



**GESAMP**

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

GESAMP 46/4/2  
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ENGLISH ONLY

46th session  
Agenda item 4

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

**Report of the Co-Chairs 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 in 2008; at IMO in London in 2010; in Malta in 2011; and at the University of East Anglia, Norwich, UK in 2013 and 2017. The 2013 workshop focused on nitrogen inputs from the atmosphere to the ocean and their impacts. 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 meetings through 2013, twelve scientific papers have been 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<sub>x</sub>, NO<sub>x</sub> and NH<sub>3</sub> 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)
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. Landolfi<sup>1</sup>, W. Koeve<sup>1</sup>, 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, "What proportion of riverine nutrients reaches the open ocean", Global Biogeochemical Cycles, **31**, 39–58, doi:10.1002/2016GB005483. (2017).
10. Jickells, T.D., E. Buitenhuis, K. Altieri, A.R. Baker, et al., "A re-evaluation of the magnitude and impacts of anthropogenic atmospheric nitrogen inputs on the ocean", Biogeochemical Cycles, **31**, 289–305, doi:10.1002/2016GB005586. (2017).
11. Baker, A.R., M. Kanakidou, K. E. Altieri, et al., "Observation- and model-based estimates of particulate dry nitrogen deposition to the oceans", Atmospheric Chemistry and Physics, **17**, 8189–8210, (2017).
12. Suntharalingam, P., L. M. Zamora, H.W. Bange, S. Bikkina, E. Buitenhuis, M. Kanakidou, J.-F. Lamarque, A. Landolfi, L. Resplandy, M. M. Sarin, S. Seitzinger and A. Singh, "Anthropogenic nitrogen inputs and impacts on oceanic N<sub>2</sub>O fluxes in the northern Indian Ocean: The need for an integrated observation and modelling approach", Deep Sea Research II, In press (2019).

2 Following the completion of the publication of the papers resulting from the 2013 workshop on the impacts of atmospheric nitrogen deposition to the ocean, WG 38 prepared a synthesis of the results from the scientific papers derived from that workshop. That report was reviewed by GESAMP and published by WMO in 2018 as GESAMP Reports and Studies No. 97, The Magnitude and Impacts of Anthropogenic Atmospheric Nitrogen Inputs to the Ocean. The primary conclusions of that report were presented in the 2018 WG 38 report and will not be repeated here.

### **Current activities of Working Group 38**

3 For the sixth year in a row WG 38 organized a session on atmospheric input of chemicals to the ocean for the 2019 European Geosciences Union meeting, held in Vienna, Austria in April – "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.

4 Tim Jickells attended the INMS International Nitrogen Management System annual meeting in Edinburgh, United Kingdom from 16 to 19 April 2018 to represent WG 38 and supported by INMS. At the meeting he informally presented the work of WG 38 to relevant leaders of the INMS activity, particularly those leading initiatives in South East Asia, and he presented them with details of our synthesis report. He made clear the enthusiasm of WG38 to work with the INMS initiatives if they felt that would be useful, and we await their responses.

5 Tim Jickells then attended and participated in the 2nd East Asia Nitrogen Conference in Tsukuba, Japan from 19 to 22 November 2018, where he gave a keynote talk on the atmosphere/ocean aspects of the nitrogen cycle on behalf of WG 38. He also participated in a subsequent workshop in Tsukuba. We hope that this effort will increase our interactions with the INMS activity, and we hope to contribute to an INMS initiative on methods to quantify nitrogen deposition

6 WG38 proposed the following activity to be considered for the OceanObs'19 ocean observing community conference: "Ocean observations to estimate atmospheric nutrient and trace metal inputs to the oceans". This has been adopted and is incorporated as part of a whitepaper that is in press in a special issue of Frontiers in Marine Science. Alex Baker is taking the lead on this effort by WG 38.

13. Smith, S.R., G. Alory, A. Andersson, W. Asher, A. Baker, D. I. Berry, K. Drushka, D. Figurskey, E. Freeman, P. Holthus, T. Jickells, H. Kleta, E. C. Kent, N. Kolodziejczyk, M. Kramp, Z. Loh, P. Poli, U. Schuster, E. Steventon, S. Swart, O. Tarasova, L.P. De La Villéon, N. Vinogradova Shiffer, "Ship-based contributions to global ocean, weather, and climate observing systems, In press, Frontiers in Marine Science, Ocean Observation section (2019).

7 Alex Baker participated on behalf of WG 38 in the Workshop on Measurement-Model Fusion for Global Total Atmospheric Deposition held in Geneva, Switzerland in February 2019. He presented results from the GESAMP-supported paper recently published in Atmospheric Chemistry and Physics, "Observation- and model-based estimates of particulate dry nitrogen deposition to the oceans", publication [11] above.

8 At the meeting of GESAMP 42 at IOC in Paris in September 2015, GESAMP approved two new workshops for WG 38. These two simultaneous workshops were related to the changing acid/base character of the global atmosphere and ocean and the impact of these changes on certain air/sea chemical exchange processes. Funding was obtained for these workshops from the US National Science Foundation (through SCOR), from WMO, and from IMO. SOLAS also sponsored these workshops. The workshops took place at the University of East Anglia (UEA) in Norwich, United Kingdom, from February 27 through March 2, 2017. The topics of the two workshops were as follows: a) Impact of Ocean Acidification on Fluxes of Atmospheric non-CO<sub>2</sub> Climate-Active Species; and b) Changing Atmospheric Nutrient Oceanic Solubility.

9 The workshops took the form of rather informal presentations from experts followed by very lengthy discussion sessions exploring multiple issues and feedbacks evident in these complex air-sea interaction issues. The invited scientists were selected for their expertise and interest in these areas, and also to provide a wide spectrum of expertise from modellers to experimentalists. 34 scientists from 16 countries and also from a wide range of career stages, from senior scientists through to graduate students, participated in the workshops. At the present time the following papers have been published, are in press, have been or shortly will be submitted, and are still in preparation from the workshop discussions:

Published:

14. Kim, J.-M, K. Lee, Y.-S. Suh, and I.S. Han, "Phytoplankton do not produce carbon-rich organic matter in high CO<sub>2</sub> oceans", Geophysical Research Letters, **45**, 4189–4197. <https://doi.org/10.1029/2017GL075865> (2018).

15 Kanakidou, M., S. Myriokefalitakis, and K. Tsigaridis, "Aerosols in atmospheric chemistry and biogeochemical cycles of nutrients, In press, Environmental Research Letters, **13**. <https://doi.org/10.1088/1748-9326/aabccb> (2018).

16. Myriokefalitakis, S., A. Ito, M. Kanakidou, A. Nenes, M. C. Krol, N. M. Mahowald, R. A. Scanza, D. S. Hamilton, M. S. Johnson, N. Meskhidze, J. F. Kok, C. Guieu, A. R. Baker, T. D. Jickells, M. Sarin, R. Shelley. A. Bowie, M. M. G. Perron, and R. A. Duce, "The GESAMP atmospheric iron deposition model intercomparison study", Biogeosciences, **15**, 6659-6684. <https://doi.org/10.5194/bg-15-6659-2018> (2018).

17. Ito, A., S. Myriokefalitakis, M. Kanakidou, N.M. Mahowald, R.S. Scanza, D.S. Hamilton, A.R. Baker, T.D. Jickells, M. Sarin, S. Bikkina, Y. Gao, R.U. Shelley, C.S. Buck, W.M. Landing, A.R. Bowie, M.M.G. Perron, C. Guieu, N. Meskhidze, M.S. Johnson, Y.

Feng, J.F. Kok, A. Nenes, and R.A. Duce, "Pyrogenic iron: The missing link to high iron solubility in aerosols", Science Advances, 5:eeau7671 (2019).

To be submitted by the end of the summer, 2019:

18. Hopkins, F.E., P. Suntharalingam, M. Gehlen, O. Andrews, S.D. Archer, L. Bopp, E. Buitenhuis, I. Dadou, R.A. Duce, N. Goris, T.D. Jickells, M. Johnson, F. Keng, C.S. Law, K. Lee, P.S. Liss, M. Lizott, G. Malin, C. Murrell, H. Naik, A. Rees, J. Schwinger, and P. Williamson, "Changing ocean acidity as a modulator of atmospheric biogeochemistry and climate", To be submitted to Proceedings of the National Academy of Sciences (2019).

19. Baker, A.R., M. Sarin, R.A. Duce, T.D. Jickells, M. Kanakidou, A. Nenes, S. Myriokefalitakis, A. Ito, D. Turner, N.M. Mahowald, R. Middag, C. Guieu, Y. Gao, P. Croot, R. Shelley, and M.M.G. Perron, "Changing Atmospheric Acidity and the Oceanic Solubility of Nutrients", To be submitted to Proceedings of the National Academy of Sciences (2019).

In preparation, for submission later in 2019:

20. Peter Croot, lead author, "Controls and impacts of atmospheric nutrient solubility in the ocean".

21. Peter Croot, lead author, "Impacts of the episodic atmospheric deposition on ocean biogeochemistry".

22. Steve Archer, lead author, "A synthesis of the DMS response to ocean acidification observed in mesocosm experiments". Dr. Archer also presented a paper on this topic at the AGU/TOS Ocean Sciences meeting in 2018.

10 On June 28, 2019 a preliminary planning meeting was held for a possible WG 38 workshop in 2020 entitled "The Atmospheric Input of Chemicals to the Ocean – Management and Policy Implications". This workshop would bring together appropriate players to discuss the management and policy implications of current knowledge about atmospheric inputs of nutrients and possibly other substances to the ocean and their interactions and impacts within the marine environment. The planning meeting was held in Norwich, United Kingdom, and included Tim Jickells, Alex Baker, Peter Liss, Peter Kershaw, David Vousden, Michael Roberts, and Robert Duce. A tentative decision was made to hold such a workshop in the spring, 2020, assuming that the workshop is approved by GESAMP. The location is still to be determined. A more detailed description of the outcomes of this planning meeting is now being prepared and will be discussed with GESAMP at GESAMP 46 at the United Nations, in New York in September.

### **Future activities of Working Group 38**

11 One goal of WG 38 for the next year is to complete the submission and publication of all papers resulting from the 2017 workshop at the University of East Anglia.

12 A second goal for the next year will be to carry out the workshop described briefly in paragraph 9 above, assuming that this is approved by GESAMP.

### **Action requested of GESAMP**

13 GESAMP is invited to consider the information provided and to take action as appropriate.