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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). Over land, N deposition models can be assessed using comparisons to regional monitoring networks of precipitation chemistry (notably those located in North America, Europe and Southeast Asia). 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 logistically very difficult.
In this work we attempt instead to use $\sim$2800 observations of aerosol nitrate and ammonium concentrations, acquired from sampling aboard ships in the period 1995 - 2012, to assess the performance of modelled N deposition fields over the remote ocean. This database is non-uniformly distributed in time and space. We selected three ocean regions (the eastern tropical North 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. Our presentation will focus on the eastern tropical North Atlantic region, which has the best data coverage of the three. We will compare dry deposition fluxes calculated from the observed nitrate and ammonium concentrations to predicted fluxes of NO_y and NHx (and nitrate and ammonium, where possible) from the ACCMIP model mean product and the TM4 model. Sources of bias between the observation-based fluxes and those derived from the models will be discussed, as will recommendations for future observation – model comparison exercises of this type.