Geophysical Research Abstracts
Vol. 15, EGU2013-10404, 2013
EGU General Assembly 2013

Sensitivity of Biosignatures on Earth-like Planets orbiting in the Habitable Zone of Cool M-Dwarf Stars to Stellar EUV and Surface Biomass

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We find that uncertainties in the UV emissions of cool M-stars have a potentially large impact upon atmospheric biosignatures in simulations of Earth-like exoplanets i.e. planets which assume Earth's development, and biomass and a molecular nitrogen-oxygen dominated atmosphere. The stellar UV input was varied starting with a Planck curve background by up to a factor $\sim$x100.This led to the formation of large planetary atmospheric ozone layers comparable with the Earth being calculated in our radiative-photochemical column model. Atmospheric methane, a key greenhouse gas, was significantly lowered in abundance since the increased UV stimulated hydroxyl abundance, which constitutes the main methane sink. For the highest UV scenarios, the warm, ozone-heated stratosphere led to a significant weakening in the ozone spectral band. We also investigated the effect of increasing the top-of-atmosphere incoming Lyman-alpha radiation but this had only a minimal effect on the biosignatures since it was efficiently absorbed in the uppermost planetary atmospheric layer mainly by water vapour, which was abundant being formed from methane. Methane is an important stratospheric heater which critically affects the vertical temperature gradient, hence the strength of spectral emission bands. We therefore varied methane and nitrous oxide biomass emissions, finding that a lowering in CH4 emissions by x100 compared with the Earth can influence temperature hence have a significant effect on biosignature spectral bands such as those of nitrous oxide. Our work emphasizes the need for future missions to characterize the (E)UV of cool M-dwarf stars in order to understand potential biosignature signals.