

Sulfur Cycle on Earth-like Exoplanets: Dependency on Host Stars and Surface Water Environments, and Implications for Constraining Habitability

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Sulfur species play a crucial role in constraining the habitability of exoplanets through observations. Loftus et al. (2019) constructed a simplified model of the sulfur cycle and concluded that, if detectable amounts of SO_2 and H_2SO_4 aerosols exist in the atmosphere of an exoplanet, it is unlikely for the planet to have oceans. This study aims to: (1) verify, using a photochemical model simulating present-day Earth, the atmospheric residence times of sulfur species derived by Loftus et al. (2019); (2) investigate how the sulfur cycle of Earth-like exoplanets varies with the spectral type of the host star and the amount of planetary surface water, using the same photochemical model; and (3) discuss the potential for constraining habitability through observations of atmospheric sulfur features based on these results. In this study, we simulated the atmospheric sulfur cycle using the "Photochem" module of "Atmos", which implements a one-dimensional photochemical model. We also calculated the altitude-dependent residence times, which refer to the average time a given species remains at a specific altitude before being removed by chemical reactions, photolysis, etc., of sulfur species (SO_2 gas, H_2SO_4 gas, H_2SO_4 aerosols).

Comparing the obtained residence times with those of Loftus et al. (2019), we found they generally agree. This supports the validity of the atmospheric residence times of sulfur species derived by Loftus et al. (2019). In the presentation, we will also discuss how the sulfur cycle depends on different host star spectral types and planetary surface water amounts. Finally, based on these findings, we will reassess the potential for constraining habitability through observations of exoplanetary atmospheric sulfur features.

Keywords: Exoplanets, Habitability, Sulfur cycle, Atmospheric chemistry, Host star spectral type, Surface water