

Mesospheric Temperature and Circulation Response to the 2022 Hunga Tonga - Hunga Ha'apai Volcanic Eruption

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CESM Atmosphere / Whole Atmosphere / Chemistry-Climate

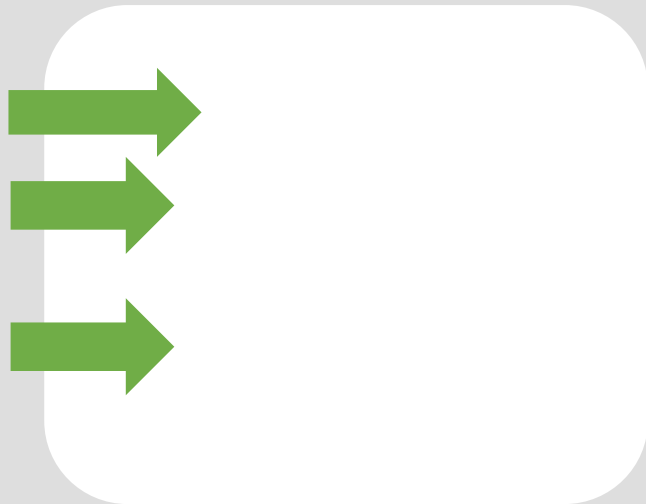
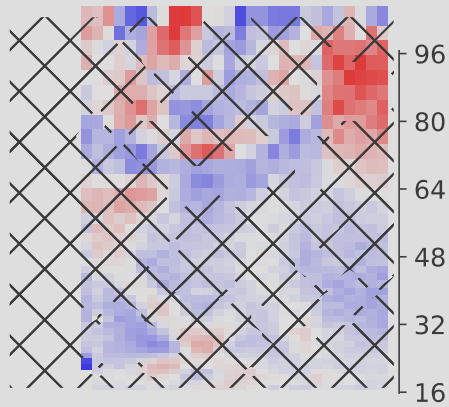
WINTER WORKING GROUP MEETING

14 February 2024

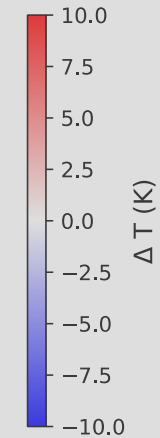
Key finding:

The stronger stratospheric westerlies in August 2022 lead to enhanced mesospheric meridional circulation, and thus temperature changes in the mesosphere.

SABER observed unprecedented mesospheric temperature variations



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2022 – climatology

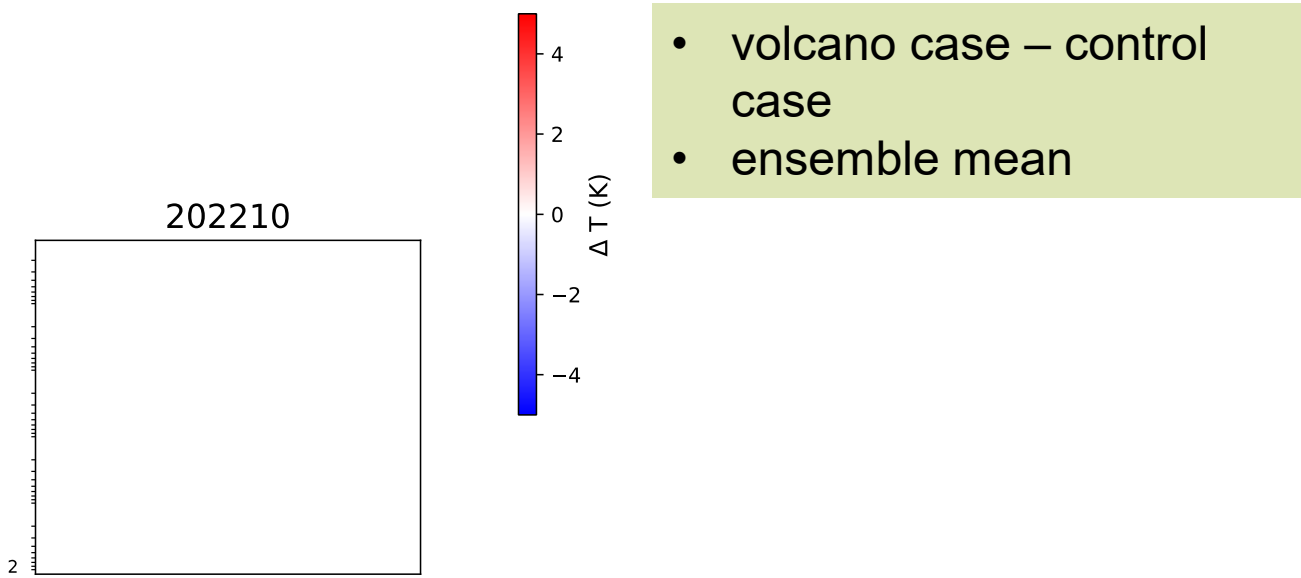
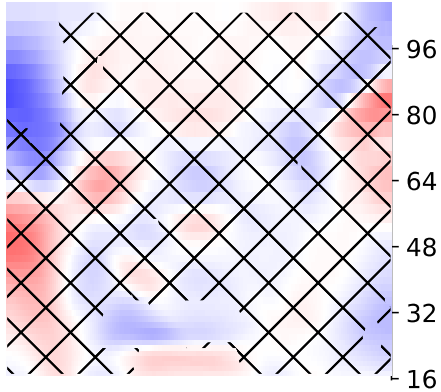
Without hatches:

Record-breaking

WACCM model settings

- 70 vertical layers, 0.95° latitude x 1.25° longitude
- Nudge to GEOS5 in January
- Fully coupled free running after ~ Feb. 2022
- 10 members, different nudge end date (1.27-2.5)
 - Control cases
 - Volcano cases: $0.42 \text{ Tg SO}_2 + 150 \text{ Tg H}_2\text{O}$ injected on 1.15, following Zhu et al., (2022)

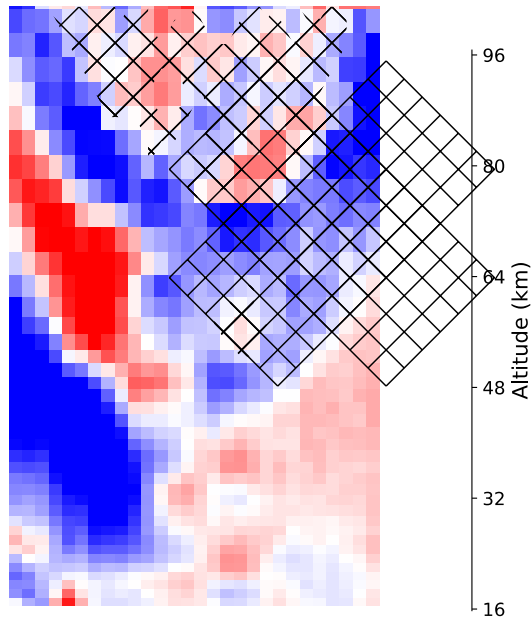
WACCM temperature anomalies also show a **maximum in August**



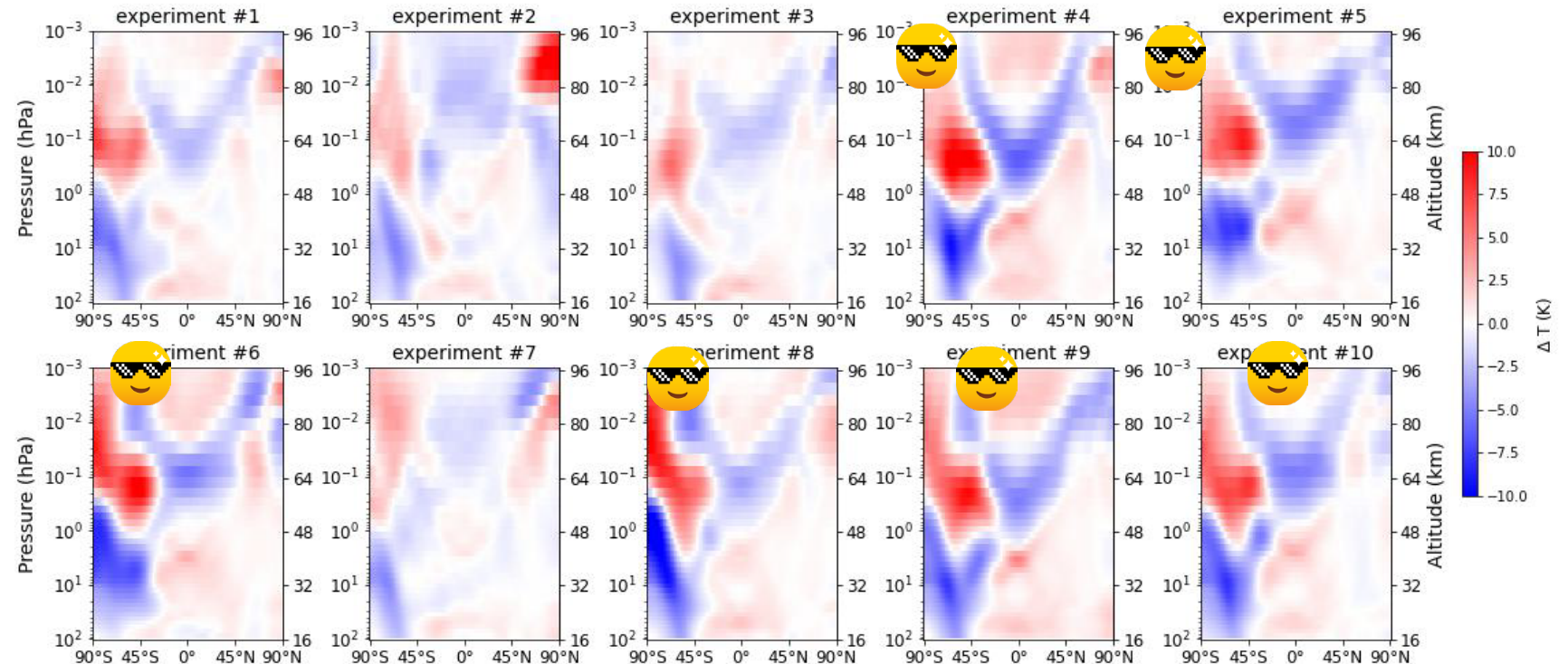
Without hatches:
P-value < 0.05

ALL ensemble members reproduce August spatial pattern, with 6 strong cases

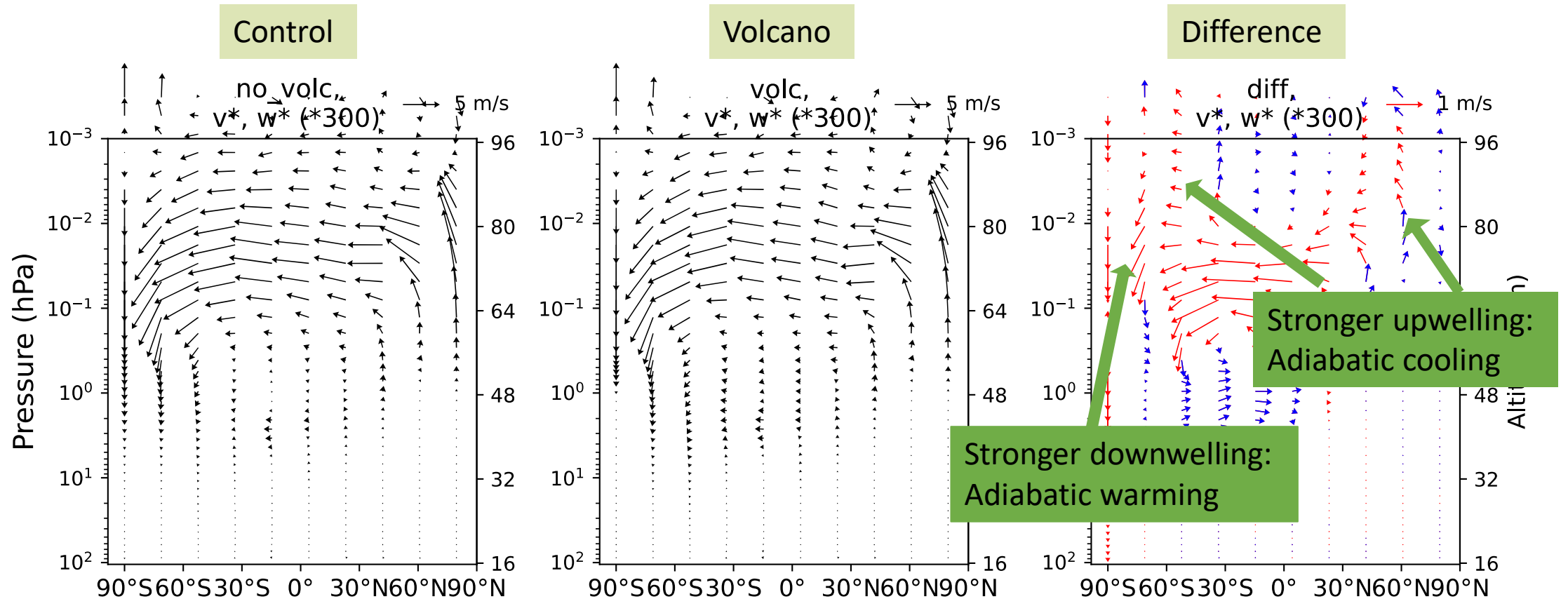
SABER,
2022 – climatology



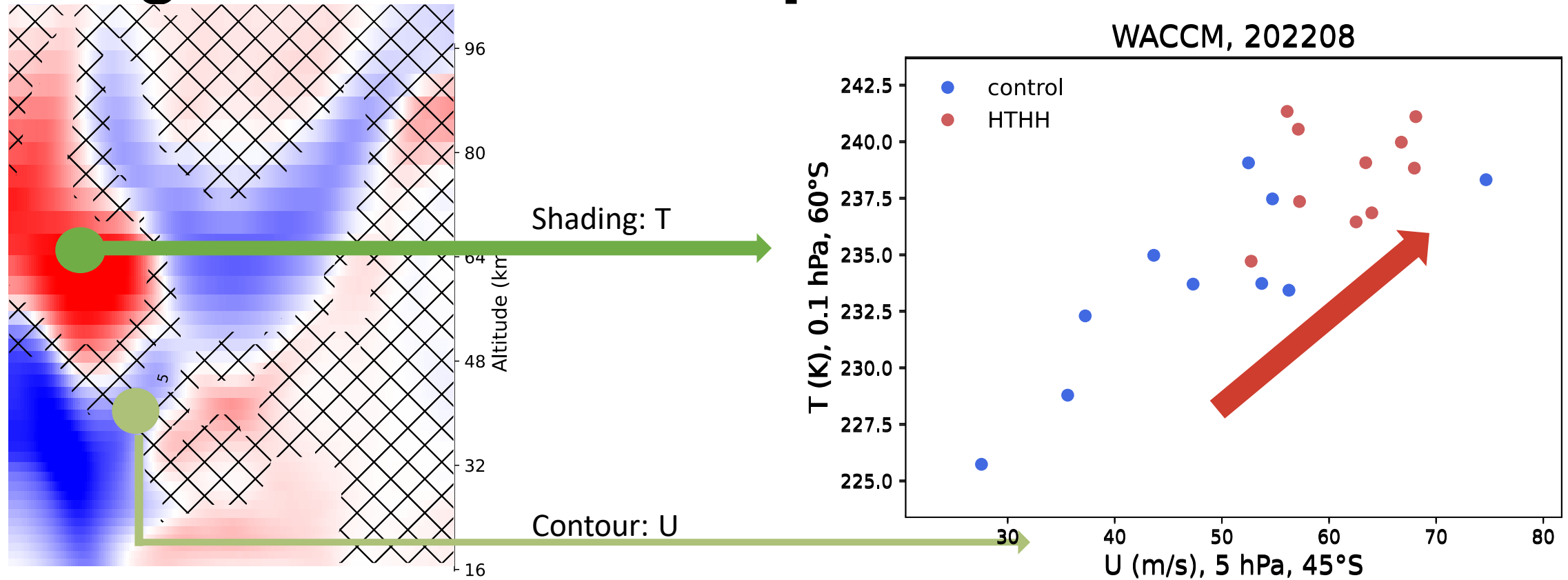
WACCM, volcano case – control case



Strengthening of the mesospheric circulation \rightarrow changes in Temperature



Changes in the mesosphere are responses to changes in the **stratospheric zonal wind**



A causal relationship between changes in stratospheric westerlies and mesospheric temperature!

Stronger stratospheric SH westerlies



More westward gravity wave drag in the SH mesosphere



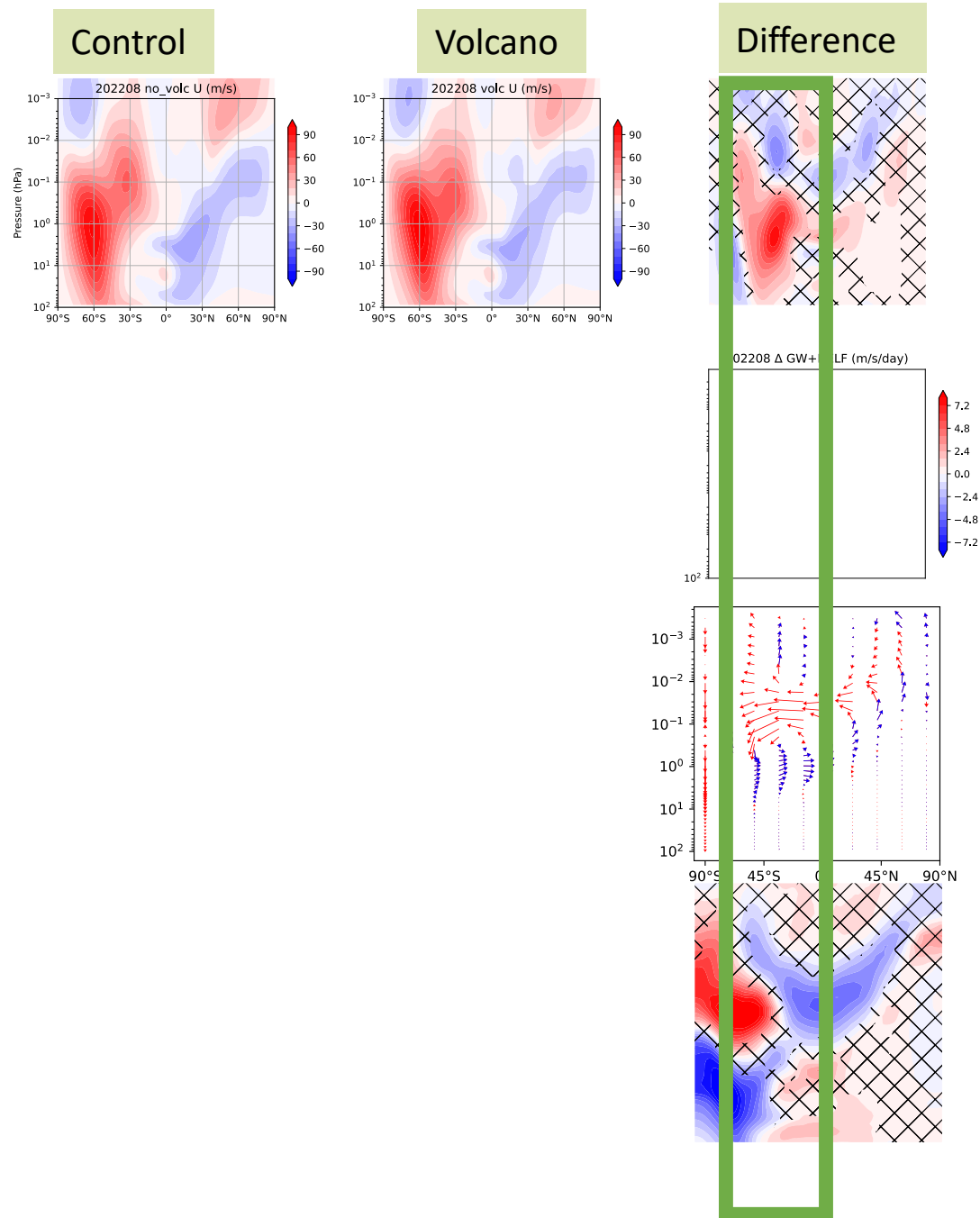
Stronger SH downwelling



Stronger circulations globally



Temperature changes globally



Other interesting HTHH related questions

- What causes the changes in the stratospheric dynamics in August 2022?
- Will polar mesospheric clouds be influenced by the HTHH injected water vapor, when?
- Will the injected water vapor enter the polar vortex, and cause possible ozone depletion, when? How will it influence the ozone chemistry?
- HTHH climate impact: sulfate aerosol cooling vs. water vapor warming?

- SABER observed unprecedented mesospheric temperature variations after the HTHH eruption, especially in August 2022.
- WACCM simulations suggest changes in the mesospheric temperature are attributed to a stronger mesospheric meridional circulation.
- The stronger stratospheric westerlies in August 2022 lead to enhanced westward gravity wave drag in the mesosphere, and thus a stronger meridional circulation.

Thanks!

**Please check our paper
for more details!**

