MONITORING AND QUALITY ASSURANCE PLAN

for the

UPPER GREEN RIVER WINTER OZONE STUDY - 2011

Prepared for

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SECTION 1

INTRODUCTION AND PROJECT OVERVIEW

This monitoring and quality assurance plan provides the basis for the collection of air quality and meteorological data for the Upper Green River Winter Ozone Study (UGWOS) for the winter of 2011, sponsored by the Wyoming Department of Environmental Quality (WY DEQ). While research in nature, the monitoring methods and objectives described in this plan are consistent whenever possible with EPA quality assurance guidance for the collection of air quality and meteorological data (US EPA 2008a and 2008b) and the most recent guidance for the collection of meteorological data for regulatory modeling applications (US EPA, 2000).

Recent high ozone events observed in this area have raised concerns regarding potential adverse health and ecological effects associated with monitored concentrations greater than the U.S. Environmental Protection Agency's ozone standard (currently set at an 8-hour average concentration of 0.075 ppm[1]). Ozone formation in the Upper Green River Basin is unusual in that the highest concentrations have been recorded during the late winter and early spring (February to April) when sun angles are relatively low and temperatures are generally below freezing. This is in stark contrast to ozone exceedances in other areas, which occur during the warm summer months when abundant solar radiation and high temperatures act to increase precursor emissions and enhance the atmospheric reactions that result in ozone formation near the earth's surface (i.e., within the planetary boundary layer). Due to the pressing need to manage ozone air quality in the Upper Green River Basin and the limited amount of information currently available about the nature and causes of these unusual events, the WY DEQ funded a comprehensive field study (the Upper Green Winter Ozone Study or UGWOS) which was conducted during the late winter – early spring seasons of 2007 through 2010. While meteorological conditions unfavorable to ozone formation encountered during the 2007 study period resulted in only limited monitoring, more favorable meteorological conditions during 2008, and to a lesser degree during 2009 and 2010, resulted in several days of high ozone concentrations, including a large number of days in 2008 when the 0.075 ppm Federal ozone standard was exceeded. Additional measurements have been planned for the winter of 2011. This QA plan addresses the 2011 monitoring effort.

Data from the 2011 study will be used to refine a conceptual model of ozone formation developed on the basis of prior year's studies of ozone formation. The conceptual model will be used along with the field data to develop accurate meteorological and air quality numerical simulations of the ozone events. Both the conceptual and numerical models will in turn be used to develop effective air quality management strategies

[1] EPA is currently considering revisions to the ozone standard which would lower the level to somewhere between 0.060 and 0.070 ppm.

needed to adequately protect public health and the environment in accordance with applicable State and Federal laws.

SECTION 2

SAMPLING PROGRAM DESCRIPTION

The sampling period for UGWOS 2011 will run from January 15, 2011 through March 31, 2011. Sampling that will be conducted for UGWOS during this period is described below.

2.1 Forecasting Protocol

The UGWOS effort for 2011 will have an intensive operating period (IOP) component. As in prior years, the UGWOS team will continue to provide ozone forecasts throughout the study period to assist the WY DEQ in identifying potential high ozone periods. The current conceptual model of the meteorological conditions conducive to the formation of high ozone levels in the Pinedale-Jonah fields during the winter and early spring is characterized by mostly clear skies, light winds, extensive snow cover and a stable atmosphere. These conditions occur during periods when the synoptic weather is dominated by high pressure over the western Rockies, Intermountain area and the northern Great Basin. The primary broad scale characteristics dominating the Green River basin during the high probability events are weak pressure gradients within the context of a subsidence-dominated air mass.

In an effort to formulate the conceptual model, the synoptic scale weather patterns prior to occurrences of escalated ozone values in the study area during the winters of 2005 and 2006 were examined. Practical experience from the 2007, 2008 and 2009 studies has provided further understanding of conditions leading to higher ozone concentrations. Although many different nuances of the general pattern were encountered, the basic characteristics of the conceptual model did emerge. Figures 2-1 through 2-4 present composite views of the 700 mb and 500 mb configurations for all of the days with surface 8-hour averaged ozone concentrations greater than 60 ppb in 2004 through 2006. Figure 2-1 shows the ridging pattern of the 500 mb height contours; Figure 2-2 presents the wind speed isotachs at 500 mb; Figure 2-3 shows the ridging pattern of the 700 mb height contours; and Figure 2-4 demonstrates that there was warmer air aloft just above the surface, indicating air mass subsidence.

National Weather Service numerical synoptic-scale models such as the North American Mesoscale model (NAM) and the Global Forecast System model (GFS), coupled with regional NWS Forecast Discussion guidance, will provide the experienced MSI and T&B Systems weather forecasters with the basis for daily long and medium range operational forecasts. An additional factor that appears to prove critical in operational forecasting is the presence of sufficient snow cover to provide the strong UV radiation flux and enhanced low level stability needed for development of high ozone concentrations. Local observations will provide this information on a day-to-day basis.

A forecast will be issued by 10 MST each day that will include both a short-term (days 1 to 3) and long-term (days 4 to 7) forecast. Quality control testing of equipment will be minimized on days of anticipated higher ozone concentrations in order to optimize data recovery.

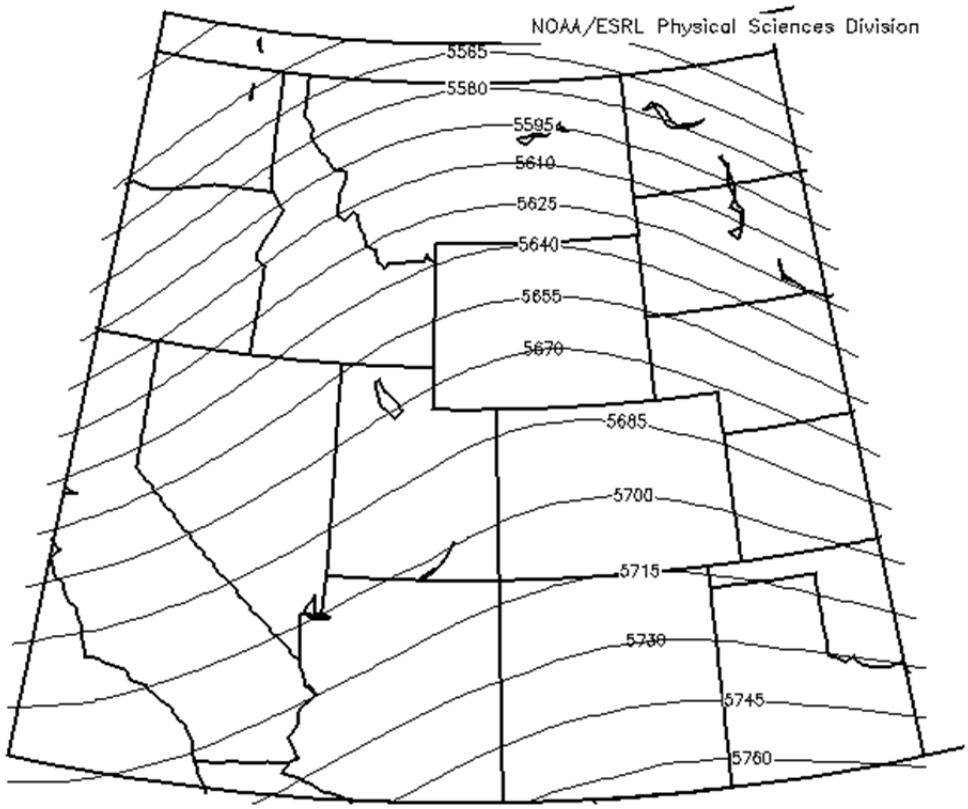

Figure 2-1 Composite 500 mb Heights During High Ozone Periods

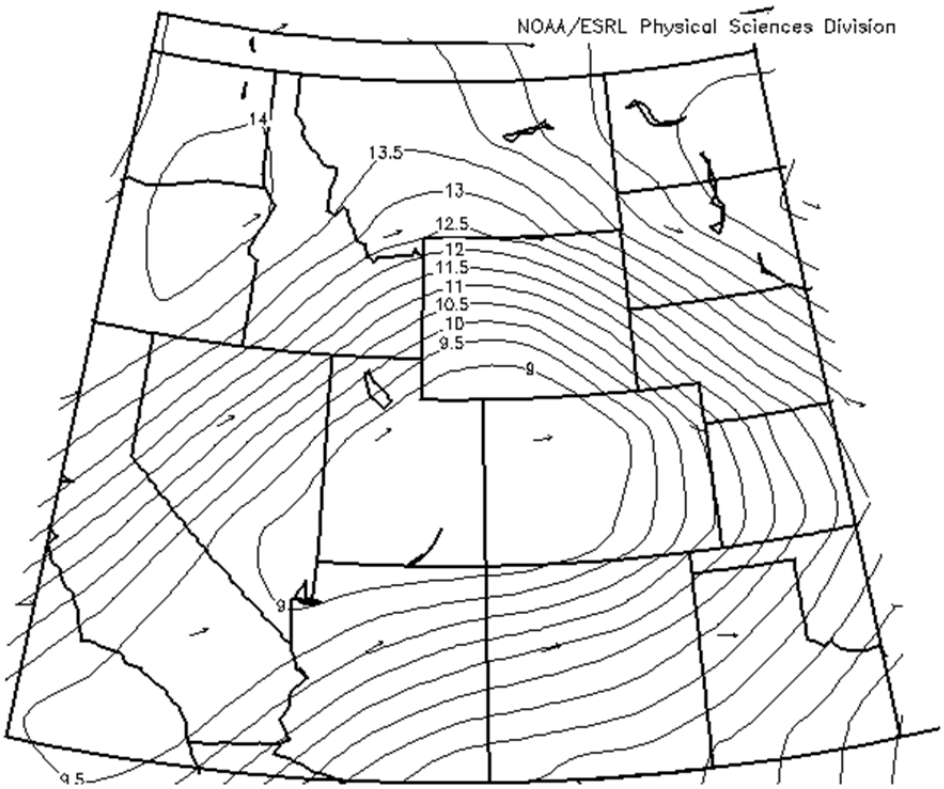

Figure 2-2 Composite 500 mb Winds During High Ozone Periods

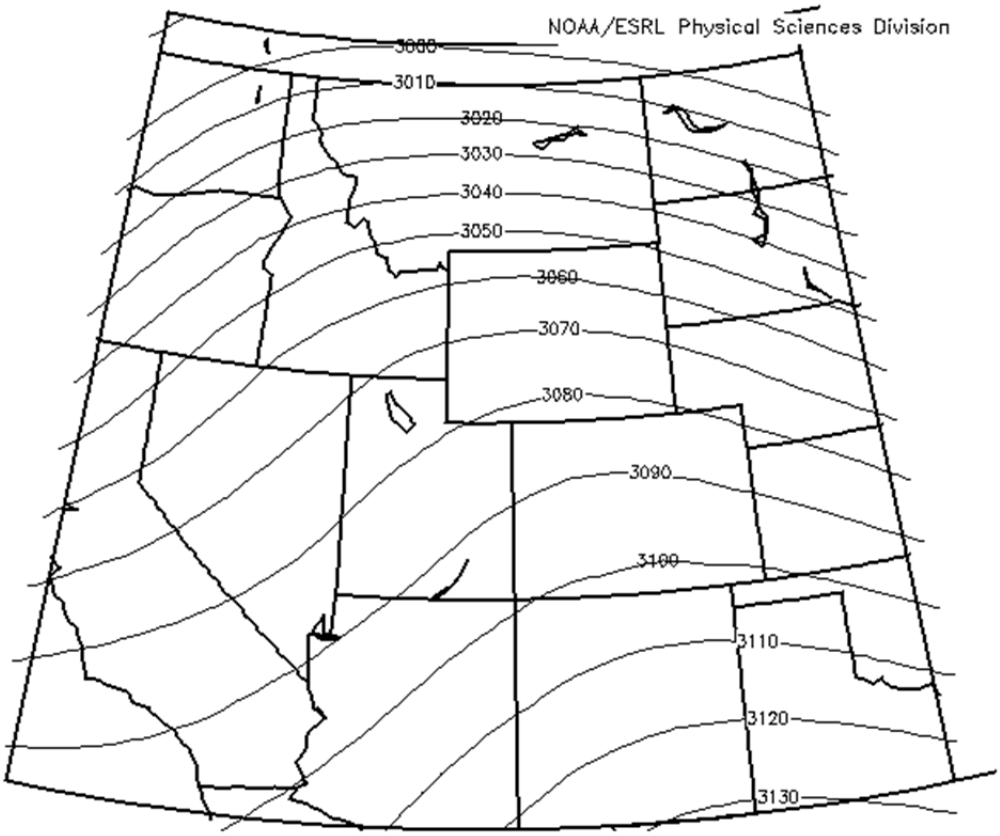

Figure 2-3 Composite 700 mb Heights During High Ozone Periods

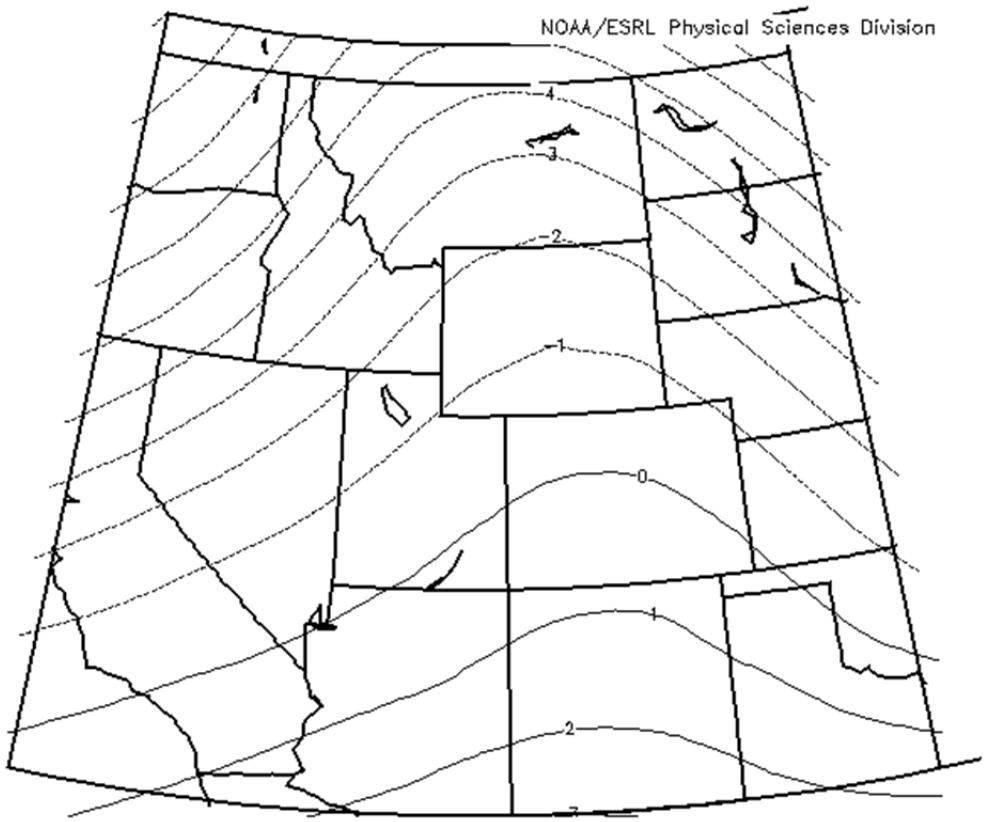

Figure 2-4 Composite 700 mb Temperature During High Ozone Periods

2.2 Continuous Measurements

Project-specific measurements to be continuously obtained over the complete field program period include surface and winds aloft, supplemental surface and above-surface air quality and meteorology, and nitrogen species.

2.2.1 Long-line Tower Measurements

Continuous measurements of ozone, NO/NOx, and methane and non-methane hydrocarbons will be made on an existing 73-meter tower using long line sampling. Long lines will be installed to four levels on the tower (73, 50, 25, and 3 meters), through which air will be continuously drawn down to the surface. The lines consist of 3/8" OD / 5/16" ID Teflon tubing. Air will be drawn down the tubing at a rate of 4 lpm, resulting in only a slight vacuum in the sample lines while maintaining a residence time of less than 20 seconds. Air from each of these levels will be directed to analyzers located at the

surface using a switching mechanism that will sequentially sample each line for 3 minutes over a 12-minute cycle. For each 3-minute sample, the first 2 minutes will be used to allow the analyzers to equilibrate to concentrations from the sampled line (in particular the hydrocarbon analyzer which must go through several cycles to obtain good data). Thus, for any given sampling level, each hour will consist of five 1-minute averages. The collection of both total hydrocarbon and methane (for calculating non-methane hydrocarbon) will be reviewed, but will depend on how the operational timing of the hydrocarbon analyzer matches the line switching described above. The sample lines will be configured to allow the drawing of canister samples, if desired.

In addition to the air quality sampling, meteorological monitoring will be conducted at each of the four levels. Wind speed, wind direction, and temperature will be monitored continuously at all levels, and relative humidity will be monitored at the 3-meter and 73-meter levels.

T&B Systems will be responsible for the air quality measurements, and MSI will be responsible for the meteorological measurements. Routine checks of the entire system will be conducted by MSI.

2.2.2 SODAR Upper Level Winds

For the 2011 monitoring effort, the WY DEQ MiniSodar (sodar) will be maintained at the existing WY DEQ monitoring site at Boulder. Both surface and aloft winds will be measured continuously. The sodar is equipped with a battery bank, solar panels and a backup generator, providing continuous measurements without the need of AC power. However, the chosen site for operations does include available AC power. Remote communications is made possible with a cellular modem. All data will be posted near real-time on a web page as well as archived data posted automatically on a FTP server. These sodar data can be reviewed remotely, as necessary.

The WY DEQ will service the sodar as necessary. T&B Systems will review the data on a daily basis, validate the wind data, and reduce mixing height data for key periods during the study.

2.2.3 HONO

The existing WY DEQ Boulder site will be expanded to included measurements of HONO. For the 2011 study, Dr. Bernhard Rappenglueck of the University of Houston will provide equipment and setup for the measurements. Routine oversight of the equipment will be conducted remotely by University of Houston personnel. MSI will be conducting regular visits to the Boulder site, including routine checks and calibrations.

2.3 Intensive Measurements

During periods when high ozone levels are forecast, additional intensive measurements will be initiated. Two three-day IOPs will be conducted, weather permitting. The key components of the intensive monitoring periods (IOPs) are:

- Tethered balloon measurements of ozone and ozone precursors

- Ozone/rawinsonde operations

2.3.1 Tethered Balloon Long-line Measurements

A tethered balloon will be used to raise long-lines to obtain continuous measurements of ozone, NO/NOx, and methane (CH4) and non-methane (NMHC) hydrocarbons at four levels during daytime hours of IOP days. The four levels will be 100 meters, 67 meters, 33 meters and 4 meters. The balloon consists of a blimp similar to those used for advertising. The balloon will be raised each morning and brought down in the late afternoon. The blimp will be secured inflated during the night between IOP days.

The monitoring methodology for the air quality parameters will be identical to that used at the tall tower, described in Section 2.2.1. In addition to sampling the air quality parameters, temperature and relative humidity will be monitored at each of the levels using small, lightweight temperature and relative humidity data loggers. The loggers will be set to record data at a 1-minute interval.

VOC samples will be collected using SUMMA canisters at the tethered balloon site during long-line sampling. A total of eight samples will be obtained during the course of the study, with the exact sample strategy determined during the study, based on real-time NMHC data. Research team technicians will be responsible for collecting the samples and filling out the affiliated documentation. Exposed sample media will be collected at the end of each intensive study period and shipped to EAS laboratory for analysis. Field sample sheets will accompany samples and the required chain-of-custody documentation will accompany each shipment.

2.3.2 Ozone/rawinsonde Operations

Concurrent to the tethered balloon free ascending balloon-borne measurements of ozone, temperature, relative humidity, and winds will be made during each IOP from the Boulder air quality monitoring site by WY DEQ personnel using equipment maintained by the WY DEQ. The sampling schedule will be determined by the WY DEQ.

A T&B Systems technician will travel out to Pinedale for 3 days of training. The training will begin with the preparation of the ozonesondes. This will use much of the first day for the testing and conditioning process. Many of the study's ozonesondes can be prepared during this time to the point where the cells can be activated for use. At least one or two of the sondes will be activated for the training flight. The second and third day will concentrate on training for launches, culminating in at least one two actual practice launches. Tips on processing and validating the collected data will be discussed.

2.4 Supplemental Monitoring and Data Collection

<u>Archiving of NOAA Products</u>

Archiving of selected NOAA data products will occur on a daily basis. The items that will be archived for the period from January 15 through March 31, 2011 are listed below:

- MSI routinely archives 00Z and 12Z surface and upper air maps for 700 mb, 500 mb and 850 mb. (Also readily available from on-line archives)

- MSI routinely archives data from all rawinsonde sites in the United States for both 00Z and 12Z time periods. (Also readily available from on-line archives)
- MSI routinely archives Visual and IR, US east and west satellite images twice per day. (Also readily available from on-line archives)

In addition to the above, the following data are currently archived on the web and available for analysis:

- Snowpack - available at NOAA's National Operational Hydrologic Remote Sensing Center
- Total Column Ozone - A web site from NASA provides historical ozone global charts, and Dobson Unit measurements for any lat/long on any particular day.
- Local Camera Images - The current local camera images from Daniel, Juel, Boulder and Pinedale can be viewed on line at the WY DEQ or UGWOS web sites, and there is also a 2 week image archive on the WY DEQ site which consists of an image at 9:00 12:00 and 15:00 MST each day. Archived images can also be requested from Air Resource Specialists, Inc. or InterMountain Labs.

SECTION 3

MONITORING SITE DESCRIPTIONS

Figure 3-1 presents a map of the UGWOS site locations. Table 3-1 presents coordinates for each of the sites. Photographs of the sites can be found in Appendix A.

Also included in Figure 3-1 and Table 3-1 are the locations of additional ozone monitoring sites, both past and present, in the study region.

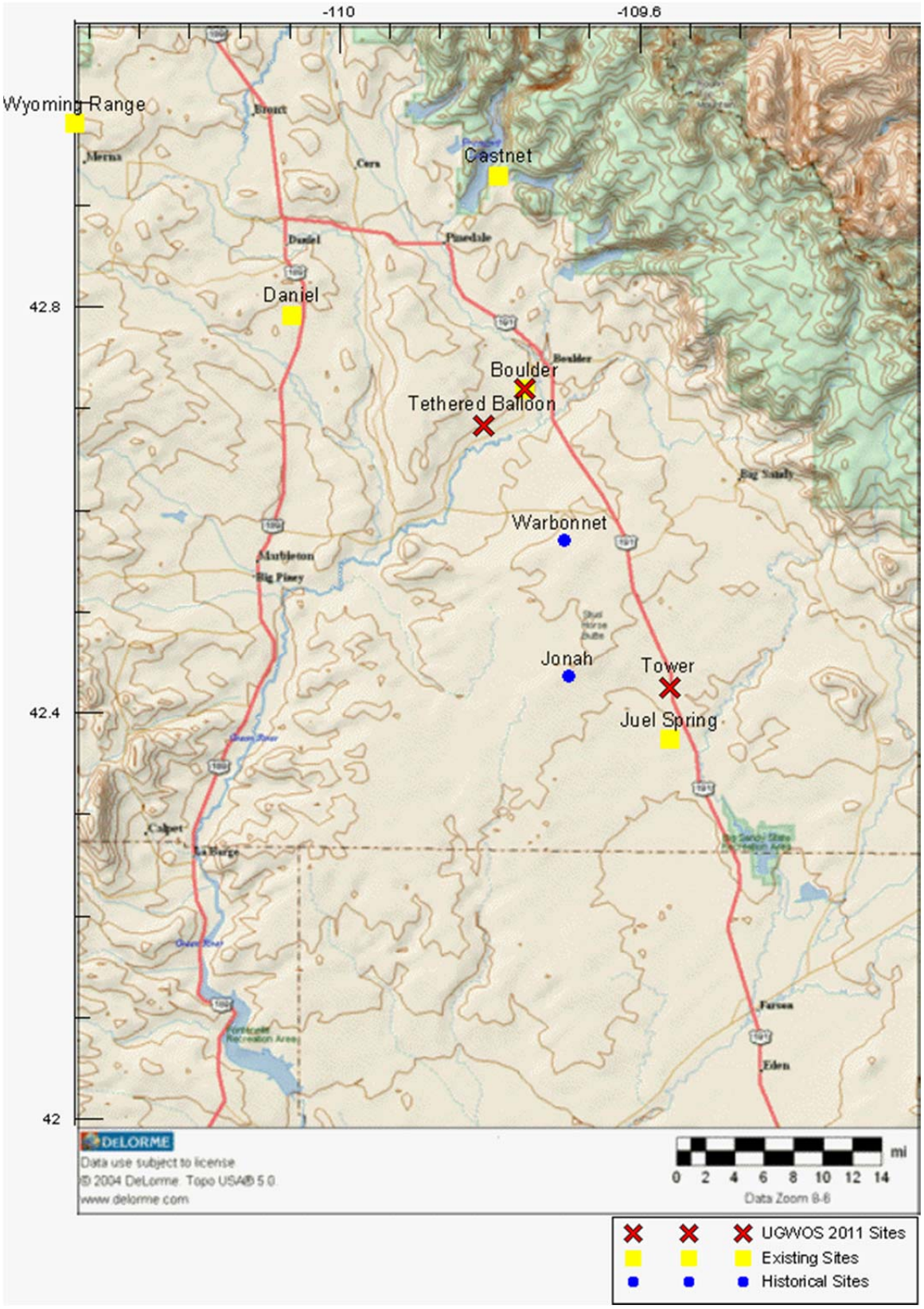
-110
-109.6
42.8
42.4
42
Wyoming Range
Castnet
Daniel
Boulder
Tethered Balloon
Warbonnet
Jonah
Tower
Juel Spring
DeLORME
Data use subject to license
© 2004 DeLorme. Topo USA® 5.0
www.delorme.com
mi
0 2 4 6 8 10 12 14
Data Zoom 8-6
UGWOS 2011 Sites
Existing Sites
Historical Sites

Figure 3-1. Map of UGWOS and Additional Ozone Monitoring Site Locations

Table 3-1. Network Locations and Identifiers

	Latitude	Longitude	Elev.
SODAR / HONO SITE			
Boulder	42.7188	-109.7529	7078’
LONG-LINE MONITORING TOWER SITE			
Tower	42.4240	-109.5609	7051’
TETHERED BALLON SITE			
M&N Yard	42.6825	-109.8090	6966’
ADDITIONAL MONITORING SITES OF INTEREST			
Pinedale (WY DEQ)	42.8698	-109.8707	7186’
Juel Spring (WY DEQ)	42.3735	-109.5605	7020’
Daniel (WY DEQ)	42.7910	-110.0650	7084’
Castnet	42.9284	-109.7880	7853’
Wyoming Range	42.9801	-110.3530	8123’

SECTION 4

MONITORING EQUIPMENT DESCRIPTION

The following section describes the monitoring equipment that will be used for UGWOS. Monitoring quality objectives (MQOs) are presented for each of the monitoring methods.

4.1 LONG-LINE MONITORING – AIR QUALITY

The equipment and sampling methodology used for the long-line monitoring are identical for both the tall tower and the tethered balloon monitoring efforts. **Figure 4-1** shows the line-switching mechanism used for both efforts.

Figure 4-1. Line-switching mechanism.

The basic flow through the mechanism is as follows:

Air is drawn into the box from each of the four sampling lines and through the rotameters, which are used for setting and monitoring the sampling flow rate at 4 lpm. Below each rotameter is normally closed solenoid, which is sequentially opened to allow the air to enter a manifold, which leads to the analyzers. The solenoids are controlled by a Campbell Scientific A6REL-12 relay drive, located on the upper half of the box door. The A6REL-12 is designed to drive up to 6 internal relays to control up to 12 external AC or DC devices. Each relay set can be controlled manually or by a datalogger control port. During routine operations, the relay drive is controlled by a programmable Campbell Scientific CR10X data logger (located on the lower half of the box door), but each solenoid can be opened or closed manually for testing or to override the CR10X sampling program. In addition to controlling the relay drive, the CR10X stores all air quality data and the station temperature data. 12-minute averages will be stored following the sample methodology discussed in Section 2.2.1. The CR10X can operate for a period in excess of four weeks before it is necessary to download data. However, the datalogger will be polled every hour and data transferred to the T&B Systems and MSI servers through the Internet.

Air quality parameters will be monitored using the following equipment:

Teledyne/API Model 200E NO/NO_2/NOx Analyzer – EPA Approval RFNA-1194-099

The Model 200E uses the chemiluminescence detection principle, coupled with state-of-the-art microprocessor technology to provide the sensitivity, stability and ease of use needed for ambient monitoring requirements. The analyzer uses multi-tasking software, which allows complete control of all functions while providing online indication of important operating parameters. Measurements are automatically compensated for temperature and pressure changes. Stability is enhanced by an Auto-Zero circuit that continuously provides a true zero reference.

Accuracy (performance checks)	±5%
Precision (performance checks)	±5%
Resolution	1 ppb
Lower Quantifiable Limit	2 ppb

Teledyne/API Model 400E Ozone Analyzer – EPA Approval EQOA-0992-087

The Model 400E UV Absorption Ozone Analyzer is a microprocessor-controlled analyzer that uses a system based on the Beer-Lambert law for measuring low ranges of ozone in ambient air. A 254 nm UV light signal is passed through the sample cell where it is absorbed in proportion to the amount of ozone present. Every three seconds, a switching valve alternates measurement between the sample stream and a sample that has been scrubbed of ozone. The result is a true, stable ozone measurement.

Accuracy (performance checks)	±5%
Precision (performance checks)	±5%
Resolution	1 ppb
Lower Quantifiable Limit	2 ppb

Baseline-Mocon Series 9000 NMHC Methane/Non-Methane Analyzer

The Series 9000 NMHC is designed to provide continuous, fully automated gas analysis of total, methane, and non-methane hydrocarbon content of gas samples over a broad range of concentrations. The analyzer is based on a flame ionization detector (FID) with FlowGuard electronic control that delivers a small portion of the sample gas to the detector flame. During the combustion process, organic or hydrocarbon-based gases in the sample are ionized and then detected by the instrument and reported as a concentration.

Accuracy (performance checks)	±5%
Precision (performance checks)	±5%
Resolution	0.1 ppm
Lower Quantifiable Limit	0.1 ppm

Teledyne/API Model 700E Calibrator

The Model 700E is a microprocessor based calibrator for precision gas analyzers. Using a combination of highly accurate mass flow controllers and compressed sources of standard gases, calibration standards are provided for multipoint span and zero checks. Up to 4 gas sources may be used. In addition, the Model 700E is equipped with an optional built-in, programmable ozone generator for accurate, dependable ozone calibrations and to produce NO_2 when blended with NO gas in the internal GPT chamber. As many as 50 independent calibration sequences may be programmed into the M700E, covering time periods of up to one year. These sequences may be actuated manually, automatically, or by a remote signal.

4.2 LONG-LINE MONITORING – METEOROLOGY

RM Young Model 05305 Wind Monitor AQ

For monitoring of wind speed and wind direction on the tall tower, a RM Young 05305 Wind Monitor AQ wind speed and direction sensor will be employed. These sensors use a propeller-type anemometer. The sensor will be mounted on a 2-meter boom extending from the tower. The direction vane will be oriented to true north using either a compass or the GPS walkoff method.

Accuracy (instrument specifications)	
Horizontal Wind Speed	±(0.2 m/s + 5% of observed)
Horizontal Wind Direction	±5 degrees
Precision (performance checks)	
Horizontal Wind Speed	±0.1 m/s
Horizontal Wind Direction	±2 degrees
Output Resolution	
Horizontal Wind Speed	0.1 m/s
Horizontal Wind Direction	1 deg.
Starting Threshold	0.5 m/s

RM Young 41342 Temperature Sensors

The temperature and delta temperature for the four levels on the tower will be measured using matched calibration sets of RM Young model 41342 Platinum RTDs. The temperature sensors will be mounted in RM Young model 43408 aspirated radiation shields.

Absolute Accuracy (performance checks)	±0.5°C
Precision (performance checks)	±0.2°C
Resolution	0.1°C

Vaisala HMP45AC Temperature / Relative Humidity Sensor

Relative humidity on the tall tower will be measured at the 5- and 73-meter level using Vaisala HMP45AC sensors.

Accuracy (performance checks)	±5% RH
Precision (performance checks)	±1% RH
Resolution	0.1% RH

Onset HOBO U23 Pro v2 Temperature/Relative Humidity Data Logger

The HOBO Pro v2 Temperature/Relative Humidity data logger is a weatherproof data logger with built-in high accuracy temperature and relative humidity sensors.

Temperature

Accuracy (performance checks)	±0.5°C
Precision (performance checks)	±0.2°C
Resolution	0.1°C

Relative Humidity

Accuracy (performance checks)	±5% RH
Precision (performance checks)	±1% RH
Resolution	0.1% RH

4.3 HONO MEASUREMENTS

The LOPAP (Long Path Absorption Photometry) instrument is described thoroughly in Heland et al. [2001] and Kleffmann et al. [2002]. It is a wet-chemical in situ instrument that consists of an external sampling unit where ambient gaseous HONO is directly sampled in a stripping coil using a mixture of sulfanilamide in hydrochloric acid. No sampling lines are used thus minimizing sampling artifacts on surfaces. The stripping reagent is transferred to the instrument where it is converted to an azodye by the reaction with N- naphthylethylenediamine-dihydrochloride. The absorption of the light from a white light-emitting diode is measured in long path absorption tubes made of Teflon AF2400 using a minispectrometer. In the external sampling unit, two stripping coils are used in series. In the first channel, HONO as well as possible interferences are determined, while in the second channel only the interferences are quantified. The difference of these two channels yields the HONO signal. The sampling time is between 1-5 min depending on the desired measurement range. The detection limit is about 1-2 pptv. The LOPAP instrument has been tested against DOAS measurements both in smog chamber studies as well as in field campaigns [Kleffmann et al., 2006].

Accuracy (performance checks)	±10%
Precision (performance checks)	±5%
Range	0.005 – 10 ppb
Detection Limit	1 – 2 ppt
Sample efficiency	>98%

4.4 REMOTE SENSING UPPER AIR METEOROLOGY

An ASC Model 4000 miniSodar will be used to collect the upper air meteorology data, providing vertically and temporally resolved boundary layer winds and boundary layer depth (i.e., mixing height) data. The system also includes a surface-based meteorological system. The Sodar provides continuous (hourly and 10-minute) wind data with a vertical resolution of 10 m at heights from about 20 m up to about 250 m agl. The exact height coverage at any given time depends on atmospheric conditions. Continuous (hourly or sub-hourly) boundary layer depth can be derived from the Sodar reflectivity data. An example of this is shown in **Figure 4-2**. The sodar will be operated under a configuration that produces the highest quality data for the typical atmospheric conditions found in the Upper Green River Basin.

Accuracy (instrument specifications)	
Horizontal Wind Speed	0.5 m/s
Horizontal Wind Direction	±5°
Maximum Altitude	250 meters
Sampling Height Increment	5 meters and greater
Minimum Sampling Height	15 meters
Transmit Frequency	4500 Hz.
Averaging and Reporting Interval	1 to 60 minutes

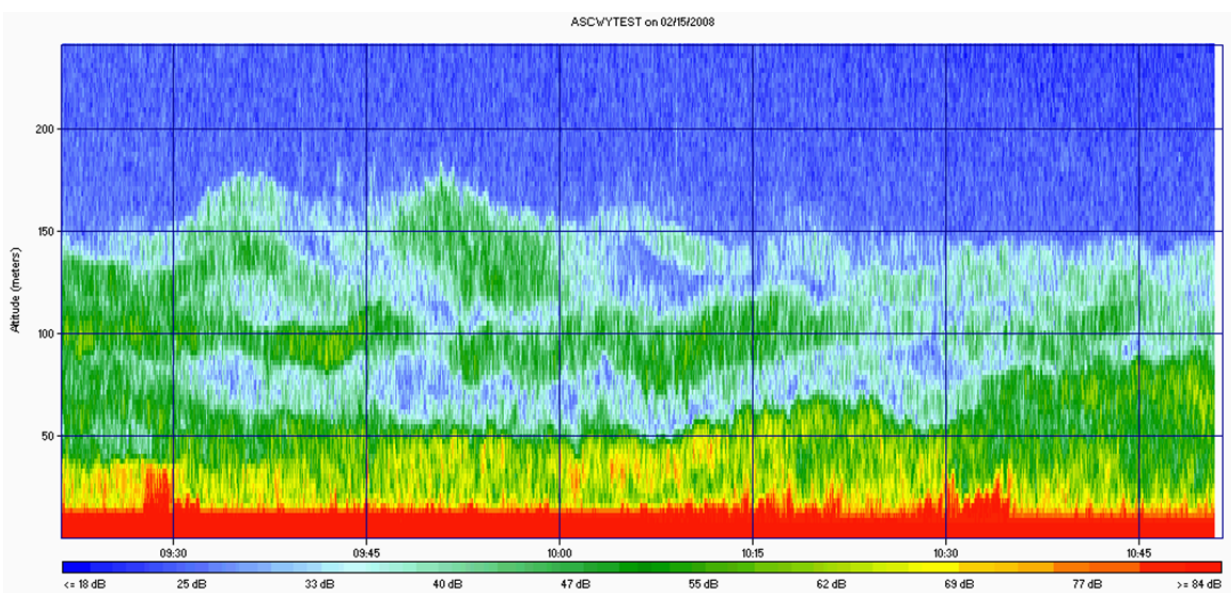

Figure 4-2. Example of sodar backscatter data capturing the daytime mixing height layers under cold wintertime conditions.

4.5 OZONE/RAWINSONDES

To profile ozone concentrations from the surface to the tropopause, we will use balloon-borne ozonesondes, with measurements placed at the Boulder air quality site. The ozonesonde systems has three primary components, described below:

iMet-3050 403 MHz GPS Upper-Air Sounding System

The iMet-3050 is an automated sounding system that operates in the 403 MHz meteorological frequency band. Pressure, temperature, and humidity data (PTU) are collected by the radiosonde and transmitted to the ground station by a digitally coded message sent once per second.

The System Computer receives the PTU data, the radiosonde GPS data, and the differential GPS data that is then processed by the iMetOS into meteorological data and met products. iMetOS also provides graphical displays, data communications and archiving capabilities.

iMet-1 RSB Radiosondes

The iMet-1 RSB radiosonde is 9 x 9 x 18 cm, weighs 260 grams, and is powered by an alkaline dry cell battery. The radiosonde transmitter sends its modulated signals in the 403 MHz range. Temperature is measured using a bead thermistor and relative humidity using a capacitive hygristor. The iMet-1 RSB incorporates a low-noise integrated circuit GPS receiver. Winds aloft are calculated from the change in balloon position (determined from navaid) with time. Height is obtained directly from GPS positioning and, unlike older systems, pressure is now a derived parameter, calculated from the hydrostatic equation, using measured height, temperature, and humidity.

Accuracy (instrument specifications)	
Horizontal Wind Speed	± 1.0 ms^{-1}
Horizontal Wind Direction	Unknown
Temperature	± 0.2° C
Relative Humidity	±5.0%
Output Resolution	
Horizontal Wind Speed	0.1 m/s
Horizontal Wind Direction	0.1°
Temperature	<0.01° C
Relative Humidity	<0.1%

EN-SCI Corporation 2ZV7-ECC Ozonesondes

EN-SCI Corporation KZ-ECC ozonesonde system will be used in conjunction with the radiosonde package described above. Ozone is measured with an electrochemical concentration cell (ECC) ozonesonde coupled through an electronic interface to the radiosonde.

The ECC ozonesonde is of a simple design consisting 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 ECC, and an electronics box containing interface circuitry which couple the ozone sensor to the radiosonde. The mainframe is mounted in a lightweight weatherproof polystyrene flight box that is taped and wired to the radiosonde during flight.

The ozone-sensing cell 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. The 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. Sample air is forced through the ECC sensor by means of a non-reactive pump fabricated from TFE Teflon impregnated with glass fibers. The pump is designed to operate without ozone-destroying lubricants. Pumping efficiency for each pump varies from pump to pump and is also dependent on ambient air pressure. The sampling flow rate is calibrated at the factory and checked in the field before launch. The ECC ozone concentration calibration is also determined prior to launch.

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

$$2KI + O_3 + H_2O \rightarrow 2KOH + I_2 + O_2.$$

The cell converts the iodine to iodide according to:

$$I_2 + 2e \rightarrow 2I^-$$

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:

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

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 Kelvin, and t is the time in seconds taken by the sonde gas sampling pump to force 100 ml of air through the sensor.

As an integral part of the ozonesonde operations, the ozone analyzer readings at the Boulder site will provide ground-truth data.

Sensitivity	2-3 ppb by volume ozone in air
Response Time	15 seconds for 67% of change; 60 seconds for 85% of change
Noise	less than 1% of full scale
Estimated Measurement Uncertainty	less than ± 10% of indicated value

4.6 VOC SAMPLING

VOC samples will be collected using SUMMA canisters at the tethered balloon site during long-line sampling. A total of eight samples will be obtained during the course of the study, with the exact sample strategy determined during the study, based on real-time NMHC data. VOC samples will be analyzed using Method TO-14 with an expanded PAMS list of compounds (see Table 4-1). Analysis will be performed by Environmental Analytical Services, Inc., Santa Barbara, CA.

Table 4-1. Target compound list for EPA Method TO-14 Toxics in Air (Expanded for PAMS).

Ethene	Cyclohexane	Total Petroleum Hydrocarbons:
Acetylene	2-Methylhexane	Total Non-Methane Hydrocarbons
Ethane	2,3-Dimethylpentane	Total Gas Non-Methane Organics
Propene	3-Methylhexane	Total Volatile Organic Compounds
Propane	2-Methyl-1hexene	TPH (gasoline)
i-Butane	Tert amyl methyl ether	TPH (diesel)
Methanol	2,2,4-Trimethylpentane	TPH (hexane)
1-Butene	n-Heptane	TPH (toluene)
1,3-Butadiene	Methylcyclohexane	TPH (methane)
n-Butane	2,5-Dimethylhexane	TPH (Jet A Fuel)
t-2-Butene	2,4-Dimethylhexane	TPH (Mineral Spirits)
c-2-Butene	2,3,4-Trimethylpentane	c6+ (hexane)
Ethanol	Toluene	Sample: Composition
3-Methyl-1-butene	2,3-Dimethylhexane	Total Identified
Acetone	2-Methylheptane	Paraffins
i-Pentane	4-Methylheptane	Isoparaffins
1-Pentene	3-Ethyl-3-methylpentane	Aromatics
Isopropanol	3-Methylheptane	Napthlenes
2-Methyl-1-butene	2-Methyl-1-heptene	Olefins
n-Pentane	n-Octane	Oxygenates
Isoprene	Ethylbenzene	Carbon Ranges:
t-2-Pentene	m,p-xylene	C2 (ethane)
c-2-Pentene	Styrene	C3 (propane)
Tert butyl alcohol	o-xylene	C4 (Butane)
2-Methyl-2-butene	1-Nonene	C5 (Pentane)
2,2-Dimethylbutane	n-Nonane	C6 (Hexane)
Cyclopentene	i-Propylbenzene	C7 (Heptane)
n-Propanol	n-propylbenzene	C8 (Octane)
Cyclopentane	a-Pinene	C9 (Nonane)
Methyl tert butyl ether	3-Ethyltoluene	C10 (Decane)
2,3-Dimethylbutane	4-Ethyltoluene	C11+ (Undecane)
2-Methylpentane	1,3,5-Trimethylbenzene	
3-Methylpentane	2-Ethyltoluene	
1-Hexene	b-Pinene	
n-Hexane	1,2,4-Trimethylbenzene	
Diisopropyl ether	n-Decane	
3-Methylcyclopentene	1,2,3-Trimethylbenzene	
Ethyl tert butyl ether	Indan	
Methylcyclopentane	d-Limonene	
2,4-Dimethylpentane	1,3-Diethylbenzene	
Benzene	1,4-Diethylbenzene	
	n-Butylbenzene	
	1,4-Dimethyl-2-ethylbenzene	
	1,3-Dimethyl-4-ethylbenzene	
	1,2-Dimethyl-4-ethylbenzene	
	Undecane	
	1,2,4,5-Tetramethylbenzene	
	1,2,3,5-Tetramethylbenzene	
	Napthalene	
	Dodecane	

SECTION 5

DATA REPORTING

5.1 DATA MANAGEMENT PLAN

A primary study objective is to produce an adequately validated data set from the field measurements that is well defined and documented, and available to researchers in a timely manner. The overall goal of the data management effort is to create a system that is straightforward and easy for users to obtain data and provide updates.

MSI will collect all measurements remotely on at least an hourly basis. Preliminary data will be posted on a near real-time basis on the UGWOS web site at http://www.metsolution.com/ugwos11/index.htm. Both sub-hourly and hourly averages will be collected. The data loggers are all equipped with internal memory that can store data. Thus, if telemetry fails at a given site, data can be collected manually. All polled data are backed up at least daily, minimizing the chance of data loss.

Each data provider will be responsible for reviewing and validating their collected data. The raw data will be validated to Level 1 as described in "The Measurement Process: Precision, Accuracy, and Validity" (Watson, 2001) before being submitted to the database. This includes flagging values for instrument downtime and performance tests, applying any adjustments for calibration deviation, investigating extreme values and applying appropriate flags. Flags used for UGWOS are presented in Table 5-1. Each data provider will be responsible for documenting the validation process so that it could be provided to the data manager and other analysts if needed.

In addition, each data provider will be responsible for furnishing information regarding the monitoring equipment used in the field study and any additional site information to the data manager as requested to enhance the overall documentation of the study. In particular, participants will provide the Monitoring Quality Objective (MQOs) defining the quality of all data submitted as "valid." These MQOs contain the following:

- Accuracy
- Precision
- Lower quantifiable limit
- Resolution
- Completeness

If cases exist where data do not meet the primary MQOs but are still deemed useable and can be defined with a secondary set of MQOs, these additional MQOs and the dates to which they apply will also be submitted.

Flag	Description

V	Valid. Data meets primary MQOs.
S	Valid, but does not meet primary MQOs. Secondary MQOs in effect.
I	Data invalid.
M	Missing. Measurement not taken.

Table 5-1. Data Flags.

Once the data have been validated to Level 1, the data will be prepared for submittal to the database in a form that clearly define the time reference, averaging period, parameter names and units. The time reference for the database is **local standard time (Mountain Standard Time)** and the averaging period reference will be standardized to **hour beginning (0 – 23)**. The data will be submitted as ASCII comma delimited text files or excel spreadsheet files, with data columns well defined to clarify site identification, parameters, instrumentation, units, and time reference.

Data will be submitted in a format similar to that of the final database structure, as outlined below. This basically has a second column for each measured value for an accompanying QC code. Data flagged as invalid or missing will be given a value of -9999. In the event that data for a given measurable is either all valid (meeting primary MQOs) or all missing, participants need not supply the flag column, though this must be specifically stated.

Database Management Design

MSI will be responsible for assimilating the submitted data into an integrated relational Microsoft ACCESS database and is managing the data for subsequent distribution and analysis. The database will consist of both information and data files. The goal is to make the database very usable by data analysts and all participants.

The following describes the design for the database, which was similarly implemented during the 2007, 2008, 2009 and 2010 field studies. The database includes an inventory spreadsheet file to help users track and ensure that all of the data were submitted and processed in a timely and consistent manner. All data files submitted will be examined to verify unique names for all sites, instruments, and parameters so that no orphan or duplicate records exist in any of the tables. A system is in place for identifying the version and or modification date of all data files. All files are backed up daily.

The data have the following flat format:

Surface Hourly Meteorological Data

SITE, DATE, HOUR, WS, WS_QC, WD, WD_QC, TP, TP_QC, and any additional met parameters and QC codes, if collected.

Ozone 8-hour averaged:

SITE, DATE, HOUR, O3_8HR, O38HR_QC

Hourly Surface Air Quality:

SITE, DATE, HOUR, OZONE, O3_QC, NO, NO_QC, NOx, NOx_QC, NOy, NOy_QC, PAN, PAN_QC and any additional air quality parameters if collected and QC codes.

Upper level meteorological and air quality data

SODAR data will be stored in both a flat file format and a CDF (common data format) or similar tabular format. CDF files are used for plotting the data. Participants should include both flat files and CDF files with their data submissions. The final flat format will be as follows:

SITE, DATE, HOUR, TIME, HEIGHT, WS, WS_QC, WD, WD_QC

The data will be formatted into the final database with the following unit configurations and naming conventions:

- Parts per billion (ppb) for O3, NO, NO_2, and NOx
- Parts per trillion for HONO
- Meters per second for wind speed (as a general rule, metric units will be used)
- Degrees Celsius for ambient temperature
- Watts/m^2 for radiation

- SITE = Alpha-numeric site code identifier
- DATE = (MM/DD/YY)
- HOUR= Nearest whole begin hour (HH) (MST)
- TIME, START_TIME or END_TIME = Time stamp of data (HH:MM:SS) (MST)
- HEIGHT = Elevation in meters above MSL
- QC_CODE, WS_QC, WD_QC, O3_QC, etc =
  "V" (valid), "M" (missing), "I" (invalid), "S" (secondary MQOs)
- NOTES = any additional information

The Level 1 data files along with the documentation files will be available for download on an FTP server.

5.2 DATA REPORTING

Files of all data collected during the study will be transmitted to WY DEQ by June 1, 2011.

The team will review the validated data collected during the field study and prepare descriptive summaries in a report format for delivery to WY DEQ. The Team will prepare summaries of air quality and meteorological conditions during the study period. In addition, the Team will prepare more detailed descriptive analyses of the air quality and meteorology measured during any high ozone events during the study period. As part of the Level 1 data validation procedures, the Team will carefully examine all of the measurements. This process typically provides insight into the critical processes that determine the extent of pollution loading such as atmospheric stability, wind shear (low-level jets, etc), layers aloft, and boundary layer development (growth rate, peak mixing heights), including the nocturnal boundary, convective boundary, and residual layer. The meteorology leading up to and during periods with high ozone levels and the diurnal behavior of ozone aloft during these periods will be characterized.

Supporting the analyses discussion, products that will be produced in this phase of the study include but are not limited to:

1. Time-series plots of continuous measurements such as ozone, ambient temperature, radiation;
2. Vertical profiles of winds;
3. Time-height cross sections of ozone, ozone precursors, winds, and mixing heights;
4. Wind roses at the surface;
5. Pollution roses at the surface; and
6. Summary tables of 1-hour and 8-hour averaged ozone as well as statistical summaries showing hourly averages and maximums.

A final report will be prepared presenting:

- The above-mentioned information and associated analyses in an easy to comprehend format.
- A summary of field operations. A measure of the associated data capture rates will be included. Problems encountered during the field operations will be discussed.
- Details of the database design including descriptions of the metafiles; field descriptors; and the accuracy, precision, lower limits, resolution, and completeness of each measurement.

A draft version of the report will be provided to WY DEQ by June 1, 2011. Voluminous tables and figures will be incorporated into electronic appendices as appropriate. All report materials will be made available via a project web site with access restricted in accordance with WY DEQ policies and procedures.

SECTION 6

QUALITY ASSURANCE PROGRAM

6.1 PROJECT MANAGEMENT

Mr. George Wilkerson will serve as overall project manager. Mr. Bill Hauze will serve as the Field Operations Manager for the study. He will be responsible for coordinating and verifying corrective action for any measurement-related problems.

An organizational chart for UGWOS 2011 is provided in Figure 6-1. Study personnel responsibilities and contact information are presented in Table 6-1.

A UGWOS study web site has been developed to assist in communications between study participants and to display real-time data. This web site can be found at http://www.metsolution.com/ugwos11/index.htm. Operational status of all UGWOS equipment can also be viewed at this site.

While it is not anticipated that the scope of the monitoring effort will change over the relatively short duration of the effort, any changes will result in a revised version of this QAPP. Mr. David Bush is responsible for the writing and distribution of the QAPP. Revisions will be distributed based on the distribution list at the beginning of this document.

6.2 DATA QUALITY OBJECTIVES

Specific monitoring quality objects have been presented for each measurement in Section 4 of this document. The overall objectives for the collection of valid data will be as follows:

Air quality data: 80% of the possible data

Meteorological data: 90% of the possible data

For the above calculation, data lost during calibrations, maintenance or audits are considered invalid.

6.3 ASSESSMENT AND OVERSIGHT

QUALITY CONTROL PROCEDURES

As part of the quality assurance program, detailed quality control procedures have been implemented to assess and maintain control of the quality of the data collected. All equipment will undergo complete checkout and acceptance prior to the start of monitoring on January 15, 2011. This checkout will occur during the week prior to the start of monitoring, as well as during setup and installation of the equipment. Standard operating procedures (SOPs) for measurements will be developed for key monitoring activities. SOPs can be found in Appendix B.

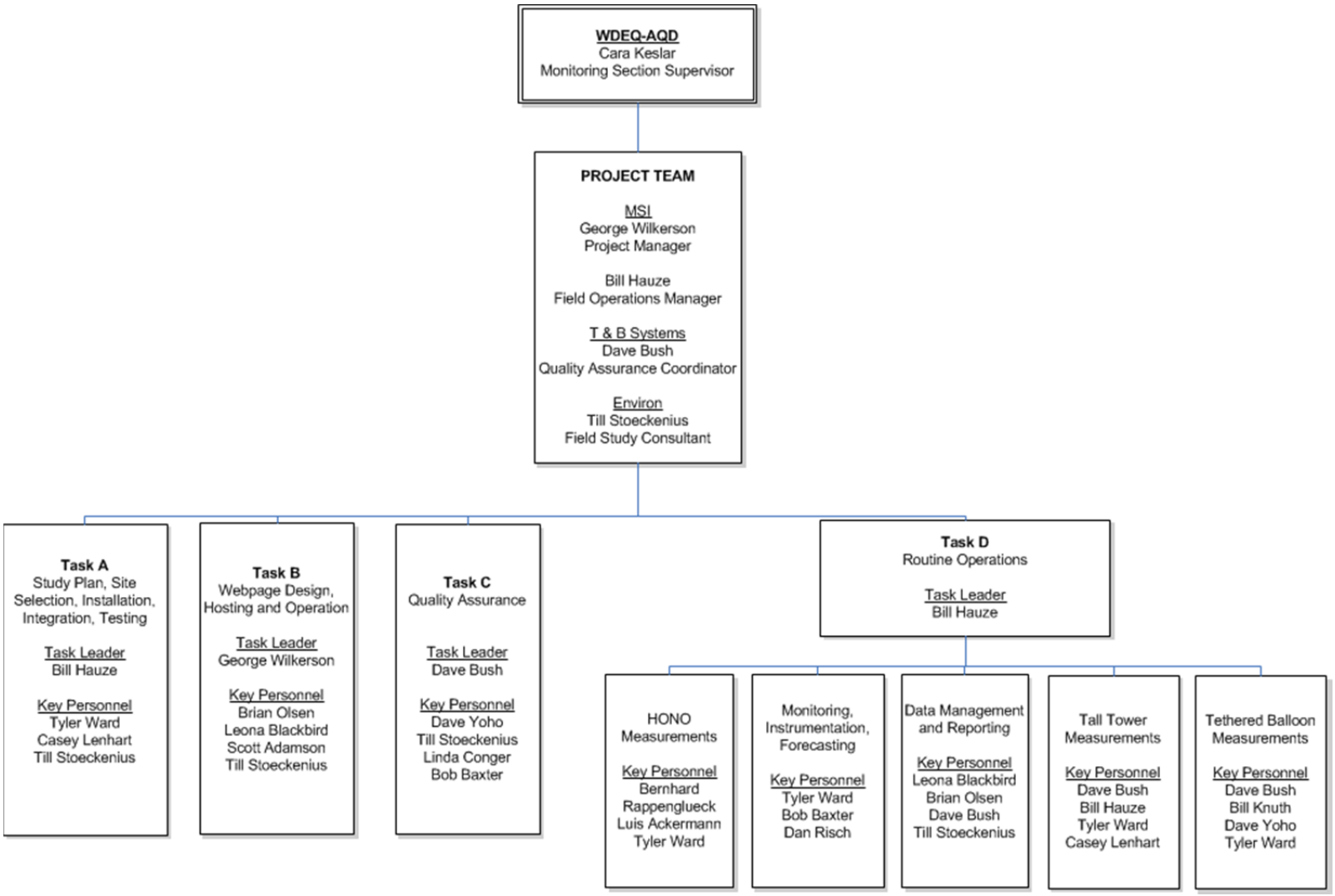

Figure 6-1. Project organization.

Table 6-2. Project Responsibilities and Contacts

Name	Organization	Key Responsibilities	Phone Numbers
Cara Keslar	Wyoming DEQ	Contract Manager	(307) 777-8684 (307) 421-9953 (cell)
Jennifer Frazier	Wyoming DEQ	General study support Daniel site operations	(307) 231-2387 (cell)
Ryan McCammon	Wyoming DEQ	Forecasting, ozonesonde operations	(307) 777-7104
George Wilkerson	MSI	Project Manager	(801) 272-3000
Bill Hauze	MSI	Field Manager	(801) 272-3000 (801) 450-3776 (cell)
Dan Risch	MSI	Forecasting	(801) 272-3000
Brian Olsen	MSI	Data polling Data processing and validation	(801) 272-3000
Tyler Ward	MSI	Full-time onsite field support	(928) 814-3926 (cell)
David Bush	T&B Systems	Quality Assurance Tower and tethered balloon measurements QAPP	(530) 647-1169 (530) 903-6831 (cell)
Bob Baxter	T&B Systems	Measurements support Quality Assurance audits Sodar operations	(661) 294-1103 (661) 645-0526 (cell)
Bill Knuth	T&B Systems	Ozonesonde training Tethered balloon measurements support	(707) 279-1661 (707) 975-4413 (cell)
David Yoho	T&B Systems	Quality Assurance audits Tethered balloon measurements support	(661) 294-1103 (661) 212-3008 (cell)
Till Stoeckenius	Environ	Data analysis and reporting	(415) 899-0709 (415) 717-0039 (cell)
Bernhard Rappenglueck	University of Huston	HONO measurements	(713) 743-1834
Luis Ackermann	University of Huston	HONO measurements support	(832) 396-8501
Bryan Bibeau	ARS	ARS support	(970) 219-8546

A summary of key elements of the QC program for each measurement is presented below:

Station Checks

Performance of all UGWOS 2011 equipment will be checked daily using the data website listed in Section 6.1. In addition, the Boulder site will be visited at least twice a week to service and check the HONO measurements. Access to the tall tower is restricted, requiring Questar personnel to accompany UGWOS personnel during any visit to the site. Thus, physical site checks of the tall tower operations will initially be limited to once every two weeks. In addition, a physical check off the tall tower will be conducted immediately before the beginning of any IOP in order to verify that all systems are operating. If this schedule is insufficient for maintaining data recoverability, it will be modified.

ARS is responsible for the performance of the analyzers in the WY DEQ trailer being used for the tethered balloon. Quality control procedures for the trailer are covered under ARS's quality assurance program and QAPP.

Ozone, NO/NOx, and CH4/NMHC Analyzers

Analyzers for the tall tower and the tethered balloon will be checked using a certified transfer standard, following operating procedures consistent with EPA guidelines. This will consist of zero and span checks conducted nightly. Certified transfer standards are being supplied by Air Resource Specialists, Inc. (ARS) in Fort Collins, CA. A pass/fail criterion of +/-10% will be used when evaluating the span and calibration data, after which corrective measures will be implemented.

MiniSodar

The status of the instruments will be checked daily via remote access of the data. If any problems are encountered that could affect data recovery, repairs will be made promptly. The data will be transferred hourly to T&B's server, using a cellular modem. Data can also be accessed in real time via a web site so that team members can use the data to assist in special monitoring and forecasting. The link to the web site is: http://tbsys.serveftp.net/ugwossodar/.

HONO

The instrument is calibrated by exchanging the sample stripping reagent with a nitrite standard (Merck, Titrisol) diluted in the stripping solution, while running under zero air. Concentrations are calculated using the concentration of the liquid standard and the measured liquid and gas flows. Zero air measurements are automatically performed in regular intervals by a second flow controller and a magnetic valve. The zero air is injected by a small PFA line directly into the inlet of the stripping coil. Zeroes are conducted every 8 hrs for 20 minutes. Calibrations are done once every 8 days or after replacing tubings or reagents, whatever occurs earlier.

CALIBRATIONS

The purpose of a calibration is to establish a relationship between the ambient conditions and an instrument's response by challenging the instrument with known values and adjusting the instrument to respond properly to those values. The calibration method for each of the air quality and meteorological variables is summarized in Table 6-3.

Calibrations of the ozone, NO/NOx, and methane/non-methane hydrocarbon analyzers will be performed upon initial installation and at the end of the study period. Additional calibrations will be performed on an as-needed basis in the event of equipment repair or replacement. All calibrations will be performed in accordance with manufacturers recommendations and consistent with USEPA guidance (USEPA, 1994, 1995, 2000).

All meteorological sensors will be calibrated at the beginning and end of the study. Wind speed sensors will be calibrated using an RM Young constant rpm motor simulating wind speeds at several points across the sensor's operating range. Wind direction sensors will be calibrated by checking responses in a least 90° increments. Temperature sensors will be calibrated using a water bath and a certified thermometer.

Table 6-3. Calibration methods for the monitored variables.

Measurement Variable	Calibration Method
Ozone (O_3)	Multipoint comparison of ozone concentrations with ozone transfer standard
NO/NOx, CH4/NMHC	Multipoint comparison of concentrations against a dilution of a certified gas standard
Wind Speed	Rotational rate using a selectable speed anemometer drive
Wind Direction	Alignment using true north and linearity with a directional protractor
Temperature	Water bath comparisons to a certified transfer standard

INDEPENDENT AUDITS

As part of the quality assurance program, an independent audit program will be implemented that will use an independent entity to verify the site operations and data accuracy. These audits will be performed using personnel independent of the measurement program. This will establish confidence in the data collected and allow the measurement processes to be supported through independent verification. Audits will be performed in accordance with the principles of the US EPA.

System audits will be conducted of all data collection operations, including the tall tower, tethered balloon measurements, and HONO measurements, as well as a review of WY DEQ ozonesonde measurements. System audits will address the following:

- Siting
- Adherence to SOPs
- QA/QC procedures

- Documentation
- Data collection and chain of custody

Mr. Bob Baxter will conduct the system audits. Mr. Baxter is independent of all UGWOS 2011 measurements. He will conduct the audits during an IOP in order to witness operations for the tethered balloon and ozonesonde operations.

In addition to the system audits, performance audits of the gaseous analyzers will be conducted at tall tower and tethered balloon sites. Performance audits will be conducted using equipment and standards independent of those used in the field. The ozone analyzers will be audited using an ozone transfer standard that is certified against T&B's primary standard maintained following EPA's guidelines at their office in Valencia, CA. The nitrogen oxide and methane/non-methane hydrocarbon analyzer will be audited using a certified dilution system and a certified cylinder of NO and methane. The standards used for the UGWOS audits will be the same as those used for the Wyoming state-wide audit program conducted by T&B Systems for the WY DEQ.

Mr. David Yoho will conduct the performance audits of all measurement platforms. These audits will be conducted near the beginning of the study, after the continuous measurements have become operational. Comments and recommendations resulting from the audits will be discussed with measurement personnel at the time of the audit, with a written memo report provided to study management within 48 hours of the audit. Mr. Bush will work with Mr. Hauze to verify that any deficiencies noted during the audit are addressed.

6.4 DATA VALIDATION

All data collected for UGWOS will be validated to Level 1 validation (see Section 5). As part of the validation effort, participant's data will be evaluated to verify that they meet the stated MQOs. If data clearly do not meet MQOs, they will be removed from the database as invalid data. If, however, data miss meeting the primary MQOs in a definable way to the point where the data are still considered useful, secondary MQOs will be assigned to the data in question. This use of secondary MQOs will be specifically documented in metafiles associated with the data.

SECTION 7

REFERENCES

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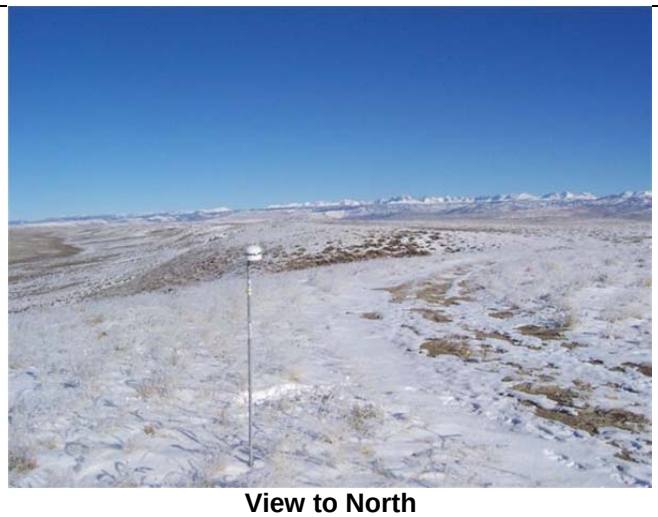
APPENDIX A

SITE PHOTOS



View to North

View to East

View to South

View to West

View of Sodar V path (SW)

View of Sodar U path (NW)

MiniSodar and HONO (Boulder) Site

View of MiniSodar	**HONO inlet with Mini Sodar in Background**

MiniSodar and HONO (Boulder) Site

View to North

View to East

View to South

View to West

View of Site

View of Site Interior

Tethered Balloon Site

View to North

View to East

View to South

View to West

View of Site

View of Site Interior

Tower Site

APPENDIX B

STANDARD OPERATING PROCEDURES

4525 Wasatch Blvd. Suite 200 SLC, UT 84124 MSI Meteorological Solutions Inc. P: 801.272.3000 F: 801.272.3040	**STANDARD OPERATING PROCEDURE**	Title: HONO LOPAP Analyzer Cleaning Procedure
	Number: SOP 74	Page: 1 of 1
	Revision Number: 0	Effective Date: 02/18/2010
Approval:	Date:	Concurred By:

HONO Cleaning Procedure

1. Turn air and liquid pumps off.

2. Detach ABS inlet tubes and connect to cleaning tubing. Insert other end of cleaning tubes into ultra pure water.

3. Join other end of ABS inlet tubes together with knotted tubing.

4. Turn pumps back on.

5. After 10 minutes replace water with pre-mixed solution of NaOH (12 g NaOH with 100 ml H_2O) and wait 10-15 minutes.

6. Again, replace NaOH with ultra pure water for 10 minutes.

7. Alternate NaOH and water as necessary ensuring that the process ends with water.

8. Turn pumps off.

9. Reconnect ABS inlet tubes.

10. Turn pumps on, which allow Reagent 1(R1) to re-enter the analyzer. Wait 10-20 minutes.

11. Adjust lamp intensities and integration time so that spectra are between 2000 and 4000 photon counts.

12. Conduct calibration (See MSI SOP 75).

Meteorological Solutions Inc. P: 801.272.3000 F: 801.272.3040 **STANDARD OPERATING PROCEDURE**	Title: HONO LOPAP Analyzer Calibration Procedure	
	Number: SOP 75	Page: 1 of 1
	Revision Number: 0	Effective Date: 02/18/2010
Approval:	Date:	Concurred By:

HONO Calibration Procedure

1. This calibration procedure must be preceded by the HONO LOPAP analyzer cleaning procedure (See MSI SOP 74).

2. Check Liquid flow using smallest volumetric flasks (5 ml). Disconnect the liquid flow tubing and allow the liquid to fill the volumetric flask to the 5 ml line. Note fill times in excel logbook.

3. Check air flow at the inlet using a flow standard. Note the value in the excel logbook.

4. Start zero air using the LOPAP analyzer menu.

5. Wait 20-30 minutes or until spectra become stable at zero. Replace R1 with liquid calibration standard.

6. Wait 20-30 minutes or until spectra rise and reach a stable plateau. Replace liquid standard with R1 and wait 10 minutes until the calibration plateau returns to zero.

7. Set Auto zero air schedule to 30 minutes active and 10 hours inactive.

SOP - UGWOS TALL TOWER AIR QUALITY MEASUREMENTS

Site Check

- Record all information of the checklist spreadsheet (see attached).
- Record the cylinder pressures and regulator settings on the checklist, verifying that they have not changed unpredictably.
- Verify that the pressure of the active hydrogen cylinder is above 500 psi.
- Verify that the rotameters are all reading 8 ± 0.5 SCFH. Record values and adjust as necessary.
- Using the TST keys on the NOx analyzer, toggle through until the sample pressure is displayed. Record the sample pressure for each level. They should be around 22" Hg, and within 0.5" Hg of each other. At the same time, verify that the solenoids are cycling. It takes three minutes to cycle from one solenoid to the next.
- Check the analyzers for any fault lights. If fault lights are visible, determine the problem and record the issue in the site log.

Zero Check

- On the calibrator display, press GEN, AUTO, and toggle through the pollutants to ZERO.
- Toggle through the pollutant key to NO (if not already present).
- Make sure that the concentration is 0000.0 and the units are PPB, and press ENTR.
- Set the Total Flow to 7.000 LPM and press ENTR.
- Wait at least 5 minutes or until concentrations of all analyzers have stabilized.
- Record the zero values on the checklist spreadsheet.
- Press STBY to end the zero check and place the calibrator in Standby mode.

Precision Check

- On the calibrator display, press GEN, and then AUTO.
- Toggle through the pollutants and select O3.
- Select an O3 concentration of 090.0 PPB and press ENTR.
- Select a Total Flow of 7.000 LPM and press ENTR.
- Wait at least 10 minutes or until the ozone concentration has stabilized.
- Record the precision value for O3 on the checklist spreadsheet, along with the photometer ozone concentration (toggle through the TST choices until the photometer concentration is displayed).

- On the calibrator display, press GEN, and then GPT.
- Select an NO concentration of 090.0 PPB and press ENTR.
- Select an O3 concentration of 000.0 PPB and press ENTR.
- Select a Total Flow of 7.000 LPM and press ENTR
- Wait at least 10 minutes or until concentrations of all analyzers have stabilized.
- Record the precision values for NO, NOx, Methane, NMHC, and THC on the checklist spreadsheet.

- On the calibrator display, press GEN, and then GPT.
- Select an NO concentration of 090.0 PPB and press ENTR.
- Select an O3 concentration of 080.0 PPB and press ENTR.
- Select a Total Flow of 7.000 LPM and press ENTR
- Wait at least 10 minutes or until concentrations of NOx analyzer have stabilized.
- Record the precision value for NO2 on the checklist spreadsheet.
- Press STBY to put the calibrator in the Standby mode.

Resetting Analyzer Responses

We do not anticipate needing to recalibrate the ozone and NOx analyzer during the course of the study. If either of these analyzers needs calibration, use existing MSI SOPs for conducting the calibrations. The response of the THC analyzer, however, has been know to drift, and resetting the analyzer response may be necessary.

- Initiate a zero calibration point using the Zero Check procedures above.
- On the THC analyzer, press the left or right arrow to get to the CALIBRATION menu.
- Use the down arrow to select Calibrate Now. The display should show "Calibration Methane Zero". The Target value should show 0.000 ppm.
- Wait at lease five minutes or until the actual concentration and detector current have stabilized.
- Press the left arrow to set the actual to the target (0.000 ppm). If the change appears successful, press Enter to accept.
- The display should now show "Calibration Methane Span".
- On the calibrator display, press GEN, and then AUTO.
- Toggle through the pollutants and select NO.
- Select an NO concentration of 200.0 PPB and press ENTR.
- Select a Total Flow of 7.000 LPM and press ENTR.
- Wait at least 5 minutes or until the methane concentration has stabilized.
- Press the left arrow to set the actual to the target (20.0 ppm). If the change appears successful, press Enter to accept.
- Repeat the above steps for "Calibration Non-Methane Zero" and "Calibration Non-Methane Span". The target value for the Non-Methane Span will be 6.0 ppm.
- After accepting the final value, the display on the THC analyzer should return to showing Methane, Non Methane, and Total Hydrocarbon.
- Press STBY to put the calibrator in the Standby mode.

Note that manuals are available at the site for the analyzers and calibrator, and they provide detailed presentations of procedures and menu choices. For the THC analyzer response adjustment, refer to Section 4.11 Performing a Manual Calibration.

Before Leaving Site . . .

- Verify that all switches on the relay board are in the Auto position.

- Verify that the calibrator is in the Standby mode.

Date	1/15/2011					
Hydrogen cylinder left	1980					
Hydrogen cylinder right	2000					
Hydrogen fuel	20					
Cal cylinder (psi)	1900					
Zero air (psi)	22.5					
Cal gas (psi)	22.5					
Level 1 flow (SCFH)	8					
Level 2 flow (SCFH)	8					
Level 3 flow (SCFH)	8					
Level 4 flow (SCFH)	8					
Level 1 NOx sample P	22.2					
Level 1 NOx sample P	22.1					
Level 1 NOx sample P	22					
Level 1 NOx sample P	21.9					
Any fault lights on?	no					
Solenoids cycling	yes					
O3 zero (ch 1)	0					
NO zero (ch 6)	0					
NOx zero (ch 11)	0					
NMHC zero (ch 16)	0					
THC zero (ch 21)	0					
O3 precision	90					
NO precision	90					
NOx precision	90					
NMHC precision	2.7					
THC precision	11.7					
NO GPT	10					
NOx GPT	90					
NO2 precision	80	0	0	0	0	0
Raven connected	yes					
Calibrator on Standby	yes					
All switches in "Auto"	yes					

Tall Tower Checklist

SOP - UGWOS OZONESONDE MEASUREMENTS

SOP Section:

1) Preparing the 2ZV7 Ozonesonde up to one month before launch day.

2) Day of Launch: Preparing the Ozonesonde for flight.

3) Day of Launch: iMet-3050 System Setup.

4) Day of Launch: Activating the iMet-1 RSB Radiosonde and 2ZV7 ozonesonde for Flight.

5) Day of Launch: Starting and Operating the Icom IC-PCR1500/2500, iMetOS, and the Intermet Ozonesonde Data Acquisition software (O3 program).

6) Day of Launch: Balloon Setup and Configuration.

7) Day of Launch: Baseline Data and O3 program operation.

8) Day of Launch: Launching the balloon and computer operations.

9) Day of Launch: Terminating Flight and Archiving Flight data.

Ozonesonde Prep. Checklists

Flight Form

References

En-Sci Corporation (2009): O3 Reference Manual: Digital Ozone and Radiosonde Data Acquisition and Processing Software for use with En-Sci Corporation Model 2Z ECC Ozonesonde incorporating the innovative system designs V7 Interface.

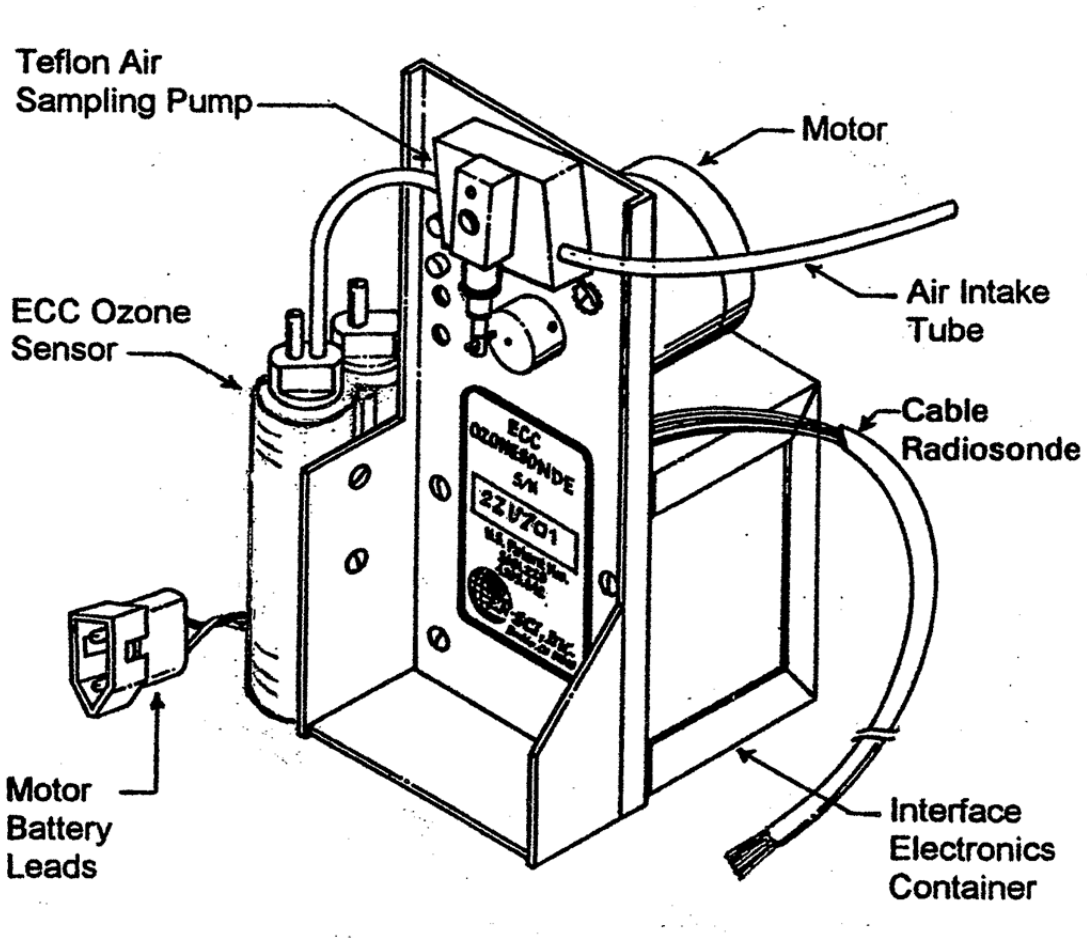
En-Sci Corporation (2009): Operating Insturctions: En-Sci Corporation Model KTU-2A Ozonesonde Ozonizer/Test Unit.

International Met Systems (2011, Draft): Users' Manual For the IMet-3050 403 MHz GPS Upper-Air Sounding System.

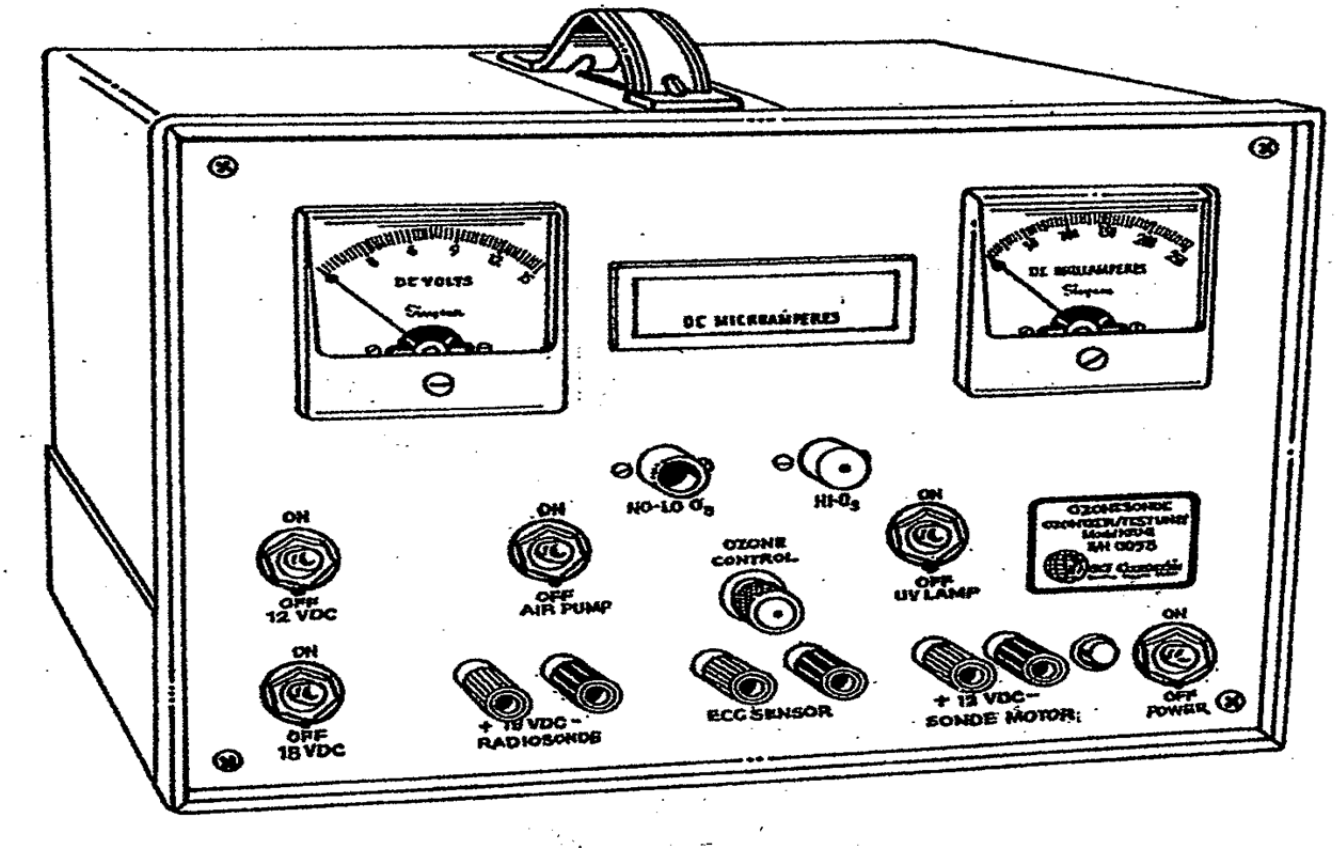
1) PREPARING THE 2ZV7 OZONESONDE UP TO ONE MONTH BEFORE LAUNCH DAY.

Note 1. 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.

Note 2. 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 breaking pump connections.



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



Model KTU-2 Ozonizer/Test Unit.

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 (Placeholder. 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. An EN-SCI Corporation Model KTU-2 ozonizer/test unit (Placeholder) is used for checking on the overall sonde performance. The unit consists of 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; and an 18 VDC power supply for powering the 403 MHz ground receiving station antenna pre-amplifier during cold weather operation, when necessary.

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 sensors' 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, except the 18 VDC power supply switch and the UV lamp switch, turned ON, operate the sonde pump for 10 minutes (during which 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 snugly into the HI OZONE port of the unit. (The connection must be snug since the sonde pump draws 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 (but not the sensor cathode chamber) 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 cathode 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 cathode 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 *A 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 *A. 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 *A to 1.5 *A 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, also, short the ECC sensor leads together with a shorting plug. This 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) Day of Launch: Preparing the Ozonesonde for flight.

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

(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 *A). Save this information as part of your raw data file (e.g., ib1 = 0.05 *A).

(c) 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 *A. Continue passing an equivalent of 5 *A 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 *A.

(d) 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:

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

t	Sensor Current,
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 (ib2) which should generally be less than about 0.1 *A.

(f) 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 someone recover it.

(g) 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.

3) Day of Launch: iMet-3050 System Setup.

The iMet-3050 403 MHz GPS Upper-Air Sounding System (see table next page for component explanation).

Item	Description	InterMet Part Number
N/S	CD with Software, Drivers, and Documentation	693,050
1	403 MHz Antenna with Base and Tripod	100,244
2	LNA to 403 MHz Antenna Cable	597,426
3	403 MHz LNA	900,002
4	403 MHz Cable	597,444
5	GPS Cable (Optional)	597,443
6	AC Power Cable	Varies
7	DC Power Supply	501,046
8	GPS Re-Radiator (Optional)	100,185
9	GPS Re-Radiator Cable (Optional)	597,422
10	iMet-3050 Meteorological Processor	100,413

Item	Description	InterMet Part Number
11	USB Cable	597,049
12	System Computer Power Cord	Optional / Varies
13	System Computer	Optional / Varies
N/S	Cable Reel for 403 MHz Cable / GPS Cable	490,005
N/S	UPS	Optional / Varies
N/S	Transportation Case for System Cables (Optional)	300,020
N/S	Transportation Case for System, Re-Rad, LNA (Optional)	300,021
N/S	Transportation Case for Tripod Unit (Optional)	300,022
N/S	Balloon Inflation Kit	100,438

a) Setup Antenna Unit outside

- Tripod may be placed up to 30 m away from iMet-3050 MP location
- High and clear areas provide for the best reception of radiosonde data
- Avoid valleys, buildings, trucks, and electrical wires
- Adjust tripod legs to orientate the 403 MHz Antenna to approximately vertical

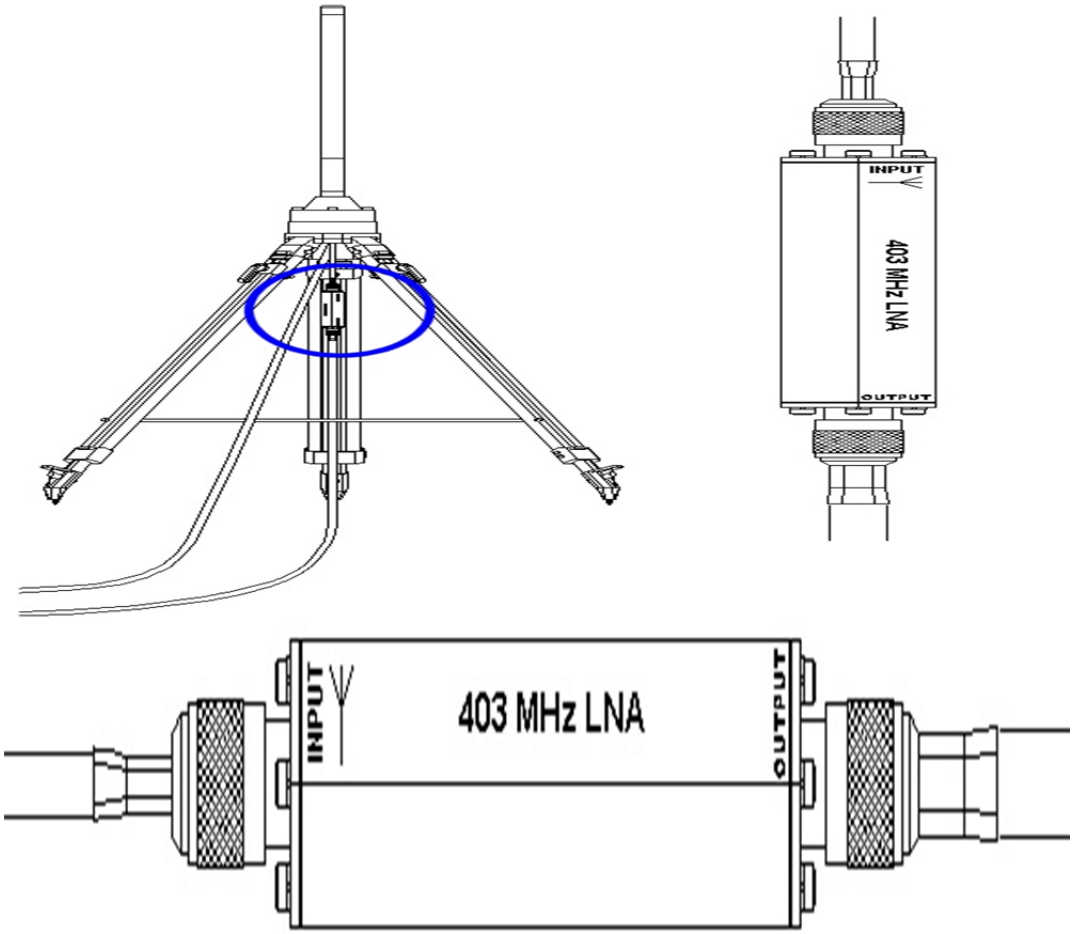
M403 MHz Antenna Unit with Cables attached.

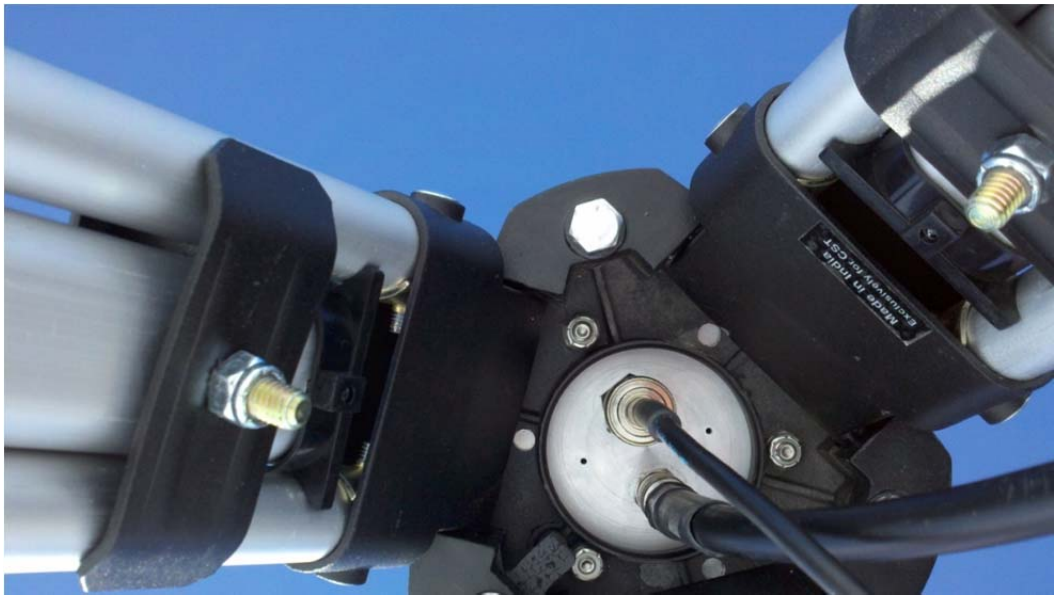
b) Connect iMet-3050 Cables to MP

- GPS Cable
- 403 MHz Cable
- USB Cable
- Power Cable
- GPS Re-radiator Cable

c) Connect the Input side of the 403 MHz LNA to the 403 MHz Antenna base (see next page)

- The input side is labeled with the schematic symbol for an antenna
- It looks like an upside down tripod
- Connect the GPS Cable to the Antenna base


INPUT
403 MHz LNA
OUTPUT
INPUT
403 MHz LNA
OUTPUT



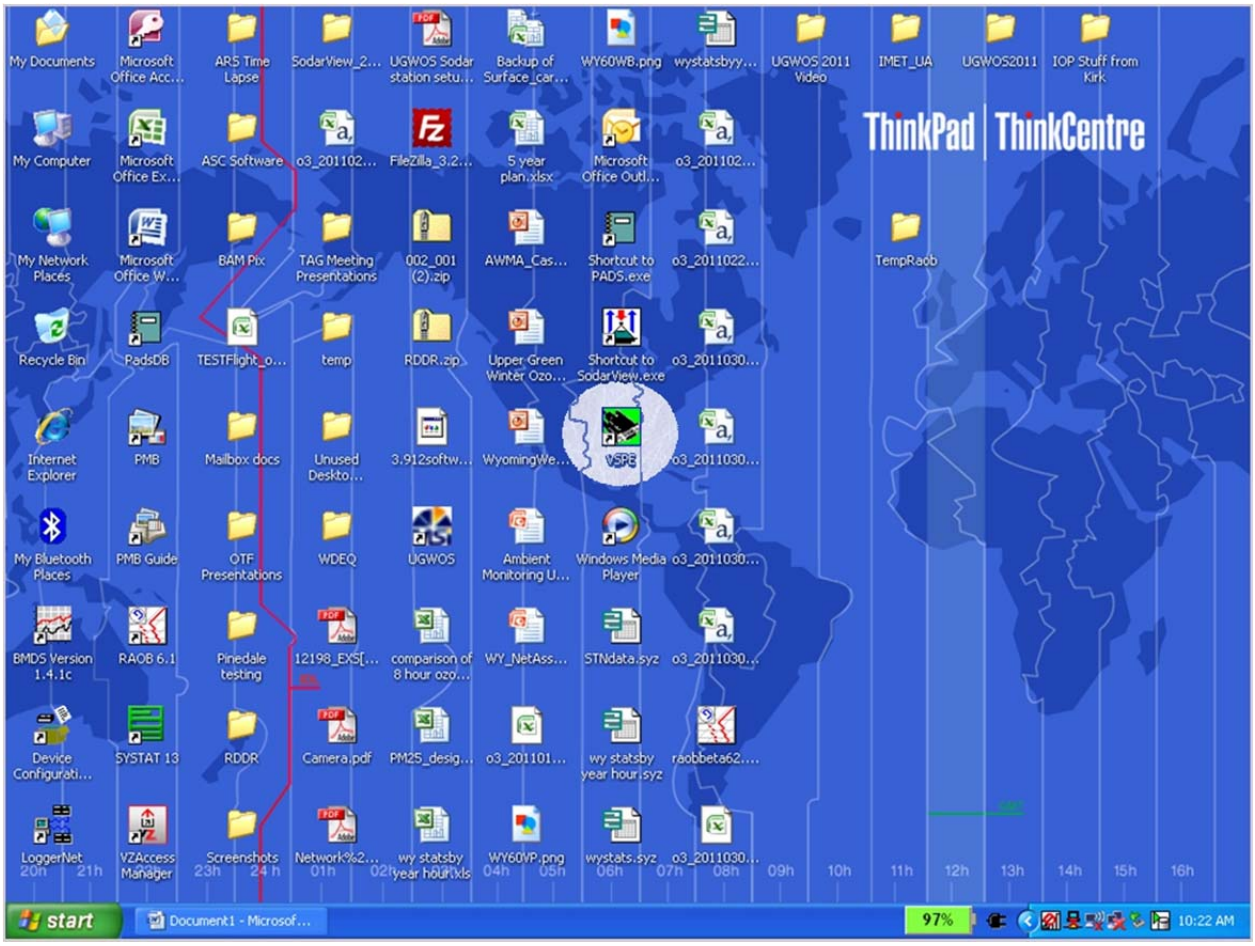
d) Power On System Laptop.

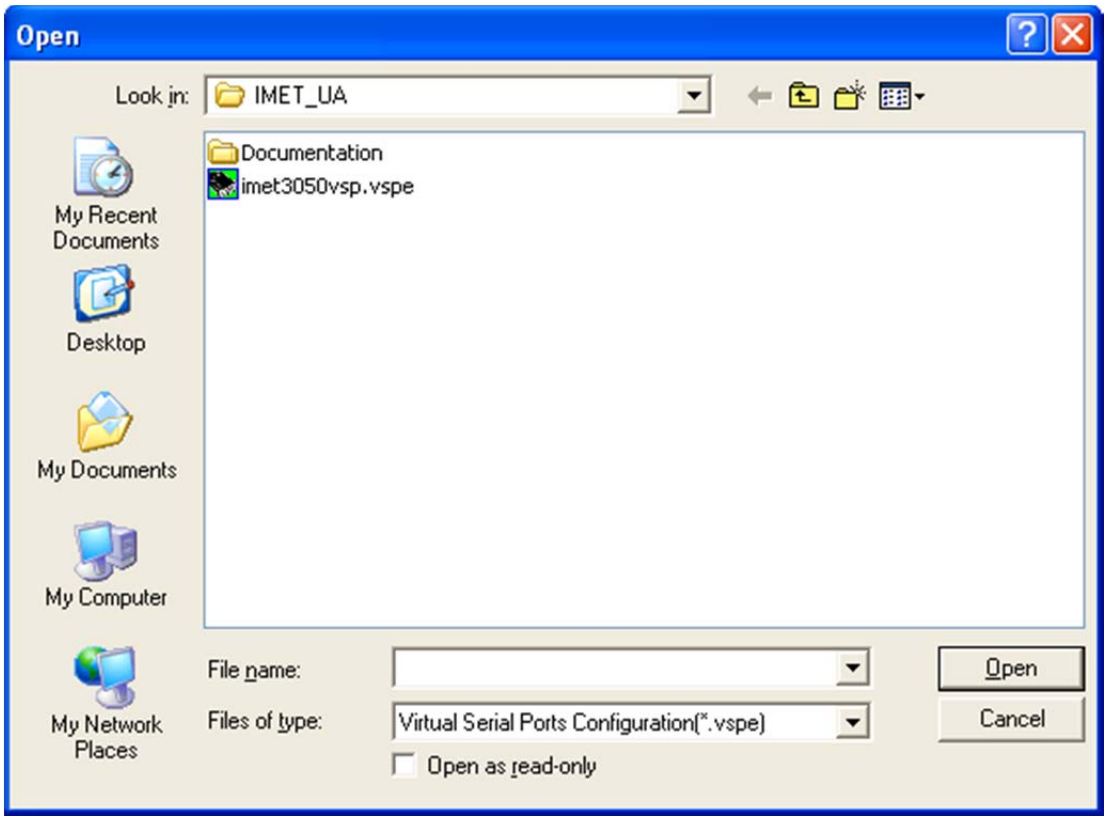
e) Connect the iMet-3050 to the System Computer with the USB Cable **(Plug into the first USB port on the right side of the laptop...first port facing the user...the system will not operate correctly unless the USB cord is plugged into the correct port)** at any time.

f) Once the USB cable is plugged in, wait a few moments before turning on the iMet-3050.

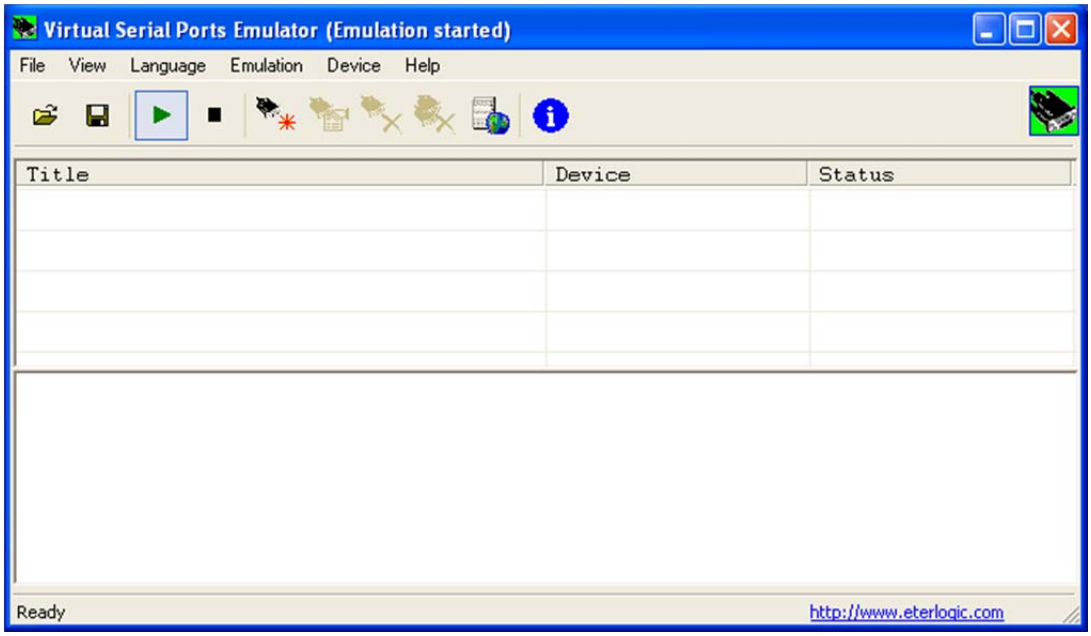
g) Turn on the iMet-3050 MP.

h) Logon, and start the Virtual Serial Port Emulator (white highlighted circle)





i) Start the VSPE (File Open, Select the .vspe file, click OK, then minimize).

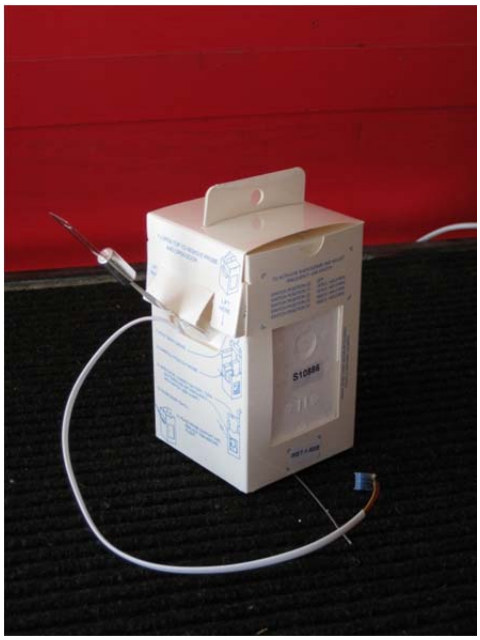


4) Day of Launch: Activating the iMet-1 RSB Radiosonde and 2ZV7 ozonesonde for Flight.

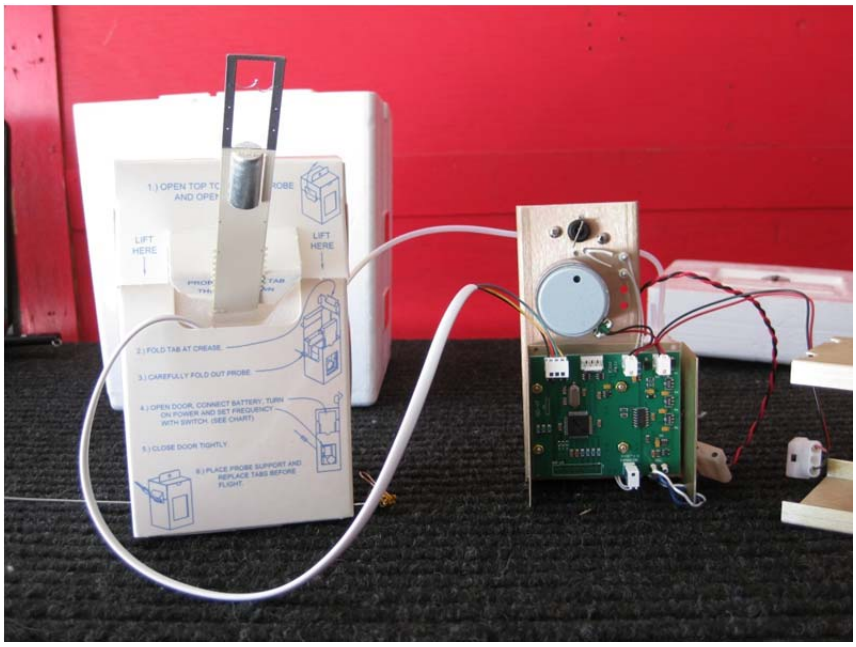
1. Being careful not to tear the box, open the tip of the carton, and slide up the Styrofoam panel on the side of the radiosonde.

2. Plug in the battery quick connect (black lead down) and select the frequency for the radiosonde to transmitter using the switch above the battery plug in. Select a different frequency than the last frequency used.

3. Once the signal has been found by the receiver close the foam door on the side of the radiosonde, fold out the sensor assembly and close the top of the box back up per the instructions on the side of the box.

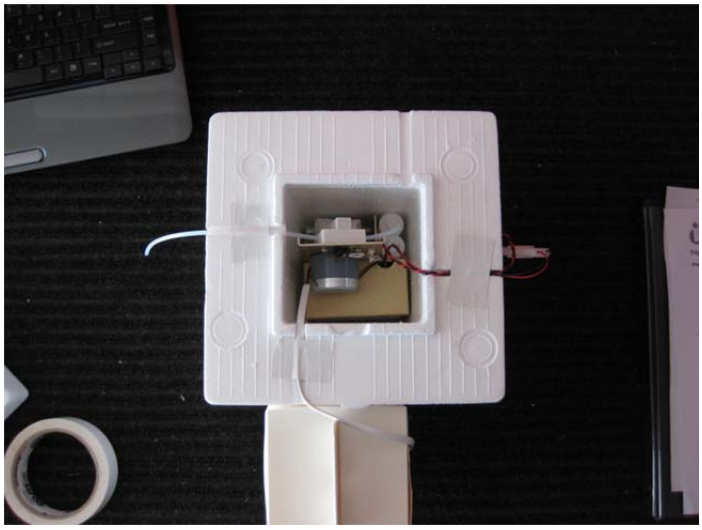


4. Open the top of the ozone sonde and remove the aluminum sensor setup from the box. Often, the inlet tube is loose in the box. Do not lose this piece.
5. Open the cover plate for the circuit board and remove the clip shorting out the two sensor leads. Plug the blue lead into the hole marked blue, white into white.
6. Connect the radiosonde cable to the 4-pin connector on the ozonesonde. This is labeled "radiosonde" on the circuit board.

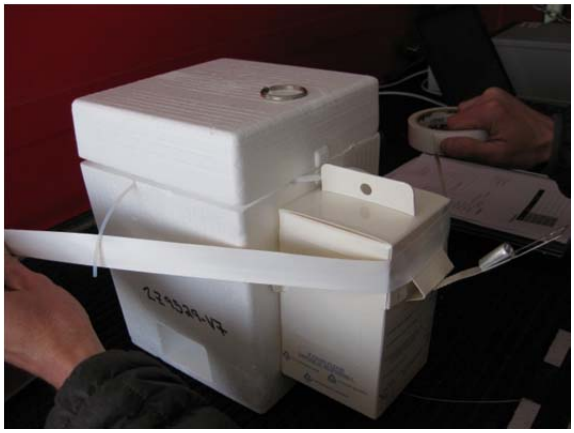


7. Remove the battery from the side of the box and use the adhesive strip to attach it to the sensor assembly in the spot provided.
8. Plug in the battery to the lead on the sensor. The pump should start working. Install the inlet tube in the hole in the side of the pump assembly, being careful not to crimp the tubing.

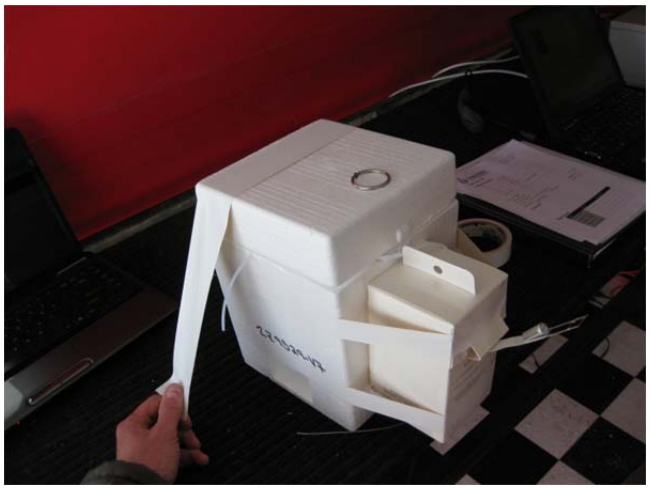
9. Replace the cover on the sensor assembly and circuit board. Do not crimp the wires.
10. Place the sensor assembly in the Styrofoam box. Note the location of the two adhesive strips on the sonde box and the orientation of the inlet, data cable and battery leads; use a small piece of tape to hold the three in place.



11. Using the two adhesive tabs on the front of the ozonesonde box, attach the radio sonde (antenna out) to the ozonesonde, making sure to center the radio sonde and keep the cable routed in the appropriate channel. Use two strips of thin white tape all the way around the two sondes to ensure they stay together.



12. Attach the lid to the ozone sonde (ring goes closest to the radiosonde) with two strips of white tape all the way around the Styrofoam box. Do not invert the Styrofoam box; do not dislodge the inlet tubing. Make sure the battery leads, inlet tube and data cable are sticking out of the box.



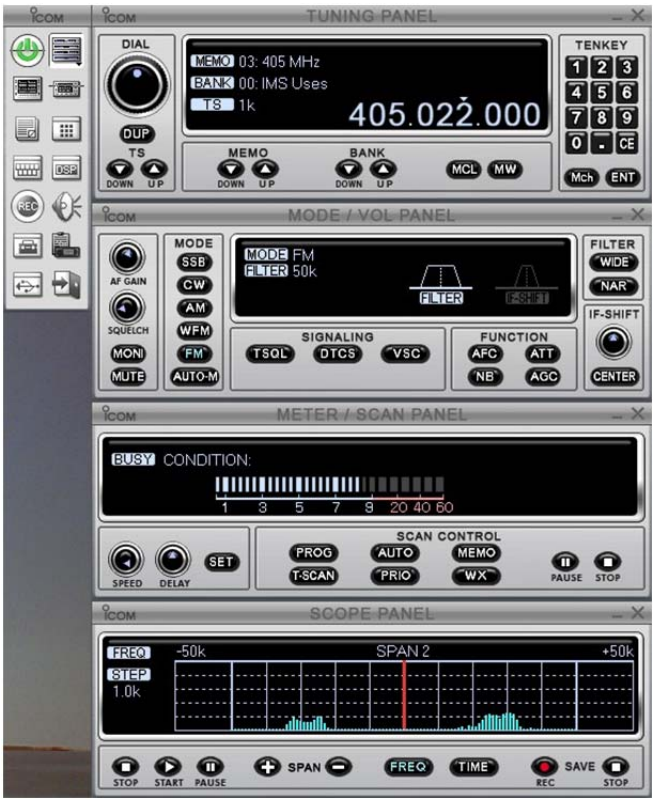
13. Place the sondes outside prior to launch on a clean, level spot.
14. Verify that the data the sondes are collecting is being received by the base station.

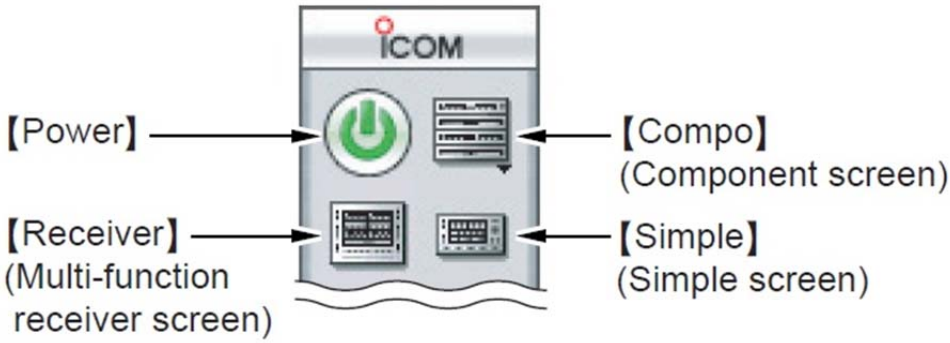
5) Day of Launch: Starting and Operating the Icom IC-PCR1500/2500, iMetOS, and the Intermet Ozonesonde Data Acquisition software (O3 program).

The Icom IC-PCR1500/2500 software is currently required to control the receiver within the iMet-3050. InterMet is currently working on allowing the iMetOS to fully control the receiver.

a. Start the Icom PC-PCR1500/2500 software by using the desktop icon.

b. Once the software has initialized, the Icom Toolbar will open and display.



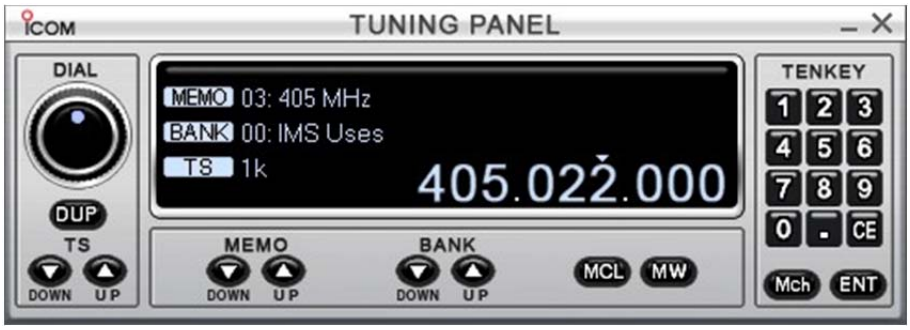


Icom Toolbar Top

c. Click the [Power] icon on the Toolbar to connect the control software and the receiver.

d. Click the [Compo] button to open the Component Screen.

e. In the Tuning Panel window, press the Bank [Up]/[Down] buttons until the Bank reads “00: IMS Uses”.



Tuning Panel

f. In the Tuning Panel window, press the Memo [Up]/[Down] buttons the radiosonde frequency is reached.

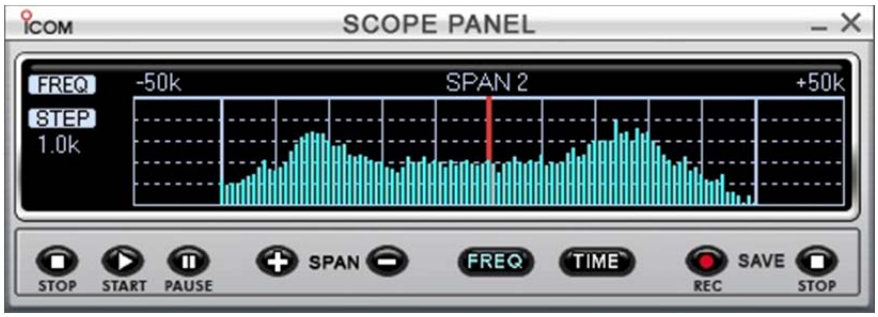
g. Adjust the audio volume as desired by [Left] or [Right] clicking the "AF Gain" knob in the Mode / Vol Panel.

h. Adjust the squelch to its lowest level by [Left] clicking the "Squelch" knob in the Mode / Vol Panel.

Mode / Vol Panel

i. While paying attention to the signal strength in the Meter/Scan Panel, press the Memo [Up]/[Down] buttons in the Tuning Panel window. Scan the four radiosonde frequencies and identify which frequency has the lowest signal strength (lowest amount of interference). Use this frequency when preparing the radiosonde.

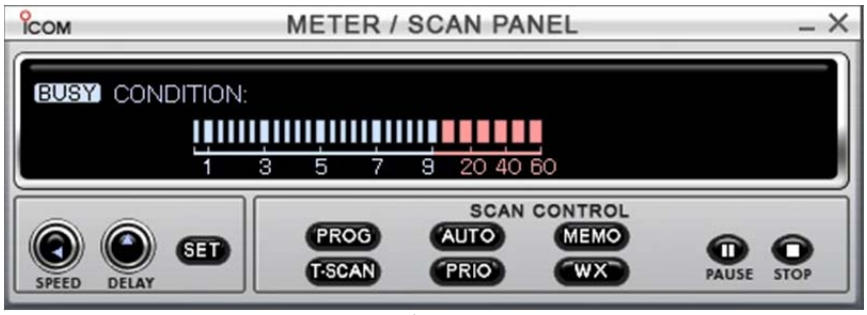
j. In the Scope Panel, use the [+] and [-] Span buttons to adjust the span until -50k and +50k are displayed on either side and SPAN 2 is displayed in the center.



Scope Panel

k. Using the Dial in the Tuning Panel, [Left] or [Right] click to fine-tune the receiver frequency such that the Red line in the Scope Panel is approximately centered between the twin peaks.

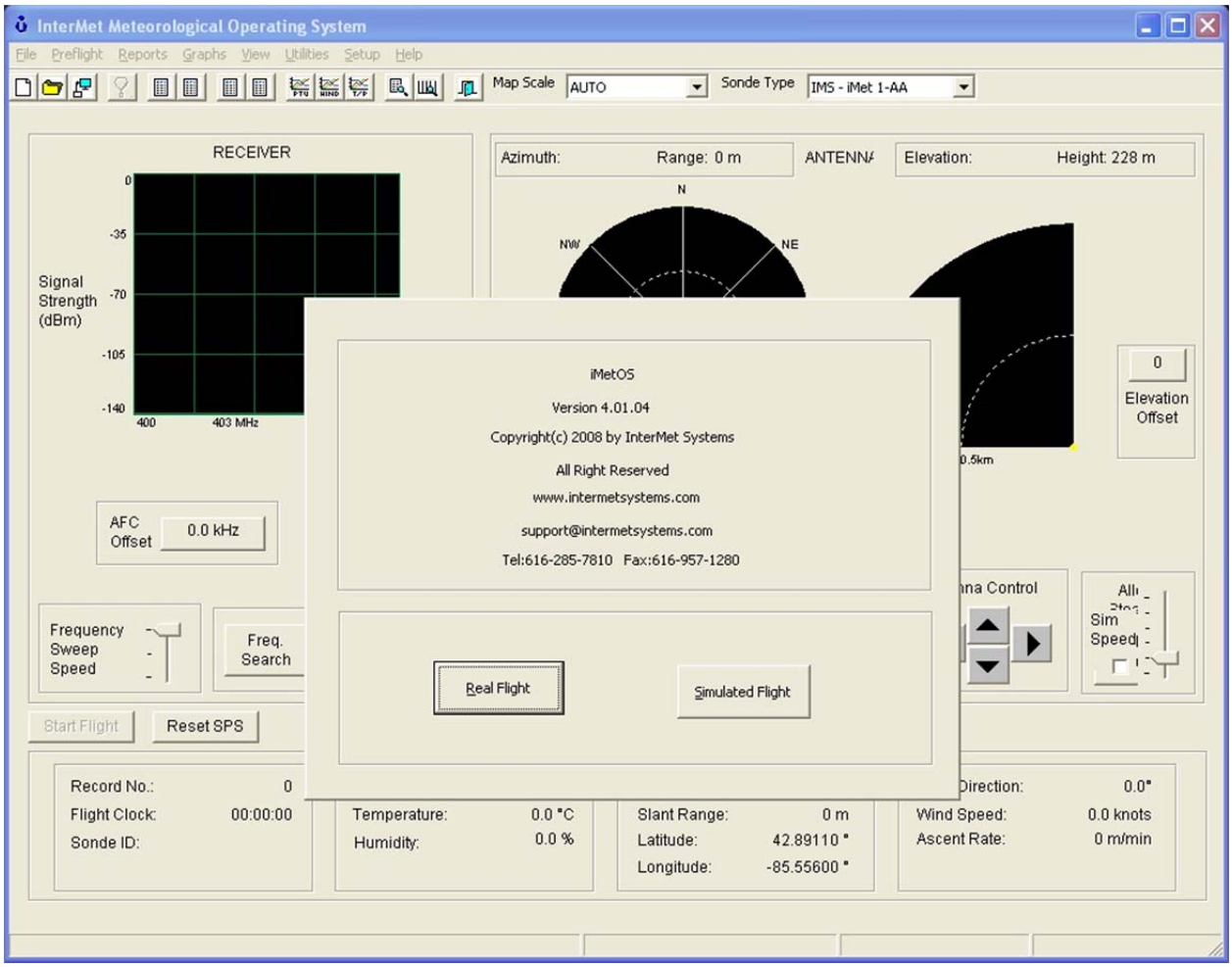
l. The signal strength in the Meter/Scan panel should now show full signal strength. If it does not, re-check the security of all the RF connectors. Also, verify that the LNA feels warmer to the touch.



Meter / Scan Panel

Setup of the Icom IC-PCR1500/2500 is complete.

m. Once the System Computer is on, initialize iMetOS using the desktop icon. The opening screen is a pane superimposed on the main Flight Screen.



Opening Screen

The opening screen pane shows the following two options:

1. Real Flight
2. Simulated Flight

Open iMetOS as a [Real Flight] and check the radiosonde type. If the radiosonde type needs to be changed, change to the proper type and restart the iMetOS. The radiosonde type is printed on the radiosonde cover. Restart the software in the desired operating mode.

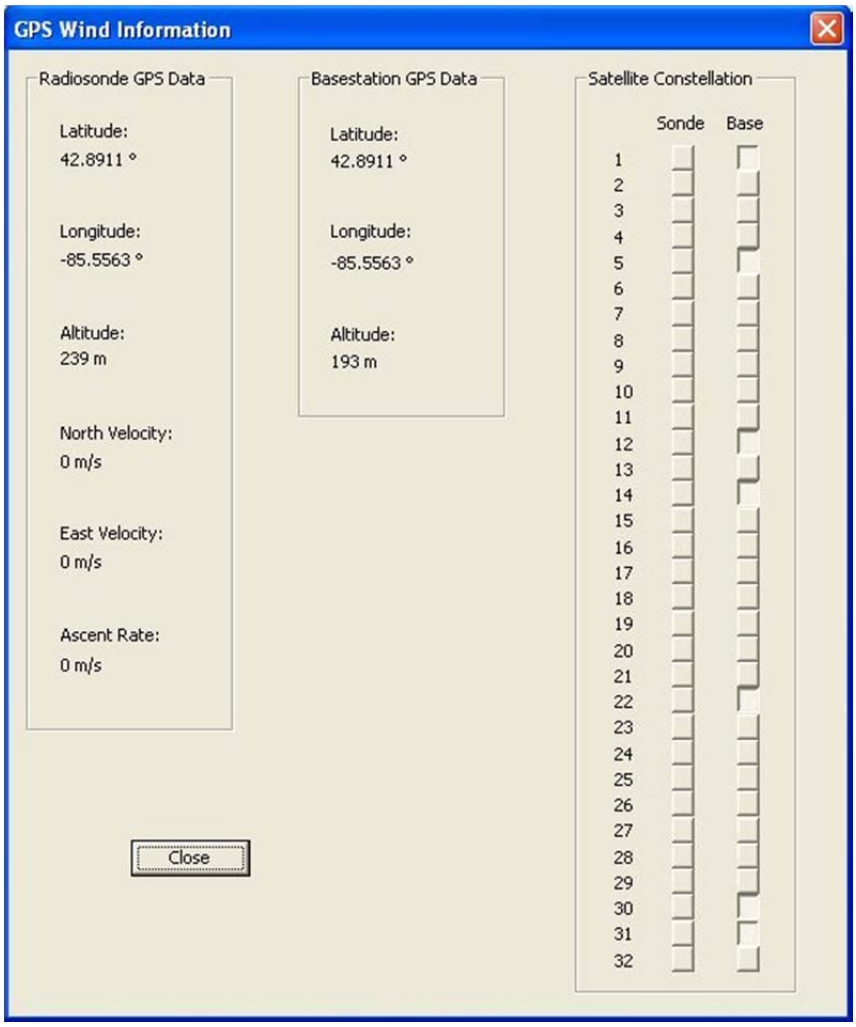
n. iMetOS Position Information

The iMetOS position information setup is different, depending on the system setup.

For a user that is portable/stationary and **has a differential GPS receiver**. A user is portable/stationary when the user sets up the iMet-3050 system in a new location each use, but does not move during the flight. A portable or stationary user **with a differential GPS** should set up the GPS position information when in a new location.

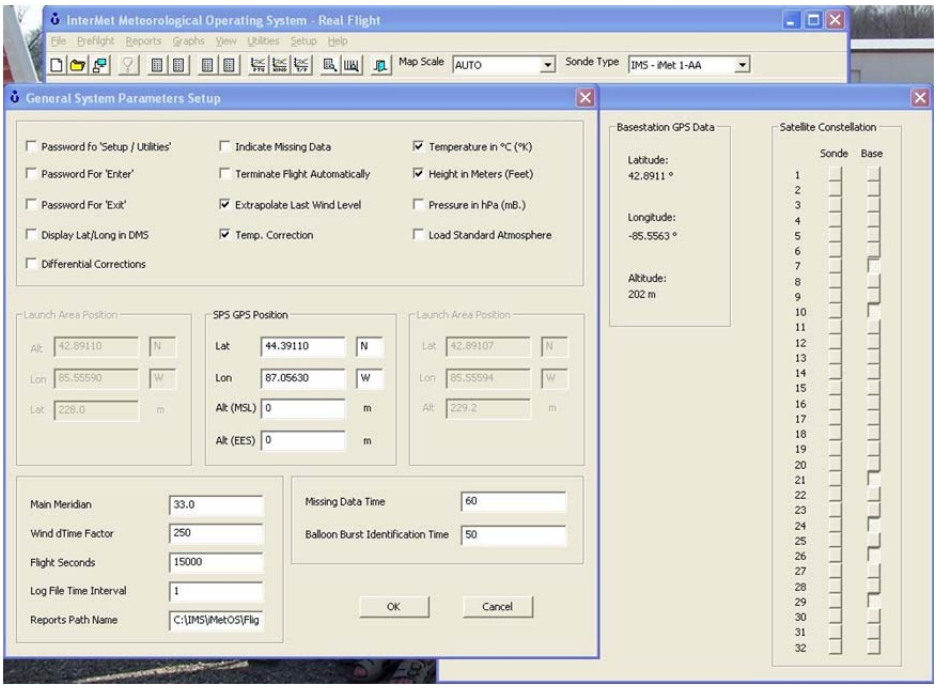
If a surveyed point for the GPS antenna is available, enter the GPS coordinates in the General System Parameters Setup window as normal, adding in the height of the GPS antenna above the surveyed control point. If a surveyed point for the GPS antenna is not available, set the iMetOS Position Information as follows.

1) Open the GPS Wind Information screen under View | View GPS Information.



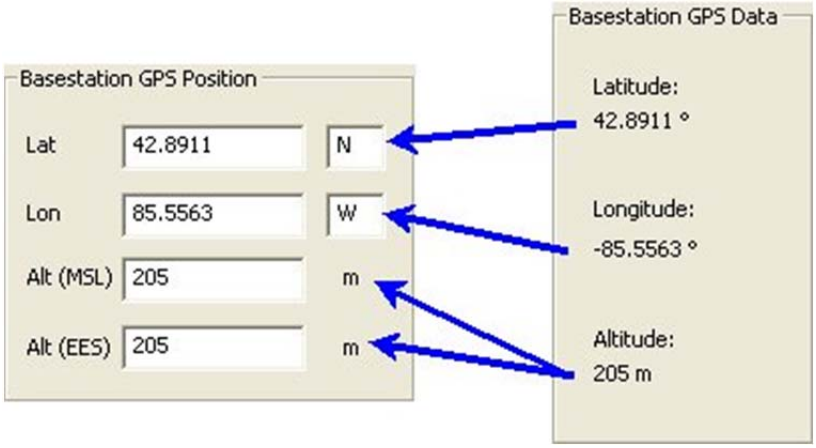
Sonde GPS

2) Open the General System Parameters Setup window under Setup | System Parameters 1.
3) Turn off Differential Corrections by deselecting the checkbox.
4) Enter 0 for the Basestation GPS Position Alt (MSL) and Alt (EES) heights. Hit [OK].
5) Open the General System Parameters Setup window under Setup | System Parameters 1.
6) Arrange the two windows as shown in the figure below.



Setting the iMetOS Position Information

7) Copy over the GPS information as shown in the figure below.



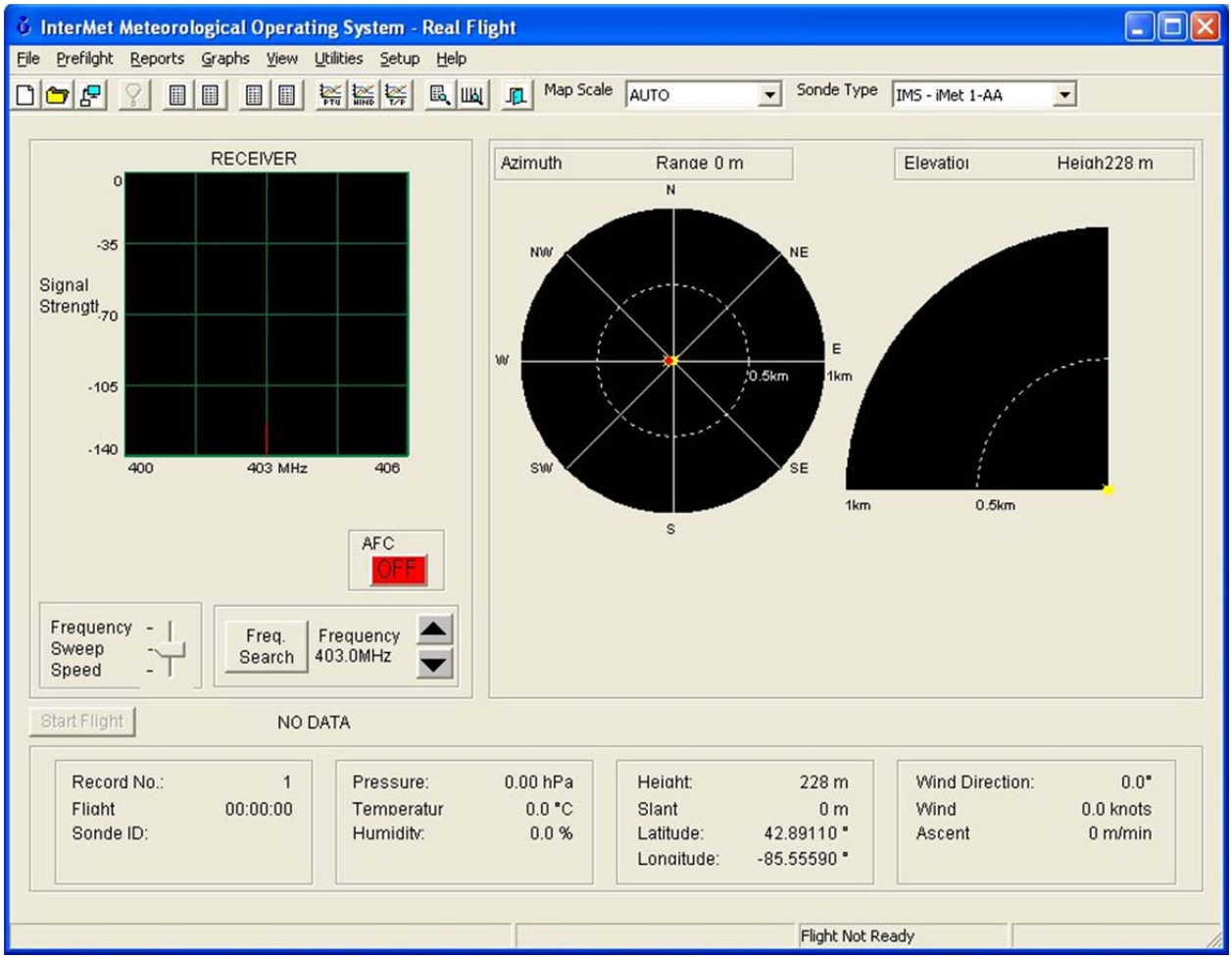
Copy the GPS Information

NOTE

Use "N" for positive latitudes or "S" for negative latitudes. Use "E" for positive longitudes or "W" for negative longitudes.

8) Turn on differential corrections.

9) Press [OK]. The setup of the GPS position is complete.



Main Flight Screen

If no signal is indicated on the Receiver frame and no PTU readings appear, this may indicate that there is a problem with the radiosonde or the receiver settings. Verify that the sonde is on and the receiver is properly tuned. When the receiver is correctly tuned, there will be no arrow indication on the receiver for the AFC setting.

Radiosonde GPS

If the radiosonde does not include its own pressure sensor (iMet-1-AA or iMet-1-BA), it is important to verify that the radiosonde is reporting a GPS position with altitude prior to beginning Preflight. Open the View | View GPS Information window to confirm that the radiosonde is reporting a GPS position and an altitude that is reasonable.

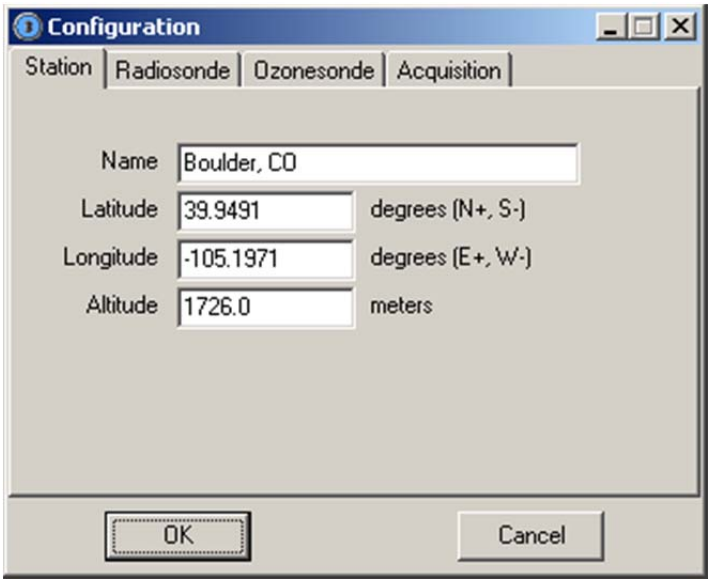
NOTE

> The iMet-1 radiosonde does not report the satellites that are being used. To verify sonde GPS, look for radiosonde latitude, longitude, altitude, and an occasional change for north, east, and vertical velocity.

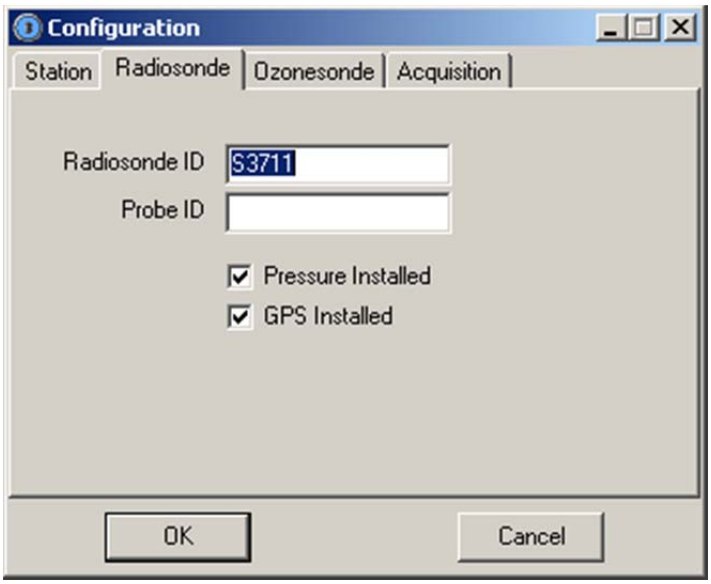
- **o.** Starting Intermet Ozonesonde Data Acquisition software and obtaining a ozonesonde signal

1) Open the “O3” program.

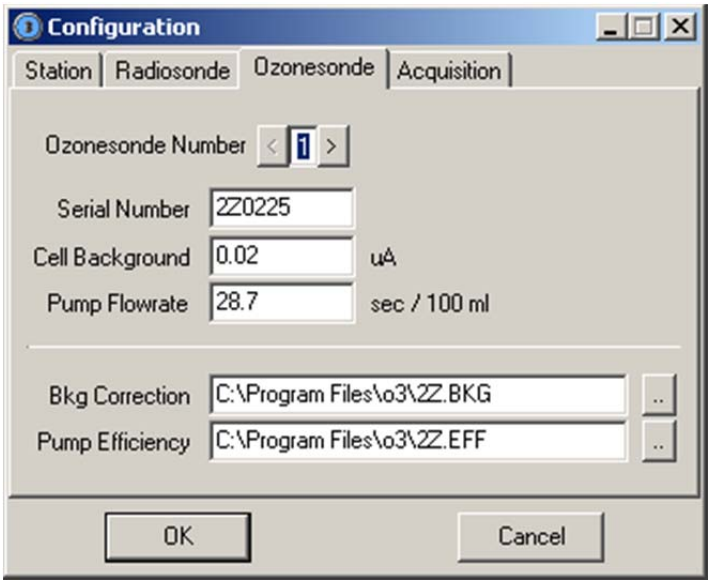
2) Press “Start” and enter Station data in the Station tab as shown below.

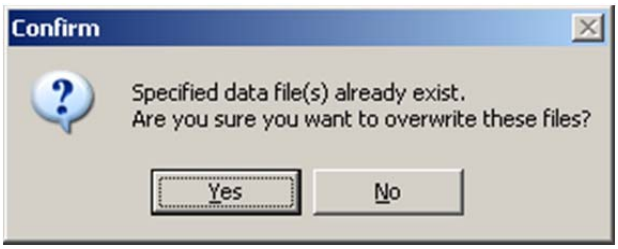


3) Enter the radiosonde ID and ensure that the “Pressure Installed” and “GPS Installed” boxes are checked as shown below.

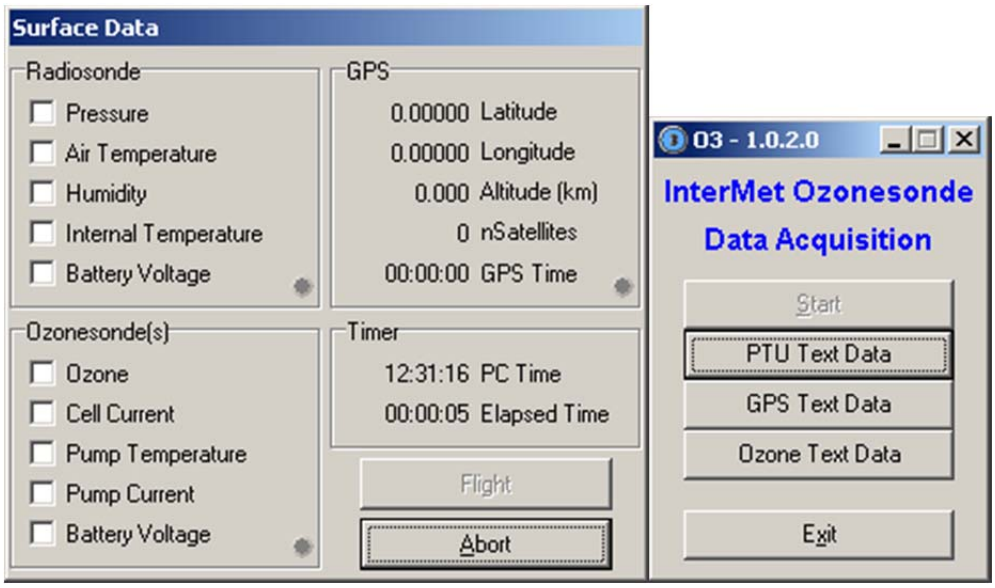


4) Enter ozonesonde information (taken from the "day of flight" ozonesonde prep. checksheet) then press "Ok" and "Yes", and leave the program window open as shown below.

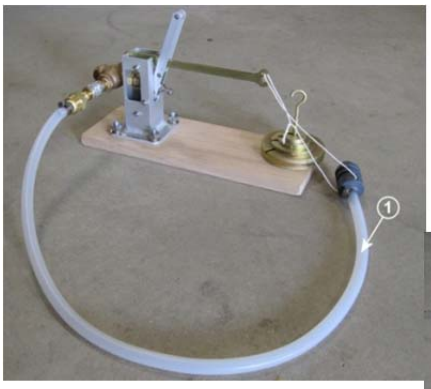




5) The "O3" software will show signals being received from not only the radiosonde but also the radiosonde by blinking green lights in the lower right hand corners of the "Radiosonde", "GPS", and "Ozonesonde" labels under the "Surface Data" screen.



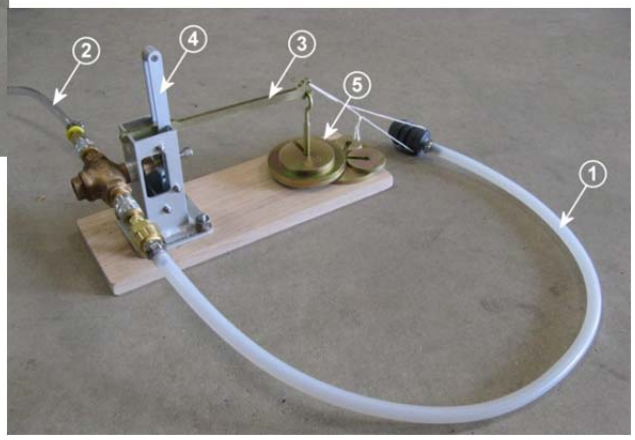
6) Day of Launch: Balloon Setup and Configuration.

1. 

Remove the inflation kit from the transportation case.

2. Connect the balloon nozzle and hose (1) to the output side of the shut-off valve.

3. Connect the input hose (2) to the input side of the shut-off valve.



4. Connect the regulator assembly to the Helium tank, then connect the input hose to the output of the regulator.

CAUTION

Do not exceed 45 PSI output pressure.

5. Lift the weight lever arm (3).
6. Pull back on the vertical valve control arm (4) and allow the weight lever arm to fall.

Condition/Option	**Add'l Weight**
Rain	

7. Select the amount of weight (5) appropriate for the flight. Options include parachutes, pibal lights, and de-reelers. The iMet-1 radiosonde weighs approximately 260 gm. During the 2011 IOPs, we were launching a 350g balloon with parachute, de-reeler radio and met sondes with 1250g of He. This worked well, provided the inflation took place <20 minutes from the release time. Longer time periods had slower ascent times, likely due to loss of gas from the balloon.

$$850gm + Radiosonde_{Mass} + Options + Conditions = ?$$

Light	+100 gm
Moderate	+200 gm
Heavy	+300 gm
Icing	
Moderate	+300 gm
Severe	+500 gm
High Surface Wind	
>25 kts (>12.5 m/s)	+100 gm
>40 kts (>20.5 m/s)	+200-300 gm
Parachute	≈70 gm
De-Reeler	≈50 gm

8. Attach the balloon to the nozzle and begin inflation by opening the gas valve on the tank. Adjust the output pressure to 10-12 PSI and lock adjusting knob. We were inflating with the regulator set at 30 psi and noted no problems. Attaching the balloon to the inflation inlet with a piece of string during inflation is recommended. Use the same knot you would use for tying your shoes.

NOTE

If used outdoors, wind may cause the weights to be lifted, stopping inflation prematurely. If this happens, reset the arm so gas continues to fill the balloon. You can test the system without resetting the arm by checking to see if the weights pull the balloon back down (need more gas) or if the weights float (enough gas).

9. Once the balloon reaches the appropriate lift, the balloon will lift the weight lever arm, shutting off the gas supply to the balloon.

10. Close the gas valve on the tank. Briefly pull back the vertical valve control arm (4) to relieve the pressure in the inflation system.

11. Cut a piece of string about 4' long, double it and tie a loop large enough to easily fit your hook/ carabiner through it.

12. Tie a series of wraps and knots to hold the neck of the balloon closed, alternating one wrap and one knot and moving down the balloon. After ¼" of wraps and knots have built up on the

balloon, finish with two overhands in a row.

13. Clip the grab loop of the string to the BLP4000 (Balloon Launching Platform) and untie the bow holding the holding the balloon on the filling nozzle.

14. Finish the tie off by folding the neck of the balloon upward and tying the same series of knots you used in step 11.

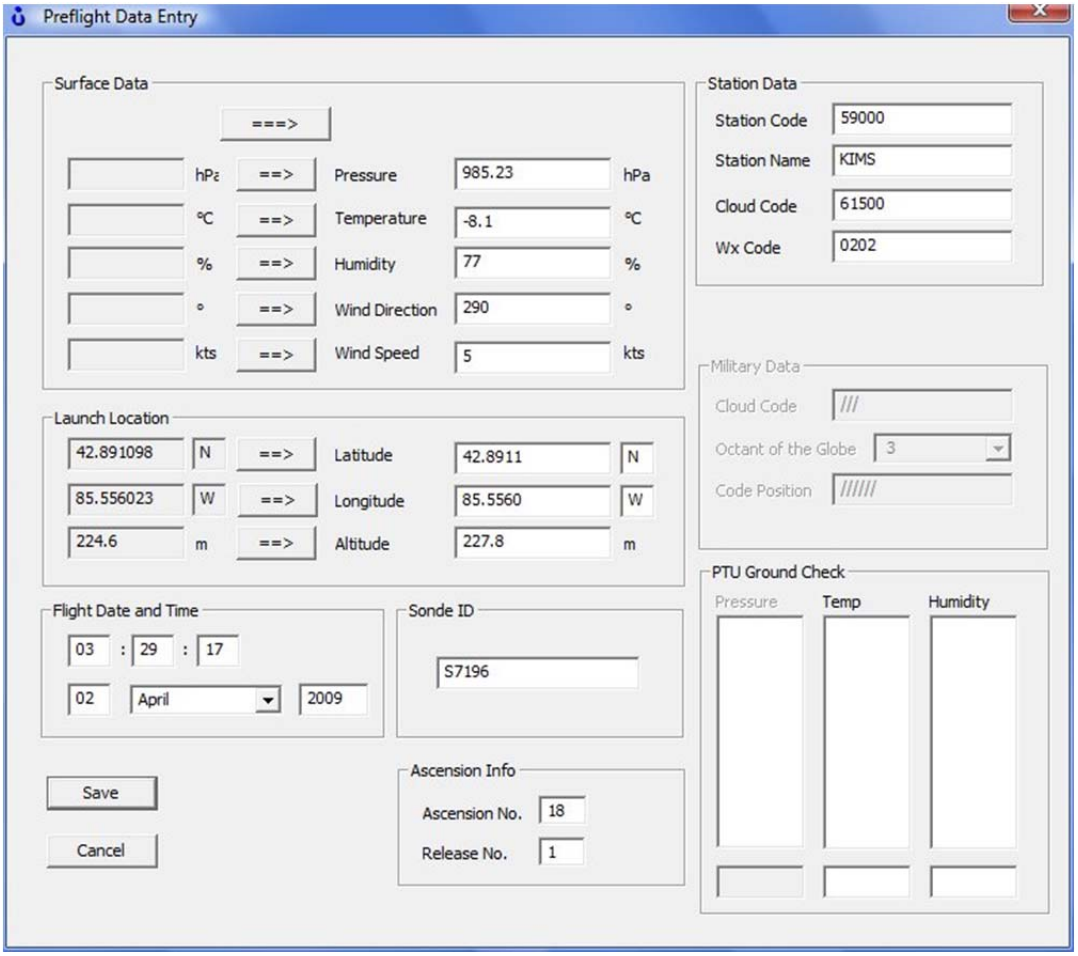
15. Tie the top of the parachute to the grab loop (the shortest loop in the picture above) on the balloon.
16. Attach the de-reeler to the elastic on the bottom of the parachute hub.

17. Attach the de-reeler to the sondes by running the zip tie through the ring on the top of the ozone sonde and down to the radio sonde's loop.

BLP4000, parachute, de-reeler, ozonesonde, and radiosonde ready for launch.

7) Day of Launch: Baseline Data and O3 program operation.

a) To initialize the flight data record, select *New* from the File menu on the Flight Screen menu bar, or from the Flight Screen toolbar. This will bring up the PreFlight data entry screen as shown below.



PreFlight Data Entry

Surface Data Area

b) Enter the baseline data manually in the right column of the Surface Data frame. Baseline data can be obtained from any calibrated sensor, including hand-held units. Latitude, Longitude and Elevation will be entered automatically by pushing the [==>] button from GPS data received from the radiosonde. This position is used as the "launch position", or the point from where all reports are based (centered).

Station Data includes the following data items:

– Station Code: The four letter code for the station. This parameter is used in certain WMO messages.

NOTE

If the user has selected MOBILE or SHIP for the Station Type in the **Error! Reference source not found.**, use the Station Code for part D…D of the TEMP message. Part D…D of the TEMP message is identified as the ship's call sign or an alphanumeric code that contains a two letter geographical designator and the first three letters of the name of the town.

- Station Name: The WMO five-digit code for the station. This parameter is used in certain WMO messages.
- Target No.: Target ascent number. This is generally 0. Increment if this is a second attempt to perform a flight.
- Cloud Code: The five-digit WMO Cloud Code used in certain WMO messages.
- Wx Code: The four-digit WMO Weather Code used in certain WMO messages.

Ascension Info:

iMetOS uses an ascension number format for all data files. The files are named *aaa_rrr*, where *aaa* is the ascension number (with leading 0's) and *rrr* is the release number (with leading 0's). Allowable ascension numbers are 0-999, while allowable release numbers are 0 through 3.

An ascension number is generally considered the number of the flight for the year. If two flights are normally flown a day, then the ascension number on the 35th day (February 4) for the 2nd flight would probably be 70. Ascension numbers are restarted with 1 for the first flight of the new year. It would be wise to archive all previous year's data prior to starting a new year.

The release number is generally considered the number of times the flight for that hour has been tried to be released. The first release would have a release number of 1, while a 2nd try would be 2.

Using 0 for the ascension number or release number generally indicates that the flight is an informal test.

Sonde ID: Use the iMet-1 RSB ID labeled on the sonde's side.

NOTE

If no accurate external measuring devices are available (ASOS, fixed or hand-held), the PTU data from the radiosonde may be used, appearing on the Flight Screen, as surface data. If sonde data is used, be sure the sonde is set outside in a suitable location to gather accurate temperature and humidity. Surface data must be entered for the PreFlight process to be completed. Flight Date and Time are entered automatically from the system PC.

NOTE

In the event of a launch delay, the user may update the preflight data prior to launch from the Preflight menu. Also, the iMet-1 radiosonde does not require recalibration prior to launch. If using an InterMet radiosonde that includes an internal pressure sensor (iMet-1-AB), it is desirable to use a calibrated barometer to apply a pressure correction prior to releasing the sonde. This correction is made automatically during the pre-flight data entry. In this case, the radiosonde should be placed at the same height of the barometer so as not to introduce a pressure error.

NOTE

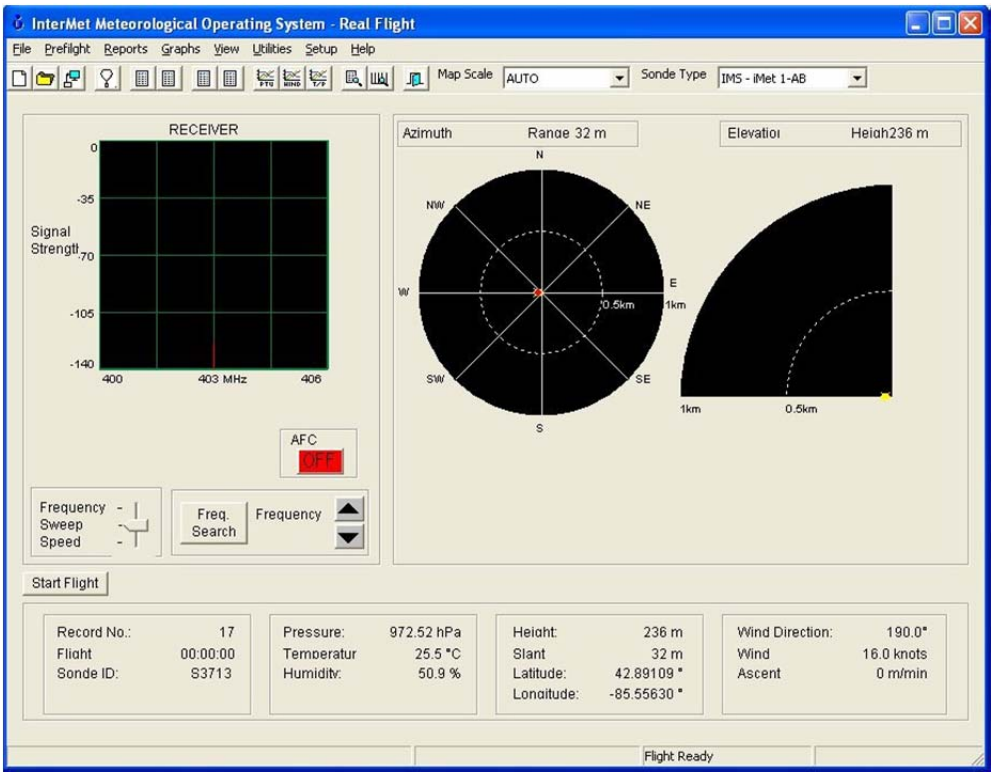
At ground level, a 10-meter vertical difference between the location or the reference pressure sensor and the radiosonde can result in an error of approximately 1 mb. If the sonde is not physically located at the same altitude as the reference sensor, a height compensation factor must be included when entering the baseline pressure data.

c) Save PreFlight Data

Baseline Data Check. The iMetOS includes checks to ensure that all Surface Data is complete and within acceptable ranges. After baseline data has been entered, iMetOS will check the values before the record is saved.

If screen displays the message "Error, incomplete entry!" when [Save] is pressed, one or more of the preflight data items were skipped; pressing [OK] on the error message will center the cursor on the first incomplete entry.

If the screen shows "Error, entry out of range!" when [Save] is pressed, one or more preflight data items were completed with a value out of range (e.g. wind direction 370°); pressing [OK] on this error message will center the cursor on first erroneous entry. When all entries requiring completion or correction have been corrected, press [Save] once more. The text **Flight Ready** will appear in the bottom status bar as show below



Flight Ready

If radiosonde launch has been delayed and there is reason to believe that surface data have changed significantly following preflight data entry, new preflight data may be entered prior to balloon launch. Simply hit [F5] to re-open PreFlight or go to the PreFlight | PreFlight menu to update the data.

Pre-Flight Status Check

Although the temperature and humidity sensors do not need to be recalibrated, it is necessary to verify before the flight that they have not been damaged or contaminated during storage.

After Surface Data has been entered, the PTU Ground Check frame can be used to verify that the sonde's output is within specifications. Each column contains the most recent readings for sonde Pressure, Temperature and Humidity. The data field at the bottom of each column calculates the difference between the most recent sonde reading and the Surface Data. If the absolute value of these differences is larger than 5 mb for pressure, 2º C for temperature, and 10% RH for humidity it is possible that the sonde sensors have been damaged or corrupted.

If the sonde PTU is outside of allowable tolerances, check first to be sure the sonde is in close proximity to the sensors used for the PreFlight Baseline. If the sonde PTU is still outside of allowable tolerances, verify that the reference sensors are calibrated and reliable. If the sonde is acceptable, press [Save] on the pre-flight screen and proceed to the Baseline Data Check. If confident that the sonde is being accurately measured against reliable sensors and is still outside of acceptable tolerances, return the sonde to the manufacturer for replacement and select a new sonde. Repeat the PreFlight process by closing iMetOS and restarting the software for a Real Flight.

8) Day of Launch: Launching the balloon and computer operations.

The 403 MHz Antenna is an omni-directional antenna. There are no restrictions for minimum launch distance between the sonde and the 403 MHz antenna. The radiosonde can be launched from directly next to the antenna as long as precautions are taken to not allow the radiosonde, string, or balloon to contact the antenna or become entangled.

The radiosonde shall be held such that the body does not block the reception of GPS signals. Hold the radiosonde midway up the side of the radiosonde case.

CAUTION

When handling the radiosonde, take care not to damage the sensor probe.

When the radiosonde is ready for launch, the status bar indicates Flight Ready. It is recommended that at least thirty (30) records be received to be sure that the radiosonde is transmitting data consistently before releasing the balloon.

Prior to release, open the View | View GPS Information window to confirm that the radiosonde is reporting a GPS position and an altitude that is reasonable.

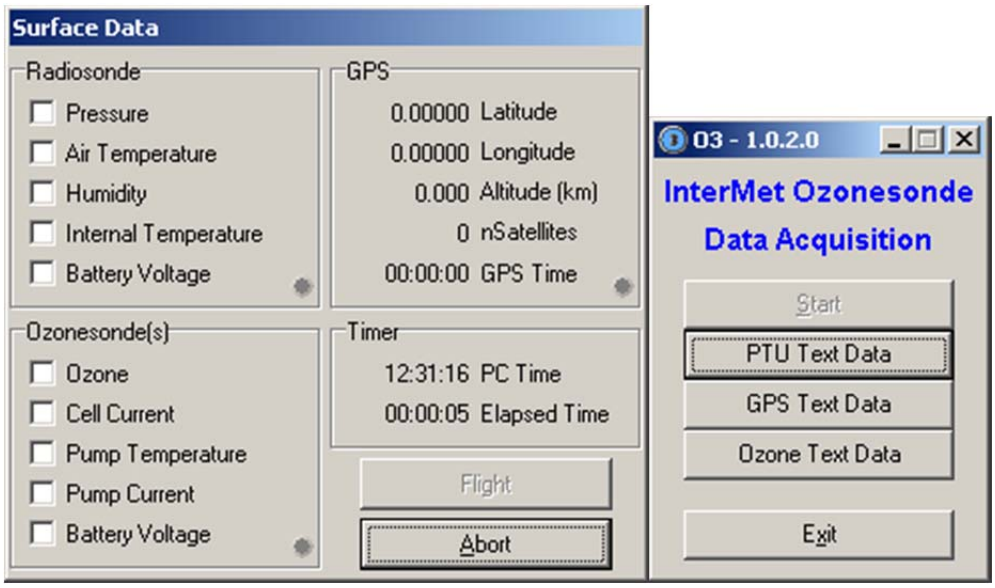
a. Carry the radiosonde train to the launch position.

b. Double-check that the radiosonde is transmitting PTU data (the record number continues to increase) **and** GPS data (View | View GPS Information window).

c. Verify that the iMetOS status bar indicates "Flight Ready".

d. On the "O3" program, ensure that the "Flight" button is highlighted (after first detecting the ozonesonde signal, there will be about a 3-5 minute delay before the "Flight" is highlighted).

1) Press "Flight", and accept/overwrite the values (**DO NOT** Press "Yes" until the balloon has been released...this is the **ONLY** way to start the flight to capture ozone data).



2) **RELEASE THE BALLOON.** Release the radiosonde as soon as the balloon tries to pull the radiosonde up.

3) **To start to the flight with the "O3" software, press "YES"** immediately after the ozonesonde lifts off the ground. **You must start the flight manually** with the "O3" software in order to start all data collection.

iMetOS does not require the [Start Flight] button to be pushed for a Real Flight. Pushing the [Start Flight] button will have no effect. iMetOS includes automatic launch detect, which will automatically start the flight processing after the flight has been launched.

Launch detect (by the iMetOS) will not occur immediately after launch, but generally occurs within 1-3 minutes of launch. Once iMetOS recognizes that the sonde is in flight, it will back process the data until the actual point of launch is found. The actual point of launch will be flight time of 0:00.

The message in the bottom status bar will be replaced by the text FLIGHT IN PROGRESS. Upon sonde release, altitude, ascent rate, and PTU values displayed on screen will begin to change rapidly. Wind data and slant range will appear on screen after about four minutes into the flight.

4) Tracking the Radiosonde

During the flight the system will automatically track the radiosonde and record the flight data received from the radiosonde as shown below during an actual flight

Laptop display of the iMetOS and "O3" programs during an actual flight.

Occasionally (at least every 15 minutes), double check that the receiver is accurately tuned to the radiosonde. Adjust the frequency, as necessary, such that the red line in the Scope Panel is centered between the twin peaks.

NOTE

> Towards the end of the flight, the signal strength will be too weak to be displayed on the Scope Panel. However, by this point in the time, the radiosonde frequency will not change enough to impair performance.

If the sonde signal is lost or not decodable at any point during flight NO DATA or STILL NO DATA warnings will appear on the screen and the record display will stop updating. When the iMetOS receives decodable data again, the record display will resume while the warning message remains for a short time. These warnings are not uncommon and will occur more often when the signal strength is low. As a rule of thumb, when there is ample signal strength (above -100 dBm), a small number of NO DATA warnings (three or fewer per minute) should be ignored. If substantially more NO DATA warnings occur, it may indicate a problem with the radiosonde or receiver.

iMetOS automatically checks the PTU data and warnings will be displayed if the PTU or GPS values appear to be invalid. If these messages are repeatedly sent during a flight, it most likely indicates the failure of a radiosonde sensor. If this happens, it is left to the user to decide whether to re-run the fight with a new sonde or to determine the appropriate procedure for editing the data. The data can be edited via the graphs (during flight or post flight) or through the physical values table (post flight only).

NOTE

> The iMet-1 radiosonde transmits data at a rate of one record per second. Moderate amounts of data loss will not prevent a successful flight and should not result in early termination unless something is clearly wrong. Data loss is more likely at the end of a flight or during periods when the sonde is directly overhead.

Data received and processed during a flight may be displayed and/or printed in real time, as graphs, or meteorological messages and reports.

9) Day of Launch: Terminating Flight and Archiving Flight data.

Ending (terminating) a flight is a 2-step process (step a must be performed before b):

a) In the "O3" software, to terminate the flight, press "End" on the "O3" software, and "Yes".

b) In the iMetOS software, the data logging process must be stopped. Press [Stop Flight] to terminate data logging. Once the flight is terminated, any messages that are programmed to be created at flight termination will be generated.

Once a flight has been terminated, the user cannot resume the flight.

c) Data Archiving

Archiving allows the user to store flight files in a single, compressed file. A normal two hour flight takes approximately 1.5 megabytes to store when not compressed. A typical archived (compressed) flight consumes 400-500 kilobytes of disk space.

Archive the flight as follows:

a. From the iMetOS menu bar, go to Utilities | Store Files.
b. Change the "To" directory to C:\IMS\iMetOS\Archives.
c. Change the "From" directory to C:\IMS\iMetOS\Flights.
d. Select the flight file name in the "File Name" box.
e. Click [Archive].
f. Click [Cancel] after the Command Prompt window automatically closes.
g. Go to the C:\Program Files\O3\Data\ directory, and copy the most recent files as shown below

Name	Size	Type	Date Modified
o3_20110228.cfg	1 KB	CFG File	2/28/2011 4:54 PM
o3_20110228.gps	157 KB	GPS File	2/28/2011 4:58 PM
o3_20110228.o3	106 KB	O3 File	2/28/2011 4:58 PM
o3_20110228.ptu	171 KB	PTU File	2/28/2011 4:58 PM
o3_20110228.raw	520 KB	RAW File	2/28/2011 4:58 PM
o3_20110228.wnd	1 KB	WND File	2/28/2011 4:58 PM

h. Go to the C:\IMS\IMETOS\Flights directory, and copy the most recent files as shown below

003_001.kml	5 KB	KML File	2/28/2011 4:58 PM
003_001.LOG	17 KB	Text Document	2/28/2011 4:58 PM
003_001.PAB	10 KB	Office Data File	2/28/2011 4:58 PM
003_001.PYS	2 KB	PYS File	2/28/2011 4:56 PM
003_001.RTX	351 KB	RTX File	2/28/2011 4:58 PM
003_001.SIG	2 KB	SIG File	2/28/2011 4:58 PM
003_001.STD	2 KB	STD File	2/28/2011 4:58 PM

Once all tasks regarding the flight are complete, the iMetOS may be closed.

Additionally, the Icom IC-PCR1500/2500 software may be closed. Push the [Power] button the Toolbar to shut down the receiver and [Exit] to close the software. Turn off the MP and unplug the USB cable from the laptop.

PREFLIGHT PREPARATION 3 – 7 DAYS PRIOR TO RELEASE

Date _____ Station _____ Operator _____
Sonde Assembly - - Label Data

ECC Sonde # _____ 3 cks __ __ __ Date Manufactured _____

Pump Volts _____ V d.c. Pump Current _____ Ma

Press.-Vac. _____/_____ in Hg Air Flow _____/_____ s/100ml

Pump Test and Conditioning Date _____

NO O3 Phase start time _____ pst Pump voltage _____V dc Current _____mA

Pump Outlet Pressure _____ (> 8.8 psi) Inlet Vac _____ (> 20 in Hg) End time _____

HIGH O3 Phase start and stop time _____/_____

NO-LO FLUSH Phase start/stop time _____/_____

Sensor Charge
Cathode Charge Time _____:____:____ Anode Charge Time _____:_____:_____

Blue and white lead disconnect time _____
One hour or more conditioning period end date/time _____/_____

Preliminary Sensor Response Tests

NO O3 Phase date _____ Elapsed time _____/_____

Five minute point
INITIAL SENSOR BACKGROUND CURRENT _____mA (<0.3 mA)

LO O3 One minute climb point
PRELIMINARY SENSOR RESPONSE CURRENT _____ mA (4 – 5 mA)

NO O3 One minute drop point Sensor Current _____ mA (<1.5 mA)

NO O3 Purge start/stop times _____/_____

STORAGE Date and Time stored (+ 3 ml cath. sol.) _____ _____PST

O3_Check_list_WDEQ-V3.docx

DAY OF LAUNCH PROCEDURE

ECC Sonde #_____ Date _____Station _____Operators _____

Flush CATHODE and refill with 6.0 ml of cathode solution and note the time _____

Flush cathode again and refill with 3.0 ml of cathode solution and note the time _____

Flush ANODE and refill with 1.5 ml of anode solution and note the time _____

Start NO O3 mode conditioning and note the time _____

Turn on the O3 lamp for warm up (rod fully in for NO O3) and note the time _____

After 10 minute of NO O3 note Sonde Pump Voltage _____ and current _____

SENSOR AIRFLOW RATE
Test results (time for 100 ml of flow in sec) _____ _____ _____ Average _____

Ambient conditions of test: _____ dry bulb _____ wet bulb _____ pressure

SENSOR BACKGROUND CURRENT
Measure after at least 10 minutes of NO O3 operation. CURRENT : _____ micro A

SENSOR RESPONSE TEST FOR OZONE INCREASE (LO O3 mode)
Pull out Rod for 5.0 micro A and after exactly one minute note Current _____ micro A

SENSOR RESPONSE TEST OZONE DECREASE (LO O3 Mode)
Fine tune the O3 Control Rod to 5.00 +/- 0.05 micro A and operate for 10 minutes or more.

Fine tuning start time _____ steady 5.00 +/- .05 micro A 10 min. end time _____
Stopwatch timed test

00 sec $= i_0$ = _____ micro A

30 sec $= i_{0.5}$ = _____ micro A

1 min $= i_1$ = _____ micro A

3 min $= i_3$ = _____ micro A

5 min $= i_5$ = _____ micro A

10 min $= i_{10}$ = _____ micro A

COMPUTE

If i_1 < or = $0.2\,(i_0 - i_{10})$

_____ < or = 0.2 (_____ - _____)

_____ < or = _____

Circle one: YES! NO!

If YES continue into prelaunch.
If NO use another O3 sonde

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