

## Report for the year 2015 and future activities

### **SOLAS USA**

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*Please note that this report has two parts!*

**Part 1:** reporting of activities in the period of January 2015 – December 2015

**Part 2:** reporting on planned activities for 2016 to 2018/19.

*The information provided will be used for reporting, fundraising, networking and strategic development. In particular, **in 2016 SOLAS will develop its Implementation Plan, which will be largely based on the information from part 2 of the national reports, as well as input from international SOLAS initiatives and activities.** This info will be crucial in order to draft a realistic Implementation Plan representative of SOLAS, internationally.*

**IMPORTANT:** *May we remind you that this report should reflect the efforts of the SOLAS community in the entire country you are representing (all universities, institutes, lab, units, groups)!*

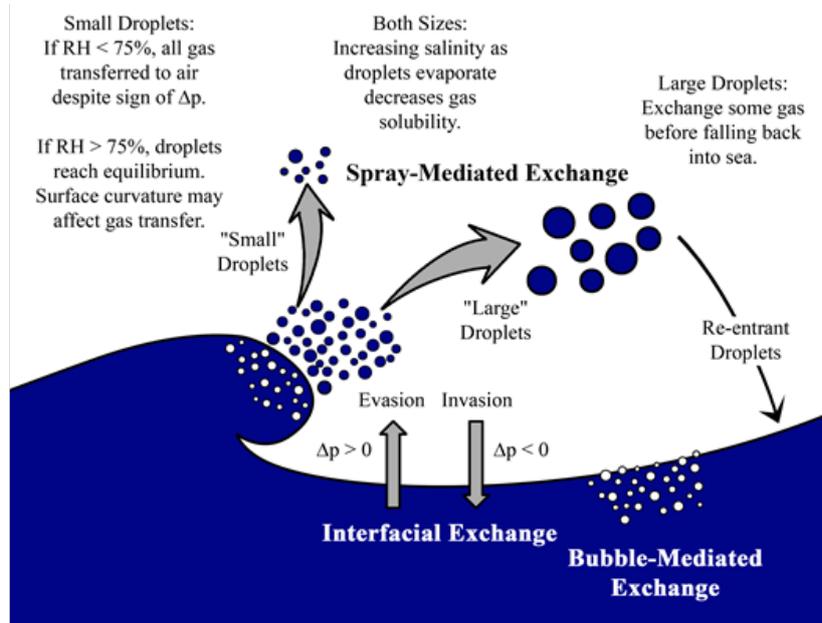
### **PART 1 - Activities from January 2015 to December 2015**

#### **1. Scientific highlight**

*Describe one scientific highlight with a title, text (max. 200 words), a figure with legend and full references. Please focus on a result that would not have happened without SOLAS, and we are most interested in international collaboration.*

#### **The Role of Sea Spray Droplets in Facilitating Air-Sea Gas Transfer**

For over 30 years, air-sea interaction specialists have been evaluating and parameterizing the role of whitecap bubbles in air-sea gas exchange. However, the mirror-image process of how sea spray droplets can facilitate air-sea gas exchange is not known. E Andreas (Northwest Research Associates), P Vlahos (University of Connecticut), and E Monahan (University of Connecticut) have been using sea-spray modelling approaches to quantify the role of sea-spray on air-sea gas transfer. First, they evaluated the three time scales that govern the exchange:  $\tau_{air}$  (the rate of transfer between the atmospheric gas reservoir and the surface of the droplet);  $\tau_{int}$  (the exchange rate across the air-droplet interface); and  $\tau_{aq}$  (the gas mixing rate within the aqueous solution droplet), and showed that these timescales are all shorter than the microphysical time scales that quantify a spray droplet's physical evolution. Therefore, the gas in a spray droplet can be assumed to be in instantaneous equilibrium with the atmospheric reservoir. As a second step, they considered the upper limit of gas exchange assuming 100% saturation of model gases and 100% evaporation of all droplets. Results showed that sea spray could be a significant source of gas transfer into the atmosphere, even without 100% evaporation. Thus, sea-spray can be very important for the air-sea transfer of gases, particularly for those of higher relative solubility and for marine derived biogenic gases. This work was funded by the US National Science Foundation.



The figure depicts three routes for gas transfer: interfacial exchange, bubble-mediated exchange, and spray-mediated exchange. Modelling studies of spray-mediated exchange show it can be a significant source of gas transfer and that the exchange depends in large part on the size of the droplets, the percent evaporation of the droplet, and the solubility of the gas.

## 2. Activities/main accomplishments in 2015 (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, etc.)

A large number of SOLAS-related research projects were conducted in the USA in 2015. A summary of all the topics would be too long to include. Thus below is simply a selection of 10 exciting projects, field campaigns, and other significant contributions, listed in alphabetical order.

**Arctic Ocean Primary Production Model-Data Comparison:** A model-data comparison spearheaded by P Matrai (Bigelow), in collaboration with Y Lee (Bigelow), M Friederich (VIMS) and V Saba (NOAA) has been comparing in situ net primary production data from 1959 to 2011 in the Arctic Ocean to predictions by a suite of numerical models of varying complexity from ocean color to earth system models. Initial results suggest that the models in general perform better in ice-free regions, in summer than in the spring, and in the recent decade compared to the older data. The models underestimate values of primary production and overestimate nitrate concentration and euphotic zone depth.

**Atmospheric Chemical Species in the Arctic:** The rich dataset of air chemistry over Arctic sea ice continues to grow with the additional deployment of four O-Buoys in 2015. The autonomous buoys collect observations of  $BrO$ ,  $O_3$ , and  $CO_2$ , as well as meteorological parameters (<http://www.o-buoy.org>). The project is a collaboration of PIs from 5 USA institutions and all data is freely available on the web at <https://www.aoncadis.org>

**Field Portable Noble Gas Mass Spectrometer:** A field portable mass Gas Equilibration Mass Spectrometer (GEMS) for measuring noble gases in air or seawater has been developed by C Manning (WHOI) and R Stanley (Wellesley College). The instrument can be used to collect continuous measurements of Ne, Ar, Kr and Xe ratios with an e-folding response time of 1.5 to 8 minutes, enabling large amounts of noble gas data to be collected with relative ease. Details on the

instrument are available in an article published in Analytical Chemistry ([doi:10.1021/acs.analchem.5b03102](https://doi.org/10.1021/acs.analchem.5b03102)).

**Gas Transfer at Water Surfaces Symposium:** The Seventh International Symposium on Gas Transfer at Water Surfaces took place from May 18 to 21, 2015 in Seattle, Washington. The symposium, organized by W Asher and A Jessup (both from the Applied Physics Lab, UW), covered a wide range of air-sea gas transfer topics including discussions of field observations, laboratory and numerical studies of gas water fluxes of mass, heat and particulates. It also included discussions of ocean acidification, biological effects, and high latitude processes. Proceedings of the conference will soon be published and will be accessible freely online.

**GEOTRACES Arctic Cruise:** The US GEOTRACES program conducted an Arctic Expedition from Aug 9 to Oct. 11, 2015. Scientists on board the US Coast Guard Cutter Healy occupied 66 GEOTRACES and Repeat Hydrography stations, collecting aerosols, water and particles. Additionally, scientists sampled under-ice seawater, snow, ice and meltponds.

**Harmful Algal Blooms stimulated by Atmospheric Deposition:** Remote sensing analysis of blooms in the East China Sea conducted by K Mackey (UC Irvine), M Kavanaugh (WHOI) and colleagues show that harmful algal blooms composed of dinoflagellates were associated with increased aerosol optical thickness and decreased sea surface temperature. By combining the remote sensing data with bottle incubation studies, the scientists hypothesize that atmospheric deposition is fueling harmful algal blooms, probably because the aerosols increase the surface ocean ratio of nitrogen to phosphorous and cause intensified phosphorus limitation.

**Nitrous Oxide Field Measurements:** Measurements of nitrous oxide ( $N_2O$ ) were integrated into the monthly sampling program at the San Pedro Ocean Time-series, located along the west coast of the U.S. By combining  $N_2O$  measurements with nitrification rates, A Santoro (U of Maryland), D Capone (USC) and colleagues are determining whether atmospheric  $N_2O$  fluxes are dominated by local production or advection from the eastern tropical North Pacific oxygen deficient zone.

**Oxygen Minimum Zone Denitrification:** Profiling floats from the Applied Physics Laboratory (UW) were equipped with gas tension devices (GTDs) by E D'Asaro, C McNeil, and A Reed to study denitrification rates and processes in OMZ's. The floats were tested in a cruise off Mexico and provided estimates of excess  $N_2$  similar to those determined by M Altabet and A. Bourbonnais (U of Massachusetts Dartmouth) using  $N_2/Ar$  from mass spectrometry.

**SUSTAIN wind-wave tank:** University of Miami's new wind-wave tank capable of reproducing category 5 hurricanes opened in 2015 under the directorship of B Haus. The acrylic tank is 23 m x 6 m x 2 m, can be filled with fresh or saltwater, and is equipped with a single 1460 HP fan that can generate winds up to  $64 \text{ m s}^{-1}$  (which, when scaled by boundary layer profile, is equivalent to wind speed of  $100 \text{ m s}^{-1}$ ). The tank can be used to investigate a wide range of atmospheric-ocean boundary processes at high wind speeds.

**Tudor Hill Marine Atmospheric Observatory** in Bermuda was rebuilt and reopened in December, 2015. The location of the tower on the island of Bermuda provides opportunity to sample marine air masses without having to use a ship or mooring. Weekly bulk aerosol and rainwater sampling have recommenced. Sampling is routinely made to monitor organic pollutants, ozone,  $CO_2$  and other greenhouse gases, and air column properties. Opportunities are open for collaboration to measure or collect other parameters. <http://www.bios.edu/research/projects/tudor-hill-marine-atmospheric-observatory/>

**3. Top 5 publications in 2015 (only PUBLISHED articles) and if any weblinks to models,**

**datasets, products, etc.**

*For journal articles please follow the proposed 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.*

Many excellent SOLAS relevant papers were published by US authors in 2015. The selection below, listed in alphabetical order, is of 5 very interesting, extremely high quality papers but the listing of these papers is not meant to claim them as necessarily the best publications of 2015.

Evans, W, J T Mathis, J N Cross, N R Bates, K E Frey, B G T Else, T N Papkyriakou, M D DeGrandpre, F Islam, W-J Cai, B Chen, M Yamamoto-Kawai, E Carmack, W J Williams, T Takahashi. 2015, Sea-air CO<sub>2</sub> Exchange in western Arctic Coastal Ocean. *Global Biogeochemical cycles*. 29: 1190-1209, DOI: 10.1002/2015GB005153

Munro D R, N S Lovenduski, B B Stevens, T Newberger, K R Arrigo, T Takahashi, P D Quay, J Sprintall, N M Freeman, and C Sweeney. 2015. Estimates of net community production in the Southern Ocean determined from time series observations (2002-2011) of nutrients, dissolved inorganic carbon, and surface ocean pCO<sub>2</sub> in Drake Passage. *Deep Sea Research Part II: Topical studies in Oceanography*. 114: 49-63. DOI: 10.1016/j.dsr2.2014.12.014

Rivero-Calle, S., A Gnanadesikan, C E Del Castillo, W M Balch, and S D Guikema. 2015. Multidecadal increase in North Atlantic coccolithophores and the potential role of rising CO<sub>2</sub>. *Science*. 350: 1533-1537. DOI: 10.1126/science.aaa8026

Schwendeman M and J Thomson: Observations of whitecap coverage and the relation to wind stress, wave slope, and turbulent dissipation. 2015. *Journal of Geophysical Research: Oceans*, 120: 8346-8363. DOI: 10.1002/2015JC011196

Varaljay, V A, J Robidart, C M Preston, S M Gifford, B P Durham, A S Burns, J P Ryan, R Marin, III, R P Kiene, J P Zehr, C A Scholin, M A Moran, 2015. Single-taxon field measurements of bacterial gene regulation controlling DMSP fate. *ISME JOURNAL* 9, 1677-1686. DOI: 10.1038/ismej.2015.23

**PART 2 - Planned activities from 2016 to 2018/19****1. Planned major field studies and collaborative laboratory and modelling studies, national and international (incl. all information possible, dates, locations, teams, work, etc.)**

**NAAMES:** NASA has commenced a five year investigation entitled North Atlantic Aerosols and Marine Ecosystem Study (NAAMES) which is aimed to study the connection between atmospheric aerosols and key oceanic processes controlling marine ecosystems, with an emphasis on implications for climates. Fieldwork associated with the project started in 2015 and will continue through 2018, consisting of four targeted ship and aircraft measurement campaigns. The field campaigns will be combined with continuous satellite and in situ ocean sensor records and with modelling studies.

**EXPORTS:** NASA is planning a large field campaign entitled Export Processes in the Ocean from RemoTe Sensing (EXPORTS). The focus of the campaign is to develop a predictive understanding

of the export and fate of global ocean net primary production (<http://dx.doi.org/10.3389/fmars.2016.00022> ). While the details of the field experiments are still being discussed by the Science Definition Team, it is likely that the main field activities will start in the North Atlantic Ocean in 2018 followed by field activities in the North Pacific in 2020. Projects related to mining previous data and modelling studies are already commencing.

**CLIVAR Repeat Hydrography Cruises:** US CLIVAR will be conducting Repeat Hydrography Cruises that aim to quantify changes and storage of CO<sub>2</sub>, heat and freshwater in the ocean. The cruises reoccupy WOCE lines and scientists onboard measure many variables from the atmosphere, the surface ocean and the deep ocean. Upcoming planned cruises consist of cruises in the Indian Ocean (I08S, I09N) in 2016 and (I05, I06S) in 2018 and 2019, in the Pacific ocean (P18, P06) in 2016 and 2017, and in the Atlantic Ocean (A13.5) in 2019.

**Ongoing US Time-series:** Regular cruises (typically monthly but each time-series differs) will occur in 2016 in the Pacific Ocean near Hawaii as part of the Hawaii Ocean Time-series (HOT), in the Sargasso Sea as part of the Bermuda Atlantic Time-series Study (BATS), in the Cariaco Basin as part of the CARIACO Ocean Time-series, and in coastal California waters as part of the California Cooperative Oceanic Fisheries Investigations (CalCOFI) time series.

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

**Arctic Science Summit Week**, March 12-18, 2016. Fairbanks, AK. Annual gathering of international scientists and policymakers who advance Arctic research.

**Cornell Satellite Remote Sensing Program**, June 3-17, 2016, Ithaca, NY. Intensive 2 week summer course to teach scientists how to access and use remote sensing data. Course is intended for scientists with essentially no experience in remote sensing.

**Ocean Global Change Biology Gordon Conference**. July 17-22, 2016. Waterville Valley, NH. Conference focuses on understanding the consequences of global ocean change on marine organisms.

**Organic Geochemistry Gordon Conference**. July 24-29, 2016. Holderness NH. Theme is applying new technologies to address current and future societal challenges.

**Ocean Carbon Biogeochemistry Workshop**: July 25-28, 2016. Woods Hole, MA. Annual workshop that highlights research and includes substantial time for community discussion of new directions.

**Joint 21<sup>st</sup> Satellite Meteorology, Oceanography and Climatology Conference and 20<sup>th</sup> conference on Air-Sea Interaction**. Aug 15-19, 2016 in Madison, WI. A special session on sea surface processes, including waves, spray, bubbles and aerosols in honour of Ed Andreas will be one of 25 separate and joint sessions between the two conferences.

**American Association for Aerosol Research Annual Conference**. Oct 17-21, 2016. Portland, OR.

**Annual Meteorological Society Annual Meeting**. Jan 22-26, 2017. Seattle.

## 3. Funded national and international projects / activities underway (if possible please list in order of importance and indicate to which part(s) of the SOLAS 2015-2025 science plan the

**activity topics relate – including the themes on ‘SOLAS science and society’ and ‘Geoengineering’)**

There are too many US projects to report. Please see the planned studies section for some large-scale projects relevant to SOLAS.

**4. Plans / ideas for future projects, programmes, proposals national or international etc. (please precise to which funding agencies and a timing for submission is any)**

Nothing to report.

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

Nothing to report.

**Comments**