Modelling trace gas chemistry in the Martian atmosphere

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Abstract

Dust-bourne heterogeneous reactions have been modeled using the UK Mars Global Circulation Model (MGCM) coupled with physics and chemistry schemes used in the Laboratoire de Météorologie Dynamique (LMD) MGCM. The seasonal ozone column abundance has been calculated using a number of different dust scenarios. Reactions involving volcanically interesting species such as water vapor, $SO_2$ and $HCl$ have been included and tracer release experiments have been conducted to mimic short and long-term volcanic outgassing. The effect of these new reactions on the bulk chemistry of the Martian atmosphere has been quantified.

1. Introduction

Investigating the seasonal distribution of trace gas species in the Martian atmosphere has the potential to shed new light on many topics such as the search for life and the history of liquid water on the planet. Studying the way that species such as ozone, water and HCl are cycled within the atmosphere and identifying potential sources and sinks of the gases will give insights into the interactions taking place between the atmosphere, lithosphere and any potential biosphere. Many missions to identify new trace gas species and measure their abundances in the atmosphere are currently being planned. One such mission is the Laboratoire de Météorologie Dynamique (LMD) MGCM [4]. These schemes are coupled to a spectral dynamic core [8] and a semi-lagrangian advection scheme which transports tracers within the atmosphere [9, 10]. The model is given an initial state, then outputs spatially and temporally resolved data for the entire globe for a set number of sols. The coupled online chemistry module was adapted from a module used to study chemistry in the terrestrial stratosphere [11]. The module has been used extensively to investigate the global distribution of ozone [4] with the addition of such elements as heterogeneous reactions acting upon water ice particles [5]. The observed water-ozone anti-correlation is well represented qualitatively [5] though more work is required to match the observations quantitatively. The anticorrelation can be seen in Figure 1.

2. The Mars Global Circulation Model

The MGCM used in this study uses physical and chemical schemes developed by researchers at LMD in Paris [7, 4]. These schemes are coupled to a spectral dynamic core [8] and a semi-lagrangian advection scheme which transports tracers within the atmosphere [9, 10]. The model is given an initial state, then outputs spatially and temporally resolved data for the entire globe for a set number of sols. The coupled online chemistry module was adapted from a module used to study chemistry in the terrestrial stratosphere [11]. The module has been used extensively to investigate the global distribution of ozone [4] with the addition of such elements as heterogeneous reactions acting upon water ice particles [5]. The observed water-ozone anti-correlation is well represented qualitatively [5] though more work is required to match the observations quantitatively. The anticorrelation can be seen in Figure 1.

3. Summary

Results from numerical experiments conducted in order to investigate the effect of dust-bourne heterogeneous reactions on the composition of the atmosphere will be presented. Results from tracer release experiments will also be discussed in order to determine the possible effects of short and long term outgassing of dust and ash particles; and other volcanic trace species on the bulk chemistry of the atmosphere. These experiments will aid in the interpretation of observations
of trace gases in the Martian atmosphere and also improve our knowledge of source and sink regions that will be of vital importance for guiding selection of future spacecraft mission landing sites. An understanding of trace species, particularly ones indentified as possible biomarkers is important not just for the study of Mars and other solar system bodies but will also have implications for the study of exoplanet atmospheres.

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References


