Integration of Mars Global Surveyor Observations of the MY 25 Planet-encircling Dust Storm on Mars: Implications for Atmospheric Modeling and Dynamics

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Datasets

- Thermal Emission Spectrometer (TES) temperature and dust opacity (Smith)
- Mars Orbiter Camera (MOC) imagery & opacity (Malin and Cantor)
- FFSM-filtered (Fast Fourier Synoptic Mapping) TES temperature (Barnes)

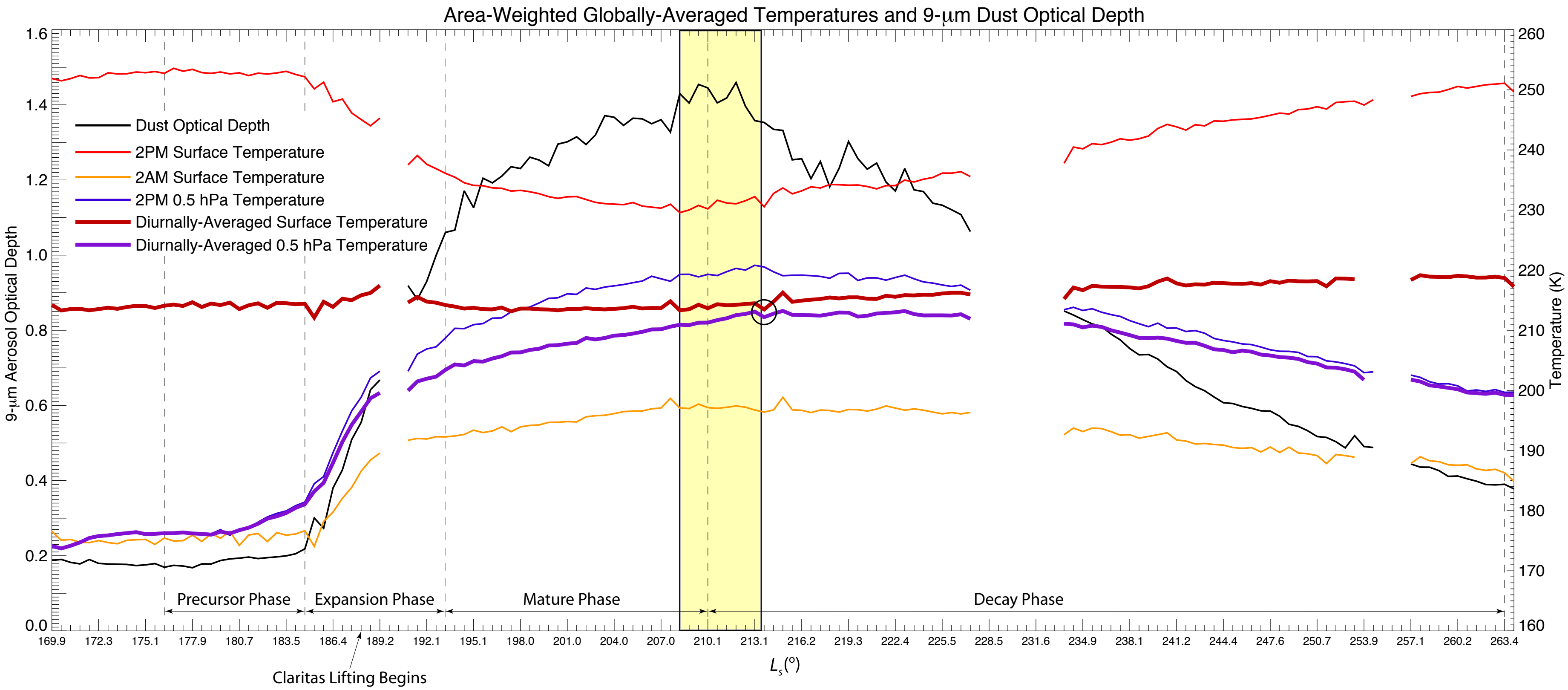
Fast Fourier Synoptic Mapping (FFSM) of TES *T*

- Spectral analysis method that creates synoptic maps from asynoptic data
  - Maintains full space-time resolution without distorting or smoothing higher frequency (~1–3 sols) weather signals
  - Removes the time mean, zonal mean, and westward diurnal tide. (Barnes 2001, 2003, 2006)
- FFSM-filtered TES data show eastward-traveling waves at 60° S with a period of ~ 3 sols.
- We hypothesize that these are eastward-traveling baroclinic eddies

Objectives

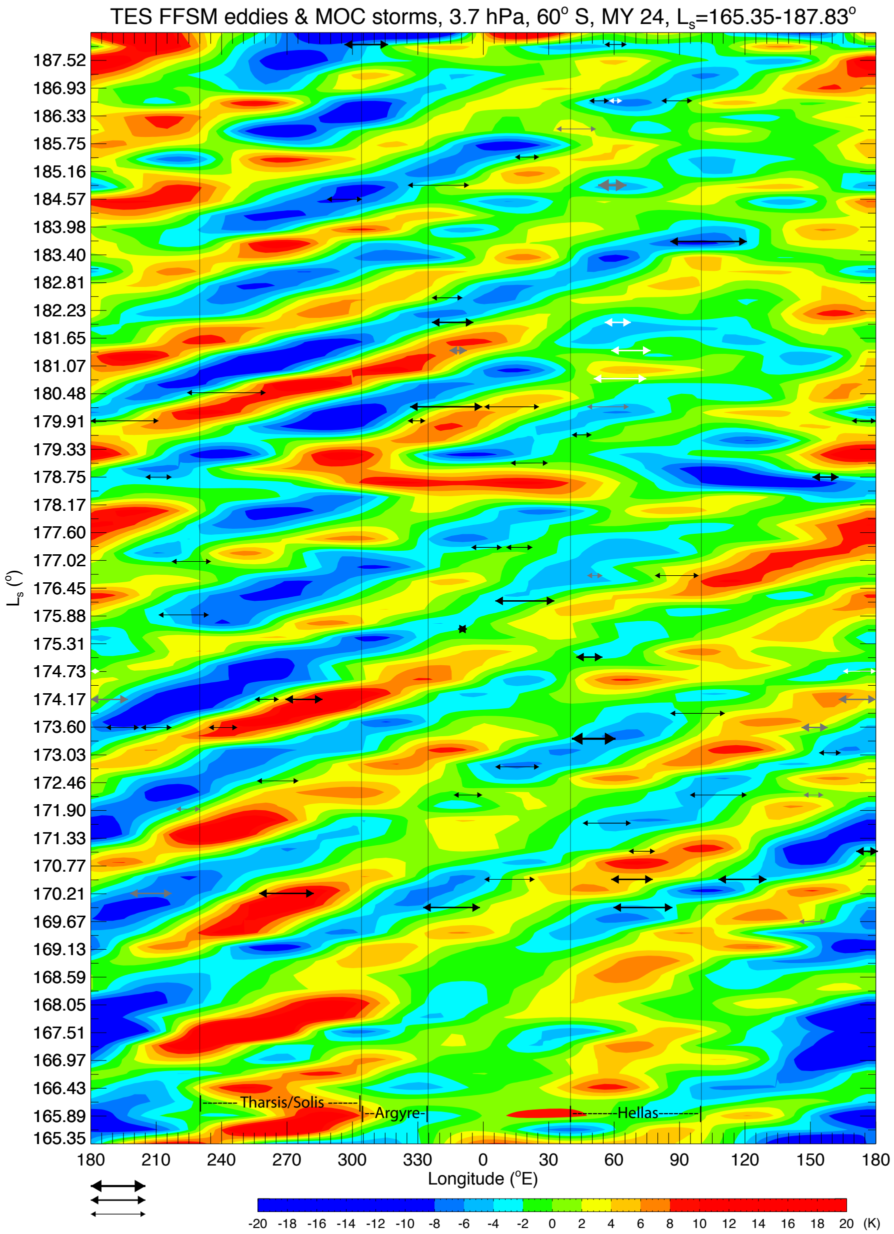
1. Integrate and examine all available MGS MY 25 data
2. Better understand and characterize dust storm initiation and expansion
   - Evolution of temperature and dust opacity fields
3. Compare MOC storms with baroclinic eddies inferred from FFSM-filtered TES temperatures
4. Produce synthesized dust opacity datasets
   - Column opacity and apparent convective activity
   - Provide better bases and constraints for future modeling

MY 25 PDS phases, TES global temperature & dust opacity



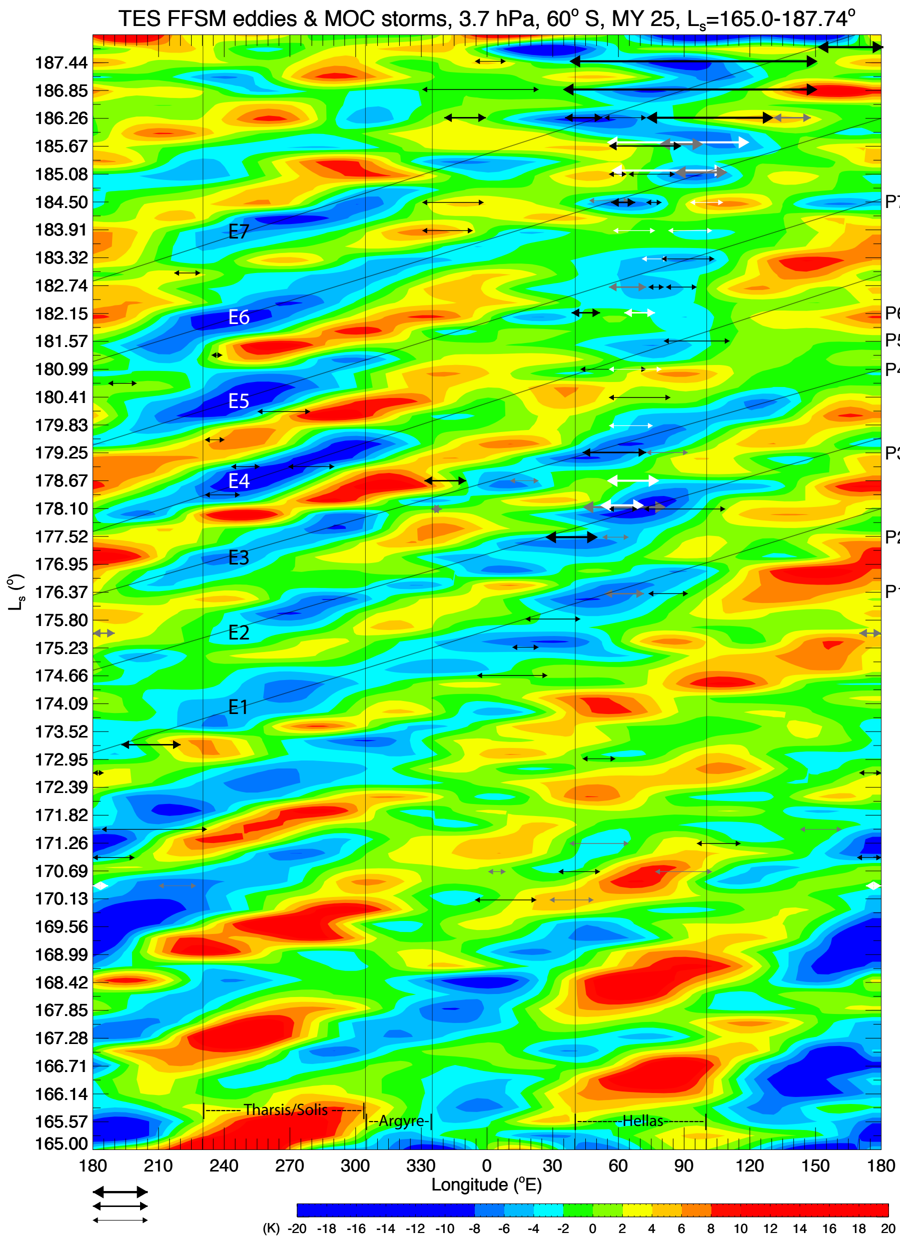
1. **Precursor**: L_s=176.2–184.7°, storm initiation and early growth around the Hellas region
2. **Expansion**: L_s=184.7–193°, expansion of storm activity east/northeast of Hellas, development of new lifting centers in Daedalia and Solis Plani, and storm growth to planetary-scale
3. **Mature**: L_s=193–210°, peak of globally-averaged opacity and temperature (sfc & 0.5 hPa)
4. **Decay**: L_s=210–263°, opacity and temperature fields return to seasonal levels

FFSM eddies and MOC storms, 60° S, 3.7 hPa, MY 24

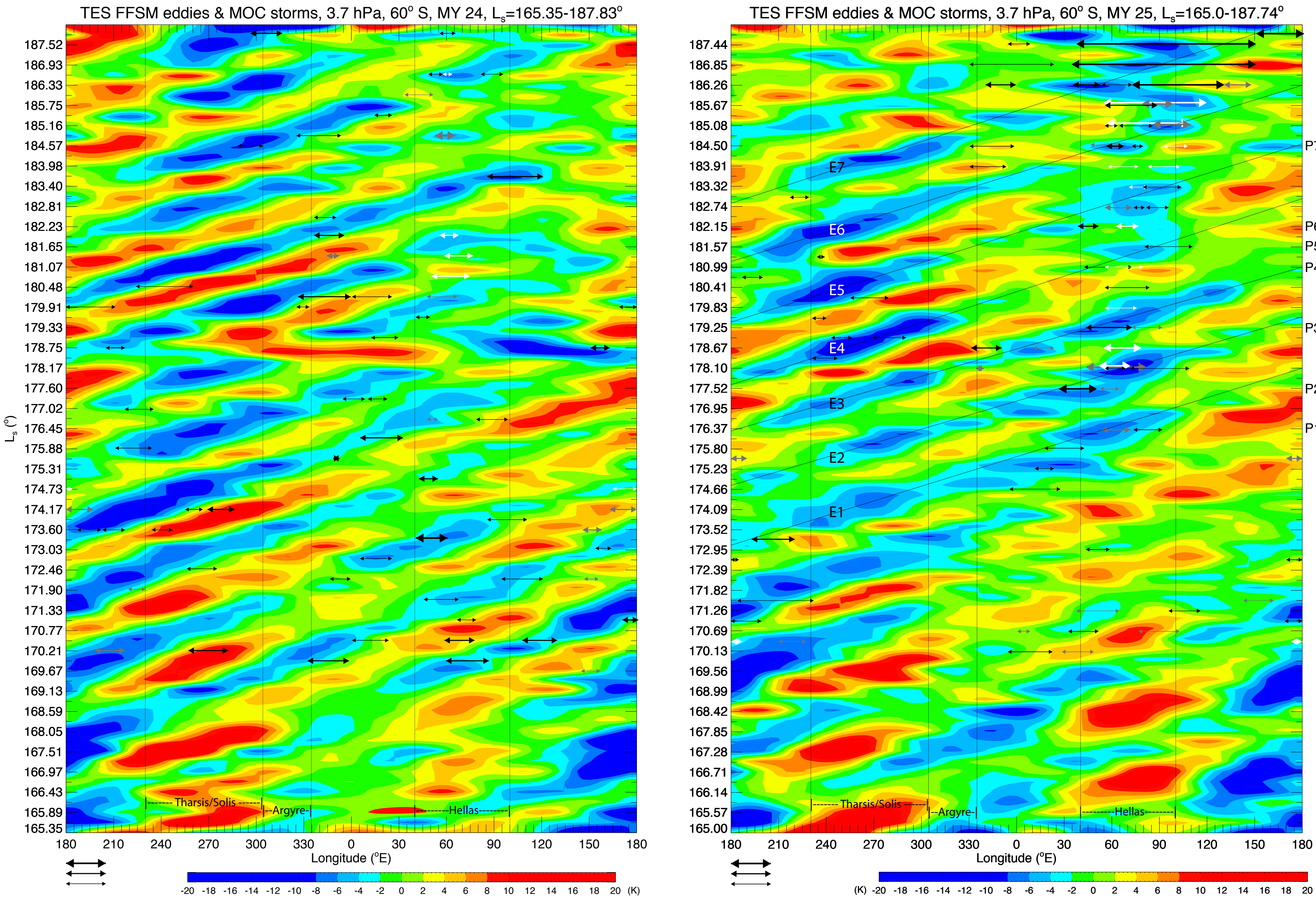


- Correlation between eastward propagation of cold anomalies and eastward evolution of storms.
- Occasional northward progression

FFSM eddies and MOC storms, 60° S, 3.7 hPa, MY 25

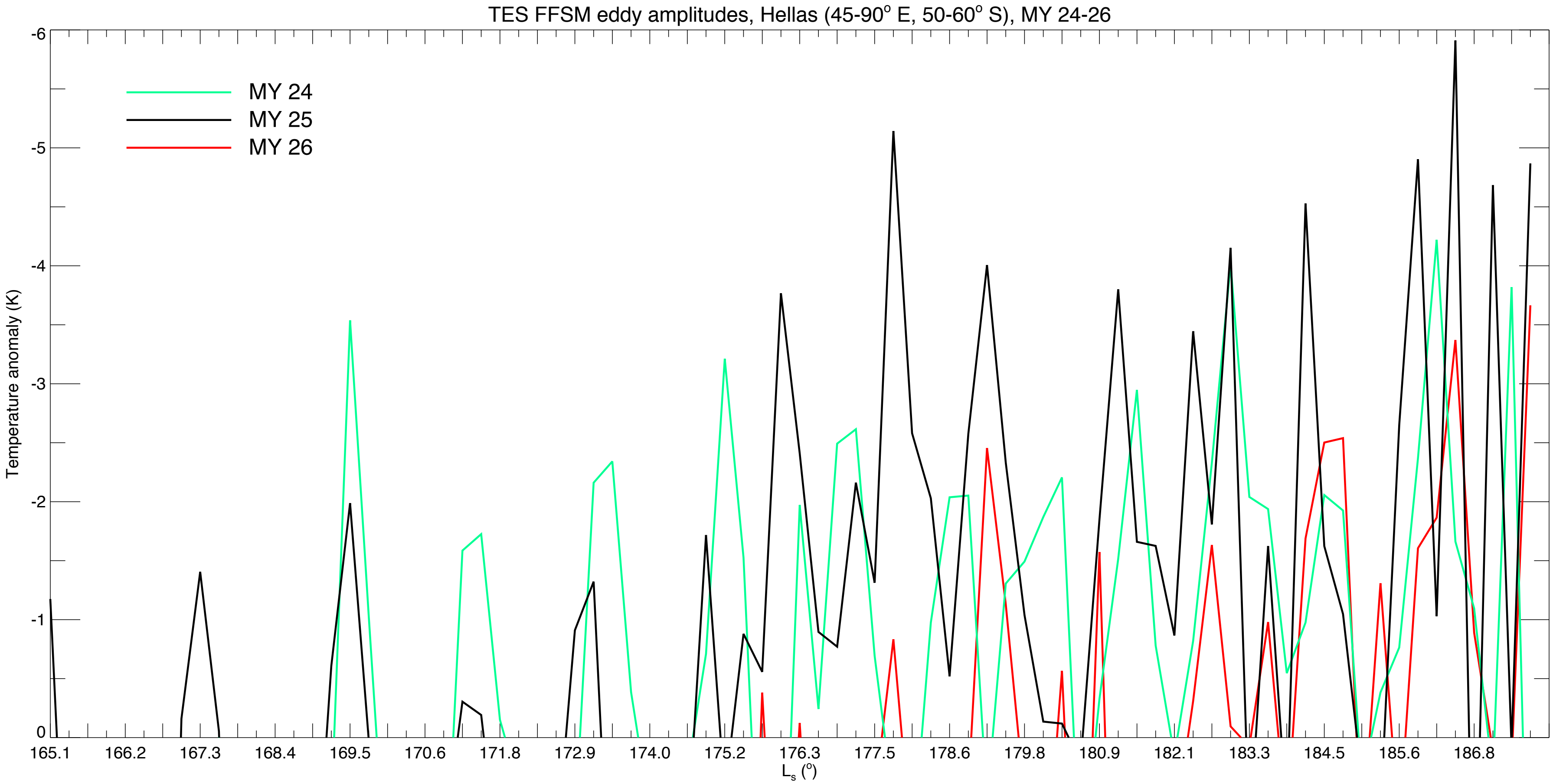


- Correlation between eastward propagation of cold anomalies and eastward evolution of storms.
  - Eastward trend is present in most of the sequences, particularly E1, 2, 3, 5, and 6
  - Northward trend is most notable as E2 and E5 pass through Hellas at ~ L_s=178 and 182°.

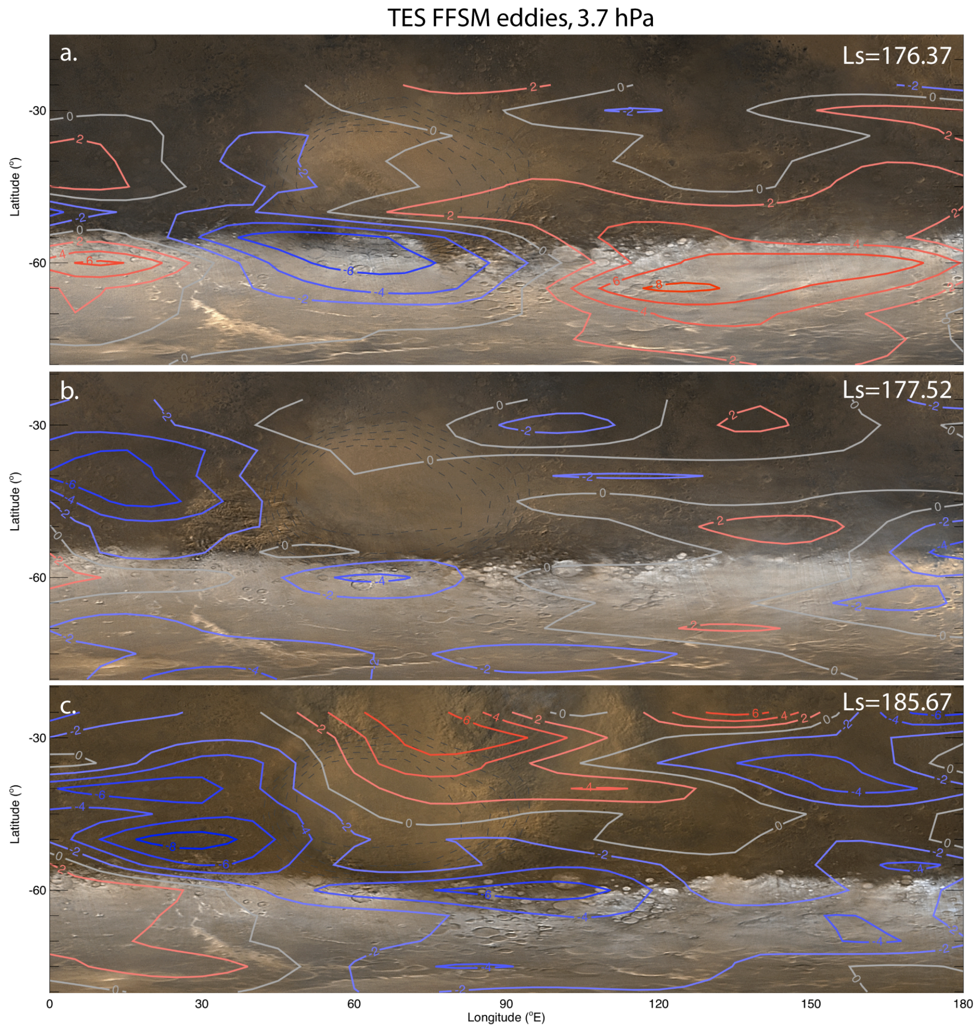


TES FFSM eddies & MOC storms, 3.7 hPa, 60° S, MY 24, Ls=165.35-187.83°
TES FFSM eddies & MOC storms, 3.7 hPa, 60° S, MY 25, Ls=165.0-187.74°
Ls (°)
Longitude (°E)
Tharsis/Solis
Argyre
Hellas
E1
E2
E3
E4
E5
E6
E7
P1
P2
P3
P4
P5
P6
P7
(K)

FFSM cold anomalies, Hellas, MY 24-26



FFSM Eddies and MOC storms, Hellas, MY 25



- Storms emerge on the leading edges of strong-amplitude cold centers
- Although a first order approximation would locate cold fronts between cold and warm FFSM anomalies, their location can not be determined from FFSM eddies alone. Pressure and wind data is also required.
- Limited vertical and longitudinal resolution of TES data, and subsequent 5° longitudinal resolution of FFSM eddy bins, precludes precise determination of cold fronts.
- Fronts are most intense close to the surface, however TES averaging of the lowest scale height reduces their signal.
- Furthermore, there is probably a phase shift between FFSM eddy and pressure fields, since isobaric and isosteric surfaces intersect under baroclinic conditions.

Conclusions

- Eddy amplitudes in Hellas are stronger in MY 25
- Data show correlation between eastward (& subsequent northward) propagation of cold anomalies and eastward evolution of storms in MY 24 and 25
    - Stronger correlation of eastward progression in MY 25
    - More northward propagation in MY 25
- Storms emerge on the leading edges of strong-amplitude cold centers
- We hypothesize that the storm was triggered by eastward-traveling baroclinic eddies in combination with topographically-enhanced cap edge circulation in the southwest region of Hellas.

- Future work:
    - Use GCM to decompose circulation components and assess their contribution to storm initiation and expansion
    - Compare MY 26 data

References

- Barnes, J. R., 2001: Asynoptic fourier transform analyses of MGS TES data: Transient baroclinic eddies. *Bulletin of the American Astronomical Society*, **33,** 1088.
- Barnes, J. R., 2003: Mars Weather Systems and Maps: FFSM Analyses of MGS TES Temperature Data. *Sixth International Conference on Mars*, Pasadena, California, USA.
- Barnes, J. R., 2006: FFSM Studies of Transient Eddies in the MGS TES Temperature Data. *Mars Atmosphere Modelling and Observations*, Granada, Spain
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