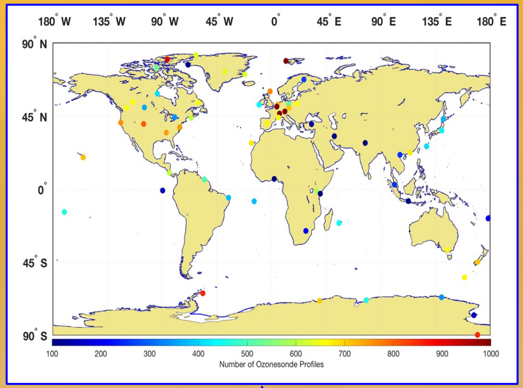
Ozonesonde Measurement Principles and Best Operational Practices

ASOPOS 2.0 (GAW Report No. 268)

(Assessment of Standard Operating Procedures for Ozonesondes)

ASOPOS-Webinar No. 5



Ozonesonde Data Quality Indicators

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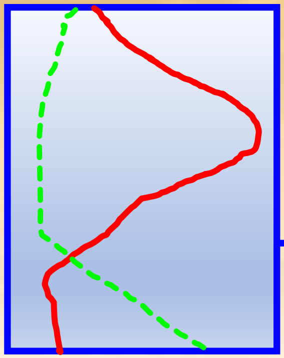

Version March 2024

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Outline

- What are examples of ozonesonde Data Quality Indicators (DQI)?
- Screening individual ozonesonde profiles to assess reliability and measurement uncertainty
- Monitor for changes to metadata and measurements in long-term records (*Note: Metadata are covered extensively in Webinar #6*)
- Assist in performing and evaluating the homogenization of long-term records or records from multiple stations

Examples of Ozonesonde DQI

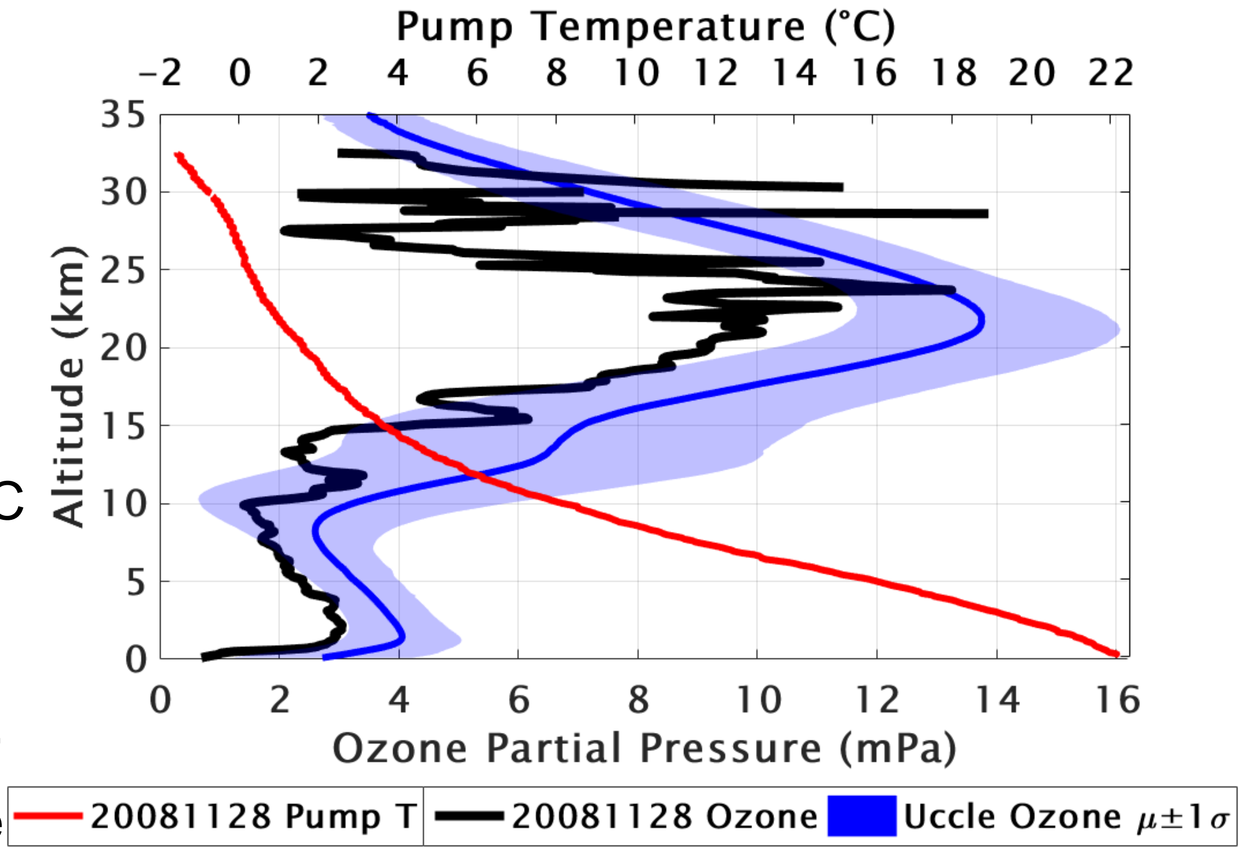
- Issues with some DQI are more common than others
- Note the difference in acceptable **Pump Temperature** values between the two ozonesonde types. This is due to the different construction of the ECC frame for SPC vs. ENSCI
- We will show examples of two DQI from an individual profile: Pump Temperature and Total Ozone Normalization Factor ★

Indicator	ECC SPC	ECC ENSCI-Z	Identifier in WOUDC
★ Total ozone normalization factor	0.9–1.1	0.9–1.1	TotalOzoneNormalizationFactor
Time to pump 100 ml [s]	25–35	25–35	FlowRateTime
Pump flowrate [ml/min]	170–240	170–240	PumpFlowRate
Response time (1/e) [s]	18–28	18–28	ResponseTimeFast
★ Pump temperature [K]	278–310	283–310	SampleTemperature
Background current before exposure to ozone [μA]	< 0.03	< 0.03	I_{B0}
Background current after exposure to ozone [μA]	< 0.07	< 0.07	I_{B1}
Pump motor current [mA]	50–120	50–120	PumpMotorCurrent
Pump motor voltage [V]	12–18	12–18	PumpMotorVoltage

Table of common ozonesonde DQI, acceptable ranges for SPC and ENSCI ECC types, and the identifier name used in WOUDC archived data files

Using DQI to Identify Problems in Profile Data

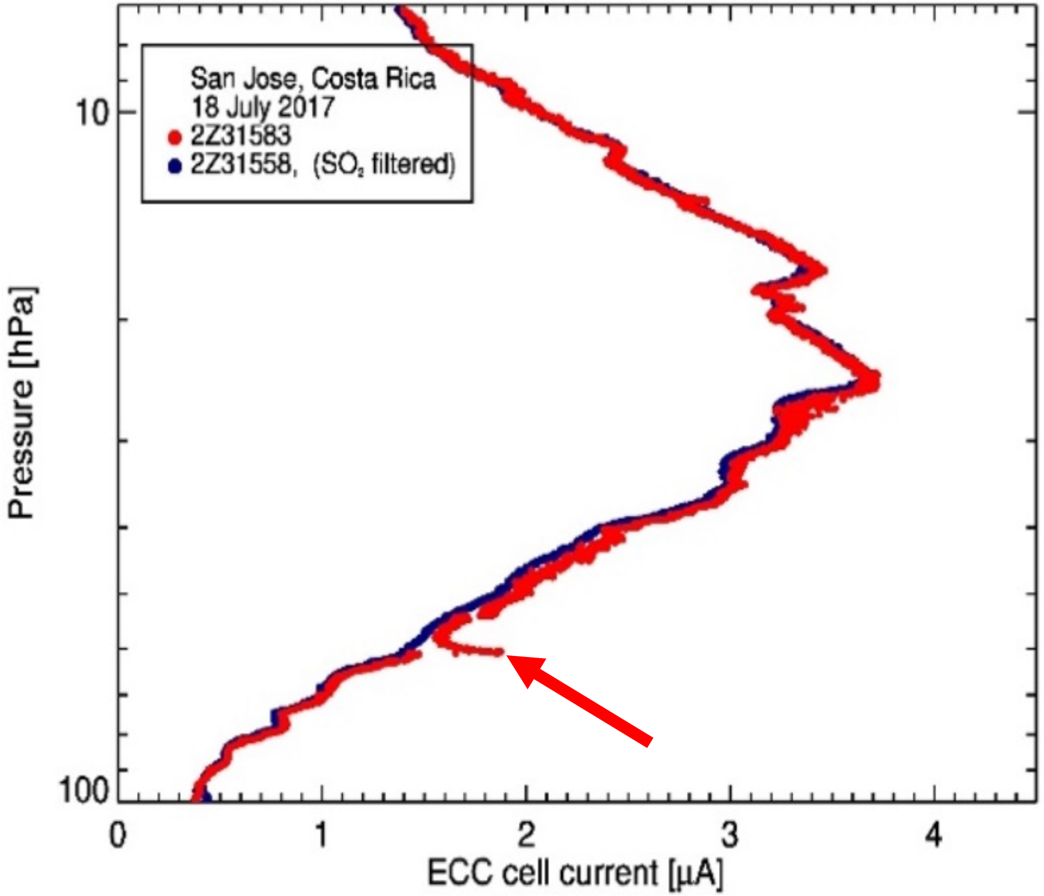
- This shows an example from Uccle, Belgium
- The profile on 20081128 measures ozone that is erratic and generally much lower in the stratosphere than is typical for Uccle
- Using the pump temperature DQI, we see that the pump is far too cold in the stratosphere, and the ECC sensing solutions are likely freezing, leading to the strange ozone measurements
- Total ozone normalization factor (OMI/ECC) is **1.157 (> 1.1).** This is an additional indicator that this profile is of lower quality



Average ± 1 standard deviation of the ozone partial pressure from all Uccle ozonesondes (blue). Ozone partial pressure from the 20081128 profile (black). Pump temperature from the 20081128 profile (red).

Other Potential Artefacts: “Ozone Spikes”

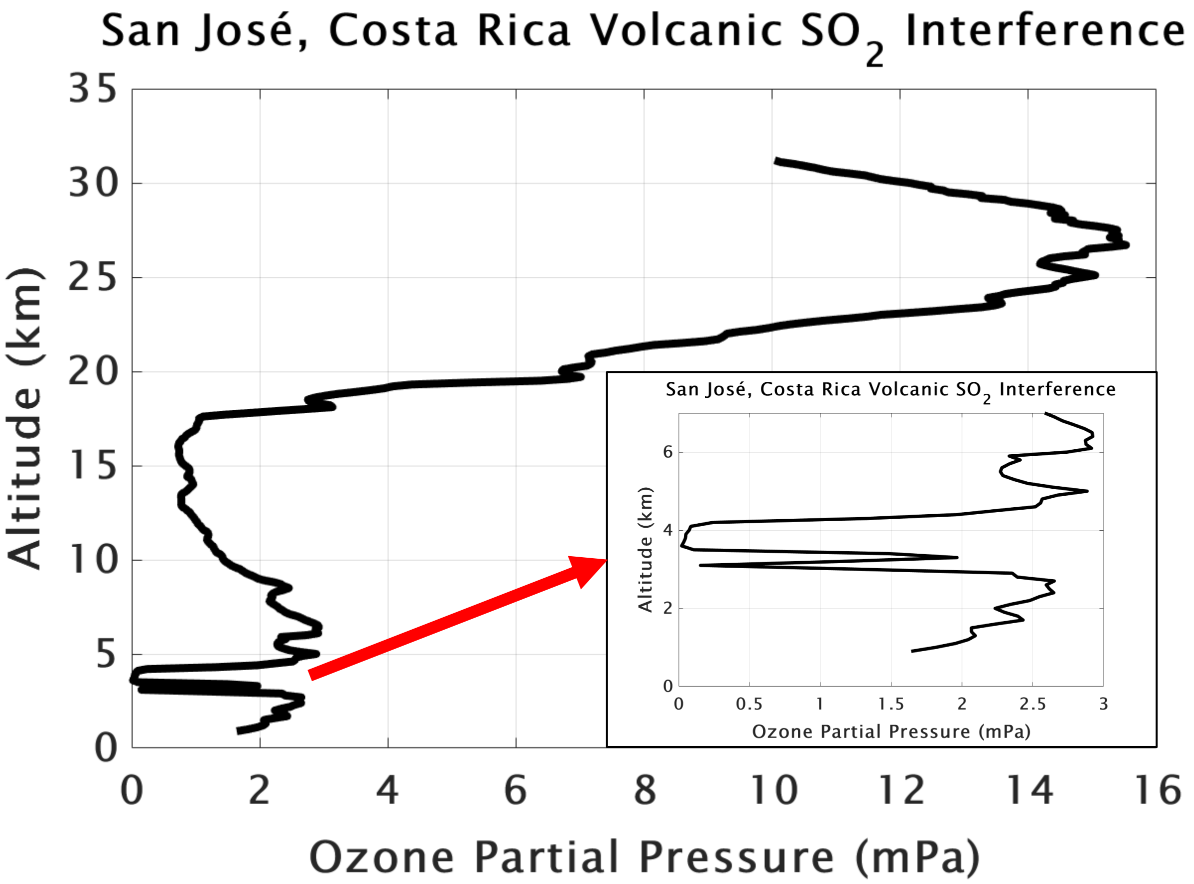
- Profile data should be examined to identify artefacts not covered by standard DQI
- This example shows an “ozone spike” at 60 hPa from one of two ozonesondes flown in dual-flight configuration at San José, Costa Rica
- These occasional artefacts are not well understood, but the affected ozone data should be removed if possible prior to final archival



Dual ozonesonde flight from San José, Costa Rica showing an “ozone spike” in the red ozonesonde profile that does not appear in the blue ozonesonde profile

Other Potential Artefacts: SO_2 Interference

- A second example from San José, Costa Rica shows the effect of SO_2 interference from a nearby volcano, which produces artificially low (sometimes zero) ozone measurements from the ECC
- These profiles are common at stations with nearby volcanic activity, and SO_2-polluted stations (less of a concern with modern data)
- These measurements should be excluded from typical ozone analyses, but are useful to include in archived data



Ozonesonde partial pressure from a flight from San José, Costa Rica on 20090605 showing volcanic SO_2 interference from 3 to 4 km AMSL

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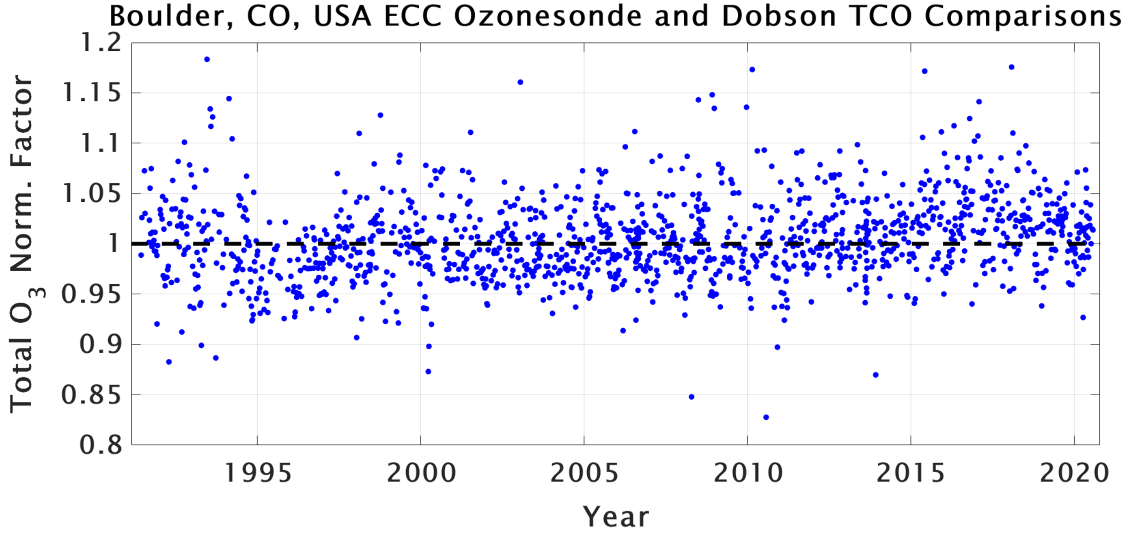
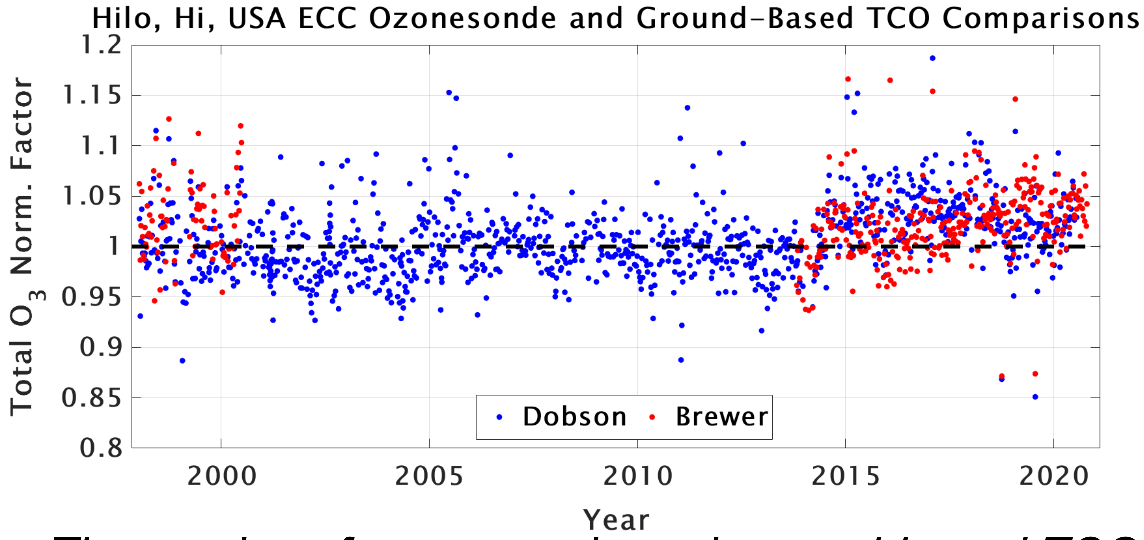
DQI Tracking for Long-Term Records

- Time series of total ozone normalization factor from satellite or ground-based total column ozone (TCO; examples at right →) can be used to track long-term data quality changes

- Note the long-term stability of normalization factors at Boulder (top), and a step change noticed in 2014 at Hilo (bottom). Changes to DQI should be investigated

- ***Do not apply normalization factors to ozonesonde profile data! This is an obsolete practice****





Time series of ozonesonde and ground-based TCO comparisons at Boulder (top) and Hilo (bottom)

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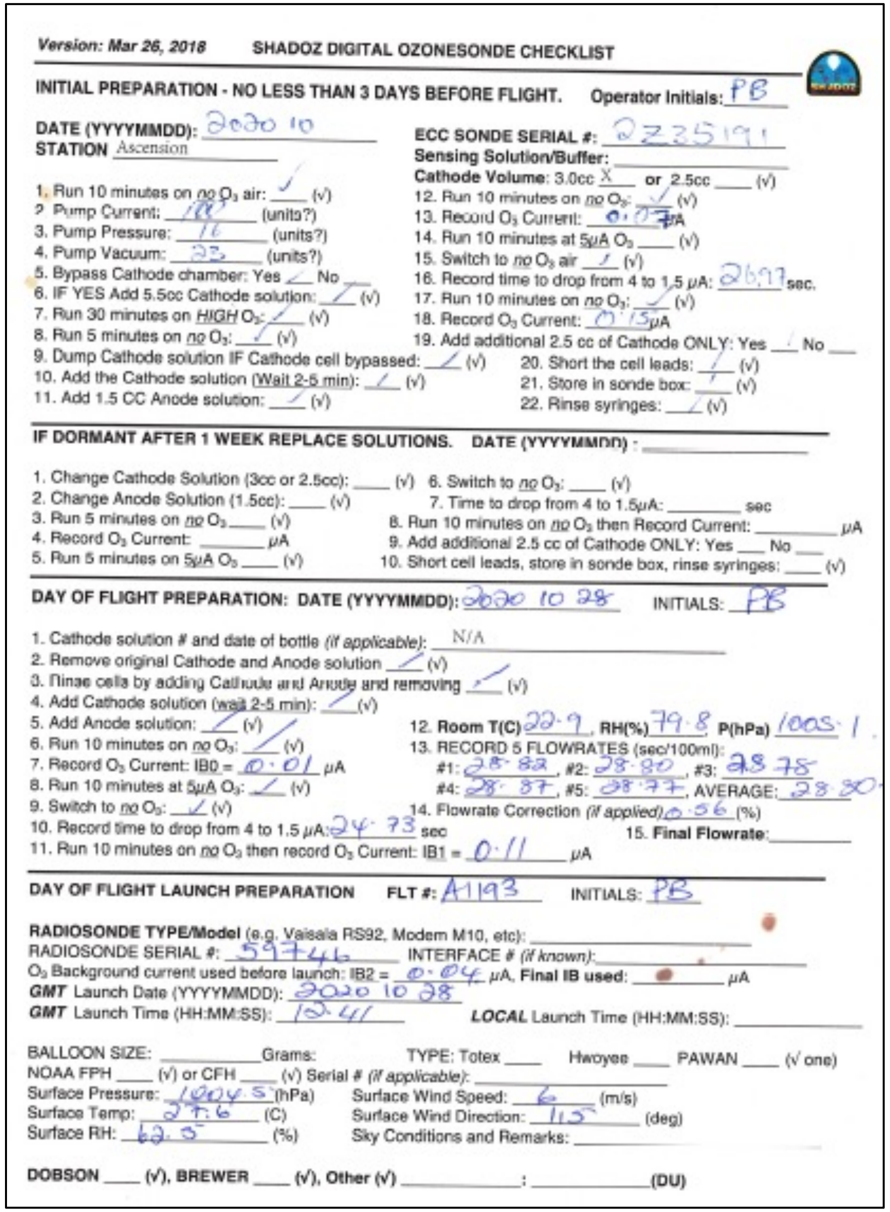
Accurate Metadata Collection and DQI

- Accurate metadata is vital to link long-term DQI evaluations with changes to ozonesonde data quality
- Metadata are <u>a requirement</u> for reprocessing and homogenizing station data
- Example checksheets (on right) should be combined with electronic recordkeeping
- More on Metadata in the separate Webinar #6 presentation…



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

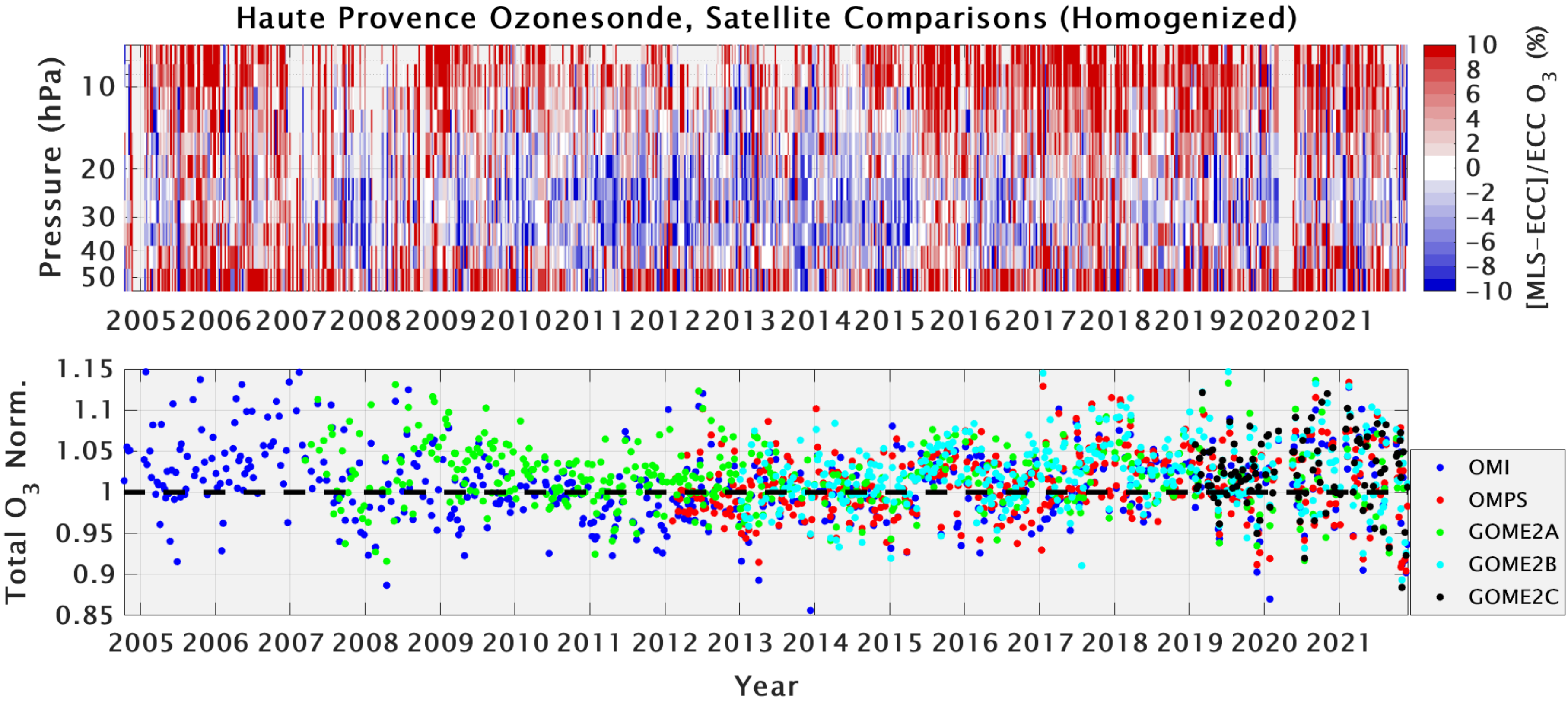
RADIOSONDE TYPE/Model (e.g. Vaisala RS92, Modem M10, etc): ____
RADIOSONDE SERIAL #: 59746 INTERFACE # *(if known)*: ____
O_3 Background current used before launch: IB2 = 0.04 µA, **Final IB used:** ____ µA
GMT Launch Date (YYYYMMDD): 2020 10 28
GMT Launch Time (HH:MM:SS): 12:41 ***LOCAL*** Launch Time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

DQI used to Assess Data Homogenization (OHP)

- DQI can be used to characterize the changes and quality/accuracy for homogenized ozonesonde time series
- The OHP station recently homogenized their data using collected metadata
- **Biases in the homogenized data are greatly reduced. This is an example of successful metadata collection and homogenization verified using DQI**
- Bias in homogenized data sets in the stratosphere (top) and TCO (bottom) compared to all instruments. The ozonesonde generally measures high TCO



Comparisons of OHP ozonesonde data with Aura MLS in the stratosphere (percent difference; top) and TCO from 5 satellite instruments (TCO normalization factor; bottom). See Ancellet et al., (2022; AMT)

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Other Evaluations to Ensure Data Quality

For more information on surface weather station best-practices, see Chapters 2-4 of WMO #8: https://library.wmo.int/doc_num.php?explnum_id=11386

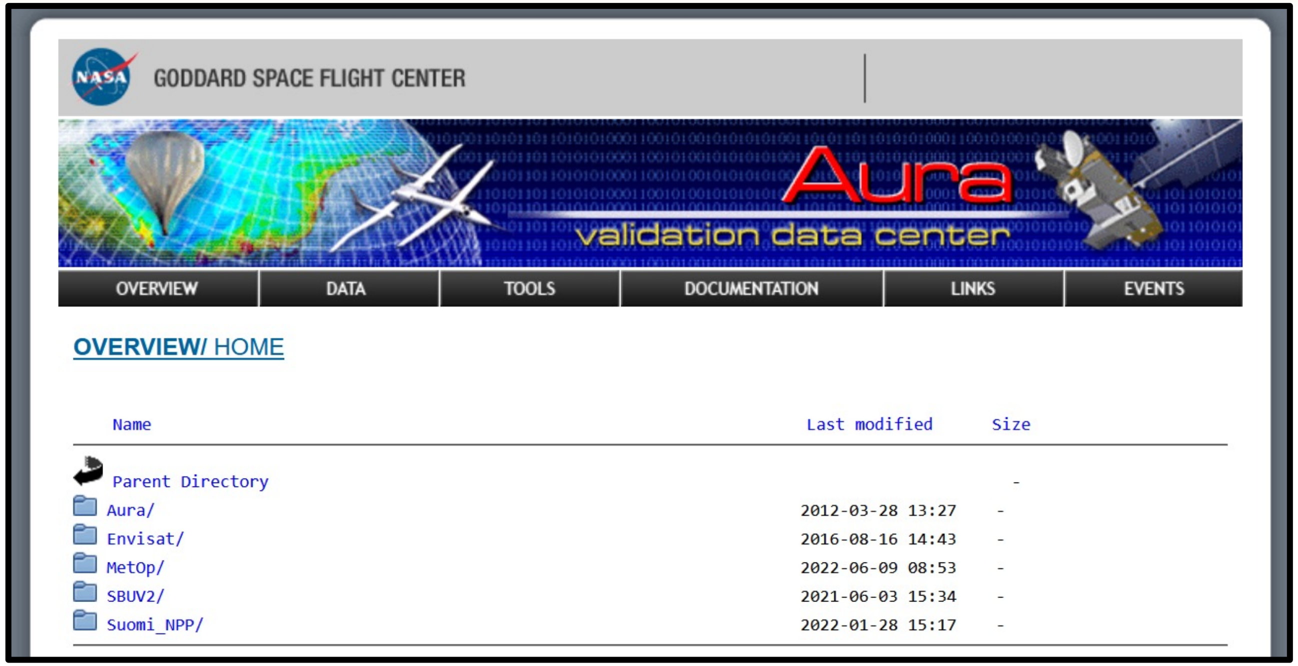
- Ozonesonde ground checks against surface ozone instrumentation should be performed where available
- Maintained long-term records of the comparisons can also be used as DQI

- Do not forget about the radiosonde! Verify surface data against a high-quality surface weather station (p, T, RH, GPS data)
- Accurate pressure and altitude registration are crucial for ozonesonde data quality

Satellite Data Sources to Evaluate DQI (AVDC)

- ASOPOS recommends, in addition to ground-based independent data (if available), to use Level 2 satellite overpass data to evaluate ozonesonde data time series

- Level 2 satellite overpass data for hundreds of locations are available at NASA/GSFC's Aura Validation Data Center (AVDC)



L2 Ozone Overpass Data File Links (used in Stauffer et al., 2020; 2022):

Aura MLS: https://avdc.gsfc.nasa.gov/pub/data/satellite/Aura/MLS/V05/L2GPOVP/O3/
OMI: https://avdc.gsfc.nasa.gov/pub/data/satellite/Aura/OMI/V03/L2OVP/OMTO3/
OMPS: https://avdc.gsfc.nasa.gov/pub/data/satellite/Suomi_NPP/L2OVP/NMTO3-L2/
GOME-2A: https://avdc.gsfc.nasa.gov/pub/data/satellite/MetOp/GOME2/V03/L2OVP/GOME2A/
GOME-2B: https://avdc.gsfc.nasa.gov/pub/data/satellite/MetOp/GOME2/V03/L2OVP/GOME2B/
GOME-2C: https://avdc.gsfc.nasa.gov/pub/data/satellite/MetOp/GOME2/V03/L2OVP/GOME2C/
Example Comparison Time Series: https://tropo.gsfc.nasa.gov/shadoz/SHADOZ_PubsList.html

Key Points/Summary 1

- Data Quality Indicators (DQI) include measures of the ozonesonde performance during laboratory preparation, and evaluation of the collected ozonesonde data

- DQI can be applied to individual profiles:
  - Anomalous ECC cell or ozonesonde pump characteristics
  - Freezing or boiling solution leading to erratic ozonesonde measurements
  - Identify problems with either the ECC or ground preparation equipment (high background current, slow response time)
  - Poor agreement (>10% difference) with independent TCO data

- DQI can be applied to track long-term data records:
  - Multi-year evaluations against independent TCO from co-located ground-based and satellite overpass data, satellite stratospheric profiles
  - Identification of step changes to DQI resulting from intentional or inadvertent changes to station practices, or changes to ECC ozonesonde manufacture/construction

Key Points/Summary 2

- Other artefacts that are less common and not covered by standard DQI:
  - "Ozone spikes" from cell chemistry that are not well understood
  - Interferences such as from SO_2, leading to artificially low ozonesonde ozone

- Accurate and complete metadata collection is vital
  - Enables, and is a requirement to homogenize and reprocess ozonesonde data
  - Combined with DQI, can be used to assess the changes and improvements to ozonesonde station time series after homogenization

- Ground checks of the ozonesonde with a surface ozone instrument, if available, and radiosonde should also be performed

Select References

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