

Report for the year 2017 and future activities

SOLAS ‘country’ compiled by: ‘Name’

This report has two parts:

- **Part 1:** reporting of activities in the period of January 2017 – Jan-Feb 2018
- **Part 2:** reporting on planned activities for 2018/2019 and 2020.

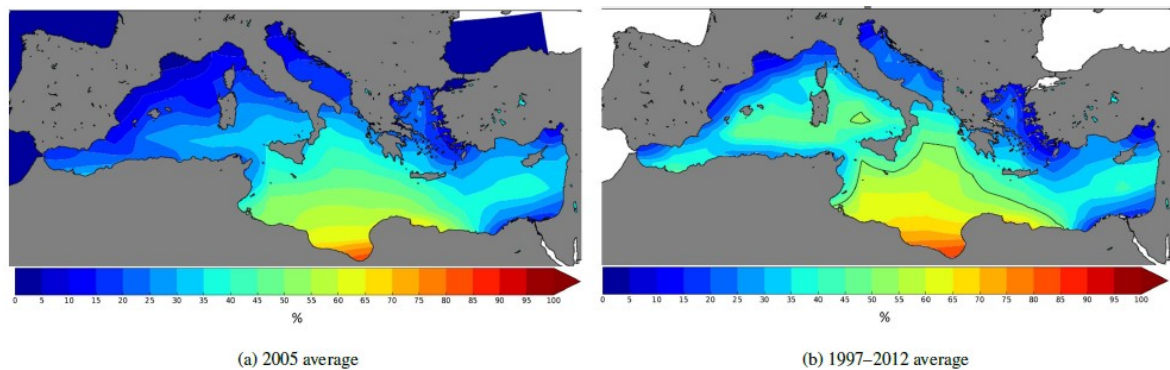
The information provided will be used for reporting, fundraising, networking, strategic development and updating of the live web-based implementation plan. As much as possible, please indicate the specific SOLAS 2015-2025 Science Plan Themes addressed by each activity or specify an overlap between Themes or Cross-Cutting Themes.

- 1 Greenhouse gases and the oceans;
 - 2 Air-sea interfaces and fluxes of mass and energy;
 - 3 Atmospheric deposition and ocean biogeochemistry;
 - 4 Interconnections between aerosols, clouds, and marine ecosystems;
 - 5 Ocean biogeochemical control on atmospheric chemistry;
- Integrated studies;
Environmental impacts of geoengineering;
Science and society.

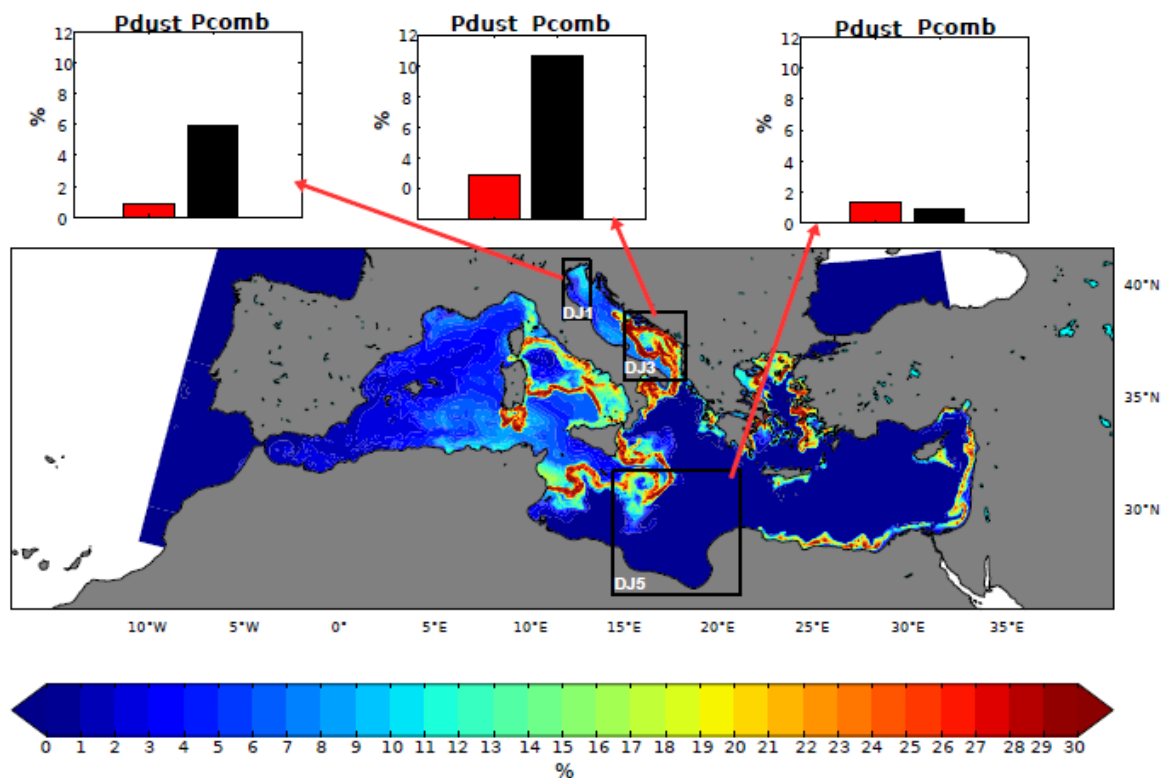
IMPORTANT: *This report should reflect the efforts of the SOLAS community in the entire country you are representing (all universities, institutes, lab, units, groups, cities).*

PART 1 - Activities from January 2017 to Jan/Feb 2018	
1. Scientific highlight	
<p>Modeling the biogeochemical impact of atmospheric phosphate deposition from desert dust and combustion sources to the Mediterranean Sea (Topic 3)</p> <p><i>Accepted to Biogeosciences</i> <i>Camille Richon (camille.richon@lsce.ipsl.fr), Jean-Claude Dutay, François Dulac, Rong Wang, and Yves Balkanski</i></p> <p>Daily modeled fields of phosphate deposition from natural dust, anthropogenic combustion and wildfires were used to assess the effect of this external nutrient on marine biogeochemistry. The ocean model used is a high resolution (1/12°) regional coupled dynamical—biogeochemical model of the Mediterranean Sea (NEMOMED12/PISCES). The input fields of phosphorus are for 2005, which is the only available daily resolved deposition fields from the global atmospheric chemical transport model LMDz-INCA. Traditionally, dust has been suggested to be the main atmospheric source of phosphorus, but the LMDz-INCA model suggests that combustion is dominant over natural dust as an atmospheric source of phosphate (PO₄, the bioavailable form of phosphorus in seawater) for the Mediterranean Sea. According to the atmospheric transport model, phosphate deposition from combustion (Pcomb) brings on average 40.5 10⁻⁶ mol PO₄ m⁻² year⁻¹ over the</p>	

entire Mediterranean Sea for the year 2005 and is the primary source over the northern part (e.g., $101 \cdot 10^{-6} \text{ mol PO}_4 \text{ m}^{-2} \text{ year}^{-1}$ from combustion deposited in 2005 over the North Adriatic against $12.4 \cdot 10^{-6}$ from dust). Lithogenic dust brings $17.2 \cdot 10^{-6} \text{ mol PO}_4 \text{ m}^{-2} \text{ year}^{-1}$ on average over the Mediterranean Sea in 2005 and is the primary source of atmospheric phosphate to the southern Mediterranean basin in our simulations (e.g., $31.8 \cdot 10^{-6} \text{ mol PO}_4 \text{ m}^{-2} \text{ year}^{-1}$ from dust deposited in 2005 on average over the South Ionian basin against $12.4 \cdot 10^{-6}$ from combustion). The evaluation of monthly averaged deposition fluxes variability of P_{dust} and P_{comb} for the 1997–2012 period indicates that these conclusion may hold true for different years. We examine separately the two atmospheric phosphate sources and their respective fluxes variability and evaluate their impacts on marine surface biogeochemistry (phosphate concentration, chlorophyll a, primary production). The impacts of the different phosphate deposition sources on the biogeochemistry of the Mediterranean are found localized, seasonally varying and small, but yet statistically significant. Differences in the geographical deposition patterns between phosphate from dust and from combustion will cause contrasted and significant changes in the biogeochemistry of the basin. We contrast the effects of combustion in the northern basin (P_{comb} deposition effects are found 10 times more important in the northern Adriatic, close to the main source region) to the effects of dust in the southern basin. These different phosphorus sources should therefore be accounted for in modeling studies.



Map of average P_{dust} proportion in total P deposition for 2005 (a- left) and 1997–2012 (b- right). The black line on the right map represents 50% P_{dust} proportion limit on the average of 1997–2012.



Map of maximal relative effects of total ($P_{\text{dust}} + P_{\text{comb}}$) deposition on primary production in the

surface Mediterranean (0-10m) during June 2005 (on a daily basis). The reference primary production concentration values are taken from REF simulation without atmospheric phosphate deposition. Barplots represent average relative effects of each source (in %) within the framed areas excluding land. The limits of the areas are described in Manca et al. (2004). There is no atmospheric deposition modeled in the Marmara and Black Seas.

PEACETIME field campaign (Topic 3)

Cécile Guieu (guieu@obs-vlfr.fr) and Karine Desboeufs (Karine.Desboeufs@lisa.u-pec.fr)

The Mediterranean Sea, a hot spot for biodiversity but also for climate change and anthropogenic pressure, is an ideal natural laboratory to study the processes occurring at the atmosphere-ocean interface. The project PEACETIME (ProcEss studies at the Air-sEa Interface after dust deposition in the Mediterranean sea) will provide the understanding necessary to accurately represent natural and anthropogenic chemical exchanges at the air-sea interface and their impacts on marine ecosystems and services, today and in the future. PEACETIME is relevant for the questions addressed in the “SOLAS 2015-2025 Science Plan and Organisation” in particular regarding the theme “Atmospheric deposition and ocean biogeochemistry”.

In the frame of PEACETIME, an oceanographic cruise onboard the R/V ‘Pourquoi Pas?’ took place in the Western/Central Mediterranean Sea May 10–June 11, 2017 (see: <https://twitter.com/peacetimecruise> and vimeo.com/channels/peacetime). The purpose of this expedition was to study critical processes induced by atmospheric deposition, in particular Saharan dust. PEACETIME yields insights into the impact of such processes on the cycle of chemical elements (nutrients, metals) and on the biogeochemical functioning of the pelagic ecosystem. The 40 scientists embarked are experts in atmosphere and ocean domains. One of the main aims of the PEACETIME expedition was the characterization of the biogeochemical processes induced by atmospheric inputs over the Mediterranean Sea, and notably the response of the system to Saharan dust inputs. To that purpose, the cruise combined in-situ observations of both the atmosphere and the ocean, as well as Climate Reactors incubation experiments. Incubation experiments were set to reproduce different water temperatures and pCO₂ conditions so that scientists could assess the atmospheric impacts in both present and future climate conditions.

Moreover, the PEACETIME strategy included an “in-situ, real-time” approach: catching a real event of atmospheric deposition in Mediterranean waters, and documenting the ensemble of interactions induced on the surface ocean ecosystem. A fine-tuned team of people (on and off-board) worked together to examine quasi-real time dust transport forecasts and satellite observations, adjust the cruise track, and position the ship in an area where deposition events were forecasted. This unique coordinated effort succeeded, and the scientists were able to sample and measure the “real-time” effects of a dust deposition event on the marine surface waters.

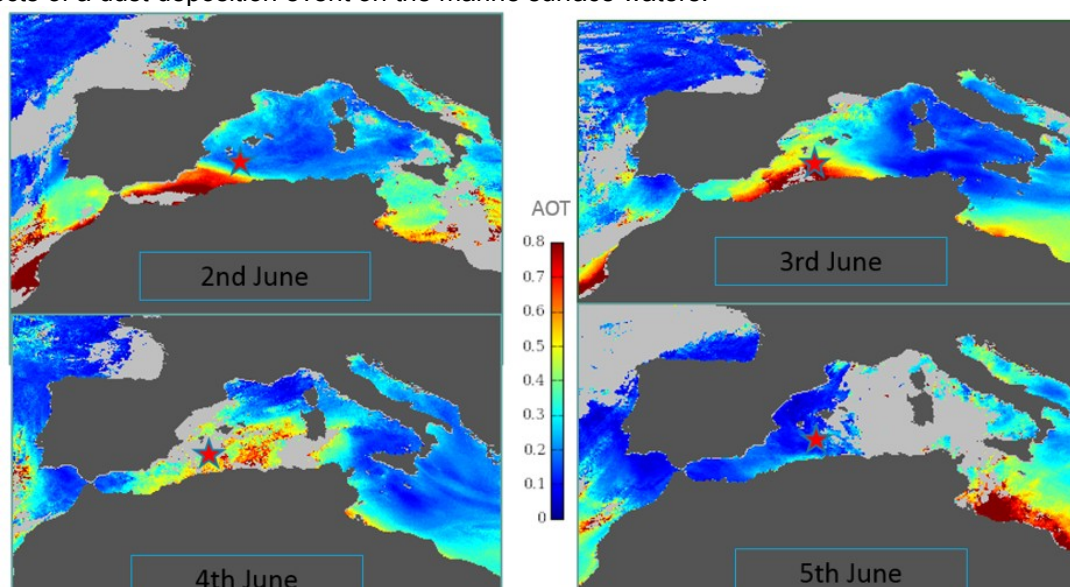


Figure 1. The Fast Action during PEACETIME allowed a direct observation of a dust deposition event to the ocean as shown on the AOT images (the boat location is the red star).

A first set of results concerning physical, chemical, and biological measurements on both the marine stations, the atmospheric and marine underway and the incubation experiments were

presented at the EGU2018 and Ocean Science Meeting in Portland.

MORE HERE: <http://peacetime-project.org/index.html> and <https://www.researchgate.net/project/PEACETIME-ProcEss-studies-at-the-Air-sEa-Interface-after-dust-deposition-in-the-MEditerranean-sea>

2. Activities/main accomplishments in 2017 (projects, field campaigns, events, model and data intercomparisons, capacity building, international collaborations, contributions to int. assessments such as IPCC, interactions with policy makers or socio-economics circles, social sciences, and media).

Surface changes in total carbon and ocean acidification in the NASG (G. Reverdin (LOCEAN) (Topic 1)

N. Metzl (LOCEAN, Nicolas.Metzl@locean-ipsl.upmc.fr), V. Racape (LOPS))

We have validated a surface archive of T, S, inorganic nutrients, DIC and total alkalinity, $\delta^{13}\text{C}_{\text{DIC}}$ (the isotopic ratio in DIC), as well as water isotopes that we collected between Iceland and Newfoundland in 1993-2017 (SURATLANT project) (Reverdin et al., 2018). The data illustrate the large increase in DIC, decrease in $\delta^{13}\text{C}_{\text{DIC}}$, little change in the air-sea contrast of $f\text{CO}_2$ (as a trend), but also large interannual and decadal variability associated with the cycle of surface warming peaking in the middle of the period associated with increased surface stratification in this region.

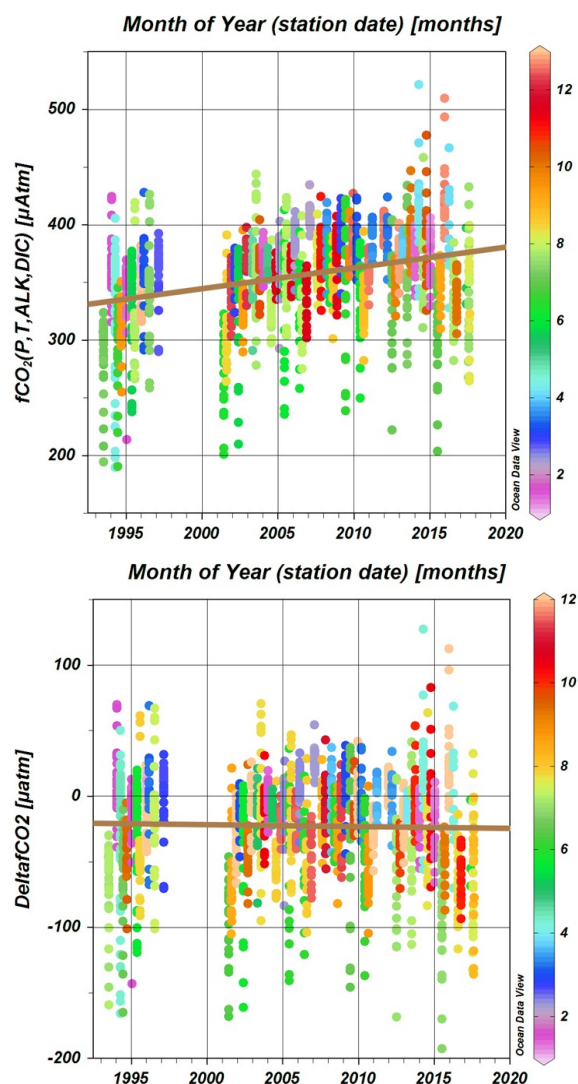


Figure: SURATLANT. Estimated surface ocean

$f\text{CO}_2$ (left panel) and sea-air difference in $f\text{CO}_2$ (right panel) (color-coded by month of the year). Notice that the NASG has remained a sink of atmospheric CO_2 (as a trend, brown curve).

An analysis of the last 10-years of data on another transect (east-west close to 60°N) (Fröb et al., 2018), which thus corresponds to a cooling period in the central NASG, illustrated also the large influence on surface properties of a freshening that took place east of the Reykjanes Ridge in the western Icelandic Sea (thus a decrease in alkalinity).

Reverdin, G. et al.. SURATLANT: a 1993-2017 surface sampling in the central part of the North Atlantic subpolar gyre. ESSD, in review.

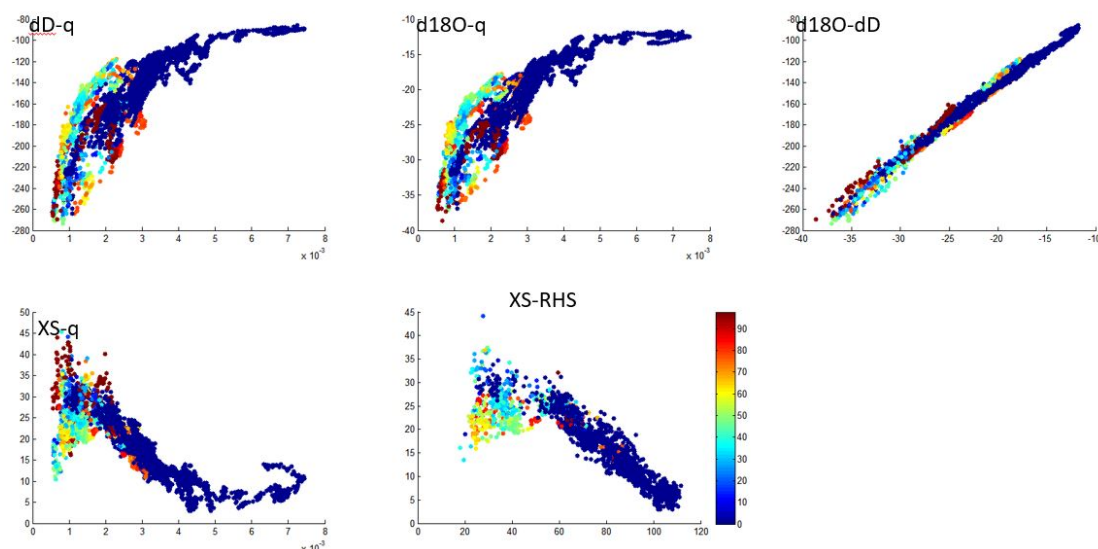
Fröb, K., A. Olsen, M. Becker, L. Chafik, T. Johannesen, G. Reverdin et A. Omar. Impact of recent North Atlantic freshening and cooling on the carbon cycle. *Geophys. Res. Lett.*, in review.

Water isotopes: a tracer of ocean-atmosphere-ice water fluxes (Topic 2)

(G. Reverdin gilles.reverdin@locean-ipsl.upmc.fr (LOCEAN), J.-B. Sallée (LOCEAN), G. Aloisi (IPGP), M. Benetti (Univ. of Iceland Reykjavik), C. Akhondas (LOCEAN))

In the past year, we have used our collection of atmospheric boundary layer and surface data of the Atlantic Ocean (from the equator to the North Atlantic subpolar gyre) to develop a qualitative model of the atmospheric boundary layer properties (Benetti et al., 2018). The model highlights how joint data of atmospheric humidity and water isotopes can be used to diagnose relative contribution of evaporation and tropospheric water vapour to the atmospheric boundary layer. In particular, this emphasizes the humidity of the air as a key factor in evaporative flux properties, and of properly estimating the properties of the evaporative fluxes including isotopic values in surface waters in order to interpret the atmospheric boundary layer properties in quiescent situations.

During the WAPITI cruise (P.I. J.-B. Sallée) continuous measurements of water vapour and surface sea water isotopic properties in the Southern Ocean from the Magellan Channel to the southern Weddell Sea (January-March 2017), over a wide range of weather conditions, including some very dry air flowing from the Antarctic continents. The sea water isotopes in the southern Weddell Sea are strongly imprinted by the formation and/or melt of sea ice, evaporation in contact with the very cold continental air, as well as with exchanges of water (and melt) of the continental ice shelves (Ronne-Filchner ice shelf). The atmospheric properties are strongly influenced in this late summer period by the presence of partial sea ice cover, as illustrated below on property diagrams showing dependencies of various variables as a function of nearby sea ice cover diagnosed from satellite AMSR2 data (the data of these different plots are colour-coded as a function of sea ice cover (from 0 dark blue to 100% in dark red)): q is the water vapour ratio, RH_s is the relative humidity reported at sea surface temperature, $\delta^{18}\text{O}$, δD are the ^{18}O and D isotopic ratios and XS the deuterium excess.



Benetti, M., J.-L. Lacour, A.E. Sveinbjörnsdóttir, G. Aloisi, G. Reverdin, C. Risi, A.J. Peters, H.-C. Steen-Larsen. A framework to study mixing processes in the marine boundary layer using water vapor isotope measurements. *Geophys. Res. Lett.*, 10 March 2018

<https://doi.org/10.1002/2018GL077167>

Modeling aerosol deposition effects on the Mediterranean biogeochemical cycles (Topic 3)

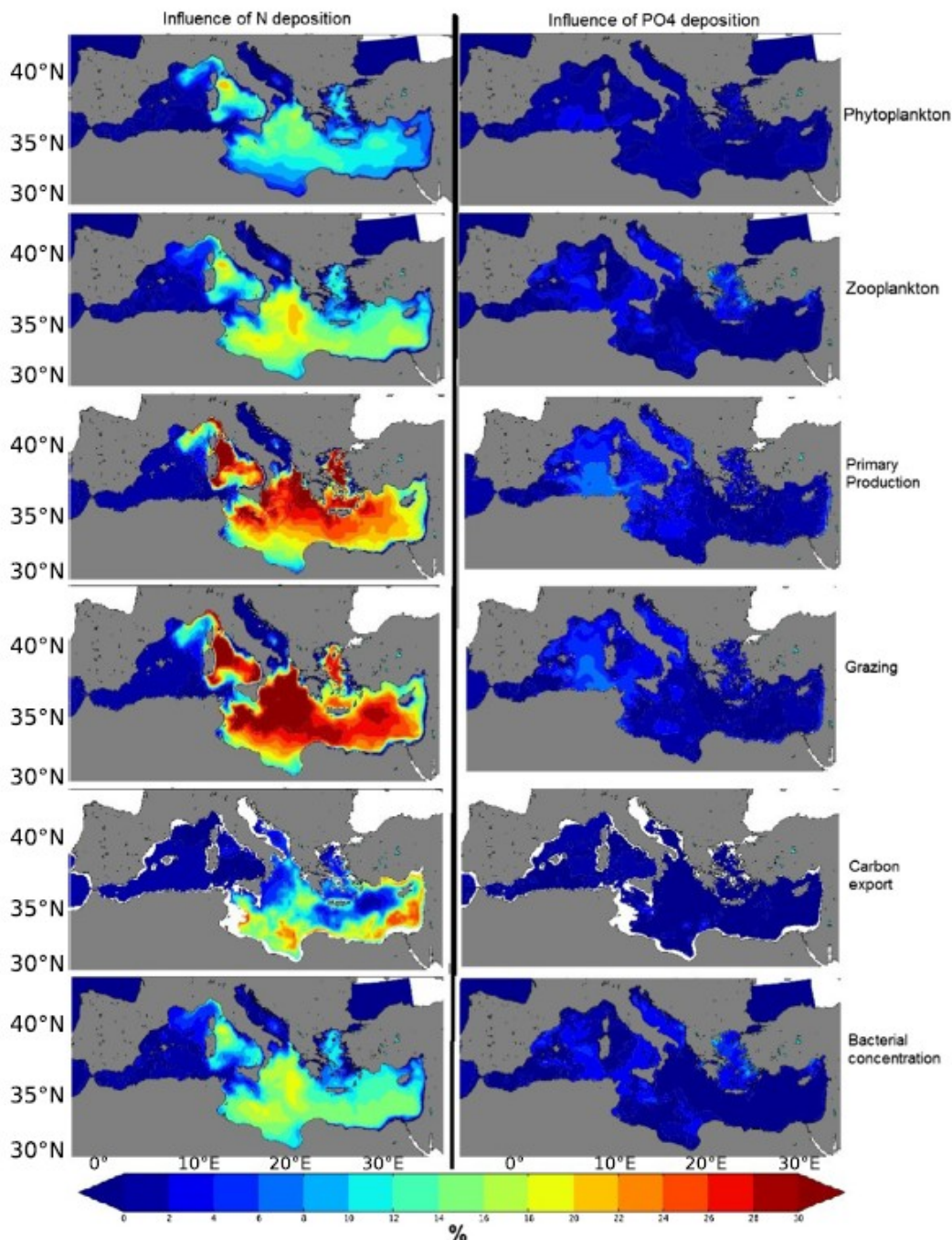
PhD Camille Richon, Paris-Saclay, december 7th, 2017 (LSCE, camille.richon@lsce.ipsl.fr)

Observations and experiments showed that aerosol deposition can increase the amount of bioavailable nutrients and favor biological production of the Mediterranean Sea. In this context, the present study yields for the first time a quantification of the effects of aerosol deposition from various sources thanks to the coupled physical-biogeochemical model NEMOMED12/PISCES.

This study consists in modeling and analyzing the effects on the Mediterranean biogeochemistry of atmospheric deposition of nitrogen and phosphate from various natural and anthropogenic sources. For this purpose, regional and global atmospheric models representing aerosol deposition were evaluated and selected. The NEMOMED12/PISCES model was modified to take into account these new nutrient sources. The analysis of the simulations showed that atmospheric deposition accounts for approximately 10 % of total external nitrate supply and 5 to 30 % of phosphate supply on average over the entire basin. Aerosol deposition can also increase biological production up to 50 % thanks to the lowering of nutrient limitations. The maximal fertilizing effects are observed during the stratified period which, in the Mediterranean region, is summer.

The effects of climate change may be particularly important in sensitive regions such as the Mediterranean. Therefore, the evolutions of basin scale biogeochemistry were evaluated under a climate change scenario. The NEMOMED8/PISCES model was used with physical and biogeochemical forcings for the IPCC A2 climate change scenario. This study shows a reduction in basin scale surface productivity by approximately 10 % triggered by warming and stratification. Nutrient limitations are modified and the Mediterranean Sea sensibility to atmospheric deposition changes.

The results of this thesis underline the importance of atmosphere as a nutrient source, in particular for nitrogen and phosphate. Deposition effects vary according to the season and the location. They are more important during the stratified period, when surface water is nutrient limited. Also, any change in biological productivity is quickly transferred along the biological chain. To refine the results, the atmospheric models could be improved and more knowledge on deposition fluxes and physical and chemical transformations of aerosols before and after deposition would be necessary. Moreover, more precise scenarios concerning climate change effects would be necessary in order to study the future evolutions of biogeochemical conditions in the Mediterranean. Finally, the recent developments on the PISCES model make new studies possible in a non redfieldian context. Preliminary results indicate that the productivity of the different phytoplanktonic groups varies with intracellular C/N/P ratios.

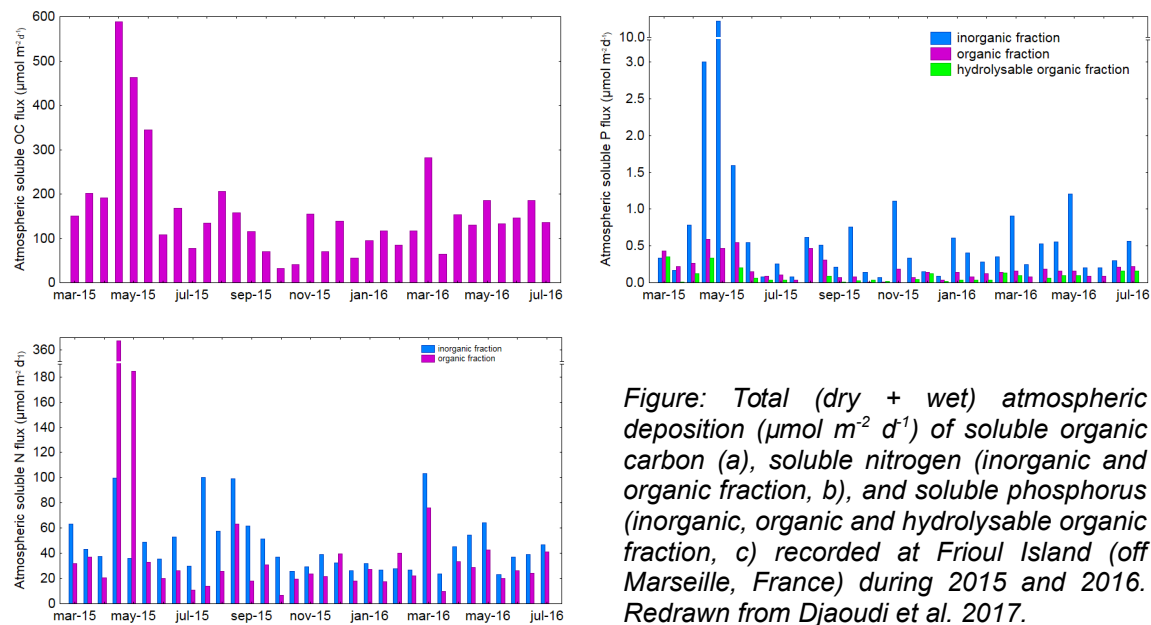


Relative influence (%) of atmospheric deposition on biological tracers for the summer season (JJA). Bacterial concentration is calculated as: $[Bact] = 0.7 [Microzoo] + 2 [Mesozoo]$. The relation has been constructed from a version of PISCES including explicit biomass calculation (Aumont et al., 2015). Carbon export is the export of carbon particles at 100 m. White zones are shallower than 100 m.

First report on atmospheric fluxes of soluble organic carbon, nitrogen and phosphorus to the Mediterranean Sea (Topic 3)

Kahina Djaoudi (kahina.djaoudi@mio.osupytheas.fr) defended her PhD thesis on 9th March 2018. One of her main accomplishments concerns the quantification of total atmospheric deposition of soluble organic matter (C, N and P) during 1.5 years at the Frioul Island, off Marseille (France). Indeed, linking atmospheric deposition to marine carbon and nutrient cycles is currently hampered by the lack of data on atmospheric fluxes of organic matter. The organic fraction in atmospheric deposition accounted for 40% of total soluble N and 25% of total soluble P. A very variable fraction (0-97%) of soluble organic phosphorus in atmospheric deposition was found to be hydrolysable by alkaline phosphatase enzyme (i.e. potentially bioavailable for marine microorganisms). We report

annual atmospheric fluxes of soluble organic C, N and P of 59 mmol C m⁻², 16.4 mmol N m⁻² and 23.6 μmol P m⁻², respectively. Assuming these values valid for the entire western Mediterranean basin, atmospheric inputs of organic matter would be higher than inputs from the Rhone River by a factor of 6, 17, and 2 for C, N and P, respectively.



Experimental evidence of the bioavailability to marine heterotrophic prokaryotes of aerosol-derived organic carbon, BATO (Topic 3)

(INSU-LEFE), Elvira Pulido (MIO, elvira.pulido@mio.osupytheas.fr). Djaoudi, K., Van Wambeke, F., Barani, A., Hélias-Nunige, S., Lefèvre, D., Nouara, A., Panagiotopoulos, C., Tedetti, M., Desboeufs, K., Pulido-Villena, E.

Atmospheric deposition is the major pathway for removal of organic carbon (OC) from the atmosphere. Data on atmospheric fluxes of OC to the ocean are scarce but suggest that they might be higher than river inputs and on the same order of magnitude as main ocean carbon fluxes such as C export. However, the fate of this aerosol-derived OC source in the surface ocean upon deposition remains unexplored hampering the assessment of its role in ocean C cycle. The main goal of this project was to investigate the potential availability of aerosol-derived dissolved OC (DOC) to marine heterotrophic prokaryotes. For this purpose, experimental biodegradation assays of DOC derived from Saharan dust and anthropogenic aerosol by marine heterotrophic prokaryotes were conducted. A third treatment amended with glucose (as labile C source) and a control treatment (no added C) were run in parallel. All incubations were run in triplicate, in the dark at controlled temperature, during 16 days. An increase in both heterotrophic prokaryote production (HPP) and abundance (HPAA) was observed following dust (D) anthropogenic (A) and glucose (G) amendments. At the end of the exponential growth phase, the increase in BA was in the same order of magnitude in the G and D treatments and lower in the A treatment (Fig. 1). Growth rate (μ, d⁻¹) and BP integrated over the exponential growth phase was highest in the G treatment, followed by D and then by A. Over the incubation period, the decrease in DOC was highest in G treatment (46 ± 7%), followed by the D-treatment (26 ± 2%) and then by the A-treatment (15 ± 5%). Bacterial growth efficiency (BGE) in the D-treatment (13 ± 4%) was similar to that of the G-treatment (9 ± 3%). In contrast, the BGE in the A-treatment was low (2 ± 1%), suggesting that most labile DOC was catabolized. These results constitute the first experimental evidence that atmospheric deposition is a source of bioavailable organic carbon to the surface ocean. Moreover, the degree of bioavailability depends on the aerosol origin: OC derived from Saharan dust shows a higher bioavailability and can potentially sustain a higher production of bacterial biomass than OC derived from anthropogenic aerosols.

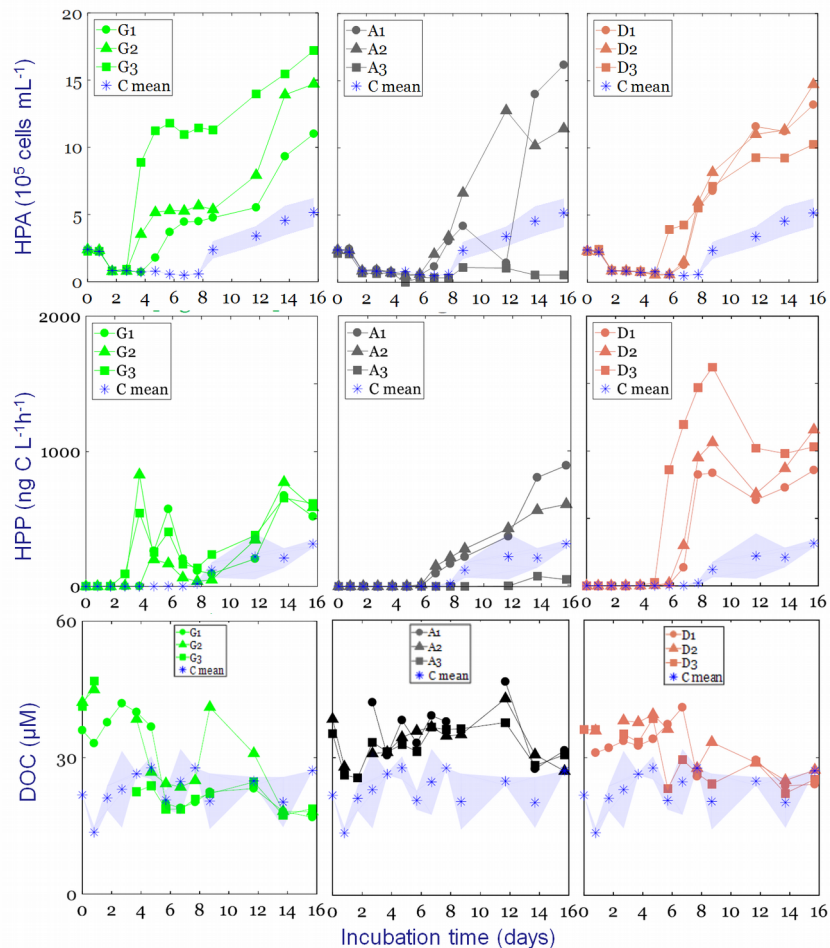


Figure: Evolution over incubation time of heterotrophic prokaryote abundance (HPA, 10^5 cells mL^{-1}), heterotrophic prokaryote production (HPP, $\text{ng C L}^{-1} \text{h}^{-1}$) and concentration of dissolved organic carbon (DOC, μM) in triplicate bottles of each experimental treatment (glucose - green plots, anthropogenic aerosols – grey plots and Saharan aerosols – brown plots). The blue plot represents the control treatment (mean \pm SD of three replicates).

Characterisation of aerosol provenance from the fractional solubility of Fe (Al, Ti, Mn, Co, Ni, Cu, Zn, Cd and Pb) in North Atlantic aerosols (Topic 3)

Shelley Rachel, William Landing, Simon Ussher, Helene Planquette, and Geraldine Sarthou (LEMAR)

The fractional solubility of aerosol-derived trace elements deposited to the ocean surface is a key parameter of many marine biogeochemical models. Yet, it is currently poorly constrained, in part due to the complex interplay between the various processes that govern the solubilisation of aerosol trace elements. In this study, we used a sequential two-stage leach to investigate the fractional solubility of a suite of aerosol trace elements (Al, Ti, Fe, Mn, Co, Ni, Cu, Zn, Cd and Pb) from samples collected during three GEOTRACES cruises to the North Atlantic Ocean. Regardless of the leaching protocol used (mild versus strong leach), the same trends were observed. These were that trace elements from aerosols from 1) North Africa were always the least soluble, and the most homogeneous (e.g. Fe was $0.36 \pm 0.12\%$ and $6.0 \pm 1.0\%$ soluble in North African and $6.5 \pm 5.5\%$ and $17 \pm 11\%$ soluble in non-African aerosols following leaches with ultra-high purity water, and 25% acetic acid, respectively), 2) aerosols from the most remote locations were generally the most soluble, but had the most spread in the values of fractional solubility and 3) primarily pollution-derived TEs (Ni, Cu, Zn, Cd and Pb) were significantly enriched above crustal values in aerosols, even in samples of North African origin. We present aerosol trace element solubility data from two sequential leaches that provides a "solubility window", covering a conservative, lower limit to an upper limit, the maximum potentially soluble fraction, and demonstrate why this lower limit of solubility may underestimate aerosol TE solubility in some regions. The leaching technique that yields the upper limit can also be used to estimate trace element solubility from suspended

particulate matter (SPM). Therefore, facilitating direct comparison with SPM leached using the same technique, thereby introducing some degree of standardisation between aerosol and SPM trace element solubility studies which may help inform of in-water processes that modify the solubility, and thus bioavailability, of atmospheric particles following deposition to the surface ocean.

See:

Shelley Rachel, William Landing, Simon Ussher, Helene Planquette, and Geraldine Sarthou, Characterisation of aerosol provenance from the fractional solubility of Fe (Al, Ti, Mn, Co, Ni, Cu, Zn, Cd and Pb) in North Atlantic aerosols (GEOTRACES cruises GA01 and GA03) using a two stage leach. This article is accepted for publication in Biogeosciences, <https://doi.org/10.5194/bg-2017-415>

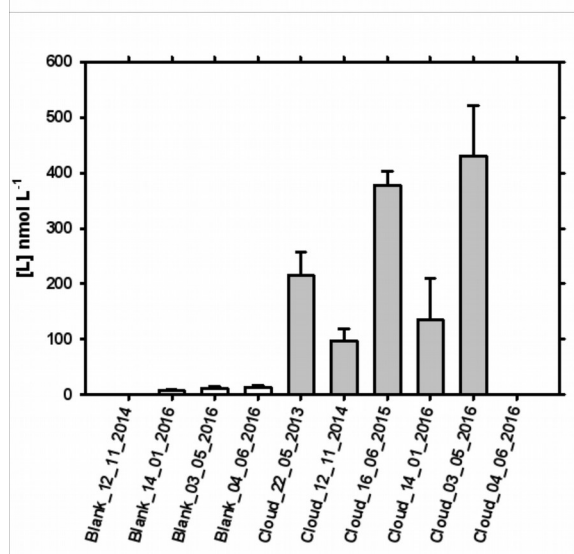
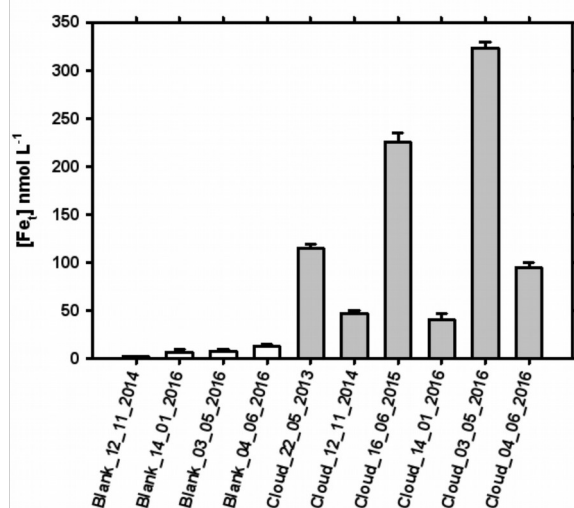
International Conference on Atmospheric Chemical and Biological Processes: Interactions and Impacts (ATMOCHEMBIO), 19-21 June 2017, in Clermont-Ferrand (<https://atmochembio.sciencesconf.org/>)

Scientific committee: Dr. Pierre AMATO, ICCF, France, Dr. Marcello BRIGANTE, ICCF, France, Dr. Laurent DEGUILLAUME, LaMP, France, Dr. Anne-Marie DELORT, ICCF, France, Dr. Janine FROHLICH, Max Planck Institute for Chemistry, Germany, Dr. Christian GEORGE, IRCELYON, France, Pr. Frank KEPPLER, Germany, Dr. Gilles MAILHOT, ICCF, France, Dr. Cindy E. MORRIS, Plant Pathology Research Unit, France, Dr. Géraldine SARTHOU, LEMAR, France, Dr. Virginie VINATIER, ICCF, France, Pr. Davide VIONE, Turin, Italy

Iron Organic Complexation In Cloud Water Samples From The Puy De Dôme Station (France) (Topic 3)

J. Boutorh, G. Sarthou, A.G. Gonzalez, M. Cheize, H. Planquette, E. Bucciarelli, Mickaël Vaïtilingom, Laurent Deguillaume, Virginie Vinatier, Anne-Marie Delort, G. Mailhot.

Iron (Fe) is a key nutrient for all microorganisms, being involved in many metabolic processes [1]. Recent studies evidenced the impact of organic ligands on Fe speciation and solubility in aerosol rainwater, and cloudwater samples (e.g. [2-5]). It was also demonstrated that Fe complexation with organic ligands increases the photochemical efficiency (OH radical formation) and the Fe stabilization ([6,7]). However, so far, the exact nature, role and sources of Fe binding ligands in the atmosphere are still largely unknown. One hypothesis is that the production of Fe-specific organic ligands by atmospheric bacteria could play a key role on the Fe organic speciation. To test this hypothesis, we first adapted to cloudwater samples a competitive ligand exchange-adsorptive cathodic stripping voltammetry method (CLE-ACSV) recently developed for rainwater samples ([3]). The method was validated with artificial matrices containing model Fe ligands (pyoverdine, oxalate, and ethylenediamine-N,N'-disuccinic acid - EDDS), at three different pH (6.00, 5.65, and 5.37). Although the sensitivity was sufficiently high for the three pH values, the detection limits were much higher for the two lowest pH values (~ 0.3 nM) compared to the one at pH 6 (0.05 nM). We then analysed six natural cloudwater samples collected at the Puy de Dôme station (France) at pH 6. Total Fe concentrations measured by SF-ICP-MS varied between 40 and 226 nM (Figure a).



(a) (b)

Figure: Total Fe (a) and Fe-binding ligand (b) concentrations in blanks and in cloud water samples collected at the Puy de Dôme station.

Results clearly evidenced the presence of Fe-binding ligands in excess to the total Fe concentration in five of the cloudwater samples (Figure b). The excess Fe-binding ligand concentrations ranged from 80 to more than 400 nM.

Our results showed, for the first time, that Fe present in cloudwater could be bound to organic ligands, with conditional stability constants close to the pyoverdine, a siderophore excreted by bacteria. These results are consistent with the potential production of siderophores by cloud microorganisms ([5]). Iron complexation by siderophores could have a significant impact on the cloud chemistry and its oxidant capacity ([8]), as well as on the global Fe biogeochemical cycle.

References

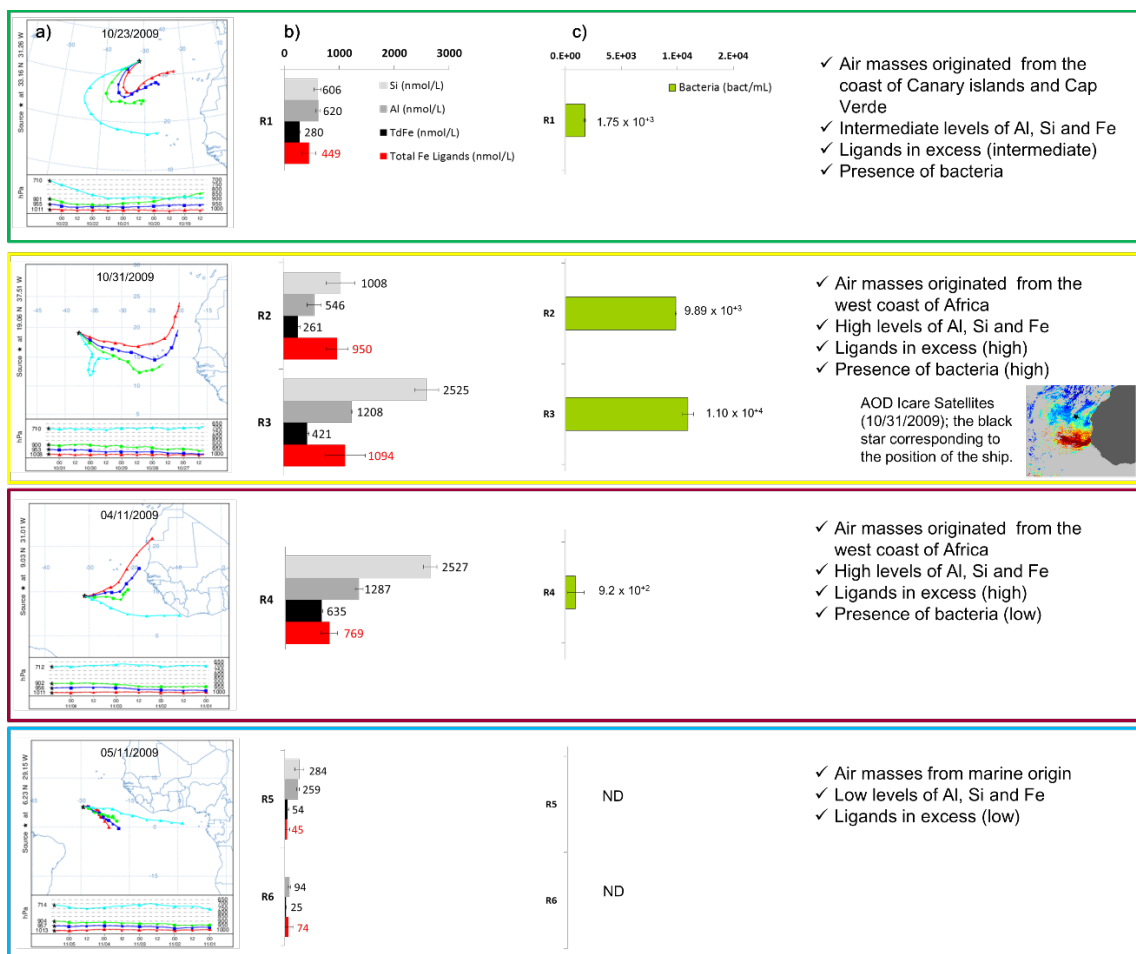
- [1] Morel et al., Science, 2003, 300(5621): 944 - 947, DOI:10.1126/science.1083545.
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See:

J. Boutorh, G. Sarthou, A.G. Gonzalez, M. Cheize, H. Planquette, E. Bucciarelli, Mickaël

A potential source of Fe binding organic ligands to the surface ocean from wet deposition. **(Topic 3)**

Iron (Fe) is an essential micronutrient for all marine organisms. More than 99% of Fe (III) is bound to natural organic ligands in seawater. One of the main inputs of iron to the surface open ocean is dry and wet aerosol deposition. We measured for the first time Fe organic speciation by voltammetry (CLE-ACSV) in seven rainwater samples collected over the Eastern Tropical North Atlantic Ocean during the AMT 19 Cruise (2009) (Figure). The potential involvement of bioaerosols on Fe organic speciation in wet deposition was also investigated.



In these rainwaters, concentrations of total dissolvable Fe (unfiltered) ranged from 25 nM to 635 nM, while concentrations of Fe organic ligands varied between 40 and 1100 nM. Conditional stability constants were characteristic of strong Fe-binding ligands ($\sim 10^{22} \text{ M}^{-1}$). The highest Fe and organic ligand concentrations were associated with the highest aluminium and silicon concentrations from a Saharan dust wet deposition event. Genomic approach revealed the presence of bacteria and yeast in the rainwater events. Their capacity to produce siderophores was tested, highlighting their ability to produce strong Fe specific organic ligands in different environmental conditions including in salty, nutrient rich and depleted media. This suggests that bioaerosols may be a source of Fe organic ligands to the open ocean that has not been considered yet. Preliminary global modeling experiments will also be discussed in terms of

potential atmospheric input of Fe organic ligands to the surface of the ocean.
Presentations in international conferences

See:

Boutorh J., G. Sarthou, A.G. Gonzalez, M. Cheize, H. Planquette, E. Bucciarelli, Mickaël Vaïtilingom, Laurent Deguillaume, Virginie Vinatier, Anne-Marie Delort, G. Mailhot, Iron Organic Complexation In Cloud Water Samples From The Puy De Dôme Station (France). ATMOCHEMBIO meeting (19-June 2017, Clermont-Ferrand)

Cheize M., A.C. Baudoux, E. Bucciarelli, A. Tagliabue, K. Desboeufs, A.R. Baker, G. Sarthou, A potential source of Fe binding organic ligands to the surface ocean from wet deposition. ATMOCHEMBIO meeting (19-June 2017, Clermont-Ferrand)

Time series: Seasonality of Saharan Dust deposition over the Caribbeans (Topic 3)

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North Africa is the largest dust source area in the world, accounting for 55% of global continental dust emission (Ginoux et al., 2012, doi.org/10.1029/2012RG000388). These dusts can impact the Atlantic and Caribbean regions (Prospero et al., 1970, 10.1016/0012-821X(70)90039-7) and is important nutrition source for local ecosystem (Muhs et al., 1990, USGS 33, 157-177). La Guadeloupe island is subjected to frequent North African dust inputs. Fore coming climate change will certainly disturb the intensity and transportation patterns of North African dust revealing a strong necessity of a better knowledge of the dynamic of dust deposition in tropical regions. A continuous atmospheric deposition sampling is already operated from two years at La Guadeloupe (15°58'50" N, 61°42'13" W) and the temporal variation of the dust deposition flux over this period is calculated. The purpose of this study is to understand and quantify the atmospheric deposition of nutrients in North Tropical West Atlantic.

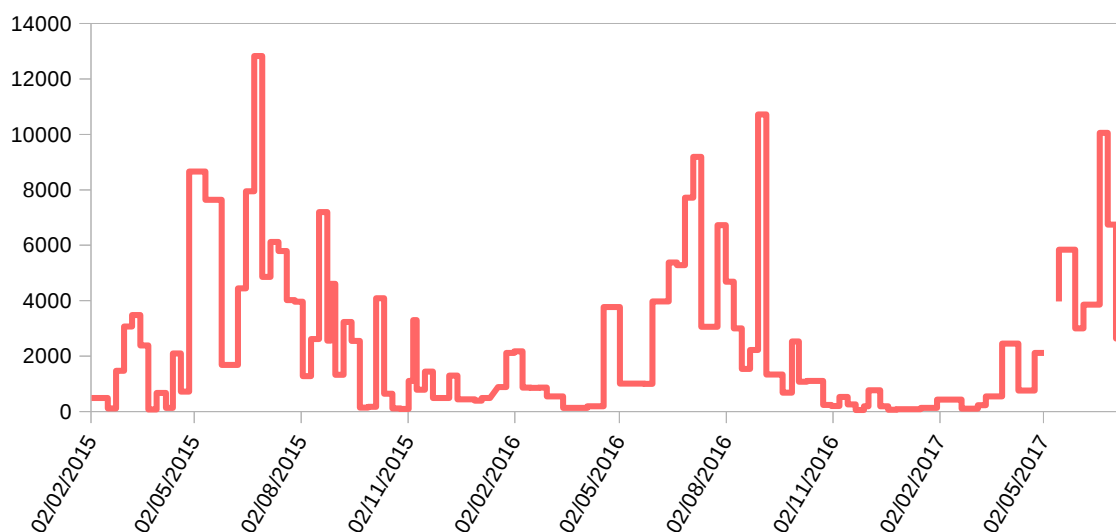


Figure: Aluminium deposition flux in $\mu\text{g}/\text{m}^2/\text{day}$ on La Guadeloupe Island.

Marine Aerosol impact on Clouds in the Arctic (MACA): Mesocosm experiments in Ny-Aesund, Svalbard (Topic 4)

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The objective of the MACA project, funded by IPEV and the Pollution in the Arctic System project (PARCS), is to identify marine sources of ice nuclei and cloud condensation nuclei in the Arctic atmosphere (Svalbard), their relationship to marine biogeochemical properties of the seawater, and the influence of atmospheric pollutant inputs to the seawater. It is an interdisciplinary project bringing together physicists, chemists and biologists from the atmosphere, as well as chemists and marine biologists. From 27 February to 27 March 2017, 3 mesocosms were deployed in the Ny-Alesund waters, to study sea-to-air exchanges. One mesocosm remained unchanged while the other two were modified with the introduction of air pollutants (sulphate, ammonia, nitrate) at representative concentrations of the maximum atmospheric concentrations measured in the Svalbard fresh snow. The atmospheric composition of the mesocosms headspace was

continuously monitored by instrumentation to characterize the physical (size distribution and concentration) and chemical properties of the particles formed from the gases emitted from the surface of the seawater. In parallel, the water of mesocosms was sampled daily in order to analyze the chemical and biological composition (Nutrients, Pigments, Chla, DOC, identification of phytoplankton species, bacteria and viruses ..) on the seawater, and the physical and chemical properties of seaspray generated via a bubble bursting system. Sea spray properties were characterized for its physical properties (size distribution and concentration), chemical composition (online concentrations by mass spectrometry, collection of aerosols on impaction supports), and hygroscopic (CCN and IN) properties.



MACA participants from left to right : Karine Sellegri (LaMP), David Picard (LaMP), Alessia Nicosia (LaMP), Sebastien Mas (U. Montpellier), Barbara D'Anna (IrceLyon now at LCE-AMU), Remy Vades (U. Montpellier), Paolo Villani (LaMP) and Clémence Rose (U. Hesinki). Marc Mallet (IrceLyon now at LISA) taking the picture.

3. Top 5 publications in 2017 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

For journal articles please follow the format:

Author list (surname and initials, one space but no full stops between initials), year of publication, article title, full title of journal (italics), volume, page numbers, DOI.

Djaoudi, K., Van Wambeke, F., Barani, A., Hélias-Nunige, S., Sempéré, R., Pulido-Villena, E. (2017). Atmospheric fluxes of soluble organic C, N, and P to the Mediterranean Sea: potential biogeochemical implications in the surface layer. *Progress in Oceanography*, doi:10.1016/j.pocean.2017.07.008.

Fröb, K., A. Olsen, M. Becker, L. Chafik, T. Johannesen, G. Reverdin et A. Omar. Impact of recent North Atlantic freshening and cooling on the carbon cycle. *Geophys. Res. Lett.*, in review.

Gazeau F., Sallon A., Pitta P., Tsiola A., L. Maugendre, M. Giani, M. Celussi, Pedrotti ML, Marro S., Guieu C., Limited impact of ocean acidification on phytoplankton community structure in an oligotrophic environment: results from two mesocosm studies in the Mediterranean Sea, *Estuarine, Coastal and Shelf Science* 186, 72-88, 2017.

Gazeau, F., Sallon, A., Maugendre, L., Louis, J., Dellisanti, W., Gaubert, M., Lejeune, P., Gobert, S., A.V. Borges, J. Harlay, W. Champenois, Alliouane, S., Taillandier, V., Louis, F., Obolensky, G., Grisoni, J.-M., and Guieu, C., First mesocosm experiments to study the impacts of ocean acidification on plankton communities in the NW Mediterranean Sea (MedSeA project), *Estuarine, Coastal and Shelf Science* 186, 11-29, 2017.

Louis J, F Gazeau, C Guieu, Atmospheric nutrients in seawater under current and high pCO₂ conditions after Saharan dust deposition: Results from three minicosm experiments, *Progress in Oceanography*, 2017 (in press)

Louis J, ML Pedrotti, F Gazeau, C Guieu, Experimental evidence of formation of Transparent Exopolymer Particles (TEP) and POC export provoked by dust addition under current and high pCO₂ conditions, *PloS one* 12 (2), e0171980

Louis J., Guieu C. and Gazeau F., Nutrient dynamics under different ocean acidification scenarios in a low nutrient low chlorophyll system : the Northwestern Mediterranean Sea, *Estuarine, Coastal and Shelf Science* 186, 30-44, 2017.

Maugendre L., J.-P. Gattuso, A. J. Poulton, W. Dellisanti, M. Gaubert, C. Guieu and F. Gazeau, No detectable effect of ocean acidification on plankton metabolism in the NW oligotrophic Mediterranean Sea: Results from two mesocosm studies, *Estuarine, Coastal and Shelf Science* 186, 89-99, 2017.

Maugendre, L., Guieu, C., Gattuso, J. P., & Gazeau, F., Ocean acidification in the Mediterranean Sea: Pelagic mesocosm experiments. A synthesis, *Estuarine, Coastal and Shelf Science*, <http://dx.doi.org/10.1016/j.ecss.2017.01.006>, 2017.

Reverdin, G. et al.. SURATLANT: a 1993-2017 surface sampling in the central part of the North Atlantic subpolar gyre. *ESSD*, in review.

Richon C, Dutay JC, Dulac F., Wang R., Balkanski Y., Nabat P., Aumont O., Desboeufs K., Laurent B., Guieu C., Raimbault P., Beuvier J., *Progress in Oceanography*, 2017, in press

Shelley Rachel, William Landing, Simon Ussher, Helene Planquette, and Geraldine Sarthou, Characterisation of aerosol provenance from the fractional solubility of Fe (Al, Ti, Mn, Co, Ni, Cu, Zn, Cd and Pb) in North Atlantic aerosols (GEOTRACES cruises GA01 and GA03) using a two stage leach, Accepted for publication in *Biogeosciences*, <https://doi.org/10.5194/bg-2017-415>

4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2017? If yes, who? How did you engage?

PART 2 - Planned activities for 2018/2019 and 2020
1. Planned major field studies and collaborative laboratory and modelling studies, national and international (incl. all information possible, dates, locations, teams, work, etc.).
2. Events like conferences, workshops, meetings, schools, capacity building etc. (incl. all information possible).
3. Funded national and international projects / activities underway.
4. Plans / ideas for future projects, programmes, proposals national or international etc. (please indicate the funding agencies and potential submission dates).

Gilles Reverdin

2018: projects

We will work on one hand to provide a synthesis of surface isotopic data in the southern ocean in early 2017, and use it (collaboration with Haumann) to better constrain E-P fluxes in the southern ocean. Plans for a future expedition in the Weddell Sea (WAPITI2) are ongoing, but it not yet clear whether the expedition will take place in early 2019 or early 2020.

We will also work with the SURATLANT and OISO data together with recent updates of the SOCAT and GLODAP data bases, and recent pH biogeochemical floats, in particular in the southern ocean in order to reconstruct recent (last 10-20 years) variability in the Indian Ocean sector of the southern ocean and in the central sub-polar North Atlantic (nutrients, DIC, AT, $\delta^{13}\text{C}_{\text{DIC}}$), and to relate it to major climate variability modes and to anthropogenic changes.

5. Engagements with other international projects, organisations, programmes etc.

Comments