EPSC Abstracts
Vol. 16, EPSC2022-674, 2022, updated on 03 Jun 2023
https://doi.org/10.5194/epsc2022-674
Europlanet Science Congress 2022

Atmospheric retrievals of terrestrial planets with future space missions

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From the White Paper series within the ESA "Voyage 2050" process [1] and the US Astro 2020 Decadal [2], it is clear that the astronomical community is going to focus on investigating temperate, terrestrial exoplanets to understand their potential habitability and search for atmospheric signatures of biospheres.

Various concepts for future space missions have been proposed, from a large IR/O/UV (LUVOIR/HabEx-like) space mission for studies in reflected light [3, 4], to the mid-infrared nulling interferometer LIFE (Large Interferometer for Exoplanets), to characterize the thermal portion of the planetary spectrum [5, 6]. Their goal is to constrain the bulk parameters, atmospheric structure and composition, and the surface conditions of dozens of terrestrial exoplanets. Atmospheric retrieval studies are essential to define the potential of future missions, determine the technical requirements, as well as to validate the analysis pipelines. It is also relevant at this stage to quantify any synergy among the various instruments, in order to identify compelling science cases whose characterization would be enhanced by observation in multiple wavelength ranges.

Bayesian retrieval routines are the key to a statistically robust analysis of a measured atmospheric spectrum. The Bayesian retrieval method builds on iteratively fitting a parametric model for the planet spectrum to the observed spectrum to get estimates on the composition of the planet's atmosphere and its structure. Such a method can be useful to quantify the amount of information that can be extracted from an observed spectrum, depending on its quality (in terms of resolution, signal-to-noise ratio, observing time, and wavelength range).

Retrieval studies are currently being performed in order to determine the requirements for the upcoming missions. In this talk, I will summarize the main results of the latest atmospheric retrieval studies that were performed during the studies of some future space mission concepts.

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LIFE collaboration: https://life-space-mission.com