



GESAMP

Joint Group of Experts on the
Scientific Aspects of Marine
Environmental Protection

GESAMP 43/4/2
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43rd session
Agenda item 4

**PLANNING OF GESAMP ACTIVITIES:
ATMOSPHERIC INPUT OF CHEMICALS TO THE OCEANS**

Report of the Co-Chairmen of Working Group 38

History, early meetings and their results

1 Working Group 38 was first formed in 2008 because of growing concern about the impact of atmospheric deposition of both natural and anthropogenic substances on ocean chemistry, biology, and biogeochemistry as well as climate. It has held meetings at the University of Arizona, Tucson, Arizona, United States, in 2008, at IMO in London in 2010, in Malta in 2011, and at the University of East Anglia, Norwich, UK in 2013. Sponsors of those WG 38 efforts have included WMO, IMO, SCOR, SIDA, the European Commission Joint Research Centre, the University of Arizona, the International Environment Institute at the University of Malta, the University of East Anglia, and the US National Science Foundation. Following the initial terms of reference and the above-mentioned meetings, five scientific papers were published in the peer-reviewed scientific literature. These were as follows:

- [1] Okin, G., A. R. Baker, I. Tegen, N. M. Mahowald, F. J. Dentener, R. A. Duce, et al., "Impacts of atmospheric nutrient deposition on marine productivity: roles of nitrogen, phosphorus, and iron, Global Biogeochemical Cycles, **25**, GB2022, doi:10.1029/2010GB003858, (2011).
- [2] Hunter, K.A., P. S. Liss, V. Surapipith, F. Dentener, R. A. Duce, M. Kanakidou, et al., "Impacts of anthropogenic SO_x, NO_x and NH₃ on acidification of coastal waters and shipping lanes", Geophysical Research Letters, **38**, L13602, doi:10.1029/2011GL047720 (2011).
- [3] Kanakidou, M., Kanakidou, M., R. Duce, J. Prospero, A. Baker, et al., "Atmospheric fluxes of organic N and P to the ocean", Global Biogeochemical Cycles, **GB3026**, doi:10.1029/2011GB004277 (2012).
- [4] Schulz, M., J. M. Prospero, A. R. Baker, F. Dentener, L. Ickes, P. S. Liss et al., "The atmospheric transport and deposition of mineral dust to the ocean - Implications for research needs", Environmental Science and Technology, **46**, doi:10.1021/es30073ul, 10,390-10,404 (2012).
- [5] Hagens, M., K. A. Hunter, Peter S. Liss, and Jack J. Middelburg, "Biogeochemical context impacts seawater pH changes resulting from atmospheric sulfur and nitrogen deposition", Geophysical Research Letters, **41**, doi:10.1002/2013GL058796 (2014).

Nitrogen workshop in Norwich, United Kingdom, 2013

2 New Terms of Reference for continued work of GESAMP WG 38 were approved in 2011 to address issues related to the impact of the atmospheric deposition of anthropogenic nitrogen to the ocean. A highly successful workshop on "The Atmospheric Deposition of Nitrogen and its Impact on Marine Biogeochemistry" was held by WG 38 at the University of East Anglia in February, 2013 to address the new terms of reference. 23 scientists participated in the workshop.

As a result of the Norwich workshop several papers have been published or submitted for publication in the peer reviewed scientific literature on this nitrogen issue. These include:

- [6] Kim, T.-W., K. Lee, R.A. Duce and P.S. Liss, "Impact of atmospheric nitrogen deposition on phytoplankton productivity in the South China Sea", Geophysical Research Letters, **41**, 3156-3162, doi: 10.1002/2014GL059665 (2014).
- [7] Somes, C., A. Landolfi¹, W. Koeve¹, and A. Oschlies, "Limited impact of atmospheric nitrogen deposition on marine productivity due to biogeochemical feedbacks in a global ocean model", Geophysical Research Letters, **43**, 4500–4509, doi:10.1002/2016GL068335 (2016).
- [8] Kanakidou, M., S. Myriokefalitakis, N. Daskalakis, G. Fanourgakis, A. Nenes, A.R. Baker, K. Tsigaridis, and N. Mihalopoulos, "Past, Present, and Future Atmospheric Nitrogen Deposition", Journal of the Atmospheric Sciences, **73**, 2039-2047, doi:10.1175/JAS-D-15-0278.1 (2016).
- [9] Sharples, J., J.J. Middelburg, K. Fennel, and T.D. Jickells, "Physical controls on riverine delivery of nutrients and carbon to the open ocean", Submitted to Global Biogeochemical Cycles (2016).
- [10] Jickells, T.D., E. Buitenhuis, K. Altieri, A.R. Baker, D. Capone, R.A. Duce, F. Dentener, K. Fennel, M. Kanakidou, J. LaRoche, K. Lee, P. Liss, J.J. Middelburg, J.K. Moore, G. Okin, A. Oschlies, M. Sarin, S. Seitzinger, J. Sharples, P. Suntharalingam, M. Uematsu, and L.M. Zamora, "A re-evaluation of the magnitude and impacts of anthropogenic atmospheric nitrogen inputs on the ocean", Submitted to Global Biogeochemical Cycles (2016).
- 3 Two additional papers will be submitted for publication during the fall of 2016:
- [11] Zamora, L., P. Suntharalingam, A. Singh, M. Sarin, S. Bikkina, L. Resplandy, S. Seitzinger, S. Schmidtko, and H.W. Bange, "N₂O emissions from the Northern Indian Ocean: the role of atmospheric and riverine nitrogen inputs", To be submitted to Global Biogeochemical Cycles (2016).
- [12] Baker, A.R., M. Kanakidou, K. Altieri, N. Daskalakis, G. Okin, S. Myriokefalitakis, F. Dentener, M. Uematsu, M. Sarin, R.A. Duce, J. Galloway, W. Keene, A. Singh, L. Zamora, J.-F. Lamarque, S.-C. Hsu, S. Rohekar, J. Prospero, "Atmospheric nitrogen deposition to the oceans: observation- and model-based estimates of dry (aerosol) deposition", To be submitted to Global Biogeochemical Cycles (2016).

Activities in 2016

4 For the third year in a row, WG 38 organized a session on atmospheric input of chemicals to the ocean for the 2016 EGU meeting, held in Vienna, Austria in April, 2016 – "Air-sea Exchanges: Impacts on Biogeochemistry and Climate". A number of oral and poster papers at this session were presented by a combination of WG 38 members and other scientists. WG 38 member Maria Kanakidou was honored by being awarded the Vilhelm Bjerknes Medal, and she presented the medal lecture as part of this symposium.

5 Robert Duce, representing WG 38, participated in the 3rd meeting of WMO's Environmental Pollution and Atmospheric Chemistry Scientific Steering Committee (EPAC SSC), held in Geneva in March, 2016. Tim Jickells, Robert Duce, and Alex Baker represented WG 38 at the WMO/GAW International Workshop on the Nitrogen Cycle in April, 2016, presenting three papers on various WG 38 efforts on nitrogen inputs to the ocean.

Plans for two new WG 38 workshops in 2017

6 At GESAMP's 42nd session held at IOC in Paris in September, 2015, GESAMP members approved two new activities for WG 38 to investigate the changing acid/base character of the global atmosphere and ocean and the impact of these changes on certain air/sea chemical exchange processes. One activity, "Changing Atmospheric Acidity and the Oceanic Solubility of Nutrients", will focus on how the changing atmospheric acidity will affect the solubility, and thus bioavailability, of aerosol-derived nutrients such as iron and phosphorus when they are deposited in the ocean from the atmosphere. The terms of reference are as follows:

- review and synthesize the current scientific information on the solubility of aerosol-associated key biogeochemical elements, the biogeochemical controls on aerosol solubility, and the pH sensitivity of those controls;
- consider the likely changes in solubility of key species into the future and the potential biogeochemical consequences of such changes;
- identify the key future research needs to reduce uncertainties in predictive capability in this area;
- publish the results of this activity in the open peer-reviewed scientific literature; and
- interact with, and provide information to, leading relevant international groups including the Future Earth core projects SOLAS, IGAC and IMBER; SCOR, particularly its GEOTRACES program; and WMO programs such as GAW.

7 The second activity, "Impact of Ocean Acidification on Fluxes of non-CO₂ Climate-Active Species", will focus on the impacts of ocean acidification on the oceanic sources of a range of non-CO₂ gaseous species, as well as aerosol precursors that are influential in regulating radiative forcing, atmospheric oxidizing capacity and atmospheric chemistry. The terms of reference are as follows:

- review and synthesize the current science on the direct impacts of ocean acidification on marine emissions to the atmosphere of key species important for climate, and atmospheric chemistry;
- identify the primary needs for new research to improve process understanding and to quantify the impact of ocean acidification on these marine fluxes (i.e., provide recommendations on the specific laboratory process studies, field measurements and model analyses needed to support targeted research activities on this topic);
- publish the results of this activity in the open peer-reviewed scientific literature; and
- provide input to and interact with national and international research programs on ocean acidification (e.g., UKOA, NOAA-OAP) and with relevant WMO programs (e.g., Global Atmosphere Watch (GAW)) to build on their recent relevant activity in achieving the above objectives.

8 These two activities will be largely implemented via two workshops to be held simultaneously at the University of East Anglia (UEA) in Norwich, United Kingdom from 27 February through 2 March, 2017. We see potential synergies between these two workshops, and individuals will have the opportunity to attend some sessions of both workshops. We have obtained financial support for these workshops from WMO, IMO, SCOR, the US National Science Foundation (NSF), UEA. SOLAS is also sponsoring these workshops. We expect a total of about 30 people to attend these by-invitation-only workshops, and detailed plans have been developed and participants invited.

Additional activity in 2017

9 A third upcoming activity of WG 38, also approved at GESAMP's 42nd session, is an assessment of the impact of nitrogen on the marine environment as a contribution to the Integrated Nitrogen Management System (INMS). INMS is a global targeted research project with the aim to provide clear scientific evidence to inform future international nitrogen policy development. WG 38 is in an excellent position to bring together observational scientists and atmospheric modelling groups to address these issues. Funding for this effort would come from the INMS.
