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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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