ECC Ozonesonde Operation Manual

EN-SCI Corporation

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Trademark Information

Terminology

Pump – base piece with sensor cell, motor, etc.

ECC Ozone Sensor – also known as the Cell, Cathode/Anode.

No Lo O3 – no ozone or O3 free or ozone free.

O3 – ozone

ppbv - parts per billion by volume

KI – Potassium Iodide

KBr – Potassium Bromide

Chambers – refer to ECC Ozone Sensor.

Cell Current
Pump Head – the back pressure exerted on the pump by the sensor cathode electrolyte.

Air Intake Tube – straw

Ozonizer Test Unit – KTU

Cap Condition -by passing ECC Ozone Sensor Cell; no cap on cathode/anode cell.

Ozone Control – Knob on front of KTU (careful pulling/pushing)

Cathode Cap – This cap has two straws that pass thru. The long straw goes over the Teflon pin and the short straw is for air circulation.

Anode Cap – This cap has one pass thru, the short straw is for air circulation.

ECC Sensor – on front of KTU panel is ECC Current

12 VDC Sonde Motor – on front of KTU panel is Motor Current

Introduction

Introduction to the ElectroChemical Concentration (ECC) Ozonesonde

The ElectroChemical Concentration (ECC) ozonesonde has been used for over 50 years to measure vertical profiles of ozone from the surface to 30 km altitude or more. Stations around the world launch the ECC ozonesonde to support a variety of research objectives. The ECC ozonesonde can be viewed as an ozone powered battery. The amount of current generated in the battery is directly related to the atmospheric ozone concentration. The current is converted to a voltage in the interface card and this data along with information on the health of the sonde systems is digitized and appended to the meteorological information gathered by the radiosonde and transmitted to the ground.

The ozone sensor of the ECC ozonesonde is made of two bright platinum electrodes immersed in potassium iodide (KI) solutions of different concentrations contained in separate cathode and anode chambers. The chambers are linked with an ion bridge that, in addition to providing an ion pathway, retards mixing of the cathode and anode electrolytes thereby preserving their concentrations. The electrolytes also contain potassium bromide (KBr) and a buffer whose concentrations in each half cell are the same. Driving electromotive force for the cell, of approximately 0.13 V, is provided by the difference in potassium iodide concentrations in the two half cells.

When ozone in air enters the sensor, iodine is formed in the cathode half cell according to the relation

$$2KI + O_3 + H_2O \rightarrow 2KOH + I_2 + O_2. \qquad (1)$$

The cell converts the iodine to iodide according to

$$I_2 + 2e \rightarrow 2\,I^- \qquad (2)$$

during which time two electrons flow in the cell's external circuit. Measurement of the electron flow (i.e., the cell current), together with the rate at which ozone enters the cell per unit time, enables ozone concentrations in the sampled air to be derived from

$$p_3 = 4.307 \times 10^{-3}(i_m - i_b)T_p t \qquad (3)$$

where p_3 is the ozone partial pressure in nanobars, i_m is the measured sensor output current in microamperes, i_b is the sensor background current (i.e., the residual current emanating from the cell in the absence of ozone in the air) in microamperes, T_p is the pump temperature in kelvins, and t is the time in seconds taken by the sonde gas sampling pump to force 100 ml of air through the sensor. As a volume mixing ratio in air, the measured ozone is derived from

$$O_3(ppbv) = 1000p_3/P = 4.307(i_m - i_b)T_p\, t/P \qquad (4)$$

where O_3(ppbv) is the measured ozone in parts per billion by volume and P is the ambient air pressure in millibars.

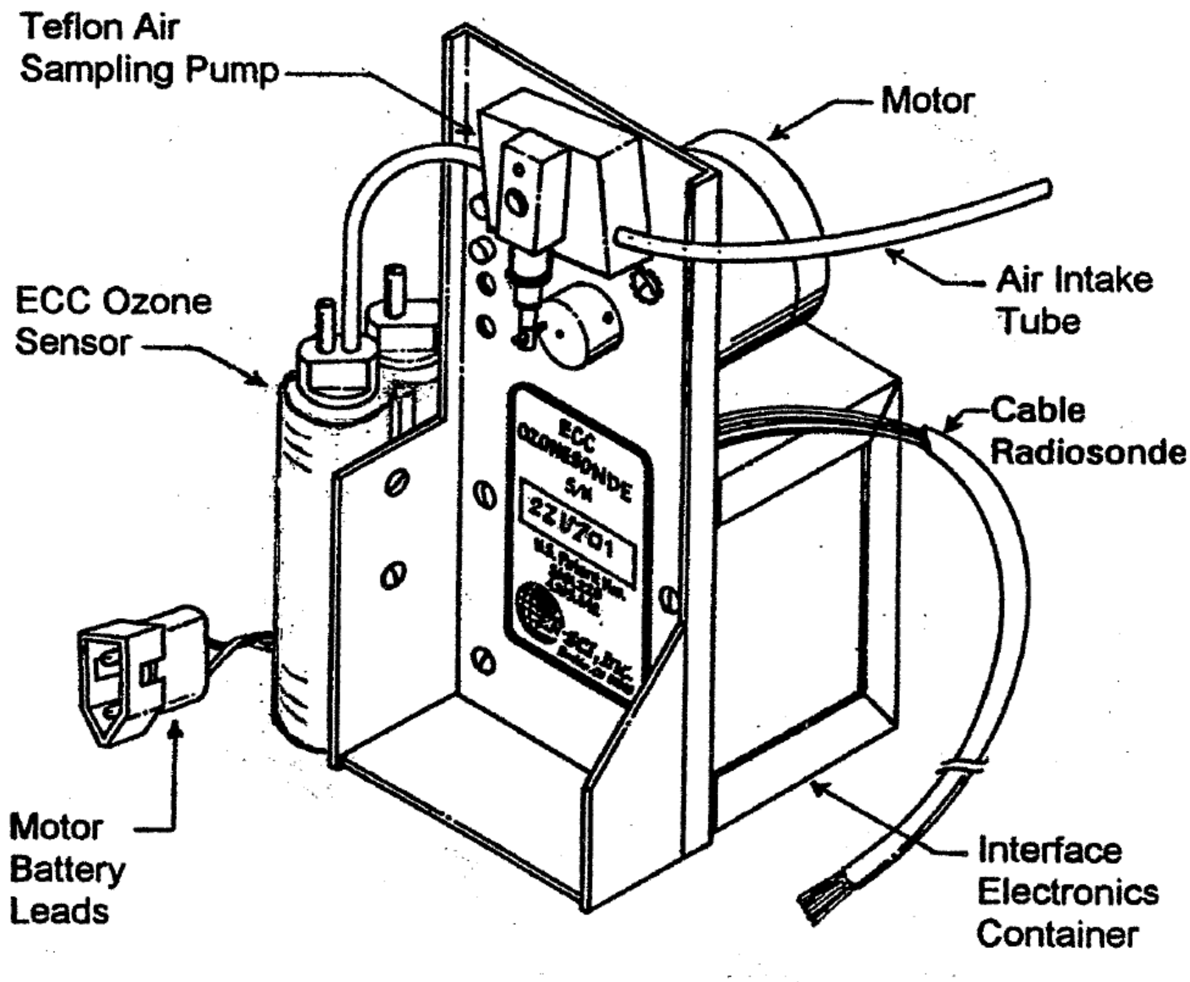
Air is forced through the ECC sensor by means of a non-reactive pump fabricated from TFE Teflon impregnated with glass fibers. A unique design permits pump operation without ozone-destroying lubricants. O-rings fitted externally on the pump cylinder press against thin, flexible portions of the cylinder to maintain an air-tight seal between the piston and cylinder. Pumping efficiency for such pumps varies with ambient air pressure, and depends upon pump leakage, the pump dead volume, and the pump head (the back pressure exerted on the pump by the sensor cathode electrolyte).

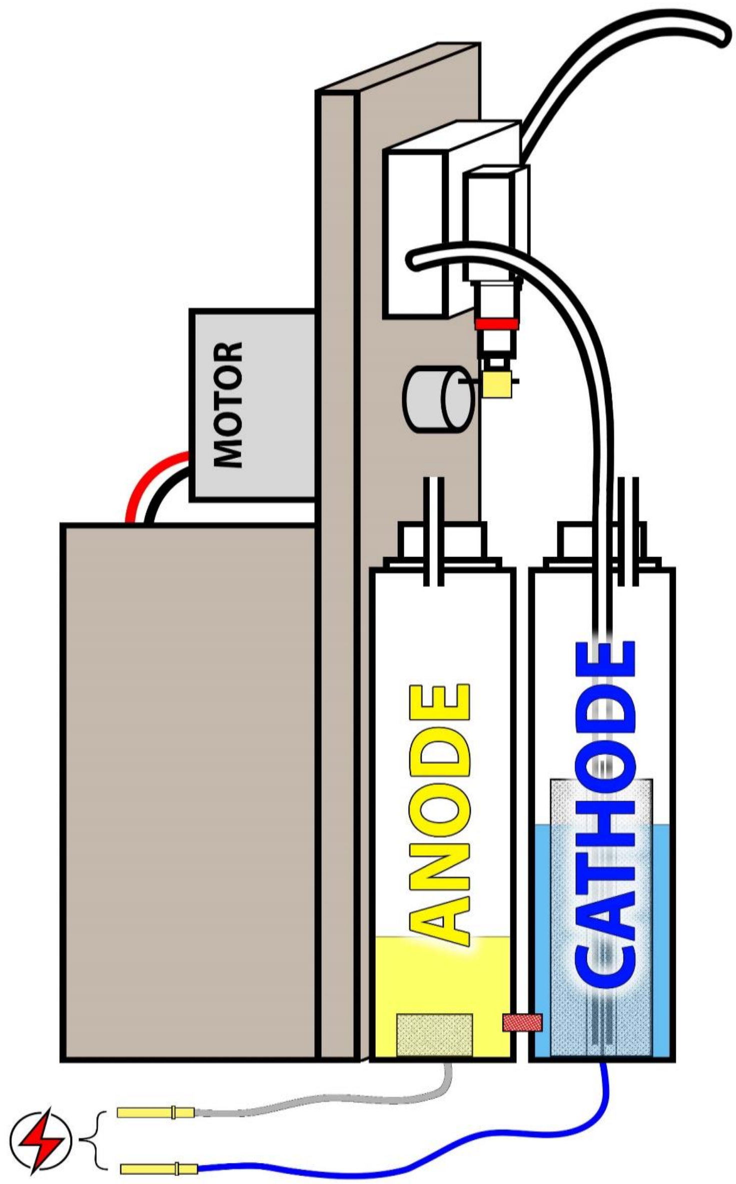
Sonde Test Configurations

Several preparation steps are required to prepare and ECC ozonesonde for flight. Note that there are also many good resources available online that describe ozonesonde preparation.

Conditioning and preparation of the ECC ozonesonde requires a source of ozone, 12 VDC power supply and low current measurement meter. The KTU test unit sold by EN-SCI provides all of these functions in a single instrument. In the following discussion the conditioning and preparation of the ECC ozone sonde will be done using the KTU-3.

Designation of ECC Sonde Components

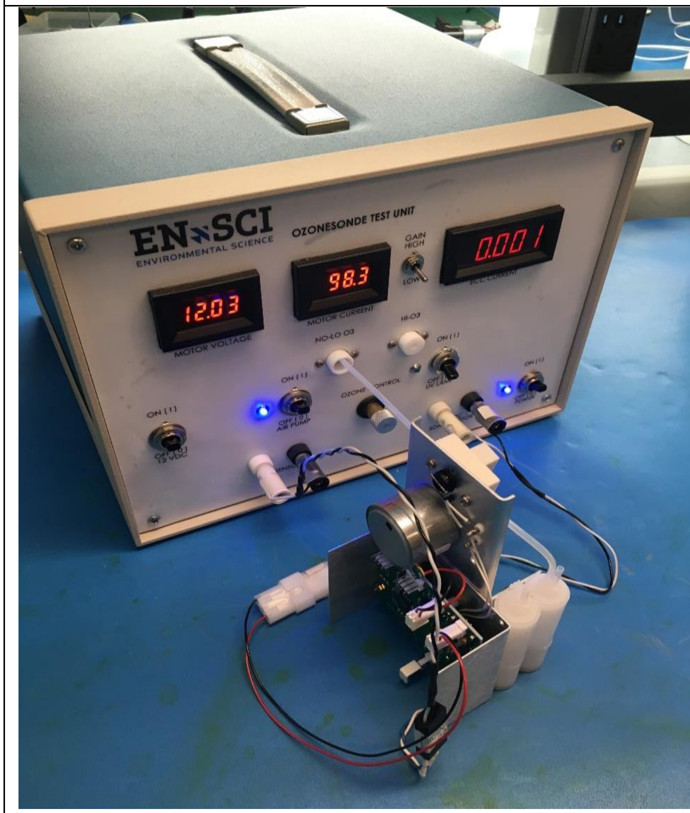




ECC Sensor Cell

Unless Noted, Sonde is connected to 12 VDC and Cell connected to ECC Sensor. Note color match of wires for Cell to ECC Sensor connection. White>White, Blue>Black.

Best Practice is to tape ECC Ozonesonde base down to bench prior to turning on. The ECC Ozonesonde will move around.



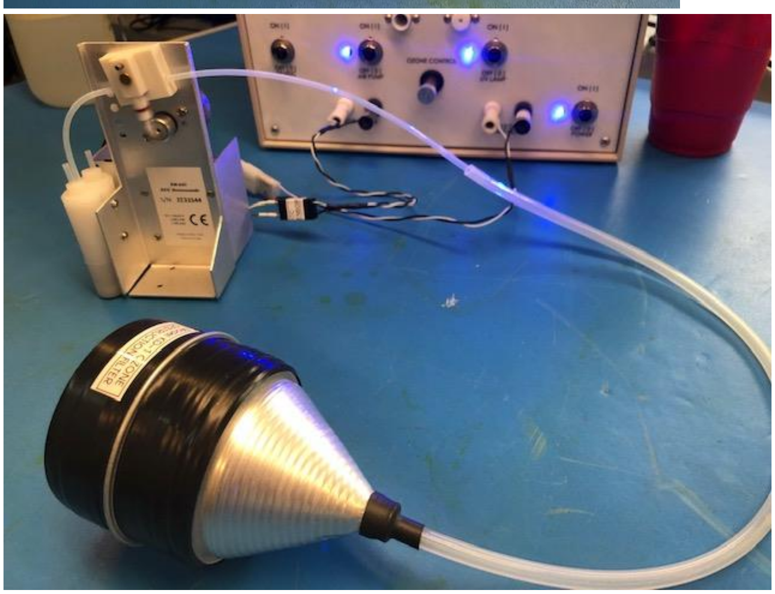
No – LO O3 Air or PUMP CURRENT MEASUREMENT

Insert Sonde inlet tube 3 cm into NO-LO O3 port. Or connect portable ozone destruction filter.

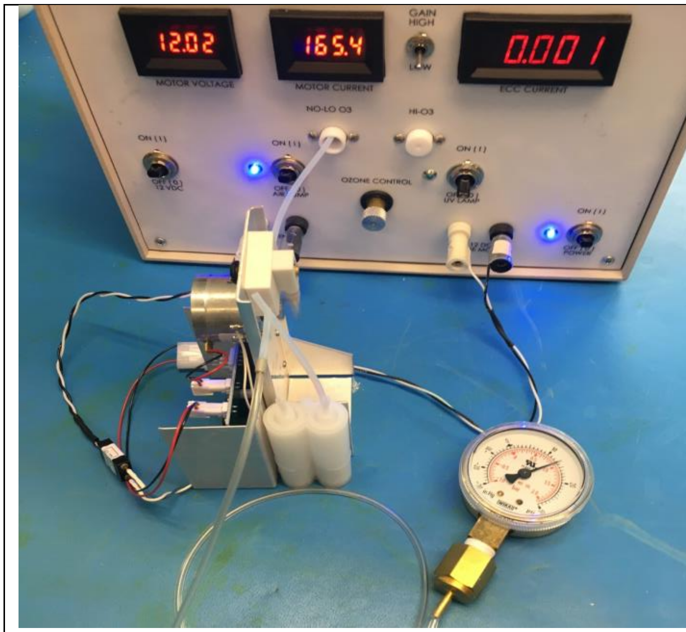
KTU POWER on.

KTU 12 VDC on.

KTU AIR PUMP on.



This is what the set up will be for the day of flight.



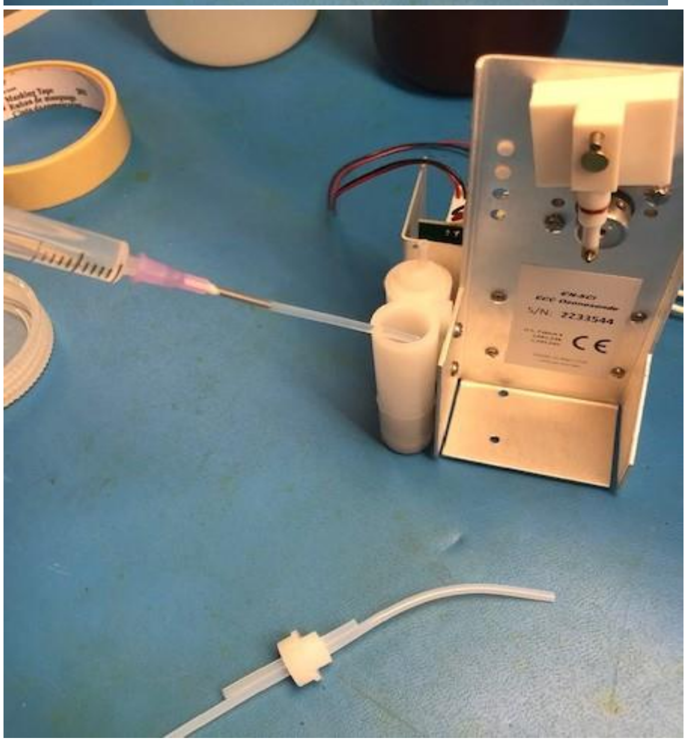
PUMP PRESSURE

Connect gauge to outlet of sonde pump.

KTU POWER on.

KTU 12 VDC on

It is critical to use care when dumping solutions from the cells or adding new solutions that there is no cross contamination between the solutions and the cells. If there is concern that the syringes or cells or caps have been contaminated the items should be rinsed with distilled water and then filled with fresh solution and those solutions discarded.

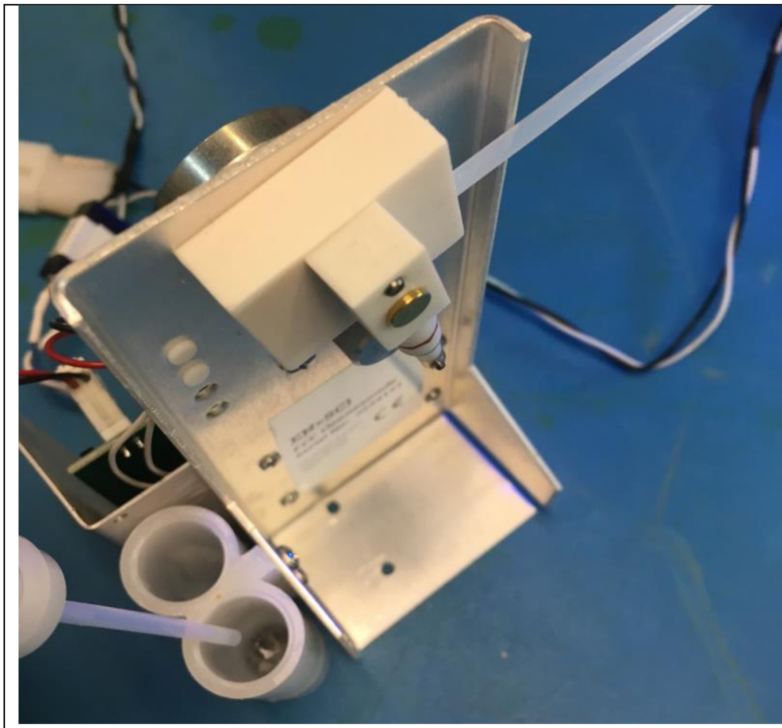


Filling the Cells

Use the syringe to fill the cells with the proper solution. Syringes are marked red band is for Anode Solution; no band one is for Cathode Solution.

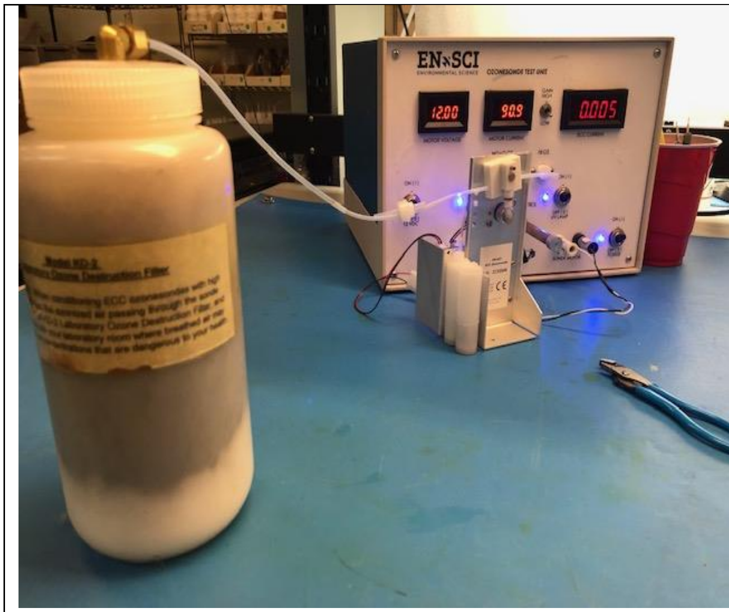
Take care that when removing the syringe from the cell that a drop does not fall off the tube and cross contaminate opposite cell or cap.

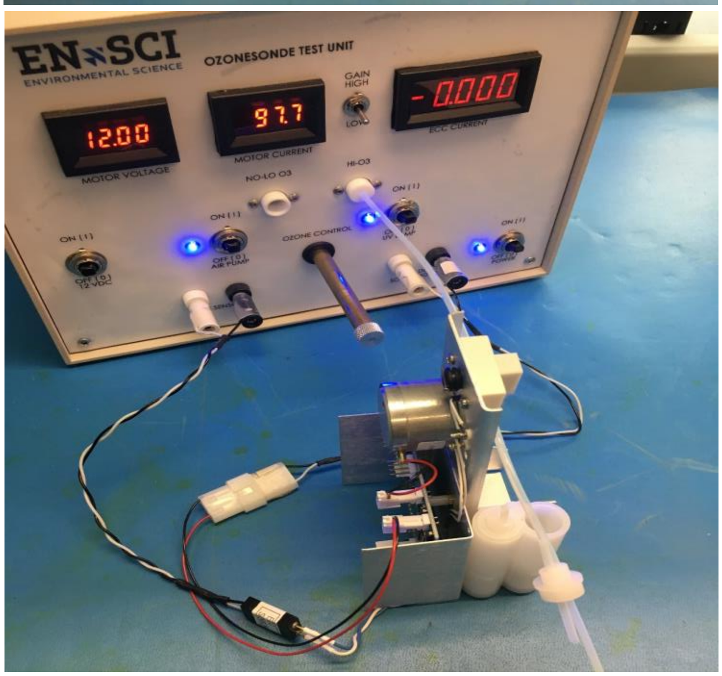
Best practice is to remove cap from each cell one at a time to avoid cross contamination.



Installing Cap on the Cathode Cell

The exit tube on the cathode cap must be installed over the Teflon pin in the center of the cathode cell. This keeps the exit tube centered in the cell.





HIGH O3-Conditioning the cap

Connect sonde inlet tube to HI O3 port.

Remove cap from cathode cell.

KTU POWER on.

KTU 12 VDC on.

KTU AIR PUMP on.

KTU UV LAMP on.

Pull OZONE CONTROL gently slide all the way out.

Connect Laboratory filter on exit of cap. Runs for 30 minutes.

Note: The connection must be air-tight since it is the sonde pump that draws highly ozonized air from the Ozonizer/Test Unit into the pump and dry sensor.

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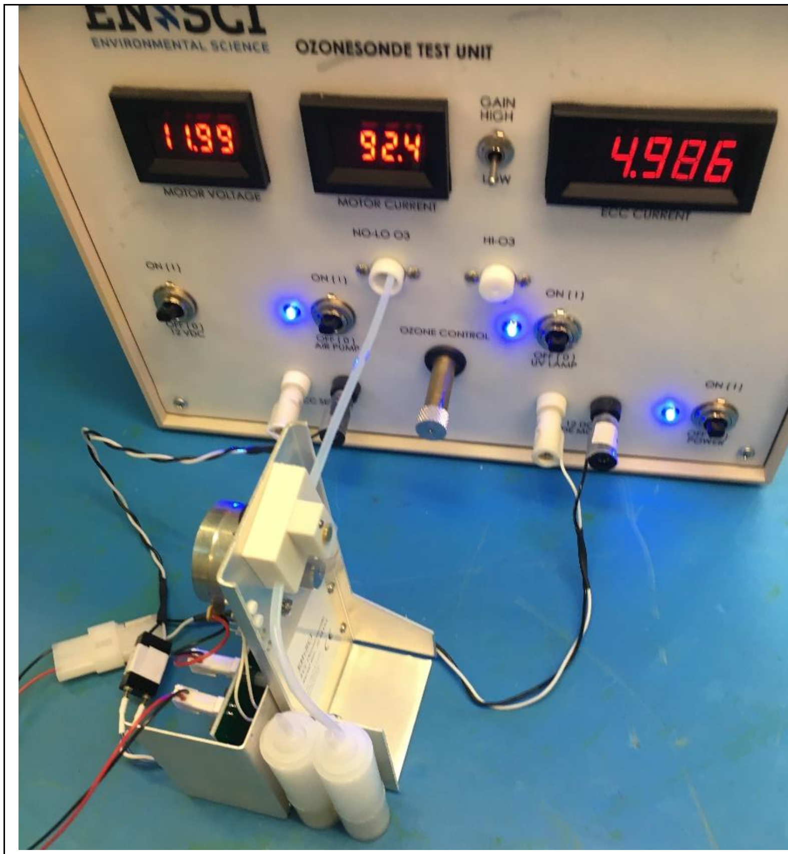
<tr>
<td>
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5µA O3

Insert Sonde inlet tube 3 cm into NO-LO O3 port or use portable ozone destruction filter.

KTU POWER on.

KTU 12 VDC on.

KTU AIR PUMP on.

KTU UV LAMP on, adjust OZONE CONTROL carefully to get to 5µA +/-0.2 µA.

To switch to ***No*** O3, turn the UV lamp off or or use portable ozone destruction filter.

Please note to gently push Ozone Control in till it stops.

NOTE: If the sonde does not have any measurable current, there is a probably a broken weld in the cells. Contact EN-SCI (sales@EN-SCI.com).
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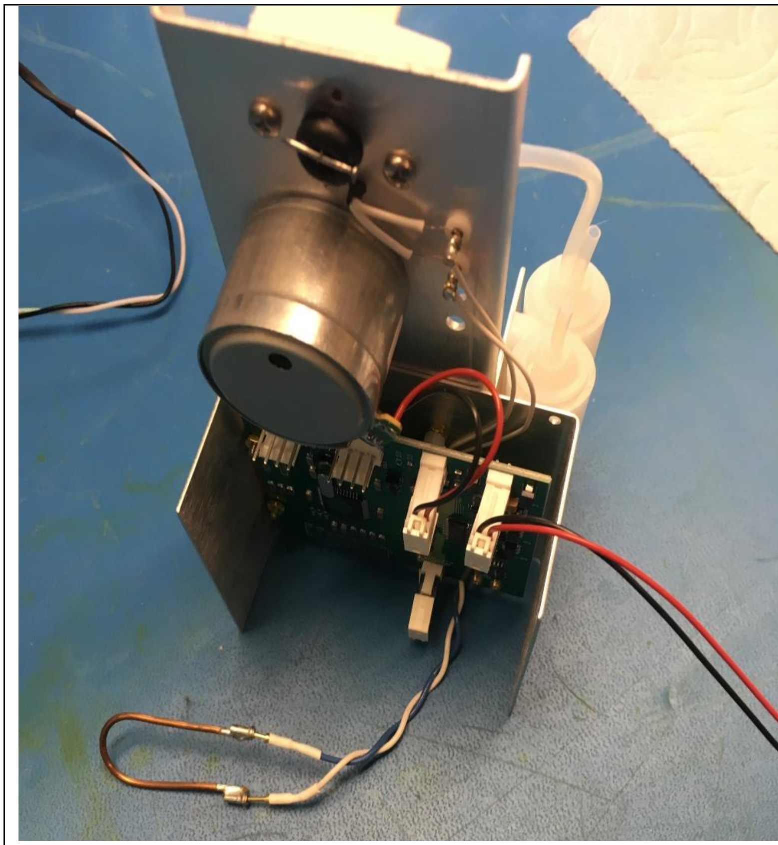
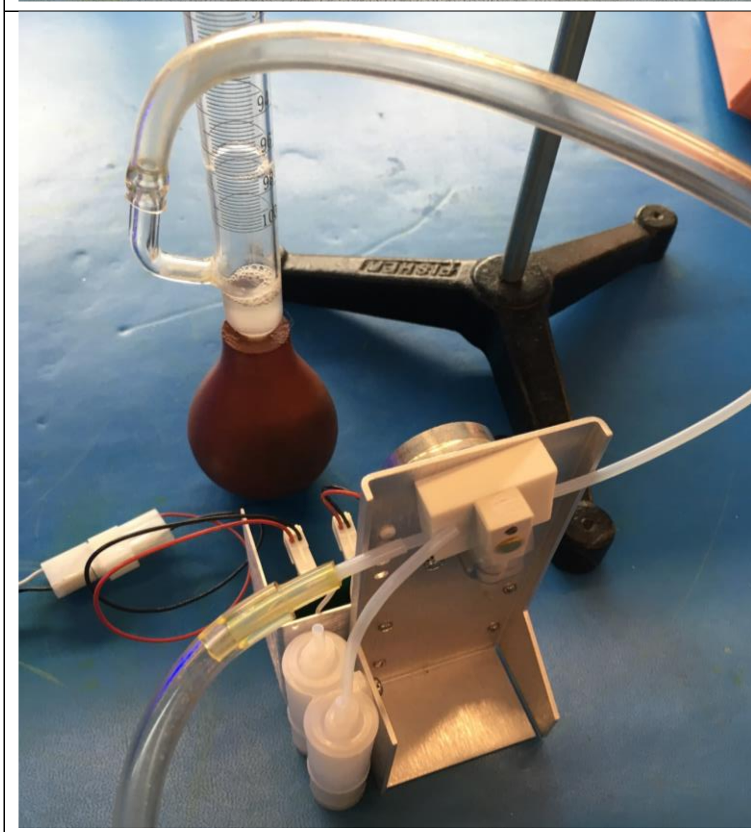
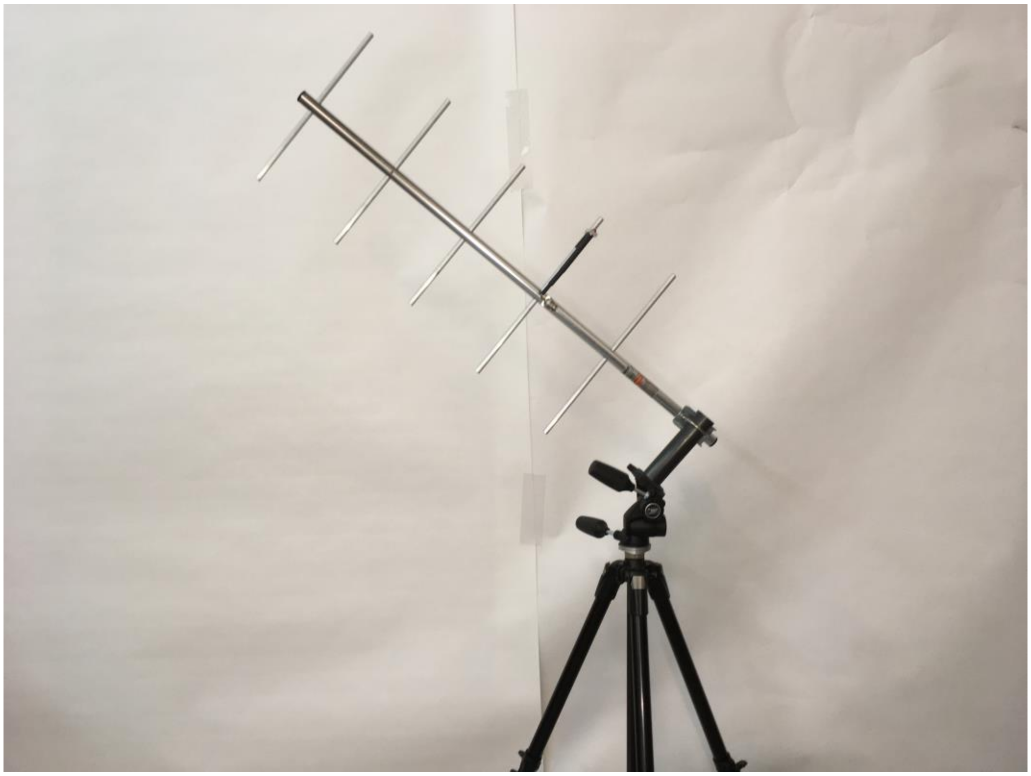
	**Shorting Plug** ALWAYS SHORT CELL LEADS, with shorting plug. Please remember to do so after each conditioning session. NOTE: Shorting plug must be used whenever the instrument is not actively measured and the Anode and Cathode cel are wet.
	Flow Rate Measurement Connect bubble flow meter to outlet of sonde pump. KTU POWER on. KTU 12 VDC on.

Troubleshooting

Problem	Solution
The sonde does not have any measurable current.	There is probably a broken weld or compromised ion bridge. Contact EN-SCI (sales@EN-SCI.com)
If the pump current is more than 120 mA <.	Let the sonde run for one hour. Repeat the current measurement. If it does not read less than 120 ma, please contact EN-SCI (sales@EN-SCI.com).
If the pump pressure does not reach 8 psi.	Do not connect the line to the cathode cell. With the pump running, squirt a few ml of acetone into the inlet straw, and allow the pump to run for 30 minutes. Check the pump pressure again. Repeat one more time if it does not reach 8 psi, then contact EN-SCI (sales@EN-SCI.com).
If ECC current is not less than 0.8 uA. (Initial Preparation or Final Conditioning)	Repeat measurements starting at step 9 on checksheet. If it fails again, use fresh solution from the stock solution bottle.
If response time is not less than 120 seconds.	Repeat measurements starting at step 9. If it fails again, use fresh solution from the stock solution bottle.
If ECC current is not less than 0.8 uA. (Initial Preparation)	Replace cell solutions, both anode and cathode, and start at step 18. If the measurement fails again use fresh solution from the stock solution bottle and start at step 18.

Data System Hardware Set Up

Antenna, amplifier and radio setup


Photograph of the assembled ground station.

All of the components with the exception of the customer provided laptop, are packed in the carrying case. Use care when unpacking the antenna as the elements can be bent if they are hooked on the edge of the case or the foam insets. If they are significantly bent, the receiving characteristics of the antenna can be changed and the performance will suffer.

Extend the tripod legs and setup the tripod. The tab on the mount at the top of the tripod needs to be pulled down to install the stub mounted on the antenna. The antenna stub has a specific orientation to fit in the mount, and make sure that it is seated before releasing the tab.

Clip the preamplifier to one of the legs on the tripod. The shorter of the cables with the large connector on the preamp box will go to the antenna. Make the knurled nut finger tight.

NOTE: Keep box sealed; this is for illustration only.

The longer cable will go to the SDR Play radio. There are two connectors on the radio that will accept the cable. It is critical that the cable is connected to the ANT B connector. This provides power to the preamplifier.

Figure 3. Connections to the SDRplay radio. The cable from the preamp must go to the ANT D connector on the radio.

No components will be damaged if the cable is connected to the wrong connector, but the system will work poorly or not at all.

SDR Radio Installation

The Software Designated Radio (SDR) is a major step forward for radiosonde systems. This allows a low cost radio to be used and have flexibility through computer control.

The radio should not be connected to the computer until the installer program requests the radio to be plugged in. Run the SRRplay_SDRuno_Installer_1.31.exe program. This is included on the memory stick with the system. Follow the prompts to install the cable to the SDRplay radio as requested.

Skysonde Software

There are three software programs used with the balloon data system. These are,

-Balloon Prediction. This program will project the balloon flight path and package landing location.

-Skysonde Server. This program controls the data acquisition and recording.

-Skysonde Client. Operates in conjunction with Skysonde Server to provide data visualization.

These programs are included on the memory stick supplied with the sonde systems. The supplied manuals are attached in Appendix XX. Some sections of Skysonde Software manuals are obsolete, and also contain sections that are not relevant. All of the programs with the exception of the SDR Installer are developed by the United States NOAA Earth Systems Research Laboratory. Details can be found at

https://www.esrl.noaa.gov/gmd/ozwv/wvap/sw.html

Balloon Prediction

Figure 1 shows the **Options** tab for the balloon prediction program. Enter the details for the launch site, and estimated landing elevation. The default value of 29 km for burst altitude is a useful default, until there is more experience with what the typical burst altitude will be.

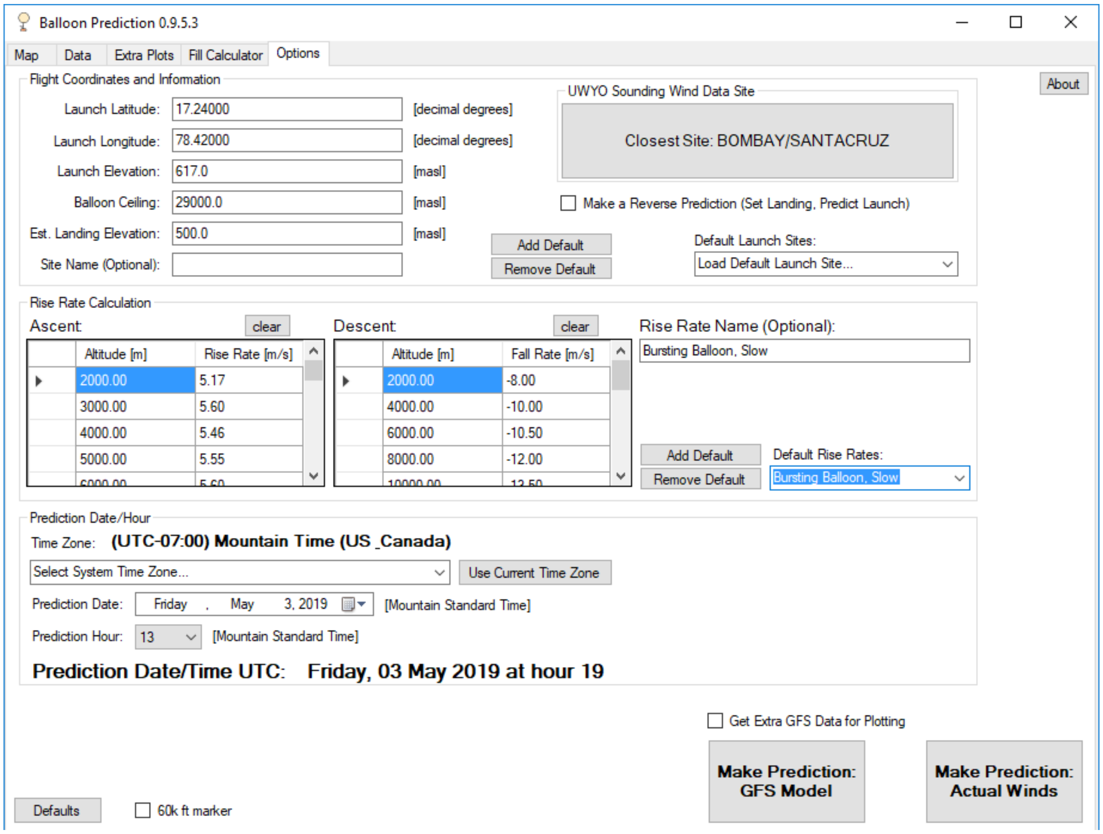


Figure 1 XX. Options tab for balloon prediction program.

Set the rise rate at Bursting Balloon, Slow. Select the time for launch. It is recommended to use the GFS Model prediction for the flight.

The **Map** tab will show the flight track, giving the ascent track, burst point and decent track to landing point. The available wind soundings to initialize the model in India are limited, so the prediction will have a larger amount of uncertainty.

The **Fill Calculation** only needs to be run once for a site, as the changes in temperature, barometric pressure and RH will only adjust the payoff weight 10-20 grams. It is not worth adjusting the payoff weight for those small changes.

Skysonde Server

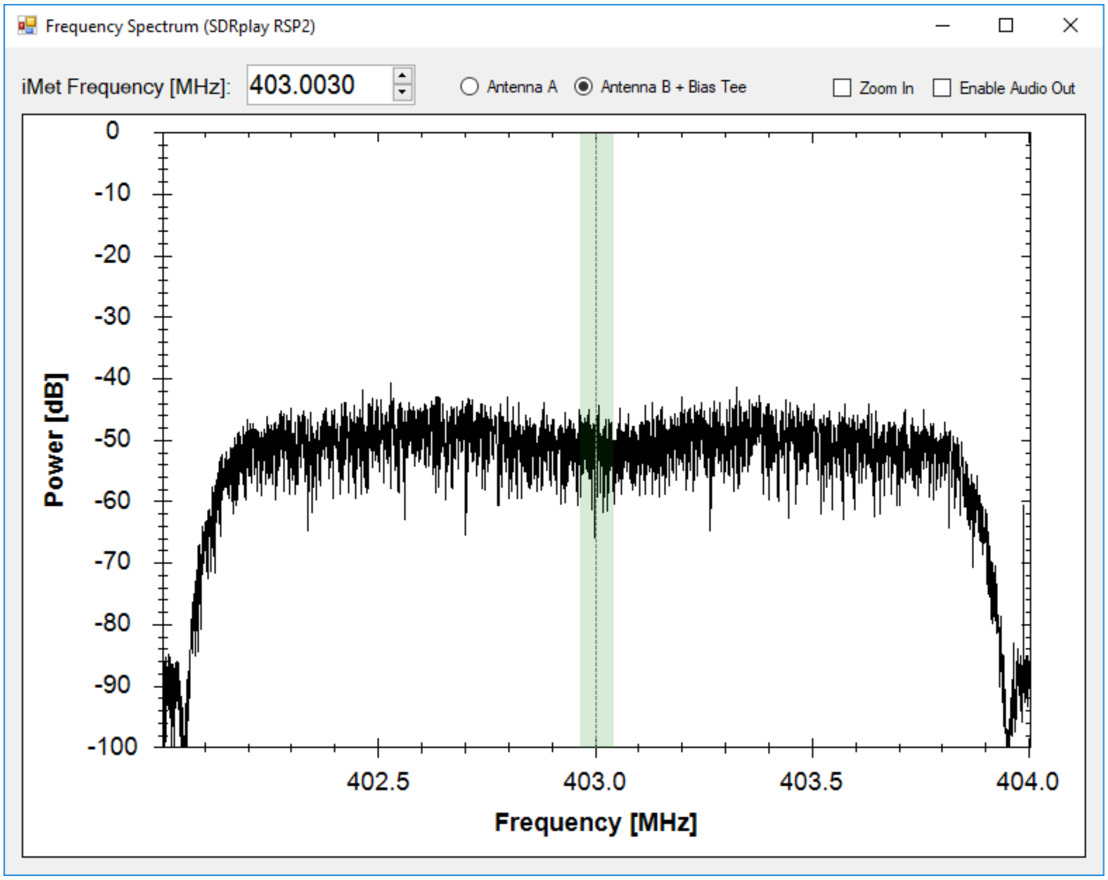
The Skysonde Server takes the data from the SDR unit and the user can see that packets are coming in through the lights on the display. The server needs to be setup to communicate with the SDR by opening the **Data Source** tab. Two options are available:

Software-Define Radio SDRplay RSP2 (Normal performance, low CPU)
Software-Define Radio SDRplay RSP2 (Good performance, high CPU)

Depending on the capability of the computer, the "Normal" is recommended for slow computer processors, and the "good" for more powerful computers. Once the correct option is selected the program will remember that option and it should not need to be set again. For most laptop computers the "good" performance is recommended as there is sufficient computing power to handle the SDR radio.

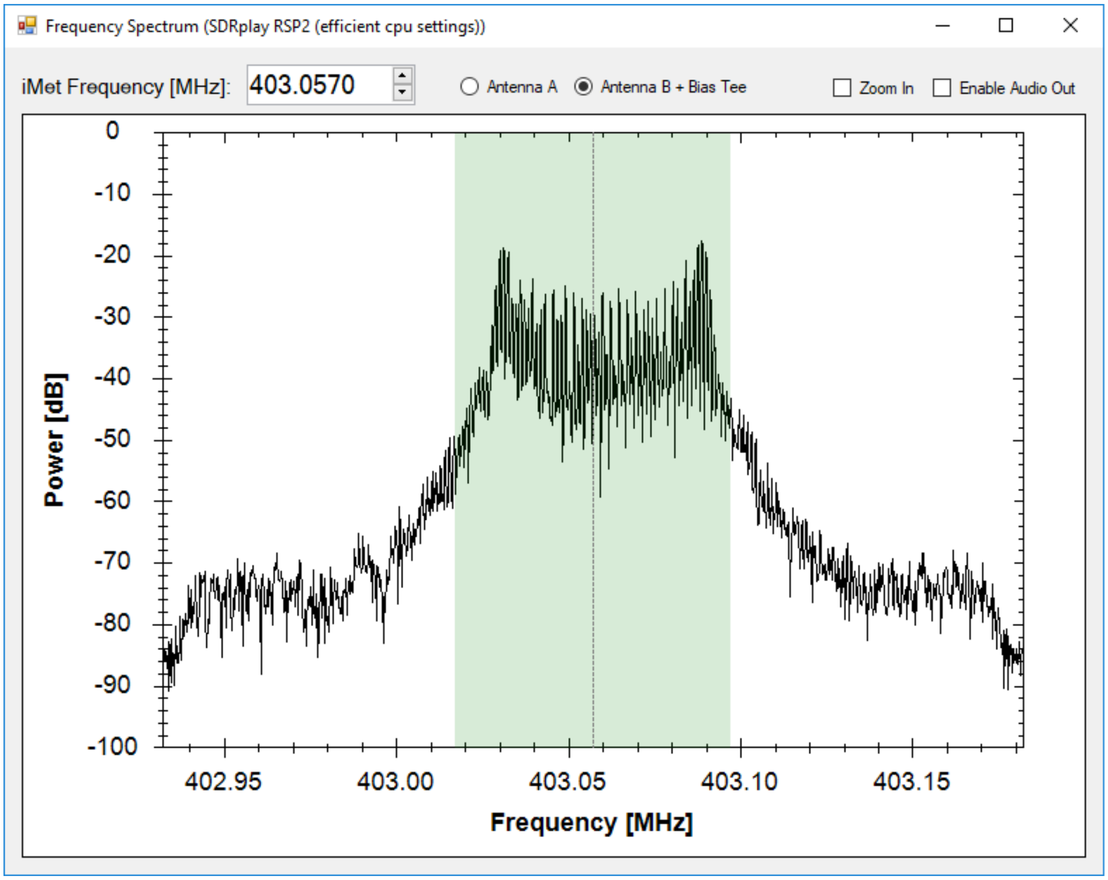
The balloon flight can be tracked on the map in real time, if the computer has internet access when the Skysonde Server program is started. If internet access is made later the balloon flight will not be tracked.

Run the Skysonde server and the frequency spectrum window will open. Set the frequency in the top left window to the frequency you plan to use. Make sure the radiosonde is not turned on at this time. The spectrum should show noise with no signal reception.



Frequency spectrum showing no signal received.

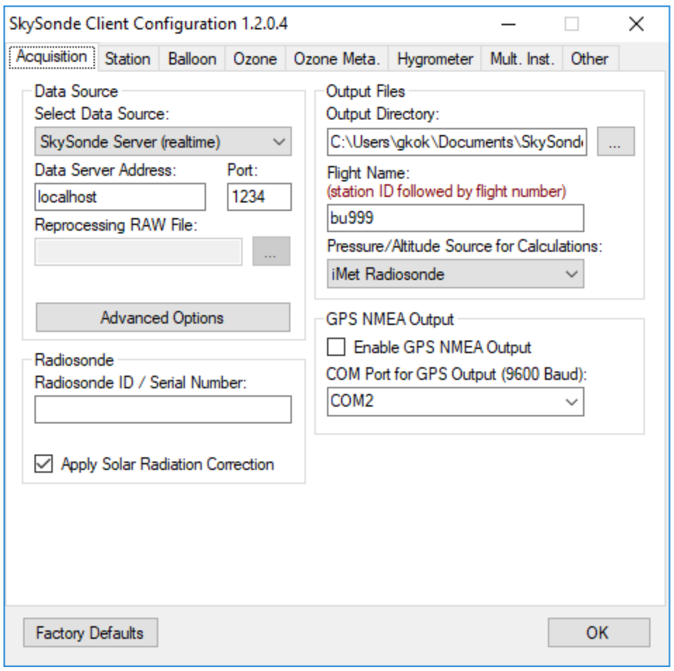
If there is a signal peak present this means that some device is transmitting at that frequency and it is recommended that another frequency has been chosen. Once a suitably frequency has been selected, turn on the radiosonde. A signal peak will appear in the spectrum. Adjust the frequency so that the cursor is in the middle of the peak shown on the frequency spectrum display.



Frequency spectrum showing signal from a radiosonde. Adjust the frequency so that the cursor is in the middle of the received signal.

Skysonde Client

The skysonde client software needs to be setup for the specific station and data input is required for each launch giving serial numbers of the sondes and the operational performance. The client program can also be used to reprocess the data, allowing for changes in pump efficiency, background current, pump flow or other parameters.
Figure XX shows the **Acquisition** tab.



Skysonde Client Acquisition Tab.

The **Hygrometer**, **Mult. Inst**, and **Other** tabs are not used unless additional instruments are added to the flight package.

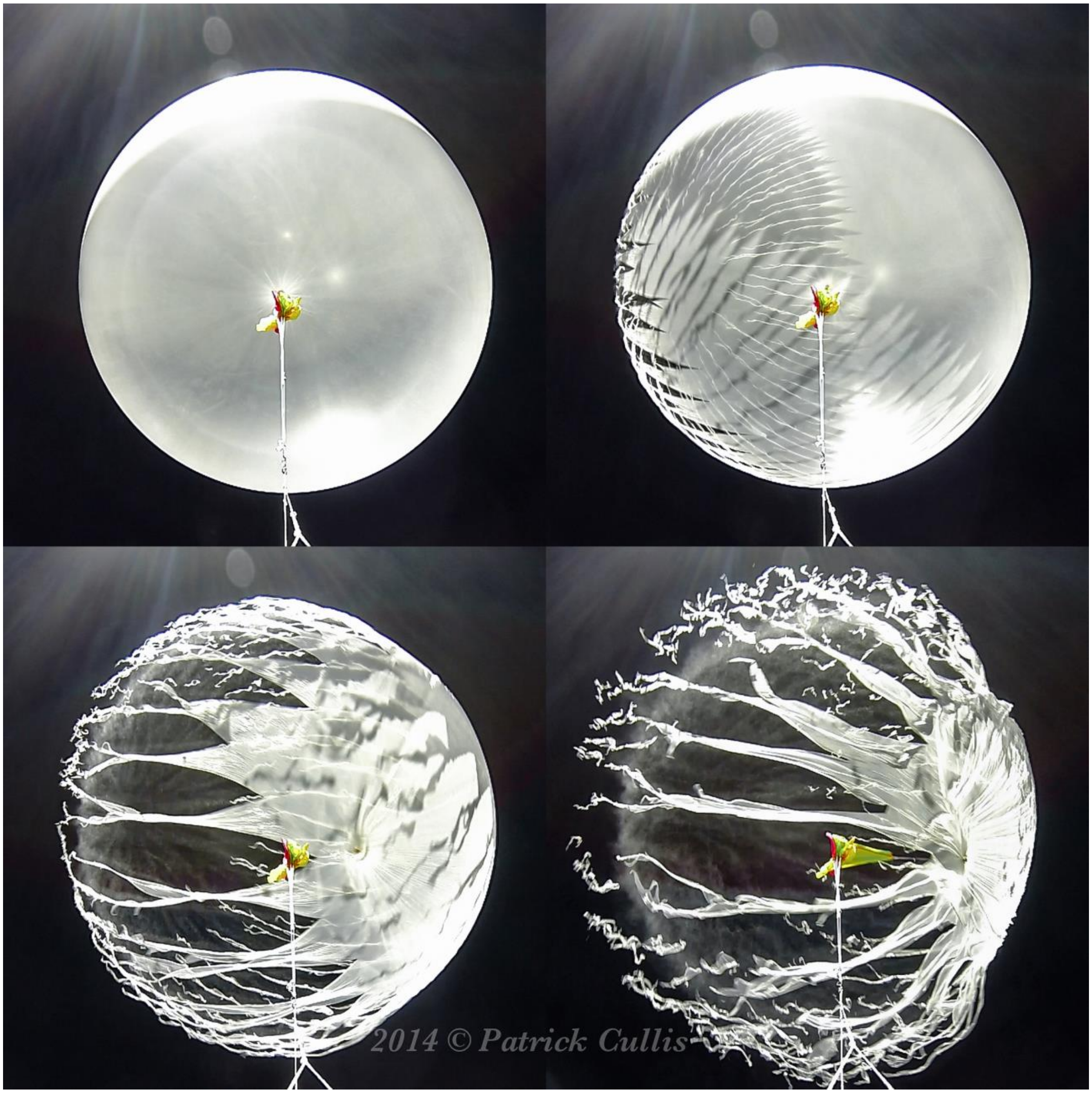
It is critical that the data be entered into the Skysonde Client program for all of the relevant sonde parameters. This way they are embedded in the data file and later data analysis and concerns can be reduced.

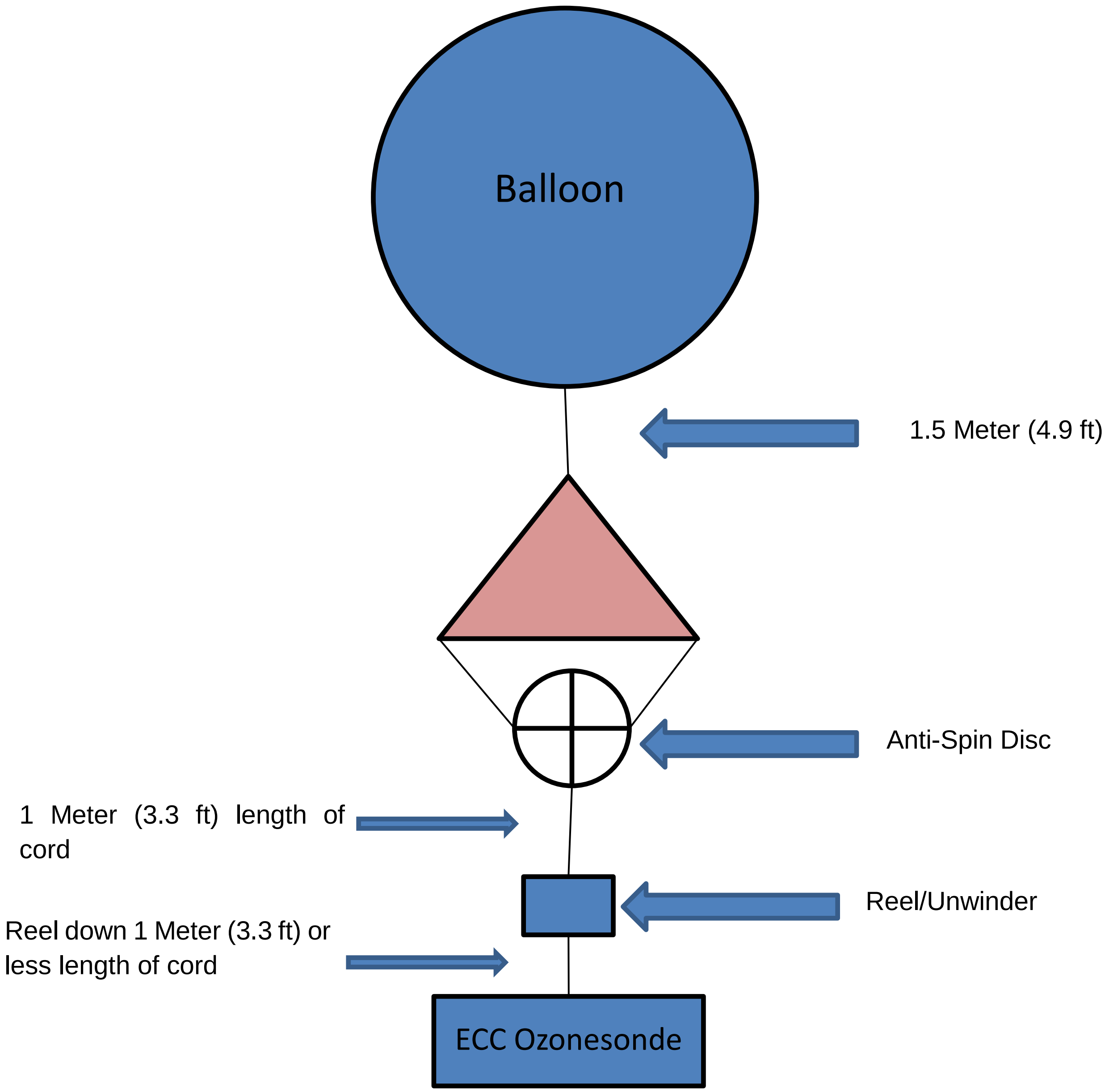
In the STATION tab, station data will need to be entered and can be saved and archived for new launch sites. Once these are saved they can be recalled.

For the BALLOON, OZONE and OZONE META tabs, enter in all of the required data for the particular launch. Once this data has been entered, click OK, and the Client menu will open.

It is important to review the critical parameters of voltages, pressures, temperatures before launch to determine that the sonde package is working properly. Click next to the boxes that you wish to have plotted during the flight. The software is setup for automatic launch detection so the plots will then switch to flight mode.

Balloon Launch

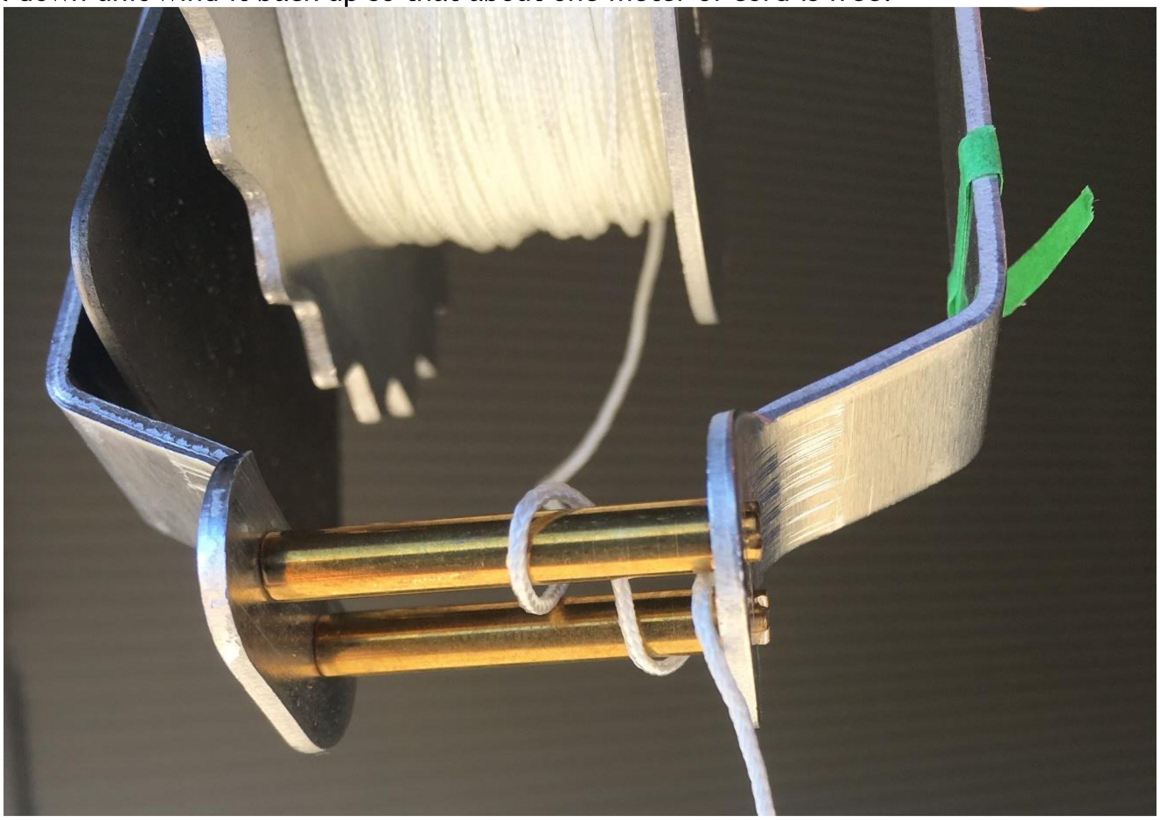



Balloon
1.5 Meter (4.9 ft)
Anti-Spin Disc
1 Meter (3.3 ft) length of cord
Reel/Unwinder
Reel down 1 Meter (3.3 ft) or less length of cord
ECC Ozonesonde

Unpack the parachute. The strings tangle easily, use care when opening the package and then unwrap the unit from the anti spin disc, which is the flat disc with the 4 holes in it. Fluff the parachute by holding on to the anti spin disc and rapidly pulling it through the air and letting the parachute open.

Carefully set the parachute aside,

Unpack the reel down unit, and loop the cord in a figure 8 around the two brass rods at the bottom of the unit. Pull gently on the cord and the cord should pay out in an incremental manner. If there is more than about one meter of cord extending from the reel down unit wind it back up so that about one meter of cord is free.



Cut a length of cord about 2 meters long, loop it through the loop tab on the anti spin disc and tie the ends together. Then loop this over the rod at the top of the reel down unit.

Carefully set the reel down and parachute assembly aside.

Clean a floor space approximately 3 meters (9.84252 feet) by 3 meters (9.84252 feet). The balloons are latex rubber and very thin and can be easily damaged if any debris are present. A damaged balloon will burst prematurely at a lower than desired altitude. If this is a concrete surface that is not smooth, lay down a tarp to protect the balloon.

Unroll the balloon from the package, taking care to just hold the balloon by the neck.

Use the bag the balloon was packaged in as a glove if you need to touch the balloon envelope. Oil from your fingers can damage the balloon envelope and again cause premature bursting.

Fit the balloon neck over the fill inlet unit. Make sure the fill inlet unit matches the neck size of the balloon. If it is not tight, the inlet needs to be modified or a proper size inlet configured. If the balloon neck is snug over the fill unit, but not tight, tie a cord around the neck to insure it does not come off during inflation.

Connect the ballast weight and the payoff weight to the fill unit cord loops.
Inflate the balloon until the payoff weight is just lifting off the ground

Measure approximately 2 meters (6.56168 feet) length of cord and tie it around the neck of the balloon just above the fill unit. This way the tie off point is about in the middle of the cord.

Tie the two ends of the cord together and tie a loop in the cord about 10 cm (3.93701 inches) up from the end. The ballast weight can then be clipped to the upper loop of cord, and the balloon taken off the fill unit.

Tie the cord on the top of the parachute to the lower loop of cord on the balloon. If the launch is taking place on a very windy day, it is recommended that the cord at the top of the parachute be replaced with heavier cord as there is a lot of strain on the cord during the launch.

The sonde package should be closed up just before the launch to avoid the unit overheating in the insulated box. Tie the sonde package to the cord extending down from the reeldown unit.

It is recommended that two persons conduct the launch, one holding the balloon, and the other person supporting the flight train. On windy launch days the flight train should be carried out first and then the balloon. In the launch run the cord through your fingers slowly allowing the flight train to become taut. The sonde package should be released just as the cord between the reel down and the sonde package becomes taut. It is imperative that the sonde package not bounce on the ground during the launch.

APPENDIX

CATHODE and ANODE SOLUTION

Cathode Solution:

To make 1 liter of 0.5% KI Buffered cathode solution:

1. Add approximately 500 ml (16.9 oz) of distilled or deionized water to a clean 1000 ml (33.8 oz) volumetric flask.
2. Use an accurate scale or balance (~ ± 0.02 grams accuracy). Place a weighing boat on the scale and tare to zero grams.
3. Measure 5.00 grams of KI (potassium iodide) on the tared weigh boat. Then transfer the 5.00 grams of KI to the water in the volumetric flask.
4. Add few ml. of distilled or deionized water to flush any KI that may be sticking to the inside of the flask neck.
5. Weigh and add 12.50 grams of KBr (potassium bromide) to the flask.
6. ***Use care to check the formula and water associated with the sodium phosphate chemicals used in the next two steps***
7. Weigh and add 0.63 grams of $NaH_2PO_4 \cdot H_2O$ (sodium phosphate monobasic monohydrate) to the flask.
8. Weigh and add *1.87 grams of* $Na_2HPO_4 \cdot 7H_2O$ (sodium phosphate, dibasic, 7-hydrate) to the flask.
9. Rinse in all chemicals that may be sticking to neck of flask. Then swirl flask around to dissolve most of chemicals.
10. Add distilled or deionized water to make up 1000.0 ml (33.8 oz) mark of the volumetric flask.
11. Invert flask several times to thoroughly mix solution. Allow cathode solution to sit in the dark in the volumetric flask for another ~10 minutes and invert a couple more times to be sure all the salts are dissolved.
12. Transfer cathode solution to the 1000 ml (33.8 oz) clean, amber Nalgene bottle.

IF: Sodium Phosphate Monobasic Monohydrate ($NaH_2PO_4 \cdot H_2O$) or Sodium Phosphate, Dibasic, 7-hydrate ($Na_2HPO_4 \cdot 7H_2O$) is not available please contact EN-SCI at sales@en-sci.com.

Anode Solution:

To make anode solution start with cathode solution saturated with KI:

1. Rinse out 125ml (4 oz) amber bottle with a few ml. of cathode solution.
2. Discard the cathode rinse.
3. Tare the empty anode bottle to zero on scale.
4. Add 80 grams of KI to the anode bottle (125 ml dark bottle).
5. Reset tare to zero so it is easier to determine how much cathode solution is being added.
6. Carefully pour in about 60 grams (or ml.) of cathode solution to anode bottle.
7. The next day the anode solution will be KI-saturated. There must be crystals of white KI visible at the bottom of the anode solution bottle to indicate it is fully saturated. If crystals are not present, add 10 grams of KI, wait one day. If there still not crystals present in the bottle add another 10 gm of KI. There must be crystals present in the bottle when the solution is used.
8. Let the solutions sit for a minimum of two weeks. Anode solution will start to develop a yellow tint.
9. Solutions should be good for a year if stored in sealed, amber bottles at room temperature. Anode may be dark yellow, rusty color by this time. It is still fine.
10. The anode solution will be consumed before the cathode solution. When it is necessary to make new anode solution, empty the bottle of any remaining solution and solid KI, rise with distilled water and prepare the solution starting with step #1 above.

For working solutions with the sondes, the anode solution can be taken directly from the 125 ml (4 oz.) bottle. The 250 ml (8.5 oz) bottle should be filled with cathode solution from the 1 liter (33.8 oz.) bottle. This 250 ml (8.5 oz.) bottle should be used for working with the sondes.

EN-SCI ENVIRONMENTAL SCIENCE

DIGITAL ECC OZONESONDE CHECKLIST

INITIAL PREPARATION—NO LESS THAN 7 DAYS BEFORE FLIGHT **OPERATOR INITIALS:** ________________
DATE (YYYYMMDD): ____________________ **STATION:** ________________________
ECC SONDE SERIAL #: __________________ **SOLUTION DATE:** ____________________

1. Run sonde 10 minutes on *No-LoO*$_3$ air: ______(√)
2. Record pump current with sonde running: _______mA. Acceptable <120 mA.
3. Record pump pressure: _____psi. Acceptable >8 psi.
4. Add 3.0 cc of cathode solution to the cathode cell: _____ (√)
5. Do not install the cap back on the cathode cell: _____ (√)
6. Run sonde for 30 minutes on HI-O_3______ (√)
7. Run sonde 5 minutes on *No-LoO*$_3$ air
8. Dump cathode solution_______ (√)
9. Add 3.0 cc of cathode solution to the cathode cell: _____ (√)
10. Wait 2-5 minutes: ______ (√)
11. Add 1.5 cc of anode solution to the anode cell: _____ (√)
12. Run 10 minutes on *No-LoO*$_3$:_____ (√)
13. Record ECC CURRENT: _______ μA. Acceptable <0.8 μA
14. Run sonde for 10 minutes at 5μA +/- O_3: _____ (√)
15. Switch to *No-Lo* O_3 air_____(√)
16. Record time for ECC CURRENT to drop from 4.0 to 1.5 μA _____ sec. Acceptable less than 120 seconds.
17. Run 10 minutes on *No-LoO*$_3$ air: _______ (√)
18. Record the ECC CURRENT: _______ μA. Acceptable <0.8 μA
19. Short the cell leads: _____ (√)
20. Store sonde in the flight box: ______(√)
21. Rinse the syringes: _____ (√)

IF DORMANT AFTER 1 WEEK REPLACE SOLUTIONS **DATE (YYYYMMDD):**____________________

1. Dump solutions from both cells_________(√)
2. Add 3 cc of cathode solution__________(√)
3. Add 1.5 cc of anode solution__________(√)
4. Run 5 minutes on *No*-LoO$_3$ air_________(√)
5. Record ECC CURRENT__________μA
6. Run 5 minutes on 5 μA O_3_________(√)
7. Switch to *No-LoO*$_3$ _______________(√)
8. Record time to drop from 4 to 1.5 μA________sec
9. Run 10 minutes on *No*-LoO$_3$ ________(√)
10. Record ECC CURRENT__________μA
11. Short cell leads_________________(√)
12. Store sonde in flight box__________(√)
13. Rinse syringes_________________(√)

FINAL CONDITIONING DATE (YYYYMMDD):__________________ **OPERATOR INITIALS:**______________

1. Record date of preparation of cathode and anode solutions, cathode____________________ anode_____________________
2. Dump original cathode and anode solutions out of cells: ___(√)
3. Rinse cells by adding 3.0 cc of cathode solution to cathode cell and 1.5 cc of anode solution to the anode cell and dumping: ____ (√)
4. Add 3.0 cc of cathode solution to the cathode cell: _____ (√)
5. Wait 2-5 minutes: _____ (√)
6. Add 1.5 cc of anode solution to the anode cell:____ (√)
7. Run 10 minutes on *No-Lo* O_3:____ (√)
8. Record the cell current: IB0=______μA.
9. Run 10 minutes at 5.0 +/- 0.2 μA ECC CURRENT: _____ (√)
10. Switch to *No-Lo* O_3: _____ (√)
11. Record time to drop from 4.0 to 1.5 μA:______sec
12. Run 10 minutes on *No-Lo* O_3 then record ECC CURRENT: IB1=_____ μA
13. Room T (deg C) _______, RH( ) ________, P(hPa)________
14. Record 5 flowrates (sec/100 ml) #1_________,#2_________ #3_________ #4_________,#5__________ Average________sec
15. Rinse syringes: ___________ (√)
16. Connect the cell leads to the interface board, observing the polarity______(√)

DAY OF FLIGHT LAUNCH PREPARATION **FLT #:**_______ **OPERATOR INITIALS:**_________________

Radiosonde Model__________
Radiosonde Serial#_______________
Balloon Size __________ Grams
Balloon Mfg.. Totex___,Hwoyee___, Pawan______
Have computer and software operational, radiosonde and ECC sonde powered, install zero filter on sonde inlet for 10 minute______(√)-Lid off box if hot.
Record O_3 Background Current Before Flight, IB2=_____μA
GMT Date(YYYYMMDD):____________

Local Date (YYYYMMDD):__________
GMT Launch Time(HH:MM:SS):______________
Local Launch Time (HH:MM:SS):___________
Surface Pressure:__________(hPa)
Surface Wind Speed:______________(m/s)
Surface Temp:__________(deg C)
Surface Wind Direction:____________(deg)
Surface RH:_____________%
Sky Conditions and notes:_________________
DOBSON_______, BREWER________: ________(DU)

Adapted from the SHADOZ OZONESONDE CHECKSHEET

Document Number – 08-2019

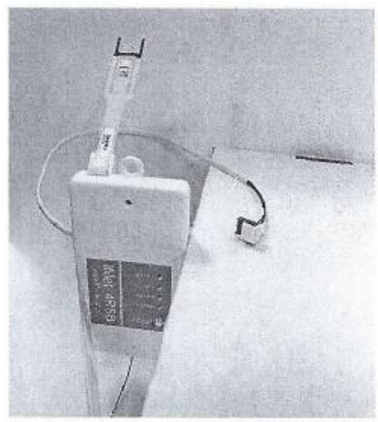
InterMet
International Met Systems

Preparing the iMet-4RSB Radiosonde for Flight

1. Remove the radiosonde from its shipping container.
2. Press and hold the "FREQ" button until the LED begins to flash.
3. Continue pressing the Freq button to set the desired frequency.

NOTE

The iMet-4RSB includes seven transmission frequencies. Whole frequencies are indicated by a single flashing LED, intermediate (half-step) frequencies by two. For example, when the 402 and 403 lights are both lit, the sonde is transmitting at 402.5 MHz.



4. Place the radiosonde outdoors in view of GPS signals. Once the radiosonde GPS, the LED will change from blinking to solid.
5. Start the iMetOS-II and select "New Sounding". Continue through the "Select/Confirm Radiosonde" section, selecting the iMet-4RSB.
6. Attach the radiosonde to your XData package so that the radiosonde hangs in a vertical position and the button is able to be pushed. Clear packing tape works well. See the picture to the right for an example. It is also recommended that the top of the radiosonde is mounted slightly above your XData package. This gives the radiosonde a better view of the sky and does not interfere with the XData cable.
7. Verify that pressure, temperature, humidity, GPS data, and XData are displayed on the system PC.
8. Carefully bend the sensor probe to a 45° angle using the locking tabs as shown. Do not touch the sensors.

NOTE

The iMet-4 no longer has an RH cap. From flights at InterMet, there is no difference in performance for fair weather flights, and during precipitation events, performance is improved without the cap.

9. Complete software steps so the iMetOS-II screen is green.
10. The radiosonde is now ready for launch.

To turn off the radiosonde, press and hold the "Freq" button until the LED turns off. The sonde can be re-started by repeating the procedure. Note that the sonde has a nominal battery life of 165 minutes and it is recommended that you not activate it more than 30 minutes prior to launch. Extended activation will shorten the profile duration.

InterMet
International Met Systems

Preparing the iMet-4RSB Radiosonde for Flight

The NWS (National Weather Service) does not recommend launching radiosondes in a thunderstorm environment. The following information is taken from the NWS Manual on radiosonde observations (http://www.nws.noaa.gov/directives/sym/pd01014001curr.pdf).

***13.3.5 Thunderstorms**. The radiosonde will not be launched into thunderstorms. If a thunderstorm is occurring at the time of balloon release, the observer will wait until the storm passes before releasing the balloon. Three important reasons not to release during a thunderstorm are:*

a. The observer increases the likelihood of being killed by a lightning strike as he/she proceeds to release the balloon. During a storm, the balloon train can become a lightning rod with the observer holding the lower end.

b. The data collected inside or near thunderstorms are erroneous and not useful for weather forecasts. The observation does not represent the synoptic scale environment and NCEP does not use such observations for ingestion into numerical weather prediction models.

c. Thunderstorms typically terminate an observation early owing to balloon icing or strong downdrafts. A thunderstorm is defined as ending when at least 15 minutes have passed since the last clap of thunder was heard...

Warranty Information

From time of delivery, radiosonde performance is guaranteed for 1 year. If properly stored, sonde performance should remain within specifications for two or more years.

If a radiosonde is not able to complete the pre-flight process due to sensor or GPS failures, please select a new sonde and contact InterMet for a replacement. If a failure occurs after launch, please email the data folder along with a description of the event to info@intermetsystems.com and mbenoit@intermetsystems.com for review. If a sonde fails in flight and we can identify an internal fault, it will be replaced. Sondes launched into thunderstorms for research purposes may be subject to failure and may not be covered by the warranty.

iMet-4 Radiosonde

403 MHz GPS Synoptic
Technical Data Sheet

Temperature and Humidity

The iMet-4 measures air temperature with a small glass bead thermistor. Its small size minimizes effects caused by long and short-wave radiation and ensures fast response times.

The humidity sensor is a thin-film capacitive polymer that responds directly to relative humidity. The sensor incorporates a temperature sensor to minimize errors caused by solar heating.

Pressure and Height

As recommended by GRUAN[3], the iMet-4 is equipped with a pressure sensor to calculate height at lower levels in the atmosphere. Once the radiosonde reaches the optimal height, pressure is derived using GPS altitude combined with temperature and humidity data.

The pressure sensor facilitates the use of the sonde in field campaigns where a calibrated barometer is not available to establish an accurate ground observation for GPS-derived pressure. For synoptic use, the sensor is bias adjusted at ground level.

Winds

Data from the radiosonde's GPS receiver is used to calculate wind speed and direction.

Radiosonde Data Transmission

The iMet-4 radiosonde can transmit to an effective range of over 250 km*.

A 6 kHz peak-to-peak FM transmission maximizes efficiency and makes more channels available for operational use. Seven frequency selections are pre-programmed - with custom programming available.

Calibration

The iMet-4's temperature and humidity sensors are calibrated using NIST traceable references to yield the highest data quality.

Benefits

- Superior PTU performance
- Lightweight, compact design
- No assembly or recalibration required
- GRUAN[3] qualified (pending)
- Status LED indicates transmit frequency selection and 3-D GPS solution
- Simple one-button user interface

** Subject to ground station, balloon size and atmospheric conditions*
[1] All uncertainties expressed at a 95% confidence level
[2] Primary atmospheric pressure derived by GPS altitude
[3] GECOS Reference Upper-Air Network
Specifications subject to change without notice, Rev 10 171208

InterMet
International Met Systems
Grand Rapids, MI USA
www.intermetsystems.com

iMet-4-AB Radiosonde

Document 202084, Rev 10

MEASUREMENTS	
Measurement cycle	1 Hz
TEMPERATURE SENSORS	Glass Bead
Manufacturer	Shibaura
Measurement range	+60°C to -90°C
Resolution	0.01°C
Response time: still air/ $5\ ms^{-1}$ (1000 hPa)	2 / < 1 sec
Repeatability in Calibration	0.2 C
Combined Uncertainty/Reproducibility [1]	
> 100 hPa	0.5 C / 0.3 C
< 100 hPa	1.0 C / 0.75 C
Night flight	0.3 C / 0.3 C
Solar correction	≤ 1.2 C
HUMIDITY SENSOR	Capacitive Polymer
Manufacturer	IST
Measurement range	0-100 % RH
Resolution	0.1%
Response time	
@ 25C	0.6 seconds
@ 5C	5.2 seconds
@ -10C	11 seconds
@ -40C	61 seconds
Repeatability in Calibration	5 %
Uncertainty/Reproducibility [1]	
> 0 C	5% / 3%
-40 to 0 C	5% / 5%
PRESSURE [2]	Sensor
Manufacturer	Measurement Specialties
Measurement range	1200 hPa - 10 hPa
Resolution	0.01 hPa
Response time	0.5 milliseconds
Uncertainty/Reproducibility [1]	
Whole range	2.0 / 1.5 hPa
1200 - 400 hPa	1.0 / 0.75 hPa
400 hPa - 10 hPa	2.0 / 1.5 hPa
PRESSURE	GPS derived
Measurement range	SFC to 3 hPa
Resolution	0.1 hPa
Uncertainty/Reproducibility [1]	
1080 - 400 hPa	2.0 / 1.5 hPa
400 hPa - 3 hPa	0.5 / 0.25 hPa

GEOPOTENTIAL HEIGHT	Pressure derived
Measurement range	SFC to 40 km
Resolution	0.1 m
Combined Uncertainty/Reproducibility [1]	
1080 - 400 hPa	15 m / 10 m
400 - 10 hPa	200 m / 150 m
GEOPOTENTIAL HEIGHT	GPS derived
Measurement range	SFC to 40 km
Resolution	0.1 m
Combined Uncertainty/Reproducibility [1]	
1080 - 400 hPa	30 m / 15 m
400 - 3 hPa	60 m / 20 m
WIND SPEED AND DIRECTION	
Resolution	0.1 m/s / 1 degree
Speed	
Combined Uncertainty/Reproducibility [1]	0.5 / 0.25 m/s
Direction	
Combined Uncertainty/Reproducibility [1]	1 degree

TELEMETRY	
Transmission type	Synthesized
Maximum Range	> 250 km
Frequency stability	± 2 kHz
Deviation, peak to peak	6 kHz
Output Power	30 – 500 mW
Modulation	GFSK
Data Rate	1200 Baud
Standard Frequencies	402, 402.5, 403, 403.5 404, 404.5, 405
Custom Frequencies	Available
GPS RECEIVER	
Manufacturer / Type	U-Blox CAM-M8
Cold Start Time	< 60 seconds (typical)

OPERATIONAL DATA	
Battery	Lithium
Operating time	> 135 minutes
Weight	120 grams
Dimensions	Body (LWH): 139x67x31
	With boom (LWH): 235x67x31
Calibration Stability	2 years

** Subject to ground station, balloon size and atmospheric conditions*
[1] All uncertainties expressed at a 95% confidence level
[2] Primary atmospheric pressure derived by GPS altitude
[3] GECOS Reference Upper-Air Network
Specifications subject to change without notice, Rev 10 171208

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Links

Link to the NOAA website with programs and details on their ozonesonde program:

https://www.esrl.noaa.gov/gmd/ozwv/wvap/sw.html
http://vimeo.com/71603488 - visual reference only

Link to the SHADOZ web site:

https://tropo.gsfc.nasa.gov/shadoz/

Link to recent paper on laboratory studies comparing ozonesonde techniques:

https://journals.ametsoc.org/doi/full/10.1175/BAMS-D-17-0311.1

Videos of balloon prep as well as other video on ballooning:

https://vimeo.com/207868473

Inflation and launching of a weather balloon:

https://www.facebook.com/video/video.php?v=144659178957635

Revisions to Manual

Rev. Date	Rev No.	Summary	Section
08/21/2019	A	New Manual	Entire manual