

GRUAN Ozonesonde Technical Document

Jacquie Witte (SSAI; NASA/GSFC/Atmospheric Chemistry and Dynamics Lab;
SHADOZ Archiver)

Greg Bodeker (Bodeker Scientific)

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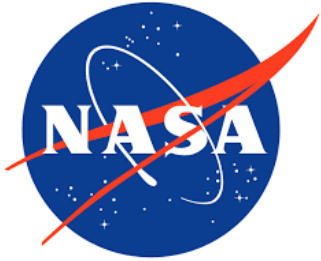
Bryan Johnson, Chance Sterling, Patrick Cullis (NOAA/GMD)

Richard Querel (NIWA/Lauder)

Rigel Kivi (FMI)



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

- First draft is complete!



- Now: Editing/Re-writing (*Greg I'm waiting*)
- Next²: 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

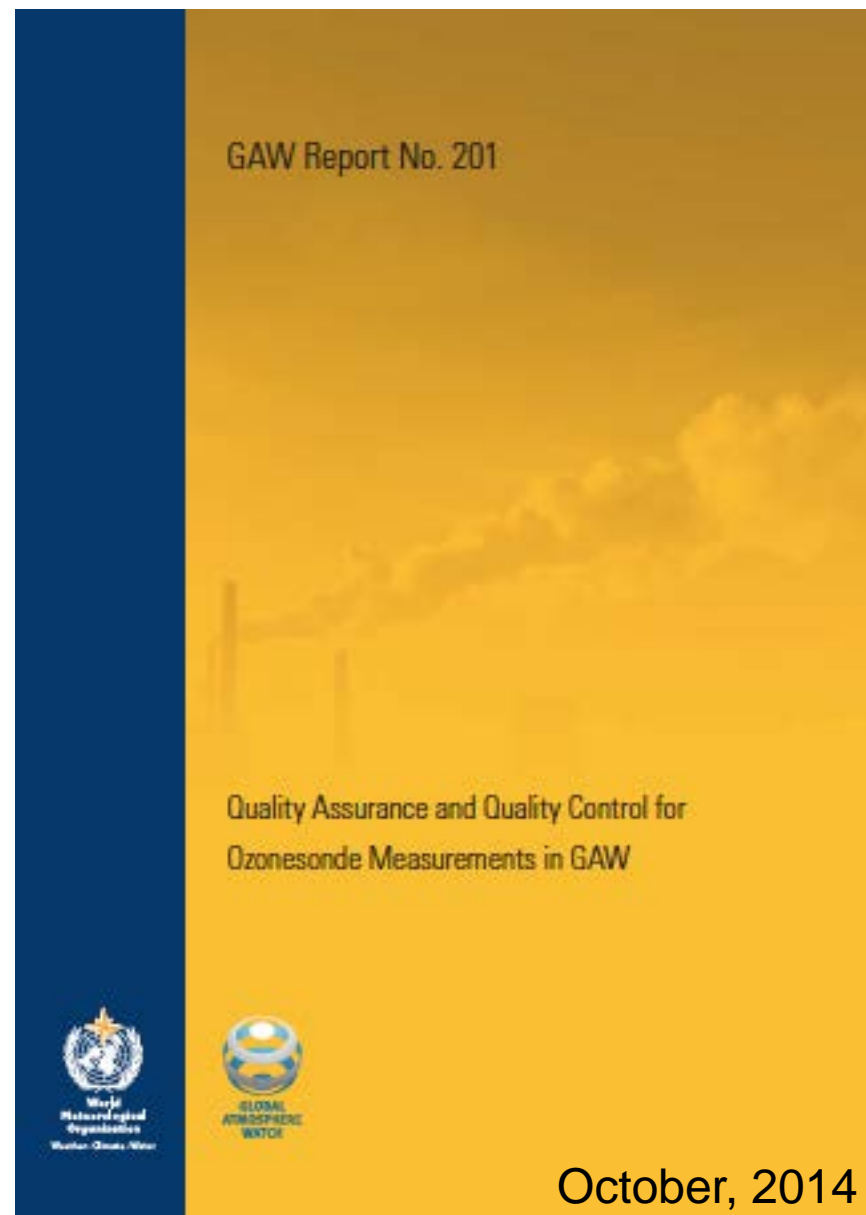
(Herman Smit, Sam Oltmans, Terry Deshler, David Tarasick, Bryan Johnson,
Frank Schmidlin, Rene Stuebi, Jonathan Davies)

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

$$\frac{\Delta P_{O_3}}{P_{O_3}} = \sqrt{\frac{(\Delta I_M)^2 + (\Delta I_B)^2}{(I_M + I_B)^2} + \left(\frac{\Delta \eta_C}{\eta_C}\right)^2 + \left(\frac{\Delta \Phi_P}{\Phi_P}\right)^2 + \left(\frac{\Delta T_P}{T_P}\right)^2 + \left(\frac{\Delta \Psi}{\Psi}\right)^2}$$

E-3-2 WMO/GAW No. 201

Summation of the individual uncertainties of the parameters that go into calculating an ozone measurement:

$$P_{O_3} = 4.307 \times 10^{-4} (I_M - I_{BG}) T_P \Phi \Psi$$

Holy Grail: Relative uncertainty of ozone partial pressure

$$\frac{\Delta P_{O_3}}{P_{O_3}} = \sqrt{\frac{(\Delta I_M)^2 + (\Delta I_B)^2}{(I_M + I_B)^2} + \left(\frac{\Delta \eta_C}{\eta_C}\right)^2 + \left(\frac{\Delta \Phi_P}{\Phi_P}\right)^2 + \left(\frac{\Delta T_P}{T_P}\right)^2 + \left(\frac{\Delta \Psi}{\Psi}\right)^2}$$

- **Background and Current uncertainty**

$$P_{O_3} = 4.307 \times 10^{-4} (I_M - I_{BG}) T_P \Phi \Psi$$



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

$$\frac{\Delta P_{O_3}}{P_{O_3}} = \sqrt{\frac{(\Delta I_M)^2 + (\Delta I_B)^2}{(I_M + I_B)^2} + \left(\frac{\Delta \eta_C}{\eta_C}\right)^2 + \left(\frac{\Delta \Phi_P}{\Phi_P}\right)^2 + \left(\frac{\Delta T_P}{T_P}\right)^2 + \left(\frac{\Delta \Psi}{\Psi}\right)^2}$$

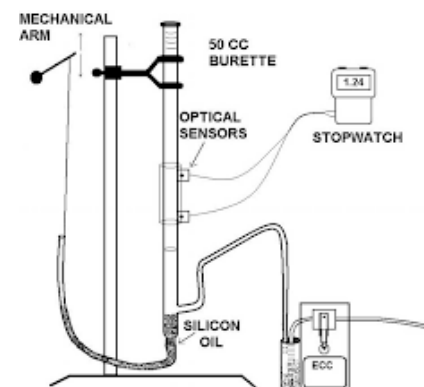
- **Background and Current uncertainty**
- **Conversion Efficiency uncertainty – Assume 1:1 Stoichiometric relationship between $O_3:I_2$**

$$P_{O_3} = 4.307 \times 10^{-4} (I_M - I_{BG}) T_P \Phi \Psi$$

Holy Grail: Relative uncertainty of ozone partial pressure

$$\frac{\Delta P_{O_3}}{P_{O_3}} = \sqrt{\frac{(\Delta I_M)^2 + (\Delta I_B)^2}{(I_M + I_B)^2} + \left(\frac{\Delta \eta_C}{\eta_C}\right)^2 + \left(\frac{\Delta \Phi_P}{\Phi_P}\right)^2 + \left(\frac{\Delta T_P}{T_P}\right)^2 + \left(\frac{\Delta \Psi}{\Psi}\right)^2}$$

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



$$P_{O_3} = 4.307 \times 10^{-4} (I_M - I_{BG}) T_P \Phi \Psi$$

Holy Grail: Relative uncertainty of ozone partial pressure

$$\frac{\Delta P_{O_3}}{P_{O_3}} = \sqrt{\frac{(\Delta I_M)^2 + (\Delta I_B)^2}{(I_M + I_B)^2} + \left(\frac{\Delta \eta_C}{\eta_C}\right)^2 + \left(\frac{\Delta \Phi_P}{\Phi_P}\right)^2 + \left(\frac{\Delta T_P}{T_P}\right)^2 + \left(\frac{\Delta \Psi}{\Psi}\right)^2}$$

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

$$P_{O_3} = 4.307 \times 10^{-4} (I_M - I_{BG}) T_P \Phi \Psi$$

Holy Grail: Relative uncertainty of ozone partial pressure

$$\frac{\Delta P_{O_3}}{P_{O_3}} = \sqrt{\frac{(\Delta I_M)^2 + (\Delta I_B)^2}{(I_M + I_B)^2} + \left(\frac{\Delta \eta_C}{\eta_C}\right)^2 + \left(\frac{\Delta \Phi_P}{\Phi_P}\right)^2 + \left(\frac{\Delta T_P}{T_P}\right)^2 + \left(\frac{\Delta \Psi}{\Psi}\right)^2}$$

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

$$P_{O_3} = 4.307 \times 10^{-4} (I_M - I_{BG}) T_P \Phi \Psi$$

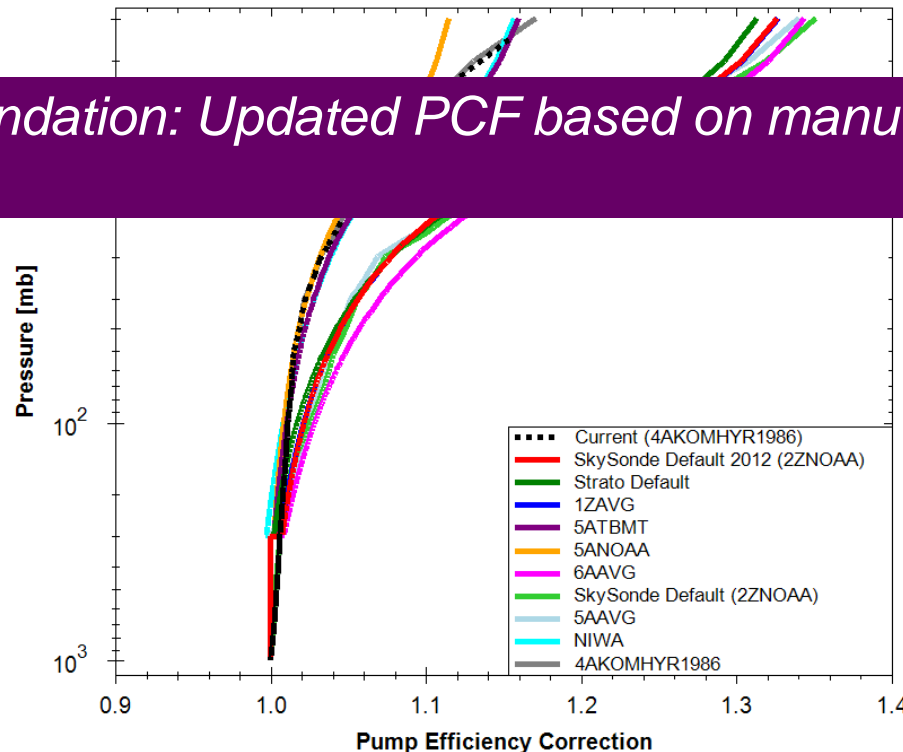


Pump Correction Factors at Low Pressures

Pressure [hPa]	Komhyr, 1986 (K86)	K86 uncertainty, $\Delta\Psi$	Komhyr et al., 1995 (K95)	K95 uncertainty, $\Delta\Psi$
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

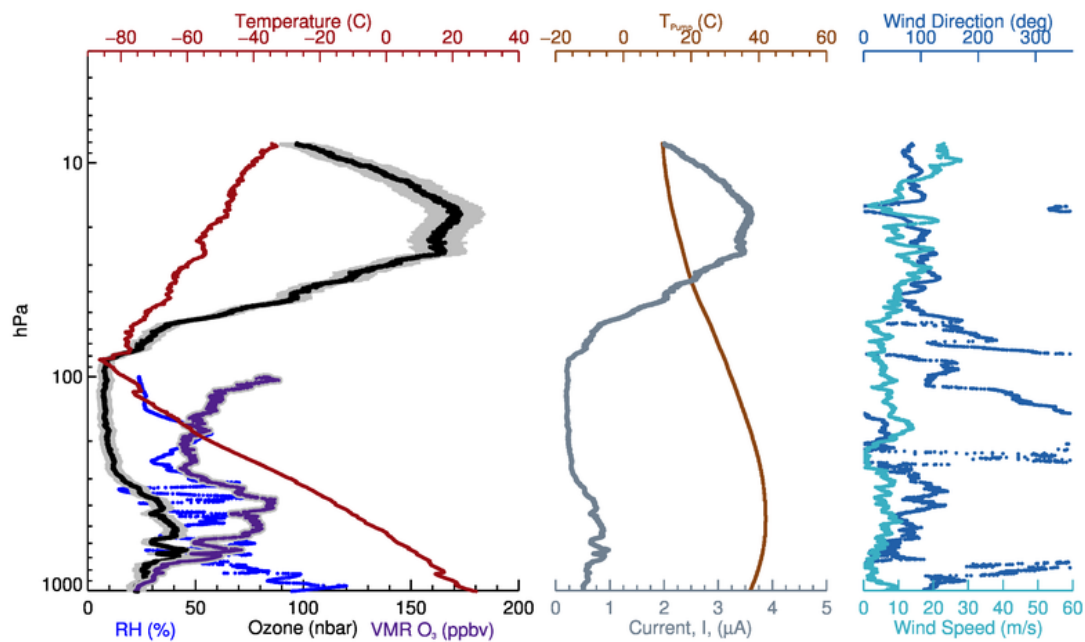
Pump corrections factors (PCF) with 1-sigma uncertainties. PCF values are taken from the GAW Report No. 201, Table 3-3 [Smit et al., 2014].

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

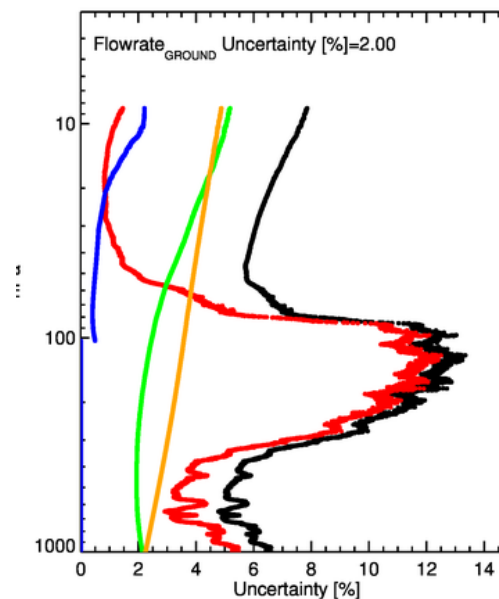


/NASA/GSFC/SHADOZ Archive
 Station: Ascension Is., UK (8.0S,14.4W)
 Launch Date: 1 April, 2016 09:15:11 UT

$P_{O_3}=4.307 \times 10^{-04} (I-I_{BG}) T_{Pump} T_{100} PCF$
 $I_{BG}=0.050, T_{100}=29.370, PCF=5ATBMT$



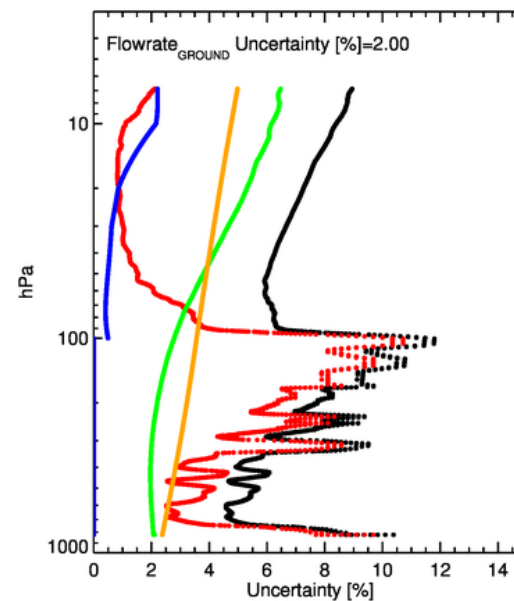
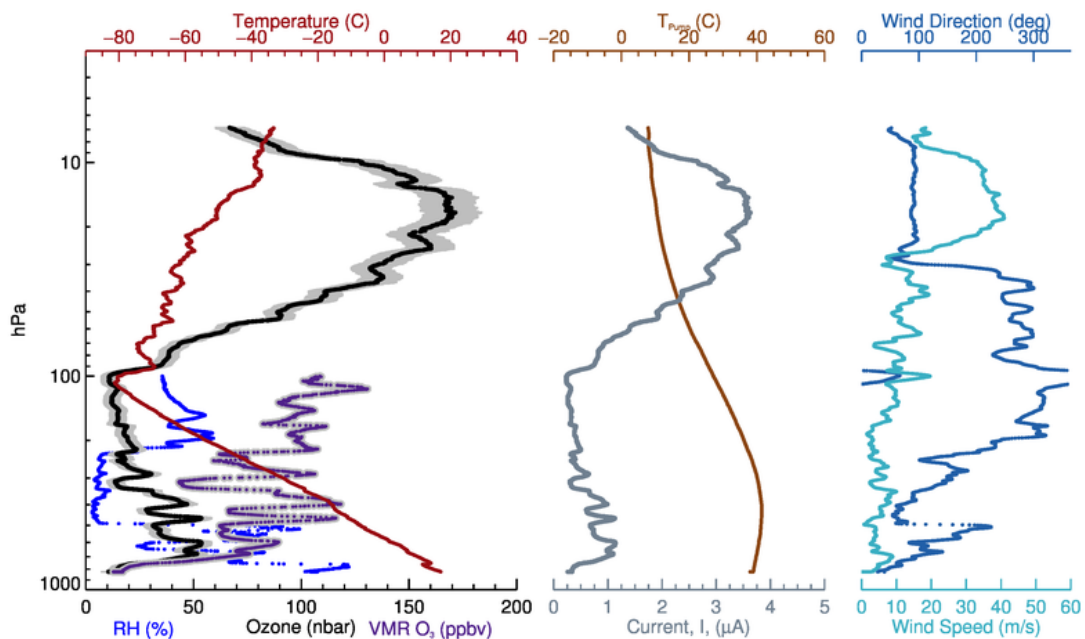
Uncertainty Contributions [%]



O₃ Partial Pressure
 Current & Background
 Pump Temperature
 Conversion Efficiency
 Pump Correction Factors

/NASA/GSFC/SHADOZ Archive
 Station: Nairobi, Kenya (1.3S,36.8E)
 Launch Date: 6 October, 2011 05:38:54 UT

$P_{O_3}=4.307 \times 10^{-04} (I-I_{BG}) T_{Pump} T_{100} PCF$
 $I_{BG}=0.05, T_{100}=29.35, PCF=Komhyr,1995$





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): _____

O₃ PUMP SERIAL #: _____

1. Run 10 minutes on LOW O₃ air: _____ (✓)
 2. PUMP CURRENT: _____ (μA)
 3. PUMP PRESSURE: _____ (psi)
 4. PUMP VACUUM: _____ (in Hg)
 5. Run 30 minutes on HIGH O₃: _____ (✓)
 6. Run 5 minutes on LOW O₃: _____ (✓)
 7. ADD 3.0 CC FRESH CATHODE (Wait 2 min): _____ (✓)
 8. ADD 1.5 CC ANODE SOLUTION: _____ (✓)
 9. Run 10 minutes on LOW O₃: _____ (✓)
 10. RECORD O₃ CURRENT: _____ μA
 11. Run 5 minutes at 5 μA O₃: _____ (✓) - then switch to LOW O₃ air.
 12. RECORD TIME TO DROP FROM 4 TO 1.5 μA: _____ sec.
 13. Run 10 minutes on LOW O₃: _____ (✓)
 14. RECORD O₃ CURRENT: _____ μA
- 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 LOW O₃: _____ (✓)
4. RECORD O₃ CURRENT: _____ μA
5. Run 5 minutes on 5 μA O₃: _____ (✓)
6. Switch to LOW O₃: _____ (✓)
7. RECORD TIME TO DROP FROM 4 TO 1.5 μA: _____ sec
8. Run 10 minutes on LOW O₃ - RECORD CURRENT: _____ μA
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 LOW O₃: _____ (✓)
4. RECORD O₃ CURRENT: _____ μA
5. Run 5 minutes on 5 μA O₃: _____ (✓)
6. Switch to LOW O₃: _____ (✓)
7. RECORD TIME TO DROP FROM 4 TO 1.5 μA: _____ sec
8. Run 10 minutes on LOW O₃ - RECORD CURRENT: _____ μA
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 LOW O₃: _____ (✓)
5. RECORD O₃ CURRENT: BG#0 = _____ μA
6. Run 10 minutes at 5 μA O₃: _____ (✓)
7. Switch to LOW O₃: _____ (✓)
8. RECORD CURRENT AFTER 30 Sec _____ μA, 1min _____ μA, 2min _____ μA
3min _____ μA, 5min _____ μA, 10min _____ μA
9. RECORD O₃ 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): _____

O₃ 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 WIND SPEED: _____ (m/s)

SURFACE TEMP: _____ (C) SURFACE WIND DIR: _____ (deg)

SURFACE RH: _____ (%)

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 (YYYYMMDD): _____
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:

O₂ 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, O-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 $\pm 5\%$ of calibrated source.

Main Takeaway

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 $P_{O_3} = 4.307 \times 10^{-4} (I_M - I_{BG}) T_P \Phi \Psi$



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

