Favorable regions for dust storm expansion on Mars

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1. Idea

Centers of regional dust storms do not always lie close to areas where many local dust storms occur.

Are there favorable regions (FRs) for dust storm expansion?

I try to understand expansion processes of dust storms by detecting **favorable regions (FRs)** for dust storm expansion and considering why dust storms tend to expand there.
This study shows the first results.

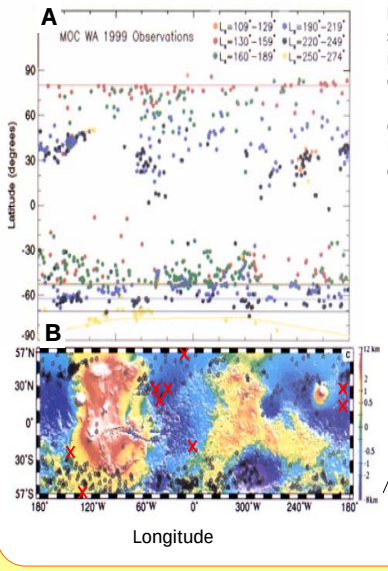
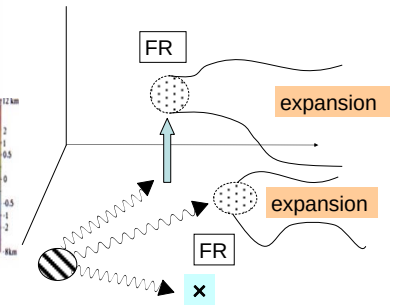


Fig 1. (A) Spatial distribution of local dust storms (Cantor et al., 2001). Colors of dots indicate seasonal bins when dust storms occurred.
(B) Martian topography and the spatial distribution of local and regional dust storms. Black dots indicate local dust storms and red crosses regional ones.

Fig 2. A schematic view of expansion processes of dust storms I assume.



2. Model, Experiments and **Global map** of dust expansion potential

I perform Martian GCM simulations in which a certain amount of dust is injected from576 sources distributed over the planet and find where injected dust spreads extensively.

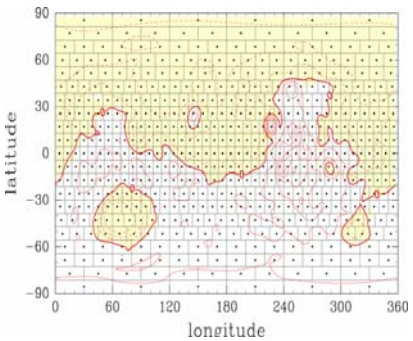


Fig 3. A global distribution of dust sources and Martian topography. Solid lines indicate positive altitudes and dashed lines negative altitudes. Contour interval is 2000[m].

Model — Primitive model on a sphere (sigma) used by Ogohara and Satomura (2008;accepted)

Resolution — T42L32 (21 layers in the ground)

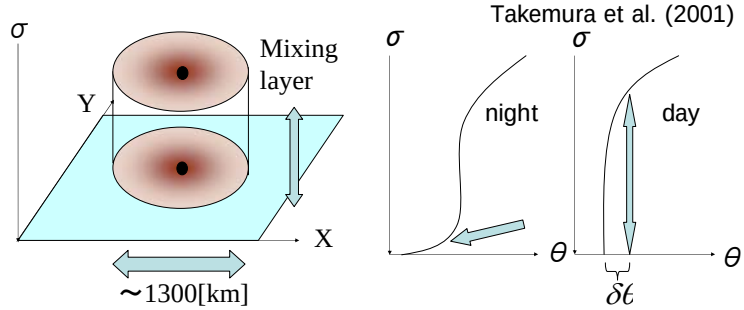


Fig 4. Schematic views of artificial dust injection.

Dust advection

$$\frac{\partial p_s q}{\partial t} = -\frac{1}{a(1-\mu^2)}\frac{\partial (p_s q U)}{\partial \lambda} - \frac{1}{a}\frac{\partial (p_s q V)}{\partial \mu} - \frac{\partial (p_s q \dot{\sigma})}{\partial \sigma} + S_{dust}$$

Dust is advected by winds calculated in the spectral part, following Nair and Machenhauer (2003) and Van Leer (1978).

S_{dust} is a dust source term.

Period of dust injection : 1 sol

Total mass of injected dust : 2.0×10^5[kg/s]x 86400[s]

3. Favorable regions for dust storm expansion (Ls=180)

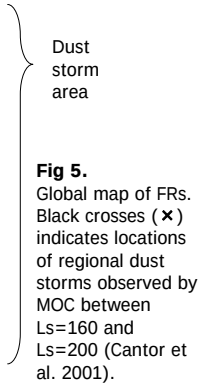


Fig 5. Global map of FRs. Black crosses (×) indicates locations of regional dust storms observed by MOC between Ls=160 and Ls=200 (Cantor et al. 2001).

Area of a dust storm:
We define a region obscured by injected dust as a region where the column dust mass is 0.002 kgm^{-2} larger than that in the control case, or larger. This value, 0.002 kgm^{-2}, corresponds to a dust optical depth (5--11.6 μm) of approximately 0.07.

Note:
A box's color shows the maximum area of the region obscured by dust injected from the dust source for 2 sols after the end of dust injection. Note that it does not indicate the column mass of injected dust inside the colored box.

Favorable regions for dust storm expansion

1. Acidalia Planitia
2. The east of Erysium Mons.
3. Arabia Terra
4. The eastern Tharsis
5. Sirenum—Aonia region

4. Additional Maps

(a) (b)

Fig 6. Additional Maps made to examine the robustness of the result shown in Fig 5.

Figure 6a shows the results 2 sols after the end of dust injection in the case where dust starts to be injected 5 sols after the start of dust injection in the case shown in Fig 5. No significant difference between Fig 5 and 6a appears except for FR in Terra Cimmeria. Figure 6b shows results 2 sols after the end of dust injection in the case where dust starts to be injected 12 hours after the start of dust injection in the case shown in Fig 5. As shown in Fig 6b, no significant difference in the northern mid-latitudes appears between Fig 5 and 6b except for slight differences around 80° E 40° N. However, dust injected around the east of Tharsis Montes and the regions from Terra Sirenum to Aonia Terra does not spread as extensively as in Fig 5.

Diurnal phenomena in these regions are highly important for dust storm expansion.

5. Summary

I perform Martian GCM simulations in which a certain amount of dust is injected from 576 sources distributed over the planet and find where injected dust spreads extensively.

1. Acidalia Planitia
2. The east of Erysium Mons.
3. Arabia Terra
4. The eastern Tharsis
5. Sirenum—Aonia region

? → Baroclinic waves? Stationary waves? Convection? Diurnal tide?

It is necessary to analyze output data precisely.