Analysis of MGS TES FFSM eddies and MOC dust storms, MY 24–26

John Noble[1,2], Robert M. Haberle[2], Alison F. C. Bridger[1,2], R. John Wilson[3], Jeffrey R. Barnes[4], Jeffrey L. Hollingsworth[2], Melinda A. Kahre[2], Bruce Cantor[5]

1. San Jose State University, 2. NASA/Ames Research Center, 3. NOAA Geophysical Fluid Dynamics Laboratory, 4. Oregon State University, 5. Malin Space Science Systems

Introduction

Mars Global Surveyor (MGS) orbiter observed a planet-encircling dust storm (PDS) in Mars year (MY) 25 from Ls=176.2–263.4° (Strausberg 2005; Cantor 2007). We have integrated and examined MGS data in order to better understand and characterize the dynamical processes responsible for MY 25 PDS initiation and expansion (Haberle *et al.* 2005; Noble *et al.* 2006, 2010, 2012; Wilson et al. 2008; Noble 2013). Here we integrate MY 26 Mars Orbiter Camera (MOC) visible dust storms and transient baroclinic eddies identified from Fast Fourier Synoptic Mapping (FFSM) of Thermal Emission Spectrometer (TES) temperatures and compare these with MY 24 & 25 data.

Uncertainty remains regarding PDS interannual variability. Are PDSs periodic or aperiodic, i.e. chaotic: governed by highly nonlinear, stochastically forced systems (Zurek and Haberle 1988)? Ingersoll and Lyons (1993) state that PDSs do not seem to be periodic, though statistics are limited. If PDSs are periodic, what environmental causes and dynamical mechanisms are responsible?

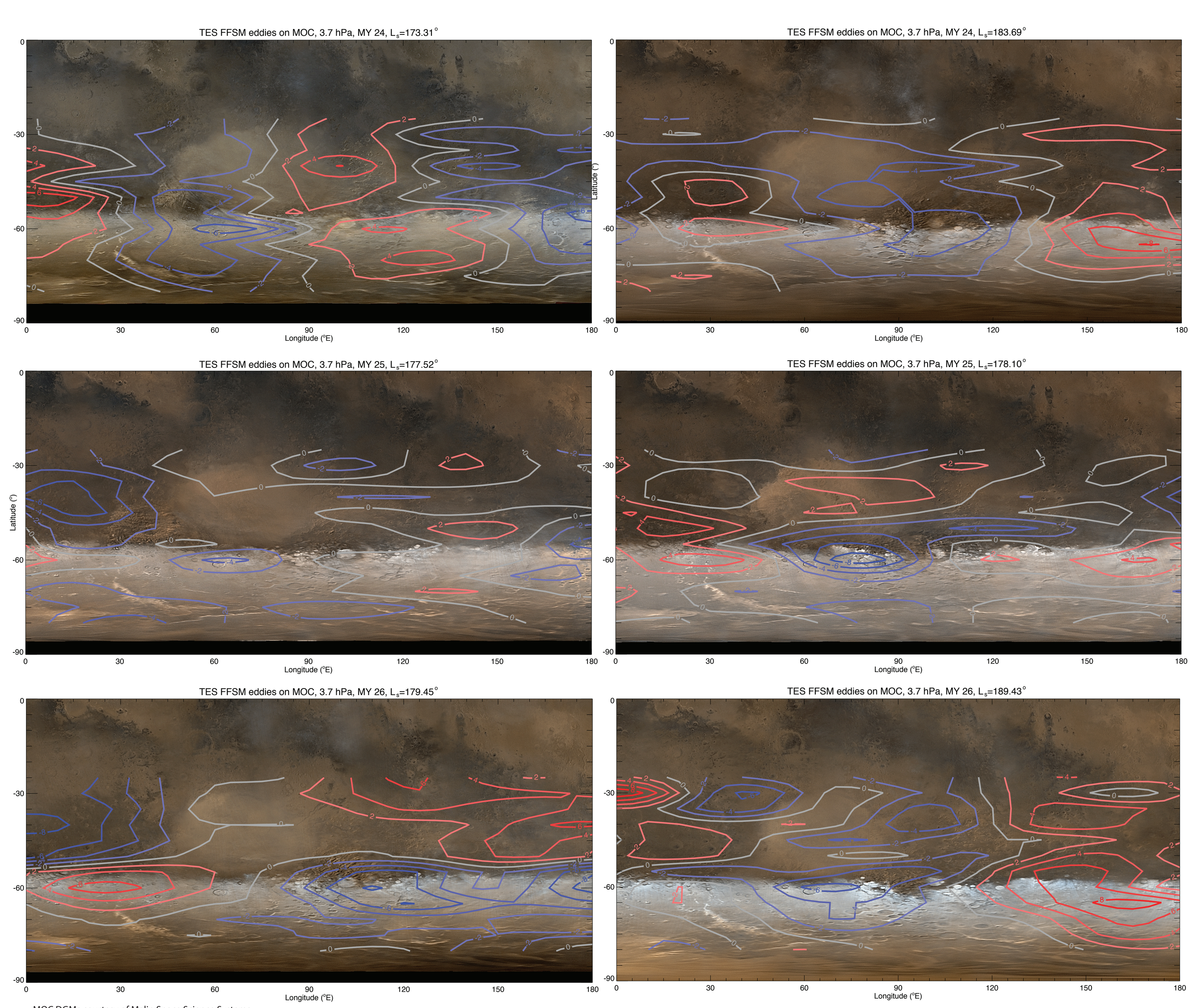
Datasets

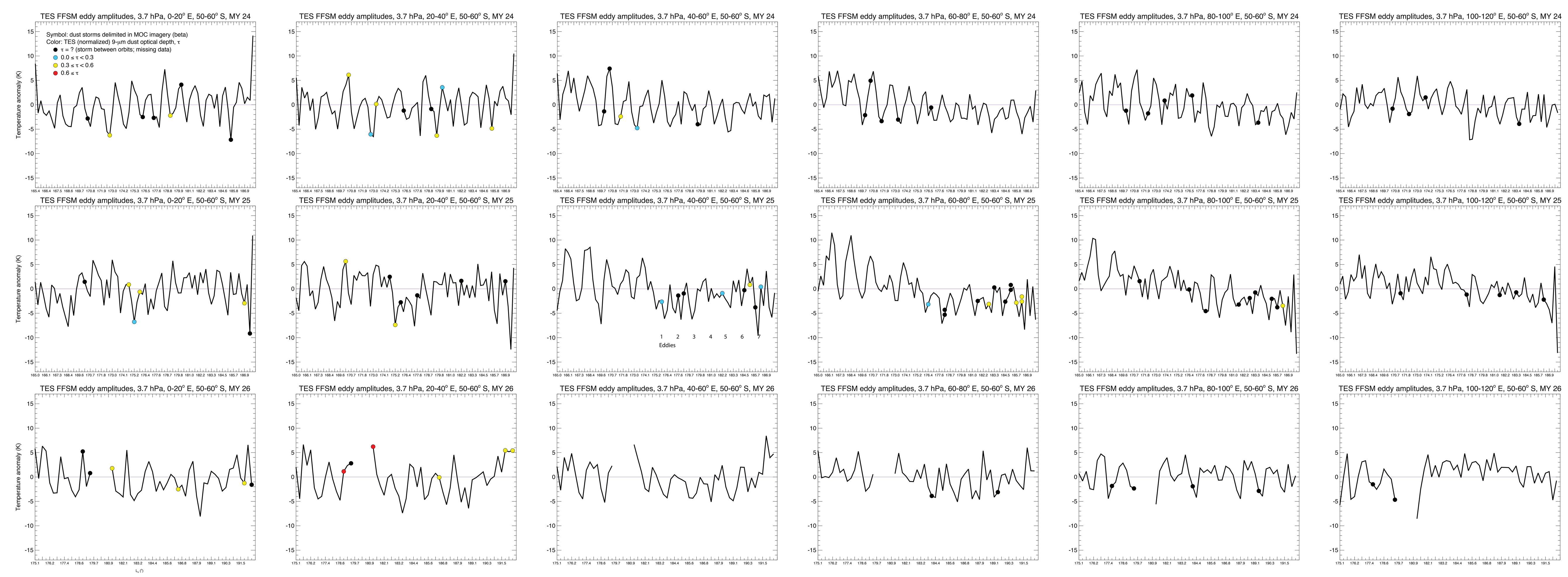
- Thermal Emission Spectrometer (TES) measurements of atmospheric temperature and 9-μm dust opacity (Smith et al. 2001)
- Mars Orbiter Camera (MOC) daily global maps (DGM) produced by Malin Space Science Systems (Cantor 2007).
- Fast Fourier Synoptic Mapping (FFSM) of TES temperatures. FFSM is a spectral analysis method that creates synoptic maps from asynoptic data, maintaining full space-time resolution without distorting or smoothing higher frequency (~1–3 sols) weather signals (Barnes 2001, 2003, 2006). This process removes the time mean, zonal mean, and westward diurnal tide.

Objectives

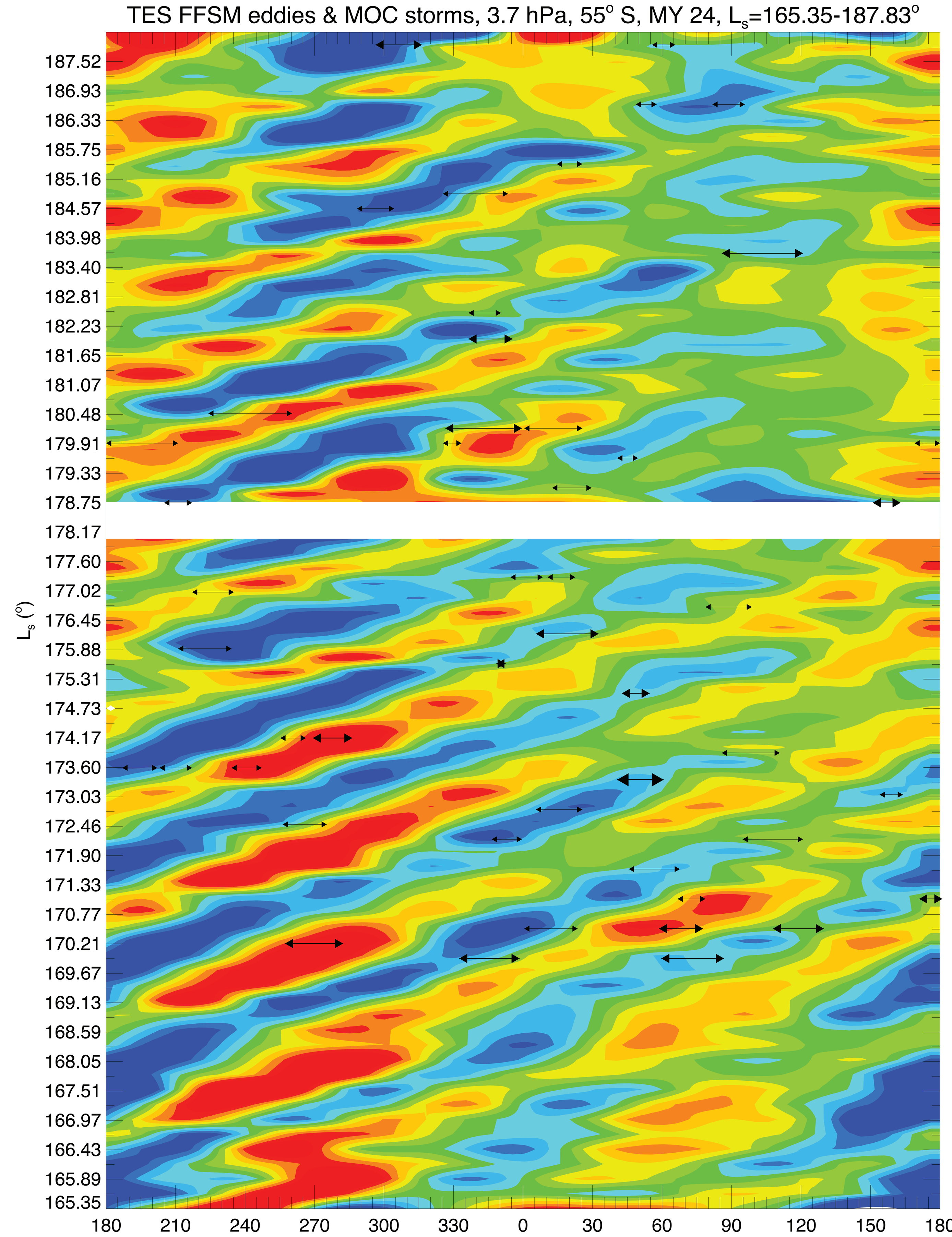
The objectives of this work are to better understand and characterize the dynamical processes responsible for PDS initiation and expansion, specifically examining the following questions:

1) Which circulation components were involved in storm onset and evolution?
2) How did the temperature and dust opacity fields evolve together?
3) Do MGS data show interannual variability that suggests why a PDS formed in MY 25 and not in MY 24 or 26?



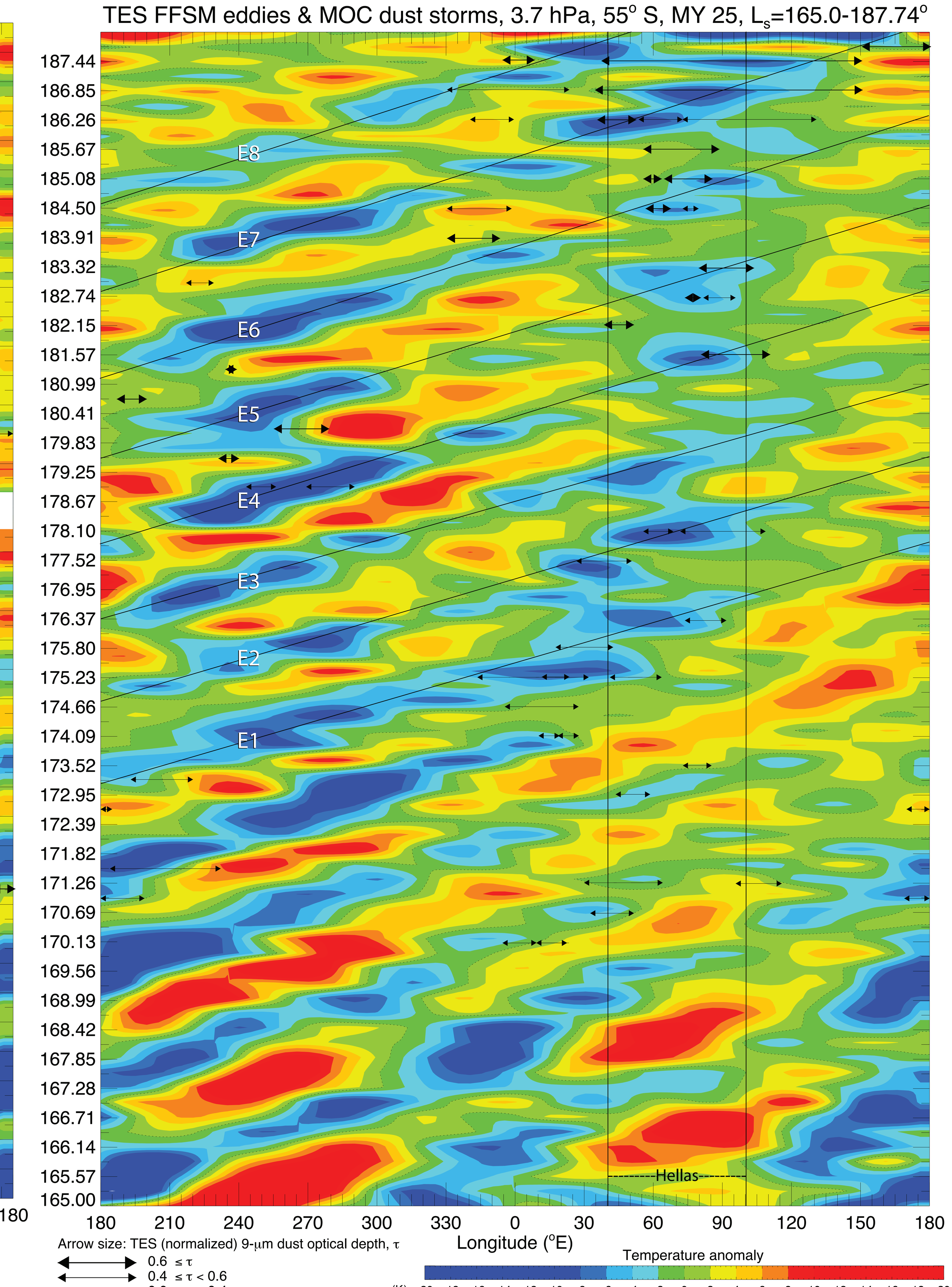


TES FFSM eddies & MOC storms, 3.7 hPa, 55° S, MY 24, L_s=165.35-187.83°



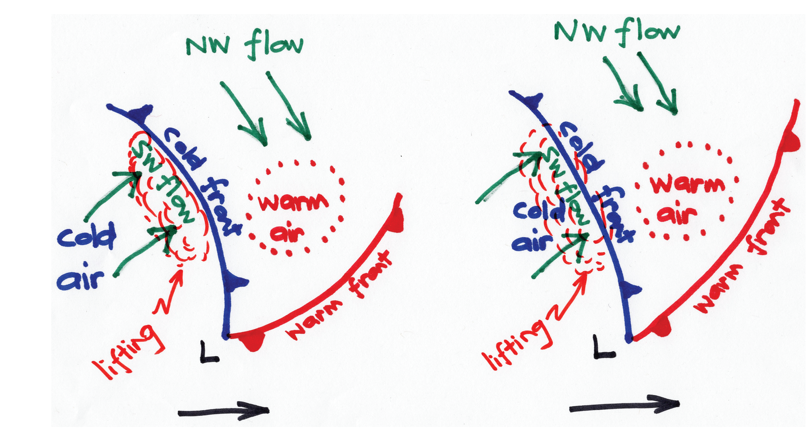
Arrows delimit the longitudinal extent of dust storms based on our analysis of MOC images.

TES FFSM eddies & MOC dust storms, 3.7 hPa, 55° S, MY 25, L_s=165.0-187.74°



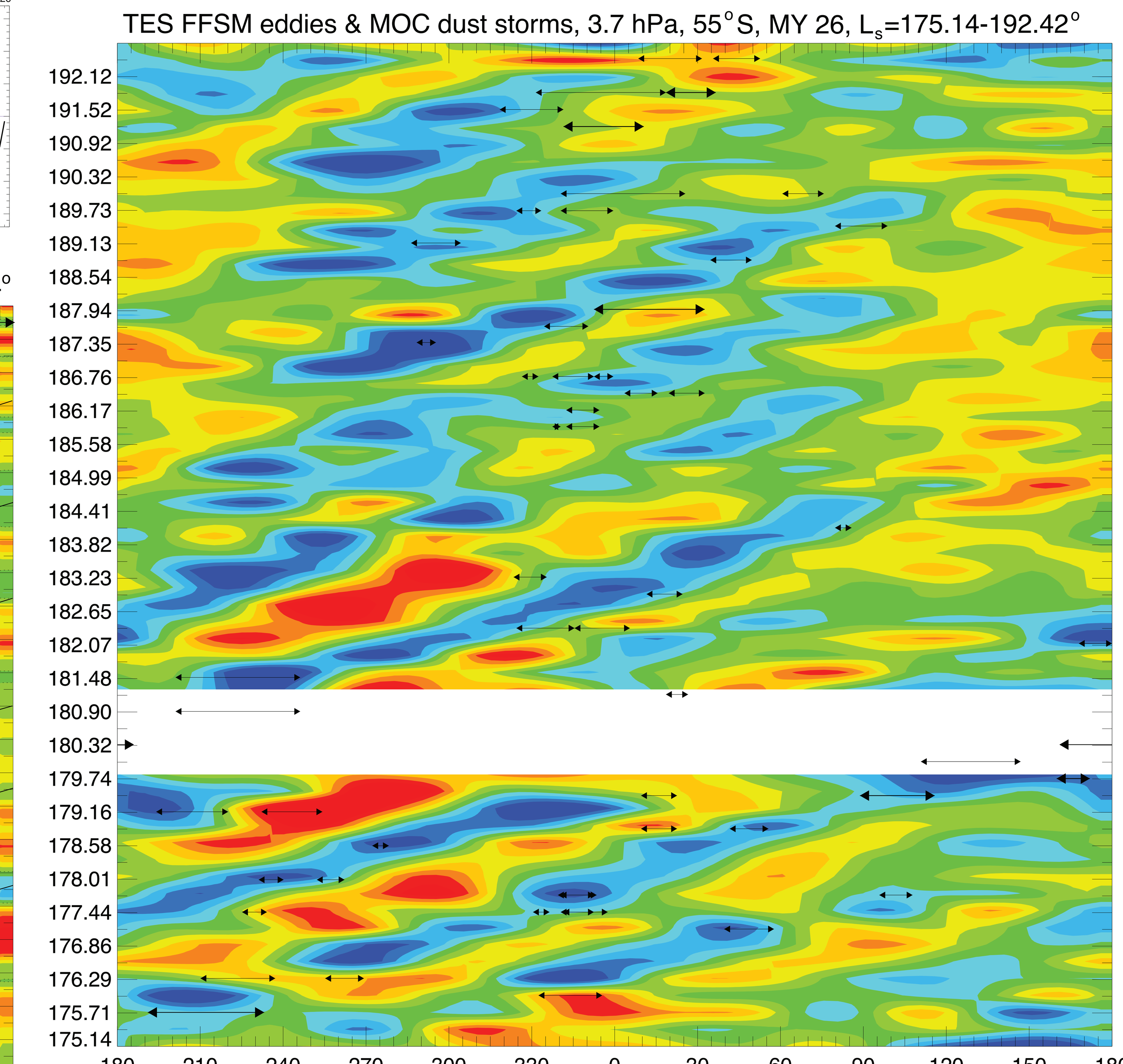
Southern hemisphere cold fronts and winds

Northward storm evolution is due in part to northward winds associated with cold fronts. Cold fronts are a characteristic of baroclinic eddies, and in the SH, baroclinic eddies cause northward winds.



Southwesterly winds west of cold front cause dust lifting

TES FFSM eddies & MOC dust storms, 3.7 hPa, 55°S, MY 26, L_s=175.14-192.42°



Working Hypothesis

MY 25 PDS

- Six eastward-traveling baroclinic eddies (E1-E6) triggered the precursor storms due to the enhanced dust lifting associated with their low-level wind and stress fields.
- Eddy E7 contributed to storm expansion on Ls=186.3
- The sustained series of high-amplitude eddies in MY 25 was a factor in PDS occurrence that year.
- Increased opacity and temperatures from dust lifting associated with eddies E1 – E3 enhanced thermal tides which supported further storm initiation and expansion out of Hellas.
- Constructive interference of eddies and other circulation components may have led to the initiation and expansion of precursor storms. These include: CO_2 sublimation flow, anabatic winds, diurnal tides, and dust-induced thermal tides. Constructive interference increases surface stresses capable of lifting dust (through the wind field)
- Non-dynamical factors in PDS interannual variability include dust sources and sinks

References

- Available on request