

Goddard
Space Flight Center

TOAR
tropospheric
ozone
assessment
report

Homogenized ozonesonde time series: Improved agreement with independent data sets

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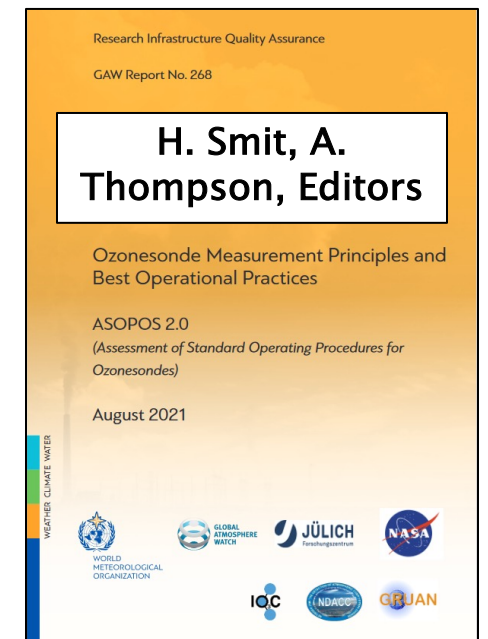
With special thanks to R. Van Malderen, D. Poyraz, H. Smit, and numerous station PIs and Co-Is for their efforts on homogenization activities. Kelowna (D. Tarasick/J. Davies), and OHP (G. Ancellet/S. Godin-Beekmann) stations are shown here

29 November 2021

TOAR-II HEGIFTOM WG Meeting

Brief Outline

- Ozonesonde measurement principles and necessary corrections for homogenization
- Status of homogenization activities in the global network
- Examples of improved accuracy/stability after homogenization
 1. Comparisons with five satellite instruments
 2. Comparisons with ground-based total column ozone (TCO)
 3. Changes in ozone time series from homogenization
- **New:** Assessment of Standard Operating Procedures for OzoneSondes (ASOPOS) v2.0 WMO/GAW Report #268. Guidebook for ozonesonde measurements and standard operating procedures (SOP). Homogenization guidelines are based on ASOPOS laboratory (JOSIE) and field (BESOS) tests



ASOPOS 2.0 GAW Report no. 268:
[https://library.wmo.int/doc_num.
php?explnum_id=10884](https://library.wmo.int/doc_num.php?explnum_id=10884)

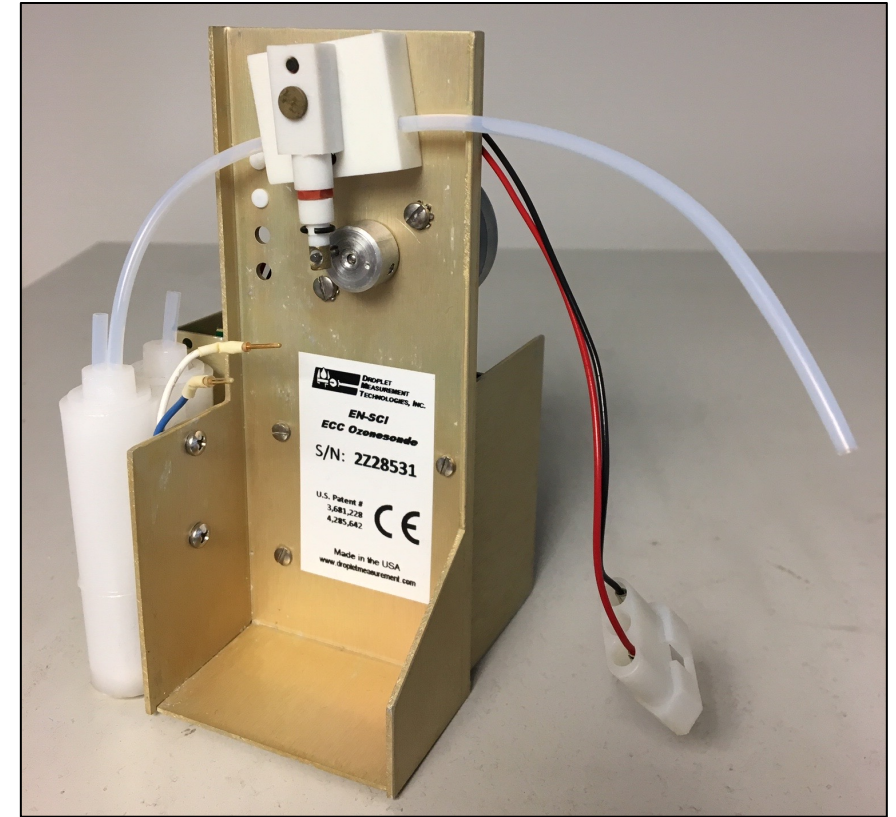
Primer on ozonesonde measurements

1. During balloon flight, ambient air is pumped into cells containing a potassium iodide solution
2. Ozone reacts with solution, causing two electrons to flow in the external circuit
3. Measure the resulting electrical current and convert into ozone partial pressure (P_{O_3}):

$$P_{O_3} = 4.307 \times 10^{-2} \frac{(I_M - I_B) T_P}{\Psi_P \Phi_P \eta_C}$$

Witte et al. (2018; JGR)

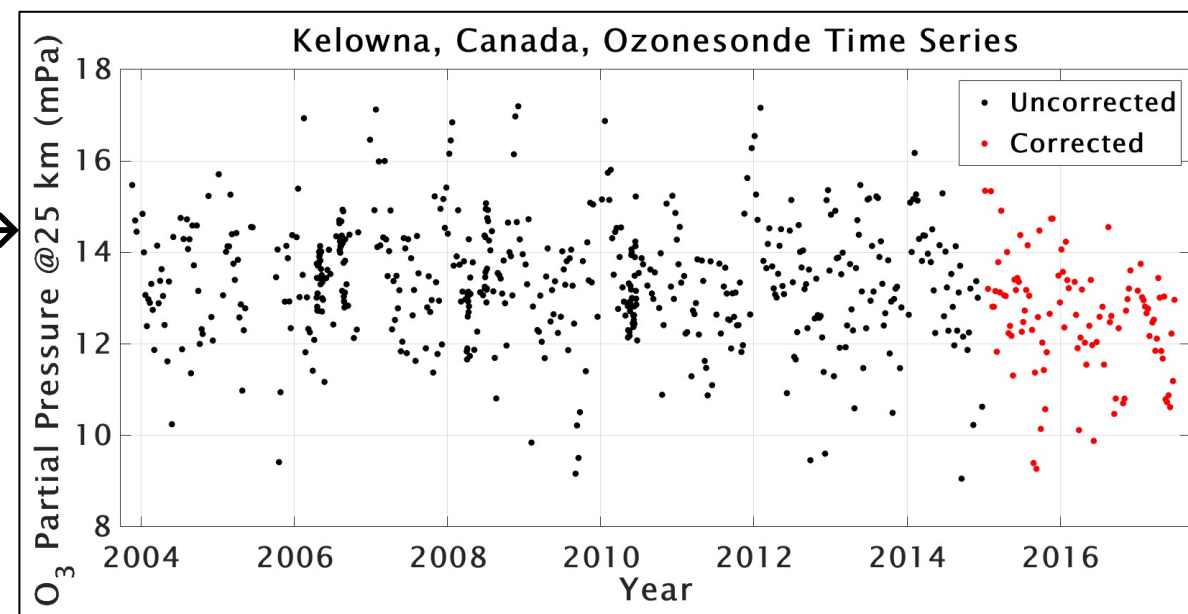
- I_M : cell current, μA (raw data);
- I_B : cell background current, μA ;
- T_P : ozonesonde pump temperature, K;
- Φ_P : pump flow rate, $mL\ s^{-1}$;
- Ψ_P : pump flow efficiency, unitless; and
- η_C : conversion efficiency, which is generally assumed to be 1
- 4.307×10^{-2} , is the half ratio of the ideal gas constant ($8.314\ J\ K^{-1}\ mole^{-1}$) to Faraday's constant ($9.6487 \times 10^4\ C\ mole^{-1}$)



ECC Ozonesonde

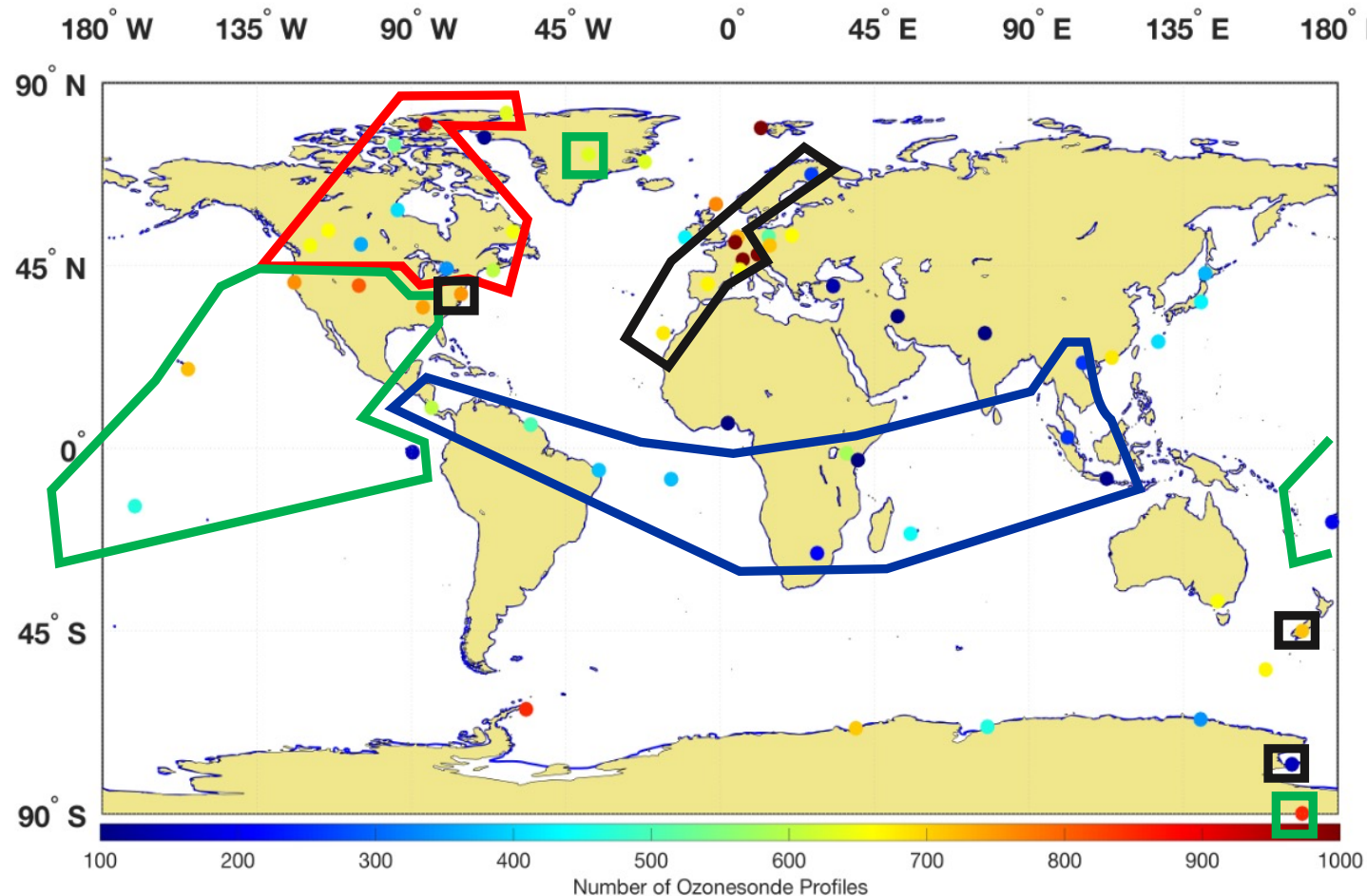
What corrections “homogenize” the data?

- Some stations require very few of these, others require several corrections to homogenize:
- Transfer function for non-standard solution/ECC combination (e.g. 1% KI in EnSci ozonesonde; standard is 1% KI in SPC, 0.5% KI in EnSci). **Example** →
- Pump temperature correction to “true” air sample temperature measurement + moving of pump thermistor position in modern ozonesonde models
- Pump flowrate “moistening effect”
- Background current → constant (no p dependence)
- No total ozone normalization!
- Others: Pump and conversion efficiency, ozone absorption for 2.5mL cathode solution, radiosonde pressure offsets



Kelowna ozone partial pressure time series. Kelowna uses 1% KI solution in the EnSci ozonesonde, which must have a transfer function applied to lower ozone by ~5%

Status of the Global Network (courtesy of R. Van Malderen)



- **Canadian network (10 sites)**
Tarasick et al., AMT, 2016
- **SHADOZ network (10 sites)**
Witte et al., JGR, 2017, 2018,
Thompson et al., JGR, 2017
- **NOAA network (9 sites)**
Sterling et al., AMT, 2018
- **Individual sites (12):** Uccle & De Bilt (*Van Malderen et al. , AMT, 2016*), Wallops Island (*Witte et al., JGR, 2019*), McMurdo, Payerne, OHP, Izaña, Madrid, Sodankylä, Lauder, Hohenpeissenberg, Legionowo
- **> 40 homogenized sites**

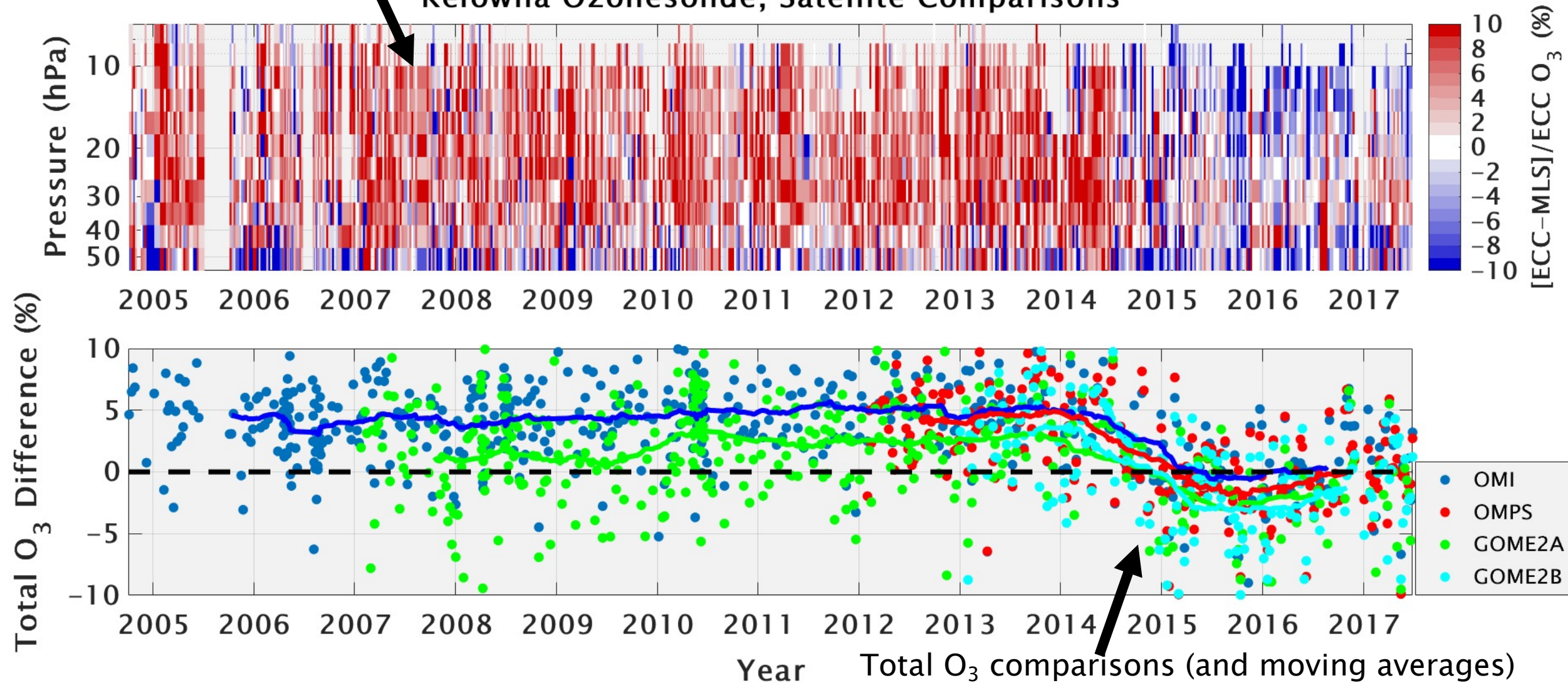
Figure 1-2: Global ECC ozonesonde station locations with the number of ozonesonde profiles from 2005-2019 (Aura satellite era) indicated by the colormap.

Fig. taken from the ASOPUS 2.0 report, courtesy of A. Thompson

Comparisons with Satellite Data: Kelowna

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

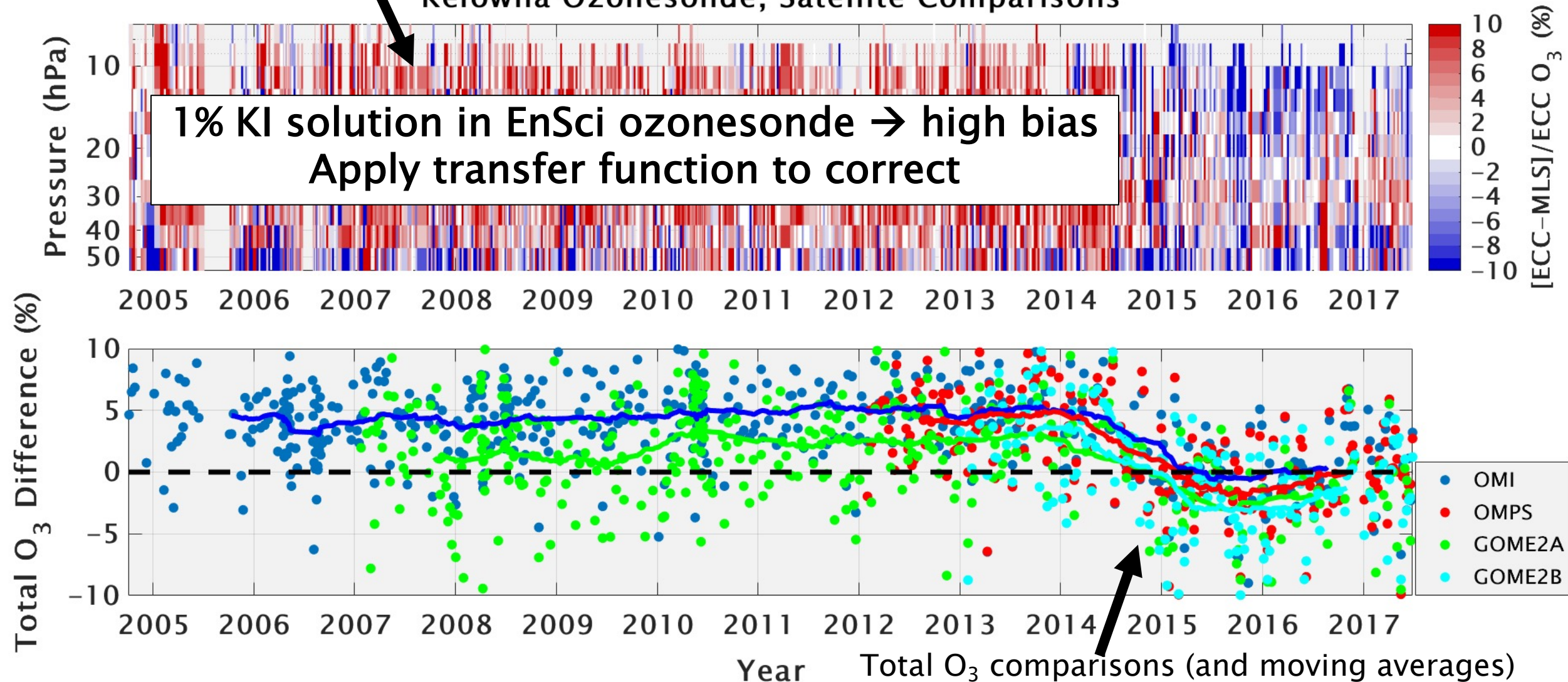
Kelowna Ozonesonde, Satellite Comparisons



Comparisons with Satellite Data: Kelowna

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

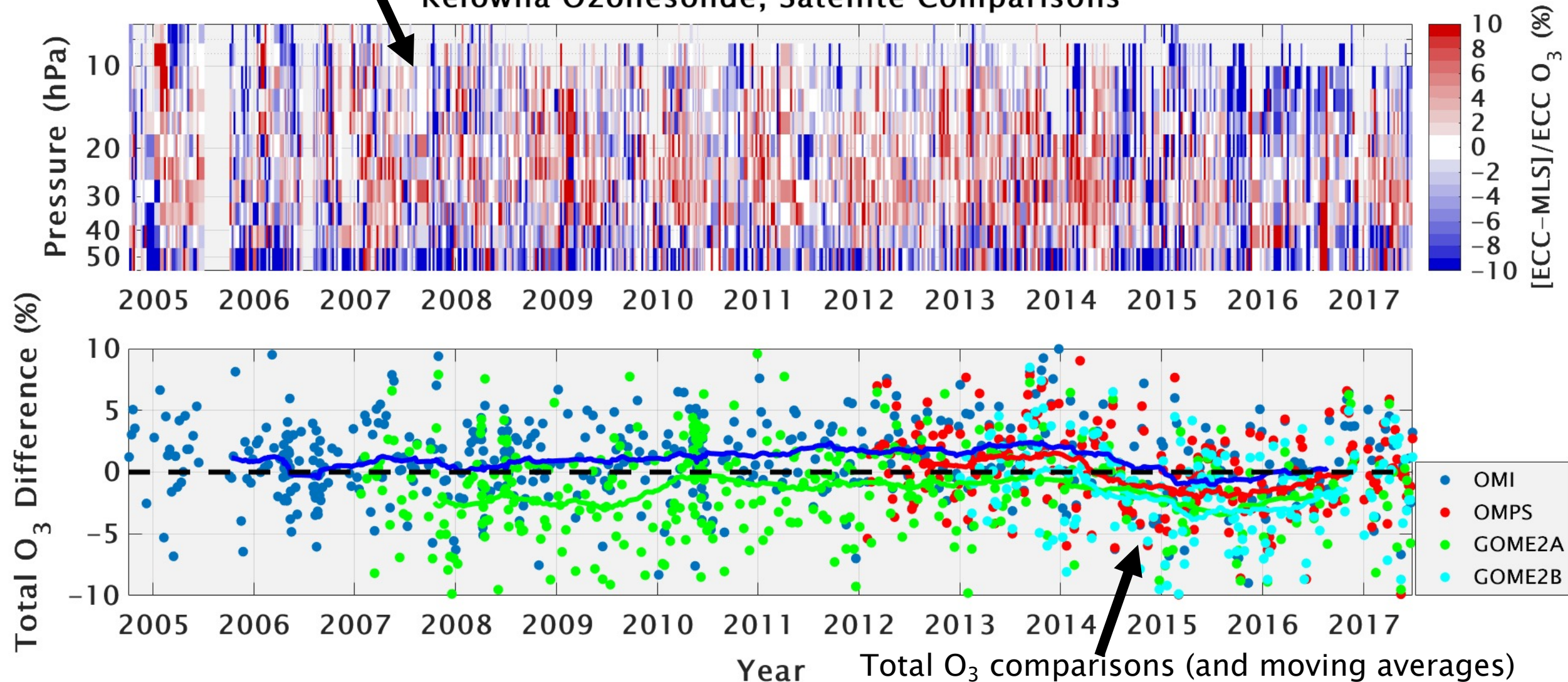
Kelowna Ozonesonde, Satellite Comparisons



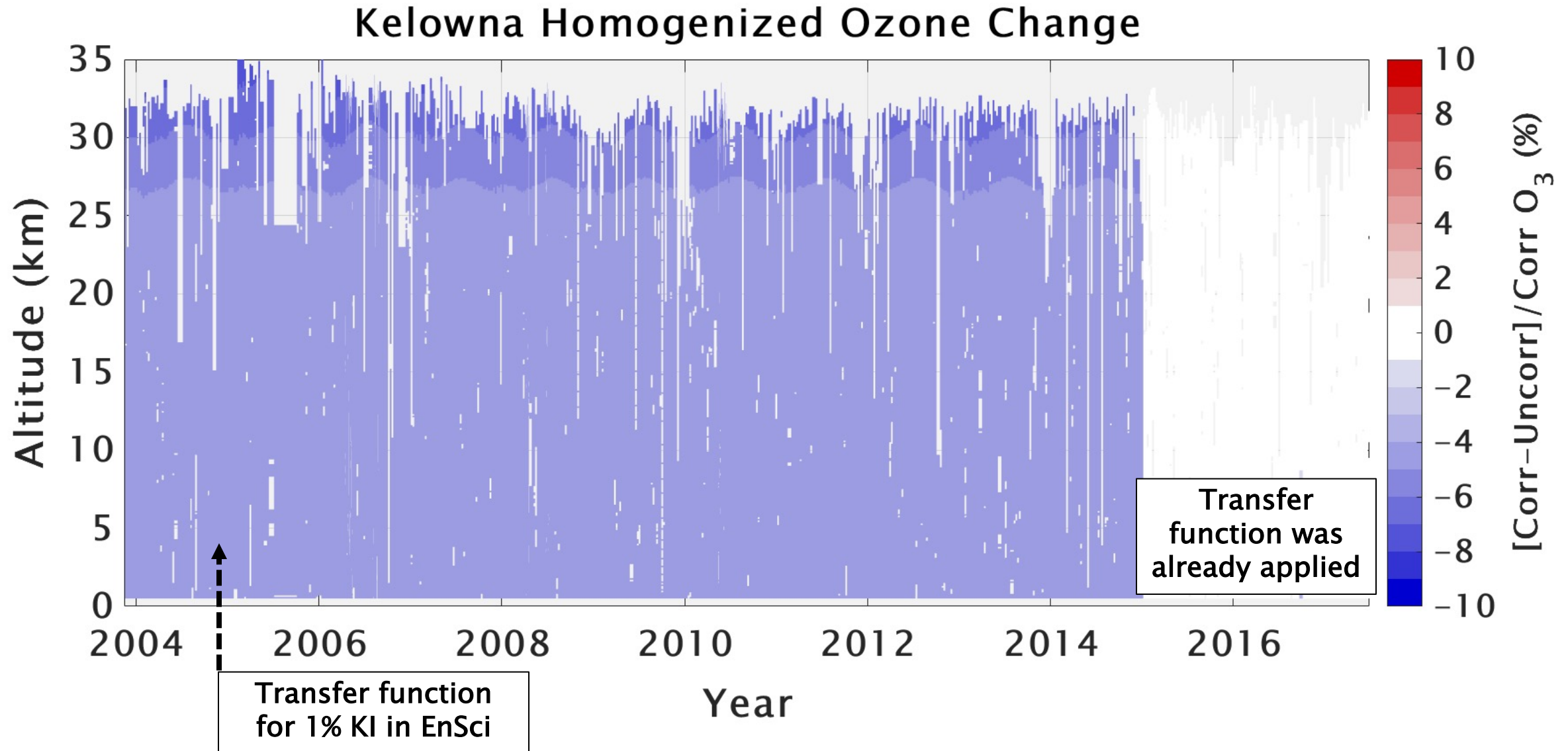
Comparisons with Satellite Data: Kelowna (corrected)

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

Kelowna Ozonesonde, Satellite Comparisons



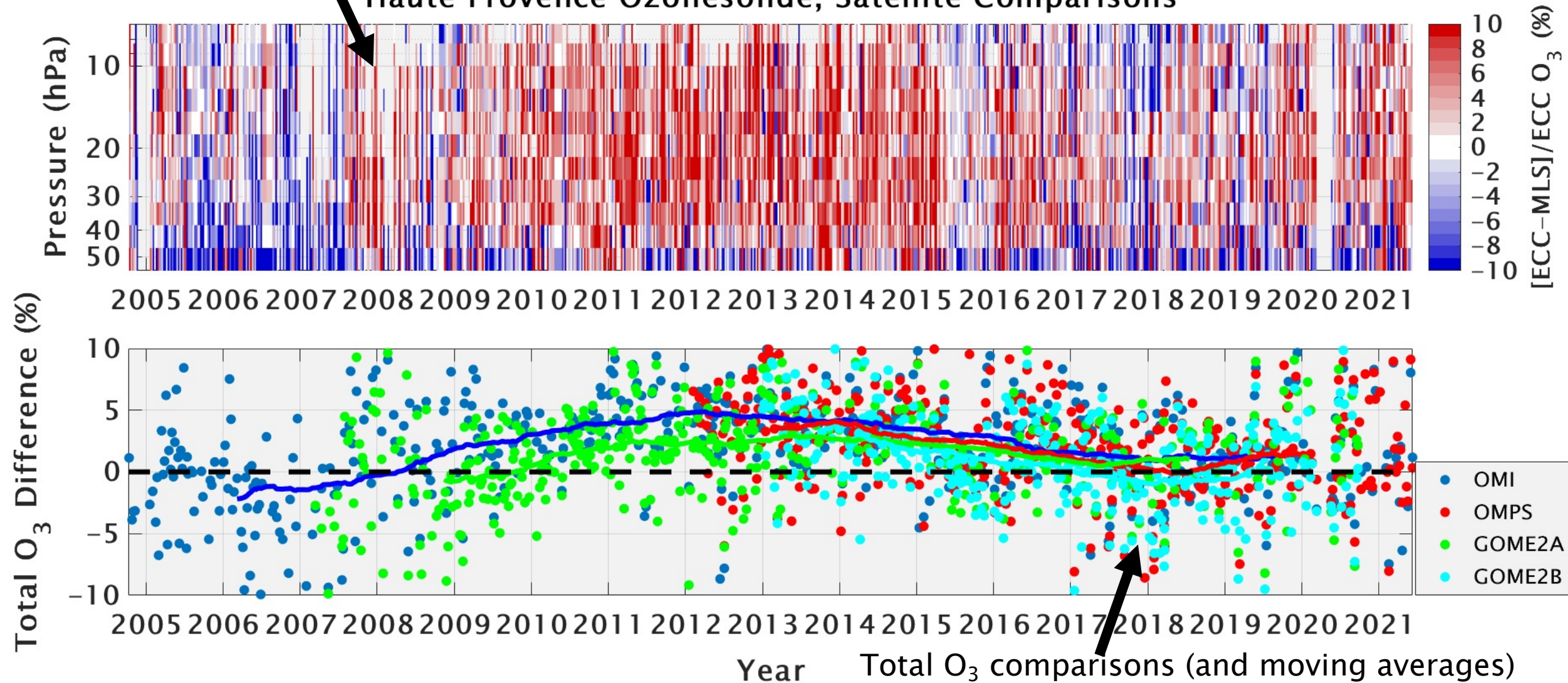
Ozone Change with Homogenization: Kelowna



Comparisons with Satellite Data: OHP

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

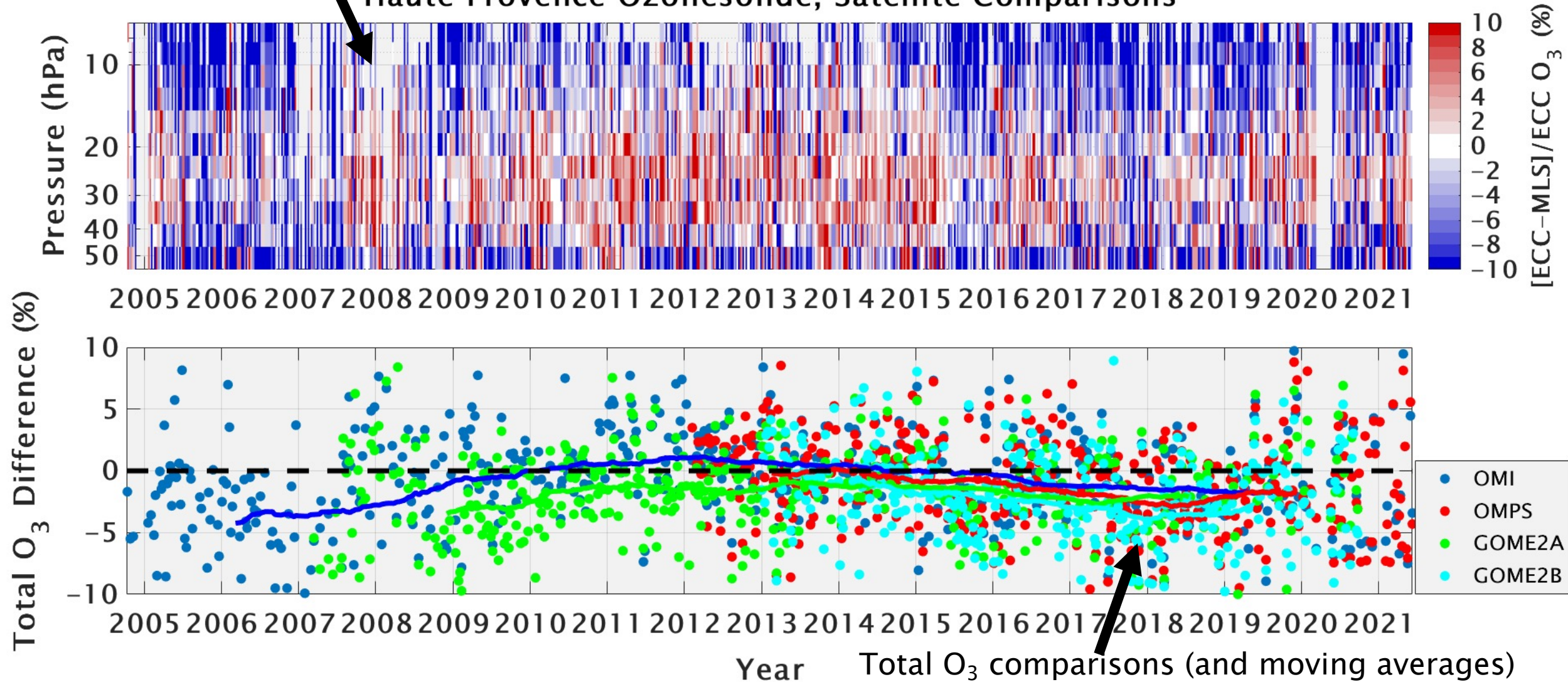
Haute Provence Ozonesonde, Satellite Comparisons



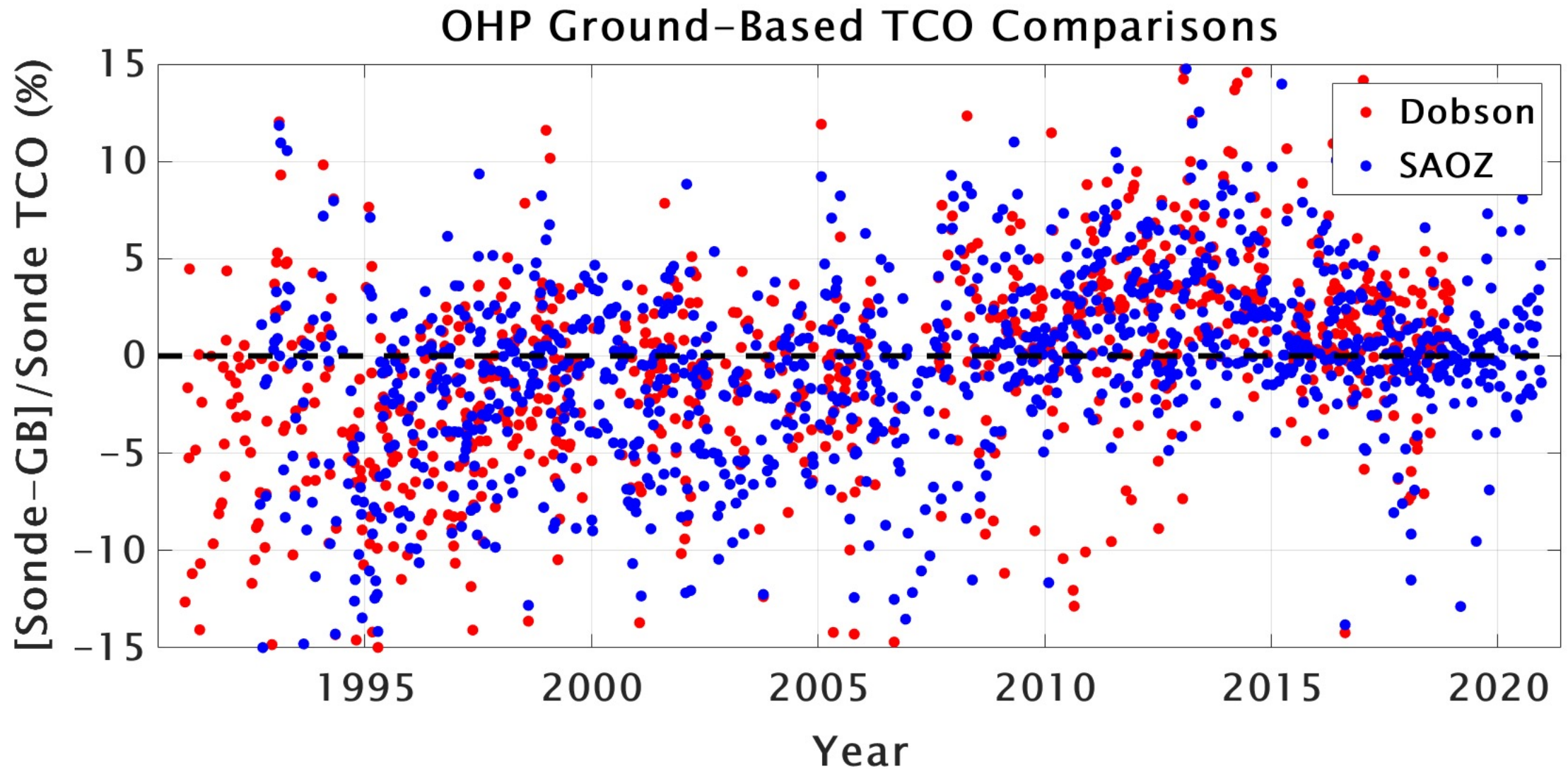
Comparisons with Satellite Data: OHP (corrected)

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

Haute Provence Ozonesonde, Satellite Comparisons

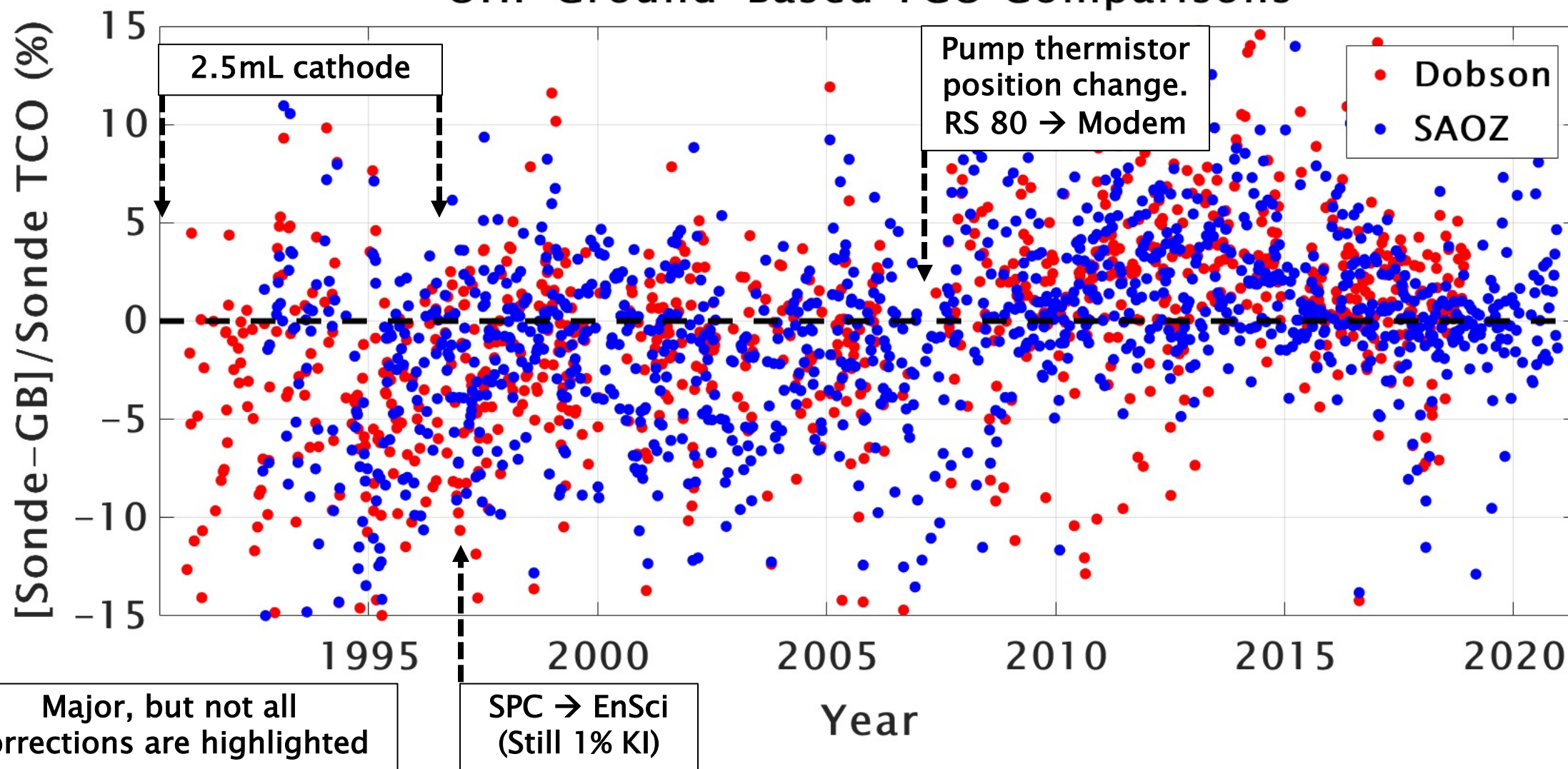


Comparisons with Ground-Based SAOZ, Dobson: OHP

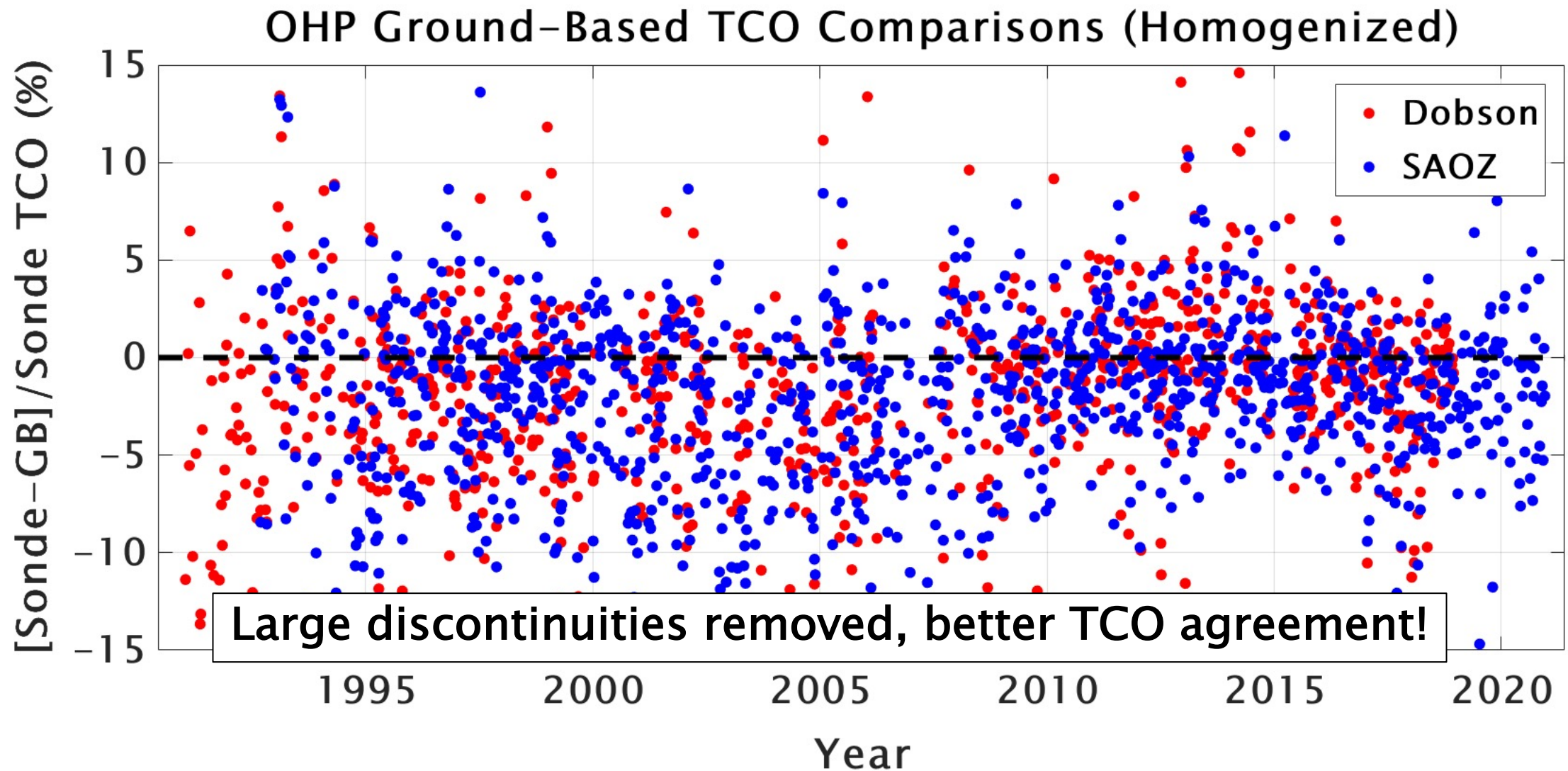


Comparisons with Ground-Based SAOZ, Dobson: OHP

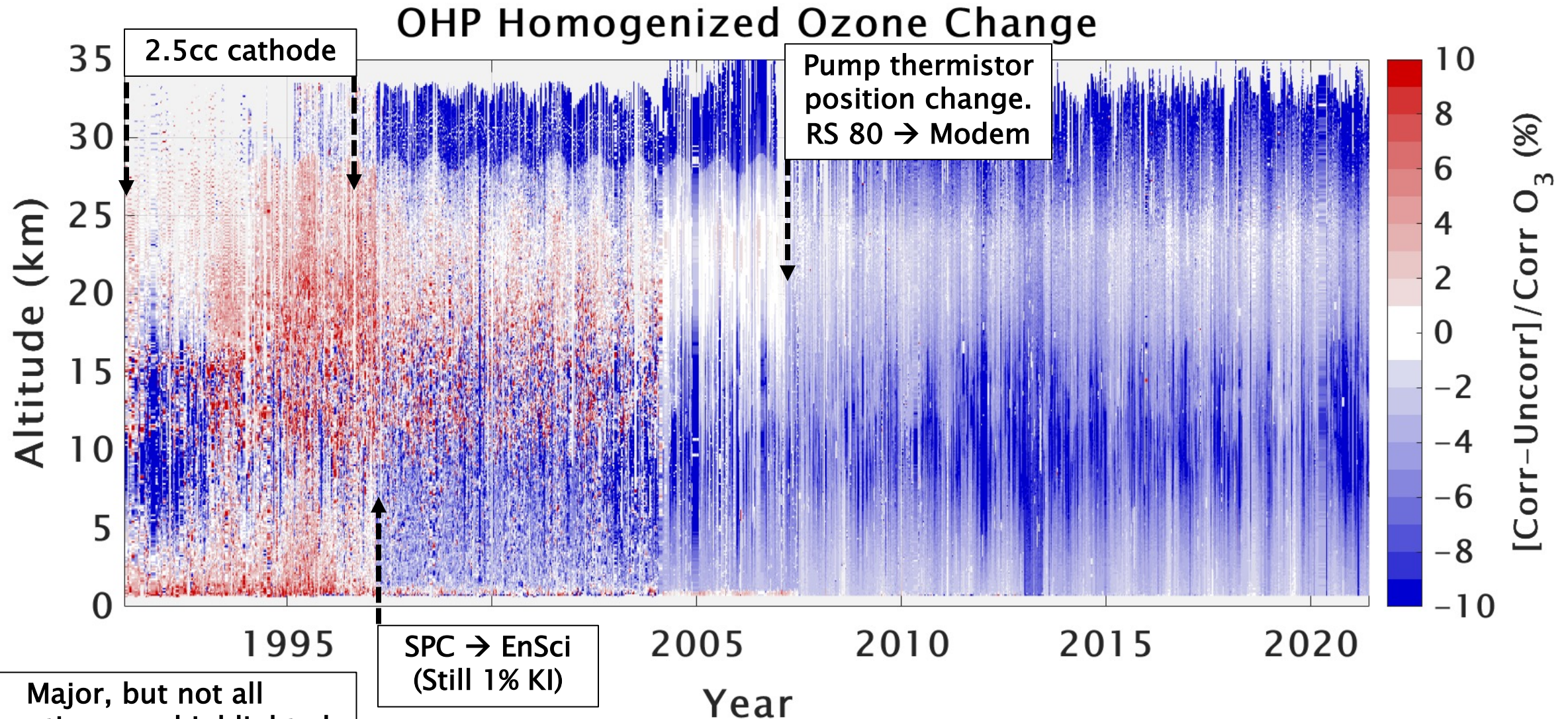
OHP Ground-Based TCO Comparisons



Comparisons with Ground-Based SAOZ, Dobson: OHP

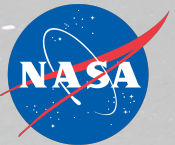


Ozone Change with Homogenization: OHP



Summary

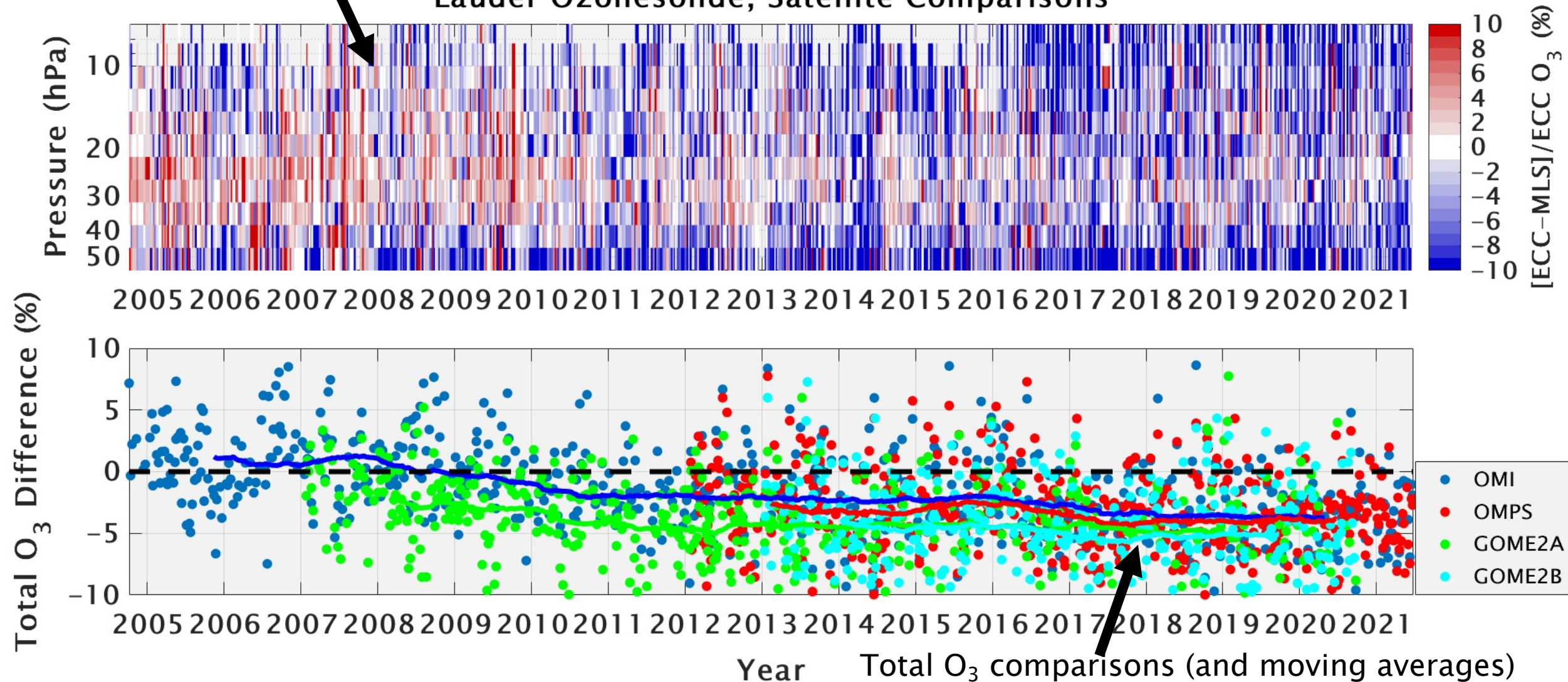
- Over 40 global ozonesonde network stations have homogenized their time series/are currently undergoing evaluation
- No Total Ozone Normalization → The ozonesondes are an independent measurement
- O3S-DQA and ASOPOS data reprocessing recommendations based on decades of laboratory and field tests have been applied → The ozonesondes are referenced to the World Calibration Centre for OzoneSondes (WCCOS) O₃ Photometer in Jülich (FZJ)
- Some issues remain to be resolved at select stations, but overall the O3S-DQA homogenization effort has been a success worth celebrating
- Next Steps: Collaborate to compare homogenized ozonesonde data to other sources (IAGOS, lidar, FTIR, MW, etc.), including tropospheric measurements for TOAR-II



Comparisons with Satellite Data: Lauder

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

Lauder Ozonesonde, Satellite Comparisons



Comparisons with Satellite Data: Lauder (corrected)

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

Lauder Ozonesonde, Satellite Comparisons

