



# 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 3: the INTEL-IRRIS starter-kit

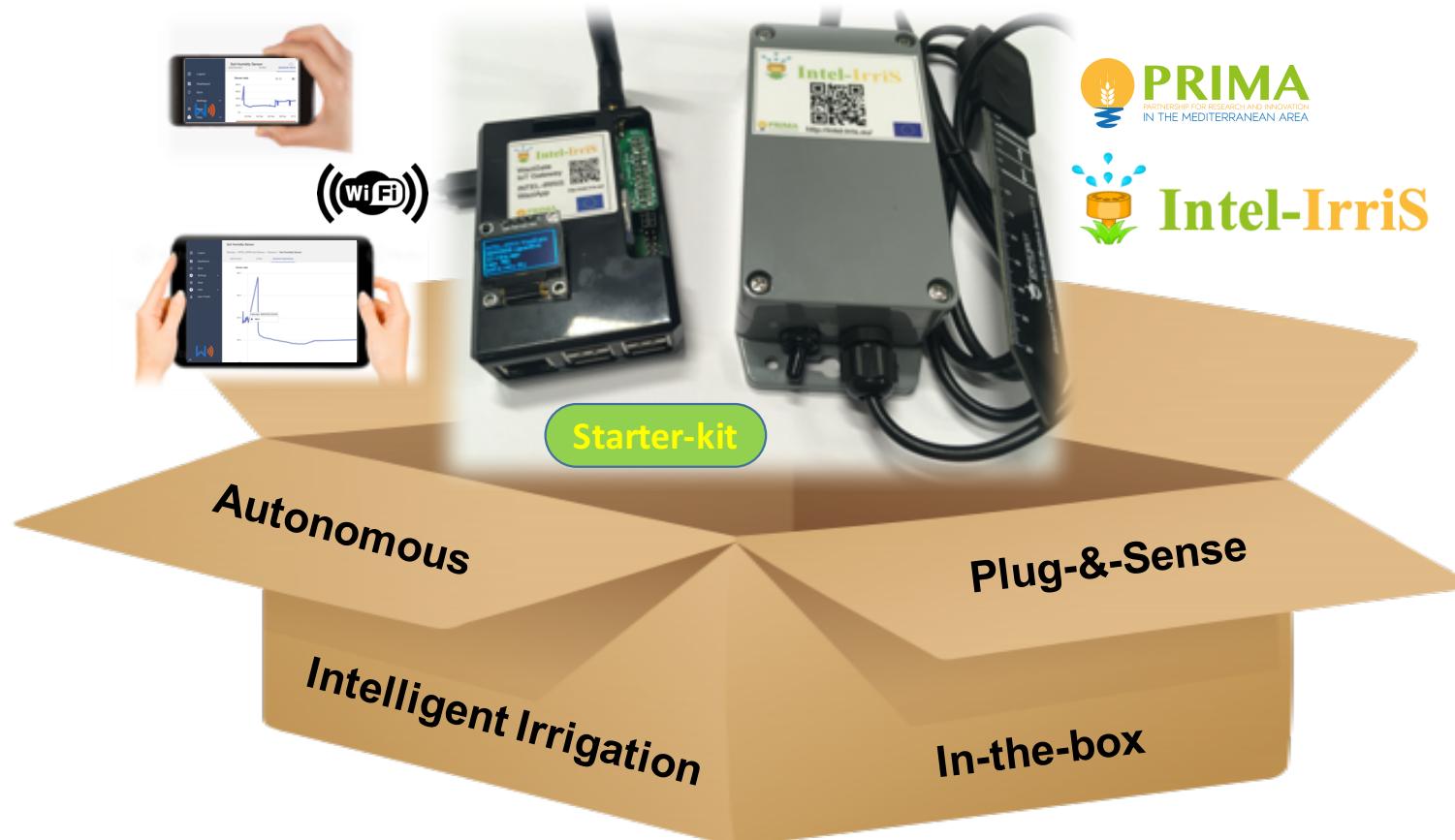


Prof. Congduc Pham  
<http://www.univ-pau.fr/~cpham>  
Université de Pau, France



# INTEL-IRRIS starter-kit

- "Intelligent Irrigation in-the-box", "plug-&-sense"



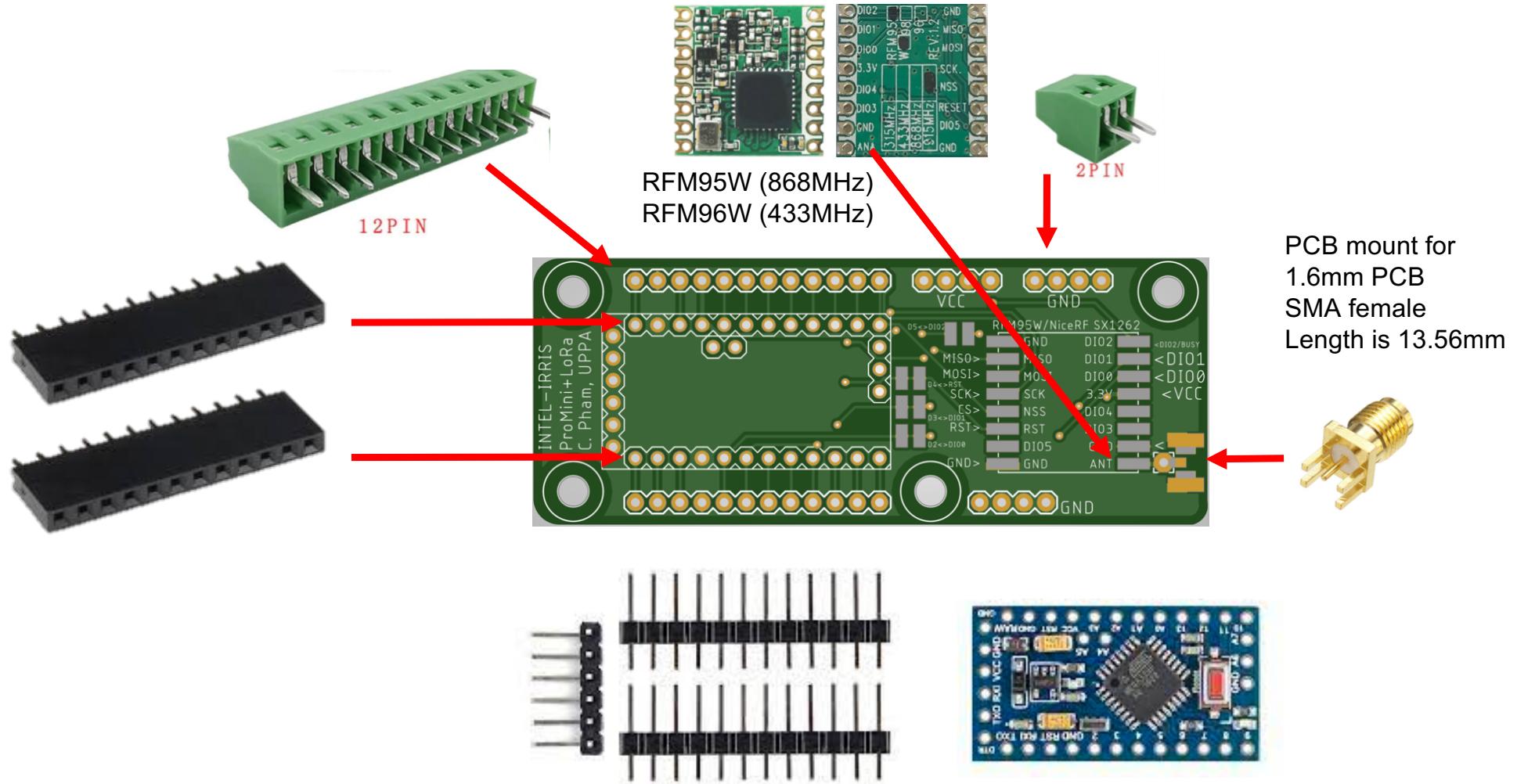
# Preparing the starter-kits at UPPA



This non-technical video shows  
the preparation of the kits  
<https://youtu.be/5nznRcloe40>

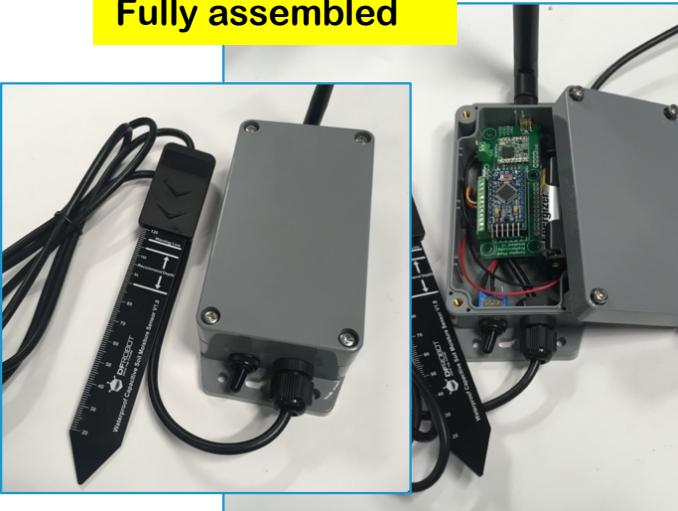


# Soil sensor: electronic parts starter-kit version



# Soil sensor device

Fully assembled

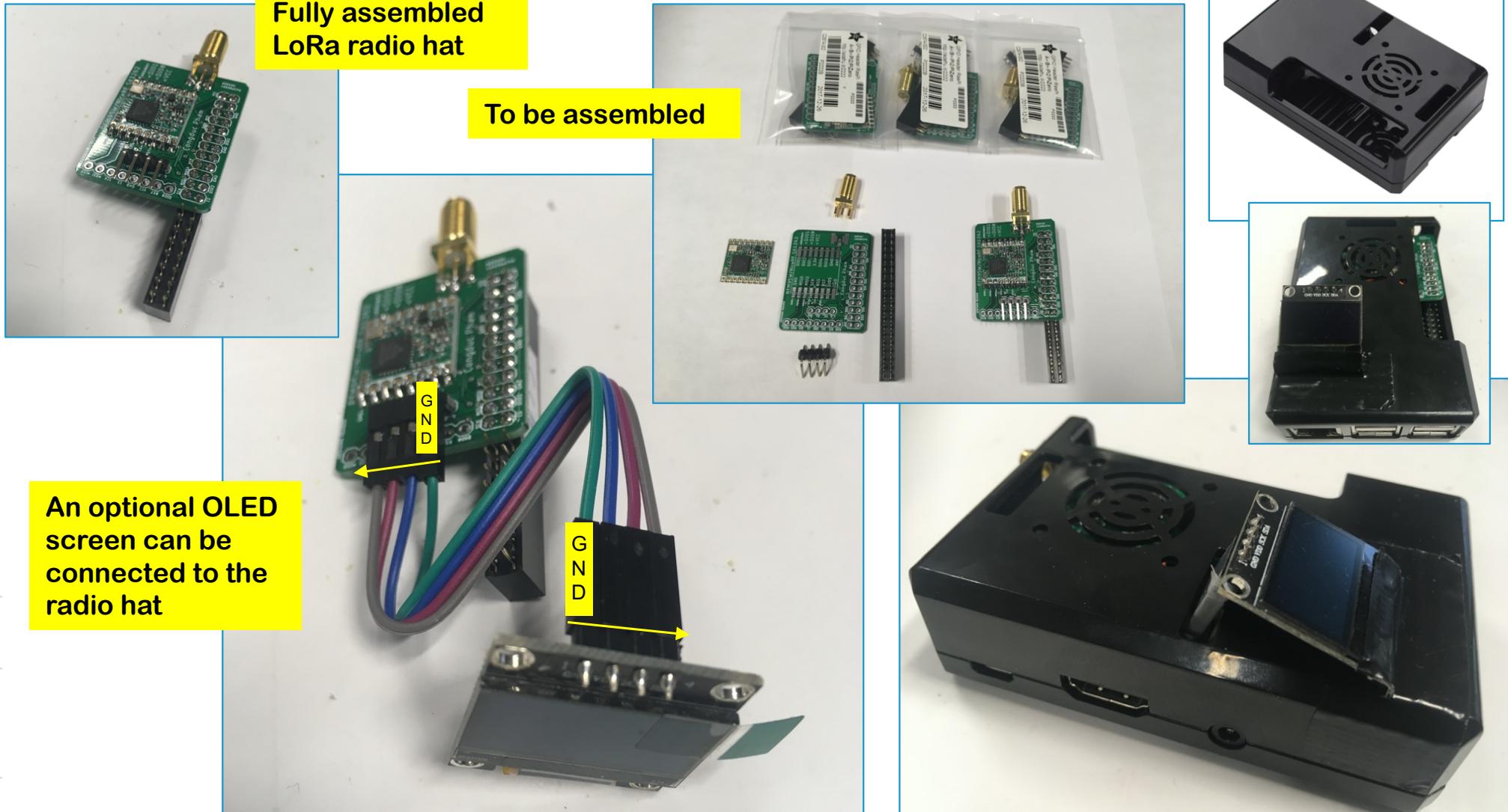


Packaging in enclosure



To be assembled

# Gateway (WaziGate)



# First round of starter-kits

- 1 fully assembled & configured soil sensor device
- NEED TO INSTALL 2-AA BATTERIES
- 4 soil sensor devices to be assembled & configured
- 1 fully assembled radio LoRa hat
- 4 radio LoRa hats to be assembled
- INTEL-IRRIS WaziGate image to be downloaded & flashed
- **IMPORTANT**
  - 1 starter-kit= 1 soil sensor + 1 INTEL-IRRIS WaziGate gateway
  - 1 starter-kit / farm to be deployed and tested
  - The WaziGate is **only pre-configured for 1 soil sensor / farm**
  - If there are several soil sensors in a farm, see **advanced configuration**
- **All tutorials & videos: <http://intel-iris.eu/tutorials-slides>**

# Assembling starter-kit

## Algeria (UORAN1), Morocco (ENSA Safi)

- Soil sensor device
  - [Tutorial slides on building & assembling the outdoor LoRa IoT soil sensor device](#)
  - [Video n°1. YouTube tutorial video showing how to build the IoT microcontroller platform for the LoRa IoT soil sensor device.](#)  
<https://youtu.be/3jdQ0Uo0phQ>
  - [Video n°2. YouTube tutorial video showing how to build the outdoor LoRa IoT soil sensor device.](#) <https://youtu.be/zcazzDbXvHk>
  - [Video n°3. YouTube tutorial video showing how to wire the SEN0308 capacitive sensor.](#) <https://youtu.be/zcazzDbXvHk>
- INTEL-IRRIS WaziGate
  - [Tutorial slides on preparing the INTEL-IRRIS WaziGate IoT gateway](#)
  - [Video n°4. YouTube tutorial video demonstrating the INTEL-IRRIS soil sensor device & WaziGate framework.](#) <https://youtu.be/zcazzDbXvHk>

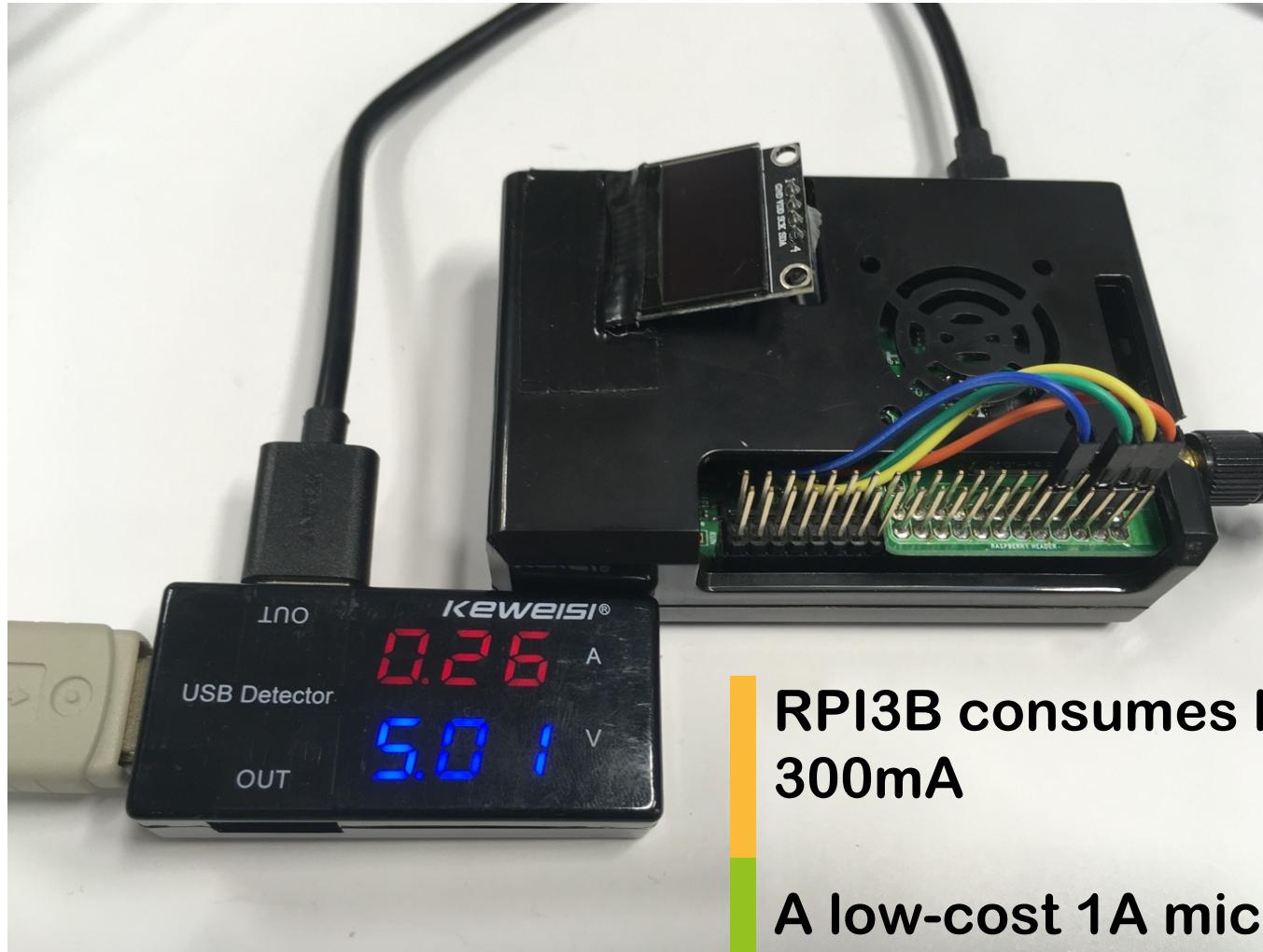
# Preparing Wazigate

- Plug the LoRa radio hat on the Raspberry, screw in the antenna



- Download SD card image from <http://intel-iris.eu/results>
- select EU433 (Algeria, Morocco) or EU868 (France)
- Flash SD card (min 8GB): [Video n°4 at t=124s](#),  
<https://youtu.be/j-1Nk0tv0xM?t=124>, then insert SD card

# Powering the WaziGate

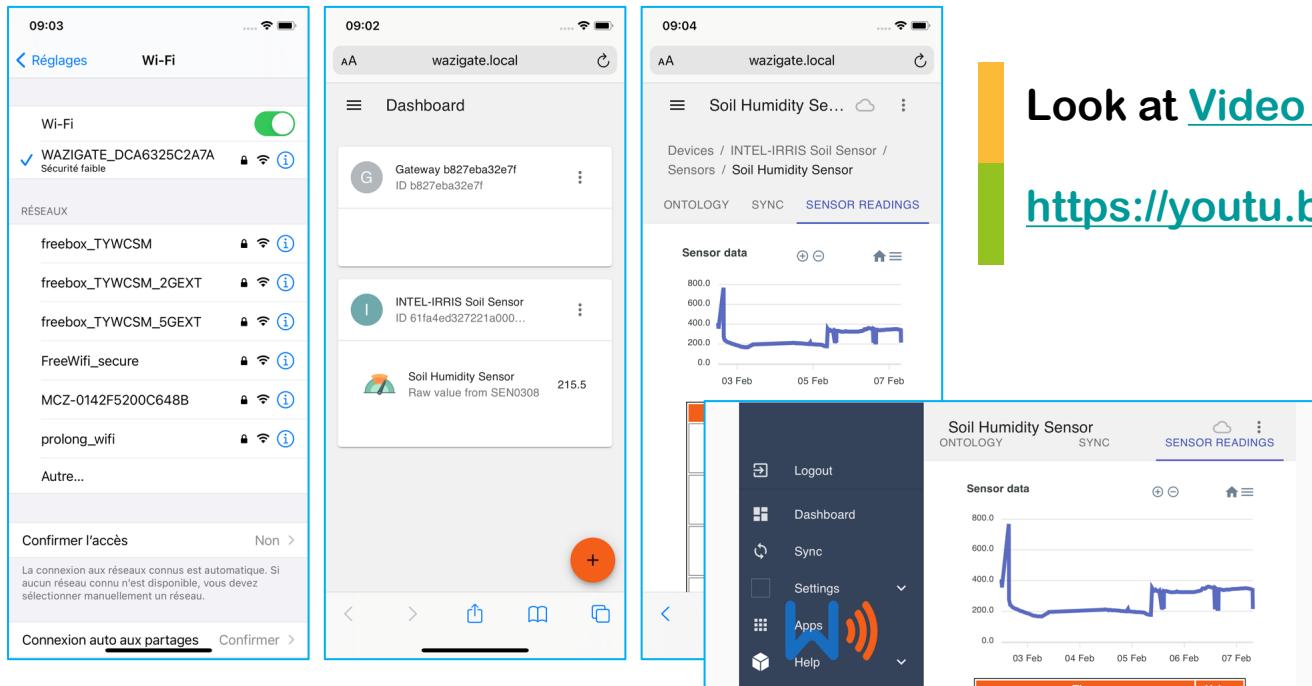


RPI3B consumes less than  
300mA

A low-cost 1A micro USB charger  
for smartphone is suitable

# Checking WaziGate

- ➊ Power the WaziGate, no Internet is required
- ➋ Wait 3-4mins for the gateway to boot
- ➌ Connect to the WaziGate's WiFi with a smartphone
- ➍ Open <http://wazigate.local> or <http://10.42.0.1>



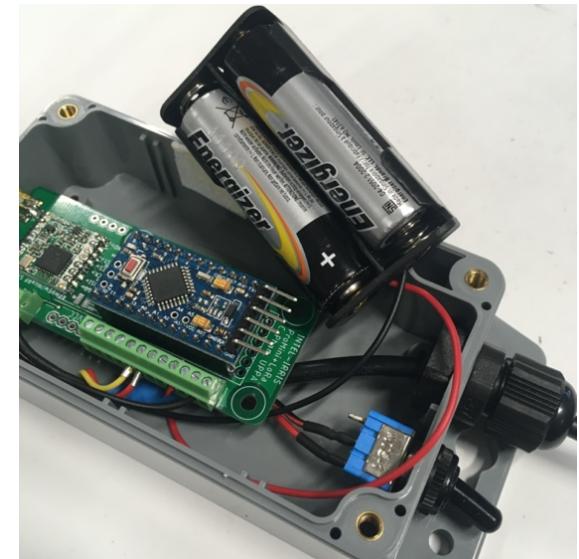
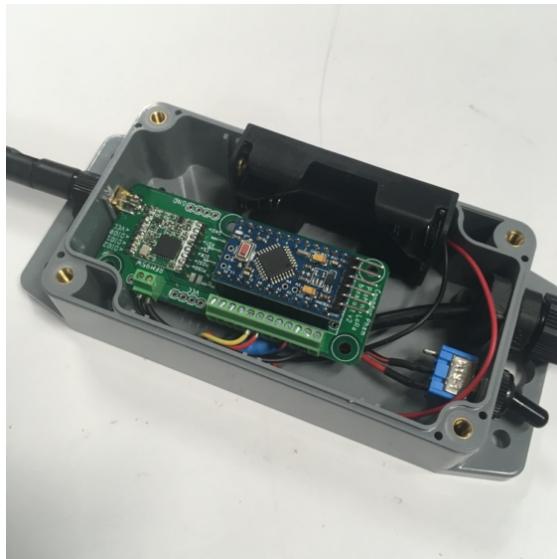
Look at [Video n°4 at t=239s](#)

<https://youtu.be/j-1Nk0tv0xM?t=239>

# Preparing soil sensor device

## install batteries

- Remove cover & install 2-AA batteries in battery holder
- Best way is to detach the battery holder



- Put back cover and be sure to tighten the cover
- Procedure is the same if you need to replace the batteries



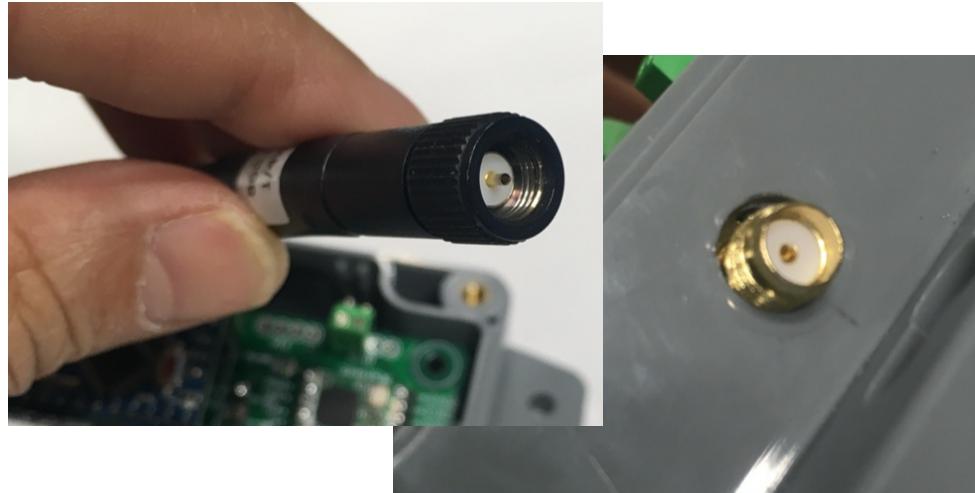
# Take good AA batteries

- Install new & high-grade alkaline AA batteries to allow for at least 2 years of autonomy
- Take a well-known brand



# Preparing soil sensor device

## screw in the antenna

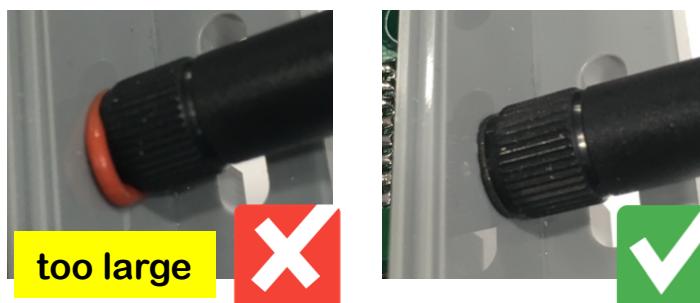
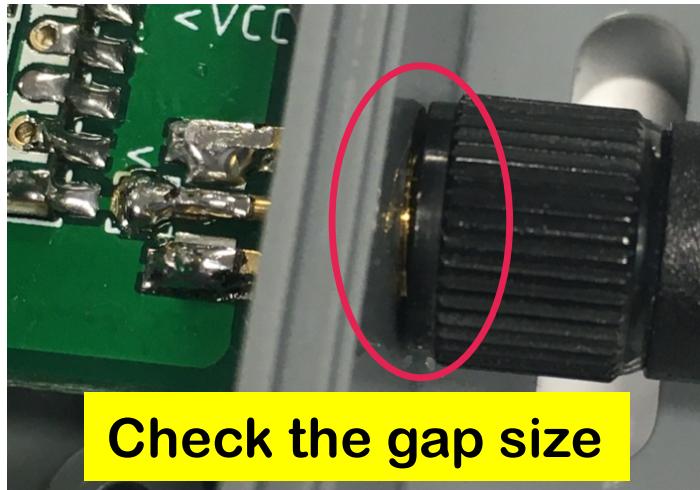


Be sure to connect the matching antenna  
Here, SMA female with SMA male antenna  
Need to screw the antenna in all the way

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



# 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

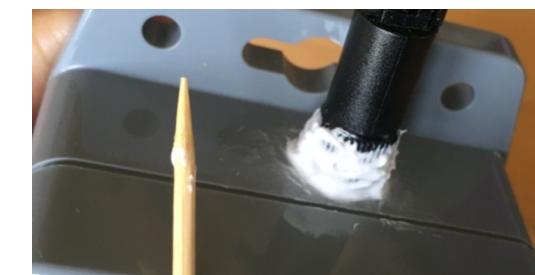
# Do not have or can not use o-ring?

Maybe the gap is too big? Use silicon joint sealant



First, screw in the antenna all the way

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 is good to add silicon!**



# Never transmit without antenna

- NEVER, NEVER transmit without an antenna
- Doing so can damage the radio module
- If your board is already connected to the radio module and you need to flash the board, connect the antenna
- If you need to update the existing code and your device already run a code that transmit data, connect the antenna
- It is safer when programming the device to remove the Arduino board from the female header and program it disconnected from the radio module
- If you deploy a device, make sure that the antenna is correctly connected before powering on the device and realizing any transmission test

- Test with the fully assembled & configured soil sensor device
  - Check that antenna is connected
  - Toggle switch on the soil sensor device to get data transmission
  - Check reception of data on WaziGate's dashboard



Look at [Video n°4 at t=331s](#)

<https://youtu.be/j-1Nk0tv0xM?t=331>

# Transmission to WaziGate



Parameters for  
INTEL-IRRIS WaziGate  
(default in red)

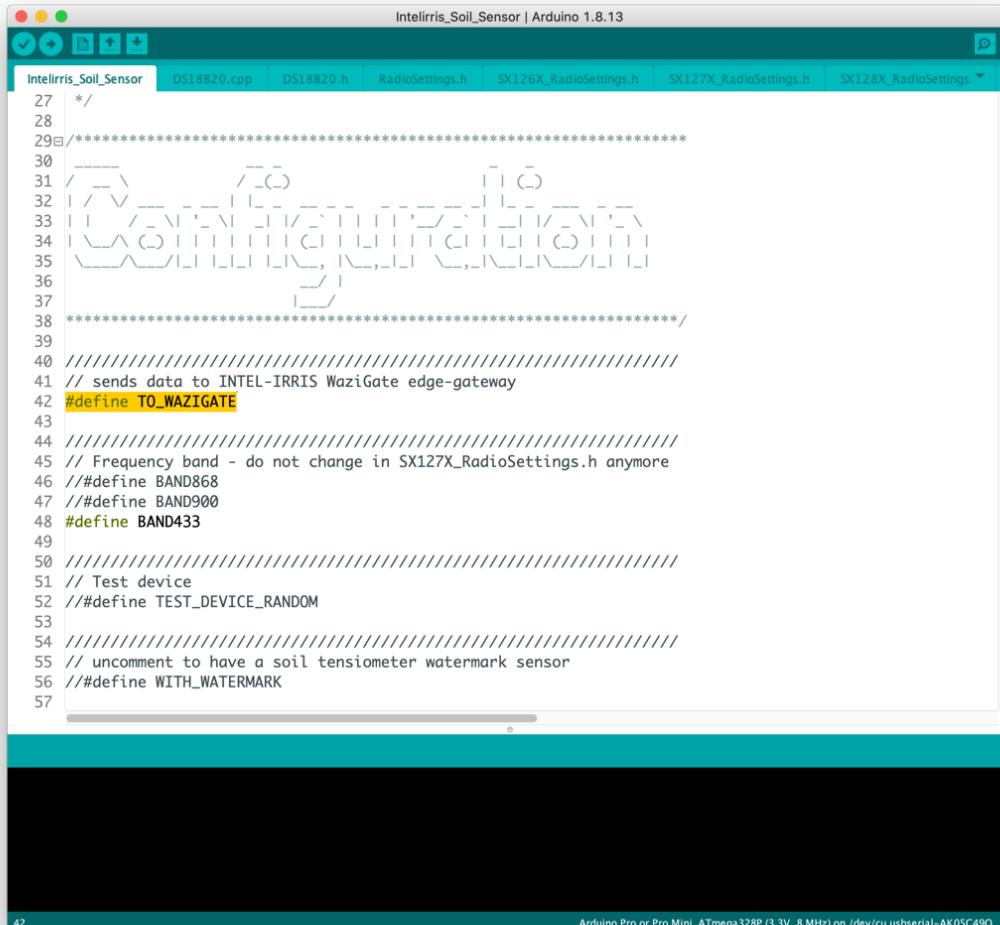
LoRaWAN   
 SF12BW125  
 868.1MHz | **433.175MHz**  
 Node id is **26011DAA**  
 1 msg/60mins  
 1 sensor  
 XLPP data



This dedicated video will show all these steps, from connecting the SEN0308 to testing transmission to the WaziGate  
 Video n°4: <https://youtu.be/j-1Nk0tv0xM>



# Configure soil device for WaziGate



```
Intelirris_Soil_Sensor | Arduino 1.8.13
Intelirris_Soil_Sensor DS18B20.cpp DS18B20.h RadioSettings.h SX126X_RadioSettings.h SX127X_RadioSettings.h SX128X_RadioSettings.h
27 /*
28
29 */
30 ****
31 /--\ /--\ /--\
32 | / \ | / \ | / \
33 | / \ | / \ | / \
34 | \ / | / \ | / \
35 \ / \ | / \ | / \
36 | / \ | / \ | / \
37 | / \ | / \ | / \
38 ****
39 /**
40 // sends data to INTEL-IRRIS WaziGate edge-gateway
41 #define TO_WAZIGATE
42 /**
43 // Frequency band - do not change in SX127X_RadioSettings.h anymore
44 //##define BAND868
45 //##define BAND900
46 #define BAND433
47 /**
48 // Test device
49 //##define TEST_DEVICE_RANDOM
50 /**
51 // uncomment to have a soil tensiometer watermark sensor
52 //##define WITH_WATERMARK
53 /**
54 /**
55 /**
56 /**
57 */

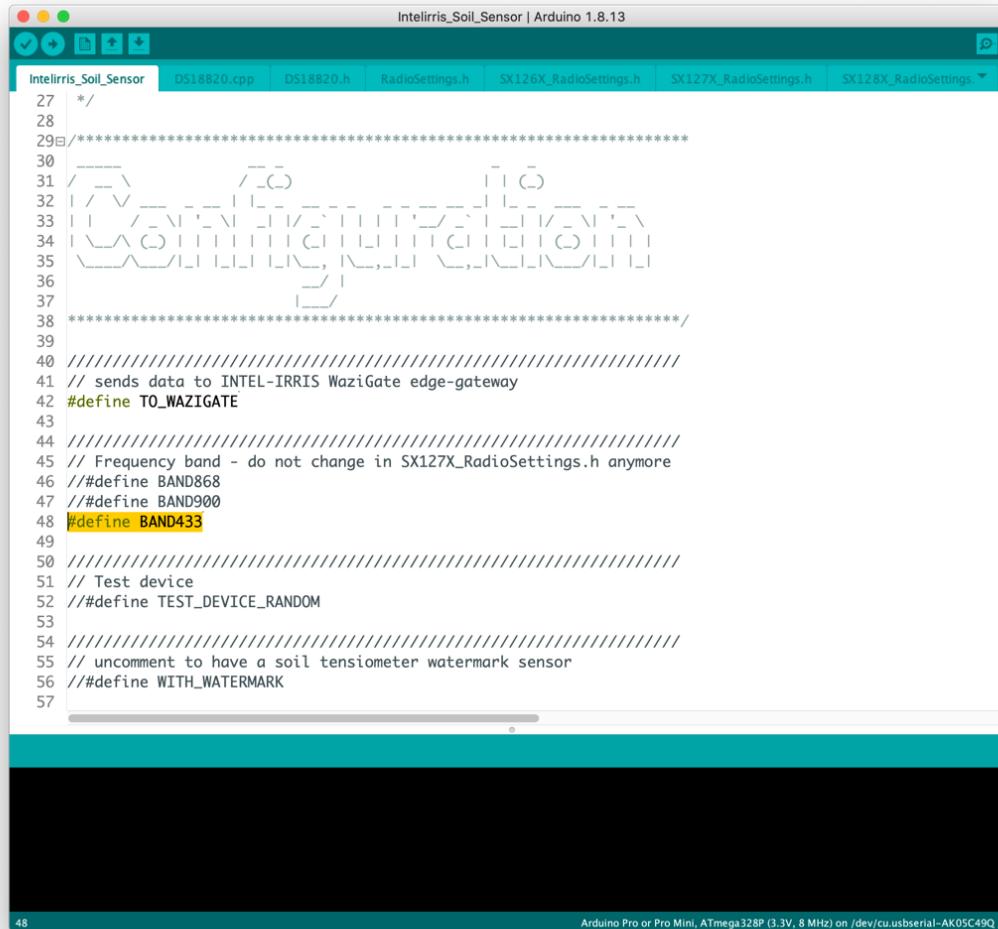
42 Arduino Pro or Pro Mini, ATmega328P (3.3V, 8 MHz) on /dev/cu.usbserial-AK05C49Q
```

Be sure that

#define TO\_WAZIGATE

is uncommented

# Configuring for EU433 band



```

Intelirris_Soil_Sensor | Arduino 1.8.13
Intelirris_Soil_Sensor DS18B20.cpp DS18B20.h RadioSettings.h SX126X_RadioSettings.h SX127X_RadioSettings.h SX128X_RadioSettings.h

27 /*
28 */
29 //*****
30 //----\ /----\ /----\ /----\
31 // / \ \ / \ / \ / \ / \ / \ / \
32 // | \ / \ / \ / \ / \ / \ / \ / \
33 // | \ / \ / \ / \ / \ / \ / \ / \
34 // | \ / \ / \ / \ / \ / \ / \ / \
35 // | \ / \ / \ / \ / \ / \ / \ / \
36 // | \ / \ / \ / \ / \ / \ / \ / \
37 // | \ / \ / \ / \ / \ / \ / \ / \
38 //*****
39 /////////////////
40 // sends data to INTEL-IRRIS WaziGate edge-gateway
41 #define TO_WAZIGATE
42
43 /////////////////
44 // Frequency band - do not change in SX127X_RadioSettings.h anymore
45 // #define BAND868
46 // #define BAND900
47 #define BAND433
48
49 ///////////////
50 // Test device
51 //#define TEST_DEVICE_RANDOM
52
53 ///////////////
54 // uncomment to have a soil tensiometer watermark sensor
55 //#define WITH_WATERMARK
56
57

```

Arduino Pro or Pro Mini, ATmega328P (3.3V, 8 MHz) on /dev/cu.usbserial-AK05C49Q

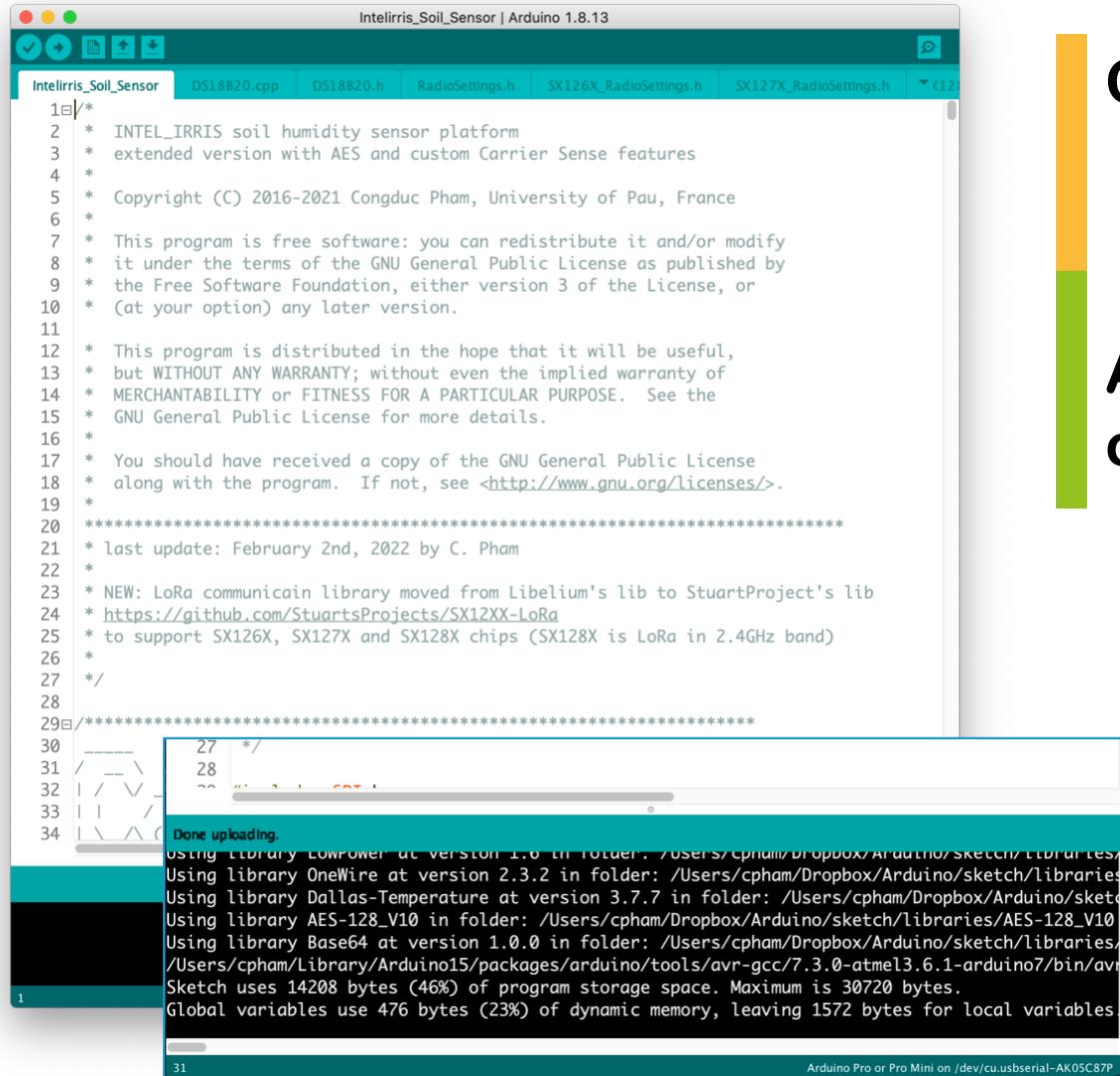
If you use the EU433 band

make sure that

#define BAND433

is the only uncommented  
band option

# Uploading to your board



```

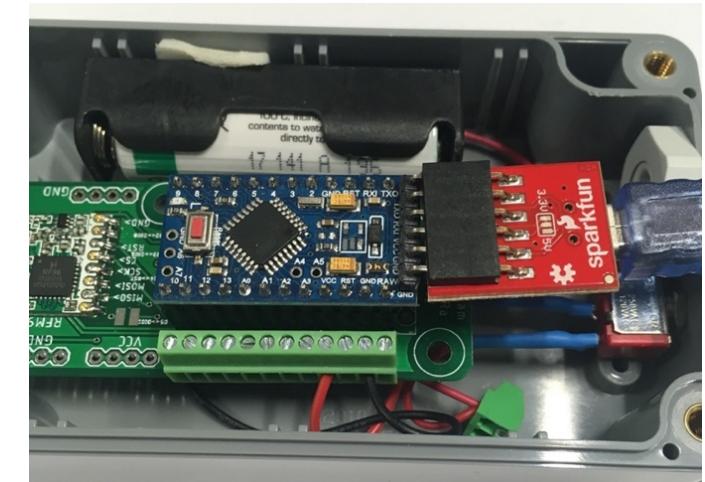
1/*  
2 * INTEL_IRRIS soil humidity sensor platform  
3 * extended version with AES and custom Carrier Sense features  
4 *  
5 * Copyright (C) 2016-2021 Congduc Pham, University of Pau, France  
6 *  
7 * This program is free software: you can redistribute it and/or modify  
8 * it under the terms of the GNU General Public License as published by  
9 * the Free Software Foundation, either version 3 of the License, or  
10 * (at your option) any later version.  
11 *  
12 * This program is distributed in the hope that it will be useful,  
13 * but WITHOUT ANY WARRANTY; without even the implied warranty of  
14 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the  
15 * GNU General Public License for more details.  
16 *  
17 * You should have received a copy of the GNU General Public License  
18 * along with the program. If not, see <http://www.gnu.org/licenses/>.  
19 *  
20 ****  
21 * last update: February 2nd, 2022 by C. Pham  
22 *  
23 * NEW: LoRa communicain library moved from Libelium's lib to StuartProject's lib  
24 * https://github.com/StuartsProjects/SX12XX-LoRa  
25 * to support SX126X, SX127X and SX128X chips (SX128X is LoRa in 2.4GHz band)  
26 *  
27 */  
28 */*****  
29 */*****  
30 */-----  
31 */ \ /  
32 | / \ /  
33 | | / /  
34 */-----  
  
Done uploading.  
Using library LowPower at version 1.0 in folder: /Users/cpham/Dropbox/Arduino/sketch/LowPower  
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.  
  
31

```

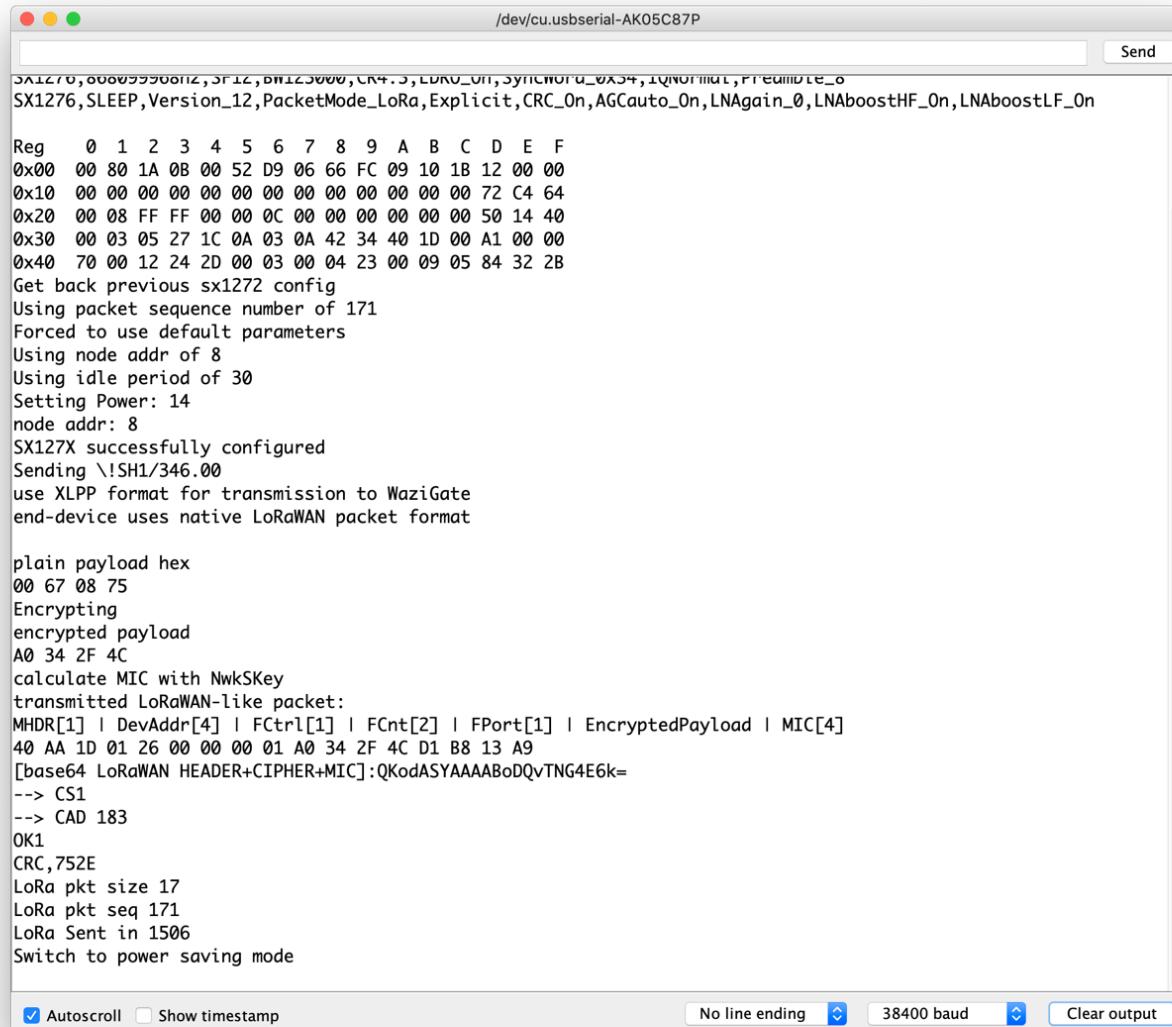
Click on the "upload" button



And wait until upload is completed



# Checking that device is operational



```

/dev/cu.usbserial-AK05C87P
Send

SX1276,0000000000000000,3F12,B0123000,CRC4.5,LDRU_0H,SYNCHRO_0X34,TQ_NORM,PREDECODE_0
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 D9 06 66 FC 09 10 1B 12 00 00
0x10 00 00 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 00 50 14 40
0x30 00 03 05 27 1C 0A 03 0A 42 34 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 171
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 \!SH1/346.00
use XLPP format for transmission to WaziGate
end-device uses native LoRaWAN packet format

plain payload hex
00 67 08 75
Encrypting
encrypted payload
A0 34 2F 4C
calculate MIC with NwkSKey
transmitted LoRaWAN-like packet:
MHDR[1] | DevAddr[4] | FCtrl[1] | FCnt[2] | FPort[1] | EncryptedPayload | MIC[4]
40 AA 1D 01 26 00 00 00 01 A0 34 2F 4C D1 B8 13 A9
[base64 LoRaWAN HEADER+CIPHER+MIC]:QKodASYAAABoDQvTNG4E6k=
--> CS1
--> CAD 183
OK1
CRC,752E
LoRa pkt size 17
LoRa pkt seq 171
LoRa Sent in 1506
Switch to power saving mode

 Autoscroll  Show timestamp
  No line ending  38400 baud  Clear output

```

**Open serial monitor**

**Set baud rate to 38400**

**See output from board**

**Check that transmission is OK**

# Deploying the starter-kit

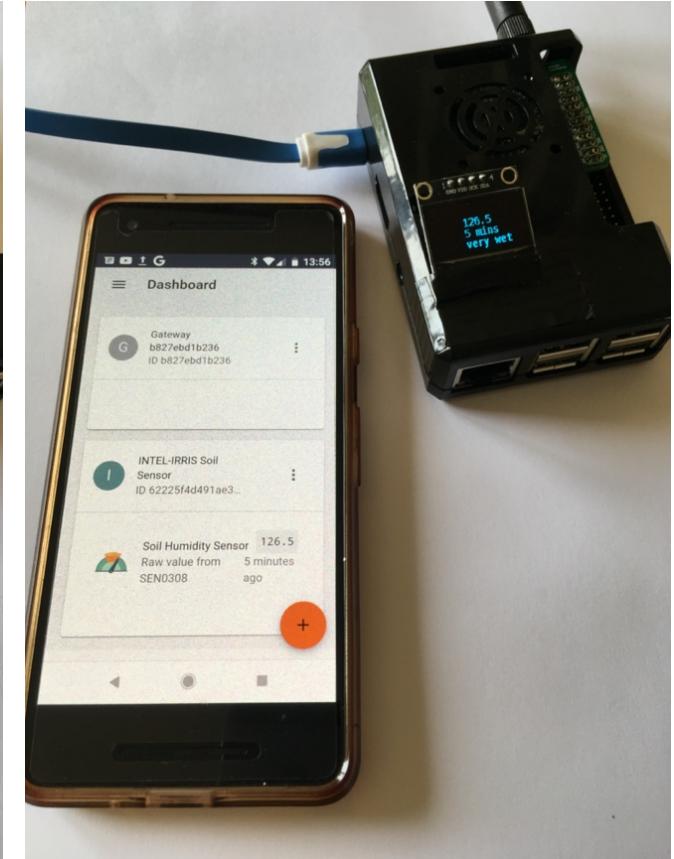
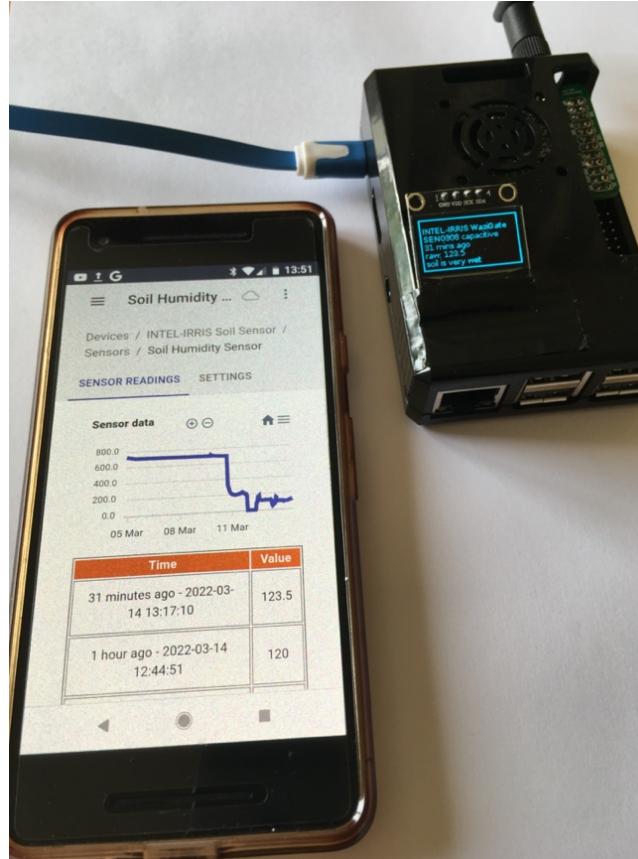
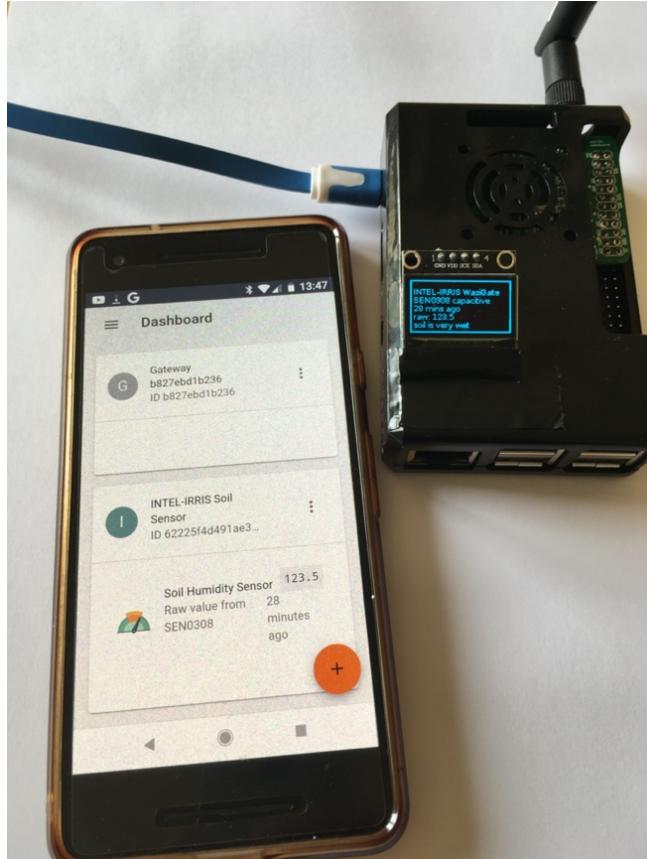
- Calibrate the soil sensor device
  - See dedicated slides/videos [to come]
- Install the soil sensor device in the field
  - See dedicated slides/videos [to come]
- Install the WaziGate in the farmer's office/home/premise
  - Just power the WaziGate, no Internet is required
  - Test access to WaziGate's dashboard with farmer's smartphone
- **NEVER TRANSMIT WITHOUT AN ANTENNA**
- Test correct data reception on WaziGate
  - Toggle switch on the soil sensor device to get data transmission
  - Check reception of data on WaziGate's dashboard

# With the optional OLED

- With a small .96" OLED screen, information summary can be easily displayed for the end-user: the sensor type, the sensor raw value, the time of last received data and the soil condition
- The main screen is displayed for 6s every 2mins where a screen saver display will show a shorter version of these information



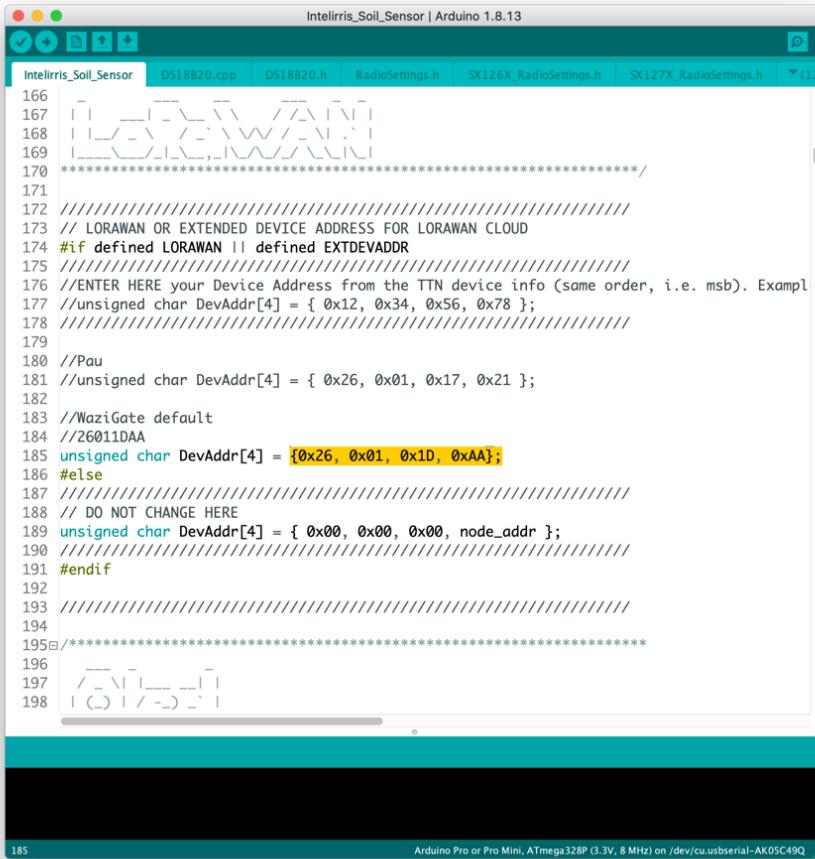
# WaziGate User Interface



# Advanced configuration

## change soil sensor device address

- Only if you need to have several soil sensors in a single farm:  
change the device address in the soil sensor Arduino code



```

166
167
168
169
170 ****
171
172 /////////////////
173 // LORAWAN OR EXTENDED DEVICE ADDRESS FOR LORAWAN CLOUD
174 #if defined LORAWAN || defined EXTDEVADDR
175 //ENTER HERE your Device Address from the TTN device info (same order, i.e. msb). Example
176 //unsigned char DevAddr[4] = { 0x12, 0x34, 0x56, 0x78 };
177 /////////////////
178
179
180 //Pau
181 //unsigned char DevAddr[4] = { 0x26, 0x01, 0x1D, 0xAA };
182
183 //WaziGate default
184 //26011DA
185 unsigned char DevAddr[4] = {0x26, 0x01, 0x1D, 0xAA};
186 #else
187 //DO NOT CHANGE HERE
188 unsigned char DevAddr[4] = { 0x00, 0x00, 0x00, node_addr };
189 /////////////////
190 #endif
191
192
193
194
195 ****
196
197
198

```

185                          Arduino Pro or Pro Mini, ATmega328P (3.3V, 8 MHz) on /dev/cu.usbserial-AK05C49Q

**Default address is**

{ 0x26, 0x01, 0x1D, 0xAA } ;

**Just increase the last byte**

{ 0x26, 0x01, 0x1D, 0xAB } ;

**Compile and upload the code  
to the soil sensor device**

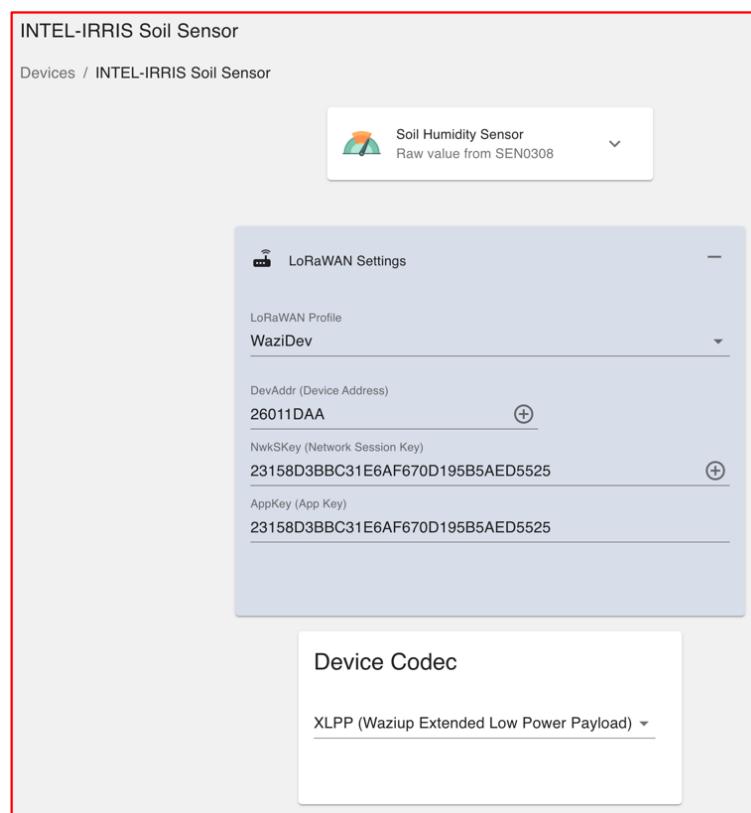
# Advanced configuration

## create a new sensor device on WaziGate

- Here is the configuration of the default soil sensor device
- Create a new sensor: INTEL-IRRIS Soil Sensor 2

**INTEL-IRRIS Soil Sensor**

Devices / INTEL-IRRIS Soil Sensor



Soil Humidity Sensor  
Raw value from SEN0308

LoRaWAN Settings

LoRaWAN Profile  
WaziDev

DevAddr (Device Address)  
26011DAA

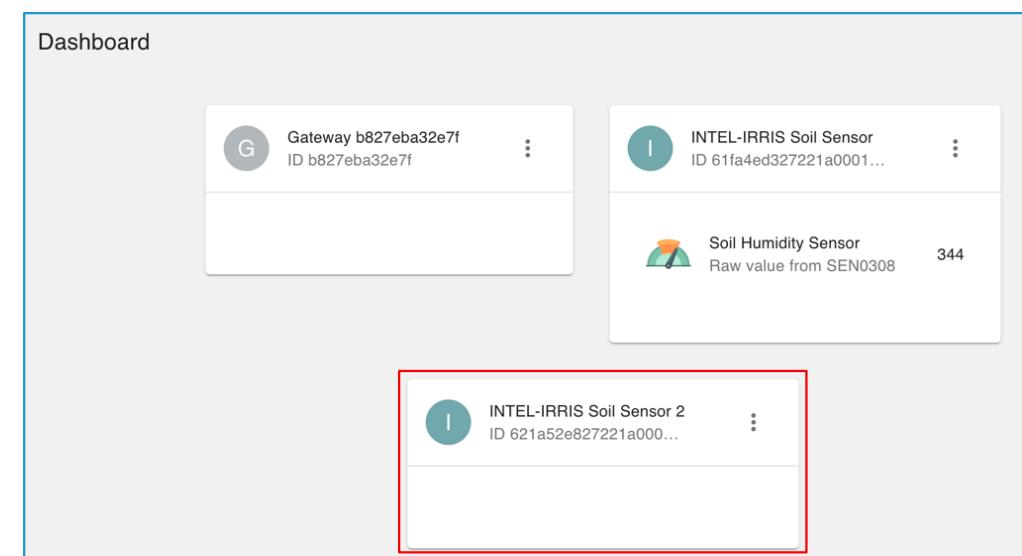
NwksKey (Network Session Key)  
23158D3BBC31E6AF670D195B5AED5525

AppKey (App Key)  
23158D3BBC31E6AF670D195B5AED5525

Device Codec

XLPP (Waziup Extended Low Power Payload)

**Dashboard**



G Gateway b827eba32e7f  
ID b827eba32e7f

I INTEL-IRRIS Soil Sensor  
ID 61fa4ed327221a0001...

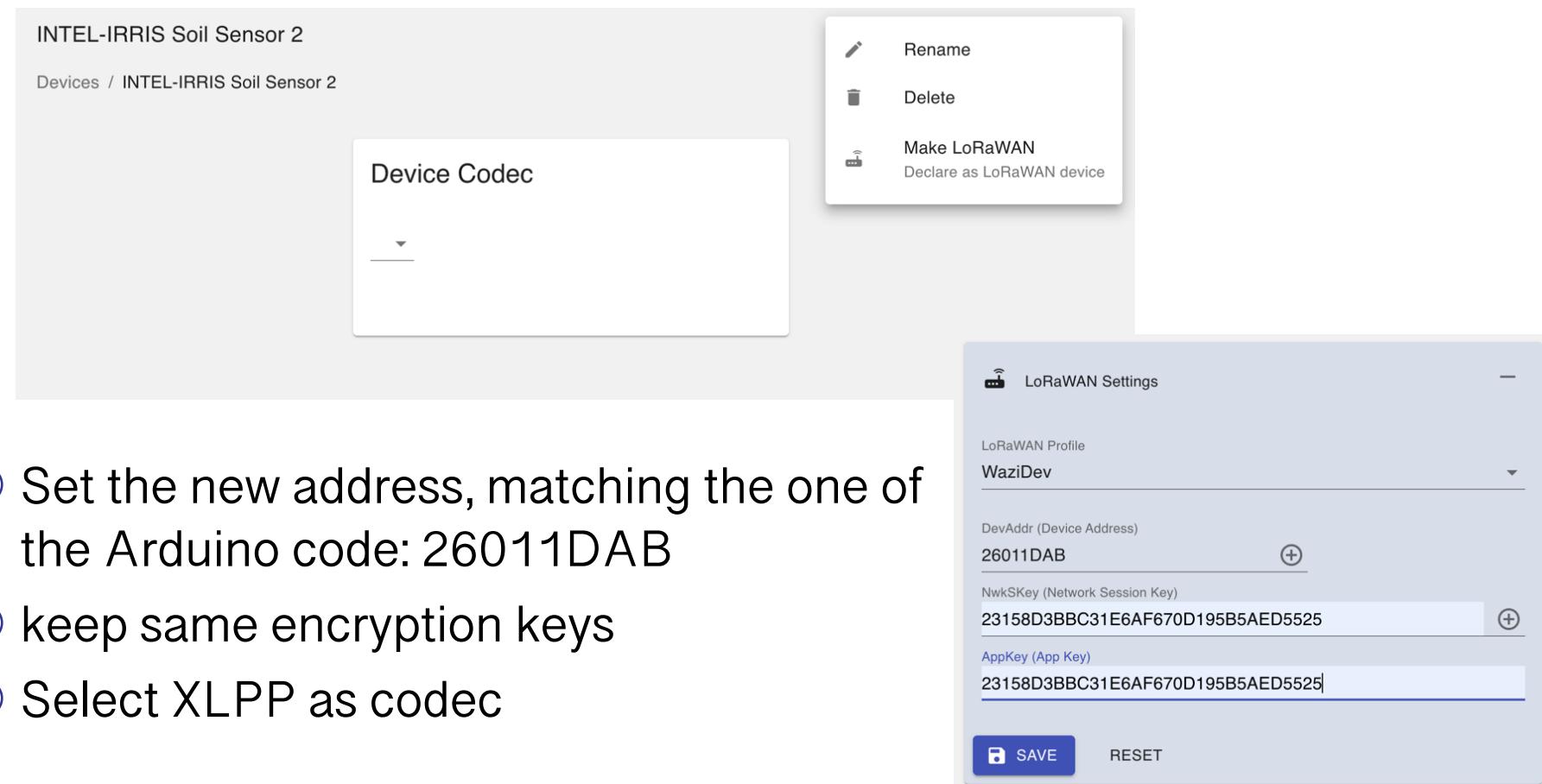
Soil Humidity Sensor  
Raw value from SEN0308 344

I INTEL-IRRIS Soil Sensor 2  
ID 621a52e827221a000...

# Advanced configuration

## configure LoRaWAN parameters

- Select the new sensor and make it as LoRaWAN device



INTEL-IRRIS Soil Sensor 2

Devices / INTEL-IRRIS Soil Sensor 2

Device Codec

Rename

Delete

Make LoRaWAN  
Declare as LoRaWAN device

LoRaWAN Settings

LoRaWAN Profile  
WaziDev

DevAddr (Device Address)  
26011DAB

NwkSKey (Network Session Key)  
23158D3BBC31E6AF670D195B5AED5525

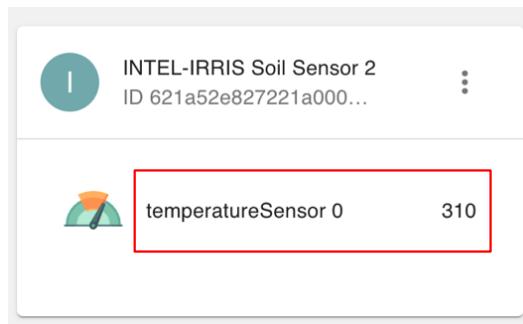
AppKey (App Key)  
23158D3BBC31E6AF670D195B5AED5525

SAVE RESET

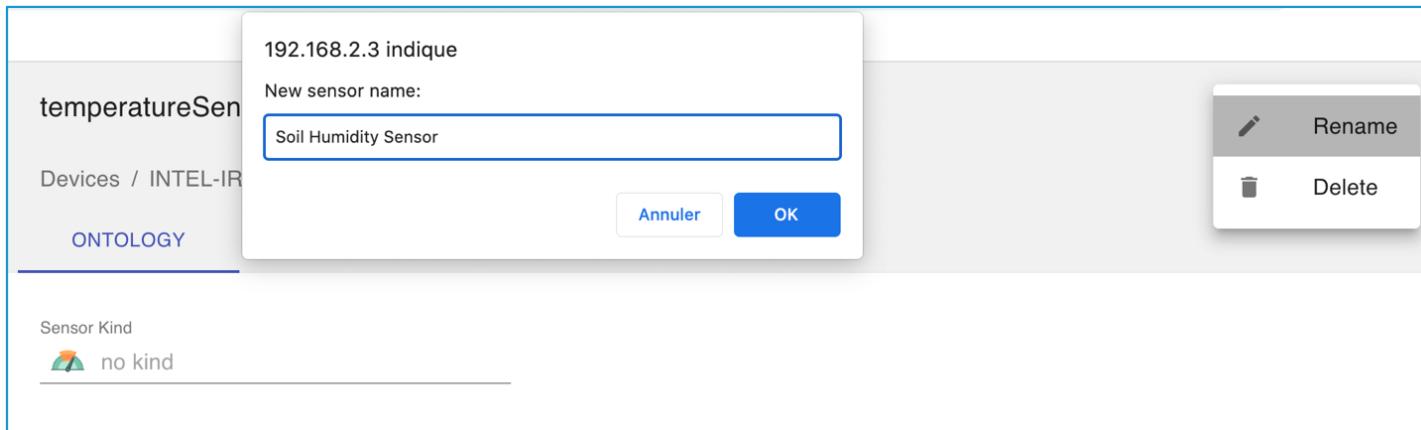
# Advanced configuration

## configure sensor name

- Power on the new soil sensor device to trigger data transmission
- Refresh the WaziGate dashboard, the new data should appear



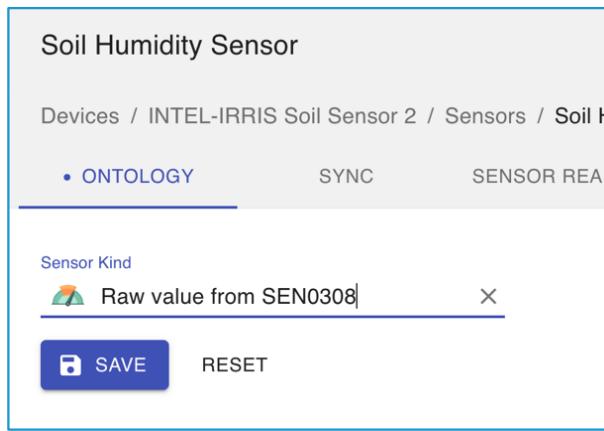
- Click on the "temperatureSensor 0" and then rename it



# Advanced configuration

## configure sensor kind

- Change de Sensor kind to "Raw value from SEN0308"



Soil Humidity Sensor

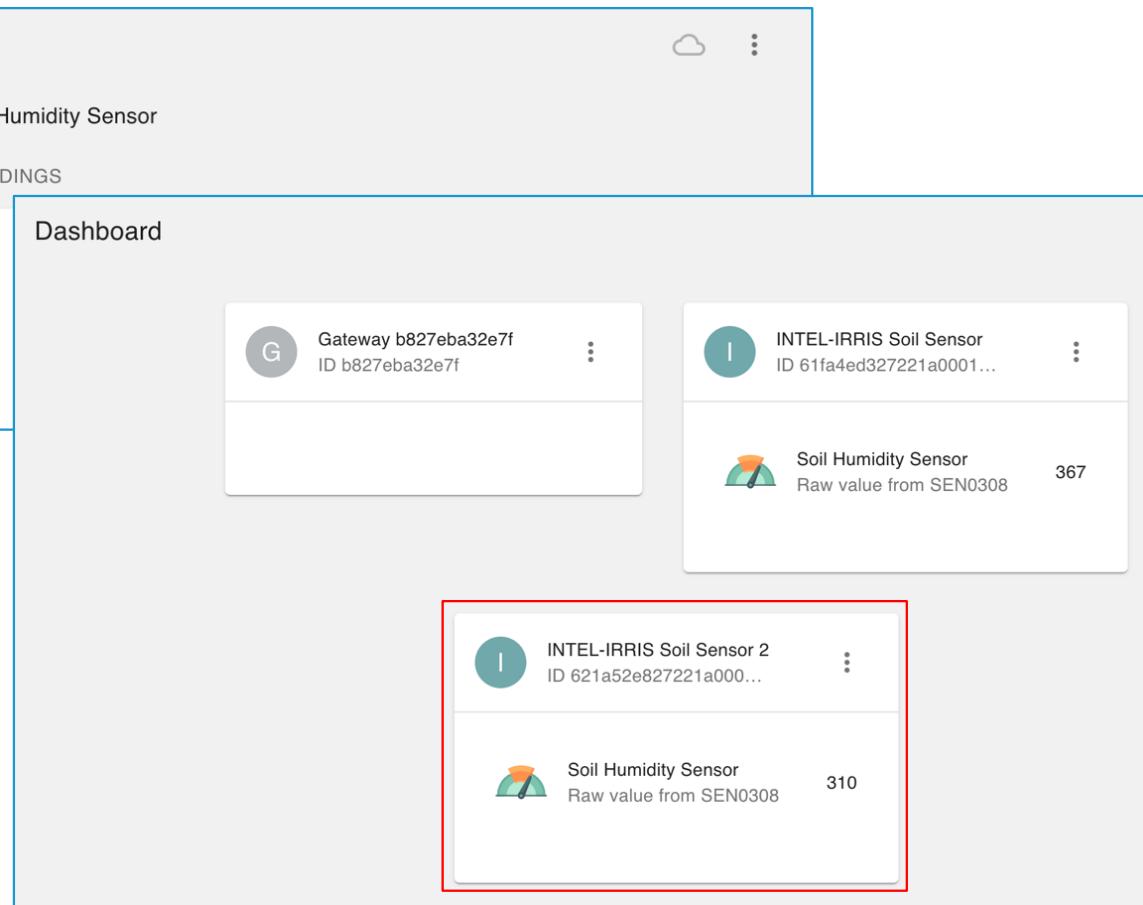
Devices / INTEL-IRRIS Soil Sensor 2 / Sensors / Soil Humidity Sensor

- ONTOLOGY
- SYNC
- SENSOR READINGS

Sensor Kind

 Raw value from SEN0308 X

SAVE RESET



Dashboard

-  Gateway b827eba32e7f  
ID b827eba32e7f ...
-  INTEL-IRRIS Soil Sensor  
ID 61fa4ed327221a0001... ...
-  Soil Humidity Sensor  
Raw value from SEN0308 367
-  INTEL-IRRIS Soil Sensor 2  
ID 621a52e827221a000... ...
-  Soil Humidity Sensor  
Raw value from SEN0308 310

- The dashboard now displays correctly the new sensor

# NOTICE ON THE STARTER-KIT



- NEVER TRANSMIT WITHOUT AN ANTENNA
- 1 FULLY ASSEMBLED & CONFIGURED SOIL SENSOR
  - NEED TO INSTALL 2-AA BATTERIES
  - TAKE HIGH-GRADE BATTERIES
  - DO NOT SWITCH ON WITHOUT ANTENNA ATTACHED
  - ALREADY CONFIGURED FOR WAZIGATE
- STARTER-KIT= 1 SOIL SENSOR + 1 WAZIGATE
- INTEL-IRRIS WAZIGATE IMAGE TO BE DOWNLOADED FROM <http://intel-iris.eu/results>
- FLASH IMAGE ON 8GB SD CARD (OR 16GB OR 32GB)
- THE WAZIGATE IS ONLY PRE-CONFIGURED FOR 1 SOIL SENSOR PER FARM
- STARTER-KIT TUTORIAL : <http://intel-iris.eu/tutorials-slides>



Starter-kit

Autonomous

Intelligent Irrigation

Plug-&-Sense

In-the-box