

Micro Specialties, Inc.
CR1000 Data Collection Program
Version 1031
September 12, 2011

<u>Station Type</u>	<u>Update Rate</u>	<u>Data Groups</u>	<u>Sensor Fields</u>	<u>Xmit Rate</u>
SNOTEL with Soils	5 minutes (1)	One	variable 6-19	1 hour

<u>Optional Sensors</u>	<u>CR1000 Flag</u>	<u>Location</u>	<u>Default</u>
YSI Air Temperature	hasYSI		1
HMP45 temp/rh	hasHMP45		0
Barometric Pressure	hasBaro		0
Tipping Bucket Accumulation	hasTB		0
Wind	hasWind		0
3 Hydra2 Soil Probes	hasSoils		0

<u>Telemetry Report Length Variations</u>	<u>Count</u>	<u>Monthly Billable Bytes*</u>
Minimum Hourly values	6	
Maximum Hourly values	19	
Minimum Daily values (transmitted at midnight)	11	
Maximum Daily values (transmitted at midnight)	17	
Minimum Daily bytes transmitted: $24(3+2*6)+11$	371	0
Maximum Daily bytes transmitted: $24(3+2*19)+17$	1001	19,031

*based on 12,000 bytes free per month and a 31 day month

Current Revision: 1031.02 (descendant of 1030.03)

CR1000 data collection program version 1031 is a Global Modem telemetry program for the CR1000 data logger. This program has a normal sensor update rate of 5 minutes, and produces a single hourly data report via Global Modem and logging storage. The telemetry values are sent using the FP2 short floating point numeric system. Each value occupies 16 data bits.

This program produces one hourly data report and requires MSI's global Modem Iridium data modem.

Special Feature Notes

This program has several special features which will allow it to be used in multiple data sites without revision. These features, however, require some attention and manipulation by the installation and service technicians.

1. **Temporary Rapid Sensor Update** - A special Public variable, **fastUpdate**, will increase the sensor update rate to 10 seconds, when its value is 1. At power up, fastUpdate is always set to 1, enabling rapid sensor update for test purposes. At midnight, fastUpdate is automatically reset to 0, reducing the sensor update rate to 5 minutes. This variable may be edited to increase the sensor update rate at any time, but its value will always return to 0 at midnight to fix the update rate to 5 minutes.
2. **Selectable Air Temperature/ rH Sensor** - Either the YSI 44211 wide-range air temperature sensor, or the HMP45 air temperature/rH sensor, or both may be utilized. See **Selecting the Air Temperature Sensor** below.

3. **Snow and Precip Sensor Setup** - Snow Water and Storage Precip sensors are selectable by setting an input location variable when setting up the site. See **Setting Snow Water and Precipitation Parameters** below.
4. **Soil Probes** - Three Hydra II soil probes are sampled. If fastUpdate is 1, the soil probes are sampled every ten seconds. Otherwise the soil probes are sampled at 59 minutes past the hour only, and only if hasSoils is 1.
5. **Snow Depth Setup** - An offset may be applied to the snow depth sensor to convert the height reported by the sensor to a snow depth value. See **Setting the Snow Depth Offset** below.
6. **Barometer Setup** - A multiplier and offset may be applied to accommodate various barometric sensors. See **Setting Barometer Parameters** below.
7. **Site ID** - A numeric value may be entered which will serve as a site identifier. This will help to ensure that data records are never transposed among the various sites. Edit the Public variable, **siteID** with LoggerNet to set the site identifier.

Site and sensor variables are initialized to default values when the program is sent to the CR1000. The technician should always verify that the variables are acceptable before leaving the site. **Figure One** (page 3) shows an example of **Public Variables**, which may be modified by right clicking, then editing each variable on a NUMERIC DISPLAY within LoggerNet.

Sensor Configuration

SENSOR	INPUT	EXITATION	XTROL	VARIABLE	SENSOR MODEL
Snow Water	SE1	SW12V	C9	snow Water	
Storage Precip	SE2	SW12V	C9	stoPrecip	
Air Temperature (YSI)	SE4	VX1		airTemp	YSI 44211 wide range
Air Temperature (HMP45)	SE5		None	airTemp	HMP 45 temp/rh
rH	SE6		None	rh	
Barometric Pressure	SE7	12V	C7	baro	
Site Battery		Internal		Batt_volt	
Snow Depth	DIFF7	12V	C3	snow Depth	Judd Snow Depth sensor
Solar Radiation	DIFF8			solarRad	LiCor 1200X
Tipping Bucket Precip	C2	5V		tbNow , tbTotal	
Soil probes (1,2,3)	C1	SW12V	C1	soilMoist,(n), soilTemp(n)	Hydra II
Wind Speed	P1			w indSpeed	RM Young
Wind Direction	SE8	VX2		w indDirect	

Control Port Assignments

CONTROL	FUNCTION
C1	Hydra Probe SDI-12 port
C2	Tipping Bucket Input
C3	Judd Snow Depth control
C4	Global Modem power enable
C5	Serial data out to Global Modem
C6	Serial data from Global Modem
C7	Barometer control
C8	Force a Global Modem data message

Special Public Setup Variables

Important: These variables are saved frequently to the Setup table so that the values are retained in the event of power failure. These variables are reset to default values whenever the program is loaded, or reloaded into the CR1000.

Label	Functionality (Public Table)
SiteID	Numeric ID to identify the particular site
snowMult	Snow water multiplier
snowOffset	Snow water offset
precipMult	Storage Precip multiplier
precipOffset	Storage Precip offset
snowDepOffset	Snow depth offset
baroMult	Barometer multiplier
baroOffset	Barometer offset
hasYSI	set to 1 to enable a YSI 44211 air temperature sensor (default=1)
hasHMP45	set to 1 to enable HMP45 temp/rh sensor
hasTB	set to 1 to enable Tipping Bucket precipitation sensor
hasBaro	set to 1 to enable CS100 barometric pressure sensor
fastUpdate	Set to 1 to update all sensors at a ten second rate. (resets to 0 at midnight)
hasWind	Set to 1 to enable RM Young wind sensor
hasSoils	Set to 1 to enable 3 Hydra2 soil probes

Current Sensor Value Locations (Public Table)

These are **public** variables, which contain the current sensor readings.

Label	Functionality
Batt_Volt	Site Battery Voltage. Requires a battery voltage divider connected to the site battery.
snowWater	Snow Water (inches)
stoPrecip	Storage Precipitation (inches)
snowHeight	-1 * Snow depth sensor height measurement (inches)
snowDepth	snowHeight + SnowDepOffset
airTemp	Air Temp (deg F)
rh	Relative Humidity (percent)
solarRad	Solar Radiation (watts/meter^2)
baro	Barometer CS100 (millibars)
tbNow	Tipping bucket 10 second accumulation (hundredths of an inch)
tbTotal	Total TB accumulation
windSpeed	Wind Speed (mph)
windDirect	Wind Direction (degrees north)
soilMoist1	Soil Moisture (percent)
soilTemp1	Soil Temperature (degrees F)
soilMoist2	
soilTemp2	
soilMoist3	
soilTemp3	

Daily Sensor Value Locations (Daily Table)

These are public variables, which contain daily values processed by the program.

Label	Functionality
ProgramMajor	Integer portion of the data collection program version (1030)
ProgramMinor	Decimal portion of the data collection program version (0)
mnBattery	Midnight battery voltage sample
mnSnowWater	Midnight snow water sample
mnPrecip	Midnight storage precipitation sample
mnAirTemp	Midnight Air Temperature sample
MaxAirTemp	Daily Maximum Air Temperature
MinAirTemp	Daily Minimum Air Temperature
AvgAirTemp	Daily Average Air Temperature
mnSnowDepth	Midnight snow depth sample
DailySolRad	Daily Average Solar Radiation
mnRH	Midnight Relative Humidity sample
mnBaro	Midnight Barometer sample
mnTB	Midnight Tipping Bucket

Wind Sensor Value Locations (Wind Table)

These are public variables, hourly and daily pertaining to the wind sensor. Units are in degrees north and MPH.

Label	Functionality
wsMax	Wind Speed Hourly Maximum
wsAvg	Wind Speed Hourly Average
wdAvg	Wind Direction Hourly Average
wdStd	Wind Direction Hourly Std Deviation
wsDayMax	Wind Speed Daily Maximum
wsDayAvg	Wind Speed Daily Average
wdDayAvg	Wind Direction Daily Average
wdDayStd	Wind Direction Daily Std Deviation

Telemetered Data Reports

Important: Hourly reports are sent to the Global Modem and are also logged to the CR1000 Data Tables. All Global Modem values are sent in FP2 format, 16 bits per value.

Hourly report - group 1

<u>Sensor Field</u>	<u>Flag or Condition</u>
1 Site Battery Sample	
2 Snow Water hourly average	
3 Storage Precip hourly average	
4 Current Air Temperature	
5 Snow Depth hourly average	
6 Solar Radiation Hourly Average	
*7 Soil Moisture, 2"	hasSoils
*8 Soil Temperature, 2"	hasSoils
*9 Soil Moisture, 8"	hasSoils
*10 Soil Temperature, 8"	hasSoils
*11 Soil Moisture, 20"	hasSoils
*12 Soil Temperature, 20"	hasSoils
*13 Relative Humidity Current Sample	hasHMP45
*14 Barometric Pressure	hasBaro
*15 Tipping Bucket Accumulation	hasTB
*16 Wind Speed Hourly Max	hasWind
*17 Wind Speed Hourly Avg	hasWind
*18 Wind Direction Hourly Avg	hasWind
*19 Wind Direction Hourly Std Dev	hasWind
**20 Max Air Temperature	Midnight
**21 Min Air Temperature	Midnight
**22 Avg Air Temperature	Midnight
**23 Solar Radiation Daily Average	Midnight
**24 Wind Speed Daily Max	Midnight + hasWind
**25 Wind Speed Daily Avg	Midnight + hasWind
**26 Wind Direction Daily Avg	Midnight + hasWind
**27 Wind Direction Daily Std Dev	Midnight + hasWind
**28 Data Program Revision (30.00)	Midnight
**29 Program Flags hasWind, etc	Midnight
**30 SWE multiplier	Midnight
**31 SWE offset	Midnight
**32 PST multiplier	Midnight
**33 PST offset	Midnight
**34 SD offset	Midnight
**35 Baro multiplier	Midnight + hasBaro
**36 Baro offset	Midnight + hasBaro

Program Flags – Program control flags are packed into the Program Flags value of the Daily Report as follows:

Bit – Flag Functionality

- 0 hasYSI
- 1 hasHMP45
- 2 hasTB
- 3 hasBaro
- 4 hasWind
- 5 hasSoils
- 6 fastUpdate

These flags are included in the daily summary report, G2, as **pFLG** and can be viewed with the **Data Msgs** link from the site's Telemetry Status page entry. Although pFLG is normally formatted as an integer, the value can easily be converted manually to binary to decipher the state of the individual flag bits.

***Sensor Fields 13 through 19 are individually enabled with setup flags as follows:**

<u>Setup Flag</u>	<u>Sensor Field</u>
hasSoils	3 Hydra2 soil probes
hasHMP45	Relative Humidity
hasBaro	Barometric Pressure
hasTB	Tipping Bucket Precipitation Accumulation
hasWind	Wind

Important: If any of the above, asterisk (*) marked sensor fields are enabled, that sensor field is added to the telemetry report, making the report one field longer than the base of 12 sensors. Optional sensors are added in order listed above. So, for example, if hasHMP45 is 1, the Relative Humidity value is added at position 13, immediately following Soil Temperature, 20".

At midnight, sensor fields marked with ** are appended to the end of the data message. The midnight data message can be as long as 35 values.

Revision History

Revision 1031.0

Initial release of 7/19/2011.

Revision 1031.01

8/20/2011 – revision solves a problem with the hourly wind summaries. Also introduces a persistent midnight data report flag: if the midnight report is not delivered for any reason (msgSent == 0), the next report will contain the midnight values.

Revision 1031.02

9/8/2011 – Rev.01 incorrectly ordered the soils values in the hourly report, although they were correctly ordered in the hourly data table. Rev.02 corrects this, as well as an incorrectly ordered default hourly sensor value set when there is no table data (prior to first hour crossing).

Selecting the Air Temperature and rH Sensors

By default, this program utilizes a YSI 44211 wide-range air temperature sensor. As an alternative, an HMP45 temperature/rH sensor may be installed instead or in addition. If you install an HMP45 sensor, you must set the setup variable named **hasHMP45** to 1. Doing so will enable the HMP45 sensor. **Important:** The sensor variable named **airTemp** will display the air temperature sampled from the HMP45 sensor when hasHMP45 is non-zero (1) and hasYSI is zero. If hasYSI is non-zero (1), airTemp will display the YSI air temperature sensor value. If hasYSI is non-zero and hasHMP45 is non-zero, the reports will use the YSI temperature and the HMP45C rH value. The following table summarizes the actions resultant from hasYSI and hasHMP45 setup variables.

<u>hasYSI</u>	<u>hasHMP45</u>	<u>Action</u>
1	0	airTemp from YSI; rH is excluded from data report
0	1	airTemp and rH from HMP45; rh is included in data report
1	1	airTemp from YSI; rH from HMP45; rH is included in data report

Enabling the Hydra2 Soil Probes

By default, the soil probes are disabled, meaning that they will neither be sampled (read) or telemetered, and their public sensor values (soilMoist1 through soilTemp3) are set to -99.9. To enable the set of 3 soil probes, edit the setup variable **hasSoils** and make its value equal to 1.0. if fastUpdate is set to 1, the soils probes will be sampled every pass through the main scan loop (every 10 seconds), otherwise they are sampled only at 59 minutes past each hour.

Setting Barometric Sensor Parameters

By default, the barometric pressure sensor is disabled. To enable the barometer, set the Setup Variable **hasBaro** to 1. By default, the barometer multiplier and offset are setup for the Vaisala PTB101 sensor, also sold by Campbell Scientific as model CS105. This sensor is no longer available from CSI, so the table below provides barMult and Offset values for both the Vaisala and the Setra 278 (CS100) barometers.

<u>Barometer Setup Variable</u>	<u>Vaisala PTB101 CS105</u>	<u>Setra 278 (CS100)</u>
baroMult	0.184	0.200
baroOffset	600	600

Setting the Snow Depth Offset Variable

The Judd snow depth sensor actually reports the distance between itself and the ground or the top surface of the snow pack. This program allows the technician to apply an offset which will convert the distance reported to actual snow depth. The snow distance (Sn_height) is made negative, then the offset (SnowDOff) is added to derive the actual snow depth. To adjust the snow depth offset simply **right click**, then edit the Input Storage Location variable named **SnowDepOffset**. If the snow depth sensor is sitting above bare ground, the value of SnowDepOffset should be set to the distance (snowHeight) reported by the sensor. **Caution:** The technician should record the height of the snow depth sensor above bare ground in case the CR1000 program needs to be reloaded during the snow season.

Setting the Site ID Variable

This program saves a variable named **SiteID** in the data summaries to help eliminate the possibility of confusing data records among the various data sites. To adjust the SiteID, simply **right click** then edit the location on the Numeric Display. The new SiteID will then be included in all subsequent data summaries.

Setting Snow Water and Precipitation Parameters

The Snow and Precip transducer sensors may be one of several types. When installing a new sensor, first verify that the sensor you are installing is compatible with the existing wiring scheme in use at the site. A couple of things to consider:

- What is the sensor's output? If the sensor's output is 4-20ma, then a termination resistor should be used at the SE inputs of the CR1000.
- What is the sensor's excitation requirement? If the sensor requires an excitation voltage other than 12VDC, some voltage conversion method may be required.

When changing a sensor, you must edit two input locations. For snow water, the locations are named **snowMult** and **snowOffset**. For storage precip, the locations are named **precipMult** and **precipOff**. Edit the locations according to this table:

Sensor	Mult	Offset	Comment
100" Druck PMP 317 used w/o 2:1 divider	0.02	-1.0	Range is 0-100"
200" Druck PMP 317 used w/o 2:1 divider	0.04	-2.0	Range is 0-200"
0-69" Druck	0.0308	-7.7	
0-50" Sensotech or Halpern	0.02	0.0	
0-100" Sensotech or Halpern	0.04	0.0	
0-200" Sensotech or Halpern	0.08	0.0	

PTX7533 Druck Submersible with 240 Ohm Termination Resistor:

PSI	Feet	Inches	multiplier (m)	offset (b)
1.5	3.460	41.52	0.01081	-10.38

Note: The Druck PMP317 transducers are calibrated by NWCC personnel. The table above assumes 0" equals 50 millivolts, and full scale equals 5050 millivolts. If this is not the case for your transducer, you may have to calculate the multiplier and offset. Use the following general formulae:

$$\text{Mult} = \text{fs} / 5000$$

Where fs is full scale value in inches ie: 100", 200"

$$\text{Offset} = 50 * \text{mult}$$

If these variables are set correctly, the Numeric Display tab should display the actual head on the transducers at the following Input Storage Locations:

snowWater for the snow water sensor

stoPrecip for the storage precip sensor

Note: If either the snow or precipitation sensor is not used, set its multiplier and offset to 0.0. This will force the CR1000 to record zero values for the non-existent sensor.

Forcing a Data Message

This program normally generates one or two data messages at the end of each hour. These data messages are sent to the **Global Modem** data modem. Usually it is highly inconvenient to wait for the end of the hour when one wishes to observe a data message being delivered to the **Global Modem** data modem. By temporarily connecting **5V** to **C8** on the CR1000 wiring panel, the technician can force the CR1000 to immediately send its hourly data messages to the **Global Modem** data modem.

Use the following procedure to force a new data message, and observe it at the **Global Modem** operator's console.

1. After completing sensor validation with LoggerNet, make sure the CR1000 public variable **msgSent** is visible in LoggerNet's Numeric Display.
2. On the CR1000 Wiring Panel, momentarily connect a jumper wire between **5V** and **C8**. This will initiate a new data message from the CR1000 within 10 seconds.
3. Observe the three lights in the **Global Modem** front panel window. Two lights should light within 10 seconds of step 2, above. This indicates that power has been applied to the **Global Modem** circuit board and the 9602 Iridium modem.
4. After a few seconds, the third **Global Modem** light should illuminate, indicating that the modem can see the Iridium satellite constellation.
5. In a few seconds, all three lights should go out. This indicates that the modem has delivered the data message to the Iridium network for delivery to AMBCS.
6. You can verify that the data message was delivered by observing the following CR1000 variables:
 - **commState** – holds the text value "msgSent" if the current message has been delivered across the network, or "Msg Failed" if repeated attempts to send the message has failed to deliver the message across the network.. Any other text value may indicate communication in progress.
 - **tries** – This variable indicates how many times (0-5) the program has attempted to deliver the data without delivery confirmation having been received from the network. Each "try" consists of powering the modem up, and attempting to connect with the Iridium global network, verifying network availability, sending the message to the network and awaiting delivery confirmation.
 - **sendLoop** – This variable indicates how many times (0-10) the program has looped in attempt to deliver the data message. The program will loop 10 times in attempt to "try" to deliver a message, waiting 20 seconds between attempts.
 - **msgSent** - This variable is 0 if the data message has not been delivered, and is 1 when the message has been delivered.

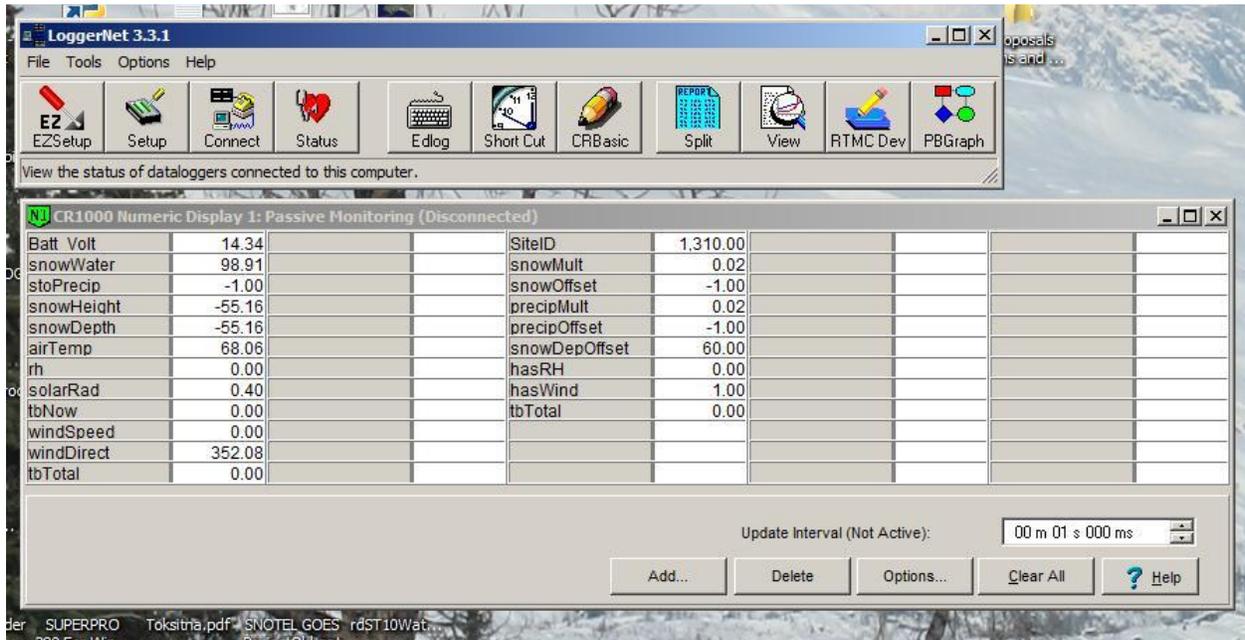


Figure One – Typical LoggerNet Numeric Display with Variables