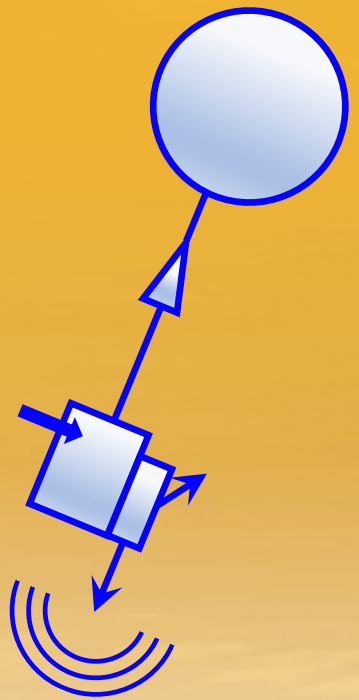
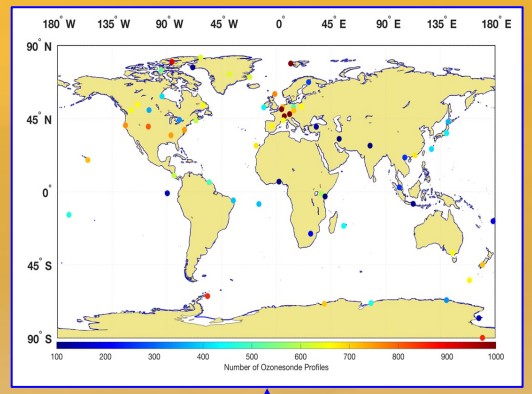
ASOPOS-Webinar Series on the Implementation of the Recommendations Made by the ASOPOS 2.0 Panel

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

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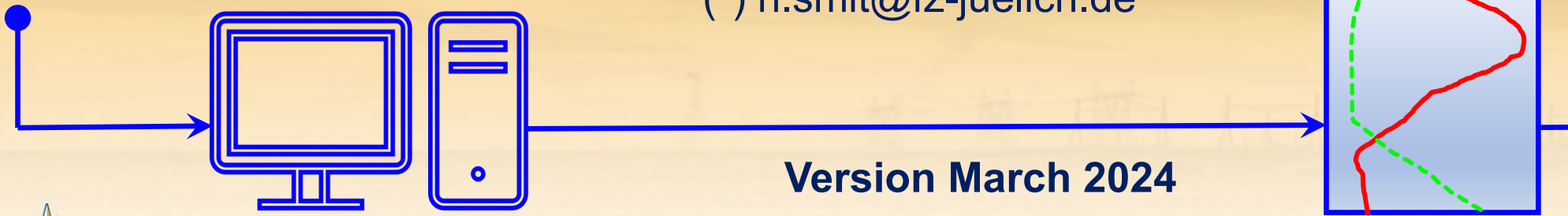


Version March 2024

WORLD METEOROLOGICAL ORGANIZATION

GRUAN

JÜLICH Forschungszentrum

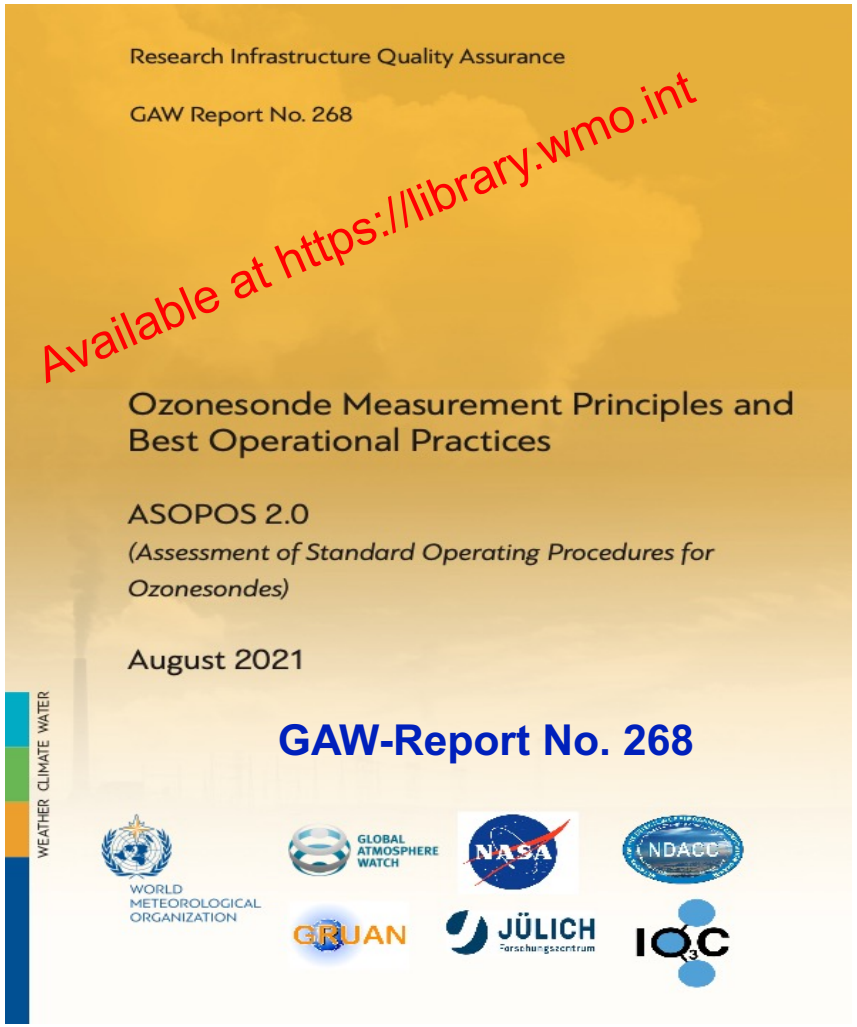
NASA

NDACC

IQ3C

GLOBAL ATMOSPHERE WATCH

Preamble – ASOPOS 2.0 Introduction

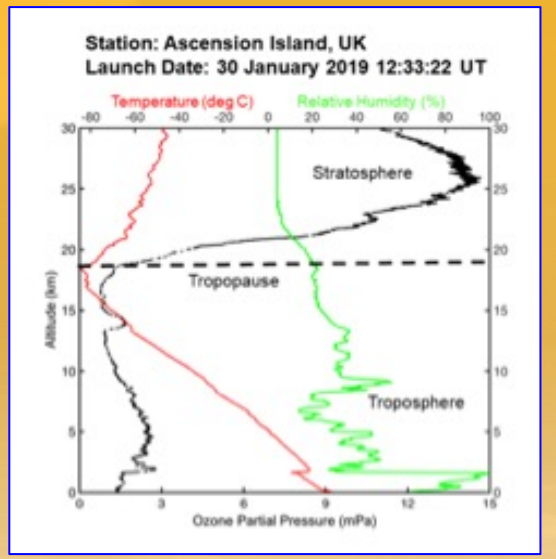


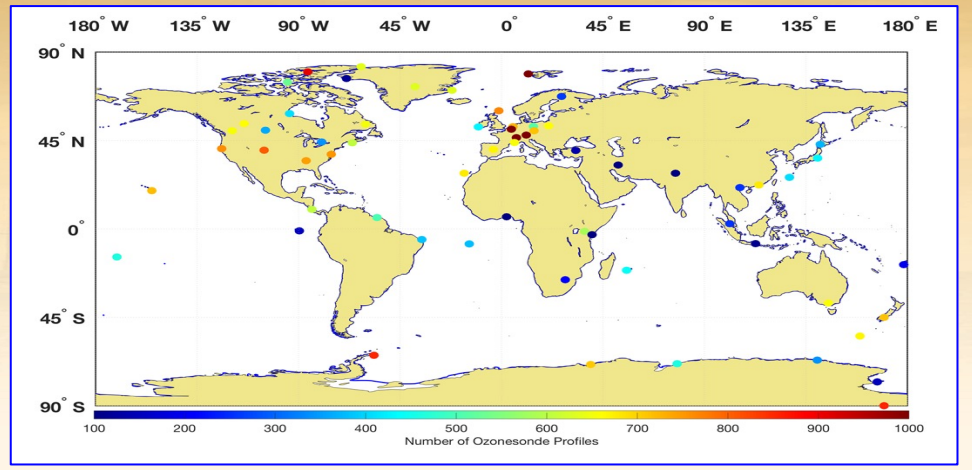
https://library.wmo.int/index.php?lvl=notice_display&id=21986#.Y2px6uTMJc8

- The ASOPOS 2.0 Report builds on an earlier ASOPOS 1.0 (GAW Report No. 201, 2014). Adoption of the 2014 SOP by many global ozonesonde stations proved that uniform practices increase QA of the sounding data. From ~15% uncertainty in sonde data 20 years ago, the first ASOPOS improved that value to 5-10%. ASOPOS 2.0 aims for 5% or better uncertainty.
- Thus, ASOPOS 2.0 Report (WMO/GAW Report No. 268) updates GAW 201, describing (1) the ECC-Ozonesonde instrument, (2) more detailed recommendations for sonde operation “best practices” and (3) data processing. The latter adds specification of uncertainties and traceability of the final ozone concentration to a single world reference.
- Note! ASOPOS Webinars **only** explain the most crucial and critical aspects of the ECC SOP. Sonde operators and data providers are referred to WMO/GAW Report 268 for step by step details.

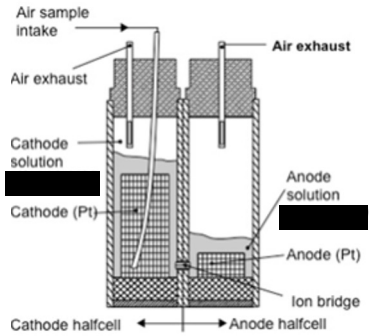
Webinar #1 Outline

- Ozonesonde Instrument, Quality Assurance (QA)
- Ozonesonde Data Uses, ASOPOS Background
  - QA Elements: WCCOS, JOSIE, ASOPOS
  - Success of Prior ASOPOS & Homogenization
  - ASOPOS 2.0 Foundation & Related Studies
- WMO/GAW Report No. 268, August 2021
- Recommended Operations & Data Archiving
- Implementing Recommendations Globally





Ozonesonde Instrument (More details in Webinar No. 2 on Hardware)



Ozonesonde:

- Small instrument (1 kg) attached to a radiosonde & flown on a weather balloon to measure O_3 concentration from surface to 35 km with ~100-m height resolution, weather independent (e.g. rain, clouds)

Electrochemical Concentration Cell (ECC) sonde:

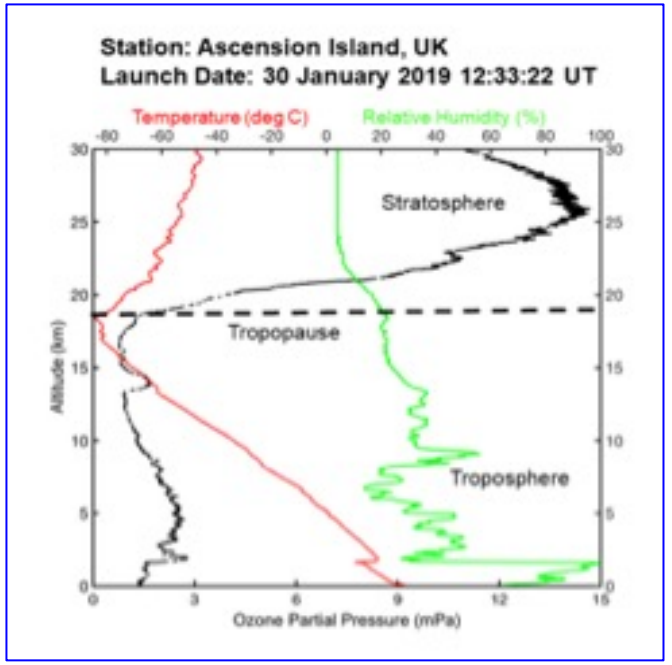
- Titrates ozone (O_3) in a KI sensing solution:

$$2\,KI + O_3 + H_2O \rightarrow I_2 + O_2 + 2\,KOH$$

- In the ECC, the I_2 produced is converted back into 2 I^- by uptake of 2 electrons, creating a current proportional to the O_3

Principle of Operation:

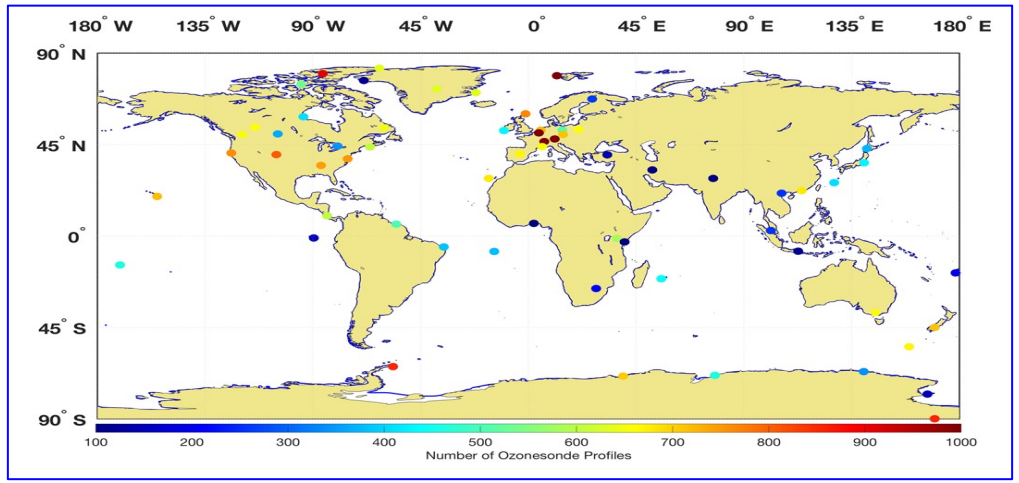
- A small pump forces ambient air through the dilute KI-solution in the cathode chamber
- The O_3 is related to the amount of sampled air



Ozonesonde QA Challenges:

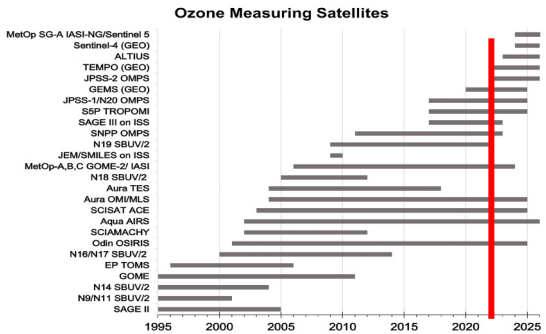
- Unique Instrument, launched & lost. Need standard preparation
- Two manufacturers (SPC & En-Sci) & three different sensing solutions types (SST's)
- Different sonde-SST pairings may not measure the same O_3 amount

Ozonesonde QA Requirements. Why SOPs Matter.



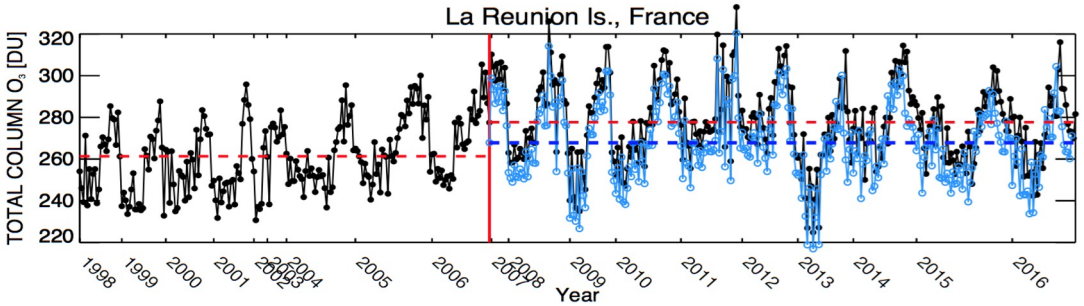
Global Ozonesonde Network. Data Uses

- ECC sondes are launched 2-5 x/month or more often at ~60 sites globally
- Sondes support validation of Satellites, Lidars, Aircraft profiles (e.g. IAGOS)



Data Needs, continued:

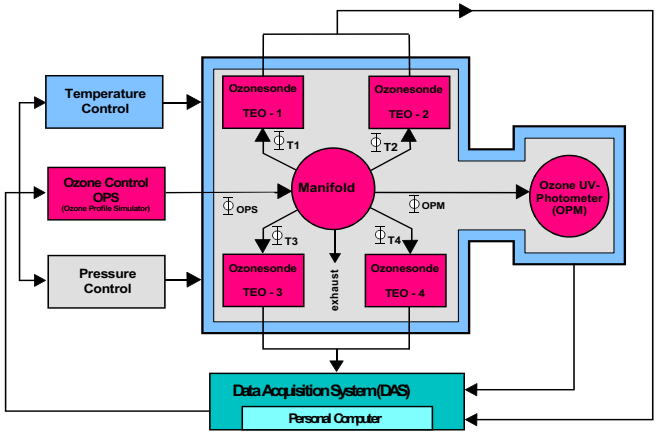
- Sondes evaluate models, air quality forecasts
- Sondes required for UNEP/WMO quadrennial Ozone Assessments that support Montreal Protocol). Users now demand 5% uncertainty!!
- QA challenge! What happens when a station changes instrument or SST? How are data compared across stations using different methods?



- Sonde community needs (a) to evaluate each sonde type and SST against absolute reference; (b) prescribe SOP for sonde preparation; (c) methods to correct „homogenize“ archived data time-series

Three Elements of Ozonesonde QA: WCCOS - JOSIE - ASOPOS

- 1994 WMO/UNEP Assessment of Ozone Depletion: **Must improve sonde data QA!!!**
- (1) In 1995 the Research Centre Jülich established the **World Calibration Centre for Ozone Sondes (WCCOS)** to support the WMO/GAW plan for ozonesonde QA. Core of WCCOS is the **ESF** (**right**) that has tested all instrument types used across the global ozonesonde network.
- (2) Six international **Jülich Ozone Sonde Intercomparison Experiments (JOSIE's)** conducted at WCCOS/ESF since 1996
- (3) JOSIE results evaluated by **Assessment of Standard Operating Procedures of Ozone Sondes (ASOPOS)** expert panel develops recommended SOP by consensus



The Environmental Simulation Facility (ESF):

- Enables control of pressure (***P***), temperature (***T***) and ozone (O_3) concentration
- Simulates quasi realistic flight conditions of ozone soundings from surface to Z=35 km
- **Dual beam UV-photometer (OPM) serves as a reference (uncertainty better than 3-5%)**
- JOSIE: Four ozonesondes are "flown" simultaneously at different vertical profiles of O_3, ***P & T*** (polar, mid-latitude, sub-tropical and tropical conditions)

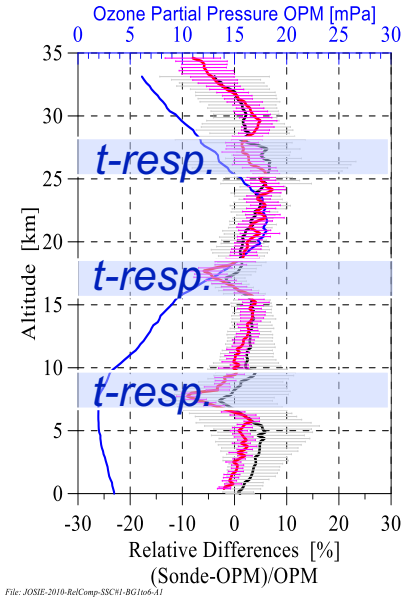
ASOPOS Success: JOSIEs and O3S-DQA (Homogenisation)

- **ASOPOS-Aim:** Provide QA evaluated sonde data for trends, satellite and model validation that are consistent across the global network, following SOPs for operations and data handling.
- **ASOPOS-Process:** A Team of ozonesonde experts (i) analyzes and evaluates the results of intercomparisons (e.g. JOSIE) and time-series homogenisations (O3S-DQA); (ii) develops sonde preparation SOPs; (iii) provides detailed SOP on data handling and re-processing

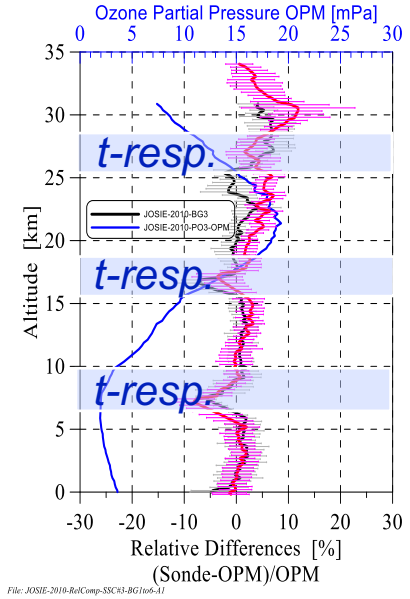
JOSIE 2009/2010

Testing ASOPOS 1.0 Recommendations

SPC-6A & SST1.0

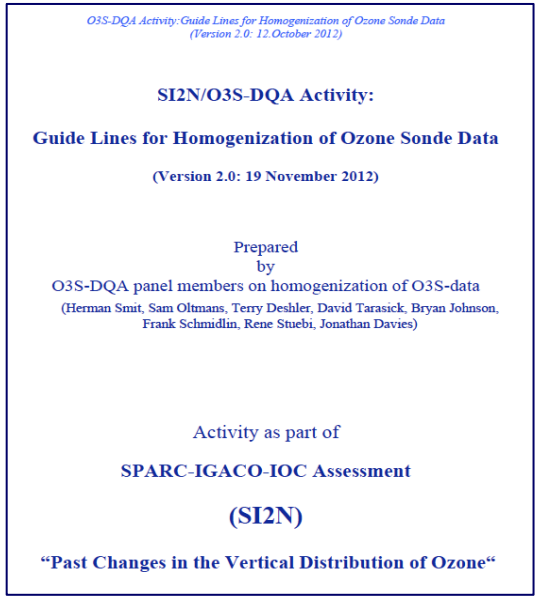


ENSCI-Z & SST0.5



O3S-DQA (2012):

Homogenisation 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

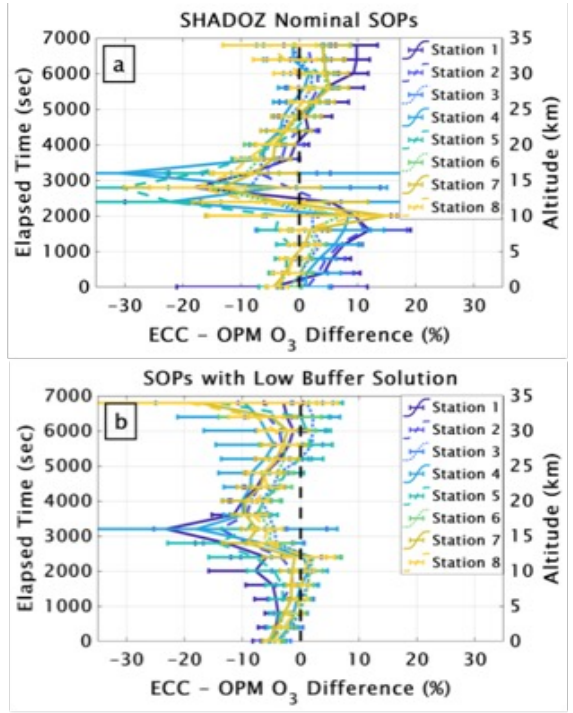
SPARC-IGACO-IOC Assessment

(SI2N)

"Past Changes in the Vertical Distribution of Ozone"

JOSIE 2017 – SHADOZ

Thompson et al. (BAMS, 2019)



ASOPOS 2.0 Foundation and Related Studies

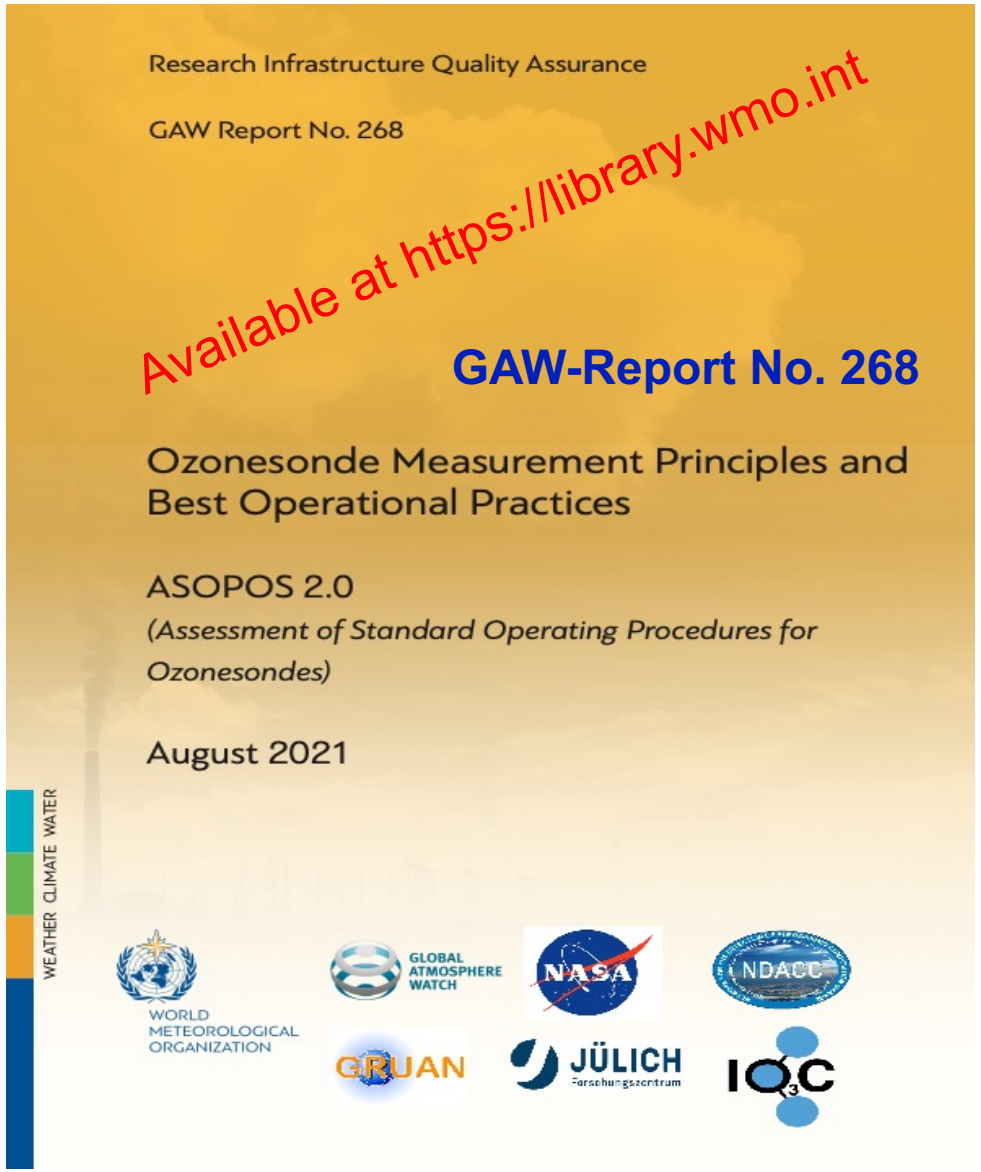
Basis of ASOPOS 2.0 (2016-2021):

- ❑ JOSIE 2009/2010, new & re-used sondes
- ❑ Analysis of Homogenised Data (O3S-DQA): more work needed for 5% uncertainty
- ❑ Results from JOSIE 2017-SHADOZ

Peer-reviewed Papers in Parallel with ASOPOS 2.0

- ❑ **Homogenisation:**
  - Tarasick et al., *AMT, 2016*
  - Van Malderen et al., *AMT, 2016*
  - Witte et al., *JGR 2017; JGR, 2018; JGR, 2019*
  - Thompson et al., *JGR, 2017*
  - Deshler et al., *AMT, 2017*
  - Sterling et al., *AMT, 2018*
  - Ancellet et al., *AMT,* 2022
  - ……and still ongoing…….
- ❑ **O3S Performance:**
  - JOSIE 2017-SHADOZ: *Thompson et al., BAMS, 2019*
  - Uncertainty Budget: *Tarasick et al., ESS, 2021*
  - Resolving fast & slow time response: *Vömel et al., AMT, 2020*
  - TCO Stability/Drop: *Stauffer et al., GRL, 2020; ESS, 2022*
  - Pump Flow Measurements, *Nakano & Morofuji, AMT, 2023*

ASOPOS 2.0: GAW Report No. 268 (2021)



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Inclusivity & Capacity Building: ASOPOS 2.0 includes UNEP "Article 5 country" participants & incorporates lab and field tests from the entire ozone community

Acknowledgements:
FZ-Jülich, NASA, NOAA. UNEP-Vienna Convention Trust Fund sponsorship of SHADOZ participants at JOSIE-SHADOZ-2017. Many organizations with long-term commitments to the ASOPOS Team. WMO/GAW, IO3C, GRUAN and NDACC

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

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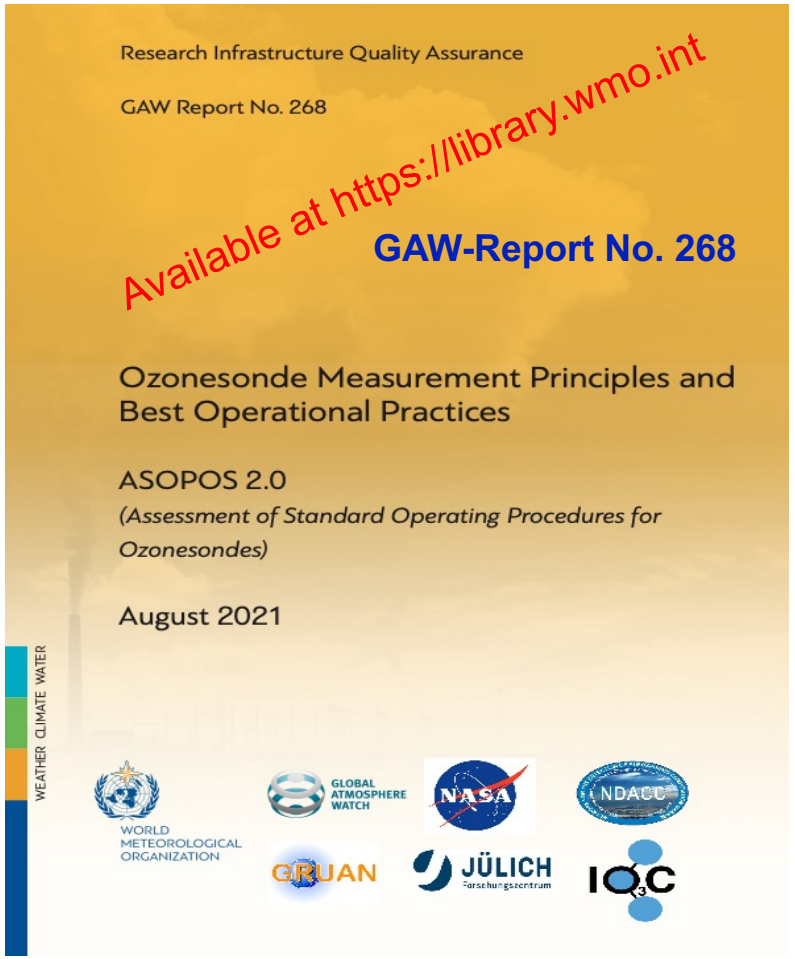

ASOPOS 2.0: Achievements & Recommendations (1)

- More strict and unified Standard Operating Procedures (SOPs)
- Recommendations on sensing solution type and ECC sonde type stay the same as in ASOPOS 1.0
- Recommendations to upgrade and regular maintenance of the zero ozone and purifying air filters and the Preparation Check Unit
- Stations are requested in general only to change operations when necessary (e.g. equipment becomes obsolete)
- Uncertainty budget analysis with overall uncertainty to store in the data archives
- Extensive list of metadata such that data can be reprocessed

ASOPOS 2.0: Achievements & Recommendations (2)

- Practical guidelines for SOPs, Meta data, Data Processing incl. Uncertainties and Homogenisation of historical long term ozonesonde records.
- Base for improved data processing (resolving fast and slow time responses).
- Quality assessment “monitoring” with frequent comparison to satellite and ground-based total column (TCO) ozone amounts
- Final data in the data archives should be traceable to a single reference standard: JOSIE-OPM at WCCOS

NOTE! OZONESONDE QA HAVE TO BE AN ONGOING PROCESS:

- Instrumentation will change, intentional or not!
- WCCOS is essential for ozonesonde community to monitor changes and to provide World Standard OPM as one unique reference for every profile

ASOPOS 2.0: 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 has been compiled into a series of six webinars

II. Regional on-line ASOPOS workshops dedicated to the operators of the ozonesounding stations to present ASOPOS 2.0 into practice: What and How to do in practical terms? (February/March 2023)

III. Coaching the ozonesonde stations individually to implement ASOPOS 2.0 into practice (2023-2024)

IV. Future capacity building by on-line and/or on-site coaching/training

Closing Remarks

- This webinar no.1 is part of a series of ASOPOS Webinars:
  1. Introduction to ASOPOS 2.0: An Overview *(Anne Thompson & Herman Smit)*
  2. Hardware *(Herman Smit & Roeland Van Malderen)*
  3. SOP: Standard Operating Procedures *(Roeland Van Malderen & Peter von der Gathen & Gary Morris & Bryan Johnson)*
  4. Data Processing *(Herman Smit & David Tarasick)*
  5. Data Quality Indicators (DQI) *(Ryan Stauffer & Holger Voemel)*
  6. Meta Data and Software *(Ryan Staufer & Roeland Van Malderen)*
- The webinars do not replace the report or associated video clips, but only highlights the most important topics and eventual changes with respect to the previous ASOPOS 1.0 report (WMO/GAW Report No. 201).
- **When any of you have any questions or need advice you can of course consult the ASOPOS Team in general !!!**

Thank you for your attention and let‘s go for good collaborations in the future !!!