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GCM SIMULATIONS OF THE MARTIAN WATER CYCLE.

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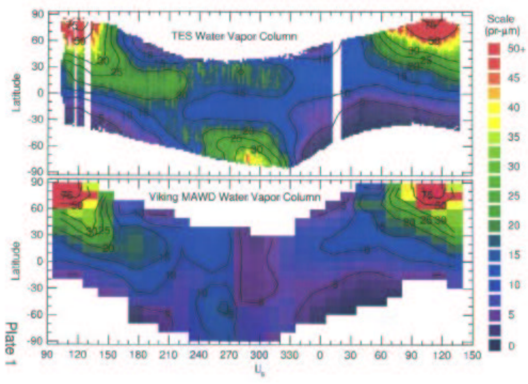

Figure 1: Observations of water vapour in the atmosphere of Mars obtained by TES (top) and MAWD (bottom) spanning a Martian year (Smith, 2001).

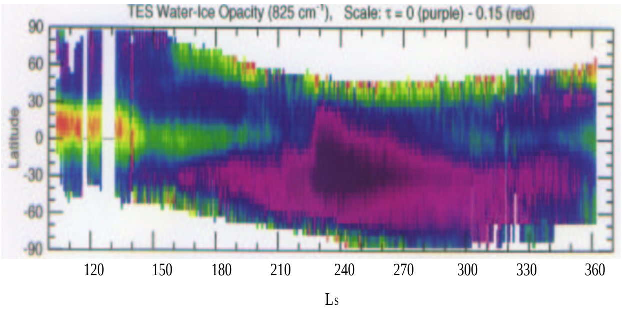

Figure 2: TES observations of zonal water ice opacity as a function of latitude and time. The polar hood clouds and equatorial cloud belt can be seen (Pearl et al., 2001).

Results from the Viking Orbiter Mars Atmospheric Water Detectors (MAWD) have long been the definitive data set for observations of the Martian water cycle (Farmer et al., 1977). The ongoing Mars Global Surveyor Thermal Emission Spectrometer (TES) observations are providing new insights into the current water cycle, with detailed longitude-latitude dependence of water vapour (Figure 1) and water cloud (Figure 2) with time, as well as information on vertical distribution of water vapour and ice cloud (Smith, 2001). The described results are derived from an ongoing project to model the current water cycle using the Oxford version of the European Mars General Circulation Model (MGCM) (Forget et al., 1999), which was developed in colaboration with LMD, Paris.

In order to model the current water cycle a number of parameterizations have been added to the physics suite of the MGCM. These include: a Semi-Lagrangian advection scheme, which has been coupled to the MGCM and was developed by Newman (2001) for purposes of dust advection; a condensation-sublimation scheme, allowing for surface ice to sublime and water vapour to condense out in the atmosphere; a simple cloud scheme, which prescribes a fixed particle radius to condensed water ice from which a gravitational settling force is calculated to act on the particle; and a Regolith model. The Regolith model is a detailed 10 layer subsurface model which takes into account the vertical diffusion of water through the subsurface, as well as the formation of ice and adsorption of water onto regolith grains. The adsorption term used is that of Zent et al. (1993).

We find that these parameterisations are indeed sufficient to enable an annual water cycle resembling observations to be modelled. Figure 3 shows a simulation of the integrated water vapour column abundance as a function of time and latitude for one Mars year. Both qualitatively and quantitatively the results are in close agreement with the TES observations. The MAWD observations are in agreement with the TES observation in the northern hemisphere but do not display a significant peak in the southern hemisphere summer as is the case in the TES observations and model simulations. This is believed to be due to a downward bias in the retrievals during the southern hemisphere summer due to the large amount of dust in the atmosphere at this time, and is therefore not believed to necessarily indicate significant interannual variability in the Mars water cycle.

The developed parameterizations allow for a number of degrees of freedom within the MGCM that can be tuned to alter the simulated water cycle. It is, however, true to say that altering parameters such as atmospheric dust loading, ice cap albedo, ice cap size amongst others, only affects the amount of water vapour and ice in the atmosphere. The overall pattern observed in the TES data of a large maximum in the northern hemisphere summer north polar region and a smaller maximum in the southern hemisphere summer south polar region, is very robust and always observed in the model. The only difference is the amplitude of the maxima and amount of vapour within the system.

Similarily, Figure 4 shows a simulation of column integrated cloud ice in pr microns as a function of time and Latitude. All the features observed by TES, including the polar hood clouds and equatorial cloud belt appear in the model simulations.

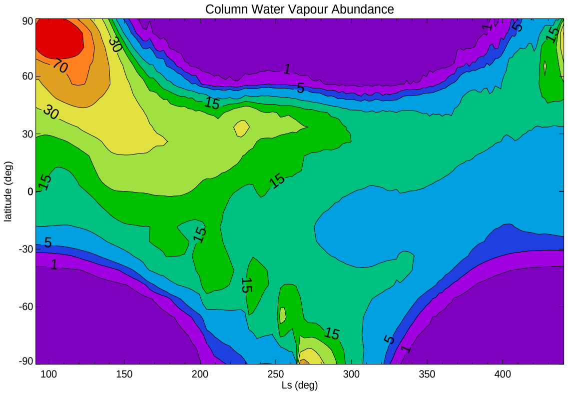

Figure 3: Results for one Martian year showing integrated column water vapour abundance in pr microns as a function of time and latitude. The qualitative and quantitative pattern closely resembles that of the TES observations.

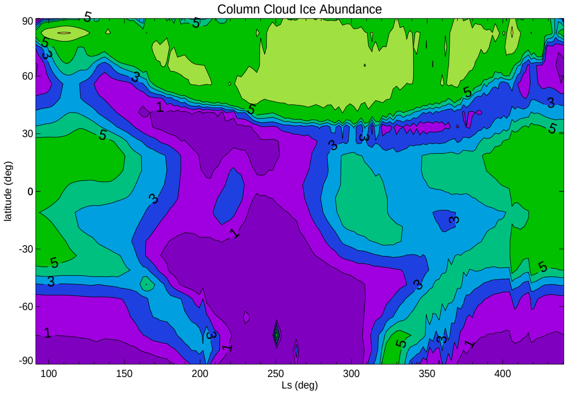

Figure 4: Results of one Martian year showing integrated column water ice cloud abundance in pr microns as a function of time and latitude. Mainy of the features evident from observations are present. The northern hemisphere CO_2 ice cap is covered by a polar hood. Clouds are evident in the equatorial regions from Ls=300-180, as well as on the edge of the southern hemisphere CO_2 ice cap.

Having established an annual water cycle which closely resembles that of the Martian observations, we will consider the longer term stability of the water cycle (by which is meant the ability to produce a repeatable annual cycle over many years). In a previous study, Richardson (1999) showed that a steady state for total atmospheric water content within the model can be obtained but only at concentrations a few times greater than those observed by TES. We will consider whether a steady state is achieved in the present study, and then outline the factors which control the longterm water cycle.

That the Regolith plays a role in the current Martian water cycle has always been assumed (eg. Titov et al., 1995). Observations and Laboratory experiments (eg. Fanale and Cannon, 1974) have shown that diurnal as well as longterm exchange with the atmosphere takes place. The complex nature of the Regolith model used in this study, for the first time allows questions concerning the role of the regolith in the annual, and longer term martian water cycle to be discussed. We will be showing results of simulations conducted with active and passive regolith, focusing mainly on the effect of the regolith over timescales of several Mars years.

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