

solas news

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▲ Photo: The SOLAS Summer School 2013 participants in Xiamen, China.

SOLAS Newsletter issue 16

This latest issue of the SOLAS Newsletter aims to provide you with a general update about SOLAS relevant research topics and events. The selection of our proposed scientific articles is influenced by the following two major events: the 6th SOLAS Summer School and the Ocean Sciences Meeting in Honolulu, USA. The contributions focus on topics that were of high interest. In August 2013, for the first time the 6th SOLAS Summer School took place in Xiamen, China and was a great success, you will be able to read more about it on page 6. In February 2014 at Ocean Sciences Meeting that a large number of the community attended, SOLAS had a strong presence. SOLAS plenary sessions, poster presentations and a booth were all part of the effort, further described on page 12. We hope you will find the articles and reports on recent developments in the field of air-sea science informative.

With SOLAS anniversary in 2014, we are also pleased to report on some major efforts that are ongoing to shape the future direction of SOLAS. You will find more details on page 2.

As in past issues, we also included some updates of the activities of SOLAS national networks and information about other international projects, which you hopefully will find useful and interesting. As we cannot include all the highly interesting reports we recommend you to browse the SOLAS website on your computer, tablet or even smartphone to find out more about the national networks, endorsed projects and partner projects. We also invite you to subscribe to our mailing list to receive our e-bulletins, future newsletters and important announcements about the next SOLAS Open Science Conference in 2015 if you are not already subscribed. Visit our homepage at www.solas-int.org

In this issue...

Scientific contributions

- Dust depositions leading to phytoplankton blooms in the Arabian Sea p10
- The importance of nitrification in the Southern Ocean and in the Southern Benguela upwelling system p11
- Carbonyl compounds in marine aerosol particles and the sea surface microlayer p14
- Air-sea exchanges driven by light p16
- Seawater surface tensiometry reveals complex chemical dynamics at air-water interfaces p18
- Nitrous oxide in surface waters of the eastern tropical South Pacific p20
- CH₄ and N₂O dynamics in a seasonally anoxic fjord p22
- MAGIC studies clouds, aerosols, radiation, and fluxes in the Eastern North Pacific p24
- Long-term Southern Ocean air-sea CO₂ flux by eddy covariance from an ice breaker p26
- Small scale turbulence at the air-sea interface and the impact on transfer processes p27
- The triple oxygen isotope tracer of primary productivity in a dynamic ocean model p28
- Linking sea ice growth mechanisms with dimethylsulfide cycling in sea ice p30
- Sea ice nutrients and associated isotopes cycling p31
- What is the origin of methane in sea-ice? p32
- Atmospheric and surface chemistry observations during SIPEX II, East Antarctica, 2012 p33
- And much more...

Future of SOLAS: On the road to the next decade of SOLAS science

In the first 10 years of the lifetime of the project SOLAS, the community has accomplished a great deal towards the goals of the original Science Plan & Implementation Strategy (IGBP report 50, 2004) and Mid-term Strategy (launched in 2008 and described in Law et al., 2013). But there are still major challenges ahead that require coordinated international research by ocean and atmospheric scientists, as this was identified by the community at the last SOLAS Open Science Conference in 2012. With this in mind, in Spring/Summer 2013, SOLAS has begun an effort to define research themes of importance for SOLAS research over the next decade. The SOLAS Scientific Steering Committee members drafted eight short White Papers. SOLAS being a bottom-up organisation, an online community consultation was carried out in Fall 2013 to give the community the possibility to send in their feedback and input on the White Papers, and to inform us if their research field is represented in the White Papers. But also they were asked more openly what they think SOLAS should be

like within the next decade, what they think are the main SOLAS science questions to be addressed.

In addition, on 3-5 December 2013, Tom Bell from the Plymouth Marine Laboratory (PML), UK hosted a very successful workshop to brainstorm on the scientific scope of SOLAS v2.0. Thirteen bright and highly motivated SOLAS early career scientists from around the world, many of them SOLAS Summer School alumni, met and constructively brainstormed about the next 10 years of SOLAS. To help place Future SOLAS in the context of the Future Earth initiative, two socio-economists from PML were invited to take part to the workshop. Together the group defined what ecosystem services mean in terms of Future SOLAS science and identified where the natural and social sciences can work together. The recommendations and outcome of this workshop are feeding into a document describing the next phase of SOLAS. (A full report of the workshop is available on the SOLAS website.)

During the next phase, with regards to scientific sponsorship, SOLAS will seek to continue its relationship with current sponsors SCOR, WCRP and ICACGP, not from IGBP as the programme is ending in 2015. SOLAS will also seek endorsement of the new ICSU initiative Future Earth: Research for Global Sustainability. A proposal describing the next phase of SOLAS and formally asking for its extension is to be submitted to the above-mentioned programmes.

To draft such a proposal based on the White Papers, taking into account feedback from the online community consultation and young scientists workshop, another workshop took place on 9-10 January 2014 in Galway, Ireland. Brian Ward from the National University of Ireland in Galway hosted this workshop. Some of the current and former SOLAS Scientific Committee members, one of the early career scientist from the workshop hosted in PML and the SOLAS Executive Officer met and set up the structure and content of the proposal.

Open access book on "Ocean-Atmosphere Interactions of Gases and Particles"

The oceans and atmosphere interact through various processes, including the transfer of momentum, heat, gases and particles. In this book leading international experts came together to provide a state-of-the-art account of these exchanges and their role in the Earth-system, with particular focus on gases and particles. It is the first synthesis of a set of disparate topics into a coherent treatment of the exchange of matter across the sea surface. Chapters in the book cover: i) the ocean-atmosphere exchange of short-lived trace gases; ii) mechanisms and models of interfacial exchange (including transfer velocity parameterisations); iii) ocean-atmosphere exchange of the greenhouse gases carbon dioxide, methane and nitrous oxide; iv) ocean atmosphere exchange of particles and v) current and future data collection and synthesis efforts.

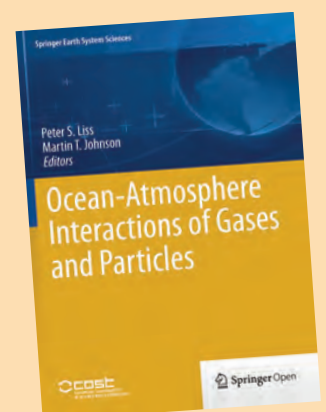
This work constitutes a highly detailed synthesis and reference; of interest to higher-level university students (Masters, PhD) and researchers in ocean-atmosphere interactions and related fields (Earth-system science, marine / atmospheric biogeochemistry / climate).

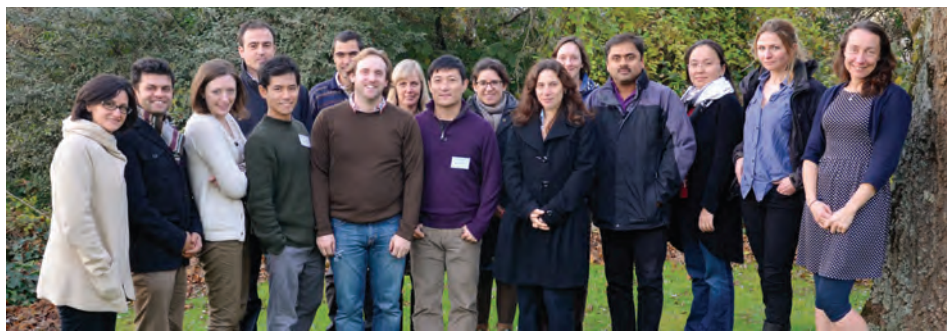
Production of this book was supported and funded by the EU COST Action 735 and coordinated by the International SOLAS project office. A considerable numbers of SOLAS scientists contributed to this major effort led by Peter Liss and Martin Johnson, the editors.

The book is available as an open access book online.

<http://www.solas-int.org/resources/books.html>

Reference: Liss, P. S. and Johnson, M. T., Ocean-Atmosphere Interactions of Gases and Particles (2013) Springer, Heidelberg





▲ Photo: Plymouth workshop participants (left to right): Angela Landolfi, Anoop Mahajan, Frances Hopkins, Nicolas Cassar, Mingxi Yang, Aurélien Paulmier, Tom Bell, Sarah Lawson, Hiroshi Tanimoto, Emilie Breviere, Christa Marandino, Caroline Hattam, Damodar Shenoy, Tzung-May Fu, Rosie Chance, Nicola Beaumont



▲ Photo: Workshop participants in Galway discussing the future of SOLAS. From left to right: Christoph Garbe, Véronique Garçon, Rafel Simo, Doug Wallace, Cecile Guieu, Eric Saltzman, Tom Bell, Christoph Heinze, Yukihiro Nojiri, not visible are: Lisa Miller, Anja Engel, Emilie Brévière, Brian Ward.

The following themes are composing SOLAS in its next phase:

1. Greenhouse gases and the oceans
2. Air-sea interface and fluxes of mass, energy
3. Atmospheric deposition and ocean biogeochemistry
4. Aerosols, clouds and ecosystems
5. Ocean emissions and tropospheric oxidizing capacity, ocean biogeochemistry and stratospheric chemistry
6. Integrated studies
7. SOLAS and society

The proposal document describing the next phase of SOLAS is well underway and an advanced draft is expected to be ready this summer 2014 and will then be submitted to the expected endorsing bodies.

Engagement with Future Earth: Research for Global Sustainability

Since the Future Earth interim Secretariat has been put into place, SOLAS has regular communication with the officers on various topics. SOLAS contributed to the formulating of the Memorandum of Understanding to be signed between projects and Future Earth, to search for Future Earth Scientific Committee members and Engagement Committee members, to the identification of the Future Earth Strategic Research Agenda. Cecile Guieu, SOLAS Vice Chair, gave a short presentation in September 2013 at one of the monthly webinar organised by Future Earth to inform about SOLAS. Finally the SOLAS Executive Officer and Chairman attended and contributed to the first Future Earth Global Environmental Change projects meeting in Washington DC, USA, in January 2014.

SOLAS envisions adding Future Earth as a co-sponsor before the end of 2014.

Scientific Committee on Oceanic Research update



One of the sponsors of SOLAS is the Scientific Committee on Oceanic Research (SCOR). SCOR's mission is to advance all areas of ocean science worldwide, by providing mechanisms to help ocean scientists work together and by helping build capacity for ocean science in developing countries. Through SCOR, the ocean science community identifies priority research topics, and develops and implements large-scale research projects like SOLAS to increase our understanding

of the ocean's role in global systems. Another large-scale project sponsored by SCOR is the GEOTRACES project, which is a global survey of trace elements and isotopes in the ocean. GEOTRACES recently released its first Intermediate Data Product. The data are available through the GEOTRACES Data Assembly Centre (<http://www.geotraces.org/dp/idp2014#>) and two- and three-dimensional sections of elemental concentrations are available at <http://www.egeotraces.org/>.

SCOR also advances ocean science through SCOR working groups, which focus on specific topics for three to four years and then are disbanded. Several ongoing groups are relevant to SOLAS science, including WG 140 on Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPsII),

WG 141 on Sea-Surface Microlayers, WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders, WG 143 on Dissolved N_2O and CH_4 measurements: Working towards a global network of ocean time series measurements of N_2O and CH_4 , and WG 144 on Microbial Community Responses to Ocean Deoxygenation (reports included in this issue). SCOR builds capacity for ocean science in developing countries through a travel grant program, sending SCOR Visiting Scholars to developing countries, and other activities.

Edward Urban, SCOR Executive Director, University of Delaware, USA
(Ed.Urban@scor-int.org)

<http://www.scor-int.org>

Future Earth update



Activities under Future Earth are moving on at pace, with a number of new initiatives started in 2014. A core team of five staff, led by Frans Berkhout, is currently working in the interim Secretariat hosted at the ICSU headquarters in Paris.

In early 2014 Future Earth announced funding from the U.S. National Science Foundation for a set of Fast Track Initiatives and Clustering Activities led by core projects. The Fast Track Initiatives are intended as a way of kick-starting integrated activities on emerging issues. 52 proposals were submitted by the core project community, and a review process involving members of the Future Earth Science and Engagement Committees is now underway. Funding for between 5 and

10 Fast Track Initiatives will be announced at the end of June 2014.

Progress is also being made on the governance and administrative structure of Future Earth. Following an open international call for applications to the Engagement Committee in early 2014, Committee members are expected to be appointed in June 2014. The bidding process to secure the permanent Secretariat for Future Earth has now closed, and an announcement on the successful bid will be made in the coming months. The Secretariat is expected to be in place and operational by the beginning of 2015.

The Future Earth website was launched in March as an online home for the latest news from the community, including science highlights from the core projects and details of how to get involved. The Future Earth blog continues to run, providing commentary and opinion articles on issues relating to Global Environmental Change. Future Earth is looking for new bloggers, and anyone

interested should have a look at the site for details of how to get involved.

Future Earth is currently running a community consultation to seek input into its 2014 Strategic Research Agenda. Following an initial solicitation of research priorities from the core projects of Future Earth, including SOLAS, an online consultation was held to gather information and ideas from Future Earth's global societal stakeholders. A priority-setting workshop was held in May in order to evaluate and synthesize the inputs from the first rounds of consultation, and a final review will be undertaken by Future Earth's Science and Engagement committees before the Strategic Research Agenda is published in late September 2014.

Lizzie Sayer, Future Earth Communications Coordinator, International Council for Science, Paris, France (lizzie@icsu.org)

<http://www.futureearth.info>

<http://www.futureearth.info/blog>

World Climate Research Programme - recent highlights



An important highlight for climate science in 2013-2014 is the IPCC Fifth Assessment Report. Many WCRP-affiliated scientists made a strong contribution to the Working Group I report unveiled in September 2013. Under the WCRP Coordinated Model Intercomparison Project Phase 5 (CMIP5), an unprecedented ensemble of climate simulations from many research centres was made available to the science community for analysis and review.

Several aspects of the climate science that are also of major importance to society are particularly challenging. WCRP has captured the highest priorities of climate research in the concept of Grand Challenges. The Grand Challenge on Regional Climate Information focuses on predictability of regional climate and provision of climate services. The "Clouds, Circulation and Climate Sensitivity" aims to improve our understanding on how the interactions between clouds, greenhouse gases and aerosols affect changes in temperature and precipitation in response to the increase in greenhouse gas concentrations. The "Cryosphere in Changing

Climate" will make needed improvements in our ability to observe, model and predict cryosphere-related changes in the climate system and will involve research on climate predictability in polar regions. The "Attribution and Prediction of Climate Extremes" will strengthen the theoretical and observational foundation for climate-related disaster risk reduction. The "Water Availability" will help to better understand and predict precipitation and support water resources management. The "Regional Sea Level" will comprise studies of both global-mean sea level and its regional variations, enabling assessments of the future sea level for coastal zone management.

WCRP has recently established the Working Group on Regional Climate to act as the primary interface between WCRP science and the Global Framework for Climate Services (GFCS). Part of the GFCS mandate is to help developing effective climate services at regional level. WCRP, in partnership with the European Commission and IPCC organized a very successful Coordinated Regional Downscaling Experiment (CORDEX) conference in November 2013. Two-way dialogue between producers and users of climate information to develop the regional climate research agenda was the main objective of the recent WCRP African Climate Conference (Arusha, Tanzania,

15-18 October 2013) and the Latin America and Caribbean Conference (Montevideo, Uruguay, 17-21 March 2014).

Validation with observations is at heart of climate model development. The WCRP Modelling and Data Advisory Councils promote consolidation of approaches used in the development of models and observations to ensure that data are available on the same grids, in a standard format, and with comprehensive metadata. The emerging capacity to effectively validate models against datasets will accelerate the improvement of the model quality and skill of climate predictions. Exploring the ways to integrate modeling and observation activities is the main topic of International Symposium on Climate that WCRP and EUMETSAT are organizing on 13-17 October 2014 in Darmstadt, Germany. The WCRP Working Groups on Coupled Modelling (WGCM) and Seasonal to Interannual Prediction (WGSIP) are also planning a new generation of experiments on the range of time scales from weeks to years and from decades to centuries, including the coupled model intercomparison experiment CMIP6.

Vladimir Ryabinin, WCRP Senior Scientific Officer, Geneva, Switzerland (vryabinin@wmo.int)

<http://www.wcrp-climate.org/>

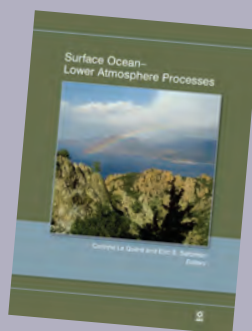
Surface Ocean - Lower Atmosphere Processes Textbook

The focus of Surface Ocean-Lower Atmosphere Processes is biogeochemical interactions between the surface ocean and the lower atmosphere. Lectures from the 2007 Summer School were developed into this textbook. The textbook is designed to provide graduate students, postdoctoral fellows and researchers from a wide range of academic backgrounds with a basis for understanding the nature of ocean-atmosphere interactions and the current research issues in this area.

The book is published by AGU and edited by Corinne Le Quéré and Eric Saltzman.

To order your copy visit www.agu.org/pubs/books

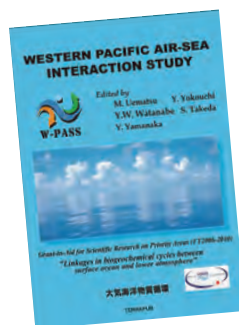
Reference: Corinne Le Quéré and Eric S. Saltzman, Surface Ocean- Lower Atmosphere Processes, 2009, Geophysical Monograph Series, Volume 187, 350 pp., hardbound, ISBN 978-0-87590-477-1, AGU Code GM1874771



Open access e-Book "Western Pacific Air-Sea Interaction Study (W-PASS)"

W-PASS was funded by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan, the Grant-in-Aid for Scientific Research in Priority Areas in the summer of 2006, for 5 years as a part of SOLAS-Japan activity. The goal of the W-PASS project was to achieve a quantitative understanding of the key biogeochemical key interactions and feedbacks between the ocean and the atmosphere. It was the aim to resolve this link through field observation studies over the western Pacific, mainly using research vessels and island observatories. Numerical modeling studies were required for systematic evaluation and quantitative assessment. The e-book is edited by M. Uematsu, Y. Yokouchi, Y. W. Watanabe, S. Takeda, and Y. Yamanaka.

www.terrapub.co.jp/e-library/w-pass



Earth Observation for Ocean-Atmosphere Interactions Science 2014 - Responding to the new scientific challenges of SOLAS

Jointly organised by ESA, SOLAS and EGU

28–31 October 2014

European Space Agency, ESRIN, Via Galileo Galilei, Frascati, 00044, Italy

This joint ESA-SOLAS-EGU Conference aims at bringing together the EO and SOLAS communities, as well as scientific institutions and space agencies involved in the observation, characterisation and forecasting of ocean-atmosphere interactions and their impacts. In particular, the conference represents a unique opportunity to facilitate the communications and scientific exchanges among these different communities in order to enhance the coordination of specific scientific efforts and advocate for a common view of major scientific needs and priority areas for the future.

www.eo4oceanatmosphere2014.info



Integrated Marine Biogeochemistry and Ecosystem Research

The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project is an international global environmental change (GEC) research project with the goal of developing a comprehensive understanding of, and accurate predictive capacity for, ocean responses to accelerating global change and the consequent effects on the Earth System and human society.

As the IMBER project will soon enter the last year of its initial plan, the IMBER-related community is actively developing a new strategic IMBER white paper, which is intended to provide a framework to define and implement the next phase of international marine research beyond 2015. This white paper will be revised during and after the IMBER Open Science Conference (OSC) 'Future Oceans – Research for marine sustainability: multiple stressors, drivers, challenges and solutions', to be held on 22-27 June 2014 in Bergen, Norway, taking advantage of the consultation and active discussions with OSC participants and the larger IMBER community. The OSC "Future Oceans" will gather about 550 participants, coming from about 50 countries.

The white paper will also provide a strong community input for a request for a 10-year extension to our sponsor, SCOR, similarly to what SOLAS is currently aiming at. The white paper will also serve as a baseline for the development of a future, integrated marine research project in the 'Future Earth' programme. It will include key future research questions and priorities in all fields relevant to the marine-related community, ranging from natural and social sciences to humanities and dealing with the marine realm and sustainability, for the next 5 to 10 years; and taking into account the evolving GEC / sustainability research landscape at the national and global scales. The value added of the newly proposed project will be a key incentive for a wide engagement for several communities that would directly benefit from such an international, integrated GEC project, already building on the legacy of the current phase of IMBER. This wide engagement is a key asset for the successful development of a new research agenda for marine sustainability.

Later this summer, the IMBER project is also organising its fourth ClimEco summer school (ClimEco4) titled, 'Delineating the issues of climate change and impacts to marine ecosystems: bridging the gap between research, assessment, policy and management' to be held on 4 -9 August 2014 in Shanghai, China. The ClimEco4 summer school will gather about 75 PhD students and early-career researchers coming from about 35 countries.

Bernard Avril, IMBER Executive Officer, Institute of Marine Research, Bergen, Norway (avrilb@imr.no)

www.imber.info

SOLAS Summer School 2013

The SOLAS International Summer School is a biennial, two week program designed to immerse early career scientists in SOLAS sciences and provide them with the skills necessary for their future scientific careers. Following the previous, highly successful summer schools held in France, in 2013 the program moved east, "Far East", and was held in Xiamen, Fujian Province, P.R. China from 23rd August to 2nd September 2013. It was co-chaired by Dr. Véronique Garçon of CNES/LEGOS and Dr. Minhan Dai of Xiamen University. 69 students from 24 different countries attended the summer school along with 15 world-leading scientists.

Lectures during the school included an introduction to SOLAS, carbon and iron cycles in the ocean, greenhouse/trace gases and their relationship to climate change, atmospheric chemistry and modeling, air-water gas exchange, ocean physics and coastal processes, remote sensing and time series observations, marine ecology, aerosols, marine genomics, macronutrients, solar radiation, and biogeochemical modeling over long time scales. In addition

to these, special sessions were also arranged that covered ethics in science, scientists and the press, and the changing Earth.

During the second week the school became more interactive. Students were divided into small groups (averaging 8-10 per group) and took part in hands on practicals that introduced them to techniques regularly employed in the field. Laboratory work focused on atmospheric and carbon cycle modeling, marine molecular ecology, and gas exchange. Students were also given the opportunity to collect, process, and analyze samples taken along the Jiulong River Estuary aboard Xiamen University's research vessel, Ocean II. These results were then presented before the faculty and peers, giving the students a chance to not only interpret their results but to practice their communication skills.

At the end of the school each student gave an oral presentation in plenaries. Faculty and students each voted for their top three during these sessions and winners were announced at the closing ceremony (Faculty selections: Eva Mayol, Spain; Natalie Freeman, USA; Neil Clark, UK; Student selections: Jana Schneider,

Germany; Raissa Philibert, South Africa; Shlomit Sharoni, Israel).

Another, equally important, though less discussed, aspect of the Summer School is the varied opportunities for networking it provides, even outside of the classroom. While exploring Xiamen, its surroundings, and culture during their free time, students and faculty alike were subconsciously creating those networks and linkages that are critical to the interdisciplinary and collaborative nature of science today.

Without the support of groups such as the Asia-Pacific Network for Global Change, PICES, Scientific Committee on Oceanic Research, the State Key Laboratory of Marine Environmental Science (Xiamen University), the National Natural Science Foundation of China, the Natural Environment Research Council, Xiamen University, the State Oceanic Administration of China, the Centre Nationale d'Etudes Spatiales, Ocean Carbon and Biogeochemistry and many more, this program would not have been possible.



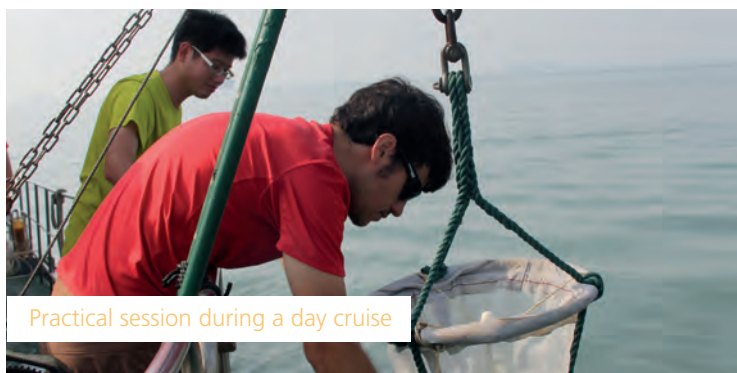
Lecture hall during the Summer School



Practical session during a day cruise



Identifying microbiology during a practical session



Practical session during a day cruise

Summer School poster winners

The SOLAS Summer School places significant emphasis on communication. Each student presents a poster and a 5-min oral talk. Award for the best posters selected by the lecturers were given to the following students. Below find their poster abstracts.

Shlomit Sharoni, Israel, Weizmann Institute of Science (shlomit.sharoni@weizmann.ac.il)

Poster Title: Characterization of marine aerosols properties as a function of algal bloom dynamics

Abstract: During the succession of phytoplankton bloom in the ocean, a significant flux of volatiles and aerosols can be released to the atmosphere. One of the most abundant and widely distributed phytoplankton's species in the oceans is the coccolithophore *Emiliana huxleyi* which forms large-scale blooms that are often terminated by specific viruses (EhV). These marine viruses infect and rapidly demise *E. huxleyi* patches. In this study we characterize and quantify aerosols produced during different stages of *E. huxleyi* growth and EhV infection. These results will potentially provide new insights on the ecological effects of host-virus interactions over large scale in the ocean.

Hilary Palevsky, USA, University of Washington (palevsky@uw.edu)

Poster Title: Quantifying the biological carbon pump: comparing in situ and satellite-based observations

Abstract: We compare satellite-based models of biological carbon export rates and export efficiency with geochemical measurement based estimates on fifteen North Pacific transects from 2008-2012. Continuous measurements of the biological supersaturation of oxygen from O_2/Ar ratios and discrete measurements of stable oxygen isotopes ($\Delta^{17}O$) along these cruise tracks allow us to estimate biological carbon export at ~4km resolution and the export efficiency (fraction of gross photosynthetic production that is exported) at ~2.5° longitude resolution. By comparing the satellite-based models with *in situ* observations, our goal is to assess the applicability of satellite observations in the measuring biological carbon export.

Young-shin Kwon, South Korea, University of Science and Technology / Korean Polar Research Institute (kwonys03@gmail.com)

Poster Title: Modeling the budget of CO in the upper ocean of the Northwest Pacific and the Southern Ocean

Abstract: Being produced by photochemistry, consumed by biota, and emitted to the atmosphere, marine carbon monoxide exhibits a diurnal cycle. CO flux (F_{CO}) and microbial consumption constants (k_{CO}) were determined by the measurements of CO in the ocean and air and dark incubation experiments, respectively. The main goals of these studies are obtaining more accurate estimates of the global CO flux in the study area and investigating factors affecting k_{CO} . Finally, to see how well the experimentally determined parameters represent the actual behavior and calculate source and sink as a function of time explicitly, a numerical modeling study was performed.

Meri Eichner, Germany, Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (meri.eichner@awi.de)

Poster Title: Combined effects of different pCO_2 levels and N sources on a N_2 -fixing cyanobacterium

Abstract: In view of climate change, we investigate pCO_2 responses of the globally important N_2 -fixing cyanobacterium *Trichodesmium*. Previous studies showed an exceptionally strong CO_2 sensitivity in this species and suggested these effects to be caused by reallocation of energy between metabolic key processes. Assessing the plasticity of energy allocation under different energetic requirements, this study focused on the combined effects of different pCO_2 levels and nitrogen sources on *Trichodesmium*. Differences in POC and PON production and intracellular carbon fluxes despite unaltered photosynthetic energy generation suggest that N sources and pCO_2 affects the cells' energy allocation and resources use efficiency.

SOLAS National Network Update

As of January 2014 SOLAS is pleased to count Poland as part of the growing SOLAS National Network. The appointed national representative is Tymon Zielinski (tymon@iopan.gda.pl) from the Institute of Oceanology, Sopot, Poland where he is affiliated with the Atmosphere-Sea Interactions section.

We also welcome three new national representatives, Leticia Cotrim da Cunha (lcotrim@uerj.br), Universidade do Estado do Rio de Janeiro (Brazil), Siv Lauvset (Siv.Lauvset@gfi.uib.no), University of Bergen (Norway) and Tom Bell (tbe@pml.ac.uk), Plymouth Marine Laboratory (UK). At the same time we thank the former national representatives Amauri Oliveira (Brazil), Abdurahman M. Omar (Norway) and Phil Williamson (UK) for their long time involvement with SOLAS.

In this issue of the SOLAS Newsletter we could only include few of the latest updates by the nations of the network and we urge you to go to our SOLAS website to find out more about the other countries activities. <http://www.solas-int.org/community/national-networks.html>



SOLAS UK

National representative:
Tom Bell (tbe@pml.ac.uk)

Sea spray aerosol has an important role in cloud formation and climate processes, particularly in the Southern Hemisphere. To date, wind speed has been used to indirectly estimate sea spray fluxes at the regional and global scale; however, wave conditions are the more direct drivers, via bubble bursting and other aerosol formation processes. Work funded at the University of Leeds under the UK SOLAS programme has shown the importance of separating wind and wave effects. Using direct eddy covariance measurements of sea spray flux in the North Atlantic on RRS Discovery, along with in situ wave state data from a ship borne wave recorder, sea spray aerosol production was determined as a function of a wave-breaking Reynolds number (Norris et al. 2013). The Reynolds number explained up to twice the variance in the flux estimates than did wind speed alone. Global wind and wave fields from ECMWF were used to drive both the new parameterization and a simple wind-speed parameterization from the same measurements (Norris et al. 2012) – significant differences were found in regions where the

surface wave field is far from equilibrium with the local wind field.

UK researchers contributed to SOLAS science goals in many ways including relevant activities in the following national programmes and major initiatives. The UK Ocean Acidification research programme (UKOA) includes the following SOLAS-relevant components, (1) observations and synthesis to establish variability and trends of oceanic pH, (2) ocean acidification impacts on sea surface biogeochemistry and climate, (3) Regional ecosystem and biogeochemical impacts of ocean acidification, (4) abrupt ocean acidification events (focus on Paleocene-Eocene Thermal Maximum) and (5) interactions between CO₂, the carbon cycle and climate. The Ocean Surface Mixing, Ocean Sub-mesoscale Interaction Study (OSMOSIS) is a programme that addresses the physical processes affecting exchanges across the ocean boundary layer. The 6th and final cruise of the Waves, Aerosol & Gas Exchange Study (WAGES) took place on RRS James Clark Ross in 2013 in the South Atlantic, between the Falkland Islands and Ascension Island. The NOC spar buoy was used to measure wave breaking and whitecaps in a wide range of conditions. Involvement in US-UK High Wind Gas Exchange Study (HiWinGS) provided

detailed information on wave state, wave breaking, turbulence intensity, bubble populations and plume extent. Complementary data collected on surface whitecap fraction, also direct eddy covariance estimates of gas and sea-spray aerosol fluxes. The UK GEOTRACES contribution to the international GEOTRACES project focused on micronutrient cycles and ocean palaeo-proxies in the South Atlantic and influence of metal input on biological processes in the tropical Atlantic. ACCACIA, the Aerosol-Cloud Coupling and Climate Interactions in the Arctic project involve groups at Manchester, Leeds, York, UEA, BAS and the Met Office, with international partners. Field campaigns in July 2013 involved ship-based measurements of surface aerosol sources and aircraft measurements of a suite of atmospheric properties. The UK Shelf Sea Biogeochemistry research programme (SSB) addresses carbon cycling, nutrient dynamics and iron fluxes in North West European shelf seas. An assessment of carbon sequestration in UK waters and its potential management ('Blue Carbon') was added to the programme in 2013. A six-cruise, multi-institution field campaign is scheduled for 2014, with focus on the Celtic Sea; also shelf-wide measurements of carbonate system parameters, as a component of the pelagic SSB Work Package.



SOLAS Brazil

National representative:
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In the framework of the Brazilian High Latitudes Oceanography Group (GOAL; www.goal.furg.br), led by the Federal University of Rio Grande (FURG), Brazil, an integrated multidisciplinary research involving several national institutions was established to focus on physical, chemical, bio-optical, and biological studies of the oceans as studies of the carbonate system in the coastal environments has become of great concern to the scientific community. In this context, the spatial and temporal variability of air-sea CO₂ fluxes (FCO₂) were investigated around the Antarctica Peninsula (successive summers from 2008 to 2010), the Argentinian Patagonia continental shelf-break (from 2007 to 2009) and in the continental shelf and slope of the South-western subtropical Atlantic (spring 2010 and summer 2011). A paper, entitled "Net sea-air CO₂ fluxes in the South-western subtropical Atlantic

continental shelf during spring 2010 and summer 2011", from Ito, R.G. *et al.*, is in its final draft version to be submitted to Continental Shelf Research.

The 3rd Brazilian Workshop on "Climate Change in coastal zone" took place in Florianópolis, SC, Brazil, 9-13 December 2013. The workshop considered three main themes: 1) Biogeochemistry of carbon and ocean acidification, 2) Oceans and coastal observational systems, and 3) Network monitoring of coastal benthic habitats. The workshop was convened by Zonas Costeiras - REDE Clima, INCT-Mudanças Climáticas & REBENTOS, and sponsored by CNPq, CAPES, FAPESP, FURG, USP and UFSC.

"Building the Marine Science - French/Brazilian Meeting" in Búzios, Brazil, 4-8 November 2013 aimed to create new interactions in all fields of Marine Sciences between Brazil and France. Research Groups from both countries have presented their current activities, and a future structured, official, cooperation agreement is sought.

The project EstARte-Sul, led by Dr. Rodrigo Kerr, was funded by the Rio Grande do Sul State agency FAPERGS to be conducted between Dec-2013/Dec-2015. The project will be responsible to measure the biogeochemical parameters along the south-south-east Brazilian continental slope. Two cruises are planned. Also the project NAUTILUS (New autonomous technologies to investigate and monitor Antarctic Bottom Water in the Weddell Sea and Antarctic Peninsula) was funded by the Brazilian Antarctic Programme via CNPq (Federal Government Agency). Activities are expected to start in austral summer 2014/2015. This project, led by Dr. Mauricio Mata (FURG), also counts with the cooperation of researchers from Sao Paulo University (USP) and Rio de Janeiro State University (UERJ), as well as from Alfred-Wegener Institute – AWI (Germany), British Antarctic Survey – BAS (UK), University of Southampton – NOCS (UK), University of East Anglia – UEA (UK), University of Alaska Fairbanks – UAF (USA), The State University of New Jersey – Rutgers (USA), Servicio de Hidrografía Naval – SHN (Argentina), and Universidad de Buenos Aires – UBA (Argentina).



SOLAS France

National representative:
Remi Losno (remi.losno@univ-paris-diderot.fr)

The SOLAS community in France is heavily involved in a number of SOLAS endorsed projects. The project FLATOCOA was set up to sample atmospheric deposition at Kerguelen and Crozet in the South Indian Ocean. Despite sampling is stopped for 4 years, new results are still obtained from new sample analyses and data interpretation. It was found that solubility of most of the crustal elements is ever more than 70% and mostly 90% in rainwater over Kerguelen Islands. A seasonality is suspected and Crozet Island is found to be influenced by Austral Africa whilst dust deposition at Kerguelen comes mostly from Patagonia.

Under MedSea, two experiments using large pelagic mesocosms took place in Corsica (summer 2012) and in the Bay of Villefranche to assess the effects of ocean acidification on planktonic communities in oligotrophic areas. The first experiment in Corsica has been a real success. The conditions were highly oligotrophic and no significant effects could be observed for the vast majority of measured parameters, suggesting a rather strong resilience of oligotrophic Mediterranean waters to CO₂ enrichment. Interestingly nitrogen fixation rates responded positively to the CO₂ enrichment, although only at the two highest levels of pCO₂ (~1000 µatm). All available parameters have been uploaded to the Pangaea database (<http://doi.pangaea.de/10.1594/PANGAEA.811018>). The second experiment has been conducted in February/March in the bay of Villefranche but had to be stopped after two weeks because of bad weather conditions. Once all data will be available, they will be uploaded to the Pangaea database.

The main goal of the project DONUT is to experimentally assess how and to which extent the response of heterotrophic prokaryotes (Hprok) to atmospheric inputs of nutrients shape the oceanic dissolved organic matter (DOM) pool and modify its bioavailability. A first experiment was conducted between November and December 2013. Mediterranean surface water collected during the stratification period was amended with a Saharan dust end-member and incubated in the dark at controlled temperature during three weeks. Bacterial activity and biogeochemical characteristics of the DOM pool were determined at selected time points. The dust addition induced an increase in mineral nutrient concentration, dissolved organic carbon and fluorescent DOM. Interestingly, at the end of the incubations a higher amount of DOC had been consumed in the dust-amended treatments but lower bacterial production rates were recorded.

DUNE, a Dust experiment in a low Nutrient, low chlorophyll Ecosystem aimed to estimate the impact of atmospheric deposition on an oligotrophic ecosystem based on mesocosm experiments simulating strong atmospheric inputs of eolian mineral dust. Mesocosm experiments aimed at being representative of real atmospheric deposition events onto the surface of oligotrophic marine waters and were an original attempt to consider the vertical dimension after atmospheric deposition at the sea surface. The project activity in 2013 was the valorisation of the pluridisciplinary results obtained and a special issue in Biogeosciences is devoted to the outputs of the project.

For further information about these projects and all other SOLAS endorsed project visit the SOLAS webpage <http://www.solas-int.org/activities/project-endorsement.html>



SOLAS Sweden

National representative:
Katarina Abrahamsson (k@chem.gu.se)

About 25 SOLAS scientists from Swedish Institutions met at the Royal Swedish Academy of Sciences in Stockholm in November 2013. Three SOLAS Scientific Steering Committee members and three representatives of Swedish funding agencies joined them to discuss on how to enhance the engagement of Swedish researchers in SOLAS, in particular in the context of the Future Earth initiative. During the workshop the participants successfully established a matrix mapping Swedish capacity in relation to the SOLAS broad scientific scope and a list of current members of the Swedish network. They are currently working on setting up collaborations. They also discussed options about having such a workshop annually. This successful workshop was initiated, organised and supported by the Swedish Secretariat for Environmental Earth System Sciences (SSEESS). As a Swedish-SOLAS Open Science Symposium will be held 27-28 Aug 2014 in Gothenburg, Sweden.

SOLAS Symposiums & Meetings 2014

This summer three different SOLAS events will take place in Israel, France and Sweden.

A SOLAS symposium took place on the 19 June 2014 in Israel in the Lopatie Conference Centre at the Weizmann Institute of Science. It was aimed at interdisciplinary exchange of ideas, insights, and knowledge, between scientists whose work deals with SOLAS related processes. In total 19 talks were given on a broad range of SOLAS topics and the day ended with a poster session. The symposium also marked the beginning of the national network of SOLAS Israel.

On 7-8 July 2014, the French SOLAS community will meet in Paris to discuss 'synthesis and future actions'. The French report submitted in 2013 on SOLAS-related activities taking place in France was the largest of such reports and demonstrated the current strong dynamic of the French community on air-sea interface research. If you like to get involved in the French SOLAS community please contact the national representative Rémi Losno (losno@lisa.univ-paris12.fr).

In Gothenburg, Sweden another SOLAS Symposium will be held 27-28 August 2014. Both established and young researchers from Swedish institutions/universities carrying out SOLAS-related science are very welcome to join this event. There will be five distinctive symposium themes, (1) greenhouse gases and the oceans, (2) the air-sea-ice interface and fluxes of mass and energy, (3) interconnections between aerosols, (4) clouds and ecosystems, ocean emissions and tropospheric oxidizing capacity and (5) ship plumes: impacts on the atmosphere and oceans. A poster competition for early career scientists with awards for outstanding posters in each session will round up the programme.

Additional info can be found at

<http://www.sseess.org/events/swedish-solas-open-science-symposium-ocean-ice-atmosphere-interactions>



Priyanka Banerjee is currently pursuing her PhD from National Institute of Oceanography, Goa, India. She has graduated in Geography from the University of Calcutta. Her research focuses on the pathways of mineral dust transport across the northern Indian Ocean and its effect on ocean primary productivity.

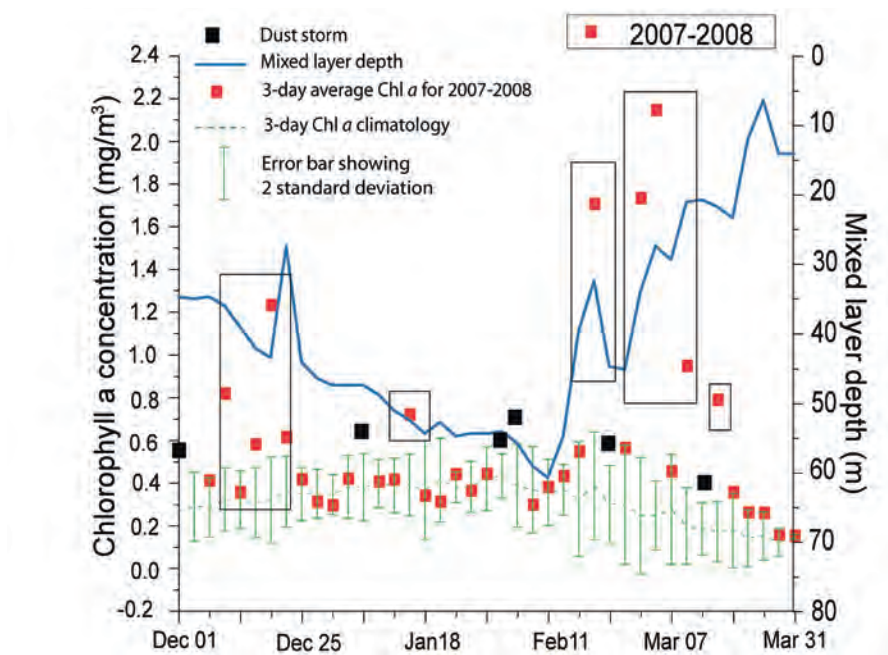
Dust depositions leading to phytoplankton blooms in the Arabian Sea

Banerjee P.* and S. Prasanna Kumar

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Atmospheric deposition of soil dust is an important source of nutrients (especially iron) to the open ocean regions. Every winter (December to March) the Arabian Sea, the northwest part of the Indian Ocean, receives large mineral dust flux from episodic dust storms that occur in the surrounding arid and semi-arid landmass. The region also experiences convection-driven entrainment blooms this time of the year (Madhupratap *et al.*, 1996). While the mechanism of the convection-driven blooms has been well studied, how far nutrients released from mineral dust flux are important in thriving phytoplankton blooms is what eludes us. By doing a simple spatial correlation between satellite-derived dust optical depth and chlorophyll *a* (Chl *a*) concentrations we show that the central Arabian Sea (CAS) can support phytoplankton blooms that may be attributed to the nutrients derived from mineral dust fluxes. This is because CAS is away from the domain of active winter convection thereby having limited oceanic supply of nutrients.

We tracked 45 dust storms for the winters of 2002–2003 to 2010–2011 and examined the Chl *a* levels following each of these dust storms by comparing the Chl *a* with climatological values. If Chl *a* levels following the dust storms exceeded twice the standard deviations of the climatological values, we took up those cases for further study. In total we could identify only six cases of Chl *a* enhancements that can be attributed to dust derived nutrients. Since the prevailing current comes from an oligotrophic region (direction south to north), the probability of advection of nutrients/Chl *a* can be ruled out for each of these cases. Also a careful examination



▲ Figure: An example of Chl *a* enhancements following dust storms in central Arabian Sea for the winter of 2007–2008. The hollow black rectangles indicate the cases of Chl *a* enhancements.

of the water column dissolved iron (DFe) from profiles collected earlier (Takeda *et al.*, 1995) showed that the deepening of mixed layer due to wind mixing or winter convection cannot supply DFe required to support the observed levels of Chl *a* enhancements for the six cases. Calculations of DFe that can be derived from modelled dust depositions versus what is required in terms of Chl *a* increase showed that the external atmospheric source is in fact necessary. The work shows that although dust-induced blooms are not ubiquitous, they are significant enough to contribute about 47% of the total Chl *a* biomass for the studied period. Intensive field based studies are required in this less-explored region to better understand dust-phytoplankton relation.

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Acknowledgements

The authors thank the Director CSIR-NIO, Goa and Council of Scientific and Industrial Research, India for support.



Raissa Philibert is completing her PhD at the University of Cape Town. She completed her undergraduate degree in Chemistry before joining the Department of Oceanography. Her research interests include nutrient cycling and microbial (phytoplankton) ecology. Raissa won the oral presentation award at the SOLAS Summer School 2013.

The importance of nitrification in the Southern Ocean and in the Southern Benguela upwelling system

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Nitrification is the oxidation of ammonium to nitrate through biological processes. Nitrification in the euphotic zone has, in the past, been considered negligible. However, quantifying this process correctly is important when linking carbon export to nitrate uptake by phytoplankton. Only the uptake of nitrate, which originated from outside the euphotic zone can be equated to carbon export. There are very few studies showing nitrate uptake and nitrification rate together in surface waters. This paper presents such data for the Southern Ocean and St Helena, which is located in the Southern Benguela upwelling system.

Nitrogen uptake and regeneration rates for the Southern Ocean were estimated during a winter cruise in July 2012 and a summer cruise in February-March 2013.

Similar estimates were done in St-Helena Bay at the beginning of an upwelling cycle (when nitrate concentrations were high) in November 2011 and March 2012. They were also repeated in March 2013 at the end of an upwelling cycle (when nitrate concentrations were low). Nitrification rates were determined by measuring the isotopic dilution of a ^{15}N tracer based on the method of Clark *et al.* (2007). Nitrate uptake was estimated according to methods of Gandhi *et al.* (2011).

Nitrification was only observed at three stations out of fifteen in the Southern Ocean where nitrification rates ranged from 37.21 ± 9.13 to $217 \pm 88 \text{ nmol.L}^{-1} \cdot \text{h}^{-1}$. These rates were much higher than the nitrate uptake rates and than most rates reported in the literature (Beman *et*

al., 2013). It is possible that only the very high nitrification rates were detectable in this region given the high background concentrations of nitrate.

In St Helena Bay, nitrate regeneration (nitrification) rates ranged from 18.6 ± 9.7 to $88.20 \pm 17.78 \text{ nmol.L}^{-1} \cdot \text{h}^{-1}$. In this region, it was found that proportion of nitrate used by phytoplankton from the regenerated pool (resulting from nitrification) rather than an upwelled source was low at the beginning of an upwelling cycle. In contrast, at the end of upwelling cycle, nitrification in the euphotic zone, on average, exceeded nitrate uptake.

The present results show that nitrate uptake cannot be equated with carbon export uniformly without accounting for nitrification as the contribution of nitrification to the nitrate pool varies regionally as well as within upwelling cycles.

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Acknowledgements

The author thanks Darren Clark (PML) and Howard Waldron (UCT) for supervising Raissa's PhD thesis. She acknowledges Greenseas, a European FP7 project, for funding this project.

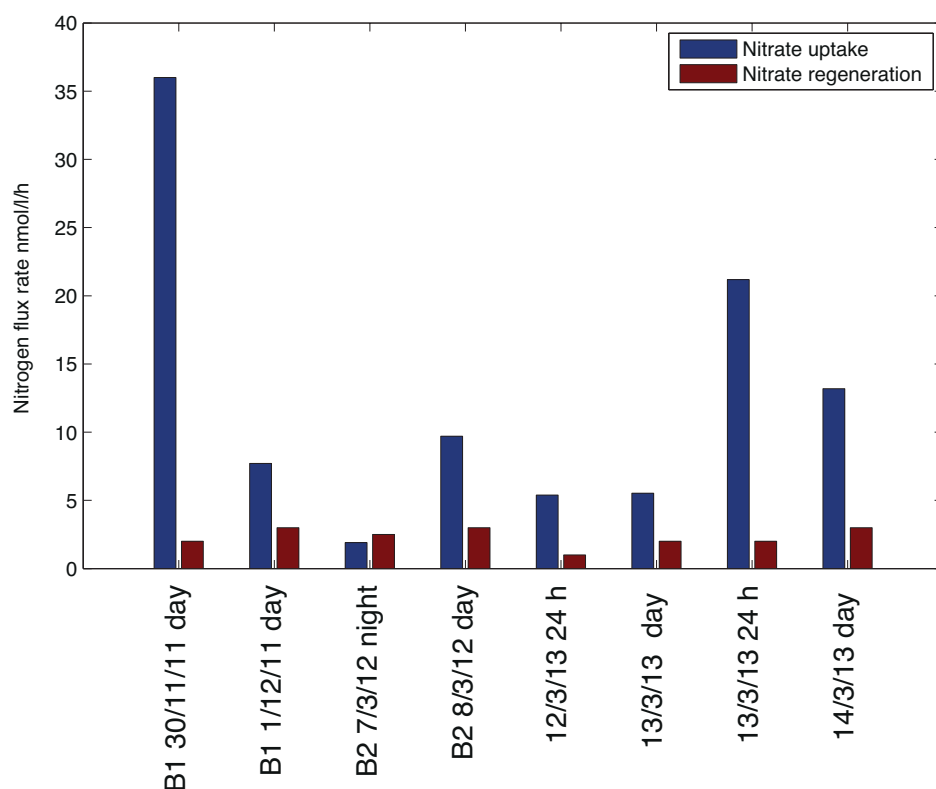


Figure: Day time Nitrate uptake and nitrification rates in St-Helena Bay for selected stations. Samples were all taken at a single location (32,719°S and 18,108°E).

SOLAS at the Ocean Sciences Meeting 2014 Honolulu, Hawaii

SOLAS had a strong presence at the 17th biennial Ocean Sciences Meeting 2014 in Honolulu, Hawaii (23-28 February), co-sponsored by the Association for the Sciences of Limnology and Oceanography (ASLO), The Oceanography Society (TOS), and the American Geophysical Union (AGU). The Meeting has become an important venue for scientific exchange across broad marine science disciplines and therefore an ideal platform for the SOLAS community to engage and meet.

Many sessions during the meeting discussed SOLAS related topics such as for example #005 Air-Sea Gas Exchange and #043 Biogenic Trace Gases In the Surface Ocean: From Source to Flux. One session was also specifically dedicated to SOLAS, the #064 Surface Ocean Lower Atmosphere Study (SOLAS): Advances and Impacts of Ocean Derived Aerosols and Atmospheric Nutrient Inputs. David Kieber and Bill Miller, former members of the SOLAS Scientific Steering Committee, led this session. Bill is currently SOLAS national representative for the USA. A session report can be found below.

During the poster sessions a large number of SOLAS related posters were presented, including one by the SOLAS International Project Office (IPO), which described the goals and functions of the international research initiative that SOLAS is. Furthermore research strategies developed since 2008 described in Law et al. (2013) and some major accomplishments synthesised in the book by Liss et al. (2014) were presented. The article and book are available on the SOLAS website (solas-int.org), as is the latest version of the SOLAS IPO poster.

For the first time SOLAS was present at a booth during a conference. The booth was placed in the exhibition hall of the Ocean Sciences Meeting along with other projects and companies. The booth and SOLAS's participation in it was made possible by the support of the Scientific Committee on Oceanic Research (SCOR)(page 3). The booth was shared with three other projects, GEOTRACES (page 13), IMBER (page 9) and SOOS (page 14). The booth gave an opportunity for people to find out more



about SOLAS and to pick up copies of the SOLAS flyer, Newsletter issues or other materials. It also served as a great and easy to find meeting point for scientists in the rather large convention center and with more than 5000 people.

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Session Summary - Surface Ocean Lower Atmosphere Study (SOLAS): Advances and Impacts of Ocean Derived Aerosols and Atmospheric Nutrient Inputs (Ocean Sciences Meeting 2014)

A SOLAS-themed session was convened at the 2014 Ocean Sciences Meeting during the last week in February in Honolulu, Hawaii, with a morning oral session followed by an afternoon poster session in the main convention hall. During these two sessions, recent results and findings were presented on topics related to two critical air-sea processes identified in the SOLAS mid-term strategy (<http://www.solas-int.org/about/mid-term-strategy.html>): (1) Ocean-derived aerosols: production, evolution and impacts, and (2) Atmospheric control of nutrient cycling and production in the surface ocean. Several posters and oral presentations provided results on the impact of atmospheric inputs of nitrogen, volcanic ash or Asian dust on oceanic productivity, and on organic enrichment of organic matter in the sea surface microlayer including gels and the impact of this organic matter on air-sea interfacial processes. Results were also presented

pointing to the importance of the oceans as a source of nitrogen to the atmosphere in the North Atlantic. Ernie Lewis provided valuable results from a survey of ambient aerosol number concentrations and size distributions in the marine boundary layer in approximately 40 transects between California and Hawaii during the MAGIC field campaign. This rich data set is currently awaiting analysis and interpretation, and is available to the wider ocean-atmosphere community at <https://www.arm.gov/campaigns/amf2012magic>. In emerging research areas, David Kieber presented results linking the removal of recalcitrant marine organic carbon to a coupled ocean – atmosphere process via marine aerosol production and atmospheric photo-oxidation, and Rainer Volkamer presented evidence pointing to the importance of marine-derived organic matter on the chemical composition in the free-troposphere. One highlight of our session

was a compelling presentation by Monica Orellana who discussed recent results using next-generation genetic sequencing technology indicating (1) the presence of marine antifreeze proteins in Arctic aerosols and (2) a link between marine microgels and cloud condensation nuclei in the high Arctic. Monica's insightful presentation prompted a follow up news piece that was recently published in Discovery News (<http://news.discovery.com/earth/oceans/fingerprinting-clouds-140310.htm>). A follow up session on these research themes are planned for the upcoming SOLAS Open Science meeting to be held in the fall of 2015 in Kiel Germany.

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GEOTRACES released its first intermediate data product!



GEOTRACES is an international programme that aims to understand biogeochemical cycles and large-scale distribution of trace elements and their isotopes in all major oceans basins. About 800 scientists from 35 nations have been involved in the programme.

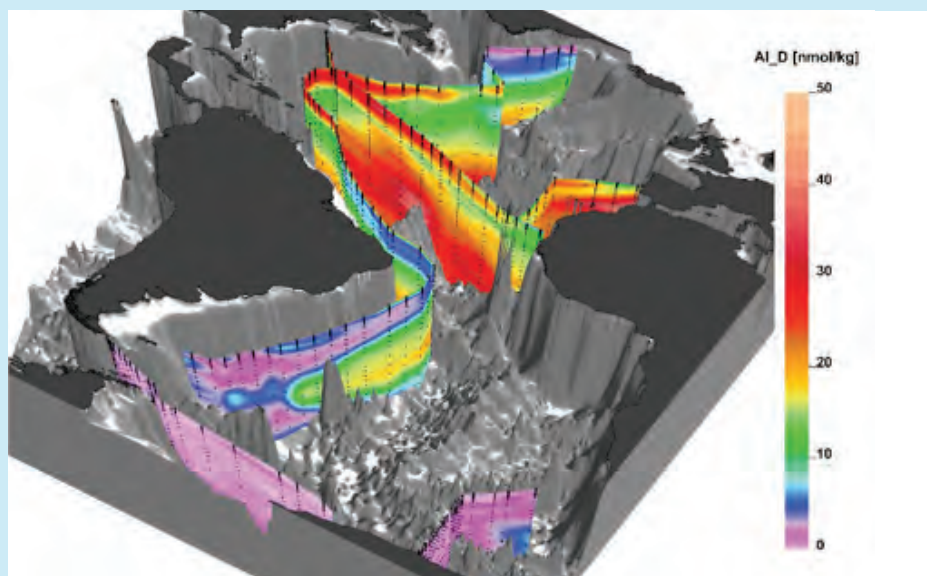
Four years after the launch of the programme, GEOTRACES has already released its first Intermediate Data Product (IDP2014). The product was successfully launched on February 25 at Ocean Science Meeting 2014 (Honolulu, Hawaii) during a town hall attended by more than 350 persons. Journals such as Science and Nature have featured reports describing the release of the product. The first GEOTRACES intermediate data product is freely available on-line.

The GEOTRACES IDP2014 consists of two parts: the digital data package and the eGEOTRACES Electronic Atlas.

The digital data package (available at <http://www.bodc.ac.uk/geotraces/data/idp2014/>) contains data from 15 cruises and more than 70 hydrographic and geochemical parameters. The data product covers the Arctic, Atlantic and Indian Oceans, data density being the highest in the Atlantic. The growing body of data from the Pacific Ocean will be included in the next data product.

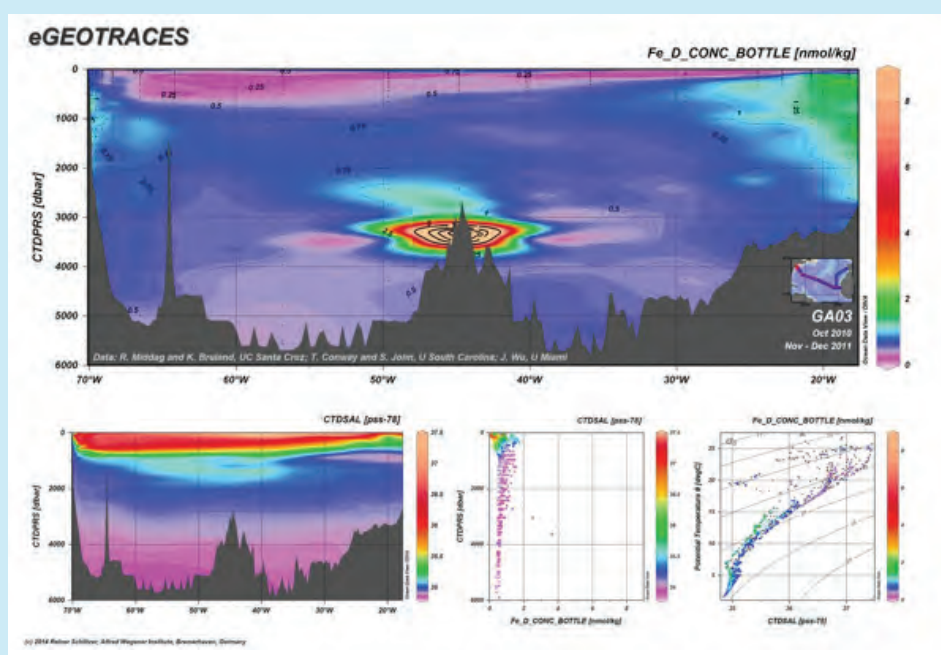
The eGEOTRACES Electronic Atlas (available at www.egeotraces.org) is based on the digital data package and provides 2D and 3D images of the ocean distribution of many of the parameters, as shown in the figures below. The 3D images provide geographical context crucial for correctly assessing extent and origin of tracer plumes as well as for inferring processes acting on the tracers and shaping their distribution. The numerous links to other tracers, sections and basins found on section plots and 3D images allow quick switching between parameters and domains and facilitate comparative studies. In addition, eGEOTRACES can help in teaching and outreach activities and can also facilitate conveying societally relevant scientific results to interested laymen or decision makers.

Rather than wait until the end of the programme, GEOTRACES sought instead to create and release a product at a time when the programme is very active and actually still expanding, both in terms of the observations as well as scientific analysis of



▲ Figure 1: 3D scene showing the distribution of dissolved aluminium (Al) in the Atlantic Ocean. Aluminium is a tracer of terrigenous inputs: in this image, high surface values are reflecting the dust inputs of Saharan origin between African and US coasts but also high concentrations at depth along the margins, also observed for other tracers, that might reflect Al release from the deposited sediments.

Source: Schlitzer, R., eGEOTRACES - Electronic Atlas of GEOTRACES Sections and Animated 3D Scenes, <http://www.egeotraces.org>, 2014.



▲ Figure 2: Full-depth distribution of dissolved iron (Fe) along GEOTRACES GA03 section in the Atlantic Ocean. Along this section, the high surface Fe concentrations clearly reflect Saharan dust inputs.

Source: Schlitzer, R., eGEOTRACES - Electronic Atlas of GEOTRACES Sections and Animated 3D Scenes, <http://www.egeotraces.org>, 2014.

the data produced so far. By releasing and sharing the data now, GEOTRACES wants to strengthen and intensify the collaboration within the oceanographic community itself; specifically, to attract and invite colleagues from other disciplines to join and devote their unique knowledge and skills to marine geochemical problems. At the same time, GEOTRACES is seeking feedback from the

ocean research community to improve future data products.

Elena Masferrer, GEOTRACES Executive Officer, LEGOS-OMP, Toulouse, France (Elena.Masferrer@legos.obs-mip.fr)

<http://www.geotraces.org>

Southern Ocean Air-Sea Fluxes: A contribution to the Southern Ocean Observing System

Future climate is strongly sensitive to processes influencing net air-sea exchange. Nowhere is this more true than in the Southern Ocean, where stratification is low, and properties that exchange across the air-sea interface can readily penetrate along sloping density surfaces into the ocean interior. Furthermore, numerous feedback mechanisms exist in the region, particularly because of the presence of sea ice. Wave breaking, sea spray, and aerosols can further modulate fluxes. Air-sea flux observations, however, are critically sparse in the open Southern Ocean, and nearly non-existent in the sea-ice zone.

Existing observation efforts are generally through separate national projects, with little internationally defined vision of long-term requirements (including observational, satellite and assimilation requirements) or coordinated strategy for addressing issues and knowledge gaps. There is, therefore, a need to bring together the greater Southern Ocean air-sea flux community and related investigators and users, to identify priority needs, to clarify community vision, and to develop a coherent strategy for continuation and enhancement of existing efforts.

The Southern Ocean Observing System (SOOS) recently highlighted the lack of air-sea flux observations from the Southern Ocean as a priority observation gap, and the development of a long-term strategy to address this is now required. Towards this end, a SOOS workshop is being planned for early 2015.

Louise Newman, SOOS Executive Officer,
Institute for Marine and Antarctic Studies,
University of Tasmania, Australia
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Manuela van Pinxteren is a post doc at the chemistry department at the Leibniz-Institut für Troposphärenforschung (TROPOS) in Leipzig. Her work is focussed on the investigation of ocean atmosphere interactions especially regarding organic matter.

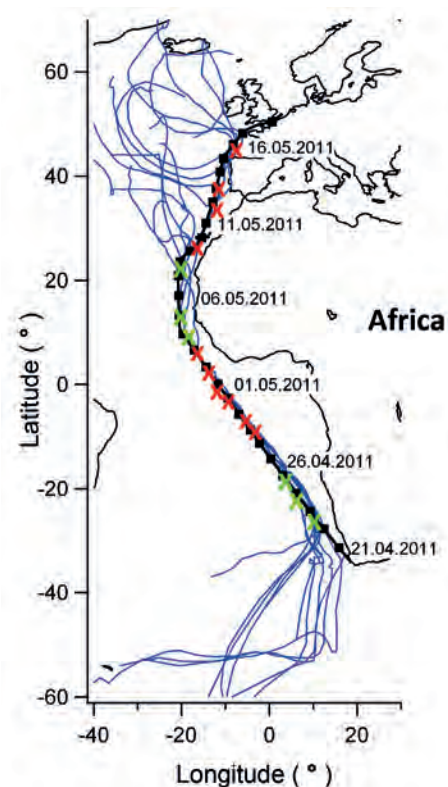
Carbonyl compounds in marine aerosol particles and the sea surface microlayer

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Oceans cover about 2/3rd of the Earth's surface and can act as sources and sinks for atmospheric gases and particles. The complex interactions of these two compartments are largely unexplored at present, especially with regards to organic compounds. Field measurements together with closely related laboratory studies aim at a better understanding of potentially important processes at the air/sea interface. In the framework of SOPRAN (Surface Ocean Processes in the Anthropocene), the German contribution to the international SOLAS program, a wide range of concerted field campaigns were operated generating a large amount of marine aerosol samples and oceanic water samples. Detailed chemical investigations combined with meteorological and biological information should help to reveal sources, formation and transport pathways of atmospheric relevant organic compounds in the marine environment. There is special interest in the sea surface microlayer (SML) – the uppermost very thin layer of the ocean that is the direct interface between the ocean and the atmosphere and has shown to be often enriched with organic compounds (Wurl *et al.*, 2011).

A focus of organic analysis in the SML and in marine aerosol particles was on two α -dicarbonyls glyoxal (GLY) and methylglyoxal (MGLY) that have attracted increasing attention over the past years because of their potential role in aqueous phase secondary organic aerosol (aqSOA) formation. Recently, Sinreich *et al.* (2010) suggested the open ocean as an important (so far unknown) source for GLY in the atmosphere and marine interactions are suggested to play a role the carbonyl cycle. However, to date, there are few available field data of these compounds in the marine area.



▲ Figure 1: Plot of the Polarstern Cruise ANT XXVII/4 from Capetown to Bremerhaven, showing seawater sampling points (red crosses), simultaneous seawater and aerosol particle sampling areas (green crosses) and backwards trajectories (blue lines).

Therefore these carbonyls were investigated in the SML and marine aerosol particles sampled during the Atlantic Polarstern Cruise ANT XXVII/4 from Chile to Bremerhaven (Fig.1).

Chemical analysis of carbonyls in seawater is challenging as these compounds are mostly present in trace levels and the salt matrix can interfere with the analytical instrumentation. Therefore, at first a detailed method optimization was performed applying an analytical approach

based on derivatisation with o-2,3,4,5,6-pentafluorobenzyl-hydroxylamine reagent (to convert the carbonyls into less volatile and less reactive species), solvent extraction with hexane (to transfer the derivatives into a compatible solvent for subsequent analysis) and gas chromatography-mass spectrometry in single ion monitoring mode (to ensure high selectivity and sensitivity of analytical determinations). The method was found to be suitable to analyse GLY and MGLY in marine aerosol particles and seawater in the nmol.L⁻¹ range.

The results of the analysis show that GLY and MGLY are present in the SML of the ocean and corresponding bulk water with average concentrations of 228 ng.L⁻¹ (GLY) and 196 ng.L⁻¹ (MGLY). Significant enrichment (average factor of 4) of GLY and MGLY in the SML was found implying photochemical production of the two carbonyls though a clear connection to global radiation was not observed (Fig. 2).

GLY and MGLY were both detected in marine aerosol particles (PM₁) with an average concentration of 0.2 ng.m⁻³.

They are strongly connected to each other, suggesting similar formation mechanisms. Both carbonyls show a very good correlation with particulate oxalate, supporting the idea of a secondary formation of oxalic acid via GLY and MGLY in aqueous phase chemistry as suggested by Ervens *et al.* (2003) and followed up more recently. A slight correlation of the two carbonyls in the SML and in the aerosol particles was found at co-located sampling areas, pointing to interactions of especially GLY between the two compartments (van Pinxteren and Herrmann, 2013).

The third phase of the German SOPRAN project has started in the beginning of 2013 and is focused on a synthesis of the different achievements of the project. In collaboration with other SOPRAN participants a comprehensive interpretation of the data from the concerted sampling activities and implementations into model approaches will help to achieve a deeper understanding of the processes regarding air/sea interactions.

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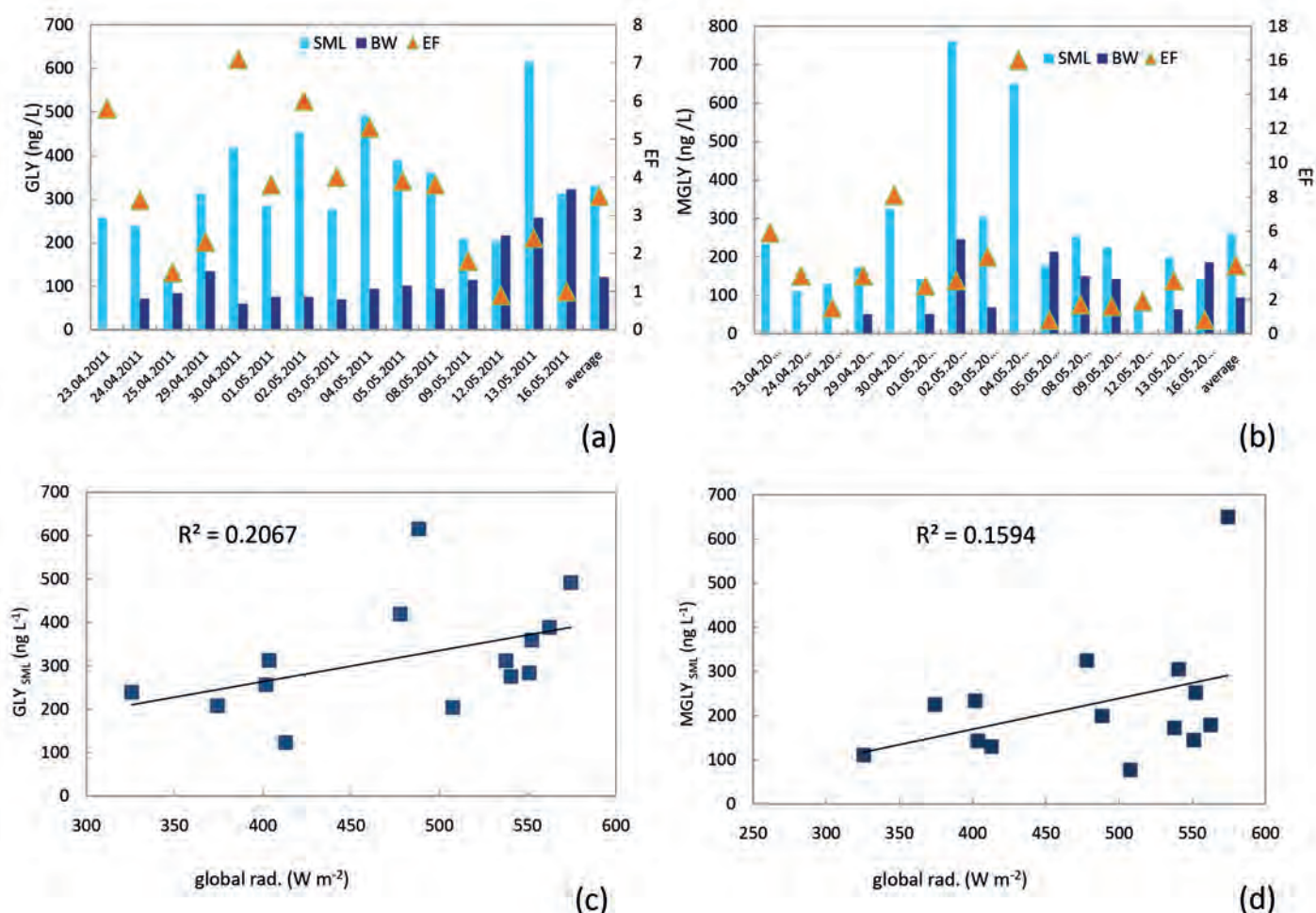


Figure 2: Concentrations of GLY (a) / MGLY (b) in the SML, bulkwater and the corresponding enrichment factor as well as correlations between global radiation and GLY (c) / MGLY (d) concentrations in the SML during ANT XXVII/4.



Global Carbon Project

The Global Carbon Project (GCP) aims at developing a complete, policy-relevant understanding of the global carbon cycle. The three main thematic areas are: diagnostics of the patterns and variability of carbon sources and sinks; vulnerability of those sources and sinks to climate change, land use change and resource use; and carbon management and development of low-carbon pathways. Research and other activities are conducted in two international project offices. The Canberra office deals with the biophysical aspects and the Tsukuba office is mainly focused on the human dimensions of carbon management.

In 2013, the GCP published its 7th annual carbon budget showing that fossil fuel emissions grew to 9.7 GtC.yr⁻¹, 2.2 % above 2011, reflecting a continued growing trend in these emissions, and leading to the largest increase in atmospheric CO₂ of 5.1 GtC.yr⁻¹. Land and ocean sinks were stable or grew. The GCP also published for the first time the complete top-down and bottom-up global methane budget showing that the resume in the growth of atmospheric methane since 2007 were due to both increased emissions from wetlands and from fossil fuels. One major achievement of 2013 was the launch of Global Carbon Atlas, becoming one of the major interfaces between GCP research products and three very distinctive audiences: Outreach – general public; Emissions – for policy makers, NGOs, and the corporate world involved in climate change policy and affairs; and Research – for the scientific community with model and other flux and pool carbon data.

Further, in 2013 GCP continued its focus on The REgional Carbon Cycle Assessment and Processes (RECCAP). A number of regional groups continued working on regional GHG budget products and major progress has been made in the Asia Chapter. As a new development, GCP also started new focus activity on Negative Emissions as an important climate mitigation option. During 2013, two workshops on Negative Emissions were held with various publications in preparation and a long-term commitment to further investment on this topic.

The GCP remains committed to the Future Earth process and its inter-and trans-disciplinary activities. The GCP, in coordination with some other GEC programmes, has proposed a fast track initiative on the energy, GHG and water nexus, with an extension to other key sustainability issues such as pollution.

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Christian George (PhD in the field of Physical-Chemistry - 1993, Habilitation in Chemistry - 1999, University Louis Pasteur - Strasbourg) has been active in the field of atmospheric chemistry and/or physical chemistry over the last decade. He acted as research scientist at the Fraunhofer Institute ITA at Hanover (Germany), at the CNRS Centre for Surface Geochemistry at Strasbourg (France) and now at IRCELYON (France).

Air-sea exchanges driven by light

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Surface microlayer chemical composition is controlled by biogeochemical and physical processes in the ocean. On one hand, it influences the organic fraction of marine aerosol produced by sea spray processes (Keene *et al.*, 2007, Facchini *et al.*, 2008). On the other hand it controls trace gas deposition to the ocean and may be involved in secondary organic aerosol formation in the marine boundary layer.

Due to the enrichment of chemicals and biota within the sea-surface microlayer, there is the widely held presumption that the surface microlayer could act as a highly efficient microreactor, effectively concentrating and transforming organic compounds brought to the interface from the atmosphere and sea by physical processes. Photochemical reactions within the marine microlayer are particularly important since they can effectively lead to the formation of new organic compounds and by this alter the gas exchange rates and secondary organic aerosols (SOA) formation. There has been little or no attention paid to date on atmospherically relevant photochemistry taking place at the air-water interface. In natural water surface microlayers, it is speculated that some photochemical processes could be enhanced, but there is little experimental evidence of this to date.

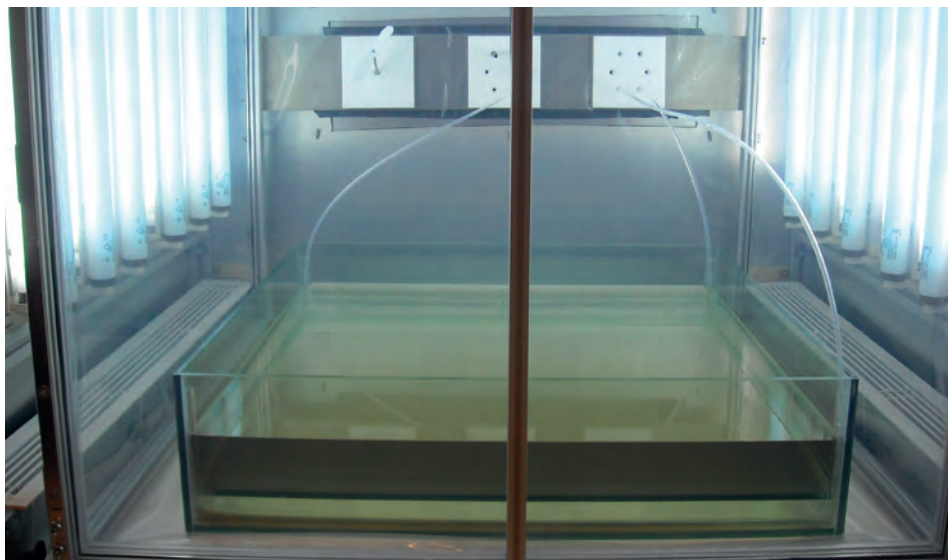
Surface seawater contains a variety of substances which act as photosensitisers. They include components of the dissolved organic matter known as marine humic material (Hoigne *et al.*, 1989), and anthropogenic organic compounds such as polycyclic aromatic ketones. Carlson *et al.* (1980, 1982) have demonstrated that organic material absorbing at wavelengths > 300 nm is enriched in the surface microlayer relative to the bulk.

These organic compounds, referred to as coloured or chromophoric dissolved organic matter (CDOM), are chemically complex mixtures known to contain phenolic moieties.

Previous works have shown that photochemical processing led to the formation of highly functionalized volatile organic compounds (VOCs), which may be potential candidates to the SOA loading. In order to bring further comprehension, a multiphase atmospheric simulation chamber has been developed and used in order to study the chemical processes occurring at the air-sea interface. The chamber is made of two m³ fluorinated ethylene propylene (FEP) film in which a glass container is inserted.

Formation of particles has been initiated through the vacuum ultraviolet (VUV) irradiation (centred at 365 nm) of a liquid mixture of humic acid used as photosensitizer and nonanoic acid as a surfactant. Particle formation was measured using an ultrafine condensation particle counter (d₅₀ > 2.5 nm) and particle growth was monitored using scanning mobility particle sizer (SMPS). VOCs formed have been identified and analysed by Proton Transfer Reaction – Time of Flight mass Spectrometer and gas chromatography-mass spectroscopy (GC/MS). The chamber is also equipped with continuously measuring NO-NO_x, SO₂, ozone and CO. In addition, analysis of liquid content was performed using an Orbitrap liquid chromatography-mass spectroscopy (LC/MS). Liquid mixture is exposed to irradiation for more than ten hours.

Under our experimental conditions, particle number concentration increased after 10 min of irradiation up to 5000 cm⁻³. It has been also observed that the aerosol number concentration decay was not logarithmic showing the occurrence of another



▲ Figure: View of the multiphase simulation chamber

nucleation episode. Particle size distribution was measured four hours after starting irradiation. At the end of the experiments, ozone was added in the dark and particle formation was observed, sustaining the presence of SOA precursors among the VOCs formed during irradiation. In addition, orbitrap analysis of the liquid content has shown clearly the presence of unsaturated aldehydes (C5-C8). Particle formation linked to the gas phase properties as well as with the liquid content will be presented. Atmospheric implication of photosensitized reactions as a source of SOA loading in the marine boundary layer will be discussed.

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Acknowledgements

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Ocean Acidification: A Summary for Policy makers

This summary for policy makers reports on the state of scientific knowledge on ocean acidification, based on the latest research presented at The Third Symposium on the Ocean in a High-CO₂ World, held in Monterey, California, in September 2012. Experts present the projected changes from ocean acidification for ecosystems and the people who rely on them, according to levels of confidence for these outcomes.

Download the summary from the recently launched Ocean acidification website <http://ocean-acidification.net/>



Ocean Acidification International Coordination Centre (OA-ICC)

As research activities on ocean acidification continue to develop, there is a growing need for international collaboration and coordination. In response to this need, the Ocean Acidification International Coordination Centre (OA-ICC) of the International Atomic Energy Agency (IAEA) was launched in 2012. Operated by the IAEA Environment Laboratories in Monaco, the project is supported by several IAEA Member States as well as international projects, including SOLAS, the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) and the EU MedSeA project. The OA-ICC is working internationally to promote overarching activities that serve the scientific community and science users, namely policymakers, media, and the general public. Among these activities, the OA-ICC is helping to establish an international observing network, to promote international cooperation on data sharing and data management, to stimulate collaboration between natural, economic and social sciences, to facilitate recommendations for best practices, to build technical capacities in developing countries, and to communicate science to scientists and non-scientists.

Here are three of its recent science products:

- the OA-ICC news stream informs scientists of recent publications, media coverage, meeting announcements, and jobs (www.news-oceanacidification-icc.org)
- the OA-ICC data compilation on the biological response to ocean acidification provides easy access to regularly updated published experimental data (<http://tinyurl.com/oaicc-data>)
- the OA-ICC bibliographic database currently holds more than 2000 references and includes citations, abstracts and keywords (<http://tinyurl.com/oaicc-biblio>)

The OA-ICC is also launching intercomparisons, the first of which has resulted in a recent publication that compares publicly available software to compute carbonate chemistry, a collaboration with the International Ocean Carbon Coordination Project (IOCCP) and the EU CARBOCHANGE project.

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Land-Ocean Interactions in the Coastal Zone (LOICZ) project overcomes critical transition hurdles and prepares for new phase

In January 2014, all Global Environmental Change (GEC) projects came together in one room in Washington D.C. for the first time ever to prepare the transition to Future Earth. There, the LOICZ representatives Ramesh Ramachandran (Chair) and Marion Glaser (Interim Director/CEO) found, somewhat disconcertingly, that among all 30 GEC projects, LOICZ was among the most vulnerable one. Not only were both parent programs, IGBP and IHDP, to be discontinued (at fate shared by a few other projects) but also, the LOICZ International Project Office (IPO) host, the Helmholtz Zentrum, Geesthacht, Germany, is terminating the hosting agreement in December 2014, after 10 years. The future of LOICZ seemed rather uncertain.

This triple vulnerability of LOICZ has now been substantially reduced. At the LOICZ Scientific Steering Committee (SSC) meeting in Hamburg (May 5-8, 2014) a new host for the LOICZ IPO was selected. Official news about this are expected shortly. The LOICZ project is now in the more comfortable position of being able to count on a continuation of the over 20 years of successful global research and to drive forward the emerging process of co-designing a global coastal knowledge building agenda with an increased range of coastal stakeholders.

The discussions in Hamburg focused on issues arising in the current transition period: The challenges and strengths of the LOICZ Regional Nodes in building a global sustainability agenda were presented in a first SWOT analysis and further work on this was planned; the potentials of the LOICZ Affiliated Project mechanisms for networking global coastal science in and across regions were presented and discussed; experiences in different coastal regions of the globe with involving non-academic coastal stakeholders were reported and compared; and approaches to conducting annual project meetings in the new era of co-design and co-production of sustainability knowledge were considered. The question of how the "new global coastal sustainability science" is to be filled with life was also intensively discussed in Hamburg. A "Signpost" document to signal new horizons for a 10-year Science Plan is now being drafted. In the spirit of co-design, this will involve consultations with major coastal stakeholders.

The coming months will be occupied with the institutional and scientific transition processes and with the preparations for the upcoming new hosting agreement for the LOICZ IPO.

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Seawater surface tensiometry reveals complex chemical dynamics at air-water interfaces

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Marine dissolved organic matter (DOM) consists of a range of chemical species at various stages of degradation; and its sea-to-air transfer associated with marine aerosol has important but poorly understood implications for the atmosphere. The origins and surface-active properties of surface-ocean DOM and related interactions in marine-aerosol production were investigated during a recent cruise aboard the NOAA R/V *Ronald H. Brown* in the eastern North Atlantic Ocean (Long *et al.*, 2014 and Quinn *et al.*, 2014).

The dynamic (time-dependent) surface tension (DST) at the air-liquid interface was characterized with bubble-pressure surface tensiometry (Adamson and Gast, 1990). In a solution containing surface-active compounds, surfactants will diffusively partition onto available surface area – e.g. a bubble – thereby depressing surface tension. Thus, temporal evolution in the pressure required to inflate a bubble within the liquid will vary as a function of speciation, concentrations, diffusion rates, and surface affinities of surface-active DOM.

DST and dissolved organic carbon (DOC) were measured simultaneously in seawater sampled from inlet and outlet streams of a seawater aeration chamber (Fig. 1; Keene *et al.*, 2007). Influences of bubble scavenging on seawater surface activity and DOC concentration were characterized in three paired sets of inlet and outlet samples from the biologically productive George's Bank and the oligotrophic Sargasso Sea north of Bermuda.

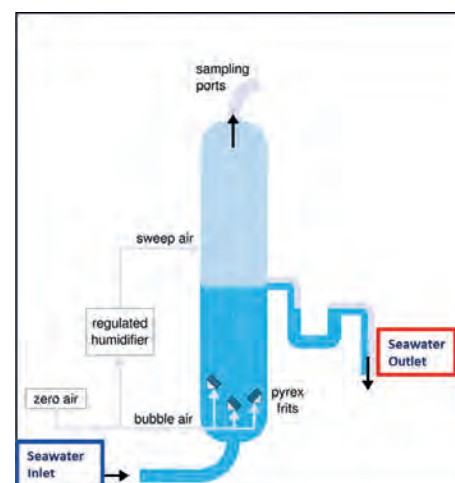
Fig. 2a shows the DST curves (reported as departures from that of surfactant-free seawater) for seawater at George's Bank. The difference between the two curves indicates that aeration modified the surfactant pool as one might expect due to scavenging and removal of the most surface-active DOM by the bubble plume. The change yielded a shallower (less negative) curve as seen in the red vs.

blue lines in Fig. 2a. However, corresponding changes in DOC concentrations measured at the inlet and outlet were statistically indistinguishable ($p < 0.01$).

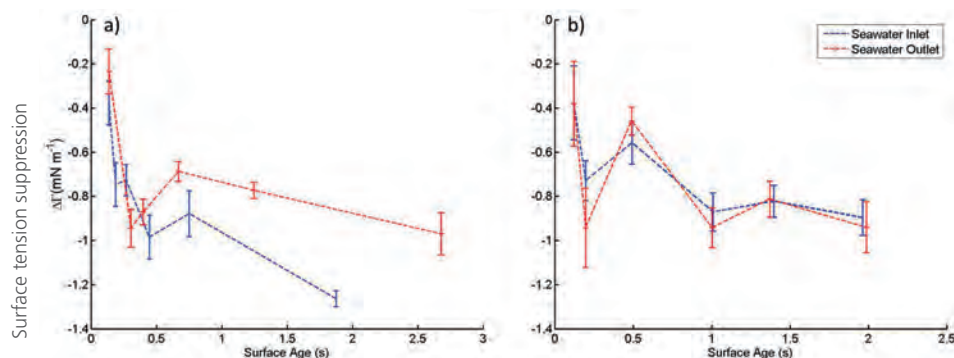
The DST curve for Sargasso seawater was similar to that for the George's Bank suggesting that both may contain similar surfactant material. However relative changes in DST and DOC due to aeration at the two stations were opposite: DST for Sargasso seawater from the chamber's inlet and outlet revealed no evidence for surfactant modification (Fig. 2b) whereas DOC concentrations decreased by an average of $23(\pm 5) \mu\text{M}$, or around 30%.

These distinct differences between productive and oligotrophic seawater may result from differences in organic matter composition. Less than 0.1% of DOC in the seawater was lost as aerosols (Long *et al.*, 2014), implying that differences between stations resulted from modification of the phase partitioning of seawater organic material via aeration.

Although distinct trends were observed at these two locations, data are preliminary warranting further more detailed studies to explore the basis for the observed



▲ Figure 1: Schematic diagram of the seawater aeration chamber.



▲ Figure 2: Surface tension suppression ($\Delta\Gamma$) versus bubble surface age for samples collected from the inlet (blue) and outlet (red) ports of the seawater aeration chamber as shown in Fig. 1. Panel (a) shows results from seawater collected at George's Bank, and panel (b) is from Sargasso Sea seawater. $\Delta\Gamma$ is the difference between observed surface tension and that of surfactant-free seawater adjusted for temperature and salinity.

differences. Despite this, these results and those reported by Long *et al.* (2014) indicate distinct, geographically variable surface-active seawater DOM that influence DST, bubble plume dynamics, phase partitioning of seawater organic matter, production of marine aerosols, and, presumably, the speciation and atmospheric chemical marine aerosol. Additional experiments investigating marine surface-active material are planned.

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SCOR Working Group 141 “Sea-Surface Microlayers”

The sea-surface microlayer (SML) is the boundary interface between the atmosphere and ocean, covering about 70% of the Earth's surface. The SML has physicochemical and biological properties that are measurably distinct from underlying waters. Because of its unique position at the air-sea interface, the SML is central to a range of global biogeochemical and climate-related processes. The SCOR working group 141 is dedicated to increase the awareness of the science community to the importance of the SML in a wide range of biogeochemical and climate-related processes. It will use a multidisciplinary perspective to suggest the future direction of SML research at an international level. The group will bring scientists from various disciplines together to consider chemical, biological and physical aspects of the SML, and to understand governing mechanisms in its formation and role in biogeochemical cycling and climate science.

Members of the group are currently working on a guide to best practices to study the

ocean's surface. The guide is expected to be completed this summer, and will be showcased during a 4-day workshop at Qingdao Ocean University, China. The workshop is being held in October and will include training students in SML sampling techniques and promoting SML research to the next generation of oceanographers. Members of the group will be attending the SOLAS Open Science Conference in Kiel, Germany in September 2015, and will organize a special session on the SML at a major international ocean science meeting in late 2015 or 2016.

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Climate Variability and Predictability

Implementation of CLIVAR's main objectives requires some specific challenges to be addressed, and to facilitate the international coordination of those, CLIVAR has established the possibility for the community to define and implement Research Foci. These Research Foci provide the CLIVAR project with the ability to remain flexible in the changing landscape of scientific research priorities, whilst the traditional CLIVAR panels maintain a focus on the core activities critical to advancing CLIVAR and WCRP goals. There are currently 7 Research Foci:

Intraseasonal, seasonal and interannual variability and predictability of monsoon systems

- Better constraint of modelled monsoon variability and change based on observation-informed process studies;
- Improving models to better represent the key processes involved in monsoon intraseasonal and inter-annual variability;

Decadal variability and predictability of ocean and climate variability

- Improving the physical understanding of decadal variability and its predictability;
- Advancing the use of past instrumental and proxy data;

Science underpinning the prediction and attribution of extreme events

- Identification of the key modes of ocean-atmosphere variability,
- Increasing observational data sets,

Marine biophysical interactions and dynamics of upwelling systems

- Identifying the key physical processes that are responsible for upwelling and improving their representation in models;
- Coupled interactions between the physical, biogeochemical and marine ecological systems;

Dynamics of regional sea level variability

- Contribution of wind-driven circulation change;
- Ocean – ice sheet interaction in Southern Ocean;

Consistency between planetary heat balance and ocean heat storage

- Earth observation measurement constraints on ocean heat budget;
- In situ observations of ocean heat content changes;

ENSO in a changing climate

- Better understand the role of different physical processes that influence ENSO characteristics and the diversity of El Niño events on decadal time scales;

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Past Global Changes update

Past Global Changes (PAGES) organizes scientists interested in long-term perspectives on global change issues. Like its sister project SOLAS, PAGES is a core project of the International Geosphere-Biosphere Programme, with plans to transition into Future Earth over the next year. Also like SOLAS, PAGES is firmly rooted in fundamental physical and biogeochemical Earth system science, coordinating the global community to address scientific priority questions in an interdisciplinary and integrative way. Scientific activities in PAGES take place through question-driven and product-oriented Working Groups that organize scientific exchange and generate syntheses of knowledge and data.

Two recent examples of PAGES' output may be of particular interest to SOLAS researchers and illustrate the power of concerted community efforts: (1) The NICOPP group has reconstructed the dynamics of the marine nitrogen cycle globally during the last big global warming transition terminating the last ice age (Galbraith *et al.*, 2013). (2) The Ocean Acidification group assessed the major carbon cycle perturbation and extinction events that took place throughout Earth's history, and the lessons to be learned for ongoing acidification (Hönisch *et al.*, 2012).

SOLAS members might also be interested in the work of the Ocean2k group, which is studying the ocean's hydrographic history over the last two millennia, as well as other groups which are currently starting up around dust and climate, and another on the ocean's overturning circulation and carbon cycle.

PAGES' Working Groups are open to colleagues with an interest and fitting expertise. This openness extends into the SOLAS community, which is welcome to join working groups, attend workshops, and in particular propose ideas for collaboration!

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Damian Arévalo-Martínez studied Marine Biology in Columbia and moved to Germany in 2009 to conduct his master studies. In 2012, Damian started his PhD at GEOMAR to investigate the distribution and sea-to-air fluxes of nitrous oxide in upwelling regions of the Atlantic and Pacific oceans.

Nitrous oxide in surface waters of the eastern tropical South Pacific

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Nitrous oxide (N_2O) is a potent greenhouse gas which has been increasing during the Anthropocene and which plays a key role in stratospheric ozone depletion (Denman *et al.*, 2007). The ocean accounts for up to 30% of the total N_2O source to the atmosphere (Bange, 2008), and yet vast areas remain uninvestigated by observational studies largely due to the coarse temporal and spatial resolution of the traditional sampling/measuring methods, which leads to considerable uncertainties in the oceanic N_2O emissions to the atmosphere (Nevison *et al.*, 1995).

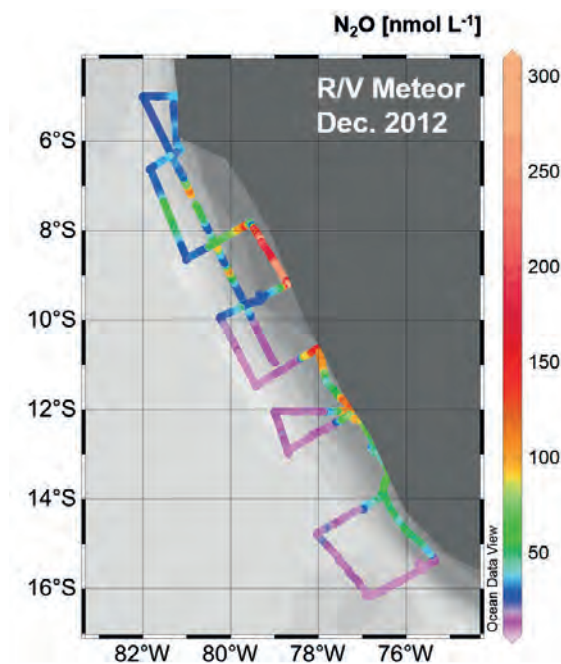
Since N_2O is mostly produced at low oxygen levels, those systems at the edge of suboxic to hypoxic conditions are of particular interest when it comes to investigate its source-sink dynamics. Eastern boundary upwelling systems are characterized by elevated primary production which, upon sinking, stimulates a high turnover of organic matter and thereby contributes to the formation and maintenance of oxygen minimum zones (OMZs, Paulmier and Ruiz-Pino, 2009). It has been recently suggested that horizontal expansion and shoaling of OMZs might lead to increased N_2O production which could, in turn, further enhance the climatic effect of N_2O (Codispoti, 2010).

Knowing that increased temporal and spatial coverage might improve our understanding of distribution and sea-to-air fluxes of N_2O , we conducted a detailed survey of the surface water concentrations of this gas in the upwelling area off Peru (Meteor Cruise M91, Dec. 2012). For this purpose, we used a novel approach based upon non-dispersive infrared detection coupled to the off-axis integrated cavity output spectroscopy (OA-ICOS) technique, which provides simultaneously,

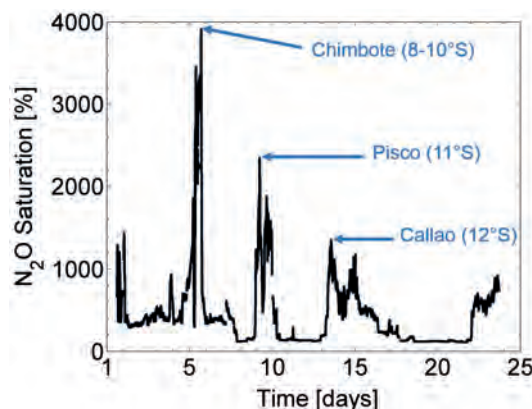
high resolution measurements of N_2O in seawater and in the atmosphere (Arévalo-Martínez *et al.*, 2013).

N_2O seawater concentration was highly variable, oscillating from close to equilibrium to extremely high values (8 nmol.L⁻¹ to 304 nmol.L⁻¹, respectively). Marked spatial differences were observed with meridional as well as cross-shore gradients in which the highest concentrations were located north of 12°S and east of 78°W (Fig. 1). Accordingly, surface waters off Peru featured mainly N_2O supersaturating conditions during the cruise, ranging between 109% and 3900% (mean 439%) and with increased values in the near-coastal area. Analysis of individual cross-shelf sections between 6°S and 16°S showed also the extent of the latitudinal differences on the concentration gradients, with a 60% enhancement in the area close to 8-12°S, suggesting this location as a main site of outgassing to the atmosphere wherein the N_2O anomalies ($\Delta N_2O = N_2O_{Osw} - N_2O_{Oair}$) were the highest.

These extreme concentrations are reported the first time for the upwelling off Peru and represent the highest ever recorded values of N_2O in surface waters (Law and Owens, 1990; Naqvi *et al.*, 2000; Bange *et al.*, 2001). We found that the observed N_2O distribution is consistent with the sea surface temperature (SST), and that it spatially coincides with the location of major upwelling cells off Peru (Zuta *et al.*, 1978, Fig. 2). The results suggest, however, that simple SST vs. gas concentration relationships are not enough to completely explain the N_2O patterns and therefore more work needs to be done in exploring the potential processes explaining these high values. Given the high variability in oxygen concentrations (not shown) and



< Figure 1: Surface concentration of N_2O during the *Meteor* cruise M91 in December 2012.



< Figure 2: N_2O saturation state of Peruvian coastal waters in December 2012. The highest values were obtained in locations characterized by strong upwelling events (blue arrows).

the physical setup, it is likely that combined nitrification and denitrification in the near surface favour elevated N_2O production which is then advected to the surface during upwelling.

Based on our observations we suggest that the Peruvian upwelling is a major hotspot of N_2O emissions to the atmosphere which so far has not been taken into account. Some of the current work includes the analysis of chemical, biological and physical data collected during the same campaign not only to provide sea-to-air flux estimates but also to elucidate potential biogeochemical pathways associated with the observed N_2O distribution.

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2013 Hutchinson Medal awarded to SOLAS scientists

The 2013 Hutchinson Medal was awarded by the international Institute of Chemical Engineers (IChemE) to Phil Williamson, Doug Wallace, Cliff Law, Phil Boyd, Yves Collos, Peter Croot, Ken Denman, Ulf Riebesell, Shigenobu Takeda, and Chris Vivian, for the article "Ocean fertilization: A review of effectiveness, environmental impacts and emerging governance" published in *Process Safety and Environmental Protection* in November 2012. The paper considered the effectiveness, risks and developing

governance around ocean fertilization and geoengineering, and arose from the 2010 Ocean Fertilization Scientific Summary for Policy Makers that was coordinated by SOLAS for the IOC of UNESCO.

The Institution of Chemical Engineers is the global organisation for professionals with experience or interests in chemical engineering and has 36000 members worldwide. The Hutchinson Medal, named after a former president of the Institute, is awarded annually for practical and

wide-ranging, philosophical or thought provoking published papers. The Institution commented "The paper is an extremely wide ranging, multi-author review of an often controversial topic, covering a large volume of relevant research and presenting it in a clear and concise fashion. It is an excellent example of chemical engineering insights complementing those of other disciplines to address a challenging topic". The ten authors are receiving their medals in separate presentations.



David Capelle completed his BSc in Geography at the University of Winnipeg, Canada in 2010. After working as a research assistant for the University of Manitoba on the CCGS Amundsen, he enrolled in a PhD program in Oceanography at the University of British Columbia, under the supervision of Dr. Philippe Tortell.

CH₄ and N₂O dynamics in a seasonally anoxic fjord

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Estuaries and coastal environments are important marine sources of the greenhouse gases CH₄ and N₂O to the atmosphere, but infrequent sampling may fail to capture seasonal variability, leading to inaccurate flux estimates (Bange, 2006). Our understanding of the processes that control cycling of CH₄ and N₂O are not well constrained. This limits our ability to predict how marine N₂O and CH₄ fluxes will respond to climate change (Naqvi *et al.*, 2010). For example, the ongoing decline of marine O₂ concentrations due to climate change may lead to increasing marine fluxes of N₂O to the atmosphere, which could further exacerbate warming (Naqvi *et al.*, 2010). Time series measurements can capture temporal variability, and provide insight into the processes responsible for this variability and their sensitivity to system perturbations (e.g. changes in O₂-availability).

We have measured monthly water column profiles of CH₄, N₂O, and a suite of other physical and biological parameters from Saanich Inlet on a monthly basis since 2006. The water column in Saanich Inlet contains a full-range of O₂ concentrations from oxic surface water to anoxic deep water, which

support a wide range of microbial pathways involving N₂O and CH₄. Furthermore, the anoxic deep basin waters are flushed with oxygenated, nutrient rich water in the fall and transition to anoxia over the following months. This provides a unique opportunity to study the effect of declining O₂ on N₂O and CH₄ cycling within a natural system.

Using this time-series we will describe the seasonal and interannual variability in water column CH₄ and N₂O in Saanich. We will also examine other physical and biological parameters in order to determine the organisms and processes responsible for CH₄ and N₂O cycling in this system and their response to changes in O₂.

There is significant seasonal variability in CH₄ and N₂O profiles, especially in the deep basin (Fig. 1). A CH₄ maximum (up to 1500nM) develops after the onset of anoxia in the deep basin, but this CH₄ appears to be consumed before diffusing into oxygenated waters above. Most of the deep basin CH₄ is consumed rapidly during renewal in late summer, presumably by microbial oxidation (facilitated by the sudden availability of O₂ in renewal

water). There is a secondary CH₄-maximum between 20-80m (~100 to 3,000% saturation), which is strongest during summer. The origin of this CH₄ is unknown, but may be due to lateral advection from sediments, production in micro-anoxic zones, and/or by cleavage of methylated compounds (e.g. DMSP). Deep basin N₂O concentrations are highest during renewal, likely due to production during nitrification and partial denitrification (Fig. 1). However, N₂O is consumed to <10% saturation once O₂ falls below ~10μM. N₂O concentrations near the surface (10m) are almost always supersaturated (90-200% saturation) and increase as hypoxic water shoals, implying that declining subsurface O₂ will lead to increased N₂O fluxes (Fig. 2).

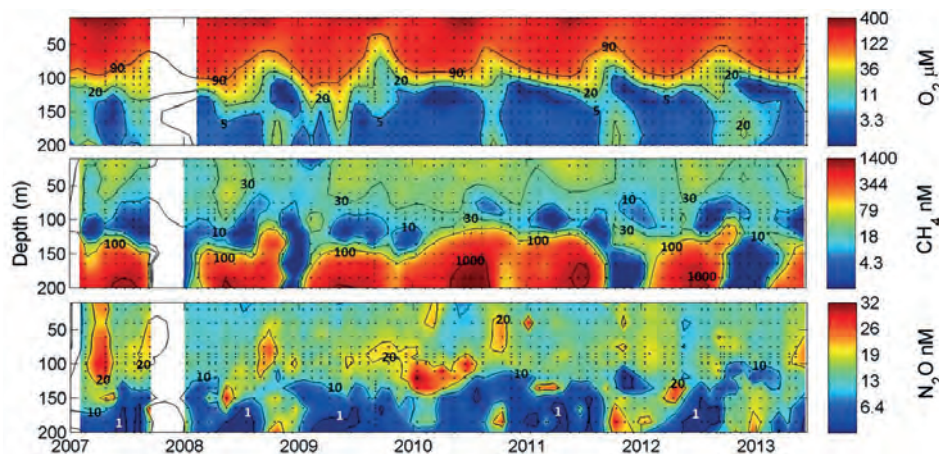
Future work will investigate rates of N₂O production from specific processes - such as archaeal and bacterial nitrification, and denitrification - under a range of in situ O₂ concentrations. We will also investigate relationships between CH₄, N₂O and the presence/abundance of functional genes responsible for the cycling of these gases in the system.

References

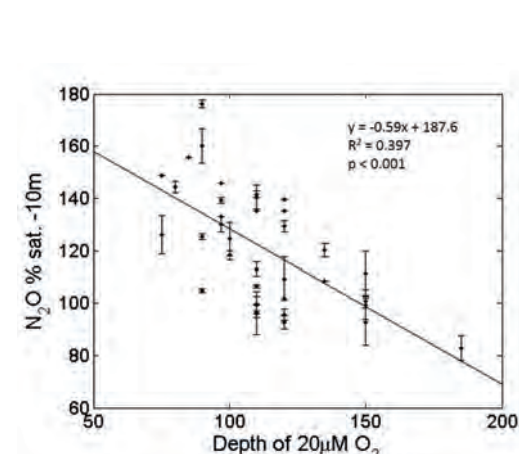
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Acknowledgements

Special thank you to the Captain and crew of the RV *Strickland*, Chris Payne, Lora Pachomova, and NSERC.



▲ Figure 1: Time series of water-column O₂, CH₄, and N₂O from a single station in Saanich Inlet, Canada. Each dot represents a discrete sample. Deep Basin flushing events are indicated by increases in O₂, and decreases in CH₄.



▲ Figure 2: Relationship between depth of 20μM O₂ boundary and N₂O concentration at 10m, which was the shallowest depth measured during this period.

SCOR Working Group 143 “Dissolved nitrous oxide (N₂O) and methane (CH₄) measurements: Working towards a global network of ocean time series measurements of N₂O and CH₄”

The global oceans represent a source of the greenhouse gases nitrous oxide (N₂O) and methane (CH₄) to the overlying atmosphere. Recent years have witnessed an increased understanding of the biogeochemical pathways and microorganisms responsible for the production of N₂O and CH₄, together with technological improvements for quantifying their concentrations and isotopic composition in seawater. Despite these advances in our knowledge and analytical capabilities, fundamental questions remain concerning these trace gas species in seawater including how do concentrations vary over short and long timescales?

To help improve the measurements of N₂O and CH₄ in the marine environment, the SCOR Working Group 143 was formed with the overarching title “Dissolved N₂O and CH₄ measurements: Working towards a global

network of ocean time series measurements of N₂O and CH₄”. The Working Group was initiated in December 2013 and will be operative until December 2017. One of the foremost objectives of the Working Group is to conduct an international intercalibration exercise for dissolved N₂O and CH₄. This will help determine the compatibility of the N₂O and CH₄ measurements conducted by independent oceanographic laboratories around the world. Ultimately any identified improvements will be applied to the measurements and reporting procedures to ensure the database of N₂O and CH₄ concentrations in the global oceans is robust and sound. The Working Group is currently halfway through its first intercalibration exercise analyzing seawater samples collected from the Hawaii Ocean Time-series (HOT) program long-term monitoring Station ALOHA in the North Pacific. Samples were collected at different

locations in the water-column to ensure a range of N₂O and CH₄ concentrations would be analyzed. We are currently compiling the datasets from the participating laboratories and have already identified some improvements and recommendations. A follow-up intercalibration is currently scheduled for the end of 2014 when the evidence of our efforts to improve and standardize analytical and reporting procedures should be apparent.

The next face-to-face meeting for the SCOR Working Group 143 members will coincide with the SOLAS Open Science Conference in Kiel, September 2015. For further information on the Working Group's activities, please contact the co-chairs.

Hermann Bange, co-Chair, GEOMAR, Kiel, Germany (hbange@geomar.de)
Sam Wilson, co-Chair, University of Hawaii, USA (stwilson@hawaii.edu)



MEMENTO - the Marine Methane and Nitrous Oxide Database is now online

Methane and nitrous oxide are powerful greenhouse gases in the earth's atmosphere, with the ocean as a significant source for both of these gases. Methane and nitrous oxide are naturally produced in the ocean, but their distribution varies strongly over space and time.

The collection of marine methane and nitrous oxide data into a global dataset is a useful tool to identify regions with strong emissions, to assess their spatial and temporal variability and long-term trends, and to quantify the oceanic methane and nitrous oxide emissions more precisely. It is also a powerful resource for the validation of biogeochemical models.

MEMENTO aims to compile available marine methane and nitrous oxide measurements into a global database with open access to the scientific community. Related atmospheric data are additionally archived in the database. Data included in the MEMENTO database undergo a strict quality control to minimize the abundance of incomplete and erroneous datasets. We are continuously updating the database with new datasets to keep it a living tool for scientists to work with marine N₂O and CH₄ data. Therefore, your contribution of new methane or nitrous oxide datasets to MEMENTO would be highly welcome.

The database is now online accessible from the MEMENTO website. Please contact us if you are interested in accessing the data portal or contributing your data. MEMENTO is supported by SOPRAN (sopran.pangaea.de) and the Kiel Data Management Team at GEOMAR (portal.geomar.de/home).

Annette Kock, MEMENTO Coordinator, GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany (akock@geomar.de)

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Framework for Ocean Observing – Implementation for Biogeochemistry

Published in 2012, an Integrated Framework for Sustained Ocean Observing (FOO) inspired a complete reform of governance of the Global Ocean Observing System (GOOS). The FOO is based on systems thinking, organizing the observing system on (i) requirements based on societal issues, driving (ii) processes (observations) which output (iii) data and products that then feed back to scientific or societal benefit, the source of the requirements. The fitness for purpose of the system is judged by the success of observing system outputs, which satisfy requirements.

The FOO structure is such that the three Ocean Observing System Panels (Physics – led by the Ocean Observing Panel for Climate, Carbon/Biogeochemistry – led by IOCCP and Biology/Ecology – in final stage of being formed) work together on the ocean observing strategy focused around the Essential Ocean Variables (EOVs).

Over the past year or so the IOCCP sought advice from programmatic, institutional and individual experts to:

- identify any major scientific and societal challenges that require sustained observations of ocean biogeochemistry variables;
- identify candidate biogeochemical EOVs;
- define the state of readiness of set requirements, existing observing system elements and existing data streams for all proposed EOVs on the various frequency and resolution levels.

The town hall meeting during the OSM'14 in Honolulu attended by over 100 colleagues across disciplines gave IOCCP an opportunity to provide a wider oceanographic community with a short status update on above tasks but most importantly IOCCP sought community's opinion on a biogeochemical EOVs proposal drafted over the past 3-4 months. Several specific questions were addressed and noted for further consideration and lively discussion moderated by Toste Tanhua clearly showed that the community is very interested in this topic. Audience was invited to consult a draft EOVs Report and 9 Specification Sheets, one for each proposed EOVs, posted on IOCCP's website (<http://www.ioccp.org/foo>) and provide their input regarding any aspect of the exercise so that the FOO implementation becomes a truly open and transparent process through community consultations.

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Maciej Telszewski, IOCCP Director, Polish Academy of Sciences, Sopot, Poland (m.telszewski@ioccp.org)

<http://www.ioccp.org/>



Ernie Lewis, a former oceanographer who investigated the carbon system in the oceans and wrote with Doug Wallace the program CO₂SYS, is an atmospheric scientist and together with Steve Schwartz author of the book *Sea Salt Aerosol Production: Mechanisms, Methods, Measurements, and Models*. He was principal investigator of the recent MAGIC campaign.

MAGIC studies clouds, aerosols, radiation, and fluxes in the Eastern North Pacific

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The MAGIC field campaign, supported and operated by the Atmospheric Radiation Measurement (ARM) Climate Research Facility of the US Department of Energy, was conducted between September, 2012 and October, 2013 on board the 272 m Horizon Lines cargo container ship *Spirit* as it plied its regular route between Los Angeles and Honolulu. This route transects cloud regimes that exert large influences on Earth's climate and are of great interest to climate modelers: the clouds are primarily stratocumulus near the coast of California and transition to trade-wind cumulus near Hawaii. Stratocumulus clouds, with large areal coverage and high albedo, reflect much of the incoming shortwave (solar) radiation back to space; additionally, as they are present in the boundary layer, they emit longwave radiation at temperatures near those of the surface. Cumulus clouds, by

contrast, exhibit much lower areal coverage, and thus much of the incoming solar radiation is absorbed by the ocean, which has much lower albedo. The transition between these cloud regimes is poorly understood, and this lack of understanding, which is reflected in large differences in global climate models (Teixeira *et al.*, 2011), is one of the largest sources of uncertainty in these models.

During MAGIC, three twenty-foot cargo containers containing instruments and computers that comprise the Second ARM Mobile Facility, AMF2, were installed on the *Spirit*. Three radars (a W-band, a Ka-band, and a radar wind profiler), two lidars, two microwave radiometers, a ceilometer, a total sky imager, and other instruments were used to measure properties of clouds and precipitation.



^Λ Figure 1: Radiosonde launch on the Horizon Spirit during MAGIC. Launches were challenging even under the best of conditions.

The W-band radar was mounted on a stable table so that it always remained zenith-pointing, allowing use of Doppler to retrieve hydrometeor velocities and thus sizes. A suite of instruments measured direct and diffuse incoming radiation, both spectrally and broadband. Other instrumentation measured key aerosol properties such as concentrations of condensation nuclei (CN), concentrations of cloud condensation nuclei (CCN) at various relative humidities, size distributions, light scattering and absorption at multiple wavelengths, and hygroscopicity. Additionally, aerosol samples were collected for later analysis of bulk and individual particle composition, individual particle morphology, and ice nucleating ability. Basic meteorological quantities and sea surface temperature were measured, allowing computation of surface energy fluxes.

Two technicians were on board during the entire deployment, and often one or more scientist observers rode the ship for a round trip. Radiosondes were launched with weather balloons every six hours, and every three hours for one round trip from July 6 to July 18, 2013, to provide information on atmospheric vertical structure. More than 500 successful radiosonde launches were completed. This is all the more remarkable as the *Spirit* is a working vessel and could not stop and orient for optimal launch conditions, requiring great persistence and ingenuity of the technicians. Nonetheless, the success rate was near 80%, and successful launches were made at relative wind speeds of more than 20 m/s!

In total, MAGIC consisted of nearly twenty round trips and 200 days at sea, yielding an unprecedented data set over a region that is vastly undersampled. The data are being ingested and deposited in the ARM data archive (www.archive.arm.gov) where they will be available to all.

The First MAGIC Science Workshop was convened May 5-7, 2014 at Brookhaven National Laboratory on Long Island, NY to present the status of MAGIC activities, allow investigators to present results or preliminary results, determine what areas require attention in order to move forward with model intercomparisons or other analyses, establish networking and collaborative possibilities, and discuss future MAGIC activities. More information on MAGIC can be found at <http://www.arm.gov/sites/amf/mag/> and <http://www.bnl.gov/envsci/ARM/MAGIC/>.

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Acknowledgements

We would like to thank Horizon Lines and the Captain and crew of the Horizon Spirit for their support for MAGIC.



Figure 2: Bridge and mast of Horizon Spirit.

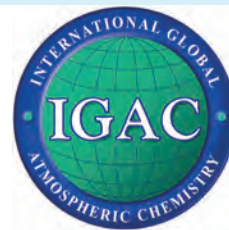


SOLAS Scientific Steering Committee News

We would like to welcome Alfonso Saiz-Lopez as a newly appointed member to the Scientific Steering Committee (SSC) of SOLAS as of January 2014.

Alfonso Saiz-Lopez completed his PhD in 2005 in Atmospheric Physical-Chemistry at the University of East Anglia, Norwich, UK. He is currently the group leader of the Atmospheric Chemistry and Climate group within CSIC's Institute of Physical Chemistry Rocasolano (IQFR) in Madrid, Spain.

At the same time we warmly thank our former SSC members Jaqueline Stefels (Netherlands), Diego Gaiero (Argentina) and Roland von Glasow (UK) who rotated-off in December 2013 for their contributions towards SOLAS.



The International Global Atmospheric Chemistry (IGAC) Project

IGAC's mission is to coordinate and foster atmospheric chemistry research towards a sustainable world by addressing scientific questions on emissions, atmospheric processes and atmospheric composition, as well as how these impact climate, human health and ecosystems.

An important component for IGAC in addressing global sustainability is working with other IGBP Core Projects such as SOLAS on crosscutting issues. Currently IGAC and SOLAS co-sponsor two activities, Ocean-Air-Sea Ice-Snowpack (OASIS), which includes the sub-activity Air-Ice Chemical Interactions (AICI), and Halogens in the Troposphere (HitT). IGAC and SOLAS continue to seek opportunities to collaborate through holding joint workshops and having joint sessions at scientific conferences.

IGAC and SOLAS also share a strong focus on supporting fundamental scientific research, as can be seen in a recent Atmospheric Environment article by IGAC and iCACGP on the importance of fundamental atmospheric chemistry research. IGAC further emphasizes the inclusion of fundamental research in its scientific activities and science conferences (Abbatt, 2014).

As IGBP comes to a close in 2015 IGAC will become a core project of Future Earth. IGAC views Future Earth as a genuine opportunity for the international atmospheric chemistry community to integrate strong laboratory, field and modeling studies on emissions, atmospheric processes and atmospheric composition with the larger Earth system research community. Through Future Earth IGAC can promote international collaborations and co-design the scientific knowledge required to respond effectively to the challenges and opportunities of global environmental change and sustainability.

Megan L. Melamed, IGAC Executive Officer (megan@igacproject.org)

Jeff Jennings, IGAC Project Officer (jeff@igacproject.org)

University of Colorado, USA

www.igacproject.org



Brian Butterworth is a doctoral student at the Atmospheric Sciences Research Center at SUNY Albany working with Dr. Scott Miller. He is researching the relationship between wind speed and air-sea gas exchange in the Southern Ocean.

Long-term Southern Ocean air-sea CO₂ flux by eddy covariance from an ice breaker

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In December 2012 we installed an eddy covariance system on the bow mast of the Nathaniel B. Palmer icebreaker to make direct measurements of carbon dioxide flux over the ocean. These data are being used in conjunction with dpCO₂ data obtained from Taro Takahashi at LDEO (underway system on the Palmer) to calculate the gas transfer velocity. Previous research on the wind speed dependence of the gas transfer velocity (k vs U) has yielded a variety of functional forms, ranging from piecewise linear (Liss and Merlivat, 1986), to quadratic (Sweeney *et al.*, 2007), to cubic (Wanninkhof and McGillis, 1999). At low wind speeds there is good agreement between the different parameterizations of transfer velocities, but the range widens at higher wind speeds (>15 m/s). By making measurements over a longer term than a typical research cruise, we hope to collect enough data to better constrain the gas transfer velocity. So far the system has been deployed on seven cruises, mostly in the Southern Ocean (Fig. 1).

The system was designed to run mostly unattended over the course of 1+ year. Automated daily emails send diagnostic and summary data that we use to monitor performance. Design considerations for the harsh Southern Ocean environment include heated inlet tubing and a heated sonic anemometer to reduce data loss due to icing and riming. We also deployed a method to detect and expel liquid water drawn into the inlet tube. Overall, these efforts have helped to keep things running; however, at times the conditions in the Southern Ocean were too severe, resulting in extended outages and requiring visits to the ship for repairs (Fig. 2).

We have obtained data under a variety of different environments with a wide range of wind and sea states. A sizeable percentage of the time the ship was deployed in regions with varying degrees of sea ice. To study the effect sea ice has on gas exchange we are working to adapt a technique used to measure whitecap fraction (Callaghan and White, 2009) to determine ice cover fraction from sea surface images. The flux system is scheduled to be removed from R/V *B. Palmer* in spring 2014.

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Acknowledgements

This work was funded by NSF.

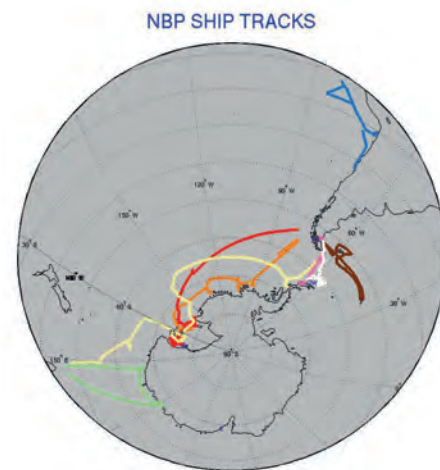


Figure 1: Ship tracks completed by the *Nathaniel B. Palmer* with our system deployed.



Figure 2: Despite the extra considerations for the Southern Ocean this ice storm took our system down for several months.



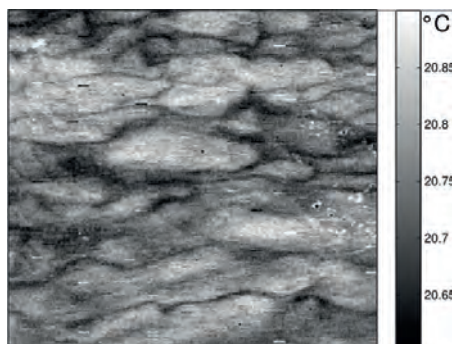
Jana Schnieders is a PhD student at the University of Heidelberg, Germany, from where she also received her Diploma in Physics. Her research focuses on turbulence near the air-water interface, image processing on infrared images, and air-sea interactions. Jana won the oral presentation award at the SOLAS Summer School 2013.

Small scale turbulence at the air-sea interface and the impact on transfer processes

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The exchange of gases through the air-sea interface strongly depends on surface processes, such as wind stress, waves and turbulence that form a complex system and cause highly variable transfer rates (Garbe *et al.*, 2014). The key coupling processes dominate at scales far too small to be resolved in a large scale simulation of weather prediction or ocean currents. Thus, CO₂ fluxes show stronger variability on small scales than climatology can possibly predict (Wanninkhof *et al.*, 2011). Gas exchange is closely linked to air-sea momentum exchange and the intensity of near surface turbulence (McKenna and McGillis, 2004). Near surface turbulence is a main driver of surface divergence which has been shown to be closely correlated to surface fluxes. Small scale surface turbulence is ubiquitous on all open water bodies but size and intensity strongly depend on environmental conditions. Directly linking small scale surface turbulence to transfer processes may ultimately lead to a more accurate, physically based parameterization of transfer rates.

Due to the cool skin of the ocean, heat can be used as a tracer to detect areas of surface convergence and thus gather information about size and intensity of a turbulent process.

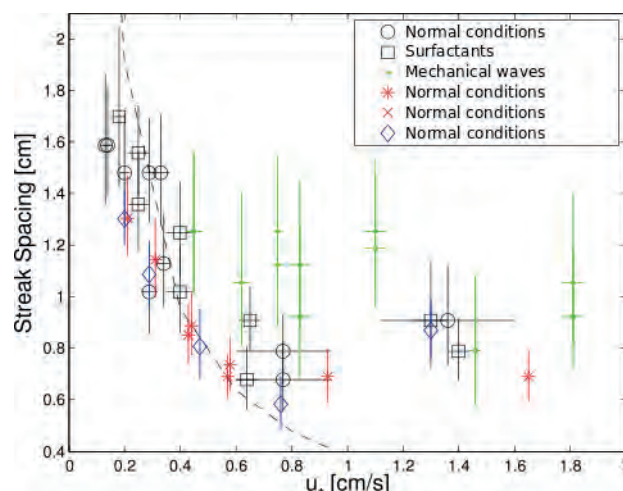


▲ Figure 1: Infrared image of the water surface. Footprint: 30 x 30 cm².

Therefore, we use infrared imagery to visualize near surface aqueous turbulence. Clearly visible cold (dark) streaks and warm plumes form a characteristic heat pattern that exhibits turbulent structures of various sizes and changes with increasing wind stress and wave field. We developed an image processing based approach to analyze the footprints of near surface aqueous turbulence with which the scales of turbulent structures can be determined very accurately (Schnieders *et al.*, 2013).

Included in the analysis were experiments in various wind-wave tanks under different conditions such as mechanical and wind-driven waves or surfactants that efficiently damped capillary waves.

In spite of entirely different boundary conditions, the spacing of small scale turbulent cells near the air-water interface shows consistent behavior in a range of laboratory facilities when expressed as a function of water sided friction velocity, u^* . The scales systematically decrease until a point of saturation at $u^* = 0.7$ cm/s. Results suggest a saturation in the tangential stress, anticipating that similar behavior will be observed in the open ocean.



◀ Figure 2: Result of the spatial analysis. The spacing of cold surface streaks is plotted against the water sided friction velocity u^* . Measurements are included from various facilities and different surface conditions.

Larger scale structures are visible in images of a clear water surface and a comparison with studies of small-scale Langmuir circulations and Langmuir numbers shows that thermal footprints in infrared images are consistent with Langmuir circulations and depend strongly on wind wave conditions.

Through the high temporal and spatial resolution of these types of measurements, the influence of different interfacial processes can be analyzed e.g. the impact of eddy sizes on the total flux. Linking transport models with our thermographic measurements, transfer velocities can be computed. One important future goal is to quantify the effect of small scale turbulence and relate it to gas transfer. This will allow us to determine the impact of turbulent scales on exchange rates and relate them to the generating processes. Based on this knowledge, future, more accurate parameterizations will be feasible.

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North Pacific Marine Science Organization

The North Pacific Marine Science Organization (PICES) provides an international forum for scientists from North America and Asia to address long-standing and emerging scientific issues of the North Pacific Ocean. Examples of the former are the influence of climate change and fishing intensity on the shelf sea ecosystems that border the North Pacific. The work of PICES is accomplished by various expert groups (EGs) that usually have clearly defined terms of reference and timelines and are coordinated by one or more of the standing or technical committees of PICES. As reported last year, an EG on Carbon and Climate developed an integrated, intercalibrated, quality controlled database of carbonate system observations in the North Pacific, which is now publicly available (<http://cdiac.ornl.gov/oceans/PACIFICA/ndp092.html>).

PICES held a successful Open Science Meeting (OSM) for its integrative scientific program FUTURE (Forecasting and Understanding Trends, Uncertainty, and Responses of North Pacific Marine Ecosystems) from April 15-18, 2014 on the Kohala Coast, Hawaii. Several new EGs have been established to address the core objectives of FUTURE (see http://www.pices.int/members/scientific_programs/FUTURE/FUTURE-main.aspx). FUTURE improved understanding of processes, increased forecasting ability, and to increased awareness of the status of North Pacific ecosystems under threat from numerous stressors ranging from global (e.g., climate change) to local (e.g., pollution, coastal development). New to this science program is an increased emphasis on developing science products that can be delivered to receptive audiences in a policy relevant, but not policy prescriptive manner.

PICES has scientific (and business) meetings annually in October. The 2013 Annual Meeting in Nanaimo, Canada, included a joint SOLAS-PICES Topic Session on "The changing carbon cycle of North Pacific continental shelves and marginal seas". The session, spread over two days, was well attended, with enthusiastic participation. The 2014 PICES Annual Meeting (PICES-2014) themed "Toward a better understanding of the North Pacific: Reflecting on the past and steering for the future" will be held October 16-24, in Yeosu, Republic of Korea. PICES traditionally has several 1/2- to 2-day workshops immediately prior to the main meeting. SOLAS is co-sponsoring a 1/2-day workshop titled, "SOLAS into the Future: Designing the next phase of the Surface Ocean-Lower Atmosphere Study within the context of the Future Earth Program", which will be on the afternoon of October 17.

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David Nicholson currently is an Assistant Scientist at the Woods Hole Oceanographic Institution and received his PhD from the University of Washington in 2009. His research focuses on upper ocean biogeochemistry and dissolved gas cycling using biogeochemical models, autonomous platforms and mass spectrometry.

The triple oxygen isotope tracer of primary productivity in a dynamic ocean model

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Accurate assessment of the metabolic rates of ecosystems in the upper ocean is a central challenge to understanding biogeochemical fluxes and their controls in the marine environment. The triple oxygen isotope (TOI) tracer has become, over the last ~15 years, one of the most commonly applied methods for assessing primary productivity in the ocean (Juranek and Quay, 2013; Luz and Barkan, 2000). The method is based on the natural isotopic composition of O₂ (¹⁶O/¹⁷O/¹⁸O) and has a number of advantages of traditional incubation-based productivity measures. Because the method is based on measuring a natural, in situ, signal it is not subject to many of the sampling artifacts and challenges associated with incubation-based methods (such as ¹⁴C). The ability to collect large numbers of samples, e.g. filled from underway seawater systems, opens the possibility of a greatly enhanced understanding of the spatiotemporal variability of mixed layer primary productivity. However, the tracer system is subject to the dynamics of advection, mixing and air-sea exchange. Physical transport of the TOI tracers and non-steady-state conditions can complicate the interpretation of TOI observations. Such processes are not taken into account by the steady-state approach that generally is used to calculate primary production from TOI observations.

To better understand the behavior of the TOI system in a dynamic ocean we added the tracer system to the Community Earth System Model (Moore *et al.*, 2013). Based on our model results, the steady-state approach significantly overestimates mixed layer gross oxygen production (GOP) (29%, globally averaged). Vertical entrainment/mixing and time rate of change of tracer were the two largest sources of bias in the steady-state approach. Entrainment/mixing resulted in the largest overestimation in mid latitudes and during summer and fall and almost never caused an underestimation of GOP. The tracer time-rate of change bias resulted both

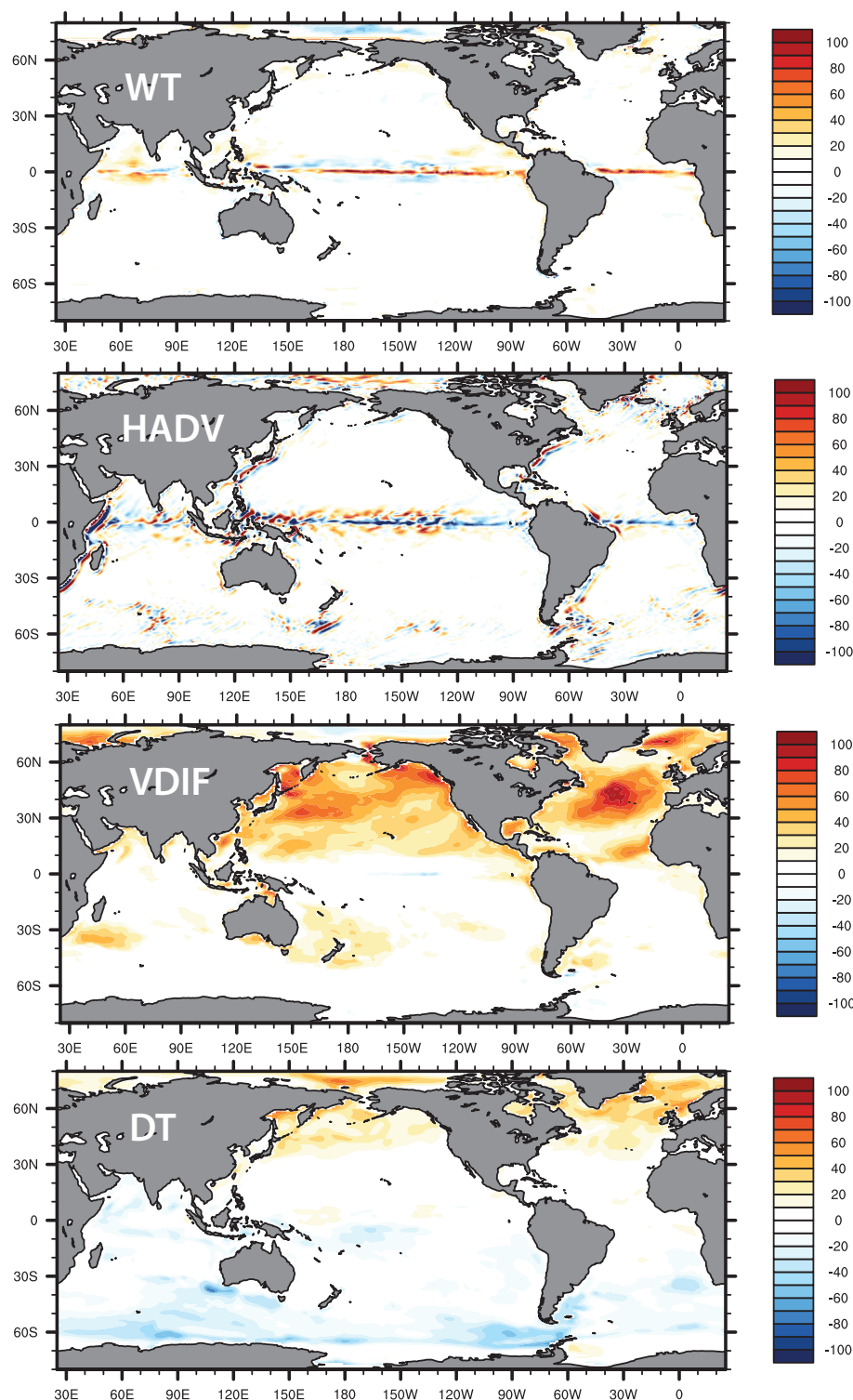
in underestimation of GOP (e.g., during spring blooms at high latitudes) and overestimation (e.g., during the summer following a bloom). Seasonally, bias was highest in the fall (Sept-Oct-Nov in the Northern Hemisphere, Mar-Apr-May in the Southern), overestimating GOP by 62%, globally averaged, primarily due to seasonal mixed layer entrainment. The steady-state method was most accurate in equatorial and low latitude regions where it estimated GOP to within ±10%.

Additionally, in our study we derive a field applicable correction term for entrainment and mixing that, base on synthetically sampling our model, captures 86% of the methodological bias. The correction requires only a single additional measurement from below the base of the mixed layer and mixed layer depth history (e.g. from Argo float data). As the application of TOI becomes increasingly widespread, studies such as this allow for a more nuanced interpretation of tracer data and will improved estimation of primary productivity and associated uncertainties.

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October

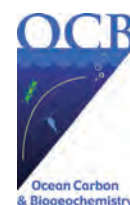


▲ Figure: Bias introduced by the steady state approach is shown for October due to the processes of vertical advection (WT), horizontal advection (HADV) vertical mixing/entrainment (VDIF) and time rate of change (DT) in $\text{mmol O}_2 \cdot \text{m}^{-2} \cdot \text{d}^{-1}$. The influence of horizontal diffusion was much smaller than other terms and is not shown. Red/Orange areas correspond to where the steady-state approach overestimates, while blue colors are areas of GOPSS underestimation.

Acknowledgements

We acknowledge support from Center for Microbial Oceanography Research and Education (CMORE) (NSF EF-0424599) and NOAA Climate Program Office (NA 100AR4310093).

We also would like to thank those who created, shared and published original TOI and ancillary data.



Ocean Carbon & Biogeochemistry (OCB) Program Update

Upcoming Activities

- 21-24 July 2014: 2014 OCB Summer Workshop (Woods Hole; registration deadline: June 15) - Plenary sessions to include 1) The Coupled North Atlantic-Arctic System: Processes and Dynamics, 2) The Biological Pump: Transport Mechanisms and Mesopelagic Processes, 3) Advances in our Understanding of the Role of Sea Ice in the Global Carbon Cycle
- 4-8 Aug 2014: Training workshop on pH sensor best practices (Scripps Institution of Oceanography, La Jolla)
- 19-21 Aug 2014: Coastal CARbon Synthesis (CCARS) Community Workshop (Woods Hole; registration deadline: May 15)

- New OCB Working Group "Carbon flux estimates at HOT, BATS, and other time-series" (Lead: K. Johnson, MBARI) (membership being finalized)

Recent Products

Benway, H.M., Coble, P.G. (Editors), 2014. Report of The U.S. Gulf of Mexico Carbon Cycle Synthesis Workshop, March 27-28, 2013, Ocean Carbon and Biogeochemistry Program and North American Carbon Program, 67 pp.

Benway, H.M., Doney, S.C. (2014). Scientific outcomes and future challenges of the Ocean Carbon and Biogeochemistry Program. *Oceanography* 27(1):106-107.

Benway, H.M., Doney, S.C. (2013). Addressing biogeochemical knowledge gaps. *International Innovation (North America, June 2013)*, 12-14.

Benway, H.M., M. Telszewski, and L. Lorenzoni (2013). Improving Intercomparability of Marine Biogeochemical Time Series, *Eos Trans. AGU* 94(17), 160.

Church, M.J., M.W. Lomas, F. Muller-Karger (2013). Sea change: Charting the course for biogeochemical ocean time-series research in a new millennium. *Deep-Sea Research Part II: Topical Studies in Oceanography* 93, 2-15 (Report from OCB Scoping Workshop on biogeochemical ocean time-series).

Cooley, S.R. et al. 20 Facts about Ocean Acidification (2013)

Lorenzoni, L., Benway, H.M. (Editors), 2013. Report of Global intercomparability in a changing ocean: An international time-series methods workshop, Nov 28-30, 2012, OCB Program and IOCCP, 61 pp.

Heather Benway, OCB Executive Officer, Woods Hole Oceanographic Institution, Woods Hole, USA (hbenway@whoi.edu)

www.us-ocb.org



Gauthier Carnat obtained his MSc in Physical Geography at the Université Libre de Bruxelles, Belgium. He is now a PhD candidate at the University of Manitoba, Canada. His research interests focus on the physical and biogeochemical controls on the cycling of carbon dioxide and dimethylsulfide in sea ice.

Linking sea ice growth mechanisms with dimethylsulfide cycling in sea ice

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Sea ice is known to produce significant concentrations of the climate-relevant trace gas dimethylsulfide (DMS) and of its biogenic precursor, the algal metabolite dimethylsulfonylpropionate (DMSP) (Levasseur, 2013). These high concentrations have been explained by the important biomass of sympagic algal communities and to the strong stress factors (e.g. extremely low temperatures and high salinities) these communities are exposed to (Trevena and Jones, 2006).

As reported for other biogenic compounds, sea ice growth mechanisms could strongly influence the DMS cycling in sea ice. Of particular interest is the influence of platelet ice formation in Antarctic coastal waters. Platelet ice typically forms through unrestrained frazil ice nucleation in supercooled ice shelf waters. Platelet crystals either grow at depth in the ocean and accumulate at the bottom of an existing ice cover, or directly grow at the freezing interface of this ice cover (Holland and Jenkins, 1999).

We hypothesized that platelet ice could regionally drive the DMS cycling in sea ice via two different processes. (1) The incorporation of micro-organisms during platelet ice growth or accumulation could drastically change the biomass and taxonomy of sympagic algal communities (DMSP production is strongly species specific). (2) Through its lattice of randomly oriented crystals platelet ice could modify the connectivity of brine inclusions and hence the permeability of the ice cover. This could in turn modify the environmental stress on the algal cells (e.g. salinity) and the vertical mobility of DMS,P within the brine network.

In the framework of the SCOR working group 140 (Biogeochemical Exchange Processes at the Sea-Ice Interfaces, BEPSII), we investigated the influence of platelet ice on the sea ice DMS cycling at Cape Evans in the McMurdo Sound (YROSIAE Study, Carnat *et al.*, 2014) during the spring-summer and winter-spring transitions of 2011 and 2012.

We found a very good correspondence between the depth of occurrence of platelet crystals (see thin section pictures in Fig panel A) in the fast ice cover and the development of local DMS and DMSP maxima in interior ice (Fig panel A). The local maxima also corresponded to the depth where dinoflagellates, strong DMSP producers, dominated over diatoms, low DMSP producers (Fig panel B), which supported our first hypothesis, and to the depth of a local increase in bulk ice salinity, which supported our second hypothesis.

In conclusion, our work provided the first evidence of a link between sea ice growth mechanisms and the DMS cycling in sea ice. This link is crucial if we want to understand and to model the vertical, regional, and seasonal variability of DMS and DMSP concentrations in coastal Antarctic sea ice.

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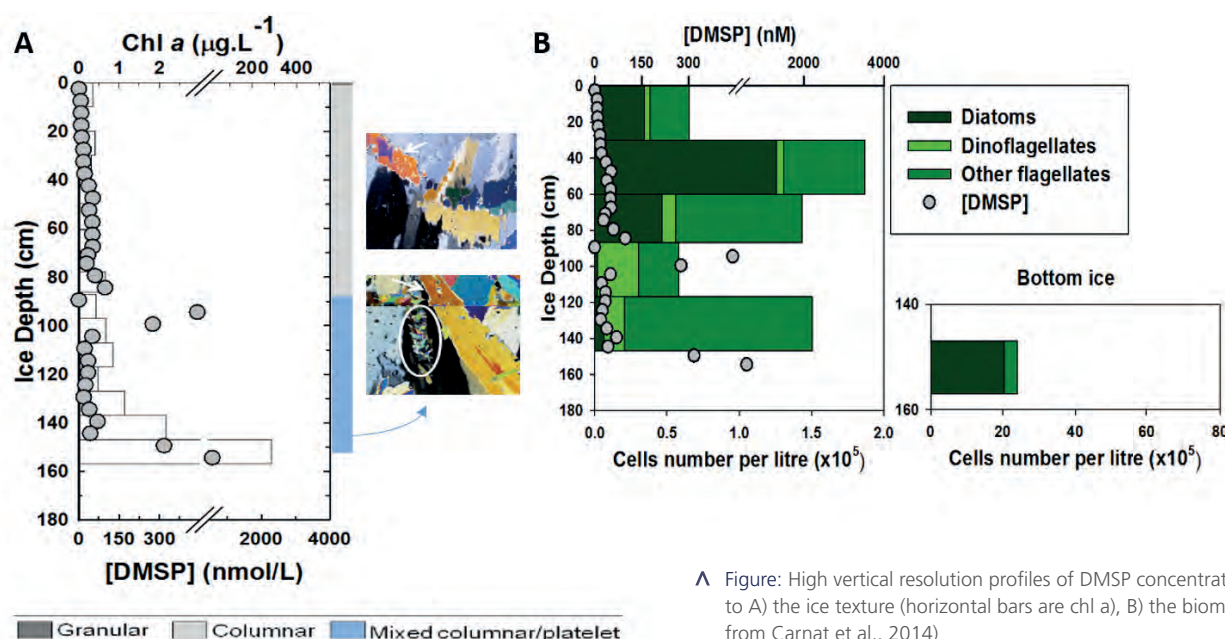


Figure: High vertical resolution profiles of DMSP concentrations in sea ice compared to A) the ice texture (horizontal bars are chl a), B) the biomass composition (adapted from Carnat *et al.*, 2014)



François Fripiat is a postdoctoral fellow (Research Foundation – Flanders), affiliated with the department of Analytical, Environmental, and Geo-Chemistry at Vrije Universiteit Brussel (Brussels, Belgium). His current research focuses on nutrients biogeochemical cycling in the polar oceans, including sea ice, with an emphasis on N- and Si-isotopes.

Sea ice nutrients and associated isotopes cycling

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Sea ice is permeated by a network of brine, hosting a sympagic community both taxonomically diverse and metabolically active (Thomas and Dieckmann, 2010). These communities are playing a significant role, but still poorly understood, on the biogeochemical dynamics of the polar oceans (Vancoppenolle *et al.*, 2013). My research consists in looking at nitrogen (N) and silicon (Si) isotopic compositions of dissolved and particulate pools ($\delta^{15}\text{N}$ and $\delta^{30}\text{Si}$; Fripiat *et al.*, 2013, 2014). These tracers provide an integrative picture of nutrient cycling, from which physical, chemical, and biochemical fluxes can be inferred.

Our findings on N isotopic composition in Antarctic pack ice suggest that: when sea ice is growing in winter (Fig.,a), brine convection is observed only at the interface with the ocean where sea ice is permeable. At the surface and in interior ice, the porosity is considered too low to allow convection. These brine structures are

closed, with expected little or no biological activity. At the beginning of spring, both primary production and porosity increase, allowing nitrate assimilation into immobile organic matter and also brine convection with seawater through the full thickness of the ice, thereby accumulating N within the sea ice (Fig.,b). Due to a net transfer of N from particulate to dissolved organic N, the latter is suggested to be the main end-product of primary production. With the subsequent development of an efficient microbial foodweb community, including nitrifiers, (Fig.,c), N is mainly regenerated.

By solving the mass and isotopic balances, we show that macro-nutrients (e.g., nitrate and silicic acid) are mainly regenerated within sea ice, instead of being supplied by seawater: with nitrification contributing up to 70% of nitrate assimilation, and biogenic silica dissolution supporting up to 90% of biogenic silica production. If correct, these findings have significant implications for the

understanding and parameterization of the sea ice biogeochemical cycles. Current sea ice biogeochemical models typically assume little or no nutrient regeneration. Further studies are required to confirm or reject this hypothesis.

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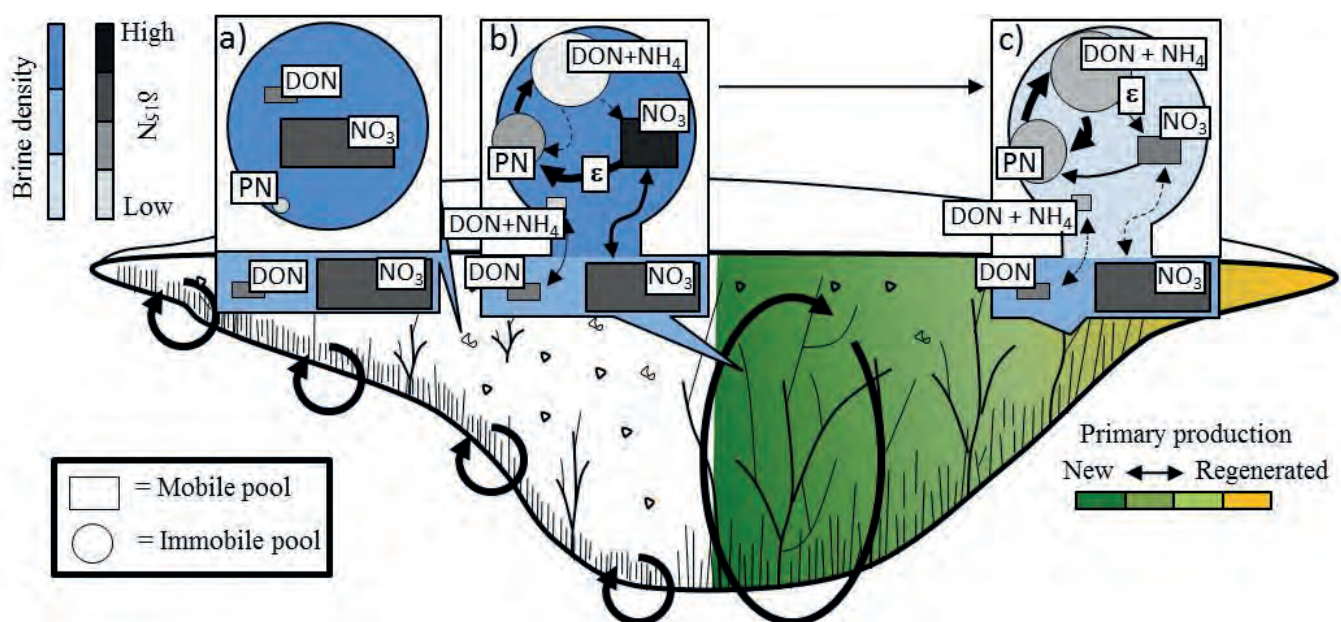


Figure: Conceptual scheme showing sea ice growth and decay and the associated nitrogen biogeochemical dynamics. The large circles illustrate brine inclusions that are connected (b, c) or disconnected (a) from the seawater below. The relative density of the brine and seawater is given by the blue color bar and the new versus regenerated primary production by the green-yellow bar. The N pools are indicated within brine inclusions, with their grayscale shade increasing with their $\delta^{15}\text{N}$. Adapted from Fripiat *et al.* (2014).



Célia Julia Sapart is a Postdoctoral researcher at the Laboratoire de Glaciologie of the Université Libre de Bruxelles, Belgium. Her research focuses on the better understanding of the methane budget using isotope analysis on different types of substrates such as air, ice, water and sediment.

What is the origin of methane in sea-ice?

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Methane (CH_4) plays an important role in the Earth's climate system. The atmospheric CH_4 concentration has increased in concert with industrialization. In the mid 80's the CH_4 growth rate started decreasing, reached almost zero in 2000, before increasing again from 2007. The underlying changes in sources and sinks that cause these variations are not yet well understood (Dlugokencky *et al.*, 2011). To predict future climate, it is essential to quantify the processes controlling the CH_4 budget, especially in the Arctic, which has large CH_4 reservoirs and is highly vulnerable to climate change. Recently, an unexpected CH_4 excess was reported above Arctic sea-ice (Kort *et al.*, 2012), pointing to sea-ice as a possible methane source or reservoir. However, the processes leading to CH_4 production in or near sea-ice has not yet been identified.

The isotopic composition of CH_4 depends on the isotopic composition of the substrates involved in its formation, and the isotopic fractionation associated with its formation/removal. Therefore, CH_4 isotope ($\delta^{13}\text{C}$ and δD) analysis, together with concentration measurements of CH_4 and its potential substrates (e.g. CO_2 , DMSP) on sea-ice samples allow determining the possible pathways involved in CH_4 production/ removal in or near sea-ice.

We performed such analyses on sea ice samples drilled from a shallow shelf (~6m depth) at Barrow, Alaska in April and June 2009 and from a deeper shelf (~100m) at McMurdo, Antarctica in December 2011 and 2012.

At both sites, sea-ice is highly supersaturated (between 2 and 10 nmol.L^{-1}) with methane over the total sea ice column (Zhou *et al.*, 2014). The methane isotopic signatures of those samples are presented in a co-isotope plot (Fig.).

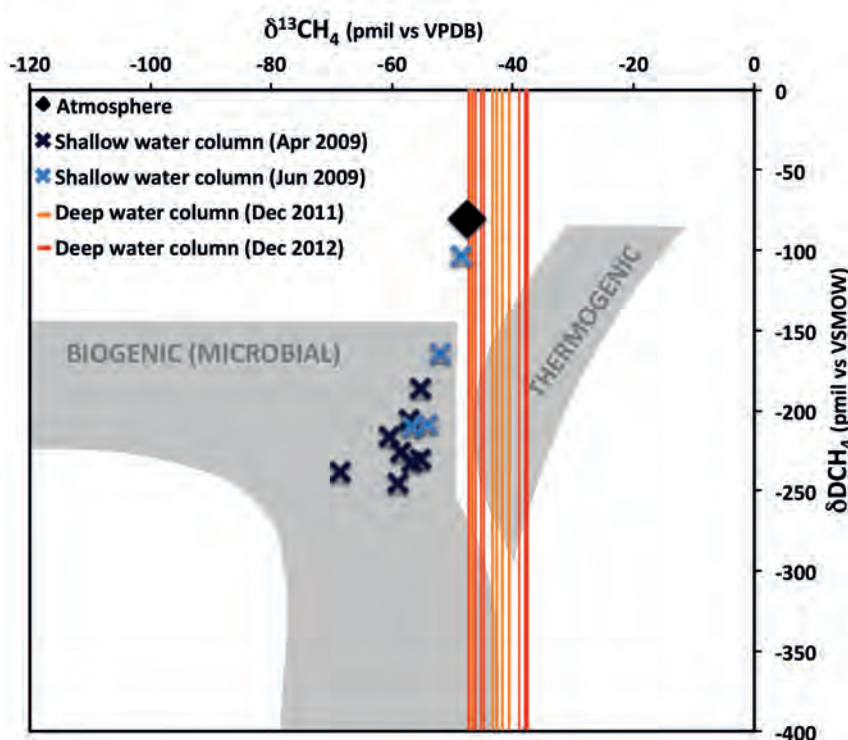
The Barrow samples reveal a clear biogenic origin of methane that is likely produced in the seafloor, transported through the shallow water column and stored in the ice. A trend towards more enriched δ values for the core drilled later in the warmer season shows an intrusion of atmospheric methane when the ice becomes more permeable, because of higher temperatures. For the ice from McMurdo, only $\delta^{13}\text{C}$ has been measured at this stage. Those data show a more enriched isotopic signature than the Barrow ice that could be considered a thermogenic signature, but it is very unlikely considering the water depth and the sampling location. Oxidation of depleted methane could explain this enrichment, but no correlation has been found between the concentrations and the $\delta^{13}\text{C}$ values, making this assumption improbable. The main difference between the Barrow and McMurdo sites is the presence of platelet ice at McMurdo. This ice is enriched in microorganisms and also in DMSP that

could potentially play the role of methane precursor in the ice.

Our preliminary conclusions are that sea-ice acts as a large methane reservoir and none or few of this methane is being oxidized in the ice. However, in presence of DMS/DMSP, sea-ice could become a methane source! Further work is being performed to verify this hypothesis and to evaluate the potential effect of sea ice on the methane budget!

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> Figure: Methane co-isotope plot for sea-ice samples from shallow (Barrow) and deep (McMurdo) shelves.



Robyn Schofield is a Climate System Science lecturer in the School of Earth Sciences at the University of Melbourne in Australia. She has worked at NIWA in Lauder, New Zealand, NOAA in Boulder, United States and AWI in Potsdam, Germany before she moved to Australia in 2011.

Atmospheric and surface chemistry observations during SIPEX II, East Antarctica, 2012

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Mercury in its elemental form has an atmospheric lifetime of approximately one year, long enough for transport processes to distribute it globally, and it to be deposited in some of the Earth's most remote environments. Human activities have increased the cycling of mercury between the oceans, land and the atmosphere up to 5 times (Selin, 2009). Between a quarter and a half of the mercury in the atmosphere is of anthropogenic origin (Biester *et al.*, 2007; Holmes *et al.*, 2010). In the polar spring large quantities of highly reactive bromine radicals are released into the atmosphere (Bottenheim *et al.*, 1990). The spatial pattern of these 'bromine explosion events' follows that of young (1 year old) sea ice (Richter *et al.*, 2002).

Aiming to detect and quantify the flux of mercury to the sea-ice and polar biosphere with polar sunrise, observations of atmospheric halogens, mercury, aerosols and ozone were conducted in 2012. Five atmospheric monitoring suites were installed on the Australian Antarctic Divisions's ship the RV *Aurora Australis* and continuous atmospheric observations were made over the Southern Ocean and in East Antarctica during the Sea-ice Physics and Ecosystems eXperiment II (SIPEX II). Ruhi Humphries (PhD candidate at the University of Wollongong) conducted the atmospheric observations with his PhD studies looking into the new particle formation processes of the Southern Ocean and sea-ice regions.

The atmospheric observations were complemented by snow, sea-ice and oceanic samples of total and methyl mercury and microbial community observations made by Caitlin Gionfriddo (PhD candidate at the University of Melbourne). With DNA sequencing soon underway the microbial community and its

interaction with the springtime depositional pulse of mercury will help to inform the next generation of biogeochemical models.

These data will enable studies that investigate how these processes will change with increased greenhouse gas loadings and altered sea-ice coverage. This unique observational data-set promises some exciting interdisciplinary modelling and science.

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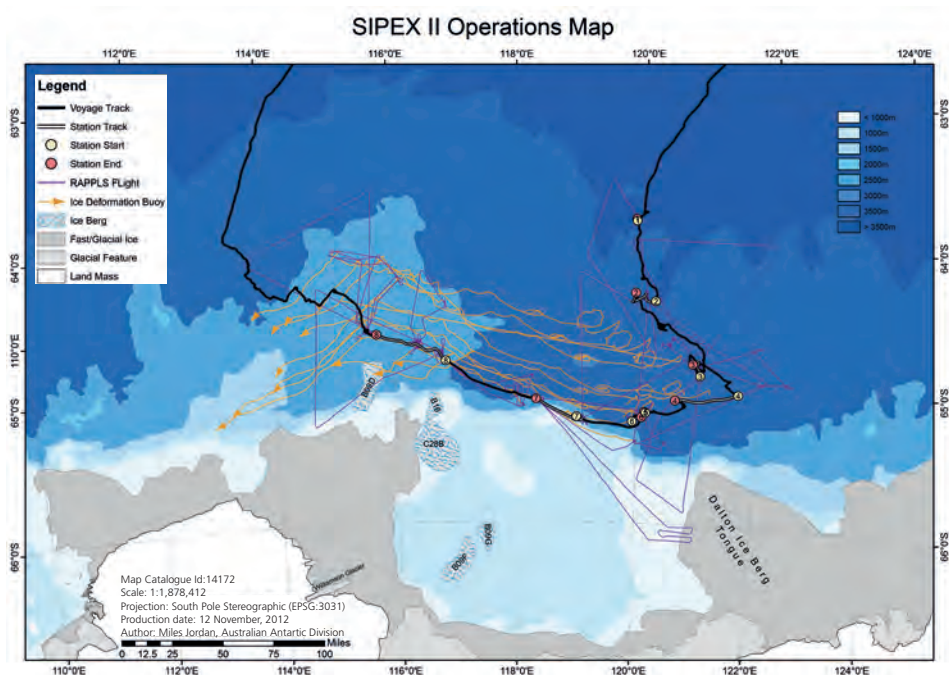
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Acknowledgements

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▲ Figure: SIPEX II involved instrumented aircraft, drift buoys and 8 ice-stations. Having atmospheric chemistry measurements throughout the voyage can be explored with detailed ice / ocean physics and ecosystem characterisations.



The "Climate and Cryosphere" project

The "Climate and Cryosphere" project (CLiC), a core project of the World Climate Research Programme (WCRP), encourages and promotes research into the cryosphere and its interactions as part of the global climate system. It seeks to focus attention on the most important issues, encourage communication between researchers with common interests in cryospheric and climate science, promote international co-operation, and highlight the importance of this field of science to policy makers, funding agencies, and the general public.

CLiC's Antarctic Sea Ice Processes and Climate Group (ASPeCt, co-sponsored with SCAR) and the Arctic Sea Ice Working Group both have standardized data collection and sharing protocols and are working on better combining observations and modeling through the creation of a sea ice and climate modeling forum. The Ice Sheet Mass Balance and Sea Level (ISMASS) group (co-sponsored with SCAR and IASC) has recently been renewed and is helping to coordinate international efforts on improving mass balance estimates of ice sheets.

In recent years, CLiC has begun to restructure to focus more on shorter-term targeted activities, many of which are meant to address the WCRP Cryosphere in a Changing Climate Grand Challenge. Some current activities include:

- Arctic Freshwater Synthesis
- Polar Coordinated Regional Downscaling Experiment (CORDEX)
- ESM-Snow Model Intercomparison Project
- West Antarctic Glacier-Ocean Modelling Comparison
- Identifying Permafrost Research Priorities
- Satellite user requirements for cryosphere research

CLiC is also working to produce a number of outreach projects, such as FrostBytes: 30-60 second videos of cryosphere research. They maintain a Cryosphere Community Calendar, several RSS feeds, and iTunes Podcast series and more.

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Sea-ice biogeochemistry and interactions with the atmosphere

Recent activities of the MTS on sea-ice are intrinsically linked to the BEPSII SCOR WG 140, chaired by Jacqueline Stefels and Nadja Steiner. BEPSII had its second meeting in March 2014 after the IGS International Symposium on Sea Ice in a Changing Environment in Hobart, Australia. Goals of the meeting were to evaluate the progress of the three Task Groups, to establish what is still missing and to set a timeline for the coming period.

TG1 (led by Lisa Miller and Lynn Russell) has 3 primary goals:

- 1) The methodological survey has been submitted to the e-journal Elementa: Science of the Anthropocene- Oceans.
- 2) For the intercomparison of methods, several potential field stations were identified and an overview of parameters that need to be intercompared, including a first approach for such a campaign, has been drafted. Not all parameters can and need to be intercompared simultaneously. Hence it was concluded that splitting-up into different campaigns is the best way forward. Possibilities for campaigns in Japan (Saroma-ko Bay) and Finland (Tvarminne) will be further investigated and stimulated. The actual realization is beyond the scope of BEPSII.
- 3) Recommendations for best practices on biogeochemical methods will be explored in the coming period. New and existing papers will be placed on the new BEPSII website.

TG2 (led by Klaus Meiners and Martin Vancoppenolle) has 2 primary goals:

- 1) The production of new data inventories and datasets by collation of existing data has resulted in the first dataset on chlorophyll-a from Antarctica pack ice (published by Meiners et al. GRL 39, 2012, doi:10.1029/2012GL053478). In addition, five other projects are ongoing or were initiated: 1. Arctic chlorophyll-a; 2. chlorophyll-a from Antarctica fast ice; 3. Inorganic carbon parameters; 4. macro-nutrients; and 5. Iron.

2) A standardized protocol for meta-data collection will be derived from the ASPeCt log sheet and made available on the BEPSII website.

TG3 (led by Nadja Steiner and Clara Deal) has four primary goals:

- 1) A short paper on "recommendations from modelers to observationalists" is underway.
- 2) Within the task to produce review papers on the major biogeochemical processes, several topics were identified: an overall review paper on the 'Role of sea ice in global biogeochemical cycles: emerging views and challenges' has been published in Quaternary Science by Vancoppenolle et al. (2013). A Special Issue in an on-line journal that allows continuous publication will be explored. Planned reviews are: the DIC-system, Fe distribution and controls, nutrient distribution, light transfer in ice, algal release from ice, DMS(P) in ice and ice-atmosphere exchange of halogens. A few more topics were identified for which lead authors will be sought.
- 3) The 1D-model intercomparison exercises is taking shape. 8 modeling groups will contribute. The target is to use two sites for model evaluation, one in the Arctic, and one in the Antarctic. A series of four simulations for each site has been developed with the aim to understand the coupling between ice physics and ocean biology.
- 4) The link to regional modeling and global earth system models be explored through activities within the AOMIP/FAMOS program.

To facilitate collaboration and scientific outreach of developments and results from the BEPSII community, a website will be built and options for future financial support will be explored.

Jacqueline Stefels, WG co-Chair, University of Groningen, Netherlands (j.stefels@rug.nl) and Nadja Steiner, WG co-Chair, Canadian Centre for Climate Modelling and Analysis (Nadja.Steiner@ec.gc.ca)



The Surface Ocean CO₂ Atlas (SOCAT) informs on the global ocean carbon sink and its variability

The Surface Ocean CO₂ Atlas (SOCAT) is a largely volunteer, international activity by the marine carbon community with more than 100 contributors to assemble surface ocean carbon dioxide (CO₂) data in a uniform, quality controlled format. Version 1 was made public in 2011, version 2 in 2013 and the release of version 3 is planned for 2015. SOCAT version 2 provides 44 years of surface water fCO₂ (fugacity of CO₂) values from 1968 to 2011 for the global oceans and coastal seas with 10.1 million unique data points. The SOCAT synthesis and gridded data products can be interrogated via interactive online viewers or downloaded in a variety of formats via the SOCAT website (www.socat.info). Three publications document SOCAT versions 1 and 2 (Pfeil et al., 2013; Sabine et al., 2013; Bakker et al., 2014).

About 3 million new fCO₂ values from 1957 to 2013 have been submitted to SOCAT version 3. Quality control by regional groups is about to start. The quality control criteria have been adapted for version 3 to accommodate calibrated CO₂ data from new sensors and alternative platforms. A major thrust is to streamline data submission and data entry procedures. Testing the automation system will commence soon.

Applications of SOCAT include process studies, quantification of the ocean carbon sink, its seasonal to year-to-year variation and ocean carbon cycle modelling. The 2013 Global Carbon Budget (www.globalcarbonproject.org/carbonbudget) has used SOCAT for quantification of the annual ocean carbon sink. A new initiative, the Surface Ocean pCO₂ Mapping

intercomparison (SOCOM), will compare surface ocean CO₂ gridded products, derived by a variety of methods, many of them based on SOCAT. To date 25 scientific articles and 3 book chapters cite SOCAT.

Colleagues are encouraged to engage in the project by submitting their surface water fCO₂ data to SOCAT, by becoming quality controllers and by using SOCAT. We ask that users provide feedback on the products and acknowledge SOCAT and its data providers, in the form of invitation to co-authorship or citation of relevant scientific articles, especially if specific data are central to a (regional) study.

A SOCAT Community Event will take place on 23 June 2014 (IMBER Open Science Conference, Bergen, Norway). Finally, Steve Hankin of NOAA/PMEL is replaced by Kevin O'Brien on the SOCAT global group. Steve, with support from the NOAA Climate Programme Office, has been instrumental in SOCAT since 2007, responsible for designing the SOCAT online quality control system, the interactive viewers and the automation system. We expect that Steve will remain closely connected with SOCAT to share his insights and wisdom on data management and protocols.

Enjoy SOCAT.

Pfeil et al. (2013). A uniform, quality controlled Surface Ocean CO₂ Atlas (SOCAT). *Earth Syst. Sci. Data* 5: 125-143. doi:10.5194/essd-5-125-2013.

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www.socat.info

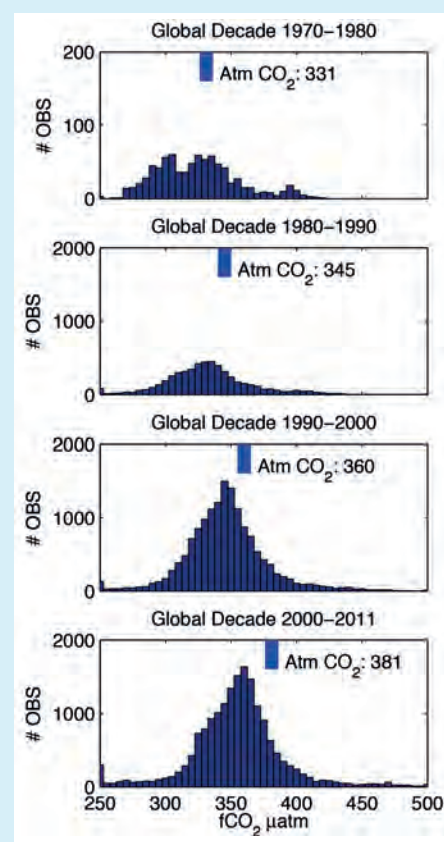


Figure: Decadal evolution of surface ocean fCO₂ in the SOCAT version 2 gridded product, where # OBS is number of gridded observations in 5 µatm bins. The mean atmospheric CO₂ concentration (ppm or µmol.mol⁻¹) from the Mauna Loa Observatory (Hawaii) is indicated by the blue bar (values from Ralph Keeling at <http://scrippsco2.ucsd.edu/>). This Figure is an update of Figure 6 in Sabine et al. (2013).



GEOMAR Helmholtz Centre for Ocean Research Kiel

Scientists at GEOMAR cooperate closely with colleagues worldwide. On the European level, GEOMAR has developed strong links with the National Oceanography Centre, UK and IFREMER, France. The three partners signed a cooperation agreement with the overall objective of fostering the marine sciences on an international and, in particular, European

level. In respect to collaborative EU projects and Marie Curie Networks, GEOMAR coordinates several projects, e.g. Natural Products from Marine Fungi for the Treatment of Cancer (MARINE FUNGI), Sub-seabed CO₂ Storage: Impact on marine ecosystems (ECO₂), and participates in several others.

Internationally, GEOMAR cooperates with major oceanographic institutions in the USA, Canada, Japan, Korea, India, China, Taiwan, Russia, Cape Verde and many other countries. The cooperations include direct academic exchange and also take place in a framework of alliances and coordinating bodies such as the "Partnership for the Observation of the Global Oceans" (POGO). Some additional highlights of international cooperation include: establishment of a long-term atmospheric/

ocean observatory at the Cape Verde Islands and construction of a Ocean Science Centre in Mindelo and the coordination of the SOLAS project with the SOLAS International Project Office (IPO) in Kiel.

GEOMAR scientists have contributed to the Intergovernmental Panel on Climate Change (IPCC) assessment reports and they are continuously contributing to large-scale international programmes, such as the Integrated Ocean Drilling Program (IODP), CLIVAR, GEOTRACES and SOLAS.

Andreas Villwock, Head Communication and Media, GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany (avillwock@geomar.de)

<http://www.geomar.de>

Newly endorsed projects

Ocean Atmosphere Sea Ice Snowpack (OASIS)

The Ocean - Atmosphere - Sea Ice - Snowpack (OASIS) program was created in 2004 as an international multidisciplinary group focused on studying chemical and physical exchange processes among the title reservoirs. The main themes of OASIS are the interrelationships between climate and tropospheric chemistry as well as surface/biosphere feedbacks in the Arctic. Sea ice is undergoing rapid change in the Arctic, transitioning from a perennial or multi-year ice (MYI) pack to a thinner, seasonal first-year ice (FYI) pack, thereby transforming into a more Antarctic -like system. Such changes in critical snow, ice and atmospheric interfaces will likely have large impacts system wide - from habitat loss to dramatic changes in heat and water vapor fluxes to changes in atmospheric chemistry. OASIS scientists are deeply involved in studies aimed at understanding interactions among components of the Ocean - Atmosphere - Sea Ice - Snowpack system and potential feedbacks at their most fundamental levels.

The outcome of this project contributes to the SOLAS Mid-Term Strategy on Sea-ice biogeochemistry and interactions with the atmosphere.

<http://www.oasishome.net/>



NETwork on Climate and Aerosols: Addressing Key Uncertainties in Remote Canadian Environments (NETCARE)



To improve the accuracy of climate predictions, the direct radiative effects of aerosol and the impacts of aerosol on clouds and precipitation have to be comprehensively addressed; it is well recognized that they represent the largest uncertainties in radiative forcing estimates. Moreover, in contrast to urban regions where extensive work has been conducted, remote regions (e.g., the Canadian Arctic) remain comparatively unstudied despite the need to establish a baseline against which future change can be evaluated. With naturally low aerosol levels, such regions are particularly sensitive to anthropogenic input. NETCARE is comprised of the leading scientists in the Canadian climate-aerosol community. The central impetus within the network is that the key uncertainties in this field must be addressed by multidisciplinary studies of interacting components of the Earth system, particularly the ocean, atmosphere, and cryosphere. While the fundamental understanding to be gained is widely applicable, the network will focus on the Arctic and Western Canada so as to have maximum impact. Observations will extend across the Arctic from land stations, an icebreaker, and research aircraft.

The outcome of this project contributes to the SOLAS Mid-Term Strategies on Ocean-derived aerosols: production, evolution and impacts and Sea-ice biogeochemistry and interactions with the atmosphere.

<http://www.netcare-project.ca/>

Western Atlantic Climate Study II (WACS II)

WACS II is a research cruise planned for the North Atlantic from May 19 to June 6, 2014 onboard the WHOI RV Knorr. Primary objectives include the characterization of freshly emitted SSA properties including chemical composition, size distribution, number concentration, cloud nucleating ability, light scattering and absorption. Simultaneous measurements of sea surface properties will allow for an assessment of links between seawater and SSA properties. Of particular interest is the impact of ocean microbiology on SSA composition and cloud-nucleating ability.

The WACS II working area includes the phytoplankton bloom region of the North Atlantic and south through the chlorophyll gradient into the oligotrophic waters of the Sargasso Sea. Measurements will be made at a series of stations across the high to low chlorophyll gradient and during transits between stations. Sea days will be divided into approximately 12 days on station and 7 days of transit.

The outcome of this project contributes to the SOLAS Mid-Term Strategy on Ocean-derived aerosols: production, evolution and impacts.

SCOR WG 142 “Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders”

The first meeting of SCOR WG 142 took place at the East/West Center of the University of Hawaii following the 2014 Ocean Science Meeting in late February. The WG membership and terms of reference are found at http://www.scor-int.org/Working_Groups/wg142.htm. The deployment of biogeochemical sensors on profiling floats and gliders is a rapidly expanding activity that is occurring at the global scale. There were 205 profiling floats with oxygen sensors active in February 2014 and some 50 floats with bio-optics and nitrate. These systems

promise to revolutionize our understanding of ocean biogeochemistry, in much the same way that the Argo system has influenced our understanding of ocean physics. However, these sensors do have several recognized deficiencies that can impact their utility as a global sensor network. Given the large number of systems that are deployed, there is a rapidly accumulating body of experience that can be used to mitigate these problems and greatly improve data quality. Furthermore, there are an expanding number of sensor manufacturers and each has

adopted differing protocols for calibration and data reporting and each sensor has different performance characteristics. The main function of SCOR WG 142 is to act as a conduit to accelerate the dissemination of this experience to users and manufacturers.

Arne Körtzinger, WG co-Chair, GEOMAR, Kiel, Germany (akoertzinger@geomar.de)

Ken Johnson, WG co-Chair, MBARI, Moss Landing/CA, USA (johnson@mbari.org)

http://www.scor-int.org/Working_Groups/wg142.htm

SCOR Working Group 144 on “Microbial Community Responses to Ocean Deoxygenation”

The SCOR WG 144 on Microbial Community Responses to Ocean Deoxygenation was approved by SCOR to run between 2014-2017. Initiated at a meeting in Santa Cruz, Chile on Microbial ecology and biogeochemistry of oxygen-deficient marine waters (18-22 March 2013), the program objectives of the newly established working group are:

- 1) Identify model ecosystems manifesting ecological and biogeochemical phenotypes across a range of water column O₂-deficiency states
- 2) Develop community standards of data collection for both process rate and molecular measurements enabling cross-scale comparisons
- 3) Establish core metrics for modeling microbial community responses to changing levels of O₂-deficiency.

4) Disseminate standards, data sets and comparative analysis to the wider oceanographic and Earth system science communities and the public.

Bess Ward will serve as the leadership coordinator, working closely with the rotating chairs to ensure that working group objectives are met. In the timeframe of 4 years the following actions are scheduled:

In year one a practical workshop in Saanich Inlet, a seasonally anoxic fjord off the coast of Vancouver Island British Columbia, Canada, will be convened in order to ground truth common standards for process rate and molecular measurements and identify model ecosystems for future cross-scale comparative analyses. In the second year a meeting at the Leibniz Institute for Baltic Sea Research in Warnemünde, Germany to codify standards

of best practice, identify leveraged funding opportunities and economies of scale, and compose a white paper describing said standards and opportunities is planned. Year number 3 will see a topical session at an international conference such as ASLO, ISME, or ASM to highlight research findings informed by the best practices described in the white paper. The last year will see a meeting at the National Institute of Oceanography in Goa, India to compile a peer-reviewed monograph, which is tentatively planned to be published as an electronic book in the Frontiers or PLoS open access journals to ensure both visibility and long-term access.

Bess Ward, leadership coordinator, Princeton University, USA (bbw@princeton.edu)

SOLAS Metadata Portal

What and where are the available data that the SOLAS community collected?

How can you contribute to the collection with the SOLAS-relevant data you have collected?

Visit the SOLAS Metadata Portal at <http://tinyurl.com/46xnf9>, a resource freely-available to the entire community.

The SOLAS Metadata portal is an ongoing effort, initiated through the SOLAS Integration project. The portal lists what SOLAS data exists and where it is archived, along with information such as where and when it was collected and the name of the data-provider. You can also help expanding the SOLAS meta-database by completing the simple template form available at <http://tinyurl.com/328zjr5> and email it to solas@geomar.de



The European Space Agency's Climate Change Initiative programme

The European Space Agency's Climate Change Initiative programme is developing 'Essential Climate Variable' (ECV) data sets, for use in climate change research. The projects aim to produce stable, long-term, multi-sensor time series of satellite data. The data sets have specific information on errors and uncertainties, often at pixel level. There has been a committed focus on meeting the data requirements of the climate community, gathered from the Global Climate Observing System, user surveys and from climate modellers. To meet those needs, work has been undertaken to examine the best processes for ECV development, including algorithm improvement, inter-comparison and selection exercises, data processing steps, and validating and evaluation of the data products. The projects also assess the best way to systematically assess, renew and continue these aspects in the long-term.

The first data sets are now available online through the main programme website: www.esa-cci.org and feedback from the wider scientific community is welcomed. Thirteen ECVs are being developed in parallel:

Ocean: Sea surface temperature, Ocean colour, Sea Ice, Sea Level

Atmosphere: Aerosol, Cloud, Ozone, Greenhouse Gases (CO₂, CH₄ over land)

Land: Ice Sheets, Glaciers, Soil Moisture, Fire, Land Cover

All data products are freely available online and all documentation pertaining to data set development is accessible on the project websites.

Cat Downy, IGBP-ESA Liaison Officer, ESA Climate Office, Harwell Oxford, UK (Cat.downy@esa.int)

www.esa-cci.org

OceanFlux: a European Space Agency (ESA) Support To Science Element project series

The OceanFlux project series aimed at reinforcing the scientific collaboration between ESA and SOLAS. The overall project objective was twofold: 1) Support the development of novel products and enhanced EO-based observations responding to the needs of the SOLAS community and 2) Advance in the integration of EO-based products, in-situ data and models in order to contribute to SOLAS major scientific gaps.

Three projects have been identified and carried out (2011-2013), and the major features and accomplishments are:

OceanFlux GHG, <http://www.oceanflux-ghg.org>

The OceanFlux Greenhouse Gases project is now nearing completion. The project has published 4 journal papers on altimeter gas transfer velocity algorithms, Arctic air-sea CO₂ fluxes and wave breaking statistics and there are another 6 journal papers in draft.

All of this work has exploited satellite Earth observation, in situ data and modelling approaches. The project has released a version of its global CO₂ flux climatology and the data processing system (called FluxEngine) that was used to create the climatology is available for the community to use and exploit. Further updates to the processing system and the climatology are expected over the next few months.

OceanFlux Upwelling, <http://upwelling.eu/>

OceanFlux Upwelling aimed at exploring the potential of EO technology to characterize the role of ocean upwelling processes as sinks and/or sources of greenhouse gases, with a distinctive focus on the Peru-Chile and Benguela Eastern Boundary Upwelling Systems (EBUS).

In this context, image processing techniques have been used to extract fluxes of GHGs from EO data. Through concomitant information on gas solubility and gas transfer velocities, the partial pressure of GHG in the ocean has been extracted. A new non-linear and multi-scale processing method for complex signals has been applied to infer a higher spatial resolution and properly map the GHG fluxes. These analyses have been linked to a coupled physical bio-geochemical model (ROMS-BioBus). The project has been officially completed, but a further 6-month extension is foreseen, allowing a further refinement of the super-resolution

CO₂ ocean fluxes algorithm (merging different data sources) and validating the methodology enlarging the two test areas beyond the initial upwelling zones.

OceanFlux SSA, <http://oceanflux.fmi.fi>

The Oceanflux Sea-Spray Aerosol (OSSA) project focused on the development of a new sea-spray aerosol (SSA) sourcefunction (SF) and effects of SSA on climate. Using two independent data sets, SSA fluxes and particle number concentrations, the OSSA SF has been parameterized in terms of five lognormal modes and the Reynolds number. It encapsulates effects of wave height, and accounts for the different flux relationships associated with rising and waning wind speeds and dependences on SST and salinity. The OSSA SF, together with a scheme for the organic fraction, was implemented in the aerosol-climate model ECHAM-HAMMOZ. Comparison of modeled concentrations of SSA and OM with in situ data and PARASOL-retrieved AOD suggest areas for further improvement. The simulated SSA contribution to the indirect radiative effect is positive, which is ascribed to the tendency of SSA to suppress both the in-cloud supersaturation and the formation of cloud condensation nuclei from sulphate.

The end of the OceanFlux projects coincided with topical workshops: Sea Spray aerosol workshop for the OSSA theme, 30 Sept & 01 Oct 2013 in Galway, Ireland and 'air-sea Gas Flux Climatology, progress and future prospects' for the themes on GHGs and upwelling, 24-27 Sept 2013, Brest, France. ESA is very interested by continuing the collaboration with SOLAS. In order to continue collaboration and identify the areas of common interest, ESA, EGU and SOLAS are organizing a topical conference on "Earth Observation for Ocean-Atmosphere Interactions Science 2014 - Responding to the new scientific challenges of SOLAS". The conference will be held in Frascati (Rome), Italy on 28-31 Oct 2014. This joint ESA-EGU-SOLAS Conference aims at bringing together the earth observation and SOLAS communities, as well as scientific institutions and space agencies involved in the observation, characterization and forecasting of ocean-atmosphere interactions and their impacts.

Roberto Sabia, Coordinator of the ESA STSE 'Changing Earth Science Network', ESA, ESRIN, Frascati, Italy (roberto.sabia@esa.int)

Conference Calendar

Dates	Conference	Location
23.06.2014 – 27.06.2014	 IMBER Open Science Conference	Bergen, Norway
21.07.2014 – 24.07.2014	OCB Summer Workshop	Woods Hole, USA
04.08.2014 – 09.08.2014	IMBER ClimEco4 Summer School	Shanghai, China
26.08.2014 – 29.08.2014	2014 PICES Summer School	Gangneung-Wonju, Korea
27.08.2014 – 28.08.2014	 Swedish-SOLAS Symposium	Gothenburg, Sweden
22.09.2014 – 26.09.2014	 13th Quadrennial iCACGP Symposium / 13th IGAC Science Conference	Natal, Brazil
07.10.2014 – 09.10.2014	EurOCEAN 2014	Rome, Italy
17.10.2014 – 26.10.2014	 PICES 2014 Annual Meeting	Yeosu, Korea
13.10.2014 – 15.10.2014	Workshop on Chemical Atmosphere-Snow-Sea Ice Interactions	Cambridge, UK
28.10.2014 – 31.10.2014	 Earth Observation for Ocean-Atmosphere Interactions Science 2014	Frascati, Italy
17.11.2014 – 21.11.2014	2nd International Ocean Research Conference	Barcelona, Spain
23.03.2015 – 27.03.2015	Third International Symposium on the Effects of Climate Change on the World's Oceans	Santos City, Brazil
07.09.2015 – 11.09.2015	 SOLAS Open Science Conference 2015	Kiel, Germany

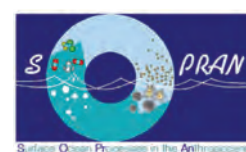
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SOLAS

Open Science Conference 2015

7-11 September Kiel, Germany

Registration opening September 2014

The Open Science Conference is the ideal venue for scientists who wish:

- to learn about current research in the field of air-sea interactions and processes,
- to develop future research collaboration,
- to share their knowledge and to present their own findings by displaying a poster or giving an oral presentation.

The harbor city of Kiel at the Baltic Sea is a great location for the conference as maritime environment of the Kiel Fjord and convenient access for international visitors combine.

We are looking forward to welcoming you in Kiel !

www.solas-int.org/osc2015.html

SOLAS International Project Office hosted by GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany