Role of Acid Mobilization in Iron Solubility of Smaller Mineral Dust Aerosols

(1) Research Institute for Global Change, JAMSTEC, Yokohama, Japan

(akinorii@jamstec.go.jp)

Akinori Ito

Iron (Fe) is an essential element for phytoplankton. The majority of iron is transported from arid regions to the open ocean, but is mainly in an insoluble form. Since most aquatic organisms can take up iron only in the dissolved form, the amount of soluble iron is of key importance. Atmospheric processing of mineral aerosols by anthropogenic pollutants may transform insoluble iron into soluble forms. Compared to dust, combustion aerosols often contain iron with higher solubility. This paper discusses the factors that affect the iron solubility in mineral aerosols on a global scale using an aerosol chemistry transport model. Bioavailable iron is derived from atmospheric processing of relatively insoluble iron from desert sources and from direct emissions of soluble iron from combustion sources such as biomass and fossil fuels burning. The iron solubility from onboard cruise measurements over the Atlantic and the Pacific Oceans in 2001 is used to evaluate the model performance in simulating soluble iron. Sensitivity simulations from dust sources with no atmospheric processing by acidic species systematically underestimate the soluble iron concentration in fine particles. Improvement of the agreement between the model results and observations is achieved by the use of a faster iron dissolution rate in fine particles associated with anthropogenic pollutants (e.g., sulphate). Accurate simulation of the abundance of soluble iron in fine aerosols has important implications with regards to ocean fertilization because of the longer residence time of smaller particles, which supply nutrients to more remote ocean biomes. The model reveals a larger deposition of soluble iron for the fine mode than that for the coarse mode in northern oceans due to acid mobilization. The ratio of deposition rate of soluble iron in the fine mode to the total aerosols in the South Atlantic Ocean (40–60%) is less than that in northern oceans (70–100%). These results suggest that Patagonian dust in South America does not efficiently supply soluble iron to significant portions of the Southern Ocean. In broad areas of the world's oceans, the combustion source of soluble iron represents less than 20% of the total deposition of soluble iron in the standard simulation. If the large uncertainties in the fractional iron solubility for biomass burning aerosols are considered, these combustion sources may contribute to more than 30% of the total deposition of soluble iron in the equatorial and southern oceans downwind from open vegetation fires. These results imply that large fires may supply a potentially important source of bioavailable iron to the open ocean, but the iron solubility in biomass burning aerosols is poorly constrained by the observations. Comprehensive research involving laboratory experiments, modeling, and observations is needed to improve the understanding by which different processes increase iron solubility in different aerosol particles.