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Geographical differences in bio-available iron supply between Northern and Southern Oceans

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Iron (Fe) is an essential nutrient for phytoplankton. Iron-containing soil dust mobilized from arid regions supplies the majority of iron to the oceans, but primarily presents in an insoluble form. Since most aquatic organisms can take up iron only in the dissolved form, a key flux is the amount of soluble iron in terms of the biogeochemical response to atmospheric deposition. Atmospheric processing of mineral aerosols by anthropogenic pollutants may transform insoluble iron into soluble forms. We discuss the effect of the acid mobilization on a relationship between aerosol iron solubility and mineral particle size in an aerosol chemistry transport model [1]. The iron solubility data from onboard cruise measurements [2, 3] over the Atlantic and Pacific Oceans are used to evaluate the model performance in simulating soluble iron. The association of smaller size with higher solubility as a role of the acid mobilization considerably improves the results of soluble iron in terms of ratio of fine to total particles, compared to constant iron solubility. The improvement of model-observation agreement provides strong evidence for faster iron dissolution in fine particles by anthropogenic pollutants. Accurate simulation of the ratio of fine to total aerosols of soluble iron has important implications with regards to the ocean fertilization because of a longer residence time of smaller particles, which supply nutrients to more remote ocean biome. The model reveals higher concentration of soluble iron in the coarse mode than that in the fine mode over the Southern Ocean except downwind regions of Australian dust, in contrast to the Northern Ocean. These results suggest that dust does not efficiently transport soluble iron to significant portions of the Southern Ocean. This corroborates hypothesis that phytoplankton blooms are not sustained by the supply of iron to surface waters from dust deposition in the Southern Ocean [4] except the Australian sector [5]. Conventional assumption in ocean biogeochemical models relies on iron dissolution measurements of dust aerosols mainly from the Northern Hemisphere and thus could exaggerate the role of atmospheric supply of iron from arid regions to significant portions of the Southern Ocean. Over the next century, sulfur dioxide emissions are projected to decrease according to the Representative Concentration Pathways (RCPs) scenarios. As a result, iron dissolution due to the acid mobilization of the iron-containing minerals could be reduced for the next century. It may imply that the supply of nutrients from other sources such as large forest fires becomes a dominant contributor of bioavailable iron [6]. Comprehensive research involving laboratory experiments, modeling, and observations is desirable for understanding the process that increases soluble iron concentration from minerals in different aerosol particles. [1] A. Ito & Y. Feng (2010), Atmos. Chem. Phys. 10, 9237-9250. [2] Y. Chen & R. L. Siefert (2003), J. Geophys. Res. 108, 4774. [3] A. R. Baker et al. (2006), Mar. Chem. 98, 43-58. [4] S. Blain et al. (2007), Nature 446, 1070-1074. [5] E. BrÈviËre et al. (2006), Tellus 58B, 438-446. [6] A. Ito (2011), Biogeosciences Discuss., 8, 1483-1527.