Geophysical Research Abstracts
Vol. 14, EGU2012-7131, 2012
EGU General Assembly 2012

Regional scale mapping of sub-surface water-rock interactions

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Rock weathering at regional scale (from catchment to mountain range) is a major player in several environmental concerns, such as atmospheric CO_2 consumption, rocks and soils strength reduction or water quality of catchments. In order to get spatial representations of the sub-surface weathering in mountainous areas, a numerical model has been built coupling a low-temperature geochemical calculator to a geographical information system (GIS). The geochemical part of this model is based on the library iPhreeqc (USGS 2011). This library is called by a simple homemade GIS program that takes care of topography, substratum composition and sub-surface water flow. A Darcy law with a D8 flow path is used to describe the water flow on a digital elevation model. Kinetics laws have been implemented to take into consideration dissolution rates of minerals.
Input data are: a regional digital elevation model, a "substratum" map with the mineralogical composition of each units, annual rainfall and temperature maps, the chemical composition of the rainwater, O_2 and CO_2 atmospheric concentrations. At regional scale (low resolution), parameters such as soil thickness, hydraulic transmissivity or reactive surface of minerals are unknown (i.e. they may vary over a wide range of magnitude). That is why electrical conductivities at the outlet of alpine watersheds are used to estimate by back-calculation average values of these parameters. Ouputs of the model are for example catchment maps of: amount of dissolved minerals (g/m2/a), atmospheric CO_2 consumption (g/m2/a) or chemical denudation (mm/a). First results, for an alpine catchment, show the major impact of traces of fast dissolved minerals (i.e. calcite and pyrite) on the geochemical budget of a large catchment. Further works will focus on improving the transport model, temperature and atmospheric CO_2 changes, integration of isotopes and sulfurs deposits impacts.