

Koninklijk Meteorologisch Instituut

Institut Royal Météorologique

Königliche Meteorologische Institut

Royal Meteorological Institute

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

Roeland Van Malderen

*WMO-GAW Quality Assessment – Scientific Activity Centre for Ozonesondes*

- 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

- launched with weather balloon, coupled with radiosonde
- pump + electrochemical concentration cells
- titration of ozone in a KI sensing solution:  
 $2 \text{KI} + \text{O}_3 + \text{H}_2\text{O} \rightarrow \text{I}_2 + \text{O}_2 + 2 \text{KOH}$
- basic formula:

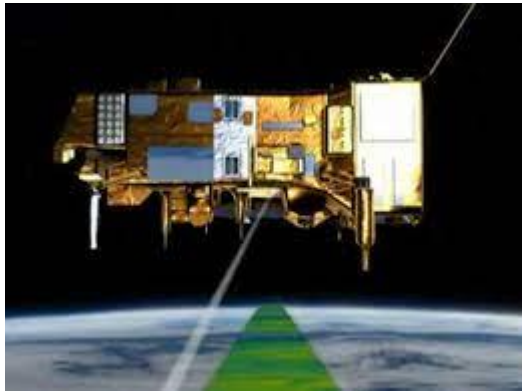
$$P_{O_3} = 0.043085 * \frac{T_P}{(\eta_P * \eta_A * \eta_C * \Phi_{P0})} * (I_M - I_B)$$

pump temperature
current

pump efficiency
pump flow rate

pre-launch  
characterization  
in lab

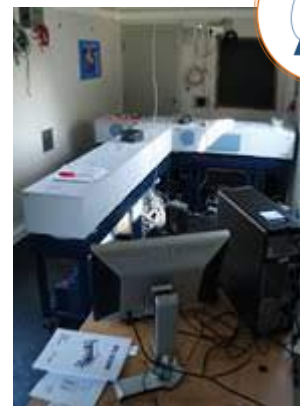
## From satellites



## In-situ



## Ground-based



advantages ozonesondes:

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

- **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

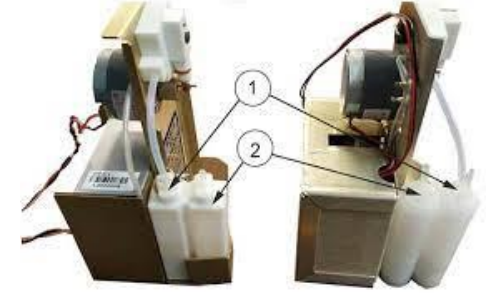
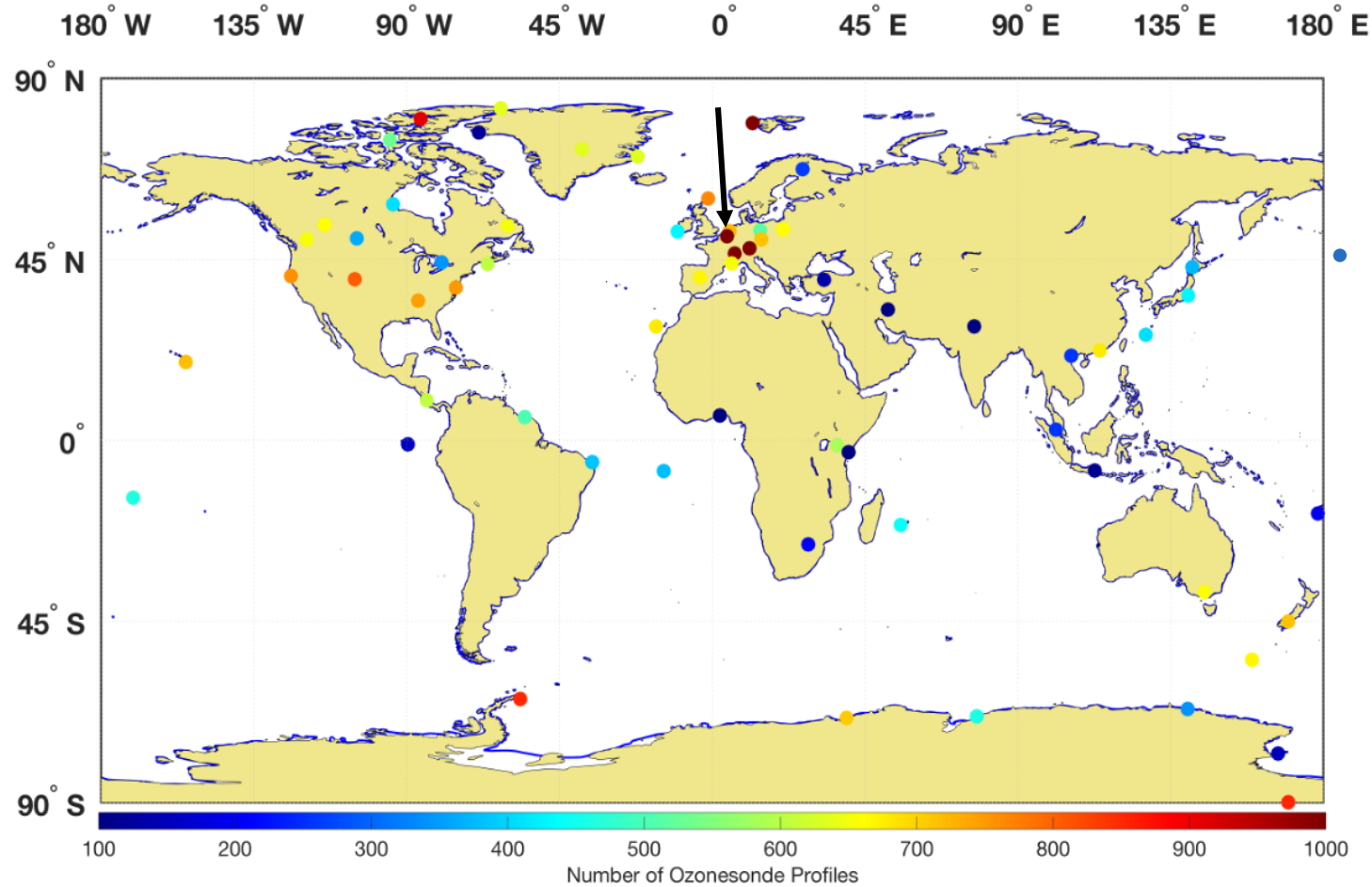


- QA/QC at Uccle
  - ✓ Comparison with reference ozone value from ozone calibrator/generator in lab, **before launch**



- ✓ total ozone column from spectrophotometer at Uccle, **after launch**



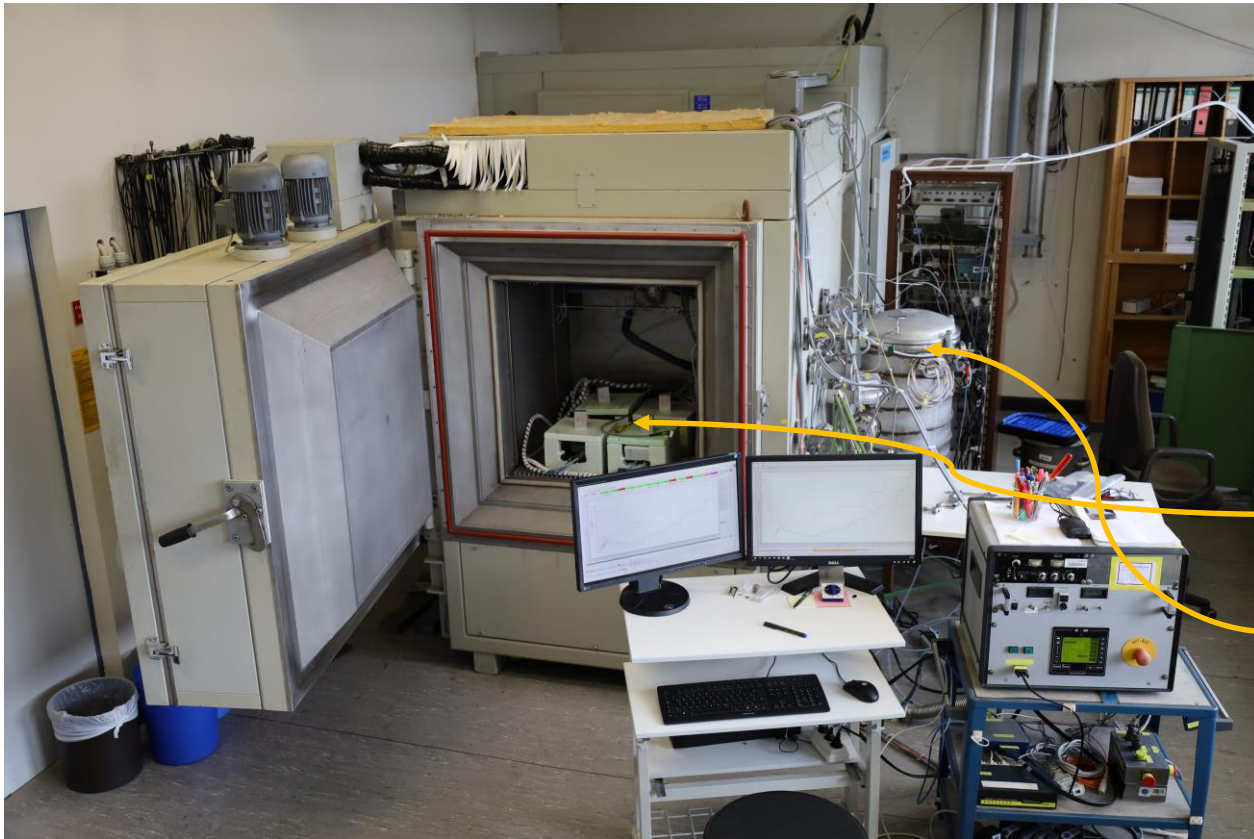


**± 60 active sites**

- ✓ 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”?

## 1. WMO World Calibration Centre for Ozonesondes (WCCOS)

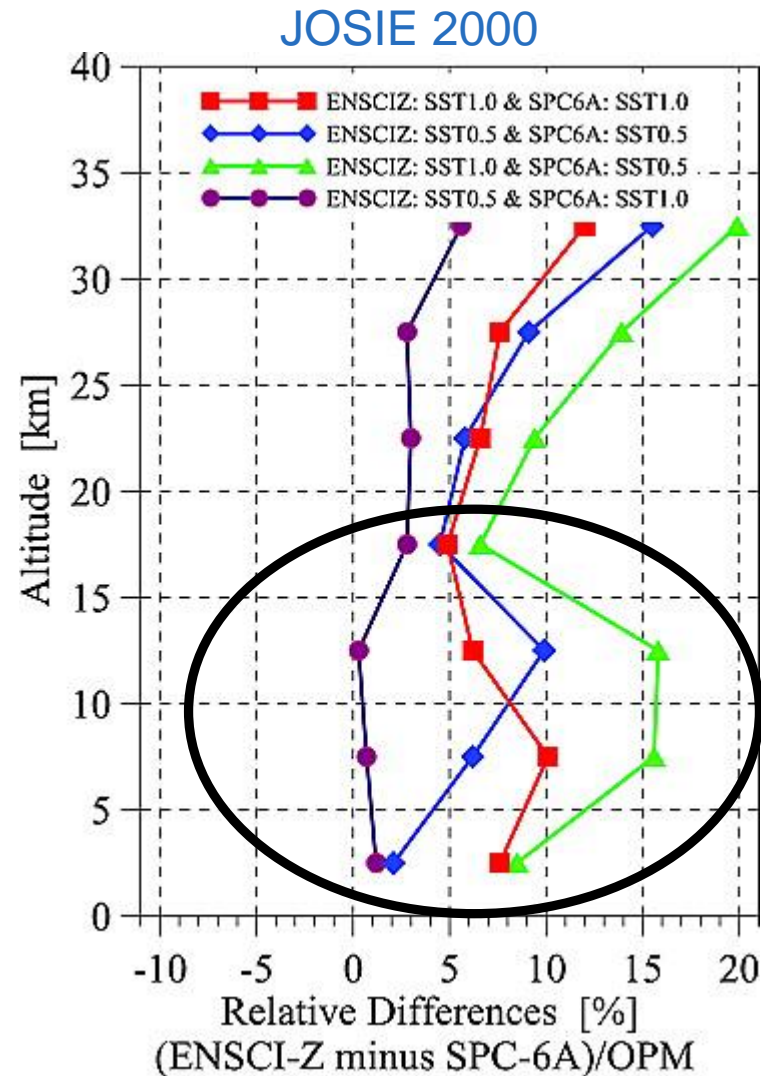
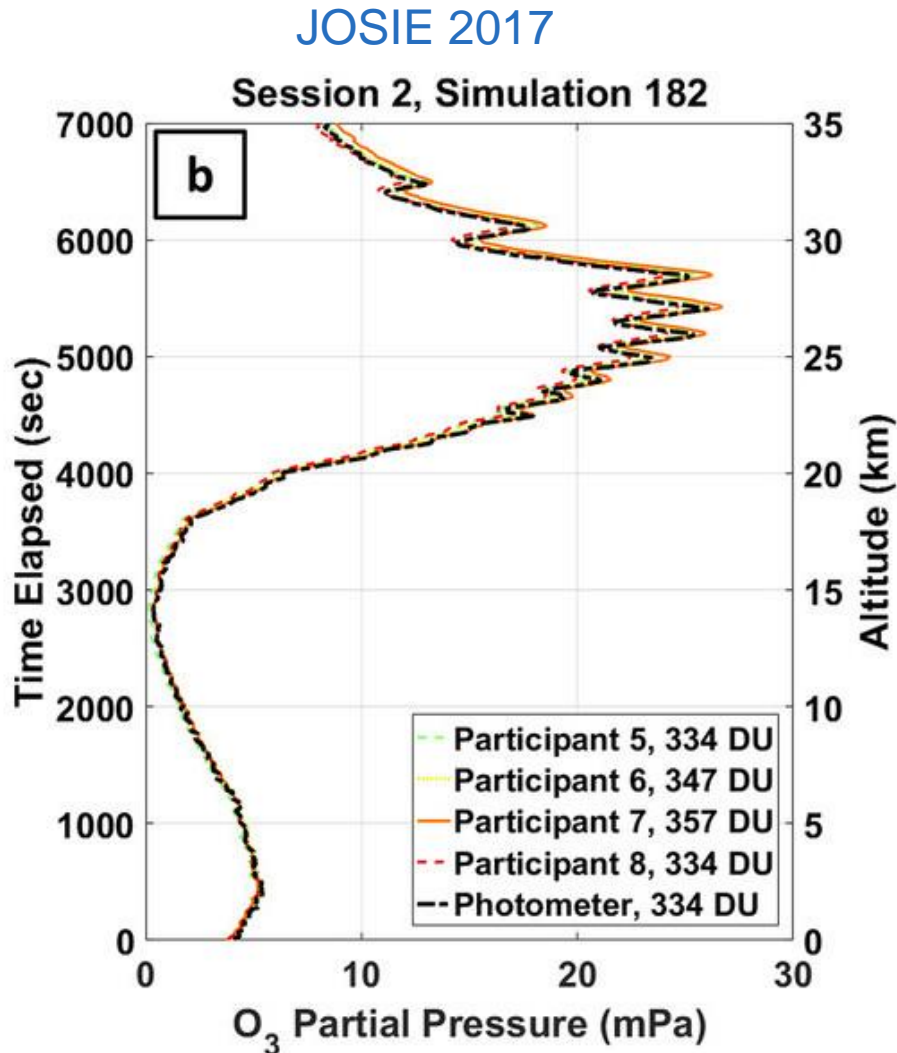


Simulation pressure chamber at Jülich (Germany), in collaboration with RMI

- ✓ 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



## 1. WMO World Calibration Centre for Ozonesondes (WCCOS)



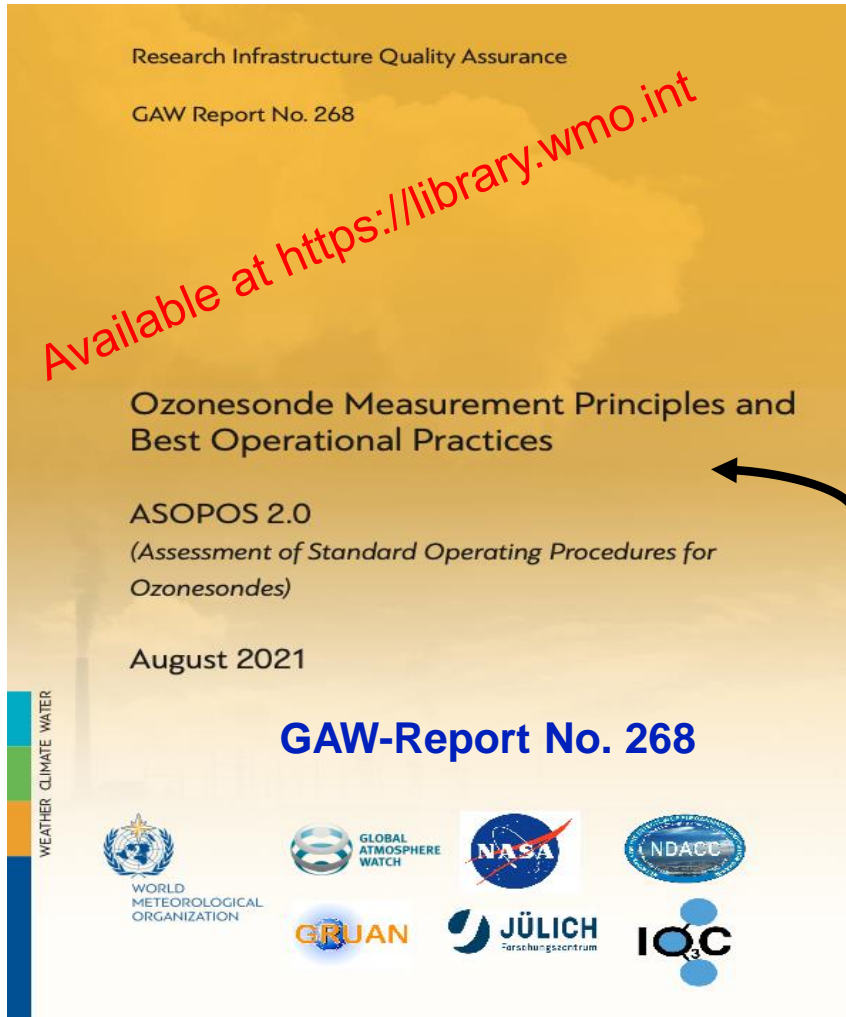
- ✓ ENSCI SST0.5 and SPC SST1.0 are within 1-5%: two standards
- ✓ ENSCI 5-10% > SPC
- ✓ SST1.0 5% > SST0.5
- ✓ troposphere: impact of operating procedures

## 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)

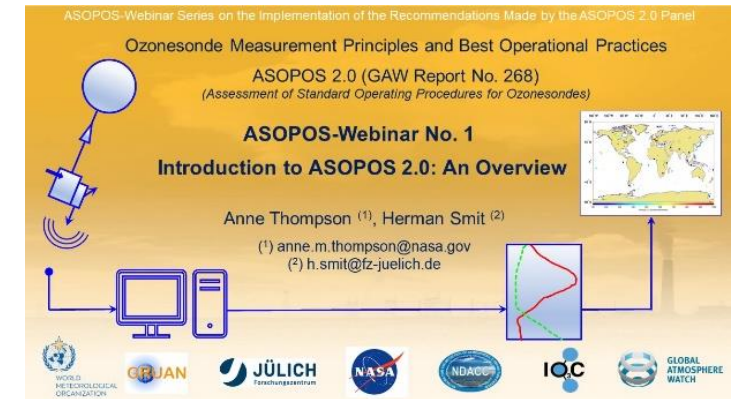
## 2. Assessment of Standard Operating Procedures for Ozonesondes (ASOPOS) Panel

**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**



ASOPOS-Webinar Series on the Implementation of the Recommendations Made by the ASOPOS 2.0 Panel

Ozonesonde Measurement Principles and Best Operational Practices

ASOPOS 2.0 (GAW Report No. 268)  
(Assessment of Standard Operating Procedures for Ozonesondes)

**ASOPOS-Webinar No. 1**  
**Introduction to ASOPOS 2.0: An Overview**

Anne Thompson<sup>(1)</sup>, Herman Smit<sup>(2)</sup>  
<sup>(1)</sup> anne.m.thompson@nasa.gov  
<sup>(2)</sup> h.smit@fz-juelich.de

Logos: WMO, GBUAN, JÜLICH Forschungszentrum, NASA, NDACC, IQC, GLOBAL ATMOSPHERE WATCH



ASOPOS-Webinar Series on the Implementation of the Recommendations Made by the ASOPOS 2.0 Panel

Ozonesonde Measurement Principles and Best Operational Practices

ASOPOS 2.0 (GAW Report No. 268)  
(Assessment of Standard Operating Procedures for Ozonesondes)

**ASOPOS-Webinar No. 5**  
**Ozonesonde Data Quality Indicators**

Ryan Stauffer<sup>1</sup> and Holger Vömel<sup>2</sup>

<sup>1</sup>NASA Goddard Space Flight Center; ryan.m.stauffer@nasa.gov  
<sup>2</sup>National Center for Atmospheric Research; voemel@ucar.edu

Version Dec 2022

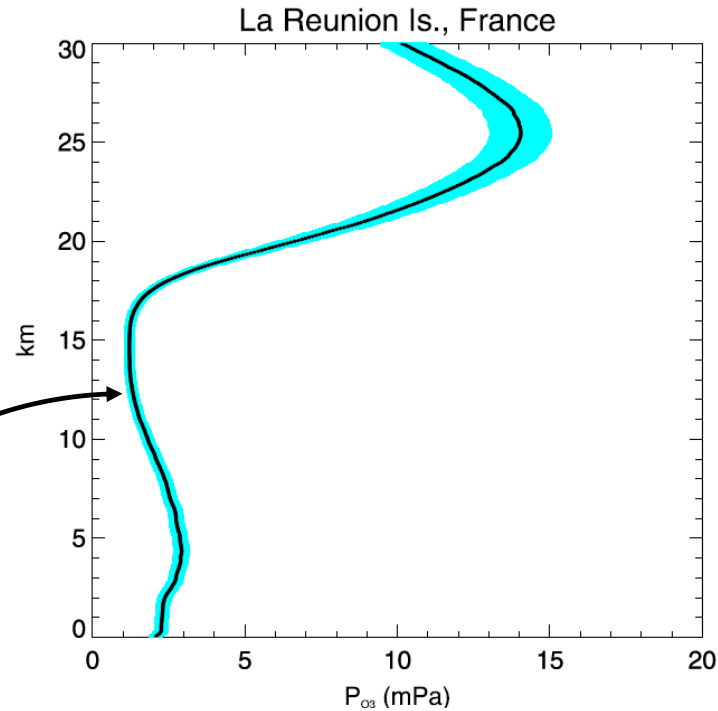
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## 3. O3S-DQA on homogenization

### 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:**

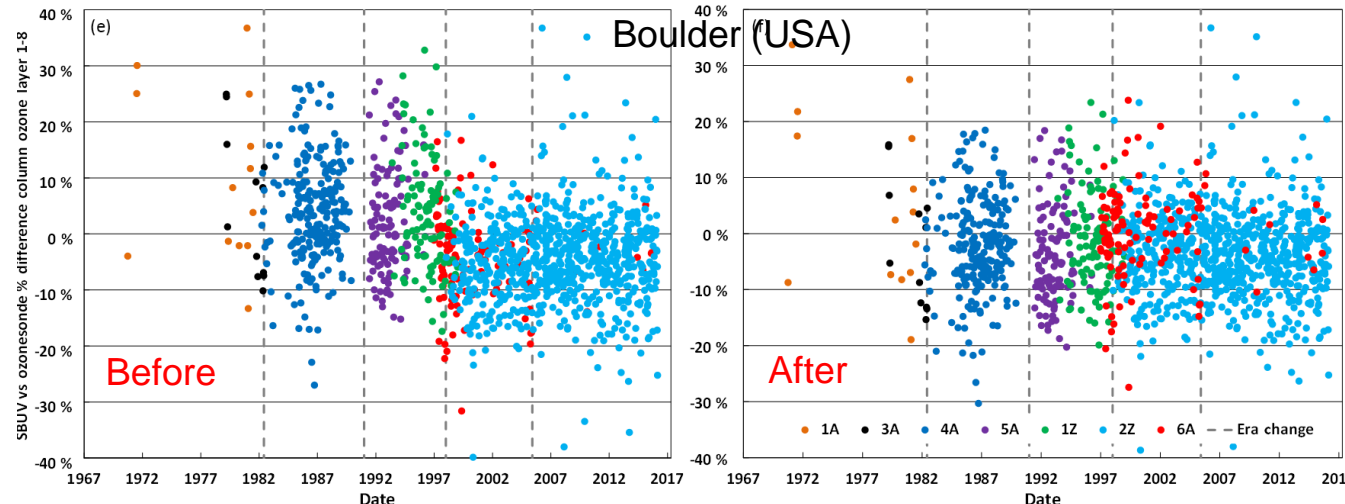
**Guide Lines for Homogenization of Ozone Sonde Data**

*(Version 2.0: 19 November 2012)*

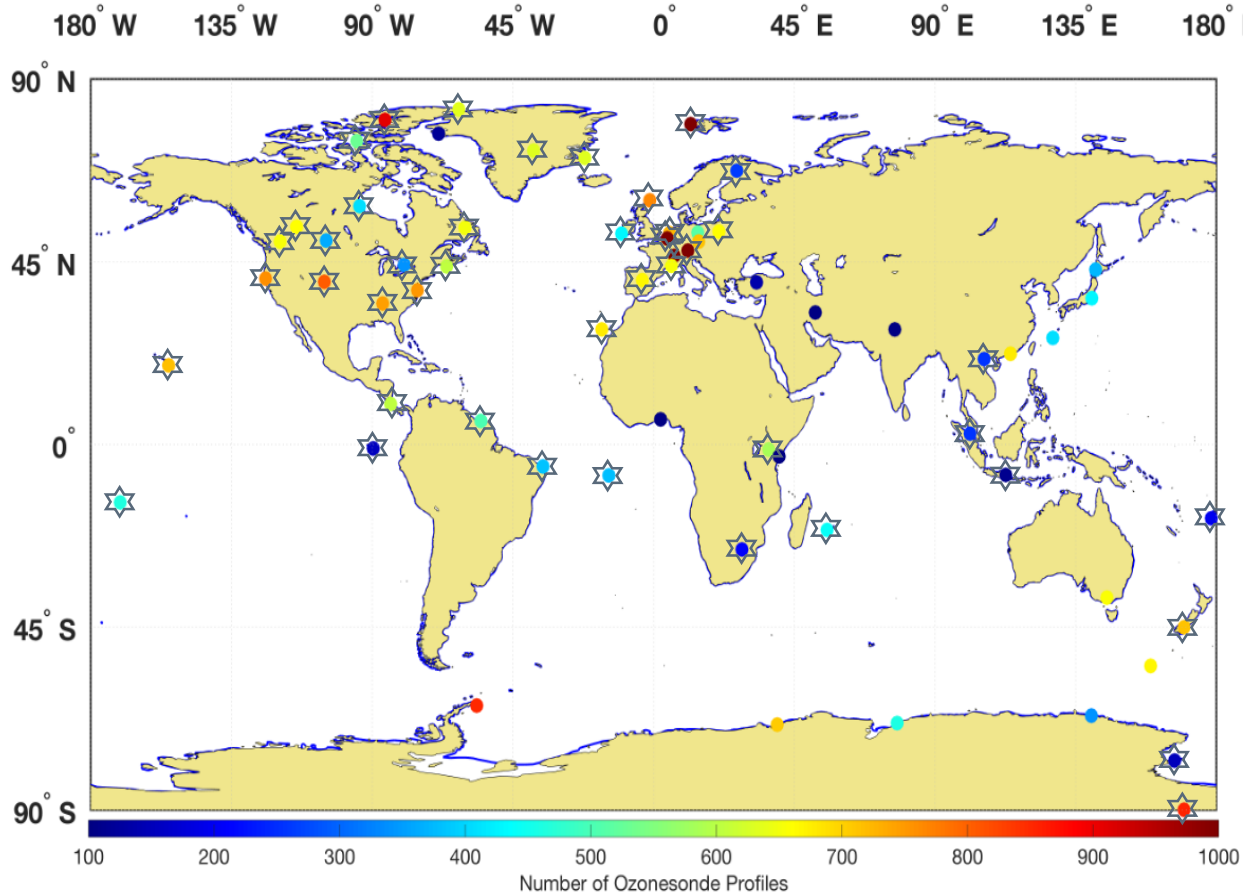
Prepared  
by  
O3S-DQA panel members on homogenization of O3S-data  
(Herman Smit, Sam Oltmans, Terry Deshler, David Tarasick, Bryan Johnson,  
Frank Schmidlin, Rene Stuebi, Jonathan Davies)

Activity as part of  
**SPARC-IGACO-IOC Assessment**  
**(SI2N)**

**“Past Changes in the Vertical Distribution of Ozone”**



## 3. O3S-DQA on homogenization

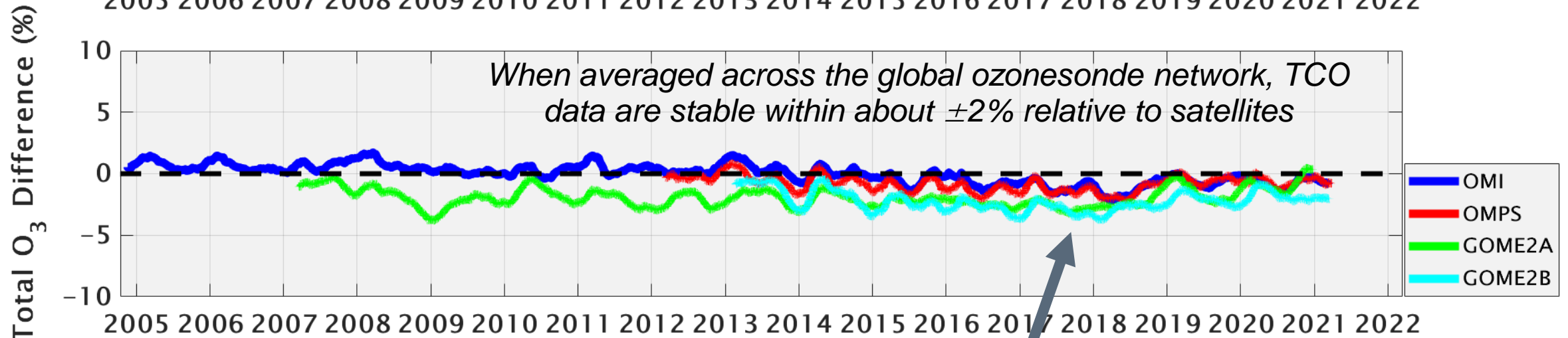
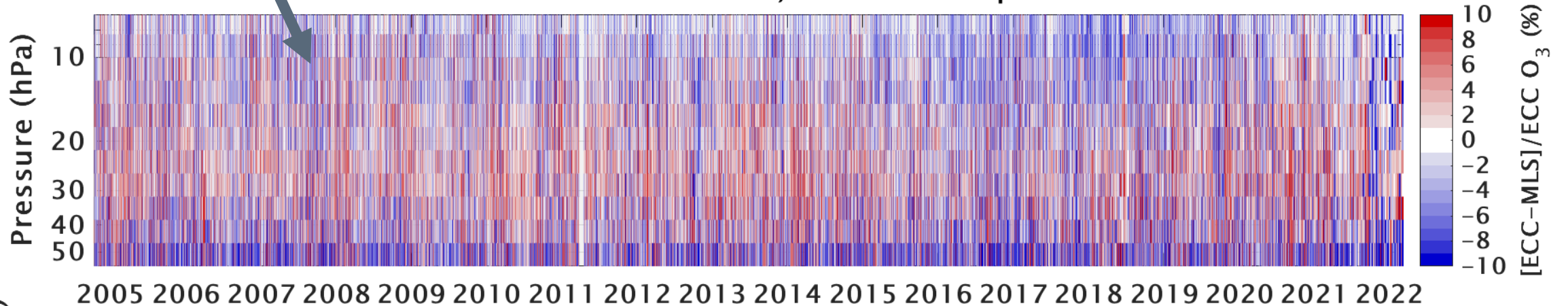


- ✓ 45 from around 60 “active” sites have been homogenized (stars), around 10 of these by RMI (code available)
- ✓ remaining: Japanese, Asian, Australian, some EU and Antarctic sites.
- ✓ Publications:
  - Tarasick et al., AMT, 2016
  - Van Malderen et al., AMT, 2016
  - Witte et al., JGR 2017, 2018,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

## 4. Continuous Quality Monitoring

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

All 60 Station Ozonesonde, Satellite Comparisons

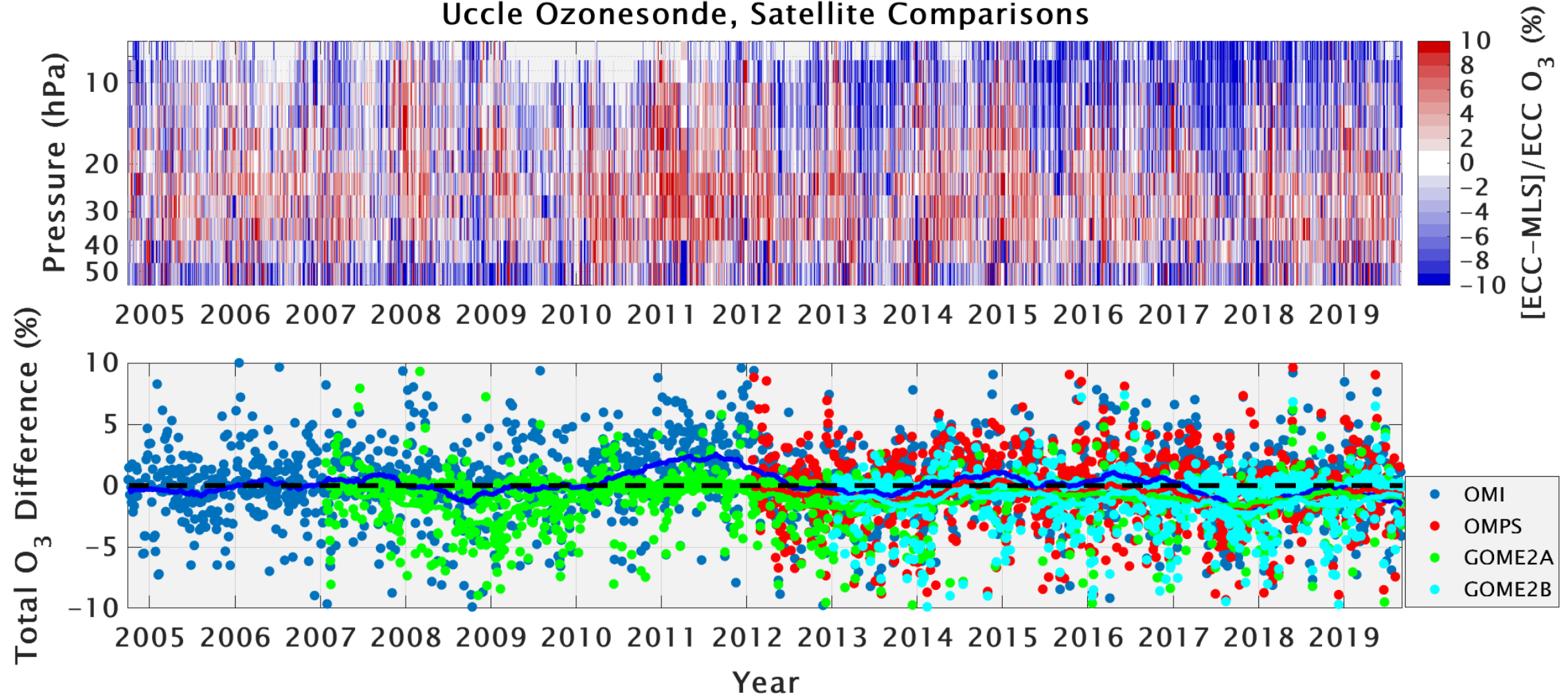


*Stauffer et al., ESS, 2022*

Total O<sub>3</sub> comparisons (500 pt. moving averages)

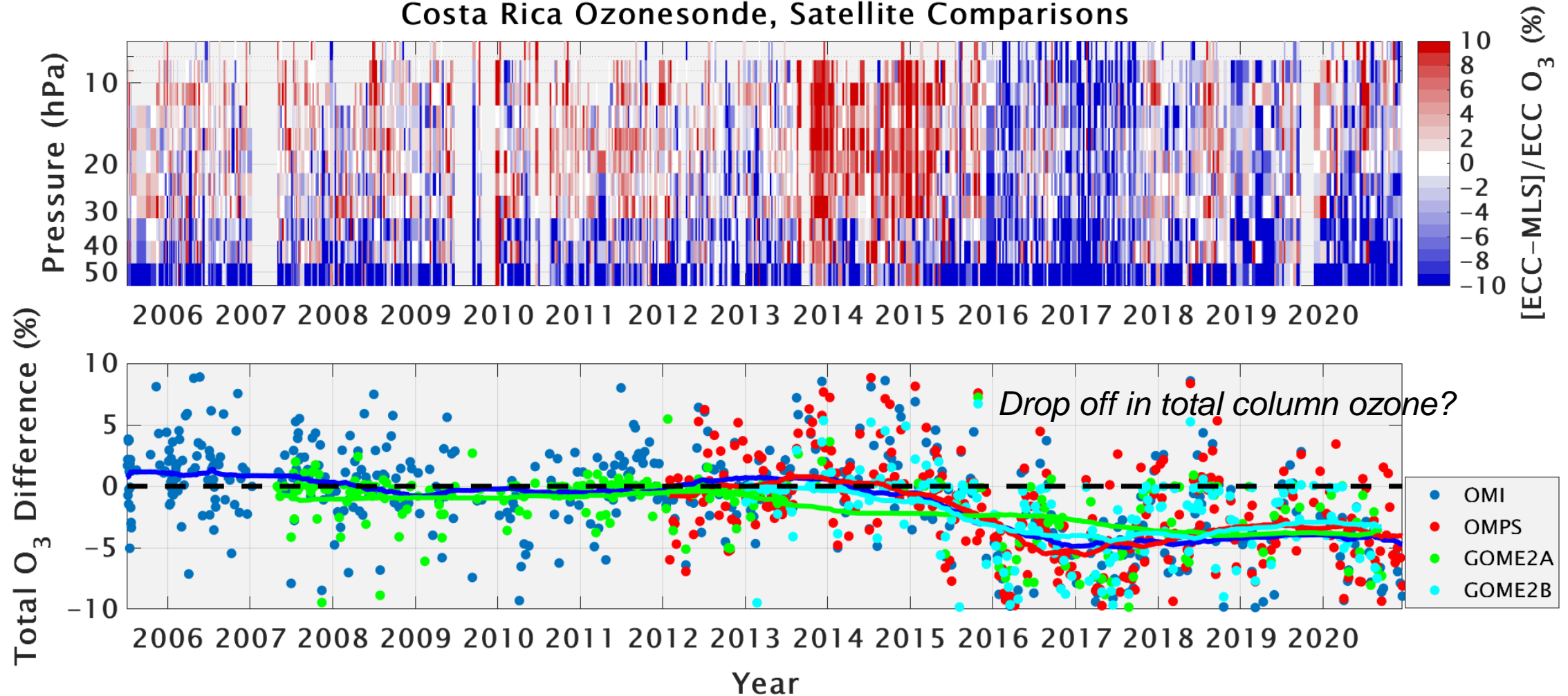
## 4. Continuous Quality Monitoring

Uccle Ozonesonde, Satellite Comparisons



## 4. Continuous Quality Monitoring

Costa Rica Ozonesonde, Satellite Comparisons





- ✓ 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

# THANK YOU

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