PennState

Ensemble Data Assimilation for a Mars Atmosphere and Aerosol Reanalysis

Hartzel Gillespie, Brandon Smith, Steven Greybush (PSU)
Matthew Wespetal, Eugenia Kalnay (UMD)
Thomas Nehrkorn, Mark Leidner, Ross Hoffman (AER)
John Wilson (NASA Ames)

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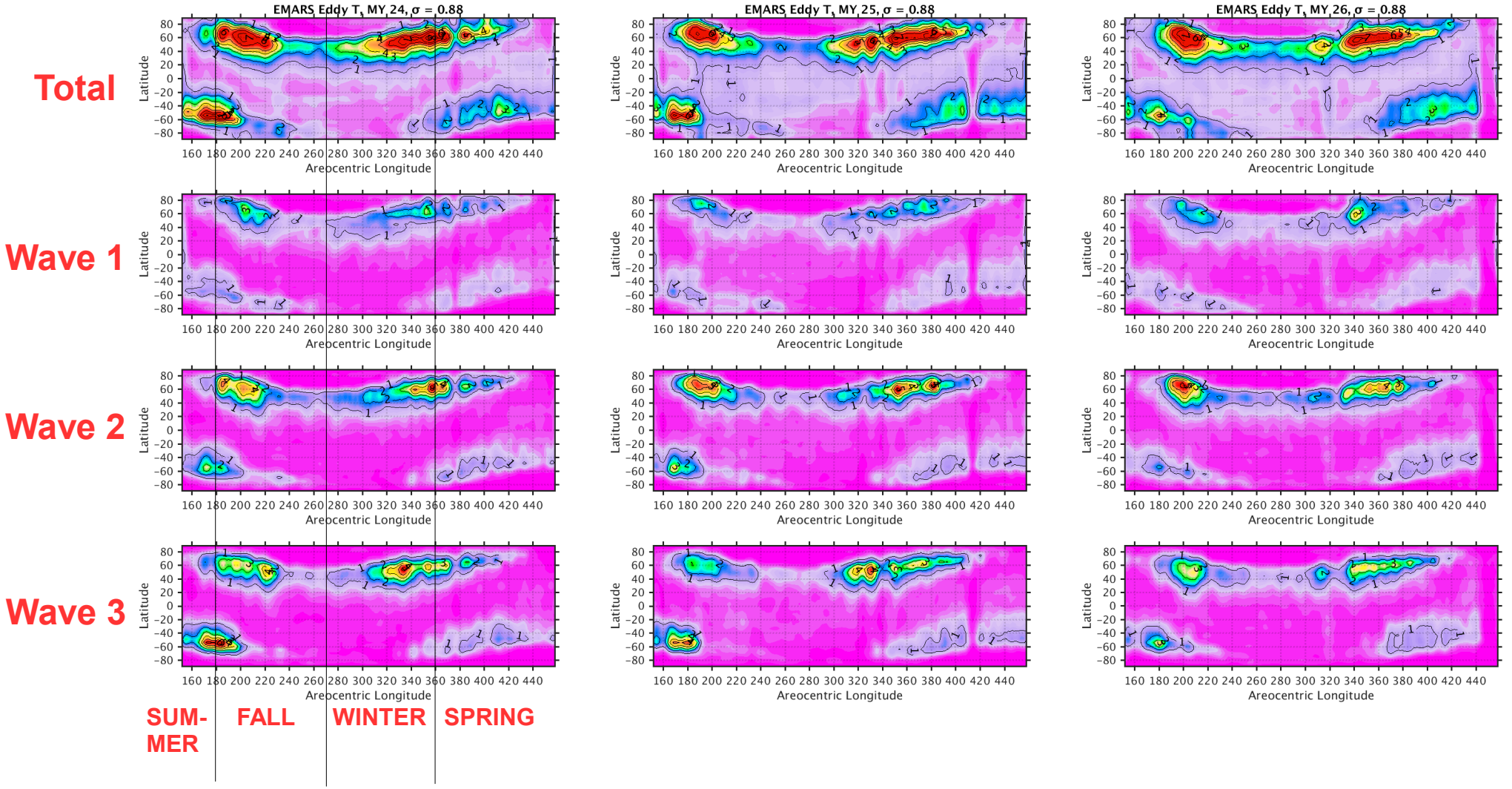
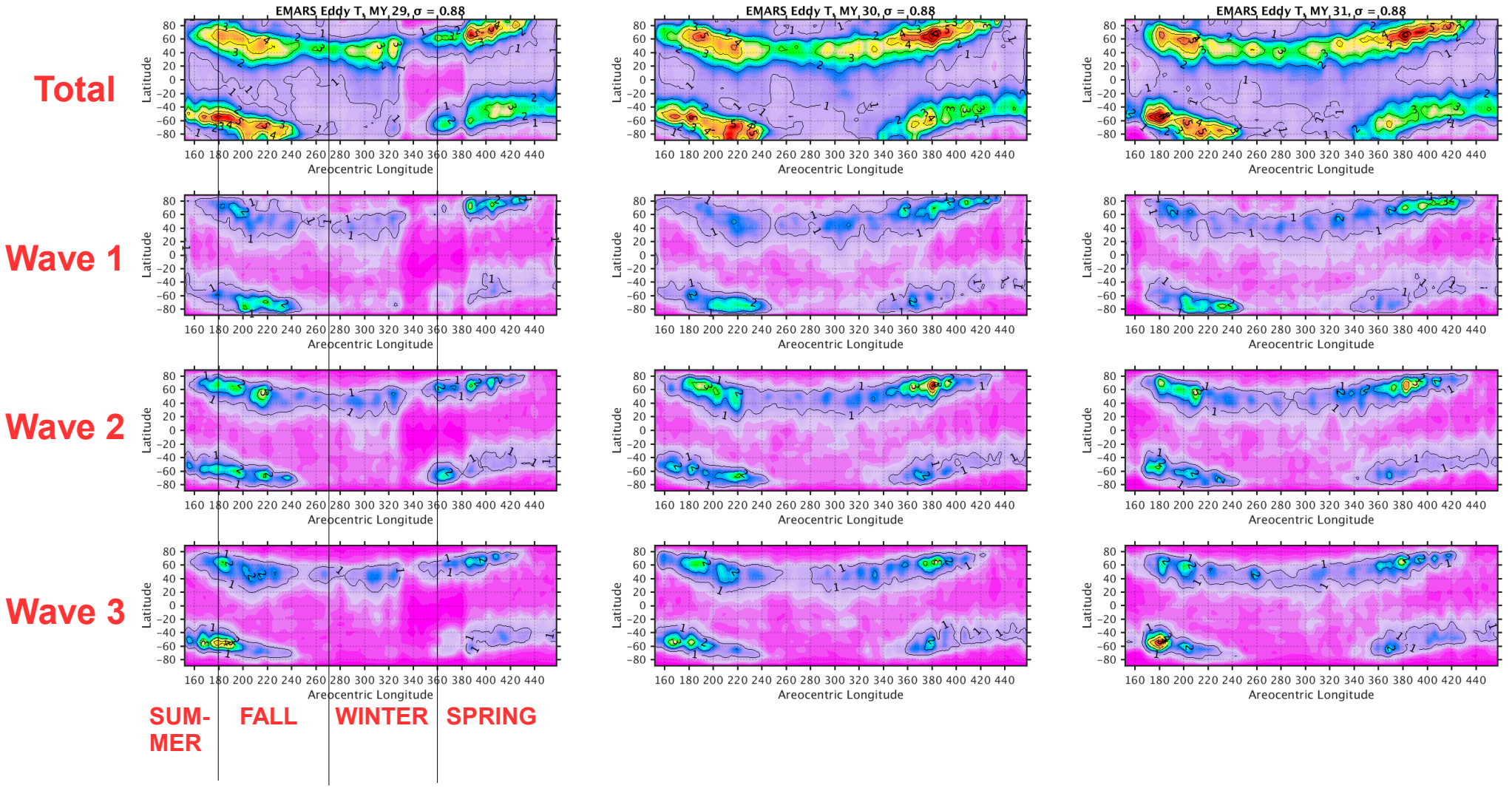
Martian Traveling Waves

- Present in the cooler months, near the edge of the polar ice cap
- Sizes of Mars's traveling weather systems comparable to Earth's
- Take approximately 7 days to travel once around Mars
- Hypothesized that dust storms occur more frequently during times dominated by short-period wavenumber 3 traveling waves

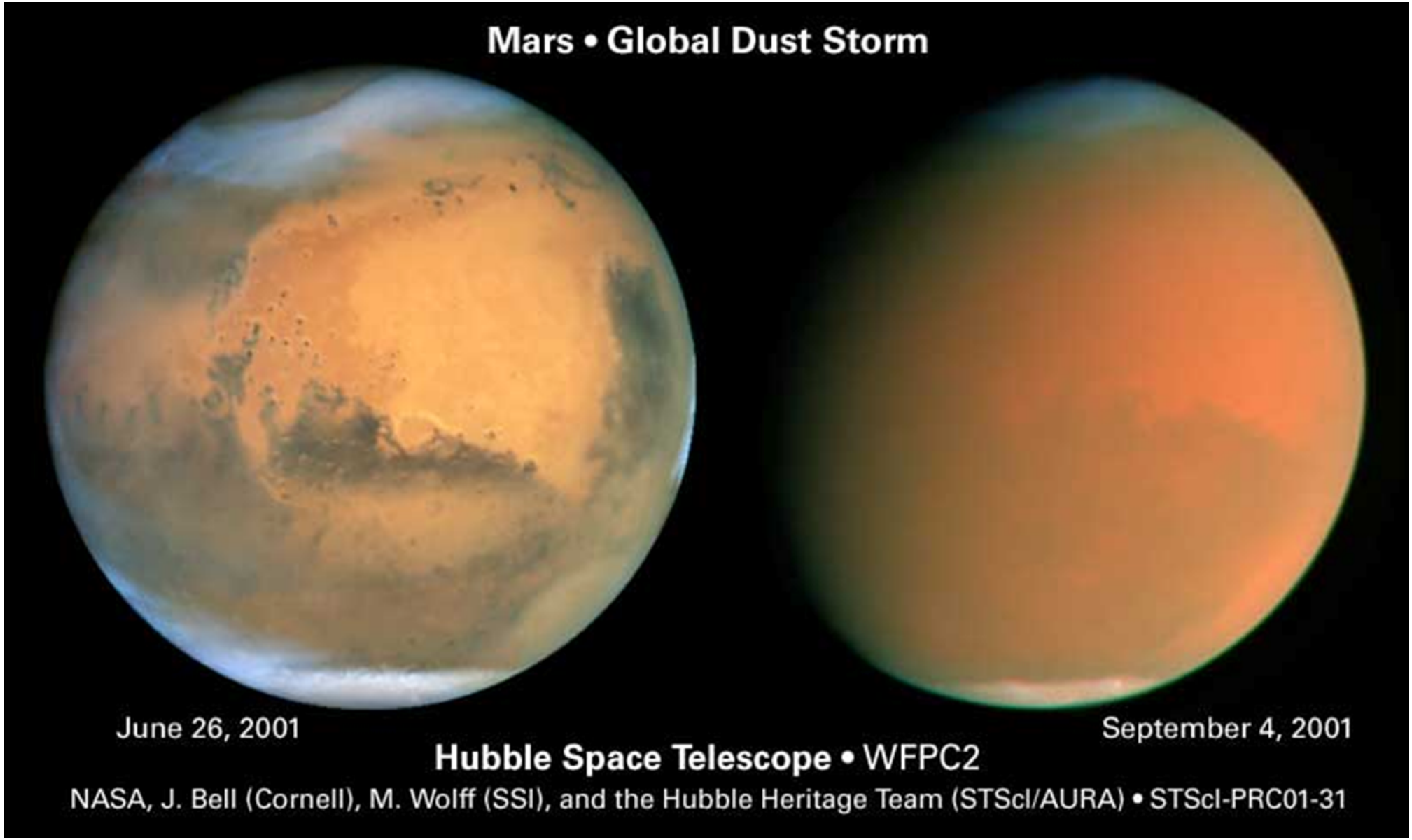


- Zonal RMS eddy temperature in the EMARS TES assimilation
- Data taken from about 1.5 km above ground

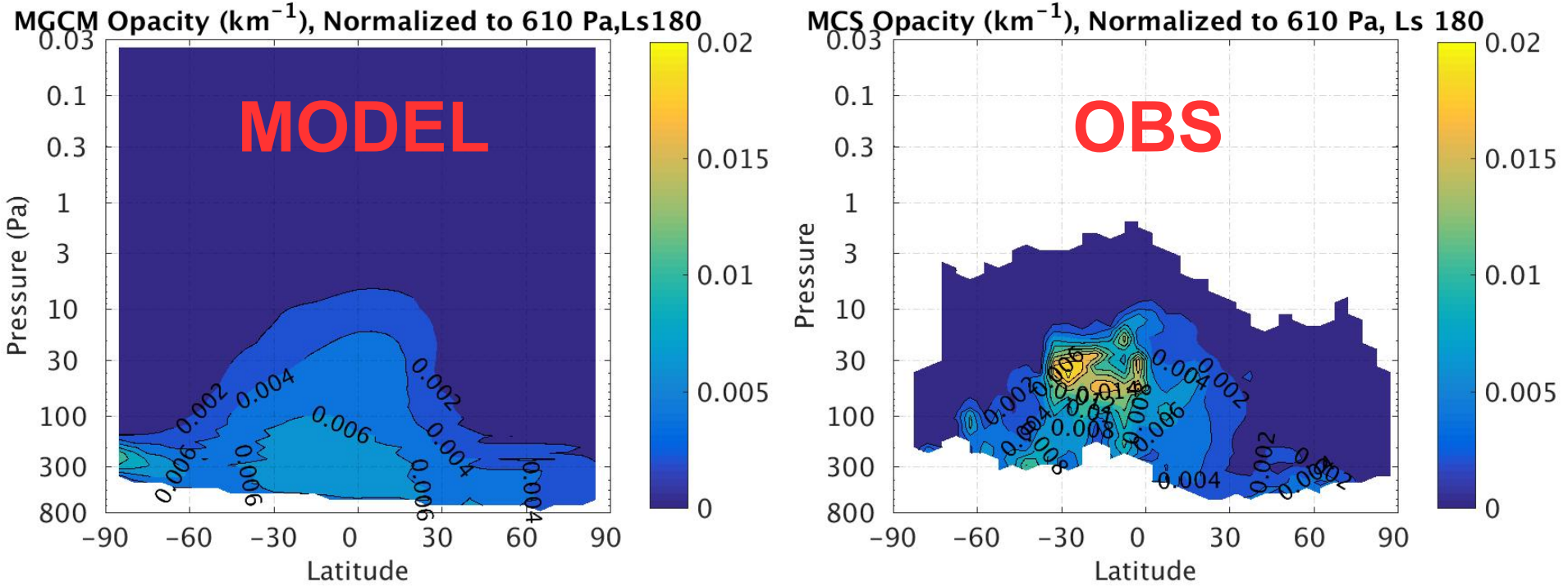


- Zonal RMS eddy temperature in the EMARS MCS assimilation
- Temperature obs from MCS used, but not dust obs

Dust is a major feature of Martian weather



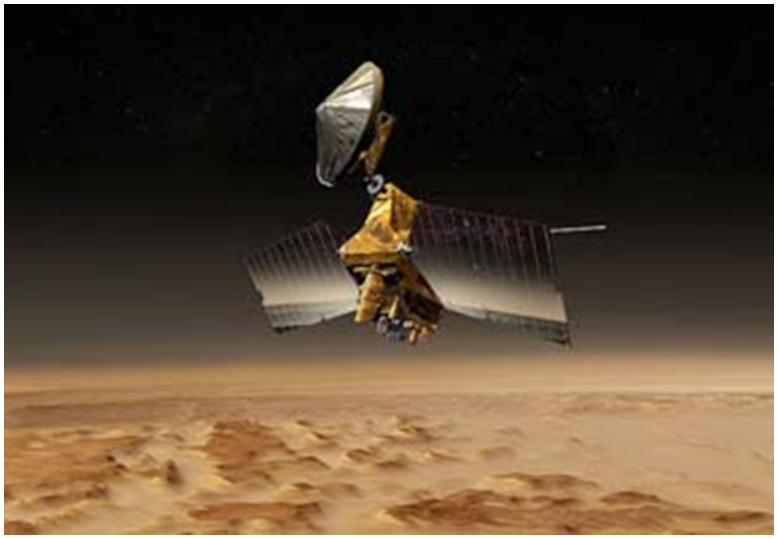
Models do not represent the observed distribution of dust on Mars well



- Model contains 3 dust tracers of different sizes, matched to observed dust by adding and removing from the boundary layer
- Detached dust layer observed but not modeled

Observations of the Martian atmosphere are limited

- MCS (Mars Climate Sounder)
- Sun-synchronous polar orbiter
- Vertical profiles of temperature, dust, and water ice retrieved

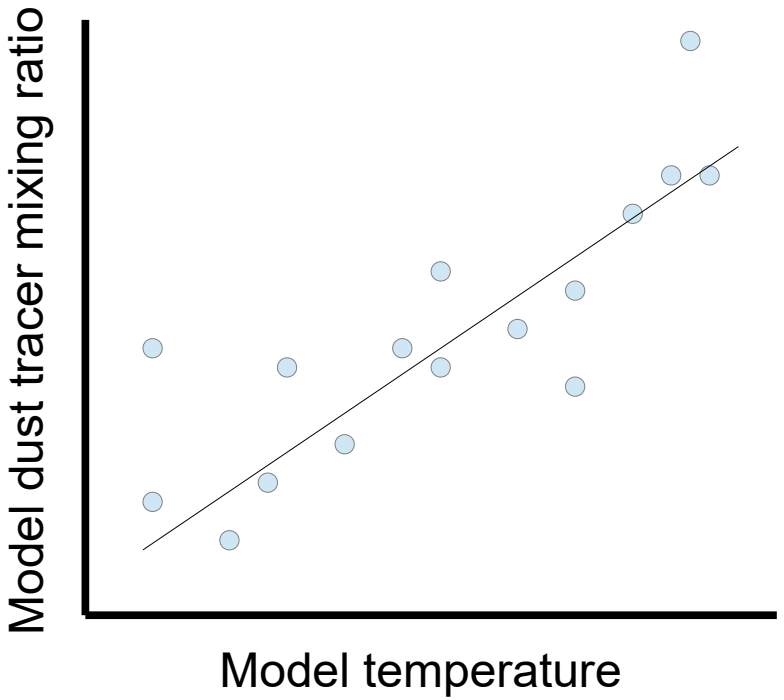


Data assimilation addresses the shortcomings of model and obs

- LETKF used to combine model and observation information
- Existing MCS assimilation updates wind, surface pressure, and temperature using temperature obs
- 16-member ensemble, with dust varied from 70% to 130% of normal among the members
- Can also update dust using temperature obs

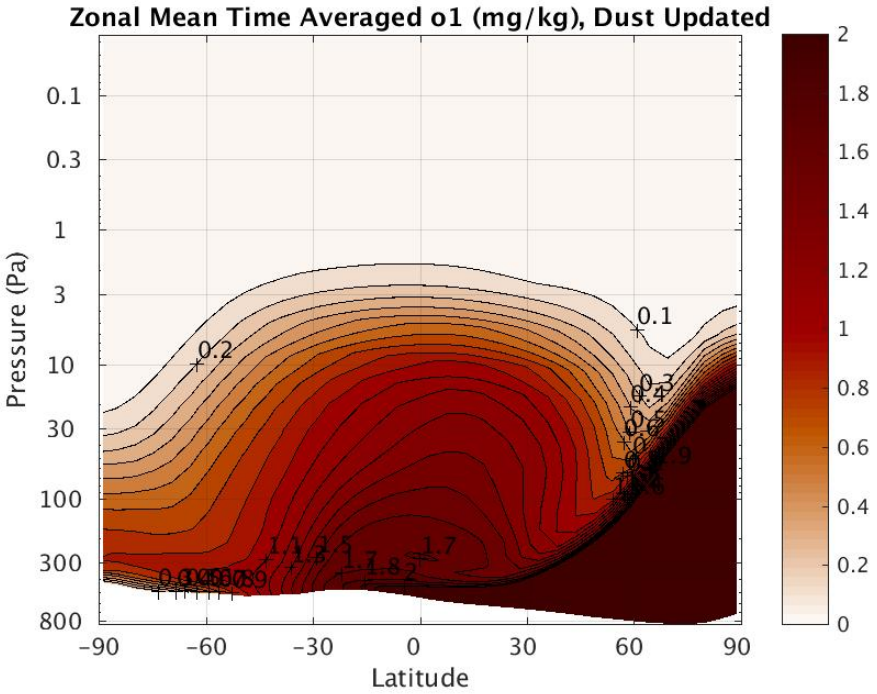
Updating dust using temperature obs

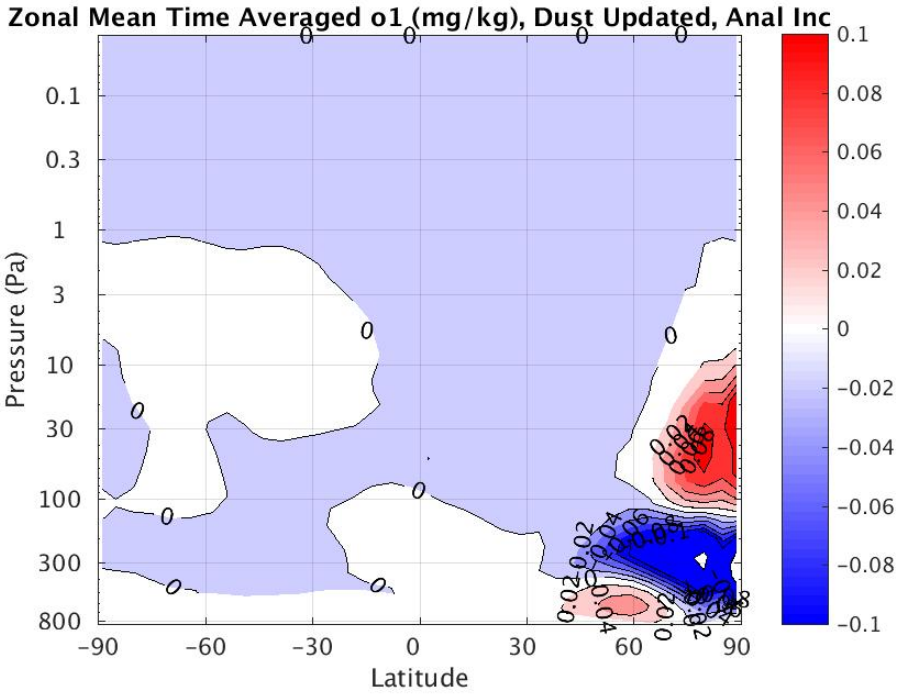
- At every location where dust will be updated using a temperature observation, compute the covariance between temperature and dust



$$\text{Slope} = \frac{\text{Covariance}}{\text{Var(Temp)}}$$

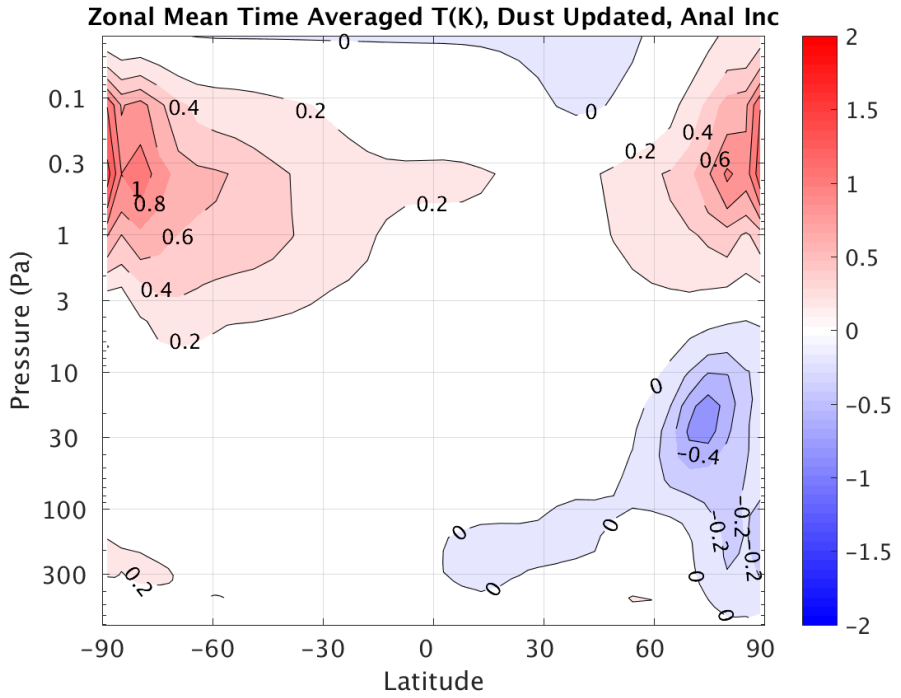
Updating dust using temperature obs without filtering is problematic

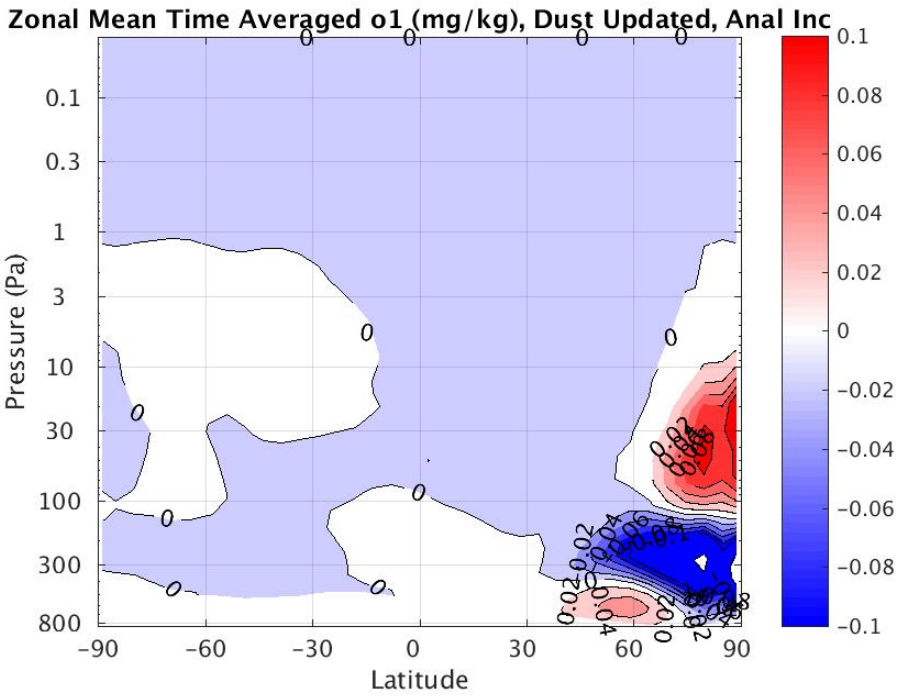




- Reanalysis performed over 116 Martian days during Northern Hemisphere autumn
- Dust builds up in the north polar region

Updating dust using temperature obs without filtering is problematic





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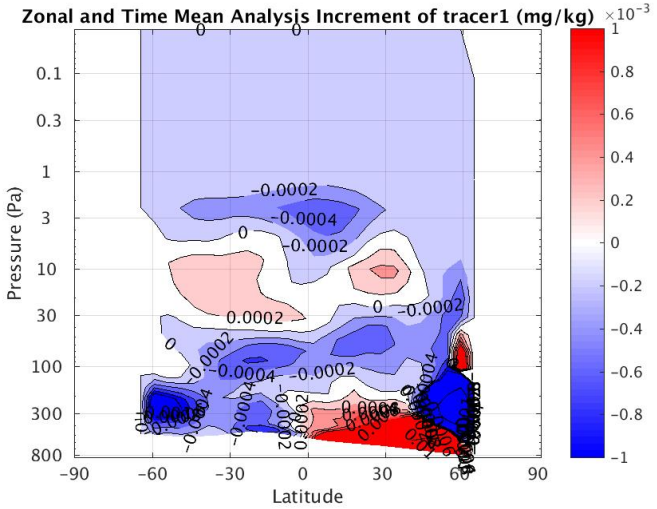
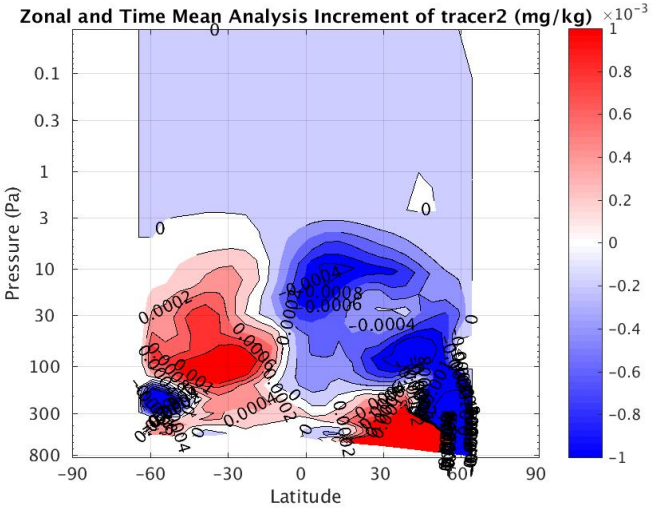
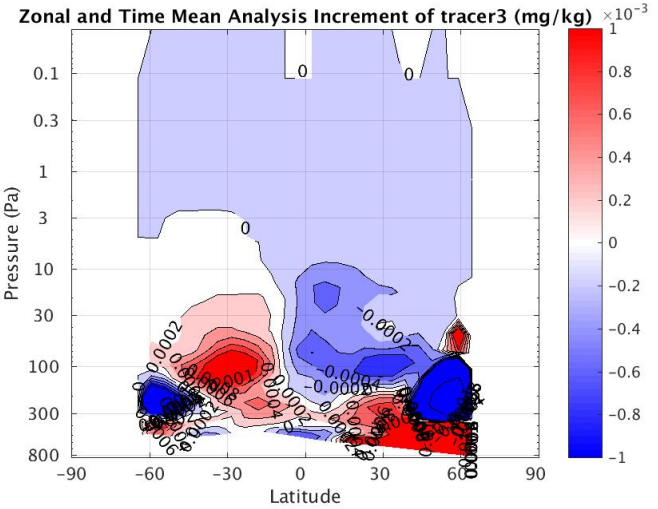
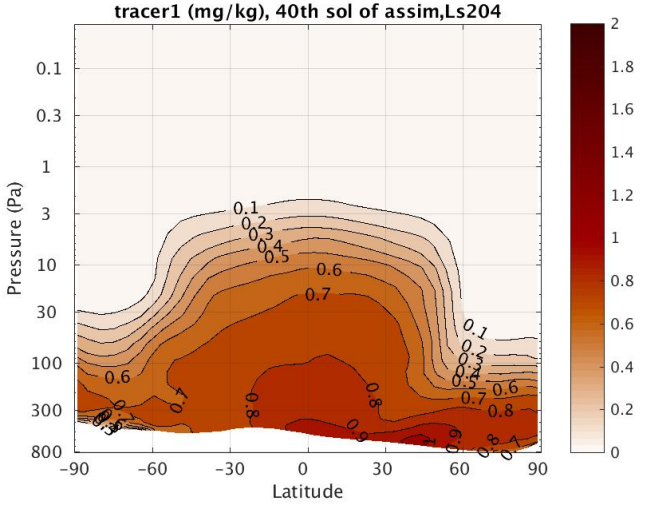
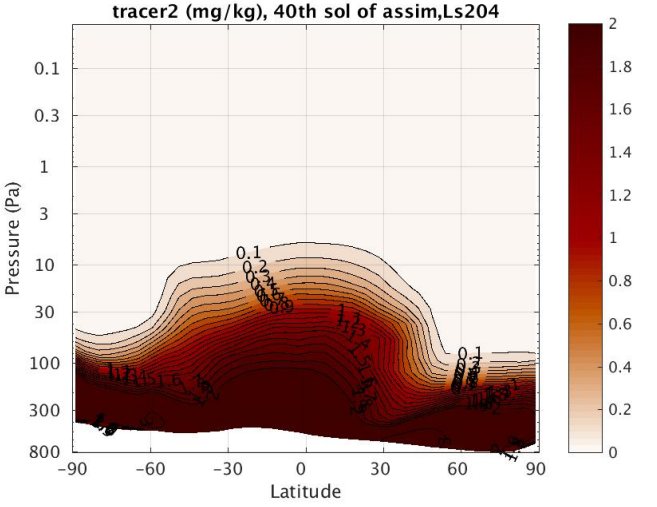
Removing the polar analysis increment helps

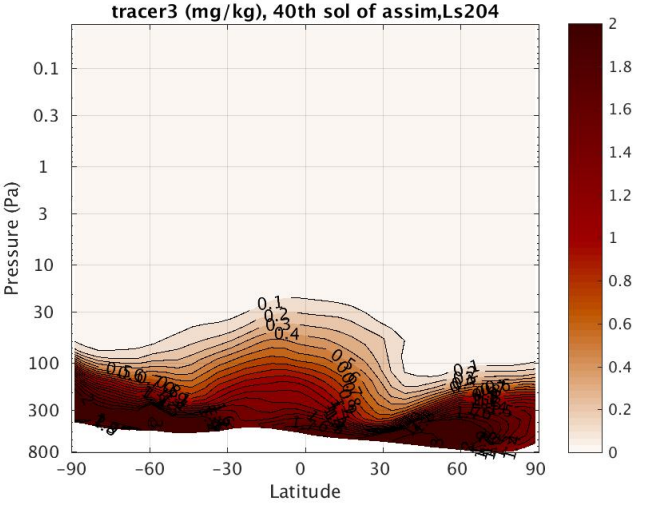




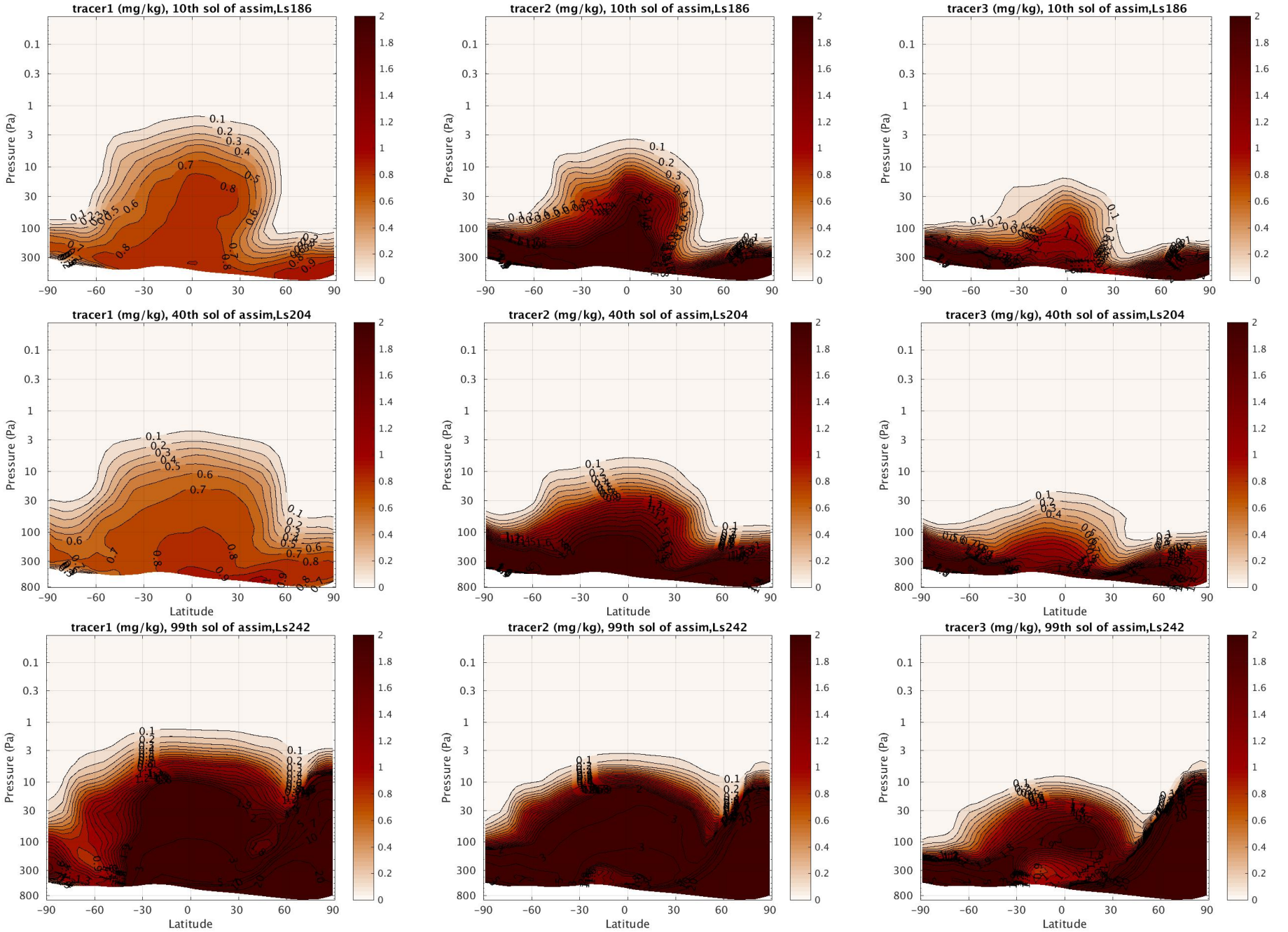








Dust still builds up in the atmosphere



Future Work

- Further stabilization in the polar region
- Assimilating dust observations from MCS
- Using parameter estimation to determine how to distribute dust among the 3 tracers modeled