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The causes of climate change over the last 800 million years

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Over the last 800 million years of the Earth history, the atmospheric CO_2 content has widely fluctuated, resulting in ample climatic changes. Potential causes of those CO_2 changes are well-known. CO_2 is released into the ocean-atmosphere system by the volcanic activity, by the oxidation of fossil organic carbon exposed at the continental surface, and by the dissolution of continental carbonate minerals under the corrosive action of sulphuric acid (itself generated by the oxidation of pyrite in tectonically active area). Atmospheric CO_2 is consumed by the chemical weathering of silicate rock, and by the burial of organic carbon into sediments.

The efficiency of those processes is dependent on their spatial distribution at the Earth surface. CO_2 can be released by magmatic activity directly into the atmosphere or into the ocean. Oxidation of fossil organic carbon and release of sulphuric acids occur in tectonically active mountain ranges. Silicate weathering is a function of the spatial distribution of the continents, of the lithology, of the vegetation, of the physical erosion. Organic carbon burial depends on the sedimentation rate driven by physical erosion.

Accounting for the role of the spatial distribution of carbon fluxes on the long term climate evolution is a main challenge. New numerical models, which couples 3D-climatic models to model describing the biogeochemical cycles open the door to the integration of the spatial factor into our description of what drives the long term climate of our planet.

In the first part of the talk, we will focus on the modulation of continental silicate weathering by continental drift. Up to know, the boosting of silicate weathering by the dislocation of the Rodinia supercontinent within the warm and humid tropical belt remains the sole explanation for the onset of the snowball glaciations in the Neoproterozoic. Conversely, the assembly of Pangea promoted the development of continental scale aridity, leading to the collapse of the CO_2 consumption by silicate weathering, and dramatically warming the Earth surface.

The second part of the talk will be devoted to an exploration of the role of large mountain ranges on the climatic long term evolution. We will show that the incorporation of a mechanistic description of physical erosion in deep time climate-carbon model open the door to the quantification of the role of silicate weathering versus organic carbon in modulating the Earth climate.