Simulation of the water cycle on Mars in a general circulation model

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There is already a lot of data for the column density distributions of water vapor and water ice from Mars Global Surveyor, Mars Express and other missions. In addition, the ground-based microwave telescopes have observed the abundance of H_2O and HDO in Martian atmosphere, and detected the hygropause (cut-off height of water vapor) on Martian low- and mid-latitude, which varies from less than 10 km (around aphelion, northern summer) and more than 25 km (around perihelion, northern winter) depending on the season. The seasonal change of hygropause and the ratio of HDO/H_2O will also be observed by the upcoming Herschel space telescope (launch in spring of 2009).

3-dimensional simulation of the atmospheric water cycle is an important step in understanding the Martian atmosphere, for the theoretical interpretation of the observational data. The investigation of the vertical distributions of water vapor/ice is especially important, because the water can be transported from summer to winter hemisphere only when the hygropause is high enough, as well as the water ice should significantly determine the temperature distributions. Moreover, the investigation of the HDO/H_2O ratio is the key to understand the climate evolutions of Mars. Here we have started the simulations including a water cycle in our Martian general circulation model, CCSR/NIES/FRCGC MGCM.

The horizontal resolution of the MGCM is set at about 5.6 degrees for both longitude and latitude (˜333 km at equator), the vertical grid consists of 30 sigma-levels with the top of the model at about 80 km. Realistic topography, albedo and thermal inertia data for the Mars surface, and CO_2 condensation/sublimation processes are included. Radiative effects of CO_2 gas (considering only LTE) and dust, in solar and infrared wavelengths, are taken into account. The condensation of supersaturated water vapor is calculated using a large scale condensation scheme. The condensed water ice falls by the gravitational sedimentation (the particle radius is set to 2 um), and is deposited on surface. With surface water ice, the surface albedo changes to 0.3-0.4. Sublimation of the surface water ice is introduced by the turbulent flux. The microphysical processes, absorption by regolith, and radiative effects of water vapor/ice are not included in the present state.

Though there are some inconsistencies with the MGS-TES observations at present (e.g. thin equatorial cloud belt in northern summer, disappearance of water vapor in northern winter), the MGCM well reproduces the change of hygropause in different season and dust opacity detected by ground-based microwave telescopes and limb-haze observations from a spacecraft. With the future improvements, this MGCM will help to investigate the meridional transport of water on Mars, combined with the upcoming observations by Herschel.