Koninklijk Meteorologisch Instituut

Institut Royal Météorologique

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Quality Assessment and Quality Control (QA/QC) of ozonesonde measurements

Roeland Van Malderen

WMO-GAW Quality Assessment – Scientific Activity Centre for Ozonesondes

Outline

- Measurement principles of ozonesonde
- QA/QC at Uccle
- The ozonesonde network
- QA/QC in the ozonesonde network
  1. World Calibration Centre for Ozonesondes
  2. Assessment of Standard Operating Procedures for Ozonesondes
  3. Homogenization
  4. Continuous Quality Monitoring
- Conclusions

Measurement principle

- launched with weather balloon, coupled with radiosonde
- pump + electrochemical concentration cells
- titration of ozone in a KI sensing solution:
  $2\ KI + O_3 + H_2O \rightarrow I_2 + O_2 + 2\ KOH$
- basic formula:

pump temperature

current

$$P_{O3} = 0.043085 * \frac{T_P}{(\eta_P * \eta_A * \eta_C * \Phi_{P0})} * (I_M - I_B)$$

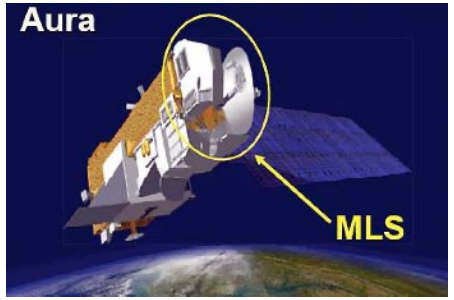
pump efficiency

pump flow rate

pre-launch characterization in lab

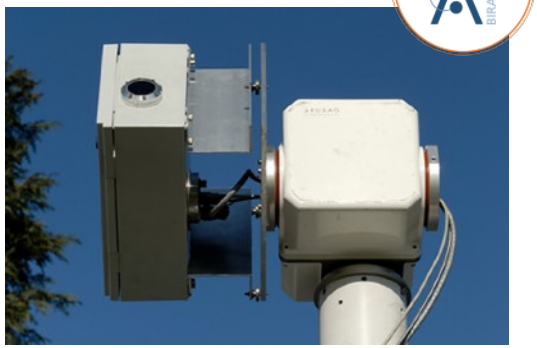
Measuring ozone profiles

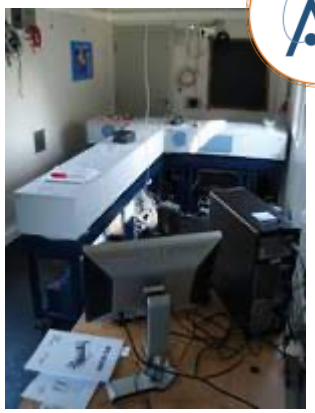
From satellites



In-situ

Ground-based





advantages ozonesondes:

- high vertical resolution
- absolute measuring device → validation source for other instruments!

QA/QC at Uccle

- drawback ozonesondes: every launch = different instrument
- at Uccle, since 1969, almost 7500 measurements!
- therefore: pre-launch conditioning/cleaning, testing, characterization and calibration following a rigid procedure

pump flow rate

background current

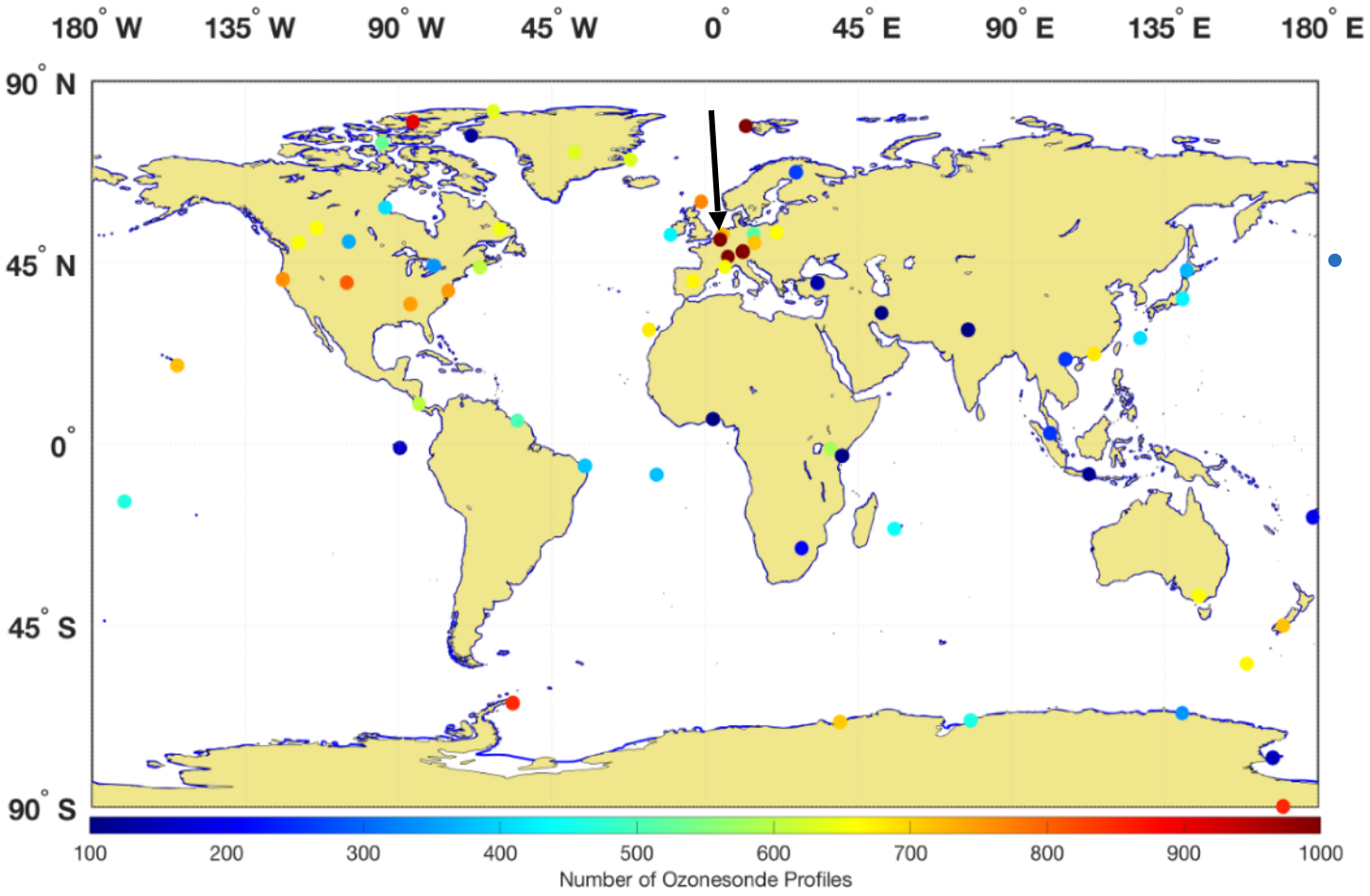
QA/QC at Uccle

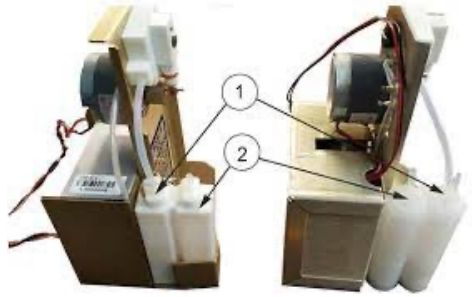
- QA/QC at Uccle

✓ Comparison with reference ozone value from ozone calibrator/generator in lab, before launch

✓ total ozone column from spectrophotometer at Uccle, after launch

The ozonesonde network





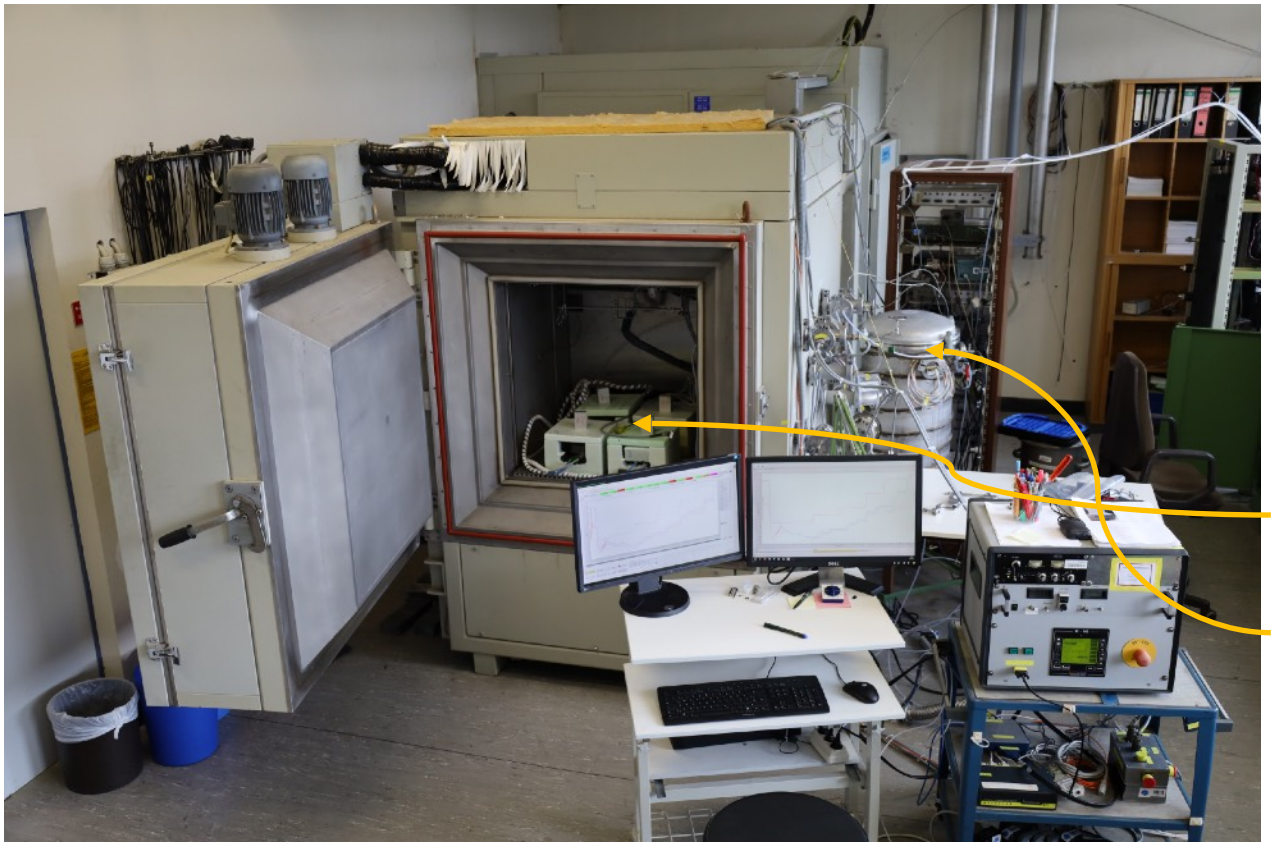
± 60 active sites

- ✓ 2 different sonde manufacturers (5% difference)
- ✓ 4 different sensing solution types
- ✓ differences in operating procedures
- ✓ differences in supporting instruments (ozone generators, spectrophotometers, etc.)

QA/QC for this “zoo”?

QA/QC for the ozonesonde network

1. WMO World Calibration Centre for Ozonesondes (WCCOS)



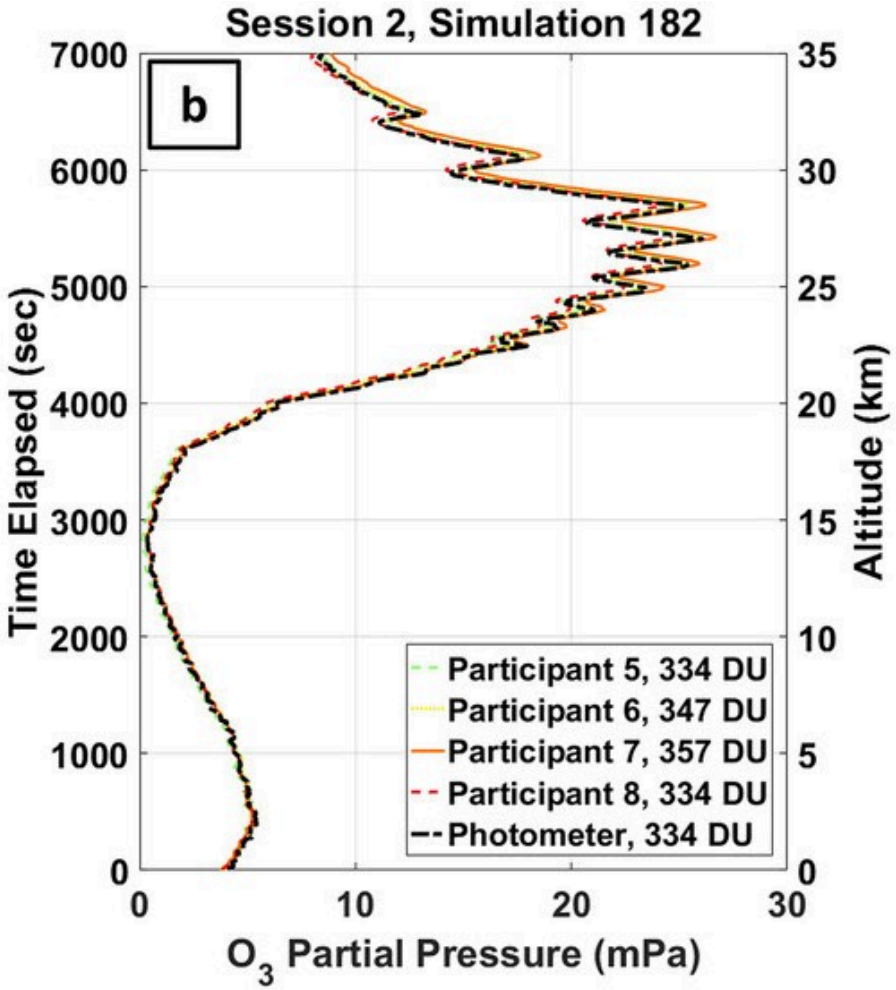
Simulation pressure chamber at Jülich (Germany), in collaboration with RMI

- ✓ enables control of pressure, temperature and ozone concentration
- ✓ simulate quasi-realistic flight conditions of ozone soundings from surface to 35 km
- ✓ can accommodate 4 ozonesondes simultaneously
- ✓ dual beam UV-photometer serves as a reference instrument (uncertainty better than 3-5 %)
- ✓ regularly Jülich OzoneSonde Intercomparison Experiments (JOSIE), since 1996

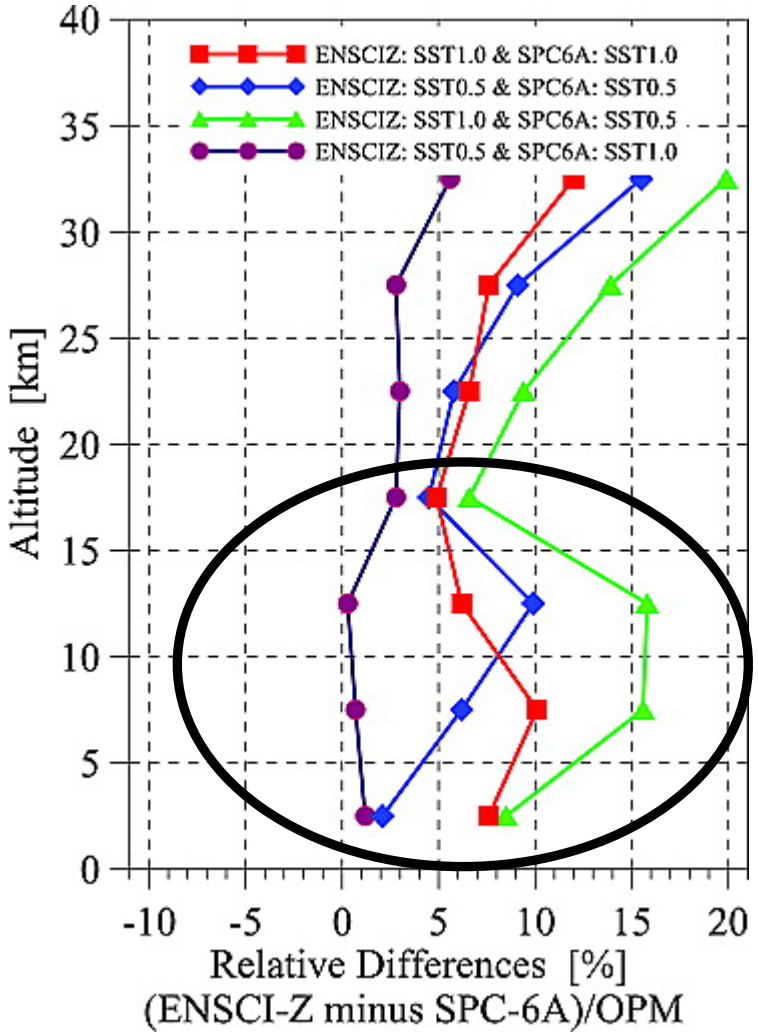
QA/QC for the ozonesonde network

1. WMO World Calibration Centre for Ozonesondes (WCCOS)

JOSIE 2017



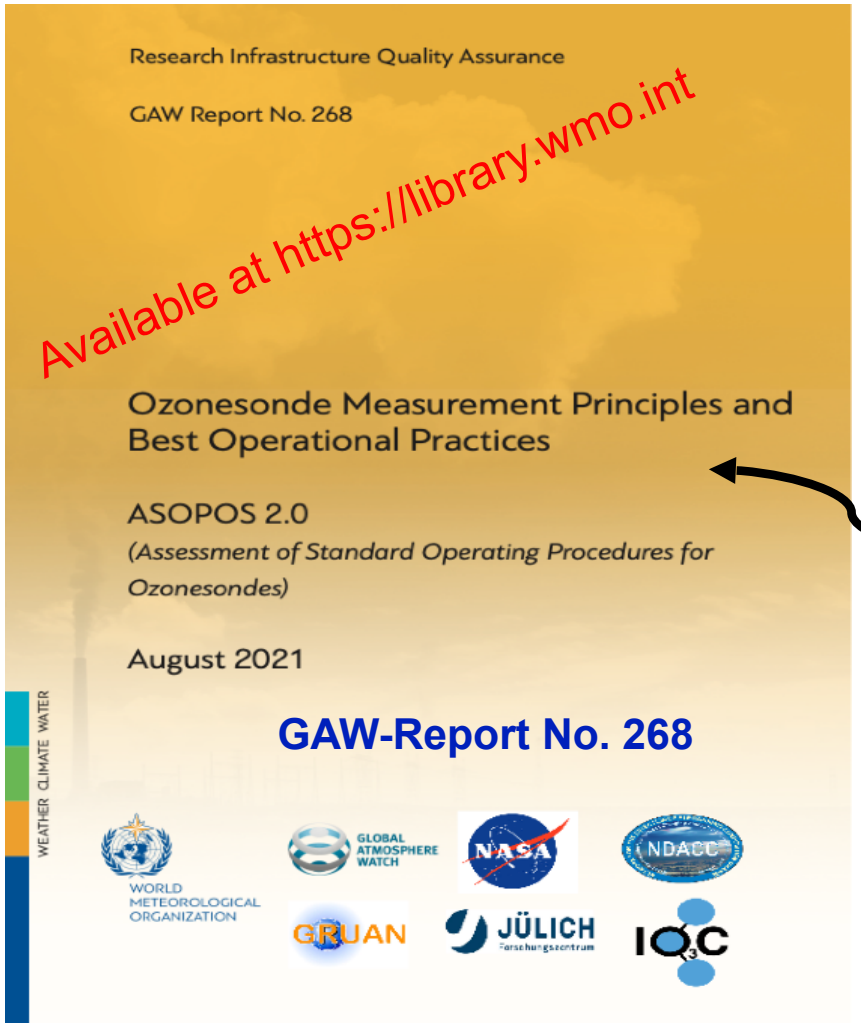
JOSIE 2000



- ✓ ENSCI SST0.5 and SPC SST1.0 are within 1-5%: two standards
- ✓ ENSCI **5-10% >** SPC
- ✓ SST1.0 **5% >** SST0.5
- ✓ troposphere: impact of operating procedures

QA/QC for the ozonesonde network

2. Assessment of Standard Operating Procedures for Ozonesondes (ASOPOS) Panel



= panel of ozonesonde experts that …

- ✓ reviews current understanding of instrument
- ✓ makes recommendations for standard operating procedures (preparation, hardware, processing, (meta)data archiving, etc.)

➔ WMO report published in 2021


ASOPOS Panel at Brussels, Belgium (Sept. 2019)

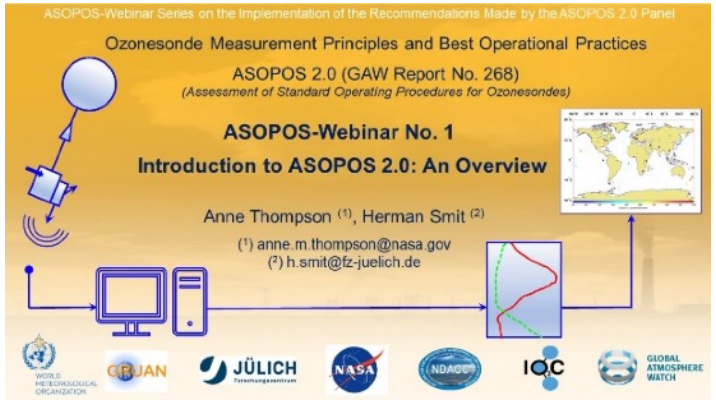
QA/QC for the ozonesonde network

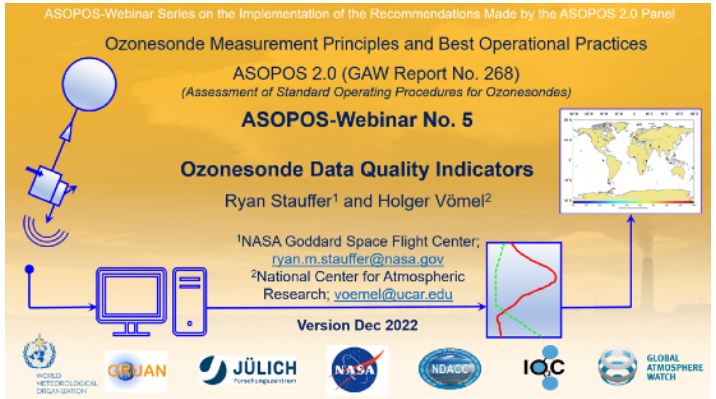
2. Assessment of Standard Operating Procedures for Ozonesondes (ASOPOS) Panel

WMO/GAW Report No. 268 Chapters have been "translated" into 6 Online Webinars:

1. Introduction to ASOPOS 2.0: An Overview *(A. Thompson & H. Smit)*
2. Hardware *(H. Smit & R. Van Malderen)*
3. Standard Operating Procedures *(R. Van Malderen, P. von der Gathen, G. Morris, B. Johnson)*
4. Data Processing *(H. Smit & D. Tarasick)*
5. Data Quality Indicators (DQI) *(R. Stauffer & H. Vömel)*
6. Meta Data and Software *(R. Stauffer & R. Van Malderen)*

+ regional meetups for interactions with station PIs





➔ implementation in the network for consistency and traceability

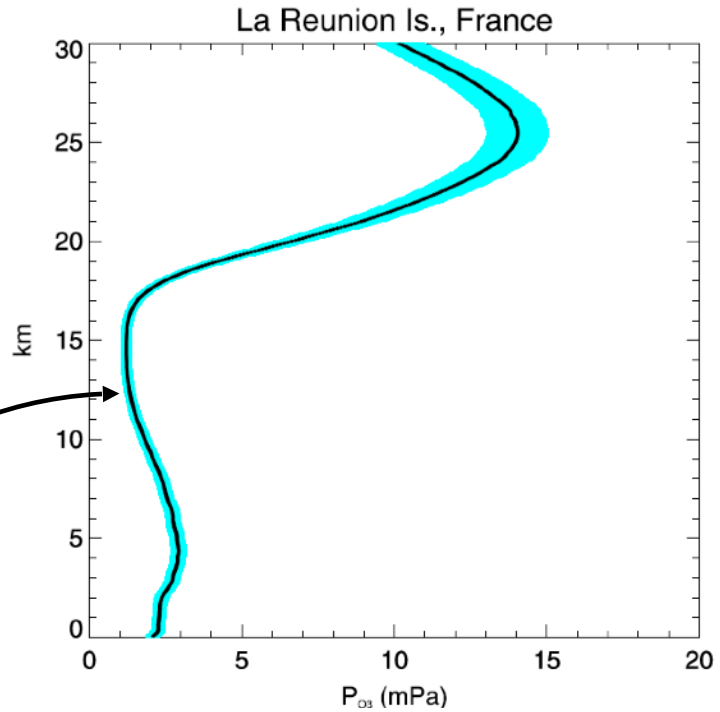
QA/QC for the ozonesonde network

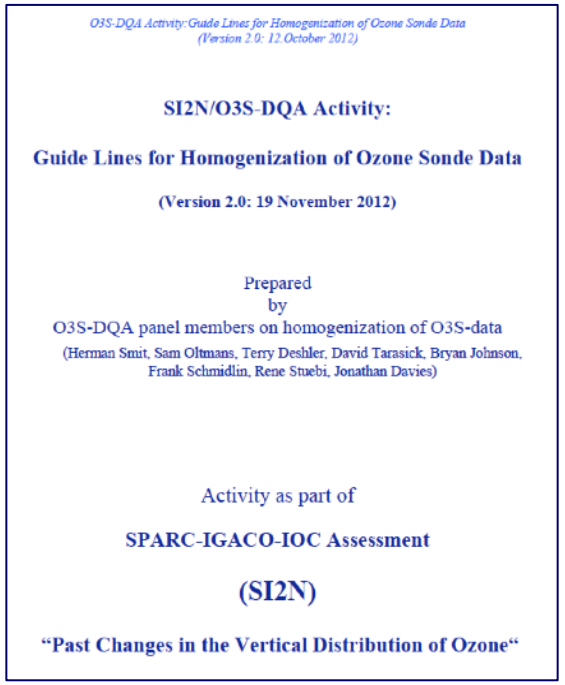
3. O3S-DQA on homogenization

Principles:

- ✓ correcting for (**biases** due to) changes in instrument type, sensing solution, post-processing, pre-flight preparation, etc.
- ✓ estimation of the uncertainty for every ozone partial pressure measurement
- ✓ provision + storage of (additional) **raw data**, needed for future reprocessing

ULTIMATE GOAL: reduce uncertainty from 10-20% to 5-10%




O3S-DQA Activity: Guide Lines for Homogenization of Ozone Sonde Data
(Version 2.0: 12 October 2012)

SI2N/O3S-DQA Activity:

Guide Lines for Homogenization of Ozone Sonde Data

(Version 2.0: 19 November 2012)

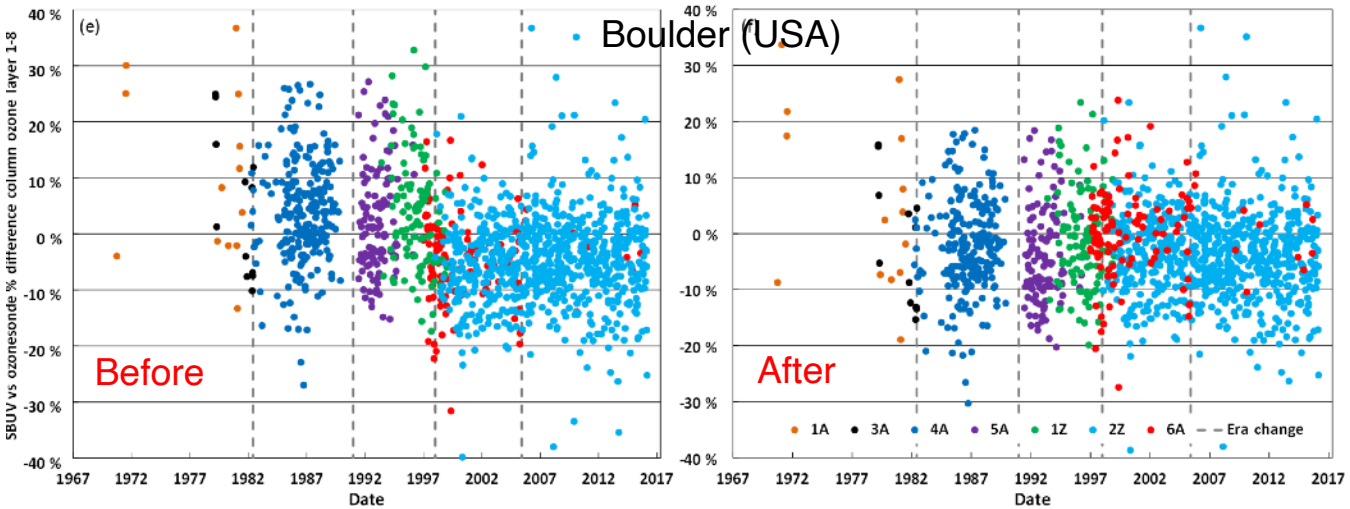
Prepared
by
O3S-DQA panel members on homogenization of O3S-data
(Herman Smit, Sam Oltmans, Terry Deshler, David Tarasick, Bryan Johnson, Frank Schmidlin, Rene Stuebi, Jonathan Davies)

Activity as part of

SPARC-IGACO-IOC Assessment

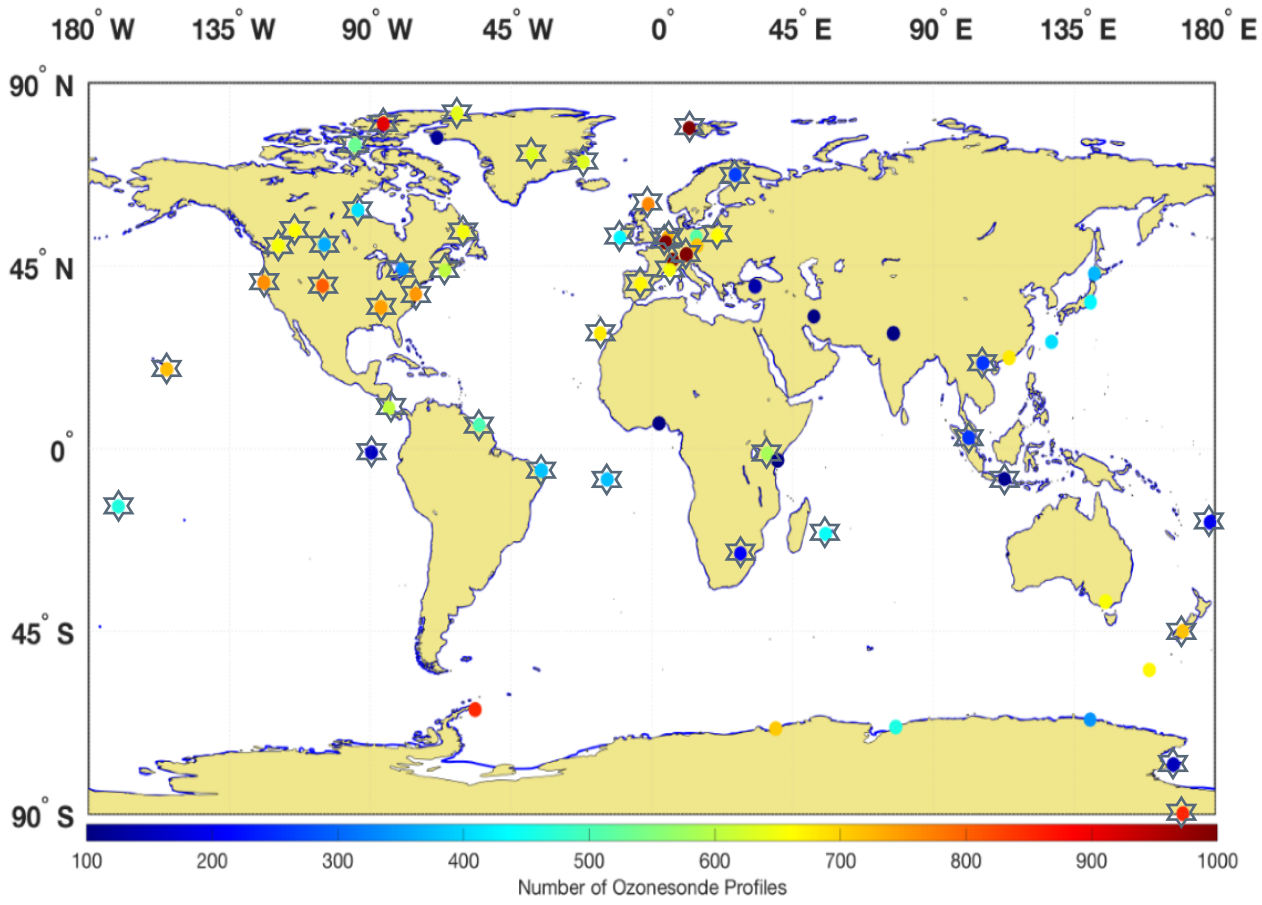
(SI2N)

"Past Changes in the Vertical Distribution of Ozone"



QA/QC for the ozonesonde network

3. O3S-DQA on homogenization

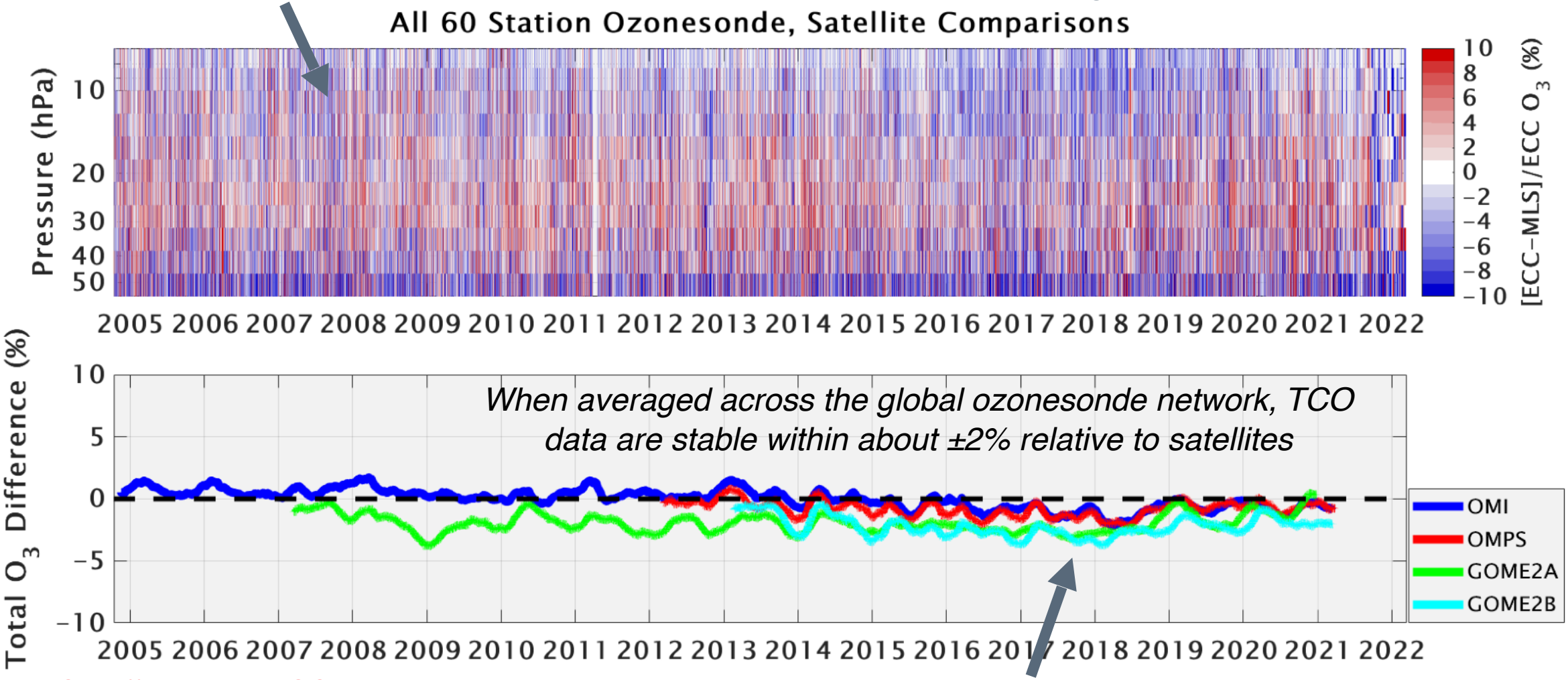


- ✓ 45 from around 60 “active” sites have been homogenized (stars), around 10 of these by RMI (code available)
- ✓ remaining: Japanese, Asian, Australian, some EU and Antarctic sites.
- ✓ Publications:
  - Tarasick et al., AMT, 2016
  - Van Malderen et al., AMT, 2016
  - Witte et al., JGR 2017, 2018, 2019
  - Thompson et al., JGR, 2017
  - Deshler et al., AMT, 2017
  - Sterling et al., AMT, 2018
  - Ancellet et al., AMT, 2022
  - …

QA/QC for the ozonesonde network

4. Continuous Quality Monitoring

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

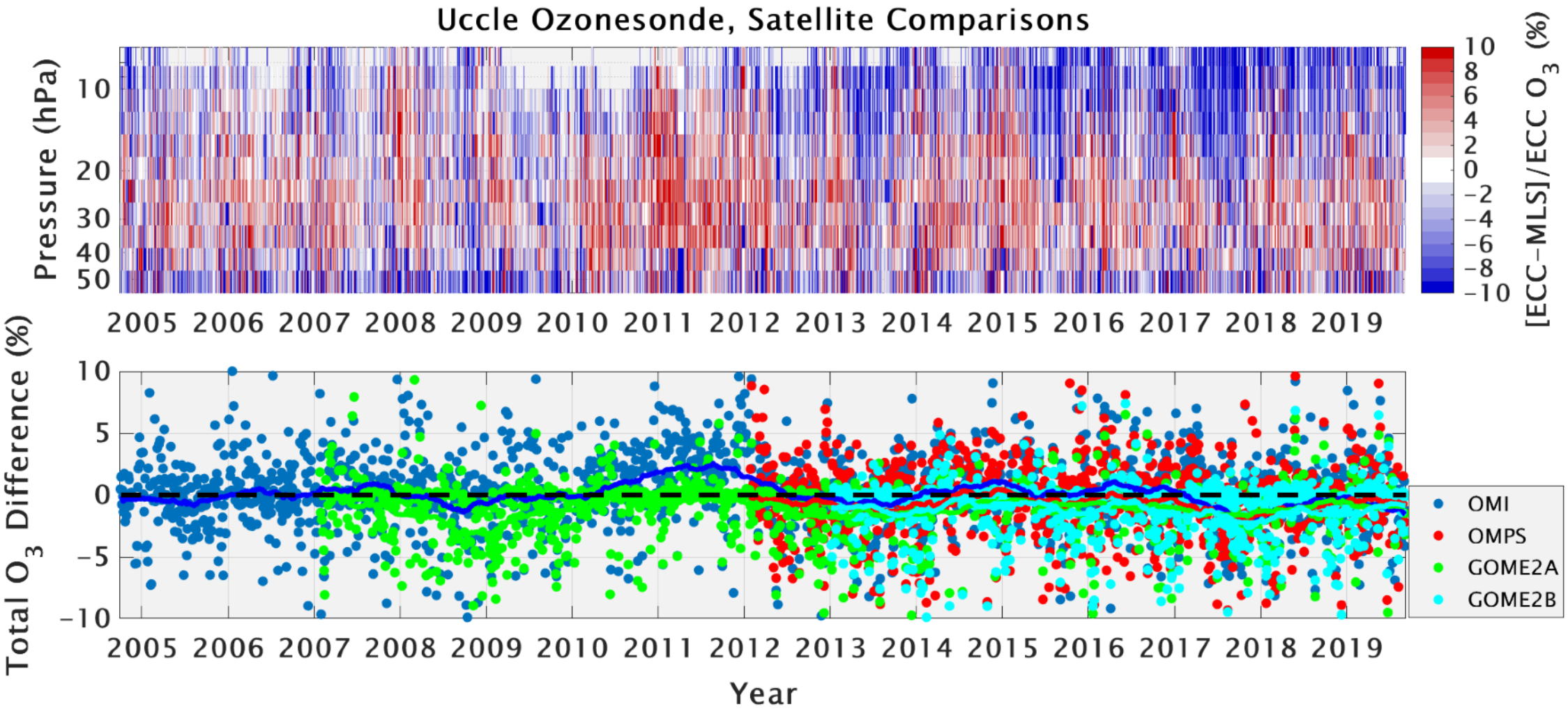


Stauffer et al., ESS, 2022

Total O_3 comparisons (500 pt. moving averages)

QA/QC for the ozonesonde network

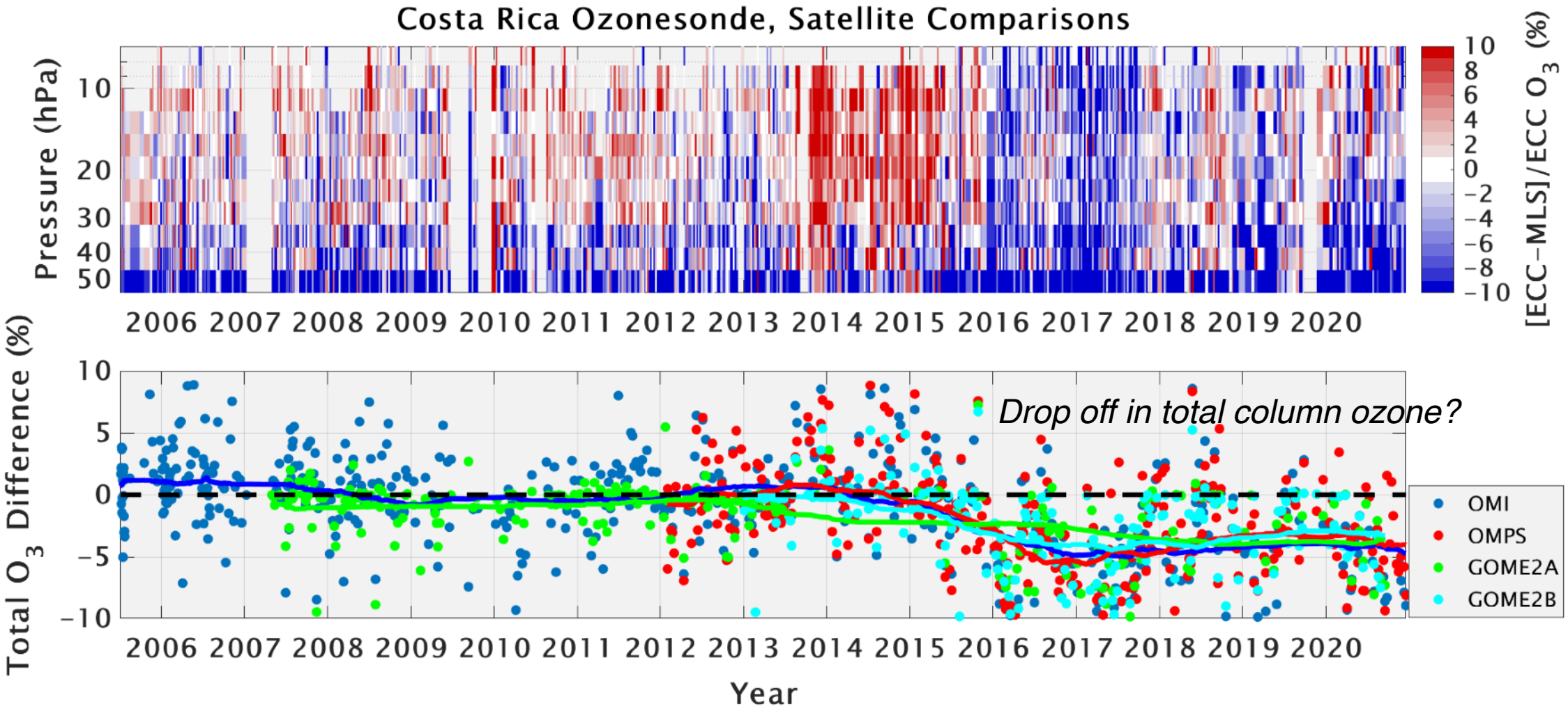
4. Continuous Quality Monitoring



https://tropo.gsfc.nasa.gov/shadoz/SHADOZ_PubsList.html

QA/QC for the ozonesonde network

4. Continuous Quality Monitoring



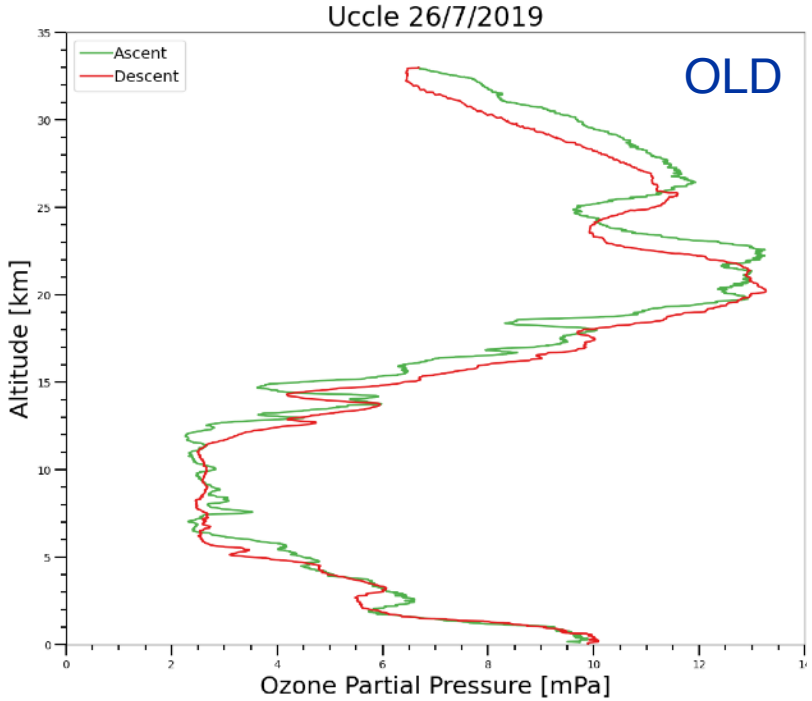
https://tropo.gsfc.nasa.gov/shadoz/SHADOZ_PubsList.html

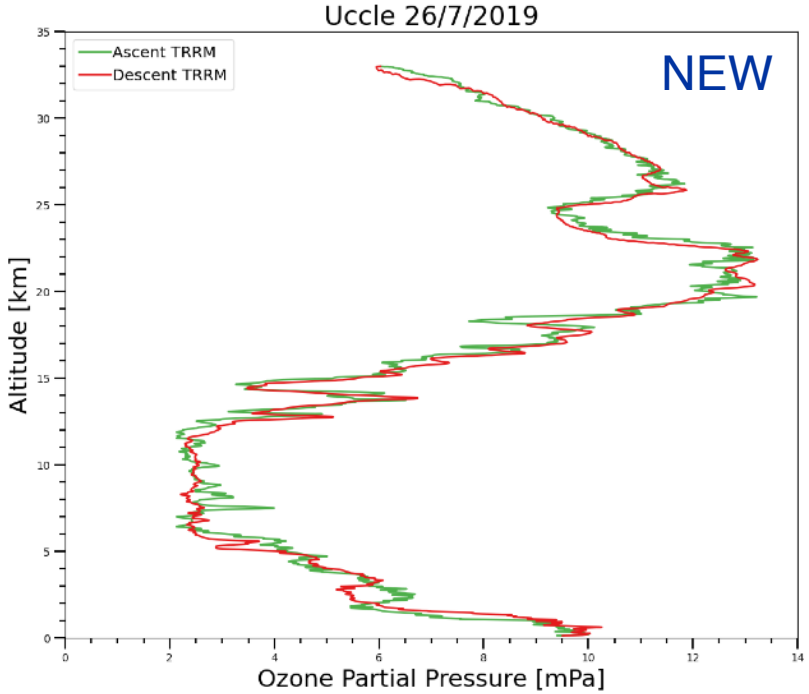
QA/QC: conclusions

- ✓ QA/QC of the global ozonesonde network relies on knowledge and understanding of the instrument, gathered in the **simulation chamber**, with the presence of a **reference** ozone photometer
- ✓ WMO/GAW **Report** by panel of ozonesonde **experts** (ASOPOS), with recommendations on operating procedures, data processing, data quality indicators, (meta)data archiving, etc.
  ➔ traceability to reference instrument
- ✓ **Implementation** of these recommendations in the global network by means of webinars, interactive regional meetups with station PIs, coaching by ASOPOS members, etc.
- ✓ Implementation of recommendations on data processing by **homogenization** activity: re-processing of historical data records
- ✓ Continuous **monitoring** of global **data quality** by comparison with satellite/ground-based measurements of ozone

QA/QC: outlook

- ✓ new data processing, based on all the previous JOSIE data (resolving two time constants in the ozonesonde signal)
- ✓ new small JOSIE intercomparison in fall 2023
- ✓ new data format (HDF), compliant with enhanced (meta)data archiving
- ✓ near-real time data delivery and quality monitoring tool





THANK YOU

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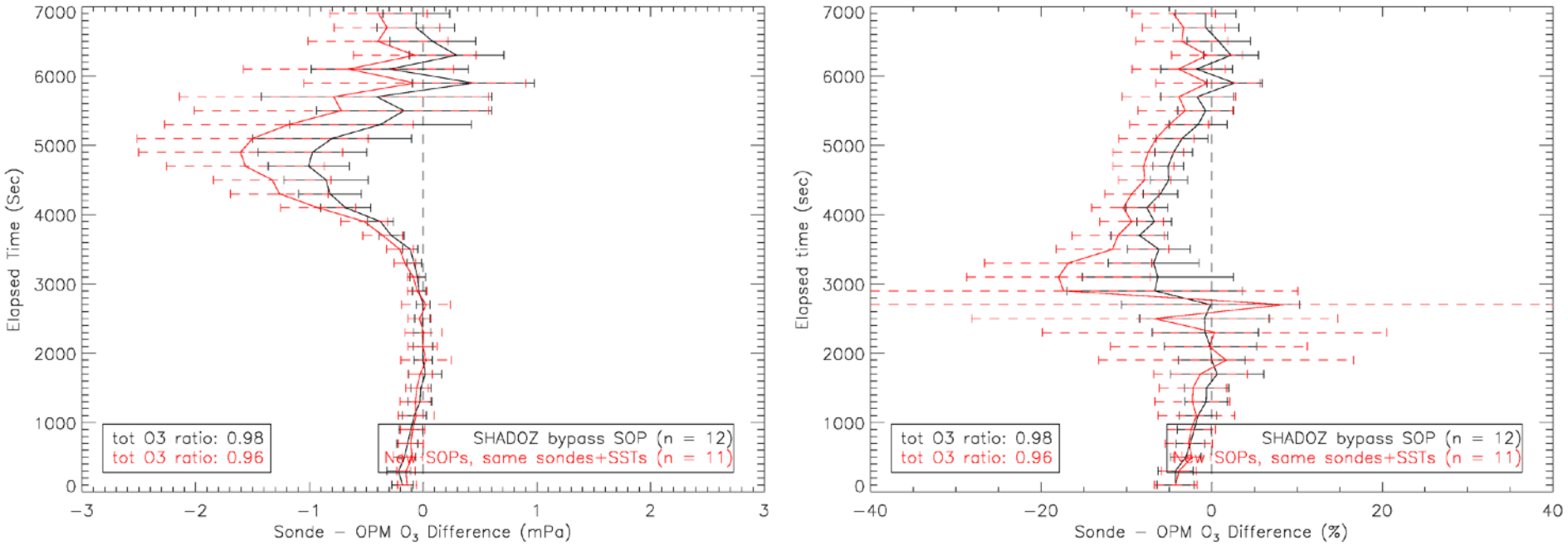
QA/QC for the ozonesonde network

1. WMO World Calibration Centre for Ozonesondes (WCCOS)

JOSIE 2017



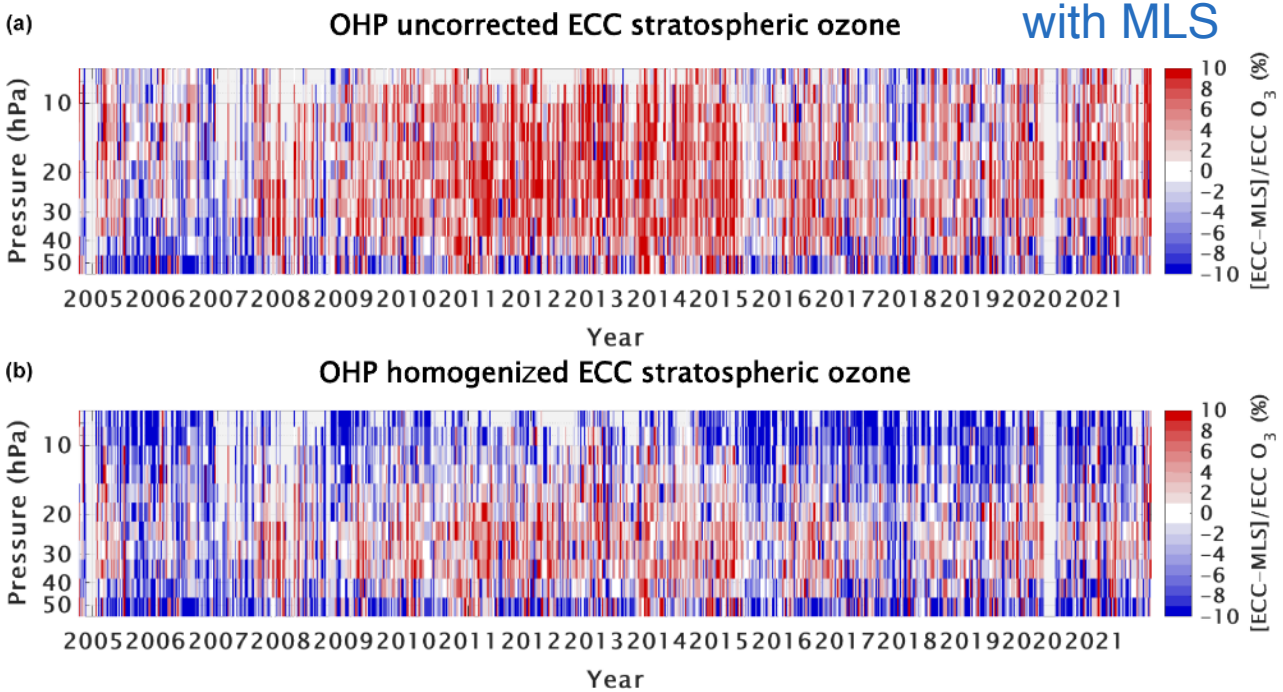
➔ only difference: preparation procedures!

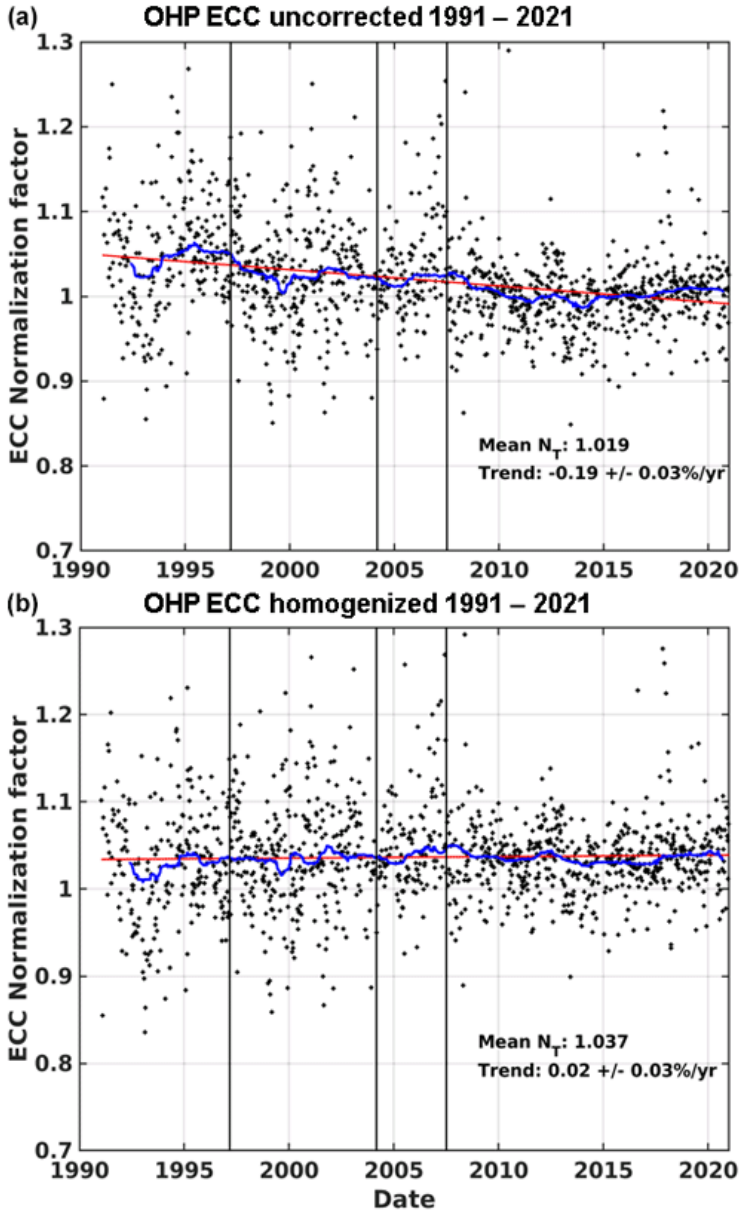
QA/QC for the ozonesonde network

3. O3S-DQA on homogenization

Observatoire Haute Provence

Profile comparison with MLS





Total Column Ozone comparison spectro-meter

- ✓ Homogenization improves comparison with MLS and decreases trend/variability in total ozone normalization factors!
- ✓ But larger negative bias of ECC TCO compared to spectrophotometer TCO.

Ancellet et al., AMT, 2022

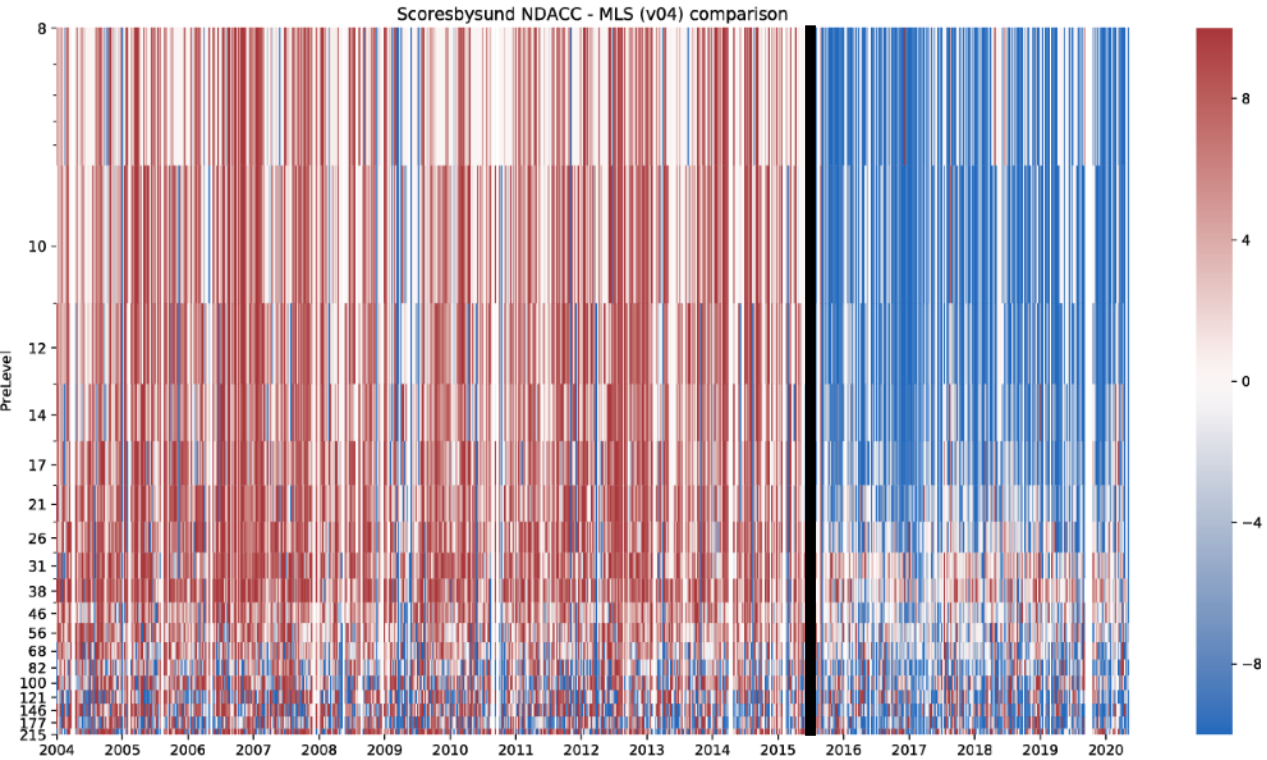
QA/QC for the ozonesonde network

3. O3S-DQA on homogenization

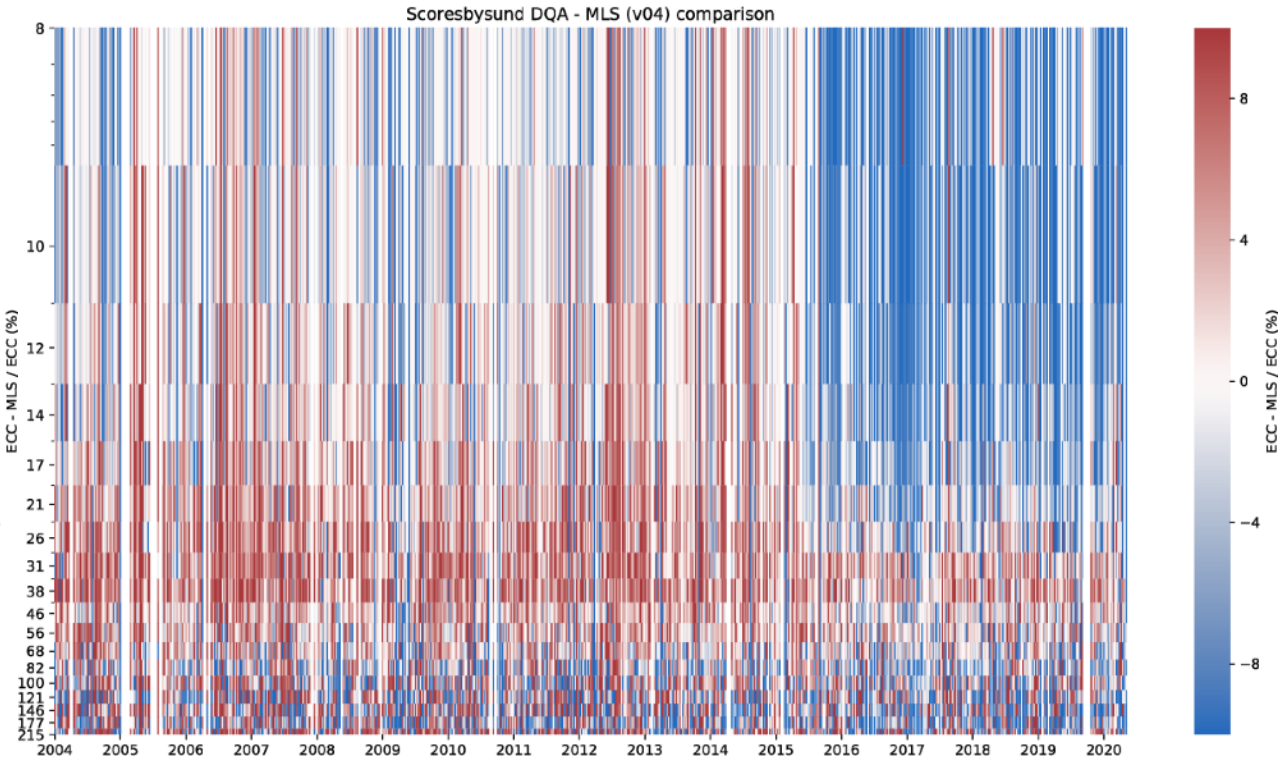
Scoresbysund (Greenland)

Comparison with MLS

Uncorrected



Corrected



start of application of transfer function to network standard (En-Sci 1.0 → En-Sci 0.5)

QA/QC for the ozonesonde network

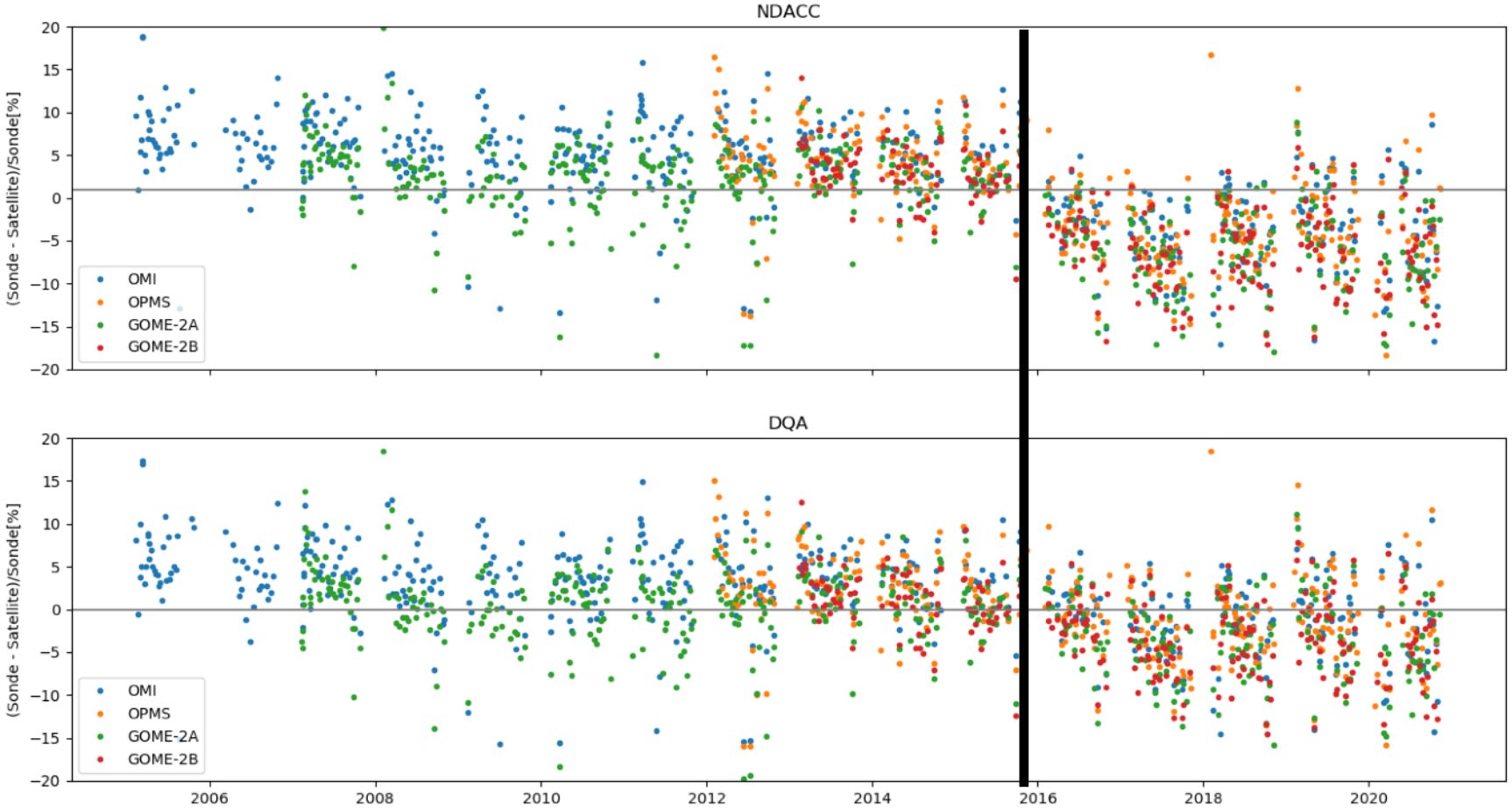
3. O3S-DQA on homogenization

Scoresbysund (Greenland)

Total Column Ozone comparison with OMI, OMPS, GOME-2 (satellites)

Uncorrected

Corrected



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QA/QC for the ozonesonde network

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

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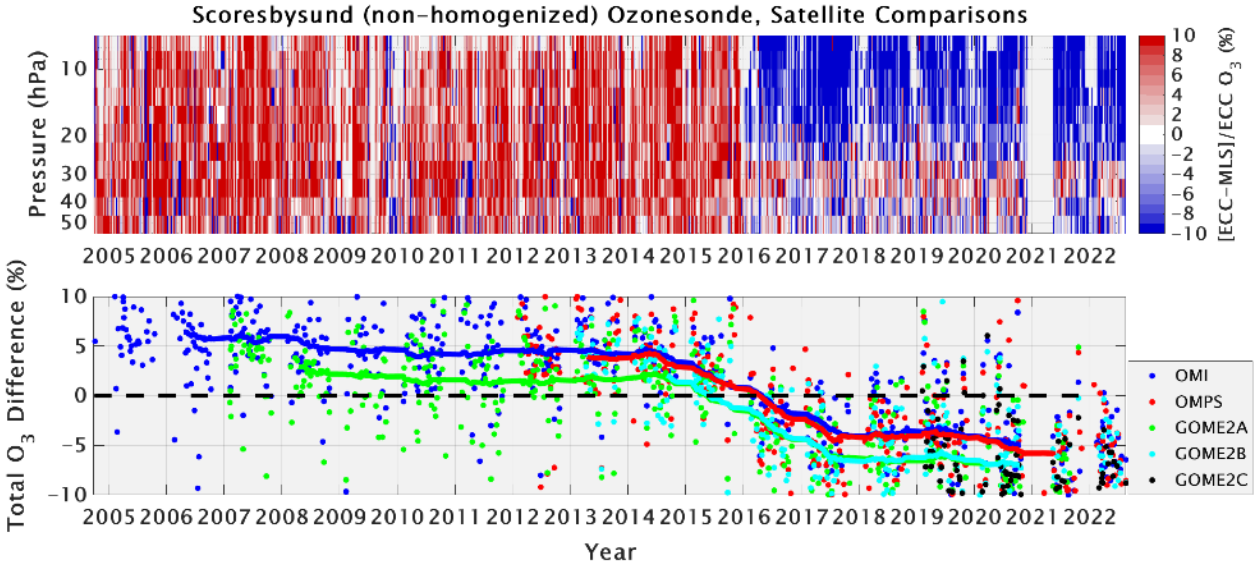

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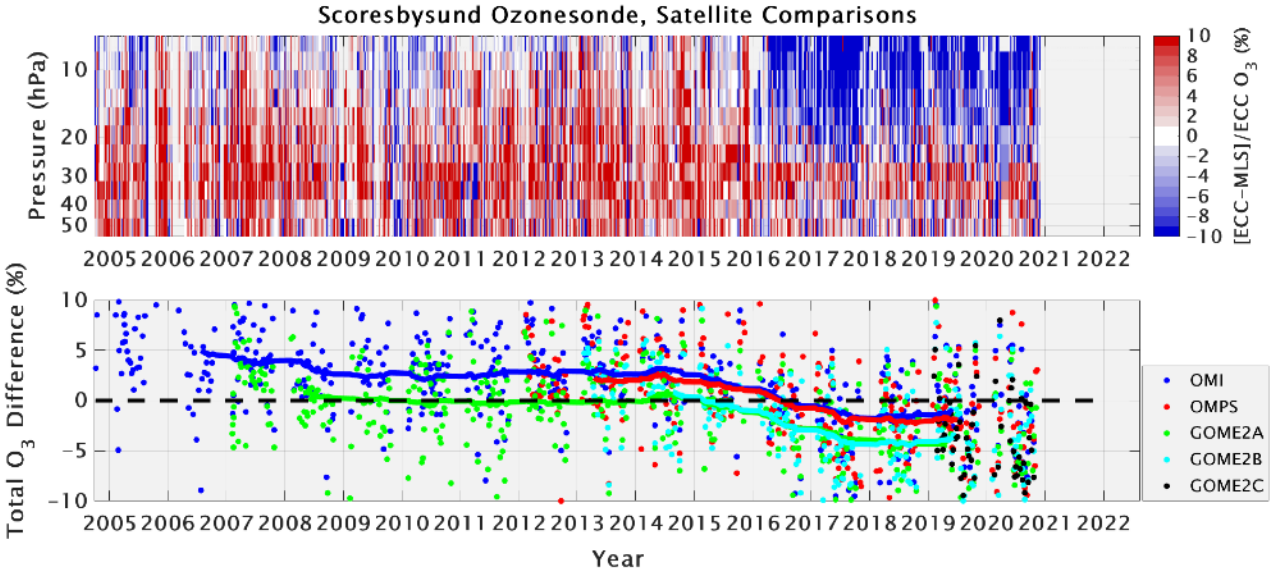
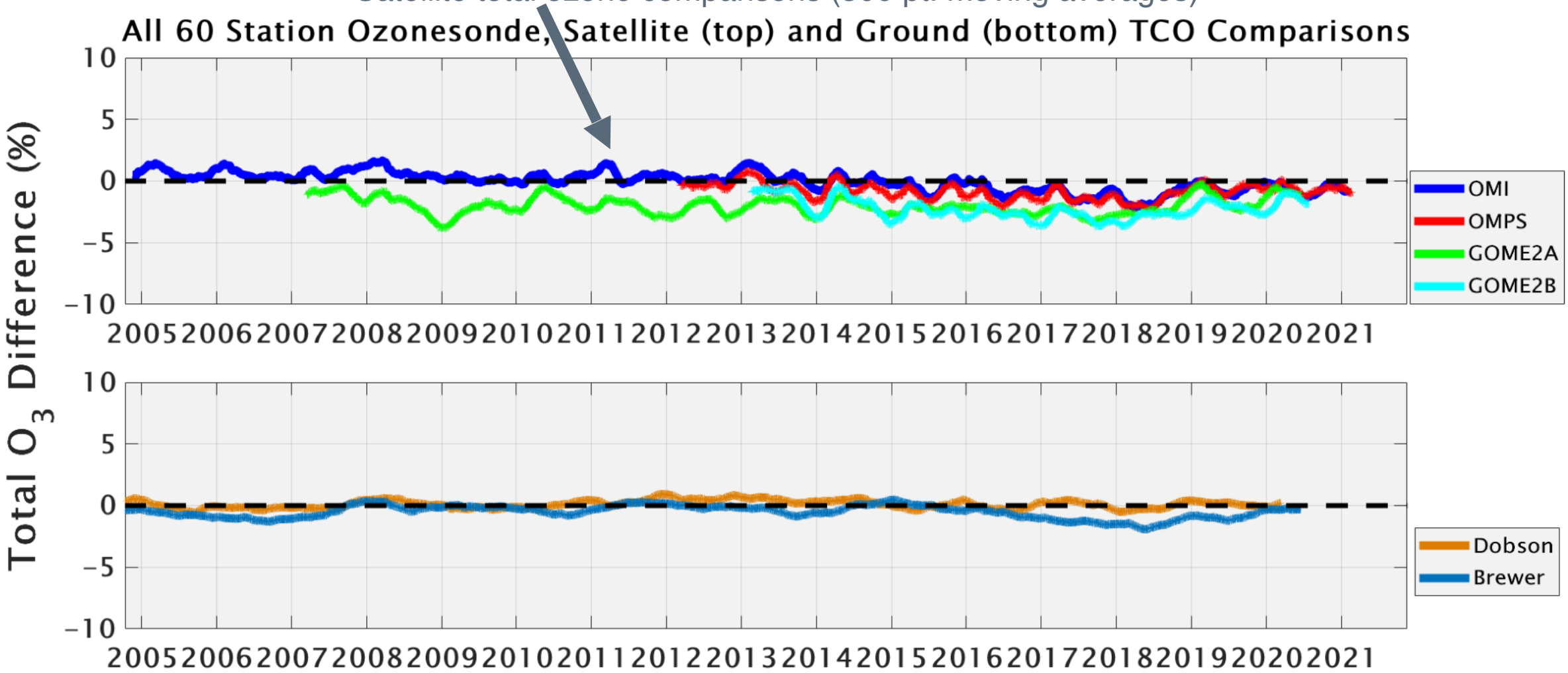


Satellite total ozone comparisons (500 pt. moving averages)

QA/QC for the ozonesonde network

4. Continuous Quality Monitoring

Satellite total ozone comparisons (500 pt. moving averages)



Stauffer et al., ESS, 2022

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