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A first evaluation of the drivers of chemical disequilibrium within the Earth's atmosphere with an atmospheric chemistry model

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The presence of life on a planetary body can be more objectively assessed by a holistic analysis of the atmospheric chemical disequilibrium, rather than a particular molecular biomarker. Rather than quantifying the disequilibrium itself, our newly developed methodology considers the generation rates of chemical free energy. This allows us to understand, on a thermodynamic basis, how life affected - and still affects - geochemical processes. Further, the thermodynamic analysis of Earth's atmosphere is necessary for a future comparison with other planets' atmospheric disequilibrium.

In this work we apply this tool to an atmospheric chemistry column model of the Earth. We consider the kinetics of the different processes (reaction kinetics and material fluxes) and we account separately for the drivers of atmospheric disequilibrium (photochemical, electrical, geochemical and biochemical power sources) in order to show their different contributions. Photochemical reactions are here considered as an external process that unidirectionally changes the amount of particular gases. Gas fluxes from the Earth's surface and their escape to outer space have been accounted for according to present observations and models.

This work quantifies the magnitude of life in relation to other abiotic processes on atmospheric disequilibrium in terms of the generated chemical free energy.