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SOLAS Introduction

SOLAS (Surface Ocean – Lower Atmosphere Study) is an international research initiative that aims “to achieve a quantitative understanding of the key biogeochemical-physical interactions and feedbacks between the ocean and the atmosphere, and of how this coupled system affects and is affected by climate and environmental change”. Achievement of this goal is important in order to understand and quantify the role that ocean-atmosphere interactions play in the regulation of climate and global change.

The domain of SOLAS is focused on processes at the air-sea interface and includes a natural emphasis on the atmospheric and upper-ocean boundary layers, while recognizing that some of the processes studied operate on larger scales. SOLAS research covers all ocean areas including coastal seas and ice covered areas.

A fundamental characteristic of SOLAS is that its research not only integrates different oceanographic disciplines (such as biogeochemistry, physics, mathematical modeling), but also requires a close collaboration between marine and atmospheric scientists. This conference presents the results of such collaborations and aims to encourage further work in this direction.

SOLAS science can be broadly divided into the following topics or foci:
Focus 1: Biogeochemical interactions and feedbacks between ocean and atmosphere.
Focus 2: Exchange processes at the air-sea interface and the role of transport and transformation in the atmospheric and oceanic boundary layers.
Focus 3: Air-sea flux of CO₂ and other long-lived radiatively active gases.

The 2009 Open Science Conference will also provide SOLAS scientists with the opportunity to discuss “hot” topics such as halogen-ozone exchanges, DMS emissions in global climate models, sea ice biogeochemistry, ocean-derived aerosols, atmospheric control of nutrient cycling, ocean-atmosphere interactions in the Mediterranean, ship plumes and air-sea fluxes in eastern boundary upwelling systems. Discussions will also address future activities, such as large scale experiments, ocean fertilization, plans for a joint ESA-SOLAS activity and cooperation between Asian SOLAS and Asian Dust and Ocean EcoSystem (ADIES).

SOLAS is sponsored by the Scientific Committee on Oceanic Research (SCOR), the International Geosphere-Biosphere Programme (IGBP), the World Climate Research Programme (WCRP) and the International Commission on Atmospheric Chemistry and Global Pollution (ICACGP).

The SOLAS International Project Office is supported by the Natural Environment Research Council (NERC) and the University of East Anglia (UEA).

http://www.solas-int.org

Welcome Notes

Days after Barcelona became the centre of world attention as host of the Barcelona Climate Change Talks, organised by the United Nations Framework Convention on Climate Change Secretariat as a means of discussion prior to December’s meeting in Copenhagen, another great event is about to take place: the SOLAS Open Science Conference.

Climate change is possibly one of the greatest challenges currently facing humanity. We have become a species with a considerable capacity for modifying and altering our surroundings to the point at which this great “success” starts to take its toll, with the risk that it may be too high for us to pay, leading to serious consequences of all types: environmental, social, economic, health...even affecting our safety. That is why it is so important that all countries be aware of this in Copenhagen and that the foundations of a post-Kyoto undertaking be laid to establish the rules of the game for the coming years, in order to reduce these risks.

However, it is absolutely essential that the decisions made are based on the best knowledge possible, and here science and scientists play a fundamental role. Nobody is unaware of the fact that climate change discussions often involve the more or less explicit defence of interests. Faced with this situation, debate must be honest, and the exchange of information transparent. These aspects are the core of the exercise of Science and of what the SOLAS Open Science Conferences exemplify.

On behalf of the Catalan Office for Climate Change, welcome to Barcelona and to Catalonia and may you long continue to do such excellent work.

Salvador Samitier i Martí
Director, Catalan Office for Climate Change

SOLAS has held major scientific meetings in Europe (Damp, Germany in 2000), North America (Halifax, Canada in 2004) and Asia (Xiamen, China in 2007). The meetings allow for communication of the breadth of SOLAS science via plenary presentations as well as for in-depth discussion at the posters and within afternoon discussion groups.

This year’s conference in Barcelona applies the same successful formula but also sees changes. Notably, the number of plenary presentations has been increased, we have a stronger focus on modern biological sciences and there is the opportunity to highlight a range of promising new approaches and techniques.

The discussion group sessions are especially important for SOLAS; they provide an opportunity to share ideas, establish networks and plan for the future. This year, several address issues that the SOLAS Scientific Steering Committee has identified as being of particular significance for the future development of SOLAS. I urge you to participate actively in these groups: this is your chance to influence and participate in the development of SOLAS at the international level.

As Chair of the SOLAS Scientific Steering Committee, I am very pleased to see the Conference held in Barcelona. The city has a >2000 year history of involvement with the ocean via trade, fishing and exploration. It has become a major centre for marine and atmospheric science. And we will have an opportunity to experience and enjoy Catalan culture. In return, I hope that our public information evening, organised in cooperation with CosmoCaixa, will be informative for the people of Barcelona.

On behalf of SOLAS I would like to thank our sponsors and local hosts, the CosmoCaixa Science Museum, the Conference Scientific Committee and the SOLAS International Project Office for their hard work and support.

I wish you a stimulating few days learning from the talks and posters, participating in the discussions, and enjoying Catalan culture!

Doug Wallace
Chair, SOLAS Scientific Steering Committee
The Spanish Ministry of Science and Innovation (Ministerio de Ciencia e Innovacion, MICINN) is responsible for the development and implementation of research policy in all sectors and the promotion and facilitation of links between science and innovation. It plays a central role in the design of the National Plan for Scientific Research, Development and Technological Innovation.

http://web.micinn.es

The Kiel Cluster of Excellence “The Future Ocean” is a unique research group located in Kiel, Germany, made up of more than 140 scientists from six faculties of the Christian-Albrechts-Universität zu Kiel, the Leibniz- Institute of Marine Sciences (IFM-GEOMAR), the Institute for World Economy (IfW) and the Muthesius Academy of Fine Sciences (IFM-GEOMAR), the Institute for World University zu Kiel, the Leibniz- Institut of Marine from six faculties of the Christian-Albrechts-

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TUESDAY 17TH NOVEMBER

08:45 Keynote: Acidification and carbon cycling in the oceans: Clues from the past
Carles Pelejero, Spain
Auditorium p14

09:30 Dani Schmidt, UK
Quantifying ocean acidification during the Paleocene Eocene thermal maximum
Auditorium p15

09:50 Rebecca Robinson, USA
Lessons from the last ice age: High latitude controls on tropical ocean biogeochemistry
Auditorium p15

10:10 Eric Galbraith, Canada
Modelling the impacts of past climate changes on global nutrient distributions
Auditorium p16

10:30 COFFEE

Theme: Aerosols over the ocean
Chair: Eric Saltzman, USA

11:00 Keynote: Distribution and chemical characterisation of marine aerosols over the Pacific Ocean
Mitsuo Uematsu, Japan
Auditorium p16

11:45 Trish Quinn, USA
Origins and composition of aerosol in the marine atmosphere
Auditorium p17

12:05 Olga Mayol-Bracero, Puerto Rico
Carbonaceous aerosols over the Caribbean region
Auditorium p17

12:25 Ashwini Kumar, India
Mineral and anthropogenic aerosols over the Arabian Sea and the Bay of Bengal
Auditorium p18

12:45 LUNCH

14:30 Parallel discussion sessions

Diego Fernández Prieto
Identifying SOLAS scientific requirements for a new joint ESA-SOLAS activity
Agora p26

David Kieber
Ocean-derived aerosols: Production, evolution and impacts
Agora p26

Peter Liss
Large-scale experiments for SOLAS
Beta p27

Stephen Archer
Laurens Ganzeveld
Does a halogen-ozone exchange feedback exist and dominate MBL reactive iodine atom sources?
Gamma p27

16:00 COFFEE

16:30 Poster session – SOLAS Focus 2
Poster hall

18:00 END
WEDNESDAY 18TH NOVEMBER

<table>
<thead>
<tr>
<th>TIME</th>
<th>EVENT</th>
<th>ABSTRACT</th>
<th>VENUE</th>
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<tbody>
<tr>
<td>08:45</td>
<td>Marcel Kuypers, Germany Quantifying microbial activity in the ocean:</td>
<td>p18</td>
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<tr>
<td>09:15</td>
<td>Oscar Schofield, USA Dawn in the age of robotic oceanography:</td>
<td>p19</td>
<td>Auditori</td>
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<tr>
<td>09:45</td>
<td>Mick Follows, USA Modelling marine microbes: Physiology, community</td>
<td>p19</td>
<td>Auditori</td>
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<tr>
<td>10:15</td>
<td>Peter Liss, UK SOLAS and the spectre of geo-engineering</td>
<td>p20</td>
<td>Auditori</td>
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<tr>
<td>10:45</td>
<td>COFFEE</td>
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**Theme:** Advanced techniques for SOLAS  **Chair:** Doug Wallace, Germany

11:20 **Keynote:** John Plane, UK Halogen chemistry in the marine boundary layer  
p20 Auditori
12:05 **Alexandra Steffen, Canada** Understanding atmospheric mercury in the world of ozone and halogens over the Arctic Ocean  
p21 Auditori
12:25 **Alfonso Saiz-Lopez, Spain** Possible climatic impacts of reactive halogens in the tropical marine atmosphere  
p21 Auditori

12:45 **LUNCH**

14:30 **Parallel discussion sessions**
- **Roland von Glasow** Ship plumes  
p30 Beta
- **Jacqueline Stefels** Sea ice biogeochemistry and exchange with the atmosphere  
p30 Auditori
- **Mitsuo Uematsu** Future for the Asian Dust and Ocean EcoSystem (ADOES) with Asian SOLAS  
p31 Gamma
- **Cliff Law** Ocean fertilization: Legislation, ethical considerations and the role of SOLAS  
p31 Agora

16:00 **COFFEE**

16:30 **Poster session – SOLAS Focus 3 and Focus 1, Part 2**  
Poster hall

18:00 **END**

19:30 **CONFERENCE BANQUET**  
See Local Information Section  
p52

THURSDAY 19TH NOVEMBER

<table>
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<tr>
<th>TIME</th>
<th>EVENT</th>
<th>ABSTRACT</th>
<th>VENUE</th>
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<tbody>
<tr>
<td>08:45</td>
<td>Keynote: Cécile Guieu, France Impact of atmospheric inputs on</td>
<td>p22</td>
<td>Auditori</td>
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<tr>
<td>09:30</td>
<td>Gwo-Ching Gong, Taiwan Effect of Asian dust storm on upper ocean</td>
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<td>09:50</td>
<td>Alex Baker, UK Field observations of nutrient deposition to the Atlantic</td>
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<tr>
<td>10:10</td>
<td>Jordi Dachs, Spain Atmosphere-ocean exchanges of organic matter:</td>
<td>p23</td>
<td>Auditori</td>
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**Theme:** Nutrient limitation and atmospheric deposition  **Chair:** Cliff Law, New Zealand

11:00 **Keynote:** Maryann Moran, USA Regulation of bacterial DMSP degradation: A functional genomic approach  
p24 Auditori
11:45 **Rebecca Langlois, Germany** Factors influencing the distribution and abundance of diazotrophs: A qPCR approach  
p24 Auditori
12:05 **Thomas Mock, UK** Whole-genome expression profiling of the marine diatom *Thalassiosira pseudonana* to identify the molecular underpinnings of nutrient limited growth  
p25 Auditori

12:25 **Closure remarks**

12:35 **END**

Will you host the next Open Science Conference in 2012?

We hope that this conference might inspire you to be willing to host the next OSC! Please feel free to question and discuss your ideas with any members of the local organising committee, scientific steering committee or SOLAS IPO during the conference. Alternatively, you can e-mail us at solas@uea.ac.uk.
Rapid and dramatic changes in seawater carbonate chemistry are predicted to occur as a result of oceanic uptake of anthropogenic CO$_2$. These changes, often summarized by the term ocean acidification, are expected to have both stimulating and detrimental effects on marine biota. Pronounced physiological and ecological changes observed in response to ocean acidification will likely affect trophic interactions and elemental cycling in the ocean. Some of these responses have the potential for significant feedback to the climate system by means of changes in export production, deep sea oxygen consumption and nitrogen cycling. Ocean acidification was found to also directly affect the production and consumption of climate-relevant organic gases by marine microorganisms, such as dimethyl sulphide and volatile iodocarbon compounds. Changes in the sea-to-air flux of these marine trace gases could influence the oxidative capacity of the atmosphere and the production of particles in the marine boundary layer. During my presentation I will review recent findings of ocean acidification effects on the production and consumption of climate relevant gases and will attempt to assess their feedback potential to the climate system. Because the underlying mechanisms responsible for most of the observed responses are still unknown, however, predictions of future changes in air/seas gas exchange remain elusive.

**Theme: Long-lived gases and ocean acidification**

**Ocean acidification and its potential effects on air/seas exchange of climate relevant gases by Ulf Riebesell** (keynote speaker) Leibniz Institute of Marine Sciences (IFM-GEOMAR), Kiel, Germany

Air-sea gas exchange is of great scientific interest because of its importance in biogeochemical cycling of climate and weather related gaseous compounds. In particular, gas exchange contributes to the mitigation of the anthropogenic greenhouse effect through absorption of excess atmospheric CO$_2$ by the oceans. Gas exchange is also important to climate and atmospheric radiative transfer because of the sea-to-air flux of dimethylsulfide (DMS), which serves as a precursor to cloud condensation nuclei (CCN). In addition, oxygen levels in ocean surface waters are critically dependent on air-sea gas exchange, and the invasion of O$_2$ can alleviate hypoxia in coastal oceans and estuaries. There is thus strong interest in simple and robust means to estimate gas fluxes. This is often done through a bulk parameterizations where the flux is the product of the concentration difference of the gas in air and water, $\Delta C$, and a parameter called transfer velocity, $k$: $F = k \Delta C$.

The $\Delta C$ can be measured directly in for small-scale studies, or estimated for regional or global investigations while $k$ is often related to wind speed. The wind speed parameterizations have proved to be very useful, but no universal relationship has been developed to date. This is in part because gas transfer is not intrinsically related to wind speed but rather to turbulence at the air-water interface, or by bubble mediated exchange. Wind speeds often are a useful proxy for these processes but it must be fully appreciated that the processes controlling air-sea gas transfer are not uniquely related to wind speed. Using the hybrid model of gas transfer, originally proposed by Prof. D. Woolf, I explore how well wind speed can represent the various processes controlling gas transfer. A major conclusion is that gas transfer of different gases cannot be simply scaled by their molecular diffusion coefficient (or Schmidt number). To emphasize the importance of the functional dependence of the relationships I show the impact the different forms of gas transfer can have on global uptake of CO$_2$ even if the relationships meet the same global constraints.
Theme continued: Advances in gas exchange parameterization

Measuring open ocean DMS fluxes: A comparison and synthesis of air-sea gas transfer velocity experiments by Christa Marandino Leibniz Institute of Marine Sciences (IFM-GEOMAR), Kiel, Germany

Atmospheric pressure chemical ionization mass spectrometry (AP-ClMS) was used to perform direct air-sea flux measurements of dimethylsulfide (DMS) with the eddy correlation technique. The DMS air-sea concentration difference was also measured in order to derive the gas transfer coefficient (k). The measurements were made aboard three cruises: 1) PHASE-I in the equatorial and northern Pacific Ocean from May-July 2004, 2) Knorr-06 in the southeastern Pacific Ocean in January 2006, 3) Knorr-07 in the north Atlantic in July 2007.

Toward quantification of upper ocean and lower atmosphere processes for improved determination of air-sea gas fluxes by Brian Ward National University of Ireland, Galway, Ireland

This talk will present recent upper ocean measurements from the Air-Sea Interaction Profiler (ASIP) during the Indian Ocean Cirene Campaign. ASIP has the ability to make repeated profiles of key processes related to air-sea exchange from below the mixed layer to the air-sea interface. This talk will also present new technological advances for making eddy correlation air-sea flux measurements from a moving platform over the ocean.

Theme: Surface ocean lower atmosphere interactions of the past

Acidification and carbon cycling in the oceans: Clues from the past by Carles Pelletier (keynote speaker) ICREA and Institut de Ciències del Mar, CSIC, Barcelona, Spain

Beyond the greenhouse effect, the anthropogenic rise of atmospheric CO2 is leading to a progressive acidification of the oceans with the potential to impact marine organisms and ecosystems in a variety of ways. Interest in the issue of ocean acidification has deepened in the past years as a growing number of specialists have begun to understand the widespread implications of this environmental problem. A wide range of research strategies has been proposed, which are tackling this issue from a variety of angles, encompassing experiments with marine organisms in the laboratory under manipulated carbonate chemistry conditions, mesocosms studies, monitoring of the natural variability, assessment of possible effects in the field, etc. In this talk, I will briefly review some of the latest and most compelling achievements of these research approaches, but I will focus specifically on clues obtained from paleo-reconstructions. This is a fruitful strategy, some times forgotten in scientific programmes and institutional research plans, that is successfully providing valuable insight on critical elements and processes, rarely approachable with experimental studies. The issue of adaptation of marine organisms to ocean acidification, for instance, is difficult to attack with conventional experimental work. However, clues on this critical subject can be obtained by studying the response of marine biota during acidification events in the past, by means of a careful examination of the fossil record. In this review, glimpses on the nature of the ocean acidification threat for the near and distant future will be reviewed from paleo-reconstructions over different timescales.

They include the discovery of interdecadal changes in reef-water pH during the last centuries and the determination of surface and deep water pH changes over glacial to interglacial time scales, together with the assessment of possible changes in the composition of phytoplankton as a possible mechanism to explain the glacial/interglacial typical changes in atmospheric CO2. Clues related to ocean acidification from more ancient episodes will be also briefly reviewed, from several short-lived warming events that occurred during the Paleocene and Eocene, to the ‘big five’ extinctions of the Phanerozoic.

Quantifying ocean acidification during the Palaeocene Eocene Thermal Maximum by Dani Schmidt Department of Earth Science, University of Bristol, Bristol, UK

Co-authors: A.J. Ridgwell 1, S.A. Kasemann 2, E. Thomas 3

1 School of Geographical Sciences, University of Bristol, UK, 2 Grant Institute of Earth Science, University of Edinburgh, Edinburgh, UK, 3 Department of Geology and Geophysics, Yale University, New Haven, USA

The ocean will absorb increasing amounts of fossil fuel CO2 in the future, with the pH of surface waters decreasing by up to 0.5-0.6 pH. The Palaeocene- Eocene Thermal Maximum (PETM) has been suggested as a close palaeo-analogue for future climate change and ocean acidification as the carbon release is thought to be comparable to that possible over the coming centuries. However, a prerequisite for the comparisons of the ecological response during the PETM to the future as a constraint on impacts of acidification on ecosystems due to fossil fuel burning is knowing how the paleo-pH changed at this time.

We present boron isotopes and the boron/calcium ratio of benthic foraminifers across the PETM at deep-sea Maud Rise and shelf at Bass River. Mg/Ca indicates a two-step temperature increase from 12.7°C to 18.5°C. The reconstructed pH record across the PETM shows a large, two-step reduction coeval with temperature rise, with a recovery period to pre-event values significantly more drawn out than that of the isotopic composition of the ocean. The pH change provides additional constraints on the amount of carbon input, the rate of change and hence our understanding of this past acidification event.

Lessons from the last ice age: High latitude controls on tropical ocean biogeochemistry by Rebecca S. Robinson Graduate School of Oceanography, University of Rhode Island, USA

Co-author: P. Martínez Université Bordeaux 1, Talence, France

The timing of variability in a range of paleoceanographic proxy records from the Pacific implies tight coupling between the polar and tropical oceans across the last glacial cycle. Proxy records of export productivity, nutrient supply, and the extent of water column denitrification from the Eastern Tropical Pacific show characteristic patterns of change since the last ice age. In particular, the deglaciation, as defined by the shifts in hydrogen and oxygen isotope records from Southern Hemisphere ice cores, stands out as a period of tight coupling. Export productivity was high in the eastern equatorial Pacific during the glacial period and reached an absolute maximum during the deglaciation. The deglacial peak in export occurred during an interval of high nutrient supply and nutrient utilization, as interpreted from carbon and nitrogen stable isotope records, respectively. Similarly, coherent changes in the extent of water column denitrification occurred along the margins of the Eastern Tropical Pacific. Denitrification, represented by sedimentary nitrogen isotope records, also peaked during the deglaciation. We posit that these features are all related to changes in the preformed nutrient content of thermocline water supplied to the low latitudes. During the deglaciation, the reinvigoration of overturning circulation and reincorporation of CO2 and nutrients into the upper ocean, causes a transient peak in the supply of nutrients to the low latitudes. The increase in supply leads to a cascade of effects including a peak in export, elevated oxygen demand, and an expansion of the oxygen minimum zone.
Theme continued: Surface ocean lower atmosphere interactions of the past

Modeling the impacts of past climate changes on global nutrient distributions by Eric Galbraith McGill University, Montreal, Québec, Canada

The sinking of organic matter continually removes nutrients from the sunlit reaches of the upper ocean, sequestering them in the deep and leaving most of the ocean surface nutrient-starved. Surface ecosystems depend on the physical ocean circulation to return those nutrients to the euphotic zone. Paleoenvironmental evidence suggests that the return fluxes of nutrients to the surface ocean varied dramatically, at the global scale, during the last glacial cycle. During the peak of the last ice age, it appears that the supply of nutrients via the polar oceans was generally decreased relative to today, while abrupt, centennial-timescale climate shifts appear to have had broad impacts with some degree of antiphasing between the northern and southern hemispheres. These changes had implications for ecosystems, for the extent of oxygen-depleted waters, and for the concentrations of atmospheric gases including carbon dioxide and nitrous oxide. Global ocean models that incorporate prognostic biogeochemical cycling can be used to explore the mechanisms linking climate changes to nutrient cycling dynamics. For example, reductions in the Atlantic meridional overturning impede the supply of nutrients to much of the global ocean, while changes in the circulation of the Southern Ocean affect the flux of nutrients through the Subantarctic Mode Water pathway. These and other relevant mechanisms will be illustrated with model simulations.

Theme: Aerosols over the ocean

Distribution and chemical characterization of marine aerosols over the Pacific Ocean by Mitsuo Uematsu (keynote speaker) Ocean Research Institute, The University of Tokyo, Japan

The Pacific Ocean, the world’s largest (occupying about 30% of the Earth’s total surface area) has several distinguishing biogeochemical features. In the western Pacific, dust particles originating from arid and semi-arid regions in Asia and Australia are transported to the north and south, respectively. Biomass burning emissions from Southeast Asia are exported to the tropical Pacific, and anthropogenic substances flowing out of Asia and Eurasia spread both regionally and globally, affecting cloud and rainfall patterns, air quality, and the radiative balance of downwind regions.

The deposition of atmospheric aerosols containing iron and other essential trace elements is important for biogeochemical cycles in the oceans because this source of nutrients helps sustain primary production and affects food-web structure; these effects in turn influence the chemical properties of marine atmosphere. Dissolved organic matter and particulate material scavenged from the water column and injected into the air by bursting bubbles, can be recycled between ocean and atmosphere.

From an atmospheric chemistry standpoint, sea-salt aerosols produced by strong winds and marine biogenic gases emitted from highly productive waters affect the physicochemical characteristics of marine aerosols. As phytoplankton populations are patchy and atmospheric processes sporadic, the interactions between atmospheric chemical constituents and marine biota vary for different regions as well as seasonally and over longer timescales.

In the subarctic North Pacific, sea fog is a common meteorological phenomenon, occurring over 30% of the time in summer; this type of advection fog often persists long enough to interact intensively with atmospheric aerosols. As a result, the size and chemistry of fog droplets are modified and so too are the numbers and chemistry of marine aerosol particles. In particular, sea fog/aerosol interactions can lead to the air-to-sea transfer of atmospheric aerosols that have become enriched with various trace elements.

Origins and composition of aerosol in the marine atmosphere by Trish Quinn NOAA PMEL, Seattle, USA

Aerosols found in the marine boundary layer are derived from the ocean itself (e.g., sea salt, biogenic non-seasalt (nss) sulfate, and organics) and from long-range transport from continental source regions (e.g., dust and nss SO$_4^{2-}$, black carbon, and organic matter resulting from anthropogenic activities). Both oceanic and continental sources contribute to the radiative effects of aerosols in the marine atmosphere. Over the past two decades, there have been many shipboard field experiments focused on the characterization of aerosol properties and to improve the understanding of atmospheric chemistry in the marine boundary layer as well as estimates of aerosol direct and indirect radiative forcing. These experiments have taken place in coastal waters and in the open ocean including parts of the Southern, Pacific, Atlantic, and Indian Oceans and the Norwegian and Greenland Seas.

A summary of the composition and climate impacts of aerosols in the marine boundary layer will be presented along with a comparison of ocean- and continentally derived aerosols.

Carbonaceous aerosols over the Caribbean region by Olga L. Mayol-Bracero Institute for Tropical Ecosystem Studies, University of Puerto Rico, San Juan, Puerto Rico

The Caribbean is an atmospherically important, but understudied region that is heavily influenced by trade winds and frequent inputs of African dust (AD). The chemical and physical properties of atmospheric particles, focusing on the carbonaceous fraction and on marine and AD, have been investigated at Cape San Juan field station in the Caribbean Island of Puerto Rico. Atmospheric particles were collected with stacked-filter units (SFUs) and a 13-stage Dekati low-pressure impactor. The sampling was supplemented with measurements of aerosols’ scattering and absorption properties. Air masses influenced by marine aerosols, AD, and anthropogenic pollution were studied. Thermal/optical analysis of SFUs backup filters indicated that 50% of the organic carbon (OC) collected on front filters was gas-phase rather than particulate-phase OC. Elemental carbon (EC) was found at low-to-non detectable levels and was also found adhering to the surface of dust particles. Particle organic matter varied with season, with lower concentrations in the summer and dust periods (~90 nm$^3$) than in the winter (~250 nm$^3$). Size-resolved results showed a trimodal OC distribution, with concentrations higher in the fine fraction and in the absence of dust. The carbonaceous material in the dust particles could have been adsorbed near the African coast (e.g., agricultural activities, biomass burning…), or while traveling over the Atlantic Ocean. Additional results on the size-resolved carbonaceous fraction of the aerosol samples will be presented as well as differences in aerosol physico-chemical properties for samples with marine, AD, and anthropogenic influence from North America.
Theme continued: Aerosols over the ocean

Mineral and anthropogenic aerosols over Arabian Sea and Bay of Bengal by Ashwini Kumar

Physical Research Laboratory, India

The chemical composition of aerosols involving water soluble constituents (Na+, NH4+, K+, Mg2+, Ca2+, Cl-, NO3-, SO42-, NO2- and SO2-) has been studied in marine atmospheric boundary layer (MABL) of Bay of Bengal (BOB) and Arabian Sea (ARS) during March-May 2006. The total suspended particulates (TSP) ranged from 5.2 to 46.6 µg m-3 and 8.2 to 46.9 µg m-3 during the campaigns in BOB and ARS respectively. On average, water-soluble species account for 44% and 33% of TSP over BOB and ARS respectively, with dominant contribution of SO42- over both the oceanic regions. The nss-SO42- varied from 2.5 to 10.2 µg m-3 over BOB (Av: 5.7 µg m-3 and account with dominant contribution of SO42- over both regions; however, contribution of NH4+ is significant over BOB compared to the dominance of nss-Ca2+ over ARS. The impact of higher abundance of nss-SO4- is further evident from the large Cl- deficit observed over BOB (greater than 85%) consistent with higher abundance of OC and EC. Abundances of Fe and Al ranged from 0.09 to 1.01 and 0.13 to 2.48 in the MABL of ARS (dominated by dust sources) and their dry-deposition fluxes are estimated to be 385 and 665 mg m-2 d-1, respectively. The dominance of anthropogenic species and dry deposition of Fe have implications to the atmospheric inputs of trace constituents those are being increasingly recognized to modulate upper ocean biogeochemistry.

Theme: Advanced techniques for SOLAS

Quantifying microbial activity in the Ocean: From single cells to global fluxes by Marcel M.M. Kuypers

MPI for Marine Microbiology, Bremen, Germany

Coupling the identity of microbes with their activity in the environment remains an important gap in our ability to explore the role of microorganisms in global biogeochemical cycles. The development of techniques to quantify the metabolic activity of single microbial cells has been especially challenging, mostly due to their small sizes. This problem has recently been solved, however, by the development of the nanometer-scale secondary ion mass spectrometry (nanoSIMS), which for the first time makes it possible to determine the chemical, isotopic, or stable isotopic composition of biomass at the sub-micron level. An even more powerful technique emerges when nanoSIMS is combined with in situ hybridization using gene probes specific to the organisms of interest. We used 19F-labeled gene probes to directly identify individual microbial cells inhabiting various marine environments by nanoSIMS. The hybridization procedure is essentially identical to that used for CARD-FISH, and the same probes were applied. By combining this probing technique with in situ incubation experiments with 15N- and 13C-labeled substrates, we assessed the metabolic activity of microorganisms and simultaneously identified their phylogenetic characteristics during a single nanoSIMS scan. This approach for the first time directly linked the identity of microbial cells in a complex microbial community to their in situ carbon and nitrogen incorporation. NanoSIMS is truly an imaging breakthrough, whose application is only just beginning to yield information once considered inaccessible.

Dawn in the age of robotic oceanography: Building an autonomous distributed network for the world’s oceans by Oscar Schofield

Rutgers University, New Brunswick, New Jersey, USA

Co-authors: Josh Kohut and Scott Glenn

Buoyancy driven Slocum gliders were a vision of Douglas Webb, which Henry Stommel championed in a futuristic vision published in 1989. Slocum gliders have transitioned from a concept to a technology serving basic research and environmental stewardship. The long duration and low operating costs of gliders allow them to anchor spatial time series. Large distances, over 600 km, can be covered using a single set of alkaline batteries. Lithium batteries can anchor missions that are thousands of kilometers in length with platforms remaining at sea for close to one year. Since the initial tests, a wide range of physical and optical sensors have been integrated into the glider allowing measurements of temperature, salinity, depth averaged currents, surface currents, fluorescence, apparent/inherent optical properties active and passive acoustics. These sensors allow gliders to now map the physics, phytoplankton load, phytoplankton composition, and photosynthetic metabolism. A command/control center, entitled Dockserver, allows users to fly fleets of gliders simultaneously in multiple places around the world via the Internet. Since October 2003, Rutgers gliders have conducted 157 missions, traversed >55,000 kilometers, logged >2600 days at sea, and logged ~350,000 vertical profiles. The capabilities of the glider make them an indispensable tool for the growing global effort to build integrated ocean observatories. For example, gliders are now a central tool within the National Science Foundation Ocean Observatory Initiative and the National Oceanic and Atmospheric Administration’s Integrated Ocean Observing System. These initiatives will deploy distributed networks of gliders and combined with European glider fleets provide a backbone that will complement global satellites & ARGOS array providing foundation of a global ocean observing pattern. We will illustrate the potential of the glider to define phytoplankton dynamics in extreme environments spanning from polar oceans to large tropical storms.

Modelling marine microbes: Physiology, community structure and biogeochemical function by Mick Follows

MIT, Cambridge, Boston, USA

Microbial communities play a critical role in the regulation of the marine food web, ocean biogeochemistry and climate. Mathematical and numerical models are used as tools to interpret, and ultimately predict, relationships between community structure, function and environment. We will discuss and illustrate recent directions in marine ecosystem modeling, including the application of “self-organizing” and evolutionary model frameworks, and the interface with genomic observations. We will discuss the importance of trade-offs at the cellular level which influence fitness and community composition and review size and resource allocation based parameterizations. We will also discuss the need to model microbial communities as an integral part of the broader food web.
Halogen chemistry in the marine boundary layer by John Plane (keynote speaker)
University of Leeds, UK

Although the role of halogens in destroying stratospheric ozone has been widely known for more than two decades, the subtler impact of halogens in the marine boundary layer is only now becoming recognised. This paper will focus on iodine and bromine. Important atmospheric sources of iodine include the biogenic production and air-sea exchange of iodocarbons (e.g. CH$_3$I$_2$, CH$_2$IBr) and molecular iodine (I$_2$). The uptake of O$_3$ and photochemical reactions in the sea-surface microlayer may be additional sources of volatile iodine compounds. The major source of bromine (and chlorine) is the release of bromide ions from sea-salt aerosol. The subsequent atmospheric chemistry of these halogens (1), changes the oxidizing capacity of the marine boundary layer by destroying ozone and changing the hydroxyl radical concentration; (2), reacts efficiently with dimethyl sulphide and mercury (in the polar regions); and (3), leads to the formation of ultra-fine particles which may contribute to cloud condensation nuclei (CCN) and hence affect climate.

This paper will report observations of IO, BrO, OIO and I$_2$ made by the technique of Differential Optical Absorption Spectroscopy (DOAS) in several contrasting marine environments: the equatorial mid-Atlantic (Cape Verde); mid-latitude clean (Mace Head, Ireland) and polluted coastal sites (Roscoff, France); and the polar marine boundary layer (Halley Bay, Antarctica and Hudson Bay, Canada). Both IO and BrO are observed in all these locations at significant concentrations (> 1 pptv), and so have a major impact on (1) and (2) above.

To complement these field campaigns we have also carried out wide-ranging laboratory and modelling studies. A new study of OIO photochemistry shows that absorption in the visible leads to I atom production with a quantum yield of unity, which means that iodine is a particularly powerful ozone-depleting agent. We have also studied the formation and growth kinetics of iodine oxide nano-particles, and shown that their efficient uptake of water, sulphuric acid and di-carboxylic acids enables them to grow large enough to contribute to the available cloud condensation nuclei in the remote marine environment.
**Theme:** Nutrient limitation and atmospheric deposition

**Impact of atmospheric inputs on oligotrophic ecosystems by Cécile Guieu (keynote speaker)**

CNRS, Villefranche sur mer, France

The biogeochemistry of the marine oligotrophic environments characterized by low nutrient and low chlorophyll (LNL) conditions, seems extremely sensitive to the magnitude and the nature of the chemical atmospheric flux. In those regions, the atmospheric input of nutrients, can indeed alter biological activity and nutrient cycling and, therefore, impact the efficiency of the ocean to store atmospheric CO₂. Although atmospheric deposition is now recognized as a significant source of iron (Fe) and other nutrients for surface waters of LNL oceanic regions, its role in the carbon cycle and its response to changes in atmospheric forcing (climate change, anthropogenic pressure) is still poorly understood. In consequence, the atmospheric forcing is poorly represented in biogeochemical models. During this talk, we will review recent studies showing how atmospheric inputs do impact biogeochemical cycles of key elements such as iron and phosphorus in LNL area and how the biota (heterotrophic and autotrophic organisms including diazotrophs) do respond to those inputs. A particular attention will be paid to the Mediterranean Sea, a region strongly submitted to atmospheric inputs that are variable both in frequency and intensity and where, during the stratification period, mainly atmospheric deposition is prone to fertilize surface waters which had become very oligotrophic due to the nutrient depletion (after the spring bloom). This review will include both micromos and mesocosm approaches that provide parameterization of the involved processes, a necessary prerequisite for their consideration in biogeochemical modeling.

**Effect of Asian dust storm on upper ocean biogeochemistry in the nutrient limited Northwest Pacific Ocean by Gwo-Ching Gong**

Inst of Marine Environmental Chemistry and Ecology, National Taiwan Ocean University, Taiwan, ROC

Co-authors: C.-C. Chung¹, C.-C. Hung¹, J. Chang² and S.-C. Hsu²

¹ Inst of Marine Environmental Chemistry and Ecology, National Taiwan Ocean University, Taiwan, ROC
² Research Center for Environmental Changes, Academia Sinica, Taiwan, ROC

Dust deposition is responsible for the enhancement of biological productivity and the drawing down of CO₂ to the cold nutrient-enriched waters at higher latitudes has been well documented. However, its effects on warm oligotrophic waters remain unclear, thus making this issue important to study. Taiwanese integrated LORECS program (Long-term Observation and Research in the East China Sea) has begun to study the effect of Asian Dust Storm (ADS) on upper ocean biogeochemistry in the nutrient-limited northwest Pacific Ocean between 2005 and 2008. A station (123.15 °E, 25.10°N water depth=1690m) approximately 160 km northeast of Taiwan was taken as the study site. Intensive field observations were conducted during the prevailing ADS period (from late winter to early spring). Phytoplankton chlorophyll, primary production and export flux of particulate organic carbon were found about two to three times higher than the values in non-ADS period. The predominant group of picophytoplankton was changed from Prochlorococcus to Synechococcus during ADS event. Vigorous growth of Synechococcus from 1.4 × 10⁴ to 1.0 × 10⁵ cells ml⁻¹ was also observed. Most of these newly appeared Synechococcus belonged to clade II based on the phylogenetic analysis of 16S rRNA. In addition, mRNA levels of iron, nitrogen and phosphorus deficiency indicator levels decreased from prominent values to non-detectable levels.

**Field observations of nutrient deposition to the Atlantic Ocean by Alex Baker**

School of Environmental Sciences, University of East Anglia, Norwich, UK

Atmospheric inputs of nutrients may play a significant role in regulating marine primary productivity, with, for example, the oligotrophic sub-tropical gyres potentially sensitive to nitrogen inputs and the high-nutrient low chlorophyll (HNLC) regions sensitive to iron. Global and basin-scale estimates of atmospheric nutrient inputs require the use of reliable, well-validated model outputs, since field sampling on these scales is generally impractical. While many models of the atmospheric deposition of individual nutrient species exist, there is an extreme lack of field data available with which to calibrate and validate these models.

**Atmosphere-ocean exchange of organic matter: Characterization, fluxes and significance by Jordi Dachs**

Department of Environmental Chemistry, IDAEA-CSIC, Barcelona Catalunya, Spain

The exchange of organic matter between the atmosphere and the ocean has been a process largely ignored except for a few individual organic compounds. In fact, the total exchange flux magnitude due to dry and wet deposition processes are unknown, and only recently a partial estimate of its importance has been reported. Here, the current knowledge on dry aerosol deposition, wet deposition and diffusive air-water exchange of organic matter will be reviewed. The exchange between the atmosphere and the ocean will be reviewed in terms of characterization of major chemical families of compounds contributing to exchangeable organic carbon, magnitude of fluxes in comparison to inorganic carbon fluxes between the atmosphere and water, and the significance of this dynamic exchange of organic compounds for the marine and global carbon cycle. The results show that most of the exchange is due to transfer of gas phase organic matter to the ocean (and vice versa), a pool largely overlooked until now. This pool of gas phase organic compounds is largely composed of chemicals with aromatic and polar functional groups, but largely uncharacterized. The magnitudes of these fluxes of organic compounds in some oceanic regions are large and important in terms of the overall carbon cycle. Potential implications and future priority research need are discussed.
Plenary Talks

Theme: Genomic and genetic studies of ocean-atmosphere exchanges

Regulation of bacterial DMSP degradation: a functional genomic approach by Maryann Moran (keynote speaker) University of Georgia, Department of Marine Sciences, Athens, USA

Dimethylsulfiniopropionate (DMSP) is an abundant organic sulfur compound in ocean waters with important roles as a substrate for marine bacterioplankton and a source of sulfur aerosols. Members of the Roseobacter lineage, an abundant group of marine alphaproteobacteria, are known to play a role in DMSP degradation in situ and are often found in association with blooms of DMSP-producing phytoplankton. Cultured members of this lineage are easily grown and manipulated in the laboratory, making them excellent model organisms for studying the genetic and physiological basis for DMSP degradation in the ocean. Recent research with Roseobacter strains has identified, for the first time, key bacterial genes mediating DMSP degradation. These genes operate in two different bacterial pathways, one leading to methanethiol and sulfur-containing amino acids, and the other leading to dimethylsulfide (DMS). Research focusing on understanding the regulation of these pathways, and implications of this regulation for DMS formation and global climate regulation, is underway. Strategies include development of oligonucleotide-based microarrays for cultured Roseobacter strains that allow transcriptional responses to DMSP to be quantified; purification and crystallization of DMSP-related bacterial enzymes; design of an environmental microarray for in situ studies of bacterial DMSP cycling in the upper ocean; and development of quantitative PCR primer sets for determining abundance, diversity, and expression of DMSP-related genes in the ocean.

Factors influencing the distribution and abundance of diazotrophs: A qPCR approach by Rebecca Langlois Leibniz Institute of Marine Sciences (IFM-GEOMAR), Kiel, Germany

Dinitrogen fixation is considered to be an important source of fixed nitrogen to the surface oceans; however factors that control dinitrogen fixation are poorly understood. Availability of nutrients and trace metals, such as iron and phosphorus, and Saharan dust have all been identified as potential factors. Many new diazotrophic (dinitrogen fixing) organisms have been described by screening environmental clone libraries for the nifH gene. Though the studies provide important information about the dinitrogen fixing potential of a sampling site, they are not quantitative and can only give preliminary indications about the factors that cause their distributions. Recently real-time quantitative PCR (qPCR) was adapted to nifH gene studies and abundances of several diazotrophic groups are available for the Atlantic and Pacific Oceans. This qPCR technique has been applied to samples collected during nutrient addition bioassay experiments conducted in the Atlantic Ocean, in which seawater was incubated with additions of nitrate, phosphate, iron, all combinations of these, and Saharan dust. The largest increase in nifH abundances occurred with additions of Saharan dust, while the maximum increase in dinitrogen fixation rates was with additions of phosphate and iron. The large increase in nifH abundance upon additions of Saharan dust was replicated in a laboratory experiment with Trichodesmium erythraeum. These results indicate that Saharan dust is potentially a very important factor in determining the distributions of diazotrophs, and thus dinitrogen fixation, in the Atlantic Ocean.

Whole-genome expression profiling of the marine diatom Thalassiosira pseudonana to identify the molecular underpinnings of nutrient limited growth by Thomas Mock School of Environmental Sciences, University of East Anglia, Norwich, UK

Diatoms contribute about 20% of total primary production on Earth and therefore drive many different biogeochemical cycles of elements. The diatom Thalassiosira pseudonana was the first marine alga for which a genome sequence became available and we used this resource to develop microarrays (tiling and gene-specific) for the identification of novel transcribed regions in the genome and for transcriptome profiling under important environmental conditions. One unique outcome of this work is the coupling of silicon and iron pathways in this diatom with many newly identified genes of unknown function. My talk will summarize these data and provide a perspective on how to identify the function of these newly identified genes and whether those can provide new insights into how diatoms are adapted to environmental conditions. These species-specific data will be linked to natural conditions of the environment by a metatranscriptome databank from eukaryotic microbes of the global upper ocean.

Info for discussion session conveners

Discussion session reports should be submitted to the SOLAS IPO (solas@uea.ac.uk) before 11th December 2009. The report should be 300-500 words and include a figure and/or a photograph. A short (50 word) biography and a photograph of the convener should also be included. The reports will be included in the newsletter and on the SOLAS website.
The discussion sessions are intended to provide an informal opportunity for round table discussions of hot topics, with the aim of fostering collaborations and furthering research. 4 sessions will take place in parallel each afternoon (see Programme).

Sessions will be 1h30min with a short (maximum 20 min) introduction. This introductory slot may include several short (1 slide) presentations, although these sessions are not intended as an arena for formal presentations. The remainder will be allocated to discussion.

A rapporteur will take minutes during each session and submit a report to SOLAS after the conference detailing the discussion and outcomes of the session for inclusion in the SOLAS Newsletter.

In the following abstracts, reference is made to the SOLAS white papers. These were produced by the SOLAS Scientific Steering Committee with the aim to stimulate research and international cooperation within specific hot topics. Abstracts and full details can be downloaded by following the “Mid-term strategy” link on the SOLAS homepage (www.solas-int.org).

### Monday 16TH NOVEMBER, 14.30-16.00

**Note:** The 4 discussion sessions proposed below will take place in parallel.

**Identifying SOLAS scientific requirements for a new joint ESA-SOLAS activity**  
*convened by Diego Fernandez Prieto*  
ESA-ESRIN, Via Galileo Galilei, Frascati, Italy

**Background and motivation**
In 2008 the European Space Agency (ESA) launched a new program, the STSE (Support To Science Element) dedicated to develop novel mission concepts, enhanced products and new applications that may respond directly to the needs of the scientific community. One of the main action lines of the program is dedicated to establish closer links between the agency and the major international scientific groups such as SOLAS. In this context, the purpose of the proposed discussion session is to explore and to identify what are the main scientific needs and requirements that may be the basis for a new dedicated ESA-SOLAS joint activity funded under the STSE.

**Intended outcome, action or product following the discussion session**
The expected output of the project is a preliminary assessment of the main areas of research and scientific priorities of the SOLAS communities in terms of novel observations, products and models, where EO and ESA data may contribute. This may be the basis for further define a more concrete collaborative action between ESA and SOLAS.

**Ocean-derived aerosols: Production, evolution, and impacts**  
*convened by David Kieber*  
State University of New York, College of Env Science and Forestry, Syracuse, USA

**Background and motivation**
The oceans are the largest global source of aerosol by mass to the atmosphere. Produced by breaking waves and bursting bubbles, freshly produced marine aerosol is mass dominated by super-µm particles composed primarily of sea salt and number dominated by submicron aerosol composed of a mixture of sea salt and organic matter. Ocean-derived aerosols affect atmospheric chemistry and are thought to play an important role in controlling cloud formation and properties thereby affecting the Earth’s radiation balance.

Nonetheless, primary marine aerosol composition, evolution and atmospheric impact are poorly constrained owing to several salient unanswered questions: 1) What is the chemical composition of ocean-derived aerosols? 2) How do upper-ocean biogeochemical processes affect the fluxes, and physical and chemical properties of marine aerosols, and how do these fluxes and properties vary seasonally and spatially? 3) What is the significance of submicron ocean-derived aerosols relative to continental emissions transported out over the oceans and emissions from marine vessels? 4) Do ocean-derived aerosols affect cloud properties?

**Intended outcome, action or product following the discussion session**
The goal of our session is to explore potential international collaborations and opportunities in the form of integrated field and modelling studies to address some fundamental yet unresolved questions regarding marine aerosols that will allow us to assess their impact on radiative transfer and tropospheric chemistry. White paper available.

**Large-scale experiments for SOLAS**  
*convened by Peter Liss*  
University of East Anglia, Norwich, UK

**Background and motivation**
The SOLAS Scientific Steering Committee (SSC) has recently been reviewing a number of proposals for large-scale air-sea exchange experiments. The idea is to launch one or more of them as international coordinated activities in the next few years. The concepts proposed will be discussed at this session with a view to assessing which of them should be taken forward. The discussion will be from the point of view of scientific value and novelty in the context of SOLAS, considering also practical and logistic factors.

**Intended outcome, action or product following the discussion session**
The outcome will be a short report to the SOLAS SSC on the conclusions of the discussion session. This may well lead to a ‘future perspectives’ article for publication in the SOLAS Newsletter, as well as in EOS or similar.

**Does a halogen-ozone exchange feedback exist and dominate MBL reactive iodine atom sources?**  
*convened by Stephen Archer*  
1Plymouth Marine Laboratory, Plymouth, UK  
2Wageningen University, Wageningen, The Netherlands

**Background and motivation**
Reactive iodine atoms are thought to influence tropospheric ozone levels, atmospheric oxidising capacity and new particle formation. Recently a feedback mechanism involving halogen- and ozone exchange at the air-sea interface has been proposed. This mechanism may be driven by 1) direct oxidation of iodide in the microlayer by ozone, producing organiodine compounds 2) halogen anion oxidation by photosensitisers, e.g. chlorophyll, being enhanced in the presence of ozone, promoting the photosensitiser cationic form. Process-based global modelling studies confirm that ozone deposition to high chlorophyll regions may be greater than previously thought. These processes put into question traditional views of photochemical and biological production of volatile organiodine compounds in the water column as principal sources of reactive iodine in the MBL. We will discuss the evidence and consequences of such a feedback, the role that water-column sources of reactive iodine atoms play in MBL chemistry and what’s needed to progress this topic.

**Intended outcome, action or product following the discussion session**
1) Report for SOLAS, detailing present understanding of the feedback mechanism and identifying key issues for future study. 2) Guidance on experimental and modelling approaches to improve our understanding of the halogen-ozone feedback and relative importance of water column sources of reactive iodine in the MBL.
Tuesday 17th November, 14.30-16.00

Note: The 4 discussion sessions proposed below will take place in parallel.

Air-sea gas fluxes at Eastern Boundary upwelling systems

covenanted by Véronique Garçon
CNRS/LEGOS, Toulouse, France

Background and motivation
Oxygen Minimum Zones (OMZs), known as suboxic layers, play a crucial role in climate evolution (greenhouse gas production) and in marine ecosystems (respiratory barrier, nitrogen loss through denitrification and anammox). However feedbacks effects of OMZs are complex and remain to be quantified. The project will focus in the OMZ of the East Pacific, namely in the East Tropical South Pacific.

- Are emissions of the most important long-lived radiatively active gases $N_2O$, $CO_2$ and $CH_4$ coupled or decoupled during upwelling events, and which is the net greenhouse effect of the OMZs?
- Have the OMZs a significant role on the atmospheric cycle for the tropospheric and stratospheric ozone $(O_3)$ through halogen compounds and $N_2O$, respectively?
- Is it possible to determine and assess the full influence of OMZs on climatic change considering their impact on greenhouse gases, clouds formation (DMS consumption) and control of $O_3$ and $N_2O$?
- What is the role, in the greenhouse gases production, of the shift between an $O_2$-respiration (aerobic remineralization) towards a $NO_3^-$, $NO_2^-$, $N_2O$ and $SO_4^{2-}$ "respiration", even to methanogenesis and to anaerobic mechanisms using other electrons acceptors (e.g. $IO_3^-$, $Mn$, $Fe$)?

Intended outcome, action or product following the discussion session
It is hoped that this white paper for SOLAS mid-term strategy planning will yield an enthusiastic response from our community and will develop into an articulated international project combining in situ data acquisition, laboratory experimentations, and coupled biogeochemical/physical modeling. The overarching outcome being a complete understanding of the OMZs role in the present ocean.

Towards a better representation of ocean DMS emissions in global climate models - status of measurement issues and model parameterisations

covenanted by Nadja Steiner
University of Victoria, Canada

Background and motivation
Over the past decade significant effort has been put into the development of DMS models, but a mechanistic representation of DMS in global climate models is still in its infancy. The large variability in specific parameters controlling the dynamics of DMS and related compounds has been a limiting factor. Likewise, issues with measurement techniques and spatially and temporally limited measurement data sets have left many questions unanswered. Environmental factors expected to change in the near future such as ocean stratification; iron delivery and acidification have the potential to affect ocean ecosystems and DMS emissions. To better represent DMS in climate models we would like to use this session to address the following questions and issues: 1) Mechanistic versus semi-empirical approaches: what is needed for global climate models?; 2) DMS dynamics at high versus low latitudes; 3) Are DMS and DMSP measurements reliable?; 4) DMS production pathways and rates: what do we know?; 5) Flux parameterizations and atmospheric reactions.

Intended outcome, action or product following the discussion session
The goal is to provide recommendations for future research in order to improve the representation of DMS in global climate models. We need to identify key players and processes most sensitive to global change, evaluate the reliability and availability of measurements and parameterizations, and consider new challenges as how DMS dynamics and physiology respond to multiple-stress factors.

Atmospheric control of nutrient cycling and production in the surface ocean

covenanted by Cécile Guleu
CNRS, Villefranche sur mer, France

Background and motivation
Atmospheric deposition is an important pathway for nutrient delivery to the surface ocean that may increase in significance in response to climate change. Atmospheric nutrient supply modifies nutrient inventories and influences phytoplankton nutrient stoichiometry, with feedbacks to atmospheric $CO_2$ via air-sea exchange and the ocean carbon sink. Yet, despite major advances in determination of spatio-temporal variability of nutrient deposition and biological impacts, the links between atmospheric deposition, ocean productivity and nutrient cycling remain poorly understood. Consequently atmospheric nutrient supply is not well represented in budgets and models. This session will address key questions, including aerosol composition from uplift to deposition, the influence of different nutrient regimes on response to deposition, and future variation in atmospheric nutrient supply, with the aim of identifying new research directions and developing coordinated approaches to monitoring and testing surface ocean biota sensitivity to atmospheric deposition.

Ocean- atmosphere interactions in the Mediterranean Sea

covenanted by Marc Mallet1 and Richard Sempéré2

1 LA/CNRS, Toulouse, France 2 LMGEM/COM-CNRS, Marseille, France

Background and motivation
The Mediterranean basin is characterized by relatively high solar radiation levels due to its weak cloud cover that favor the accumulation of primary pollutants. Mediterranean waters present oligotrophic character that allows light penetration and surface photochemistry and typical bio-optical state that limit accuracy of primary production models. Mediterranean atmosphere is regularly modified by Saharan dusts, biomass burning and anthropogenic aerosol inputs from industrial activity, that play a role on incoming radiation budget as well as on photosynthetically available radiation. By contrast, atmospheric inputs may represent an important source of new nutrients to the system. Concerning the gas exchanges, Mediterranean Sea acts as a slight to medium sink for atmospheric $CO_2$ whereas global exchanges of others gas and volatile organic compounds are not well established. This session address key questions dealing with ocean-atmosphere interaction in the whole Mediterranean Sea with the aim of identifying new research directions, and appropriate observation.

Intended outcome, action or product following the discussion session
Wednesday 18th NOVEMBER, 14.30-16.00

**Note:** The 4 discussion sessions proposed below will take place in parallel.

**Ship plumes**
*Convened by Roland von Glasow*

**University of East Anglia, Norwich, UK**

**Background and motivation**
Emissions of gases and particles from ocean-going ships have major impacts on photochemistry in the marine boundary layer and are potentially important for the deposition of nutrients to the ocean. Throughout large regions of the ocean, ship emissions dominate the natural sulfur emissions, largely of DMS, and have therefore to be considered in estimates of climate forcing by sulfate aerosols which are also directly released from ships (Activity 1.3 of the SOLAS Science and Implementation Plan). Ship emissions are important sources of nitrogen and the input of nitrogen into marine ecosystems might affect marine productivity (Activity 1.5). Furthermore, the fluxes of carbonaceous aerosol particles as well as hydrocarbons are also significant. The effects on atmospheric photochemistry (Activity 1.2) include the production of ozone in regions that are usually sinks for ozone and the pollution-induced release of reactive chlorine from sea salt, which has a lifetime of several days (due to multiphase cycling), so that it is significantly longer than the lifetime of the ship plume itself. Ship traffic has increased significantly in recent years and is projected to keep increasing.

**Intended outcome, action or product following the discussion session**
1) Establishment of working group on ship plumes
2) Decide on how to improve the white paper and whether to make a peer-reviewed review paper out of it
3) Plan workshops to address points in white paper

**Sea ice biogeochemistry and exchange with the atmosphere**
*Convened by Jacqueline Stefels*

**University of Groningen, Haren, The Netherlands**

**Background and motivation**
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. The currently observed reductions in ice extent and thickness appear to be ahead in time of model forecasts, illustrating both the rapidity of the observed changes and the difficulty of understanding and modeling all the feedbacks involved in the change. In current global models, sea ice’s main impact is on Earth’s radiative balance through its albedo, on deepwater formation and on air-sea-exchange processes of gases. The latter impact refers to sea ice as a “cap” on the ocean surface. Emerging views indicate, however, that sea ice itself plays an important role in the biogeochemical cycling and exchange of climate gases. Therefore, the main question for this discussion session is: What are the main climate-relevant compounds and processes associated with sea ice and can we quantify their impact?

**Intended outcome, action or product following the discussion session**
The intended outcome is to prioritize key questions that need to be solved in order to quantify the role of sea ice in global biogeochemical cycles and more specific in the production and fluxes of climate-relevant gases, both directly through ice/snow-atmosphere interactions and indirectly through impacts of ice melt on surface waters and subsequent sea-air fluxes. White paper available.

**Future for the Asian Dust and Ocean EcoSystem (ADOES) with Asian SOLAS**
*Convened by Mitsuo Uematsu*

**University of Tokyo, Tokyo, Japan**

**Background and motivation**
The aim of this session is to further our understanding of the transport processes of Asian dust with a special focus on the changes in the physical and chemical properties of dust particles during their transport from source regions to the ocean, and their impacts on different marine ecosystems. New issues related to Asian dust will be discussed and we will explore the possibility to initiate an international cooperative research program. The following themes will be discussed:
- Physical and chemical variations of dust aerosols during their downwind transport
- Transport path and layer of dust and its deposition flux to the marginal seas and the northern Pacific Oceans
- Impacts of dust on biogeochemistry and ocean ecosystem
- Feedback of marine ecosystems to dust deposition

The comparative studies of the effects of Asian, Australian, Sahara and South American dust on the global ocean, and additionally the different effect of dust on open and coastal oceans should be promoted.

**Intended outcome, action or product following the discussion session**
- Possibility to start an international cooperative experimental program in the North Pacific.
- Identify the scientific issues in the world oceans affected by dust deposition processes.
- Establish a network to exchange the information of dust impact to oceans.

**Ocean fertilization: legislation, ethical considerations and the role of SOLAS**
*Convened by Cliff Law*

**NIWA, Wellington, New Zealand**

**Background and motivation**
Ocean fertilisation is receiving considerable attention as a potential geoengineering solution to increasing atmospheric CO2. Commercial organisations promoting this option focus on the phytoplankton blooms stimulated in iron addition experiments and the perceived cost-effectiveness, whereas subsequent carbon sequestration, side-effects and verification remain major areas of uncertainty. The transition of iron addition from research-driven mesoscale experiments to potential large-scale commercial operations presents a range of challenges for scientists. International legislation currently under development prohibits fertilisation for carbon credit gain, but also requires assessment of the scientific legitimacy of nutrient addition experiments, with implications for future oceanographic research. Future addition experiments, regardless of whether research or commercially driven, present ethical dilemmas for scientists and research organisations, with potential issues of transparency and conflict of interest influencing media/public perception. This session will inform on the current legislation and associated issues, and provide a forum for discussion on the ethical issues and the role of SOLAS in future ocean fertilisation.

**Intended outcome, action or product following the discussion session**
In order to support students and encourage excellence, SOLAS and Environmental Chemistry are offering prizes for the top student posters. All participants registered as students will automatically be entered in the competition. Each day a panel of judges will identify the best posters based on research quality and presentation. Prizes will be awarded at the banquet on Wednesday 18th November.

Schedule
Poster titles and numbers are listed below in alphabetical order by first author (or presenting author for those marked by a *) for each of the 3 sessions and a special section on SOLAS-related project overviews.

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Public transport—general information

There is a good network of tubes/trains and buses in Barcelona. Trains run from 5 am to midnight Monday–Thursday, from 5 am to 2 am on Fridays and all night on Saturdays. Underground lines are “Metro” and train lines are “Ferrocarrils de la Generalitat de Catalunya (FGC)”. The same tickets can be used for all means of transport.

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<th>Ticket type</th>
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<tr>
<td>Single² (no transfer)</td>
<td>1.35</td>
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<tr>
<td>T-10 (10 journeys)²</td>
<td>7.70</td>
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<tr>
<td>2-day travel card</td>
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<td>3-day travel card</td>
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<td>4-day travel card</td>
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<td>5-day travel card</td>
<td>23.10</td>
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<tr>
<td>2-day Barcelona card³</td>
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<td>4-day Barcelona card³</td>
<td>36.00</td>
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<tr>
<td>5-day Barcelona card³</td>
<td>42.00</td>
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¹ Valid for a single journey without transfer between different means of transport. Single tickets can be purchased from any metro station or on the bus. Some stations are unmanned and tickets are available from ticket machines. Note that some of these only accept coins.
² A single journey can include several connections with other means of transport as long as the total journey time is less than 1h15 and you don’t exit and re-enter the tube. T-10 tickets can be purchased from any metro station and also from the airport at the entrance to the RENFE train.
³ Provides discounts on many tourist attractions as well as unlimited travel (see http://www.barcelona-tourist-guide.com/en/general/barcelona-card.html). The Barcelona card can be purchased on-line and collected from the Airport Tourist Information Office during opening hours (09:00 to 21:00). You will be asked to provide the voucher you obtained on-line and some form of photographic identification.

Local Information - Transport

Transport to/from Barcelona airport

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<th>Train (to station Passeig de Gracia)</th>
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<tr>
<td>Route</td>
<td>Aerobus A1</td>
<td>Not recommended¹</td>
<td>-</td>
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<tr>
<td>Frequency</td>
<td>every 10 min</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Days/hours</td>
<td>7d/week, 6am-1am (from airport) or 5.30 am-0.30 am (to airport)</td>
<td>24/7</td>
<td></td>
</tr>
<tr>
<td>Duration</td>
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<td>30-35 min</td>
<td></td>
</tr>
<tr>
<td>Cost</td>
<td>€5 single/ €8.65 return</td>
<td>approx €30²</td>
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<table>
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<tr>
<th>Terminal 2A, 2B, 2C</th>
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<th>Train (to station Passeig de Gracia)</th>
<th>Taxi</th>
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<tr>
<td>Route</td>
<td>Aerobus A2</td>
<td>RENFE R10</td>
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<tr>
<td>Frequency</td>
<td>8-15 min</td>
<td></td>
<td>-</td>
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<tr>
<td>Days/hours</td>
<td>7d/week</td>
<td>7d/week, 6am-11.30 pm</td>
<td>24/7</td>
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<tr>
<td>Duration</td>
<td>25-30 min</td>
<td>25 min</td>
<td>25-30 min</td>
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<tr>
<td>Cost</td>
<td>€4.25 single/€ 7.30 return</td>
<td>€ 2.80¹</td>
<td>€25-30²</td>
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¹ The trains only run from T2 (between T2A and T2B) and the free shuttle bus service running between T1 and T2 takes 30 min so it’s not worth getting the train. For the same reason, make sure you know which terminal to go to. To find out which terminal your airline operates from, go to http://www.barcelona-tourist-guide.com/en/airport/airport-barcelona.html.
² A luggage supplement (€1) and “airport surcharge” (€3.10) will be applied to the meter reading. A €3 supplement is charged at weekends between midnight and 6 am.
³ You can also use your T-10 or Barcelona card if you are going to buy one for the duration of the conference (see Public Transport section overleaf).

Taxis

Official Barcelona taxis are black and yellow. They can be hailed on the street (if their green light is illuminated) or caught from taxi ranks. The rate is around €2 + €1.10/km, therefore the journey from the Catalonian hotels and Marti-Codolar to the city centre should cost between €7 and €10.

Official city taxi numbers

All numbers begin (0034) 93 followed by:

225 0000  433 1020  357 7755  300 2314  300 1100
303 3033  284 8888  330 0000  339 9262

Did you know?

The SOLAS project comprises over 1500 participants in 77 countries. There are 26 established country networks each with a national representative (list available at www.solas-int.org). Some of these representatives are attending the conference. Don’t miss the opportunity to meet your country’s representative and provide him/her with an update of your SOLAS research. A report of each country’s recent activities is published on the SOLAS website at the beginning of each year.
<table>
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<tr>
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<th>To City Center</th>
<th>By bus</th>
<th>By metro/ train</th>
<th>Walking¹</th>
<th></th>
</tr>
</thead>
</table>
| **Residencia Salesiana Marti-Codolar**  
Avenida Cardenal y Barraquer, 1  
Barcelona 08035  
Tel. +34 93 429 1803  
Fax: +34 93 420 8817 | Line 60 to Cosmocaixa  
Start: “Ciutat Sanitària de la Vall d’Hebron”  
End: “Adrià Margarit-Teodor Rovira”  
Time: 25 min  
or  
Line 17 to  
Pl. de John F. Kennedy²  
Start: “Granja Vella-Av. Marti Codolar”  
End: “Pl. Alfonso Comín-Doctor Ribas i Pardigò”  
Time: 24 min | Not recommended  
30 min walk (2.5 km). Very complex and easy to get lost | Metro line 3 from “Montbau” to “Catalunya”  
Time: 15 min |   |   |
| **Hotel Catalonia Castellnou**  
Carrer de Castellnou, 61  
Barcelona 08017  
Tel. +34 932 030550  
Fax: +34 93 236 00 26 | Not recommended | FGC line 6 from “Tres Torres” to “Gràcia” and connect with line 7 from “Gràcia” to “Avinguda del Tibidabo”²  
Time: 28 min | FGC line 6 from “Tres Torres” to “Catalunya”  
Time: 11 min |   |   |
| **Hotel Catalonia Mikado**  
Paseo de la Bonanova, 58  
Barcelona 08017  
Tel. +34 932 114166  
Fax: +34 93 236 00 26 | Line 22 or 75 to  
Pl. de John F. Kennedy²  
Start: “Pg. Bonanova- Vilana”  
End: “Pg. de Sant Gervasi- Balmes”  
Time: 15 min | FGC line 6 from “Sarrià” to “Gràcia” and connect with line 7 from “Gràcia” to “Avinguda del Tibidabo”²  
Time: 34 min | FGC line 6 from “Sarrià” to “Catalunya”  
Time: 12 min |   |   |

¹ Walking directions can be found on the “Hotel and Transport” webpage of the Conference website.

² See following map to get from Plaça J. Kennedy (where Avinguda del Tibidabo station and bus stops 22/75 are located) to CosmoCaixa. The distance is 800 m and should take around 10 minutes. From the square, take Passeig Sant Gervasi then turn right onto Cister Street then right again onto Quatre Camins Street. Here you will find a ramp to enter the museum. If arriving on the n°60 bus, you can enter the museum from Isaac Newton Street.
Venue

CosmoCaixa (tel. +34 93 319 7393) is located at 47-51 Carrer de Teodor Roviralta, but entrances are on Carrer de Isaac Newton and Carrer dels Quatre Camins.

- Plenary talks will take place in the Auditori (Floor/Planta -2).
- Discussion sessions will take place in the Auditori, Agora, beta and gamma rooms (Floor/Planta -2).
- Poster presentations will take place in the Poster Hall located in a tent in the Science Square (Floor/Planta -1).

Wireless internet is available throughout the building.

Maps of CosmoCaixa building can be found on the following pages.

Catering

Coffee breaks - Morning coffee breaks will be in the corridor outside the Auditori; afternoon coffee breaks will be in the Poster Hall.

Poster sessions - Drinks and nibbles will be served during each poster session.

Lunch - A buffet lunch will be served on the Monday free of charge for all conference attendants.

Please note that there are very few restaurants in the vicinity of the conference venue and that these are very expensive. Therefore, on the Tuesday and Wednesday participants will have the option of purchasing a packed lunch (€ 8-9) or paying for a buffet lunch (€10-12). All tickets will have to be purchased from the registration desk by 2.30 pm on Monday 16th November. When you purchase your ticket, please specify if you have any allergies/dietary requirements.
Useful information

The currency is the Euro (€). Visa and Mastercard are accepted almost everywhere. American Express is also commonly accepted. Some places may require pin entry with credit cards. Most shops will require photographic identification for credit card payments.

Useful numbers

Emergency 112  Police 088  Fire brigade 080  Ambulance 061

Language

The official languages are Spanish (Castellano) and Catalan. The latter is most commonly used.

Useful vocabulary and phrases

<table>
<thead>
<tr>
<th>English</th>
<th>Castellano</th>
<th>Catalan</th>
<th>English</th>
<th>Castellano</th>
<th>Catalan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hello</td>
<td>Hola</td>
<td>Hola</td>
<td>Breakfast</td>
<td>Desayuno</td>
<td>Esmorzar</td>
</tr>
<tr>
<td>Good morning</td>
<td>Buenos días</td>
<td>Bon día</td>
<td>Lunch</td>
<td>Almuerzo</td>
<td>Dinar</td>
</tr>
<tr>
<td>Good afternoon</td>
<td>Buenas tardes</td>
<td>Bona tarda</td>
<td>Dinner</td>
<td>Sopar</td>
<td>Cena</td>
</tr>
<tr>
<td>Good evening/night</td>
<td>Buenas noches</td>
<td>Bona nit</td>
<td>Open</td>
<td>Abierto</td>
<td>Obert</td>
</tr>
<tr>
<td>Goodbye</td>
<td>Adiós</td>
<td>Adeu</td>
<td>Closed</td>
<td>Cerrado</td>
<td>Tancat</td>
</tr>
<tr>
<td>Please</td>
<td>Por favor</td>
<td>Si us plau</td>
<td>Street</td>
<td>Calle</td>
<td>Carrer</td>
</tr>
<tr>
<td>Sorry</td>
<td>Perdone</td>
<td>Perdoni</td>
<td>Square</td>
<td>Plaza</td>
<td>Plaça</td>
</tr>
<tr>
<td>You’re welcome</td>
<td>De nada</td>
<td>De res</td>
<td>Thanks</td>
<td>Gracias</td>
<td>Gràcies</td>
</tr>
</tbody>
</table>

English Castellano Catalan

Where is …? Dónde está …? On está …?
How much is it? Cuánto cuesta? Quant val?
Where can I…? Dónde puedo …? On puc …?
Do you speak English? Habla inglés? Parla angles?
I don’t understand No entiendo No l’entenc
What time does the train/bus arrive/leave? ¿A qué hora llega/sale el tren/autobús? A quina hora arriba/surt el tren/autobús?
I would like a single/return ticket Quisiera un billete sencillo/de ida y vuelta Voldria un bitllet senzill/d’anada i tornada
I have a booking for a single/double room in the name… Tengo una reserva de una habitacion individual/doble al nombre… Tinc una reserva d’una habitació individual/doble al nom de…
Do you have a menu in English? Tiene una carta en inglés? Té una carta en anglès?
Can you bring me the bill,please? Me puede traer la cuenta por favor? Em pot portar el compte si us plau?

Dining out

The Ciutat Vella (old town) is probably the nicest area of Barcelona, comprising in particular Las Ramblas (Metro Catalunya/Liceu) and la Barceloneta (port/beach), good for seafood, Metro Barceloneta where a range of restaurants can be found to suit all budgets (see http://www.eat-out.net/restaurant/barcelona).

Tourist information

For information on tourist attractions in Barcelona, please visit the tourist information office:
Placa de Catalunya, 17 (underneath the square)
Metro Catalunya (lines 1 and 3)
Open 9:00-20:00 7 days/week or visit http://www.barcelona-tourist-guide.com
David Ho
University of Hawaii
Department of Oceanography
1000 Pope Road,
MS 517
Honolulu, HI 96822
United States of America
ho@hawaii.edu

Frances Hopkins
Plymouth Marine Laboratory
School of Environmental Sciences
The Hoe, Prospect Place
Plymouth, PL1 3DH
United Kingdom
fhop@pml.ac.uk

Claire Hughes
LGMAC, School of Environmental Sciences
University of East Anglia,
Norwich NR4 7TJ
United Kingdom
claire.hughes@uea.ac.uk

Keith Hunter
University of Otago
Department of Chemistry
PO Box 56, Dunedin 9054
New Zealand
khunter@chemistry.otago.ac.nz

Kirsten Isensee
JAMSTEC, RIGC
3173-25 Showa-machi,
Kanazawa-ku, Yokohama
236-0001, Japan
kirsten.isensee@jamstec.go.jp

Akinori Ito
JAMSTEC
Research Institute for Global Change
3173-25 Showa Town
Kanazawa Ward, Yokohama
Kanagawa 236-0001, Japan
akiori@jamstec.go.jp

Toru Iwata
Okayama University
Graduate School of Environmental Science
3-1-1, Tsushima-naka, Kita-ku,
Okayama 700-8530, Japan
iwata@cc.okayama-u.ac.jp

Jeremy Jackson
Scripps Institution of Oceanography, UCSD
9500 Gilman Drive
La Jolla, CA, 92093
United States of America
jjackson@ucsd.edu

Jung Jinyoung
The University of Tokyo
Ocean Research Institute,
Minamidai 1-15-1, Nakano-ku,
Tokyo 164-8639 Japan
jjyoung@ori.u-tokyo.ac.jp

Sohiko Kameyama
National Institute for Environmental Studies
16-2, Onogawa,
Tsukuba 305-8506
Japan
kameyama.sohiko@nies.go.jp

Daniel Kiefer
IUP & HCI,
University of Heidelberg
Air-Sea Interaction Group
Im Neuenheimer Feld 229
Heidelberg 69120, Germany
daniel.kiefer@iup.uni-heidelberg.de

Kimitaka Kawamura
Institute of Low Temperature Science
N19 W8, Kita-ku
Hokkaido University
Sapporo, 060-0819, Japan
kawamura@lowtem.hokudai.ac.jp

Jevon Keane-Brennan
National University of Ireland, Galway
CCAPS, Physics Department
University Road,
Galway, Co. Galway, Ireland
jevon.keanebrennan@gmail.com

William Keene
University of Virginia
Environmental Sciences
291 McCormick Road
P.O. Box 400123, Charlottesville
VA 22904-4123
United States of America
wck@virginia.edu

David Kieber
State University of NY, College of Env. Sci. and Forestry
Department of Chemistry SUNY-ESF
1 Forestry Drive, Syracuse
New York 13210
United States of America
dkieber@esf.edu

Arunasalam Karunaharan
University of Leicester
Department of Chemistry
University road
Leicester, LE1 7RH
United Kingdom
kar120@le.ac.uk

Khitika Kamimura
Plymouth Marine Laboratory
Prospect Place, West Hoe
Plymouth PL1 3DH
United Kingdom
sukim@pml.ac.uk

Vassilis Kitidis
Plymouth Marine Laboratory
Prospect Place, West Hoe
Plymouth PL1 3DH
United Kingdom
vaki@pml.ac.uk

Annette Kock
IFM-GEOMAR
RD2 Chemical Oceanography
Duesternbrooker Weg 20
Kiel 24105 Germany
akock@ifm-geomar.de

Daisuke Komatsu
Hokkaido University
Faculty of Science 6-8-07, N10 W8,
Sapporo 060-0810, Japan
damboo@mail.sci.hokudai.ac.jp

Kosei Komatsu
University of Tokyo
Graduate School of Frontier Sciences
1-15-1 Minamidai, Nakano-ku,
Tokyo 164-8639 Japan
kosei@ori.u-tokyo.ac.jp

Fumiyoshi Kondo
The University of Tokyo
1-15-1, Minamidai, Nakano-ku
Tokyo 164-8639 Japan
fkondo@ori.u-tokyo.ac.jp

Ronald Kiene
University of South Alabama
Marine Sciences
LSCB-25, Mobile
Alabama 36688
United States of America
rikien@disl.org

Susan Kimmane
Plymouth Marine Laboratory
Prospect Place, West Hoe
Plymouth PL1 3DH
United Kingdom
sukim@pml.ac.uk

Ashwini Kumar
Physical Research Laboratory
Geosciences Division
Navrangpura, Ahmedabad
Gujarat 380009 India
ashwini@prl.res.in

Marcel Kuyper
MPI for Marine Microbiology
Celsiusstr. 1, Bremen
D-28369 Bremen, Germany
mkuyper@mpi-mb.de

Aranzazu Lana
Paseig Maritim de la Barceloneta 57-49
Barcelona, 8003 Spain
lana@cnima.csic.es

Rebecca Langlois
Institut für Meereswissenschaften
Bundesstrasse 55
24105 Kiel Germany
rlanglois@ifm-geomar.de

Chris Lang
University of South Australia
Department of Geosciences
Mawson 5229, Australia
chris.lang@unisa.edu.au

Baerbel Langmann
University of Hamburg
Institute of Geophysics
Bundesstrasse 55
Hamburg 20146 Germany
baerbel.langmann@zarm.de

Julie LaRoche
Leibniz Institut für Meereswissenschaften
Düsternbrooker Weg 20
Kiel 24105 Germany
jlaroche@ifm-geomar.de

Kristian Laß
Christian-Albrechts-Universität zu Kiel
Institut für Physikalische Chemie
Olshausenstr. 40, Kiel 24098 Germany
lasis@phc.uni-kiel.de

Siv Lauvset
University of Bergen
Geophysical Institute
Allégaten 55, Bergen 5007 Norway
siv.lauvset@bjerkes.uib.no

Cliff Law
NIWA
Ocean-Atmosphere
Private Bag 14-901, Kilbirnie
Wellington 6002 New Zealand
c.law@niwa.co.nz

Sarah Lawson
CSIRO PMB1, Marine and Atmospheric Research
Aspendale, 3195 Australia
sarah.lawson@csiro.au

James Lee
University of York
York YO10 SDU
United Kingdom
jdl3@york.ac.uk

Sarah Lawson
CSIRO PMB1, Marine and Atmospheric Research
Aspendale, 3195 Australia
sarah.lawson@csiro.au
Contacts List

Ayako Okubo
University of Tokyo
Yayoi 1-1-1, Bunkyo-ku
Tokyo 113-8657
Japan
aya@mail.ecc.u-tokyo.ac.jp

Naziil Olgin
IFM-GEOMAR
Division Marine Biogeochemistry and
Division Dynamics of the Ocean Floor
Wischhofstr 1-3, Kiel 24148
Germany
nolgun@ifm-geomar.de

Ana Paula Oliveira
INRB, I.P. / IPMAR
UAM, Av. Brasilia
Lisbon 1449-006
Portugal
aoliveira@ipimar.pt

Roger Olivella Pujol
Institut de Ciencies del Mar (CMIMA-CSIC)
Physical Oceanography Department
Passeig Maritim de la Barceloneta 37-49
Barcelona 08003
Spain

Abdulrahman Omar
University of Bergen
Allagaten 55
Bergen, 5007
Norway
abdrrahman.oman@gfi.uib.no

Goh Onitsuka
National Fisheries University
2-7-1 Nagata-Honnachi
Shimonoseki 759-6595
Japan
onitsuka@fish-u.ac.jp

Anna Orlikowska
Leibniz Institute for Baltic Sea Research Warnemünde IOW
Marine Chemistry
Seestrasse 15
Rostock-Warnemünde 18119
Germany
anna.orlikowska@io-warnemuende.de

Kazu Osada
Nagoya University, Graduate School of Environmental Sciences
Chikusa-ku, Furo-cho
Kanyo Sagokan-725
Nagoya 464-8601
Japan
kosada@nagoya-u.jp

Natalia Ospina-Alvarez
Marine Research Institute (IM-CSIC)
Eduardo Cabello 6
Vigo, Pontevedra 36208
Spain
ospina@im.csic.es

Xia Pan
British Oceanographic Data Centre
Joseph Proudman Building
6 Brownlow Street, Liverpool L3 5DA
United Kingdom
xp@bodc.ac.uk

Rodolphe Paris
LISA Université Paris Diderot
61, avenue du General de Gaulle
Citeel 94010 Cedex
France
Rodolphe.Paris@lisa.univ-paris12.fr

Matthew Patey
University of Southampton
School of Ocean and Earth Science
National Oceanography Centre
European Way, Southampton
SO14 3ZH
United Kingdom
mpatey@noc.soton.ac.uk

Aurélien Paulmier
IRD
LEGO
18 Avenue Edouard Belin
Toulouse Cedex 09 31401
France
apaulmier@ifm-geomar.de

Carles Pelejero
Institut de Ciencies del Mar, CSIC
Pg. Martim de la Barceloneta, 37-49
Barcelona 08003
Spain
pelejero@icm.cat

Fiz F. Pérez
Instituto Investigaciones Marinas (CNS)
Oceanography Department
Eduardo Cabello 6, Vigo
E36208, Spain
fiz.perez@im.csic.es

Francesc Peters
Institute of Marine Sciences (CSIC)
Maritime Port
Barcelona 37-49
Barcelona, 08003
Spain
cesc@icm.csic.es

Jan B.C. Pettersson
Department of Chemistry
Gothenburg University
Department of Chemistry
Gothenburg 41296, Sweden
jbp@chem.gu.se

Matthew Patey
University of Southampton
School of Ocean and Earth Science
National Oceanography Centre
European Way, Southampton
SO14 3ZH
United Kingdom
mpatey@noc.soton.ac.uk

Andrea Pineda Rojas
Centro de Investigaciones del Mar y la Atmosfera
CIMA/CONICET-UBA
Facultad de Ciencias Exactas y Naturales (UBA)
Pabellon II, Piso 2
Ciudad de Buenos Aires C1428
Argentina
pineda@cima.fcen.uba.ar

Jacek Piskozub
Institute of Oceanology PAS
Physical Oceanography
ul. Powstancow Warszawy 55
Sopot 87122 Poland
piskozub@pian.gda.pl

John Plane
University of Leeds
School of Chemistry
Woodhouse Lane, Leeds
West Yorkshire LS2 9JT
United Kingdom
j.m.c.plane@leeds.ac.uk

Ulrich Platt
University of Heidelberg
Institute for Environmental Physics
INF 229 Heidelberg 69120
Germany
ulrich.platt@iup.uni-heidelberg.de

Falk Pollehne
Liebritz Institute for Baltic Sea Research Warnemünde
Biological Oceanography
Seestrasse 15, Rostock 18119
Germany
falk.pollehne@io-warnemuende.de

Claire Powell
University of East Anglia
School of Environmental Sciences
Norwich, NR4 7TJ
United Kingdom
c.f.powell@uea.ac.uk

Andrea Pineda Rojas
Centro de Investigaciones del Mar y la Atmosfera
CIMA/CONICET-UBA
Facultad de Ciencias Exactas y Naturales (UBA)
Pabellon II, Piso 2
Ciudad de Buenos Aires C1428
Argentina
pineda@cima.fcen.uba.ar

Jacek Piskozub
Institute of Oceanology PAS
Physical Oceanography
ul. Powstancow Warszawy 55
Sopot 87122 Poland
piskozub@pian.gda.pl

John Plane
University of Leeds
School of Chemistry
Woodhouse Lane, Leeds
West Yorkshire LS2 9JT
United Kingdom
j.m.c.plane@leeds.ac.uk

Ulrich Platt
University of Heidelberg
Institute for Environmental Physics
INF 229 Heidelberg 69120
Germany
ulrich.platt@iup.uni-heidelberg.de

Falk Pollehne
Liebritz Institute for Baltic Sea Research Warnemünde
Biological Oceanography
Seestrasse 15, Rostock 18119
Germany
falk.pollehne@io-warnemuende.de

Claire Powell
University of East Anglia
School of Environmental Sciences
Norwich, NR4 7TJ
United Kingdom
c.f.powell@uea.ac.uk

Axel Pütz
University of Hamburg
Institut für Geowissenschaften
Helmholtz-Zentrum Geesthacht
Hamburg 21502
Germany
axel.puetz@hzg.de

Maciej Rysiński
University of Gdansk
Institute of Oceanology PAS
Pobrane 16
Gdansk 81-077
Poland
mri@ioz.gda.pl

Ivonne Radjawane
Institut Teknologi Bandung
Oceanography Department
Labtek XI, 1st floor,
Jalan Ganesha 10
Bandung, West Java 40132
Indonesia
ivonne@geoph.itb.ac.id

Kevin Randall
Université Laval
Québec-Ocean
Pavillon Alexandre-Vachon
1045, av. de la médecine - local 2071 Quebec G1V 0A6
Canada
kevin.randall.1@ulaval.ca

Rafael Rasse
IVC
Carretera panamericana. km 11.
Caracas, 20632
Venezuela
rsasse@ivic.vc

Katie Read
University of York
School of Chemistry
Heslington, York
North Yorkshire
YO10 5DD
United Kingdom
km519@york.ac.uk

Rosa Reboreda
University Of Aveiro
Departamento de Física, CESAM
Campus de Santiago
Aveiro 3810-193
Portugal
rosareboreda@yahoo.es

Kerstin Richter
IUP & HCI, University of Heidelberg
Workgroup Air-Sea Interaction
Im Neuenheimer Feld 229
Heidelberg 69120
Germany
kerstin.richter@iup.uni-heidelberg.de

Diego Fernández Prieto
EO Science, Applications and Future Technologies Department
European Space Agency (ESA)
Via Giacconi 1
00044 Frascati (Rome) Italy
Diego.Fernandez@esa.int

Alex Pszenny
University of New Hampshire
Institute for the Study of Earth,
Oceans, and Space
Morse Hall, 8 College Rd.
Durham, NH 3824
United States of America
alex.pszenny@unh.edu

Elvira Pulido-Villena
CNRs
Laboratoire d’Océanographie de Villefranche
Chemin du Lazaret, Batiment Jean Maetz
Villefranche-sur-Mer 06234 France
pulido-villena@obs-vifr.fr

Winda Deflani Putri
Institut Teknologi Bandung
Oceanography Department
Jl. Ganesha no. 10
Bandung, West Java 40132
Indonesia
winda.deflani@gmail.com

Jianhua Qi
Ocean University of China
College of Environmental Science and Engineering
238 Songling Road, Qingdao
Shandong Province, 266100
People’s Republic of China
jianhua@ouc.edu.cn

Trish Quinn
NOAA PMEL
7600 Sand Point Way NE
Seattle 98115
United States of America
patricia.k.quinn@noaa.gov

Qijianhua
People’s Republic of China
Shandong Province, 266100
Qingdao
Science and Engineering
College of Environmental Ocean University of China

Winda Deftiani Putri
Institut Teknologi Bandung
Oceanography Department
Jl. Ganesha no. 10
Bandung, West Java 40132
Indonesia
winda.deflani@gmail.com
Contacts List

Céline Ridame
LOCEAN
Biogeochemistry Department
UPMC LOCEAN - Tour 46-00,
Seme etage - 4 Place Jussieu
Paris Cedex 05 75252
France
celine.ridame@upmc.fr

Ulf Riebesell
Düsternbrooker Weg 20
Leibniz Institute of Marine Sciences
(IfM-GEOMAR)
Kiel, 24105
Germany
ulfr.riebesell@ifm-geomar.de

Aida Rios
CSIC, Instituto de Investigaciones Marinas
Eduardo Cabello, 6
Vigo, Pontevedra, 36028
Spain
aida@im.csic.es

Carol Robinson
University of East Anglia
School of Environmental Sciences
Norwich NR4 7TJ
United Kingdom
carol.robinson@uea.ac.uk

Rebecca Robinson
UPEI
Graduate School of Oceanography
South Ferry Rd, Narragansett
RI 2882
United States of America
rebeccar@gso.upei.ca

Estela Romero
Instituto de Ciencias del Mar (ICM-CSIC)
Marine Biology and Oceanography
Pg. Maritim de la Marina
Barceloneta 37-49
Barcelona 08003
Spain
estela@icm.csic.es

Anna Rutgersson
Uppsala University
Department of Earth Sciences
Villavagen 16, Uppsala 752 36
Sweden
anna.rutgersson@met.uu.se

Alfonso Saiz-Lopez
Laboratory for Atmospheric and Climate Research / CSIC
Rio Ciembro s/n, Toledo
Castilla la Mancha 45007
Spain
asaliz@cafa.harvard.edu

Matt Salter
Newcastle University
Oakfield, Chatter Alley,
Dogsmeatfield, Hook
Hampshire RG27 8SS
United Kingdom
m.e.salter@ncl.ac.uk

Eric Saltzman
University of California, Irvine
Earth System Science
3325 Croul Hall, Irvine
California 92697-3100
United States of America
esaltzman@uci.edu

Rosa Santana Pérez
University of Las Palmas de Gran Canaria
Chemistry Department
Campus Universitario de Tafira s/n
Las Palmas de Gran Canaria
Las Palmas, 35017 Spain
rsantana@iccm.rcanaria.es

Michael Scarratt
Fisheries and Oceans Canada
850 Route de la mer, Mont-Joli
Quebec G5H3Z4
Canada
Michael.Scarratt@dfo-mpo.gc.ca

Hendrik Schäfer
University of Warwick
Warwick HR
Wellensiume CV35 9EF
Germany
H.Schafer@warwick.ac.uk

Bianca Schippmann
Leibniz Institute for Baltic Sea Research
University of Rostock
Seestrasse 15, Rostock 18119
Germany
bianca.schippmann@io-warnemuende.de

Dani Schmidt
University of Bristol
Earth Science
Wills Memorial Building
Bristol BS8 1TR
United Kingdom
d.schmidt@bristol.ac.uk

Robert Schmidt
Leibniz Institute for Baltic Sea Research
Warmeinude 18119
Germany
robert.schmidt@io-warnemuende.de

Oscar Schofield
Rutgers University
Coastal Ocean Observation Lab
71 Dudley Road, New Brunswick
New Jersey 8901
United States of America
oscar@marine.rutgers.edu

Sophie Seeyave
SOLAS International Project Office
School of Environmental Sciences
University of East Anglia
Norwich NR4 7TJ
United Kingdom
s.seeyave@uea.ac.uk

Katja Seitz
University of Heidelberg
Institute of Environmental Physics
IUP, INF 229 Heidelberg 69120
Germany
Katja.Seitz@iup.uni-heidelberg.de

Richard Sempéré
CNRS, Center of Oceanology of Marseille
13 LMGM, COr, Case 901,
Campus de Luminy, Marseille Cedex 9 13288
France
richard.sempere@univmed.fr

Pablo Serret
University of Vigo
Ecology and Animal Biology
Facultad Ciencias del Mar
Campus Universitario Lagoas Marcosendo, Vigo
Pontevedra 36310
Spain
pserret@uvigo.es

Marvin Shaw
University of York, Chemistry
Heslington, York
North Yorkshire Y010 5DD
United Kingdom
ms099@york.ac.uk

Jinhui Shi
Ocean University of China
College of Environmental Science and Engineering
238 Songling Road, Qingdao
Shandong 266100
People’s Republic of China
engroup@ouc.edu.cn

Zongbo Shi
University of Leeds
Woodhouse Lane
Leeds, LS2 9JT
United Kingdom
shizongbo@163.com

Rachel Stanley
Woods Hole Oceanographic Institution
Department of Marine Chemistry and Geochmistry
266 Woods Hole Rd., MS #25
Woods Hole MA 2543
United States of America
rstanley@whoi.edu

Jacqueline Stelfes
University of Groningen
Dept. of Plant Ecophysiology
PO Box 4, Haren 9750 AA
Netherlands
j.stelfes@rug.nl

Alexandra Steffen
Science and Technology Branch
Environment Canada
4905 Dufferin St., Toronto
Ontario M3H 5T4, Canada
alexandra.steffen@ec.gc.ca

Sebastian Steigenberger
National Oceanography Centre
European Way
Southampton, SO14 3ZH
United Kingdom
ss2p07@noc.soton.ac.uk

Nadja Steiner
ICS/CCMa
Fisherries and Oceans Canada
University of Victoria
PO Box 30065 STN CSC
Victoria, BC V8W 3V6
Canada
nadja.steiner@ec.gc.ca

Toshio Suga
Tohoku University
Department of Geophysics
Graduate School of Science
Aramaki Aza-Aoba 6-3, Aoba-ku
Sendai, Miyagi 980-8578
Japan
suga@pol.gp.tohoku.ac.jp

Contacts List

Anna Rutgersson
Uppsala University
Department of Earth Sciences
Villavagen 16, Uppsala 752 36
Sweden
anna.rutgersson@met.uu.se

Alfonso Saiz-Lopez
Laboratory for Atmospheric and Climate Research / CSIC
Rio Ciembro s/n, Toledo
Castilla la Mancha 45007
Spain
asaliz@cafa.harvard.edu

Matt Salter
Newcastle University
Oakfield, Chatter Alley,
Dogsmeatfield, Hook
Hampshire RG27 8SS
United Kingdom
m.e.salter@ncl.ac.uk

Eric Saltzman
University of California, Irvine
Earth System Science
3325 Croul Hall, Irvine
California 92697-3100
United States of America
esaltzman@uci.edu

Rosa Santana Pérez
University of Las Palmas de Gran Canaria
Chemistry Department
Campus Universitario de Tafira s/n
Las Palmas de Gran Canaria
Las Palmas, 35017 Spain
rsantana@iccm.rcanaria.es

Michael Scarratt
Fisheries and Oceans Canada
850 Route de la mer, Mont-Joli
Quebec G5H3Z4
Canada
Michael.Scarratt@dfo-mpo.gc.ca

Hendrik Schäfer
University of Warwick
Warwick HR
Wellensiume CV35 9EF
Germany
H.Schafer@warwick.ac.uk

Bianca Schippmann
Leibniz Institute for Baltic Sea Research
University of Rostock
Seestrasse 15, Rostock 18119
Germany
bianca.schippmann@io-warnemuende.de

Dani Schmidt
University of Bristol
Earth Science
Wills Memorial Building
Bristol BS8 1TR
United Kingdom
d.schmidt@bristol.ac.uk

Robert Schmidt
Leibniz Institute for Baltic Sea Research
Warmeinude 18119
Germany
robert.schmidt@io-warnemuende.de

Oscar Schofield
Rutgers University
Coastal Ocean Observation Lab
71 Dudley Road, New Brunswick
New Jersey 8901
United States of America
oscar@marine.rutgers.edu

Sophie Seeyave
SOLAS International Project Office
School of Environmental Sciences
University of East Anglia
Norwich NR4 7TJ
United Kingdom
s.seeyave@uea.ac.uk

Katja Seitz
University of Heidelberg
Institute of Environmental Physics
IUP, INF 229 Heidelberg 69120
Germany
Katja.Seitz@iup.uni-heidelberg.de

Richard Sempéré
CNRS, Center of Oceanology of Marseille
13 LMGM, COr, Case 901,
Campus de Luminy, Marseille Cedex 9 13288
France
richard.sempere@univmed.fr

Pablo Serret
University of Vigo
Ecology and Animal Biology
Facultad Ciencias del Mar
Campus Universitario Lagoas Marcosendo, Vigo
Pontevedra 36310
Spain
pserret@uvigo.es

Marvin Shaw
University of York, Chemistry
Heslington, York
North Yorkshire Y010 5DD
United Kingdom
ms099@york.ac.uk

Jinhui Shi
Ocean University of China
College of Environmental Science and Engineering
238 Songling Road, Qingdao
Shandong 266100
People’s Republic of China
engroup@ouc.edu.cn

Zongbo Shi
University of Leeds
Woodhouse Lane
Leeds, LS2 9JT
United Kingdom
shizongbo@163.com

Rachel Stanley
Woods Hole Oceanographic Institution
Department of Marine Chemistry and Geochmistry
266 Woods Hole Rd., MS #25
Woods Hole MA 2543
United States of America
rstanley@whoi.edu

Jacqueline Stelfes
University of Groningen
Dept. of Plant Ecophysiology
PO Box 4, Haren 9750 AA
Netherlands
j.stelfes@rug.nl

Alexandra Steffen
Science and Technology Branch
Environment Canada
4905 Dufferin St., Toronto
Ontario M3H 5T4, Canada
alexandra.steffen@ec.gc.ca

Sebastian Steigenberger
National Oceanography Centre
European Way
Southampton, SO14 3ZH
United Kingdom
ss2p07@noc.soton.ac.uk

Nadja Steiner
ICS/CCMa
Fisherries and Oceans Canada
University of Victoria
PO Box 30065 STN CSC
Victoria, BC V8W 3V6
Canada
nadja.steiner@ec.gc.ca

Toshio Suga
Tohoku University
Department of Geophysics
Graduate School of Science
Aramaki Aza-Aoba 6-3, Aoba-ku
Sendai, Miyagi 980-8578
Japan
suga@pol.gp.tohoku.ac.jp
Contacts List

Hisahiro Takashima  
JAMSTEC  
Environmental Biogeochemical Cycle Research Program (EBCRP)  
3173-25 Showa-machi, Kanazawa-ku, Yokohama  
Kanagawa 236-0001 Japan  
hisahiro@jamstec.go.jp

Sai-Chun Tan  
Institute of Atmospheric Physics, CAS  
No. 40 Huayuanli, Chaoyang District  
Beijing 100029 Peoples Republic of China  
sctan@mail.iap.ac.cn

Hiroshi Tanimoto  
National Institute for Environmental Studies  
16-2 Onogawa, Tsukuba  
Ibaraki 305-8506 Japan  
tanimoto@nies.go.jp

Mitsuhiro Toratani  
Tokai University  
School of High Technology for Human Welfare  
317 Nishino, Numazu  
Shizuoka 4100395 Japan  
toratani@pml.ac.uk

Ricardo Torres Almarza  
Plymouth Marine Laboratory  
Ecosystem Modelling  
Prospect Place, The Hoe  
Plymouth, PL1 3DH United Kingdom  
rto@pml.ac.uk

Sophie Tran  
Laboratoire des Sciences du Climat et de l’Environnement Biogeochemical Cycles  
15 Avenue du General Leclerc  
Palaiseau 91120 France  
sophie.tran@isce.iips.fr

Jens Tschirrler  
Institute of Environmental Physics  
Im Neuenheimer Feld 229  
Heidelberg 69120 Germany  
jens.tschirrler@iup.uni-heidelberg.de

Atsushi Tsuda  
University of Tokyo  
Ocean Research Institute  
1-15-1 Minamidai, Nakanogaku  
Tokyo 164-8639 Japan  
tsuda@ori.u-tokyo.ac.jp

Osamu Tsukamoto  
Okayama University  
Department of Earth Sciences  
3-1-1, Tsubohashi-naka, Kita-ku  
Okayama 700-8530 Japan  
tsukamoto@cc.okayama-u.ac.jp

Urum Tsunogai  
Faculty of Science  
Hokkaido University  
Earth and Planetary System Science  
N10 W8, Kita-ku, Sapporo  
Hokkaido 060-081 Japan  
urerum@mail.sci.hokudai.ac.jp

Daniela Turk  
Marine Biology Station  
Fornace 41  
National Institute of Biology  
Piran, 6330 Slovenia  
daniela.turk@imbss.org

Sayako Ueda  
Graduate School of Environmental Studies  
Nagoya University  
Furo-cho, Chikusa-ku, Nagoya  
464-8601 Japan  
ueda.sayako@d.mbox.nagoya-u.ac.jp

Mitsuo Uematsu  
The University of Tokyo  
Ocean Research Institute  
1-15-1 Minamidai, Nakano-ku  
Tokyo 164-8639 Japan  
uematsu@ori.u-tokyo.ac.jp

Damodarao Valavala  
National Institute of Oceanography  
Dona Paula, Goa 403004 India  
dvalavala@nio.org

Tessa Vance  
Australian Antarctic Division  
Centenary Building  
Grosvenor Court, Sandy Bay  
Tasmania 7005 Australia  
tessa.vance@aad.gov.au

Daura Vega Moreno  
University of Las Palmas de G.C.  
Oceanography Department  
Campus Universitario de Tafira s/n  
Las Palmas de G.C.  
Las Palmas 35017 Spain  
daura@iicm.rcanaria.es

Maria Vilà-Costa  
University of Georgia  
Department of Marine Sciences  
Athens, GA United States of America  
mariavila-costa@gmail.com

Daniela Turk  
Marine Biology Station  
Fornace 41  
National Institute of Biology  
Piran, 6330 Slovenia  
daniela.turk@imbss.org

Sayako Ueda  
Graduate School of Environmental Studies  
Nagoya University  
Furo-cho, Chikusa-ku, Nagoya  
464-8601 Japan  
ueda.sayako@d.mbox.nagoya-u.ac.jp

Mitsuo Uematsu  
The University of Tokyo  
Ocean Research Institute  
1-15-1 Minamidai, Nakano-ku  
Tokyo 164-8639 Japan  
uematsu@ori.u-tokyo.ac.jp

Rainer Volkmerr  
University of Colorado at Boulder  
Chemistry, Biochemistry and CIRES  
UCB215, Boulder, CO  
80309-0215 United States of America  
rainer.volkmerr@colorado.edu

Roland von Glasow  
University of East Anglia  
School of Environmental Sciences  
Norwich NR4 7TJ United Kingdom  
v.r.von-glasow@uea.ac.uk

Douglas Wallace  
IFM-GEOMAR,  
Marine Biogeochemistry Research Division  
Düsternbrooker Weg 20  
Kiel, 24105 Germany  
dwallace@ifm-geomar.de

Sylvia Walter  
IMAU  
Pincetontplein 5  
Utrecht University  
Utrecht, 3894 cc  
Netherlands  
s.walter@uu.nl

Jinhiu Wang  
Shanghai Jiao Tong University  
School of Environmental Science and Engineering  
800 Dongchuan Road, Min Hang,  
Shanghai 200240 People’s Republic of China  
jinhiuwang@sjtu.edu.cn

Joanna Waniek  
Marine Chemistry Department  
Leibniz Institute for Marine Biosciences  
Am Handelshafen 12  
Bremerhaven, 27570 Germany  
joanna.waniek@ior.de

Rik Wanninkhof  
NOAA/AOML  
4301 Rickenbacker Causeway  
Miami, Florida 33149  
United States of America  
rik.wanninkhof@noaa.gov

Matthew Woodhouse  
University of Leeds  
School of Climate and Atmospheric Science  
Environment Building  
University of Leeds,  
Leeds LS2 9JT United Kingdom  
m.woodhouse@see.leeds.ac.uk

David Wooff  
UH Millennium Institute  
Environmental Research Institute  
Castle Street, Thurso  
Caithness, Scotland KW14 7JD United Kingdom  
david.wooff@thurso.uhi.ac.uk

Gui-Peng Yang  
Ocean University of China  
College of Chemistry and Chemical Engineering  
238 Songling Road, Qingdao  
Shandong Province 266100 People’s Republic of China  
gpyang@ouc.edu.cn

Noureddine Yassaa  
University of Sciences and Technology Houari Boumediene Chemistry Department  
BP 32 El-Alia Bab-Ezzouar  
Algiers 16111 Algeria  
n_yassaa@yahoo.fr

Ying Ye  
Marine Biogeoosciences  
Am Handelshafen 12  
Alfred Wegener Institute  
Bremerhaven, 27570 Germany  
ying.ye@awi.de

Yoko Yokouchi  
National Institute for Environmental Studies  
Division of Environmental Chemistry  
16-2, Onogawa, Tsukuba  
Ibaraki 305-8506 Japan  
yokouchi@nies.go.jp

Keiya Yumimoto  
Kyushu University  
Research Institute for Applied Mechanics  
Kasuga Park 6-1, Kasuga  
Kasuga 816-8580 Japan  
yumimoto@rim.kyushu-u.ac.jp

Honghai Zhang  
Ocean University of China  
College of Chemistry and Chemical Engineering  
238 Songling Road, Qingdao  
Shandong Province 266100 People’s Republic of China  
hzh@oceanu.edu.cn