Quantifying the deposition of biologically-essential trace elements from the atmosphere to the oceans: impacts on primary production and climate

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Atmospheric aerosol deposition is an important factor in the regulation of global climate through the coupling of biolimiting trace element cycles to the carbon cycle. Continental dust and anthropogenic aerosols are sources of iron (Fe) to high-nitrate, low-chlorophyll (HNLC) regions. Atmospheric deposition also supplies important macronutrients such as nitrogen and phosphorus as well as potentially toxic elements, e.g. copper, which may have deleterious effects on phytoplankton.

We have advocated measuring the "instantaneous" solubility of biogeochemically important aerosol trace elements, using both ultrapure deionized water (UHP) and filtered surface seawater. Our flow-through extraction was designed to avoid solution saturation with respect to Fe(III) by exposing the aerosol particles to a constant stream of fresh solution over a very short period of time (≤10 s). The UHP leaching solutions can be directly analyzed for most of the GEOTRACES "key parameter" trace elements and isotopes (TEIs) using HR-ICP-MS. These samples can also be analyzed for soluble aerosol Fe(II). The UHP leach has also been shown to mimic the effects of aerosol scavenging and subsequent dissolution by rainfall. Our method provides a measure of initial dissolution upon deposition but does not account for processes acting on aerosol derived particulate and dissolved TEIs within the surface ocean. We have now adopted a more aggressive leaching scheme (25% acetic acid with 2mM hydroxylamine added) to quantify the "ultimate" solubility for aerosol trace elements in the upper ocean; this method compares extremely well with the time-consuming "extended seawater leach".

Advances have also been made in using the radiotracer 7Be to help quantify aerosol deposition to the oceans. The method relies on the premise that the 7Be inventory in the upper ocean must be supported by wet and dry deposition of aerosol 7Be, therefore inventory measurements coupled with aerosol 7Be measurements can be used to derive a bulk (wet plus dry) deposition velocity that can be used to calculate the flux of other aerosol species.