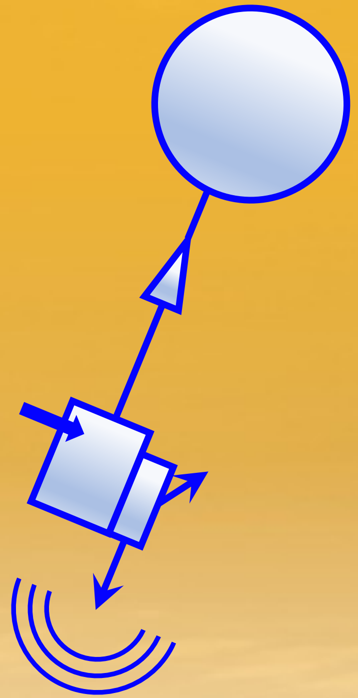
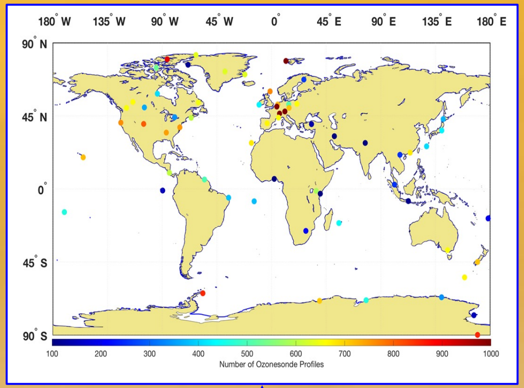
ASOPOS-Webinar Series on the Implementation of the Recommendations Made by the ASOPOS 2.0 Panel

Ozonesonde Measurement Principles and Best Operational Practices

ASOPOS 2.0 (GAW Report No. 268)

(Assessment of Standard Operating Procedures for Ozonesondes)





ASOPOS-Webinar No. 6

Metadata and Software

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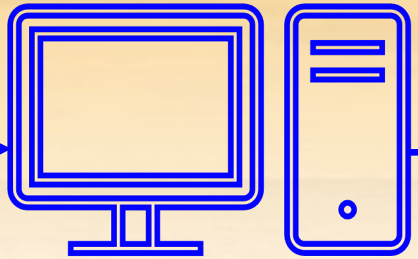
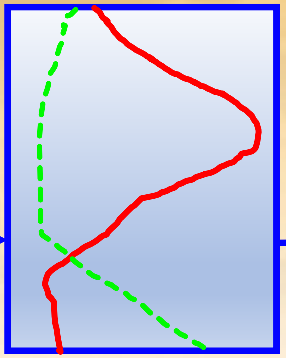
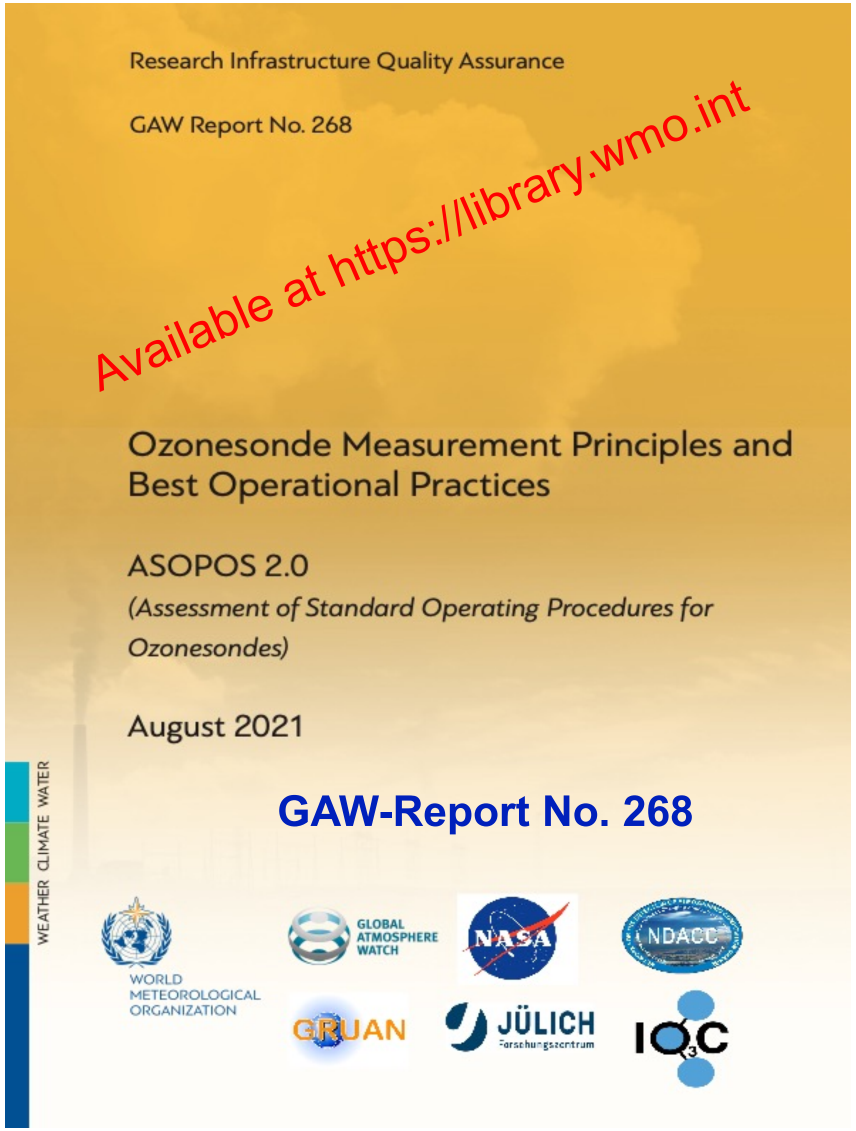




Version March 2024

WORLD METEOROLOGICAL ORGANIZATION · GRUAN · JÜLICH Forschungszentrum · NASA · NDACC · IO3C · GLOBAL ATMOSPHERE WATCH

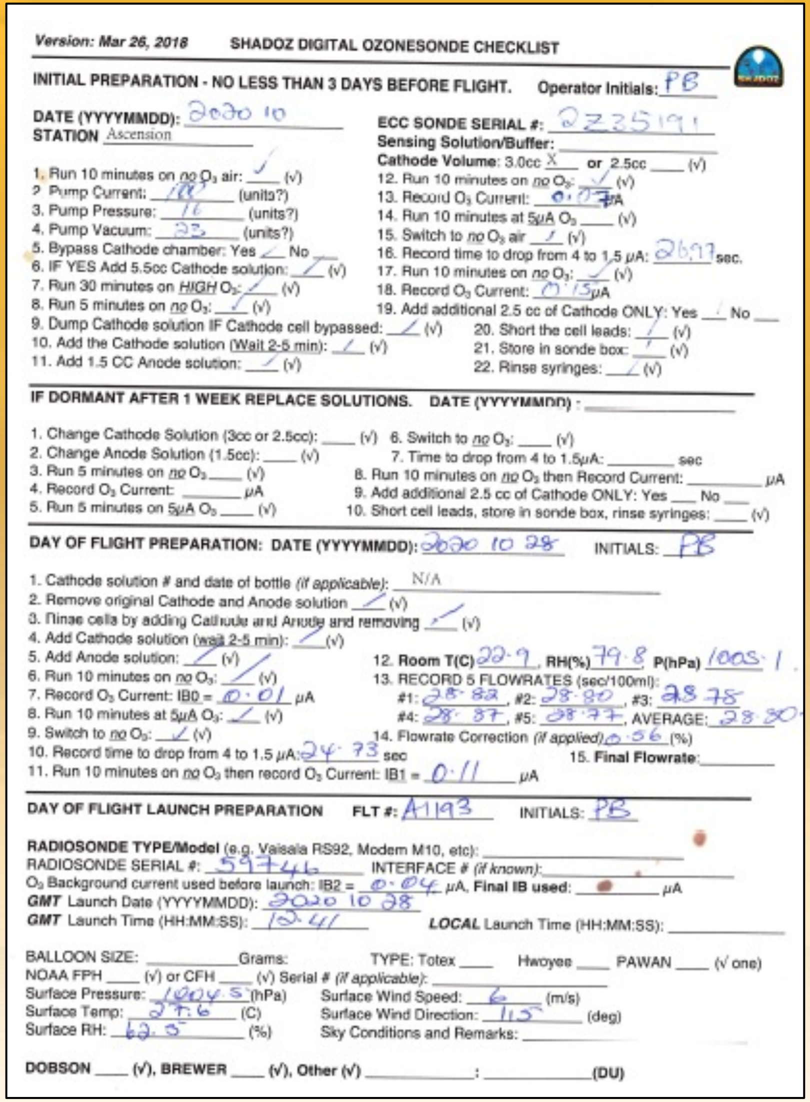
Preamble



- This ASOPOS 2.0 Report builds on the earlier **ASOPOS 1.0** (GAW Report No. 201, 2014)
- However, metadata was only slightly treated in the previous report within the context of the (new) ozonesonde **data format**.
- Metadata has a prominent role in WMO GAW 268, **Annex B** entirely devoted to it. This Annex lists and defines/describes the ozonesonde metadata.
- In this Webinar, we will not go through the list of metadata fields, but focus on the importance of digitally archiving (which) metadata, and how this could be implemented in practice.

Outline

- Introduction
- Categories of metadata
- Metadata in Practice
- Software
- Take away messages



Version: Mar 26, 2018 **SHADOZ DIGITAL OZONESONDE CHECKLIST**

INITIAL PREPARATION - NO LESS THAN 3 DAYS BEFORE FLIGHT. **Operator Initials:** PB

DATE (YYYYMMDD): 2020 10
STATION Ascension

ECC SONDE SERIAL #: 2Z35191
Sensing Solution/Buffer: ______
Cathode Volume: 3.0cc X **or** 2.5cc ____ (√)

1. Run 10 minutes on *no* O_3 air: ✓ (√)
2. Pump Current: 100 (units?)
3. Pump Pressure: 16 (units?)
4. Pump Vacuum: 23 (units?)
5. Bypass Cathode chamber: Yes ✓ No ____
6. IF YES Add 5.5cc Cathode solution: ✓ (√)
7. Run 30 minutes on *HIGH* O_3: ✓ (√)
8. Run 5 minutes on *no* O_3: ✓ (√)
9. Dump Cathode solution IF Cathode cell bypassed: ✓ (√)
10. Add the Cathode solution (Wait 2-5 min): ✓ (√)
11. Add 1.5 CC Anode solution: ✓ (√)
12. Run 10 minutes on *no* O_3: ✓ (√)
13. Record O_3 Current: 0.07 μA
14. Run 10 minutes at 5μA O_3 ____ (√)
15. Switch to *no* O_3 air ✓ (√)
16. Record time to drop from 4 to 1.5 μA: 26.97 sec.
17. Run 10 minutes on *no* O_3: ✓ (√)
18. Record O_3 Current: 0.15 μA
19. Add additional 2.5 cc of Cathode ONLY: Yes ✓ No ____
20. Short the cell leads: ✓ (√)
21. Store in sonde box: ✓ (√)
22. Rinse syringes: ✓ (√)

IF DORMANT AFTER 1 WEEK REPLACE SOLUTIONS. DATE (YYYYMMDD) : ______

1. Change Cathode Solution (3cc or 2.5cc): ____ (√)
2. Change Anode Solution (1.5cc): ____ (√)
3. Run 5 minutes on *no* O_3 ____ (√)
4. Record O_3 Current: ____ μA
5. Run 5 minutes on 5μA O_3 ____ (√)
6. Switch to *no* O_3: ____ (√)
7. Time to drop from 4 to 1.5μA: ____ sec
8. Run 10 minutes on *no* O_3 then Record Current: ____ μA
9. Add additional 2.5 cc of Cathode ONLY: Yes ____ No ____
10. Short cell leads, store in sonde box, rinse syringes: ____ (√)

DAY OF FLIGHT PREPARATION: DATE (YYYYMMDD): 2020 10 28 INITIALS: PB

1. Cathode solution # and date of bottle *(if applicable)*: N/A
2. Remove original Cathode and Anode solution ✓ (√)
3. Rinse cells by adding Cathode and Anode and removing ✓ (√)
4. Add Cathode solution (wait 2-5 min): ✓ (√)
5. Add Anode solution: ✓ (√)
6. Run 10 minutes on *no* O_3: ✓ (√)
7. Record O_3 Current: IB0 = 0.01 μA
8. Run 10 minutes at 5μA O_3: ✓ (√)
9. Switch to *no* O_3: ✓ (√)
10. Record time to drop from 4 to 1.5 μA: 24.73 sec
11. Run 10 minutes on *no* O_3 then record O_3 Current: IB1 = 0.11 μA
12. **Room T(C)** 22.9, **RH(%)** 79.8, **P(hPa)** 1005.1
13. RECORD 5 FLOWRATES (sec/100ml): #1: 28.82, #2: 28.80, #3: 28.78, #4: 28.87, #5: 28.77, AVERAGE: 28.80
14. Flowrate Correction *(if applied)* 0.56 (%)
15. **Final Flowrate**: ______

DAY OF FLIGHT LAUNCH PREPARATION **FLT #:** A1193 INITIALS: PB

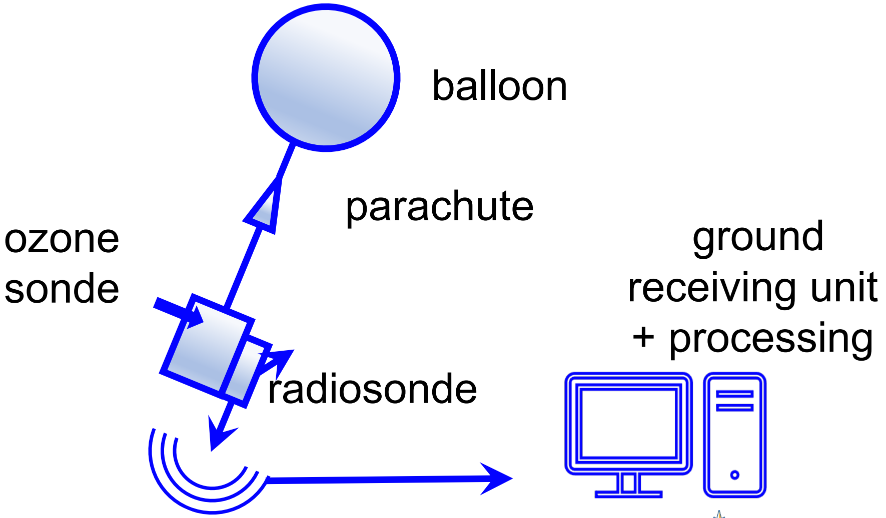
RADIOSONDE TYPE/Model (e.g. Vaisala RS92, Modem M10, etc): ______
RADIOSONDE SERIAL #: 59746 INTERFACE # *(if known)*: ______
O_3 Background current used before launch: IB2 = 0.04 μA, **Final IB used:** ____ μA
GMT Launch Date (YYYYMMDD): 2020 10 28
GMT Launch Time (HH:MM:SS): 12:41 ***LOCAL*** Launch Time (HH:MM:SS): ______

BALLOON SIZE: ______ Grams: TYPE: Totex ____ Hwoyee ____ PAWAN ____ (√ one)
NOAA FPH ____ (√) or CFH ____ (√) Serial # *(if applicable)*: ______
Surface Pressure: 1004.5 (hPa) Surface Wind Speed: 6 (m/s)
Surface Temp: 27.6 (C) Surface Wind Direction: 115 (deg)
Surface RH: 62.5 (%) Sky Conditions and Remarks: ______

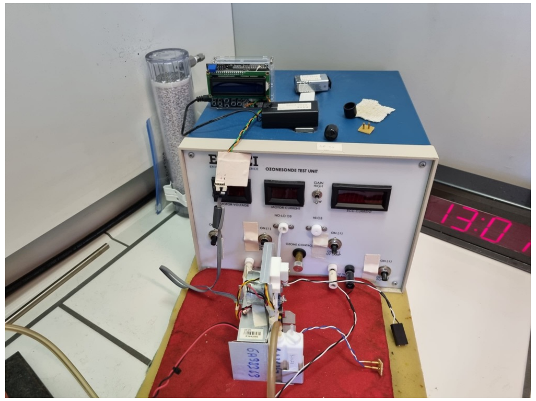
DOBSON ____ (√), **BREWER** ____ (√), **Other** (√) ______ : ______ **(DU)**

What is metadata?

- ✓ **Wikipedia**: "data about data", "data that provides information about other data"
- ✓ **WMO WIGOS Metadata Standard document**: "data describing the data", 10 categories: *(1) observed variable, (2) purpose of observation, (3) station/platform, (4) environment, (5) instruments and methods of observations, (6) sampling, (7) data processing and reporting, (8) data quality, (9) ownership and data policy, (10) contact*
- ✓ **ASOPOS report**: "additional information to calculate ozone concentrations from the raw data and to describe the observations"; metadata characterizes the environment under which ozone measurements were taken, the ozonesonde itself, and how it was used.



environment



ozonesonde preparation & characterisation

Introduction

What is metadata?

- ✓ During the ozonesonde preparation, measurements to characterize the ozonesonde and its performance are captured **(see Webinar #3: SOPs)**
- ✓ Some of these data, noted on the prepsheets **(see Webinar #3: SOPs)** should be archived!

Pre-conditioning (prepared 3 to 30 days before flight)

1. Date of pre-conditioning: YYYYMMDD
2. Operator Initials: JCW
3. Station ID: San Pedro, Costa Rica
4. ECC serial number: 2Z00000 or 6A00000
5. Manufacture Date: YYYYMM or YYYYMMDD
6. Manufacturer pump motor voltage (DC): 12.3
7. Manufacturer pump motor current (mA): 67 < 120
8. Manufacturer pump flowrate (s/100ml): 27.1/26.1
9. Sensing Solution/Buffer: 0.5% Half Buffer or 1% Full Buffer, or other
10. Sensing Solution Identifier: Batch date (yyyymmdd), ID number, or other
11. Run 10 min of no-Ozone air: √
12. Bypass Cathode chamber: Yes __ or No _√_
13. Run 30 min on High Ozone: √
14. Run 5 min on no-Ozone air: √
15. Add Cathode solution (wait minimum 2 min): 3.0cc √
16. Add 1.5cc Anode solution: √
17. Run on no-Ozone air until the current drops below 0.3 μA within less than 30 min
18. Run 10 min on 5μA Ozone: √
19. Switch to no-Ozone air and record time to drop from 4 to 1.5 μA (s): 25
20. Run 10 min on no-Ozone air: √ Record Ozone Current (μA): 0.07
21. Short cell leads: √
22. Store in sonde box, with tissue under the cells, and store at dark place: √

Final conditioning for 0–1 day prior to launch

1. Date: YYYYMMDD
2. Operator Initials: HV
3. Check tissue under the cells for any leakage: √
4. Remove original Cathode and Anode solution: √
5. Add Cathode solution (wait minimum 2 min): **3.0cm³** √
6. Add **1.5cm³** Anode solution: √
7. Run 10 min of NO-Ozone air: √
8. Record ECC current (I_{B0}) (μA): 0.02 **<0.03**
9. Run 10 min at 5 μA Ozone: √
10. Switch to no-Ozone air and record time to drop from 4 to 1.5 μA (s): 25
11. Run on no-Ozone air: √
12. Record 5 t_{100} times (s/100ml) to determine flow rate:
    a. 28.10
    b. 28.30
    c. 28.00
    d. 28.40
    e. 28.20
13. Average t_{100} time (s/100ml) for flowrate: 28.20 (should be between 25 and 35 sec/100 ml)
14. Lab. Temperature T_{Lab} (°C): 274.5
15. Lab. Relative Humidity RH_{Lab} (%): 55
16. Lab. Pressure P_{Lab} (hPa): 850.5
17. After 10 min on NO-Ozone air, record Cell Current (I_{B1}) (μA): 0.02 **<0.07**
18. Pump Motor Current (mA): 105
19. End time of preparation (UTC): HH:MM:SS

Introduction

Why archive metadata?

- ✓ Needed for **processing** the data (ozone partial pressures)
- ✓ Metadata are a requirement for **reprocessing** and homogenizing station data.
- ✓ Metadata might be necessary for future reprocessing of the data with **new methods**.
- ✓ **Digital** archiving of historical metadata for future generations, in international databases (WOUDC, NDACC, SHADOZ, NOAA)
- ✓ Metadata helps to ensure the traceability, transparency, and data quality (uncertainties).
- ✓ Accurate metadata is vital to link long-term DQI evaluations with changes to ozonesonde data quality (see **Webinar #5 “Ozonesonde Data Quality Indicators”**)

Which metadata should be archived?

Introduction

NDACC
WOUDC
SHADOZ
NOAA
ALL

Which metadata should be archived?

PTU ozonesonde lab
Reprocessed
Ozonesonde response time
Transfer function
Dry flowrate correction
Burst pressure
Total ozone stop pressure
Payload weight
Ground equipment
Time to pump 100 ml
Background currents IB0, IB1
Balance weight used for inflation
Heating method of box
Type Ozone-free air
Launch date/time
Cathode Soln Volume Correction
Ozonesonde/Radiosonde serial number
Pump Temperature Correction
Vertical averaging/smoothing method
Balloon lift percentage
Lifting gas
Solution type/volume
Balloon material/brand/type/weight/volume/pretreatment
Weather at launch
Unwinder length
Station latitude/longitude/height
Processing software

➔ WMO GAW No. 268, Annex B: guidelines to harmonize the metadata definition and content between the different archives! How much and which data should be archived (min – optimum – max)?

➔ WMO GAW No. 268, Annex B: guidelines for the (radiosonde system) software providers about incorporating metadata fields

Different categories

In WMO GAW No. 268, **different categories of metadata** are defined:

1. **Required Metadata**
   - Without which processing of the raw data is not possible
   - Appear in the ECC equation $P_{O3} = 0.043085 * \frac{T_P}{(\eta_P * \eta_A * \eta_C * \Phi_{P0})} * (I_M - I_B)$ [E-2-1]

2. **Essential Metadata**
   - To understand the performance of the instrumentation
   - Describe most aspects of the ozonesonde preparation and its behaviour during preparation (prepsheets!)

3. **Desirable Metadata**
   - Needed to fully understand all aspects regarding an ECC ozonesonde observation

4. ***Obsolete Metadata***
   - *Used/archived in the past, but no added value anymore*

1: **Required** Metadata I

WMO/GAW #268 E-2-1 →

$$P_{O3} = 0.043085 * \frac{T_P}{(\eta_P * \eta_A * \eta_C * \Phi_{P0})} * (I_M - I_B)$$

- **Pump Flowrate (Φ_{P0})**. Ozone data cannot be processed without Φ_{P0}. Day of Flight **t100** (Φ_{PM}, sec/100mL) timing shown →
- See GAW #268 **Table 4-1** and related equations on humidification correction of Φ_{PM} (measured flowrate) to $\mathbf{\Phi_{P0}}$

12. Record 5 t_{100} times (s/100ml) to determine flow rate: **See Step A-5.4 #31**
    a. 28.10
    b. 28.30
    c. 28.00
    d. 28.40
    e. 28.20
13. Average t_{100} time (s/100ml) for flowrate: 28.20 (should be between 25 and 35 sec/100 ml)

Note: Use a stopwatch with .01s resolution (not a cell phone!)

Φ_{PM} Pump flowrate measurement. See: https://vimeo.com/502869920/2388d5c95a

1: **Required** Metadata II

WMO/GAW #268 E-2-1 →

$$P_{O3} = 0.043085 * \frac{T_P}{(\eta_P * \eta_A * \eta_C * \Phi_{P0})} * (I_M - I_B)$$

- **4 to 1.5 µA response time (sec)** on Day of Flight
- Does not appear in **E-2-1** ozone partial pressure equation, but is a **requirement** for data processing with the time response correction *(Vömel et al., 2020; Tarasick et al., 2021, Smit et al., in prep.)*

7. Run 10 min of NO-Ozone air: √
8. Record ECC current (I_{B0}) (µA): 0.02 <0.03 **See Step A-5.2 #29**
9. Run 10 min at 5 µA Ozone: √
10. Switch to no-Ozone air and record time to drop from 4 to 1.5 µA (s): 25

See Step A-5.3 #30

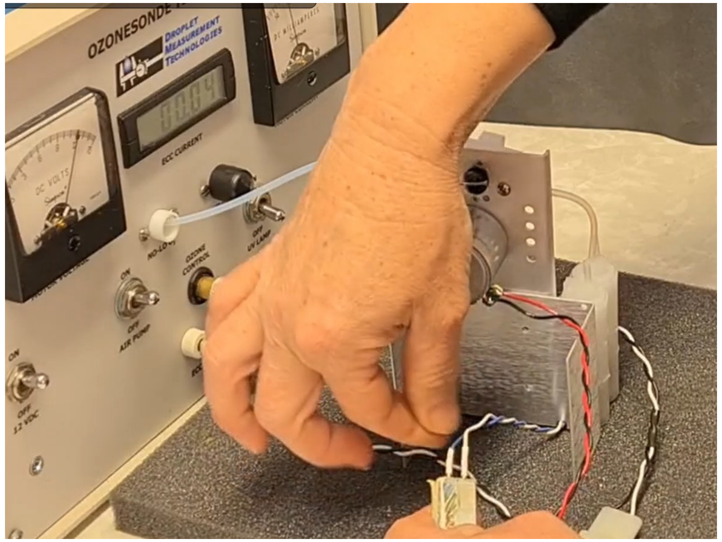
4 to 1.5 µA response time. See: https://vimeo.com/502869920/2388d5c95a

2: **Essential** Metadata I

- **Background current (IB0 and IB1).** Recall that ***IB background current used in processing*** is Required metadata. **Use IB1!**

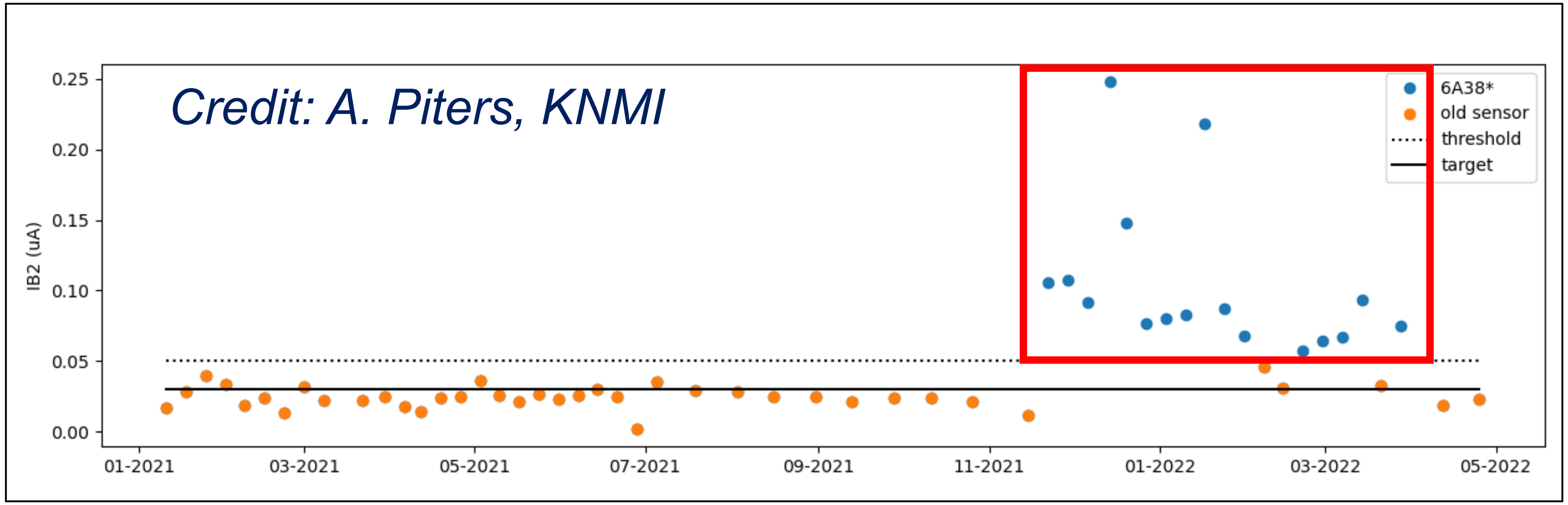
- IB0 and IB1 characterize the performance of the ECC cell

Background current measurement →
https://vimeo.com/502869920/2388d5c95a



- Several stations found high background currents from sets of SPC ECCs in the ~38000 serial number range

- Example from Paramaribo shown (**blue dots**) →



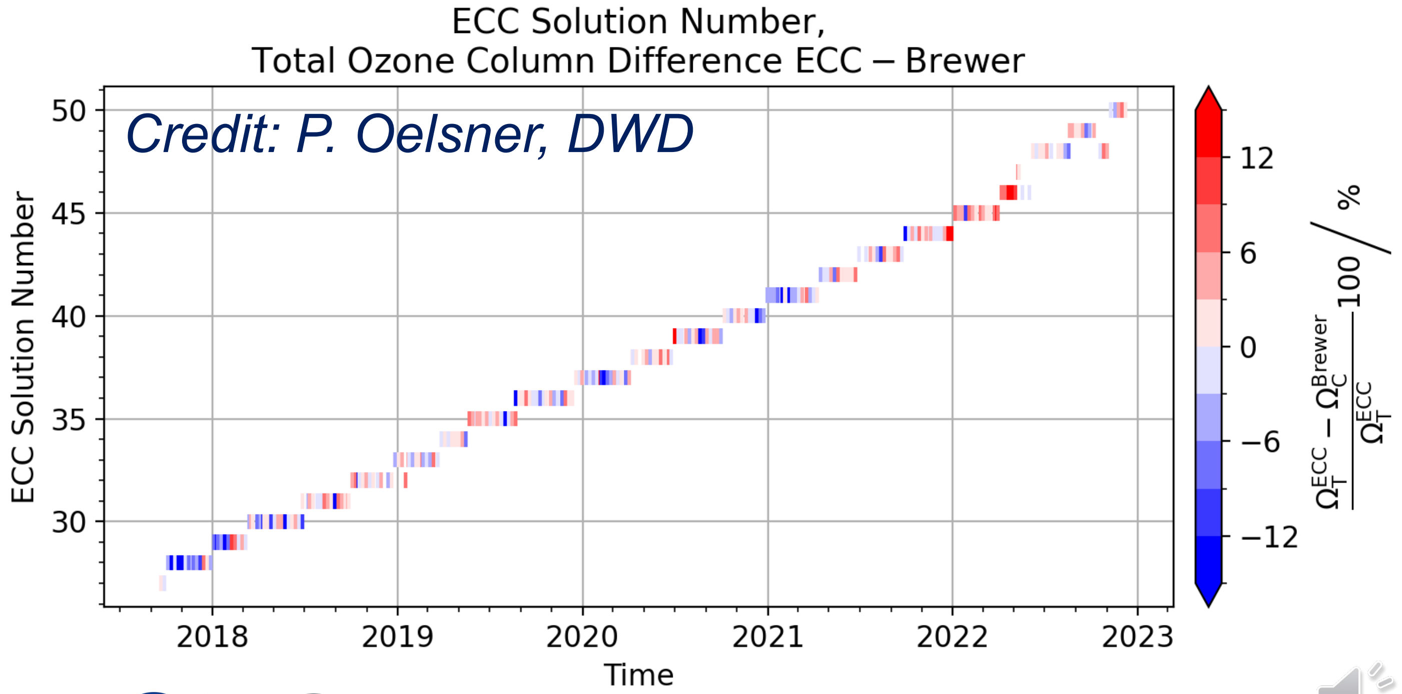
2: **Essential** Metadata II

- **Date or # identifier for Sensing Solution Type (SST)** is useful for tracking any ECC performance changes related to SST batch

7. Manufacturer pump motor current (mA): 67 < 120 **See Step A-4.1 #4**
8. Manufacturer pump flowrate (s/100ml): 27.1/26.1
9. Sensing Solution/Buffer: 0.5% Half Buffer or 1% Full Buffer, or other
10. Sensing Solution Identifier: Batch date (yyyymmdd), ID number, or other
11. Run 10 min of no-Ozone air: √ **See Step A-4.1 #4**

- Careful preparation of ECC sensing solutions is critical to ozone data quality. **See Webinar #2 Sensing Solutions: Requirements**

- Example: Lindenberg use SST identifier to investigate a recent high bias in ECC ozone at their station →

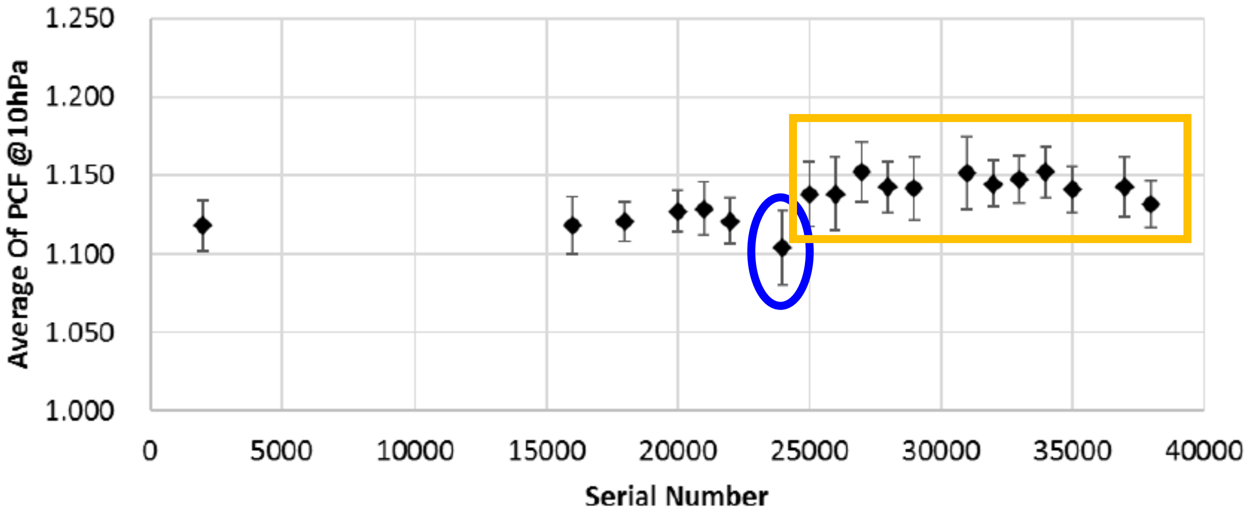


2: **Essential** Metadata III

- **ECC Serial Number**, either 6AXXXXX for SPC or 1/2ZXXXXX for EN-SCI

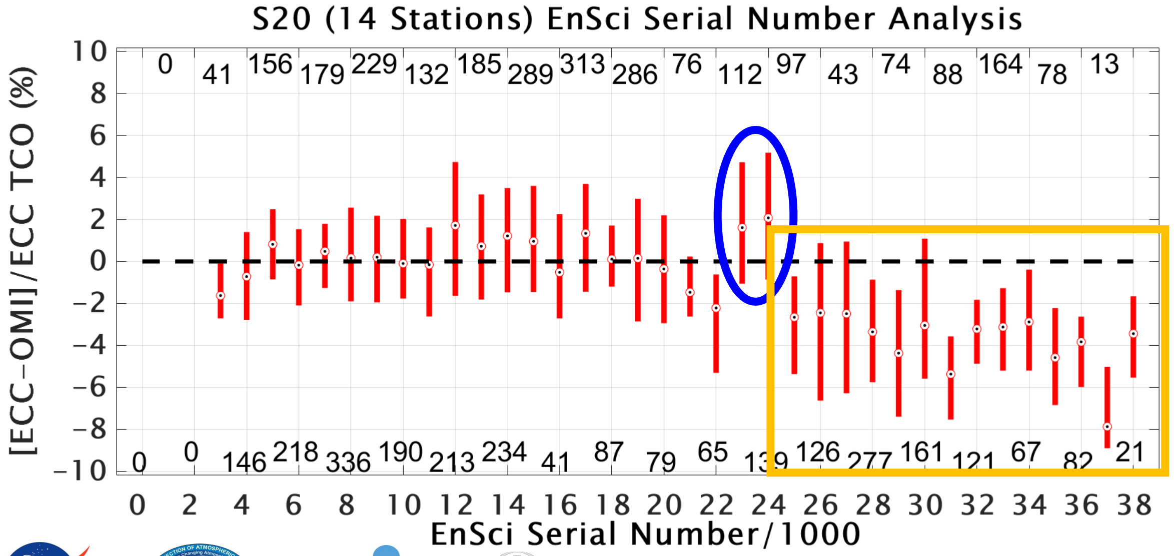
Pre-conditioning (prepared 3 to 30 days before flight)

1. Date of pre-conditioning: YYYYMMDD — **See Step A-4.1 #1**
2. Operator Initials: JCW
3. Station ID: San Pedro, Costa Rica
4. ECC serial number: 2Z00000 or 6A00000
5. Manufacture Date: YYYYMM or YYYYMMDD
6. Manufacturer pump motor voltage (DC): 12.3
7. Manufacturer pump motor current (mA): 67 < 120 — **See Step A-4.1 #4**



- ***Extremely Important*** for assessing ECC production quality and performance

- Nakano and Morofuji (2022; EGUsphere) show changes to EN-SCI stratospheric pump efficiencies (top). This effect may contribute to the EN-SCI “Dropoff” low bias (Stauffer et al., 2022; bottom), as the serial numbers are correlated →



3: **Desirable** Metadata

For Recovered ECCs: **Date of Previous Launch**

- Characterize the performance of recovered and refurbished ECCs
- See GAW #268 **4.2.3: "SOP for Re-Use of Recovered Sondes" →**

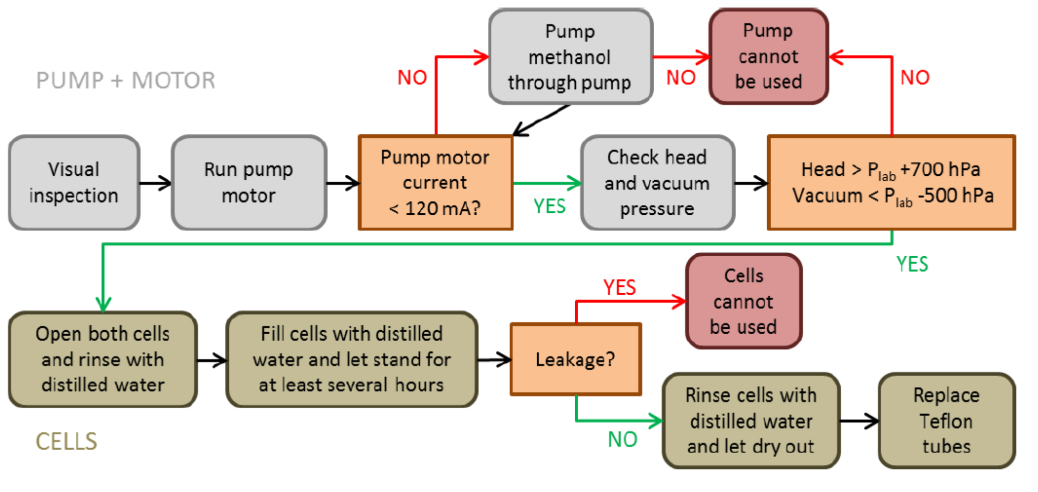


Figure 4–3: Flow chart with the most important steps to prepare recovered ozonesondes for re-use

Where Applicable: **Sonde Heater (Y/N? and Type)**

- Used primarily at very cold locations and the tropics (cold upper troposphere) where freezing of ECC solutions are a common concern
- Types: Passive (water can, other thermal materials) and Active (electric and thermostat heaters). **See Webinar #2 "Proper In-Flight Pump Temperatures"**
- Recall **Webinar #5** on importance of **Pump Temperature Data Quality Indicator**

Obsolete Metadata

- **IB2** is now considered Obsolete Metadata and is replaced by “***IB background current used in processing.*”** ***<u>Use IB1</u>!***

- *Inconsistencies in timing and the quality of ozone filters at stations led to the elimination of IB2 in ASOPOS 2.0 SOPs*

- Typical ozone destruction filter used for IB2 just prior to launch. **Not recommended for pre-launch! →**

- Zero ozone air/filtered air *should not* be given to the ECC after IB1 measurement. See **Webinar #3 on SOPs**

Metadata in Practice

Table **B-3** of metadata fields in Annex B

- **Radiosonde software** should be aligned with this table *(see next slides)*
- Metadata content in the ozonesonde **archives** (WOUDC, NDACC, SHADOZ, NOAA) should be consistent with this table *(more news on this in the coming months)*
- ASOPOS will provide an updated (meta)data template, with explanatory description, for the **missing** metadata fields (e.g. total ozone normalization factors), as a supplement to Annex B
- Not only uniformity in *amount* of reported metadata fields, but also in their meaning & format
  - ✓ meaning: metadata fields are well **defined**/described, with suggested naming convention
  - ✓ format: use **type**, **unit** and **missing value** definition of B-3 (pages 129-130 of the report)
- GOAL: **all** Annex B metadata fields for each sounding
  MINIMUM: "**required + essential**" metadata fields

Metadata in Practice

Metadata & Processing

- Concept of "Configuration File":
  - ✓ Contains metadata fields that are **invariable** over several soundings *(e.g. background correction method, sensing solution recipe, source of zero air, ECC sonde/RS manufacturer, processing software and version, sonde heater, etc.)*
  - ✓ **Minimizes** the typing in of metadata values by the ozonesounding **operator**

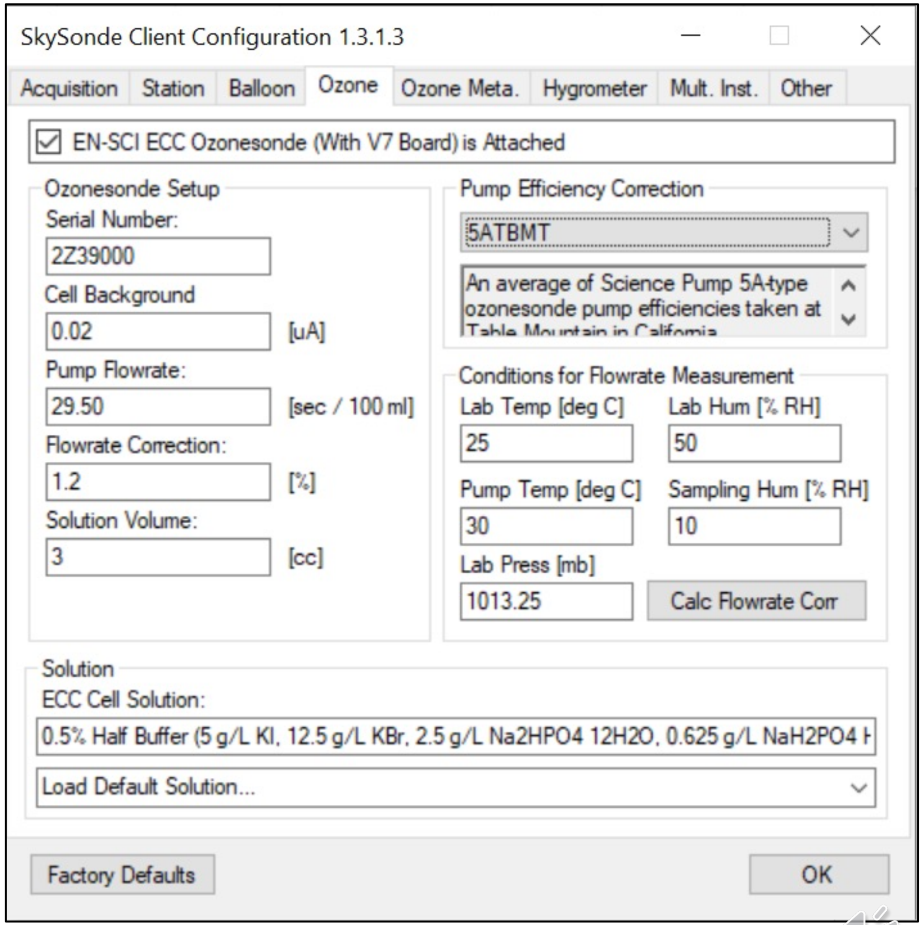
- Concept of "Consistent or RS-Supplied Processing"
  - ✓ Some networks (SHADOZ, NOAA) do a ***consistent processing*** *across* several stations with a common software package (e.g., SkySonde).
  - ✓ If RS **manufacturer software packages** align with the metadata implementation and data processing+formatting of WMO GAW No. 268, individual stations might rely on those software for their (meta)data provision
  - ✓ RS manufacturer-supplied processing might be helpful for **near-real time data provision** (e.g. upload to (European/AURA) Validation Data Centers, CAMS validation, etc.).

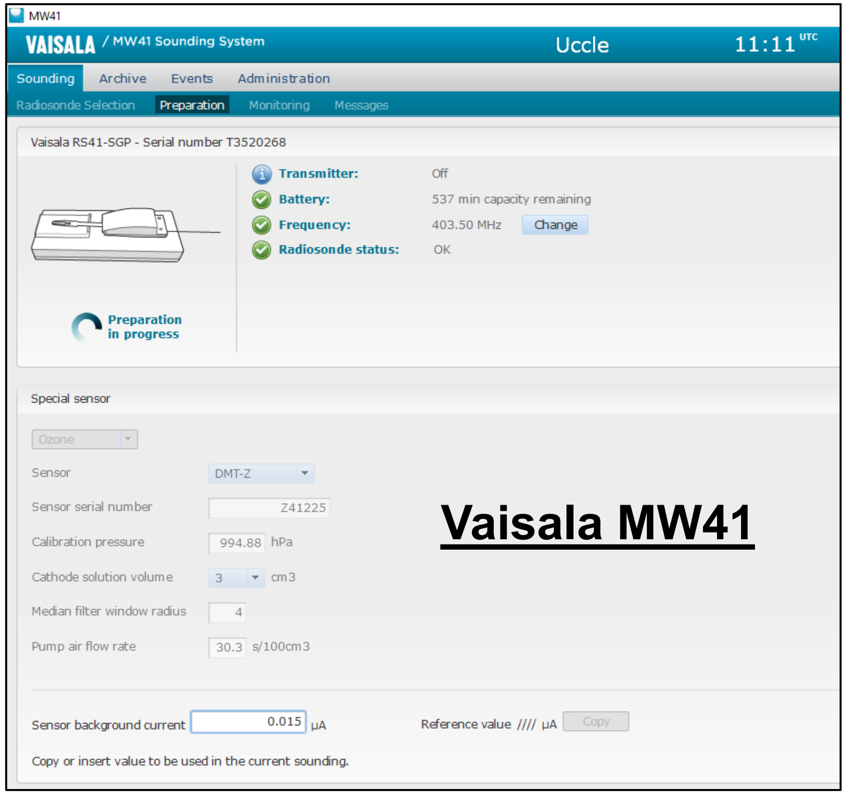
Metadata Entry in Sounding Software

- Example screenshots from software provider metadata entry shown below. Current software packages **currently do not capture all metadata fields specified in WMO/GAW #268 Annex B**

- ASOPOS 2.0 has contacted providers about implementation of GAW #268 metadata recommendations. **Stay tuned!**

NOAA SkySonde





Vaisala MW41

Key Points/Summary 1

- Metadata are captured and recorded to calculate ECC ozone measurements, and characterize the performance and attributes of individual ECC sensors

- Three Categories defined by ASOPOS 2.0 WMO/GAW #268:
  1. **Required** Metadata, without which ozone partial pressure calculation and reprocessing is **impossible**
  2. **Essential** Metadata, used to understand the performance of the ECC and its preparation
  3. **Desirable** Metadata, which are useful to understand <u>all</u> aspects of the ECC measurement and conditions

- Obsolete Metadata such as IB2 are no longer of use for ECC measurements and data processing

Pre-conditioning (prepared 3 to 30 days before flight)

1. Date of pre-conditioning: YYYYMMDD **See Step A-4.1 #1**
2. Operator Initials: JCW
3. Station ID: San Pedro, Costa Rica
4. ECC serial number: 2Z00000 or 6A00000
5. Manufacture Date: YYYYMM or YYYYMMDD
6. Manufacturer pump motor voltage (DC): 12.3
7. Manufacturer pump motor current (mA): 67 < 120 **See Step A-4.1 #4**
8. Manufacturer pump flowrate (s/100ml): 27.1/26.1
9. Sensing Solution/Buffer: 0.5% Half Buffer or 1% Full Buffer, or other
10. Sensing Solution Identifier: Batch date (yyyymmdd), ID number, or other
11. Run 10 min of no-Ozone air: √ **See Step A-4.1 #4**
12. Bypass Cathode chamber: Yes __ or No _√_
13. Run 30 min on High Ozone: √ **See Step A-4.1 #5**
14. Run 5 min on no-Ozone air: √ **See Step A-4.1 #6**
15. Add Cathode solution (wait minimum 2 min): 3.0cc √ **See Step A-4.2 #8**
16. Add 1.5cc Anode solution: √ **See Step A-4.2 #10**
17. Run on no-Ozone air until the current drops below 0.3 μA within less than 30 min √
18. Run 10 min on 5μA Ozone: √
19. Switch to no-Ozone air and record time to drop from 4 to 1.5 μA (s): 25 **See Step A-4.3 #13**
20. Run 10 min on no-Ozone air: √ Record Ozone Current (μA): 0.07 **See Step A-4.3 #14**
21. Short cell leads: √ **See Step A-4.3 #15**
22. Store in sonde box, with tissue under the cells, and store at dark place: √

Key Points/Summary 2

- Metadata can be used to formulate **Data Quality Indicators (see Webinar #5)** to track the performance of individual ECCs, and any changes to long-term records
- Metadata are captured in RS-provided sounding software and hand-written notes. **Electronic records** of all metadata must be kept
- RS software currently **does not** capture all Metadata specified in Annex B. Stay tuned for updates from ASOPOS 2.0 and the manufacturers
- Stations should strive to archive as much Metadata as feasible from Annex B (minimum: **required + essential**), so that future reprocessing is enabled and ECC performance is well-quantified
- Stay tuned for updates of the **(meta)data content and format** of the archives (WOUDC, NDACC, etc.)

Final conditioning for 0–1 day prior to launch

1. Date: YYYYMMDD
2. Operator Initials: HV
3. Check tissue under the cells for any leakage: √ — **See Step A-5.1 #18**
4. Remove original Cathode and Anode solution: √ — **See Step A-5.1 #21**
5. Add Cathode solution (wait minimum 2 min): **3.0cm³** √ — **See Step A-5.1 #22 & 23**
6. Add **1.5cm³** Anode solution: √ — **See Step A-5.1 #24**
7. Run 10 min of NO-Ozone air: √
8. Record ECC current (I_{B0}) (μA): 0.02 **<0.03** — **See Step A-5.2 #29**
9. Run 10 min at 5 μA Ozone: √
10. Switch to no-Ozone air and record time to drop from 4 to 1.5 μA (s): 25 — **See Step A-5.3 #30**
11. Run on no-Ozone air: √
12. Record 5 t_{100} times (s/100ml) to determine flow rate: — **See Step A-5.4 #31**
    a. 28.10
    b. 28.30
    c. 28.00
    d. 28.40
    e. 28.20
13. Average t_{100} time (s/100ml) for flowrate: 28.20 (should be between 25 and 35 sec/100 ml)
14. Lab. Temperature T_{Lab} (°C): 274.5 — **See Step A-5.4 #32**
15. Lab. Relative Humidity RH_{Lab} (%): 55
16. Lab. Pressure P_{Lab} (hPa): 850.5
17. After 10 min on NO-Ozone air, record Cell Current (I_{B1}) (μA): 0.02 **<0.07**
18. Pump Motor Current (mA): 105
19. End time of preparation (**UTC**): HH:MM:SS

Select References

- Smit, H. & A. M. Thompson, and the ASOPOS 2.0 Panel, "Ozonesonde Measurement Principles and Best Operational Practices", GAW Report #268, 2021: https://tinyurl.com/4ysxpk9m
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- Stauffer, R. M., et al., "An Examination of the Recent Stability of Ozonesonde Global Network Data", ESS, 2022: https://tinyurl.com/2t8mx4m8
- Tarasick, D. W., et al., "Improving ECC Ozonesonde Data Quality: Assessment of Current Methods and Outstanding Issues", Earth Space Sci., 2021: https://tinyurl.com/bdh5ysys
- Vömel, H., et al., "A New Method to Correct the Electrochemical Concentration Cell (ECC) Ozonesonde Time Response and its Implications for "Background Current" and Pump Efficiency", Atmos. Meas. Tech., 2020: https://tinyurl.com/4r2d64vc
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Closing Remarks

- This webinar no. 6 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 Vömel)*
  6. Meta Data and Software *(Roeland Van Malderen & Ryan Stauffer)*
- The webinars do not replace the Report or associated video clips, but only highlight the most important topics and updates from the previous ASOPOS 1.0 report (WMO/GAW Report No. 201).
- **Whenever you have questions or need advice, consult the authors of this webinar or any of the ASOPOS Team members listed above !!!**

Thank you for your attention. We look forward to future collaborations!!!