Constraining the mineral and elemental composition of dust aerosol

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The climate effect of soil dust aerosols depends upon the particle mineral composition. Dust radiative forcing is related to the presence of iron oxides like hematite. Structural iron within clays makes an additional contribution to marine productivity and carbon uptake. Here, we discuss how to constrain the regional distribution of various iron-bearing minerals using measurements of mineral and elemental composition along with information about soil weathering.

We present a prognostic model of aerosol mineral content, based upon previous work relating the soil fraction of each mineral to the soil type. The model is embedded with the NASA GISS Earth System Model and predicts the regional distribution of illite, kaolinite, smectite, calcite, quartz, feldspar, iron (hydr)oxide, and gypsum. Evaluation of the predicted mineral content is challenging because this quantity is infrequently measured. Elemental composition is more commonly availiable but does uniquely constrain the mineral distribution, partly because the modeled minerals are only a subset of those contributing to observed elemental composition. We use mineral content and elemental composition within the same measured samples to derive a likely chemical composition for each modeled mineral. This can be applied to the model for comparison to the observed elemental composition.

An additional challenge is predicting the size distribution of each mineral at the time of emission. Previous work prescribes the mineral fraction in each of the soil clay and silt size categories. One challenge is that the clay and silt amount is biased by disturbance and disaggregation of larger particles during size characterization of soils. This leads to predictions of excessive structual iron within the clay size at the expense of aggregates in the silt size. We describe how sparse measurements of the mineral size distribution can be used to constrain the emitted size distribution.

The iron-bearing minerals are related to soil weathering that can be related to various measured quantities such as the Parker index. Using published soil measurements, we evaluate the representation of soil weathering in the model, which provides an independent constraint upon the iron-bearing minerals within the soil that are transported by the model.

Oxidation of Cu(I) in Seawater at Low Oxygen Concentrations

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The oxidation of nanomolar copper(I) at low oxygen ($6\mu M$) concentrations was studied as a function of pH (6.7–8.2), ionic strength (0.1–0.76 M), total inorganic carbon concentration (0.65–6.69 mM), and the added concentration of hydrogen peroxide, H_2O_2 (100-500 nM) over the initial 150 nM $H2O2$ concentration in the coastal seawater. The competitive effect between H_2O_2 and O_2 at low O_2 concentrations has been described. Both the oxidation of Cu(I) by oxygen and by H_2O_2 had a reaction order of one. The reduction of Cu(II) back to Cu(I) in the studied seawater by H_2O_2 and other reactive oxygen intermediates took place at both high and low O_2 concentrations. The effect of the pH on oxidation was more important at low oxygen concentrations, where $\delta\log k/\delta pH$ was 0.85, related to the presence of H_2O_2 in the initial seawater and its role in the redox chemistry of Cu species, than at oxygen saturation, where the value was 0.6. A kinetic model that considered the Cu speciation, major ion interactions, and the rate constants for the oxidation and reduction of Cu(I) and Cu(II) species, respectively, was applied. When the oxygen concentration was lower than 22 μM and under the presence of 150 nM H_2O_2, the model showed that the oxidation of Cu(I) was controlled by its reaction with H_2O_2. The effect of the pH on the oxidation rate of Cu(I) was explained by its influence on the oxidation of Cu(I) with O2 and H_2O_2, making the model valid for any low oxygen environment.