CHARACTERISTICS OF DUST DEVILS IN TWO PRE-SELECTED LANDING REGIONS OF THE TIANWEN-1 MISSION – COMPARING OBSERVATIONS AND PREDICTIONS BY NUMERICAL MODEL

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Abstract:

The spatial and temporal distribution of dust devils (DDs) in two pre-selected landing regions (ZA and ZB, Figure 1) of the Tianwen-1 mission in southern Utopia Planitia have been investigated by using images from the Context Camera (CTX) of the Mars Reconnaissance Orbiter (MRO). From the images of the regions in 8 Martian years, no DD was found in ZA while 77 DDs were found in ZB. The observed DDs are mainly distributed in the northeastern part of ZB. The temporal variation of the observed DDs shows a prominent two-peak pattern in their local early spring and late summer (Figure 2). The size and height of the observed DDs have also been evaluated from the images, and they show a similar temporal variation as the occurrence.

These patterns are also supported by the results of the numerical simulations with the Mars climate model MarsWRF model. Some questions have been put forward based on the observational results. For instance, why DDs are more in ZB compared with ZA? Why there are two peaks for the occurrence of DDs in the temporal distribution? What are the possible factors which determine the spatial distribution of DDs in ZA and ZB (e.g., DDs are mainly in the northeastern part of ZB)? To investigate the possible conditions pertinent to these observed patterns of DD distribution, some analysis based on the thermodynamic theory of heat engine was performed using the output of MarsWRF.

DDs are mainly concentrated in the first half of the year and there are more DDs in ZB than that in ZA (Figure 2). The analysis for simulated results suggests that the difference in dust lifting by DDs (DLIF) between ZA and ZB is mainly dominated by the difference in sensible heat flux, which is mainly caused by the surface-to-air temperature difference. Thermal efficiency plays a relatively minor role. Furthermore, ZB has a stronger net short wave radiative flux at the surface due to the lower albedo (~ 0.205) at the surface than ZA (~ 0.229). Overall, the results of the analysis suggest that more DDs in ZB are mainly caused by the lower albedo in ZB.

Both the observed and predicted DDs have a two-peak feature in their local early spring and late summer, and are generally coincident with the time of maximum solar radiation in their local time. This suggests that the temporal variation of solar radiation due to the revolution of Mars is primarily responsible for the two-peak pattern of temporal distribution.

The spatial distributions of DDs both in ZA and ZB are mainly related to the distribution of sensible heat flux and surface-to-air temperature difference. In ZA, solar radiation at surface dominates the spatial distribution of sensible heat flux, thus causing the particular spatial distribution of DLIF. In ZB, our results suggest that the spatial distribution of surface-to-air temperature difference and sensible heat flux are mainly determined by the albedo, and so the resulting DLIF is concentrated in the northwest. The surrounding topography has little effect on the distribution of the predicted DDs. In the southeast corner of ZB, the surface-to-air temperature difference is relatively small which is not favorable for the occurrence of DDs.

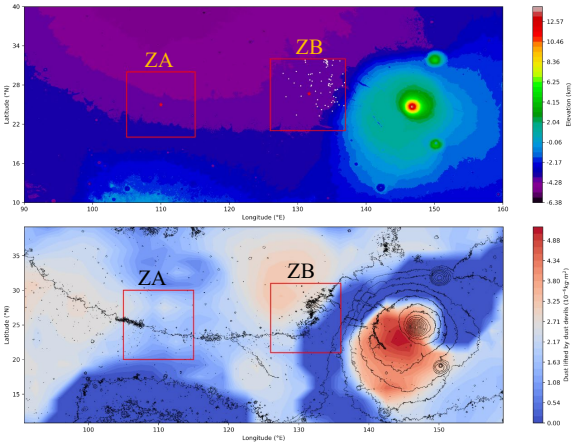

Figure 1. (Top) Topography (contour) and spatial distribution of DDs (white dots) from observations in Zone A and zone B (Red boxes). (Bottom) Dust lifted by dust devils (shading) from MarsWRF.

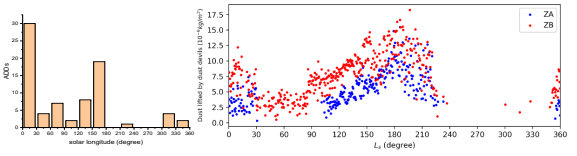

Figure 2. Time series of the number of DDs from CTX images in the study area (left), and total daily dust lifting by dust devils (DLIF) averaged in ZA (blue dots) and ZB (red dots)(right).