Temperature and humidity dissimilarity in the marine surface layer

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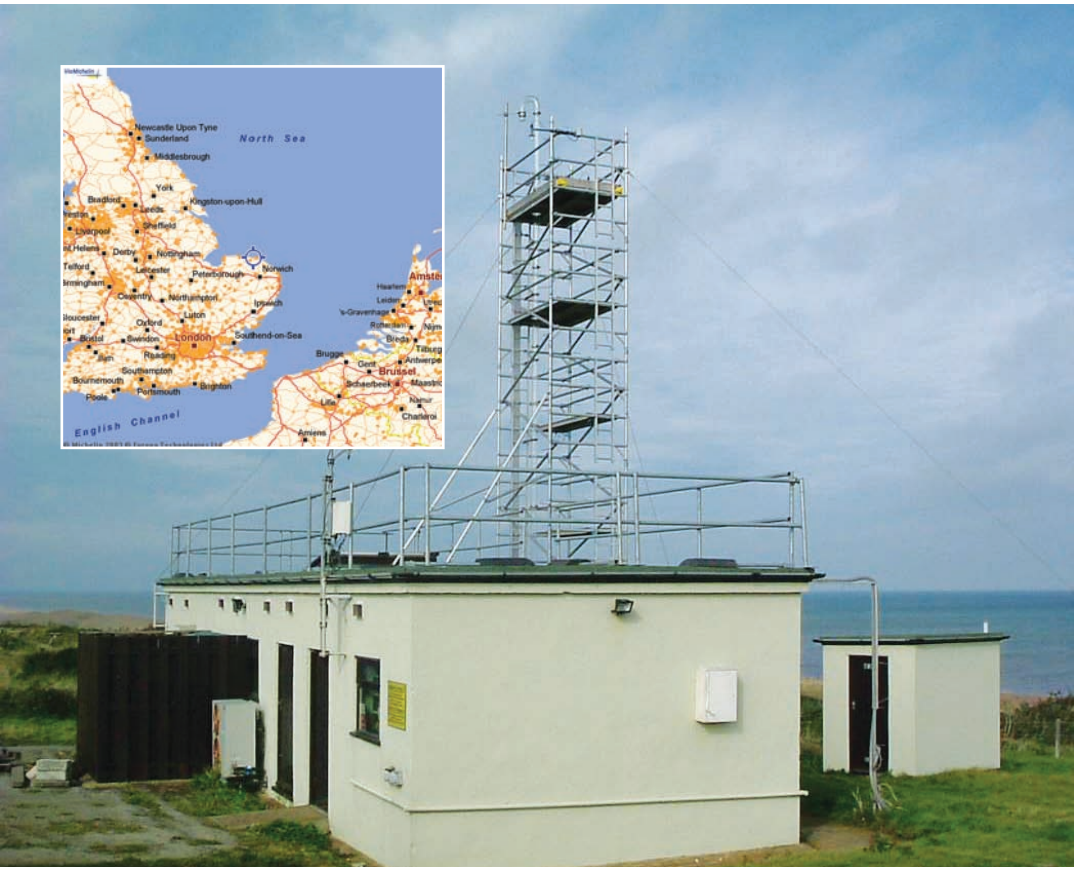

Λ Photo: Weybourne Atmospheric Observatory (WAO) situated near Weybourne on the north Norfolk coast at 52° 57′ N, 1° 7′ E UK. (Photo: Brian Bandy) See page 2 for further information.

SOLAS Approaching Events

Over the past year we, at the SOLAS International Project Office, have seen some changes and whilst wishing Dr Jeffrey Hare and Dr Justin Ho every success as they return to the USA and Australia, respectively, we have welcomed Dr Emily Brévière back, from her secondment at IGBP, as Executive Officer and I became Project Officer.

We are busier than ever organising the two major SOLAS events and would like to make the following announcements:

Firstly, we would like to make a call to all PhD students and early career scientists to apply for the SOLAS Summer School, which will take place between 3rd and 15th August 2009 in Cargèse, Corsica. Information about the school and how to apply is now available on the revamped website (http://www.solas-int.org/summerschool/). We would like to especially thank Dr Véronique Garçon for her continued efforts in coordination and invaluable assistance.

Secondly, we would like to similarly thank our local organising committee, Dr Rafel Simo and Dr Isabel Cacho, who are working with us organising our next International SOLAS Open Science Conference to be held between 16th and 19th November 2009 in Barcelona, Spain.

We will keep you updated with developments via our new format e-bulletin. If you wish to sign up to the SOLAS mailing list to receive the monthly e-bulletin, please e-mail me with your contact details.

Georgia Bayliss-Brown
SOLAS International Project Officer
Email: g.bayliss-brown@uea.ac.uk

in this issue...

plus...

Front cover: Weybourne Atmospheric Observatory, UK

Weybourne Atmospheric Observatory, officially opened by Sir William Waldegrave in 1994, experiences an uninterrupted, "clean air" seaward aspect to the North. We are also able to measure plumes from many differing origins including London and the Arctic.

Ozone, oxides of nitrogen and sulphur, carbon monoxide, carbon dioxide, oxygen, hydrogen, and condensation nuclei are routinely measured. New instrumentation is also available to determine GHG's and VOC's utilising Gas chromatography and PTRMS.

A SODAR RASS and Sonic system is run providing meteorological information about the atmospheric column above the site.

The facility also has ample room to house temporary external applications; with the ability to provide 32amp, 16amp and three-phase electrical supply. Accommodation in the area is both plentiful and high quality. Norwich International airport is forty minutes drive away ensuring that mainland Europe is easily accessible.

For more information:
Contact: Dr Brian Bandy
(b.bandy@uea.ac.uk)

national report

Chile

The scientific activities related to SOLAS Chile are mainly associated to the research efforts of scientists of the Centro de Investigación Oceanográfica en el Pacífico Sur-Oriental (COPAS). COPAS researchers are working actively in determining carbon fluxes and reservoirs and their impact on fCO_2. The role of bacterioplankton (bacteria and archaea) within the photicand mixed layer is leading to the formulation of new paradigms that challenge the predominance of short, energy efficient food chains in upwelling ecosystems. Of special interest is the research activity that is being conducted within the oxygen minimum zone (OMZ) which is one of the world's most pronounced. The activity of anoxic bacteria and archaea relevant microbial groups is of particular relevance to the understanding of carbon and nitrogen cycles in the Humboldt Current System area.

I-I Lin obtained her Ph.D. degree in Remote Sensing from the University of Cambridge, England in 1995. From 1995-1999, she worked as a Research Scientist in the Centre for Remote Imaging, Sensing, and Processing of the National University of Singapore. In 2000 she returned to her home country, Taiwan, and is currently an Associate Professor in the Department of Atmospheric Sciences, National Taiwan University. Her research interest is in using synergy of multiple remote sensing data to study air-sea interaction problems, including typhoon-ocean interaction, dust storm-ocean interaction, and the role of surfactants in air-sea gas exchange.

Multiple remote sensing for air-sea biogeochemical interaction research in the western north Pacific and neighbouring seas

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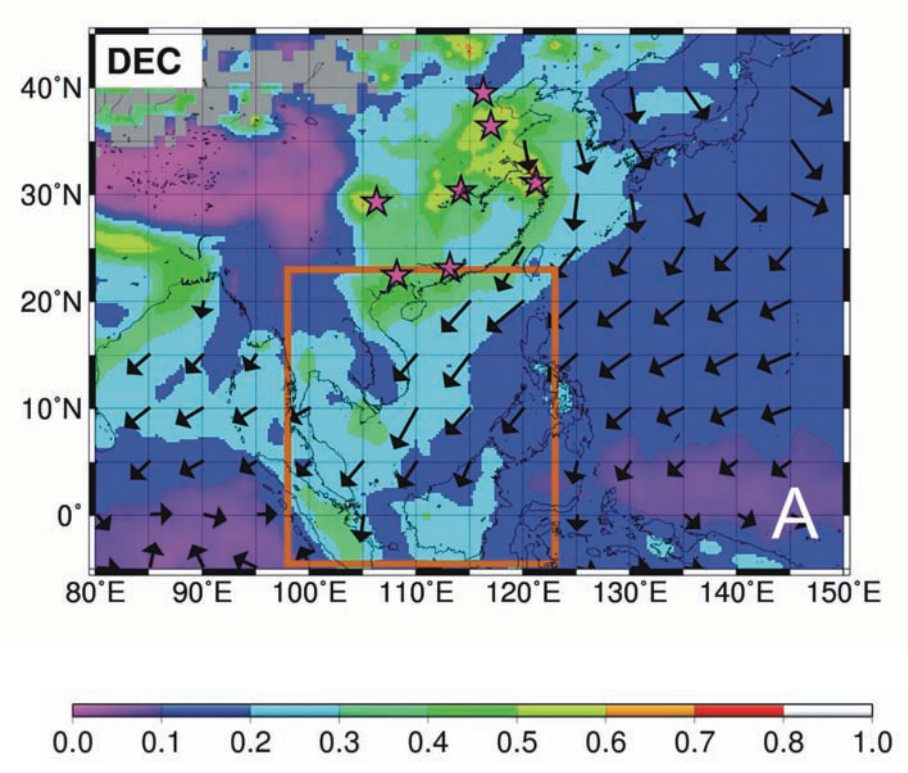
Air-sea biogeochemical interaction related processes are a critical component in the Earth's ecological and climate system. However, due to the complex and dynamic nature of these processes, many of the processes are poorly-observed and little understood. This is especially true in the vast western North Pacific Ocean and the neighbouring seas as this vast oceanic region is subject to frequent atmospheric episodic forcing from events like typhoons and dust storms. It has been difficult to use discrete ship-borne point measurements with irregular time and spatial intervals to observe these highly episodic processes. With the advancement in space-borne remote sensing offering frequent and systematic observations, it has become more feasible to take a glimpse at these complex dynamic processes. In this research, multiple remote sensors are used as it is necessary to have observations of a suite of physical and biogeochemical parameters for both atmosphere and ocean. In this research, five types of remote sensing data are used and they are: (a) ocean colour data (chlorophyll-a concentration and ocean colour spectra) from the NASA's SeaWiFS (Sea-viewing Wide Field-of-view Sensor) and MODIS satellites (O'Reilly et al., 1998); (b) aerosol optical thickness and fine mode fraction data from the NASA



MODIS (MODerate Resolution Imaging Spectro-radiometer, Kauffman et al., 2002) satellite; (c) SST data from the TRMM (Tropical Rainfall Measuring Mission) and AMSR-E satellites (Wentz et al. 2000); (d) the Sea Surface Height Anomaly (SSHA) data from TOPEX/Poseidon and JASON-1 satellites (Fu et al., 1994); and (e) ocean surface wind vectors from the NASA QuikSCAT satellite (Liu et al., 1998). This suite of sensors are applied to a number of applications in the western North Pacific Ocean and neighbouring seas and are introduced as follows.

Application 1: Typhoon-Ocean Interaction (Lin et al. 2003)

Traditionally accepted mechanisms of nutrient supply to the upper ocean are insufficient for supporting the new production in the oligotrophic ocean estimated from geochemical tracers. This paradox, whose resolution is critical for a full understanding of the global carbon cycle, has generated an intensive search for sources of allochthonous nutrients to the upper ocean. Episodic injections of nutrients, as a result of enhanced vertical mixing and upwelling across the nutricline pumped by tropical cyclones, is a possibility that has been much speculated yet largely undocumented by direct observations.
Here Lin et al. (2003) use a combination of remote sensors to show that the impact of a moderate cyclone can be far reaching. In July 2000, tropical cyclone Kai-Tak transgressed through the South China Sea (SCS). It caused up to a 300 times increase in phytoplankton biomass and 9°C reduction of sea surface temperature. A minimum of 0.8 Mt of carbon, equivalent to 2-4% of the annual new production in the oligotrophic SCS, has been generated. Given that there are in average 14 tropical depressions/cyclones passing SCS annually, their contribution to the SCS carbon cycle is estimated to be as high as 20-30%, though it has been totally neglected before. Related report on this work can also be found in the Nature 'News and Views in Brief' in August 2003.

Application 2: Aerosol-Ocean Interaction in the South China Sea (SCS) (Lin et al. 2007)

For long it has been much hypothesised that Asian desert dust is the primary source of aerosol loading impacting the biogeochemistry in the SCS. In Lin et al. (2007), the MODIS aerosol optical thickness (AOT) and fine mode fraction data together with QuikSCAT wind vectors are used to test this hypothesis and systematically investigate the situation. It is found that the current hypothesis is over-simplified and that desert dust is not the primary aerosol source in the SCS. Rather, anthropogenic aerosol loading from the fossil fuel burning of eastern China is the primary aerosol loading source. As can be seen in Fig.1A, high anthropogenic AOT loading in Eastern China, especially near major cities of even higher AOT, loadings of 0.5 and above (depicted in stars) from eastern China were transported by the prevailing northeast monsoon to the SCS. Even during the dust storm season in March (Fig.1B), the anthropogenic fossil fuel aerosols are mixed with the desert dust and transported together to the SCS. Thus the situation is much more complicated as it was hypothesised to be and an integrated approach is deemed necessary to further understand the aerosol impact biogeochemistry of the SCS.

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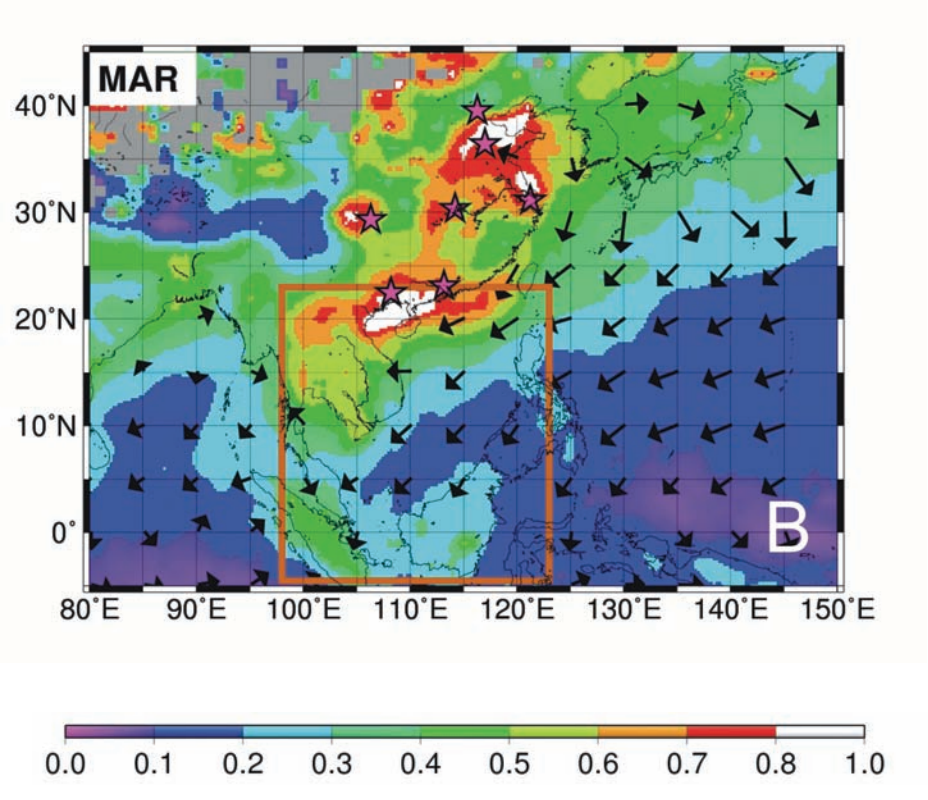

< Figure 1: 3-year (2002-2004) averaged total AOT from MODIS for December (non-dust season, Fig. A) and March (dust season, Fig. B) in the South China Sea (boxed region) and neighbouring regions. QuikSCAT ocean surface wind vectors are overlaid. Major Chinese cities are annotated in stars.

Jean-Louis Tison, glaciologist, is a professor at the Université Libre de Bruxelles, Belgium. His expertise is based on numerous polar field expeditions and on the development of equipments and analytical techniques dedicated to the multi-parametric study of ice at interfaces (ice-bedrock, ocean or the atmosphere). The main objective of this research effort is to gain a better understanding of initial and boundary conditions of large ice masses (continental or marine), together with a comprehensive approach of the processes governing their interactions with the climate at a global scale. Jean-Louis Tison is the coordinator of the Belgian SIBClim program.

Sea Ice Biogeochemistry in a Climate change perspective (SIBClim)

The SIBClim Community: Jean-Louis Tison[1], Christiane Lancelot[1], Lei Chou[1], Bruno Delille[2], Sylvie Becquevort[1], Véronique Schoemann[1], Jeroen de Jong[1], Delphine Lannuzel[3], Isabelle Dumont[1], Anne Trevena[1], Frédéric Brabant[1], Nicolas-Xavier Geilfus[1], Gauthier Carnat[4], Véronique Verbeke[1], Alberto Borges[2], Marie-Line Sauvée[1]

[1]Université Libre de Bruxelles (Glaciology-LOCGE-ESA), Brussels, Belgium ; [2]Université de Liège (COU), Liège, Belgium; [3]Antarctic CRC, Hobart, Australia ; [4]CEOS, Winnipeg, Canada. Contact: jtison@ulb.ac.be

Recently, there has been growing evidence that sea ice might play a crucial role in controlling and contributing to the exchanges of climatically significant biogases between the ocean and the atmosphere. In this framework, we have launched a Belgian research program (SIBClim - 2003-2007) dedicated to the study of the relationships between physical, chemical and biological properties of sea ice (both in the Arctic and the Antarctic), focusing on their impact on the sinks and sources of CO_2, DMS, CH_4 and other related gaseous species to the atmosphere. Three Antarctic cruises - ARISE (Aus.), 2003; ISPOL (D), 2004, SIMBA (US), 2007 - and two Arctic programs - CFL (Can) 2007-2008 and Point Barrow (US) 2009-2010, have and will provide(d) the opportunity to build up a large, multiparametric, "process oriented" data set that will be used to parametrize new 1-D and 3-D modelling efforts (the SIMCO model) of biogeochemical cycles in sea ice.

Figure 1 illustrates some of the wealthy outputs of these studies, for the case of unflooded (the snow-ice interface remains above the floatation level) first-year Antarctic pack ice (ISPOL R.V. Polarstern cruise in the western Weddell Sea) during the spring-summer transition (December 2004). Because of increased internal melting, the brine system within the sea ice switches from convection to stratification which has a profound impact on the biogeochemistry of the sea ice cover. Whilst sea water underneath is still typically supersaturated in carbon dioxide, the pCO_2 of the brines in the sea ice cover can reach values as low as a few tenths of ppmV (Figure 1a), under the combined effect of brine dilution, calcium carbonate dissolution and primary production of sympagic algae (Tison et al., 2008b; Delille, 2006, Delille et al. 2006). Depending on the brine transport regime, these low values are more or less compensated by diffusion, mainly from the atmosphere in the case where no flooding occurs. Observing these carbon dioxide dynamics in various locations around Antarctica and at different times, we have shown that a clear relationship exists between the snow-ice interface temperature and the intensity of the CO_2 fluxes to the sea ice cover. Applying this relationship for the whole of Antarctica, deducing yearly snow-ice interface temperatures from a sea ice model (NEMO-LIM, Institut Georges Lemaître, UCL, Belgium), we obtain a first-order estimate of about -0.025 $PgCy^{-1}$, which lies between 10 and 50% of the open ocean values below 50°S, depending on the data set considered (Takahashi, 2003; Takahashi et al., in press).

Although certainly controlled by the speciation of the sympagic microbial community, DMSP (Fig.1b) and its conversion to DMS (Fig.1c) also appear to be regulated by the evolution of the ice cover temperature and salinity regime. While keeping high concentration levels (up to three orders of magnitude higher than in the underlying sea water) in the biologically active bottom "skeletal layer" during the summer decay process, DMSP and DMS are generally strongly decreasing in the highly porous upper half of the unflooded sea ice cover, under the combined effect of brine migration and DMSP conversion into DMS, with further release of the latter to the atmosphere and to the microsurface water layer of the leads surrounding the ice floe (Zemmelink et al., 2005, Zemmelink et al. 2008). Underlying sea water is also steadily enriched in DMS(P), although it remains modest in this unflooded sea ice case (Figure 1b,c). Our data from the SIMBA floe however show a much more sustained release under active "flood-freeze" cycles, which enhance convective processes.

Iron is also a hot topic in these HNLC waters. D. Thomas (2003) has underlined the "conundrum" lying in the fact that phytoplankton growth in sea ice is apparently not iron-limited although it is growing from mostly iron-limited waters. Our data sets clearly indicate that iron concentrations in sea ice can indeed be up to nearly two orders of magnitude higher than those in surface waters (Fig.1d top; Lannuzel et al., 2008), as opposed to most inorganic impurities that are generally depleted in the ice. Strong positive relationships with particulate organic matter (including EPS) in our data suggest that the latter might actually play an important role in enhancing iron incorporation into the sea ice cover. As sea ice decays, iron is quickly released into the underlying sea water (especially during the initial convective stages, Fig.1d). We have shown that, during these periods of ice decay, iron release from the sea ice can contribute up to 70% of the total daily flux to the surface waters.

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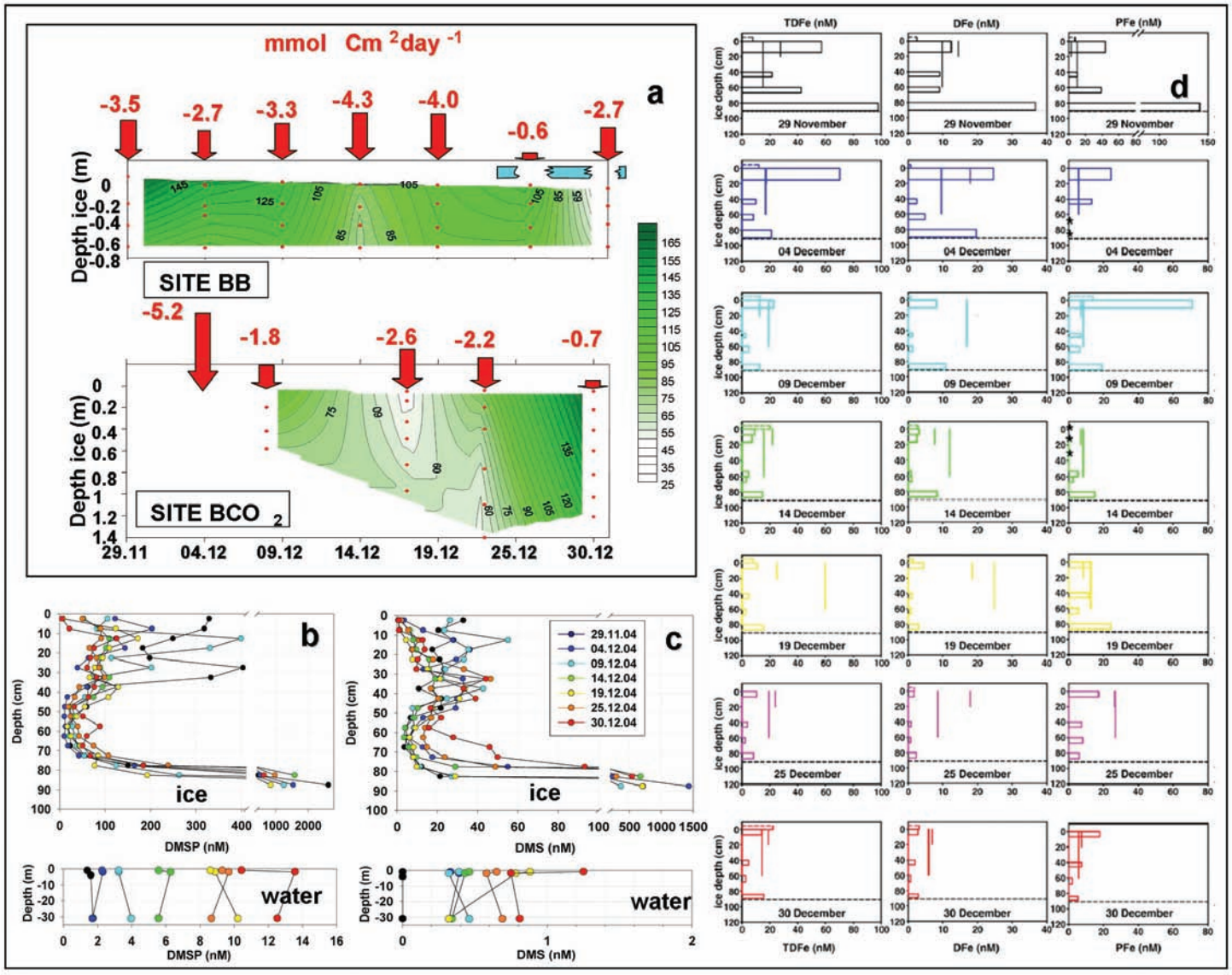

Λ Figure 1: Selected results from the unflooded first year sea ice process study at ISPOL (December 2004, western Weddell Sea): a) pCO_2 of the brines and accumulation chamber CO_2 fluxes at two different locations, b) DMSP and c) DMS profiles in the ice and underlying sea water at site BB (data collected in collaboration with J. Stefels, University of Gröningen), d) Total dissolvable/leachable iron (TDFe), Dissolved iron (DFe) and Particulate iron (PFe) in the ice (bars), brines (vertical lines) and snow (dotted bars). See text for details and appropriate references.

Australian Government

Bureau of Meteorology

The Cape Grim Baseline Air Pollution Station

The Cape Grim Baseline Air Pollution Station is one of 25 Global Atmosphere Watch Stations and has been operating for over 32 years. It is situated on the NW tip of Tasmania, where it receives clean on-shore winds for 30-40% of the year.

There are 12 routine research programs at Cape Grim including meteorology, particle physics and chemistry, precipitation chemistry, solar radiation, greenhouse gases, surface ozone and radon. Regular flask samples are collected in "Baseline" conditions and shipped around the world to collaborating laboratories. The Station is funded and operated by the Bureau of Meteorology and the Science Program involves CSIRO Marine and Atmospheric Research (CMAR) and other Australian agencies and universities.

Cape Grim has an Annual Science Meeting late in each calendar year. This year the meeting will be held at CMAR in Melbourne, on 27-28 November, and focuses on the previous 12 months of work performed at Cape Grim.

Recent research has focussed on particle formation in the clean marine boundary layer and the Cape Grim welcomes the use of Station as a platform for measurements or major experiments outside routine activities. Earlier this year, the Station hosted an Aerosol Ionisation Spectrometer (University of Helsinki) and a Proton Transfer Reaction Mass Spectrometer (CMAR) and in the next month a group from Korea and the University of Wollongong will visit to use a Fourier Transform Infrared Spectrometer to monitor greenhouse gases, plus carbon monoxide, at Cape Grim. There is limited funding to support such activities available through the Cape Grim Program and requests should be made via the Officer in Charge and the Cape Grim Working Group (oicbaps@bom.gov.au).

http://www.bom.gov.au/inside/cgbaps/

Jacyra Soares earned her PhD in physical oceanography at University of Southampton, UK. Currently she is Associate Professor at University of São Paulo, Brazil. Her research interests include boundary layer meteorology, air sea interactions and ocean modelling.

FluTuA Project

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The FluTuA Project intends to measure turbulent fluxes at the atmospheric surface layer and vertical profiles of meteorological and oceanographic parameters over the western tropical Atlantic Ocean. The major goals are to characterize, observationally, the interaction between the atmosphere and the ocean in different time scales. The surface boundary layer fluxes will be determined from an instrumented tower (Fig.1) located in the Brazilian tropical island "São Pedro and São Paulo Archipelago" (SPSPA). This archipelago - located in the open sea at approximately 1100 km off the coast of Brazil - is an outcrop of the mid-Atlantic Ridge (0 5'N, 29 20'W) and its largest island has an area of 7500 m^2 and the highest point measure only 17m.

The project performs long and short duration field campaigns. The long duration campaign measures vertical profiles of wind velocity, air temperature and air relative humidity at 3 different levels in 10m tower using a logarithmic scale; wind direction at 10m; atmosphere pressure; precipitation; sea surface temperature; soil temperature; soil heat flux; net radiation at 10m and radiation balance components at 2m, continuously (over a minimum of 2 years). The short duration campaigns will measure atmospheric parameter fluctuations, at sampling rate of 1-30 Hz, of air-sea CO_2 and water vapor density, wind components and air temperature.

Very little is known about the atmospheric and oceanographic conditions in the SPSPA region. During 1983-1984, *in situ* wind measurements

Λ Figure 1: Micrometeorological tower in the Archipelago of São Pedro and São Paulo.

were collected at SPSPA, as part of Francais Océan Climate Atlantique Equatorial / Seasonal Equatorial Atlantic Experiment (FOCAL/SEQUAL) experiment. The wind velocity showed a relaxation period from February through April in 1983 and from January through May in 1984. From April through November 1983 and from May to the end of October 1984, they were practically constant, with a mean velocity of about 6.9 m s^{-1} in 1983 and 6 m s^{-1} in 1984 (Colin and Garzoli, 1987). The referred wind relaxation is associated to the Intertropical Convergence Zone (ITCZ) seasonality and positioning. From February to April, the winds became very weak because the low wind confluence zone was positioned over the SPSPA in 1983. According to Wainer and Soares (1997), the sea surface temperature in the tropical Atlantic is in phase with the meridional displacement of the ITCZ and out of phase with NNE Brazil rainfall.

The diurnal evolution of the radiation balance components over the tropical Atlantic ocean, based on measurements carried out on board a Brazilian Navy ship, during the first observational campaign of the FluTuA Project (Fig.1) from 15 to 23 May 2002, indicated that the albedo responds as expected to the atmospheric attenuation effects with a diurnal evolution similar to the Fresnel albedo. In general, the longwave observed values agreed better with the estimated values obtained without longwave reflection. In agreement with the literature, the average surface emissivity was around 0.97. The net radiation, estimated from published equations for albedo, atmospheric transmissivity and surface emissivity, agreed with the observations (Fig.2) indicating that these parameters are representative of the radiometric properties of the air-sea interface in the region between Natal (6°S, 35.2°W) and São Pedro and São Paulo Archipelago.

Acknowledgements

The FluTuA Project is supported by Brazilian Navy, Fapesp and CNPq.

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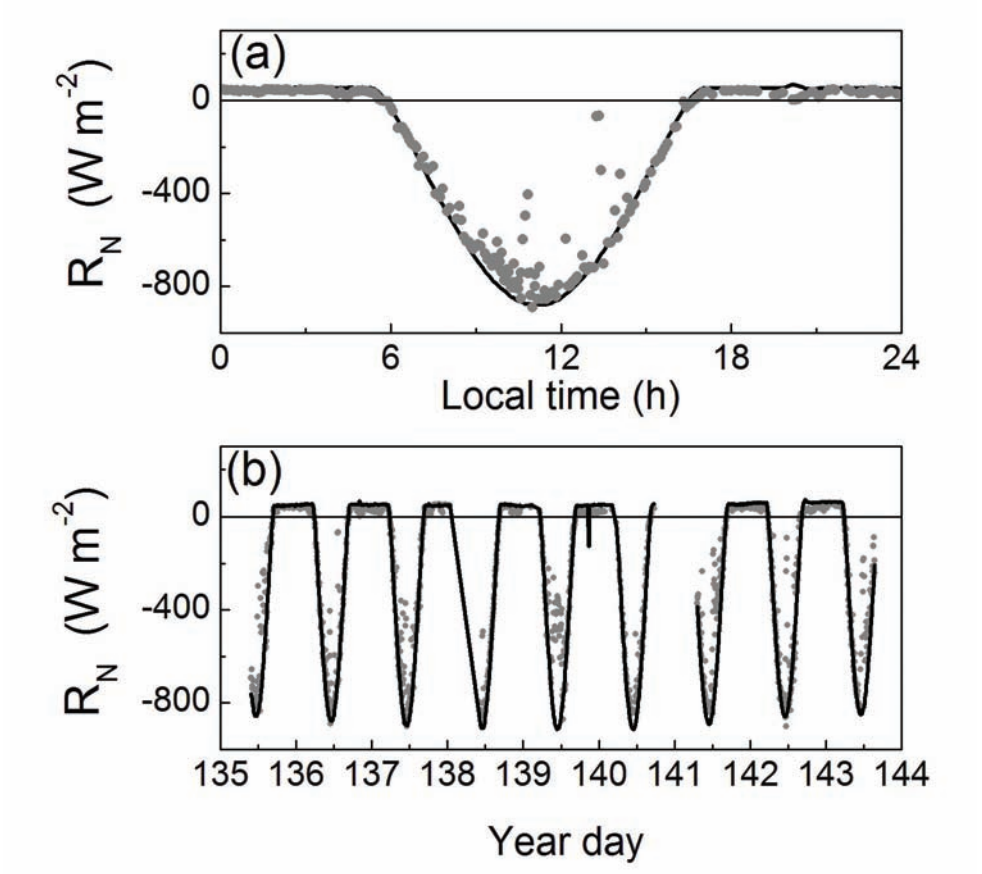

Λ Figure 2: Time evolution of observed (grey circles) and estimated (continuous line) net radiation (R_N) during (a) year day 136 and (b) the whole experiment.

partner projects

IHDP

The International Human Dimensions Programme on Global Environmental Change (IHDP) announces that the 7th International Science Conference on the Human Dimensions of Global Environmental Change (Open Meeting), "Social Challenges of Global Change", originally scheduled for October 2008, will take place from 26-30 April 2009 in Bonn, Germany. The new venue will be the former German Parliament premises (World Conference Center Bonn) at the United Nations Campus. All panel, paper and poster acceptances for the Open Meeting remain valid.

Coinciding economic developments forced our decision to relocate the Open Meeting originally planned in New Delhi. However, the reasons for the new location of the Open Meeting in Bonn are far from being exclusively financial. Beautifully located at the banks of the Rhine River, the city has managed over the past decade to shape, for itself, a new profile as the German City of the United Nations and a centre of international dialogue on key issues of the future. The IHDP Secretariat is looking forward to welcoming the global Human Dimensions community to the UN Campus.

IHDP is also pleased to confirm that the International Human Dimensions Workshops (IHDW) will still be held at New Delhi in October as planned.

Differing organizational arrangements allow us to still convene our most important capacity development activity in one of the most important emerging countries. The IHDP Secretariat in Bonn will be seeking additional funding which will allow participants in the IHDW to take part in the rescheduled Open Meeting. If there are any queries about this announcement, please contact the IHDP Secretariat at openmeeting@ihdp.unu.edu or visit our website at www.ihdp.org

solas 2012 Surface Ocean Lower Atmosphere Study

Let us publicise your research highlights by emailing us with the project details at solas@uea.ac.uk

Peter Croot began his oceanographic studies in New Zealand (PhD- University of Otago) and subsequently has spent time working in the USA (WHOI), Sweden (AMK) and the Netherlands (NIOZ) before moving to IfM-Geomar in 2002. His SOPRAN (German SOLAS) research focuses on trace metal speciation and photochemistry in the upper ocean at the TENATSO site in Cape Verde.

SOPRAN making waves in Cape Verde

Dr. Peter Croot, Tim Fischer, Maija Heller, Wiebke Mohr, Dr. Philipp Raab, Evgenia Ryabenko and Prof. Julie La Roche. IFM-GEOMAR, Kiel Germany. Nicola Wannicke IOW, Warnemunde, Germany.

Pericles da Silva, Ivanice Monteiro, Anibal Medina, Carlos Santos and Dr. Oscar Melicio
Instituto Nacional de Desenvolvimento das Pescas (INDP), Mindelo, Cape Verde. Contact: pcroot@ifm-geomar.de

During July 2008, researchers from the IFM-GEOMAR performed bioassay experiments in Cape Verde as part of the German SOLAS program, SOPRAN (http://sopran.pangaea.de/), in cooperation with coworkers from the INDP in Cape Verde and the IOW in Germany. Research cruises were carried out using the recently renovated INDP research vessel, *Islandia*, and included a 24 hour diel station occupation for microstructure profiling at the TENATSO Ocean observatory site (http://tenatso.ifm-geomar.de) as well as four separate cruises to open ocean waters to collect trace metal clean water for bioassay experiments. These cruises saw the successful testing of new hydraulic and CTD systems on the *Islandia* as well as the first use of a specially designed 3m laboratory container for performing biogeochemical sampling at sea. SOLAS specific activities included the collection of trace metal clean samples from the mixed layer using both a MITESS sampler and a towed fish.

Large volumes of trace metal clean seawater were collected during these cruises and transported back to a Class-5 portable clean container (IFM-GEOMAR) temporarily installed at the INDP in Mindelo. Under clean room conditions the seawater was then sub-sampled into 4L polycarbonate bottles and amended with either N, P, Fe or dust (collected from the nearby TENATSO Atmospheric Observatory). The bottles were then placed in water cooled, light shaded incubators for 48 hours. The bioassay experiments are designed to examine the key limiting nutrients in these oligotrophic waters and the impacts of Saharan dust on ocean biogeochemistry in this region. A key component of this work is quantifying nitrogen fixation and identifying the organisms responsible and the nitrogen fixing (nif) genes they possess. Included with the bioassays were a set of abiotic experiments in which filtered seawater was amended with dust and/or organic chelators to examine the dissolution processes that take place when Saharan dust deposits in the ocean.

As this was the first time such bioassay experiments have been performed on land, instead of on the deck of a research vessel, there were many logistical issues that required attention; however all problems were eventually solved by a cooperative team effort and helpful local science community. Special thanks go to the captain and crew of the *Islandia* for their help and expertise both at sea and in loading/unloading equipment at the dockside. The initial bioassay results indicate the strong nitrogen limitation on the phytoplankton community in the oligotrophic waters around Cape Verde and further work is planned for later in 2008 and early in 2009 in order to examine this region over a seasonal cycle.

Λ Figure 1: The INDP research vessel *Islandia* at the TENATSO Ocean Observatory (Photo: Pericles da Silva, INDP).

Since 2001 Hermann Bange has been working as a chemical oceanographer in the Marine Biogeochemistry Research Division of IFM-GEOMAR in Kiel. Currently he is coordinating the German SOPRAN project. His research interests include the oceanic emissions and pathways of trace gases such as nitrous oxide, methane and dimethyl sulfide. He is interested in the distributions of short-lived intermediates of the marine nitrogen cycle such as hydroxylamine and hydrazine. Hermann participated in several cruises to the North and Baltic Seas, the Aegean Sea, the Arabian Sea and the tropical North Atlantic Ocean.

Enhancement of oceanic nitrous oxide emissions by storms

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The world's oceans (including the coastal zones) account for about one-third of the global nitrous oxide (N_2O) emissions to the atmosphere (IPCC, 2007). In the tropical ocean containing pronounced oxygen minimum zones (OMZs) – such as those found in the Arabian Sea and the eastern tropical North Pacific (ETNP) – maximum accumulation of up to 80 nmol L^{-1} of dissolved N_2O generally occurs at water depths of 50-150 m (Bange, 2008) For comparison: typical N_2O concentrations in the surface mixed-layer are 5-10 nmol L^{-1} (Bange, 2008). However, N_2O from this upper-ocean maximum is not ventilated to the atmosphere because of stratification. Weather disturbances such as storms can, nevertheless, deepen the mixed layer considerably, thereby entraining N_2O from the subsurface maximum to the surface layer, where it easily escapes to the atmosphere. This simple scenario of enhanced N_2O emissions from the ocean caused by strong wind events (such as cyclones in the North Indian Ocean and hurricanes in the East Pacific Ocean) has never been demonstrated because scientific ship campaigns usually avoid storms.
In a recent paper, Naik et al. (2008) provide the first evidence for this phenomenon. These authors could obtain data on vertical distribution of N_2O in the central Arabian Sea just before and after a cyclone crossed the region in December 1998, and found a significant enhancement of N_2O concentration in the surface layer along with a decrease in temperature and an enrichment of macronutrients (nitrate and phosphate), all testifying to intense vertical mixing caused by the cyclone. On the basis of their data they calculated that the N_2O inventory in the upper 50 meters increased by about 2.3 Gg N_2O following the cyclone. Assuming that an equal amount would already have escaped to the atmosphere (because of the high wind speeds facilitating vigorous air-sea gas exchange) during and shortly after the cyclone (4-8 days) before the observations were made, we estimate that this single event, which lasted only for 7 days, contributed an extra 1% to the annual Arabian Sea N_2O emissions of about 500 Gg N_2O (Bange et al., 2001). The central Arabian Sea on an average experiences 2 cyclones every year (mean calculated from the 1945-2007 data given at http://weather.unisys.com/hurricane/n_indian/index.html). Thus, the annual contribution of cyclone-triggered N_2O should be at least 4.6 Gg yr^{-1}. The average hurricane frequency in the ETNP is much higher (14 per year, calculated from the 1949-2007 data given at http://weather.unisys.com/hurricane/e_pacific/index.html). In the ETNP comparable N_2O accumulation occurs in the shallow subsurface layer. Assuming a similar efflux of N_2O caused by each cyclone or hurricane, we estimate that a total of about 80 Gg N_2O is released from the Arabian Sea and the ETNP annually as a result of tropical storms. This amounts to about 1.3% of the global open ocean N_2O emissions of 6000 Gg yr_{-1} (IPCC, 2007). This is a very conservative estimate, however, because the effect of storm events on N_2O emissions from adjacent ocean areas such as the coastal upwelling in the Arabian Sea has not been taken into consideration, and Cyclone 08A-98, the data for which have been used here, was of a very moderate intensity (maximum wind speed ~120 km h_{-1} as compared to, for example, 270 km h_{-1} for the super-cyclone Gonu that hit exactly the same area during 27 May - 5 June 2007). Moreover, Patra et al. (2004) used a model to simulate N_2O emissions from the Arabian Sea triggered by a cyclone (03A-98) in June 1998: They estimated that as much as 40 Gg N_2O was released to the atmosphere during this single 7-day event (that was intermediate of 08A-98 and Gonu in intensity – maximum wind 185 km h_{-1}). This corresponds to about 8% of the annual N_2O emissions from the Arabian Sea alone, and about 0.7 % of the annual global open ocean emissions. The global contribution of cyclone-triggered N_2O emissions from the North Indian Ocean should be even larger when including regions such as the Bay of Bengal (where there is also a large build-up of N_2O beneath the strongly stratified surface layer (Naqvi et al., 1994) and cyclones are far more frequent and intense than in the Arabian Sea). Therefore, we conclude that N_2O emissions triggered by strong wind events – cyclones in the North Indian Ocean and hurricanes in the ETNP – contribute significantly to both the regional and global oceanic N_2O fluxes. This contribution must be included in future model scenarios of oceanic N_2O emissions.

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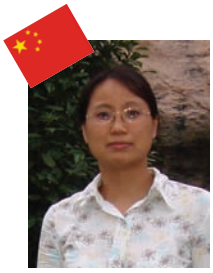
The International Ocean Carbon Coordination Project, sponsored by the Intergovernmental Oceanographic Commission of UNESCO and the Scientific Committee on Oceanic Research, promotes the development of a global network of ocean carbon observations for research through technical coordination and communications services, international agreements on standards and methods, and advocacy and links to the global observing systems.

Several IOCCP activities are carried out in collaboration with the Joint IMBER/SOLAS Carbon Research Working Group (or "SIC" for SOLAS-IMBER Carbon).

The Surface Ocean CO_2 Atlas (SOCAT) project is developing a common format dataset of all publicly available surface CO_2 data. This compilation currently includes data from more than 10 countries, producing an initial database composed of more than 1250 cruises from 1968 to 2007 with approximately 4.5 million measurements of various carbon parameters. The 2nd level quality-controlled dataset will be published in late 2009, and will be made available through Live-Access Server. The project will also develop a gridded product of monthly surface water fCO_2 means on a 1° x 1° grid with no temporal or spatial interpolation.

The Global Ocean Ship-based Hydrographic Investigations Panel (GO-SHIP), sponsored by the IOCCP, CLIVAR, and the SIC, brings together interests from physical hydrography, carbon, biogeochemistry, Argo, OceanSITES, and other users and collectors of hydrographic data, to develop guidelines and advice for the development of a globally coordinated network of sustained ship-based hydrographic sections, post-CLIVAR. One of the first tasks of the group is to update the 1994 WOCE Hydrographic Program Manual. Draft chapters of the manual will be made available on-line for open community review for a 3 month period, starting in September 2008.

For more information about these and other activities, please visit the IOCCP web-site (www.ioccp.org).



Jinhui Shi is an associate professor in Atmospheric and Environmental Sciences at Ocean University of China. Her research focuses on the influence of atmospheric depositions in nitrogen cycles of China Seas.

Water-soluble organic nitrogen in aerosols over the marginal seas of China in spring

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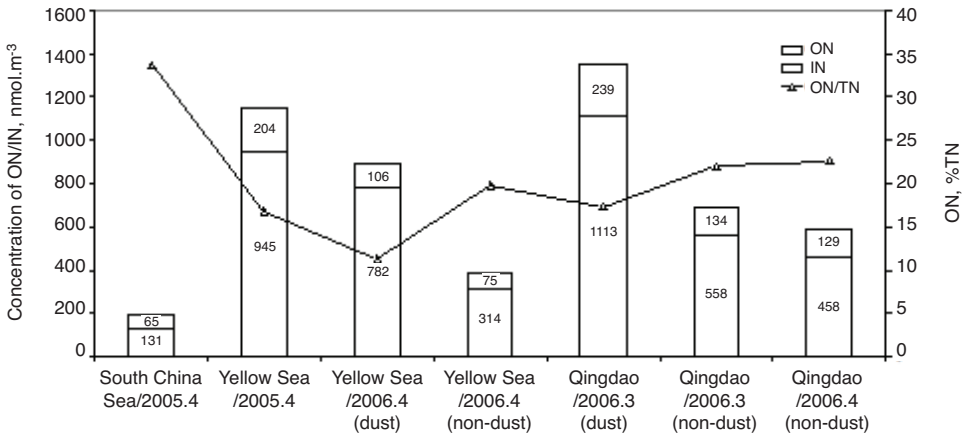
Organic nitrogen (ON) is an important component of aerosols at the marine boundary layer and hence contributes considerably to the nitrogen cycle in atmosphere and marine ecosystem (Cornell, 1995). Amino acids and urea are possible candidates of ON components which may have a significant influence on the marine ecosystem in terms of photosynthetic uptake, however, their contributions to the ON pool have not been quantified (Cornell, 2003). We characterized the water-soluble organic nitrogen (WSON), amino acids and urea in 26 total suspended particulate (TSP) samples and 11 size-segregated particles collected over the Yellow Sea, the South China Sea and at Qingdao located to the west coast of the Yellow Sea in spring, 2005 and 2006. Some of the samples provided an opportunity to investigate the influence of soil dusts on ON in aerosols.

Concentration of WSON ranged from 51 to 79 nmol m^{-3} and on average accounted for ~30% of the total nitrogen (TN) in TSP over the South China Sea (Fig.1). Over the Yellow Sea and Qingdao, concentration of WSON varied between 23-383 nmol m^{-3} and 69-475 nmol m^{-3}, respectively, and accounted for ~20% of TN in TSP. During the dust episodes, the concentrations of WSON significantly increased while the contribution of WSON to TN decreased. More than 70% of WSON was included in the < 2.1 μm fine particles (Fig.2) which indicated that WSON in the aerosols was mainly derived from gas-particle conversion and long-range transport from in-land sources. About 10% of the WSON in the marine aerosols was found in the 7.0-11.0 μm coarse particles suggested that a substantial fraction of WSON might be entrained from nearby sea-salt particles. In the dust aerosols, the contribution of WSON increased ~20% in the 2.1-4.7 μm coarse particles, suggesting ON might be entrained from large particles of soil or dust material and/or be combined with coarse mineral aerosols via adsorption.

Urea was an important component of ON in the aerosols collected from the marginal seas of China as it averagely represented ~8% of the ON. The concentrations of urea were 2.6~29.1 nmol N m^{-3} in these samples, higher than those reported in other areas of the world, which may be a consequences of local strong emission sources of urea induced by the large usage of urea fertilizer in China. Urea was



Λ Figure 1: Contributions of total ON to TN pool in marine and coastal aerosols.

present in both fine and coarse modes indicating possible contribution from gas-particle conversion of sublimed urea and wind-blown soil particles and/or sea-salt aerosols. During the dust periods, the concentrations of urea significantly increased and the contribution of urea also remarkably increased in the 2.1-4.7 μm coarse particles.

Free amino acids (FAA) only contributed ~1% of the total ON. The concentration of FAA was 201-1737 pmol N m^{-3} in the marine aerosols and 730-4342 pmol N m^{-3} in the coastal aerosols. The size distribution of FAA showed a bi-modal size distribution. Two peaks were presented in the range of 0.43-1.1 μm and 3.3-4.7 μm, respectively accounting for ~50% and ~10% of FAA. A uni-modal size distribution was observed during the dust episodes, with the peak of 2.1-3.3 μm, contributing ~25% to FAA.

Acknowledgements

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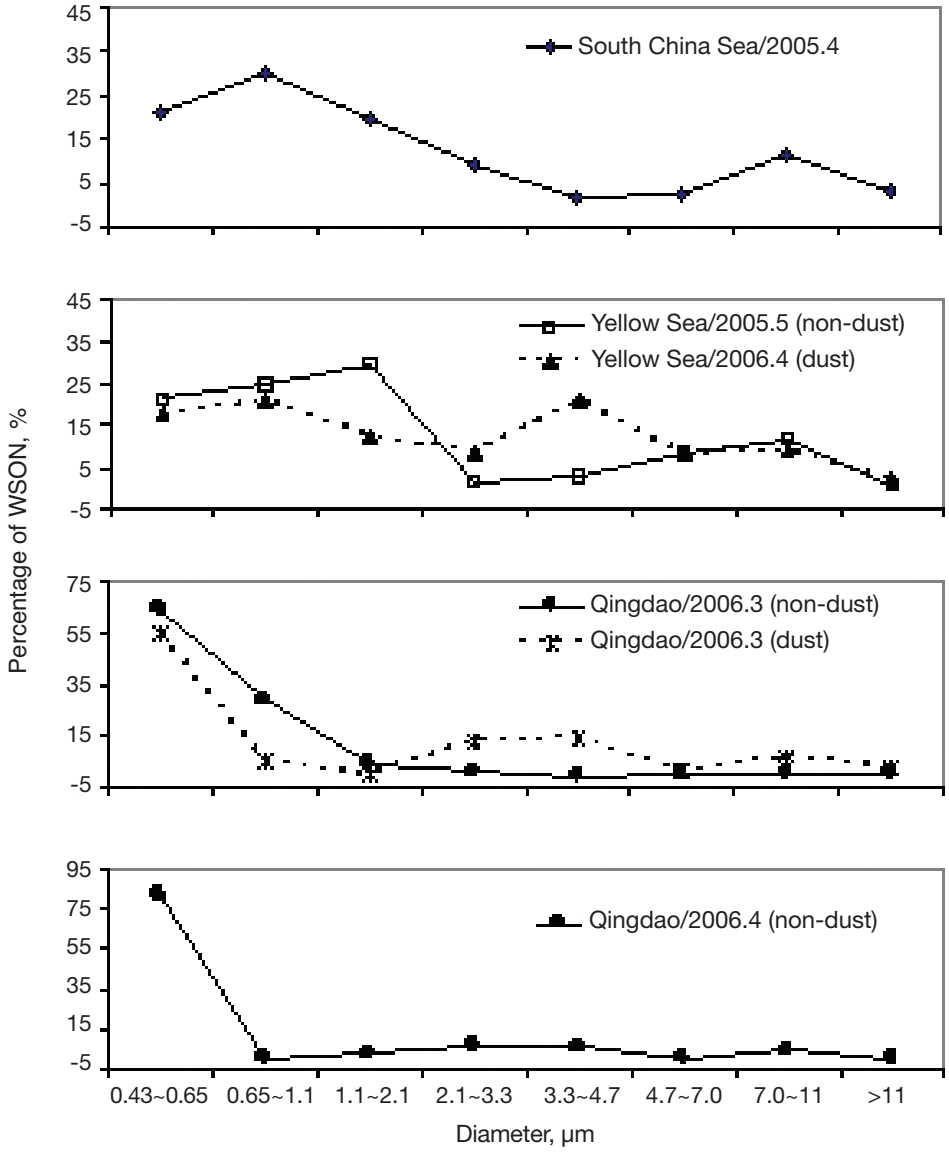

Λ Figure 2: Distributions of WSON in different size fraction of aerosols

national report

Finland

Finnish Research Institutes active in SOLAS-related activities include the Universities of Helsinki and Kuopio, the Finnish Meteorological Institute and the Finnish Institute of Marine Research. There is a strong involvement in the MAP (Marine Aerosol Properties) project; with modelling and experimental activities. Modelling includes nucleation, development of a sectional aerosol model and an aerosol dynamics scheme. Experimental activities include the characterization of aerosol physics: new particle formation through air ion; particle size distribution; hygroscopicity and CCN measurements. Sea spray covariance flux measurements are analyzed to develop a sea spray source function. At Mace Head, several instruments are deployed during an extended period including an aerosol mass spectrometer (AMS) for chemical analysis.

UHEL participated in the ICEALOT (International Chemistry Experiment in the Arctic LOwer Troposphere) project on the R/V Knorr during 18 March to 12 April. A high resolution AMS measured the chemical composition of sub-micron aerosol. Particle hygroscopicity and air ion mobility were also measured. The ICEALOT objective was to study the transport and evolution of pollutants to the Arctic region.

Physical and chemical factors affecting air-sea CO_2 exchange are studied through measurement of fluxes of CO_2, moisture, momentum and heat, wind waves and CO_2 partial pressure in sea water on RV Aranda, including other components (total inorganic carbon, total alkalinity, pH) of the carbon balance in the seawater. FIMR makes two to three cruises in the Baltic Sea per year. The Baltic Sea has strong seasonal variations in e.g. temperature, biological activity and wave climate, as well as strong hydrographical processes such as upwelling, affecting the carbon balance. Changes from coastal to open sea areas are also studied.

There is strong involvement in Antarctic and Arctic research including snow and sea ice.

National Representative:
Gerrit de Leeuw gerrit.leeuw@fmi.fi

Xiaoli Guo Larsén received a PhD in Meteorology from Uppsala University, Sweden in 2003, on the subject of Air-Sea Interaction. Since then she has worked as a Post-Doc and now as a scientist at Wind Energy Department, Risø National Laboratory for Sustainable Energy, Technical University of Denmark. She works mostly on the subject of extreme winds and offshore meteorology, by using observations, global and regional climate models and mesoscale modeling.

Temperature and humidity dissimilarity in the marine surface layer

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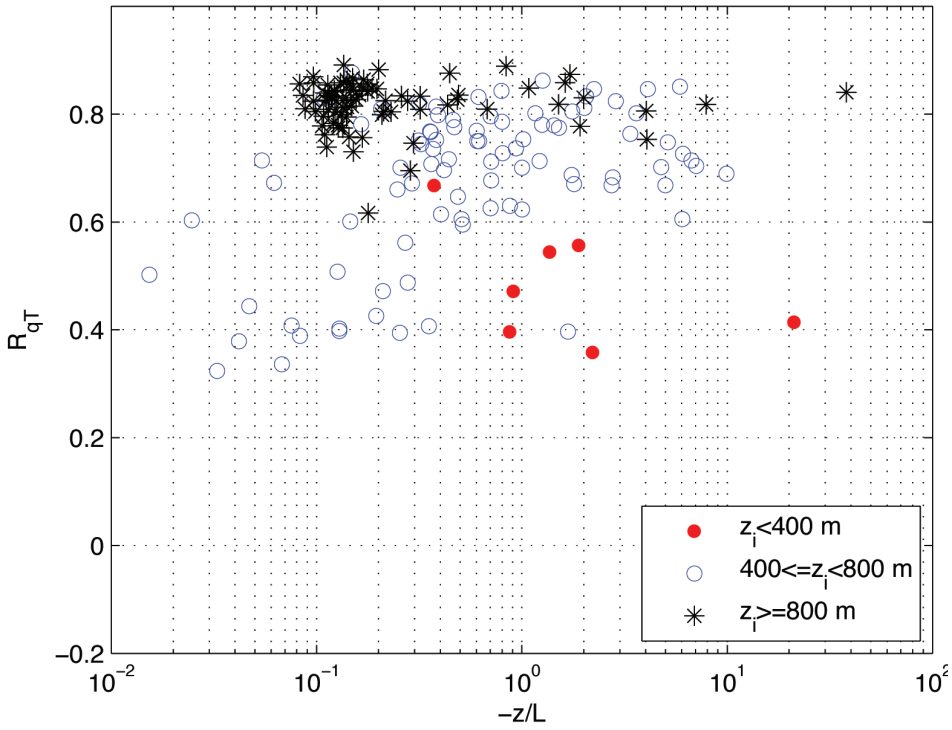
Water vapor is the most important greenhouse gas and it is involved in an important climate feedback loop. In the general circulation models, the surface water vapor flux is parameterized in terms of similarity theories for scalar fluxes. In these theories, it is assumed that there is a similarity between the exchange of the water vapor and that of the temperature.

The issue of scalar similarity and dissimilarity is fundamental and it has received significant attention for over three decades, see Katul et al. (2008) for an overview. The conditions of non-homogeneity in the humidity (q) and temperature (T) fields and non-stationarity in the latent and sensible heat (related to q and T, respectively) transfer processes contribute to the dissimilarity.

The method of co-spectral analysis has been used widely in the investigation of the significance of atmospheric motions at different scales/frequencies. Asanuma et al. (2007) examined the correlation coefficient of q and T in the spectral domain for the turbulence data collected over sparse grasslands on the Tibetan plateau. Here, we also use the spectral analysis for the correlation coefficient, as well as the relative transfer efficiency and the phase angle of q and T to data collected from a marine site in the Kattegat (refer to Sempreviva and Gryning 2000 for data details). Superior to many other studies, we have first-hand measurements of the height of the boundary layer, identified by visual inspection in radio-sounding profiles of temperature and humidity. Thus the data from three intensive measuring campaigns are examined in groups of different stability conditions with different boundary layer height.

As demonstrated in the current study, in the marine boundary layer, even over an undisturbed water fetch, the conditions of non-homogeneity in the field of q and T and non-stationarity in their transfer processes are often present. In Sempreviva and Gryning (2000), it was shown that there is a dependence of the mean correlation coefficient between q and T, R_{qT}, on the stability condition and an indication of the effect of the boundary layer height. Here with Figure 1 we clearly show the dependence of R_{qT} on the two parameters. The data are 30-min averages and from 22-m height. Obviously, q and T are best correlated when the boundary layer top is high and when it is of not-too-neutral stability conditions. When the boundary layer top is lowest, q and T are badly correlated. This is speculated as a result of the impact of boundary layer scale transfer processes that break the assumption of "same source, same sink" for scalars. This speculation is supported by our spectral analysis where one can see the energy containing range is affected by the low frequency (large scale) fluctuations at the presence of a low boundary layer top.

The third group in blue circles in Figure 1 is data with moderate boundary layer height, and the corresponding correlation coefficient R_{qT} is varying between those of the other two groups at similar stability conditions. One significantly interesting feature with the blue circle group is that there is a considerable scatter of R_{qT} with generally low values at the unstable but close to neutral condition. At this condition, in the marine surface layer, there is very limited sensible heat exchange but persistent latent heat exchange from the local surface processes. In addition, at this condition when the winds are often strong,



Λ Figure 1: The correlation coefficient of humidity and temperature, R_{qT}, is plotted versus the surface stability parameter $-z/L$, where z is the height above the surface, here 22m, L is the Obukhov length. Data are grouped according to boundary layer height, z_i: high (*), moderate (o) and low (•).

sea spray contributes significantly to the latent heat close to the water surface. It is at this condition, which was termed as "the unstable very close to neutral regime" by Smedman et al. (2007), Smedman et al. found that the sensible heat flux differs from that predicted from the classical surface layer theory. They found in the co-spectra of the sensible heat flux, accompanying the change of stability from unstable to very neutral, there is a transition of the dominant eddies from the low frequency at the scale of the boundary layer height to the high frequency. They interpreted it as high-speed air from above the surface layer is engulfed into the surface layer and brought down to the surface as detached eddies, and this plays an important role for the exchange of sensible heat. These processes giving different sources and sinks to the sensible and latent heat in the marine surface layer determines that the standard surface flux parameterization by the similarity between *q* and *T* is problematic.

The method of examining the *q*-*T* correlation in the spectral domain has shown to be of great use in understanding the impact of the atmosphere motions of different scales. This method will be extended to study the correlation between other scalars, e.g. CO_2 and *T*.

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Géraldine Sarthou earned her PhD in marine geochemistry at Paul Sabatier University (Toulouse, France) in 1996 and performed postdoctoral research in the UK (University of Liverpool), Germany (GEOMAR, Kiel), and France (LEMAR UMR 6539, Plouzané). She is currently a research scientist at LEMAR, where she leads the "Physics and Biogeochemistry in the Open Ocean" group. Her research interest includes the quantification of the various sources of iron to the surface ocean (e.g. the atmospheric input) and the interactions between these sources, the iron speciation and bioavailability, and the food web.

Biogeochemistry of iron at the Ocean-Atmosphere interface; Interactions between atmospheric iron inputs and food web

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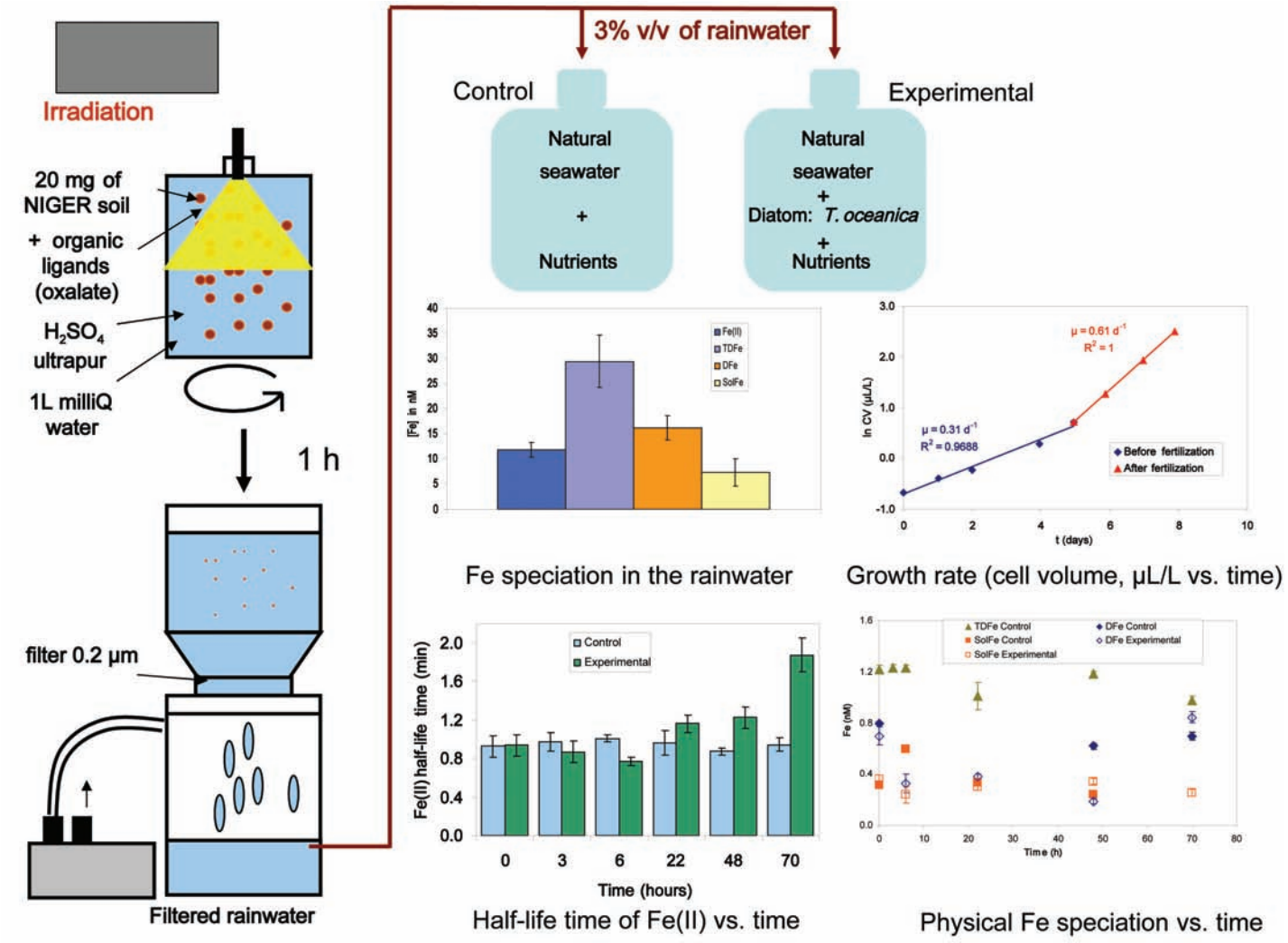
Artificial and natural Fe fertilisation experiments univocally demonstrated the key role of Fe in the structure and functioning of marine ecosystems (Boyd et al., 2007; Blain et al., 2007). The abundance as well as the bioavailability of Fe are controlled by a combination of processes including the sources, the sinks, and the internal cycling that remain largely unknown. In many open-ocean regions the input of new iron to the surface waters is dominated by dust deposition, mainly from the great deserts of the world (Duce et al., 1991; Jickells et al., 2005). As deserts are thought to be very sensitive to global change, their impact through iron deposition may alter ocean productivity and hence climate in the next decades, as it might have been the case in the past .

However, an important parameter that controls the impact of these atmospheric inputs on the ecosystem is Fe speciation in the oceanic surface layer, although the bioavailability of the different Fe species (soluble/colloidal/particulate, Fe(II)/Fe(III) and Fe bound to organic ligands) still needs to be determined. In order to better constrain our predictions of the ocean response to climate changes, one of the main issues is then to better understand and quantify how the coupling between the ocean and the atmosphere will influence the chemical, physical, and biological processes that govern the speciation and bioavailability of Fe from the atmosphere.



Λ Figure 1: Results of an experiment carried out within the BOA project coupling rainwater inputs, iron speciation and biological activity.

The main objective of the BOA project is to improve our knowledge on the biogeochemistry of Fe at the air-sea interface in order to better understand and quantify interactions between the atmospheric Fe cycle, its chemistry in the ocean and the food web. The biogeochemical cycle of Fe is here described with a complete and innovative point of view. On one hand its chemistry is studied and quantified in all its atmospheric and oceanic aspects (redox, organic, and physical speciation), and, on the other hand, its interactions (bioavailability/regeneration) with food web (from bacteria to zooplankton) is considered. This multidisciplinary project includes atmospheric chemistry, biogeochemistry, and biology (with a genomic and proteomic approach), in addition to a very strong methodological development (ICP/MS, Flow Injection Analysis, voltammetry, microplate, …).

Using both experimental and modelling approaches, we (i) exhaustively characterize the physico-chemistry of Fe in atmospheric wet and dry depositions, (ii) quantify the physico-chemical processes (biotic and abiotic) that control Fe transfers at the sea-air interface, (iii) study interactions between atmospheric inputs, Fe speciation and bioavailability, and biological activity (phytoplankton, bacteria), (iv) study feedbacks of biological activity (phytoplankton and bacterial growth, zooplankton grazing) on Fe speciation and bioavailability, and (v) study the impact of all these processes on the global carbon cycle.

So far, our studies showed the crucial role of the mineralogy for iron dust dissolution (Journet et al., 2008), together with the organic matter within both the atmospheric and seawater phases (e.g. Wagener et al., 2008). Process studies for the interactions between iron and biological activity showed a strong bacterial response to dust pulses from both *in vitro* and *in situ* approaches (Pulido-Villena et al 2008), as well as the impact of phytoplankton growth on the stability of Fe(II) and on the colloidal Fe concentrations (Chever et al., 2008).

One of the major results of the BOA project will be the significant improvement of the parameterisation of global models of the carbon cycle, taking into account the biogeochemical cycle of Fe from its atmospheric input to its interactions with biological activity.

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http://www.univ-brest.fr/IUEM/UMR6539/prog_scientif/boa/boa_uk.htm

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- Climate-sensitivities of biogeochemical cycles and interactions with ecosystem structure

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- Terrestrial/coastal carbon fluxes and exchanges
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July 20-23, 2009:
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A key objective of the OCB Project Office is to strengthen ties to related national and international activities, such as Surface Ocean Lower Atmosphere Study (SOLAS), Global Carbon Project (GCP), Integrated Marine Biogeochemistry and Ecosystem Research (IMBER), U.S. Carbon Cycle Science Program (USCCSP), North American Carbon Program (NACP), CARBOOCEAN, GEOTRACES, and International Ocean Carbon Coordination Project (IOCCP). Current OCB partnership activities include partial support of an IMBER IMBIZO focused on the mesopelagic November 9-13, 2008 (Miami, FL), an IOCCP time-series workshop November 5-7, 2008 (La Jolla, CA), and an international workshop to develop a best practices guide for ocean acidification research November 19-21, 2008 (Kiel, Germany). The Project Office is also assisting in the coordination of a coastal synthesis for the NACP Interim Synthesis Activities. **www.us-ocb.org**

In Focus

In this issue of SOLAS News, we give you the chance to meet some of the national representatives of the SOLAS community. We wish to introduce to you: Katarina Abrahamsson (Sweden), Giovanni Daneri (Chile), Søeren E. Larsen (Denmark), Kitack Lee (Korea), Maurice Levasseur (Canada), Abdiraman Omar (Norway) and Amauri Periera de Oliveira (Brazil).

Katrina Abrahamsson - Sweden

Katarina Abrahamsson studied chemistry and biology at Göteborg University, where she also took her PhD in chemistry 1990. She then worked as Assistant Professor at Göteborg University and became "docent" in Marine Chemistry in 1996. In 1998 Katarina was employed at Chalmers, first as Associate Professor and in 2001 as "biträdande professor". She is head of a research group within Analytical Chemistry, specialising in environmental and bioanalytical chemistry and has been appointed as Professor of Analytical Chemistry, since 2004. Contact: k@chalmers.se

Giovanni Daneri - Chile

Giovanni Daneri is Executive Director of the Centro de Investigacion en Ecosistemas de la Patagonia (CIEP) a regional research Center located in Coyahique in the Chilean Patagonia and is a Research Associate of the Center for Oceanographic Research in the Eastern South Pacific (COPAS) of the University of Concepcion, Chile. He received his PhD in 1992 in biological oceanography from the University of Southampton, England. He has studied Primary and Bacterial Secondary Production in the Humboldt Current System off Chile and is now working on Fiord pelagic ecology in Patagonia. His research group is actively working on the bacterial response to phytoplankton productivity and its effect on bulk parameters such as fCO_2 and dissolved organic carbon. Contact: gdaneri@udelmar.cl

Søeren E. Larsen - Denmark

Søren Larsen's research is focused on boundary layer meteorology, notably within the atmospheric marine boundary layer and its exchange with the ocean. As such he has worked with the air-sea exchange of gases and aerosols, as well as heat and energy, with associated description of the surface waves, recently supplemented with technical and environmental questions associated with offshore wind farms. After a Masters in Engineering Physics, he received his PhD in Micrometeorology from the Technical University of Denmark (DTU) in 1971. Since, he has been employed by Risø National Laboratory, the University of Washington Seattle and Navy Post Graduate School Monterey. At Risø DTU, he was head of a Meteorology program and is presently working on an expansion of the educational activities there; specifically within wind and other renewable energies. He has participated in and coordinated several international projects such as the EUROTRAC Air-sea Exchange projects. Presently, he works on measurements of air-sea exchange of CO_2; mesoscale variability in the marine atmospheric boundary layer; and the development of internal boundary layers in the coastal zone and around wind farms. He has written about 600 publications with about 100 in refereed journals. Contact: Soeren.larsen@risoe.dk

Kitack Lee - Korea

Kitack Lee received his Ph.D. in 1996 in marine chemistry from the Rosenstiel School of Marine and Atmospheric Science of the University of Miami, USA. He has studied the thermodynamics of inorganic carbon and associated species in the open ocean and has verified algorithms that are essential in global carbon cycle modeling. His research group has recently become engaged in using deliberate tracers to study physical and chemical processes. This is a relatively new and powerful approach in chemical oceanography to mark water masses and perform detailed process studies. His group has also recently involved in studying the effect of rising CO_2 on phytoplankton using a mesocosm facility. He currently works as Associate Professor at the School of Environmental Science and Technology of Pohang University of Science and Technology, Korea. Contact: ktl@postech.ac.kr

Maurice Levasseur - Canada

Maurice Levasseur obtained a BA. in Biology and a MSc. in Marine Biology at University Laval, and a Ph.D. in Oceanography at the University of British Columbia. He then researched as Head of the Primary Production Section at the Maurice Lamontagne Institute of Fisheries and Oceans. Trained as an algal ecophysiologist, he soon became curious - and then addicted – to the intricate role of planktonic organisms on the oceanic production of DMS and on climate. In 2002, he moved to University Laval to hold the Canada Research Chair on Plankton-Climate Interactions and took the leadership of the Strategic Network Quebec-Ocean. He contributed to the launch and became chair of the Canadian SOLAS Network; co-chaired the implementation of the SOLAS Focus I and recently co-chaired the SOLAS Workshop on the Comparison of DMS models (CODiM). He is currently leading the Canadian Arctic SOLAS program and a new joint program with China on the impact of Asian dust on the North Pacific Ecosystem. Contact: Maurice.levasseur@bio.ulaval.ca

Abdiraman Omar - Norway

Abdirahman M. Omar born and grew up in Somaliland. He obtained his MSc. in Optics and Laser Physics and PhD. in Chemical Oceanography at University of Bergen (UiB), Norway. Currently, he holds a post-doctoral position shared by the Geophysical Institute and Bjerknes Centre for Climate Research, UiB. His areas of interest include the response of the oceanic carbon sink to the increasing atmospheric carbon dioxide (CO_2) and the role of sea-ice and brine formation in the oceanic uptake of atmospheric CO_2. His current research is based on marine carbon data gathered from different shelf and marginal seas by scientific cruises and/or Voluntary Observing Ships (VOS). He has been Norway's National Representative for SOLAS, since 2006.
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Amauri Periera de Oliveira - Brazil

Amauri Periera de Oliveira received his Ph.D. degree in Meteorology in 1990, in the State University of New York, at Albany, USA. His Ph.D. thesis investigated the Amazon Boundary Layer. His scientific activities are concentrated into investigating turbulent transport processes in the planetary boundary layer; applied to understand the local circulation over continental regions and the air-sea interaction between the atmosphere and ocean in tropical and subtropical regions of Brazil. He participated in and coordinated several field campaigns in Brazil and is now involved in research projects to carry out turbulence measurements in Atlantic Tropical. Contact: apdolive@usp.br

Bernd Schneider studied Chemistry at the University of Kiel, Diploma in Physical Chemistry, PhD degree at the Institute for Marine Research in Kiel (1979) on the enrichment of trace elements in the sea surface microlayer. For about 10 years he researched on the atmospheric deposition of trace metals onto the sea surface. Since 1993 he is head of the research group "The Marine CO_2 System and Air/Sea Gas exchange" at the Leibniz Institute for Baltic Sea Research in Warnemuende (Germany). His research concentrates on the use of the marine CO_2 system for the identification and quantification of biogeochemical processes and on gas exchange processes in the Baltic Sea.

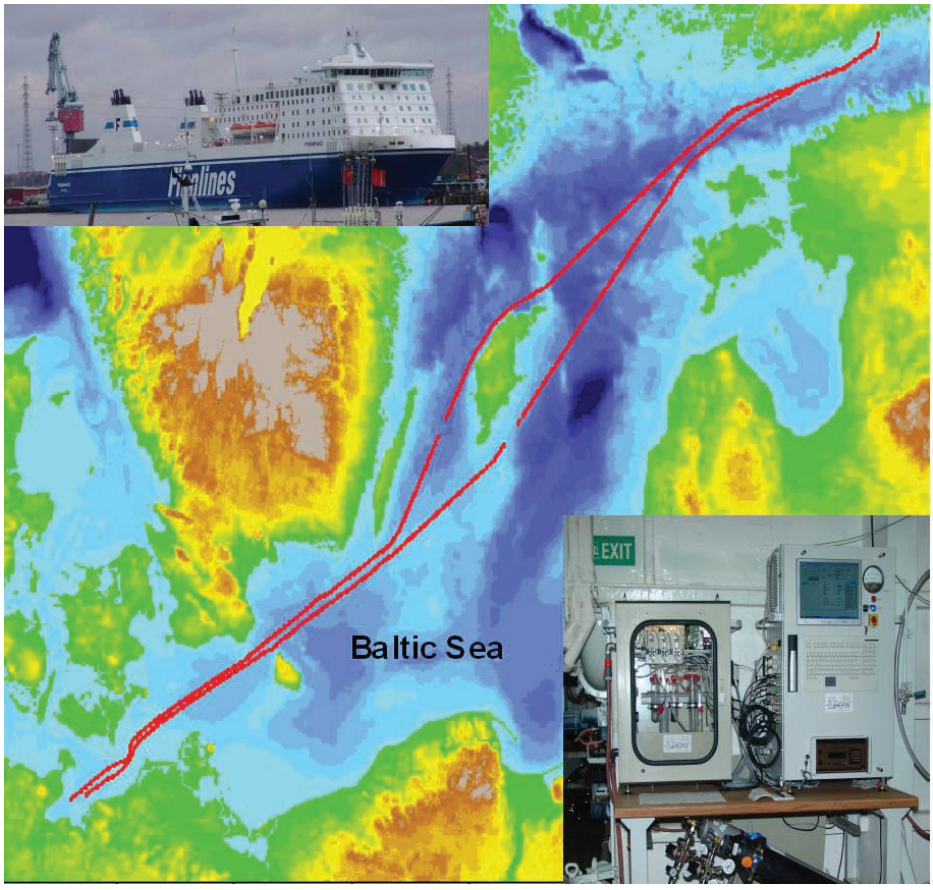
The gas exchange transfer velocity determined by CO_2/O_2 measurements on a cargo ship in the Baltic Sea: Revival of Liss/Merlivat?

Bernd Schneider, University of Rostock, Baltic Sea Research Institute, Germany Contact: bernd.schneider@io-warnemuende.de

A fully automated measurement system for recording the surface water CO_2 partial pressure, pCO_2, was deployed on a cargo ship in 2003 in cooperation with the Finnish Algaline Project. The ship commutes regularly at two-day intervals between the Mecklenburg Bight in the southwest and the Gulf of Finland in the northeast of the Baltic Sea (Fig.1). The spatial resolution of the measurements amounted to 1 – 2 nautical miles. The investigations aimed at three major goals:

1. Identification of plankton bloom events and quantification of the net biomass production by a CO_2 mass balance (Schneider et al., 2003) with special emphasis on the nitrogen fixation period;
2. CO_2 gas exchange calculations and identification of the Baltic Sea as a sink or source for atmospheric CO_2; and,
3. Estimates of the gas exchange transfer velocity.

To achieve the latter goal, the measurement system was complemented by a module for the determination of the O_2 partial pressure (Schneider et al., 2007). Fig.2 shows the O_2 data (percentage O_2 saturation) as a function of the pCO_2 along two transects in winter and in spring 2006. Due to the maximum of the convective mixing, the February pCO_2 indicated oversaturation with regard to the atmospheric CO_2 whereas O_2 undersaturation was observed along the entire transect. Both the CO_2 and O_2 winter data were confined to a narrow range indicating a rather homogenous distribution. Due to the spring bloom production, low pCO_2 and high pO_2 were observed in May. The wide range of data reflect regional differences in the development stages of the spring bloom, in the vertical mixing characteristics and in the availability of nutrients. The distinct relationship between the CO_2 and O_2 data is a consequence of CO_2 consumption and O_2 production during photosynthesis. However, the relationship does not necessarily reflect the stoichiometry of the photosynthesis because it is affected by gas exchange. Since O_2 is much faster equilibrating with the atmosphere than CO_2, the relationship between CO_2 and O_2 changes with time and can therefore be used to estimate the gas exchange transfer velocity. Mass balance equations for CO_2 and O_2 were formulated which related the temporal change in total CO_2 and O_2 concentrations to the net biomass production and to the air/sea gas exchange.



Λ Figure 1: Route of VOS "Finnmaid" and the measurement system consisting of the "wet" unit (left) for the CO_2 and O_2 equilibrators and the dry unit (right) with the IR CO_2 analyzer and the control system

The two equations allowed the independent determination of both the mean transfer velocity (k_{660}) and the biomass production for a given time interval. For the calculations, we used spring bloom CO_2 and O_2 data from the eastern Gotland Sea where a distinct thermocline prevented mixing with deeper water layers and where intense production generated strong CO_2 and O_2 signals. Furthermore, it was assumed that the molar ratio between the photosynthetic O_2 release and the consumption of CO_2 was 1.6. Based on data from five time intervals during a three-week period, k_{660} were calculated and related to wind speed (u) which varied between 3 ms^{-1} and 8 ms^{-1}. Assuming a quadratic dependency, a least square fit yielded: $k_{660} = 0.20 * u^2$. Comparing this equation with other currently used

parameterizations of k_{660}, the best agreement was found with the linear Liss and Merlivat (1986) approach. However, our findings are based on the analysis of only one episode and we are aware that final conclusions require a broader data base and confirmation by other methods which are the objectives of our SOPRAN (SOLAS) Project.

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Acknowledgements

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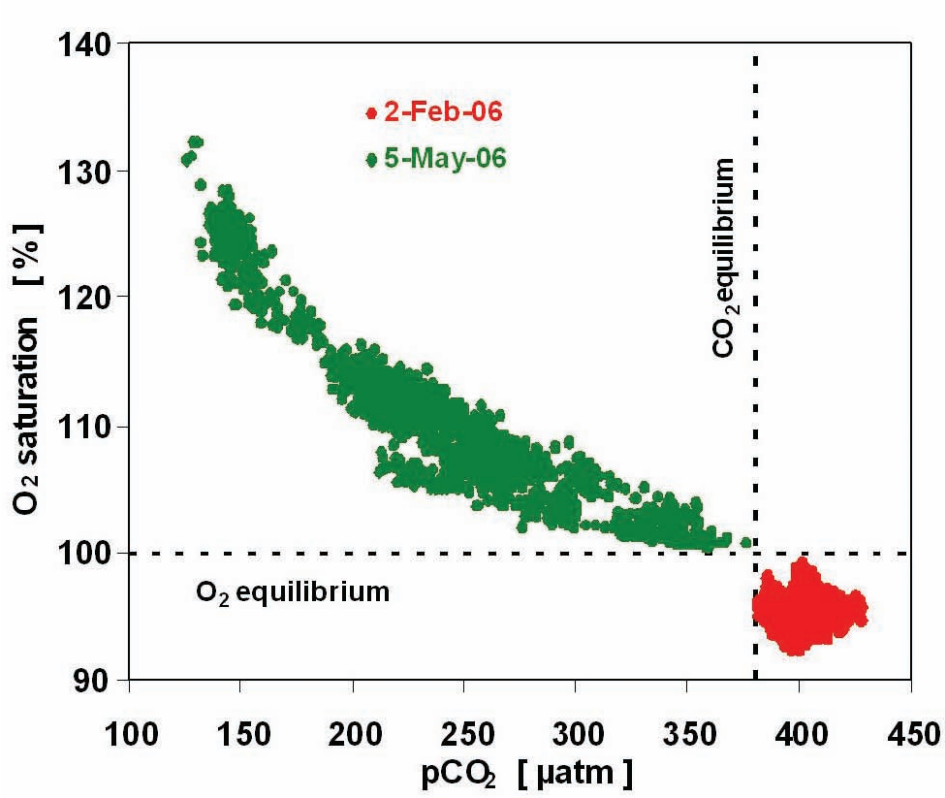

Λ Figure 2: O_2 saturations versus pCO_2 for two transects in February and May 2006. The dashed lines indicate CO_2/O_2 equilbria between surface water and the atmosphere.

COST Action 735: Short Term Scientific Missions

COST Action 735 provides opportunities for young scientists to collaborate with senior researchers on short one to two week Short Term Scientific Missions (STSMs). These STSMs are based around the COST 735 working group foci and aim to promote an international community of young scientists working within the scope of the COST foci. The STSMs also offer a chance for young scientists to develop data sets, experimental methods, and gas flux product development.
For more information visit www.cost-735.org/science/STSM.html'

partner projects

Asia-Pacific Network for Global Change Research (APN)

The APN was established in 1996 as a network of member governments in the Asia-Pacific region to foster global change research, increase developing country participation in that research, and strengthen interactions between the science community and policy-makers. To date, 21 countries have joined the network and APN has financially supported 171 research and capacity building projects in the past 12 years.

This year, the APN has launched its 2008 Annual Calls for Proposals under the ARCP and CAPaBLE Programmes and the special Call for Comprehensive Research Proposals. Currently supporting 20 projects under ARCP, 13 capacity building activities and 3 comprehensive research projects, the APN is able to promote research and capacity enhancement activities on global changes in climate, ocean and terrestrial systems, and on related physical, biogeochemical and socio-economic processes. In so doing, the APN contributes to the development of policy options for responses to global change that leads to sustainable development.

APN's contribution to Global Change (GC) science and to policy development through research is evident with a lot of APN funded research and project outcomes cited in the IPCC Fourth Assessment Report. The APN has also been engaged in a number of outreach activities since the adoption of its Second Strategic Plan in 2005, linking its ideas, practices and activities to the efforts of other organisations, groups, specific audiences and the public at large. Publications are also being produced and disseminated to policy-makers and the public to provide scientific information and encourage involvement in APN activities.

The APN plays a significant role in supporting GC research in the region and now has a successful 12-year record of promoting cooperation and enhancing scientific research capacity, particularly in developing regions, with the active involvement of it members and the collaboration of other GC Programmes. In the next years, the APN will continue to build on these foundations and focus on achieving its mission and goals in the most effective and efficient way.

For more information about the APN, please visit: http://www.apn-gcr.org/en/indexe.html.

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Vedula VSS Sarma received a PhD in Marine Chemistry from the University of Goa in 1998. After holding a Post-Doc position at University of Aix-Marseille III, France, he moved to Nagoya University, Japan, and worked for six years on triple isotopic composition of dissolved oxygen to understand plankton metabolic balance in the western North Pacific. Recently in 2007, he moved to the National Institute of Oceanography Regional Centre, Visakhapatnam, India and is aiming to understand biogeochemical cycling of carbon and nitrogen in the rivers, estuaries and Bay of Bengal, northeastern Indian Ocean.

Spatial variations in time-integrated plankton metabolic rates using triple oxygen isotopes and O_2:Ar ratios

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Marine primary production accounts for about 50% of total carbon fixation in the biosphere. Out of this, most of the primary production (about 60-90%) is respired by heterotrophs in the upper few meters (Laws et al. 2000). The balance between gross primary production (GPP) and community respiration (R) dictates whether oceans are net sources or sinks of CO_2 to the atmosphere. Several studies have suggested that metabolic processes are substantially out of balance in the open ocean regions, i.e., respiration is higher than production (del Giorgio and Durate 2002) while coastal oceans are net autotrophic (Ducklow and McAllister 2005). However, both opinions are hotly debated. Karl et al (2003) observed existence of dominant heterotrophy in the oligotrophic subtropical Ocean (Hawaii Ocean Time Series station) and attributed to missing of episodic high productivity events in the incubation experiments that may support net heterotrophy in oligotrophic regions. However, the importance of such events cannot be assessed accurately on the basis of any single sampling because of the short time period covered by incubations.

Recently, triple oxygen isotopes of dissolved O_2 and the dissolved O_2:Ar ratio have been used as a tracer to estimate GPP and net to gross production ratios (N:G) in the mixed layer (Hendricks et al. 2004; Sarma et al. 2005; 2006*a,b*, 2008). Unlike traditional incubation methods, this multiple tracer approach measures ambient dissolved O_2, in the absence of incubation, and the resulting isotope and concentration data reflect all productivity and respiration that occurred over the residence time of O_2 in the water column (Luz and Barkan, 2000). Here we report first measurements on basin wide plankton metabolic balance in Sagami Bay, Northwestern Pacific.

Figure 1a shows surface Chl *a* concentrations, which ranged from 1 to 10 mg m^{-3} and decreased from coastal to offshore regions. Higher oxygen-saturation was observed in the coastal than in the offshore regions (Fig. 1b). The fact that the distribution of oxygen saturation well associated with Chl *a* suggests that oxygen saturation was mainly due to phytoplankton production. Based on the mixed layer depth and sea to air flux of O_2, the residence time of oxygen in the mixed layer in the study region varied from 8 to 14 days in Sagami Bay during study period.

Three processes control the $\delta^{18}O$ distribution in the surface waters: biological oxygen production, community respiration, and air-sea exchange. Since lighter $\delta^{18}O$ is produced during photosynthesis, higher rates of production relative to respiration result in lower $\delta^{18}O$ values. Community respiration increases $\delta^{18}O$ due to the preferential consumption of ^{16}O (Bender, 1990) while air-sea exchange drives dissolved $\delta^{18}O$ towards the close to atmospheric equilibrium ($\delta^{18}O$ = 0.8 per mil at 25°C). Therefore, the distribution $\delta^{18}O$ in dissolved oxygen in the surface waters indicates which of these processes are predominant in the water column.

The oxygen isotopes samples were collected using high spatial resolution underway sampling system recently developed by Sarma et al. (2006b). The distribution of $\delta^{18}O$ values in Sagami Bay shows that coastal waters have relatively lower $\delta^{18}O$ values (<-0.3 per mil) compared to offshore (>-0.1 per mil) suggesting higher production in the coastal regions (Fig.1c). Slightly more than equilibrium $\delta^{18}O$ values are found (0.9 to 1.1 per mil) in the southwestern Bay, where O_2 under-saturation was observed which could be due to a dominance of respiration over production.

The $^{17}\Delta$ anomaly ranged from 27 to 155 per meg relative to atmospheric O_2 in Sagami Bay (Fig.1d). The highest anomaly was found (155 per meg) in the coastal compared to the offshore (27 to 57 per meg). The $^{17}\Delta$ anomaly in the mixed layer is influenced by in situ GPP and influx of oxygen from the atmosphere. However, the distribution pattern of $^{17}\Delta$ anomaly is consistent with Chl *a*, and oxygen saturation suggesting a predominant influence of biological production on the $^{17}\Delta$ anomaly relative to air-sea exchange. The GPP estimated based on Luz and Barkan (2000) model varied from 34 to 963 mmol O_2 m^{-2} d^{-1} in the mixed layer with higher production rates in the coastal regions (Fig.1e). The ratio of net to gross production (N:G) indicates the fate of photosynthetic products in the upper layer. A higher N:G ratio indicates that a large portion of photosynthetically produced carbon is eventually exported to deeper layers or lost to the atmosphere, whereas a lower ratio indicates that most of the product is consumed in the upper layers and a lower fraction is exported. In addition, a negative value for N:G suggests that the system is heterotrophic, i.e., community respiration is greater than primary production. N:G ratios in Sagami Bay varied from -0.5 to 0.28, with higher

ratios in the southeastern Bay and lowest ratios in the southwestern Bay in the rest of the Bay (Fig. 1f). Negative N:G ratios in the southwestern bay are consistent with low oxygen saturation (~97%) and heavier $\delta^{18}O$ (~1.1 per mil), suggesting that community respiration was dominant over production during the study period.

This study suggests that spatial scale variability in the plankton metabolic rates can be more accurately estimated using triple oxygen isotopes and O_2:Ar ratios in the mixed layer. Estimation of such rates on monthly to seasonal scale will give us unique information on how plankton metabolic carbon balance occurs in the ecosystem, and the strength of biological pump in carbon sequestration with less ambiguity.

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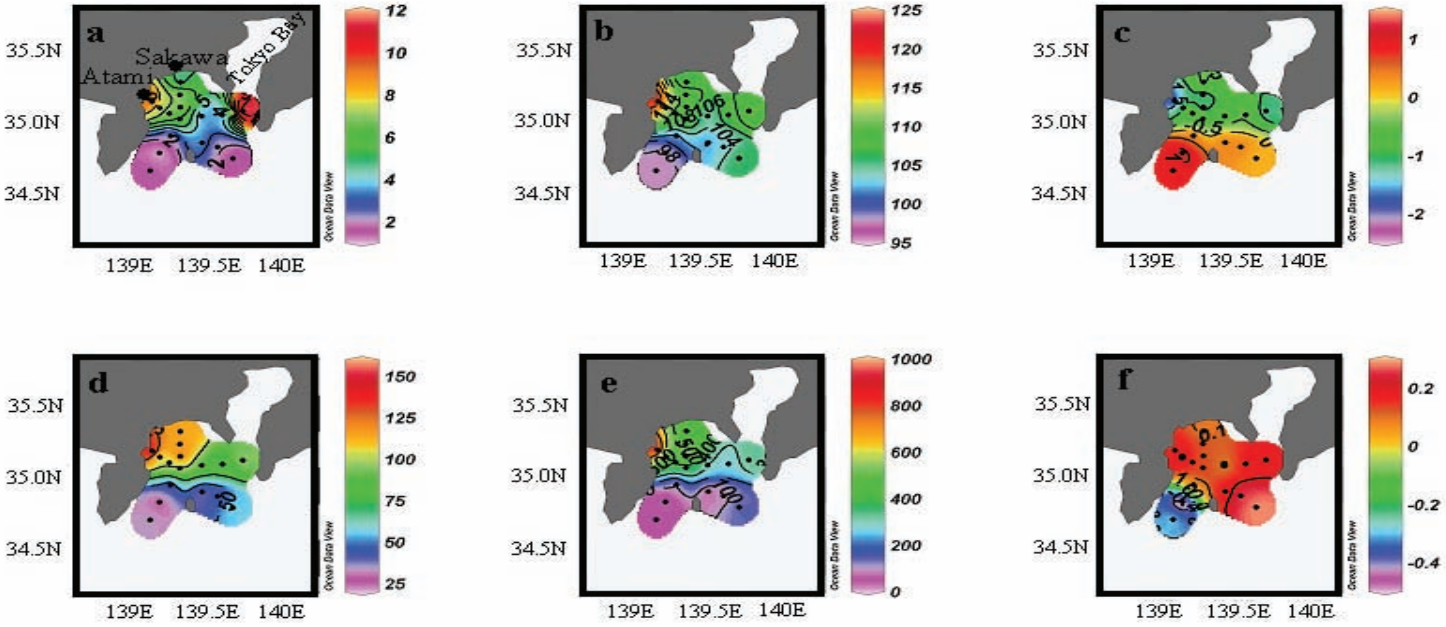

Λ Figure 1: Spatial variations in a) Chlorophyll-a (mg m^{-3}), b) dissolved oxygen saturation, c) $\delta^{18}O$ (per mil), d) $^{17}\Delta$ anomaly (per meg), e) GPP and f) N:G ratios in the Sagami Bay during May 2006.

Maria Cristina Facchini is a Senior Scientist at the Institute for Atmospheric Sciences and Climate of the Italian National Research Council (ISAC-CNR), in Bologna. Her research interest is in the physical and chemical processes of multiphase atmospheric systems (aerosols and clouds), in particular the influence of organic aerosol chemical properties on aerosol hygroscopicity and CCN activity.

New insights into organic marine aerosol

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The marine aerosol constitutes one of the most important natural aerosol systems at the global level and comprises of organic and inorganic components of primary and secondary origin. Primary aerosol is generated via bubble bursting processes at the ocean surface, caused by wind stress. Secondary components result from gas-to-particle conversion processes, the most relevant of which is the oxidation of gaseous reduced sulphur to particulate sulphate and methanesulphonic acid (MSA). Concerning secondary organic aerosol (SOA), beside MSA, several oxidation mechanisms from isoprene or other natural VOC have been proposed, but a relevant fraction of the observed concentrations of oxidized organic matter in marine aerosol still remains unaccounted, suggesting that other formation mechanisms and alternative SOA components should be considered.

Here, some new results on organic marine aerosol obtained within the European Project MAP (Marine Aerosol Production, http://macehead.nuigalway.ie/map/) and recently published in literature (Facchini et al., 2008a; b) are summarised.

These observations confirmed previous evidences that the concentration of primary and secondary organic aerosol components in the clean marine atmosphere is driven by the seasonality of oceanic biological productivity (O'Dowd et al., 2004).

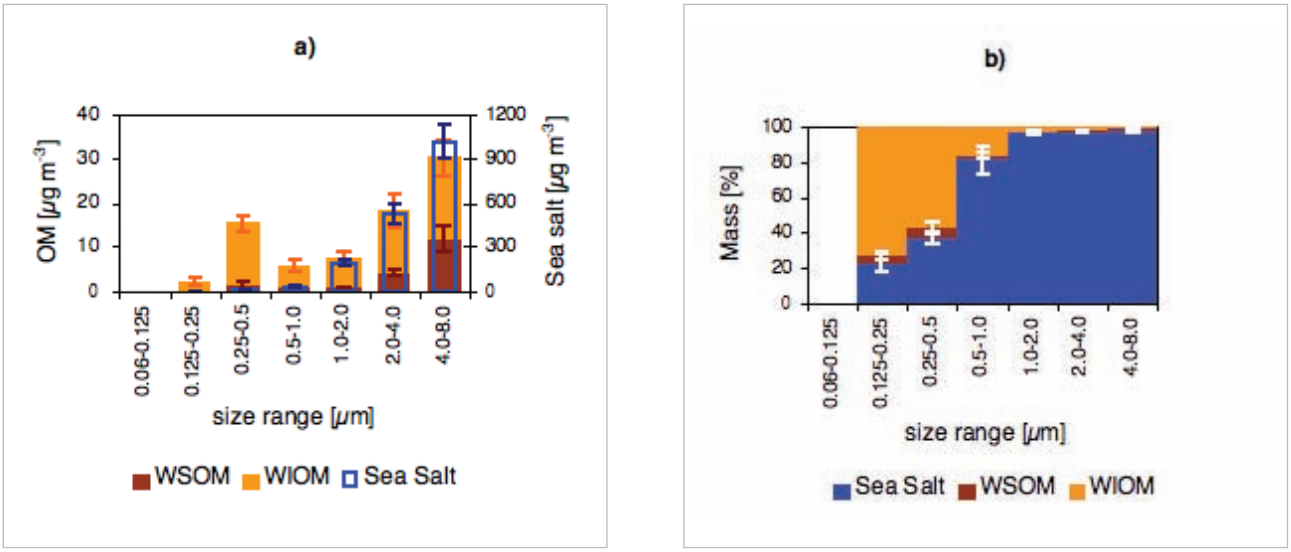
Primary organic marine aerosol

The chemical properties of sea-spray aerosol particles produced by artificially generated bubbles using oceanic waters rich of organic matter during period of phytoplankton bloom were investigated through an experiment carried out in the North Atlantic on board the oceanic vessel Celtic Explorer (Figure 1).

Spray particles exhibited a progressive increase in the organic matter (OM) content from 3±0.4% up to 77±5% with decreasing particle diameter from 8 to 0.125 µm (see Figure 2). The OM transferred within the submicron particles generated by bubble bursting was mainly water insoluble (WIOM) (on average 94 ± 4% of total carbon), while the organic water soluble fraction (WSOM) increased its contribution (up to 33±3%) of total carbon in the coarse size interval (4-8 µm). WIOM was found to be composed of phytoplankton exudates-lipopolysaccarides occurring in seawater as fine particulate organic matter (POM) or large colloids. The results of this experiment indicate that the partitioning of OM between WIOM and WSOM in primary marine aerosol is regulated by similar mechanisms as for oceanic POM and DOM (dissolved organic matter), and that aggregation processes of OM and their surface-active properties control the observed size-dependent enrichment of insoluble material in the finest aerosol size intervals. The pattern of WIOM and sea-salt content in the different size intervals observed within the bubble bursting experiments is similar to that measured in atmospheric marine aerosol samples collected during periods of high biological activity (HBA), pointing to a WIOM/sea-salt fingerprint associated to submicron primary marine aerosol production in biologically rich waters.

Secondary organic nitrogen marine aerosol

A new secondary organic aerosol component, produced through the reaction of gaseous amines with sulphuric acid has been found in marine aerosol over the North Atlantic. Dimethyl and diethyl ammonium salts (DMA^+ and DEA^+) are the most abundant organic species, second only to MSA, detected in fine marine particles and represent on average 11% of SOA and a dominant part (35% on average) of the aerosol water soluble organic nitrogen (WSON). Several evidences support the hypothesis that DMA^+ and DEA^+ have a biogenic oceanic source. In fact, they exhibit a seasonal variation connected to the oceanic biological activity, with high average



Λ Figure 2: Average chemical composition of bubble bursting samples: a) absolute concentration b) relative concentration.

Λ Figure 1: The oceanic vessel Celtic Explorer equipped with the instrumentation for the MAP experiment in summer 2006.

concentration during HBA periods (26 ng m^{-3}), and much lower concentrations (on average 1 ng m^{-3}) during periods of low biological activity (LBA). In polluted air masses the observed concentrations of (DMA^+ and DEA) are very low (on average 2 ng m^{-3}), thus excluding significant anthropogenic sources.

These observations point to a potentially important source of marine SOA and atmospheric organic nitrogen at the global scale, with a seasonal variation connected to the oceanic biological productivity and an atmospheric cycle parallel to that of the organo-sulphur species.

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Meet the IPO

The International Project Office (IPO) serves as the secretariat for SOLAS and administers the project on a day-to-day basis.

The IPO is responsible for assisting the Scientific Steering Committee (SSC) in all aspects of its work, and collates and communicates information related to national and international SOLAS research. The IPO works with the sponsors to secure resources for SOLAS as an umbrella organisation. The IPO also keeps a record of SOLAS products, which are made freely available on the SOLAS website, wherever possible.

The IPO is currently located in the School of Environmental Sciences at the University of East Anglia, UK and is funded by the Natural Environment Research Council (NERC).

Emily Brévière holds a French engineering diploma in chemistry and chemical engineering from the ENSCMu, and post-graduate in oceanographic sciences. Her PhD work encompassed the temporal variability of air-sea CO_2 fluxes in the Southern Ocean. She then joined the SOLAS International Project Office (IPO) as Project Officer, and following a secondment with our parent body as Deputy Director in Natural Sciences at IGBP she returned to the IPO as Executive Officer. She is also the Administrative Officer of COST Action 735.

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Georgia Bayliss-Brown completed her BSc in Environmental Sciences at the University of East Anglia in 2006 focussing mainly on meteorology, fluid dynamics and palæoclimatology. She then joined the SOLAS IPO as Research Assistant and has recently been promoted to Project Officer. Georgia is hoping that we can beat 2007's attendance to the Open Science Meeting, next year in Barcelona, and always looks forward to meeting more people from the SOLAS community. She enjoys watching the ocean and works best with coffee.

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WCRP WGSF 2008 Progress Report

Over the last 4 years the WCRP Working Group on Surface Fluxes (WGSF) has carried out a considerable amount of work. Impressive progress has been achieved in our understanding of the mechanisms forming air-sea flux variability on different temporal and spatial scales. New flux products of higher accuracy and finer resolution have been developed and now can be used for all types of climate research. WGSF initiated systematic validation activities, building new methodologies of air-sea flux field production, developing guiding materials for climate-quality flux observations and assessing all sources of errors and uncertainties in the air-sea flux products. See www.esrl.noaa.gov/psd/psd3/wgsf/ for information and links.

Given the complexity of the issues related to surface fluxes over the oceans as well as over land, and the necessity to deal with both physical and biogeochemical exchanges at the same time, the WCRP now faces the need to provide more co-ordination in this area. The Working Group on Surface Fluxes could be transformed into a group with expertise in all these scientific areas, covering different space-time scales from microscale to global and from seconds to decades, and different sources of surface flux estimates (in-situ, satellites, NWP).

There is a clear need to continuously address the changing requirements of all WCRP research components in surface fluxes and to facilitate the generation of new flux products representing ocean-atmosphere (including sea ice) and land-atmosphere physical and biogeochemical interactions. The inclusion of land fluxes into surface flux work fits perfectly with the goals of CLIVAR linking, in particular, ocean signals with continental climate variability. This task will be more than relevant to GEWEX which currently leads both SEAFLUX and LANDFLUX activities. Finally, such work will be of benefit to CliC which deals with fluxes associated with both marine and terrestrial cryosphere.

In other words, we are approaching a branch-point in the WCRP strategy for dealing with flux issues. More detailed comments on this topic can be found in the article Surface Fluxes and WCRP Science, by Gulev, Fairall, and Ryabinin published in Vol. 5 of Flux News (ftp://ftp.etl.noaa.gov/user/cfairall/wcrp_wgsf/newsletter/)

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Fabrice Veron earned his PhD from Scripps Institution of Oceanography at the University of California San Diego. He currently holds a position of Associate Professor at the University of Delaware. His research interests focus on air-sea interactions and in particular, the impacts of small scale phenomena such as drops and air- and water-side turbulence, on the multiple air-sea transfers.

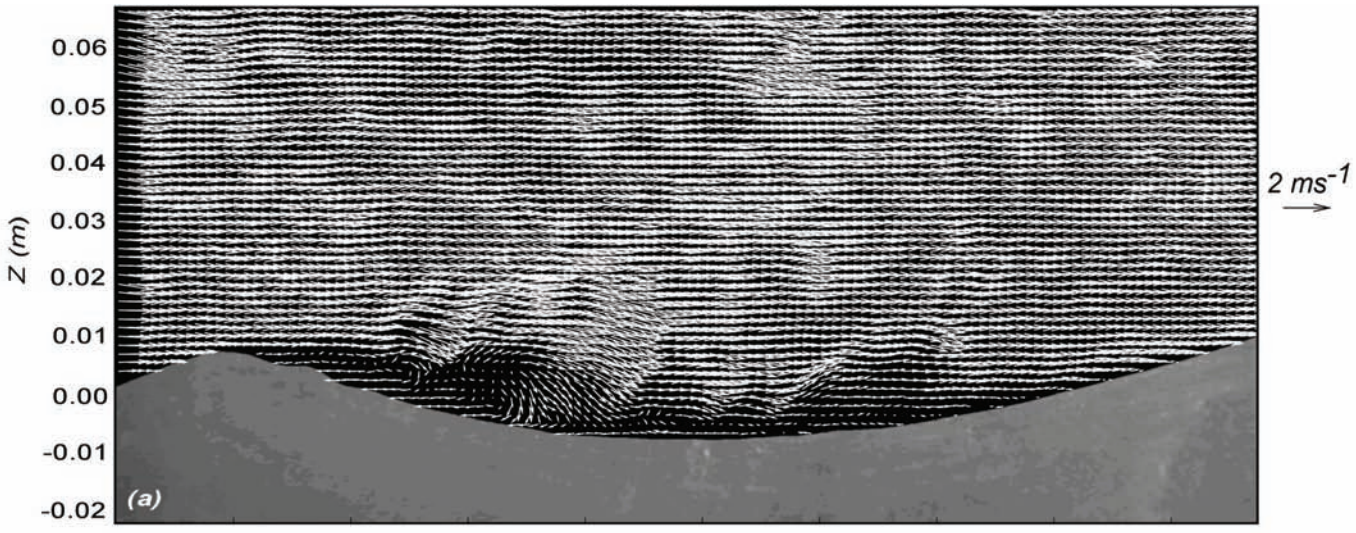
Airflow separation above wind waves

Fabrice Veron, College of Marine and Earth studies, University of Delaware, Newark, USA. Contact: fveron@udel.edu

The coupled air-sea boundary layers play an important role in the flux of momentum between the atmosphere and the ocean which in turn is pivotal in controlling the evolution of weather and climate. The air-sea interface, where these boundary layers connect, is a complex, dynamic system and the surface is influenced by drift currents and populated with surface waves and turbulent eddies over a large spectrum of scales. There are other phenomena such as bubble injection, spray ejection, rainfall, foam and surfactants, which further affect the dynamics and complicate the problem. For example, we now know that breaking waves, small-scale turbulence, bubble injections, and rainfall significantly enhance mixing and consequently heat and gas fluxes. On the atmospheric side, it has become apparent that surface wave processes can play an important role in the kinematics and dynamics of the marine atmospheric boundary layer. In fact, recent measurements and models of the drag of the sea surface on the atmosphere suggest that most of it is supported by the waves. Yet, our understanding of phenomena such as the separation of the airflow above the wave and its consequence on the air sea momentum flux and drag remain quite poor, especially at high wind speeds.

The experiments described here were conducted in the large wind-wave-current tank at the Air-Sea Interaction Laboratory of the University of Delaware. High resolution, two-dimensional velocity fields in the airflow above the surface were collected using a Particle Image Velcocimetry (PIV) system consisting of a digital camera and a pulsed Nd-Yag laser.

We show here an example of a single velocity field which shows the separation of the viscous boundary layer above the wind-generated waves (Figure 1a). The results have been plotted over the waterside portion of the original digital image (that was excluded of the PIV calculation). The vector plot, for clarity, only shows a fifth of the available data in each direction. It shows that the airflow is attached to the wave on the windward side where the viscous sublayer is very thin (barely visible in the velocity field). On the leeward side of the wave, there is a large turbulent region, presumably generated by the boundary layer separation. Some large coherent vortices are clearly visible. The gradual thinning of the turbulent cloud past the trough of the wave and the re-establishment of the viscous sublayer depict the re-attachment. This is perhaps better shown on Figure 1b, which shows a thin region of very high vorticity (dominated by shear), attached to the surface, which is the signature of the viscous sublayer. As the flow separates, the vortical/shear layer leaves the surface. This vortical/shear layer remains coherent and clearly visible in figure for some distance. In fact, the turbulent detached region and the remaining undisturbed flow above are relatively well segregated by this shear layer. The high shear in the flow, unsupported by the surface, is however unstable and the vortical thin layer, breaks down, mixes, and disappears. The airflow separation acts as a source of vorticity in the flow and therefore enhances mixing in the separated region. Figure 1c shows the near-surface viscous tangential stresses along the surface. The data show that the surface tangential stress is highest on the windward face of the wave with its peak value locally superior to that of the total average air-sea momentum flux

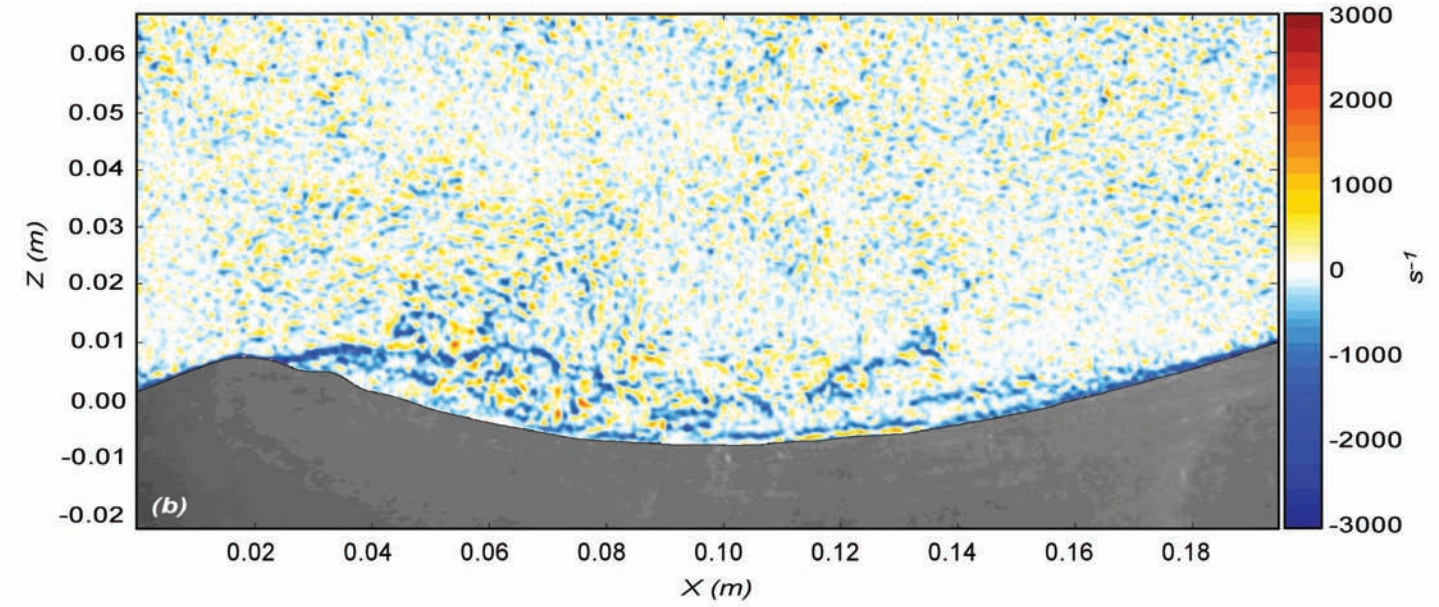


Λ Figure 1a: Velocity vector plot of the separating airflow over the waves for a wind speed of U10 = 5.7m/s.

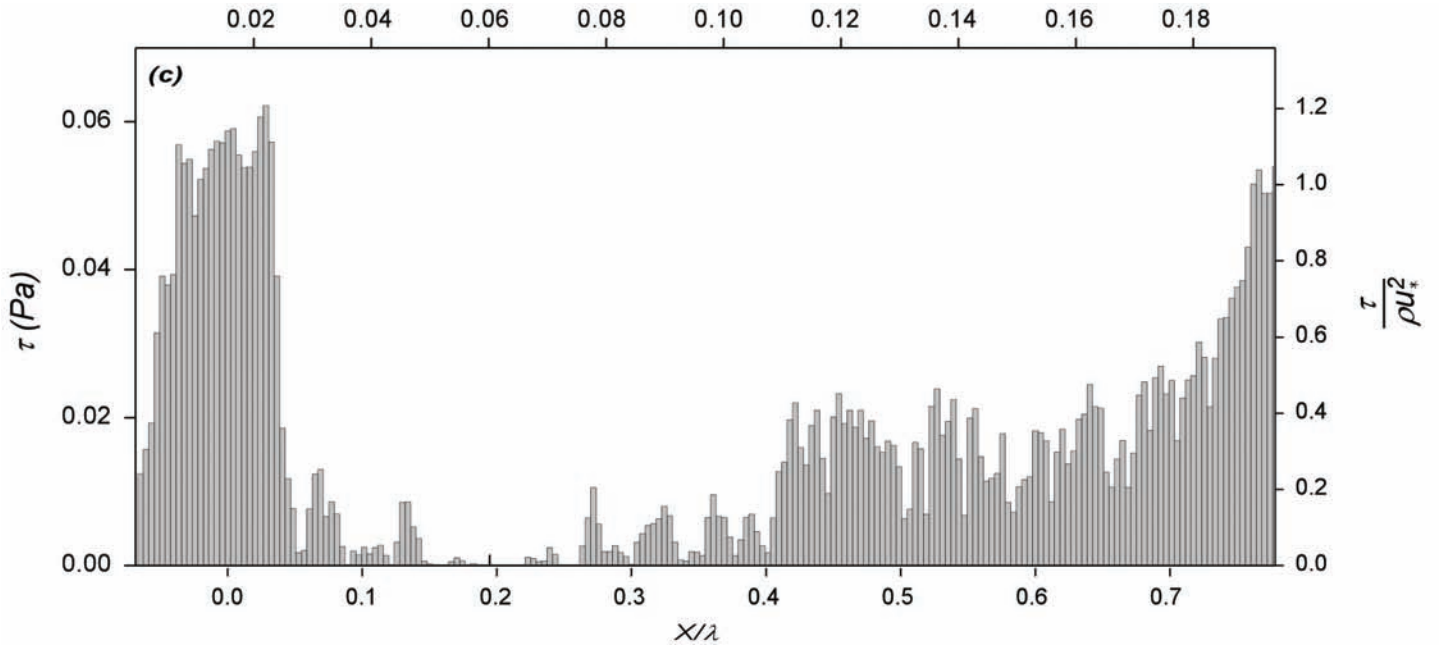
pu_*^2. Once the flow detaches, the near-surface viscous stress abruptly drops to approximately 0 and past the trough of the wave, the near-surface stress gradually becomes positive again.

Our data shows clear evidence of airflow separation over small wind-generated waves, and we have seen some evidence that airflow separation leads to a dramatic reduction of the near surface velocity, with a sign reversal, indicating the presence of what is usually referred to as a recirculating bubble. Concurrently, the viscous tangential stress near the surface dramatically drops at the point of separation leading to extreme along-wave variability of order pu_*^2 in the span of half a wavelength.

With such richness in the phenomena and dynamics at the air-sea interface, it is perhaps not surprising that air-sea interaction is a growing field and that several of these phenomena have far reaching global implications on the heat, gas, and momentum balances between the ocean and the atmosphere. The work presented here shows modest, yet promising progress in our understanding of the complicated nature of the phenomena at the ocean surface.



Λ Figure 1b: Shows the corresponding vorticity field.



Λ Figure 1c: The viscous tangential stress is closest to the surface.

Are Olsen received his PhD in chemical oceanography in 2002 from the University of Bergen. He is currently a research scientist at the Bjerknes Center for Climate Research located in Bergen, Norway and is co-leader of their research activity 8; entitled the 'Ocean Carbon cycle and biogeochemistry'. He deals mainly with the ocean carbon cycle, collecting, synthesising and interpreting observations.

The Bjerknes Centre pCO_2 observing network

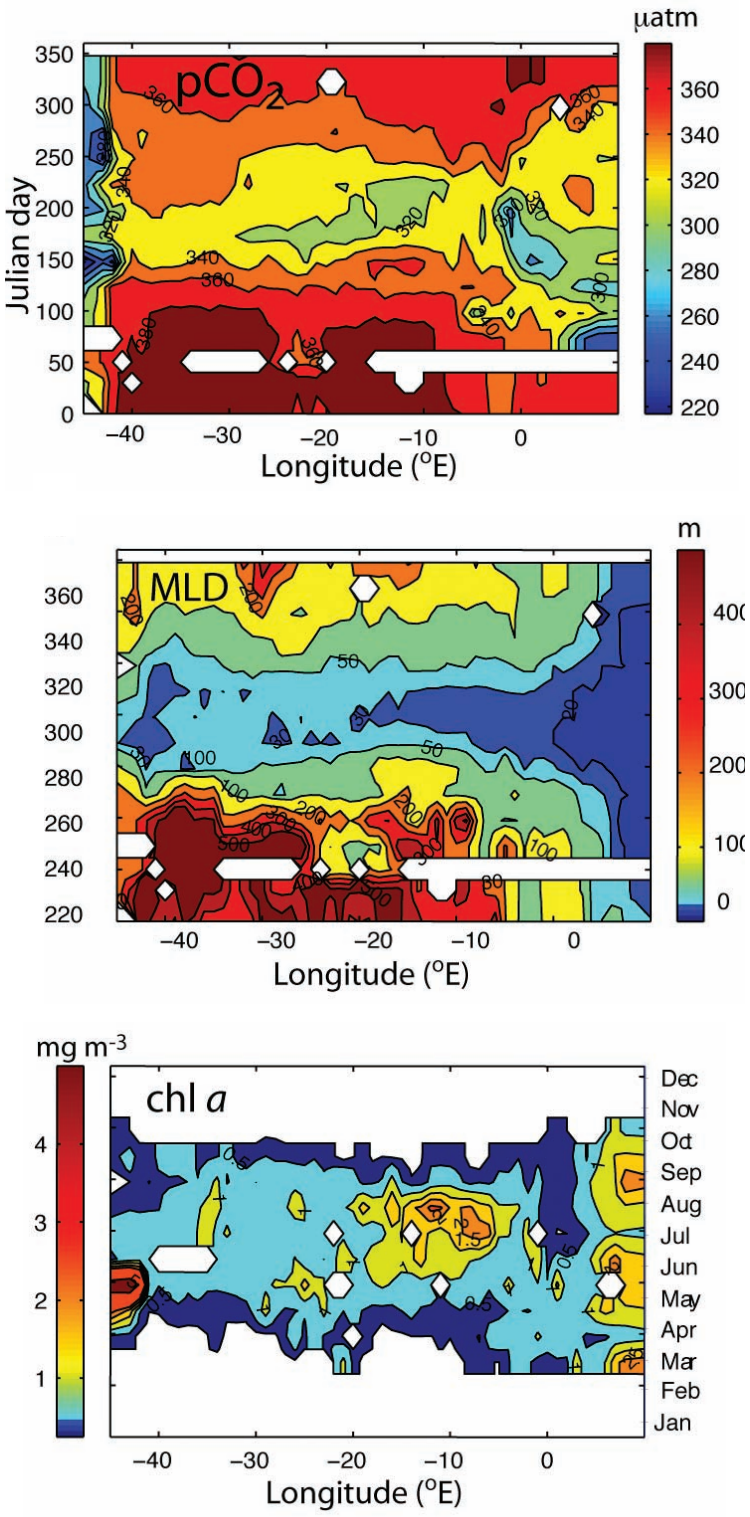
Are Olsen, Abdirahman Omar, Ingunn Skjelvan, Siv K. Lauvset, Truls Johannessen and Craig Neill. Contact: are.olsen@gfi.uib.no

The Bjerknes Centre for Climate Research and Geophysical Institute at the University of Bergen, in Norway, maintains an extensive surface ocean pCO_2 observing network in the northern North Atlantic, with instruments mounted on board 2 commercial vessels, 2 research vessels and one ocean weather station.

The M/V Nuka Arctica is a container carrier operated by Royal Arctic Lines, sailing between Denmark and Greenland on a biweekly schedule. A pCO_2 instrument has been installed on board since 2004, supported by the EU IP CARBOOCEAN. The data reveals clear covariance between surface pCO_2 and both chlorophyll a and mixed layer depth in the northern North Atlantic (Figure 1), as described by Olsen et al. (2008). The covariance has allowed for development of algorithms that can be used to estimate pCO_2 to an accuracy of 10 µatm, from remotely sensed and ocean analysis data (Chierici et al., in press). This allows for mapping of pCO_2 saturation degree and air-sea CO_2 fluxes on an annual basis. For further information. please contact: are.olsen@gfi.uib.no

Data from the North Sea are obtained onboard Trans Carrier, a containership operated by Sea-Cargo AS . The ship sails between Bergen and Amsterdam on weekly basis and measurements began during fall 2005 as part of the EU integrated project CARBOOCEAN. The acquired data is of great importance for the documentation and understanding of the spatio-temporal variability of CO_2 exchange between atmosphere and the North Sea. For further information. please contact: abdir.omar@gfi.uib.no

M/V Polarfront, which is the last weather ship in the world, operates Ocean Weather Station M at 66° N 2° E in the Norwegian Sea. The station is situated in the Norwegian Atlantic Current over the Norwegian continental slope, and since 1948, oceanographic and meteorological data have been collected at the site. In 2006 a pCO_2 instrument (Pierrot et al., in press) was



Λ Figure 1: Hovmöller diagram of 2005 pCO_2 data obtained on Nuka Arctica between the southern tip of Greenland (45°W) and Denmark (20°E) in 2005, along with MLD data from the FOAM ocean analysis of the UK met office and Chl *a* from SeaWiFS (see Olsen et al., 2008 for details).

installed and continuous measurements of sea surface and atmosphere CO_2 were started. After two years of continuous measurements it is time for an evaluation and interpretation of the data. The perspective spans from diurnal and seasonal variations including process studies to interannual and decadal variability. So far, an indirect method where surface pCO_2 was calculated based on total inorganic carbon values (Skjelvan et al., 2008) shows an increasing CO_2 content in the sea surface over years, and the increase is faster compared to the observed increase of atmospheric CO_2. We expect to see a similar trend in the measured pCO_2 data over the years, but it remains to fully understand the variability on a smaller time scale.
For further information. please contact: ingunn.skjelvan@gfi.uib.no

The instruments on the two research vessels Johan Hjort and G.O. Sars are currently supported by the Norwegian Research Council project CARBON-HEAT. This project seeks to study the relationship between changes in oceanic pCO_2, heat exchange, and flow rates in the Nordic Seas and Barents Sea. pCO_2 data from G.O. Sars goes back to 2003 and the instrument onboard Johan Hjort was installed in fall 2007. These two instruments are the only two operating in the Nordic Seas and Barents Sea.
For further information, please contact: siv.lauvset@bjerknes.uib.no

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SOLAS Special Reports

BIOCAT Summer School at IFM-GEOMAR, Kiel, 15-19 September 2008

As part of the German SOPRAN project, 27 students from ten nationalities attended the BIOCAT (Biogeochemical Interactions between the Ocean and the ATmosphere) Summer School which took place at the IFM-GEOMAR in Kiel, Germany, from 15th to 19th September 2008. The students were selected on the basis of an international and competitive selection process.
A combination of twelve morning and evening lectures, four afternoon short practicals and an evening poster session addressed the wide breadth of SOLAS science. The topics covered were marine biology (Gerhard Herndl) and chemistry (Doug Wallace); oceanic trace metals (Peter Croot) and trace gases (Hermann Bange); the marine nitrogen cycle (Wajih Naqvi), physical oceanography of the upper ocean (Markus Dengler); spectroscopy at the sea surface (Gernot Friedrichs); atmospheric chemistry (Jonathan Williams) and aerosols (Alex Baker); air-sea gas exchange (Phil Nightingale) and biogeochemical modelling (Hans Burchard). In the short practicals, the students were introduced to the 'science' of manuscript writing (Avan Antia), statistical approaches (Mark Lenz), the use of the GOTM model (Inga Hense) and analytical methods to measure dissolved trace gases (Annette Kock, Gert Petrick). Despite the unusually cold, late-summer weather, the most popular short practical was the trip on board R/V Littorina, to the IFM-GEOMAR long-term monitoring station Boknis Eck in the Eckernförder Bight, where both nutrient and O_2 measurements were introduced by Hans Peter Hansen. This combination of disciplines provided the BIOCAT students with a basic background as well as cutting-edge knowledge of the complex interactions and processes that operate close to the atmosphere-ocean interface. One of the highlights of BIOCAT was a Discussion Forum on geo-engineering moderated by Doug Wallace with contributions from Victor Smetacek, Andreas Oschlies and Jonathan Williams; which gave the students an excellent opportunity to discuss scientific and ethical issues associated with the controversial geo-engineering solutions to climate change.

The BIOCAT students made the best of their (very rare) free time by dining and socializing in the town of Kiel and during the official BIOCAT dinner on Friday evening; which marked the end of a busy and successful week.

More information about BIOCAT can be found at http://www.sopran.pangaea.de/biocat. BIOCAT was funded through SOPRAN by the German Ministry for Education and Research (BMBF); the German Science Foundation (DFG); the Integrated School of Ocean Sciences (ISOS), Kiel, and the SOLAS IPO at UEA, Norwich.

Hermann W. Bange, IFM-GEOMAR, Kiel, Germany

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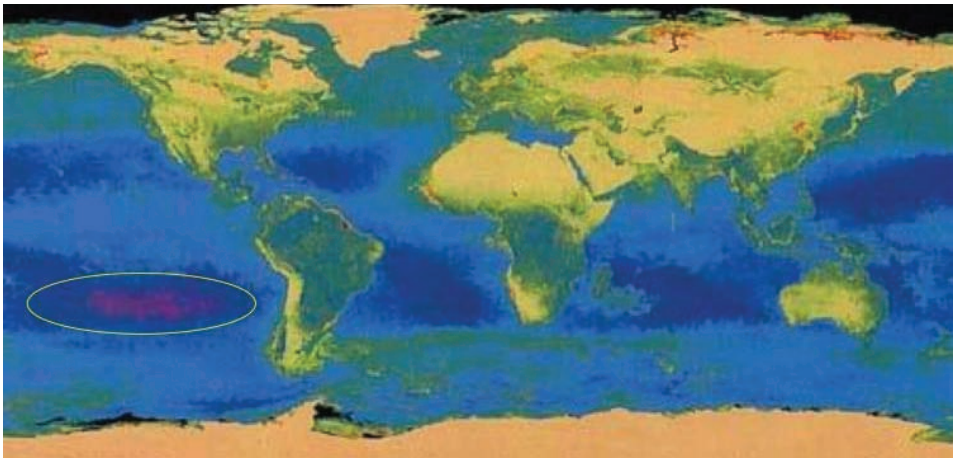
Photo: BIOCATs learning how to measure dissolved N_2O.

IGAC SOLAS Workshop

A workshop organised by the IGAC-SOLAS task AICI in Grenoble in 2006 lead to a series of review papers that were published in a special edition of Atmos. Chem. Phys. on all aspects of polar snow and ice chemistry with many details relevant for halogen chemistry (http://www.atmos-chem-phys.net/special_issue80.html).
A number of open questions were defined at this workshop and detailed in these papers which were the motivation for a AICI/HitT/SPARC workshop in Cambridge in June 2008 entitled "Ices and Halogens: Laboratory Studies to Improve the Modelling of Field Data" that was organised in five sessions:

1. Surface and bulk properties of ices and clouds;
2. New experimental approaches to the study of ices and aerosols;
3. Halogen activation in the atmosphere;
4. Mercury in the cold;
5. Kinetics of the cold atmosphere were each introduced.

Each session was introduced by a tutorial/overview presentation followed by three - four talks and sufficient time for in-depth discussions. A number of exciting new techniques were presented including glancing-angle laser-induced fluorescence probing for chemical interactions at the air-aqueous interface (Donaldson et al), 2D and 3D X-ray micro-tomography (Huthwelker, Hutterli et al), electrospray mass spectrometry (Hoffmann et al.) and X-ray diffraction studies of crystallisation (Murray et al.). The need for high quality laboratory experiments to provide quantitative data for the interpretation of field data and as input for atmospheric models was stressed. The idea of using a large "smog chamber"-like facility for a "field study in the lab" came up, in order to investigate interactions between the gas phase and ice phases (snow, QLL, ice crystals); this will require an international effort for the realisation and equipment with the relevant instrumentation.



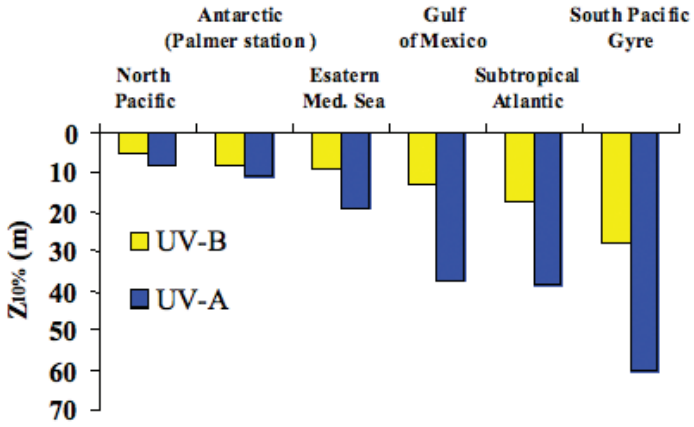
Scientific Steering Committee Statement on UV in the Ocean

The waters of the South Pacific Gyre (offshore the Easter Islands) exhibit an unparallel optical and chemical purity. These results were found by measuring the UV penetration depth during the BIOSOPE cruise and was a collaborative research between the Laboratoire de Microbiologie, Géochimie et Ecologie Marines (Marc Tedetti, Richard Sempéré, LMGEM/COM) and the Laboratoire d'Oceanographie de Villefranche (Herve Claustre, André Morel, LOV/OOV). Recently published in Geophysical Research Letters and Limnology and Oceanography, the results were respectively a "highlight" and a "featured article" on the behalf of publishers.

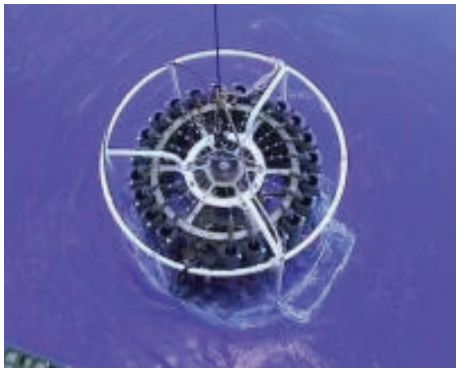
In the current context of climate change, scientists are interested in the impact of solar radiation on marine ecosystems, especially the impact of ultraviolet (UV: 280-400 nm) radiation. Highly energetic, the latter may affect planktonic organisms by altering their DNA molecule and thus their metabolism.
It can also oxidize or cleave dissolved organic matter (DOM), the world's largest reservoirs of carbon at the Earth's surface, and thus alter its bioavailability to heterotrophic bacteria. Consequently, UV radiation plays a significant role in the carbon cycle within the surface layer of the ocean.

SeaWiFS composite showing the chlorophyll concentration in the upper layer of the ocean, the violet color emphasizes the hyper-oligotrophic nature of the study area © SeaWiFS Project, NASA/Goddard Space Flight Center, ORBIMAGE.

In 2004, during the BIOSOPE campaign (BIogeochemistry and Optics SOuth Pacific Experiment : a French CNRS-SOLAS programme), researchers from LOV/OOV and LMGEM/COM made solar irradiance measurements in the South East Pacific waters, along a transect from the Marquesas Islands to the coast of Chile.



Λ Figure 1: Depth at which the downward irradiance is 10% of its surface value (Z10%) at 305 nm (UV-B), and 325, 340 and 380 nm (UV-A) determined between 0 and 30 m in the hyper-oligotrophic zone of the South Pacific Gyre (Tedetti et al. 2007). For comparison, we reported Z10%(UV) values obtained for North Pacific (Goes et al., 1995, Photochem. Photobiol. 62, 703-710), Antarctica (Helbling et al., 1995, Mar. Ecol. Prog. Ser. 126, 293-298), Eastern Mediterranean Sea (Obernosterer et al., 1999, Aquat. Microb. Ecol. 20, 147-156), Gulf of Mexico (Weinbauer et al., 1997, App. Environ. Microbiol. 63, 2200-2205), Subtropical Atlantic Ocean (Obernosterer et al., 2001, Limnol. Oceanogr. 46, 632-643; see also Review in Tedetti and Sempéré, 2006).



Λ Figure 2: Seawater color close to violet in the South Pacific Gyre (© LOV/OOV, Joséphine Ras).

They found that the depth at which the downward irradiance is 10% of its surface value (Z10%) was reached at 30 m for UV-B (305 nm), 60 m for UV-A (340 nm), and 80 m for PAR radiation (400-700 nm). These Z10% values are the highest ever reported for oceanic waters. However, it is noticeable that similar values have been found in the ice-covered Lake Vanda in Antarctica. The optical purity of the waters of the South Pacific Gyre was really unexpected. These waters do not receive any continental inputs from the atmosphere or rivers, because of their remoteness from continents. Moreover, the hydrodynamic structure of the Gyre does not allow a fertilization of the surface waters by nutrient-enriched deep waters (N, P). As such, the surface waters of the Gyre are very poor in phytoplankton, particulate and dissolved absorbing matter.

Therefore, the color of these waters is also amazing: while the Sargasso Sea or the Eastern Mediterranean Sea are known for their "deep blue", in this area, a further degree is crossed and indigo blue was almost violet. This "ultra-pure" water reservoir is considerable (the size of the Mediterranean Sea), and that is the last straw, the purity of this water reservoir is higher than those achieved for purified water obtained in laboratory. Light absorption coefficients of these natural waters are lower than those commonly accepted for purified water! If water absorption in the spectral domains from blue to violet and near UV (460-320 nm) is not known with precision, on the one hand it is very low (less 0.5% per meter), and therefore difficult to measure accurately, and on the other hand it is quite impossible to remove organic traces (absorbing matter in the spectral domain considered) from water, and thus to achieve a high optical purity. It is nonetheless true that the existence of such a volume of water as pure naturally came as a surprise and remains a mystery. In the absence of reliable experimental data for water absorption in the spectral domain (ranging from blue to UV), these extreme conditions have helped indirectly to infer what might be the upper limits of the plausible water absorption. UV effects on marine DOM and bacterial activities are currently studied in the framework of the French CNRS/SOLAS programme (UVECO: http://www.com.univ-mrs.fr/LMGEM/uveco/uveco_fr/index.htm).

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SOLAS and IMBER

An important goal for SOLAS and IMBER is the establishment of surface ocean and atmosphere carbon observing systems for constraining the net annual air-sea CO_2 (carbon dioxide) flux to at least 0.2 Pg C yr-1 per basin. Detecting interannual and longer term variation in CO_2 air-sea fluxes and identifying the natural or anthropogenic origin of such variation is also central in the Joint SOLAS-IMBER Carbon Group (sic!). The Surface Ocean CO_2 Atlas (SOCAT) project emerged during the 2007 Surface Ocean CO_2 Variability and Vulnerability (SOCOVV) workshop (http://www.ioccp.org/) as a way of assessing whether we are approaching these goals. Two types of SOCAT products will be made available with regular updates: 1) a 2nd level quality controlled, global surface ocean fCO_2 (fugacity of CO_2) data set following agreed procedures and regional review, 2) a gridded SOCAT product of monthly surface water fCO_2 means on a 1° x 1° grid with no temporal or spatial interpolation. The decision was made to use the well-documented, common format data set of Benjamin Pfeil (CarboOcean data manager) and Are Olsen (Bjerknes Centre, Norway) as the basis for SOCAT (see figure). This data set already contains over four million data points over the period 1968-2007 and is rapidly growing. Regional groups for the oceans and coastal seas, as well as an overview global group were established during SOCOVV to ensure that the quality control procedures are tailored to regional issues, but still comparable on a global scale. The IOCCP (International Carbon Coordination Project) and the Joint SOLAS-IMBER Carbon Group (sic!) sponsored a small, technical kickoff meeting on SOCAT for the global and regional group leaders, data managers and LAS (Live Access Server) specialists at IOC/UNESCO (Paris) on 16 and 17 June 2008. A report of this SOCAT-2 meeting will be soon available at http://www.ioccp.org/.

Over the next few months the regional groups will become firmly established, will identify and submit missing data sets and will explore which 2nd level quality control checks may be performed in each region (deadline 1 September 2008). After 15 September 2008 the regional groups are asked to carry out 2nd level quality control on the SOCAT data and address key process-related scientific questions requiring large-scale joint synthesis efforts, while aiming for scientific presentations at ICDC-8 (International Carbon Dioxide Conference) in September 2009 and a first public release of the two SOCAT products by late 2009. Marine CO_2 scientists and modelers keen in to participate in the above activities are encouraged to contact regional or global group leaders.

SOLAS Data Integration

Tom Bell

University of East Anglia
Norwich

Integrating data to produce SOLAS concentration and flux climatologies by Tom Bell

The exchange of gases across the air-sea interface has classically been described using:

$$Flux = k.\Delta C$$

According to the equation above, to properly quantify the net annual global flux of any gas across the air-sea interface (or indeed the deposition of a particle to the sea surface), it is necessary to know its concentration gradient (or ΔC). In other words, we (the scientific community) must compile our data into databases describing the global distribution of atmospheric and oceanic concentrations. This information can then be used, with the most up-to-date understanding of the transfer velocity, k (or in the case of particles, the deposition velocity), to produce best estimates of global fluxes. Such products are of use to the scientific community (both modellers and experimentalists) and can inform policy. Good examples of this already exist in the literature, in particular for CO_2 (Takahashi et al., 1997; 2002) and DMS (Kettle et al., 1999).

Over the past two years, I have been working with the SOLAS community as 'SOLAS Project Integrator' to try to establish projects that will produce such global datasets and products. This section of the SOLAS newsletter will provide updates on progress, previews and highlights of the various projects currently underway or about to take place.

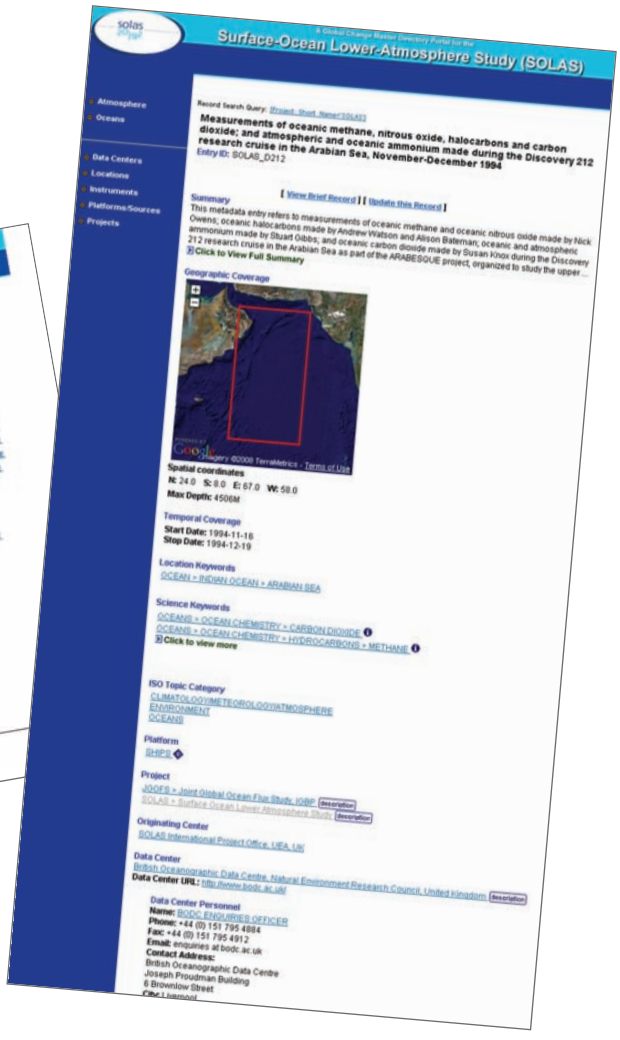
In this edition of the SOLAS newsletter, we focus upon ongoing work (in conjunction with the SOLAS International Project Office) to identify what SOLAS-related data exists and where it is archived.
This metadata has been assembled and archived into an inventory and a Metadata Portal constructed: http://tinyurl.com/46xnf9 (see screenshot 1). The portal contains links to information about various SOLAS-related data that have been collected over recent years.
This resource is freely-available to the entire community and enables the user to identify relevant datasets that include information about the actual data's location, the name of the data-provider and relevant click-through links (see screenshot 2 for an example).

A wide range of compound and particle types are covered (see screenshot 1), making this useful to a wide range of SOLAS research, enabling increased collaboration and adding value to past and present scientific endeavour.

This resource will continue to develop over the next few years as additional metadata are included. Even in its current state, the SOLAS Metadata Portal is an invaluable resource, in particular for communities that wish to generate a compilation of all relevant historical measurements at a global scale.

Please don't hesitate to contact me (Thomas.Bell@uea.ac.uk) if you would like to contribute to any of the datasets that are being compiled as part of this project or if you wish to find out more the SOLAS Metadata Portal.

In the next edition of the SOLAS newsletter, we will be discussing initial results from DMS-GO, a project that aims to produce new DMS climatologies from the substantially-updated DMS database.



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