surface ocean solas lower atmosphere study

Report for the year 2018 and future activities

SOLAS *'The Netherlands'*
compiled by: 'Jacqueline Stefels & Jan-Berend Stuut'

This report has two parts:

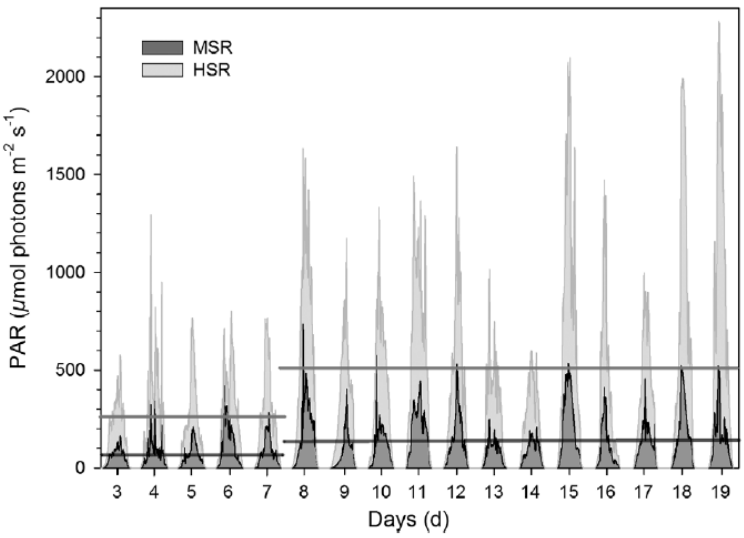
- Part 1: *reporting of activities in the period of January 2018 – Jan-Feb 2019*
- Part 2: *reporting on planned activities for 2019/2020 and 2021.*

PART 1 - Activities from January 2018 to Jan/Feb 2019

1. Scientific highlights

Highlight I (Theme I) **CO_2 and light effects on Antarctic phytoplankton**

To assess the potential for future biological CO_2 sequestration around the Western Antarctic Peninsula, a natural phytoplankton assemblage from Ryder Bay, was incubated under a range of pCO_2 levels (180 µatm, 450 µatm, and 1000 µatm) combined with either moderate or high natural solar radiation (MSR: 124 µmol photons m^{-2} s^{-1} and HSR: 435 µmol photons m^{-2} s^{-1}, respectively). The initial and final phytoplankton communities were numerically dominated by the *prymnesiophyte Phaeocystis antarctica*, with the single cells initially being predominant and solitary and colonial cells reaching similar high abundances by the end. Only when communities were grown under ambient pCO_2 in conjunction with HSR did the small diatom *Fragilariopsis pseudonana* outcompete *P. antarctica* at the end of the experiment. Such positive light-dependent growth response of the diatom was, however, dampened by OA. These changes in community composition were caused by an enhanced photosensitivity of diatoms, especially *F. pseudonana*, under OA and HSR, reducing thereby their competitiveness toward *P. antarctica*. Moreover, community primary production (PP) of all treatments yielded similar high rates at the start and the end of the experiment, but with the main contributors shifting from initially large to small cells toward the end. Even though community PP of Ryder Bay phytoplankton was insensitive to the changes in light and CO_2 availability, the observed size-dependent shift in productivity could, however, weaken the biological CO_2 sequestration potential of this region in the future.



Two outdoor incubators were covered with ~30% and ~10% neutral density light filters generating two distinct light conditions of MSR and HSR. Lines indicate the mean daily irradiances over the two experimental phases of the MSR treatment in black and for the HSR treatment in dark gray. During the first experimental phase, which lasted until day 7, MSR and HSR treatments were exposed to a lower daily irradiance than after day 7.

Citation: **Impact of ocean acidification and high solar radiation on productivity and species composition of a late summer phytoplankton community of the coastal Western Antarctic Peninsula**
Heiden, J P; Völkner, C; Jones, E M; Van de Poll, W H; Buma, A G J; Meredith, M P; De Baar, H J W; Bischof, K; Wolf-Gladrow, D; Trimborn, S 2019 *Limnology & Oceanography* 9999, 1-21 doi:10.1002/lno11147

Highlight II (Integrated) **Temporal & spatial variability of glacial meltwater effects on phytoplankton**
Glacial meltwater discharge in fjords on the west coast of Spitsbergen is increasing due to climate change. The influence of this discharge on phytoplankton nutrient limitation, composition, productivity and photophysiology was investigated in central (M) and inner (G) Kongsfjorden (79°N, 11°40'E). Freshwater influx intensified stratification during June 2015, coinciding with surface nutrient depletion. Surface nutrient concentrations were negatively correlated with stratification strength at station M. Here, nitrate addition assays revealed increasing N limitation of surface phytoplankton during the second half of June, which was followed by a pronounced compositional change within the flagellate-dominated phytoplankton community as dictyochophytes (85% of chl a) were replaced with smaller haptophytes (up to 60% of chlorophyll a) and prasinophytes (20% of chlorophyll a). These changes were less pronounced at station G, where surface phosphate, ammonium and nitrate concentrations were occasionally higher, and correlated with wind direction, suggesting wind-mediated transport of nutrient-enriched waters to this inner location. Therefore, glacial meltwater discharge mediated nutrient enrichment in the inner fjord, and enhanced stratification in inner and central Kongsfjorden. Surface chlorophyll a and water column productivity showed 3–4-fold variability, and did not correlate with nutrient limitation, euphotic zone depth, or changed taxonomic composition. However, the maximum carbon fixation rate and photosynthetic efficiency showed weak positive correlations to prasinophyte, cryptophyte, and haptophyte chlorophyll a. The present study documented relationships between stratification, N limitation, and changed phytoplankton composition, but surface chlorophyll a concentration, phytoplankton photosynthetic characteristics, and water column productivity in Kongsfjorden appeared to be driven by mechanisms other than N limitation.

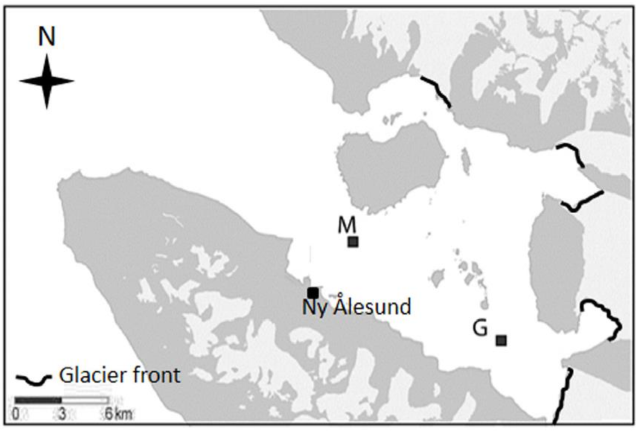
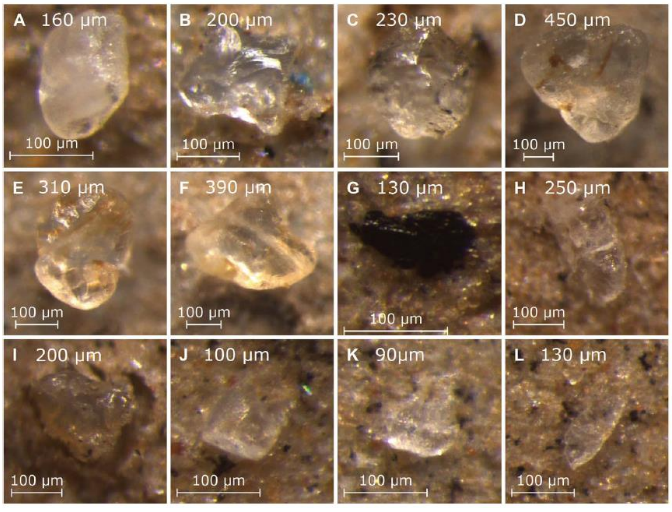


Figure 1: Map of Kongsfjorden, Spitsbergen (79°N, 11°40'E). Indicated are two stations M and G at which the experiments were carried out. doi:10.1525/elementa.307.f1

Citation: **Contrasting glacial meltwater effects on post-bloom phytoplankton on temporal and spatial scales in Kongsfjorden, Spitsbergen** Van de Poll, W H; Kulk, G; Rozema, P D; Brussaard, C P D; Visser, R J W; Buma, A G J 2018 Elementa Science of the Anthropocene 6(50) 1-13 doi:10.1525/elementa.307

Highlight III (Theme III) **'Giant' aerosol particles**
Giant mineral dust particles (>75 mm in diameter) found far from their source have long puzzled scientists. These wind-blown particles affect the atmosphere's radiation balance, clouds, and the ocean carbon cycle but are generally ignored in models. Here, we report new observations of individual giant Saharan dust particles of up to 450 mm in diameter sampled in air over the Atlantic Ocean at 2400 and 3500 km from the west African coast. Past research points to fast horizontal transport, turbulence, uplift in convective systems, and electrical levitation of particles as possible explanations for this fascinating phenomenon. We present a critical assessment of these mechanisms and propose several lines of research we deem promising to further advance our understanding and modeling.



'Giant' Saharan-dust particles sampled from the air by autonomous dust-collecting buoys at >2,500 km from the African west coast.

Citation: **The mysterious long-range transport of giant mineral dust particles** Van der Does, M; Knippertz, P;. Zschenderlein, P; Harrison, G R; Stuut, J-B W 2018, *Science Advances*, *4*(eaau2768).

Highlight IV (Environmental impacts of geoengineering) Ocean Solutions
The Paris agreement target of limiting global surface warming to 1.5-2°C compared to pre-industrial levels by 2100 will heavily impact the ocean. While ambitious mitigation and adaptation are both needed, the ocean provides major opportunities for action to reduce climate change globally and its impacts on vital ecosystems and ecosystem services. A comprehensive and systematic assessment of 13 global- and local-scale, ocean-based measures was performed to help steer the development and implementation of technologies and actions towards a sustainable outcome. We show that (1) all measures have tradeoffs and multiple criteria must be used for a comprehensive assessment of their potential, (2) greatest benefit is derived by combining global and local solutions, some of which could be implemented or scaled-up immediately, (3) some measures are too uncertain to be recommended yet, (4) political consistency must be achieved through effective cross-scale governance mechanisms, (5) scientific effort must focus on effectiveness, co-benefits, disbenefits, and costs of poorly tested as well as new and emerging measures.

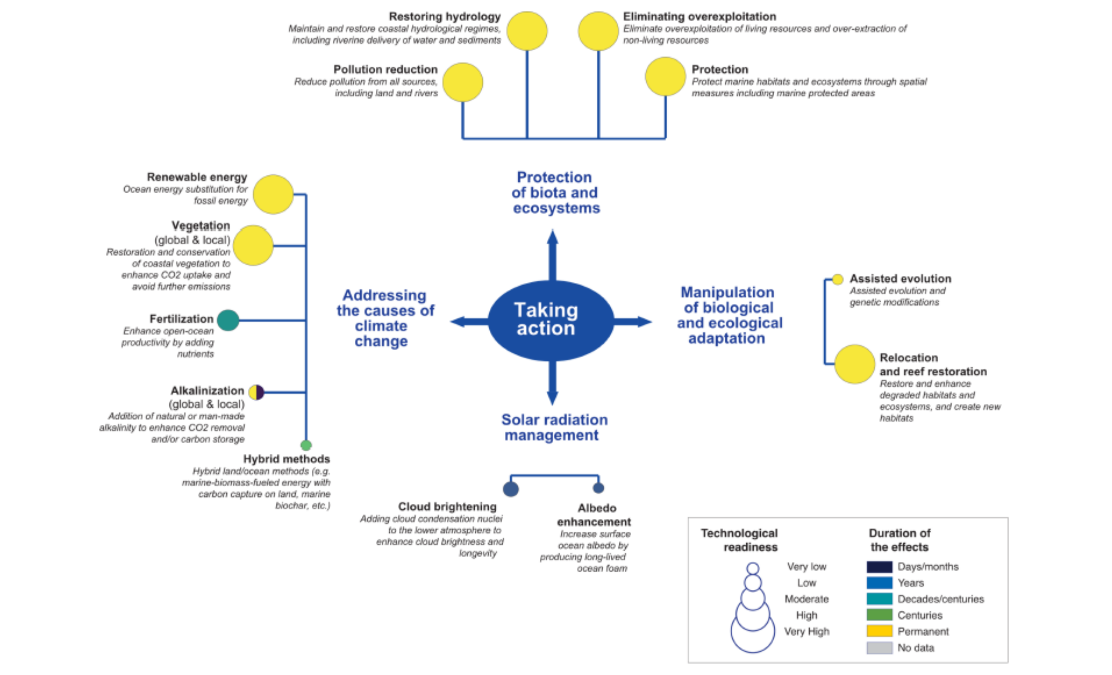


FIGURE 2 | Potential ocean solutions. Four main groups are considered: addressing the causes of climate change (i.e., reducing anthropogenic greenhouse gas emissions or increasing the long-term removal of greenhouse gases, primarily CO_2), solar radiation management, protection of biota and ecosystems (habitats, species, resources, etc.), and manipulation of biological and ecological adaptation.

Citation: **Ocean Solutions to Address Climate Change and Its Effects on Marine Ecosystems**
Gattuso, J-P, et al. 2018 Frontiers in *Marine Science 5*(337) doi:10.3389/fmars.2018.00337.

Highlight V (Theme II) Extreme spikes in DMS flux from Antarctic coastal waters
Biogenic dimethylsulfide (DMS) is a significant contributor to sulfur flux from the oceans to the atmosphere, and the most significant source of aerosol non-sea-salt sulfate ($NSS\text{-}SO_4^{2-}$), a key regulator of global climate. In Webb et al. (2019) we present the longest running time-series of DMS-water (DMS_W) concentrations in the world, obtained at the Rothera Time-Series (RaTS) station in Ryder Bay, West Antarctic Peninsula (WAP). We demonstrate the first ever evaluation of interseasonal and interannual variability in DMS_W and associated flux to the atmosphere from the Antarctic coastal zone and determine the scale and importance of the region as a significant source of DMS. Impacts of climate modes such as El Niňo/Southern Oscillation are evaluated. Maximum DMS_W concentrations occurred annually in January and were primarily associated with sea-ice break-up. These concentrations resulted in extremely high (up to 968 µmol m^{-2} d^{-1}) DMS flux over short timescales, which are not parameterised in global-scale DMS climatologies. Calculated DMS flux stayed above the aerosol nucleation threshold of 2.5 µmol m^{-2} d^{-1} for 60% of the year. Overall, using flux determinations from this study, the total flux of DMS-sulfur from the Austral Polar Province (APLR) was 1.1 Tg sulfur yr^{-1}, more than double the figure suggested by the most recent DMS climatologies.

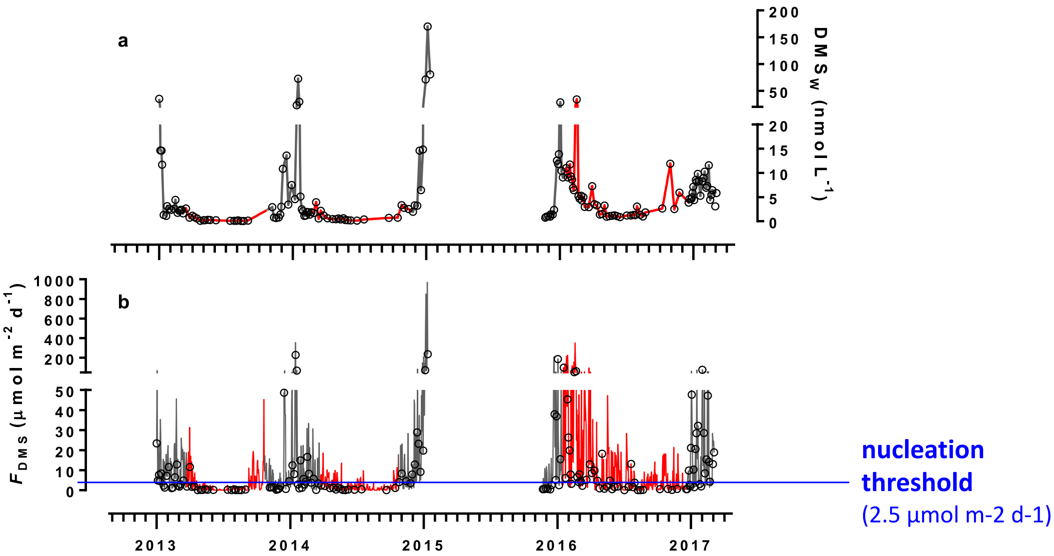


Figure. (**a**) DMS (nmol L^{-1}) over the 5-year time-series in Ryder Bay at the West Antarctic Peninsula, presented as the mean over the surface 15 m and **b)** DMS flux (µmol m^{-2} d^{-1}), calculated from DMS concentration, daily average wind speed and SST. Black solid lines represent summer (Nov–Mar) interpolated values calculated from *in-situ* measured DMS and red solid lines represent winter (Apr–Oct) interpolated values based on stored DMSPd samples analysed the following summer.

Citation: **Extreme spikes in DMS flux double estimates of biogenic sulfur export from the Antarctic coastal zone to the atmosphere** Webb, A L; Van Leeuwe, M A; Den Os, D; Meredith, M P; Venables, H J; Stefels, J 2019 *Scientific Reports* 9:2233 doi:10.1038/s41598-019-38714-4

2. Activities/main accomplishments in 2018 (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).

- RV *Pelagia* expedition 64PE443: Saharan-dust monitoring in the Mediterranean, August 2018. Chief scientist: Dr. Jan-Berend Stuut, NIOZ, the Netherlands.
- RV *Maria S. Merian* expedition MSM79: “MacPie”, a joint German-Dutch cruise studying SOLAS related process studies off the African west coast, November 2018. Chief scientist: prof Karin Zonneveld, MARUM-Bremen, Germany.
- RV *Polarstern* expedition PS117 to the Weddell and Lazarev Sea (Antarctica) December 2018 – February 2019. Chief scientist: Dr. Olaf Boebel, AWI-Bremerhaven, Germany (GEOTRACES PI: Dr. Rob Middag, NIOZ, the Netherlands)

3. Top 5 publications in 2018 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

Bitanja, R; Katsman, C; Selten, F (2018) **Increased Arctic precipitation slows down sea ice melt and surface warming** *Oceanography* 31(2) doi:10.5670/oceanog.2018.204

Kim, H; Ducklow, H W; Abele, D; Ruiz Barlett, EM; Buma, AGJ; Meredith, MP; Rozema, PD; Schofield, OM; Venables, HJ; Schloss, IR (2018) **Inter-decadal variability of phytoplankton biomass along the coastal West Antarctic Peninsula** *Philosophical Transactions of the Royal Society* 376 (2122) doi:10.1098/rsta.2017.0174.

Middelburg, J J (2019), **Marine Carbon Biogeochemistry - a primer for earth system scientists**, 118 pp., Springer, Dordrecht. doi: 10.1007/978-3-030-10822-9

Van der Does, M; Pourmand, A; Sharifi, A; Stuut, J-B W (2018), **North African mineral dust across the tropical Atlantic Ocean: Insights from dust particle size, radiogenic Sr-Nd-Hf isotopes and rare earth elements (REE)**, *Aeolian Research*, *33*, 106-116, doi:https://doi.org/10.1016/j.aeolia.2018.06.001.

Webb, A L; Van Leeuwe, M A; Den Os, D; Meredith, M P; Venables, H J; Stefels, J (2019) **Extreme spikes in DMS flux double estimates of biogenic sulfur export from the Antarctic coastal zone to the atmosphere** *Scientific Reports* 9:2233 doi:10.1038/s41598-019-38714-4

4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2018? If yes, who? How did you engage?

--

PART 2 - Planned activities for 2019/2020 and 2021

1. Planned major field studies and collaborative laboratory and modelling studies, national and international (incl. all information possible, dates, locations, teams, work, etc.).

In 2019-2020, the Netherlands will participate in the international MOSAiC campaign (***M**ultidisciplinary drifting **O**bservatory for the **S**tudy of **A**rct**ic** **C**limate*; https://www.mosaic-expedition.org) with three projects:

1. Arctic Sea Ice-Pelagic Coupling of the Carbon and Sulfur Cycles (Stefels, University of Groningen)
2. The role of sea ice in the life cycle of polar cod (Boreogadus saida) and its prey (van Franeker, Wageningen Marine research)
3. Multi-scale model analysis of Arctic surface-boundary layer exchange of climate-active trace gases and aerosol precursors (Ganzeveld, Wageningen University)

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

- Scientific session at the European Geosciences Union, Vienna, 8-12 April 2019 Dusty Session CL4.28/AS3.6/GM10.2/SSP3.25: **Aeolian dust**

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).

--

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

Comments

The SOLAS community in the Netherlands is very active on a personal basis; there are many scientists that are involved in SOLAS-related studies, without being organised as SOLAS-NL. With the installation of a new national coordinator, we strive to improve the visibility of Dutch SOLAS-related science.