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Modelling radiatively active water ice clouds in the Martian water cycle

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Introduction

Aerosols, both water ice and dust, play a key role in the Martian climate. However, our understanding of the interactions between these phase changes occurs at the boundary between the surface (polar ice caps, frost) in the atmosphere (vapour, ice clouds) and the distribution of properties of dust is currently incomplete.

Water ice clouds have been observed at many locations in the Martian atmosphere, and they occur in many different forms, such as polar hood clouds, encircling clouds and ground fogs. The largest spatial distribution of clouds belongs to the aphelion cloud belt, which appears during northern hemisphere spring and summer each year in a zonal band between around 10° S and 30° N [1, 2].

In this paper, we demonstrate the potential impact of water ice clouds on a Mars Global Circulation Model (MGCM), and test the sensitivity of the model to varying dust opacity. We use independent model experiments and assimilations of Mars Thermal Emission Spectrometer (TES) retrievals and validate the model against Mars Climate Sounder (MCS) observations.

Sensitivity of the model to dust distribution

Due to the radiative effects of dust, its temporal and spatial distribution will have a large effect on other atmospheric properties. To test the sensitivity of the MGCM to the distribution of dust, we have run the model using the Mars Climate Database (MCD) shows the distribution of dust, though the dust from the MCD is not as strong as that from the assimilation.

Plots of the meridional mass streamfunction (MMS) averaged over an entire Martian year are shown in Figure 3. The MMS from both the simulations and the modelled data from the Mars Climate Database (MCD) shows the distribution of dust, though the dust from the MCD is not as strong as that from the assimilation. The two simulations using the 2003 and 2005 dust schemes do show stronger, southerly circulation than that from the MCD, but it is still weaker than in the assimilation.

Figure 2 shows the difference in visible dust opacity averaged over Mars month 5 for both dust schemes. As can be seen, the 2003 dust scheme showed increased opacity globally, particularly in the southern hemisphere poleward of around 40° S.

Figure 2. Difference in dust column visible opacity between simulations run with different TES dust schemes (2005 – 2003), averaged over Ls = 120° – 150°.

As well as comparing the two simulations with each other, we have also carried out comparisons with observations from the MCS and modelled data from the MCD, which is used as a convenient summary of model experiments from the MARPEX cycle. Project aims

The project will model the Martian water cycle, including radiatively active water ice clouds, to interpret new observations from MCS. We will be using the latest version of the LMD MGCM, which includes the new LMD physics routines. A unique data assimilation system [10] will be used to obtain a complete, dynamically self-consistent reconstruction of the extraterrestrial global climate for the complete period of the MCS mission data. A series of diagnostic studies will be made to characterise the climatology and synoptic meteorology of Mars over seasonal and interannual timescales, including detailed case studies of events such as the formation of cyclonic weather systems. The assimilation results can be used to test the validity of the new cloud schemes introduced to the model, improving our understanding of the Martian water cycle.

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References