The Non-local impact of Dust Storms on Martian Atmospheric Dynamics

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Contributors

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Outline

Objective: Impact of Martian Dust Storms on Dynamical Phenomena "At Distance" (Non-Local)

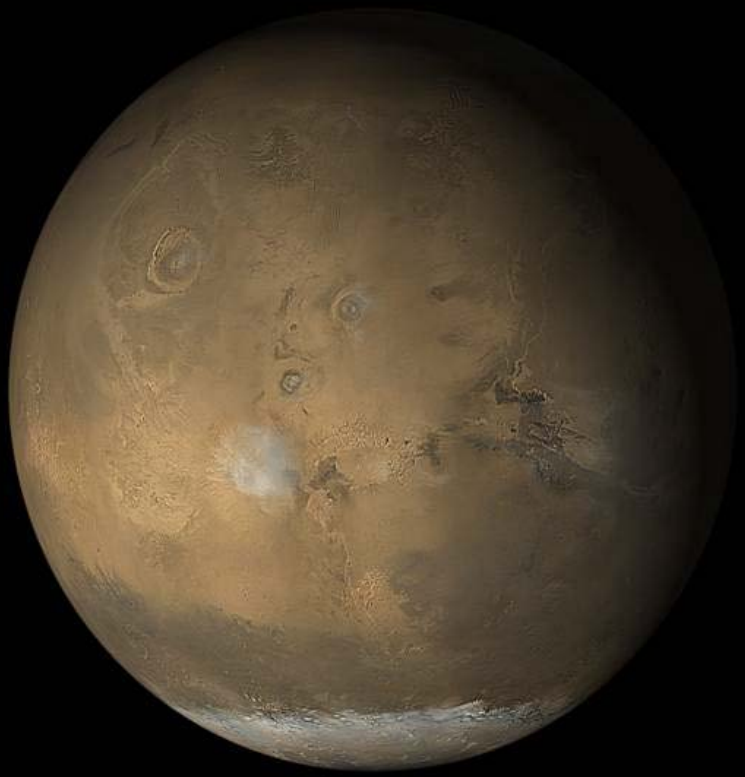
Case Studies:

1. 2001 Planet-Encircling Dust Storm (MY25, L_s~186°)
2. 2003b Regional Dust Storm (MY26, L_s~316°)

Dynamical Phenomena:

- Teconnection event
- Super-rotating westerly equatorial jet
- Polar vortex anomaly (and "sudden polar warming")

2001 Planet-encircling Dust Storm

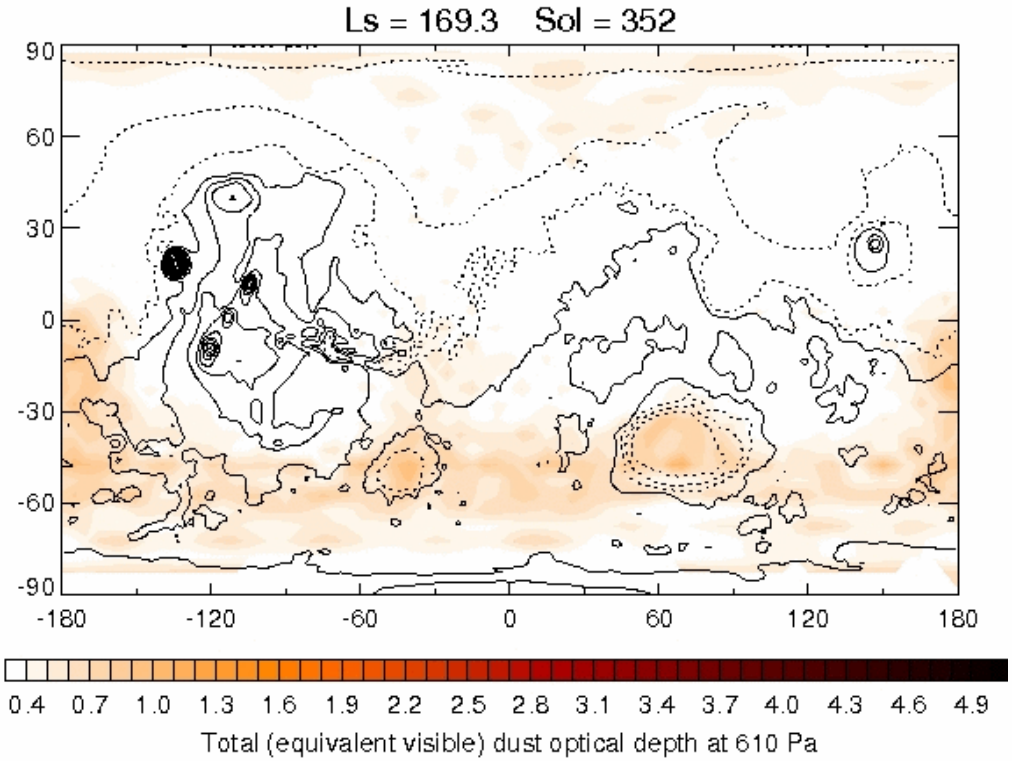


20 June 2001

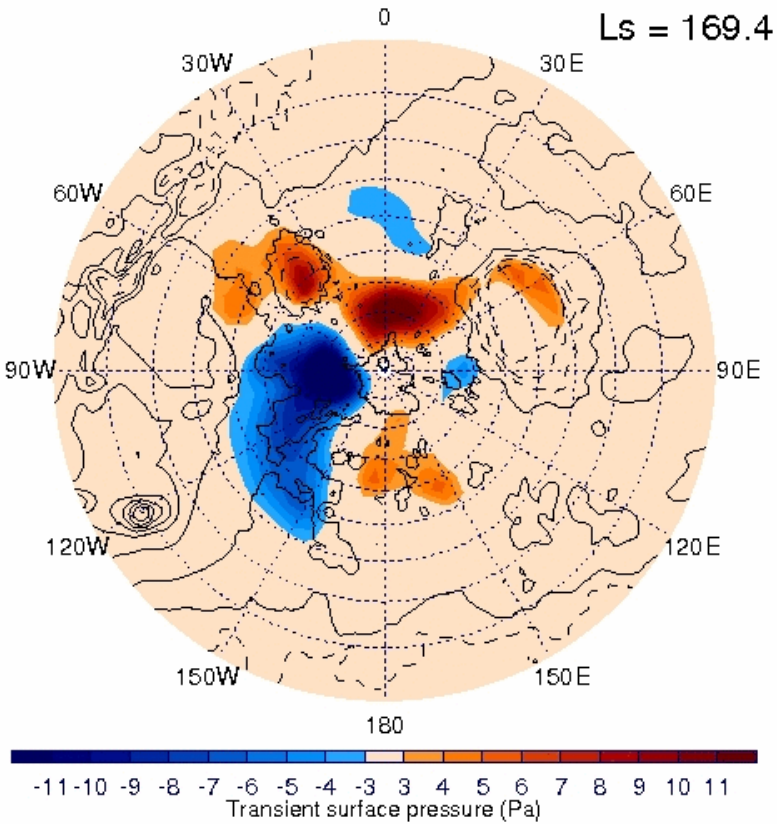
31 July 2001

Mars Global Surveyor spacecraft MOC camera

Synopsis of the 2001 dust storm

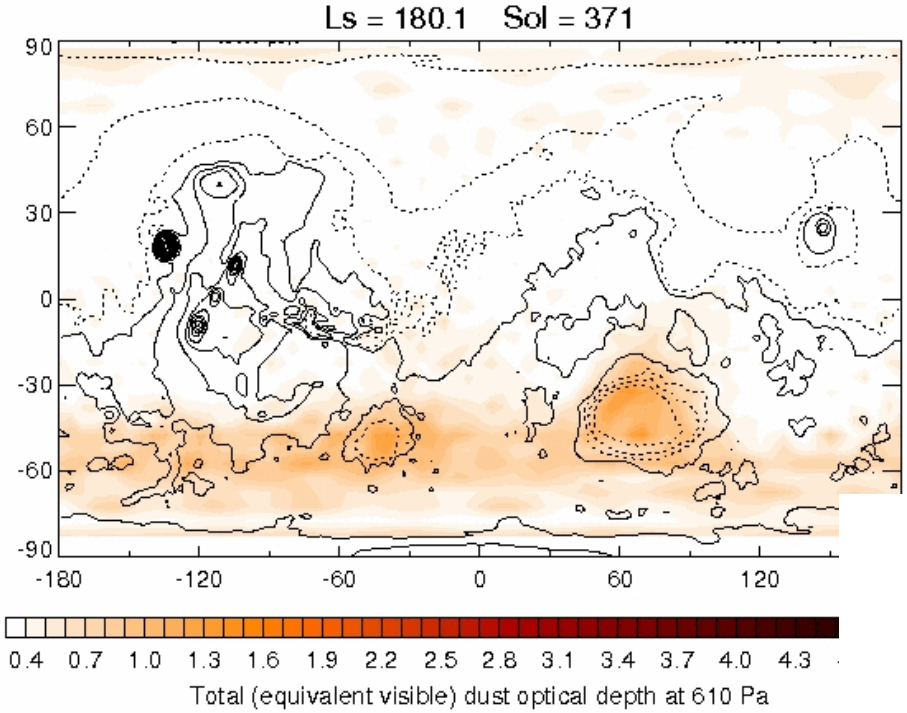


L_S ~
169° →180°



Pre-storm events: baroclinic waves

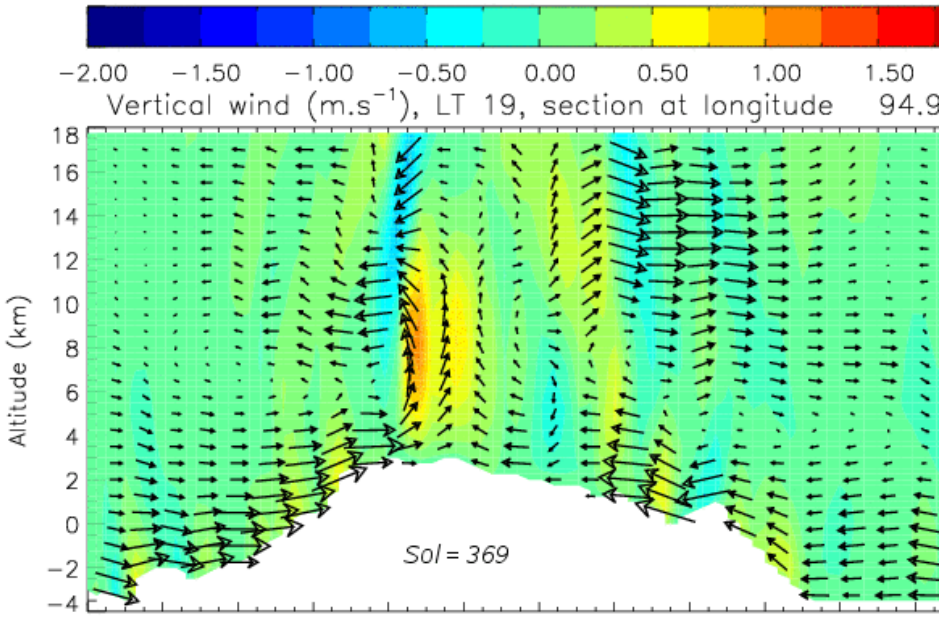
Synopsis of the 2001 dust storm



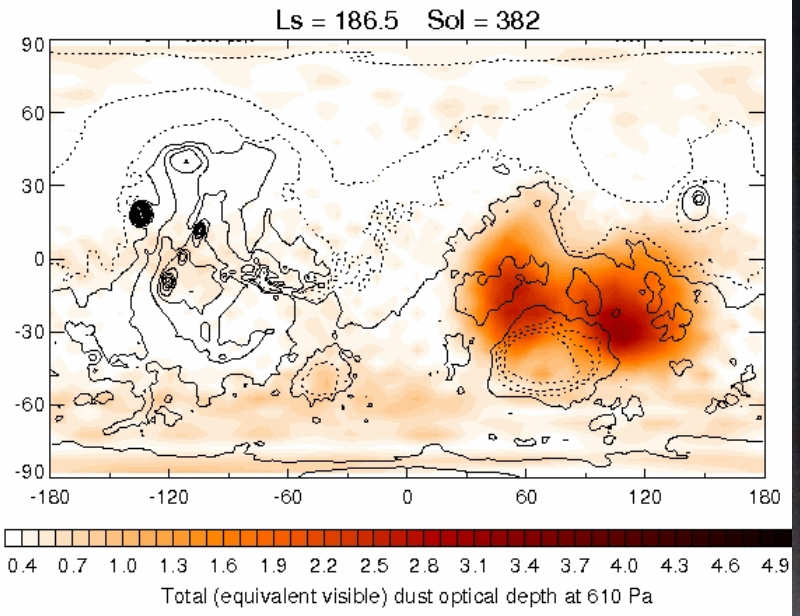
L_S ~ 180° →187°

LMD Mesoscale Model, 50 km horizontal resolution. Boundary conditions from data assimilation.

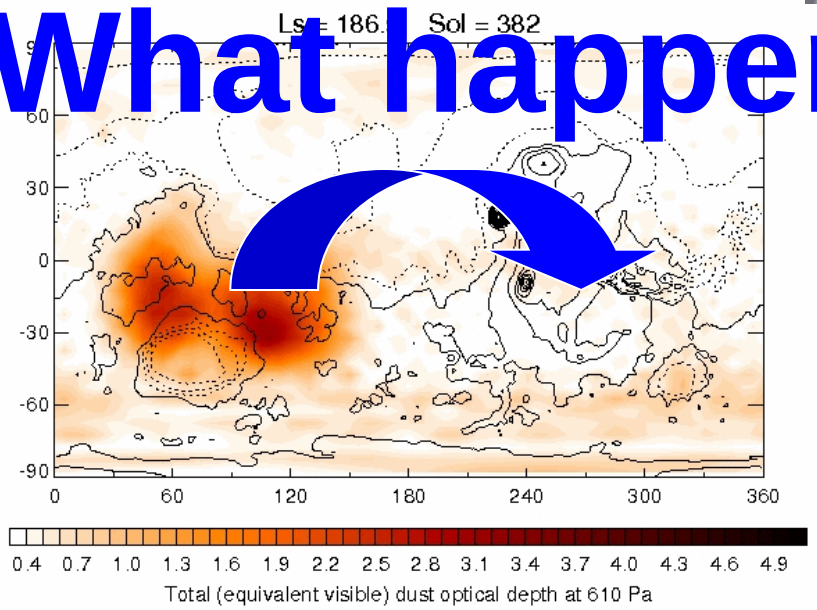
Explosive growth: strong updrafts

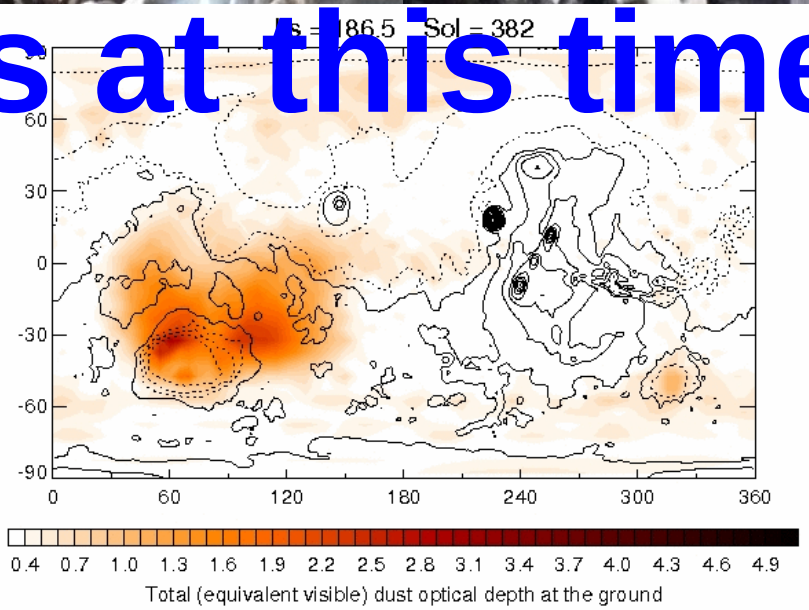


Synopsis of the 2001 dust storm



What happens at this time?





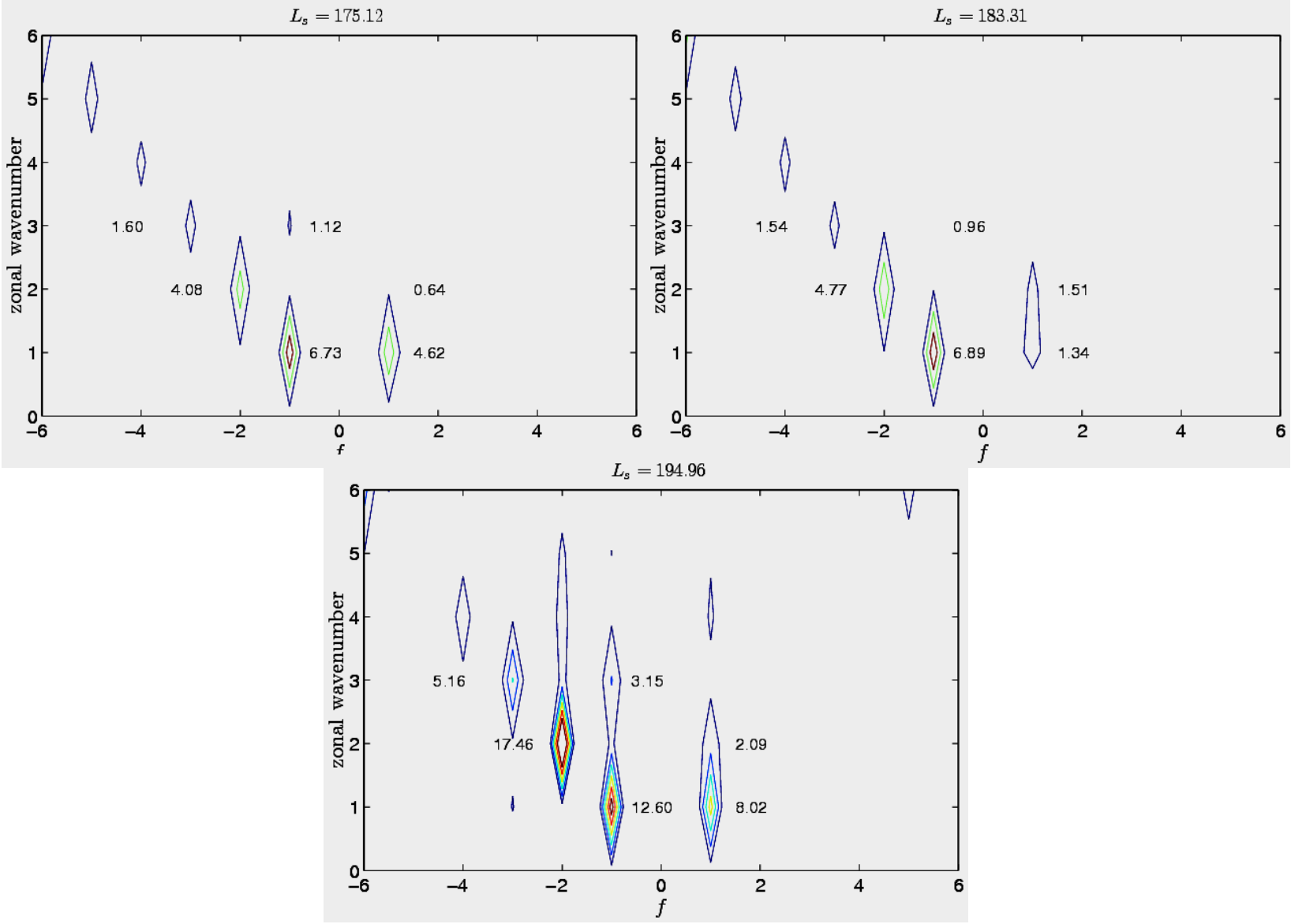
Questions

1. What is the origin of such a teleconnection event?

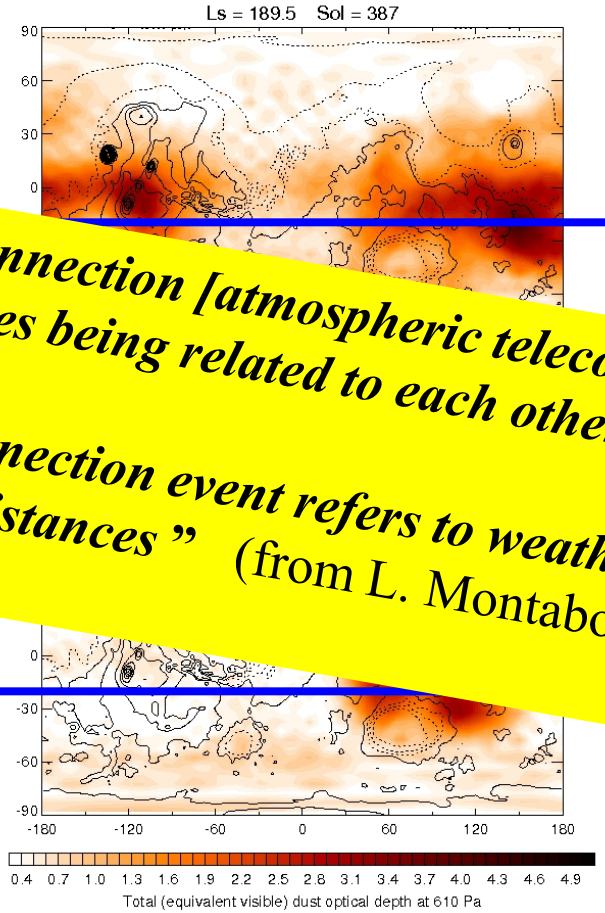
2. Is this a “teleconnection event”?

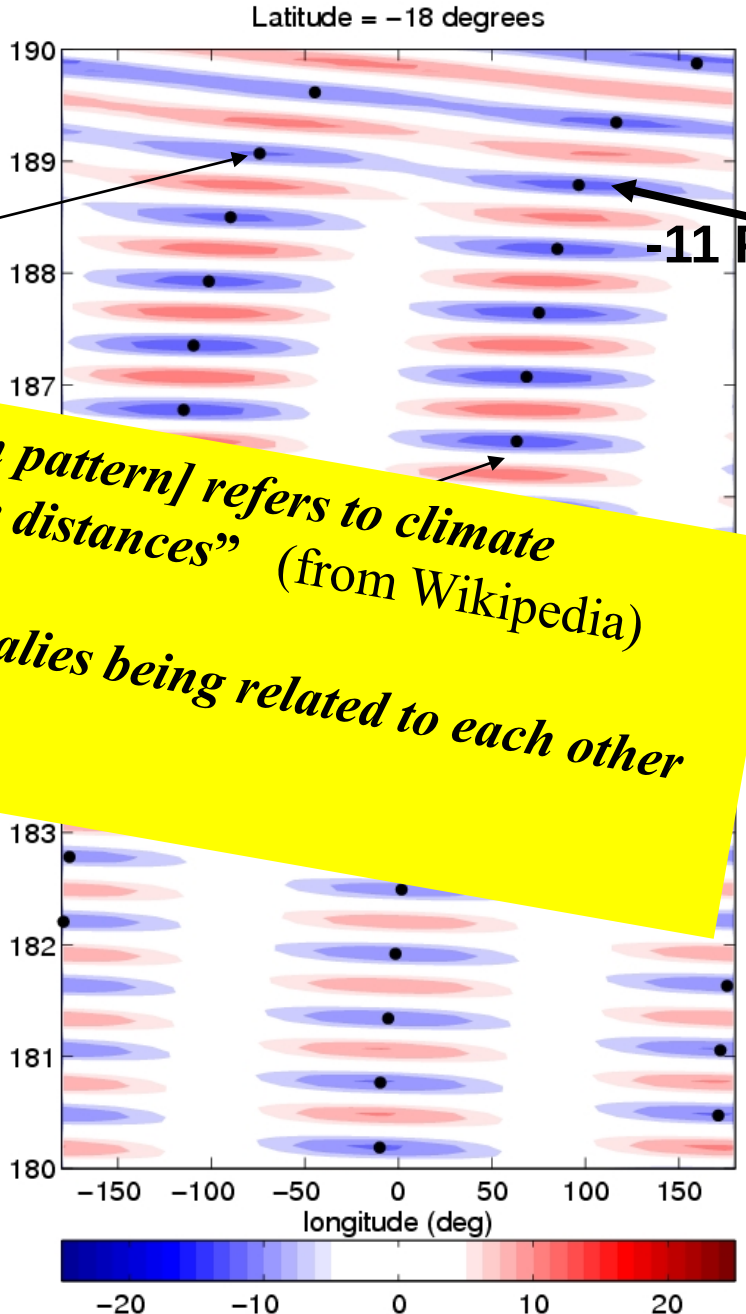
3. Does the advection towards the east of the dust lifted in Hesperia Planum cause the longitudinal displacement of surface pressure extrema?

Thermal tides



Teleconnection event





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Tim

" Teleconnection [atmospheric teleconnection pattern] refers to climate anomalies being related to each other at large distances" (from Wikipedia)

" Teleconnection event refers to weather anomalies being related to each other at large distances " (from L. Montabone ☺)

Longitudinal anomalies of surface pressure:

Amplitudes of diurnal + Kelvin components

Teleconnection event

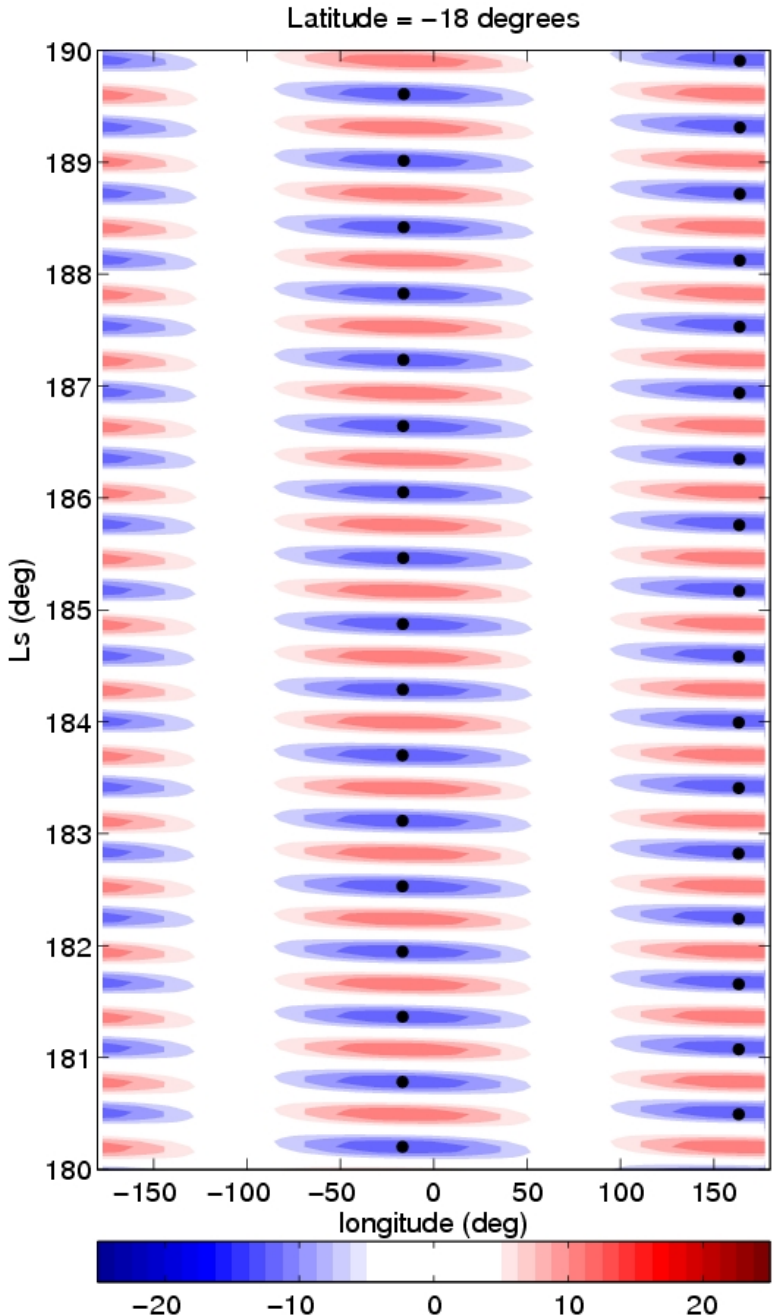
Time

Uniform and constant dust:

τ =0.4

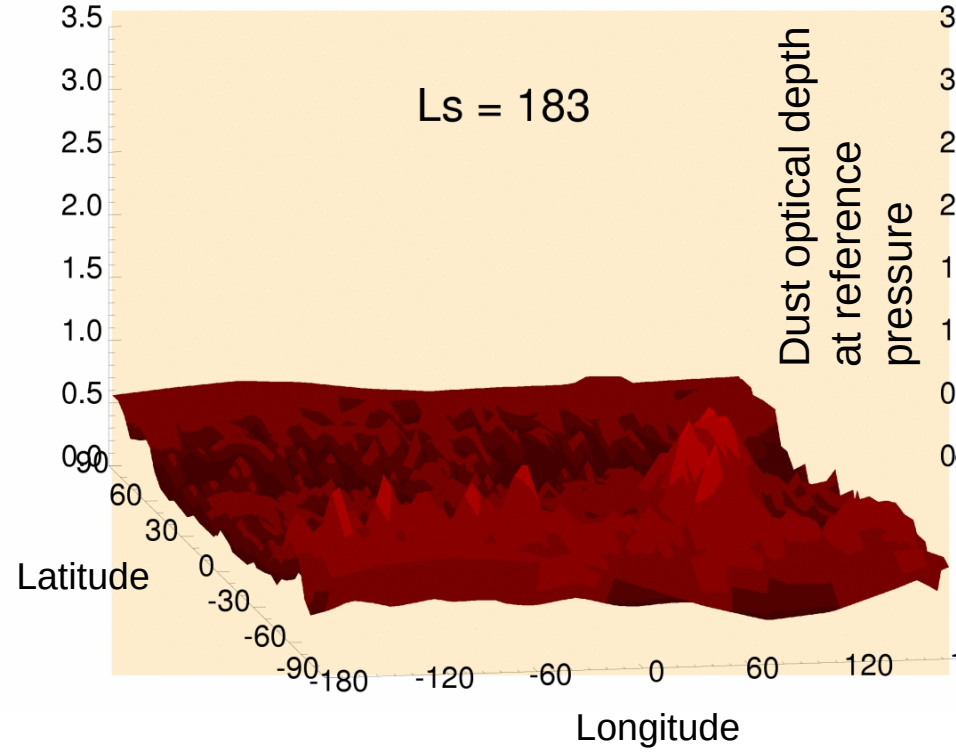
Longitudinal anomalies of surface pressure:

Amplitudes of diurnal + Kelvin components

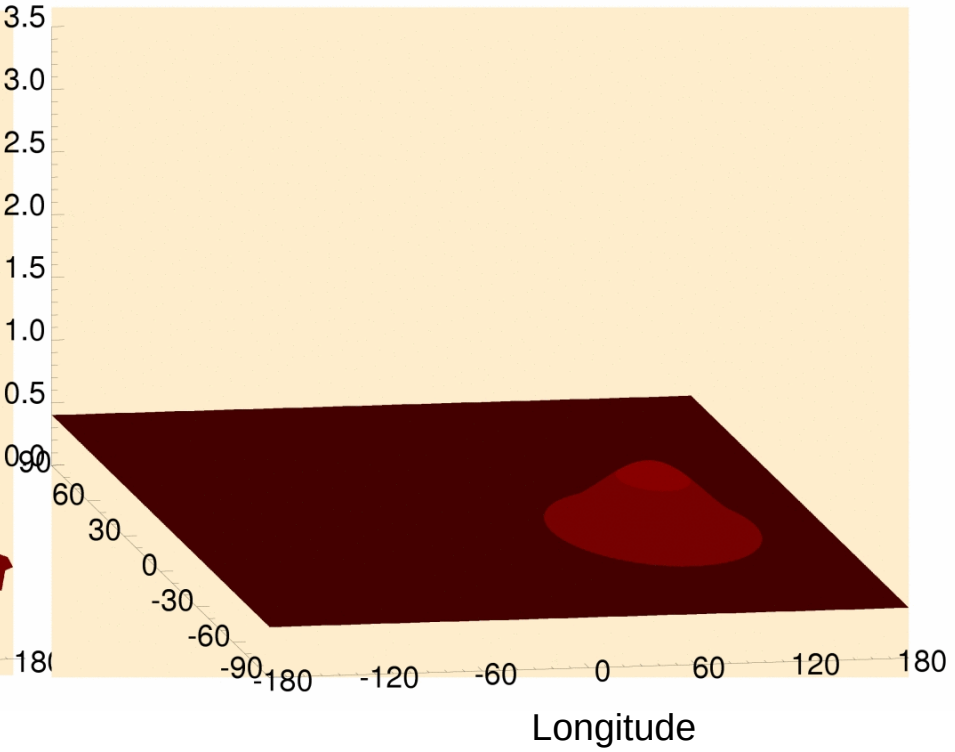


Model of the initial burst of dust in Hesperia Planum

Data assimilation

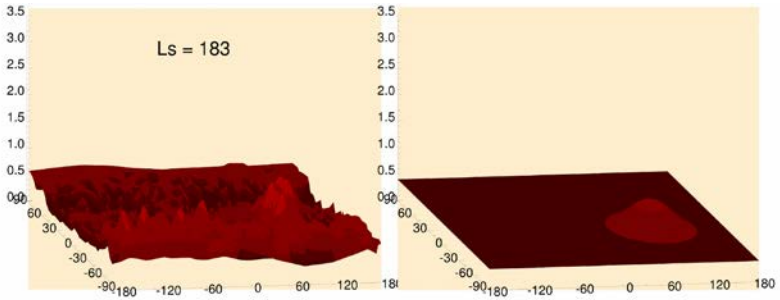


Gaussian dust storm



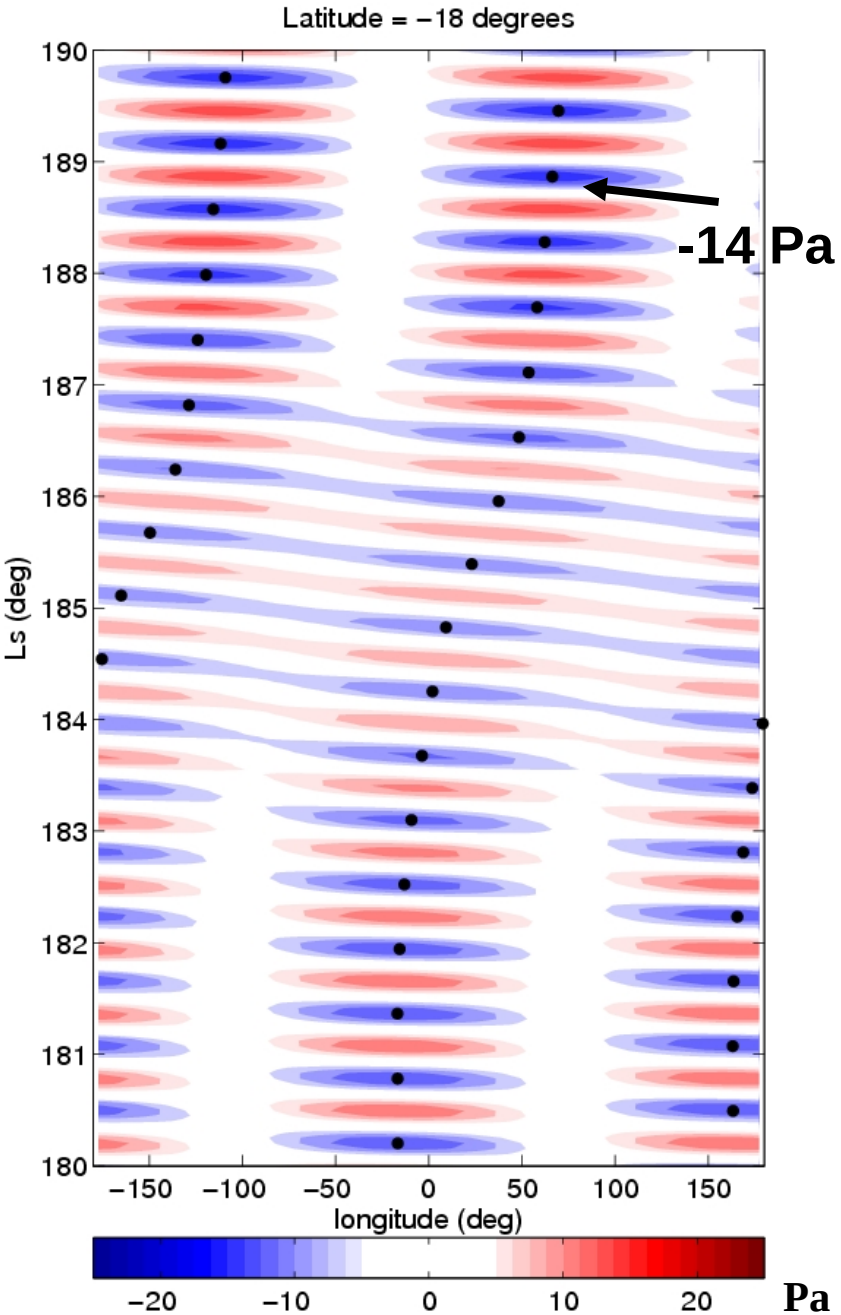
Teleconnection event

Time

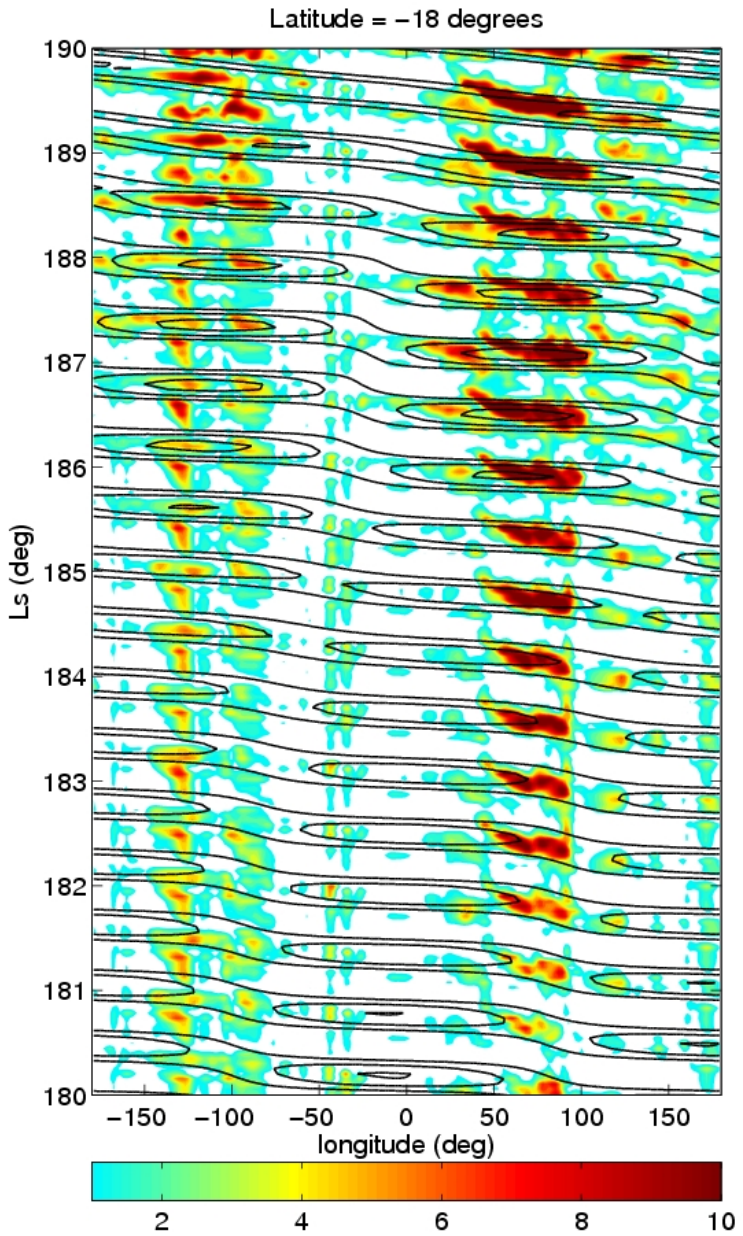


Longitudinal anomalies of surface pressure:

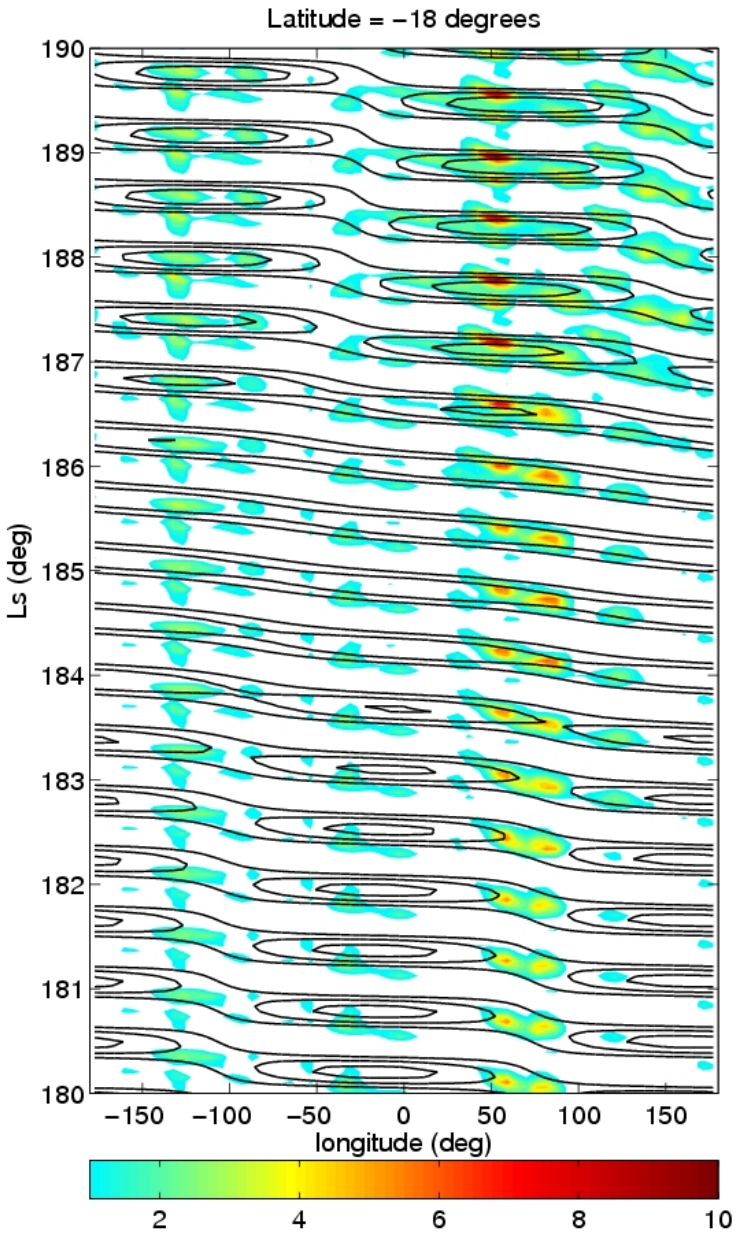
Amplitudes of diurnal + Kelvin components



Near surface wind stress



Data assimilation N/m^2



Gaussian model N/m^2

Partial conclusions...and further questions

✓ Hesperia Planum and the Tharsis region were connected at distance ("teleconnected") at short time scale via the thermal tides during the onset of the 2001 planet-encircling dust storm

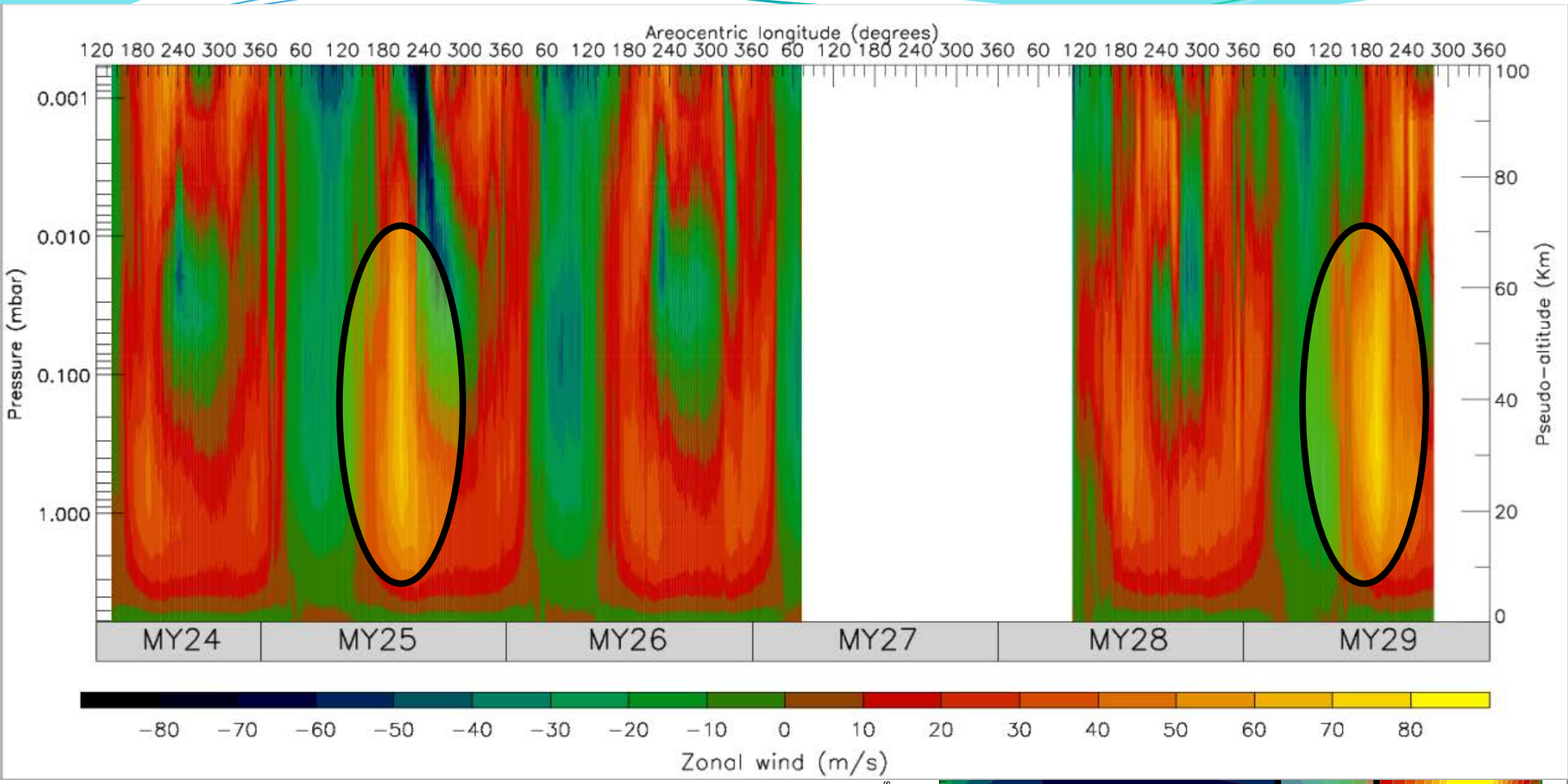
✓ Such non-local effect developed in presence of localized atmospheric forcing (initial burst of dust in Hesperia Planum)

✓ There was an effect of such a teleconnection on surface wind stress (therefore on potential dust lifting), but it can only partially explain the increase of surface wind stress in the reanalysis.

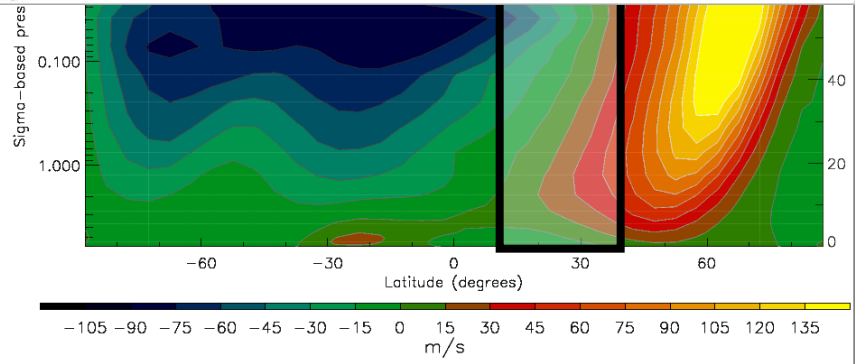
✓ How important was eastward dust advection via atmospheric middle-altitude wind?

✓ Can we explore the attribution problem (i.e. cause-effect relationship) for the initiation of secondary lifting in Tharsis? Effect of teleconnection vs effect of advection?

Westerly Equatorial Jet



Work inspired by results in Lewis & Read, 2003

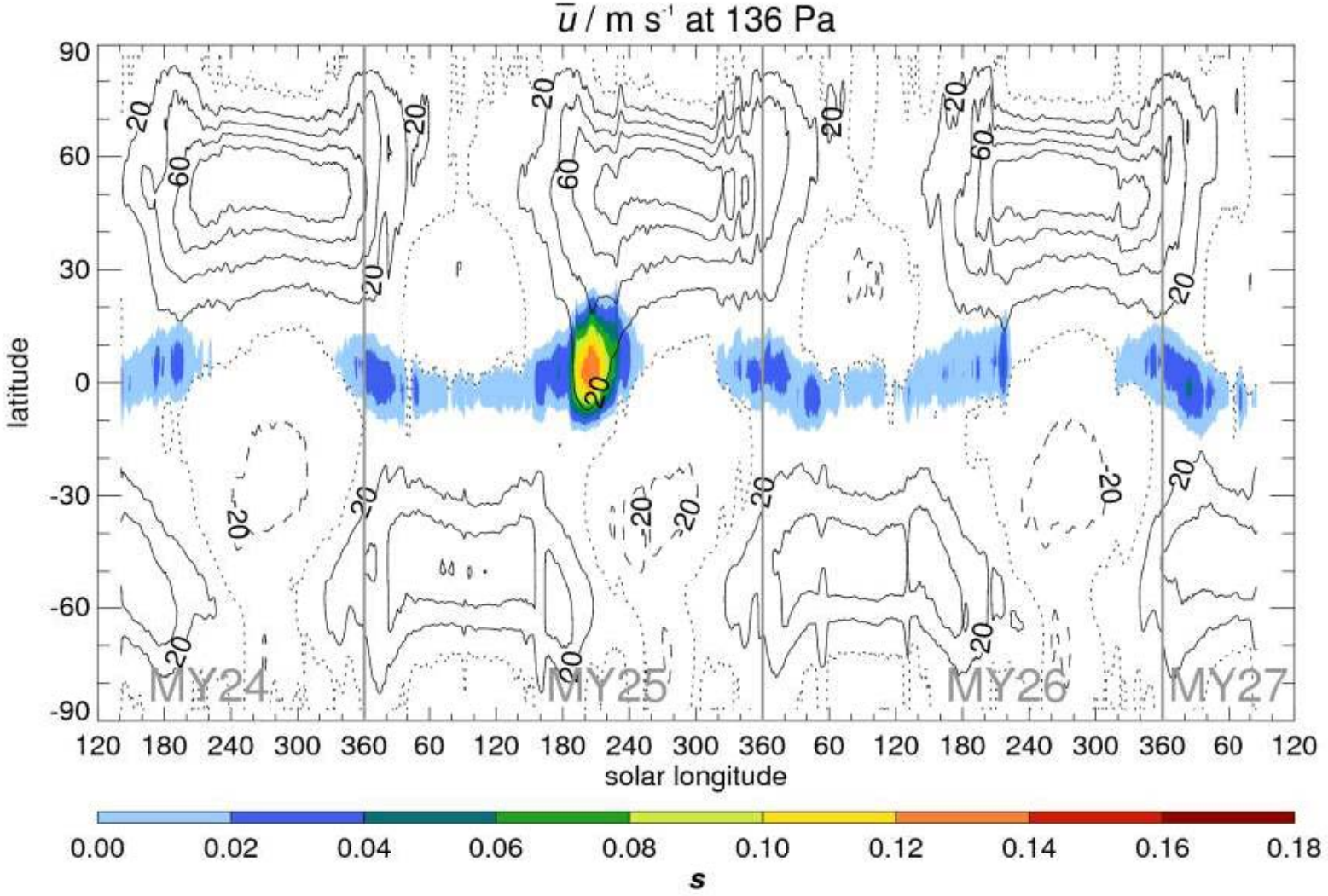


Zonal mean, daily averages

Westerly Equatorial Jet

Local super-rotation index: Mars

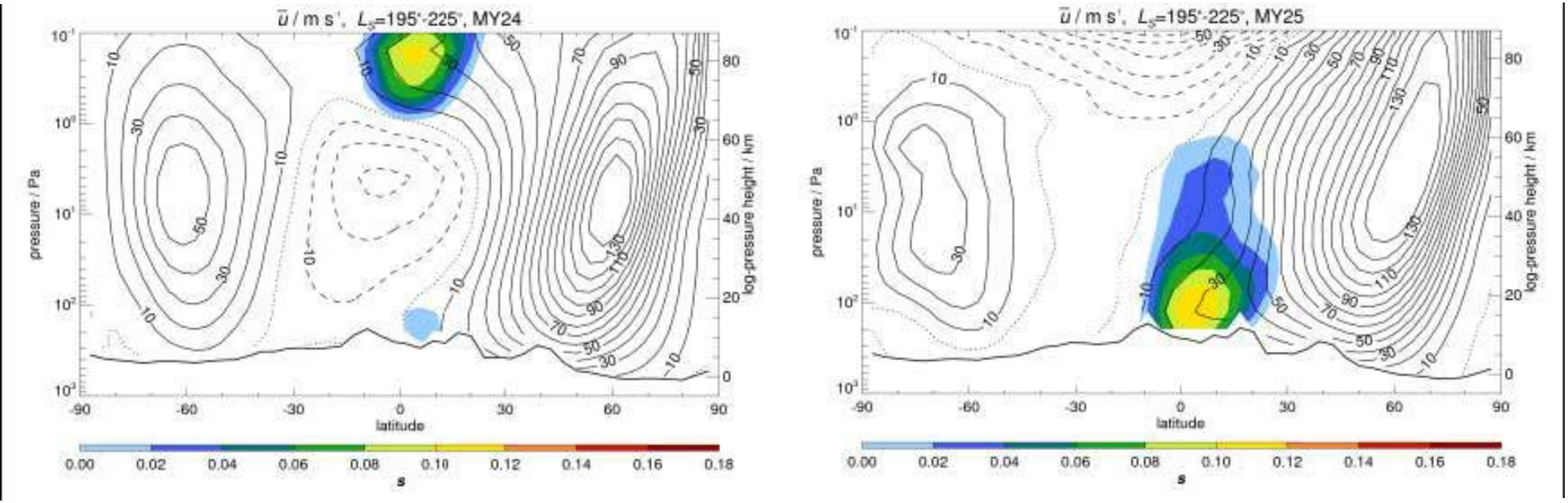
$$s = \frac{L_{atm}}{L_{rest}} - 1 > 0$$



Westerly Equatorial Jet

Local super-rotation index: Mars

$$s = \frac{L_{atm}}{L_{rest}} - 1 > 0$$

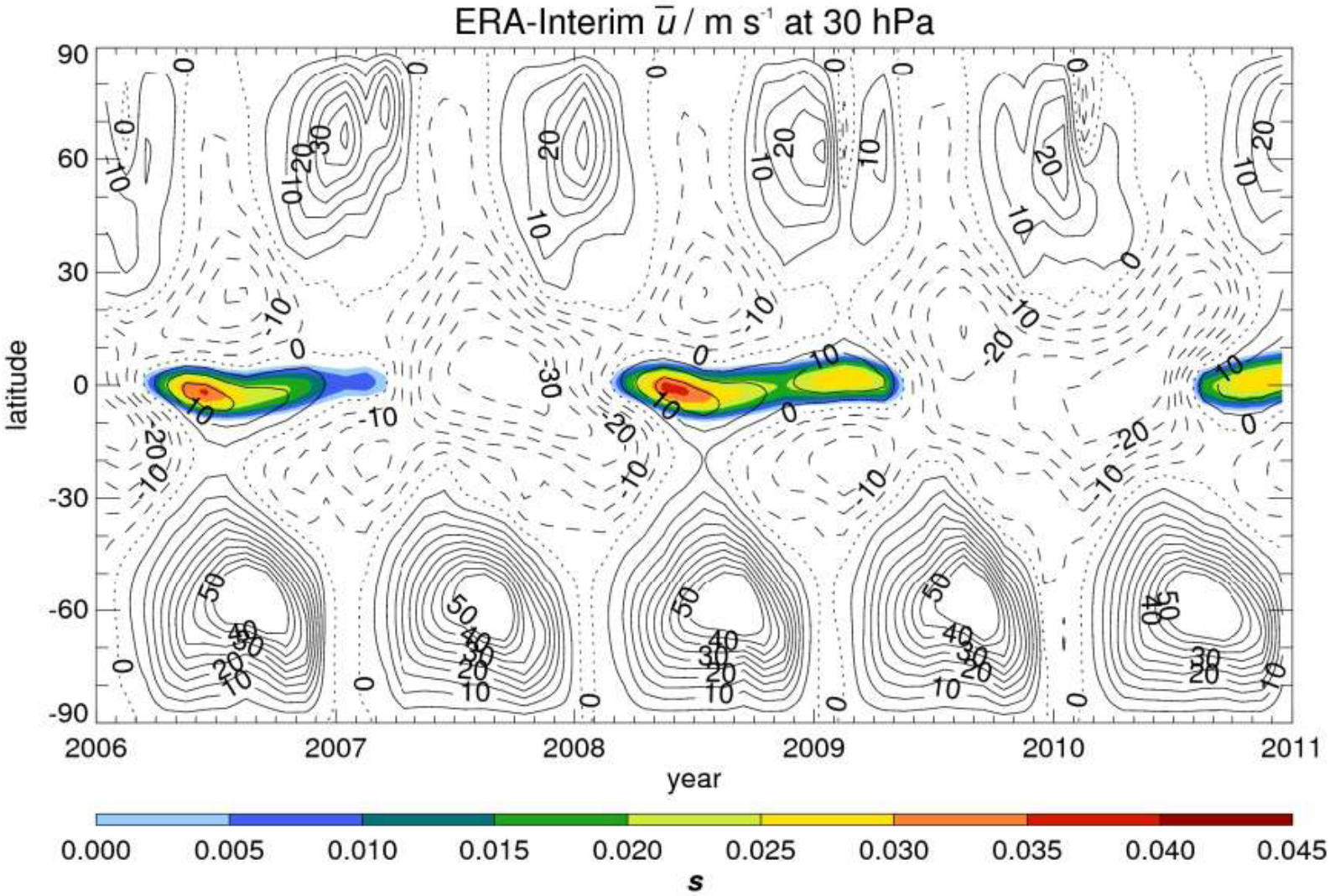


Autumn (L_S = 195°—225°) in MY24 and MY25

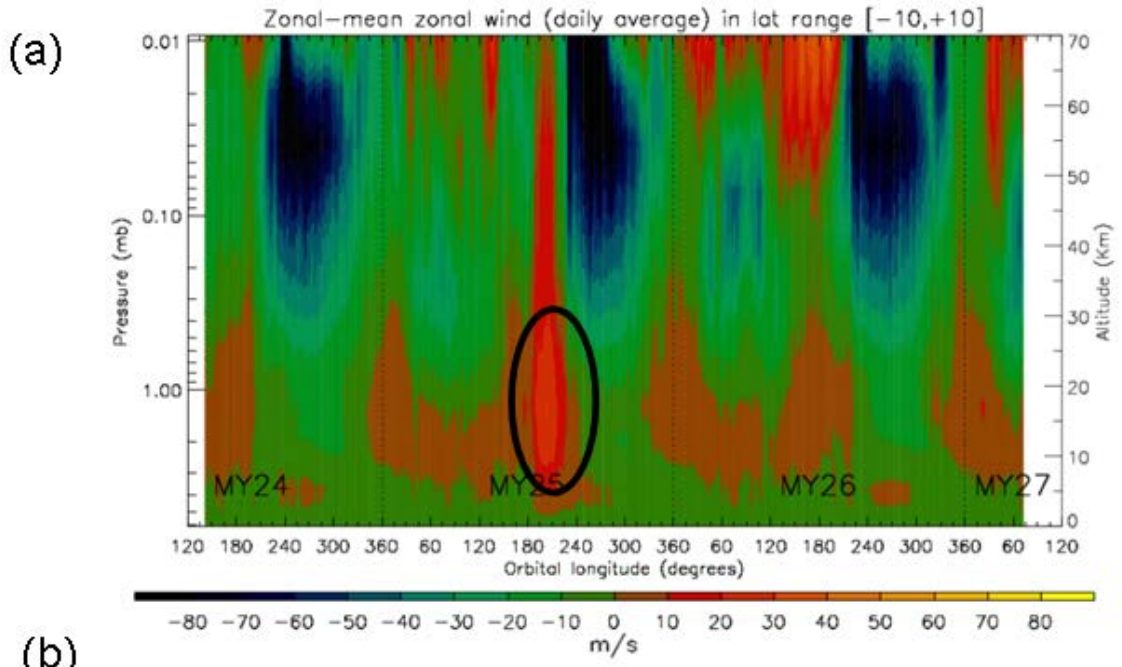
Westerly Equatorial Jet...on Earth

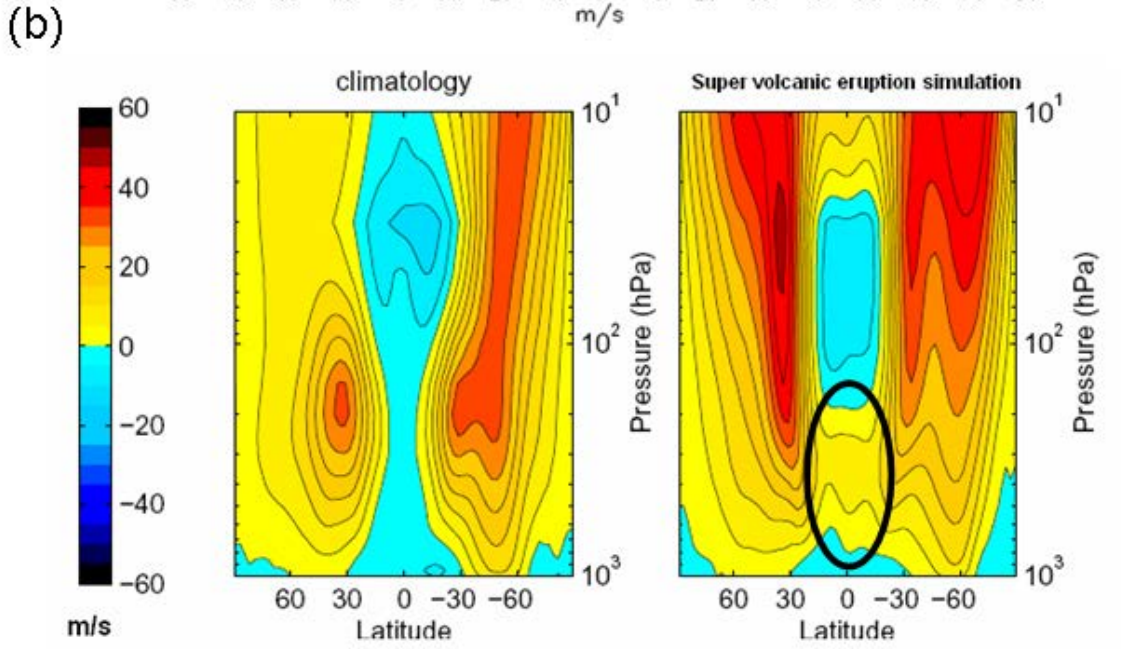
Local super-rotation index: Earth

$$s = \frac{L_{atm}}{L_{rest}} - 1 > 0$$



Westerly Equatorial Jet...on Earth

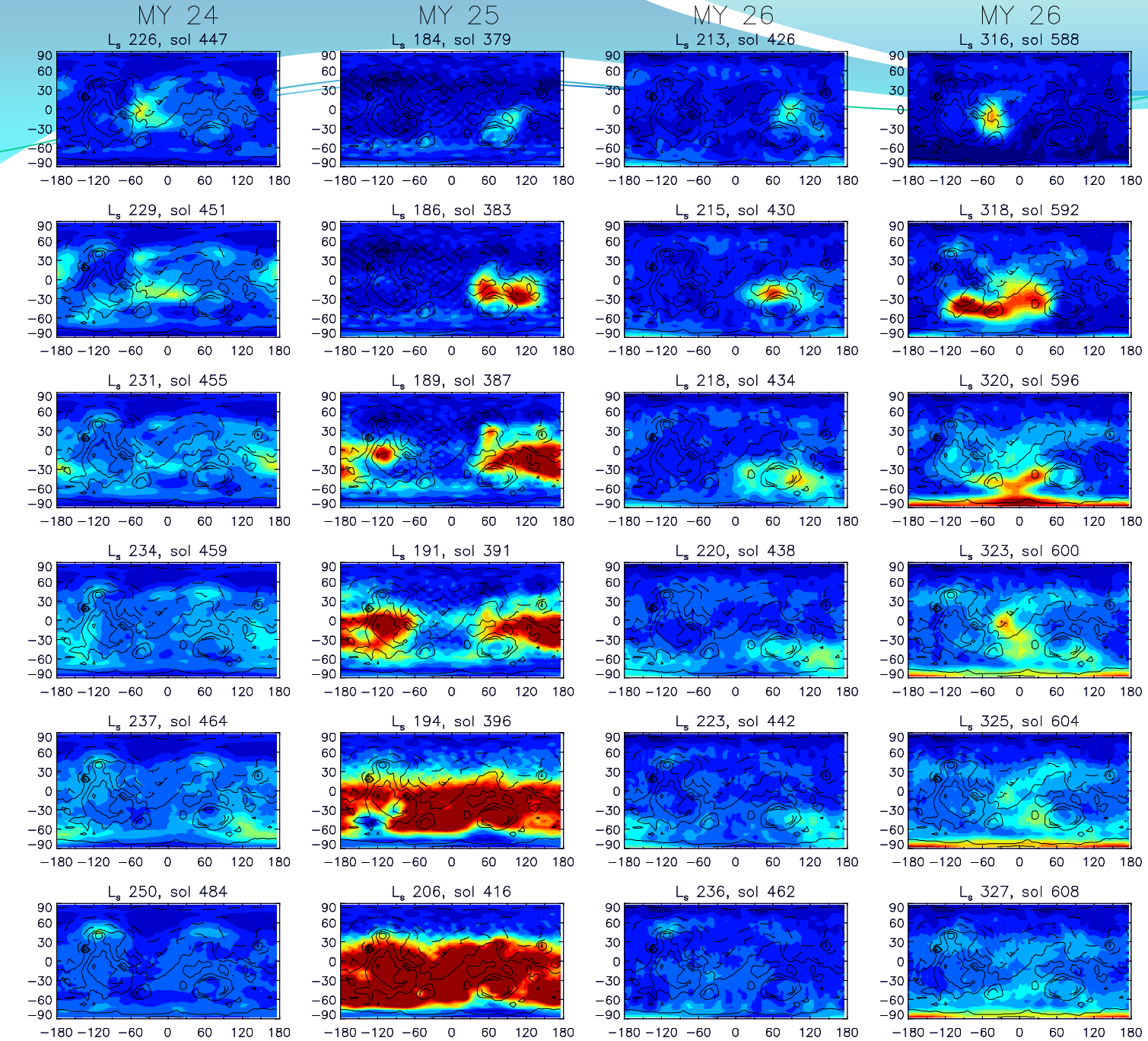




Mars

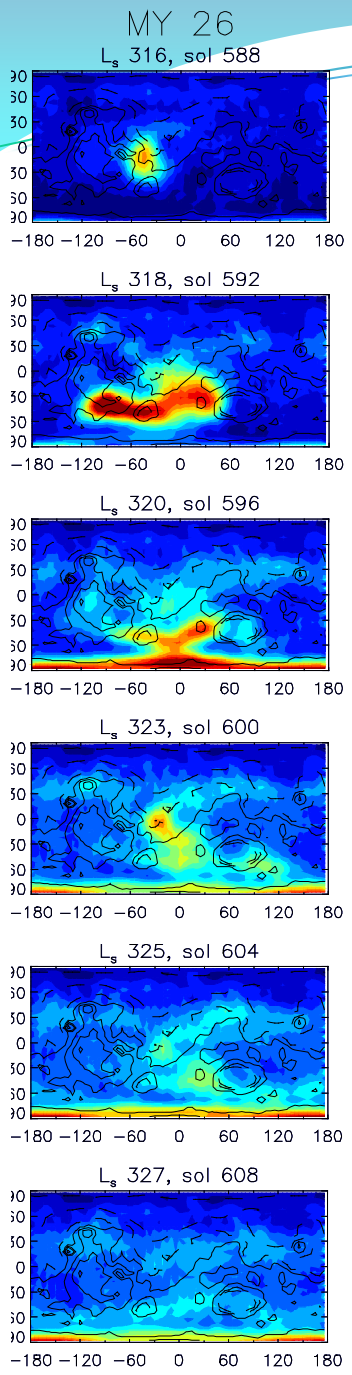
(Past) Earth

B. Harris (Ph.D. thesis, 2009)

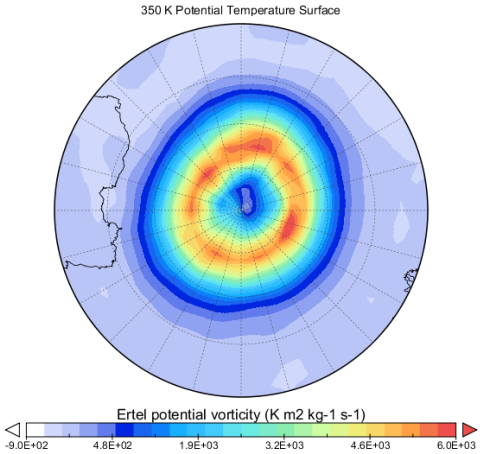


Dust Storm Atlas

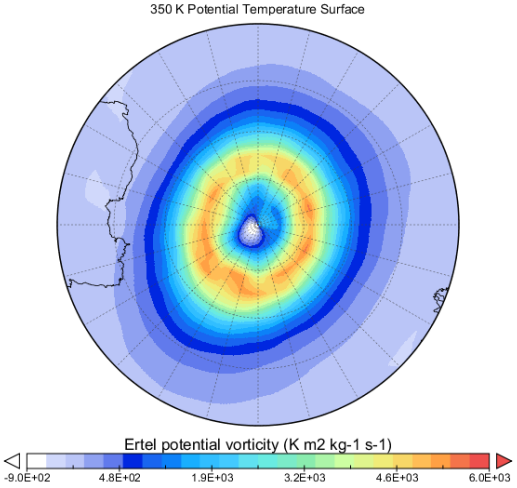
2003b Regional Dust Storm: Impact on NH polar vortex



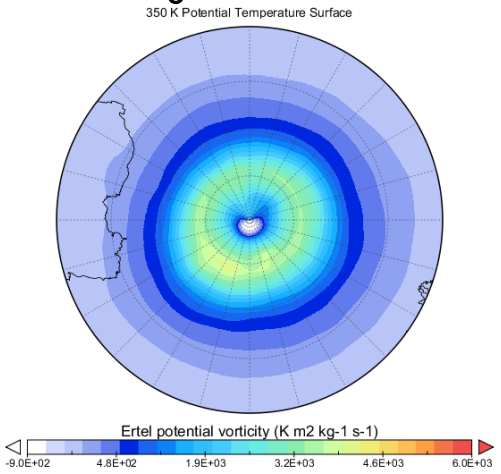
15 sols before



15 sols after



L_s~324°



ありがとうございます。!