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# Modelling trace gas chemistry in the Martian atmosphere

**M. K. D. Duffy**, N. J. Mason and S. R Lewis;
Department of Physical Sciences, The Open University, Walton Hall, Milton Keynes, UK (m.k.d.duffy@open.ac.uk)

## Abstract

Dust-bourne heterogeneous reactions have been modelled 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 vapour, $SO_2$ 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 NASA/ESA Trace Gas Orbiter (TGO) the aim of which will be to explain recent observations such as the Tharsis methane plumes [1] and the presence of perchlorate in the North polar plains [2].

Currently, there are two Mars Global Circulation Models (MGCMs) that have fully coupled, online photochemistry modules: the 3D Mars Global Multiscale Model (GM3) [3] and the Laboratoire de Météorologie Dynamique (LMD) MGCM [4, 5]. The focus in both of the modules is odd-hydrogen ($HO_x$) and odd-oxygen ($O_x$) chemistry, they are not yet capable of accurately simulating more complex chemical interactions. The benefit of fully-coupled MGCMs is that both the chemical behaviour and the global transport of trace species can be studied. In the current project we plan to study the general effect of dust-bourne heterogeneous reactions and the sporadic outgassing of dust and other species representative of volcanic eruptions. The new reaction schemes are based upon laboratory simulations that are also being conducted at The Open University [6].

## 2. The Mars Global Circulation Model

The MGCM used in this study uses physical and chemical schemes developed by reseachers at LMD in Paris [7, 4]. These schemes are coupled to a spectral dynamic core [8] and a semi-langrangian 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 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

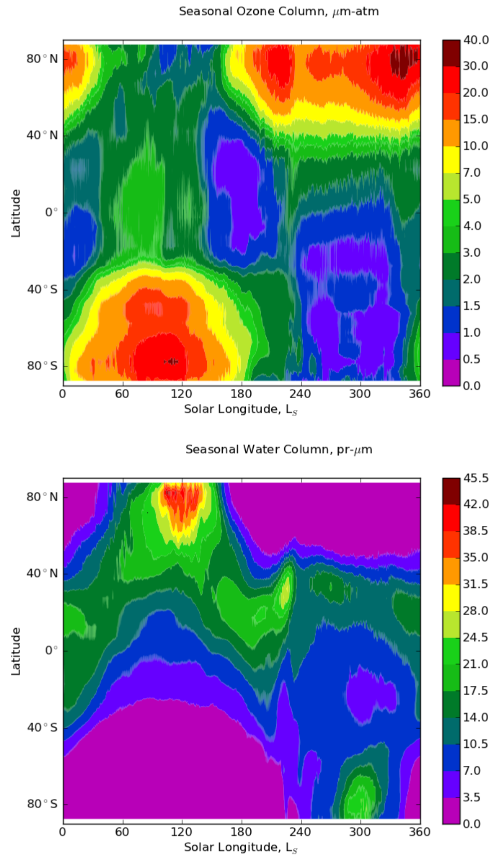


Figure 1: Seasonal, zonally averaged plots of ozone column abundance (top) and water vapour column abundance (bottom for one Martian year. Ozone column is measured in atmospheric microns and water vapour in precipitable microns.

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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