EPSC Abstracts
Vol. 6, EPSC-DPS2011-457-1, 2011
EPSC-DPS Joint Meeting 2011

Analyzing O_2 and O_3 production and destruction pathways in the Martian atmosphere

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Abstract

Ozone and molecular oxygen are of central importance for the Martian atmosphere, since they have a significant impact on the photochemical stability of the main atmospheric constituent, CO_2, and are suitably observable species. Their abundance is controlled by chemical pathways which will be investigated in this contribution. In order to achieve this, we apply a unique algorithm, called the Pathway Analysis Program - PAP to the results of the JPL/Caltech photochemical column model of the Martian atmosphere.

1. Introduction

Besides CO_2, N_2, and Ar, O_2 is one of the most abundant species in the Martian atmosphere. O_2 and O_3 have a significant impact on the photochemical stability of the atmosphere [3, 10], because they participate in CO_2 formation. Furthermore, O_3 is known to exhibit strong spectral features e.g. [1, 2]. Identifying chemical O_2 and O_3 production and destruction mechanisms may also help to improve the understanding of the so-called biomarker chemistry with respect to false positive signals for biological activity [8]. Therefore, there exists a strong motivation to analyze the chemical processes which govern the amount of the oxygen bearing species O_2 and O_3.

The concentrations of O_2 and O_3 are influenced by chemical trace species which act as catalysts in chemical pathways, whereby a pathway can be understood as a list of chemical reactions, each associated with a positive integer number indicating the multiplicity of the reaction within this pathway. Thus, the chemical trace species can provide more efficient routes, which can affect the abundance of the major gases in the atmosphere (e.g. CO_2 on Mars [5, 7, 9]). The efficiency of a chemical pathway is characterized by a net flow/rate through it.

Finding chemical pathways in complex reaction schemes, like the Martian atmosphere, is in general a challenging task. Therefore, automated computer algorithms are useful to address such problems. In this study, we use the Pathway Analysis Program - PAP [4] in order to identify and quantify chemical pathways throughout the Martian atmosphere.

2. Method

In order to investigate the O_2 and O_3 chemistry, we apply the PAP algorithm to the updated JPL/Caltech photochemical column model of the Martian atmosphere, which is based on the version of the model described by [6].

The column model provides the necessary quantities for the computation of chemical pathways with PAP (see Fig. 1), i.e. time-averaged number densities, time-averaged reaction rates, and net changes in number densities due to the chemical reactions included in the model.

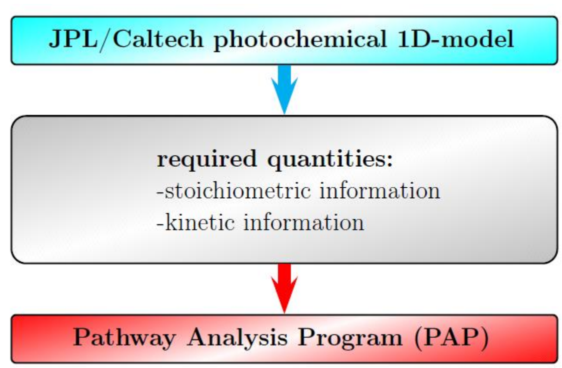

Figure 1: Schematic overview of the coupling of PAP with the JPL/Caltech photochemical column model.

Rates of individual O_2 and O_3 production and destruction pathways are computed for different altitudes, by applying the PAP algorithm to each vertical layer of the column model separately. From these results the global contributions of chemical pathways are obtained by integration over atmospheric height.

3. Outlook

In this study, we will present the chemical pathways identified and quantified by the PAP algorithm, relevant for the production and destruction of O_2 and O_3 in the Martian atmosphere. The altitude variations of these pathways are discussed with respect to their efficiency.

Acknowledgements

This research has been partly supported by the Helmholtz Association through the research alliance "Planetary Evolution and Life".

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