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Coupled evolution of the carbon cycle, the climate, and the continental regolith cover

Yves Godderis (1), Pierre Maffre (1), Sebastien Carretier (1), and Yannick Donnadieu (2)

(1) CNRS, Observatoire Midi-Pyrénées, Geosciences-Environment Toulouse, Toulouse, France (yves.godderis@get.omp.eu), (2) CNRS, CEREGE, Aix-en-Provence, France

The sensitivity of the chemical weathering to climatic conditions is one of the masterpiece of the Earth climatic evolution at the geological timescale. Classically, the CO_2 consumption by silicate weathering is thought to be dependent on the amount of water flowing on the continents and on the air temperature. This dependence generates the negative feedback stabilizing the Earth climate (Walker et al., 1981).

Several recent contributions have emphasized the role of physical erosion on the efficiency of silicate weathering (West et al., 2005 ; Maher and Chamberlain, 2014 ; Carretier et al, 2014). A weathering system characterized by a low physical erosion develops a thick regolithic cover depleted in fresh minerals (shielding effect), potentially limiting the strength of the weathering feedback. At the geological timescale, this means that a globally warm world, displaying large continental areas covered by thick regoliths, might be climatically less stable facing an external forcing (such as an intense magmatic degassing) than a cooler world.

Whether this reasoning can be exported to the whole continental surfaces or not is a matter of debate. Here, we explore the sensitivity of the Earth climate to an intense magmatic degassing for two different initial conditions : a high CO_2 world where thick regoliths cover most of the continents, and a low CO_2 world where reduced temperature and runoff result in a thinner regolithic cover. The simulated timeslice is the end Permian period with the eruption of the Siberian Traps. The model used is the spatially-resolved GEOCLIM model (Goddéris et al., 2017) coupled to the 1D regolith model of Gabet and Mudd (2009). For each continental grid element and at each time step of the calculation, the spatial distribution of the regolith cover is calculated, and the efficiency of the weathering of the fresh bedrock is modulated by the regolith thickness. We then compare the sensitivity of the atmospheric CO_2 level and of the Earth climate, depending on the initial state of the continental surfaces. The dynamic coupling between the carbon cycle, the regolith evolutions and the climate will be discussed.