Ticosonde: Over 15 years of Balloon-borne Water Vapor and Ozone Profiling in Costa Rica

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University of Maryland and NASA/GSFC

SAGE III/ISS Science Team Meeting

20 October 2020, 330 pm

Talk Roadmap

- A Brief History of Ticosonde and Quick Facts
- Ticosonde Water Vapor and Ozone Science
- Data Caveats and Issues
  1. Ozonesonde stratospheric “dropoff”
  2. Water vapor drift relative to Aura MLS
- What’s Next for Ticosonde?

The History of Ticosonde

- Soundings began during TCSP in July 2005 under leadership of **Holger Vömel** with launches at La Universidad Nacional (Jessica Valverde; UNA)

- Monthly water vapor soundings as well as intensive campaigns in January-March 2006 in conjunction with CR-AVE, in July-August 2006, and in July-August 2007 in conjunction with TC4

- March 2011: New PI **Rennie Selkirk**, sounding program moved to Universidad de Costa Rica (UCR) GasLab under **Jorge Andres Diaz**, where it continues today

- **Current PI Susan Strahan. Launching 2-4 ozonesondes per month, and 1 CFH water vapor sonde per month**

Ticosonde workshop and visit to GasLab in March 2019

Ticosonde Quick Facts

- Ozonesonde Profiles (SHADOZ): **614**
- CFH Water Vapor Profiles (NDACC): **221**

- Only long-term *in-situ* tropical (10° N) water vapor sounding data set in existence

- Cryogenic Frostpoint Hygrometer (CFH) water vapor soundings are currently coordinated with SAGE III/ISS occultations

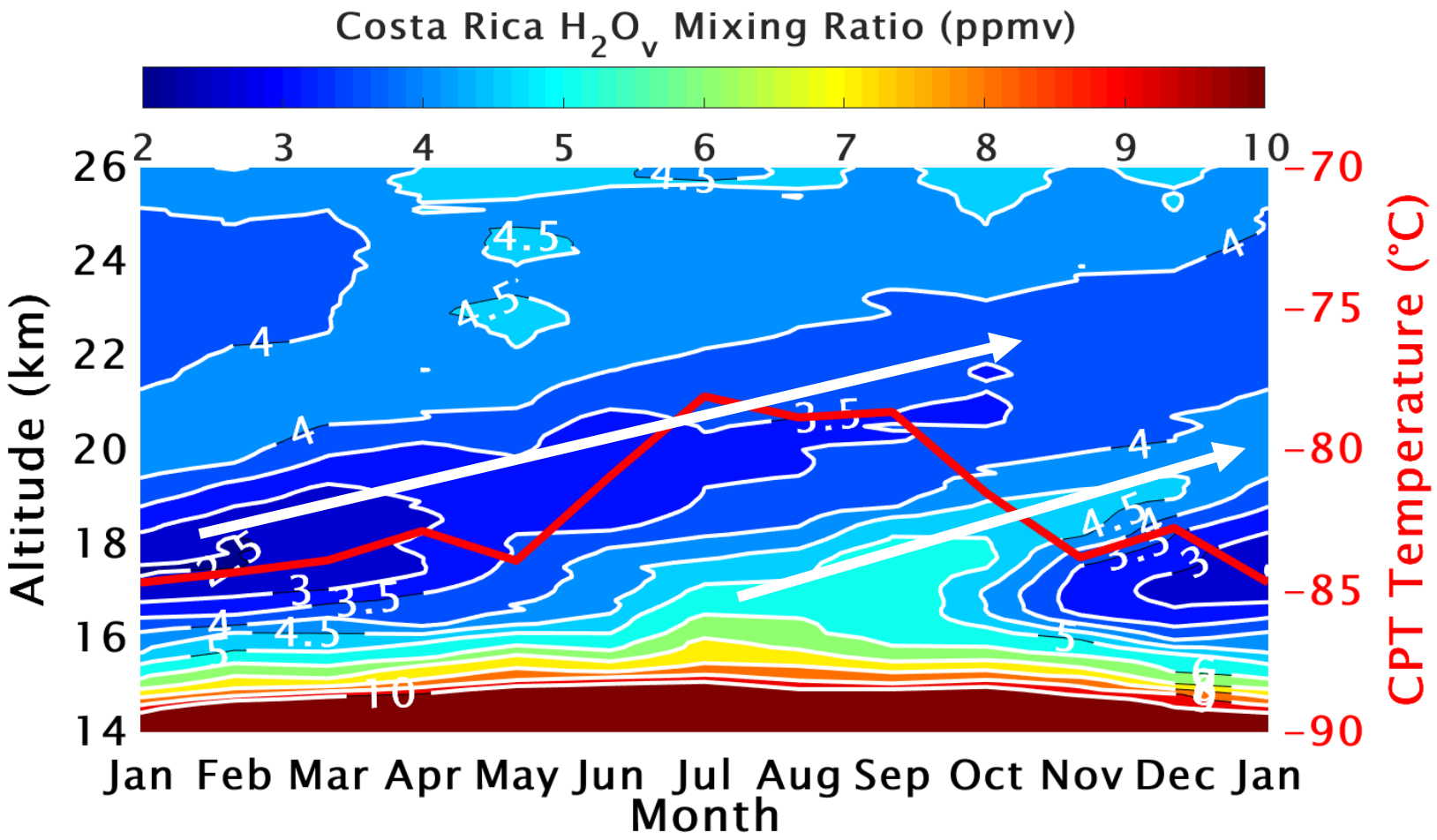
- Featured annually in the *AMS State of the Climate Report*

- Website: https://acd-ext.gsfc.nasa.gov/Projects/Ticosonde/index.html

Ticosonde Ozone and Water Vapor Science

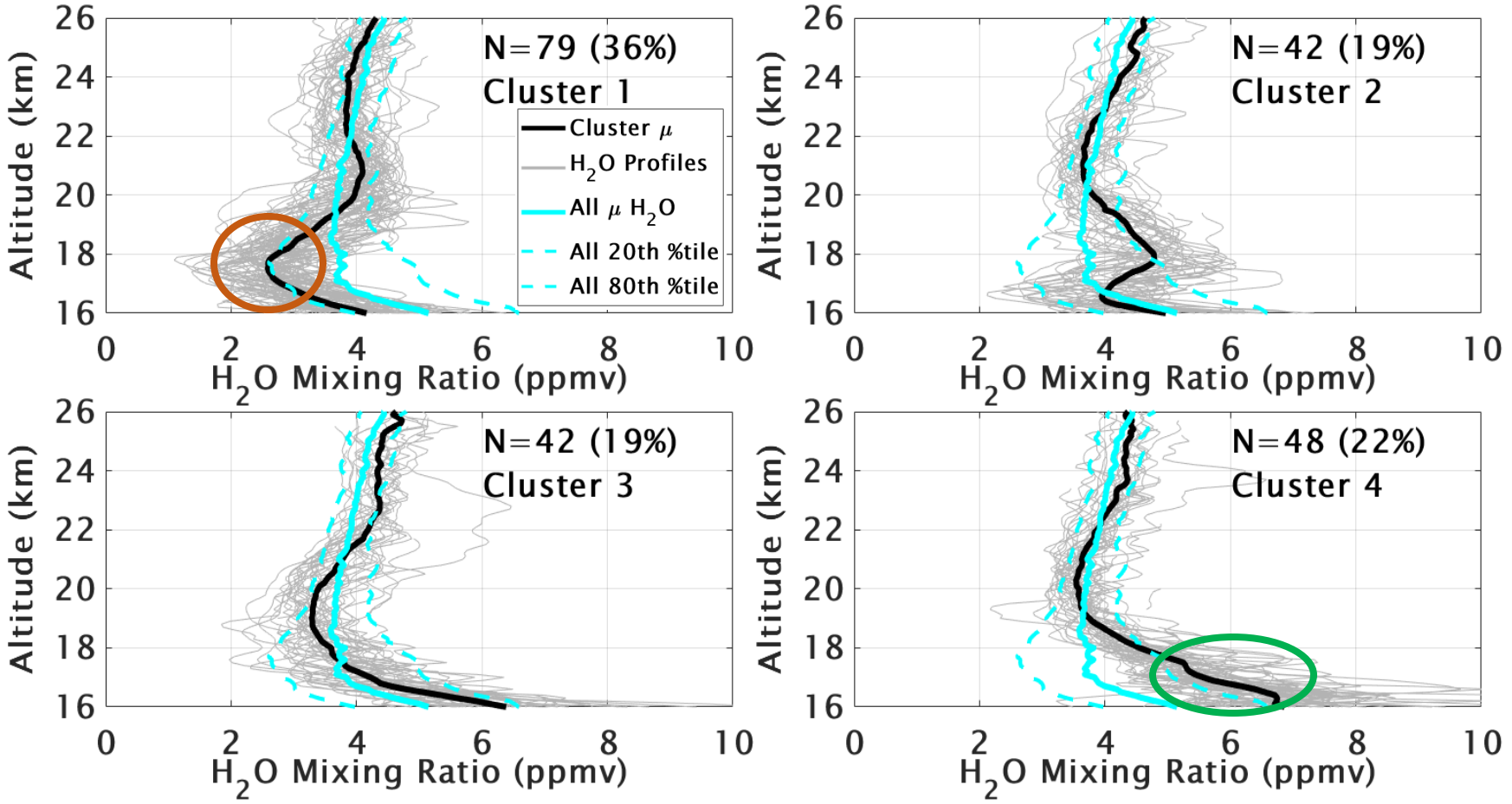
Ticosonde Water Vapor

- The *in-situ* water vapor profiles help characterize tropical dynamics with unmatched vertical resolution
- Figure on right shows monthly H_2O climatology and **cold-point tropopause** temperature
- The tropical water vapor tape recorder is prominent, which relates tropopause temperature to stratospheric water vapor content
- Slanted minima and maxima (**arrows**) quantifies the rate of ascent of stratospheric air



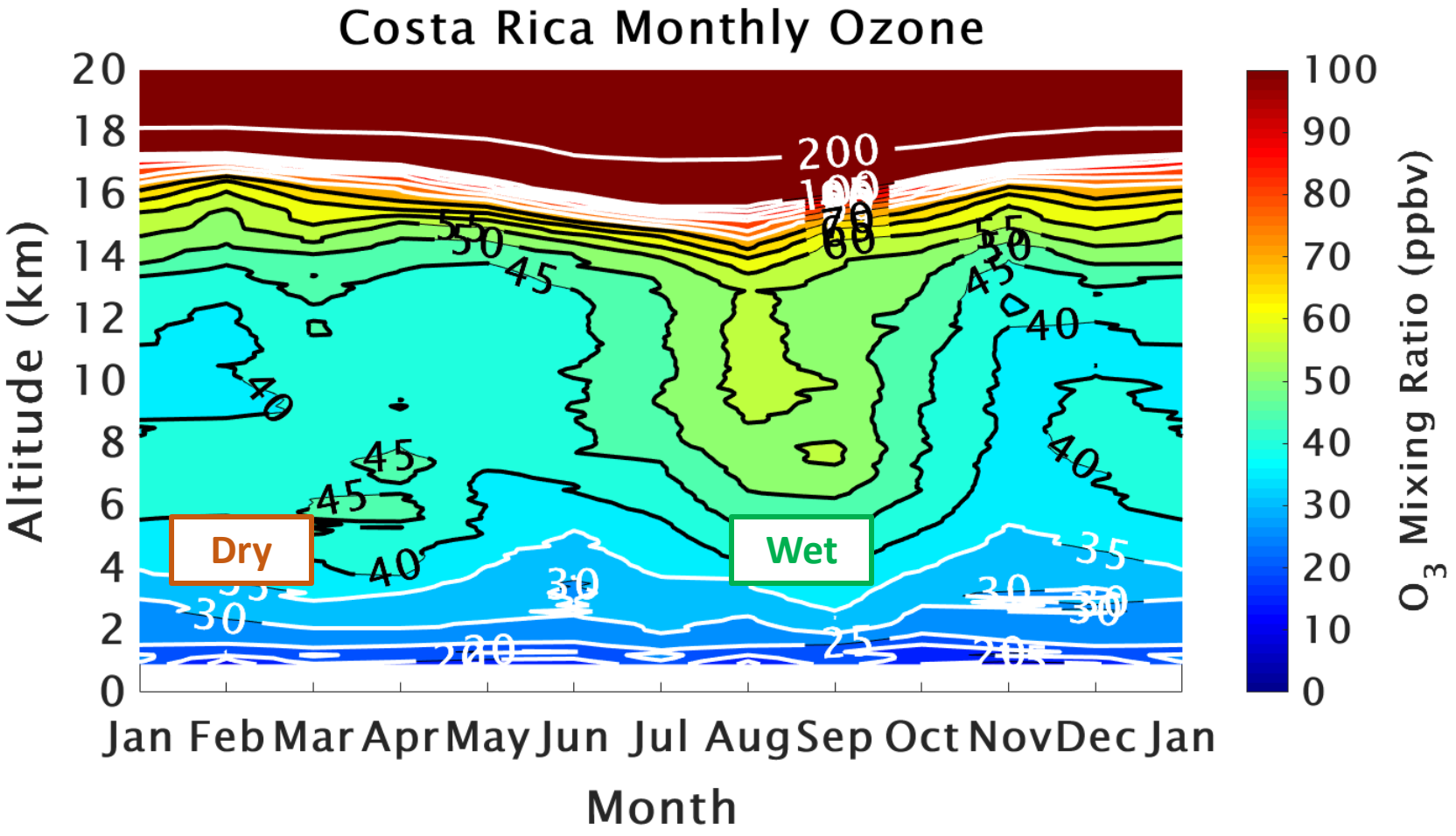
Ticosonde Water Vapor Clustering

- Taking a step beyond a simple climatology, we can use a clustering technique (self-organizing maps) to identify "prototype" water vapor profiles
- Note that clusters 1 and 4 show profiles that are particularly **dry** and **wet** and in the UT/LS
- We can use these clusters to identify how model and satellite biases are related to geophysical processes



Ticosonde Ozone

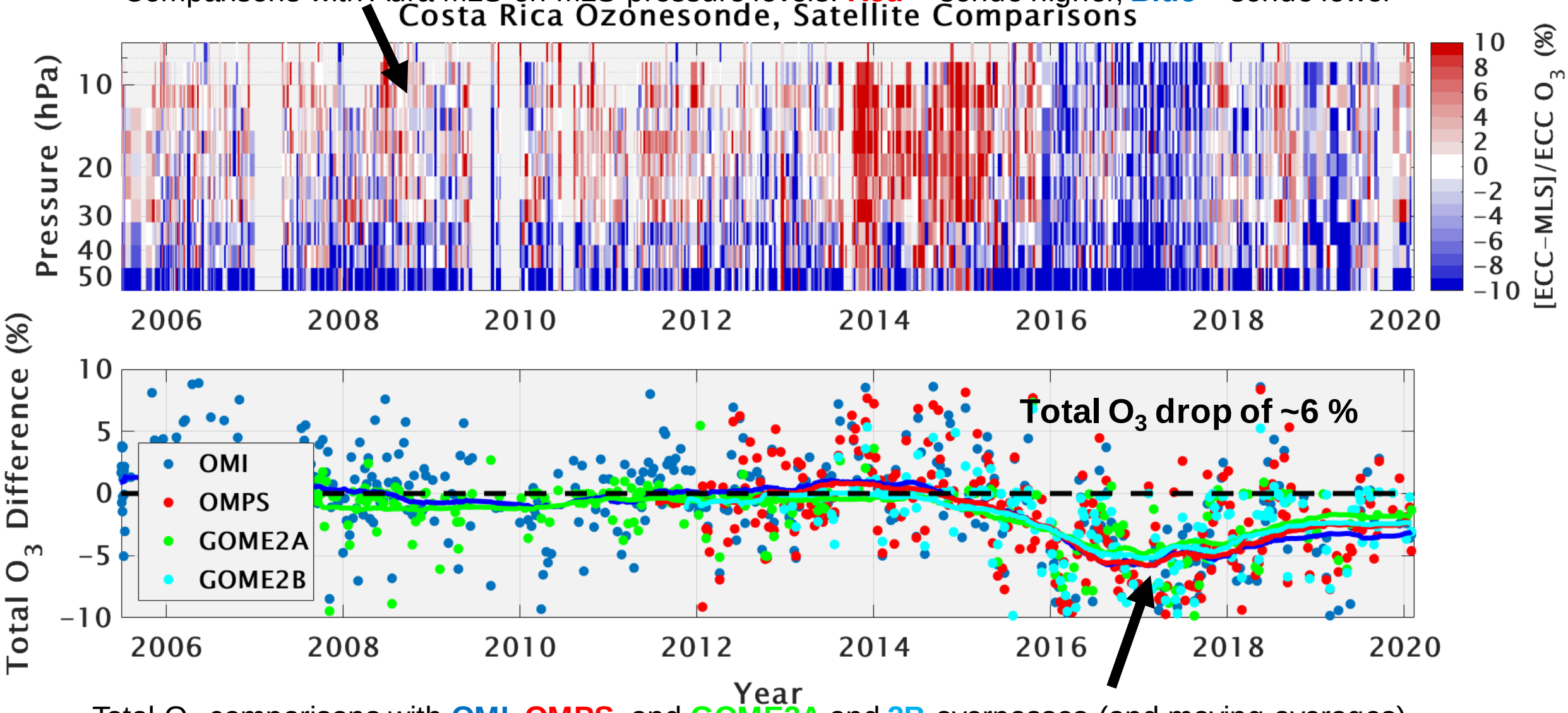
- Maximum tropospheric ozone in July to October
- Minimum tropospheric ozone in November to February
- The greatest tropospheric O_3 amounts occur during the wet season, and the lowest tropospheric O_3 occurs during the dry season
- This is atypical compared to other SHADOZ stations. Another ozone paradox??



Data Caveats and Issues

Ozonesonde "Dropoff" Problem

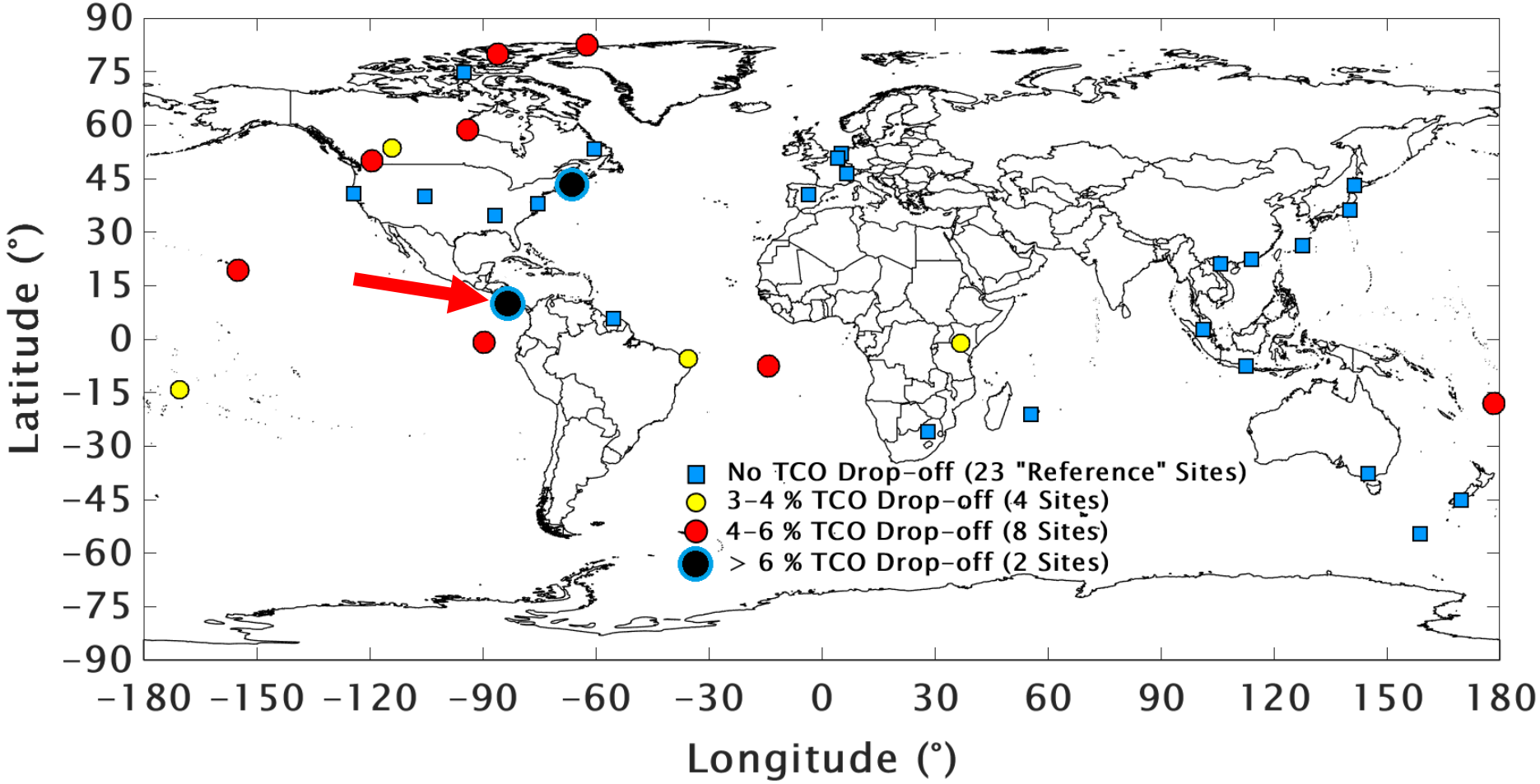
Comparisons with Aura MLS on MLS pressure levels. **Red** = sonde higher, **Blue** = sonde lower



Total O_3 comparisons with **OMI**, **OMPS**, and **GOME2A** and **2B** overpasses (and moving averages)

Global Ozonesonde "Dropoff" Problem

- The dropoff issue is not unique to Costa Rica. Over a dozen sites, which similarly use one of the two major ozonesonde manufacturers, are affected
- The largest low biases are found in the stratosphere and are 5-10% or more
- It is critical to be aware of this issue if using Ticosonde ozone to validate stratospheric satellite measurements

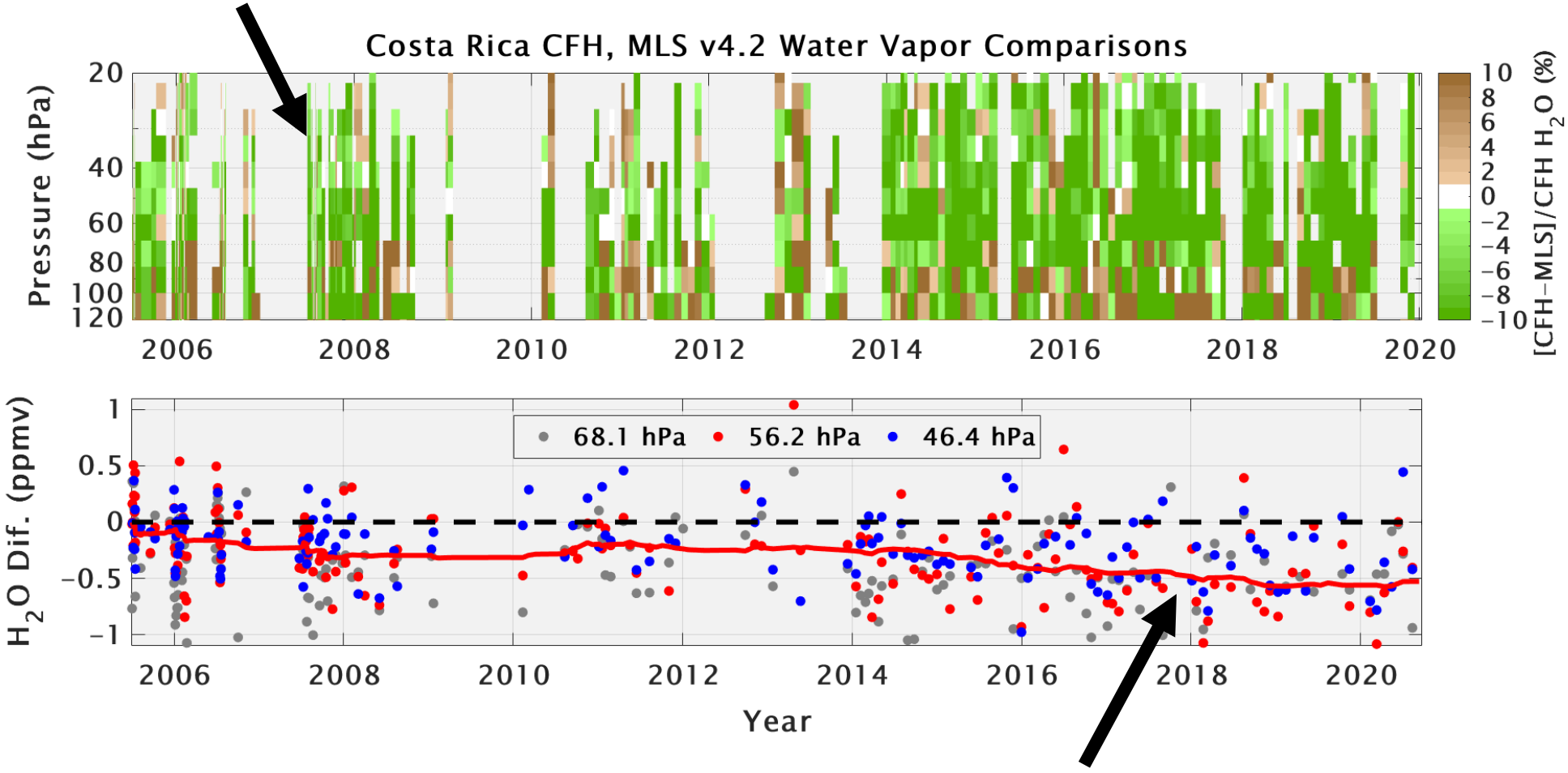


MLS H_2O Drift?

Comparisons with Aura MLS on MLS pressure levels. **Green** = MLS higher, **Brown** = MLS lower

- A global survey of frost point sonde comparisons with the Aura MLS record (**Hurst et al., 2016**) showed a positive drift in MLS of ~1%/year

- The drift was less severe at Costa Rica than at mid-latitude sites…but is that changing?



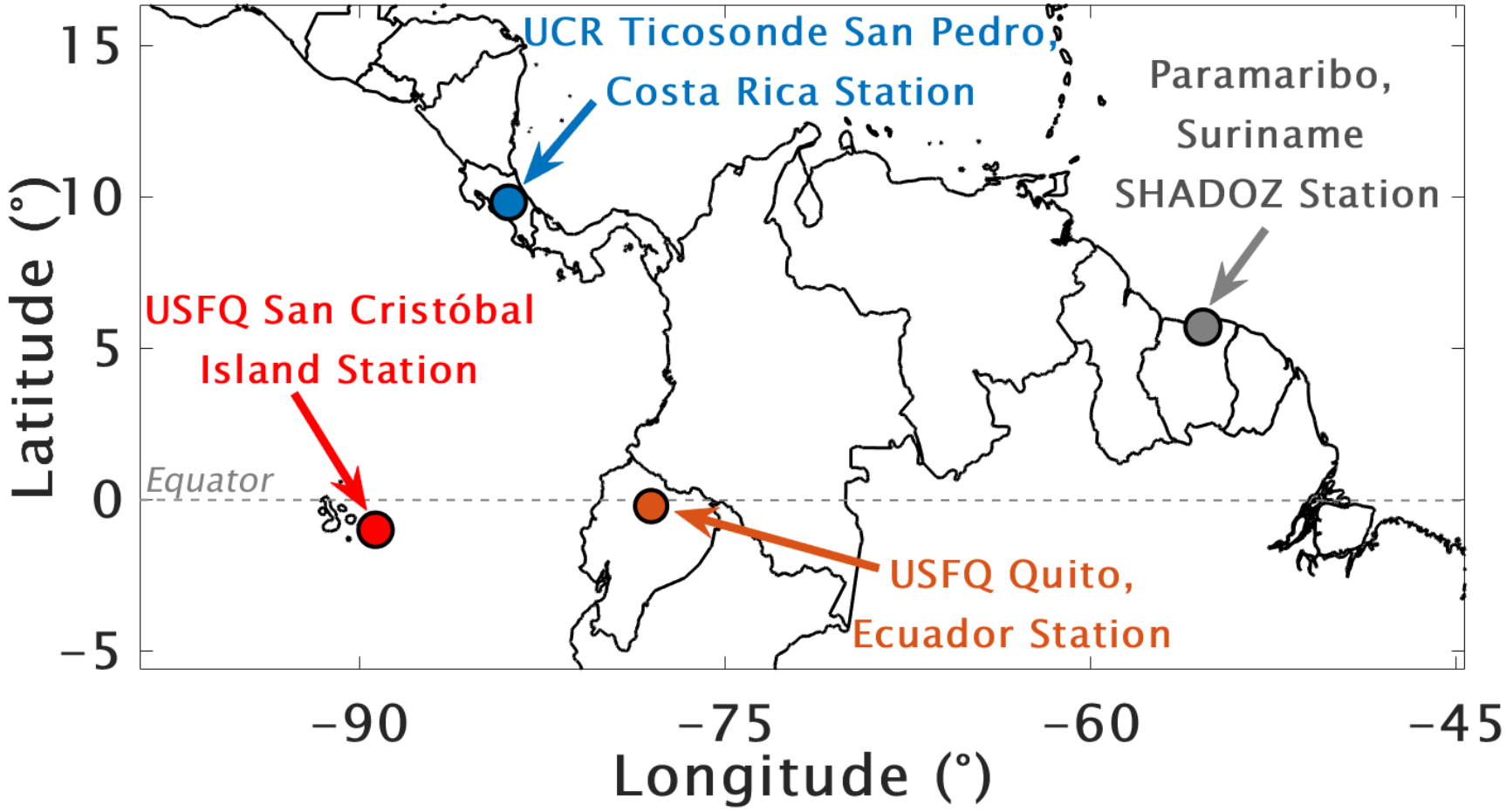
Moving average suggests that MLS wet bias may be increasing at the 56.2 hPa MLS pressure level

What's Next for Ticosonde?

- Proposal submitted to NASA ROSES UACO program for continued 2021-2024 water vapor and ozonesonde profiles

- Highlighting the Equatorial Americas, including the reactivation of the San Cristobal SHADOZ station (stoppage since 2016)

- Proposal PI/Co-I Team:
  - R. Stauffer (PI, NASA)
  - A. Thompson (Co-I, NASA)
  - A. Diaz (Co-I, UCR)
  - M. Cazorla (Co-I, USFQ)
  - H. Vömel (Co-I, NCAR)



Thanks!

Select References:

- 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, 47, e2019GL086791. 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, accepted for Atmos. Meas. Tech. (discussion: https://amt.copernicus.org/preprints/amt-2020-62/).
- Vömel, H., Naebert, T., Dirksen, R., and Sommer, M. (2016), An update on the uncertainties of water vapor measurements using cryogenic frost point hygrometers, Atmos. Meas. Tech., 9, 3755–3768, https://doi.org/10.5194/amt-9-3755-2016.

Data:

- SHADOZ Ozone: https://tropo.gsfc.nasa.gov/shadoz/CostaRica.html
- NDACC H_2O: ftp://ftp.cpc.ncep.noaa.gov/ndacc/station/costa_rica/ames/wvsonde/
- AVDC SO_2: https://avdc.gsfc.nasa.gov/pub/tmp/TICOSONDE_SO2_archive/data/