AditNW
Business and Professional Development

Aparato Meteorologico

User Manual

Revision 1.1 DRAFT

DRAFT

Notes on Field Test Units (revs A):

Release A.x units are field tests. Development continues on this open source project so the following items are future plans or known issues:

- (future addition) Unit will not operate without a USB flash drive. Will add ability for it to operate without recording
- (future addition) Ability to change language in MX
- (illusive bug) The units will occasionally stop operating normally but the Rpi Zero has not crashed. This is indicated by a frozen pulse (green LED or LCD flower), no reaction to buttons, or logging to USB.

User Manual: Aparato Meteorologico

Autonomous weather station specifically designed and tested for use on small farms in Latin America.

Key features:

- Monitors Rain, Wind, Sunlight, Temperature, and Relative Humidity
- Solar powered with power monitor
- Data is recorded hourly and in a daily summary on USB flash drive

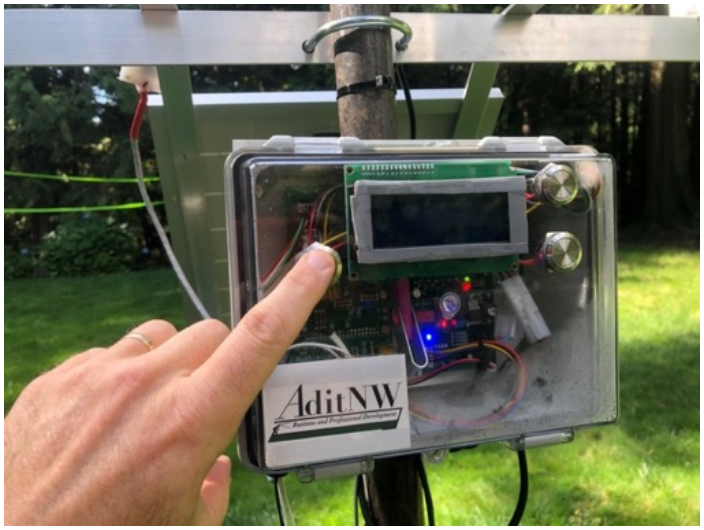
Using on the Farm

The AditNW Apareto Meteorologic is an autonomous weather station designed and tested with the following goals:

- Operate autonomously on remote farms without any type of network access
- Monitor the key parameters necessary to understand and forecast farm irrigation requirements.
- Allows access to key irrigation data by lightly trained farmers
- Record weather data on a USB flash drive
    - Data recorded each hour (weatherData.csv)
    - Daily summary recorded at midnight (weatherHistory.csv)
- Uses Penmon-Monteith equation to determine necessary irrigation
- Is updated from the USB flash drive using files that can be sent electronically
- Solar powered

A farmer should be taught the following skills for using the weather station:

1. Wake the display by pressing any button
2. Page through the key irrigation data
3. Indicate when full or partial irrigation has been completed
4. Properly remove and replace the USB flash drive
5. Use MX to properly shutdown the unit prior to removing USB for long period of time, moving unit, or replacing battery.
6. Recognize if the unit is operating correctly based on indicator lights and the display
7. (field test units) Restart a unit that has stopped functioning



Push any of the three buttons to wake the display. If the display does not come on, something is wrong.

Main Display

Current Relative Humidity (RH) and temperature

Current Wind Speed

Pulse indicator (flower pulse)

Irrigation indicators. More drops indicate urgent need to irrigate

Total rain today (since midnight)

Sun intensity in Lux. Lux is energy per unit time similar to Watts for light.

Push this button for next page of information (note that the left button always goes to the next page)

Indicates to push this button for maintenance (MX) functions

NOTE: Display updates at various cycles depending on the sensor. Some of the readings will take 5-10 seconds to update if the conditions change

Irrigation Pages

The following pages are accessed by pushing the Page Button (left button)

The rain page shows mm of rain for today and the past 5 days in mm. This data comes from the weatherHistory.csv file on the USB Flash Drive. If you have placed a new USB Flash Drive in the weather station or if you have erased the weatherHistory.csv file, then it will show no data (ND) for rain on past days.

NOTE: this number is on field test units and is used for monitoring the irrigation calculations.

Irrigation pages are by crop. Crops, such as beans, represent a wide variety of crops with size, shape and growth pattern. The first screen gives water required in mm.

The water requirements are based on the growth stage of the crop represented by four icons. Some judgment is required in deciding these phases but they are essentially:

Initial – sowing through initial sprout. Area is mostly soil.

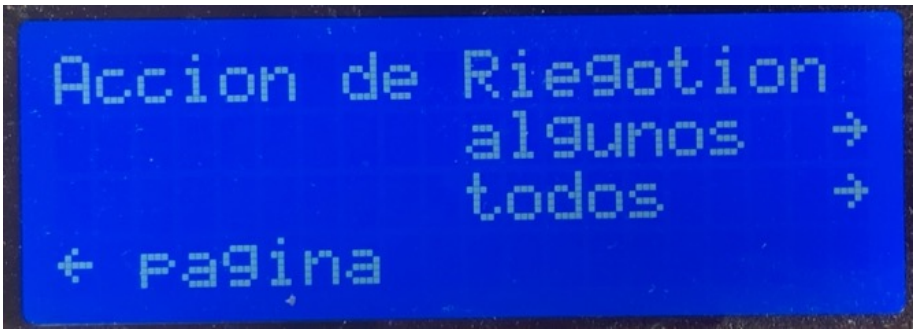
Early Development – crop is growing rapidly but area still has significant open soil.

Mid Season– longer period where crop is growing and producing fruit.

Late Season– Plant is fully developed but fruit or grain is maturing.

Irrigation (continued)

Each crop has a second page showing water required in liters per unit of land area. Land area unit is set in configuration and can be Nicaraguan manzana, hectare, or acre.



In the final page, the farmer can indicate if they have irrigated. Pushing the top right button indicates a partial irrigation and the bottom right indicates a full irrigation.

Full irrigation – at least as much water is placed on the crop as indicated in the irrigation required pages.

Partial irrigation – ¼ - ¾ the amount indicated in the irrigation required pages for that crop.

Normal Maintenance Situations

The Maintenance Screens are accessed by pushing the MX button on the lower right. The farmer may need to do this for the following reason:

1. To remove and replace the USB Flash Drive
2. To shut down the unit prior to moving it

All maintenance pages are indicated on top line

Scroll through the various MX pages using the right buttons

If a page has a function, then the left button will execute that function. Pushing the ”do it” (left) button on this page will exit MX and return to the main screen.

Indicates the maintenance page function. Some pages have a function (e.g. exit) other simply give information.

Normal Maintenance Situations (con't)

Remove and Replace the USB Flash Drive

To properly remove the USB Flash Drive:

1. Go to the MX pages
2. Scroll to the Eject USB page
3. Push the "do it" (left) button to eject the drive

4. You will then see this screen saying you need to reboot after you replace the USB. **It is safe to remove the USB drive at this point.**

5. The screen will automatically go to the reboot screen. You can remove and replace the USB at this point.
6. When you replace the USB Flash Drive, press the "do it" (left button) to reboot the computer.
7. Wait for the reboot.

NOTE: if you need more than 3 minutes to replace the USB (for example are copying data to a laptop, then shut down and restart the weather station).

USB drive and files

The weather station will operate with a high quality USB Flash Drive (e.g. Sandisk). The USB drive does not need to be very large, 4 GB is more than enough.

The drive should be formatted for Microsoft or FAT if done on a Mac. Most USB Flash drives are already formatted for this.

The weather station will, upon startup, create two data files on the USB Drive:

weatherData.csv – records data each hour

weatherHistory.csv – records a summary of the data each night at midnight (based on the internal clock time)

Both data files can easily be converted to Excel format for analysis or graphing

Key Point: all that is required is a properly formatted USB Drive for the weather station to operate, the drive can be empty.

The USB Flash drive can also have a **weatherUPDATE** folder which contains the software package for the weather station. This is not required for operation but is for software update.

Note: some software versions may place additional files on the USB Drive. These can generally be ignored and do not need to be on the drive for operation.

Examples of Data Files

weatherData.csv

	A	B	C	D	E	F	G	H	I	J
1	DateTime	Temp	RH	Rain total (mm)	Wind avr	Wind gust	Solar	Water loss (mm)	Cum loss (mm)	
2	2019-09-27:11:00	13	83	0	0	1	5723	0.026	0.026	power up/
3	2019-09-27:12:00	14	76	0	0	1	8537	0.04	0.066	/
4	2019-09-27:13:00	21	58	0	0	0	69575	0.367	0.433	/
5	2019-09-27:14:00	18	61	0	0	2	6767	0.034	0.467	/
6	2019-09-27:15:00	10	84	0	0	3	772	0.003	0.07	/
7	2019-09-27:19:00	9	89	4	0	1	13	0	-3.13	/
8	2019-09-27:20:00	9	87	4	0	1	0	0	-3.53	/
9	2019-09-27:21:00	9	88	6	0	0	0	0	-5.93	/
10	2019-09-27:23:00	8	88	8	0	0	0	0	-7.53	/
11	2019-09-28: 0:00	8	86	8	0	0	0	0	-7.53	/
12	2019-09-28: 1:00	8	87	0	0	0	0	0	-7.53	/
13	2019-09-28: 2:00	8	87	0	0	0	0	0	-7.53	/
14	2019-09-28: 3:00	8	85	0	0	0	0	0	-7.53	/
15	2019-09-28: 4:00	8	86	0	0	0	0	0	-7.53	/
16	2019-09-28: 5:00	8	86	0	0	0	0	0	-7.53	/
17	2019-09-28: 6:00	8	86	0	0	0	0	0	-7.53	/
18	2019-09-28: 7:00	8	87	0	0	0	21	0	-7.53	/
19	2019-09-28: 9:00	9	84	0	0	0	2518	0.006	-7.524	/
20	2019-09-28:10:00	10	84	0	0	0	1796	0.004	-7.52	/
21	2019-09-28:11:00	11	82	0	0	0	2669	0.006	-7.513	/
22	2019-09-28:12:00	12	80	0	0	0	3705	0.016	0.016	power up/
23	2019-09-28:13:00	18	54	0	0	0	50229	0.252	0.269	/
24	2019-09-28:14:00	17	58	0	0	0	62280	0.307	0.575	/
25	2019-09-28:15:00	17	59	0	0	1	11450	0.056	0.632	/

Notes on data:

- Temp is in deg C
- RH is in %
- Rain total is cumulative through the day and clears at midnight
- Wind is averaged through an hour
- Wind gust is the highest reading for that hour
- Solar is in Lux
- Water loss is mm water calculated as lost do to evaporation and transpiration during the hour
- Water loss cumulative is continuous. It is cleared by an irrigation.
- The comments (separated by '/') are inserted for various situations. They include:
    - Power up – any normal power up
    - Low Battery power down – when the weather station shuts down due to a low voltage command from the Power Board.

Data file con't

weatherHistory.csv

	A	B	C	D	E	F	G	H	I	J
1	DateTime	Temp max	Temp min	RH max	RH min	Rain total	Wind max	Wind min	Wind gust	Solar avr
2	9/27/19	22	8	93	47	8	0	0	3	1950
3	9/28/19	20	7	89	45	3	0	0	1	3414
4	9/29/19	18	6	89	46	0	0	0	1	1982
5	9/30/19	22	3	84	26	0	0	0	2	2819
6	10/1/19	24	4	86	27	0	0	0	1	4088
7	10/2/19	24	5	83	29	0	0	0	1	2966
8	10/3/19	24	10	87	33	1	0	0	1	2926
9	10/4/19	16	10	89	54	1	0	0	2	1248
10	10/5/19	20	9	85	48	0	0	0	1	2430
11	10/6/19	23	6	86	37	0	0	0	1	3118
12	10/7/19	19	9	88	59	0	0	0	4	827
13										

Solar avr (Solar total) – this number is somewhat arbitrary but is roughly a total solar energy for that day. It gives an idea of how sunny/cloudy/etc. the day was.

Advanced Maintenance

The following maintenance situations are geared primarily for a technician who is setting up or troubleshooting the weather station.

Reboot – this will initiate a reboot of the system from start. It is automatically initiated after a software update. You will be redirected to this maintenance page when you eject the USB Drive.

View Data and View History – these pages tell how many lines of data are in the weatherData.csv and weatherHistory.csv plus the date and time of the last entry. Useful for monitoring if data recording is happening as you expect without pulling the USB Flash Drive and viewing in a computer.

Advanced MX (con't)

Set Clock – each time "do it" (left) button is pressed this will change to another part of the date that can be changed using the scroll arrows at the right. The changeable portion will be indicated at the top of the page.

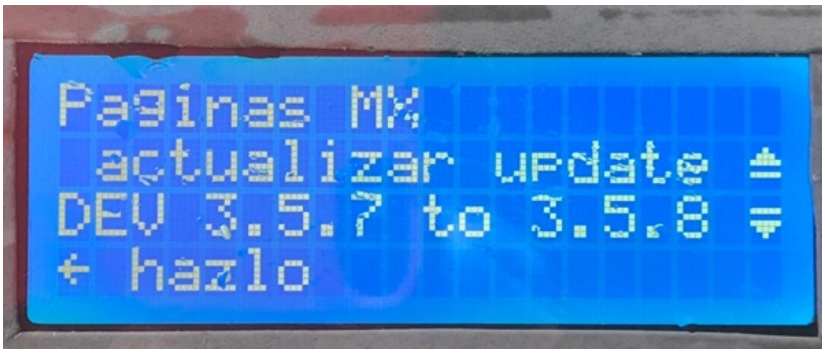
Indicates scroll buttons (right) will change the year.

Right buttons exit without saving new clock setting.

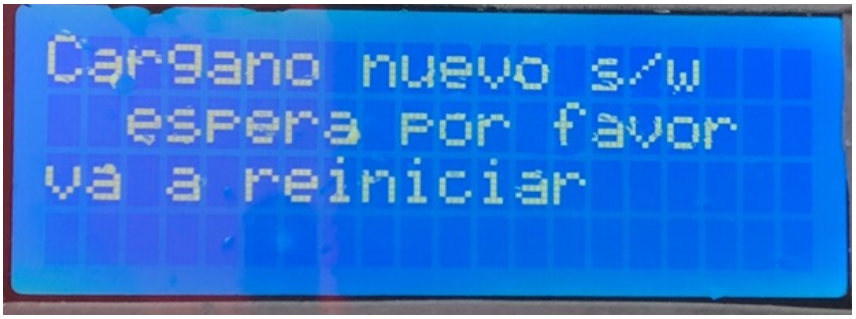
Left button will save changes so clock will have new time

Advanced Maintenance (con't)

Software Update– Software update will update the weather station computer to new software that is on the USB Flash Drive. The current revision and the revision on the USB Flash Drive show in the display.



If you press the "do it" (left button) the system will transfer the new software from the USB Flash Drive to the computer then reboot. Simply wait for it to start up.



Some notes on software:

- Weather station software is written in Python 3
- The only dependencies are part of the Python Standard Library or included in the package. There are no additional dependencies.
- A r**eadme** file is included with information on the release
- **config.py** contains all settings and can be modified using a text editor.
- **EnglishSpanish.py** is a dictionary of English phrases tied to Spanish phrases. Although you could change the Spanish phrases in this dictionary, the English phrases are the dictionary indexes so they can not be changed without modifying the main program.
- **weather.py** is the main operational code.
- Other contained files are drivers for sensors and peripherals

NOTE: if you receive a software update by email, copy all of the files in the update folder into the weatherUPDATE file on the USB Drive. This is more reliable than copying the weatherUPDATE file directly.

Advanced Maintenance (con't)

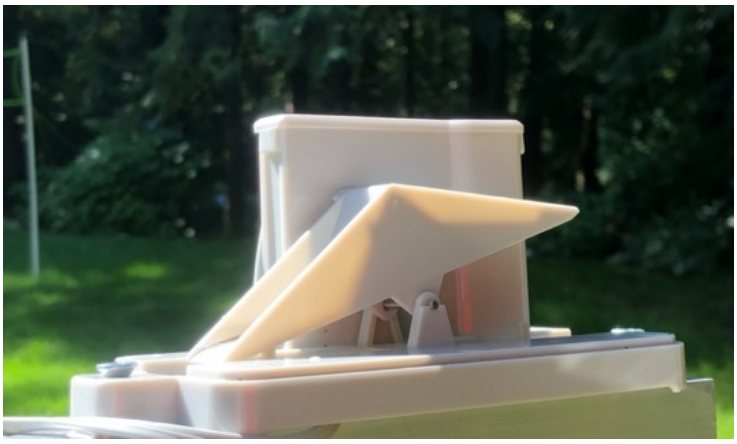
Two pages are available to test the mechanical sensors. Both the anemometer and the rain gage contain Hall Effect switches that operate once for each cycle. By looking at the maintenance page you can see if those switches and the associated code interrupts are functioning.

Anemometer– spin the anemometer and you should see the count increase one for each full revolution. If you use a different anemometer part you might need to change the radius in the config.py file.

Rain Gage– the rain gage is a tipping bucket style. Each time a bucket fills (there are two) the assembly tips and actuates the switch.

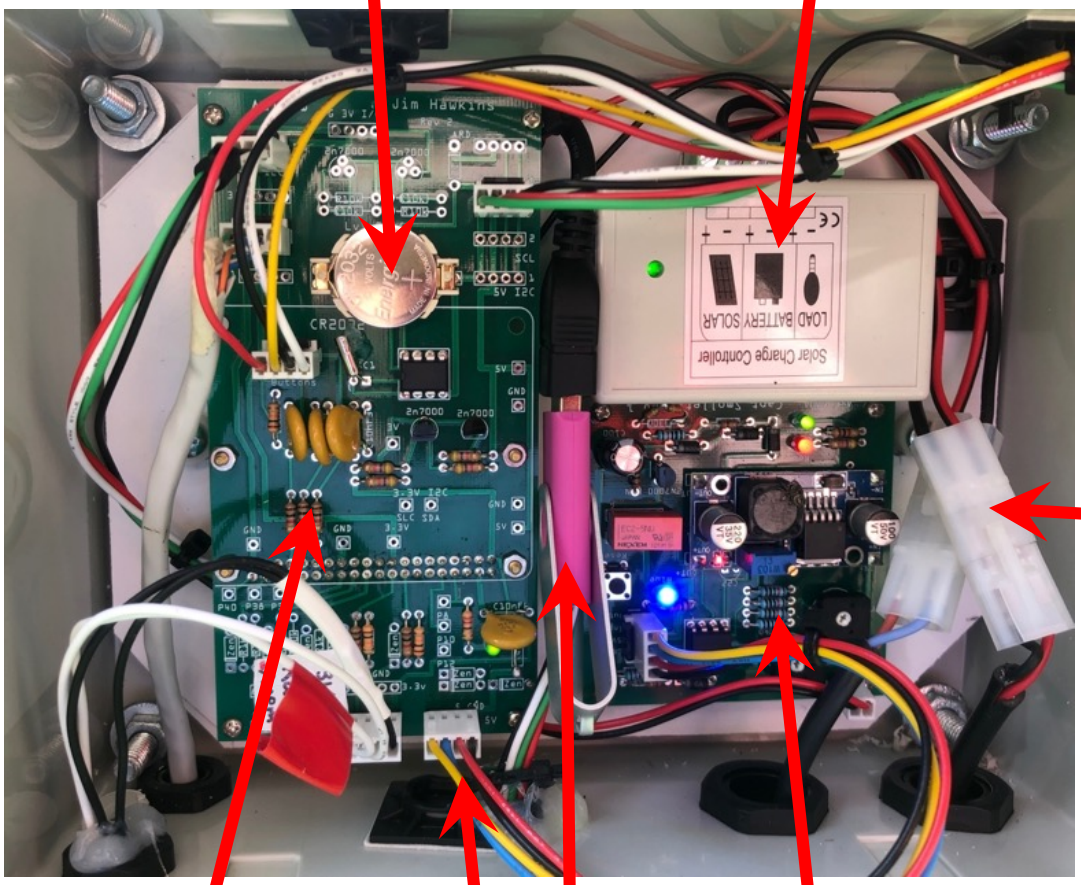
The internal functioning parts are shown in the photo to the right.

Pro Tip: Instead of taking the cover off, pour clean water into the funnel on the top and watch the count change. It does not take much water.



What is What in the Control Panel

There is no master on/off switch for the weather station. The 4-wire Power Connector from the Power Board to the Jim Hawkins board serves this purpose.



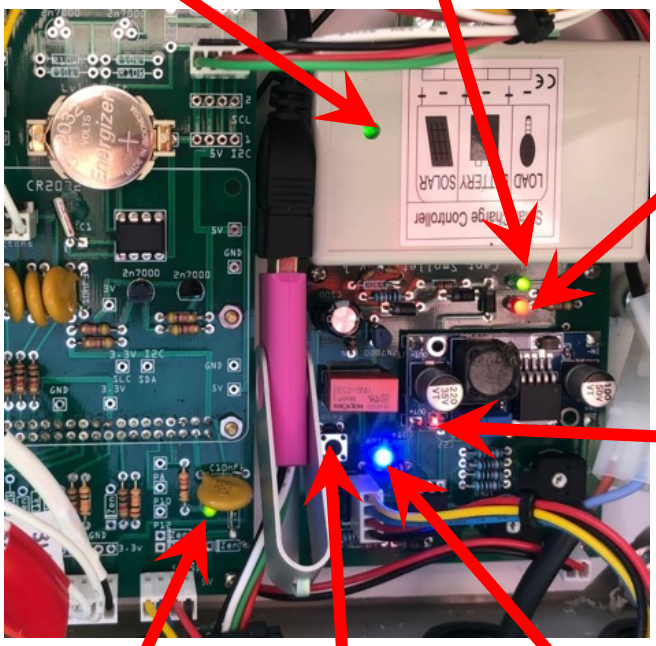
Power and Charge Indicators

The Rpi Zero is a computer that should shut down before power is disconnected. The Power Board monitors power from the battery and Solar Charge controller. It tells the Rpi Zero to shut down if battery voltage is low

Solar LED (Solar Charge Controller) Flashes green when charging

Green LED (Power Board) On-voltage indicator. (details below)

Red LED (Power Board) Off-voltage indicator. Details below



Small Red LED (Power Board) Indicates power to power board, should always be on.

Pulse LED (Jim Hawkins Board) Flashes when operating normally. (Only flashes when on main display, not MX or irrigation/rain pages)

Blue LED (Power Board) Indicates power on for the Jim Hawkins board and Rpi Zero. Details below.

Reset Switch(Power Board) Disconnects all power to Jim Hawkins board. Do not push if Rpi Zero is operating

Power Board LEDs	what's going on (***weather station should be operating
● ● ●	Battery charged, power supplied to weather station***
● ● ○	Battery discharging, power supplied to weather station***
○ ○ ○	Battery below 11 volts, system off waiting to recharge
○ ● ○	Battery charging but not ready to supply power to station

Installation

Locate the weather station

- Open to the sun in as wide an angle as possible
- Attach to a metal pole approximately 2 meters high (if the anemometer is more or less than 2 meter, then it must be calibrated slightly differently)
- Open to the sky with no trees or overhangs to block rain
- Away from wind blocks although the weather station should generally be in the same wind area as the crop

Materials included

- Sensor bar
- Solar cell brackets
- Solar cell
- Control Panel
- Anemometer
- Rain Gauge
- Zip ties and U-bolts
- Note: mounting hardware comes loosely attached to components

Required Materials

1. 50 – 65 mm diameter pipe or pole that extends approximately 2 meters above the ground.
2. 12 Volt car or motorcycle battery (preferred). Must be at least 10 AH (not cranking amps). Larger is better and sealed lead-acid batter or AGM preferred.
3. Battery box to protect battery. Locate on ground at base of pole.

Battery Harness

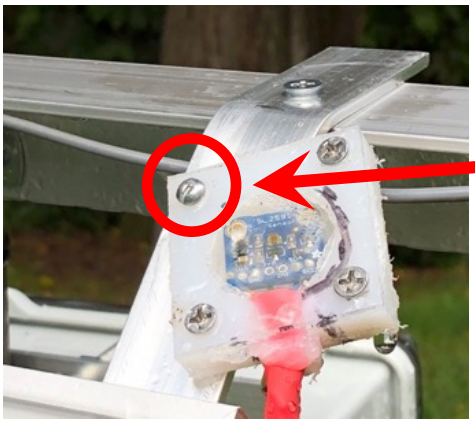
Installation (con't)

Installation

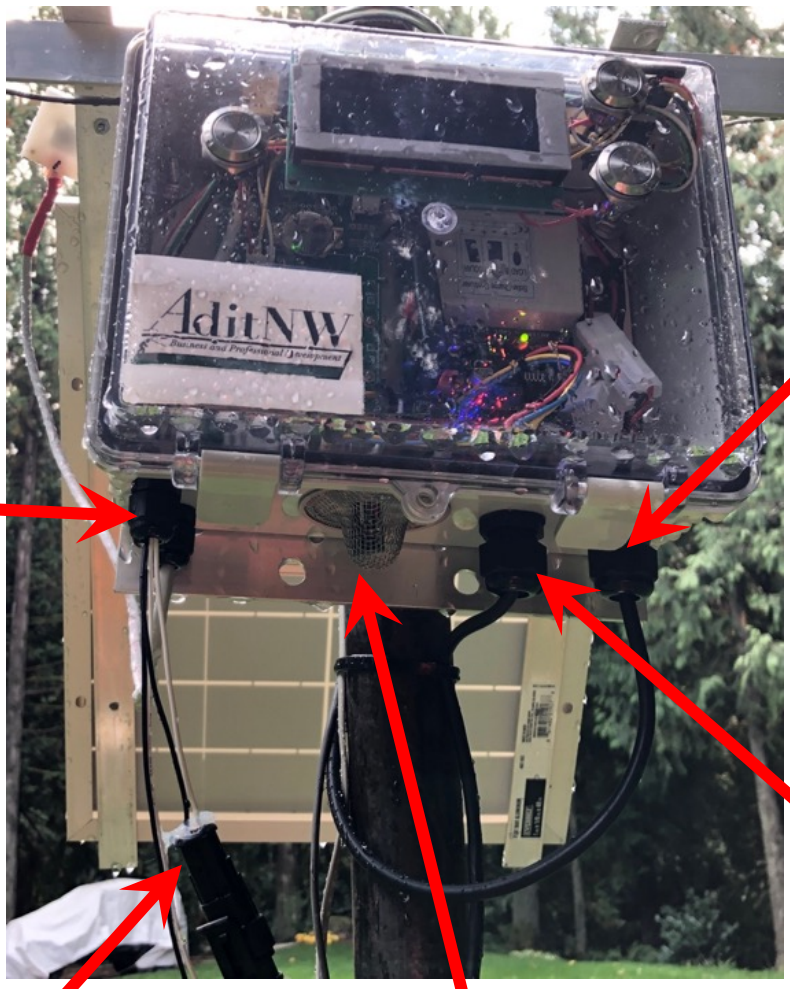
1. NOTE how the 4-pin power connector is not connected to the Jim Hawkins board. **DO NOT ATTACH THIS UNTIL INSTRUCTED TO DO SO!**
2. Securely install pipe or pole into the ground (supplied by installer)
3. Attach solar cell supports , anemometer and rain gage to sensor bar using bolts and self-locking nuts
4. Use pipe clamp to attach sensor bar to pipe
5. Hang the solar cell from the supports using the two small clips as hangers
6. Use two U-bolt pipe clamps to attach control panel to pipe approximately even with bottom of the solar cell. If a shorter U-bolt is included, it is the lower mount.
7. A 12 volt battery is required for operation and must be supplied by the installer as well as a battery box for the battery.
8. Attach battery harness securely to the battery assuring red wire is connected to positive (+) terminal of battery.

Installation (con't)

These photos are included for reference



Solar Lux Sensor – is retained with this one screw.



Solar Cell

Solar Lux cable

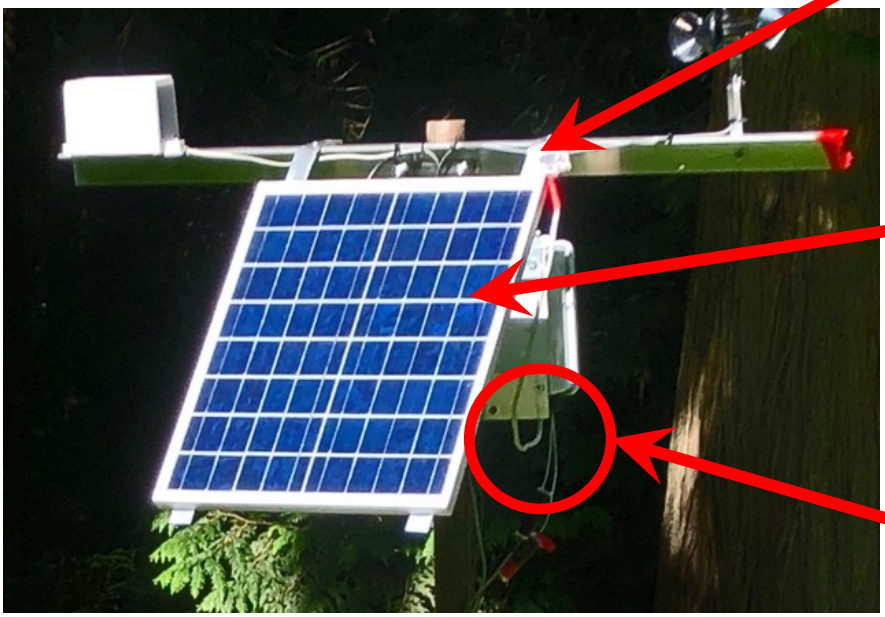
Battery

Anemometer and Rain gage water resistant connectors.

Temperature & RH sensor with screen protector.

Installation (con't)

8. Attach solar lux sensor to the sensor bar using the single bolt and nut.
9. Install wire from solar cell as follows: 1) remove plastic nut from water seal grommet, 2) feed plug through hole, 3) Install plastic grommet. **Do not connect white power connectors in box yet.**
10. Use wire ties to route wires up pipe and sensor bar neatly. Form drip loops below control box so water running down the wire will drip at the bottom of the loop and not flow directly into the connector.
11. Read the section in this manual titled **Battery and Solar Cell Maintenance** to familiarize yourself with powering the unit on and off. **IMPORTANT: Verify the four wire power connector from the Power Board to the Jim Hawkins board is disconnected.**
12. Connect the two white power connectors on the right side of the control box. This will connect power from the battery and the solar cell to the system.
13. Verify that a USB Flash drive is installed.
14. Double check everything is installed correctly
15. Connect the Four Wire Power Connector to the Jim Hawkins board. The weather station should power up.



Solar Lux Sensor– attached to solar cell hangers.

Solar Cell– sits on hangers and hooks to clips. It slides into place.

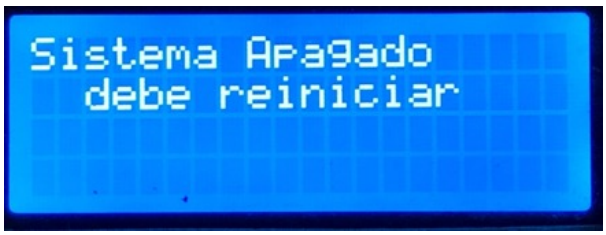
Drip Loop – prevents water from dripping directly into water resistant fitting.

Shutdown and Restart the Weather Station

The weather station uses a computer with an operating system and therefore must be properly shut down. ”Pulling the plug” without doing this can cause damage to the computer.

ALWAYS SHUT DOWN THE COMPUTER PRIOR TO REMOVING POWER!

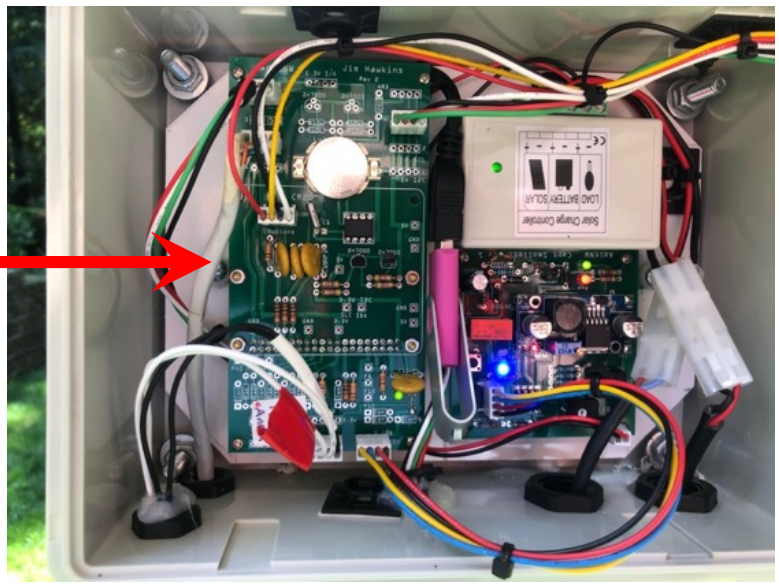
1. Go to MX – Shut Down
2. Press the “do it” (left button) to initiate shutting down.
3. You will see a screen saying the system is shutting down
4. Wait 30 seconds, then you can remove the USB Flash Drive or disconnect power.
5. To restart, you will need to press and hold the reset switch on the Power Board (see next page).



Pro Tip: The weather station computer is a Raspberry Pi Zero mounted under the Jim Hawkins board. The Rpi Zero has a small, square, green LED that indicates when the processor is operating. If it is flashing, the processor is operating and you may cause damage if you remove power. If the green LED is off, the processor is off and it is safe to remove power.

If the unit is not responding, it is generally safe to remove power if the green LED is on solid and not flashing.

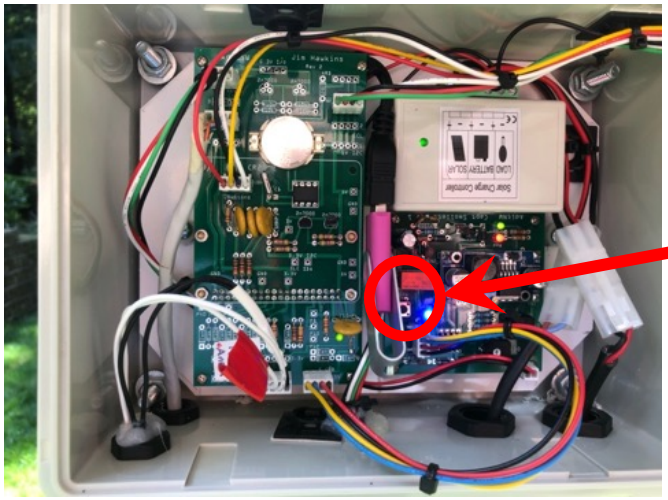
Raspberry Pi Zero – the weather station computer is mounted under the Jim Hawkins board. A square, green LED is visible here.



Restart the Weather Station

You will need to restart the weather station if:

1. It was shut down
2. It is not responding to the buttons and the pulse light (green LED on Jim Hawkins board or little flower on display) is not flashing
3. Use a clean, dry finger to press and hold the reset button for 5 seconds.
4. The blue LED will go out then come back on and the weather station should restart.



Reset Button– Located on the Power Board. It is a small, black button.

Battery & Solar Cell Maintenance

The weather station must be properly shutdown and disconnected prior to any work on the battery, solar cell, or their associated wiring.

NOTE: The weather station does not have a power switch. The only way to disconnect power is to follow this procedure.

WARNING: THERE IS NO BETTER WAY TO FRY THE WEATHER STATION THAN TO DO MAINTENANCE WHILE CONNECTED TO THE POWER!

To properly disconnect the power for maintenance:

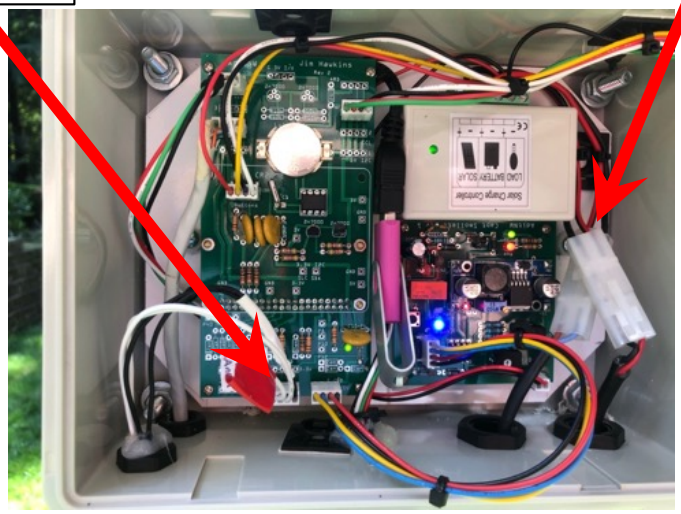
1. Follow the shutdown procedure to shut down the weather station computer.
2. Unplug the four-wire power harness that connects the Jim Hawkins board to the Power Board at the connection to the Jim Hawkins board.
3. Unplug the two white power connectors on the right side of the box. These are wired so they can't be plugged in incorrectly but it is still worth watching which one came from where.
4. Re-connect in the reverse order. If the battery or solar cell are providing the minimum voltage then the blue LED will light and the weather station will start.

IF NO LEDS SHOW , THE BATTERY IS CONNECTED IN REVERSE. CHECK THIS BEFORE CONNECTING THE POWER TO THE JIM HAWKINS BOARD.

Step 1– Shut down the computer.

Step 2– Unplug this connector.

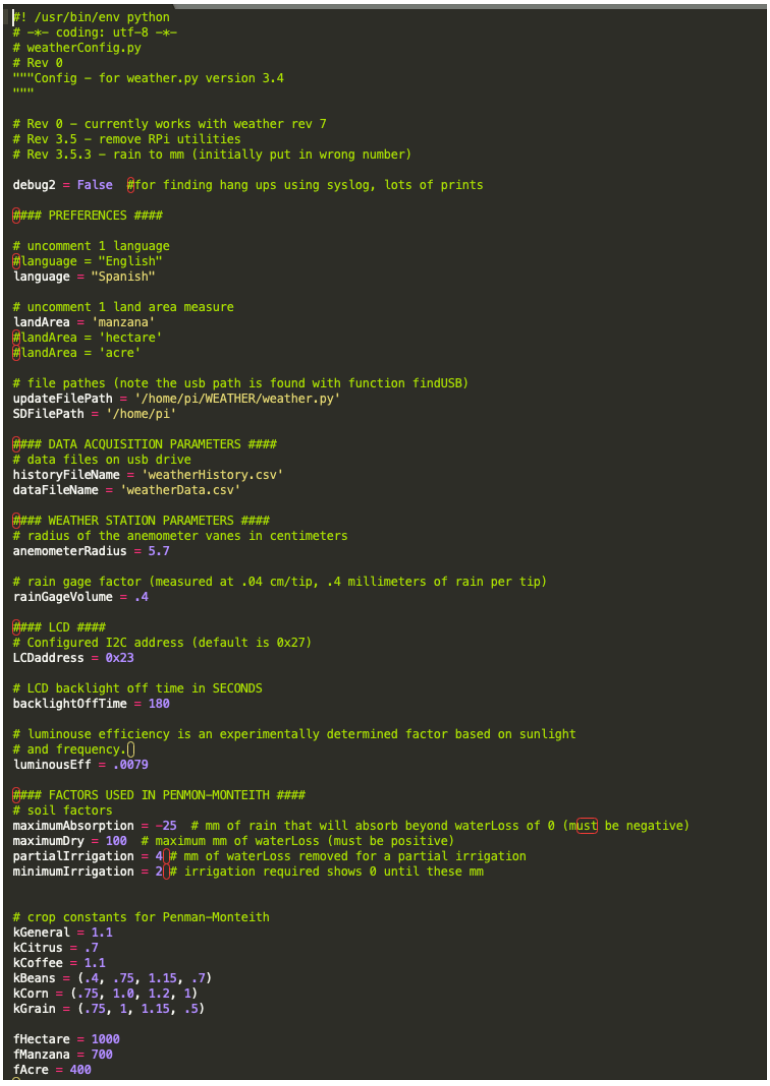
Step 3– Unplug these two white connectors.



Configuration settings

Most of the settings for the weather station are contained in a configuration file. This file is titled **config.py** and is a Python 3 programming file. It is fairly simple to change settings using the following process:

1. Modify the file in the **weatherUPDATE** folder on the USB Flash Drive (it is a good idea to copy this to your laptop prior to modifying as a backup.
2. Use a text editor (e.g. notepad or text edit) to modify the file. **DO NOT USE A WORD PROCESSOR SUCH AS MS WORD OR PAGES!**
3. The screenshot below shows a color coded version.
4. Do not change variable names (white)
5. # indicates a commented out line (computer can't read it). Some settings (i.e. language and land area) are changed by moving the # to a different line.
6. Values (purple) can be changed.
7. Save changes to the USB Flash Drive
8. Install drive in the weather station
9. Perform a **MX – Software Update**



```
#! /usr/bin/env python
# -*- coding: utf-8 -*-
# weatherConfig.py
# Rev 0
"""Config - for weather.py version 3.4
"""

# Rev 0 - currently works with weather rev 7
# Rev 3.5 - remove RPi utilities
# Rev 3.5.3 - rain to mm (initially put in wrong number)

debug2 = False  #for finding hang ups using syslog, lots of prints

#### PREFERENCES ####

# uncomment 1 language
#language = "English"
language = "Spanish"

# uncomment 1 land area measure
landArea = 'manzana'
#landArea = 'hectare'
#landArea = 'acre'

# file pathes (note the usb path is found with function findUSB)
updateFilePath = '/home/pi/WEATHER/weather.py'
SDFilePath = '/home/pi'

#### DATA ACQUISITION PARAMETERS ####
# data files on usb drive
historyFileName = 'weatherHistory.csv'
dataFileName = 'weatherData.csv'

#### WEATHER STATION PARAMETERS ####
# radius of the anemometer vanes in centimeters
anemometerRadius = 5.7

# rain gage factor (measured at .04 cm/tip, .4 millimeters of rain per tip)
rainGageVolume = .4

#### LCD ####
# Configured I2C address (default is 0x27)
LCDaddress = 0x23

# LCD backlight off time in SECONDS
backlightOffTime = 180

# luminouse efficiency is an experimentally determined factor based on sunlight
# and frequency.()
luminousEff = .0079

#### FACTORS USED IN PENMON-MONTEITH ####
# soil factors
maximumAbsorption = -25  # mm of rain that will absorb beyond waterLoss of 0 (must be negative)
maximumDry = 100  # maximum mm of waterLoss (must be positive)
partialIrrigation = 4 # mm of waterLoss removed for a partial irrigation
minimumIrrigation = 2 # irrigation required shows 0 until these mm


# crop constants for Penman-Monteith
kGeneral = 1.1
kCitrus = .7
kCoffee = 1.1
kBeans = (.4, .75, 1.15, .7)
kCorn = (.75, 1.0, 1.2, 1)
kGrain = (.75, 1, 1.15, .5)

fHectare = 1000
fManzana = 700
fAcre = 400
```

Example: Change the Language

The config.py should look like this in your text editor:

```
#! /usr/bin/env python
# -*- coding: utf-8 -*-
# weatherConfig.py
# Rev 0
"""Config - for weather.py version 3.4
"""

# Rev 0 - currently works with weather rev 7
# Rev 3.5 - remove RPi utilities
# Rev 3.5.3 - rain to mm (initially put in wrong number)

debug2 = False  #for finding hang ups using syslog, lots of prints

#### PREFERENCES ####

# uncomment 1 language
#language = "English"
language = "Spanish"

# uncomment 1 land area measure
landArea = 'manzana'
#landArea = 'hectare'
#landArea = 'acre'

# file pathes (note the usb path is found with function findUSB)
updateFilePath = '/home/pi/WEATHER/weather.py'
SDFilePath = '/home/pi'

#### DATA ACQUISITION PARAMETERS ####
# data files on usb drive
historyFileName = 'weatherHistory.csv'
dataFileName = 'weatherData.csv'

#### WEATHER STATION PARAMETERS ####
# radius of the anemometer vanes in centimeters
anemometerRadius = 5.7

# rain gage factor (measured at .04 cm/tip, .4 millimeters of rain per tip)
rainGageVolume = .4

#### LCD ####
# Configured I2C address (default is 0x27)
LCDaddress = 0x23

# LCD backlight off time in SECONDS
backlightOffTime = 180

# luminouse efficiency is an experimentally determined factor based on sunlight
# and frequency.
luminousEff = .0079

#### FACTORS USED IN PENMON-MONTEITH ####
# soil factors
maximumAbsorption = -25  # mm of rain that will absorb beyond waterLoss of 0 (must be negative)
maximumDry = 100  # maximum mm of waterLoss (must be positive)
partialIrrigation = 4 # mm of waterLoss removed for a partial irrigation
minimumIrrigation = 2 # irrigation required shows 0 until these mm


# crop constants for Penman-Monteith
kGeneral = 1.1
kCitrus = .7
kCoffee = 1.1
kBeans = (.4, .75, 1.15, .7)
kCorn = (.75, 1.0, 1.2, 1)
kGrain = (.75, 1, 1.15, .5)

fHectare = 1000
fManzana = 700
fAcre = 400
```

Example Change the Language (con't)

The current language setting is "Spanish" as this line does not have the comment symbol (#) in front of it:

```
# uncomment 1 language
#language = "English"
language = "Spanish"
```

Move the comment symbol (#) to the "Spanish" line (comment it) and out of the "English" line (uncomment it):

```
# uncomment 1 language
language = "English"
#language = "Spanish"
```

The new settings will take effect when they are updated on the weather station. So you must:

1. Save the config.py file on the USB drive in the weatherUPDATE folder
2. Install the USB drive in the weather station and reboot
3. Perform a MX – Software Update (note: since you did not change the software version, this will show you updating to the same version. That is ok).

Calculating Irrigation Requirements

The Aperato Metelogico uses the Penmon-Monteith equation to calculate irrigation requirements. This approach is presented in detail in this document:

FAO Irrigation and Drainage Paper No. 56: Crop Evapotranspiration
Richard Allen, Luis Pereira, Dirk Raes, Martin Smith, 1990

The following information is just the tip of the iceberg on this extensive research and approach.

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{37}{T_{hr} + 273} u_2 (e^o(T_{hr}) - e_a)}{\Delta + \gamma(1 + 0.34 u_2)} \qquad (53)$$

where
- ET_o reference evapotranspiration [mm hour^{-1}],
- R_n net radiation at the grass surface [MJ m^{-2} hour^{-1}] (Equation 40),
- G soil heat flux density [MJ m^{-2} hour^{-1}] (Equations 45 and 46),
- T_{hr} mean hourly air temperature [°C],
- Δ saturation slope vapour pressure curve at T_{hr} [kPa °C^{-1}] (Equation 13),
- γ psychrometric constant [kPa °C^{-1}] (Equation 8),
- $e^o(T_{hr})$ saturation vapour pressure at air temperature T_{hr} [kPa] (Equation 11),
- e_a average hourly actual vapour pressure [kPa] (Equation 54),
- u_2 average hourly wind speed [m s^{-1}].

```python
#### WATER LOSS and IRRIGATION ####
def penmanMonteith(self, hourTemp, hourRH, hourWindAvr, hourLux, printFactor):
    ''' Calculates mm water lost in 1 hour
    ONLY WORKS FOR 1 HOUR PERIOD
    '''
    if printFactor is True: print(hourTemp, 'deg C, ', hourRH, '% ', hourWindAvr, 'km/hr, ', hourLux, 'Lux')

    # Solar Radiation
    solarRadiation = hourLux * config.luminousEff * (3600/1e6)# (MJ/m^2-hr)

    outgoingRadiation = 0# equation 39 but am assuming this is small
    netRadiation = ((1 - .23) * solarRadiation) - outgoingRadiation# equation 38 gives the .23 constant
    if printFactor is True: print('netRadiation: ', '{:3.6f}'.format(netRadiation))

    #Ground Heat Flux
    if hourLux > 3000:
        soilHeatFlux = .1 * netRadiation  # Daytime Gn MJ/m^-hr
    else:
        soilHeatFlux = .5 * netRadiation  # Night Gn MJ/m^-hr

    #psychometric constant is .067 at sea level and .060 at 3000 feet in kPa/deg C
    psychometricConstant = .0665# (kPa/deg C)

    # e sub zero(T)  saturation vapor pressure at air temp T
    saturationVaporPressure = .6108 * (math.exp((17.27 * hourTemp)/(hourTemp + 273)))# (kPa/deg C)


    # saturation slope vapor pressure at air temperature
    saturationVaporSlope = (4098 * saturationVaporPressure) / ((hourTemp +237.3)**2)# KPa/deg C

    vaporPressure = saturationVaporPressure * (hourRH/100)# e sub a kPa
    windSpeed = hourWindAvr * .278  # wind speed converted to m/sec

    # Penman Monteith Equation in three parts then the whole
    solarComponent = ((.408 * saturationVaporSlope) * (netRadiation - soilHeatFlux))
    if printFactor is True: print('solar component: ', '{:4.3f}'.format(solarComponent))

    windComponent = (psychometricConstant * (37 / (hourTemp + 273))) * windSpeed * (saturationVaporPressure - vaporPressure)
    if printFactor is True: print('wind component: ', '{:4.3f}'.format(windComponent))

    workingDenominator = saturationVaporSlope + (psychometricConstant * (1 + (.34 * windSpeed)))
    if printFactor is True: print('denominator: ', '{:4.3f}'.format(workingDenominator))
    if printFactor is True: print('')

    # final Penman-Monteith
    evapoTranspiration = (solarComponent + windComponent) / workingDenominator

    return evapoTranspiration  # mm of water lost in that one hour
```

Calculating Irrigation Requirements (con't)

FIGURE 20
Typical K_c for different types of full grown crops

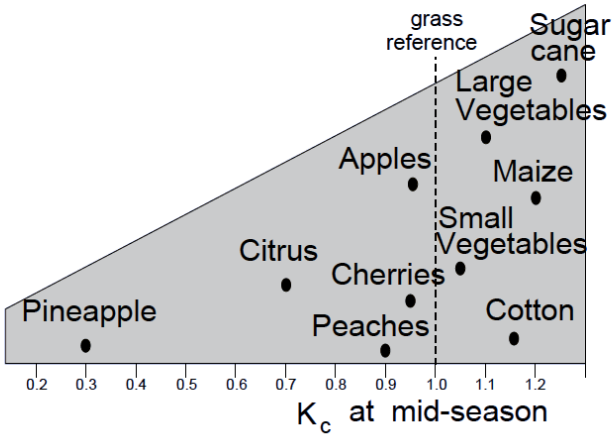


FIGURE 21
Extreme ranges expected in K_c for full grown crops as climate and weather change

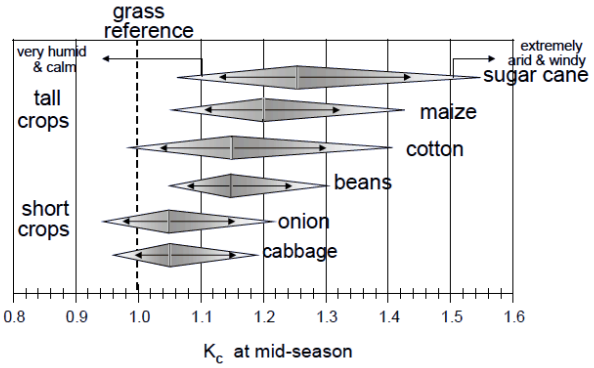
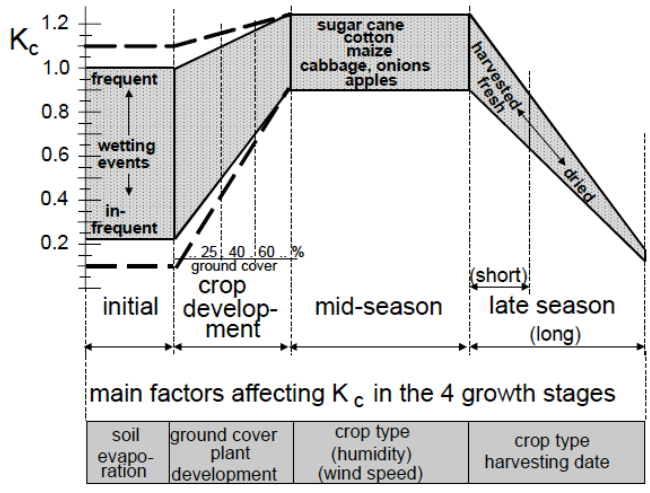


FIGURE 24
Typical ranges expected in K_c for the four growth stages



Dealing with Problems

- **Battery is Connected but no light on Power Board –** Verify battery is connected properly (is + and – reversed?)

- **Display does not come on when a button is pushed** –
    - Verify unit is properly powered. Is blue LED lit on Power Board? Is the green pulse LED flashing?
    - Verify four-wire harness from Jim Hawkins board to display is connected and seated in connectors.
    - Perform a manual reset using the button on the Power Board

- **Pulse LED is not flashing**: try pushing one of the display buttons and wait 5 minutes. If the pulse does not resume:
    1. Verify the Rpi Zero CPU light (square green LED) is not on or flashing. (if it is, wait until it isn't)
    2. Press and hold Power Board reset switch for 5 seconds, then release.
    3. System should reboot

- **LCD suddenly is hard to read** (poor contrast, viewing angle, or extra lines): this is typically caused by low voltage to the Jim Hawkins board.

- **Can't set the clock**: low voltage to Jim Hawkins board

- **Low voltage to Jim Hawkins board**: supply voltage on the 4-pin connector should be 5.2 volts with 4.8 volts being the bare minimum. If this is low or high, the voltage regulator on the Power Board

- **Buzzing sound from Power Board**: this is caused by a short circuit. Things to check:
    - USB adapter into the Rpi Zero is upside down

Contact us

AditNW developed this Aperato Metologico weather station in cooperation with Pontis Nicaragua.

For support, contact:

Brad.Allen@AditNW.com

AditNW.com