DYNAMET 5

Weather Station

User Manual v. 2.1

Version 2.1

This manual refers to Lascano-Van Bavel ETP computation algorithm, implementation of the algorithm in Dynamet 5 weather station, including PC400 data logger support software for Dynamet 5 Weather station.

Updated: 12/19/2019

Includes documentation for Lascano-van Bavel RCM ET computation algorithm. Programs written and algorithms verified by

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1.0 Introduction to Dynamet 5

The Dynamet 5 weather station is completely pre-wired, and assembled in a weatherproof enclosure, including software to read data from weather sensors. Data is collected and stored in the data logger non-volatile memory. Up to 500,000 records (180 days) can be stored in the data logger. A block diagram of Dynamet 5 weather station logger is shown on the following page. Data logger and weather sensors are installed on a 6ft. (2 m) tripod with collapsible legs, ground stakes, and slide collars for leveling. A crossbar is used for mounting the wind set, pyranometer and leveling stand, and a 12-plate radiation shield for RH/temperature probe are installed as shown in the figure below. Grounding rod, Lightening arrestor, and ground rod cables are required to protect system from lightening surges. The Dynamet 5 weather station is a specially designed automated system to record the critical weather parameters affecting the growth and harvest yield of crops.

Each station includes software for weather data retrieval, and RCM ETP algorithm, Lascano-Van Bavel Evapotranspiration (ETP), for computing ETP in mm/hr, with daily water use. Crop growth models and Crop Water Index are developed with this information for grower applications of irrigation, pest control, and performing the optimum harvest. Many other crop manager decisions can benefit from the hourly weather records, and current information. Standard evapotranspiration modeling software is packaged with the Dynamet 5 weather station. The purpose is to compute the potential evapotranspiration from short grass (ETP) in mm per hour on an hourly basis. A daily total in mm is also computed. The algorithms are based on the method originally proposed by Penman, but with several modifications by Dr. C.H.M. Van Bavel and Dr. Robert J. Lascano, that updated the procedure.

Dynamet 5 System Features

- Portable 2 meter (6ft) tripod,
  - 3 meter (10ft) optional
- Sealed enclosure
- MaxiMet GMX500 Weather Station
- Ultrasonic wind speed & direction
- Built in ETo iterative RCM calculation
- CR1000 data logger
- 10 Watt solar panel, mast mounted
- Battery and charger circuit
- Scientific grade weather sensors
- 500,000 data values in recorded data memory
- 2 MB Total program and storage memory
- RS-232 Interface, USB and PC 9-pin cable (3 m)
- Power Up Program Start
- PC400 support software

1.1 Unpacking

Using the following bill of materials, open the cartons and check off the items to see that all material was received in good condition. Notify Dynamax no later than 10 days after receipt if there are any discrepancies. Notify the shipper and Dynamax immediately if goods are damaged in transit by mishandling. The white Dynamet 5 enclosure contains the CR10000 logger, voltage regulator for solar panel (sometimes voltage regulator may be installed at the back of the solar panel). Sensor cables with sensors installed on the end, and 5' RS232 interface cable, exit from the bottom of the system enclosure. Each sensor lead is labeled with a sequence number.
Be careful at all times not to step on or otherwise bend the gage connector leads.

A CD Rom containing your programs includes:
PC400 software supplied with Dynamet 5 systems. A PC400 manual is included in a pdf form. Dynamet 5 data logger programs directory with the standard program, and a test program. A directory with your custom program tuned for your weather application, to run the logger with additional sensors, and a specific solar sensor supplied for your weather station.

1.1.1 Bill of materials

1. CM106 – 10ft Tripod with Grounding and antenna Kit
2. Mounting arm – Cross Mount and 1" (25 mm ID) SCH40 Aluminum Pipe x 48" (1.2 m)
3. MaxiMet 1.5" ID mount
4. LI200S Pyranometer Sensor
5. LI2003s Pyranometer Leveling Base
6. Pyranometer Mounting Stand - Right Angle Bracket
7. CR1000 Data Logger
8. GM500 MaxiMet – Ultrasonic Wind Speed, Wind Direction, Relative Humidity, Temperature, Barometric Pressure, Dew Point
9. 6ft SDI-12 Cable
10. TE525 Tipping Bucket Rain Gage with 25ft lead
11. TM10 Soil Temperature Probe
12. 10W Solar Panel & Mounts
13. 5Ahr, 12V Battery
14. Enclosure 14 x 12 Mounting Brackets & Hardware
15. Serial (RS232) to USB Adapter
16. (2 ea.) 2.5 x 5/16 " SS bolts and nuts, (2 ea.) 2.5 x ¼" SS bolts and nuts for vertical pipe

2.0 Software Installation

Dynamet 5 is a completely integrated weather station capable of reading a variety of scientific grade weather sensors. Sensor readings are then stored in data loggers memory of 1MB memory. In addition removable storage modules are available for expanding the available data memory. Data from the logger is available for down load using data logger support software. Down loaded data from the logger contains measurements from individual sensors at the interval defined in the program and calculated ETP in mm/hour using Lascano-Van Bavel Evapotranspiration (ETP) algorithm on an hourly basis and accumulated daily ETP mm/day. Dynamet 5 weather station is based on CR1000 data logger. Hence can be operated using any of the following data logger support software,

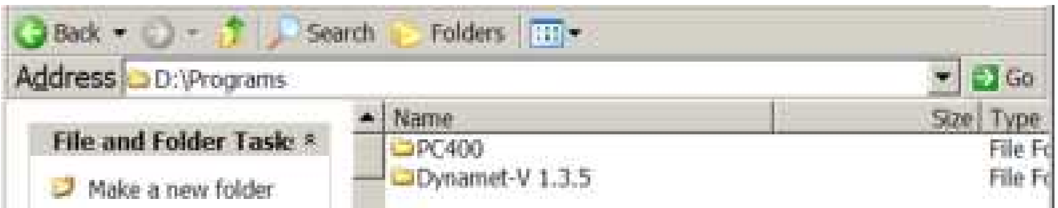
- PC400
- LoggerNet

For Procedure to connect, program download data refer to chapter 5. In this manual we describe working with Dynamet 5 weather station using PC400. As described above full capabilities of Dynamet 5 weather station is obtained by using two sets of software programs,

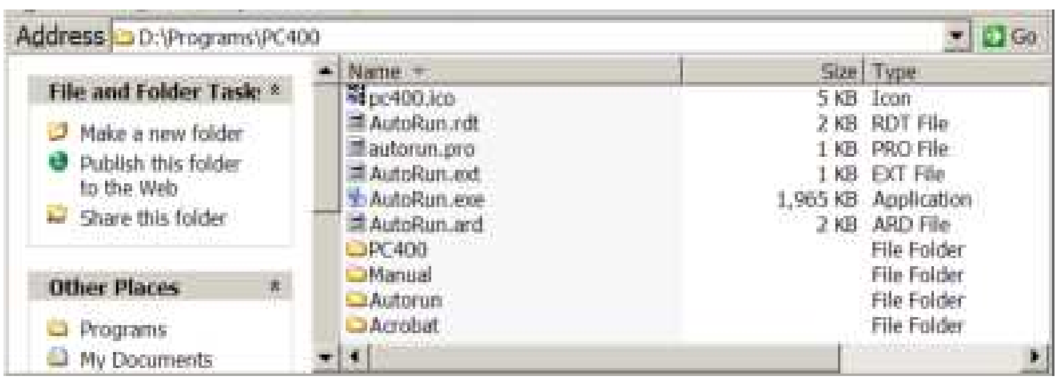
1. Data logger support software - PC400 (Logger Net software for advanced applications
2. Data logger program Dynamet 5.cr1 to load in to CR1000 data logger for reading variety of weather sensors, compute weather data from electrical measurements and store to logger memory.
3. In addition custom weather station configurations may require a modified version of Dynamet 5.cr1 program.

2.1 PC400 Installation

PC400 Logger utilities software is provided on a CD-ROM. Insert the CD into the CD-ROM. It should automatically present the installation panels. If it does not then open windows explorer (My Computer) to view the following list of files on the install CD.



Enter the PC400 Directory, click on it.
Then find the installation autorun icon.



Double click on autorun.exe to launch the installation. The installation wizard will guide you through the process. Any of these directories can be used for installation.

C:\CampbellSci\Program Files\PC400 (Default install directory) or
D:\CampbellSci\Program Files\ PC400 or
E:\CampbellSci\Program Files\ PC400 or
C:\CampbellSci\ PC400 or
D:\CampbellSci\ PC400 or
E:\CampbellSci\ PC400

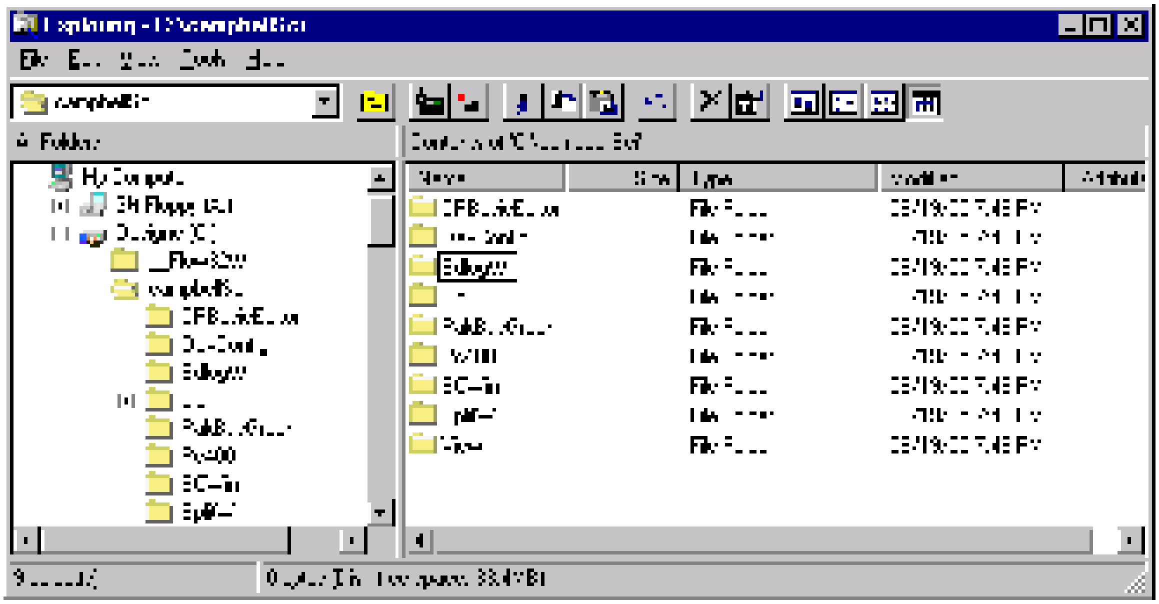
Refer to next page for working directory installation.

2.1.1 Working Directory Location

PC400 install wizard prompts for working directory location. By default working directory is

C:\CampbellSci\PC400

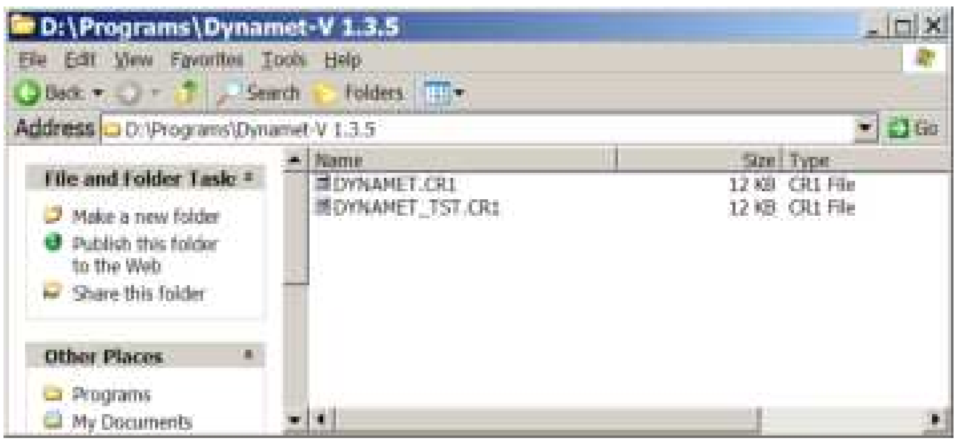
This can be changed by specifying a different path location on the hard-drive. This directory stores temporary files. Following is a typical list of working directory when working directory and PC400 executables are stored in different locations.



2.2 Lascano-Van Bavel ET program for Dynamet 5

Each Dynamet 5 station is supplied with a standard Dynamet 5 program Dynamet 5.cr1 and a test program Dynamet 5Tst.cr1. These programs are supplied in a CD along with the system. Dynamet 5.cr1 program is loaded into the logger before it is shipped out. Copy Dynamet 5.Cr1 and Dynamet 5Tst.Cr1 programs to the PC and save them to a preferred location on the PC. These are READ ONLY files. Any changes to these files are not allowed; you can make changes in the CRBasic editor and save the modified program with a new file name.

In addition if the Dynamet 5 system shipped is a custom one, with additional soil moisture sensors etc., these are shipped with custom programs Dynamet 5Cust1.Cr1 and Dynamet 5Cust1Tst.Cr1 or similar names in a CD disk.



Create a directory for your weather station control program, and data retrieval location called:
C:\\Dynamax\Dynamet 5\

Copy the contents of CD ROM Dynamet 5-V 1.X.X shown above to:

C:\\Dynamax\Dynamet 5\

If you wish to have an on-line manual, copy the .pdf file in the CD root directory to your directory above as well.

3.0 Dynamet and Sensor Installation

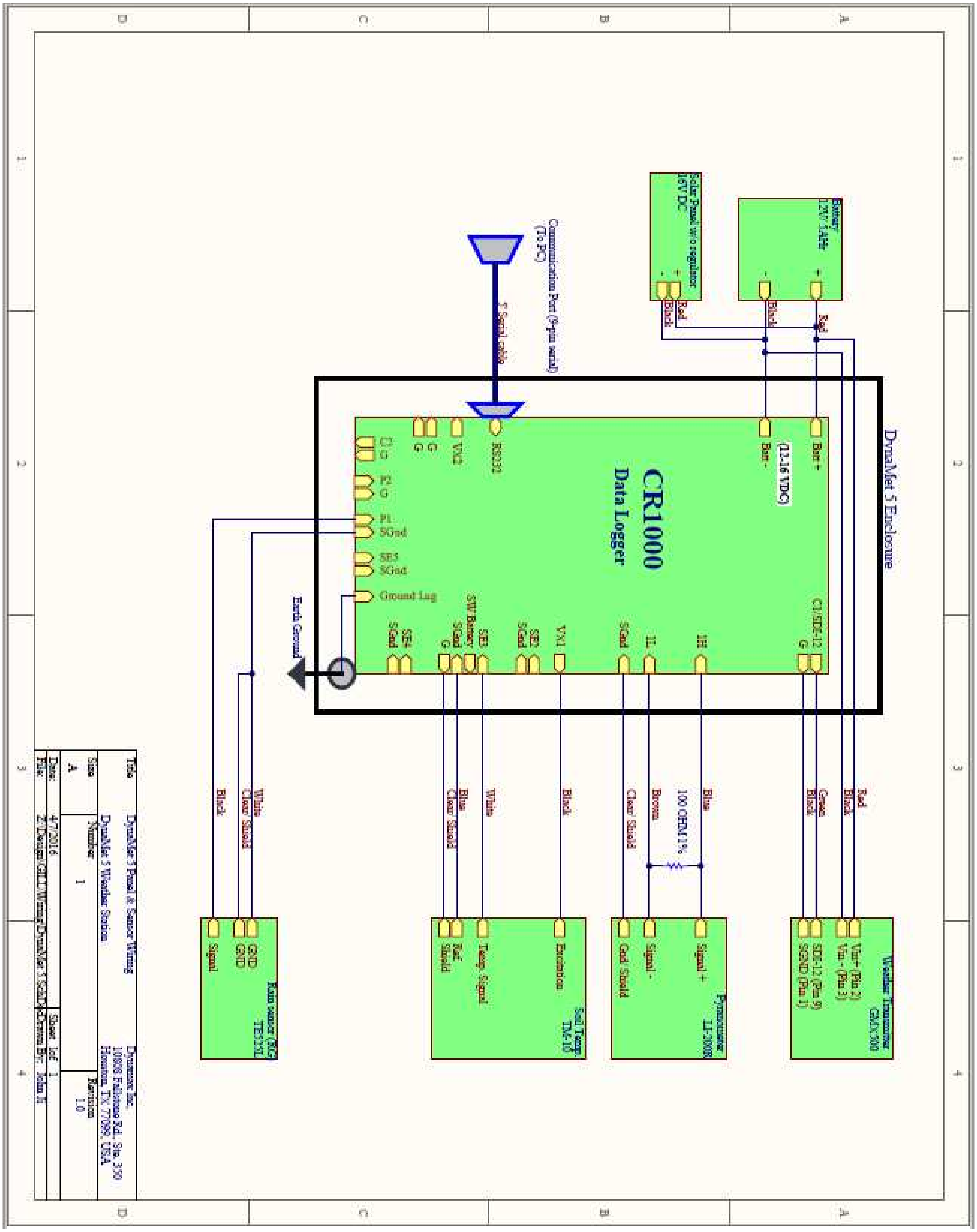
Dynamet 5 weather station is completely integrated system with data collection/ processing and storage unit along with basic meteorological sensors. Dynamet 5.cr1 program supplied with the system can read all the basic weather sensors (solar radiation, air temp., RH, Wind speed, wind direction, rain gauge, soil temp., soil moisture), process data according to the applied algorithms and constants, compute ETP and store in data loggers memory for retrieval at a later time. At the time of order can be added to the Dynamet 5 weather station and these custom stations will be assembled and programmed with a custom program before the units are shipped from our factory. So, all the assembly and programming of the weather station is performed at our factory. This leaves end-user with only installation of the weather station at the required site.

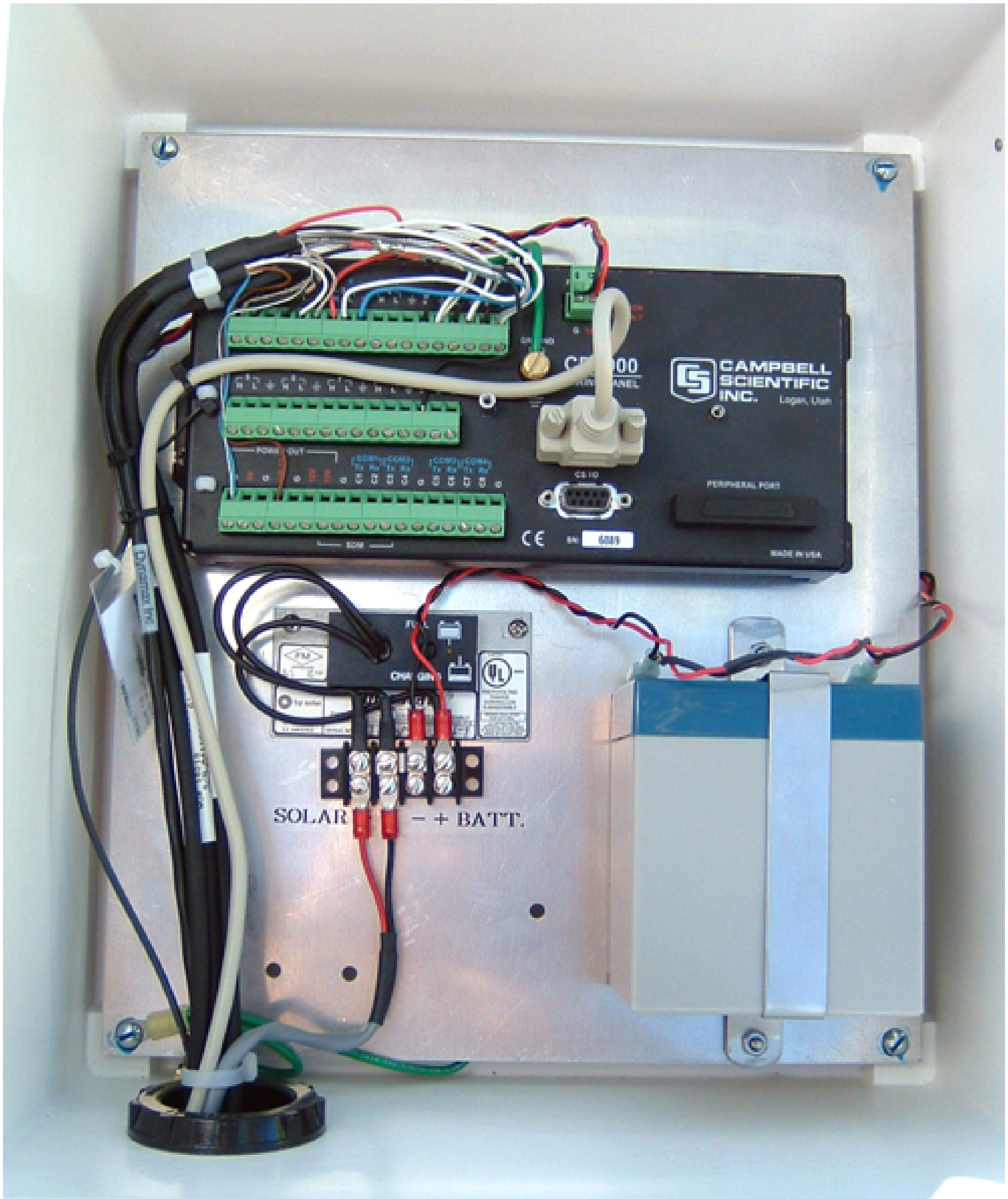
Dynamet 5 weather station installation on Tripod (Model#: CM6 or CM10) is explained in detail in "**Tripod Weather station Installation manual**" supplied with Dynamet 5. This chapter discusses basics of tripod installation, system mounting and sensor wiring and solar panel installation. Selecting an appropriate site for installation of weather station is critical to obtain accurate meteorological data. The site should be away from urban and natural obstructions such as buildings and trees, sprinkler irrigation. This chapter explains steps involved in:

- Tripod/ tower installation
- Dynamet 5 weather station installation
- Solar panel installation
- Sensor installation on the tripod

3.1 List of Tools required

- Post for rain gage - 1 in ID galvanized pipe 3 ft. (1 m) long
- Shovel
- Rake
- Small sledge hammer
- 12’ tape measure
- Felt-tipped marking pen
- Open-end wrenches: 3/8”, 7/16”, ½”, 9/16”
- Socket wrench and 7/16” deep well socket
- Level (12” - 24”)
- 5/64” Allen wrench
- Straight-bit screwdrivers (small, medium, and large)
- Magnetic compass
- Calculator
- Digital multi-meter
- Wire ties and tabs
- Conduit and associated tools as required
- 6’ ladder
- Data logger prompt sheet / manuals
- Station log/ pen
- Lock and key for enclosure


DynaMet 5 Enclosure
CR1000
Data Logger
Ground Lug
Earth Ground



Dynamet 5 Logger Assembly – wiring, internal battery, and solar charge regulator.

3.2 Dynamet and Tripod Installation

Operation, Overview and Quick start guide

1. Site selection and preparation.

2. Unpacking system.

3. Mounting Tripod CM6 or CM10 explained in Tripod manual.

4. Mount Dynamet 5 enclosure, connect sensor cables, connect Power, and Connect Grounding.

5. Install sensors on the tripod.

6. Connect personal computer.

7. Install data logger support software PC400 on PC.

8. Copy Dynamet 5 program files (supplied on USB flash drive) to PC.

9. Using data logger support software, connect to the Dynamet weather station. Set the logger internal clock with the PC time/date **Click on the Set Datalogger Clk**

10. Download **Dynamet5Tst.cr1** to logger Dynamet 5 weather station starts working and collect data at the specified intervals. Monitor sensor output and calculated ET data.

11. If the sensors data and ETP output are within the acceptable ranges, means that the sensors and system are installed properly.

12. Now modify the Dynamet.cr1 program, for site-specific parameters, save with a different name. Compile the new program and send to logger. Now the data logger collects sensor data every minute, compute ET every hour and store hourly and daily data to the logger.

13. After few days down load data stored in the logger memory.
    PC400 -> Connect -> Collect all button
    Retrieve data, then it's saved data into *.DAT files on disk directory.

14. The retrieved data contains two different files. One containing hourly output of sensor data and computed ETP. The second file containing daily output of accumulated ET, average/ maximum/ minimum values of the sensor output.

3.2.1 Tripod Installation

The following parts are supplied with Tripod kit.

- Tripod base Assembly
- Mast Assembly, three steel pipes precut, with MaxiMet mast (Al)
- Cross Arm Mount and (40" Short pipe) XARM4 cross-arm
- Lightning Rod with Clamp
- Grounding Rod with Clamp
- 5', 4AWG wire
- 4', 12AWG wire
- Hold down stakes
- Cable ties
- (2 ea.) 2.5 x 5/16 " SS bolts and nuts, (2 ea.) 2.5 x ¼" SS bolts and nuts for vertical pipe.

- Select site for installing tripod and weather station. The site should be away from obstructions and sprinklers. A flat ground is recommended for installation, even though the tripod can be installed in many different terrains with some professional help.
- Prepare an area of 10' diameter for installing tripod with little disturbance to the ground surface or vegetation.
- Decide if you are mounting the center of the wind sensor at 2 m or 3 m or 6 ft. The hardware is installed for mounting at 3 m. The mast comes in 4 parts.
- The bottom section is a 39 in (1 m) upright 1.5" ID (3.8 cm) pole inserted into a 20 in (50 cm) 1.75 ID (4.45 cm ID) sleeve. These parts are already joined with a 2.5" x ¼" bolt and nut.
- The upper part is inserted on top of the bottom section to make a 3 m height total from the ground to the center of the wind sensor. The upper part has the MaxiMet Aluminum mount installed with two 2.5" x 5/16 " bolt and nuts.
- To mount the wind sensor at 2 m above ground, remove 18 cm (7 in) by cutting the upper part at the bottom of the pole with a hack saw. The bottom section part will not be used.
- To mount the wind sensor at 6 ft. above ground, remove 10 in (25 cm) by upper part at the bottom of the pole with a hack saw. The wind sensor mast is moved down 4 inch as well. The bottom section part will not be used.
- Mark the tripod legs to indicate how far they should extend. Each leg has a slide collar with a single bolt for loosening or tightening the collar. Loosen the bolt on each collar with ½" wrench.

- For 2 m or 3 m height, the Distance from the bottom bolt to the end of the sliding bracket is18“ (46 cm).

- Stand the tripod upright and orient it so on leg points south. Extend the leg until the top of the slide collar is even with the marks made before and tighten the bolt. Extend all the other legs in the same manner. The height of the bracket should be 40“ to 41” above the ground level.

- Loosen the six affixing nuts on the tripod center clamp, and then insert the bottom part (for a 3 m mast) or the upper part (only for 2 m or 6 ft. mast). The bottom part has a smaller diameter tube 1.5“ ID which will slide into the bottom of the center clamp, and the larger diameter pipe sets onto 3 brackets. As shown here.

- Tighten the six affixing bolts to the center clamp, and tighten the other adjusting bolts as well so all of the sliding and pivot bolts of tripod are secure.

- Insert the MaxiMet Support Tube inside the 1 ¾" ID. Mast tube (larger tube with Danger sign) and secure with two 5/16" x 2.5in bolts with washer into the top two holes of the upper mast. The support tube will fit snug inside the mast for added stabilization as shown above. This step is done at the factory before shipping.

- Before wiring the GMX500 into the data logger:

  1) Disconnect the GMX500 from the data logger, making sure the cables are marked clearly; the sensor has been tested and therefore needs to be disconnected.

  2) Run the cable through the top of the 1.5 in ID upper mount and thread the cable through the designated hole in the support tube as shown below.

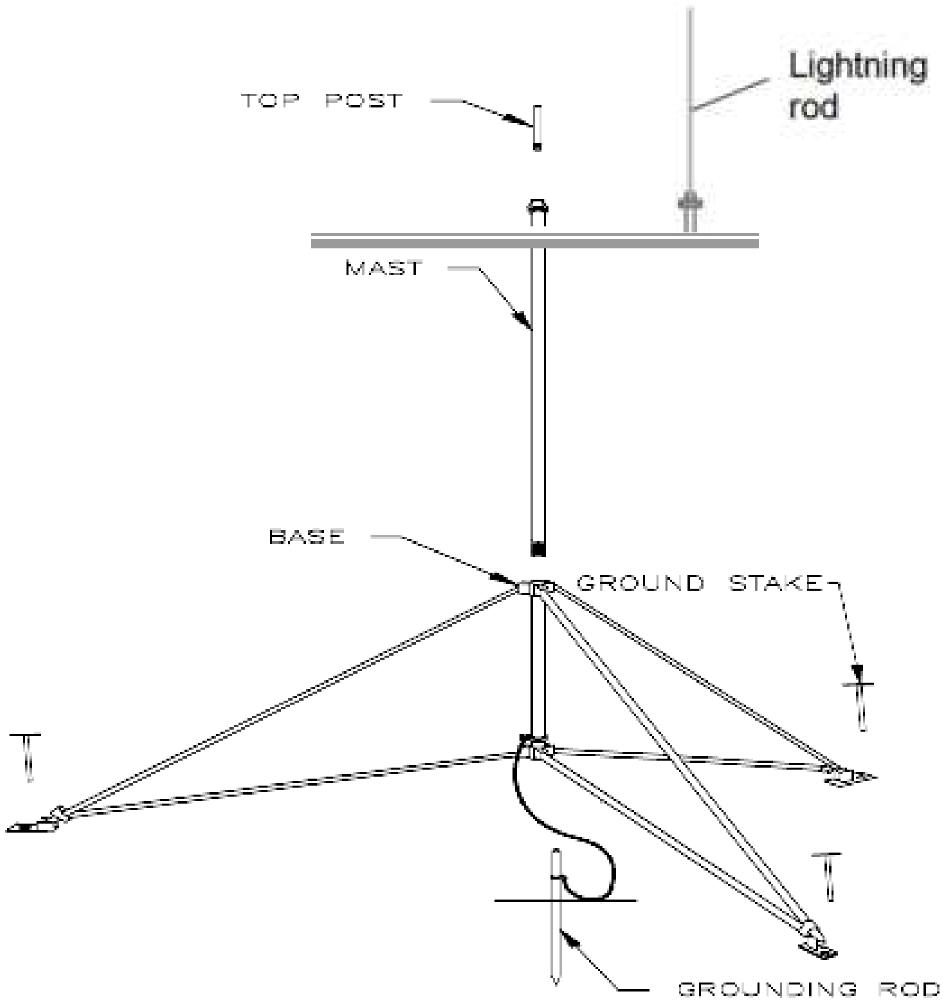
  3) Secure the connector carefully into the MaxiMet, observing the locking guides. Then turn the securing connector clockwise, and then in the last ¼ turn the housing is turned until it clicks into place.

- Install the MaxiMet GMX500 on top of the support tube using the supplied 3 x M5 screws. Secure the MaxiMet, and be aware that the housing is delicate while moving the mast. Secure the MaxiMet wiring with a cable tie wrap, with some slack just below the cable entry hole.

Insert the top pole to the height marked on the bottom pole for the 3 M sensor position. 1 inch x 5/16” galvanized nut will secure the position of the upper pole, and then insert the 2.5 “ and ¼” to lock the mast into place.

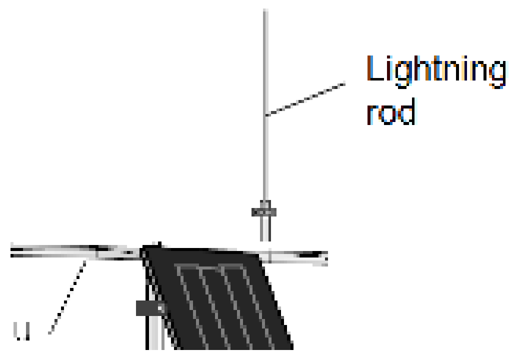
Then 2.5 x ¼” bolt – 2 washers, lock washer and nut secures position. Tighten into place.

First insert a 1 x 5/16” bolt – secures position.

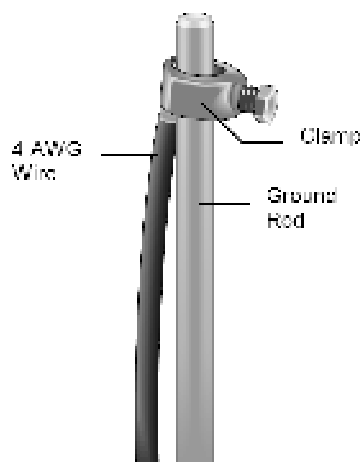


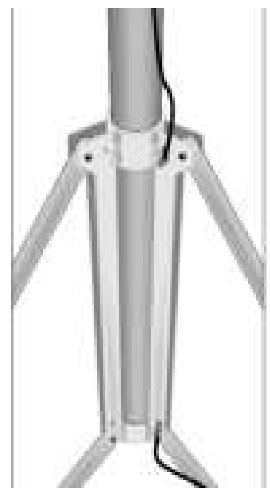
- Plumb the mast by adjusting the south and northeast facing legs. Loosen the slide collar bolt on the south facing leg. With the level on the south side of the mast, adjust the leg so the level reads plumb, and then tighten the bolt. Repeat the same procedure for the northeast facing leg with the level on the east side of the mast.
- Drive the six rebar stakes through the holes in the feet into the ground surface to secure tripod.
- Loosen the sent screws in the two-brass ground lugs attached to the center bracket of the tripod. Strip 1" of insulation from the other end of the 4AWG wire and inset it into the lower ground lug. Strip 1" of insulation from one end of the 12AWG wire and insert it into the upper ground lug. Tighten the setscrews. Attach the other end of the 12AWG wire to the ground lug of the enclosure.
- Attach MT-XARM4 cross-arm to the mast. Maintain the center of the bracket 20 in (50 cm) below the top of the MaxiMet mount on top of the mast. Orient cross arm mount in east/west direction with the cross arm bracket facing East (northern hemisphere) and tighten the U-bolts.

- **Lightning Rod:** Position the lightning rod on one end of the XARM cross arm, on the opposite side of the pyranometer. Ensure the lightning rod set screw is tight.



- **Grounding:** Slide the clamp down the ground rod before driving it in the ground. Drive Ground rod close to the center of the tripod using a fence post driver of sledgehammer. In hard soils use water to prime the soil and hole to make driving the rod easier.

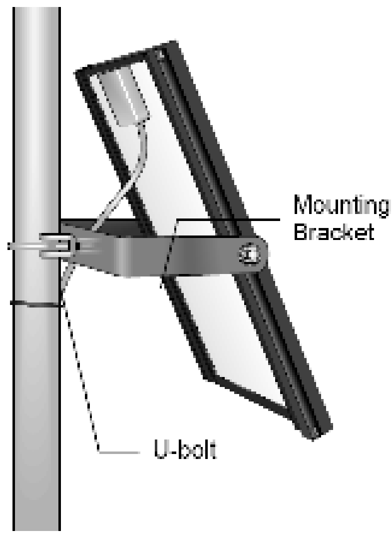


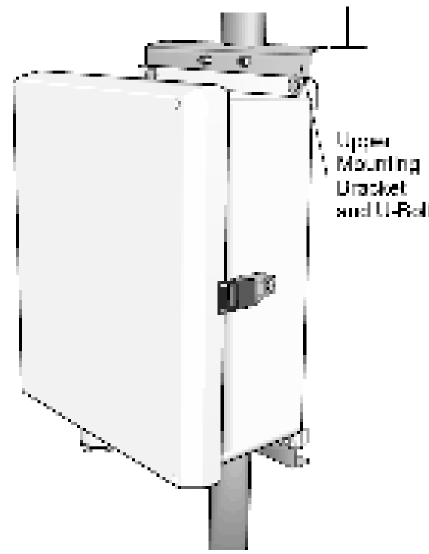


Loosen bolt that attached clamp to the ground rod. Strip 1" insulation from one end of the 4AWG wire and insert it between the rod and the clamp. Tighten the clamp bolt.

3.2.2 Solar Panel Installation

Solar panel with regulator models are shipped with a 12V regulator attached at the back of the panel for Dynamet6 and Dynamet5. The Dynamet2 already includes a battery charger inside the CR200 logger. A 15' cable is attached to the regulator and the other end of the cable must be connected to the pigtail hanging from the Dynamet conduit labeled "Solar Panel". Mount solar panel to the mast, facing south (in northern hemisphere) Position solar panel mounting at the top of the 1 ¼" diameter section of the mast. Install U-bolt muffler clamp and nuts. The solar panel should be oriented to receive maximum insulation over the course of the year. Below table lists tilt angles at various latitudes. Once the tilt angle is determined, loosen two bolts that attach mounting bracket to the panel. Adjust the angle, and then tighten the bolts as shown below.





3.2.3 Install Dynamet 5 Enclosure

Dynamet 5 weather station enclosure contains CR1000 data logger, and other storage of communication peripherals if any. Sensor cables, Power cables, Communication cables connected to the data logger or any peripherals routed out of the enclosure through a PVC conduit. So it is not necessary of an end-user to make any wiring inside the enclosure. All the connectors are accessible out of the box. Position the enclosure on the north side of the mast or tower (northern hemisphere). Secure enclosure as shown in the figure using U-bolts and mounting brackets. Route the 12AWG wire from the Ground Lug on the enclosure to the tripod-grounding clamp. Tighten the screws. Grounding is critical not only for the accuracy of data/ reduce signal noise but also to protect equipment from any lightening surges.

3.3 Sensor Installation

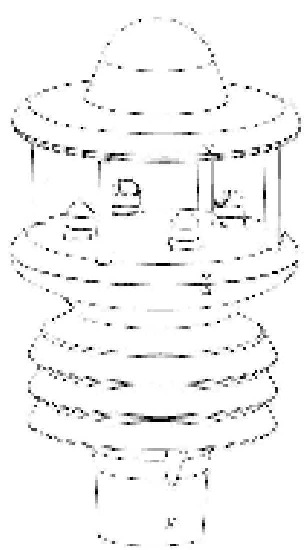
Dynamet 5 weather station sensors basic or additional are supplied with sensors or connected to the data logger in the Dynamet 5 enclosure. In this section we discuss the procedure to install the sensors on tripod along with Dynamet 5 enclosure, cable routing, setting up/ orientation of the sensors and Entering parameters in the Dynamet 5 program.

3.3.1 MaxiMet GMX500

MaxiMet GMX500 is an advanced compact weather station designed and manufactured by Gill instruments using proven technology to measure meteorological and environmental parameters to international standards.

- The MaxiMet uses the Gill WindSonic wind speed and direction sensor. The WindSonic measures the times taken for an ultrasonic pulse of sound to travel from the North (N) transducer to the South (S) transducer, and compares it with the time for a pulse to travel from S to N transducer. Likewise times are compared between West (W) and East (E), and E and W transducer.

- If, for example, a North wind is blowing, then the time taken for the pulse to travel from N to S will be faster than from S to N, whereas the W to E, and E to W times will be the same. The wind speed and direction can then be calculated from the differences in the times of flight on each axis. This calculation is independent of factors such as temperature.



- The compass point and polarity of U and V if the wind components along the U and V axis are blowing in the direction of the respective arrows.

- MaxiMet can output the following wind readings depending on use of a Compass or GPS.
    - Relative wind – wind speed and/or direction, uncorrected, but relative to the north marker, which may not be facing North.
    - Corrected wind – with the aid of the Compass Magnetic North corrected wind direction can be output.
    - True wind – wind speed and/or direction information corrected by GPS for any direction misalignment of the north marker and/or for any motion of the station. (E.g. vehicle or vessel).

- A Met Spec Multi-Plate Radiation Shield is used. The special shield plate geometry, with its double louvre design, provides excellent response time performance of quick ambient temperature changes while still working effectively as a baffle to stop larger contaminants such as salt or dirt from reaching the temperature and humidity sensor. The shield benefits from very robust material choice and extremely high UV protection requiring no maintenance.

- There is an internal solid state instrument contained within the Radiation shield that provides digital output signals for Relative Humidity, Temperature and calculated Dew point.

- Barometric pressure output is provided by a solid-state device fitted on to a circuit board inside a MaxiMet molding.

- MaxiMet contains a 2-axis compass and magnetic field sensing module using Magneto-Inductive (MI) sensors. The sensor changes inductance by 100% over its field measurement range. It incorporates a temperature and noise stabilized oscillator/counter circuit. The compass has a high degree of azimuth accuracy. MaxiMet uses the internal compass to electronically sense the difference in the earth's field from the system's magnetic field, then an on-board microprocessor electronically subtracts out the system's magnetic fields, reporting highly accurate compass readings. Wind direction data is corrected for the orientation of the sensor. The output of the wind direction is relative to magnetic North. The MaxiMet compass is calibrated at Gill Instruments before the unit is delivered. Prior to installing MaxiMet it is suggested that for best accuracy a declination figure should be entered. Use of the Compass Corrected Wind direction readings allows the unit to be installed such that accurate positioning of the MaxiMet North Marker is not required.

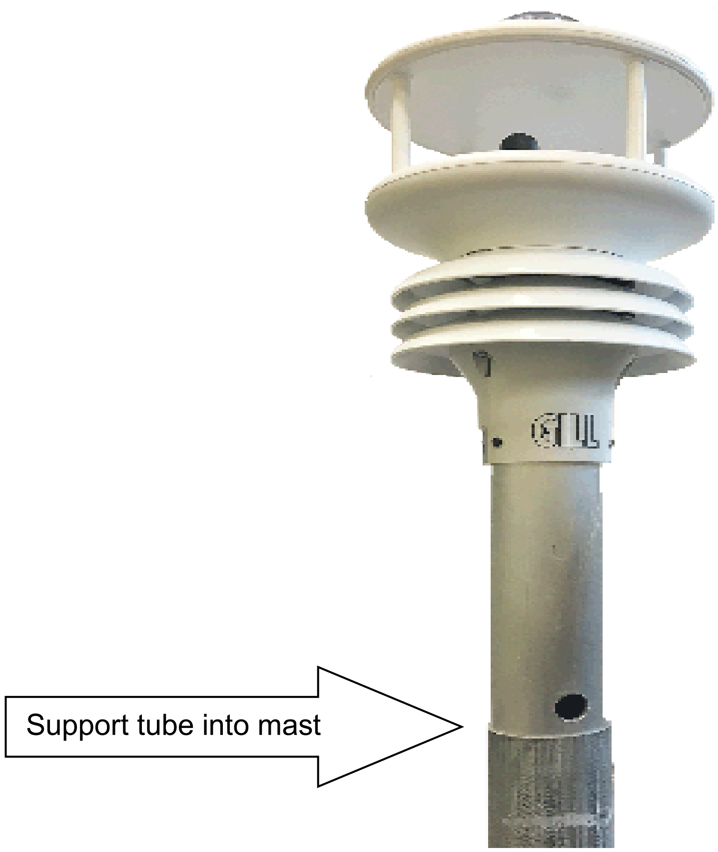
- Declination is the magnetic declination (the angle between Magnetic North and True North) in degrees. This is a correction factor that is added to the magnetic north heading from the compass. Map and declination figures in decimal figures can be obtained from

  http://www.ngdc.noaa.gov/geomag/declination.shtml

- MaxiMet uses a highly accurate GPS (Optional) antenna receiver module including a ceramic GPS patch antenna. The module is capable of receiving signals from up to 48 GPS satellites and transferring them into position and timing information that can be read over a serial port. Small size and high-end GPS functionality are combined with low power consumption.

- When GPS Speed and GPS heading are available and GPS Speed transitions are above 5m/s, Corrected Wind Speed shall be computed as the True Wind speed using GPS speed and GPS heading.

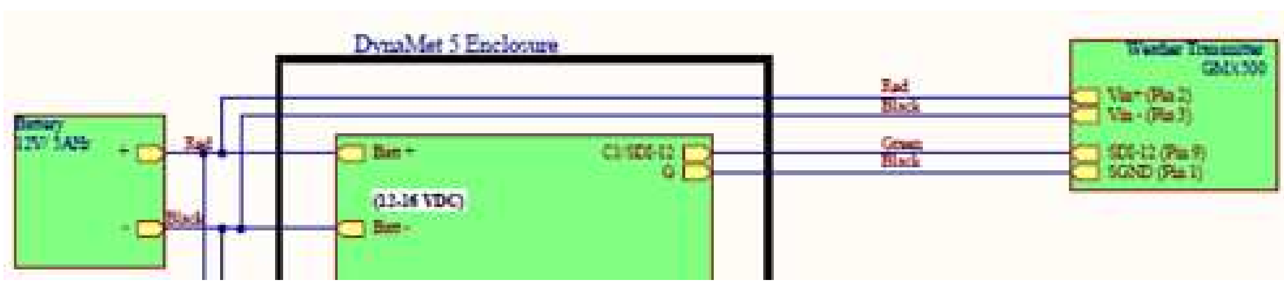
- When GPS Speed is available and GPS Speed transitions are below 4m/s, Corrected Wind Speed shall be computed as the True Wind Direction using GPS speed and Compass heading.



- Insert the MaxiMet Support Tube inside the 1 ¾" ID. Mast tube (larger tube with Danger sign) and secure with two 5/16" x 2.5in bolts with washer. The support tube will fit snug inside the mast for added stabilization as shown above.

Before wiring the GMX500 into the data logger, run the cable through the designated hole in the support tube as shown below. Observe the connection guide marks before sliding the female connector and then turning the clamping nut clockwise to secure. The last ¼ turn has a clicking snap connection before complete.

- Install the MaxiMet GMX500 on top of the support tube using the supplied 3 x M5 screws.



Attach the GMX 4 wires to the logger with the instructions from the wiring list above (or see page 14).

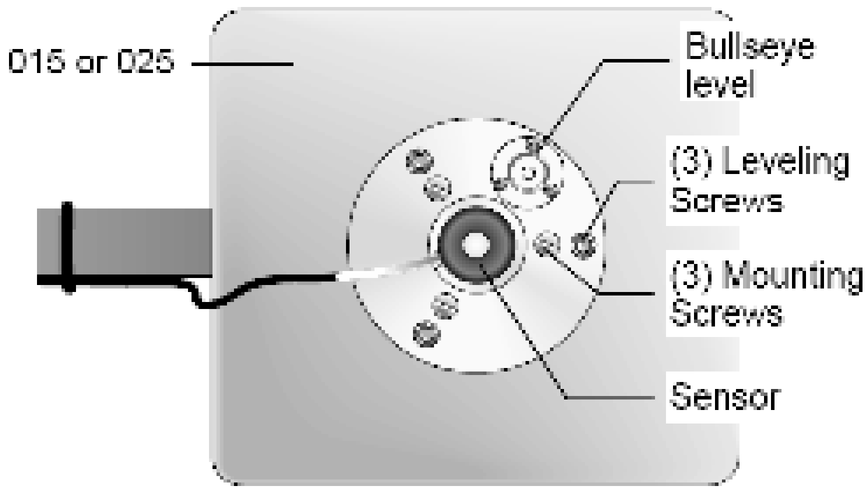
3.3.2 Solar Radiation (LI200S)

LI200SZ solar radiation sensor is supplied with LI2003S mounting base/leveling fixture. The base includes a bubble lever, sensor holder and three adjustment screws for level setting. The LI2003S base/ leveling fixture is attached to a tripod using a pyranometer mounting arm (angled) mounted with one U-bolt to the 25 mm ID (1 inch) horizontal pole.

Pyranometer Mounting Stand - Right Angle Bracket

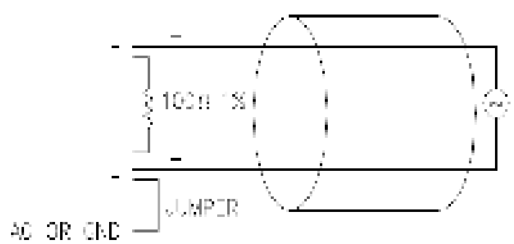
- LI2003 mounting base, insert 3 brass mounting screws into the top of the mounting stand, screw into the Mounting stand - and do not tighten the set screws.

- Adjust the three leveling screws (Stainless) flush with the bottom of the LI2003S so the levelling plates are parallel to the angle bracket.
- Position the base of the sensor in the mounting flange on the LI2003S and tighten the setscrews with the Allen wrench provided.
- Mount LI2003S to the tripod mast using angle fixture



- Level LI2003S using the bubble level with the leveling screws and tighten the mounting screws, once the bubble is level. Remove the red protective cap prior to use.

- As shown in the figure below, signal positive of the pyranometer is connected to the High end (H) of the differential input channel and signal negative to the corresponding low side (L) A jumper of the differential channel. A jumper wire is installed between analog ground and Low side(L) of the differential channel. A 100 Ohm 1% precision resistor is installed between the High (H) and Low (L) of the differential channel.



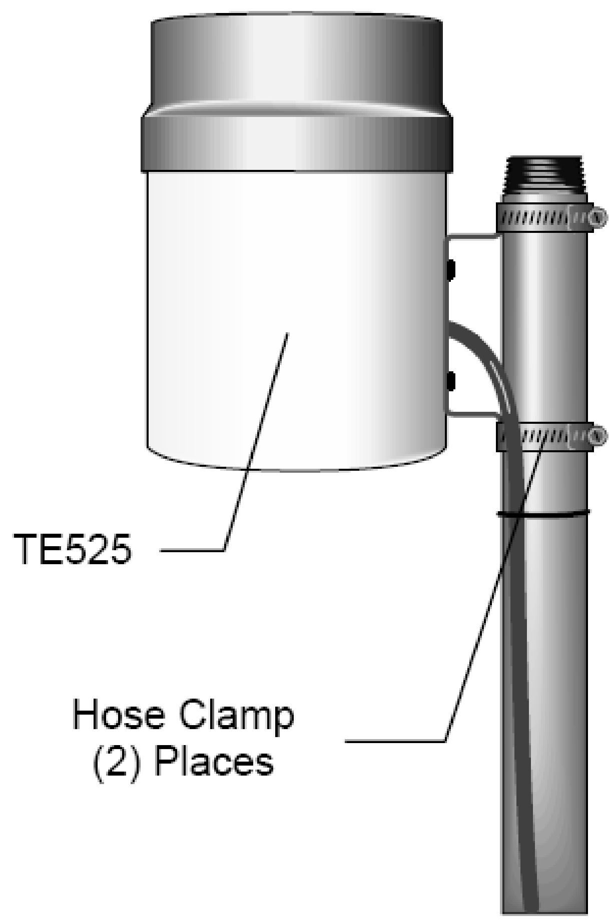
- A multiplier must be entered in the CR1000X Dynamet 2 program (Dynamet.cr1) before any valid data can be obtained from the sensor. Each LI200S sensor is calibrated at the factory and shipped with date of calibration constant and LICOR calibration constant (labeled as multiplier on the sensor tag). Identify the Licor calibration constant (C) from the sensor tag, apply this value in the formula below to calculate Multiplier for the Dynamet program. Resultant solar radiation data from the data LI200S/logger is in W/m^2.

$$Multiplier = \left(\frac{1}{C * 0.1}\right) * 1000$$

3.3.3 Rain Gauge (TE525)

Select a location about 10’ to 20’ (3-6 m) from the tripod installation, Install a vertical pole.

- Mount the rain gauge to the vertical pipe (user supplied). We suggest a 1 in water pipe pounded into the ground or mounted into a concrete base. Level the top part of the rain gage to make sure the top is horizontal and base is adjusted securely with the two clamps.
- Route the sensor lead to the Dynamet enclosure/ Tripod in plastic or metal conduit. Check that there is a grey O-ring inside the male portion of the connector, seated with silicone grease inside. Connect the circular plastic connector, carefully aligning the alignment guides inside the connector, and then twist the locking nut clockwise until the last ¼ turn there is a click securing the locking nut.



3.3.4 Soil Temperature Sensor

The TM10 is designed to measure the temperature of air, water, or soil. For air temperature measurements, a solar radiation shield (41301) is typically used to house the probe, while limiting solar loading on the sensor. The temperature probe can also be buried or submerged to 50 feet. The probe is not weighted for submergence (i.e., it will float), so the installer should plan to add a weighting system or secure the probe to a fixed, submerged object, such as a piling. The TM10 has a measurement temperature range of -35° to +50°C and outputs a full scale range of 0 to 2.2 Volts. TM10 comes with a standard lead length of 10', and offered lead lengths are 25, 50, 75, and 100 feet, although the sensor may be ordered with lead lengths up to 1000 ft. Temperature measurement is made in degrees C.

Color	Function	CR1000 channel wiring
Black	Excitation	Switched Excitation
White	High Signal	Single-ended channel
Blue	Analog Ground	SGnd
Silver/ Shield	Shield	Earth Ground

3.3.5 Soil Moisture Sensor ML3 Theta Probe (Optional)

ML3 soil moisture sensor measures volumetric soil moisture content by the principle of dielectric constant of the medium changes with water content. The change in dielectric constant is measured in mV DC voltage. Dynamet weather station reads the DC voltage and converts to volumetric soil content in %. Soil moisture sensor ML3 is wired to the Dynamet weather station. Select the location for installing the ML3 sensor, usually close to the sprinkler fall area or under the drip nozzle. Push the sensor in to the soil until the rods are fully covered. Route the wire to Dynamet station and secure it from any damage. Based on the type of soil in which measurements are made, identify the constants A0 and A1. Enter these values in CR1000 program to calculate soil moisture for either organic or mineral soil using polynomial equation.

	Polynomial Equation	
	A0	**A1**
Mineral Soil	1.6	8.4
Organic Soil	1.3	1.7

4.0 Lascano-VanBavel ETP Program

The value of ETP (Potential Evapotranspiration) is a reference measure of the evaporative demand, as determined by weather conditions. Using Lascano-VanBavel ET algorithm we calculate ETP estimation from a well-watered short grass. ETP is normally expressed in mm/hr or inch/hr and daily-accumulated values are expressed in mm/day or inches/day. It can be related to hourly or daily data for the sap flow rate, and used to normalize such data against day-to-day variations in the weather, or to identify deviations in the sap flow rate from normal patterns. ETP is also used to create and index reference to schedule irrigation and to calculate crop coefficients. Lascano-VanBavel ET algorithm is embedded in Dynamet.CR1 and DynametTst.CR1 programs supplied with Dynamet 5 weather station. In addition custom Dynamet weather station programs can also be supplied with embedded ET calculations. The new Lascano-VanBavel RCM algorithm for ETP does not assume a value for temperature and saturation humidity at the evaporation surface, but rather derives both from closing the energy balance.

Using Dynamet.Cr1 or any of the variation of these programs and a Dynamet 5 weather station user can collect sensor data as well as the computed ET data (both hourly and daily) from the station. Hence, there is not further processing of the collected data. Output of the data logger already contains raw sensors data, computed ET data as well as daily-accumulated data.

4.1 Application of ETP Information

In the interpretation of data on the sap flow rates in crops and trees it is essential to compare their hourly pattern within that of the concurrent evaporation demand. A general comparison can also be made of daily totals, as an indication of water stress, or other influences that cause the plant to use less water than expected.

For example, the weather data may give a value of 10.3 mm/day for ETP and, from stem flow gauges, the total water used by a tree on 10 m2 of land is found as 94 kg/day (converts to 9.4 mm/day). On the next day, if the value for ETP is 10.6 mm/day, but the water use measured as 46 kg/day (4.6 mm), stomatal closure and reduced transpiration has occurred. The reduced transpiration can be a result of reduced soil water availability, but possibly a result of other factors such as low root zone temperature, vascular disease, or others.

In the case of irrigation management, a comparison of the ETP rates with the stem flow data serves <u>the dual purpose of diagnosing the need for supplying water and the basis for calculating how much water should be applied.</u> For example, if a four-day sequence of water use a transpiration showed, respectively, 94 kg/day, 96 kg/day, 50 kg/day, and 28 kg/day, while the ETP was essentially constant, we would know that irrigation is needed and overdue, on the 5^{th} day. By adding up the sap flow, we also know that the total amount that has to be replaced equals 266 kg.

To this amount we must add the losses by soil evaporation, which must be estimated from previous data, if available. Assuming one tree occupies a 10 m2 area, and if the transpiration is 80% of ETP, then the suggested irrigation is 333 kg or 86 gallons (per 10 m2), i.e. 266 kg / 80 %. That would translate to an irrigation of 33.3 mm to replenish the water used over four days. Many variations on this theme can be formulated for a specific application.

One caution should be stated. The ETP estimate is only a quantitative measure of the evaporative demand, and is not intended to be an estimate of the actual water use by the crop or the trees, even if they are well watered. Therefore, the two variables, ETP and stem or trunk flow rate, are expressed as mm per hour and kg/plant/hour, respectively, even though the water use by vegetation is often also expressed as mm per hour or per day. The relation between daily ETP and daily stem or trunk flow rate is not even necessarily linear, that is, the quotient (stem or trunk flow rate). ETP may not be constant over the entire range of weather conditions or the development period of a crop.

4.2 ET Program Basics

This section covers the basics of Evapotranspiration algorithms and the ET algorithm implemented in Dynamet.Cr2.

The ET program contains two constants that are always set for the customers site, and two constants that could be modified for various situations. Parameters lev and zot should be modified only by persons thoroughly familiar with ETP modeling. Normally, the last two constants are altered to account for the barometric pressure and the height of the wind measurement. The present form of the program is adapted to metric units. Each user needs to know the height of the weather station above ground level, and the altitude above sea level in feet.

zot = 0.0005	surface roughness parameter in m, for ¾ in. high turf grass
zom = 2.0	wind speed height of measurement in meters, 2 m typical.
has = 1004.0	Specific air heat capacity in J/KgC

In this section we discuss definition of these parameters and their units followed by procedure to modify these parameters in Dynamet program to meet the geography of the location of weather station.

4.2.1 Elevation and Average Barometric Pressure Calculation

The user should calculate the Average Barometric Pressure as indicated in the following formula and substitute the calculated average barometric pressure (abp) figure for line two of the select elements. The Average Barometric Pressure is computed as follows:

Average barometric pressure in mb, $abp = 1013.2 \cdot e^{(-elf \cdot 3.817E-0.5)}$

As a simple example, at sea level, elf is zero, so the ABP is 1013 Mb.

If the altitude is 100 ft (elf=100), enter abp=1009 in line two of the select elements calculation.

4.3 ET Variables and complete algorithm

Constants or site-specific variables:

Notation	Description	Units
zom	Height of measurement	M
zot	Roughness parameter for heat and vapor profile	M
abp	Average barometric pressure	Mb
lev	Heat of vaporization	J/Kg
has	Specific heat air capacity	J/Kg.degC at 30C

Input variables:

Notation	Description	Units
hgr	Hourly average solar radiation	W/m2
hta	Hourly average of air temperature	degC
hrh	Hourly average or relative humidity	%
hws	Hourly average of wind speed	M/s
hts	Hourly average of s temperature	DegC

Calculated variables:

Notation	Description	Units
had	Air Density	Kg/m3
hum	Ambient Humidity	Kg/m3
ras	Aerodynamic resistance	S/m
skl	Sky long-wave radiation	W/m2
htc	Surface temperature	DegC
rnt	Net radiation balance	W/m2
sht	Sensible heat flux	W/m2
hums	Humidity at the surface	Kg/m3
evt	Evapotranspiration	Kg/m2.s
EVT	Evapotranspiration in standard units	mm/hour

RCM ET Algorithm

Site Specific Variables :

$$lev = (2.501 - 0.002361 \cdot hta) \cdot 10^6$$

$$abp = 1013.2 * e^{(-elf*3.817E-5)}$$

Dew Point Calculation :

$$e_s(T_a) = 6.1078 \cdot e^{\left(\frac{17.2693882 \cdot T_a}{237.3 + T_a}\right)}$$

$$e_a = e_s(T_a) \cdot hrh$$

$$hdp = \frac{\left(237.3 \cdot \ln\left(\frac{e_a}{6.1078}\right)\right)}{\left(17.2693882 - \ln\left(\frac{e_a}{6.1078}\right)\right)}$$

RCM algorithm for ET calculation :

$$had = 1.1548 \cdot \frac{abp}{1013.2}$$

$$hum = 1.323 \cdot \frac{e^{\left(17.269 \cdot \frac{hdp}{hdp + 237}\right)}}{hdp + 273.2}$$

$$ras = \frac{\ln\left(\frac{zom}{zot}\right)^2}{0.16 \cdot hws} \qquad or \qquad ras = \frac{\ln\left(\frac{zom}{zot}\right)^2}{0.16 \cdot (hws + 0.1)} \qquad when\ hws < 0.1$$

$$skl = 5.67E - 8 \cdot (hta + 273.2)^4 \cdot (0.70 + 0.08241 \cdot hum \cdot e^{\left(\frac{1500}{hta + 273.2}\right)}$$

$$htc = root\left[\left\{\left(0.80 \cdot hgr - 5.67E - 8 \cdot (htc + 273.2)^4 + skl\right) + \frac{(hta - htc) \cdot had \cdot has \cdot 303.16}{(hta + 273.2) \cdot ras} - \frac{1.323 \cdot \frac{e^{\left(17.269 \cdot \frac{htc}{htc + 237}\right)}}{htc + 273.2} - hum}{ras} \cdot lev\right\} \cdot \frac{ras}{\left(\frac{had \cdot has \cdot 303.16}{hta + 273.2}\right)}, htc\right]^{htc=10}$$

$$rnt = \left(0.80 \cdot hgr - 5.67E - 8 \cdot (htc + 273.2)^4 + skl\right)$$

$$sht = \left[\frac{had \cdot has \cdot 303.16 \cdot (hta - htc)}{(hta + 273.2) \cdot ras}\right]$$

$$evt = \frac{rnt + sht}{lev}$$

$$EVT = evt \cdot 3600$$

4.4 CR1000 Program for Dynamet 5 and ET computation

Every standard and custom Dynamet 5 system is supplied tested and supplied with a program to read sensors every minute and calculate average, ET and store to logger every hour, as well as store daily-accumulated variables at mid night. This enables the user to simply power up the Dynamet 5 system and the unit starts collecting data as long as all the sensors are connected and operating properly. In addition to this each system is supplied with a USB flash drive containing the same program currently stored in the logger and a test program with a smaller scan and store intervals. For example read sensors every 5 seconds and calculate and store to logger memory every minute. This test program is helpful as a learning tool for a new user as well as for testing the installation for any problems and an invaluable tool in trouble shooting the weather station, sensors, cabling or installation.

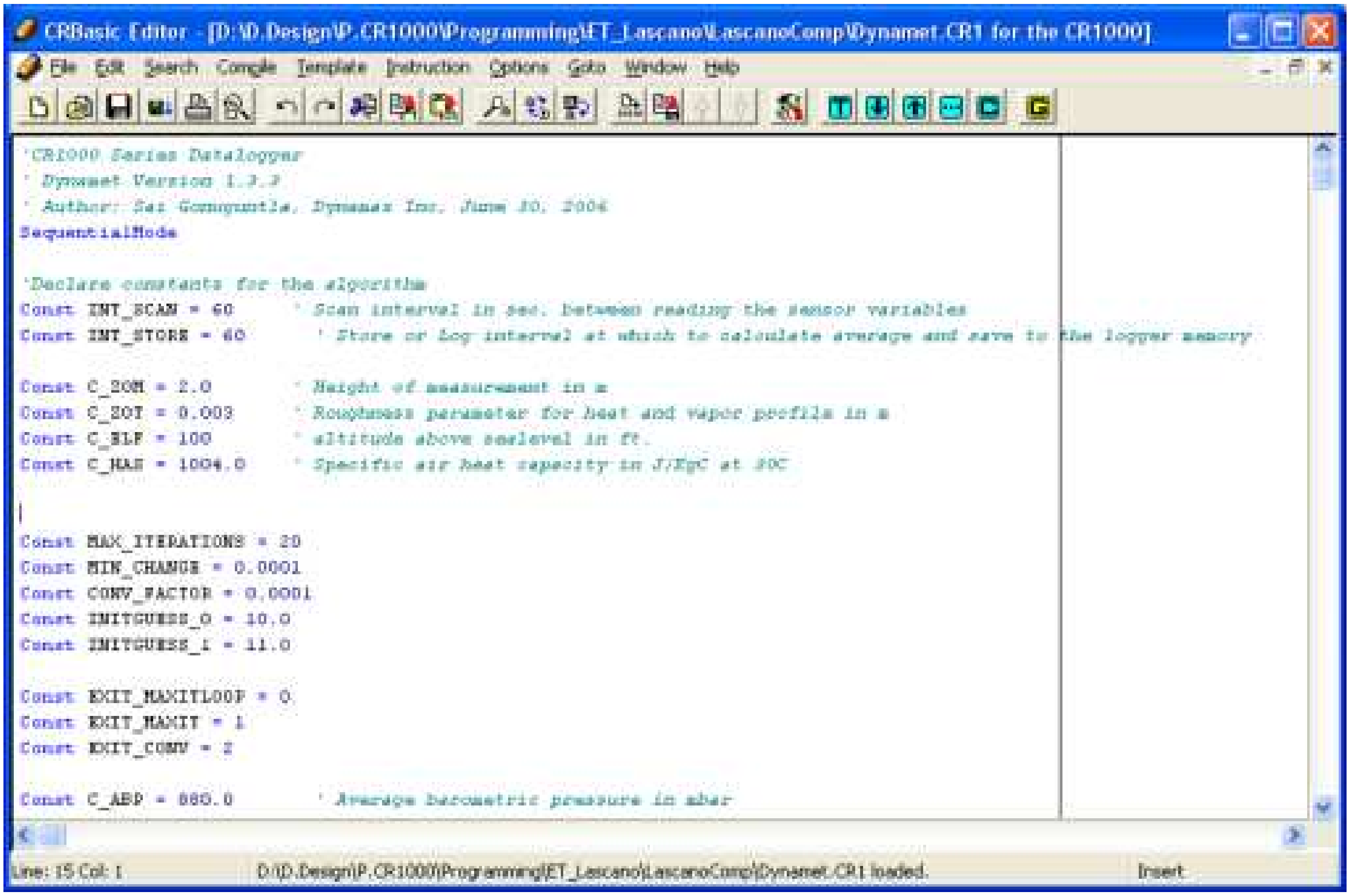
Even though Dynamet 5 weather station is shipped ready to flip the switch and operate, we recommend the user to modify the site specific constants/ variables to meet the geography of the location where the station is setup, compile the program and send the new program to logger. These site specific variables are,,

Parameter	Constant notation in program	Description	Units	Default Values
zom	C_ZOM	Height of measurement	M	2.0
zot	C_ZOT	Roughness parameter for heat and vapor profile	M	0.003
elf	C_ELF	Altitude above sea level	ft.	100
has	C_HAS	Specific Air Heat capacity	J/Kg.degC at 30C	1004.0

In addition an advanced user familiar with CRBasic programming can experiment with timing loops in the program such as scan interval and log interval.

Notation	Description	Units	Default Values
INT-SCAN	Time interval in seconds between successive reading of the data from meteorological sensors	sec	60
INT_STORE	Time interval in minutes at which to calculate average of the raw weather variables, calculate ETP and store to logger memory	min	60

Program supplied with Dynamet 5 system has the above list of variables present at the top of the program. Following is screen capture of the program Dynamet.CR1 as viewed in CR Basic editor. As shown in the picture above list of variables appear in the following order at the top of the program.



Notice in the figure timing loop parameters and site-specific parameters appear at the top of the program to enable any users identify these variables and make changes if necessary.

Const INT_SCAN
Const INT_STORE

Const C_ZOM
Const C_ZOT
Const C_ELF
Const C_HAS

The following site-specific parameters must be modified to meet the geographical location at which the station is setup to collect data. Timing loop parameters are options as the industry standard is to collect data every hour.

Const C_ZOM
Const C_ZOT
Const C_ELF
Const C_HAS

4.5 Customizing the Program

Following examples show how to modify the parameters, save and compile the program before making it ready to send to the logger.

Procedure to Modify the Program:

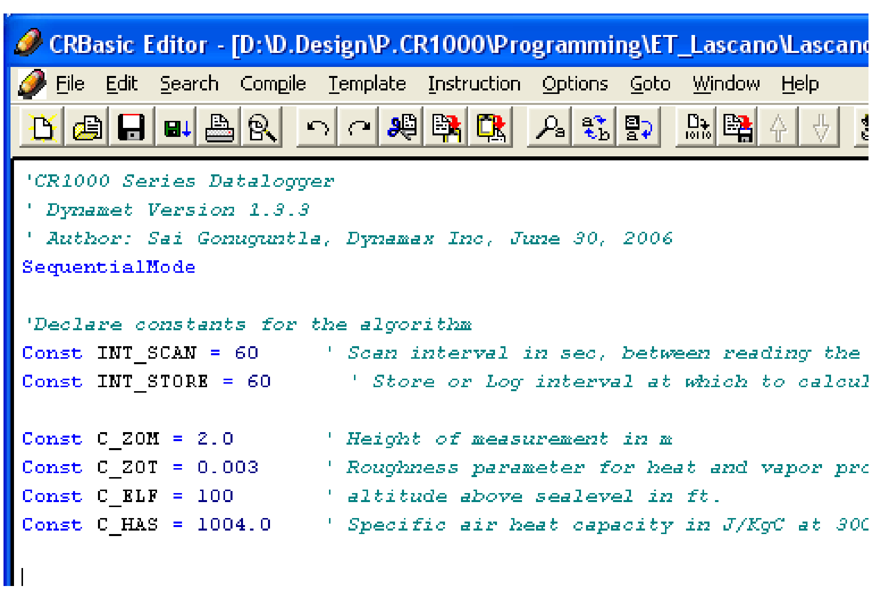
- Open CR Basic Editor by clicking on CRBasic icon .
- Open the file Dynamet.CR1 in the editor.
- Now identify the site-specific or timing loop variables at the top of the program as shown in the previous above.
- Modify values assigned to the constants as required.
- Save the program under a different file name (DynametSiteA.cr1) so that the original program is not modified. Save the program and compile.
- Now the new program DynametSiteA.cr1 is ready to send to logger.

Example 1:

Dynamet 5 weather station is setup at a site that is only 50 ft. above the sea level. The system is installed on top of a tower whose height is 20 m. Roughness parameter of the location of the installation is found to be 0.001 m and the specific air heat capacity is 1002.0 J/KgC. Modify the program Dynamet.cr1 and send to logger so that the Dynamet station can calculate ET using the Lascano-VanBavel RCM algorithm.

From the program it is clear that the required station parameters are,
zom = 20 m
zot = 0.001 m
has = 1002.0 J/KgC

Open the program in Dynamet.CR1 in CRBasic. As shown below are the default parameters.



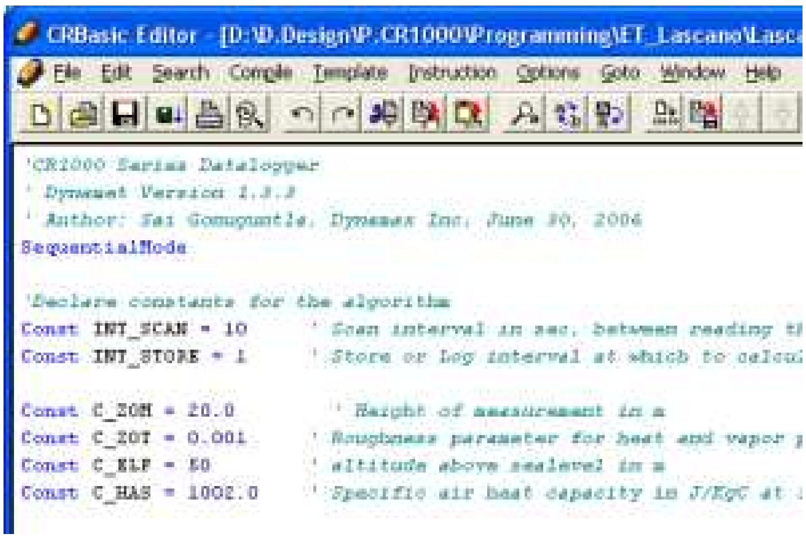
Now modify the station parameters/ constants in the program to reflect the new settings.

C_ZOM = 20. If you are installing on a tower of 20 m

C_ZOT = 0.001

C_HAS = 1002.0

Enter these values in program as shown below.



Save the program as a different name DynametEx1.Cr1. Compile the program. In CRBasic editor and the program is ready for sending to logger for data collection and ET computation with the revised parameters.

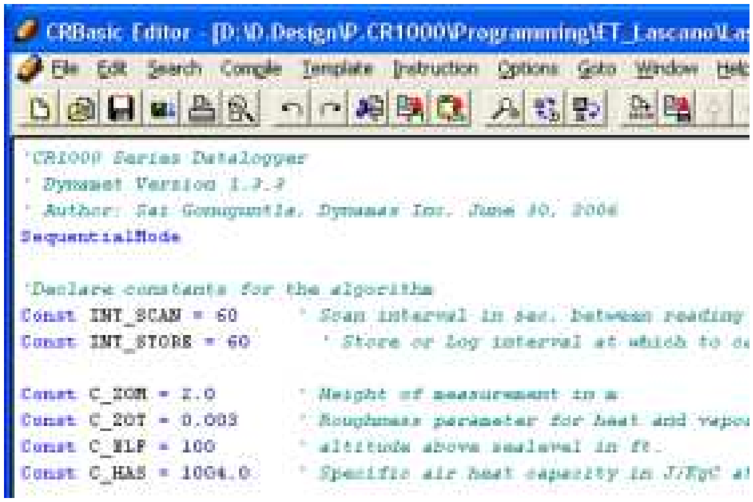
Example 2:

Dynamet weather station is setup at a site that is only 200 ft. above the sea level. The system is installed on top of a tower whose height is 5 m. Roughness parameter of the location of the installation is found to be 0.004 m and the specific air heat capacity is 1002.0 J/KgC. The station is located in a research site and the project requires sensor data to be read every 5 seconds and store to logger every one minute. Modify the program Dynamet.cr1 and send to logger so that the Dynamet 5 station can calculate ET using the Lascano-VanBavel RCM algorithm.

From the program it is clear that the required station parameters are,
zom = 5 m
zot = 0.0004 m
elf = 200 ft.
has = 1002.0 J/KgC

Scan interval = 5 sec
Store interval = 1 min

Open the program in Dynamet.CR1 in CRBasic. As shown below are the default parameters.



Now modify the station parameters/ constants in the program to reflect the new settings.

INT_SCAN = 5

INT_STORE = 1

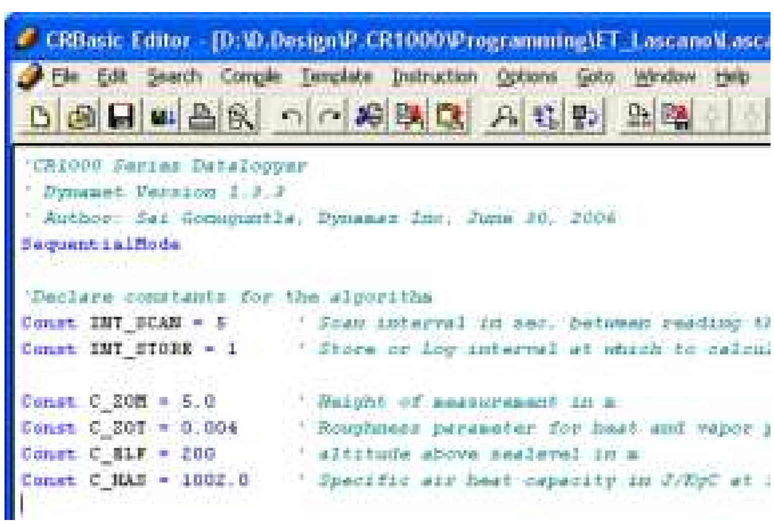
C_ZOM = 5

C_ZOT = 0.004

C_ELF = 200

C_HAS = 1002.0

Enter these values in program as shown below.

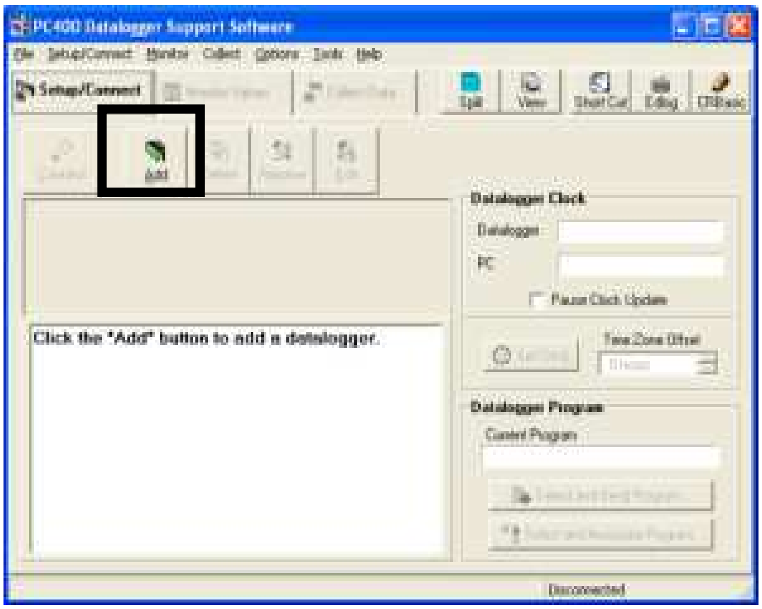


Save the program as a different name DynametEx2.Cr1. Compile the program. In CRBasic editor and the program is ready for sending to logger for data collection and ET computation with the revised parameters.

5.0 USING PC400

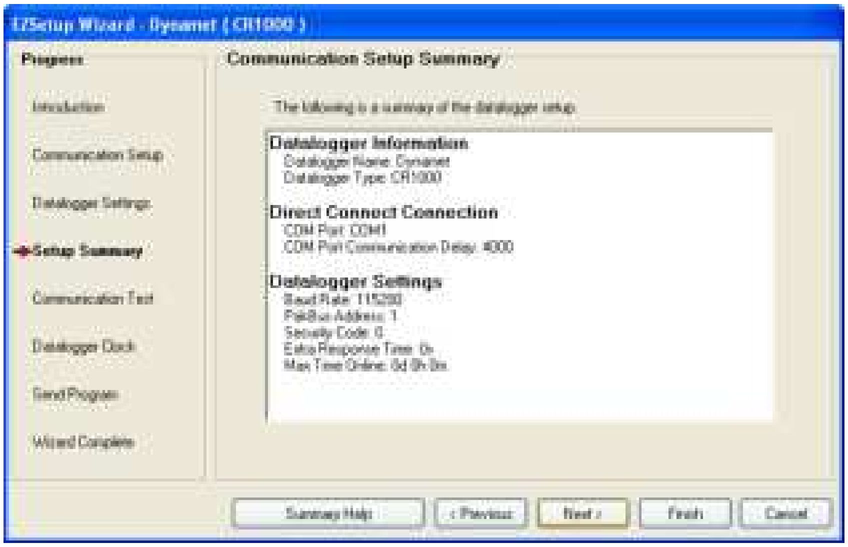
5.1 Setup, Program Logger and Communications

1. If this first time using software or to add a new logger station to the software setup click on **Add** button. **PC400 offers a easy to use step-by-step EZSetup wizard** that will guide through adding stations and connecting to logger. If the station is already added in the list, proceed with connect to logger in section 5.2.

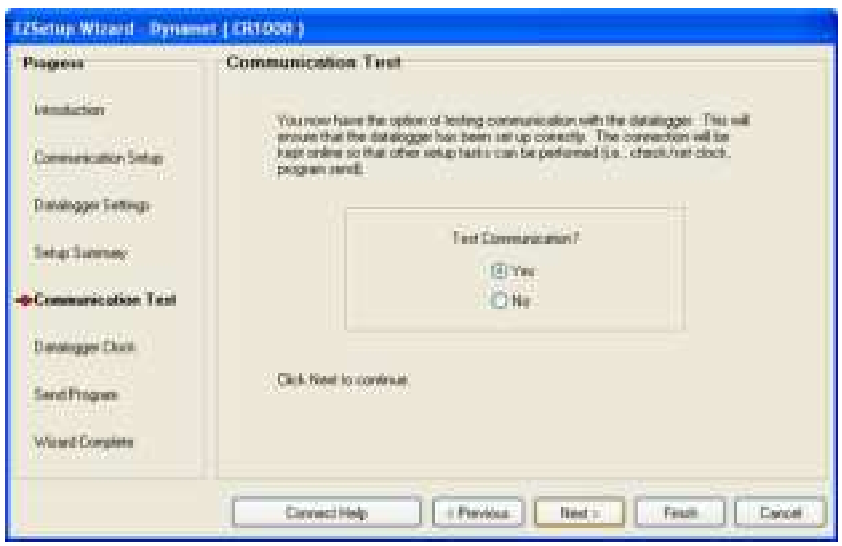


2. EzSetup wizard is shown in the screen to the left. Click **Next** to start the wizard and complete setup process. Select the data logger as CR1000, assign Dynamet as the Name of the data logger and enter the following settings in the setup wizard.

3. Setup wizard displays a summary of the settings as follows in the setup summary window. For any changes such as COM port, baud rate click Previous button to change the settings. When all the parameters are entered as required click next to proceed with setup wizard.



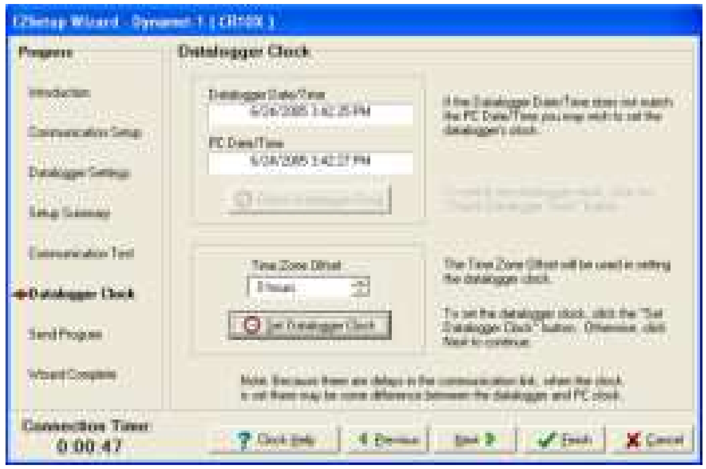
4. At this point if data logger is connected to PC COM port using 5' RS232 communication cable, you may proceed with communication test by selecting **Yes** for the radio button clicking **Next**. Or click **Finish** to close setup wizard, add this station (**Dynamet-1**) to the station list for connection and data retrieval in future.



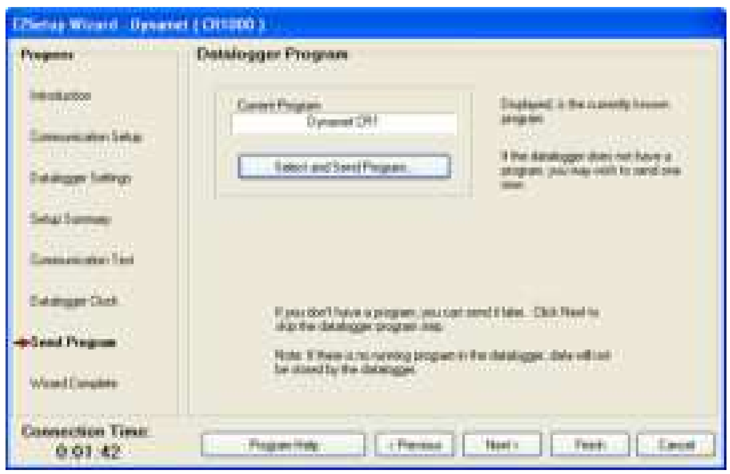
5. If **Test Communication** is selected in the previous window, PC400 software tries to connect to the specified logger on the COM port assigned in the setup wizard. If the Communication test is unsuccessful software responds with **Communication test Failed** message and reverts back to the communication test window. At this point make sure communication cable is connected to PC and logger is powered and retry the communication test. Click Finish to skip communication test and connect at a later time.

6. If the communication test is successful **Communication test successful** window will be displayed. Click Next to continue with setup wizard.

7. In the **Datalogger clock** window is displayed as shown in the figure. If Datalogger Date/Time is different from the PC Date/Time, select time zone offset between data logger and PC and click **Set Datalogger Clock** command button. Click **Next** to continue.

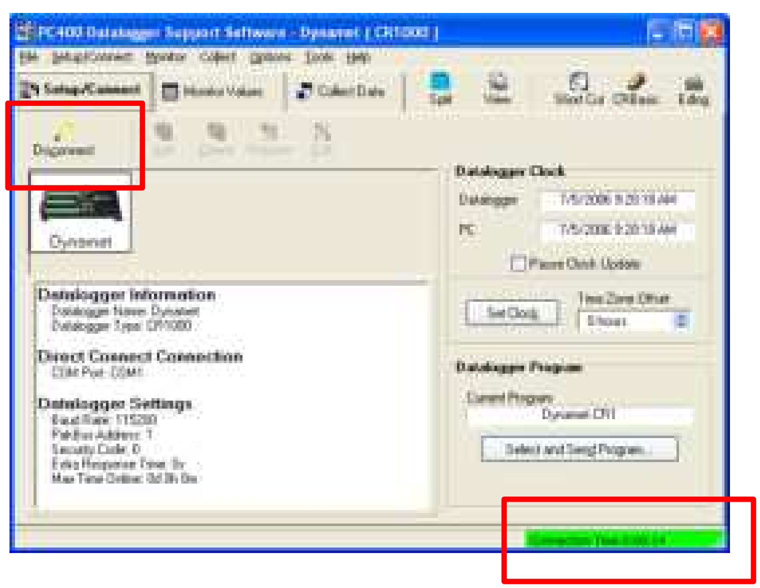


8. In the **Send Program** window click command button **Select and Send Program** to select *.cr1 program (Dynamet.cr1) using windows file selector and send to the data logger. Alternatively, you many click on command button **Select and associate program** for sending to data logger at a later time.



9. Click Next to complete the wizard and then finish to close the Ezsetup wizard and revert back to PC400 main window as shown below. Choose stay connected to keep the communication and close the Ezsetup wizard. Notice that a new station "Dynamet" is added in the station list, along with the station parameters entered while in the setup wizard.

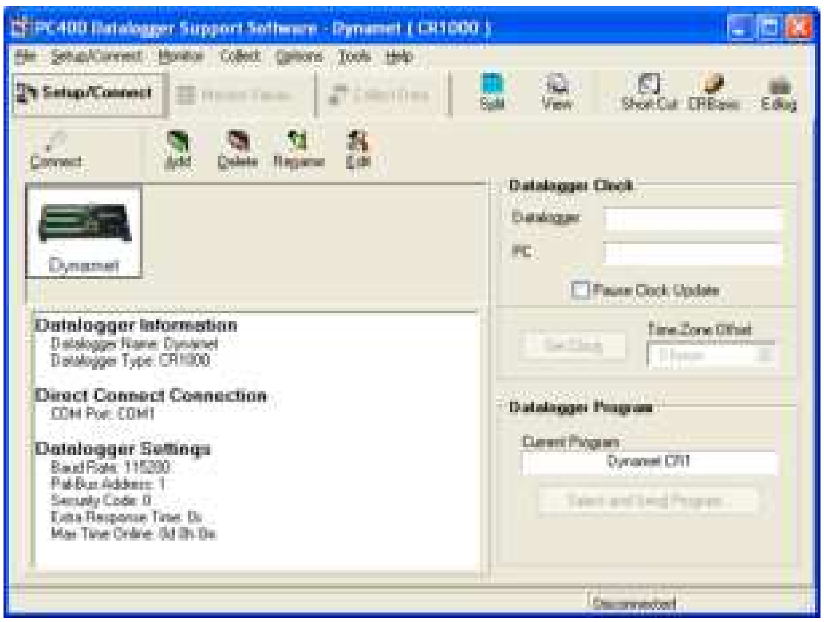
10. In the PC400 **Setup/Connect Tab** notice "Disconnect button is displayed" as shown in the figure and on the bottom right corner displays Connection time, implying software is currently connected to the data logger. Also data logger clock and data logger program can be set from this window.



11. Connecting to a data logger already setup in the software is described in the next section.

5.2 Connect To Logger

PC400 saves data logger setting once added in the software for future connections. A list of stations with name assigned is displayed in the **Setup/ Connect** tab of PC400 software as shown in the figure. A summary of the previously assigned settings in the software is displayed on in this window as shown below. Click on a station to view the settings previously entered to that particular station. To change or edit a station's settings simply click Edit button while the station is selected.

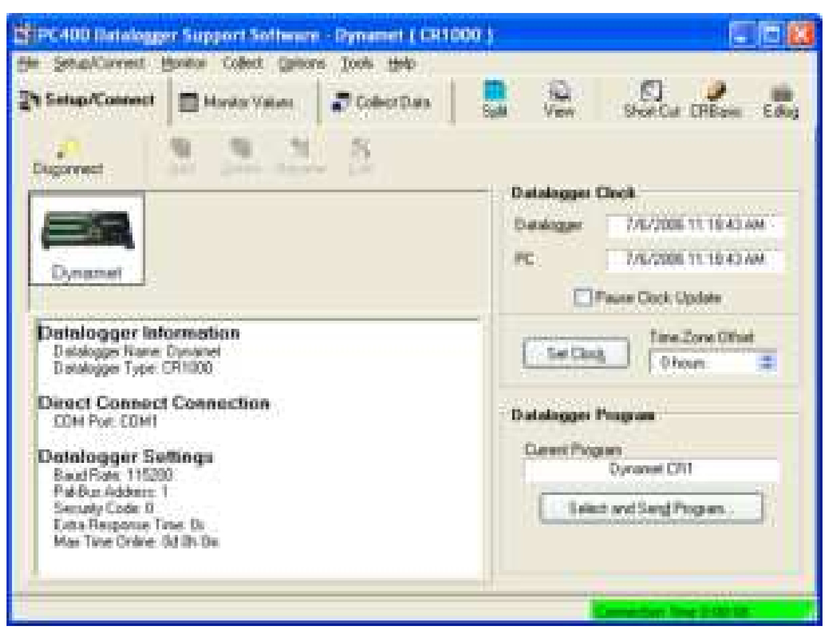


To connect to a logger for setting up program or data retrieval, simply select the station name and click on **Connect** button.

If the connection is successful Connect button changes to **"Disconnect"** and Connection time is displayed at the bottom right corner indicating software is currently connected to the data logger.

If data logger clock and PC clock are different select **Offset** and click **Set Clock** to update data logger clock.

Click command button **Select and Send Program** to send a new program to the logger.



5.3 Monitor Data in Real Time

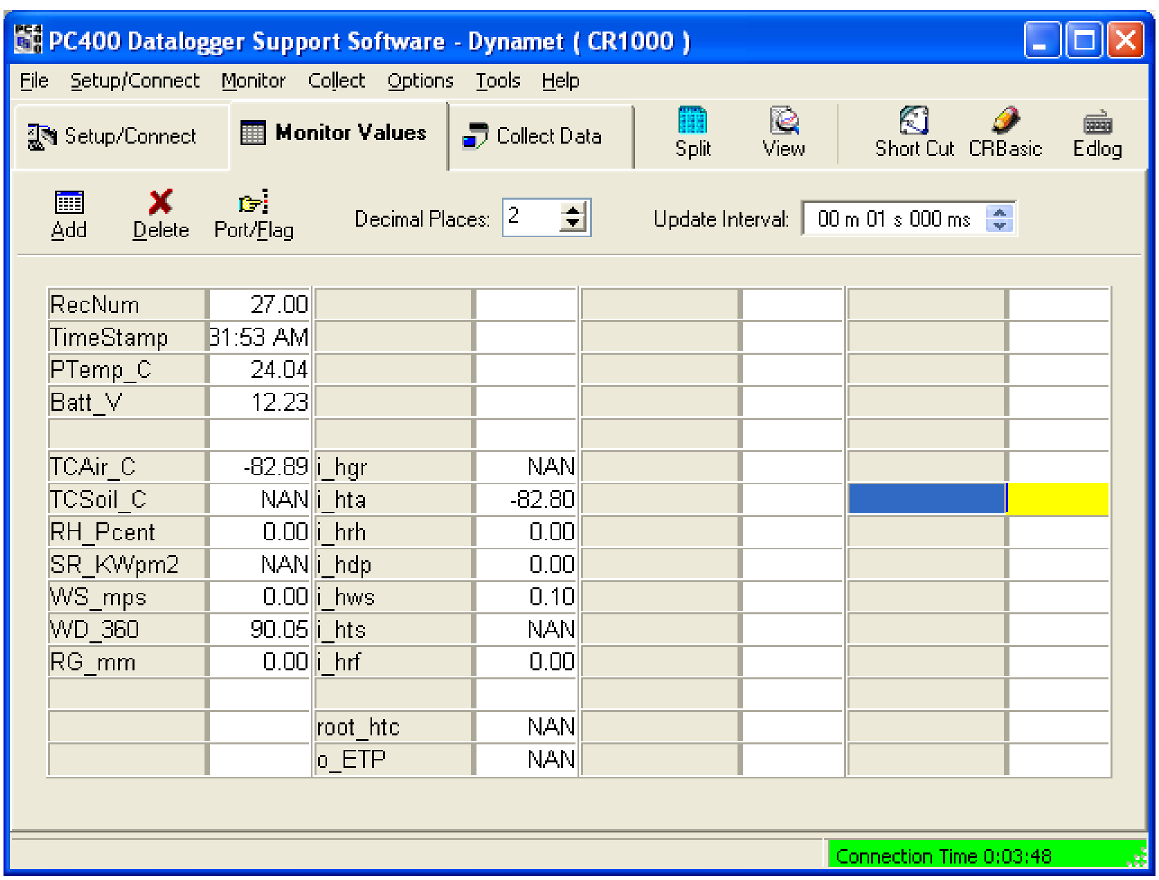
With communication established between software and the data logger, select **Monitor Values** tab in PC400 window. This is similar to Numeric panel in LoggerNet.

1. Click on Add button to open the signal list. Select Public from the left column to display public variables available in the right column. Select desired signals from the right column. Click on a cell in the Monitor values window, Click Paste button. All the selected signals will be displayed in the Monitor values window. Note that if you have a long averaging interval, it will take that amount of time to see a new reading. You may want to temporarily select a smaller interval or use maintenance program to test the operation. And then download the program with required long term averaging interval later. Any unwanted signals in Monitor window can be removed simply by selecting the cell and click **Delete** button.

2. Once in the Add menu, to select a range of values select the starting label, click on the beginning (for example TCAir_C) and then a **SHIFT-Click** on the ending of the range (for example RG_mm) and then click the **Paste** button.

3. Note any variables displaying a “-NAN” are an out of range, or in the case of a sensor input location; it is an open circuit wire.

4. In the figure below all Dynamet sensor variables are displayed in the monitor mode.



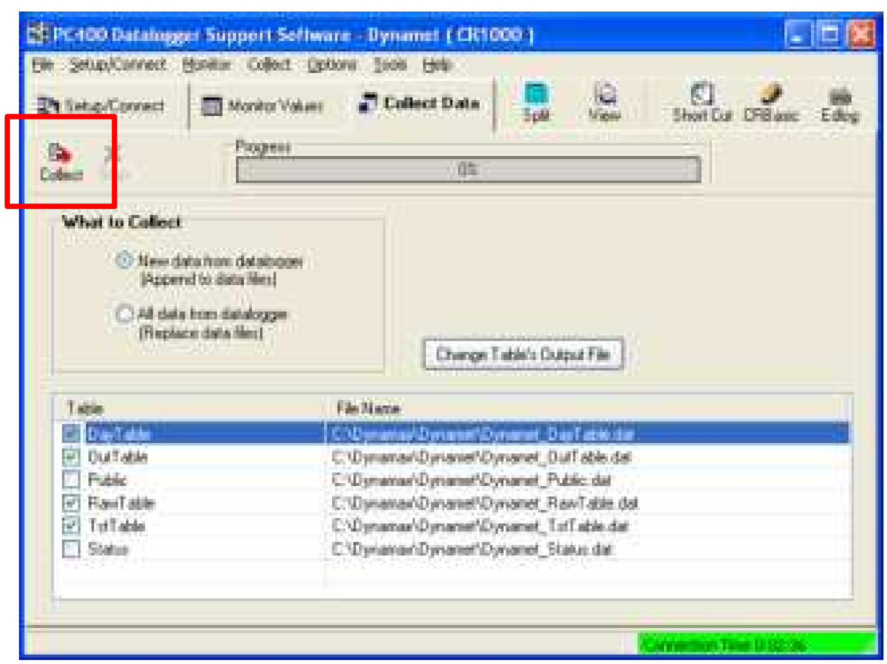
5.4 Data Collection

An active communication to the data logger is required to connection between software and weather station and for collecting data. In labs, nearby field tests or environmental chambers, the logger can be within RS232 cable connection range (100 ft.), or within the range of a broadband radio link up to 40 miles (using Dynamax's RFMX modem) or cellular wireless connection (using Dynamax's GSM modem). In addition to data collection real-time monitoring of data can be performed from a remote station explained in the previous sections. Following steps explain data retrieval manually at will.

1. With software connected to the data logger select **Collect Data** tab in PC400 software to display data retrieval options and controls.

2. Select the required tables to collect by simply enabling the check box to the left of the table name. If desired change the file name or path by double clicking on the table name or by clicking on **Change the Table's output file** command button while the required table is selected. Notice that the output files can be assigned .csv, .dat, .prn etc and corresponding file formats. We recommend using a .csv format such that the downloaded data files can be viewed easily using any spreadsheet application such as Excel.

3. Select **what to collect** option; choose **New data from logger** option to collect only new data since the last retrieval and appends to specified file name. Choose **All data from logger** collect and dump all the data present in the logger and overwrite the specified file name. **Note: All data from logger option over-writes any existing data in the file.**



4. Before proceeding make sure desired file name and properties are displayed in Collect tab.

5. Click **Collect** button to start data collection and save to file. Wait for software to complete retrieval and respond with "Collection Complete" message. Click on **stop** command button to stop data collection at any time.

6. Now the data is collected and saved to data file for further processing and analysis.

PC400 supports only manual data collection. For applications using network communication options, automatic data retrieval and schedule choose advanced data logger support software such as LoggerNet.

5.5 Advanced PC400 Features

In addition to basic options explained above for DynaMet operations an advanced user can explore a myriad of other features offered by PC400 data logger support software's explained else where in the manual or in different booklet

5.5.1 View data and Graphics

View is a program that can be used to open data files (*.DAT, *.PRN, *.CSV), or other CSI file types (*.DLD, *.CSI, *.PTI, *.FSL, *.LOG, *.CR5, *.CR9). Data files can be viewed numerically, or up to two traces can be plotted on a graph. Both numeric data and graphs can be sent to a printer. Graphs can be saved to disk in BMP, WMF, or EMF format.
View data feature is explained in chapter 6 and PC400 manual.

5.5.2 Short Cut/SCWIN

Short Cut for Windows (SCWIN) is an application for generating programs for Campbell Scientifics' data loggers and pre-configured weather stations. SCWIN guides you through four steps to program a data logger to measure your sensors and select the data to be stored in the data logger's final storage. Once a program is completed, SCWIN generates a wiring diagram for connecting your sensors to the data logger. SCWIN software feature is not applicable to DynaMet but an advanced user may choose to use SCWIN for advanced programming.

5.5.3 CRBasic – Program Editor

CRBasic is programming editor and compiler for table-based data loggers such as CR1000 etc. This feature is not applicable to current version of DynaMet data logger.

6.0 Data Format, View and Graphs

Connecting to Dynamet 5 weather station using PC400 software and collecting data is described in the previous chapter. This discusses in detail

- File formats
- Data formats
- Open data file using VIEW, Plot signals
- Open data file using Excel, Plot signals

As explained in the previous chapter section, “Collect data for offline processing”, the tables (files) of interest to the end-user are,

LOG Table…………saved in………… Dynamet 5_TableLOG.csv

In this section we discuss in detail contents of these data tables (files), format of data presented in these files, units, how to view and chart data and further analysis if any.

6.1 File Format

As explained in the previous chapter, section 5.4 Data Collection, the Dynamet data files can be saved with the .csv, .dat, .txt, .prn extensions. Comma separated file format is the recommended file format as it allows the files to be viewed using any of the spreadsheet applications such as Excel. Following table shows some of the key differences among the file formats.

.csv Data points with in a line are delimited by a comma. Simply open the file in Excel to view the data in a more readable format in rows and columns.

.dat Same as .csv but saved with extension .dat, to readily view the files in text editors as well as Campbell scientific’s VIEW application

.txt Same as .csv but saved with .txt extension.

.prn Data saved with TAB delimitor. This enables to view easily in a row and column format in a text editor or to print easily in the row and column format from a text editor.

6.2 Dynamet Data Format

Data collected from Dynamet 5 is in three different files as shown below. All these files are saved with a header showing the logger type, column header/ variable name.

LOG Table…………saved in…………   Dynamet 5_TableLOG.csv

Raw Table file containing raw data form the meteorological sensors Air Temperature, Soil Temperature (if available), Solar radiation (Global) sensor, Wind speed, Wind direction and Rain gauge.

Raw data Table format:

Time Stamp
Record#
Jday
HHMM

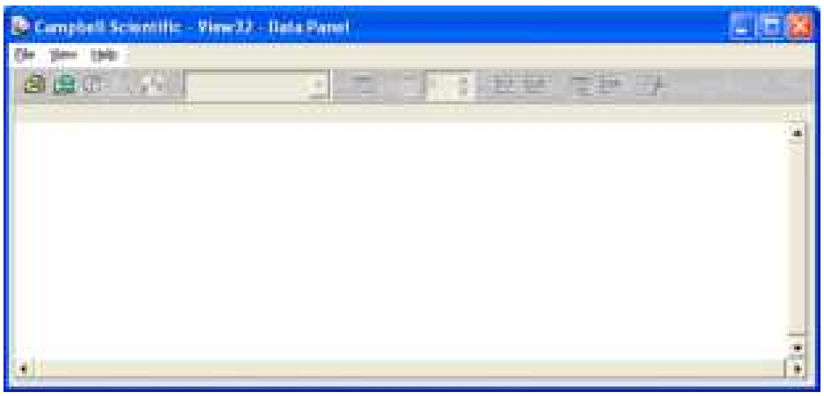
TCAir_C
RH_Pcent
SR_Wpm2
WS_mps
Wdir_Deg
WS_mps_WVc(1)
WS_mps_WVc(2)
WS_mps_WVc(3)
RG_mm
TCSoil_C

Batt_V
Ptemp_C of CR1000 logger

Out Table file contains raw sensors values averaged over the storage interval and calculated Dew Point in degC, calculated Surface temperature in degC using iterative RCM algorithm, calculated ETP using Lascano-VanBavel recursive algorithm.

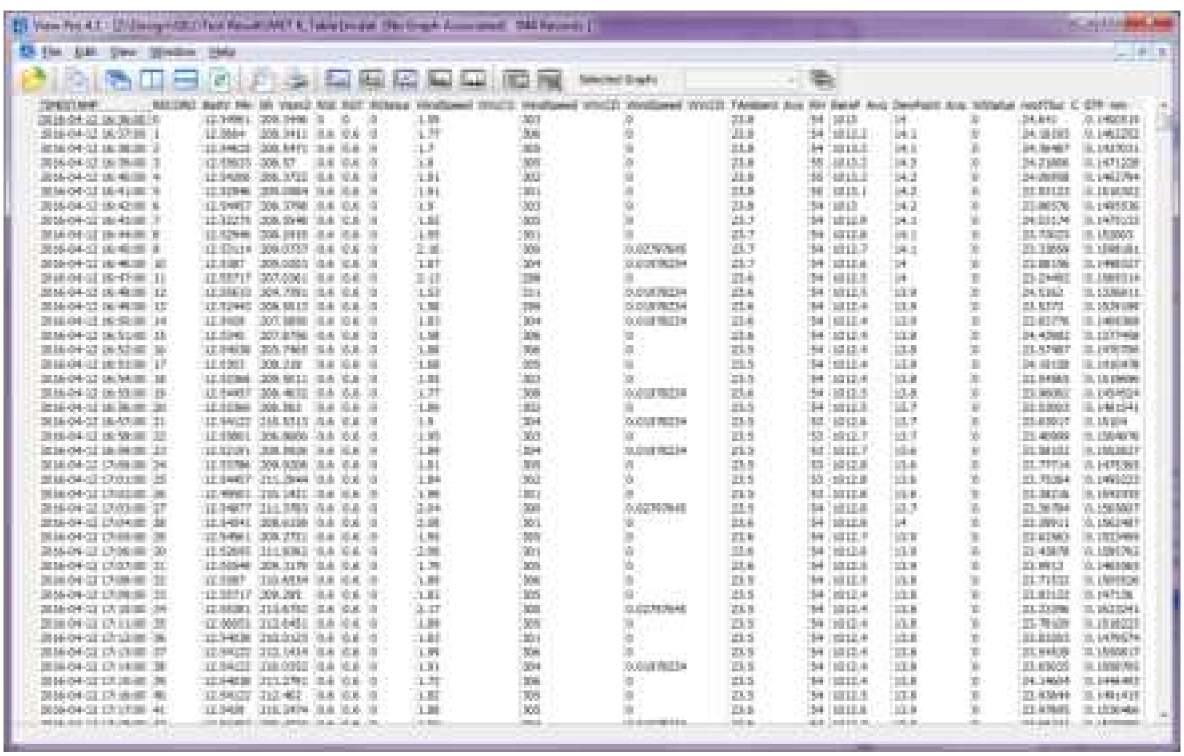
6.3 Open Data – Using "View"

1. Now that the data is retrieved from the CR1000 logger, PC400 VIEW utility is a great tool for a quick look at the data. VIEW also allows plotting two columns at a time for observation and save to bitmap file. Click on the VIEW button on the PC400 main toolbar to launch VIEW utility.

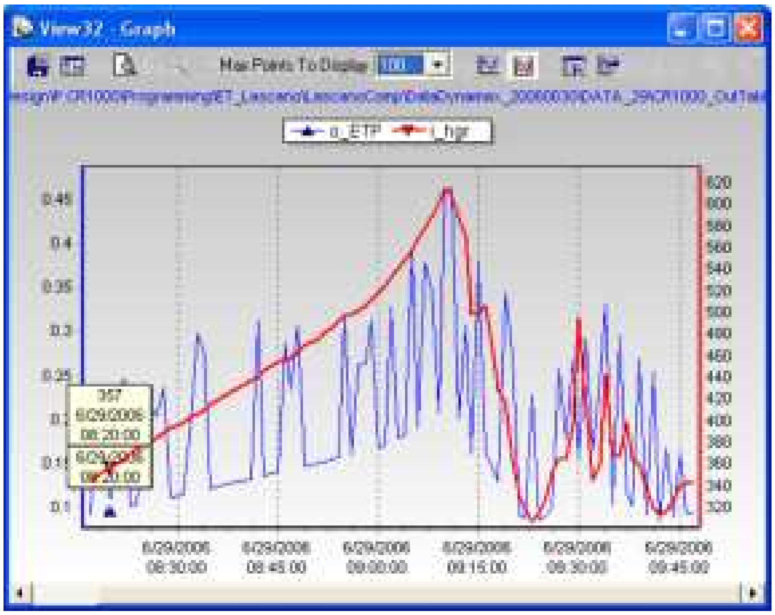


2. Click on **File Menu** and browse down to **Dynamet_TableLOG.csv**

3. Now the output table is displayed in the VIEW window in csv format. Click on View Menu and then Expand tabs to see the data in the column format, shown below. Format of the data was discussed earlier. Column header shows the variable name associated with the values displayed in the column along with the units.



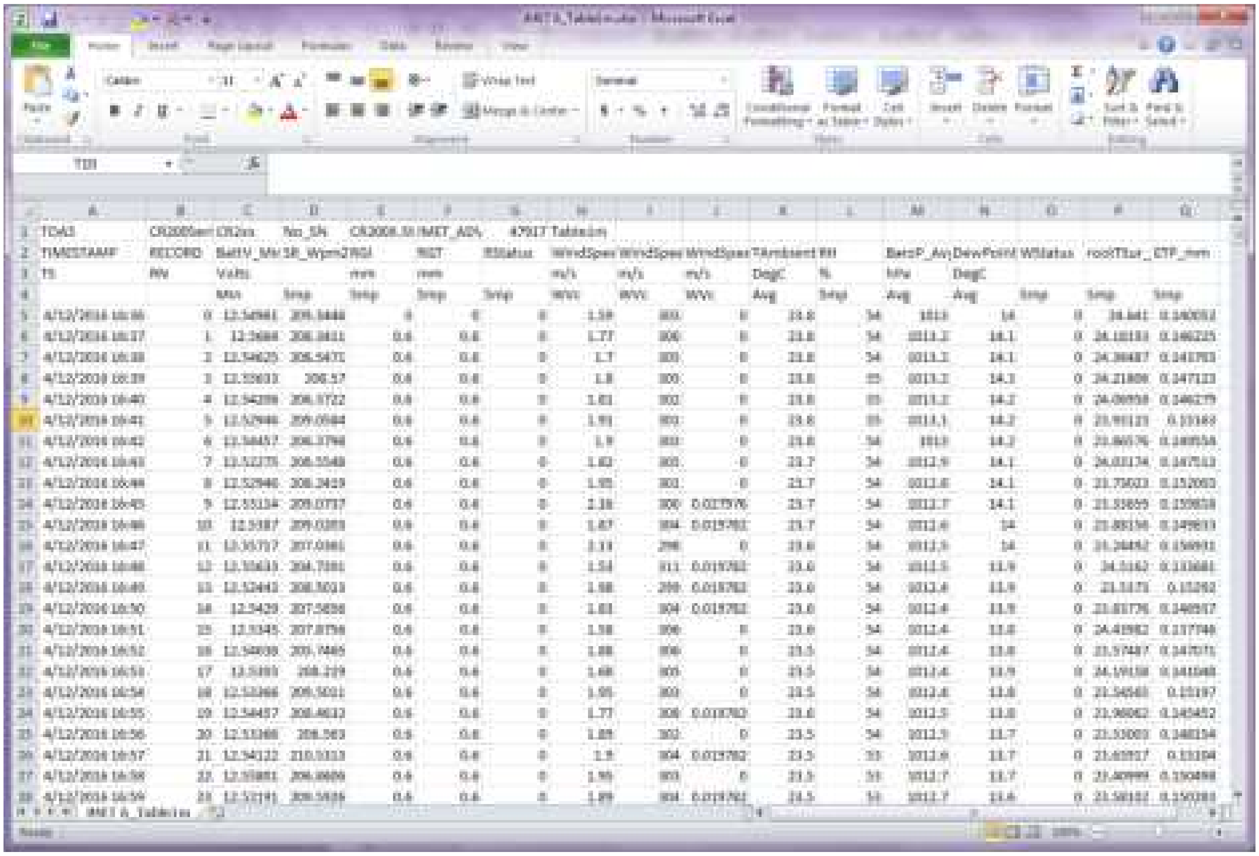
4. Now select one or more of the required columns to view in a chart format. Example shown here is for ETP (in Blue) and Global radiation (in Red). To select multiple columns click on the second column with mouse while holding down the shift key. Once the required columns are selected, click on the tool bar button, show graph (2Y axes) to display the chart of the selected data.



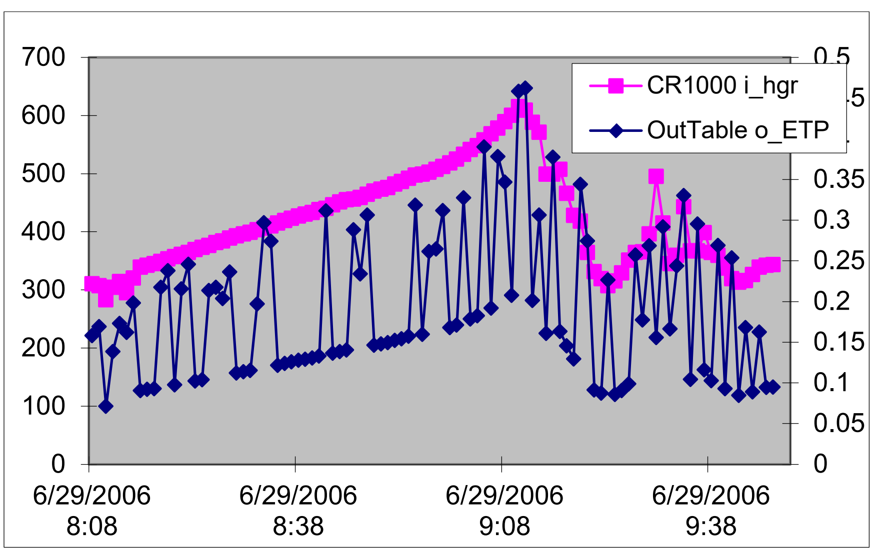
5. Similarly VIEW tool can be used to view data from other data files raw and daily average tables.

6.4 Open Data – Using EXCEL

1. In the earlier sections it was recommended to save collected data in .csv format such that the collected data can be readily opened in Excel or any preferred spreadsheet application. In the windows explorer navigate to the location where data files are saved. Select the required file (saved in .csv) format and double click to open this Excel. Alternatively, Launch Excel application, and open the file using open wizard and csv format. Figure below shows the Output table file Dynamet_TableLOG.csv as displayed in excel window.



2. In excel it is much simpler to plot required columns and there is no limitation on the number of columns that can be displayed in a chart. Ideally all the variables saved in the OutTable can be displayed in the same chart using multiple axes option. Select column/ columns for charting along with the Time stamp or Jday and HHMM for X-axis. Click on chart wizard button, follow steps in the wizard to complete the wizard and display chart as shown below for ETP, Global radiation.



3. Plots for other variables can be plotted in the same manner.

Appendix A: Lascano-Van Bavel Iterative ET Algorithm

Constants or site-specific variables:

Notation	Description	Units
zom	Height of measurement	M
zot	Roughness parameter for heat and vapor profile	M
lev	Heat of vaporization	J/Kg
has	Specific heat air capacity	J/Kg.degC at 30C

Input variables:

Notation	Description	Units
hgr	Hourly average solar radiation	W/m2
hta	Hourly average of air temperature	degC
hrh	Hourly average or relative humidity	%
hws	Hourly average of wind speed	M/s
hts	Hourly average of soil temperature	DegC

Calculated variables:

Notation	Description	Units
had	Air Density	Kg/m3
hum	Ambient Humidity	Kg/m3
ras	Aerodynamic resistance	S/m
skl	Sky long-wave radiation	W/m2
htc	Surface temperature	DegC
rnt	Net radiation balance	W/m2
sht	Sensible heat flux	W/m2
hums	Humidity at the surface	Kg/m3
evt	Evapotranspiration	Kg/m2.s
EVT	Evapotranspiration in standard units	mm/hour

RCM ET Algorithm:

Site Specific Variables:

$$lev = (2.501 - 0.002361 \cdot hta) \cdot 10^6$$

$$abp = 1013.2 * e^{(-elf * 3.817E-5)}$$

Dew Point Calculation:

$$e_s(T_a) = 6.1078 \cdot e^{\left(\frac{17.2693882 \cdot T_a}{237.3 + T_a}\right)}$$

$$e_a = e_s(T_a) \cdot hrh$$

$$hdp = \frac{\left(237.3 \cdot \ln\left(\frac{e_a}{6.1078}\right)\right)}{\left(17.2693882 - \ln\left(\frac{e_a}{6.1078}\right)\right)}$$

RCM algorithm for ET calculation:

$$had = 1.1548 \cdot \frac{abp}{1013.2}$$

$$hum = 1.323 \cdot \frac{e^{\left(17.269 \cdot \frac{hdp}{hdp + 237}\right)}}{hdp + 273.2}$$

$$ras = \frac{\ln\left(\frac{zom}{zot}\right)^2}{0.16 \cdot hws} \quad or \quad ras = \frac{\ln\left(\frac{zom}{zot}\right)^2}{0.16 \cdot (hws + 0.1)} \quad when\ hws < 0.1$$

$$skl = 5.67E - 8 \cdot (hta + 273.2)^4 \cdot (0.70 + 0.08241 \cdot hum \cdot e^{\left(\frac{1500}{hta + 273.2}\right)}$$

$$htc = root^{htc=10}\left[\left\{\left(0.80 \cdot hgr - 5.67E - 8 \cdot (htc + 273.2)^4 + skl\right) + \frac{(hta - htc) \cdot had \cdot has \cdot 303.16}{(hta + 273.2) \cdot ras} - \frac{1.323 \cdot \frac{e^{\left(17.269 \cdot \frac{htc}{htc + 237}\right)}}{htc + 273.2} - hum}{ras} \cdot lev\right\} \cdot \frac{ras}{\left(\frac{had \cdot has \cdot 303.16}{hta + 273.2}\right)}, htc\right]$$

$$rnt = \left(0.80 \cdot hgr - 5.67E - 8 \cdot (htc + 273.2)^4 + skl\right)$$

$$sht = \left[\frac{had \cdot has \cdot 303.16 \cdot (hta - htc)}{(hta + 273.2) \cdot ras}\right]$$

$$evt = \frac{rnt + sht}{lev}$$

$$EVT = evt \cdot 3600$$

Appendix B: References

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Appendix C: Sensor Specifications

Dynamet 5
Weather Station

Dynamax

The DynaMet-5 is a complete ETp (Evapotranspiration) weather station which includes the DynaLog1000 data logger and the MaxiMet 500 compact weather station kit. The rainfall sensor included is the TE525, which is a very rugged and accurate rainfall sensor. A soil temperature probe is also included. The system comes with all software for programming, data collection, and calculation of ETp. The DynaMet-5 is a research grade, weather station ideal for research, commercial, or agricultural applications. Comes complete with a 6 ft Tripod, cross-arm, grounding kit, rechargeable battery and 10 Watt solar panel.

Evapotranspiration Software

Standard evapotranspiration modeling software is packaged with the Dynamet weather station. The purpose is to compute the potential evapotranspiration from short grass (ETP) in mm per hour on an hourly basis. A daily total in mm is also computed. The algorithms are based on the method originally proposed by Penman, but with several modifications by Dr. C.H.M. Van Bavel that updated the procedure. Whereas the original method was designed to give only daily totals from average daily weather data, the present method uses hourly input data and provides a more realistic picture of the evaporative demand. PENV software facilitates a variety of research and commercial weather tracking projects.

MaxiMet™

MaxiMet is an advanced compact weather station designed and manufactured by Gill Instruments using proven technology to measure meteorological and environmental parameters to international standards. MaxiMet incorporates all the measurement parameters that meet the requirements of users in demanding applications where cost, quality and performance are essential.

Mast - Enclosure Specifications

6 ft. (2 m) tripod with collapsible legs, ground stakes, and slide collars for levelling. Crossbar mount for wind set, pyranometer mounting, levelling stand, and 12 plate radiation shield for RH /temperature probe are included. Grounding rod, lightening arrestor, and ground rod cables are included. Logger is mounted in a sealed and lockable NEMA 4 white fiberglass enclosure 12” x 14”.

Features

- **MaxiMet 500 Compact weather station**
- **Portable 2 meter (6 ft.) tripod, 3 meter (10 ft.) optional**
- **Sealed enclosure**
- **CR1000 data logger**
- **10 Watt solar panel, mast mounted**
- **Battery and charger circuit**
- **Scientific grade weather sensors**
- **4 MB of storage**
- **RS-232 Interface & PC9-pin cable (3 m)**
- **Power Up Program Start**
- **PENV - Penman-Van Bavel ETP**

Specifications

Wind Speed	
Range	0.1 m/s to 60 m/s
Accuracy	± 3% to 40 m/s, ± 5% to 60 m/s
Resolution	0.01 m/s
Wind Direction	
Range	0 to 359°
Accuracy	± 3° to 40 m/s, ± 5° to 60 m/s
Resolution	1°
Barometric Pressure	
Range	300 to 1100
Accuracy	± 0.5 hPa @ 25°C
Resolution	0.1 hPa
Units of measure	hPa, bar, mmHg, inHg
Air Temperature	
Range	-40°C to +70°C
Accuracy	± 0.3°C @ 20°C
Resolution	0.1
Units of measure	°C, °F, °K
Relative Humidity	
Range	0-100%
Accuracy	± 2% @ 20°C (10%-90% RH)
Resolution	1%
Units of measure	% Rh, g/m3, g/Kg
Dew Point	
Range	-40°C to +70°C
Resolution	0.1 °C
Units of measure	°C, °F, °K
Accuracy	± 0.3°C @ 20°C
Rain Gage	
Sensor Type	Tipping bucket with magnetic reed switch
Housing Material	Anodized aluminum
Resolution	1 tip
Volume per Tip	4.73 ml/tip (0.16 fl. oz/tip)
Rainfall per Tip	0.254 mm (0.01 in.)
Accuracy	±1% (up to 1 in./h) +0, -3% (1 to 2 in./h) +0, -5% (2 to 3 in./h)
Solar Radiation	
Accuracy	Absolute error in natural daylight is ±5% maximum (±3% typical)
Sensitivity	0.2 kW m^{-2} mV^{-1}
Light Spectrum Waveband	400 to 1100 nm

MaxiMet

GMX500 Compact Weather Station

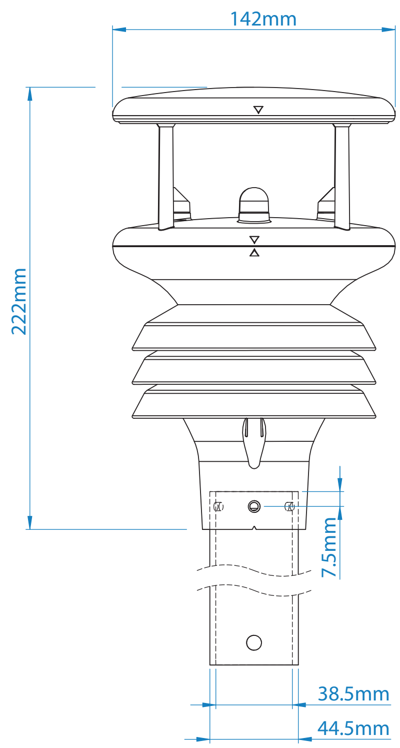
The MaxiMet range of compact weather stations is designed and manufactured by Gill Instruments. MaxiMet products use reliable, high quality instruments to provide accurate meteorological information in a wide variety of applications.

GMX500 Features

Temperature, humidity, pressure. A combined instrument mounted inside three double louvered, naturally aspirated radiation shields with no moving parts. The results are high performance across each measurement over long periods of time.

Wind. Wind speed and direction measurements are provided via an ultrasonic sensor and the addition of an electronic compass provides apparent wind measurements. Average speed and direction together with WMO averages and gust data is also provided. Add GPS (optional) to provide true wind and other features.

TEMP, HUMIDITY & PRESSURE	WIND	GPS (OPTION)	PARAMETERS
▪ Air Pressure / Temperature ▪ Relative / Absolute humidity ▪ Naturally aspirated UV stable radiation shield ▪ Protection against wind-blown precipitation/dust	▪ Wind speed & direction ▪ Apparent and true wind (with GPS) ▪ WMO wind averages and gust ▪ Compass	▪ Height above sea level *m* ▪ MSL pressure	▪ Temperature *℃ / ℉ / °K* ▪ Relative humidity *% Rh* ▪ Barometric pressure *hPa, mbar, mm Hg, In Hg* ▪ Absolute humidity *g/m³* ▪ Wind speed *m/s, km/hr, mph, kts, ft/min* ▪ Wind direction *°* ▪ True/apparent wind ▪ Angle of Tilt ▪ Outputs *RS232, 422, 485 (ASCII), SDI-12, NMEA, MODBUS, Analogue (option)*



All MaxiMet Models Feature

- Quality Measurements
- Lightweight and Robust
- Low Power Mode
- Free of Charge Software
- Gill Proven Reliability
- Compact Integrated Design
- Real Time Output
- Easy Installation
- Gill Customer Support
- 2 Year Warranty

* Please see the manual for a full list of derived parameters

Applications

- Building and Industrial Controls
- Authorities
- Transport
- Coastal
- Agricultural
- Safety
- Educational
- Commercial
- Energy

WIND SPEED	
Range	0.1 m/s to 60 m/s
Accuracy	± 3% to 40 m/s, ± 5% to 60 m/s
Resolution m/s	0.01
Starting Speed	0.1 m/s
Sampling Rate	1 Hz
Units	m/s, km/hr, mph, kts, ft/min

WIND DIRECTION	
Range	0-359°
Accuracy	± 3° to 40 m/s ± 5° to 60 m/s
Resolution	1°
Sampling Rate	1 Hz
Units	Degrees

TEMPERATURE	
Range	-40°C to +70°C
Resolution	0.1
Accuracy	± 0.3°C @ 20°C
Sampling Rate	1 Hz
Units	°C, °F, °K

HUMIDITY	
Range	0-100%
Resolution	1%
Accuracy	± 2% @ 20°C (10%-90% RH)
Sampling Rate	1 Hz
Units	% Rh, g/m³

DEW POINT	
Range	-40°C to +70°C
Resolution	0.1
Accuracy	± 0.3°C @ 20°C
Units	°C, °F, °K
Sampling Rate	1 Hz

PRESSURE	
Range	300 to 1100 hpa
Resolution	0.1 hPa
Accuracy	± 0.5 hPa @ 25°C
Sampling Rate	1 Hz
Units	hPa, mbar, mmHg, inHg

OUTPUTS	
Output rate	1/s, 1/min, 1/hr
Digital Comms Modes	Serial RS232, RS422, RS485, SDI-12, NMEA, MODBUS, ASCII
Analogue Outputs	Available via separate optional device

POWER	
Power Supply	5 to 30 Vdc
Power (Nominal) 12 Vdc	25 mA continuous high mode. 0.7 mA eco-power mode (1 hour polled)

ENVIRONMENTAL CONDITIONS	
IP Rating	66
Operational Temperature Range:	-40°C to +70°C
EMC Standard:	BS EN 61326 : 2013 FCC CFR47 parts 15.109
CE Marking	YES
RoHS compliant	YES
Weight	0.7 Kg
Origin	UK

Specifications may be subject to change without prior notice

Dynamax

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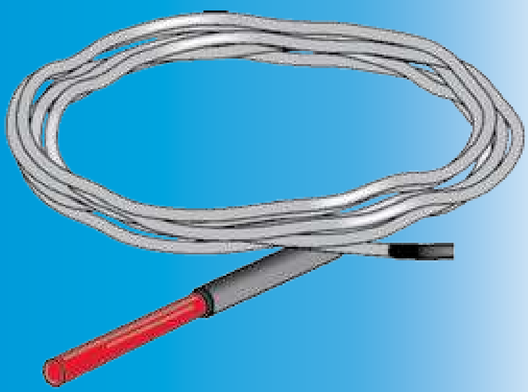
Suite 350
Houston, TX 77099

Tel: 281-564-5100
admin@dynamax.com
www.dynamax.com

nqa. ISO 9001 Registered

1957-008 Iss 4

TM10 Temperature Probe



General

The TM10 Temperature Probe uses a thermistor to measure temperature. The standard lead length is 10 feet and custom lead lengths are available up to 1000 feet.

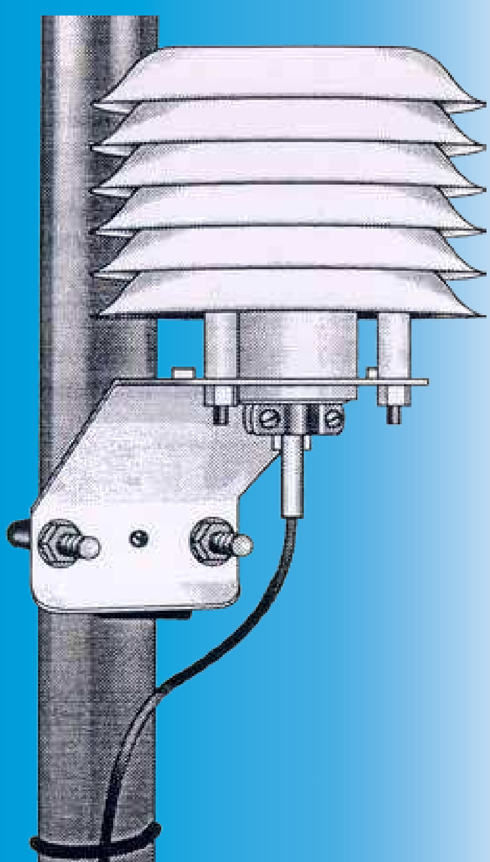
The TM10 Temperature Probe is designed for measuring air/soil/water temperatures. For air temperature, a 41301 radiation shield is used to mount the TM10 Probe and limit solar radiation loading. The, TM10 is designed to be buried or submerged in water to 50 feet.

Specifications

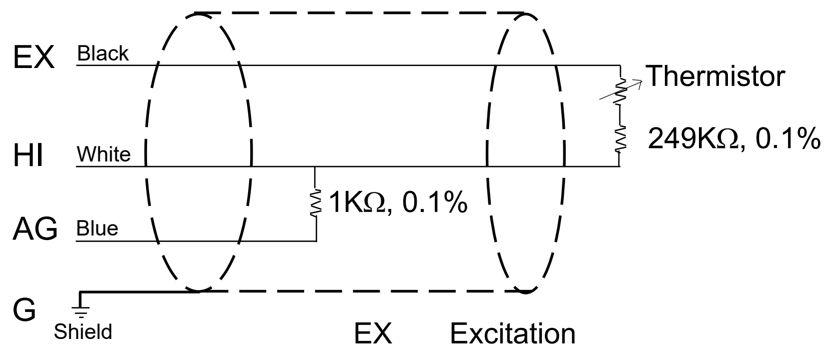
Measurement Range:	-35° to + 50° C
Thermistor Interchangeability Error:	Typically <± 0.2° C over 0° C to 60° C; ± 0.4 @ -35° C
Temperature Survival Range:	-50°C to +100° C
Polynomial Linearization Error:	<± 0.5° C over -35°C to +50° C
Time Constant in Air:	200 ± 10 seconds

Installation and Wiring

For air temperature measurement, the TM10 must be housed inside a radiation shield when used outdoors. The number of TM10 probes per excitation channel is physically limited by the number of lead wires that can be inserted into a single excitation terminal (approximately 6).



The TM10 and Radiation Shield on a Tripod Mast.



EX Excitation
HI High Signal
AG Analog Ground
G Earth Ground

Connections for: CR1000 Datalogger

TM10 Temperature Probe

Electrically Noisy Environment

AC power lines can be the source of electrical noise. If the datalogger is in an electronically noisy environment, the TM10 temperature measurement should be measured with the AC half bridge with the 60 Hz rejection integration option on the DNX1K and slow integration on the 23X and CR7. Instruction 11's fast integration will not reject 60Hz noise.

Sample DNX1K Instructions Using AC Half Bridge

01:	P5	AC Half Bridge
01:	1	Rep
02:	22**	7.5 mV 60 Hz rejection range
03:	1*	IN Chan
04:	1*	Excite all reps w/ EXchan 1
05:	2000**	mV Excitation
06:	1*	Loc [:Air Temp]
07:	800	Mult
08:	0	Offset
02:	P55	Polynomial
01:	1	Rep
02:	1*	X Loc Air Temp
03:	1*	F(X) Loc [:Air Temp]
04:	-53.46	C0
05:	90.807	C1
06:	-83.257	C2
07:	52.283	C3
08:	-16.723	C4
09:	2.211	C5

* Proper entries will vary with program and datalogger channel and input location assignments.
** On the 23x and CR7 use the 15 mV input range and 4000 mV excitation.

Long Lead Lengths

If the TM10 has lead lengths of more than 300 feet, use the DC Half Bridge instruction with a 2 millisecond delay to measure temperature. The delay provides a longer settling time before the measurement is made. Do not use the TM10 with long lead lengths in an electrically noisy environment.

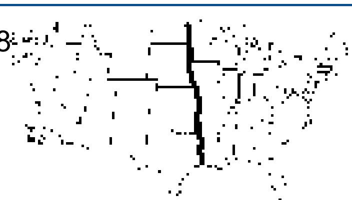
Sample Program DNX1K Using DC Half Bridge with delay

01:	P4	Excite, Delay, Volt (SE)
01:	1	Rep
02:	2**	7.5 mV slow range
03:	1*	IN Chan
04:	1*	Excite all reps w/ EXchan 1
05:	2	Delay (units .01 sec)
06:	2000**	mV Excitation
07:	1*	Loc [:Temp C]
08:	.4***	Mult
02:	P55	Polynomial
01:	1	Rep
02:	1*	X Loc Temp C
03:	1*	F(X) Loc[:Temp C]
04:	-53.46	C0
05:	90.807	C1
06:	-83.257	C2
07:	52.283	C3
08:	-16.723	C4
09:	2.211	C5

* Proper entries will vary with program and datalogger channel and input location assignments.
** On the 23x and CR7 use the 15 mV input range and 4000 mV excitation.
*** Use a multiplier of 0.2 with a 23X abd CR7.

1-800-896-7108
Toll Free

1-800-727-3570
US & Canada



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Dynamax

Temperature, Resistance and Datalogger Output

Temperature °C	Resistance OHMS	Output °C
-40.00	4067212	-39.18
-38.00	3543286	-37.55
-36.00	3092416	-35.83
-34.00	2703671	-34.02
-32.00	2367900	32.13
-30.00	2077394	-30.18
-28.00	1825568	-28.19
-26.00	1606911	-26.15
-24.00	1416745	-24.11
-22.00	1251079	-22.05
-20.00	1106485	-20.00
-18.00	980100	-17.97
-16.00	869458	-15.95
-14.00	772463	-13.96
-12.00	687276	-11.97
-10.00	612366	-10.00
-8.00	546376	-8.02
-6.00	488178	-6.05
-4.00	436773	-4.06
-2.00	391294	-2.07
0.00	351017	-0.06
2.00	315288	1.96
4.00	283558	3.99
6.00	255337	6.02
8.00	230210	8.04
10.00	207807	10.06
12.00	187803	12.07
14.00	169924	14.06
16.00	153923	16.05
18.00	139588	18.02
20.00	126729	19.99
22.00	115179	21.97
24.00	104796	23.95
26.00	95449	25.94
28.00	87026	27.93
30.00	79428	29.95
32.00	72567	31.97
34.00	66365	33.99
36.00	60752	36.02
38.00	55668	38.05
40.00	51058	40.07
42.00	46873	42.07
44.00	43071	44.05
46.00	39613	46.00
48.00	36465	47.91
50.00	33598	49.77
52.00	30983	51.59
54.00	28595	53.35
56.00	26413	55.05
58.00	24419	56.70
60.00	22593	58.28