Numerical simulation of water cycle in a Martian atmosphere by the use of a planetary atmosphere general circulation model, DCPAM

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Spacecraft observations of Mars revealed distributions of water vapor and water ice cloud in the Martian atmosphere. Those observations covered an almost global region and a long period. For example, the Mars Global Surveyor (MGS) observed column densities of water vapor and water ice cloud for about 9 Martian years. The MGS observation characterizes the seasonal variation of the water distribution in the Martian atmosphere. On the other hand, general circulation models (GCMs) have been used to investigate water cycle in the Martian atmosphere. Those models represented distributions of water vapor and water ice cloud consistent with observed ones, successfully.
In our group, we have been developing an atmosphere GCM, DCPAM, which is applicable to planetary atmospheres. By the use of the DCPAM, we have been performed simulations of Martian atmosphere without water cycle. In this study, the simulations of water cycle in the Martian atmosphere are performed by implementing relevant processes in the DCPAM. By performing the simulations, features of water cycle in the Martian atmosphere will be investigated and the model will be validated under a condition of Mars.
The DCPAM used in this study consists of a dynamical core based on the primitive equation system and physical processes relevant to Martian atmosphere. The dynamical core solves the primitive equation system by the use of spectral transform method with the finite difference method in vertical direction. The included physical processes are the radiation, the turbulent mixing, the surface processes, the CO2 and H2O condensation, and gravitational sedimentation. In the model, the radius of cloud particles is assumed to be a constant. By the use of a "Mars mode" of this model, several experiments have been performed. In the experiments, the dust distribution in the atmosphere is prescribed. In the vertical direction, the Conrath-type distribution is assumed. In the horizontal direction, the optical depth is prescribed following observations. In order to simulate water cycle, large amount of water ice is placed north of 80N. Further, the surface temperature south of 85S is fixed to 145 K to represent a permanent CO2 ice cap. Those H2O and CO2 ices at southern and northern high latitude regions act as source and sink of the water. The resolutions used for this study is T21L36, which is equivalent to about 5.6 degrees longitude-latitude grid and has 36 vertical levels. Under these conditions, the model is integrated for 10 Mars years from an initial condition of isothermal atmosphere at rest. The result during the last Martian year is analyzed.
The model is evaluated by comparing the column densities of water vapor and water ice cloud simulated by the model with those observed by the MGS. The simulations with ice cloud radius of 7 micron meter show following features of seasonal variation of those values which are roughly consistent with observations. From northern summer to northern fall, the water vapor is transported from northern cap to low latitude. At the same time, water ice cloud forms in northern low latitude where the ascending motion of Hadley circulation occurs. However, the low latitude water ice cloud from northern winter to northern spring is slightly thicker in the model than observed one. This may be caused by crude treatment of ice cloud in the model. In the presentation, features of water cycle represented in the model will be presented in more details.

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