

Stratospheric Water Vapor Observations from the International Space Station by the Stratospheric Aerosol and Gas Experiment III (SAGE III/ISS)

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12th Atmospheric Limb Workshop:

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sage.nasa.gov

Image Credit: NASA Astronaut Ricky Arnold



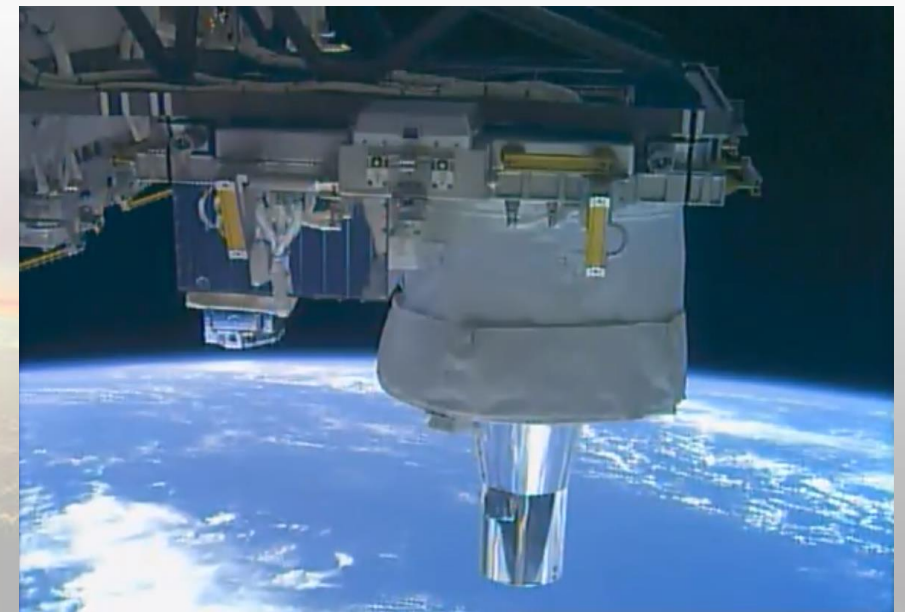
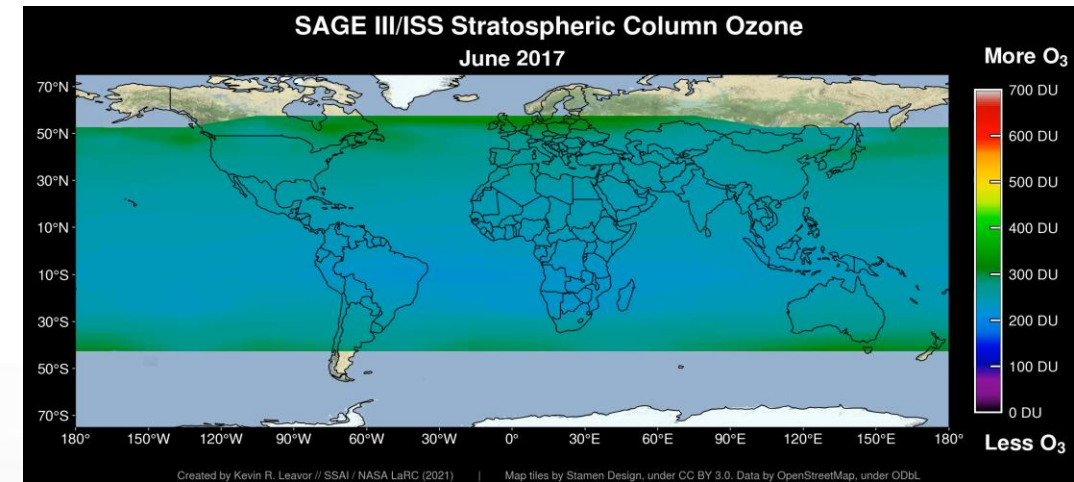


SAGE III/ISS Overview

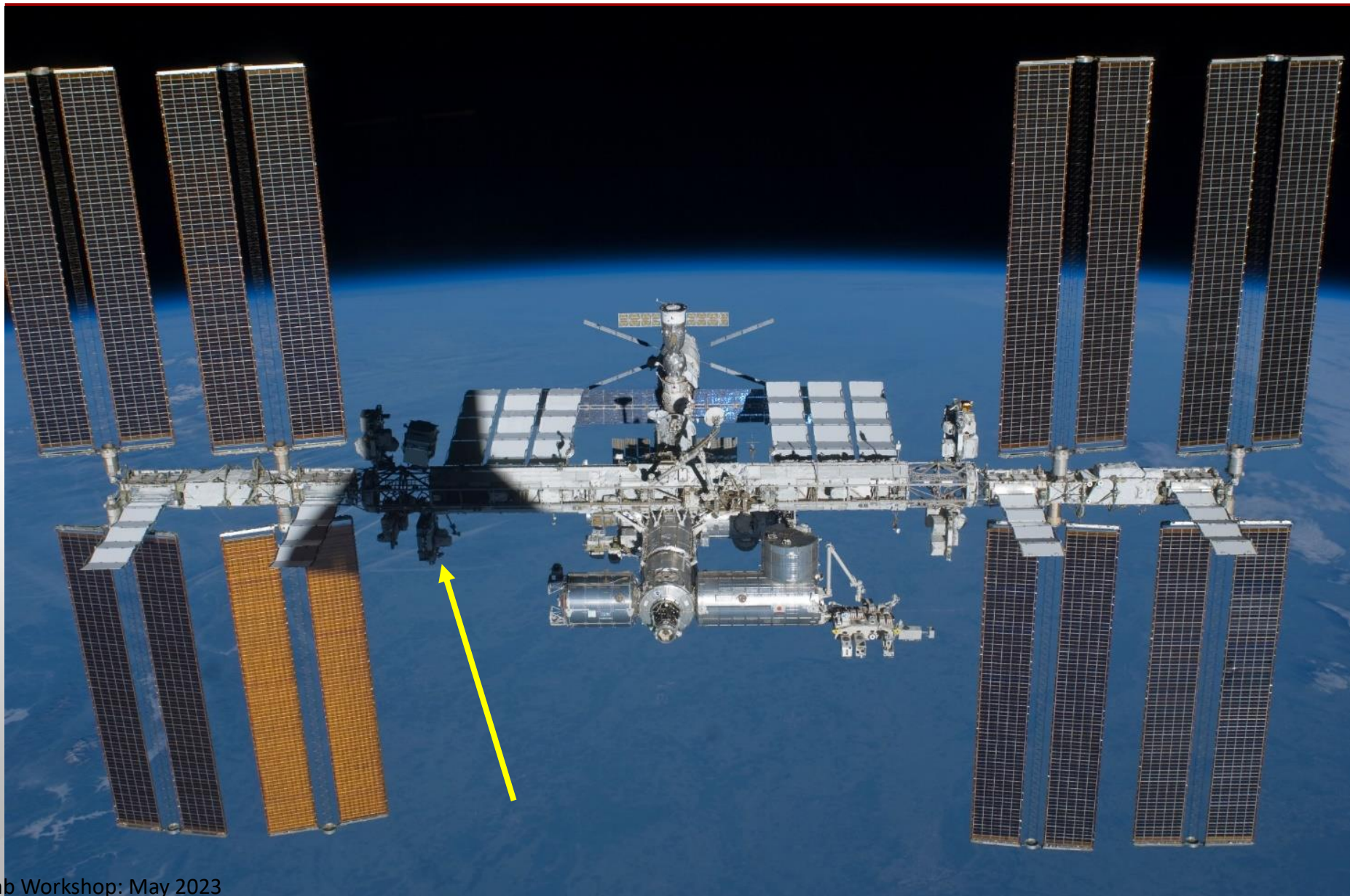


- SAGE produces high vertical resolution profiles of aerosols, ozone, water vapor, and other trace gases in the stratosphere and upper troposphere using the very stable occultation technique
- Core element of WMO International Ozone Assessment and WCRP SPARC
- Acquired >50k occultation events June 2017 - October 2022
- 5 ¼ years science mission; in year 3 of extended mission; anticipating 2023 Senior Review
- Current data products V5.2; V5.3 in works
- ROSES Science Team, 2nd cycle, entering 2nd year
- 37 peer-reviewed papers using SAGE III/ISS data products, with others in review
- Vibrant internship program with ~5 NIFS students/yr

STRATOSPHERIC OZONE

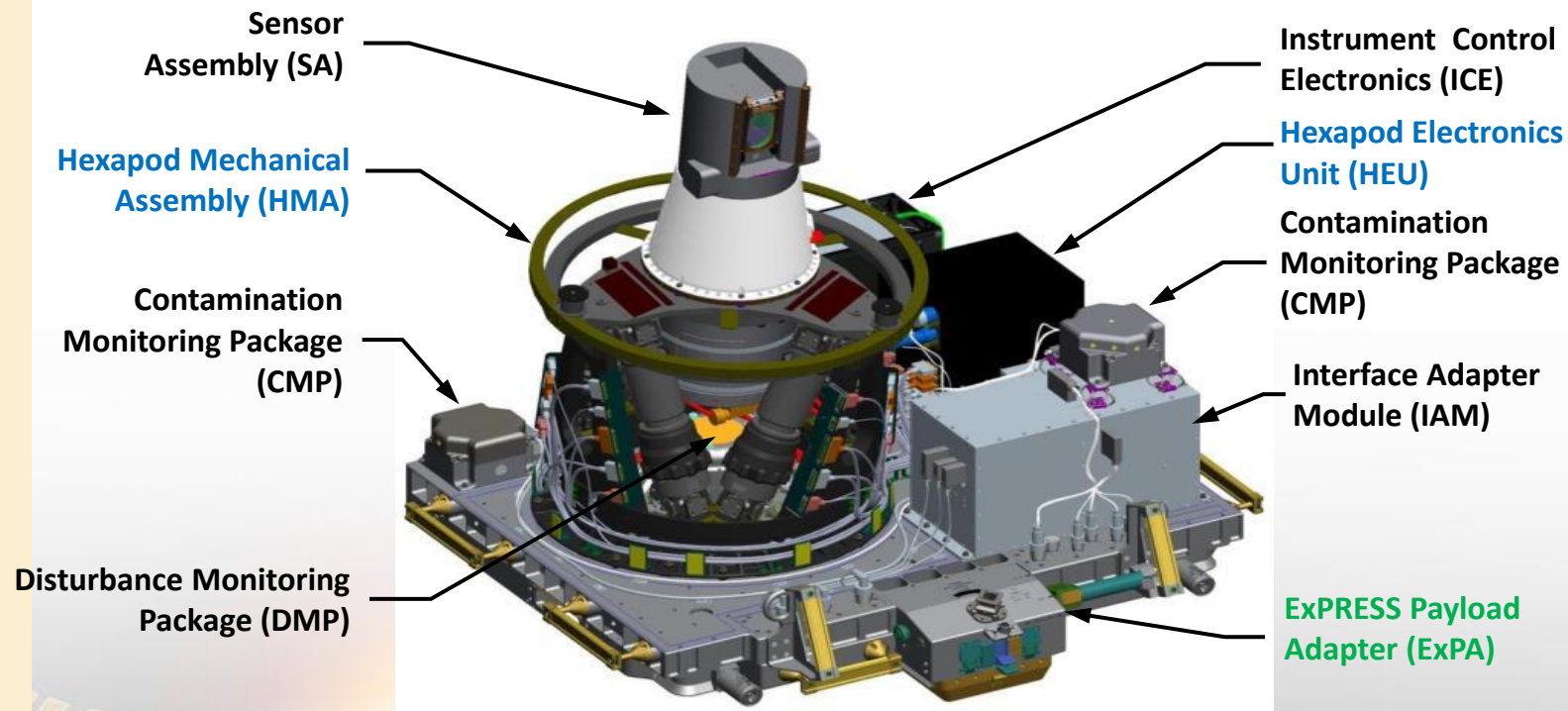


SAGE III's location



Payload Key Features:

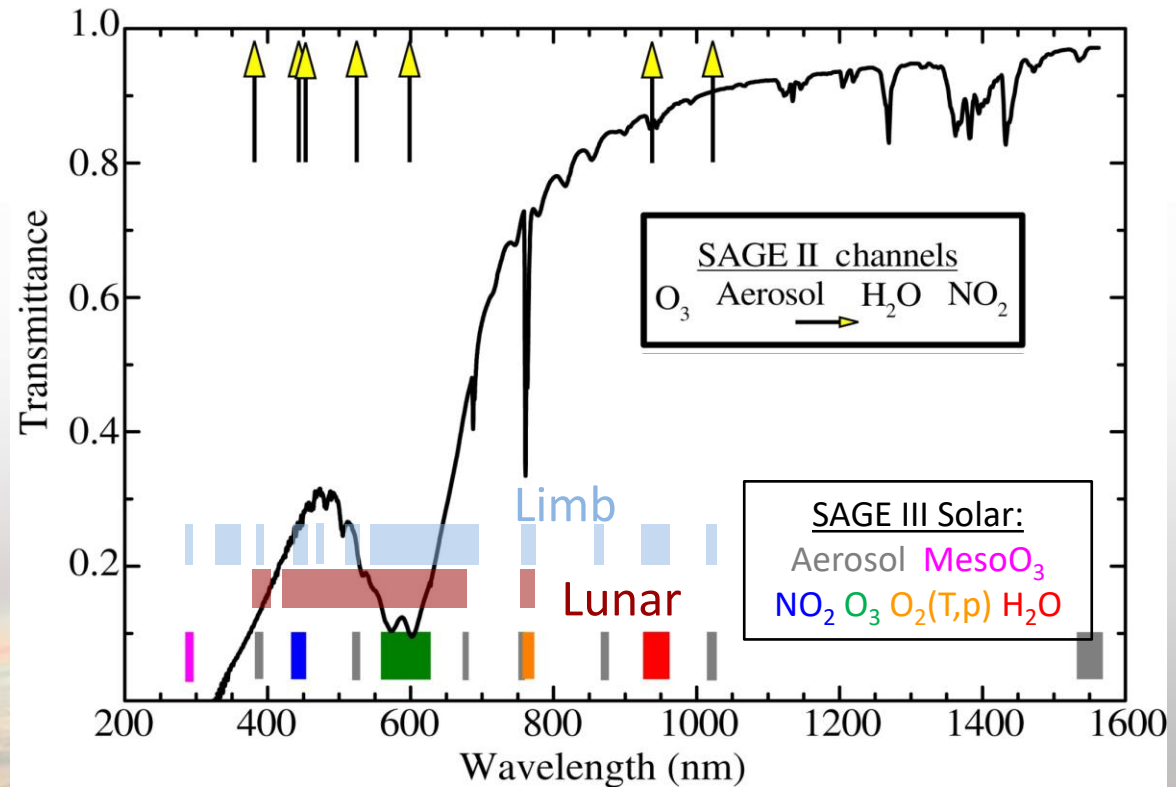
- Spectrometer covering 290-1030 nm
- Quartz contamination door over telescope aperture
- Scan head azimuth rotation range > 360°
- Hexapod accounts for ISS attitude variation prior to data collection
- DMP records platform attitude variations during data collection
- CMP to guide Operations for limiting contamination to optics



SAGE Spectral Sampling

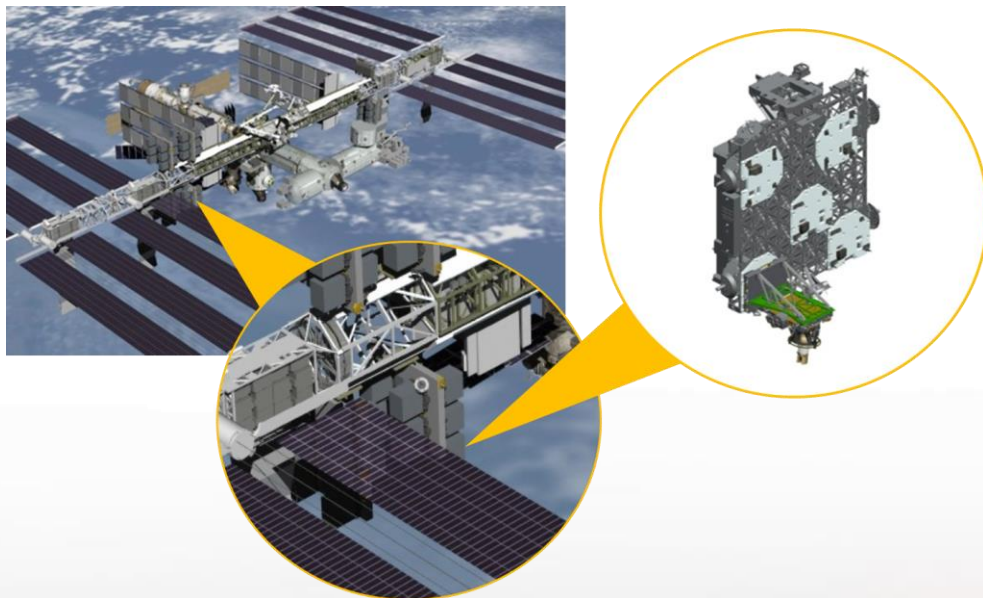
➤ The SAGE III water vapor product is derived from sampling spectra covering the $\rho\sigma\tau$ water vapor absorption band (~940nm), like SAGE II, but with improved spectral resolution and an updated algorithm (Thomason et al., 2010).

SAGE III/ISS Spectral Sampling



SAGE III ON ISS

ISS Location & View

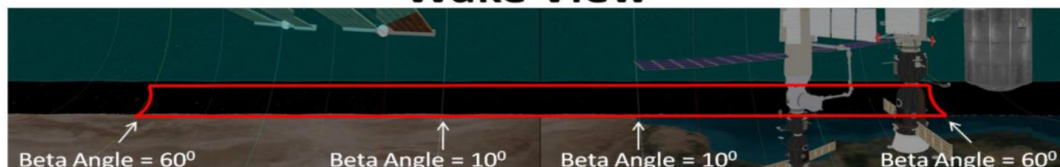


SAGE III installed with the Earth's limb in the background

Ram View

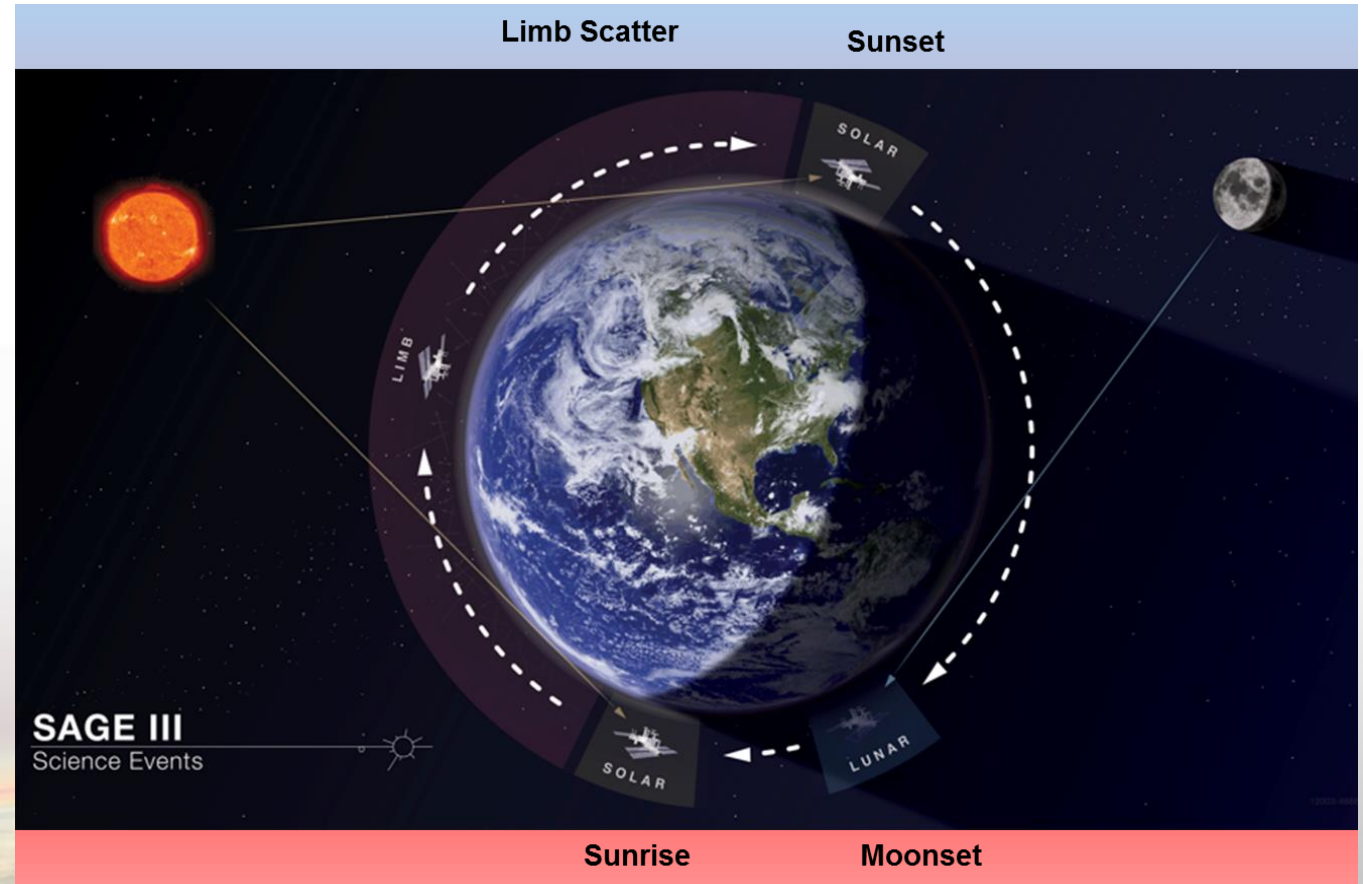


Wake View



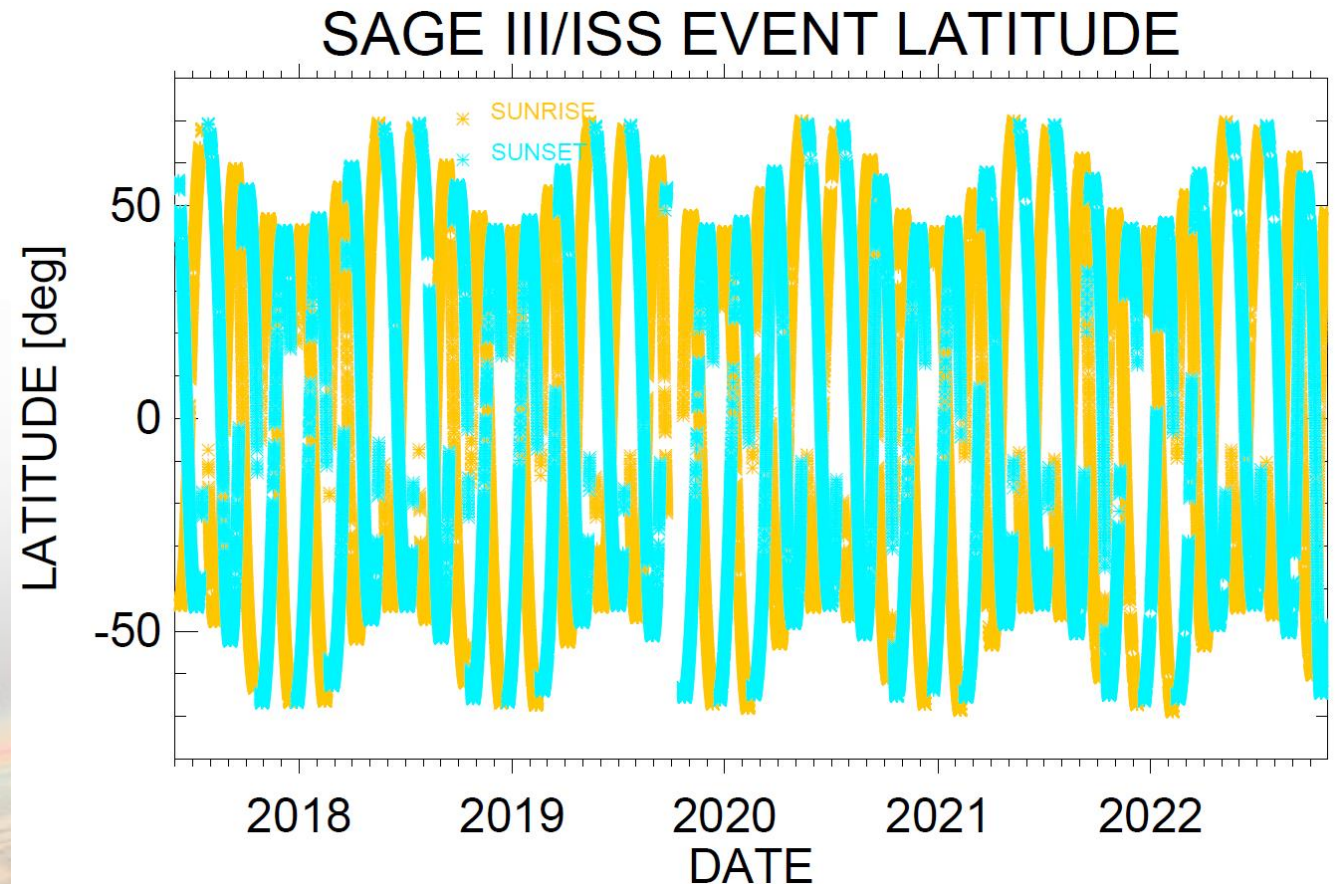
Science Collection Modes

- Operational Modes include: Solar Occultation (SO), Lunar Occultation (LO) & Limb Scatter (LS)
- Occultation events dictated by orbital mechanics



Spatial-Temporal Sampling

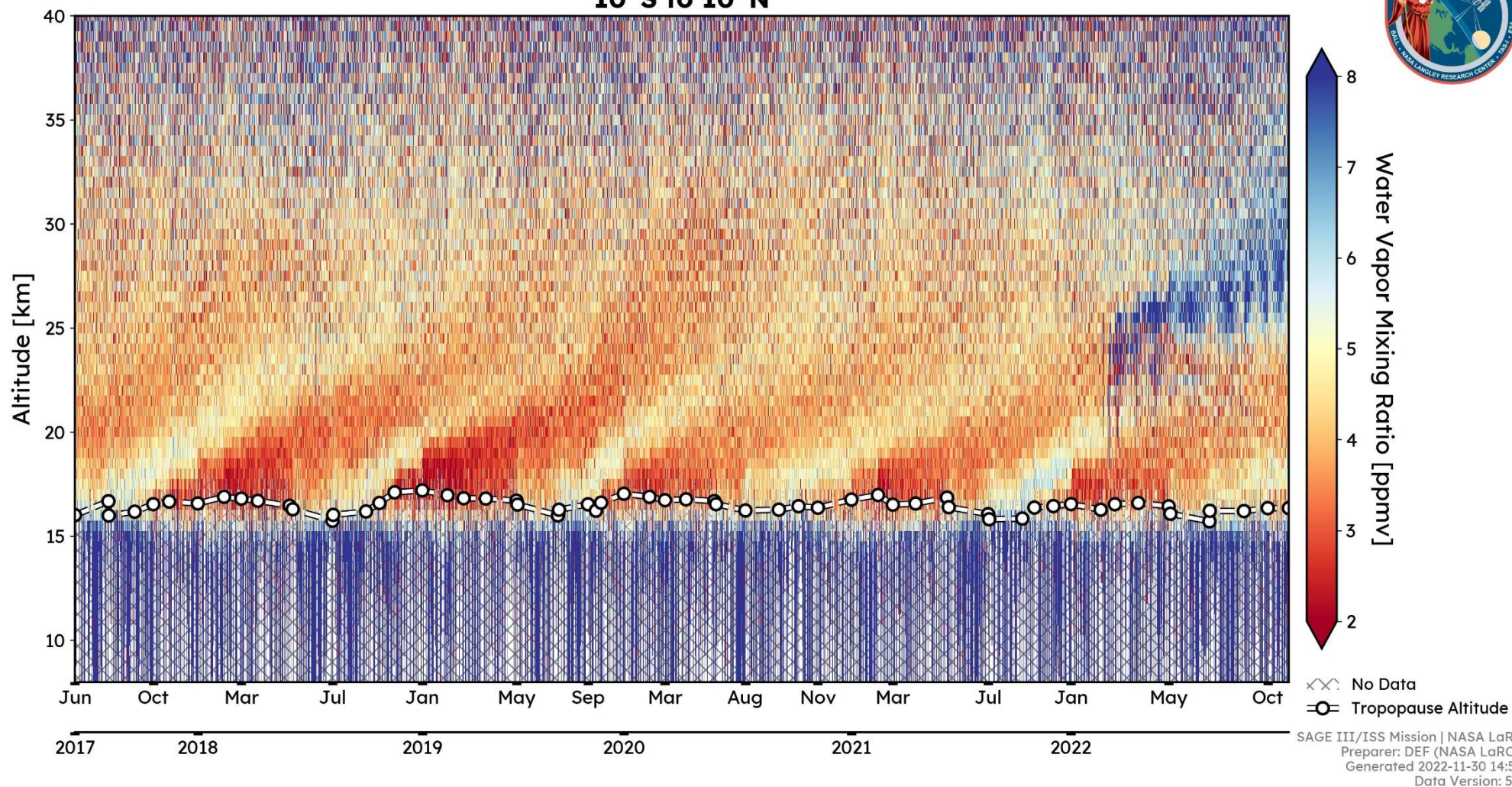
- **The 51.6° inclined orbit of the ISS is well-suited for SO and provides near-global observations on a monthly basis with coverage of low and mid-latitudes similar to that of the SAGE II mission, which operated for over two decades.**





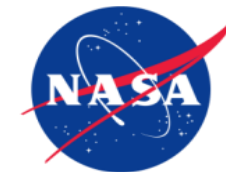
Tropical Tape Recorder

SAGE III/ISS Water Vapor Mixing Ratio - Mission Overview 10°S to 10°N

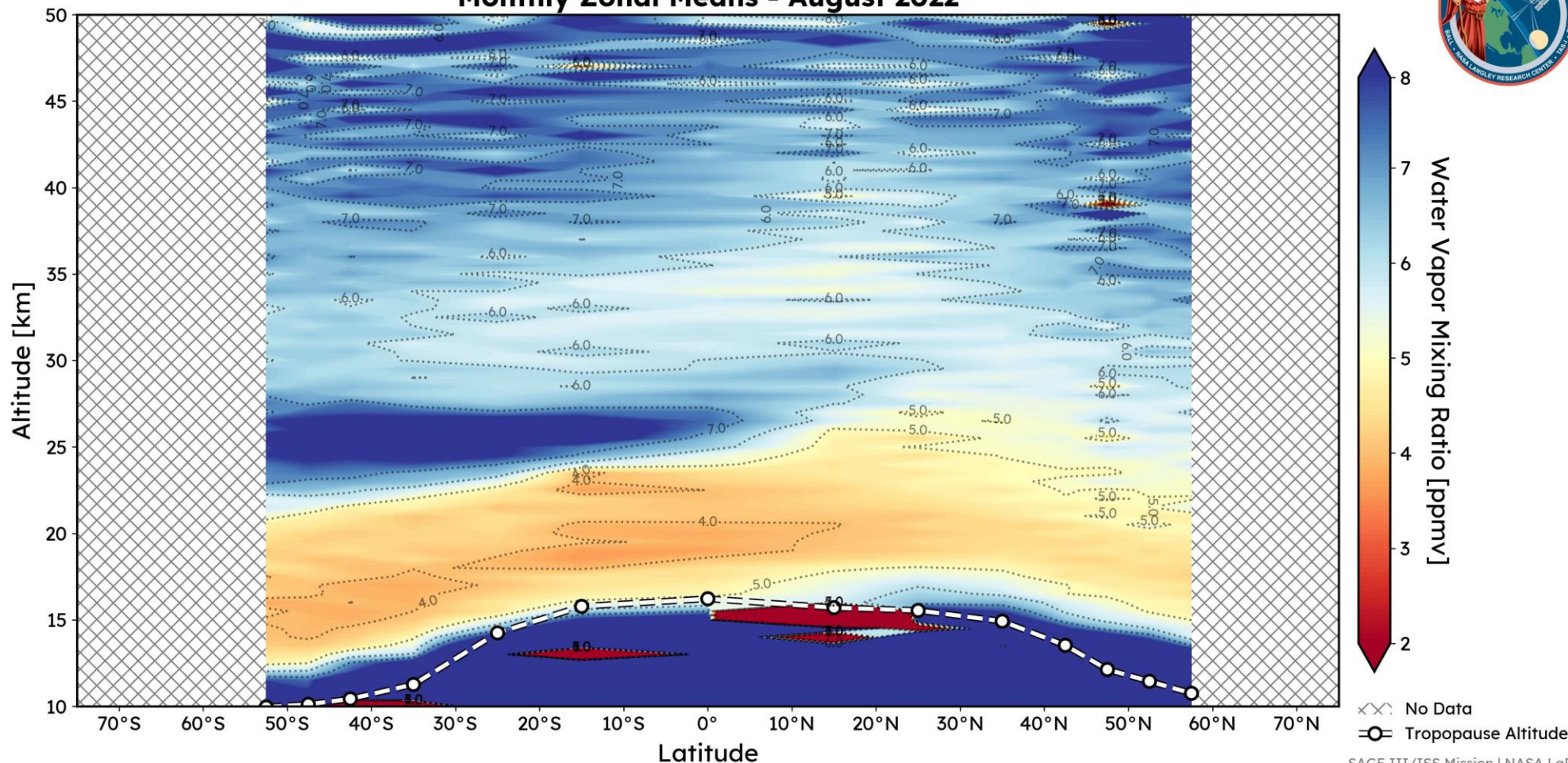




Water Vapor Monthly Snapshot



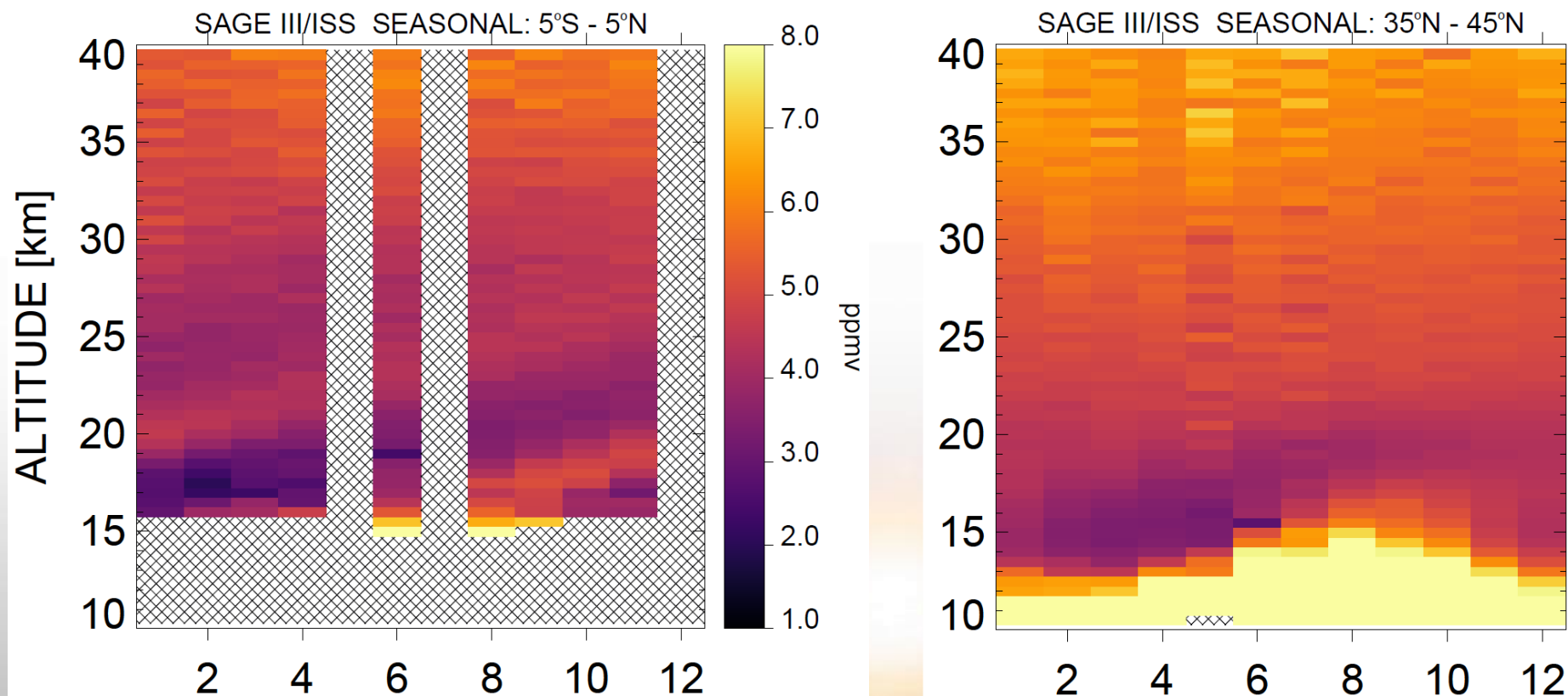
SAGE III/ISS Water Vapor Mixing Ratio Monthly Zonal Means - August 2022



×× No Data
○ Tropopause Altitude

SAGE III/ISS Mission | NASA LaRC
Preparer: Dave Bonehead ()
Generated 2022-10-10 02:53
Data Version: 5.2

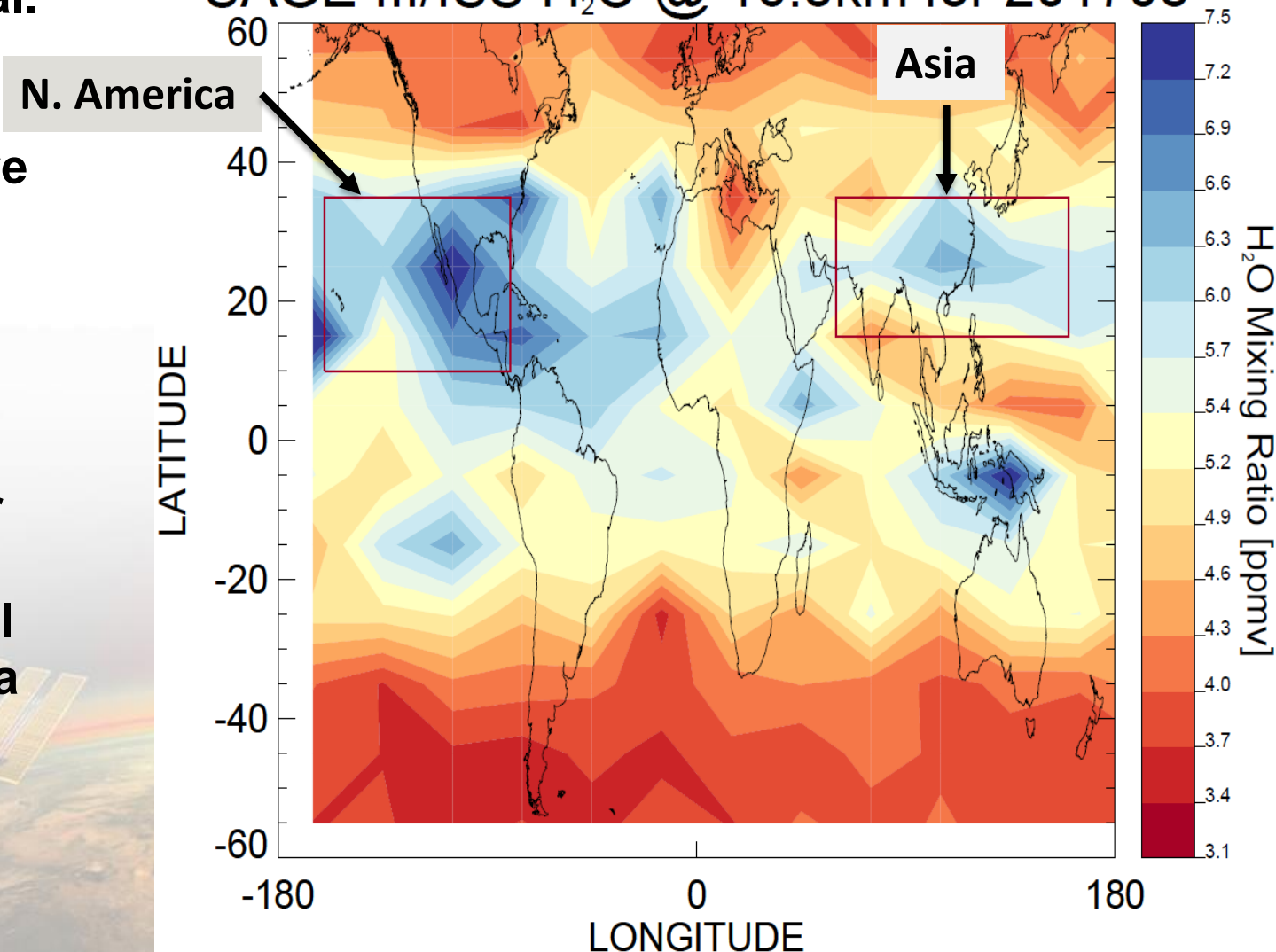
Seasonal Cycle



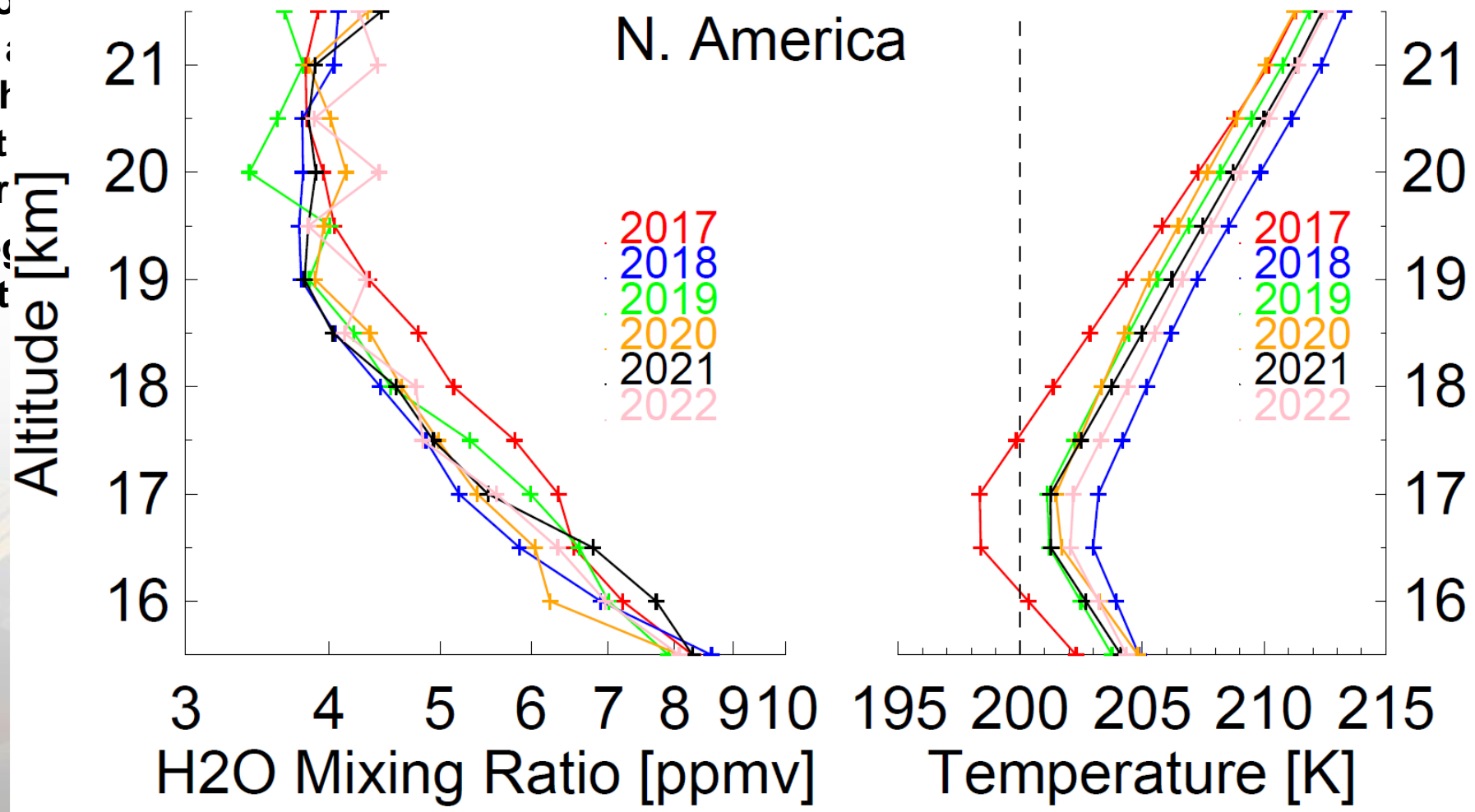
Summer Monsoon

- Revisiting the work of Park et al. (2021) who examined two summer monsoon regions within the Northern Hemisphere and associated variations in stratospheric water vapor (SWV): Asia & N. America. For N. American monsoon, August 2017 remains moister/cooler than other years, while warmer years are associated with a drier lower stratosphere. Local temperature is most likely not a driver in SWV as it is in the tropics.

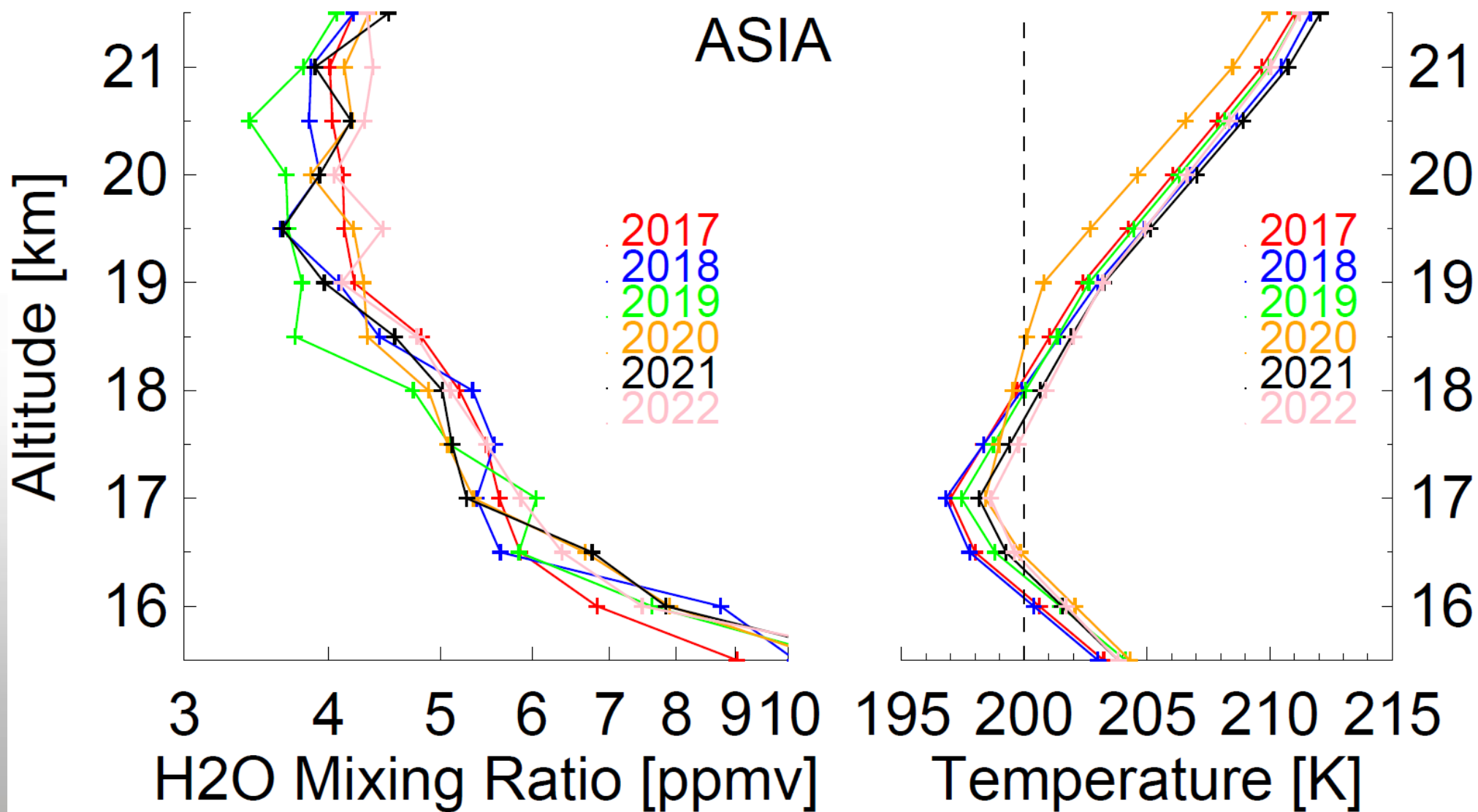
SAGE III/ISS H₂O @ 16.5km for 201708



- For N. American monsoon, August 2017 remains moister/cooler than other years while warmer years are drier lower stratospheric temperature is most SWV as it is in the troposphere
- Results for Asian region show similar variation from year to year

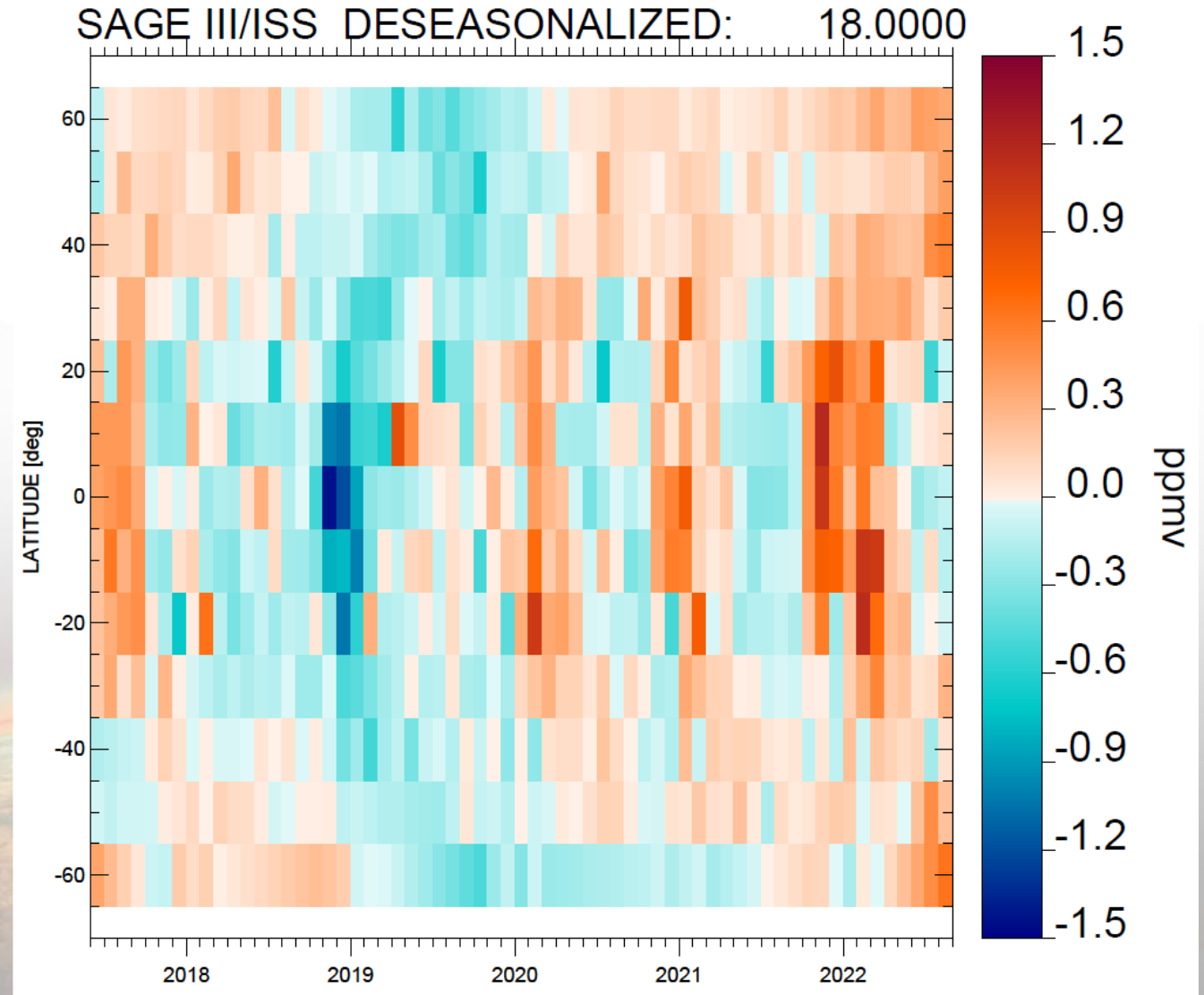


Asia Show Little Year-to-Year Variation



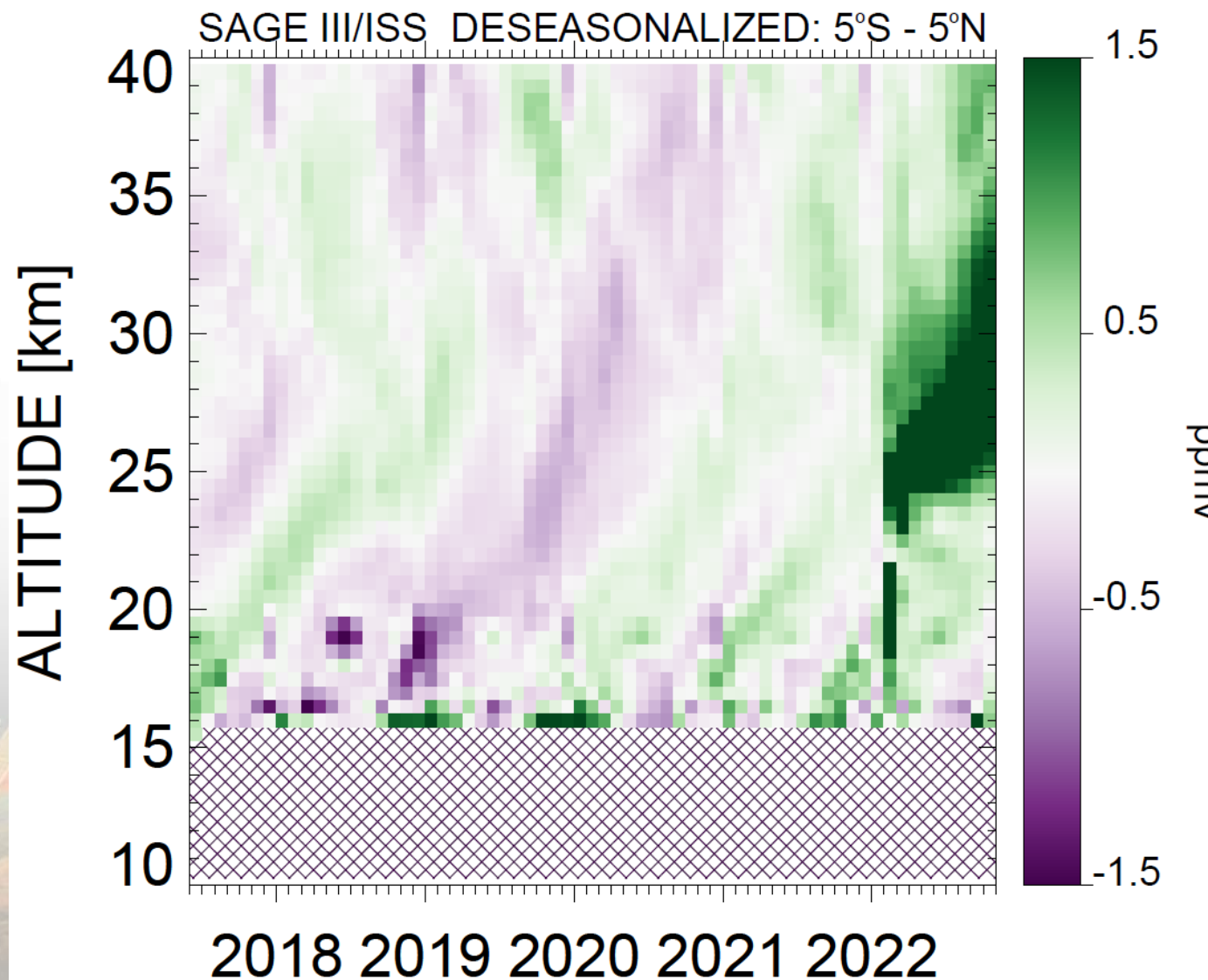
H2O Deseasonalized 18 km

Deseasonalized SAGE III/ISS water vapor observations depicting a modulation of lower stratospheric water vapor in the sub-tropics and mid-latitudes associated with tropical variations.

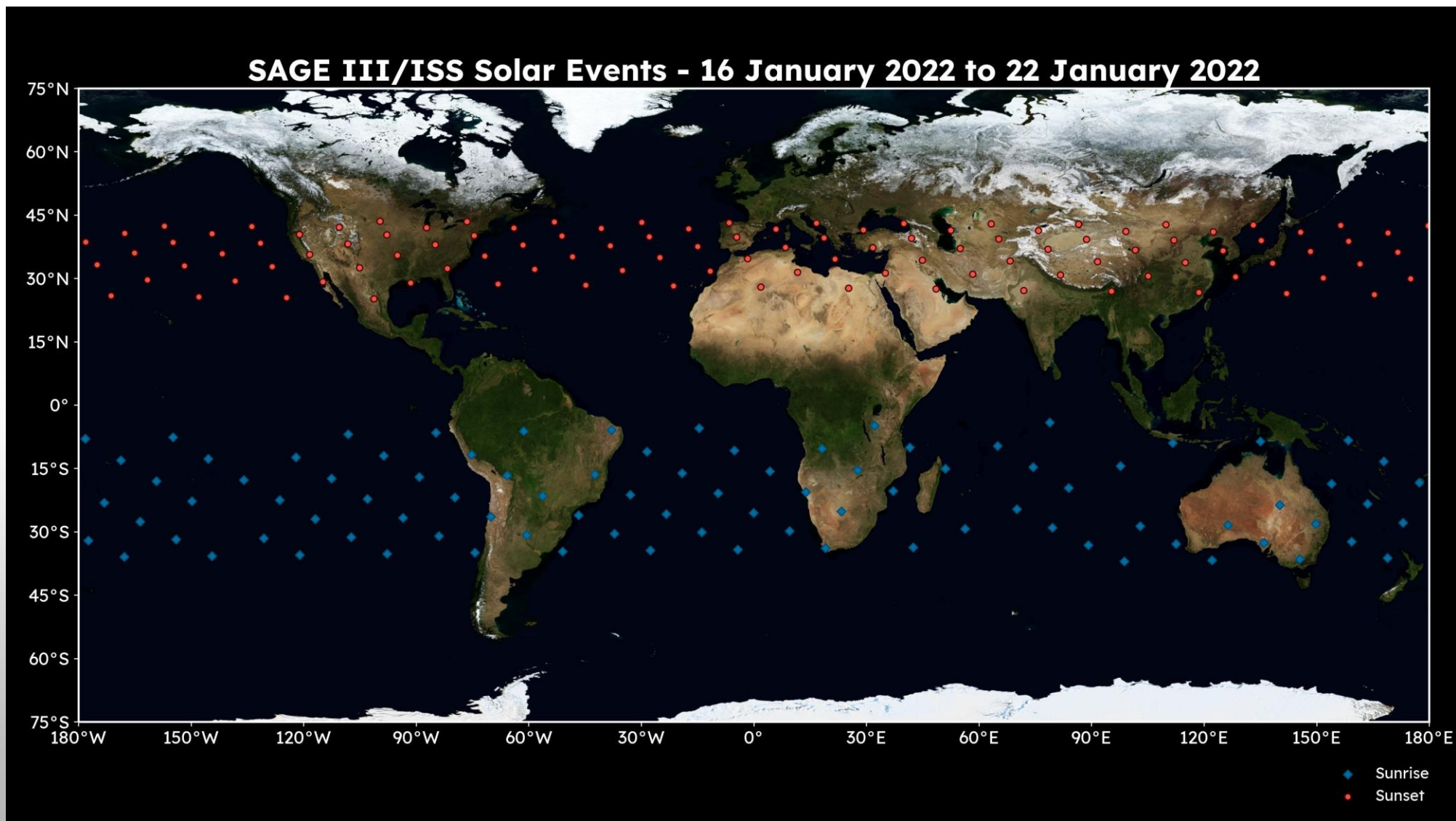


H2O Deseasonalized Tropics

For the time period June 2017-October 2022, the tropical deseasonalized stratospheric water vapor shows a higher frequency of switching between dry and wet anomalies.

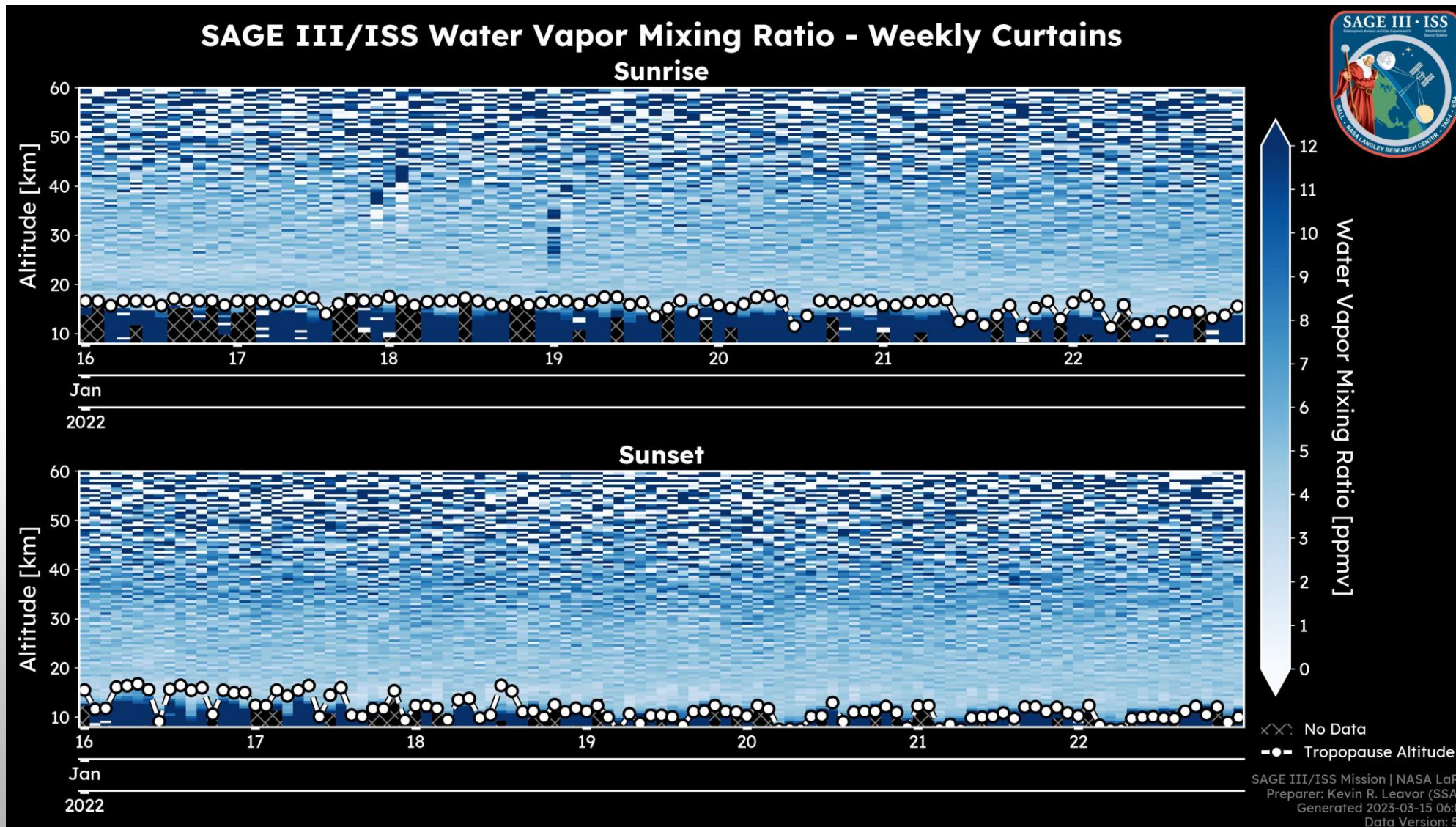


Hunga Tonga – Hunga Ha’apai

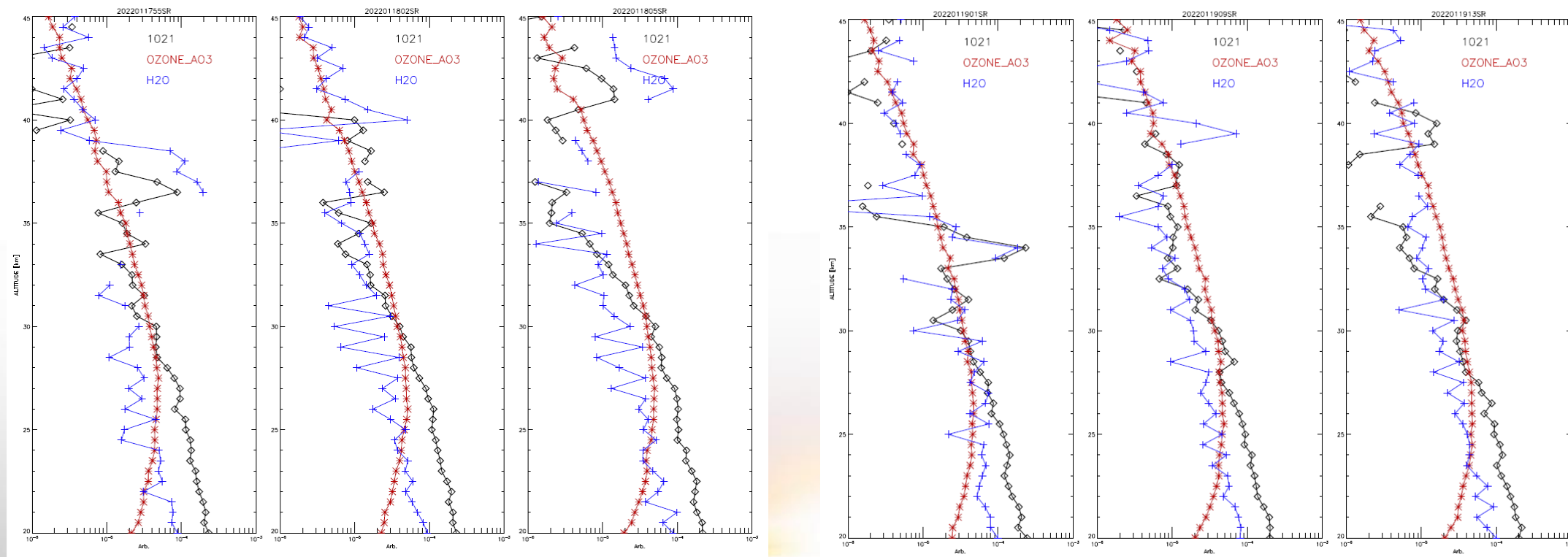




SAGE III/ISS Water Vapor

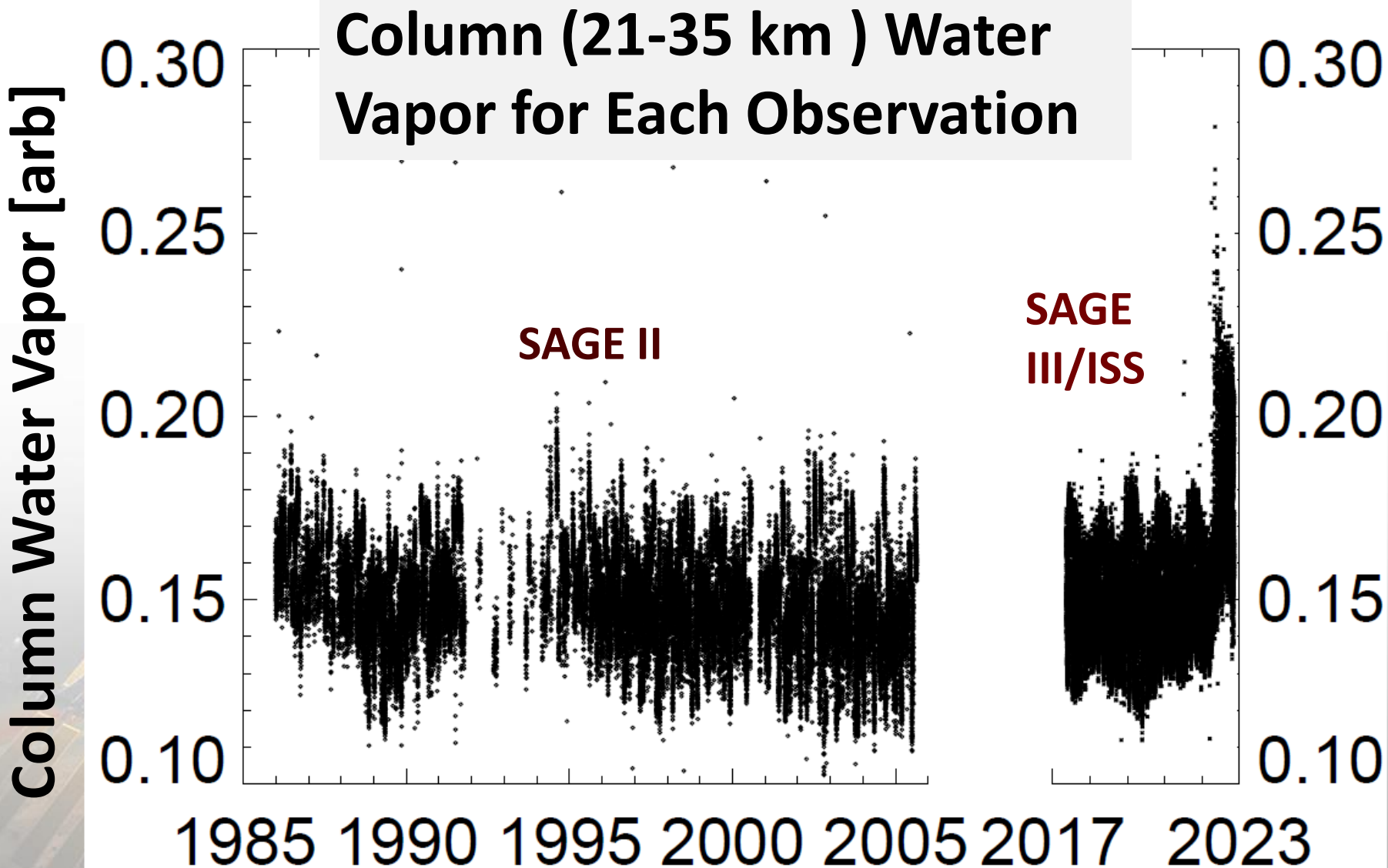


SAGE Profiles – Soon After Eruption



HTHH SWV Largest in Satellite Era

- Mid-stratospheric water vapor column (21-35 km) within Southern Hemisphere HTHH water vapor layer has increased 50-70% beyond previous SAGE measurements dating back to 1984.





Summary



- **SAGE III/ISS is a collaborative Earth science climate-continuity mission to study the recovery of the global ozone layer and the evolving climate**
- **Since June 2017, SAGE III/ISS has documented many natural variations of stratospheric water vapor and the historical perturbation by the HTHH volcanic eruption.**
- **NASA Langley Research Center manages the mission for NASA Earth Science with major contributions from the ISS Program and the European Space Agency**