

Report for the year 2017 and future activities

SOLAS South Africa

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PART 1 - Activities from January 2017 to Jan/Feb 2018

1. Scientific highlight

Re-evaluating the magnitude and impacts of anthropogenic atmospheric nitrogen deposition to the global ocean

Across much of the global ocean, primary production in surface waters is limited by the availability of bioavailable nitrogen (N). Nitrogen is supplied to sunlit surface waters mainly as nitrate upwelled from depth, which exists mainly as nitrate in the deep ocean, support most of this primary production. External inputs of N to the ocean from rivers, groundwater, oceanic N₂ fixation, and atmospheric deposition may further augment ocean productivity. Prior to human intervention, we assume that the ocean's N budget was in steady state, with the external inputs balancing the losses. However, the global N cycle is now being massively perturbed by human activity, such that the estimated anthropogenic release of N into the global environment (160 Tg N/yr) is now of similar magnitude to all natural N₂ fixation (250 Tg N/yr) and is likely to increase in future with a growing global population. The increasing inputs of N from human activity have the potential to modify oceanic, and even global, biogeochemical systems. However, our understanding of the scale and impact of such perturbations on the oceans is limited.

Premised on the idea that atmospheric deposition is the dominant mechanism by which anthropogenic perturbations of the N cycle affect the open ocean, Duce et al. (2008) provided the first comprehensive estimates of atmospheric N inputs to the global ocean and attempted to quantify the impact of this deposition on ocean biogeochemistry. Since then, new (data and modeling) studies of atmospheric N emissions and their deposition to the oceans have motivated an effort to reevaluate the conclusions of Duce et al. (2008). The present study (Jickells et al. 2017), which involves authors from all over the world, many of whom contributed to the original Duce et al. (2008) paper, reports improved estimates of preindustrial and modern atmospheric N inputs to the ocean, details improved models to describe the distribution and impact of these inputs on the oceans and their effects on the exchange of some important greenhouse gases, and considers possible future changes in atmospheric N fluxes to the ocean.

In brief, Jickells et al. (2017) find that anthropogenic N inputs are currently increasing oceanic carbon sequestration at a rate of 0.4% per year (equivalent to 0.15 Pg C/yr, which is less than the Duce et al. (2008) estimate). The resulting reduction in climate forcing driven by this additional oceanic CO₂ uptake is partially offset by an increase in marine N₂O emissions. The authors identify four important feedbacks in the ocean-atmosphere N system that need to be better quantified if we are to improve our understanding of the perturbation of ocean biogeochemistry by atmospheric N inputs. These include recycling of (1) ammonia and (2) organic N from the surface ocean to the lower atmosphere and back again, (3) the suppression of N₂ fixation by increased N concentrations in surface waters from atmospheric N deposition, and (4) increased loss of N from the ocean by denitrification due to increased productivity stimulated by atmospheric N inputs.

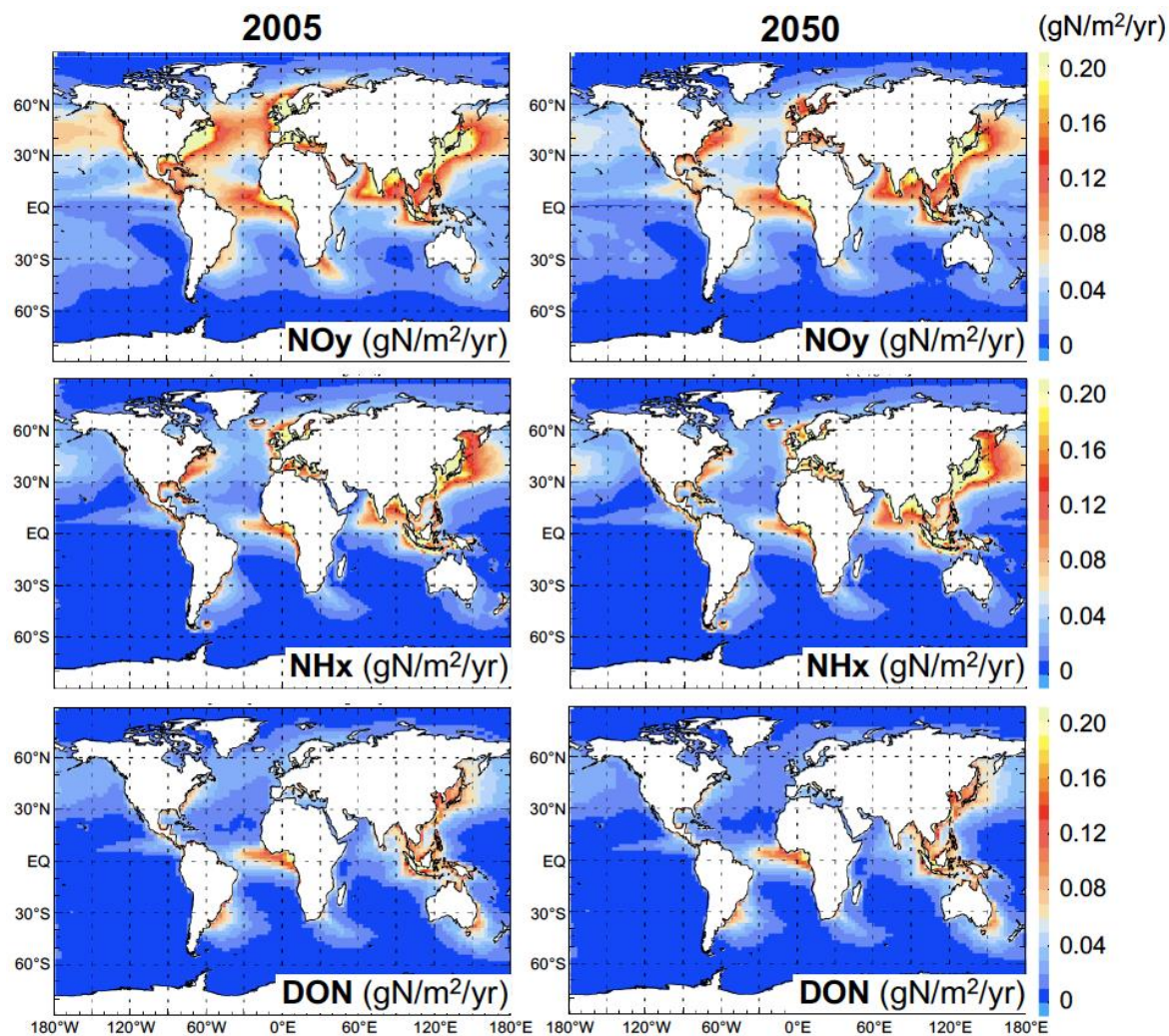


Figure: Atmospheric deposition (in $\text{g N/m}^2/\text{yr}$) to the ocean for 2005 (left) and 2050 (right) for oxidized N (NO_y ; top row), reduced N (NH_x ; middle row), and organic N (bottom row). Estimates are based on the TM4-ECPL model (Daskalakis et al. 2015; Tsigaridis et al. 2014) and agree well with other model outputs and with data (Kanakidou et al. 2016).

Citation: Jickells TD, et al. (2017). A re-evaluation of the magnitude and impacts of anthropogenic atmospheric nitrogen inputs on the ocean, *Global Biogeochemical Cycles*, 31, 289-305, doi:10.1002/2016GB005586.

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).

Research cruises aboard the R/V *SA Agulhas II*: SANA E (South African National Antarctic Expedition) November 2016-February 2017 and November 2017- February 2018 (Cape Town to Antarctica along the GoodHope Line), Prince Edward Islands (April/May 2017), Marginal Ice Zone and WOCE IO-6 line (June/July 2017), SEAmester cruise along the SAMBA line (Southeast Atlantic, Cape Town to meridian along 34.5°S); IIOE-2 (2nd International Indian Ocean Expedition) Durban to Dar-e-Salaam (October 2017); Tristan de Cunha and Gough Island (September 2017) (SOLAS themes 1, 2, 3, 4 and 5, as well as *Science and Society*).

Integrated Ecosystem Programme (IEP) research cruises (February, May, August, November 2017) aboard the R/V *Algoa* to the southern Benguela upwelling system to monitoring the physics, chemistry and biology of the region (SOLAS themes 1 and 2).

Wave Glider wind stress and pCO₂ flux deployments (CSIR SOCCO for more details); Each R/V SA *Agulhas II* cruise was continuously collecting air-sea heat flux data to derive bulk net heat flux estimates. Also, dissolved inorganic carbon, alkalinity, pCO₂ (SOLAS themes 1 and 2).

Phytoplankton sampling of SAMBA line in Southeast Atlantic Ocean. Phytoplankton sampling of winter sea-ice in South Indian ocean at 55 degrees South, and meridional line into South Indian Ocean. In both cases coupled with primary production and nutrient uptake, nitrification experiments.

Monitoring and collection of size-segregated aerosols on the R/V SA *Agulhas II*, as well as at the Cape Point Global Atmospheric Watch Tower (SOLAS themes 1, 2, 3, 4 and 5).

Southern Ocean ecosystem response to dust input (SOLAS themes 3 and 4).

Aerosol monitoring in Stellenbosch town (January to October 2017)

Microbial Community dynamics in the Benguela upwelling region and around a Seamount south of Madagascar (MADRIDGE cruise project).

Continued field campaign at Cape Point to measure and monitor atmospheric halocarbons. This campaign was in partnership with the Atmospheric Chemistry Research Group at the University of Bristol and the South African Weather Service GAW Department (SOLAS themes 3 and 4).

Focus on surface wind speed and the turbulent latent heat flux across area of high SST gradient (eddies and Agulhas Current). Data intercomparison and data analysis (reanalysis and satellite remote sensing), model, international collaborations (SOLAS theme 2).

Southern Ocean biogeochemical monitoring: net carbon drawdown by the upper ocean ecosystem; rates of net primary production, nitrogen uptake, nitrification on varying timescales and using various methods; microbial community composition and function; role of sea ice in setting upper ocean chemistry, air-sea-ice fluxes of heat; trace metal concentrations and cycling (SOLAS themes 1, 2 and 3, as well as *Science and Society*).

Antarctic Circumnavigation Expedition (ACE) (2016-2018): funded by the Swiss Polar Institute and involving 22 projects from all over the world focused on the coupled ocean-atmosphere-ice-climate system (<http://spi-ace-expedition.ch/>). December 2016-March 2017: research cruise aboard the *Akademik Treshnikov* circumnavigating Antarctica. Two South African-led projects, with South African scientists involved in six other projects (SOLAS themes 1, 2, 3, 4 and 5, as well as *Science and Society*).

SEAmester: South Africa's first class afloat (annually from 2016) (<http://www.seamester.co.za/>): funded by the National Research Foundation, the goal of SEAmester is to encourage interaction between young South African scientists, lecturers and field specialists in a hands-on, practical environment on board the R/V SA *Agulhas II*. 40 students and 20 lecturers and numerous technicians at sea for 11 days, engaging in classroom learning, hands-on oceanography and atmospheric sampling, and "real" science. 2017 cruise was along the SAMBA line (Southeast Atlantic, Cape Town to meridian along 34.5°S) (SOLAS theme *Science and Society*).

The Preface program allowed the deployment and annual maintenance of an Atlas mooring at 6°S, 8°E during preface cruises. A first mooring was bought by South Africa in 2006 and was deployed successfully for a year during a pilot project. Preface then funded a second mooring in order to establish a permanent monitoring location. This is an extension of the PIRATA array of moorings in the tropical South-East Atlantic (Prediction and Research Moored Array in the Atlantic; designed to study ocean-atmosphere interactions in the tropical Atlantic that affect regional weather and climate variability on seasonal, interannual and longer time scales) and an African contribution to the global observing system. The "Kizomba" mooring is equipped with an extra current meter at 10 m and an extra shortwave radiation sensor that allows for the calculation of the radiative flux and the net heat budget at a 10 minute temporal resolution. Turbulent, sensible and latent heat fluxes can also be calculated at a 10 minute resolution. Sensible and daily averages are available in real time. A CO₂ sensor is also deployed on the mooring. The strategic location of the mooring in the stratocumulus deck, which is a problem for coupled models, offshore of the Congo River panache and upstream of the Angola Current make this mooring a unique measuring platform which has continuously worked in real time since May 2013 (SOLAS themes 1 and 2) (SOLAS themes 1 and 2).

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

Botha, R., Labuschagne, C., Williams, A.G., Bosman, G., Brunke, E.-G., Rossouw, A., Lindsay, R. (2018) Characterising fifteen years of continuous atmospheric radon activity observations at Cape Point (South Africa). *Atmospheric Environment* 176, 30-39, doi:10/1016/j.atmosenv.2017.12.010.

Du Plessis M, Swart S, Ansorge I J, Mahadevan A (2017) Submesoscale processes promote seasonal restratification in the Subantarctic Ocean. *Journal of Geophysical Research Oceans* 122, 2960-2975, doi:10.1002/2016JC012494.

Gregor L, Kok S, Monteiro P M S (2017) Empirical methods for the estimation of Southern Ocean CO₂: support vector and random forest regression. *Biogeosciences* 14, 5551-5569, doi:10.5194/bg-14-5551-2017.

Mawren D, Reason C J C (2017) Variability of upper ocean characteristics and tropical cyclones in the South West Indian Ocean. *Journal of Geophysical Research Oceans* 122, 2012-2028, doi: 10.1002/2016JC012028

Schmidt K, Swart S, Reason C J C, Nicholson S (2017) Evaluation of satellite and reanalysis wind products with *in situ* Wave Glider wind observations in the Southern Ocean. *Journal of Atmospheric and Oceanic Technology*, doi.org/10.1175/JTECH-D-17-0079.1

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?

International: Collaborative research and shared student supervision with MIT, CalTech, Princeton University, University of Connecticut, Florida State University, University of Bristol, Hong Kong University of Science, Swiss Polar Institute, ICEMASA, Max Planck Institute for Chemistry.

National (non university): Collaborative research and shared student supervision with the Council for Scientific and Industrial Research, Department of Environmental Affairs, South African Weather Service, Department of Science and Technology, South African Environmental Observation Network. Department of Agriculture, Forestry and Fisheries.

Collaborations included shared field work (specifically, research cruises, field campaigns, research at the Cape Point Global Atmospheric Watch Tower), student exchanges, modelling efforts, secondment of faculty from foreign institutions to teach and co-supervise students.

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.).

NO-PANTS – New Observations of Processes within Antarctic Sea-ice (August 2018): multiple glider, ship, wave glider and perhaps other buoy deployments in the marginal ice zone, East Weddell to measure surface fluxes and impact on upper ocean stratification processes (SOLAS themes 1 and 2).

SANAP – South African National Antarctic Programme (2018-2020) Winter and summer cruises to the Southern Ocean on the R/V *SA Agulhas II* (ice-breaker), including sampling of the marginal ice zone. Annual cruises to the Prince Edward Islands (Subantarctic) and Gough Island (SOLAS themes 1, 2, 3, 4 and 5).

Southern Benguela Integrated Ecosystem Programme (IEP; Department of Environmental Affairs) – four cruises annually to the SBUS to monitor the region's physics, chemistry and biology (SOLAS themes 1 and 2).

PLATO – The role of PLankton in a coupled Atmosphere-Ocean System: Biannual cruises to the Benguela upwelling system, modelling efforts, atmospheric sampling to investigate the role of phytoplankton in albedo and global climate: The coupled ocean-atmosphere Benguela System

(SOLAS themes 1, 2, 3, 4 and 5).

Continued aerosol collection, trace gas monitoring (including CO₂, CH₄, NO_x, N₂O, bromoform, etc), mercury deposition at the Cape Point GAW tower (SOLAS themes 1, 4 and 5).

SOLSTICE-WIO – Sustainable Oceans, Livelihoods and food Security Through Increased Capacity in Ecosystem research in the Western Indian Ocean (<http://solstice-wio.org/>) (2017-2020): Focus on the Agulhas bank (SOLAS themes 1 and 2).

Antarctic Circumnavigation Expedition (ACE) (2016-2018): 22 international projects focused on understanding the Subantarctic Ocean-Atmosphere system (SOLAS themes 1, 2, 3, 4 and 5).

False Bay (Western Cape) monitoring project (2018-2019): Water quality, biogeochemistry, rocky shore ecology, pollution (run-off, atmospheric deposition), aerosols (SOLAS themes 3, 4, 5, as well as *Science and Society*).

IIOE-2 (2nd International Indian Ocean Expedition) (2017 onwards): Investigation of western Indian Ocean physics, chemistry, biology (with Mozambique, Tanzania, Mauritius) (SOLAS themes 1, 2, 5, as well as *Science and Society*).

Preface: Continued deployment and maintenance of the "Kizomba" mooring (South Africa's contribution to the PIRATA array of moorings in the tropical South-East Atlantic) – measurements of currents, radiative flux and the net heat budget, CO₂ fluxes (SOLAS themes 1 and 2).

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

SOFLUX meeting at Polar2018 (Davos) - SOOS Southern Ocean Flux Working Group: June 2018. OSM 2018 (Portland) side meeting between SOFLUX and SOLAS for future collaboration and engagement on common issues (SOLAS themes 1 and 2).

Polar2018 (Davos): June 2018. South African researchers and students engaged in Antarctic research will present their findings at the SCAR Open Science Conference. South Africa also participates in the SCAR business meetings held alongside the conference (SOLAS themes 1, 2, 3, 4 and 5, as well as *Science and Society*).

ACE (Antarctic Circumnavigation Expedition) meetings: January 2018 (Lusanne, Switzerland) and June 2018 (Davos, Switzerland). Two South African-led projects are part of the 22 international projects funded through the Swiss Polar Institute (South African contribution to SOLAS themes 1 and 3, as well as *Science and Society*).

PHYCOLOG workshops – PHYtoplankton COmmunities along the Land-Ocean Gradient in a warmer climate (South Africa and Denmark): 2018-2019. Four workshops over the course of two years (the first held in March 2018) involving researchers and students from the University of Cape Town, Cape Peninsula University of Technology, and Aarhus University (SOLAS themes 1 and 3, as well as *Science and Society*).

SANAP (South African National Antarctic Programme) symposium (Hermanus): August 2018. Four-day meeting of all South African scientists engaged in Antarctic research (addresses SOLAS themes 1, 2, 3, 4 and 5, as well as *Science and Society*).

SCOR Working Group 155: "Eastern boundary upwelling systems (EBUS): diversity, coupled dynamics and sensitivity to climate change". One South African full member and one associate member. First meeting June 2018 (Washington, DC). Terms of reference include: 1) synthesizing existing knowledge of EBUS forcing and feedbacks, 2) development of an assessment tool for EBUS, 3) review paper, 4) recommendations of regional observation systems, 5) socio-economic evaluation that provides guidance for all stakeholders. Also, planned contribution to Ocean Obs'19 and IPCC WGII, possible collaboration with CLIVAR RF EBUS, and organization of summer school (likely in Senegal or Peru) focused on EBUS (SOLAS themes 1, 2 and 4, as well as *Science and Society*).

NOSASSO (N-OSmolytes Across the Surface Southern Ocean: Environmental Drivers and Bioinformatics) workshop (September 2018): post-cruise activity to exploit data and knowledge generated during ACE (see above) to address cross-disciplinary issues and increase international breadth. This project will address four major themes: 1) Microbes, genes, trace gases and their precursors; 2) Nutrient influences on osmolytes, trace gases and productivity; 3) Ocean-atmosphere exchange: ocean emissions and the chemistry of aerosols; 4) Data extrapolation via remote sensing and modelling (SOLAS themes 1, 3, 4 and 5).

SASAS (South African Society for Atmospheric Sciences) Conferences planned for 2018 and 2020 (SOLAS themes 1, 2, 3, 4 and 5).

SAMSS (South African Marine Sciences Symposium) Meeting planned for 2020 (SOLAS themes 1 and 3, as well as *Science and Society*).

3. Funded national and international projects / activities underway.

Sweden Wallenberg NO-PANTS project (see above) together with Southern Ocean Carbon and Climate Observatory (SOCCO), CSIR (SOLAS themes 1 and 2).

SANAP (2018-2020): Role of Southern Ocean on Western Cape drought and flood events; Biogeochemical controls on the sources and chemical composition of Southern Ocean marine aerosols; A nitrogen cycle view of atmospheric CO₂ sequestration in the Antarctic Ocean; South Ocean ecosystems response to dust input; Shifts in phytoplankton and microbial community composition and functional diversity; trace metal cycling and availability in the Southern Ocean; Southern Ocean CO₂ and heat fluxes; submesoscale physical processes in the Southern Ocean; phytoplankton community composition (remote sensing/optical measures) (SOLAS themes 1, 2, 3, 4 and 5, as well as *Science and Society*).

SEAmester – South Africa's first class afloat (annually): teaching university aboard the R/V SA Agulhas II (SOLAS theme *Science and Society*).

SA-SAMOC (South Atlantic Meridional Overturning Circulation) (2018-2020): continued monitoring of volume transport across the South Atlantic (with the University of Cape Town, France, Brazil, USA and UK) (SOLAS theme 2).

ASCA (Agulhas System Climate Array): continued monitoring (with the University of Cape Town, South African Environmental Observation Network, Netherlands and USA) (SOLAS theme 1 and 2).

ACCESS (Alliance for Collaboration on Climate and Earth Systems Science) (2018-2020): Annual cycle of ocean-atmosphere interaction over ocean hotspots near southern Africa and influence on regional climate variability; The role of phytoplankton in albedo and global climate: The coupled ocean-atmosphere Benguela System (with Namibia, USA, UK); Predictability of seasonal anomalies for societal benefit (SOLAS themes 1, 2, 3, 4 and 5, as well as *Science and Society*).

South African National Research Foundation Competitive Support Programme: Investigation of the sources and interactions of reduced nitrogen species in the remote marine atmosphere (with USA); Late Quaternary ocean-climate interactions: palaeo-science training through palaeo-climate research (with USA, Germany) (SOLAS themes 1, 3, 4 and 5, as well as *Science and Society*).

SOLSTICE project (2017-2020). Focusing on the Agulhas bank, the microbial dynamics of the nephloid layer and its effect on squid recruitment.

Activities underway: Airborne particle monitoring in Western Cape (year round); **see also major field studies above for activities underway.**

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

H2020 proposal being submitted: University of Gothenburg and CSIR collaborating on pCO₂ and heat flux Work Package (SOLAS themes 1 and 2); University of Cape Town, CSIR and UK partners collaborating on Phytoplankton Work Package (SOLAS themes 1 and 4).

South African Water Research Commission (submission date May-July 2018): Drivers and indicators of water quality in South Africa's largest natural bay: weather patterns, nitrogen biogeochemistry, and fishers' knowledge (SOLAS themes 3, 4 and 5, as well as *Science and Society*).

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

ORCHESTRA, UK; GEOTRACES; COMICS; GO-SHIP; ROSES; BIO-ARGO; SOCCOM; ACE; SOOS; SCAR; SCOR; CLIVAR

Comments