surface ocean solas lower atmosphere study

# Report for the year 2015 and future activities

## SOLAS Norway *compiled by: Siv K. Lauvset*

*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

A new study by Lauvset et al. (2015) has shown that the average global ocean pH trend has been -0.0018 units per year between 1991 and 2011. Unfortunately, there are not enough data in the 1980s for a trend estimate in the period 1981-2011, but the Pacific Ocean trend in the 30-year period (-0.0020 per year) is roughly consistent with the global 20-year trend. This signifies that there has not been any significant change and/or acceleration in ocean acidification the past few years.

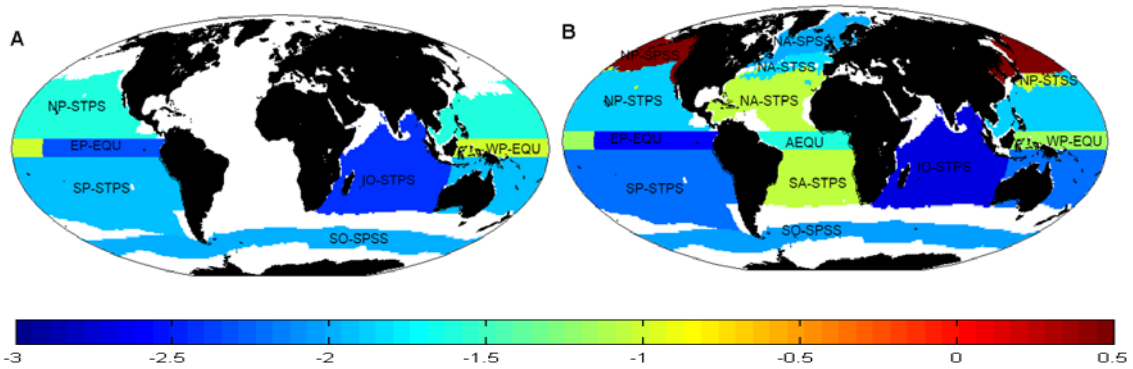


Fig. 1. Global map showing the (A) 1981-2011 and (B) 1991-2011 pH trend in different biomes. The color bar signifies changes in $10^{-3}$ pH units.

Because of the large-scale ocean circulation and how this transports carbon in the ocean, it was expected that ocean pH changes would present spatially very variable. However, the results in Lauvset et al. (2015) show that ocean pH changes have been very spatially homogeneous (Fig. 1), but that there are large uncertainties due to the high levels of noise in the data and the relatively short time frame in which we have observations. A

comparison with pH changes in the Norwegian Earth system model NorESM showed that we need to improve the data coverage both in time and in space in order to further understand the underlying mechanisms that drive the pH changes and their spatial variability. It is likely that changes in the ocean buffer capacity is a main reason for spatial variability in the pH changes, but it is yet not fully understood how and how much the buffer capacity has changed. Overall the observed pH changes found by Lauvset et al. (2015) are consistent with the ocean being in thermal equilibrium with the atmosphere. Such that the increasing $CO_2$ in the atmosphere drives increased $CO_2$ concentrations in the ocean which again drives the pH change.

Lauvset, S. K., Gruber, N., Landschützer, P., Olsen, A., and Tjiputra, J.: Trends and drivers in global surface ocean pH over the past 3 decades, Biogeosciences, 12, 1285-1298, 2015.

**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.)**

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

Frigstad, H., Henson, S. A., Hartman, S. E., Omar, A. M., Jeansson, E.,Cole, H., Pebody, C., and Lampitt, R. S.(2015): Links between surface productivity and deep ocean particle flux at the Porcupine Abyssal Plain sustained observatory, *Biogeosciences*, 12, 5885-5897, doi:10.5194/bg-12-5885-2015, 2015

Goris, N.,Tjiputra, J.,Schwinger, J.,Heinze, C.(2015). Responses of carbon uptake and oceanic *p*CO2 to climate change in the North Atlantic: A model study with the Bergen Earth System Model, *Global Biogeochem. Cycles*, 29,doi:10.1002/2015GB005109

Jeansson, E., Bellerby, R. G. J., Skjelvan, I., Frigstad, H., Ólafsdóttir, S. R., and Olafsson, J., 2015, Fluxes of carbon and nutrients to the Iceland Sea surface layer and inferred primary productivity and stoichiometry, *Biogeosciences*, 12, 875-885, doi:10.5194/bg-12-875-2015.

Lauvset, S. K., Gruber, N., Landschützer, P., Olsen, A., and Tjiputra, J.: Trends and drivers in global surface ocean pH over the past 3 decades, Biogeosciences, 12, 1285-1298, 2015.

Le Quéré, C, R Moriarty, R M Andrew, J G Canadell, S Sitch, J I Korsbakken, P Friedlingstein, G P Peters , R J Andres, T A Boden , R A Houghton , J I House, R F Keeling, P Tans, A Arneth, D C E Bakker, L Barbero, L Bopp , J Chang, F Chevallier, L P Chini, P Ciais, M Fader, R A Feely, T Gkritzalis, I Harris, J Hauck, T Ilyina, A K Jain , E Kato, V Kitidis, K Klein Goldewijk, C Koven , P Landschützer, S K Lauvset, N Lefèvre, A Lenton , I D Lima, N Metzl , F Millero, D R Munro, A Murata, J E M S Nabel, S Nakaoka, Y Nojiri, K O'Brien, A Olsen, T Ono, F F Pérez, B Pfeil, D Pierrot, B Poulter, G Rehder, C Rödenbeck, S Saito, U Schuster, J Schwinger, R Séférian, T Steinhoff, B D Stocker, A J Sutton, T Takahashi, B Tilbrook, I T van der Laan-Luijkx, G R van der Werf, S van Heuven , D Vandemark, N Viovy, A Wiltshire, S Zaehle , and N Zeng , 2015, Global Carbon Budget 2015. Earth Syst. Sci. Data, 7, 349–396. www.earth-syst-sci-data.net/7/349/2015/ doi:10.5194/essd-7-349-2015.

## 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.)**

1. Carbon-VOS lines Nuka Arctica and G.O.Sars will be continued and Carbon-VOS line Trans Carrier will be re-started as part of ICOS RI, all lines measuring fCO2 in surface water in the Nordic Seas, North Sea, and north Atlantic (Uni Research Climate/University of Bergen).
2. Biogeochemistry measurements in surface and deep water four times a year south of Bergen at the west coast of Norway (Uni Research Climate/University of Bergen).

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

**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')**

FixO3 – Fixed-point open ocean observatories, EU project 2013-2017 (SOLAS Focus 2).
Ocean Acidification program – Norwegian project 2013-2016 (SOLAS Focus 2)
EXPECT – Exploring the Potential and Side Effects of Climate Engineering ('Geoengineering theme')

**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)**

EU proposal - Cooperation between Norway and Red Sea University of Sudan, analyses and data management of biogeochemical time series, capacity building (Uni Research Climate, University of Bergen, Red Sea University), submission March 2016.

Atmospheric inverse modelling is a key tool for reconstructing anthropogenic carbon emissions. The accuracy of air-sea and land-air fluxes depends on the atmospheric data base, but also the quality of air-sea fluxes. Norway (Bergen) plans to contribute with biogeochemical re-analyses to provide interannualy varying air-sea fluxes globally with different approaches: (a) A neural network regression approach. (b) A bottom-up combined state-parameter estimation using an Earth system model. In both cases, multi-tracer data sets of biogeochemical observations together with modelling frameworks will be employed. The re-analyses would help to create an independent greenhouse gas emission verification system.

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

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