



# INTEL-IRRIS

Intelligent Irrigation System for Low-cost Autonomous Water Control  
in Small-scale Agriculture



# INTELLIGENT IRRIGATION SYSTEM FOR LOW-COST AUTONOMOUS WATER CONTROL IN SMALL-SCALE AGRICULTURE



## Building the Intel-IrriS LoRa IoT platform Part 1: soil sensor device



Prof. Congduc Pham  
<http://www.univ-pau.fr/~cpham>  
Université de Pau, France



# Review: Technology components



# Review: Low-cost sensors



- Build on low-cost, low-power IoT expertise
- Increase accuracy of low-cost sensors by automatic and remotely controlled procedures for advanced calibration
- Enable deployment of several complementary low-cost sensors
- Include agricultural models / knowledge with corrective & predictive analytics

# Review: Smart embedded control

- Build on low-cost embedded & open IoT gateway expertise
- Implement the “Intelligent Irrigation in-the-box” with "plug-&-sense" approach
- Model complex water-soil-plant interaction
- Embed Decision Support System (DSS) and disruptive Artificial Intelligence (AI)
- Integration of various knowledge streams
- Fully autonomous

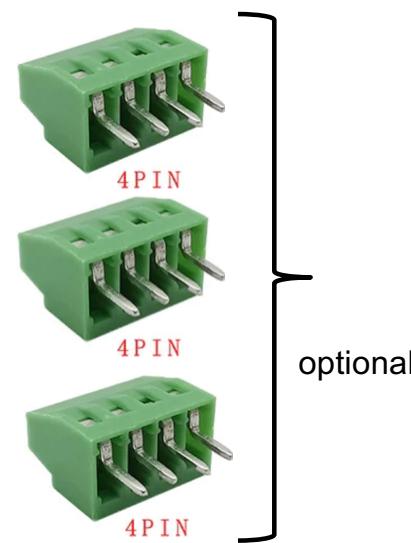
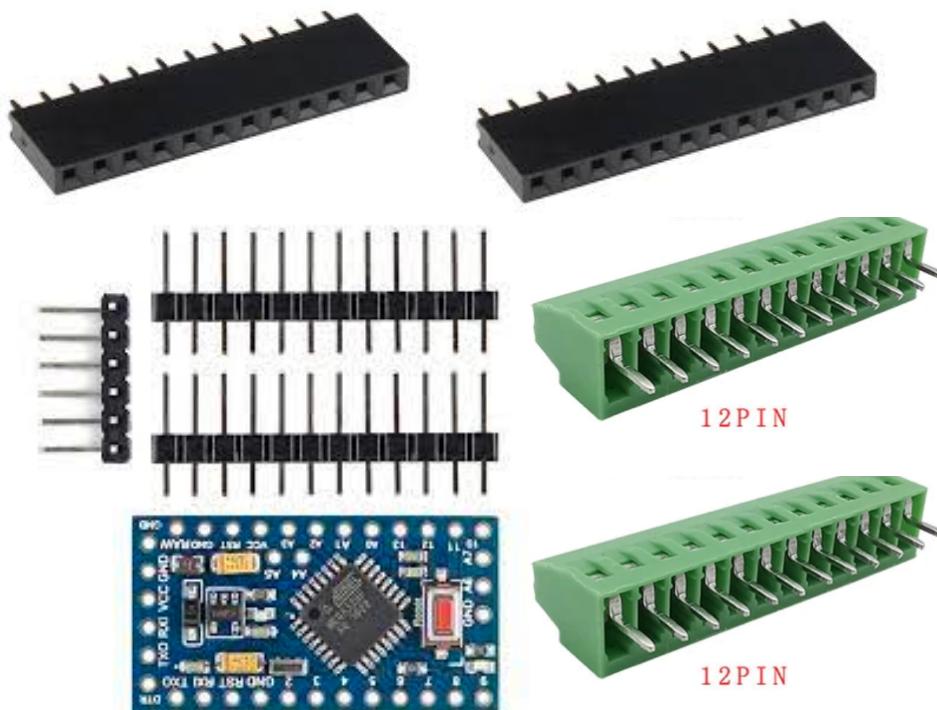
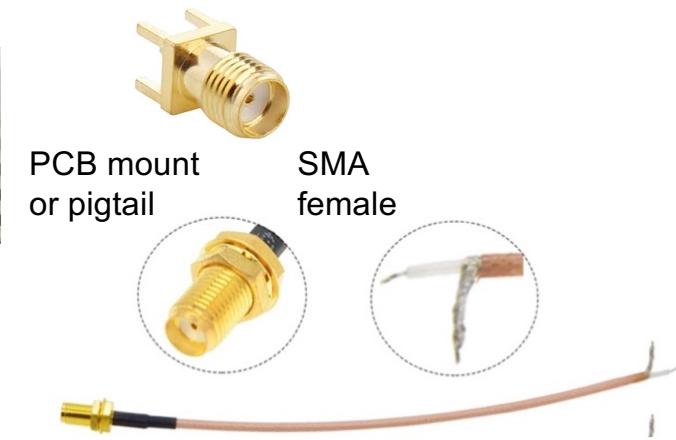
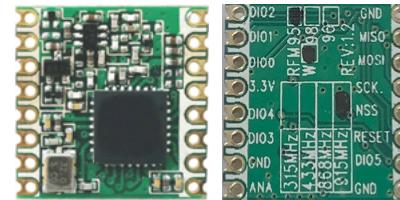
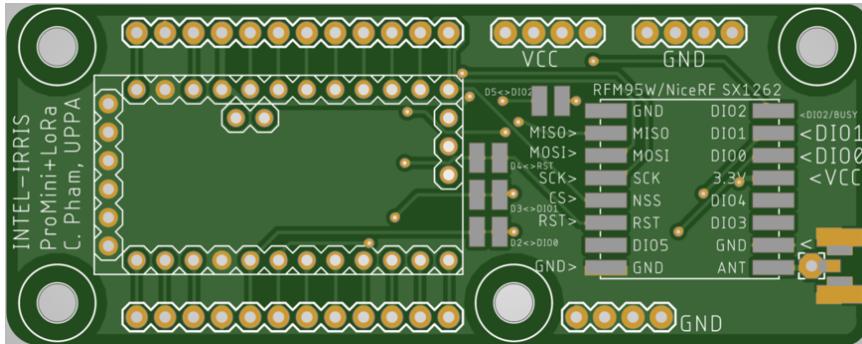


# Review: Starter-kits

- "Intelligent Irrigation in-the-box", "plug-&-sense"
- At least 100 starter-kit will be distributed



# Soil sensor: electronic parts



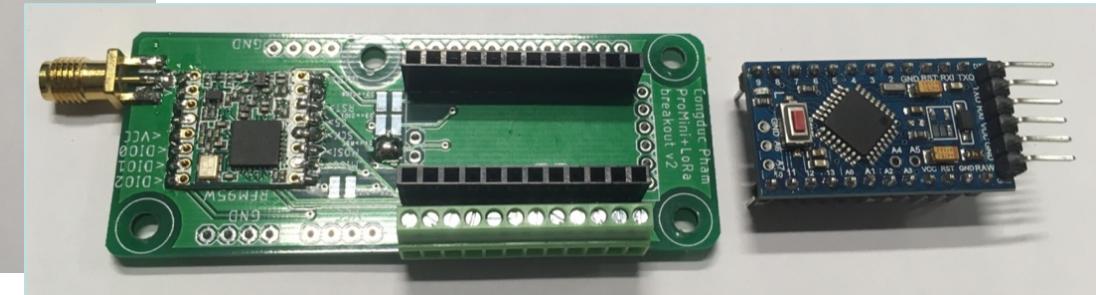
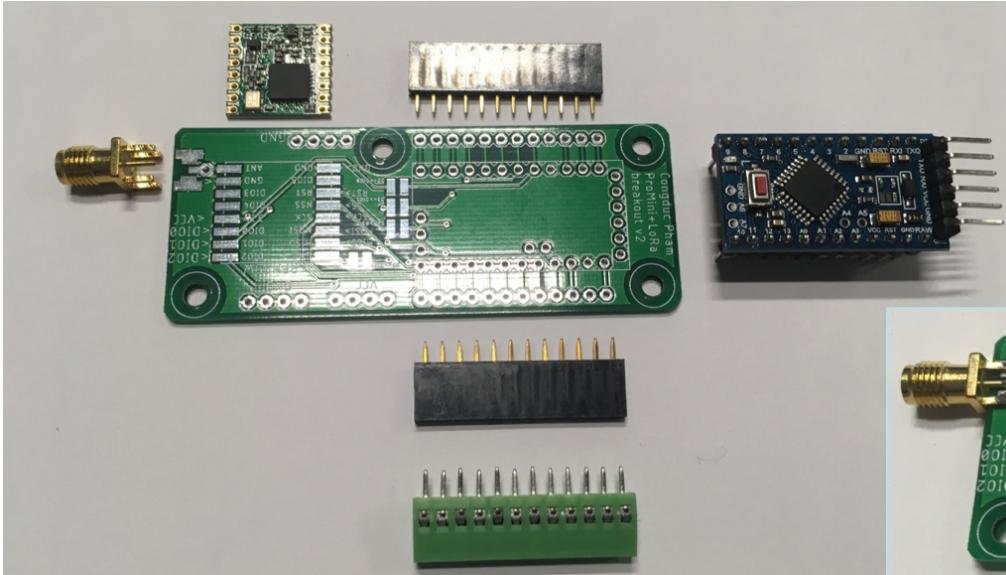
# Soil sensor: enclosure & integration



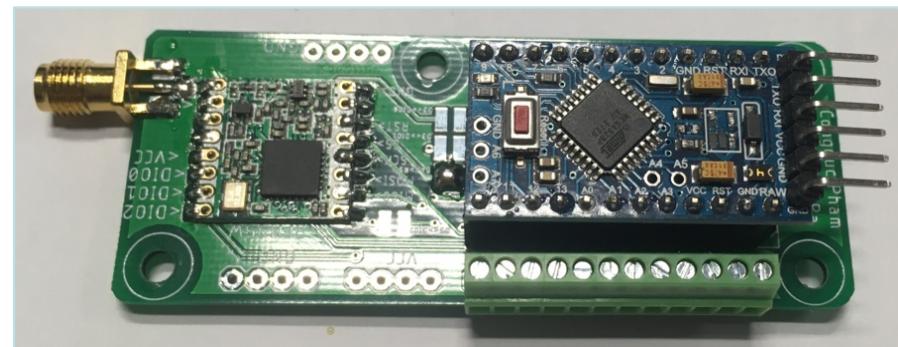
proof-of-concept



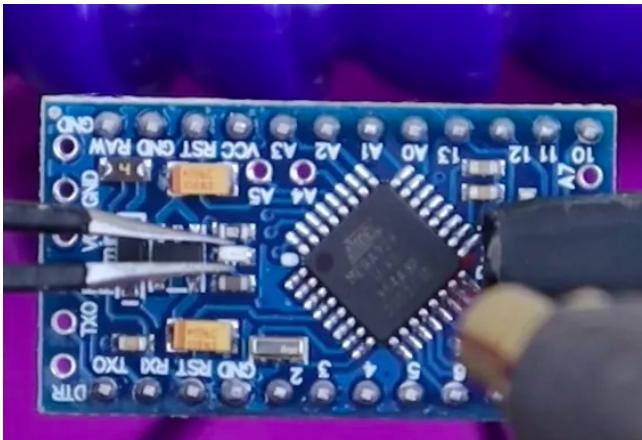
# Assembling the PCB board



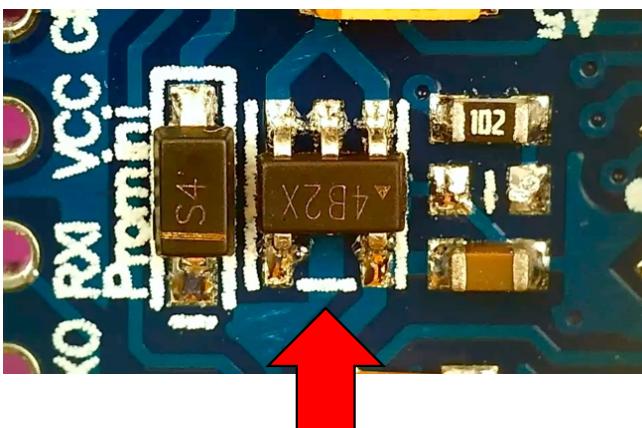
This dedicated video will show  
how to solder all the components  
<https://youtu.be/3jdQ0Uo0phQ>



# Reducing power consumption



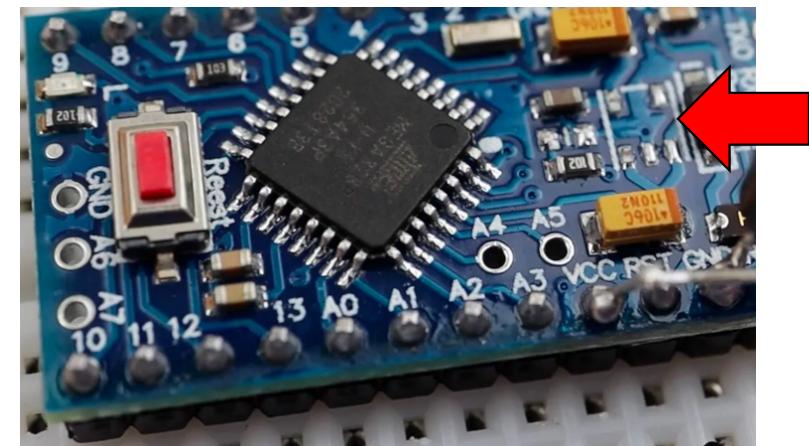
**Remove the power LED by just clipping it off with some wire cutters**



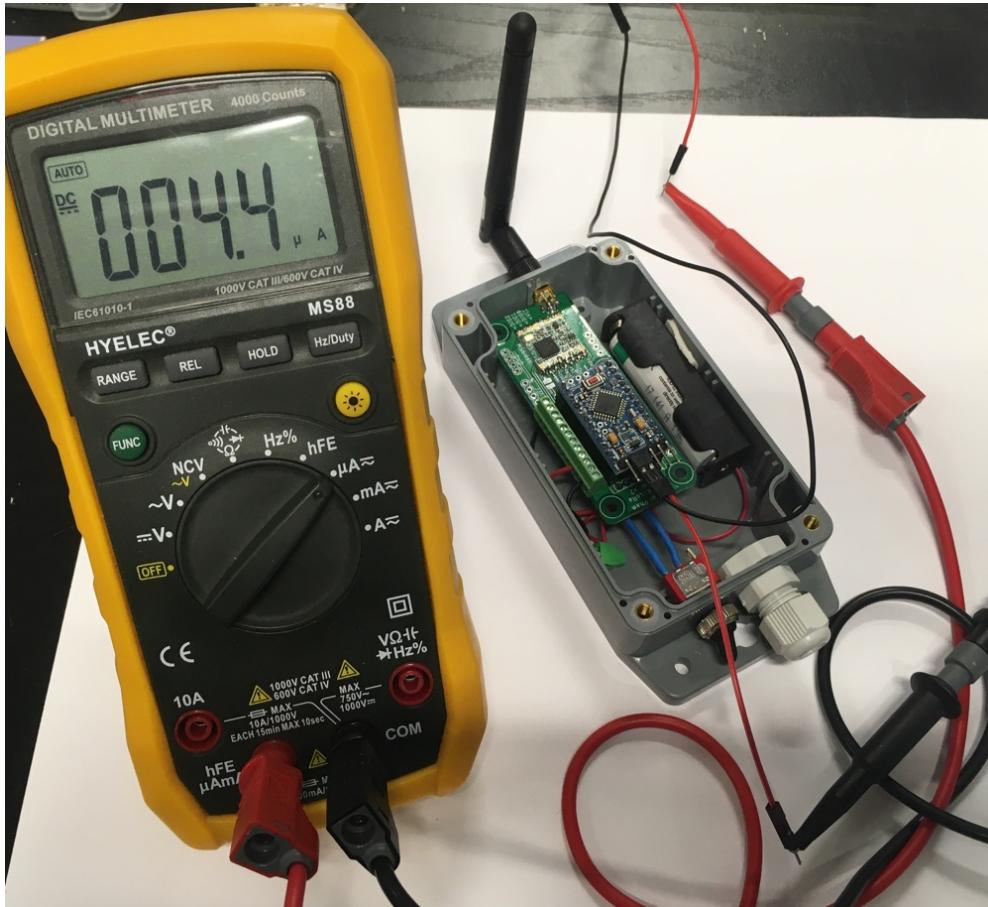
**Remove the voltage regulator with a small plier**

**Only inject up to 3.6V through the VCC pin**

## Below 5uA in deep sleep



# Power consumption in deep sleep



Measured below 5 $\mu$ A in deep sleep, between 2 active periods with transmissions

Expected autonomy with 1 transmission / hour is over 2 years with either 2 AA batteries or 1 AA 3.6V Lithium battery

# Get an enclosure for outdoor usage



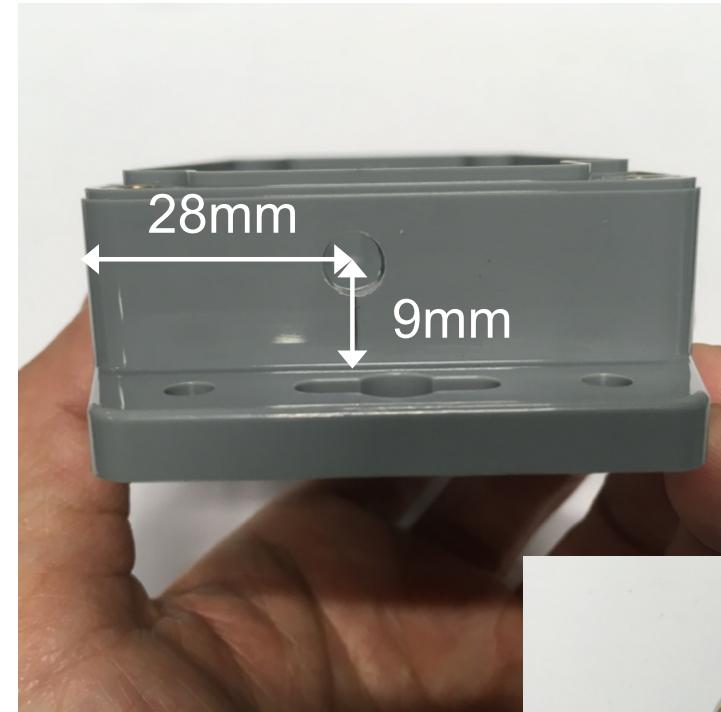
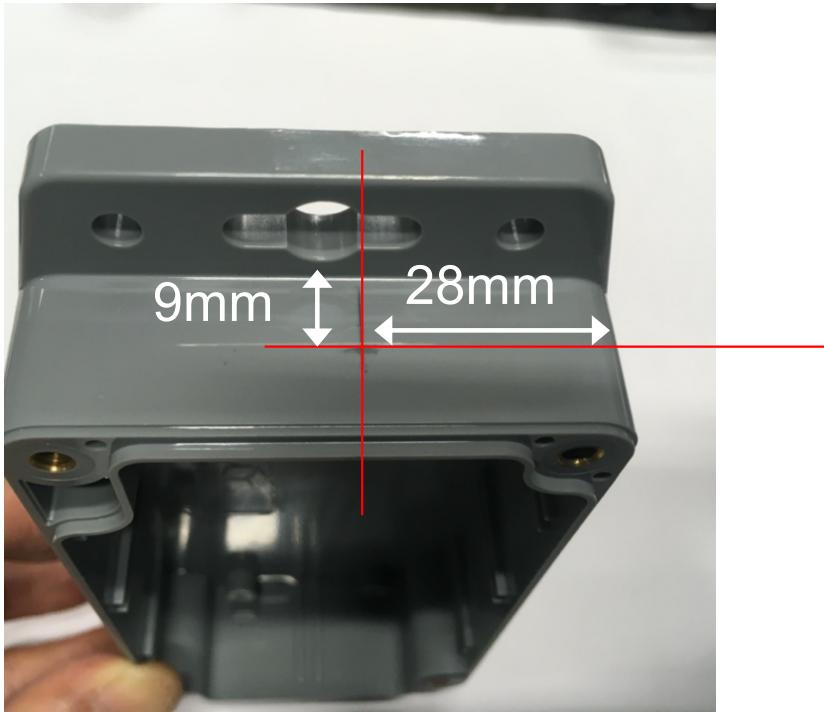
Here, it is an IP65 box which dimension is 115 x 65 x 40mm  
<https://www.gotronic.fr/art-boitier-abs-etanche-g304m-17977.htm>

# Drilling machine and drilling bits



At least a simple cordless drilling machine is necessary  
If you have a (small) bench drilling machine it is of course better  
Then you need an assortment of drilling bits for **metal**, not for  
wood nor concrete! Here, you will mainly need 7mm and 13mm bits  
It is also interesting to have step drill bits

# Drill a hole for the SMA connector



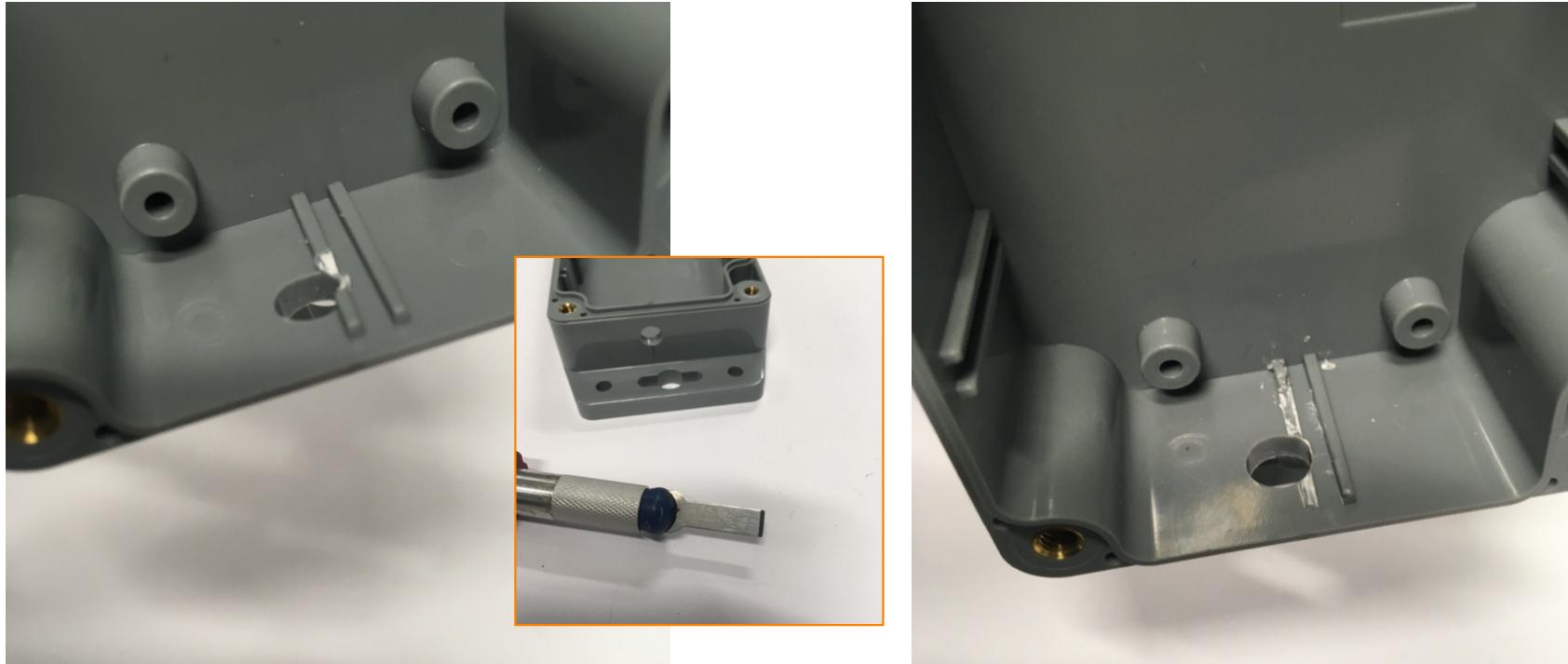
**28mm for the right edge:**

- measure from the flat side as the corner is round

**9mm from the outside bottom**

**use a 7mm drill bit for metal, not for wood nor concrete!**

# Remove unwanted plastic part



we need to remove the plastic reinforcement part for this particular enclosure  
use a flat cutter for instance to remove and smooth the inside part  
(a small plier can be used first to remove most of the part)

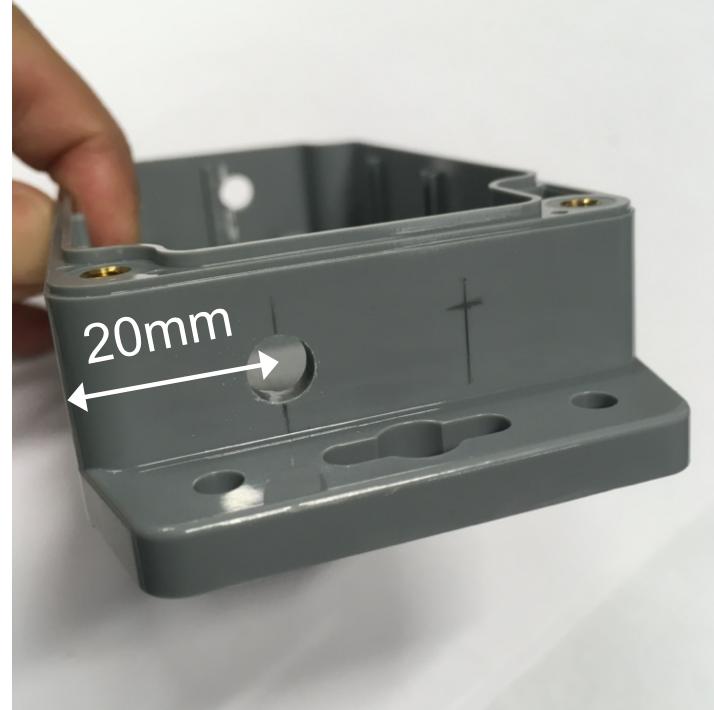
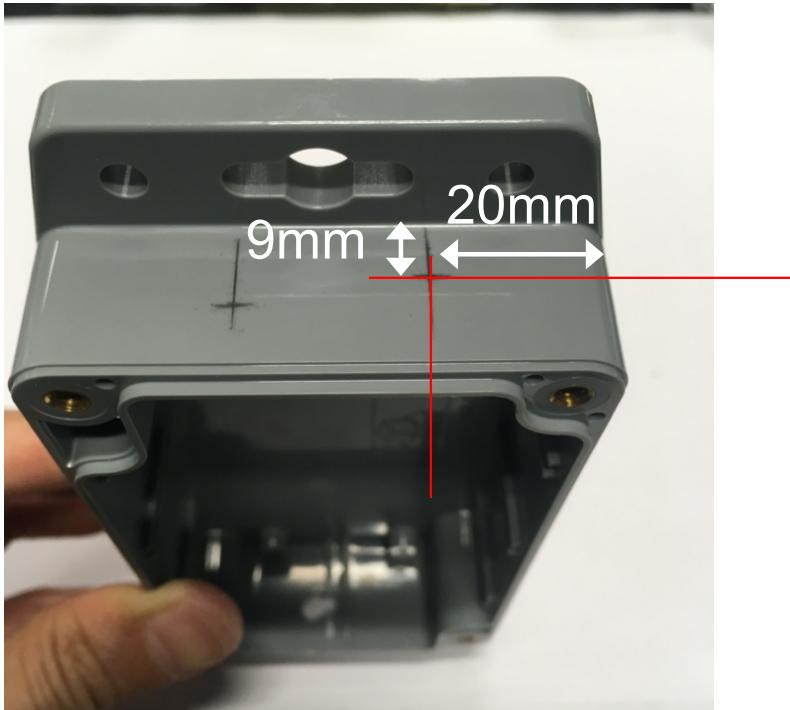
# Placing the PCB board



the PCB board can be placed, with the SMA connector going through the hole

both 2-AA (left) and 1-AA (right) battery holder can be used

# Drill a hole for the external switch



**20mm for the right edge:**

- measure from the flat side as the corner is round

**9mm from the outside bottom**

**use a 7mm drill bit for metal**

# Drill a hole for the cable gland



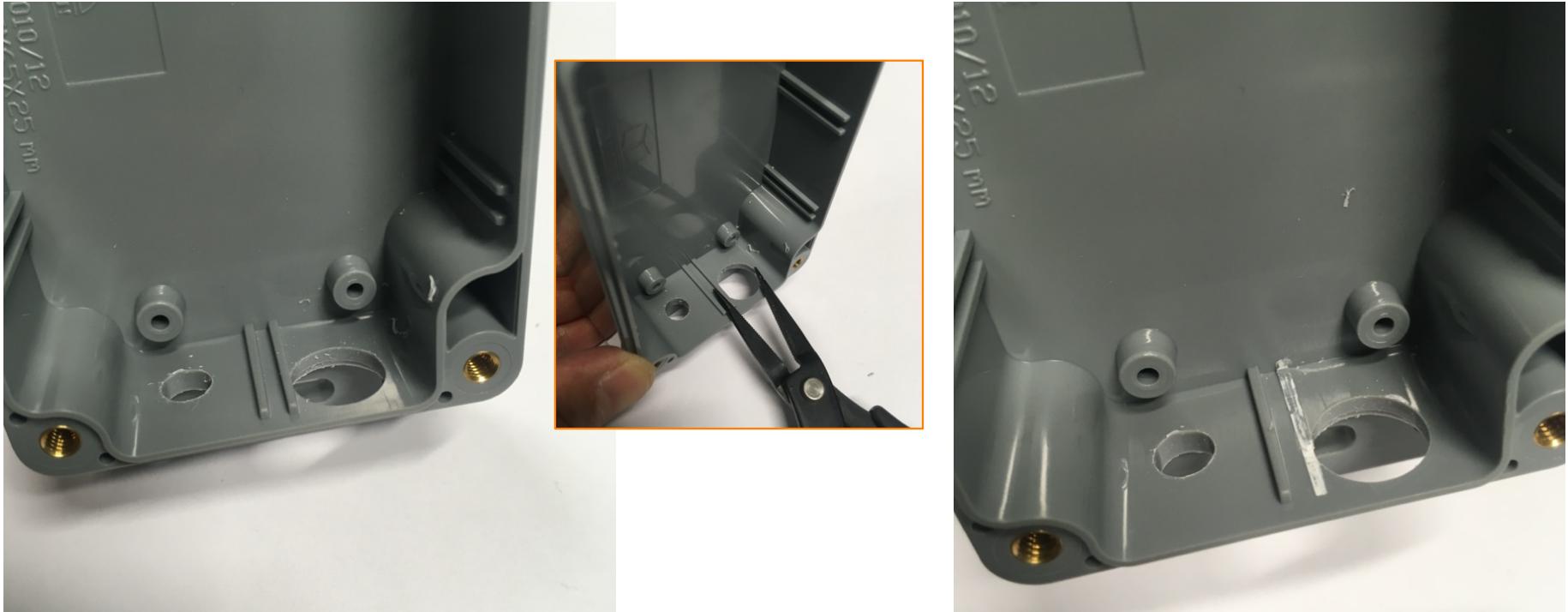
41mm for the right edge:

- measure from the flat side as the corner is round

9mm from the outside bottom

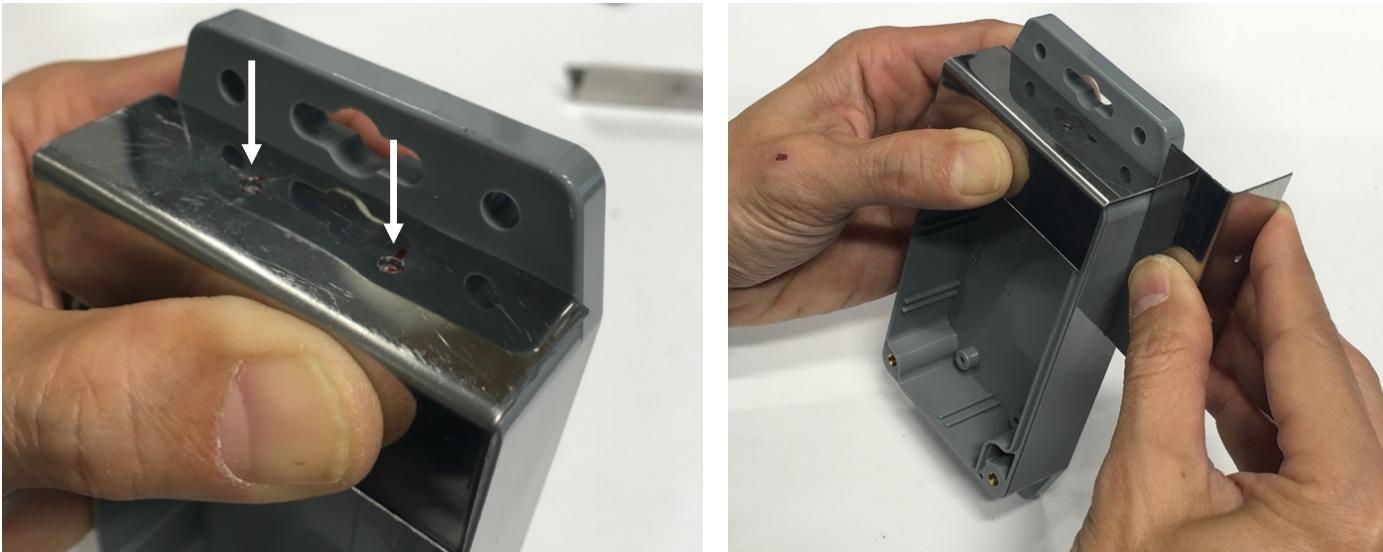
use a 13mm drill bit for metal

# Remove unwanted plastic part



again, we need to remove the plastic reinforcement part for this particular enclosure  
use a flat cutter for instance to remove and smooth the inside part  
(a small plier can be used first to remove most of the part)

# Going for larger production



If you need to prepare many enclosures, it may be faster to first make an assembly jig (here a piece of metal) for marking the holes

But be sure to precisely align the edge of the jig with the edge of the enclosure

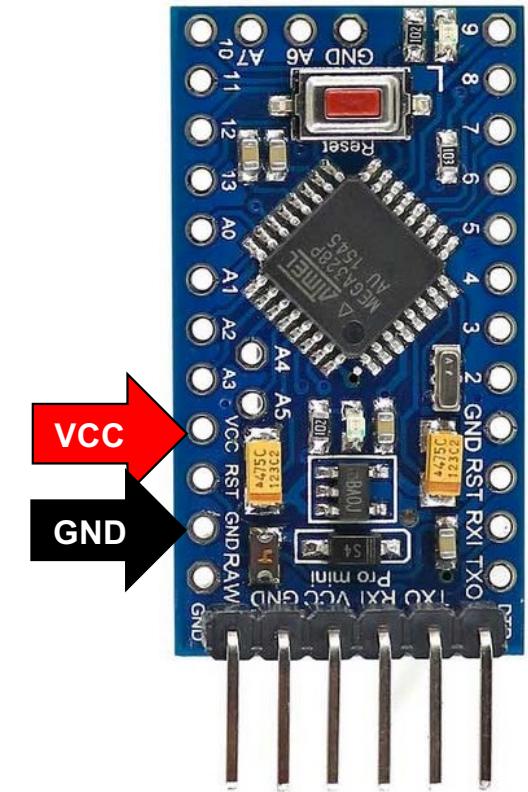
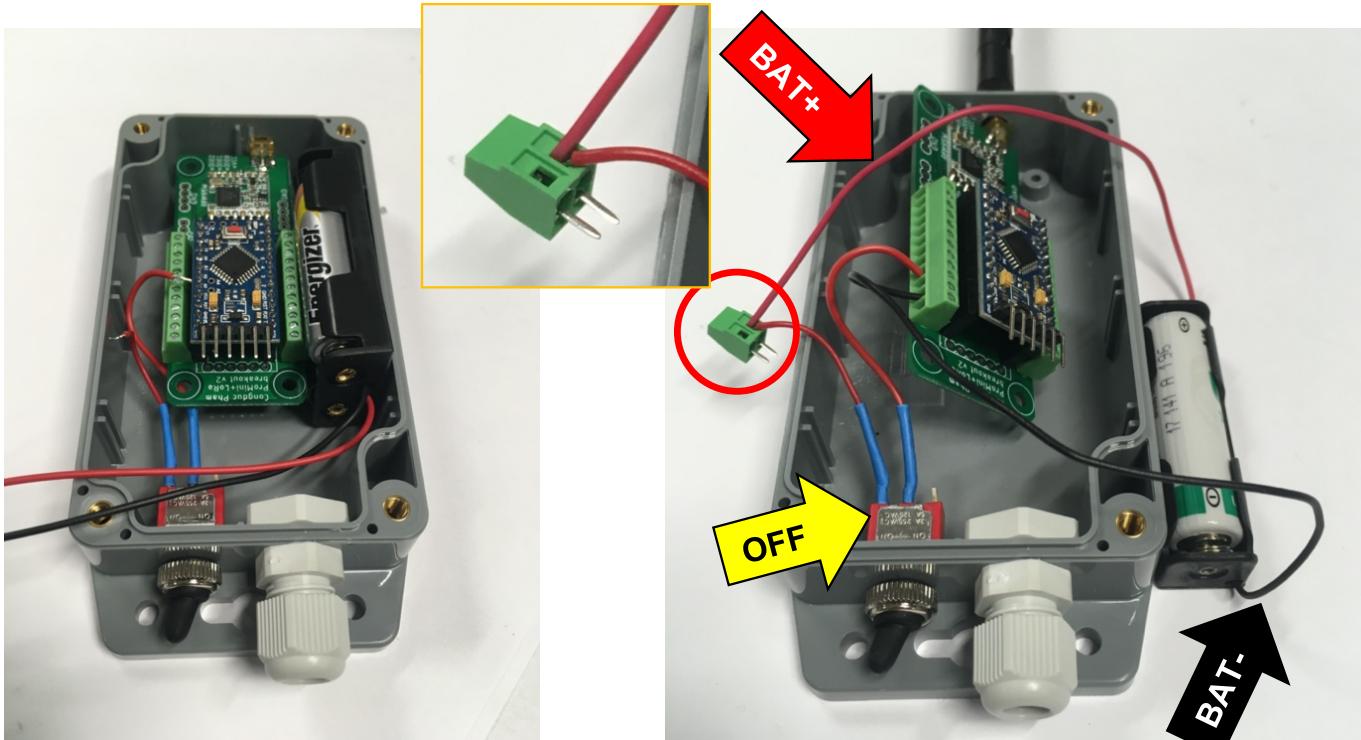
# Placing switch and cable gland



test that everything is OK

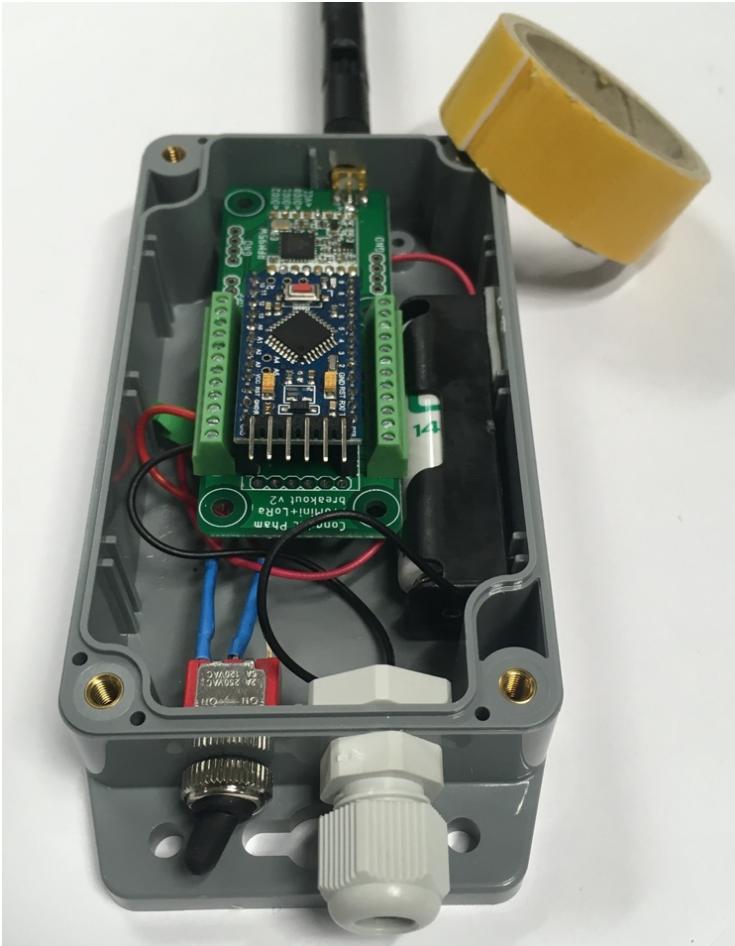
the switch has a water-proof cap

# Connecting switch, battery & board



Connect together switch "off" pin (left) with BAT +  
 Connect directly switch "on" pin (middle) to board's VCC  
 Connect directly BAT – to board(s) GND  
 Toggling the switch to right will then power the board

# Putting it altogether

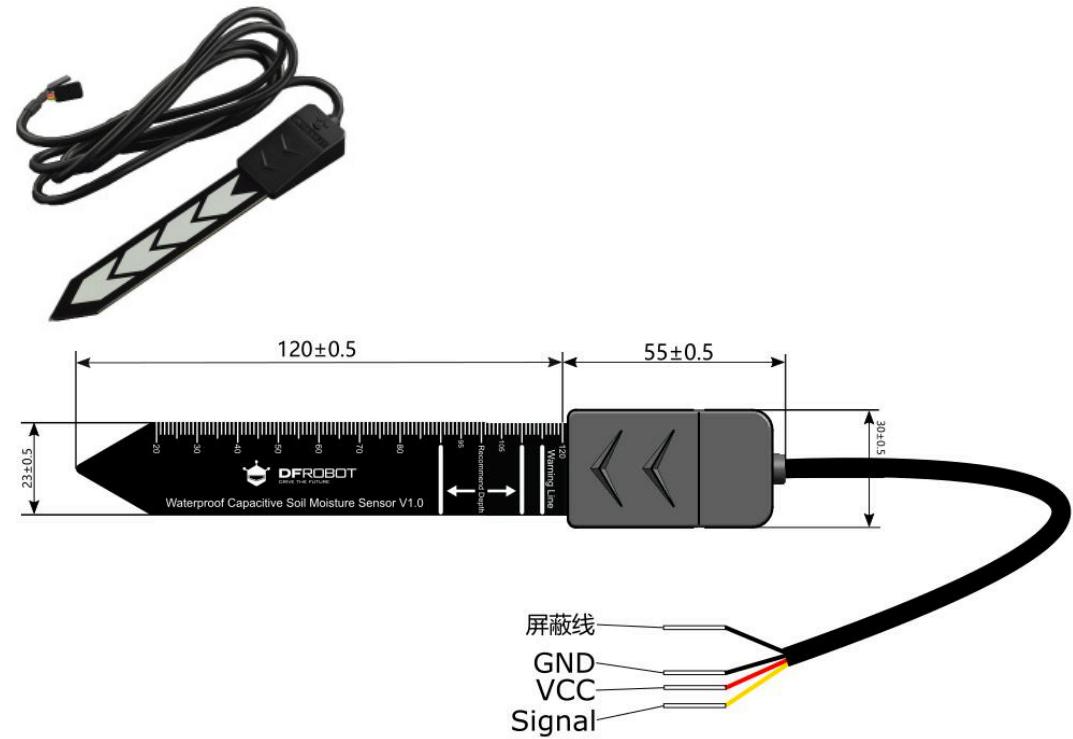


Here we use a 1-AA battery pack  
Fix the battery pack with double-side tape  
e.g. those used to fix mirrors on wall  
Then we use a 3.6V Lithium battery

This dedicated video will show  
how to build the outdoor soil device  
<https://youtu.be/zcazzDbXvHk>



# Last step: wire the SEN0308

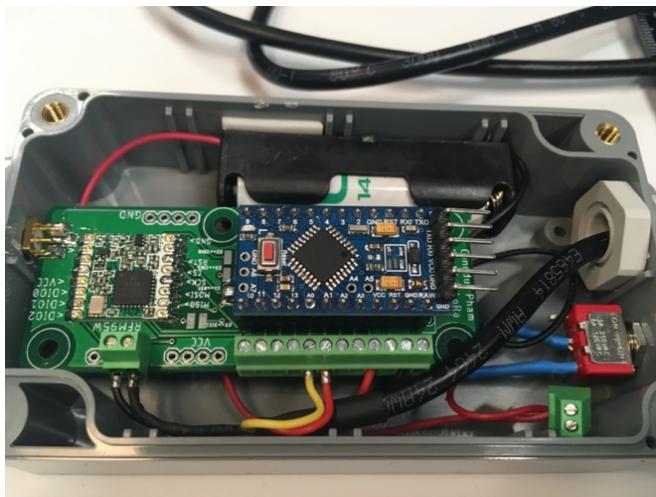
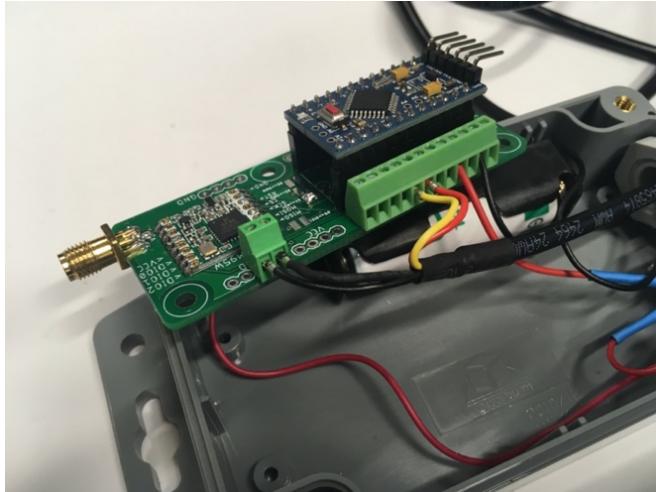


Insert sensor's wire through cable gland

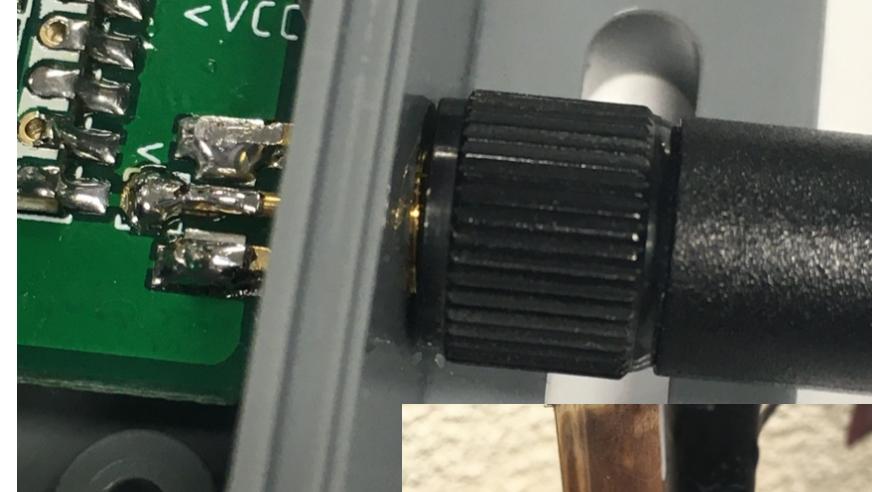
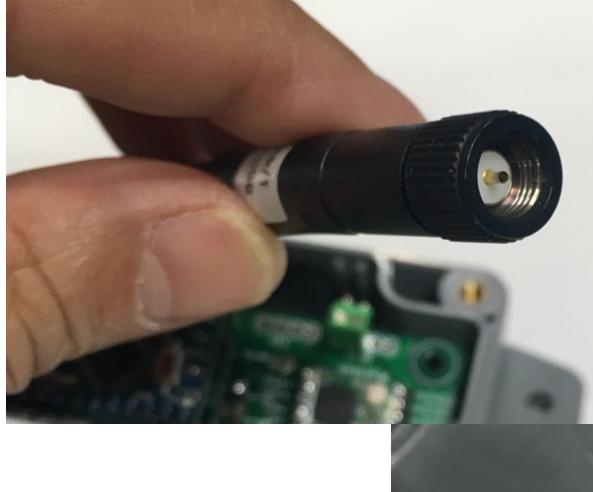
Connect SEN0308's wires to board:

- VCC to board's A1
- GND to board's GND (there are 2 GND wires)
- Signal to board's A0

# The complete soil sensor device



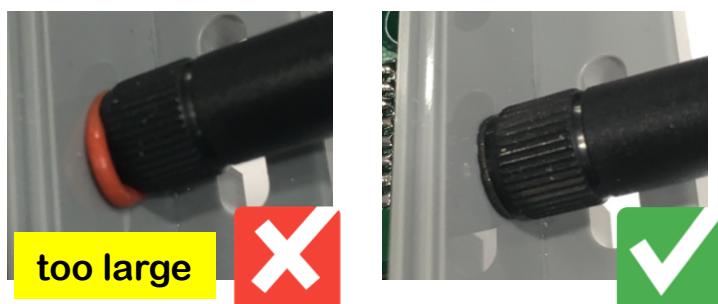
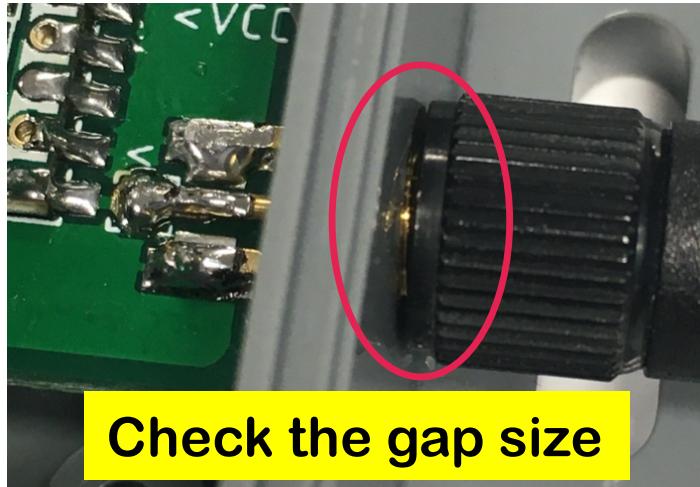
# Connecting antenna



Be sure to connect the matching antenna  
Here, SMA female with SMA male antenna  
Need to screw the antenna in all the way

The antenna junction is critical because this  
is where rain water can come in

# Waterproofing the antenna junction



Even when the antenna is screwed in all the way, there might still be a gap

Even with no apparent gap, it is necessary to waterproof the junction

Take an o-ring for that purpose, but do not take it too thick or too large!

Too thick: the antenna will not be screwed in all the way!

There are o-ring for SMA connector but the gap size is an indication

# Do not have or can not use o-ring?

Maybe the gap is too big? Use silicon joint sealant



Put small amount of silicon around the antenna junction (use a flat screw driver or other flat tool)



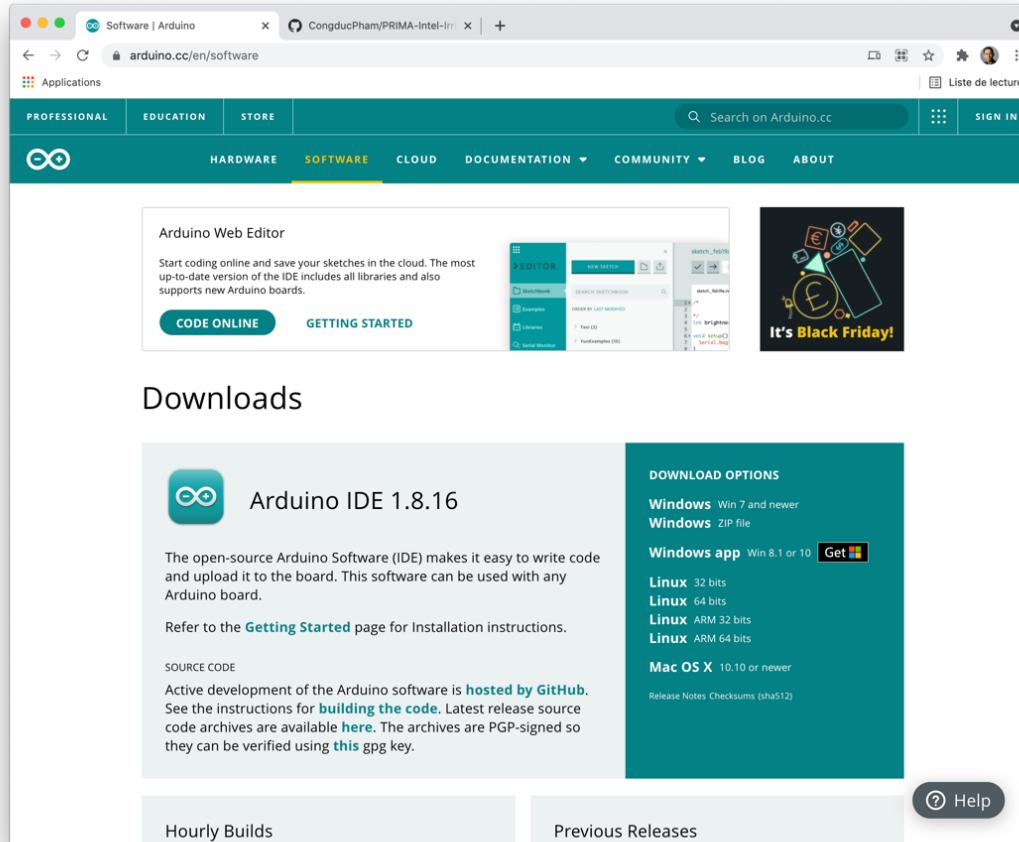
Use a wet toothpick to finish and clean the silicon all around the antenna junction



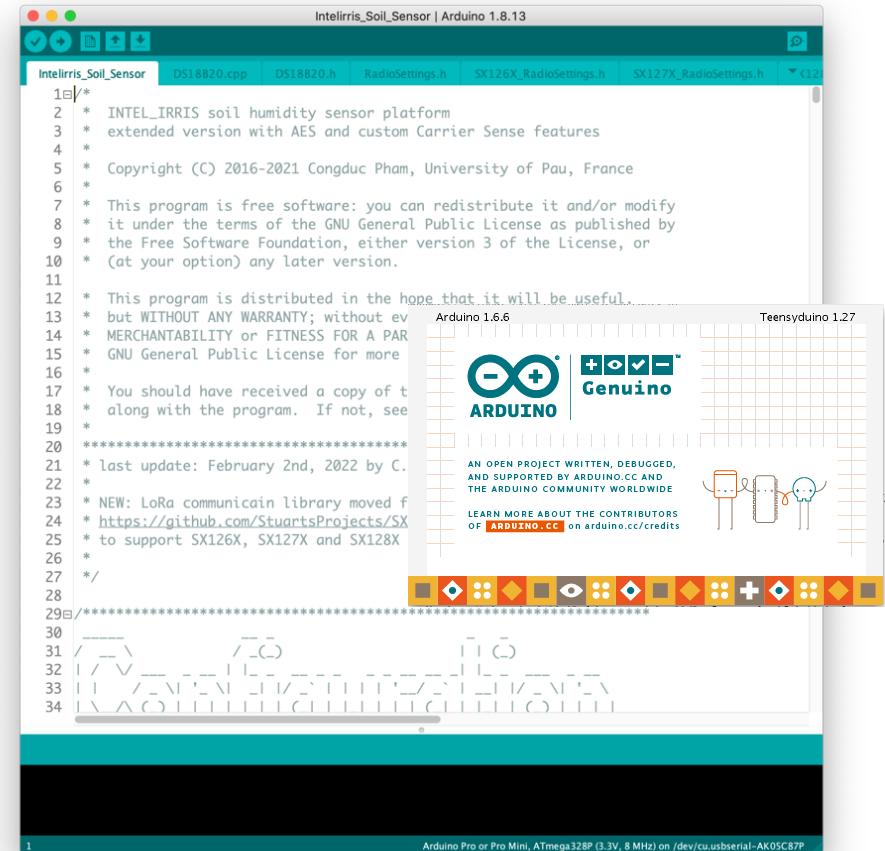
check especially  
the back side

Even with o-ring, if you have a doubt, add silicon!

# Getting the software: Arduino IDE



The screenshot shows the Arduino website's software download section. It features a prominent "Arduino IDE 1.8.16" download button. To the right, there are "DOWNLOAD OPTIONS" for Windows (Win 7 and newer, ZIP file), Windows app (Get), Linux (32 bits, 64 bits, ARM 32 bits, ARM 64 bits), and Mac OS X (10.10 or newer). Below these are links for "SOURCE CODE", "Release Notes", and "Checksums". At the bottom, there are links for "Hourly Builds" and "Previous Releases", along with a "Help" button.



The screenshot shows the Arduino IDE interface with the sketch "Intelirris\_Soil\_Sensor" open. The code editor displays the following header comments:

```

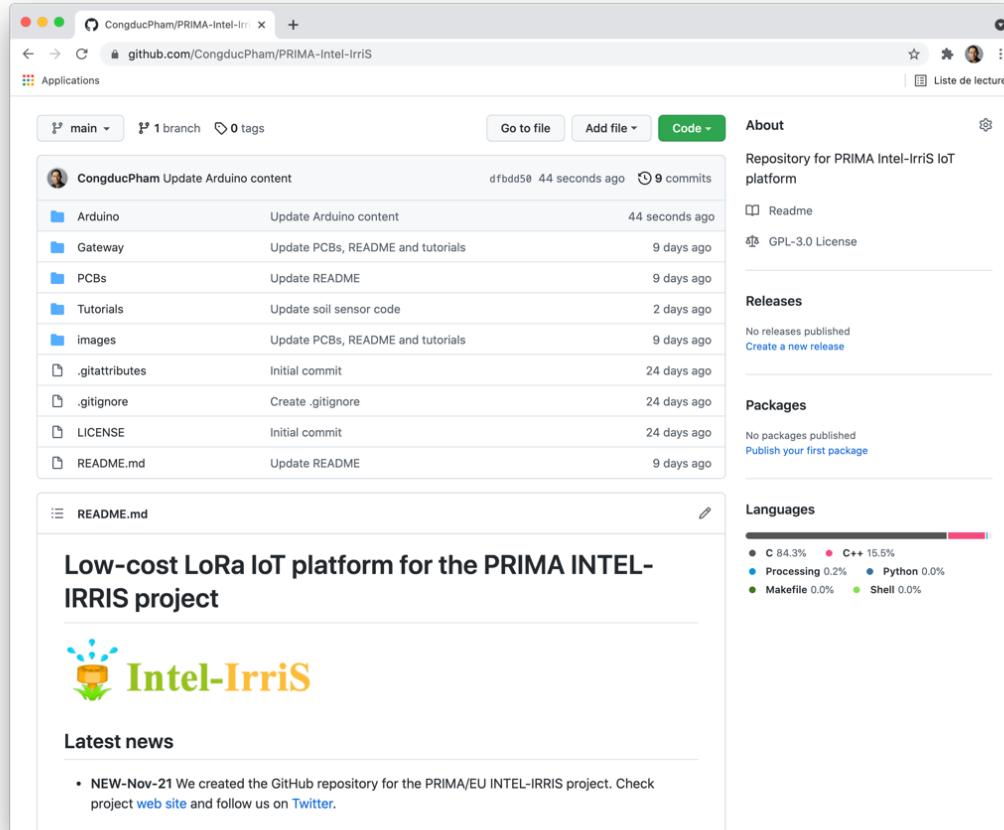
/*
 * INTEL_IRRIS soil humidity sensor platform
 * extended version with AES and custom Carrier Sense features
 *
 * Copyright (C) 2016-2021 Congduc Pham, University of Pau, France
 *
 * This program is free software: you can redistribute it and/or modify
 * it under the terms of the GNU General Public License as published by
 * the Free Software Foundation, either version 3 of the License, or
 * (at your option) any later version.
 *
 * This program is distributed in the hope that it will be useful,
 * but WITHOUT ANY WARRANTY; without even
 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
 * See the GNU General Public License for more details.
 *
 * You should have received a copy of the GNU General Public License
 * along with the program. If not, see <a href="http://www.gnu.org/licenses/">http://www.gnu.org/licenses/.
 */

```

The interface also shows the Arduino 1.6.6 and Teensyduino 1.2.7 toolbars at the top, and various icons and components on the right side of the screen.

Install latest version of Arduino IDE from  
<https://www.arduino.cc/en/software>

# Getting the software: Intel-IrriS code

The screenshot shows the GitHub repository page for CongducPham/PRIMA-Intel-IrriS. The repository has 1 branch and 0 tags. The main branch contains 9 commits from CongducPham, all made 44 seconds ago. The commits are: Update Arduino content, Update PCBs, README and tutorials, Update README, Update soil sensor code, Update PCBs, README and tutorials, Initial commit, Create .gitignore, Initial commit, and Update README. The repository includes files like Arduino, Gateway, PCBs, Tutorials, images, .gitattributes, .gitignore, LICENSE, and README.md. The README.md file describes the Low-cost LoRa IoT platform for the PRIMA INTEL-IRRIS project. The repository also features an 'About' section with a description of the PRIMA Intel-IrriS platform, a 'Readme' file, and a 'GPL-3.0 License'. It lists 'Releases' and 'Packages' and includes a 'Languages' chart showing C at 84.3%, C++ at 15.5%, Processing at 0.2%, Python at 0.0%, Makefile at 0.0%, and Shell at 0.0%.

On your computer, create a sketch folder

Then download the whole repository as ZIP file

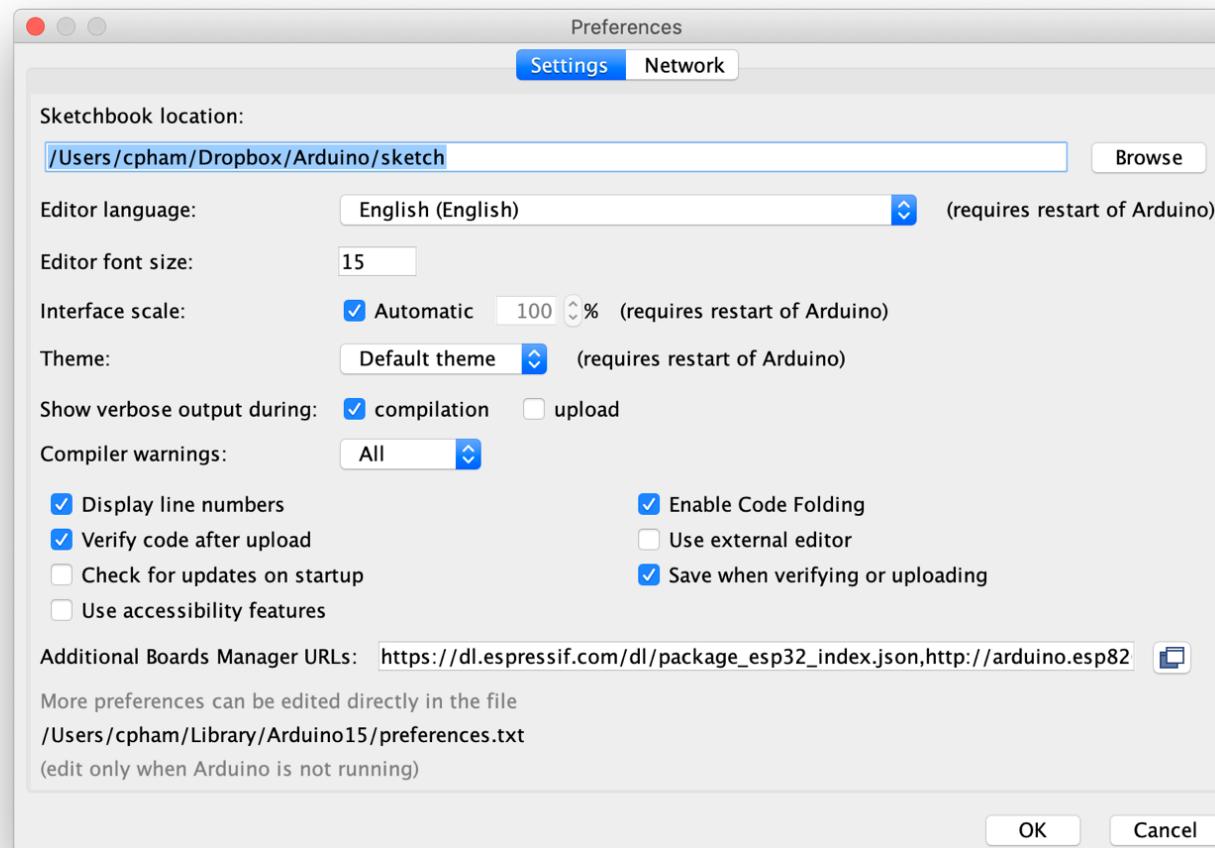
Unzip the file and copy the content of Arduino folder into your sketch folder

The entire Intel-IrriS GitHub repository is hosted here  
<https://github.com/CongducPham/PRIMA-Intel-IrriS>



**GitHub**

# Setting your Arduino IDE



Run Arduino IDE, open Preferences  
 Indicate your sketch folder in Sketchbook location

# Compiling the soil sensor code

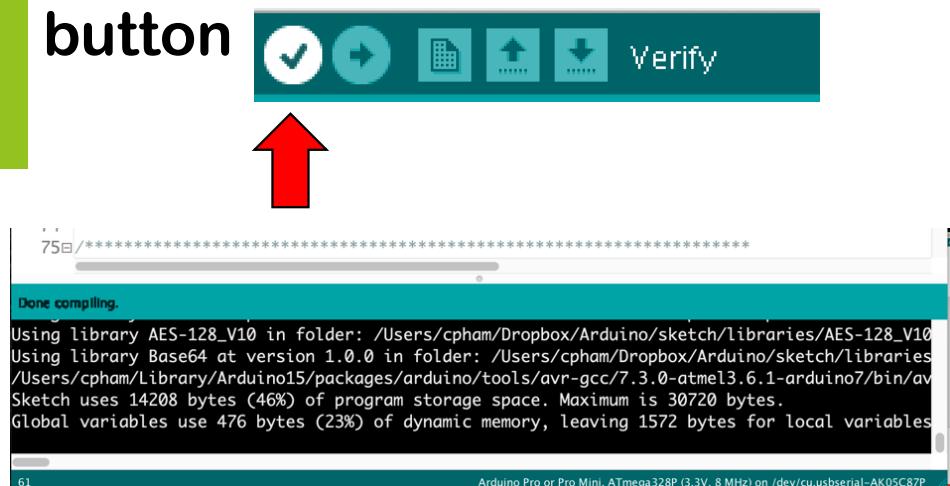


The screenshot shows the Arduino IDE interface. The sketch titled "Intelirris\_Soil\_Sensor" is open. The "Tools" menu is pulled down, showing various options like Auto Format, Archive Sketch, and Board selection. Under Board selection, it lists "Board: Arduino Pro or Pro Mini" and "Processor: ATmega328P (3.3V, 8 MHz)". This option is selected, indicated by a blue highlight and a checked checkbox. Other options shown include ATmega328P (5V, 16 MHz), ATmega168 (5V, 16 MHz), and ATmega168 (3.3V, 8 MHz). The code itself is visible in the main window, starting with a copyright notice and ending with a LoRa communication library note.

**Open Intelirris\_Soil\_Sensor sketch – no change required**

**Select the ProMini board,  
3.3V and 8MHz version**

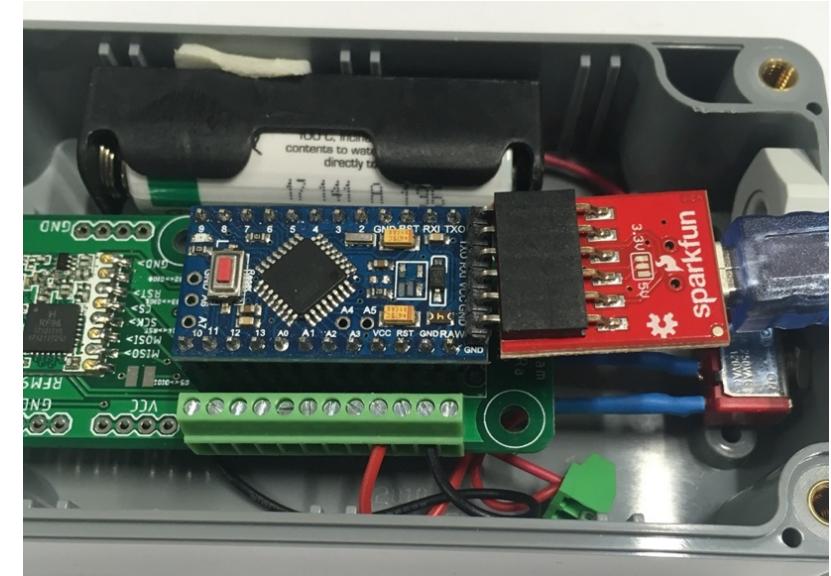
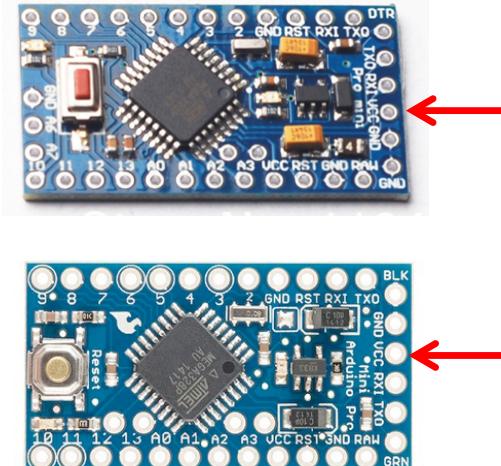
**Then click on the "verify"  
button**



# Connecting with an FTDI cable



Some clone version, check the VCC pin



For the ProMini, you need to have an FTDI breakout cable working at 3.3v

Check the VCC pin position and make it to correspond to the VCC pin of the FTDI breakout.

# Select serial port for uploading



After connecting the cable to your computer/laptop USB port, try to find the serial port

If you don't find it, you may need to install specific drivers

<https://learn.sparkfun.com/tutorials/how-to-install-ch340-drivers/all>

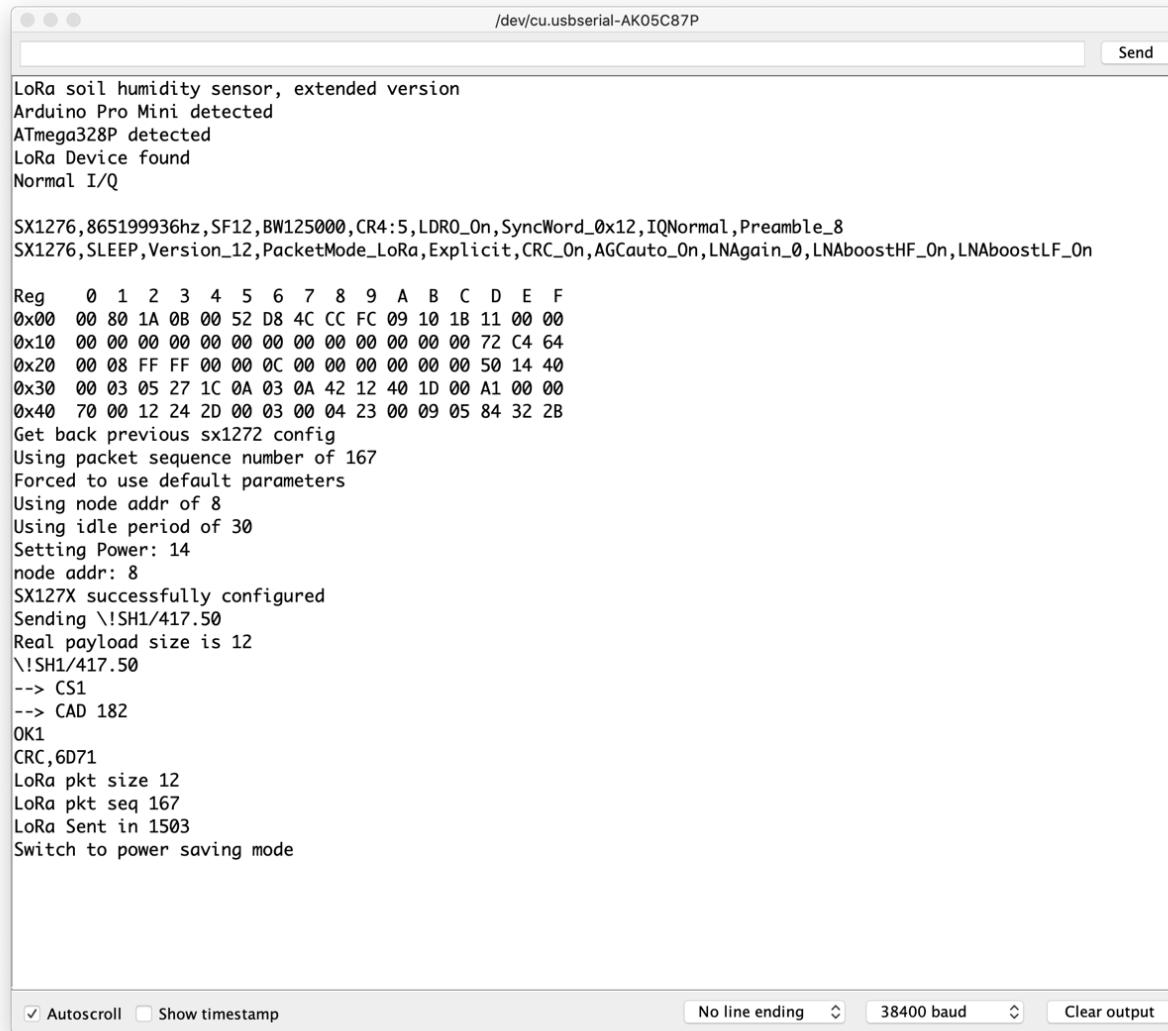
**Click on the "upload" button**



And wait until upload is completed

```
27 */  
28  
29  
30  
  
Done uploading.  
Using library LowPower at version 1.0 in folder: /Users/cpham/Dropbox/Arduino/sketch/libraries/  
Using library OneWire at version 2.3.2 in folder: /Users/cpham/Dropbox/Arduino/sketch/libraries/  
Using library Dallas-Temperature at version 3.7.7 in folder: /Users/cpham/Dropbox/Arduino/sketch/  
Using library AES-128_V10 in folder: /Users/cpham/Dropbox/Arduino/sketch/libraries/AES-128_V10  
Using library Base64 at version 1.0.0 in folder: /Users/cpham/Dropbox/Arduino/sketch/libraries/  
/Users/cpham/Library/Arduino15/packages/arduino/tools/avr-gcc/7.3.0-atmel3.6.1-arduino7/bin/avr  
Sketch uses 14208 bytes (46%) of program storage space. Maximum is 30720 bytes.  
Global variables use 476 bytes (23%) of dynamic memory, leaving 1572 bytes for local variables
```

# Checking that device is operational



The screenshot shows a terminal window titled '/dev/cu.usbserial-AK05C87P' displaying the output of a LoRa device configuration script. The output includes:

- LoRa soil humidity sensor, extended version
- Arduino Pro Mini detected
- ATmega328P detected
- LoRa Device found
- Normal I/Q
- SX1276, 865199936hz, SF12, BW125000, CR4:5, LDR0\_On, SyncWord\_0x12, IQNormal, Preamble\_8
- SX1276, SLEEP, Version\_12, PacketMode\_LoRa, Explicit, CRC\_On, AGCAuto\_On, LNAGain\_0, LNABoostHF\_On, LNABoostLF\_On
- Reg 0 1 2 3 4 5 6 7 8 9 A B C D E F
- 0x00 00 80 1A 0B 00 52 D8 4C CC 09 10 1B 11 00 00
- 0x10 00 00 00 00 00 00 00 00 00 00 00 00 72 C4 64
- 0x20 00 08 FF FF 00 00 0C 00 00 00 00 00 00 50 14 40
- 0x30 00 03 05 27 1C 0A 03 0A 42 12 40 1D 00 A1 00 00
- 0x40 70 00 12 24 2D 00 03 00 04 23 00 09 05 84 32 2B
- Get back previous sx1272 config
- Using packet sequence number of 167
- Forced to use default parameters
- Using node addr of 8
- Using idle period of 30
- Setting Power: 14
- node addr: 8
- SX127X successfully configured
- Sending \!SH1/417.50
- Real payload size is 12
- \!SH1/417.50
- > CS1
- > CAD 182
- OK1
- CRC, 6D71
- LoRa pkt size 12
- LoRa pkt seq 167
- LoRa Sent in 1503
- Switch to power saving mode

At the bottom of the window, there are checkboxes for 'Autoscroll' and 'Show timestamp', and dropdown menus for 'No line ending' (set to 'None'), '38400 baud' (set to '38400'), and 'Clear output'.

**Open serial monitor**

**Set baud rate to 38400**

**See output from board**

**Check that  
transmission is OK**

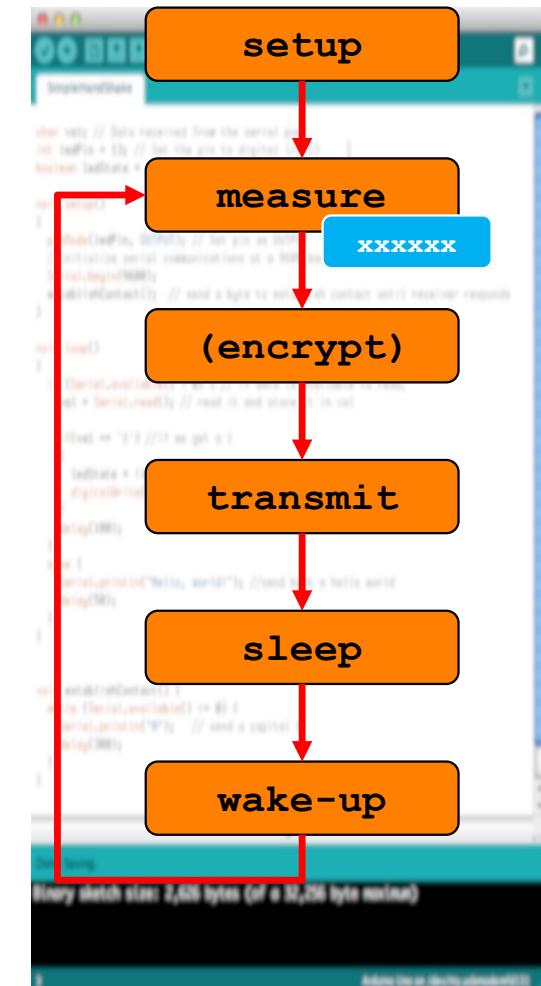
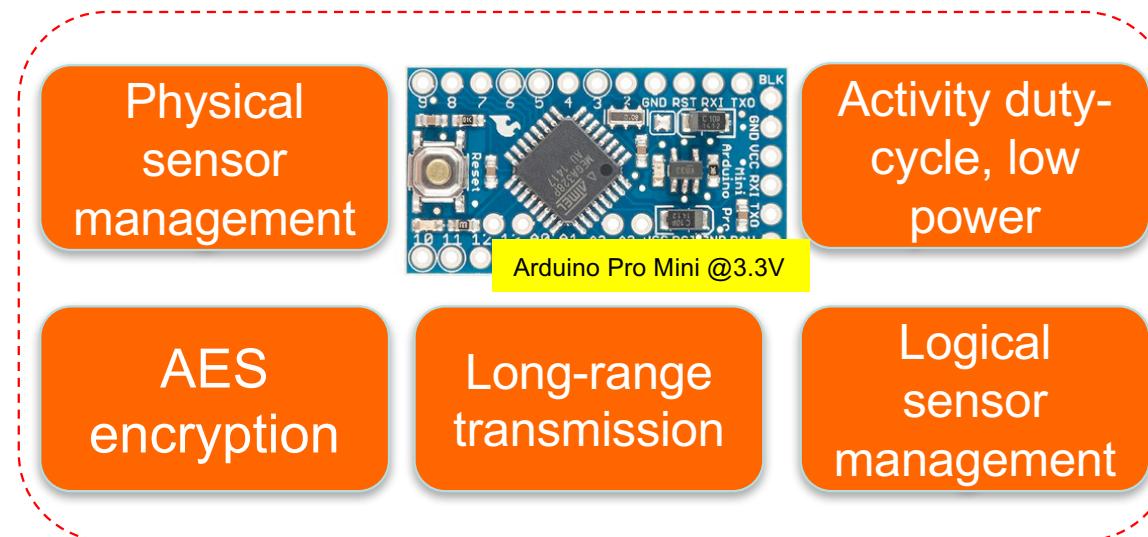
# Generic & cyclic behavior

2 sensors can be attached

SEN0308: soil humidity  
 A0 (signal), A1 (pwr)



DS18B20: soil temperature  
 3 (signal), 4 (pwr)



# Transmission to non-LoRaWAN gateway



Default parameters

raw LoRa  
SF12BW125  
865.2 MHz  
node id is 8  
1 msg/30mins  
1 sensor  
ex: \! SH1/750.50

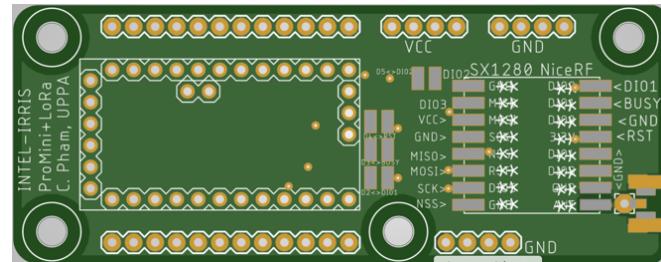


This dedicated video will show all these steps, from wiring the SEN0308 to testing transmission to the gateway  
<https://youtu.be/zcazzDbXvHk>



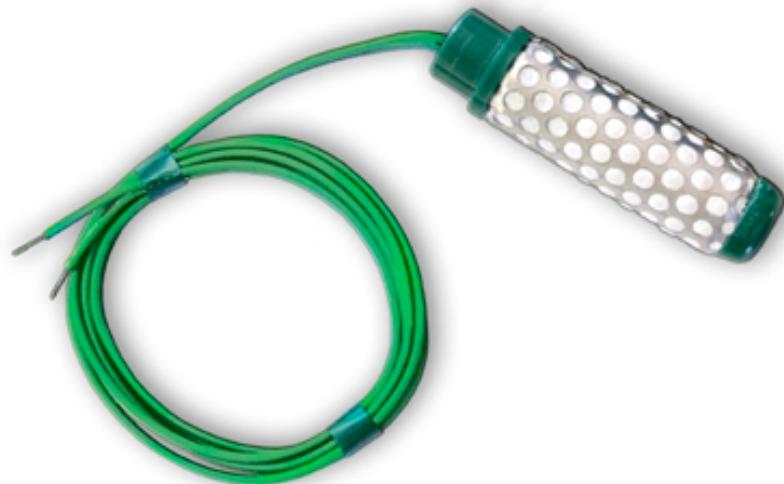
# Advanced options

- The Intelirris\_Soil\_Sensor sketch can
  - Drive SX127X, SX126X and SX128X LoRa chips
  - SX128X requires a dedicated PCB for NiceRF SX1280



- Send AES 128-bit encrypted packet
- Send uplink LoRaWAN packet (encrypted)
- Receive downlink LoRaWAN packet
- Can read additionally from a DS18B20 soil temperature sensor
- Can read from a Watermark tensiometer sensor
- Support WaziSense and WaziDev boards

# With a Watermark sensor



with a Watermark sensor, the "pseudo-AC Short Pulse" method will be used – see <https://www.irrometer.com/200ss.html>  
D6 and D7 will be used to alternating power the sensor  
A0 will be used to read signal from sensor



Starter-kit

*Autonomous*

*Intelligent Irrigation*

*Plug-&-Sense*

*In-the-box*