Geophysical Research Abstracts
Vol. 16, EGU2014-13996, 2014
EGU General Assembly 2014

Atmospheric Nitrogen Deposition to the Oceans: Observation- and Model-Based Estimates

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The reactive nitrogen (Nr) burden of the atmosphere has been increased by a factor of 3-4 by anthropogenic activity since the industrial revolution. This has led to large increases in the deposition of nitrate and ammonium to the surface waters of the open ocean, particularly downwind of major human population centres, such as those in North America, Europe and Southeast Asia. In oligotrophic waters, this deposition has the potential to significantly impact marine productivity and the global carbon cycle.

Global-scale understanding of N deposition to the oceans is reliant on our ability to produce effective models of reactive nitrogen emission, atmospheric chemistry, transport and deposition (including deposition to the land surface). The Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP) recently completed a multi-model analysis of global N deposition, including comparisons to wet deposition observations from three regional networks in North America, Europe and Southeast Asia (Lamarque et al., Atmos. Chem. Phys., 13, 7977-8018, 2013).

No similar datasets exist which would allow observation – model comparisons of wet deposition for the open oceans, because long-term wet deposition records are available for only a handful of remote island sites and rain collection over the open ocean itself is very difficult. In this work we attempt instead to use $\sim$2600 observations of aerosol nitrate and ammonium concentrations, acquired chiefly from sampling aboard ships in the period 1995 - 2012, to assess the ACCMIP N deposition fields over the remote ocean. This database is non-uniformly distributed in time and space. We selected four ocean regions (the eastern North Atlantic, the South Atlantic, the northern Indian Ocean and northwest Pacific) where we considered the density and distribution of observational data is sufficient to provide effective comparison to the model ensemble. Two of these regions are adjacent to the land networks used in the ACCMIP comparison, while the others are far removed from land regions for which the model output has been rigorously compared to observational data. Here we will present calculated dry deposition fluxes of nitrate and ammonium from average observed concentrations in these regions, using deposition velocities of 0.9 cm/s and 0.1 cm/s respectively, and the results of a comparison of these fluxes to the ACCMIP model ensemble product. Uncertainties in the comparison and potential sources of bias between the observations and model will be discussed.