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Ticosonde: Balloon-borne Water Vapor and Ozone Profiles in Costa Rica since 2005

NASA: Ryan Stauffer* (NASA PI); Anne Thompson (Presenting) Julie Nicely (UMD PI); Ghassan Taha; Megan Damon; Rennie Selkirk; Debra Kollonige

UCAR: Holger Vömel. NOAA: Sean Davis; Bryan Johnson

UCR: Ernesto Corrales; Alfred Alan; Catalina Morales; Andrés Diaz

*Email: ryan.m.stauffer@nasa.gov

SAGE III/ISS Science Team Meeting at GA Tech

12 September 2023

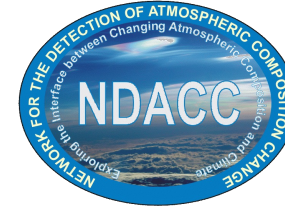
Talk Roadmap



- Ticosonde (2005–2023+) quick facts and status update
- Validation of SAGE–III/ISS v5.3 WV and Tropical Tape Recorder
- How is the Hunga Tonga WV enhancement evolving above Costa Rica?
- Quick update on tropical ozonesonde low bias vs. SAGE – correction on the way! (A. Thompson previous talk)

Ticosonde Quick Facts (2005–Present)

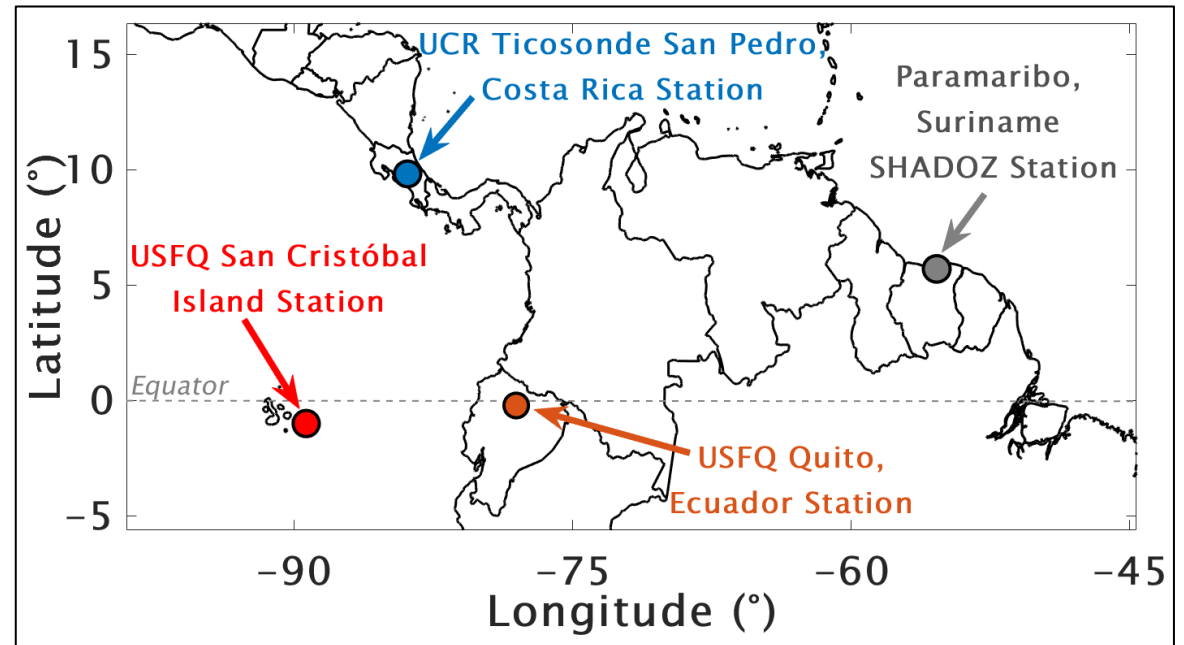
- Ozonesonde Profiles (SHADOZ): 700+
- CFH Water Vapor Profiles (NDACC): 245+
- Only long-term *in-situ* tropical (10° N) water vapor data set in existence
- Cryogenic Frostpoint Hygrometer (CFH) water vapor and ozonesonde soundings are currently coordinated with SAGE-III/ISS occultations
- Ticosonde featured annually in the *AMS State of the Climate Report*
- Website: <https://acd-ext.gsfc.nasa.gov/Projects/Ticosonde/index.html>

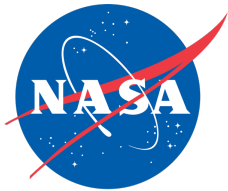




Ticosonde Updates

- NASA UACO grants support Ticosonde for monthly CFH profiles and 2x monthly ozonesonde profiles through mid-2025 at UCR
- ^Also includes ozonesonde profiles from **San Cristóbal** (reactivated SHADOZ station) and **Quito**, Ecuador (data since 2014)
- *Now* 2 Costa Rica AERONETs at UCR & Guanacaste! Pandora coming soon...





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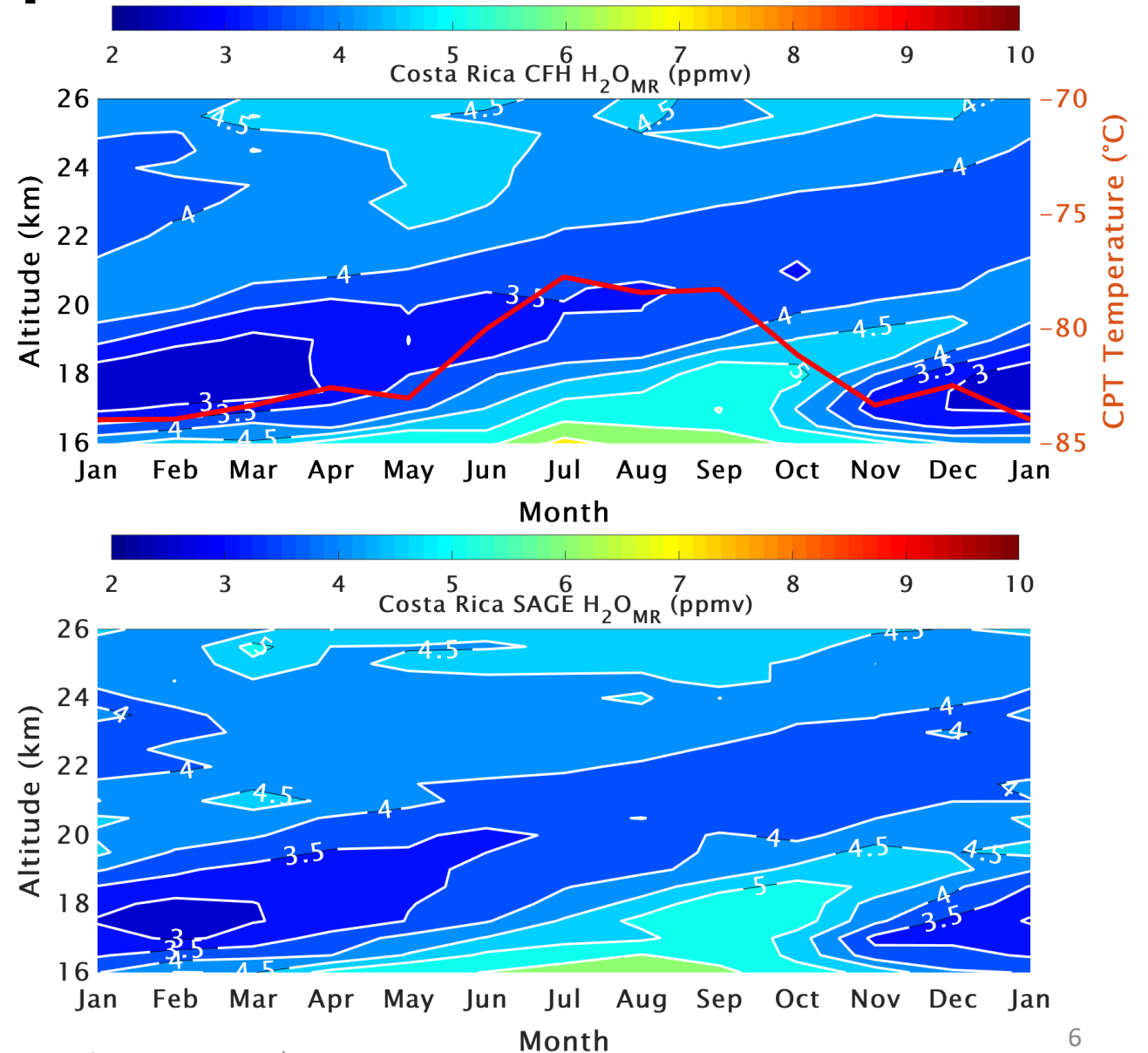
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CFH Comparisons with SAGE-III/ISS Data

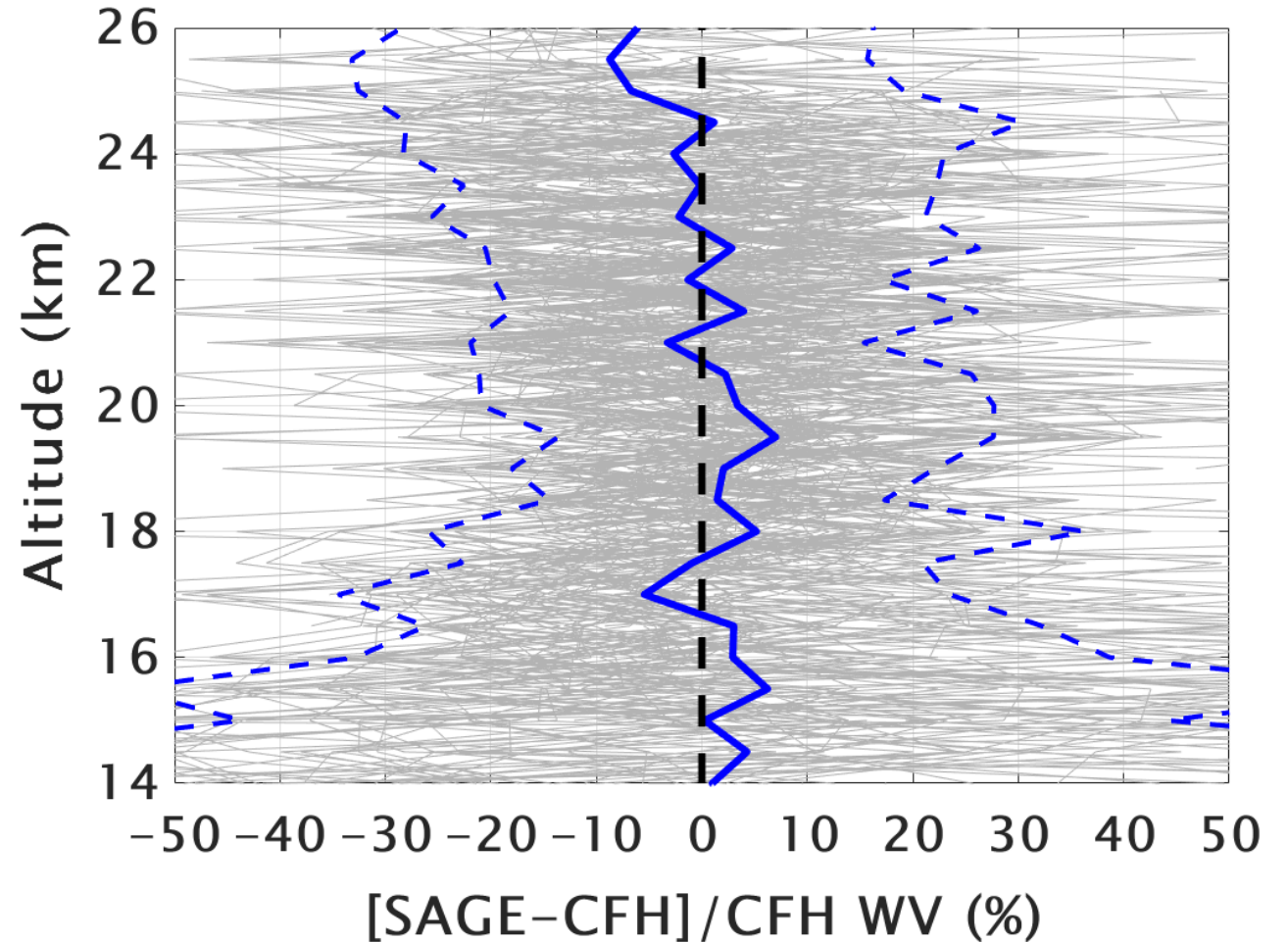
Ticosonde Water Vapor vs. SAGE-III/ISS

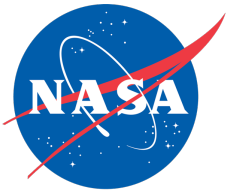
- CFH scheduling for SAGE-III/ISS overpasses allows for water vapor comparisons down into the mid-to-upper troposphere. *Thanks to Carrie Roller for overpass notifications!*
- Top: All CFH (246 total) profiles showing water vapor tape recorder and monthly **cold point tropopause**
- Bottom: All SAGE (399 total) within 6° lat, 30° lon of Costa Rica
- SAGE captures well the structure and monthly evolution of the tape recorder



Ticosonde Water Vapor vs. SAGE-III/ISS

- Direct SAGE/CFH matches (105 total) show very small biases that **average** within $\pm 5\%$ ($\pm 1\sigma$ also shown)
- Coincidence Criteria:
 - $\pm 6^\circ$ lat, $\pm 30^\circ$ lon, within 24 hours of CFH launch
 - 105 total profile matches





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Hunga Tonga–Hunga Ha'apai Water Vapor Enhancements and Evolution

Hunga Tonga WV at Costa Rica

- We observed the enhanced stratospheric water vapor following the 15 January 2022 HTHH eruption (**red circle**)
- The largest peaks were found in **February and March 2022**, with broader ~ 1 ppmv enhancements in recent profiles

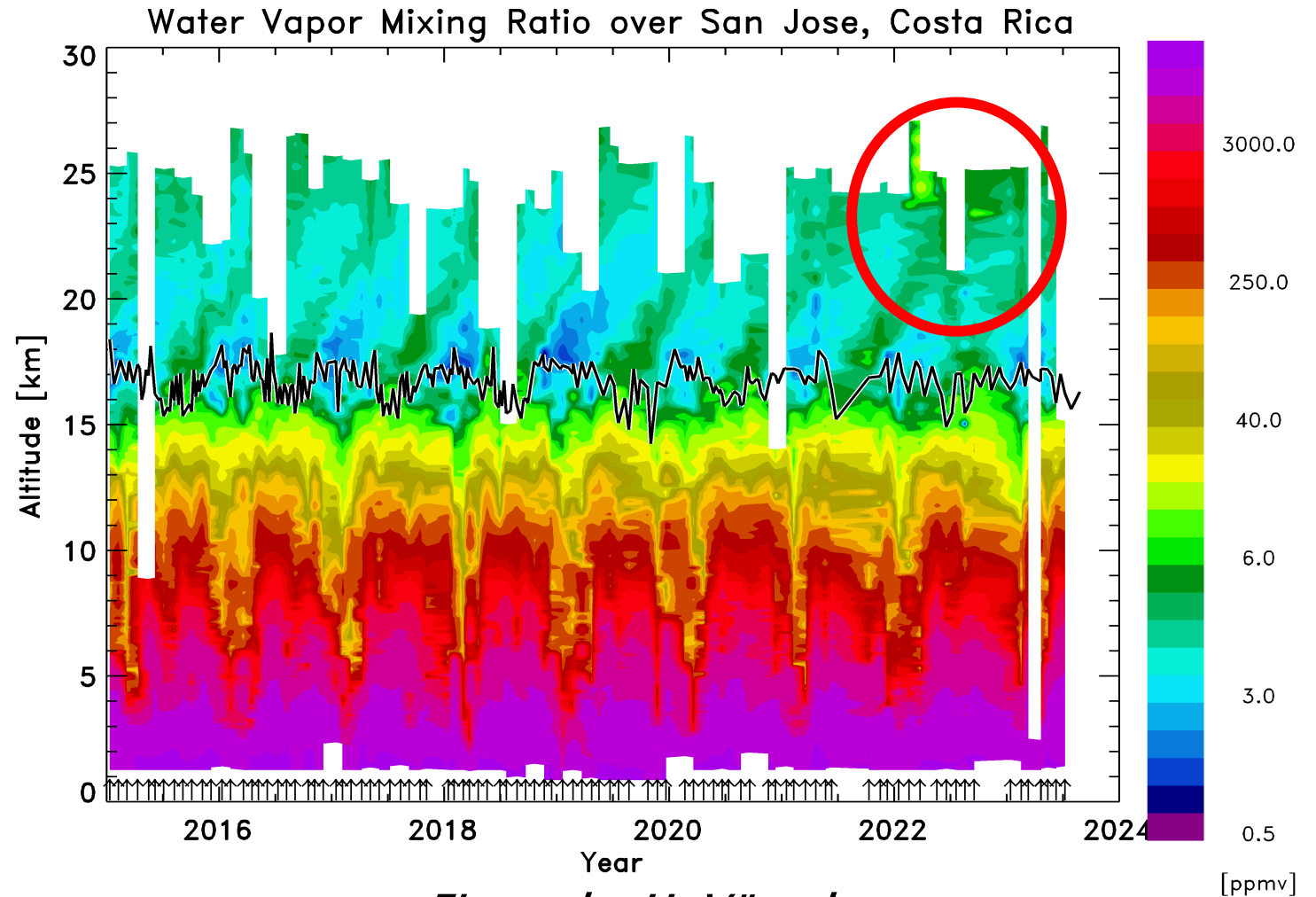
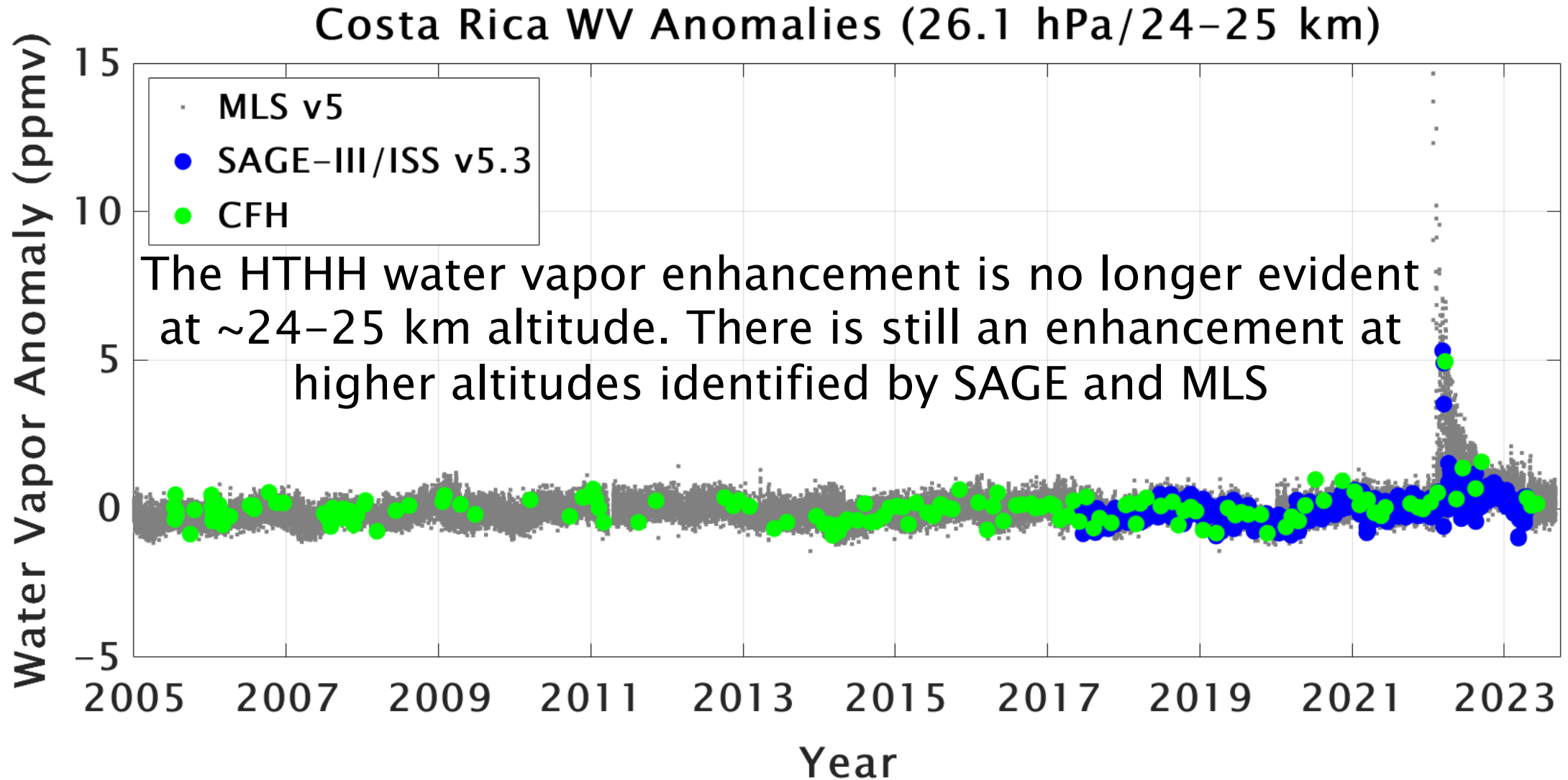
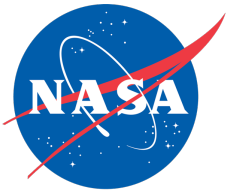


Figure by H. Vömel

SAGE, Aura MLS, and CFH WV Anomalies





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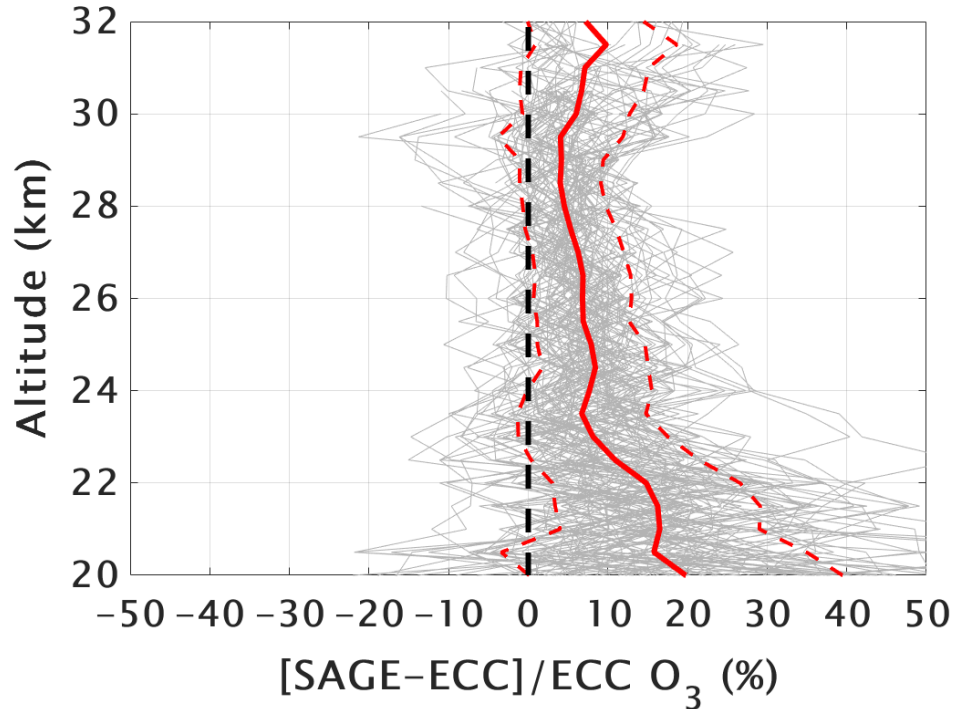


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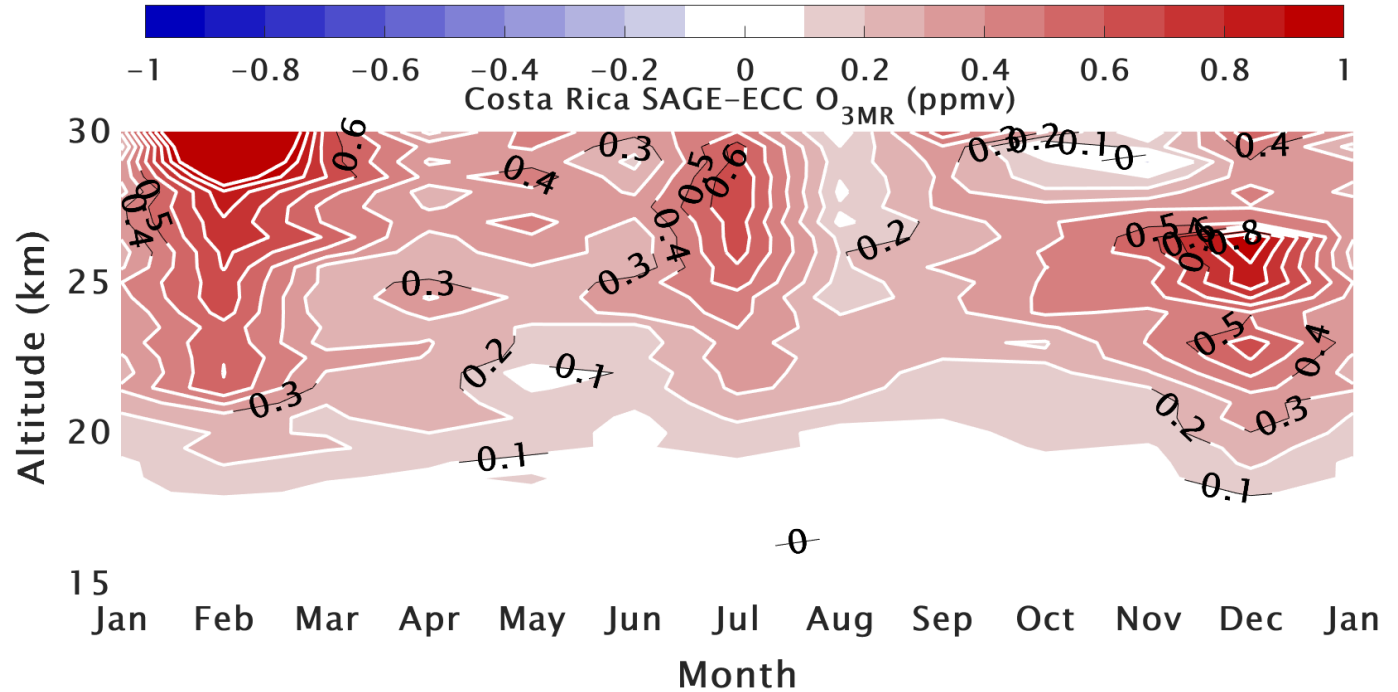


Quick Update on “Ozonesonde Low Bias”

SAGE and Ozonesonde Differences



105 matched coincidences in % O₃ difference



Difference in monthly O₃ averages from all available profiles

Ozonesondes show ~5% low bias (SAGE higher; right) in the mid-stratosphere, amounting to ~0.2 to 0.8 ppmv (left). A correction (A. Thompson talk) is on the way that will mitigate much of this low bias in the ozonesondes

Summary

- Ticosonde has collected CFH (>245) and ozonesonde (>700) profiles since 2005, and we strive to match SAGE-III/ISS overpasses whenever possible
- SAGE comparisons with CFH WV at Costa Rica are superb and within about 5% of matched profiles in the stratosphere. SAGE captures the tropical tape recorder above Costa Rica
- We observed the Hunga Tonga eruption stratospheric water vapor enhancement above Costa Rica. The lingering enhancement is now above the altitude of the balloons, but SAGE and MLS are still measuring this enhancement at higher altitudes
- Ozonesondes still show a ~5% low bias compared to SAGE, but a correction is on the way!

Thank You!



K. Jucks, UACO Program Manager and NASA HQ for continued support of Ticosonde

Data:

- SHADOZ Ozone: <https://tropo.gsfc.nasa.gov/shadoz/CostaRica.html>
- NDACC H₂O: <https://www-air.larc.nasa.gov/missions/ndacc/data.html>
- AVDC SO₂ (Turrialba & Poás): https://avdc.gsfc.nasa.gov/pub/tmp/TICOSONDE_SO2_archive/data/

Select References:

- Vömel, H., et al. (2016), An update on the uncertainties of water vapor measurements using cryogenic frost point hygrometers, Atmos. Meas. Tech., <https://doi.org/10.5194/amt-9-3755-2016>.
- Stauffer, R. M., et al. (2020), A post-2013 dropoff in total ozone at a third of global ozonesonde stations: Electrochemical concentration cell instrument artifacts? Geophysical Research Letters, <https://doi.org/10.1029/2019GL086791>.
- Vömel, H., et al. (2020), A new method to correct the ECC ozone sonde time response and its implications for “background current” and pump efficiency, Atmos. Meas. Tech. <https://doi.org/10.5194/amt-2020-62>
- Stauffer, R. M. et al. (2022), An Examination of the Recent Stability of Ozonesonde Global Network Data, Earth and Space Science, <https://doi.org/10.1029/2022EA002459>