Mem. S.A.It. Vol. 87, 213

Memorie della

Disequilibrium in planetary atmospheres and the search for habitability

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Abstract.

It has long been observed that Earth's atmosphere is uniquely far from its thermochemical equilibrium state in terms of its chemical composition. Studying this state of disequilibrium is important for its potential role in the detection of life on other suitable planets (Lovelock 1965; Kleidon 2010; Simoncini and Grassi 2015).

We developed a methodology to calculate the extent of atmospheric chemical disequilibrium(Simoncini and Grassi 2015; Kondepudi et al. 1996). This tool allows us to understand, on a thermodynamic basis, how life affected - and still affects - geochemical processes on Earth, and if other planetary atmospheres are habitable or have a disequilibrium similar to the Earth's one.

A new computational framework called KROME has been applied to atmospheric models in order to give a correct computation of reactions kinetics (Grassi et al. 2015).

In this work we present a first computation of the extent of disequilibrium for the present Earth atmosphere, considering the specific contribution of the different atmospheric processes, such as thermochemical reactions, eddy diffusion, photochemistry, deposition, and the effect of the biosphere. We then assess the effect of life on atmospheric disequilibrium of the Earth and provide a useful discussion about how the study of atmospheric disequilibrium can help in finding habitable (exo)planets.

We finally compare the chemical disequilibrium of Earth and Mars atmospheres, for present and early conditions.

References

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