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

ODAKA, Masatsugu[1] ; SUGIYAMA, Ko-ichiro[2] ; TAKAHASHI, Yoshiyuki O.[3] ; NISHIZAWA, Seiya[4] ;
HAYASHI, Yoshi-Yuki[3]; HASHIMOTO, George L.[5]

[1] Department of Cosmosciences, Hokkaido University [2] Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency
[3] Department of Earth and Planetary Sciences, Graduate School of Science, Kobe University [4] RIKEN Advanced Institute for Computational Science
[5] Department of Earth Sciences, Okayama University

Summary

To evaluate plausible range of meteorological conditions at proposed landing site of MELOS1, some assessments of Mars surface environment are performed by using a planetary atmospheric general circulation model, DCPAM. Viking and Mars Pathfinder meteorological data are well reproduced by using DCPAM data with systematic calibrations. Based on these results, assessment of surface environment at Newton Crater is performed. In future work, variability associated with mesoscale and boundary layer scale disturbances will be evaluated by using regional meteorological model and large eddy simulation model to improve our assessment.

1. Introduction

The Mars exploration program MELOS1 is now planned by space engineering and planetary science community in Japan.

- The main science targets are life and surface environment exploration.
- To support designing the landing module and observation instruments and ensure safety mission operation, evaluation of plausible range of meteorological conditions at MELOS1 landing site is required.

Our research group now progress to assess the Mars surface environment by using following three numerical models results.

- General Circulation Model (GCM): for planetary and synoptic scale assessment (DCPAM, Takahashi et al. 2012).
- Regional Meteorological model (RMS): for mesoscale assessment (CReSS, Sugiyama et al. 2013) .
- Large Eddy Simulation (LES) model: for boundary layer scale assessment (SCALE-LES, Nishizawa et al. 2013).

In this presentation, we show following results:

- **Compare simulation results of DCPAM to observation results (Viking , Mars Pathfinder (MPF)) and proper method for assessment of Mars surface environment by using DCPAM data.**
- **Some assessment results at proposed landing sites of MELOS1.**

2. Model and Simulation setup

DCPAM is a planetary atmospheric general circulation model developed by GFD Dennou Club (Takahashi et al. 2012, Figure 1).

- A spectral GCM designed by using primitive equation system.
- Physical processes (subgrid scale turbulence, CO2 condensation/ sublimation, atmospheric and dust radiation, surface process) are including.
- The topography, surface albedo and thermal inertia in the model are based on observation results obtained by Mars Global Surveyor (MGS).

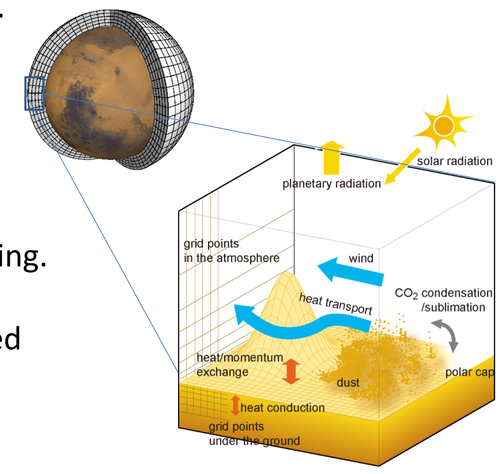

Figure 1: Schematic figure of DCPAM

Simulation setup is as follows.

- The horizontal truncation wave number is 31, which corresponds to about 200 km horizontal grid size. The number of vertical layer is 36 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 (Figure 2).
- Numerical integration is performed for 7 Mars years with isothermal no motion initial condition.
- The data of last two years are used for analysis.

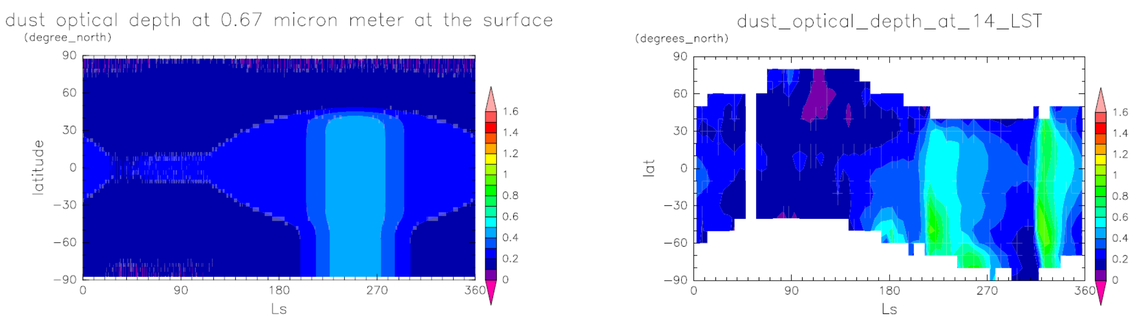

Figure 2: Seasonal variation of zonal mean total dust optical depth at 0.67 μm radiation prescribed to DCPAM (left panel) and observed by MGS (right panel) .

3. Comparison results

3.1. Surface atmospheric temperature

Diurnal variation of atmospheric temperature at 1.4 m height observed by MPF is well reproduced interpolating with ground temperature and atmospheric temperature at 2nd model level (about 12.5 m height).

- Logarithmic wind and temperature profiles under neutral stratification are assumed in evaluating temperature at 1.5 m height.

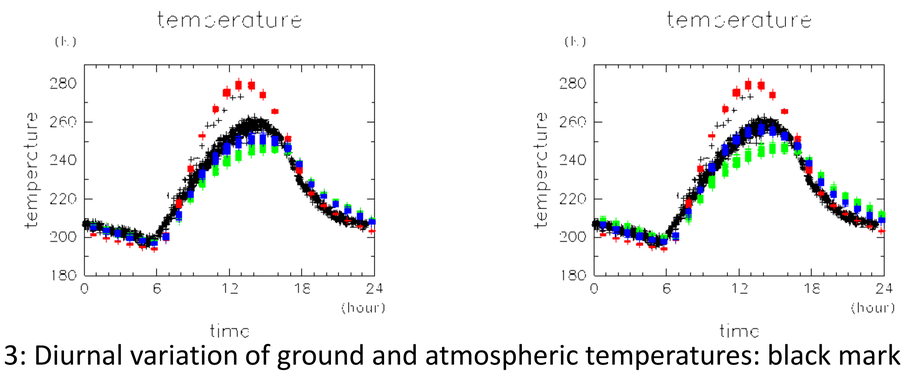

Figure 3: Diurnal variation of ground and atmospheric temperatures: black mark indicates MPF observation at 1.5 m height, and red mark indicates model ground temperature: (left panel) Green mark indicates model lowest level (about 3 m height) temperature and blue mark indicates estimated atmospheric temperature at 1.5 m height, (right panel) Same as left panel but 2nd level (about 12.5 m height) temperature is used for estimation of temperature at 1.5 m height.

3.2. Surface atmospheric pressure

The seasonal variation of surface pressure observed by Viking Lander 1 (VL1) is almost represented by the model with some calibrations considering a height difference between the model grid and actual landing site by using a scale height at 10th model level, and uncertainty of global mean atmospheric mass by subtracting 60 Pa.

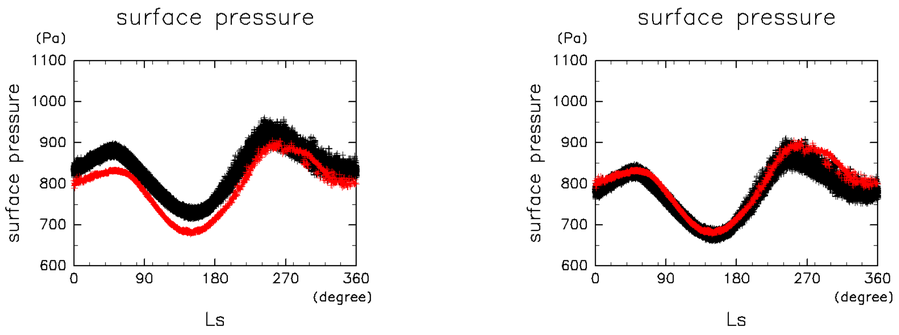

Figure 4: Seasonal variation of surface pressure at Viking Lander 1 site: red mark indicates VL1 results and black mark indicates model surface pressure: (left panel) before calibration and (right panel) after calibration.

4. Assessment of surface environment for MELOS1

Based of the calibration method, assessment of surface environment at proposed landing site is performed.

- Location: Newton Crater (41.6°S, 202.3°E)
- Season: Ls=327°-333° (Northern late winter)

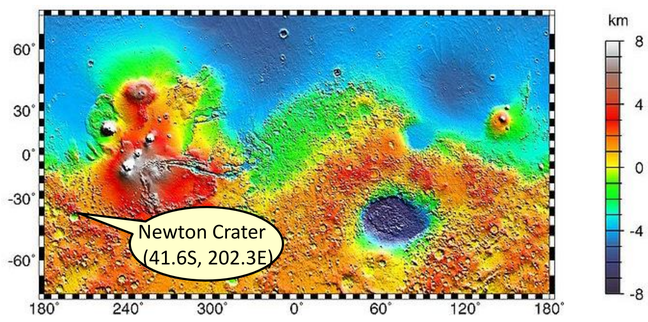

Figure 5: Martian surface topography.

Summary of assessment (Figure 6):

- The diurnal mean atmospheric temperature is about 220 K, and the amplitude of diurnal change of atmospheric temperature is about 70 K.
- The diurnal mean wind velocity is about 4 m/sec.

This assessment is represent possible meteorological condition due to planetary and synoptic scale disturbances. Its variability associated with mesoscale and boundary layer scale disturbances should be estimated by using RMS and LES in future work.

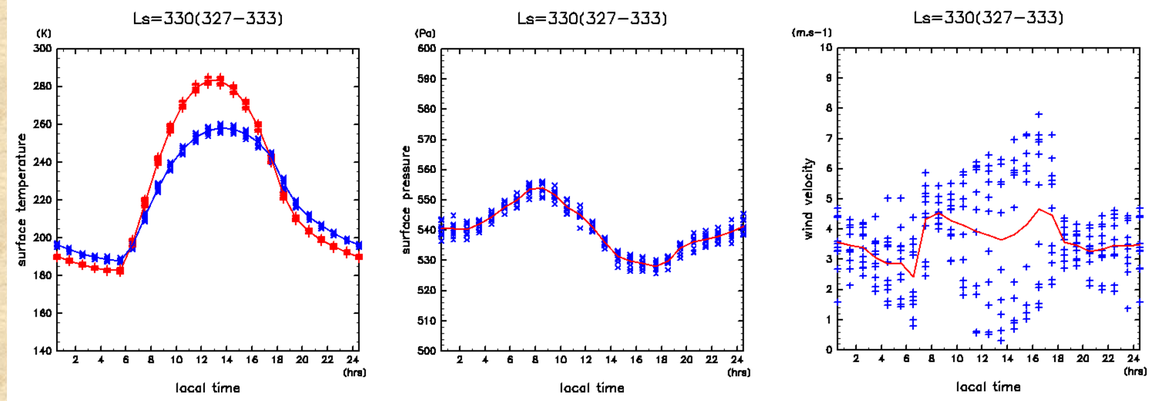

Figure 6: Diurnal variation of ground and 1 m height atmospheric temperatures (left panel), surface pressure (middle panel), and surface wind velocity (right panel) at Newton crater from Ls=327° to 333°. Solid line in each figure indicates mean value.