REGIONALITY OF DUST HAZE TRANSPORT IN THE MARS ATMOSPHERE REVEALED BY ENSEMBLE SIMULATIONS. K. Ogohara[1], [1]University of Shiga Prefecture (2500, Hassaka, Hikone, Shiga, Japan, ogohara.k@e.usp.ac.jp).

Introduction: Dust is the major source of the solar heating in the Martian atmosphere and then drives the circulation of dust itself. Dust events (dust storms, dust devils and dust haze) are disasters in the Mars atmosphere near the surface because they can generate strong winds and block sunlight almost completely. Statistics of dust events have been studied by analyzing atmospheric temperature, dust optical depth and visible images observed by successive orbiters, landers and rovers. Active areas of local dust storms, including curvilinear and textured storms have been identified observationally ([1, 2, 3, 4]). The tendency of such small scale dust events should be affected by the large scale atmospheric conditions such as thermal or dynamical stabilities. Activity of regional dust storms has been investigated using the vast number of images observed by MGS/MOC and MARCI/MRO. They tend to break out near the storm zones in the northern mid-latitudes and are probably very linked to baloclinic instability and the fronts ([5, 6]). Although mechanisms of the growth, maintenance and decay of global dust storms have not been well investigated, most of global dust storms started in the southern spring to summer seasons as regional storms were merging with each other.

Questions about the mechanisms of dust storms and haze are as follow:

- Why does a dust storm/haze break out?
- Why does the dust storm/haze expand?

Mechanisms of initiation and maintenance of local dust storms will be understood and categorized into a few types in the near future by statisticalcal studies such as [1, 2, 3, 4]. They can be also inferred from observations and theories of terrestrial dust storms. However, there are local dust storms also in the northern mid-latitudes. Why do not the local storms grow into regional dust storms? Why do not all regional dust storms merge with each other? [7] found five favorable regions for expansion of local dust haze (FRs) and revealed what kind of the atmospheric phenomena controls the dust haze transport around such regions. However, it still remains unclear whether these five FRs are also favorable for dust haze transport climatologically because they performed just a single year calculation. Thus, I identify the climatologically robust FRs in this study by ensemble simulations. If such FRs were found, atmospheric phenomena characteristic of the FRs would govern the dust transport around there.

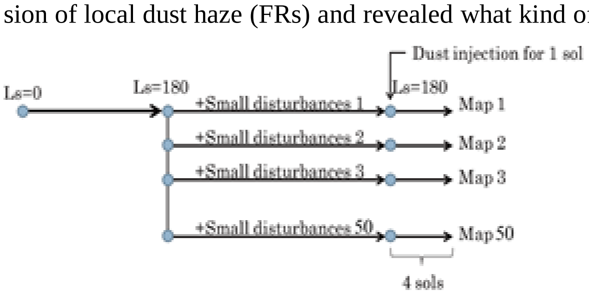

Figure 1 A schematic view of ensemble simulations in this study.

Experiment Description: Each ensemble simulation is performed in the same manner as that by [7]. Although [7] could not separate injected dust from the background dust due to the model architecture, I modify the model in this study so that I can treat the injected and background dust separately. The background dust distribution is set to that used by [8]. As shown in Figure 1, the first spin-up run started from an isothermal (220 K) condition with constant surface pressure (6.4 hPa) and no wind over the entire planet. Fifty kinds of small disturbances are added to the temperature output data of the first spin-up run. The small disturbances of temperature at each σ level are normal random numbers. The standard deviation of the distribution function is 0.01 times of the standard deviation of temperature at the σ level of the first spin-up result. The second spin-up runs are performed for 1 MY from L_s=180 independently using the 50 kinds of the output data of the first spin-up run with small disturbances as the initial data. After these spin-up runs, fifty global maps of dust haze expansion potential are made using the output data from the

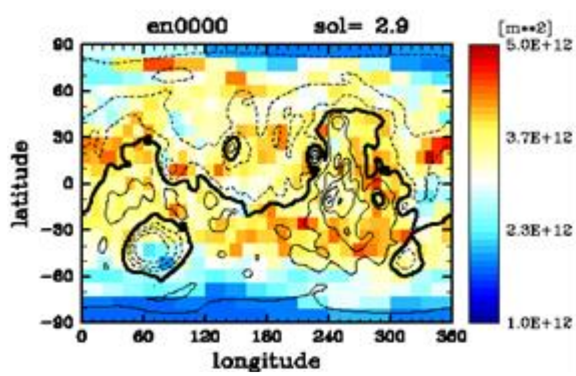

Figure 2 A global map of the dust haze expansion potential on 3 sols after the start of dust haze injection for the control case. The black contours indicate the surface height. The contour interval is 2000 m.

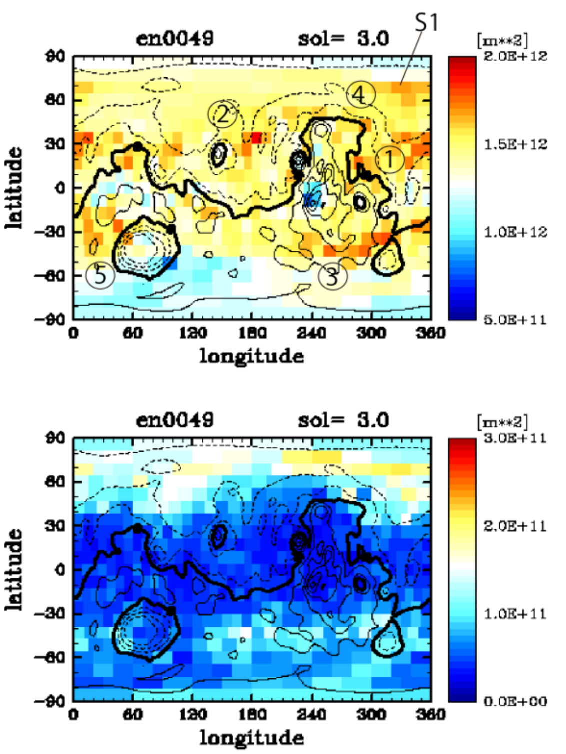

Figure 3 (top) Ensemble means and (bottom) standard deviations in dust haze expansibility among all ensemble members.

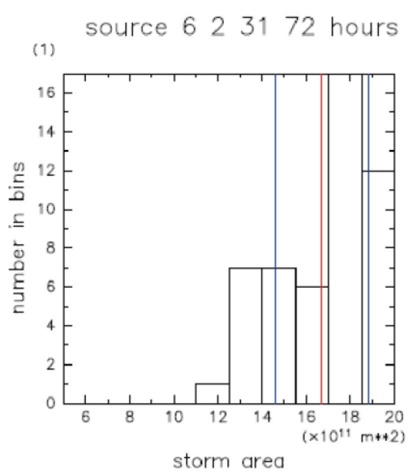

Figure 4 A histogram of the dust haze areas in the case where dust is injected from S1. The red and blue lines indicate the ensemble mean and the ensemble mean ± the ensemble standard deviation, respectively.

50 kinds of the second spin-up runs as the initial data. I also perform a control map produced using the output data from the second spin-up run without the small disturbances. The numbers of hours in a sol and sols in a MY are set to 25 hours and 660 sols.

Results:

A control map: Figure 2 shows a global map of dust haze expansion potential for the control case on 3 sols after the start of dust injection. Each box indicates a location of each dust source. Each color indicates area of a dust haze injected from each dust source, which is defined as an area with the dust optical thickness (visible) of > 0.26. Favorable regions for dust haze expansion are the Arabia, the east of Tharsis, the Sirenum-Aonia region, the east of Elysium Mons and the northern Utopia. Dust haze does not tend to expand easily in high latitudes, the Margaritifer Terra and the Hellas Basin.

Ensemble mean and standard deviation: Figure 3 shows ensemble means and standard deviations of dust expansion potential among the 50 ensemble members. Note that area of a dust haze is redefined as an area with the dust optical thickness of > 0.5. Regions with high averages and low standard deviations of dust expansion potential are (1) the Arabia-Chryse region, (2) the east of Elysium Mons and (5) the Noachis Terra, which are robust favorable regions for dust haze transport. Dust haze around these regions was transported widely into other areas in most of the 50 ensemble members. Therefore, actual regional dust storm initiations around these regions depend on whether a local dust haze with the horizontal scale of <1000 km is initiated or not by the mesoscale and microscale wind systems.

Regions with high averages and modest standard deviations of dust expansion potential are (3) the vast regions from the Daedalia Planum to the Aonia and (4) the Acidalia Planitia.

The two storm tracks in the northern hemisphere, the Utopia and the Acidalia, are not remarkable FRs although these were regarded as the outstanding FRs by [7]. However, dust hazes around these regions were transported widely in some ensemble members as suggested by the result that the standard deviations of expansion potential are relatively large.

Discussions:

Composite structures near the Acidalia storm zone: Figure 4 shows a histogram of the area of dust haze on 3 sols after the start of dust injection in the case where dust is injected from S1 (Figure 3). The dust haze area does not tend to be close to the mean value and is likely to have an extreme value. As shown in Figure 5, a low pressure lies around S1 in the ensemble members where the dust haze expanded in the case of dust injection from S1. Dust was transported extensively probably because the westerly wind is relatively strong on the south of a low pressure. On the other hand, the wave number 1 component in high latitudes is weak and S1 is located on the north of the low pressure of the wave number 2 or 3 components in the case where the dust haze did not expand extensively from S1 (Figure 6). In these cases, dust haze expansion is relatively suppressed since the westerly wind is weakened around the dust source.

Summary: I have detected the climatologically robust FRs by ensemble simulations with 50 members. The robust favorable regions for dust haze expansion are 1) the Arabia-Chryse Terra, 2) the east of the Elysium Mons and 3) the Noachis Terra. I will show that 2) of these three FRs is a truly robust FR, which has been clarified by additional ensemble simulations. The dust expansibility of dust around the other FRs depends on local time of the start of dust injection. Therefore, some FRs migrate longitudinally and then are associated with thermal tides and the amount of dust accumulated during the night. Dust transport around the east of the Elysium Mons, a truly robust FR, results from large scale stationary waves as pointed by [7]

The vast regions from the Daedalia to the Aonia and the Acidalia Planitia become FRs in some members. Although the northern mid-latitudes, especially the Utopia and the Acidalia, are not outstanding FRs, these regions become FRs in some ensemble members. Therefore, dust haze expansibility in these regions is probably associated with some kinds of large scale waves (e.g. baloclinic waves and planetary Rossby wave).

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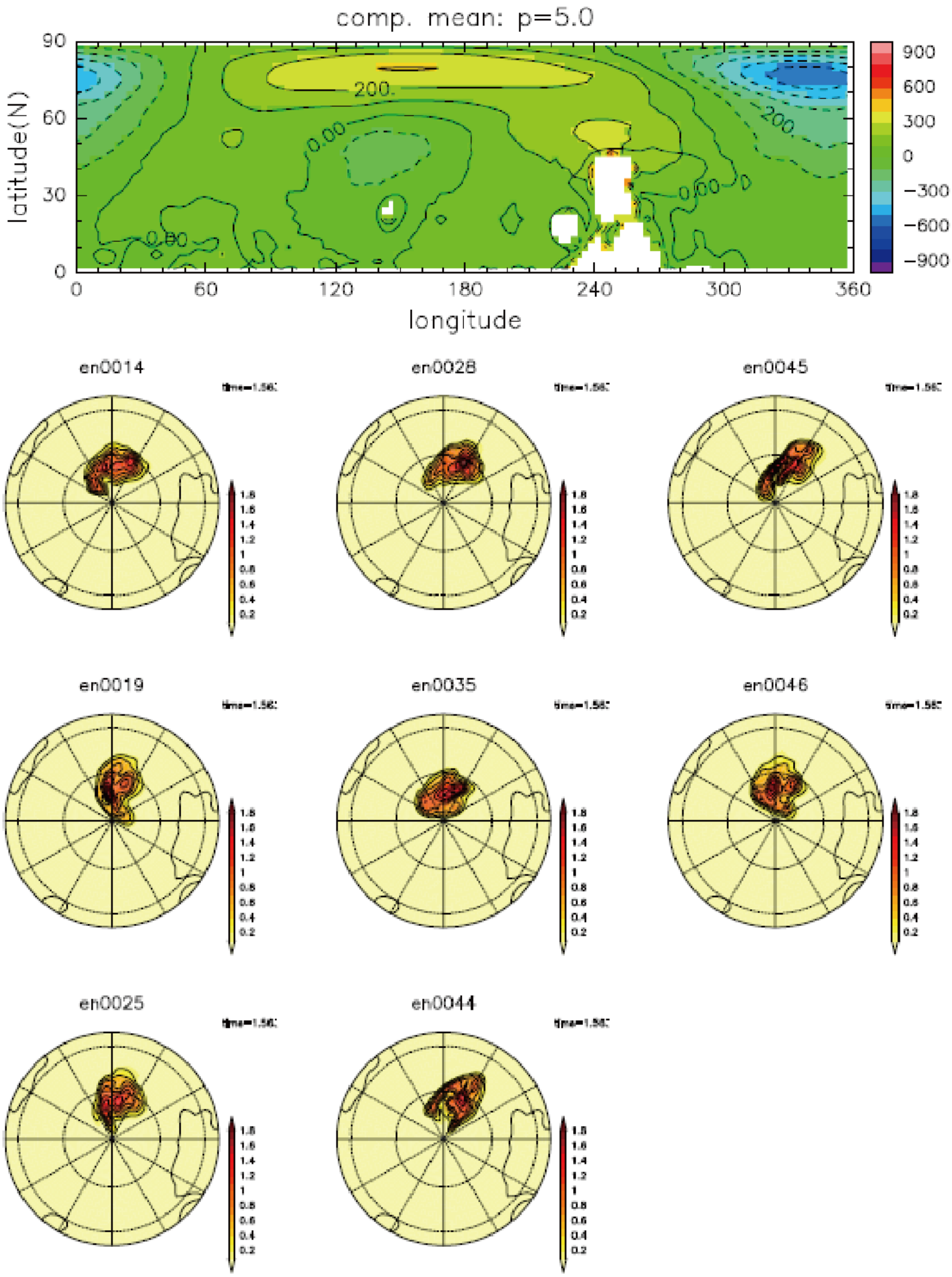

Figure 5 A composite structure of 5 hPa geopotential height in the control cases among ensemble members where area of dust haze injected from S1 becomes larger than (the ensemble mean + the ensemble standard deviation) of dust haze area. This composite structure is the time average for the first sol of the simulations. Horizontal distributions of dust optical depth of these members on 48 hours after the start of dust injection are also shown.

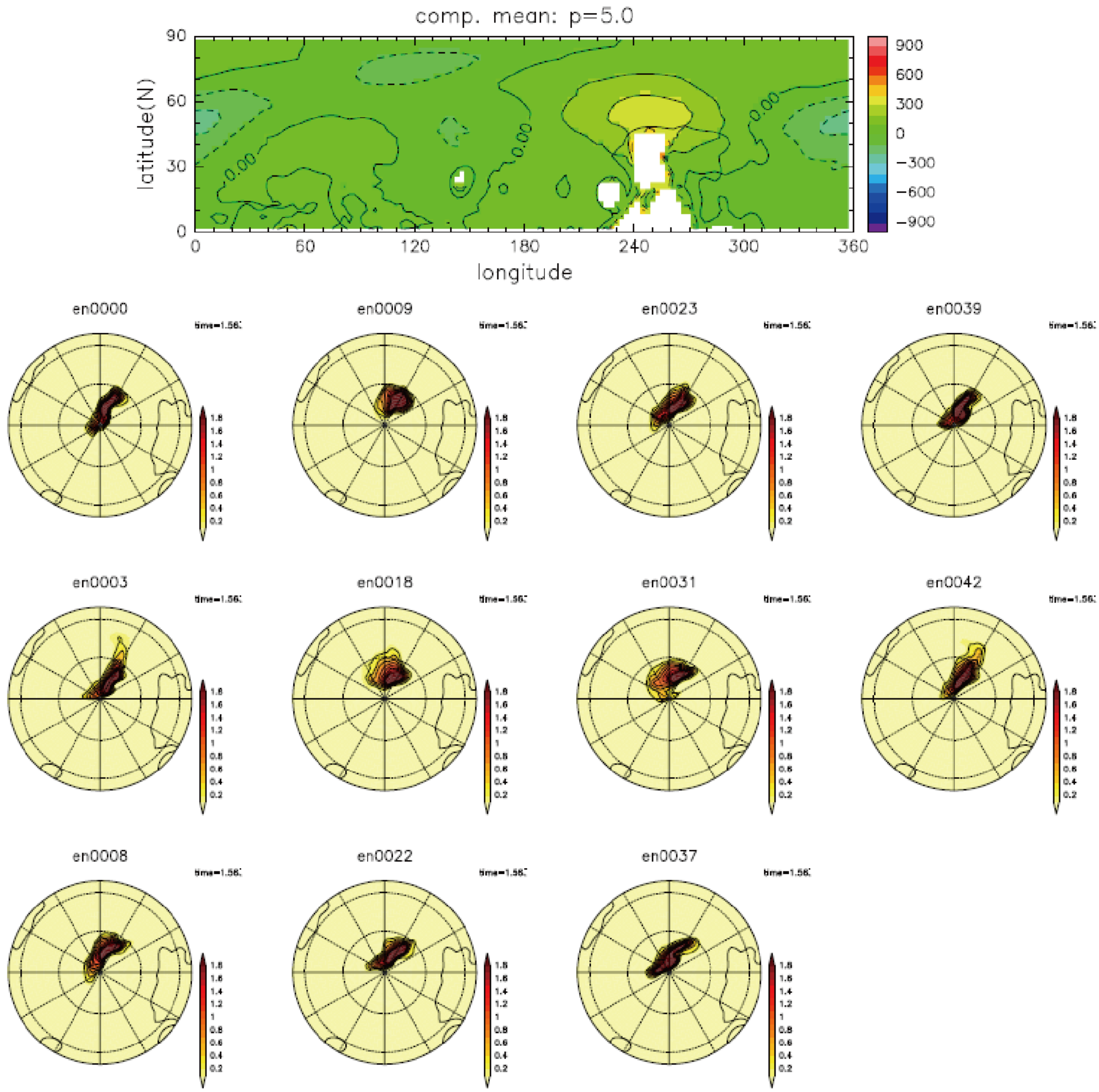

Figure 6 The same figure of as Figure 5 except for the ensemble members. They are ensemble members where area of dust haze injected from S1 becomes smaller than (the ensemble mean - the ensemble standard deviation) of dust haze area.