Koninklijk Meteorologisch Instituut

Institut Royal Météorologique

Königliche Meteorologische Institut

Royal Meteorological Institute

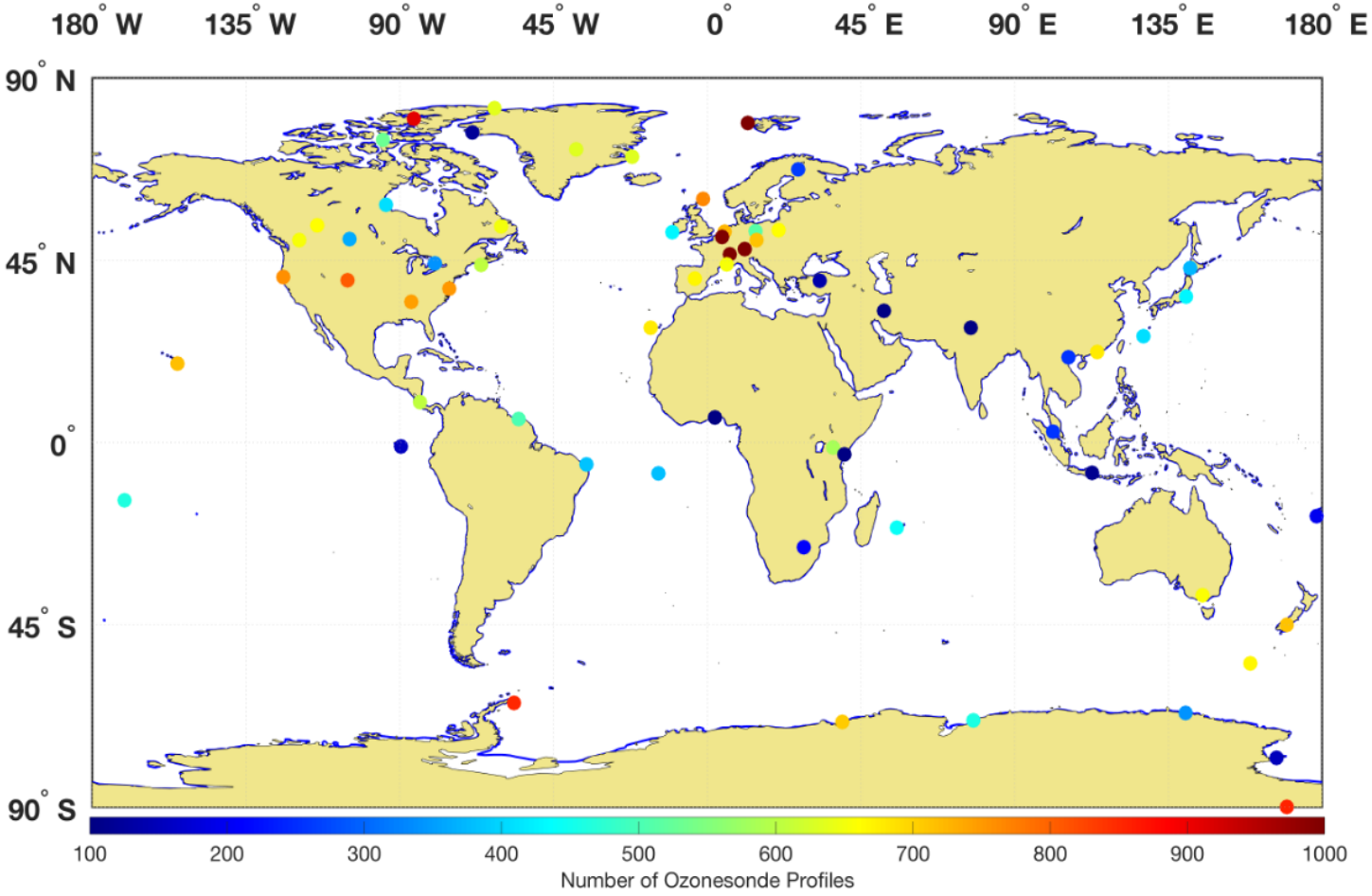
International Ozonesonde Activities

Roeland Van Malderen

Royal Meteorological Institute of Belgium,
WMO-GAW Quality Assessment – Science Activity Centre for Ozonesondes
NDACC Sonde WG representative, HEGIFTOM co-chair

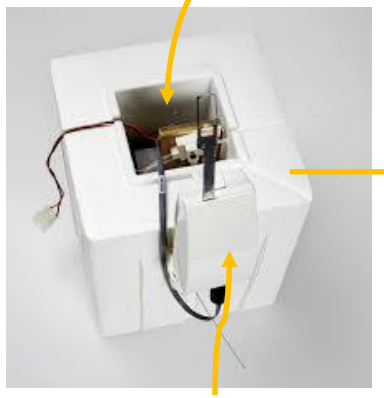
… and inputs from Herman Smit, Anne Thompson, Ryan Stauffer, Debra Kollonige, Bryan Johnson, David Tarasick, and other ASOPOS members

Introduction: the World of Ozonesondes



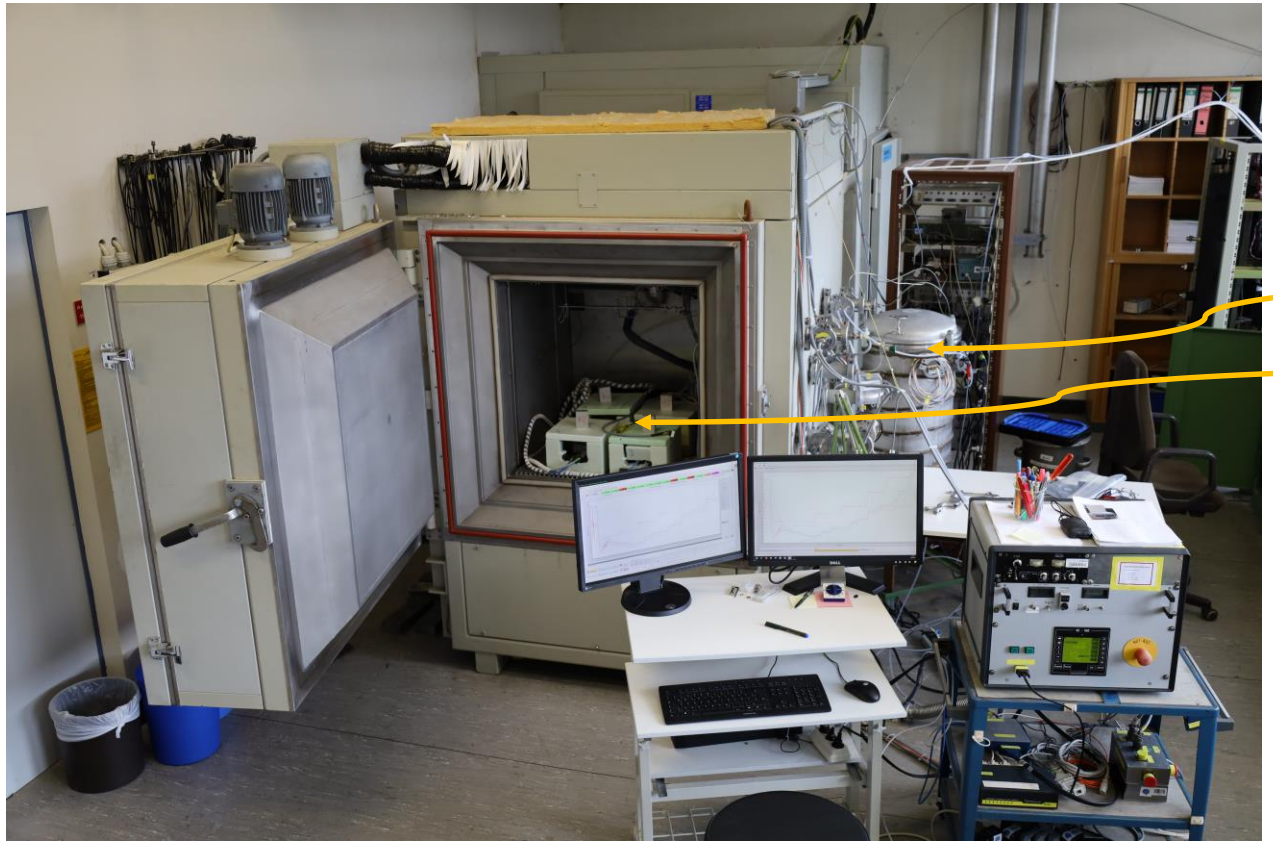
- ± 60 active ozonesonde sites

ozonesonde



radiosonde

Introduction: the World of Ozonesondes



- ± 60 active ozonesonde sites
- World Calibration Centre for Ozonesondes (WCCOS) @ FZJ: *simulation chamber + reference ozone photometer ➔ Julich Ozonesonde Intercomparison Experiments (JOSIE)*
- Quality Assurance – Science Activity Centre (QA-SAC) @ RMI

Introduction: the World of Ozonesondes

ASOPOS Panel at Brussels, Belgium (Sept. 2019)

- ± 60 active ozonesonde sites
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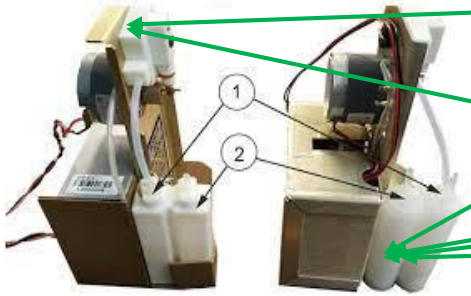
- Quality Assurance – Science Activity Centre (QA-SAC) @ RMI
- Panel for the Assessment of Standard Operating Procedures for Ozonesondes (ASOPOS)

Introduction: the World of Ozonesondes

2 ECC ozonesonde manufacturers



±5%

different sensing solution strengths

SST1.0

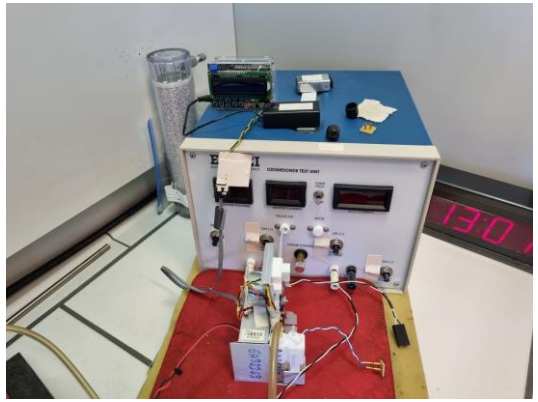
±5%

SST2.0

SST0.5

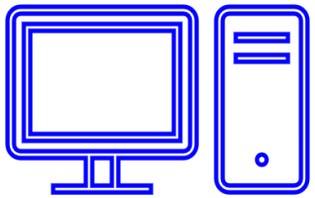
SST0.1

ozonesonde preparation



OPERATING PROCEDURES

different data correction steps, that also changed over time.



PROCESSING

different data in those different databases

in different (ascii) data formats

WMO GAW

WOUDC

NDACC

SHADOZ

NOAA 50 YEARS

GML
ESRL

AVDC
EVDC
CDS
etc.

ARCHIVING

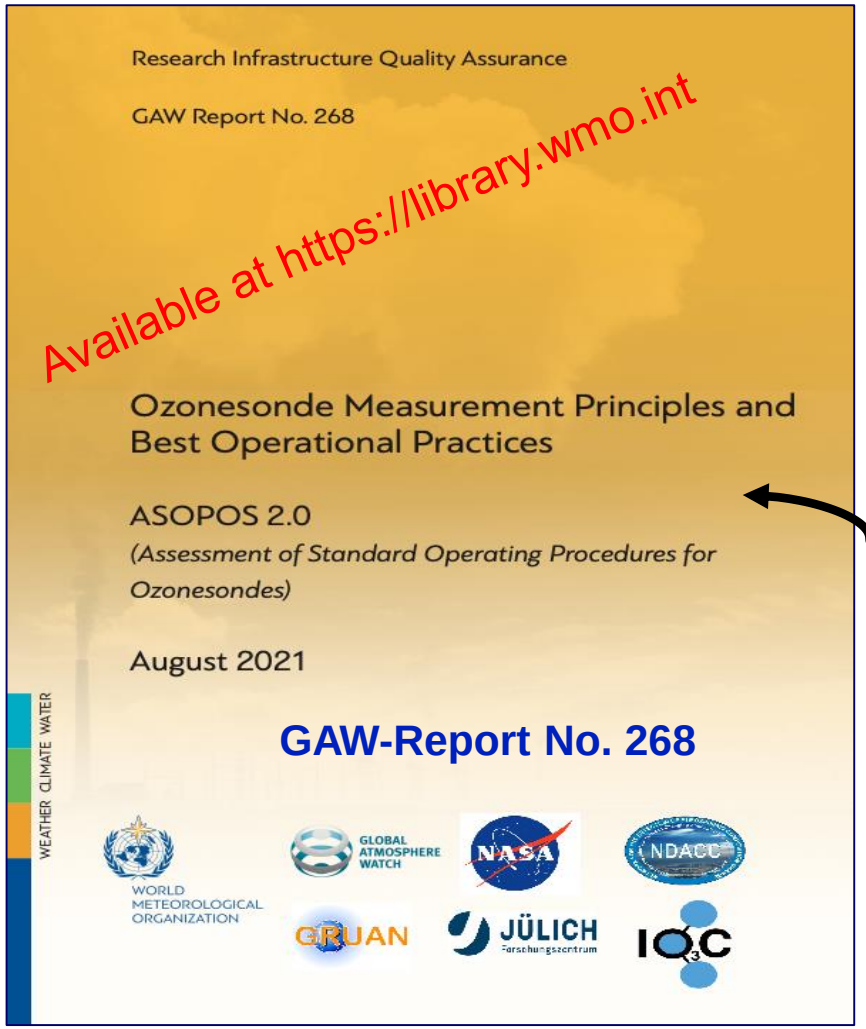
Outline

This presentation: past, current and future **Harmonization** Activities in those 3 pillars:

- Standardization of Operating Procedures
  - ✓ *WMO-GAW Report No 268 by ASOPOS Panel*
  - ✓ *Webinars*
- Data (re)processing activities
  - ✓ *Homogenization according to O3S-DQA (HEGIFTOM)*
  - ✓ *QA/QC*
  - ✓ *Time Response Correction + Calibration Method*
- Harmonization of (meta)data Archiving and Formats
  - ✓ *Updated GEOMS-HDF format for all archives*
- Conclusions and Outlook

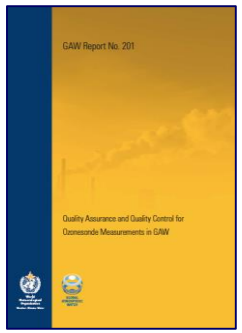
Standardization of Operating Procedures

Assessment of Standard Operating Procedures for Ozonesondes (ASOPOS) Panel



- Reviews current understanding of instrument by analysing and evaluating the results of intercomparisons (e.g. JOSIE) and time-series homogenisations (O3S-DQA) & analyses;
- Makes recommendations for standard operating procedures (preparation, hardware, processing, (meta)data archiving, etc.)

➔ **WMO-GAW report No 268, published in 2021 (update!)**



ASOPOS 1.0 Report:

"Quality Assurance and Quality Control for Ozonesonde Measurements in GAW"

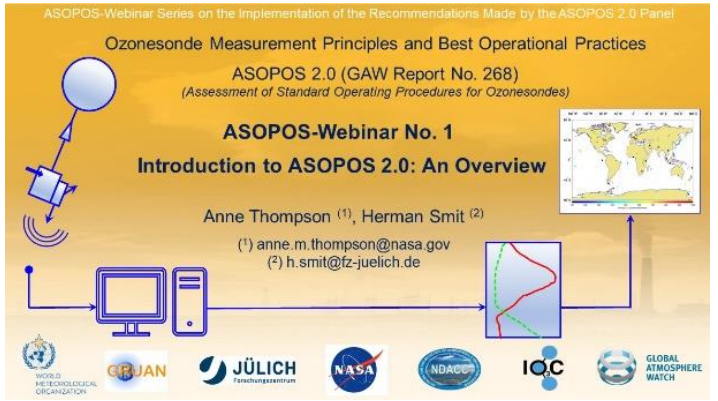
GAW Report # 201 printed by WMO/GAW (2014)

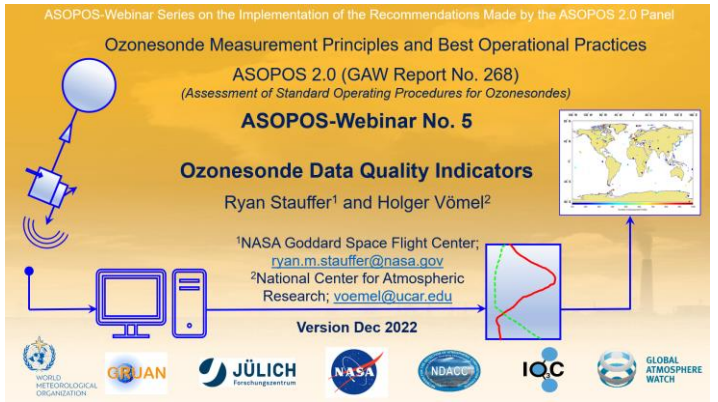
Standardization of Operating Procedures

WMO/GAW Report No. 268 Chapters have been "translated" into

6 online webinars (https://www.wccos-josie.org/asopos):

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

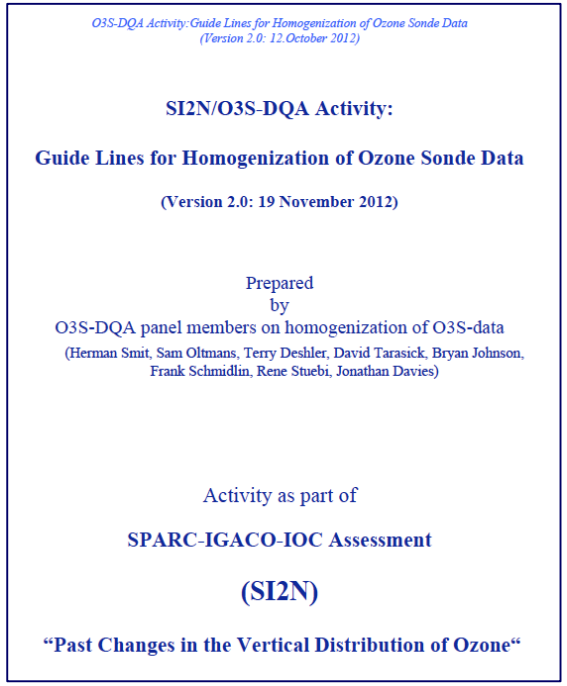
Data (re)processing

O3S-DQA 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)

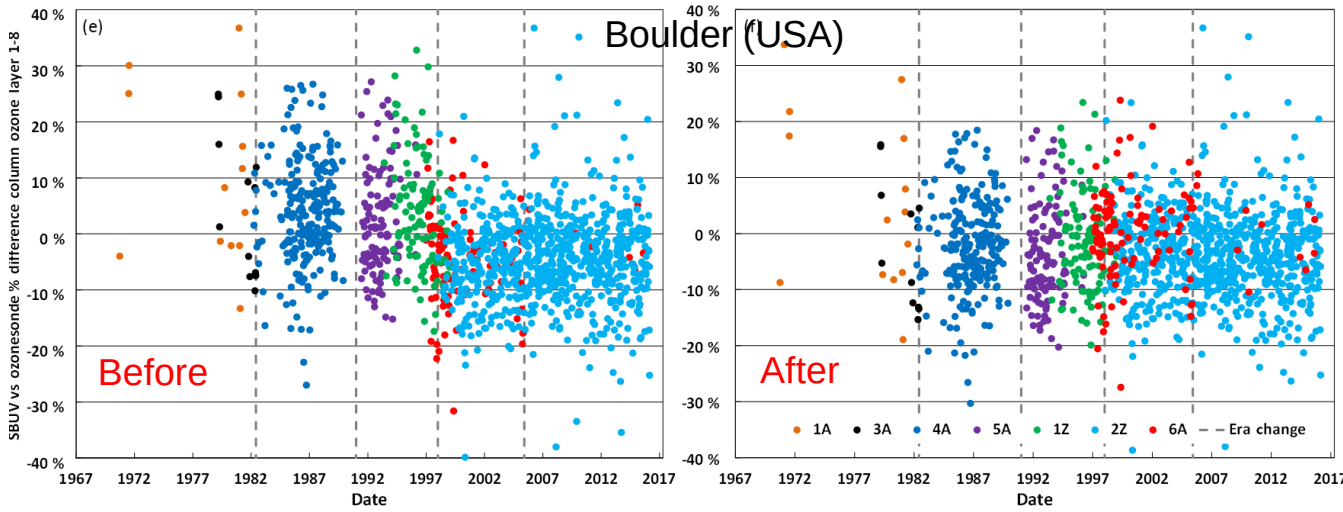
Activity as part of

SPARC-IGACO-IOC Assessment

(SI2N)

"Past Changes in the Vertical Distribution of Ozone"

Comparison with SBUV total column ozone from sfc-25 hPa



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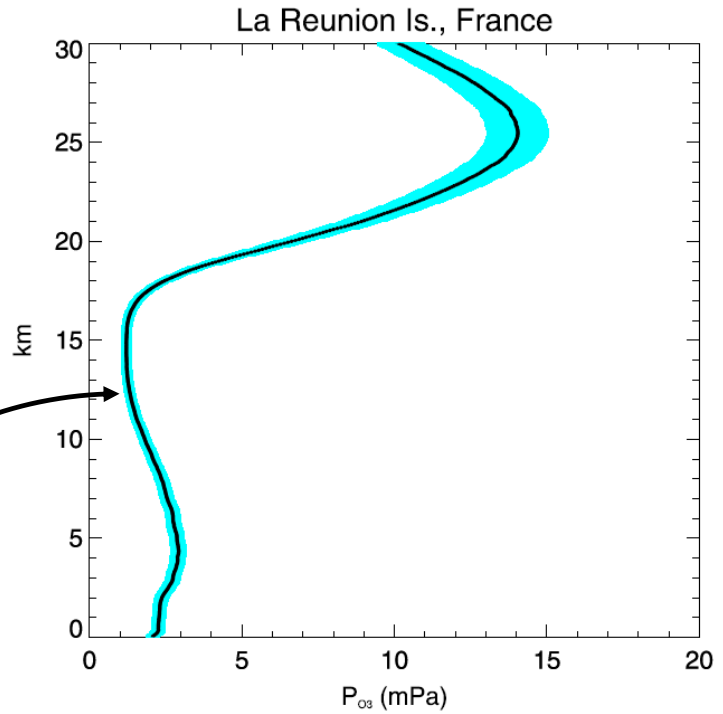

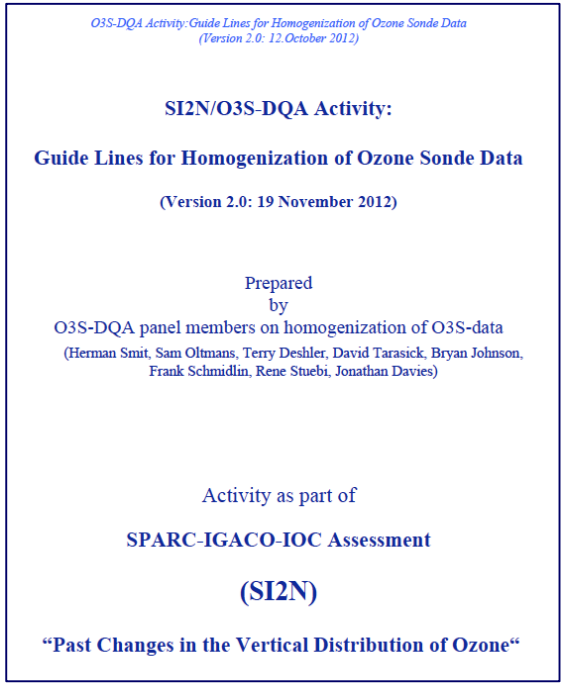
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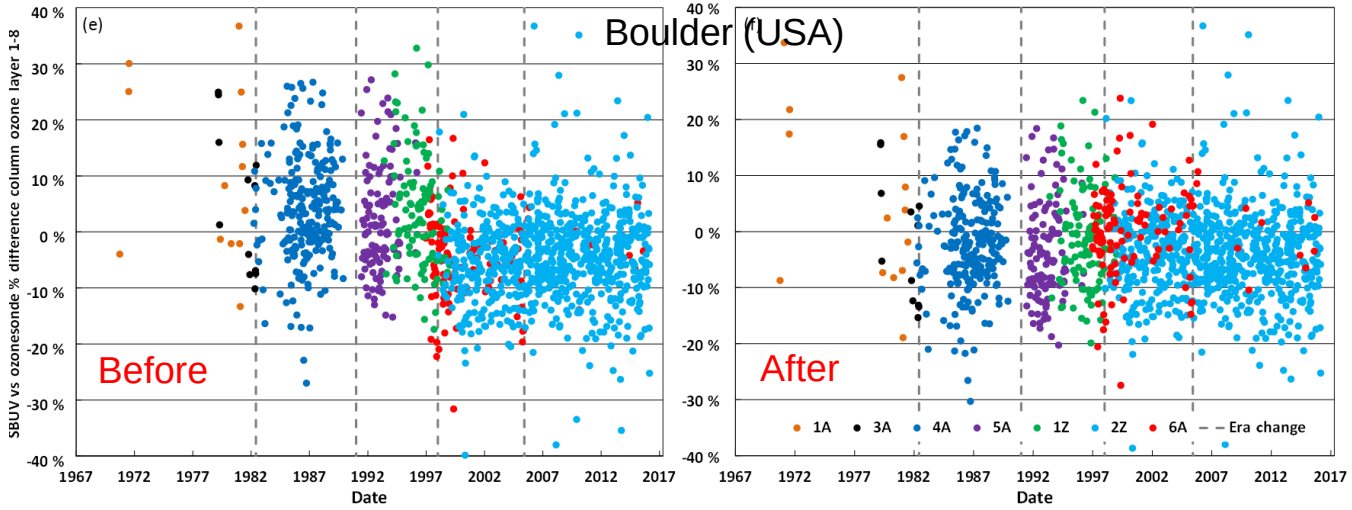
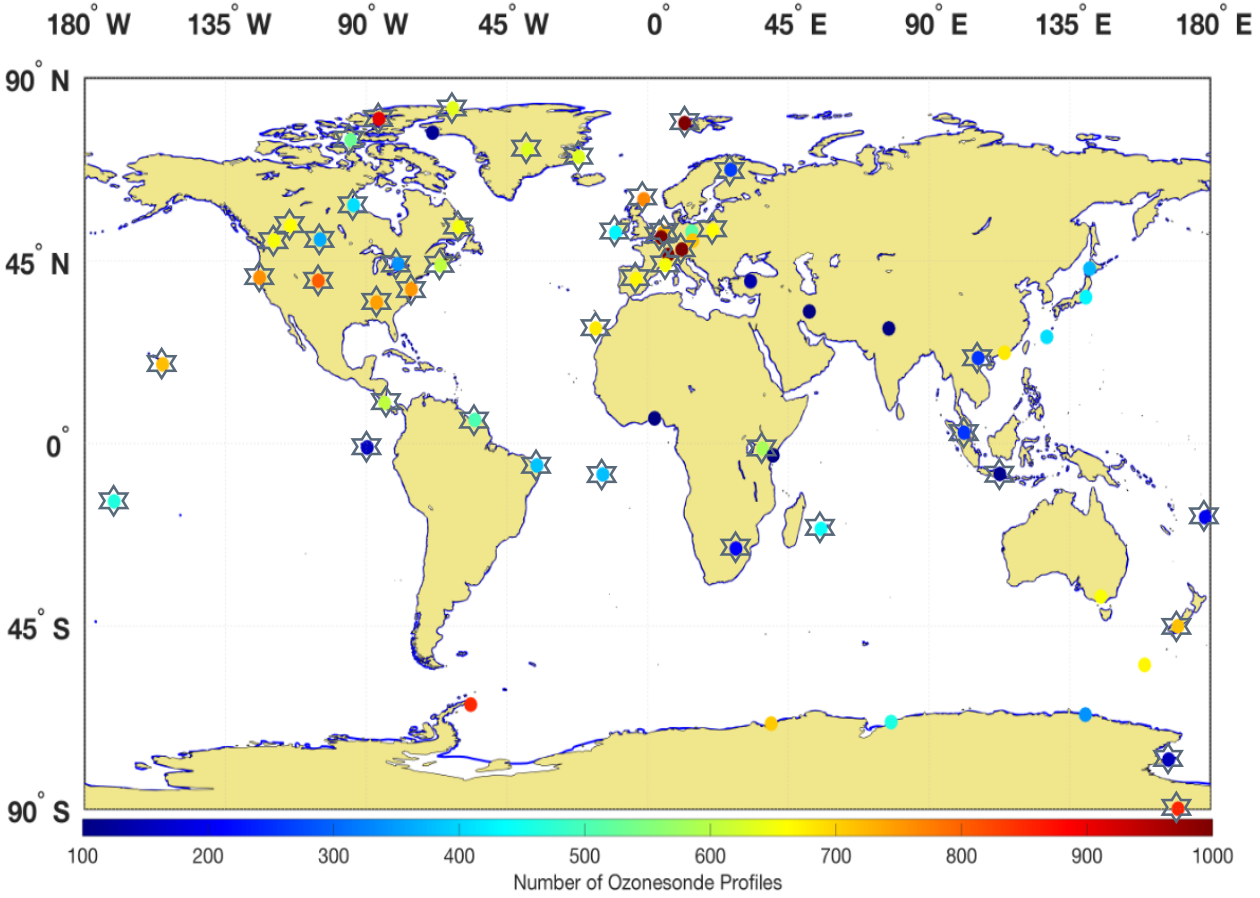


Data (re)processing

O3S-DQA Homogenization

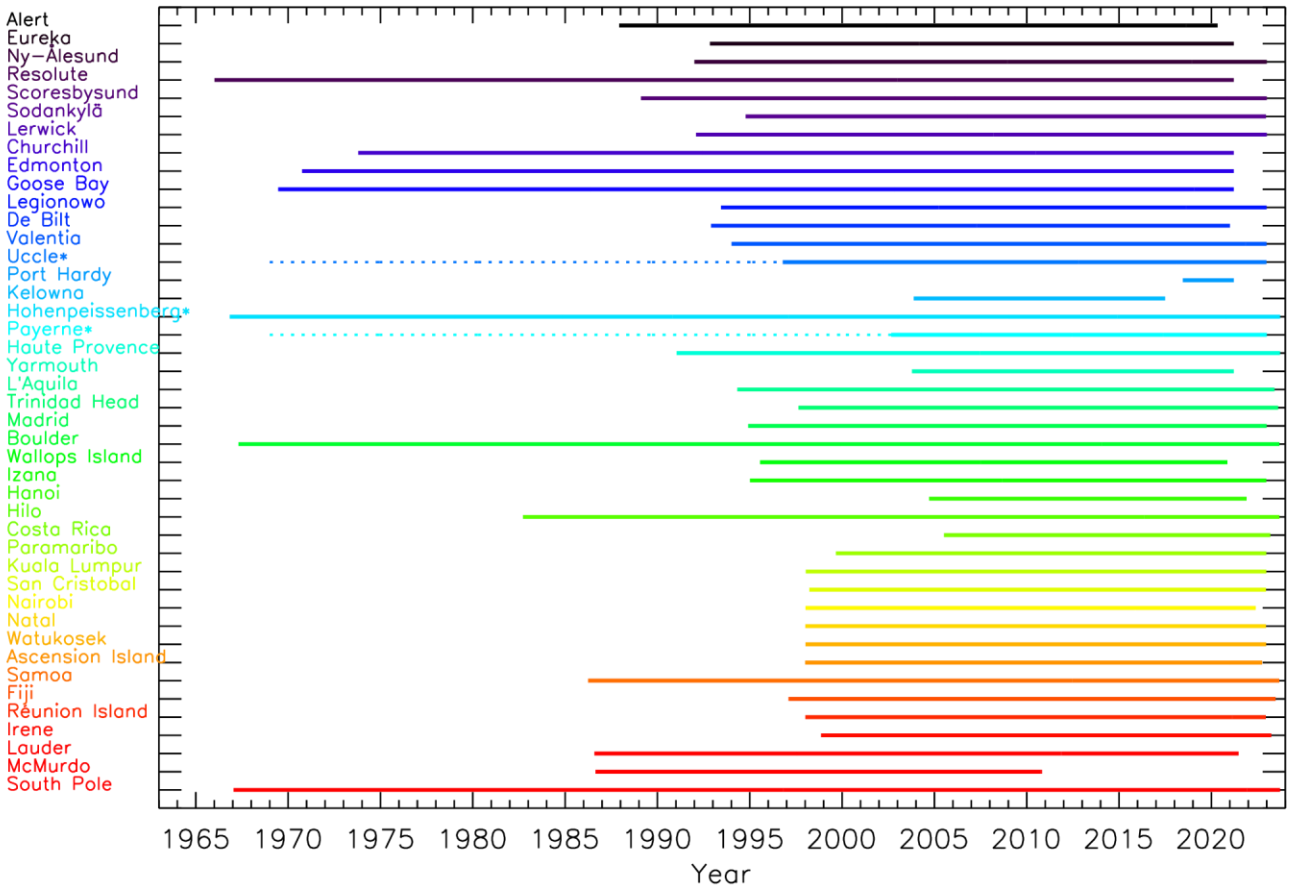


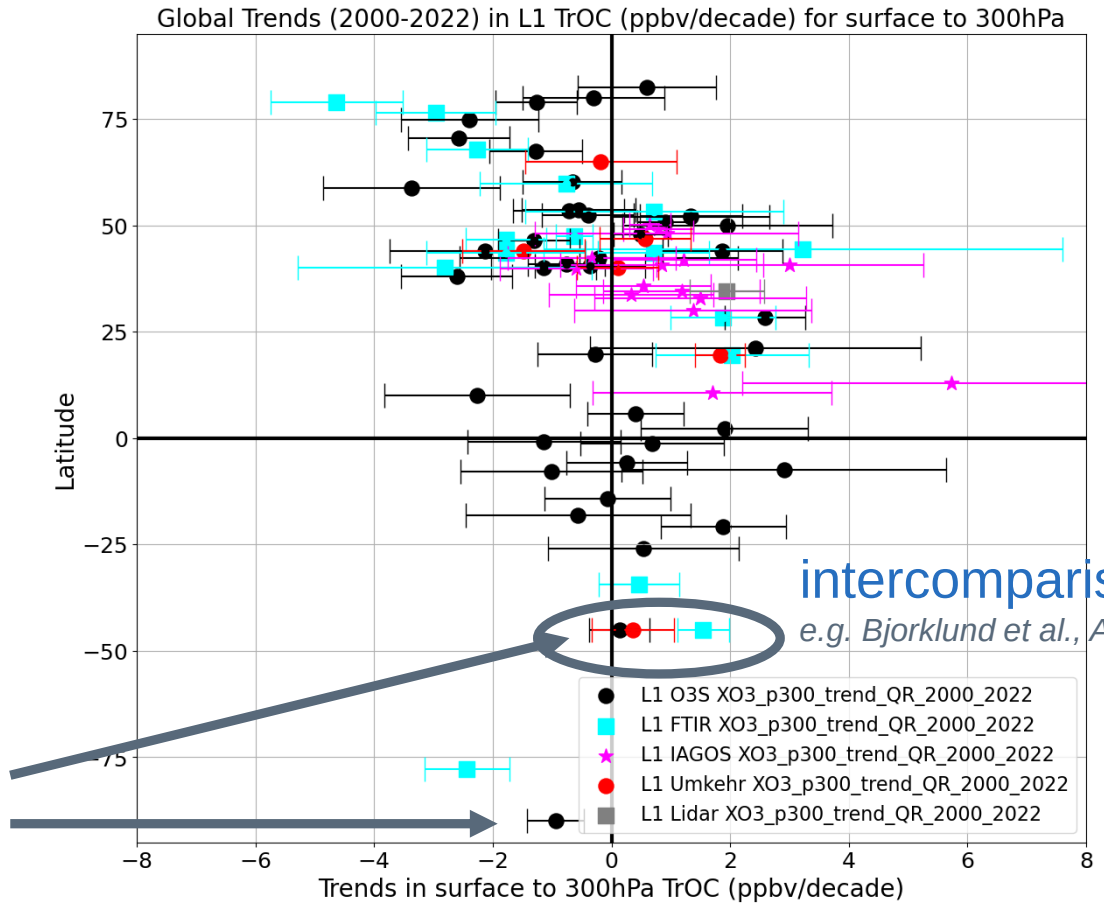
- 45 from around 60 “active” sites have been homogenized (stars)
- Remaining: Japanese, Asian, Australian, some EU and Antarctic sites.
- Publications:
  - ✓ *Tarasick et al., AMT, 2016*
  - ✓ *Van Malderen et al., AMT, 2016*
  - ✓ *Witte et al., JGR 2017, 2018, 2019*
  - ✓ *Thompson et al., JGR, 2017*
  - ✓ *Deshler et al., AMT, 2017*
  - ✓ *Sterling et al., AMT, 2018*
  - ✓ *Ancellet et al., AMT, 2022*
  - ✓ *Zeng et al., ACPD, accepted*
  - ✓ *….*
- Under the TOAR-II HEGIFTOM umbrella:

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

Data (re)processing

O3S-DQA Homogenization





intercomparisons!

e.g. Bjorklund et al., AMTD

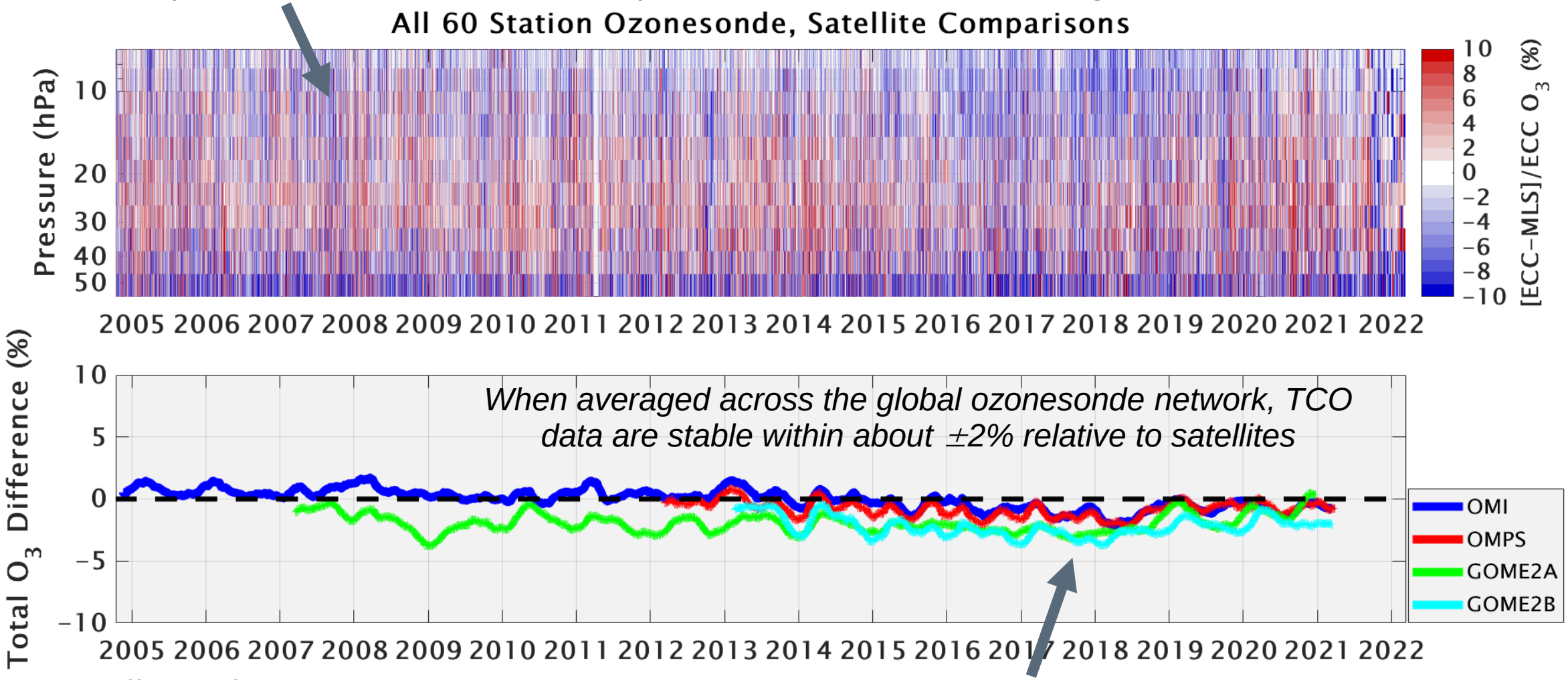
https://hegiftom.meteo.be/datasets/ozonesondes

"HEGIFTOM" tropospheric ozone column trends

Data (re)processing

Quality Assessment/Quality Control

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

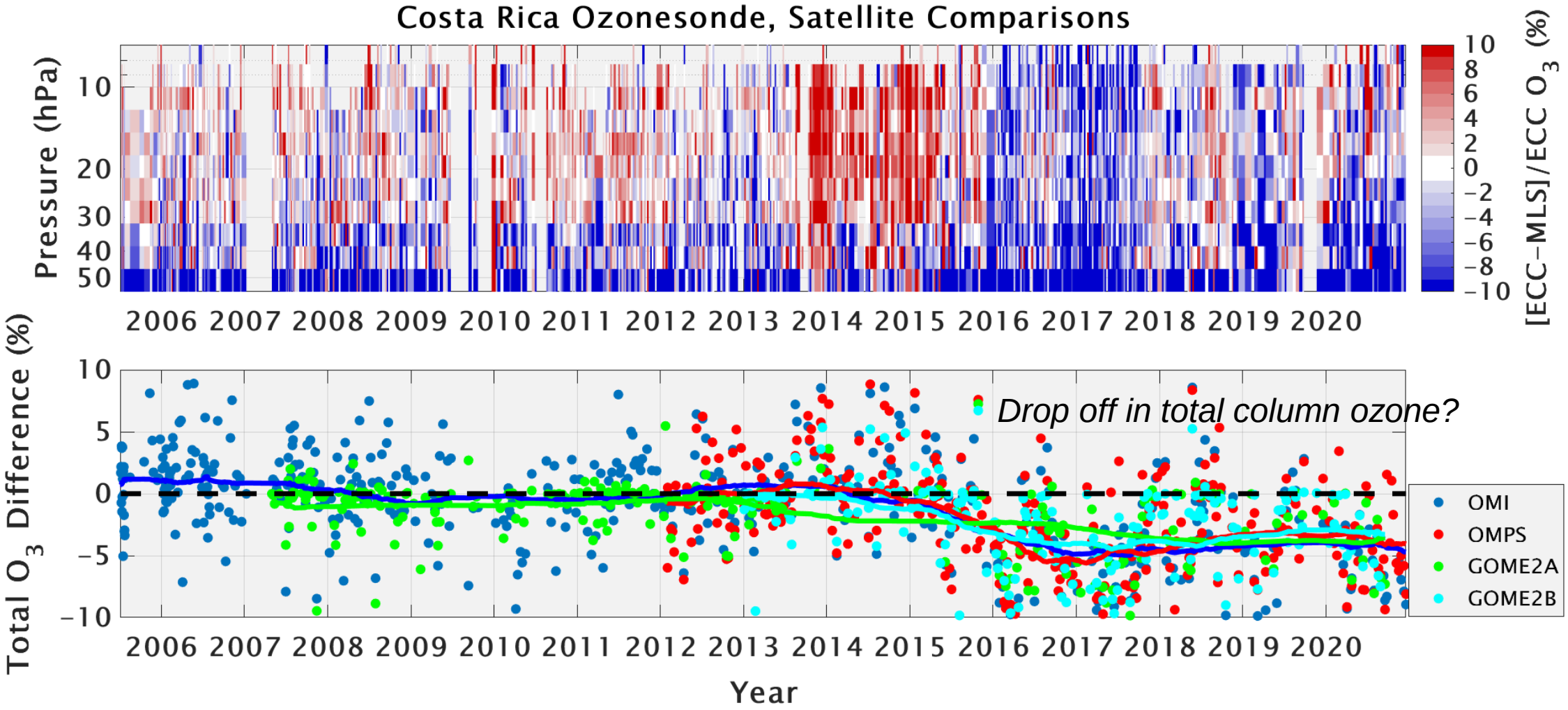


Stauffer et al., ESS, 2022

Total O_3 comparisons (500 pt. moving averages)

Data (re)processing

Quality Assessment/Quality Control



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

Stauffer et al., GRL, 2020

Data (re)processing

New Data Processing

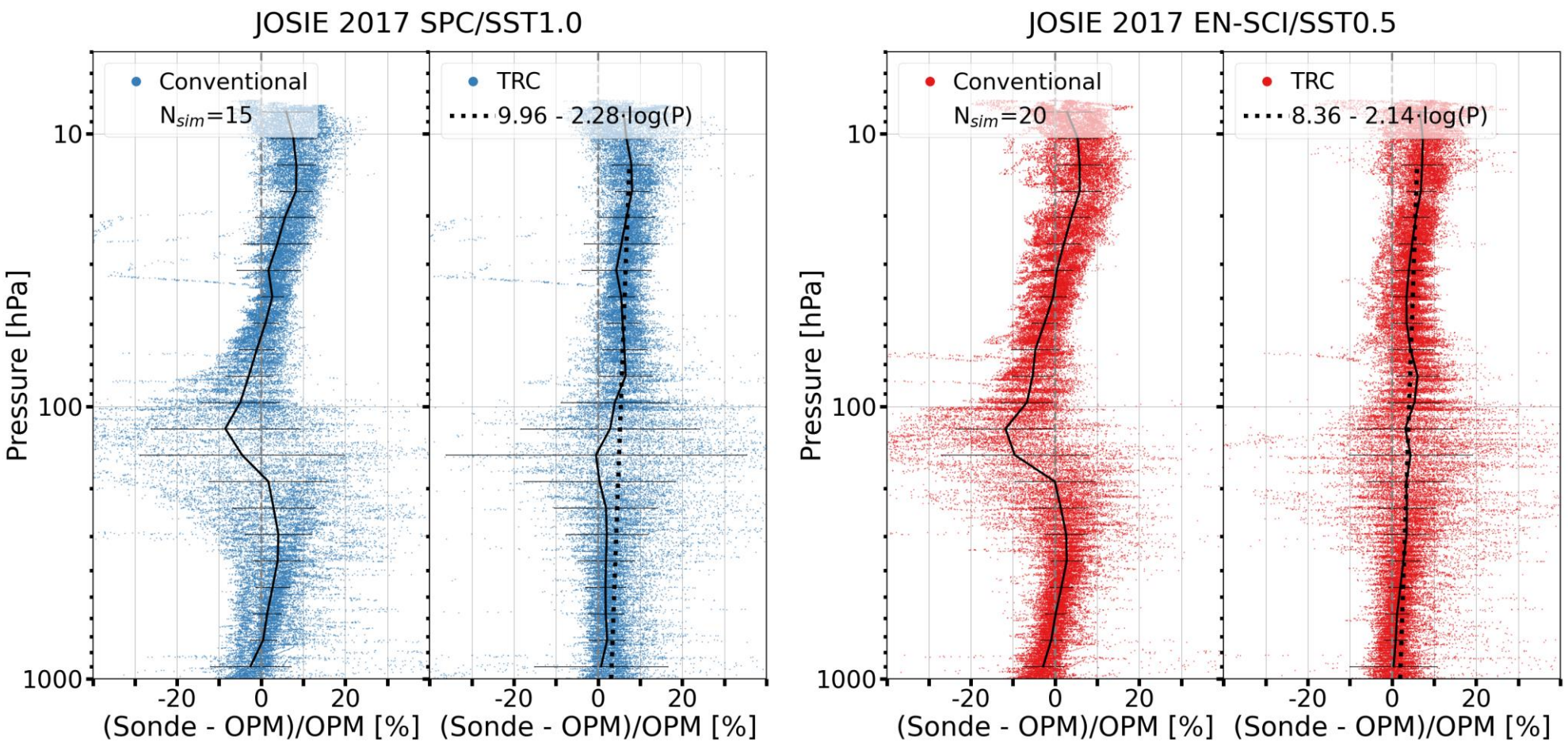
Overall, ozonesonde data of high quality… but we can do better:

- Resolving two time constants (25 s + 25 min) in the ozonesonde signal, and their respective (relative) contributions: Time Response Correction (TRC)
- Analyzing all previous JOSIE campaign data (reference instrument!); some of them including dedicated time response tests.
- Using actual measured pump flow efficiencies from *Nakano & Morofuji, AMT, 2023*
- Measurements referred to ozone photometer in Jülich simulation chamber
- Described in *Smit et al., AMT, 2024 & Vömel et al., AMT, 2020*

Data (re)processing

New Data Processing (TRC): on JOSIE 2017 (tropical) data

Comparison with reference ozone photometer in simulation chamber

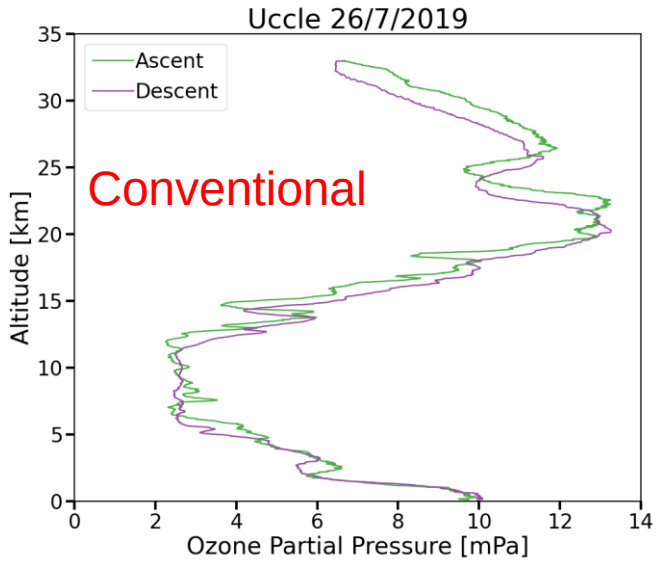


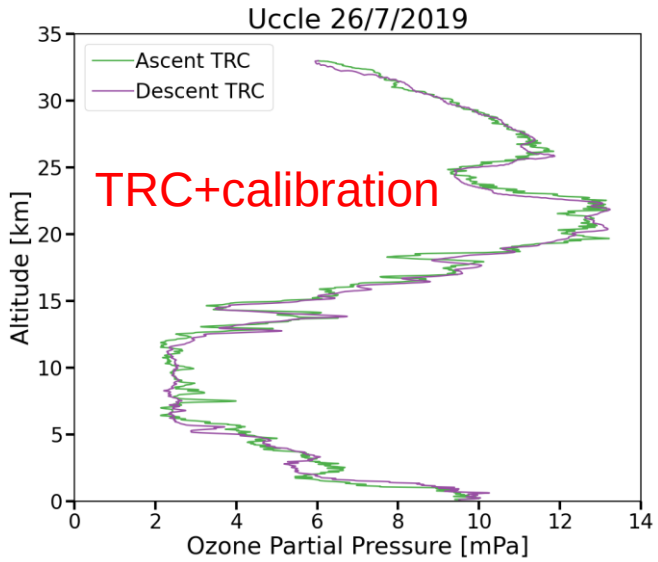
- Large reduction of rel. differences UT!
- Major improve-ment with TRC: independent on ozone profile or pressure
- Slightly linearly increasing bias with decreasing pressure: ***calibration functions***

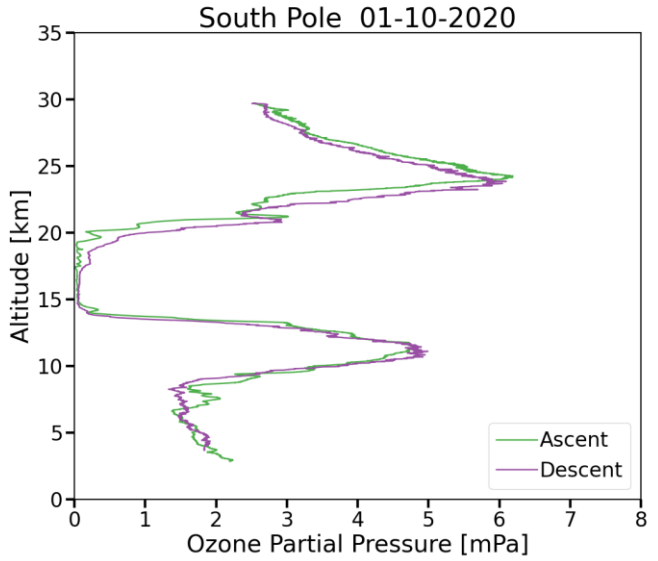
2 recommended standard combinations in the network

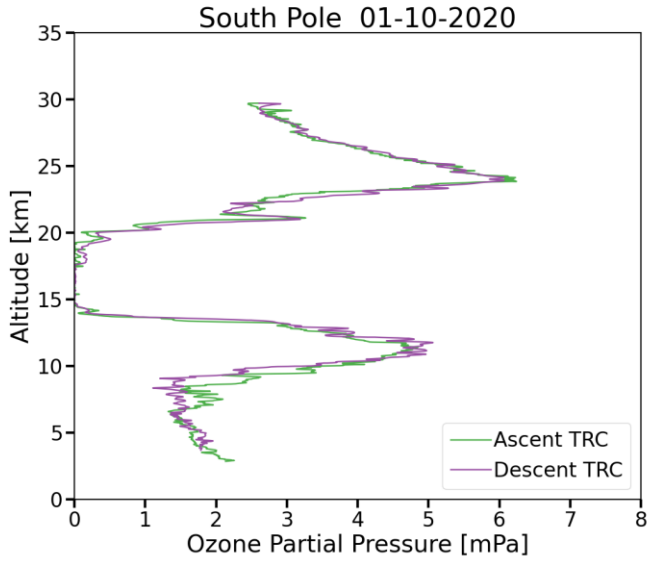
Data (re)processing

New Data Processing (TRC): on sounding data









- Remarkably improved agreement between ascent and descent profiles (→ correction for fast time response component) with TRC+calibration
- Also better agreement in ascent/descent profile shapes with TRC+calibration
- Amplification of features in TRC+calibration profiles after correcting for the fast time constant (>< increased noise?)

(Meta)data Archiving and Formats

- WMO GAW No. 268, Annex B: **guidelines to harmonize the metadata** definition and content between the different archives! How much and which (meta)data should be archived (min – optimum – max)?
- Agreement between **different data archives** (WOUDC, NDACC, SHADOZ) to follow those guidelines (+ metadata required for new processing)
- Agreement between different data archives to use one common format: **GEOMS-HDF**
- Existing **GEOMS-HDF template** for ozonesondes (EVDC) will be **updated** with additional (meta)data fields
- Extend existing (EVDC) tools to **convert the old (ascii) formats to GEOMS-HDF** (distribute tools, central processing, etc.)
- Interaction with **radiosonde manufacturers** for implementation in their **software**

Conclusions and Outlook

- Last 5 years: a lot of effort in **harmonizing** operating procedures, data processing, and (meta)data archiving & formatting
- More work on (**meta)data archiving and formatting** is needed to make data more user-friendly
- Ozonesonde data **accuracy remains very high (±5-10%)**, but improvements are still possible and **continuous data quality control monitoring** is key.

Conclusions and Outlook

- Ozonesonde Network Status
  - ✓ Strength! **WCCOS** guaranteed by FZJ + RMI ensures future Quality Assurance … for now. But no long-term structural funding commitment from international bodies (e.g. ACTRIS).
  - ✓ Two Ongoing Challenges:
    - **Maintaining** ozonesonde station network (Indonesia, Irene, Lauder, closure of 2 Japanese sites). Extension (tropics! SH!) even more difficult, but Palau coming online, ongoing efforts for opening up additional African site (Bujumbura?, Abuja)
    - **Data archiving**: Stations launch but do not archive data at e.g. WOUDC, NDACC
  - ✓ Replacement of **retired station PIs** with scientists?
  - ✓ Better engage **Asian** ozonesonde networks (Chinese/Indian/Japanese) in international activities (JOSIE, O3S-DQA)

THANK YOU

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