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Ticosonde: 17 Years of Balloon-borne Ozone and Water Vapor Profiles in Costa Rica

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SAGE III/ISS Science Team Meeting at NASA/LaRC

13 October 2022

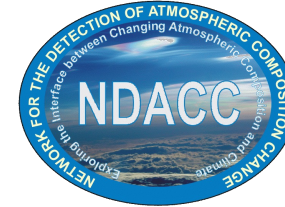


Talk Roadmap

- Ticosonde (2005–2022+) quick facts and status update
- Water vapor and ozone comparisons with SAGE–III/ISS overpasses
 - Excellent sonde agreement with SAGE–III/ISS v5.2 water vapor
 - Ozonesonde TCO drop affects ozone comparisons (A. Thompson previous talk)
- Hunga Tonga–Hunga Ha'apai enhanced water vapor in 2022 (plus bonus May 2022 Lauder profile)

Ticosonde Quick Facts (2005–Present)

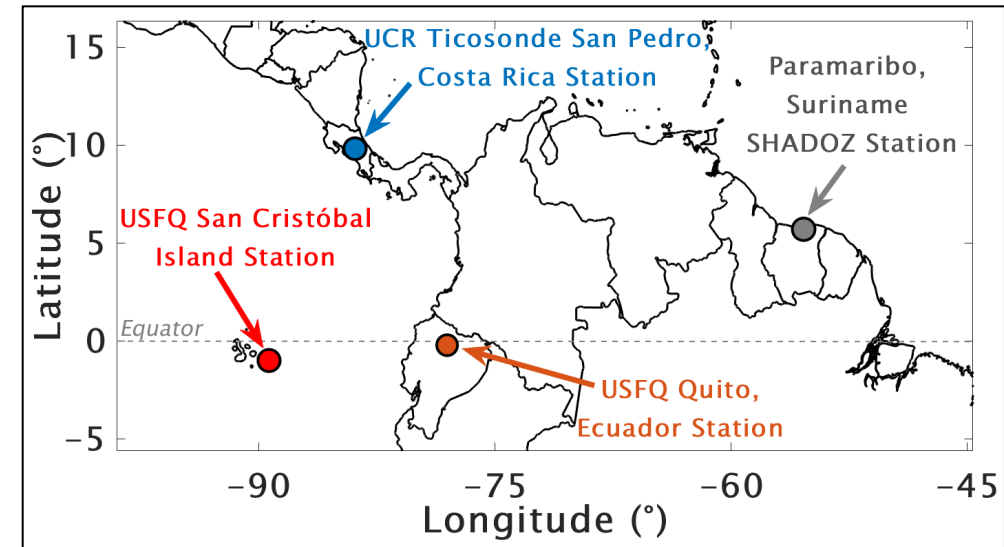
- Ozonesonde Profiles (SHADOZ): 680+
- CFH Water Vapor Profiles (NDACC): 240+
- Only long-term *in-situ* tropical (10° N) water vapor data set in existence
- Cryogenic Frostpoint Hygrometer (CFH) water vapor and ozonesonde soundings are currently coordinated with SAGE–III/ISS occultations
- Ticosonde featured annually in the *AMS State of the Climate Report*
- Website: <https://acd-ext.gsfc.nasa.gov/Projects/Ticosonde/index.html>

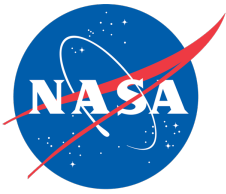




Ticosonde Updates

- 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)
- *New* AERONET installed at UCR. Second Guanacaste (NW) site coming soon!





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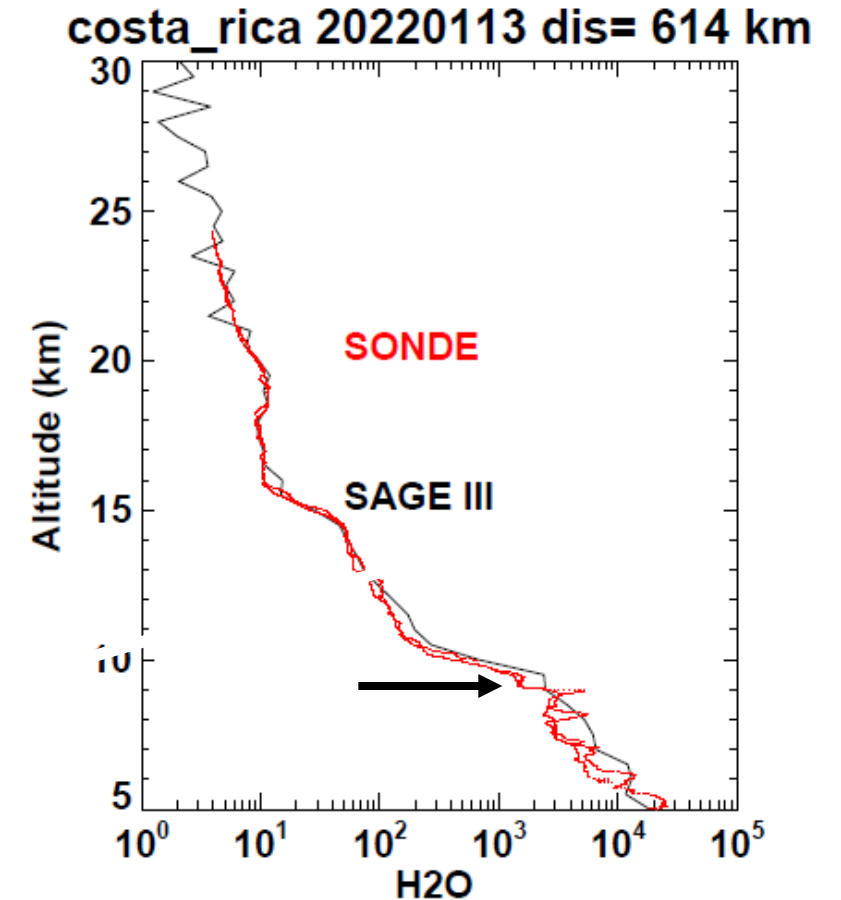
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Comparisons with SAGE-III/ISS Data

Ticosonde Water Vapor vs. SAGE-III/ISS

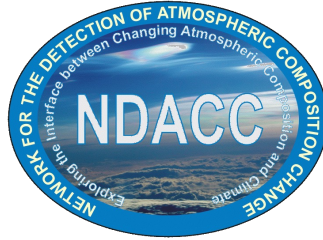
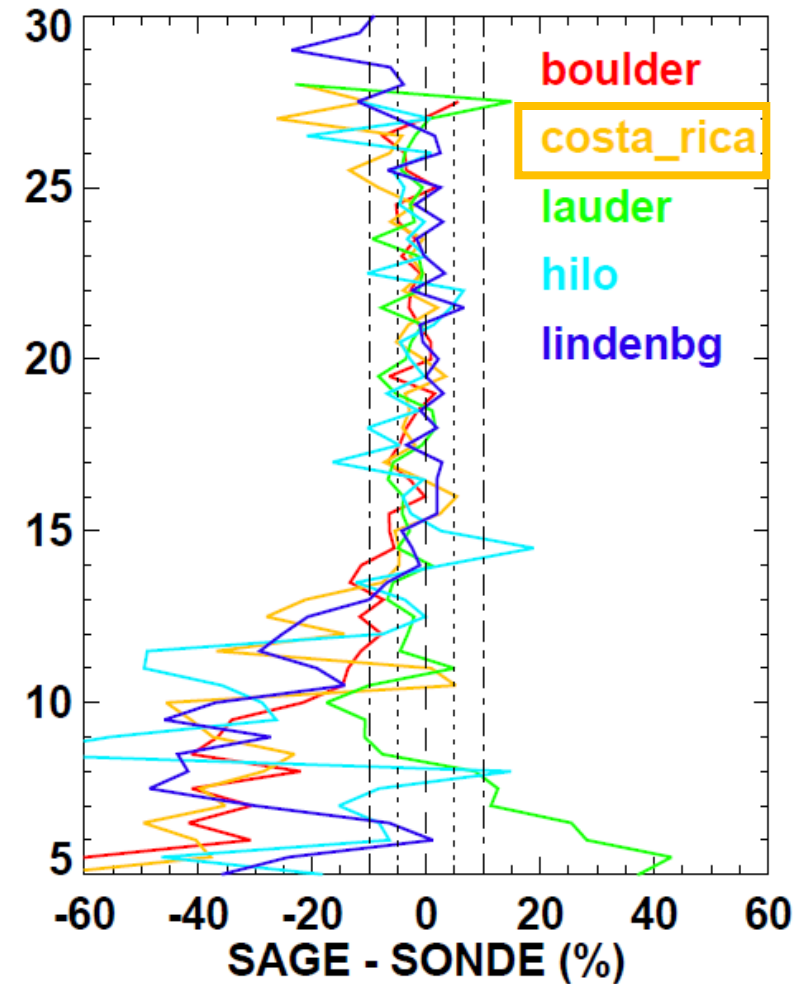
- CFH scheduling for SAGE-III/ISS overpasses allows for water vapor comparisons into the mid-to-upper troposphere. Thanks to Carrie Roller for overpass notifications!
- Figure: Water vapor structure well-represented down to 5 km in SAGE v5.2 on 13 Jan 2022 profile
- Coincidence Criteria: 6° lat, 30° lon, same day: 60 SAGE-III/ISS and Costa Rica water vapor matches (includes multiple coincidences for single CFH sonde)



Water vapor mixing ratio profiles for **CFH** and SAGE on 13 Jan 2022. Credit: G. Taha

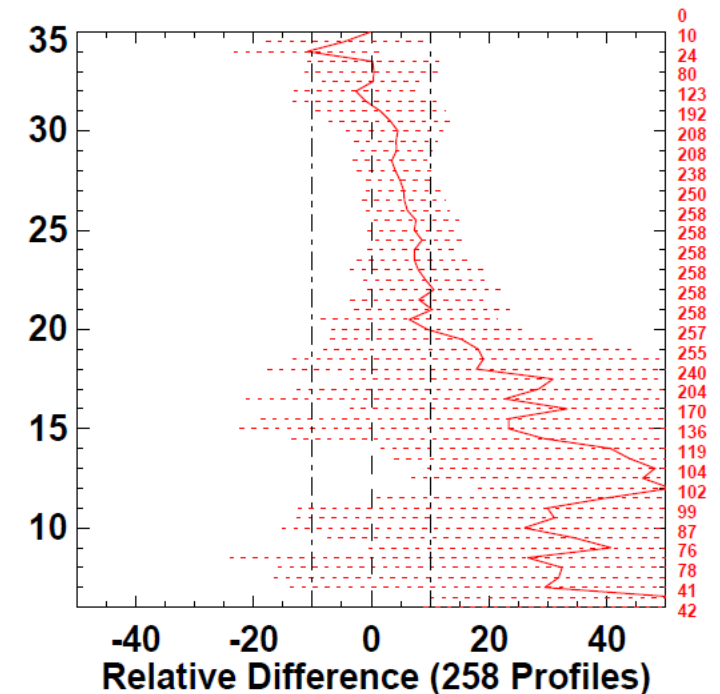
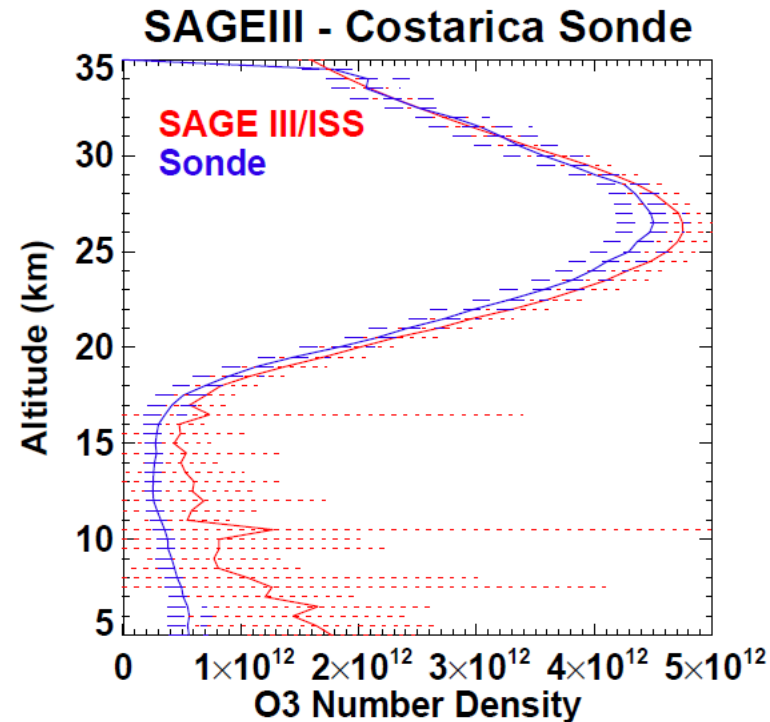
NDACC Water Vapor vs. SAGE-III/ISS

- Last year we showed that SAGE-III/ISS v5.1 data had a 5–10% dry bias above 15 km
- v5.2 data agreement is within ~5% in the mid-stratosphere
- No clear differences in stratospheric agreement among the 5 NDACC stations shown here. Global consistency!

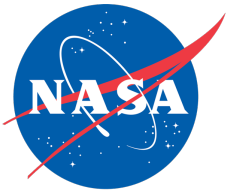


Ticosonde Ozone (Ozonesonde “Dropoff”)

- Post-2013 ozonesonde “dropoff” (Stauffer et al., 2020; 2022) continues to affect Costa Rica O₃ data
- Costa Rica is not the only station with this issue
- Update: Changing En-Sci pump efficiencies coincident with the dropoff offer a promising path toward bias correction



Left: Average ozone profile comparisons show that the sondes are low-biased in the stratosphere, and SAGE is high-biased in the troposphere. Right: Percentage differences indicate ozonesonde 5% low bias at ozone peak, and a changing bias with altitude above the peak



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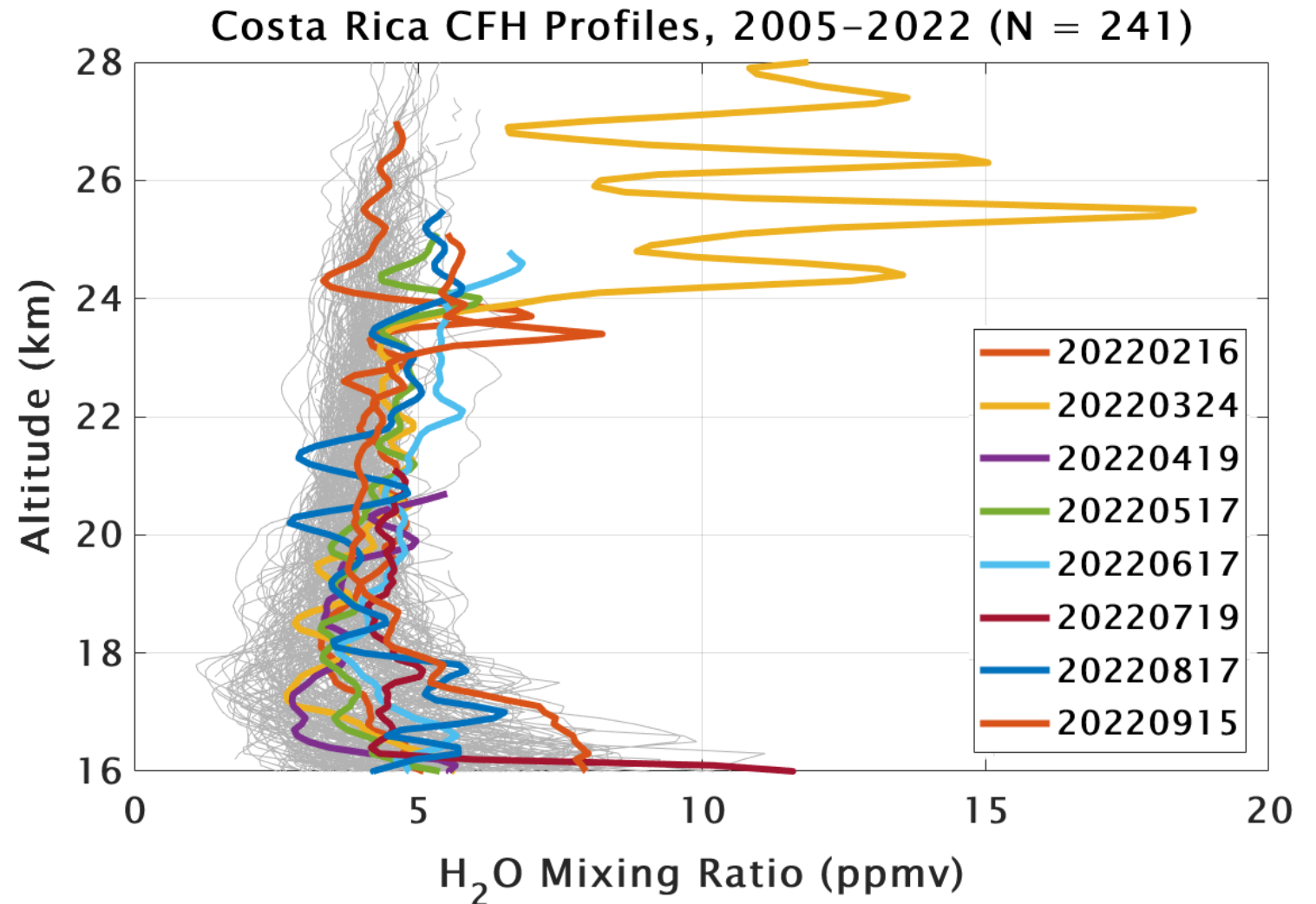
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Latest Profiles Show Hunga Tonga–Hunga Ha'apai Water Vapor Enhancements

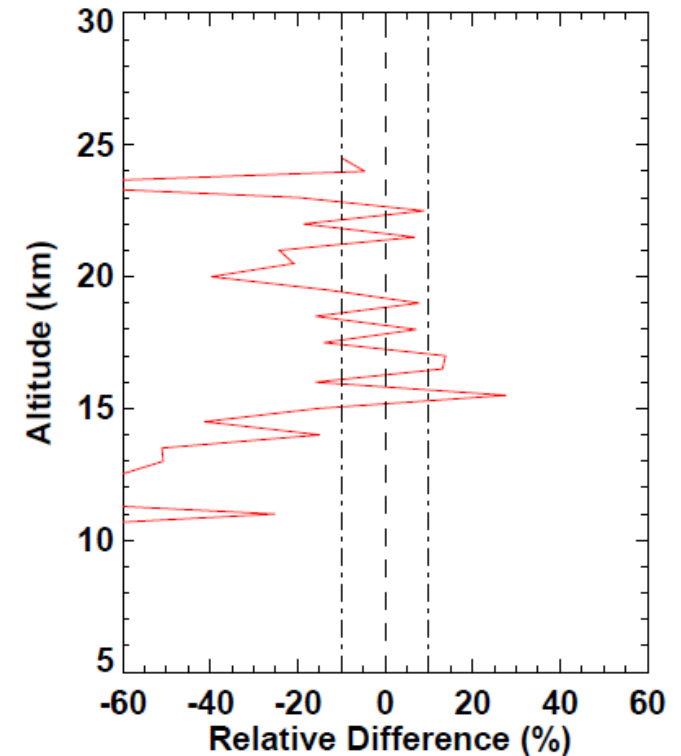
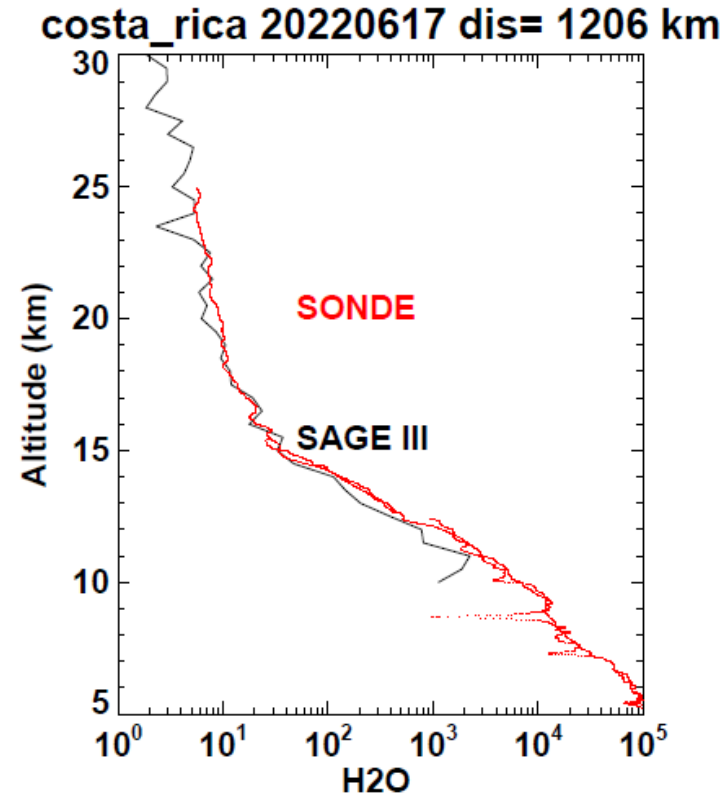
Hunga Tonga WV at Costa Rica

- We have observed, and continue to observe enhanced stratospheric water vapor following the 15 January HTHH eruption
- The largest peaks were found in **February** and **March**, with broader ~ 1 ppmv enhancements in recent profiles

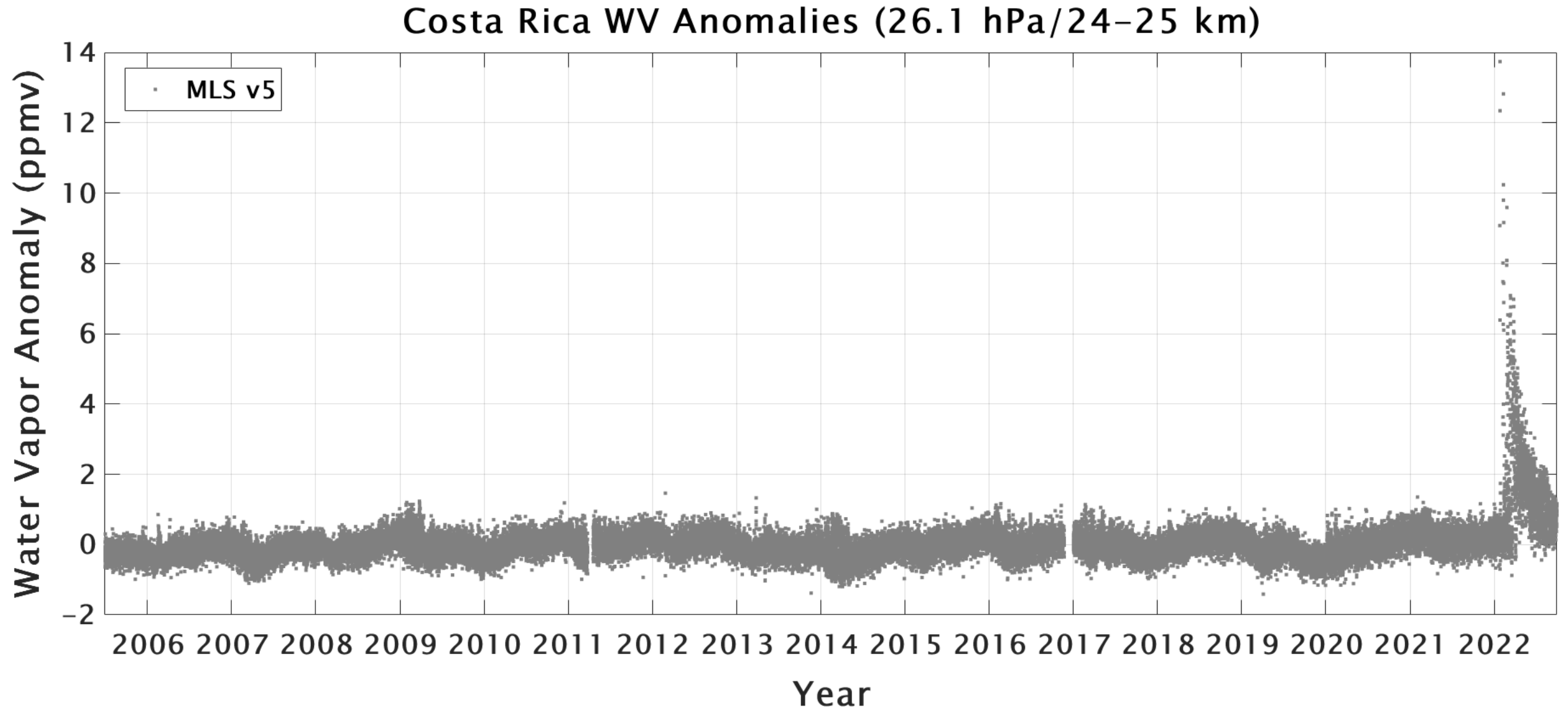


WV Profile Comparisons on 17 June 2022

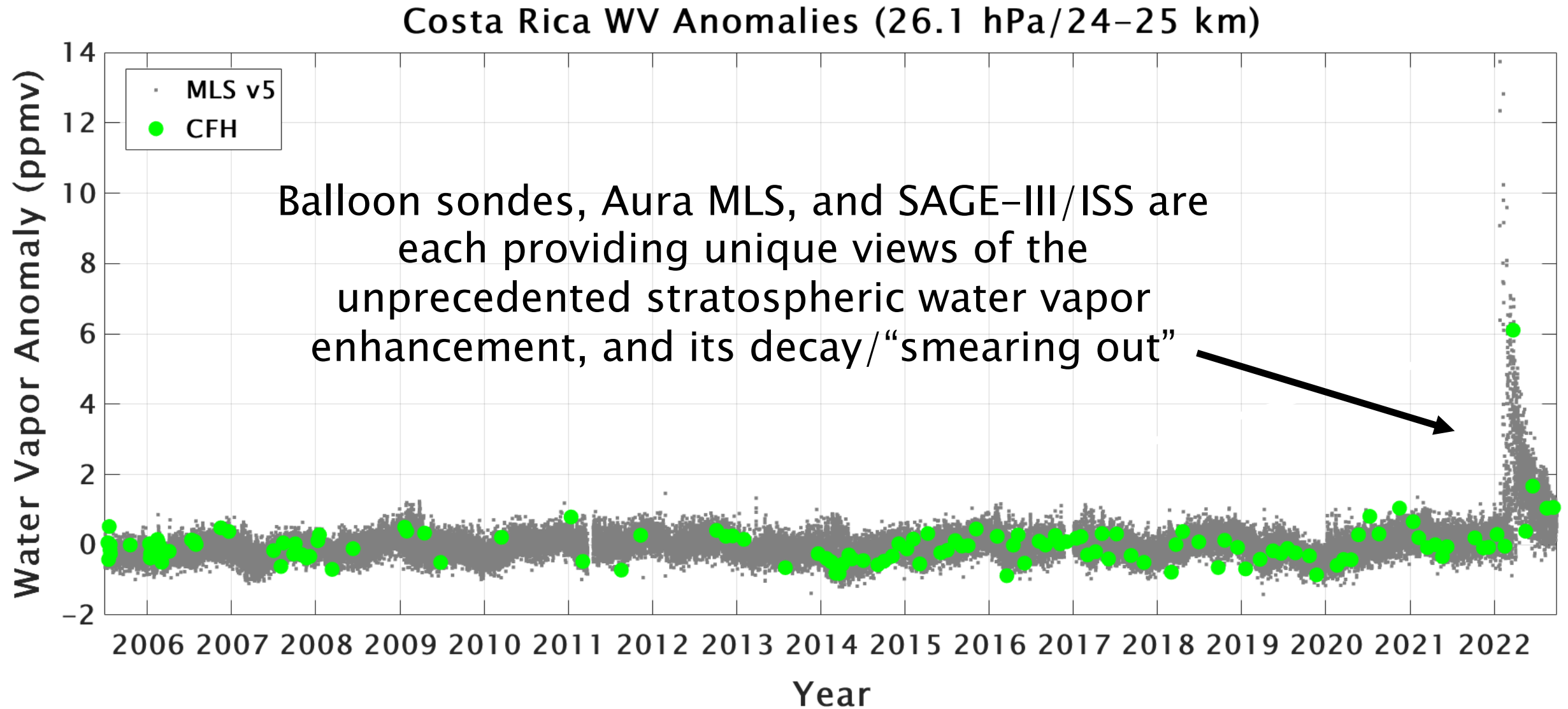
- In some cases, the enhancements are difficult to detect, and on the order of ~ 1 ppmv above Costa Rica
- Regardless, CFH and SAGE-III/ISS above Costa Rica remain in good agreement
- We continue to target SAGE overpass opportunities to increase statistics during the enhanced stratospheric water vapor conditions



Aura MLS and CFH WV Anomalies

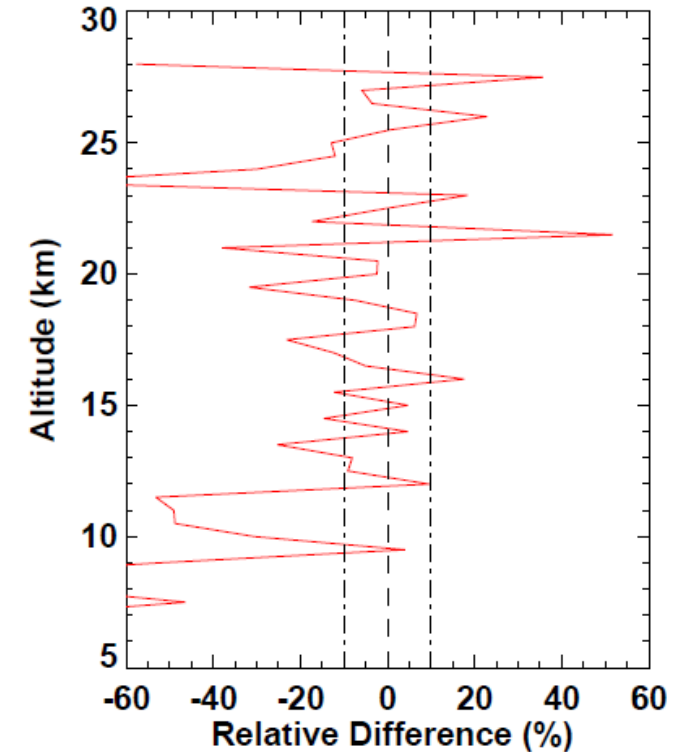
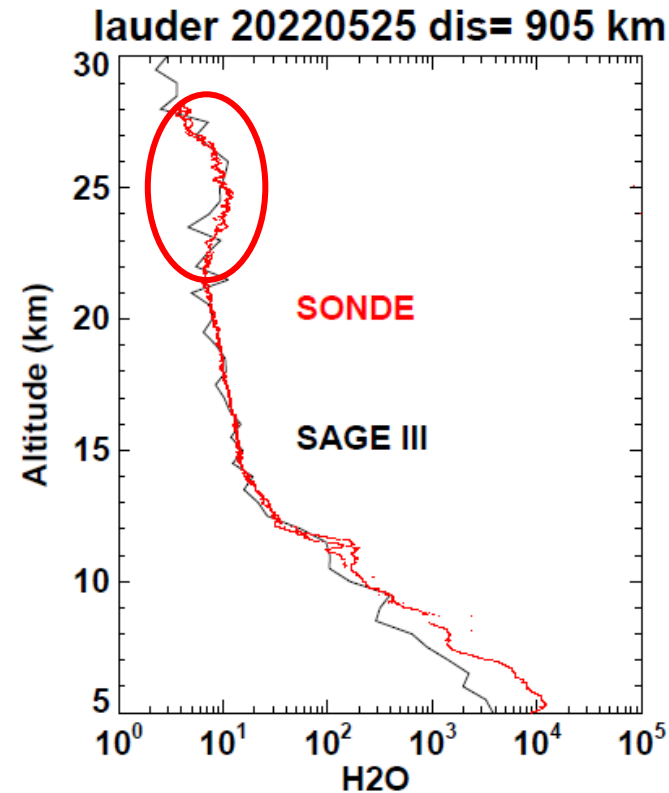


Aura MLS and CFH WV Anomalies



Bonus: Lauder FPH WV on 25 May 2022

- Lauder, NZ is closer to the region of maximum water vapor enhancement
- Broad WV peak > 10 ppmv at 25 km captured by both FPH and SAGE-III/ISS. Excellent agreement!
- SAGE-III/ISS continues to play a key role in stratospheric observations, especially as Aura MLS nears end of life



Summary

- Ticosonde has collected CFH (>240) and ozonesonde (>680) profiles since 2005
- SAGE-III/ISS WV agrees within $\sim 5\%$ of Costa Rica (and other station) frostpoint data. Ozonesonde data are low-biased, but we now understand why and are working towards a correction
- We observe the Hunga Tonga eruption stratospheric water vapor enhancement above Costa Rica. Both sonde and satellite data will be vital to tracking its evolution/decay and to understand the effects on climate

Thank You!



UCAR



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>.
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- 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>