

solas news

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▲ University of Tokyo Ocean Research Institute student Yoko Iwamoto took this photo from the deck of the Hakuho-Maru during a cruise from 10S to 53N along 160W in the summer of 2005. In addition of marine atmospheric measurements and marine biogeochemical parameters, the group used the eddy covariance technique to attempt measurements of particle fluxes using the equipment shown at the top of the foremast.

Welcome to the SOLAS Newsletter

This issue of the Newsletter mainly features the activities of SOLAS Focus 1: Biogeochemical Interactions and Feedbacks Between Ocean and Atmosphere.

The objective of Focus 1 is to quantify feedback mechanisms involving biogeochemical coupling across the air-sea interface, which can only be achieved by studying the ocean and atmosphere in concert. The articles in this issue demonstrate the importance of interactions among biology, chemistry and physics. Recently the Implementation Group co-chaired by Maurice Levasseur (Canada) and John Plane (UK) finished writing the Implementation Plan for Focus 1 (IMP 1) of SOLAS. It is now available as a pdf file (1.3 Mb) through the SOLAS web site. New IMP 1 co-chairs, William Miller (USA) and Mitsuo Uematsu (Japan), have recently been selected to work with the project

officer Véronique Schoemann (Belgium) and the IMP 1 advisory group to reorganize and continue reviewing and discussing relevant scientific accomplishments and new scientific directions. Together, we will continue to establish and promote increased international and scientific cooperation, including field expeditions, and standardized observations and intercalibrations. We welcome input and ideas that would help promote SOLAS and Focus 1, looking forward to exciting times as research on Focus 1 science unfolds.

William Miller - co-chair, IMP 1; Marine Science Department, University of Georgia

Mitsuo Uematsu - co-chair, IMP 1; Ocean Research Institute, University of Tokyo

Véronique Schoemann – International Project Officer, IMP 1, Université Libre de Bruxelles

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GLOBEC (Global Ocean Ecosystem Dynamics) is a core project of the International Geosphere-Biosphere Programme (IGBP) and is co-sponsored by the Scientific Committee for Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO).

The implementation plan was approved in 1999, with a mandate to run until December 2009. GLOBEC is therefore entering its second phase and moving into Integration and Synthesis (I+S), and, in 2010, GLOBEC will merge with the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project.

In preparation for the I+S phase, the GLOBEC Scientific Steering Committee (SSC) drafted a document entitled "Blueprint to I+S" (see www.globec.org to download) with suggestions for activities, which were then placed on the web for comments and input from working group members, national representatives and GLOBEC researchers. A webtool was subsequently implemented to allow individual scientists to suggest workshops, activities, and specific synthesis outputs.

For more information on GLOBEC, see the webpage or contact Project Office Director Manuel Barange at m.barange@pml.ac.uk.



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Prof. Min Hu is from Peking University, and her scientific research focuses on (1) natural emission of DMS in the eastern coastal areas of China, DMS oxidation in the atmosphere and its relationship with sulfur cycle, acid precipitation and climate change. (2) characterizations of fine particles and its impact on air quality, regional air pollution and human health.

Dimethylsulfide emission in China nearshore waters

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In China, huge terrestrial pollutants load nearshore water as a result rapid economic development. As a consequence, the frequency of red tides increase. Eutrophication stimulates the population size of poisonous algae resulting in higher DMS production. Therefore, more DMS may be emitted to the atmosphere in the polluted nearshore waters, compared with clean water. In addition, anthropogenic SO₂ emissions and atmospheric SO₂ concentrations are decreasing continuously in recent years under pollution control and the use of low sulfur containing coal and clean energy in coastal cities. However, the oxidation capacity of the ambient air is enhanced due to secondary air pollution, thus more DMS could be oxidized. The changes in ambient air oxidation capacity and SO₂ level and coastal water quality may impact the roles of DMS in the atmosphere. Therefore, it is necessary to investigate the spatial-temporal distribution of DMS in China nearshore waters in order to identify the major factors related to the production and emission of DMS.

Qingdao nearshore waters, Jiulong Jiang Estuary, Pearl River Estuary (PRE) and adjacent northern South China Sea (SCS) have been selected as

study areas, as they are highly eutrophicated with high primary productivity. The average concentration of DMS in China nearshore waters was relatively high and showed evident seasonal variation. In Qingdao nearshore waters the highest level of DMS concentrations were observed in summer with mean value of 1169.5 ngL⁻¹ and the lowest concentration was in winter with mean value of 48.2 ngL⁻¹. In PRE and northern SCS the highest mean DMS concentration was 478.5 ngL⁻¹ in spring and the lowest value 91.3 ngL⁻¹ in winter. In Jiulong Jiang Estuary and PRE, the highest concentration of DMS was observed in the river stream. In the estuarine maximum turbidity zone, the salinity of seawater changes greatly and the congregated algae emit high concentration of DMS. The phytoplankton's DMS productivity in the three study areas is different with their own characteristics. Of the physical environmental factors, temperature and transparency (radiation) are key factors for DMS production in Qingdao coastal water. While salinity plays an important role in determining DMS productivity in Jiulong Jiang and Pearl River estuaries.



Figure 1: The study areas and sampling sites, 1. Qingdao nearshore waters (2001-2003); 2. Jiulong River Estuary (2001); 3. Pearl River Estuary and Northern South China Sea (2000-2004)



Figure 2: Scientific investigation ship "Dong Fang Hong II"

Based on the concentration of DMS in seawater, the sea-to-air flux of DMS can be estimated using stagnant film model. The seasonal variation of flux was similar to that of seawater DMS concentration. In the Qingdao coast, the highest flux was 8.00 μmol m⁻² d⁻¹ in summer and the lowest was only 0.14 μmol m⁻² d⁻¹ in winter. In PRE and northern SCS, the flux ranged from 3.4 to 42.4 μmol m⁻² d⁻¹ as the average of the four cruises in 2000-2004, which was much higher in the sea shelf than in the estuary and open sea.



Bill Miller is the Associate Director for Marine Programs and the Director of the Sapelo Island Marine Institute at the University of Georgia, USA. Following a PhD from the Graduate School of Oceanography at the University of Rhode Island in 1990, he held a National Research Council Postdoctoral fellowship with the U.S. Environmental Protection Agency and served for 9 years as a professor of Oceanography at Dalhousie University, Canada.

Estimating ultraviolet radiation in the surface ocean with SeaUV

William L. Miller and Cedric Fichot, University of Georgia, Department of Marine Science, Athens, GA, USA - contact: bmiller@uga.edu

High-energy ultraviolet radiation (UVR) is a natural component of the solar spectrum reaching the Earth's surface and its potential effects on ecosystem function, and biogeochemical cycling in natural waters, as well as its potential role in global change feedback scenarios have long been recognized (Zepp *et al.*, 1998). The study of UVR as it relates to the production/ destruction of atmospherically important trace gases (AITGs: alkyl nitrates, halocarbons, COS, CS₂, ketones, aldehydes, CO, CO₂, DMS) or as a driver for photobiological processes that directly impact biology in the surface ocean falls squarely in the SOLAS domain. In almost all natural waters, chromophoric dissolved organic matter (CDOM) is the main regulator of UVR and adjacent blue wavelengths, causing significant variations in both general water transparency and the vertical domain of photochemical and photobiological processes. Clearly, operational tools to evaluate the spatial and temporal variability of CDOM absorbance ($ag(\lambda)$; where wavelength is indicated inside the parenthesis) and UVR attenuation ($Kd(\lambda)$) in the ocean will improve our understanding and predictions of the effect of UVR on the marine environment and provide critical input for quantitative models describing the air-sea exchange of AITGs in SOLAS.

Over the past twenty years, work on ocean color has led to the development and

implementation of a number of empirical, semi-analytical and analytical models that permit the retrieval of inherent and apparent optical properties from remote sensing reflectance, $Rrs(\lambda)$, or normalized water-leaving radiances, $nLw(\lambda)$, with primary attention on the estimation of biological variables such as chlorophyll and primary productivity. Only recently has the oceanographic community shown interest in developing algorithms directed at CDOM variability with relevance to the UV radiation field. Consequently, much work remains to fully develop and validate robust algorithms that permit retrieval of $Kd(\lambda)$ and $ag(\lambda)$ in the 280 - 490nm range.

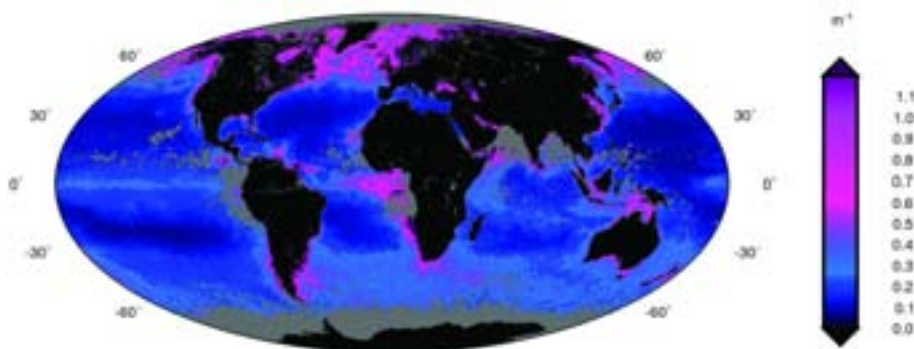
Applying principal component analysis and a multispectral classification to our large "training dataset" (> 320 nm, simultaneous *in situ* measurements of remote sensing reflectance, attenuation, and CDOM absorbance, gathered over the last 8 years in a wide range of water-types), we have developed two improved and "ready-to-use" algorithms (SeaUV & SeaUVC) for estimating UV-VIS diffuse attenuation ($Kd(320-490nm)$) and CDOM absorbance ($ag(320nm)$) from spectrally-resolved remote sensing reflectance in visible wavebands. The algorithms are optimized for application to *in situ* and airborne radiometers as well as to the current ocean color satellites SeaWiFS and



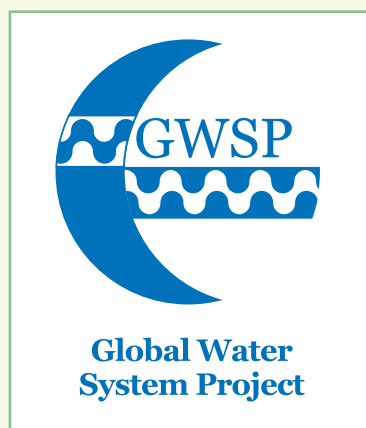
▲ Figure 1. Lori Ziolkowski and Jane Sherrard collect UV optical data for algorithm development aboard Louisiana Universities Marine Consortium (LUMCON) RV Pelican in the Gulf of Mexico.

MODIS, providing estimates for $Kd(\lambda)$ and $ag(\lambda)$ in the 320-490nm spectral range.

Using the SeaUV models, we have begun to investigate UV attenuation dynamics in different hydrological and biogeochemical domains with an eye toward identifying specific processes that dominate CDOM variability in the various regions of the world. An example of the dynamic nature of UV attenuation is shown in the accompanying global picture of $Kd(320)$ in July, 1999. Large "UVR attenuation features" can be seen that reflect coastal, riverine, bloom, and upwelling dynamics. Continued work will be toward a classification of the world's oceans into a number of distinct regions that reflect the variability and predictability of UVR attenuation together with dominant regulatory processes. As these optical tools are refined, it will become possible to quantify the spatial and temporal variability of UVR dependent photochemical and photobiological reactions. Resulting depth-resolved models for ecosystem and biogeochemical response to changing UV radiation should advance SOLAS research to a new understanding and predictability of AITG exchange between the surface ocean and lower atmosphere.



▲ Figure 2. Global map of downwelling attenuation at 320 nm ($Kd(320) \pm 15\%$) for July 1999.



The Global Water System Project (GWSP) addresses a central research question: How are humans changing the global water cycle, the associated biogeochemical cycles, and the biological components of the global water system and what are the social feedbacks arising from these changes?

Recent activities include the development of a Global Water System Lexicon, a Digital Water Atlas, an international workshop on 'Governance and the Global Water System', and a global study on water indicators and on environmental flows. The GWSP seeks to expand its portfolio of activities and to develop partnerships with colleagues around the world by endorsing pioneering projects concerned with critical questions about the global water system.

You can join our network by subscribing to our newsletter 'Global Water News' and to our emailing list. If you are interested in getting involved with the GWSP please consult the project website at www.gwsp.org or contact the GWSP International Project Office (ipo@uni-bonn.de).



Call for Contributions

SOLAS News is published every 6 months, and we welcome your comments on the content and layout. What would you like to see in your newsletter?

We need your contributions to the scientific and informational content. Do you have a meeting or activity coming up, and would you like to inform the SOLAS Network? Do you have a science article for publication?

We welcome contributions from graduate students to senior researchers, articles short and long. Send an e-mail to solas@uea.ac.uk



Christa Marandi received her B.S. in Chemistry in 1998 from George Washington University. In 2000, she began work on her PhD at University of California, Irvine with Dr. Eric Saltzman. Her research aim is to use atmospheric pressure chemical ionization mass spectrometry to perform eddy correlation measurements of the air-sea flux of dimethyl sulfide and acetone.

Eddy correlation measurements of acetone air-sea fluxes over the N. Pacific Ocean

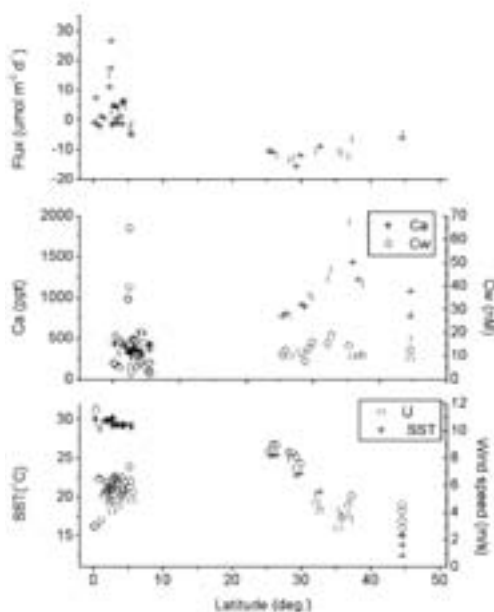
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Because the upper troposphere is dry, the major sources of HOx are oxygenated organic compounds, such as acetone. In order to understand the reactivity of this portion of the atmosphere, studies of the global budget of these compounds are needed. Previous field campaigns have shown that acetone concentrations are significant in the upper troposphere (Singh *et al.*, 1995), but the sources of acetone are not entirely understood. The role of the ocean in the acetone budget is particularly in question. A large ocean source was inferred from aircraft measurements of acetone over the remote Pacific Ocean (Jacob *et al.*, 2002 and references therein), but has been recently called into question by measurements showing depletion of acetone in the Pacific marine boundary layer relative to the overlying free troposphere (Singh *et al.*, 2004 and references therein). Previous budgets have ranged in the ocean's role, varying from a 21 Tg yr⁻¹ source (Jacob *et al.*, 2002) to a 14 Tg yr⁻¹ sink (Singh *et al.*, 2004). In this study, eddy correlation was used to directly measure the air-sea flux of acetone over the North Pacific Ocean aboard the R/V Wecoma from May to July, 2004.

One Hz measurements of acetone were made using an atmospheric pressure chemical-ionization mass spectrometer (API-CIMS) (Eisele, 1986). Air was sampled from the bowmast at 27 slpm from 10m height through 250 feet of 3/8" ID Teflon tubing. Simultaneous measurements of 3D winds and platform angular rates and accelerations were made to allow calculation of air-sea flux by eddy covariance (Edson *et al.*, 1998). Seawater acetone levels are determined by analyzing an air stream continuously equilibrated with seawater pumped from the bow at a depth of 5m. The measurement protocol consisted of alternating measurements of seawater (10 minute) and air (60 minutes). Flux was determined by integrating the cospectrum of fluctuations of the vertical wind and atmospheric acetone mixing ratio. The overall uncertainty in the flux due to low and high frequency corrections and motion correction is estimated to be 30-40% (Edson *et al.*, 1998).

In the western tropical Pacific Ocean, atmospheric acetone levels were 0.361 ± 0.051 ppb (Fig). Air mass back-trajectories show consistent easterly trade wind flow over equatorial waters. These levels are similar to boundary layer aircraft measurements previously reported for this region (Jacob *et al.*, 2002 and references therein). Acetone levels were higher northward of 25°N, with a mean of 1.04 ± 0.33 ppb, reflecting continental influence. Air mass back-trajectories and chemical tracers suggest that some of the spikes in acetone observed during this period may have been due to biomass burning over the NW Canada and Alaska.

Acetone levels in seawater exhibited a different pattern of variability than the atmosphere (Fig.). In the tropical waters, seawater acetone concentrations were 14.5 ± 12.7 nM. Seawater acetone in this region was more variable than the atmospheric levels. Northward of 25°N, the mean ocean level of acetone was 12.1 ± 3.0 nM. The seawater concentrations of acetone measured in this study are similar to those reported previously, approximately 3 and 18 nM (Zhou and Mopper, 1997; Williams *et al.*, 2004).



▲ Figure: Equatorial and North Pacific measurements of acetone. From top: 1) Measured air-sea fluxes; 2) Air and seawater levels; 3) Sea surface temperature and mean wind speed.

All of the acetone fluxes measured by eddy covariance in this study were negative (Fig), illustrating that the air/sea flux is uniformly into, rather than out of the ocean. In the equatorial region the fluxes measured by eddy covariance in this region had a mean of $-3.1 \pm 0.9 \mu\text{mol m}^{-2} \text{day}^{-1}$. Just north of Hawaii, between 25 and 30°N, the mean eddy covariance flux was $-7.2 \pm 3.2 \mu\text{mol m}^{-2} \text{day}^{-1}$ and at latitudes above 30°N the mean flux was $-9.3 \pm 3.7 \mu\text{mol m}^{-2} \text{day}^{-1}$. The air/sea fluxes of acetone were consistently larger in the mid latitudes than in the tropics, reflecting the higher atmospheric acetone levels and higher wind speeds.

We found a strong relationship between the measured flux and the atmospheric concentration, which we used to extrapolate these results globally. The observed correlation suggests that either: 1) surface acetone levels are small compared to the atmospheric levels, and have little impact on the air-sea concentration gradient, or 2) surface acetone levels co-vary with the atmospheric concentration, resulting in an air-sea gradient roughly proportional to C_a . To make this calculation, we use Comprehensive Ocean-Atmosphere Data Set (COADS) monthly mean $1^\circ \times 1^\circ$ grid wind speed, temperature and pressure. We assume acetone levels in the marine boundary layer, ranging from 400 to 1000 ppt, based on this study and previously reported measurements (Jacob *et al.*, 2002). We calculate a global air-to-sea flux of 48 Tgyr^{-1} .

An ocean sink of this magnitude would greatly imbalance the current atmospheric acetone budget (Jacob *et al.*, 2002; Singh *et al.*, 2004). This imbalance is nearly offset by the recent reevaluation of the quantum yield for acetone photodissociation, suggesting that the atmospheric loss due to photolysis is considerably less than previously thought (Blitz *et al.*, 2004). Using the revised quantum yields, we estimate a global loss rate of acetone by photolysis of 24 Tgyr^{-1} , roughly half of the previous rate. Summing all the calculated loss rates yields a

global acetone loss rate of 101 Tgyr^{-1} , similar to the previous analysis, but with ocean uptake responsible for about half. Understanding this acetone ocean sink and its impact on atmospheric chemistry requires direct flux measurements with broader seasonal and spatial coverage, and insight into processes controlling oceanic acetone levels near the air-sea interface.

References

- Blitz, M.A., D.E. Heard, and M.J. Pilling (2004), Pressure and temperature-dependent quantum yields for the photodissociation of acetone between 279 and 327.5 nm, *Geophys. Res. Lett.*, 31, L06111, doi: 10.1029/2003GL018793.
- Edson, J.B., *et al.* (1998), Direct Covariance flux estimates from mobile platforms at sea, *J Atmos. Ocean Tech.*, 15, 547-562.
- Eisele, F.L. (1986), Identification of tropospheric ions, *J. Geophys. Res.*, 91, 7897.
- Jacob, D.J., *et al.*, (2002), Atmospheric budget of acetone, *J. Geophys. Res.*, 107, doi:10.1029/2001JD000694.
- Singh, H.B., M. Kanakidou, P.J. Crutzen, and D.J. Jacob (1995), High concentrations and photochemical fate of oxygenated hydrocarbons in the global troposphere, *Nature*, 378,50-54.
- Singh, H.B., *et al.*, (2004), Analysis of the atmospheric distribution, sources, and sinks of oxygenated volatile organic chemicals based on measurements over the Pacific during TRACE-P, *J. Geophys. Res.*, 109, D15S07, doi:10.1029/2003JD003883.
- Williams, J., *et al.*, (2004), Measurements of organic species in air and seawater from the tropical Atlantic, *Geophys. Res. Lett.*, 31, L23S06, doi:10.1029/2004GL020012.
- Zhou, X., and Kenneth Mopper (1997), Photochemical production of low-molecular-weight carbonyl compounds in seawater and surface microlayer and their air-sea exchange, *Mar. Chem.*, 56, 201-213.

announcement

International Symposium on Biological and Environmental Chemistry of DMS(P)

The 4th International Symposium on Biological and Environmental Chemistry of DMS(P) will be hosted by Gill Malin and colleagues at the Laboratory for Global Marine and Atmospheric Chemistry (LGMAC), School of Environmental Sciences (ENV), University of East Anglia (UEA), in Norwich, UK from 2-6 May 2006.

Following the early registration deadline we are expecting about 60 people to attend the Symposium and there is still room for additional symposium delegates and poster presentations. We have received an excellent array of abstracts for posters and talks that cover the whole range of research on DMS and

related compounds. The conference presentations will range from field and laboratory studies, through to modelling and effects of global climate change on DMS emissions. At the time of writing we are finalising the detailed conference programme and you will be able to find this on our web site <http://lgmacweb.env.uea.ac.uk/lgmac/dmsp/> in due course.

For further information please take a look at the conference web site or if you have specific questions email Rosie Cullington the meeting administrator via r.cullington@uea.ac.uk.

national reports



Belgium

A SOLAS.be cluster has been accepted for funding by the Belgian Federal Science Policy Office. This organises SOLAS-related research projects and consolidates activities, including: a SOLAS.be Communication Office at the Université Libre de Bruxelles (ULB), an online link with International SOLAS, data-base management, coordination of modelling efforts, and a website.

Two new SOLAS-related projects were recently selected for funding by the same office: the Belcanto-III project 'Integrated study of Southern Ocean biogeochemistry and climate interactions in the anthropocene', and the PEACE project 'Role of pelagic calcification and export of carbonate production in climate change'.

Belgium remains active in coordinating SOLAS-related meetings. The 37th International Liège Colloquium on Ocean Dynamics was held in mid-2005 at the Université de Liège and focused on Gas Transfer At Water Surfaces. This fall, ULB will host a DMS ecosystem model intercomparison workshop.

For information on SOLAS-be, contact Christiane Lancelot (lancelot@ulb.ac.be)



Denmark

A Danish carbon cycle project will be a part of a large Danish cruise (www.galatea3.dk) starting out in August this year and ending in April 2007. This will be a world wide cruise going from Denmark via Greenland, then to India, Thailand, Australia, Antarctica, the west coast of South America to Galapagos, the West Indies and back to Denmark. The Carbon cycle project will have SOLAS activity, where we will measure the surface exchange of CO_2 by dpCO_2 method and direct atmospheric CO_2 fluxes.

Dr. Lise Lotte Soerensen will be leading the activity of CO_2 air-sea exchange.



In 2006, ICSU celebrates its 75th Anniversary by publishing its first Strategic Plan. The plan has developed in close consultation with the 104 National Members and the twenty-nine International Scientific Unions. The ICSU Interdisciplinary Bodies (including DIVERSITAS, the International Geosphere-Biosphere Programme; IGBP, the International Human Dimensions Programme; IHDP and the World Climate Research Programme; WCRP) have also contributed to the planning exercise over the past few years.

The focus of the Strategic Plan is on: (i) International research collaboration, including a review of the global change research programmes, participation in the Global Earth Observation System of Systems (GEOSS), planning for the International Polar Year (IPY) and a new programme on hazards; (ii) ensuring that science is policy relevant and that political decisions are based on the best available scientific knowledge; and (iii) ensuring the universality of science. The plan is available on www.icsu.org. For more information, contact Thomas.Rosswall@icsu.org.



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New pages include: job listings, updated national reports, SOLAS structure, the three new Implementation Plans, and much more.

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Dierdre Toole earned a PhD from the University of California, Santa Barbara in 2003 and carried out postdoctoral research at SUNY College of Environmental Science and Forestry and the Woods Hole Oceanographic Institution (WHOI). She is currently an assistant scientist at WHOI and continues to focus on the interactions between light and upper-ocean organic sulfur cycling.

The effects of ultraviolet radiation of DMS and DMSP biogeochemical cycling

Dierdre A. Toole¹, Doris Slezak², Ronald P. Kiene², and David J. Kieber³ - contact: dtoole@whoi.edu
 1 Woods Hole Oceanographic Institution, Massachusetts, USA; 2 University of South Alabama, Alabama, USA; 3 SUNY - College of Environmental Science and Forestry, New York, USA.

Upper-ocean foodwebs are a major source of atmospheric dimethylsulfide (DMS), a radiatively important trace gas. To date, however, fundamental gaps in our understanding of the marine sulfur cycle have prohibited us from fully evaluating a hypothesized negative phytoplankton-DMS-climate feedback mechanism (e.g. Charlson *et al.*, 1987). Emerging evidence indicates that oceanic DMS and dimethylsulfoniopropionate (DMSP, the chemical precursor to DMS) concentrations and biogeochemical cycling rates may be strongly regulated by physical and chemical stress factors, including exposure to high doses of ultraviolet radiation (UVR).

To isolate and quantify the effects of UVR we have carried out a variety of deckboard and *in situ* incubations in regions as diverse as the Sargasso Sea, the Gulf of Maine, the continental shelf off of the eastern seaboard of the United States, the Southern Ocean, and

the Ross Sea. Specifically we used ³⁵S-DMS and ³⁵S-DMSP radioisotopes to quantify (1) DMS photochemical loss rates, (2) microbial DMS consumption rates, (3) microbial dissolved DMSP consumption rates, and (4) the percentage DMS yield from microbial DMSP consumption as a function of UV light dose and spectral quality (see Kiene and Linn, 2000 for isotope methods). Samples were either incubated on deck in flowing water baths under a variety of long-pass optical filters or on free floating drifter arrays in the water column with the light environment regulated by the natural attenuation of light with depth.

All of our experimental results from throughout the world's oceans clearly indicate that UVR has a strong ability to structure the cycling rates (Figure). DMS photochemical loss is driven almost entirely by UVR with significantly higher rates observed in the Southern Ocean characterized by high concentrations of nitrate

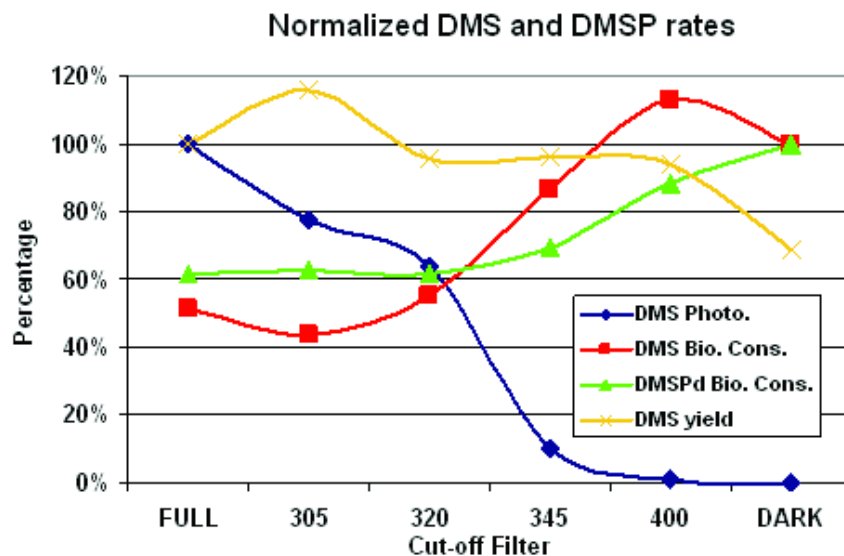


Figure: FDMS and DMSP biogeochemical cycling rates from within a *Phaeocystis antarctica* bloom observed in the Ross Sea (~ -179, -77.6) on November 28 – 30th, 2005. DMS photolysis rates and the DMS yield from dissolved DMSP consumption are normalized to full solar spectrum rates while the biological DMS and DMSP consumption rates are normalized to dark rates. Cut-off filters are in terms of wavelength with FULL representing exposure to the complete solar spectrum.

and photochemically-reactive chromophoric dissolved organic matter. Biological DMS and DMSP consumption rates can be inhibited to as little as 10% of the dark consumption rates at surface levels of UVR with inhibition varying among sites. We also have evidence of UVR induced microbial recovery reflected in increases in the DMS consumption rates above dark values in the Ross Sea and the Sargasso Sea.

While great strides have been made in measuring microbial and photochemical DMS and DMSP rates, at present no robust method exists for determining *in vivo* production of DMSP and DMS by phytoplankton. We must resort to a balance of known rate processes in conjunction with known concentration determinations. Unfortunately these mass balance approaches do not allow the contributions of phytoplanktonic synthesis to be separated from the roles of higher trophic levels. We see the development of these types of methods as a key goal for the sulfur community over the next several years.

A variety of efforts are ongoing to develop seasonally- and spatially-resolved global biogeochemical models to estimate the flux of

DMS to the marine boundary layer. While these models all demonstrate varying degrees of success in certain geographic regions, a review by Belviso *et al.*, (2004a) indicates extremely weak correlations between empirically modeled and measured DMS concentrations in all cases. From our experimental results, we infer that this lack of agreement may be due to the failure to explicitly include the effects of UVR on key biogeochemical cycling rates, as well as our inability to parameterize phytoplanktonic DMS and DMSP synthesis rates.

References

- Belviso, S., *et al.*, Comparison of global climatological maps of sea surface dimethyl sulfide, *Global Biogeochem. Cycles*, 18, GB3013, doi:10.1029/2003GB002193, 2004a.
- Charlson, R.J., J.E. Lovelock, M.O. Andreae, and S.G. Warren, Oceanic phytoplankton, atmospheric sulfur, cloud albedo and climate, *Nature*, 326, 655-661, 1987.
- Kiene, R.P., and L.J. Linn, The fate of dissolved dimethylsulfoniopropionate (DMSP) in seawater: tracer studies using 35S-DMSP, *Geochim. Cosmochim. Acta*, 64, 2797-2810, 2000.

announcement

An inter-comparison of models to predict DMS production and emissions from the surface ocean

Dimethylsulfide (DMS) is a volatile organic sulfur compound produced by biological activity in the surface ocean. Once ventilated in the atmosphere, DMS is oxidized and implicated in a potentially climate-stabilizing feedback loop (the CLAW hypothesis) that is an important focus for SOLAS. The production and emission of DMS is subject to complex physical, biogeochemical and ecological interactions. There has been progress in modeling ocean DMS distributions and dynamics; however, much work remains to build confidence these models. Following a recommendation from a discussion forum at the 2004 SOLAS Open Science Meeting 2004 in Halifax, Belgian office for Federal Science Policy and SOLAS International Project Office will sponsor a workshop for the inter-comparison of DMS models.

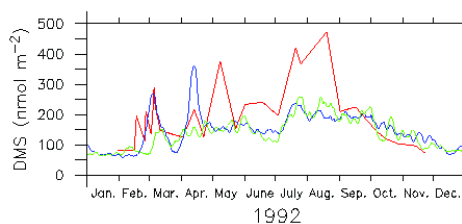
Two types of data sets have been identified for the systematic evaluation and comparison of DMS models: fixed-station data and data garnered from the various iron enrichment experiments.

The workshop organizers have proposed to use a common simulation framework based on the General Ocean Turbulence Model to ensure identical physical representations. In addition, the same sea-to-air DMS ventilation parameterization may be implemented to facilitate comparison between surface DMS emissions from different models.

This invitation-only workshop will involve a small, well-balanced group of modelers and experimentalists to discuss model parameterizations in light of the results obtained by the different models. Simulations will be run prior to the workshop, and the time will be devoted to interpretation of results and identification of key processes and parameters. The product of the

workshop will be a joint publication in an international peer-reviewed journal. This publication will aim to (i) identify models convergences and divergences with respect to the data, (ii) quantify the impact of model differences on simulated DMS emissions to the atmosphere, and (iii) identify best practice in modeling DMS(P) dynamics and research directions for improving the models.

The workshop is scheduled for December 4-8 2006 at the Universite Libre de Bruxelles in Brussels, Belgium. A planning meeting is scheduled for the next International Symposium on Biological and Environmental Chemistry of DMS(P) and Related Compounds at the University of East Anglia (UEA), in Norwich, UK (2-6 May 2006). If you are interested, please contact the scientific coordinator, Yvonnick Le Clainche at yvonnick.leclainche@giroq.ulaval.ca.



▲ Figure: Comparison of two different DMS ocean models (green and blue lines) against water-column integrated DMS data at the Bermuda time series station (red line). Adapted from Le Clainche *et al.* 2004. *Can. J. Fish. Aquat. Sci.*, 61: 788-803.

national reports



Japan

A few months ago an important proposal "Development of Continuous Determination Techniques for Marine Biogenic Carbon Cycles - BIOCARBON-" was funded.

Goals of the project are to establish the techniques of eddy covariance for material flux on shipboard, to develop continuous surface seawater sampling equipment for trace metals while the ship is cruising at ~15 knot, and to establish the DOC molecular size separation technique under the 10-year GEOSS (Global Earth Observation System of Systems) program by MEXT (Ministry of Education, Culture, Sports, Science and Technology), Japan. This project will be supported for three years.

In March of this year, a SOLAS-Japan committee meeting and a joint workshop with IMBER-Japan were held at Nagoya. We discussed the cruise schedule of research vessels for 2007-2009.

In June 2006, the Subtropical Nitrogen Fixation Flux Study (SNIFFS) cruise will be carried out by the SOLAS-Japan group.



Netherlands

SOLAS activities in The Netherlands are in the fields of air sea exchange of aerosols (in particular, sea spray aerosol: source function from field campaigns, satellite remote sensing and modeling), DMS, CO₂ and momentum fluxes. Several institutes work on the carbon cycle with a strong participation in the EU Integrated Project CARBO-OCEAN. One institute works on nitrogen fixation. Effects of bubbles on air sea gas transfer and aerosols are studied in the field and through laboratory experiments. Many activities are closely related to IMBER. Re-vitalization and organization of SOLAS activities in The Netherlands has been started up this spring. Responses were received from 10 individuals from 8 different institutes and likely there are more interested parties.

In early May 2006, we will hold a workshop of Netherlands SOLAS/IMBER/GEOTRACES in conjunction with the SOLAS SSC meeting in Amsterdam.

For more info contact Dr Gerrit De Leeuw : deleeuw@fel.tno.nl



Sree Kumar is a Marine Biology post graduate and in the final year of her PhD in 'Study of the Role of Microbes as Source and Sink of Dimethyl Sulphide in Coastal Waters' at the National Institute of Oceanography, Goa, India. She is interested in studying about marine microbes and their role in various biogeochemical cycles in the marine environment.

Role of bacteria in DMS(P) cycle

Sree S. Kumar, Usha Chinchkar, Shanta Nair, P. A. Loka Bharathi and D. Chandramohan - contact: ksree@nio.org

National Institute of Oceanography, Dona Paula. Goa. India. 403 004

Dimethyl sulphide (DMS) was reported in oceanic waters by Lovelock *et al.*, (1972). Its precursor Dimethyl sulfoniopropionate (DMSP) is ubiquitous in the euphotic zone especially in regions dominated by phytoplankton. The biogeochemical importance of DMSP is based on its bacterial (Wolfe *et al.*, 1999) or algal mediated (Steinke *et al.*, 2002) enzymatic cleavage to acrylic acid and dimethyl sulphide (DMS). Dissolved DMSP can satisfy 1-15% of the total bacterial carbon and virtually all of the bacterial sulfur demand (Kiene *et al.*, 2000; Simo *et al.*, 2002). Bacteria play an important role in the cycling of sulfur and their role in the conversion of DMSP to DMS is important. The coastal ecosystems, especially tidally influenced estuaries are biogeochemically active zones. The estuarine region also harbours high DMSP concentrations, as they are highly productive areas. Although the importance of estuarine systems in determining the coastal DMS(P) cycle has been covered, studies pertaining to tropical areas are sparse. Hence this work examines the temporal variation in DMSP levels in Dona Paula waters. It also examines the influence of the different physiological groups of bacteria in DMS utilization. Knowledge of the abundance, physiology of the bacteria involved in DMS(P) cycle are vital in understanding the dynamics of these compounds.

The Dona Paula Bay, Goa (Fig.) is located on the west coast of India at the terminus of Zuari estuary. Sampling was carried out once in a month during receding high tide. Samples were analyzed for Total Viable Count

(TVC) (Kogure *et al.*, 1984), 'DMS' and 'DMSP' utilizers (Visscher *et al.*, 1991), TDLO (Thiobacillus denitrificans like organisms) (Loka Bharathi, 1989), SRB (Sulphate Reducing Bacteria) (Loka Bharathi and Chandramohan, 1985) and Heterotrophs respectively.

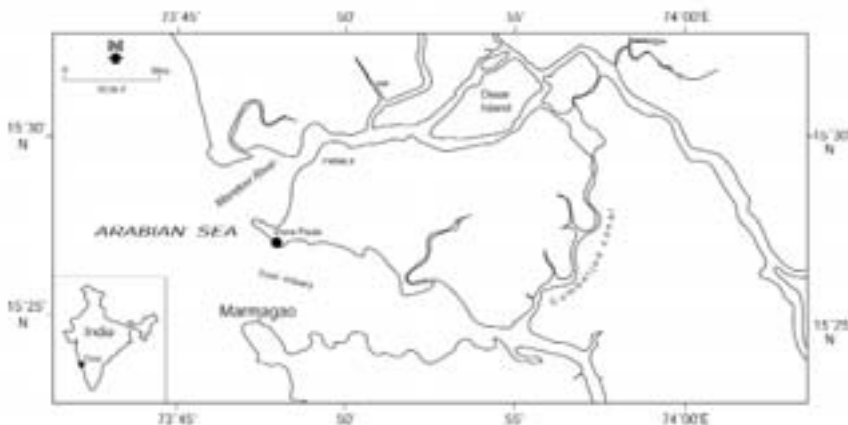
DMSP averaged high during monsoon (13.4 ± 2 nmol L⁻¹) with peaks in post - monsoon months of Nov (13.2 nmol L⁻¹) and Dec (15.1 nmol L⁻¹). DMS averaged high in post - monsoon (9.5 ± 9 nmol L⁻¹) with a peak in November (22.2 ± 2 nmol L⁻¹).

Total viable count (TVC) of bacterial population varied from 0.01 to 3.87×10^6 cells L⁻¹. Average Most Probable number (MPN) of bacteria utilizing DMSP were 2.4×10^3 , 7.5×10^3 , 6.7×10^3 cells L⁻¹, DMS utilizers were 1.6×10^2 , 4.6×10^2 , 2.9×10^2 cells L⁻¹ during pre-monsoon, monsoon and post-monsoon respectively. A positive coupling between TVC and DMS and DMSP utilizers during pre and post monsoon may suggest the response of the bacteria to the available substrates.

Utilization of DMS by different physiological groups of bacteria isolated from the field were monitored in the laboratory to grade their metabolic potential towards the substrate. The utilization rate day for TDLO was 0.6 nmol L⁻¹ day⁻¹, for heterotrophs 0.4 nmol L⁻¹ and SRB was 0.3 nmol L⁻¹ day⁻¹. On per cell basis, the values were 0.6, 0.43, and 0.23 fmol cell⁻¹ day⁻¹ for TDLO, heterotrophs and SRB respectively.

References

- Bharathi P. A. L, and D.Chandramohan. 1985. Indian Journal of Marine Science.14. 182-191.
- Bharathi P. A. L. 1989. The occurrence of denitrifying colourless sulphur-oxidising bacteria in marine waters and sediments as shown by the agar shake technique. FEMS Microbiol. Ecol. 62: 335-342.
- Kiene, R.P., L.J. Linn, and J. A. Bruton, 2000. New and important roles for DMSP in marine microbial communities. J. Sea Res. 43 : 209-224.
- Kogure K, Simidu U, Taga N (1984) An improved direct viable count method for aquatic bacteria. Arch Hydrobiol 102: 117-122.
- Lovelock, J. E., R.J. Maggs, and R.A. Rasmussen, 1972. Atmospheric dimethylsulfide and the natural sulfur cycle. Nature, 237:452-453.
- Simo S.D., C. Archer Pedros-Alio, L. Gilpin, and C.E. Stelfox-Widdicompe. 2002. Coupled dynamics of dimethyl sulphoniopropionate and dimethyl sulphide cycling and the microbial food web in surface waters of the North Atlantic. Limnol. Oceanogr. 47 : 53-61.
- Steinke, M., G. Malin, D. A. Stephen, H.B. Peter, and P.S. Liss. 2002. DMS production in a coccolithophorid bloom: evidence for the importance of dinoflagellate DMSP Lyases. Aquat. Microb. Ecol. 26 : 259-270.
- Visscher, P.T., P Quist, and H. Gemerden Van. 1991. Methylated sulphur compounds in microbial mats: *In situ* concentrations & metabolism by a colourless sulphur bacterium. Appl. Environ. Microbiol. 57 :1758-1763.
- Wolfe, G.V., M. Levasseur, G. Cantin, and S. Michaud. 1999. Microbial consumption and production of dimethyl sulphide (DMS) in the Labrador Sea. Aquat. Microb. Ecol. 18 : 197-205.
- Yoch, D.C., 2002. Dimethyl sulphoniopropionate: Its sources, role in the marine food web, and biological degradation to dimethyl sulphide. Appl. Environ. Microbiol. 68 : 5804 - 5815.



▲ Figure: Study site



Emily White is a PhD student in Chemistry at the State University of New York, College of Environmental Science and Forestry. Her research focuses on the photochemistry of dissolved organic matter. Emily is currently completing her dissertation on the photochemical production of dissolved inorganic carbon in estuarine and marine waters.

Photochemical mineralization of chromophoric dissolved organic matter in seawater

Emily M. White¹, David J. Kieber¹, and Kenneth Mopper² - ¹ Chemistry Department, State University of New York, College of Environmental Science and Forestry, Syracuse, NY, USA; ² Department of Chemistry and Biochemistry, Old Dominion University, Norfolk, VA, USA - contact: emwhit01@syr.edu

Chromophoric dissolved organic matter (CDOM) plays an important role in the emission of trace gases from the ocean to the atmosphere. CDOM in the surface ocean absorbs UV radiation, resulting in the production of a variety of climatically-relevant trace gases (e.g., CO, COS, CS₂, CH₃I, and alkenes). Photochemical degradation of CDOM also influences the bioavailability of dissolved organic carbon and the optical properties of seawater which indirectly control the cycling of these trace gases. Therefore, a better understanding of CDOM photochemistry is needed to quantitatively predict trace gases emissions on a global scale.

Photochemical mineralization of CDOM results in the production of significant amounts of dissolved inorganic carbon (DIC) as CO₂. While the importance of this process to the marine carbon cycle has been recognized (e.g., Miller and Zepp 1995; Johannessen and Miller 2001), DIC photoproduction rates have not been determined in seawater. Estimates for the global oceanic flux of photochemically produced CO₂ range from 2.7 PgC yr⁻¹ (Mopper and Kieber 2000) to ~12 PgC yr⁻¹ (Johannessen 2000). In order to better constrain the magnitude of this flux, we have determined CO₂ photoproduction rates and investigated the relationship between optical properties (i.e., CDOM character and

concentration) and CDOM photoreactivity in a variety of waters. Estuaries and other coastal areas are of particular importance due to large inputs of terrestrial organic matter.

We employed a highly sensitive analytical system to measure CO₂ photoproduction rates in the Northwest Atlantic Ocean and along the salinity gradient of the Delaware Estuary. Prior to irradiation, ambient DIC was stripped from acidified, 0.2 μm-filtered water samples. After adjustment back to the original pH, the resulting low DIC samples (< 0.5 μmolC L⁻¹) were pneumatically transferred to gas-tight quartz tubes and exposed to sunlight in a circulating water bath.

Within the estuary, rates of photochemical CO₂ production were highest at the freshwater end member (1.43 ± 0.04 μmolC L⁻¹ h⁻¹ at S = 0.09) and decreased non-linearly with salinity to 0.15 ± 0.07 μmolC L⁻¹ h⁻¹ near the mouth of the bay. Differences in photoreactivity along the salinity gradient were largely due to the dilution of terrestrial CDOM, resulting in a constant CO₂ photoproduction efficiency throughout the estuary. Based on our results, we estimate a loss of 1-5 % of dissolved organic carbon (DOC) per day by photochemical mineralization of CDOM in surface water of the estuary. With a flushing time on the order of 100 days, photochemistry can account for a significant loss of organic carbon within the estuary.

Photochemical mineralization rates were comparatively lower in Northwest Atlantic Ocean, ranging from 0.020 to 0.130 μmol L⁻¹ h⁻¹ at open ocean and coastal stations, respectively. CO₂ photoproduction was dependent on the CDOM absorbance, quantified by the absorption coefficient at 300 nm (a₃₀₀). Our preliminary work with coastal and open ocean waters indicates a turnover of 0.1-0.4% DOC per day in the coastal surface ocean.

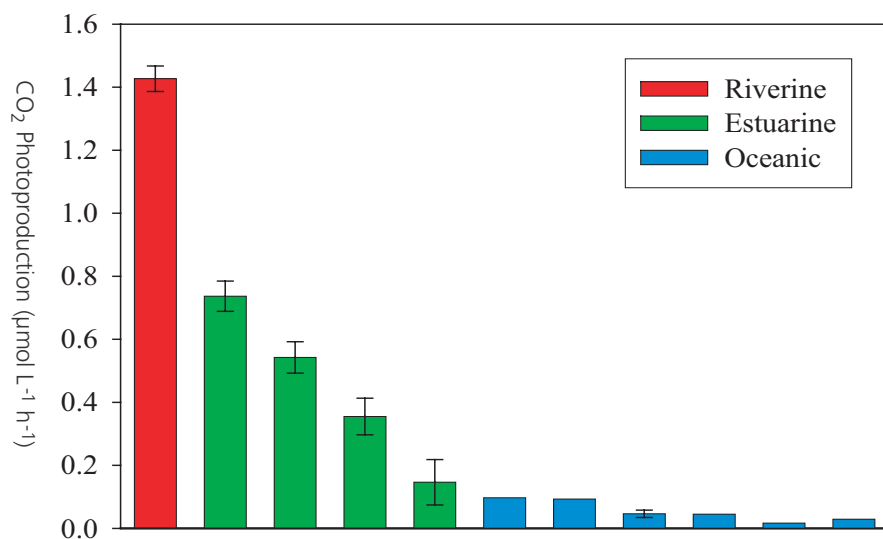
The efficiency of CO₂ photoproduction (rates normalized to a₃₀₀) differed with water type according to the following trend: riverine > estuarine > oceanic. This suggests that differences in CDOM character (i.e., terrestrial versus marine origin) must be considered when using measurements of CDOM to predict photochemical production rates.

Acknowledgements

This study was based on work supported by the National Science Foundation Chemical Oceanography Program (OCE-9711206, OCE-0196220 and OCE-0096426 to KM; OCE-9711174 and OCE-0096413 to DJK) and NASA Headquarters under the Earth System Science Fellowship Grant (NGT5-30431, EMW).

References

- Johannessen, S. C., 2000. A photochemical sink for dissolved organic carbon in the ocean. Ph.D. thesis. Dalhousie University.
- Johannessen S. C., and W. L. Miller. 2001. Quantum yield for the photochemical production of dissolved inorganic carbon in seawater. *Marine Chemistry* 76: 271-283
- Miller, W. L., and R. G. Zepp., 1995. Photochemical production of dissolved inorganic carbon from terrestrial organic matter: Significance to the oceanic organic carbon cycle. *Geophysical Research Letters* 22: 417-420.
- Mopper, K., and D. J. Kieber., 2000. Marine photochemistry and its impact on carbon cycling, p. 101-129. In S. de Mora, S. Demers and M. Vernet [eds.], *Effects of UV Radiation in the Marine Environment*. Cambridge Environmental Chemistry Series. University Press.



▲ Figure: CO₂ photoproduction rates in riverine, estuarine, and oceanic waters. Error bars denote the standard deviation of replicate analyses of multiple light and dark treatments.



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IUGG Associations and Union Commissions encourage scientific investigation of Earth science and especially interdisciplinary aspects. The Associations of relevance to SOLAS include the domains of Meteorology and Atmospheric Science (IAMAS) and the Physical Sciences of the Ocean (IAPSO).

The IUGG will be holding its next General Assembly, entitled "Earth: Our Changing Planet," in July of 2007, in Perugia, Italy. For more information, see <http://www.iugg.org>



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Nicholas Meskhidze completed his PhD in 2003 in atmospheric chemistry at Georgia Institute of Technology, where he is currently employed as a research scientist with Athanasios Nenes. His primary research interest is in comprehensive understanding of the mechanisms responsible for iron mobilization in mineral dust.

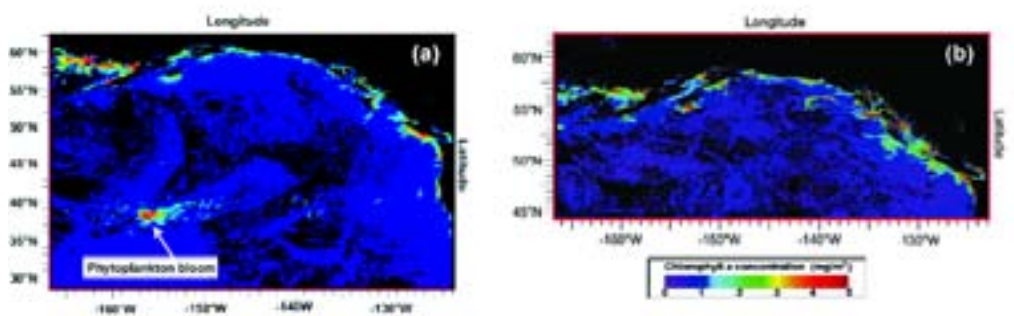
Dust storm surprise: Pollution can convert airborne iron into soluble form

Nicholas Meskhidze¹, Athanasios Nenes^{1,2} and William L. Chameides³ - contact: nmeskhidze@eas.gatech.edu
 1. School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta GA, 30332; 2. School of Chemical and Biomolecular Engineering, Georgia Institute of Technology, Atlanta, GA, 30332; 3. Chief Scientist, Environmental Defense, 257 Park Avenue South, New York, NY 10010

Iron (Fe) is one of the nutrients needed by phytoplankton to carry out photosynthesis. The availability of Fe might limit phytoplankton productivity in large areas of the remote ocean, particularly in high-nitrate low-chlorophyll (HNLC) regions. The HNLC waters comprise a large traction of the world's ocean, and thus the supply of Fe to the surface waters of the ocean may play a key role in regulating ocean productivity, the atmospheric CO₂ concentration and climate (Jickells *et al.*, 2005 and references therein). Since Fe is one of the most abundant elements in the Earth's crust, atmospheric transport and deposition of mineral dust is believed to be the dominant source of new (not acquired via nutrient recycling) Fe to the remote ocean. While mostly soluble Fe is bioavailable, virtually all the Fe found at the source regions is in a crystalline Fe-III form, highly insoluble in seawater (Jickells *et al.*, 2005). Thus for phytoplankton to utilize the Fe deposited in mineral dust, some fraction of the Fe must be mobilized during transport in the atmosphere. The fraction of dissolved Fe in airborne mineral dust (DIF) is uncertain. Previous estimates of DIF generally range from less than 0.01% to more than 90%. Such a large range, if used in global models, would change ocean waters from being everywhere strongly Fe limited to Fe saturated (c.f., Fung *et al.*, 2000).

We have proposed an "acid-mobilization" as a primary mechanism for the formation of soluble Fe in mineral dust. The hypothesized mechanism involved acidification of dust by sulfur dioxide (SO₂), an acidic trace gas emitted from industrial facilities and power plants, and the subsequent dissolution of the Fe contained in acidic mineral aerosols (Meskhidze *et al.*, 2003).

To further explore the combination of processes that act to solubilize Fe in mineral dust along its atmospheric trajectory we developed a Lagrangian equilibrium model and used it to simulate the chemical evolution of Fe during documented episodes of Asian dust advection over the North Pacific Ocean (NPO). The major objective of this research was to find out how variations in anthropogenic air pollution and mineral dust may affect iron solubilization during the plume's transport over the ocean. The model calculations were combined with remotely sensed data from space-borne platforms to identify specific mineral dust events from East Asia, track their trajectories across the Pacific Ocean, estimate the likely input of bioavailable Fe to the surface waters of the NPO during these dust events and determine if the passage of these dust plumes across the Ocean can be correlated with the occurrence of a chlorophyll-a pulse. Modeling results were quite unexpected; for large dust storms that carried vast amounts of mineral dust model predicted negligible amounts of dissolved Fe, while



▲ Figure 1: MODIS-observed [Chl a] over the NPO for the period of (a) 30 March to 6 April, 2001 and (b) 15 to 22 April, 2001. The black color over the ocean denotes the missing data due to clouds, and the thin white lines indicate the coastal boundary. The arrow indicates the location of an enhanced-[Chl a] patch (Meskhidze *et al.*, 2005).

calculations showed that in small dust plumes 0.5 - 10 % of mineral-Fe can be in dissolved form. The differing results were attributed to the ratio of dust to SO₂ prior to the plumes departure from the continent. Because large storms contain a higher proportion of calcium carbonate they are highly alkaline and the amount of SO₂ typically encountered in most industrial cities of China is not high enough to acidify mineral dust and initialize Fe dissolution. As small plumes get relatively easily acidified, the percentage of soluble Fe in small dust plumes can be many orders of magnitude higher than large dust storms. The estimated change in phytoplankton population inferred from the model-calculated inputs of bioavailable Fe for two historic dust transport episodes was consistent with the satellite-measured surface ocean chlorophyll-a [Chl a] concentrations in the NPO. Fig. 1a shows that the chlorophyll-a concentration after the passage of small dust plume increased by more than an order of magnitude above the background level, while the large storm that deposited massive amounts of dust to HNLC waters of NPO showed no increased phytoplankton activity (Fig.1b) (Meskhidze *et al.*, 2005). Therefore, our research showed that the recipe of adding pollution to mineral dust from East Asia may actually enhance ocean productivity and, in so doing, draw down atmospheric carbon dioxide. Thus, China's current plans to reduce sulfur dioxide emissions, which will have far-reaching benefits for the environment and health of the people of China, may have the unintended consequence of exacerbating global warming.

References

- Fung, I.Y., S.K. Meyn, I. Tegen, S.C. Doney, J.G. John, and J.K.B. Bishop (2000), Iron supply and demand in the upper ocean, *Global Biogeochem. Cy.*, 14, 281-295.
- Jickells, T. D., Z. S. An, K. K. Andersen, A. R. Baker, G. Bergametti, N. Brooks, J. J. Cao, P. W. Boyd, R. A. Duce, K. A. Hunter, H. Kawahata, N. Kubilay, J. laRoche, P. S. Liss, N. Mahowald, J. M. Prospero, A. J. Ridgwell, I. Tegen, R. Torres (2005), Global iron connections between desert dust, ocean biogeochemistry, and climate, *Science*, 308, 67-71.
- Meskhidze, N., W. L. Chameides, A. Nenes, and G. Chen (2003), Iron mobilization in mineral dust: Can anthropogenic SO₂ emissions affect ocean productivity?, *Geophys. Res. Lett.*, 30(21), 2085, doi:10.1029/2003GL018035.
- Meskhidze, N., W. L. Chameides, and A. Nenes (2005), Dust and pollution: A recipe for enhanced ocean fertilization?, *J. Geophys. Res.*, 110, D03301, doi:10.1029/2004JD005082.

Areas that require more research:

- Full exploration of the significance of acid mobilization mechanism on a global carbon cycle and climate.
- What fraction of bioavailable Fe in dust plumes mixed with high concentrations of industrial and power plant pollutants may have an anthropogenic origin?
- How and to what extent are the Fe mediated phytoplankton blooms affecting cloud properties?



▲ A local artist creates the Hawaiian style SOLAS logo in the Waikiki International Marketplace. Go to page 22 to see the finished version, and to find out about SOLAS sessions held at the AGU/ASLO/TOS Ocean Sciences Meeting, Honolulu February 20-24, 2006.

national reports



Norway

Norway's most significant connection to SOLAS science is through the EU-sponsored CARBOOCEAN programme (<http://www.carboocean.org/>). Much of the Norwegian component of this multinational programme is conducted at the Bjerknes Centre of Climate Research (BCCR) which has been nominated as a Centre of Excellence by the Norwegian Research Council (NRC). Additional work of interest to SOLAS is the BCCR contribution to the NRC project CABANERA (Carbon flux and ecosystem feedback in the northern Barents Sea in the era of climate change; <http://www.nfh.uit.no/cabanera/>). BCCR also has joined the EUR-OCEANS (European Network of Excellence for Ocean Ecosystem Analysis) network and has developed a Marie Curie Training Site on the role of ice-ocean-atmosphere processes in high latitude climate change. The SOLAS liaison for the International Polar Year (IPY) is also located at BCCR (Richard.Bellerby@Bjerknes.uib.no). For more information on SOLAS-Norway, contact the SOLAS National Representative, Abdirahman Omar (Abdir.Omar@gfi.uib.no).



China (Taipei)

Three SOLAS-relevant research projects are on-going: Asian Dust Storms and their Impact on Taiwan and Vicinity (ADS), Long-Term Observation and Research of the East China Sea (LORECS), and South-East Asia Time-series Study (SEATS). The ADS project has been conducting field surveys since 2002 and will continue until 2010. LORECS was initiated in 2000 and aims to understand biogeochemical cycles in the East China Sea under natural conditions and to detect changes induced by human activities. The response of phytoplankton to dust storms in spring is one focus of LORECS, which has close links with ADS. The SEATS project began in 1998 with seasonal cruises and moored instruments in the northern South China Sea. The intent of SEATS is to investigate biogeochemical responses to physical forcings at different time scales: short-term (typhoons), seasonal (monsoons) and inter-annual oscillations (ENSO). The standing National Steering Committee includes: Gwo-Ching Gong (gcgong@mail.ntou.edu.tw), Kon-Kee Liu (kkliu@ncu.edu.tw), and Wu-Ting Tsai (wttsai@ncu.edu.tw).

Welcome...

The Scientific Steering Committee would like to extend a warm welcome to new members Sergey Gulev and Isabel Cacho, and also a grateful farewell and sincere thanks to departing members Peter Schlosser and Elsa Cortijo.

Sergey Gulev's primary research interests are in air-sea interaction processes and their role in climate. He received an MSc degree from Moscow State University in 1980, and worked at the State Oceanographic Institution; first as a Junior, then Senior Research Scientist, and became Head of the Marine Meteorology Lab in 1988. He joined the P.P. Shirshov Institute of Oceanology of the Russian Academy of Science as the Head of the Air-Sea Interaction and Climate Laboratory. Over the course of the past decade, Sergey has conducted research on the global analysis of ocean waves for basin-scale estimates of wind-wave interaction, in climate diagnostics of synoptic activity of the atmosphere, and in ocean general circulation modeling. He holds a position as Professor of Oceanography and Meteorology at Moscow State University. From 1996 to 2001, Sergey served as co-chair of WCRP/SCOR Working Group on intercomparison and validation of ocean-atmosphere flux fields. Since 2001 Sergey has been a member of the Joint Steering Committee of the WCRP.

Isabel Cacho graduated in Geology from the Universitat de Barcelona (Spain) in 1992. She was introduced to the research of ancient oceanography (paleoceanography) during her Master thesis performed in collaboration between the Universitat de Barcelona and the Universität zu Kiel (Germany). During her PhD she was captivated by the study of past rapid climatic variability in the Mediterranean region by the analysis of molecular biomarkers; the thesis was presented in the University of Barcelona in 2000. During 2000-2003 she moved to the fresher and stimulating atmosphere of Cambridge University (United Kingdom) where she broadened her geochemical training applied to the reconstruction of past sea water properties. Currently, she is a researcher in the Universitat de Barcelona working on paleoceanographical reconstructions from different regions but mostly in the Eastern Equatorial Pacific, Mediterranean Sea and North Atlantic Ocean.

...and thank you

Peter Schlosser is Vinton Professor of Earth and Environmental Engineering and Professor of Earth and Environmental Sciences at Columbia University, New York. He is also a Senior Research Scientist at the Lamont-Doherty Earth Observatory and Associate Director of the Earth Institute at Columbia University. He received an MS from Heidelberg in 1981 and a PhD in 1985. Peter's research focuses on water systems, primarily in oceans and groundwater including problems caused by human impact. His studies of the hydrosphere utilize natural and anthropogenic trace substances such as radiocarbon, oxygen-18, radioactive hydrogen and its decay product He-3, as well as measurement of noble gases. Schlosser's ocean research concerns water circulation in the ocean surface, movement into the deep ocean, and circulation patterns within the deep ocean, as well as gas exchange at the air-sea interface. Current research also is directed toward exploration of mixing and gas exchange in river and estuary environments. Schlosser presently chairs the Science Steering Committee of the SEARCH program (Study of Environmental Arctic Change).

Elsa Cortijo is a CNRS research scientist in palaeoclimatology in the Palaeoceanography team at Laboratoire des Sciences du Climat et de l'Environnement in Gif-sur-Yvette (France), a laboratory of the Institut Pierre Simon Laplace (LSCE/IPSL). She is a specialist in micropaleontology, and in geochemistry measurements on foraminifera shells, used to reconstruct the hydrological characteristics of water masses. During her PhD-thesis, she worked on quantifying the North Atlantic hydrological changes during rapid climatic variability in glacial times in terms of temperature and salinity, allowing for quantitative model reconstructions of the so-called Heinrich Events. Her recent research has focused on palaeoceanography during the interglacial periods, to understand the relationships between orbital forcing, sea level changes and ocean circulation changes. She is 37 years old and has published about 40 scientific papers. She was the head of the paleoceanography team for several years and is currently associate director of LSCE.



In Focus

In each issue of SOLAS news, we give you the chance to meet some of the members of the SOLAS Scientific Steering Committee. This issue, we meet distinguished members from 4 continents.



Tim Jickells

Tim Jickells was born and raised in Barry in South Wales. He then went to Reading University to do a degree in chemistry and subsequently to Southampton University for an MSc in Oceanography. He worked for the Clyde River Purification Board in Glasgow, and then Tim moved to a position at the Bermuda Biological Station before accepting a position in the School of Environmental Sciences at the University of East Anglia. Tim holds the position of Professor and Director of the Laboratory for Global Marine and Atmospheric Chemistry. His research interests include coastal nutrient cycling and atmospheric inputs to the oceans and their effects.

Mitsuo Uematsu

Dr. Mitsuo Uematsu was born in Osaka, Japan. He received his PhD in Geochemistry from Hokkaido University, Japan in 1980. He then worked on the Sea/Air Exchange (SEAREX) Program at the Center for Atmospheric Chemistry at the Graduate School of Oceanography (GSO), the University of Rhode Island (URI) as a Research Associate from 1980 to 1987. Mits then joined the new Department of Marine Science and Technology at Hokkaido Tokai University until 1997. He is currently a Professor at the Center for International Cooperation, Ocean Research Institute, at the University of Tokyo. Mits' major research interests include the long-range transport of natural and anthropogenic substances over the ocean, and marine aerosol properties and their impact on marine environment. He serves as Vice-President of the Oceanographic Society of Japan and as a Chairperson of SOLAS-Japan.



Barry Huebert

Born in Nebraska, Barry Huebert is the son of a preacher, and as a child, Barry's family moved every few years all over the central US. He graduated from Occidental College with a degree in Chemistry in 1967 and from Northwestern University with a PhD in Physical Chemistry in 1970. His concern about air pollution initiated his work on analytical methods for measuring atmospheric trace species, and several mentors taught him to continually challenge the assumption that results faithfully represent atmospheric concentrations. He is proudest of those projects that have improved our ability to measure concentrations and fluxes. Barry now spends most of the year in Kailua, Hawaii with his wife and Shetland sheepdog. He also spends part of the year in Colorado Springs, the home of his two grandkids. Barry spends his free time cooking for friends, gardening, and trying to rationalize spending large sums of money on photographic equipment and large prints that don't sell.



Paty Matrai

Paty Matrai is a Senior Research Scientist at the Bigelow Laboratory for Ocean Sciences. She studied nutrient cycling in an upwelling system for her BS in Marine Biology from the Universidad de Concepción, Chile, and her MS from Scripps (SIO) focused on phytoplankton species distributions along an open ocean-to-coastal gradient. Paty also obtained her PhD from Scripps, with a study on organic sulfur cycling in marine waters. She served on the faculty at the Rosenstiel School of Marine and Atmospheric Sciences at the University of Miami, and has been at Bigelow since 1995.

Paty's current research is focused on biological production and consumption of organic sulfur and halogenated compounds of climatic relevance and their environmental controls in various oceanic environments. This has led into research on the precursors and controls of the production of new atmospheric particles in the Arctic, the role of the physiological ecology of phytoplankton and associated foodweb on carbon and sulfur cycling, and the inclusion of such biogenic rates and controls in climate models.



