Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PPS002-P01 Room:Convention Hall Time:May 25 16:15-18:45

The study of the dust lifting into the Martian atmosphere using Mars general circulation model

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Airborne dust plays an important role in the Martian climate system. Aerosol particles absorb and scatter the solar flux, and therefore, atmospheric temperature is strongly affected by temporal and spatial distributions of dust. The latter is supplied from the ground, and especially strong dust lifting occurs during socalled dust storms. Depending on the size and duration of the storms, they can be divided into three types: local, regional and global (planet-encircling). Numerous observations show that dust storms are generated mainly in the southern hemisphere every Martian year, although not every dust storm develops into global one. Implementation of the dust cycle in general circulation models (GCM) is highly important for simulations of the Martian climate system. Many existing Martian GCMs employ the observational data in order to evaluate the seasonal dust distributions in the atmosphere. We developed a dust lifting scheme, and implemented in into the GCM. The scheme accounts for dust particles lifting if the near-surface wind exceeds a certain threshold, their transport by the local wind, and sedimentation. The scheme is interactive in the sense that the simulated dust distributions affect radiative calculations, and ,thus, provide the feedback to the atmospheric wind and temperature. The scheme currently undergoes an extensive validation and sensitivity tests.

The simulated vertical flux of dust particles on the surface is seen that strong dust lifting occurs near 30S, in a good agreement with observations. Some patterns like global dust storm are simulated. In case of the strong dust lifting, opacities go up more than 0.3 for infrared wavelength. The southern summers of opacities are good agreement with the observations comparatively. Otherwise the northern winter ones are much lower.

Keywords: Mars, dust storm, Mars general circulation model

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Climate history on Mars as seen from the polar layered deposits

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The layered deposits that consisted of ice and dust in the polar cap of Mars were discovered by Martian exploration in recent years. As for the periodicity of the layer structure, it is pointed out that there are insolation variation and relativity. It is known well that the insolation variation is the most important element that causes the climatic variation. Such relativity is confirmed by the ice core of Greenland and the South Pole in the Earth, and is used as an index of a past climatic variation in paleoclimate study. If similar study can be done in Mars, it becomes possible to examine a past climatic variation of Mars. On the other hand, in the Mars north pole, it was pointed out that there was a strong correlation in the change of a perpendicular direction of the radiance of the layered deposit seen from the image that showed the valley and in a past insolation variation of an Arctic summer solstice in the north polar region [Laskar et al., 2002]. Moreover, a past climatic variation is examined also in the Mars South Pole by a similar technique [Moroi et al., 2008]. However, these examples of analyzing that were not still enough and evaluated only subjective correlation. Then, the present study aimed to improve the positive proof of the relativity of the radiance change of the quantity of insolation variation of Mars and the layered deposit by expanding the analysis example.

The present study used the optical imagery obtained by High Resolution Imaging Science Experiment(HiRISE) of Mars Orbiter Camera(MOC) of Mars Global Surveyor and Mars Reconnaissance Orbiter and the altimeter data obtained by Mars Orbiter Laser Altimeter(MOLA). The optical imagery analyzed mainly the point with geographical features in the cliff etc. where seeing the layer structure in the Mars South Pole, and the altitude difference were large. Moreover, the distribution situation of the resembled layered sediment was examined by comparing the layer structures.

The optical imagery analyzed mainly the point with geographical features in the cliff etc. where seeing the layer structure in the Mars South Pole, and the altitude difference were large. Moreover, the distribution situation of the resembled layered sediment was examined by comparing the layer structures. This announcement shows a part of the result of the relativity of the layer structure of the layered sediment exposed in the Mars South Pole region and the quantity of insolation variation.

Keywords: Mars, South pole, layered deposits, climate, polar, insolation

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Mapping of Mars crustal magnetic field using Equivalent-Pole-Reduction method

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Mars has presently no a planetary, dynamic magnetic field. This planet has, however, strong, localized magnetic fields of lithospheric origin, which is much lager than the terrestrial lithospheric magnetic field. To assess the origin of the magnetic field of Mars, it is indispensable to make a magnetic field map in detail.

In this study, the Mars magnetic field is represented by surface poles using the Equivalent-Pole- Reduction (EPR) method of Toyoshima et al. (2008). It has already been applied to the moon magnetic field and has given stable results to draw the magnetic anomaly map.

The data used here is from magnetometer on board the Mars Global Surveyor spacecraft operated from 1996 to 2006. Previous studies have focused on making global Martian magnetic field map, while this study focus on more detailed maps of several regions where some prominent features is seen on the previous maps; Tharsis Bulge including Olympus Mons the tallest volcano in the Solar-System, Valles Marineris the largest canyon on Mars, Herras Planitia the largest impact crater on Mars, Terra Cimeria and Terra Sirenum with very intense magnetic anomaly.

The surface magnetic charges computed using EPR method are used to generate an altitude-normalized magnetic map from different altitudes data. We superimpose the magnetic anomaly maps on the topographical maps. The correlation of these two maps seems to go down to smaller scale than that argued in the previous studies.

Keywords: Mars, crustal magnetic field, Equivalent-Pole-Reduction method, Mars Global Surveyor

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Numerical analysis of impact-induced tsunami and geological implications for paleo-ocean and paleo-crate lakes on Mars

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Since 1980s, presence of the paleo-ocean on Mars has been proposed (e.g., Brandenburg et al. 1987). Although some morphological features are suggested to be possible paleo-shorelines (e.g., Head et al. 1999), it is highly controversial because of the lack of confidential geological and sedimentological evidence. On the other hand, crater lakes highly likely existed in the past with abundant lake water (Fassett et al. 2007). This in turn suggests that surface of Mars was rich in liquid water during a certain periods in the past.

If there were large meteorites impact into the paleo-ocean or crater lakes on Mars, they must have generated huge tsunami and left some geomorphological and sedimentological features around the shorelines. Considering the fact that tidal and tectonic activities are very weak on Mars, the traces of impact-induced tsunami may habe been preserved until today. In this study, we conducted numerical simulations on the paleo-ocean and crater lakes on Mars, assuming that there were meteorite impacts into the water bodies, and examined the behavior of the tsunami at around the shorelines. Furthermore, we examined satellite imageries around the presumable shorelines to find traces of the tsunamis induced by the impacts.

We firstly conducted numerical simulations of impact-induced tsunami with a one-dimension model based on the shallow water theory. There are three types of tsunamis generated by the impact (Matsui et al. 2002). Among them, we focused on the behavior of the rim wave and receding-rushing waves, which might have been large enough to leave geomorphological and sedimentological features along the shorelines. We then examined the relationship between the crater diameter and the magnitude of the tsunami. As a result, we found that the crater diameter and the magnitude of the tsunami are in the direct proportion. In addition, we found that the tsunami on Mars is around 1.5 times larger than that on the Earth because of the difference in gravity.

We also conducted the two-dimensional calculation using the topography of a real crater, which is a possible candidate of paleo-crater lakes. The tsunami might have been affected the shoreline and left some geomorphological and sedimentological features when the wave overflow the crater rim.

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Rootless Cone? Pingo? or Mud Volcano? in Central Elysium Planitia, Mars

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Central Elysium Planitia (CEP) on Mars is famous for having very smooth vast plains, which seem to be composed of material emanated from Cerberus Fossae. The nature of this material has been in long-standing dispute. Here we can found very young aged (10 Ma or less) lava flows have been identified (Hartmann et al., 2000, Vaucher et al., 2009) while aqueous floods also have been identified to emanate from Cerberus Fossae (Burr et al., 2002). If most of landscape in this area are lava flow origin, then this young volcanism is distinct from those at Tharsis Montes in many points and we consider it should be a key to understand present-day thermal state of Mars. If they are mostly aqueous flood origin high temperature lava is not necessary, which suggests different thermal state in the present mantle. In this respect geological interpretation of CEP is critical but still in debate even though high resolution images have been available. In this presentation we present a new interpretation for the formation of distinct ”double cone structure” along magmatic origin.

In CEP, pervasive existence of cone-like morphological features (CLF) have been revealed by high resolution images. Until now three different interpretations are proposed for the origin of CLF: rootless cone (Fagents et al., 2002), pingo (Page, 2006) and mud volcano (Kangi, 2007). Rootless cones are product of phreatomagmatic eruption, which are located on lava flows that have moved over a substrate containing ice/water at the surface or subsurface. Pingo is a periglacial morphology, which is formed by upthrust of underground ice. Mud volcano is formed by effusion of mud by over-pressurization. Since the first interpretation is consistent with lava flow origin and the latter two support aqueous flood origin, CLF is a key morphology.

Some of CLF are known to have peculiar morphology. They have double cone structure (Double Cone Feature, DCF). From outside to center there exist 4 concentric features. Inside caldera-like depression surrounded by low rise rim main cone stands. At the top of the cone vent-like depression exists. In side depression another small cone rises. At the top of this cone a small pit exists. We focus on this morphology and investigate its spatial distribution and measure morphological parameters such as diameters and height by using HiRISE high resolution images. As for the estimate of height footprint of MOLA is so sparse compared to the size of DCF (mostly less than 200 m) photoclinometry is adapted. As for the distribution DCF is preferentially clustered in the area closer to Cerberus Fossae than normal CLF (single cone like feature). This indicates multiple passage of hot lava flows by using the same route. This may give rise to successive eruptions and later event should be smaller in magnitude because of exhaustion of water. Double cone structure is thus consistent with rootless cone activity while it is difficult to form by pingo/mud volcano.

Keywords: Mars, Magmatism, Central Elysium Planitia, rootless cone, magma/ice interaction

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High resolution characterization of martian surface in terms of slope/roughness

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By recent observations by high resolution images about martian surface various types of the surface are known to be systematically correlated with latitude, which is called as latitude-dependent morphology. They are interpreted as products of climatic control which is induced by variation of the obliquity. The basic type is mantling of dust-ice mixture which has smoother surface than the original surface of mostly aeolian erosion control.

In this presentation we report high resolution estimates of surface roughness/slopes corresponding to various types of latitude-dependent morphology with intention to provide data for future rover exploration.The basic method is photoclinometry applied to HiRISE data to estimate m-scale roughness. Kirk et al(JGR 113,2008) have already conducted m-scal topographic mapping for the survey of Phoenix landing site Our aim is to construct basic data base for roughness/slope statistics of m-scale of typical surface types. Since the coverage of HiRISE image is limited we measured roughness by MOC and THEMIS-VIS data at coarser length scales. We combined fine scale(m-length scale) roughness spectrum and coarse scale(10-20 m) spectrum to a consistent spectrum. In combination to conventional photoclinometry approach we used thermal infrared images to estimate roughness. Bandfield et al (Icarus 193,2008) reported thermal infrared response of the surface irradiated by insolation is controlled by local roughness and a possibility to estimate subpixel scale roughness. We followed this approach.

We selected several test fields where four different types of images(HiRISE,MOC,THEMIS-VIS and THEMIS-IR) are available on the same target. They are west of Scaparelli crater, Amazonis Planitia and Eastern part of Utopia Planitia.

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Development of the Martian upper thermosphere and exosphere DSMC model

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Although the exosphere is traditionally modeled by Chamberlain approach, recently they are often calculated by using the direct simulation Monte Carlo (DSMC) method. Chamberlain theory, which is based on the Liouville theory, calculates the exospheric densities and velocity distributions using exobase (Kn ˜ 1) conditions as boundary conditions on the assumption that collisions are negligible above the exobase, collisions maintain a complete Maxwellian distribution below the exobase, exobase parameters are uniform over a spherical exobase, and the exosphere is spherically symmetric. Around the exobase, however, there exists a transitional domain (between collision and collisionless domains) where the collision frequency is not high enough to maintain equilibrium in the flow but the momentum exchange in a collision between atmospheric molecules is still important. Moreover the exosphere is not spherical symmetric due to non-uniform exobase parameters.

In the transitional regime, where the Knudsen number region between 0.01 and 10, neither a continuum nor a free molecule assumption would be appropriate. The DSMC method is a standard numerical method for solving such a rarefied gas flow. In the DSMC method, the flow is represented by the positions and velocity component of many simulated particles, which obey the underlying physical law governing real flow. Its solutions converge to Boltzmann equation solutions in the limit of infinite number of simulated particles, and vanishing cell size and t. Chemical reacting and polyatomic gases, which are hard to deal with by the direct solution of the Boltzmann equation, can be analyzed by the method.

We have been developing a model for the Martian upper thermosphere and exosphere using the multi-species DSMC method. In this paper, we will show the initial results.