GRUAN Ozonesonde Technical Document

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Background: Qualification and Philosophy

SHADOZ Sites, URL=http//:croc.gsfc.nasa.gov/shadoz

- SHADOZ: Southern Hemisphere ADditional OZonesonde
  - Premier archive of ozonesonde data from sub/tropical, remote, 'exotic' locations.
  - 1998-present: launching, processing, archiving, teaching, analyses.
  - Open access, inclusive, unrestricted membership.
  - Provide guidance with SOPs, reprocessing, formatting, troubleshooting.

Purpose

Provide mandatory and non-mandatory guidelines to ozonesonde stations that want to become GRUAN certified.

Objectives

- Improve/maintain data quality assurance and control through ‘best practices’.
- Establish homogeneity across the GRUAN network.
- Provide metadata records that capture all ECC sensor characteristics

Status

- **<u>First draft is complete!</u>**

- <u>Now</u>: Editing/Re-writing *(Greg I'm waiting)*
- Next^2: Peer-review

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Primary source materials

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)

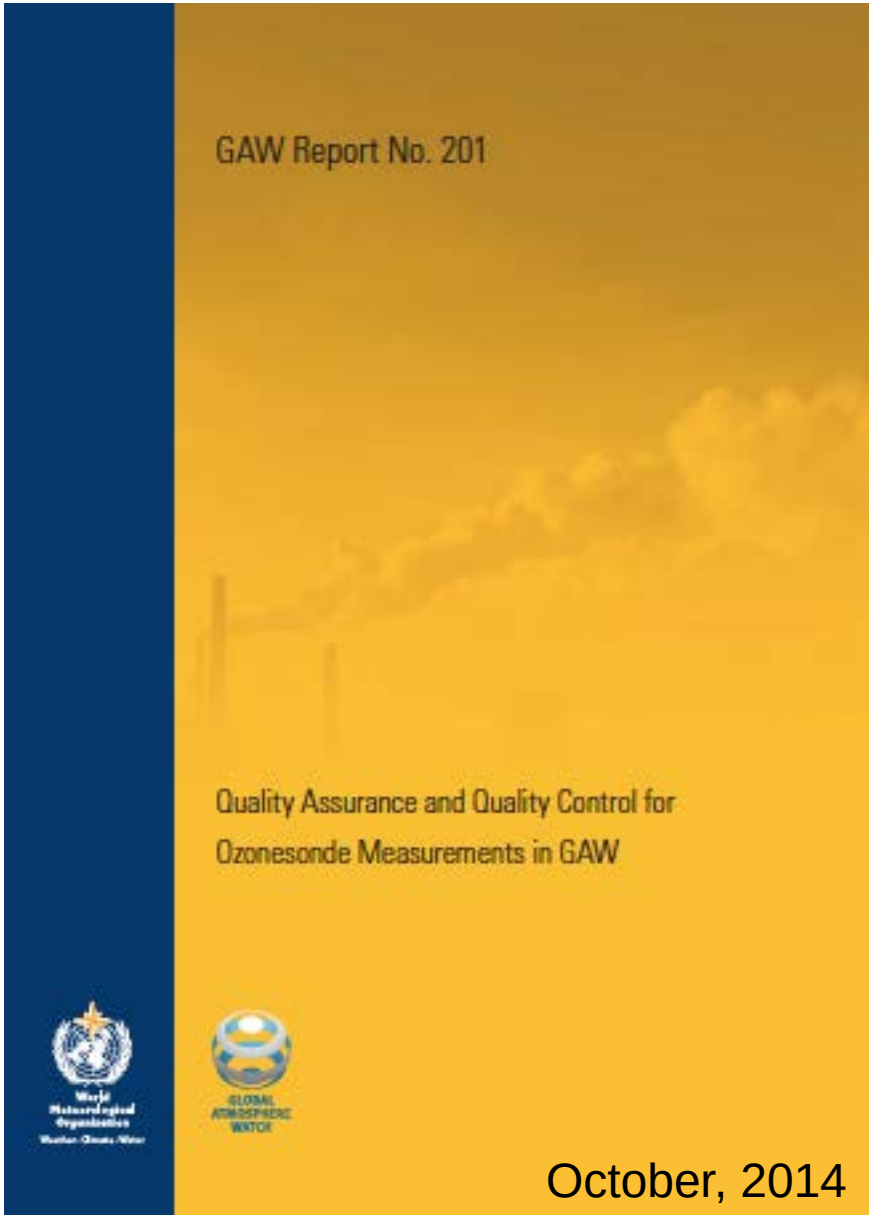
Prepared
by
O3S-DQA panel members on homogenization of O3S-data
(Herman Smit, Sam Oltmans, Terry Deshler, David Tarasick, Bryan Johnson, Frank Schmidlin, Rene Stuebi, Jonathan Davies)

Activity as part of

SPARC-IGACO-IOC Assessment

(SI2N)

"Past Changes in the Vertical Distribution of Ozone"



Holy Grail

Relative uncertainty of ozone partial pressure

$$\boxed{\frac{\Delta P_{O3}}{P_{O3}}} = \sqrt{\frac{(\Delta I_M)^2 + (\Delta I_B)^2}{(I_M + I_B)^2} + \left(\frac{\Delta \eta_C}{\eta_C}\right)^2 + \left(\frac{\Delta \Phi_P}{\Phi_P}\right)^2 + \left(\frac{\Delta T_P}{T_P}\right)^2 + \left(\frac{\Delta \Psi}{\Psi}\right)^2}$$

E-3-2 WMO/GAW No. 201

<u>Summation</u> of the individual uncertainties of the parameters that go into calculating an ozone measurement:

$$P_{O3} = 4.307\times10^{-4}\,(I_M - I_{BG})T_P\Phi\psi$$

Holy Grail: Relative uncertainty of ozone partial pressure

$$\frac{\Delta P_{O3}}{P_{O3}} = \sqrt{\boxed{\frac{(\Delta I_M)^2 + (\Delta I_B)^2}{(I_M + I_B)^2}} + \left(\frac{\Delta \eta_C}{\eta_C}\right)^2 + \left(\frac{\Delta \Phi_P}{\Phi_P}\right)^2 + \left(\frac{\Delta T_P}{T_P}\right)^2 + \left(\frac{\Delta \Psi}{\Psi}\right)^2}$$

- **Background and Current uncertainty**

$$P_{O3} = 4.307\times10^{-4}\,(I_M - I_{BG})T_P\Phi\psi$$

Background Currents
The Poster Child of Non-uniformity

For GRUAN

1. IB0 (DOF; prior to response test)
2. Lowest value of all the backgrounds
3. No backgrounds applied
4. Threshold value = 0.05 μA
5. Fixed value
6. IB2 (background prior to launch)

at the mercy of the destruct filters (not practical for a number of SHADOZ sites).

Holy Grail: Relative uncertainty of ozone partial pressure

$$\frac{\Delta P_{O3}}{P_{O3}} = \sqrt{\frac{(\Delta I_M)^2 + (\Delta I_B)^2}{(I_M + I_B)^2} + \boxed{\left(\frac{\Delta \eta_C}{\eta_C}\right)^2} + \left(\frac{\Delta \Phi_P}{\Phi_P}\right)^2 + \left(\frac{\Delta T_P}{T_P}\right)^2 + \left(\frac{\Delta \Psi}{\Psi}\right)^2}$$

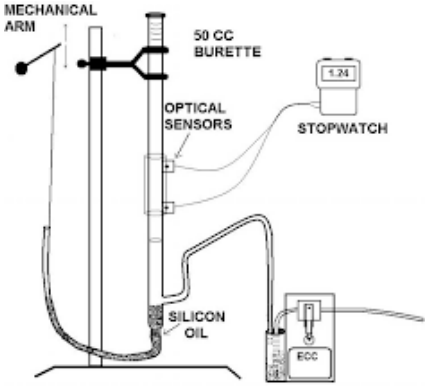
- **Background and Current uncertainty**
- **Conversion Efficiency uncertainty – Assume 1:1 Stoichiometric relationship between O_3:I_2**

$$P_{O3} = 4.307\times10^{-4}\,(I_M - I_{BG})T_P\Phi\psi$$

Holy Grail: Relative uncertainty of ozone partial pressure

$$\frac{\Delta P_{O3}}{P_{O3}} = \sqrt{\frac{(\Delta I_M)^2 + (\Delta I_B)^2}{(I_M + I_B)^2} + \left(\frac{\Delta \eta_C}{\eta_C}\right)^2 + \boxed{\left(\frac{\Delta \Phi_P}{\Phi_P}\right)^2} + \left(\frac{\Delta T_P}{T_P}\right)^2 + \left(\frac{\Delta \Psi}{\Psi}\right)^2}$$

- **Background and Current uncertainty**
- **Conversion Efficiency uncertainty**
- **Pump Flow Efficiency uncertainty at the ground**



$$P_{O3} = 4.307\times10^{-4}\,(I_M - I_{BG})T_P\Phi\psi$$

Holy Grail: Relative uncertainty of ozone partial pressure

$$\frac{\Delta P_{O3}}{P_{O3}} = \sqrt{\frac{(\Delta I_M)^2 + (\Delta I_B)^2}{(I_M + I_B)^2} + \left(\frac{\Delta \eta_C}{\eta_C}\right)^2 + \left(\frac{\Delta \Phi_P}{\Phi_P}\right)^2 + \boxed{\left(\frac{\Delta T_P}{T_P}\right)^2} + \left(\frac{\Delta \Psi}{\Psi}\right)^2}$$

- **Background and current uncertainty**
- **Conversion efficiency uncertainty**
- **Pump Flowrate uncertainty at the ground**
- **Pump temperature uncertainty**

$$P_{O3} = 4.307\times10^{-4}\,(I_M - I_{BG})T_P\Phi\psi$$

Holy Grail: Relative uncertainty of ozone partial pressure

$$\frac{\Delta P_{O3}}{P_{O3}} = \sqrt{\frac{(\Delta I_M)^2 + (\Delta I_B)^2}{(I_M + I_B)^2} + \left(\frac{\Delta \eta_C}{\eta_C}\right)^2 + \left(\frac{\Delta \Phi_P}{\Phi_P}\right)^2 + \left(\frac{\Delta T_P}{T_P}\right)^2 + \left(\frac{\Delta \Psi}{\Psi}\right)^2}$$

- **Background and current uncertainty**
- **Conversion efficiency uncertainty**
- **Pump Flowrate uncertainty**
- **Pump temperature uncertainty**
- **Uncertainty of the pump correction factors at low pressures**

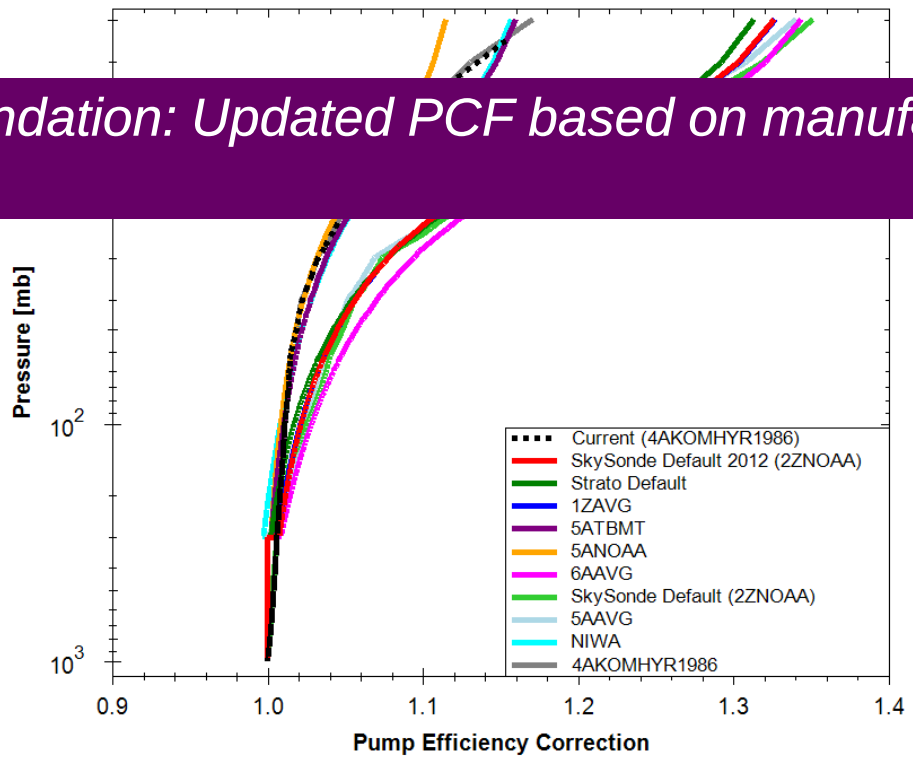
$$P_{O3} = 4.307\times10^{-4}\,(I_M - I_{BG})T_P\Phi\psi$$

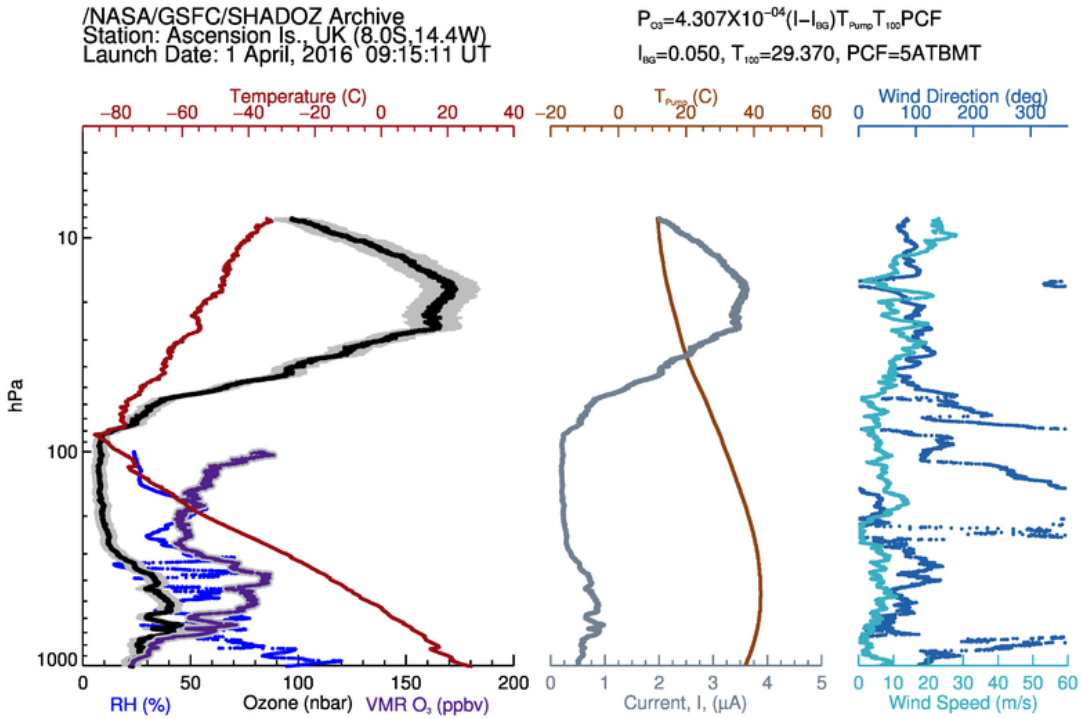
Pump Correction Factors at Low Pressures

Pressure [hPa]	Komhyr, 1986 (K86)	K86 uncertainty, ΔΨ	Komhyr et al., 1995 (K95)	K95 uncertainty, ΔΨ
Sfc-100	1.000	1.000	1.000	1.000
100	1.007	± 0.005	1.007	± 0.005
50	1.018	± 0.006	1.018	± 0.005
30	1.022	± 0.008	1.029	± 0.008
20	1.032	± 0.009	1.041	± 0.012
10	1.055	± 0.010	1.066	± 0.023
7	1.070	± 0.012	1.087	± 0.024
5	1.092	± 0.014	1.124	± 0.025
3	1.124	± 0.025	1.241	± 0.043

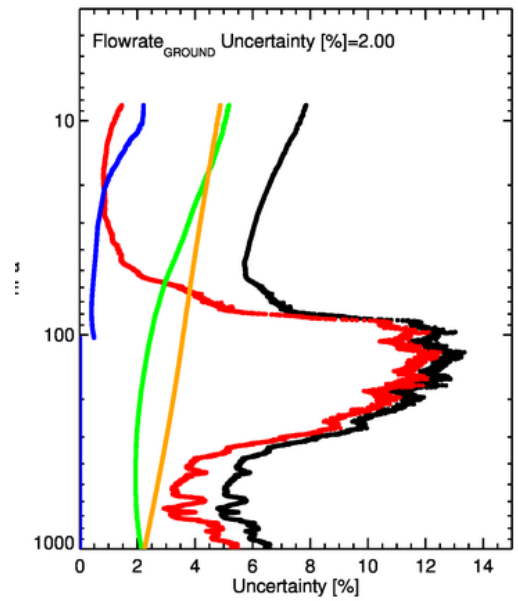
Pump corrections factors (PCF) with 1-sigma uncertainties. PCF values are taken from the GAW Report No. 201, Table 3-3 [Smit et al., 2014].

Recommendation: Updated PCF based on manufacturer, model, and solution.

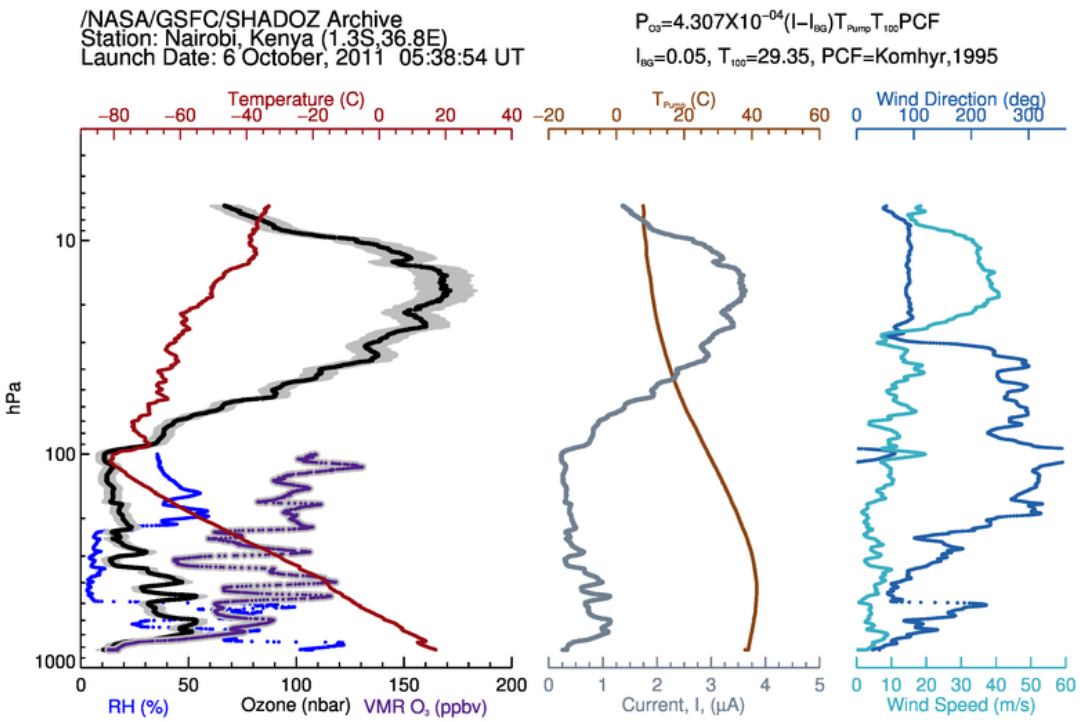


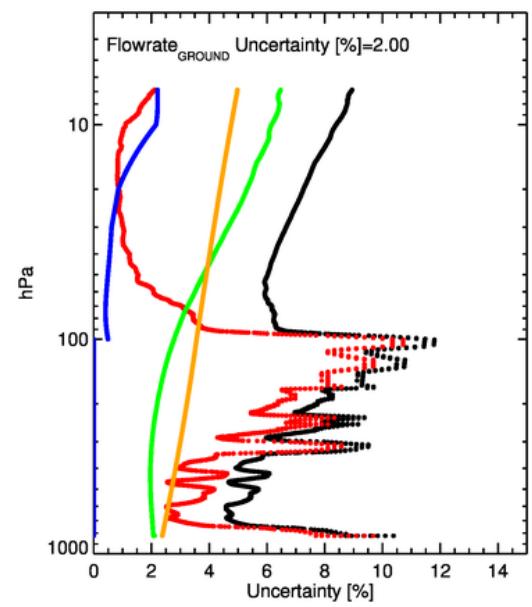


Uncertainty Contributions [%]



O_3 Partial Pressure
Current & Background
Pump Temperature
Conversion Efficiency
Pump Correction Factors





Standard Operating Procedures (SOP)

(Metadata reporting)

Appendix A.1: GRUAN STANDARD OPERATING PROCEDURES CHECK LIST

Follows the WMO GAW Report #201 SOP

INITIAL PREPARATION - NO LESS THAN 3 DAYS BEFORE FLIGHT.
OPERATOR INITIALS: _____
FLT # _____
DATE (YYYYMMDD): _____
O_3 PUMP SERIAL #: _____

1. Run 10 minutes on *no* O_3 air: ____ (√)
2. PUMP CURRENT: _____ (µA)
3. PUMP PRESSURE: _____ (psi)
4. PUMP VACUUM: _____ (in Hg)
5. Run 30 minutes on *HIGH* O_3: ____ (√)
6. Run 5 minutes on *no* O_3: ____ (√)
7. ADD 3.0 CC FRESH CATHODE (Wait 2 min): ____ (√)
8. ADD 1.5 CC ANODE SOLUTION: ____ (√)
9. Run 10 minutes on *no* O_3: ____ (√)
10. RECORD O_3 CURRENT: _____ µA
11. Run 5 minutes at 5µA O_3 ____ (√) - then switch to *no* O_3 air.
12. RECORD TIME TO DROP FROM 4 TO 1.5 µA: ____ sec.
13. Run 10 minutes on *no* O_3: ____ (√)
14. RECORD O_3 CURRENT: _____uA

For refurbished sensors, follow calibration procedures.

15. Add additional 2.5 cc of CATHODE : ____ (√)
16. Short the cell leads: ____ (√)
17. Intake tube stored in sonde frame: ____ (√)
18. Store inside Styrofoam flight box: ____ (√)

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

1. CHANGE CATHODE SOLUTION (3cc): ____ (√)
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. RECORD TIME TO DROP FROM 4 TO 1.5 µA: _____ sec
8. Run 10 minutes on *no* O_3 – RECORD CURRENT: _____ uA
9. Short cell leads and Store in Styrofoam flight: ____ (√)

IF DORMANT AFTER ANOTHER WEEKS REPLACE SOLUTIONS.
DATE (YYYYMMDD) : _____

1. CHANGE CATHODE SOLUTION (3cc): ____ (√)
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. RECORD TIME TO DROP FROM 4 TO 1.5 µA: _____ sec
8. Run 10 minutes on *no* O_3 – RECORD CURRENT: _____ uA
9. Short cell leads and Store in Styrofoam flight: ____ (√)

DAY OF FLIGHT PREPARATION IN LAB:
DATE (YYYYMMDD): _____
OPERATOR INITIALS: _____

1. CHANGE CATHODE SOLUTION (3cc): ____ (√)
2. CHANGE ANODE SOLUTION (1.5cc): ____ (√)
3. Run 10 minutes on *no* O_3: ____ (√)
5. RECORD O_3 CURRENT: BG#0 = _____ µA
6. Run 10 minutes at 5µA O_3: ____ (√)
7. Switch to *no* O_3: ____ (√)
8. RECORD CURRENT AFTER 30 Sec_____µA, 1min_____ µA, 2min_____ µA
   3min_____ µA, 5min_____ µA, 10min_____ µA
9. RECORD O_3 CURRENT: BG#1 = _____ µA
10. ROOM TEMP (C): _____, ROOM RH (%): _____,
    ROOM Pressure (hPa)_____
11. RECORD T100 FLOWRATE TIMES:
    FLOWRATE #1: _____ sec
    FLOWRATE #1: _____ sec
    FLOWRATE #1: _____ sec
    FLOWRATE #1: _____ sec
    FLOWRATE #1: _____ sec
    AVERAGE T100:_____ sec

DAY OF FLIGHT AT THE LAUNCH SITE:
FLT #: _____
OPERATOR INITIALS: _____

Dobson *(if available)*: _____(DU)
Brewer *(if available)*: _____(DU)
Other *(if available)*: _____(DU)

RADIOSONDE SERIAL #: _____
INTERFACE # *(if applicable)*:_____
O_3 BACKGROUND CURRENT BEFORE FLIGHT BG#2: _____ µA

GMT Date (YYYYMMDD): _____
GMT Launch Time (HH:MM:SS): _____
LOCAL date (YYYYMMDD): _____
LOCAL Launch time (HH:MM:SS): _____

BALLOON SIZE: _____Grams:
TYPE: TOTEX ____ Hwoyee ____ PAWAN ____ (√ one)

SURFACE PRESS: _____(hPa)
SURFACE TEMP: _____ (C)
SURFACE RH: _____ (%)
SURFACE WIND SPEED: _____ (m/s)
SURFACE WIND DIR: _____ (deg)

Sky Conditions and General Remarks:

Further topics to investigate

- Refurbished sondes
  - SOP, thresholds, selection criteria
- Japanese KC-79, KC-96 sensor (1990-2009)
  - Transfer functions, re-processing, uncertainty calculations, QA/QC
- Radiosonde biases/offsets *(GRUAN Radiosonde WG)*
  - Correction, RS-80/RS-92 transfer function?, transfer functions among radiosondes.
- Central processing issue: There are 6 radiosonde/ozonesonde configurations: Vaisala, Modem, ChangFeng, IMet, LMS, Meisei
  - Need Radiosonde WG input/guidance, another intercomparison campaign??
- Transfer Functions
  - Testing
  - KC/ECC, BM/ECC

Refurbished Sondes *(Richard Querel/NIWA)*
SOP, thresholds, selection criteria

Appendix A.2: RECOVERED OZONESONDE CHECKLIST

DATE (YYYYMMD): _____
OPERATOR INITIALS: _____

Was this a GPS Sonde recovered on day of flight? ____ Yes/No
If No, how many days between launch and recovery? ____days

HISTORY:
O_3 PUMP SERIAL #: _____
FORMER FLIGHT #: _____
DATE FLOWN (YYYYMMDD): _____
DATE FOUND (YYYYMMDD): _____
DATE RETURNED (YYYYMMDD): _____

COMMENTS: OVERALL SONDE/PUMP CONDITION: (looks new, dirt or coloring around pump present, signs of corrosion anywhere, 0-ring condition, pump noisy?, etc.)

INITIAL RINSE/RECONDITIONING – SOON AFTER DELIVERY:

Check that the cam that drives the piston is not turning off-center, loose or rubbing too close to the metal frame. If it is too close or has come loose then the sonde will be noisy and run with a high current. Sonde should not be flown in this case.

Rinse off outside of cells with warm tap water. ____(√)
Squirt De-ionized water (DIW) through running pump inlet (2 or 3 times for about 5 seconds). ____(√)
Rinse cells and tubing with DIW. ____(√)
Fill cells about ¾ full of DIW. ____(√)
Store sheet and ozonesonde until ready for the 3-7 day pre-condition. ____(√)
Date stored on shelf until ready for the 3-7 day pre-condition (YYYYMMDD): _____

During normal pre-conditioning preparations, an ozone calibrator, e.g. TEI, is strongly recommended to test the performance of the refurbished sonde. Re-conditioned sondes should not be flown if the sonde values are ±5% of calibrated source.

Main Takeaway


Boulder, CO

Key to uniformity, quality assurance, and quality control in ozonesonde performance and record keeping:

- Consensus on standard operating procedures
- Consensus on metadata requirements
- Consensus on uncertainty calculations
- Consensus on what goes into $P_{O3} = 4.307\times10^{-4}\,(I_M - I_{BG})T_P\Phi\psi$


Quito, Ecuador


Lusaka, Zambia


Heredia, CR


Suva, Fiji


Nairobi, Kenya


Kuala Lumpur, Malaysia


Lauder, NZ

Lab/Field Ozonesonde Intercomparison Campaigns are important !

WCCOS (World Calibration Center for Ozone Sondes)

BESOS Campaign, Laramie, WY
April 5-23, 2004