Recent global ozonesonde network data quality underscores the success of homogenization efforts

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2022 NDACC Steering Committee Meeting

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Outline

- Current status of global ozonesonde data homogenization activities
- Examples of ozone changes/improvements after data homogenization
- Summary of global ozonesonde data quality and “dropoff” status
- Example station where homogenization and the dropoff low bias are both factors that affect data quality

Current “homogenization” activities within O3S

- harmonizing Standard Operating Procedures by new WMO-GAW report No. 268 in https://library.wmo.int/doc_num.php?explnum_id=10884

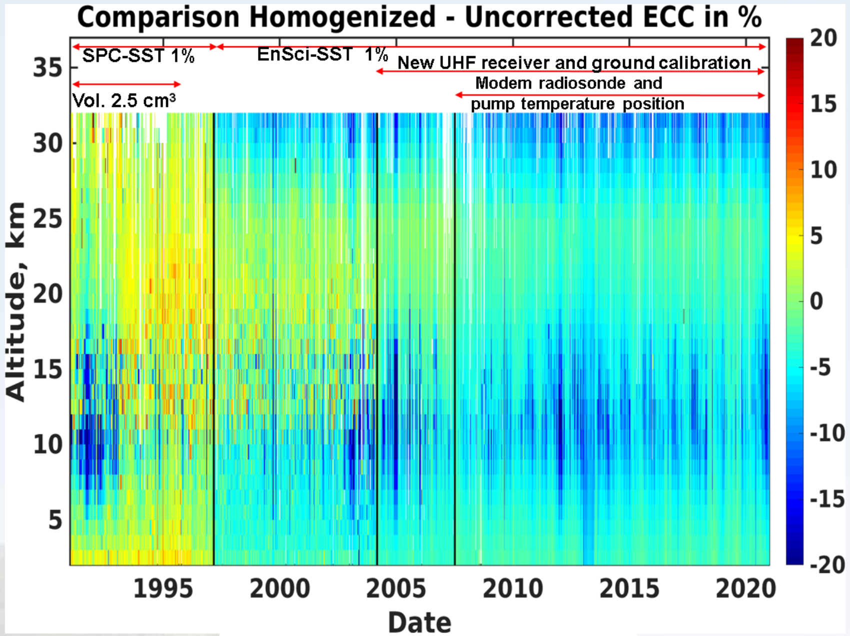
- continuation of O3S-DQA (Ozone Sonde Data Quality Assessment) activity (°2011)

- Harmonization and Evaluation of Ground-based Instruments for Free Tropospheric Ozone Measurements within the TOAR-II Focus Working Group “HEGIFTOM”

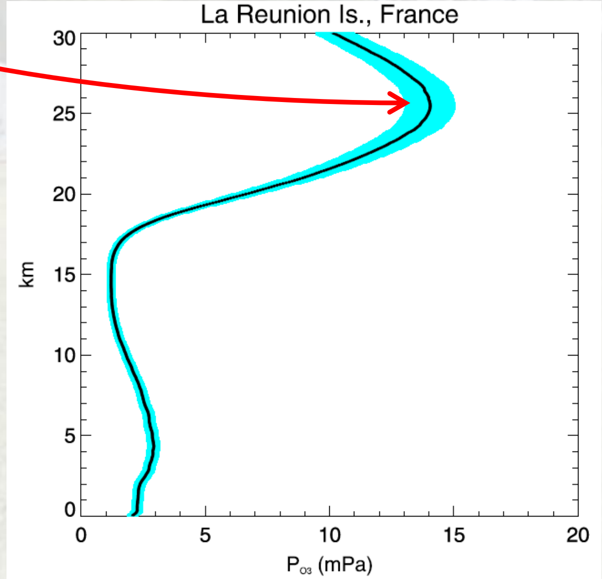
O3S-DQA principles

- correcting for (biases due to) changes in instrument type, sensing solution strength/volume, pre-flight procedures, post processing, etc.
- estimation of uncertainties for every ozone partial pressure measurement
- provision of raw data (“currents”), needed for any future reprocessing of the data

➔ reduce uncertainty from 10-20% to 5-10%



Ancellet et al., 2022



Witte et al., 2018

O3S-DQA status: HEGIFTOM Respository

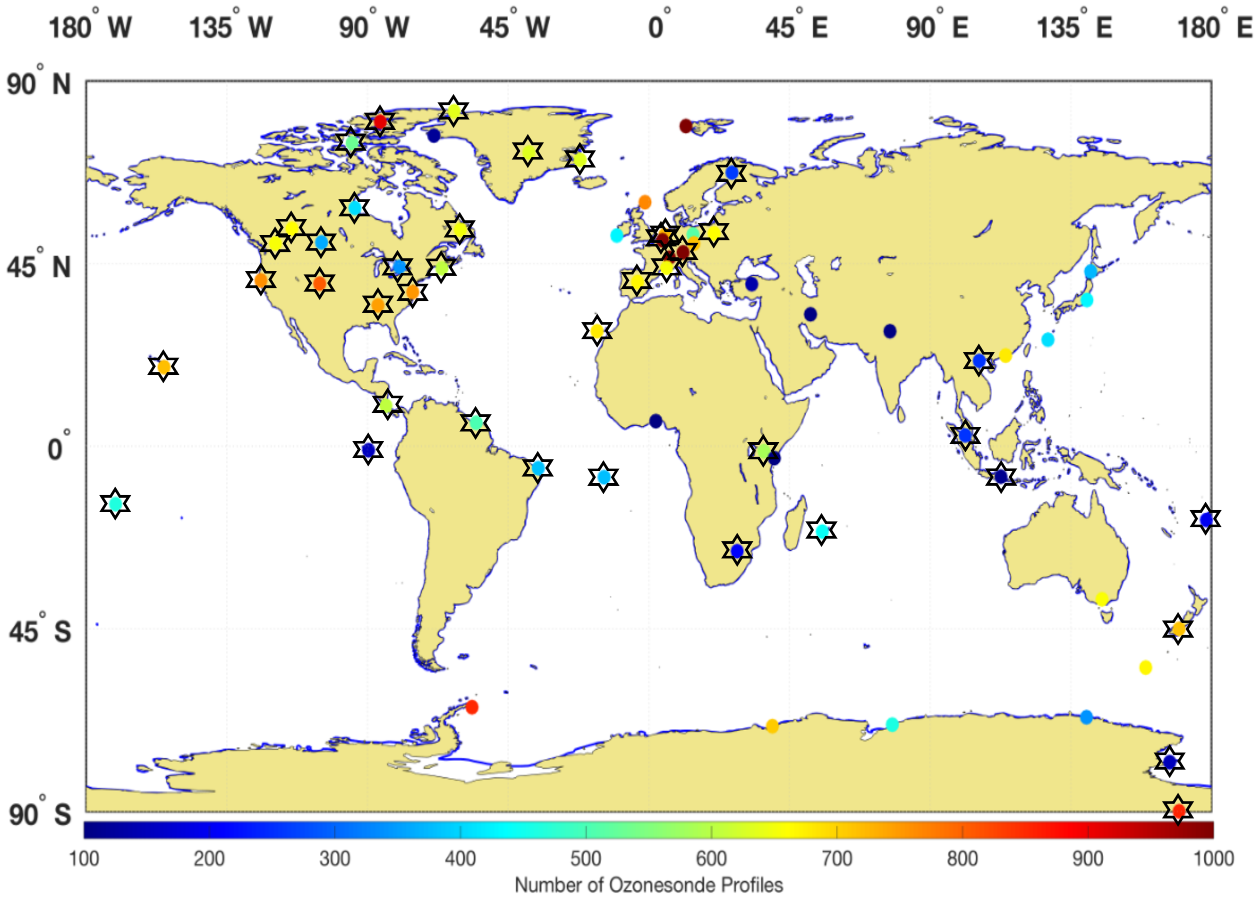


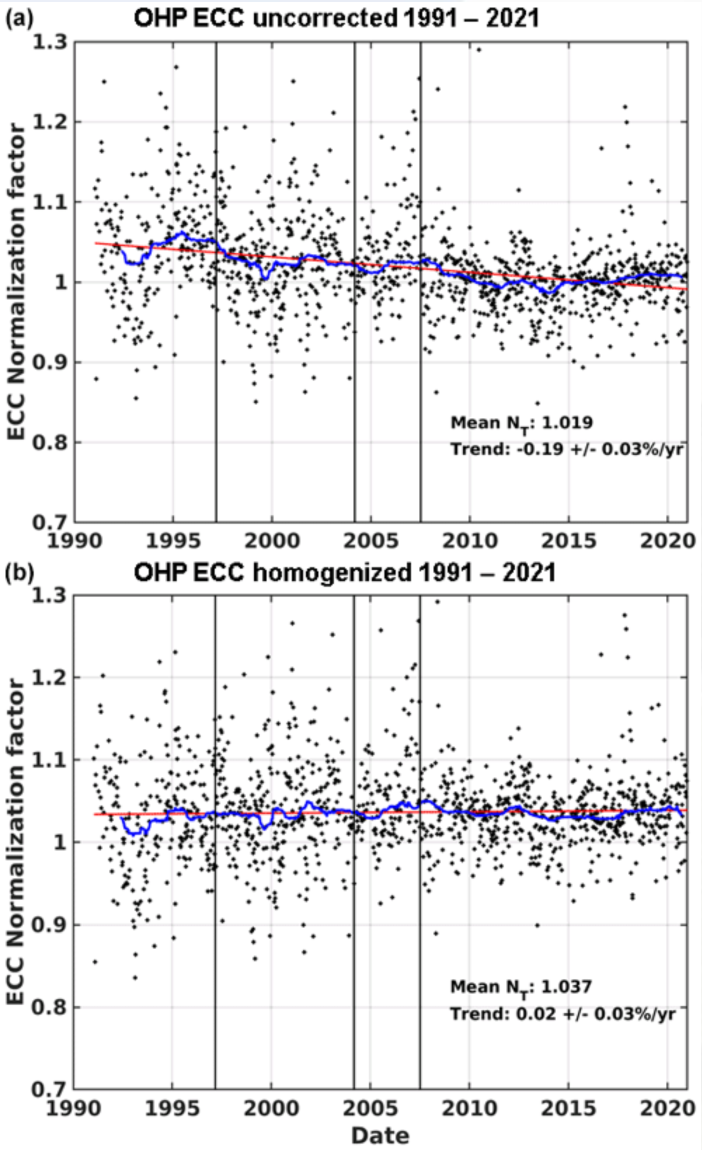
Figure 1-2: Global ECC ozonesonde station locations with the number of ozonesonde profiles from 2005-2019 (Aura satellite era) indicated by the colormap.

- 42 from around 60 "active" sites homogenized (stars)
- remaining: Japanese, Asian, Australian, some EU and Antarctic sites.
- all homogenized data (and only homogenized data!) are available on a ftp-server, together with general description and link to github Python code on HEGIFTOM website:

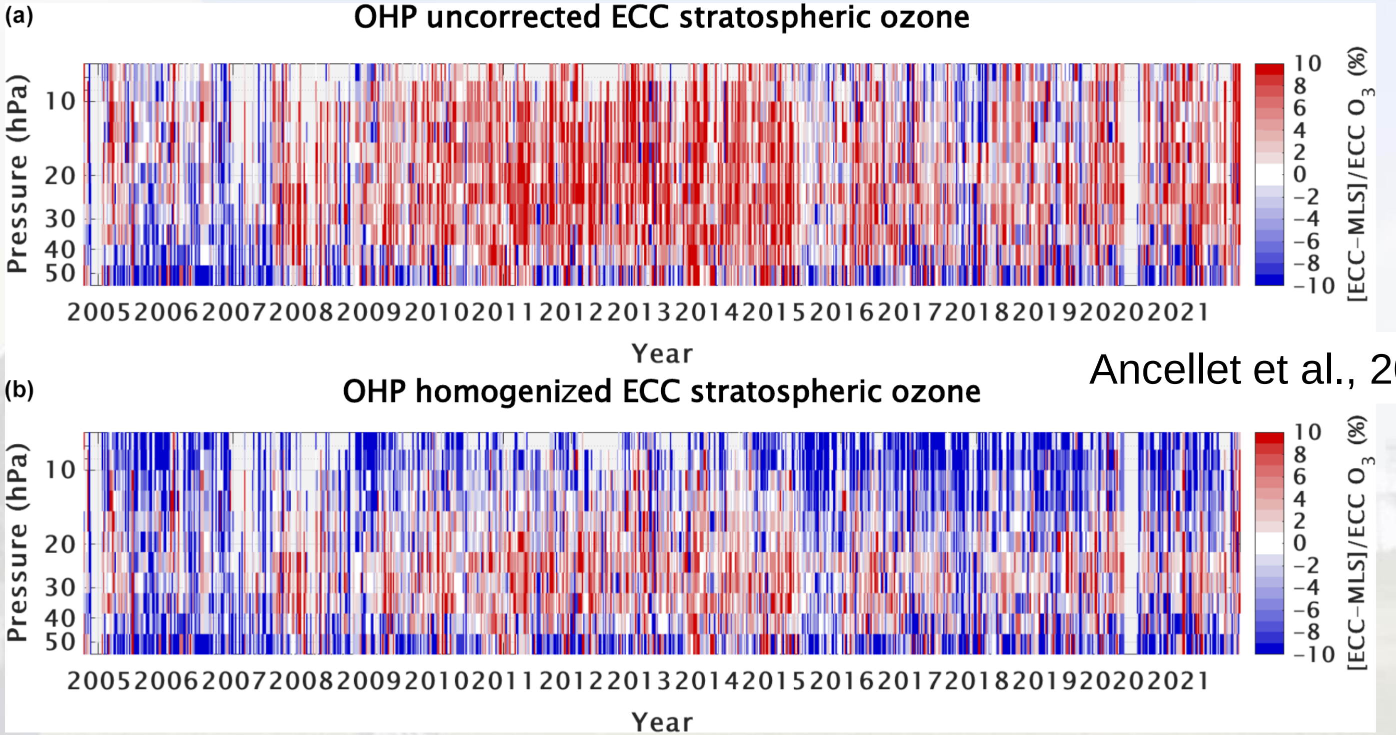
https://hegiftom.meteo.be/datasets/ozonesondes

O3S-DQA: examples (i) OHP

Total ozone



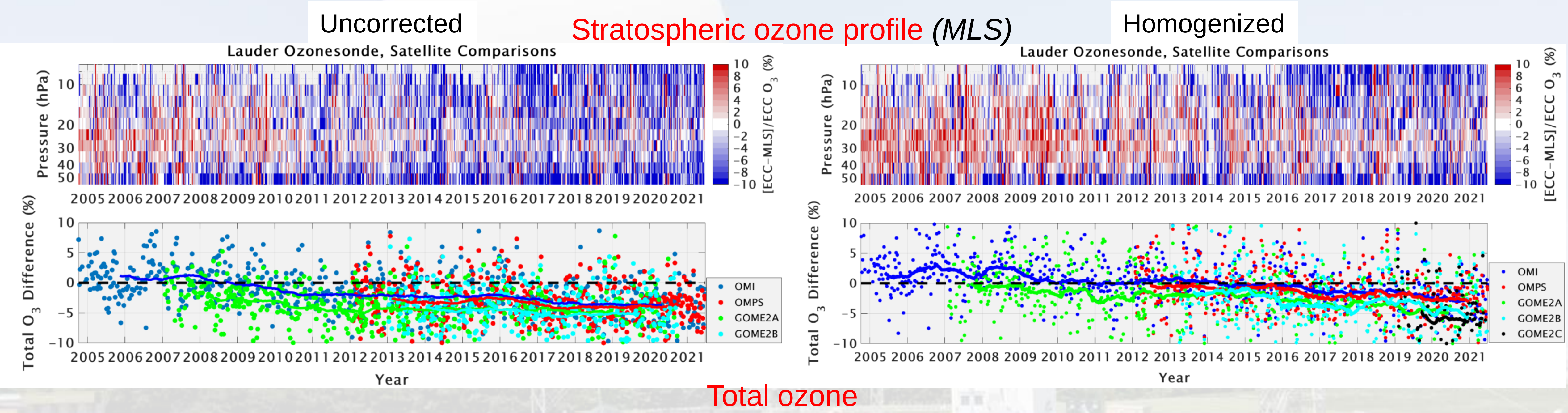
Stratospheric ozone profile
(MLS)



Ancellet et al., 2022

- smaller drift (TCO)
- smaller relative biases

O3S-DQA: examples (ii) Lauder



- overall TCO underestimation disappears
- remaining drift
- TCO drop off around 2016?

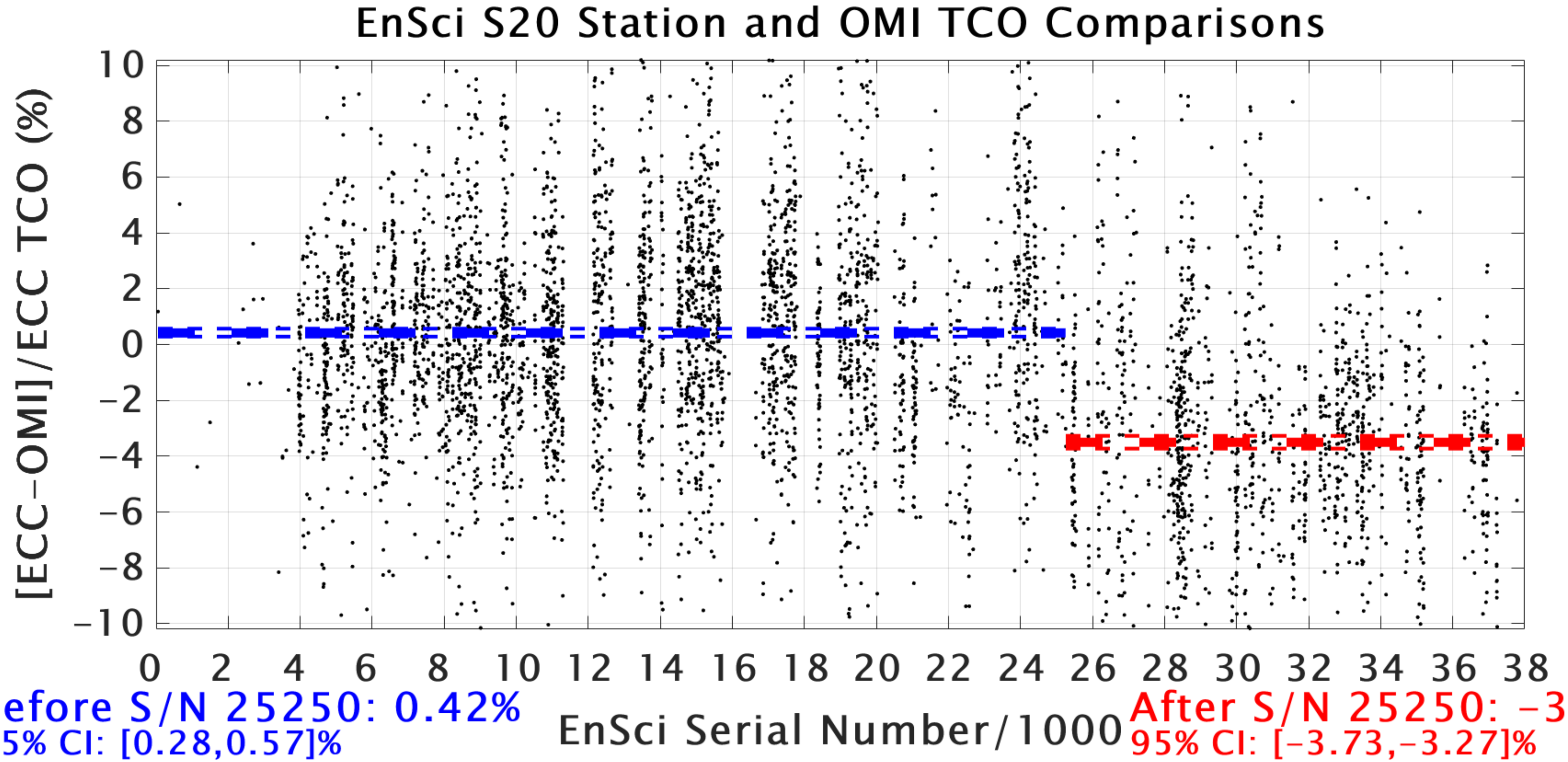
More on the EnSci Ozonesonde “Dropoff”, and the status of global network data accuracy →

Science Pump: SPC

<u>En-Sci</u>

EnSci "Dropoff" Found at Homogenized Stations

Changepoint identified at EnSci S/N 25250, so we estimate this as being the "dropoff point"

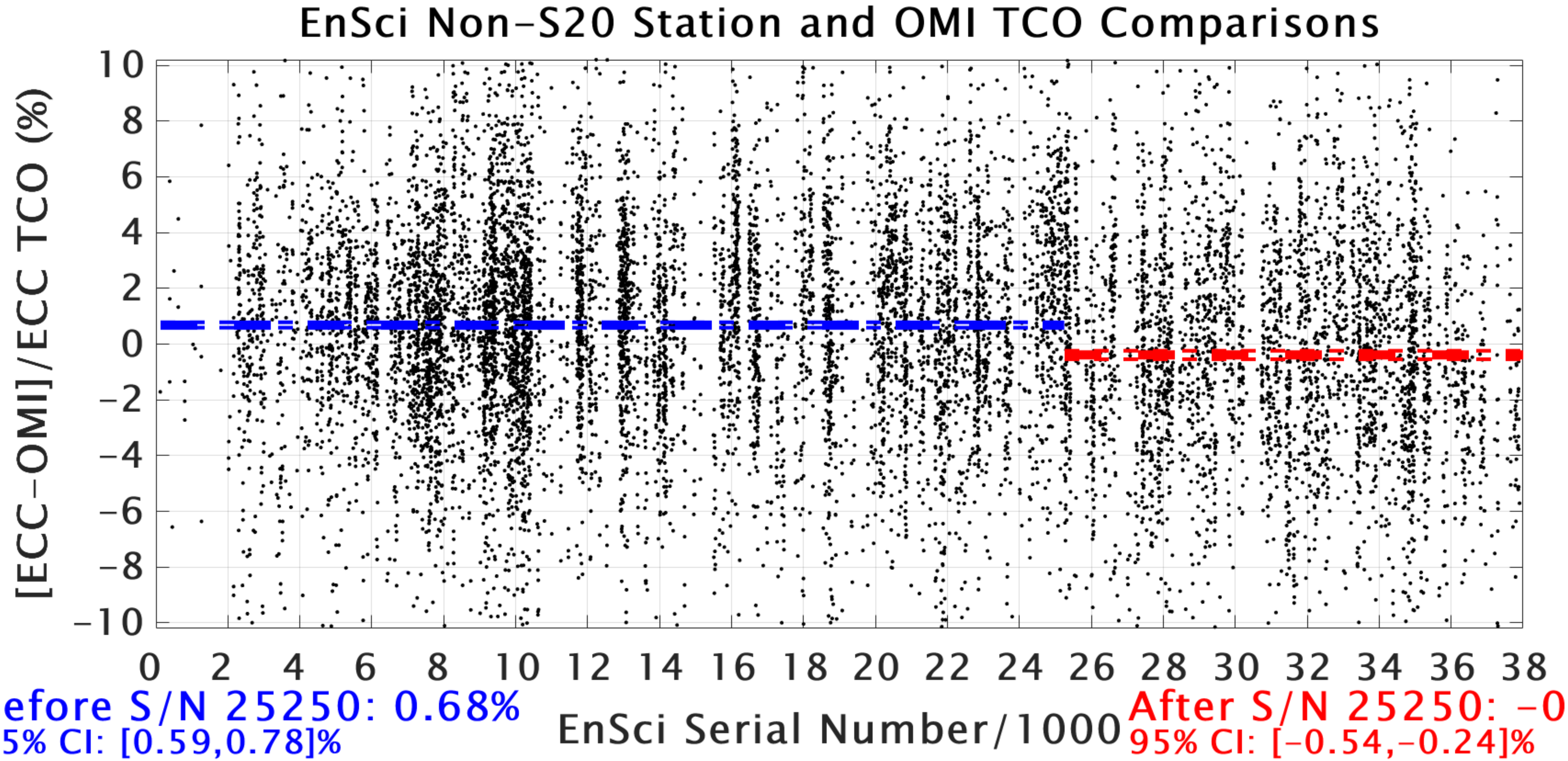


Before S/N 25250: 0.42%
95% CI: [0.28,0.57]%

After S/N 25250: −3.5%
95% CI: [−3.73,−3.27]%

Small "Dropoff" Found at All EnSci Stations?

Even the EnSci stations not considered "dropoff" show a step change at EnSci S/N 25250



Before S/N 25250: 0.68%
95% CI: [0.59,0.78]%

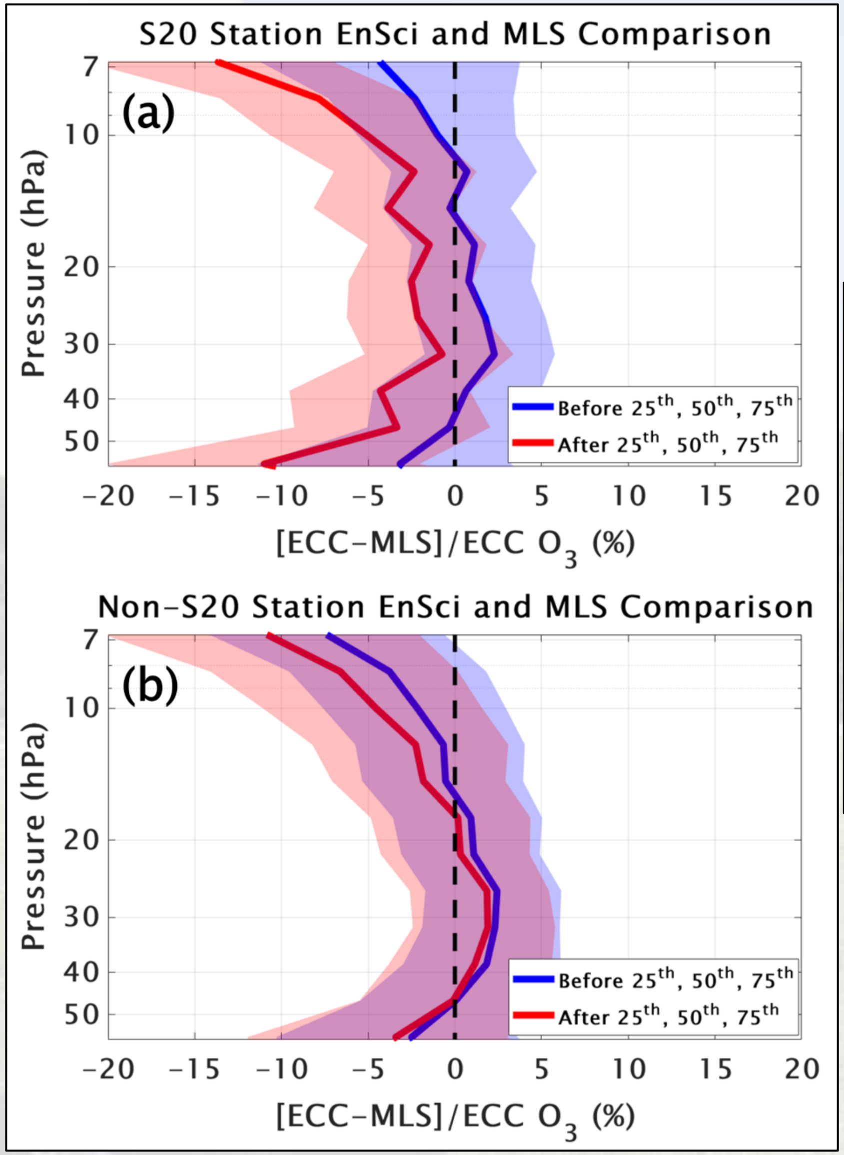
After S/N 25250: −0.39%
95% CI: [−0.54,−0.24]%

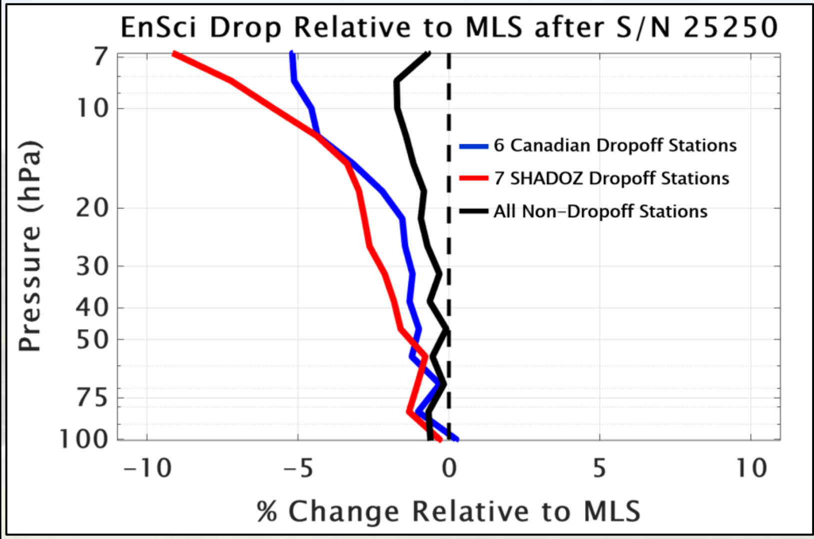
Small "Dropoff" Found at All EnSci Stations?

- Using the EnSci S/N 25250 as a breakpoint, we can see how the ozonesonde comparisons with Aura MLS in the stratosphere have changed

- Clearly a larger change at the so-called "dropoff" stations (**top**)

- However, for both cases, there is a downward change in the ozonesonde ozone relative to MLS that increases with altitude → could this be associated with pump performance decreases in the stratosphere?

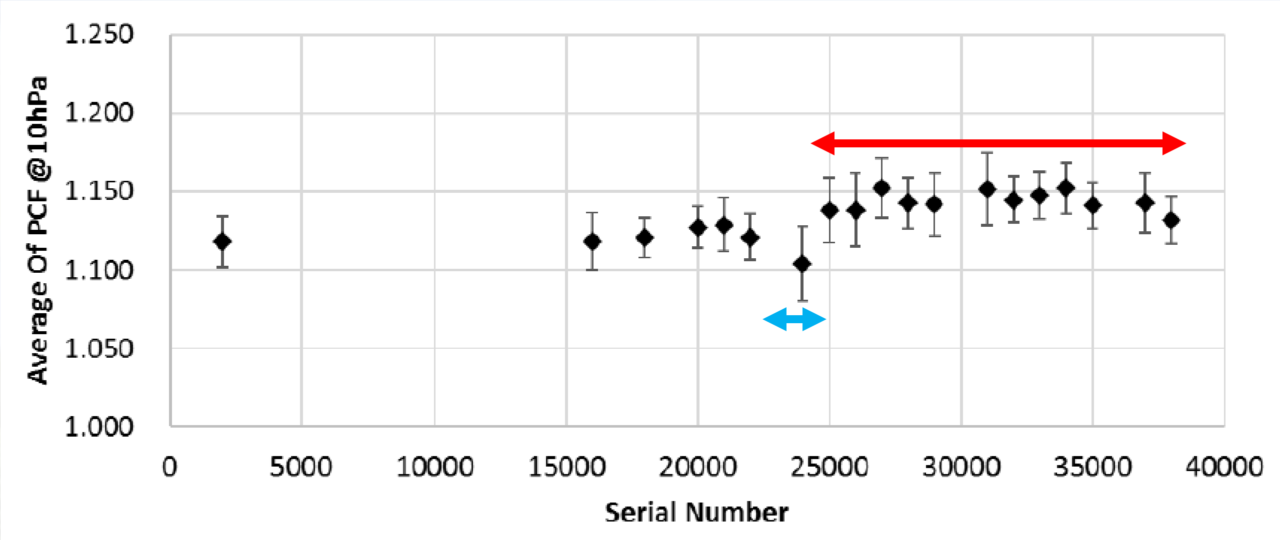


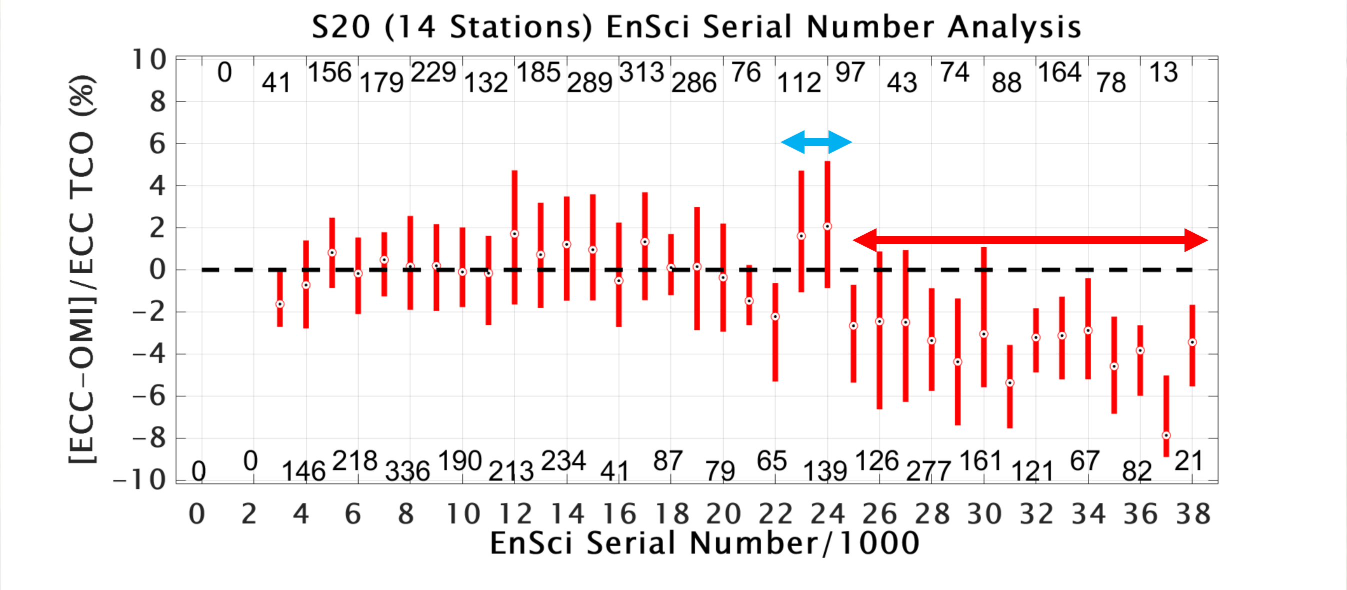


Timing of Pump Changes and Dropoff

- A new paper, Nakano and Morofuji (2022; AMTD) shows that there have been changes to the EnSci pump efficiency corrections that are coincident with the ozonesonde TCO dropoff

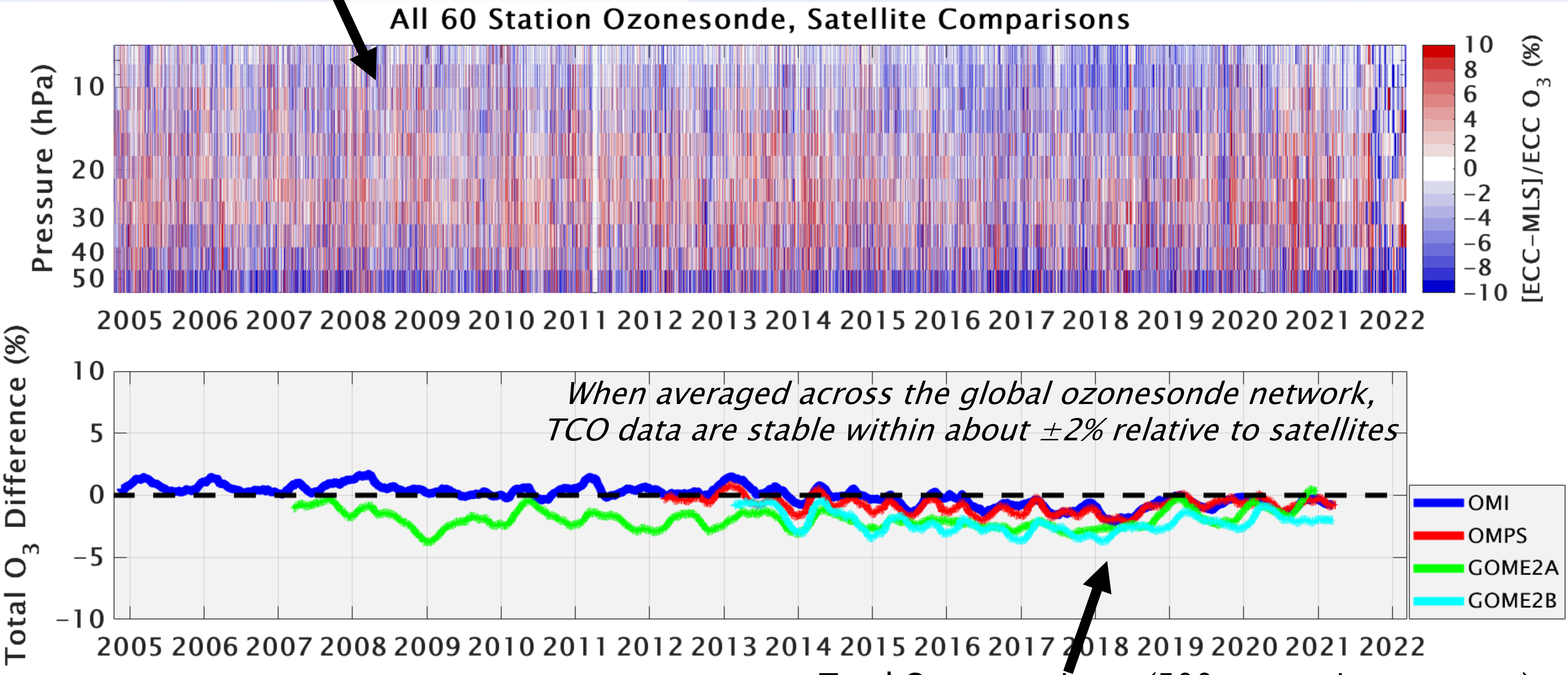
- Reprocessing ozonesonde data using this data set may resolve some of the magnitude of the TCO drop





Global Network Time Series vs. Satellites

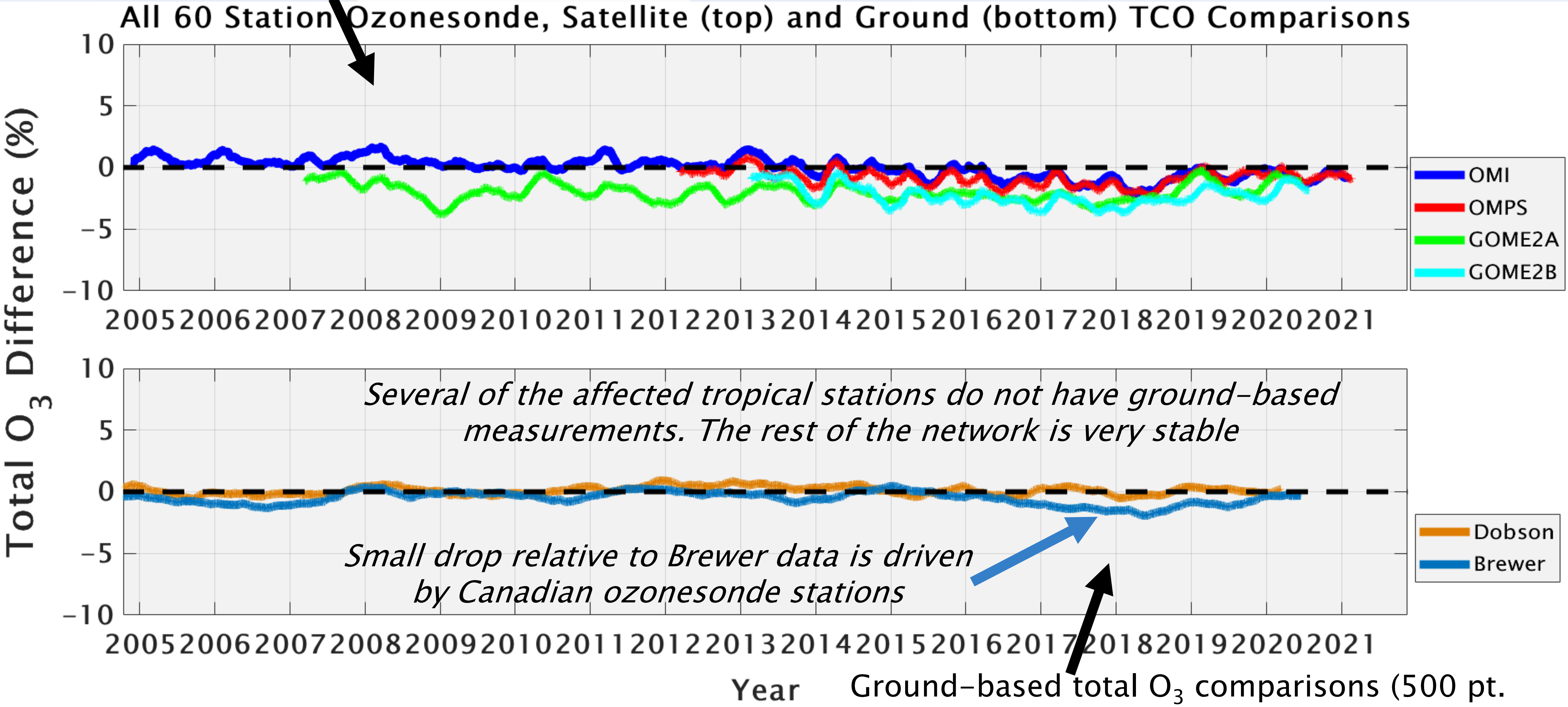
Comparisons with Aura MLS on MLS pressure levels. **Red** = sonde higher, **Blue** = sonde lower



Total O_3 comparisons (500 pt. moving averages)

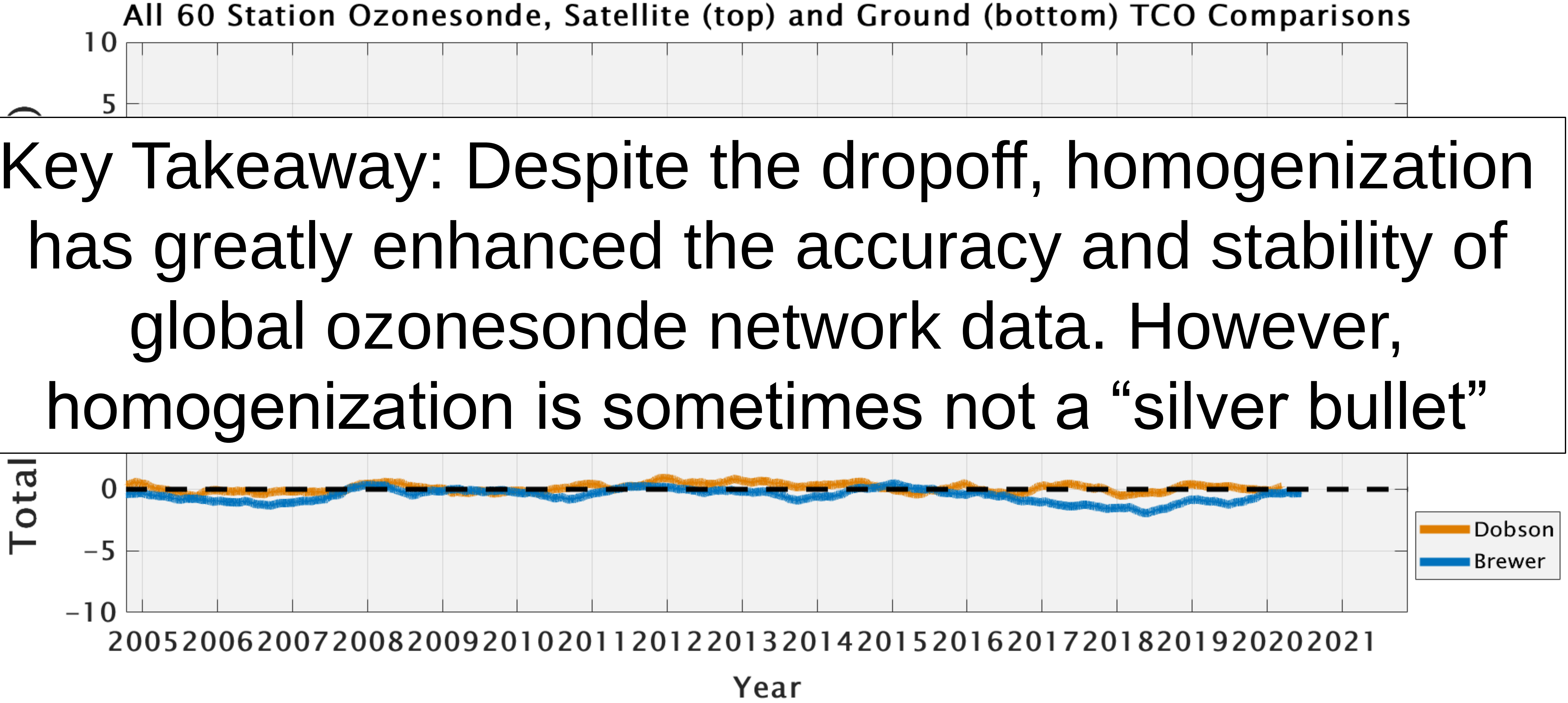
Global Network vs. Satellite and Ground-Based TCO

Satellite total O_3 comparisons (500 pt. moving averages)



Ground-based total O_3 comparisons (500 pt. moving averages)

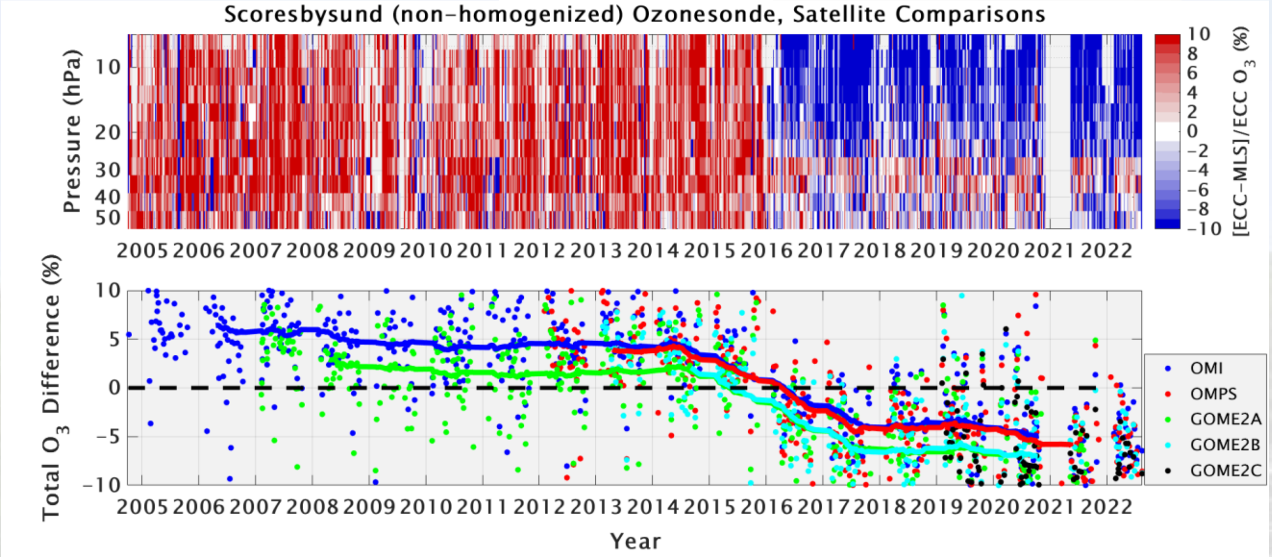
Global Network vs. Satellite and Ground-Based TCO



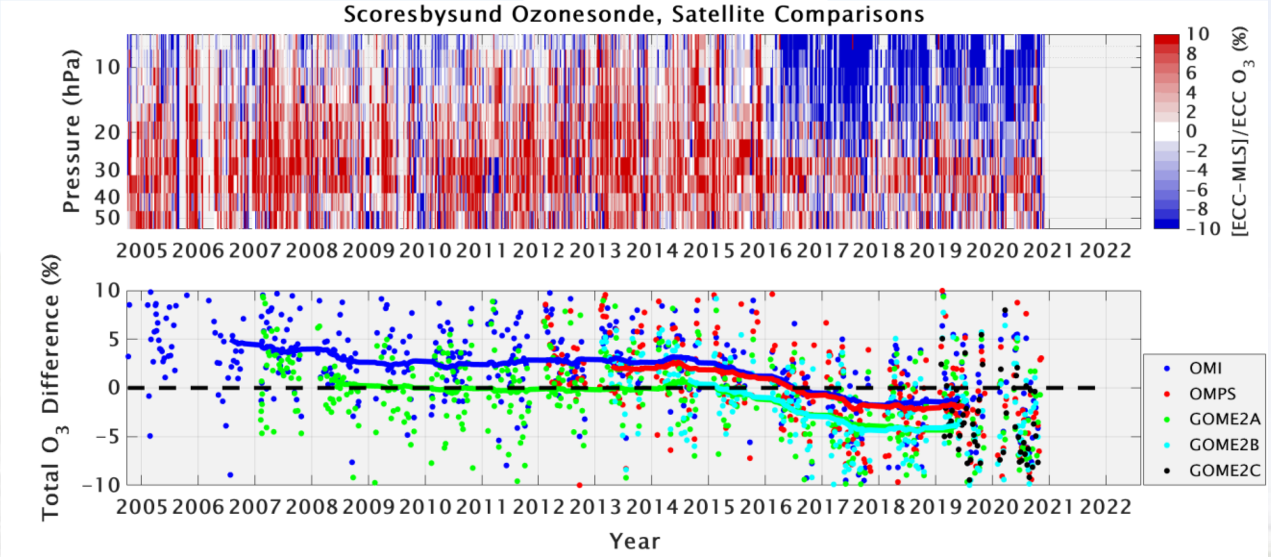
Key Takeaway: Despite the dropoff, homogenization has greatly enhanced the accuracy and stability of global ozonesonde network data. However, homogenization is sometimes not a “silver bullet”

Homogenization and TCO drop off

Uncorrected

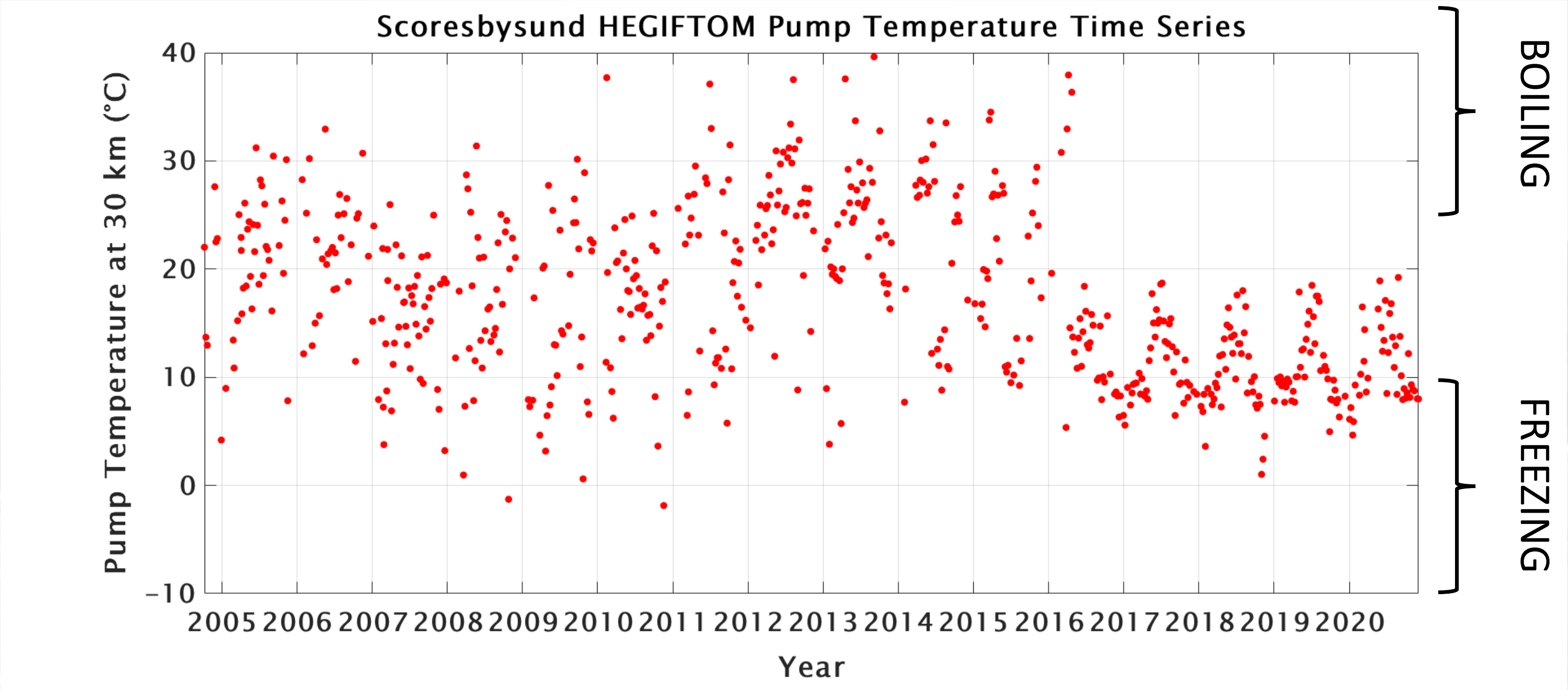


Homogenized



- large discontinuity in 2016 due to start of application of transfer function to network standard (En-Sci 1.0 → En-Sci 0.5)
- after homogenization, TCO drop off around 2016 remains

Homogenization and TCO drop off



Changes around 2016:

- radiosonde type
- p from pressure sensor -> p from GPS
- interface type
- active heating system in the box
- water activated batteries for pump -> Li batteries

➔ Need for continuous quality monitoring!!!

Summary

- Homogenization has been completed at **42** (of ~60) global ozonesonde stations. The homogenized data show improvements in comparisons to independent ozone data (ground-based and satellite)

- Some issues such as step changes and drifts remain at homogenized stations that are still under investigation

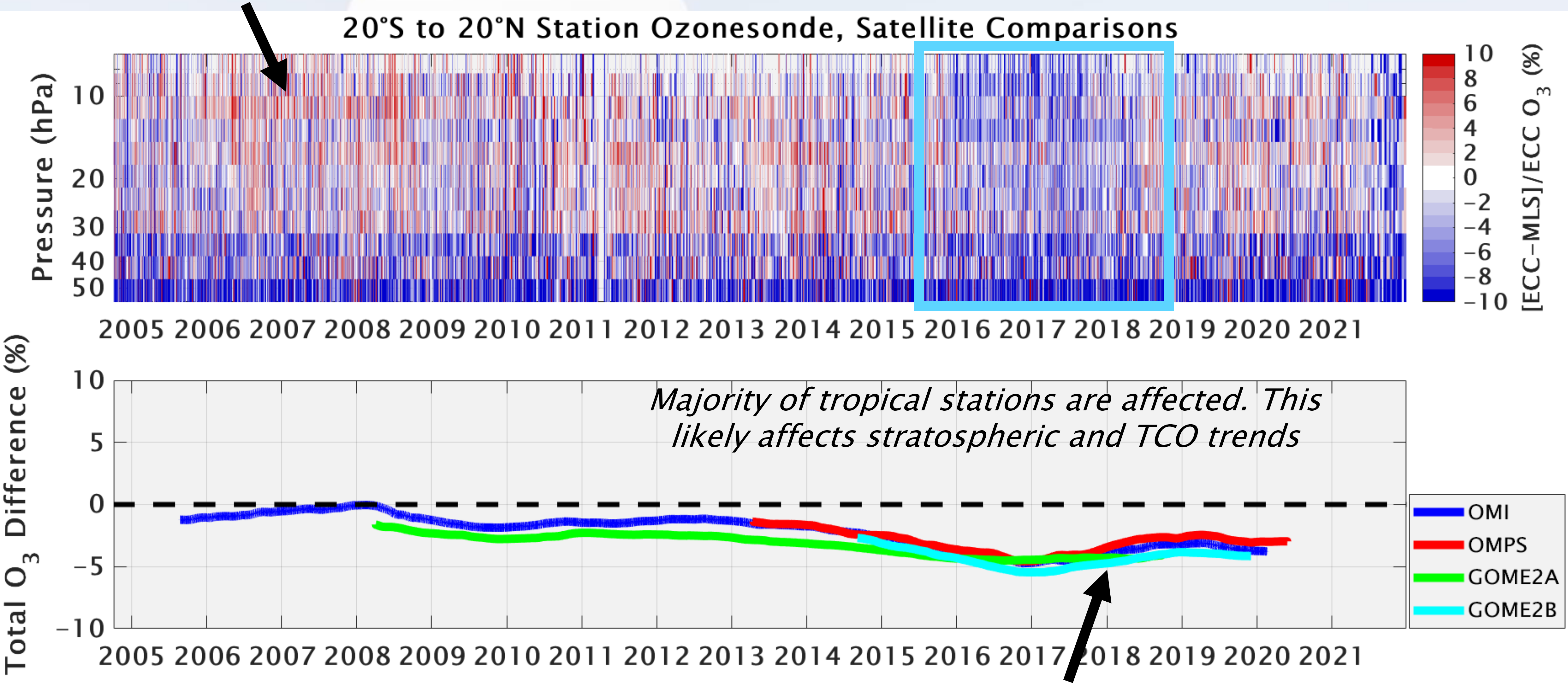
- The EnSci ozonesonde “dropoff” is likely at least partially explained by reduced ozonesonde stratospheric pump efficiencies. **Tests underway soon to quantify this effect**

- Overall, global ozonesonde network data on average are stable to within about ±2% TCO compared to ground-based and satellite data. Tropical stations are affected more by the dropoff

Extras

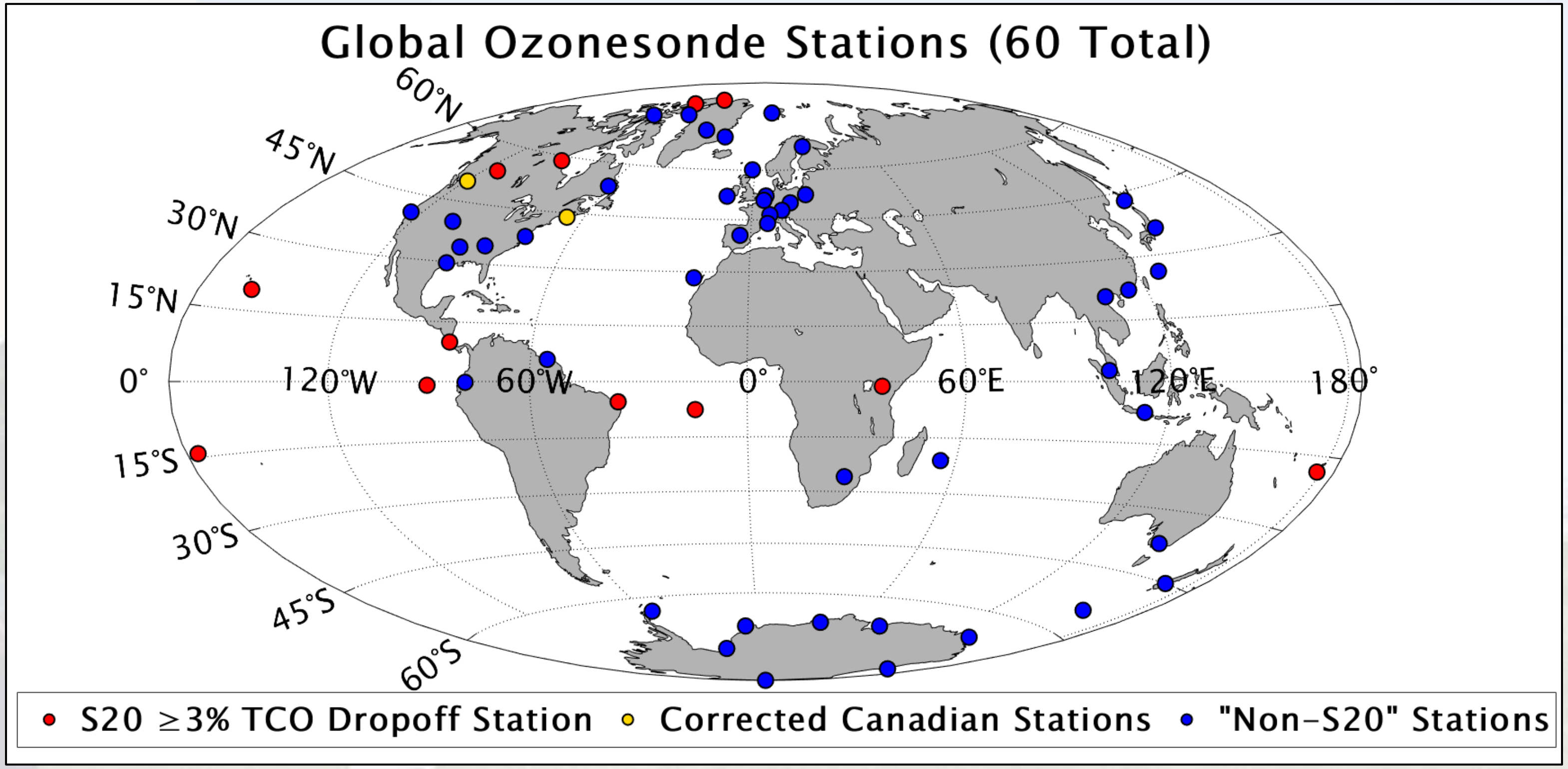
Tropical Network vs. Satellites

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



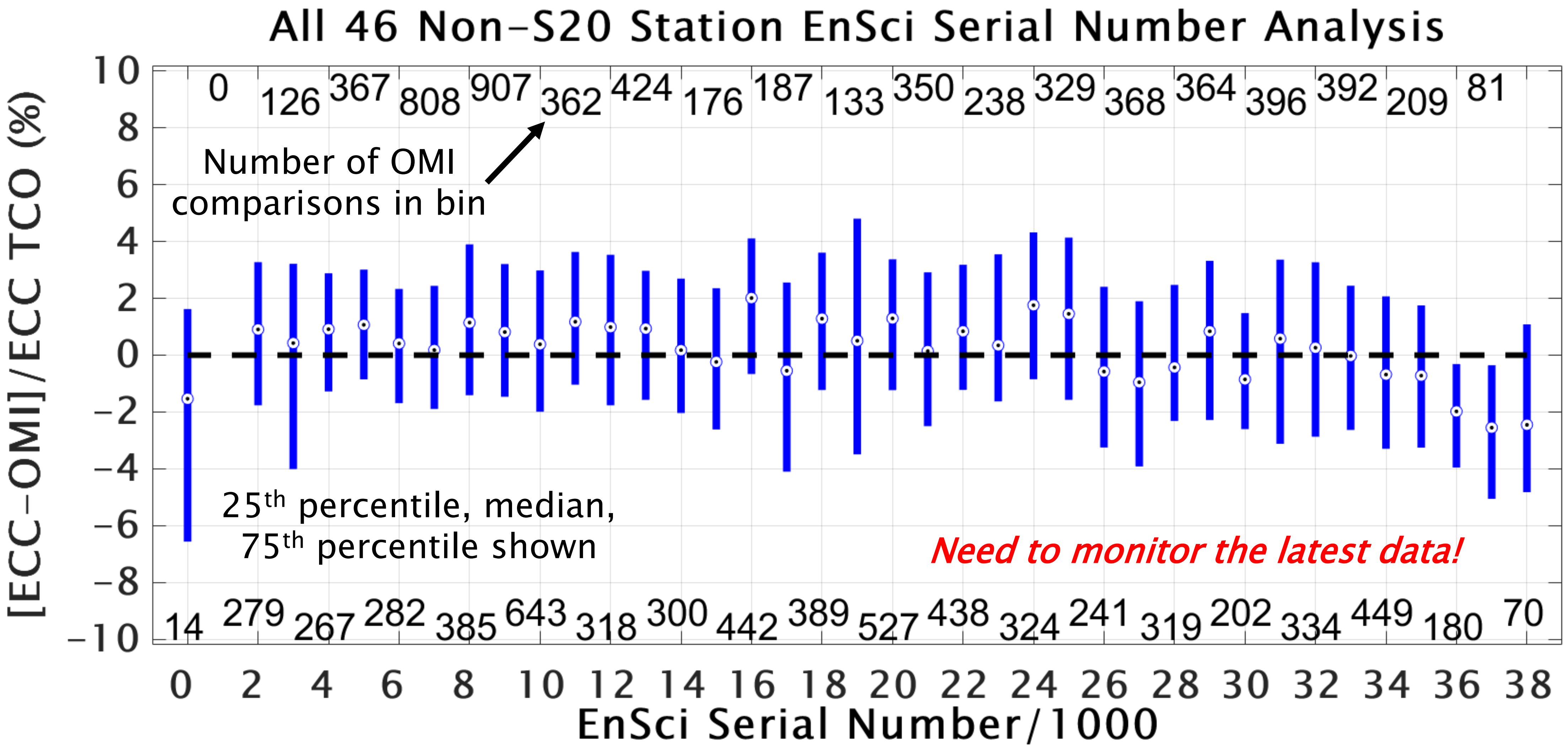
Summary

- Expansion from the 37 S20 stations to 60 global stations (mainly Europe and Antarctica)
- Dropoff station defined as having a **3% TCO drop** relative to OMI
- Kelowna and Yarmouth Canadian station data were **missing a correction** for non-standard ozonesonde sensing solution
- >30,000 OMI and ozonesonde TCO comparisons to evaluate, in addition to other independent data



Summary

Serial numbers grouped in bins of 1000: (25 = S/N 25000s)



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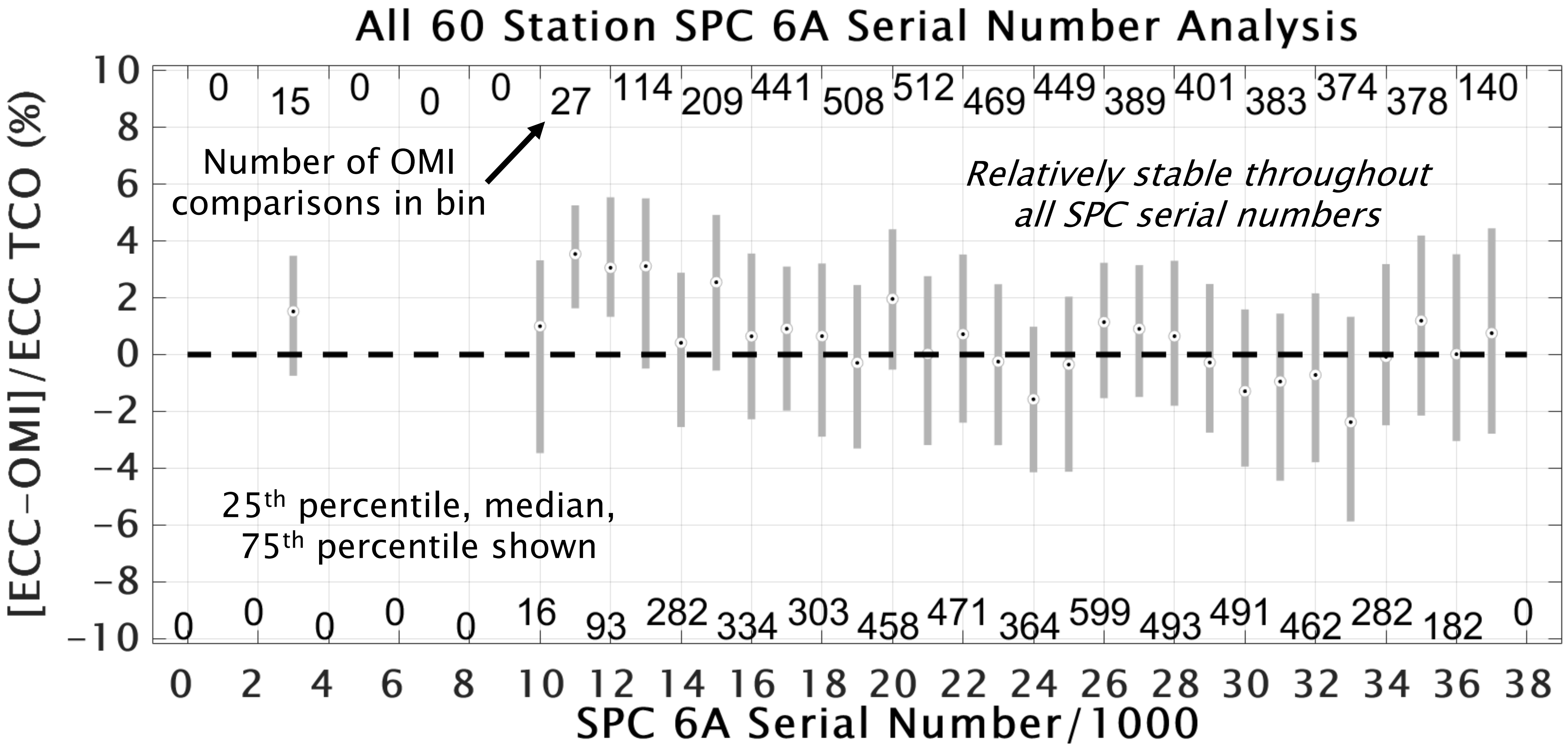
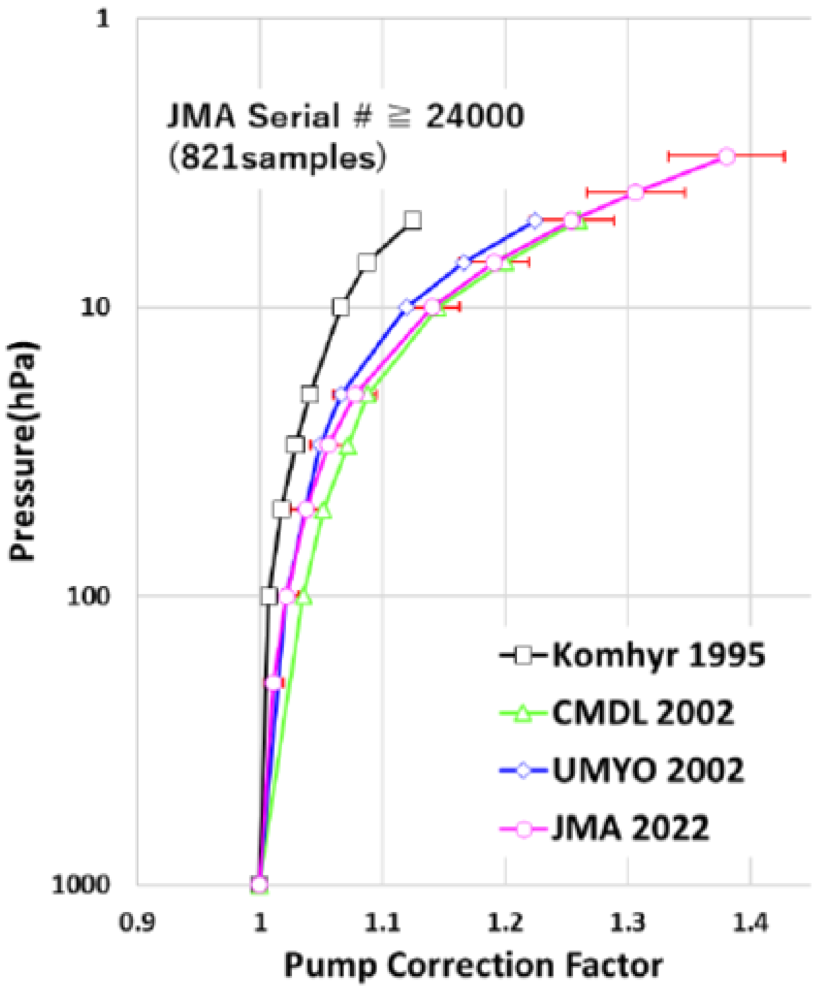


Summary

- Ozonesonde pump efficiency corrections are applied to every profile to account for reduced efficiency at stratospheric pressures

- <u>**Key Assumption**</u>: These values do not significantly change with time



Press.	Pump Correction Factor [JMA 2022]
3	1.381 ± 0.047
4	1.307 ± 0.040
5	1.254 ± 0.034
7	1.191 ± 0.028
10	1.140 ± 0.023
20	1.078 ± 0.017
30	1.056 ± 0.015
50	1.038 ± 0.013
100	1.021 ± 0.010
200	1.011 ± 0.008

Summary

- An unaccounted decrease in stratospheric pump efficiency would cause greater ozone “losses” in **tropical** profiles compared to **higher latitudes**

- However, there are considerations for different ozonesonde solution types, transfer functions, etc.