Observations and Analysis of the Mars 2001 Global Dust Storm

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Overview

- Goal: To better understand the dynamical processes involved in the origin, evolution, and decay of the storm

- Datasets include: Mars Orbital Camera (MOC) daily global maps, Thermal Emission Spectrometer (TES), Mars Horizon Sensor Assembly (MHSA).

  Notes: Only a few representative plots are included in this presentation – please see complete animations at: http://humbabe.arc.nasa.gov/~noble/

Comparison of datasets

- MOC, TES, MHSA maps are not true synoptic maps but are mosaics of 12 sun-synchronous swaths stitched together.

- MHSA and TES temperature data are quite consistent with each other, especially regarding the initiation and propagation of the wave one feature which reaches peak amplitude at ~L_s=187°

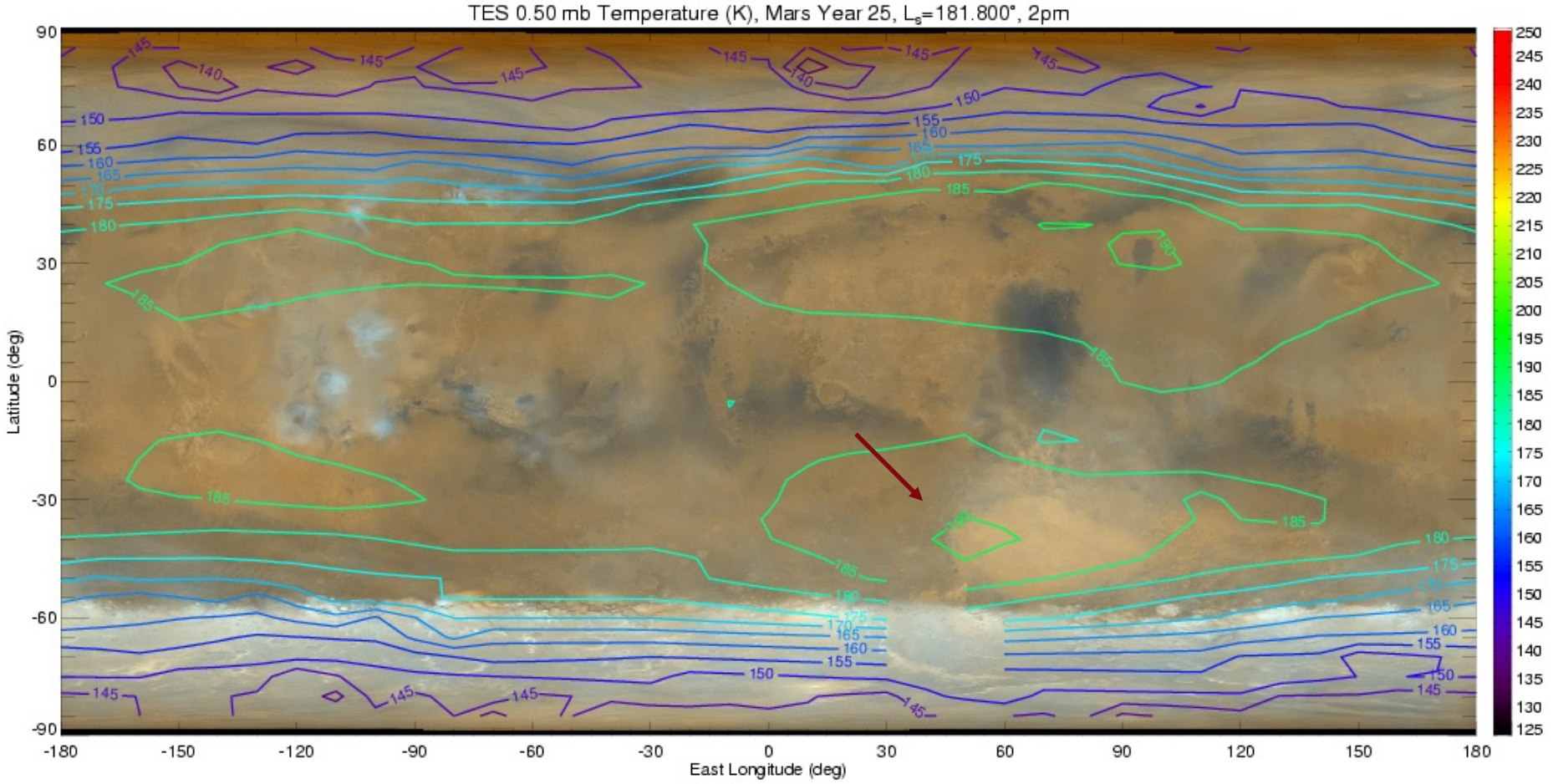
- TES data has a a stronger horizontal temperature gradient than the MHSA data. This is due to the deep weighting function of the MHSA data (averaged over ~10-40 km).

Pre storm activity: L_s=170°–L_s=182°

- At least seven pulses, which came every 2 – 3 sols, led up to initiation of the global dust storm which began in Hellas. (Cantor, 2004)

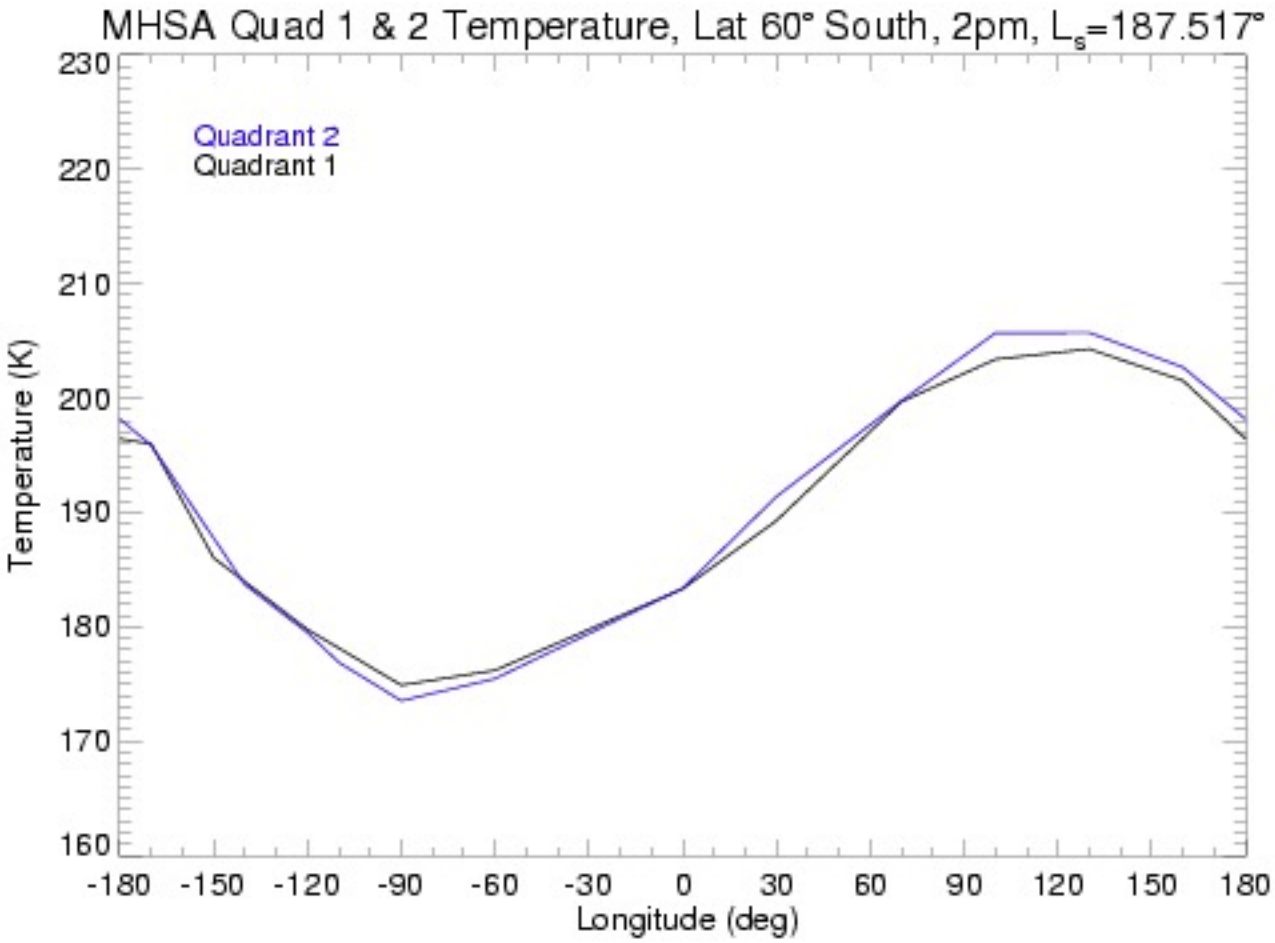
- These pulses may be the signature of traveling baroclinic eddies since this is their typical period.

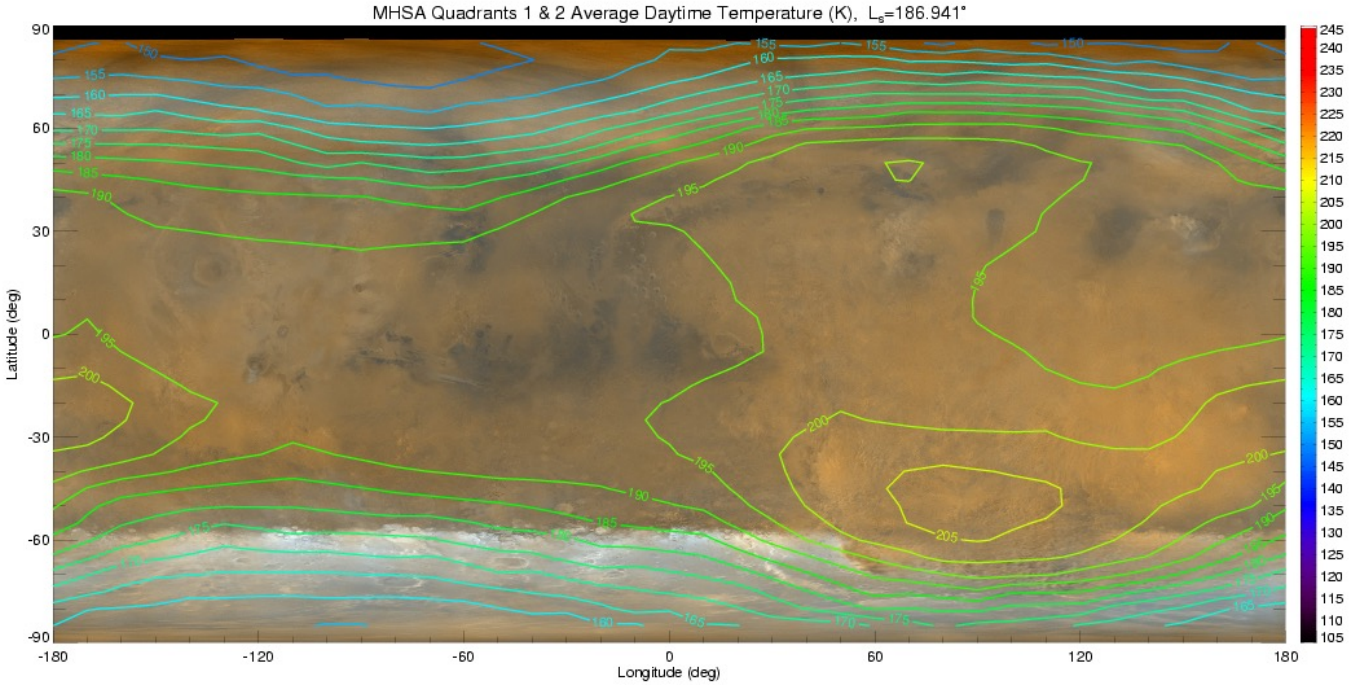
Regional storm on the southwestern rim of Hellas, L_s=181°



Development and propagation of wave one feature: L_s=183°–L_s=190°

- Maximum amplitude occurs at ~ L_s=187°
- 30K - 40K peak to trough temperature change over latitude circle of 60°
- Hemispheric symmetry of both excitation and relaxing back to a more zonally uniform state (happens semi-simultaneously).
- Hemispheric symmetry of the wave one feature may indicate excitation of a global mode.
- Less than 1° of L_s after maximum amplitude, dust lifting begins in the Claritas region.


MHSA Quad 1 & 2 Temperature, Lat 60° South, 2pm, L_s=187.517°
Quadrant 2
Quadrant 1
Temperature (K)
230
220
210
200
190
180
170
160
-180
-150
-120
-90
-60
-30
0
30
60
90
120
150
180
Longitude (deg)


MHSA Quadrants 1 & 2 Average Daytime Temperature (K), L_s=186.941°
Latitude (deg)
Longitude (deg)
90
60
30
0
-30
-60
-90
-180
-120
-60
0
60
120
180
245
240
235
230
225
220
215
210
205
200
195
190
185
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165
160
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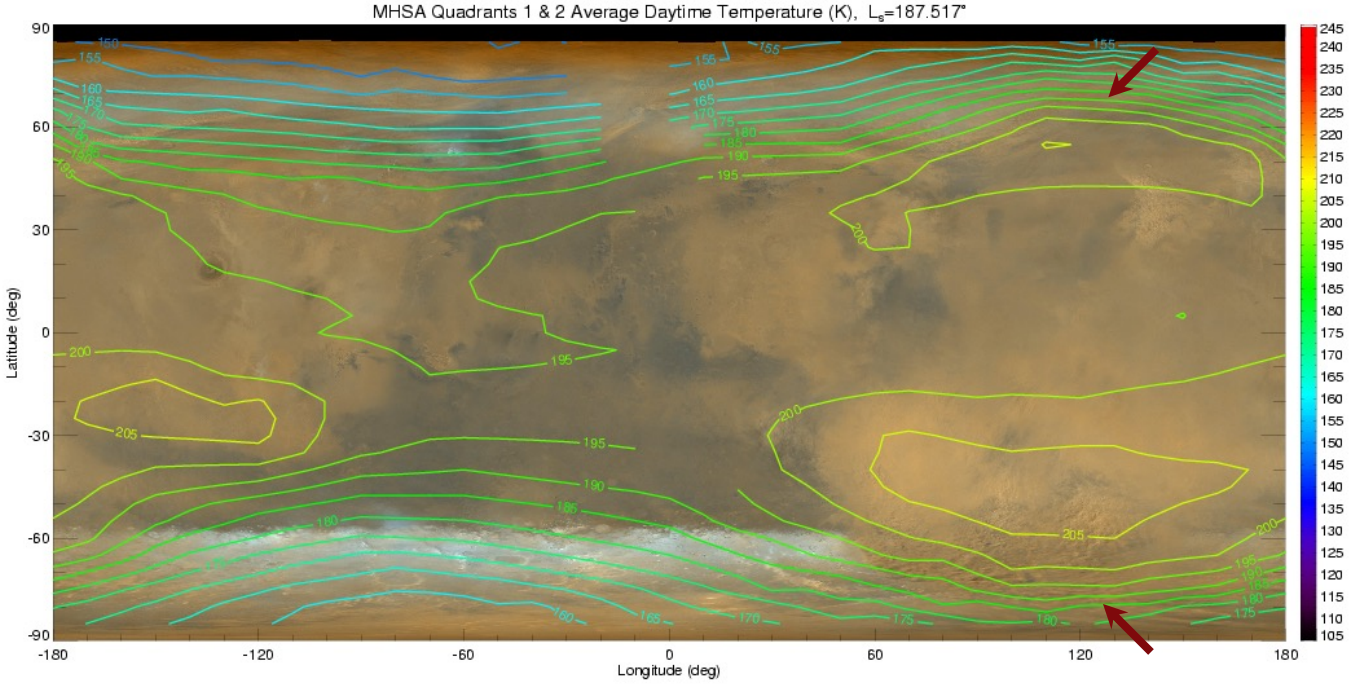
105


MHSA Quadrants 1 & 2 Average Daytime Temperature (K), L_s=187.517°
Latitude (deg)
Longitude (deg)
90
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-30
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-180
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60
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180
245
240
235
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220
215
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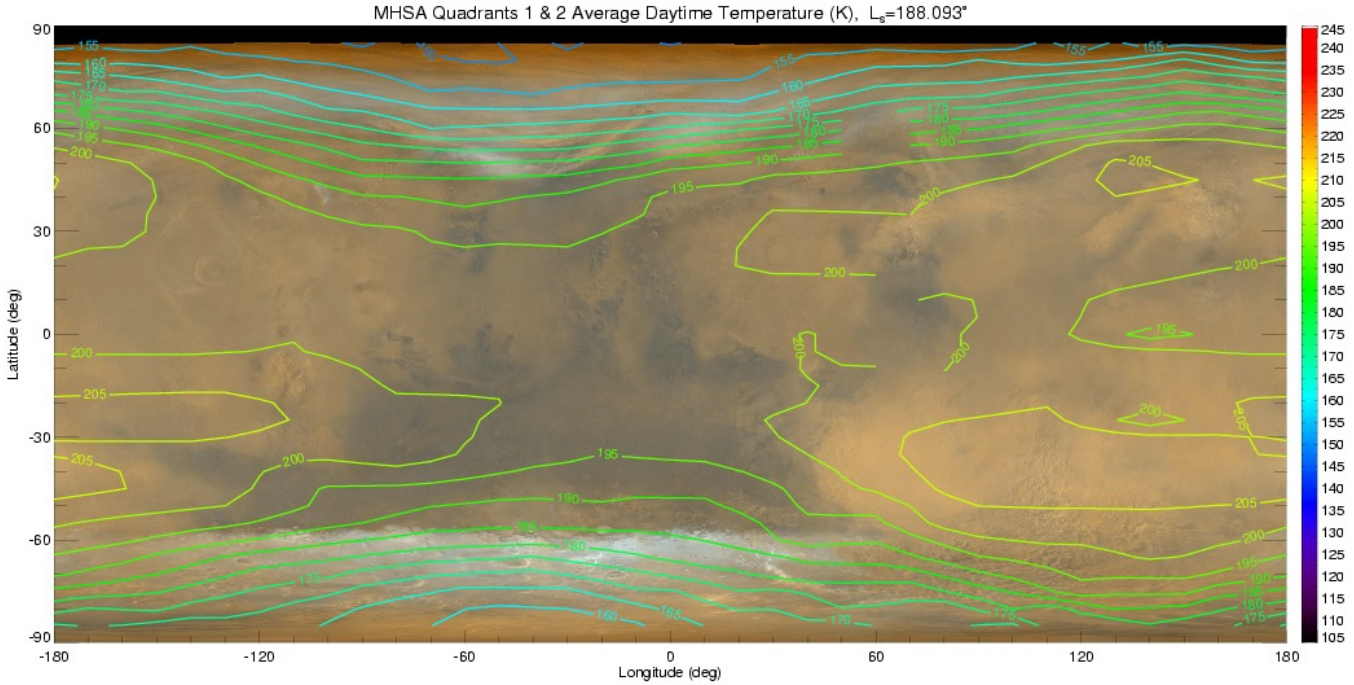
MHSA Quadrants 1 & 2 Average Daytime Temperature (K), L_s=188.093°
Latitude (deg)
Longitude (deg)
90
60
30
0
-30
-60
-90
-180
-120
-60
0
60
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180
245
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220
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210
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200
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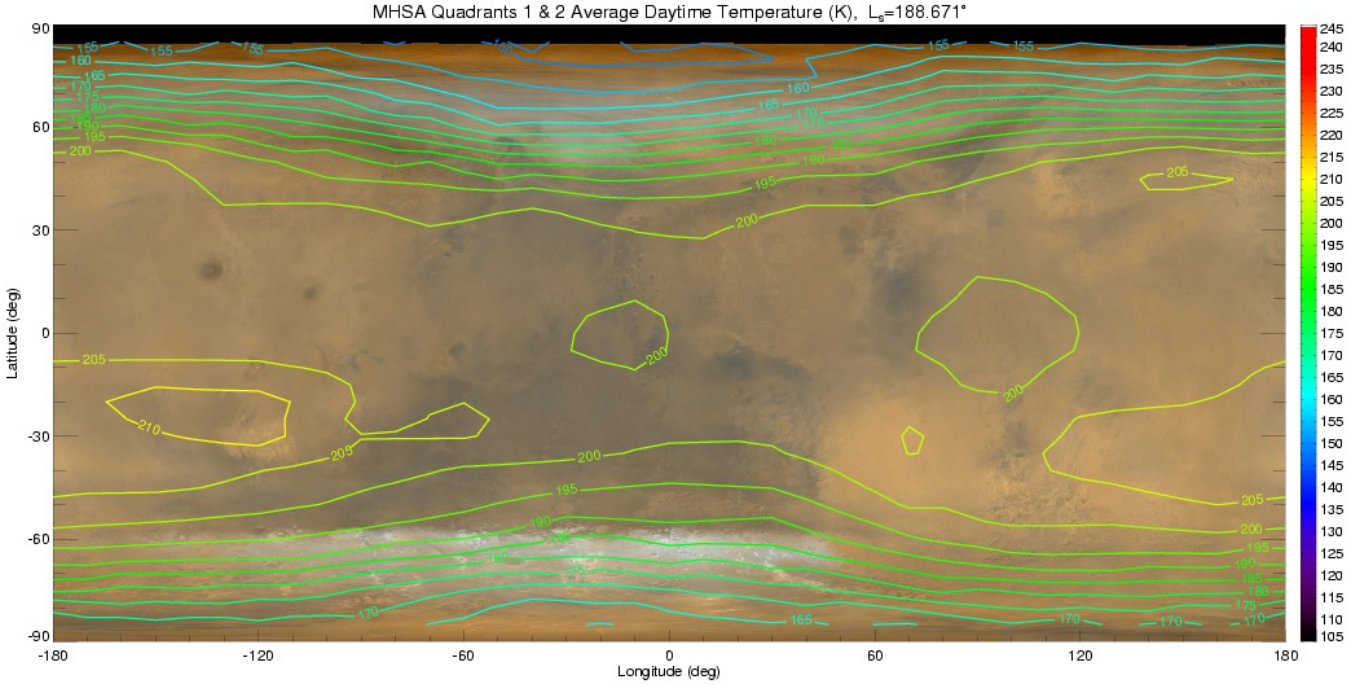
MHSA Quadrants 1 & 2 Average Daytime Temperature (K), L_s=188.671°
Latitude (deg)
Longitude (deg)
90
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-180
-120
-60
0
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245
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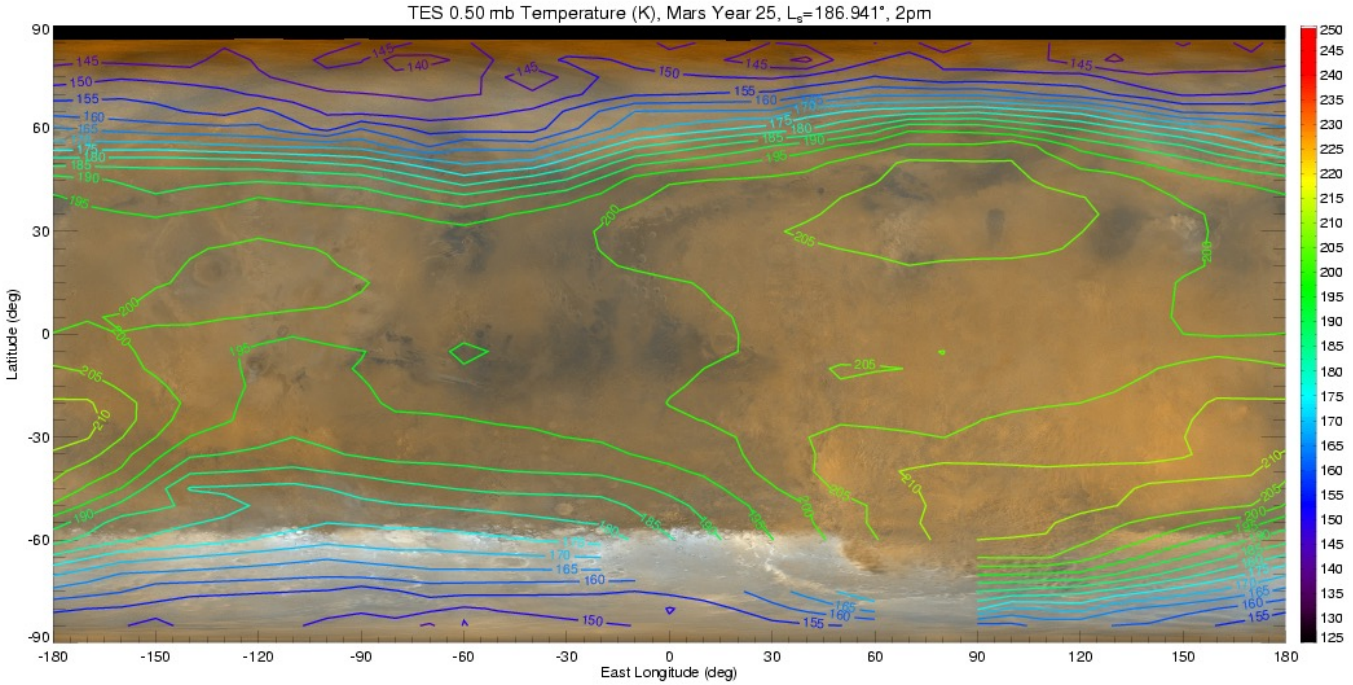
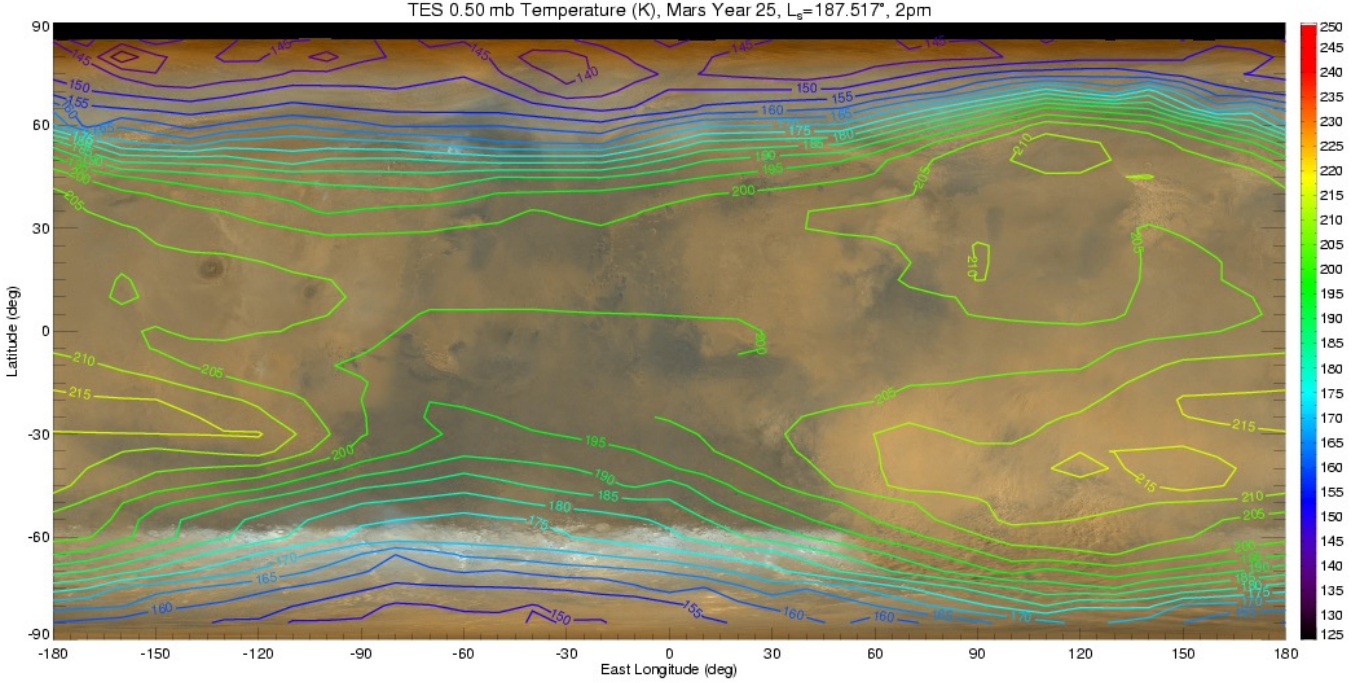
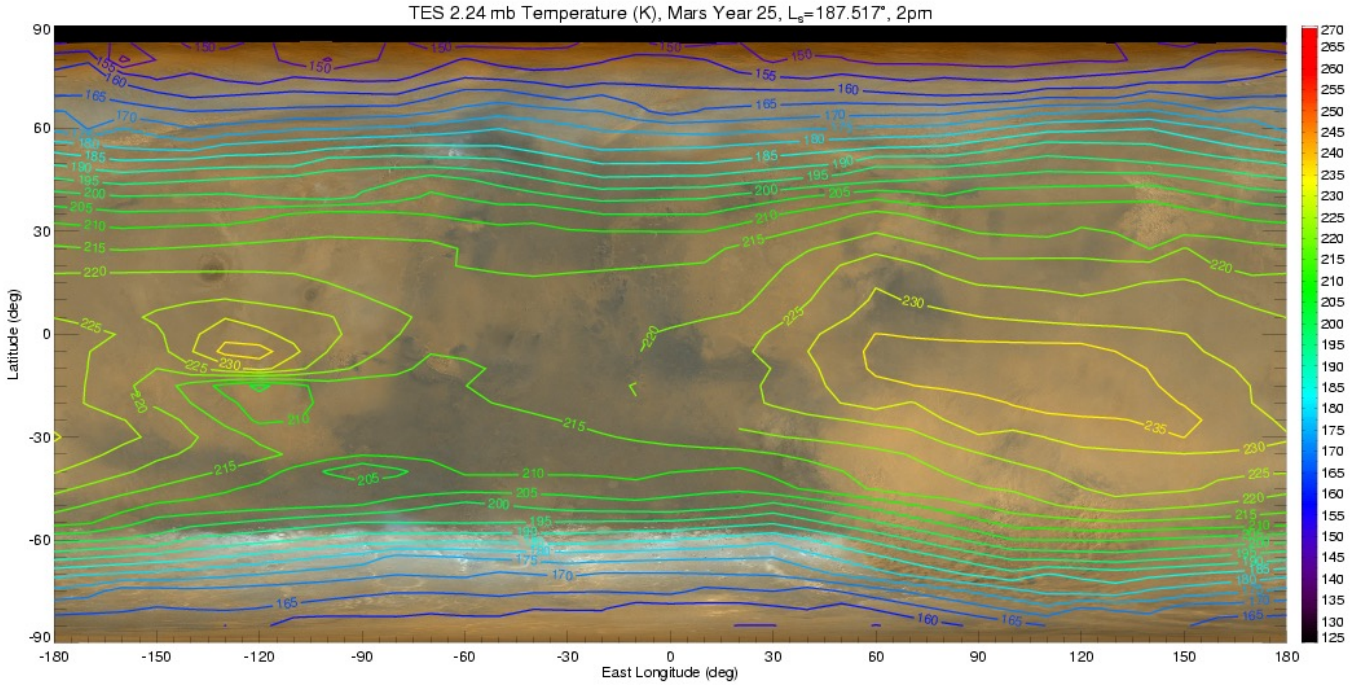
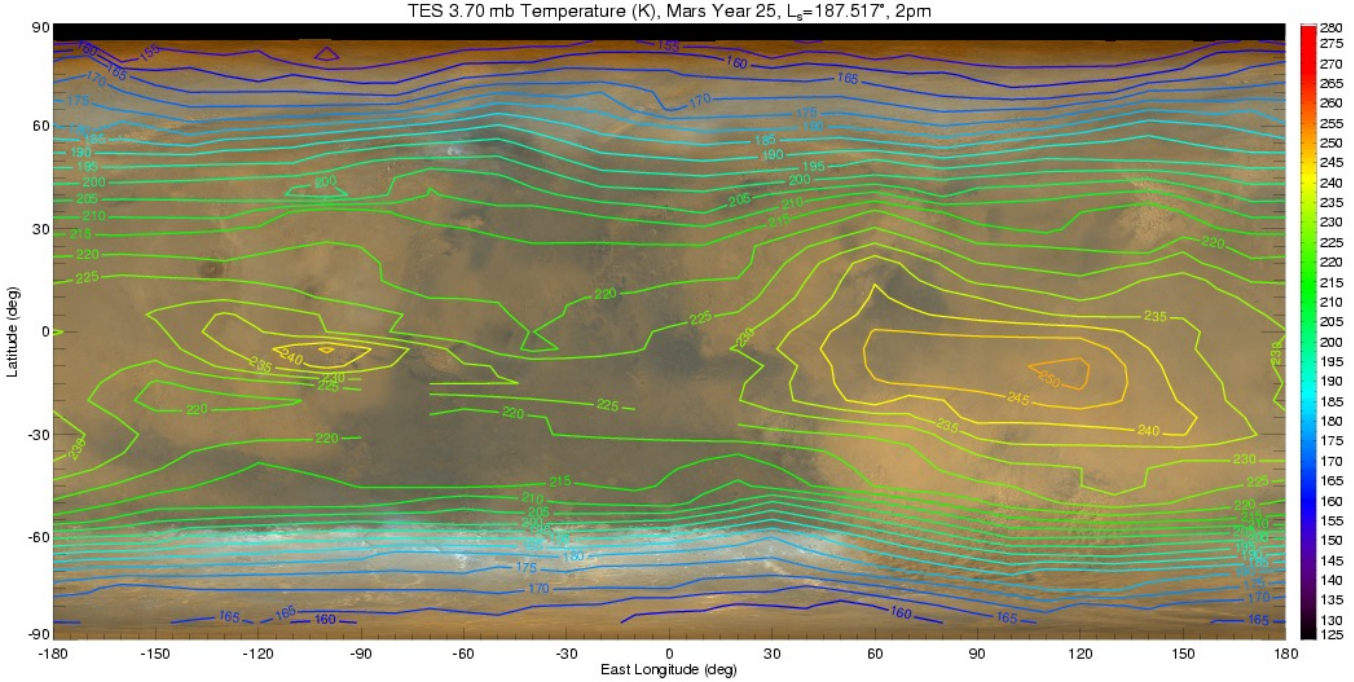
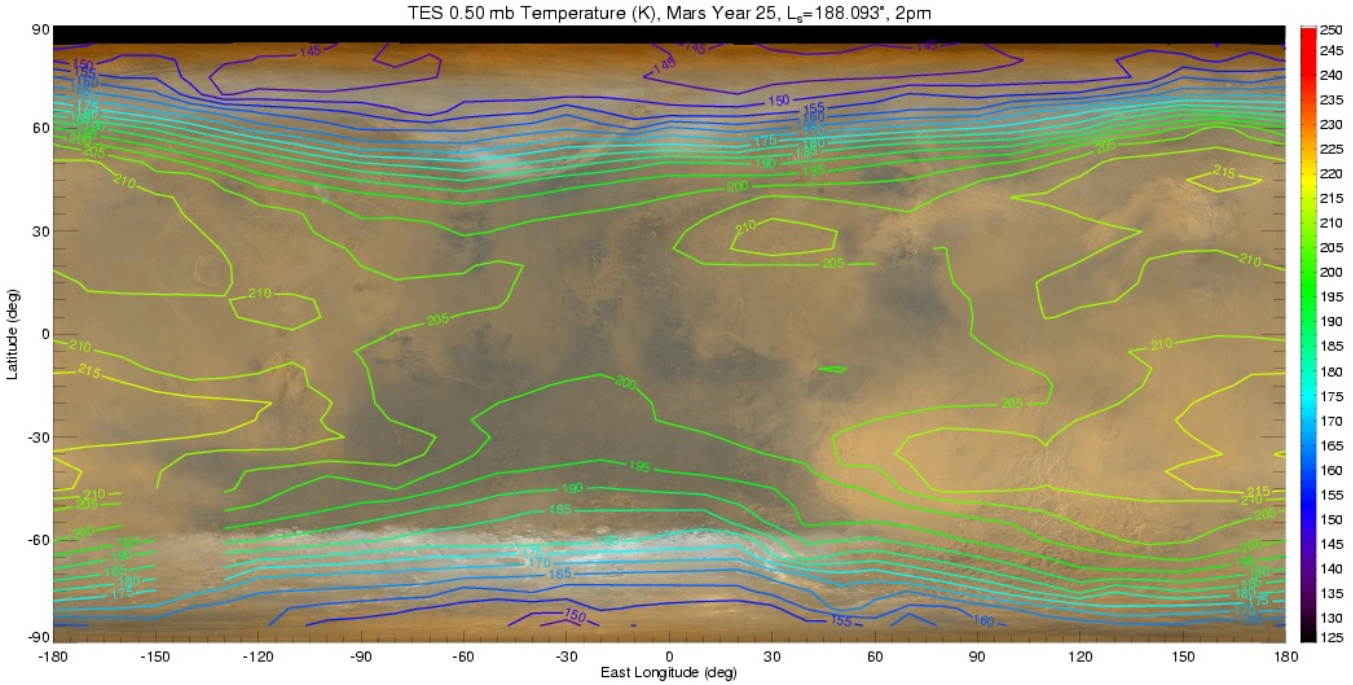
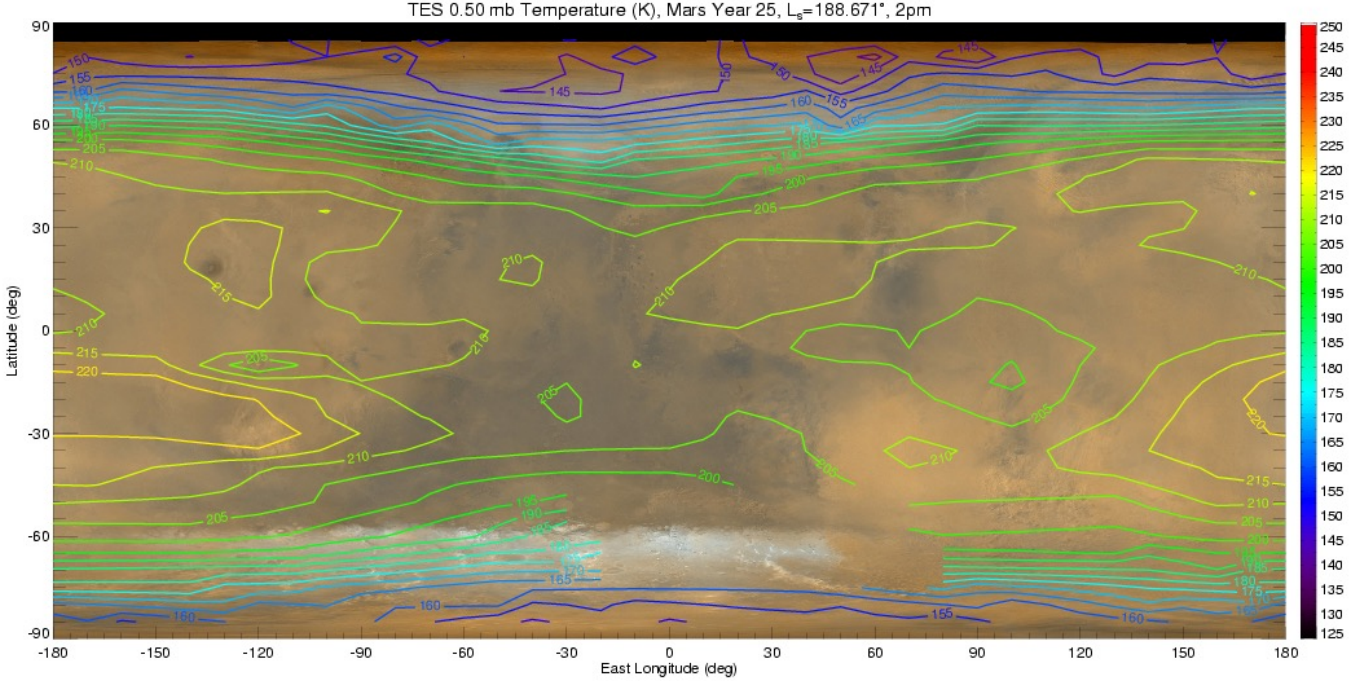

TES 0.50 mb Temperature (K), Mars Year 25, L$_s$=186.941°, 2pm
Latitude (deg)
East Longitude (deg)

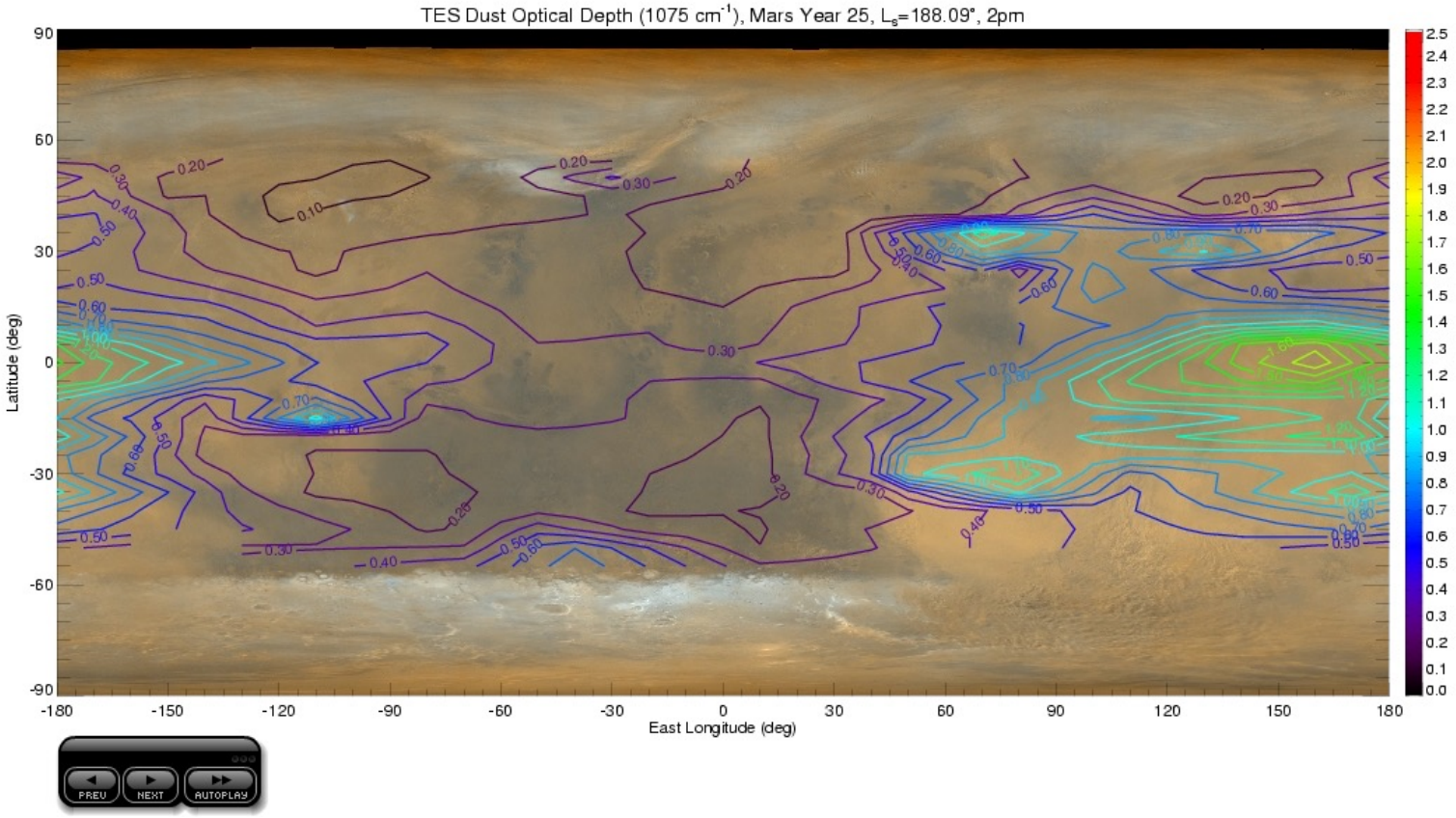

TES 0.50 mb Temperature (K), Mars Year 25, L$_s$=187.517°, 2pm
Latitude (deg)
East Longitude (deg)


TES 2.24 mb Temperature (K), Mars Year 25, L_s=187.517°, 2pm
Latitude (deg)
East Longitude (deg)


TES 3.70 mb Temperature (K), Mars Year 25, L_s=187.517°, 2pm
Latitude (deg)
East Longitude (deg)


TES 0.50 mb Temperature (K), Mars Year 25, L$_s$=188.093°, 2pm
Latitude (deg)
East Longitude (deg)

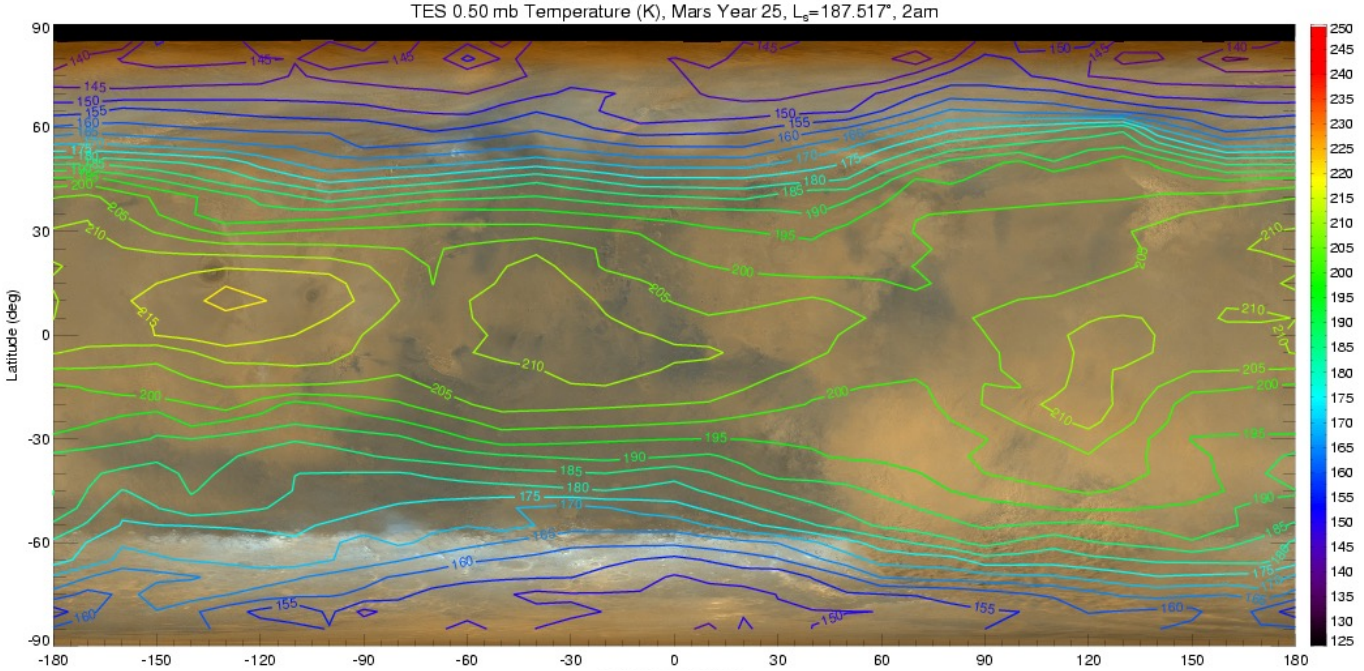

TES 0.50 mb Temperature (K), Mars Year 25, L$_s$=188.671°, 2pm
Latitude (deg)
East Longitude (deg)


TES Dust Optical Depth (1075 cm-1), Mars Year 25, Ls=188.09°, 2pm
Latitude (deg)
East Longitude (deg)
PREV
NEXT
AUTOPLAY

Dynamical processes

- Hemispheric symmetry is quite pronounced. What dynamical processes caused this wave one amplification?

- If it were purely a function of a diurnal tide, then one would expect both peak and trough to shift 180° from 2am to 2pm. Such a shift, however, is not evident in the observations.


TES 0.50 mb Temperature (K), Mars Year 25, L_s=187.517°, 2am
Latitude (deg)
90
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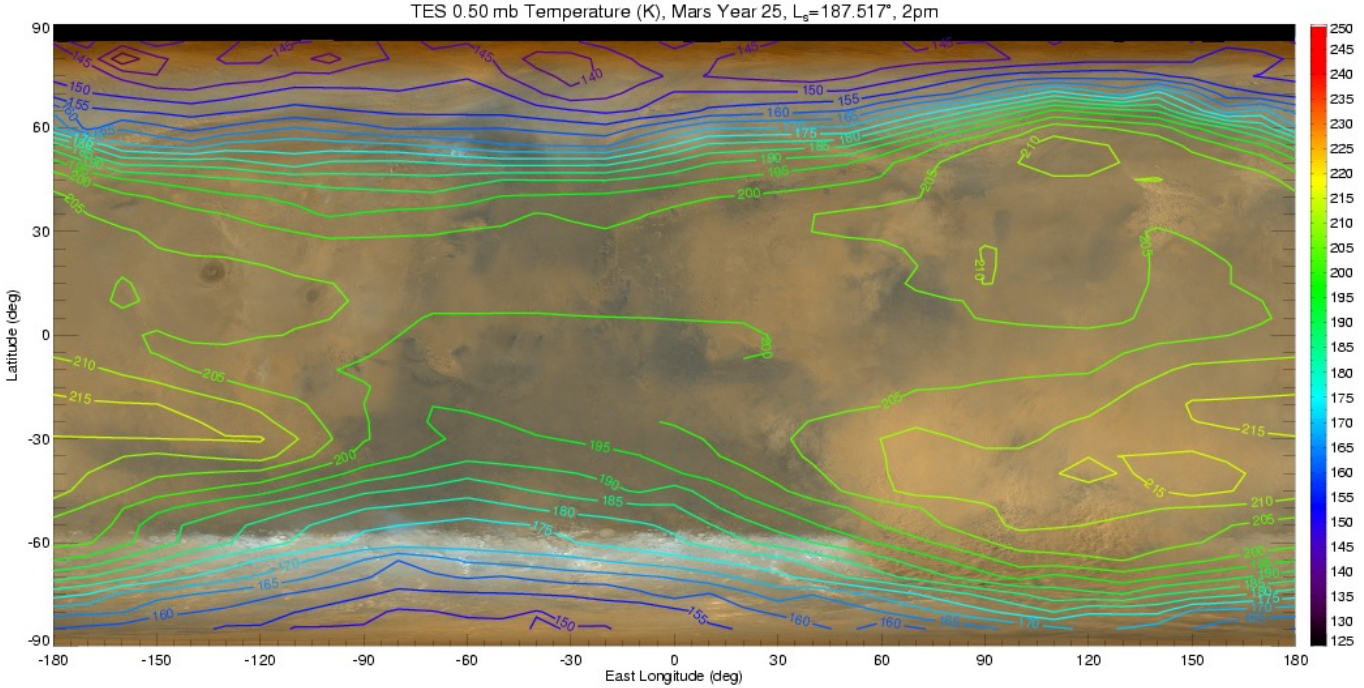
TES 0.50 mb Temperature (K), Mars Year 25, L_s=187.517°, 2pm
Latitude (deg)
East Longitude (deg)
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Working Hypothesis

- Precursory storm pulses are associated with traveling baroclinic eddies
- A combination of baroclinic eddies and cap edge flow triggered lifting in Hellas
- Once significant amounts of dust start to fill the atmosphere, wave amplification starts to occur.
- Southward movement of the dust is associated with a stationary wave
- Regional atmospheric heating in Hellas excites global Rossby wave train
- Claritas lifting is associated with propagation of Rossby wave train

Future Work

- Examine inter-annual variability: Look for wave features in subsequent years.

- Use the model:
  - First, prescribe the observed distribution of dust, adjust the altitude, and see what it excites.
  - Next, specify a source of dust in Hellas, and see what a truly consistent time interactive simulation would produce.

- Compare other lifting centers to Rossby wave train centers from model.