Geophysical Research Abstracts
Vol. 19, EGU2017-4981, 2017
EGU General Assembly 2017

The role of sediments stored in valleys in modulating the Quaternary weathering flux variations

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Silicate weathering is known to be central to the regulation of atmospheric CO_2. Yet it is unclear how weathering responds to climatic variations. Data sets based on different proxies in sediment cores suggest either negligible Quaternary silicate weathering variations, or more weathering during wet and hot periods, or even the reverse. For example, a recent study based on d7Li in clay of Himalayan river terraces suggests, counter-intuitively, a less intense weathering during hot and wet periods compared to dry periods for the last 40 ka, with no clear physical explanation. We analyse catchment scale weathering signals using the numerical model Cidre, coupling landscape evolution with chemical weathering. Chemical weathering occurs within a regolith, either produced in situ at a rate depending on regolith thickness, temperature and precipitation, or corresponding to a deposit. The chemical flux is calculated from the dissolution of granitoid clasts, first exhumed on the hillslopes and then transported and potentially stocked in the valleys. This approach accounts for part of the stochastic nature of grain weathering within a catchment. We prescribe an uplift to an initial horizontal surface to reach a dynamic equilibrium under a constant climate. Then, we vary the precipitation rate and the temperature, alternating cold and dry periods with hot and wet periods (10 to 400 ka tested). When these variations are applied to an equilibrium mountain covered by a regolith ("transport-limited"), the weathering outlfux and the erosion flux are larger during wet and hot periods. On the contrary, for less weatherable conditions such that the mountain is not covered by regolith ("kinetically-limited"), the weathering is the highest at the beginning of the dry, cold and low erosive periods. This apparent paradox is explained by the temporary accumulation of sediment in the valleys in response to the drought. The hillslopes being striped, these valley deposits constitute the only weathering reservoir, whose large volume compensates for the unfavourable climatic conditions. Such a behaviour explains out-of-phase weathering signals, and suggests that the dominant weathering reservoir goes back and forth between the hillslopes and the valleys during climatic oscillations.