Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS02-P01 Room:Poster Time:April 28 18:15-19:30

Interannual analyses of the meridional distributions of Martian dust and clouds obtained by MRO-MCS

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We investigated the interannual variability of the meridional distributions of dust and clouds in the Martian atmosphere by using Mars Reconnaissance Orbiter Mars Climate Sounder (MRO-MCS) measurements. As the previous analyses did not consider measurement errors to depict the zonal averages, we took a criterion of 10% for the measurement error. Results show that Mars Year (MY) 29, which is regarded as a standard year in the previous analyses, had an enhancement of dust in the high altitudes (above 10 Pa) in the tropical region, and such an enhancement was not found in other MYs (28, 30 and 31). On the other hand, the distribution of ice clouds in MY 29 roughly agreed with other MYs' distribution.

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Implementing Martian dust lifting scheme into DCPAM, and a diagnosis experiment of surface dust flux

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The Martian dust cycle influences thermal states of its atmosphere, hence it plays an important role for determining states of the Martian atmosphere(Gierasch and Goody, 1968). Dust processes to be considered are dust lifting, turbulent mixing, advection, and gravitational sedimentation. Parameterizations of lifting by model resolved wind stress and by model unresolved vortices such as dust devils are considered. The Martian dust cycle has been simulated with general circulation models implemented above dust process schemes by some research groups. For example, Kahre et al.(2006) roughly simulated a seasonal variation of dust loading. The seasonal variation of dust loading has a peak in during northern autumn and winter. In contrast, DCPAM (Takahashi et al., 2012), which is a general circulation model developed by our group, has not been implemented above dust process schemes. Aims of this study are to implement dust process schemes into DCPAM, and to perform numerical experiments on the dust cycle with it. In the future, we will consider about interannual variability of the Martian dust distribution, which still has not been reproduced. In this work, we implement dust lifting scheme by model resolved wind stress into DCPAM. Addtionally, we perform an experiment with dust lifting to investigate behavior of this dust lifting scheme. And, we compare our model's results with thoses of Kahre et al.(2006).

The model utilized is DCPAM which is developed by GFD Dennou Club. DCPAM adopted three dimensions primitive equations. A radiative scheme by Takahashi et al.(2003, 2006) is used. This include the radiative effects of gaseous CO_2 and suspended dust. And, used suspended dust distribution is spatially and temporally fixed. A turbulent process is estimated by used vertical diffusivity based on Mellor and Yamada(1974). A surface process is estimated based on Louis et al.(1982). Each parameter are selected as Martian values. We use a surface distribution of thermal inertia, albedo and topography observed by Mars Grobal Surveyor. A horizontal discretization is the spectral method, and the trauncation wavenumber is 21. A vertical discretization is the finite difference method, and the number of layor is 32. We integrate 3 Mars year, and use the last 1 Mars year for analysis.

First, we implement a dust lifting scheme called by KMH scheme(Kahre et al., 2006) into DCPAM. Then, we perform a diagnosis experiment of surface dust flux with this. This result is similar to result by Kahre et al.(2006) as follows. In regions around latitude 50N degree and 30S degree, strongly dust lifting occurs during northern autumn and winter. At latitude 50N degree, it appears that eastward waves, which have zonal wavenumber 1 and period 6 Mars days, contribute to dust lifting. it is to be considered the baroclinic wave(Briggs et al., 1979). At latitude 30S degree, it appears that westward waves, which have zonal wavenumber 1 and period 1 Mars days, contribute to dust lifting. It is to be considered the diurnal thermal tidal wave(Joshi et al., 1979), and dust lifting tends to occur at 16 o'clock local time. These results qualitatively are consistent with these of Kahre et al. (2006), but are not quantitatively consistent with these of Kahre et al.(2006). For example, our model's surface dust flux is greater by a degree of magnitude then these of Kahre et al.(2006) in the northen polar cap. The reason is probably that the number of vertical levels and the method for estimating turbulent mixing are diffrent from those of Kahre et al.(2006). In this work, we implemented dust lifting scheme by model resolved wind into DCPAM. We are now implementing dust lifting scheme by dust devils into DCPAM. Then, we are going to implement advective scheme and gravitational sedimentation scheme into DCPAM in turn, and perform numerical experiments for their implementation test.

Keywords: Dust, Mars, General Circulation Model

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Assessment of Mars surface environment for MELOS1 lander using Planetary General circulation model DCPAM

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1. Introduction

The Mars exploration program MELOS1, which is to mainly challenge life and surface environment exploration, is now planning by space engineering and planetary science community in Japan. To support designing the landing module and observation instruments and ensure safety experiments during entry, decent and landing phase, plausible range of meteorological conditions at MELOS1 landing site is required.

We try to assess the Mars surface environment from planetary to atmospheric boundary layer scale by using simulation results obtained by General Circulation Model (GCM), Regional Meteorological model, and Large Eddy Simulation (LES) model (LES). For mesoscale assessment, CReSS which is developed by HyArc Nagoya University will be used. For boundary layer scale, SCALE-LES which is developed by RIKEN AICS will be used as LES model. Both numerical model are now tuned to Mars and preliminary experiments are performed (Sugiyama et al. 2013; Nishizawa et al. 2013). For planetary scale assessment, we use a planetary atmospheric general circulation model DCPAM which is developed by GFD Dennou Club (Takahashi et al. 2012). In this study, we compare simulation results of DCPAM to observation results of Viking and Mars Path Finder (MPF) and investigate proper method for assessment of Mars surface environment by using DCPAM data. By using this method, we show some assessment results at proposed landing sites of MELOS1.

2. Data

DCPAM is a spectral GCM including physical processes appropriate for Martian atmosphere. The topography, surface albedo and thermal inertia in the model is based on observation results obtained by Mars Global Surveyor (MGS). The horizontal truncation wave number is 31, which corresponding horizontal resolution is about 200 km. The number of vertical layer is 16 and the height of lowest level is about 3 m. The seasonal variation of atmospheric dust distribution is given which is based on typical case of MGS observation. Numerical integration is performed for 7 Mars years with isothermal no motion initial condition. The data of last two years are used for analysis. The proposed landing sites are Newton Crater, Nili Fossae, and Isidis Planitia. The period of analysis is 90 sols from Ls = 331, 324, 14, and 135 which are corresponding to four mission window. In each period, diurnal variations every 15 sols are investigated.

3. Methods of analysis and results

In comparing the DCPAM results to observation results of Viking and MPF, the atmospheric temperature and wind velocity at observed altitude are estimated assuming the boundary layer similarity theory in neutral case is valid near the model surface. The surface pressure at actual altitude is estimated assuming hydrostatic balance with constant scale height which is calculated by the using model temperature. The comparison between estimated values from DCPAM results and observations show that the observed diurnal variation of atmospheric temperature is well reproduced by using 2nd level (about 12.5 m height) temperature of DCPAM, and seasonal variation of surface pressure is almost represented by using the scale hight corresponding to 10th level (about 1.35 km height) model temperature and subtracting offset value (60 Pa).

Based on above results, analysis of the DCPAM data at the three proposed landing site during four mission periods are performed. At Newton Crater, which is the first proposed site, during 90 sols from Ls = 331, the diurnal mean atmospheric temperature ranges from 190 to 220 K. The amplitude of diurnal change of atmospheric temperature is about 50 - 70 K. The air temperature is almost constant during this period and its value is about 140 K. The maximum values of direct and diffuse solar radiative flux are 480 Wm^{-2} and 40 Wm^{-2}, respectively. We will also estimate the extent of variation of meteorological variables, such as temperature and pressure, at the proposed landing sites by analyzing DCPAM data with different dust distribution.

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Keywords: Exploration of Mars, General Circulation Model, Surface environment of Mars

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Estimation of Martian atmospheric composition change caused by CO2 condensation and its application to radio occultation

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We estimated the Martian atmospheric composition change caused by CO_2 condensation using the Ar measurements obtained by Gamma Ray Spectrometer (GRS) onboard the 2001 Mars Odyssey. We applied this estimation of the composition change to the rederivation of the radio occultation (RO) measurements of Mars Global Surveyor (MGS) obtained at polar latitudes of the winter hemisphere, because the MGS RO standard product which is available to the public did not consider the atmospheric composition change by CO_2 condensation. Using the rederived MGS RO measurements, we investigated the occurrence of CO_2 supersaturation in the Martian polar winter atmosphere and found that there were more supersaturation in the rederived data than in the original data.

Keywords: Mars, CO2, supersaturation, condensation, radio occultation

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Equation of state of $(Fe,Ni)_3S$ phase - Implications for Mars internal structure

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The existence of lower mantle ($MgSiO_3$-perovskite layer) has an important role on Mars thermal evolution. The layer thickness of Mars lower mantle depends on the depth of the core-mantle boundary (CMB). The depth of CMB is related to the Mars core density. Although the structure model of Mars core was discussed based on the equation of state of pure iron and FeS (e.g., Urakawa et al., 2004), Fe_3S phase and also the effect of nickel on the density should be considered.

We newly established the equation of state (EoS) of $(Fe_{0.89},Ni_{0.11})_3S$ up to about 40 GPa by high pressure experiment using diamond anvil cell. Considering EoSs of γ-Fe (Tsujino et al., 2013), γ-FeNi (Tsujino, 2012), Fe_3S (Seagle et al., 2006), and $(Fe_{0.89},Ni_{0.11})_3S$, the effects of nickel and sulfur on the density was determined. Then, we determined the Mars core density corresponding to the composition model based on SNC meteorites. Our new model shows relatively thin lower mantle compare to previous one. Moreover, if Mars core contains 16 wt.%S and 7 wt.%Ni (Sanloup et al., 1999) and if Mars has an entirely liquid core (Fei and Bertka, 2005), there is a possibility of disappearance of Mars lower mantle.

Keywords: Mars core, equation of state, Mars lower mantle