



# 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 2: edge-enabled gateway (WaziGate)



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# 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



# INTEL-IRRIS starter-kit

- "Intelligent Irrigation in-the-box", "plug-&-sense"
- From idea to reality!



# WaziGate

- WaziGate is an IoT LoRa Gateway developed by WAZIUP
- WaziGate implements the edge-enabled IoT gateway approach
  - customized applications can be directly hosted in the gateway
  - the gateway can easily work without Internet connectivity
  - data are available to end-users in an embedded database
  - web-based visualization module provides graphical user interface
- You can find all the WaziGate documentation on the [WaziGate documentation page](#). There are 4 main sections describing the generic WaziGate main features:
  - [Quick start:](#) [https://www.waziup.io/documentation/wazigate/v2/quick\\_start/](https://www.waziup.io/documentation/wazigate/v2/quick_start/)
  - [Installation:](#) <https://www.waziup.io/documentation/wazigate/v2/install/>
  - [LoRaWAN:](#) <https://www.waziup.io/documentation/wazigate/v2/lorawan/>
  - [WaziApps:](#) <https://www.waziup.io/documentation/wazigate/v2/waziapps/>
  - Look at the generic installation video: <https://youtu.be/DvGdmdsGZHA>

# Install your WaziGate (1)

## ● **INTEL-IRRIS WaziGate distribution (RPI3B/3B+/4B)**

- comes pre-configured with a soil sensor device
- will work out-of-the box with the INTEL-IRRIS soil sensor device
- will be updated to host the INTEL-IRRIS irrigation application
- **Download the INTEL-IRRIS WaziGate SD card image from project website**
- <http://intel-iris.eu/results>
- Image uses EU433 frequency band
- EU868 can be configured afterwards
- Flash the SD card image on 8GB SD card class 10

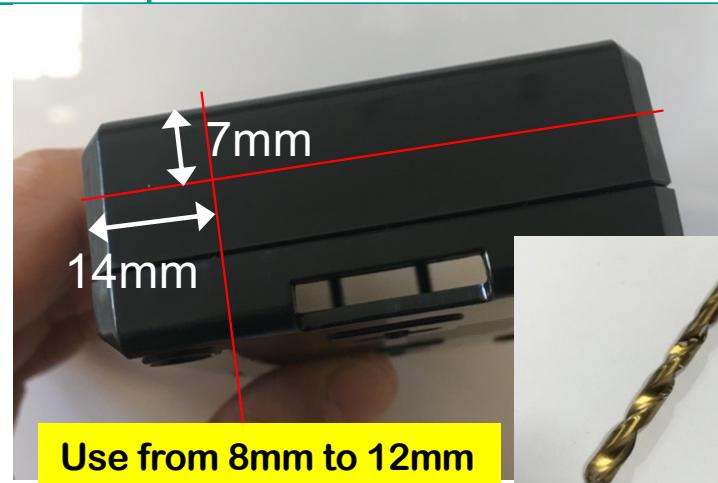


Look at the INTEL-IRRIS WaziGate video

Video n°4 at t=124s: <https://youtu.be/j-1Nk0tv0xM?t=124>

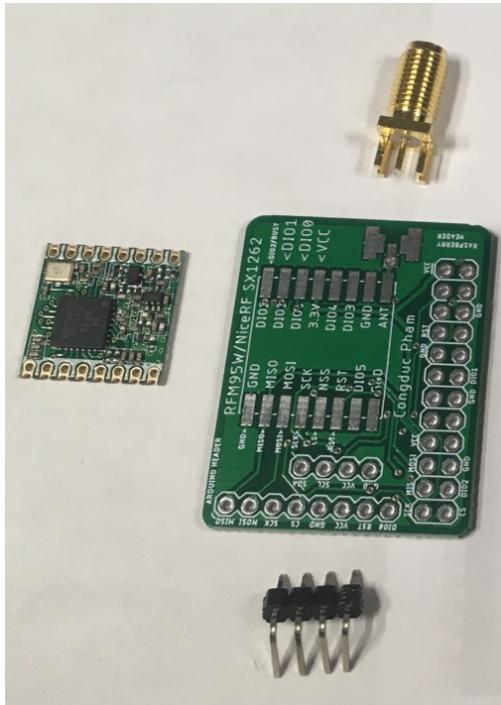
# Install your WaziGate (2)

- Recommended RPI model is RPI3B
  - plug in the radio LoRa hat
  - The OLED screen is optional but highly recommended
- Drill a hole for the SMA connector on the RPI enclosure, at the SD card slot side
- <https://fr.aliexpress.com/item/32718435597.html>



# The LoRa radio hat

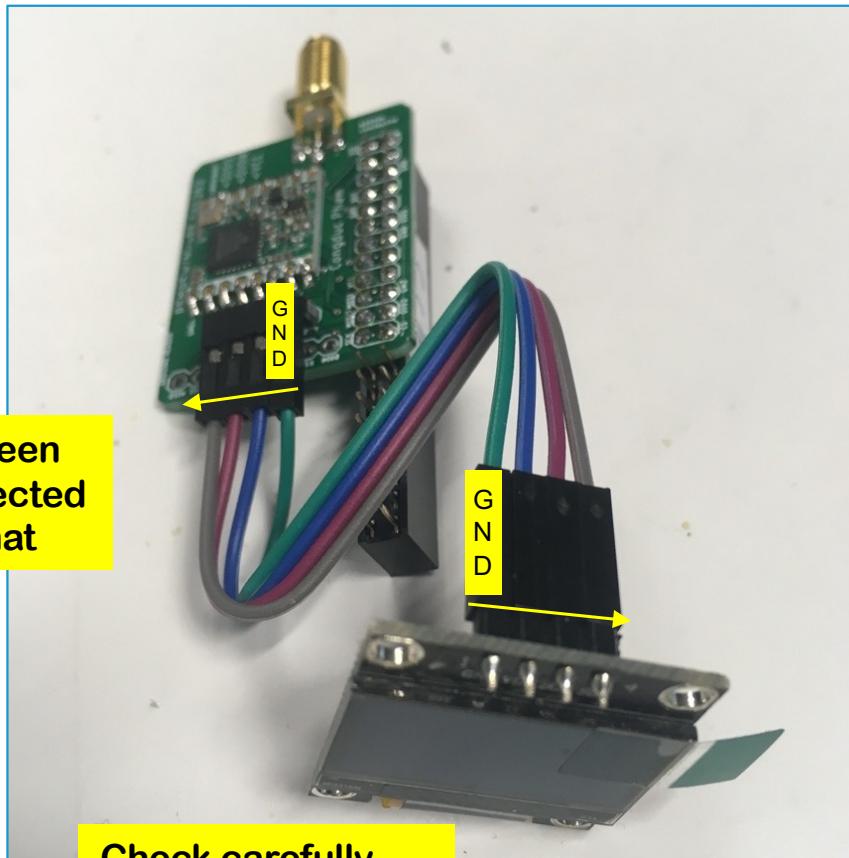
<https://github.com/CongducPham/PRIMA-Intel-Irris/blob/main/Tutorials/Intel-Irris-PCB.pdf>



2-row 12-pin header  
or  
2 X 1-row 12-pin header



# Installing OLED

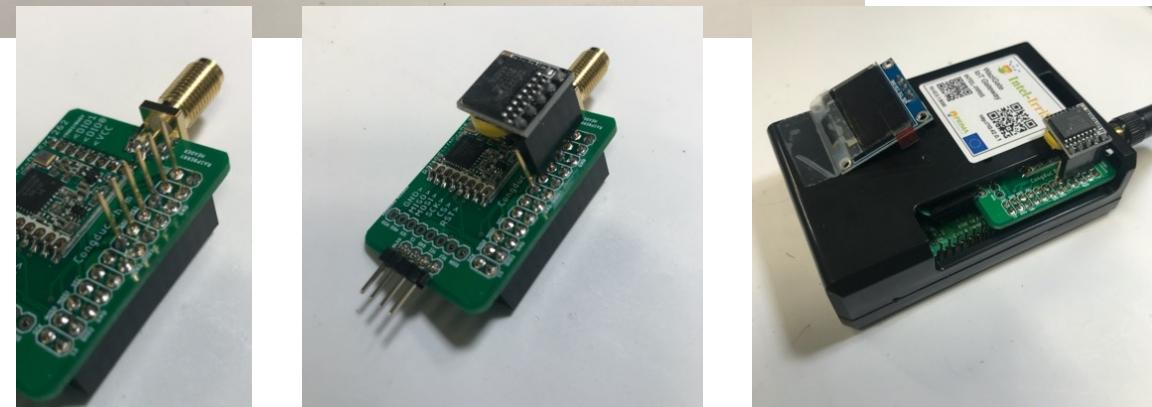
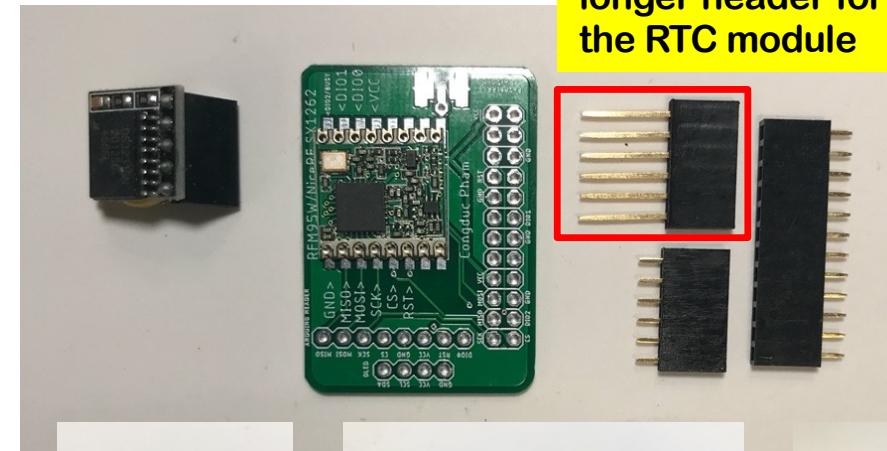


# Connecting an RTC module (1)

- Several possibilities depending on availability of components



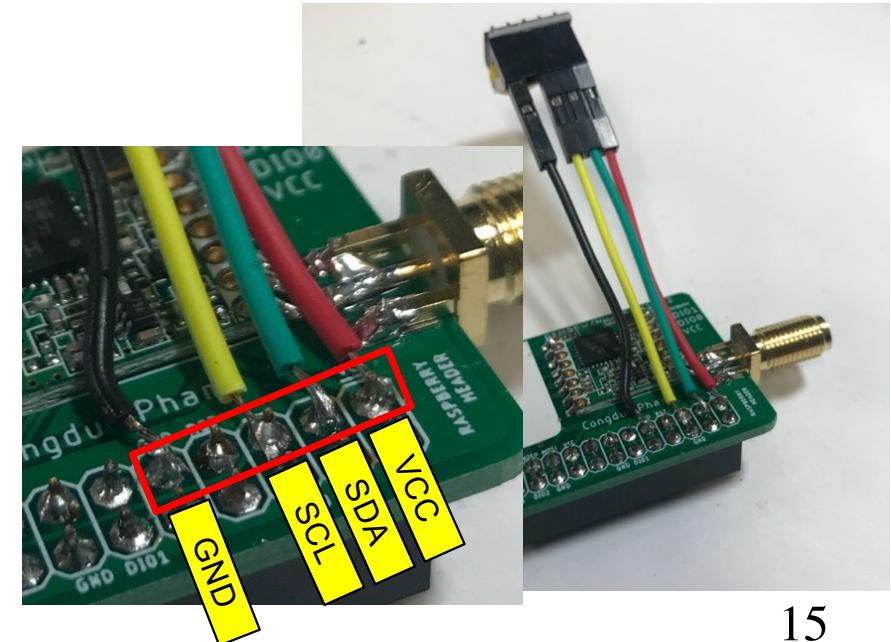
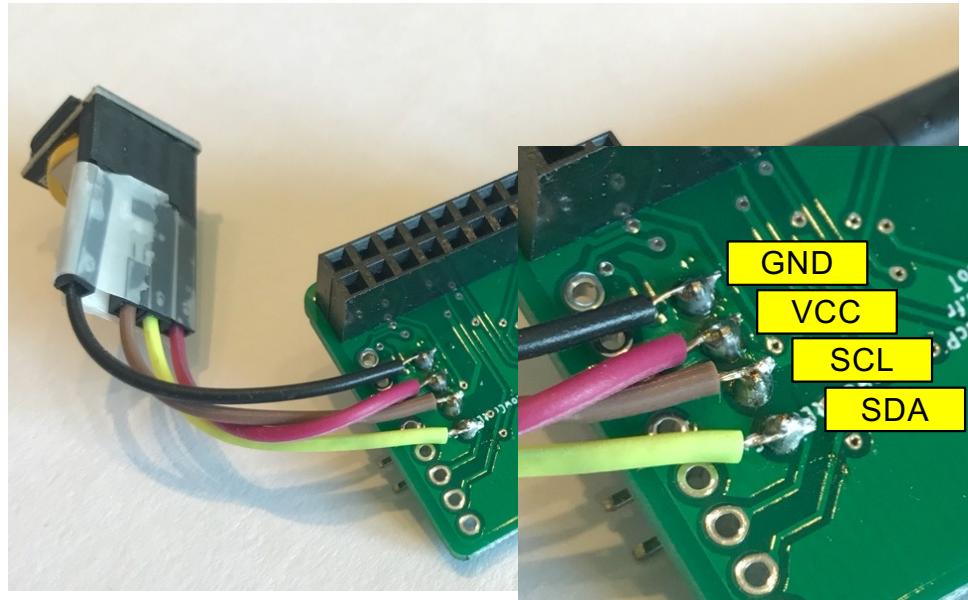
Solder a header with longer pins to connect the RTC module. You can then cut the remaining pins if you want



# Connecting an RTC module (2)

- If you already have the LoRa hat, you can also just solder 4 wires for the RTC module. 2 possibilities
  - On the back side of the I2C header (left figure)
  - On the RPI GPIO header (right figure)
- Check carefully to avoid short circuits

Pin#	NAME
01	3.3v DC Power
03	GPIO02 (SDA1 , I <sup>C</sup> )
05	GPIO03 (SCL1 , I <sup>C</sup> )
07	GPIO04 (GPIO_GCLK)
09	Ground
11	GPIO17 (GPIO_GEN0)
13	GPIO27 (GPIO_GEN2)



# WaziGate power consumption



RPI3B consumes less than 300mA

There can be peak up to 800mA when booting

However, a 2.5A micro USB charger is needed to avoid undervoltage

# Checking the WaziGate (Ethernet)

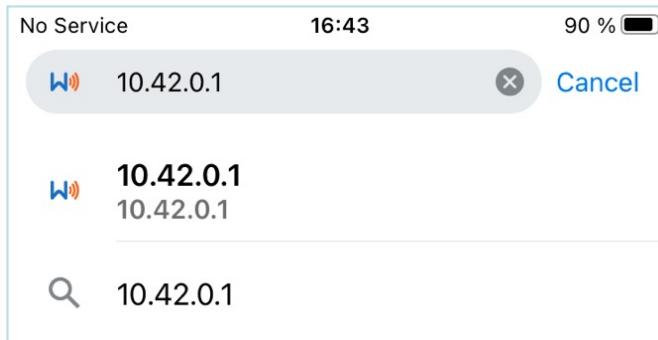
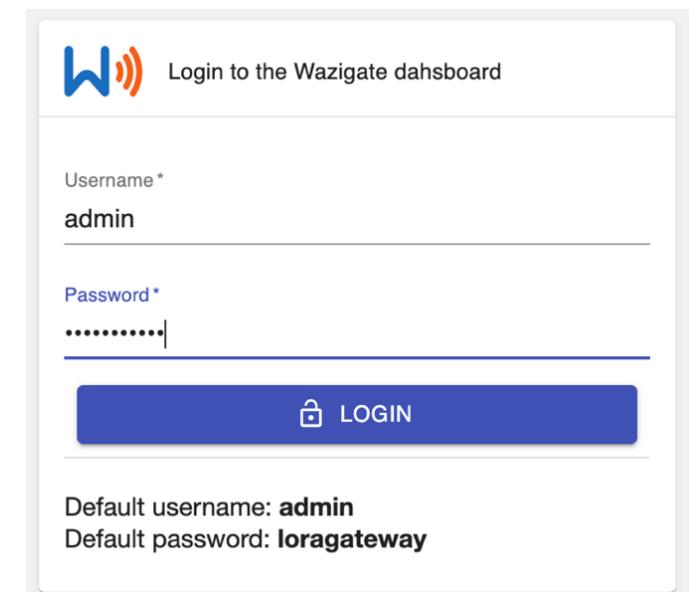
- Connect the WaziGate to your laptop which has Internet
- Enable Internet sharing, laptop provides IP address to WaziGate
- Power the WaziGate, wait 3-4mins for boot process
- Open web navigator. Go to <http://wazigate.local> or use IP address

The image shows a screenshot of a web browser window titled "Wazigate". The address bar displays "http://wazigate.local". Below the address bar, there is a search bar with the text "http://wazigate.local - Recherche". A yellow callout box is overlaid on the screen, containing the text: "You can use an IP scanner program to find the IP address assigned to your WaziGate (such as Angry IP Scanner)". To the right of the browser window, a separate screenshot of the "Login to the Wazigate dashboard" page is shown. This page features a logo with a blue 'W' and a red signal icon. It has fields for "Username\*" (containing "admin") and "Password\*" (containing "loragateway"). A blue "LOGIN" button is at the bottom. Below the login form, text indicates "Default username: admin" and "Default password: loragateway".

- Use default login to connect
  - User: admin
  - Password: loragateway

# Checking the WaziGate (WiFi)

- Use a smartphone to check access to WaziGate through WiFi
- Connect to WAZIGATE\_XXXXXXXXXXXXXX WiFi network
  - default WiFi password is loragateway
- Open web navigator. Go to <http://wazigate.local> or <http://10.42.0.1> or flash QR code

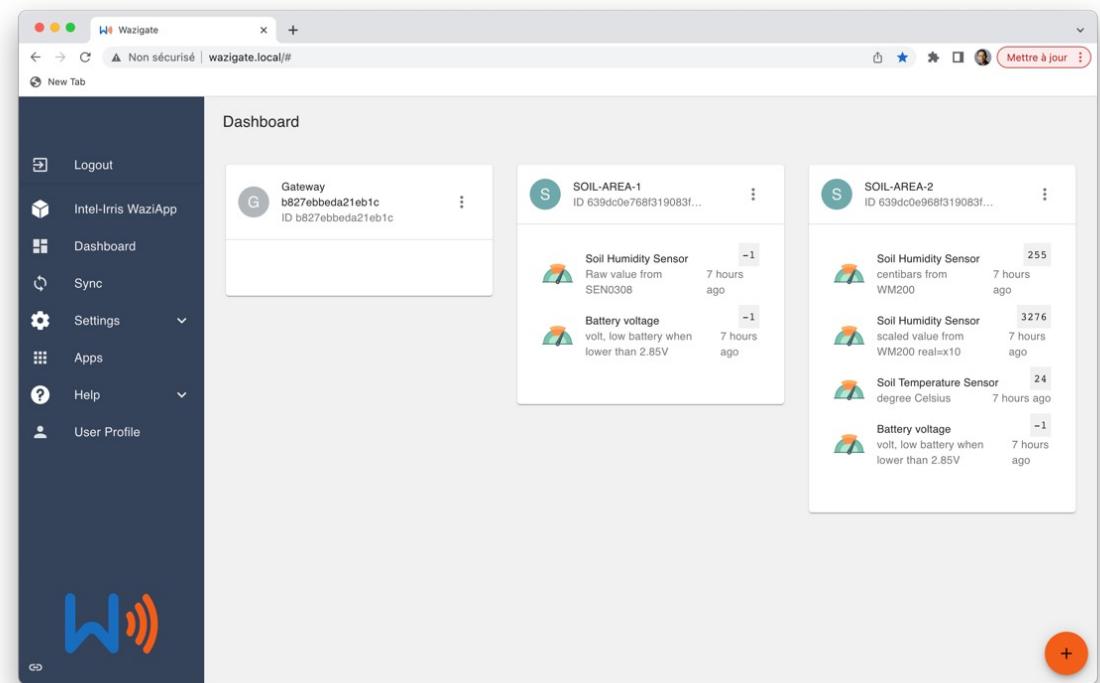



The login screen for the Wazigate dashboard. It has a header "Login to the Wazigate dashboard" with the Intel-Irris logo. Below it is a form with fields for "Username \*" containing "admin" and "Password \*" containing "\*\*\*\*\*". A blue "LOGIN" button is at the bottom. At the bottom of the page, text states "Default username: admin" and "Default password: loragateway".

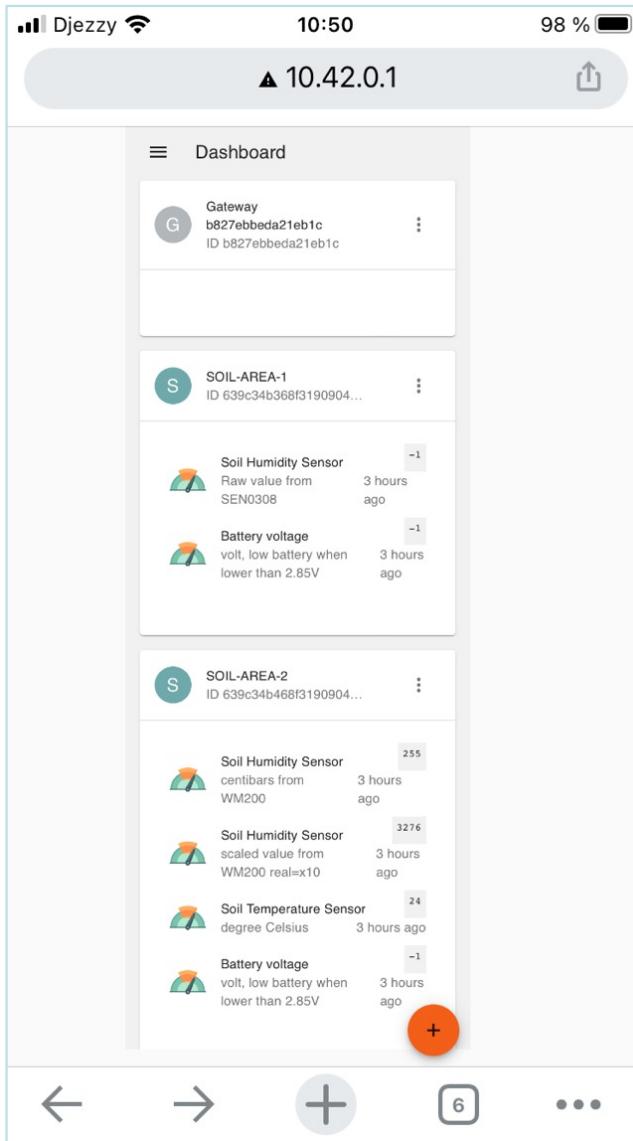
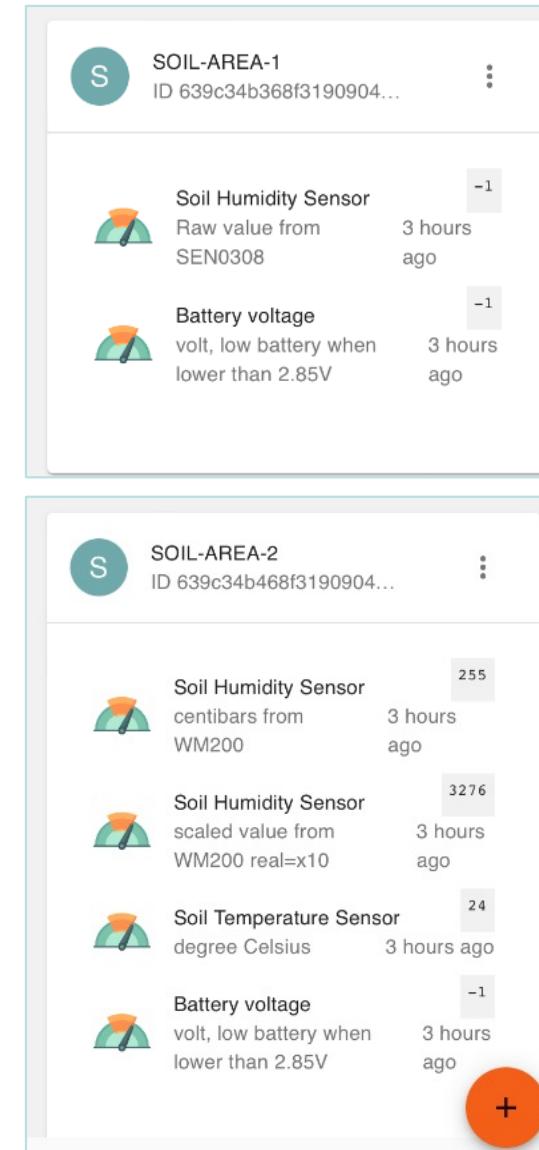
- Use default login to connect
  - User: admin
  - Password: loragateway

# Default WaziGate configuration (1)

- For the starter-kit, the INTEL-IRRIS WaziGate will be ready for
  - 1 capacitive sensor named SOIL-AREA-1 with address 26011DAA
  - 1 tensiometer sensor named SOIL-AREA-2 with address 26011DB1
- Capacitive device will show humidity and battery values
- Tensiometer device will show centibar, raw resistance, soil temperature and battery values



# Default WaziGate configuration (2)

This section shows the WaziGate mobile application interface for two different soil monitoring areas: SOIL-AREA-1 and SOIL-AREA-2.

- SOIL-AREA-1:** Displays two entries:
  - Soil Humidity Sensor: Raw value from SEN0308, value "-1", timestamp "3 hours ago".
  - Battery voltage: volt, low battery when lower than 2.85V, value "-1", timestamp "3 hours ago".
- SOIL-AREA-2:** Displays four entries:
  - Soil Humidity Sensor: centibars from WM200, value "255", timestamp "3 hours ago".
  - Soil Humidity Sensor: scaled value from WM200 real=x10, value "3276", timestamp "3 hours ago".
  - Soil Temperature Sensor: degree Celsius, value "24", timestamp "3 hours ago".
  - Battery voltage: volt, low battery when lower than 2.85V, value "-1", timestamp "3 hours ago".

Each entry includes a small sensor icon and a timestamp indicating when the data was last updated.

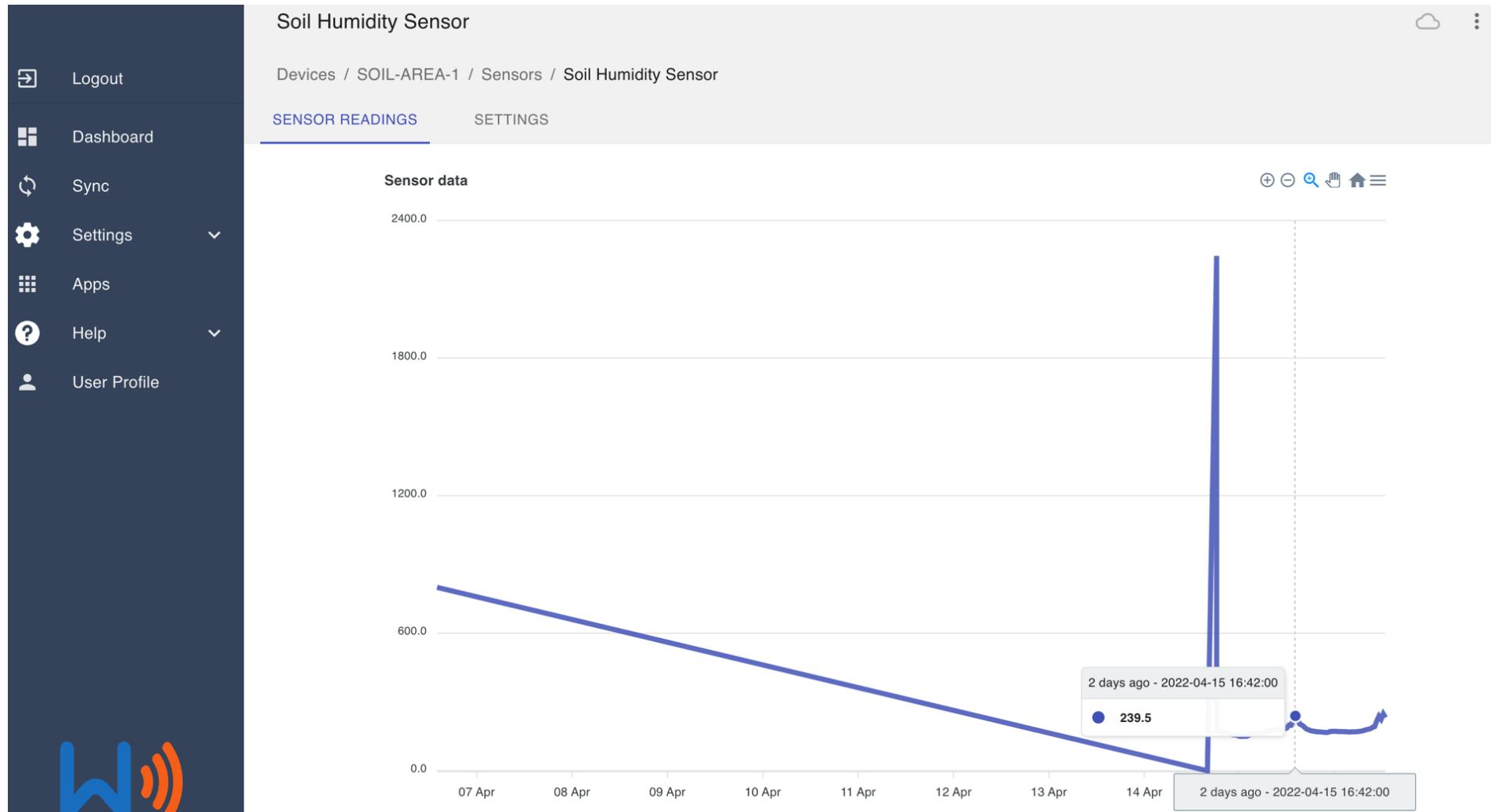
**Default values for the SEN0308 capacitive sensor**



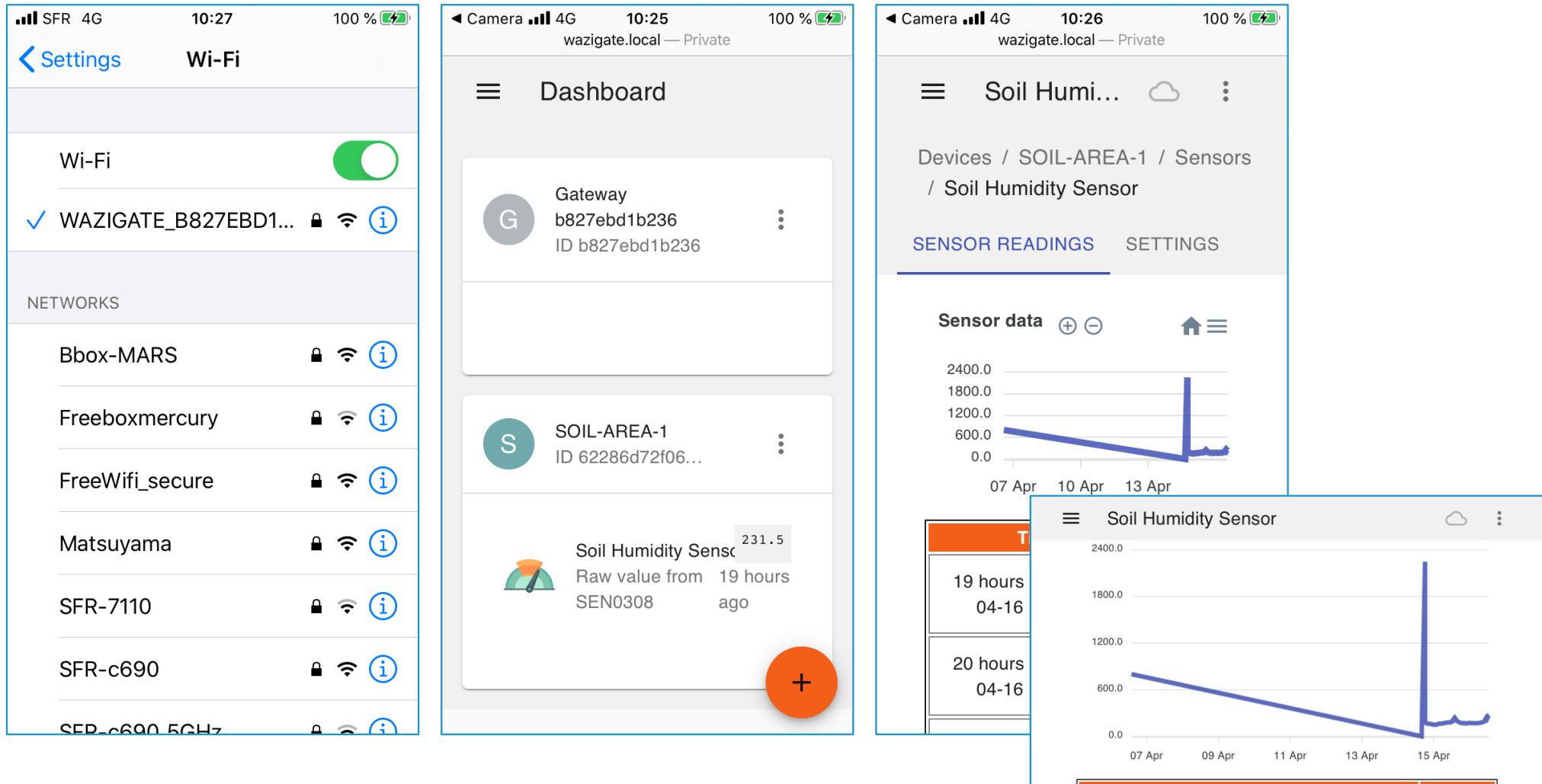
**Default values for the WM200 tensiometer sensor**



# Display sensor data



# All these steps with a smartphone



The figure consists of three mobile application screenshots arranged horizontally.

- Left Screenshot:** Shows the "Wi-Fi" settings screen. The device is connected to "WAZIGATE\_B827EBD1..." with a signal strength of 4G. The time is 10:27 and battery level is 100%. The "Wi-Fi" toggle switch is turned on. Below it, a list of available networks includes "Bbox-MARS", "Freeboxmercury", "FreeWiFi\_secure", "Matsuyama", "SFR-7110", "SFR-c690", and "SFR\_c690\_5GHz".
- Middle Screenshot:** Shows the "Dashboard" screen. The device is connected to "wazigate.local" with a signal strength of 4G. The time is 10:25 and battery level is 100%. It displays two main items: "Gateway" (ID b827ebd1b236) and "SOIL-AREA-1" (ID 62286d72f06...). A large orange "+" button is at the bottom right.
- Right Screenshot:** Shows the "Soil Humi..." screen for "SOIL-AREA-1 / Sensors / Soil Humidity Sensor". The time is 10:26 and battery level is 100%. It shows a "SENSOR READINGS" chart from April 7 to April 15. The chart shows a sharp drop in soil humidity on April 15. Below the chart is a table of raw values:
 

Time	Raw value
19 hours 04-16	231.5
20 hours 04-16	2400.0

# QR code for connecting to WiFi

- The WaziGate WiFi is WAZIGATE\_XXXXXXXXXXXX where XXXXXXXXXXXX is the MAC address of the RPI
- For instance WAZIGATE\_B827EBD1B236
- With the OLED, a QR code for joining the WiFi network is dynamically generated at boot time and displayed for 10s before the main screen so that users can automatically join with a smartphone
- Then, users can scan the static QR code on the WaziGate sticker to connect to the WaziGate's dashboard or the INTEL-IRRIS IIWA App



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

# Be sure that

```
#define TO WAZIGATE
```

# is uncommented

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 ///////////////////////////////////////////////////
41 // sends data to INTEL-IRRIS WaziGate edge-gateway
42 #define TO_WAZIGATE
43
44 ///////////////////////////////////////////////////
45 // Frequency band - do not change in SX127X_RadioSettings.h anymore
46 //#define BAND868
47 //#define BAND900
48 #define BAND433
49
50 ///////////////////////////////////////////////////
51 // Test device
52 //#define TEST_DEVICE_RANDOM
53
54 ///////////////////////////////////////////////////
55 // uncomment to have a soil tensiometer watermark sensor
56 //#define WITH_WATERMARK
57
```

If you use the EU433 band  
make sure that

```
#define BAND433
```

**is the only uncommented  
band option**

Intelirris\_Soil\_Sensor | Arduino 1.8.13

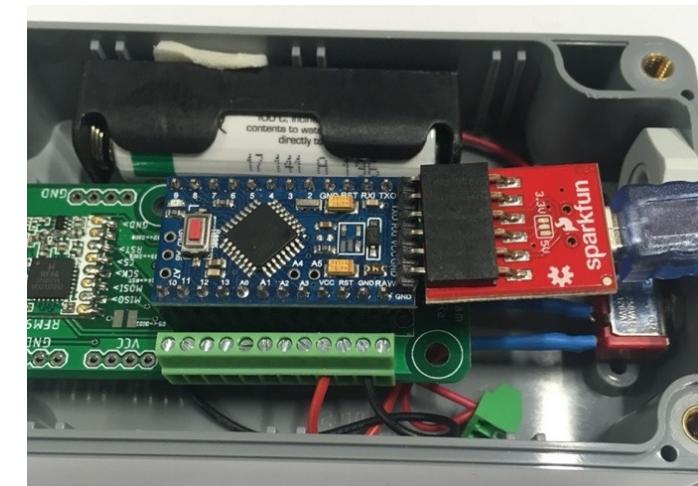
```
Intelirris_Soil_Sensor DS18B20.cpp DS18B20.h RadioSettings.h SX126X_RadioSettings.h SX127X_RadioSettings.h
```

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 | / \v  
33 | | / /  
34 | \ \ \ \ 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/libraries/  
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

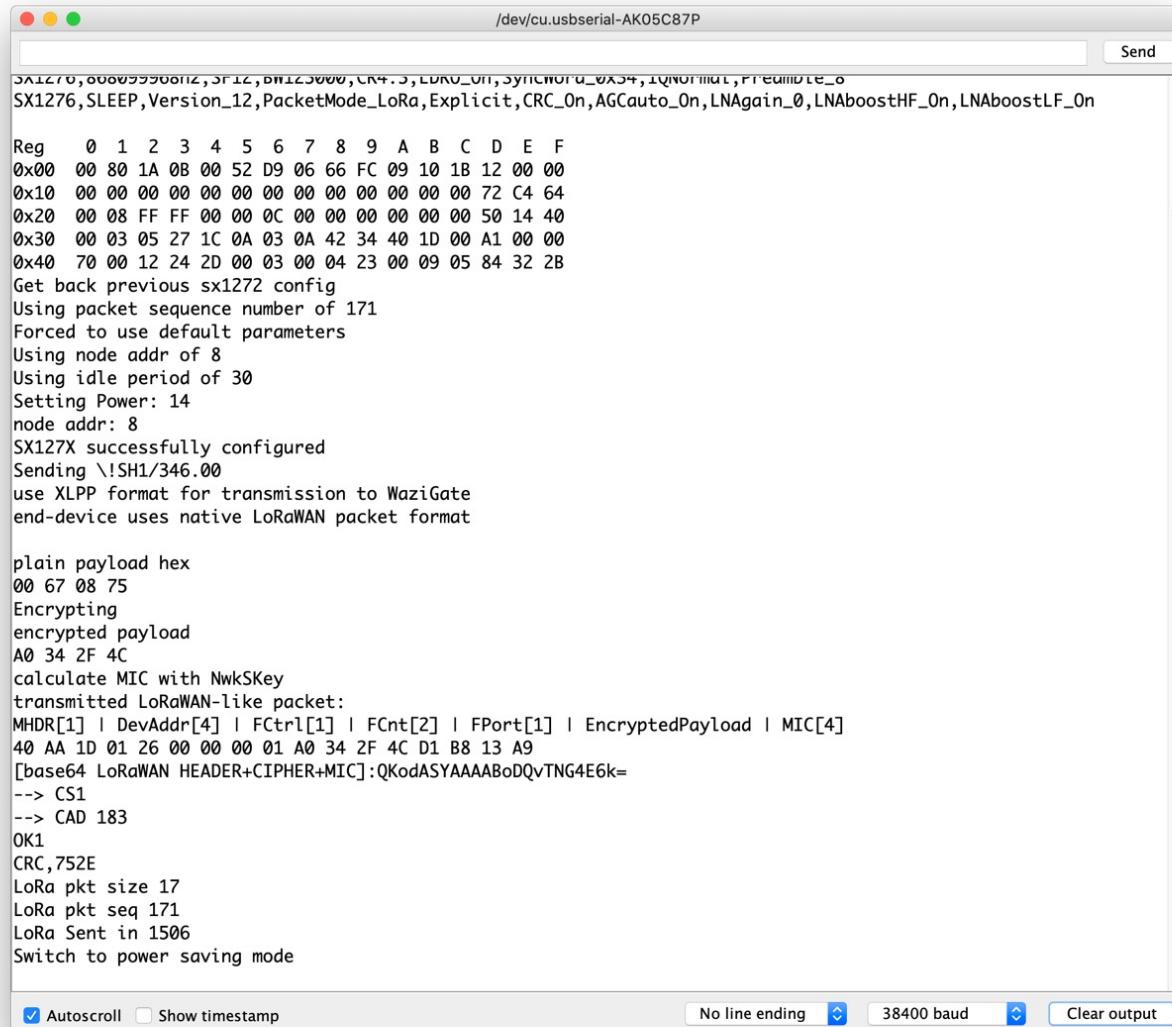
**Click on the "upload" button**



And wait until upload is completed



# Checking that device is operational



```

/dev/cu.usbserial-AK05C87P
Send

SX1276,0000000000000000,3F12,B0123000,CR4.5,LDRU_0H,SYNCH0D_0X34,TQNormal,Preamble_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**

# Transmission to WaziGate



Parameters for  
INTEL-IRRIS WaziGate



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>

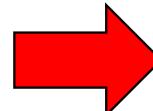


# Check data reception on OLED

YOU CAN ALSO VIEW ON DASHBOARD

Default values for the  
SEN0308 capacitive sensor

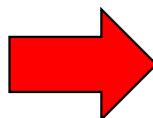
Testing with  
capacitive device



VALUES ARE ONLY INDICATIVE

Default values for the WM200  
tensiometer sensor

Testing with  
tensiometer device



# Soil sensor information on OLED

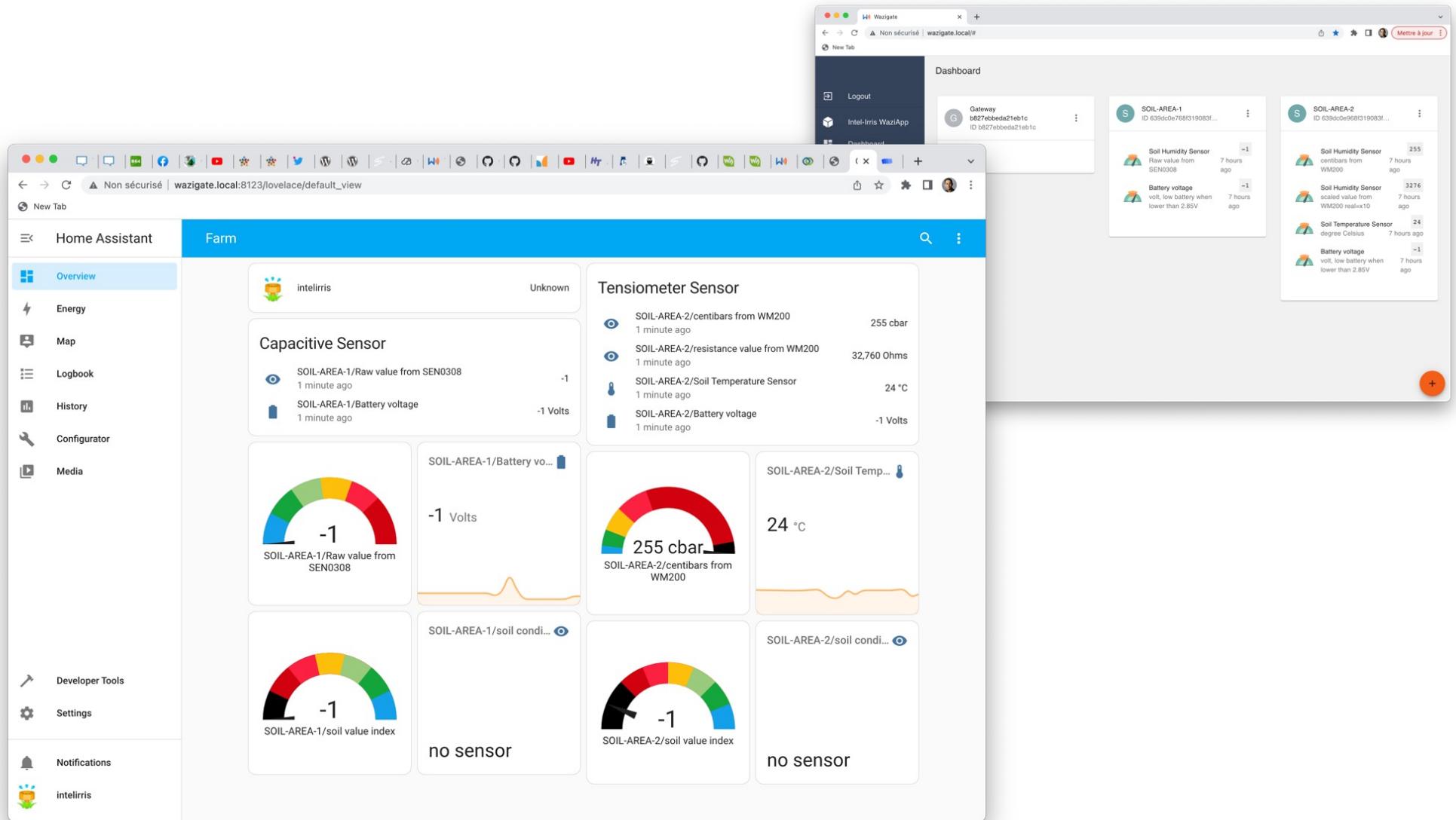
- The OLED displays the latest received sensor data for the end-user: the device name, the time of last received data, the sensor raw value and the soil condition
- The main screen is displayed for 6s every 30s. Then a screen saver display will show a shorter version of these information with a 5-bar visual
- 5 bars: saturated | 4 bars: wet
- 3 bars: wet | 2 bars: dry
- 1 bar: dry | 0 bar: very dry



# Home Assistant integration

- Download the INTEL-IRRIS WaziGate **w/HA integration** SD card image from the project website: <http://intel-irris.eu/results>
- Power & boot your RPI
- When connected to the WaziGate (either with wired Ethernet or through the WaziGate's WiFi), open a web browser and open
  - `http://wazigate.local:8123` if wired Ethernet
  - `http://10.42.0.1:8123` if through WaziGate's WiFi
- The HA login page should appear
  - User: inteliris
  - Password: inteliris
- The HA default dashboard shows the default configuration of the starter-kit
- Of course, the WaziGate default dashboard is still available

# Home Assistant dashboard



The image displays two side-by-side screenshots of a Home Assistant interface. The left screenshot shows the 'Farm' section with a sidebar containing 'Home Assistant', 'Overview', 'Energy', 'Map', 'Logbook', 'History', 'Configurator', and 'Media'. The main area shows a 'Capacitive Sensor' card for 'SOIL-AREA-1' and a 'Tensiometer Sensor' card for 'SOIL-AREA-2'. The right screenshot shows the 'Wazigate' interface with a 'Dashboard' tab, displaying sensor data for 'SOIL-AREA-1' and 'SOIL-AREA-2'.

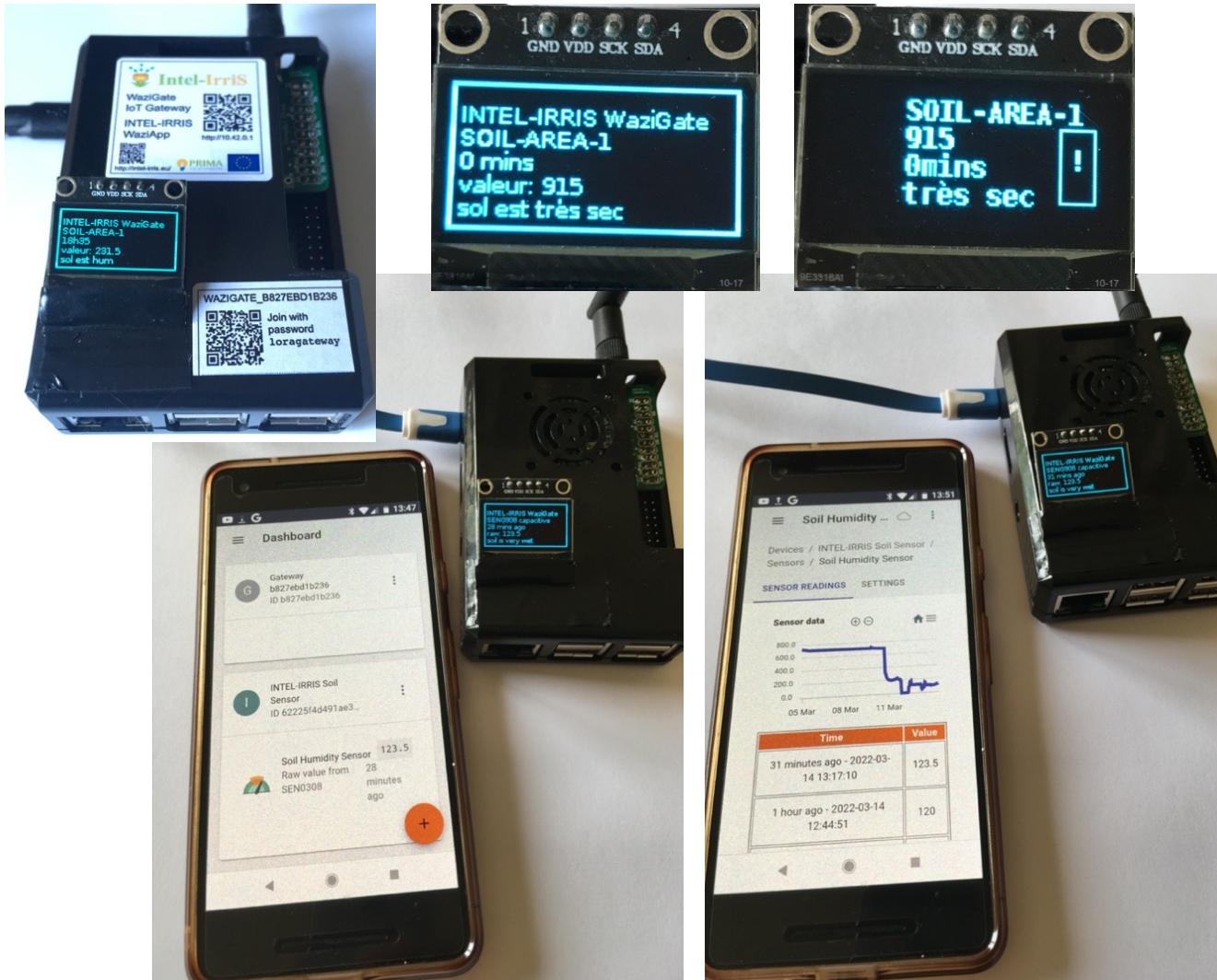
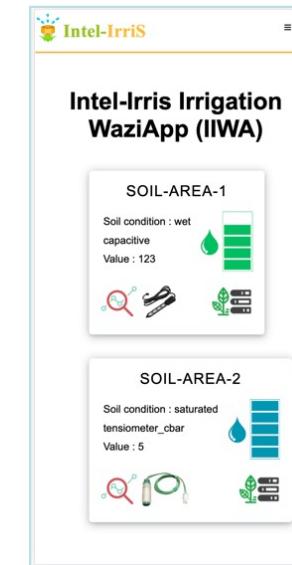
**Farm Overview:**

- Capacitive Sensor (SOIL-AREA-1):**
  - SOIL-AREA-1/Raw value from SEN0308: -1 (1 minute ago)
  - SOIL-AREA-1/Battery voltage: -1 Volts (1 minute ago)
- Tensiometer Sensor (SOIL-AREA-2):**
  - SOIL-AREA-2/centibars from WM200: 255 cbar (1 minute ago)
  - SOIL-AREA-2/resistance value from WM200: 32,760 Ohms (1 minute ago)
  - SOIL-AREA-2/Soil Temperature Sensor: 24 °C (1 minute ago)
  - SOIL-AREA-2/Battery voltage: -1 Volts (1 minute ago)

**Wazigate Dashboard:**

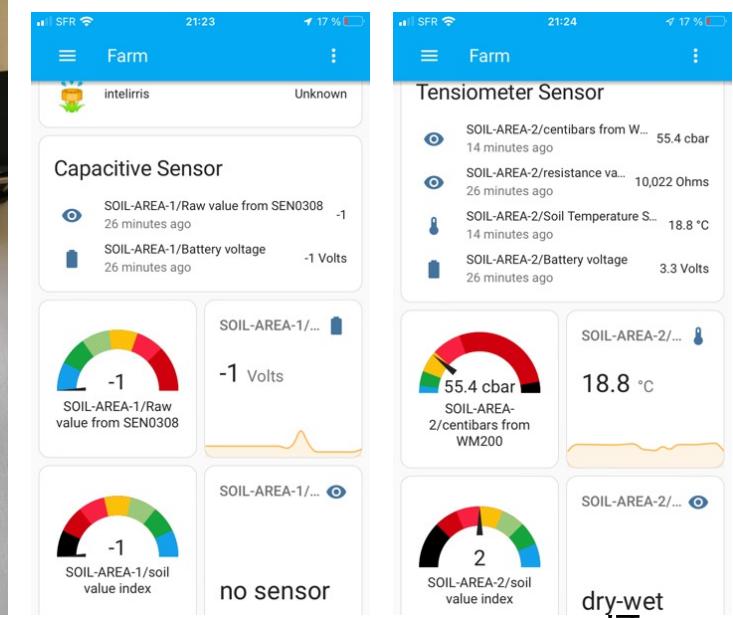
- SOIL-AREA-1:**
  - Soil Humidity Sensor: Raw value from SEN0308 (-1) 7 hours ago
  - Battery voltage: volt, low battery when lower than 2.85V (-1) 7 hours ago
- SOIL-AREA-2:**
  - Soil Humidity Sensor: centibars from WM200 (255) 7 hours ago
  - Soil Humidity Sensor: scaled value from WM200 realxx10 (3276) 7 hours ago
  - Soil Temperature Sensor: degree Celsius (24) 7 hours ago
  - Battery voltage: volt, low battery when lower than 2.85V (-1) 7 hours ago

# Summary of INTEL-IRRIS WaziGate various User Interfaces

**Intel-Irris Irrigation WaziApp (IIWA)**

Area	Condition	Value
SOIL-AREA-1	Soil condition : wet capacitive	Value : 123
SOIL-AREA-2	Soil condition : saturated tensiometer_cbar	Value : 5



**Farm**

**Tensiometer Sensor**

Sensor	Value	Time
SOIL-AREA-2/centibars from WM200	55.4 cbar	14 minutes ago
SOIL-AREA-2/resistance value	10,022 Ohms	26 minutes ago
SOIL-AREA-2/Soil Temperature S...	18.8 °C	14 minutes ago
SOIL-AREA-2/Battery voltage	3.3 Volts	26 minutes ago

**Capacitive Sensor**

Sensor	Value	Time
SOIL-AREA-1/Raw value from SEN0308	-1	26 minutes ago
SOIL-AREA-1/Battery voltage	-1 Volts	26 minutes ago

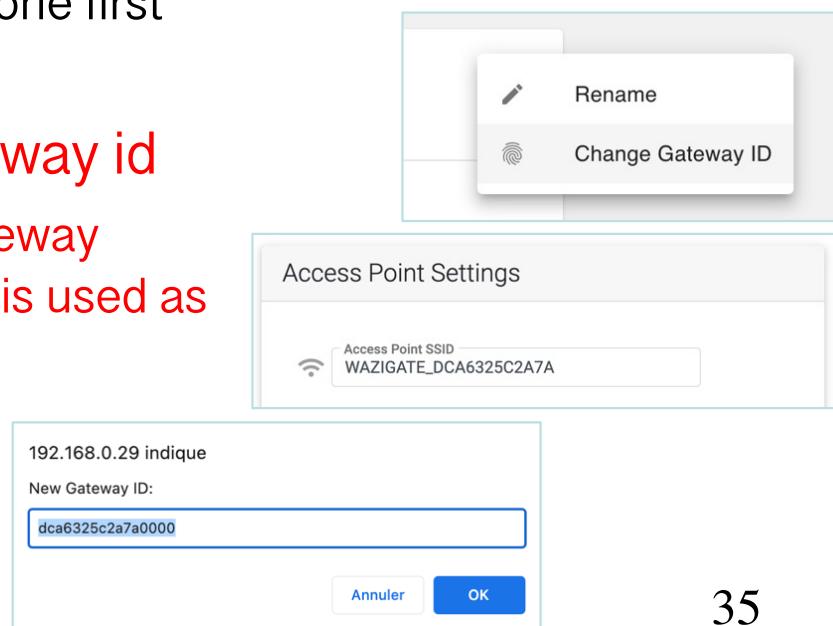
**SOIL-AREA-1/soil value index**

Index	Value
SOIL-AREA-1/soil value index	2
SOIL-AREA-2/soil value index	dry-wet

# Advanced configuration

## Synching your WaziGate to the cloud

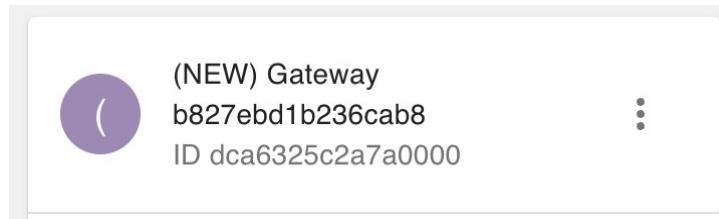
- If you want to sync your WaziGate to the Waziup Cloud, look at this tutorial page
  - <https://www.waziup.io/documentation/wazigate/v2/install/#registration-with-the-cloud>
- You will need an account on Waziup Cloud dashboard
  - If you don't have one, you need to create one first
  - <https://dashboard.waziup.io/>
- Then, you NEED to change your gateway id
  - Use the unique MAC address of your gateway that appears in Settings/Configuration (it is used as your gateway's WiFi hotspot)
  - Here: DCA6325C2A7A
  - Add 0000 at the end to have 16 digits
  - -> DCA6325C2A7A0000



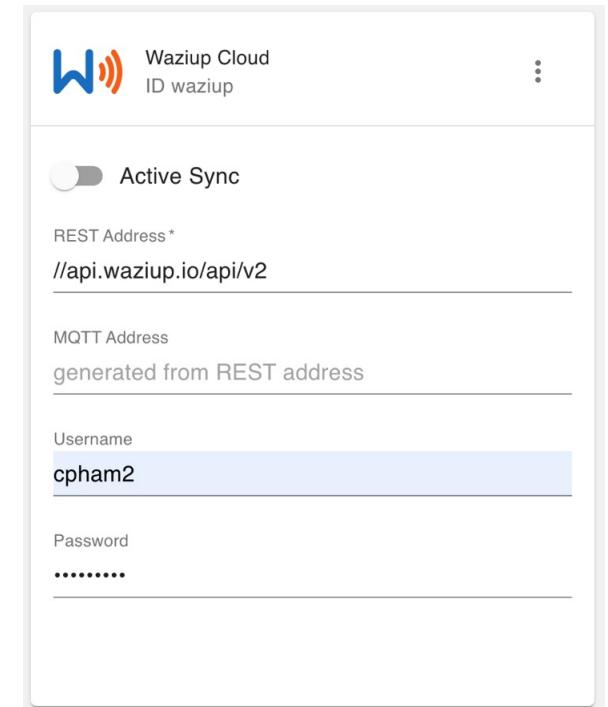
# Advanced configuration

Synching your WaziGate to the cloud, con't

- You should have a new gateway on your dashboard with the new ID



- Enter your Waziup Cloud credentials in the Sync menu
- Then, just activate sync on your WaziGate which needs to be connected to Internet
- Log in the Waziup Cloud dashboard and check that you see your gateway and your device
- You can activate/deactivate synchronization at anytime



# Advanced configuration

## MQTT integration from WaziCloud

- With sensor data on WaziCloud, it is possible to subscribe to those data with MQTT protocol
- With command line `mosquitto_sub`
  - `mosquitto_sub`  
`-L "mqtt://api.waziup.io/devices/<deviceID>/sensors/<sensorID>/value"`
  - `mosquitto_sub`  
`-h api.waziup.io -t devices/<deviceID>/sensors/<sensorID>/value`
- With other MQTT integration client/platform
  - Host: `api.waziup.io`
  - Topic: `devices/<deviceID>/sensors/<sensorID>/value`
- Output
  - `{ "value": 34, "timestamp": "2022-12-23T10:23:54Z" }`

# Advanced configuration

## MQTT integration – MQTT client on a smartphone

- ➊ Example with an MQTT client (EasyMQTT) on an iPhone7

