GESAMP Working Group 38

The Atmospheric Input of Chemicals to the Ocean

BACKGROUND AND CONTEXT FOR THE WORKING GROUP

Recognition continues to grow concerning the impact of the atmospheric input of both natural and anthropogenic substances on ocean chemistry, biology, and biogeochemistry as well as climate. In the 1980s, GESAMP formed a working group sponsored by the World Meteorological Organization (WMO), UNESCO, and the United Nations Environment Program (UNEP) that developed a comprehensive review of the input of atmospheric trace species to the global ocean (GESAMP, 1989). That benchmark effort led to a scientific publication in Global Biogeochemical Cycles (Duce, Liss et al., 1991) that for more than 10 years was the state-of-the-art reference in this area, leading to over 500 citations in the literature. However, the information in those reports is now almost 20 years old, the documents are clearly out of date, and much new information on this topic is now available. A number of important environmental issues persist in this area and in many cases are considered to be more serious than previously thought, and new issues have arisen.

The atmospheric input of chemicals to the ocean is closely related to a number of important global change issues. For example, a recent workshop in Norwich, UK, sponsored by SOLAS and SCOR, found that the increasing input to much of the ocean of atmospheric anthropogenic nitrogen species, including nitrate, ammonia, and water-soluble organic nitrogen, may cause a low level fertilization of the ocean that could result in an increase in marine 'new' productivity of up to ~3%. This in turn could cause a possible sequestering of up to 0.3 Pg C/yr of atmospheric CO_2 in the ocean, which would affect the radiative properties of the atmosphere and thus climate (Duce et al., 2008). The atmospheric input of this anthropogenic nitrogen may also lead to the increased oceanic production and emission of N_2O, a powerful greenhouse gas that could offset as much as 2/3 of the decrease in radiative forcing from the increased drawdown of CO_2. In addition, the recognition that much of the oceanic iron, which is a limiting nutrient in many areas of the ocean, originates from the atmospheric input of minerals as a result of the long-range transport of sand and dust has catalyzed an intense interest in the atmospheric and marine chemistry of iron, its chemical form, and rate of input to the ocean (Jickells et al., 2005). The transport of mineral dust and iron affects the large areas of the global ocean where iron is the limiting nutrient. There is also a close connection with climate here, as a windier and dryer climate would result in increased quantities of iron entering the ocean, with its consequent impact on marine productivity and thus both CO_2 drawdown and dimethyl sulfide release, both of which in turn would provide a climate feedback. In both of these examples (nitrogen and iron), the fates of these substances and changes in their fluxes in the future are potentially related to climate and climate change. While the atmospheric input of nitrogen species and iron are currently topics of greatest interest, the input of other substances that may have an impact on the ocean, such as phosphorus, lead, cadmium, and POPs, may also be of concern, but have had little focused study to date. In addition, there is little information about whether inputs of sulfur dioxide from the atmosphere can add to the ocean acidification occurring by rising levels of carbon dioxide. Such sulfur dioxide input may be particularly critical in heavily trafficked shipping lanes and/or offshore of industrialized land areas.

The atmospheric deposition of the critical nutrient phosphorus, which is a co-limiting nutrient in some marine areas, is a particularly important topic (Mills et al., 2004). For example, as pointed out in the recently completed Duce et al. (2008) paper on atmospheric nitrogen deposition, atmospheric reactive nitrogen deposition, in the absence of significant atmospheric deposition of phosphorus, may exacerbate phosphorus-limitation of N_2-fixation. The long-term effect of atmospheric nitrogen deposition on N_2-fixation depends on whether P or Fe limits N_2-fixation and on the supply ratio of bioavailable N:P:Fe derived from atmospheric deposition. Atmospheric deposition of phosphorus is apparently much less perturbed by human activity than reactive nitrogen. Hence the overall impact of atmospheric deposition is likely to be a shift in the N/P balance of surface waters. However, we emphasize that we have very little data available on chemical forms of atmospheric phosphorus or of their fluxes to the ocean (e.g., see Baker et al., 2003 and 2006) or to the terrestrial biosphere (e.g., see Mahowald et al., 2005). Thus this is an important issue not only for the marine enviroment, but also for the terrestrial environment.

The development of atmospheric models and measurement programs to simulate the long-range transport and deposition of chemicals to the Earth's surface has expanded significantly in the last twenty years. The concern and interest of the marine community about atmospheric inputs to the ocean has also grown significantly, as outlined above. However, to date there has been relatively little interaction between the atmospheric and oceanic communities in this area. There is now an excellent opportunity for the inclusion of atmospheric transport and deposition studies to the ocean in new and developing atmospheric research and monitoring programs. For example, WMO is developing plans to initiate new, and improve existing, measurement and modeling programs in the areas of precipitation chemistry. WMO is also developing a Sand and Dust Storm Warning and Assessment System that links products of operational research forecasts of sand and dust to users. Until now there has been little involvement of the marine community in either of these efforts, although clearly both would be of significant interest and value to the ocean sciences.

It is proposed that GESAMP Working Group 38 - The Atmospheric Input of Chemicals to the Ocean - be initiated to address the issues outlined above and to enhance the interaction of the marine community with these developing atmospheric programs. There should be representatives of both of the above WMO programs in the membership of Working Group 38 if possible. In addition, the international research program SOLAS (Surface Ocean/Lower Atmosphere Study) of the International Geosphere/ Biosphere Program (IGBP) is addressing a number of the scientific questions that are very relevant to the Terms of Reference of Working Group 38. It is suggested that Working Group 38 also have representatives from SOLAS in its membership.

TERMS OF REFERENCE FOR THE WORKING GROUP

Based on the discussion above, the Terms of Reference of Working Group 38 are as follows:

- Assess the need for the development of new model and measurement products for improving our understanding of the impacts of the atmospheric deposition of nitrogen species and dust (iron) to the ocean;

- Review the present information on the atmospheric deposition of phosphorus species to both the marine and terrestrial environments, considering both natural and anthropogenic sources, and

evaluate the impact of atmospheric phosphorus deposition on marine and terrestrial ecosystems. Consider whether such a review of any other substance would be useful.

- Work with the WMO Sand and Dust Storm Warning and Assessment System and with the WMO Precipitation Chemistry Data Synthesis and Community Project to evaluate the needs of the marine community and assist in clearly articulating them in the development of these WMO efforts

To address these issues, individuals with the following expertise are required as members of the working group: atmospheric chemistry, marine biogeochemistry, air/sea chemical exchange, atmospheric dust and iron, nitrogen, and phosphorus measurement and modeling, general atmospheric transport modeling, precipitation chemistry measurement and modeling.

WORK PLAN FOR THE WORKING GROUP

Some preliminary efforts have already taken place as part of the development of the working group. The entire working group is expected to have two meetings, and it would also work intersessionally by correspondence.

Preliminary Activities of the Working Group

One of the proposed Co-Chairs of the Working Group (RD) participated in the WMO Sand and Dust Warning System meeting in Barcelona, Spain in November, 2007. At this meeting dust research forecasting scientists met with the user and observation community. RD was able to provide information to the participants on the importance of the input of dust and other chemicals to the ocean and also to learn about the plans for the development of the Sand and Dust Warning System and how GESAMP Working Group 38 might interact with that effort. In February, 2008 RD participated in the WMO Precipitation Chemistry Data Synthesis and Community Project Meeting in Las Vegas, NV. Again he provided information on the importance of accurately measuring the input of chemicals to the ocean and discussed the plans of the Precipitation Chemistry Project and how it could interface with GESAMP Working Group 38. The importance of a review of atmospheric phosphorus deposition to the earth's surface was discussed. Plans for the activities of Working Group 38 will also be reported at the meeting of GESAMP 35 in Accra, Ghana, 12-17 May 2008

First Working Group Meeting

The first meeting of Working Group 38 will be held at the Inn of the Mountain Gods in Ruidoso, New Mexico, USA. The GRAME/GESAMP Task Team has also used this site very successfully as a meeting locale in February, 2008. The dates of the meeting must be determined after soliciting information from the proposed working group members as to when they could attend. They will be polled very shortly, with four possible time periods suggested: the weeks of 18 August, 25 August, 17 November, and 8 December 2008.

At the first meeting the following would be accomplished:

1) Evaluate our current understanding of the input to the ocean of atmospheric iron (dust) and nitrogen species, with the goal of ascertaining a) if any additional reviews or syntheses of available

data are necessary; b) if any specific types and/or locations of chemical measurements are necessary; and c) if current models of the atmospheric transport and deposition of iron and nitrogen species to the ocean are adequate, and if they are not, what kinds of changes need to be made. As necessary, determine how these issues should be addressed intersessionally.

2) Discuss the development of an in-depth review of phosphorus from the atmosphere to the ocean and the terrestrial environment. An outline for such a review should be drawn up and intersessional tasks should be assigned for the preparation of preliminary short draft papers on critical issues that would be addressed by the review. There should also be discussions about whether there are any additional substances that might be of sufficient importance to be considered for a later similar type of review, such as sulfur dioxide.

3) Evaluate how the working group can most effectively provide information and advice to the WMO Sand and Dust Storm Warning and Assessment System relative to the forecasting of dust inputs from the atmosphere to the ocean. Assign intersessional tasks to members for this if necessary.

4) Evaluate how the working group can most effectively provide information and advice to the WMO Precipitation Chemistry Data Synthesis and Community Project that will enable that project to develop better estimates of the input of chemicals to the ocean via precipitation. Assign intersessional tasks to members for this if necessary

Second Working Group Meeting:

The second meeting of Working Group 38 would be held in the summer or fall of 2009 at some location in Europe. At the second meeting the following would be accomplished:

1) A report would be finalized that would address the four issues outlined above. Much of the text of parts 1), 3), and 4) would have been completed before the second working group meeting. Preliminary short papers under part 2) would also be completed before the meeting. The primary goal of the second meeting would be to complete a comprehensive review of the atmospheric deposition of phosphorus to the earth's surface and its impacts.

2) The working group would once again assess the need for additional reviews of the input of substances from the atmosphere to the ocean, and if it decided that such were needed, it would approach GESAMP about possibly continuing the efforts of the working group for another session.

Peer Review and Report Publication

The Working Group report will be subject to peer review according to the GESAMP Rules of Procedure. Potential reviewers will be identified by the Lead agency with the assistance from the GESAMP Office, and the peer review process is expected to take place in late 2009 or the first months of 2010, leading to an estimated publication date of mid 2010, subject to review and approval by GESAMP.

The report of the meeting would be published as part of the GESAMP Reports and Studies series, but it is very likely that the phosphorus review would also be published as a separate peer-reviewed

journal article, in which case the reviewers would be selected by the journal.

ADMINISTRATIVE ARRANGEMENTS

Sponsors, Budget, and Funding

The Lead agency for Working Group 38 will be WMO. A GESAMP Trust Fund has been developed between WMO and other contributing partners for the support of this working group. This trust fund will be used to support:

- Participation of members of GESAMP Working Group 38 in meetings related to the working group activities;
- Implementation of tasks recommended by Working Group 38; and
- Production of publications and reports documenting outcomes and benefits of Working Group 38 activities.

WMO has indicated that it will support Working Group 38 to the extent of $10,000 in 2008 and $10,000 in 2009. As a co-sponsor, IMO has indicated that it will support Working Group 38 to the extent of $10,000 in 2008 and possibly additional support in 2009. The GESAMP Office has indicated that SIDA (Swedish International Development Agency) will provide support for participants from developing countries in Working Group 38 to the extent of $20,000 total for 2008 and 2009. Other agencies are cordially invited to become co-sponsors of Working Group 38.

Working Group Chairpersons and Membership

The proposed Chairpersons would be Prof. Robert Duce from the United States and Prof. Peter Liss from the United Kingdom. Both of these individuals have had extensive experience in the area of air/sea exchange of chemicals and have participated in earlier GESAMP reports addressing similar issues.

The proposed membership of the working group was selected considering the types of expertise needed, as outlined on page 3. The membership would be as follows, with expertise indicated in parentheses:

Robert Duce - United States - Co-Chair (atmospheric chemistry, air/sea exchange)
*Peter Liss - United Kingdom - Co-Chair (atmospheric/marine chemistry, air/sea exchange)
Alex Baker - United Kingdom (atmospheric deposition of metals and nutrients to the ocean)
&Frank Dentener - Italy (atmospheric transport and deposition modeling)
Keith Hunter - New Zealand (ocean surface microlayer chemistry, marine biogeochemistry)
Maria Kanakidou - Greece (atmospheric chemistry)
*Nilgun Kubilay - Turkey (atmospheric organic nitrogen and mineral dust)
Natalie Mahowald, United States (dust and phosphorus transport and deposition modeling)

Greg Okin - United States - (nutrient dynamics in the ocean)
Joseph Prospero - United States (atmospheric mineral dust measurements and impacts)
Manmohan Sarin - India (nitrogen and other atmospheric species)
[$]Ina Tegen - Germany (atmospheric dust measurements and modeling)
*Mitsuo Uematsu - Japan (atmospheric chemistry measurements and modeling)

(*SOLAS contact) ([&]WMO Precip Program contact) ([$]WMO Sand and Dust Storm Warning and Assessment System contact)

Technical Secretary for the Working Group

The Technical Secretary for Working Group 38 will be Dr. Slobodan Nickovic of the World Meteorological Organization.

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