surface ocean solas lower atmosphere study

Report for the year 2017 and future activities

SOLAS FINLAND

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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
Marine shipping fuels will get a whole lot cleaner in 2020 when a regulation by the International Maritime Organization (IMO) requires fuels to contain 80-86 percent less sulphur. Study finds cleaner ship fuels will reduce childhood asthma by 3.6 percent globally but it will also accelerate climate change.

Photo: Hannu Manninen

The new IMO rule will decrease the allowable amount of sulphur in fuel oil from 3.5 percent to 0.5 percent, a reduction from 35,000 parts per million (ppm) to 5,000 ppm. This is the most significant improvement in global fuel standards for the shipping industry in 100 years, intended to achieve significant health benefits on a global scale. Now, a new study in *Nature Communications* quantifies these health benefits and finds cleaner shipping fuels will result in a 3.6 percent reduction of childhood asthma globally.

The team studied the impacts of sulphur emitted by ships using current marine fuels, which produce air pollution particles that are small enough to be breathed deeply into the lungs and are considered harmful to human health. Ship air pollution effects are greatest in areas where heavily travelled ship routes exist in, and next to, densely populated communities. Some key regions include China, Singapore, Panama, Brazil and coastlines of Asia, Africa and South America.

Refining industries will invest in the necessary technology to produce, and shipping will invest to adapt engine systems to use, these cleaner fuels. "Essentially, we document how much health benefit to expect from the 2020 adoption of cleaner ship fuels," said James Corbett, professor of marine science and policy in UD's College of Earth, Ocean, and Environment, and the paper's corresponding author.

Roughly 14 million annual cases of childhood asthma are estimated to be related to global ship pollution using current fuels. The change to cleaner ship fuels will reduce the ship-related childhood asthma cases by half. Additionally, shipping pollution is estimated to contribute to 400,000 premature deaths from lung cancer and cardiovascular disease annually. Using health risk estimates for ships comparable with the World Health Organization totals, ships account for about 3-4 percent of global lung cancer and cardiovascular deaths caused by air pollution. About one-third of these ship-related cardiovascular disease and lung cancer deaths will be reduced with cleaner fuels.

Public health benefits bring climate tradeoffs

"Researchers used a state-of-the-art model of ship traffic based on satellite records to determine where ship activity was producing emissions", explains FMI researcher Jukka-Pekka Jalkanen.

While the health benefits are clear, the research also quantifies tradeoffs in terms of climate. "Sulphur dioxide emissions from ships create small particles. These sulphur containing particles reflect sunlight and help form brighter clouds, creating a global effect that temporarily diminishes the warming effects of carbon dioxide. The use of cleaner ship fuels will increase the rate of global warming by about 3 percent," said FMI senior researcher Mikhail Sofiev, who led the climate related research. "This means more attention may be needed to reduce greenhouse gases across all sectors of the global economy."

Think of this warming effect like a pot of water boiling on the stove. Adding ice cubes to the boiling water can slow how quickly the water heats up, but it does not stop the heating itself. It's the same with sulphur in the atmosphere.

At the same time, shipping activity is expected to increase with global trade and continue to produce harmful air emissions and greenhouse gases. Despite the upcoming reductions, low-sulphur marine fuels will still account for approximately 250,000 deaths and 6.4 million childhood asthma cases annually, so more stringent standards beyond 2020 may be needed to provide additional health benefits.

The study was led by University of Delaware's and included an international team of researchers from the Finnish Meteorological Institute (FMI), Rochester Institute of Technology (RIT) in New York and Energy and Environmental Research Associates. Study was funded in part by ClimateWorks Foundation, the Academy of Finland, with in-kind support from the Finnish Meteorological Institute and Energy and Environmental Research Associates, LLC.

Reference:

Sofiev, M., Winebrake, J.J., Johansson, L., Carr, E.W., Prank, M., Soares, J., Vira, J., Kouznetsov, R., Jalkanen, J.-P., Corbett, J.J., " Cleaner fuels for ships provide public health benefits with climate tradeoffs", Nature Communications Vol. 9, Article number: 406 (2018) doi:10.1038/s41467-017-02774-9, https://www.nature.com/articles/s41467-017-02774-9

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).

Most of marine research in Finland is coordinated by Finnish Marine Research infrastructure FINMARI. FINMARI partners are Arctia Shipping Ltd, Finnish Environment Institute (SYKE), Finnish Meteorological Institute (FMI), Geological Survey of Finland (GTK), University of Helsinki (UHEL), University of Turku (UTU), Åbo Akademi University (ÅAU) and Natural Resources Institute Finland (LUKE).

FINMARI combines all major components of the Finnish marine research community. It is an infrastructure network of field stations, research vessels and multi-purpose icebreakers, laboratory facilities, ferry boxes, fixed measurement platforms and buoys. In addition to experimental research, FINMARI facilitates modelling research through observations and communication.

FINMARI www-pages: https://www.finmari-infrastructure.fi/

As the Baltic Sea is shallow, on Finnish coast typically less than 100 m deep, we list here different actions and projects which may influence sea-atmosphere interphase in quite general sense.

Core Theme 1: Greenhouse gases and the oceans

- At Utö Atmospheric and Marine Research Station (operated by the Finnish Meteorological Institute and Finnish Environment institute) sea-atmosphere CO_2-flux measurement tests continued and observations now considered reliable (http://en.ilmatieteenlaitos.fi/uto).
- Jerico-next (Joint European Research Infrastructure Network for Coastal Observatory – Novel European expertise for coastal observatories: development of coastal observing systems) General Assembly was held in Helsinki 13-16 March 2017 as a joint effort of FMI and SYKE. In total, more than 60 people from around 15 countries participated the meeting.

- Pojo Bay is a fjord-like embayment in Tammisaari, southern Finland. It receives freshwater from river Mustionjoki and low-salinity water from the brackish Baltic Sea. In the middle of the bay a shallow sill separates the inner bay from the outer, creating salinity-stratified conditions in the inner bay which are prone to late summer hypoxia. The previous sampling campaigns by UHEL have shown that the deep waters of the inner bay accumulate methane and nitrous oxide during the period of low-oxygen conditions. However, the annual cycle of accumulation of these greenhouse gases, their potential release to the atmosphere, and the biogeochemical mechanisms controlling their distribution, are poorly constrained.

  In 2017 UHEL studied the sources and sinks of methane and nitrous oxide along a transect from river mouth towards the open sea and related these to physical and biogeochemical variables. We hypothesized that the quantity but especially the quality of organic matter limits nitrogen processes in early summer, whereas in late summer the rates are controlled by oxygen availability. As N_2O production is highest in systems suffering from external stress and shifts in environmental conditions, we expect higher N_2O to N_2 ratios in stations prone to hypoxia than at normoxic stations. We used ^{15}N stable isotope methods to measure nitrous oxide production rates in denitrification, ammonia oxidation and nitrifier denitrification. As the last step of denitrification is the only known sink for nitrous oxide, the sink function is defined as the efficiency of nitrate reduction to N_2 gas instead of N_2O. Methane oxidation rates in sediments were measured using ^{14}C radiotracer methods. In total, three field campaigns were carried out in contrasting seasons: March (concentrations below ice, nutrients, no processes); June (nitrogen process rates, concentrations in water column, carbon quantity and quality) and August (nitrogen process rates, methane oxidation rates, concentrations in water column,

carbon quantity and quality).

All process rate measurements were complemented with mapping and vertical profiling of organic carbon quality and quantity in the sediments, which is expected to regulate both the heterotrophic denitrification via energy and carbon source and autotrophic ammonia oxidation, and nitrifier denitrification via availability of ammonia released from organic matter. Bulk pore water chemical profiles of the sediments were also generated to investigate the likely zones of methane-related processes. The physicochemical characteristics of the water column were described by CTD measurements (including oxygen), and methane, nitrous oxide and nutrient concentration profiling.

Core Theme 2: Air-sea interface and fluxes of mass and energy

- In June, Karasalo et al published a modeling and measurement study on underwater noise from Baltic Sea shipping: "Estimates of Source Spectra of Ships from Long Term Recordings in the Baltic Sea"

Core Theme 3: Atmospheric deposition and ocean biogeochemistry

- At UHEL, Tvärminne Field station, Two YSI Exo 2 loggers (T, S, O_2, pH, Turb) were installed and a public online portal called MONICOAST opened: https://www.helsinki.fi/en/research-stations/tvarminne-zoological-station/research/monicoast

- Shipping & Environment SHEBA-SOLAS conference was held in Gothenburg, Sweden in Oct 2017, Special issue on shipping and its environmental impacts, Atmos. Chem. Phys. & Ocean Science, opens 1.2.2018. The Finns have made/are still working with the following studies:
    - Manuscript on modelling contaminant/nutrients from ships to sea in preparation Bilge, ballast, waste, scrubber wash water, stern tube oil, antifouling paints; how these were implemented in STEAM
    - Manuscript on small boat contribution to atmospheric emissions & antifouling paints, in preparation
    - Manuscript on environmental impacts of ship emissions to air/water, in preparation
    - Magnusson et al., Marine Pollution Bulletin, "Risk assessment of bilge water discharges in two Baltic shipping lanes", in press
    - Wilewska-Bien et al., Journal of Engineering for the Maritime Environment, "Phosphorus flows on ships –case study from the Baltic Sea", accepted
- A manuscript by the FMI shipping traffic researchers on climate impacts was accepted in Nature Communications. Under embargo at the moment, will be out in Feb 2018.

- ÅAU: A vertical profiling buoy was deployed in the NW Åland measuring basic oceanographic parameters such as temperature, salinity and oxygen content from 4 to 40 metres depth. The profiling is to be continued early spring 2018.

Core Theme 4: Interconnections between aerosols, clouds, and marine ecosystems

- Publishing of a new aerosol-cloud-precipitation interaction model UCLALES-SALSA suited to study the evolution of cloud topped marine boundary layer with different forcing components. Model is distributed as open source code, and already employed in several project in Finland and internationally. At Finnish Meteorological Institute the model has been used to study Arctic clouds, especially how aerosol is affecting the properties and precipitation formation.
- Please see also the "Scientific highlight" above.

Core Theme 5: Ocean biogeochemical control on atmospheric chemistry.

- Together with SYKE, GTK published a paper about rapid fluctuations in H_2S, temperature, pH and dissolved oxygen in near-bottom water in the northern Baltic Sea. The H_2S fluctuations are linked to free gas (methane) content in the underlying sediments, and variability in the rate of anaerobic methane oxidation in the surface sediments.

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

Five selected publications:

1) * Sofiev, M., Winebrake, J.J., Johansson, L., Carr, E.W., Prank, M., Soares, J., Vira, J., Kouznetsov, R., Jalkanen, J.-P., Corbett, J.J., " Cleaner fuels for ships provide public health benefits with climate tradeoffs", Nature Communications Vol. 9, Article number: 406 (2018) doi:10.1038/s41467-017-02774-9, https://www.nature.com/articles/s41467-017-02774-9
2) * Tonttila, J., Maalick, Z., Raatikainen, T., Kokkola, H., Kühn, T., and Romakkaniemi, S.: UCLALES–SALSA v1.0: a large-eddy model with interactive sectional microphysics for aerosol, clouds and precipitation, Geosci. Model Dev., 10, 169-188, doi:10.5194/gmd-10-169-2017, 2017.
3) * Almén A-K, Glippa O, Petterson H, Alenius P, Engström-Öst J (2017) Changes in wintertime pH and hydrography of the Gulf of Finland (Baltic Sea) with focus on depth layers. Environmental Monitoring and Assessment (2017) 189: 147.
4) * Glippa O, Brutemark A, Johnson J, Spilling K, Candolin U, Engström-Öst J (2017) Early development of the threespine stickleback in relation to water pH. Frontiers in Marine Science, 4:427.Hornick T, Bach LT, Crawfurd KJ, Spilling K, Achterberg EP, Woodhouse JN, Schulz KG, Brussaard CPD, Riebesell U, Grossart H-P (2017) Ocean acidification impacts bacteria-phytoplankton coupling at low-nutrient conditions. Biogeosciences, 14: 1-15.
5) * Myllykangas JP, Jilbert T, Jakobs G, Rehder G, Werner J, Hietanen S (2017) Effects of the 2014 major Baltic inflow on methane and nitrous oxide dynamics in the water column of the central Baltic Sea. Earth System Dynamics 8:817-826; doi: 10.5194/esd-8-817-2017

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?

- Finnish meteorological Institute has a seat at the European Sustainable Shipping Forum, to provide scientific support for European Commission in issues of environmental impact of ships. FMI is leading WPs concerning ship emission modeling, emission factors for ships, efficiency of emission abatement techniques and primary/secondary particle matter.

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.).

- In 2018 Finnish Meteorological Institute plans to use UCLALES-SALSA to study how marine stratocumulus clouds response to changes in aerosol properties, especially the presence of giant sea salt particles which are hypothesized to initiate precipitation formation followed by cloud breakup. The simulations will be compared against literature data. Similar study will be done to study how entrainment of aerosol of anthropogenic origin above the boundary layer is delaying the precipitation formation and thus prolonging the cloud lifetime. As the third topic the model will be employed to study the phase of Arctic clouds, and how aerosol and cloud dynamics are affecting it.
- Many ongoing projects continue, there are too many individual projects to be listed. In general, work is coordinated through FINMARI research infrastructure.

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

- FINMARI science days at Tvärminne Zoological Station 26-28 February 2018.
- Construction of Finnish marine observing network continues as part of FINMARI

3. Funded national and international projects / activities underway.

All individual FINMARI partners have received significant amount of national and international funding together with a large number of national and international partners.

In addition, FINMARI obtained 2 M€ national infrastructure funding for the years 2017-18 from Finnish Academy.

At Finnish Meteorological Institute, e.g. following projects will be active in 2018

Finnish Academy:

1) “Supercooled Water in Mid-level Mixed-Phase Clouds: Microphysics, Dynamics and Global Radiation Balance.”
2) “Ice Clouds and Ice Nucleation in the Arctic”
3) “Aerosol Cloud –Interactions: From Measurements to Modelling”

4) GLORIA, Global health risks related to atmospheric composition and weather, ship emission and chemical transport modeling, health effect evaluation
5) KAMON (Kara-Arctic Monitoring and Operation Planning Platform), winter navigation and inclusion of sea ice in ship emission modeling.

European Regional Development Fund

- Environmental Impact of Low Emission Shipping: Measurements and Modelling Strategies (EnviSuM), Local and regional scale ship emission modeling work, FMI research support to European Sustainable Shipping Forum

Bonus/EU

- Sustainable Shipping and Environment of the Baltic Sea region (SHEBA), EU/BONUS funding, extension of FMI modeling capabilities to cover emissions from ships to ice and water + underwater noise. Air quality studies in local/regional scales
- Bonus-Integral: Integrated carbon and trace gas monitoring for the Baltic Sea: Integration of the different data streams of ICOS and related infrastructure in the pan-Baltic area
- Jerico-Next: Joint European Research Infrastructure Network for Coastal Observatory – Novel European expertise for coastal observatories: development of coastal observing systems continues

Finnish Transport Safety Agency

- ShipNOEm, Annual Baltic Sea ship emission reporting for the benefit of the Helcom member states, generation of ship emission inventories

European Center for Medium Range Weather Forecasts

- Copernicus Atmospheric Modeling Services (CAMS-81). Regular updates of the European and global ship emission inventories

Nordic Council of Ministers

- Emissions from shiP and the Impacts on human healTh and envirOnMEnt - now and in the future (EPITOME). Ship emissions, air quality and its impacts in Arctic areas. Ship emission scenarios.

Finnish Prime minister's office

- The cost of shipping environmental legislation changes to Finnish economy (MERSU) Synthesis report on the existing and upcoming costs of of legislative changes to shipping environmental regulation.

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

There are several national and international applications to EU, Nordforsk, BONUS, national funding agencies and private foundations by the individual FINMARI partners, and different combinations of the FINMARI partners, and together with international parties. There are too many to be listed and also some plans by partners may also be confidential.

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

There are too many to be listed: EMBRC, EURO-ARGO, ICOS, ACTRIS, COPERNICUS etc.

Comments