# Supporting Information for "Assimilation of temperatures and column dust opacities measured by ExoMars TGO-ACS-TIRVIM during the MY34 Global Dust Storm"

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### Text S1: A note about GCM sol numbers and solar longitude $L_s$

In this paper we compare real observations of Mars with model states computed on the LMD Mars GCM grid. It is critical that observation times correspond exactly to the equivalent time in the model. For the LMD Mars GCM, this is complicated because the orbit of Mars around the Sun is slightly different in the GCM than for real Mars. In this "LMD Mars GCM world", two simplifications are made to the orbit and calendar:
(a) Sol 0 (and hence $L_s = 0°$) occurs at midnight at longitude zero. This means that the sol numbers in the GCM do not match the real sol numbers exactly.
(b) The year is exactly 669 sols long, and the sol of periapsis is 485°. Mars' real orbit around the Sun takes 668.6 sols and the sol of periapsis is 485.35°.

When running the model alone, these simplifications do not pose any issues, but we must be careful when comparing GCM times with observation times that use Mars' real orbit. The GCM time variable is sol number defined by (a) and (b) above. Observation times must be converted to the equivalent GCM sol number for accurate comparison. Observations have a $L_s$ and a longitude associated with them, and usually a very precisely known local time of day. We convert the $L_s$ to a sol number using the GCM orbital parameters (Forget et al., 2015). However, because of (a), this sol number is only accurate to the nearest sol. [There are other small errors associated with (b), and due to Mars' orbital parameters not being known to more than five significant figures.] To obtain the decimal sol number, we use the local time of day (local true solar time for the GCM) and its longitude to compute the decimal time of day relative to the start-of-day in the GCM.

In this paper, when we refer to specific observations, we use the $L_s$ value from the observational dataset. The equivalent GCM sol number may be added in brackets for reference. When we refer to model states (GCM output or LETKF analysis) we use the GCM sol number. The equivalent $L_s$ may be added in brackets for reference, using the LMD Mars GCM world orbit for the sol-$L_s$ conversion. Plots that have time on the $x$-axis display $L_s$ on the lower axis when the plot shows observations, and GCM sol number on the lower $x$-axis when the plot shows model/analysis. Both may include a secondary $x$-axis showing the other quantity; this is approximate apart from the extreme values, as the conversion between sol and $L_s$ is nonlinear.

## References

Forget, F., Millour, E., & Lewis, S. R. (2015). *Mars Climate Database v5.1 Detailed Design Document* (Tech. Rep.). Laboratoire de Météorologie Dynamique.

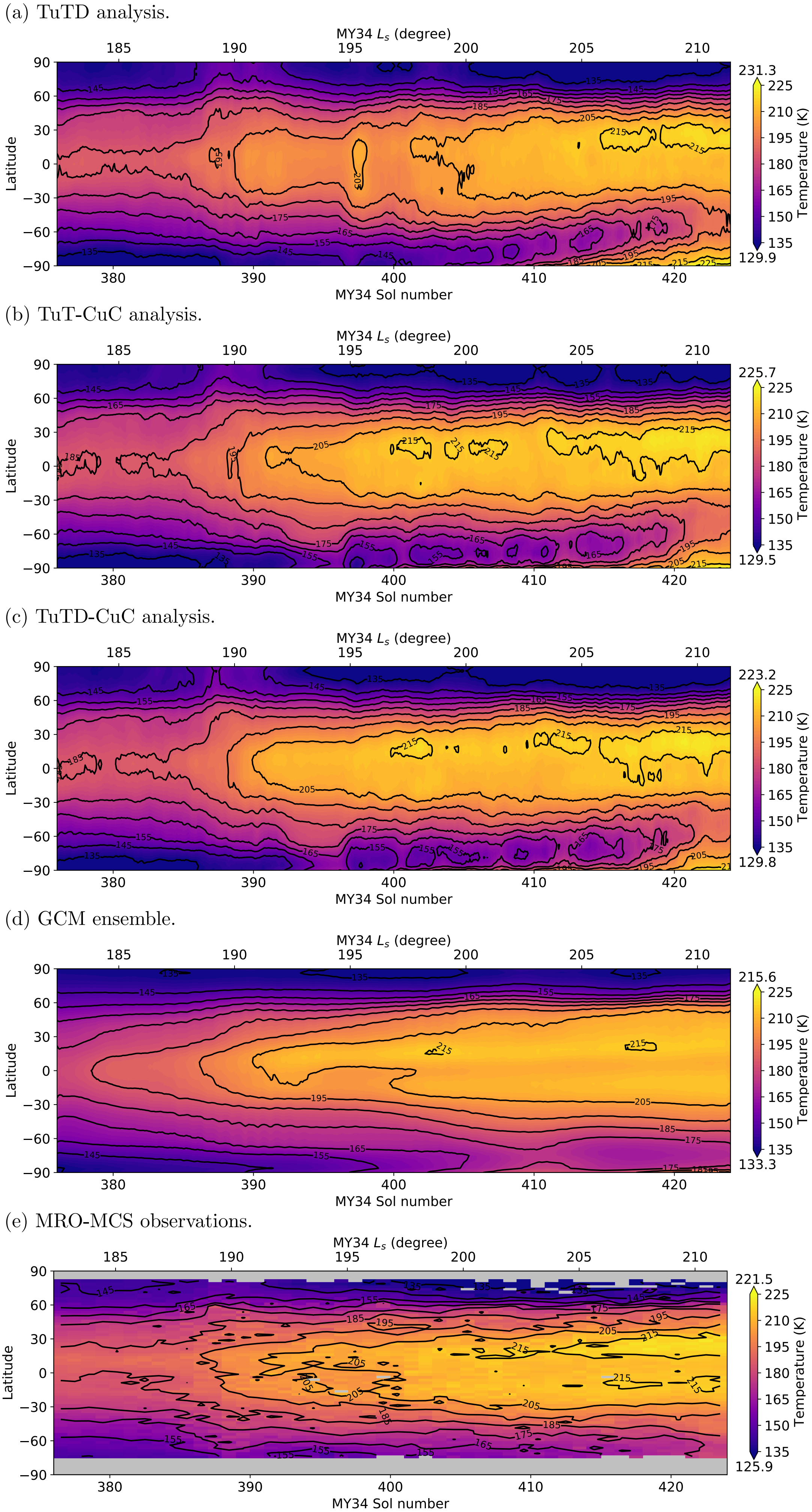
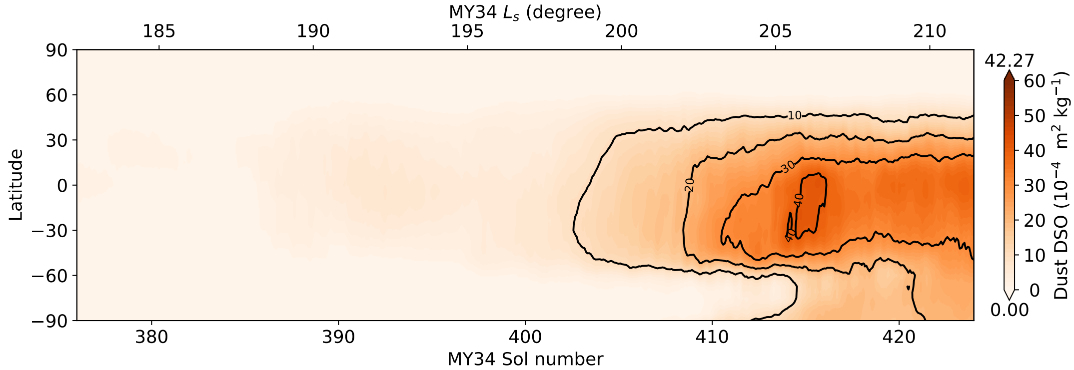
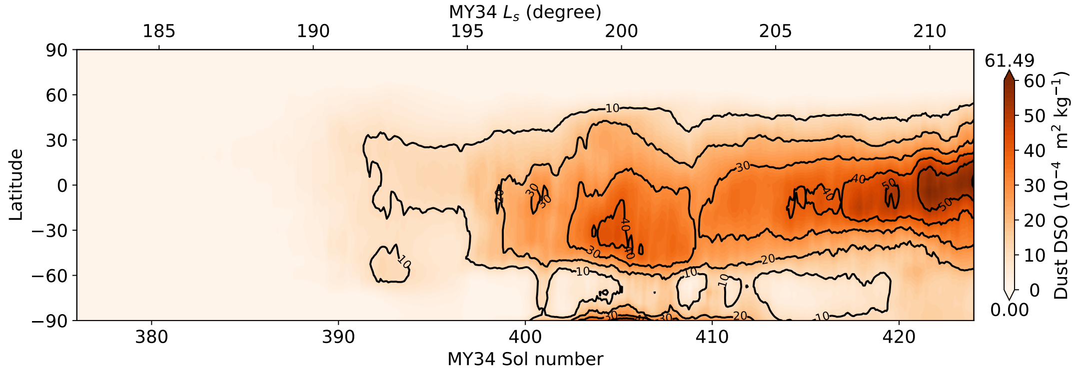



**Figure S1.** As Fig. 11 in the main text, but showing Hovmöller diagrams of temperature at 30 Pa at 3 AM local mean solar time.

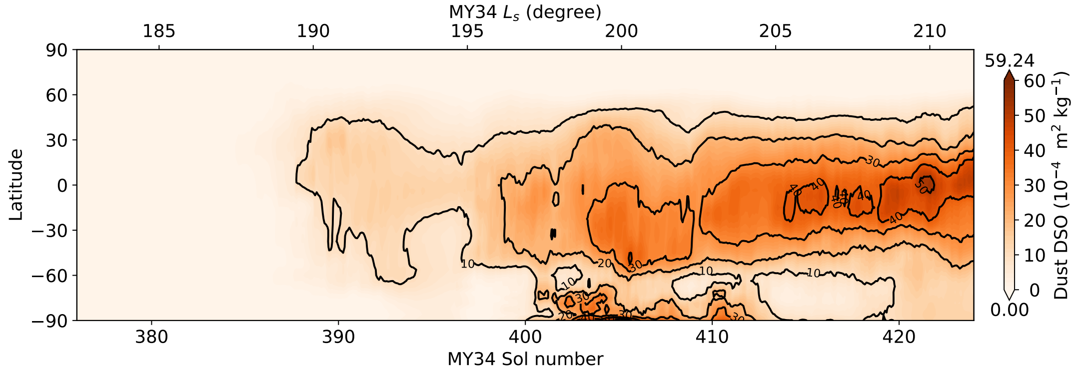
(a) TuTD analysis.



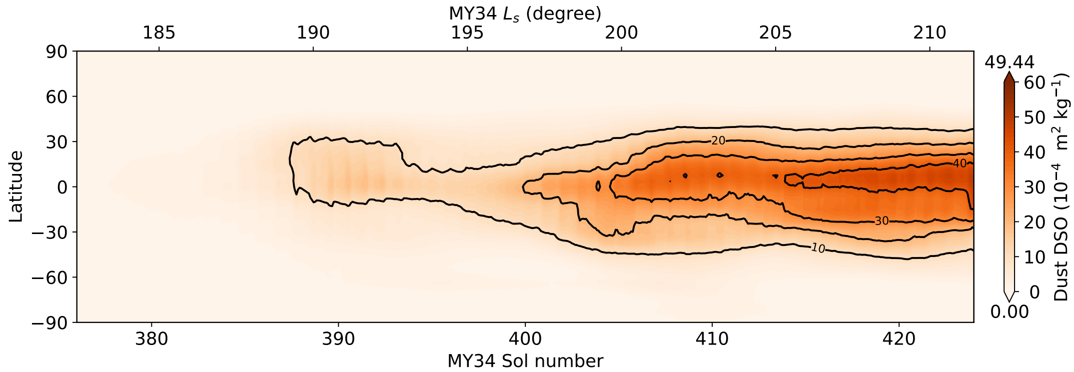

(b) TuT-CuC analysis.




(c) TuTD-CuC analysis.




(d) GCM ensemble.




(e) MRO-MCS observations.

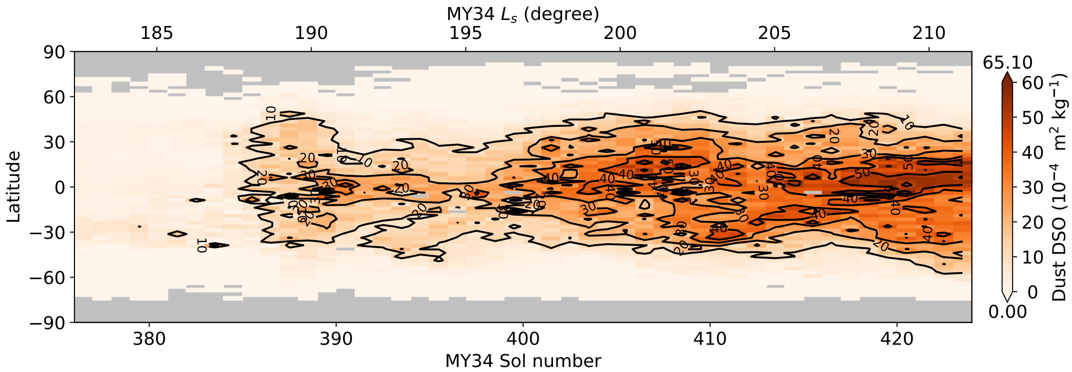



**Figure S2.** As Fig. 12 in the main text, but showing Hovmöller diagrams for dust density-scaled opacity at 30 Pa at 3 AM local mean solar time.

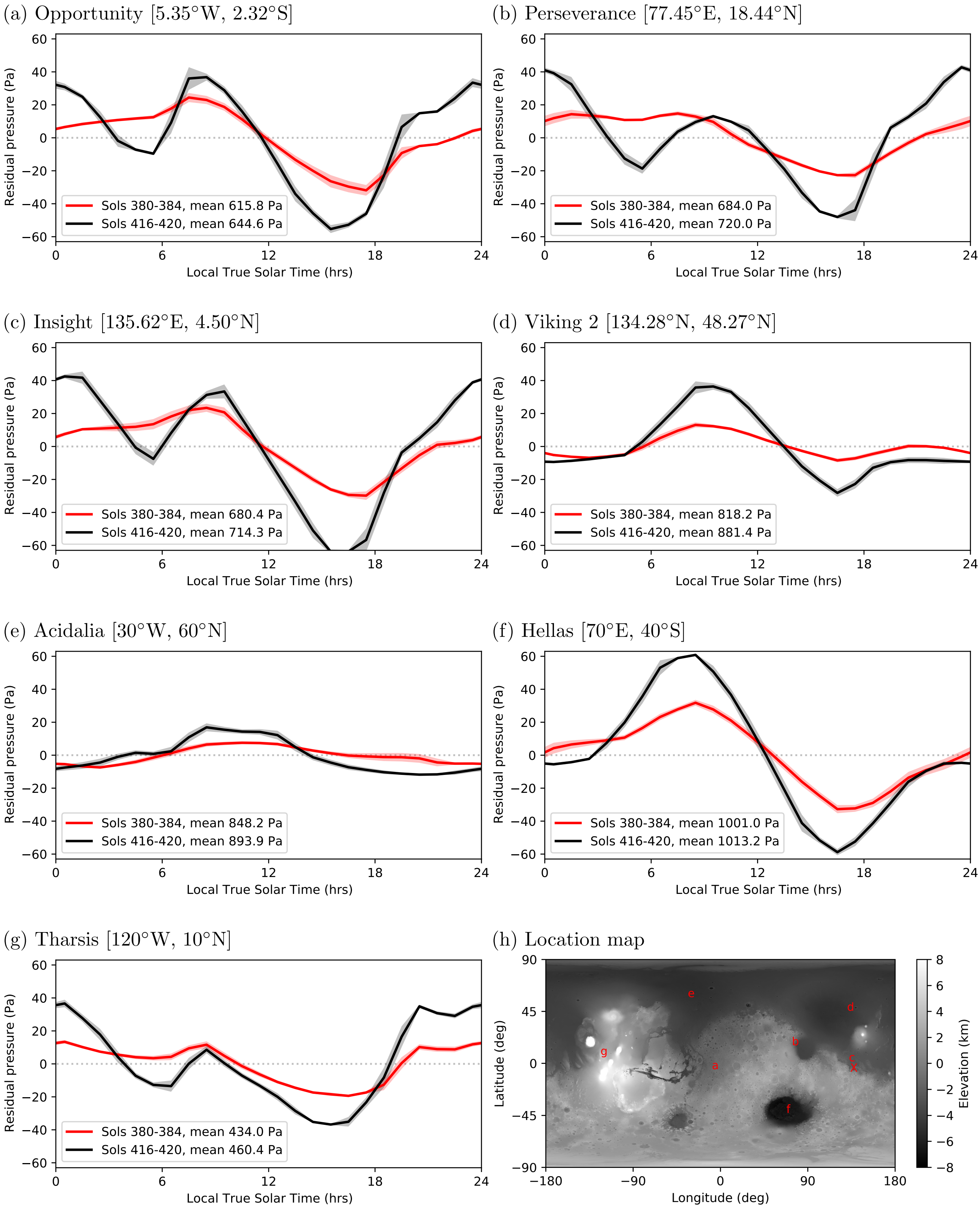



**Figure S3.** As Fig. 22 in the main text, but showing surface pressure diurnal cycles at various locations for the GCM ensemble.