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Thick regoliths and the geological history of climate

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The weathering of continental silicate rocks is a main sink of CO_2 at the geological timescale. As it is dependent on the climatic conditions (more weathering in a warmer world), the silicate weathering acts as a negative feedback on the carbon cycle, limiting the amplitude of past climatic changes.

Many contributions have shown that silicate weathering efficiency (the « weatherability ») is strongly correlated to the physical erosion. Because of this tight link, many works have focused on the role of mountain ranges in the climatic evolution, because those areas are characterized by intense physical denudation, thus potentially boosting chemical weathering. Simply speaking, periods of active mountain building are suspected to generate cold conditions.

Conversely, little attention has been paid to the role of large and flat continental areas. Due to the lack of physical erosion in those flat areas, the weathering processes will generate thick regoliths, progressively shielding the bedrock and ultimately decreasing the weatherability. Periods of limited mountain building activity might generate very high CO_2 level and warm climatic episodes.

However, this simple scheme, defining two extreme poles for the surficial Earth system (one mountainous and cold, the other flat and warm) raises several questions:

- the two modes (mountainous and flat) generally co-exist. Their relative role in the control of the climate is probably dependent on the continental configuration, and on the location of tectonically active and non-active areas in latitude and longitude.
- the dynamics of the thick regolith is not well constrained. How long does it take to generate thick regoliths? What is the response time of thick regoliths to a perturbation?
- what about the horizontal transfer of sediments? Recent works have shown that sediments are exported from mountain ranges and weathered in plains at the feet of the mountains. How can we incorporate this into numerical models?

We will explore the role of the regolith thickness with the spatially-resolved GEOCLIM model. We will focus on the consequences of the colonization of the continents by vascular land plants over the course of the Devonian. This event is suspected to have impacted the weatherability of all the continental surfaces in the same direction (increase in weatherability). We will show that the way

atmospheric CO_2 is responding is depending on the initial state of the weathering system, prior to the colonization event. We will also explore the response time of the regolith cover to the global environmental change. We show that short glacial events can be generated in the direct vicinity of the colonization event, if the response time of the regolith layer is long and the colonization is fast. This cold overshoot disappears when the colonization time is assumed to be long (10 Myr), and the continental configuration becomes a critical factor impacting the CO_2 evolution.