LOCAL MEASUREMENTS, GLOBAL STUDIES: THE UTILITY OF BALLOON-BORNE FROST POINT HYGROMETER MEASUREMENTS FOR STUDYING GLOBAL STRATOSPHERIC WATER VAPOR

Sean M. Davis

Karen H. Rosenlof, Robert W. Portmann

Dale F. Hurst, Emrys G. Hall, Allen F. Jordan

NOAA ESRL Chemical Sciences Division

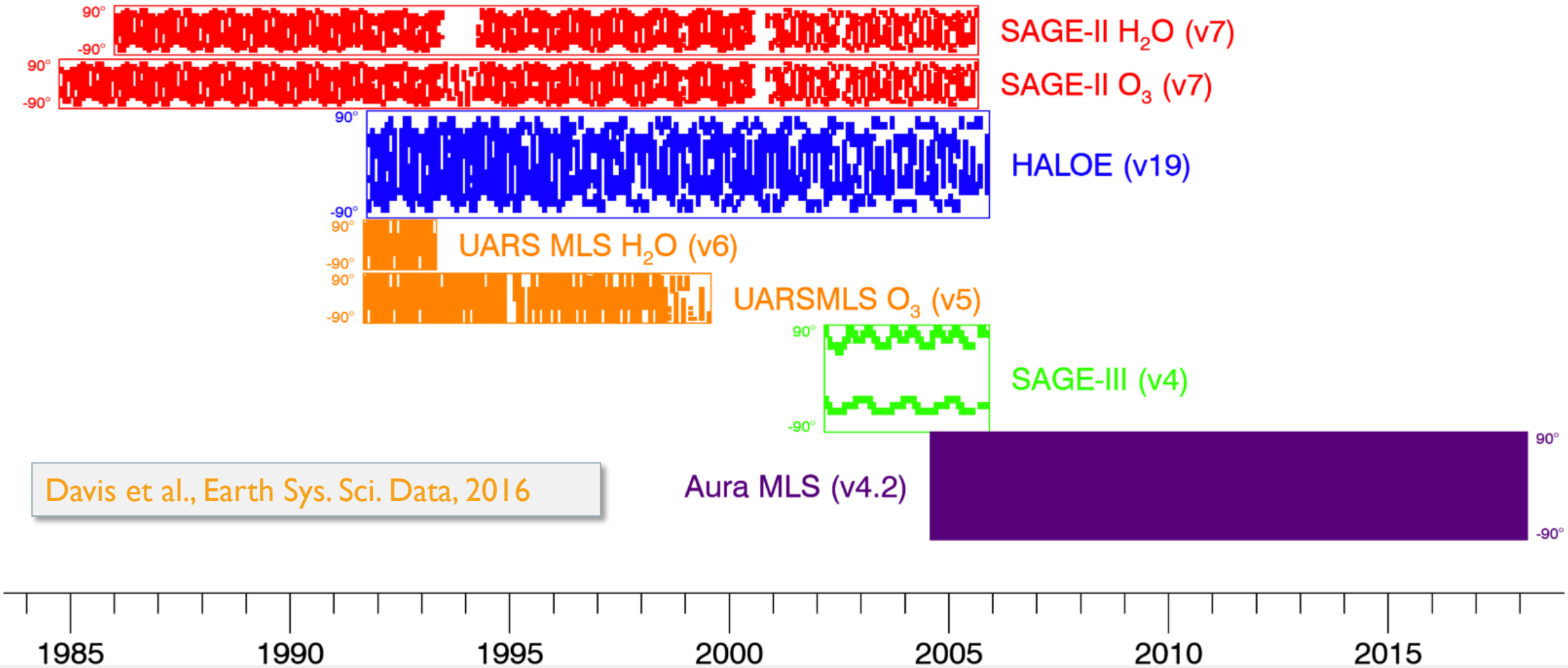
NOAA ESRL Global Monitoring Division

OVERVIEW

- **<u>Take-home message:</u>** Understanding short-term variability and long-term changes in stratospheric water vapor requires a synergy of long-term measurements from satellites and balloon-based hygrometers
  - Satellites provide global coverage, but with limited spatial resolution
  - Balloon-based hygrometers provide high spatial resolution, stability, and accuracy

- The rest of this talk
  - The role of frost point balloon measurements in making a long-term satellite record
  - Detecting satellite drift
  - Model/reanalysis/satellite assessment
  - Dealing with future satellite gaps

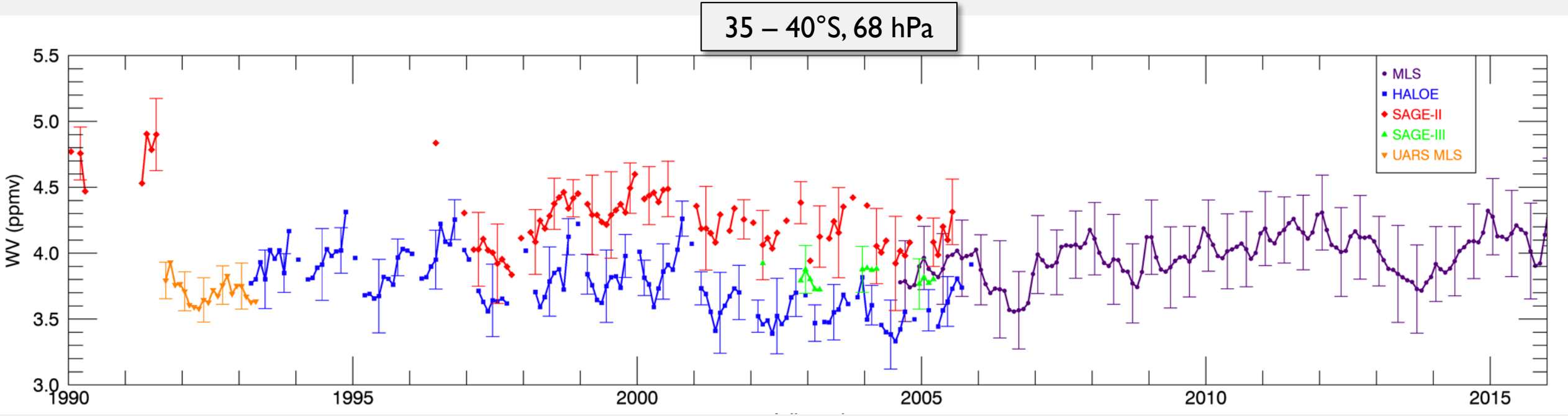
THE STRATOSPHERIC WATER AND OZONE SATELLITE HOMOGENIZED (SWOOSH) DATA SET



Davis et al., Earth Sys. Sci. Data, 2016

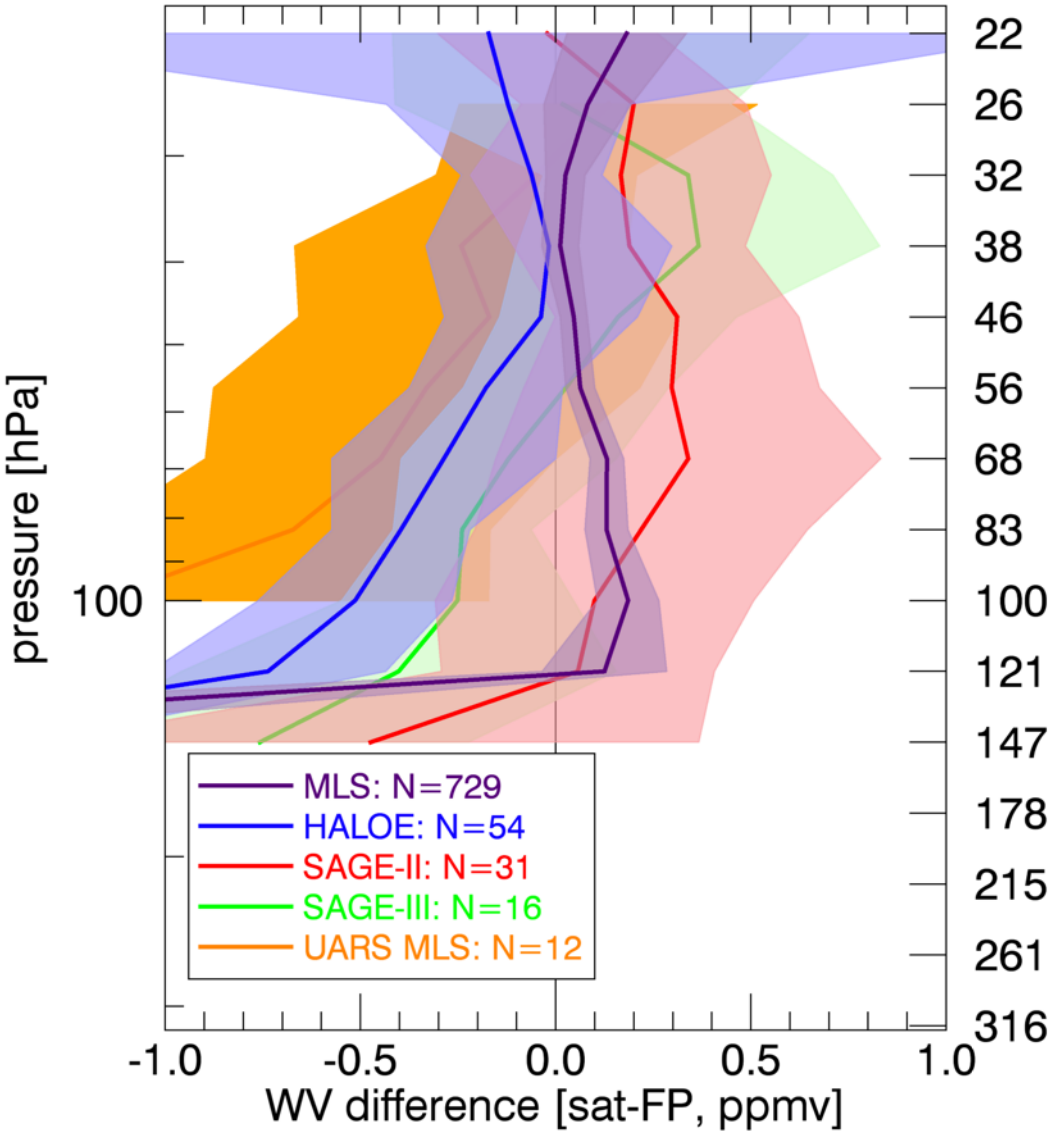
FROSTPOINTS DETERMINE SWOOSH REFERENCE DATA SET

Satellite measurements are biased and need to be adjusted. Which one to adjust to?



Adapted from Davis et al., *Earth Sys. Sci. Data*, 2016

FROSTPOINTS DETERMINE SWOOSH REFERENCE DATA SET



FP-Satellite matches

Δt = 1 day

Δx = 2000 km

Δy = 1000 km

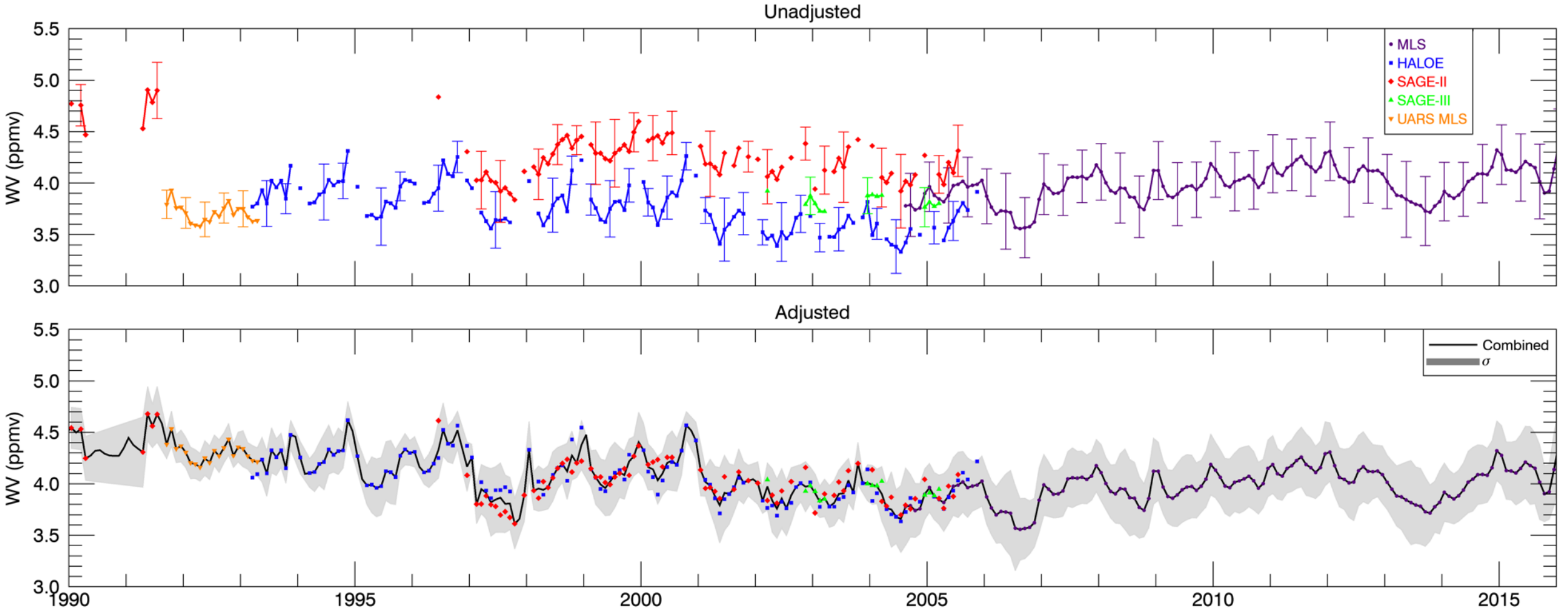
Δeq. lat[100 hPa – 46 hPa] = 5°

→ Best agreement with MLS

→ MLS is reference for SWOOSH

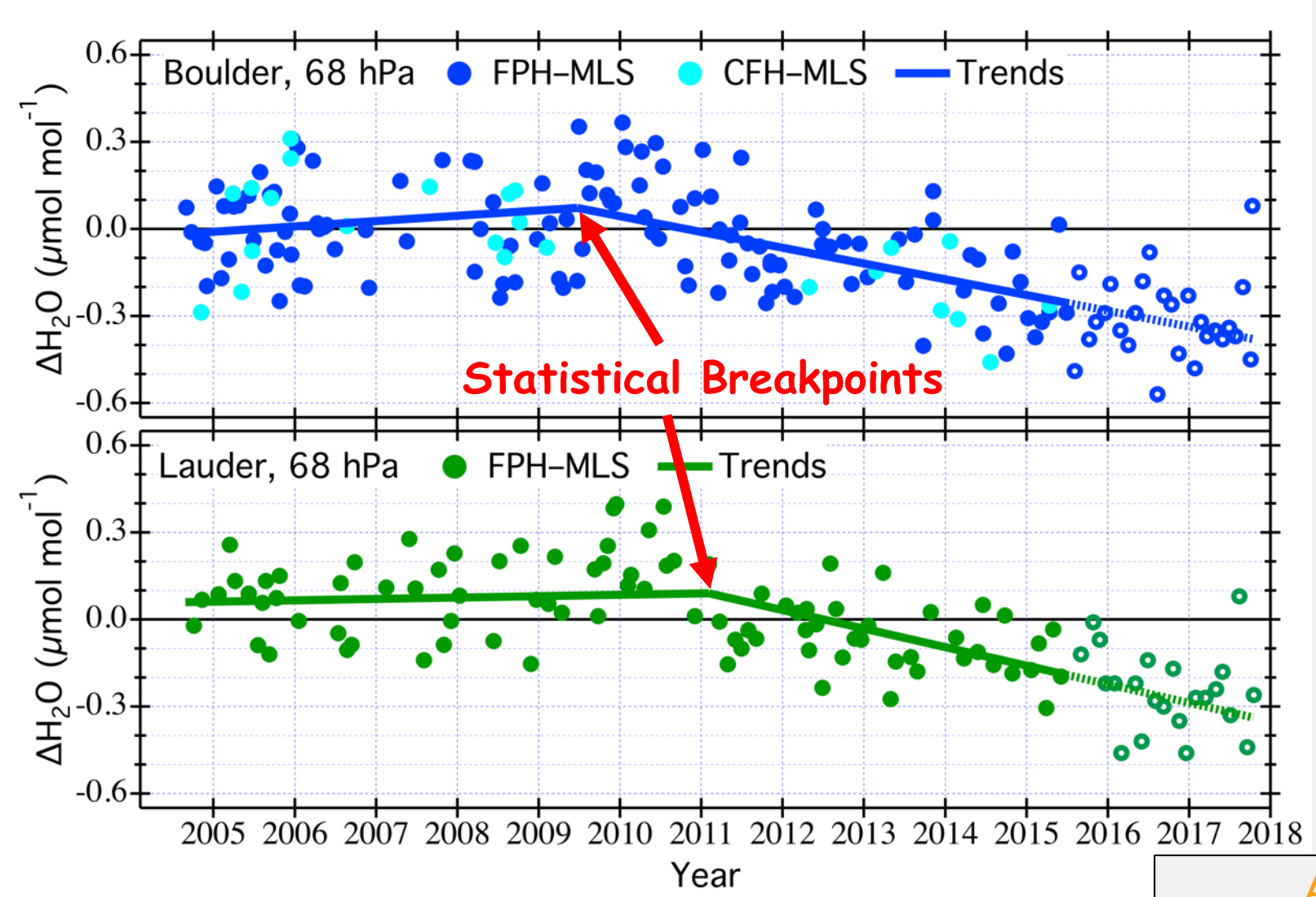
Davis et al., *Earth Sys. Sci. Data*, 2016

FROSTPOINTS DETERMINE SWOOSH REFERENCE DATA SET



Adapted from Davis et al., *Earth Sys. Sci. Data*, 2016

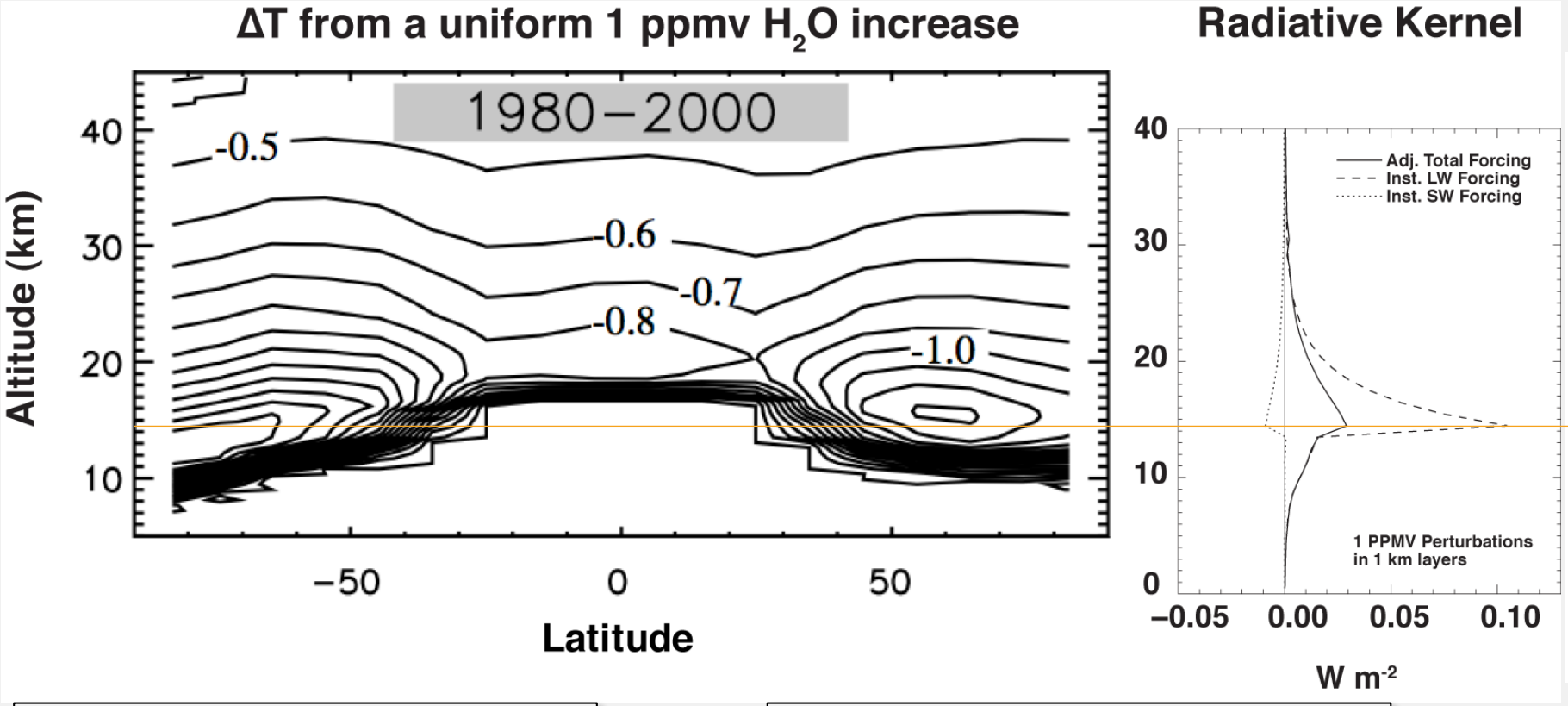
FROSTPOINTS FOR DRIFT DETECTION

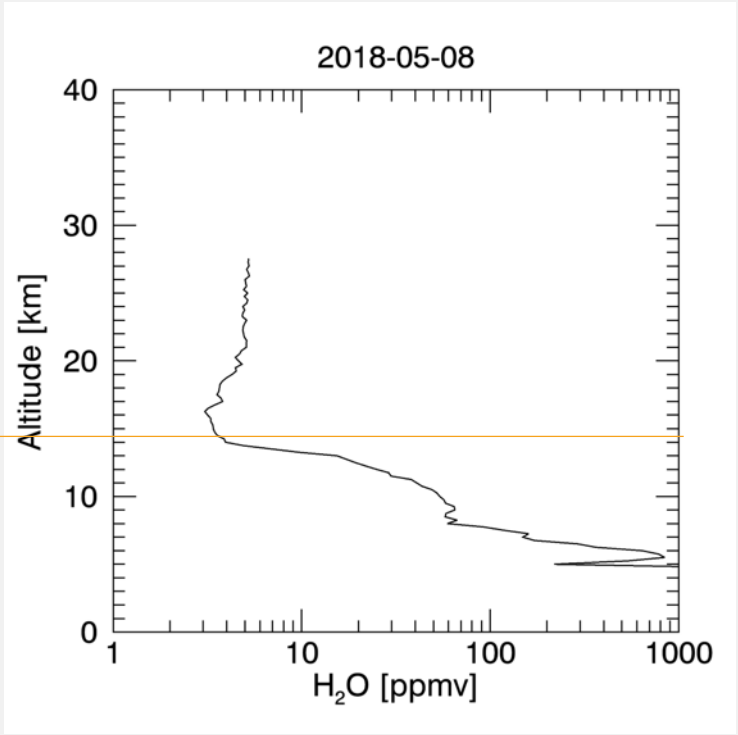


Adapted from Hurst et al., *JGR*, 2016

FROSTPOINTS FOR MODEL/SATELLITE VALIDATION IN UTLS

UTLS is a region of strong vertical gradients in WV
Very important for radiative forcing!
Low SNR, vertical gradient, and clouds makes it difficult for satellites. Radiosonde humidity not reliable!



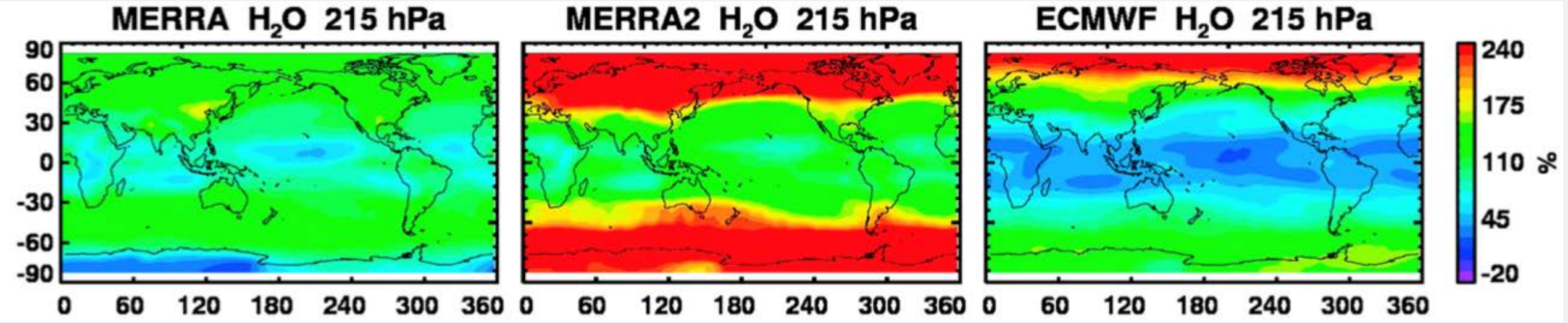


Forster and Shine, *GRL*, 2002

Solomon et al., *Science*, 2010

FROSTPOINTS FOR MODEL/SATELLITE VALIDATION IN UTLS

Reanalyses (models) have 150% more water in this region than MLS

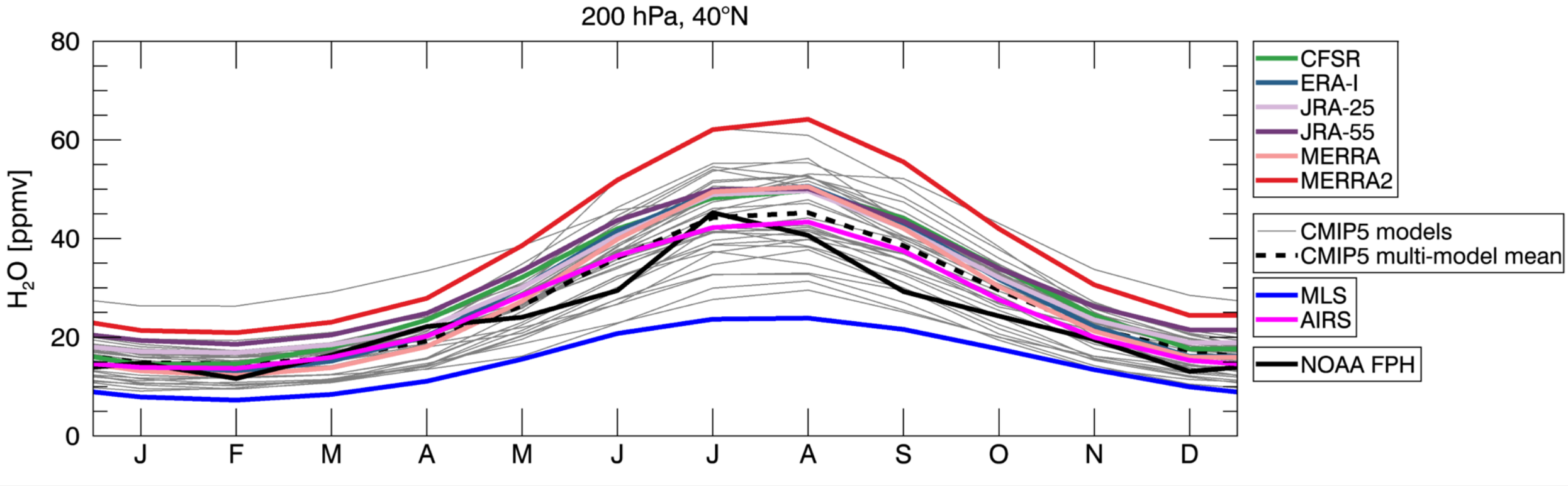


%: (Reanalysis – MLS) / MLS * 100

Jiang et al., *JGR*, 2015

FROSTPOINTS FOR MODEL VALIDATION IN UTLS

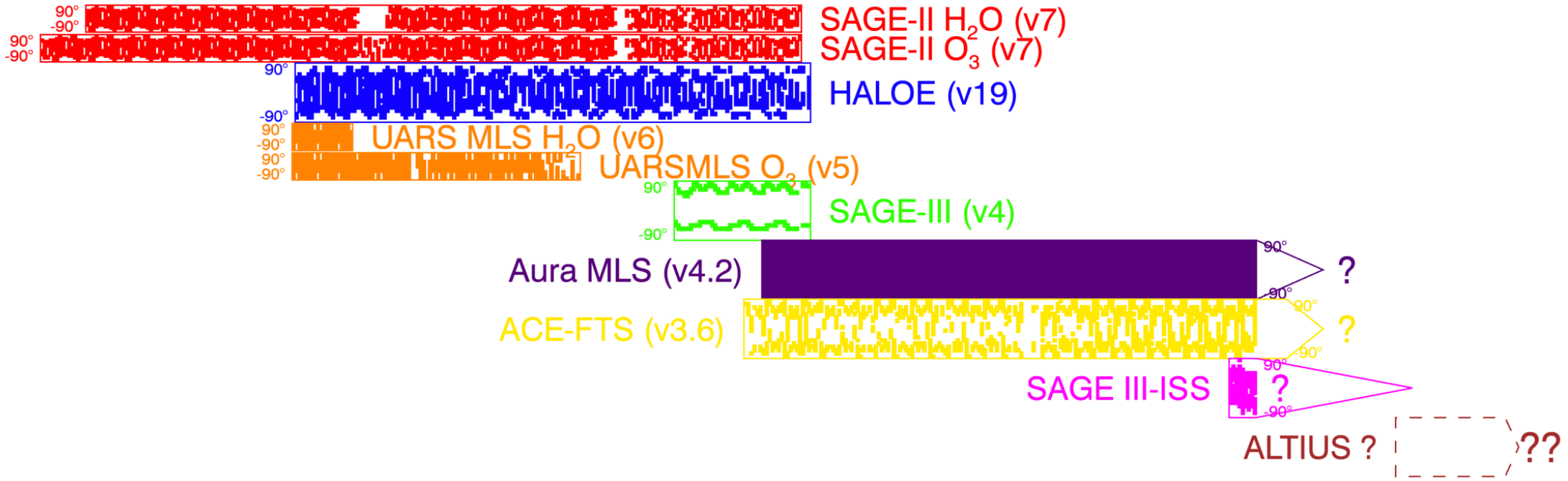
Boulder FPH indicates that MLS is biased in this region



Adapted from SPARC Reanalysis Intercomparison Project (S-RIP) analysis (Davis et al., *ACP*, 2017)

FROSTPOINTS FOR BRIDGING SATELLITE GAPS

If we lose Aura MLS data, stratospheric WV sampling will be severely limited
Frostpoint balloon measurements could be the transfer standard



CONCLUSIONS

Satellite and balloon-borne in situ measurements are ***complementary***

Near global coverage from satellites

Accuracy and fine spatial resolution from frostpoints

Frostpoint measurements are critical for assessing satellite and model accuracy

- SWOOSH reference instrument determination
- Satellite drift detection
- Reanalysis / model verification

Frostpoint measurements may be used as a transfer standard for potential future gaps in the satellite record