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A continental scale model for dissolved silica mobilization in North America

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Silicon is one of the few elements that link to both the organic and inorganic carbon cycles. Dissolved silicon (DSi) is an important nutrient in terrestrial and aquatic ecosystems. Cations accompanying the release of DSi by chemical silicate rock weathering are generally balanced by soil/atmospheric CO_2. Chemical weathering is the major source of "new" bioavailable DSi for continental aquatic systems to compensate for the loss of DSi by outflow or organic precipitation and burial.

We use river water chemistry data from 164 monitoring stations from the conterminous United States (WQN and NAWQA networks). Selected stations are characterized by low population density and low influence of water bodies to minimize human and DSi retention impact. Observed DSi yield in these catchments is assumed to represent natural DSi mobilization by chemical weathering. The catchments have an average size of 4400 km^2 (Median: 991 km^2) with a discharge weighted average DSi yield of 4.34 t SiO_2 $km^{-2}a^{-1}$.

To predict mobilization of DSi from chemical weathering a lumped non-linear empirical model is developed, considering control factors such as climate, morphology, hydrology, land cover, soil and lithology. A multi-lithological model approach is chosen because only very few mono-lithological catchments were identified in the dataset. The model is then extrapolated to the conterminous United States to regionally quantify the amount of DSi that is released into the river systems by chemical weathering.

Small outcrops of certain lithological classes characterized by a high DSi yield are not represented on previously available small scale lithological maps. Because such localities may have a major influence on DSi fluxes from small catchments (Hartmann et al., 2009) a new high resolution lithological vector-map for North America is developed and applied in the introduced model.

In accordance with previous studies, runoff and lithology are identified as the major predictors for specific DSi flux (Bluth and Kump, 1994; Hartmann et al., 2009). Only in relation to some lithological classes, temperature and terrain slope constitute significant predictors. An influence of land cover, soil properties or other predictors is not observed. This is partly attributed to geodata resolution and classification. Lithological classes "Basic Volcanics and Pyroclastics" and "Basic and Intermediate Plutonics" show the highest DSi yields, with respect to a given discharge. The lithological class "Siliciclastic Sedimentary Rocks" is characterized by the lowest DSi yield. The model explains 89% of the DSi yield variance; the average yield of catchments employed in model calibration is 4.32 t SiO_2 $km^{-2}a^{-1}$, somewhat above the global average yield of 3.3 t SiO_2 $km^{-2}a^{-1}$ (Dürr et al., 2009).

The model quantifies DSi fluxes from the terrestrial into the continental aquatic systems. This helps to estimate DSi retention within fluvial systems (Lauerwald et al., submitted) and improves understanding of this part of the silicon cycle.

References:

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