Southern Hemisphere Stratospheric Polar Vortex Variability in WACCM6: links to tropical winds, ozone and Hunga Eruption

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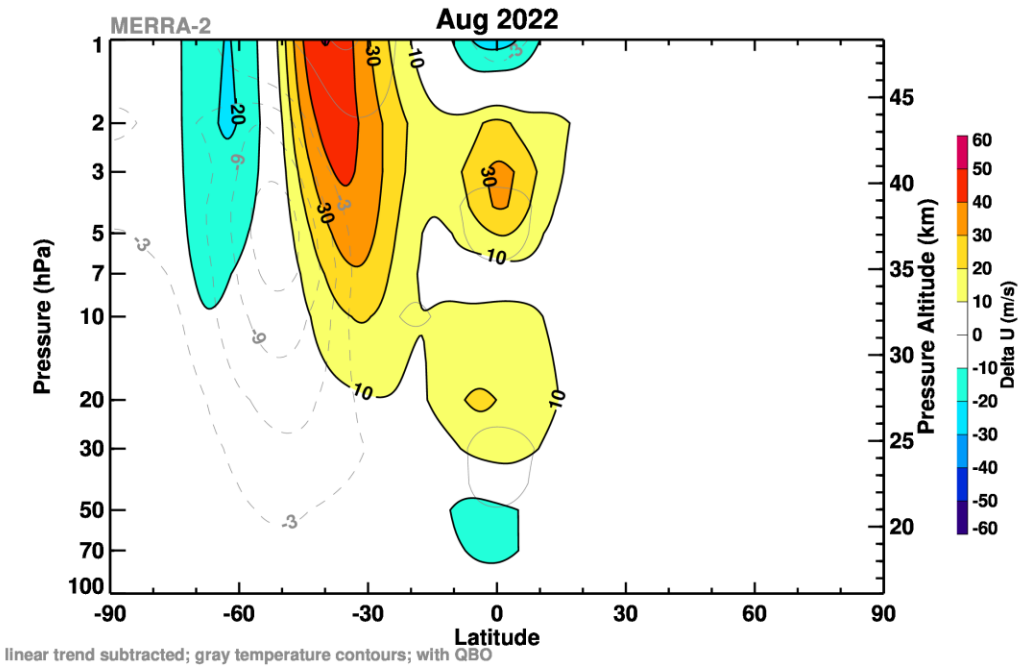
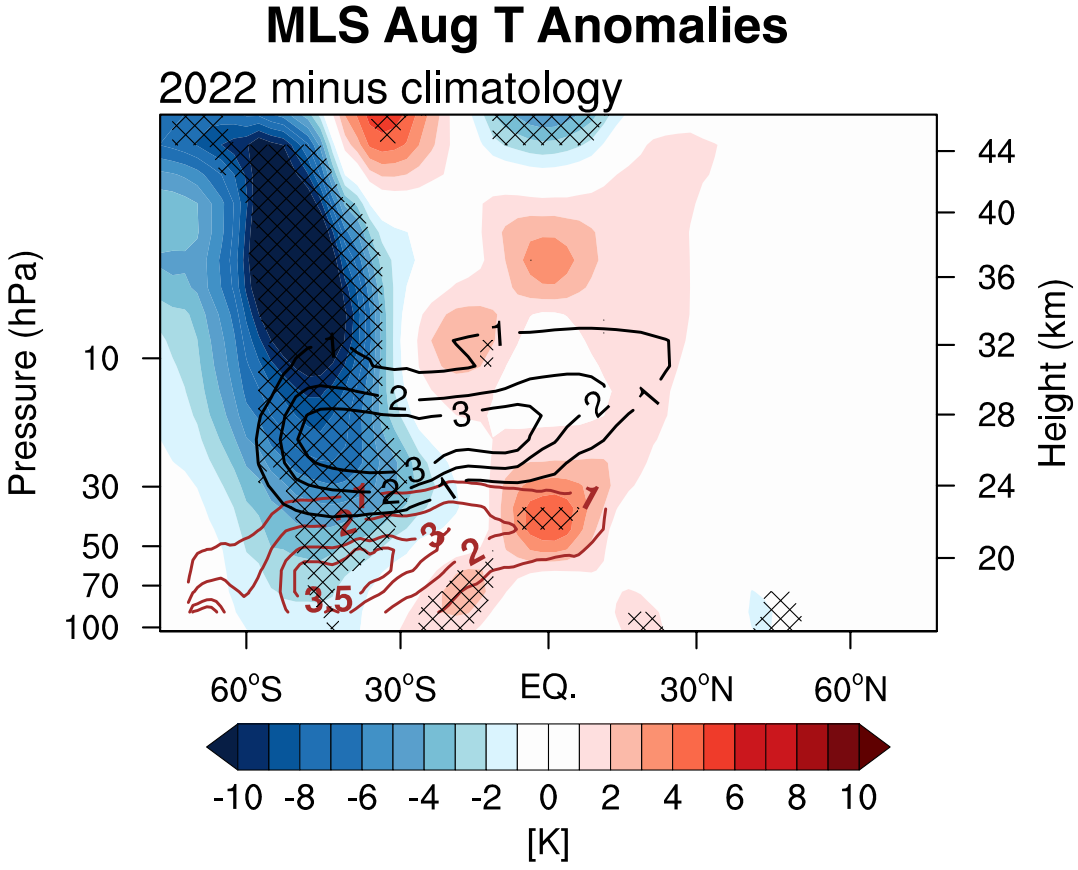
ACOM

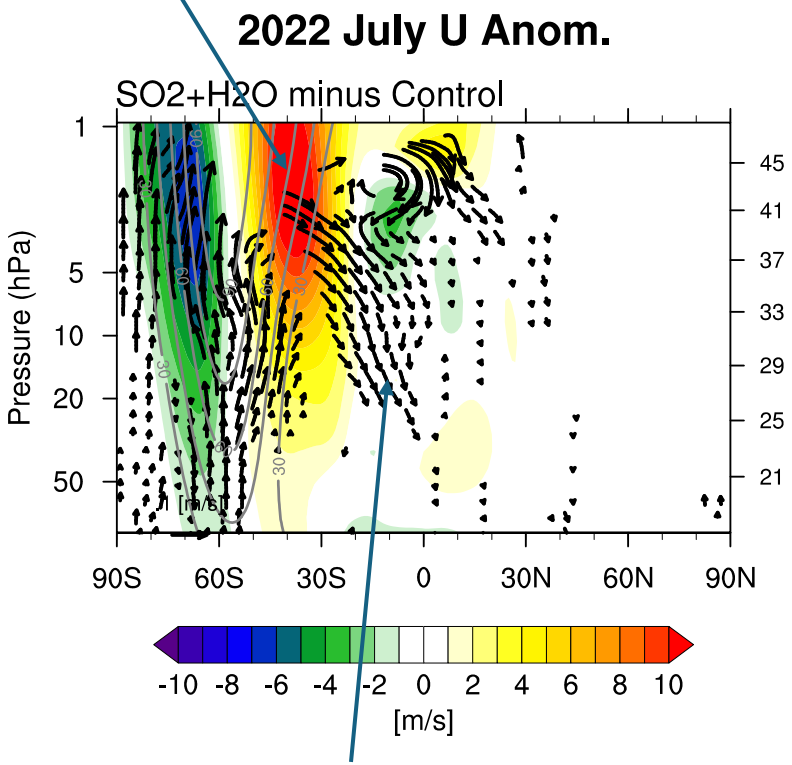
- Equatorward shift of the Antarctic polar vortex in 2022 wintertime
- Cold temperatures at 40-50 S in 2022 wintertime



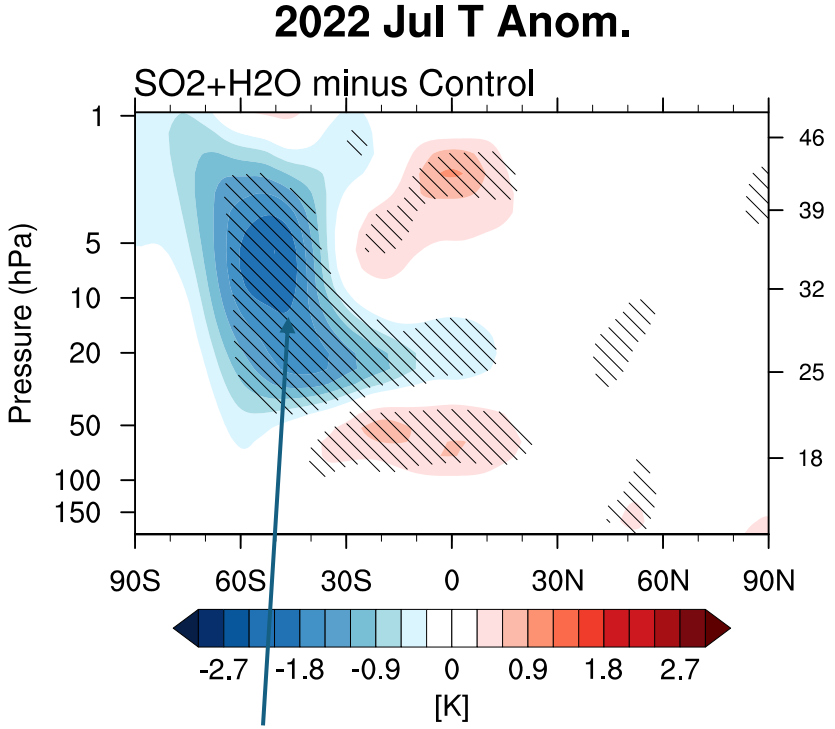


- 50 control & 50 Hunga runs with SO_2+H_2O forcings imposed in Jan 2022 and free-running through 2031 (Zhu et al., HTHH-MOC, submitted to GMD)

+Uwind anom @40S: equatorward shift of the polar vortex



Weakened BDC

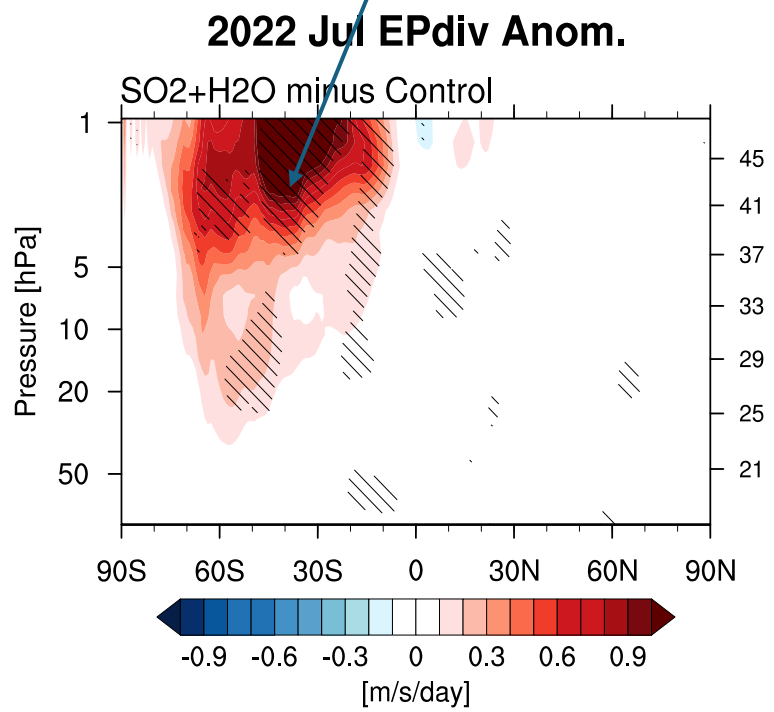


Cold temperature over high latitudes

Hatched: significant

+EPdiv anom. (weaker wave)

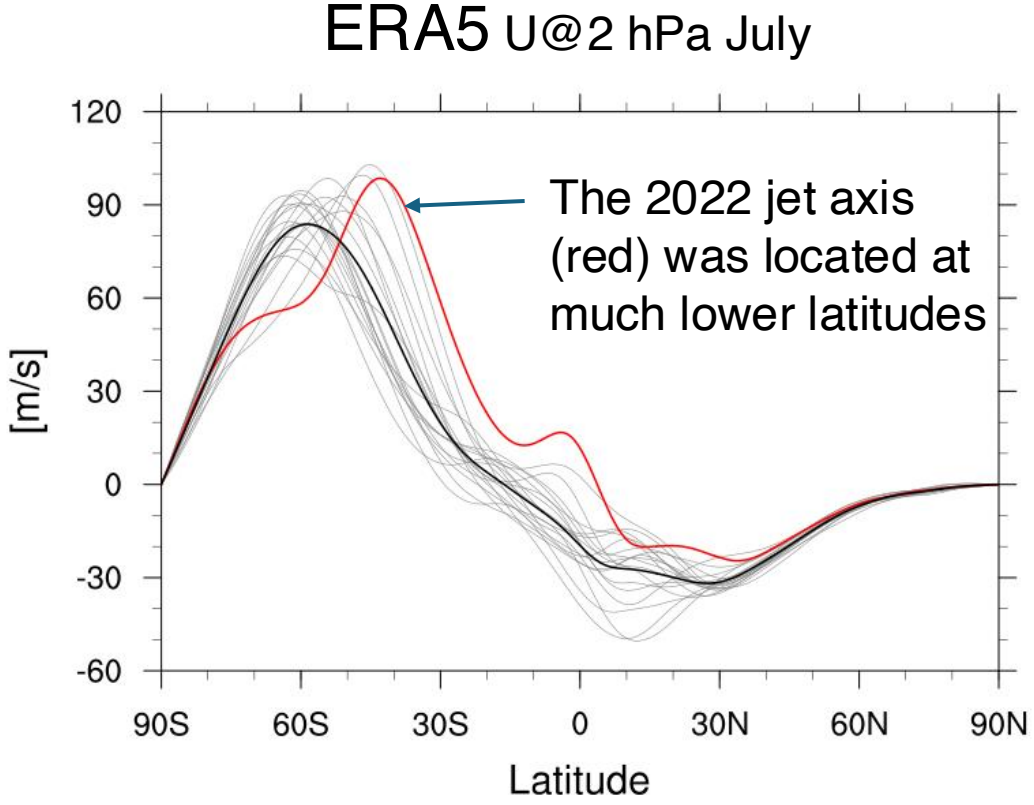
Hatched: significant

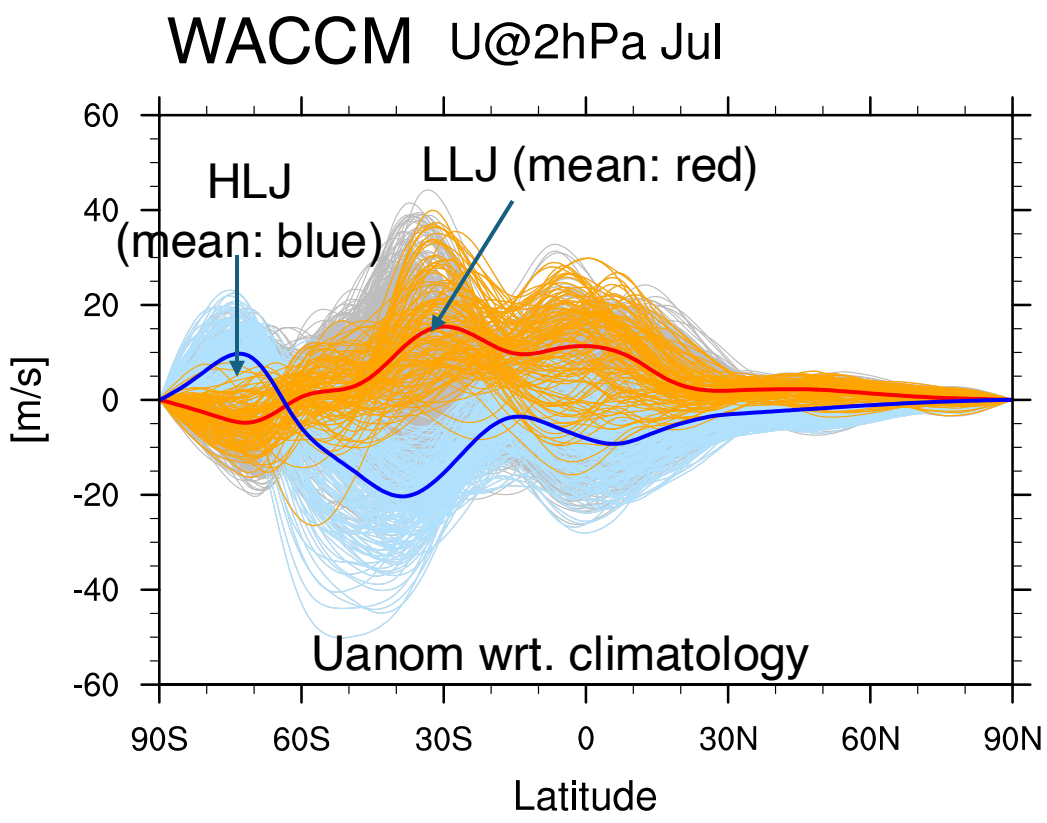


Special thanks to Simone Tilmes, Yunqian Zhu and Jun Zhang for setting up the model runs

- Maximum of U wind occurs at different latitudes
- Hunga in 2022 is an anomalous **low latitude jet (LLJ)** year

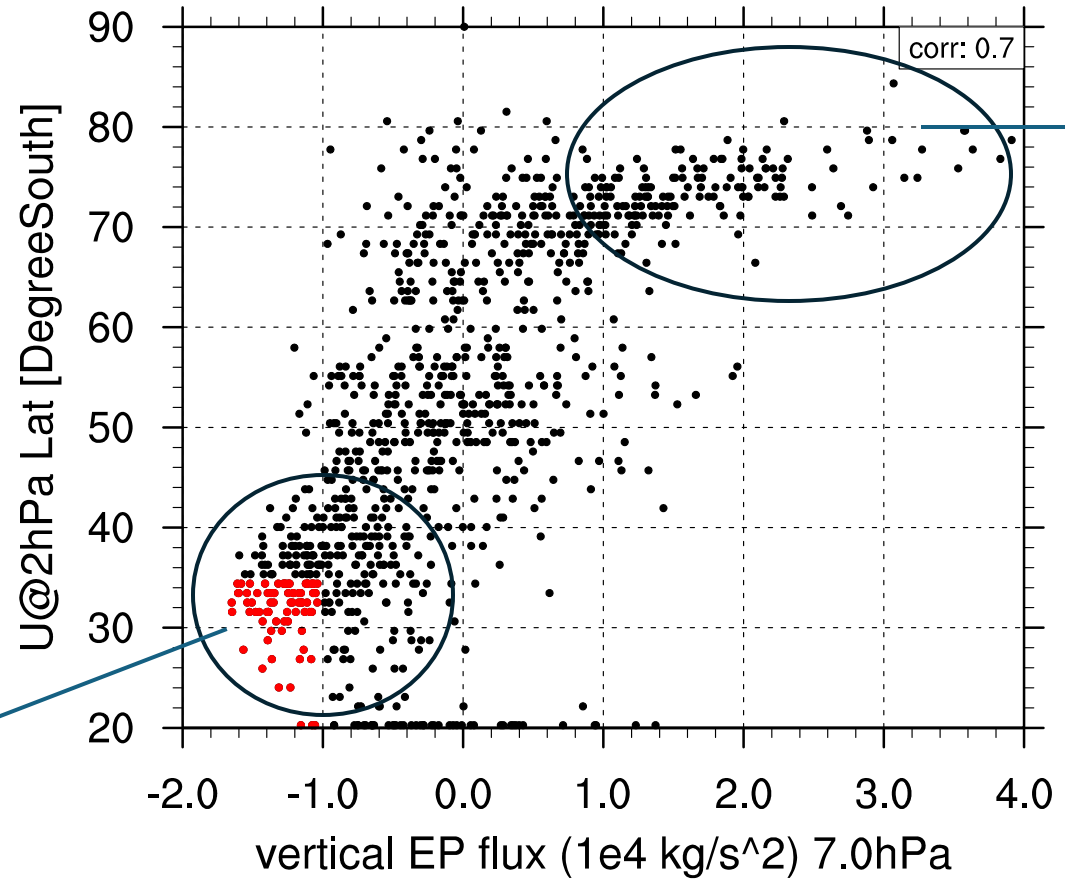
- SH wintertime stratosphere circulation can be organized according to the presence of a LLJ in the upper stratosphere





- Location of Uanom maximum is strongly correlated (corr: 0.7) with the wave activity in the stratosphere
- LLJ years are defined by both uanom at low-latitudes and weaker wave (red dots)

Uanom occurs at lower latitudes

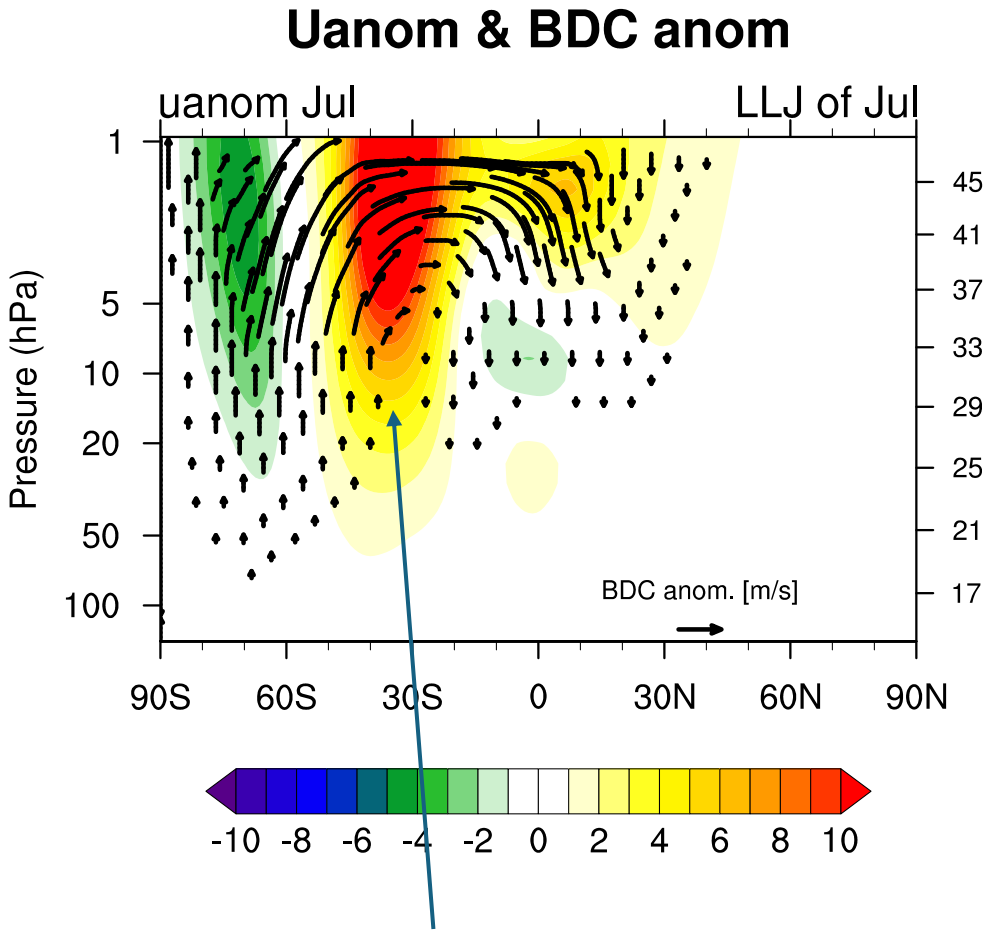


Uanom @ higher latitudes & stronger wave

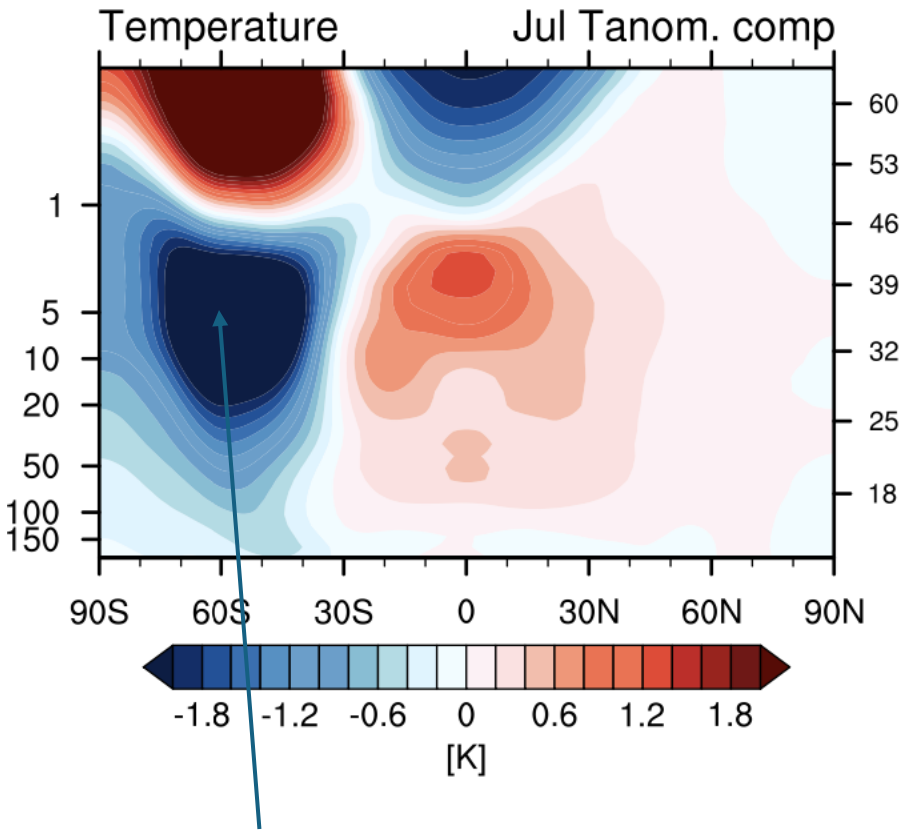
Uanom @ lower latitudes & weaker wave

Stratospheric wave gets weaker

- LLJ composites show an equatorward shift of the westerly polar vortex, a weaker residual circulation, and a cold midlaitude



+Uwind @30-40 S: LLJ
Weakened BDC in vectors

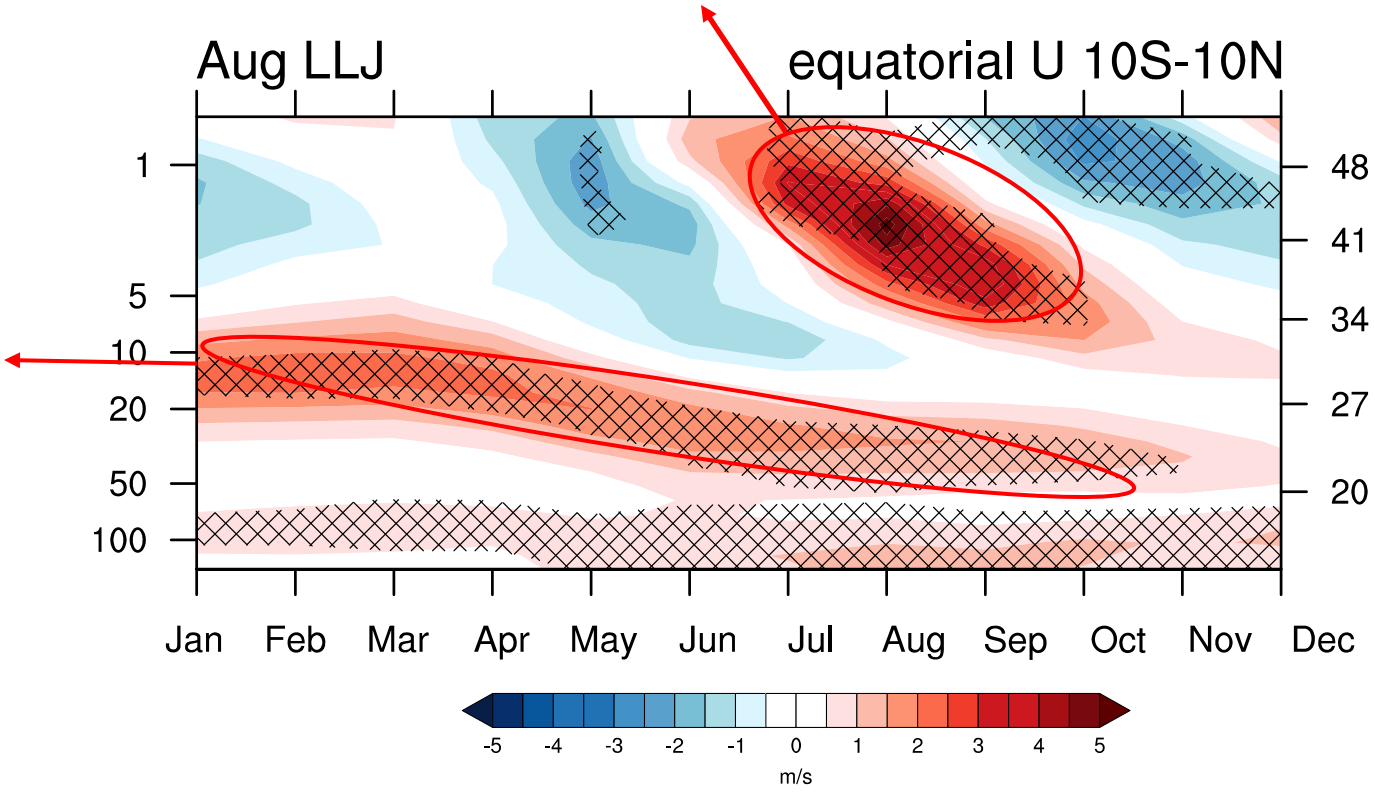


Stratospheric cooling @60-40 S: LLJ

- LLJ is linked to tropical westerly anomaly in the mid (10-50 hPa) to upper stratosphere (1-5 hPa).
- HLJ is associated with easterly anomaly (not shown).

Equator 10-50 hPa: +Uwind anom. (westerly) begins in Jan and descends to the lower stratosphere by July

Equator 5 hPa: +Uwind anom starting from winter months



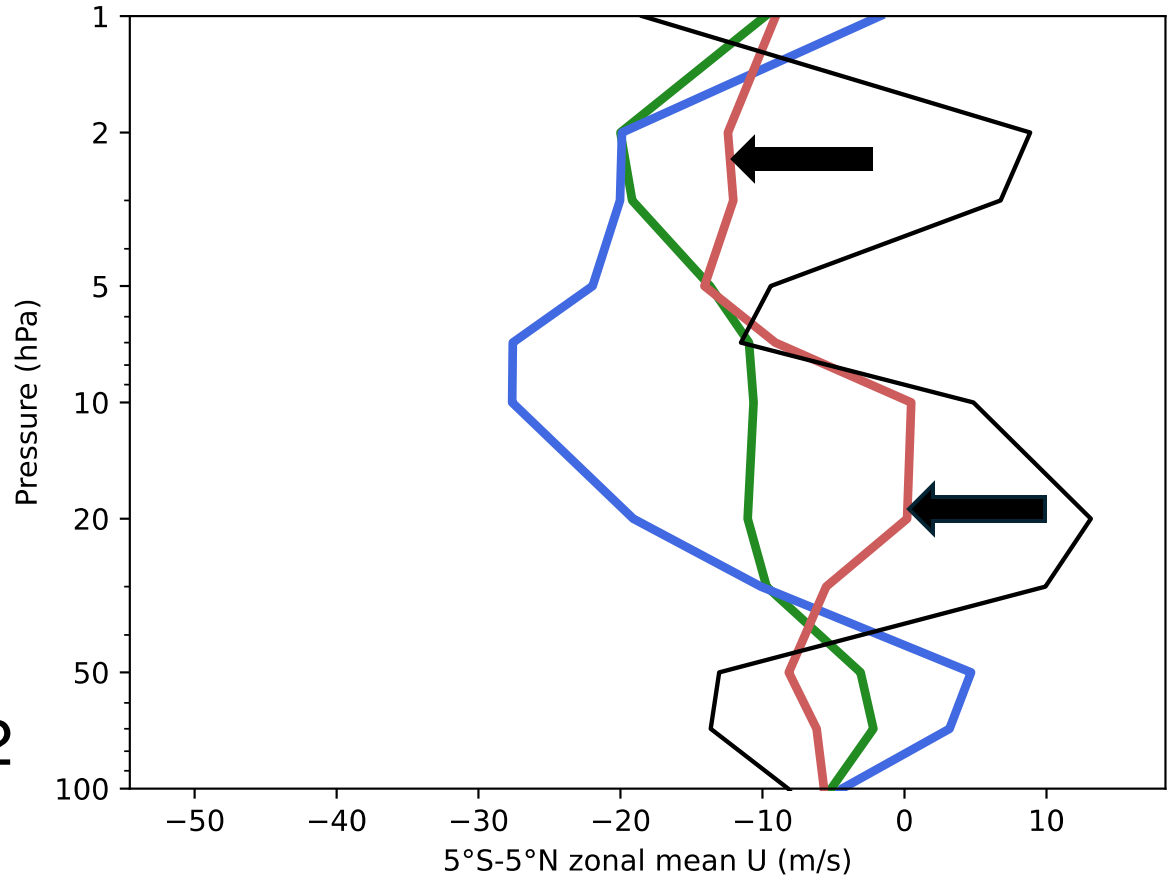
- A consistent tropical wind structure is found in ERA5
  - LLJ (red) is linked to westerly within 10-50 hPa

LLJ

HLJ

Others

Hunga 2022



A companion study using reanalysis data led by Wandi Yu

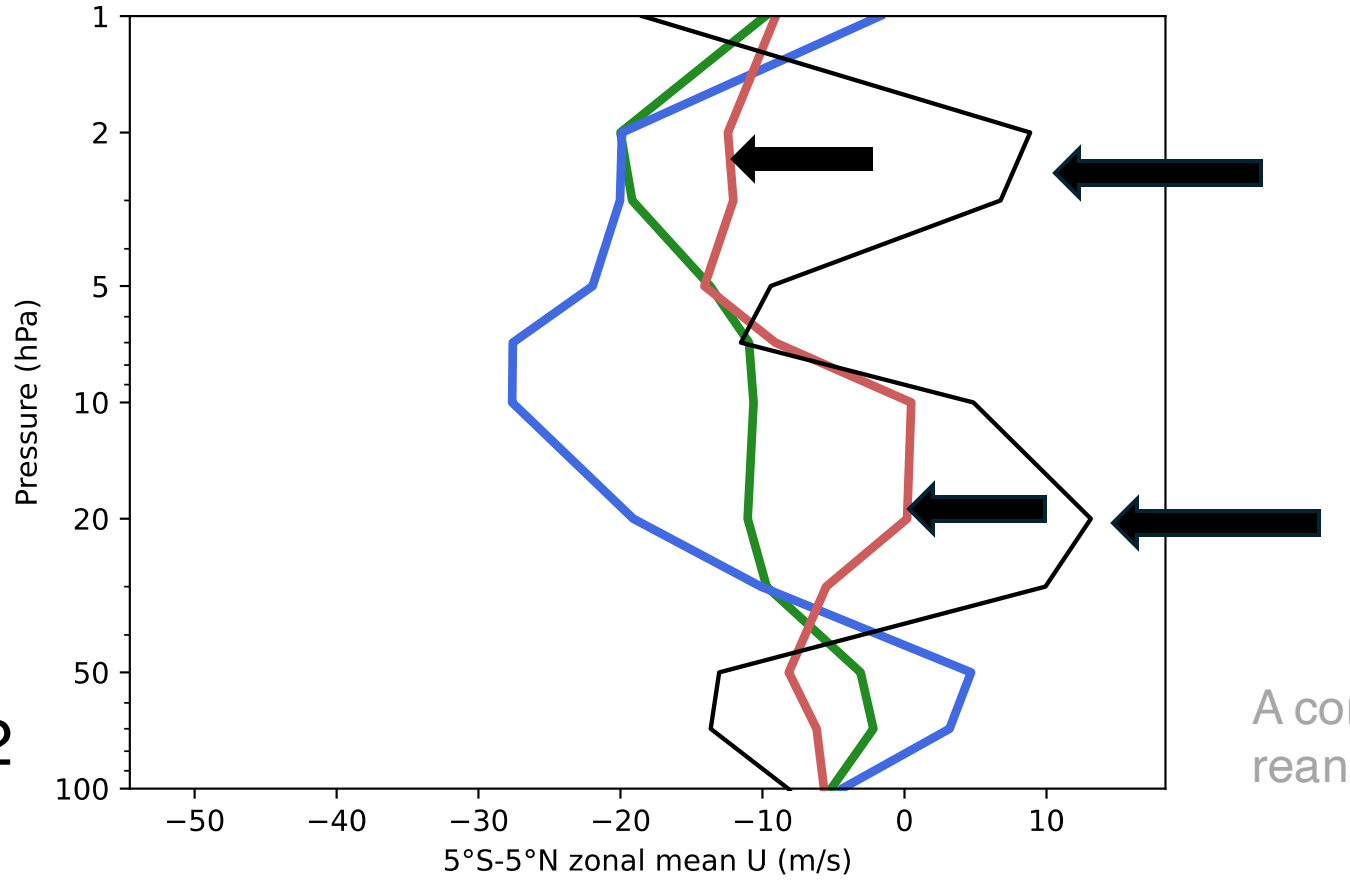
- A consistent tropical wind structure is found in ERA5
  - LLJ (red) is linked to westerly within 10-50 hPa
  - 2022 Hunga year (black) is an anomalously strong LLJ year, with enhanced westerly at 10-50 hPa and 5 hPa.

LLJ

HLJ

Others

Hunga 2022



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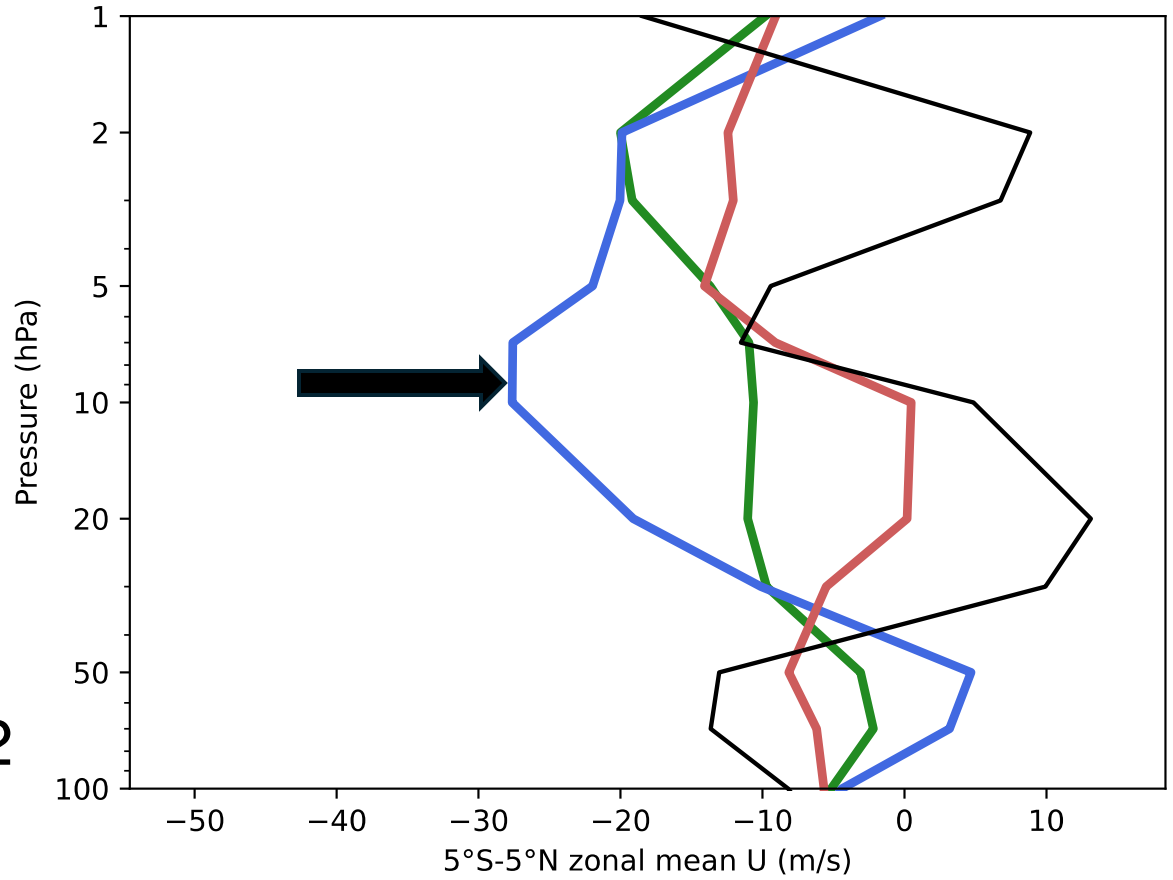
- A consistent tropical wind structure is found in ERA5
  - LLJ (red) is linked to westerly within 10-50 hPa
  - 2022 Hunga year (black) is an anomalously strong LLJ year, with enhanced westerly at 10-50 hPa and 5 hPa
  - HLJ (blue) is linked to easterly tropical wind

LLJ

HLJ

Others

Hunga 2022



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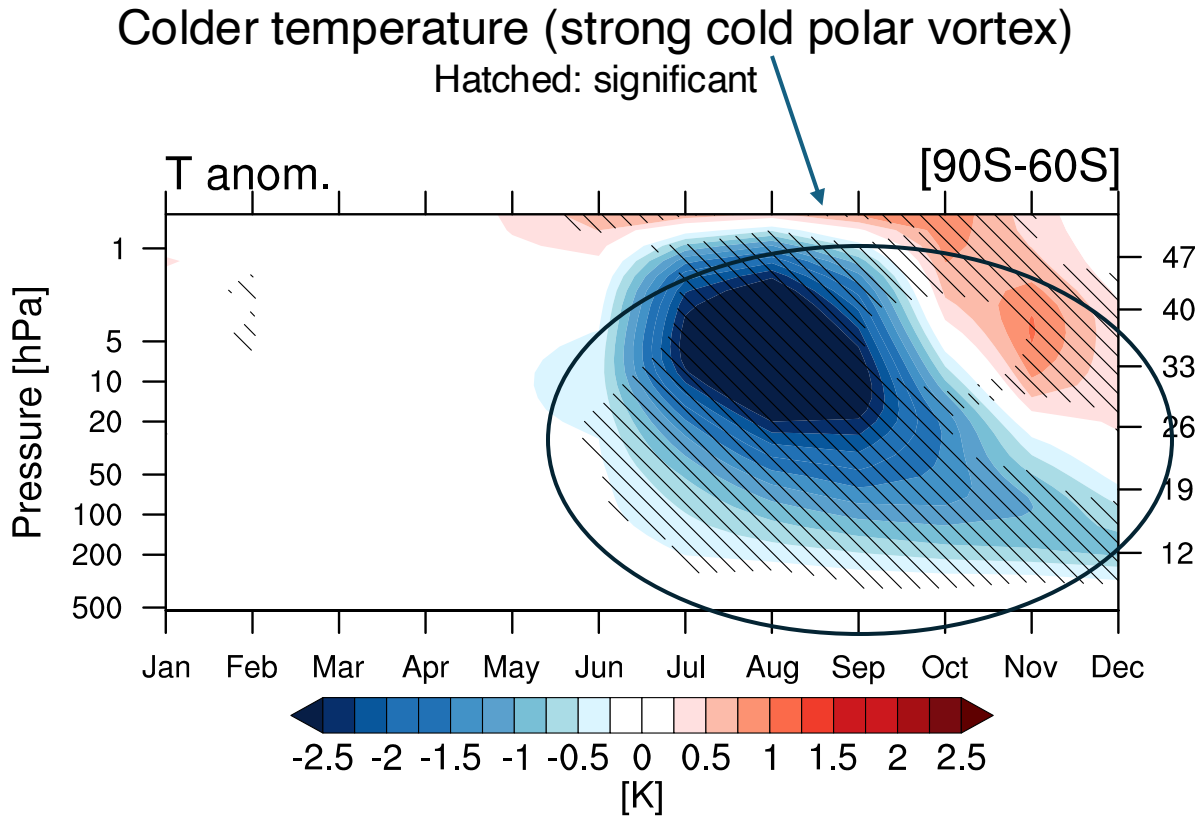
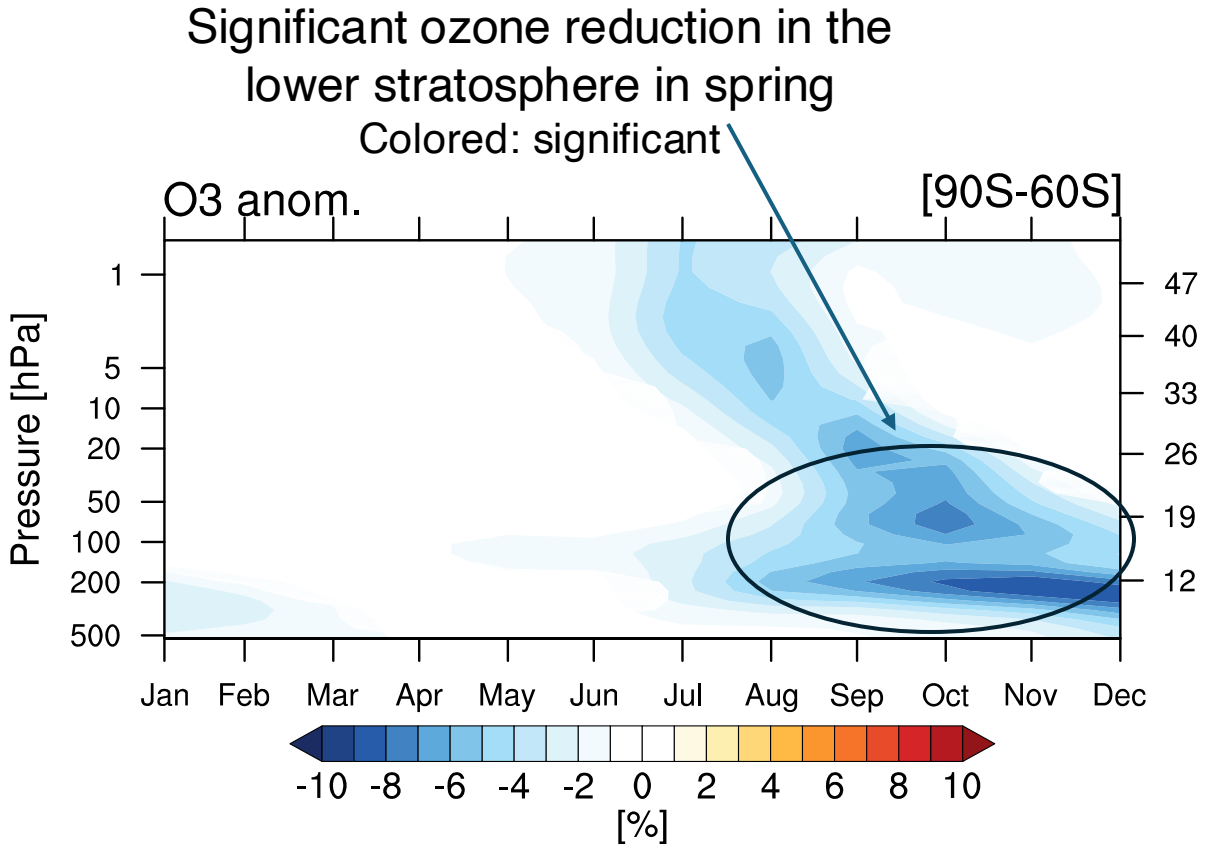
- LLJ is linked to persistent strong vortex in the lower stratosphere during October-December [colder polar temperature and weaker geopotential heights (not shown)].
- The LLJ stronger polar vortex is associated with enhanced ozone losses in spring.





Summary

- SH stratosphere circulation can be organized according to the presence of a low-latitude jet (LLJ) in the upper stratosphere, which develops during winter months.
- LLJ is linked to weak planetary wave activity and tropical westerly winds in the middle and upper stratosphere during early and middle winter.
- LLJ is linked to persistent strong cold vortex in the lower stratosphere during October-December and enhanced ozone loss.
- Hunga in 2022 is an anomalously strong LLJ year.

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