Global Modem CR1000 Basic Weather Station for AELP

Revision: AELP3_GM.CR1 Date: 11/15/2016

This data collection program revision implements a configurable telemetry weather station for Alaska Electric Light and Power (AELP) with automated telemetry using MSI's Global Modem which operates within the Iridium global network. This program is based on AELP1e_GM.cr1, adding optional sensors which are enabled by editable program control varaiables.

Sensors

Parameter	Sensor	Sensor Variables	Control Variable
Battery Voltage	CR1000 internal	BattV	
Barometer	Setra 278 (CS100)	BaroMb	hasBaro
Air Temperature	Rotronix HC2S3	AirTC	
Relative Humidity	Rotronix HC2S3	RH	
Wind	RM Young 050103	WS_ms, WindDir	hasWind
Snow Depth	Judd Sonic	snowDepthCm	hasSnoDepth
Snow Board	Judd Sonic	snowBoardCm	hasSnoBoard
Solar Radiation	Apogee SP230	solRadWm2	hasSolRad
Net Solar Radiation	Apogee SN500	sn500SWin, n500SWout, sn500LWin, sn500LWout	hasNetRadiation
Precipitation	Ott Pluvio	totaPrecipIntRT, totalPrecipAccRT	hasPluvio
Precipitation	Tipping Bucket	totalPrecipTB	hasTipBucket
Snow Temperature	Apogee ST100 (3)	T109_C_01, T109_C_02, T109_C_03	hasSnoTemps

Sensor Sample Rate

All Sensors except snow depth, barometer and Pluvio	3 seconds
Snow Depth, Barometer	60 minutes*
Pluvio precipitation sensor	1 minute

*The snow depth and barometer are sampled normally at 58 minutes past the hour, except when special control variable fastUpdate is > 0, in which case they will be sampled once per minute. FastUpdate will be cancelled automatically at the end of the hour. The snow depth (snowDepthcm) has a companion variable, snowSensorHeightcm, which when set to the height of the sensor above ground, will cause the value returned to be the snow depth in centimeters, rather than the distance from the snow pack to the sensor. **See Understanding and Setting the Snow Depth Variables section on page 4**.

Sensor wiring				
Sensor	**Function**	**Wire Color**	**CR1000 Wire Point**	**Sample Rate**
Wind - RM Young	Speed Signal	Red (Red)*	P1	3 seconds
	Speed Return	Black (Blu)*	G	
	Direct. Excitation	Blue (Wht)*	VX1	
	Direction Signal	Green (Grn)*	SE1	
	Direction Return	White (Blk)*	Analog Ground	
	Static Shield	Shield	G	
Air Temp/RH (HC2S3-L)	Air Temp Signal	Brown	SE3	3 seconds
	RH Signal	White	SE4	
	Signal Return	Yellow	Analog Ground	
	Sensor Power	Green	12V	
	Sensor Pwr Ground	Gray	G	
	Static Shield	Shield	G	
Snow Depth Judd	Sensor Power	Red	12V	hourly
	Sensor Enable	Green	C3	
	Signal +	White	DIFF7H	
	Signal -	Brown	DIFF7L	
	Power Ground	Black	G	
	Static Shield	Shield	G	
Snow Board Judd	Sensor Power	Red	12V	hourly
	Sensor Enable	Green	C2	
	Signal +	White	DIFF6H	
	Signal -	Brown	DIFF6L	
	Ground	Black	G	
	Static Shield	Shield	G	
Setra 278 Barometer	Power	Red	12V	1 minute
	Signal	Blue	SE9	
	Ground	Black	G	
	Signal Ground	Yellow	Analog Ground	
	Trigger	Green	C8	
	Shield	Clear	G	
Apogee SP230 Pyrometer	Signal +	Red	DIFF8H	1 minute
	Signal -	Black	DIFF8L	
	Analog Ground	Clear	Analog Ground	
	Heater +12V	White	12V	
	Heater Ground	Green	G	
Apogee SN500 Net Radiometer	Power +	Red	12V	1 minute
	Data	Black	C1	
	Ground	White, Shield	G	
Generic Tipping Bucket Precip.	Signal		P2	3 seconds
	Signal Return		G	
Ott Pluvio Storage Precip.	12V Sensor Supply	Green	12V	1 minute
	SDI12 Data	White	C7	
	Common	Black	G	
Snow Pack Temperature 1	Excitation	Red	VX3	3 seconds
	Signal	Black	SE5	
	Signal Ground	Blue, Shield	Analog Ground	
Snow Pack Temperature 2	Excitation	Red	VX3	3 seconds
	Signal	Black	SE6	
	Signal Ground	Blue, Shield	Analog Ground	

Snow Pack Temperature 3	Excitation	Red	VX3	3 seconds
	Signal	Black	SE7	
	Signal Ground	Blue, Shield	Analog Ground	

***Wind sensor wire colors in parentheses are for the RMYoung Alpine sensor purchased directly from Young. The non-parentheses colors are for the young sensor purchased from Campbell Scientific.**

Logger Tables

Hourly Table

The hourly data report via telemetry is built from the hourly data table and some setup parameters.

Parameter	Units	Process	Local Variable Name
Battery	Volts	Sample	tdhBatt
Barometer	Millibars	Sample	tdhBaro
Air Temperature	Deg C	Sample	tdhAirTempC
Relative Humidity	Percent	Sample	tdhRHpct
Wind Speed	Meters/Second	Maximum	tdhWsMaxMps
Wind Speed	Meters/Second	Vector Average	tdhWsAvgMps
Wind Direction	Degrees	Vector Average	tdhWdAvgDeg
Wind Direction	Degress	Std Deviation	tdhWdStdDev
Snow Depth	Centimeters	Sample	tdhSnowDepthCm
Snow Board	Centimeters	Sample	tdhSnowBoardCm
Snow Temperature1	Degrees C	Sample	tdhSnoTemp1
Snow Temperature2	Degrees C	Sample	tdhSnoTemp2
Snow Temperature3	Degrees C	Sample	tdhSnoTemp3
Tipping Bucket Precip	Millimeters	Sample	tdhPrecipTBmm

SolarHourly Table

Parameter	Units	Process	Local Variable Name
Solar Radiation	Watts/Meter	Average	tdhsSolRadWm2
Short Wave In	Watts/Meter	Average	tdhsSWinWm2
Short Wave Out	Watts/Meter	Average	tdhsSWoutWm2
Long Wave In	Watts/Meter	Average	tdhsLWinWm2
Long Wave Out	Watts/Meter	Average	tdhsLWoutWm2

Pluvio Hourly Table

This table logs the two primary rainfall accumulation variables from the Ott Pluvio precipitation sensor.

Parameter	Units	Process	Local Variable Name
PluvioAccRT_NRT	cm	Sample	
PluvioAccNRT	cm	Sample	

six2six Table

This table runs at 0600 each day and is populated with 24 hour calculations. Most of its content is reported at 0600 each day via Global Modem only.

Parameter	Units	Process	Local Variable Name
Air Temperature	Degrees C	Maximum	tddAirTempMax
Air Temperature	Degrees C	Minimum	tddAirTempMin
Air Temperature	Degrees C	Average	tddAirTempAvg
Relative Humidity	Percent	Maximum	tddRHmax
Relative Humidity	Percent	Minimum	tddRHmin
Relative Humidity	Percent	Average	tddRHavg
Wind Speed	Meters/Second	Maximum	tddWindSpMax
Wind Speed	Meters/Second	Minimum	tddWindSpMin
Wind Speed	Meters/Second	Average	tddWindSpAvg
Battery	Volts	Maximum	tddBattMin
Battery	Volts	Minimum	tddBattMin
Battery	Volts	Average	tddBattAvg
Solar Radiation	Watts/Meter	Average	tddSolRadAvg
Solar Radiation	Watts/Meter	Maximum	tddSolRadPeak

Setup Table

The setup table contains operational parameters which must be retained through a battery failure. The setup parameters are loaded when the program restarts following a low battery condition or when power is removed from the logger.

Note: The Setup Table is destroyed when a new program is sent to the logger.

Parameter	Functionality	Default
setUpTest	Table validity test	None
snowSensorHeightcm snowBoardHeightcm	The snow depth sensor height AGL, in centimeters (for both snow depth sensors)	None
hasTipBucket	Enables the tipping bucket precip sensors	1 (enabled)
hasPluvio	Enables the Ott Pluvio precipitation sensor	0 (disabled)
hasSolRad	Enables the Solar Radiation sensor	1 (enabled)
hasNetRadiation	Enables the sn500 Net radiation sensor	1 (enabled)
hasBaro	Enables the CS100 barometer	1 (enabled)
hasSnoDepth	Enables the Judd Snow Depth sensor	1 (enabled)
hasSnoBoard	Enables a Judd Snow Board Sensor	1 (enabled)
hasSnoTemps	Enables three (3) Apogee ST100 temperature sensors	1 (enabled)
hasWind	Enables a Young Anemometer	1 (enabled)
totalPrecipIntRT	Running Accumulation: Pluvio Intensity RT_NRT	None
totalPrecipAccRT_NRT	Running Accumulation: Pluvio AccRT_NRT	None
totalPrecipTB	Running Accumulation: Tipping Bucket	None
PluvioRimHeat	Current State (1 = on, 0 = Off)	None
rptsAttempted	Number of reports posted for delivery	None
rptsFailed	Number of reports which failed to be delivered	None

Telemetry Report Content

Telemetry Report Interval: 60 minute Interval

Pos.	Source Label	Conditions	Default Condition
1	tdhBatt	Always Enabled	
2	tdhAirTempC	Always Enabled	
3	tdhRHpct	Always Enabled	
4	tdhWsMaxMps	If enabled (hasWind > 0)	Enabled
5	tdhWsAvgMps	If enabled (hasWind > 0)	Enabled
6	tdhWdAvgDeg	If enabled (hasWind > 0)	Enabled
7	tdhWdStdDev	If enabled (hasWind > 0)	Enabled
8	tdhSnowDepthCm	If enabled (hasSnoDepth > 0)	Enabled
9	tdhSnowBoardCm	If enabled (hasSnoBoard > 0)	Enabled
10	totalPrecipIntRT	If enabled (hasPluvio > 0)	Disabled
11	totalPrecipTB	If enabled (hasTipBucket > 0)	Enabled
12	tdhBaroMB	If enabled (hasBaro > 0)	Enabled
13	tdhSolRadWm2	If enabled (hasSolRad > 0)	Enabled
14	tdhsSWinWm2	If enabled (hasNetRadiation > 0)	Enabled
15	tdhsSWountWm2	If enabled (hasNetRadiation > 0)	Enabled
16	tdhsLWinWm2	If enabled (hasNetRadiation > 0)	Enabled
17	tdhsLWoutWm2	If enabled (hasNetRadiation > 0)	Enabled
18	tdhSnoTemp1	If enabled (hasSnoTemps > 0)	Enabled
19	tdhSnoTemp2	If enabled (hasSnoTemps > 0)	Enabled
20	tdhSnoTemp3	If enabled (hasSnoTemps > 0)	Enabled

Daily summary values added to hourly report at <u>6 AM only</u>

21	tddAirTempMax	Always Enabled	
22	tddAirTempMin	Always Enabled	
23	tddAirTempAvg	Always Enabled	
24	tddRHMax	Always Enabled	
25	tddRHMIn	Always Enabled	
26	tddRHAvg	Always Enabled	
26	snowSensorHeightcm	If enabled (hasSnoDepth > 0)	Enabled
27	snowBoardHeightcm	If enabled (hasSnoBoard > 0)	Enabled
28	tddWindSpMax	If enabled (hasWind > 0)	Enabled
29	tddWindSpMin	If enabled (hasWind > 0)	Enabled
30	tddWindSpAvg	If enabled (hasWind > 0)	Enabled
31	tddSolRadAvg	If enabled (hasSoRad > 0)	Enabled
32	tddSolRadPeak	If enabled (hasSoRad > 0)	Enabled
33	rptsAttempted	Always Enabled	
34	rptsFailed	Always Enabled	
35	packedFlags	This variable contains the sensor control flags	

Understanding the Snow Depth Sensors and their Variables

The Snow Depth Sensor measures the distance from the gold disk on the bottom of the sensor to the ground, or the top of the snow pack. The sensor has a 15 degree visibility "cone", so the distance to the closest object to the sensor within that 15 degree cone will be the distance measured by the sensor. The data collection program uses several variables to resolve and adjust the snow depth values recorded. The following table describes the logger program variables which are used to interrogate the snow depth sensor. No averaging or array processing is utilized in this program. The program normally simply captures one reading from each snow depth sensor at 59 minutes past the hour, but the rate at which the snow depth sensors are interrogated can be temporarily increased to once per minute by setting the value of fastUpdate to 1. fastUpdate active upon program startup, and is always reset (deactivated) at the end of the current hour.

The **snowSensorHeightcm** variable is saved in the program's **setup table**, on every odd minute, so are not reset when logger power is removed.

Logger Variable	Units	Functionality
snowDistRawcm	Centimeters	The measured distance between the snow sensor and the snow pack
TCSD	Centimeters	The snowDistRaw value adjusted for the current air temperature.
snowSensorHeightcm	Centimeters	The height of the snow depth sensor above ground level (AGL). TCSD is subtracted from the snowSensorHeight to derive the snowDepth.
snowDepthcm	Centimeters	The height of the top of the snow pack above bare ground level (AGL).
TCSD1	Centmeters	The Temp Compensated distance measurement from the SnowBoard sensor
snowboardHeightcm	Centimeters	The snow board height above the bare board.
snowBoardCm	Centimeters	SnowBoardCm = snowBoardHeightcm – TCSD1

Setting the Snow Sensor Height Values

The logger program derives the snow depth for each sensor by subtracting the temperature compensated snow distance (TCSD) from the snow sensor height above ground level (snowSensorHeightcm) as follows:
snowDepthcm = snowSensorHeightcm –TCSD

You should set the snowSensorHeightcm variable after the sensor has been installed and the logger program has been loaded into the logger. The snowSensorHeightcm variable is retained in the setup table, even if site power is lost. The only times the

snowSensorHeightcm variable need to be edited are when the snow depth sensor is relocated or when the program is loaded into the logger.

The snowSensorHeightcm variable is initially set to 0.0 (zero) when the program is loaded into (sent to) the logger. This means that the reported **snowDepthcm** will be equal to the **TCSD.** To set the snowSensorHeightcm variable:

1. Set the **fastUpdate** variable to 1. This will cause the program to read the snow depth sensor once per minute until the end of the current hour. At the end of the current hour fastUpdate will be reset automatically.
2. If you know the exact distance from the snow depth sensor to bare ground, set that distance in centimeters into the snowSensorHeightcm variable.
3. If you do not know the distance from the sensor to bare ground, you can probe the snowpack under the snow depth sensor to determine the snow depth. You can then set the snowSensorHeightcm so that the snowDepthcm indicates the correct snow pack depth.

Either way, you should record the snowSensorHeightcm so that you will know what value to set it to if you ever have to reload the logger program, or replace the logger. This program adds the **snowSensorHeightcm** variable to the telemetry report at 0600 each day as an integrity check.

Barometer Sampling Rate

This program now employs only a Setra 278 pressure sensor. Since barometric pressure changes slowly, there is no need to sample it at the 3 second sampling rate used for wind. Therefore the barometer is sampled only once per hour, at 54 minutes past the hour, unless fastUpdate is greater than zero. When fastUpdate is greater than zero, the barometer is sampled once per minute.

Global Modem Wiring

The Global Modem should be wired directly to the CR1000 data logger's wiring panel as follows. The modem has two cables: one for **power** and the other for **data** connectivity with the logger. Wire the modem to the CR1000 wiring panel per the table below

Cable	Function	Wire Color	CR1000 Wire Point
Data	TXD	Green	C6
	RXD	Red	C5
	PWR ENABLE	White	C4
	GND	Black	G
Power	+12V	Red	12V
	-12V	Black	G

Forcing a Data Message

During a site visit, it is sometimes helpful to force the logger to transmit a data message to verify communications are working. In this revision, no pulse ports are available for manually triggering a report . In this revision, a report can be triggered by setting the **reportTrigger** variable to 1. When you initiate a report in this way, you should see the modem power up as its status lights will illuminate. Once the report is initiated reportTrigger will be automatically reset to zero. See the Global Modem Performance Evaluation document for more information regarding Global Modem performance monitoring.