Model 2ZV7-ECC Atmospheric Ozonesonde Sounding System

DOC-0372, Rev B-2

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Trademark Information

Warranty

The seller warrants that the equipment supplied will be free from defects in material and workmanship for a period of one year from the confirmed date of purchase of the original buyer. Service procedures and repairs are warrantied for 90 days. The equipment owner will pay for shipping to DMT, while DMT covers the return shipping expense.

Consumable components, such as tubing, filters, pump diaphragms, and Nafion humidifiers and dehumidifiers are not covered by this warranty.

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1.0 Introduction

The DMT/EN-SCI Corporation Model 2ZV7-ECC atmospheric ozone sounding system is designed for ozone measurements from balloon platforms. The system allows for real-time data acquisition and processing. It consists of several components:

- InterMet radiosonde (Model iMet-1-RSB)
- A Model 2ZV7 electrochemical concentration cell (ECC) ozonesonde [Komhyr, 1969].
- V7 interface electronics to couple the ECC ozonesonde to a meteorological radiosonde.
- A ground station for receiving data. The ground station consists of a portable, tripod-mounted, 403 MHz Yagi antenna with built-in pre-amplifier. A 15-m long coaxial cable connects the antenna to a 403 MHz receiver.
- A laptop (supplied) with pre-installed data acquisition and processing software. This allows data to be received and processed during the balloon flight. The laptop is connected via a 1200 baud modem to the 403 MHz receiver.

Figure 1 shows an overview of the sounding system.

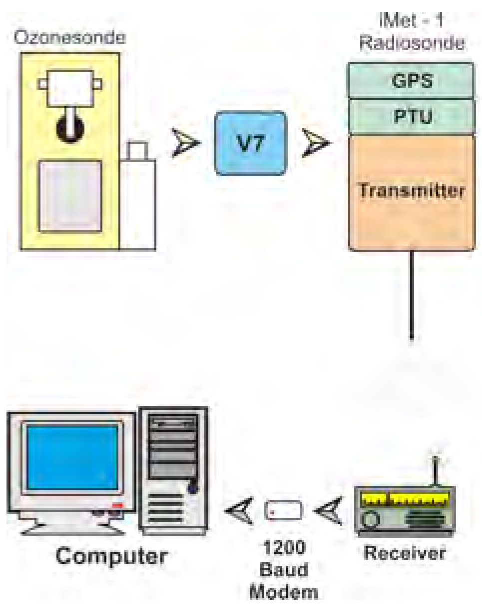


Figure 1: System Overview

The Model 2ZV7 electrochemical concentration cell (ECC) ozonesonde is lightweight, compact, inexpensive, and of simple design. It is readily prepared for use, and is capable of yielding highly accurate ozone measurement data.

As shown in Figure 2, the sonde consists of a rigid mainframe on which is mounted a motor-driven Teflon/glass air sampling pump, a thermistor for measuring pump temperature, an ozone sensing electrochemical concentration cell, and an electronics box containing V7 interface circuitry which couples the ozone sensor to an InterMet Systems iMet-1-RSB GPS 403 MHz meteorological radiosonde. For ascent into the stratosphere, the instrument is encased in a molded polystyrene weatherproof box.

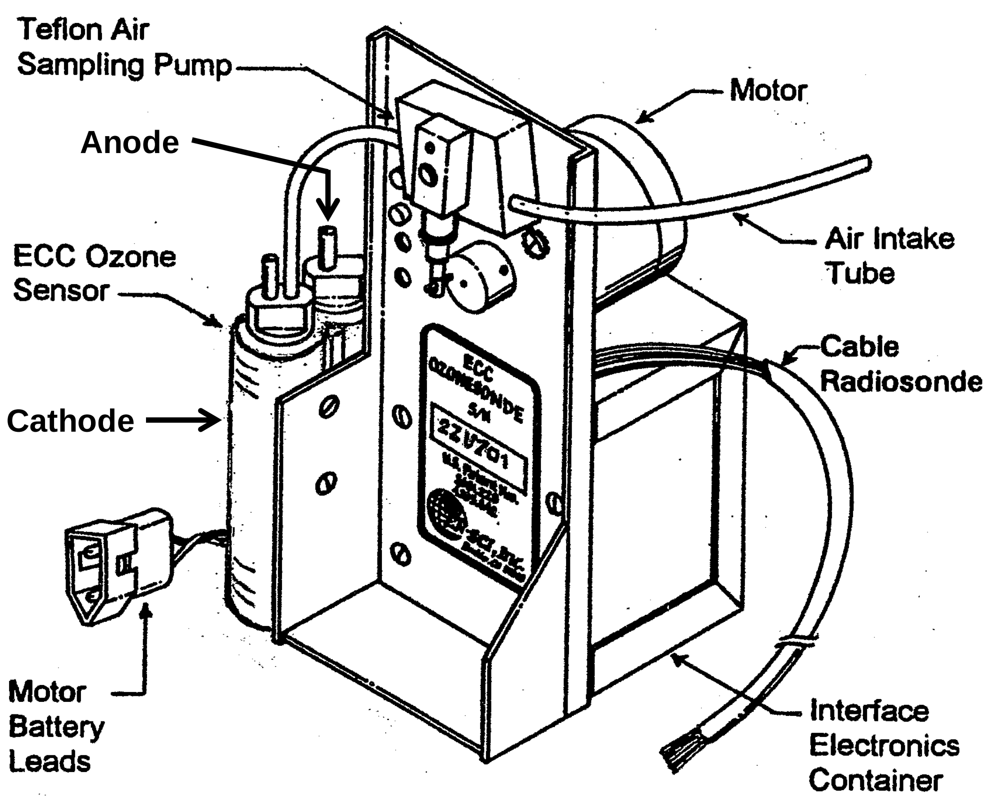


Figure 2: Balloon-borne Model 2ZV7 Electrochemical Concentration Cell (ECC) Ozonesonde

The ozonesonde telemeters the following measured parameters to the ground receiving station:

- Ozone concentration
- Sonde pump temperature

- Sonde pump motor voltage
- Sonde pump motor current

The radiosonde telemeters the following meteorological parameters:

- Atmospheric pressure
- Air temperature
- Humidity
- GPA (if radiosonde is configured for GPS transmission; GPS readings are used to calculate wind data)

For additional details concerning the ECC ozonesonde theory of operation and the V7 interface electronics, see Appendix G.

1.1 Specifications

Technique	Electrochemical process that generates electrical current in proportion to ozone concentrations
Measured Parameters	Ozone partial pressure, sonde housekeeping parameters
Operating Pressure	1050-4 hPa
Operating Temperature	0 - 40 °C
Power Requirements	12 – 18 VDC, 120 mA
Weight	550 g with battery, not including radiosonde
Instrument Dimensions	7.6 cm x 7.6 cm x 13.3 cm
Flight Box Dimensions	19.1 cm x 19.1 cm x 25.4 cm

2.0 Preparing the Model 2ZV7 ECC Ozonesonde for Flight

This section describes how to prepare an ECC Ozonesonde for flight. Note that there are also many good resources available online that describe ozonesonde preparation. For instance, NOAA researchers have prepared an excellent video that goes through all the steps necessary to condition and prepare the ozonesonde. This video can be viewed at http://vimeo.com/71603488. For additional online resources, visit http://www.dropletmeasurement.com/Sonde_Resources.

Preparation of the ozonesonde for flight should always be performed in a clean environment where smoking is prohibited; otherwise the performance of the instrument may be adversely affected.

Tubing connections to the sonde pump are made with pressure-fitted Teflon tubing. Should the fit appear to be too loose, enlarge the Teflon tube using a clean, awl-shaped tool of outside diameter slightly larger than the inside diameter of the tube. Use small strips of sand paper with which to grasp the Teflon tubing firmly when making or removing pump connections.

2.1 Instrument Preparation: 3 Days to 1 Week Prior to Flight Time

The first step in preparing the ozonesonde for use is to check the overall performance of the instrument, and to charge the sensor with sensing solution (Appendix A). Initial charging of the sensor should be done 3 days to 1 week before flight time in order to attain a low sensor background current. (For information on preparing an instrument for use and flying it the same day, see section 2.3.) A DMT Corporation Model KTU-2 ozonizer/test unit (Appendix B) is used for checking on the overall sonde performance. The unit consists of the following components:

- a high-ozone source for conditioning the sonde air intake tube, pump, and sensor air intake tube with ozone
- a variable low-ozone source for conditioning the sonde sensor charged with sensing solution, and for checking on the sensor background current and response time
- a 12 VDC power supply for operating the sonde motor
- electrical meters for use in checking on the sonde motor/sensor characteristics

Proceed as follows in advance preparation of the instrument for use. The preparation should be performed in a clean room at a temperature of 20-25° C.

(a) Remove the sonde from its polystyrene flight box and connect the Teflon air intake tube packed with the instrument to the sonde pump.

(b) Connect the ozonesonde battery power leads to the ozonizer/test unit's 12 VDC output power supply terminals. Pull the ECC sensor's air intake tube away from the pump. Next insert the pump air intake tube into the NO-LO OZONE port of the unit. With all ozonizer/test unit switches turned on except the UV lamp switch, operate the sonde pump for 10 minutes. During this time, clean, ozone-free air will be passed through the pump. After the 10-minute interval, check the current drawn by the sonde (pump motor and V7 interface board) at about 12.3 VDC. The current should be less than 100 mA. (The current drawn by the interface board is about 8 mA.) If the current is larger, the fit between the piston and cylinder may be too tight and may cause excessive frictional heating. Continue operating the pump for an additional 20 minutes to see if the current decreases. If it does not, take remedial action as outlined in Appendix C. A properly adjusted pump will draw less than 90 mA of current, and develop at least 50 cm (~20 inches) of Hg pressure and 45 cm (~18 inches) of Hg vacuum. Measure the pressure and vacuum developed by the pump with a pressure/vacuum gauge.

(c) With proper pump performance attained, remove the sonde air intake tube from the NO-LO OZONE port of the ozonizer/test unit, and insert it <u>snugly</u> into the HI OZONE port of the unit. (The connection must be snug since the sonde pump <u>draws</u> highly ozonized air from the unit.) Next remove the top plug with air intake tube from the sensor cathode chamber, and re-connect the air intake tube to the pump. Now turn OFF the AIR PUMP switch, but turn ON the UV LAMP switch, and pull out the OZONE CONTROL tube as far as possible out of the chassis. Conditioning of the sonde Teflon tubing, pump, and sensor air intake tube (<u>but not the sensor cathode chamber</u>) with high ozone now begins. Blue light visible through a hole in the front of the OZONE CONTROL tube indicates that the UV lamp is ON. During the conditioning avoid direct breathing of the ozonized air coming out of the sensor air intake tube. Condition with high ozone for 30 minutes.

(d) After conditioning with high ozone is completed, push the OZONE CONTROL tube as far as possible into the ozonizer/test unit chassis, turn ON the AIR PUMP switch, and withdraw the sonde air intake tube from the HI OZONE port and insert it into the NO-LO OZONE port. Ozone-free air will now be passing through the pump and sensor air intake tube to flush out the ozone. Continue flushing for 3-5 minutes.

(e) Now unplug the sensor leads from the sonde electronic interface board, and plug them into the sensor cable connector of the ozonizer/test unit. Then charge the sensor with sensing solution as follows:

The sensor <u>cathode</u> must always be charged first to allow cathode solution to permeate the sensor's ion bridge. Using a Teflon-tipped syringe especially reserved for use with <u>cathode</u> sensing solution, inject 3.0 ml of the solution into the sensor cathode chamber. This is the chamber containing the large platinum screen. When re-installing the top plug of the cathode, make sure that the air intake tube is correctly centered within the cathode chamber by inserting the tube carefully over a thin Teflon rod projecting out of the bottom plug of the sensor cathode chamber. Rinse the syringe with distilled water prior to storage.

Note: Do not attempt to fill or empty the sensor cathode through the short air exhaust tube of the cathode chamber top plug; otherwise the platinum screen may be damaged (distorted), leading to sensor malfunction.

Next, after waiting 2 minutes to allow the cathode sensing solution to permeate the sensor's ion bridge, use a syringe especially reserved for dispensing anode solution to inject 1.5 ml anode sensing solution into the sensor anode chamber. Rinse the syringe with distilled water prior to storage.

(f) After charging the sensor with solution, run the sonde on ozone-free air for 5-10 minutes. The sensor current, as observed on the ozonizer/test unit microammeter should be low, 0.5 μA or less. Now set the ozonizer/test unit OZONE CONTROL tube position for a low ozone output—one that produces a sensor current of 5 μA. Continue input of ozonized air into the sensor for 10 minutes while periodically adjusting the OZONE CONTROL tube position as needed. At the end of the 10-minute interval, abruptly push the OZONE CONTROL tube as far as possible into the ozonizer/test unit front panel to begin the flow of ozone-free air through the sensor. Read the microammeter current 1 minute later; it should then have decreased from the original value of 5 μA to 1.5 μA or less, indicating satisfactory ECC sensor performance.

(g) Continue running the sonde on ozone-free air for 10 minutes. Then turn off all ozonizer/test unit switches, and disconnect the sonde from the unit. Prior to storage of the sonde until flight day, add 2.5 ml cathode sensing solution to the sensor cathode chamber to fill it about 3/4 full. Re-insert the sensor cathode chamber air intake tube into the sensor, and store the sonde in a dark, clean-air environment at a temperature of 20-25° C until the day of the flight.

IMPORTANT! Prior to storage, short the ECC sensor leads together with a shorting plug. Shorting plugs are provided with the ECC Ozonesonde Start-up Kit, if you have ordered one. Shorting the sensor leads will allow a sensor cleaning action to proceed during storage. (Do not re-plug the sensor into the sonde's electronic interface board for storage since the unpowered board's input impedance may be high, and proper sensor cleaning action would not proceed.)

2.2 Instrument Preparation: the Day of Release

2.2.1 Option A: Using the KTU-2 Ozonizer/Test Unit

The preparation should be conducted in a clean room at a temperature of 20-25° C.

(a) Remove the top plug from the sensor cathode chamber and remove all solution from the chamber. Now rinse the chamber by injecting into it 3.0 ml fresh cathode solution, then removing the solution completely from the chamber. Finally, refill the chamber with 3.0 ml cathode solution. (Note: For soundings of duration less than 3-4 hours, made primarily to measure tropospheric ozone, 2.5 ml cathode sensing solution may be used, instead. Sensor response time will then be improved.) Replace the top plug.

Next, remove the top plug from the sensor anode chamber and remove all anode solution from the chamber. Re-fill the chamber with 1.5 ml of fresh anode solution. Replace the anode plug.

(b) Connect the ECC sonde motor and sensor leads to the ozonizer/test unit, and insert the sonde air intake tube into the NO-LO OZONE port of the unit to a distance of about 7 cm. Set the controls so that ozone-free air passes through the air pump and sensor. Next, turn on the UV LAMP switch to warm up the lamp. Continue passing ozone-free air through the sensor for a total of 10 minutes. At the end of the 10-minute interval, record the sensor background current (which generally should be less than 0.05 μA). Save this information as part of your raw data file (e.g., i_{b1} = 0.05 μA).

(c) Next, pull the OZONE CONTROL tube out of the ozonizer/test unit a distance such that, after several minutes, the sonde sensor output current becomes approximately 5 μA. Continue passing an equivalent of 5 μA ozone current through the sensor for a total of 10 minutes. Periodically adjust the position of the OZONE CONTROL tube so that at the end of the 10-minute interval the ECC sensor current is exactly 5.0 μA.

(d) Now check the ECC sensor response time as follows: Using a stopwatch, at time t = 0 quickly push the ozonizer/test unit OZONE CONTROL tube all the way into the instrument chassis and turn the UV LAMP switch OFF. As the ECC sensor current continues to fall, record the current for times t = 0, 0.5, 1, 3, 5 and 10 minutes as shown in the example on the following page giving typical measurement results at 20° C. Record also the room temperature at which this test was performed. Save all the information as part of the raw data file. Sensor response time R, is satisfactory if

$$R = 100[(i_{m(t=0)} - i_{m(t=1)})/i_{m(t=0)}] \geq 80\%. \quad (5)$$

t	Sensor Current, i_m
0 min.	5.00 μA

0.5	1.61
1	0.82
3	0.25
5	0.20
10	0.10

For the above example, R = 83.6%. Sensor response time becomes faster as sensor temperature increases.

(e) After the sensor response time check is completed, continue running the ozonesonde on ozone-free air for another 10-15 minutes. During this time re-connect the ECC sensor leads to the V7 interface board. Connect the ozonesonde to the InterMet radiosonde. Activate your data acquisition system for operation in the “Calibration” mode to begin receiving and recording the radiosonde and ozonesonde data by computer. (See Appendix E for configuration of the data acquisition system). This procedure will enable you to check for satisfactory performance of the ozone-radiosonde instrument package as-a-whole. At this stage, the ozonesonde should still be operated without its flight box at a room temperature of 20-25° C, and powered by the ozonizer/test unit's 12 VDC power supply. Power the InterMet radiosonde with an auxiliary 6 V battery power supply. As the sonde is continuing to be run on ozone-free air, perform a sonde pump air flow rate according to instructions given in Appendix D. Check to insure that the pump motor voltage is about 12.3 volts. Record the pump motor voltage and current (which should be less than about 110 mA). Record also the pump air flow rate and the room temperature, and save all information as part of the raw data file. Now enter into your computer raw data file all pertinent ozonesonde and radiosonde calibration data, instrument serial numbers, station name, release date, etc. At the end of the final 10-minute ozone-zero air conditioning period, record in the raw data file, also, the ECC sensor background current (i_{b2}) which should generally be less than about 0.1 μA.

(f) Now turn off power to the ozonizer/test unit. (By this time inflation of the flight balloon and preparation of the flight train should have been completed.) Install the ECC sonde into its flight box together with the sonde pump motor battery, but do not activate the battery. Activate the radiosonde by plugging the leads connector of the 2-cell lithium battery pack, located within the radiosonde, into its mating connector mounted on the radiosonde electronics board. Tape the radiosonde to the ozone instrument flight box (see Appendix F for configuring the instrument package for flight). Affix a return address/reward notice to the cover so that the instrument could be returned to your laboratory should it be recovered by someone.

(g) Now carry the ozonesonde package outdoors, and suspend it from a pole (or set it on a platform) at a height of about 1.5 meters above the ground, with the sonde air intake tube pointing into the wind. Connect the sonde pump motor battery leads to begin ECC ozonesonde operation. Activate the 403 MHz ground receiving equipment for operation in the “Surface Ozone Measurement” mode to measure and record surface ozone data for 10 minutes.

In very warm weather, the surface ozone measurement should be made with the cover off the sonde weatherproof box to prevent excessive heat build-up within the box. Tape the cover on to the box prior to instrument release (see method of taping shown in Appendix F).

(h) Finally, attach the ozonesonde instrument package to the balloon train and release the balloon.

2.2.2 Option B: Using a Calibrated Ozone Source

Note: Follow these instructions for instrument preparation on the day of release instead of those given in Section 2.2.1 if you have available a calibrated ozone source such as a Dasibi or a Thermo Environmental Instruments (TEI) ozone calibrator.

Preparation should be performed in a clean room at a temperature of 20-25° C.

(a) First turn ON the calibrated ozone source instrument (e.g., the TEI ozone calibrator) to let the instrument warm up for at least half an hour. The ozone output of the calibrator should be set to zero.

(b) While the TEI ozone calibrator is stabilizing, remove the top plug from the ozonesonde sensor cathode chamber and remove all solution from the chamber. Rinse the chamber by injecting 3.0 ml fresh cathode solution into it, then removing the solution completely from the chamber. Finally, refill the chamber with 3.0 ml cathode solution and replace the cathode plug. (***Note***: For soundings made primarily to measure tropospheric ozone, 2.5 ml of cathode sensing solution may be used, instead (see Sec. 2.2 (a)). Sensor response time will then be improved.)

Now remove the top plug from the sensor anode chamber and remove all anode solution from the chamber. Re-fill the chamber with 1.5 ml fresh anode solution. Replace the anode plug.

(c) Next, plug the ECC sensor leads and the radiosonde connector cable into the interface board. Connect the 12 and 18 volt d.c. power cables from the model

KTU-2 ozonizer/test unit to the ozonesonde and radiosonde, but do not power the ozonizer/test unit yet.

(d) While the TEI ozone calibrator is continuing to stabilize setup your data acquisition system; enter the radiosonde calibration data into a file in the computer if that had not been done earlier; inflate the flight balloon; and prepare the balloon train (parachute, reel, etc.).

(e) After the TEI ozone calibrator has been operating for at least 1/2 hour, obtain ECC ozonesonde flight calibration constants as follows: First insert the sonde air intake tube about 5 cm into the ozone output manifold of the TEI instrument. Secure it there with a piece of masking tape taking care not to impede air flow. Now turn the ozonizer/test unit ON to provide power to the ozonesonde and radiosonde. Activate the ozonesonde data acquisition and processing software, and enter required information (station, time, ozone instrument and radiosonde serial numbers, etc.) into the computer. Set operation to the "Calibrate" mode and begin recording the ECC sensor background current. Record the current for 5-10 minutes, or until the readings settle to a low value.

(f) Now adjust the ozone control on the TEI ozone calibrator for an ozone output given by

$$O_3\ (\text{ppbv}) \approx (1.8 \times 10^5)/P \qquad (5)$$

where P is the mean station pressure in hPa. (This correspond to a an ECC sensor output current of about 5 μA.) Continue to operate the TEI instrument in this mode for 10 minutes.

(g) After the 10 minutes are up, *quickly* adjust the TEI instrument to give zero ozone output. This will begin final measurement of the ECC sensor background current as well as provide information on sensor response time. Continue running the sonde on zero (ozone-free) air for 10 minutes. Then as the instrument continues to run on ozone-free air, perform a pump air flow rate measurement according to instructions given in Appendix D. Finally, after not less than 15 minutes of run time to obtain stable background current, disconnect power from the ozone instrument and the radiosonde.

(h) Enter into the computer the pump air flow rate, t, as well as the lowest sensor background current, i_{b2} , obtained near the end of the time of the background current measurement.

(i) Now insert the sonde into its polystyrene flight box together with the sonde pump motor battery, but do not activate the battery to operate the sonde pump.

(If a water activated battery is used, it should have been water activated 10-15 minutes before this time (see Appendix F). Activate the radiosonde battery, and tape the radiosonde to the ozone instrument flight box (see Appendix F for configuring the instrument package for flight). Affix a return address/reward notice to the box cover so that the instrument could be returned to the laboratory should it be found by someone.

(j) Carry the ozonesonde package outdoors and suspend it from a pole (or set it on a platform) at a height of about 1.5 meters above the ground, with the sonde air intake pointing into the wind. Connect the sonde pump battery leads to activate the sonde for a 10-minute surface ozone measurement. For this measurement, set the computer output to operate in the "Surface Ozone" mode.

In very warm weather, the surface ozone measurement should be made with the cover off the sonde weatherproof box to prevent excessive heat build-up within the box. Tape the cover to the box prior to instrument release.

(k) Finally, set the computer software to operate in "Flight" mode. Attach the ozonesonde instrument package to the balloon train, and release the balloon.

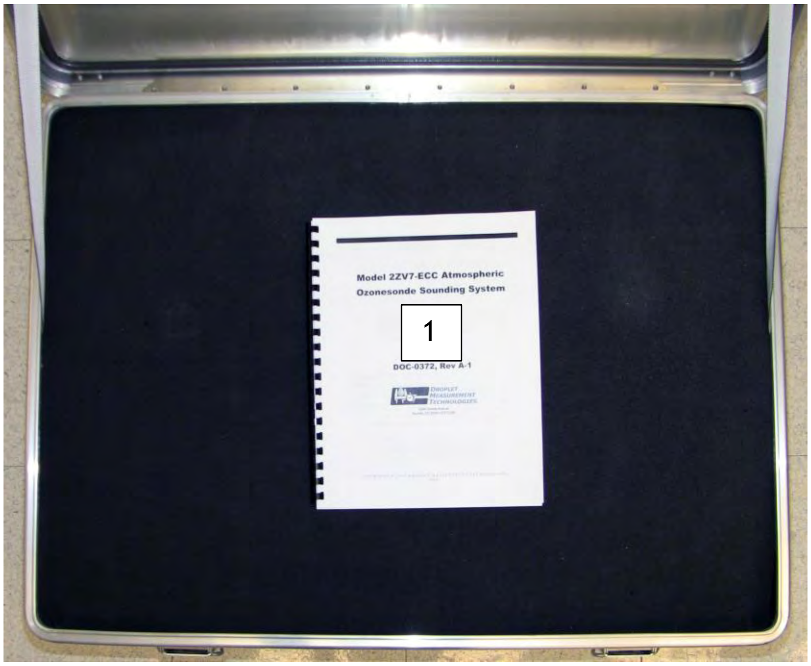
2.3 Preparing and Flying an ECC Ozonesonde on the Same Day

The ECC ozonesonde can be prepared and flown on the same day, but the background current may be slightly higher than normal. In preparing the instrument for such use, follow instructions given in section 2.1 (a)-(g). After charging the sensor with sensing solution, pass ozone-free air through the sensor for 10 minutes, then replace the cathode solution with fresh solution. Run the instrument again on ozone-free air for 10 minutes to achieve a sensor background current of 0.1-0.2 μA. (The solution replacement may have to be repeated.) If possible let the instrument then stand without use for several hours. At the end of that time, proceed with preparing the instrument for flight according to the instructions given in section 2.2.1 (a)-(e).

3.0 Ground Station Set-up

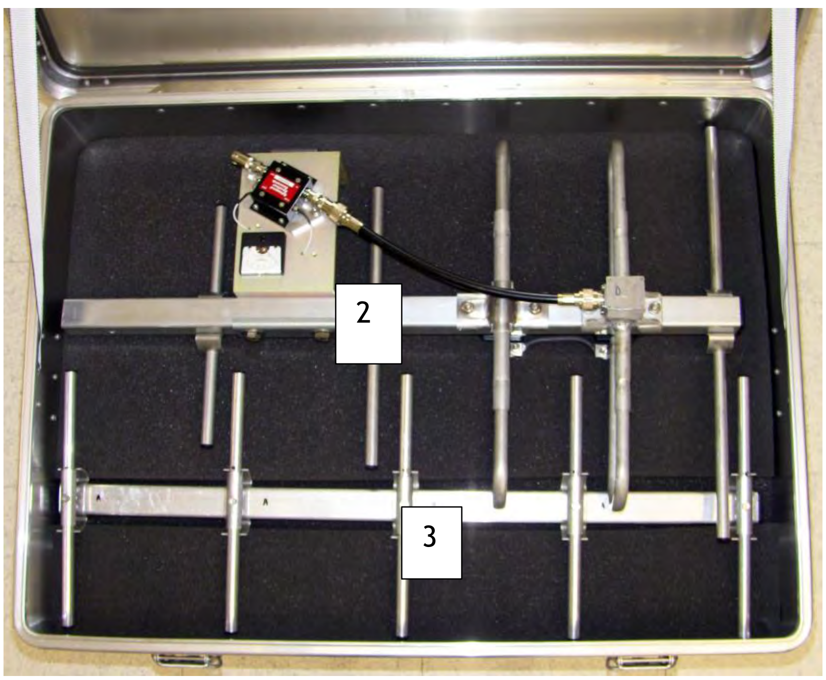
3.1 Unpacking

The Ground Station and Data Acquisition System (DAS) arrive in a sturdy carrying case. Contents are arranged in three layers, as shown on the following pages.



Top layer:

1. Manual for Model 2ZV7-ECC Atmospheric Ozonesonde Sounding System; checklist of included materials (underneath manual in picture)

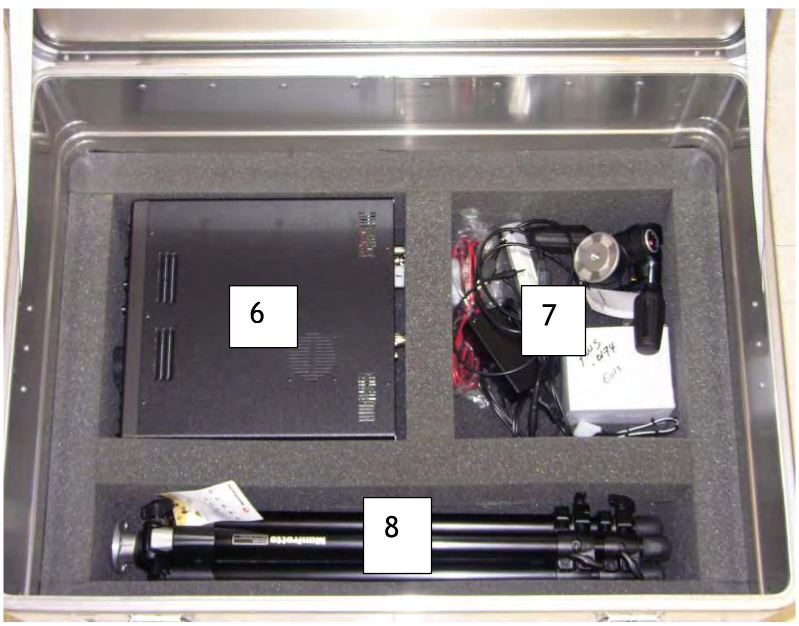


Second Layer:

2. Antenna base with pre-amp
3. Antenna tail

Third Layer:

4. Laptop computer
5. RG8 antenna cable



Bottom Layer:

6. Receiver
7. Tripod head and other hardware:
   - Pre-amp receiver
   - Modem
   - Thumb drive
   - Power supply
   - DC power cable
8. Tripod legs and base

Figure 3: Contents of Carrying Case, Arranged in Layers

Unpack the top three layers and carefully set the contents aside. You will first set up the tripod, which is stored in the bottom layer.

3.2 Tripod and Antenna Assembly

3.2.1 Tripod Assembly

1. Extend the legs of the tripod using the adjustable clamps.

2. Adjust the length of each leg so that the tripod base is level.

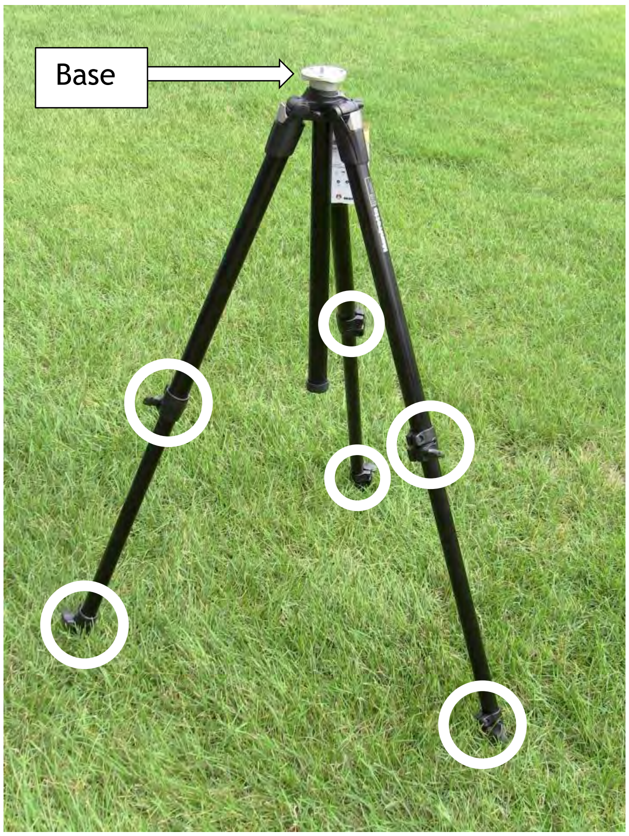


Figure 4: Adjustable Clamps (Circled) and Tripod Base

3. Secure the tripod legs by tightening the clamps.

4. Attach the three-way adjustable head of the tripod (Figure 5) to the base.

Figure 5: Attaching Tripod Head to Tripod Base

3.2.2 Antenna Assembly

1. Secure the antenna base (Figure 6) to the clip on the tripod head (Figure 7). The assembly should now resemble Figure 8.

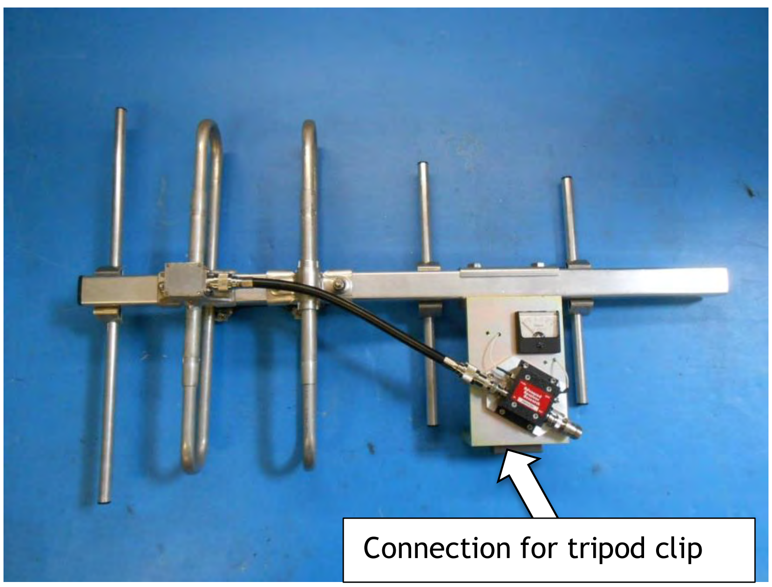


Figure 6: Antenna Base

Figure 7: Clip to Attach Tripod Head to Antenna Base

Figure 8: Attaching Tripod Head to Antenna Base

2. Attach the antenna tail with the antenna insert and two thumb screws to the antenna base (Figure 9).

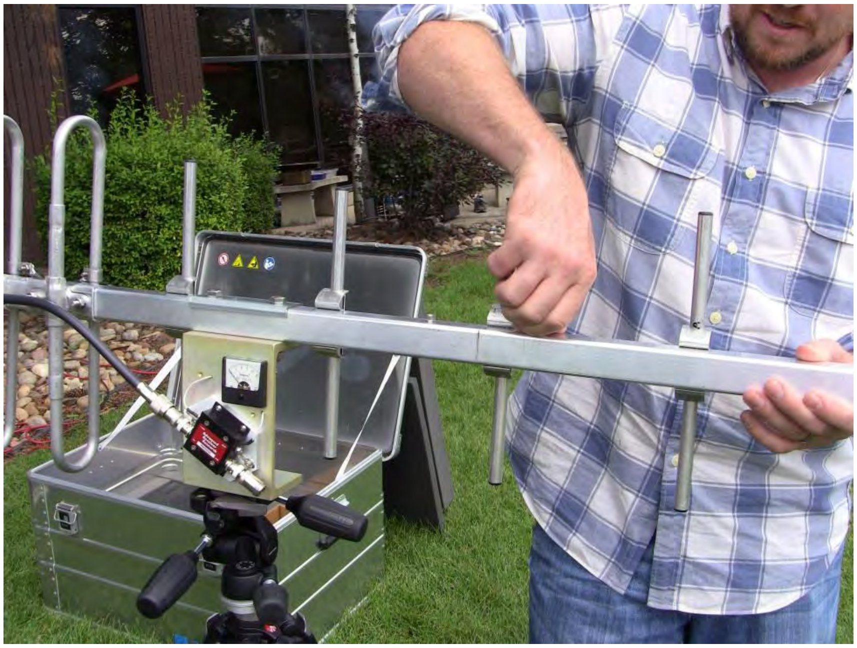


Figure 9: Screwing in the Antenna Tail

3. Point the antenna in the direction of the weather balloon. The balloon will move under the wind's influence. The antenna's direction (north, south, east, or west) is more important than the pitch (the angle the antenna forms with the ground).

4. Plug the antenna cable into the antenna. Turn the ring on the BNC plug on the connector to secure it.

Figure 10: Attaching Cable to Antenna

3.3 Assembling the Receiver and Laptop

1. Remove the receiver (Figure 11) from the carrying case. If protective plastic wrap is present, remove it.

Figure 11: Receiver

2. Connect the power supply to the rear panel of the receiver (Figure 12).

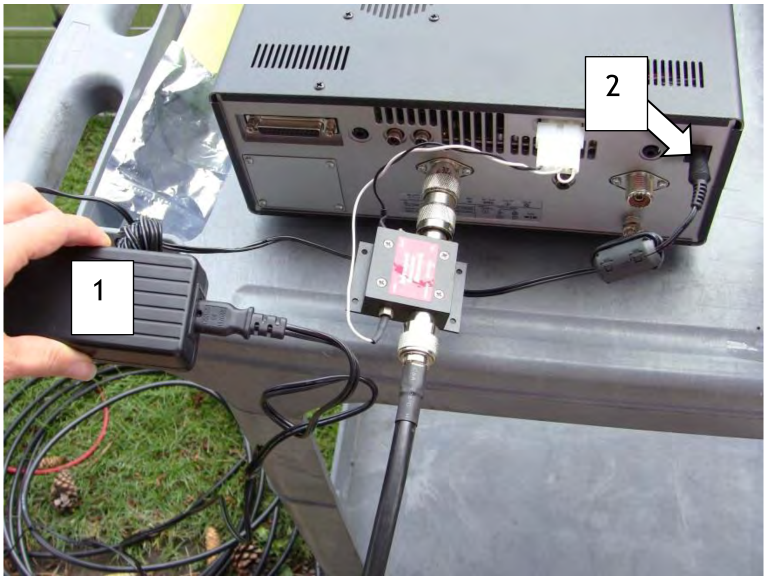


Figure 12: Power Supply Box (1) and Power Supply Port Connection (2)

3. Plug the pre-amplifier power supply and wire harness into the pre-amplifier power supply port at the rear of the receiver (Figure 13).

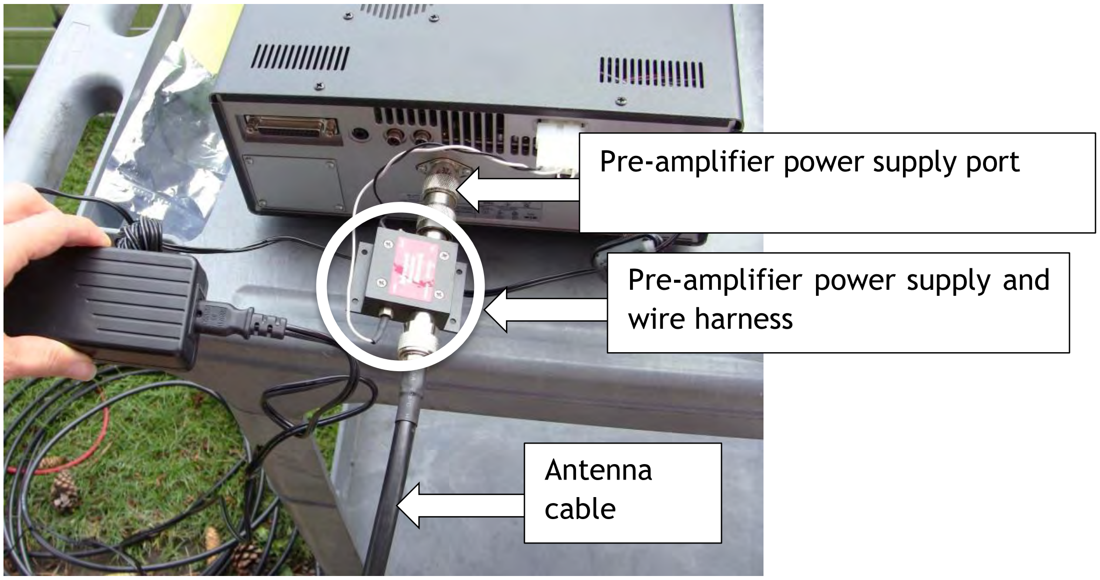


Figure 13: Antenna Cable Connected to Pre-amplifier and Receiver

4. Plug the white DC injector into the rear panel of the receiver.

Figure 14: DC Injector Port on Rear Panel of Receiver

5. Plug in the laptop power supply.

6. Turn on the laptop.

7. Plug the 1200 baud modem (COMP-0186) into the computer (Figure 15). ***Warning:* The cable from the receiver to the modem input should not be connected when plugging the modem into the computer's USB port. If there is an active serial data stream coming from the modem when it is plugged into an USB port, the Windows operating system will identify the modem as a serial mouse and send the mouse pointer randomly around the screen.**

8. Wait one minute, so that the computer has sufficient time to register the modem. Plug the modem into the receiver's **REC OUT** port (Figure 15).

Figure 15: 1200 Baud Modem Connected to Laptop, Left, and Receiver, Right

9. Power on the receiver by pushing the **Power** button in the upper left corner.

10. Check that a power signal is registering on the pre-amplifier (Figure 16).

Figure 16: Antenna Pre-amplifier Registering Power Signal

11. Check the band settings on the receiver's front panel:
    a. The Band should be set to WFM. The Band setting is shown on the receiver's digital display (Figure 17). If WFM is not displayed, select it by pressing the WFM button (Figure 18).

Figure 17: Band Setting Shown in Digital Display

Figure 18: The WFM Button

    b. Note the frequency setting. The frequency is prominently shown in the digital display; in Figure 18, it is 404.0000. Set this frequency to match the radiosonde frequency, which should be 402-405. You can adjust the frequency using the dial (Figure 19) or the keypad (Figure 20).

Figure 19: Receiver Dial

Figure 20: Receiver Keypad

12. With the radiosonde operational and transmitting, check the signal strength meter. It should be registering positive, preferably in the red zone (Figure 21).

Figure 21: Signal Meter Registering Strong Signal

3.4 Assembling the Radiosonde

To preserve battery life, the radiosonde is packaged with the battery unplugged. Follow the instructions below to plug power into the radiosonde.

1. Open the radiosonde box and gently slide out the Styrofoam top cover (Figure 22).

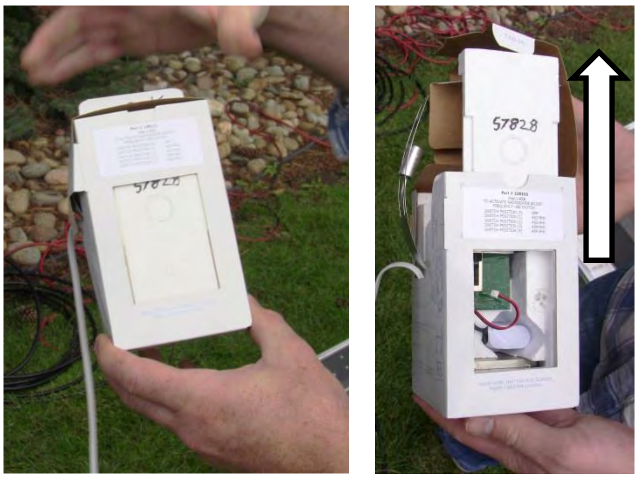


Figure 22: Removing the Radiosonde's Styrofoam Cover

2. Plug in the battery (Figure 23).

Figure 23: Radiosonde with Battery Plugged in

3. Set the frequency switch inside the box. The sonde frequency setting should match the frequency setting on the receiver, which was set in Section 3, step 9.b and should be 402-405 Mz. Figure 24 shows a typical radiosonde switch.

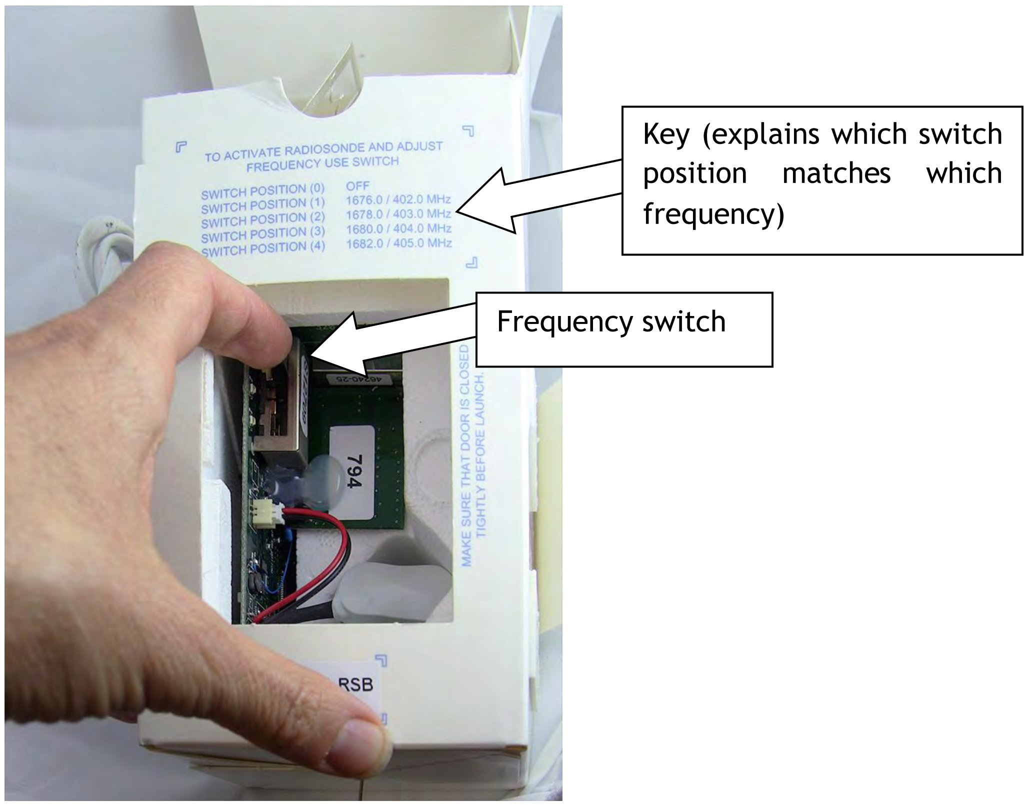


Figure 24: Adjusting the Radiosonde's Frequency Switch

4. Without touching the sensor itself, adjust sensor arm so it is outside the box in a good sampling position (Figure 25).


Figure 25: Radiosonde Sensor (Circled) Protruding from Box

5. Repackage the sonde in the box. The sensor arm should still be protruding. Use the tab to hold the arm out.

4.0 The Balloon Train

4.1 General Guidelines

ECC ozonesondes are generally flown with 1200 g or 1500 g rubber balloons that attain maximum pressure altitudes of 7-20 hPa. The exact maximum depends on balloon size, quality, and stratospheric temperatures. Balloons should be inflated to barely float weights of 2000 and 2300 g, respectively. Adjust the inflation weights, if necessary, to attain average balloon ascent rates of about 300 m/min. Somewhat more helium (or hydrogen) may be required when stratospheric temperatures are very cold or the flights are made at night. Commercially available plastic balloons may also be used. These attain higher burst altitudes than do rubber balloons when flown in the cold temperatures of the Arctic or Antarctic polar night.

The ozonesonde should be suspended during flight about 30 m below the balloon. Winding a cord on a ratchet-type reel will facilitate the balloon release. In cold climates, attach a snap-type clip to the reel cord for quick connection of the ozonesonde package to the balloon train.

If a release is made in a populated region, a parachute of diameter about 1.5 m should be suspended by a cord 5-10 m below the balloon. When conducting ozone soundings from a flight control area (e.g., in the vicinity of an airport), check with your local aviation authority for regulations regarding balloon releases.

4.2 Online Resources

A number of videos are available on balloon inflation, i.e. the handling of the balloon and proper filling technique. A video done with compressed time frame, making the inflation process happen 8 times faster than usual, is available at

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

A useful software program for predicting the trajectory of the balloon, the burst point, and the landing point has been developed by Allen Jordan of NOAA. For a manual on the program and details on obtaining it, visit
http://www.allenjordan.info/balloonprediction.html

Additional online resources are available at
http://www.dropletmeasurement.com/Sonde_Resources

5.0 Sonde Battery Power

Lithium batteries are provided for powering the Model 2ZV7 ECC ozonesondes. The battery must be located in the instrument compartment of the flight box to prevent excessive cooling of the battery and, hence, excessive voltage drop. (Water-activated batteries may also be used.) For more detailed instructions concerning battery usage, see Appendix G.

6.0 Ozonesonde Data Acquisition Software

Ozonesonde data acquisition software and source code are provided by DMT for processing the Model 2ZV7 ECC sonde data. The software is based on data processing instructions [Komhyr, 1986] that have been used by many research institutions since the mid-1980s.

Benefits of the system are the elimination of errors, improved accuracy and resolution, and enhanced data visualization.

6.1 Configuration

The configuration information for the software is stored in the *o3.ini* file located in the Windows directory. The operator can set almost all of the parameters from within the program. There are, however, a few settings that must be changed by directly editing the *o3.ini* file. Editing the file is done using a text editor such as Notepad, which is included with Windows. In the configuration file, each section starts with a section name enclosed in square brackets.

Under a section there are entries set to some value. The section name and entry are not case sensitive. Any text appearing after a semicolon is considered a comment and is ignored. A complete *o3.ini* file is listed in Appendix C.

The entries below are not editable in the program itself, and must be changed by editing the *o3.ini* file:

```
[acq]
files='"C:\Program Files\o3\data\bldr_'yyyymmdd"
reqSFC=5
launchDetPr=3.0
launchDetHgt=10.0
burstDet=10
```

The “files” entry is used to define what the default data filename format will be. In the example listed above, the “yyyymmdd” will be replaced with the current year month and day automatically. The operator can over-ride this default filename at flight time.

The “reqSFC” entry is used to determine the required length of time, in minutes, that the operator must stay in the Surface Mode of data collection before moving on to Flight Mode.

Setting “reqSFC=0” will allow the operator to move to Flight Mode as soon as possible, but it will not allow the operator to switch to Flight Mode immediately. A minimum of at least 15 values of pressure, temperature, and humidity (PTU) data must be collected in Surface Mode, which will be used to calculate surface data, before allowing the operator to switching to Flight Mode.

If the radiosonde is equipped with a pressure sensor then the “launchDetPr” is used to detect when the balloon is launched. If the radiosonde does not have a pressure sensor then the GPS height data and “launchDetHgt” will be used to detect when the balloon is launched.

The “burstDet” entry is used to detect when the balloon has popped and is descending.

This value is used to eliminate false descent detection.

6.2 Set-up for a New Flight

Making an ozone flight requires thorough preparation of the ozonesonde before flight time. The radiosonde does not require any preparation before flight unless you know that you want to modify the radiosonde from its default configuration.

Remember if using the radiosonde equipped with a GPS that the radiosonde requires a clear view of the sky with no obstructions to acquire an accurate position. The time required for the GPS to lock on to its current position is directly related to its view of the sky. Obstructions will limit the number of satellites the GPS can receive data from, and will therefore require more time. It is important to have the GPS position acquired before launching the balloon. Usually the GPS should acquire its position while the package is placed outside to acquire surface data. However, there are times when solar activity will prevent the GPS from receiving signals from satellites. Solar activity data can be obtained from the National Weather Service Space Weather Prediction Center at http://www.swpc.noaa.gov.

Start the ozonesonde data acquisition program by clicking on the desktop icon. After briefly showing the program logo, the main window will open which will look like the image shown in Figure 26.

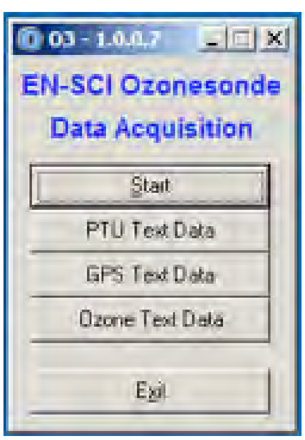


Figure 26: Software Main Window

When you are ready to start a new flight, press the “Start” button. The other three “Text Data” buttons are used to display the appropriate data streams in simple ASCII text. Note that no data will be displayed in these windows until the software enters acquisition mode.

Once the “Start” button is pressed the main window will close, and in its place will be displayed a configuration window as shown in Figure 27 below. The configuration window contains four tabs; Station, Radiosonde, Ozonesonde, and Acquisition. You should check the settings in each of the four tabs before pressing the “Ok” button.

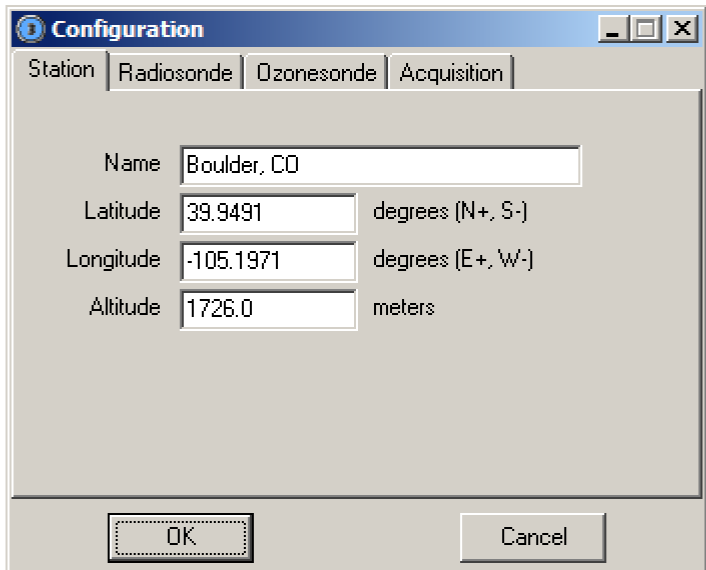


Figure 27: Station Configuration Tab

The “Station” tab contains information about where you will be launching the balloon from. Once the station information is set it is rarely changed.

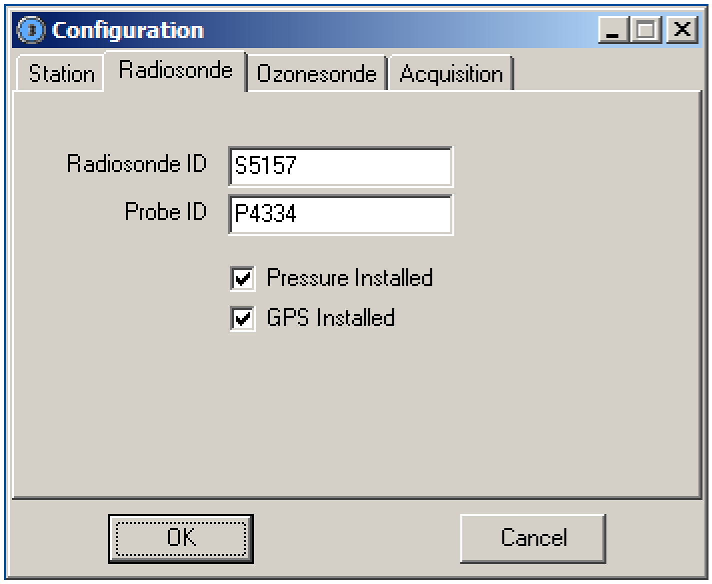


Figure 28: Radiosonde Configuration Tab

The "Radiosonde" tab contains information about the radiosonde configuration. Many times the "Probe ID" is not visible and cannot be read without disassembling the radiosonde. In this case you may simply leave it blank, as it is for information purposes only. The software program is written such that the radiosonde must at least have a pressure sensor or a GPS installed. It may have both sensors, but it must have at least one. Check the appropriate box depending on the radiosonde configuration.

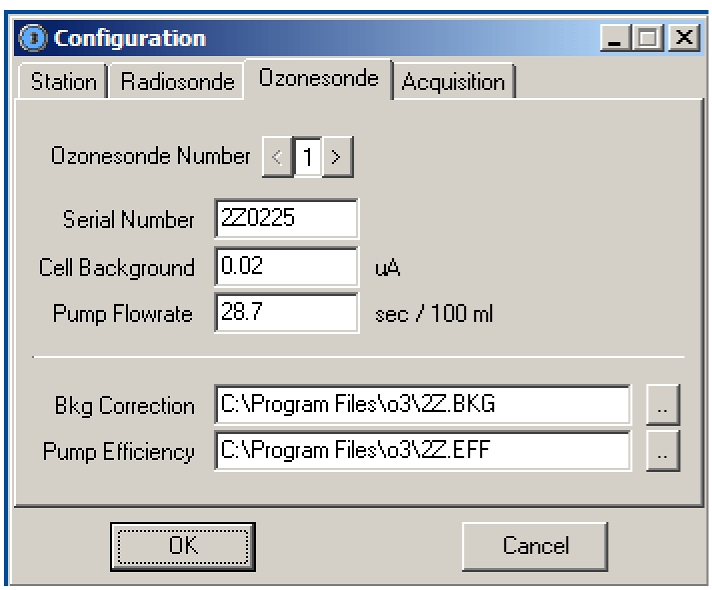


Figure 29: Ozonesonde Configuration Tab

The “Ozonesonde” tab contains information for up to 4 ozonesondes. Use the “<” and “>” buttons to navigate through the ozonesonde configuration data. The same Bkg Correction and Pump Efficiency files are used when processing ozone data from all ozonesondes. The Bkg Correction and Pump Efficiency files are text files that can be edited with a text editor such as notepad. Changing this data should be a very rare event.

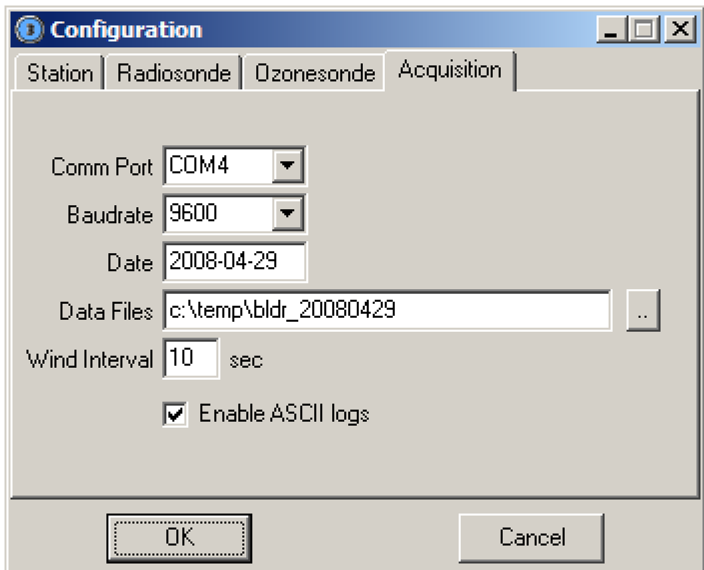


Figure 30: Acquisition Configuration Tab

The “Acquisition” tab is where the serial port for the data stream from the modem is selected along with the baud rate or speed. Both of these settings will depend on your hardware and software configuration. The baud rate should be set to 1200 when using the USB modem. The date field is automatically set based on the PC’s clock. The base data filename is automatically generated based on the setting in the *o3.ini* file. The different files generated by the ozonesonde data acquisition program will all have this name, and the extension will be used to identify the different files. The Wind Interval is used to determine how often wind data is calculated. Too short of an interval will lead to noisier data. Wind data is displayed in real-time based on this interval. If you wish to see the ASCII log files of the incoming data then you should check the box enabling the logs.

6.3 Data Acquisition

There are two phases of data collection, Surface and Flight. The Surface phase collects surface data and will require that the flight package be placed outside in a representative location. The data collected during this phase should be compared with other surface instruments, if available, to confirm proper operation before the instrument is flown. The user should never launch any instrument unless he or she is satisfied with its performance on the ground. The data from a malfunctioning instrument will seldom improve during a flight. The last phase of data collection is the flight itself.

The software will not terminate the flight when the balloon bursts, thus allowing the user to collect ascent and descent data. The data plot colors will change when the software detects that the balloon has popped to facilitate easier viewing of ascent and descent data. The user should terminate the flight manually when enough data has been collected.

6.3.1 Data Collection: Surface Phase

The first phase of data collection records surface data. The ozonesonde should be prepared for flight using the actual batteries that will be used in flight. The user should also verify that the radiosonde frequency is clear and make any frequency adjustments at this time to prevent interference.

The instrument package should be placed in an appropriate location for measuring surface data and receiving GPS satellites if installed. The ozonesonde pump temperature should be monitored to prevent overheating in warm climates or cooling too much in cold climates. This may involve placing the instrument package in a shaded location and/or removing the ozonesonde cover. If removed, the ozonesonde cover must be reattached prior to launching the instrument.

The Surface window should look similar to Figure 31. The Surface window determines which plots the software will generate. If you check the "Pressure" checkbox, for instance, the software will create a plot showing surface pressure data. Figure 32 is an example pressure surface plot.

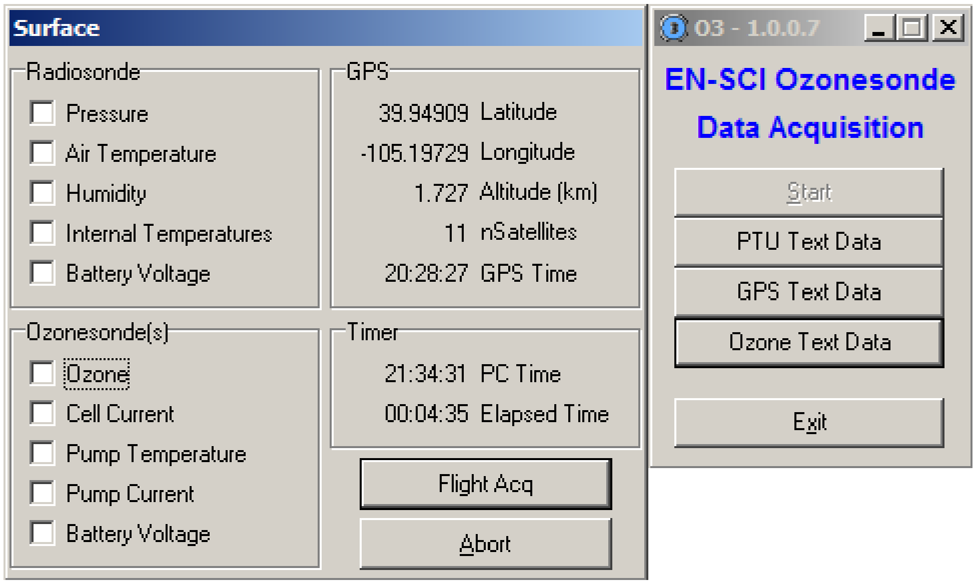


Figure 31: Software Surface Window

For good GPS data, you should have reception from at least 4 satellites (nSatellites). The more satellites that the GPS can receive the better the location information will be. The time reported by the GPS will also be indicated. GPS time is not UTC time. The GPS specification made no prevision for leap seconds. Currently, GPS time leads UTC time by 14 seconds.

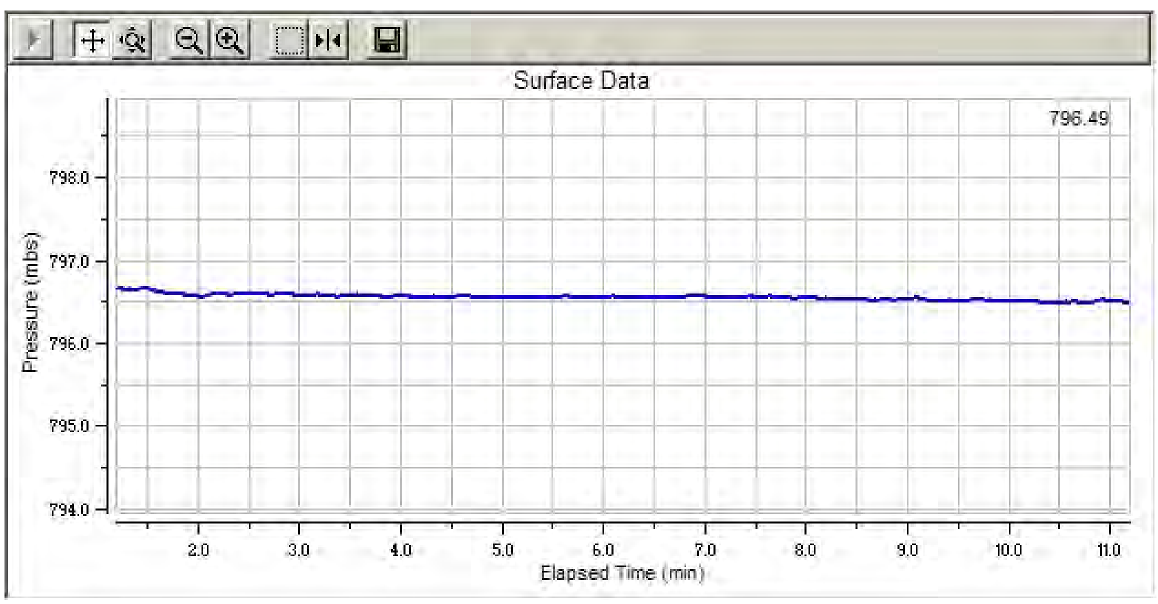


Figure 32: Surface Pressure Plot

The toolbar located at the top of the window shown in Figure 11 perform the following functions (from left to right):

- *Resume:* Continue plot monitoring to keep the trace(s) in the plot window. Axis Pan - Move the selected axis.
- *Axis Scale:* Expand or shrink the selected axis scale.
- *Zoom Out:* Expand both X and Y axis scales by a factor of 2. Zoom In - Shrink both X and Y axis by a factor of 2.
- *Zoom Box:* Zoom in on the selected area.
- *Cursor:* Activate the cursor to display data values. Save - Save the current plot as an image.

The “Flight Acq” button will be disabled until sufficient time has elapsed. The time required is set by the “reqSFC” parameter in the o3.ini file (see section 4.1 above). Once the required amount of time has elapsed, the “Flight” button will be enabled. At that point you may continue on to the flight acquisition phase of data collection. At any time you may press the “Abort” button which will stop data collection and revert back to the very beginning as if the software program had just been started.

When you are satisfied with the surface data collected, but before launching the balloon, press the “Flight” button to advance to flight acquisition. Before the flight acquisition windows are opened, you will first be prompted for surface PTU data as measured by a standard set of instruments. The surface data window will appear as shown in Figure 33. This standard data can be used to confirm the accuracy of the radiosonde data. If the radiosonde is not equipped with a pressure sensor then the surface pressure and GPS data will be used to calculate pressure. In this case, the accuracy of the surface pressure is very important. If you do not have surface standards available then you may leave the values blank. If the surface pressure does not match the radiosonde pressure, you will be required to confirm that you wish to continue. You may cancel this window and return back to surface acquisition by pressing the “Cancel” button, or you may accept the values entered and continue to flight acquisition by pressing the “Accept” button.

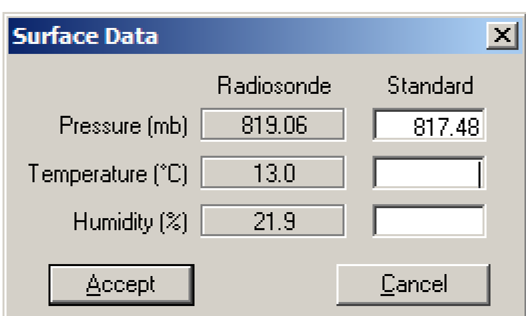


Figure 33: Standard Surface Data

6.3.2 Data Collection: Flight Phase

The final phase of data collection will record data as the instrument package is flown on the balloon. After verifying that the instruments are still operating properly, the radiosonde and ozonesonde package should be tied to the balloon per instructions provided by EN-SCI. The software will detect the balloon launch by the change in pressure transmitted from the radiosonde. If the radiosonde is not equipped with a pressure sensor then the software will use the GPS height data to determine when the balloon is launched.

The user should monitor the signal strength on the receiver and tune the receiver if necessary throughout the flight. The operator will also need to aim the antenna during the flight when using a directional antenna. The "Balloon Direction" field located in the lower right section of the Flight window (Figure 34) can be used to assist the operator in aiming the antenna if the radiosonde is equipped with GPS. Wind data will also be calculated in real-time when a GPS is installed.

The wind data is located in the lower left section of the Flight window.

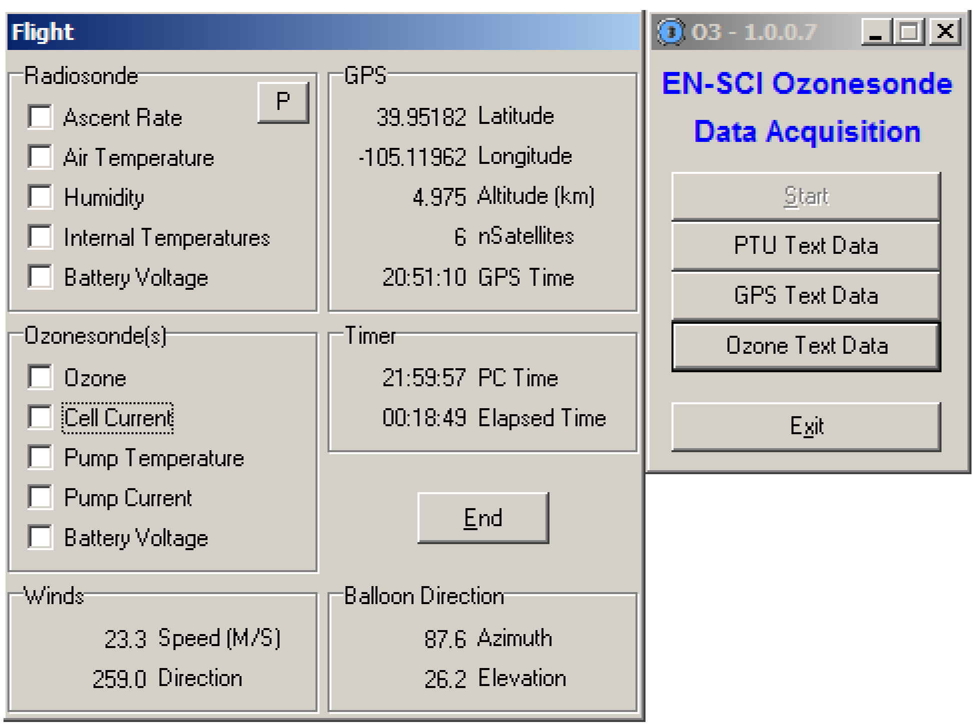


Figure 34: Software's Flight Window

The Flight window is similar in appearance to the Surface window. Balloon direction and wind data are included in the Flight window and appear at the bottom. A new button now appears in the “Radiosonde” section. The button appears as a “P” button in Figure 34. This button is used to define the vertical axis in all flight plots. When the button is pressed, the text will toggle between “P” and “H”. When the button text is “P”, all data plots will use pressure as the vertical axis. When the button text is “H”, all plots will use height as the vertical axis. The left graph in Figure 35 shows what a typical ozone plot will look like when plotted against pressure, while the right graph shows what it would look like plotted against height.

To terminate the flight you must press the “End” button. Do not press this button until you are certain that you do not want to collect any more data. There is no resume feature built in to the software when the program has terminated normally. (You can, however, reboot the system to continue collecting data; see section 6.3.3.)

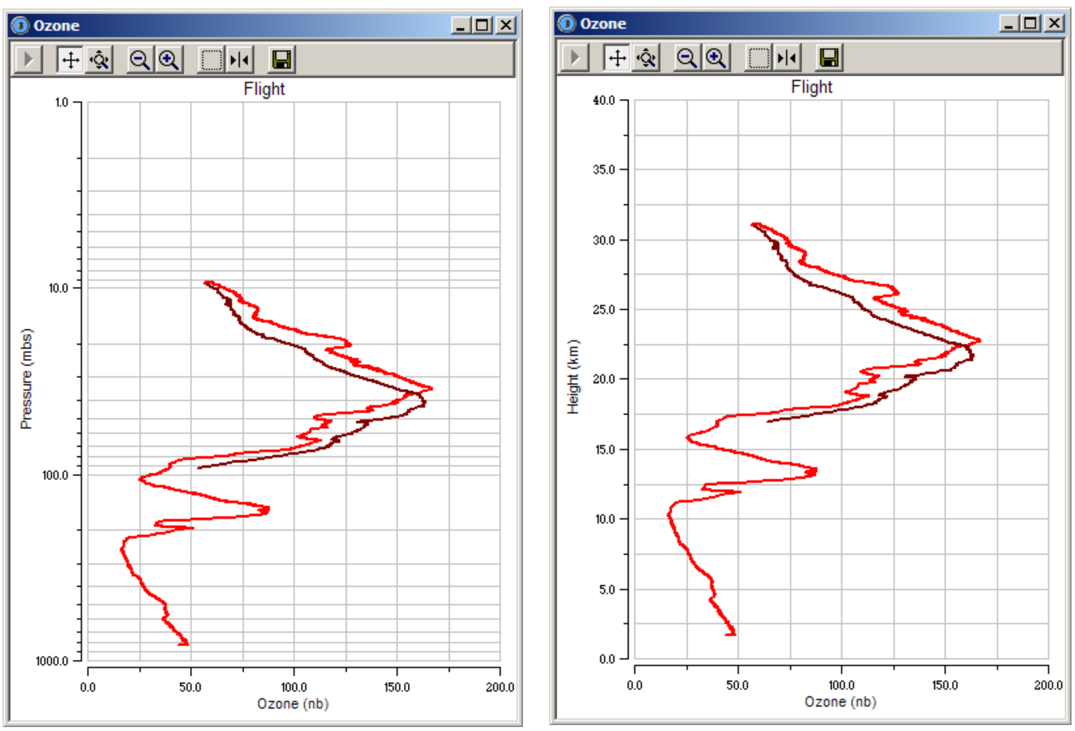


Figure 35: Ozone Levels on Ascent and Descent, Plotted against Pressure (Left) and Height(Right)

6.3.3 Resuming an Unintentionally Aborted Data Acquisition Session

In the unfortunate circumstance that data acquisition is terminated before the end of the flight due to an abnormal program close by the operating system, the user may continue data collection by restarting the ozonesonde data acquisition program. The program will detect that it did not terminate properly and prompt you as to whether you wish to continue the flight. If you select to continue the flight, the program will reload all of the previous data and then start collecting flight data again.

7.0 Data Processing Issues

7.1 Sensor Background Current

Although small (generally $\leq$0.1 μA), ECC sensor background current may be of appreciable magnitude when compared with sensor output current due to ozone in the high troposphere or above 5 hPa in the stratosphere. Various researchers have used several methods of treating the background current when processing their sonde data, none of which is completely satisfactory.

Komhyr [1969] suggested that the background current i_b, resulted largely from a residual sensitivity of the ECC sensor to oxygen. The procedure originally adopted in processing the sonde data, therefore, was to assume that the measured background current (see section 2.2(e), where $i_b = i_{b2}$) decreased with altitude (or air pressure) in proportion to the rate at which oxygen entered the sensor. Special treatment and pre-conditioning of ECC sensor platinum electrodes in recent years, however, has significantly reduced sensor background current compared to values observed in the past. The newer sensors exhibit little, if any, sensitivity to oxygen. A more appropriate treatment of the background current when processing the sonde data is, therefore, to assume that the background current measured just prior to instrument release remains constant during balloon flight. The ECC sensor current due to ozone at all altitudes then becomes $i_m - i_b$ where $i_b = i_{b2}$. This method of treating sensor background current is recommended, and is incorporated into the software used in processing the data.

In addition, it is possible that the sensor background current varies with the ozone concentration being measured. Because a standard method of applying ECC sensor background current corrections has not been universally accepted, it is important that the currents i_{b1} and i_{b2}, as well as a brief description of how these values were used in data processing, be recorded in the raw and processed data files for each sounding. With such information permanently stored, it will be possible in the future to optimize the quality of the sonde data through data reprocessing should a consensus be arrived at on how best to treat the background current.

7.2 Pump Efficiency Corrections

The efficiency of ECC ozonesonde air sampling pumps decreases with altitude. Measured ozone amounts must, therefore, be corrected for the efficiency loss. Ozone data pump correction factors recommended for use in the past have been those determined from tests made in an environmental chamber using a bag inflation technique [Komhyr, 1986]. More recently Komhyr et al. [1994] employed a pump efficiency measurement technique based on the premise that pumps working against no back pressure pump at nearly 100% efficiency at all pressures: The method yielded "Table Mountain" pump efficiency correction factors given in Table 1 below.

Pressure (hPa)	C.F.
1,000	1.000
200	1.000
150	1.002
100	1.007
70	1.013
50	1.018
30	1.029
20	1.041
15	1.048
10	1.066
7	1.087
5	1.124
3	1.240

Table 1: Table Mountain Corrections to Ozone for Pump Efficiency Decrease With Altitude

These are closely similar to those used previously for ambient air pressures down to about 7 hPa, but larger at 3-7 hPa. Use of these revised pump efficiency correction factors is recommended.

While the correction factors given in Table 1 for low pressures may be underestimates of true values, their use in data processing is intended to compensate roughly for an improvement in pumping efficiency that occurs at higher altitudes as pump head decreases due to evaporation of sensor cathode electrolyte, for the increased sensitivity of the ECC sensor to ozone that occurs as the sensor cathode electrolyte concentration increases due to evaporation, and for a slight increase in sensor background current that occurs following measurement of high ozone by the sensor in the region of the ozone maximum.

It is important to include in the raw and processed data files for each ozone sounding the pump efficiency correction factors used in processing the data. This will allow improvement of the processed sonde data in the future should more definitive pump efficiency information become available.

7.3 Pump Temperature Thermistor Characteristics

The thermistor employed for measuring Model 2ZV7 ECC ozonesonde pump temperature is Fenwal Electronics, Incorporated, Uni-Curve thermistor, P/N 192-103LET-A01. Uni-Curve thermistors are interchangeable, have a nominal resistance of 10,000 ohms at 25° C, and a temperature tolerance over the temperature range 0-70° C of ±0.2° C. For data processing, the R-T characteristics of the thermistors are incorporated into the data processing software.

7.4 Normalization of ECC Ozonesonde Data to Dobson Spectrophotometer Total Ozone

It has been the general practice to normalize ozonesonde ozone profile data to quasi-simultaneously obtained Dobson spectrophotometer total ozone. The method employed, for ozone soundings attaining a pressure altitude of at least 15 hPa, involves determining a normalization factor from the ratio of the Dobson spectrophotometer total ozone and total ozone determined from integration of the sonde profile assuming a constant ozone mixing ratio above balloon-burst height to 1 hPa pressure altitude. With Dobson spectrophotometer total ozone measured on the Vigroux [1953, 1967] ozone absorption coefficient scale during 1987-1992, numerous ECC ozone soundings yielded a mean normalization factor of close to 1.0, with a standard deviation of about 0.05. The ECC sonde's response to ozone is sensitive to the concentration of KI used in the sensor's cathode electrolyte. During development of the instrument, a 1% KI cathode electrolyte was chosen for use since it yielded approximately 1:1 stoichiometry in the conversion by the ECC sensor of ozone to iodine.

On January 1, 1993, new ozone absorption coefficients were adopted for use with Dobson spectrophotometers [Komhyr et al., 1993], based on the measurements of Bass and Paur [1985]. The new coefficients yield ozone values 2.6% lower than did the Vigroux coefficients. Because, also, pump efficiencies have improved in recent years, ECC ozonesondes employing 1% KI cathode sensing solution tend to overestimate ozone even more. Laboratory tests [W.D. Komhyr, EN-SCI Corporation, Boulder, Colorado, unpublished data, 1996] with a Thermo Environment Instruments (TEI), Inc., standard ozone source, with calibration traceable to the primary ozone standard of the U.S. National Institute for Standards and Technology (NIST), have indicated that the use of 1/2% KI cathode ozone sensing solution (see Appendix A) in ECC sensors results in improved measurements of ozone. ECC ozonesondes employing the less concentrated solution yield integrated total ozone amounts that agree closely with Dobson spectrophotometer total ozone.

A number of questions remain regarding the normalization procedure. For example, the validity of the assumption of constant ozone mixing ratio at atmospheric pressures less than 15 hPa needs re-examination. It may be more appropriate to use climatological high-altitude ozone data derived from satellite observations for normalization of the ECC sonde ozone profiles.

Appendix A: Preparation of ECC Sensor Sensing Solution

ECC sensor solution should be prepared from reagent-grade chemicals and double or triple distilled water.

(1) Cathode Solution

To 500 ml distilled water add:

5.00 g		KI
12.50 g		KBr
0.63 g		$NaH_2PO_4 \bullet H_2O$
2.50 g		$Na_2HPO_4 \bullet 12H_2O$
	or	
1.87 g		$Na_2HPO_4 \bullet 7H_2O$

Shake vigorously to dissolve the chemicals, then add distilled water to make up 1000 ml of cathode sensing solution.

(2) Anode Solution

Fill a 100-ml plastic bottle one-half full with 50 ml cathode solution (prepared as described above). Add 70 g KI crystals to the solution, and shake vigorously to dissolve the crystals. Some crystals will remain undissolved, indicating that the solution is saturated.

(3) Storage

Store the cathode and anode sensing solutions in a dark place at 20° to 25° C. After several months of storage old solution should be discarded and new solution prepared for use.

Appendix B: Model KTU-2 Ozonizer/Test Unit

The EN-SCI Corporation Model KTU-2 ozonizer/test unit has been designed for conditioning ECC ozonesondes with ozone, and for checking the performance of the sondes prior to release by balloon. A diagram of the unit is shown below. It measures 36 x 28 x 21 cm, and weighs 9 kg. Components of the unit are listed below.

(1) A HI OZONE source for conditioning the sonde pump and dry sensor with ozone;

Figure 36: Model KTU-2 Ozonizer/Test Unit

(2) A NO-LO OZONE source, for checking on the sensor background current and for conditioning ozone sensors charged with sensing solution;

(3) A 12 VDC sonde pump motor power supply and meters for checking on the motor voltage and current drain;

(4) A microammeter (0-10 μA) for measuring the sonde ECC sensor output current.

Appendix C: Reconditioning Model Z ECC Ozonesondes

Improving Pump Performance

Prolonged storage of ECC ozonesondes prior to use, or submission of the instruments to extreme temperature changes during storage, may alter the pump characteristics of the instruments. It is important that, during use, the fit between the pump piston and cylinder is not too tight to avoid excessive frictional heating. An indication of the fit of the piston-cylinder assembly is the current drawn by the pump motor, which should be less than 90 mA.

If the pump motor current is greater than 90 mA when the instrument is first operated, continue operating the pump for 10-30 minutes during which time the motor current should decrease to an acceptable level. If it does not, take the following remedial action:

Remove the pump piston from the cylinder, taking care to note how the piston is oriented relative to the cylinder in order that it may be replaced later without 180° rotation. Rub the cylindrical surface of the piston forcefully with clean, lint-free tissue paper moistened with methyl alcohol or distilled water. Re-assemble the pump, and operate it for 15-20 minutes. The pump current should decrease. The process may have to be repeated once or twice.

If the high current persists, clamp the brass portion of the cylinder in a hand-held electric drill. Using a strip of black, wet/dry No. 400 grit sand paper laid over a rigid, flat-surfaced strip of metal of size about 2x10 cm to form a sanding block, draw the sanding block in a linear motion under the piston but in contact with it as the piston is being rotated by the drill. A thin uniform film of material removed from the surface of the piston will become visible on the sand paper. Do not over-sand. Now clean the sanded piston with methyl alcohol, and re-install it into the pump. Run the pump for 10 minutes to check on the pump current, which should have decreased. Repeat the process, if necessary, to attain a pump current of less than 90 mA after 10-20 minutes of pump operation. Check for adequate pressure and vacuum developed by the pump.

Reconditioning a Recovered Ozonesonde

Customers are encouraged to recondition their own ozonesondes by following the instructions below. Technical advice and instrument components needing replacement are available from the instrument manufacturer.

Remove the ozonesonde from its polystyrene flight box, and discard the sonde batteries. Clean all the external instrument parts of sensing solution residue or grime that may be present.

Discard the air intake tube; replace it with a new tube made from Teflon spaghetti, size AWG No. 12.

Remove the sensor from the sonde, and thoroughly wash the cathode and anode chambers under running tap water. Rinse with distilled water, then fill the anode chamber one-half full and the cathode chamber full with distilled water. Let stand for several hours. After several hours or more, rinse the sensor chambers several times with distilled water, and clean the sensor cathode and anode top plugs and tubing with distilled water and finally methanol. Let the sensor remain unassembled for several hours to dry before re-assembling it for use.

Disassemble the Teflon gas sampling pump, taking care to note the orientation of the piston relative to the cylinder for future similar re-assembly. Using a razor blade and a pointed knife, gently scrape any impurities from the pump base piece, cylinder, and piston that may be present. Wash all Teflon parts first with tap water, then with distilled water, and finally with methanol. After re-assembling the pump into its original configuration, activate the pump motor and squirt 1-2 cm^3 of methanol into the operating pump for final cleaning.

Using a stroboscope, check the pump motor speed. It should be nearly constant and approximately 2400 r.p.m. over the voltage range of 10-15 volts. Check, also, to ensure that the sonde pump develops sufficient pressure and vacuum (see section 2.1(b)) when operating at 12.3 VDC and drawing less than 100 mA current.

Appendix D: Measurement of Ozonesonde Air Flow Rate

Required Equipment

- Burette with filling tube, 100-ml capacity
- Rubber bulb, 60-ml capacity
- Stopwatch
- Burette stand with clamp
- Tygon tubing, approximately 60 cm long, 0.32 cm internal diameter
- Teflon tubing, thin wall, approximately 2.54 cm long, AWG No. 10
- Soap bubble solution, made by adding 1 teaspoon of liquid detergent and 1 teaspoon of glycerol to 1 cup of water

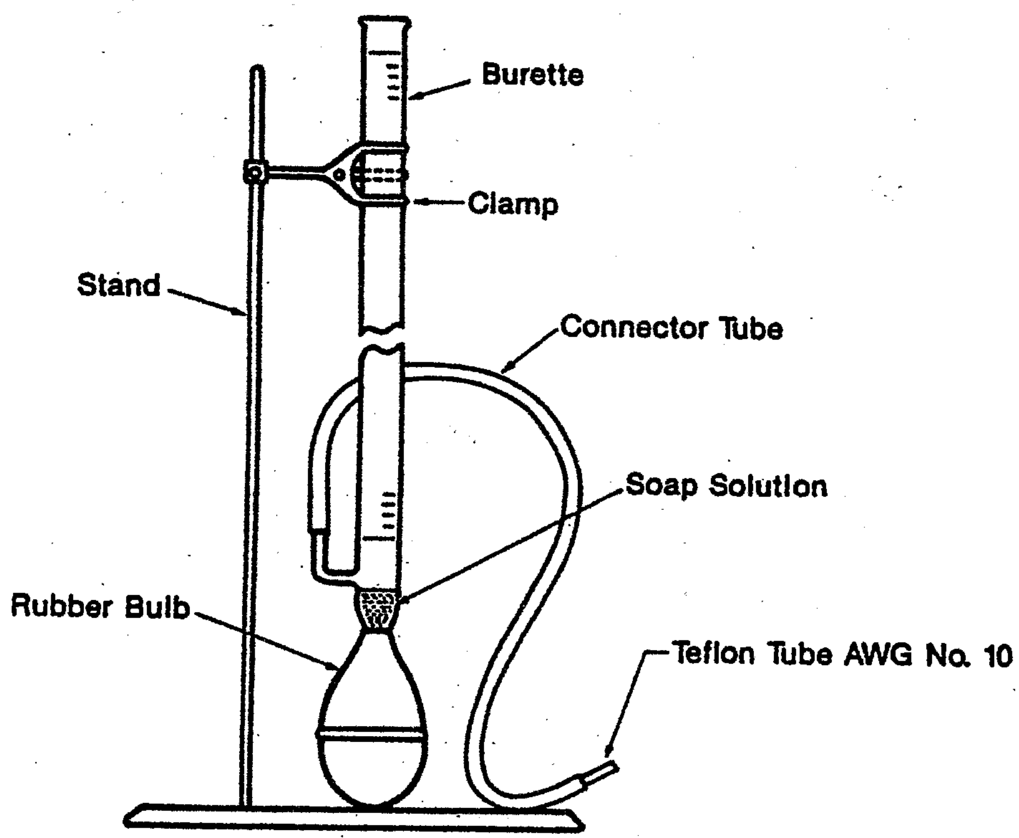


Figure 37: Apparatus for Measuring ECC Ozonesonde Pump Air Flow Rate

Procedure

Arrange the apparatus as shown in the diagram on the previous page. Fill the rubber bulb and burette with soap bubble solution to just below the filling tube of the burette as shown. (Maintain the soap solution at about the level indicated at all times by periodically adding distilled water or more soap solution to the apparatus.)

The sonde pump air flow rate measurement is made with the ECC sensor charged with sensing solution. To make the measurement, connect the apparatus to the sensor cathode air-exhaust tube. This is done by slipping the Teflon-tipped connector tube of the apparatus over the short Teflon tube protruding from the top plug of the sensor cathode chamber.

With the sonde air pump operating, squeeze the rubber bulb slightly to cause several soap bubbles to rise up the burette. Repeat the process several times until bubbles reach the top of the burette without breaking.

Now cause one bubble to form, and using a stop watch determine the time t required to displace the bubble 100 ml. Repeat the measurement several times to obtain a mean value. Record the result in the raw data file for the instrument and ozone sounding to be made.

Note: Ambient air that is not already saturated with moisture will pick up moisture from the cathode-sensing solution. Thus a more precise air flow rate measurement can be made by using air pre-saturated with moisture for measurement.

Appendix E: Flight Box Configuration

The ozonesonde environmental box and the iMet-1 radiosonde should be assembled together for balloon flight as shown in the diagram below.

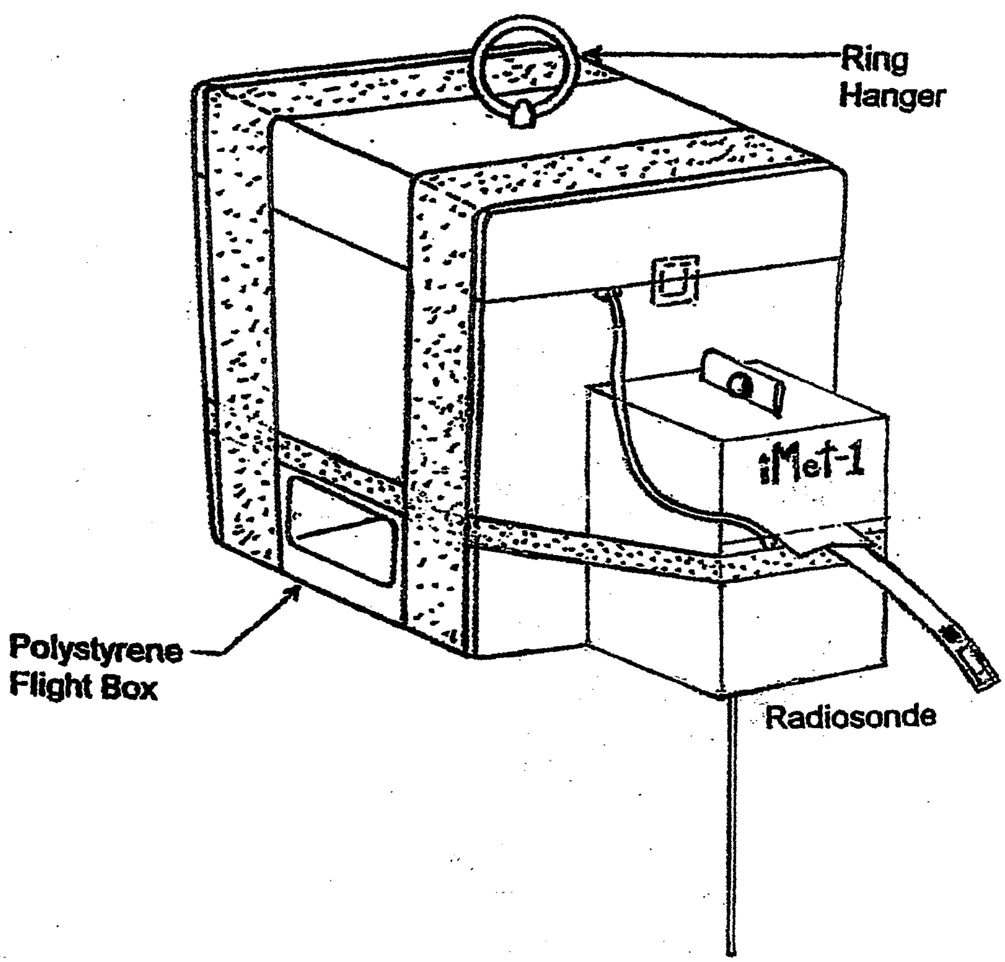


Figure 38: Ozone Instrument Flight Package

Fasten the radiosonde instrument to the polystyrene flight box using double-sided sticky tape in the position shown above. Reinforce the connection between the two instrument boxes with a 1” (2.52cm) wide duct tape, as shown above. (This method of connecting the two instruments for flight permits access to the radiosonde battery compartment for, e.g., battery activation and for radiosonde carrier frequency selection (402, 403, 404, or 405 MHz) during instrument check-out prior to flight). Fasten the ozonesonde box cover, also as shown above, to the polystyrene flight box using 2-inch (5.08 cm) wide duct tape. Allow for about a 10-inch (25.4 cm) overlap in each tape band to ensure secure fastening even at extremely cold stratospheric temperatures.

The flight box is supplied with a ring hanger. The ring hanger is located at the vertical center of gravity of the flight box in order to maintain the flight package approximately level during balloon ascent.

To prevent excessive cooling, lithium batteries used to power the ozone instrument should be flown inside the ozone instrument compartment of the polystyrene flight box, and not in the battery compartment near the bottom of the box that is reserved for locating water-activated batteries. Using the double sided sticky tape taped to the bottom of the battery, stick the battery to the base plate of the ozonesonde, adjacent to the ECC sensor and below the sonde pump.

Sonde box internal temperature at flight termination (balloon-burst altitude) should ideally be between 10 and 5 °C, though satisfactory instrument performance will continue to temperatures as low as -1 to -2 ºC. (Sonde pump temperatures are about 5 °C higher than sonde box temperatures.) If a sonde is to be flown when stratospheric temperatures are unusually cold, as within the polar vortex during winter, make certain that the initial box temperature at launch, including battery temperature, is between 25 and 30 ºC. Also, if using a lithium battery to power the sonde, fill the battery compartment of the flight box with insulation, and tape the opening closed. This will retard battery heat loss and help maintain sonde box temperature above freezing. To conserve even more heat, also tape up the box ventilation port located on the side of the box opposite to the side to which the radiosonde is taped. (Under conditions of extremely cold temperatures, it may be necessary to install an additional heat source into the flight box.)

In very warm weather, the ventilation port should be left open to prevent excessive heat build-up within the sonde. If more ventilation is needed, a second hole may be punched through the sonde box wall (and reinforced, e.g., with a 0.25" D (0.64-cm D) plastic "straw"). The hole should be located on the side of the box to which the radiosonde is taped, next to the radiosonde and about 3.25" (~27 cm) above the bottom of the box.

If using a water-activated battery, locate the battery in the flight box battery compartment. Because the battery dissipates considerable heat during operation, it should generally be flown within the battery compartment taped only partially closed. Water activation of the battery , according to manufacturer's instructions, should begin about 15 minutes prior to the time of intended use of the battery. During this time the battery should be placed under load (use a 100 ohm, 2 watt resistor) in order to facilitate battery power build-up.

Appendix F: Theory of Operation

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. Thus, an external battery is not needed to drive the cell.

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

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

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).

The Innovative System Designs' V7 interface electronics, which couple the ozone sensor to the 403 MHz InterMet GPS radiosonde, permit use of inexpensive ground equipment for ozone (and meteorological) signal data receiving and processing. Data from the ozonesonde are measured by the V7 interface, which then formats the data into an asynchronous text message that is sent to the radiosonde at 9600 baud. Multiple ozonesondes may be daisy-chained together when using the V7 interfaces. The radiosonde compresses the received ozonesonde data and transmits it to the ground receiving station. The output from the receiver on the ground is demodulated by a 1200 baud modem and sent to a computer through a serial USB port for real-time data processing. Data are sent from the V7 interface to the radiosonde at 1-second intervals.

The V7 interface includes 8 channels of analog input (0 – 5.0 VDC) with 10-bit resolution. Over-sampling provides an effective resolution of 14-bits by measuring each channel over 500 times per second. Four of the eight available channels are used to measure the ozonesonde data, leaving four channels available for future use. The analog to digital converter (ADC) uses a very accurate and stable reference voltage so that no adjustments or calibrations are required to achieve an accuracy of +/-0.1% throughout the flight. The ECC cell current-to-voltage conversion is performed by an auto-zeroing amplifier for ultra-low offsets. Full scale current is fixed at 10.0 uA, which translates to a resolution of 0.0006 uA/bit.

Appendix G: Binary Radiosonde Packet Definition

PTU data packet

offset	bytes	Description
0	1	SOH = 0x01
1	1	PKT_ID = 0x01
2	2	PKT = packet number

offset	bytes	Description
4	3	P, mbs (P = n/100)
7	2	T, °C (T = n/100)
9	2	U, % (U = n/100)
11	1	Vbat, V (V = n/10)
12	2	CRC (16-bit)

packet size = 14 bytes
transmission time at 1200 baud = 117 mSec

PTU (enhanced) Data Packet

offset	bytes	Description
0	1	SOH = 0x01
1	1	PKT_ID = 0x04
2	2	PKT = packet number
4	3	P, mbs (P = n/100)
7	2	T, °C (T = n/100)
9	2	U, % (U = n/100)
11	1	Vbat, V (V = n/10)
12	2	Tint, °C (Tint = n/100)
14	2	Tpr, °C (Tpr = n/100)
16	2	Tu, °C (Tu = n/100)
18	2	CRC (16-bit)

packet size = 20 bytes
transmission time at 1200 baud = 167 mSec

GPS Data Packet

offset	bytes	description
0	1	SOH = 0x01
1	1	PKT_ID = 0x02
2	4	Latitude, +/- deg (float)
6	4	Longitude, +/- deg (float)
10	2	Altitude, meters (Alt = n-5000)
12	1	nSat (0 - 12)
13	3	Time (hr,min,sec)
16	2	CRC (16-bit)

packet size = 18 bytes

transmission time at 1200 baud = 150 mSec

GPS (enhanced) Data Packet

offset	bytes	description
0	1	SOH = 0x01
1	1	PKT_ID = 0x05
2	4	Latitude, +/- deg (float)
6	4	Longitude, +/- deg (float)
10	2	Altitude, meters (Alt = n-5000)
12	1	nSat (0 - 12)
13	4	East-West velocity, m/s (float)
17	4	North-South velocity, m/s (float)
21	4	Up-Down velocity, m/s (float
25	3	Time (hr,min,sec)
28	2	CRC (16-bit)

packet size = 30 bytes
transmission time at 1200 baud = 250 mSec

Extra Data Packet

offset	bytes	description
0*	1	SOH = 0x01
1*	1	PKT_ID = 0x03
2*	1	N = number of data bytes to follow
...	...	Data (50 bytes max)
3 + N*	2	CRC (16-bit)

* = automatically generated by radiosonde
packet size = N+5 bytes (55 bytes max)

Ozonesonde Data (Using Extra Data Packet)

offset	bytes	description
0*	1	SOH = 0x01
1*	1	PKT_ID = 0x03
2*	1	N = 8

offset	bytes	description
3	1	Instrument_type = 0x01
4	1	Instrument_number (1-255)
5	2	Icell, uA (I = n/1000)
7	2	Tpump, °C (T = n/100)
8	1	Ipump , mA (255 mA max)
10	1	Vbat, V (V = n/10, 25.5 V max)
11*	2	CRC (16-bit)

* = automatically generated by radiosonde
packet size = 12 bytes

transmission time at 300 baud = 400 mSec, 1200 baud = 100 mSec

Appendix H: Radiosonde Commands

When equipped with an external cable, the iMet radiosonde can transmit data to the ground system from a large assortment of sensors. Some of the radiosonde settings can also be programmed through this cable. Communications with the iMet radiosonde are at 9600 baud, no parity, 8 data bits, and 1 stop bit (9600,n,8,1). It is important to note that the signals are at 3.3V levels and connect directly to the microprocessor. A small USB adapter is available from EN- SCI which is designed to allow a computer to communicate directly with the radiosonde through the external cable. With a null-modem style cable, this USB adapter can also be used to communicate with the V7 board located in the 2Z ozonesonde.

The following commands are recognized by the iMet radiosonde, they are not case sensitive. All commands are terminated by a carriage return (Enter) and will generate a response from the radiosonde.

i.e.,
SID – The *SID* (sonde ID) command will get or set the radiosonde id. The maximum length of the *SID* data is 12 characters. The *SID* is the main number used to identify the radiosonde and is located on the Styrofoam box cover as well as the power switch. (i.e., “sid=S1234”)

PID – The *PID* (probe ID) command will get or set the probe ID (i.e., “pid=P1234”). The maximum length of the *PID* data is 12 characters. The *PID* is located on the sensor arm near the end that connects to the main board of the radiosonde. The number may not be visible unless the Styrofoam box is disassembled.

TXRF – The *TXRF* (RF transmitter) command is used to turn the transmitter power amplifier on or off. If the transmitter is turned off then data cannot be received at the ground system. (i.e., "txrf=on" or "txrf=off")

DATA – The *DATA* command is used to turn on or off the serial data streams for pressure, temperature, and humidity (PTU), position (GPS), and status (STAT). Once a data steam is turned on, the data will be sent from the radiosonde at a 1-second interval over the external cable (9600,n,8,1). (i.e., "data=on" or "data=off")

PTU – The *PTU* command is used to turn on or off the serial data stream for pressure, temperature, and humidity (PTU). Once a data steam is turned on, the data will be sent from the radiosonde at a 1-second interval over the external cable (9600,n,8,1). (i.e., "ptu=on" or "ptu=off") The PTU data is sent in the following format:

PTU: pressure(mbs), air_temperature(˚C), humidity(%)

STAT – The *STAT* command is used to turn on or off the serial data stream for radiosonde status information. Once a data steam is turned on, the data will be sent from the radiosonde at a 1-second interval over the external cable (9600,n,8,1). (i.e., "stat=on" or "stat=off")

The status information is sent in the following format: STAT: battery_voltage(V), T_internal(˚C)

GPS – The *GPS* command is used to turn on or off the serial data stream for radiosonde position information. Once a data steam is turned on, the data will be sent from the radiosonde at a 1-second interval over the external cable (9600,n,8,1). (i.e., "gps=on" or "gps=off")

The position information is sent in the following format:

GPS: latitude(deg), longitude(deg), altitude(M), number_of_sats, hh:mm:ss

Note – The time included in this message is the GPS time, not UTC time. GPS time does not account for leap-seconds. GPS time is currently 14 seconds ahead of UTC time.

HSP – The *HSP* (heater set-point) command is used to get or set the minimum temperature inside the radiosonde. When the internal temperature drops below the heater set-point, internal heaters will be activated. The heaters consume power from the radiosonde battery pack and will shorten battery life if the temperature is set too high. (i.e., "hsp=-10")

LEDS – The *LEDS* command is used to enable or disable the light emitting diodes (LEDs). The LEDs are used to indicate proper radiosonde operation. The LEDs do not consume a large amount of power, but may be turned off to maximize battery life. (i.e., “leds=on" or "leds=off")

PTURR – The *PTURR* (PTU report rate) command is used to get or set the pressure, temperature, and humidity (PTU) report rate (in seconds). This controls the interval between successive PTU packets transmitted by the radiosonde. It does not control the report rate over the external serial cable. Setting the *PTURR* to 0 (“pturr=0”) will disable PTU data transmissions. (i.e., "pturr=1")

GPSRR – The *GPSRR* (GPS report rate) command is used to get or set the GPS report rate (in seconds). This controls the interval between successive GPS packets transmitted by the radiosonde. It does not control the report rate over the external serial cable. Setting the *GPSRR* to 0 (“gpsrr=0”) will disable GPS data transmissions. (i.e., "gpsrr=1")

TXFREQ – The *TXFREQ* (transmitter frequency) command is used to get or set the transmission frequency assigned to each position of the main switch. The default frequencies are 402 MHz, 403 MHz, 404 MHz and 405 MHz, for the 403 MHz transmitter.

(i.e., "txfreq=403.5" to assign switch pos 1, "txfreq=401.0,401.5,403,403.5" to assign all switch positions)

XDATA – The *XDATA* (external data) command is used to transmit data from an external instrument, like an ozonesonde, to the ground system. Binary data are sent to the radiosonde using the external cable (9600,n,8,1) in an ASCII format. Two characters are used to represent each byte of data in a hexadecimal format. The maximum amount of data that can be sent in one message is 50 bytes (100 characters). The radiosonde uses Xon/Xoff handshaking to prevent buffer overflows, so the external device should listen for these characters to prevent corrupt data transmissions. There is no need to include a checksum byte in the data stream because the radiosonde will append the necessary bytes to the data transmission, which includes a 16- bit CRC. Refer to Appendix G for more information on the format of the external data packets as sent by the radiosonde. (i.e., "xdata=0102030405060708090A")

DMT highly recommends that any new instrument follow the example of the ozonesonde data packet and include instrument type and instrument number as the first two bytes in each data string (packet). This information will allow the ground software to distinguish the instrument type and order (if multiple instruments flown).

PTUX – The *PTUX* command is used to turn on or off the enhanced pressure, temperature, and humidity (PTU) data stream that is transmitted to the ground system (i.e., "ptux=on" or “ptux=off").

GPSX – The GPS*X* command is used to turn on or off the enhanced GPS data stream that is transmitted to the ground system (i.e., "gpsx=on" or "gpsx=off").

SAVE – The *SAVE* command is used to save the current configuration to non-volatile (NV) memory. Changes to the radiosonde settings may be made, and tested, without fear of changing the default configuration because the changes will not be committed to NV memory until the save command is executed. If changes were made to the radiosonde configuration that you do not wish to keep, simply cycle the radiosonde power and the default values will be restored. Once the *SAVE* command has been executed, the current configuration will become the default configuration used when power is applied.

Appendix I: Ozonesonde Data Acquisition Software File Formats

RAW Data File Format

The software program will save all data with a valid CRC into a *.raw* file. Listed below are a few lines from such a file. Each data packet appears on a single line that is data and time stamped for when the packet was received. The date appears in "year/month/day" format. The time appears in "hour:minute:second" format. The data that follows is the data packet, starting with the SOH character and ending with the CRC. The data are hex bytes formatted for text display.

```
2009/10/28, 23:42:29.406, 0103080101029E07664B9D0E61
2009/10/28, 23:42:30.812, 01020000000000000000088130200000007ED4
2009/10/28, 23:42:31.000, 01042902504201A30356153653072907 0C04654E
2009/10/28, 23:42:31.609, 0103080101029C07664B9D4AE2
2009/10/28, 23:42:31.812, 01020000000000000000088130200000007ED4
2009/10/28, 23:42:32.015, 01042B025D42016203E515355A072707F90395A3
2009/10/28, 23:42:32.609, 0103080101029A07664B9C9746
```

Sample o3.ini File

```
[station]
name="Boulder,  CO"
lat=39.9491
long=-105.1971
alt=1726.0
[radiosonde]
sondeID=S371
1
probeID=P318
2   P_inst=1
GPS_inst=1
[acq]
port=
1
baud=
1200
files="'C:\Program      Files\o3\data\bldr_'yyyymmdd"
alog=1
```

```
reqSFC=5
launchDetPr=3.0
launchDetHgt=10.0
burstDet=10
windInterval=10

[rec
over
y]
acti
ve=0
date
=
file
=

[ozonesonde]
bkg_corr="C:\Program                 Files\o3\2Z.BKG"
pump_eff="C:\Program Files\o3\2Z.EFF"
[ozonesonde#1]
sn=2Z0225
bkg=0.02
flow=28.7

[ozonesonde#
2] sn=
bkg
=
flo
w=

[ozonesonde#
3] sn=
bkg
=
flo
w=

[ozonesonde#
4] sn=
bkg
=
flo
w=
```

Appendix J: Correction Files

There are two correction files associated with processing the ozonesonde data: One for cell background, and the other for pump efficiency. The format of the two files is identical, but the data in the files is used differently. A correction file is a table of correction factors stored in ascending (decreasing pressure) order. A maximum of 64 entries are allowed in each file or table. Both correction tables, background fall-off and pump efficiency, use linear interpolation between data points in the table. Pump efficiency correction also uses linear extrapolation.

Background correction uses the last known value from the table. The table consists of two columns, pressure (mbs) and a correction factor. The pressure column must be in decreasing increments for the table to be used properly. Sample background fall-off and pump efficiency tables are listed below.

The background fall-off correction is used to correct the ECC cell background during flight. There are different methods for processing the background. One method, the default method, assumes the background cell current remains constant throughout the flight. Another method assumes that the background current gradually drops to zero during the flight. Either method of background reduction can be implemented in the background fall-off correction file.

Cell Background Correction Data

1200	1.0
0.1	1.0

Pump Efficiency Correction Data

Pressure (hPa)	C.F.
1,000	1.000
200	1.000
150	1.002
100	1.007
70	1.013
50	1.018
30	1.029
20	1.041

Pressure (hPa)	C.F.
15	1.048
10	1.066
7	1.087
5	1.124
3	1.240

Appendix K: References

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Appendix L: Revisions to Manual

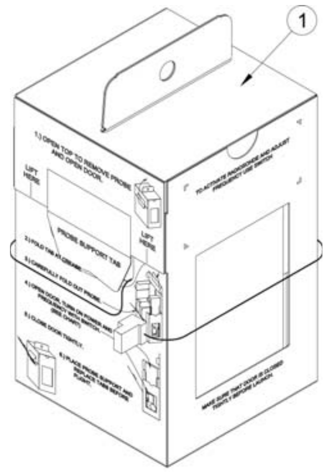
Rev. Date	Rev. No.	Summary	Section
11/18/13	B	Combined DOC-0372, the DAS and Ground Station Setup Manual, with DOC-0378 (the O3 Reference Manual) and DOC-0325 (the 2ZV7 ECC Ozonesonde Manual).	Throughout
4/8/14	B-1	Updated Figure 2 to show anode and cathode	1.0
		Identified port on receiver that modem plugs into; emphasized warning regarding modem being identified as a serial mouse	3.3
6/2/2014	B-2	Updated photo of Ozonesonde Test Unit	Appendix B
		Corrected incorrect reference to another appendix	Appendix H

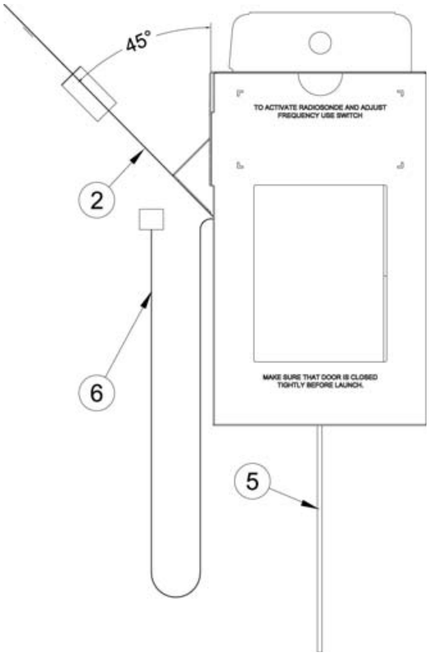
Appendix M: Preparing an iMet-1 Model RSB 403 MHz Radiosonde for Flight

These instructions can be found on the following pages.

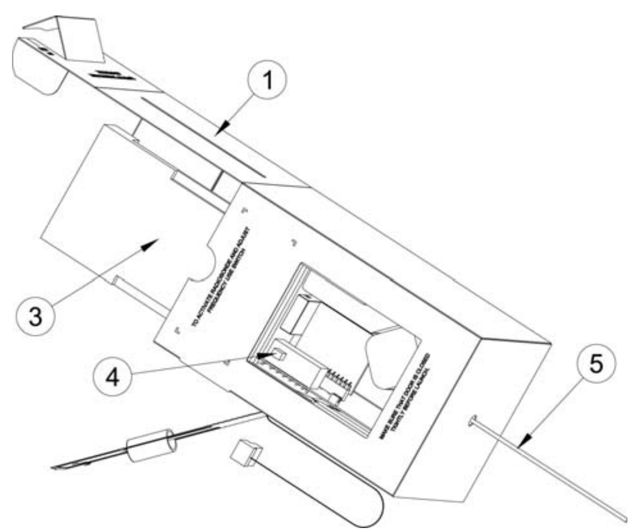
Remove sonde from shipping bag

1. Open top flap (1) and deploy the temperature/humidity probe (2).
2. Bend temperature/humidity probe (2) to approximately a 45° angle.





3. Slide back access cover (3) and connect the battery lead to the power input. Activate the sonde by setting the frequency switch (4) according to the transmit frequency information on the radiosonde sleeve. Replace the access cover and close top flap**.** ***Do not connect the external device (ozone, CFH, etc.) until this step is completed.***
4. Bend the transmit antenna (5) so that it projects straight down from the bottom of the radiosonde.



5. Using the PC workstation, initialize flight software according to instructions for the package in use (iMetOS, O3, SkySonde, STRATO).
6. Place the radiosonde in unobstructed view of GPS signal. Wait for the sonde to obtain satellite lock. GPS lock has occurred when Position and Velocity data is available at your workstation***. Do not continue until GPS lock is achieved.***
7. Verify that pressure, temperature and humidity data are available at your workstation and the values are within reasonable ranges relative to ground observations. ***If starting values are not within reasonable ranges, select another sonde.***
8. Connect AUX Data cable (6) to external device and activate device according to instructions
9. Connect radiosonde and external device to the flight train

The radiosonde is now ready for launch

Recommended Receiver Settings

Data from the iMet-1-RSB can be received using any good quality FM receiver and Bell-202 decoder. If the RSB sonde you are using is programmed for wide band transmission, set the receiver to FM Mode at 50kHz Bandwidth with AFC off.

If the RSB is programmed for narrow band transmission, set the receiver to FM at 15 kHz bandwidth with AFC on. The transmission mode should be indicated on the radiosonde sleeve. ***If you do not know which type of sonde you are using, contact InterMet before proceeding further.***

Troubleshooting Guide

Condition: Radiosonde LEDs are flashing, but no data is being received

Resolution:
1.) Check the receiver tuning. Receivers can vary and may require tuning up or down a small amount.
2.) Check cables from receiver to decoder to PC and make sure they are in good condition and connected properly.
3.) Turn off radiosonde and listen for another radiosonde transmitting at the same frequency. If found, tune your sonde to another frequency.

Condition: Radiosonde LED’s are not flashing after you have activated sonde

Condition: Radiosonde Red LED flashes quickly and no data is received

Resolution:
1.) If radiosonde is connected to an external device, turn off the radiosonde and disconnect the external device.
2.) Wait five seconds for sonde to reset
3.) Turn radiosonde back on and reacquire GPS lock

Condition: Radiosonde LED’s are flashing but humidity reports negative 50%

Condition: Radiosonde LED’s are flashing but pressure and/or air temperature aren’t changing, or are reporting "999"

Condition: Radiosonde isn’t reporting Latitude, Longitude, and/or Altitude

Resolution:
1.) Disconnect any external device and turn radiosonde off
2.) Wait five seconds for sonde to reset
3.) Turn radiosonde back on and reacquire GPS lock
4.) Check for good data. If data is OK, reconnect external device

If problems persist, select a new sonde and repeat the start-up procedure. If still not successful, contact InterMet for assistance.

Help is available Monday – Friday, 8am – 5pm ET at: (616) 285-7810. If no answer, contact: support@intermetsystems.com via e-mail.