

# Tropical width determined from cloud, aerosol, and trace gas measurements

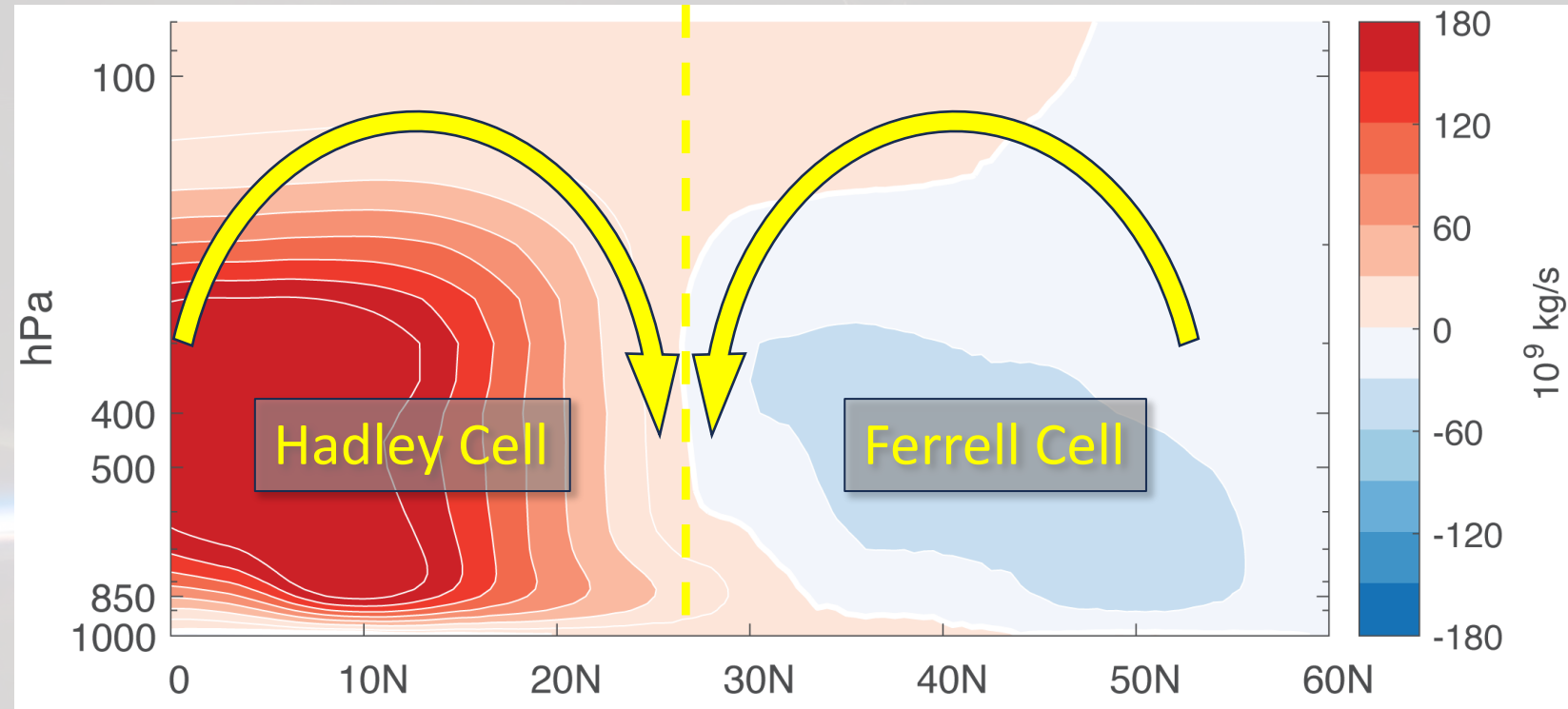
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Additional thanks: Mahesh Kovilakam (NASA), the ISSI TWIST team, and the SAGE operations team!

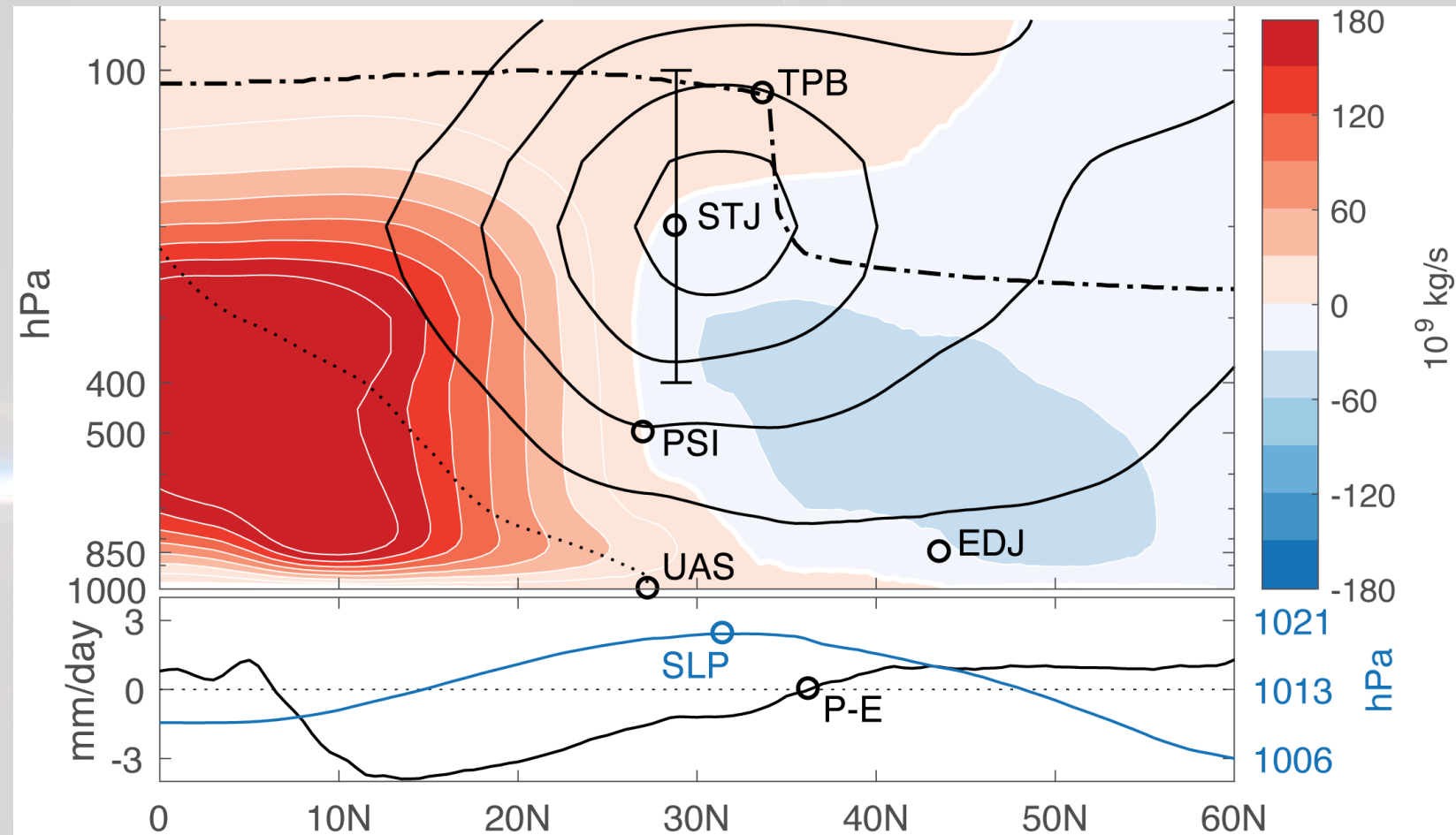
# What is tropical width?

- A catchall for the boundary between tropical and extratropical circulation
- Often, directly relating to the edge of the Hadley cell



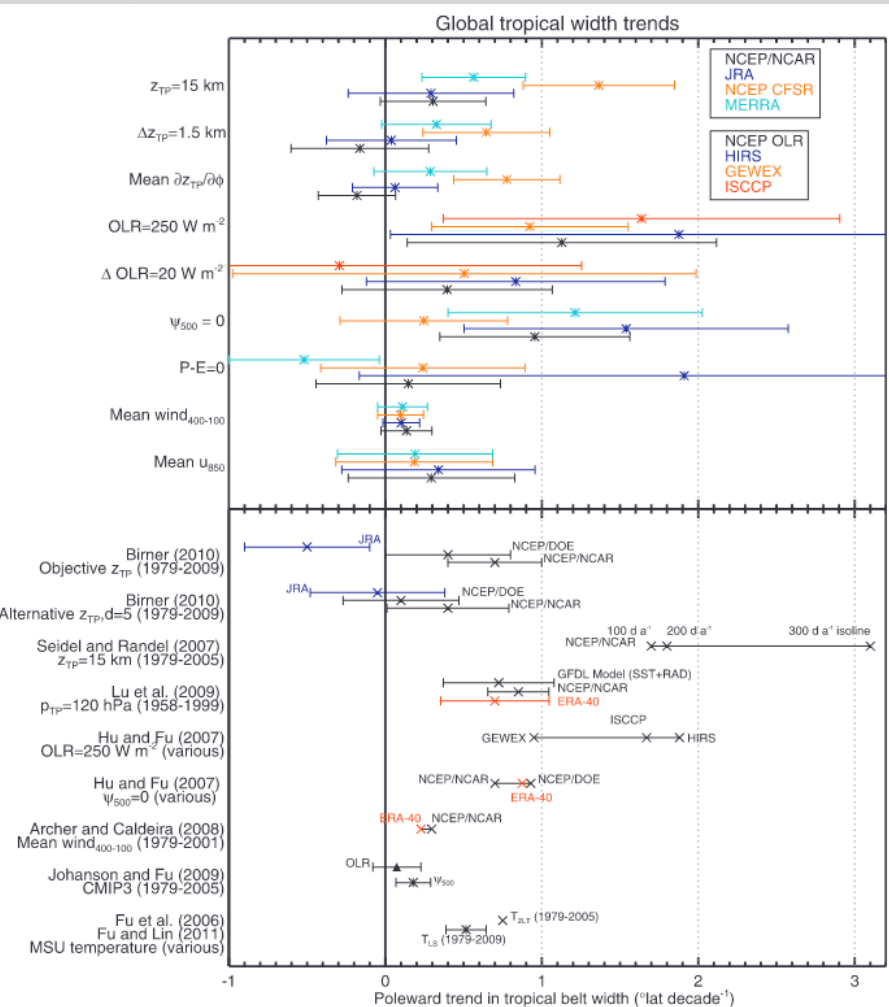
# What is tropical width?

- A catchall for the boundary between tropical and extratropical circulation
- Often, directly relating to the edge of the Hadley cell
- Many other definitions...

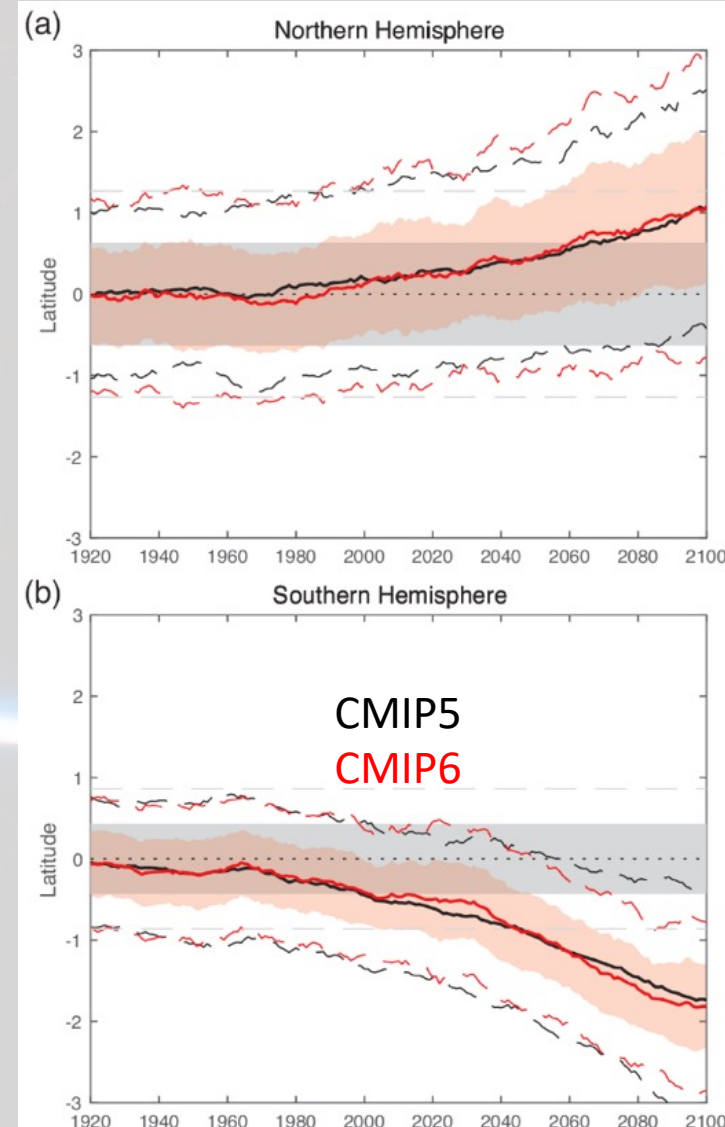


# Tropical widening?

- Observational evidence of tropical widening, but conflicting results...
- Tropical widening due to GHG increases, ozone depletion



Davis and Rosenlof, J. Climate, 2012

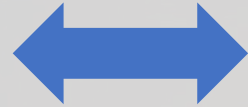


Grise and Davis, ACP, 2020

# Tropical width: 'lower' vs. 'upper' metrics

- "Lower" metrics: directly related to Hadley Cell
- "Upper" metrics: tropopause break, subtropical jet

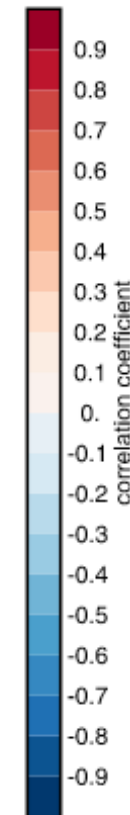
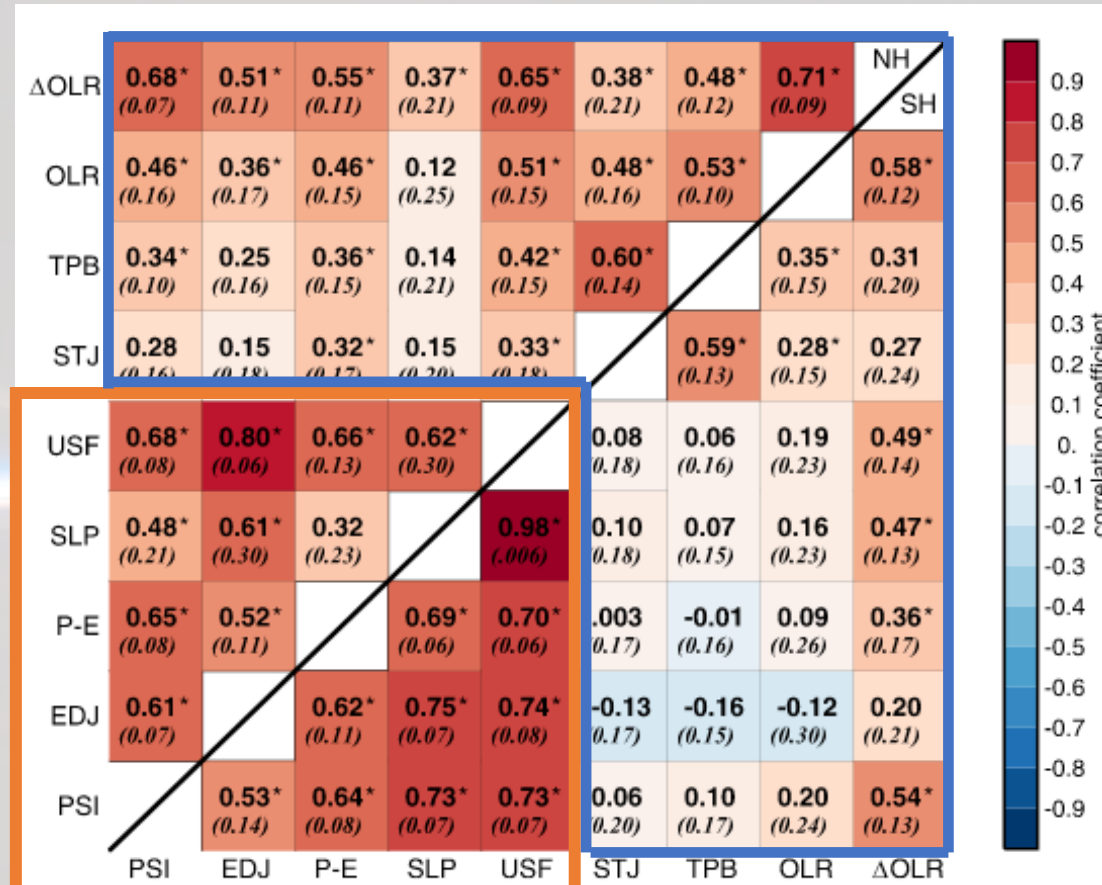
"Upper"



"Lower"



Multi-model mean correlation with Hadley cell edge



# Tropical width: stratospheric questions

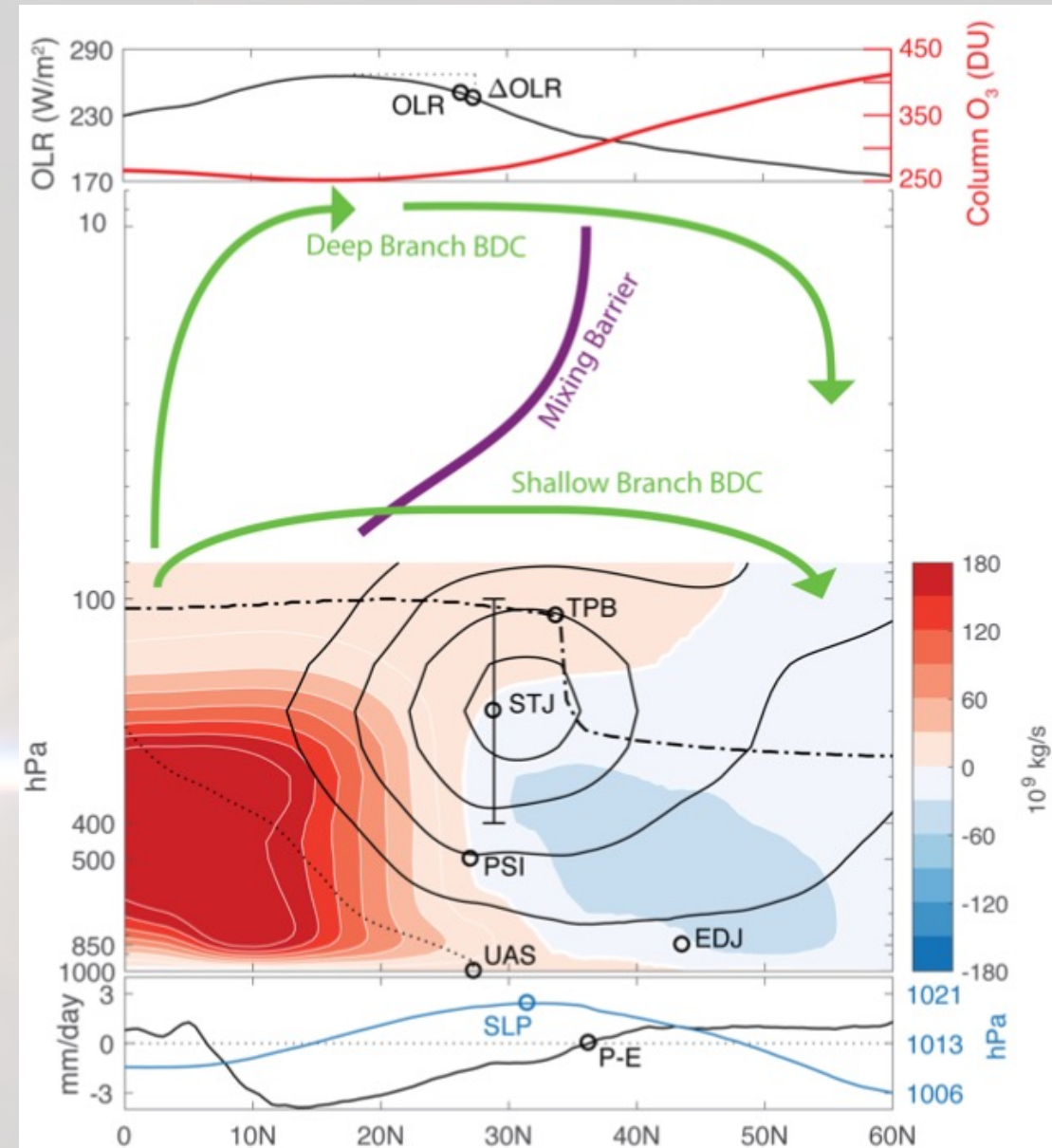
- Relation between “lower”, “upper” metrics, and stratospheric circulation
- ISSI Tropical Width Impacts on the Stratosphere (TWIST) group

## This talk:

- Use meridional gradients in trace gasses, aerosol extinction, and clouds to define tropical edges.

## Motivation:

- Most observational studies use reanalyses
- SAGE and other satellites could provide independent estimates.

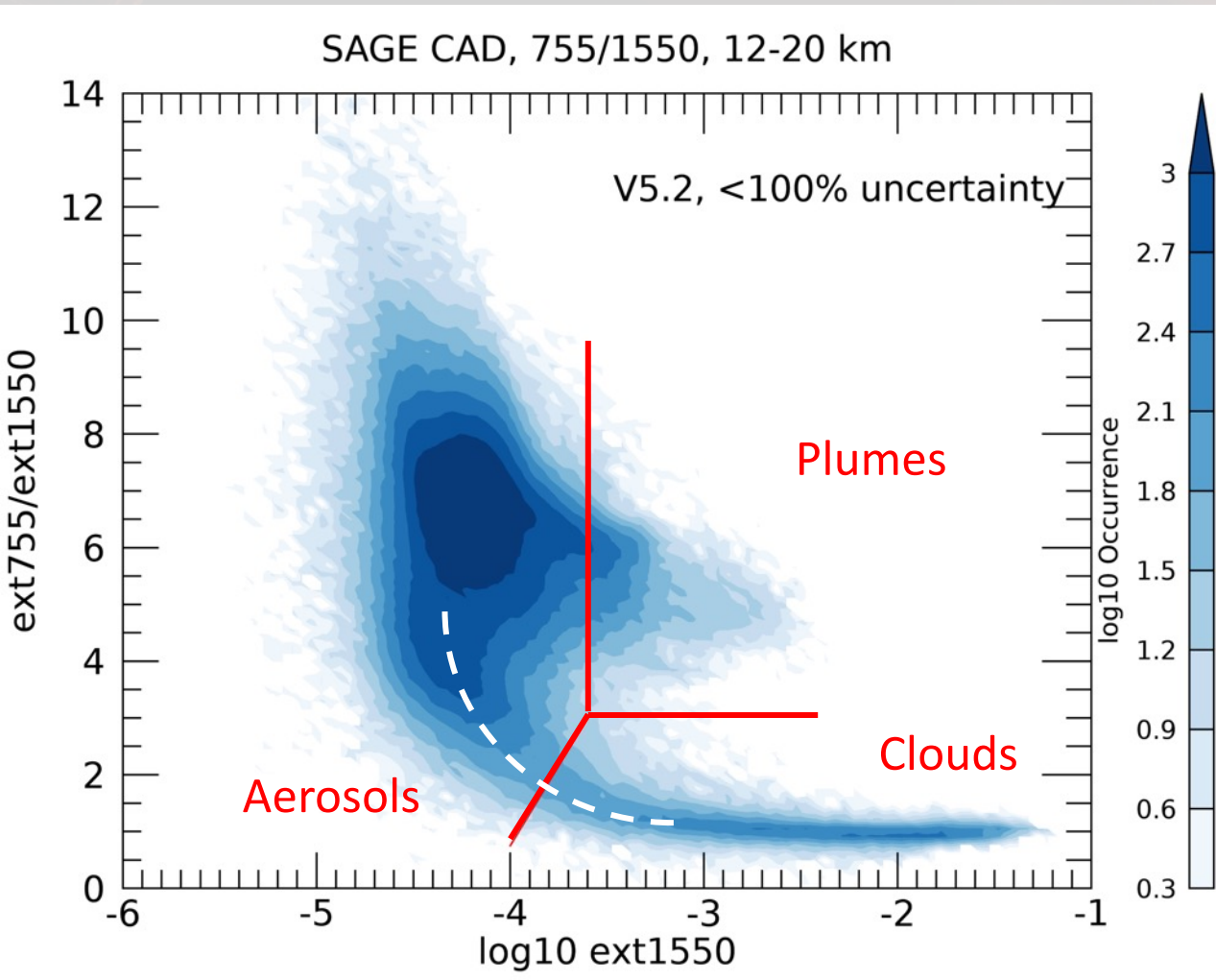


# Data sources

- Single-satellite data sources:
  - SAGE III/ISS O<sub>3</sub>, water vapor, extinction, (v5.3)
  - CALIOP extinction, cloud occurrence (v4.51 test)
- SWOOSH v2.7 (NOAA CSL, [csl.noaa.gov/swoosh](http://csl.noaa.gov/swoosh)) – merged record of O<sub>3</sub> and WV
  - SAGE II, HALOE, UARS MLS, Aura MLS, ACE-FTS, OMPS-LP, SAGE III/ISS (v5.3)
- GLOSSAC v2.21 (NASA LaRC) – merged aerosol record
  - SAGE III/ISS (v5.2), many many others

# Tropical width: SAGE III/ISS

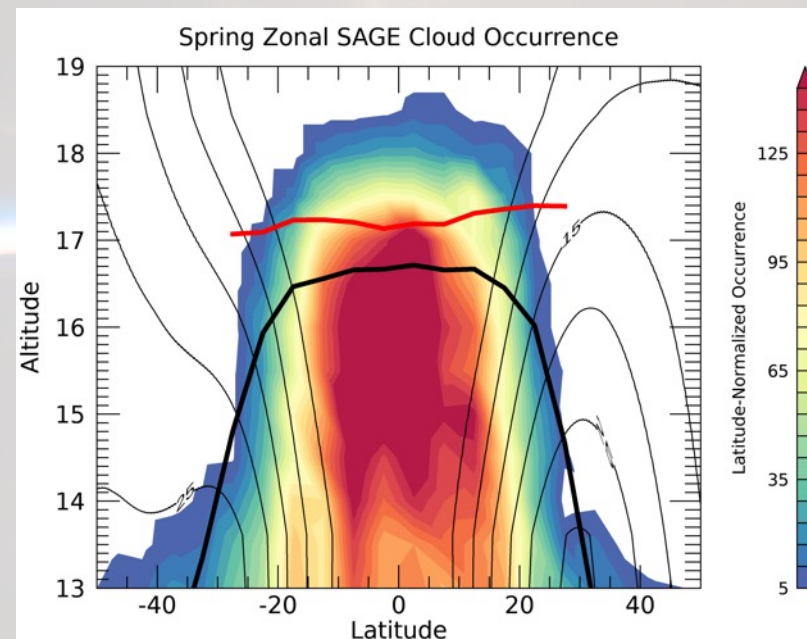
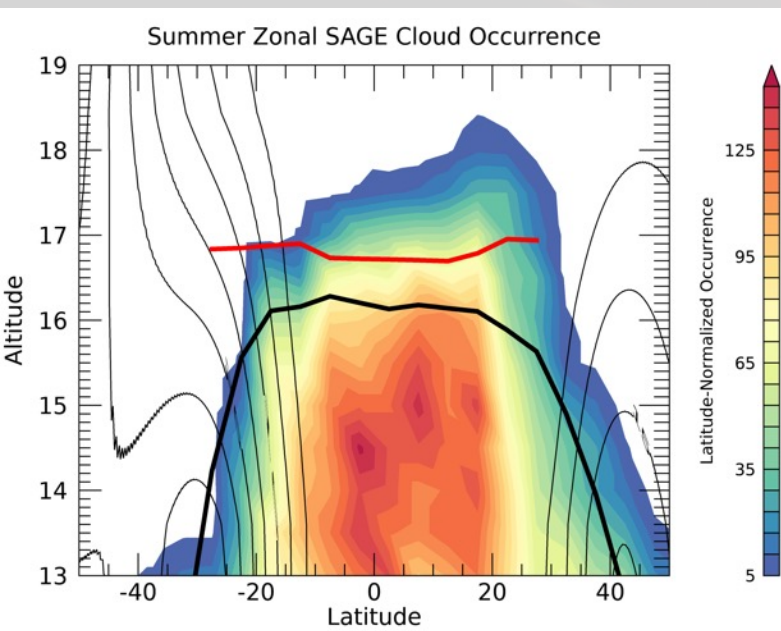
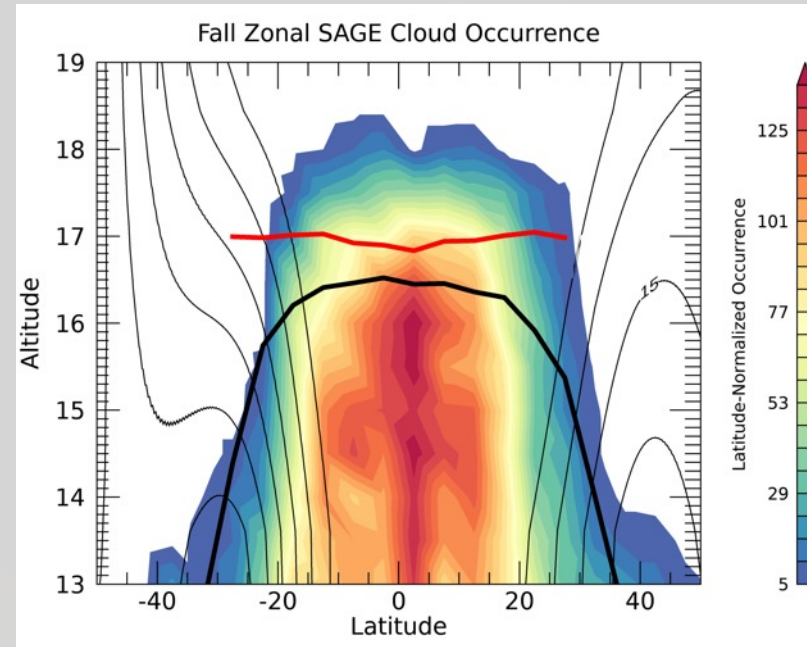
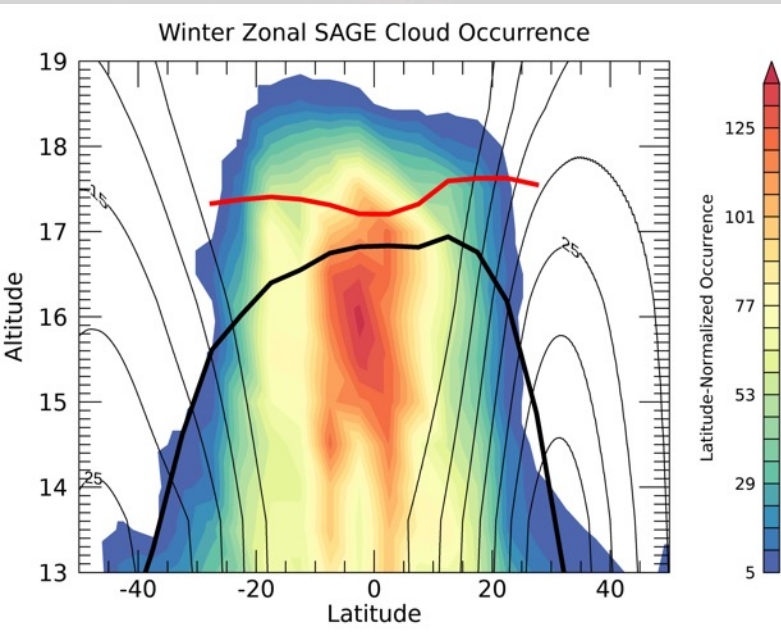
- We first need to separate out clouds and aerosols for this analysis



Cloud-Aerosol Discrimination (CAD)  
inspired by TV2013 and Kovilakam et al.  
(2023)



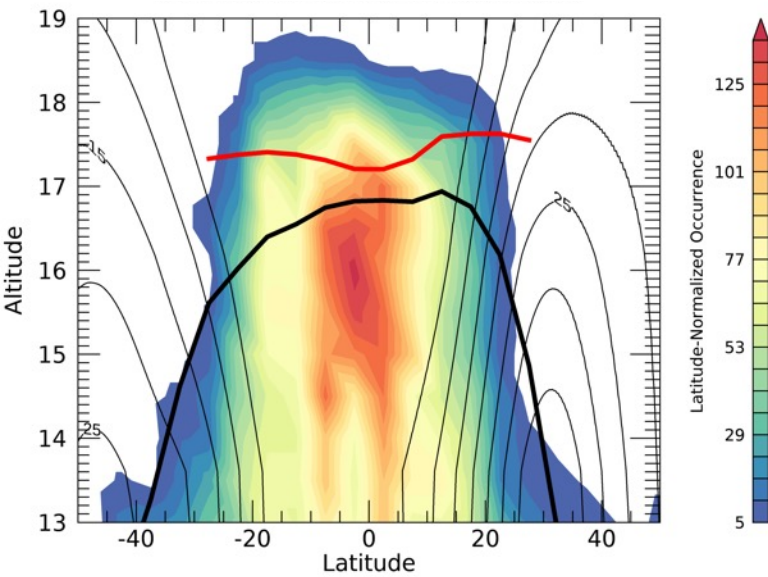
# Tropical width: SAGE III/ISS clouds



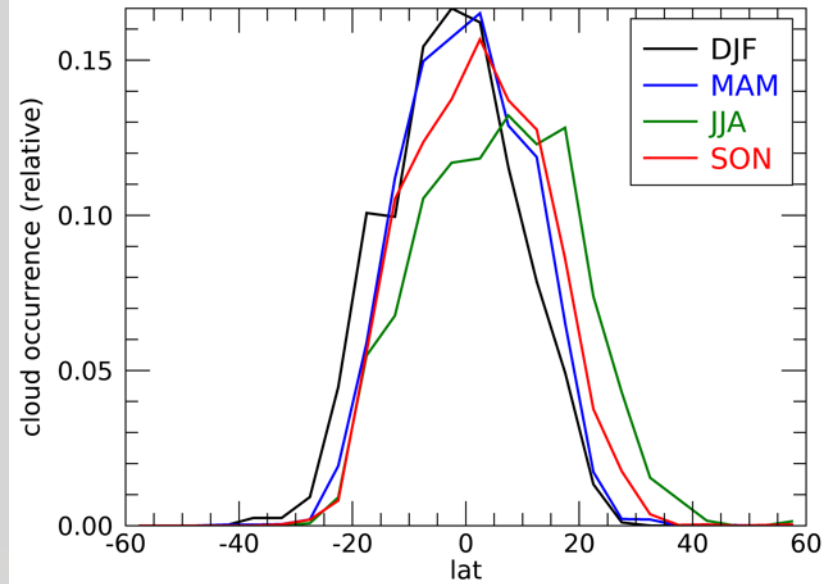
Seasonal back-and-forth of clouds, tropopause

# Tropical width: CALIOP & SAGE III/ISS clouds

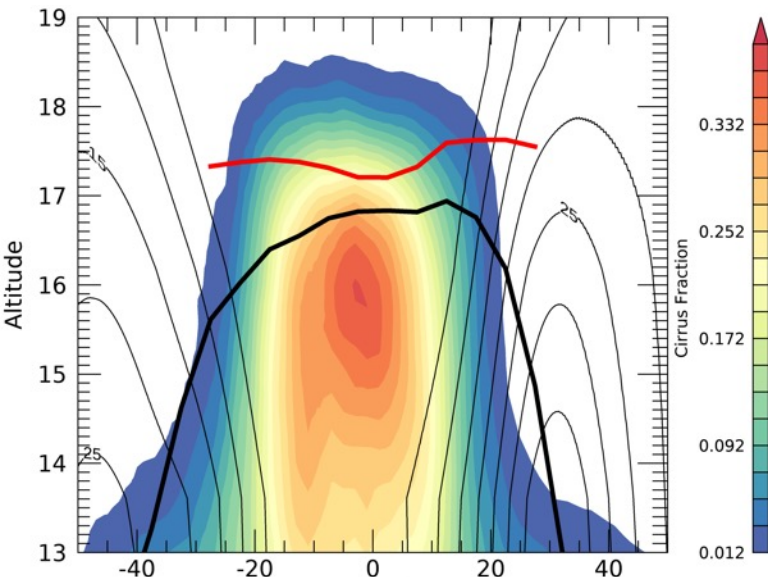
SAGE III/ISS DJF cloud occurrence



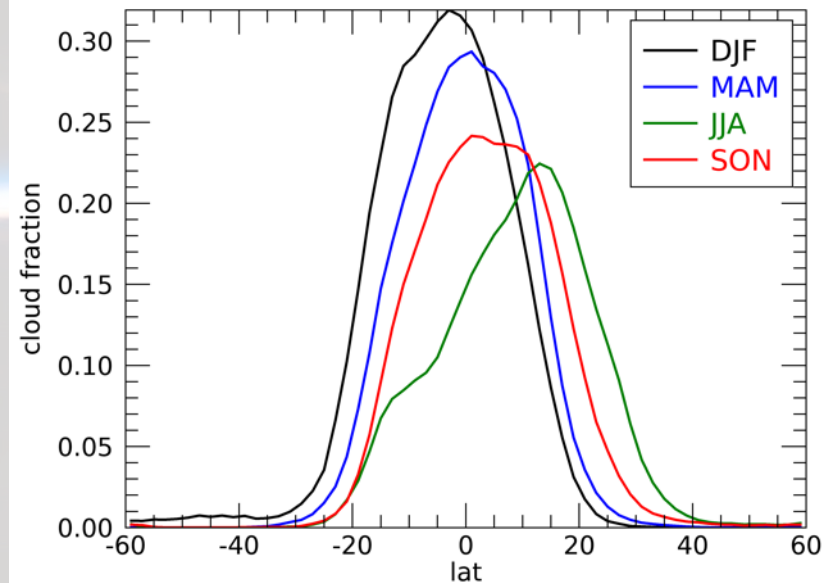
SAGE



CALIOP DJF cloud occurrence



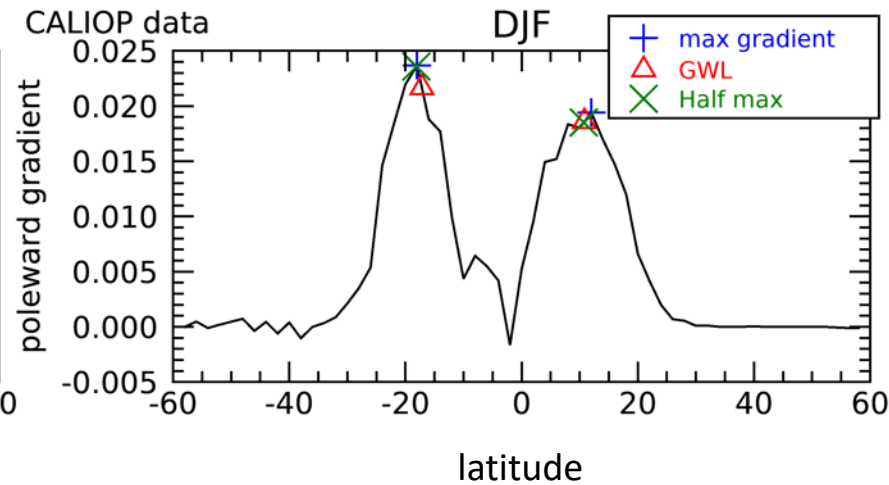
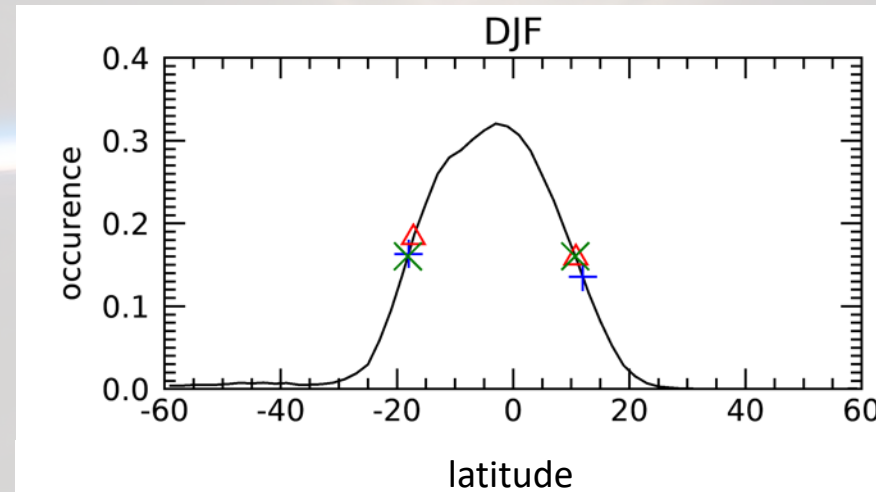
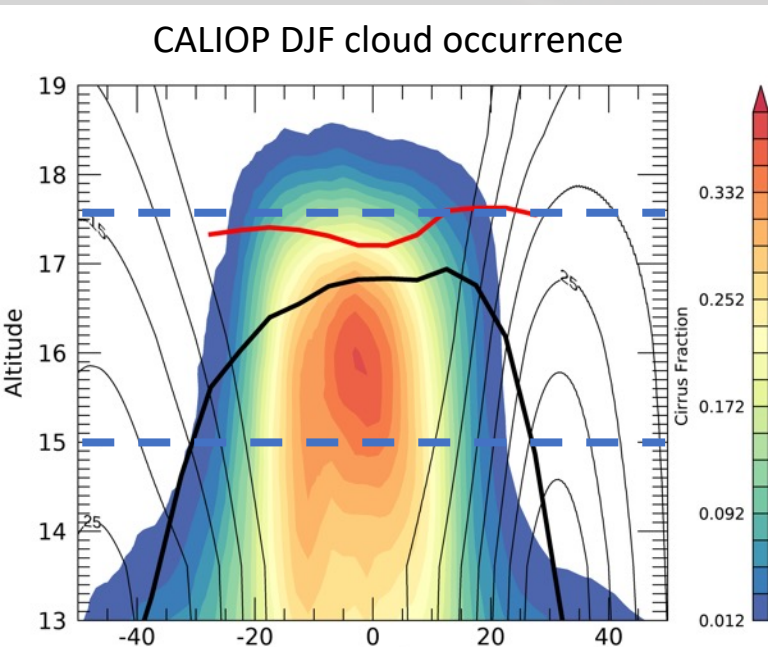
CALIOP



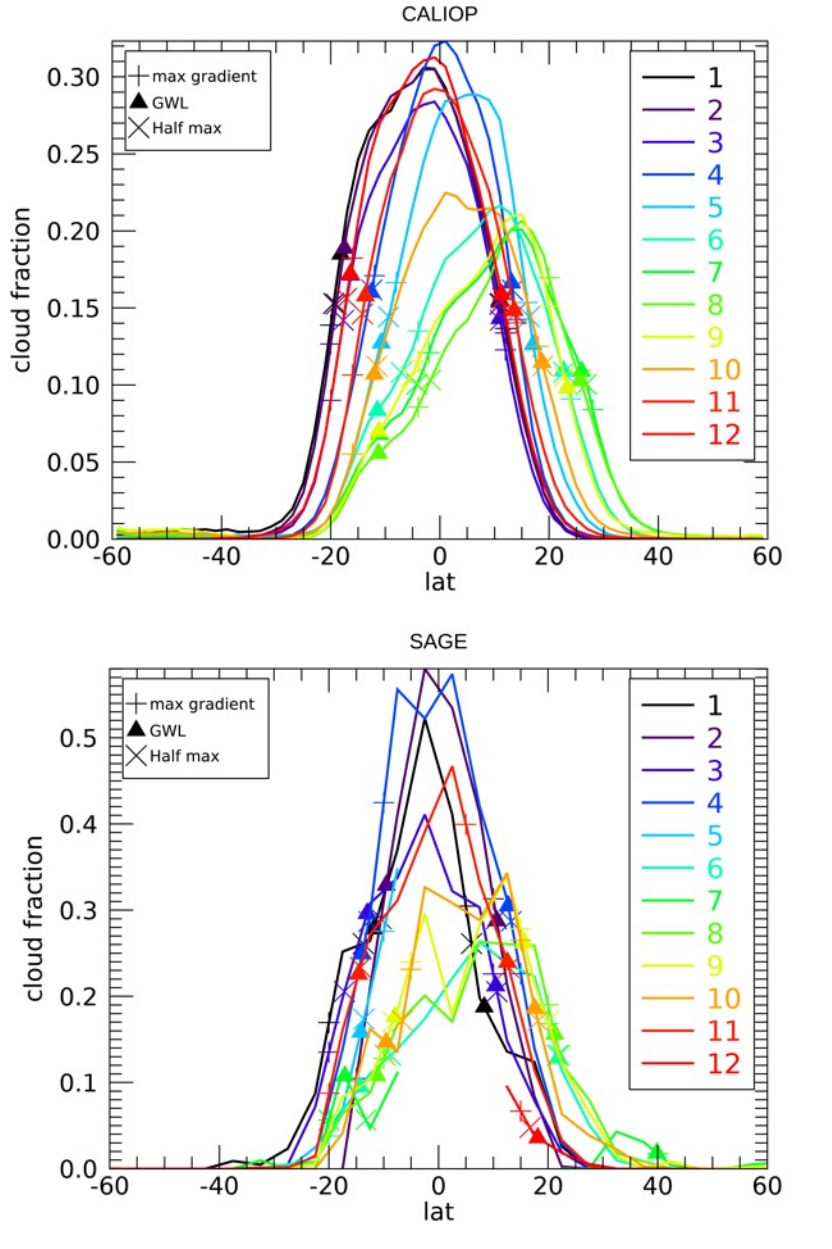
- SAGE & CALIOP capture the seasonality of the cloud field

# Tropical width: cloud example

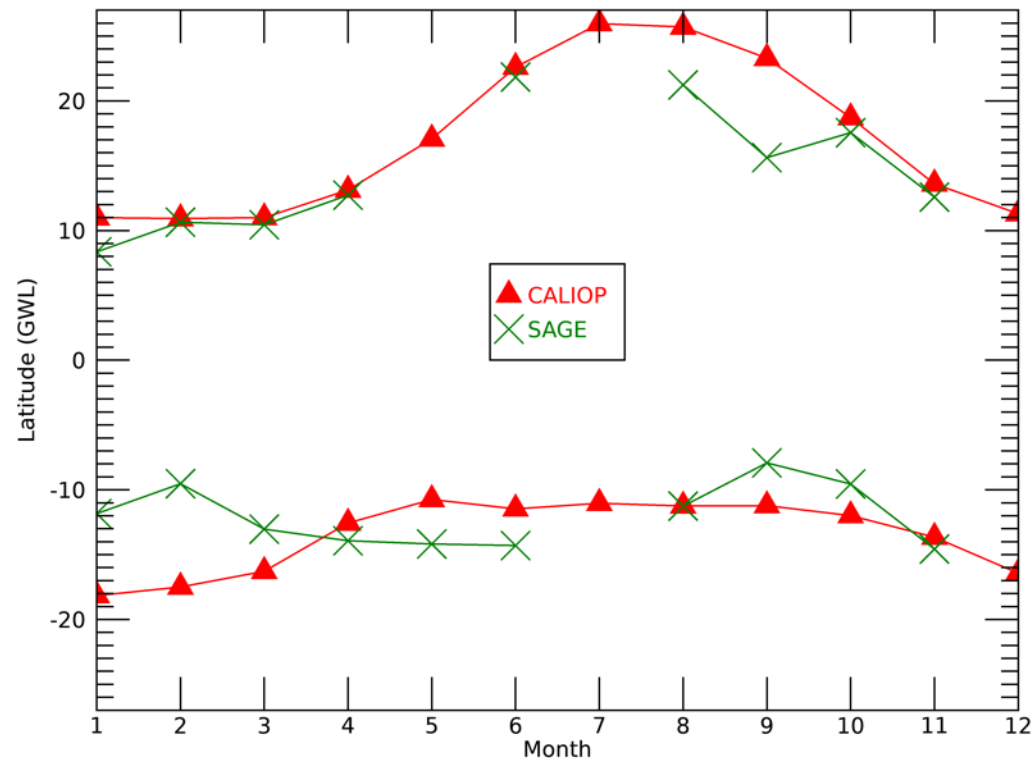
- Average cloud occurrence near tropopause (15-17.5 km)
- Find latitude of peak poleward gradient



# Tropical width: cloud seasonality

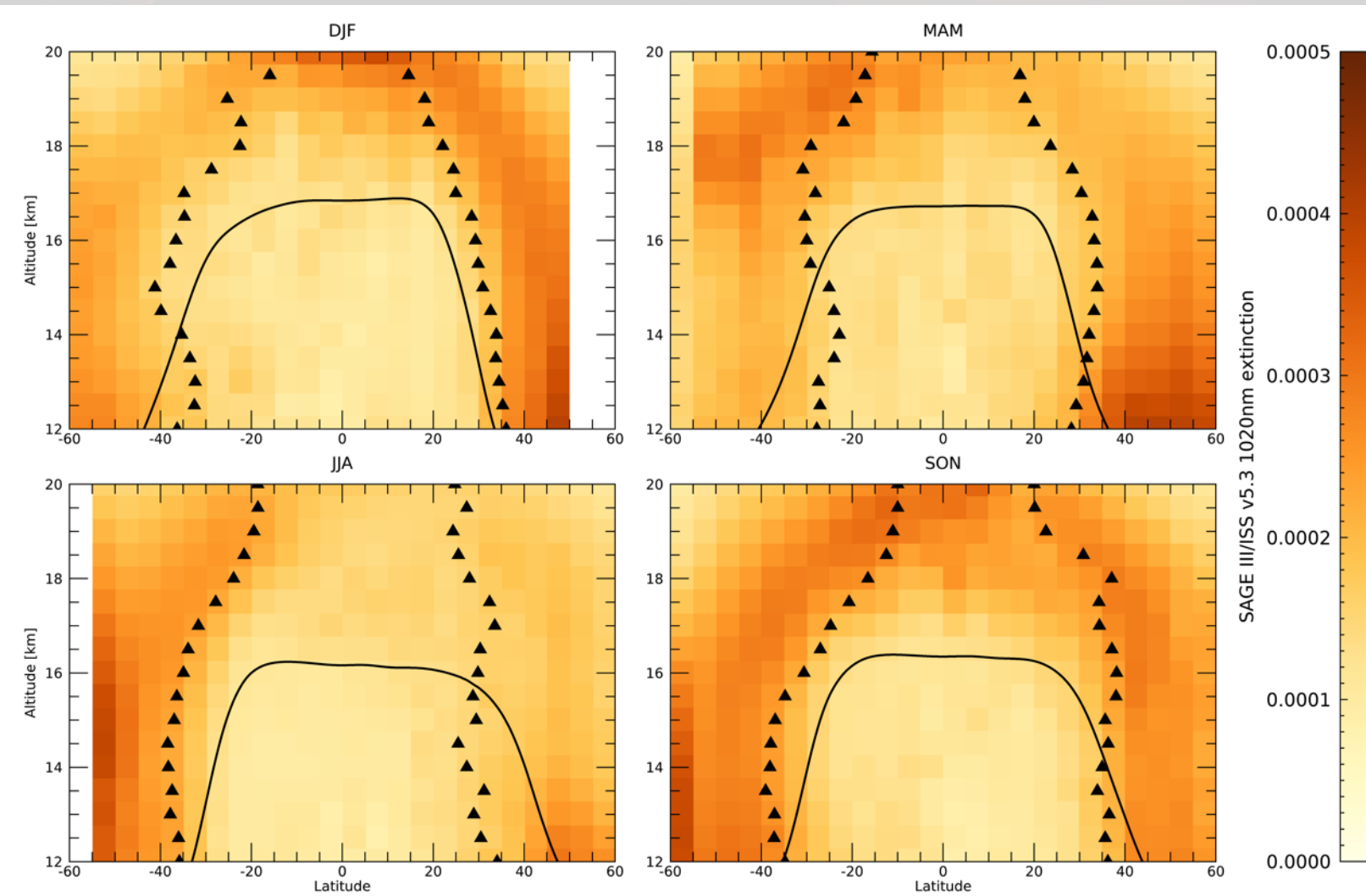


- SAGE and CALIOP are broadly similar in NH
- Noisier results in SH
- SAGE is quite noisy at monthly level



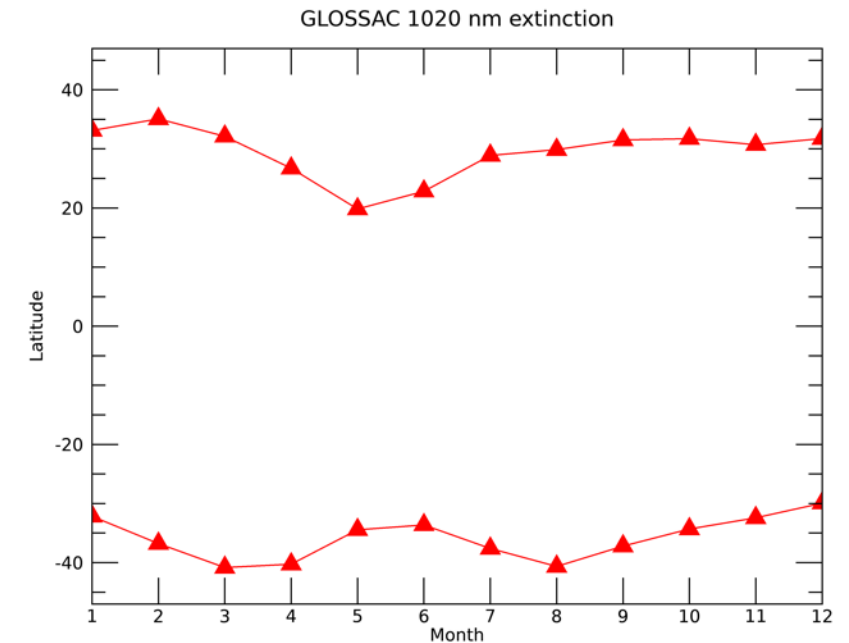
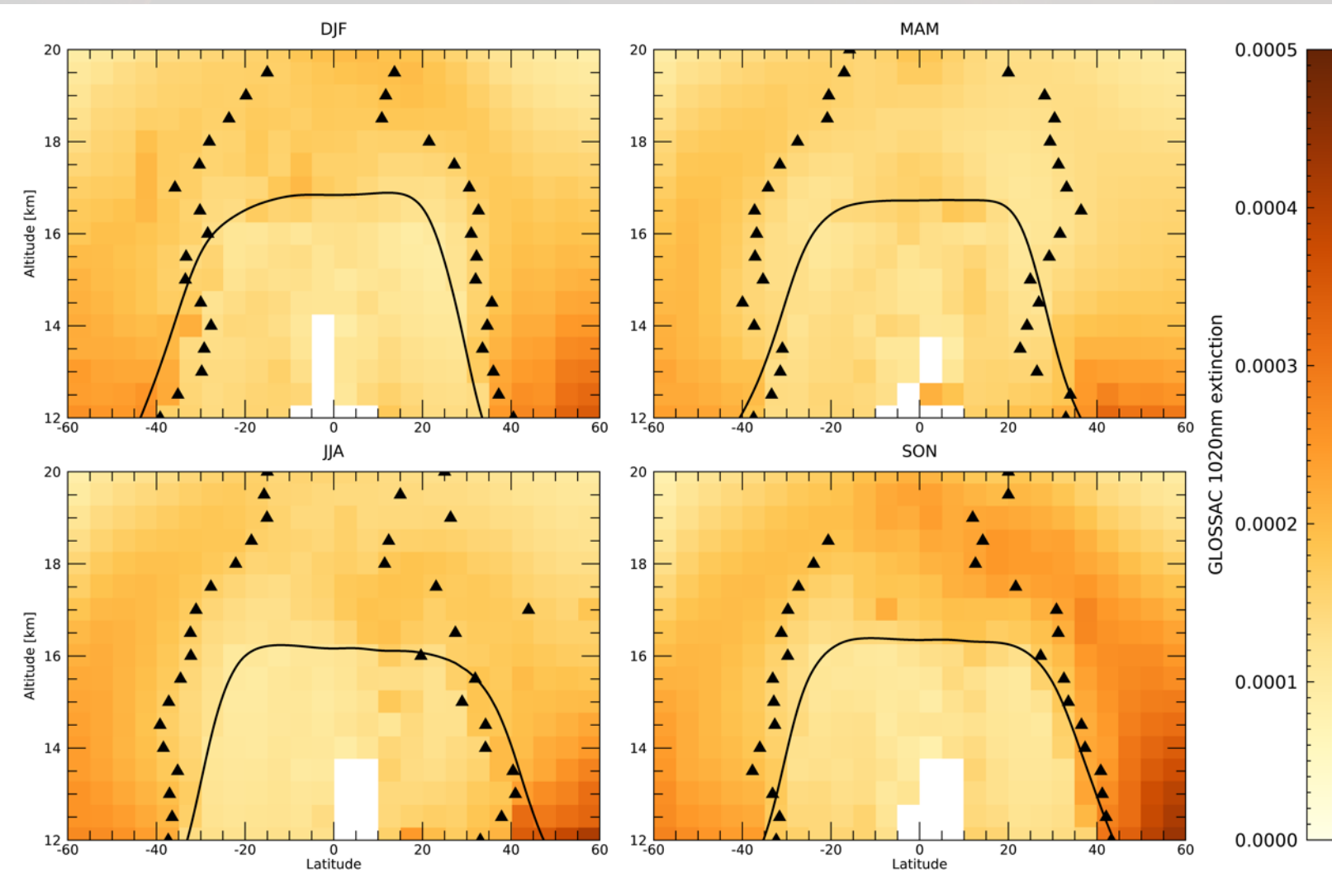
# Tropical width: SAGE III/ISS aerosols

- Peak aerosol gradient roughly follows the tropopause break in some seasons



# Tropical width: GLOSSAC aerosols

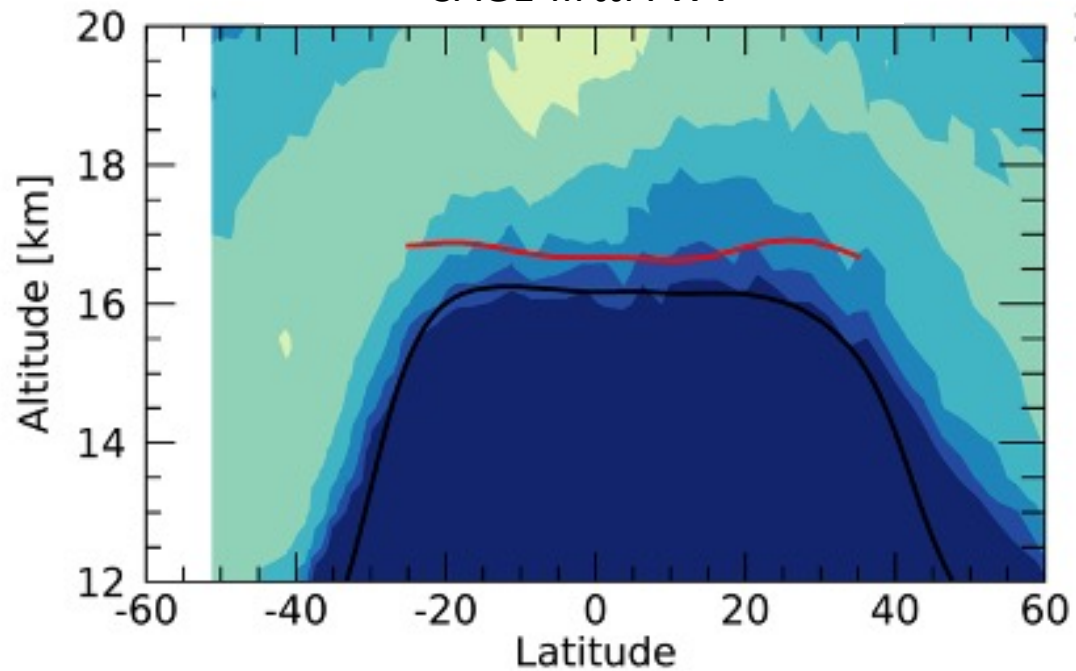
- Peak aerosol gradient roughly follows the tropopause break
- Odd seasonality – needs further research!



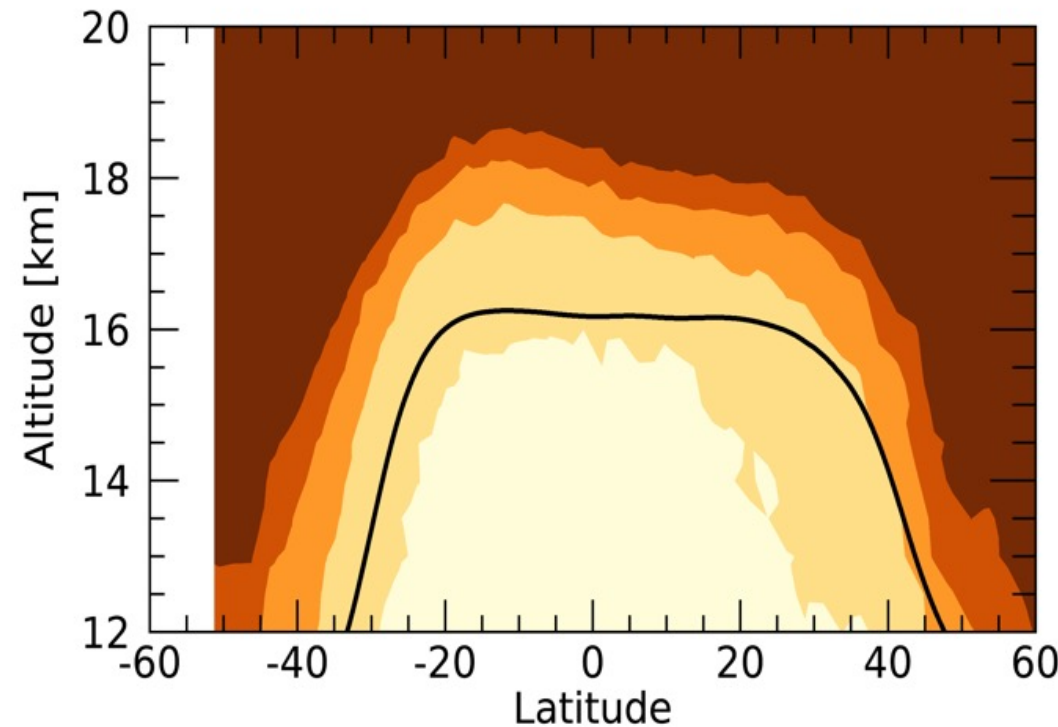
# Tropical width: trace gas example

- Strong gradients in WV and O<sub>3</sub> at specific levels
- Ongoing work as part of the ISSI Tropical Width Impacts in the Stratosphere (TWIST) group

SAGE-III JJA WV

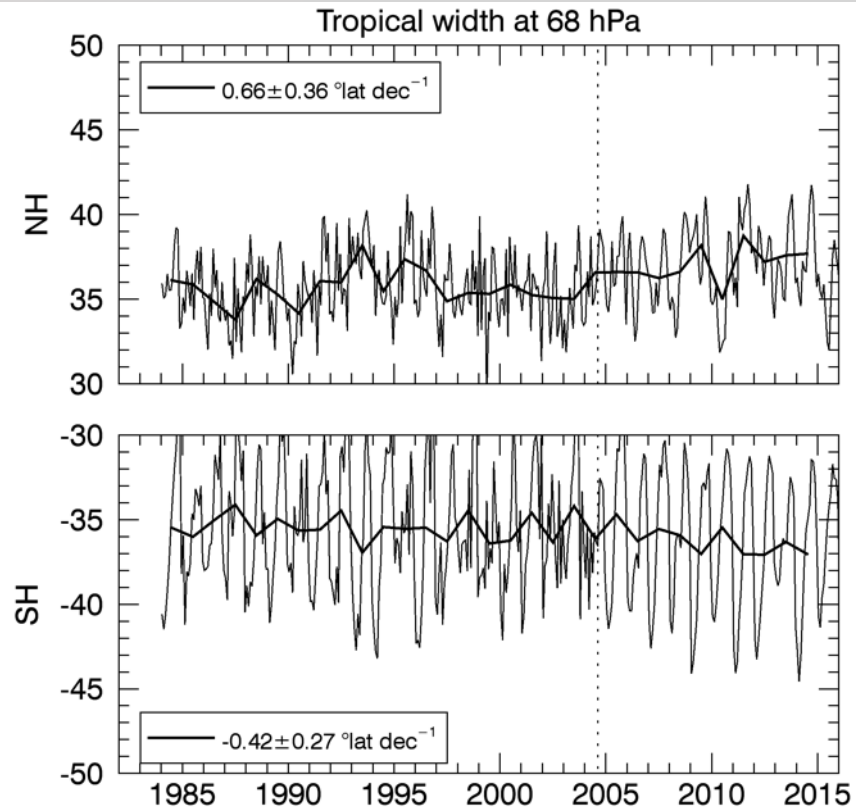
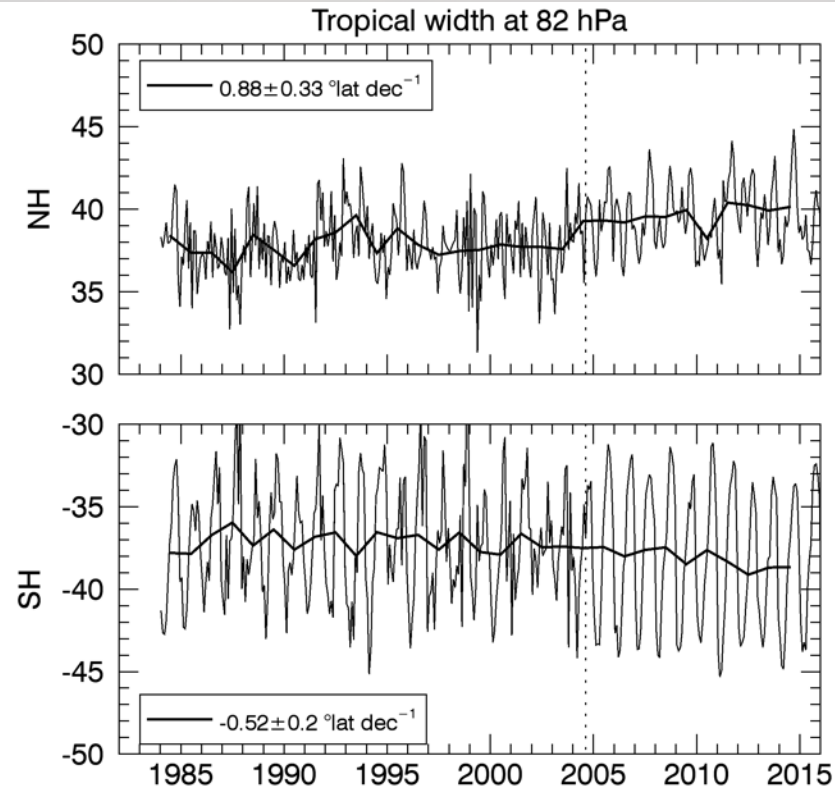
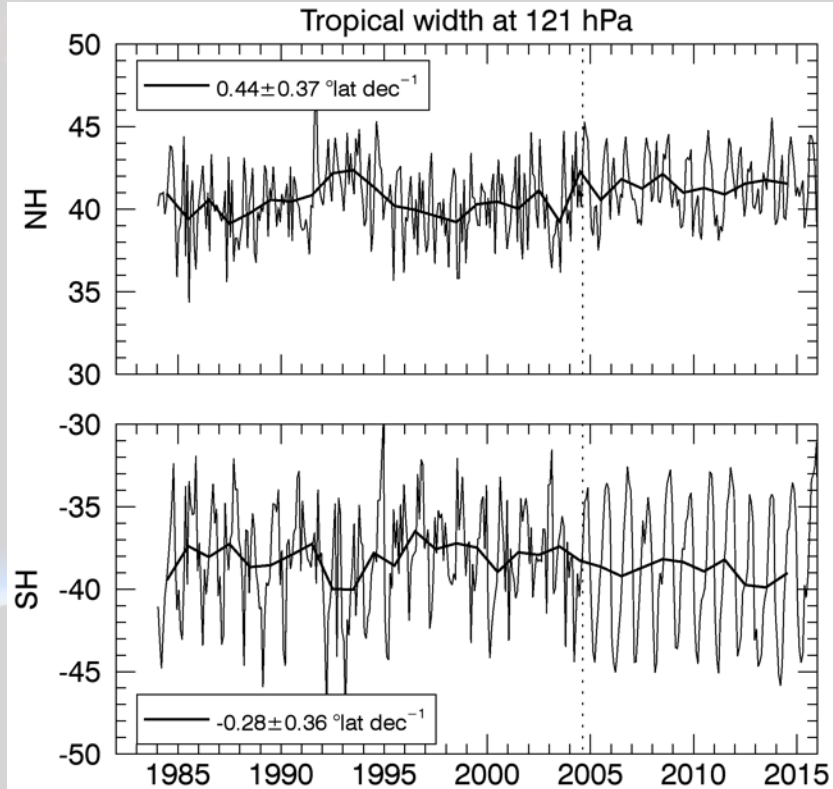


SAGE-III JJA Ozone



# Tropical width: SWOOSH ozone example

- Possibly significant trends at some levels.
- Needs careful investigation of satellite transition periods





# Conclusions

- Clouds
  - Reasonable seasonal cycle detectable by SAGE
  - Limited SAGE sampling complicates detection on finer timescales
  - Ongoing efforts to analyze 2006-2023 from CALIOP
- Aerosols
  - Peak gradient occurs near tropopause in some seasons
  - Odd seasonality – requires further investigation
  - Complicated by episodic events (volcanoes, fires)
  - Potential to extend back in time
- WV and O<sub>3</sub> gas-based edge detection
  - Strong gradients around tropopause
  - Ongoing work with ISSI TWIST group
- Future plans for assessing edge detection in models

# NH seasonality

