surface ocean solas lower atmosphere study

Report for the year 2017 and future activities

SOLAS *'Germany'*
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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

Biogenic contribution to submicron marine aerosol particles

SOLAS 2015-2025 Science Plan Theme 4: Interconnections between aerosols, clouds, and marine ecosystsems

The export of organic matter from ocean to atmosphere represents a substantial carbon flux in the Earth system, yet the impact of environmental drivers on this transfer is not fully understood. Here we show that organic carbon concentration and enrichment in seawater (bulk water and the sea surface microlayer; SML) tended to be relatively uniform across the North and Central Atlantic Ocean. However, the organic carbon levels observed in submicron aerosol particles were significantly affected by varying levels of chlorophyll-a (chl-a). On the basis of the present ambient concerted measurements, enrichment factors for organic carbon in ambient marine aerosol particles, hitherto not reported in the literature, were obtained. The results obtained in the present study support the thesis that elevated local biological activity (as indicated by chl-a concentrations) enhances (primary) organic carbon concentration on aerosol particles. However, a prediction of the organic carbon measurement results (transferred to $OMss_A$) by source functions based on wind

speed and chl-a levels showed a strong underestimation of $OMss_A$ in oligotrophic regions, especially at high wind speeds. For the North and Central Atlantic Ocean there may be additional parameters – either connected to biological factors not served by chl-a level as an indicator or to factors of a different nature – that must be taken into consideration in order to accurately predict the organic fractions on aerosol particles.

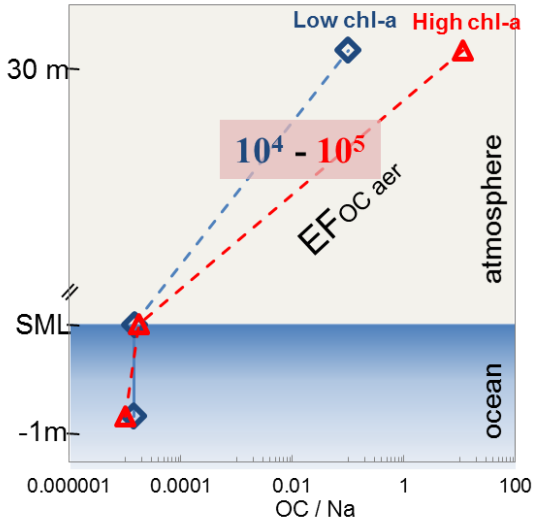

Fig 1: The enrichment of organic carbon in the SML and in aerosol particles: Comparison of the seawater and aerosol ratios of OC to sodium (Na+) to illustrate their enrichments in SML and aerosol particles at different chl-a conditions.

Citation: *van Pinxteren, M., Barthel, S., Fomba, K., Müller, K., von Tümpling, W., and Herrmann, H.: The influence of environmental drivers on the enrichment of organic carbon in the sea surface microlayer and in submicron aerosol particles – measurements from the Atlantic Ocean, Elem Sci Anth, 5, https://doi.org/10.1525/elementa.225, (2017)*

Oceanic nitrogen cycling and N_2O flux perturbations in the Anthropocene

SOLAS 2015-2025 Science Plan Theme 3: Atmospheric deposition and ocean biogeochemistry

Anthropogenic changes in ocean warming, deoxygenation, and atmospheric N deposition can all individually affect the marine N cycle and the oceanic production of the greenhouse gas nitrous oxide (N_2O). However, the combined effect of these perturbations on marine N cycling, ocean productivity, and marine N_2O production is poorly understood. We used an Earth system model of intermediate complexity to investigate the combined effects of estimated 21st century CO_2 atmospheric forcing and atmospheric N deposition. Our simulations suggest that anthropogenic perturbations cause only a small imbalance to the N cycle relative to preindustrial conditions (~+5 $TgNy^{-1}$ in 2100). More N loss from water column denitrification in expanded oxygen minimum zones (OMZs) is counteracted by less benthic denitrification, due to the stratification-induced reduction in organic matter export. The larger atmospheric N load is offset by reduced N inputs by marine N_2 fixation. Our model predicts a decline in oceanic N_2O emissions by 2100. This is induced by the decrease in organic matter export and associated N_2O production and by the anthropogenically driven changes in ocean circulation and atmospheric N_2O concentrations.

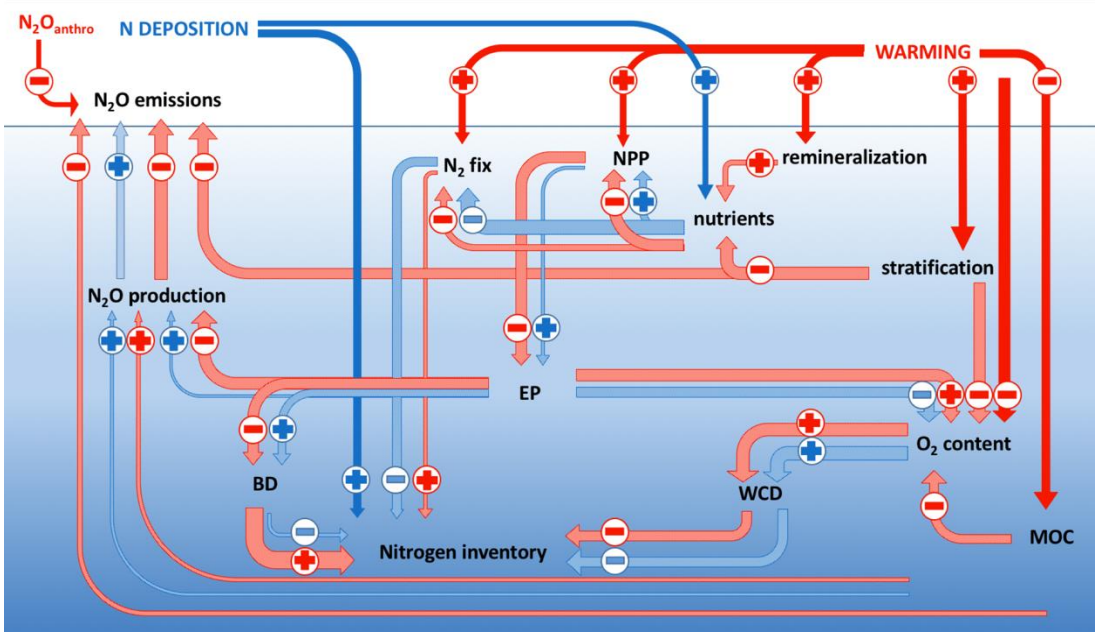

Fig. 2 Schematic of the biogeochemical feedbacks and their sign of change associated with warming and increased N deposition. Solid lines represent direct effects, light-colored lines represent indirect effects. Thickness of the lines represent, in a semiquantitative way, the intensity of the perturbation.

Landolfi, A., et al., (2017), Oceanic nitrogen cycling and N_2O flux perturbations in the Anthropocene, Global Biogeochem. Cycles, 31, 1236–1255, doi:10.1002/2017GB005633.

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).

MarParCloud / MARSU campaign at the CVAO; Investigation of organic matter in the marine environment, characterization of the processes of organic matter from the (biological) formation in seawater, enrichment in the sea surface microlayer, transfer to aerosol particles and function as INP, turbulence measurements in the marine boundary layer, Activities: sampling of bulk water, sea surface microlayer (glass plate, catamaran), aerosol particles (bulk and size resolved), ice nucleating particles, cloud water on the Mt. Verde, helikite studies, Tank studies for investigation of organic matter transfer under controlled bubble bursting conditions, Dates: 18.09.2017-13.10.2018 at the CVAO and OSCM in Mindelo, Team: TROPOS, ICMB Wilhelmshaven, IOW, ZMT, CNRS-IRCELYON, CNRS-ICARE, Univ. Fudan. Theme 4

Time series of aerosol chemical composition at the CVAO: Continuous characterisation of the chemical and physical properties of mineral dust and marine aerosol particles at the CVAO was performed. This ongoing task helps provide a consistent time series of the chemical components of the aerosol particles in this region of the Atlantic. Investigations of dust chemical composition and provenance, dust deposition, sea salt content as well as aerosol source apportionment were carried out using data collected from continuous and short-term field measurements. TROPOS, Theme 4

Air quality Arabian peninsula cruise in summer 2017 (Max Planck Institute for Chemistry, Mainz): The cruise AQABA went from France to Kuwait and back, measuring concentrations of trace gases and particles both in extremely polluted marine regions (Arabian Gulf and Red Sea) and in the clean, upwelling impacted air of the northern Indian Ocean (south of Yemen and Oman). Data work-up is on-going. Themes 3 and 5

MILAN: The international and multidisciplinary project MILAN (sea-surface MIcroLAyer at Night) arose from the discussion group 'Microbial life at the air-sea interface' at the SOLAS conference 2015 lead by Christian Stolle (IOW, ICBM) and Mariana Ribas-Ribas (ICBM). MILAN addressed the impact of solar radiation on the sea surface microlayer (SML) in regulating air-sea exchange processes. In March/April 2017, Christian Stolle, Mariana Ribas-Ribas, and Oliver Wurl from the working group 'sea surfaces' welcomed 23 scientists from 8 countries at the ICBM-Terramare in Wilhelmshaven, Germany to study full diel cycles in the coastal North Sea employing diverse platforms (vessels, catamaran, free-drifting buoy, aerosol sampler). These field studies were combined with ex situ experiments using a laboratory gas exchange tank, solar simulators, a sea spray simulation chamber, and microsensor technology. MILAN collected unprecedented observation of the SML during day and night and will help to understand how diel solar radiation influences the physical and biogeochemical properties of the uppermost water column and the air-sea exchange of gases and aerosols. Themes 2 and 4

Contribution to the upcoming WMO, Ozone Assessment 2018: Birgit Quack contribution on marine halocarbons and stratospheric ozone. Theme 5

Using aerial drones for air-sea sampling: For the first time a team of scientists from GEOMAR Helmholtz Center for Ocean Research Kiel (Quack, Marandino, Fuhlbrügge, Paulsen) has successfully used a drone to collect marine air and water samples. The objective of the study was to better understand the role of coastal waters as a source of reactive trace gases. In April 2017, a DJI Matrice 600 drone was used to take water and air samples on the west coast of the island of Sylt during variable weather conditions with wind speeds of more than 10 m/s, where the drone proved to be very good. Both horizontal (500m) and vertical profiles (100m) were flown from the shore line to take the samples. The gas exchange between ocean and atmosphere is enhanced by wave breaking, which was detectable via whitecap coverage. The air samples were analyzed for more than 50 trace gases including halocarbons (e.g. bromoform, dimethylbromide, methyl iodide), non-methane hydrocarbons (e.g. isoprene), and sulfur containing compounds (e.g. dimethyl sulfide by Elliot Atlas at RSMAS, University of Miami). First results show, that natural halocarbon concentrations (methyl iodide, bromoform and dibromomethane) decreased in water across the surf zone towards the coast and also with height in the atmosphere. Horizontal gradients in the atmosphere were dominated by the origin of air masses and showed relative concentration variations over time, influenced by rain events, while a horizontal gradient across the surfzone was absent, but concentrations varied between the different sampling days. Theme 5

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

Engel, A, Bange, H W Cunliffe, M, Burrows, S M, Friedrichs, G, Galgani, L, Herrmann, H, Hertkorn, N, Johnson, M, Liss, P, Quinn, P, Schartau, M, Soloviev, A, Stolle, C, Upstill-Goddard, R, van Pinxteren, M, and Zaencker, B, 2017, The ocean's vital skin: Towards an integrated understanding of the sea surface microlayer, *Frontiers in Marine Science,* DOI: 10.3389/fmars.2017.00165.

Rahlff, J, Stolle, C, Giebel H-A, Brinkhoff, T, Ribas Ribas, M, Hodapp, D, and Wurl, O, 2017, High wind speeds prevent formation of a distinct bacterioneuston community in the sea-surface microlayer, *FEMS Microbiology Ecology,* DOI: https://doi.org/10.1093/femsec/fix041.

Ribas Ribas, M, Mustaffa, N I H, Rahlff, J, Stolle, C, an d Wurl, O, 2017, Sea Surface Scanner (S3): A catamaran for high-resolution measurements of biogeochemical properties of the sea surface microlayer, *Journal of atmospheric and oceanic technology*, DOI: 10.1175/JTECH-D-17-0017.1.

Schlundt, C., Tegtmeier, S., Lennartz, S. T., Bracher, A., Cheah, W., Krüger, K., Quack, B., and Marandino, C. A., 2017, Oxygenated volatile organic carbon in the western Pacific convective center: ocean cycling, air–sea gas exchange and atmospheric transport, *Atmospheric Chemistry and Physics*, 17, pp. 10837-10854, https://doi.org/10.5194/acp-17-10837-2017.

Ziska, F., Quack, B., Tegtmeier, S. Stemmler, I., and Krüger K., 2017, Future emissions of marine halogenated very-short lived substances under climate change, Journal of Atmospheric Chemistry, 74, p. 245, https://doi.org/10.1007/s10874-016-9355-3.

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?

The full SOLAS Science and Society group (interdisciplinary group, including lawyers and economists, which met in Brussels in 2016 and is lead by Christa Marandino and Erik van Doorn, both from Kiel) submitted a manuscript to Ambio that is now being revised. The subgroup on shipping had their paper accepted to a Frontiers journal. The subgroups on carbon and on air-sea policy met in Monaco and Rome, respectively, to work on their papers. These papers are still in preparation.

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.).

1) PHOSDMAP campaigns: 01.06 – 22.06.2018: Cape Verde (CVAO) and 29.04 -15.05.18, Namibia (Gobabeb).Investigation of phosphorus, iron and carbon content in size-resolved marine aerosol particles. Team: TROPOS, INMG, Gobabeb, MPI jena. Activities: Sampling of bulk and size-resolved aerosol particles.
2) Cruise Baltic Sea May/June 2018 (lead: Christian Stolle – IOW/ICBM) in frame of SAW-project MarParCloud and ERC-starting grant PASSME to explore the relation between SML variability, CO_2 gas-exchange and organic composition of aerosols in the Baltic Sea. Participating institutes: IOW, ICBM, TROPOS, ZMT, Uni Stockholm
3) Birgit Quack (GEOMAR) - Investigation of halocarbon as tracer substances for natural and anthropogenic island effects, how far does the anthropogenic imprint reaches into the open ocean in water and atmosphere
4) As the Northern Indian Ocean was identified as a region where future N_2O emissions might be highly impacted by changing nutrients, A. Landolfi (GEOMAR) is contributing towards an on-going analysis to better assess the N_2O regional susceptibility (Suntharalingam et al., in prep.).
5) A. Landolfi (GEOMAR) is contributing with model output towards an international effort to develop a Global Nitrous Oxide (N_2O) Budget to provide best estimates of the current global N_2O budget, with the option to update it at regular intervals (2 – 5 years).
6) BalticGasEx cruise organized by GEOMAR, Kiel University, and US partners (David Ho – University of Hawaii, Peter Schlosser – Columbia University) in June and September, 2018 will investigate the role of natural surfactants on air-sea gas exchange. We will employ the dual tracer technique together with eddy covariance measurements of CO_2 and DMS, while sampling the SML.

2. Events like conferences, workshops, meetings, schools, capacity building etc. (incl. all information possible).

Anja Engel (co-lead together with Brian Ward, NUI Galway) and Christa Marandino (helped with organisation and leading a discussion group) from GEOMAR were involved with the SOLAS Theme 2 workshop held in Cargese, Corsica in May.

3. Funded national and international projects / activities underway.

Marine biological production, organic aerosol particles and marine clouds: a process chain (MarParCloud)	Leibniz Association SAW funding	05/2016 - 10/2019	Coordinator: TROPOS, partners: ICBM Wilhelmshaven, IOW, ZMT
Phosphorus speciation in mineral dust and marine aerosol particles (PHOSDMAP)	German research foundation (DFG)	01.01.2018-31.12.2020	Coordinator: TROPOS, partners: INMG, Gobabeb, MPI Jena
Southern ocean trace gas air-sea exchange (SO-TRASE)	Germany Ministry for Education and Research (BMBF)	1.8.2017 – 31.7.2020	GEOMAR with Chinese partners in Xiamen

4. Plans / ideas for future projects, programmes, proposals national or international etc. (please indicate the funding agencies and potential submission dates).

Birgit Quack (GEOMAR) - Natural and anthropogenic biogeochemical imprints of islands in different environments on ocean and atmosphere, air- sea fluxes (Poseidon cruise proposal)

Birgit Quack (GEOMAR) - Beneficial and deleterious effects of macro algal farming around islands and polluted environments in different latitudes, biodiversity, mitigation of pollution, climate change, erosion, etc., air- sea fluxes (potential EU proposal)

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

Comments