Laboratory simulation of Martian atmospheric chemistry

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An example: The effect of heterogeneous reactions on ozone

Heterogeneous chemistry involves reactions between species in different phases. In the Earth's atmosphere reactions that occur on the surface of liquid aerosols and solid particles in the air can be very important, 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-phase chemistry in 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 (HO=OH, HO₂) catalyse 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 underpredicted the maximum concentration at aphelion (LS=71°) and in late summer where the ozone did not increase quickly enough to match the observations. This was remedied by the addition of heterogeneous reactions involving HO₃ occurring on the surface of water ice cloud particles as seen in Figure B.

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 characterise them as they are not currently well understood.