

Panel for the Assessment of Standard Operating Procedures for Ozonesondes (ASOPOS) 2.0: overview and current activities

Roeland Van Malderen, Herman Smit, Anne Thompson, Ryan Stauffer, Debra Kollonige, David Tarasick, Bryan Johnson, Holger Vömel, Peter von der Gathen, Gary Morris, Richard Querel, Jonathan Davies, Patrick Cullis

Outline

- Why ASOPOS 2.0?
- New WMO-GAW Report 268
- Implementing the new report
- ASOPOS current activities
 - ✓ (META)DATA FORMAT
 - ✓ DATA (RE)PROCESSING
 - ✓ DATA QUALITY MONITORING
- ASOPOS and WCCOS

ASOPOS 1.0



3 pillars:



JOSIE
Jülich
Ozone
Sonde
Intercomparison
Experiment

Smit et al., JGR 2007, based on:

- *JOSIE 1996 (GAW Report No.130)*
- *JOSIE 1998 (GAW Report No.157)*
- *JOSIE 2000 (GAW Report No.158)*



ASOPOS 1.0
Assessment for
Standard
Operating
Procedures for
Ozone
Sondes

*Meeting September 2004
at FZJ, Juelich (Germany)*



BESOS 2004
Balloon
Experiment on
Standards for
Ozone
Sondes

Deshler, JGR, 2008



ASOPOS 1.0 Report:

“Quality Assurance and Quality Control
for Ozone Sonde Measurements in GAW

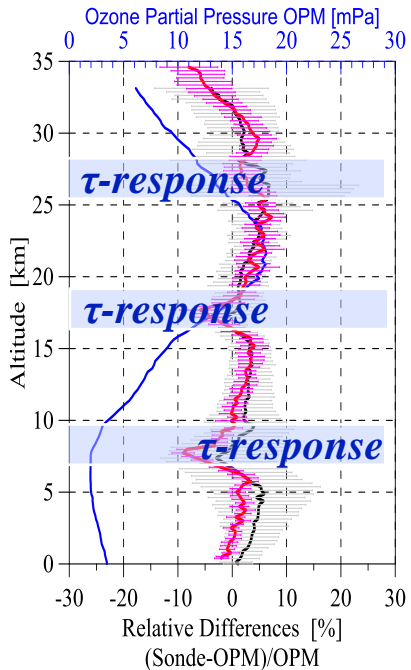
GAW Report # 201 printed by WMO/GAW
(2014)

➤ **Achievement: 10 % uncertainty in the global network**

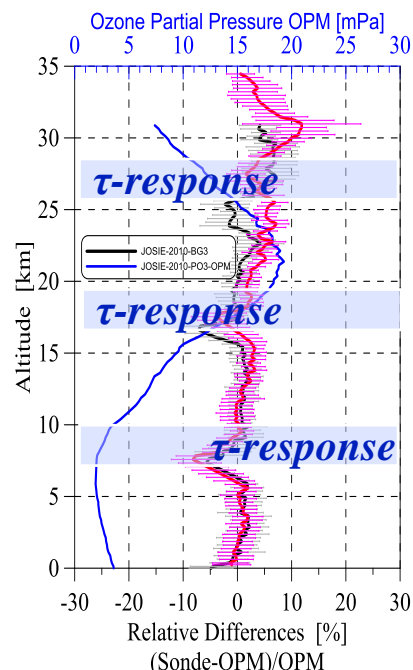
ASOPOS 1.0 +

JOSIE 2009 (Brand New) & JOSIE 2010 (Refurbished)

SPC-6A & SST1.0



ENSCI-Z & SST0.5



O3S-DQA (2012-...): Homogenization of Long Term O3S Time Series

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

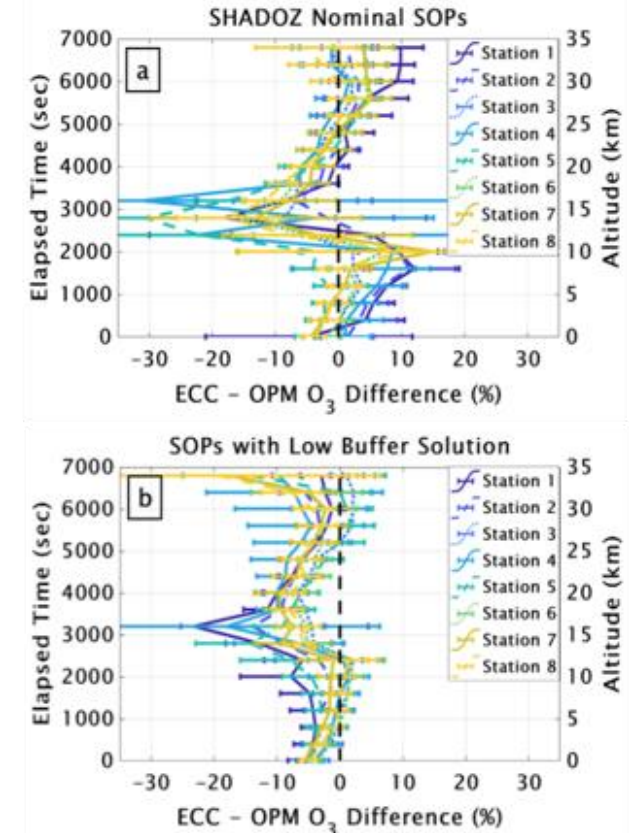
SI2N/O3S-DQA Activity:
Guide Lines for Homogenization of Ozone Sonde Data
(Version 2.0: 19 November 2012)

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“

JOSIE 2017 – SHADOZ *Thompson et al. (BAMS, 2019)*



- Confirmed earlier JOSIE & BESOS results: Consistent & systematic differences for SPC-6A & ENSCI using SST1.0 and SST0.5
- Precision $\approx 3\%$ for brand new sondes and $\approx 5\%$ for refurbished sondes, resp.

- Resolving after established guidelines all known inhomogeneities in ozonesonde data records
- Improve the uncertainty from 10-20% down to 5-10%.

- Confirmed earlier JOSIE & BESOS results, also on systematic bias effects deploying different SST's and Sonde types.
- **BUT: to reach 5% uncertainty even more strict and unified SOP's are needed !!!**

ASOPOS 2.0 (2016-...)

Base for ASOPOS 2.0:

- ❑ Results from JOSIE 2009/2010
- ❑ Results from Homogenisation (O3S-DQA)
- ❑ Results from JOSIE 2017-SHADOZ

Published in peer reviewed literature:

A.) on O3S Performance:

- JOSIE 2017-SHADOZ: *Thompson et al., BAMS, 2019*
- Uncertainty Budget: *Tarasick et al., ESS, 2021*
- Resolving fast and slow time response: *Voemel et al., AMT, 2020*
- TCO-Drop: *Stauffer et al., GRL, 2020 & ESS, 2022*

B.) on Homogenisation:

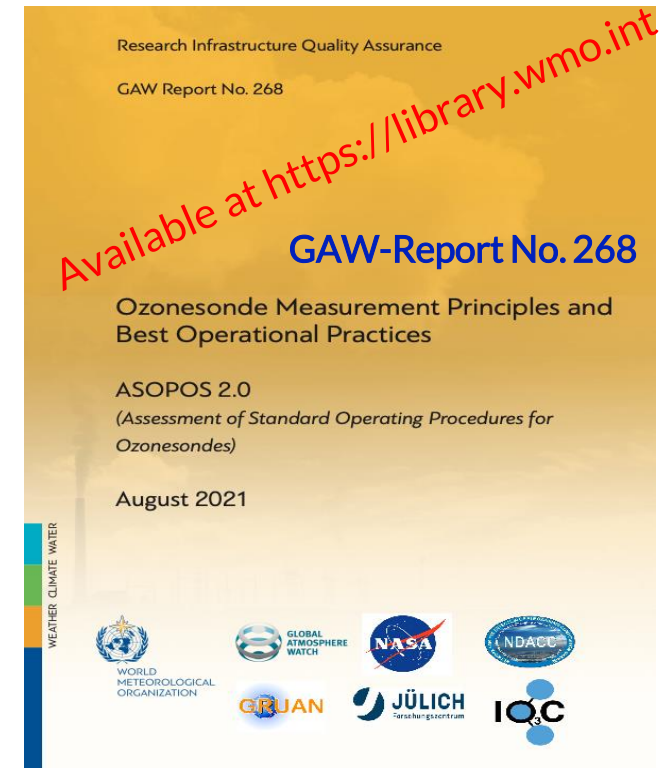
- *Tarasick et al., AMT, 2016*
- *Van Malderen et al., AMT, 2016*
- *Witte et al., JGR 2017, 2018-A & -B, 2019*
- *Thompson et al., JGR, 2017*
- *Deshler et al., AMT, 2017*
- *Sterling et al., AMT, 2018*
- *Ancellet et al., AMT, 2022*



ASOPOS 2.0

Assessment for
Standard
Operating
Procedures for
Ozone
Sondes

*Meetings September 2018 &
2019 at WMO (Geneva) & RMI
(Brussels)*



Goals:

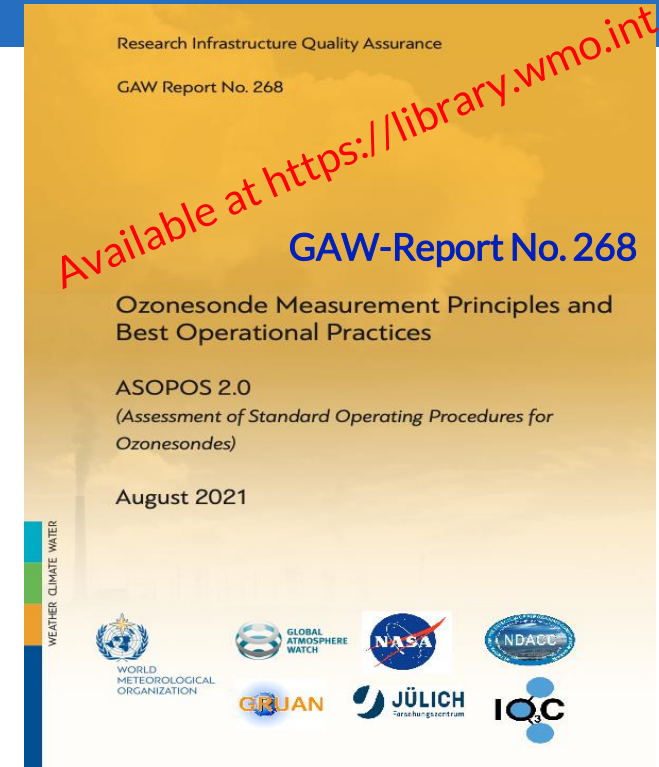
- **Uncertainty of 5 %** in the global network through the use of a single coherent set of SOPs on preparation, metadata & data processing at all ozonesounding stations in the global network
- To establish a **more effective QA-system** on data **quality control** through quasi-continuous data screening and alerting on sudden artifacts in the global network

“Ozonesonde Measurement Principles and Best Operational Practices” (WMO/GAW-Report No. 268)

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Reviewers: Maria del Carmen Cazorla (Univ. San Francisco de Quito , Ecuador), Gert Coetzee (SAWA, South Africa), Masatomo Fujiwara (Hokkaido Univ., Japan), Samuel Oltmans (NOAA, USA), Wolfgang Steinbrecht (DWD, Germany), Matt Tully (BOM, Australia)



Editors: Herman Smit (FZJ, Germany) & Anne Thompson (NASA, USA)

Lead Authors: Herman Smit, Anne Thompson, Bryan Johnson (NOAA, USA), Debra Kollonige (NASA, USA), Gary Morris (St. Edwards Univ./NOAA, USA), Ryan Stauffer (NASA, USA), David Tarasick (ECCC, Canada), Peter von der Gathen (AWI, Germany), Roeland Van Malderen (RMI, Belgium), Holger Vömel (NCAR, USA), Jacquelin Witte (NCAR, USA), Richard Querel (NIWA, New Zealand), Jonathan Davies (ECCC, USA), Patrick Cullis (NOAA, USA)

ASOPOS 2.0 Outcome: Implementation into the global network

The outcome of ASOPOS 2.0 with their important recommendations will now be implemented into the global ozonesonde network by:

- I. **On-line webinars** as video clips: Key outcome and recommendations of ASOPOS 2.0 will be compiled into a series of six webinars (Available online at WCCOS-server end of 2022)
 1. Introduction to ASOPOS 2.0: An Overview
 2. Hardware
 3. SOP: Standard Operating Procedures
 4. Data Processing
 5. Data Quality Indicators (DQI)
 6. Meta Data and Software
- II. **Regional on-line ASOPOS workshops** dedicated to the operators of the ozonesounding stations to present ASOPOS 2.0 in practice: What to do and How in practical terms? (January/February 2023)
- III. **Coaching** the ozonesonde station individually to implement ASOPOS 2.0 in practice (2023)

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(META)DATA FORMAT

WMO/GAW Report #268 sets a new standard for (meta)data archiving (→ re-processing!) including uncertainties, flagging, etc.

STEP 1: ascii Formats

- current ascii formats (NASA-Ames, WOUDC, SHADOZ, GRUAN) need to be updated to be compliant with WMO/GAW#268, but also with each other! → **streamlining ongoing**
- station PIs are open for a change in the ascii format
e.g. survey in NDACC reports on modifying NASA-Ames format:
 - *“YES”: 17 stations*
 - *“MAYBE”: 5 stations*
 - *“NO”: 2 stations*
 - *no answer: 4 stations*

(META)DATA FORMAT

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STEP 2: GEOMS-HDF/CF-netcdf formats

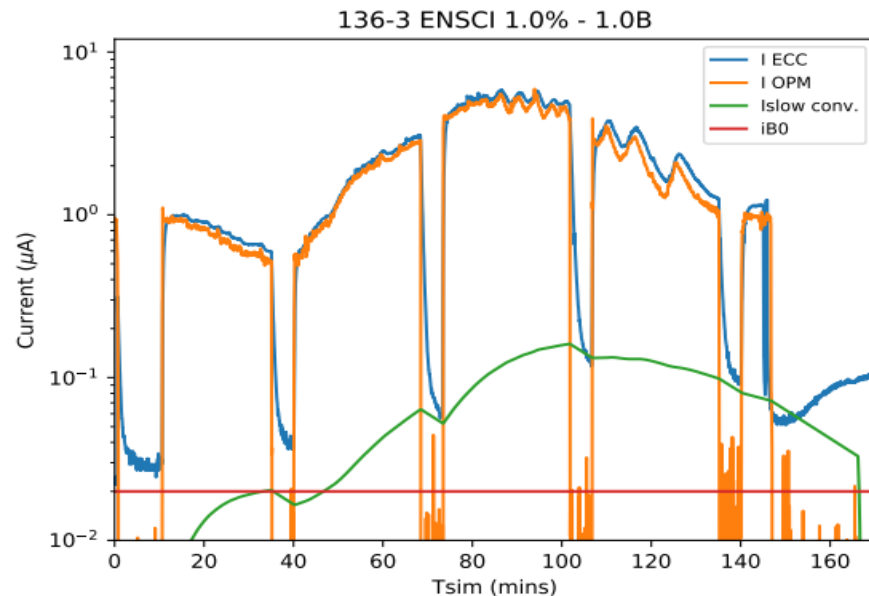
- operational ozonesonde data available in **GEOMS-HDF at EVDC & AVDC**
 - *meetings with EVDC GEOMS team (e.g. Ian Boyd, Bavo Langerock) to make their GEOMS-HDF template for ozonesondes compliant with WMO/GAW #268*
 - *exchange of code and scripts to convert ozonesonde data in NASA-Ames, WOUDC, SHADOZ, etc. to GEOMS-HDF*
- ozonesonde data will be available in **CF-netcdf at Copernicus CDS**
- different **versions** of ozonesonde site time series available (homogenized vs. operational), future reprocessing of data is envisioned.
 - *test case for conversion to GEOMS-HDF: homogenized data at temporary HEGIFTOM ftp-server (→ archives, different version)*
- code and scripts will be made available to entire community and/or central processing

DATA (RE)PROCESSING

- O3S-DQA homogenization
 - *correction for biases*
 - *uncertainties*
 - *provision of raw measurements (“currents”) for reprocessing*

➔ see HEGIFTOM talk

- new processing: resolving fast and slow time response (*Tarasick et al., ESS, 2021; Vömel et al., AMT, 2020; Smit et al., in preparation*)



I ECC: original ECC current

I OPM: current measured by reference photometer in Jülich

I slow conv.: convoluted slow part of the signal

iB0: background current

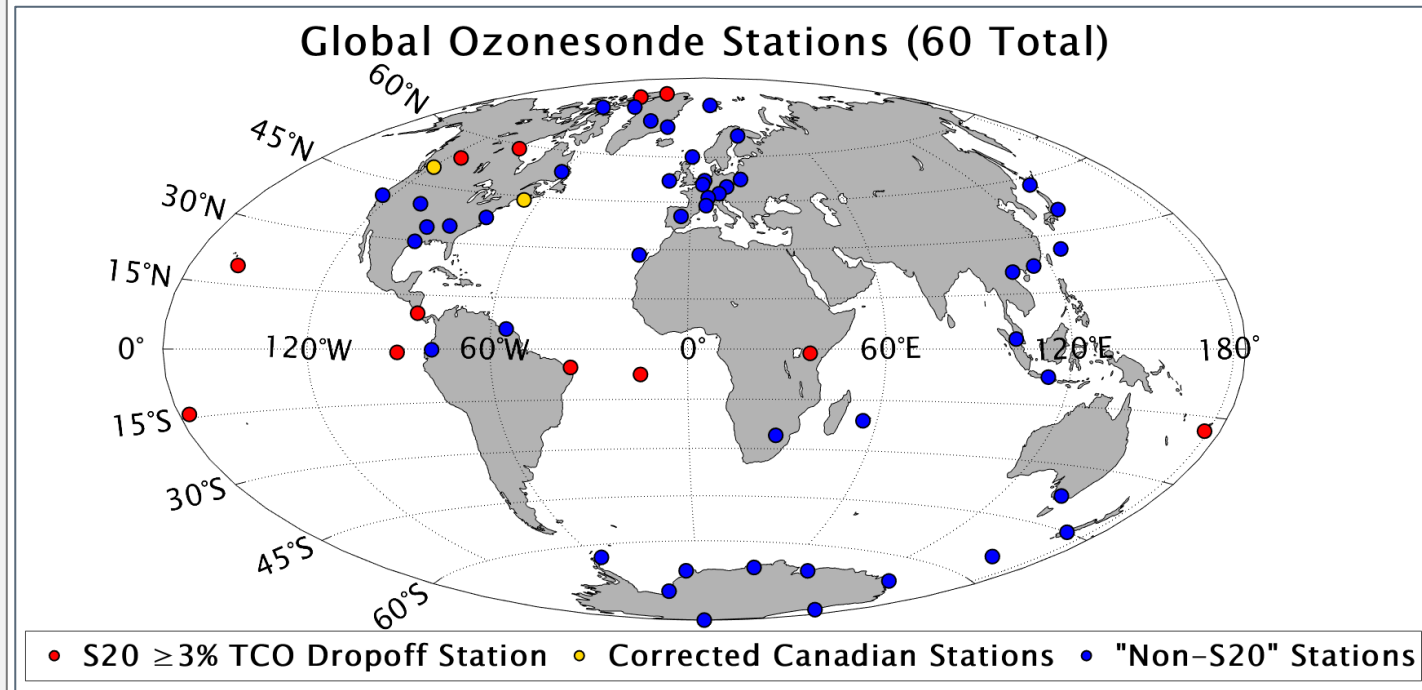
Ozonesonde response to ozone is composed of fast (20-25s) time response ($\pm 95\%$) and slow (20-25 min) time response ($\pm 5\%$).

ASOPOS 2.0 current activities

DATA QUALITY MONITORING

ASOPOS Task team for En-Sci TCO dropoff

- expansion from the 37 *Stauffer et al. GRL, 2020* (S20) stations to 60 global stations (mainly Europe and Antarctica)
- dropoff station defined as having a **3% TCO drop** relative to OMI
- Kelowna and Yarmouth Canadian station data were **missing a correction** for non-standard ozonesonde sensing solution
- >30,000 OMI and ozonesonde TCO comparisons to evaluate, in addition to other independent data



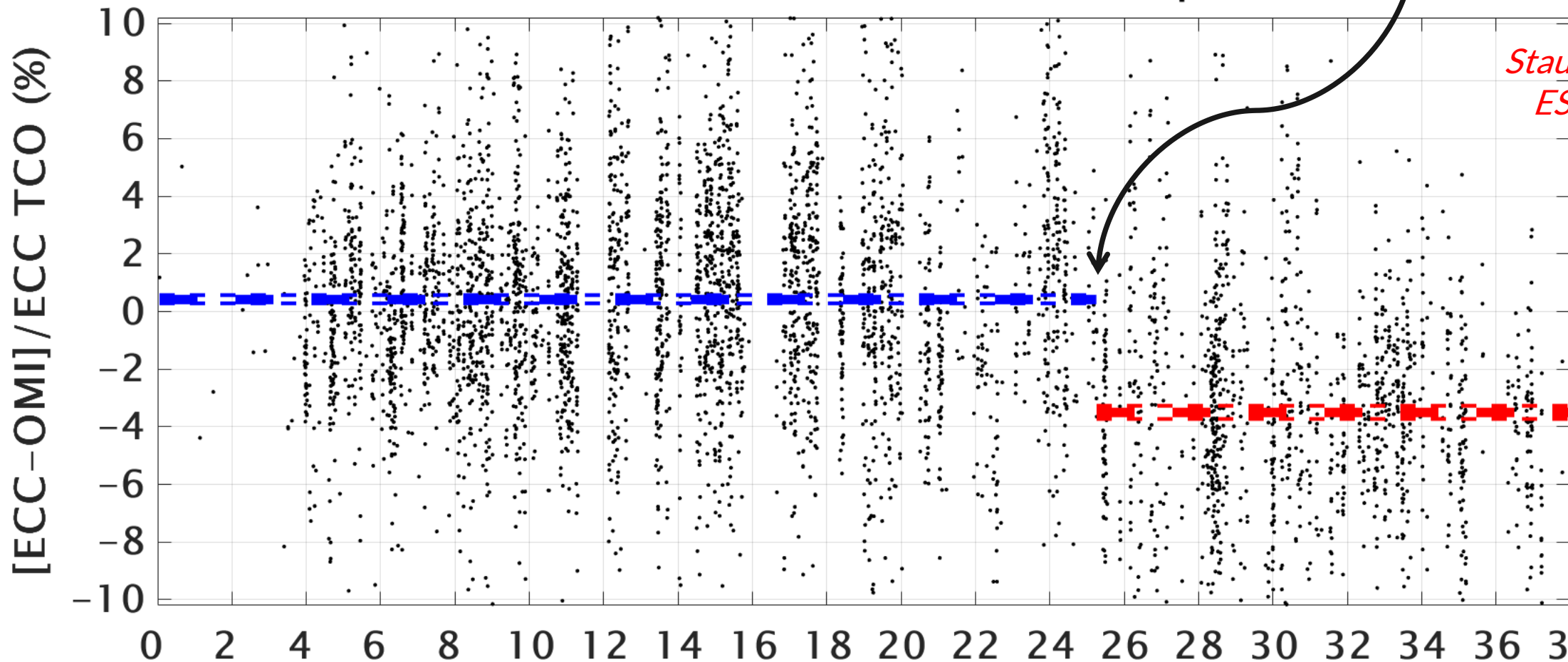
ASOPOS 2.0 current activities

DATA QUALITY MONITORING

ASOPOS Task team for En-Sci TCO dropoff

Changepoint identified at En-Sci S/N 25250, so we estimate this as being the “dropoff point”

EnSci S20 Station and OMI TCO Comparisons



*Stauffer et al.,
ESS, 2022*

Before S/N 25250: 0.42%
95% CI: [0.28,0.57]%

After S/N 25250: -3.5%
95% CI: [-3.73,-3.27]%

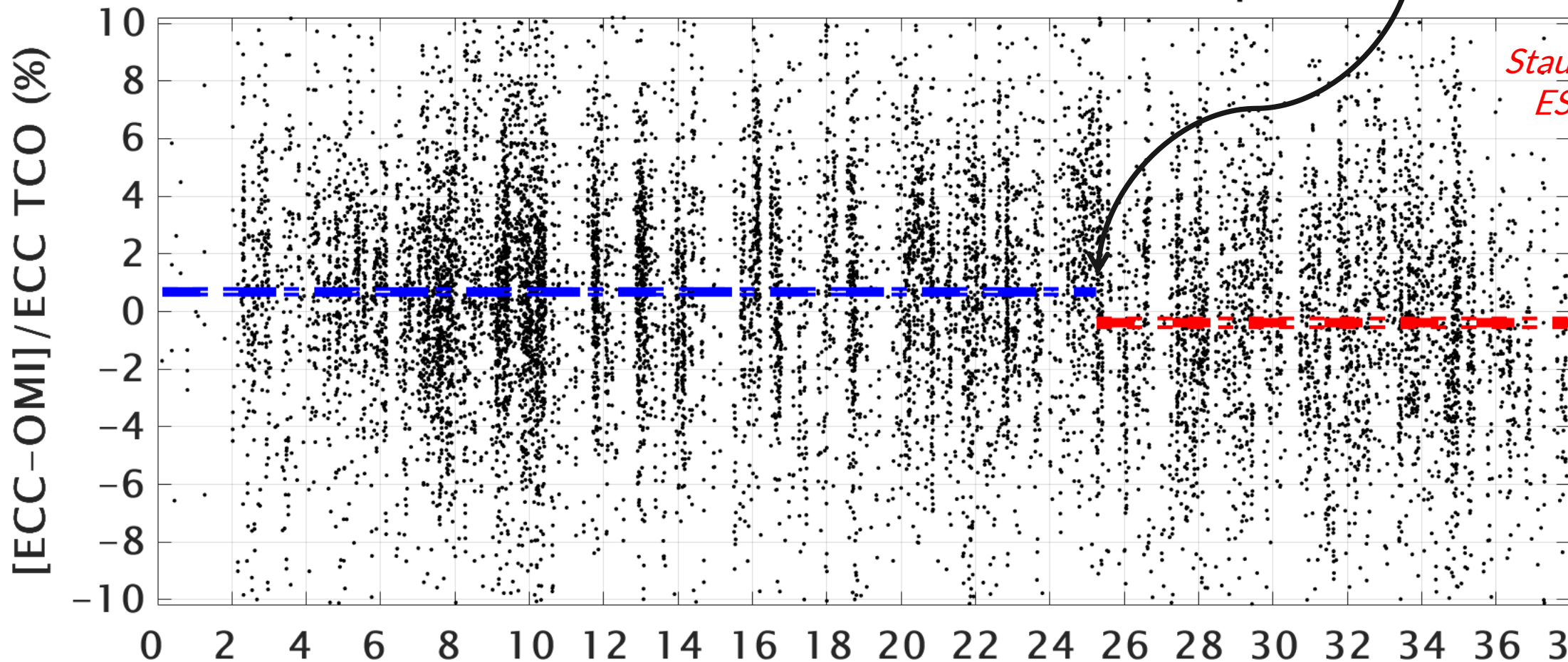
ASOPOS 2.0 current activities

DATA QUALITY MONITORING

ASOPOS Task team for En-Sci TCO dropoff

Even the En-Sci stations not considered “dropoff” show a step change at EnSci S/N 25250

EnSci Non-S20 Station and OMI TCO Comparisons



*Stauffer et al.,
ESS, 2022*

Before S/N 25250: 0.68%
95% CI: [0.59, 0.78]%

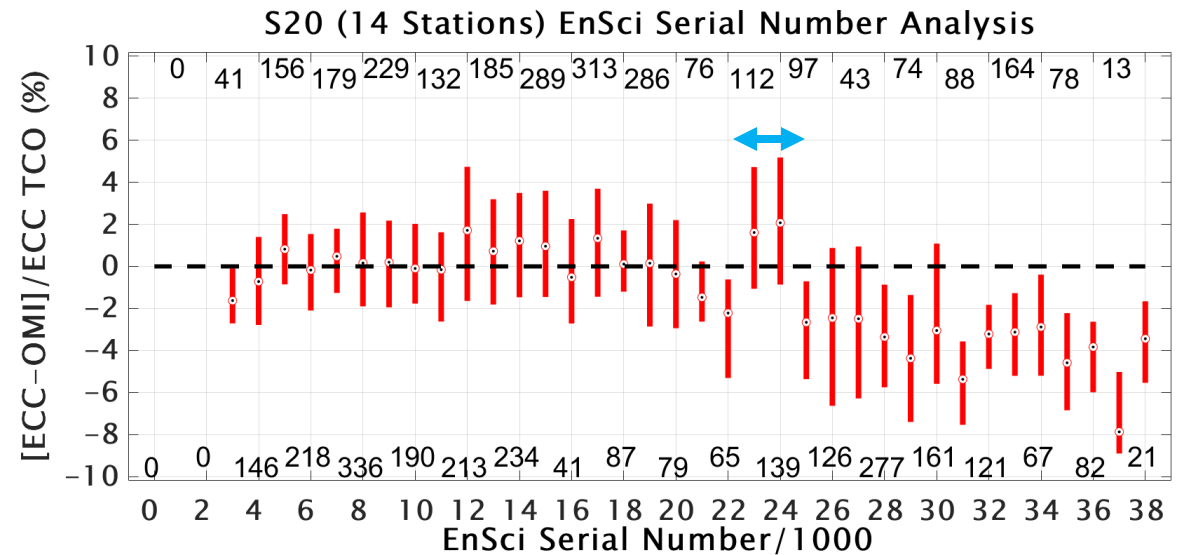
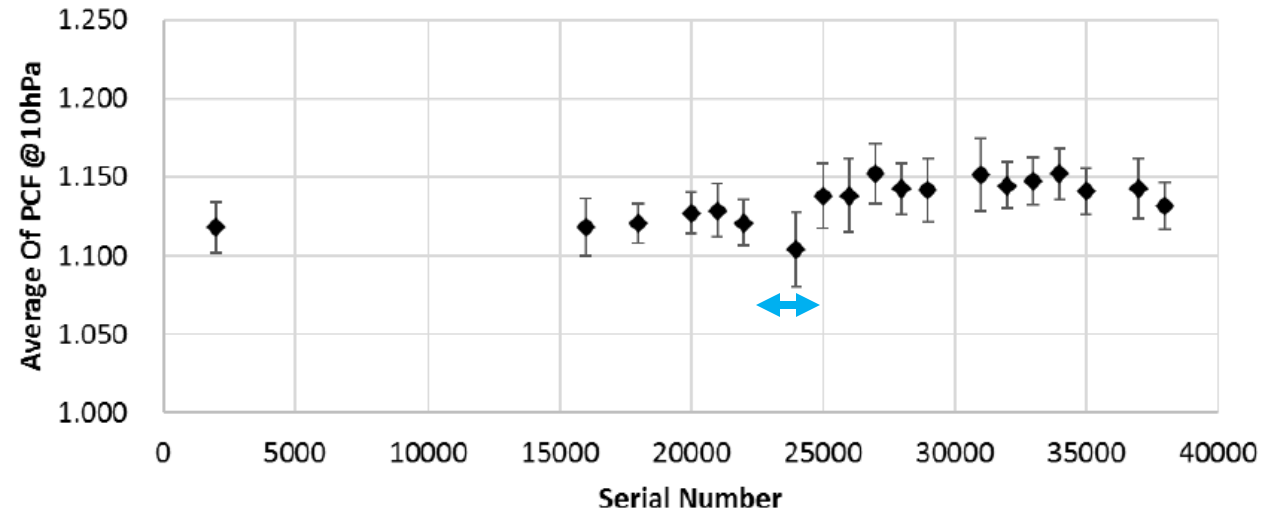
After S/N 25250: -0.39%
95% CI: [-0.54, -0.24]%

ASOPOS 2.0 current activities

DATA QUALITY MONITORING

ASOPOS Task team for En-Sci TCO dropoff

- A new paper (*Nakano and Morofuji, AMTD, 2022*) shows that there have been changes to the EnSci pump efficiency corrections that are coincident with the ozonesonde TCO dropoff
- Reprocessing ozonesonde data using this data set may resolve some of the magnitude of the TCO drop

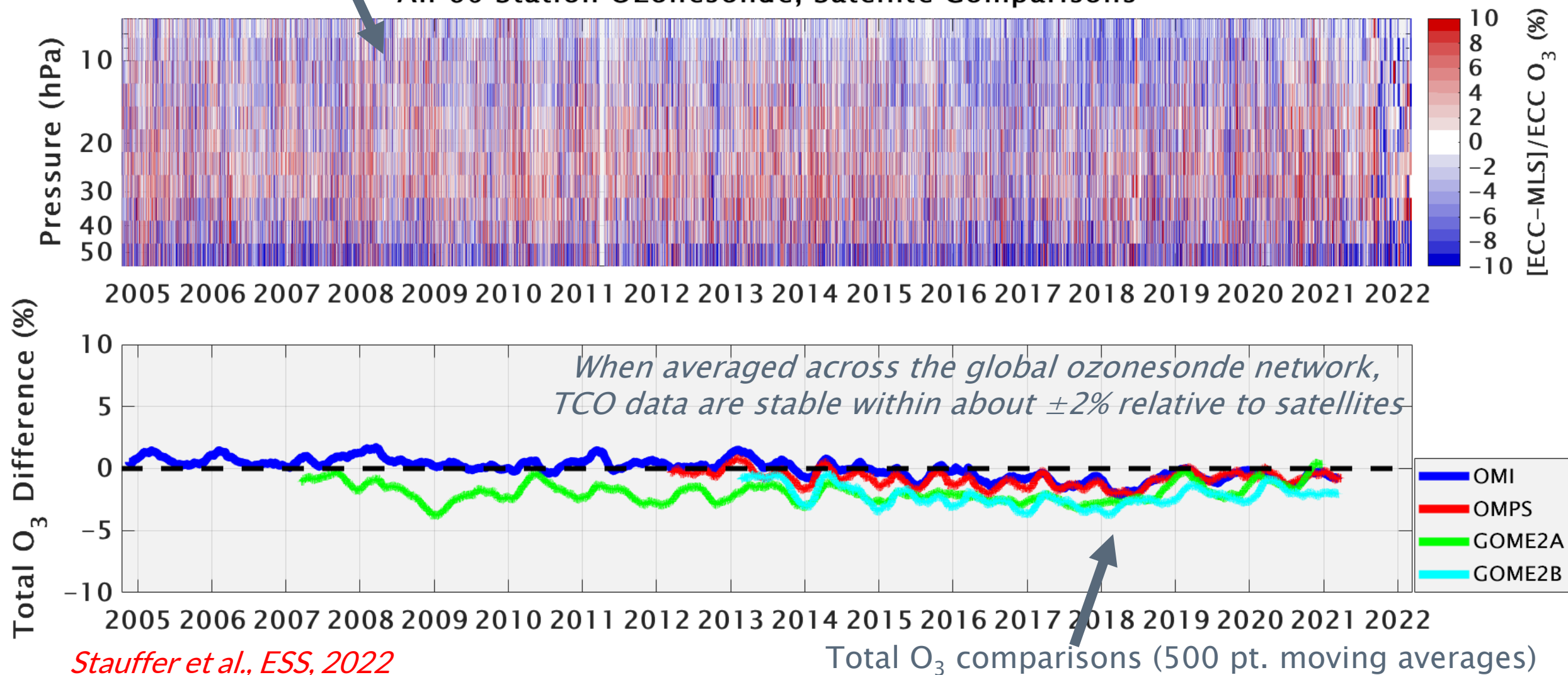


ASOPOS 2.0 current activities

DATA QUALITY MONITORING

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

All 60 Station Ozonesonde, Satellite Comparisons



World Calibration Centre for Ozone Sondes (WCCOS)

Recent activity

- Intercomparison campaign between WCCOS OPM (ozonesonde reference) to IAGOS/CARIBIC ozone monitoring instruments
- Goal: Both ozonesonde and IAGOS-ozone aircraft traceable to the same reference (HEGIFTOM!)

Future of WCCOS

- Herman Smit, head of WCCOS, retired in 2021
- MoU between FZJ and RMI signed
(a couple of weeks ago)
 - ✓ FZJ hosts the WCCOS with the Central Calibration Laboratory (CCL) for ozonesondes (simulation chamber + OPM) + technical maintenance and operation
 - ✓ RMI hosts the Quality Assurance/Scientific Activity Centre (QA/SAC)
 - ✓ JOSIE: collaboration (technical + logistics + scientific)

Memorandum of Understanding
for an envisaged cooperation to perform JOSIE
(Jülich Ozone Sonde Intercomparison Experiment)
activities in the framework of the quality assurance plan of the
WMO-GAW

Summary

- New **WMO-GAW Report #268** is new **standard** for ozonesonde measurements & is placeholder for future reprocessing
- Main ASOPOS2.0 task: **implementing** the report guidelines into network
 - ✓ SOPs + hardware
 - ✓ data processing (uncertainties, flagging, metadata, data format, versioning)
 - ✓ data quality monitoring
- **En-Sci TCO dropoff** seems to be at least partially explained by changing ozonesonde pump characteristics
- **WCCOS & JOSIE** will be maintained

Thank you for your attention!



“Ozonesonde Measurement Principles and Best Operational Practices” (WMO/GAW-Report No. 268)

ASOPOS 2.0: What's new?

- “Empirical” correction factors for stratospheric data that compensate for decreasing pump motor efficiency (Ch. 3).
- Specification of uncertainties in each sonde profile *and* referencing final data to OPM (Ch. 3) – Tarasick et al. (2021).
- Data handling that accounts for two-reaction pathways of chemicals in sensing solution (Ch. 3) – Vömel et al. (2020).
- Updated guidelines for preparation steps (Ch. 4).
- Quality assessment monitoring: frequent comparison to satellite and ground-based total column (TCO) ozone amounts (Ch. 5).
- Specification of extensive metadata for every sonde launched to facilitate re-processing of data in future (Ch. 5)