

Report for the year 2017 and future activities

SOLAS New Zealand

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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

Overview of the SOAP (Surface Ocean Aerosol Processes) Campaign

Establishing the relationship between marine boundary layer (MBL) aerosols and surface water biogeochemistry is required to understand aerosol and cloud production processes over the remote ocean, and represent them more accurately in Earth System Models and global climate projections. This was addressed by the SOAP (Surface Ocean Aerosol Production) campaign, which examined air-sea interaction over biologically-productive frontal waters east of New Zealand. The Voyage overview published in 2017 details the objectives, regional context, sampling strategy, and provisional findings of a pilot study, PreSOAP, in austral summer 2011, and the following SOAP voyage in late austral summer 2012. Both voyages characterised surface water and MBL composition in three phytoplankton blooms of differing species composition and biogeochemistry, with significant regional correlation observed between chlorophyll-a and DMS_{sw}. Surface seawater dimethylsulfide (DMS_{sw}) and associated air-sea DMS flux showed spatial variation during the SOAP voyage, with maxima of 25 nmol L⁻¹ and 100 μmol m⁻² d⁻¹, respectively, recorded in a dinoflagellate bloom. Inclusion of SOAP data in a regional DMS_{sw} compilation indicates that the current climatological mean is an underestimate for this region of the South-west Pacific. Estimation of the

DMS gas transfer velocity (k_{DMS}) by independent techniques of eddy covariance and gradient flux showed good agreement, although both exhibited periodic deviations from model estimates. Flux anomalies were related to surface warming and sea surface microlayer enrichment, and also reflected the heterogeneous distribution of DMS_{sw} and the associated flux footprint. Other aerosol precursors measured included the halides and various volatile organic carbon compounds, with first measurements of the short-lived gases glyoxal and methylglyoxal in pristine Southern Ocean marine air indicating an unidentified local source. The application of a real-time clean-sector, contaminant markers, and a common aerosol inlet facilitated multi-sensor measurement of uncontaminated air. Aerosol characterisation identified variable Aitken mode, and consistent sub-micron sized accumulation and coarse modes. Sub-micron aerosol mass was dominated by secondary particles containing ammonium sulfate/bisulfate under light winds, with an increase in sea-salt under higher wind-speeds. MBL measurements and chamber experiments identified a significant organic component in primary and secondary aerosols. Comparison of SOAP aerosol number and size distributions reveals an underprediction in GLOMAP-mode aerosol number in clean marine air masses, suggesting a missing marine aerosol source in the model. The SOAP data will be further examined for evidence of nucleation events, and also to identify relationships between MBL composition and surface ocean biogeochemistry that may provide potential proxies for aerosol precursors and production. The SOAP Campaign contributed to SOLAS Theme 4. (Interconnections between aerosols, clouds, and marine ecosystems) and was also a SOLAS Endorsed project.

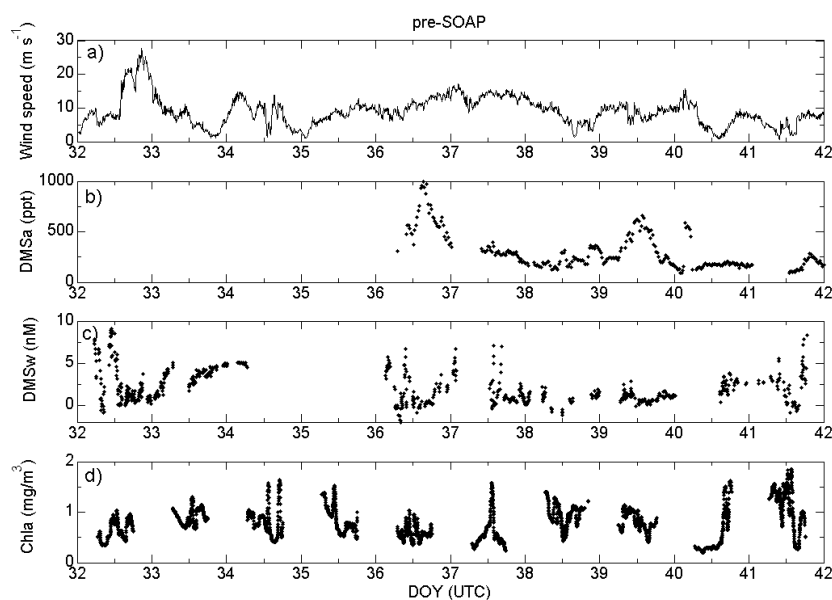


Figure 3. Continuous measurement during PreSOAP of a) windspeed (m s^{-1}), b) atmospheric DMS (ppt), c) surface water DMS (nmol l^{-1}), and d) surface chlorophyll-a (mg m^{-3} ; quenched data removed).

Citation: Law CS, Smith MJ, Harvey MJ, Bell TG, Cravigan LT, Elliott FC, Lawson SJ, Lizotte M, Marriner A, McGregor J, Ristovski Z, Safi KA, Saltzman ES, Vaattovaara P, Walker CF. An Overview of the Surface Ocean Aerosol Production (SOAP) campaign. *Atmospheric Chemistry Physics Discussions*, <https://doi.org/10.5194/acp-2017-535>

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).

SOLAS Theme 1:

1. The New Zealand Ocean Acidification Observing Network (NZOA-ON)

A coastal observing network comprising 14 sites throughout New Zealand was sampled fortnightly in collaboration with partners from local councils, research institutes, Māori iwi,

aquaculture and fishing industries. The resulting ocean acidification data is publicly available via a website and data portal (<https://marinedata.niwa.co.nz/>).

2. Munida Transect

Time series CO₂ data has been collected from the surface Munida transect for 19 years, with 6 voyages per year conducted along the 65 km long transect. The data has contributed to the IGMETS Status report (O'Brian et al, 2016), and several journal papers (Baltar et al, 2016, Baltar et al, 2016b, Law et al 2017, Law et al, 2017b, Morales et al 2018)

Surface SOOP CO₂ data was collected from 11 voyages of the RV Tangaroa in the South West Pacific Ocean, and submitted to SOCAT. These data then contributed to the Global Carbon Budget (Le Quere et al, 2018)

3. Coastal Acidification: Rates, Impact & Management (CARIM) <http://www.carim.nz/>

RA1 - Continuous monitoring and bottle samples at 3 sentinel sites (Firth of Thames, Nelson Bays, Karitane); data quality controlled and publicly available on NZOA-ON website

RA2 – Biogeochemical budgets produced and ROME model further developed for Firth of Thames

RA3 – 22-day mesocosm experiment completed examining responses of coastal plankton to ocean acidification and warming

RA4 – Experiments completed examining impact of low pH on mussel and paua adults, larvae and fertilisation, including adult pre-exposure assessments

RA5 – determination of adaptation potential to low pH in different families of Greenshell Mussel & Paua

SOLAS Theme 4: Interconnections between aerosols, clouds, and marine ecosystems;

4. Surface Ocean Aerosol Production (SOAP)

<https://www.niwa.co.nz/atmosphere/research-projects/soap>

10 papers published to date, with 8 in a Special Issue in *Ocean Science and Atmospheric Chemistry & Physics* and *Ocean Science* at http://www.ocean-sci.net/special_issue10_333.html

5. Deep South National Science Challenge

<http://www.deepsouthchallenge.co.nz/programmes/processes-and-observations>

<http://www.deepsouthchallenge.co.nz/programmes/earth-system-modelling-and-prediction>

The Deep-South National Science challenge is building capacity at the interface between Atmospheric Processes and Observations and Earth System Modelling and Prediction to refine the Earth System Modelling representation of clouds and aerosols. There is a focus on latitudes poleward of 60°S in this work where the models underestimate the radiative impact of clouds. Novel measurements include RPAS/drone deployment of light-weight aerosol sensors. Results were discussed this year at a number of international meetings including EGU, International Conference on Nucleation and Atmospheric Aerosols, Finland, NZ Antarctic conference, DeepSouth Symposium, NZ Met Society. Methods have been developed for regional regime based evaluation of GCM cloud simulations using self-organizing maps (PI McDonald, U Canterbury, NZ)

6. Ship based observation of aerosols, shipping Emissions and In situ aerosol profiles

Multi-tracer/meteorological variables have been found to be necessary for identifying pollution contamination of background aerosol sampled from ships. Parallel analyses have been done in connection with NZ and Australian SOLAS programmes with RV Tangaroa and RV Investigator (PI's Harvey, NIWA, Humphries, CSIRO). Results were discussed at the 2017 Annual Atmospheric Composition & Chemistry Observations & Modelling Conference, NSW, Australia.

In collaboration with the Australian SOLAS activity PI: Ristovski, QUT, a new method was developed to investigate particulate emissions from ships using airborne in-situ profiling sensors deployed from tethered balloons and RPAS through measurement of ship exhaust plume CO₂ and particulates

7. Sources of sulfate aerosol at Baring Head, New Zealand

New analyses have shown a mix of biogenic and anthropogenic sources of background sulfate through stable isotopic analyses of sulfate and nitrate aerosol from size-resolved selective sampling at Baring Head. PI: Michalski, Perdue University, USA, GNS NZ, NIWA NZ.

Cross-Cutting Theme: Science & Society

8. Climate Change Impacts on the NZ EEZ

Results synthesized and published with recommendations

9. Mitigation of Coastal Acidification around Mussel Farms

Field measurements and experiments completed to examine the potential of using waste shell and aeration to ameliorate impacts of low pH at mussel farm scales.

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

Burrell TJ, Maas EW, Hulston DA, Law CS, 2017. Variable response to warming and ocean acidification by bacterial processes in different plankton communities. *Aquatic Microbial Ecology* 79:49-62. <https://doi.org/10.3354/ame01819>

Law CS, Smith MJ, Harvey MJ, Bell TG, Cravigan LT, Elliott FC, Lawson SJ, Lizotte M, Marriner A, McGregor J, Ristovski Z, Safi KA, Saltzman ES, Vaattovaarra P, Walker CF. 2017. Overview and preliminary results of the Surface Ocean Aerosol Production (SOAP) campaign. *Atmospheric Chemistry Physics*, 17(22): 13645--13667, doi: 10.5194/acp-17-13645-2017

Law CS, Bell JJ, Bostock HC, Cornwall CE, Cummings V, Currie K, Davy SK, Gammon M, Hepburn CD, Hurd CL, Lamare M, Mikaloff-Fletcher SE, Nelson WA, Parsons DM, Ragg NLC, Sewell MA, Smith AM, Tracey DM, 2017. Ocean Acidification in New Zealand waters. *New Zealand Journal of Marine & Freshwater Research* <http://dx.doi.org/10.1080/00288330.2017.1374983>

Law CS, Rickard GJ, Mikaloff-Fletcher SE, Pinkerton MH, Behrens E, Chiswell SM, Currie K, 2017. Climate Change projections for the surface ocean around New Zealand. *New Zealand Journal Marine Freshwater Research*, doi: 10.1080/00288330.2017.1390772

Lizotte M, Levasseur M, Law CS, Walker CF, Safi KA, Marriner A, Kiene RP 2017. Dimethylsulfoniopropionate (DMSP) and dimethyl sulfide (DMS) cycling across contrasting biological hotspots of the New Zealand subtropical front, *Ocean Science*, 13, 961-982, <https://doi.org/10.5194/os-13-961-2017>, 2017.

O'Brien, T. D., Lorenzoni, L., Isensee, K., Valdes, L., and Currie, K. C.: What are Marine Ecological Time Series telling us about the ocean? A status report. IOC-UNESCO, IOC Technical Series, No 129, 296, 2016.

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?

SOLAS Theme 1:

CARIM <http://www.carim.nz/>

The CARIM project has major interaction with Maori and other national stakeholders, including the shellfish fishery sector, MPI, regional councils, DOC and the Hauraki Gulf Forum, as well as international scientists in the US and Australia. CARIM scientists presented and discussed the issue of coastal acidification with iwi (Maori tribes) at hui (meeting) in both the North and South Island. In addition, discussions with regional councils and the mussel industry has led to spin off projects and co-funding. The CARIM project also has a major Outreach component that includes an "Oceans Guardians" programme for schools and local communities around the sentinel sites.

The New Zealand Ocean Acidification Observing Network (NZOA-ON)

<https://marinedata.niwa.co.nz/nzoa-on/>

NZOA-ON – Collaborators collect fortnightly water samples, and are the backbone of the NZOA-ON. Engagement is via email and website; and sampling Partners include Auckland Council, Auckland University, NIWA, Bay of Plenty Regional Council, Cawthron Institute, Aquaculture New Zealand, Puaa Industry Council, University of Otago, Fishing Industry, Department of Conservation, Ngai Tahu).

The 10th New Zealand National Ocean Acidification Workshop

<http://nzoac.nz/workshops/>

A two-day meeting at the University of Otago, included a session on Maori environmental values and concerns.

Educational resource Unit for Secondary Schools on Ocean Acidification

<http://www.otago.ac.nz/marine-studies/resources/download/otago636544.pdf>

New Zealand scientists have been training secondary school teachers following the release of the Educational resource “*The Ocean of Tomorrow: Ocean acidification and the marine world*”

International Ocean Acidification Alliance <https://www.oaalliance.org/>

The Ocean Foundation, SPREP and the University of the South Pacific in Fiji recently hosted a series of courses on ocean acidification monitoring and research. Kim Currie from the NIWA / University of Otago Research Centre for Oceanography in Dunedin joined scientists from NOAA to train participants from Pacific Island nations in the analytical and field skills necessary to initiate and implement an ocean acidification monitoring and research programme. An Introductory Course involved lectures, lab and field work; this was followed by an applied course providing hands-on training. A parallel course focused on policy development. This suite of skills will enable the participating nations to work towards enhancing resilience of local marine environments to changing ocean chemistry resulting from uptake of anthropogenic carbon and other stressors. These include coral reefs, mangroves and sea grass beds which are of social and economic importance to our South Pacific neighbours.

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.).

SOLAS Theme 1:

CARIM

RA1 – Continued monitoring at sentinel sites plus a spatial survey of the Firth of Thames

RA3 – A 4th mesocosm experiment examining the effect of OA and warming on larval survival in coastal plankton communities

The New Zealand Ocean Acidification Observing Network (NZOA-ON)

Additional sites will be added in collaboration with regional councils. Data will be available via the GOA-ON web portal

Munida Transect – continuing into its 21st year

SOLAS Theme 4:

Deep South Aerosol-Cloud interaction observations – Ross Sea –

A voyage to the Ross Sea will investigate oceanographic and ecosystem function of the northern Ross Sea region in conjunction with the establishment of the Ross Sea marine protected area

<https://www.niwa.co.nz/our-science/voyages/antarctica-2018>

<https://www.mfat.govt.nz/en/environment/antarctica/ross-sea-region-marine-protected-area/>

A work – package of the voyage is the multi-faceted assessment of aerosol and precursor emissions and aerosol-cloud interaction in the region in support of Earth System modelling refinement. The study involves NZ/European/US collaborators from NZ: NIWA, U Canterbury, Auckland University of Technology, Bodeker Scientific, France: LAMP CNRS, Germany: Forschungszentrum Jülich,

Helmholtz Centre for Ocean Research Kiel, USA: Sigma Space Corp, NASA, Colorado State University.

Cross-Cutting Theme: Science & Society

Mitigation of Coastal Acidification around Mussel Farms

A measurement campaign examining carbonate variability and processes around a mussel farm is planned for March 2018

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

SOLAS Theme 1:

The CARIM Workshop will take place at the University of Waikato in February 2018

The 11th NZ National Ocean Acidification Workshop will take place at the University of Waikato in February 2018

SOLAS Theme 4

The 14th annual Australia / New Zealand Aerosol assembly will be held in New Zealand, date TBA in second half of 2018.

3. Funded national and international projects / activities underway.

SOLAS Theme 1:

HYDEE - Determination of the impacts of seafloor methane seeps on water column biogeochemistry

The New Zealand Ocean Acidification Observing Network (NZOA-ON)

Munida Transect

Mitigation of Coastal Acidification around Mussel Farms

SOLAS Theme 4:

Deep South Aerosol-Cloud interaction observations – Ross Sea

New projects:

Improving the representation of sulfate aerosols over the Southern Ocean in the NZESM PI: Laura Revell, Bodeker Scientific: new Deep-South project:

Versatile 4D Drones for observations of deep-south key earth system variables: PI Wolfgang Rack, U Canterbury, NZ: new Deep-South project.

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

International collaborative project:

Sea2Cloud: - Are marine living microorganisms influencing clouds?

PI: Karine Sellegri – LAMP CNRS / NIWA – EU Horizons 2020

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

SOLAS Theme 1:

SCOR Working Groups:

WG 143 Dissolved N₂O and CH₄ measurements: Working towards a global network of ocean time series measurements of N₂O and CH₄ : intercalibration of standards and samples

WG149: Changing Ocean Biological Systems (COBS): How will biota respond to a changing ocean?

IOCCP Scientific Steering Group

SOCAT Global QC Group

OA-ICC Advisory Board and member of SOLAS-IMBER Working Group on Ocean

Trainer at two ocean acidification capacity building workshops for Pacific Island States and Nations

SOLAS Theme 4:

CSIRO Access ESM and Southern Ocean Aerosol-Cloud Research

Australia/New Zealand aerosol assembly (ANZAA), a special interest group of CASANZ <https://www.casanz.org.au/casanz-sigs/australia-and-new-zealand-aerosol-assembly/> includes background aerosol processes

New Zealand Earth System Model development is collaborating with CSIRO and the Australian Community Climate and Earth System Simulator (Access) with GLOMAP aerosol model (PI: Dr. Matthew Woodhouse) for Surface Ocean aerosol production and the Southern Ocean Aerosol-Cloud Research.

The Deep South National Science Challenge: <http://www.deepsouthchallenge.co.nz/> polar aerosol processes.

Process and observation studies of Aerosol-Cloud: "Sea2Cloud Are marine living microorganisms influencing clouds?" (PI Karine Sellegri, Laboratoire de Météorologie Physique – CNRS, France

Ice nucleation measurement programme PI: Paul J. DeMott, Colorado State University

The Deep South National Science Challenge: <http://www.deepsouthchallenge.co.nz/>

Comments