AEOLIAN INPUT OF BIO-AVAILABLE IRON TO THE OCEAN

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ABSTRACT

Atmospheric deposition of mineral dust aerosols supplies the essential nutrient of iron to the ocean. However, only the readily soluble iron is available to biological uptake while the insoluble iron precipitates to the ocean bottom. Here we present a global model simulation of Aeolian iron input to the ocean, considering hematite dissolution in mineral dust aerosols catalyzed by nitric and sulfuric acids. Our model suggests that atmospheric deposition of soluble iron to the oceans is much larger than previous model results in high nitrate low chlorophyll (HNLC) regions.

INTRODUCTION

Fertilization of surface seawater with soluble iron has been found to increase phytoplankton growth and biomass in the sub-arctic North Pacific, eastern Equatorial Pacific, and the Southern Oceans [*Boyd et al.*, 2004; *Coale et al.*, 2004; and references therein]. Nitrogen fixation and calcification by marine organisms are also found to depend on the concentration of dissolved Fe in the ocean [*Falkowski et al.*, 1998; *Schulz et al.*, 2004]. Atmospheric transport and deposition of dust particles originating from arid and semi-arid lands supply Fe and other trace metals to sustain biological production in the oceans [*Duce et al.*,1991]. The solubility of Fe in dust aerosols is an important parameter, given the global iron connections between desert dust, ocean biogeochemistry, and climate [*Jickells et al.*, 2005].

A constant Fe solubility between 1% and 10% is often assumed for the aeolian dust deposition in ocean biogeochemical models. Recognizing potentially large variations of Fe solubility in the atmosphere, *Hand et al.* [2004] attempt to estimate increasing Fe solubility due to solar radiation and cloud processing. In contrast, *Meskhidze et al.* [2003] consider hematite dissolution in the aqueous coating as the main source of soluble iron in dust particles. In this study, we use a global atmospheric model to simulate dust entrainment, transport and deposition, with parameterizations for the development of acid coating and hematite dissolution on dust particles.

METHODS

For the development of acid coating, we consider cloud processing [*Wurzler et al.*, 2000]: cloud droplets collect dust particles and gaseous SO_2 followed by aqueous oxidation of SO_2 and droplet evaporation. We also consider "chemical aging" due to absorption of HNO_3 and SO_2 molecules. Heterogeneous reactions involving N_2O_5 and H_2SO_4 and possibly HCl may also be important but are neglected in this study.

Hematite is the main form of mineral Fe in dust particles originating from the deserts. We calculate hematite dissolution following *Meskhidze et al.* [2003], but use a larger rate constant based on more recent measurements [*Duckworth and Martin*, 2001].

RESULTS

Our model results are compared to and generally agree with available measurements of soluble Fe fraction in aerosols, rain and snow. The soluble fraction increases with distance from the desert source, and is much higher than 10%, an upper limit in previous studies, over the remote oceans. The soluble Fe fluxes simulated with aging and hematite dissolution are shown in Figure 1 (a), in comparison with Fe fluxes calculated from total Fe deposition with a uniform soluble fraction of 10% (b). The ratio of the two fluxes, (a)-to-(b), is shown in Figure 1(c).

Figure 1 shows that atmospheric input of bio-available Fe may be much higher than previously estimated. Our model results also imply that anthropogenic emissions of SO_2 and NO_x may have caused an increase of hematite dissolution and soluble Fe input to the ocean.

Figure 1. Average Fe Flux in umol/(m2*yr)

(a) Soluble Fe flux

(b) 10 percent of mineral Fe flux

(c) Flux ratio (a)-to-(b)
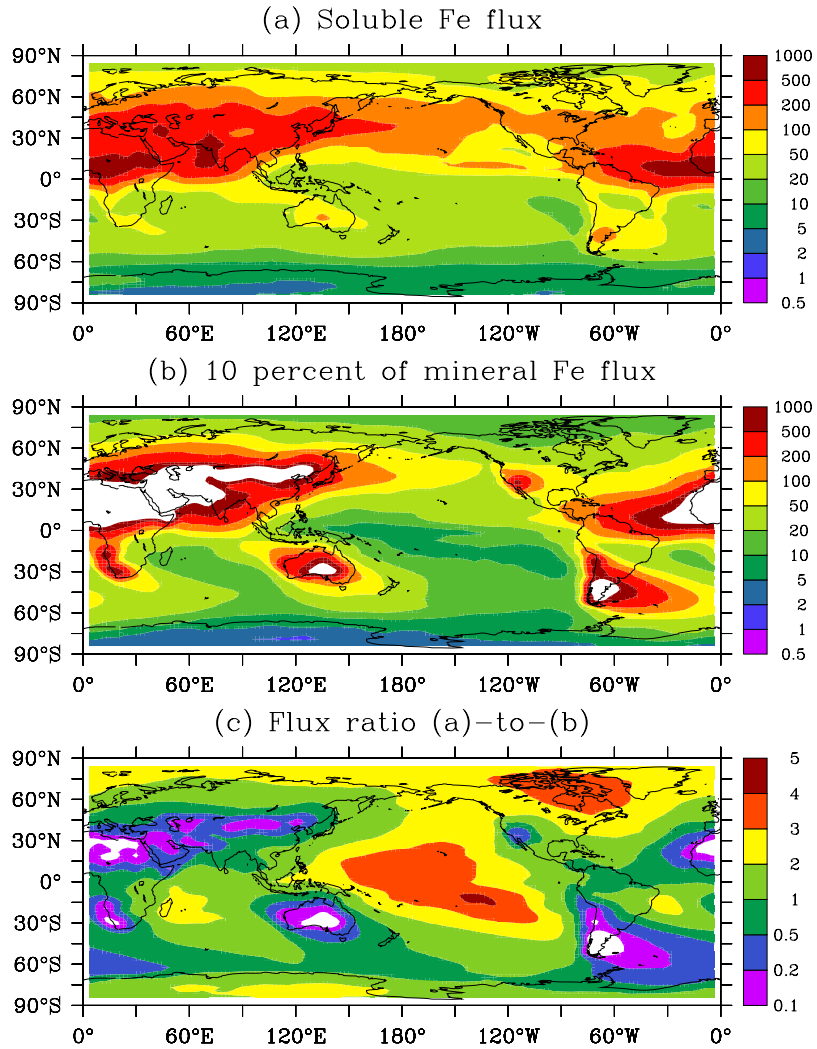
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