Modeling the B Regional Dust Storm on Mars

Courtney Batterson[1], Melinda Kahre[2], Alison Bridger[3], R. John Wilson[2], and Richard Urata[1]

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Abstract

The B storm is an annually recurring, regional-scale dust storm that occurs over the south pole of Mars during southern summer solstice season during years lacking a global dust storm [1]. The B storm begins just after perihelion (Ls = 251°), reaches peak strength around southern summer solstice (Ls = 270°), and decays through ˜Ls = 290° [2]. The B storm is associated with mid-level atmospheric warming in which 50 Pa (2.5 scale heights) temperatures increase to over 200 K. Mid-level dust concentrations more than triple during the B storm, exceeding 4 ppm throughout the duration of the storm and exceeding 10 ppm at peak strength (Ls = 270°) [1,2]. Our observational analysis, which was presented at AGU in 2020, shows that elevated dust concentrations (> 4 ppm) and associated warming (> 200 K) are observable as high as 25 Pa during peak intensity, and that the B storm is a southwestward-propagating storm that develops over 60° S and strengthens as it travels poleward [2,3]. We have since carried out simulations of B storms using the NASA Ames Mars Global Climate Model (MGCM), which is based on the NOAA/GFDL cubed-sphere finite volume dynamical core, at high spatial (1x1°, 60x60 km) resolution. We find that B storm dust is lofted upwards of 50 Pa by episodic pluming events somewhat resembling the rocket dust storms described in Spiga et al. (2013) [4]. Detached dust layers sometimes form from these plumes at altitudes between 25-3 Pa (3-5 scale heights). These detached layers maintain altitude for ˜1 sol before the sedimentation rate of the dust exceeds the upward vertical velocity generated by the radiative heating of the suspended dust [5]. We will present results from the MGCM-simulated B storm using three-dimensional animations to illustrate the hourly evolution of the dust that is lofted during the storm. 1. Kass D. M. et al. (2016). Geophs. Res. Letters, 43, 6111–6118. 2. Batterson, C.M.L. et al. (2021). Scholarworks, SJSU Master's Theses, 5174. 3. Batterson, C.M.L. et al. (2020). Martian B Storm Evolution: Modeling Dust Activity over the Receding South Polar CO2 Ice Cap at Southern Hemisphere Summer Solstice, Abstract (P080-0002) presented at 2020 AGU Fall Meeting, 1-17 Dec. 4. Spiga, A. et al. (2013). JGR: Planets, 118(4), 746-767. 5. Daerden, F. et al. (2015). Geophs. Res. Letters, 42, 7319-7326.

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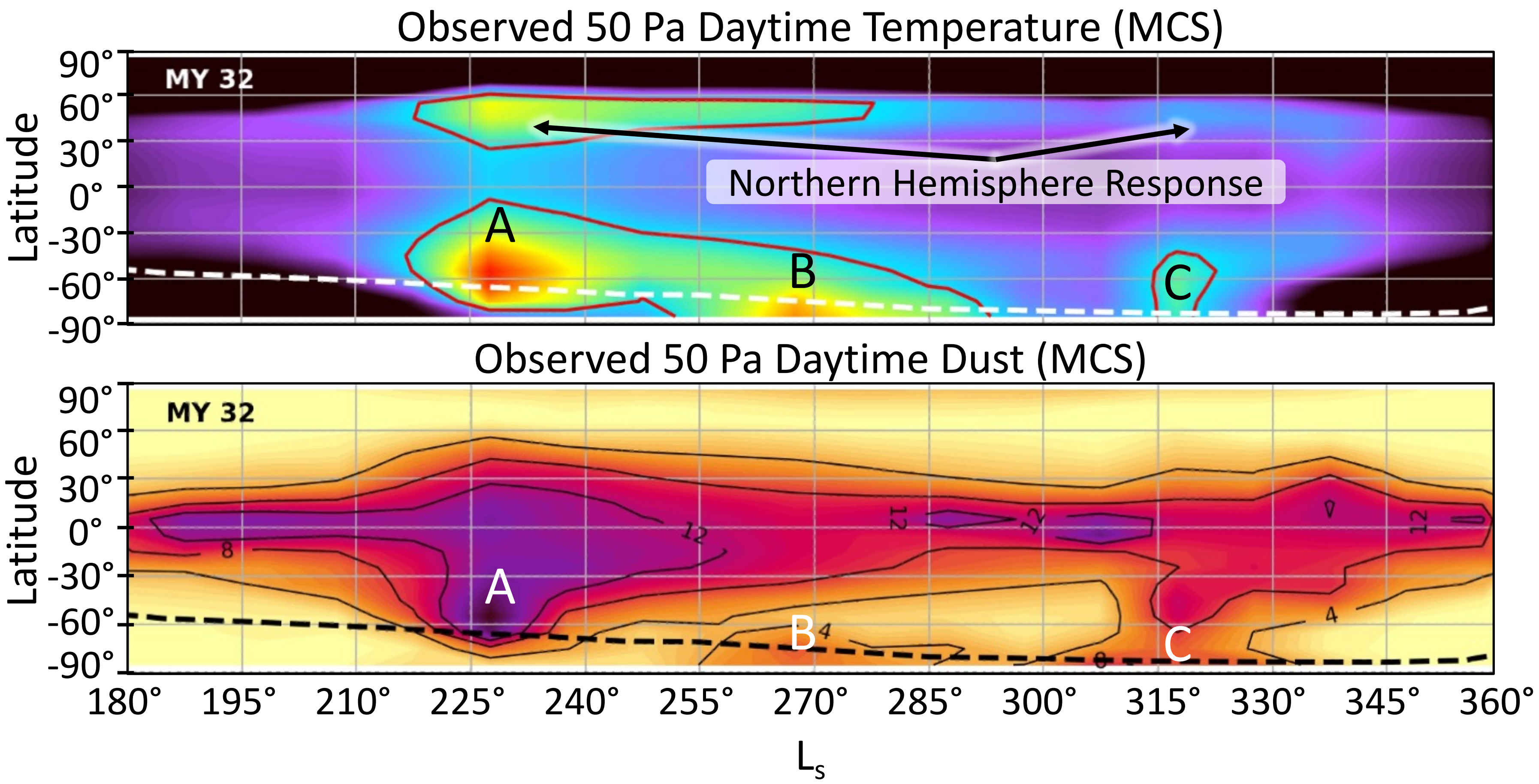
The B Storm[1] is an annual southern summer solstice dust event occurring over the south pole in non-GDS years.

How is dust lofted?

How is dust lifted?



MY32 is a representative year

2. Haberle et al. 2019
3. Kahre et al. 2009

NASA Ames Mars GCM

Cubed-Sphere, Finite-Volume Dynamical Core from NOAA/GFDL

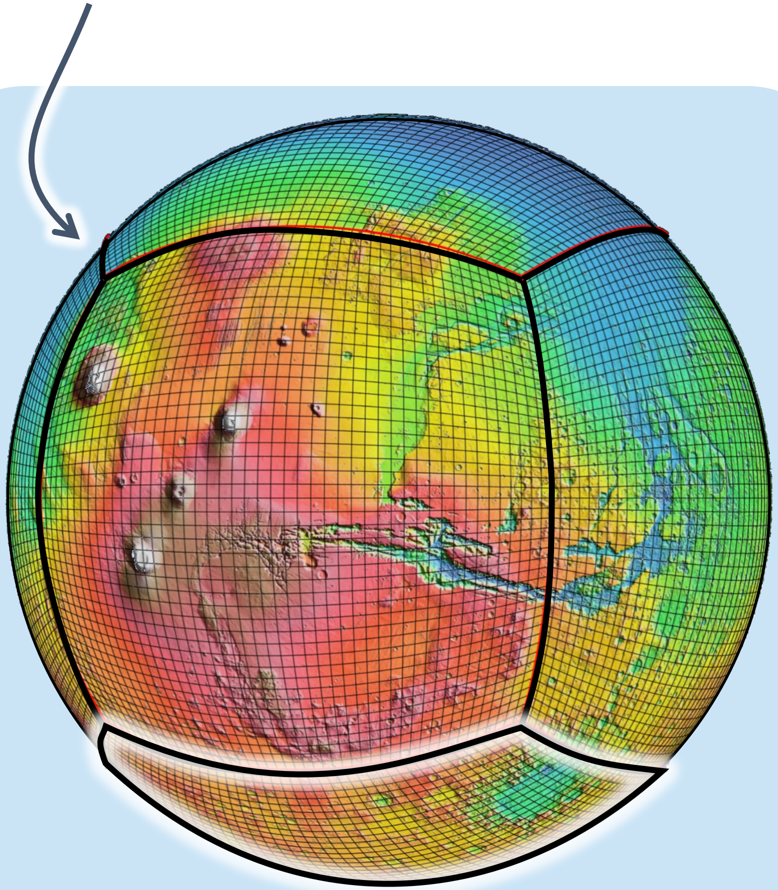


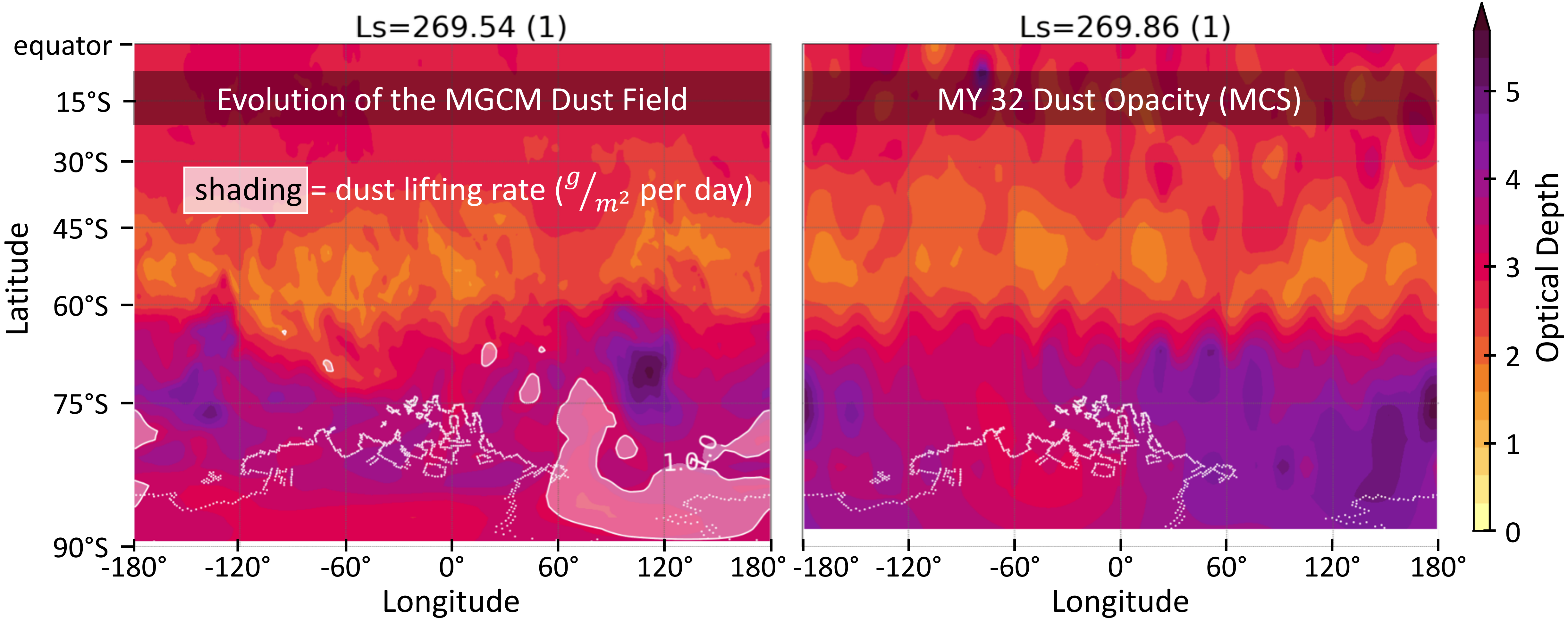
Illustration of the cubed-sphere grid, highlighting the tile over the south pole

- NASA Ames Legacy MGCM physics[2]
- $1x1°$ $(60\ km)$ horizontal resolution
- 30 vertical layers
- No water ice clouds
- Dust Scheme: assimilated dust lifting[3]
- Lifted dust particle size distribution defined by $r_{effective}$ = 3 microns

NASA Ames Mars GCM

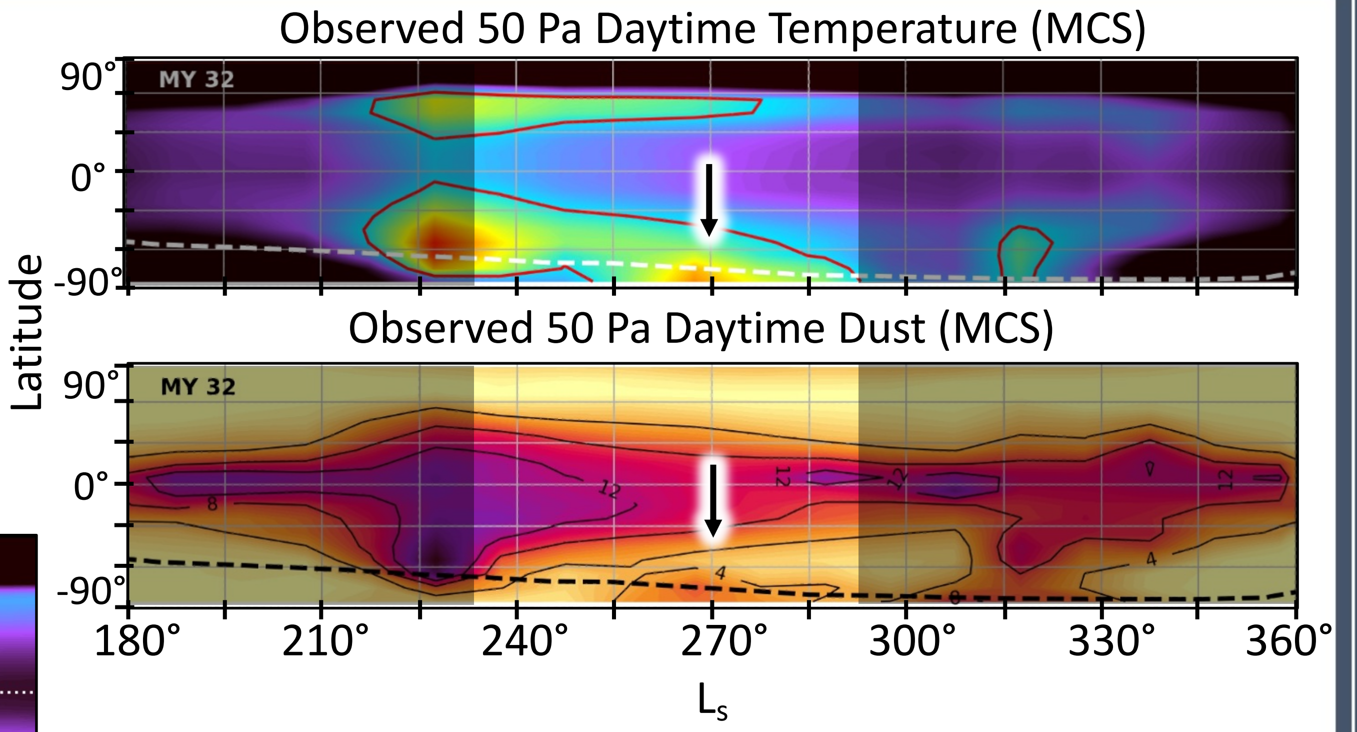
Cubed-Sphere, Finite-Volume Dynamical Core from NOAA/GFDL

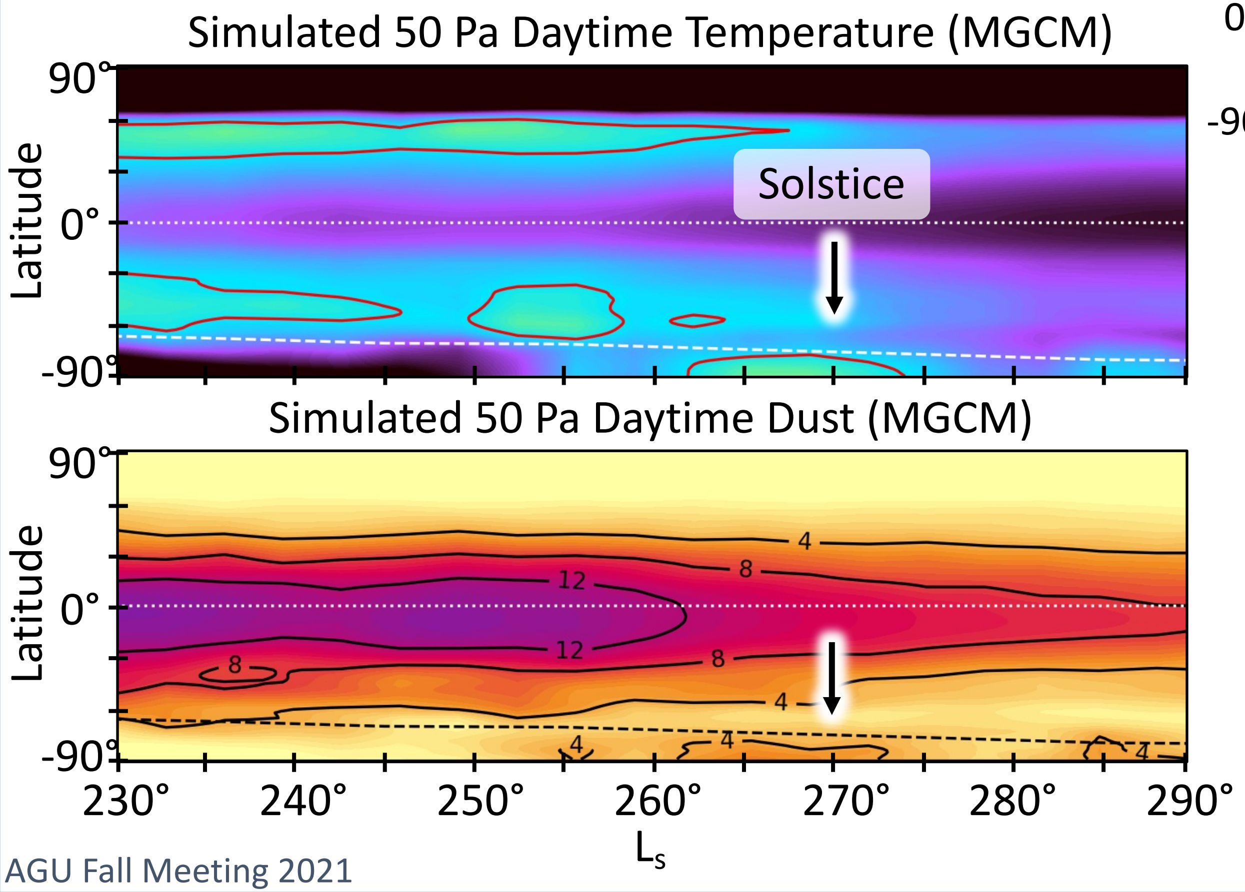
Illustration: Assimilated Dust Lifting Scheme



Key Result #1

The B Storm is reproducible in the MGCM





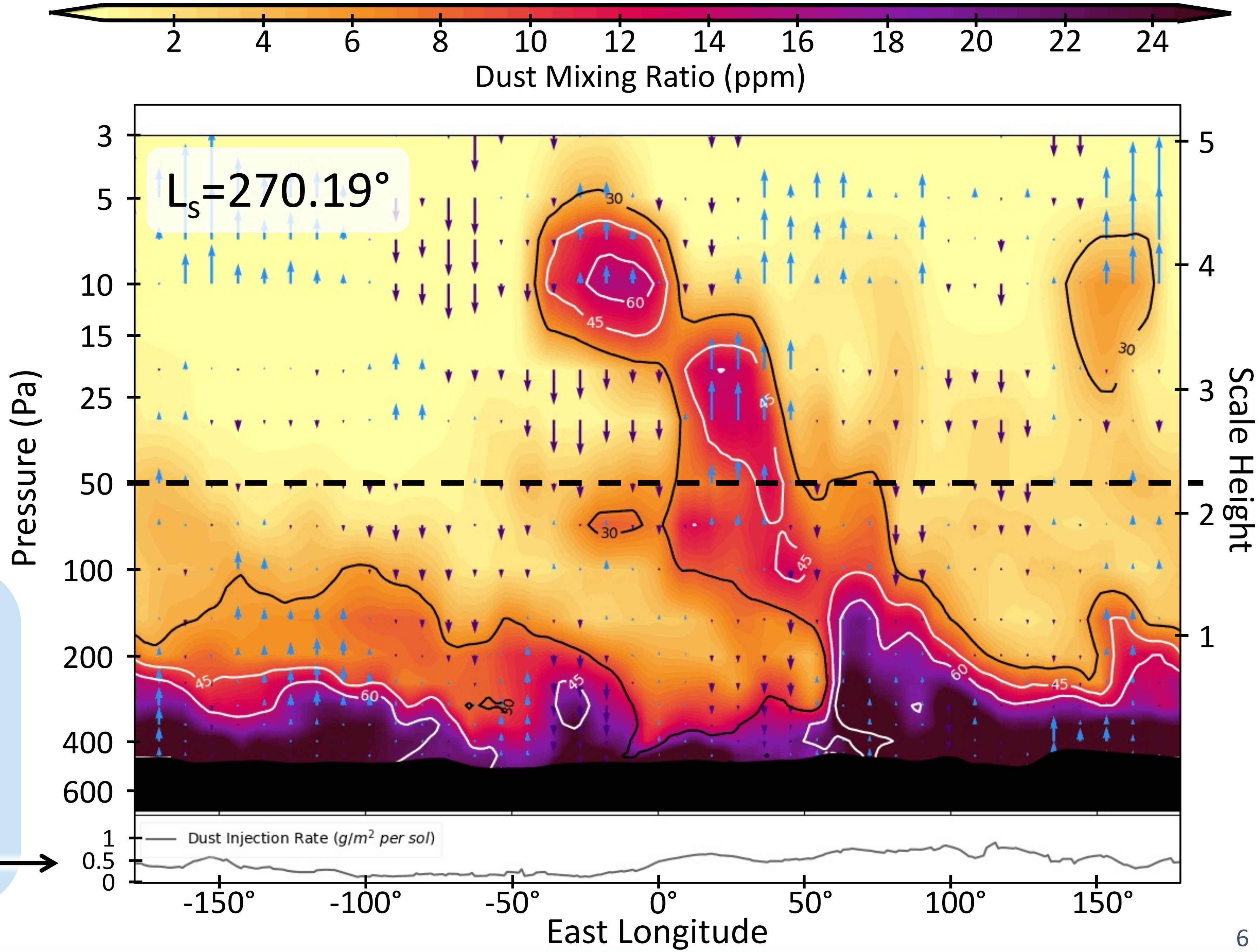
Simulated B storm is less intense but captures the key features of the observed B storm.

$1\ ^{m}/_{s}$ =

Peak Shortwave Heating Rates:
30, 45, and 60 $^{Kelvin}/_{day}$

Local Noon =

20° L_s Rolling Average



Key Result #2

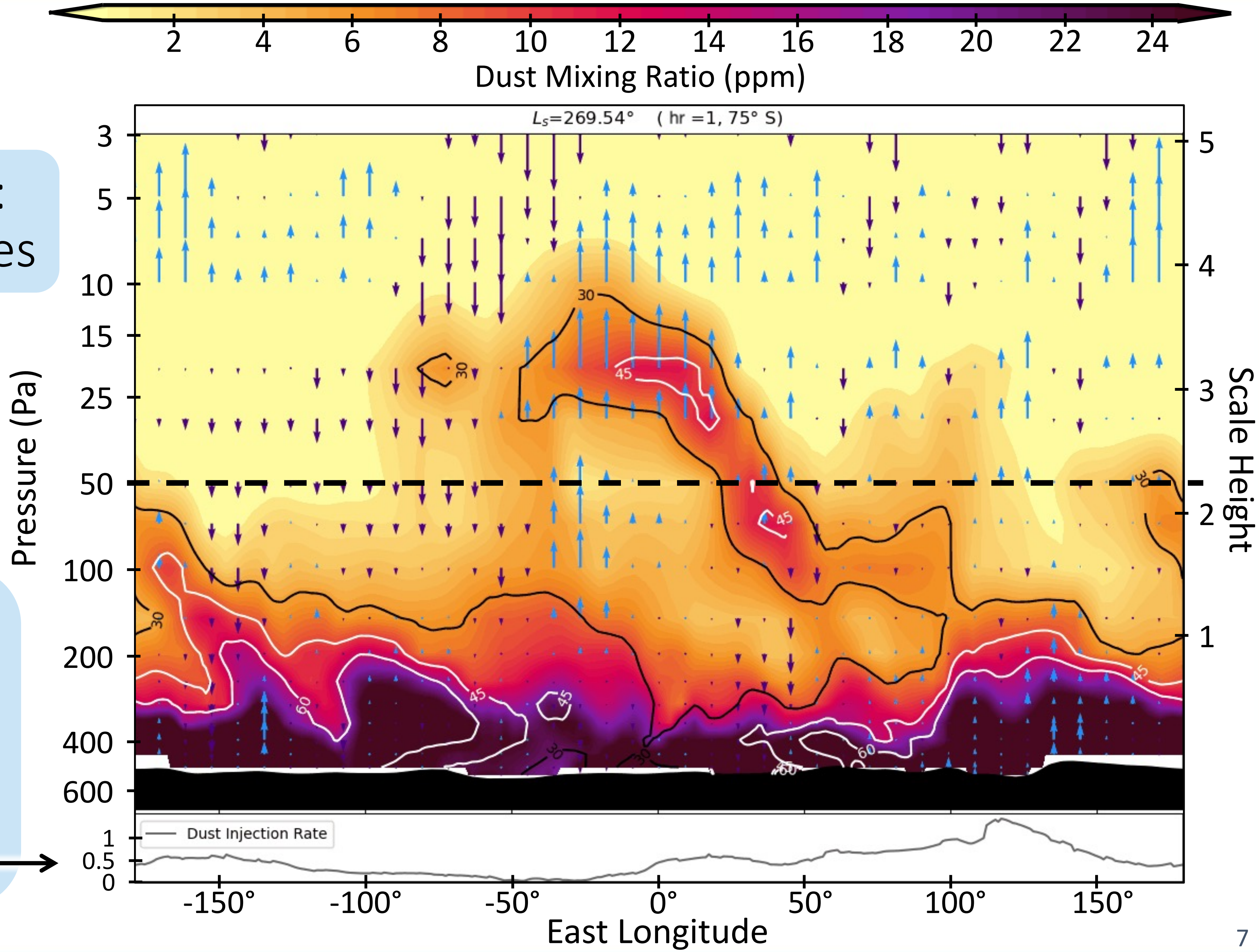
Lofting mechanism: episodic dust plumes

$1\ ^{m}/_{s}$ = ↑

Peak Shortwave Heating Rates:
30, 45, and 60 $^{Kelvin}/_{day}$

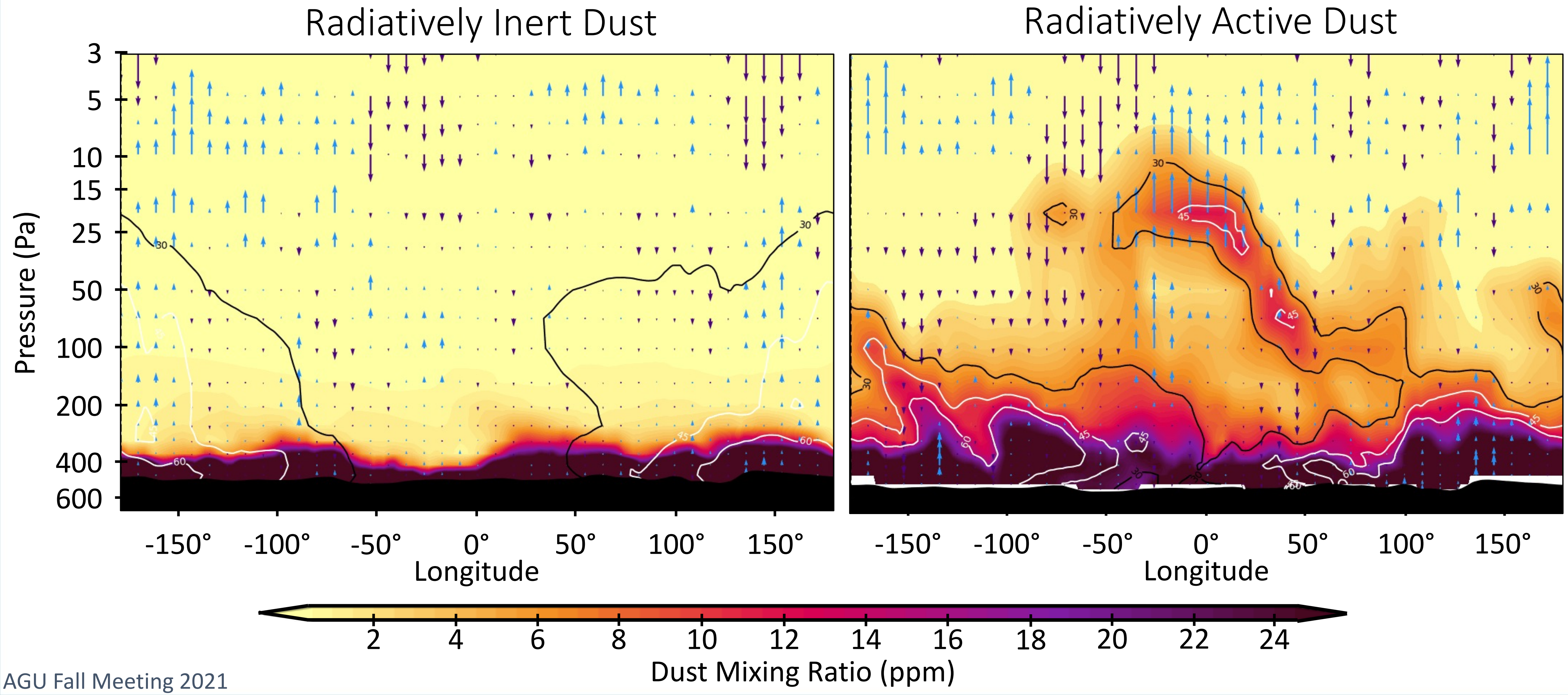
Local Noon = ╎

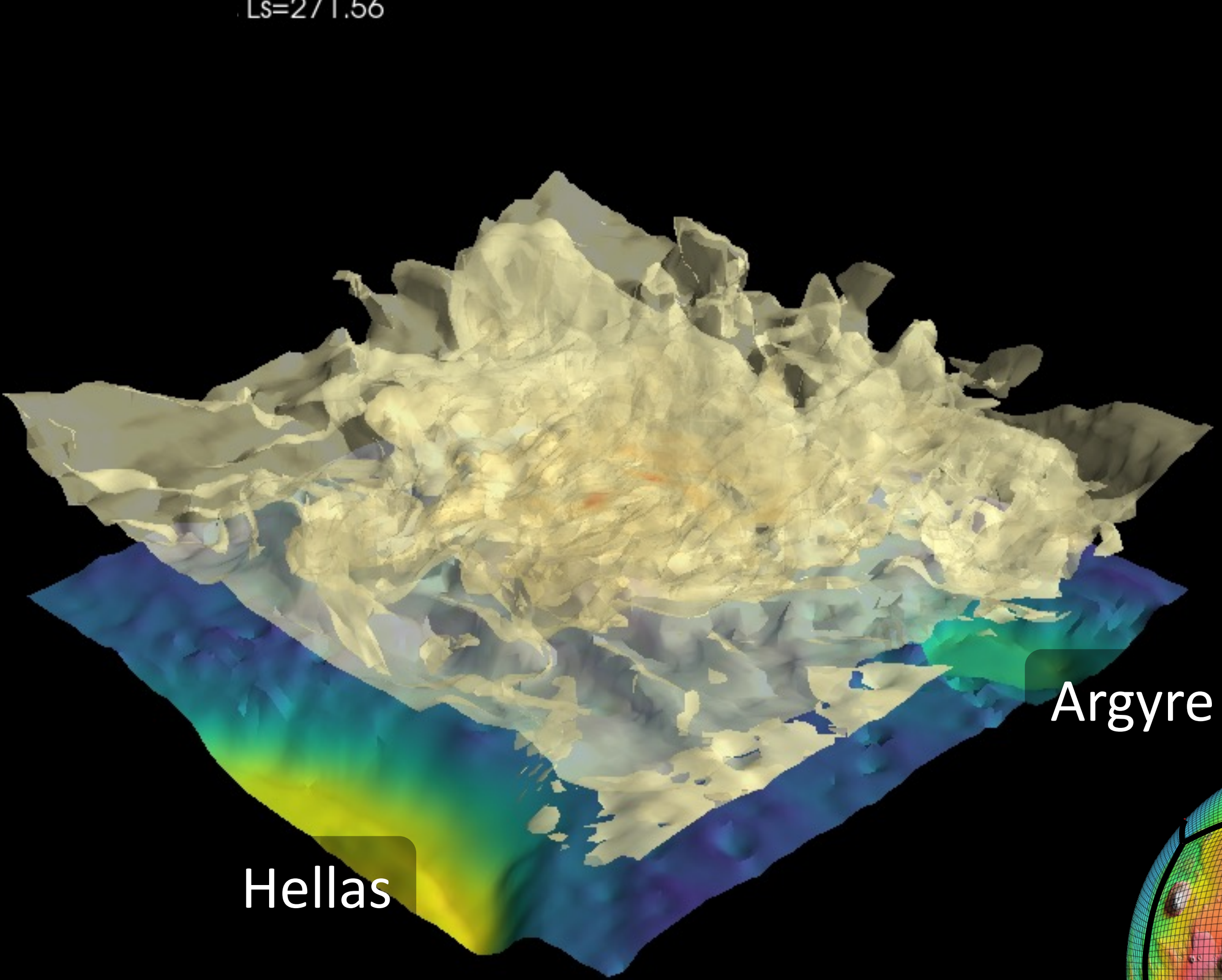
20° L_s Rolling Average →



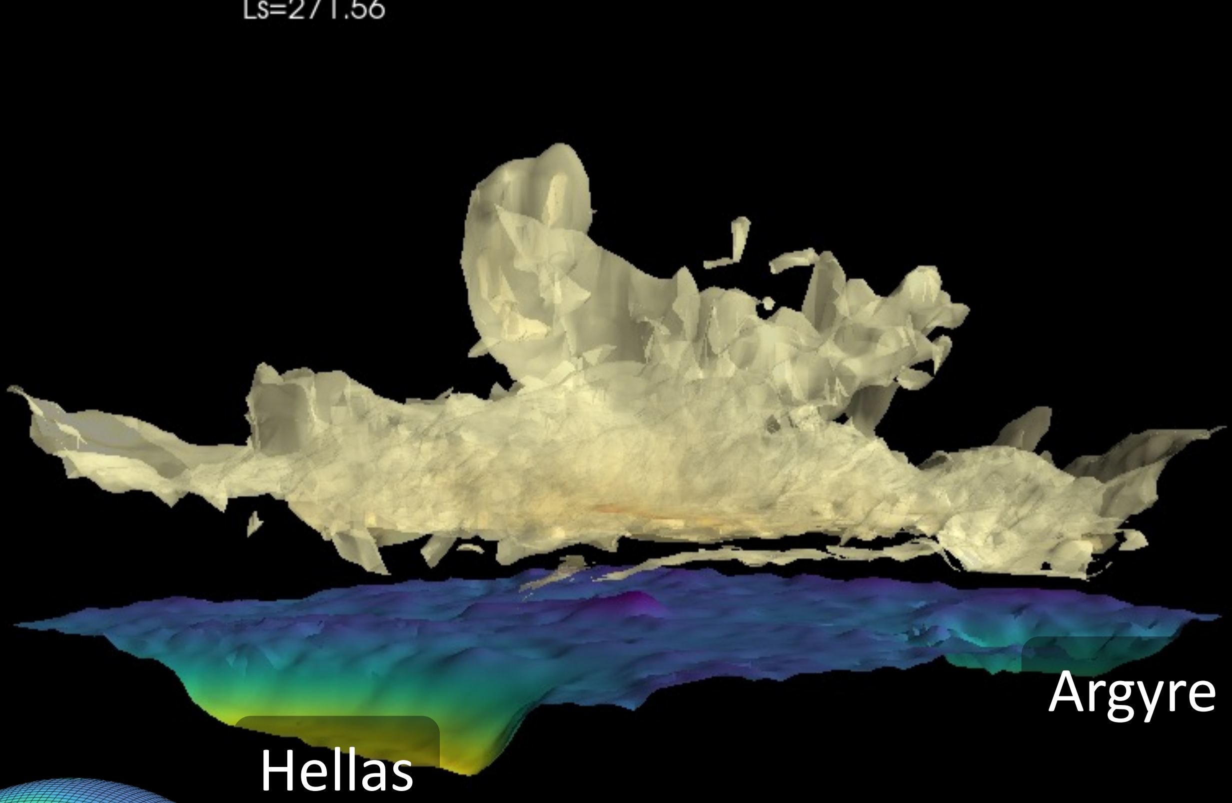
Key Result #3

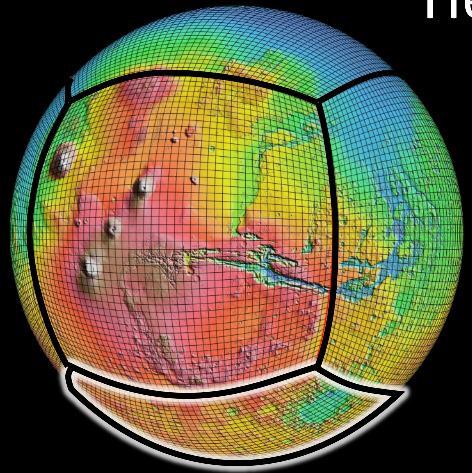
Radiative-dynamic feedbacks are crucial





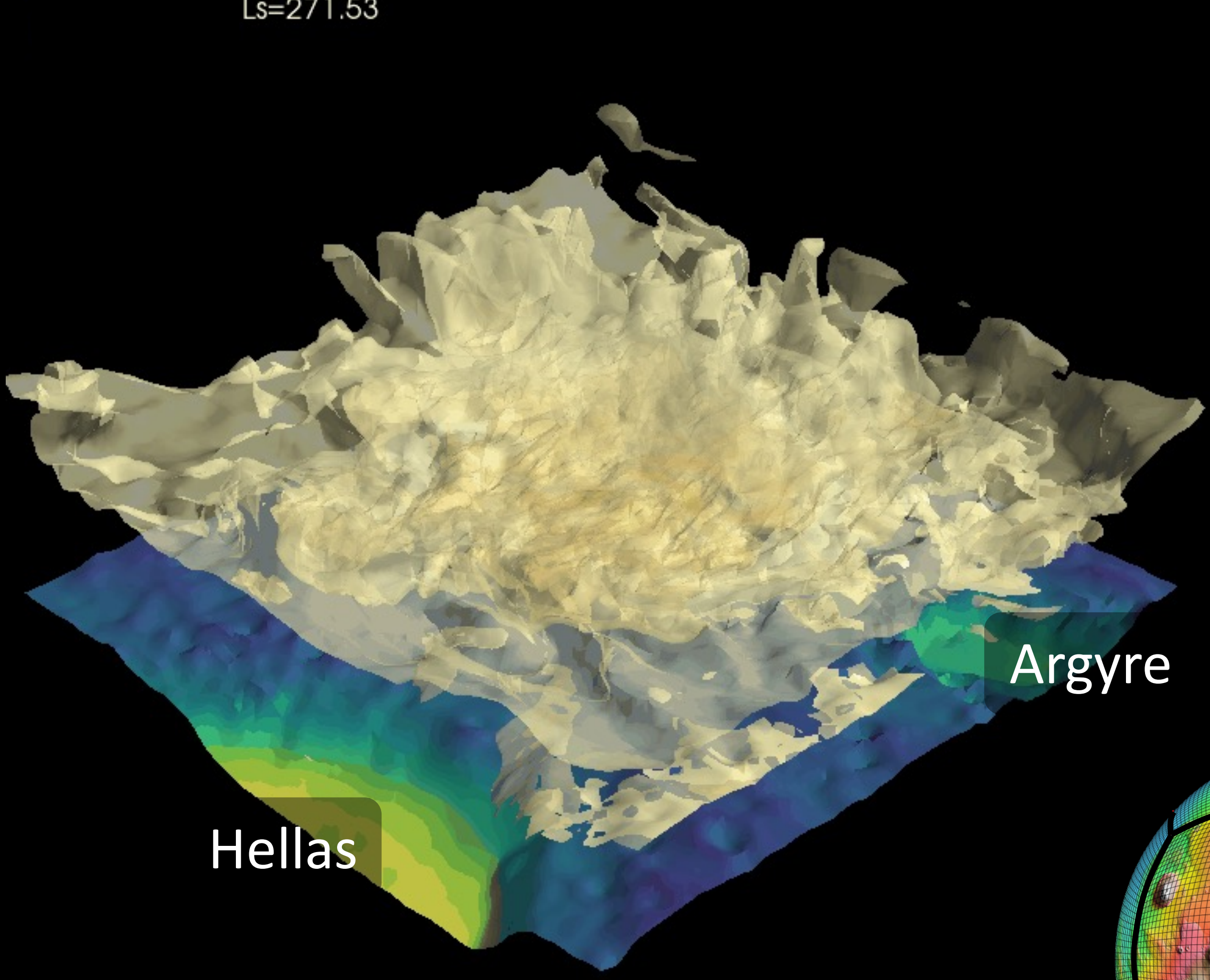
Top View



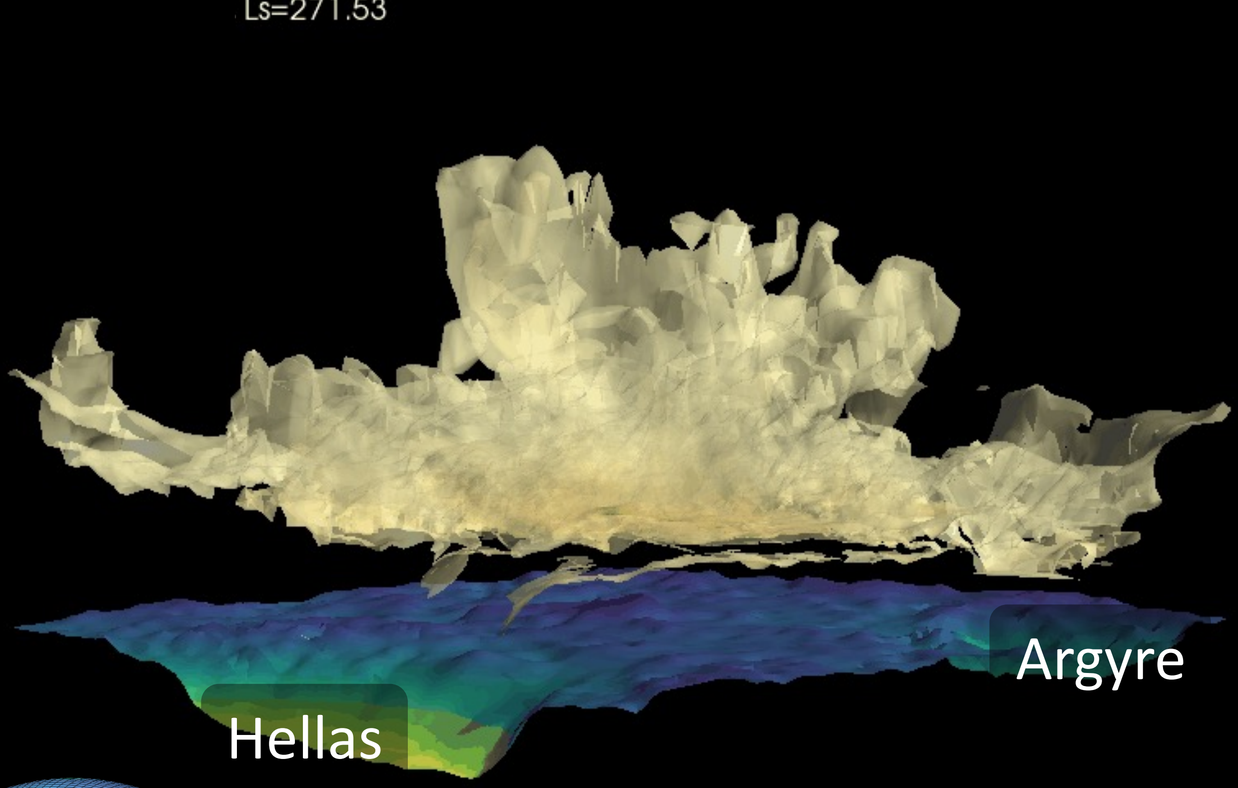


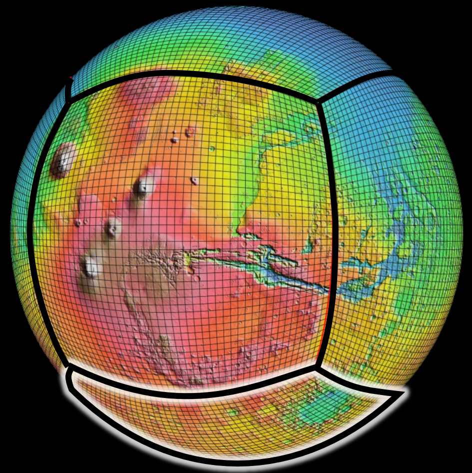
Side View

Dust over the south pole



Top View





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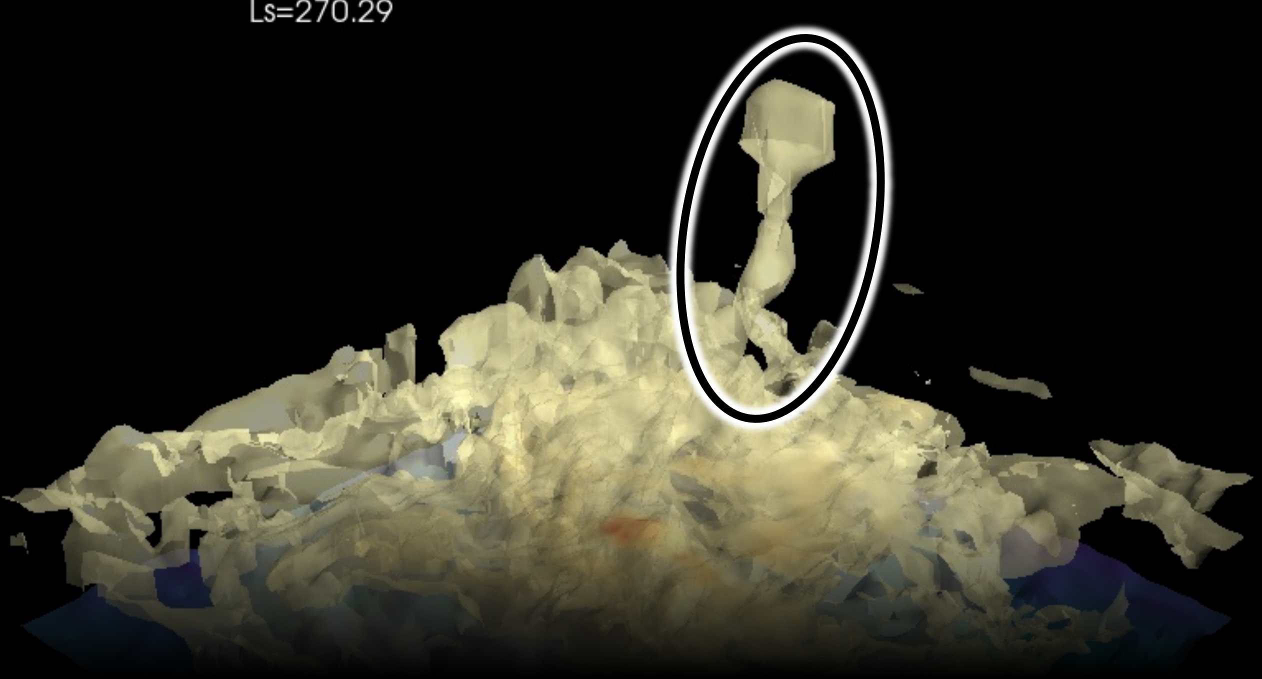
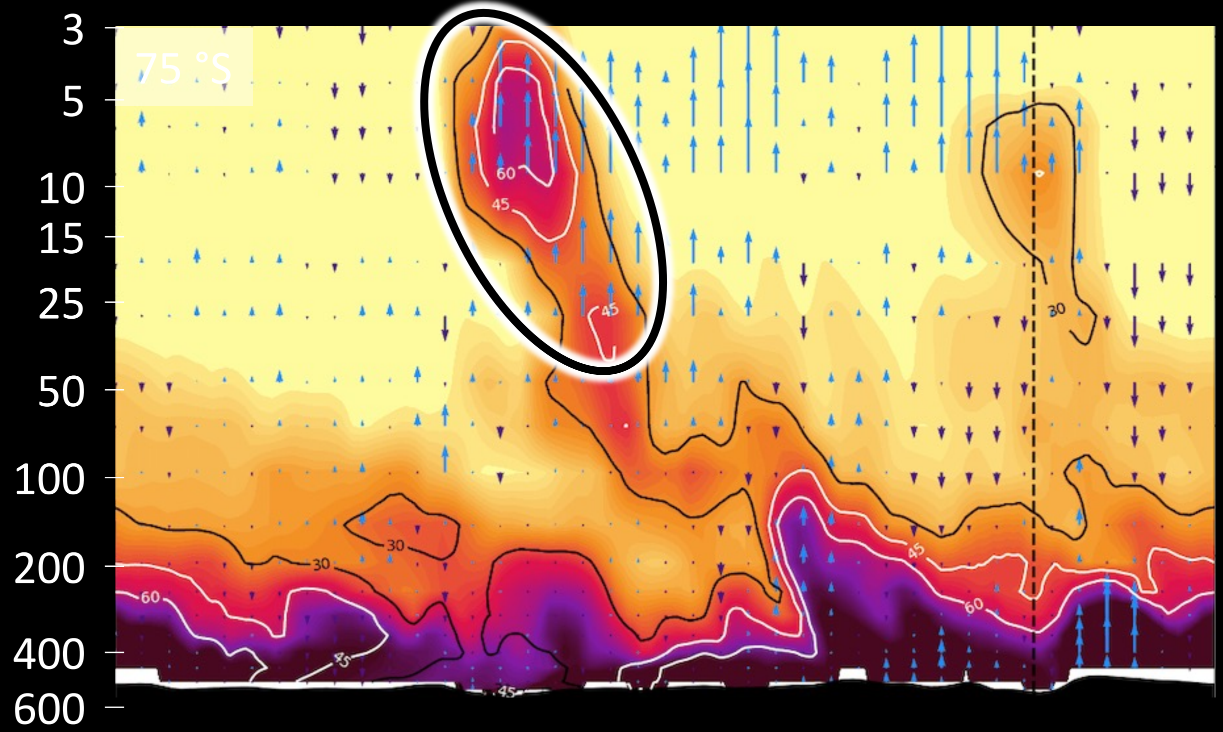
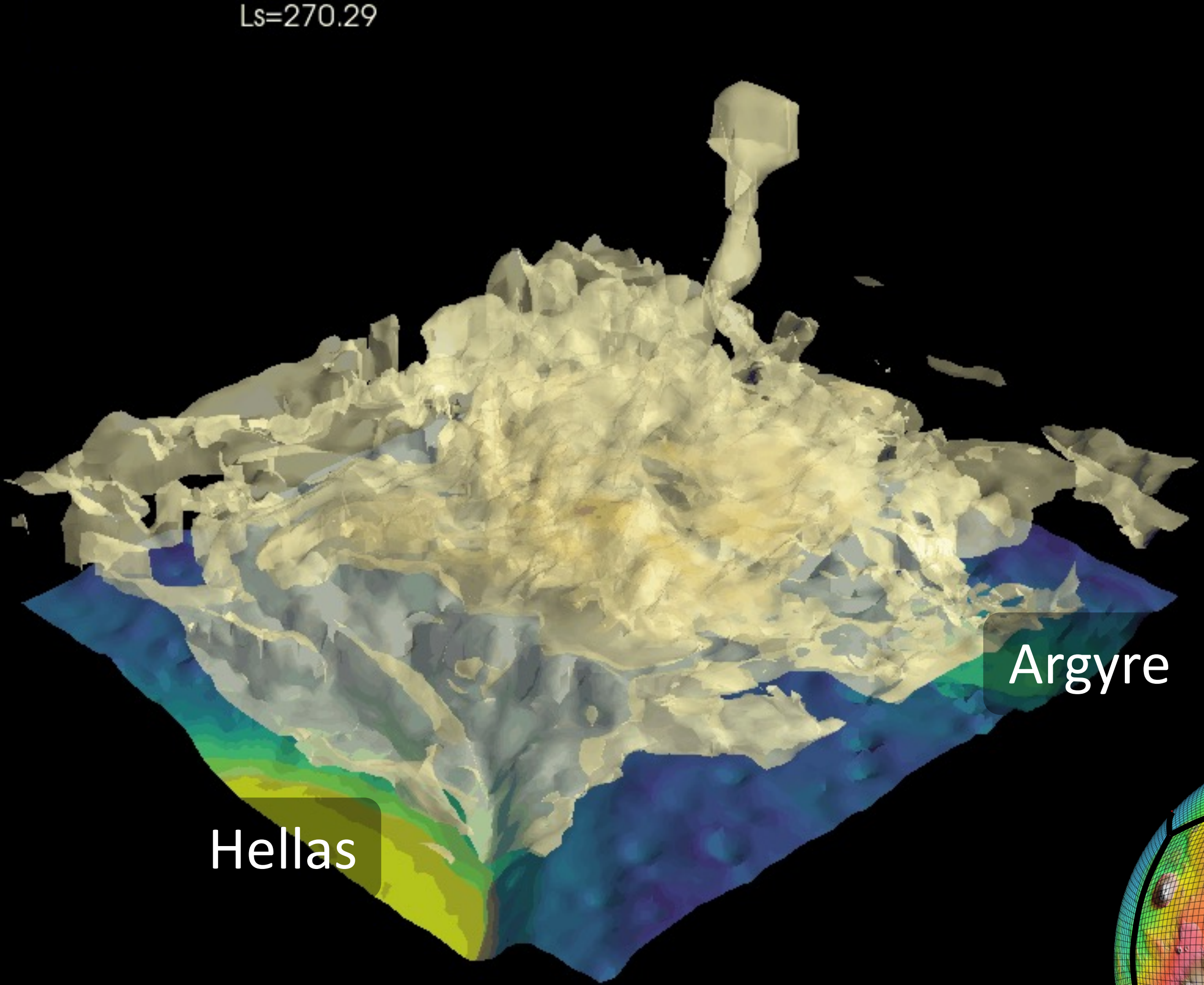
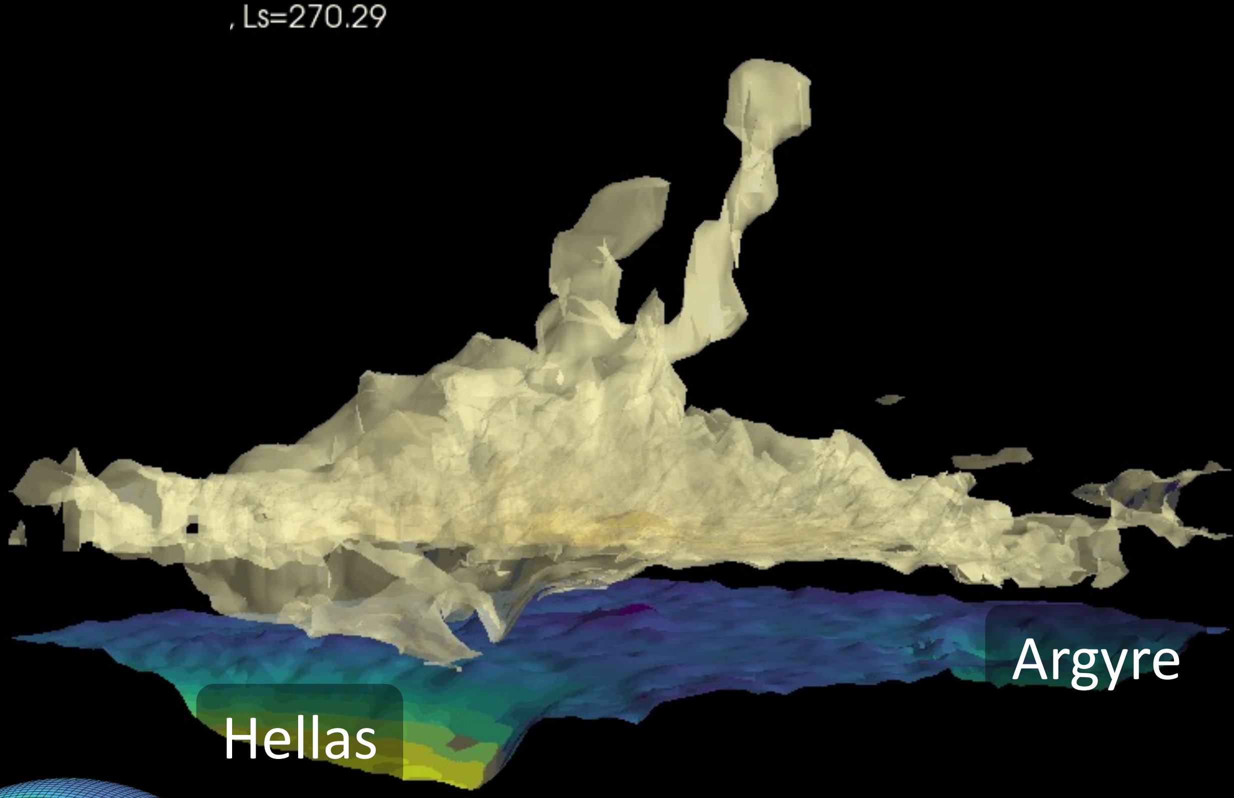

Ls=270.29


Ls=270.29

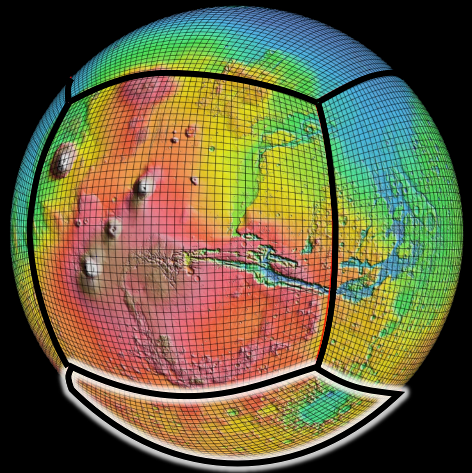

3
5
10
15
25
50
100
200
400
600
75 °S
60
45
30



Top View



Side View



Dust over the south pole

Summary

Key Results

1. MGCM reproduces the B storm well
2. Dust is lofted in dust plumes
3. Radiative-dynamic feedbacks drive the dust plumes

- How is dust lofted?

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Notable Patterns

Plumes produce detached dust layers with behavior resembling the "solar escalator" effect[4].

Self-lifting of dust layers due to the radiative heating of the dust

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- How is dust lofted?
- How is dust lifted?

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Self-lifting of dust layers due to the radiative heating of the dust

Future Work

Identifying the cause(s) of dust lifting:

- Topographical variation
- Cap-edge processes
- The CO_2 sublimation flow.

Live Session

Processes in the Present-Day Atmosphere of Mars II

Wednesday December 15, 2021

07:45 – 09:00 Pacific Standard Time

Room 395-396 or virtually