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Atmospheric Composition Retrieval from Transit Spectra of Terrestrial Exoplanets: A Feasibility Study using Earth Observations

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Abstract

For an assessment of the detectability of molecular concentrations from transit spectra of Earth-like exoplanets, occultation spectra observed by an operational Earth observation satellite mission have been modeled with a line-by-line infrared radiative transfer code. Retrieval of atmospheric composition utilizing a nonlinear least squares fit of degraded spectra allows to infer detection limits for different spectral regions, resolution and noise levels.

1. Introduction

With more than 3600 exoplanet known today, including some dozen Earth-like and super-Earths, the characterization of their atmospheres has come into the focus of current research. Despite the limited quality of currently available exoplanet spectral observations, the methodology developed for Earth and Solar System Planet remote sensing can be readily applied to the analysis of terrestrial extrasolar planet data. For the retrieval of atmospheric composition, transmission spectroscopy analyzing the attenuation of stellar light along its optical path through the planet's atmosphere is particularly suited. In this contribution we use a high resolution line-by-line infrared radiative transfer code to model co-added occultation measurements in order to assess the feasibility to quantify the concentration of atmospheric constituents.

2. Radiative Transfer Modeling

The Generic Atmospheric Radiative Transfer Line-by-Line Infrared Code — GARLIC [1] has been developed with emphasis on efficient and reliable numerical algorithms and a modular approach appropriate for simulation and/or retrieval in a variety of applications (observation geometry, instrumental spectral response and field–of–view). The core of GARLIC's subroutines constitutes the basis of forward models used to implement inversion codes to retrieve atmospheric state parameters from limb and nadir sounding instruments. Furthermore, GARLIC has been used for a variety of exoplanetary atmosphere studies, e.g. [2].

3. Earth Observation Data

Limb sounding in the microwave, infrared, and ultraviolet-visible spectral range is a well-established approach for the characterization of Earth's atmosphere, in particular for remote sensing of the stratosphere and mesosphere with high altitude resolution. The effective height spectra generated by integrating (summing) a limb sequence of infrared spectra over all tangent heights serve as transit spectra expected to be observed for an Earth-like atmosphere.

4. Results

Using a nonlinear least squares optimization solver coupled to the GARLIC radiative transfer code we have retrieved the atmospheric composition from Earth's transit spectra. For an assessment of the detectability of atmospheric constituents from realistic exoplanet observations, the high-quality Earth observations have been smeared to lower resolution by convolution with appropriate spectral response functions and further deteriorated by adding noise.

5. Summary and Conclusions

Transit spectra of Earth's atmosphere observed by an operational satellite instrument have been modelled by our high resolution code GARLIC. The comparison of modelled and observed spectra clearly indicates the impact of various molecular species as well as continuum-like contributions. Varying the spectral range, spectral resolution, and noise level allows to quantify the detection level for various molecules.

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References

[1] F. Schreier, S. Gimeno García, P. Hedelt, M. Hess, J. Mendrok, M. Vasquez, and J. Xu. GARLIC – a general purpose atmospheric radiative transfer line-by-line infrared-microwave code: Implementation and evaluation. *J. Quant. Spectrosc. & Radiat. Transfer*, 137: pp. 29–50, 2014.

[2] P. Hedelt, P. von Paris, M. Godolt, S. Gebauer, J.L. Grenfell, H. Rauer, F. Schreier, F. Selsis, and T. Trautmann. Spectral features of Earth-like planets and their detectability at different orbital distances around F, G, and K-type stars. *A & A*, 553:A9, 2013.