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Photochemistry of potential biosignatures in Super-Earth atmospheres

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Abstract

Understanding spectral signals of biomarkers in the atmospheres of terrestrial-type exoplanets is a central goal in exoplanet science. Planets orbiting in the Habitable Zone (HZ) of M-stars are particularly interesting due to favourable planet-star contrast ratios. We report on the photochemical processes affecting the biomarkers ozone (O_3) and nitrous oxide (N_2O) for such earthlike planets, analysing the same scenarios as in Rauer et al. (see abstract, this session).

1. Introduction

Ozone (O_3) is an important biomarker in Earth's atmosphere, being formed mainly from molecular oxygen (O_2) (Chapman, 1930) which itself comes ultimately from photosynthesis. O_3 photochemistry is however complex - e.g. it is destroyed in the stratosphere by catalytic cycles (e.g. Crutzen, 1970). Nitrous oxide (N_2O) is formed from denitrifying bacteria at the surface and destroyed by photolysis and reaction with excited O atoms. In this work we will examine photochemical responses of the biomarkers O_3 and N_2O in the HZ of M-stars. To do this we will use a new tool - called the Pathway Analysis Program (PAP) - developed by Lehmann (2004) and applied to the Earth by Grenfell et al. (2006) to analyse the chemical pathways for these two key biomarker species.

2. Models and tools

We apply a coupled climate-photochemical column model originally developed from Kasting et al. (1984) and developed further e.g. in Segura et al. (2003), Rauer er al (2010), submitted. The PAP routine takes as input chemical reactions and rates over two successive model iterations and calculates as output the chemical pathways for a specie of choice e.g O_3. We perform a range of scenarios varying the class of central star and increasing gravity up to three times that of the Earth (3g).

3. Summary

Results (Grenfell et al. in preparation) suggest a fundamental change in the O_3 production mechanism for some of the M-star scenarios, whereby the major O_3 formation route changes from the Chapman mechanism, as is usual for the Earth, to the smog mechanism (Haagen-Smit, 1952). We discuss the consequences of this result for interpreting O_3 biosignatures.

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