Addendum to the SOLAS 2013/14 Annual Report to SCOR:
National SOLAS networks 2013 annual reports

Version of 30 May 2014 by Dr Emilie Brévière

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Annual Report for the year 2013:

SOLAS Australia

compiled by: Sarah Lawson and Andrew Bowie

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

Science Highlight 1 – VOCs and aerosol properties on SOAP voyage

Biologically-active regions of the surface ocean influence aerosol particle production, composition and properties in the overlying marine boundary layer. In February–March 2012 the SOLAS-endorsed SOAP (Surface Ocean Aerosol Production) voyage examined biotic influences on aerosol production to the east of New Zealand, by targeting phytoplankton blooms along the Sub-Tropical Front, with the aim of constraining the relationships between DMS and aerosol flux and characteristics, and phytoplankton biomass and community composition, by multi-disciplinary research.

Initial analyses show that a range of biogenic gases were associated with summer phytoplankton blooms. Very high atmospheric concentrations of DMS up to ~ 1 ppb were observed (Fig 1), and DMS and acetone were correlated over bloom 1 and bloom 3, suggesting a common biological source (Lawson et al. 2011)

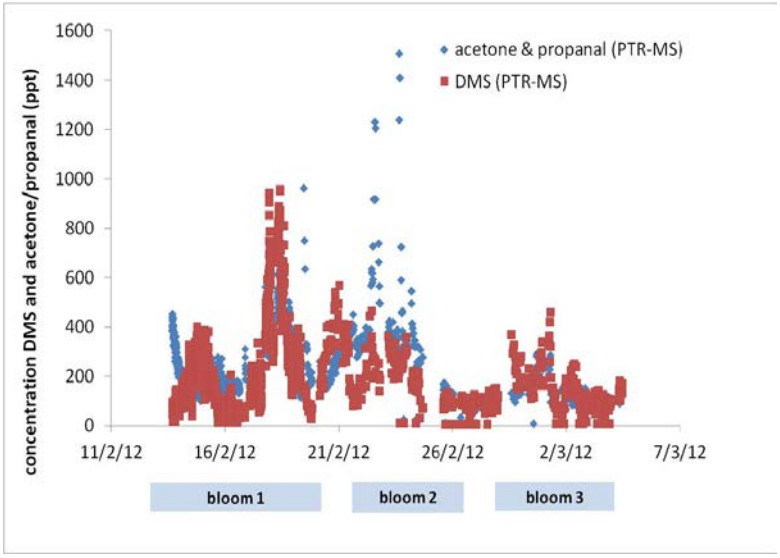


Figure 1: Time series of DMS and acetone/propanal during voyage showing individual bloom periods

Observed hygroscopic growth factors (HGF) of Aitken and accumulation mode particles suggest marine aerosol was dominated by moderately hygroscopic particles suggesting non sea salt sulphates, with contributions from sea salt and organics (Cravigan et al 2013) broadly consistent with observations from other locations using hygroscopicity methods (Swietlicki et al 2008)

Over phytoplankton blooms, particles were consistently volatile at ~150°C, providing further evidence for the dominance of non-sea salt sulphates (Fig 2). HGF were reduced over blooms, suggesting presence of secondary organics along with sulphates. Bubble bursting experiments

indicated the organic volume fraction of the primary marine aerosol ranged from approximately 3-18% (Cravigan et al 2013).

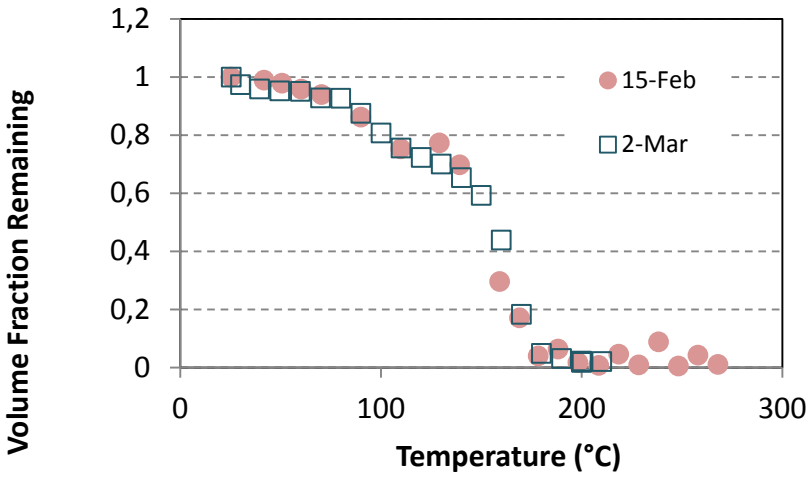


Figure 2: Volatility of 50 nm marine aerosol particles

Lawson, S.J., Keywood, M.D, Galbally, I.E., Harvey, M., Law, C., Selleck, P.W., Cheng, M. and Ristovski, Z (2012) Characterising VOCs in the Marine Boundary Layer During the SOAP Voyage, Chatham Rise, 44ºS. SOLAS Open Science Conference, Cle Elum, Washington State 7-10 May 2012.

Cravigan, L.; Mallet, M.; Ristovski, Z.; Vaattovaara, P.; Talbot, N.; Olivares, G.; Harvey, M.; Law, C. (2013). "Marine Aerosol Hygroscopicity and Volatility, Measured on the Chatham Rise (New Zealand)." The European Aerosol Conference (EAC 2013), Prague, Czech Republic 1 – 6 Sep 2013.

Swietlicki, E., Hansson, H. C., Hämeri, K., Svenningsson, B., Maßling, A., McFiggans, G., Mcmurry, P. H., Petäjä, T., Tunved, P., Gysel, M., Topping, D., Weingartner, E., BALTENSPERGER, U., Rissler, J., Wiedensohler, A. and Kulmala, M.: Hygroscopic properties of submicrometer atmospheric aerosol particles measured with H-TDMA instruments in various environments - A review, Tellus, Series B: Chemical and Physical Meteorology, 60 B(3), 432–469, 2008.

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

1. Australian scientists from CSIRO Marine and Atmospheric Research and Queensland University of Technology (QUT) are involved in the SOAP international collaborative effort in marine biogeochemistry air-sea exchange and atmospheric chemistry along with experimenters in New Zealand (NIWA), U.S. (UCI, U Chapman, SUNY), Germany (IFM-G), Eire (NUIG), U.K. (U Camb), Canada (U Laval), & Finland (UEF). A Special Issue of *Atmospheric Chemistry & Physics, and Ocean Sciences,* has been initiated for presentation of the SOAP results Sarah Lawson (CSIRO) and Luke Cravigan (QUT) attended the SOAP workshop in Wellington, New Zealand in March 2013 to discuss preliminary results. SOAP results have also been presented at the following international conference and workshops in 2013:

Cravigan, L., Mallet, M., Ristovski, Z., Vaattovaara, P., Talbot, N., Olivares, G., Harvey, M., Law, C. (2013) Marine aerosol hygroscopicity and volatility, measured on the Chatham Rise (New Zealand): 19th International Conference on Nucleation and Atmospheric Aerosols. Fort Collins, CO, AIP Publishing: 1527 (1547). Doi: 10.1063/1.4803329

Cravigan, L.; Mallet, M.; Ristovski, Z.; Vaattovaara, P.; Talbot, N.; Olivares, G.; Harvey, M.; Law, C. (2013). "Marine Aerosol Hygroscopicity and Volatility, Measured on the Chatham Rise (New Zealand)." The European Aerosol Conference (EAC 2013), Prague, Czech Republic 1 – 6 Sep 2013.

Lawson, S., Keywood, M., Galbally, I., Harvey, M., Law, C., Selleck, P., Cheng, M., Ristovski, Z. (2013). The Surface Ocean Aerosol Production (SOAP) voyage: Characterising Volatile Organic Compounds (VOCs) over Chatham Rise, 44ºS. 21st International Clean Air and Environment Conference, 7 – 11 September, 2013, Sydney, Australia

Cravigan, L., Milic, A., Miljevic, B., Mallet, M., Vaattovaara, P., Harvey, M., Law, C., Olivares, G., Lawson, S., Keywood, M., Ristovski, Z.; (2013). Marine aerosol composition from organic rich waters in the South East Pacific. The 9th Australia and New Zealand Aerosol Workshop. 12-13 September, Australian Nuclear Science and Technology Organisation, Darling Harbour, Sydney.

2. Sarah Lawson (CSIRO) attended the Future SOLAS Early Career Scientist workshop at PML Plymouth UK, 3-5 Dec 2013

3. Galbally, Ian E. and Martin G. Schultz (2013) Guidelines for Continuous Measurement of Ozone in the Troposphere, GAW Report number 209, World Meteorological Organisation, Geneva Switzerland.

4. Holly Winton and Marc Mallet attended the 2013 SOLAS Science School in Xiamen China.

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

<u>Research cruises</u>

Measurements of greenhouse gases and ozone during a circumnavigation of Australia on the RV Southern Surveyor (Kubistin et al 2013)

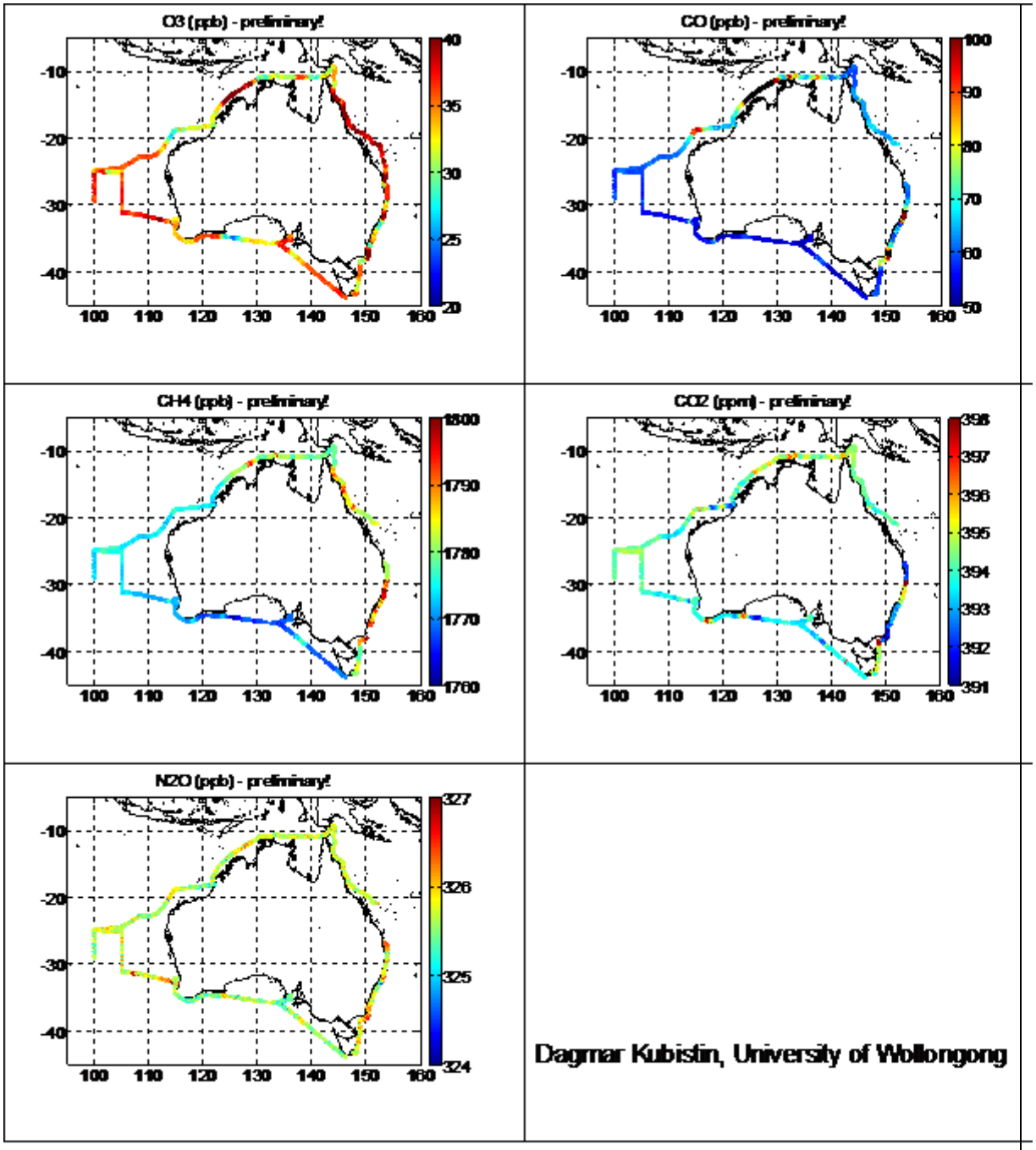
Climate change is one of the most pressing global environmental issues of our time, driven in particular by the large growth in greenhouse gases. However the data coverage in the southern hemisphere is still extremely sparse and the impact of the Australian continent on the southern hemispheric background atmosphere has not been well characterised. Comprehensive measurements of the key greenhouse gases in the Australasian marine boundary layer can improve

our current knowledge of their budget in this region.

Continuous in situ measurements of methane, carbon dioxide, nitrous oxide and ozone as well as carbon monoxide were performed during a circumnavigation around Australia on board the Australian research vessel RV Southern Surveyor form June till October 2013. The data were collected by using a fully automated Fourier Transform Spectrometer for CH_4, CO_2, N2O, ^{13}C, CO and a UV absorption instrument for O_3. The preliminary data are shown in the figures below.

Predominantly air downwind of Australia was sampled throughout the cruises, showing signatures of emissions and photochemistry from large metropolitan areas, desert and rain forest, as well as biomass burning. Strong enhancements in the trace gas concentrations were predominant when back trajectories indicate that the air mass has travelled over biomass burning regions. This unique dataset will be used in future comparison with global and regional models to characterise the different source attributions and to improve the emission inventories of the Australasian region.

D. Kubistin, C. Paton-Walsh, J. A. Fisher, G. Kettlewell & D. W. T. Griffith (2013), Greenhouse Gas Emissions and Ozone from Australia to the Marine Boundary Layer: Measurements from a Circumnavigation of Australia on the RV Southern Surveyor. Abstract: Atmospheric Composition & Chemistry Observations & Modelling Conference proceedings, incorporating the Cape Grim Annual Science Meeting 2013, Aspendale, Australia



New Research Vessel – RV Investigator update

Australia's new research vessel, the RV Investigator, is nearing completion and is currently undergoing sea trials in Singapore. In early 2014 it will sail to Hobart, Australia for final scientific fit out. The RV Investigator has dedicated atmospheric chemistry and aerosol laboratories onboard, and permanent measurements of aerosol properties and composition, greenhouse gases, and reactive gases. The Australian atmospheric science community (including CSIRO Marine and Atmospheric Research, University of Melbourne, University of Wollongong, Queensland University of Technology, ANSTO, Macquarie University) and trace element oceanographic community (University of Tasmania, Antarctic Climate & Ecosystems CRC, Australian National University, Australian Institute of Marine Science), will undertake a number of short (5 day) commissioning voyages from Hobart in the first half of 2014 to gain experience at sea.

Sea Time Applications for 2015-16 are closed and currently under review. The call for pre proposals for 2016-17 will be made in July-August 2014. Collaboration between Australian and International Research groups is encouraged.

http://www.marine.csiro.au/nationalfacility/application/index.htm

SOLAS- relevant Atmospheric Field Campaigns

1. The Measurements of Urban, Marine and Biogenic Air campaign (MUMBA) took place in Wollongong (lead by Uni of Wollongong), NSW from 21st December 2012 to 15th February 2013. The campaign aimed to study gaseous and aerosol composition at the ocean/forest/urban interface. The main measurement site was located approximately half a kilometer from the ocean, with prevailing north easterly winds bringing predominantly clean marine air to the site. Characterization of the marine air sampled during the campaign is underway and may be of interest to the SOLAS community (Paton Walsh et al 2013)

2. The Sydney Aerosol Study was a measurement campaign involving collaboration between CSIRO, QUT, ANSTO, Uni Wollongong which investigated the processes leading to particle formation via a comprehensive observation program during February 2011. During measurements of aerosol chemical composition in summer sea salt was found to make a substantial contribution (up to 75% of total) to PM2.5 in a residential area 36km inland from the coast in summer over 4 weeks. Chemical analysis of the sea salt showed it was a mixture of 64% fresh emissions and 36% aged particles. This study used a chemical transport model to assess the contribution of the aged sea salt component to health effects on the Sydney population. This concluded that the chemical ageing of sea salt particles results in significant human exposure to nitrate and sulphate particulate matter in Sydney. Given that sea salt contributes over 3000 Tg per year to total global aerosol this is likely to be a significant finding for coastal cities around the world. This study highlights the interaction between urban and marine emissions as having an impact both on air quality management and policy and also on human health (Emmerson et al 2013).

Emmerson, K.M., Cope, M.E., Galbally, I.E., Keywood, M.D., Selleck, P.W. (2013). 'Aged sea salt in the urban Sydney environment: a cause for concern?' 21st International Clean Air and Environment Conference, Sydney Australia, 7-11 September 2013. Preparation of a full manuscript is underway.

Paton-Walsh, C. Guérette, É.-A., Humphries R., Kubistin D., Wilson S.,. Griffith D,. Buchholz R, Velazco V.,. Shi X, Galbally I.,. Keywood M, Lawson S., Selleck P., Cheng M., Molloy S., Bhujel M., Griffiths A., Chambers S & Davy, P. (2013) Overview of the MUMBA Campaign: Measurements of Urban, Marine and Biogenic Air. Abstract: Atmospheric Composition & Chemistry Observations & Modelling Conference proceedings, incorporating the Cape Grim Annual Science Meeting 2013, Aspendale, Australia

SOLAS – relevant Workshops and meetings

1. 21st International Clean Air and Environment Conference, Darling Harbour Sydney 7-12 September 2013
2. 9th Australia and New Zealand Aerosol Workshop, Darling Harbour, Sydney, from 12-13 September 2013, hosted by ANSTO.
3. The Atmospheric Composition Observations and Modelling Conference & Cape Grim Annual Science Meeting, 28-30 Nov 2013, hosted by CSIRO Aspendale
4. Strategic Science in Antarctica. A joint Australian & New Zealand Conference 2013. Hobart, 24-26 June 2013. http://conference.antarctica.gov.au/

Development of SOLAS- relevant background measurement facilities

1. The Gunn Point Tropical Atmospheric Observatory (lead by CSIRO) located 1 km from the coast in tropical northern Australia has expanded to a second measurement container in 2013 for reactive gas and aerosol measurements (in additional to greenhouse gas measurements). The site experiences clean marine air from SE Asia for several months during the monsoon season so provides opportunity for SOLAS-related science. Current international collaboration includes short-lived halocarbons measurements by U Cambridge.

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

RV Investigator blog

http://csirofrvblog.com/tag/rv-investigator/

News story in local media about launch of RV Investigator

http://www.themercury.com.au/news/tasmania/launch-of-csiro-research-vessel-investigator-a-complicated-affair/story-fnj4f7k1-1226783993435

TV story on Catalyst Science Program about decommissioning of Southern Surveyor and commissioning of replacement, RV Investigator http://www.abc.net.au/catalyst/stories/3816267.htm

5. Top 10 publications in 2013 (Reports, ACCEPTED articles, models, datasets, products, website etc)

Roger J. Francey, Cathy M. Trudinger, Marcel van der Schoot, Rachel M. Law, Paul B. Krummel,Ray L. Langenfelds, Paul Steele, Colin E. Allison, Ann R. Stavert, Robert J. Andres and Christian Rödenbeck Atmospheric verification of anthropogenic CO2 emission trends (2013), *Nature Climate Change*, Vol 3 May 2013 DOI: 10.1038/NCLIMATE1817

Tessa R. Vance,, Andrew T. Davidson, Paul G. Thomson, Maurice Levasseur, Martine Lizotte, Mark A. J. Curran, Graham B. Jones *(2013)* Rapid DMSP production by an Antarctic phytoplankton community exposed to natural surface irradiances in late spring *Aquat Microb Ecol* Vol. 71: 117–129, 2013, doi: 10.3354/ame01670

Leahy, S., Kingsford, M and Steinberg, C. (2013). Do clouds save the Great Barrier Reef? Satellite Imagery Elucidates the cloud-SST relationship at the local scale *PLoS ONE* 8(7): e70400. doi:10.1371/journal.pone.0070400

Graham Jones (2013), Coral animals combat stress with sulfur, *Nature*, News and Views, 31 Oct 2013, Vol 502

Cropp RA, Gabric AJ, Levasseur M, McTainish, GH, Bowie AR, Hassler CS, Law CS, McGowan H, Tindale N, Viscarra Rossel R, 2013. The likelihood of observing dust-stimulated phytoplankton growth in waters proximal to the Australian continent. *Journal of Marine Systems*, 117-118, 43-52. ISSN 0924-7963 (2013)

Morton PL, Landing, WM, Hsu S-C, Milne A, Aguilar-Islas AM, Baker AR, Bowie AR, Buck CS, Gao Y, Gichuki S, Hastings MG, Hatta M, Johansen AM, Losno R, Mead C, Patey MD, Swarr G, Vandermark A, Zamora LM, 2013. Methods for the sampling and analysis of marine aerosols: Results from the 2008 GEOTRACES aerosol intercalibration experiment. *Limnology and Oceanography*: Methods, 11 (FEB) pp. 62-78. ISSN 1541-5856 (2013)

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

1. RV Investigator: The Australian atmospheric science community (including CSIRO Marine and Atmospheric Research, University of Melbourne, University of Wollongong, Queensland University of Technology, ANSTO, Macquarie University), will participate in a number of short (5 day) commissioning voyages from Hobart in the first half of 2014 to gain experience at sea.
2. In Jan 2014 CSIRO CMAR and IMAS are hosting the annual meeting of the Partnership for Observation of the Global Oceans (POGO) and will involve around 50 heads of agencies active in oceanography from 21 countries. The meeting is mainly a forum for member heads of agency to discuss ways in which we collectively can work to influence, improve, or expand

international programs to observe the ocean. There will be a series of small workshops associated with the main meeting to discuss the Southern Ocean Observing System (SOOS), observations of the tropical Indo-Pacific, developing autonomous devices for observing the deep ocean (e.g. below 2000m), and mechanisms of improving provision of data streams from the array of national and international observing programs.

7. Other comments

Annual Report for the year 2013:

SOLAS BELGIUM

compiled by:Christiane Lancelot

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

Measurement and modelling of Argon dynamics within sea ice provide insights on gas transport in sea ice

We measured Ar concentration in landfast ice (Barrow, AK) from January to June 2009. We observed that Ar responds differently to brine dynamics than the other biogeochemical compounds. This contrast is attributed to the specific effect of bubble nucleation on inert gas transport. Mechanism for Ar bubble formation and transport in sea ice was explored with a sea ice model. Ar dynamics is dominated by uptake, transport by brine dynamics and bubble nucleation in winter and early spring; and by an intense and rapid release of gas bubbles to the atmosphere in spring.

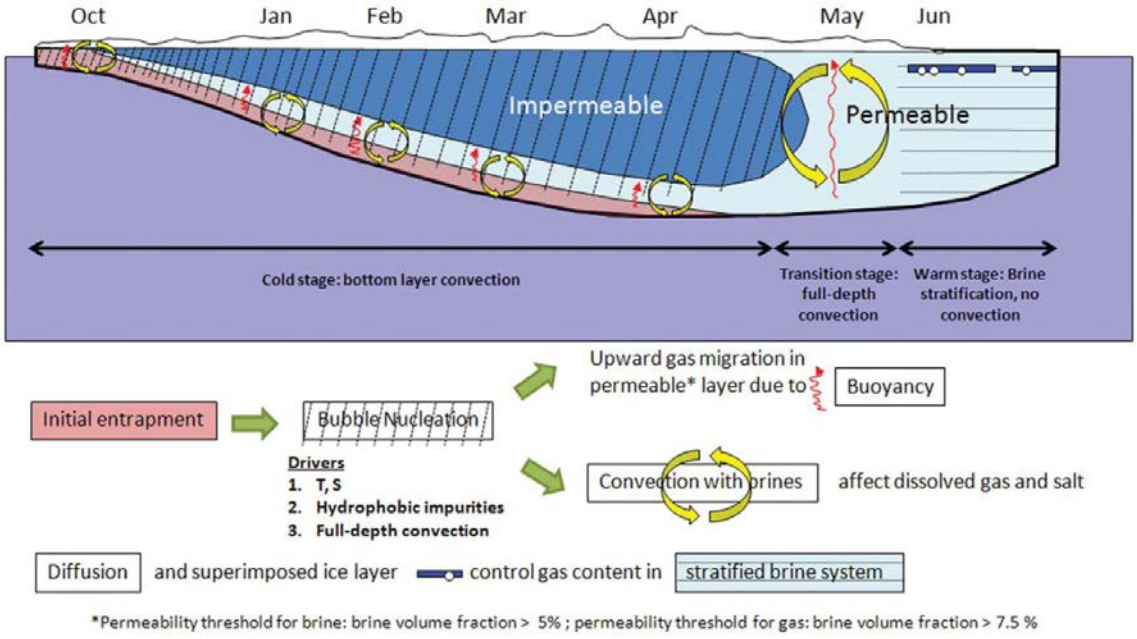


***Figure**: Schematic view of gas entrapment and evolution in sea ice through the three stages of brine dynamics. After the entrapment, changes in temperature (T) and salinity (S), the presence of hydrophobic impurities, and full-depth convection contribute to bubble nucleation. Bubbles could then migrate upward in permeable layers due to their buoyancy compared to the brines, while gas dissolved in brine would migrate as salt does, due to brine convection. Diffusion and the formation of superimposed ice layers may also control gas content in permeable sea ice.*

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

A.V. Borges and G. Munhoven are contributing authors to Chapter 6 of the 2013 IPCC report

A.V. Borges contributed to the SOCAT synthesis :
- Pfeil et al. A uniform, quality controlled Surface Ocean CO2 Atlas (SOCAT), Earth System

Science Data, 5, 125-143, doi:10.5194/essd-5-125-2013, 2013
- Sabine et al. Surface Ocean CO_2 Atlas (SOCAT) gridded data products, Earth System Science Data, 5, 145-153, doi:10.5194/essd-5-145-2013

A.V. Borges and B. Delille contributed to Chapter 3 (Air-Sea Interactions of Natural Long-Lived Greenhouse Gases (CO_2, N_2O, CH_4) in a Changing Climate) of the SOLAS synthesis "Ocean-Atmosphere Interactions of Gases and Particles" (P. Liss and MT Johnson, Eds).

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

Cruises and research projects

We completed a one-year survey of sea ice biogeochemistry in landfast ice in Mc Murdo Sound in the frame of the Bigsouth/YROSIAE (Year-Round Ocean-Sea Ice-Atmosphere Exchanges). Focus was given to the link between sea ice physics and biogeochemistry especially the fluxes of climate gases (CO_2, DMS, CH_4, N_2O) to the atmosphere. This project results from a tight collaboration with T. Haskell from Callaghan Innovation and Antarctica New Zealand.

We participated in AWECS (ANTARCTIC Winter Ecosystem Climate Study) cruise on board the RV Polarstern (Alfred Wegner Institute, Germany). The cruise was an integrated multidisciplinary study of pack ice biogeochemistry in the Weddell Sea during the winter 2013 (June-August). Samples were collected in the atmosphere above (gas fluxes), in the snow cover, in the bulk ice (ice cores), in the brines (sackholes) and in the sea water below (0m, 1m, 30 m).

Meeting organisation and session chairs

A.V. Borges and N. Gypens as SC members of the 45th International Liege Colloquium on "The variability of primary production in the ocean: from the synoptic to the global scale" held from 13-17 May 2013.

A.V. Borges co-chaired a session on "Biogeochemistry of coastal seas and continental shelves" at EGU 2013.

A.V. Borges co-chaired a session on "Ocean Acidification at ICES 2013 Annual Science Conference, 23-27 September 2013, Reykjavik, Iceland

N. Gypens co-chaired a session on "Coastal ecosystem under anthropogenic pressure: impact on ecosystem structure and services" at EGU 2013.

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

5. Top 10 publications in 2013 (Reports, ACCEPTED articles, models, datasets, products, website etc)

De Jong JTM, Schoemann V, Maricq N, Mattielli N, Langhorne P, Haskell T, Tison J-L, 2013, Iron in land-fast sea ice of McMurdo Sound derived from sediment resuspension and wind-blown dust attributes to primary productivity in the Ross Sea, Antarctica, *Marine Chemistry*, 24-40, doi:10.1016/j.marchem.2013.07.001

Geilfus N-X, Carnat G, Dieckmann GS, Halden N, Nehrke G, Papakyriakou T, Tison J-L, Delille B, 2013, First estimates of the contribution of $CaCO_3$ precipitation to the release of CO_2 to the atmosphere during young sea ice growth, *Journal of geophysical Research – Ocean,* doi:10.1029/2012JC007980

Gledhill M, Hassler CS and Schoemann V, 2013, The environmental bioinorganic chemistry of aquatic microbial organisms. *Frontiers in Microbiology*, 4, 100, doi: 10.3389/fmicb.2013.00100

Vancoppenolle M, Meiners KM, Michel C, Bopp L, Brabant F, Carnat G, Delille B, Lannuzel D, Madec G, Moreau S, Tison J-L, van der Merwe P, 2013, Role of sea ice in global biogeochemical cycles: Emerging views and challenges, *Quaternary Science Reviews*, 79:207-230, doi:10.1016/j.quascirev.2013.04.011

Zhou J, Delille B, Eicken H, Vancoppenolle M, Brabant F, Carnat G, Geilfus N-X, Papakyriakou T, Heinsesch B, Tison J-L, 2013, Physical and biogeochemical properties in landfast sea ice (Barrow, Alaska): insights on brine and gas dynamics across seasons, *Journal of geophysical Research – Ocean*, 118(6):3172-3189

Salt L.A., H. Thomas, A.E.F. Prowe, A.V. Borges, Y. Bozec & H.J.W. de Baar, 2013 Variability of North Sea pH and CO2 in response to North Atlantic Oscillation forcing, JGR-Biogeosciences, 118, doi:10.1002/2013JG002306

Cai W-J, C.-T.A. Chen & A.V. Borges, 2013. Carbon dioxide dynamics and fluxes in coastal waters influenced by river plumes, Chapter 7, pp. 155-173, Biogeochemical Dynamics at Large River-Coastal Interfaces: Linkages with Global Climate Change (Editors: T.S. Bianchi, M.A. Allison, and W.-J. Cai), 704 pp., Cambridge University Press

Regnier P, P Friedlingstein, P Ciais, F.T. Mackenzie, N. Gruber, I. Janssens, G.G. Laruelle, R. Lauerwald, S. Luyssaert, A.J. Andersson, S. Arndt, C. Arnosti, A.V. Borges, A.W. Dale, A. Gallego-Sala, Y. Goddéris, J. Hartmann, C. Heinze, T. Ilyina, F. Joos, D. E. LaRowe, J. Leifeld, F.J.R. Meysman, G. Munhoven, P.A. Raymond, R. Spahni, P. Suntharalingam & M. Thullner , 2013. Anthropogenic perturbation of the carbon fluxes from land to ocean, Nature Geosciences, doi: 10.1038/NGEO1830

Gypens, N, Borges, AV, Speeckaert, G, Lancelot,C, 2014. The dimethylsulfide cycle in the eutrophied Southern North Sea: a model study integrating phytoplankton and bacterial processes. PloS ONE 9(1) e85862. doi10.1371/journal.pone.0085862.

Moreau S, Vancoppenolle M, Zhou J, Tison J-L, Delille B & Goosse H, Modelling argon dynamics in first-year sea ice, Ocean Modelling, in press

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

Experimentation and modelling

Further analysis and synthesis of data (trace metals, Fe organic complexation and isotopic composition (Fe, Zn, Cu), gases, nutrients, POC, DOC) collected in snow, sea ice, brines and seawater as well as dusts during the land-based sampling program YROSIAE at Cape Evans (McMurdo Sound, Ross Sea, Antarctica) from Nov-Dec 2011 and from Aug-Dec 2012, the IceARc cruise (Polarstern XXVII-3) in Central Arctic (Aug-Oct 2012)(only trace metals analysi) and during the AWECS (Antarctic Winter Ecosystem and Climate Study) cruise (Polarstern ANTXXIX-6) in the Weddell Sea during the winter 2013 (June-August).

Laboratory study of the variability of the DMSP content and DMSP lyase activity of selected key species of the Southern North Sea for further integration in the recently published DMS-MIRO model.

Laboratory experiments using diatoms are being conducted to investigate the influence of atmospheric dust addition and of pCO_2 on phytoplankton growth. A joint VUB-ULB cruise aboard RV Belgica is planned, aiming at assessing the different biogeochemical processes controlling the nitrogen cycle, in particular the N_2 fixation, in the oligotrophic NE Atlantic waters (Biscay and Iberian margins). In addition, the impact of the marine iron biogeochemistry on the phytoplankton and diazotrophs will be investigated.

Meeting organisation and session chairs

Organisation (A.V. Borges) of the 46th International Liège Colloquium on “Low oxygen environments in marine, estuarine and fresh waters” (5-9 May 2014)

Co-chair (A.V. Borges) of Session on “Biogeochemistry of coastal seas and continental shelves” (EGU May 2014)

Co-chair (N. Gypens) of Session on “Coastal ecosystem under anthropogenic pressure: impact on ecosystem structure and services (EGU May 2014)

Co-chair (V. Schoemann) of Session on " Dust in the Sea- impact on biogeochemistry and climate" at DUST 2014 International Conference on Atmospheric Dust, Castellaneta Marina (TA), Italy, June 1-6.

Conference participation with abstracts

EGU 2014

IGS International Symposium on Sea Ice in a Changing Environment 2014

7. Other comments

SOLAS Brazil

compiled by: L. C. da Cunha (local SOLAS representative, UERJ, lcotrim@uerj.br) together with R. Kerr (FURG), R. Ito (FURG), F. Bonou (UFPE), B. Pinheiro (UFPE), M. Araújo (UFPE), M. F. Landim de Souza (UESC), L. Cotovitz Jr (UFF), B. Knoppers (UFF)

Notes:
Reporting Period is January 2013 – December 2013
UERJ – Rio de Janeiro State University; FURG – Federal University of Rio Grande; UFPE – Federal University of Pernambuco; UESC – Santa Cruz State University; UFF – Federal Fluminense University.

1. Scientific highlights

1. Sampling of net sea-air CO_2 fluxes in less documented ocean margins

Studies of the carbonate system in the coastal environments has become of great concern to the scientific community. In the framework of the Brazilian High Latitudes Oceanography Group (GOAL; www.goal.furg.br), led by the Federal University of Rio Grande (FURG), Brazil, an integrated multidisciplinary research involving several national institutions was established to focus on physical, chemical, bio-optical, and biological studies of the oceans. In this context, the spatial and temporal variability of air-sea CO_2 fluxes (FCO_2) were investigated around the Antarctica Peninsula (successive summers from 2008 to 2010), the Argentinian Patagonia continental shelf-break (from 2007 to 2009) and in the continental shelf and slope of the South-western subtropical Atlantic (spring 2010 and summer 2011) (Fig.1). In addition to the high variability in the FCO_2 distribution, due to complex interactions between biogeochemical and physical processes in these regions, those studies add observation datasets in less documented areas of the ocean margins, that can significantly contribute to better estimates the oceanic uptake of atmospheric CO_2. A paper, entitled "Net sea-air CO_2 fluxes in the South-western subtropical Atlantic continental shelf during spring 2010 and summer 2011", from Ito, R.G. et al., is in its final draft version to be submitted to Continental Shelf Research.

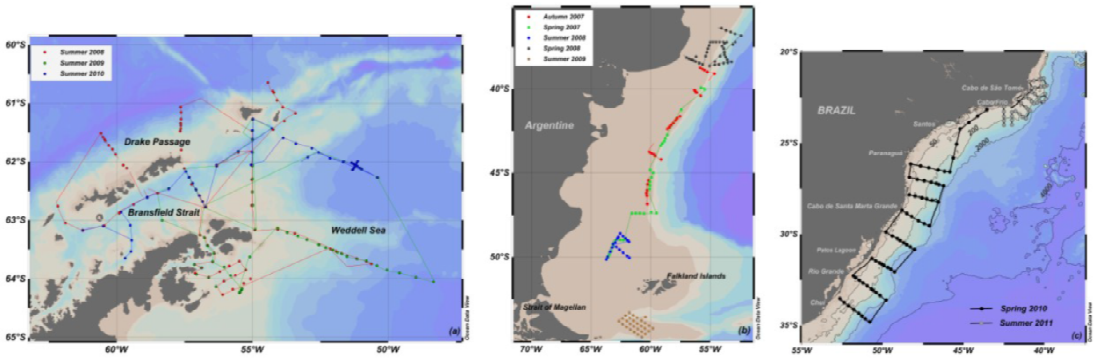


Fig. 1 - Study areas showing pCO_2 sampling (lines) and hydrographic stations (dots), related to oceanographic cruises in the Antarctica Peninsula (a), Argentinian Patagonia (b) and in the South-western subtropical Atlantic (c).

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

→ *2nd International Workshop on "Global Ocean Acidification Observing Network (GOA-ON)"*. St. Andrews, UK, 24-26 July 2013. The participation of the BrOA leader Dr. Rodrigo Kerr in this workshop gave BrOA an opportunity to start contacts with other international group, especially with South American groups developing research on ocean acidification issues. Also, to met the Director of the NOAA Ocean Acidification Program, Dr. Libby Jewett, was beneficial for the whole group as she was invited to collaborate with the first meeting organized by the group after BrOA implementation.

→ *3rd Brazilian Workshop on "Climate Change in coastal zone"*. Florianópolis, SC, Brazil, 9-13 December 2013. The workshop considered three main themes: 1) Biogeochemistry of carbon and ocean acidification, 2) Oceans and coastal observational systems, and 3) Network monitoring of coastal benthic habitats. The workshop was convened by Zonas Costeiras - REDE Clima, INCT-Mudanças Climáticas & REBENTOS, and sponsored by CNPq, CAPES, FAPESP, FURG, USP and UFSC. Over 200 scientists are expected to attend the symposium, including five international invited speakers: Dr. Thomas C. Malone (University of Maryland, USA), Dr. Tim Moltmann (IMOS, Australia), Dr. Colin Woodroffe (GeoQUEST / University of Wollogong, Australia), Dr. Libby Jewett (NOAA, USA), and Dr. Steven Crooks.

→ "*Building the Marine Science - French/Brazilian Meeting"*. Búzios, Brazil, 4-8 November 2013. This Colloquium aimed to create new interactions in all fields of Marine Sciences between Brazil and France. Research Groups from both countries have presented their current activities and a future structured, official, cooperation agreement is sought. BrOA co-leader Leticia Cotrim da Cunha has presented the group's main activities in 2013, emphasizing some already on-going Brazilian-French cooperation in the field of ocean acidification, sea-air CO_2 fluxes, and biogeochemistry modelling. BrOA members Bastiaan Knoppers and Luiz Cotovitz Jr (UFF) have presented their work on sea ↔ air CO2 fluxes at Guanabara Bay, Rio de Janeiro, in cooperation with Gwenäel Abril (CNRS, Uni-Bordeaux, France).

→ Leticia Cotrim da Cunha has participated as an expert reviewer to the IPCC Fifth Assessment Report – WG 1 (The Physical Science Basis).

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

**Research projects (Approved projects in 2013 and ongoing projects)*

→ The project EstARte-Sul, led by Dr. Rodrigo Kerr, was funded by the Rio Grande do Sul State agency FAPERGS to be conducted between Dec-2013/Dec-2015. The project will be responsible to measure the biogeochemical parameters along the south-south-east Brazilian continental slope. Two cruises are planned to occur along the south-south-east Brazilian continental slope, under the umbrella of the project EstARte-Sul, between 2014-2015. Cruises' dates to be defined later.

→ The project NAUTILUS (New autonomous technologies to investigate and monitor Antarctic Bottom Water in the Weddell Sea and Antarctic Peninsula) was funded by the Brazilian Antarctic Programme via CNPq (Federal Government Agency). Activities are expected to start in austral summer 2014/2015. This project, led by Dr. Maurício Mata (FURG), also counts with the cooperation of researchers from Sao Paulo University (USP) and Rio de Janeiro State University (UERJ), as well as from Alfred-Wegener Institute – AWI (Germany), British Antarctic Survey – BAS (UK), University of Southampton – NOCS (UK), University of East Anglia – UEA (UK), University of Alaska Fairbanks – UAF (USA), The State University of New Jersey – Rutgers (USA), Servicio de Hidrografia Naval – SHN (Argentina), and Universidad de Buenos Aires – UBA (Argentina).

→ The ongoing research programme INCT AMBTROPIC (National Institute on Science & Technology in TROPICAL MARINE ENVIRONMENTS, http://www.inctambtropic.org/), funded by federal agency CNPq, and executed by a consortium of 20 institutions involving circa 200 researchers, has 2 research themes directly related to SOLAS, CLIVAR and PIRATA activities:

- ***GT3.1 – Ocean-Atmosphere Interaction, Climatic Variability and Predictability in the North-north-east of Brazil and in the Tropical Atlantic:*** Processes derived from the ocean-atmosphere interaction are partially responsible for the climate variability at different spatial and temporal scales. For instance, the monsoon system in South America (especially characterized by the rainy season in the basin of the Amazon river during the southern summer and by the presence of the South Atlantic Convergence Zone (SACZ)), and the distribution of rainfalls in the North of Brazil (NB) and North-east of Brazil (NEB) are modulated by intra-seasonal to inter-decennial variability of sea surface temperature in the Pacific and Atlantic. The variability of precipitation, evaporation and inflow of fresh water from rivers is directly associated with the variability of surface salinity, and therefore it is an indicator of the intensity of the hydrological cycle over oceanic regions. *WG PIs: Marcus Silva (UFPE) & Doris Veleda (UFPE).*

- ***WG 3.2 – Biogeochemical Cycles, CO_2 Fluxes and Acidification of the Tropical Atlantic Ocean:*** Although the tropical Atlantic is known as a source of CO_2 to the atmosphere, very little is known about the spatial and seasonal-interannual variability in the CO_2 flux along the air-sea interface in this oceanic region, while much less is known about its long-term progress in times of increased atmospheric CO_2. However, if the tropical Atlantic operates globally as a source of CO_2 to the atmosphere, specific and important regions have been characterized as CO_2 capturing areas, such as the oceanic areas located near the discharges of large rivers such as the Amazon. This WG main objective is to study the oceanographic processes controlling the variability of biogeochemical properties of the tropical Atlantic Ocean. The intent of this proposal is to increment the capability to predict the responses of the tropical Atlantic to the increasing human activities, particularly those associated with capture and cycling of atmospheric CO_2 and potential ocean acidification. *WG PIs: Moacyr Araújo (UFPE) & Nathalie Levèfre (IRD, France).*

**Cruises*

→ Frédéric K. Bonou (PhD student, Federal University of Pernambuco – UFPE) participated to the German cruise M98 between 01 to 28 July 2013, from Fortaleza (Brazil) to Namibia (Africa) aboard RV Meteor (chief Scientist: Prof. Dr. Peter Brandt, GEOMAR, Germany). During the cruise underway fCO_2, N_2O and DMS measurements were made, together with nutrient analysis. Direct measurements of CO_2 flux using the eddy covariance technique led by Tobias Steinhoff from GEOMAR (Germany) were also performed: Eddy covariance air-sea fluxes were determined by measuring the vertical wind fluctuations simultaneously with the fluctuations in the concentration of the CO_2. The flux is the covariance of the two quantities. Since these measurements are made on a moving platform, the winds were corrected for the platform motion before correlating. Winds were measured using Campbell CSAT 3 sonic anemometers and the ship motion was measured using a Systron Donner MotionPak II. These devices were rigidly mounted directly on the mast, ideally 10 m above the sea surface. The CO_2 flux measurements were made with a LICOR 7500.

→ Luiz Cotovitz Jr. (PhD student, Federal Fluminense University, UFF), Bastiaan A. Knoppers (Professor, UFF), Nilva Brandini (posdoc, UFF), Suzan J. C. Santos (UFF), Ludmila P. Costa (UFF) and Gwenäel Abril (CNPq – Université de Bordeaux, France) are currently performing continuous measurements of pCO_2 in subsurface waters of Guanabara Bay (Rio de Janeiro), one of the most eutrophic coastal systems in the world. The campaigns include horizontal profiling of continuous

and georeferenced pCO_2, dissolved oxygen (DO), pH, salinity, temperature and chlorophyll-*a* (fluorescence). The results indicate that the Bay can be separated in 5 sectors related to pCO_2 spatial distributions: 1) Marine domain: levels of pCO_2 between 350-650 ppm and mesotrophic conditions; 2) "Rio de Janeiro Harbour Domain", with salinities between 27 and 31, hypoxic-anoxic conditions, highest pCO_2 concentrations (800-3000 ppm), and outgassing flux; 3) The central domain, with the more constant values of pCO_2 in the Bay (350-450 ppm); 4) The Guapimirim domain, receiving relatively unpolluted freshwater from rivers, high variations of pCO_2 concentrations (350-1100 ppm); 5) The Governador Island Domain, hypertrophic conditions, where the pCO_2 showed high diurnal variations (50-2200 ppm), turning from CO_2 sink at daytime to CO_2 source at night time. The processes of production/respiration of organic matter and the proximity of the effluent discharge are the most important factors of the pCO_2 dynamics in the bay, overcoming the influences of atmospheric anthropogenic CO_2 (ocean acidification hypothesis).

**Events*

During the Seminar "Antarctica, 2048: climate changes and global balances", held in Porto Alegre, RS, Brazil, in November 2013, a special section mediated by Dr. Rodrigo Kerr was dedicated to "Climate change: impacts of a global environment", with a discussion of Ocean Acidification in Antarctic environment given by Dr. Rosane G. Ito. More information about the event at the website http://www.antartica2048.com.br/.

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

- Barbara R. Pinheiro (PhD Student from UFPE, Recife) participated to the Ocean Acidification summer course at Friday Harbor Labs, University of Washington, USA, from 22 July to 23 August 2013. The course served as a rapid indoctrination into essential topics in geochemistry, de-mystifying this essential piece of ocean acidification research throughout lectures on fundamental topics, practical discussions of measuring techniques and equipment and extensive laboratory experience with the critical measurement tools. And most important we gained experience with a range of techniques for conducting experimental manipulations of environmental conditions (analysing dissolved inorganic carbon, total alkalinity and Spec-pH).

- BrOA student BSc. Iole B. M. Orselli (FURG, Rio Grande) participated to the summer school "Biogeochemical cycles in highly productive marine ecosystems" was held in Buenos Aires, between 2-14 December 2013. The course proposed reviewed the basis of the biogeochemical process in the ocean and showed examples of highly productive regions. Dr. Michelle Ivette Graco (IMARPE, Peru) taught the main classes, with invited lecturers presenting the knowledge of the physical and biophysical process. This event was a valuable opportunity to the student, as her master studies focus on anthropogenic carbon quantification in the Patagonian shelf-break.

- Frédéric K. Bonou (PhD Student from UFPE, Recife) participated to Germany cruise M98 occurred between 30 June to 29 July, from Fortaleza (Brazil) to Namibia (Africa) aboard of Meteor Ship Fig2. Aboard of this ship each scientific participant gave a presentation focusing on the main results of their own research project.

5. Top 10 publications in 2013 (Reports, ACCEPTED articles, models, datasets, products, website etc.)

BrOA website - www.broa.furg.br

da Cunha L C & Kerr R, 2013, *Brazilian Research on Ocean Acidification (BROA)*, Building the Marine Sciences, a Brazil-France Meeting, Búzios, Brazil, Available on-line at http://marinebrazil.sciencesconf.org/25807/document

Kerr R & da Cunha L C, 2012, *1st Brazilian Ocean Acidification Research report*, 22p. Released on-line in September 2013 at http://joomla.furg.br/broa/images/doc/BROA.pdf

Kerr R, da Cunha L C, de Souza M F L, Wainer I, Ito R G, Calil P H R & Garcia C A E, 2013, *Activities of the Brazilian Ocean Acidification Research (BROA) group*, 2nd International Workshop: Global Ocean Acidification Observing Network, St. Andrews, UK, poster nº 16, pp 14-15. Available on-line at http://www.nerc.ac.uk/research/programmes/oceanacidification/events/documents/goa-on-booklet.pdf

da Cunha L C, Buitenhuis E T, 2013, Riverine influence on the tropical Atlantic Ocean biogeochemistry. *Biogeosciences*, 10,6357–6373. doi: 10.5194/bg-10-6357-2013.

Abril G, Martinez J-M, Artigas LF, Moreira-Turcq P, Benedetti MF, Vidal L, Meziane T, Kim J-H, Bernardes MC, Savoye N, Deborde J, Souza EL, Albéric P, Landim de Souza MF*, Roland F. Amazon River carbon dioxide outgassing fuelled by wetlands. Nature, December 2013, advance on, doi: 10.1038/nature12797.

* Marcelo F. Landim de Souza (Universidade Estadual de Santa Cruz – UESC, Ilhéus, Bahia)

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

The short term goal established by BrOA group (i.e. to identify and to integrate the Brazilian scientific community that studies aspects related with ocean acidification issues) in our 1st Report was fully completed during 2013, being finalized with the release of the 2nd report after the Florianopolis meeting in early 2014.

Our medium term goals include: 1) implementing the necessary scientific equipment and analyses certification for ocean acidification research; 2) participation of Brazilian laboratories to international inter-calibration exercises, and 3) strengthen the cooperation with experimented international groups.

BrOA is planning for the next year a South American meeting on "Ocean Acidification Issues" to be held in the second semester, probably concomitant to the PIRATA Meeting at Recife. The meeting aims to better connect the activities and collaborations between South American researchers on this topic and to establish possible collaborations among the biogeochemistry branch of PIRATA.

Coming in 2014:

- The coastal buoy network SIMCOSTA, coordinated by FURG, will start its activities. The continuous measurements include meteorological, sea-level, oceanographic and biogeochemistry measurements in 4 buoys located over the southern Brazilian coastal zone. Real-time data will be available at http://www.simcosta.furg.br/portal/.
- UERJ's proposal entitled “Rio de Janeiro Coastal and Ocean Monitoring System (SiMOC)” was funded by FINEP (federal agency). It includes the deployment of a *meteorological-oceanographic-biogeochemistry buoy off Rio de Janeiro shelf, an eddy-covariation tower for CO2 measurements in a mangrove area*, and an analytical facility for measuring PAH contamination in biological samples.

7. Other comments

The Brazilian Research Group on Ocean Acidification (BrOA) was created in December 2012 during the Workshop "Studying Ocean Acidification and its effects on marine ecosystems", organized by the Brazilian IGBP Office, São Paulo University (USP), Federal Council for Research and Development (CNPq), and the National Institute for Space Research (INPE).

We also aim at improving at national level our capacity building and scientific equipment, as well as contributing to current international programmes like SOLAS, IMBER, CLIVAR, and LOICZ.

The PIs of the above mentioned INCT AMBTROPIC programme (some being also BrOA members) are planning to submit SOLAS IPO a request for endorsement in 2014.

Annual Report for the year 2013:

SOLAS CANADA *compiled by: M Levasseur & R Christensen (NETCARE)*

Notes:This report includes mostly NETCARE activities
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

Highlight 1:

Direct evidence of the fertilizing power of volcanic ash in the Gulf of Alaska

Josiane Mélançon,[1] Maurice Levasseur,[1] Martine Lizotte,[1] Pierre Delmelle,[2],a Jay Cullen,[3] Roberta C. Hamme,[3] Angelica Peña,[4] Kyle G. Simpson,[4] Michael Scarratt,[5] Jean-Éric Tremblay,[1]
Jie Zhou,[3,6] Keith Johnson,[4] Nes Sutherland,[4] Michael Arychuk,[4] Nina Nemcek,[4] and Marie Robert[4]

1 Université Laval, Department of biology (Québec-Océan), Québec, Canada
2 University of York, Environment Department, York, United Kingdom
3 University of Victoria, School of Earth and Ocean Sciences, Victoria, British Columbia, Canada
4 Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, British Columbia, Canada
5 Fisheries and Oceans Canada, Maurice Lamontagne Institute, Mont-Joli, Que´bec, Canada
6 Hangzhou Dianzi University, Department of Environmental Science and Engineering, Hangzahou, People's Republic of China

In August and September 2008, unusually high concentration of chlorophyll *a* was measured in the Gulf of Alaska. This stimulation of growth was linked to the explosive eruption of Kasatochi volcano on August 7th, 2008. Volcanic ash deposition is a potential source of iron fertilization in HNLC areas, yet not much is known about its iron bioavailability and effect on phytoplankton community. Ash-enriched incubations of Gulf of Alaska waters were conducted to quantitatively assess the first response of the phytoplankton community to an ash deposition. Following a 4 d lag period, we observed significant increases in carbon fixation rates (up to a factor of 10) and chlorophyll a concentrations (up to a factor of 3) in the ash-enriched treatments. Our results suggest that deposition of 1 mg-ash L^{-1}, which is in the lower range of the concentrations estimated to have caused the August 2008 bloom, would have sufficed to trigger the 2008 bloom in the Gulf of Alaska. Considering that ash and dust deposition fluxes are similar on a millennial timescale (Olgun et al. 2011), our results call for a reevaluation of the importance of volcanic ash in the iron budgets of HNLC oceanic regions.

Reference:

Mélançon et al. (2014) Early response of the northeast subarctic Pacific plankton assemblage to volcanic ash fertilization. *Limnol. Oceanogr.* 59(1): 55-67.

Olgun et al. (2011) Surface ocean iron fertilization: The role or airborne volcanic ash from subduction zone and hot spot volcanoes and related iron fluxes into the Pacific Ocean. *Glob. Biogeochem. Cycles* **25**: GB4001, doi:10.1029/2009GB003761

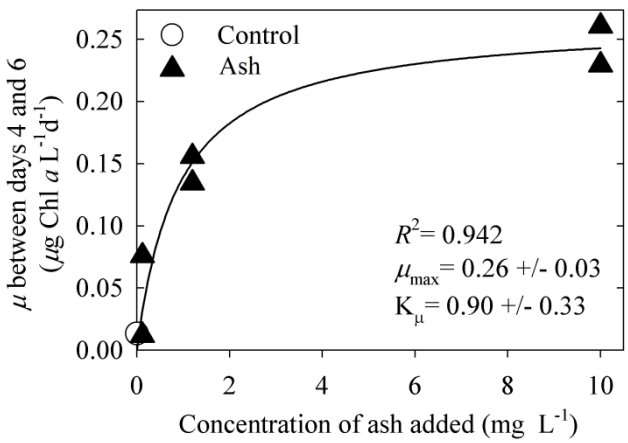


Figure 1: Growth rate (µg Chl *a* L^{-1} d^{-1}) during the exponential phase (between days 4 and 6 after enrichment) plotted against the concentration of ash added in the replicates where growth has been observed. A Monod equation $\mu = \mu_{max} \times [ash] (K_\mu + [ash])^{-1}$ was fitted through the data. Correlation is significant (p = 0.0003).

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

SOLAS Endorsement

NETCARE has been officially endorsed by SOLAS in 2013.

With NETCARE funding, already-strong collaborations with Canadian government and foreign researchers have been reinforced. These collaborations with government scientists are doubly important to the success of the network. First, our large scale ocean and atmospheric measurement campaigns are being performed entirely collaboratively with Environment Canada (EC) and Fisheries and Oceans Canada (DFO). Second, collaboration with government scientists provides a clear mechanism for knowledge transfer from the academic scientists to the government, primarily through access to the Canadian Earth System model and the GEM on-line transport model. Below we highlight some of the most active collaborations since the start of the network.

Continuation of the collaboration between SOLAS and ArcticNet

The Network of Centres of Excellence ArcticNet is the largest group of Arctic researchers in Canada. It involves over 145 researchers from 30 Canadian Universities, 8 federal and 11 provincial agencies and departments collaborate with research teams in Denmark, Finland, France, Greenland, Japan, Norway, Poland, Russia, Spain, Sweden, the United Kingdom and the USA. The 2014 and 2016 NETCARE cruises in the Arctic will be conducted in collaboration with ArcticNet. This collaboration between SOLAS activities in Canada and ArcticNet was initiated in 2007 with the IPY Arctic SOLAS program (2007-2011).

Expansion of Collaboration with the Alfred Wegener Institute

In the original NETCARE funding proposal, we requested funding for two 60-flight hour campaigns. While sufficient, this was the minimum number of flight hours possible given that 22 flight hours are required to get from Muskoka to the Arctic. Through financial contributions from AWI, the summertime 2014 campaign has been expanded to 90 hours and the springtime 2015 campaign

to 105 hours. In addition, in 2015 the POLAR6 will be accompanied by a second plane, the POLAR5, which will provide aerosol lidar measurements along similar flight tracks to the POLAR6. This is an extensive financial contribution to the NETCARE science plans from AWI, indicating their committed collaboration. In particular, the 2015 campaign becomes a joint NETCARE-PAMARCMIP campaign, with shared resources and more extensive measurements than described in the NETCARE proposal. Our list of new international collaborators include: Prof. Alex Huffman at the University of Denver, Dr. Johannes Schneider at the Max Planck Institute for Chemistry, Mainz; Prof. Peter Hoor, University of Mainz; Dr. Oliver Wurl, Leibniz Institute for Baltic Sea Research; and Drs. Kathy Law and Jennie Thomas from the LATMOS laboratory in France.

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

Netcare Ucluelet Field Campaign

To address the importance of marine sources of ice nuclei (IN), the network conducted its first large-scale field experiment in August 2013. Experiments were conducted from August 2 to 29 at the Coast Guard Station at Ucluelet, on the west coast of Vancouver Island. The research participants included scientists from the U of British Columbia, U of Toronto, U of Denver, Fisheries and Oceans Canada, Environment Canada, and the Leibniz Institute for Baltic Sea Research. In total, 14 scientists visited the site and are directly involved in the data collection and/or analysis. Measurements included: size distributions and hygroscopicity (SMPS, APS, CCN), fluorescent particle loadings (WIBS, UV-APS), particle composition (MOUDI/IC), deposition ice nuclei (CFDC) and immersion ice nuclei (microscope technique). As well, sea surface microlayer samples were collected from offshore, and through atomization, the ice nucleation properties of these particles were analyzed.

Detailed analyses of these data are now underway. One novel result is that we have identified highly efficient deposition IN in the sea surface microlayer samples that do not exist in bulk water seawater. As well, when these samples are filtered, this IN activity is removed. To our knowledge, this is the first direct demonstration that the sea surface microlayer contains significant numbers of potential ice nuclei. This observation was confirmed from using samples also collected (and then stored frozen) from a summer 2014 Pacific cruise. We are planning a more comprehensive follow-up experiment, using samples collected at the Institute of Ocean Sciences on Southern Vancouver Island. We will analyze those samples at IOS and/or the U of Toronto.

Preparations for Netcare Field Campaigns

NETCARE-POLAR

Extensive preparations have occurred for the large-scale NETCARE-POLAR aircraft campaigns, the scope of which has expanded from the plans in the original NETCARE funding proposal. While the first campaign in summer 2014 will largely address the impact of oceanic emissions on new particle formation and growth in the Arctic we hope to also study ship emissions in an Arctic environment and we will assess the input of biomass burning BC during this season. The campaign will now consist of 90 flight hours (60 in the original proposal) from June 16 to July 15 2014 (with instrument integration starting three months earlier), and will be based primarily out of Resolute, Nunavut. We have been in discussions with both the POLAR aircraft operators (Kenn Borek Air) and the Coast Guard (in particular, the Captain of the Amundsen) to investigate the possibilities of using the Amundsen as the source of ship BC and OC emissions, to be studied using the aircraft.

The second campaign, which focuses on the distribution and properties of aerosol, especially BC and OC, across the Arctic and its relationship to ice clouds and aerosol optical properties, will take place in springtime (April 7 to May 8, 2015) rather than springtime 2016 as in the original NETCARE funding proposal. The springtime campaign will start in Germany and then proceed with stops in Longyearben, Station Nord, Alert, Eureka, Resolute, Inuvik, Fairbanks and Barrow before returning to Muskoka. Detailed flight plans have been developed, personnel have been identified to fly on the plane, equipment upgrades are underway, and planning of required instrumentation

(e.g. analysis of power, weight requirements) and overall logistics are underway. As well, analysis of data from past POLAR flights has commenced, with initial indications of a source of BC occurring from flaring operations in North Russia.

NETCARE-Canadian ice-breaker Amundsen

2013 was marked by several meetings and exchanges in view of the 2014 Netcare cruise in the Arctic. Preparations are proceeding in the laboratories to make the atmospheric and oceanographic instrumentation campaign-ready. For example, a CIMS approach is being developed to permit sensitive on-line DMS and VOC measurements. As well, development of an automated sampling system to be coupled to a GC-SCD to measure atmospheric DMS concentrations is well underway. A trap and valve system has been constructed, field tested and is able to detect DMS concentrations at the level of 10 ppt. An on-line IC system is being developed that will permit rapid measurement of soluble species, including MSA.

Netcare Annual Workshop

The annual workshop was held November 18-19, 2013 in Toronto, at which we had 55 participants attending and about half a dozen following remotely. The full External Steering Committee, all co-investigators, and many of our major collaborators were able to participate.

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

Netcare Highly Qualified Personnel Training

The network has ramped up activity rapidly, with already 24 HQPs involved.

5. Top 10 publications in 2013 (Reports, ACCEPTED articles, models, datasets, products, website etc)

NETCARE has not produced any publication during the 2013 year. We anticipate network publications throughout the 2014 academic year.
Netcare new website can be found at the following address: www.netcare-project.ca

SOLAS-related publications

Levasseur M (2013). The Arctic meltdown and the microbial cycling of sulphur. Nature Geoscience 7: 691-700.

Mélançon J, Levasseur M, Lizotte M, Delmelle P, Cullen J, Hamme RC, Peña A, Simpson K, Scarratt M, Tremblay JE, Zhou J, Johnson K, Sutherland N, Arychuk M, Nemcek N, Robert M (2014). Early response of the northeast subarctic Pacific plankton assemblage to volcanic ash fertilization. Limnol. Oceanogr. 59: 55-67.

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

NETCARE's overall goals are to a) address key uncertainties in predictions of aerosol effects on climate by using a variety of observational and modeling approaches, and b) use that increased knowledge to improve the accuracy of Canadian climate and Earth system model predictions of aerosol radiative forcing.

To achieve these goals, NETCARE has research proceeding in four distinct but inter-related research activities: i) Carbonaceous Aerosols (including Black Carbon), ii) Ice Cloud Formation and Impacts, iii) Ocean-Atmosphere Interactions, and iv) Implications of Measurements on Simulations

of Atmospheric Processes and Climate.

i) Understanding the climatic role of carbonaceous aerosol (including black carbon (BC)) in remote regions

It is well recognized that modelling the sources and processes associated with short-lived forcing agents such as BC represents one of the largest uncertainties in understanding climate in remote regions such as the Arctic. BC is a strong shortwave forcing agent that has impacts on not only atmospheric heating rates but also, after it is deposited, on the snowpack albedo. As well, associated with BC is organic carbon (OC) aerosol that has a counteracting, cooling effect on the atmosphere. Specific questions being addressed are:

- *How do BC and OC loadings from biomass burning compare with anthropogenic BC and OC over the Arctic and Western Canada?*
- *What is the relative importance of the mechanisms for BC and OC deposition to Arctic snow and ice? In particular, what is the vertical distribution of BC in the Arctic atmosphere? Is there evidence for dry deposition in the boundary layer and/or via ice clouds?*
- *What are the levels and sources of BC and OC, including brown carbon, in snow? What are the implications of carbonaceous loadings in snow on radiative forcing?*

To achieve these goals requires new measurements of BC and OC in remote environments which, when compared to model output, can be used to assess sources and losses. As a result, a major effort within NETCARE is to provide new aircraft measurements, conducted in two seasons (summer and spring) in the Canadian Arctic. These measurements will be used, along with existing datasets, to improve models that assess aerosol-climate connections.

In addition to the NETCARE-POLAR flights, BC measurements at Whistler in Western Canada are proceeding, providing a long term data set that is being used to assess different BC sources, such as biomass burning, to that location. This work is done in collaboration with Environment Canada (EC). As well, planning is underway for the collection of snow samples at Alert during the winter season of 2014-2015. These samples will be assessed for their BC, OC and brown carbon content, as a joint project between NETARE co-investigators and EC collaborators. C14 analysis will indicate the balance between fossil and fresh carbon BC sources. Together, these measurements will provide information on BC and OC fluxes and source types to the snowpack in the high Canadian Arctic.

ii) Understanding the formation and impacts of ice clouds in remote regions

Whereas the mechanisms leading to warm cloud formation are relatively well understood, the nucleation processes that lead to ice clouds and mixed phase clouds are highly uncertain, representing one of the major uncertainties in climate modelling in cold environments. These clouds are radiatively active, dehydrate the Arctic, and provide a mechanism for aerosol scavenging. The major questions that NETCARE is addressing are:

- *What are the concentrations of IN (ice nuclei) in remote marine, Arctic, and free troposphere environments?*
- *What is the relative role of different IN (dust, biomass burning, black carbon, biological, oceanic) in these locations?*
- *Are primary particles from the open ocean a source of IN in the Arctic and mid-latitude marine boundary layer?*
- *What is the role of ice crystal precipitation in the removal of anthropogenic pollution to the Arctic during polar winter and springtime (see Activity 1 above)?*

To achieve these goals, new measurements of ice nuclei number (IN) will test our understanding of ice cloud formation processes, providing the information needed to develop better parameterizations in climate models (see Activity 4). The new measurements will occur from Whistler and Alert (to start in 2014-2015), from the POLAR aircraft and from the Amundsen icebreaker cruises. Detailed planning for these activities commenced in the past year.

iii) Understanding the impact of ocean-atmosphere interactions on Arctic aerosol and climate

As the Arctic sea ice melts and is replaced by open ocean, there is the potential for a significantly different impact of natural (i.e. oceanic) processes on polar atmospheric aerosol. As well, the emissions from melt ponds forming on the sea ice surface may affect future climate. A major initiative within NETCARE is to couple teams in oceanic chemistry/biology and atmospheric science, to study the connections between the ocean and atmosphere. New oceanic and atmospheric measurements from ice breaker cruises will be used to further develop a coupled ocean-atmosphere-sea ice biogeochemical model. Specific questions being addressed are:

- *What are the relative contributions of bacteria, ice algae, under-ice phytoplankton blooms, melt ponds and open water phytoplankton blooms to DMS production at the ice edge in spring-early summer? Is DMS escaping directly through the ice at a significant rate?*
- *Is the sea-surface microlayer a source of primary organic atmospheric aerosol, and what are the cloud nucleating properties of these particles?*
- *What oceanic and atmospheric conditions favour particle nucleation and growth arising from oceanic emissions?*
- *What is the vertical extent of new particle formation and growth events and do such events occur primarily in the atmospheric boundary layer, or do ventilated emissions above the boundary layer promote nucleation more efficiently?*

To address the source of DMS, the nature of the microlayer, and the prevalence of nucleation and growth events, Amundsen ice breaker cruises in the Arctic will take place in summer 2014 and 2016. To assess the degree of particle nucleation and growth above the ocean, the POLAR6 campaign is scheduled for the summer of 2014, during which fine particle measurements will be made in both the boundary layer and above.

iv) Implications of Measurements on Simulations of Atmospheric Processes and Climate

This activity integrates the new measurements into our understanding of climate processes. This will be done by comparing the measurements to model predictions, which will lead to improved understanding of how to represent key aerosol-climate processes within the models and, ultimately, to improved climate predictions. The data analysis and modelling group has begun a broad range of activities designed to develop, evaluate, and improve simulations of Arctic aerosol. This effort includes general circulation models (University of Victoria, University of Waterloo), chemical transport models (Dalhousie University, and UQAM), an ocean biochemistry model (University of Victoria), and development of remote sensing algorithms (University of Sherbrooke and Dalhousie University) to provide additional observational constraints to the simulations. Broad questions motivating these studies include:

- *How well do models represent aerosol processes in remote areas of Canada?*
- *How do aerosol processes drive uncertainties in model simulations and how can aerosol simulations be improved?*
- *How do aerosols contribute to changes in climate at mid-high latitudes?*

7. Other comments

Annual Report for the year 2013:

SOLAS China

compiled by: Minhan Dai and Huiwang Gao

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

(1) Why are some marginal seas sources of atmospheric CO_2?

Dai, MH, ZM. Cao, XH. Guo, WD. Zhai, ZY. Liu, ZQ. Yin, YP. Xu, JP. Gan, JY. Hu and CJ. Du, 2013, ***Geophysical Research Letters***, 40, 2154-2158, doi:10.1002/grl.50390.

The contemporary coastal ocean, characterized by abundant nutrients and high primary productivity, is generally seen as a significant CO_2 sink at the global scale. However, mechanistic understanding of the coastal ocean carbon cycle remains limited, leading to the unanswered question of why some coastal systems are sources while others are sinks of atmospheric CO_2. Here we proposed a distinct physical-biogeochemical setting, Ocean-dominated Margin (OceMar), in order for better shaping the concept of the coastal ocean carbon study. OceMars, in contrast to previously recognized River-dominated Ocean Margins, are characterized by dynamic interactions with the open ocean, which may provide nonlocal CO_2 sources thereby modulating the CO_2 fluxes in OceMars. Using the basin areas of the largest marginal seas of the Pacific and the Atlantic, the South China Sea and the Caribbean Sea as examples of OceMars, we demonstrated that such external CO_2 sources controlled the CO_2 fluxes.

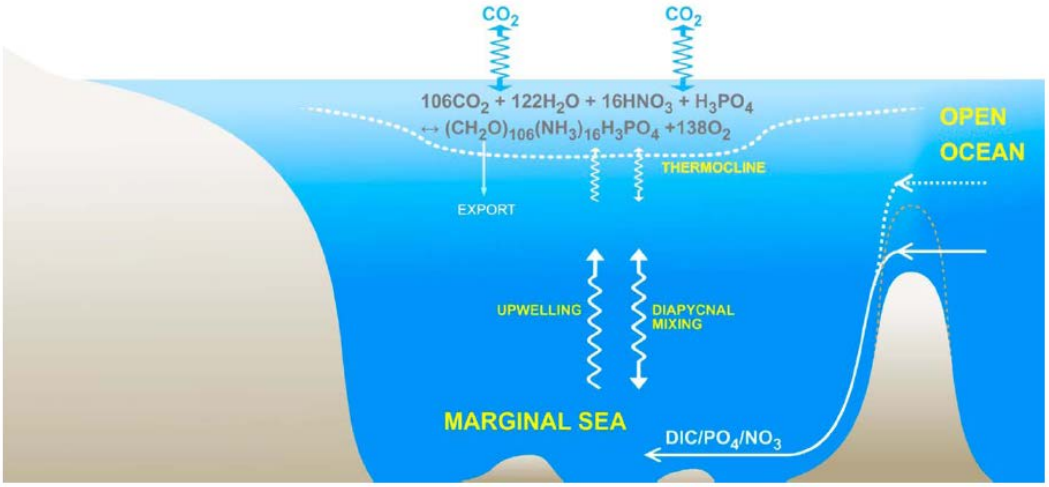


Figure 1. Schematic diagram of the main processes controlling the sea-air CO_2 fluxes in Ocean-dominated Margin (OceMar). For a given marginal sea, the source water mass has a characteristic ratio of DIC and nutrients, which depends on the depth where intrusion from the adjacent open ocean occurs. Such open ocean-originated DIC, PO_4, and nitrate(NO_3) are subsequently transported upward into the thermocline of the marginal sea through vertical mixing and upwelling. The coupled DIC and nutrient consumption via the organic carbon production in the thermocline (or the surface mixed layer) ultimately determines the sea-air CO_2 flux of the marginal sea. Higher ΔDIC than the corresponding $106\Delta PO_4$ or $6.6\Delta NO_3$ suggests that "excess ΔDIC" would be removed by CO_2 degassing into the atmosphere (i.e., CO_2 source), whereas lower ΔDIC than the corresponding $106\Delta PO_4$ or $6.6\Delta NO_3$ suggests that "deficient ΔDIC" would be supplied via the atmospheric CO_2 input to the ocean (i.e., CO_2 sink). The values of 106 and 6.6 are the Redfield C/P and C/N uptake ratios (approximately 106/1 and 106/16; [Redfield et al., 1963]), respectively.

(2) Investigating Aerosol Sources in Chinese Yellow Sea and Bohai Sea Using High-time Resolution Single Particle Aerosol Mass Spectrometry

Mei Zheng[1]*, Huaiyu Fu1,[2], Caiqing Yan[1], Xiaoying Li[1], Zhigang Guo[2], Xiaohong Yao[3], Huiwang Gao3

Chemical compositions and sizes of aerosol in the range of 0.2-2 micrometers were measured continuously using an online instrument, single particle aerosol mass spectrometer (SPAMS) in Chinese Yellow Sea (longitude 120°30'44"~124°49'62", latitude 31°98'04"~38°74'75") and Bohai Sea (longitude 118°95'41"~120°92'62", latitude 37°72'05"~39°54'78") during cruises from November 2nd to 20th, 2012 on board the Research Vessel Dongfanghong 2. This project was led by Prof. Mei Zheng at Peking University and closely collaborated with Prof. Zhigang Guo from Fudan University and Profs. Xiaohong Yao and HuiwangGao from Ocean University of China. The highlights of this study are: 1) sources of fine particlescollected every hour over these two Chinese seas were mapped with six major sources identified and quantified including secondarily formed particles, fresh sea-salt, aged sea-salt, biomass burning, soot-like, lead-containing, and other sources (see Figure 1), which is a significant improvement compared to traditional 24-h or longer filter sampling for aerosol analysis in marine environment, 2) The dominance of non-sea-salt particles indicated a strong anthropogenic influence. Aerosols in Bohai Sea and North Yellow Sea were relatively enriched in anthropogenic particles compared to South Yellow Sea, probably due to emissions from the more developed upwind regions, and 3) Particle counts as well as major and minor chemical components of aerosols exhibited clear changes from land to sea, but variations of their physicochemical characteristics depended more on the transported air masses and meteorology but less on the distance to land.

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

(1) Minhan Dai, What Controls CO_2 fluxes in the Coastal Ocean?, 9th International Carbon Dioxide Conference, June 3-7, 2013, Beijing, China.

(2) Minhan Dai, Carbon Biogeochemistry in the South China Sea - river dominated or ocean dominated?, Gordon Research Conference on Chemical Geography of the Sea, August 4-9, 2013, Biddeford, Maine, USA.

10 papers from CHOICE-C members have been published in Biogeosciences special issue “Biogeochemistry and ecosystems in the western north Pacific continental margins under climate change and anthropogenic forcing”, edited by K.-K. LIU, C.-K. KANG, T. KOBARI, **H. B. LIU**, C. RABOUILLE, K.FENNEL.

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

3.1 Workshop organized

1) 2013 CHOICE-C Pre-review Meeting, May 1-12, 2013, Xiamen, China.

2) 2013 CHOICE-C Review Meeting, Sept. 24-26, 2013, Tianjin, China.

3.3 New projects funded

1) National Basic Research Program of China funded by MOST "Atmospheric deposition and Its impact on marine primary production and nitrogen cycle (2014-2018)" , 15 millions RMB. PI: Huiwang Gao from Ocean University of China.
2) Major International Joint Research Project of Natural Science Foundation of China "Impacts of ocean acidification on estuary and nearshore marine ecosystems and biogeochemical processes of biogenic active gases (2014-2018)", 3.3 millions RMB. PI: Gui-Peng Yang from Ocean University of China ; Co-PI: Maurice Levasseur, from University of Laval, Canada.
3) Major Program "South China Sea-Deep" funded by National Science Foundation of China "Coupled physical-biogeochemical processes in the deep South China Sea and their impact on the air-sea CO2 fluxes (2014-2017), 4.2 millions RMB. PI: Minhan Dai from Xiamen University.

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

The 2nd Ocean and Me---2013 Xiamen University Ocean Sciences Open House, November 10, 2013, Ziqin Building, Xiamen University, China

5. Top 10 publications in 2013 (Reports, ACCEPTED articles, models, datasets, products, website etc)

(1) Dai, M. H., Z. M. Cao, X. H. Guo, W. D. Zhai, Z. Y. Liu, Z. Q. Yin, Y. P. Xu, J. P. Gan, J. Y. Hu and C. J. Du, 2013. Why are some marginal seas sources of atmospheric CO_2? , ***Geophysical Research Letters***, 40, 2154-2158, doi:10.1002/grl.50390.

(2) Zhai, W.D, M.H. Dai, B.S Chen, X.H Guo, Q Li, S.L Shang, C.Y Zhang, W.J Cai, and D.X Wang, 2013.Seasonal variations of air-sea CO2 fluxes in the largest tropical marginal sea (South China Sea) based on multiple-year underway measurements, ***Biogeosciences***, 10: 7775-7791

(3) Du, C., Z. Liu, M. Dai, S. Kao, Z. Cao, Y. Zhang, T. Huang, L. Wang, and Y. Li, 2013. Impact of the Kuroshio intrusion on the nutrient inventory in the upper northern South China Sea: insights from an isopycnal mixing model, ***Biogeosciences***, 10: 6419-6432.

(4) Li, Q.L., F. Wang, Z. A. Wang, D. Yuan, M. Dai, J. Chen, J. Dai and K. A. Hoering, 2013. Automated Spectrophotometric Analyzer for Rapid Single-Point Titration of Seawater Total Alkalinity, ***Environmental Science & Technology***, 47(19): 11139-11146.

(5) Jin P., Gao K.S. and Beardall J., 2013. Evolutionary responses of a coccolithophorid Gephyrocapsa oceanica to ocean acidification. ***Evolution***, 67(7): 1869-1878.

(6) Zhou, K. B., M. H. Dai, S.-J. Kao, L. Wang, P. Xiu, F. Chai, J. W. Tian and Y. Liu, 2013. Apparent enhancement of ^{234}Th-based particle export associated with anticyclonic eddies, ***Earth and Planetary Science Letters***, 381: 198-209.

(7) Zhen, H., Yang G.P., Lu, X.L., Zhang, H.H., 2013. Distributions and sea-to-air fluxes of volatile halocarbons in the Yellow Sea and the East China Sea in spring. ***Environmental Pollution***, 177: 28-37.

(8) Wang, L., Qi, J.H., Shi, J. H., Chen, X.J., Gao, H.W., 2013. Source apportionment of particulate pollutants in the atmosphere over the Northern Yellow Sea. ***Atmospheric Environment***, 70: 425-434.

(9) Shi, J.H., Zhang, J., Gao, H.W., Tan, S.C., Yao, X.H., Ren, J.L., 2013. Concentration, solubility and deposition flux of atmospheric particulate nutrients over the Yellow Sea. ***Deep Sea Research Part II: Topical Studies in Oceanography,*** 97: 43-50.

(10) Zhen, H., Yang G.P., Lu, X.L., Ding, Q.Y., Zhang, H.H., 2013. Halocarbons in the marine atmosphere and surface seawater of the South Yellow Sea during spring. ***Atmospheric Environment***, 80: 514-523.

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

SOLAS-Endorsed Project CHOICE-C has ended in 2013.

The Joint 7th Workshop on Asian Dust and Ocean EcoSystem (ADOES) with Asian SOLAS will be hosted by Ocean University of China in 2014 to promote regional exchanges.

A joint session on Status, trends and effects of climate, natural disturbances and anthropogenic stressors on ocean ecosystems (by Dr. Uematsu Mitsuo, Dr. Thamasak Yeemin, Prof. Dr. Huiwang Gao) at IOC-WESTPAC 9th international Scitific Symposium will be held in 2014 in Vietnam.

7. Other comments

SOLAS France

compiled by Rémi Losno, C. Guieu and V. Garçon

Notes:
Reporting Period is January 2013 – December 2013

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

1. Scientific highlights

- **AMOP** for *"Research Activities dedicated to the Oxygen Minimum in the East Pacific* (contact Aurélien Paulmier : aurelien.paulmier@gmail.com and Ivonne Montes: ivonne.montes@gmail.com, Boris Dewitte, Véronique Garçon, Isabelle Dadou and Andreas Oschlies).

The connection between the equatorial mean circulation and the oxygen minimum zone (OMZ) in the Eastern Tropical Pacific is investigated through sensitivity experiments with a high-resolution coupled physical-biogeochemical model. Two sets of climatological open boundary conditions for the physical variables which differ slightly on the intensity and vertical structure of the Equatorial Current System (ECS) are shown to lead to contrasted characteristics of the simulated OMZ by the regional model. Results demonstrate that the secondary Tsuchiya jet is a key feature of the sensitivity of the OMZ to the equatorial circulation. There is a significantly different balance between physical and biogeochemical processes within the energetic coastal current system between both simulations, illustrating the large sensitivity of the OMZ dynamics to the open boundary conditions.

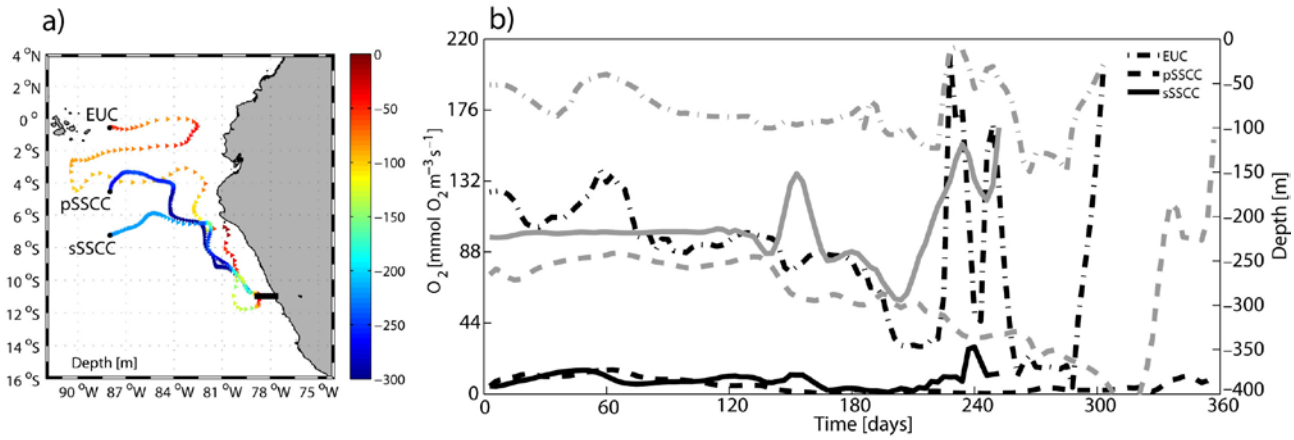


Figure 1. *Spaghetti diagrams of selected particles showing typical routes of floats associated to each main eastward equatorial subsurface current (Equatorial Under Current -EUC, 1st and 2nd Tsuchiya jets) feeding the PCUC. Black circles are initial positions of each float, colors represent the along-trajectory depth (in m) and, the cross-shore black bar, at ~9°S, is the PCUC section reaching the floats. Evolution of b) the oxygen content (black lines, scale on left axis) and depth (gray lines, scale on right axis) along the float pathways. In b, the dash-dotted, dashed and solid lines indicate the EUC, and 1st and 2nd Tsuchiya jets, respectively. (Montes et al., 2014, in revision)*

- ***Atmospheric new nutrients associated with Saharan dust pulses do significantly stimulate N_2 fixation in the Mediterranean Sea and that N_2 fixation is not a key process in the carbon cycle in such oligotrophic environments.***

The response of N_2 (dinitrogen) fixation to contrasted (wet and dry) Saharan dust deposition was studied in the framework of the DUNE project (a DUst experiment in a low-Nutrient, low-chlorophyll Ecosystem) during which realistic simulations of dust deposition (10 gm^{-2}) into large mesocosms ($52m^3$) were performed. Three distinct experimental dust additions were conducted in June 2008 (DUNE- 1-P: simulation of a wet deposition, DUNE-1-Q: simulation of a dry deposition) and 2010 (DUNE-2-R: simulation of 2 successive wet depositions) in the northwestern oligotrophic Mediterranean Sea. Results (figure 1) show that wet and dry dust deposition induced a rapid (24 h or 48 h after dust additions), strong (from 2- to 5.3-fold) and long (at least 4–6 days duration) increase in N_2 fixation, indicating that both wet and dry Saharan dust deposition was able to relieve efficiently the nutrient limitation(s) of N_2 fixation. The contribution of N_2 fixation to primary production was negligible (≤1 %) before and after dust addition in all experiments, indicating that N_2 fixation was a poor contributor to the nitrogen demand for primary production. Despite the stimulation of N_2 fixation by dust addition, the rates remained low, and did not significantly change the contribution of N_2 fixation to new production since only a maximum contribution of 10% was observed.

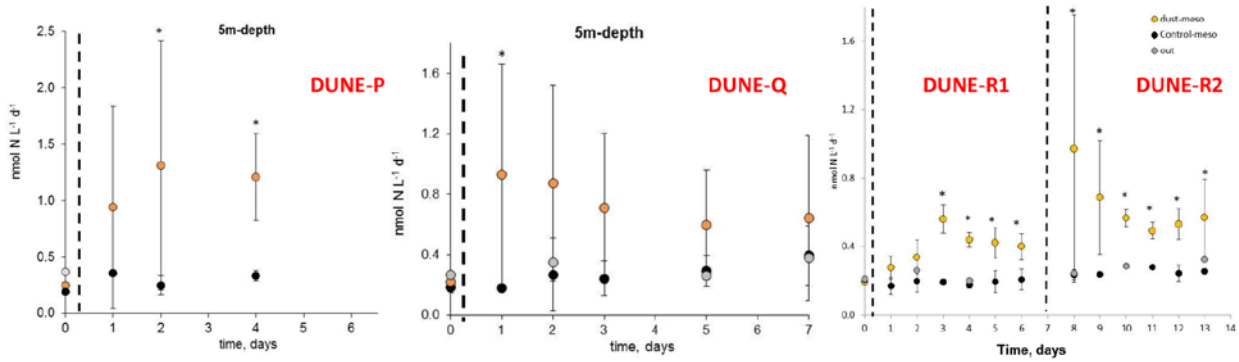


Figure 2. *Mean N_2 fixation rate (n=3) in nmol NL^{-1} d^{-1} during the 3 DUNE experiments in the Control-meso (black dot), Dust-meso (orange dot) and Out (grey dot) at 5m depth. The dotted line represents the time of the dust seeding. Data in the Control- and Dust-meso represent the average and standard deviation of the three replicate mesocosms. Means in the Dust-meso that were significantly different ($p < 0.05$) from the Control-meso are labeled with the * symbol.(from Ridame et al., 2013)*

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

Close international collaborations within AMOP: Peru, Germany, France, Spain, Denmark and Mexico. Participation of B. Dewitte (LEGOS) to the German Retreat SFB754 “Climate – Biogeochemistry interactions in the tropical ocean”, GEOMAR, Kiel Germany

MedSeA (EU FP7, started in February 2011, Mediterranean Sea Acidification in a changing climate. A first joint experiment using large pelagic mesocosms took place in Corsica (summer 2012) to assess the effects of ocean acidification on planktonic communities in oligotrophic areas (see article in this issue). Another experiment will take place in the Bay of Villefranche in Feb-March 2013. (see report in SOLAS NEWS issue 14, summer 2012).

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

2011; J.-P. Gattuso, gattuso@obs-vlfr.).

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

- ***Workshop*** on "Towards an integrative regional coupling in the Eastern Boundary Upwelling Systems (EBUS), Instituto Geofisico del Peru, Lima, 26- 27 November 2012 , as a Contribution to the SOLAS Mid-Term Strategy Initiative "Air-sea gas fluxes at Eastern Boundary upwelling and Oxygen Minimum Zone systems (http://solas-int.org/mts/research-strategy-5.html), 30-31 and Oceanflux projects: a collaboration between the European Space Agency (ESA) and SOLAS , 39-40.

- ***SOLAS Mid-Term Strategy Initiative*** *"Air-sea gas fluxes at Eastern boundary upwelling and Oxygen Minimum Zone (OMZ) systems":*

- **Participation to the Symposium : Microbial Ecology and Biogeochemistry of Oxygen-Deficient Marine Waters**, March 17-11, 2013, Santa Cruz, Chile, supported by the Agouron Institute and the Gordon and Betty Moore Foundation (V. Garçon).

- -**SCOR Working Group on Microbial Community Responses to Ocean Deoxygenation, Approved for 4 years (V. Garçon, full member)**. Summary: Water column oxygen (O_2) deficiency shapes food web structure by progressively directing nutrients and energy away from higher trophic levels and into microbial community metabolism. There is increasing evidence that ocean warming trends will decrease dissolved O_2 concentrations within the coastal and interior regions of the ocean, resulting in oxygen minimum zone (OMZ) expansion. These processes will directly impact coastal benthic ecosystems and fisheries productivity due to habitat compression and changes in nutrient cycles with currently unconstrained feedbacks on the global ocean. This SCOR working group will catalyze knowledge creation at the forefront of research on microbial community responses to changing levels of water column O_2-deficiency. It will unite oceanographers, microbial ecologists and biogeochemists to define model ecosystems, new standards of practice, and economies of scale needed for effective comparative analyses and enhanced forecasts of ocean deoxygenation. The deliverables will include one field experience, two program meetings, a white paper on best practices, and a peer-reviewed monograph.

- **ESA-EGU-SOLAS international workshop** "Air-sea Gas Flux Climatology; Progress and Future Prospects, Brest, 24-27 September 2013, (Session co-Chairman : V. Garçon)

- **EUR-OCEANS** Hot topics Conference: a changing ocean, 6-8 November, Telde, Gran Canarias, Spain

SOLAS ENDORSED PROJECT.

- ***AMOP*** for *"Research Activities dedicated to the Oxygen Minimum in the East Pacific* (contact Aurélien Paulmier : aurelien.paulmier@gmail.com, Boris Dewitte, Christophe Maes and Véronique Garçon).

Figure 3. *Deployment of multidisciplinary mooring on January 5, 2013 from R/V Meteor off Callao (12°S, 77°40'W) for a 3 years period, serviced in June 2013 with R/V Olaya and February 2014 with R/V L'Atalante. Sensors include 5 O_2-optodes (SBE63), 5 P-T-S (SBE37), 6 T (SBE56), 1 fluorimeter and 1 ADCP (RDI: Workhorse Quatermaster) sensors, 2 sediment traps (PPS3 Technicap) and buoyancy.*

- ***FLATOCOA***, R. Losno (losno@ipgp.fr) SOLAS endorsed. This program was set up to sample atmospheric deposition at Kerguelen (49.30°'S 70.12°E) and Crozet (46.35°S 51.70E) in the South Indian Ocean.

Despite sampling is stopped for 4 years, new results are still obtained from new sample analyses and data interpretation. It was found that solubility of most of the crustal elements are ever more than 70% and mostly 90% in rainwater over Kerguelen Islands. Time series of 18 12 months at Kerguelen and Crozet respectively were published. A seasonality is suspected and Crozet Island is found to be influenced by Austral Africa whilst dust deposion at Kerguelen comes mostly from Patagonia. *Ref: Heimburger et al. (2013a), Heimburger et al. (2013b)*

- ***MedSea:*** Mesocosms experiment (contact Frederic Gazeau – gazeau@obs-vlfr.fr),

SOLAS endorsed. MedSeA (EU FP7, started in February 2011, Mediterranean Sea Acidification in a changing climate.Two experiments using large pelagic mesocosms took place in Corsica (summer 2012) and in the Bay of Villefranche to assess the effects of ocean acidification on planktonic communities in oligotrophic areas. The first experiment in Corsica has been a real success. The conditions were highly oligotrophic and no significant effects could be observed for the vast majority of measured parameters, suggesting a rather strong resilience of oligotrophic Mediterranean waters to CO_2 enrichment. Interestingly, as it has been already observed in many laboratory experiments, nitrogen fixation rates responded positively to the CO_2 enrichment, although only at the 2 highest levels of pCO_2 (~1000 µatm). All available parameters have been uploaded to the Pangaea database (http://doi.pangaea.de/10.1594/PANGAEA.811018). A blog has been published during the experiment: http://medseastareso2012.obs-vlfr.fr. The second experiment has been conducted in February/March as this early spring period corresponds to the maximum of chlorophyll *a* in the bay of Villefranche and very different environmental conditions than the ones in the ultra-oligotrophic bay of Calvi in Summer. The experiment was anticipated to run for at least a month but had to be stopped after 2 weeks because of bad weather conditions. A dedicated blog has been published during the experiment: http://medseavillefranche2013.obs-vlfr.fr. Once all data will be available, they will be uploaded to the Pangaea database as we did for the results of the first mesocosm experiment.

- ***DONUT,*** E. Pulido-Villena (elvira.pulido@univ-amu.fr), SOLAS endorsed. The main goal of DONUT is to experimentally assess how and to which extent the response of heterotrophic prokaryotes (Hprok) to atmospheric inputs of nutrients shape the oceanic DOM pool and modify its bioavailability.

A first experiment was conducted between November and December 2013. Mediterranean surface water collected during the stratification period was amended with a Saharan dust end-member and incubated in the dark at controlled T during three weeks. Bacterial activity and biogeochemical characteristics of the dissolved organic matter (DOM) pool were determined at selected time points. Although most obtained samples are still being analyzed, some preliminary results are already available. The dust addition induced an increase in mineral nutrient concentration, dissolved organic carbon and fluorescent DOM. Interestingly, at the end of the incubations a higher amount of DOC had been consumed in the dust-amended treatments but lower bacterial production rates were recorded. We hypothesize that the addition of dust reduced the bioavailability of DOM with presumed, and so far unexplored, consequences on the role of dust on marine C cycle. A new experiment will be conducted in April 2014 in an attempt to assess the proposed hypothesis.

- ***DUNE.*** a DUst experiment in a low Nutrient, low chlorophyll Ecosystem, C. Guieu (guieu@obs-vlfr.fr).

The main goal of project DUNE was to estimate the impact of atmospheric deposition on an oligotrophic ecosystem based on mesocosm experiments simulating strong atmospheric inputs of eolian mineral dust. Our mesocosm experiments aimed at being representative of real atmospheric deposition events onto the surface of oligotrophic marine waters and were an original attempt to consider the vertical dimension after atmospheric deposition at the sea surface. After a series of mesocosm experiments conducted in the Mediterranean Sea in 2008 and 2010, the project activity in 2013 was the valorisation of the pluridisciplinary results obtained and a special issue in BIOGEOSCIENCES is devoted to the outputs of the project. From laboratory results on the solubility of trace elements in dust to biogeochemical results from the mesocosm experiments and associated modelling, these papers describe how the strong simulated dust deposition events impacted the marine biogeochemistry.

- **MERMeX** (Marine Ecosystems Response in the Mediterranean Experiment)-WP4. (contact: Karine Desboeufs - karine.desboeufs@lisa.u-pec.fr, Marc Mallet - Marc.Mallet@aero.obs-mip.fr, Elvira Pulido-Villena elvira.pulido@univ-amu.fr).

The main MERMEx activities relevant to SOLAS are the assessment of gas fluxes (CO_2) and acidification and the impacts on ecosystems and biogeochemical cycles, the study of aerosol fluxes at the air-sea interface [coupled with the component ChArMEx of MISTRALS (Chemistry-Aerosol Mediterranean Experiment)] considers both the formation of marine aerosol and the atmospheric deposition of nutrients and the influence of solar radiations on biogeochemical cycles includes the potential effect of aerosol and tropospheric ozone attenuation on marine ecosystems. A full report of the MERMeX-SOLAS activities can be find in the SOLAS endorsed projects reports.

Among those projects, we briefly describe some of them here:

- **CHIPIE**: Comportement des éléments d'intérêt biogéocHImiques et du carbone Particulaire a l'interface atmosphère-océan dans un contexte d'évolution des conditions Environnementales (Cécile Guieu, guieu@obs-vlfr.fr). (co-funding UPMC, MERMEX). The objective of this project is to study the impact of climate and environment change (temperature, acidification) on the behaviour of chemical elements and particulate carbon at the atmosphere-ocean interface. We have developed a new experimental approach that consists in performing artificial dust seeding over large tanks (300L) inside a clean room where temperature, turbulence and pH can be controlled. In 2013, three experiments were conducted in the frame of a PhD thesis (J. Louis) in order to follow the evolution of the total concentrations and organic/inorganic speciation of nutrients (P, N, Fe) after the dust seeding. Experiments were performed with seawater representative of different trophic regimes under two different pCO_2 conditions.

OTHER PROJECTS RELATED TO SOLAS

- ***OCEANFLUX –Theme Upwelling*** (http://due.esrin.esa.int/stse/projects/stse_project.php?id=160 and http://upwelling.eu/index.php?id=2).

This project is funded by the European Space Agency ESA) Support To Science Element Program and performed in collaboration with LEGOS, University of Heidelberg, Karlsruhe Institute of Technology in Germany and INRIA Bordeaux in France. In recent years the role of submesoscale activity is emerging as being more and more important to understand global ocean properties, for instance, for accurately estimating the sources and sinks of Greenhouse Gases (GHGs) at the air-sea interface. The scarcity of oceanographic cruises and the lack of available satellite products for GHG concentrations at high resolution prevent from obtaining a global assessment of their spatial variability at small scales. In this project we develop a novel method to reconstruct maps of CO_2 fluxes at super resolution (4km) using SST and ocean colour data at this resolution, and CarbonTracker CO2 fluxes data at low resolution (110 km). The responsible process for propagating the information between scales is related to cascading properties and multiscale organization, typical of fully developed turbulence. The methodology, based on the Microcanonical Multifractal Formalism, makes use, from the knowledge of singularity exponents, of the optimal wavelet for the determination of the energy injection mechanism between scales. We perform a validation analysis of the results of our algorithm using pCO2 ocean data from in-situ measurements in the upwelling region off Namibia.

- ***ETIC**: Study of atmospheric transport over Indian ocean*, PI J.L Baray (J.L.Baray@opgc.fr), LaMP, Clermont Ferrand, new project. This program is a collaboration between LaCy (La reunion, LSCE and LATMOS (Paris).

This program worked on the fate of atmospheric pollution over Indian Ocean. Time series measurements of ozone, CO and aerosols are done at La Réunion Island and during travels of "Marion Dufresne" ship. In addition, radiosondes were performed at Kerguelen Island. The most important result is the highlight of an inter hemispheric transport from South-East Asia.

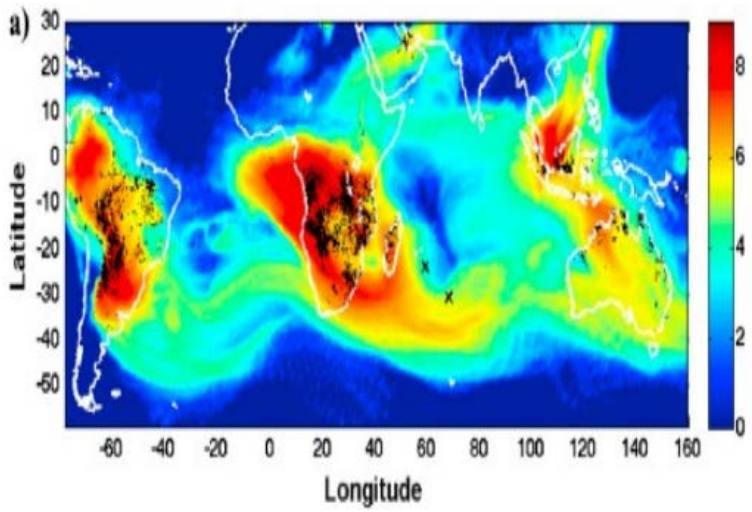


Figure 4. *Particle distribution between 14 and 16 / 09 / 2009 computed by GIRAFE.*

- ***DORADE**: Dissolved Organic matter composition and degradation in the ocean*, *HMWDOM measurements*, Christos Panagiotopoulos (christos.panagiotopoulos@univ-amu.fr), MIO, Aix-Marseille.

About 50 novel sugar compounds were identified as methylated sugars within the HMWDOM pool. Methylated sugars (APS-F3 fraction) accounted for 2-3% of the acyl polysaccharides (APS). Mono and dimethylated hexoses were the most abundant in the surface, while at 1800 m monomethylated 6-deoxy hexoses were the dominant sugars. The overall results suggest various sources of methylated sugars in the DOM. In addition we detected for the first time anhydrosugars within the APS pool. These compounds are known to be tracers of burning biomass of cellulose (e.g. forest fires) and are delivered in important amounts in the atmospheric aerosols. Although additional measurements are necessary, our results suggest that anhydrosugars may delivered in seawater by atmospheric deposition. *Ref: Panagiotopoulos et al (2013)*.

- ***CLIOPP:*** *CLImatic scenarios on Ocean Primary Production in low metal environments*, Denis de la Broise (denis.de-labroise@univ-brest.fr), LEMAR, Brest.

Started in 2013, this project aims to determine the evolution of oligotrophic ecosystems caused by increasing environmental carbon dioxide concentrations. This project is based on laboratory experiments in ultra clean environments. Four Coccolithophores species are introduced in an open flow bio reactor with a close control of pH using gaseous carbon dioxide injection. Another system uses microplates technics in trace metal free synthetic seawater. Because of ultra-clean operating conditions, trace metal concentration (including Zn, Cd and Co) are well determined without any usage of EDTA. This program is at its development stage and results are expected next years.

- ***SAMOA****:Monitoring mercury atmospheric deposition on austral ocean*, Aurélien Dommergue (dommergue@lgge.obs.ujf-grenoble.fr), LGGE, Grenoble.

Continuous mercury measurements are performed since 2012 at Pointe Bénédicte station on Amsterdam Island (Figure 5). They are carried out using Tekran 2537B gas-phase mercury vapor analyzer and Tekran 1130-1135 speciation units for gas phase and total deposition is also sampled. Gaseous elementary mercury (GEM) is stable about 1 ng.m^3 while reactive gaseous mercury (RGM) and Particulate mercury (PHg) are very low and very variable with an average of 0.37±0.47 pg.m^{-3} and 0.34±0.49 pg.m^{-}3 for RGM and PHg, respectively. Generally, GEM reactivity is found to be much lower than model previsions. These measurements are also supported by GMOS-Global Mercury Observation System (FP7), the French Polar Institute (IPEV, program GMOstral) and LABEX OSUG@2020.

Figure 5. *Tekran front-end modules 1130 and 1135 installed on the roof Pointe Benedicte's laboratory at Amsterdam Island (37,79604°S, 77.55095°E).(from Barret M., A. Dommergue, C.P.*

- ***SPURS** program and results of STRASSE cruise (NO Thalassa).* Gilles Reverdin (reve@locean-ipsl.upmc.fr), LOCEAN, Paris.

The SPURS program is aimed at better understanding surface salinity variability in the North Atlantic subpolar gyre and how its changes relate to the variations of evaporation and of ocean circulation. This will contribute to understand what has been causing the increase of upper ocean salinity of the subtropical gyres in the last 30 years. An array of in situ instrumentation (in particular, moorings, gliders, special Argo profilers, surface drifters) was operated to monitor upper ocean variability on a large range of spatial and temporal scales as well as analyses of data from Aquarius and Smos band-L radiometric satellite Argo profilers and drifters still contribute to provide intensive sampling in this region and measure upper ocean currents, temperature and salinity, STRASSE took placve in 2012 but data are exploited in 2013. We aimed to understand how horizontal and vertical variance of salinity in summer is enhanced by stratification and evaporation. We focussed on the investigation of wave and swells and their influence on the air-sea exchanges (LOS, LATMOS, LPO, LOCEAN), exchanges of water isotopologues across the sea surface. We also studies of the primary production of the very stratified upper waters and the contribution of diazotrophy, because of the strong warming (in particular, during the afternoon), the ocean was found to bea source of CO_2 for the atmosphere. *Ref: Reverdin et al. (2013), Kolodciewczyk et al. (2013), Benetti et al. (in press).*

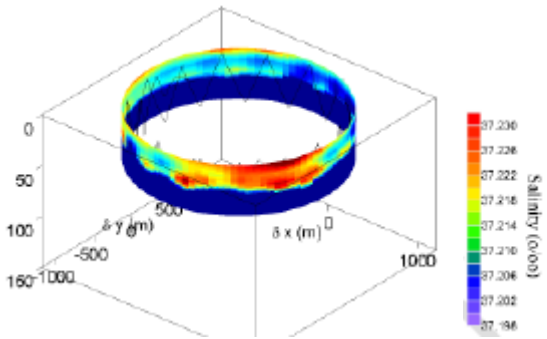


Figure 6. *Salinity measured in North Atlantic during the cruise STRASSE (29.5°N, 32.7°W).*

- ***DATABASE**, Building a database to collect offshore biogeochemical data*.

This project is lead by Catherine Schmechtig (schmechtig@obs-vlfr.fr), LOV, Villefranche sur mer. The database is 15 year old and is hosted by the laboratory LOV. This data base was firstly devoted to store results obtained during oceanographic campaign and is now extended to host buoy and profilers like BIO-ARGO. A new web interface was developed to grant an access to the base (http://www.obs-vlfr.fr/proof/).

- ***EUCFe-ISOFERIX,** Iron isotopic ratios*, François Lacan (francois.lacan@legos.obs-mip.fr) and Marie Labatut, LEGOS, Toulouse.

In the context of the EUCFe cruise (RV Kilo Moana, 2006, PI J. Murray) along the Equatorial Pacific, iron isotopes have been measured in aerosols and in seawater both in the dissolved (<0.4µm) and particulate phases (>0.4µm). Whereas aerosols had previously always been characterized by an isotopic composition in a narrow range around the crustal value ($\delta^{56/54}Fe_{/IRMM}$ around +0.07‰), we found a slightly heavy iron isotopic signature for the aerosols sampled in the Western Equatorial Pacific, in the Papua New Guinea Area (Bismarck Sea), with $\delta^{56/54}Fe_{/IRMM}$ around 0.3‰. Compared to the surface seawater data, found in the ranges [-0.03;+0.53‰] and

[+0.01;+0.30‰] for the dissolved and particulate phases respectively, these data help deciphering the different sources of iron (rivers, sediments, aerosols, hydrothermalism) to this oceanic area.

- ***Heat and mass exchange at the water interface***, Guillemette Caulliez (guillemette.caulliez@univ-amu.fr).

The characterization and parameterization of the various turbulent processes affecting the upper water surface layer, of crucial importance for modelling heat and mass exchanges at the air-sea interface, remains a challenging task owing to the technical difficulties raised by investigation of water subsurface dynamics. Among these processes, wave breaking and microbreaking generating mean flow, vorticity, turbulence and bubbles in water as well as droplets in air play a key role in these exchanges. However, the basic features of naturally occurring wind wave breakers as observed at sea are far from being identified up to now. Therefore, to better describe these phenomena, in particular their surface signatures at small-scales, an investigation of breaking wind wave motions were made in the large Marseille-Luminy wind wave tank for a wide range of fetches and wind speeds. Using high-resolution visualizations of longitudinal surface wave profiles, the ranges of scales for which wave microbreaking and breaking occur were determined, and a number of kinematical and dynamical wave features associated with these breaking events were documented. This study reveals that microscale breaking takes place for wind waves longer than 10 cm and manifests itself in a very localized surface disruption on the forward face of the crest. This crest breakdown generates turbulent motions in water but no bubbles. More strikingly, in an unexpecting way, plunging wave breaking with the formation of a crest bulge, a microjet hitting the water surface and a splash-up was found to occur for short gravity waves just exceeding 20 cm in wavelength. This small-scale event generates significant turbulent mixing in water and may cause air entrainment. *Ref: Cauliez et al. (2013).*

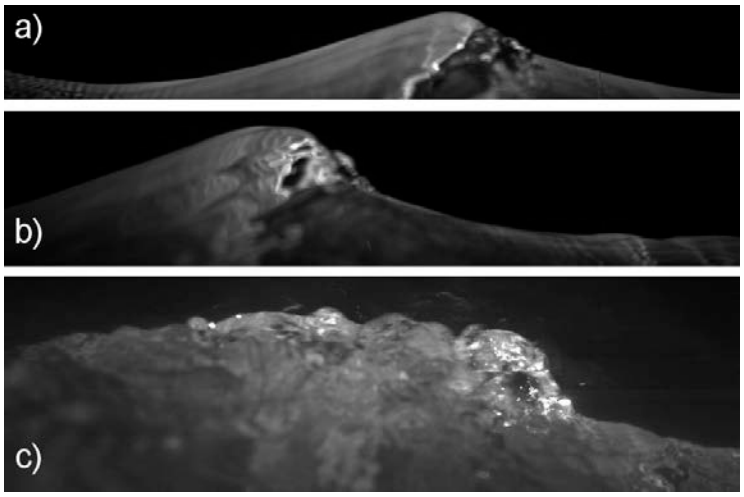


Figure 7. *Various type of breaking observed in a large wind-wave tank: a): Microbreaking observed at 13 m fetch and 6 m/s wind speed; b): Small-scale breaking observed at 13m fetch and 8 m/s; c): Spilling breaking (successive small jets) observed at 26 m fetch and 12 m/s. The wavelenght of visualized breaking waves is 18, 24 and 75 cm respectively with a camera field of view of ~20 cm in lenght.*

- ***DFP****, Dust From Patagonia*, R. Losno (losno@ipgp.fr).

An extensive sampling of about 150 Patagonian soils is undergone. A chemical analyse is performed and aerosols are generated from these soils using a laboratory device. The finest fraction (<10 µm) of the soil is extracted by a vibrating system and an elemental analyse is performed. We have produced maps of chemical composition of soils and generated aerosols. A Lidar network for aerosol measurements was installed to cover most of the Patagonian area; this network is primarily supported by the air transport companies to prevent problems caused by volcanoes ash and data are used here to map dust layers in the atmosphere.

DEMO-ChArMEx: *Dust Mass Deposition Monitoring in the Mediterranean Area* (contact: B. Laurent, benoit.laurent@lisa.u-pec.fr, PRIMEQUAL-ADEME, ChArMEx-MISTRALS). In the framework of the DEMO project, a number of original results have been achieved. A sampler for collecting atmospheric insoluble deposition with a large autonomy (up to six months) was developed as part of this project, tested on site and adapted to meet particular constraints like intense rain events or intense snowfall. In order to form a network of insoluble atmospheric deposition measurements in the Western Mediterranean area, this collector was deployed on six stations (Lampedusa - Italy; Mallorca - Spain; Ersa, Frioul, Casset and Montandon - France), as well as two more stations of partner sites in Granada (Spain) and Medenine (Tunisia).

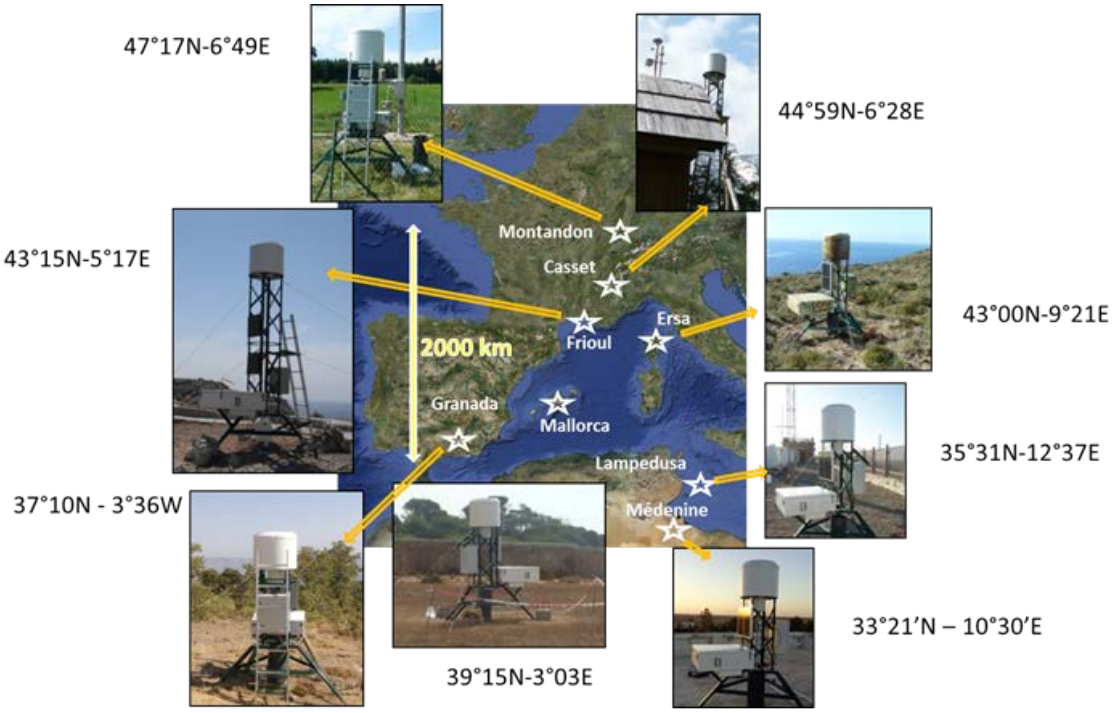


Figure 8. *DEMO network of total insoluble deposition collectors (CARAGA) in the Western Mediterranean area (LISA, DEMO-ChArMEx project).*

Sampling performed simultaneously and identically by CARAGA allowed acquiring a unique data set to study the spatial and temporal variability of the occurrence and intensity of Saharan deposits (in the period 2011-2013). The sporadic nature of the Saharan events was observed with 10 major events sampled at Lampedusa and 6 in Mallorca over a one-year period. The results show that the deposition intensity decreases with distance from the African coast with average annual values of 10 g m-2 yr-1 in Lampedusa (very close to sources) and 2-3 g m-2 yr-1 for stations located in the center of the western basin. These values are significantly lower than those obtained in the late 1980s from samples taken in Corsica. These dust deposition measurements, combined with the concentrations, optical thickness, particles size data obtained during the 2012 and 2013 ChArMEx summer SOP in the Western Mediterranean basin, form an original set of data to perform a complete validation of chemistry-transport models (CHIMERE, REG-CM, ALADIN).

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

6th International SOLAS Summer School 23RD August- 2nd September 2013, State Key Laboratory of Marine Environmental Science, Xiamen University, China (Co-chairs :V. Garçon and M. Dai)

5. Top 10 publications in 2013 (Reports, ACCEPTED articles, models, datasets, products, website etc)

Barret M., A. Dommergue, C.P. Ferrari and O. Magand, The monitoring of atmospheric mercury species in the Southern Indian Ocean at Amsterdam Island (38°S), E3S Web of Conferences 1, 27001 (2013), DOI: 10.1051/e3sconf/20130127001.

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de Leeuw, G., C. Guieu, A. Arneth, N. Bellouin, L. Bopp, P. Boyd, H. Denier van der Gon, K. Desboeufs, F. Dulac, C. Facchini, B. Gantt, B. Langmann, N. Mahowald, E. Maranon, C. O'Dowd, N. Olgun, E. Pulido-Villena, M. Rinaldi, E. Stephanou, T. Wagener (2013). Ocean-Atmosphere interactions of particles. In: P. Liss and M. Johnson (Editors), in: "Ocean-Atmosphere Interactions of Gases and Particles" Springer Berlin Heidelberg, p. 171-246

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Goubanova, K., Illig, S., Machu, E., Garcon, V., and Dewitte, B., (2013), SST subseasonal variability in the central Benguela upwelling system as inferred from satellite observations (1999–2009), *Journal of Geophysical Research*, 118, 1–19, doi:10.1002/jgrc.20287.

Guieu C., Dulac. F., Ridame C. and Pondaven P., 2013, Introduction to project DUNE, a DUst experiment in a low Nutrient, low chlorophyll Ecosystem, Biogeosciences, 11, 425-442, 2014, (Special Issue DUNE)

Gutknecht, E., Dadou, I., Le Vu, B., Cambon, G., Sudre, J., Garçon, V., Machu, E., Rixen, T., Kock, A. Flohr, A., Paulmier, A., Lavik, G., 2013a. Coupled physical/biogeochemical modeling including O2-dependent processes in the Eastern Boundary Upwelling Systems: application in the Benguela. *Biogeosciences*, 10, 3559–3591.

Gutknecht E., Dadou, I., Marchesiello, P., Cambon, G., Le Vu, B., Sudre, J., Garçon, V., Machu, E., Rixen, T., Kock, A., Flohr, A., Paulmier, A., Lavik, G., 2013b. Nitrogen transfers off Walvis Bay: a 3-D coupled physical/biogeochemical modeling approach in the Namibian upwelling system. *Biogeosciences*, 10, 4117-4135, 2013

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Reverdin, G., S. Morisset, D. Bourras, N. Martin, A. Lourenço, J. Boutin, C. Caudoux, J. Font, J. Salvador. (2013) A SMOS surface drifter for air-sea interaction (SURPACT). Oceanography, 26, 48-57.

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

Plan for future activities

- **AMOP** *for "Research Activities dedicated to the Oxygen Minimum in the East Pacific*" (Aurélien Paulmier: aurelien.paulmier@gmail.com, C. Maes : christophe.maes@ird.fr, B. Dewitte and V. Garçon): Ongoing cruise 25 January -23 February 2014 on board French

R/V L'Atalante off shore the OMZ of Peru. The main objective is to understand all mechanisms controling the OMZ off shore Peru and to study the impacts of deoxygenation on biogeochemical cycles of nitrogen, oxygen, etc. and marine ecosystems. The team cruise is multi-disciplinary combining physical oceanographers, marine biogeochemists, microbial ecologists, atmosphericists and is aiming to produce an O_2 budget as complete as possible. It is planned to try to establish on Hormigas de Afueras Islands an ocean site off shore Peru to monitor regional climate, sea level and sismic activity (PI: IGP Peru).

- **PEAcEtIME** "ProcEss studies at the Air-sEa Interface: a Mediterranean Experiment" (Cécile Guieu, Karine Desboeufs). In the frame of MERMEX and CHARMEX projects, this cruise is planned for summer 2016. The main objective of the PEACETIME cruise is to study the fundamental processes and their interactions at the ocean–atmosphere interface following an event of Saharan dust deposition. These key processes are defined in 4 objectives: *(1) Effect of dust deposition on chemical element (including nutrients) cycling and ecosystem functioning, and their modelling from 0D to 3D; (2) the impact on gas/aerosols emissions from the surface water; (3) Impact on optical properties both above and below the air-sea interface; (4) Future of the Med Sea*

Future events

A meeting SOLAS-France is going to be held in Paris 7-8 July. The future of SOLAS activities in France will be fully discussed here.

7. Other comments

Annual Report for the year 2013:

SOLAS GERMANY

compiled by: Hermann W. Bange

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

Global sea-to-air flux climatology for bromoform, dibromomethane and methyl iodide

F. Ziska[1], B. Quack[1], K. Abrahamsson[2], S. D. Archer[3,*], E. Atlas[4], T. Bell[5], J. H. Butler[6], L. J. Carpenter[7], C. E. Jones[7,**], N. R. P. Harris[8], H. Hepach[1], K. G. Heumann[9], C. Hughes[10], J. Kuss[11], K. Krüger[1], P. Liss[12], R. M. Moore[13], A. Orlikowska[11], S. Raimund[14,***], C. E. Reeves[12], W. Reifenhäuser[15], A. D. Robinson[8], C. Schall[16], T. Tanhua[1], S. Tegtmeier[1], S. Turner[12], L. Wang[17], D. Wallace[13], J. Williams[18], H. Yamamoto[19,****], S. Yvon-Lewis[20], and Y. Yokouchi[19]

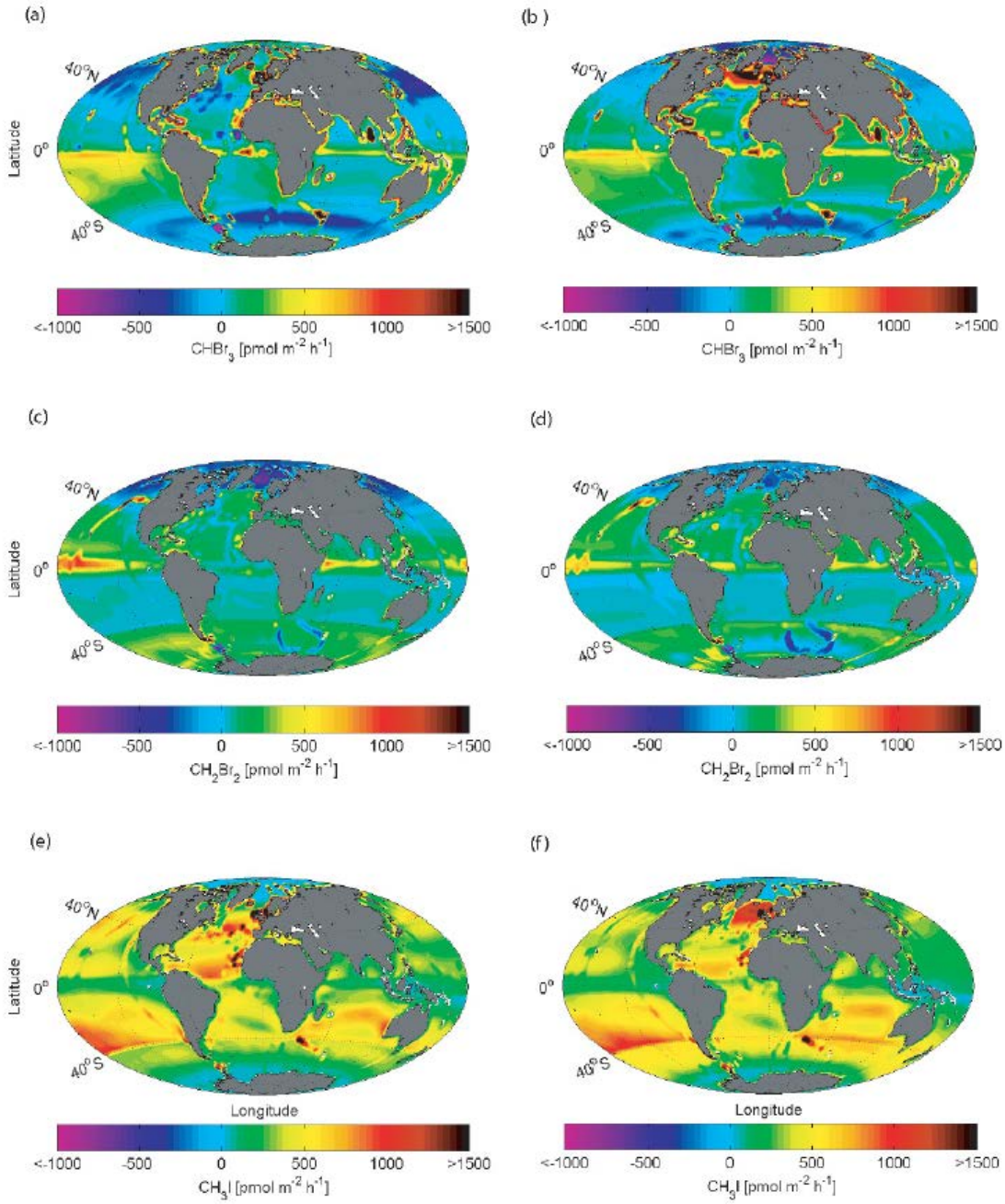
[1]GEOMAR, Helmholtz-Zentrum für Ozeanforschung Kiel, Kiel, Germany
[2]Department of Analytical and Marine Chemistry, Chalmers University of Technology and Gothenburg University, Gothenburg, Sweden
[3]Plymouth Marine Laboratory, Plymouth, PMI, Plymouth, UK
[4]Marine and Atmospheric Chemistry, Rosenstiel School of Marine and Atmospheric Science, University of Miami, MAC, Miami, USA
[5]Department of Earth System Science, University of California, UCI, Irvine, USA
[6]Earth System Research Laboratory, Global Monitoring Division, ESRL/NOAA, Boulder, USA
[7]Department of Chemistry, University of York, York, YO10 5DD, UK
[8]Department of Chemistry, University of Cambridge, Cambridge, CB2 1EW, UK, Cambridge, UK
[9]Institut für Anorganische Chemie und Analytische Chemie, Johannes Gutenberg-Universität, JGU, Mainz, Germany
[10]Laboratory for Global Marine and Atmospheric Chemistry, University of East Anglia, LGMAC/UEA, Norwich, UK
[11]Institut für Ostseeforschung Warnemünde, IOW, Rostock-Warnemünde, Germany
[12]School of Environmental Science, University of East Anglia, Norwich, UK
[13]Department of Oceanography, Dalhousie University, Halifax, B3H 4R2, Canada
[14]CNRS, UMR7144, Equipe Chim Marine, Stn Biol Roscoff, 29680 Roscoff, France
[15]Bayerisches Landesamt für Umwelt, Augsburg, Germany
[16]Fresenius Medical Care Deutschland GmbH, Frankfurterstraße 6–8, 66606 St. Wendel, Germany
[17]Rutgers State University of New Jersey, New Brunswick, USA
[18]Max Planck Institute for Chemistry, Air Chemistry Department, MPI, Mainz, Germany
[19]National Institute for Environmental Studies, Tsukuba, Ibaraki 305-0053, Japan
[20]Department of Oceanography, Texas A&M University, College Station, USA
[*]now at: Bigelow Laboratory of Ocean Sciences, Maine, USA
[**]now at: Graduate School of Global Environmental Studies, Kyoto University, Yoshida-Honmachi, Sakyo-ku, Kyoto 606-8501, Japan
[***]now at: GEOMAR, Helmholtz-Zentrum für Ozeanforschung Kiel, Kiel, Germany
[****]now at: Marine Works Japan, Ltd., Oppamahigashi, Yokosuka 237-0063, Japan

Atmos. Chem. Phys., 13, 8915-8934, 2013, doi:10.5194/acp-13-8915-2013: www.atmos-chem-phys.net/13/8915/2013/

Volatile halogenated organic compounds containing bromine and iodine, which are naturally produced in the ocean, are involved in ozone depletion in both the troposphere and stratosphere. Three prominent compounds transporting large amounts of marine halogens into the atmosphere are bromoform ($CHBr_3$), dibromomethane (CH_2Br_2) and methyl iodide (CH_3I). In order to improve emission inventory estimates, we calculate data-based high resolution global sea-to-air flux estimates of these compounds from surface observations within the HalOcAt (Halocarbons in the Ocean and Atmosphere) database (https://halocat.geomar.de/). Global maps of marine and atmospheric surface concentrations are derived from the data which are divided into coastal, shelf and open ocean regions. With the generated surface concentration climatologies for the ocean and atmosphere, global sea-to-air concentration gradients and sea-to-air fluxes are calculated (see Fig. 1 below). Contrary to recent studies, negative fluxes occur in each sea-to-air flux climatology, mainly in the Arctic and Antarctic regions. "Hot spots" for global polybromomethane emissions are located in the equatorial region, whereas methyl iodide emissions are enhanced in the subtropical gyre regions.

Inter-annual and seasonal variation is contained within our flux calculations for all three compounds. Compared to earlier studies, our global fluxes are at the lower end of estimates, especially for bromoform.

Fig. 1: Gobal sea-to-air flux climatology of bromoform (a,b), dibromomethane (c,d) and methyl iodide (e,f) in pmol/m2/h. Fig. from Ziska et al., ACP, 2013.



A new method for continuous measurements of oceanic and atmospheric N_2O, CO and CO_2: performance of off-axis integrated cavity output spectroscopy (OA-ICOS) coupled to non-dispersive infrared detection (NDIR)

D. L. Arévalo-Martínez, M. Beyer, M. Krumbholz, I. Piller, A. Kock, T. Steinhoff, A. Körtzinger, and H. W. Bange

GEOMAR, Helmholtz-Zentrum für Ozeanforschung Kiel, Germany

Ocean Sci., 9, 1071-1087, 2013, doi:10.5194/os-9-1071-2013: www.ocean-sci.net/9/1071/2013/

A new system for continuous, highly resolved oceanic and atmospheric measurements of N_2O, CO and CO_2 is described. The system is based upon off-axis integrated cavity output spectroscopy (OA-ICOS) and a non-dispersive infrared analyzer (NDIR), both coupled to a Weiss-type equilibrator. Performance of the combined setup was evaluated by testing its precision, accuracy, long-term stability, linearity and response time. Furthermore, the setup was tested during two oceanographic campaigns in the equatorial Atlantic Ocean in order to explore its potential for autonomous deployment onboard voluntary observing ships (VOS). Results from a direct comparison of the method and well-established discrete methods for oceanic N_2O and CO_2 measurements showed very good consistency. The potential of the system as an improved platform for measurements of trace gases was explored by using continuous N_2O and CO_2 data to characterize the development of the seasonal equatorial upwelling in the Atlantic Ocean during two R/V *Maria S. Merian* cruises. A similar record of high-resolution CO measurements was simultaneously obtained, offering, for the first time, the possibility of a comprehensive view of the distribution and emissions of these climate-relevant gases in the area studied.

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

Projects

- BIOACID
- InGOS
- SHIVA
- TransBrom
- CarboChange
- SCOR WGs #141, #142, and #143
- Boknis Eck Time Series Station
- CVOO/CVAO
- and many more

Partner Institutions

- INDP, Mindelo, Cape Verde
- IMARPE, Callao, Peru
- Ocean University China, Qingdao, China
- and many more

International Organisations

- IPCC
- and many more

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

- InGOS Annual Meeting, 12-14 March 2013, Bremen
- SOPRAN Annual Meeting, 19/20 March 2013, Leipzig
- BMBF FONA Forum, 10/11 September 2013, Leipzig
- SFB754 Eddy Workshop, 25/26 November 2013, GEOMAR, Kiel

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

Several newspaper articles, TV features, etc. about SOPRAN activities have been produced.

5. Top 10 publications in 2013 (Reports, <u>ACCEPTED</u> articles, models, datasets, products, website etc)

Arévalo-Martínez, D. L., M. Beyer, M. Krumbholz, I. Piller, A. Kock, T. Steinhoff, A. Körtzinger, and H. W. Bange (2013), A new method for continuous measurements of oceanic and atmospheric N_2O, CO and CO_2: performance of off-axis integrated cavity output spectroscopy (OA-ICOS) coupled to non-dispersive infrared detection (NDIR), *Ocean Science*, *9*, 1071-1087.

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

- SOPRAN III Mesocosm experiment 2014, February-April 2014, Canary Islands (PI: Ulf Riebesell, GEOMAR)
- SOPRAN III Joint Air/Sea Gas Exchange Experiment at the Aeolotron facility, Heidelberg, November 2014 (PI: Bernd Jähne, U Heidelberg)
- R/V Sonne cruise 235 – OASIS (June/July 2014) to the western Indian Ocean (PIs: K. Krüger, B. Quack, C. Marandino, GEOMAR)
- SOLAS Open Science Conference in Kiel, September 2015 (in cooperation with Kiel University, Future Ocean Excellence Cluster Kiel and SOLAS IPO)
- Planning and construction of the Ocean Science Center in Mindelo, Cape Verde Island

7. Other comments

As

Annual Report for the year 2013:

SOLAS Italy *compiled by:___Chiara Santinelli__*

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

Relationship between phytoplankton activity and biogenic aerosols in oligo-mesotrophic central Mediterranean Sea

The analysis of daily PM10 samples collected at Lampedusa (35.5°N, 12.6°E) was combined with Ocean Color remote sensed data (SeaWiFS, MODIS-Aqua) and continuous solar radiation measurements over the period 2005-2008 in order to assess the relationship between methanesulfonate (MS_) in the atmospheric aerosols and marine primary production.

The multi-year evolution of MS_ atmospheric concentration shows a well-defined seasonal cycle with a summer maximum, corresponding to the annual peak of solar radiation and to the minimum of phytoplankton biomass (Fig. 1). Statistically significant linear relationships between monthly means of atmospheric MS_ and both the phytoplankton productivity index (PB) and the solar radiation dose are found in the upper mixed layer. These correlations are mainly driven by the common seasonal pattern and suggest that DMS production in the marine surface layer is mainly related to the phytoplankton physiology. High values of PB are also the expression of stressed cells. The main stress factors in Mediterranean Sea during summer are high irradiance and shallow depth of the upper mixed layer, which lead to enhanced DMS emissions and higher MS_ amounts in the atmosphere. The occurrence of anomalously high values in Spring 2005 is hypothesized to be related to the negative phase of the North Atlantic Oscillation.

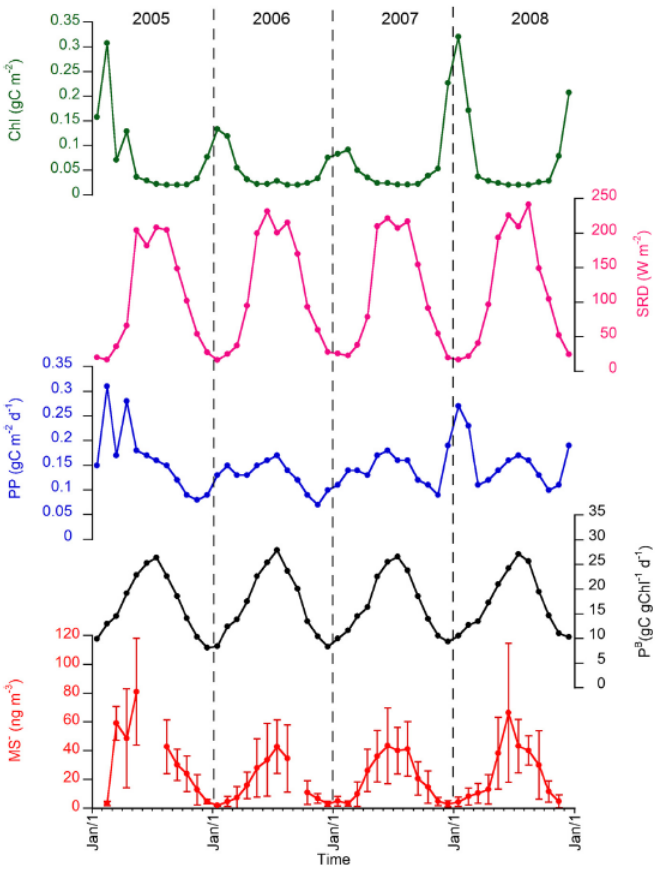


Figure 1: Temporal evolution of monthly mean Chlorophyll a (green line), solar radiation dose (pink line) primary production (blue line), specific production index (PB black line), and methanesulfonate in the aerosol (red line) during the years 2005-2008. Vertical lines in the MS- graph represent the standard deviation calculated over the month.

Reference: Becagli S, Lazzara L, Fani L, Marchese C, Traversi R, Severi M, di Sarra A, Sferlazzo D, Piacentino S, Bommarito C, Dayan U, Udisti R, 2013, Relationship between methanesulfonate (MS^-) in atmospheric particulate and remotely sensed phytoplankton activity in oligo-mesotrophic Central Mediterranean Sea, *Atmospheric Environment*, 79, 681-688, doi: 10.1016/j.atmosenv.2013.07.032.

Determining the influence of desert dust on the sea surface radiation budget in the Mediterranean

The study is focused on the determination of the direct radiative effects produced by Saharan dust in the Mediterranean, and follows previous studies on the same topic [e.g., di Sarra et al., 2008, 2011; Di Biagio et al., 2009, 2011; Meloni et al., 2003, 2004] made at the Station for Climate Observations at Lampedusa (35.5°N, 12.6°E). Aerosol optical properties, column water vapour, and downward solar and photosynthetic irradiance were measured during the propagation of a gravity wave in the Southern Mediterranean. The wave produced an oscillation in the aerosol optical depth and column water vapour, which was found also in the downward irradiances.

The modulation of the downward surface irradiances is in opposition of phase with respect to aerosol optical depth and water vapour column variations The direct radiative forcing efficiency (i.e., the direct radiative effect produced by an unit optical depth aerosol) is determined at different solar zenith angles as the slope of the irradiance perturbation versus the aerosol optical depth (Figure 1). The estimated direct surface forcing efficiency at about 60° solar zenith angle is −(181±17) Wm^{-2} in the shortwave, and −(83±7) Wm^{-2} in

the photosynthetic spectral range. The estimated daily average forcing efficiencies are of about −79 and −46 Wm^{-2} for the shortwave and photosynthetic spectral range, respectively. The quantification of these effects is crucial for a correct determination of the energy budget at the sea surface.

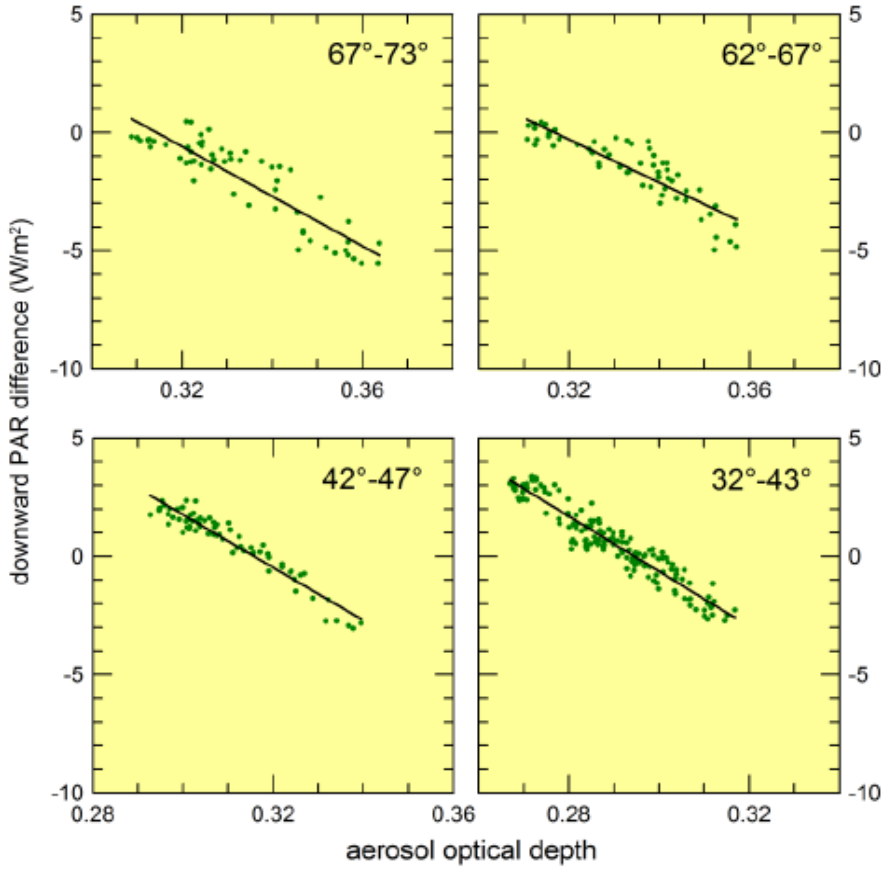


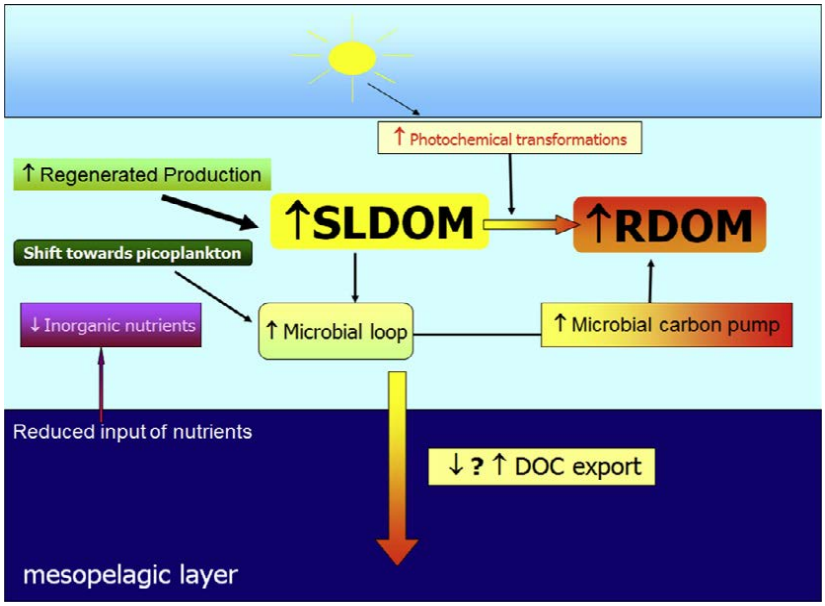
Figure 1: Deviations of the measured downward PAR irradiance from the estimated PAR irradiance at fixed aerosol optical depth versus the measured aerosol optical depth, in four intervals of solar zenith angle.

Reference: di Sarra A, Fuà D, Meloni D, 2013, Estimate of surface direct radiative forcing of desert dust from atmospheric modulation of the aerosol optical depth, *Atmospheric Chemistry and Physics*, 13, 5647-5654, doi: 10.5194/acp-13-5647-2013.

Influence of stratification on marine dissolved organic carbon (DOC) dynamcis: The Mediterranenan Sea case

Stratification strongly influences DOC dynamics in the Tyrrhenian and Adriatic Seas, with patterns similar to those observed in the sub-tropical and temperate regions of the open ocean, respectively. Recent findings suggest that enhanced stratification associated with a warmer ocean could further increase the DOC concentrations in the mixed layer. The coupling between this accumulation and the net export of DOC in deeper layer is however still elusive. The processes leading to a reduction in the export might be mitigated or overcompensated by parallel processes which might increase it. The Mediterranean Sea, hosting a wide range of vertical transfer processes over a short temporal scale, may serve as a model for the study of the impact of global warming on the C cycle. In addition, the observation that in some areas C export as DOC can be notably higher than that due to POC confirms that the conventional view of carbon export, in which POM is considered the main player, should be revised. DOM may contribute to oceanic

carbon export more than is currently recognized, therefore this component should be included in the models studying the role of the warming ocean in the global carbon cycle.



Schematic of DOM dynamics affected by enhanced stratification. The ↑ and ↑ indicate an increase or a decrease in the concentrations/importance of the relevant process, respectively. SLDOM and RDOM refer to semi-labile and refractory fractions, respectively.

Reference: Santinelli C., Hansell D.A., Ribera d'Alcalà M., 2013. Influence of stratification on marine dissolved organic carbon (DOC) dynamics: The Mediterranean Sea case. Progress in Oceanography 119, 68-77.

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

Contribution to IPCC:
Maria Cristina Facchini contributed as Chapter 1 Lead Author to the IPCC Fifth Assessment Report (Climate Change 2013: The Physical Science Basis).

International collaborations:

- Analyses of data relevant to SOLAS have been made by ENEA (Italy) jointly with the Universities of Jerusalem and Tel Aviv (Israel).
- CNR has collaboration with:
  - IEO (La Coruna, Spain),
  - GEOMAR (Kiel, Germany),
  - National University of Ireland Galway, *Bacchius Project*
  - MIO, Marseille, France, *CNR-CNRS bilateral project*.

Links with observation communities

- GOA-ON (Global Ocean Acidification Observing Network)
- ICOS (Integrated Carbon Observing System) networks
- Global Ocean Observing System (GOOS) (ISAC-CNR)
- Coastal Ocean Observing Panel (COOP) (ISAC-CNR)
- The European Earth Observation Programme – COPERNICUS (ISAC-CNR)

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

1. **Research projects**

- **ACCENT Plus** Atmospheric composition change the european network, Coordinator: CNR-ISAC
- **BACCHUS** (2013-2016): Impact of Biogenic versus Anthropogenic emissions on Clouds and Climate: towards a Holistic UnderStanding
- **FIXO3** (2013-2017): The Fixed point Open Ocean Observatory network (FixO3) seeks to integrate European open ocean fixed point observatories and to improve access to these key installations for the broader community. OGS is leading the WP2 - Technological harmonization
- **JERICO** (2011-2015) Towards a Joint European Research Infrastructure network for Coastal Observatories
- **MyOcean-2** (2012-2014): Prototype Operational Continuity for GMES Ocean Monitoring and Forecasting Service. Seventh Framework Programme. CNR-ISAC is leading the Ocean Colour Thematic Assembling Centre that is providing ocean colour satellite products for the global ocean and for the European Seas (http://www.myocean.eu.org/)
- **PEGASOS** (2011-2015): Pan-European Gas-AeroSol-climate interaction Study
- **PERSEUS** (2012-2016) Policy-oriented marine Environmental Research in the Southern European Seas. Seventh Framework Programme.
- **RITMARE** (2012-2017), Italian Flagship Project, supported by the Italian Ministry for University and Research (http://www.ritmare.it/).
- **SSD-Pesca** (2011-2014) Decision support system for the sustainable management of fishery in the South of Italy, Italian Project aimed at supporting the development of productive activities in the South

2. **Workshop and conferences organization**

- *Seventh International Workshop on Sand/Dust storms and Associated Dust fall (http://dustworkshop2013.enea.it/)*, co-organized by ENEA and ESA, 2-4 December, Frascati (Italy). About 110 attendees from 17 countries.
- *Atmospheric aerosol in air quality and climate: the science and solutions.* Section at the Gordon McFiggans at Goldsmicth 2013, 25-30 August 2013, Florence, Italy. Co-ordinator: Cristina Facchini.
- *XXI Congress of the "Associazione Italiana di Oceanologia e Limnologia"*. Lignano Sabbiadoro (UD), Italy, 23-26 September 2013. organized by OGS, CNR-ISMAR, Trieste University and Riserva Marina Miramare.

3. **International workshops and conferences participation**

- "Chlorophyll-a and other ocean color products as predictive tools of the organic mass fraction in submicron sea spray", "*OSSA Sea Spray Aerosol workshop*". 30 September - 1 October, 2013, Galway, Ireland. The workshop was organized in the context of the OceanFlux Sea Spray Aerosol project (OSSA, see http://oceanflux.fmi.fi/ for more information), one of the three projects supported by the European Space Agency (ESA) as part of the ESA STSE (Support To Science Element) in cooperation with SOLAS. (Matteo Rinaldi, CNR-ISAC, **invited oral presentation**).
- "Marine polymers/micro-gels distribution and atmosphere ocean interactions" *Gordon Conference 2013*. Mount Snow, Vermont, USA, 28 July – 2 August. (Maria Cristina Facchini, CNR-ISAC, **invited oral presentation**).
- Álvarez M, Luchetta A, Sanleón H, Mintrop L, Tanhua T, Civitarese G. The CO2 system in the Mediterranean Sea: a basin wide perspective. *40th CIESM*

Congress. Marseille, France, 28 October-1 November 2013.

- Azzaro M, La Ferla R. Variability of Electron Transport System activity in the deep water of Southern Adriatic pit in the period 1993-2008. *Marine Research Horizon 2020 (MARES 2020).* Varna, Bulgaria. 17-20 September 2013.
- Brunetti F, Cardin V, Nair R, Medeot N, Ingrosso G, Giani M. "Short term variability of pCO2 in the Gulf of Trieste". *2nd International Workshop on Global Acidification Observing Network. St Andrews*, UK. 24-26 July 2013.
- Cantoni C, Sparnocchia S, Luchetta A. Air-sea CO2 fluxes in the Adriatic sea: two seasonal snapshots in February and October 2008. *40th CIESM Congress*. Marseille, France, 28 October-1 November 2013.
- Cantoni C, Sparnocchia S, Luchetta A, Celio M, Cozzi S, Finotto S, Bastianini M, Raicich F. "Five years of observational efforts on ocean acidification in the North Adriatic Sea. The experience of PALOMA station, Gulf of Trieste." *2nd workshop of Global Ocean Acidification Observing Network. St Andrews*, UK, 24-26 July 2013.
- Caruso G, Azzaro M, Caroppo C, Decembrini F, Monticelli L S, Maimone G, Zaccone R, La Ferla R. Microbial community and its potential as descriptor of environmental status within the FP7 PERSEUS program. *Marine Research Horizon 2020 (MARES 2020).* Varna, Bulgaria. 17-20 September 2013.
- Celussi M, Dellisanti W, Del Negro P, Franzo A, Gaubert M, Gazeau F, Giannakourou A, Konstadinopoulou A, Maugendre L, Pitta P, Tsiola A. Ocean acidification effect on microbial metabolism in two different locations in the Mediterranean Sea. *13th SAME Symposium on Aquatic Microbial Ecology*. Stresa, Italy, 8-13 September 2013.
- Franzo A, Cibic T, Beaubien S, Graziani S, Del Negro P, De Vittor C. Phototrophic and heterotrophic benthic communities in a shallow CO2-dominated Hydrothermal vent (Panarea Island, Tyrrhenian Sea). *40th CIESM Congress.* Marseille, France, 28 October-1 November 2013.
- Giani M, Djakovac T, Degobbis D, Cozzi S, Cabrini M, Solidoro C, Fonda Umani S. "Changes of trophic conditions in the northern Adriatic Sea" *IMBER IMBIZOIII*. Goa, India, 28-31 January 2013.
- Giani M, Ingrosso G, Del Negro P, De Vittor C, Fabbro C, Karuza A, Kralj M. "The implementation of carbonate system measurements at a LTER site in the Gulf of Trieste". *2nd International Workshop on Global Acidification Observing Network*. St Andrews, UK. 24-26 July 2013.
- Ingrosso G, Giani M, Celussi M, Cibic T, Comici C, Del Negro P, De Vittor C, Fabbro C, Karuza A, Kralj M. Physical and biological influences on the variability of pH and carbonate system in the gulf of Trieste (northern Adriatic sea). *40th CIESM Congress*, Marseille, France, 28 October-1 November 2013.

4. National conferences participation

- Cantoni C, Luchetta A, Chiggiato J, Cozzi S, Schroeder K. The 2012 event of dense water formation in the Adriatic: carbonate system key properties. *XXI Congress of the "Associazione Italiana di Oceanologia e Limnologia"*. Lignano Sabbiadoro (UD), Italy, 23-26 September 2013.
- Luchetta A, Cantoni C, Kovacevic V. Latitudinal distributions of pHT25 and calcium carbonate saturation states in the central Mediterranean Sea. *XXI Congress of the "Associazione Italiana di Oceanologia e Limnologia"*. Lignano Sabbiadoro (UD), Italy, 23-26 September 2013.

5. **Cruises**

- **WMED-BIOOPT 2013**, R/V MINERVA 2, April 10-29, 2013, CNR-ISAC, Roma (Chief scientist, Dr. F. Bignami & Dr. B. Buongiorno Nardelli). Participants: CNR-IBF, ENEA, Frascati, SZN. Main goals of the cruise: (1) Characterization of bio-optical properties of coastal waters of the Tyrrhenian Sea during the spring phytoplankton bloom phase; (2) Extension of the Mediterranean Sea in situ bio-optical dataset for the support of marine biological parameter estimates using satellite data; (3) Validation of regional algorithms for the estimates of marine chlorophyll and primary production from satellite data; (4) Development of new regional algorithms for the estimates of chlorophyll, primary production, chromophoric dissolved organic matter (CDOM) and phytoplankton species from satellite data.
- **ENV-ADRI-LTER-5 2013,** R/V URANIA, April 23 – May 7, 2013. (Chief Scientists: M. Ravaioli) and **ENV-ADRI-LTER-6 2013,** R/V Dallaporta, October 1-21, 2013. (Chief Scientists: M. Ravaioli). Participants: CNR-ISMAR Trieste, Venezia, Bologna, Ancona. Main goals of the cruise: (1) determination of spatial variability of carbonate system properties, other chemical parameters(DO, DIN, DIP,SiO_2), and phytoplankton in a shelf region, highly sensitive to ocean acidification, (2) computation of air–sea CO_2 fluxes, (3) maintenance of instruments and sensors on buoys, (4) Seawater pCO_2 acquisition, (5) starting atm pCO_2 time-series in the Gulf of Trieste (fixed station PALOMA).
- **Transmediterranean MEDSEA research cruise** (international program GEOTRACES), R/V Angeles Alvarino, May 2 – June 2 2013). Participants: researchers from Spain (IEO, Barcelona University), France (University of Perpignan), Greece (HCMR), Italy (OGS) and Lebanon (National Center for Marine Sciences). Main goals of the cruise: (1) Refine climatological maps of carbonate species distribution (pH, pCO_2, CO_3^{2-}, C_T, A_T, Ω_a, Ω_c,), along with their isotopic signatures, in the Mediterranean Sea, (2) Report on the determination of the anthropogenic carbon distribution throughout the whole Mediterranean Sea and its associated uncertainty estimate; (3) Determine the effects of carbonate chemistry on Mediterranean calcifying and non-calcifying planktonic organisms.
- **BANSIC13** (June 26-July 16), CNR-IAMC Capo Granitola and Messina. R/V Urania, June 26 – July 16, 2013. The main goal of the multidisciplinary research cruise was to obtain an holistic picture of the microplankton food web which sustains the fish stocks in the Iblean-Maltese platform (Sicily Channel). The study addressed the description of the C flux throuthout the planktonic populations and the analysis of the functioning of the microbial food web starting from CO_2 uptake (primary production) to C remineralization by biological respiration.

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

Outreach activity

Lessons about Oceanography, Marine Carbon cycle and Climate Change in primary schools (8-10 years old children).

5. Top 10 publications in 2013 (Reports, ACCEPTED articles, models, datasets, products, website etc)

1. Becagli S, Lazzara L, Fani L, Marchese C, Traversi R, Severi M, di Sarra A, Sferlazzo D, Piacentino S, Bommarito C, Dayan U, Udisti R, 2013, Relationship between methanesulfonate (MS-) in atmospheric particulate and remotely sensed phytoplankton activity in oligo-mesotrophic Central Mediterranean Sea, *Atmospheric Environment*, 79, 681-688, doi: 10.1016/j.atmosenv.2013.07.032.
2. Caruso G, Azzaro F, La Ferla R, De Pasquale F, Raffa F, Decembrini F (2013): Microbial enzymatic activities and prokaryotic abundance in the upwelling system of the Straits of Messina (Sicily): distribution, dynamics and biogeochemical considerations, *Advances in Oceanography and Limnology*, DOI:10.1080/19475721.2012.755568.
3. de Leeuw, G, Guieu, C, Arneth, A, Bellouin, N, Bopp, L , Boyd, P W, Denier van der Gon, H A C, Desboeufs, K V, Dulac, F, Facchini, M C, Gantt, B, Langmann, B, Mahowald, N M, Marañón, E, O'Dowd, C, Olgun, N, Pulido-Villena, E, Rinaldi, M, Stephanou, E G, Wagener T (2013). Ocean-Atmosphere interactions of particles. In: Liss, P. S. and Johnson, M. T. (Editors), "*Ocean-Atmosphere Interactions of Gases and Particles*" Springer, Heidelberg DOI: 10.1007/978-3-642-25643-1; ISBN: 978-3-642-25642-4 (Print) 978-3-642-25643-1 (Online).
4. di Sarra A, Fuà D, Meloni D, 2013, Estimate of surface direct radiative forcing of desert dust from atmospheric modulation of the aerosol optical depth, Atmospheric *Chemistry and Physics*, 13, 5647-5654, doi: 10.5194/acp-13-5647-2013.
5. Mihanović H, Vilibić I, Carniel S, Tudor M, Russo A, Bergamasco A, Bubić N, Ljubešić Z, Viličić D, Boldrin A, Malačič V, Celio M, Comici, C, Raicich, F, 2013. Exceptional dense water formation on the Adriatic shelf in the winter of 2012, *Ocean Sci*ence, 9, 561-572.
6. O'Dowd C, Ceburnis D, Ovadnevaite J, Rinaldi M and Facchini M C, 2013, Do anthropogenic or coastal aerosol sources impact on a clean marine aerosol signature at Mace Head?, *Atmospheric Chemistry and Physics Discussions*, 13, 7311-7347.
7. Raicich F, Malačič V, Celio M, Giaiotti D, Cantoni C, Colucci R R, Čermelj B, Pucillo A, 2013. Extreme Air-Sea Interactions in the Gulf of Trieste (North Adriatic) during the strong Bora event in winter 2012, *Journal of Geophysical Research*, 118, 1-13, doi: 10.1002/jgrc20398.
8. Rinaldi M, Fuzzi S, Decesari S, Marullo S, Santoleri L, Provenzale A, von Hardenberg J, Ceburnis D, Vaishya A, O'Dowd C D, Facchini M C, 2013, Is chlorophyll-a the best surrogate for organic matter enrichment in submicron primary marine aerosol?, *Journal of Geophysical Research: Atmospheres*, 118, 1-10, doi:10.1002/jgrd.50417.
9. Santinelli C, Hansell D A, Ribera d'Alcalà M, 2013, Influence of stratification on marine dissolved organic carbon (DOC) dynamics: The Mediterranean Sea case, *Progress in Oceanography,* 119, 68-77.
10. Tesi T, Langone L, Giani M, Ravaioli M, Miserocchi S, 2013, Source, diagenesis, and fluxes of particulate organic carbon along the western Adriatic Sea (Mediterranean Sea), *Marine Geology*, 307, 156-170.

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

- An integrated air-sea observatory is under development in the central Mediterranean Sea (Lampedusa Island: 35.5°N, 12.6°E). Existing observations, mostly dedicated to atmospheric parameters (see http://www.lampedusa.enea.it), will be complemented with air-sea exchange measurements on a buoy close to the

atmospheric measurement site on the island. Measurements will include radiation budget, p(CO_2), oceanic optical properties, etc.

- Investigation on the role of sea spray as ice nuclei (IN) through both atmospheric measurements and laboratory experiments held at Mace Head (Ireland) in cooperation with National University of Ireland Galway. EU Project BACCHUS (FP7-603445).
- Validation of regional algorithms for the estimates of marine chlorophyll and primary production from satellite data.
- Development of new regional algorithms for the estimates of chlorophyll, primary production, chromophoric dissolved organic matter (CDOM) and phytoplankton species from satellite data.
- Study of CDOM photodegradation processes and their role in CO_2 fluxes to the atmosphere.
- Study of the atmospheric input of DOM and CDOM in key areas of the Mediterranean Sea.
- Performing optical measurements (absorption and fluorescence) of CDOM at different season with different stages of phytoplankton to characterize the different CDOM sources in offshore and nearshore waters of the southern Adriatic sea and lagoon systems.
- Acquisition of a time series of optical data in continuum by oceanographic platforms already installed in the Adriatic Sea.
- To continue the study of the role of heterotrophic microbial community in the biogeochemical processes, trophic dynamics and CO_2 balance in the biosphere, with particular regards to CO_2 sequestration in the ocean's interior.
- To continue the observations on carbonate system (pH, TA) and other chemical parameters (dissolved inorganic nutrients and DO) for studies on OA in the Adriatic Sea at basin scale;
- Keeping the acquisition of a times series of pCO_2 (continuous measurements), in seawater and in atmosphere, in the North Adriatic Sea (GoT).

7. Other comments

Annual Report for the year 2013:

SOLAS Ireland

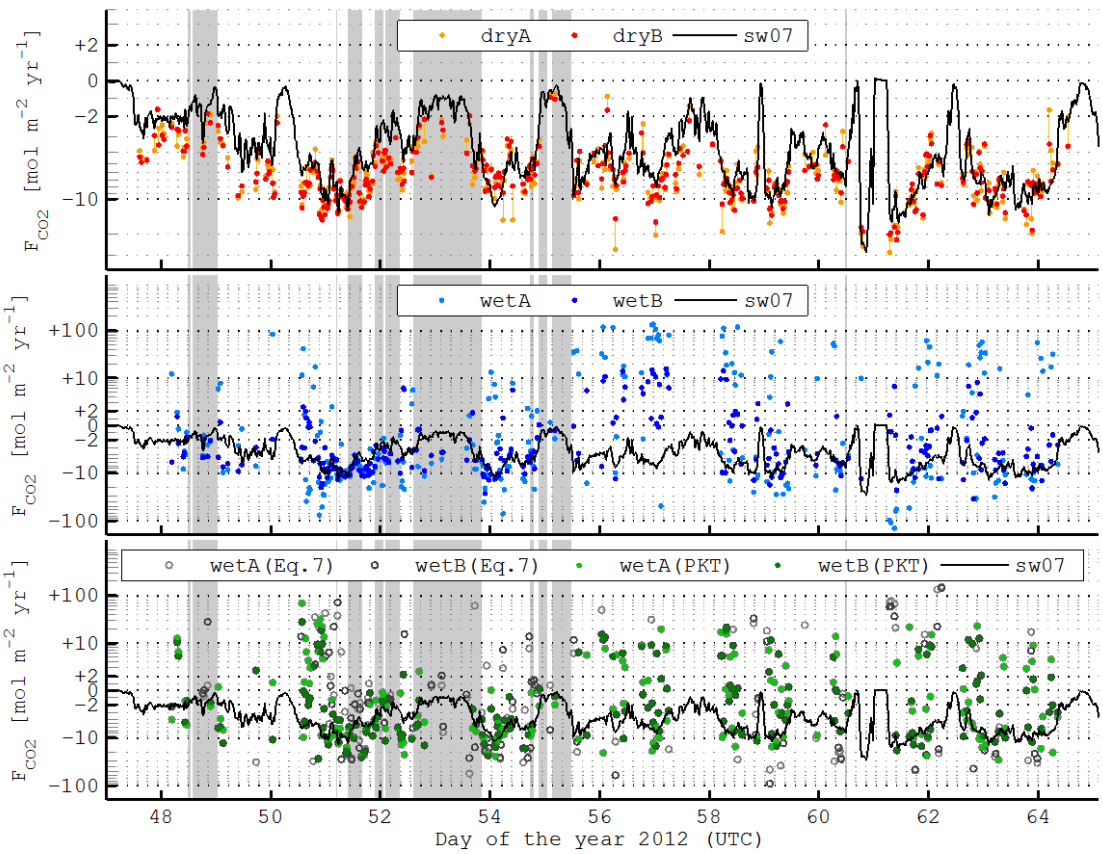
compiled by: Brian Ward

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

Analysis of the PKT correction for direct CO_2 flux measurements over the ocean

Eddy covariance measurements of air-sea CO_2 fluxes can be affected by cross-sensitivities of the CO_2 measurement to water vapour, resulting in order-of-magnitude biases. Well established causes for these biases are (i) cross-sensitivity of the broadband non-dispersive infrared sensors due to band-broadening and spectral overlap (commercial sensors typically correct for this) and (ii) the effect of air density fluctuations (removed by determining the dry air CO_2 mixing ratio). Another bias related to water vapour fluctuations has recently been observed with open-path sensors, attributed to sea salt build-up and water films on sensor optics. Two very different approaches have been used to deal with these water vapour-related biases. Miller et al. (2010) employed a membrane drier to physically eliminate 97% of the water vapour fluctuations in the sample air before it entered a closed-path gas analyser. Prytherch et al. (2010) employed the empirical (Peter K. Taylor, PKT) post-processing correction to correct open-path sensor data. We tested these methods side by side using data from the Surface Ocean Aerosol Production (SOAP) experiment in the Southern Ocean. The air-sea CO_2 flux was directly measured with four closed-path analysers, two of which were positioned down-stream of a membrane dryer. The CO_2 fluxes from the two dried gas analysers matched each other and were in general agreement with common parametrisations. The flux estimates from the un-dried sensors agreed with the dried sensors only during periods with low latent heat flux (less than 7 Wm^{-2}). When latent heat flux was higher, CO_2 flux estimates from the un-dried sensors exhibited large scatter and an order-of magnitude bias. Applying the PKT correction to the flux data from the un-dried analysers did not remove the bias when compared to the data from the dried gas analyser. The results of this study demonstrate the validity of measuring CO_2 fluxes on dried air and show that the PKT correction is not valid for the correction of CO_2 fluxes.



Time series of the direct CO_2 fluxes and the flux calculated with the parametrisation of Sweeney et al. (2007), plotted on logarithmic scale with sign. Values between ±2 molm-2 yr-1 are plotted on linear scale. Shaded areas mark low latent heat fluxes (Hl ≤7 Wm-2). Top: fluxes from dryA and dryB parallel measurements are linked with vertical lines; middle: fluxes from wetA and wetB ; bottom: fluxes from wetA and wetB after the PKT correction has been applied to the CO2 measurements overlaid with the PKT results.

Reference

S. Landwehr, S. D. Miller, M. J. Smith, E. S. Saltzman, and B.Ward. Analysis of the PKT correction for direct CO2 flux measurements over the ocean. Atmos. Chem. Phys. Discuss , 13 , 1–30. doi:10.5194/acpd-13-1-2013 [2013]

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

Participation in the SOAP data workshop in Wellington, New Zealand, April 2013

Participation in the meeting The Atlantic – A Shared Resource, Galway, May 2013

Participation on the ESA-SOLAS workshop OSSA, October 2013

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

MIDAS-SPURS cruise in the Tropical North Atlantic as part of the air-sea freshwater exchange experiment

Member of the WCRP Data Advisory Council

Member international GEOTRACES standards and intercalibration committee

Absorption of light, macro-algae and the atmosphere (ALMA-MATER) project as part of the FP7 Intra-European fellowships

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

Irish Times April 29th 2013: Saltiness of world's oceans measured by NUI Galway Instrument - http://www.irishtimes.com/business/saltiness-of-world-s-oceans-measured-by-nui-galway-instrument-1.1373819

Science Omega May 2nd 2013: Ocean salinity could provide fresh insights into climate change - http://www.scienceomega.com/article/1056/ocean-salinity-could-provide-fresh-insights-into-climate-change

Galway Independent May 1st 2013: NUI scientists to test ocean salinity - http://galwayindependent.com/20130430/news/nui-scientists-to-test-ocean-salinity-S17283.html

Science Daily 30th April 2013: Exploring the Saltiness of the Ocean to Study Climate Change - http://www.sciencedaily.com/releases/2013/04/130430131343.htm

Galway Tribune May 3rd 2013: Galway scientists test saltiness of the oceans - http://mediaone.kantarmedia.ie/mms3/monitorClipViewPublic.html?reqFrom=alert&fname=F001GF2V.txt&siteId=684

5. Top 10 publications in 2013 (Reports, ACCEPTED articles, models, datasets, products, website etc)

B. Scanlon, G. A. Wick, and B. Ward. Near-surface diurnal warming simulations: Validation with high resolution profile measurements. Ocean Sci. , **9** , 1–10. doi:10.5194/os9-1-2013 [2013]

K. H. Christensen, J. Röhr, B.Ward, I. Fer, G. Broström, Ø. Sætra, and Ø. Breivik. Surface wave measurements using ship mounted ultrasonic altimeter. Method Oceanogr. , **6** , 1–15. doi:10.1016/j.mio.2013.07.002 [2013]

S. Landwehr, S. D. Miller, M. J. Smith, E. S. Saltzman, and B.Ward. Analysis of the PKT correction for direct CO2 flux measurements over the ocean. Atmos. Chem. Phys. Discuss ,**13** , 1–30. doi:10.5194/acpd-13-1-2013 [2013]

N. O'Sullivan, S. Landwehr, and B. Ward. Mapping flow distortion on oceanographic platforms using computational fluid dynamics. Ocean Sci. , **9** , 855–866. doi:10.5194/os-9-855-2013 [2013]

G. Sutherland, K. H. Christensen, and B. Ward. Wave-turbulence scaling in the ocean mixed layer. Ocean Sci. , **9** , 597–608. doi:10.5194/os-9-597-2013 [2013]

Reverdin, S. M. G., H. Bellenger, J. Boutin, N. Martin, P. Blouch, J. Rolland, F. Gaillard, P. Bouruet-Aubertot, and B. Ward. Near-sea surface temperature stratification from svp drifters. J. Atmos. Oceanic Technol. , 30 , 1867–1883. doi:10.1175/JTECH-D-12-00182.1 [2013]

Dammshäuser, A., Wagener, T., Garbe-Schönberg, D. and Croot, P., 2013. Particulate and dissolved aluminum and titanium in the upper water column of the Atlantic Ocean. Deep Sea Research Part I: Oceanographic Research Papers, 73(0): 127-139.

Heller, M.I., Gaiero, D.M. and Croot, P.L., 2013. Basin scale survey of marine humic fluorescence in the Atlantic: Relationship to iron solubility and H2O2. Global Biogeochemical Cycles, 27(1): 88-100.

Olgun, N. et al., 2013a. Possible impacts of volcanic ash emissions of Mount Etna on the primary productivity in the oligotrophic Mediterranean Sea: Results from nutrient-release experiments in seawater. Marine Chemistry, 152(0): 32-42.

Olgun, N. et al., 2013b. Geochemical evidence of oceanic iron fertilization by the Kasatochi volcanic eruption in 2008 and the potential impacts on Pacific sockeye salmon. Marine Ecology Progress Series, 488: 81-88.

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

Contribute to the SOLAS v2 document

Co-ordinate a Marie-Cuie ITN specifically for SOLAS

Conduct upper ocean turbulence studies in the Arctic marginal ice zone

7. Other comments

Annual Report for the year 2013:

SOLAS Japan

compiled by: Mitsuo Uematsu

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

Risk maps for Antarctic krill under projected Southern Ocean acidification

Marine ecosystems of the Southern Ocean are particularly vulnerable to ocean acidification. Antarctic krill (Euphausia superba; hereafter krill) is the key pelagic species of the region and its largest fishery resource. There is therefore concern about the combined effects of climate change, ocean acidification and an expanding fishery on krill and ultimately, their dependent predators—whales, seals and penguins. However, little is known about the sensitivity of krill to ocean acidification. Juvenile and adult krill are already exposed to variable seawater carbonate chemistry because they occupy a range of habitats and migrate both vertically and horizontally on a daily and seasonal basis. Moreover, krill eggs sink from the surface to hatch at 700–1,000m, where the carbon dioxide partial pressure (p_{CO2}) in sea water is already greater than it is in the atmosphere. Krill eggs sink passively and so cannot avoid these conditions. Here we describe the sensitivity of krill egg hatch rates to increased CO_2, and present a circumpolar risk map of krill hatching success under projected p_{CO2} levels. We find that important krill habitats of the Weddell Sea and the Haakon VII Sea to the east are likely to become high-risk areas for krill recruitment within a century [Fig. 1]. Furthermore, unless CO_2 emissions are mitigated, the Southern Ocean krill population could collapse by 2300 with dire consequences for the entire ecosystem [1].

1. Kawaguchi S, Ishida A, King R, Raymond B, Waller N, Constable A, Nicol S, Wakita M, Ishimatsu A, 2013, Risk maps for Antarctic krill under projected Southern Ocean acidification, Nature Climate Change, doi:10.1038/nclimate1937.

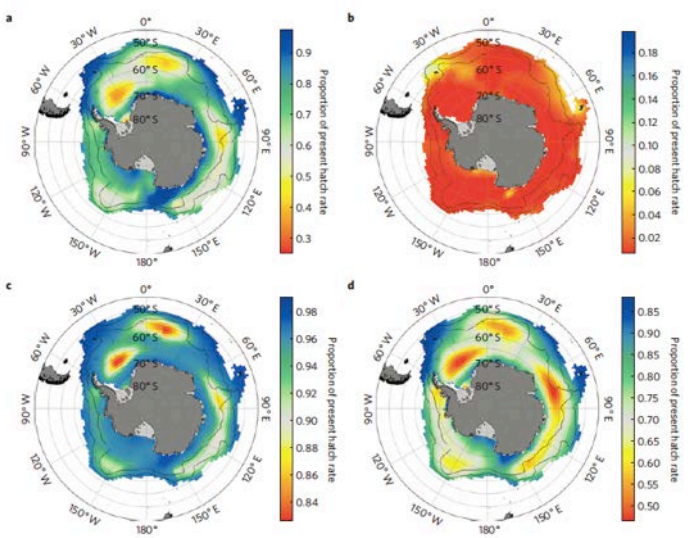


Figure 1: *Circumpolar risk maps of krill hatching success under projected future pCO2 levels. a–d,Hatching success under the RCP 8.5 emission scenario for 2100 (a) and 2300 (b); and under the RCP 6.0 emission scenario for 2100 (c) and 2300 (d). Note the different colour scales on each panel. The southern-most black line shows the northern branch of the Southern Antarctic Circumpolar Current Front, and the northern-most line shows the middle branch of the Polar Front.*

Strong relationship between dimethyl sulfide and net community production in the western subarctic Pacific

Although much attention has been paid to describing the distribution of oceanic dimethyl sulfide (DMS) concentrations, establishing robust relationships between DMS concentrations and biological, physical, and chemical variables is still challenging. Previous studies have proposed semiempirical parameterizations by combining multiple physical and biogeochemical parameters to better understand and reproduce the global distribution of sea surface DMS. However, none of these parameterization schemes could reconcile regionally elevated DMS peaks found in high-resolution DMS measurements made in the western subarctic Pacific. Here we found that DMS concentrations are highly correlated with the net community production, a parameter that integrates biological activity over time [Fig. 2]. We anticipate that this relationship may be exportable to other regions with high primary productivity, such as the Southern Ocean or upwelling regions, and can be used as an important parameterization scheme, combined with solar radiation relationship [2].

2. Kameyama S, Tanimoto H, Inomata S, Inoue HY, Tsunogai U, Tsuda A, Uematsu M, Ishii M, Asano D, 2013, Strong relationship between dimethyl sulfide and net community production in the western subarctic Pacific. Geophysical Research Letter, 40, 3986–3990.

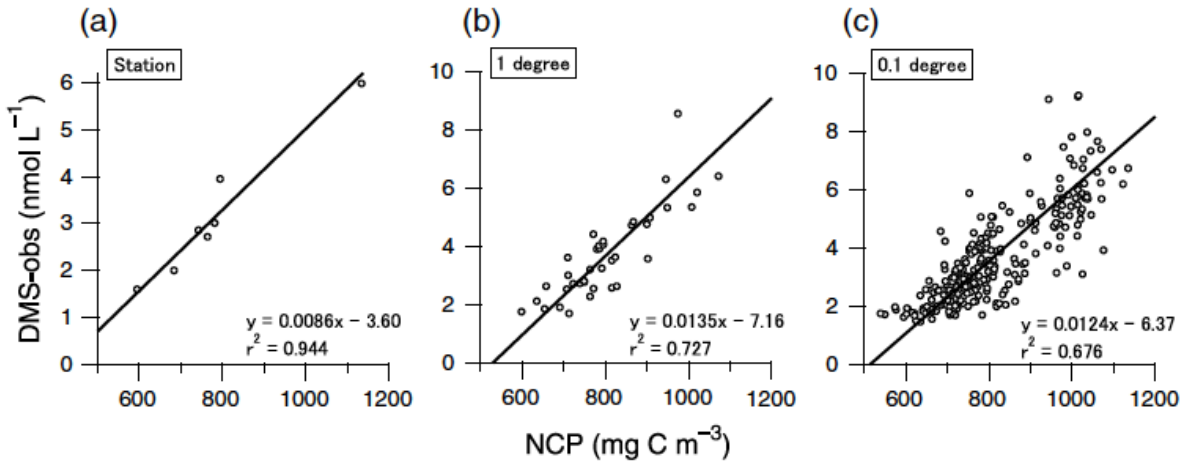


Figure 2: *Relationship between observed DMS concentrations and net community production (NCP). The data presented are (a) observations at discrete stations and means of (b) 1° and (c) 0.1° grids.*

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

Yukihiro Nojiri, a member of the SOLAS SSC hosted the 13th SOLAS Scientific Steering Committee Meeting at Tsukuba, Japan on 28-30 May 2013. After that, the SOLAS Symposium with Young Scientists in Japan was held there on 31 May 2013.

SOLAS-Japan activity poster was presented for the celebration of the 50th Anniversary of the IOC/WESTPAC during the 27th Session of the IOC Assembly, 26th June - 5th July 2013.

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

The NEOPS (New Ocean Paradigm on Its Biogeochemistry, Ecosystem and Sustainable Use) project (PI: Ken Furuya, U of Tokyo) has been funded for the IMBER community involving the SOLAS Japan members for 5 years in 2012.

The R/V Hakuho Maru KH-13-7 research cruise has been carrying on from the equator to 50˚S along 170˚W iine as part of NEOPS project. We are trying to produce a 3D mapping of marine ecological and biogeochemical parameters in the entire Pacific.

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

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

Morss Colloquium "Fukushima and the Ocean", co-organized by Ken Buesseler and Mitsuo Uematsu, was held at WHOI, MA, USA for the public in the evening of 9 May. Jota Kanda and Hiroyuki Matsuda were also speakers from Japan. During the panel discussion, seven panelists and audience had lively questions and answers and broadcasted it through an Internet as a live. We distributed a booklet OCEANUS special issue "Fukushima and the Ocean" to all participants over 200. The booklet is available from the URL:

http://www.whoi.edu/website/fukushima-symposium/

5. Top 10 publications in 2013 (Reports, ACCEPTED articles, models, datasets, products, website etc)

Yokouchi Y, Inoue J, Toom-Sauntry D, 2013, Distribution of natural halocarbons in marine boundary air over the Arctic Ocean, *Geophysical Research Letter*, 40, 4086-4091.

Kameyama S, Tanimoto H, Inomata S, Inoue HY, Tsunogai U, Tsuda A, Uematsu M, Ishii M, Asano D, 2013, Strong relationship between dimethyl sulfide and net community production in the western subarctic Pacific. *Geophysical Research Letter*, 40, 3986–3990.

Nakagawa F, Suzuki A, Daita S, Ohyama T, Komatsu DD, Tsunogai U, 2013, Tracing atmospheric nitrate in groundwater using triple oxygen isotopes: Evaluation based on bottled drinking water, *Biogeosciences*, 10, 3547-3558.

Kondo Y, Takeda S, Nishioka J, Sato M, Saito H, Suzuki K, Furuya K, 2013, Growth stimulation and inhibition of natural phytoplankton communities by model organic ligands in the western subarctic Pacific, *Journal of Oceanography*, 69,97-115.

Okubo A, Takeda S, Obata, H, 2013, Atmospheric deposition of trace metals to the western North Pacific Ocean observed at coastal station in Japan, *Atmospheric Research*, 129-130,20-32.

Kawaguchi S, Ishida A, King R, Raymond B, Waller N, Constable A, Nicol S, Wakita M, Ishimatsu A, 2013, Risk maps for Antarctic krill under projected Southern Ocean acidification, *Nature Climate Change*, doi:10.1038/nclimate1937.

Omori Y, Tanimoto H, Inomata S, Kameyama S, Takao S, Suzuki K, 2013, Evaluation of using unfiltered seawater for underway measurement of dimethyl sulfide in the ocean by online mass spectrometry, *Limnology and Oceanography: Methods*, 11, 549-560.

Tanimoto H, Kameyama S, Iwata T, Inomata S, Omori Y, 2013, Measurement of air-sea exchange of dimethyl sulfide and acetone by PTR-MS coupled with gradient flux technique, *Environment Science and Technology,* doi:10.1021/es4032562.

Jung J, Furutani H, Uematsu M, Kim S, Yoon S, 2013, Atmospheric inorganic nitrogen input via dry, wet, and sea fog deposition to the subarctic western North Pacific Ocean, A*tmospheric Chemistry and Physics*, 13, 411–428, doi:10.5194/acp-13-411-2013.

Takahashi Y, Furukawa T, Kanai Y, Uematsu M, Zheng G, Marcus M A, 2013, Seasonal changes in Fe species and soluble Fe concentration in the atmosphere in the Northwest Pacific region based on the analysis of aerosols collected in Tsukuba, Japan, *Atmospheric Chemistry and Physics*, 13, 7695-7710, doi:10.5194/acp-

13-7695-2013.

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

In the summer of 2014, R/V Hakuho Maru KH-14-3 cruise will be carried out from 5˚S to 75˚N along 170˚W iine as part of the NEOPS project followed by the KH-13-7 cruise.

7. Other comments

Annual Report for the year 2013:

SOLAS Mexico

compiled by: Jose Martin Hernandez-Ayon

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

Defining the northern boundary OMZ in the eastern Pacific Ocean off Mexico

The work establishes a baseline to understand the mechanisms that influence the latitudinal variability and the upper limit of the shallow oxygen minimum zone (OMZ) in the northeastern Pacific Ocean. The dynamic northern boundary of the OMZ was identified in the eastern tropical Pacific off Mexico (ETPM; 16° to 23°N). The mean depth of the upper limit ranges from 300 to 400 m from 20° to 23°N, where the California Current water (CCW) induces the advection of oxygen rich water. Further south (from 16° to 20°N), the shallow upper limit of the OMZ (~60 m) results from the poleward transport of hypoxic Subtropical Subsurface Water (StSsW) near the surface layer (~25.6 kg m-3). A transitional zone is located in the north (20° to 23°N), where the influence of StSsW disappears, and the top of the OMZ is forced deeper by eddies generating southward intrusion of CCW. This oxygen-rich water (50 to 150 µmol L-1), transported overlying the 18°C isotherm, defines the northern boundary of the shallow OMZ in the ETPM. The mechanisms involved in the definition of the northward distribution of the shallow OMZ are associated with seasonal advection of CCW and StSsW as well as the intensification of regional mesoscale circulation. The dynamics of these two subsurface water masses determine the position of the northern boundary of the shallow OMZ in the ETPM. Understanding latitudinal, vertical and temporal OMZ variability is fundamental to interpret the influence of climate change on dissolved oxygen levels in the ocean, and their control over marine habitats [1].

1. "The mechanisms involved in defining the northern boundary of the shallow oxygen minimum zone in the eastern tropical Pacific Ocean off Mexico." Deep Sea Research Part I: Oceanographic Research Papers (2013).

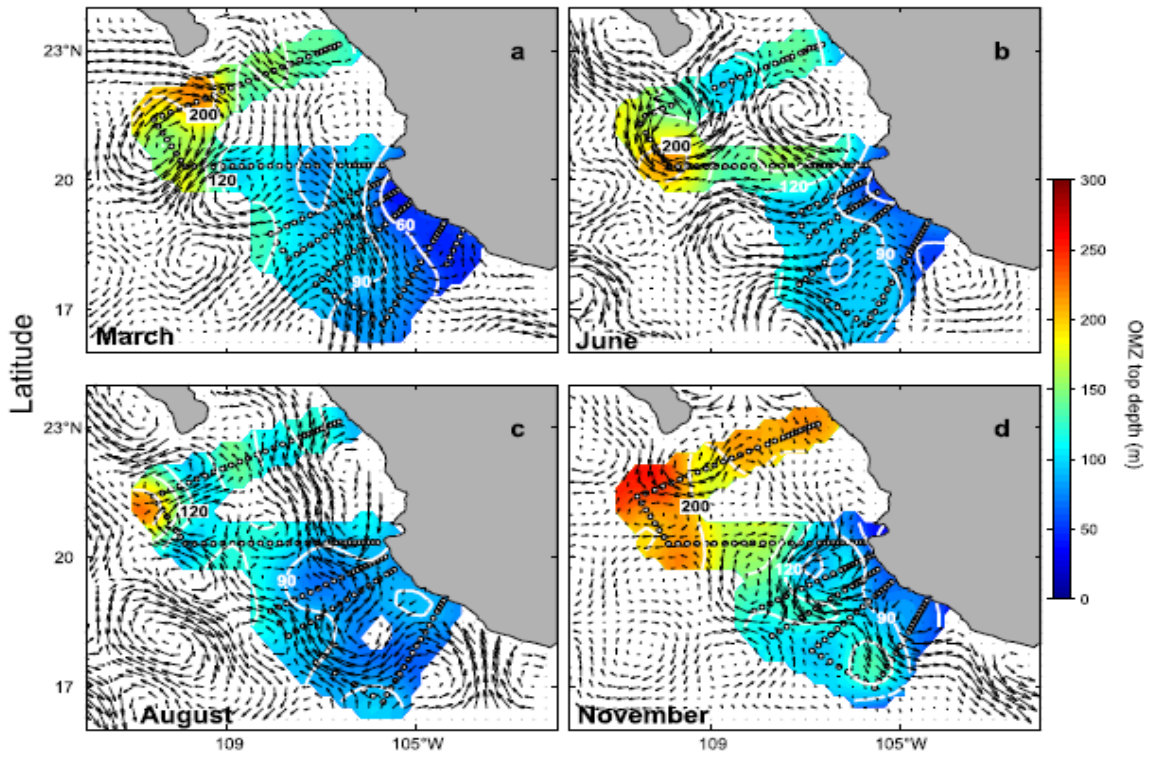


***Figure**. Depth (m) of the upper limit of the oxygen minimum zone (DO = 9 µmol L-1 isoline). Arrows indicate geostrophic circulation. White lines indicate depth isolines. White circles indicate sampling stations (CTD casts and DO measurements). a) March 2007, b) June 2005, c) August 2006, and d) November 2005.*

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

Mexico participate in the second international workshop of the Global Ocean Acidification Observing Network (GOA-ON) organized in St. Andrews, UK, on 24-26 July 2013. The workshop was to build upon progress made during the first international workshop to document the status and progress of ocean acidification in open-ocean and coastal environments, and to understand its drivers and impacts on marine ecosystems. A coordinated multidisciplinary multinational approach for observations and modeling is fundamental to establishing a successful research strategy for ocean acidification. The purpose of this meeting was to facilitate the development of our capability to predict present-day and future responses of marine biota, ecosystem processes, biogeochemistry, and climate change feedbacks. Required research elements include regional and global networks of observations collected in concert with process studies, manipulative experiments, field studies and modelling - to be carried out with close linkages to other global ocean observing activities. Global and regional observation networks will provide the necessary data required to firmly establish impacts attributable to ocean acidification. As a part of the international network, Mexico is considering three sites for the OA monitoring: Two in in the West coast of Baja California (Ensenada Station and Magdalena Bay) and one more in Cabo Pulmo (A reef area in the subtropical area in the Pacific).

With support from the International Ocean Carbon Coordination Project; the UK Ocean Acidification Research Programme (co-funded by NERC, Defra, and DECC); the NOAA Ocean Acidification Program; the Global Ocean Observing System; the Integrated Ocean

Observing System; the Ocean Acidification International Coordination Centre of the International Atomic Agency; the UK Science & Innovation Network (co-funded by FCO and BIS); the Intergovernmental Oceanographic Commission (IOC) of UNESCO; the University of Washington; and others, this international workshop will continue to build and document an integrated global observing network for both carbon and ocean acidification that addresses the requirements of nations affected by this emerging environmental problem in response to societal needs. *Information source from* "http://www.pmel.noaa.gov/co2/GOA_ON/2013".

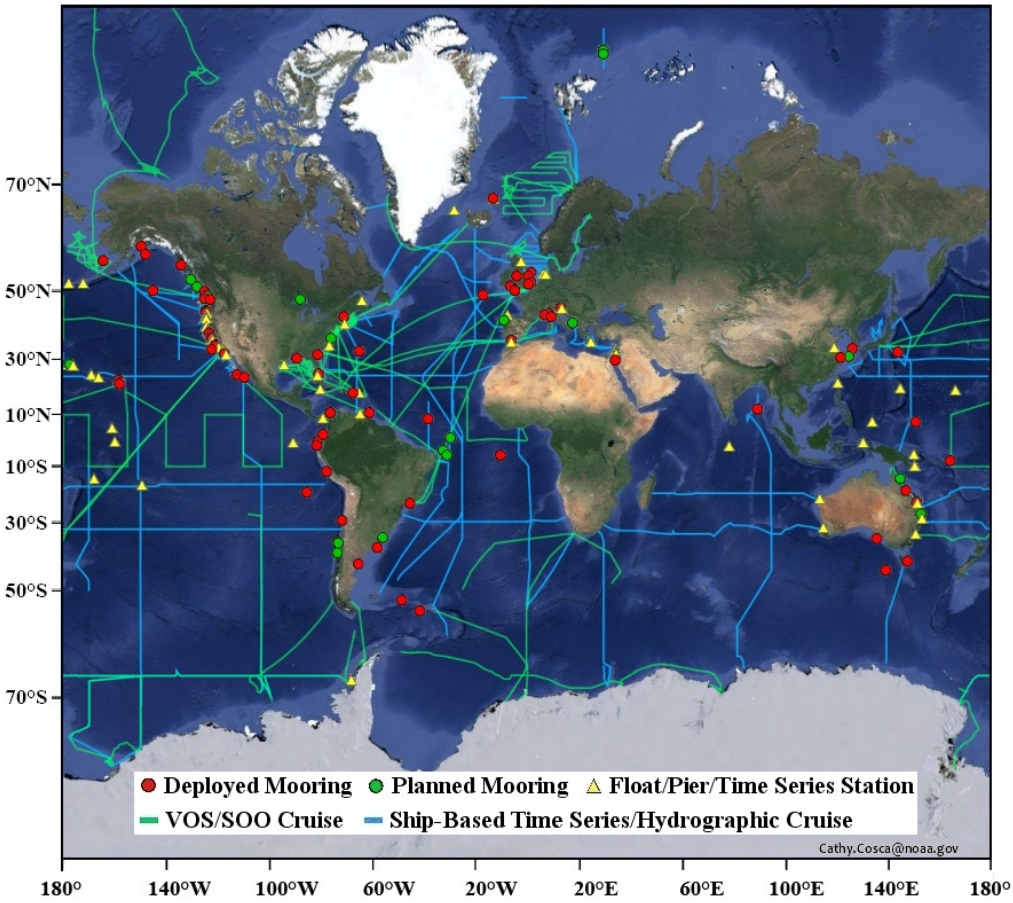


***Figure 2**. International network (m) for Ocean Acidification studies. In the network Mexico is considering three sites: Two in in the West coast of Baja California (Ensenada Station and Magdalena Bay) and one more in Cabo Pulmo (A reef area in the subtropical area in the Pacific).*

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

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

5. Top 10 publications in 2013 (Reports, <u>ACCEPTED</u> articles, models, datasets, products,

website etc)

Herguera, Juan Carlos, P. Graham Mortyn, and Miguel Àngel Martínez-Botí (2013). *"Links between southern California current variability and northern hemisphere temperatures: The past millennium." Quaternary International* 310.Complete.

Cepeda-Morales, Jushiro, Gilberto Gaxiola-Castro, Emilio Beier, and Víctor M. Godínez. *"The mechanisms involved in defining the northern boundary of the shallow oxygen minimum zone in the eastern tropical Pacific Ocean off Mexico." Deep Sea Research Part I: Oceanographic Research Papers* (2013).

Carriquiry, José D., Linda M. Barranco-Servin, Julio A. Villaescusa, Victor F. Camacho-Ibar, Hector Reyes-Bonilla, and Amílcar L. Cupul-Magaña. *"Conservation and Sustainability of Mexican Caribbean Coral Reefs and the Threats of a Human-Induced Phase-Shift."* (2013).

Reimer, Janet J., Rodrigo Vargas, Stephen V. Smith, Ruben Lara-Lara, Gilberto Gaxiola-Castro, J. Martín Hernández-Ayón, Angel Castro, Martin Escoto-Rodriguez, and Juan Martínez-Osuna. *"Air‐sea CO2 fluxes in the near‐shore and intertidal zones influenced by the California Current." Journal of Geophysical Research: Oceans* 118, no. 10 (2013): 4795-4810.

Muñoz-Barbosa, Albino, and Miguel Angel Huerta-Diaz. *"Trace metal enrichments in nearshore sediments and accumulation in mussels Modiolus capax along the eastern coast of Baja California, Mexico: Environmental status in 1995."* *Marine pollution bulletin* 77, no. 1 (2013): 71-81.

Macías-Zamora, José Vinicio, Karel Castro-Morales, Roger Allen Burke, and Manuel López-Mariscal. *"Dissolved methane in the sills region of the Gulf of California." Ciencias Marinas* 39, no. 2 (2013).

Leal-Acosta, María Luisa, Evgueni Shumilin, Nicolai Mirlean, Francisco Delgadillo-Hinojosa, and Ignacio Sánchez-Rodríguez. *"The impact of marine shallow-water hydrothermal venting on arsenic and mercury accumulation by seaweed Sargassum sinicola in Concepcion Bay, Gulf of California."Environmental Science: Processes & Impacts* 15, no. 2 (2013): 470-477.

Hernández-Ayón, José Martín, Cecilia Chapa-Balcorta, Francisco Delgadillo-Hinojosa, Víctor Froylan Camacho-Ibar, Miguel Angel Huerta-Díaz, Eduardo Santamaría-del-Angel, Salvador Galindo-Bect, and José Antonio Segovia-Zavala. *"Dynamics of dissolved inorganic carbon in the Midriff Islands region of the Gulf of California: Influence of water masses." Ciencias Marinas* 39, no. 2 (2013).

Bjorkstedt E, Goericke R, McClatchie S, Weber E, Watson W, Lo N, Peterson W, Brodeur R, Bograd S, Auth T, Fisher J, Morgan C, Peterson J**, Durazo R, Gaxiola-Castro G, Lavaniegos B**, Chavez F, Collins CA, Hannah B, Field J, Sakuma K, Satterthwaite W, O'Farrell M, Sydeman W, Thompson SA, Warzybok P, Bradley R, Jahncke J, Golightly R, Schneider S, Largier J, Kim SY, Melin S, DeLong R y Abell J (2012). *State of the California Current 2011-2012: Ecosystems respond to local forcing as La Niña wavers and wanes*. CalCOFI Reports, 53, 41-76.

Ruiz-de la Torre, Mary Carmen, Helmut Maske, Jose Ochoa, and Cesar O. Almeda-Jauregui. "Maintenance of Coastal Surface Blooms by Surface Temperature Stratification and Wind Drift." *PloS one* 8, no. 4 (2013): e58958.

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

XVIII Congreso Nacional de Oceanografia, June 04 to 06 in 2014, La Paz Baja California.

7. Other comments

Annual Report for the year 2013:

SOLAS New Zealand

compiled by: Cliff Law

1. Scientific highlights

Brix, Currie and Mikaloff-Fletcher (2013) make use of bi-monthly measurements of carbonate parameters from 1998 through 2010 in upper Sub-Antarctic Surface Water east of New Zealand's South Island at 45.85°S 171.50°E to investigate seasonal cycles and trends in these species and processes controlling their variability. This time-series reveals positive trends in salinity-normalized dissolved inorganic carbon (ΔDIC) and the partial pressure of carbon dioxide (pCO_2) that are smaller than would be expected from the anthropogenic increase in atmospheric pCO_2 alone, possibly due to a decrease of the average temperature over the observational period. The seasonal cycle of pCO_2 is dominated by that of DIC, but is substantially modified by the influence of the annual cycle of sea surface temperature. Investigations with a $^{13}C^{oc}$-constrained diagnostic box model suggest that net community production (NCP) is the dominant process controlling the observed seasonal variability in ΔDIC by removing 1.2±0.7 mol C m^{-2} yr^{-1} from the mixed layer. This carbon drawdown, aided by an additional carbon removal due to horizontal transport, is balanced by vertical diffusion, entrainment, and air-sea gas exchange of CO_2. Oceanic pCO_2 is below atmospheric pCO_2 for nearly the entire year, leading to an annual mean surface ocean pCO_2 undersaturation of about 12 µatm and an annual oceanic uptake of CO_2 from the atmosphere of 0.9±0.1 mol C m^{-2} yr^{-1}.

Brix, H, Currie, KI, Mikaloff-Fletcher, SE, 2013. Seasonal variability of the carbon cycle in subantarctic surface water in the South West Pacific. *Global Biogeochemical Cycles* 27(1): 200-211.

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

IPCC - P.W. Boyd, Lead Author on IPCC WGII AR5 Chapter 6 Ocean Systems

International SOLAS - C. Law Lead Author on publication of SOLAS Mid-Term Strategies (Law CS et al 2013. Evolving Research Directions in Surface Ocean Lower Atmosphere (SOLAS) Science. *Environmental Chemistry*, 10:1–16 http://dx.doi.org/10.1071/EN12159)

IGBP Fast Track Initiatives - P.W. Boyd, co-author on publication on nutrient limitation (Moore et al, Nature Geosciences, 6(9): 701-710).

United Nations - Law, C.S., Ocean acidification and ecosystem impacts in the South-West Pacific. 14th Meeting of the United Nations Open-Ended Informal Consultative Process on Oceans and the Law of the Sea Ocean, United Nations Headquarters, New York, USA, 18/6/2013

Ocean acidification, GOA-ON - K. Currie, Presentations at GOA-ON meeting – Currie, K.I., 2013. Biological and Physico-Chemical Controls on pH in Coastal and Shelf Waters. 2nd International Workshop: Global Ocean Acidification Observing Network, St Andrews, Scotland.

Ocean acidification, - New Zealand-USA JCM Technical Steering Committee Meeting: Marine and Ocean Research, C. Law, Leader on Ocean Acidification topic.

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

Marine biogenic aerosol production - SOAP (Surface Ocean Aerosol Production) is an SOLAS-endorsed international collaboration in marine biogeochemistry, air-sea exchange and atmospheric chemistry between SOLAS scientists led by New Zealand (NIWA), with collaboration with U.S. (UCI, U Chapman, SUNY), Germany (IFM-G), Eire (NUIG), U.K. (U Camb), Canada (U Laval), Australia (CSIRO and QUT), & Finland (UEF). Data collected during the SOAP voyage (February-

March 2012) were discussed at a workshop held in Wellington in March 2013 convened by C. Law, M. Smith & M. Harvey, with 12 national & international participants.

Sub-Antarctic Water carbonate chemistry - 6 research cruises were completed in 2013 on the Munida Time Series, which has been running since 1998 for 14 years. Measurements of the carbonate chemistry and associated parameters are obtained along a surface transect including neritic, modified subtropical and sub-Antarctic surface waters. The suite of measurements is currently being increased so that it is compliant with the proposed Goal One Level One Global Ocean Acidification Observing Network. (Keith Hunter and Kim Currie)

Spatial-temporal variability in pCO_2 in the SW Pacific - An autonomous pCO_2 system (General Oceanics) has been successfully running on the RV Tangaroa since February 2013, making measurements in surface waters of the SW Pacific Ocean & the Southern Ocean south of New Zealand. The data is being worked up for submission to IMOS and CDIAC. (Murray Smith and Kim Currie).

Coastal CO_2 - A seasonal series of sampling for pCO_2, carbonate system components and nutrients is providing an insight in to the biogeochemical cycling in coastal waters of the Firth of Thames, New Zealand. The results were consistent with earlier research made using mass-balance budgeting of water, salt and nutrients, which showed the Firth is a highly heterotrophic system, probably driven by agricultural land use in its catchment. This demonstrated the strong effects that agriculture can exert on net greenhouse gas emissions and acidification in estuaries. (John Zeldis and Kim Currie).

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

Law, C.S., Ocean acidification and ecosystem impacts in the South-West Pacific. 14th Meeting of the United Nations Open-Ended Informal Consultative Process on Oceans and the Law of the Sea Ocean, United Nations Headquarters, New York, USA, 18/6/2013.

6th NZ Ocean Acidification Workshop. Southern contributions to a second decade of OA research. 7th-8th February 2013, University of Otago, 50 participants, Convenors C. Hurd, K. Currie, P. Boyd, A. Smith.

Future proofing New Zealand's shellfish aquaculture: monitoring and adaptation to ocean acidification, Rutherford Hotel, Nelson, NZ, December 3rd-4th 2013, 50 particpants, Convenors J. Guinotte, T. Capson, D. Tracey, V Cummings, N. Ragg & A. Crosbie,

5. Top 10 publications in 2013 (Reports, <u>ACCEPTED</u> articles, models, datasets, products, website etc)

Brix, H, Currie, KI, Mikaloff-Fletcher, SE, 2013. Seasonal variability of the carbon cycle in subantarctic surface water in the South West Pacific. *Global Biogeochemical Cycles* 27(1): 200-211.

Boyd, PW, Bakker, DCE, Chandler, C, 2012. A New Database to Explore the Findings from Large-Scale Ocean Iron Enrichments Experiments. *Oceanography* 25(4): 64-71.

Cropp, RA, Gabric, AJ, Levasseur, M, McTainsh, GH, Bowie, A, Hassler, CS, Law, CS, McGowan, HA, Tindale, N, Viscarra Rossel, RA, 2013. The likelihood of observing dust-stimulated phytoplankton growth in waters proximal to the Australian continent. *J. Mar. Systems* 117–118:43–52.

Hoffmann, LJ, Breitbarth, E, McGraw, C, Law, CS, Hunter, KA 2013. A trace-metal clean, pH controlled incubator system for ocean acidification studies. *Limnology and Oceanography: Methods* 11: 53–61.

Jones, KN, Currie, KI, McGraw, CM, Hunter, KA, 2013. The effect of coastal processes on phytoplankton biomass and primary production within the near-shore Subtropical Frontal Zone. *Estuarine, Coastal and Shelf Science* 124: 44-55.

Landwehr, S., Miller, S.D., Smith, M.J., Saltzman, E.S. & B. Ward. 2013. Analysis of the PKT Correction for Direct CO2 Flux Measurements over the Ocean. *Atmospheric Chemistry Physics Discussions*, 13, 28279-28308. doi:10.5194/acpd-13-28279-2013

Law, CS, Brévière, E, Leeuw, G, Garçon, V, Guieu, C, Kieber, D, Kontradowitz, SD, Paulmier, A, Quinn, PK, Saltzman, E, Stefels, J, von Glasow, R., 2013. Evolving Research Directions in Surface Ocean Lower Atmosphere (SOLAS) Science. *Environmental Chemistry*, 10:1–16 http://dx.doi.org/10.1071/EN12159

Maas, EW, Hall, JA, Law, CS, Pickmere, S, Currie, KI, Chang, FH, Voyles, KM and Caird, D, 2013. Effect of ocean acidification on bacterial abundance, activity and diversity in the Ross Sea, Antarctica. *Applied Microbial Ecology*, 70:1–15 doi: 10.3354/ame01633

MacDiarmid AB, Law CS, Pinkerton M, Zeldis J (2013). New Zealand marine ecosystem services. *In* Dymond JR ed. Ecosystem services in New Zealand – conditions and trends. Manaaki Whenua Press, Lincoln, New Zealand.

Weller, DI, Law, CS, Maas, EW, Marriner, A, Nodder, S, Chang, H, Stephens, J, Archer, S, Wilhelm S, 2013. Temporal variation of methanogenesis in a mesoscale eddy during a phytoplankton bloom in the southwest Pacific Ocean. *Progress in Oceanography* 116:193-206, 10.1016/j.pocean.2013.07.008.

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

1. SOAP data analysis & publications. A joint special Issue has been opened in *Atmos. Chem. Phys. & Ocean Science.* Timeline: 01 Jul 2013 – 31 Jul 2015

http://www.atmos-chem-phys-discuss.net/special_issue197.html

http://www.ocean-science.net/submission/scheduled_special_issues.html#12

2. National ocean acidification monitoring network using protocols developed within GOA-ON
3. Development of research on biogenic influences on marine aerosol formation

7. Other comments

Annual Report for the year 2013:

SOLAS Norway

compiled by: Siv K. Lauvset

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

Full Seasonal Cycle of Air-Sea fluxes of CO_2 in the Barents Sea

New research using three years of fCO_2 data from the Barents Sea found that in summer multi-linear algorithms using sea surface temperature (SST), mixed layer depth (MDL) and chlorophyll-a (Chl-a) can be used to map fCO_2 in the entire Barents Sea with an RMSE of 13.8 matm. In winter such mapping can be made using a linear relationship with sea surface salinity (SSS) with an RMSE of 4.88 matm. This research, which appeared in Journal of Marine Systems, has been used to calculate data-based air-sea fluxes of CO_2 in the Barents Sea (see figure).

Previous studies of the air-sea CO_2 fluxes in the Barents Sea have come up with a wide range of total annual fluxes (e.g. Omar et al., 2007; Årthun et al., 2012). Considering that the Barents Sea is a very strong CO_2 sink – among the strongest in the Arctic – this newest research helps to better constrain the magnitude of this sink. Lauvset et al. (2013) found an annual flux in 2007 of (-48±5 gC m^{-2}) which is consistent with other recent studies, and which indicates that previous estimates based on climatologies of fCO_2 seem to underestimate the annual fluxes in the Barents Sea.

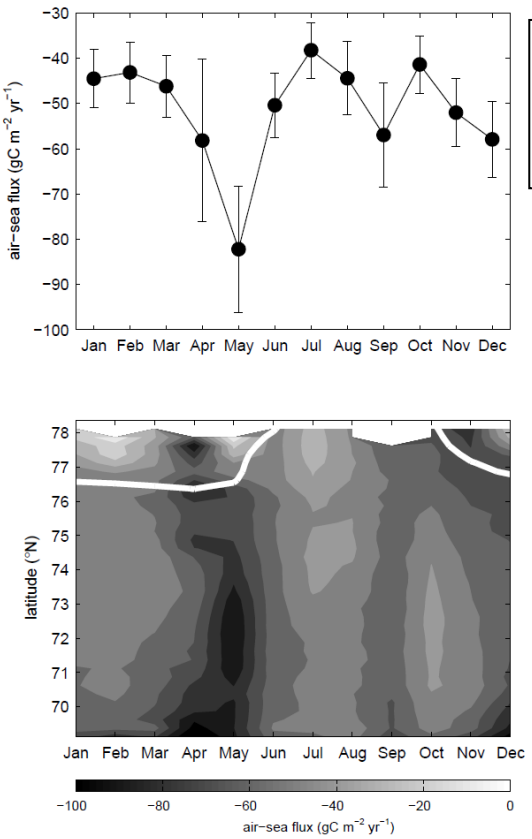


Figure. The top figure shows the mean seasonal cycle of air-sea CO_2 flux in 2007. The bottom figure shows the north-south spatial variability in air-sea CO_2 flux averaged over the entire longitude range (17-42ºE). The thick white line is the 0 ºC isotherm. ***Figure 8 in Lauvset et al. (2013)***

References:

Lauvset, S. K., Chierici, M., Counillon, F., Omar, A., Nondal, G., Johannessen, T., & Olsen, A. (2013). Annual and seasonal

fCO2 and air–sea CO2 fluxes in the Barents Sea. *Journal of Marine Systems, 113–114*(0), 62-74. doi: http://dx.doi.org/10.1016/j.jmarsys.2012.12.011

Omar, A. M., Johannessen, T., Olsen, A., Kaltin, S., & Rey, F. (2007). Seasonal and interannual variability of the air-seaCO(2) flux in the Atlantic sector of the Barents Sea. *Marine Chemistry, 104*(3-4), 203-213. doi: 10.1016/j.marchem.2006.11.002

Årthun, M., Bellerby, R. G. J., Omar, A. M., & Schrum, C. (2012). Spatiotemporal variability of air-sea CO2 fluxes in the Barents Sea, as determined from empirical relationships and modeled hydrography. *Journal of Marine Systems, 98-99*(1), 40-50.

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

Contributions to IPCC AR5 2013: Christoph Heinze – review editior chapter 6, Jerry Tjiputra – contributing author chapter 6
SOLAS SSC member Christoph Heinze attended the SOLAS SSC meeting in Tsukuba, Japan, in May 2013 and organised a consultation meeting at the European Commission on future funding/resreach at 25 Nov 2013.
Christoph Heinze and the CARBOCHANGE consortium contributed with EO FP7 project CARBOCHANGE significantly to SOLAS resreach; CARBOCHANGE submits a separate report summarising all activities with respect to SOLAS.

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

Cruise to 75ºN repeat section with R/V G.O.Sars in summer 2013.
Friederike Hoffmann and Christoph Heinze (both UiB) organised a side event at the 9th International Carbon Dioxide Conference, Beijing, China, June 2013 on: Shaping tomorrow's carbon cycle research: Knowledge gaps, international collaboration, and funding priorities, 75 international participants.

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

Ocean acidification – TV news report featuring Dr. Ingunn Skjelvan (link below):
http://tv.nrk.no/serie/kveldsnytt/nnfa23100513/05-10-2013

5. Top 10 publications in 2013 (Reports, ACCEPTED articles, models, datasets, products, website etc)

Bopp, L., L. Resplandy, J.C. Orr, S.C. Doney, J. P. Dunne, M. Gehlen, P. Halloran, C. Heinze, T. Ilyina,R. Séférian, J. Tjiputra, and M. Vichi, 2013, Multiple stressors of ocean ecosystems in the 21st century:projections with CMIP5 models, *Biogeosciences*, 10, 6225–6245.

Cocco, V., F. Joos, M. Steinacher, T.L. Frölicher, L. Bopp, J. Dunne, M. Gehlen, C. Heinze, J. Orr, A. Oschlies, B. Schneider, J. Segschneider, and J. Tjiputra, 2013, Oxygen and indicators of stress for marine life in multi-model global warming projections, *Biogeoscience*s, 10, 1849–1868.

Frigstad, H., T. Andersen, D. O. Hessen, E. Jeansson, M. Skogen, L.-J. Naustvoll, M. W. Miles, T. Johannessen, and R. G. J. Bellerby (2013), Long-term trends in carbon, nutrients and stoichiometry in Norwegian coastal waters: Evidence of a regime shift, *Progress in Oceanography*, 111(0), 113-124.

Heinze, C., and M. Gehlen, 2013, Modeling Ocean Biogeochemical Processes and the Resulting Tracer Distributions (Ch. 26), in Siedler, G., Griffies, S., Gould, J. and Church, J. (Eds.): Ocean Circulation and Climate, 2nd Ed. A 21st century perspective, Elsevier, 667-694. (The book chapter is peer reviewed.)

Ilyina, T., D. Wolf-Gladrow, G. Munhoven, and C. Heinze, 2013, Assessing the potential of calcium-based artificial ocean alkalinization to mitigate rising atmospheric CO2 and ocean acidification,

Geophysical Research Letters, 40, 1–6, doi:10.1002/2013GL057981.

Lauvset, S. K., Chierici, M., Counillon, F., Omar, A., Nondal, G., Johannessen, T., & Olsen, A. (2013). Annual and seasonal fCO2 and air–sea CO2 fluxes in the Barents Sea. *Journal of Marine Systems, 113–114*(0), 62-74. doi: http://dx.doi.org/10.1016/j.jmarsys.2012.12.011

Pfeil, B., Olsen, A., Bakker, D.C.E., Hankin, S., Koyuk, H., Kozyr, A., Malczyk, J., Manke, A., Metzl, N., Sabine, C.L., Akl, J., Alin, S.R., Bates, N., Bellerby, R.G.J., Borges, A., Boutin, J., Brown, P.J., Cai, W.J., Chavez, F.P., Chen, A., Cosca, C., Fassbender, A.J., Feely, R.A., González-Dávila, M., Goyet, C., Hales, B., Hardman-Mountford, N., Heinze, C., Hood, M., Hoppema, M., Hunt, C.W., Hydes, D., Ishii, M., Johannessen, T., Jones, S.D., Key, R.M., Körtzinger, A., Landschützer, P., Lauvset, S.K., Lefèvre, N., Lenton, A., Lourantou, A., Merlivat, L., Midorikawa, T., Mintrop, L., Miyazaki, C., Murata, A., Nakadate, A., Nakano, Y., Nakaoka, S., Nojiri, Y., Omar, A.M., Padin, X.A., Park, G.H., Paterson, K., Perez, F.F., Pierrot, D., Poisson, A., Ríos, A.F., Santana-Casiano, J.M., Salisbury, J., Sarma, V.V.S.S., Schlitzer, R., Schneider, B., Schuster, U., Sieger, R., Skjelvan, I., Steinhoff, T., Suzuki, T., Takahashi, T., Tedesco, K., Telszewski, M., Thomas, H., Tilbrook, B., Tjiputra, J., Vandemark, D., Veness, T., Wanninkhof, R., Watson, A.J., Weiss, R., Wong, C.S., Yoshikawa-Inoue, H. (2013). A uniform, quality controlled Surface Ocean CO2 Atlas (SOCAT). *Earth Syst. Sci. Data, 5*(1), 125-143. doi: 10.5194/essd-5-125-2013

Sabine, C.L., Hankin, S., Koyuk, H., Bakker, D.C.E., Pfeil, B., Olsen, A., Metzl, N., Kozyr, A., Fassbender, A., Manke, A., Malczyk, J., Akl, J., Alin, S.R., Bellerby, R.G.J., Borges, A., Boutin, J., Brown, P.J., Cai, W.J., Chavez, F.P., Chen, A., Cosca, C., Feely, R.A., González-Dávila, M., Goyet, C., Hardman-Mountford, N., Heinze, C., Hoppema, M., Hunt, C.W., Hydes, D., Ishii, M., Johannessen, T., Key, R.M., Körtzinger, A., Landschützer, P., Lauvset, S.K., Lefèvre, N., Lenton, A., Lourantou, A., Merlivat, L., Midorikawa, T., Mintrop, L., Miyazaki, C., Murata, A., Nakadate, A., Nakano, Y., Nakaoka, S., Nojiri, Y., Omar, A.M., Padin, X.A., Park, G.H., Paterson, K., Perez, F.F., Pierrot, D., Poisson, A., Ríos, A.F., Salisbury, J., Santana-Casiano, J.M., Sarma, V.V.S.S., Schlitzer, R., Schneider, B., Schuster, U., Sieger, R., Skjelvan, I., Steinhoff, T., Suzuki, T., Takahashi, T., Tedesco, K., Telszewski, M., Thomas, H., Tilbrook, B., Vandemark, D., Veness, T., Watson, A.J., Weiss, R., Wong, C.S., Yoshikawa-Inoue, H. (2013). Surface Ocean CO2 Atlas (SOCAT) gridded data products. *Earth Syst. Sci. Data, 5*(1), 145-153. doi: 10.5194/essd-5-145-2013

Tjiputra, J.F., C. Roelandt, M. Bentsen, D. M. Lawrence, T. Lorentzen, J. Schwinger, Ø. Seland, and C. Heinze, 2013, Evaluation of the carbon cycle components in the Norwegian Earth System Model (NorESM), *Geosci. Model Dev*., 6, 301–325.

Wanninkhof, R., G.-H. Park, T. Takahashi, C. Sweeney, R. A. Feely, Y. Nojiri, N. Gruber, G. McKinley, A. Lenton, C. Le Quéré, C. Heinze, J. Schwinger, H. Graven, S. Khatiwala, and S. C. Doney, 2013, Global Ocean Carbon Uptake: Magnitude, Variability and Trends, *Biogeosciences*, 10, 1983–2000.

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

7. Other comments

SOLAS Peru

compiled by Michelle Graco

With the scientific contribution and participation of the Direction of Oceanography and Climate Change from the Marine Research Institute of Peru (IMARPE) and collaborators partners.

Reporting Period is January 2013 – December 2013

1. Scientific highlights

1- RESULTS FROM THE "M91 PERU SOPRANO" A SOLAS CRUISE ALONG THE PERUVIAN COAST

In October 8 2013 the first results from the "M91 PERU SOPRANO" SOLAS CRUISE (December 1-26 2012) were presented that were the goal to assess the role of this area as source or sink of climate relevant trace gases. This cruise involved different sub-projects of SOPRAN and several international partners with the principal investigator Dr. Herman Bange (GEOMAR-Kiel GERMANY) and is a contribution to the *SOLAS (Surface Ocean – Lower Atmosphere Study)* midterm strategy initiative 'Air-sea gas fluxes at eastern boundary upwelling and oxygen minimum zones systems'. The Peruvian team (Georgina Flores, Violeta León and Avy Bernales, IMARPE) participate in the phytoplankton characterization and the connection with the DMS production as well as the distribution of relevant parameters as pH and Cl-a. The results on December 2012 along the Peruvian coast show on the north the influence of the equatorial system that influences the position of the OMZ (< 22 μmol/Kg) bellow 200 m from the surface. This low oxygen conditions are associated with a water mass of low pH values (< 7.8) distributed between 200 and 1300 m. Off the central area (Chimbote, Callao) the oceanographic conditions, oxygen and pH evidence the presence of Cold Coastal Waters on the coastal area consequence of an active upwelling event. A very shallow position of the OMZ upper layer around 25-30 m from the surface and very shallow low pH values (< 7.8). Associated with the phytoplankton communities, the abundance of phytoflagellates (7 x 10^5 cel / L) appear associated with the highest values of DMS (> 1.0 nmol/L) in the upper ten meters of the water column.

2- A PERUVIAN-FRENCH PROJECT "AMOP, SUBSURFACE MOORING OFF CENTRAL PERU

On January 5th 2013 on board of the METEOR research vessel (with the support of the GEOMAR-SFB 754 project) was deployed the subsurface mooring AMOP in front of Callao (30 nm). This project takes place in the frame of the agreement between the Marine Research Institute from Peru (IMARPE) and the Development Research Institute (IRD), the international Mix Laboratory LMI DISCOH "Dinámica del Sistema de la Corriente de Humboldt". This initiative is leading by the LEGOS institute in close collaboration of IMARPE is a contribution with the Mid-Term Strategy Initiatives of the research SOLAS program (Surface Ocean-Lower Atmosphere Study) associated with the Eastern Boundary Upwelling Systems and the OMZ. During June 25-26 2013 in the frame of the eruvian Project (IMARPE) "Integrated study of the Peruvian coastal upwelling system" was performed a cruise off Callao on the Peruvian research vessel JOSE OLAYA. During this cruise we collect oceanographic and biological information on the mooring site and were recover the data information and sediment trap samples form the mooring. This operation was performed by a Peruvian-French team. On January 2014 will planned the next recovery of the mooring on the French Research Vessel Atalante during the AMOP cruise (PI: C. Maes) along the central coast off Peru.

Recover and deployment of the subsurface AMOP mooring- R/V Olaya, June 2013 courtesy IMARPE Peru

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

Workshop " KOSMOS PERU " A MARINE ACIDIFICATION MESOCOSM EXPERIM

On October 2013 in Lima the first workshop in the frame of the project "Future Changes in the ocean upwelling system off Peru, KOSMOS Perú " led by Dr. Ulf Riesebell, the German Institute GEOMAR, in close collaboration with the Instituto del Mar del Peru (IMARPE) took place. On this workshop participated different institutions from Peru (Universities UPCH. UCSUR) related with the marine research and also members of the German Embassy, Environmental Minister, the Minister of Production and the Hydrography Direction. The goal of this workshop was to present the project and start the actions in order to implement on 2015-2016 the mesocosm system off Peru. Through this project, that represent a unique multidiciplinary platform, is expected to contribute to the knowledge of the Peruvian Upwelling System as a natural laboratory to the possible impacts of climate change in a relevant topic as is ACIDIFICATION in different relevant thematics in the field of molecular biology, ecology, biogeochemistry, oceanography and atmospheric chemistry.

Mesocosm experiment (courtesy of Dr. Ulf Riebesell GEOMAR from the Artic experiment).

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

On December 2013 by the support of SCOR with a Visiting Scholar, Dr. Michelle Graco teaches a course in Argentina on the “Biogeochemical Cycles and Highly Productive System”. This course coordinated by the University of Buenos Aires UBA (Dr. Martin Saraceno) was an excellent opportunity for 27 graduate students from different countries (Mexico, Brazil, Chile, Colombia, Peru, Argentina) to discuss and update the knowledge on different relevant SOLAS themes as Oxygen Minimum Zones, acidification, the carbon cycle, traces and greenhouse gases.

4. Top 10 publications in 2013 (Reports, ACCEPTED articles, models, datasets, products, website etc)

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

See point 1 and 2

6. Goals, priorities and plans for future activities/events
Short and long term goals: -Reinforce the monitoring of the upwelling system of Peru in terms of meteorological, oceanographic and chemical parameters (the carbonate system (total CO_2, pH and alkalinity) and greenhouse and trace gases). -To participate in national and international efforts to curry out multidisciplinary research focus in the SOLAS OMZs-EBUEs Mid-Term Strategy Initiative topics. -Integrate local efforts associated with SOLAS activities and particularly in the frame of the Upwelling SOLAS Mid-Term strategy topics.
7. Other comments

Annual Report for the year 2013:

SOLAS Poland

compiled by: Tymon Zielinski

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

1. Vertical coarse aerosol fluxes in the boundary layer over the Baltic Sea. Institute of Oceanology Polish Academy of Sciences.

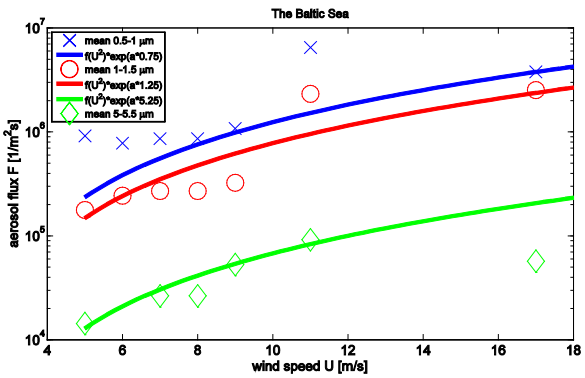
During a number of cruises conducted on board of r/v Oceania between 2008 and 2012 many data were collected which were used to calculate the Sea Salt Generation Function (SSGF) over the Baltic Sea with the Gradient Method [1]. A Laser Particle Counter was placed on the mast of the r/v Oceania.
Based on the averaged vertical concentration, and using the Monin - Obuchow theory, profiles of vertical sea spray fluxes in the near water layer were calculated. Then the sea spray emission fluxes have been calculated for all particles of sizes from 0.5 µm to 8 µm, and for particles of sizes from fifteen channels of 0.5 µm width. Using these fluxes the SSGF was calculated. This Function provides information on the emission of particles of different sizes, depending on wind speed at a 10 m elevation (U_{10}).

Finally, we propose the SSGF formula in a following form (*r* is particle radius):

$$F(U_{10}, r) = (18251 * U_{10}^{2} - 135085)\exp(-1.24 * r)$$

[1] Petelski, T. (2003), Marine aerosol fluxes over open sea calculated from vertical concentration gradients, J. Aerosol Sci., 34, 359– 371.

Figure: The final result of the SSGF fitting for the exemplary ranges. Lines represent the predicted values of the SSGF for each particle diameter. Symbols represent average flux values from the measurements.



2. Baltic Sea as a source of emission of CO_2 to the atmosphere. Institute of Oceanology Polish Academy of Sciences.

Recent studies indicate the importance of the marine environment in the circulation of CO_2, which is due to the so called "biological pump" mechanism.
The results obtained identify the Baltic Sea as a source of emission of CO_2 to the atmosphere. When the calculated value of -2.58 Tg C yr^{-1} – is divided by the Baltic surface of 3.85×105 km^2 (excluding the Kattegat), the mean CO_2 emission of -6.7 g C m^{-2} yr^{-1} (-24.6 g CO_2 m^{-2} yr^{-1}) is obtained. When the most recent data of CO_2 flux at the air-water

interface for the entire Gulf of Bothnia (-3.61 Tg C yr^{-1}) are used in this calculation, the mean CO_2 flux in the remaining part of the Baltic Sea area amounts to 3.6 g C m^{-2} yr^{-1}. The value is smaller than the literature data obtained by Kulinski and Pempkowiak (2011), i.e. 9.0 g C m^{-2} yr^{-1}, and by Thomas and Schneider (1999) who reported 10.8 g C m^{-2} yr^{-1}. While, the results obtained by Wesslander et al. (2010) for the East Gotland Basin and for the Bornholm Deep, indicate emissions of CO_2 to the atmosphere at the level of -19.7 g C m^{-2} yr^{-1} and -28.1 g C m^{-2} yr^{-1}.

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

1. Expertise in reviewing Chapters 7 and 8 of the Fifth IPCC report provided by the Air-Sea Interaction team of the Institute of Oceanology Polish Academy of Sciences (IOPAS).
2. Leaders in the POLAND-AOD network.
3. Polish coordination in the NASA Maritime Aerosol Network.
4. Coordination of the abiotic team in the 7 FP project Eduscience.
5. Investigators in the 7 FP project Sea for Society.
6. Establishment and membership in the Scientific Council of the Climate Forum – Science on Climate.
7. Coordination of the Sopot Association for the Advanced Sciences activities.

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

1. Co-coordinating role in the iAREA, Polish-Norwegian Fund Grant (2013-2016).
2. Co-organization and participation in 6 sea cruises in the Baltic and the European Arctic.
3. Operation of the ACTRIS Sopot aerosol station (lidar, sunphotometers, particle counters, nephelometers).
4. Participation in the remote sensing intercomparison campaign – Strzyzow 2013.

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

1. Co-organization of the I National Conference, Role of aerosols in climate system.
2. Organization of the Sopot Forum for Young Scientists.
3. Co-ordination of the public consultations within the Sea for Society project.
4. Lessons on sea and marine impact on climate changes for students of all ages within the EDUSCIENCE project.

5. Top 10 publications in 2013 (Reports, <u>ACCEPTED</u> articles, models, datasets, products, website etc)

1. Publication of the Springer GeoPlanet: Earth and Planetary Sciences book entitled: Insights on environmental changes, ISBN 978-3-319-03682-3, due: January 2014.
2. Organizing and editing of the Topical Issue in the Acta Geophysica – Optical Methods in Atmospheric Sounding; 12 papers, due: January 2014.
3. Organic carbon burial rates in the Baltic Sea sediments, A. Winogradow; J. Pempkowiak; Est.Coast.Shelf Sci.; ECSS-D-13-00602; due: 2014.
4. 19 oral and poster presentations at both national and international conferences.

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

New Generation Function; Institute of Oceanology Polish Academy of Sciences

It is planned to use the archive data from many former Arctic cruises - AREX (the Institute of Oceanology annual summer ARctic EXperiment) and determine the new Generation Function for the North Polar Waters of the Atlantic. Both the eddy correlation and the gradient method will be used.

Such development, based on the SSGF, gives an opportunity to make the comparison for two different marine environments – the Baltic Sea and the North Polar Waters of the Atlantic.

Evaluation of marine aerosol fluxes based on wind wave characteristics;

Institute of Oceanology Polish Academy of Sciences and University of Gdansk

The main goal of a planned study is the estimation of marine aerosol fluxes produced by breaking sea waves in the Baltic Sea. The estimation procedures will base on wind wave characteristics provided by the numerical wind wave forecasting model implemented in the Institute of Oceanography, University of Gdansk which runs in an operational mode. Based on the estimation methods developed within the study a numerical module, providing distribution maps of marine aerosol fluxes generated over the Baltic Sea, will be constructed.

Further studies within the chemical component regarding the CO_2 emission to the atmosphere will be continued.

7. Other comments

Annual Report for the year 2013:

SOLAS Spain

compiled by: Rafel Simó

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

Role of Doñana Park wetlands in carbon sequestration

We measured the exchange of carbon dioxide (CO_2) between the atmosphere and aquatic ecosystems of Doñana National Park, SW Spain, and discovered that these important Mediterranean wetlands function as a carbon sink. The length and timing of wetland flooding influences the capture of CO_2, which is important in terms of the future role the wetlands may play in climate regulation, as water availability is strongly affected by human activities in the region. The high productivity of the marsh plants drives the annual sink for atmospheric CO_2. During flooding, organic material is washed into the marshes and degrades forming CO_2 in the water column, some of which is released to the atmosphere. Gradually stimulated by the nutrients released from the organic matter, aquatic plants fix CO_2 into biomass. Some of this trapped carbon ends up buried in the sediments, meaning that over long time scales, the ecosystem is helping to remove CO_2 generated by burning fossil-fuels from the atmosphere. The work revealed that areas with longer periods of inundation captured more CO_2. Therefore, any reduction in the natural water supply to the wetlands will modify the carbon sequestration function of Doñana National Park.

Morris EP, Flecha S, Figuerola J, Costas E, Navarro G, Ruiz J, Rodríguez P and Huertas IE (2013) Contribution of Doñana wetlands to carbon sequestration. *PLOS ONE*, 8: e71456 DOI: http://dx.plos.org/10.1371/journal.pone.0071456

More information: Emma Huertas, ICMAN-CSIC, Cadiz

Circulation-driven slowdown in the Atlantic carbon uptake

CO_2 uptake is reduced in the North Atlantic Ocean (NAO) by weakening of the meridional overturning circulation. The air-sea CO_2 uptake in the subtropical gyre is predominantly driven by anthropogenic carbon, while the subpolar gyre accounts almost exclusively for the natural uptake of CO_2 in the North Atlantic. The subpolar gyre presents a strong temporal variability dominated by the change of the NAO. The air-sea heat loss in the upper limb of the overturning circulation, along the subpolar gyre, is the factor determining the strength of the natural CO_2 uptake.

Pérez FF, Mercier H, Vázquez-Rodríguez M, Lherminier P, Velo A, Pardo PC, Rosón G, Ríos AF, 2013, Atlantic Ocean CO_2 uptake reduced by weakening of the meridional overturning circulation. *Nature Geoscience*, 6: 146-152. doi: 10.1038/NGEO1680. 2013.

More information: Fiz F. Pérez, IIM-CSIC, Vigo.

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

CARBOCHANGE (Changes in carbon uptake and emissions by oceans in a changing climate), funded by the 7th Frame Program of the European Commission, 2011-2014. Spanish partners: CSIC and Universidad de Las Palmas de Gran Canarias. Contacts: A.F. Rios, IIM-CSIC aida@iim.csic.es; M. González-Dávila, ULPGC mgonzalez@dqui.ulpgc.es

INGOS (Integrated non CO_2 greenhouse gas observing system), funded by the 7th Frame Program of the European Commission, 2011-2015. Spanish partners: CSIC and Fundación Centro de Estudios Ambientales del Mediterráneo. Contact: E. Huertas, ICMAN-CSIC emma.huertas@icman.csic.es

CATARINA (CArbon Transport and Acidification Rates In the North Atlantic). National Project funded by the Ministry of Economy and Competitiveness and co-funded by FEDER (Ref. CTM2010-17141), from 01/01/2011 to 31/12/2013. PI: Aida F.Rios, IIM-CSIC, aida@iim.csic.es; with participation of University of Vigo, LPO/IFREMER from France, University of Bremen.

TARA OCEANS POLAR CIRCLE 2013. Tara embarked in May 2013 to circumnavigate the Arctic Ocean. This international expedition is in collaboration with countries bordering the Arctic Ocean and in association with the Prince Albert II de Monaco Foundation. IIM-CSIC of Vigo was involved in the underway measurements of air-sea CO_2 fluxes during the expedition. Prof. Diana Ruiz Pino of Université Pierre et Marie Curie (Paris; France) was the contact researcher of the project.

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

Research Projects:

CARBOCHANGE (*Changes in carbon uptake and emissions by oceans in a changing climate*), funded by the 7th Frame Program of the European Commission, 2011-2014. Spanish partners: CSIC and Universidad de Las Palmas de Gran Canarias. Contacts: A.F. Rios, IIM-CSIC <aida@iim.csic.es>; M. González-Dávila, ULPGC mgonzalez@dqui.ulpgc.es.

INGOS (*Integrated non CO_2 greenhouse gas observing system*), funded by the 7th Frame Program of the European Commission, 2011-2015. Spanish partners: CSIC and Fundación Centro de Estudios Ambientales del Mediterráneo. Contact: E. Huertas, ICMAN-CSIC emma.huertas@icman.csic.es.

Assessment of the capacity of a Patagonian fjord (Huinay, Chile) as a carbon sink, funded by the CSIC, Fundación Endesa and Fundación San Ignacio del Huinay. Contact: Edward P. Morris, ICMAN-CSIC edward.morris@csic.es.

CATARINA (*CArbon Transport and Acidification Rates In the North Atlantic*). National Project funded by the Ministry of Economy and Competitiveness and co-funded by FEDER (Ref. CTM2010-17141), from 01/01/2011 to 31/12/2013. PI: Aida F.Rios, IIM-CSIC, aida@iim.csic.es; with participation of University of Vigo, LPO/IFREMER from France, University of Bremen.

ADEPT (Aerosol deposition and ocean plankton dynamics), funded by the MINECO (Spain), 2012-2014, is conducting aerosol deposition measurements in Barcelona and Blanes, airborne pollen measurements in Blanes, and high-frequency water column sampling at several coastal stations along the Catalan coast. PI and contact: F. Peters cesc@icm.csic.es

MANIFEST (Marine Acidification: New Insights From manipulative Experiments on selected Species and paleoceanographic reconstructions over key periods of Time), funded by the MINECO (Spain), 2013-2015, delves into the study of ocean acidification from pH manipulation experiments targeting a selection of key marine organisms (jellyfish, marine sponges, coccolithophores and cold-water corals). This project also aims at sedimentary paleoceanographic reconstructions of the role of the oceans in regulating atmospheric CO_2

concentration. PI and contact: C. Pelejero, ICM-CSIC <pelejero@icm.csic.es>.

Cruises:

The FICARAM-15 oceanographic cruise was conducted on board the RV Hespérides in the Atlantic ocean from the Falkland Islands to the Gibraltar Strait, 20 March to 20 May 2013, supported by the CATARINA, CARBOCHANGE and DOREMI projects. Researchers from the IIM-CSIC (Vigo), ICM-CSIC (Barcelona), and University of Barcelona conducted measurements of the carbon system (pH, alkalinity, total inorganic carbon, pCO_2) biogeochemical tracers, and dissolved organic carbon. Chief scientist of the Leg 1and contact: A.F. Ríos, IIM-CSIC aida@iim.csic.es.

TARA OCEANS POLAR CIRCLE 2013. Tara embarked in May 2013 to circumnavigate the Arctic Ocean. This international expedition is in collaboration with countries bordering the Arctic Ocean and in association with the Prince Albert II de Monaco Foundation. IIM-CSIC of Vigo was involved in the underway measurements of air-sea CO_2 fluxes during the expedition. Prof. Diana Ruiz Pino of Université Pierre et Marie Curie (Paris; France) was the contact researcher of the project.

Three oceanographic campaigns in the Strait of Gibraltar on board the RVs Sarmiento de Gamboa (May, as part as the FICARAM section and within the CATARINA project) and Angeles Alvariño (June and October) were conducted to sample the GIFT time series, and for maintenance and data download of moored pCO_2 and pH sensors that are used to monitor the temporal variability of CO_2 and ocean acidification in the outflow of Mediterranean water. PI and contact: E. Huertas, ICMAN-CSIC <emma.huertas@icman.csic.es>

A cruise along Comau Fjord (north of the Patagonian Fjord region, Chile) was carried out in November on board the Mytilus (Huinay Scientific Field Station) to determine the functioning of the carbon cycle in the area and the role of the fjord in the exchange of CO_2 with the atmosphere. PI and contact: E. Morris, ICMAN-CSIC <edward.morris@csic.es>

Workshops and Symposia:

The Workshop *Ocean acidification: state of the art and challenges for international cooperation* organized by SCOR-Spain as part of the Symposium *Integrating New Advances in Mediterranean Oceanography and Marine Biology* sponsored, among others, by the Institute of Marine Sciences (CSIC) that took place in Barcelona on Nov 26-29, 2013. Contact: Marta Estrada, ICM-CSIC <marta@icm.csic.es>.

MedOcean Symposium on Integrating New Advances in Mediterranean Oceanography and Marine Biology. Institute of Marine Sciences (CSIC) Barcelona, Spain, 26-29 November 2013. Held under the auspices of IMBER, SOLAS and LOICZ. The symposium invited speakers and accommodated contributions on issues related to the SOLAS objectives such as aerosol deposition and effects and the ecosystem level, carbonate chemistry and acidification and other. http://www.icm.csic.es/bio/medocean. Contact: Francesc Peters, ICM-CSIC cesc@icm.csic.es.

Data intercomparison:

Inter comparison exercise of different analytical methods (Gas Chromatograph, GC versus Off-Axis Integrated Cavity Output Spectrometer, OA-ICOS) for determination of CH_4 and N_2O in seawater. Contributors: GEOMAR Helmholtz- Zentrum für Ozeanforschung Kiel and CSIC. In order to validate the new OA-ICOS method for surface underway measurements of N_2O, and to cross-check the accuracy of the standards used for GC measurements of nitrous oxide (N_2O) and methane (CH_4), an intercomparison exercise was carried out during 2012-2013. Comparison tests were performed during two cruises in the equatorial Atlantic Ocean, and through lab-based GC measurements in both laboratories of samples collected on November 2013 at the Boknis Eck time series station (BE) located in the Baltic Sea. A set of standard gases were also exchanged between GEOMAR and CSIC and measured independently in each laboratory. A complete report is available

through the Ingos project.

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

Radio interview in OLA-RTV "Doñana wetlands behaviour in the removal of atmospheric CO_2", 29 August 2013.

The Pérez et al. (2013) Nature Geosciences publication has received a good coverage (46 mentions), with interviews and features in national and local newspapers, digital press, and various other portals.

On 4, 11, 18 and 25 January 2013, Channel 2 of the public Spanish TV, RTVE, programmed the four documentaries about the Malaspina Circumnavigation Expedition produced by VIVAC and RTVE.

5. Top 10 publications in 2013 (Reports, ACCEPTED articles, models, datasets, products, website etc)

Bramanti L, Movilla J, Gurón M, Calvo E, Gori A, Dominguez-Carrió C, Grinyó J, Lopez-Sanz A, Martínez-Quintana A, Pelejero C, Ziveri P, Rossi S, 2013, Detrimental effects of ocean acidification on the economically important Mediterranean red coral (Corallium rubrum) *Global Change Biology*, 19: 1897-1908.

Cobo-Viveros AM, Padin XA, Otero P, de la Paz M, Ruiz-Villarreal M, Ríos AF, Pérez FF, 2013, Short-term variability of surface carbon dioxide and sea-air CO_2 fluxes in the shelf waters of the Galician coastal upwelling system. *Scientia Marina*, 77S1, 37-48, doi: 10.3989/scimar.03733.27C.

Galí M, Ruiz-González C, Lefort T, Gasol J M, Cardelús C, Romera-Castillo C, Simó R, 2013, Spectral irradiance dependence of sunlight effects on plankton dimethylsulfide production. *Limnology and Oceanography* 58, 489-504.

Galí M, Simó R, Vila-Costa M, Ruiz-González C, Gasol J M, Matrai P, 2013, Diel patterns of oceanic dimethylsufide (DMS) cycling: microbial and physical drivers. *Global Biogeochemical Cycles* 27, 1–17, doi:10.1002/gbc.20047.

Jiang Z P, Hydes D J, Tyrrell T, Hartman S E, Hartman M C, Dumousseaud C, Padin X A, Skjelvan I, 2013, Key controls on the seasonal and interannual variations of the carbonate system in the Northeast Atlantic. *Journal of Geophysical Research*, 118, 785-800.

Morris EP, Flecha S, Figuerola J, Costas E, Navarro G, Ruiz J, Rodríguez P and Huertas IE, 2013, Contribution of Doñana wetlands to carbon sequestration. *PLOS ONE*, 8: e71456 DOI: http://dx.plos.org/10.1371/journal.pone.0071456.

Otero P, Padin XA, Ruiz-Villarreal M, Garcia-Garcia LM, Rios AF, Perez FF, 2013, Net sea–air CO_2 flux uncertainties in the Bay of Biscay based on the choice of wind speed products and gas transfer parameterizations. *Biogeosciences*, 10, 2993–3005.

Pérez FF, Mercier H, Vázquez-Rodríguez M, Lherminier P, Velo A, Pardo PC, Rosón G, Ríos AF, 2013, Atlantic Ocean CO_2 uptake reduced by weakening of the meridional overturning circulation. *Nature Geoscience*, 6, 146-152.

Ribas-Ribas M, Anfuso E, Gómez-Parra A, Forja J M, 2013, Tidal and seasonal carbon and nutrient dynamics of the Guadalquivir estuary and the Bay of Cadiz (SW Iberian Peninsula). *Biogeosciences*, 10, 4481–4491.

Schuster U, McKinley GA, Bates N, Chevallier F, Doney SC, Fay AR, González-Dávila M, Gruber N, Jones S, Krijnen J, Landschützer P, Lefèvre N, Manizza M, Mathis J, Metzl N, Olsen A, Rios AF, Rödenbeck C, Santana-Casiano JM, Takahashi T, Wanninkhof R, Watson AJ, 2013, An assessment of the Atlantic and Arctic sea–air CO2 fluxes, 1990–2009. *Biogeosciences*, 10, 607–627.

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

Installation of a underway CO_2 measuring system with an oxymeter on board R/V José María Navaz belonging to the Instituto Español de Oceanografía (IEO) for estimating the air-sea gas exchange in the sea surface of Rias Baixas during the weekly monitoring cruises as an voluntary observing ship. PI: Emma Huertas, ICMAN-CSIC, Cadiz.

Project NICANOR, funded by the Galician Government, has been launched with the aim to quatify nitrogen fixation and vertical diffusive fluxes of nitrogen in the NW Iberian shelf. PI: Bea Mouriño-Carballido, Universidad de Vigo.

The PEGASO cruise on the R/V Hesperides to the Southern Ocean is planned for January 2015. The cruise aims at studying the biological and biogeochemical controls of aerosol precursors in the region of South Georgia Island and Weddell Sea. PI: Rafel Simó, ICM-CSIC, Barcelona.

As part of the activities of project ADEPT, aerosol sampling and deposition measurement facilities have been set up at the ICM-CSIC, Barcelona, aerosol samplers have been installed at the CEAB-CSIC, Blanes, and aerosol deposition measurements will be started at the Stazione Zoologica Anton Dohrn in Napoli (Italy). These data will be used to seek relationships to coastal plankton dynamics, and aerosol amendment experiments are being conducted to explore cause-effect relationships. PI: Francesc Peters, ICM-CSIC, Barcelona.

7. Other comments

The research groups from the ICMAN-CSIC and IIM-CSIC were represented in the 9th International Carbon dioxide Conference in Beijing (China) in June 2013.

Annual Report for the year 2013:

SOLAS Sweden

compiled by:__Katarina Abrahamsson_____

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

1. Scientific highlights

Influence of coastal upwelling on the air-sea gas exchange of CO_2 in a Baltic Sea Basin

During coastal upwelling cold water from the ocean interior with high CO_2 concentration is brought up to the surface, allowing this water to interact with the atmosphere. This sets the stage for events with potentially altered sea-air CO_2 fluxes. Upwelling events off the east coast of Gotland in the Baltic Sea were analyzed to assess the impact of upwelling on the air-sea exchange of CO_2. For each event, the observed pCO_2 were found to be a function of sea-surface temperature (SST) in the upwelling area, which allowed satellite observations of SST to form a proxy for surface water pCO_2. A bulk formula was then used to estimate the air-sea CO_2 flux during the upwelling events. The results show that the CO_2 fluxes in the study area are highly influenced by the upwelling. A rough estimate indicates that it may also be of significant importance for the average annual CO_2 flux from the Baltic Sea. Including upwelling possibly decreases the Baltic Sea annual average uptake by up to 25%.

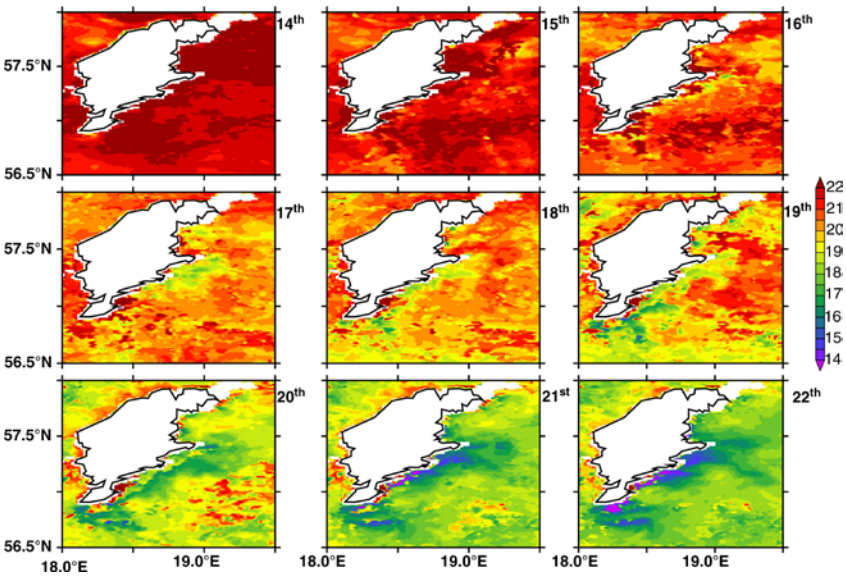


***Figure**: Daily averaged satellite images of sea-surface temperature (SST) (8C) around the island of Gotland in the Baltic Sea during 14-22 July 2005 (Period 1). The colours represent the SST value described by the colour bar (from Norman et al., 2013).*

Karl, M., Leck, C., Coz, E. and Heintzenberg, J. (2013) Marine nanogels as a source of atmospheric nanoparticles in the high Arctic, Geophys. Res. Lett., 40: 3738–3743, doi:10.1002/grl.50661.

Statistical analysis of the aerosol size distribution data recorded in the years 1991, 1996, 2001, and 2008 classified 75 nanoparticle events covering 17% of the observed time period as nanogel-type events, characterized by the spontaneous appearance of several distinct size bands below 200 nm diameter.

To explain the high Arctic nucleation events a novel route to atmospheric nano-particles that appears to be operative in the high Arctic is suggested. It involves the injection of marine granular nanogels into the air from evaporating fog and cloud droplets, and is supported by observations [*2*].

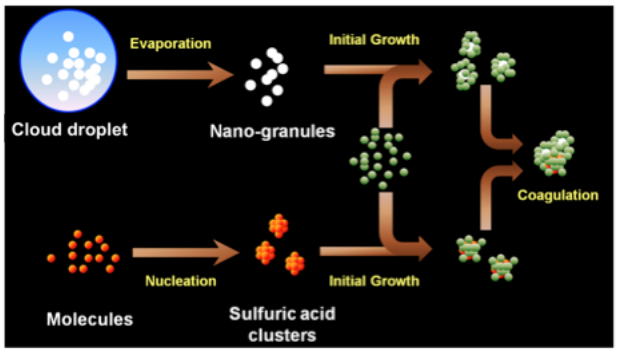


***Figure**: Schematic outline of the suggested route to new atmospheric nano-particles, involving sulfuric acid (orange), organic vapor (green), and marine nano-granules (white): 1) release of nano-granules from evaporating fog/cloud droplets, 2) nucleation of H_2SO_4 molecules to form stable clusters, 3) condensation of low-volatile vapors onto both nano-granules and H_2SO_4 clusters, 4) coagulation of nano-granules and H_2SO_4 clusters to form >3 nm diameter sized particles.*

2. International interactions and collaborations (including contributions to international assessments such as the IPCC, links with observation communities, links with policy makers or socio-economics circles, etc.)

* Baltic Earth (Earth System Science in the Baltic Sea region), ongoing development of the successor program of BALTEX (Baltic Sea Experiment). International scientific network focusing Earth System Science in the Baltic Sea region (http://www.baltex-research.eu/balticearth/).
* DAMOCLES: Several Annual Meetings ending with the "The Arctic Climate system; its present status, future evolution and potential impacts" symposium November 2009 in Brussels, Belgium, and the final DAMOCLES Science Symposium May 2010 in Tromsö, Norway.
* WCRP/WGNE & WWRP: Invited presentation at the Joint Workshop on Physics in Weather and Climate Models, at California Institute of Technology in March 2012 in Pasadena, California, USA.
* IASC: International Arctic Science Committee's Atmospheric Working Group Workshop on Arctic Observing September 2011, in Postdam, Germany.
* WCRP/GEWEX & WWRP: Invited lectures at both the European centre for Medium Range Weather Forecast (ECMWF) and GEWEX Atmospheric Boundary Layer Study (GABLS) Joint workshop on Stable Boundary Layers and Surface Interaction, November 2011, and in WWRP Polar Prediction Workshop in June 2013, both in Reading, UK.
* IASC: Several workshops and planning meetings for the MOSAiC multidisciplinary experiment involving an icebreaker borene icedrift at least one year across the Arctic.

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

SSEESS-SOLAS Workshop The Royal Swedish Academy of Sciences Stockholm, Sweden, November, 2013
Research expedition AWECS (ANT 29/6 and 7) to the Weddell Sea in Austral winter with R/V Polarstern

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

Book: Ocean-Atmosphere Interactions of Gases and Particles, **Eds Liss, Johnsson**

5. Top 10 publications in 2013 (Reports, <u>ACCEPTED</u> articles, models, datasets, products, website etc)

Claremar, B., Wällstedt, T., Rutgersson, A.,Omstedt, A. (2013) Deposition of acidifying and neutralising compounds over the Baltic Sea drainage basin between 1960 and 2006. Bor. Env. Res. 18 (6) , pp. 425-445

Granfors A., Karlsson A., Mattsson E. Smith W. and Abrahamsson K., Contribution of sea ice to the flux of volatile halogenated organic compounds to the atmosphere of the Southern Ocean. Geophysical Research Letters. VOL. 40, 1–6, doi:10.1002/grl.50777, 2013

*Gålfalk, M., D. Bastviken, S. Fredriksson and L. Arneborg (2013). "Determination of the piston velocity for water-air interfaces using flux chambers, acoustic Doppler velocimetry, and IR imaging of the water surface." <u>Journal of Geophysical Research: Biogeosciences</u> **118**(2): 770-782.*

Hassellöv, I.-M., D. R. Turner, A. Lauer, and J. J. Corbett (2013), Shipping contributes to ocean acidification, Geophys. Res. Lett., 40, 2731-2736. doi:10.1002/grl.50521.

Högström, U., Rutgersson, A., Sahlée, E., Smedman, A., Hristov, T. S. , Drennan, W. M., and Kahma, K. K. (2013) Air-sea interaction features in the Baltic Sea and at a Pacific trade-wind site-an inter-comparison study. Bound. Layer Met., 147:139–163, DOI 10.1007/s10546-012-9776-8

Kapsch M-L, Graversen R G, and Tjernström M, 2013, Springtime atmospheric transport controls Arctic summer sea ice. Nature Climate Change, DOI: 10.1038/NCLIMATE1884

Karl, M, Leck, C, Coz, E and Heintzenberg, J, 2013, Marine nanogels as a source of atmospheric nanoparticles in the high Arctic, Geophysical Research. Letters, 40, 3738–3743, doi:10.1002/grl.50661.

*Karlsson, A., Theorin, M., Abrahamsson, K. Distribution, transport and production of volatile halocarbons ($CHBr_3$, CH_2Br_2, $CHBr_2Cl$ and CH_2ClI) in the upper waters of the ice covered high Arctic Ocean. Global Biogeochemical Cycles 27 **4** (2013) 1246-1261. DOI: 10.1002.2012.GB004519*

*Kupiszewski P, **Leck C**, Tjernström M, Sjogren S, Sedlar J, Graus M, Müller M, Brooks B, Swietlicki E, Norris S, and Hansel A, 2013, Vertical profiling of aerosol particles and tracer gases over the central Arctic Ocean during summer, Atmospheric Chemistry and Physics Discussions, 13, 10395-10461, DOI 10.5194/acpd-13-10395-2013.*

Leck, C., Gao, Q., Mashayekhy Rad, F., and Nilsson, U.: Size resolved airborne particulate

polysaccharides in summer high Arctic, Atmospheric Chemistry and Physics, 13, 12573–12588, 2013 www.atmos-chem-phys.net/13/12573/2013/doi:10.5194/acp-13-12573-2013.

Mattsson E., Karlsson A. and Abrahamsson K.Southern Ocean – a sink for Bromoform. Geophysical Research Letters. VOL. 40, 1–6, doi:10.1002/grl.50783, 2013

Meskhidze, N., Petters, M.D., Tsigaridis, K., Bates, T., O'Dowd, C., Reid, J., Lewis, E.R., Gantt, B. Anguelova, M.D., Bhave, P.V., Bird, J., Callaghan, A.H., Ceburnis, D., Chang, R., Clarke, A., de Leeuw, G., Deane, G., DeMott, P.J., Elliot, S., Facchini, M.C., Fairall, C.W., Hawkins, L. Hu, Y.X., Hudson, J.G., Johnson, M.S., Kaku, K.C., Keene, W.C., Kieber, D.J., Long, M.S., ***Mårtensson, E.M.****, Modini, R.L., Osburn, C.L., Prather, K.A.,Pszenny, A., Rinaldi, M., Russell, L.M., Salter, M., Sayer, A.M., Smirnov, A., Suda, S.R., Toth, T.D., Worsnop, D.R., Wozniak, A., Zorn, S.R., 2013, Production mechanisms, number concentration, size distribution, chemical composition, and optical properties of sea spray aerosols., ATMOSPHERIC SCIENCE LETTERS, 14, Issue: 4, 207-213, DOI: 10.1002/asl2.441.*

Norman, M., Raj Parampil, S., Rutgersson, A., Sahlee, E.. Influence of coastal upwelling on the air-sea gas exchange of CO_2 in a Baltic Sea Basin. ***Tellus B****, 2013. Available at: <http://www.tellusb.net/index.php/tellusb/article/view/21831>*

*Norman, M., Rutgersson A. and Sahlee, E. Impact of improved air–sea gas transfer velocity on fluxes and water chemistry in a Baltic Sea model, J. Mar. Syst. (2013), 11:****175-188,*** *http://dx.doi.org/10.1016/j.jmarsys.2012.10.013*

Omstedt, A., Edman, M., Claremar, B., Frodin, P., Gustafsson, E., Humborg, C., Mörth, M., Rutgersson, A., Schurgers, G., Smith, B., Wällstedt, T., and Yurova, A.(2013). Future changes of the Baltic Sea acid-base (pH) and oxygen balances. Tellus B 2012, 64, 19586, http://dx.doi.org/10.3402/tellusb.v64i0.19586.

Shupe M D, Persson P O G , Brooks I M, Tjernström M, Sedlar J, Mauritsen T, Sjogren S, Leck C, 2013, Cloud and boundary layer interactions over the Arctic sea ice in late summer, Atmospheric Chemistry and Physics, 13, 9379-9399, doi:10.5194/acp-13-9379-2013

Struthers, H., Ekman, A. M. L., Glantz, P., Iversen, T., Kirkevag, A., Seland, O., ***Mårtensson, E. M.,*** *Noone, K., Nilsson, E. D., Climate-induced changes in sea salt aerosol number emissions: 1870 to 2100, 2013, J. Geophys. Res., 670-682, DOI: 10.1002/jgrd.50129*

Tjernström M & 42 coauthors, 2013, The Arctic Summer Cloud-Ocean Study (ASCOS): overview and experimental design, Atmospheric Chemistry and Physics Discussions, 13, 13541-13652, DOI 10.5194/acpd-13-13541-2013

Zábori, J., Krejci, R., Ström, J., Vaattovaara, P., Ekman, A. M. L., Salter, M. E., ***Mårtensson, E. M.,*** *Nilsson, E. D., Comparison between summertime and wintertime Arctic Ocean primary marine aerosol properties . 2012, Atmos. Chem. Phys., 13, Pages: 4783-4799 DOI: 10.5194/acp-13-4783-2013.*

Zhang, Q., R. A. Handler and S. T. Fredriksson (2013). "Direct numerical simulation of turbulent free convection in the presence of a surfactant." International Journal of Heat and Mass Transfer ***61****: 82-93.*

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

Further development of the fields station Östergarnsholm.

The Arctic Clouds in Summer Experiment (ACSE) is part of the SWERUS-C_3 expedition that will deploy three months on the icebreaker Oden in the East Siberian Sea in July – October of 2014. During the expedition we will focus on surface/boundary-layer/cloud interactions during late spring-to-summer and summer-to-autumn conditions in sea ice, the marginal ice zone and in open ocean.

A multi-month Arctic field experiment deployed on the Swedish icebreaker *Oden* planned for the summer of 2017 or 2018 with an integrated study, from ocean mixed layer through the ice and the troposphere. To study this necessitates a strong interdisciplinary approach including the biogeochemical sources that were thought to lead to aerosol formation, possible growth processes and characterization of the aerosol that actually influences the properties of clouds. To allow for this approach the program comprises four subprograms: marine ecology, gas/aerosol chemistry/aerosol physics, meteorology, and oceanography.

<u>Commercial shipping as a source of acidification in the Baltic Sea</u>

David Turner et al.

Sulphur and nitrogen oxides (SOX and NOX) from ship exhausts are a potentially significant contributor to Ocean Acidification in heavily trafficked areas. The maximum sulphur content of marine fuel oil in Emission Control Areas (including the Baltic Sea) will be reduced from 1% to 0.1% in 2015. Two possibilities are available for commercial shipping: to use expensive low-sulphur fuel, or to use seawater scrubbing systems to absorb acidic gases from the engine exhaust. This second option generates large volumes of seawater at pH 3, which acidify the water if not neutralised before release. In either case, the consequences of the release for marine organisms are unknown. This project will examine the consequences for the Baltic Sea of SOX and NOX emissions from shipping. A range of scenarios will be developed by combining current projections from IPCC and EMEP, downscaled to the Baltic, with different options for the use of low-sulphur fuel, or high-sulphur fuel with scrubbing. In addition, the biological consequences of releasing scrubber output will be assessed on natural pelagic communities in different target areas. The scenarios will be developed in dialogue with a reference group representing the shipping industry and government authorities. A monitoring programme for shipping-derived acidification in the Baltic will be designed. The results of this research will support future policy development for regulation and monitoring of SOX and NOX emissions from shipping.

7. Other comments

Annual Report for the year 2011:

SOLAS Turkey

compiled by Mustafa Kocak

Notes:
Reporting Period is January 2013 – December 2013
Information will be used for: reporting, fundraising, networking, strategic development & outreach

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

Toward self-describing and workflow integrated Earth system models: A coupled atmosphere-ocean modeling system application

Ufuk Utku Turuncoglu [a*], Nuzhet Dalfes [c], Sylvia Murphy [b], Cecelia DeLuca [b]

[a] Istanbul Technical University, Informatics Institute, Istanbul 34469, Turkey
[b] National Oceanic and Atmospheric Administration, CIRES, Boulder, CO, USA
[c] Istanbul Technical University, Eurasia Institute of Earth Sciences, 34469 Maslak, Istanbul, Turkey

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The complexity of Earth system models and their applications is increasing as a consequence of scientific advances, user demand, and the ongoing development of computing platforms, storage systems and distributed high-resolution observation networks. The common component interfaces of Earth system models can be redesigned to increase interoperability between models and other applications such as various web services, data portals and science gateways. The models can be made self-describing so that the many configuration, build options and inputs of a simulation can be recorded. In this paper, a coupled modeling system is presented that includes the proposed methodology to create self-describing models with common model component interfaces. The designed coupled atmosphere-ocean modeling system is also integrated into a scientific workflow system to simplify routine modeling tasks and relationships between these tasks and to demonstrate the enhanced interoperability between different technologies and components. Later on, the work environment is tested using a realistic Earth system modeling application (Fig.1).
This study demonstrates the viability of using framework and workflow approaches together to create a self-describing modeling system with common component interfaces and execution environment that is specialized for Earth system related applications. The results show that the developed workflow environment facilitates integration of different components of the modeling system and also enables an easy to use and efficient work environment. The complexities of the overall coupled modeling system are reduced particularly for the average user, which enables the user to focus on the science of the experiment. The study addressed the difficulty of coupling Earth system models that have non-standard coupling and configuration interfaces with a scientific workflow. Solutions were created for the prototype that generalized these interfaces for the models used. The results and tools produced by the study are likely to be applicable to models other than WRF and ROMS that used in this paper.

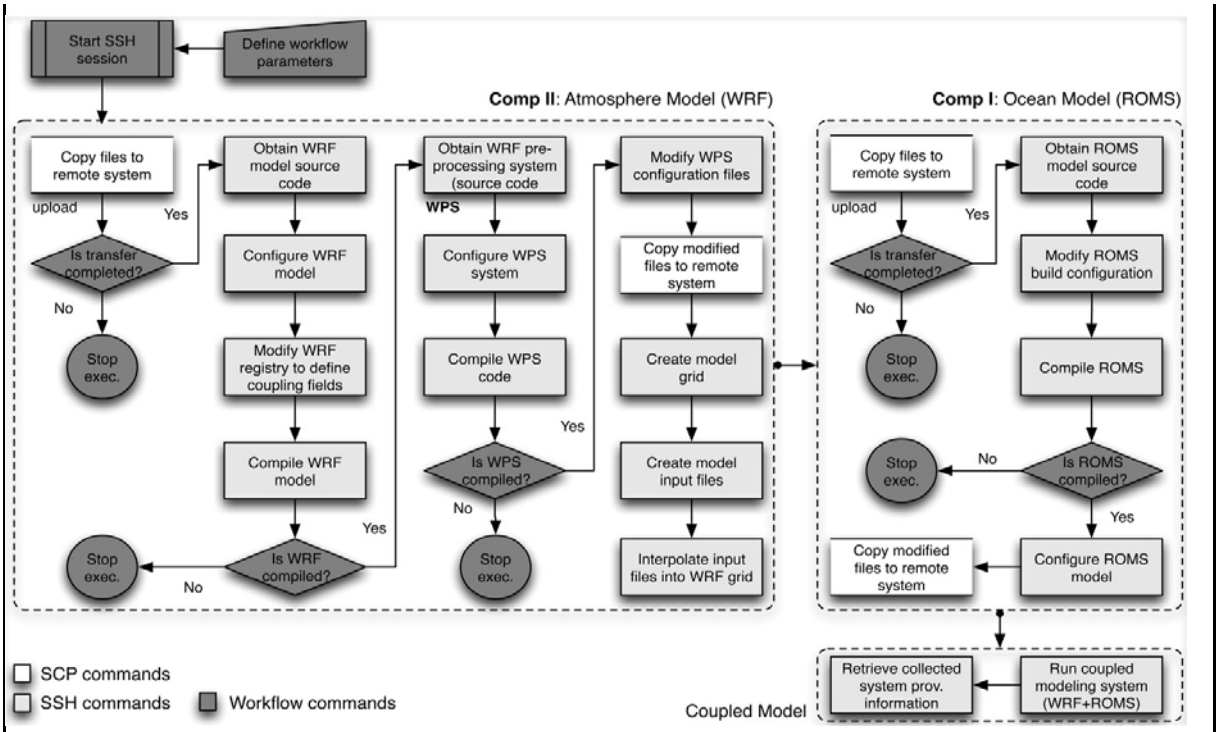


Fig. 1. Conceptual coupled modeling system workflow

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

Two projects were funded (national-TUBITAK, French project MerMex).

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

4. Top 10 publications in 2012 (Reports, articles, models, datasets, products, website etc)

Bozkurt, D., Sen, L.O., 2013. Climate change impacts in the Euphrates–Tigris Basin based on different model and scenario simulations. Journal of Hydrology, 480, 149-161. DOI:10.1016/j. jhydrol.2012.12.021

Ozdemir, H., Pozzoli, L., Kindap, T., Demir, G., Mertoglu, B., Mihalopoulos, N., Theodosi, C., Kanakidou, M., Im, U., Unal, A., 2014. Spatial and temporal analysis of black carbon aerosols in Istanbul megacity. Science of The Total Environment, Volumes 473–474, Pages 451-458 DOI: 10.1016/j.scitotenv.2013.11.102

Im, U., Christodoulaki, S., Violaki, K., Zarmpas, P., Kocak, M., Daskalakis,N., Mihalopoulos, N., Kanakidou, M., 2013. Atmospheric deposition of nitrogen and sulfur over southern Europe with focus on the Mediterranean and the Black Sea. Atmospheric Environment, 81, 660-670. DOI: 10.1016/j.atmosenv.2013.09.048

Theodosi, C., Stavrakakis S., Koulaki, F., Stavrakaki, I., Moncheva, S., Papathanasiou, E., Sanchez-Vidal, A., Koçak, M., Mihalopoulos, N., 2013. The significance of atmospheric inputs of major and trace metals to the Black Sea. Journal of Marine Systems, Volumes 109–110, Pages

94-102. DOI: 10.1016/j.jmarsys.2012.02.016

Lagaria, A., Psarra, S., Gogou, A., Tugrul, S., Christaki, U., 2013. Particulate and dissolved primary production along a pronounced hydrographic and trophic gradient (Turkish Straits System–NE Aegean Sea). Journal of Marine Systems, Volumes 119–120, June 2013, Pages 1-10. DOI: 10.1016/j.jmarsys.2013.02.009

Turuncoglu, U.U., Dalfes, N., Murphy, S., DeLuca, C, 2013. Toward self-describing and workflow integrated Earth system models: A coupled atmosphere-ocean modeling system application Environmental Modelling & Software, Volume 39, Pages 247-262 DOI:10.1016/j.envsoft.2012.02.013

Santinelli, C., Ibello, V., Lavezza, R., Civitarese, G., Seritti, A., 2013. New insights into C, N and P stoichiometry in the Mediterranean Sea: The Adriatic Sea case . Continental Shelf Research 44 83–93. DOI:10.1016/j.csr.2012.02.015

Turuncoglu, U.U., Giuliani, G., Elguindi, N., Giorgi, F., 2013. Modelling the Caspian Sea and its catchment area using a coupled regional atmosphere-ocean model (RegCM4-ROMS): model design Ocean Science and preliminary results . Geosci. Model Dev., 6, 283–299. DOI:10.5194/gmd-6-283-2013

Onol, B., Bozkurt, D.,Turuncoglu, U.U., Sen, L.O., Dalfes, H.N., 2013. Evaluation of the twenty-first century RCM simulations driven by multiple GCMs over the Eastern Mediterranean–Black Sea region. Climate Dynamics Print ISSN: 0930-7575, Online ISSN: 1432-0894. DOI:10.1007/s00382-013-1966-7

Elguindi, N., Giorgi, F., Turuncoglu, U., 2013. Assessment of CMIP5 global model simulations over the subset of CORDEX domains used in the Phase I CREMA . Climatic Change Print ISSN: 0165-0009, Online ISSN: 1573-1480. DOI: 10.1007/s10584-013-0935-9.

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

ENVIMED MerMex TRACOMED (TRansfer of Atmospheric COntaminants to the MEDiterranean Sea, coordinator: Dominique Aubert, France-Greece-Israel-Turkey) has been qualified.

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

New instruments will be obtained in order to explore concentrations and variability of ozone, NOx, SO2, PM10 and BC in the Eastern Mediterranean.

7. Other comments

Annual Report for the year 2013

SOLAS-UK

compiled by Phil Williamson p.williamson@uea.ac.uk

Notes:

- *Reporting Period is January 2013 – December 2013*
- *Information will be used for: reporting, fundraising, networking, strategic development & outreach*
- *Following completion of the UK SOLAS Research Programme (2004-2010), this report covers other SOLAS-relevant national programmes and projects*

1. Scientific highlights

Relating sea spray flux to wave state

Sea spray aerosol has an important role in cloud formation and climate processes, particularly in the Southern Hemisphere. To date, wind speed has been used to indirectly estimate sea spray fluxes at the regional and global scale; however, wave conditions are the more direct drivers, via bubble bursting and other aerosol formation processes. Work funded at the University of Leeds under the UK SOLAS programme has shown the importance of separating wind and wave effects. Using direct eddy covariance measurements of sea spray flux in the North Atlantic on RRS *Discovery*, along with *in situ* wave state data from a ship borne wave recorder, sea spray aerosol production was determined as a function of a wave-breaking Reynolds number (Norris *et al*. 2013). The Reynolds number explained up to twice the variance in the flux estimates than did wind speed alone (Fig. 1). Global wind and wave fields from ECMWF were used to drive both the new parameterization and a simple wind-speed parameterization from the same measurements (Norris *et al*. 2012) – significant differences were found in regions where the surface wave field is far from equilibrium with the local wind field (Fig. 2).

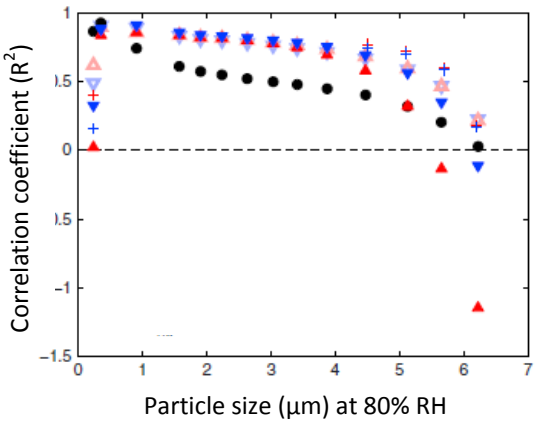
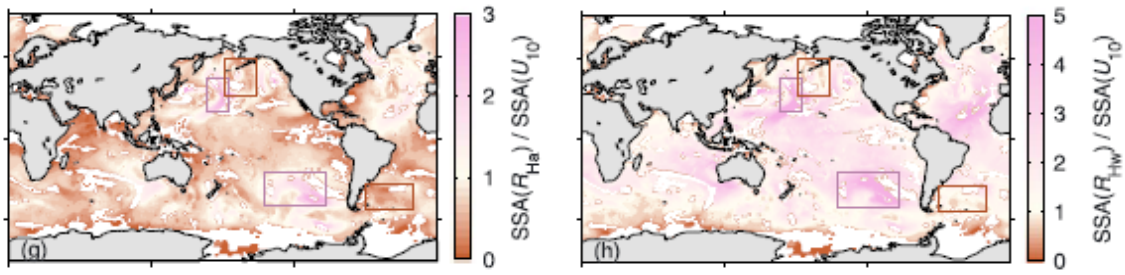


Figure 1 (left). R^2 values for the fits of observed sea spray source flux to wind at 10m (•) and to wave state as described by Reynolds numbers based on viscosity of air (red symbols) and water (blue symbols).

Figure 2 (below). Ratio of sea spray source flux estimated from wave state to the flux estimated from wind speed. Left map, air-based estimate of Reynolds number; right map, wind-based estimate of Reynolds number.

For more detailed figure legends, see Norris *et al* 2013.



Norris S J, Brooks IM & Salisbury DJ (2013) A Reynolds number parameterization of the sea-spray aerosol source flux, *Geophys. Res. Letts.* 40, 1-5, doi:10.1002/grl.50795

Norris S J, Brooks IM, Hill MK, Brooks BJ, Smith MH & Sproson DAJ (2012) Eddy covariance measurements of the sea spray aerosol flux over the open ocean. *J. Geophys. Res.* 117, D07210, 15pp, doi: 10.1029/2011JD016549

Marine production underestimated by standard methods, due to photochemical processes

The most widely used methods for measuring net community production (NCP) in marine planktonic communities are oxygen-based, using 24 hr *in vitro* incubations to determine the balance of oxygen production through photosynthesis and its removal by respiration. However, oxygen can also be removed photochemically, by its light-driven change to reactive oxygen species (OH, $^1O_2$, O_2^- and H_2O_2), that are mostly very short-lived. Such species react with dissolved organic matter (DOM), resulting in significant oxygen consumption when both DOM and light levels are high. These oxygen photolysis effects were quantified by UK SOLAS studies in the Mauritanian upwelling off NW Africa (Fig. 4). Results from this work, led by Plymouth Marine Laboratory, showed oxygen photolysis may exceed community respiration in near-surface waters, playing a substantial role in upper-ocean oxygen dynamics (Kitidis *et al,* 2014). Thus oxygen-based methods of determining NCP will underestimate marine production, by not accounting for this sink. Screening for UV radiation does not remove this effect, since visible light is primarily involved. The observed underestimation of NCP, using *in vitro* methods, was 2-22 % (Fig. 5), with the highest values in low productivity waters. *In situ* geochemical methods (using oxygen-argon ratios, or oxygen isotopes) may be affected further.

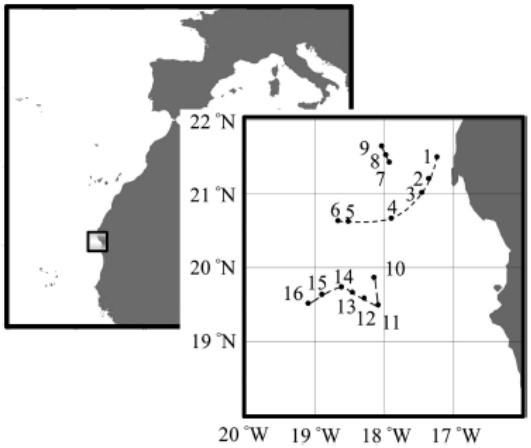


Figure 4. Study area and station locations. ^3He and SF_6 were used to label three upwelled water bodies, and follow their biogeochemical evolution.

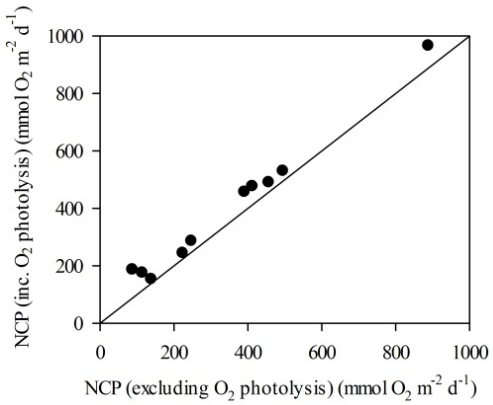


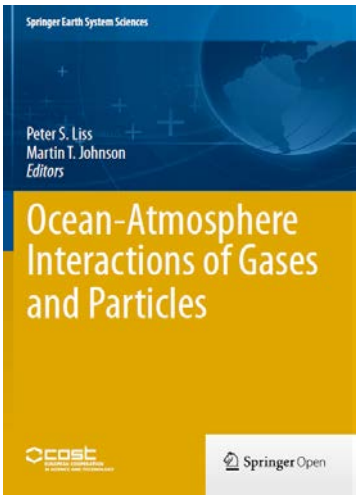
Figure 5. Comparison of net community production estimates including and excluding photochemical oxygen demand.

Kitidis V, Tilstone G, Serret P, Smyth T, Torres R & Robinson C (2014) Oxygen photolysis in the Mauritanian upwelling: implications for net community production. *Limnol. Oceanogr*. 59, 299-310; doi: 10.4319/lo.2014.59.2.0299

Open access publication of state-of-the art SOLAS synthesis

COST[1]Action 735 was a 5 year project to facilitate the integration and synthesis of SOLAS science, through working group meetings and short-term scientific missions. The study, led by the University of East Anglia, involved more than 300 scientists from 30 countries. Whilst many topic-specific outcomes have already been published, including the IRONMAP, HalOcAt, MEMENTO and SOCAT databases, the

main COST Action product has been a 315 page, peer-reviewed book, now published under open-access arrangements (Liss & Johnson, 2014). Although comprising only five chapters –on short-lived trace gases; transfer across the air-sea-interface; air-sea interactions of long-lived greenhouse gases; ocean-atmosphere interactions of particles; and perspectives and integration in SOLAS science – the volume has 90 authors, including both senior and early-career SOLAS researchers, and topics are covered in considerable detail. The open-access publication arrangements[2]) are expected to achieve very wide international dissemination and impact, making a major 'legacy' contribution to SOLAS capacity-building and training.



[1] COST (European Cooperation in Science and Technology) is an intergovernmental framework to assist scientific collaboration and networking, primarily within Europe. It is co-supported by the European Science Foundation and the European Union RTD Framework programme.

[2] http://link.springer.com/book/10.1007%2F978-3-642-25643-1

Liss PS & Johnson MT (Eds) (2014) *Ocean-Atmosphere Interactions of Gases and Particles.* Springer, Heidelberg. 315 pp. doi: 19.1007/978-3-642-25643-1

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

UK researchers contributed to SOLAS science goals in many ways in 2013. The main relevant activities are identified below, covering 10 national programmes and major initiatives. Summary information on 16 other ongoing projects is also given.

- The ***UK Ocean Acidification research programme*** (UKOA), co-funded by NERC, Defra and DECC (£12m; 2010-2015) involves >25 research groups and includes the following SOLAS-relevant components, funded through six consortium awards and an analytical facility:
  - Observations and synthesis to establish variability and trends of oceanic pH
  - Ocean acidification impacts on sea surface biogeochemistry and climate
  - Regional ecosystem and biogeochemical impacts of ocean acidification
  - Abrupt ocean acidification events (focus on Paleocene-Eocene Thermal Maximum)
  - Interactions between CO_2, the carbon cycle and climate.

  Information on UKOA international links and science-to-policy engagement is given in Section 5. The 4th and final UKOA research cruise was completed in the Southern Ocean in January-February 2013, and most component research grants and studentships also ended in 2013. Cruise blog at http://www.antarcticoacruise.org.uk; programme website: www.oceanacidification.org.uk; contact p.williamson@uea.ac.uk (UKOA Science Coordinator).

- The ***Ocean Surface Mixing, Ocean Sub-mesoscale Interaction Study (OSMOSIS)*** is a NERC-funded programme (£3.8m; 2011-2015) that addresses the physical processes affecting exchanges across the ocean boundary layer, with participants at Reading, Bangor, NOC, Oxford, Scottish Marine Institute, Southampton and UEA, in partnership with the UK Met Office and the European Centre for Medium Range Weather Forecasting. The main OSMOSIS fieldwork was in 2012. Website: http://www.osmosis.ac.uk; contact: Stephen Belcher s.e.belcher@reading.ac.uk (lead PI).

- ***Waves, Aerosol & Gas Exchange Study (WAGES)*** is a NERC-funded project (£0.9m, 2010-2014) at Leeds and NOC. The 6th and final WAGES cruise took place on RRS *James Clark Ross* in May-June 2013 in the South Atlantic, between the Falkland Islands and Ascension Island. The NOC spar buoy was used to measure wave breaking and whitecaps in a wide range of conditions (sea temperatures between 2 - 28°C; wind speeds between 4 - 20 m s^{-1}). Surfactant patches were created using oleyl alcohol, to quantify their effects on wave breaking and whitecap persistence. Although the 3 year continuous flux measurements on *James Clark Ross* ended after that cruise, the WAVEX wave radar will continue operating as part of the ship's standard underway measurement capability. Website: http://noc.ac.uk/project/wages; Contact: Margaret Yelland; m.yelland@noc.ac.uk.

- Involvement in ***US-UK High Wind Gas Exchange Study (HiWinGS)***, through NERC support (£1.2m, 2012-16 "Turbulent exchange: aerosols, bubbles and gases") to Leeds, NOC and Southampton, and participation in US-led RV *Knorr* cruise in North Atlantic, October-November 2013. Sampling included storm conditions with peak wind (30 min average U_{10}) >27 m s^{-1}, significant wave heights >9 m, and peak waves >15 m. UK gear deployments included the 11m NOC spar buoy (constructed for UK SOLAS cruises in 2006/7), and the 4m spar (constructed for the WAGES project) providing detailed information on wave state, wave breaking, turbulence intensity, bubble populations and plume extent. Complementary data collected on surface whitecap fraction, also direct eddy covariance estimates of gas and sea-spray aerosol fluxes. Contact: Ian Brooks i.brooks@see.leeds.ac.uk (lead UK PI)

- ***UK GEOTRACES*** is the NERC-funded UK contribution (£3.9m, 2010-2014) to the international GEOTRACES project, with focus on micronutrient cycles and ocean palaeo-proxies in the South Atlantic (research cruise, December 2011-January 2012), and influence of metal input on biological processes in the tropical Atlantic (February-March 2011). Also participation in Polish-led studies in the Baltic Sea (November 2011), and planning of research project in the Greenland Sea. Participants at Oxford, Bristol, Cambridge, Edinburgh, Imperial College. Manchester, NOC, PML, Plymouth, Southampton and UEA. Website: www.ukgeotraces.com; contact: Gideon Henderson, gideon.henderson@earth.ox.ac.uk (lead PI).

- ***Aerosol-Cloud Coupling and Climate Interactions in the Arctic (ACCACIA***) is a NERC funded project (£3m, 2012-15) involving groups at Manchester, Leeds, York, UEA, BAS and the Met Office, with international partners. Field campaigns in July 2013 involved ship-based measurements of surface aerosol sources and aircraft measurements of a suite of atmospheric properties. Website: http://arcticaccacia.wordpress.com; contact: Ian Brooks i.brooks@see.leeds.ac.uk (lead PI)

- The ***UK Shelf Sea Biogeochemistry*** research programme (SSB) is co-funded by NERC and Defra (£9.5m, 2013-2017) and addresses carbon cycling, nutrient dynamics and iron fluxes in North West European shelf seas. An assessment of carbon sequestration in UK waters and its potential management ('Blue Carbon') was added to the programme in 2013. A six-cruise, multi-institution field campaign is scheduled for 2014, with focus on the Celtic Sea; also shelf-wide measurements of carbonate system parameters, as a component of the pelagic SSB Work Package. Website: www.uk-ssb.org; contact: Phil Williamson p.williamson@uea.ac.uk (SSB Science Coordinator)

- ***Radiatively Active Gases from the North Atlantic Region and Climate Change (RAGNARoCC)*** is the marine component (£2.5m, 2013-17) of the NERC-funded Greenhouse Gases UK research programme. RAGNARoCC aims to quantify the size and variability of sources and sinks of greenhouse gases (primarily CO_2) in the North Atlantic using voluntary observing ships and other

data sources. Partners include Exeter, NOC, Southampton and PML. Website: www.greenhouse-gases.org.uk/ragnarocc; contact: Andrew Watson andrew.watson@exeter.ac.uk (lead PI)

- The UK-France ***Oceanflux Greenhouse Gases*** project (2011-2013; ESA funded) involves partners at University of the Highlands & Islands, PML, NOC and IFREMER. Website: http://www.oceanflux-ghg.org; contact: David Woolf, d.k.woolf@hw.ac.uk.
- The NERC ***National Centre for Atmospheric Science, NCAS*** www.ncas.ac.uk, continues to support a wide range of SOLAS-relevant research and sustained observations, the latter including the ***Weybourne Atmospheric Observatory*** http://weybourne.uea.ac.uk and UK involvement in the Observatório Atmosferico de Cabo Verde: Humberto Duarte Fonseca (Cape Verde Atmospheric Observatory).

Other SOLAS-relevant projects active in 2013 include the following NERC research grants and training awards (alphabetical by lead PI). Note that: i) research limited to atmospheric-only or marine-only topics is excluded, unless there are linking elements; and ii) this list does not claim to be comprehensive. For abstracts and additional details, see http://gotw.nerc.ac.uk/goti.asp?c=1.

Project title	**Award, dates**	**Lead PI; university or research centre**
Iron biogeochemistry in high latitude North Atlantic	£528k, 2007-13	Eric Achterberg, Southampton (also awards at Portsmouth, Essex, NOC, UEA & Liverpool)
Physical and chemical forcing of diazotrophy in the (sub) tropical Atlantic Ocean	£833k, 2010-14	Eric Achterberg, Southampton (also awards at NOC, UEA, Liverpool & Plymouth)
Development of an oceanic *in situ* carbon dioxide sensor for high spatial and temporal resolution measurements (training award)	£71k, 2011-15	Eric Achterberg, Southampton
Development of an oceanic *in situ* lab-on-a-chip alkalinity sensor for high spatial and temporal resolution measurements (training award)	£74k, 2013-17	Eric Achterberg, Southampton
Oceanic reactive carbon: chemistry-climate impacts	£530k, 2013-16	Steve Arnold, Leeds (also award at York)
Air-Sea Interactions and Sea Spray in Typhoons (ASIST)	£372k, 2010-14	Ian Brooks, Leeds
Coordinated Airborne Studies in the Tropics (CAST)	£431k, 2012-16	Lucy Carpenter, York
Tropospheric halogen chemistry: reaction mechanisms, processes and global impacts	£399k, 2012-15	Martyn Chipperfield, Leeds (also UEA award)
Addressing the ocean methane paradox: the role of microenvironments in oceanic methane production	£617k, 2010-14	Angela Hatton, SAMS (also award at Warwick)
The physiological and ecological functions of volatile halogen production by marine diatoms	£78k, 2013-15	Claire Hughes, York
Blowing snow and sea-ice surfaces as a source of polar sea salt aerosol	£522k, 2012-15	Anna Jones, British Antarctic Survey (also awards at Cambridge and Leeds)

Determination of the CO_2 system at sub-zero temperatures in seawater and seawater-derived brines	£854k, 2012-15	Hilary Kennedy, Bangor (also awards at NOC & Southampton)
Ocean circulation, nutrient cycling and atmospheric carbon dioxide	£188k, 2011-14	Tim Lenton, Exeter
Synthesis and integration of global air-sea gas and particle fluxes to improve models and assessments of future climate and pollution	£192k, 2010-13	Peter Liss, UEA
Making and breaking DMS by saltmarsh microbes – populations and pathways, revealed by stable isotope probing and molecular techniques	£519k, 2010-14	Henrik Schaefer , Warwick (also award at UEA)
Role of dimethyl sulphide (DMS) in pelagic tritrophic interactions	£144k, 2010-14	Michael Steinke, Essex

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

Many of the programmes and projects identified above included work on knowledge exchange, stakeholder dialogue and public engagement – meeting the requirement of UK Research Councils that 'pathways to impact' activities are included within research proposals and project implementation.

For the UK Ocean Acidification (UKOA) research programme, co-funding by the Department for Environment, Food and Rural Affairs (Defra) and the Department of Energy and Climate Change (DECC) provides in-built policy linkages, in addition to opportunities for wider engagement. Such co-funding enables direct communication with governmental stakeholders (e.g. at the UKOA Annual Science Meeting; St Andrews, 22-24 July 2013), and has supported additional 'added value activities' for dissemination and policy-related knowledge exchange activities; for example, a supplementary award to Cardiff University in 2013-14 for a survey of public perceptions of ocean acidification. Information on UKOA international outreach and science-to-policy engagement is given in Section 5.

The Shelf Sea Biogeochemistry (SSB) research programme also benefits from governmental co-funding by the Department for Environment, Food and Rural Affairs (Defra), with associated science-policy linkages. SSB outreach is further facilitated by:

- Involvement in the EU-funded Celtic Seas Partnership (a stakeholder engagement network, with focus on achieving good environmental status under the Marine Strategy Framework Directive)
- Scientific partnerships with researchers in Ireland, France, Spain, Germany, Denmark and Norway, with regard to shelf-wide data collection on CO_2/carbonate system parameters
- Working links with the Carbon Trust, IUCN and other bodies with regard to the Blue Carbon SSB component, to quantify carbon fluxes and sequestration in UK and European shelf seas.

A 'watching brief' has been kept on ocean fertilization as a potential climate geoengineering technique, with involvement of SOLAS-UK researchers in:

- Authorship of a forward-look report on research relating to climate impacts of geoengineering, published by the Living with Environmental Change (LWEC) programme [Jones *et al*, 2013; full citation in Section 4 below].
- Provision of advice to UK government (Defra) on scientific issues relating to the regulation of ocean fertilization and other potential ocean-based geoengineering techniques by the London Convention/London Protocol
- Engagement in an expert consultation led by University of Cambridge (funded by IASS, Germany) on the potential impacts of a range of geoengineering techniques and related research needs.

NERC provided support for 5 UK students to participate in the 6th SOLAS Summer School (Xiamen, 23 August – 2 September 2013) and there were 6 UK lecturers and demonstrators at the School.

4. Top 10 publications in 2013 (Reports, accepted articles, models, datasets, products, website etc)

The following list of SOLAS-relevant, peer-reviewed 2013 publications (n = 66) with UK authors/co-authors is based on researchers' input and Web of Science searches. The 10 papers in bold with UK-based lead authors indicate the range of achievements, without any formal designation that these are the "top 10" in terms of scientific quality or importance. [*Publication directly or indirectly arising from UK SOLAS research programme and associated funding; **publication mentioned in Section 1 above].

Achterberg EP, Moore CM, Henson SA, Steigenberger S, Stohl A, Eckhardt S, Avendano LC, Cassidy M, Hembury D, Klar JK, Lucas MI, Macey AI, Marsay CM & Ryan-Keogh TJ (2013). Natural iron fertilization by the Eyjafjallajokull volcanic eruption. *Geophys. Res. Lett*., 40, 921-6; doi: 10.1002/grl.50221

Alvain S, Le Quéré C, Bopp L, Racault MF, Beaugrand G, Dessailly D & Buitenhuis ET (2013) Rapid climatic driven shifts of diatoms at high latitudes. *Remote Sensing Environ.,* 132, 195-201; doi: 10.1016/j.rse.2013.01.014

Andrews OD, Bindoff NL, Halloran PR, Ilyina T & Le Quéré C (2013) Detecting an external influence on recent changes in oceanic oxygen using an optimal fingerprinting method. *Biogeosciences,* 10, 1799-813; doi: 10.5194/bg-10-1799-2013

Andrews SJ, Jones CE & Carpenter LJ (2013) Aircraft measurements of very short-lived halocarbons over the tropical Atlantic Ocean. *Geophys. Res. Lett*., 40, 1005-10; doi: 10.1002/grl.50141

Archer SD, Kimmance SA, Stephens JA, Hopkins FE, Bellerby RGJ, Schulz KG, Piontek J & Engel A (2013) contrasting responses of DMS and DMSP to ocean acidification in Arctic waters. *Biogeosciences,* 10, 1983-1908

Arnold HE, Kerrison P & Steinke M (2013) Interacting effects of ocean acidification and warming on growth and DMS-production in the haptophyte coccolithophore *Emiliania huxleyi. Glob. Change Biol*., 19, 1007-16; doi: 10.1111/gcb.12105

Artioli Y, Blackford JC, Nondal G, Bellerby RGJ, Wakelin SL, Holt JT, Butenschön M & Allen JI (2013) Heterogeneity of impacts of high CO_2 on the North Western European Shelf. *Biogeosciences Discuss*., 10, 9389-9413; doi: 10.5194/bgd-10-9389-2013

*Baker AR, Adams C, Bell TG, Jickells TD & Ganzeveld L (2013) Estimation of atmospheric nutrient inputs to the Atlantic Ocean from 50 degrees N to 50 degrees S based on large-scale field sampling: Iron and other dust-associated elements. *Global Biogeochem. Cycles*, 27, 755-67; doi: 10.1002/ gbc.20062

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

The UK hosted a "Future SOLAS early career scientist workshop" (Plymouth Marine Laboratory, 3-5 December) when young researchers from eight countries discussed research priorities for the next phase of SOLAS. Report at http://www.solas-int.org/files/solas-int/content/downloads/pdf/events/SOLAS%20workshop%20summary_Lawson%20final.pdf.

A comprehensive account of other international activities by SOLAS-UK researchers is not possible here. However, examples of scientific collaborations are given in Sections 2 and 3 above (e.g. UK involvement in HiWings, GEOTRACES and Oceanflux Greenhouse Gases projects, also SSB's European partnerships) and strong UK involvement in multinational publications is evident in Section 4.

International partnerships and science-to-policy engagement by the UK Ocean Acidification programme included the following activities in 2013:

- Participation in UNCLOS Informal Consultation Process meeting on Ocean Acidification, including presentations, Panel membership and a side event (New York, 17-21 June)
- Hosting and co-organising 2nd international workshop to develop Global Ocean Acidification Observing Network (GOA-ON; St Andrews, 24-26 July); subsequent co-chairing of GOA-ON Executive Council and major role in preparation of GOA-ON Plan, with NOAA, IOC, IOCCP, OA-ICC and others
- UK chairing and strong participation in first meeting of the re-constituted international Ocean Acidification Reference User Group (iOA-RUG; Monaco, 2-4 December)
- Participation in annual meeting of SOLAS-IMBER Working Group on Ocean Acidification (Villefranche, 13-14 May) with UK chairing of associated meeting of the Advisory Board of the Ocean Acidification International Coordination Centre
- Participation in 2nd meeting of the ICES-OSPAR Study Group on Ocean Acidification (Copenhagen, 7-1-0 October)
- Co-authorship and editing roles for the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC; WG II for publication in 2014)
- Involvement in the 19th Conference of Parties of the UN Framework Convention on Climate Change (UNFCCC; Warsaw, 11-23 November) through an exhibit with international partners, presentations at side-events, and input to press conferences.

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

Each of the programmes and projects identified in Section 3 above has its own goals and future plans, and a wide range of new activities are under discussion by the research community, for submission as funding bids at various scales. Many of these are congruent with international SOLAS objectives (and have developed from the UK SOLAS programme, benefitted from the work of the SOLAS IPO and the SOLAS SSC). Linkages between activities are, however, informal, without any SOLAS-specific coordinating arrangements or structures to facilitate collective planning on a national basis. In particular, the role of NERC Theme Leaders in assisting the development of new national programmes ended in 2013. Replacement mechanisms for stimulating and assessing strategic, large-scale initiatives have recently been announced by NERC, for implementation in 2014-15 onwards.

SOLAS-UK researchers participated in a UK Future Earth Town Hall meeting (21 June, London; http://www.britac.ac.uk/intl/future_earth.cfm). The Royal Society and British Academy subsequently convened a Working Group to discuss options of how a new UK Future Earth structure could best be formed and funded, and its future function.

SOLAS-UK researchers have also made contributions to the "Future SOLAS" discussions, commenting on the eight research themes identified by the SOLAS SSC (www.solas-int.org/about/future_solas.html), and with lead involvement in the Future SOLAS workshop at Plymouth, mentioned in Section 5.

7. Other comments

As indicated in Sections 1-5 above, the SOLAS-UK community remains extremely active and productive, with strong national and international connectivity. Although there may be a reduction in 'top down'

planning for SOLAS-directed work, there is no shortage of high quality 'bottom up' research ideas and activities that address the linkages between marine and atmospheric processes.

This is my last annual report as SOLAS-UK national representative. I am very pleased that Tom Bell tbe@pml.ac.uk is taking on that responsibility; his wide expertise – and knowledge of the SOLAS community – make him ideally suited as my successor.

Phil Williamson