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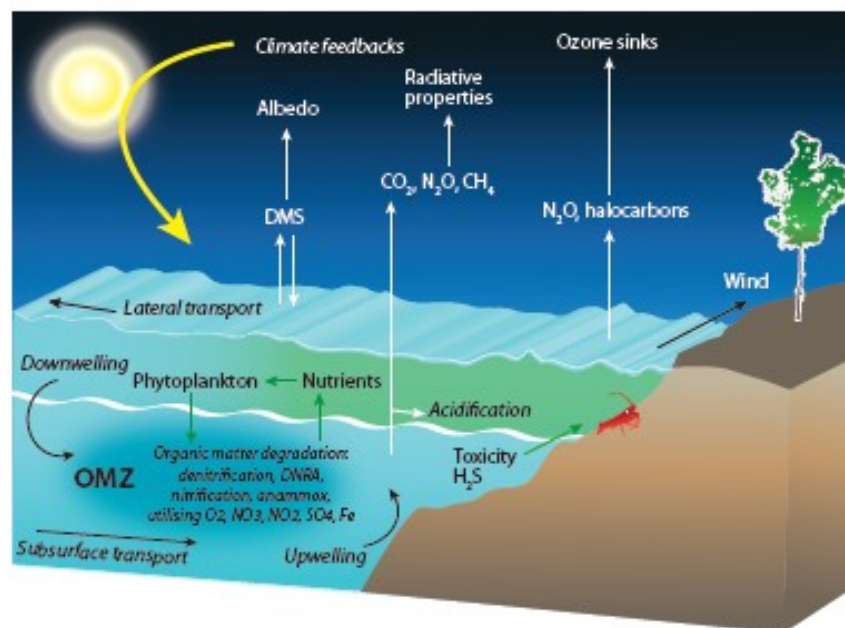
Reporting Period is January 2012 – December 2012

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

1. Scientific highlights
Evolving Research Directions in Surface Ocean-Lower Atmosphere Science (SOLAS)

Oxygen Minimum Zones (OMZs)

Eastern Boundary Upwelling Systems and their associated OMZs are crucial sites for greenhouse gas, trace gas, aerosol and nutrient cycling. These regions influence climate, cloud properties and marine productivity, yet feedbacks are complex and poorly quantified. French SOLAS with the AMOP project aims to determine the overall climate impact of these regions, by considering CO₂ and trace gas production and emission, with a focus on the East Tropical South Pacific off Peru, using multiple sampling platforms to develop new data bases, remote sensing, parameterizations, regional coupled atmospheric-physical and biogeochemical models.

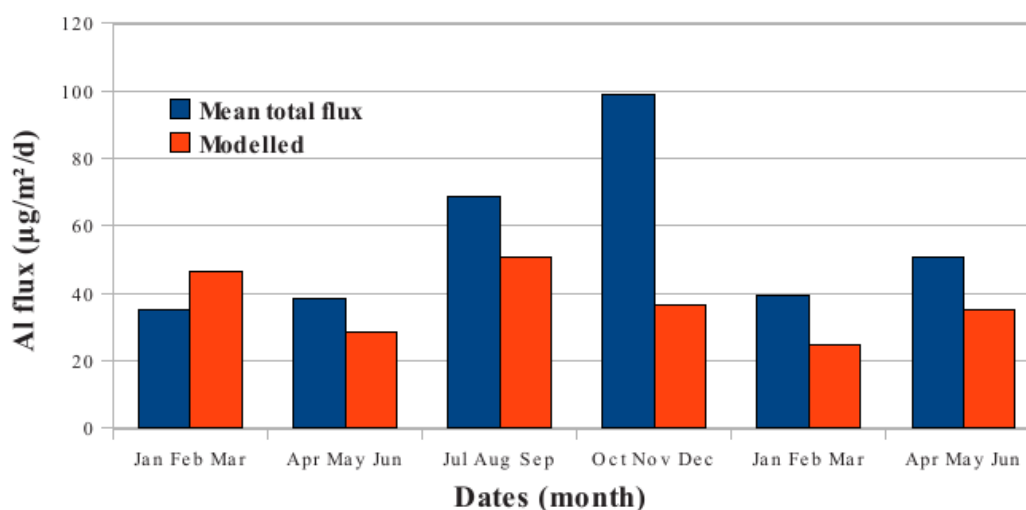


Conceptual diagram illustrating the main issues, processes and species relating to EBUS and OMZs. Processes are indicated in italics.

¹Law, C.S., Brévière, E., de Leeuw, G., Guieu, C., Garçon, V.C., Kieber, D.J., Konradowitz, S., Paulmier, A., Quinn, P.K., Saltzman, E., Stefels, J., and Roland von Glasow, 2012,

Micronutriments atmospheric deposition flux into Southern Oceans

Total atmospheric deposition and crustal aerosol concentrations are monitored on Kerguelen Islands (49°18'S; 70°07'E) in the Southern Ocean during a short campaign in early 2005 and then continuously for about 2 years (2009–2010). Results are published now and show that atmospheric dust and trace metals concentrations are very low in the area but that direct measured deposition fluxes are much higher than expected from atmospheric concentrations and consistent with global models. The averaged total dust deposition flux as derived from Al deposition measurements is $659 \mu\text{g m}^{-2} \text{d}^{-1}$. Observations and model results suggest that dust is transported above the marine atmospheric boundary layer to Kerguelen Islands, and thus that surface concentrations are not representative of the total dust column. Indeed, using surface aerosol concentrations leads to very large computed wet scavenging ratios, and to the conclusion that it is not appropriate to derive deposition fluxes from surface concentrations at remote ocean sites. These results are parts of SOLAS endorsed project FLATOCOIA.



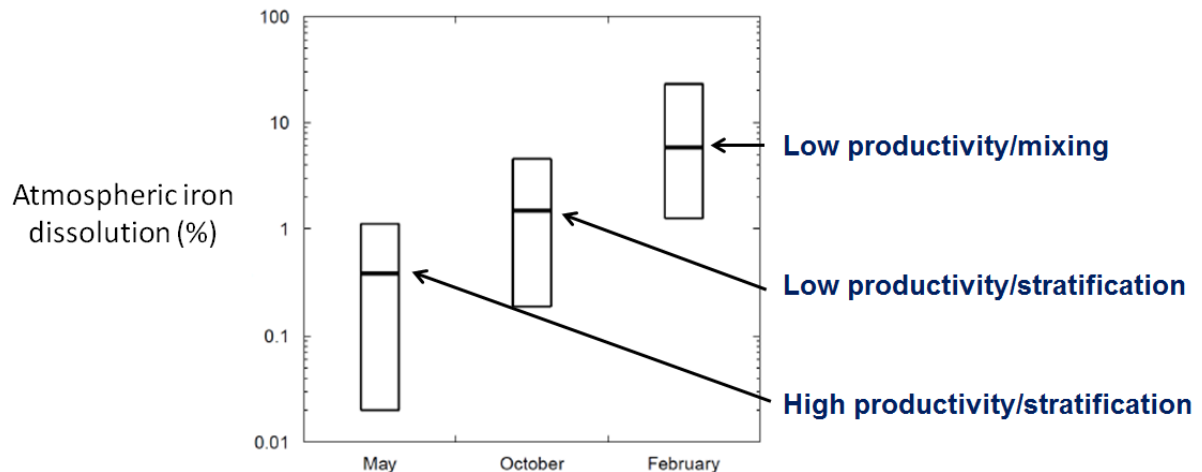
Three-month sampling time weighted average (full) of total deposition fluxes of Al for the years 2009–2010 and corresponding modelled outputs (hatched), from Heimbürger et al.².

²A. Heimbürger, R. Losno, S. Triquet, F. Dulac and N. Mahowald, *Direct measurements of atmospheric iron, cobalt and aluminium-derived dust deposition at Kerguelen Islands, Global Biogeochemical Cycles*, **26-4**, GB4016, doi:10.1029/2012GB004301.

Organic complexation versus scavenging: What really happens to new atmospheric iron in the ocean's surface?

By the mean of abiotic experiments conducted in clean “minicosm”, we have been studying the influence of the composition and the concentration of the dissolved organic matter (DOM) on the fate of atmospheric new nutrients (N, P and Fe). We have shown that atmospheric iron dissolution is depending on age and amount of dissolved organic matter in

seawater. Post-depositional processes controlled by DOM, are thus very important to take into consideration to predict biota response to atmospheric deposition of nutrients. This work was presented during the last SOLAS OSC meeting in Cle Elum in May 2012 (M. Bressac winner of the student poster award). A paper is currently under review [Bressac and Guieu, submitted to GBC].



Atmospheric Iron dissolution: one order of magnitude difference depending on in situ biogeochemical conditions; the same experimental conditions were used for the 3 'clean minicosm' experiments conducted in abiotic conditions (same dust, same deposition flux) at 3 contrasted seasons (0.2 μm seawater sampled in the Bay of Villefranche/mer). (Bressac M., 2012, PhD and Bressac & Guieu, submitted GBC).

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

SOLAS OSC: The 2012 SOLAS OSC at Cle Elum (USA, WA) included 10 french contributions and a well represented attendance.

An invited talk was given by Sophie Bonnet (IRD, MIO): "Dinitrogen fixation above Oxygen Minimum Zones". One special session (Impact of dust and ash on ocean productivity) was co-convened by R. Hamme, R. Losno, I. Lin and Diego Gaiero. In addition to "SOLAS-France", 8 scientific posters were presented:

- Remote atmosphere sampling and storage for mercury and very low level trace metals (S. Triquet)
- Physical and biogeochemical processes maintaining the Oxygen Minimum Zone of the Benguela Upwelling System using an eddy resolving model (V. Garçon).
- AMOP: activities of research dedicated to the minimum of oxygen in the eastern Pacific (A. Paulmier)
- Dust emission from Patagonia (R. Losno).
- Impact of Saharan dust deposition on dissolved-colloidal-particulate nutrient distribution in seawater (M. Bressac, winner of the student poster award).
- A plan for a SOLAS campaign across the Mediterranean Sea in 2015 (C. Guieu).
- Atmospheric deposition of trace elements over the Southern Indian Ocean (A. Heimburger).
- A new mineralogical database for atmospheric dust to estimate soluble iron fluxes to surface ocean (E. Journet).

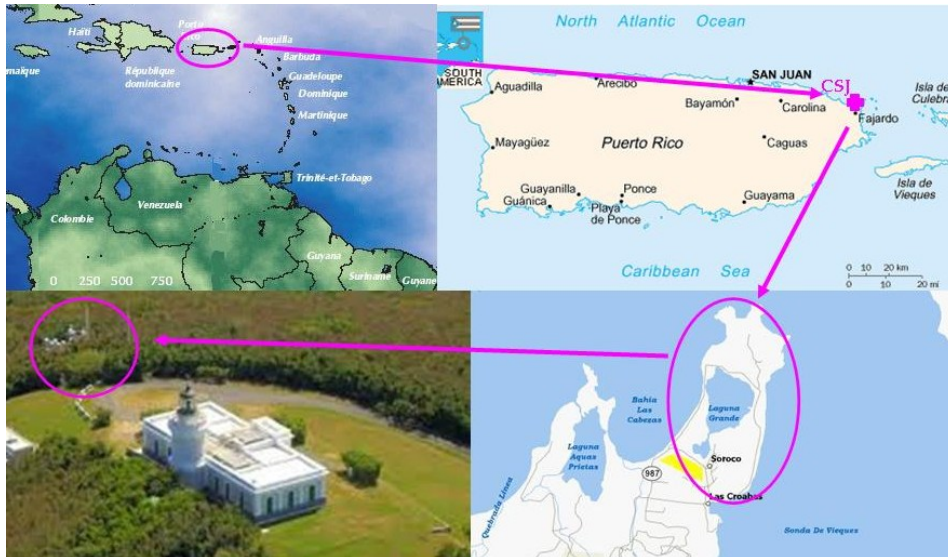
Full textes are available in SOLAS-France web pages (http://www.lisa.u-pec.fr/SOLAS/OSS_attendance.html)

SOLAS News: 5 scientific contributions, 1 special report and 3 endorsed project reports were given for publication in issue 14 (summer 2012). Pages are for 'on screen' version:

- S. Bonnet, NanoSIMS reveals efficient transfer of fixed N₂ from Trichodesmium to large size phytoplankton, 5-8, scientific contribution.
- Bressac M., Dust deposition: the fate of atmospheric new nutrients, interactions with organic matter and the impact on carbon export. 12-14, scientific contribution.
- E. Journet, Iron solubility and dust mineralogy, 22-24, scientific contribution.
- A. Paulmier, V. Garçon, M. Graco, C. Maes, D. Gutierrez, B. Dewitte and K. Takahashi, AMOP: Activity of research dedicated to the Minimum of Oxygen in the Eastern Pacific, 25-27, scientific contribution.
- Heimbürger A., R. Losno and N.M. Mahowald, Field measured atmospheric deposition fluxes over the Southern Ocean, 35-38, scientific contribution.
- EUR-OCEANS Conference 'Ocean deoxygenation and implications for the marine biogeochemical cycles and ecosystems' 24-26 October 2011, Toulouse, France. Dewitte, B., Garçon, V. and Paulmier, A., 87-88, special report.
- FLATACOA: Atmospheric dust in South Hemisphere, R. Losno and A. Heimbürger, 113-114, endorsed project.
- MERMEx (Marine Ecosystems Response in the Mediterranean Experiment), X. Durrieu de Madron, C. Guieu and R. Sempéré, 115-117, endorsed project.
- MedSea project, Gazeau F., 120-122, endorsed project.

SOLAS Mid-Term Strategy Initiative "Air-sea gas fluxes at Eastern boundary upwelling and Oxygen Minimum Zone (OMZ) systems": Workshop on "Towards an integrative regional coupling in the Eastern Boundary Upwelling Systems (EBUS), Instituto Geofísico del Perú, 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>) (V. Garçon, Veronique.Garcon@legos.obs-mip.fr). Publications in SOLAS NewsLetters n° 14: A. Paulmier et al., AMOP and EUR-OCEANS.

Dust Attack (*Dust Aging and transport from Africa to the Caribbean*), Contact: Paola Formenti (paola.formenti@lisa.u-pec.fr), LISA, Paris: This project, funded by Partner University Fund, aims to improve our knowledge on the evolution of mineral dust properties during atmospheric transport, notably the modification of their fractional solubility in nutrients, as Fe. The strategy is to compare measurements close to African source regions and after few-days of transport in the atmosphere. In this purpose, a field campaign was conducted in Puerto Rico at the Cape San Juan, a noaa/wmo sampling station, in June/July 2012. Measurements of mineral dust composition, size distribution, individual particle shape, morphology and soluble fraction were carried out. Measurements on dust properties were also did in the wet deposited fraction. Five dust events were collected during the field campaign. The collected dust was shown to be issued from major sources in Sahara, but presents very close features. The next step is the comparison of these results with database of physico-chemical properties of mineral dust in the proximity of source regions of African dust impacting the Caribbean which has been collected during the AMMA experiment.



The Cape San Juan Sampling site

Dust From Patagonia (contact remi.losno@lisa.u-pec.fr)

The South America and particularly the Argentinean Patagonia is suspected to be a major source of dust for southern hemisphere oceans. A field campaign is involved at Rio Gallegos, Bariloche and Comodoro Rivadavia in order to sample continuously aerosols close to their sources and to observe temporal variations of their vertical profile before export of dust to the South Atlantic Ocean and beyond.

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 (CO₂) 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 found in the SOLAS endorsed projects reports.

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

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

SOLAS Open Science Conference , 7-10 May, 2012: Parallel discussion session on Earth Observations for SOLAS science, Cle Elum, USA

Integrative regional coupling in the Eastern Boundary Upwelling Systems (EBUS)

Lecture day on “Towards an integrative regional coupling in the Eastern Boundary Upwelling Systems(EBUS), Instituto Geofísico del Perú, Lima, 28 November 2012, 8 lectures for peruvian Master and graduate students, 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>) (V. Garçon)

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

- Bressac M., C. Guieu, D. Doxaran, F. Bourrin, G. Obolensky and JM Grisoni (2012), A mesocosm experiment coupled with optical measurements to observe the fate and sinking of atmospheric particles in clear oligotrophic waters, *Geo-Marine Letters* 32: 153-164
- Chami, M., Mallet M., Gentili, B., Quantitative analysis of the influence of dust sea surface forcing on the primary production of the subtropical Atlantic Ocean using a ten-year time series of satellite observations, *JGR-Oceans*, 117, C07008 DOI: 10.1029/2012JC008112, 2012
- Coupel, P., H. Y. Jin, Joo M., Horner R., Bouvet H.A., Sicre M-A., Gascard J-C., Chen J-F., V. Garçon, and Ruiz-Pino, D. (2012), Phytoplankton distribution in unusually low sea ice cover over the Pacific Arctic , *Biogeosciences*, 9, 4835-4850.
- 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), “*Ocean-Atmosphere Interactions of Gases and Particles*” Publisher: Springer, Heidelberg, in press.
- Garbe, C.S., A. Butz, I. Dadou, B. Dewitte, V. Garçon, S. Illig, A. Paulmier, J. Sudre and H. Yahia (2012), Climatically-Active Gases In The Eastern Boundary Upwelling And Oxygen Minimum Zone (OMZ) Systems, *IEEE International Geoscience and Remote Sensing*, in press.
- Garçon, V. C., Bell, T. G., Wallace, D., Arnold S. R., Baker A., Bakker, D. C. E., Bange, H. W., Bates, N. R., Bopp, L., Boutin, J., Boyd, P. W., Bracher, A., Burrows, J. P., Carpenter, L. J., Fennel, K., Font, J., Friedrich, T., Garbe, C. S., Gruber, N., Jaeglé, L., Lana, A., Lee, J. D., de Leeuw, G., Liss, P. S., Miller, L. A., Olgun, N., Olsen, A., Pfeil, B., Quack, B., Read, K. A., Reul, N., Rödenbeck, C., Rohekar, S. S., Saiz-Lopez, A., Saltzman, E. S., Schneising, O., Schuster, U., Séférian, R., Steinhoff, T., Yves Le Traon, P., Wittke, F. (2013) Perspectives and Integration in SOLAS science. In: Liss, P. S. and Johnson, M. T. (Editors), “*Ocean-Atmosphere Interactions of Gases and Particles*” Publisher: Springer, Heidelberg, in press.
- Heimbürger, A., M. Tharaud, F. Monna, R. Losno, K. Desboeufs and E. Bon Nguyen, (2012) SLRS-5 elemental concentrations of thirty-three uncertified elements deduced from SLRS-5/SLRS-4 ratios, *Geostandards and Geoanalytical Research*, doi: 10.1111/j.1751-908X.2012.00185.
- Heimbürger, A., R. Losno, S. Triquet, F. Dulac and N. Mahowald, Direct measurements of atmospheric iron, cobalt and aluminium-derived dust deposition at Kerguelen Islands, *Global Biogeochemical Cycles*, **26-4**, GB4016, doi:10.1029/2012GB004301.
- Kalvelage, T., Lavik, G., Lam, P., Contreras, S., Arteaga, L., Löscher, C., Oschlies, A., Paulmier, A., Stramma, L., and M.M.M. Kuypers, 2013, Organic matter export regulates nitrogen cycling in the South Pacific oxygen minimum zone, *Nature Geoscience* (Accepted)
- Law, C.S., Brévière, E., de Leeuw, G., Guieu, C., Garçon ,V.C., Kieber, D.J., Konradowitz, S., Paulmier, A., Quinn, P.K., Saltzman,E., Stefels, J., and Roland von Glasow, 2012, Evolving Research Directions in Surface Ocean-Lower Atmosphere (SOLAS) Science, *Environmental Chemistry*, in press.
- Sudre, J., Maes,C. ,and Garçon,V., 2012, On the global estimates of geostrophic and Ekman surface currents, *Limnology and Oceanography: Fluids and Environments*, in press.
- Wallhead,P., Garçon,V., and Martin, A., 2012, Efficient upscaling of ocean biogeochemistry, *Ocean Modelling*, <http://dx.doi.org/10.1016/j.ocemod.2012.12.002>, in press.

5. 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, Ireland, Spain, China, Denmark and Mexico.

EUR-OCEANS Flagship on Ocean deoxygenation in Eastern Boundary Upwelling Systems has been awarded to IFM-GEOMAR, Kiel, Germany, LEGOS CNRS and IRD, Toulouse; and LOCEAN, Paris, France; with IMARPE, IGP, Lima, Peru as co-partners.

Research program "Dust from Patagonia" is conducted with argentinean laboratory CEILAP (Buenos Aires, E. Quel) part of CNRS UMI 3351 IFAECI (Buenos Aires). This research team is involved in atmospheric optics and LIDAR developments. A LIDAR array covering Patagonia is about to be set up for a dust vertical profile survey over this area. French laboratory LISA is in charge of the determination of aerosol chemical properties determination.

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

Plan for future activities

DONUT '*Dependance of dissolved organic matter cycling on atmospheric inputs of nutrients*' (Elvira Pulido-Villena) The main goal of DONUT is to assess how and to which extent the response of heterotrophic prokaryotes to atmospheric inputs of nutrients shape the DOM pool and modify its bioavailability. There are recent evidences of the preferential uptake of dust-derived nutrients by heterotrophic prokaryotes resulting in heterotrophic processes being more stimulated by dust pulses compared to autotrophic processes. How can we go further on our understanding of the consequences of these results on C cycling? The stimulation of bacterial respiration by dust pulses during the stratification period would decrease the amount of carbon susceptible to be exported to depth through winter mixing. Nevertheless, the efficiency of the Microbial Carbon Pump depends not only on the amount of carbon in the dissolved pool but also on the characteristics of the DOM which may modify its residence time in the water column. How and to what extent dust pulses can, through the stimulation of Hprok activity, shape the surface DOM pool remains totally unexplored and constitute one bottleneck to our advances to understand the role of atmospheric deposition on marine C cycle. The DONUT strategy is based on the experimental assessment of the transformation of DOM during bacterial degradation under simulated dust inputs.

AMOP for "Research Activities dedicated to the Oxygen Minimum in the East Pacific" (Aurélien Paulmier aurelien.paulmier@gmail.com): Deployment of multidisciplinary mooring planned for January 5, 2013 from R/V Meteor off Callao (12°S, 77°40'W) for a 3 years period, and servicing every 3 months. Oceanographic cruise planned for 2013, early 2014 in the OMZ off Peru.

CHIPIE: *Comportement des éléments d'intérêt biogéochimiques et du carbone Particulaire aux Interfaces atmosphère-océan et continent-océan dans un contexte d'évolution des conditions Environnementales* (Cécile Guieu, guieu@obs-vlfr.fr). The objective of this project is to study the impact of climate and environment change (temperature, acidification) on the behavior of biogeochemical elements and particulate carbon at the atmosphere-ocean interface. The experimental approach ('clean minicosm in abiotic conditions') initiated at the end of the DUNE project (see Bressac, 2012) will be completed by temperature and turbulence controls and an integrated sampling system will be developed. Such

developments are currently done in order to perform three experiments in 2013. A PhD started in fall 2012 (J. Louis, LOV) and 3 experiments are scheduled in 2013. (funding University Paris VI).

PEAcEtIME "*ProcEss studies at the Air-sEa Interface: a Mediterranean Experiment*" (Cécile Guieu, Karine Desboeufs). A working group is currently working on a proposal for a field cruise planned in 2015 (this will be a joint experiment between MERMEX and ChArMEX). This project was presented at the 2012 OSC to call for international collaboration on that "SOLAS cruise" in the Mediterranean; it will be submitted for funding at the autumn 2013.

7. Other comments