



Koninklijk Meteorologisch Instituut

Institut Royal Météorologique

Königliche Meteorologische Institut

Royal Meteorological Institute

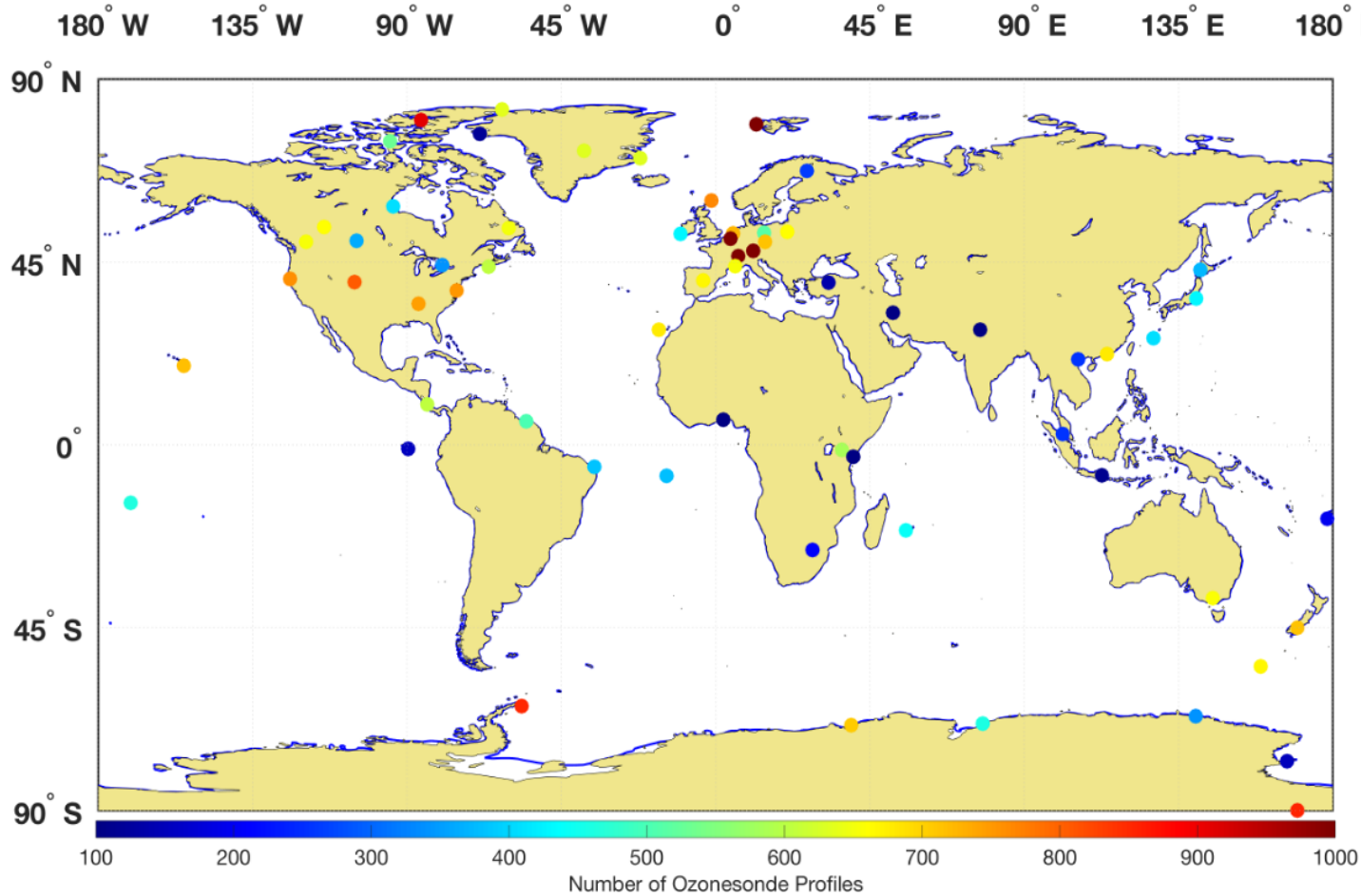
International Ozonesonde Activities

Roeland Van Malderen

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

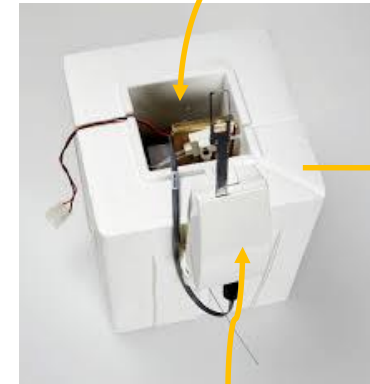
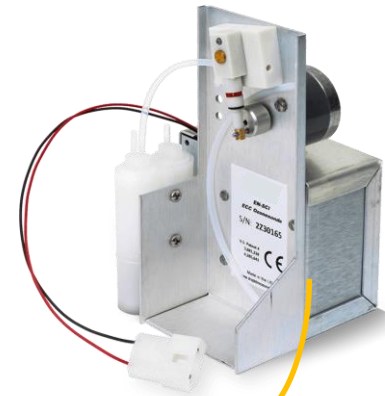
... and inputs from Herman Smit, Anne Thompson, Ryan Stauffer, Debra Kollonige, Bryan Johnson, David Tarasick, and other ASOPOS members

Introduction: the World of Ozonesondes



- ± 60 active ozonesonde sites

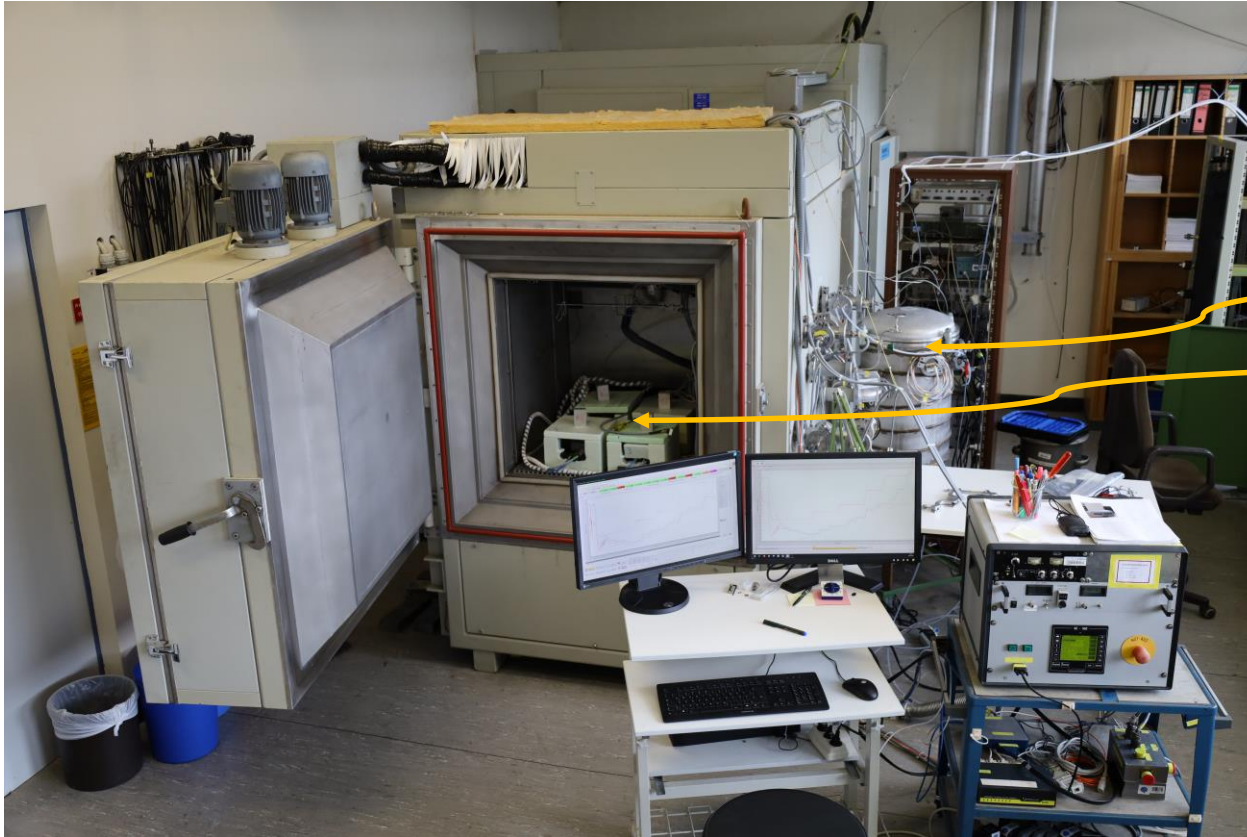
ozonesonde



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

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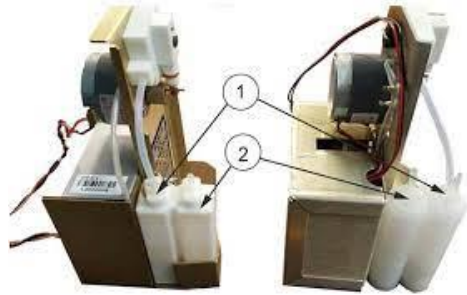


ASOPOS Panel at Brussels, Belgium (Sept. 2019)

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- Panel for the Assessment of Standard Operating Procedures for Ozonesondes (ASOPOS)

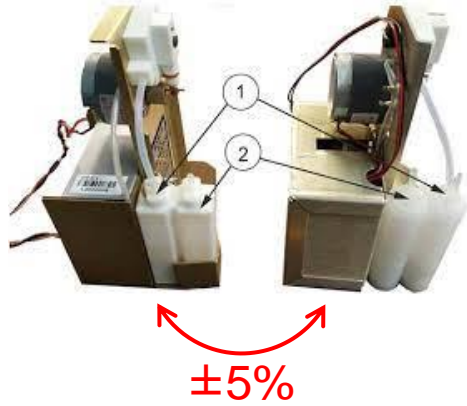
Introduction: the World of Ozonesondes

2 ECC ozonesonde
manufacturers



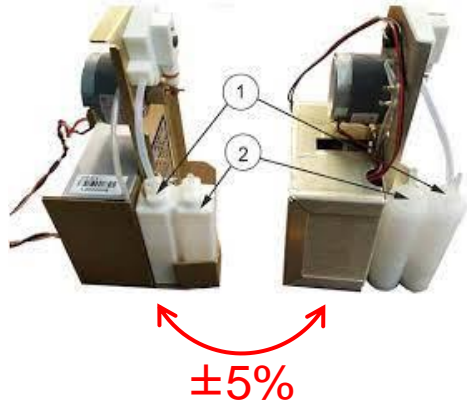
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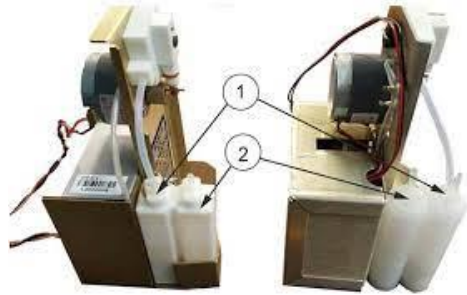


different sensing
solution strengths



Introduction: the World of Ozonesondes

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$\pm 5\%$

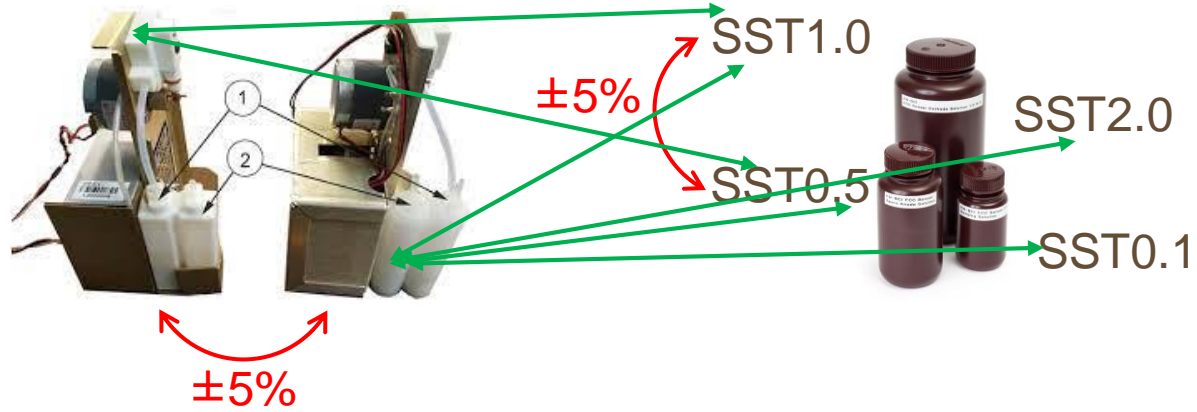
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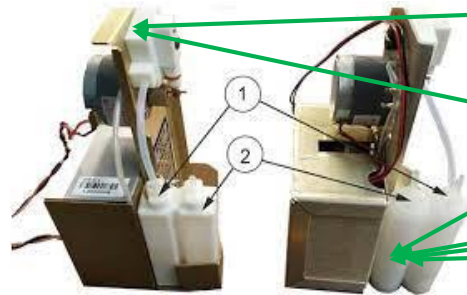
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manufacturers

different sensing
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Introduction: the World of Ozonesondes

2 ECC ozonesonde manufacturers

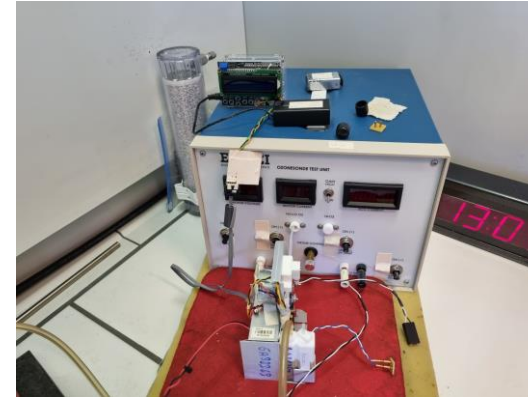


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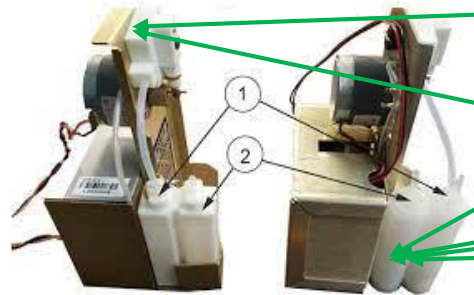


ozonesonde preparation



Introduction: the World of Ozonesondes

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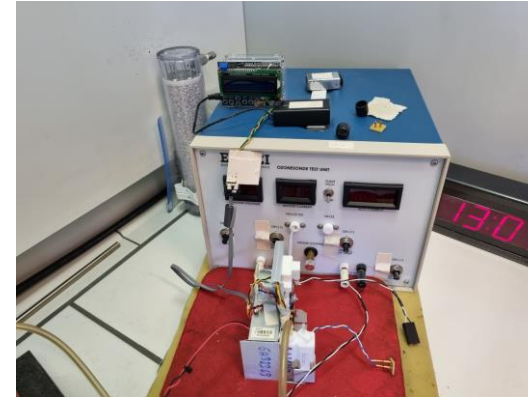


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different sensing solution strengths



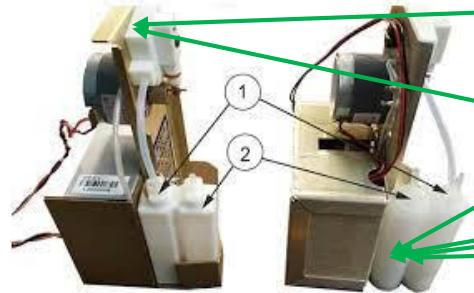
ozonesonde preparation



OPERATING PROCEDURES

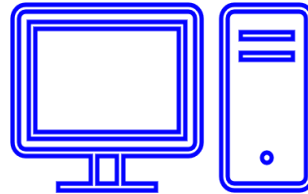
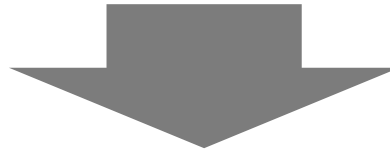
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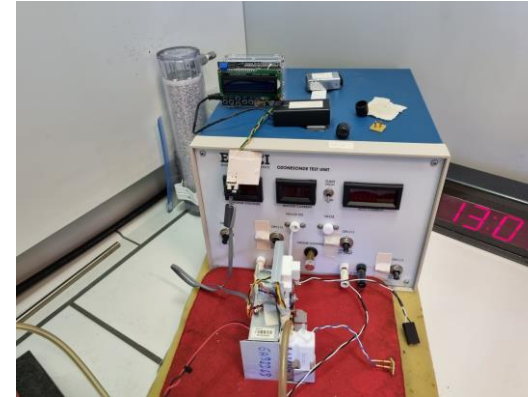


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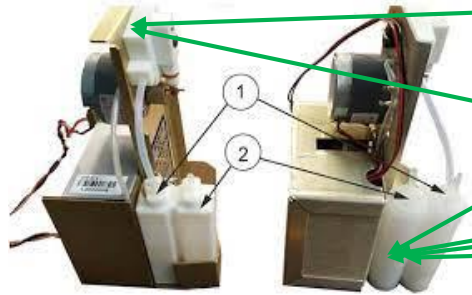


OPERATING PROCEDURES

PROCESSING

Introduction: the World of Ozonesondes

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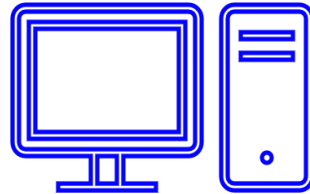


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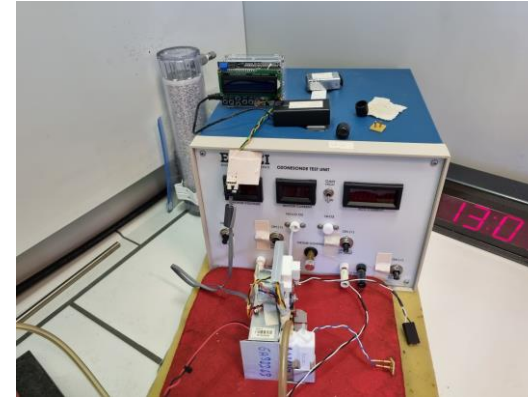
different sensing solution strengths



different data correction steps, that also changed over time.



ozonesonde preparation

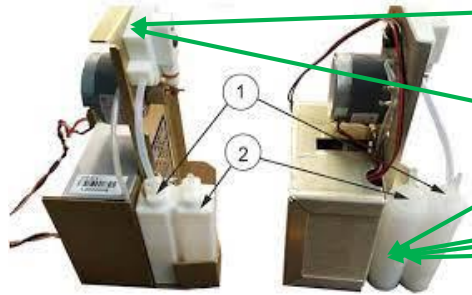


OPERATING PROCEDURES

PROCESSING

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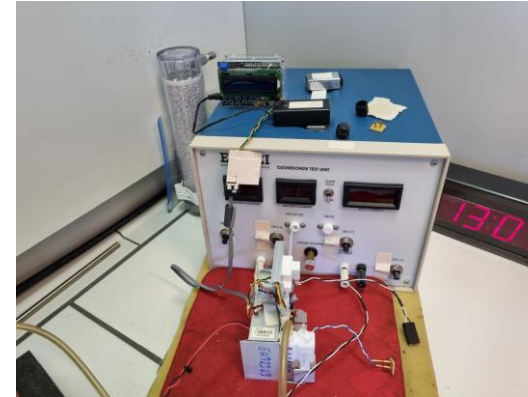


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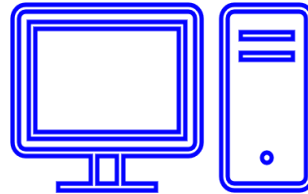


ozonesonde preparation



OPERATING PROCEDURES

different data correction steps, that also changed over time.

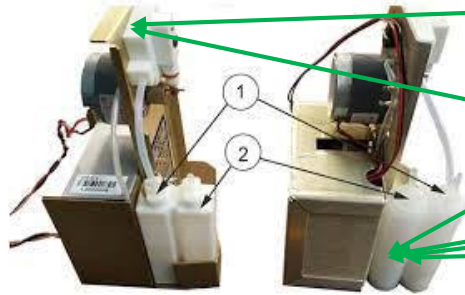


PROCESSING

ARCHIVING

Introduction: the World of Ozonesondes

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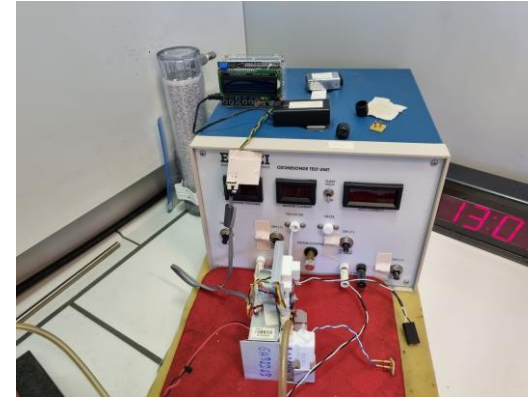


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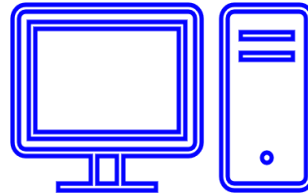


ozonesonde preparation



OPERATING PROCEDURES

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PROCESSING

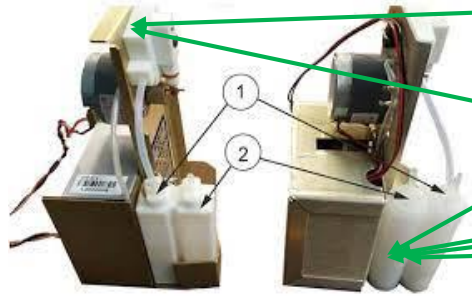


AVDC
EVDC
CDS
etc.

ARCHIVING

Introduction: the World of Ozonesondes

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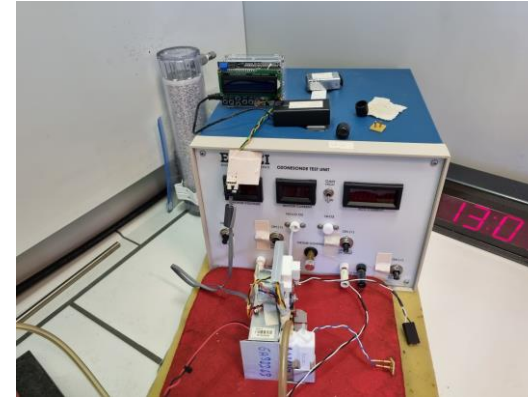


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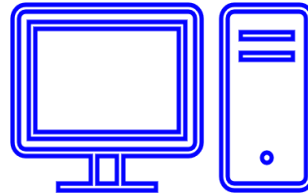


ozonesonde preparation



OPERATING PROCEDURES

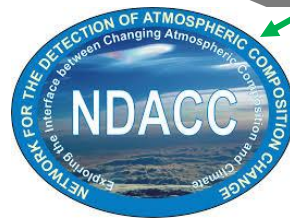
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PROCESSING

different data in those different databases

in different (ascii) data formats



ORM 12 Meeting, 24-26 April 2024, Geneva (Switzerland)



AVDC
EVDC
CDS
etc.

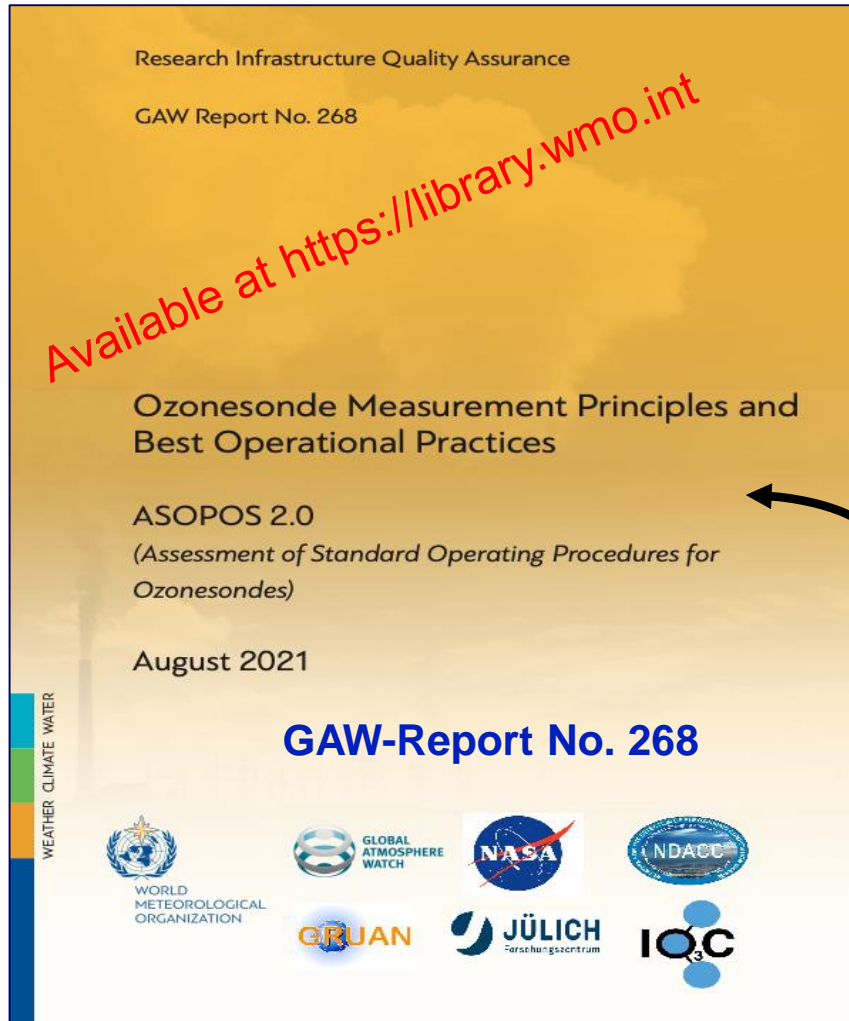
ARCHIVING

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 Ozone Measurements in GAW”

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

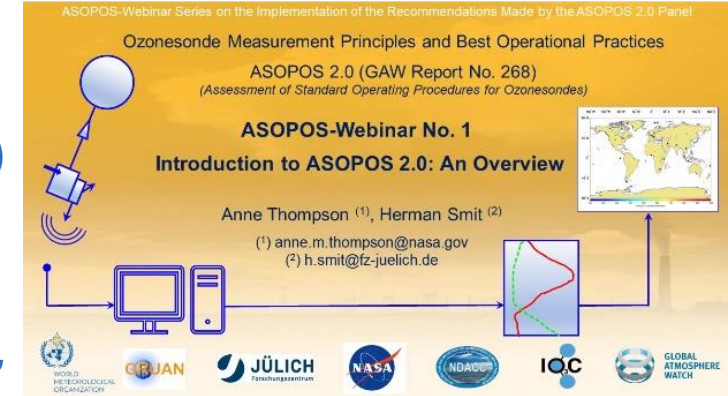
WMO/GAW Report No. 268 Chapters have been “translated” into

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



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 ⁽¹⁾, Herman Smit ⁽²⁾

⁽¹⁾ anne.m.thompson@nasa.gov
⁽²⁾ h.smit@fz-juelich.de

Logos: WMO, GRUAN, JÜLICH Forschungszentrum, NASA, NDACC, IOC, 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 Stauffer¹ and Holger Vömel²

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

Version Dec 2022

Logos: WMO, GRUAN, JÜLICH Forschungszentrum, NASA, NDACC, IOC, GLOBAL ATMOSPHERE WATCH



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“



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Comparison with SBUV total column ozone from sfc-25 hPa

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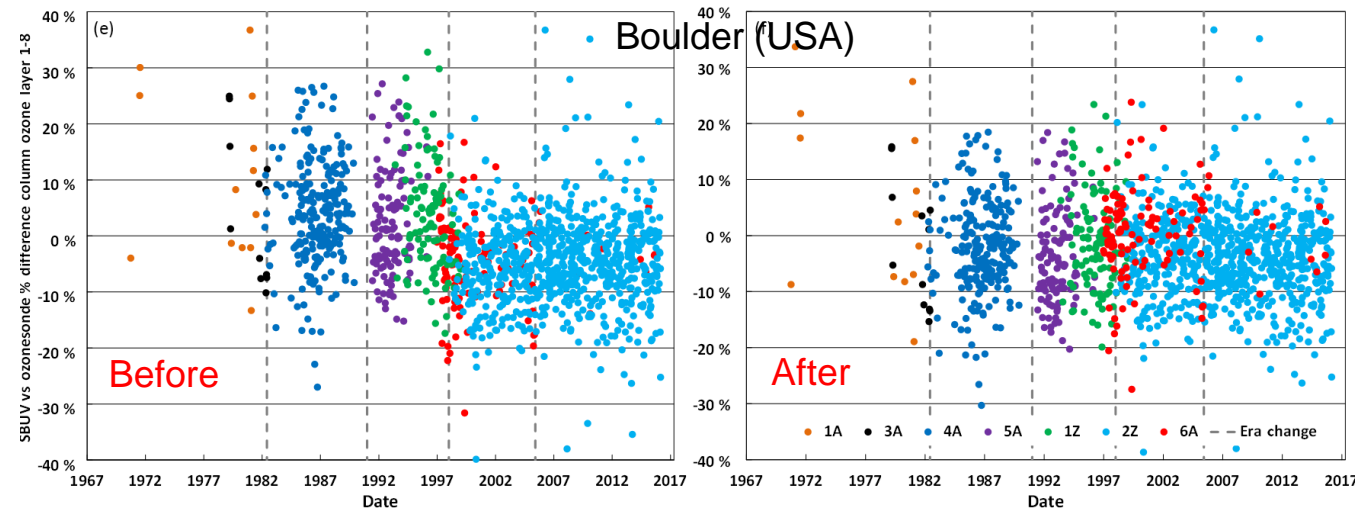
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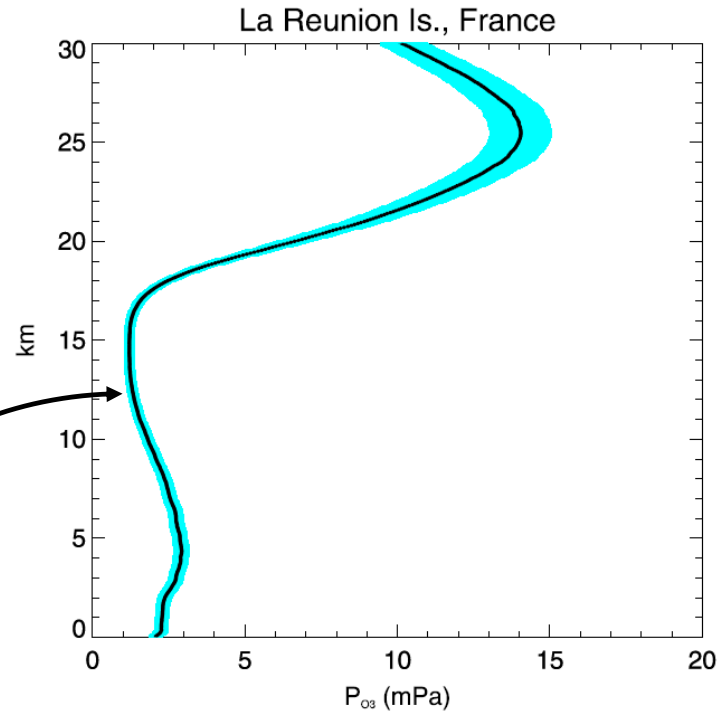


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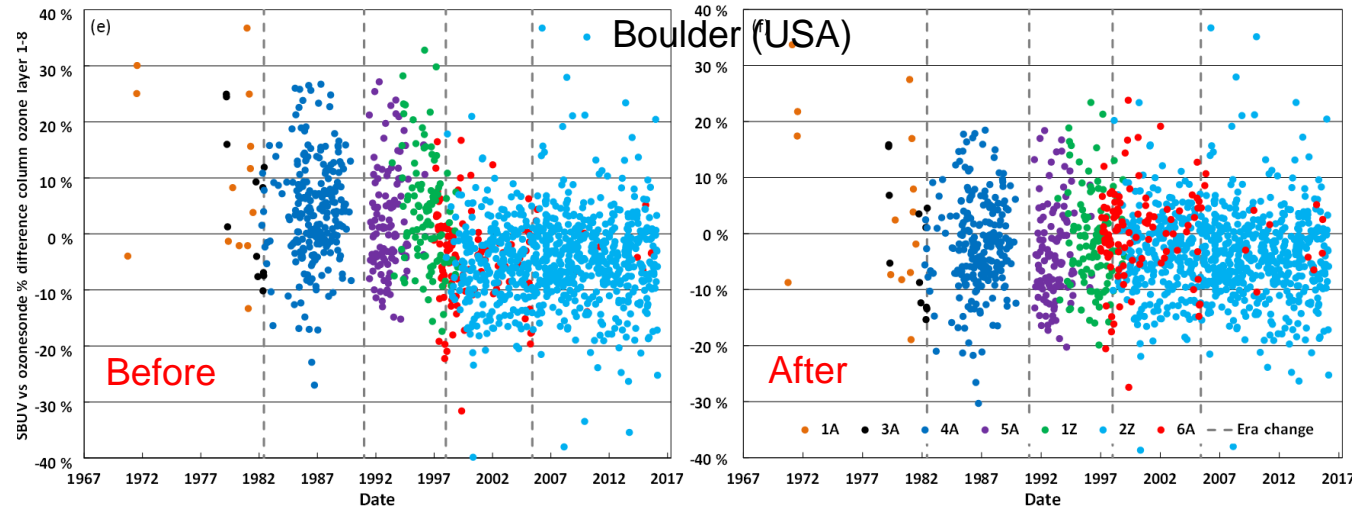
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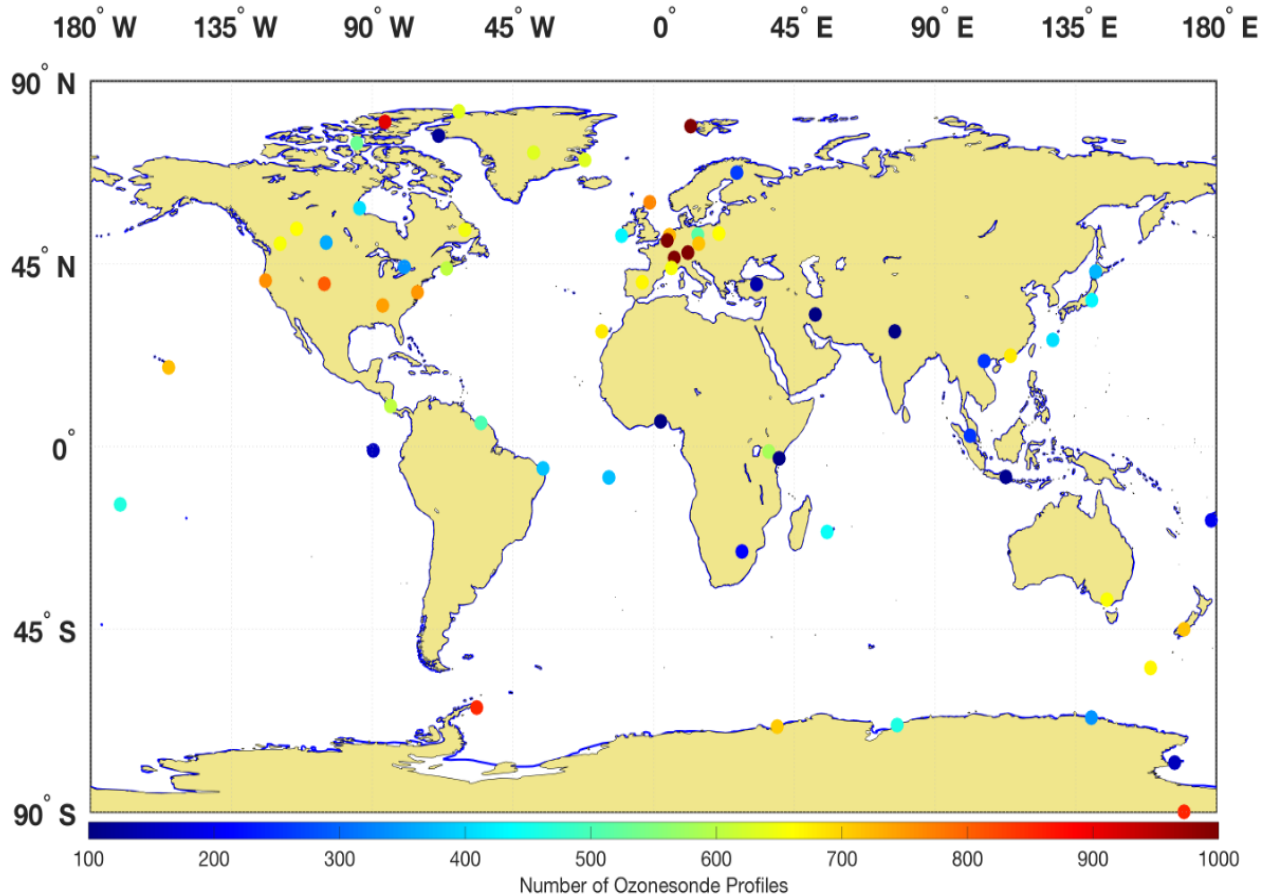
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O3S-DQA Homogenization



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- Remaining: Japanese, Asian, Australian, some EU and Antarctic sites.

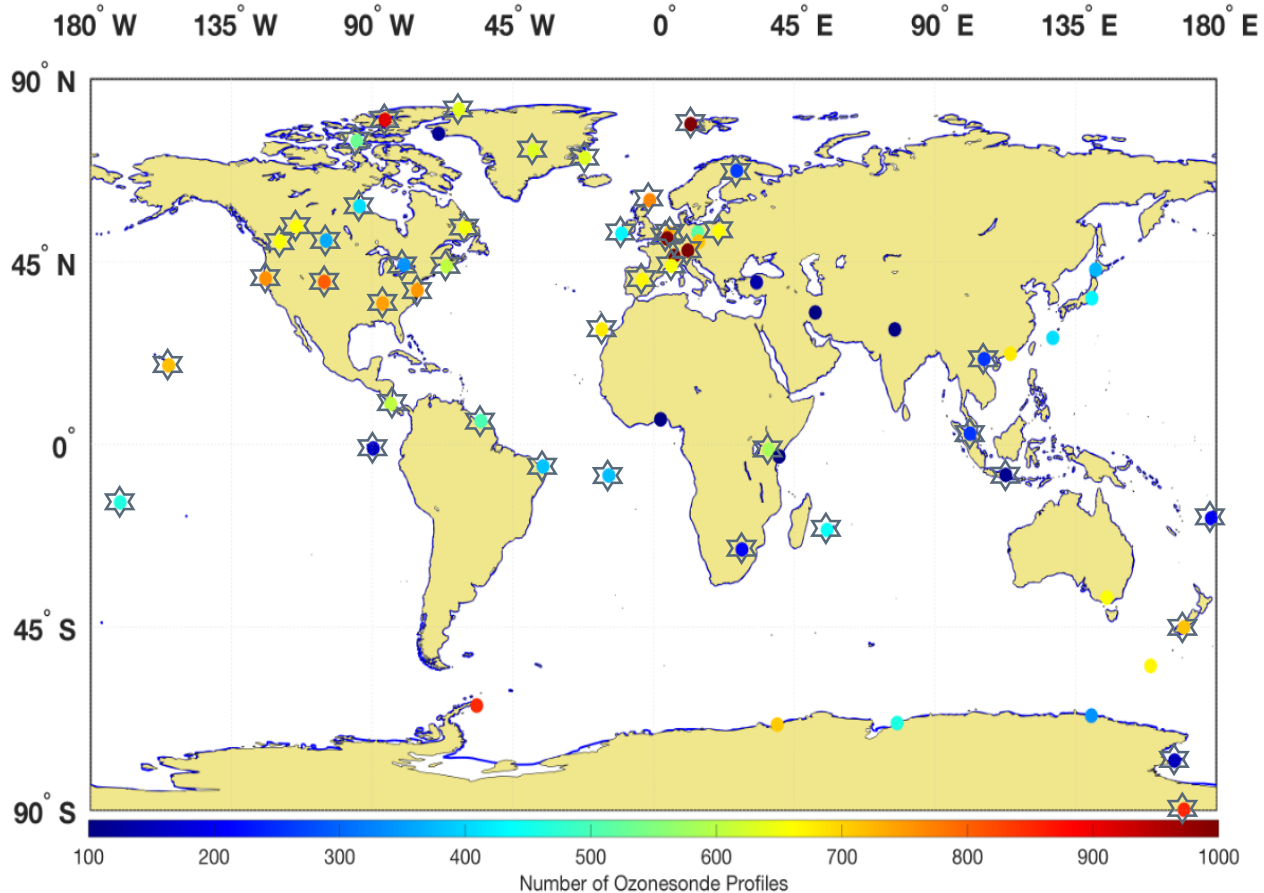
- Publications:

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- ✓ *Witte et al., JGR 2017, 2018, 2019*
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- ✓ *Sterling et al., AMT, 2018*
- ✓ *Ancellet et al., AMT, 2022*
- ✓ *Zeng et al., ACPD, accepted*
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- Under the TOAR-II HEGIFTOM umbrella:

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

O3S-DQA Homogenization



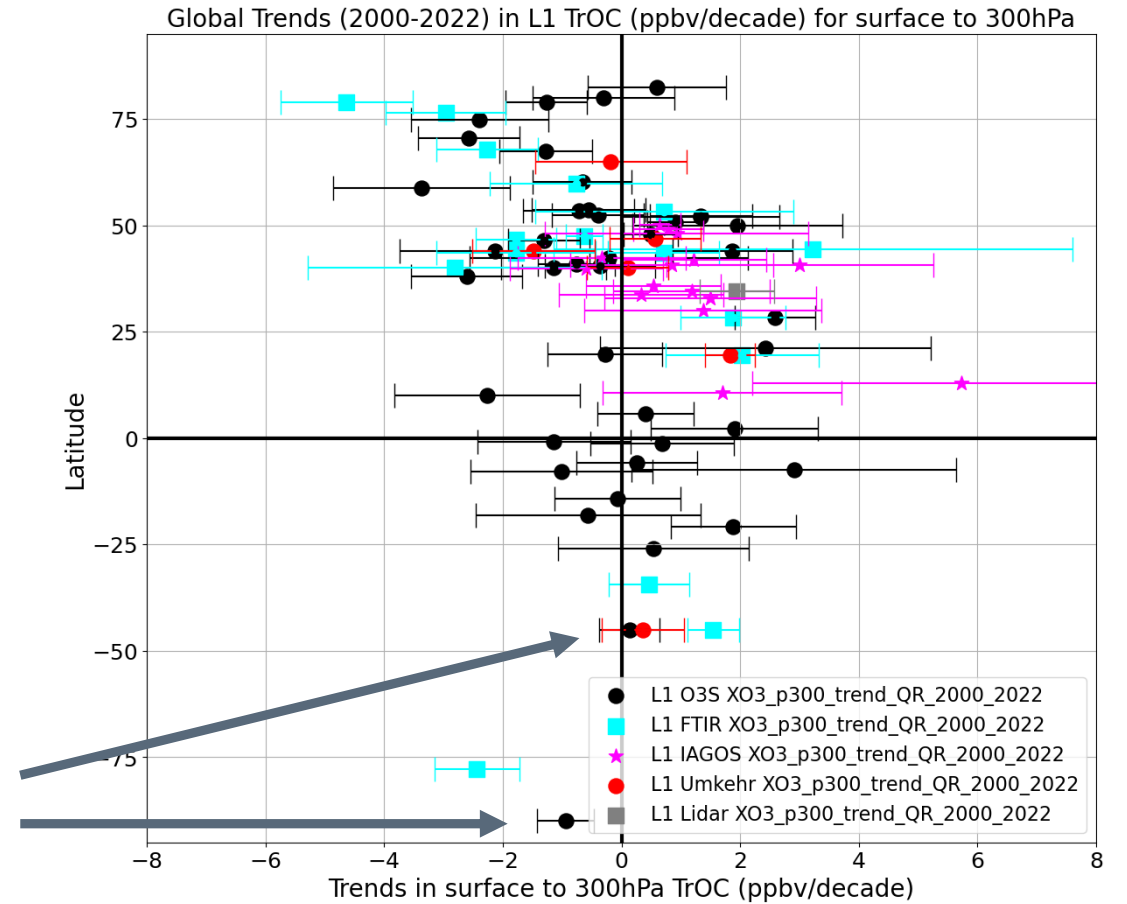
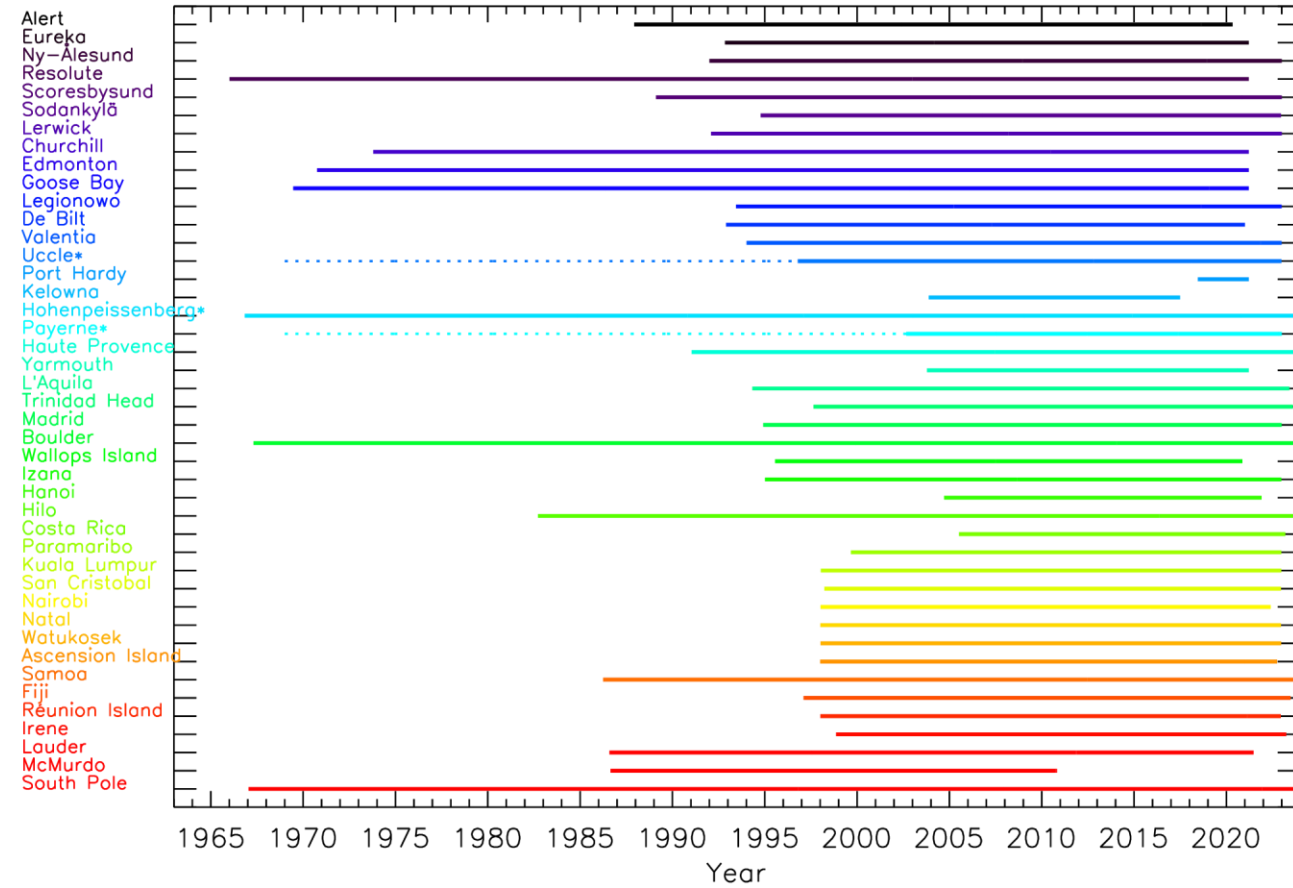
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Data (re)processing

O3S-DQA Homogenization



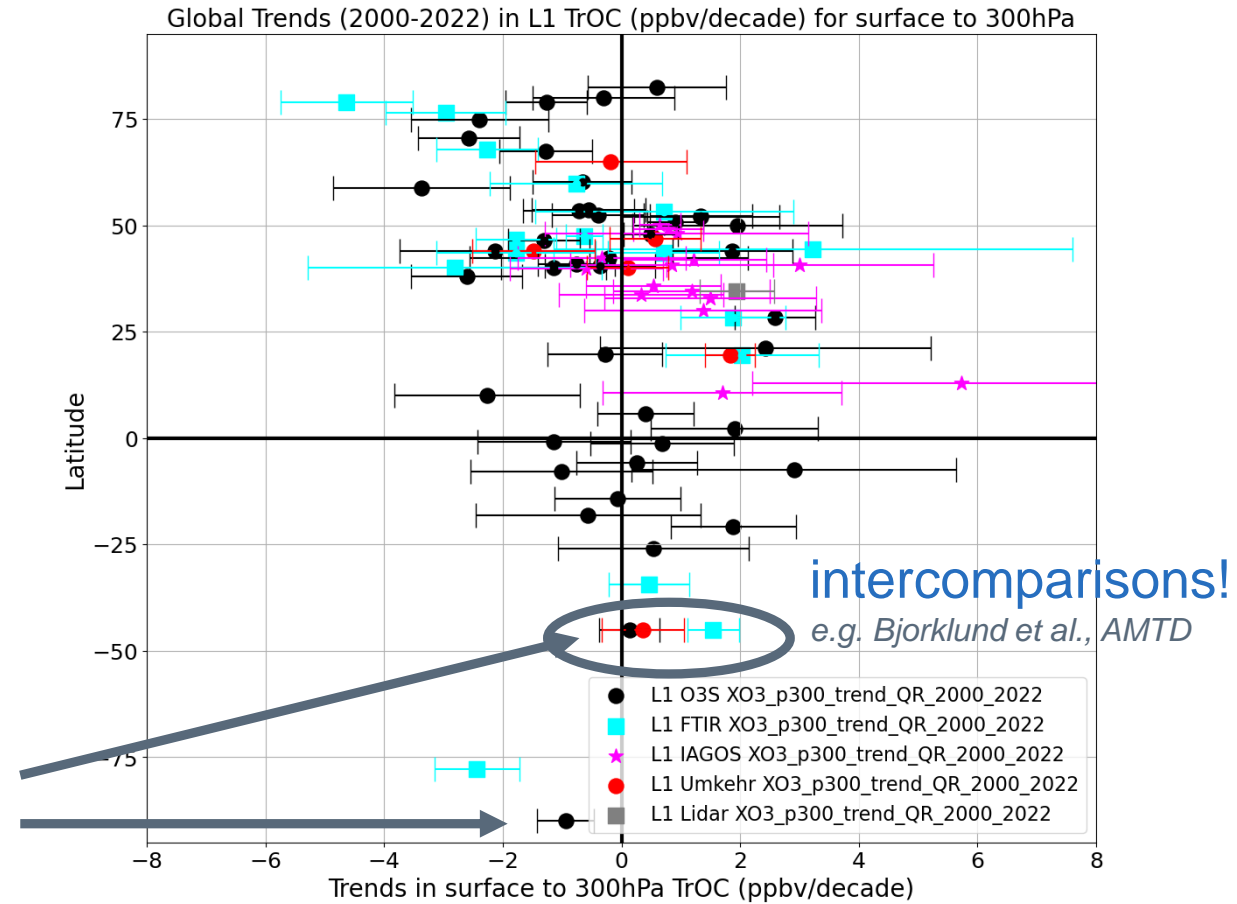
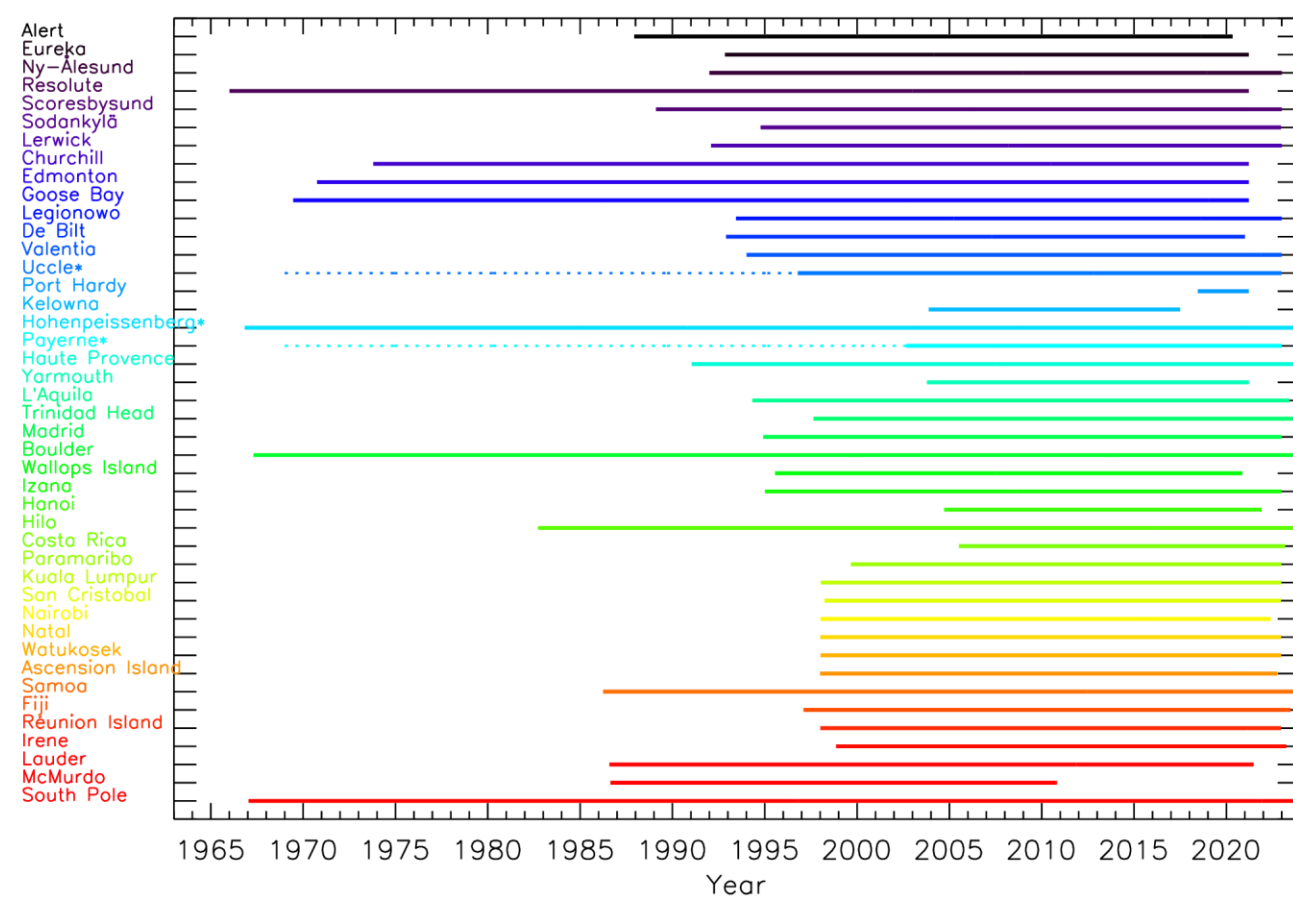
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“HEGIFTOM” tropospheric ozone column trends



Data (re)processing

O3S-DQA Homogenization



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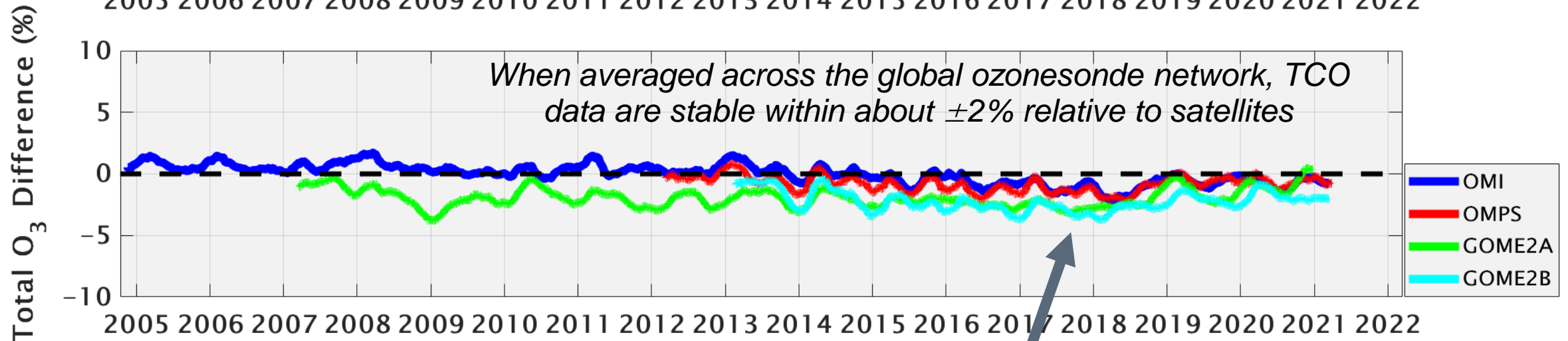
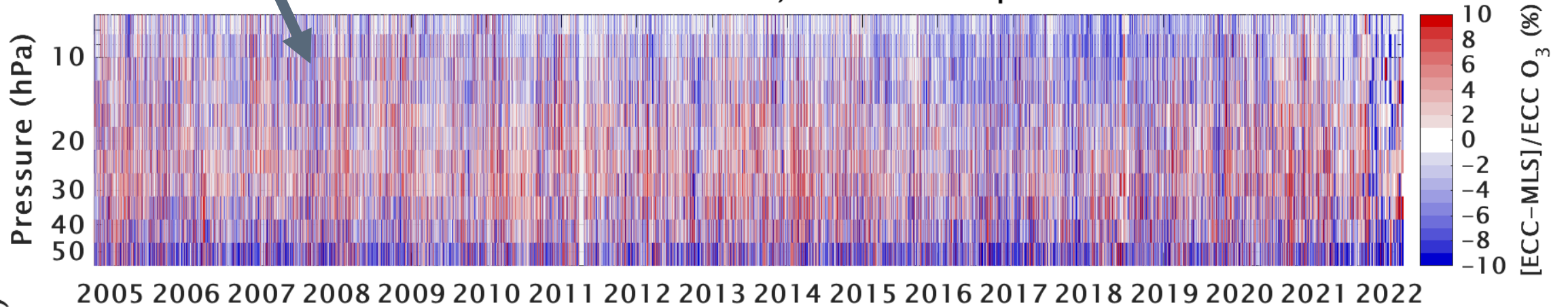


Data (re)processing

Quality Assessment/Quality Control

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

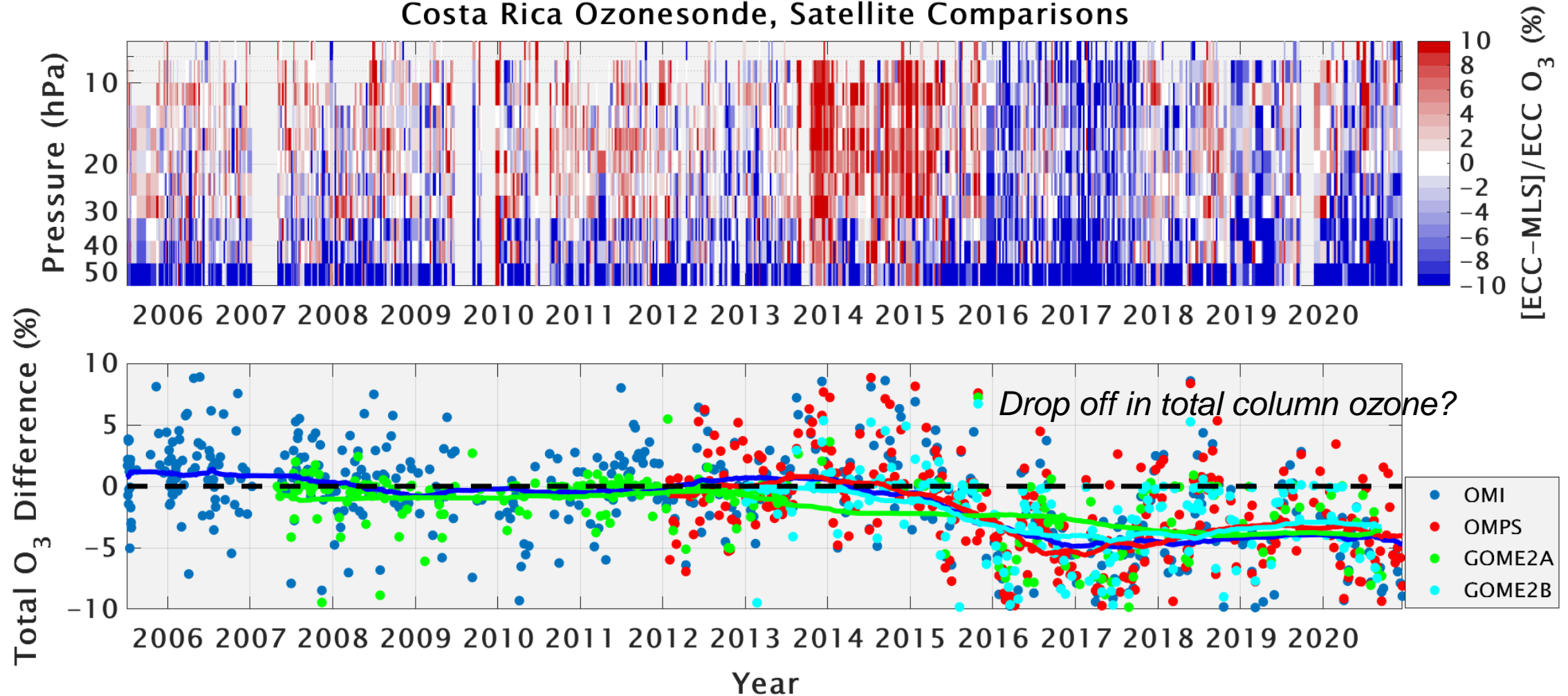
Total O₃ comparisons (500 pt. moving averages)



Data (re)processing

Quality Assessment/Quality Control

Costa Rica Ozonesonde, Satellite Comparisons



New Data Processing

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

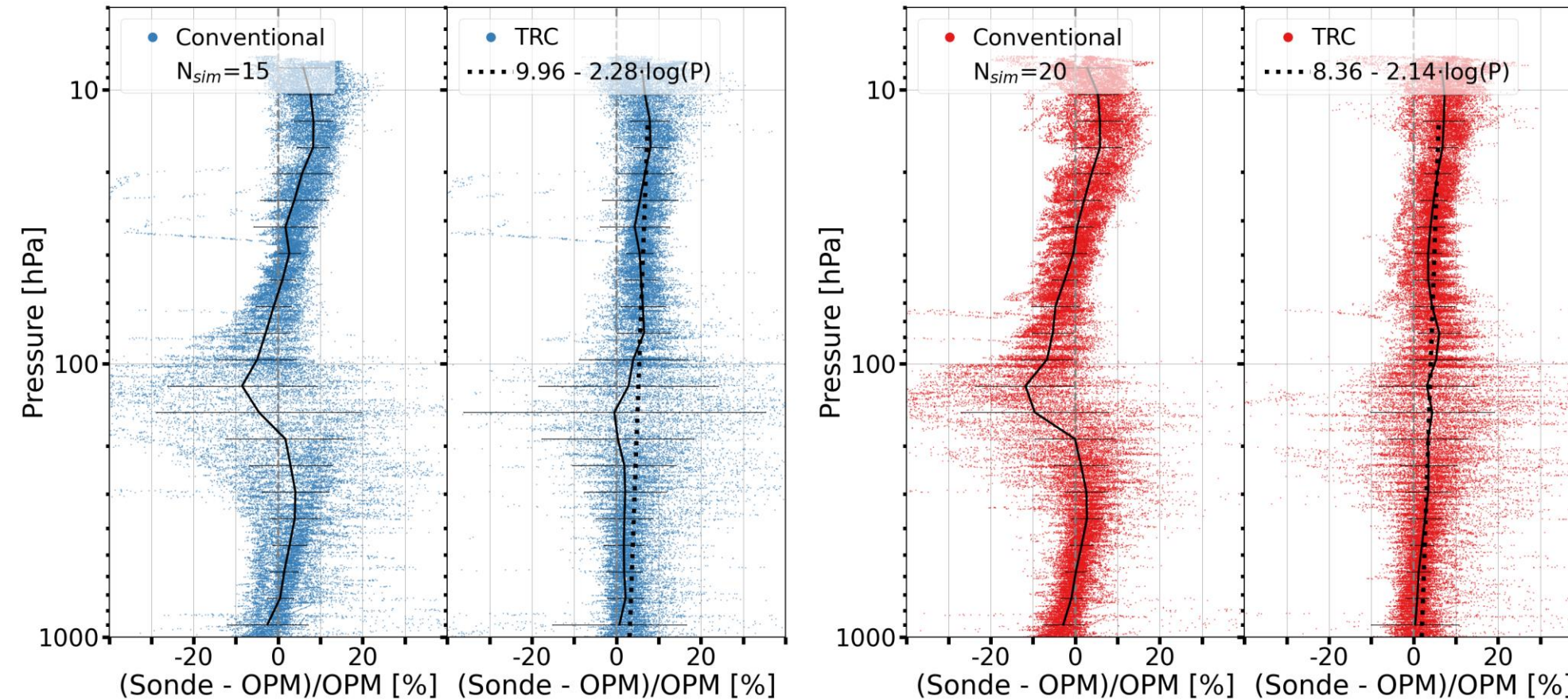
- Resolving two time constants (25 s + 25 min) in the ozonesonde signal, and their respective (relative) contributions: **Time Response Correction (TRC)**
- Analyzing all previous JOSIE campaign data (reference instrument!); some of them including dedicated time response tests.
- Using actual measured 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*

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

Comparison with reference ozone photometer in simulation chamber

JOSIE 2017 SPC/SST1.0

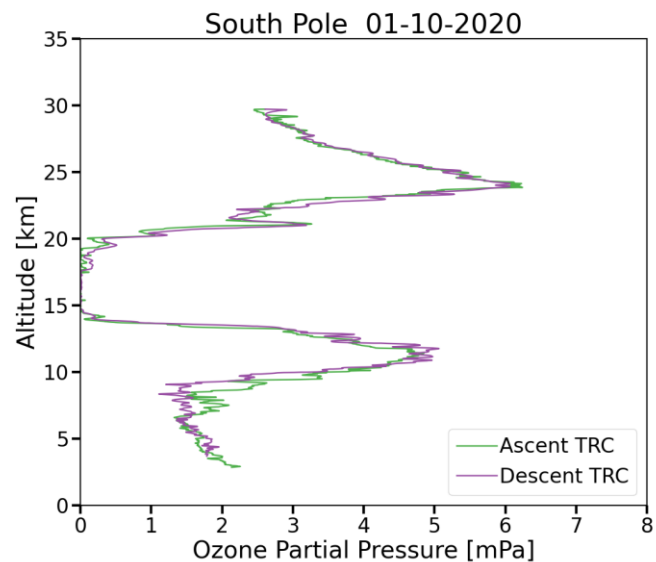
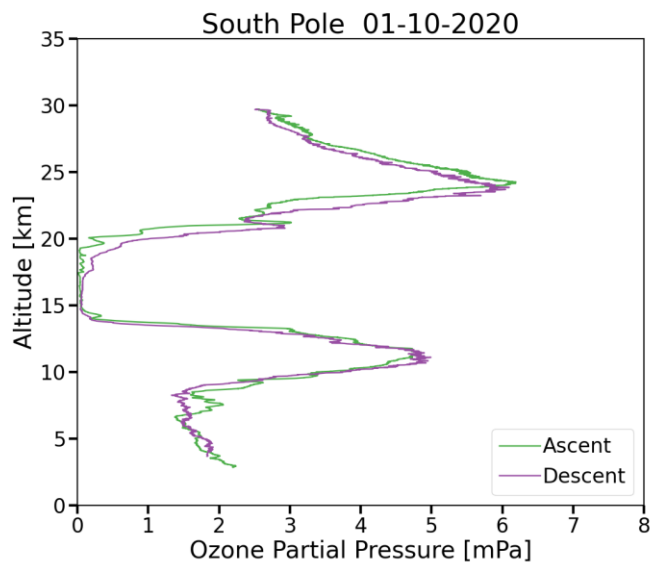
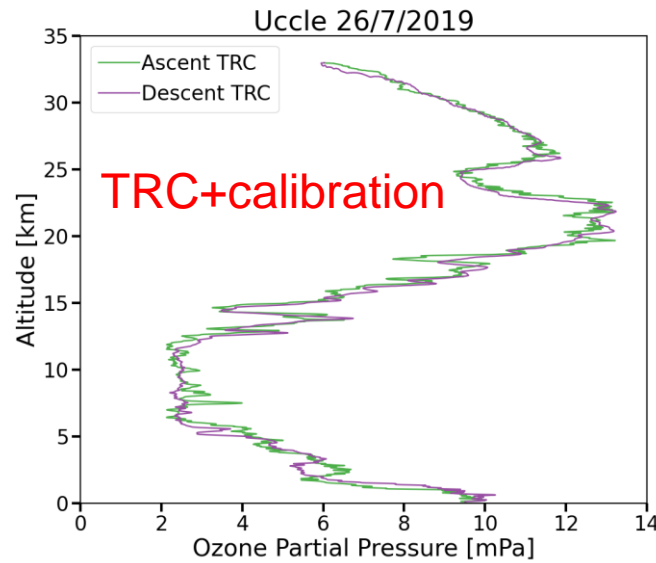
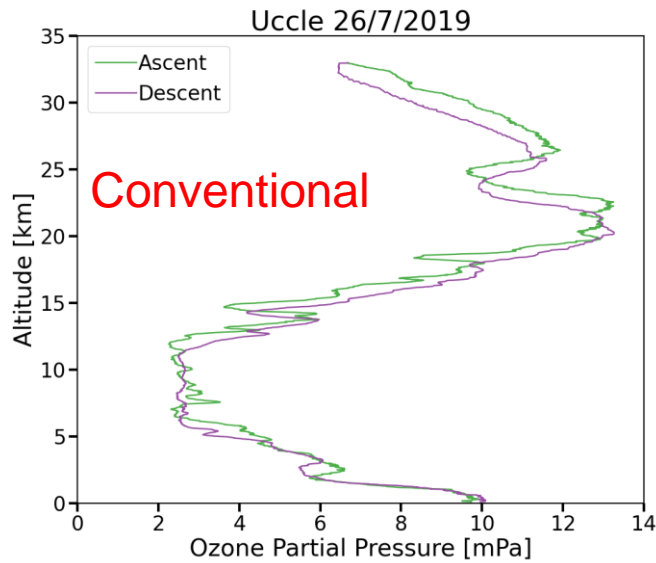
JOSIE 2017 EN-SCI/SST0.5



2 recommended standard combinations in the network

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

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 ($\pm 5-10\%$)**, 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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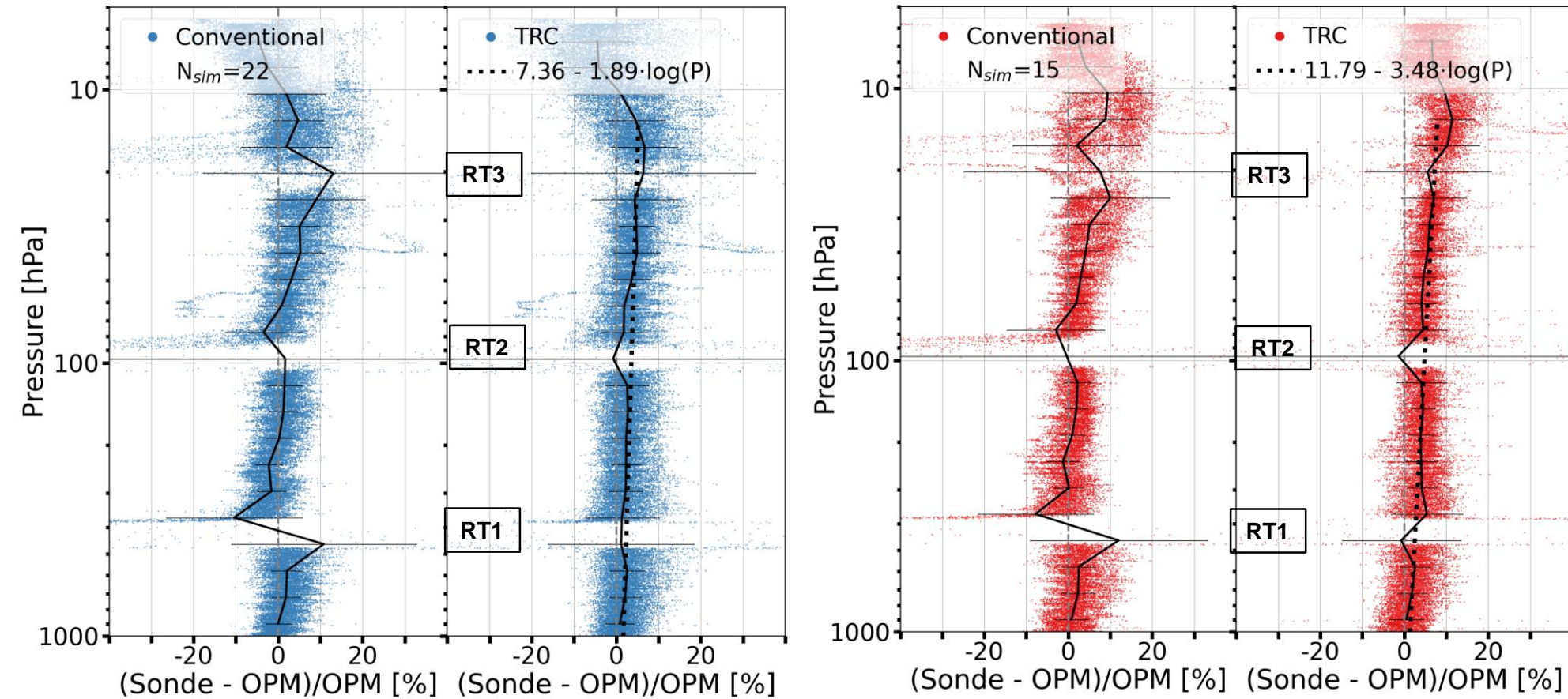
Vertrauenswürdige Dienstleistungen für Öffentlichkeit und Behörden begründet auf Forschung, Innovation und Kontinuität.

New Data Processing (TRC): on JOSIE 2009/2010 (mid-latitude) data

Comparison with reference ozone photometer in simulation chamber

JOSIE 2009/2010 SPC/SST1.0

JOSIE 2009/2010 EN-SCI/SST0.5



- Large reduction of rel. differences around response time (RT) intervals
- Major improvement with TRC: independent on ozone profile or pressure
- Slightly linearly increasing bias with decreasing pressure: **calibration functions**

2 recommended standard combinations in the network