Welcome to Campbell Scientific Training

Campbell Station Essentials

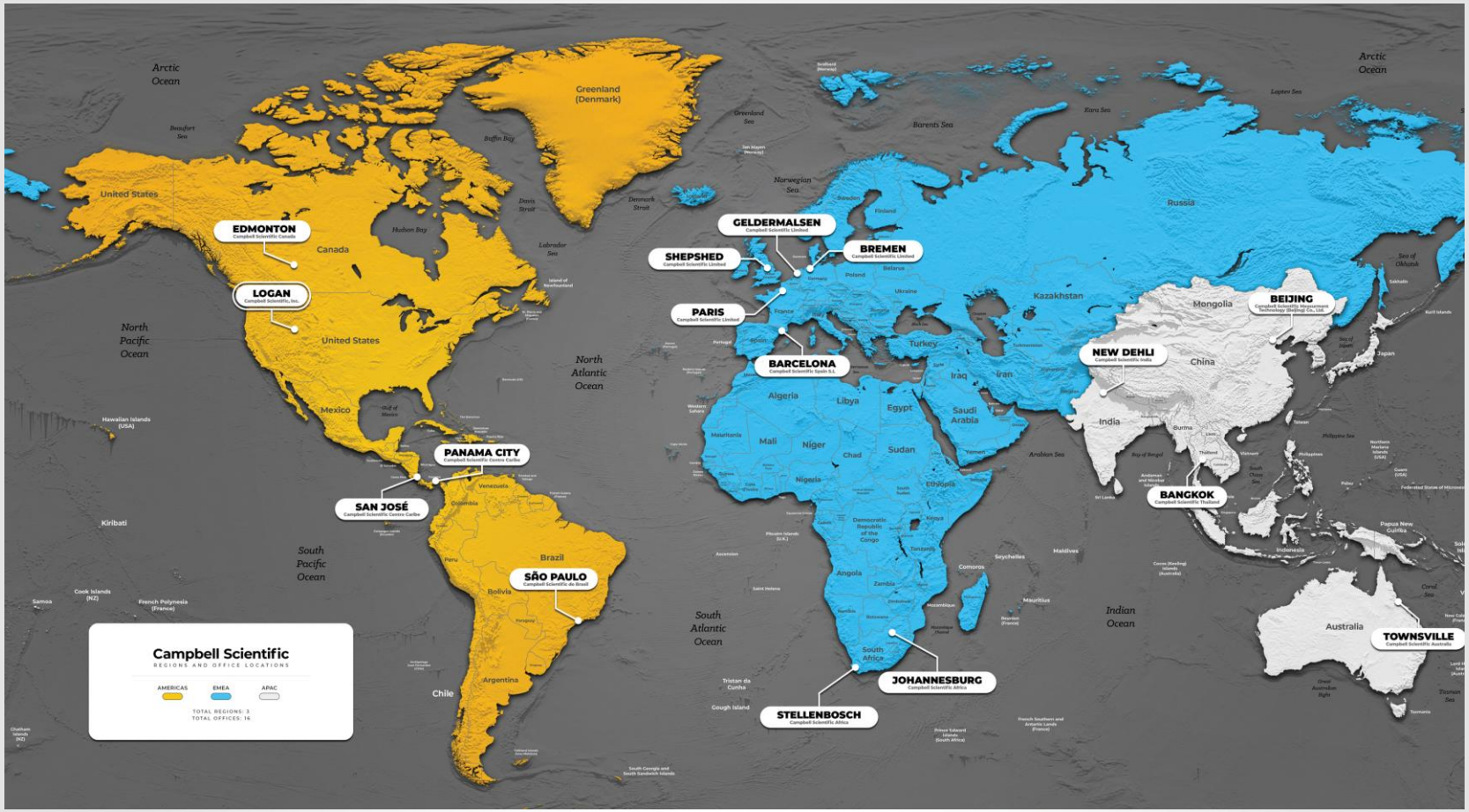
Welcome

- Introductions. Tell us:
  - Who you are,
  - What your responsibilities are
  - What are your expectations of the training

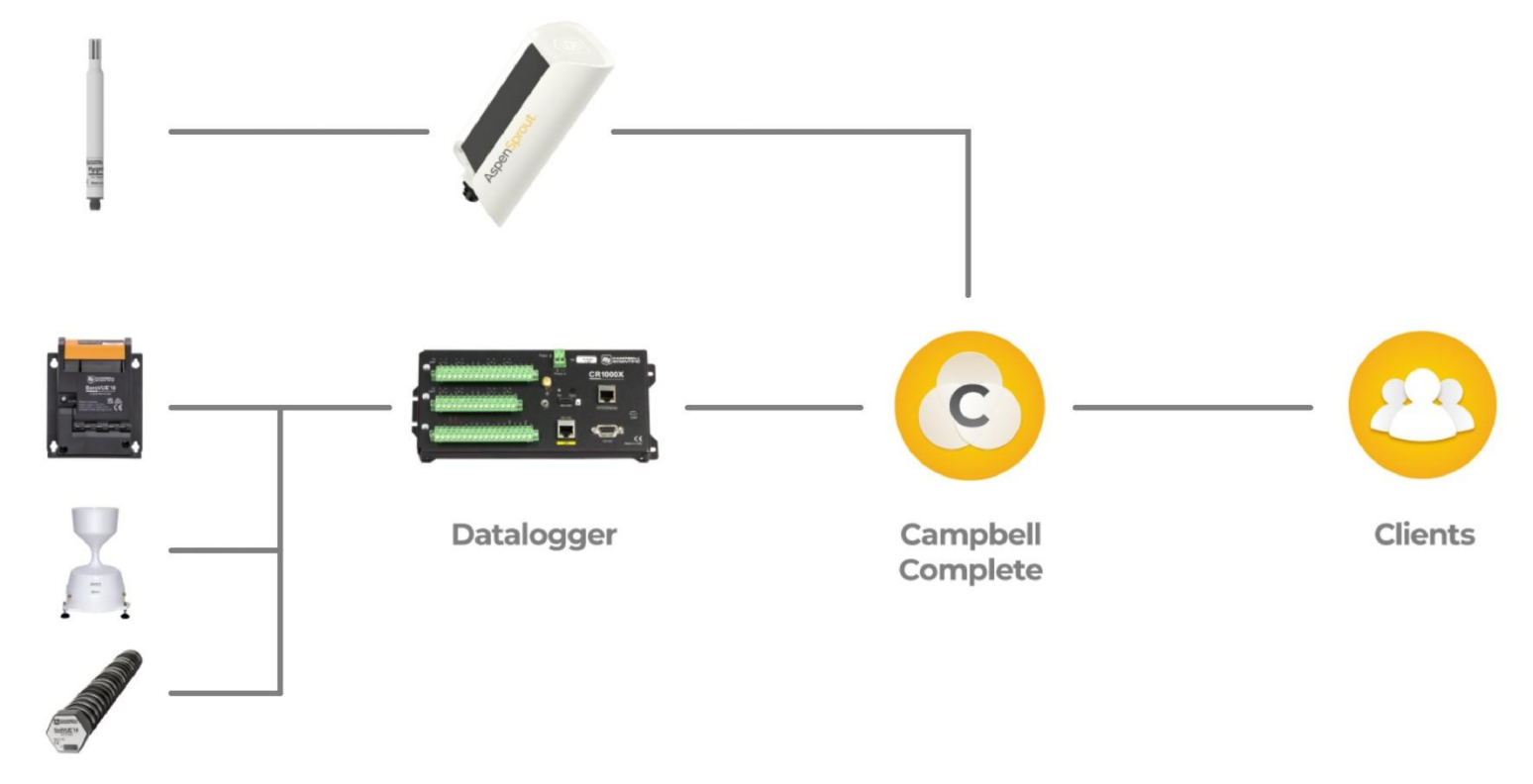
Who is Campbell Scientific ?

We are...

- Established in 1974
- 16 offices around the globe
- Africa office established 1996
- 828 Employees Worldwide
- A strong global and growing company
- We have a Vision: From Measurement to Insight, M2I


Arctic Ocean
Greenland (Denmark)
United States
EDMONTON
Campbell Scientific Canada
Canada
LOGAN
Campbell Scientific, Inc.
United States
North Pacific Ocean
North Atlantic Ocean
Mexico
Hawaiian Islands (USA)
PANAMA CITY
Campbell Scientific Centro Caribe
SAN JOSÉ
Campbell Scientific Centro Caribe
Kiribati
South Pacific Ocean
Brazil
SÃO PAULO
Campbell Scientific do Brasil
Peru
Bolivia
Argentina
Chile
Samoa
Cook Islands (NZ)
French Polynesia (France)
Campbell Scientific
REGIONS AND OFFICE LOCATIONS
AMERICAS
EMEA
APAC
TOTAL REGIONS: 3
TOTAL OFFICES: 16
GELDERMALSEN
Campbell Scientific Limited
SHEPSHED
Campbell Scientific Limited
BREMEN
Campbell Scientific Limited
PARIS
Campbell Scientific Limited
BARCELONA
Campbell Scientific Spain S.L.
Russia
Kazakhstan
Mongolia
BEIJING
NEW DEHLI
Campbell Scientific India
China
India
BANGKOK
Campbell Scientific Thailand
Turkey
Iraq
Iran
Saudi Arabia
Egypt
Libya
Algeria
Sudan
Chad
Niger
Mali
Nigeria
Ethiopia
Kenya
Democratic Republic of the Congo
Angola
Zambia
South Africa
JOHANNESBURG
Campbell Scientific Africa
STELLENBOSCH
Campbell Scientific Africa
South Atlantic Ocean
Indian Ocean
Australia
TOWNSVILLE
Campbell Scientific Australia

Our Vision

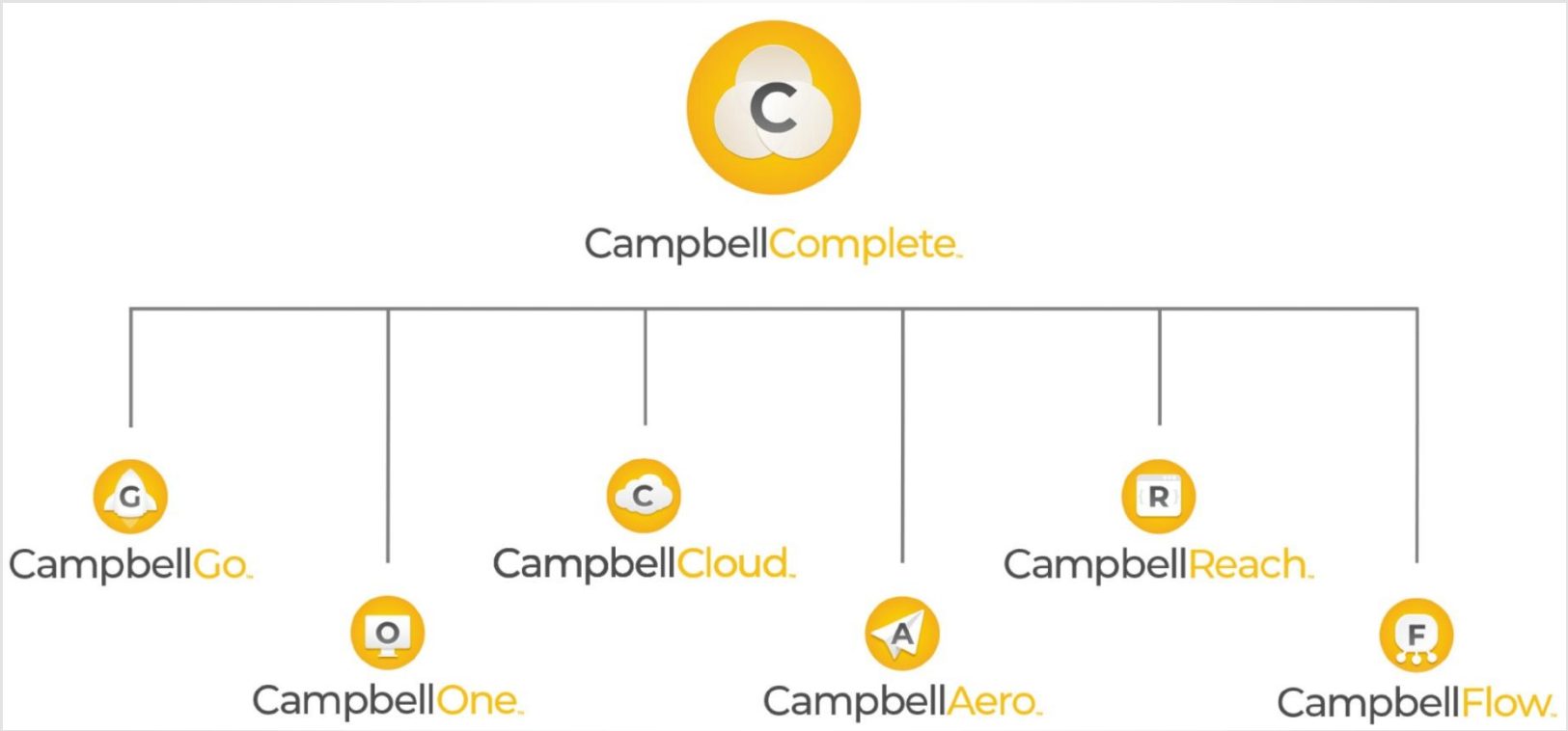


Sensors — Datalogger — Software

- Measurement to Insight

Solution Development • Project Delivery • Services & Support

Our Vision



Software

We are making a positive difference

From the depths of Death Valley, where our equipment recorded the hottest temperature in the world...

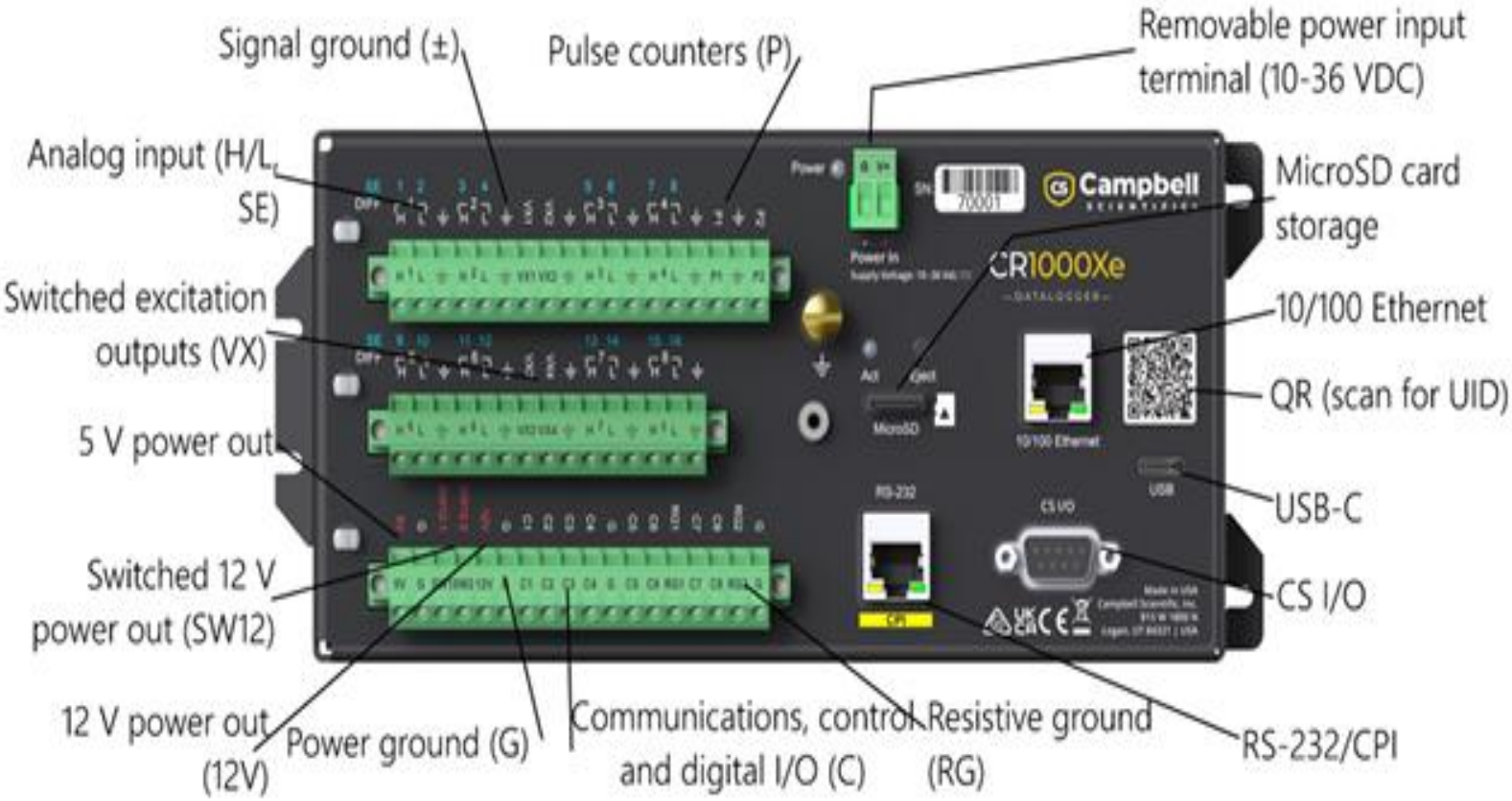
To the heights of Mount Everest, the highest weather stations in the world, to help study upper atmospheric conditions and potential impact on water supply for more than 1 billion people.

Understanding CR1000Xe

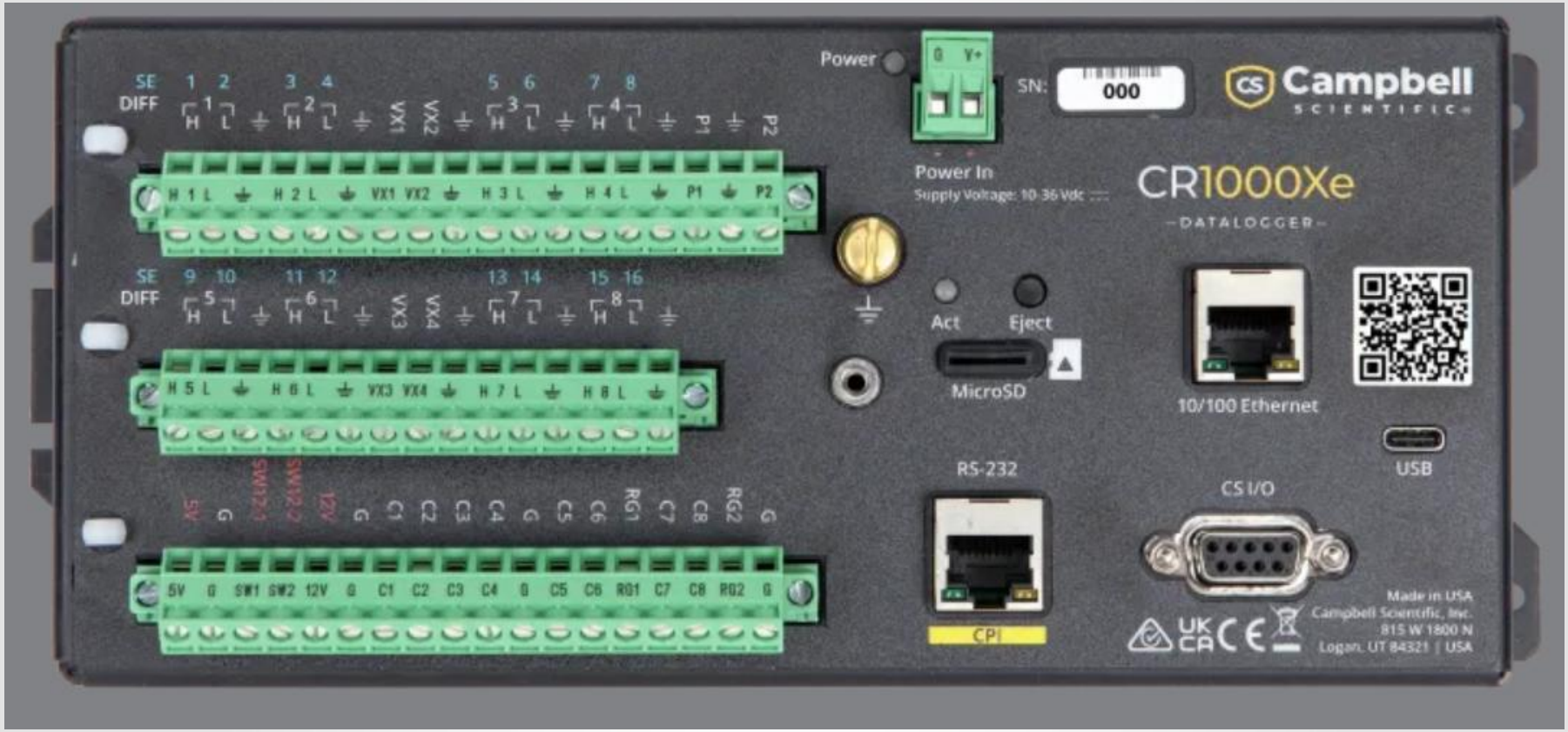
Important characteristics of a datalogger

- **Low power consumption** (measurement system often powered from solar)
- **Extremely reliable** (installations often in remote locations, expensive and cumbersome to revisit sites, some sites cannot be revisited during winter time (e.g. some locations in Canada)
- **Ruggedized** to operate under extreme environmental conditions (-40C to + 60C)
- **Self correcting (watchdog circuit** to automatically recover from problems)
- **Accuracy of measurements** ("When measurements matter")
- **Built-in noise filtering** on analogue measurements (e.g. 50Hz rejections)
- **Built-in and automated calibration routines** on analogue circuitry
- **Continued "refresh" through new OS releases** (new functionality and bug fixes)
- **Long lifetime support** (20 or more years since introduction)

CR1000Xe Wiring panel



CR1000Xe Wiring panel



Weather station overview

- **The main components are**:
  - Datalogger (CR1000Xe stations) with LTE modem
  - Sensors
    - Thies First Class anemometer
    - Thies compact wind vane
      - TempVUE10 Class A Temperature sensor
      - EE181 Temperature and relative humidity sensor
      - NESA RSG2STD-N Pyranometer
      - 4X NESA SM2.2 –C Soil Temperature and Moisture
      - 52203 RM Young Rain Gauge with syphon
      - 1X BaroVUE10

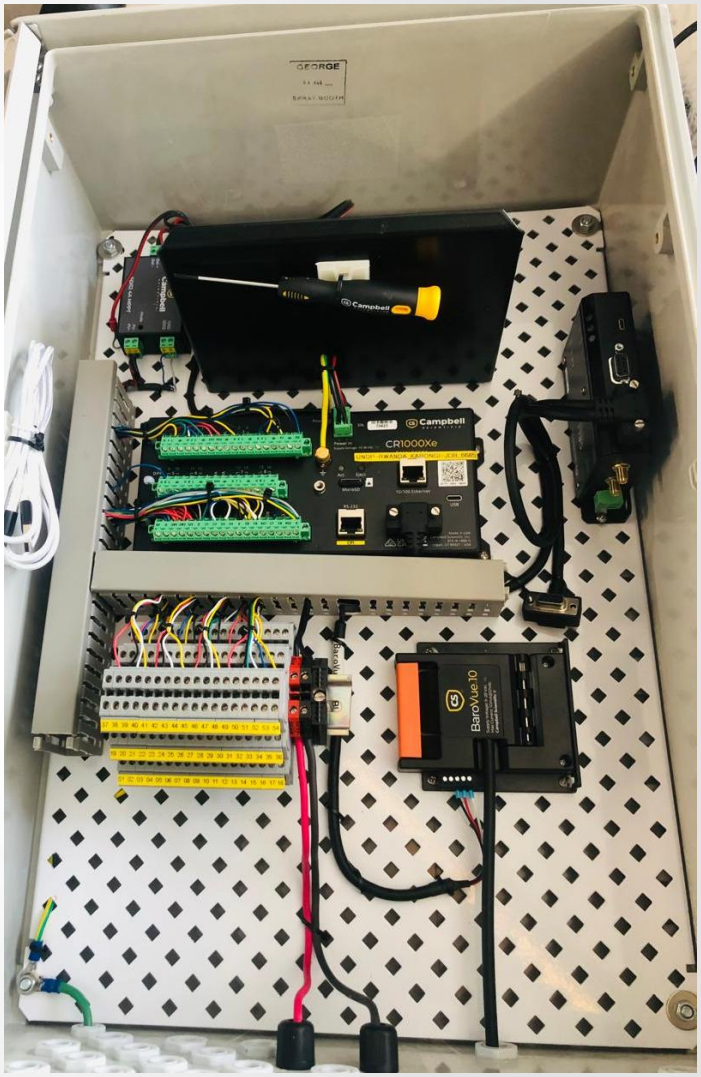
Weather station overview

- **The main components are**:
  - Datalogger (CR1000Xe stations) with LTE modem
  - Communication Devices
    - Cell215 Cellular modem
    - CS MPTT Regulator
  - Enclosure

Enclosure layout

- Enclosure main components are:
- Battery
- Cell 215 LTE Cellular Gateway
- CR1000X datalogger
- CS MPPT Solar charger
- BaroVUE10 Barometer

Wiring diagram located on the inside of the enclosure door



Wiring diagram

UNDP RWANDA Feb-23

Ngoma

CSA J6685

1	**4.3151.10.020**	**WIND DIRECTION SENSOR FIRST CLASS Electronical potentiometer**				***Cable Length = 10 Meter***
	Sensor Function	**Connector Pin**	**Sensor Wire Colour**	**Dinrail NR**	**Internal Wire Colour**	**CR1000Xe connection**
	Signal	1	Green	1	Blue	SE1
	Ground	2	Blue	2	Yellow	G
	Power Supply	3	Red	3	Red	VX1
	Power Analogue Ground	4	Yellow	4	Green	⏚
	Ground	6	Clear	5	Black	G
2	**4.3352.10.000**	**WIND TRANSMITTER FIRST CLASS ADVANCED II**				***Cable Length = 10 Meter***
	Sensor Function	**Sensor Connector Pin**	**Sensor Wire Colour**	**Dinrail NR**	**Internal Wire Colour**	**CR1000Xe connection**
	Supply Voltage (+)	3	Red	6	Red	12V
	Supply Voltage (-)	2	Blue	7	Blue	G
	Signal	1	Green	8	Yellow	P1
	Shield	Shield	Clear	9	Green	G
3	**TempVUE10**	**PT-100 RTD Class A Precision Air Temperature Sensor**				***Cable Length = 5 Meter***
	Sensor Function	**Sensor Connector Pin**	**Sensor Wire Colour**	**Dinrail NR**	**Internal Wire Colour**	**CR1000Xe connection**
	RTD signal/– RTD		Yellow	10	White	2H
	RTD signal ref		Blue	11	Blue	2L
	Sense signal		Orange	12	Yellow	3H
	Sense signal ref		Purple	13	Black	3L
	Volt excite/+ RTD		Brown	14	Red	VX2

Component	Make and model	Major characteristics	Picture
Datalogger	Campbell CR1000Xe	• 16 Analogue measurement channels • 8 * Digital I/O • 2 * Pulse • USB, LAN, CSI I/O, RS-232 ports	
Temperature and humidity	EE181	• TEMPERATURE • 1000 Ω Platinum Resistance Thermometer (PRT) • Tested and conforms to IEC61326:2013. • -40° to +60°C • Accuracy - Voltage Output • ±0.2°C (at +23°C)RELATIVE HUMIDITY • Sensing Element Capacitoance • ±(1.3 + 0.003 • RH reading) % RH (at -15° to +40°C, 0 to 90% RH) • ± 2.3% RH (at -15° to +40°C, 90 to 100% RH) • ± (1.4 + 0.01 • RH reading) % RH (at -25° to +60°C) • ± (1.5 + 0.015 • RH reading) % RH (at -40° to +60°C)	

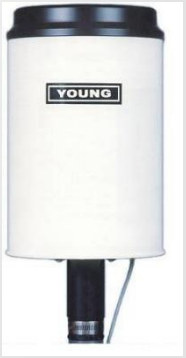
Main components

Component	Make and model	Major characteristics	Picture
Wind speed	Thies First Class	• Measuring range 0 ... 75 m/s • Accuracy < 1 % of meas. value (0.3 ... 50 m/s) or < ±0.2 m/s • Linearity r > 0.99999 (4 ... 20 m/s) • Delay distance < 3 m (aac. to ASTM D 5096-96)	
Wind direction	Thies compact	• Measuring range 0 - 360° • Accuracy - ±5 ° • Ambient temp.-40 ... +70 °C	

Main components

Component	Make and model	Major characteristics	Picture
Solar radiation	NESA RSG2STD-N Pyranometer	• Range Max 2000 W/m2 • Spectral range 0,3µm ÷ 3µm • Typical Sensibility 10 µV/(W/m2) on 2□sr • Typical signal output 10 mV / (kW/m2) • Resolution < 2 W/m2	

Main components

Component	Make and model	Major characteristics	Picture
Soil Temperature and Moisture	SM2	• Measure Humidity (VWC) • Temperature Range 0-100% m3 -40°C ÷ +80°C • Accuracy ± 3% (0-50%) ± 0.2°C • Resolution (m3/m3) <0.002 m3/m3 <0.05°C • Signal Output 4÷ 20mA, 0÷2V, (ModBus RS485 optional) • Response time < 1s Power supply and consumption 12÷24Vdc (max 12mA ÷ 60mA)	
Precipitation (rainfall)	52203 RM Young	• Resolution 0.1 mm • Collected area of 200 cm2, with a • Resolution of 0.1 mm, which complies with WMO recommendations • Switch tipo reed (N.O.), 24VAC/DC 500mA • Accuracy of ±2% up to 25mm/hr, ±3% up to 50mm/hr	

Main components

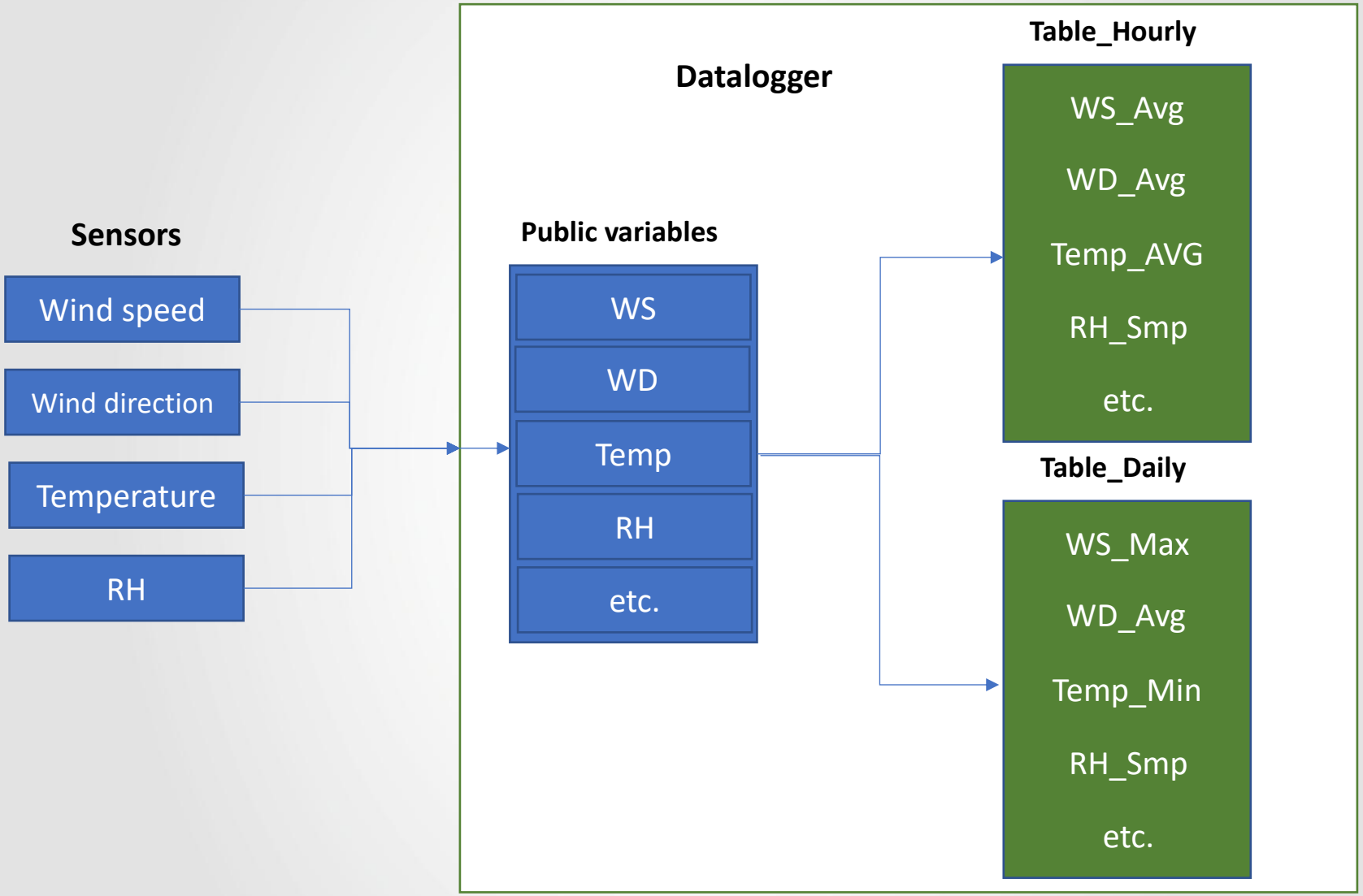
Component	Make and model	Major characteristics	Picture
Barometric pressure sensor	BaroVUE10	Performance • Barometric pressure range: 500 hPa to 1100 hPa • Linearity:< 0.05 hPa • Accuracy (20): 0.10 hPa • Operating environment • Temperature range: −40 °C to +60 °C • Relative humidity: 0 to 100 %RH • Supply voltage • Supply voltage: 10 to 28 V DC	

Welcome to Campbell Scientific Training

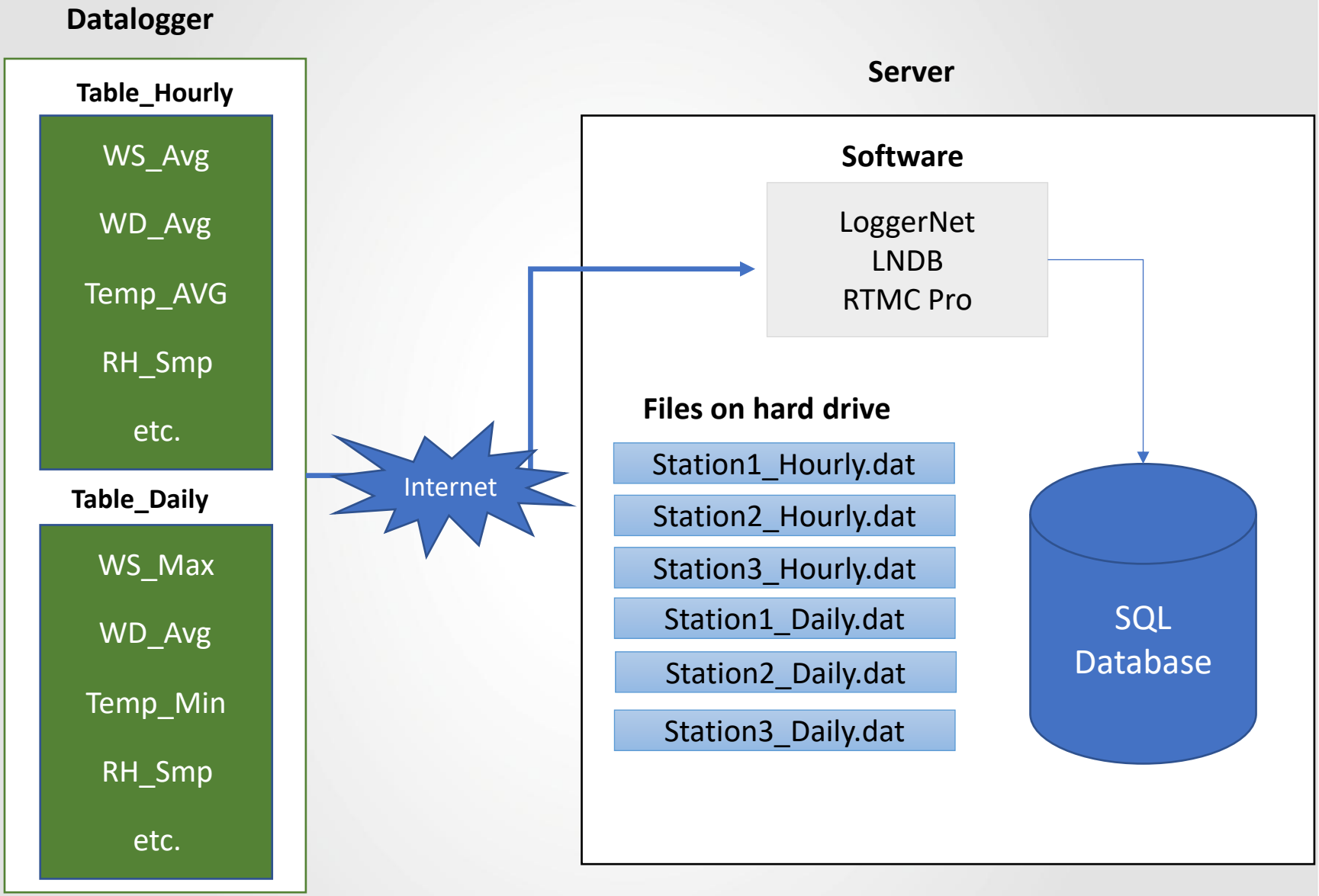
Campbell Station Essentials

Data architecture

Data Flow – sensors to datalogger tables



Data Flow – datalogger to PC



Data tables – 10m

TIMESTAMP
RECORD
JobID
StationID
WSpd_Min
WSpd_Max
WSpd_Avg
WSpd_Std
Thies_WDir_Avg
Thies_WDir_Std
AirTemp_Avg
RH
DewPointTemp_Avg
SlrW_Avg
SlrMJ_Tot
Rain_Tot
LeafWetkOhms_Avg
LeafWetCount_Tot
BPress_Avg
VWC_5cm_Avg
PermittivityBulk_5cm_Avg
SoilTemp_5cm_Avg
ECBulk_5cm_Avg
VWC_10cm_Avg
PermittivityBulk_10cm_Avg
SoilTemp_10cm_Avg
ECBulk_10cm_Avg
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SoilTemp_60cm_Avg
ECBulk_60cm_Avg
VWC_75cm_Avg
PermittivityBulk_75cm_Avg
SoilTemp_75cm_Avg
ECBulk_75cm_Avg
VWC_100cm_Avg
PermittivityBulk_100cm_Avg
SoilTemp_100cm_Avg
ECBulk_100cm_Avg
LoggerSerialNumber
ProgramName
ProgramSignature
LoggerBattery_Avg
LoggerTemp_Avg
LoggerLithiumBatt_Avg
PingTime_Avg
ScanCount

Communications architecture – Pakbus Routing

Monitoring/ maintenance PC

Tablet/ Smartphone

INTERNET

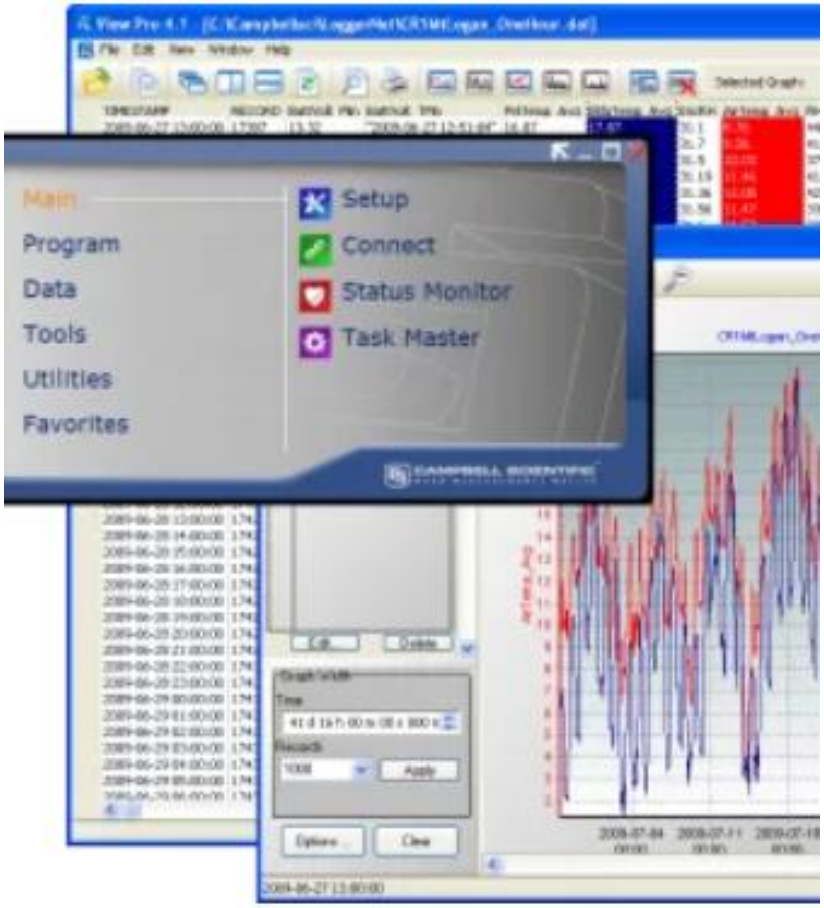
Connection /
Routing Server
(Hosted LoggerNet)

Download server/ PC
- Data Download
- Data archiving
- Reports

Remote Stations with unique PAKBUS addresses opens TCP communications sockets

Loggernet Introduction

Introduction to Loggernet



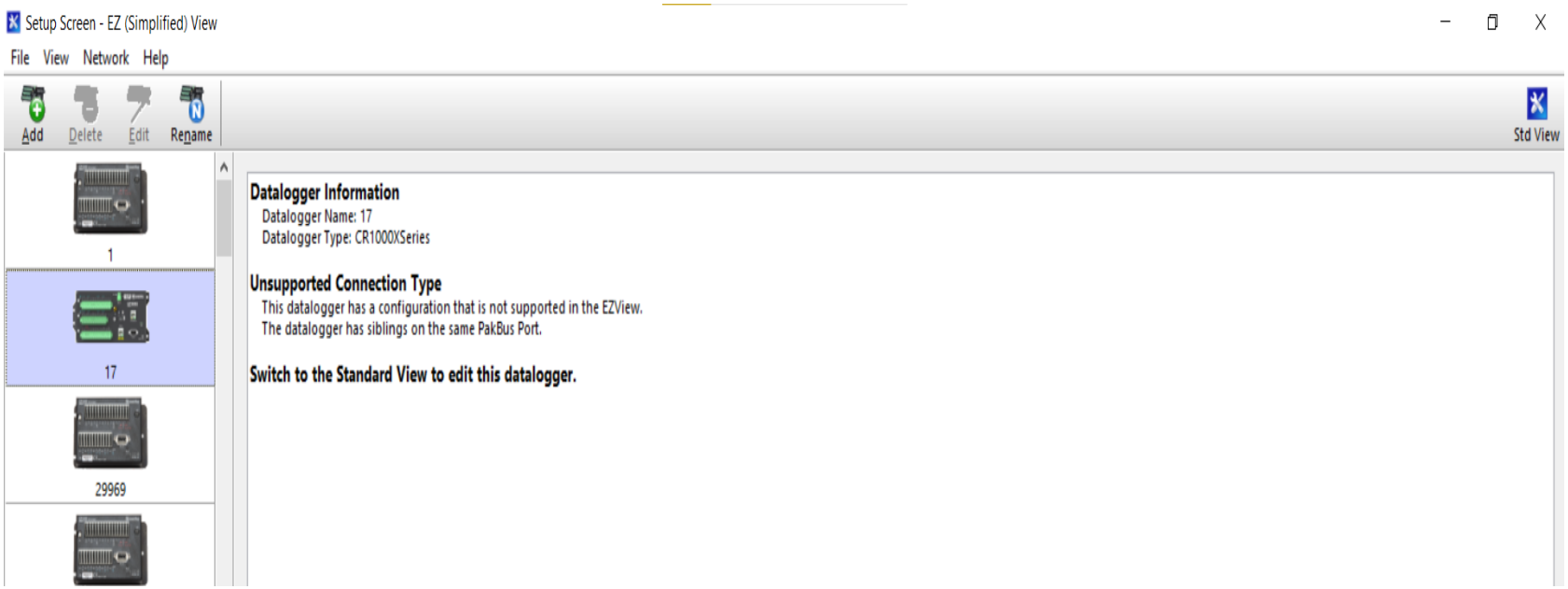
The following software has been supplied:

- EZSetup
- Connect
- Status Monitor

EZSetup

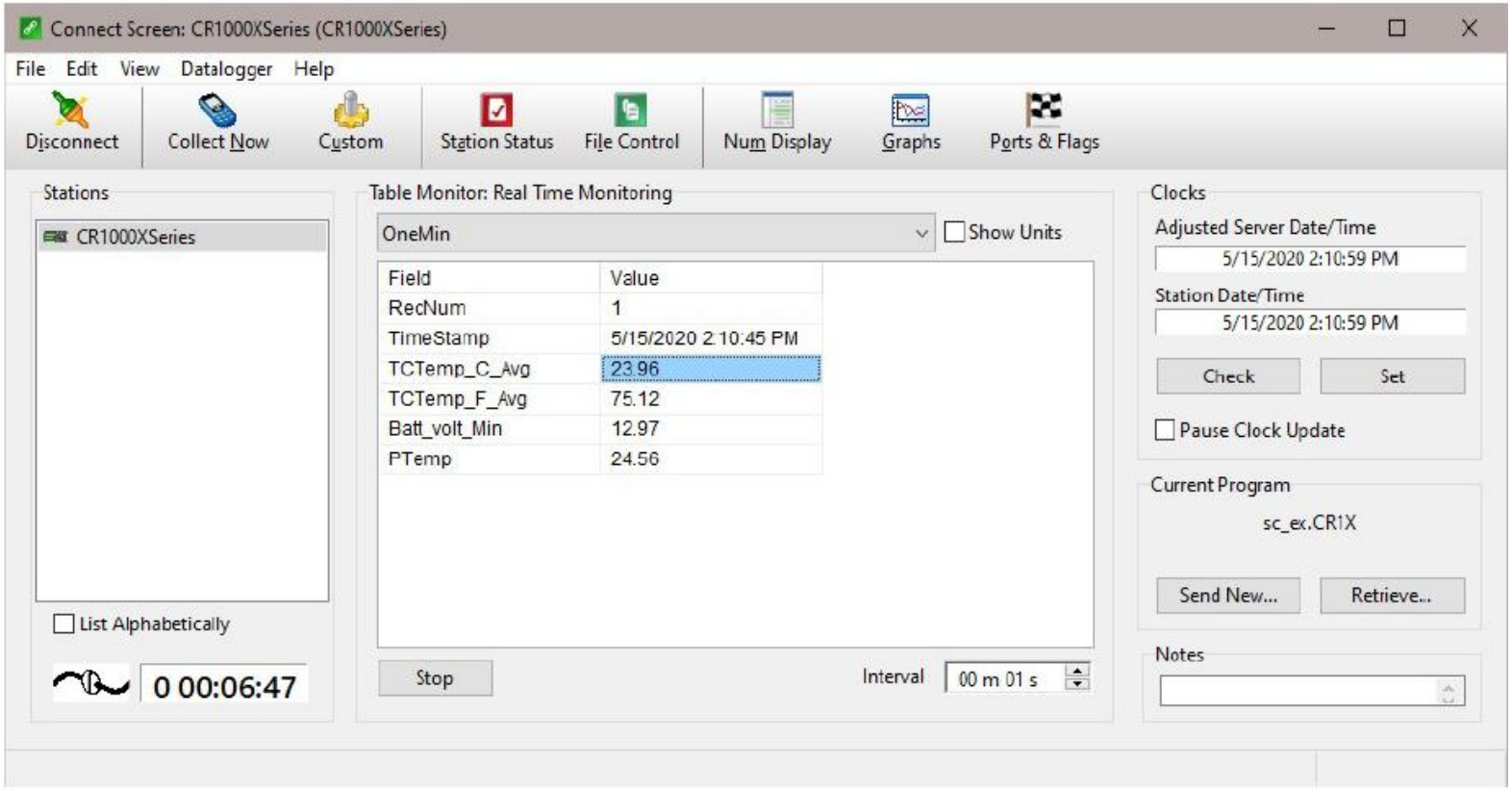
•EZSetup uses a point-and-click format for setting up communications between a CR1000X and the computer.

•This is the first step in using LoggerNet with your data logger.

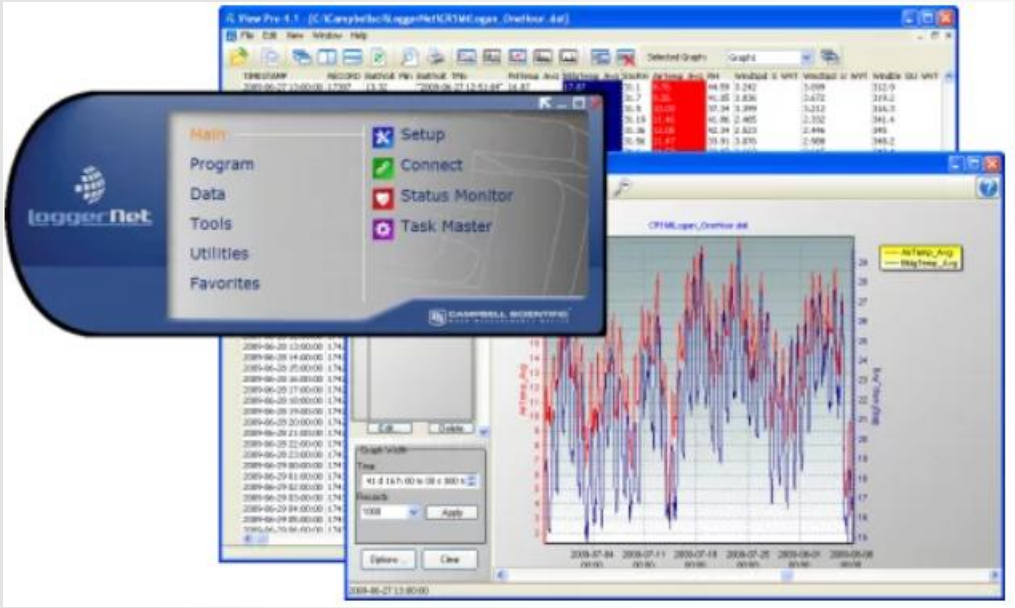


Connect Screen

- The Connect Screen contains tools for initializing or checking operation of a datalogger and manually collecting data.



Software for download server



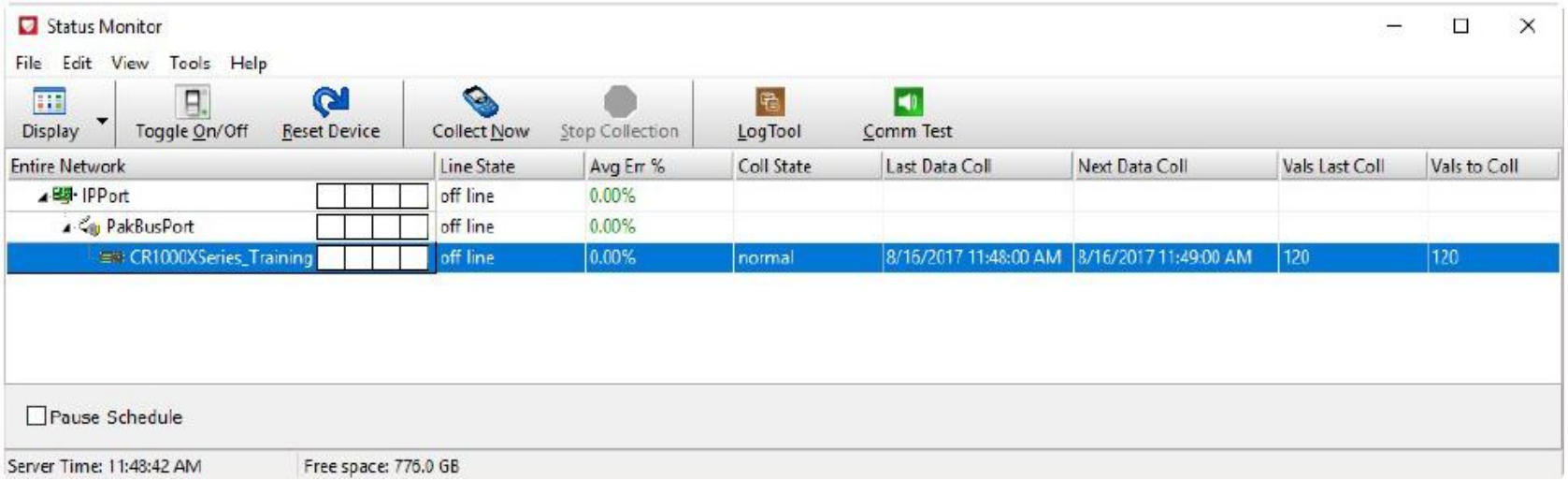
The following software has been supplied:

- LoggerNet
- LNDB
- RTMC Pro

Status Monitor

Once set up for scheduled data retrieval, use the LoggerNet Status Monitor to monitor:

- The progress of data retrieval.
- error rates,
- amount of data retrieved
- scheduled calling times.



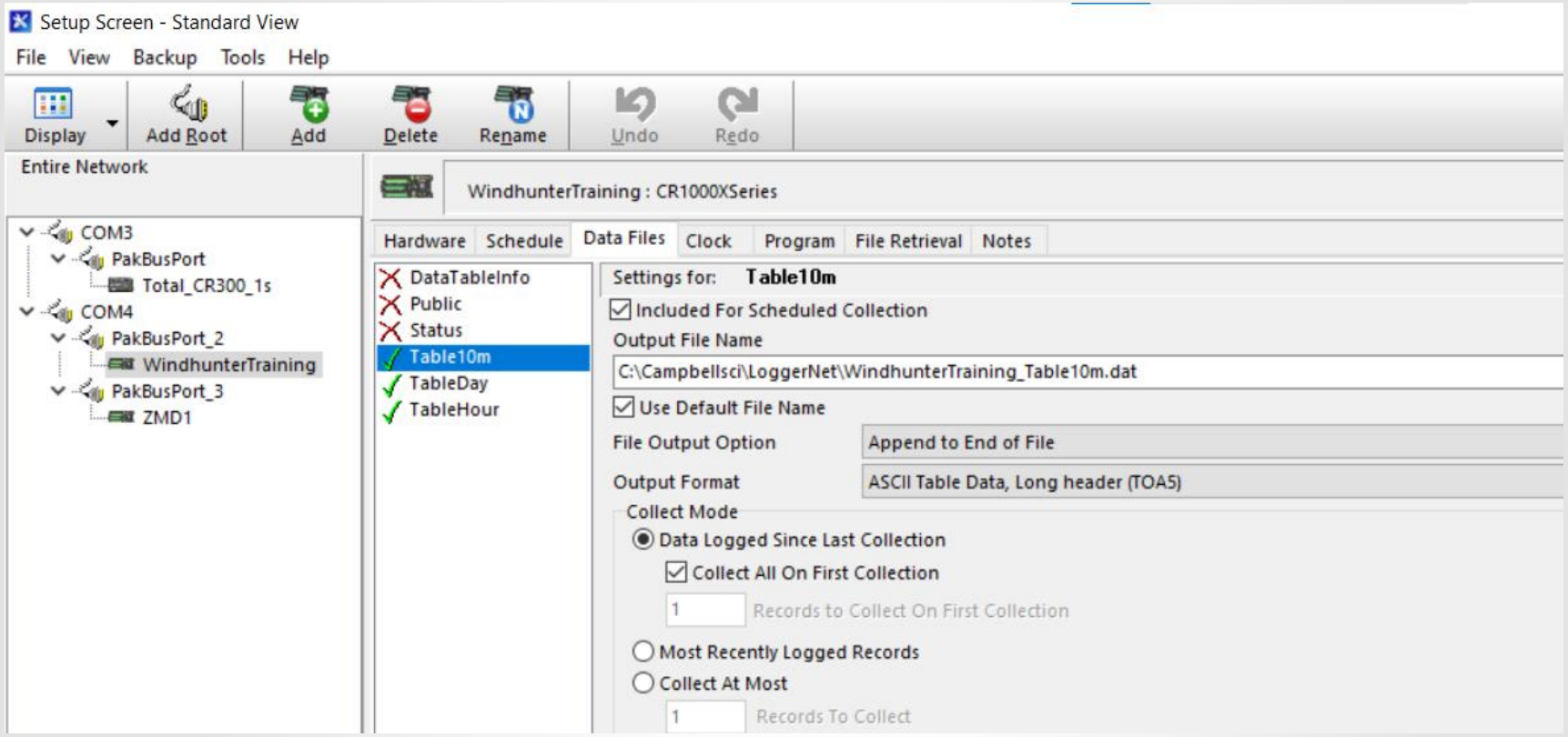
Software overview

Software	Overview
PC 400W	Free software. Can be used to view realtime data, download data to a laptop, set datalogger clock etc.
LoggerLink	Free iOS and Android software. Requires an IP connection
LoggerNet Mobile Connect	Free iOS and Android software. Connect to the LoggerNet Server
Device Config Utility	Free software. Can be used to change datalogger settings, set clock, view realtime data, download data etc.
LoggerNet	Full featured software to create datalogger program, automate downloads from a network of stations (cellular, satellite or radio)
LoggerNet Database (LNDB)	Automates the import of data to a SQL database after LoggerNet has downloaded the data.
RTMC Pro	Graphical display software. Displays data that has been downloaded. Graphs, indicators, alarms
LoggerNet, LNDB and RTMC Pro works in unison to download data, import to a SQL database and display data	

LoggerNet Modules

Product	Overview
Setup	Setup connections to dataloggers, setup automated downloads, clock cheks etc.
Connect	Allows connections to dataloggers that have already been setup. Check real-time data, manual downloads, clock check etc.
CRBasic	Programming interface to create datalogger programs
ShortCut	Wizard like program interface. Only works for the supported set of sensors included in the App.
ViewPro	Easy to use viewer for downloaded data, supports basic graphs
Status Monitor	Provides overview of connection and download status for all logger in network. Good for systems administrator
RTMC/ RTMC Pro	RTMC Included in LoggerNet. RTMC Pro add more functionality
Applications for legacy dataloggers	Edlog, Transformer, Split, CardConvert

Data storage – text files

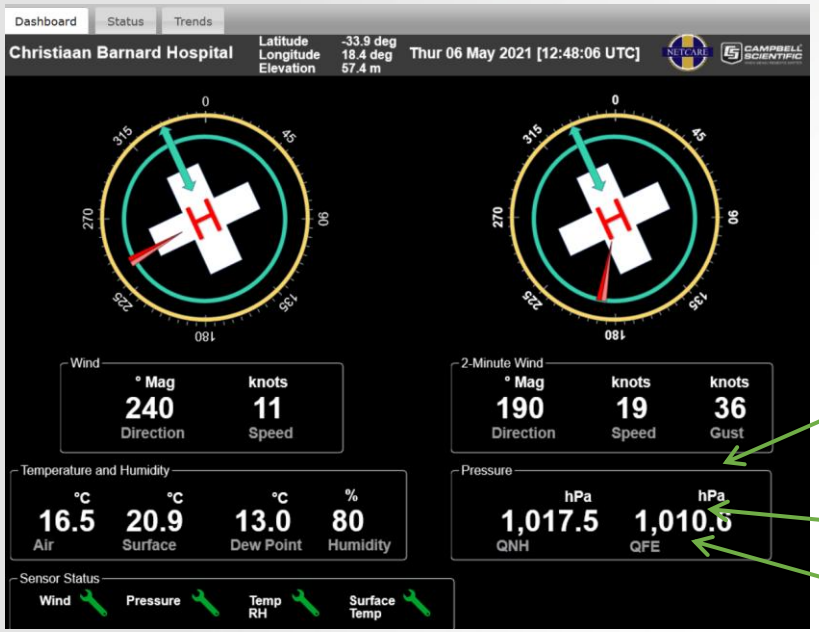


- Data files can be written to any directory on the computer hard drive or to a mapped drive

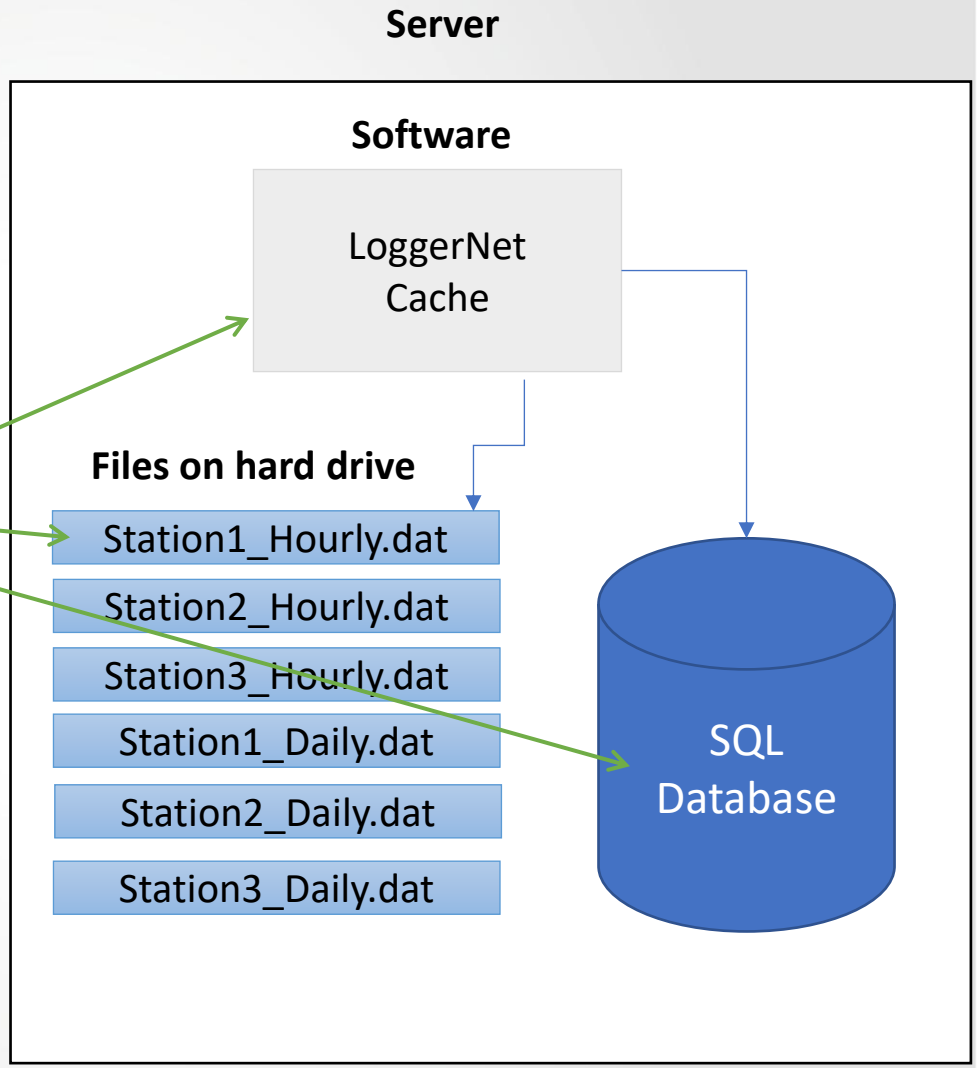
End of Session

RTMC Data Feed

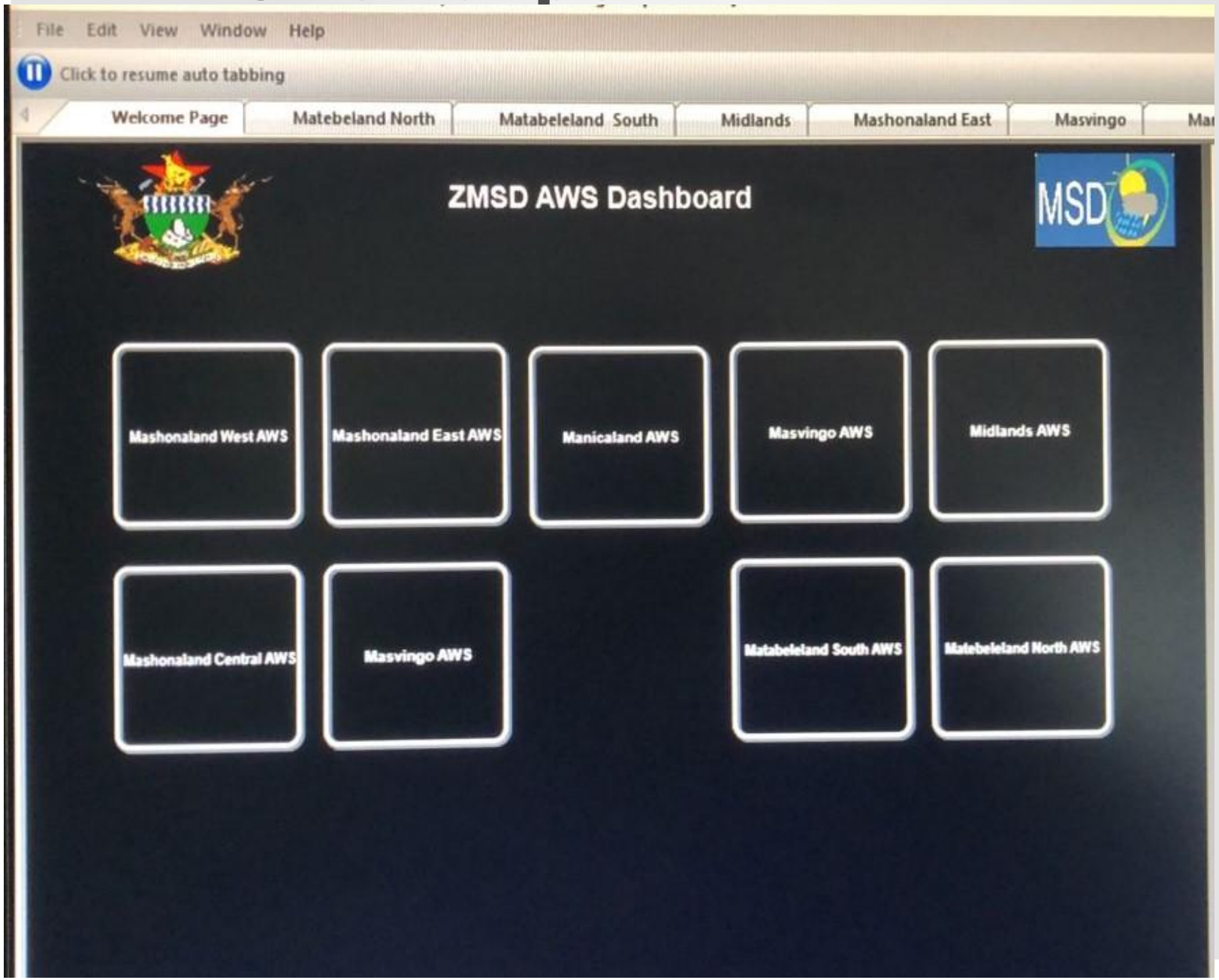
Datalogger



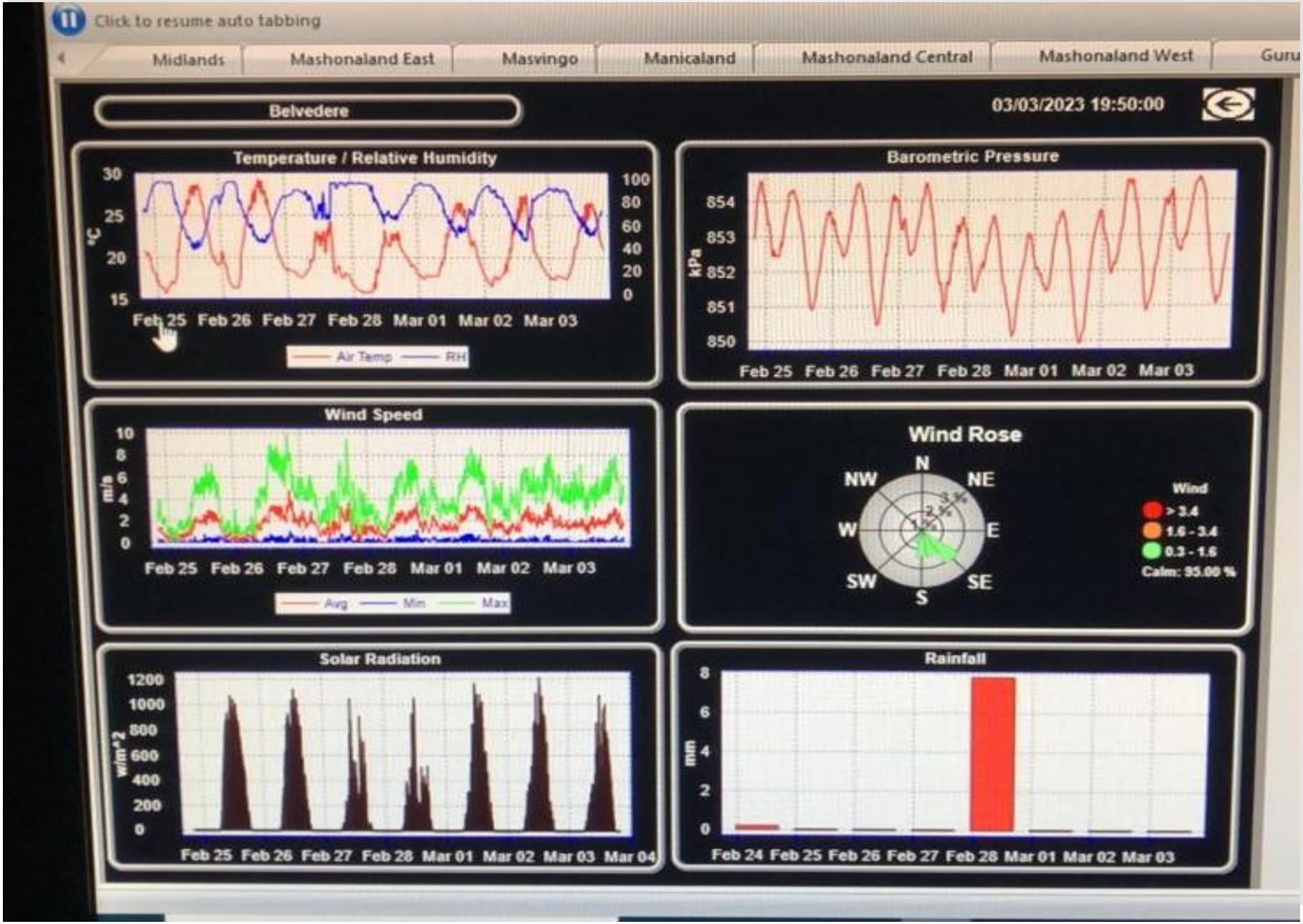
- Each RTMC Display element has to be linked to a field in a data table.
- The data for the data table can be:
  - In the LoggerNet Cache
  - In a text file on the hard drive
  - In a LNDB Database table (preferred option)
- RTMC data has to be downloaded before it will display



RTMC Pro Example



RTMC Pro Example



Practical Exercise

- Setup RTMC Pro Monitoring screens for the 20-station network:
  - Step 1: Define system health parameters to be displayed/ alarms created (battery status, time to last communications, Lithium battery level et.
  - Step 2. Define a typical display screen per station. What would our users like to see?
  - Step 3. Define QA/ QC screens
    - Which stations are in similar areas – display data on same graph – we want to see changes in patterns
  - Step 4. Decide on the different display screens/ tabs
  - Step 5. Start developing the display screens, test, update, repeat

Maintenance recommendations – sustainable measurement networks

Sustainable measurement networks

- Campbell Scientific supplies sustainable measurement networks built around the following principles:

1) A reliable datalogger with long service life. This is achieved through:
   a. The inherent reliability of the datalogger
   b. Regular and free operating system (OS) updates that keeps the datalogger "modern".
   c. A commitment by the supplier to continue to support the datalogger even after it has reached its end of life (EOL).
2) A flexible datalogger that allows integration of sensors of a wide range of manufacturers to ensure there is no "lock-in".
3) Open architecture software that delivers data into a non-proprietary database that allows easy integration to third party applications as well as integration of legacy weather stations.
4) Data downloads that are entirely under the control of the customer and do not have annual licensing fees. (only cellular data related costs)
5) Software products that do not require annual licensing fees.

Components of a sustainable measurement networks

- Well trained and motivated personnel
- Maintenance plan
- Maintenance budget
- Robust sensors
- Planned replacement of sensors
- Calibrations and verification of standards
- Renewal plan for older stations

Definitions

Definition	Meaning
Verification	Verification is typically performed at the installation site by comparing the station's measurements to a second set of similar of higher grade instruments and is normally just a single point comparison of measurements. The aim of the verification process is assess whether all installed sensors still operate satisfactorily of might require calibration of replacement.
Calibration	Calibration is a more formal procedure than the verification procedure with the aim of producing a calibration certificate to confirm the accuracy of the measurements. Customers such as mines of national meteorology services are legislated to perform calibrations according to a fixed schedule (e.g. yearly). Calibrations are performed against a set of sensors with a traceable calibration record. Where possible calibration should be performed under laboratory conditions which is easier to control than field conditions.
Accredited calibrations	Calibrations is traceable to a recognised national or international standard
Non-accredited calibrations	Calibrations is not traceable to a recognised national or international standard, but done according to good calibration practice. Non-accredited calibrations can be as accurate as accredited calibrations
Adjustment	Changes made to a sensor or to the sensor's multiplier and offset to bring its readings back into specification.
QMS	Quality measurement system

Maintenance program

Frequency	Activities	Estimated time
Daily	• Review data to ensure that all sensors operate within their expected ranges • Campbell's RTMC software can be used to create graphical display screens and alarms can be set for parameters out of range. • It is also a good idea to plot the same parameters from similar stations on the same graphs as it makes it easy to spot a change in trends.	Manhours for a 5 min activity
Monthly to 2-monthly	Site visit to perform following activities • Clean funnel of rain gauge from debris • Clean lens of pyranometer. • Inspect wind speed and direction sensor. Wind speeds sensor should spin easily without noise from bearings. Wind direction sensor should be able to turn through 360 degrees with no observed stiffness through this range. • Inspect for insects in enclosure. • Visual inspection of station. Ensure enclosure is properly closed, no lose components, wires etc. • Ensure grass around weather station is regularly cut.	Manhours for 30 minute site visit

Maintenance program

6 Monthly	• **All the activities of site visit** • **Replace desiccant in enclosure**	**Manhours for 30 minute site visit**
Yearly to 2 yearly	Calibrate station. This can be performed on-site or the datalogger and sensors can be sent to a calibration lab. Calibration agency should preferably be nationally accredited	Calibration cost
2 Yearly	• Replace RH chip of Temp/RH sensor • Replace enclosure RH sensor (if fitted) • Replace 12V battery	
4 Yearly	• Replace datalogger internal battery • Replace pyranometer (applies to lower cost silicon cell pyranometers) • Replace Temp/ RH Sensor • Replace bearings on Wind speed and direction sensor (if not an ultrasonic sensor)	

Quality Management System (QMS)

The quality management system (QMS) details the procedures used by Met Services to ensure quality of observations. The QMS, must as a minimum cover the following:

- Data management
- Regular station verifications
- Sensor calibrations
- Calibration standards and calibration of these standards

Over a period of time, the Met service should work towards implementing and planning for certification of a quality management system according to the WHO Guidelines on Quality Management in Climate Services

Core skills for maintenance technicians

The following are recommended core skills for maintenance technicians doing site visits:

- Check battery level using a multi-meter
- Check charging voltage of solar panel
- Know how to use Device Config Utility / PC400
- Connect to the station with USB cable and monitor real-time values
- Know what expected values should be for core parameters such a temperature, humidity, solar radiation etc.
- Know how to lower and raise a mast
- Know how to replace sensors (quick connectors, secure cables with cable ties etc.)
- Replace desiccant in enclosure
- Clean pyranometer and solar panel (if required)
- Check cellular connection state
- Replace cellular sim card

Exercise

- Check battery level using a multi-meter
- Connect to the station with USB cable and monitor real-time values
- Check cellular connection state
- Replace cellular sim card

Practical exercise: Getting to know the mobile calibrator and Vaisala Humidity Calibrator

(Not part of training but left for those interested)

Transfer standard

- The transfer standard can be used to verify operation of stations using recently calibrated sensors
- **To develop their own site verification methodology**
- Example methodology
  - Only do site verification on cloudless days and plan around midday
  - Mount Temp and RH sensor in second Gill screen on mast and allow 20 minutes to equilibrate
  - Mount solar radiation sensor next to stations sensor and ensure well levelled and no shading
  - Disconnect rain gauge, poor measured amount of water slowly through rain gauge and count the tips. Reconnect the rain gauge and test working (1 tip)
  - Record temp and RH for both sensors
  - Lift tranfer standard enclosure to same level as station barometer and record readings form both barometer
  - Document all readings from site verification and analyse differences against the known accuracy of the sensors

Practical exercise

- Use the mobile calibration kit to verify temperature readings between the two stations in the training room.
- How can we perform a 2 point verification of the temperature?

HMP155A-L	**-80 °C to +60 °C**	**±(0.226 – 0.0028 x temperature) °C (at -80° to +20°C)** **±(0.055 + 0.0057 x temperature) °C (at +20° to +60°C)**

HMP155A-L	**0 to 90%**	**±1% (5° to 25°C)**
	90 to 100%	±1.7% (5° to 25°C)
	-60° to -40°C	±(1.4 + 0.032 × reading) % RH
	-40° to -20°C	±(1.2 + 0.012 × reading) % RH
	-20° to +40°C	±(1.0 + 0.008 × reading) % RH
	40° to 60°C	± (1.2 + 0.012 × reading) % RH

- **As can be seen from the above, when comparing RH data of the HMP155's sensor has an accuracy of ±1 %. So the 2 readings can be 2% apart and still fall within the accuracy range of the sensors**

Vaisala Humidity Calibrator

- Vaisala uses different salts with known saturation humidity levels
- Some of the salt solutions stabilisation points are temperature dependent
- It can take long for chamber conditions to stabilises – 30 to 40 minutes
- We do not recommend this as a field calibration test

Certified and ready dosed salts [1]	
Ready-dosed LiCl salt package (LiCl salt 11 %RH, total uncertainty ±1.3 %RH) [2]	19729HM
Ready-dosed $MgCl_2$ salt package ($MgCl_2$ salt 33 %RH, total uncertainty ±1.2 %RH) [2]	19730HM
Ready-dosed NaCl salt package (NaCl salt 75 %RH, total uncertainty ±1.5 %RH) [2]	19731HM
Ready-dosed KCl salt package (KCl salt 85 %RH, total uncertainty ±2.0 %RH) [2]	251377HM
Ready-dosed K_2SO_4 salt package (K_2SO_4 salt 97 %RH, total uncertainty ±2.0 %RH) [2]	19732HM

Practical exercise

- Mix at least one salt solution
- Test the RH Sensor of the mobile calibrator

Practical exercise (small group)

- The following to be achieved:
  - Setup al stations and schedule data downloads
  - Setup clock synching for all 20 stations
  - Setup internet clock synching for server
  - Verify network status with Monitor Screen
  - Select tables from all 20 stations for LNDB
  - Verify tables created and data import started
  - Develop SQL Server back-up procedure
  - Develop back-up procedures for text files
  - Metcap link
  - Climsoft link

Practical exercise (larger group)

- Setup RTMC Pro Monitoring screens. The aim of the screens are:
  - Visualisation of data for Met Services Employees
  - Screens to assist with data quality assurance
    - Think creatively about screens that will help to find errant data. Options:
      - Alarms on too low of too high values
      - Plot data of “similar” stations on the same graph and look out for changes in trends.
  - Specific alarm screens
    - Low battery voltages
    - Low lithium battery voltages
    - Long time since last successful data download

Data extraction

Practical exercise

- Locate text file for 10 minute data of one of the stations
- View data using ViewPro
    - Draw graphs of Temperature
- Extract data from LNDB
    - Select 10m table from one of the stations
    - Selected Temp and RH elements
    - Select data range and extract
- Open a text file using Excel
    - Remember to “select all files types” when browsing in Excel
    - Use the import Wizard and select Comma delimited

Review

Review session

- List the training items that need to be reviewed in the final session