlorophyll and dissolved DMS. Marine air masses origin was followed with HYSPLIT trajectories.

The TDMA measurements showed nucleation and Aitken mode sized particles including a clearly detectable organic fraction. During intensive solar radiation periods secondary organic contribution is highly probable in those ultrafine particles. Furthermore, the comparison between *in situ* bubble burst chamber and atmospheric particles composition measurements strongly support a secondary origin of the atmospherically observed ultrafine particles. Comparison with the secondary organic fraction observations on Atlantic, Arctic, and Pacific oceans reveals that although the secondary organic fraction clearly exists in ultrafine particle phase, the properties of the fraction can be dependent on the marine area conditions.

Remote sensing used, model and data intercomparisons etc)

The Pre-SOAP voyage was carried out in February 2011 as a pilot study for the 2012 SOAP voyage. Sampling strategy around the productive Chatham Rise region east of New Zealand was informed by ocean colour images, and determined in real time by underway data collection (chl-a, pCO$_2$, pH, DMS, backscatter). Over 11 days three different types of phytoplankton blooms (diatom, dinoflagellate & coccolithophore – dominated), with unique biogeochemical characteristics, were sampled. Surprisingly, the coccolithophore bloom (high underway back-scatter, low pCO$_2$ & high Chl-a) had the lowest DMS signal. A number of instruments, sensors and sampling designs were successfully trialled during PreSOAP. Of particular note were the performance of the in-line sensor suite, real-time output on the ships DAS system, the SCD-GC for measuring atmospheric DMS, the aerosol particle size suite which identified several pulses of new particle formation, the flux catamaran for measurement of CO$_2$ and DMS flux at distance from the ship, new microlayer sampling techniques, and the identification of ultrafine particle formation including an organic fraction in shipboard measurement and bubble burst experiments with detection by TDMA (see above highlight).

3. Human dimensions (outreach, capacity building, public engagement etc)

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


Z.Ristovski, L.Cravigan, P.Vaattovaara, N.Talbot, G.Olivares, C.Law, M.Harvey, and A.Laaksonen Sea spray aerosol production via bubble bursting during the Surface Ocean Aerosol Production (SOAP) study. EAC 2011, Manchester, UK, 4-9/9/11.


5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

Planning for SOAP voyage in February 2012, with international participation:-

NIWA (NZ), QUT, CSIRO (Australia), UEF (Finland), UC Irvine, U Chapman (USA), IfM-Geomar (Germany) and U. Laval (Canada).

6. Goals, priorities and plans for future activities/events

Completion of SOAP voyage in February 2012, with presentation of selected data at the SOLAS OSC in May 2012.

7. Other comments
- SOLAS Task Team 2011 annual report
HitT – Halogens in the Troposphere
compiled by Roland von Glasow

Notes:
Reporting Period is January 2011 – December 2011
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)

(1) Very wide-spread occurrence of iodine oxide (IO) in the marine boundary layer (MBL)

Presentations from Univ Heidelberg (Großmann et al., Tschritter et al.), Bremen (Peters et al.), Boulder (Volkamer et al.) at EGU 2011 showed that IO appears to be almost omnipresent in the tropical North Atlantic and Western Pacific at mixing ratios of 1-2ppt.

(2) Role of chlorine atoms for methane (CH₄) oxidation underestimated in North Atlantic/globally

Lawler et al (2011) showed very widespread presence of Cl₂ and for the first time HOCl in the tropical North Atlantic (Cape Verde). They estimated that the chlorine atom would be responsible for about 15% of CH₄ destruction in the tropical MBL

![Graph showing O₃, CO, HOCI, and Cl₂ concentrations over time.]

(3) Bromine-induced mercury depletion events in Dead Sea

Obrist et al (2011) showed that not only under polar conditions but also under the very different conditions in the Dead Sea are, bromine explosions can lead to depletion of mercury
Thomas et al (2011) developed a coupled atmosphere-snow chemistry model that was able to reproduce observed levels of BrO at the Summit research station, Greenland from first principles.

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)

- AICI-HiT workshop, New York, June 2011
- EGU session on halogens, Vienna, April 2011
- AGU session on halogens, December 2011
- HALOPROC salt lake campaign in Australia, March/April 2011
- Masaya campaign (UEA, Oxford, Heidelberg)
### 3. Human dimensions (outreach, capacity building, public engagement etc)

- Various media contacts (e.g. Masaya campaign; TV, radio and newspaper reports following on from press conference, March 2011)
- HALOPROC workshops (Oberjoch, Hohnstein)

### 4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)


Commame et al., Iodine monoxide at a clean marine coastal site: observations of high frequency variations and inhomogeneous distributions, Atmos. Chem. Phys., 11, 6721-6733, 2011

Lawler et al., HOCI and ClO observations in marine air, Atmos. Chem. Phys., 11, 7617-7628, 2011

Lowe et al., Modelling multi-phase halogen chemistry in the coastal marine boundary layer: investigation of the relative importance of local chemistry vs. long-range transport, Atmos. Chem. Phys., 11, 979-994, 2011

Mahajan et al., Concurrent observations of atomic iodine, molecular iodine and ultrafine particles in a coastal environment, Atmos. Chem. Phys., 11, 2545-2555, 2011

Obrist et al., Bromine-induced oxidation of mercury in the mid-latitude atmosphere, Nature Geosc., 4, 22-26, 2011


Theys et al., Global observations of tropospheric BrO columns using GOME-2 satellite data, Atmos. Chem. Phys., 11, 1791-1811, 2011

Thomas et al., Modeling chemistry in and above snow at Summit, Greenland - Part 1: Model description and results, Atmos. Chem. Phys., 11, 4899-4914, 2011

Toyota et al., Analysis of reactive bromine production and ozone depletion in the Arctic boundary layer using 3-D simulations with GEM-AQ: inference from synoptic-scale patterns, Atmos. Chem. Phys., 11, 3949-3979, 2011

### 5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)

- Participation in international field campaigns
- Conferences and workshops (see above)
- Special issues in ACP(D)
  - Radical chemistry over sunlit snow: interactions between HOx and halogen chemistry at Summit, Greenland
  - The TransBrom Sonne ship campaign in the West Pacific
- Strong link to OASIS/AICI:
  - special sections in JGR and ACP(D)

### 6. Goals, priorities and plans for future activities/events

- Workshop on global relevance of reactive chlorine in the MBL
- Robust global assessments of the relevance of tropospheric halogen chemistry
- TORERO project involves ship and aircraft: fieldwork early 2012
- Field campaign in Dead Sea (HALOPROC)

### 7. Other comments

Web page: www.HitT-task.net
- IGBP/SCOR FTI SOLAS-relevant 2011 annual report
Fast-Track Initiative – ‘Upper Ocean Nutrient Limitation’
compiled by Mark Moore

Notes:
Reporting Period is January 2011 – December 2011
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Key scientific SOLAS-relevant highlights/findings (you may include figures and references)
The key SOLAS relevant highlights resulting from the workshop will all be incorporated within the primary review paper which is nearing the submission stage. In particular, a novel meta-analyses of nutrient addition experiments and natural marine microbial responses within dust addition experiments will be included within this manuscript.

2. Activities/main accomplishments (research projects, cruises, special events, workshops, remote sensing used, model and data intercomparisons etc)
The main workshop related to the workshop was undertaken in November 2010, consequently the principal activity during 2011 has been preparation of the primary review paper resulting from the workshop. Progress of this has been a little slower than desirable, partly due to the large amount of new information to be incorporated. Novel data meta-analyses have been produced as part of generating the review paper and extensive work has been performed on these during the past 12 months. The third and hopefully final full draft is now nearing completion and submission to Nature Geoscience is planned for early 2012.

3. Human dimensions (outreach, capacity building, public engagement etc)
No specific outreach activities were performed during 2011. International capacity building continues through the involvement of researchers from economies in transition within the FTI.

4. Top 10 publications in 2011 (Reports, articles, models, datasets, products, website etc)
No peer reviewed publications were produced in 2011, work on the draft manuscript continues and all the pre-workshop reports were posted on the FTI website following the meeting in late 2010 (http://ocean.stanford.edu/IGBP_FTI/products.html). Preliminary information related to the novel meta-analyses performed was posted on the website during 2011 (http://ocean.stanford.edu/IGBP_FTI/working_groups.html) and will be disseminated further alongside the published manuscript. An article associated with the workshop was published in issue 12 of the SOLAS Newsletter ‘Workshop associated with the IGBP Fast Track Initiative (FTI) on “Upper Ocean Nutrient Limitation: Processes, Patterns and Potential for change”’ SOLAS News 12 page 28

5. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities etc)
International interactions continue through collaborations with the workshop participants who represent 10 countries across 4 continents. Collaborations and links with other IGBP projects (AIMES, PAGES/NICOPP) and GEOTRACES. Unfortunately a joint application led by Cecile Giueu for a related session a the 2012 ‘Planet Under Pressure’ conference was unsuccessful.

6. Goals, priorities and plans for future activities/events
The major goal and priority over the coming months is the submission and guidance through the review process of the principal review paper. As mentioned above, this is planned within the next 2-3 months.

7. Other comments
The final report submitted to IGBP is attached and contains further details on much of the above.
IGBP-FTI: Upper ocean nutrient limitation: processes, patterns and potential for change

Co-ordinators: Dr. Mark Moore (NOCS, UK), Dr. Matt Mills (Stanford University, US), Dr. Emilie Brévière (SOLAS, Germany), Prof. Doug Wallace (SOLAS, IGBP SC liaison, Germany)

Final Report: 08-02-2011

Although the following represents the final report on the IGBP Fast Track Initiative (FTI) on Upper Ocean Nutrient Limitation which commenced in May 2009, activities relating to the FTI are ongoing and in particular publications are planned for the coming 6 months.

Introduction and objectives

The FTI was set up as a mechanism for providing a synthesis of the current state of knowledge concerning patterns of upper ocean nutrient limitation, alongside the subsequent importance of nutrient limitation for wider ocean biogeochemistry. In conceiving the FTI, it was recognised that a large number of observational, experimental and modelling studies had recently addressed issues related to patterns of nutrient limitation in the upper ocean. It was hence realised that an opportunity was available to attempt to review and synthesise this large body of work. In addition to establishing the current state of the art, the FTI also considered the conceptual constructs and techniques used in the evaluation of nutrient limitation and explicitly considered how nutrient limitation may have changed in past and may respond to potential future perturbation. More detailed background, rationale and objectives for the FTI were set out in the original proposal.

Progress

IGBP initially allocated 13k euro to the FTI. Subsequent successful applications to the US Ocean Carbon and Biogeochemistry programme (OCB), SCOR and EU-COST-735 secured an additional $7k, $5k and 2k euro respectively. The high level of support from IGBP and the other sources was much appreciated and facilitated the running of the main workshop at no additional cost to a highly international participant list (see appendix 1).

Implementation of the FTI involved 2 principal activities:

The first was a special session at the joint AGU/ASLO Ocean sciences meeting in Oregon (February 2010) convened by Mills and Moore. These sessions attracted 27 abstracts from experimental oceanographers, modellers and paleoceanographers, full details of both the oral and poster sessions are available on-line: [http://www.agu.org/meetings/os10/os10-sessions/os10_BO11C.html, oral] [http://www.agu.org/meetings/os10/os10-sessions/os10_BO15G.html, poster].

Both sessions were well attended and generated considerable cross disciplinary interest. The main implementation activity followed later in the same year. A dedicated workshop was run from 3rd-5th November 2010 at the National Oceanography Centre, Southampton, UK. A total of 19 participants from 10 countries attended, with a further 2 having to withdraw at the last minute due to illness (see appendix 1). The range of different disciplines and level of expertise facilitated a dynamic environment for stimulating and productive cross disciplinary discussions. A total of 9 pre-workshop reports were prepared by working subgroups and disseminated prior to the workshop. The titles of these reports can be viewed on the dedicated webpage which was set up to facilitate communication and interest for the FTI [http://ocean.stanford.edu/IGBP_FTI/]. Following the workshop, full texts of all the reports and presentations were also made available to all participants within a secure region of the website.

The first day of the workshop was devoted to the presentation and subsequent discussion of the material within the pre meeting reports. A wide range of collated information was considered in detail and it was recognised that the reports would be a vital resource for informing a proposed major review paper (see below). Potential wider dissemination of the reports is still under consideration, although transfer of information to the review paper may make this unnecessary. Subgroups met to further consider emerging unifying themes on day 2 of the workshop. In particular concepts and definitions of nutrient limitation, current patterns of limitation, expected changes in the future and implications of changes, were all discussed in detail. A novel meta-analysis of results from nutrient perturbation experiments was also conceived and the subsequent data-base will become a key aspect of a review manuscript. The data base is likely to represent a highly
useful resource for the biogeochemical modelling community and hence will be disseminated alongside the review paper, for example as 'supplementary information'. We are also investigating independent dissemination via the website following publication. After consideration the group felt that an overview manuscript covering the breadth of material, written for a high profile journal and a general (biogeo-)science audience, was the overall preferred method for dissemination. The majority of the final day thus involved initial condensation of the large volume of information already collected into material suitable for this principal product. The scope of such a manuscript will necessarily leave some material unused. Consequently a number of sub-groups have already indicated interest in developing more specialist manuscripts following completion of the overview.

**Outputs**

The working papers, presentations and ongoing data-base development constitute major scientific outcomes. The synthesis of this material, initiated at the meeting, will form the basis of a review which should mark a significant statement on the current state of the art. Discussions with the editor of *Nature Geoscience* on whether they would consider such a review article remain very positive. Writing work on this principal product is well advanced with the first complete draft having been disseminated to all workshop participants/coauthors. Incorporation of subsequent substantial comments/suggestions into the second complete draft is nearly complete and one more round of comments will be solicited from the co-authors before subsequent submission to *Nature Geoscience* hopefully within 2 months. A meeting report was also prepared for the SOLAS newsletter. Reports were also delivered to OCB and EU-COST 735. As mentioned above, further products in the form of specialist reviews may follow submission of the overview manuscript. The completed data base will also represent a substantial resource for the community.

**Timeline**

- Feb 22nd-26th 2010: Special Session at Ocean Sciences meeting **Complete**
- Nov 3rd-5th 2010: Dedicated workshop, NOCS UK **Complete**
- March 2011: Preparation of 1st draft of principal manuscript **Complete**
- Current Preparation of 2nd draft of principal manuscript **Ongoing**
- September 2011: Submission of manuscript to *Nature Geoscience* **Projected**

**Appendix 1**

List of workshop attendees alongside specialisms with affiliations to other projects:

<table>
<thead>
<tr>
<th>Name</th>
<th>Discipline/specialism</th>
<th>Country, Gender</th>
<th>Other affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ililana Berman-Frank</td>
<td>Nutrient limitation of diazotrophs (Israel, Female)</td>
<td></td>
<td></td>
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<tr>
<td>Laurent Bopp</td>
<td>Modelling (France, Male)</td>
<td>AIMES SSC</td>
<td></td>
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<tr>
<td>Eric Galbraith</td>
<td>Paleoclimatology, Paleoclimatology (Canada, Male)</td>
<td></td>
<td>NICOPP/PAGES</td>
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<tr>
<td>Richard Geider</td>
<td>Phyttoplankton physiology and stoichiometry (UK, Male)</td>
<td></td>
<td></td>
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<tr>
<td>Cecil Guieu</td>
<td>Nutrient limitation, atmospheric inputs (France, Female)</td>
<td>SOLAS SSC</td>
<td></td>
</tr>
<tr>
<td>Samuel Jaccard</td>
<td>Paleoceanography, modelling (Switzerland, Male)</td>
<td>NICOPP</td>
<td></td>
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<tr>
<td>Tim Jickells</td>
<td>Atmospheric nutrient inputs (UK, Male)</td>
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<tr>
<td>Julie La Roche</td>
<td>Diazotroph nutrient limitation (Germany, Female)</td>
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<tr>
<td>Tim Lenton</td>
<td>Modelling, nutrient stoichiometry (UK, Male)</td>
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<tr>
<td>Emilio Maranon</td>
<td>Phyttoplankton ecology and physiology (Spain, Male)</td>
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<tr>
<td>Irina Marinov</td>
<td>Nutrient biogeochemistry, modelling (US, Female)</td>
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<tr>
<td>Mark Moore</td>
<td>Phyttoplankton ecology and physiology (UK, Male)</td>
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<tr>
<td>Matt Mills</td>
<td>Microbial biogeochemistry (US, Male)</td>
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<tr>
<td>Takeshi Nakatsuka</td>
<td>Paleoceanography, Paleoceanography (Japan, Male)</td>
<td>PAGES SSC</td>
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<tr>
<td>Andreas Oschlies</td>
<td>Biogeochemistry, Modelling (Germany, Male)</td>
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<tr>
<td>Mak Saito</td>
<td>Nutrient co-limitation, trace metal bioavailability (US, Male)</td>
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<tr>
<td>Frede Thingstad</td>
<td>Bacterial resource limitation (Norway, Male)</td>
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<tr>
<td>Atsushi Tsuda</td>
<td>Iron limitation, trophic interactions (Japan, Male)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oswaldo Ulloa</td>
<td>Phyttoplankton ecology and biogeochemistry (Chile, Male)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following people who unfortunately were unable to attend were all involved in the preparation of pre-workshop reports and continue to be involved in post-workshop manuscript preparation:

Kevin Arrigo  Phyttoplankton ecophysiology (US Male)
Phil Boyd     Phyttoplankton Fe limitation (New Zealand, Male) GEOTRACES SC
Natalie Mahowold Atmospheric nutrient inputs (US, Female)
Keith Moore   Modelling multiple limiting nutrients (US, Male)
Doug Wallace  Marine biogeochemistry (Germany, Male)
- SCOR WG SOLAS-relevant 2011 annual report
SCOR WG Sea-Ice  
compiled by Jacqueline Stefels

Sea-ice biogeochemistry and interactions with the atmosphere - Progress 2011

First year of SCOR WG on Sea-Ice begins 2012

**Background**
Near-future climate change is predicted to have its strongest impact in polar regions due to direct changes in surface area of polar oceans and ice sheets and to subsequent feedback processes. Observed reductions in sea ice cover appear to be occurring faster than predicted by current model forecasts. Currently, global models include the seasonal wax and wane of sea ice, but restrict associated properties to only a few physical features. Emerging views indicate, however, that sea ice itself plays an important role in the biogeochemical cycling and exchange of climate relevant compounds, whereby physical, chemical and biological processes interact in distinctive and complex ways. Relevant examples of such processes are:

- The impact of biology on climate-relevant gases such as CO2, DMS, N2O, halocarbons, etc.
- Dramatic halogen chemistry on and above the sea ice in springtime that destroys lower tropospheric ozone and mercury.
- Atmospheric aerosol formation from organic material produced by algae during the summer sea-ice melt.
- The impact of biology on ice structure: porosity, energy absorption and associated optical properties.
- Strong precipitation and dissolution processes of CO2 in brines.
- The release of macro and trace nutrients (N, P, Fe) for surrounding waters during ice melt.

Apart from the need for a better understanding of the biogeochemical cycles in sea ice for future climate models, this is also important for unravelling palaeoclimatology. Sea-ice extent is an important indicator for past climate. Proxies in Antarctic ice cores, such as methane sulfonic acid and ikaite crystals, are used to reconstruct regional sea-ice extent. Combining knowledge on sea-ice related processes involved in the formation of both compounds with data analyses from firn, will improve our understanding of palaeoclimate.

**Proposed Developments**

- To stimulate the development of an international community on sea-ice biogeochemistry.
- To stimulate the interaction between experimentalists and modellers working on this topic.
- To help the community articulate research priorities and identify optimized and cost-effective approaches and research platforms in internationally resource-limited times.

**Progress**

In 2010/11, the SOLAS-related sea-ice biogeochemistry community has grown to over 50 interested scientists from 15 countries. Ties with the OASIS community have been strengthened and a first exploratory workshop was held in Amsterdam, April 2011, under the auspices of the European Cost Action 735. The workshop was attended by a significant cross-section of the sea-ice biogeochemical community (http://www.cost-735.org/meetings/meetings.html).

The specific outcomes of the workshop were:

- a proposal for a SCOR working group on 'Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII)' (contact Jacqueline Stefels: j.stefels@rug.nl); and
- a commitment to compile a review on the current state-of-the-art of methodologies for sea-ice biogeochemical studies. Input from the global community will be solicited for the paper (contact Lisa Miller: lisa.miller@dfo-mpo.gc.ca).
- a commitment to write a white paper in collaboration with the OASIS community.
- an effort will be made to find additional funding for network support.

At the end of 2011, the SCOR WG proposal BEPSII received positive markings: “The National SCOR committees expressed that the proposal is timely because of the rapid changes in sea ice and the lack of sufficient understanding to parameterize global models, and that the topic is a priority for ocean science and for SCOR. A SCOR Working Group should be a good mechanism to advance this topic and will give a strong impulse to assembling existing expertise around this highly interdisciplinary topic. There was a special recognition of the need to improve sea ice components in climate and biogeochemical models.” The WG will start in 2012.

Several participants of the SOLAS-Cost workshop also participated in a workshop organised by the OASIS community in Telluride, Colorado, in June 2011. OASIS is a SOLAS, IGAC, WCRP/SCAR CLiC, AMAP, and IPY (http://www.oasishome.net/) endorsed project that was set-up in 2004 and culminated in several sea-ice field campaigns during IPY. During the workshop there was general agreement that the OASIS team and the SOLAS Mid-Term Strategy on sea ice should join forces. As a first effort, a feature article to be published in EOS was drafted. This is now accepted and will be published in early 2012.