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A new chemical denudation model for landscape evolution numerical modeling

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Two types of erosion are classically distinguished: physical (or mechanical) and chemical. The latter corresponds to the removal of material by dissolution. Several models of physical erosion, corresponding to different processes (river incision, glacial denudation, etc), have been proposed for numerical modeling of landscape evolution. But, as far as we know, no similar model has been proposed to estimate the chemical denudation (Hovius et al. 2004). We propose a simple model of chemical denudation coupling in a GIS, with a Darcy law, a flow path model (D8, Taborton et al. 1991) with a kinetics model of rock dissolution. The freeware PHREEQC (Parkhurst and Appelo 1999) in which we have implemented a kinetics law from the transition state theory is used as a motor of thermodynamics calculation. This model has been tested with an alpine catchment whose bedrock is made of different lithologies (silicates, carbonates, sulfates). The input data are: a DEM, a map of the substratum (with the mineralogical compositions), a map of precipitation and one of the temperatures. Depending on the goals of the simulation, the chemical composition of the rainwater and the atmospheric pressures of CO2 and O2 can be adapted. The model can be calibrated from either hydrogeological parameters (permeabilities and reactive surfaces if known) or by back-calculation using the electrical conductivity of river waters (much easier to measure). Different output maps can be produced: chemical denudation [mm/ka or mg/m2/a], CO2 consumption (silicates versus carbonates), river water electrical conductivities and others. This is only a first proposition for a simple chemical denudation model. Several improvements can be made, such as the implementation of a double circulation (soil/bedrock) or the taking into consideration of some stable isotopes like Sr. Finally, because of its simplicity, we work on the integration of this model into a more complete landscape evolution numerical model including uplift and different physical erosions laws.