Laboratory simulation of Martian atmospheric chemistry

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Introduction

Recently there has been a great deal of interest in predicting the concentration and distribution of gases within the Martian atmosphere due to the observation of trace species such as methane [1,2] that could hold clues to currently unobserved processes such as volca

Mars Global Circulation Models (MGCMs) can predict both the seasonal and spatial variability of trace gases on Mars. Current models are very effective at predicting the variability due to transport (dynamical) pro-

The chemical sub-model contains 16 species (CO₂, CO, O₃, O₂, O₃, O₂, H₂, H₂O, H₂O₂, CH₄, Ar, N₂, H₂O ice and H₂O vapour) undergoing 42 chemical reactions [4]. The concentration of each gas species is calculated every 30 minutes taking into account advection, verti
cal diffusion, convection and chemistry plus any effects of the CO₂ and water cycles.

The Laboratory Set-up

Figure 1. Shows a photo of the current laboratory set-up .

The UK-LMD MGCM is a state of the art MGCM developed by researchers from the Laboratoire de Métérolo
gie Dynamique (LMD), France; the Instituto de Astrof i

císca de Andalucía, Spain and Oxford University and The Open University in the UK. The UK-LMD version utilises a spectral dynamical core [6] and a semi

The model predicts the qualitative distribution of ozone well. In both results for similar conditions from the LMD MGCM [4,11].

The Problem

The study of trace gas chemistry on Mars is interesting as it offers clues into underlying active pro

An example: The effect of heterogeneous reactions on ozone

Heterogeneous chemistry involves reactions between species in differ

tent phases. In the Earth’s atmosphere reactions that occur on the sur

face of liquid aerosols and solid particles in the air can be very impor
tant, particularly to reactive species such as ozone.

The figures to the right show zonally-averaged seasonal plots of ozone column density (µm-atm) on Mars. Figure A is a run using purely gas-

the chemical sub-model while in Figure B a suite of heterogeneous reactions have been added. These simulations were run using the UK-LMD version of the MGCM and agree with the published results for similar conditions from the LMD MGCM [4,11].

The model predicts the qualitative distribution of ozone well. In both Figures the maximum value of ozone column density occurs during polar winter (Winter solstice is at Ls=90° in the South and Ls=270° in the North). The maxima occur when the concentration of water vapour in the atmosphere is lowest. This is because species that form from the photolysis of water (HO₂=H₂O, HO₂) cause the destruction of ozone.

However, the LMD team found that the predicted ozone distribution did not agree quantitatively when compared with observations from the IR spectrometer aboard SPICAM [11]. The model underestimated the maxi

These are unlikely to be the only heterogeneous reactions of interest. Indeed, reactions that occur on the surface of dust particles will likely be important on Mars though laboratory simulations are required to char
acterise them as they are not currently well understood.

Summary

To understand observations of trace gases they must be modelled by MGCMs that are capable of predicting their seasonal and spatial distribution because of both transport and chemical processes.

Laboratory simulations of chemistry under Martian environmental conditions are needed both to im

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