EPSC Abstracts
Vol. 8, EPSC2013-420, 2013
European Planetary Science Congress 2013

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

J. L. Grenfell (1), S. Gebauer (2), P. von Paris (1), M. Godolt (1) and H. Rauer (1,2)
(1) Institute of Planetary Research, German Aerospace Centre (DLR), Berlin, Germany (lee.grenfell@dlr.de) (2) Berlin University of Technology (TUB), Centre for Astronomy and Astrophysics (ZAA), Berlin, Germany

Abstract

We find that variations in the UV emissions of cool M-dwarf stars have a potentially large impact upon atmospheric biosignatures in simulations of Earth-like exoplanets i.e. planets with Earth's development, and biomass and a molecular nitrogen-oxygen dominated atmosphere. Starting with an assumed black-body stellar emission for an M7 class dwarf star, the stellar UV irradiation was increased stepwise and the resulting climate-photochemical response of the planetary atmosphere was calculated. Results suggest a "Goldilocks" effect with respect to the spectral detection of ozone. At weak UV levels, the ozone column was weak (due to weaker production from the Chapman mechanism) hence its spectral detection was challenging. At strong UV levels, ozone formation is stronger but its associated stratospheric heating leads to a weakening in temperature gradients between the stratosphere and troposphere, which results in weakened spectral bands. Also, high UV levels can lead to enhanced abundances of hydrogen oxides which oppose the ozone formation effect. At intermediate UV the conditions are "just right" for spectral detection. We also investigated the effect of increasing the top-of-atmosphere incoming Lyman-α radiation but this had only a minimal effect on the biosignatures since it was efficiently absorbed in the uppermost planetary atmospheric layer, mainly by abundant methane. Earlier studies have suggested that 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 CH_4 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.