

# ***sensors don't behave so what !***



**what MySense does about it**

**\* correcting sensor measurements**

*dust* mass values differ between manufacturers

*meteo* sensors fail too often, RH differ too much

**\* the data exchange format implications**

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ver. Behoud de Parel

<http://behouddeparel.nl>

# MySense air quality sensing project

open and free and it's not a free beer



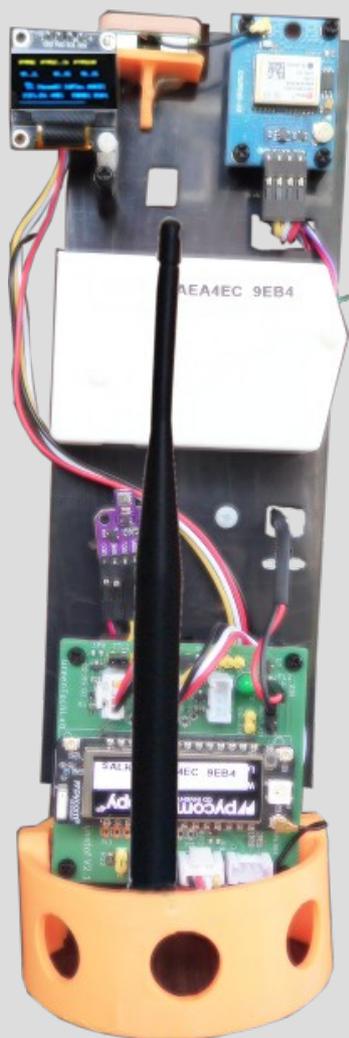
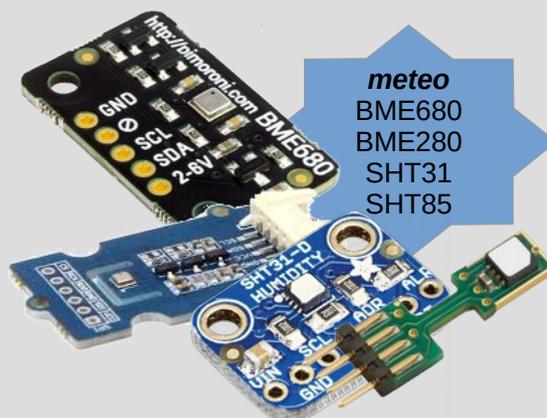
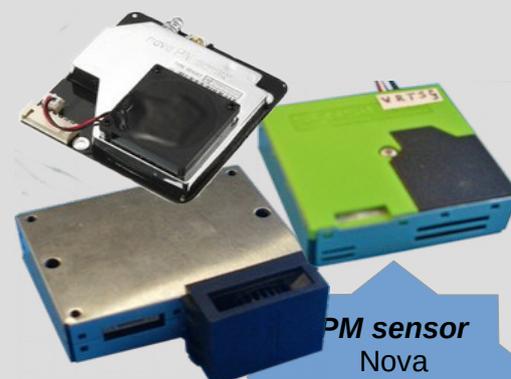
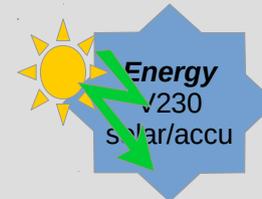
## ♦ goal:

- know what is locally happening
- develop and measure *together* with citizens, with farmers and scientists
- focus on agricultural environments, e.g. bio-industry

## ♦ how:

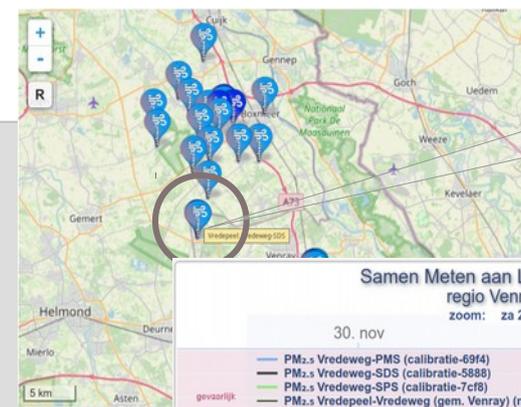
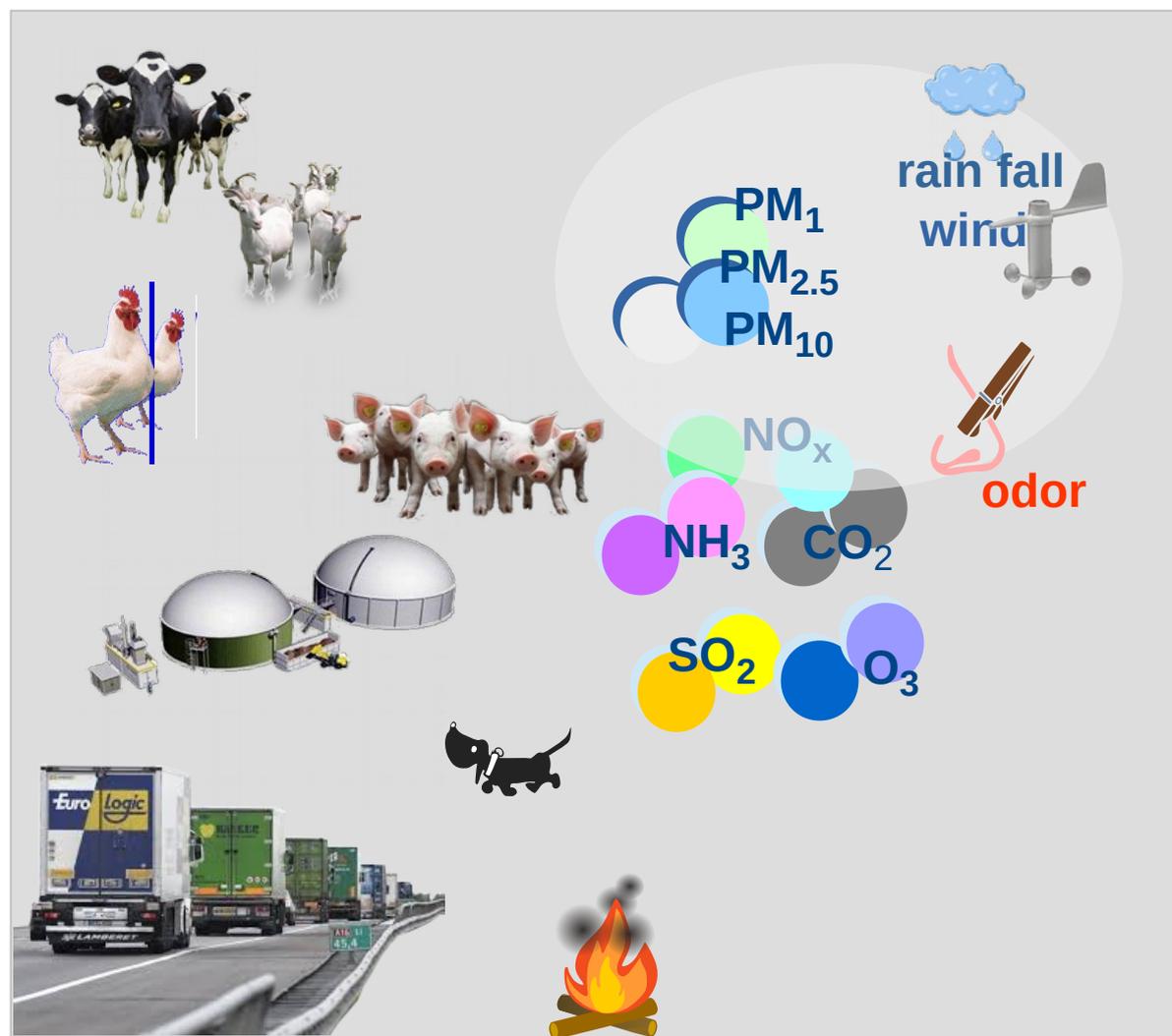
- sense pollutants, develop sensor kits, show results and technology
  - **info:** <http://behouddeparel.nl/samen-meten>
  - **technology:** [shttp://github.com/teusH/MySense](https://github.com/teusH/MySense)
- where in Nld: east N-Brabant, south Gelderland and N-Limburg
- MySense kits ca 45 operational, see <http://behouddeparel.nl/meetkits>
- presentations, statistical overviews, open data

# MySense hardware components

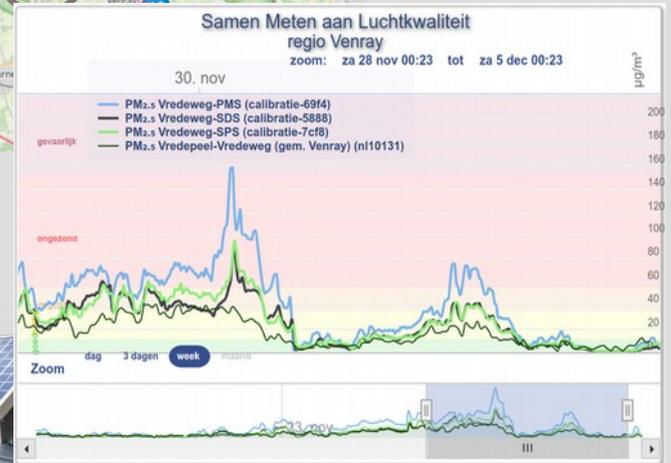




# sensing in an agricultural region

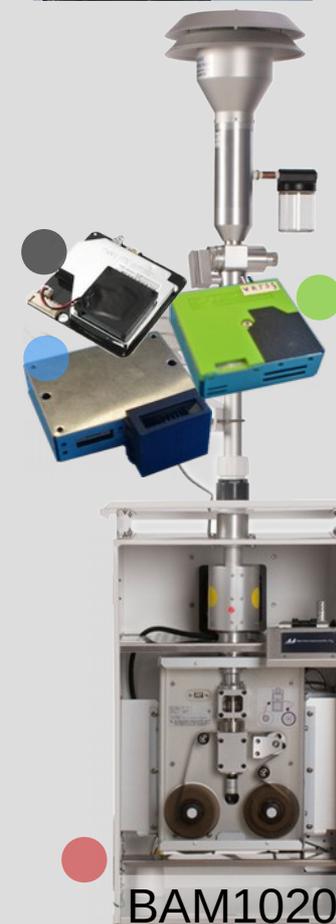
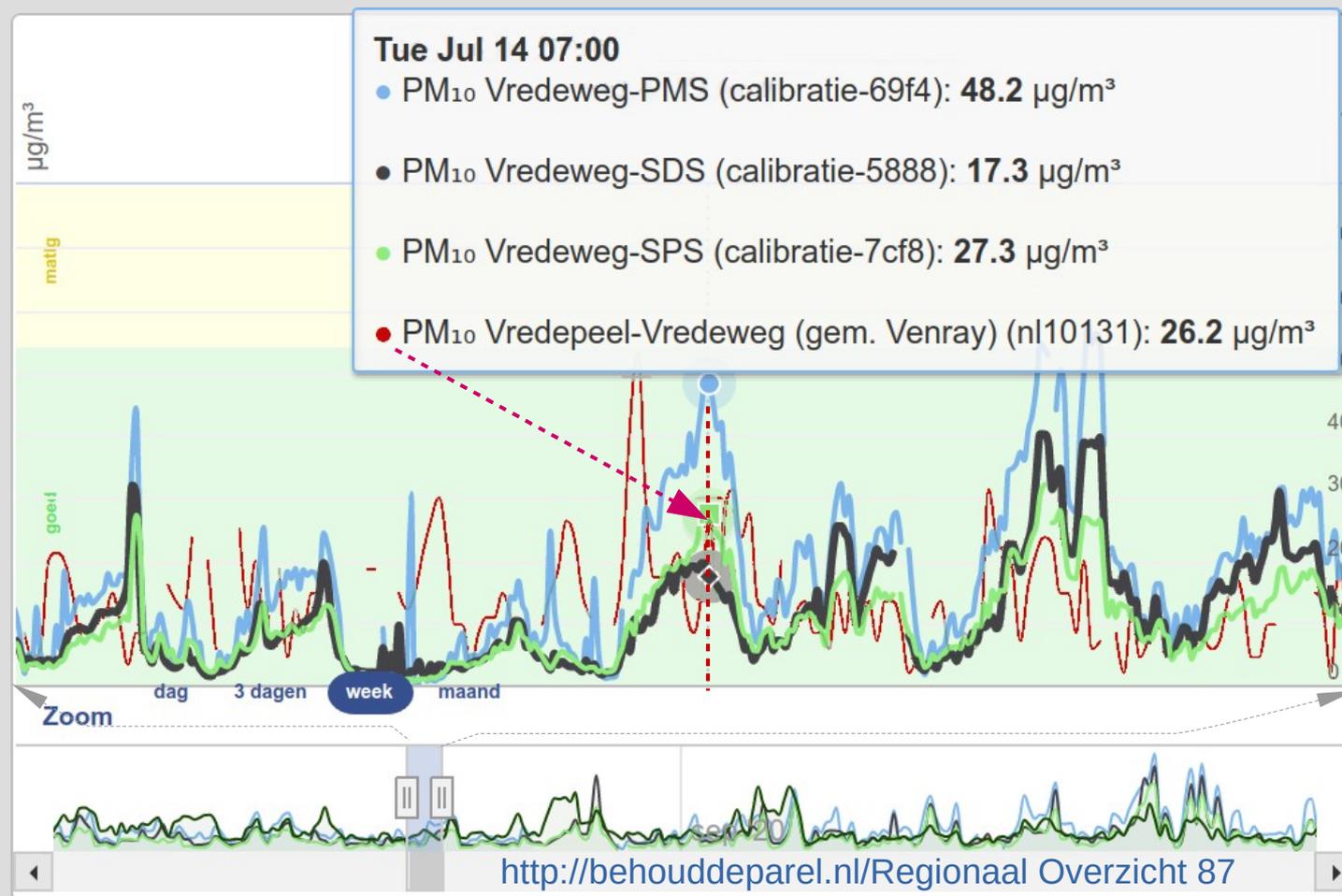


Vrededepeel near Venray Nld



# PM<sub>10</sub> sensor compared with NSL/RIVM BAM1020 dust sensor (Vredepeel)

dust sensors: Nova, Plantower en Sensirion

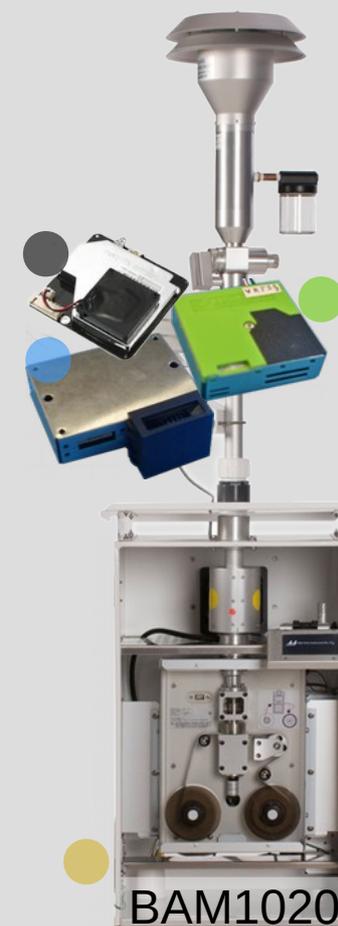
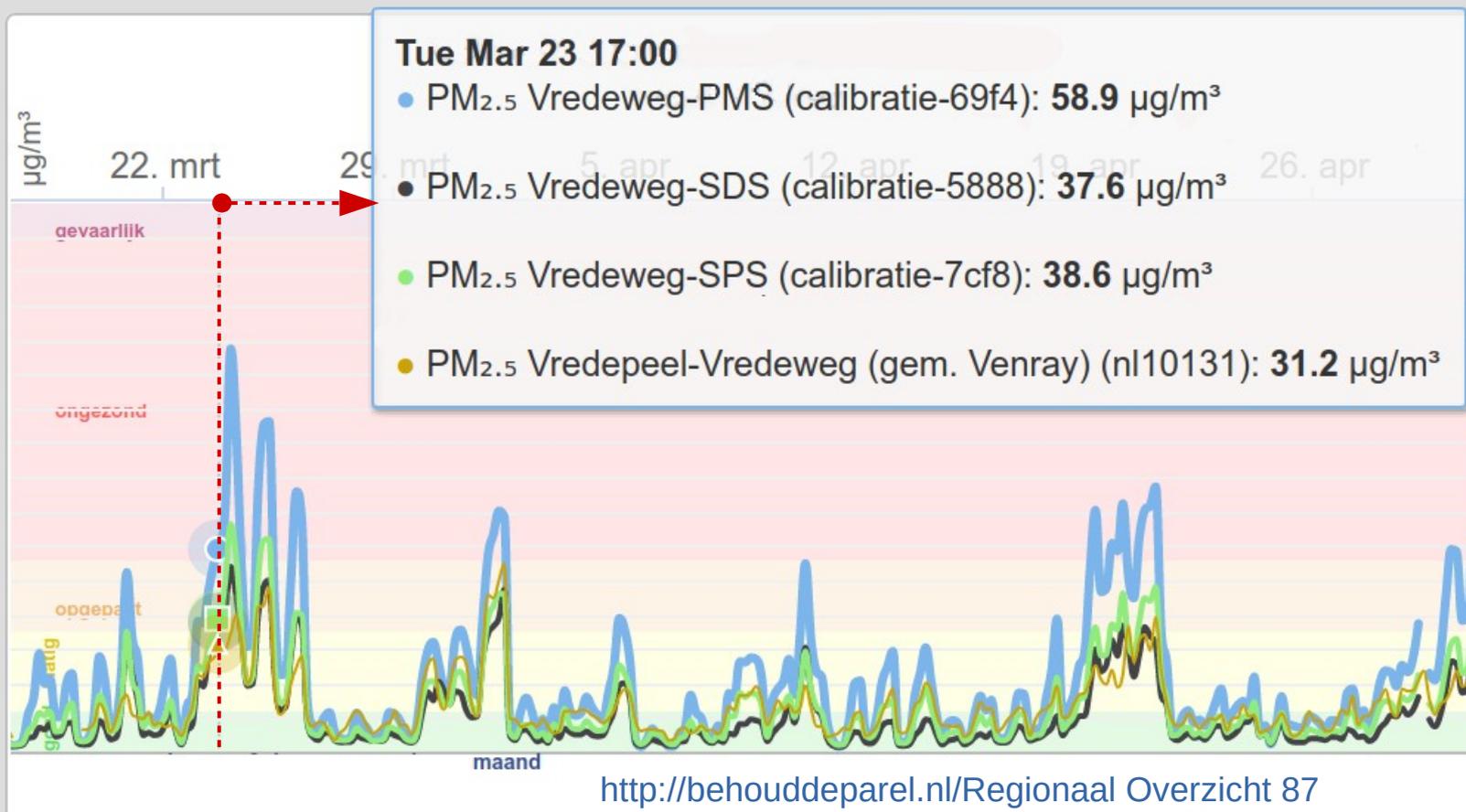


# PM<sub>2.5</sub> sensor compared with

## NSL/RIVM BAM1020 dust sensor (Vredepeel)

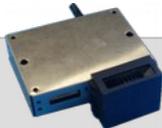


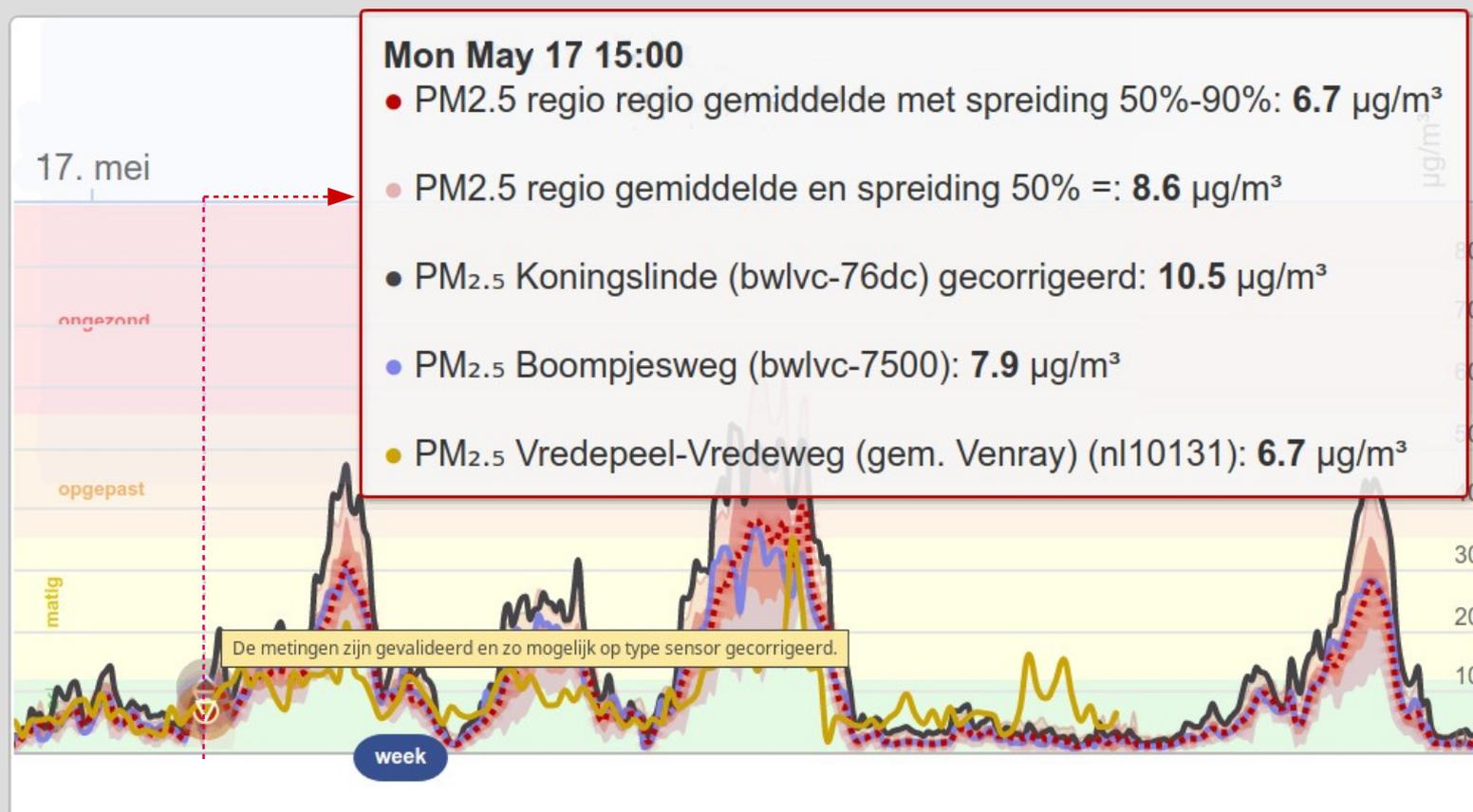
dust sensors: Nova SDS, Plantower PMS en Sensirion SPS



# PM<sub>2.5</sub> sensor corrected May 2021

## MySense sensors in the region St Anthonis, Brabant

dust sensors: Plantower (PMSx003)  and Sensirion (SPS30),   
as well BAM1020 Vredepeel (10 km away) ●



# 4 dust sensors compared

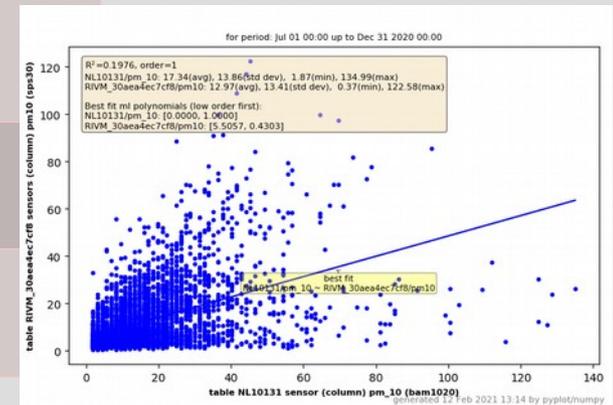
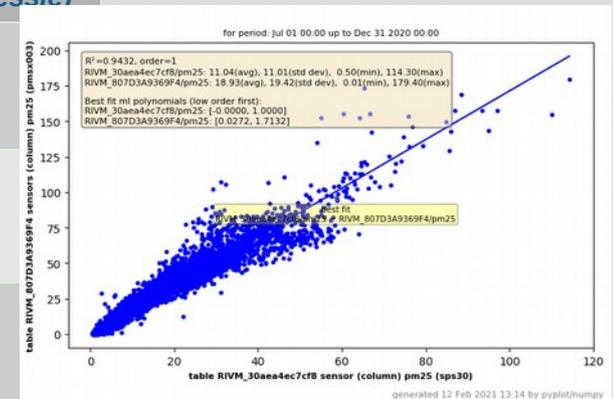
location: Vredepeel, Vredeweg on the roof of governmental measurement station

period: July - December 2020

sensor types: Sensirion SPS30, Plantower PMSx003, Nova SDS011, MetOne BAM1020



weergaven in massa type sensors	$PM_{2.5}$ R square ( $R^2$ )	$PM_{2.5}$ beste fit (lineaire regressie)	$PM_{10}$ R square ( $R^2$ )	$PM_{10}$ beste fit (lineaire regressie)
SPS30 ↔ SDS011	0.89	+ 4%	0.79	+ 20%
PMSx003 ↔ SDS011	0.90	- 50%	0.71	- 66%
SPS30 ↔ PMSx003	0.94	+ 71%	0.80	+ 45%
BAM1020 ↔ SDS011	0.58	+ 36%	0.14	- 50%
BAM1020 ↔ SPS30	0.73	+ 40%	0.19	- 43%
BAM1020 ↔ PMSx003	0.65	+ 234%	0.14	+ 57%



[https://github.com/teusH/MySense/blob/master/statistics/CorrelationReport\\_2021-02-12\\_Vredepeel\\_4-dustsensors\\_2020.pdf](https://github.com/teusH/MySense/blob/master/statistics/CorrelationReport_2021-02-12_Vredepeel_4-dustsensors_2020.pdf)

# comparing meteo sensors

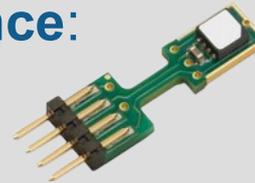
## need them to calibrate PM measurements

### *meteo*

SHT85  
BME680  
BME280  
SHT31  
Si7021  
HS300x  
DHT11

#### ♦ current list, ordered by preference:

1. SHT85 (°C, RH)
2. BME680 (°C, RH, hPa, VOC/AQI)
3. BME280 (°C, RH, hPa)
4. maybe Si7021, NS300x (°C, RH)
5. no go: DHT11/22 (°C, RH)



#### ♦ issues:

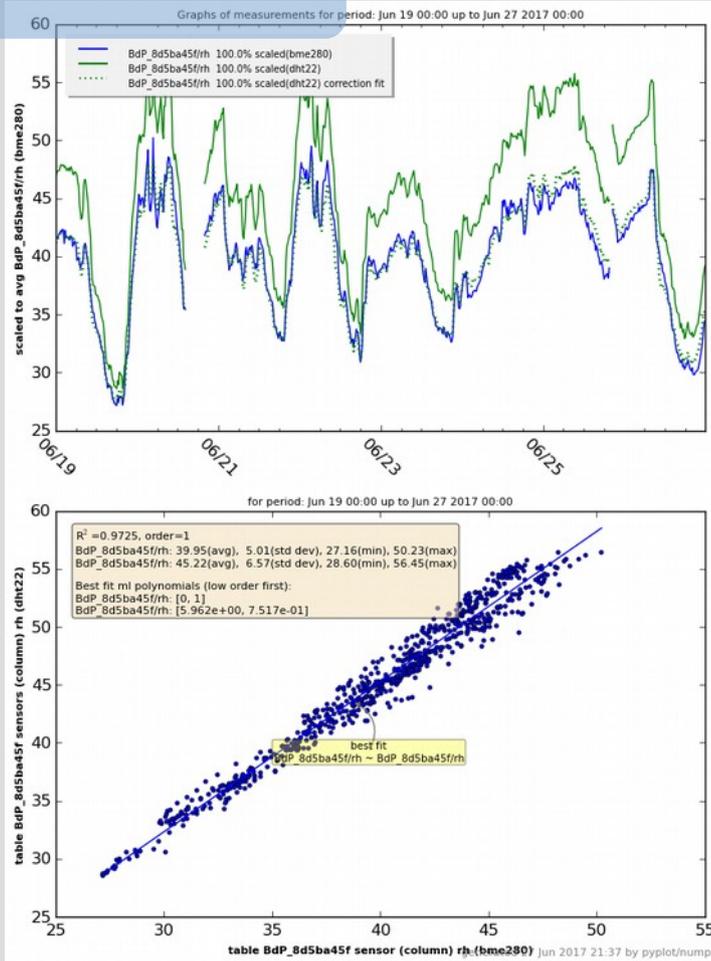
- developed for indoor: RH fall out 30% (try power cycle), 5% dead
- temperature differ is 1-2 °C, linear correction
- RH differ is 10 % too much to correct PM measurements
- BME680 Bosch VOC hard to calibrate
- no need for air pressure
- SMD solder oxidation

# meteo sensors differ (of course)

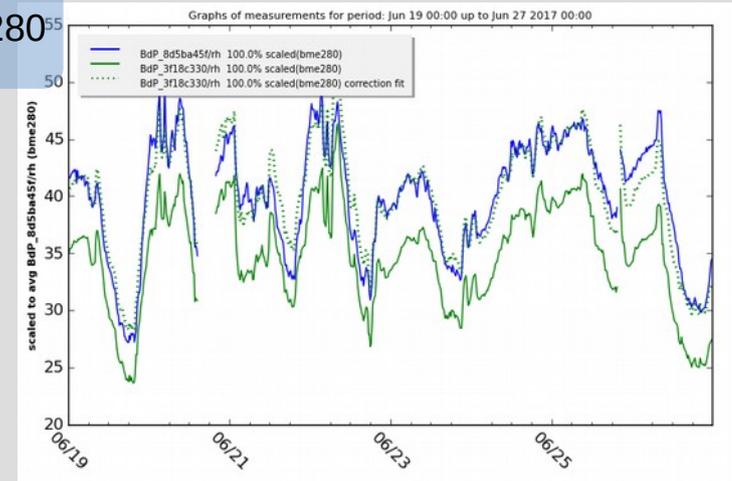
## results: correlation 7 days RH measurements

### every hour a 1 minute sample in juni 2017

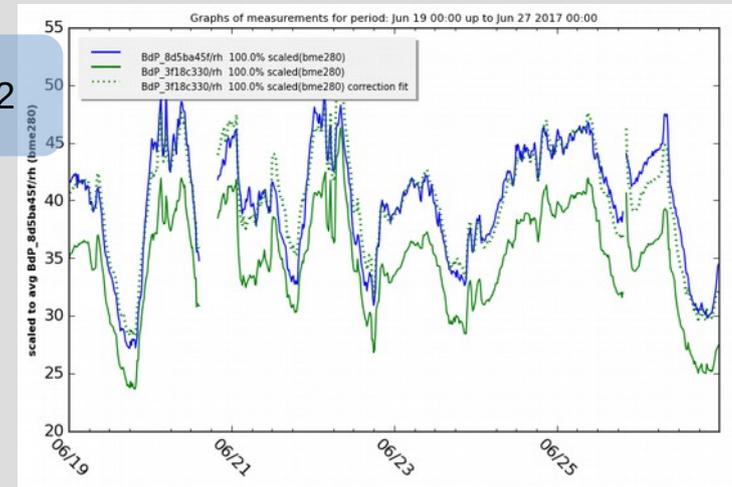
BME280 ↔ DHT22



BME280 ↔ BME280

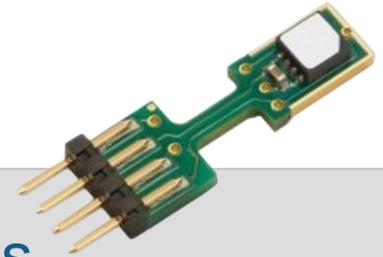


DHT22 ↔ DHT22



# all meteo sensors show outdoor RH (temp) problems

## maybe the newer Sensirion SHT85 not?



- ♦ error: **30%** of similar equipped measurement kits they show null measurements or just static values
- ♦ some do not show errors, most errors in winter time
- ♦ power cycle helps to recover, 5-8% just go dead
- ♦ some types (Bosch 680, Sensirion) have a heat up function
- ♦ the solar kits (40% of installed base) did not show this problem! deepsleep does a power cycle for 10 minutes (4 per hour).
- ♦ do not forget the solder oxidating (current leakage) problem:  
*seal the solder parts*

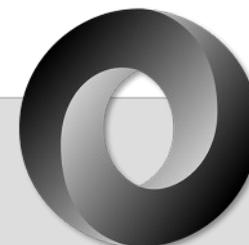
# measurement data exchange format

## and do not wait till it is too late

it only smells like Open Data Format (O-DF) from 'the Open Group'

### what is needed:

- timestamp
- version
- key translation table, definition of defaults, and ???
- **meta data**
  - home location (geohash)
  - kit id, version
  - sensor configuration, sample timing, ...
  - definition defaults
  - ...
- **measurement data**
  - sensor types, measurements, unit of measurement
  - 1+ sensors of one type
  - measurement location
  - timestamp
  - ...



{JSON}



# data format requirements

human readable, easy to implement, dynamic



a real world example to start with? header and meta data part:

```
{
```

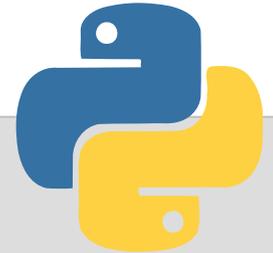
```
  "id": { "project": "SAN", "serial": "78CECEA5167524" },  
  "timestamp": 1621862416, // or "dateTime": "2021-05-24T15:20+02:00",  
  "keys": { "timestamp": "unixTime", "rv": "RH", "lat": "latitude", ", ... }, // and/or "keyID": "nl",  
  "units": { "temperature": "C", "altitude": "m", ... }, // and/or "unitsID": "nl",
```

```
  "meta": {  
    "dust": "PMSx003",  
    "geolocation": { "lat": 51.54046, "lon": 5.85306, "alt": 31.3, }, // "geohash": "u1hjjnwhfn"  
    "version": 0.5,  
    "meteo": [ "BME680", "SHT31" ],  
    "energy": { "solar": "5W", "accu": "Li-Ion" },  
    "gps": "NEO-6"  
  },
```

```
}
```

# data format requirements

human readable, easy to implement, dynamic



a real world example to start with?

```
{
  "id": ...,
  "timestamp":...,
  "meta": { ... },
  "data": {
    "version": 0.2,
    "NEO-6": { "geohash": "u1hjjnwhfn", "alt": 23 },
    "BME680": {
      "aqi": (29.9,"%"), "rv": None, "luchtdruk": (1019,"hPa"), "voc": 169, "temp": (293.7,"K") },
    "SHT31": [ { "temp": 20.1, "rv": 70.1 }, { "temp": 20.3, "rv": 67.3 } ], // 1+ sensors
    "PMSx003": {
      "pm05_cnt": 1694.1, "pm10": 29.4, "pm25_cnt": 2396.9,
      "grain": 0.5,
      "pm1_cnt": 2285.7, "pm25": 20.4, "pm10_cnt": 2.4, "pm1": 13.0 },
    "accu": (89.5,"%")
  }
}
```

implementation: <https://github.com/teusH/MySense/scripts/MyTTN-datacollector.py> and [MyLoRaCode.py](#) (not yet released)

# discussion, questions?



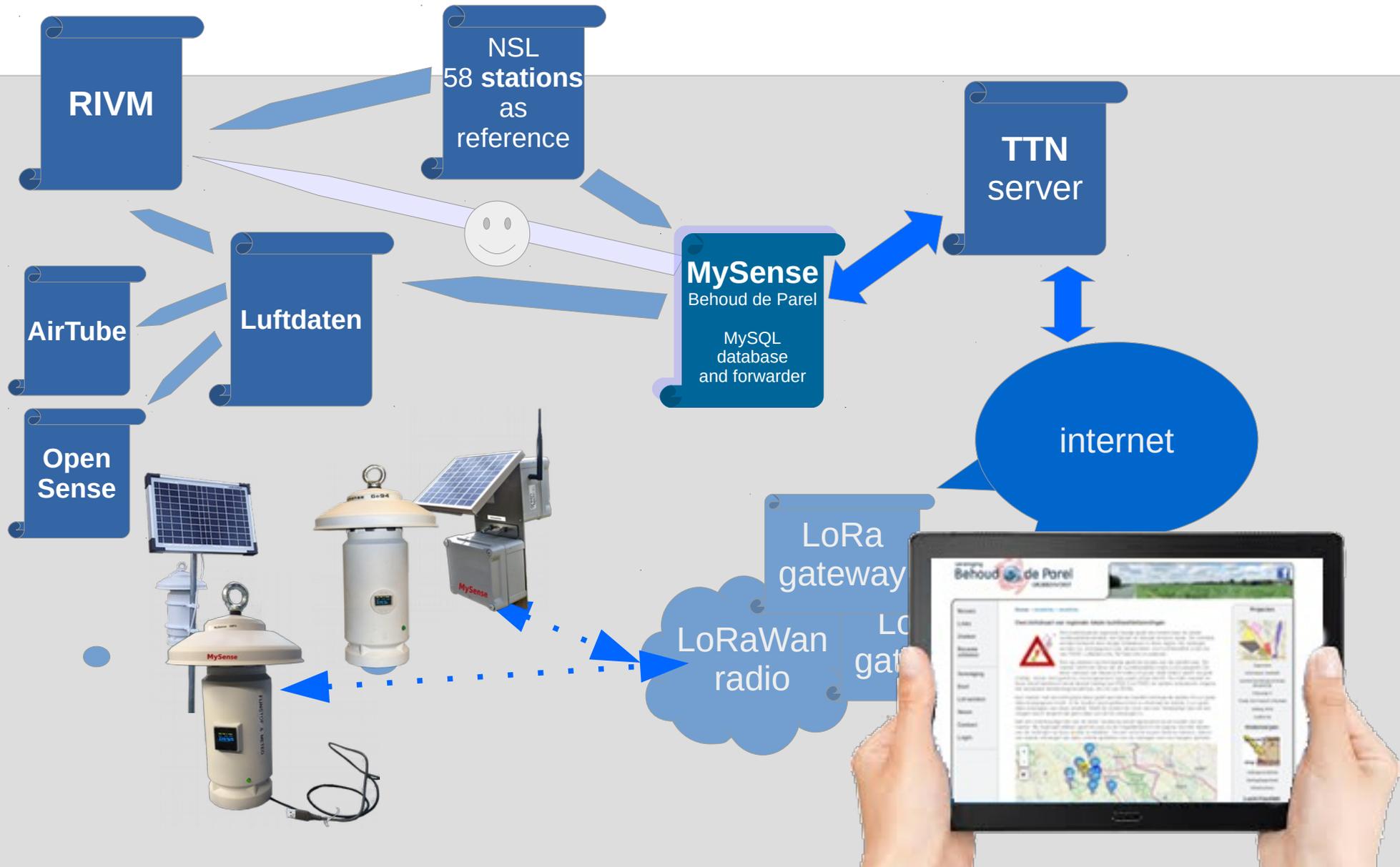
*time* is expensive, *time* is up

## ◆ where to find MySense?

- <http://behouddeparel.nl/MySense>
- <http://behouddeparel.nl/MySense%020status>
- <https://github.com/teusH/MySense>
- [mysense@behouddeparel.nl](mailto:mysense@behouddeparel.nl)



# data from sensor kit via LoRaWan (TTN) to data archive and to the data portals



# statistics: calibration

much to thank RIVM (NSL stations) and Scapeler/Visibilis in Berghaven

ref: article aug 2019 in international journal *Atmosphere* 'Samen Meten'

ref: Visibilis report dec 2019 *calibration/validation of PM sensors*

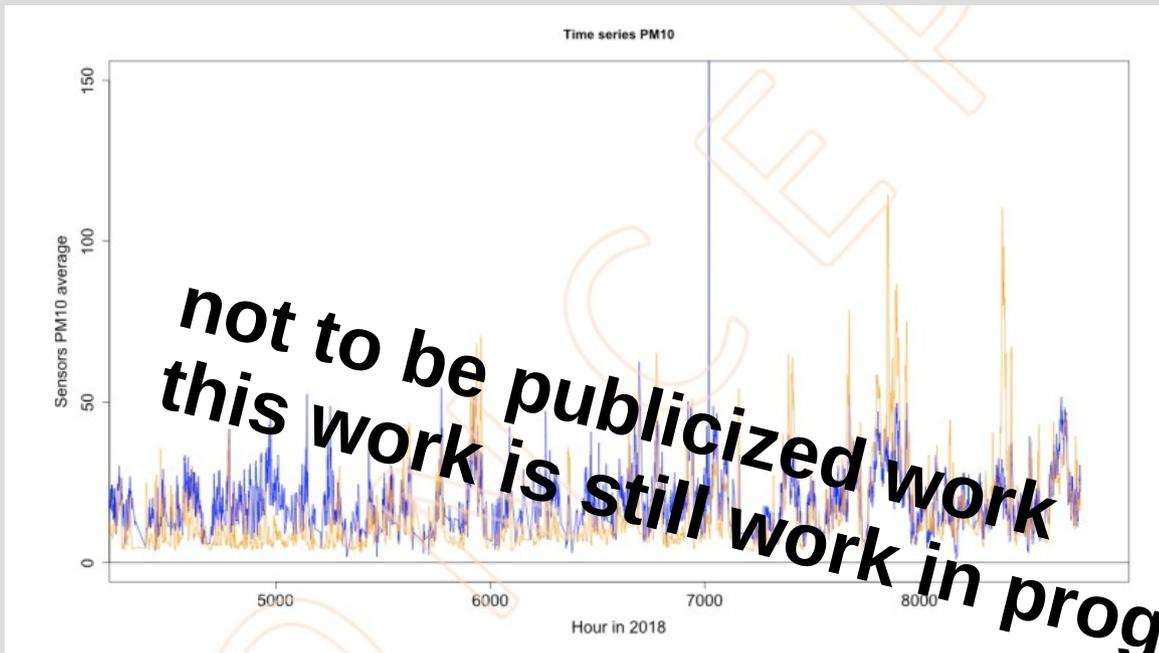


- ♦ using statistical/correlation/regression software
  - public domain Python software
  - input: database measurement data
  - correlation orde N, statistics e.g.  $R^2$  check, and much more ...
- ♦ *from using at this moment 1 minute averaged samples:*
  - Sensirion/Nova/Plantower is correlating 'fine' with ref BAM1020, but ...  
corrections from rel. humidity, temp, wind, ... for local situation
  - meteo sensors differ among each other  $\sim 2$  °C, RH  $\sim 10\%$  !!!
  - dust sensor PPD42NS is a dump (e.g. too many  $PM_{10}$  "null readings")
  - one need particle count values from dust sensors!, e.g. Plantower and Sensirion

# calibration ref BAM1020 (Met One)?

2019-2021 data is studied (RIVM, 2-3 citizen science initiatives)

RIVM is providing support and making progress (R-Studio)



**not to be publicized work  
this work is still work in progress**

