

**waag**  
technology & society

# Hollandse Luchten

## Technische cursus

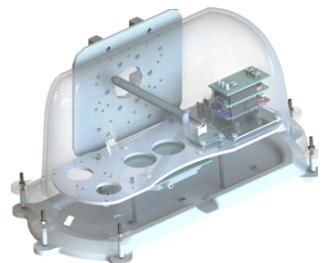
Emma Pareschi, hardware developer  
06 March 2020



## Agenda

- Explanation of the basic and extended sensors?
- Debug and How can you tell if a sensor is working?
- Repository of the HoLu kit.

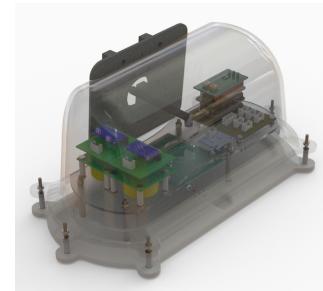
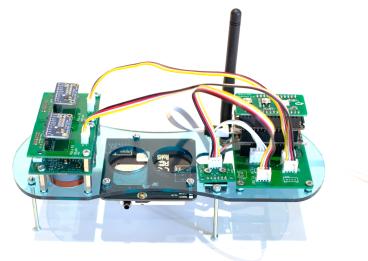
**HoLu kit BASIC**



**It is provided as a kit  
that must be assembled.**

**It measures:**  
- PM2.5  
- PM10

**HoLu kit EXTENDED**



**It is already assembled.**

**It measures:**  
- PM2.5  
- PM10  
- temp/hum  
- NO2  
- O3

## Sensors - PM sensor VS Gas sensor

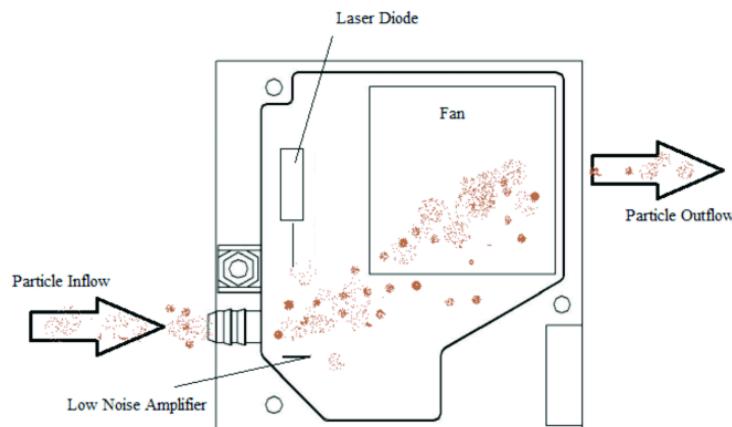


It has its own software that send the PM concentration, it uses Serial Communication.



It generates a small electric signal, the microcontroller read the signal. We integrated extra hardware, ADC, to be able to read this small signal (few mV). It uses I2C communication.

## Sensors - why the gas sensors are so different from the SDS011?



Principle of laser scattering

### AAN 104      How Electrochemical Gas Sensors Work

Alphasense toxic gas sensors are electrochemical cells that operate in the amperometric mode. That is, they generate a current that is linearly proportional to the fractional volume of the toxic gas, such as CO or H<sub>2</sub>S. Figure 1 shows schematically the structure of a toxic gas sensor.

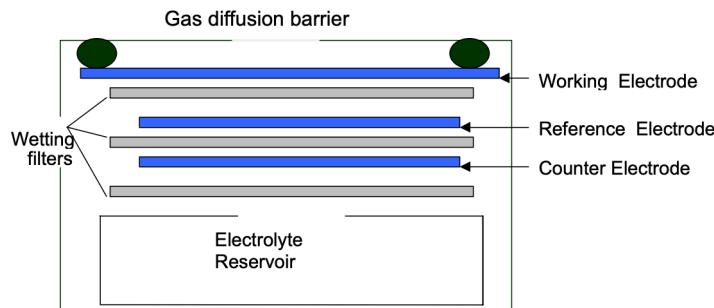


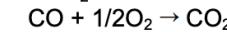
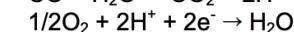
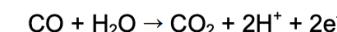
Figure 1. Schematic diagram of electrochemical toxic gas sensor. Three metal strips connect each electrode to the three pins outside of the sensor body.

Electrochemical cell.

Working electrode

Counter electrode

The overall cell reaction is:



## Sensors - life time - PM sensor



Nova Fitness Co., Ltd.

SDS011 sensor

### About service life

Service life is the key parameter of laser dust sensor. The laser diode in this sensor has high quality and its service life is up to 8000 hours. If you need real-time data (such as detector), you can use the default configuration that measures at the frequency of 1time per second. On the occasion of real-time demand is not high (such as filter, air quality monitoring, etc.), you can use the discontinuous working method to prolong the service life. For example, you can start the sensor for 30 seconds per minutes. If you have any other requirements, please contact us, we are willing to serve for manufacturers and developers.

Datasheet: <https://cdn-reichelt.de/documents/datenblatt/X200/SDS011-DATASHEET.pdf>

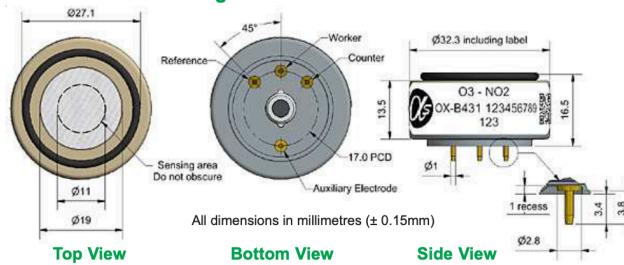
## Sensors - life time - gas sensor

### OX-B431 Oxidising Gas Sensor Ozone + Nitrogen Dioxide 4-Electrode



Patented

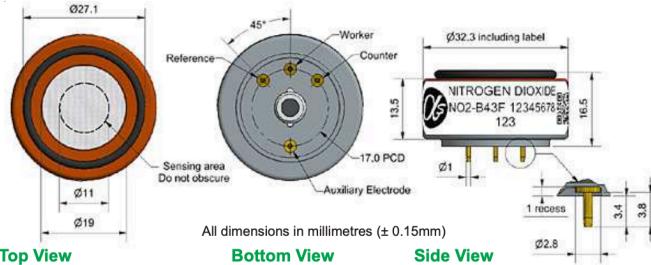
Figure 1 OX-B431 Schematic Diagram



### NO2-B43F Nitrogen Dioxide Sensor 4-Electrode



Figure 1 NO2-B43F Schematic Diagram



#### LIFETIME

Zero drift  
Sensitivity drift  
Operating life

ppb equivalent change/year in lab air  
% change/year in lab air, monthly test  
months until 50% original signal (24 month warranted)

0 to 20  
-20 to -40  
> 24

#### Datasheets:

<http://www.alphasense.com/WEB1213/wp-content/uploads/2019/09/NO2-B43F.pdf>

<http://www.alphasense.com/WEB1213/wp-content/uploads/2019/09/OX-B431.pdf>

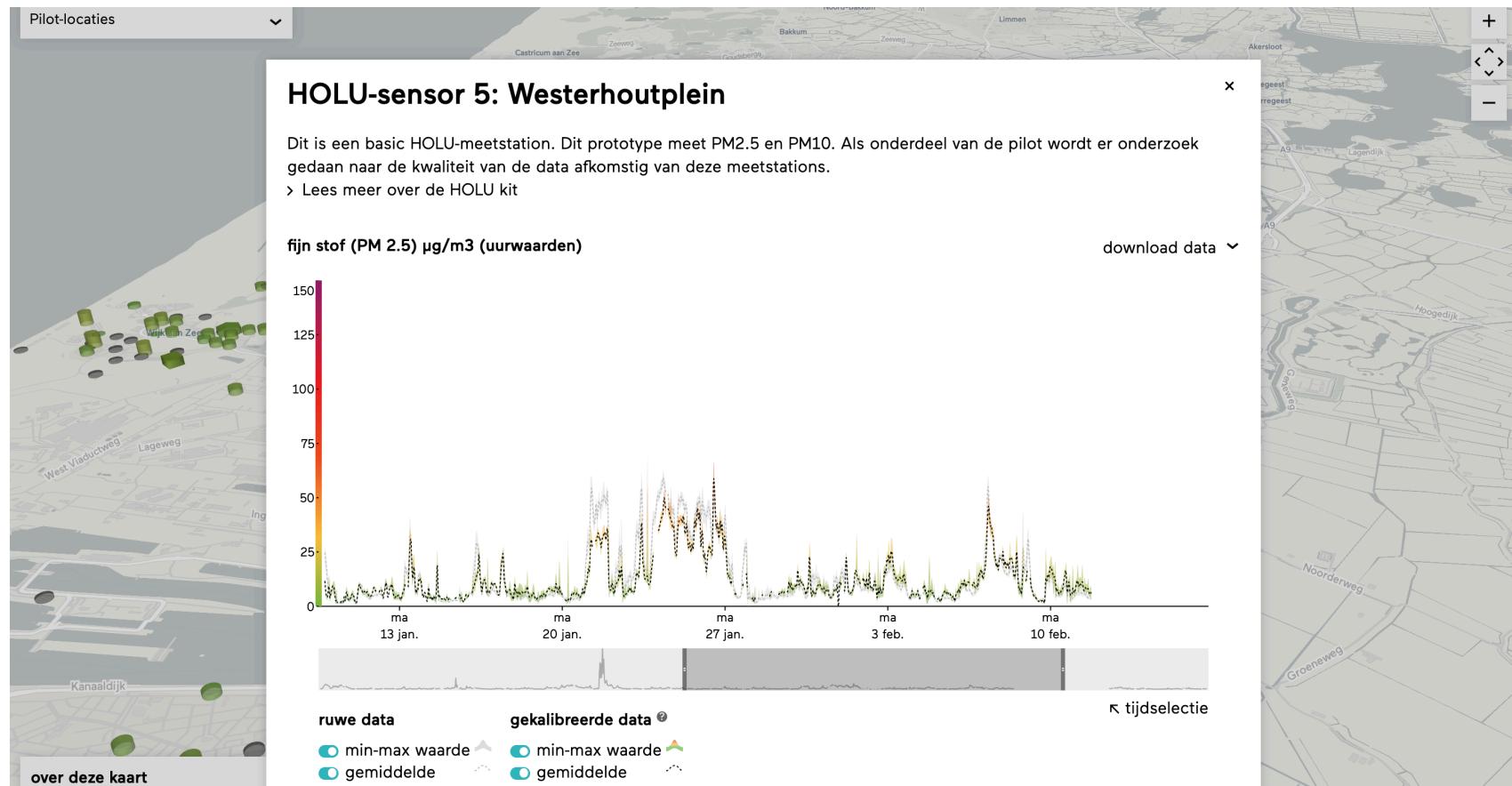
## Sensors - calibration of the gas sensors



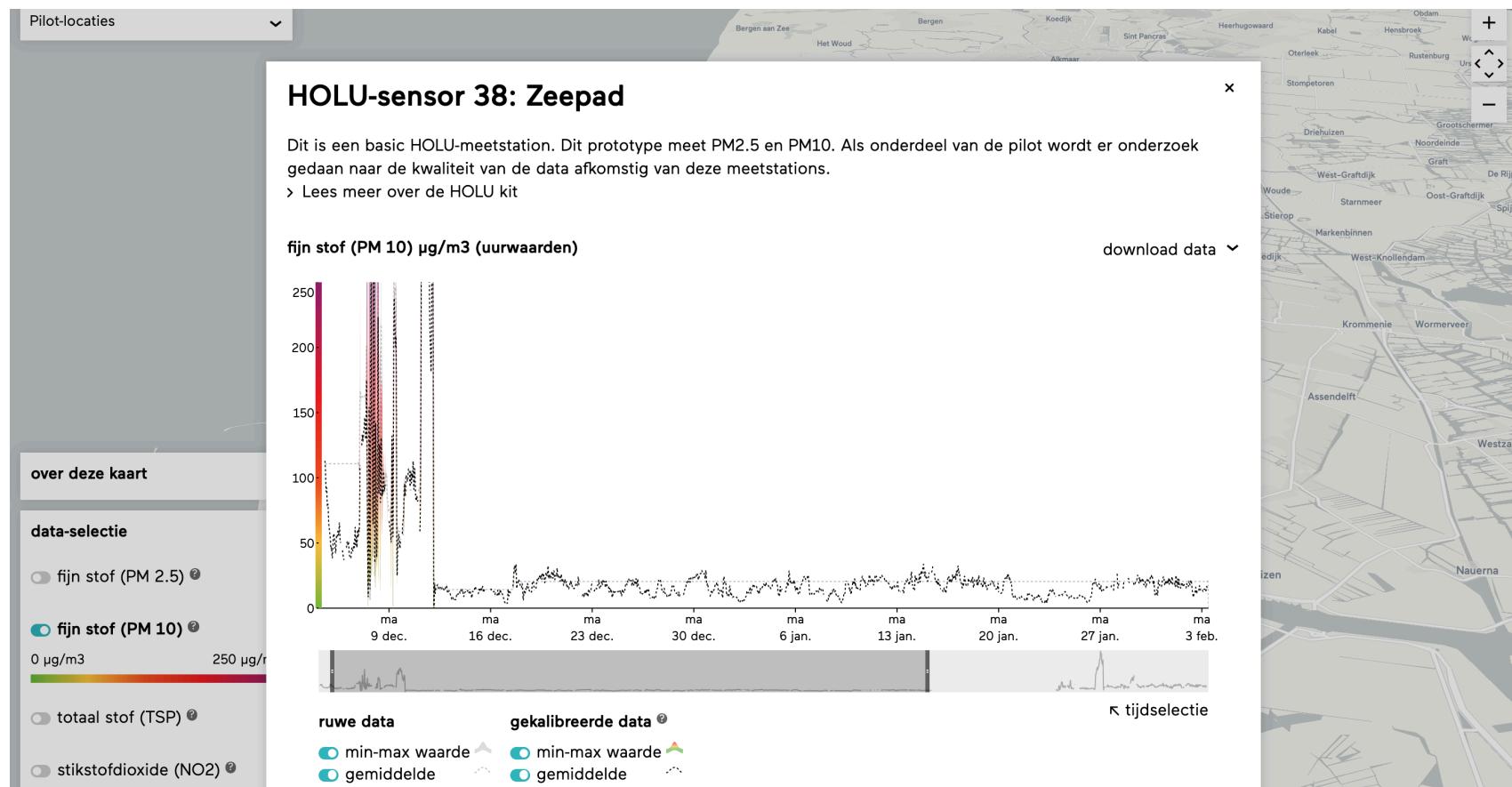
**trouble #0** - The HoLu kit doesn't show any light.



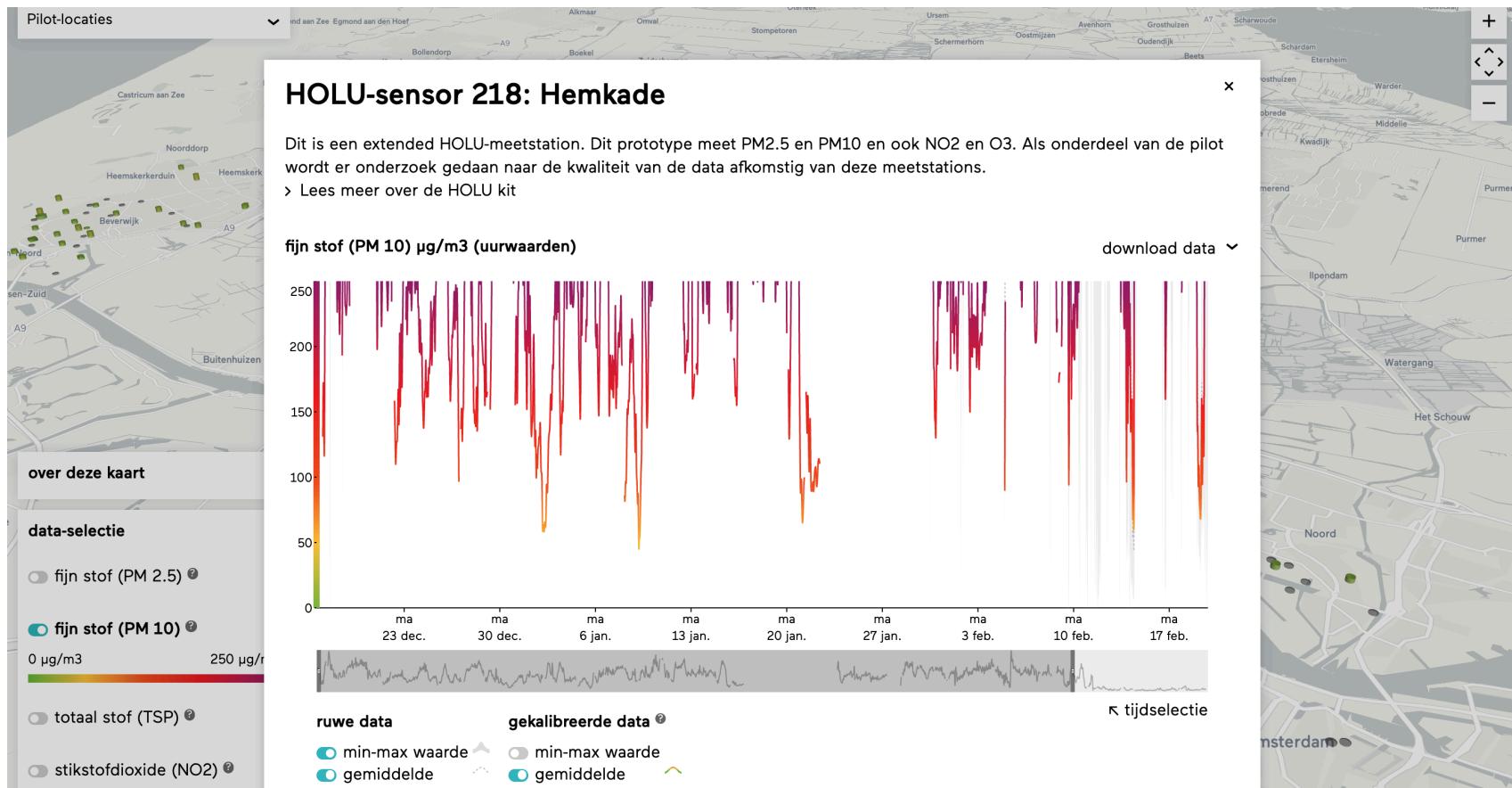
## trouble #1 - The HoLu kit was online and now it is not.



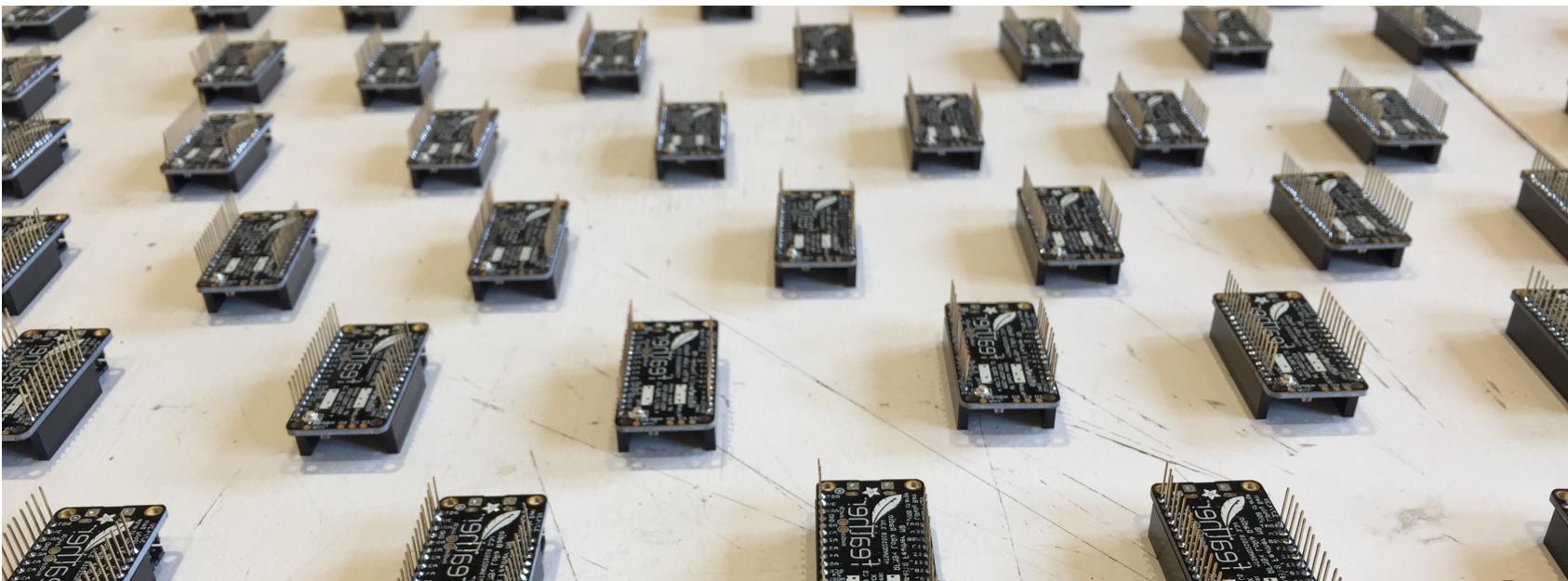
## trouble #2 - The data of the HoLu kit is unreadable.



## trouble #2 - The data of the HoLu kit is unreadable.



## **DEBUG PROCESS**



- 1) Reset the kit**
- 2) Debug power issues**
- 3) Visual Inspection**
- 4) Computer Inspection**

**action #1. Reset the Kit**



Approach the power cable.



Unplug the USB cable.



Plug the USB cable again.

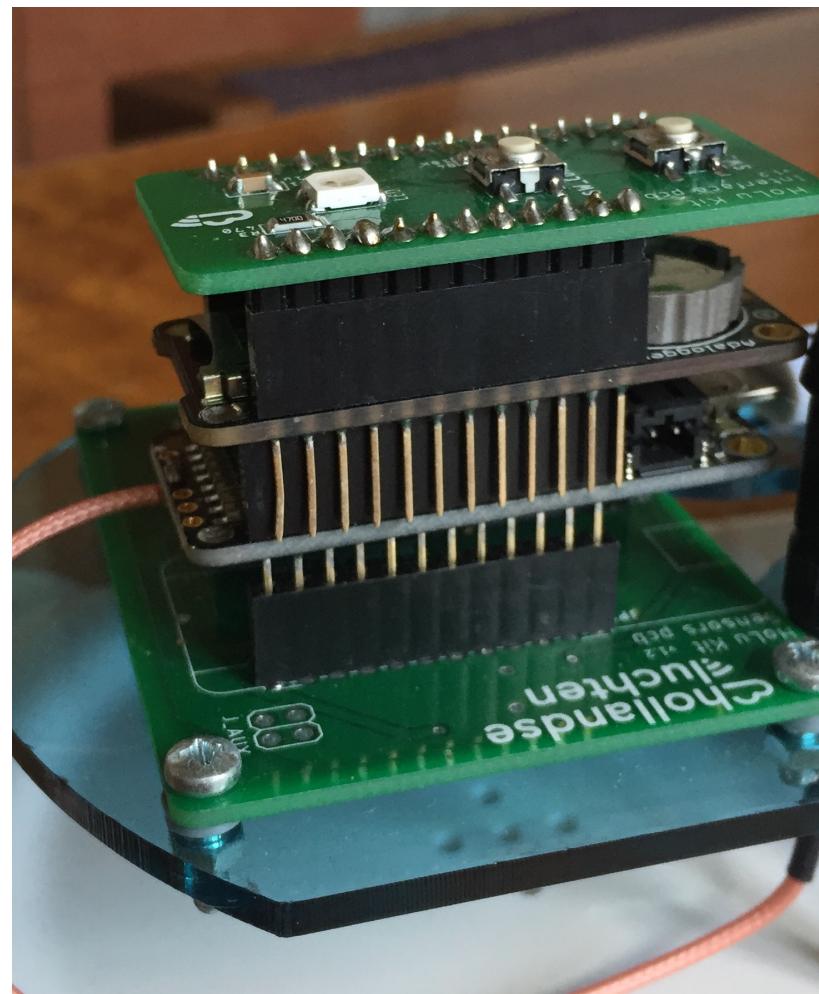
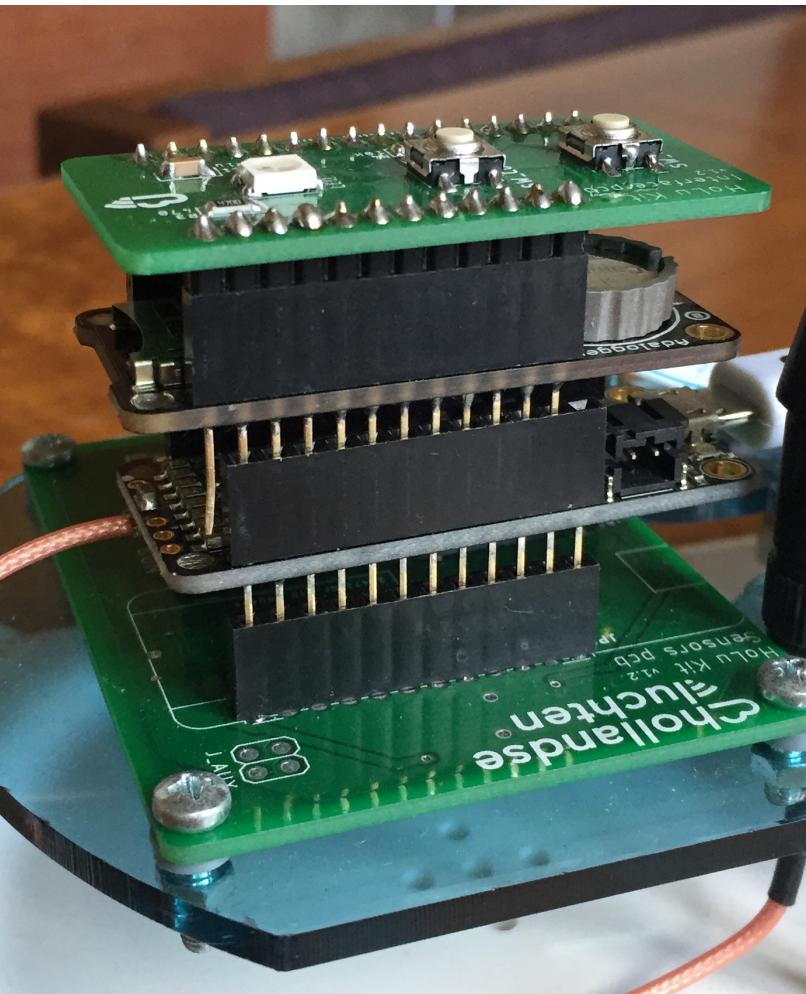
## **action #2.** Debug power issue

In some cases, the cable and/or the wall USB adapter were damaged, even tough the kit looked powered, with the light ON. The only way to discover such a bug, is to replace the parts.

I suggest to use a different cable and/or a different adapter. You can also use the USB port of your computer.

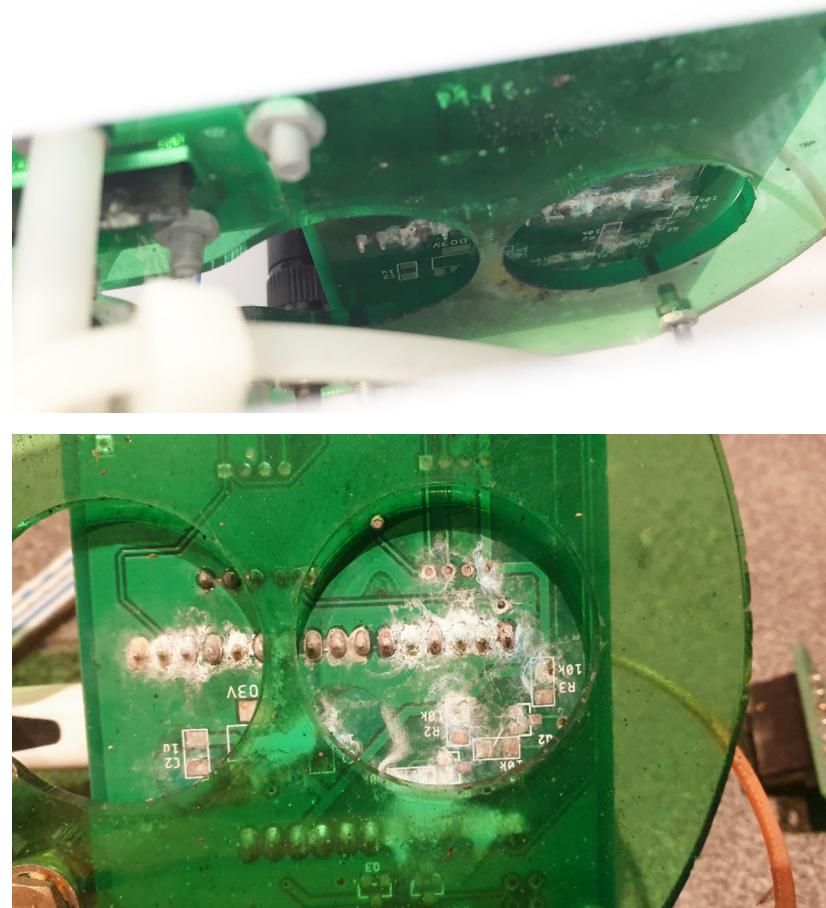


**action #3. Visual Inspection**



#### **action #4. Visual Inspection**

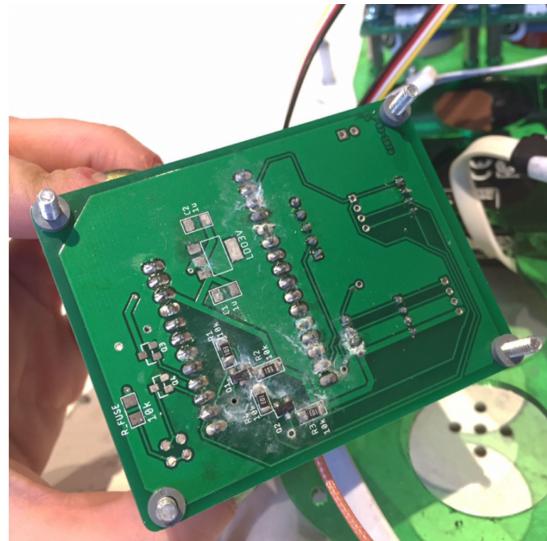
Mostly in Jimond Regio, after few weeks in the field, the electronic boards showed such degradation, oxidation and salt.  
This can cause the wrong functionality of the kit.



#### **action #4. Visual Inspection**

It is possible to clean the electronic board with a brush.

To reduce this risk it happens again, it is helpful to protect the boards with an isolating product, nail polish or silicon based product .



## action #5. Computer Inspection

### 1 - Preparation of the computer

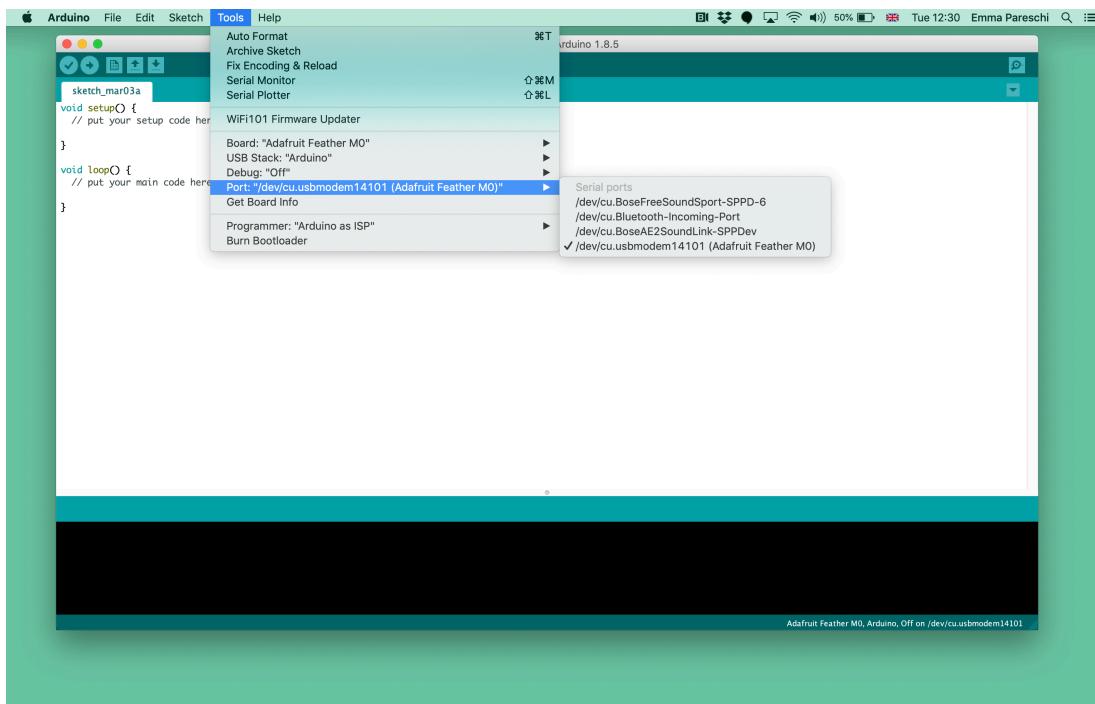
Download and install the last stable version of the software Arduino IDE.

To download: <https://www.arduino.cc/en/main/software>

Set-up the Arduino IDE for the Adafruit Feather M0:

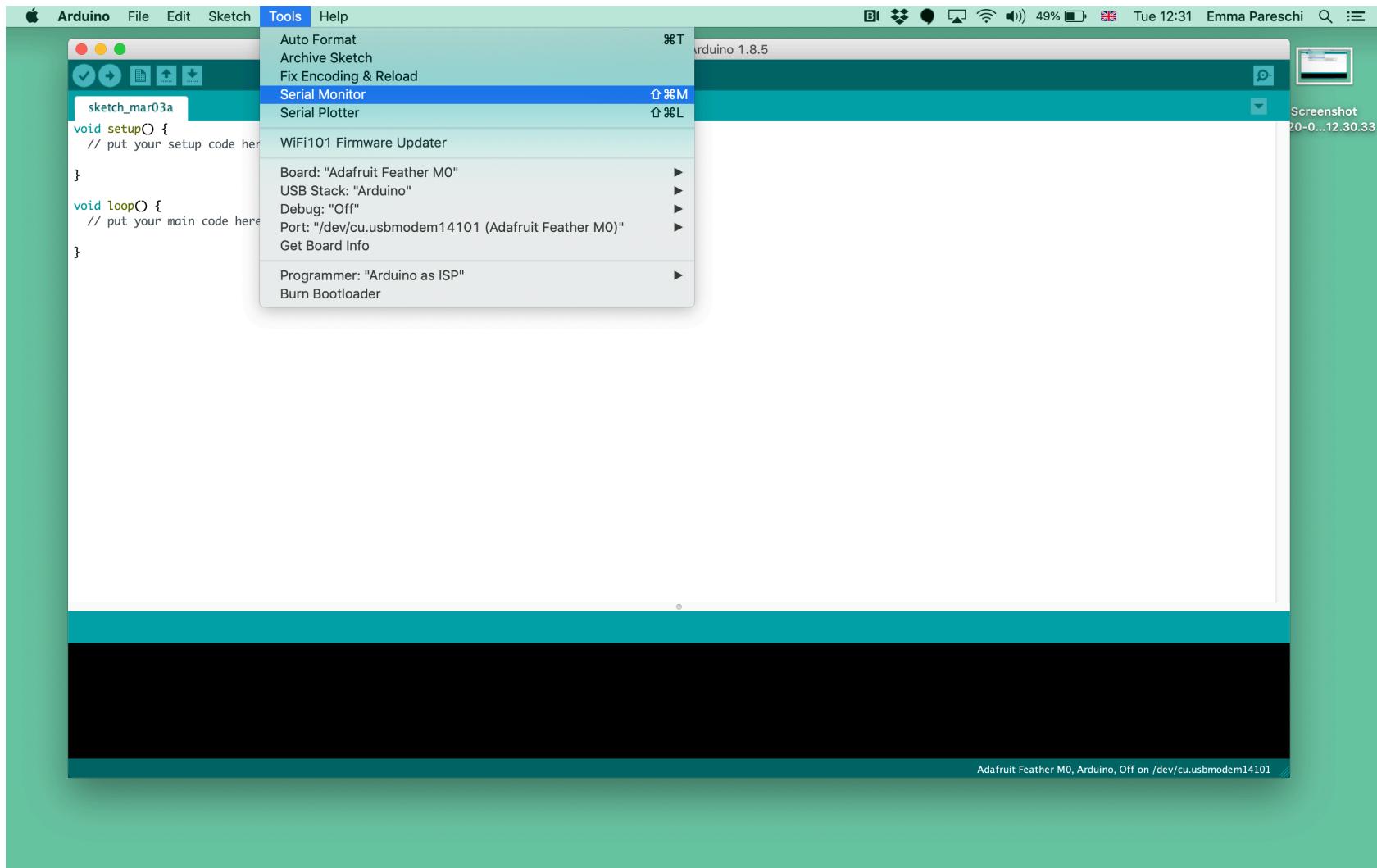
- follow this instructions: <https://learn.adafruit.com/adafruit-feather-m0-basic-proto/setup>
- follow this instructions until "Install Adafruit SAMD" paragraph: <https://learn.adafruit.com/adafruit-feather-m0-basic-proto/using-with-arduino-ide>. If you use Windows, you also need drivers, look at "Install Drivers (Windows 7 & 8 Only)" section.

### 2 - Open Arduino IDE, plug the USB cable of the HoLu kit and select the port in Arduino IDE



## action #5. Computer Inspection

### 3 - Open the Serial Monitor



## action #5. Computer Inspection

### 4 - Read the Serial Monitor

The screenshot shows the Arduino IDE interface on a Mac OS X desktop. The main window displays the serial monitor output for the sketch `sketch_mar03a`. The output shows the following information:

```
Starting
Holu kit v1.2
code version: 2.00
device ID: 185
Connected sensors:
-> sds011: pm25, pm10
-> bme280: temp, hum
-> NO2 alphasense
-> O3 alphasense

****CARD*****
card initialized.
file name: data147.txt
header: DeviceID, Timestamp, PM2.5, PM10, Temp (C), Humidity (%), NO2 op1, NO2 op2, O3 op1, O3 op2

RTC ready:
2020/3/3 - 11:38:8

****BME280*****
bme ready.
Temp: 22.69
Hum: 34.71

****ALPHA NO2*****
no2 sensor ready?
no2a: 1190
no2b: 1128

****ALPHA O3*****
o3 sensor ready?
o3a: 1529
o3b: 1636

Packet queued
738268: EV_JOINING
    ECOUNT SEC= 1
    ECOUNT SEC= 2
    ECOUNT SEC= 3
    ECOUNT SEC= 4
    ECOUNT SEC= 5
    ECOUNT SEC= 6
Board at /dev/cu.usbmodem14101
1184317: EV_JOINED
1367053: EV_TXCOMPLETE (includes waiting for RX windows)
    ECOUNT SEC= 7

Autoscroll You've pressed Send but nothing was sent. Should you select a line ending? No line ending 9600 baud Clear output
```

The Arduino IDE sidebar shows recent screenshots and the serial port list, which includes the board connected at `/dev/cu.usbmodem14101`.

## action #5. Computer Inspection

If everything runs smoothly this is what you should see:

```
Starting
HoLu kit v1.2
code version: 2.00
device ID: 185
Connected sensors:
-> sds011: pm25, pm10
-> bme280: temp, hum
-> NO2 alphasense
-> O3 alphasense

***CARD*****
card initialized.
file name: data147.txt
header: DeviceID, Timestamp, PM2.5, PM10, Temp (C), Humidity (%), NO2 op1, NO2 op2, O3 op1, O3 op2

RTC ready:
2020/3/3 - 11:38:8

***BME280*****
bme ready.
Temp: 22.69
Hum: 34.71

***ALPHA NO2*****
no2 sensor ready?
no2a: 1190
no2b: 1128

***ALPHA O3*****
o3 sensor ready?
o3a: 1529
o3b: 1636

Packet queued
738268: EV_JOINING
    ECOUNT SEC= 1
    ECOUNT SEC= 2
    ECOUNT SEC= 3
    ECOUNT SEC= 4
    ECOUNT SEC= 5
    ECOUNT SEC= 6

1184317: EV_JOINED
1367053: EV_TXCOMPLETE (includes waiting for RX windows)
    ECOUNT SEC= 7
PM2.5 = 3.30
PM10 = 6.60
Day: 2020 3 3
Time: 11 38 27
```

Annotations pointing to specific log entries:

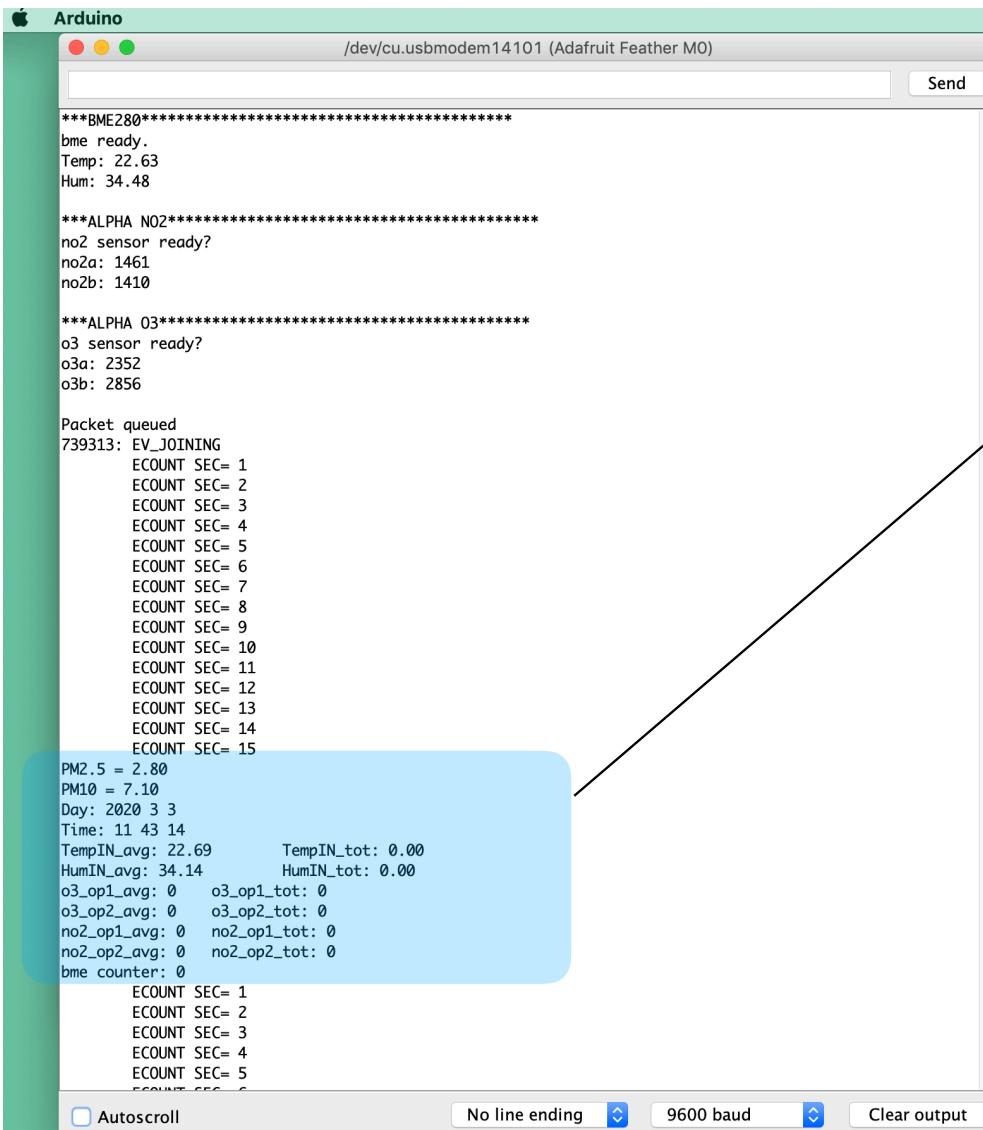
- A blue callout points to the BME280 sensor section: "Temp/Hum sensor".
- A blue callout points to the NO2 sensor section: "Gas sensors".
- A green callout points to the "EV\_JOINING" event: "Request to join the network".
- A green callout points to the "EV\_JOINED" event: "Request has been accepted!!!!".

Terminal window controls at the bottom:

- Autoscroll (unchecked)
- You've pressed Send but not... (red text)
- No line ending
- 9600 baud
- Clear output

## action #5. Computer Inspection

If there is not network



The screenshot shows the Arduino Serial Monitor window titled "Arduino" connected to "/dev/cu.usbmodem14101 (Adafruit Feather M0)". The monitor displays sensor data in three sections:

- BME280 Data:**  
bme ready.  
Temp: 22.63  
Hum: 34.48
- ALPHA NO2 Data:**  
no2 sensor ready?  
no2a: 1461  
no2b: 1410
- ALPHA O3 Data:**  
o3 sensor ready?  
o3a: 2352  
o3b: 2856

Below these sections, the message "Packet queued" is followed by a series of ECOUNT values from 1 to 15. A blue callout box highlights the PM2.5 and PM10 measurements:

```
PM2.5 = 2.80
PM10 = 7.10
Day: 2020 3 3
Time: 11 43 14
TempIN_avg: 22.69      TempIN_tot: 0.00
HumIN_avg: 34.14      HumIN_tot: 0.00
o3_op1_avg: 0          o3_op1_tot: 0
o3_op2_avg: 0          o3_op2_tot: 0
no2_op1_avg: 0          no2_op1_tot: 0
no2_op2_avg: 0          no2_op2_tot: 0
bme counter: 0
    ECOUNT SEC= 1
    ECOUNT SEC= 2
    ECOUNT SEC= 3
    ECOUNT SEC= 4
    ECOUNT SEC= 5
    ECOUNT SEC= 6
    ECOUNT SEC= 7
    ECOUNT SEC= 8
    ECOUNT SEC= 9
    ECOUNT SEC= 10
    ECOUNT SEC= 11
    ECOUNT SEC= 12
    ECOUNT SEC= 13
    ECOUNT SEC= 14
    ECOUNT SEC= 15
```

At the bottom of the monitor, there are buttons for "Autoscroll", "No line ending", "9600 baud", and "Clear output".

Every three minutes you will see this block of text. In here you see the PM2.5 and PM10 measurements received by the sensor.

## REPO

Screenshot of a GitHub repository page for `waagsociety / holu-kit-20`.

The repository statistics are:

- 19 commits
- 1 branch
- 0 packages
- 0 releases
- 2 contributors

The latest commit was made by `EmmaPareschi` 1 minute ago.

The repository contains the following files:

- BOM
- External Casing
- Internal Hardware
- Presentations
- Software
- Images
- .gitignore
- README.md

The `README.md` file contains the following content:

## holu-kit-20

Hollandse Luchten sensor kit, version 2.0.



This repo has the scope to host the source files of the HoLu kit v2. In the repo there are:

- sketches for basic and extended HoLu kit
- 3D model of the case
- pcb files and images
- BOM

Some extra information:

- Assembling manual of the HoLu kit: [https://hollandseluchten.waag.org/wp-content/uploads/sites/9/HOLU\\_manual\\_English.pdf](https://hollandseluchten.waag.org/wp-content/uploads/sites/9/HOLU_manual_English.pdf)
- Parts descriptions: <https://hollandseluchten.waag.org/holu-sensorkit/>
- Troubleshooting: <https://hollandseluchten.waag.org/veelgestelde-vragen/>

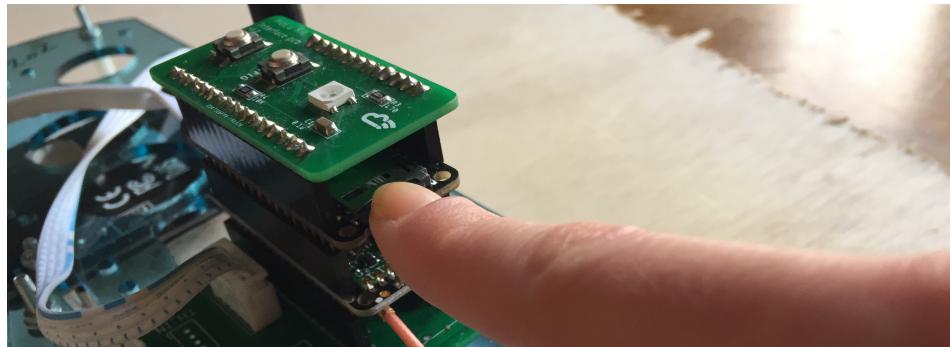


## Agenda

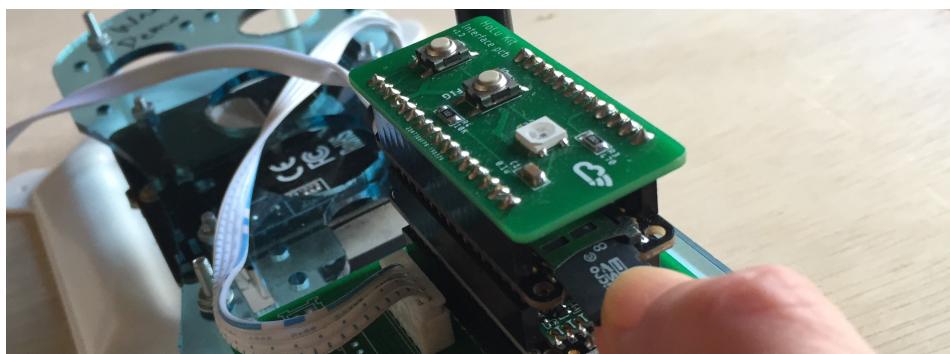
- SD card, how to collect the data
- HoLu kit and the Map

## SD card - extraction

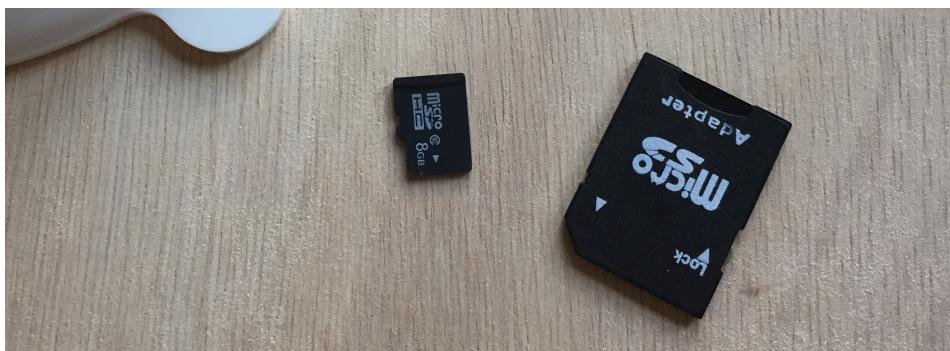
Push on the side of the SDcard.  
It will do a click.



Remove SD card from the holder.



Use the adapter provided with  
the HoLu kit to download the  
data.



## **SD card - files**

The SD card can be read as an USB stick and contains the text files.

The files are named as "data###.txt" where ### is a number.

Every time the kit is powered-on a new file is generated, following a decrescent number annotation. For example:

data001.txt  
data002.txt  
data003.txt  
data004.txt

The files are text with comma separated values format.

The measurements saved in the SD card are the raw data collected by the sensors, no calibration is applied and they are saved every 3 minutes.

In the basic HoLu kit the data are saved as following:

DeviceID, Timestamp, PM2.5, PM10, Temp (C), Humidity (%)  
202,2019:12:4/17:35:32,10.60,15.10,0.00,0.00  
202,2019:12:4/17:38:33,9.40,13.90,0.00,0.00

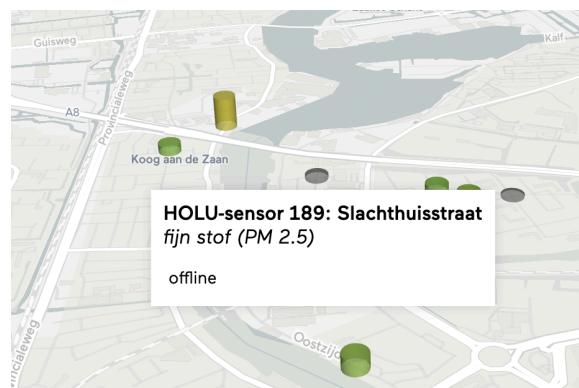
In the extended HoLu kit the data are saved as following:

DeviceID, Timestamp, PM2.5, PM10, Temp (C), Humidity (%), NO2 op1, NO2 op2, O3 op1, O3 op2  
185,2019:12:17/16:34:44,2.80,5.70,21.53,43.17,0,0,0,0  
185,2019:12:17/16:37:44,2.70,6.20,21.63,42.75,979,592,1556,1357  
185,2019:12:17/16:40:44,2.50,4.90,21.69,42.35,1107,932,1393,1279

## The map and the HoLu kit

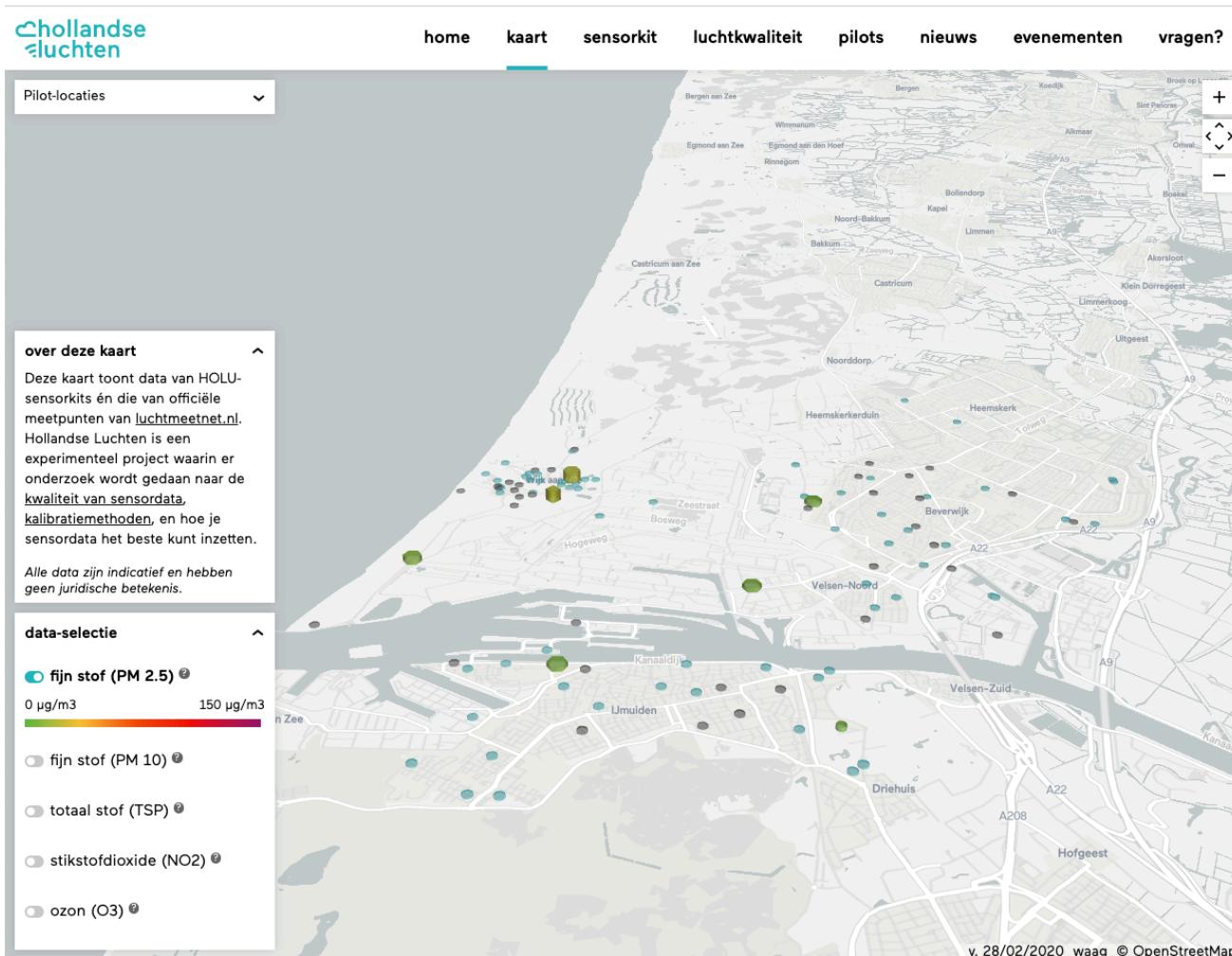


When the kit joins to the network, the light in the HoLu kit turns green and on the map you will visualise your kit as a transparent light blue. The light blue means there are not calibrated data.



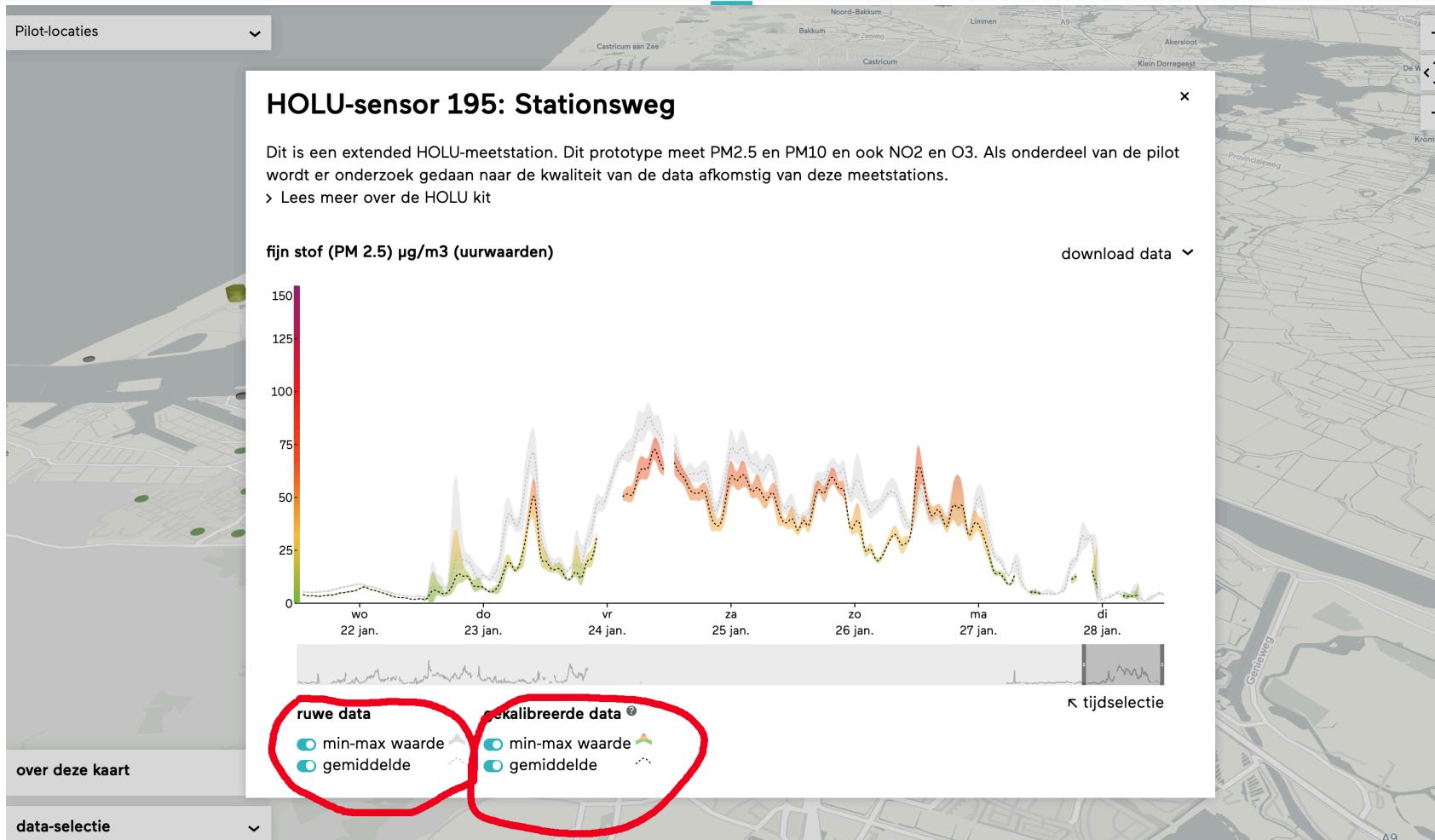
When the kit goes offline, it takes 8 hours to go grey again.

## The map and the HoLu kit



A lot of Zero Measurements? Check the raw data.

## The map and the HoLu kit





**open-**  
**-fair**  
**inclusiv**  
**e**

