

Micro Specialties, Inc.
CR1000 Data Collection Program
Version 1031.14x
Revised March 1, 2017

<u>Station Type</u>	<u>Update Rate</u>	<u>Data Groups</u>	<u>Rpt Length</u>	<u>Report Rate</u>
SNOTEL	5 minutes (1)	Two: hour, midnight	2 to 54	1 hour

<u>Optional Sensors</u>	<u>CR1000 Flag Location</u>	<u>Default</u>
Snow Water Content	hasSWE	1
Snow Scale	hasSnowScale	1
Storage Precipitation	hasPST	1
YSI Air Temperature	hasYSI	1
HMP45 temp/rh	hasTempRH	0
Solar Radiation	hasSolrad	1
Tipping Bucket Accumulation	hasTB	0
Barometric Pressure	hasBaro	0
Wind	hasWind	0
0 to 10 Hydra2 Soil Probes	numSoilProbes	0

Important: If any of the above sensor fields are enabled, that sensor field is added to the telemetry report, making the report at least one field longer than the base of 2 sensors. For snow and precipitation sensors, the multiplier and offset values are also added to the midnight data group if that sensor is enabled.

Non-optional Sensors

Battery
Snow Depth

See this program's configuration webpage for details regarding the data stream and throughput costs for various configurations:

http://denali.micro-specialties.com/cgi/prog1031_14DataStream.cgi

Current Revision: 1031.14x (descendant of 1031.11)

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. Wind sensors are always sampled at a 10 second interval. The telemetry values are sent using the FP2 short floating point numeric system. Each value occupies 16 data bits.

This version improves SnowDepth accuracy through the use of special snow depth array processing which accurately and reliably finds the true median of the hourly snow depth sample array.

1031.14x resets its MOMSN variable each midnight. This will resolve any scenario in which the modem's msgsn variable might "roll over", or if the modem is replaced, which would make msgsn zero.

This program produces one hourly data report and requires MSI's Global Modem Iridium data modem. Daily values are appended to the midnight report.

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. **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 also **Setting Snow Water and Precipitation Parameters** below.
3. **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.
4. **Soil Probes** – 0 through 10 Hydra II soil probes are sampled. If fastUpdate is 1, the soil probes are sampled every 60 seconds. Otherwise the soil probes are sampled at 59 minutes past the hour only, and only if numSoilProbes is greater than zero.
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 CR1000 Configuration

SENSOR	INPUT	EXITATION	XTROL	VARIABLE	SENSOR MODEL
Snow Water	SE1	SW12V	C9	snowWater	
Snow Scale	SE2,3,9	5V		sweSnowScale	SSC300
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	snowDepth	Judd Snow Depth sensor
Solar Radiation	DIFF8			solarRad	LiCor 1200X
Tipping Bucket Precip	C2	5V		tbNow, tbTotal	
Soil probes (1..10)	C1	SW12V	C1	soilMoist(n), soilTemp(n)	Hydra II
Wind Speed	P1			windSpeed	RM Young
Wind Direction	SE8	VX2		windDirect	

CR1000 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 Public 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.

Important: These variables are defined in the Public table, but are saved automatically to the Setup table. You should edit the variables only in the Public table. Never edit or modify the variables in the Setup table.

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
hasSWE	set to 1 to enable the Snow Water sensor (default=1)
hasSnowScale	set to 1 to enable the Snow Scale sensor (default=1)
hasPST	set to 1 to enable the Storage Precipitation sensor (default=1)
hasYSI	set to 1 to enable a YSI 44211 air temperature sensor (default=1)
hasHMP45	set to 1 to enable HMP45 temp/rh sensor (default=0)
hasSolRad	set to 1 to enable the Solar Radiation sensor (default=1)
hasTB	set to 1 to enable Tipping Bucket precipitation sensor (default=0)
hasBaro	set to 1 to enable CS100 barometric pressure sensor (default=0)
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 (default=0)
numSoilProbes	Set to number Hydra2 soil probes deployed (default=0)
LC1_m	Snow Scale Load Cell 1 multiplier
LC1_o	Snow Scale Load Cell 1 offset
LC1_b	Snow Scale Load Cell 1 calculated offset for "b" value in equation $Y=mx+b$..usually not necessary
LC2_m	Snow Scale Load Cell 2 multiplier
LC2_o	Snow Scale Load Cell 2 offset
LC2_b	Snow Scale Load Cell 2 calculated offset for "b" value in equation $Y=mx+b$..usually not necessary
LC3_m	Snow Scale Load Cell 3 multiplier
LC3_o	Snow Scale Load Cell 3 offset
LC3_b	Snow Scale Load Cell 3 calculated offset for "b" value in equation $Y=mx+b$..usually not necessary

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)
sweSnoScale	Snow Scale Water Equiv. (inches)
SWE1_inch	SnowScale segment 1 (inches)
SWE1_inch	SnowScale segment 2 (inches)
SWE3_inch	SnowScale segment 3 (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)
soilMoist(1)	Soil Moisture (percent)
soilMoist(2)	
soilMoist(3)	
soilMoist(4)	
soilMoist(5)	
soilMoist(6)	
soilMoist(7)	
soilMoist(8)	
soilMoist(9)	
soilMoist(10)	
soilTemp(1)	Soil Temperature (degrees F)
soilTemp(2)	
soilTemp(3)	
soilTemp(4)	
soilTemp(5)	
soilTemp(6)	
soilTemp(7)	
soilTemp(8)	
soilTemp(9)	
soilTemp(10)	
LC_1_mV	Millivolt output from Snow Scale Load Cell 1
LC_2_mV	Millivolt output from Snow Scale Load Cell 2
LC_3_mV	Millivolt output from Snow Scale Load Cell 3
LC_1_Tare	LC_n_mv - LC_n_o (sensor offset removed)
LC_2_Tare	LC_n_mv - LC_n_o (sensor offset removed)
LC_3_Tare	LC_n_mv - LC_n_o (sensor offset removed)
SWE1_inch	SWE pressure in inches of water for load cell #1
SWE2_inch	SWE pressure in inches of water for load cell #2
SWE3_inch	SWE pressure in inches of water for load cell #3
sweDundorf	SWE calculated by Dundorf equation

Daily Sensor Value Locations (Daily Table)

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

Label	Functionality
mnAirTemp	Midnight Air Temperature sample
MaxAirTemp	Daily Maximum Air Temperature
MinAirTemp	Daily Minimum Air Temperature
AvgAirTemp	Daily Average Air Temperature
DailySolRad	Daily Average Solar Radiation
windSpeed Max	Daily Maximum Wind Speed
windSpeed WVc(1)	Daily Wind Speed Vector Average
windSpeed WVc(2)	Daily Wind Direction Vector Average
windSpeed(WVc(3)	Daily Wind Direction Standard Deviation
tbTotal	Midnight tipping bucket accumulation

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.

See this program's webpage to view the data stream generated by the program with various sensor enabling Program Flags: http://denali.micro-specialties.com/cgi-bin/prog1031_14DataStream.cgi

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 fastUpdate
- 6 hasSWE
- 7 hasPST
- 8 hasSolRad
- 9 hasSnoScale

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.

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 **hasTempRh** 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>hasTempRH</u>	<u>Action</u>
1	0	airTemp from YSI; rH is excluded from data report
0	1	airTemp and rH from the temp/rh sen; rH is included in data report
1	1	airTemp from YSI; rH temp/rh sen; 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 soil probes, edit the setup variable **numSoilProbes** and make its value equal to the number of probes deployed. If fastUpdate is set to 1, the soils probes will be sampled once per minute, 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 can 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
2.5	5.768	69.20	0.01802	-17.299
5.0	11.54	138.42	0.03605	-34.608
7.5	17.303	207.63	0.05407	-51.907

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 “msg Delivered” 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.
 - **rptAttempts, rptFailures** – Running count of message delivery attempts and failures.. rptAttempts is incremented each time a message is passed to the Global Modem for delivery. rptFailures is incremented each time a report fails to be delivered. Both counters are reset to zero if rptAttempts exceeds 8000.
 - **MOMSN** – This is the modem's current network modem-originated message serial number. The logger program tracks the MOMSN to verify that the current report-in-progress has been properly acknowledged by the network. This number will automatically reset at midnight. When replacing a modem, it is recommended that operator set MOMSN to -1. This will allow the process to synchronize to the new modem correctly.

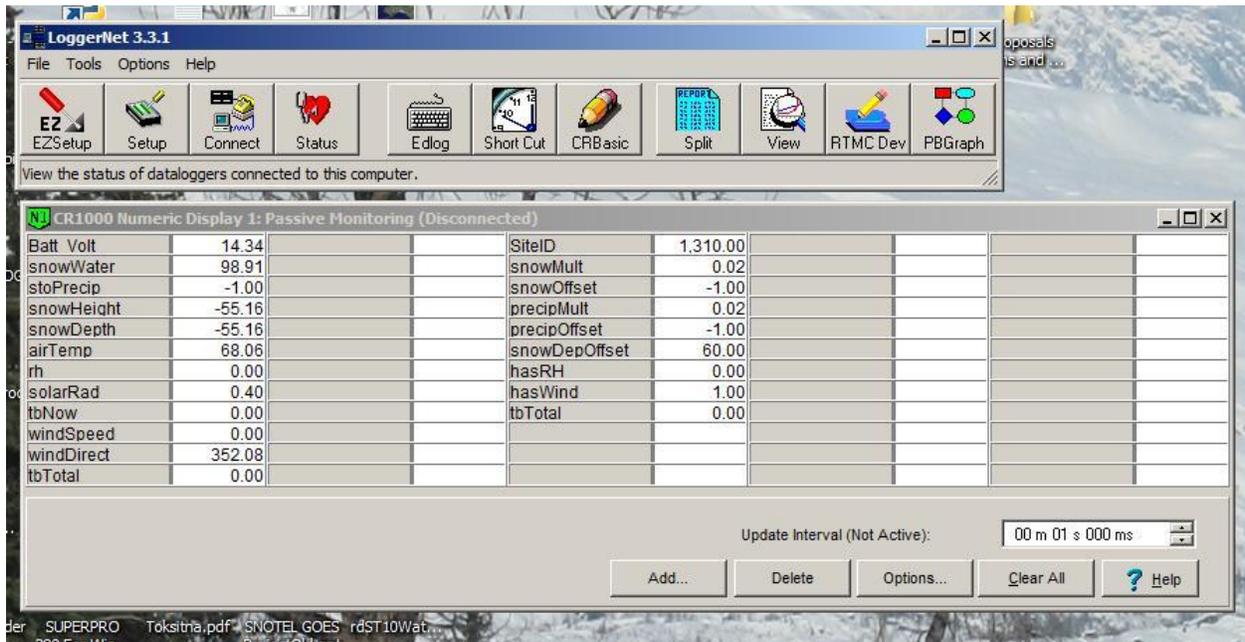


Figure One – Typical LoggerNet Numeric Display with Variables