Foreword

January 2014

At the beginning it was RasPi MAX @ home

January 2015

January 2016

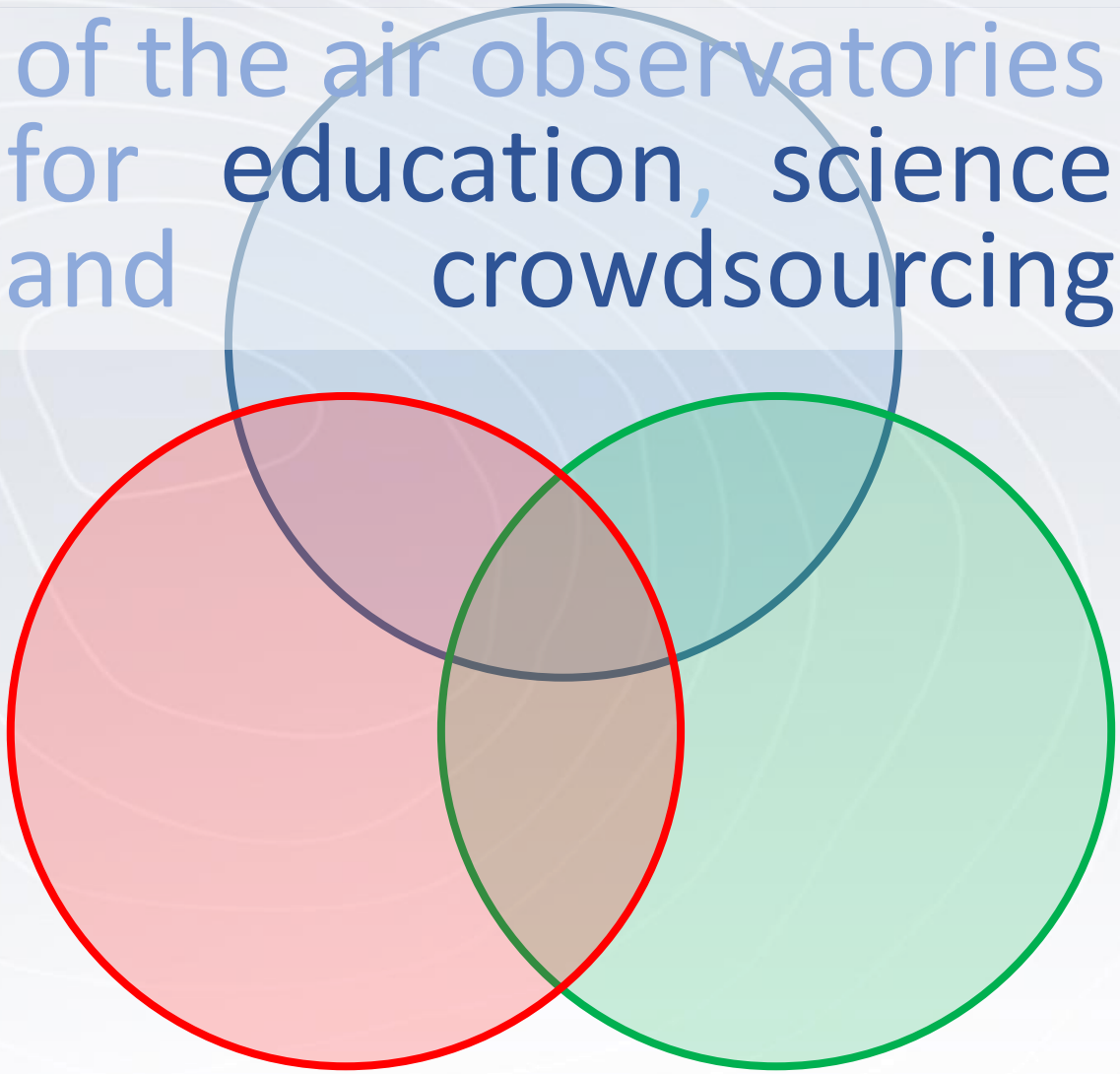
January 2017

miniMET Project

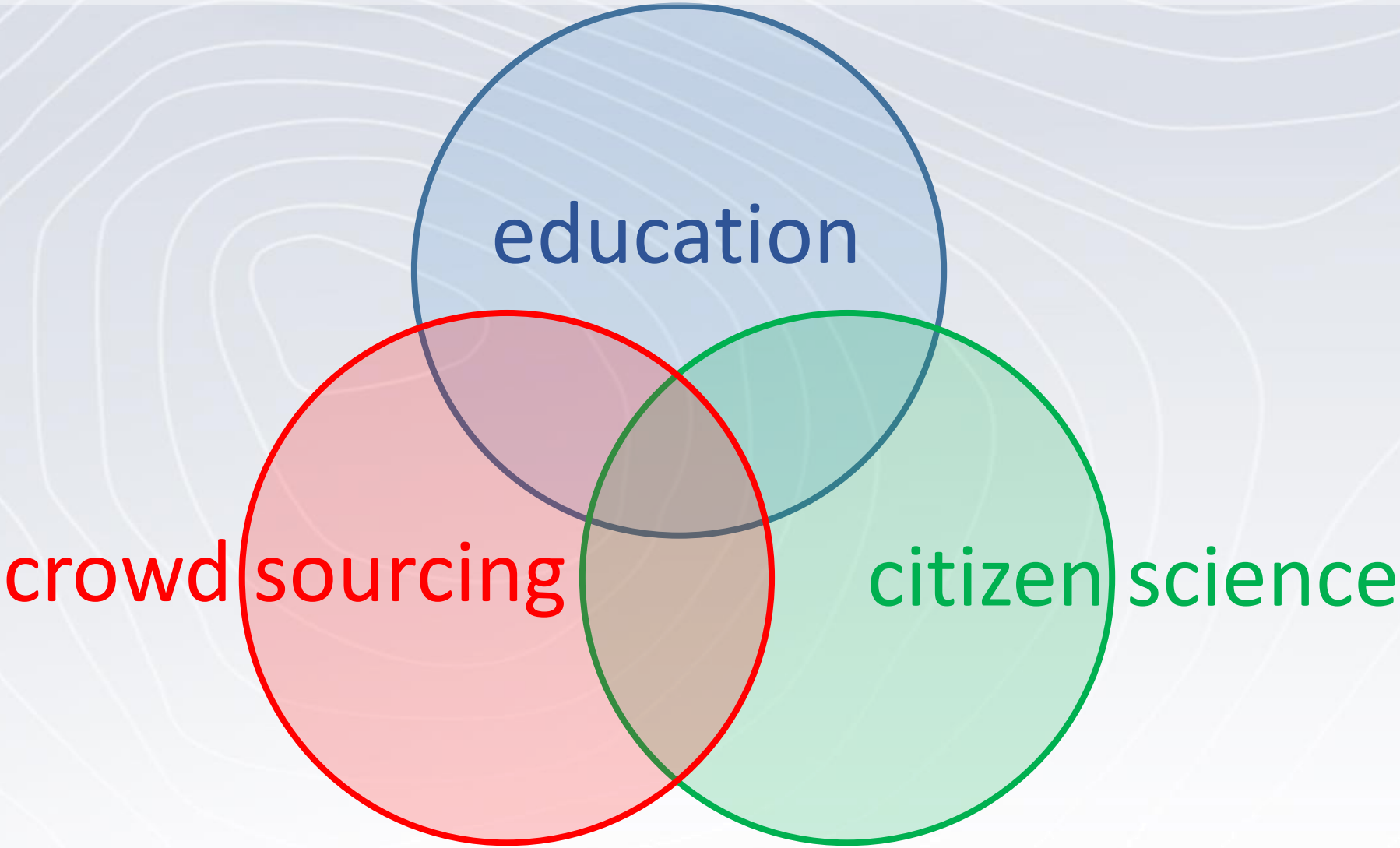
of the air observatories for education, science and crowdsourcing

miniMET Project

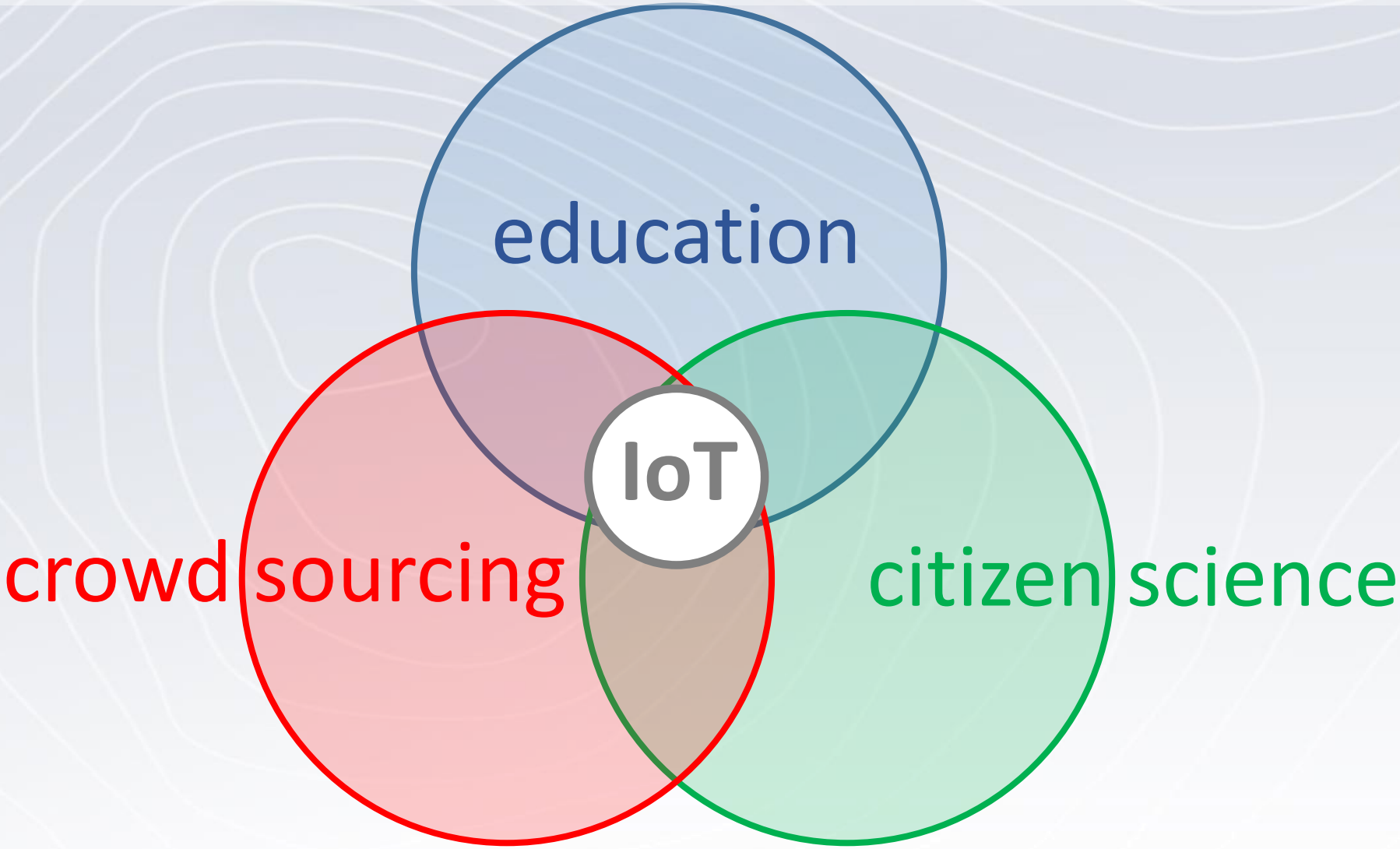
of the air observatories for education, science and crowdsourcing



miniMET Project



miniMET Project



miniMET Project

key concepts

Education is the key: we do not pretend to invent an amateur meteorological network but to teach the whole process of the meteorology beginning with building the station itself. We are teaching about science and environment care and we need the help of citizen science concepts.

Citizen Science implies a peer to peer relationship among citizens and professional scientists with a clear social commitment. It needs to be taught from school.

Crowdsourcing understood as crowd-outsourcing is an initiative of a company or institution which needs the voluntary collaboration of non professional people for certain tasks.

education: the miniMET manifesto

Care and **respect** for the environment, and particularly for the atmosphere, should be the natural response of our **love** for them. This response arises from the **knowledge**, and lead us to methodically promote the **observation of the air**, both in its **dynamic** and **phenomenal** aspects, as well as those related to **quality**, and in our influence on them.

This constitutes the starting point of an **awareness raising state**.

Scientists and meteorology professionals, as well as **educators** of every level, have the unavoidable **duty** of **communicating** to students of every age **the love for the study and observation of the environment, providing them the appropriate tools** and the enthusiasm of the **discovery.**

For educators miniMET Project for schools

will provide didactic materials to several educational areas:

- **Technology, ICT** (hardware, programming, internet)
- **Environmental studies**: meteorology and climatology
- **Statistics, analysis of results, comparisons** with data from other stations / schools, etc.

For educators miniMET
covers the following aspects:

- DIY a weather station shelter
- Introducing miniPCs and development boards.
- Introducing sensors and communications.
- Introducing programming in Python and others.
- Integration and testing of the station.
- Location, installation and start up.
- Reading and analysis of observed data.
- Transmission and retrieval of data.

miniMET is citizen science

- From **meteorology**, and with the **support of education community**, we will be able to **involve** the whole society, encouraging to **potential amateur scientists** of every age the vocation and voluntary **commitment to participate in this scientific process of observation and discovery**.
- This commitment will also contribute to obtain **huge and valuable feedback data** to the scientific, professional and academic environment, within the **OPEN SCIENCE paradigm**.
- This new paradigm is **promoted** both **from the scientific community and the civil society**, as well as from the **European Union** through **CITIZEN SCIENCE projects**.

miniMET is citizen science

- **Citizen Science** and the principles of **Research and Responsible Innovation (RRI)** are part of the European agenda for **research and innovation - HORIZON 2020 -** which is based on the concept of

  "Science with and for society" (SWAFS)

- **SWAFS** promotes active **participation of citizens in science** and the **social commitment of researchers and innovators with society**, in order to build effective **cooperation between science and society** that links scientific excellence with **social awareness and responsibility.**

- When **citizen science meets education**, in the mid and long term:

  We are encouraging the scientist inside every citizen

  We are educating the citizen inside future professional scientists

AEMET and Citizen Science activity

- "**Fomenting education and citizen science**" is included in its fifth strategic line and faces the research and innovation challenge of the **European Union's HORIZON 2020**

- **Participating** in the *First National Action Planning for the Development and Consolidating of Citizen Science in Spain,* for the *Ministry of Economy, Industry and Competitiveness.*

- **Presenting** the miniMET Project at the *Third National Meeting of Citizen Science in Spain at Medialab-Prado* in Madrid

(december 2017)

miniMET is crowdsourcing

In addition, the project aims to reinforce - and recover - the key participation of non-professional **AEMET collaborators** that since the beginning of the 20th century established our important secondary observation network. A first official call in 1910 was answered by about 800 people, 400 of them teachers from small towns from all over Spain.

These collaborators are in fact **crowdsourcing**. Although the term crowdsourcing appeared for the first time in 2006 and was closely related to new technologies, the deep concept is the same, that is, outsourcing specific tasks to a voluntary and non-professional crowd.

The AEMET Crowdsourcing

A century of volunteering

In the AEMET network there are around 3,000 people involved who voluntarily collect data every day of the year.

Among these collaborators there are those who are dedicated to taking data manually from **rainfall and thermopluviometric stations**, and others dedicated to serving more than 550 automatic stations spread throughout the country.

Some are even **phenological observers**, who provide information about their observations of the behavior of plants and animals in relation to environmental conditions.

In our country, volunteers have been carrying out this service since 1911, when José Galbis, head of the then Central Office of Meteorology, made the **strategic decision** to expand the professional observation network with other data collected by **non-professional personnel**.

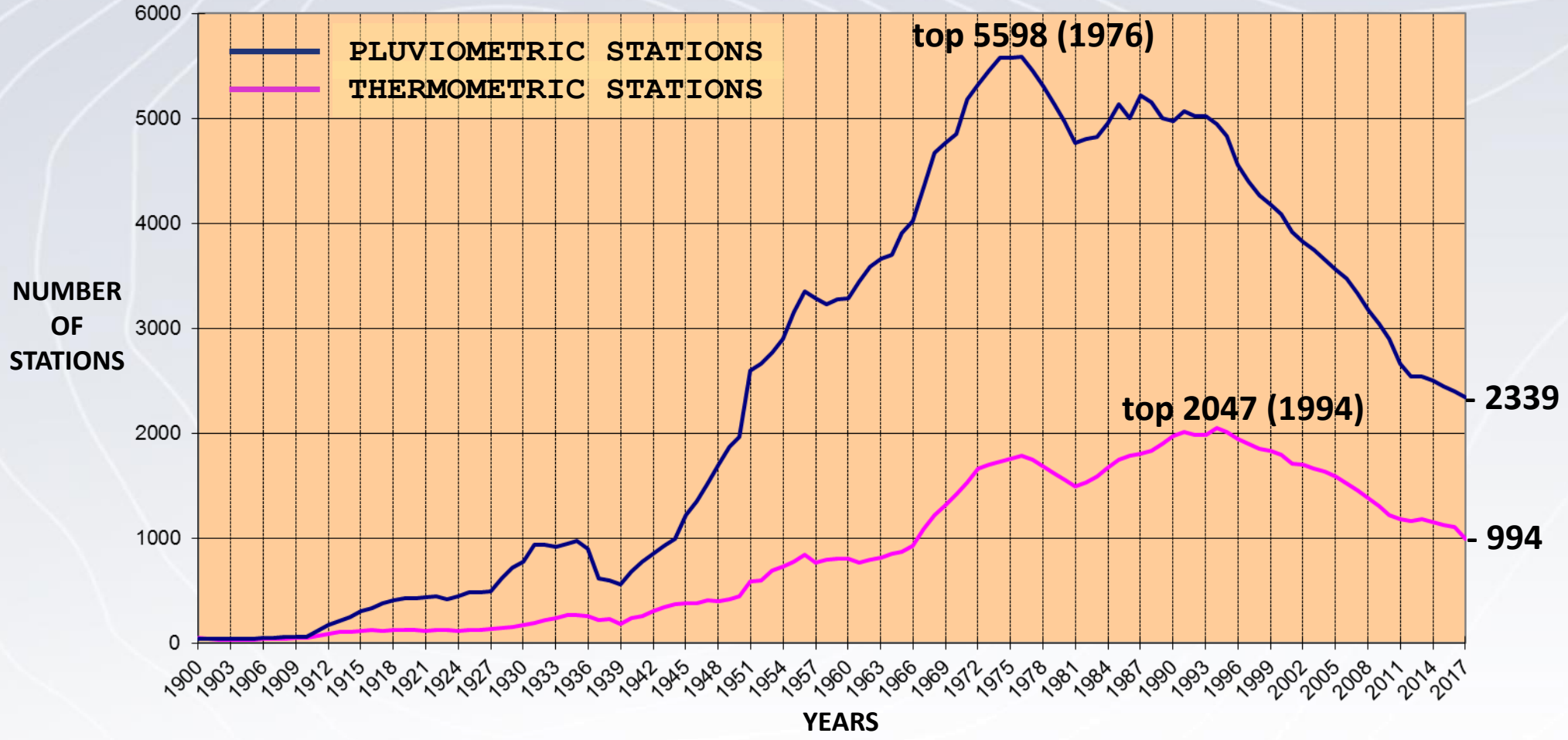







Although since then we have reached to have far more than 5000 collaborators, with pluviometric and thermopluviometric stations (1970~1990 stats), **the harsh reality is that that number has been dropped in half today**, mainly due to the difficulty of finding young successors of these vocations in these small villages where there is less and less young population and also these ones are less motivated to collaborate.

Evolution of the number of collaborator stations in Spain since 1900 to present



miniMET in AEMET

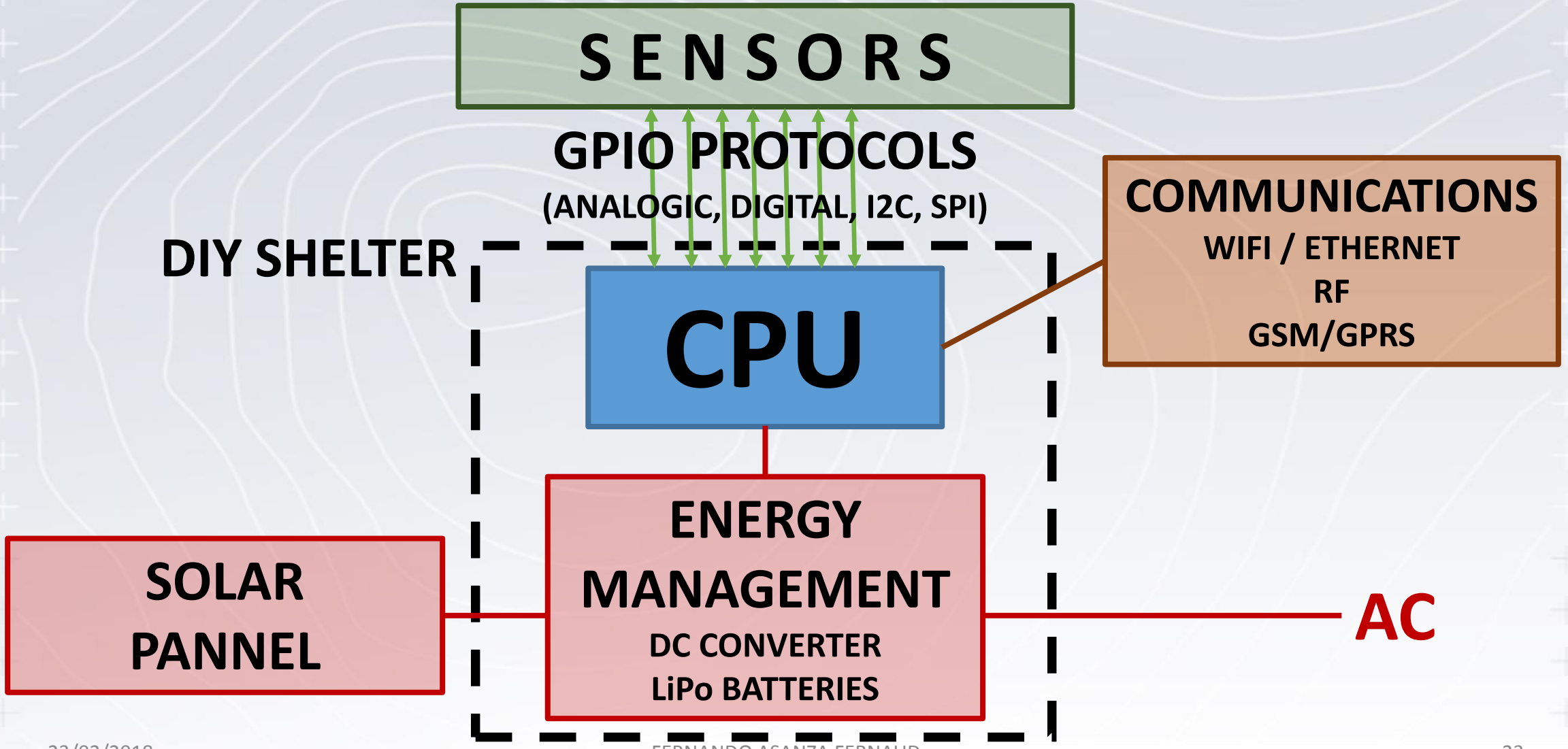
- **miniMET** is **a necessarily cross-project** that involves the following areas of AEMET:
    - Observation Network,
    - Exploitation and Data Management,
    - Climatology,
    - Training,
    - Innovation,
    - Quality,
    - Communication
    - Institutional Relationships, among others

WHAT IS THE miniMET PROJECT?

- AEMET will contribute with the **definition and construction of a network of environmental observatories** for schools, AEMET official collaborators, and also, amateur meteorologists.

- **HOW**? Several **Automatic Weather and Air Quality Station (AWAQS)** prototypes of simple and well-defined construction are proposed to schools as a technology project with affordable and reliable elements of **open hardware** and **free software.**

miniMET STATION SCHEMATIC



WHAT DOES THE PROTOTYPE STATIONS MEASURE?

- Temperature / Humidity
- Pressure
- Direction and wind speed
- Precipitation
- Air quality
- Lightning detector
- Luminance / Infrared / Ultraviolet

Also they have:

- Webcam
- Rechargeable batteries
- Solar panel
- Internet connectivity through Ethernet cable or Wi-Fi

miniMET sensors being tested

METEOROLOGICAL

- **ATMOSPHERIC PRESSURE**: GROVE BMP280 I2C
- **TEMPERATURE AND HUMIDITY:** GROVE AM2315 I2C
- **WIND AND RAIN:** SPARKFUN WEATHER RACK
- **SUNLIGHT/IR/UV:** GROVE Sunlight IR UV I2C
- **LIGHTNING DETECTOR** GROVE MOD1016G Lightning sensor I2C (+IRQ D)

IMAGING

- **WEBCAM:** wide angle cam reporting regularly a picture of the most representative área sky condition of the observatory

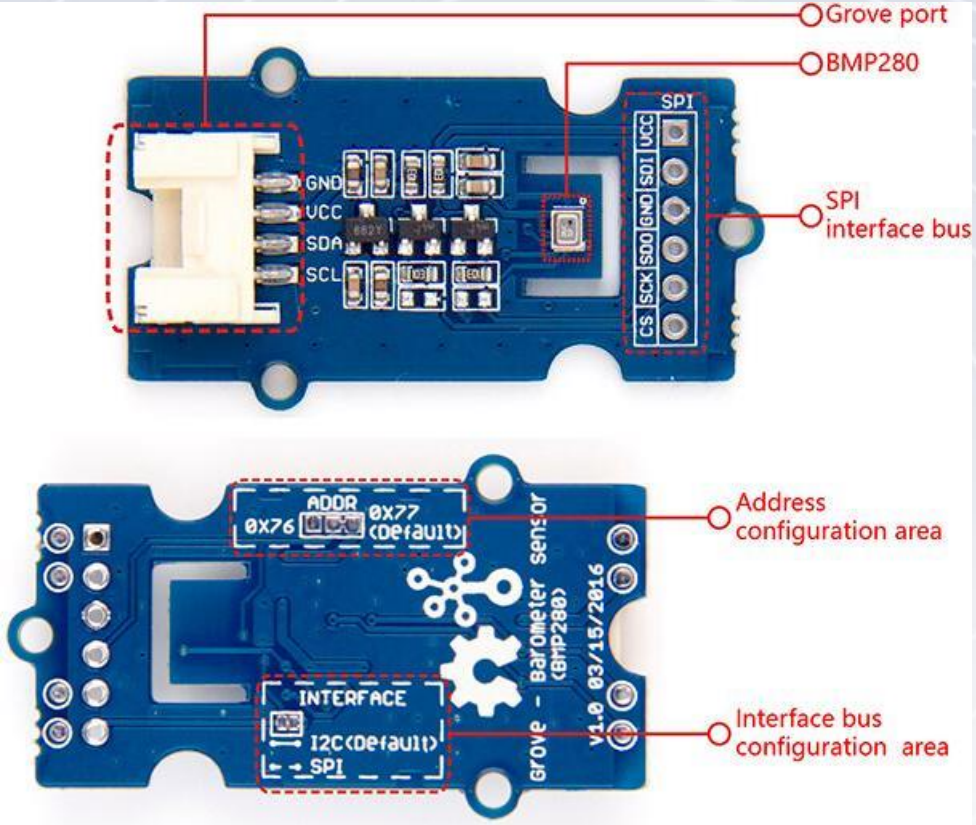
miniMET sensors being tested

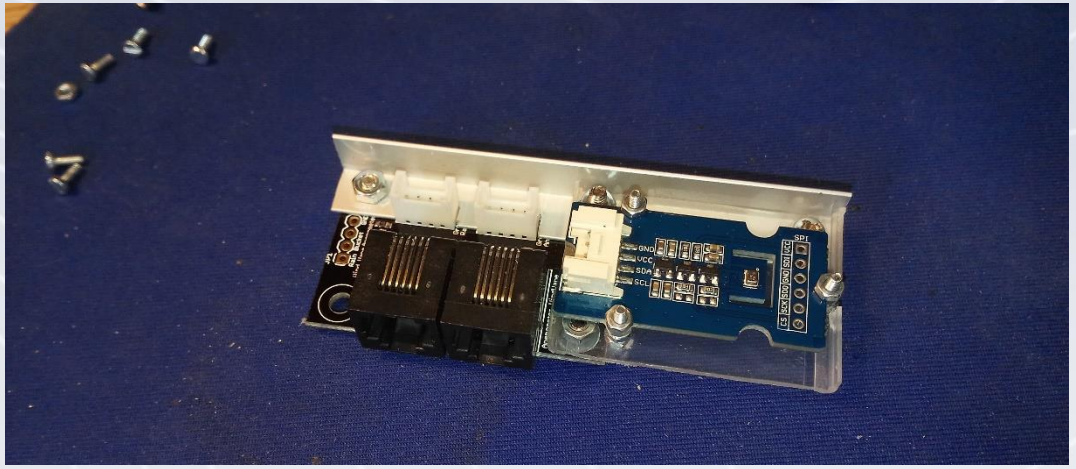
AIR QUALITY / ACOUSTICS

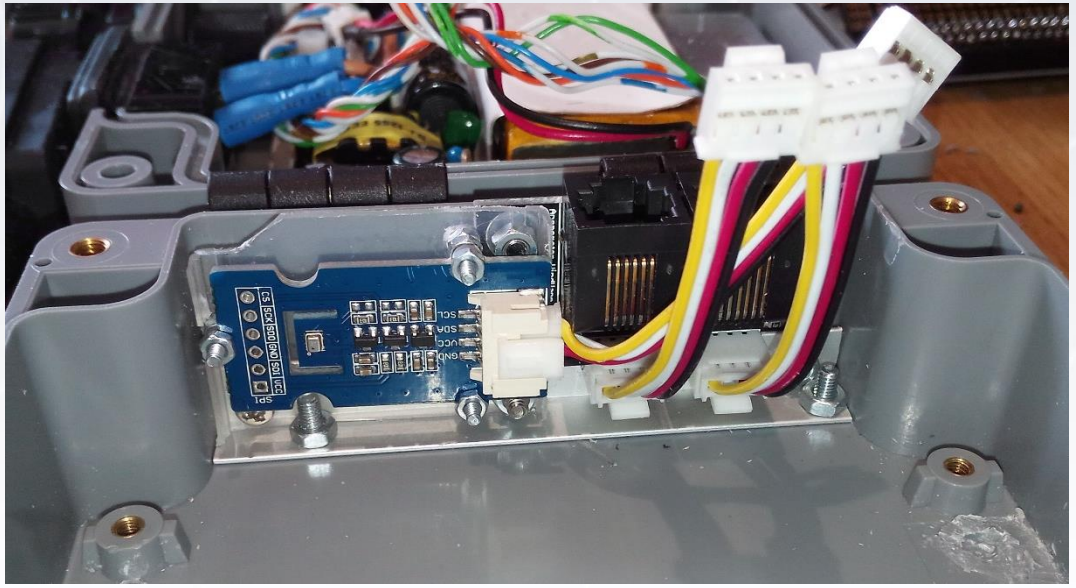
- **GASES:** GROVE MULTICHANNEL GAS SENSOR I2C
  - Carbon monoxide CO 1 – 1000ppm
  - Nitrogen dioxide NO2 0.05 – 10ppm
  - Ethanol C2H6OH 10 – 500ppm
  - Hydrogen H2 1 – 1000ppm
  - Ammonia NH3 1 – 500ppm
  - Methane CH4 >1000ppm
  - Propane C3H8 >1000ppm
  - Iso-butane C4H10 >1000ppm

- **ACOUSTICS**: GROVE Loudness Sensor (Analog)

miniMET sensors: atmospheric pressure

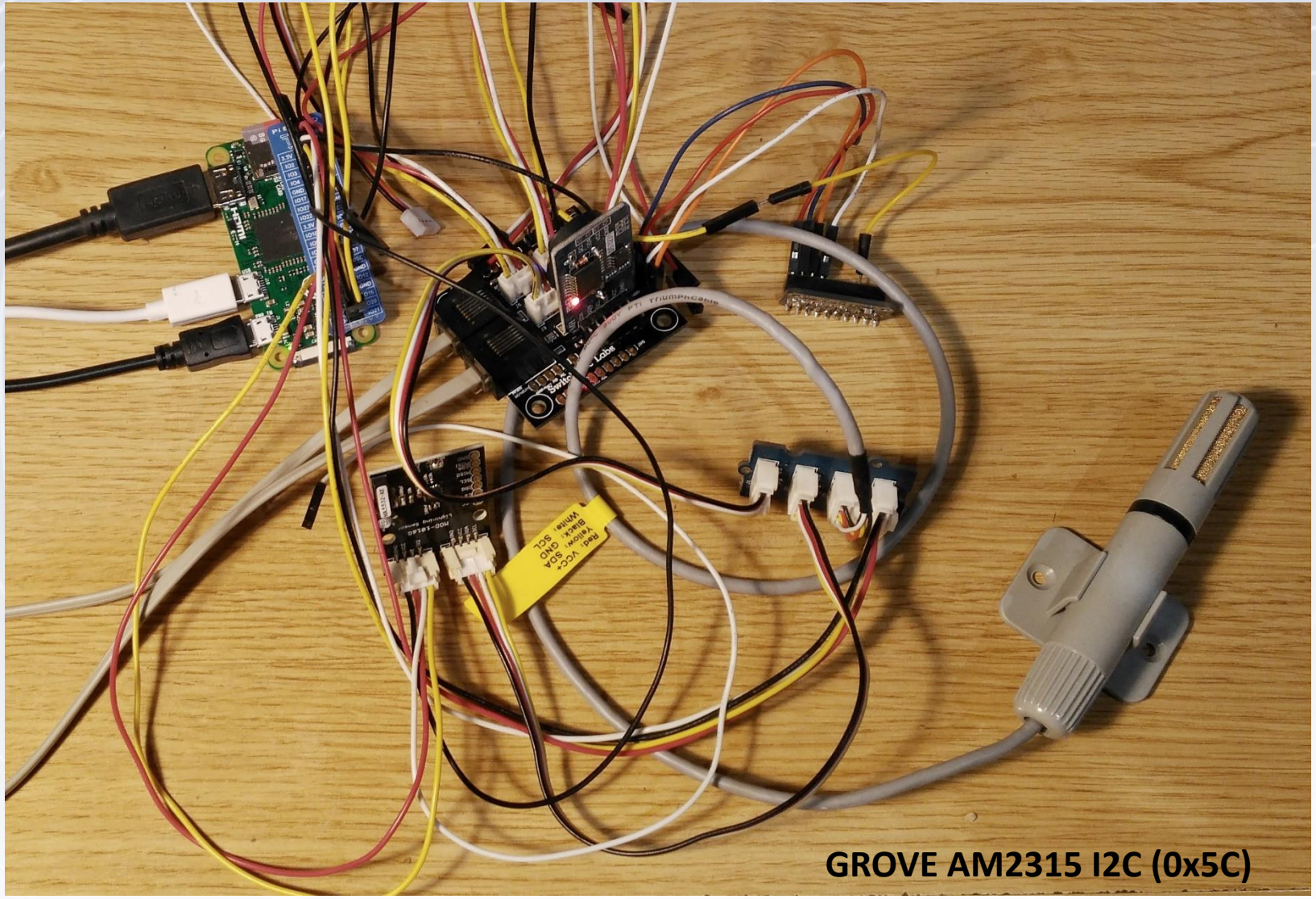




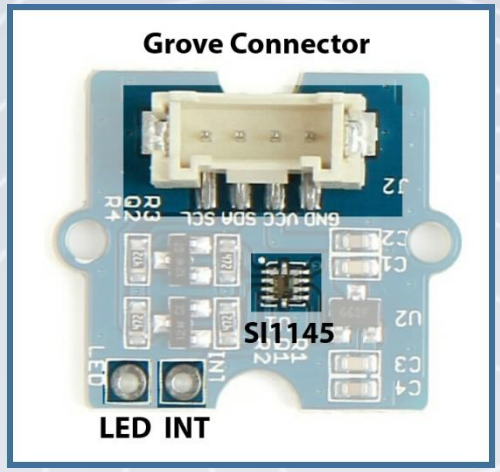


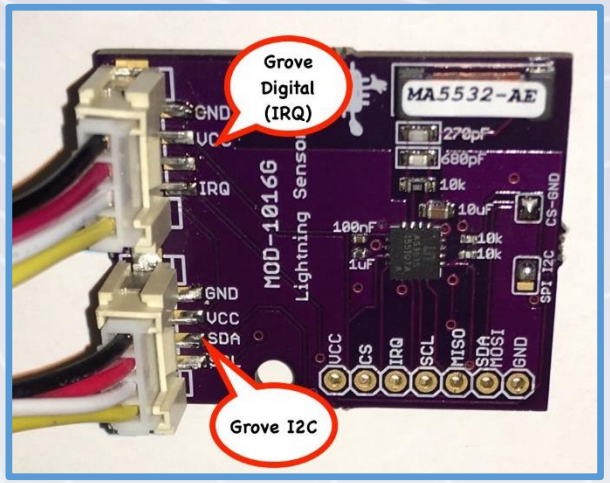
GROVE BMP280 I2C (0x76/0x77)

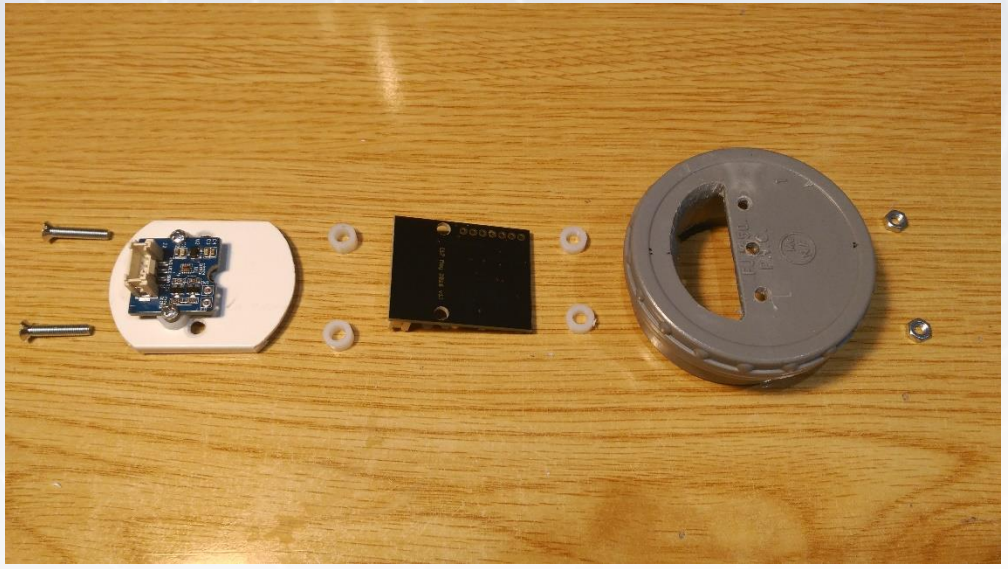
miniMET sensors: temperature and humidity

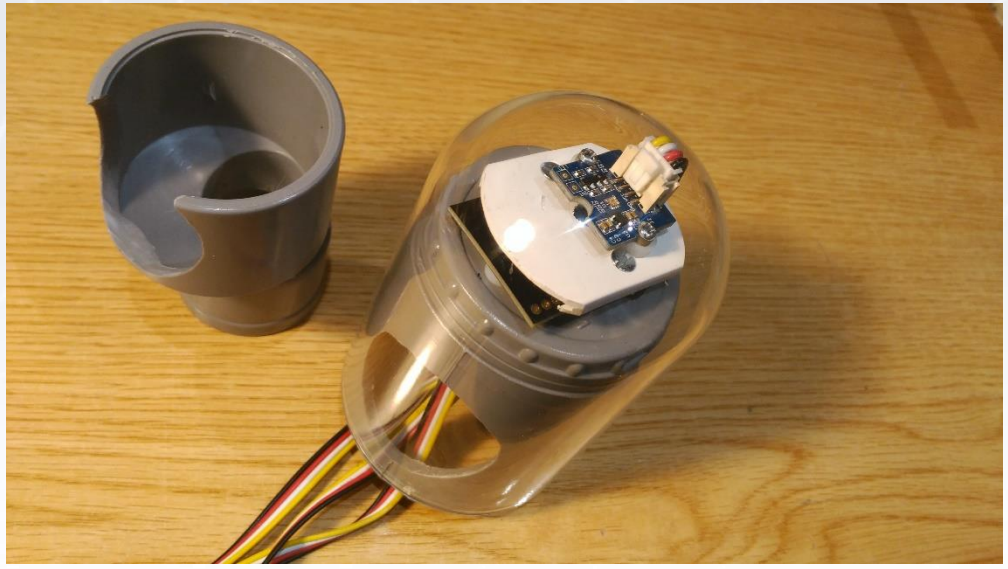


miniMET sensors: sunlight/IR/UV, lightning detector

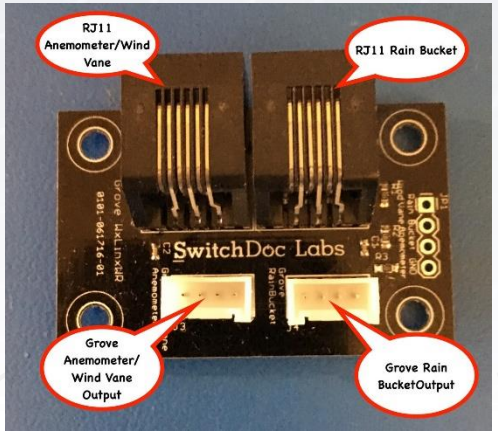




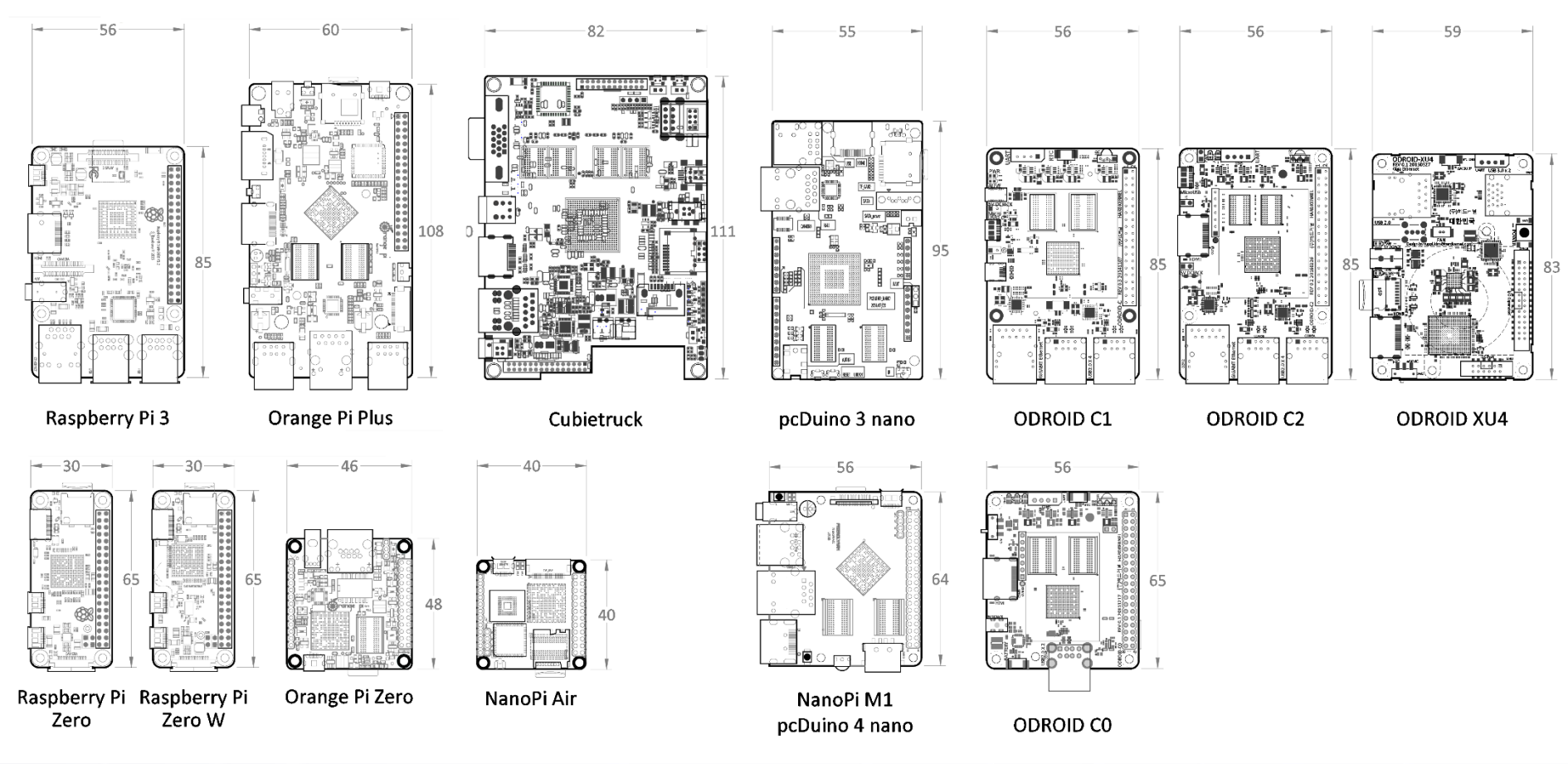




WIND AND RAIN SENSORS



MINIPCS WITH GNU/LINUX OS AS STATION CPU



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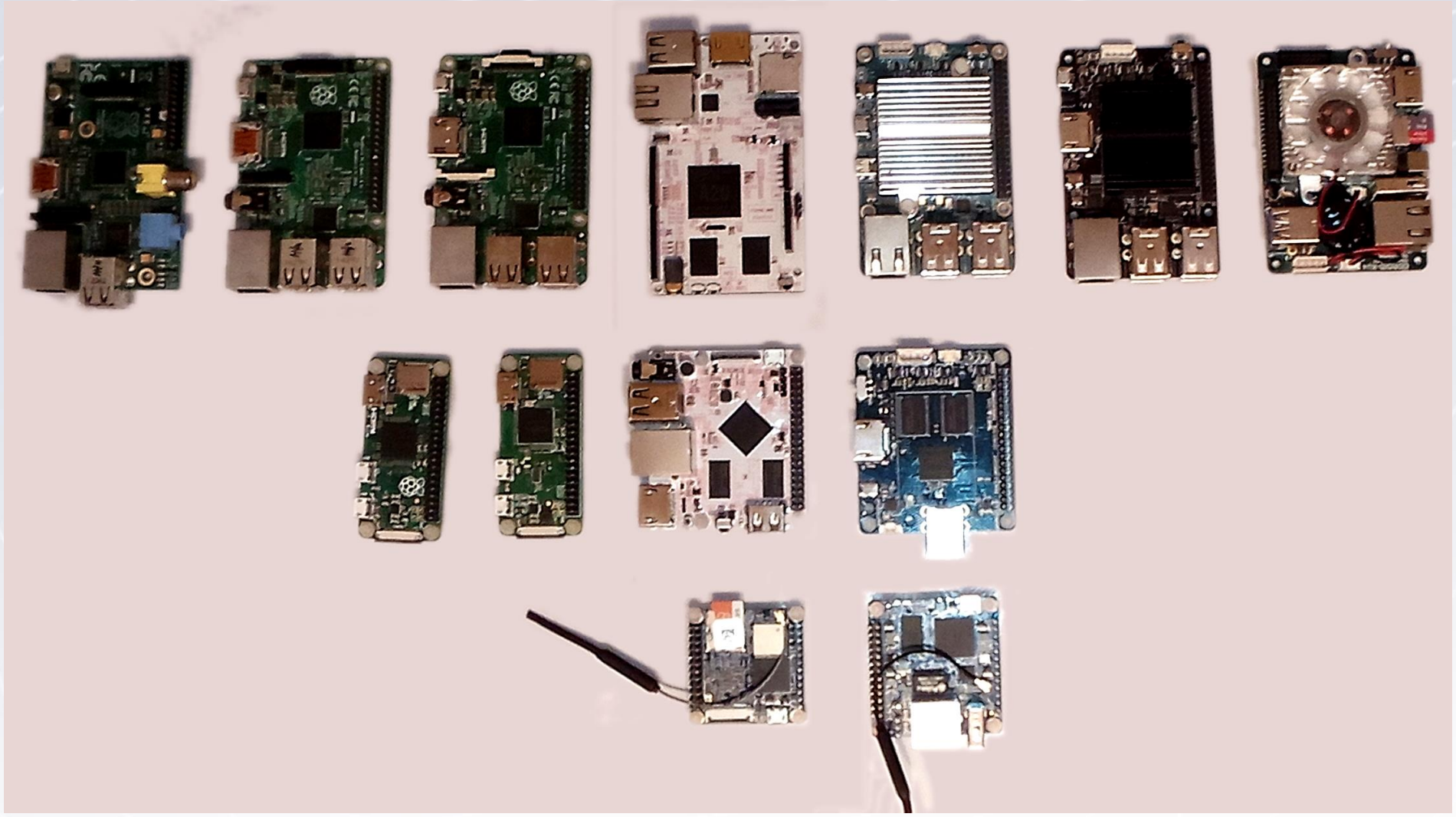
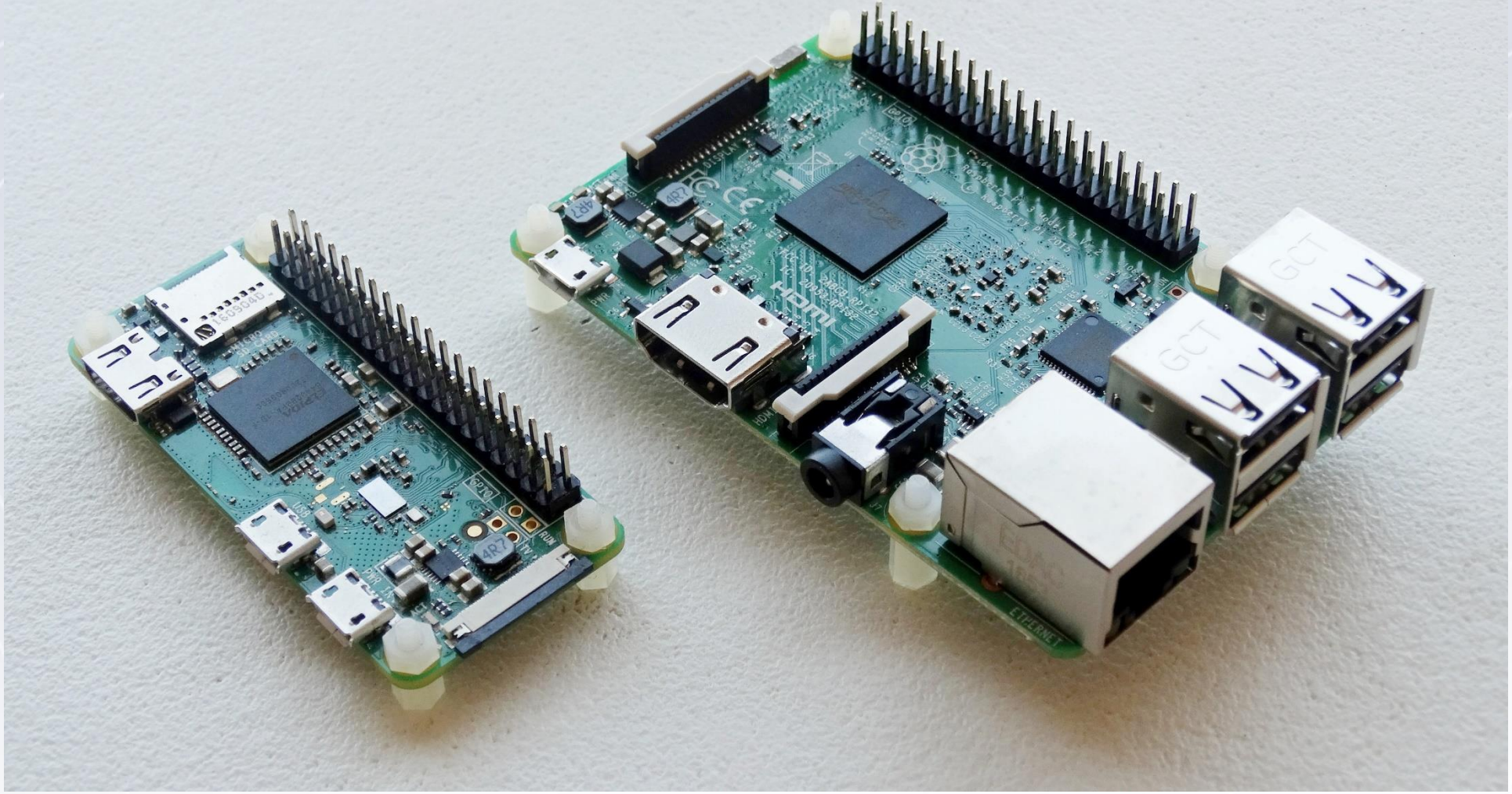
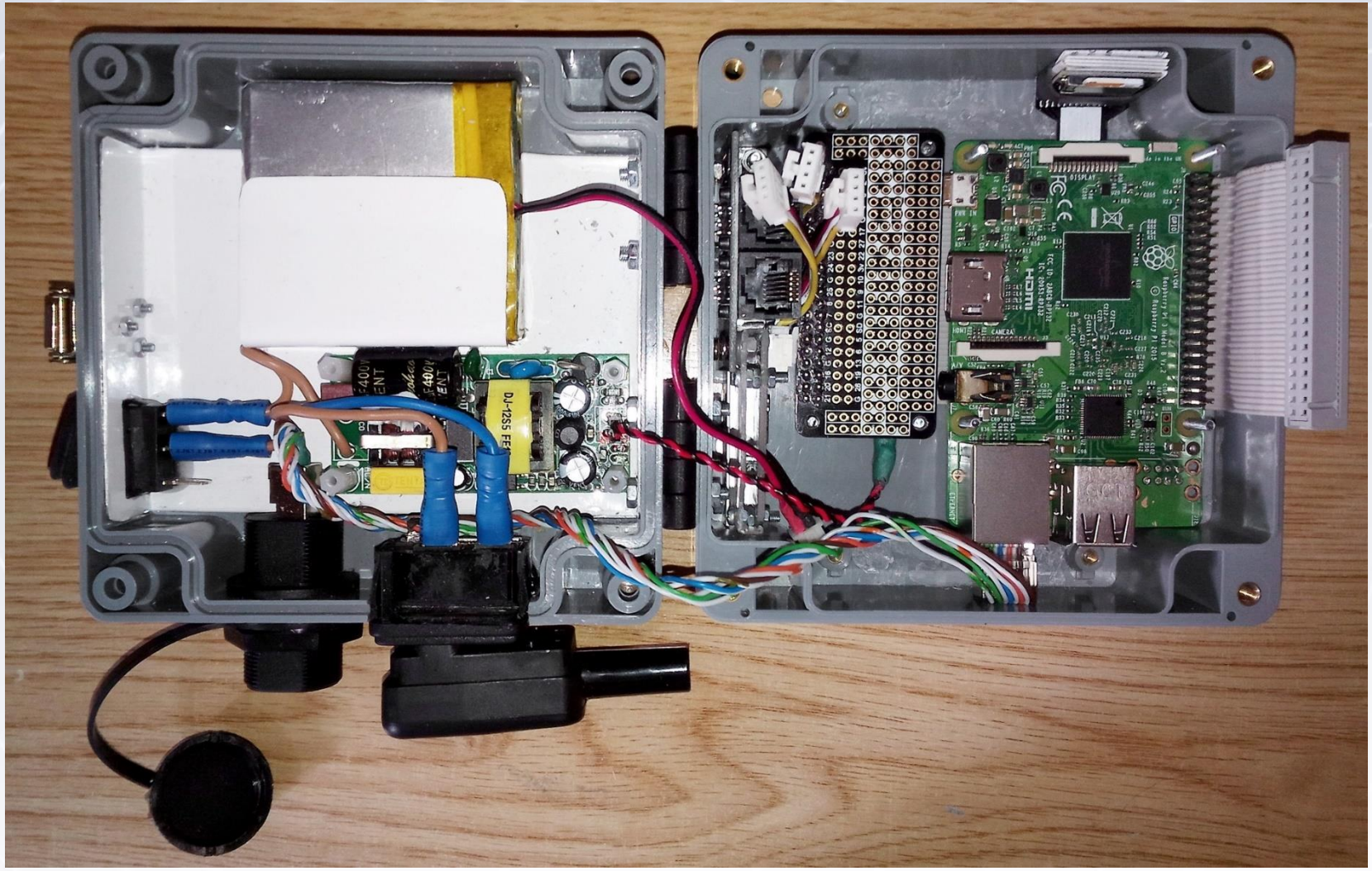


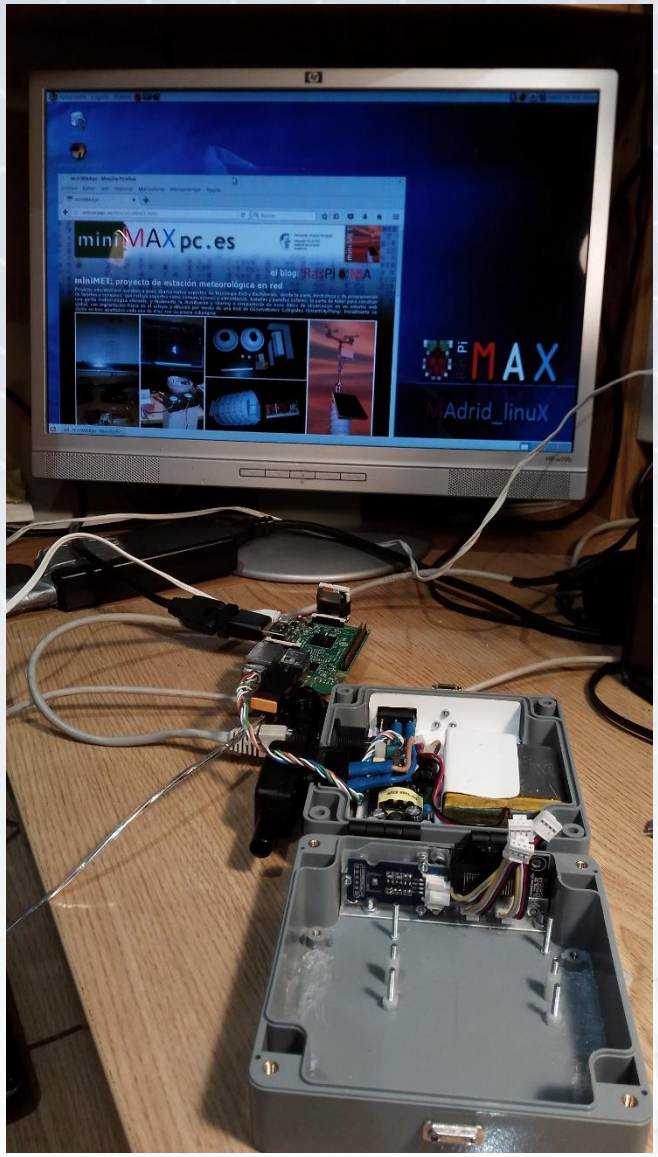
RASPBERRY PI ZERO AND 3 AS CPU



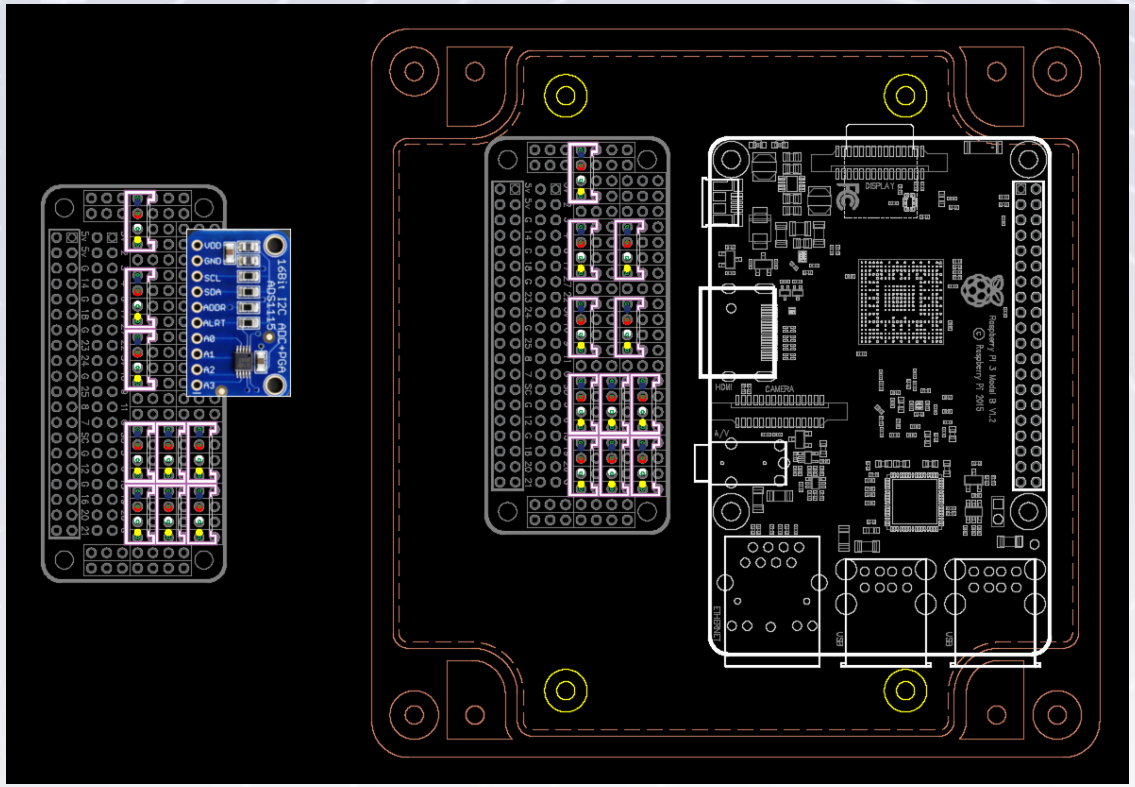
PROTOTYPE STATION based in RASPBERRY PI 3



PROTOTYPE STATION based in RASPBERRY PI 3



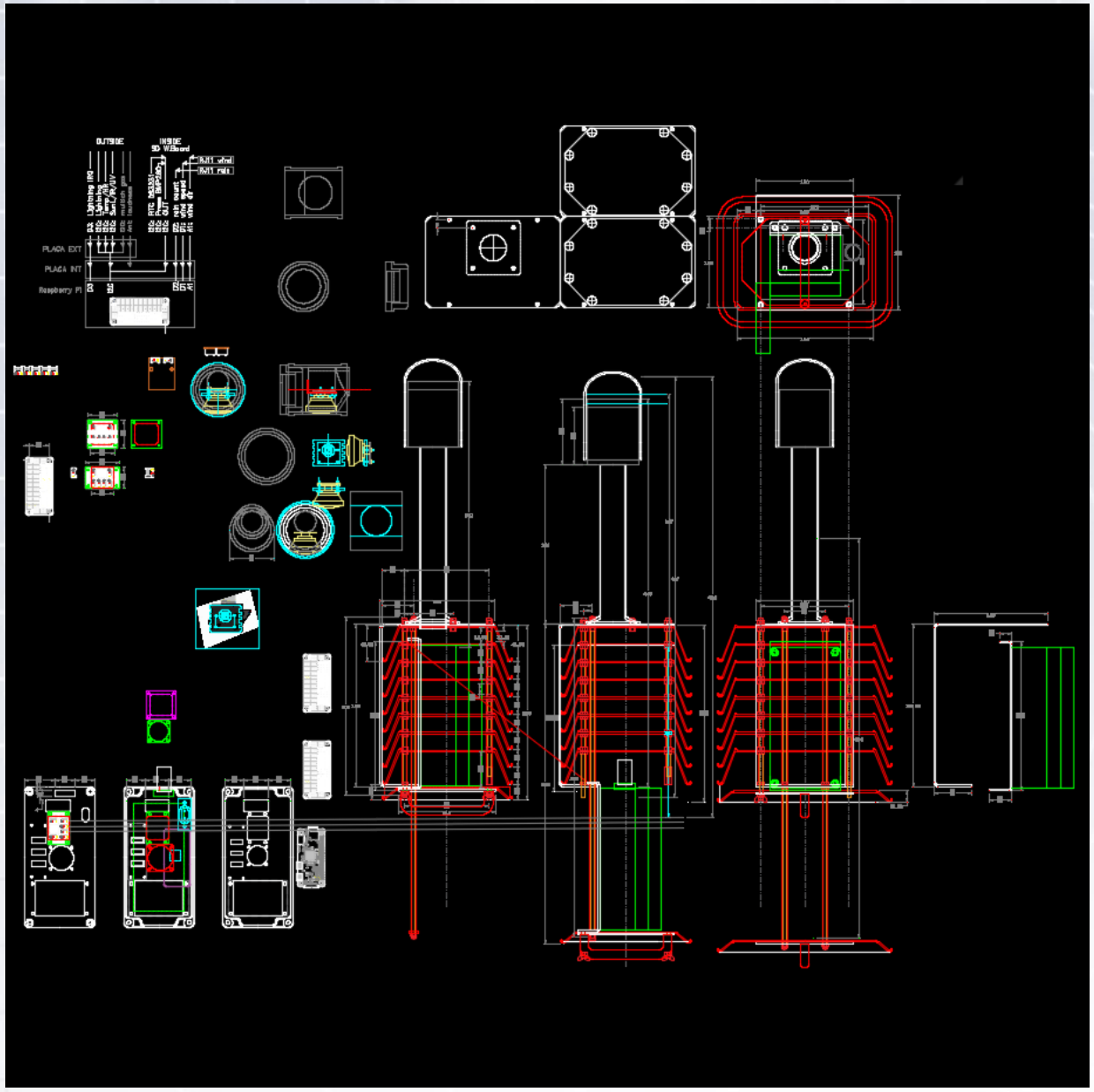
PROTOTYPE STATION based in RASPBERRY PI 3



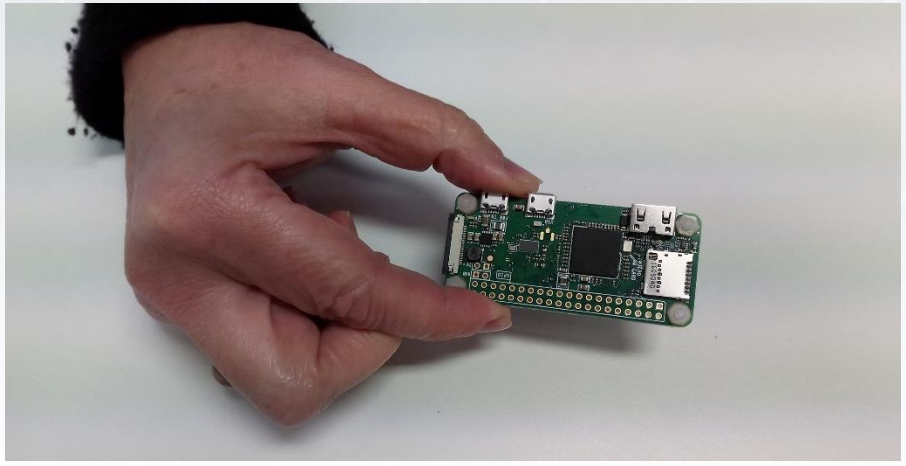
Raspberry Pi 3 GPIO Header

	Pin#	NAME		NAME	Pin#			
	01	3.3v DC Power		DC Power 5v	02			
	03	GPIO02 (SDA1 , I²C)		DC Power 5v	04			
	05	GPIO03 (SCL1 , I²C)		Ground	06			
	07	GPIO04 (GPIO_GCLK)		(TXD0) GPIO14	08			
	09	Ground		(RXD0) GPIO15	10			
	11	GPIO17 (GPIO_GEN0)		(GPIO_GEN1) GPIO18	12			
	13	GPIO27 (GPIO_GEN2)		Ground	14			
	15	GPIO22 (GPIO_GEN3)		(GPIO_GEN4) GPIO23	16			
	17	3.3v DC Power		(GPIO_GEN5) GPIO24	18			
	19	GPIO10 (SPI_MOSI)		Ground	20			
	21	GPIO09 (SPI_MISO)		(GPIO_GEN6) GPIO25	22			
	23	GPIO11 (SPI_CLK)		(SPI_CE0_N) GPIO08	24			
	25	Ground		(SPI_CE1_N) GPIO07	26			
	27	ID_SD (I²C ID EEPROM)		(I²C ID EEPROM) ID_SC	28			
	29	GPIO05		Ground	30			
Anemometer	31	GPIO06		GPIO12	32	Rain		
AS3935 IRQ	33	GPIO13		Ground	34			
	35	GPIO19		GPIO16	36			
	37	GPIO26		GPIO20	38			
	39	Ground		GPIO21	40			

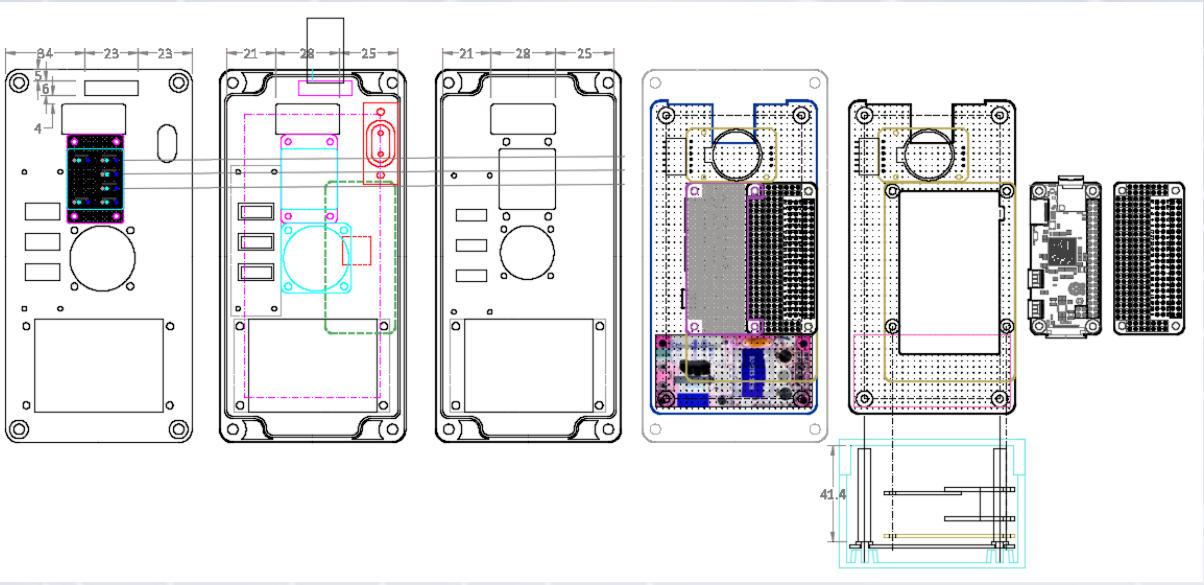
		I2C Addresses	
		0x:	
	--	TCA9545 (FRAM)	73
		AM2315 (T/HR)	5C
		Sunlight/IR/UV	60
		BMP280	77
	?	DS3231(RTC)	68
		AT24C32 eeprom	57
		AS3935 (Lightning)	03 +GPIO13
	?	ADC1x15	48
	?	multichannel-gas	04
UPS PICO		version, mode	69
		bat	6b

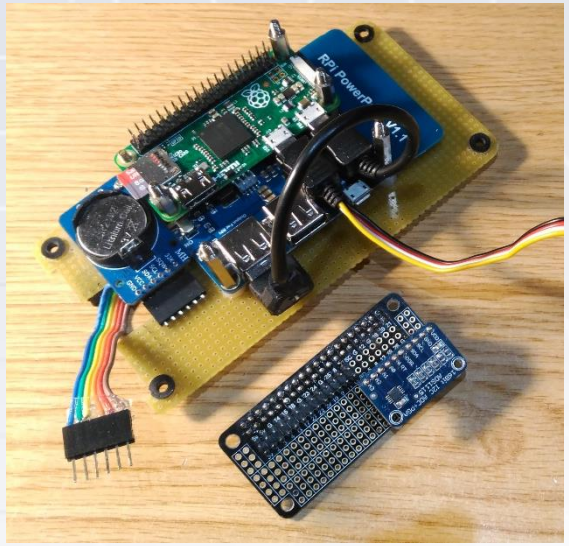


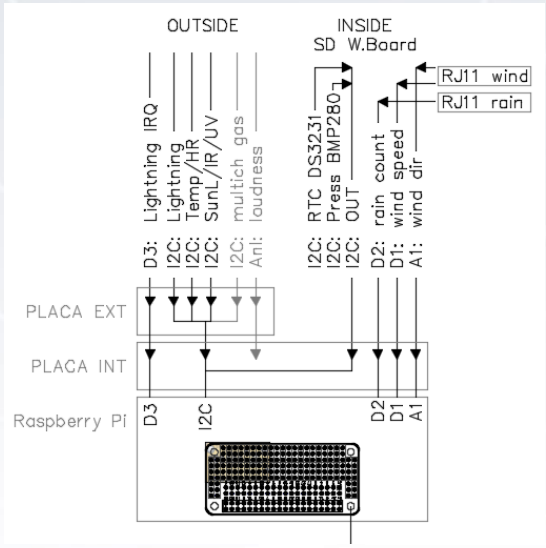
PROTOTYPE STATION based in RASPBERRY PI ZERO

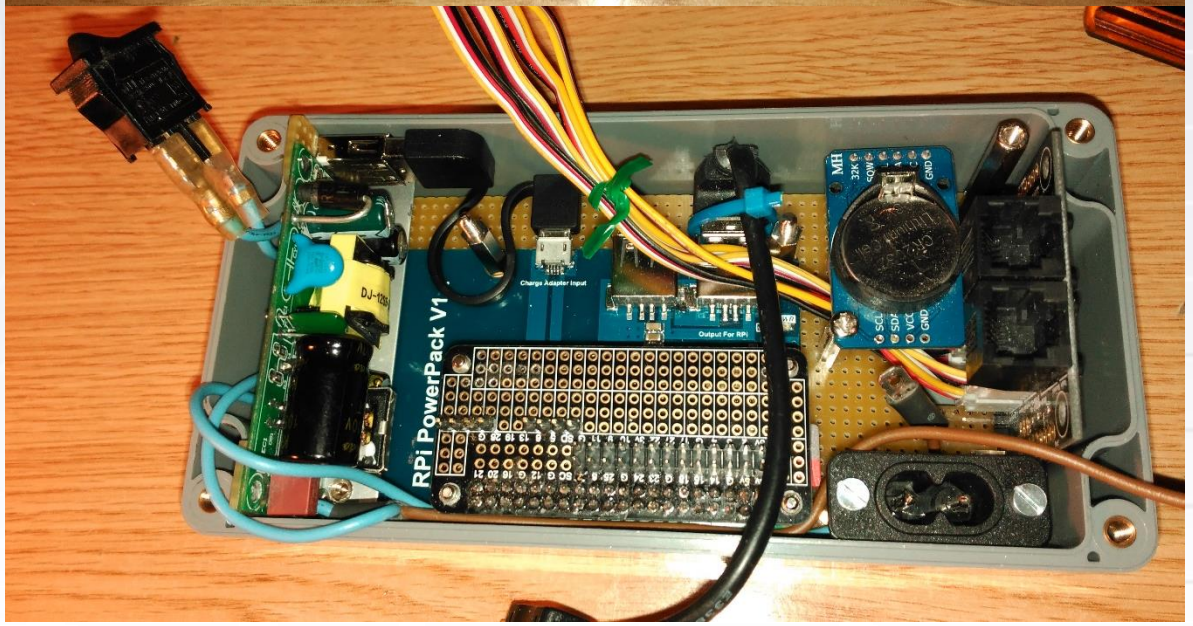


PROTOTYPE STATION based in RASPBERRY PI ZERO



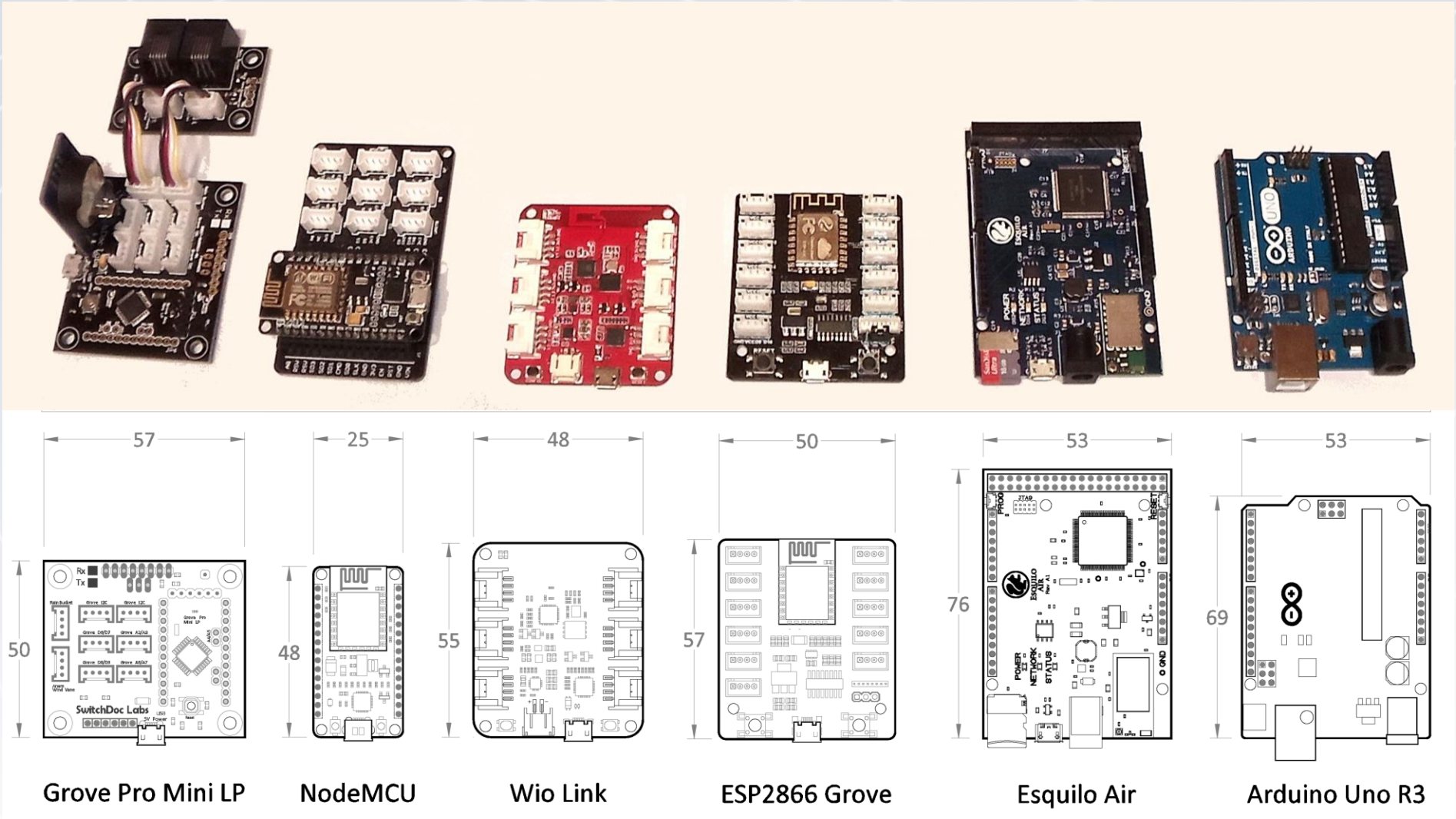






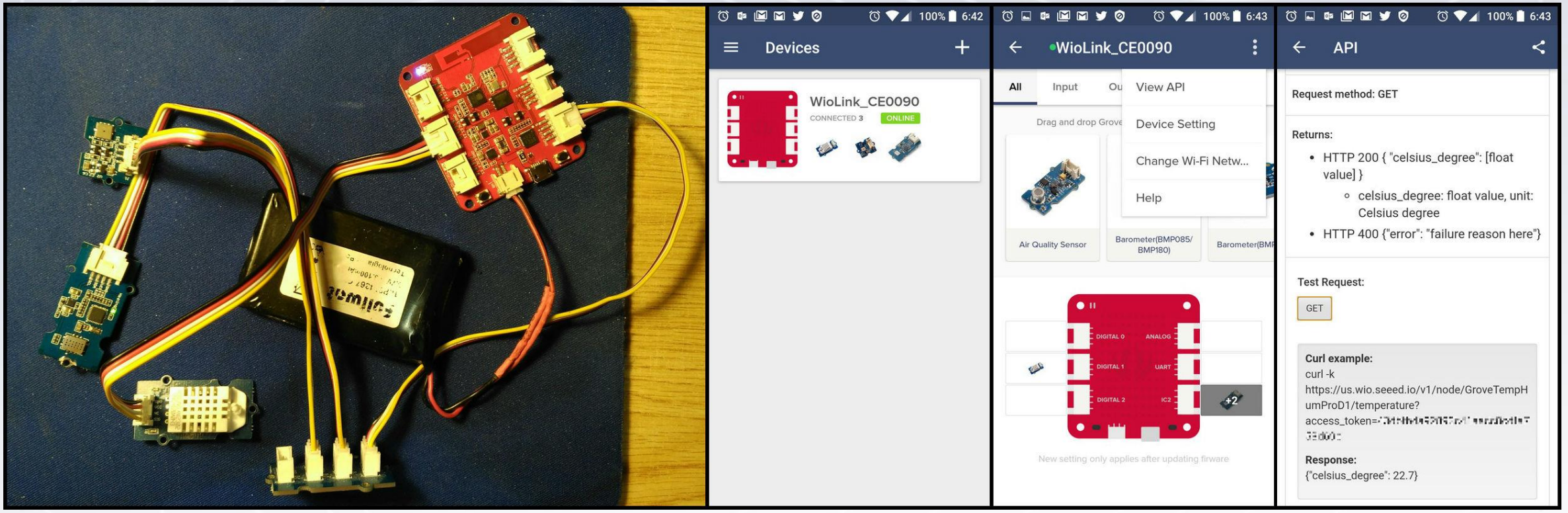
DEVELOPMENT BOARDS AS IoT DEVICES

(with WIFI capabilities)



PROTOTYPE based in WIOLINK IoT DEVICE

with WIFI capabilities

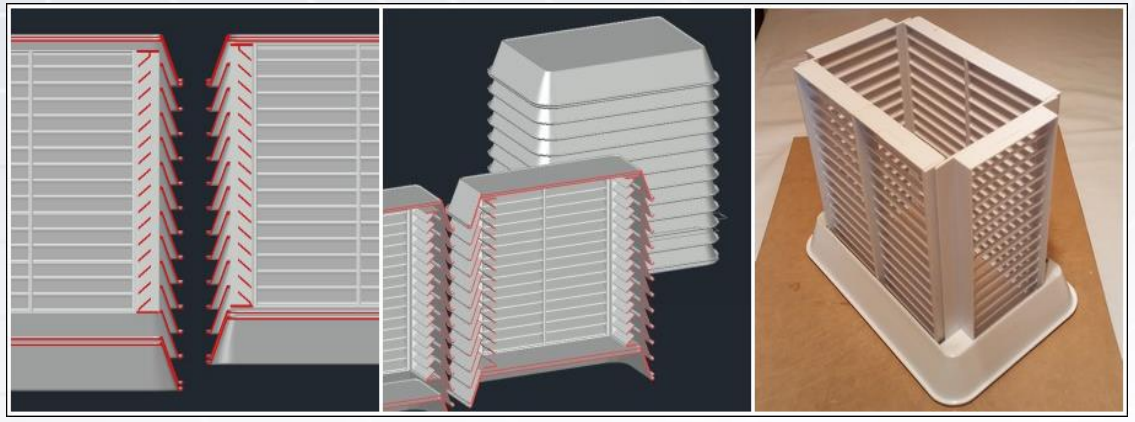


Energy management I

Energy management II

DIY A WEATHER STATION SHELTER

DIY A WEATHER STATION SHELTER V4



LOCATION FOR TESTING THE STATION PROTOTYPES ON THE AEMET TERRACE

HOW MUCH DO THESE PROTOTYPE STATIONS COST AND WHERE TO BUY THEM? I

- Each prototype is designed and documented to be built by each one, whether it is a school classroom or a particular amateur meteorologist, so **every component** must be easily found and purchased for everyone, either in local physical or virtual stores, or abroad (only a few one of them).

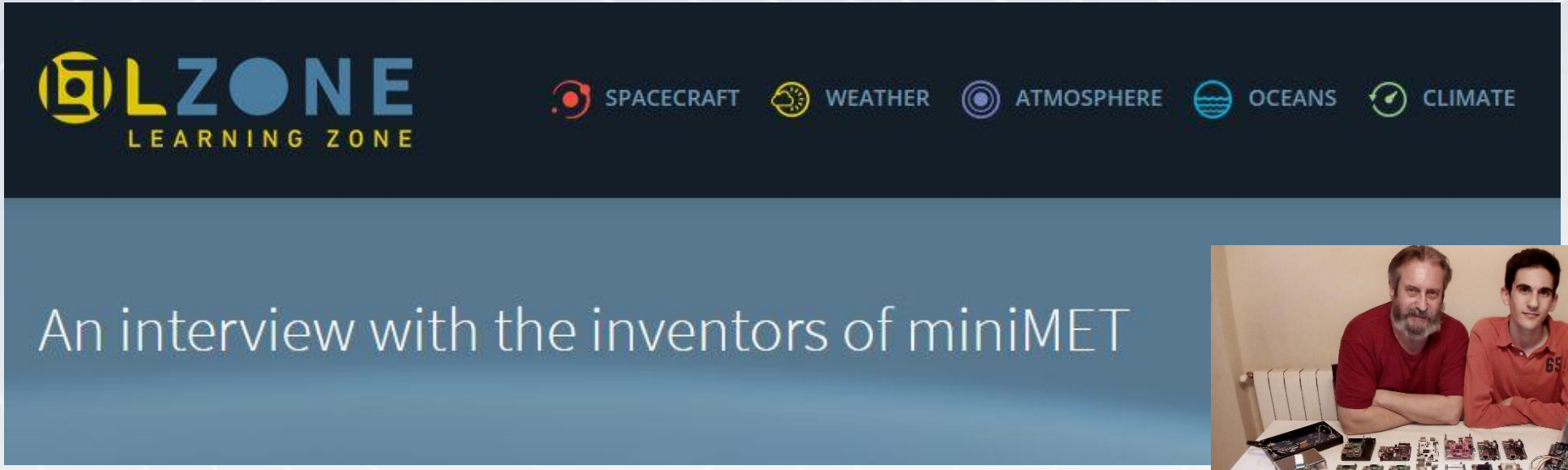
- Small hardware, electric and electronic components including minipcs and sensors may sum around **600~1000€** really far from those 12000~18000€ or even more of those official Thies or Vaisala automatic weather stations.

HOW MUCH DO THESE PROTOTYPE STATIONS COST AND WHERE TO BUY THEM? II

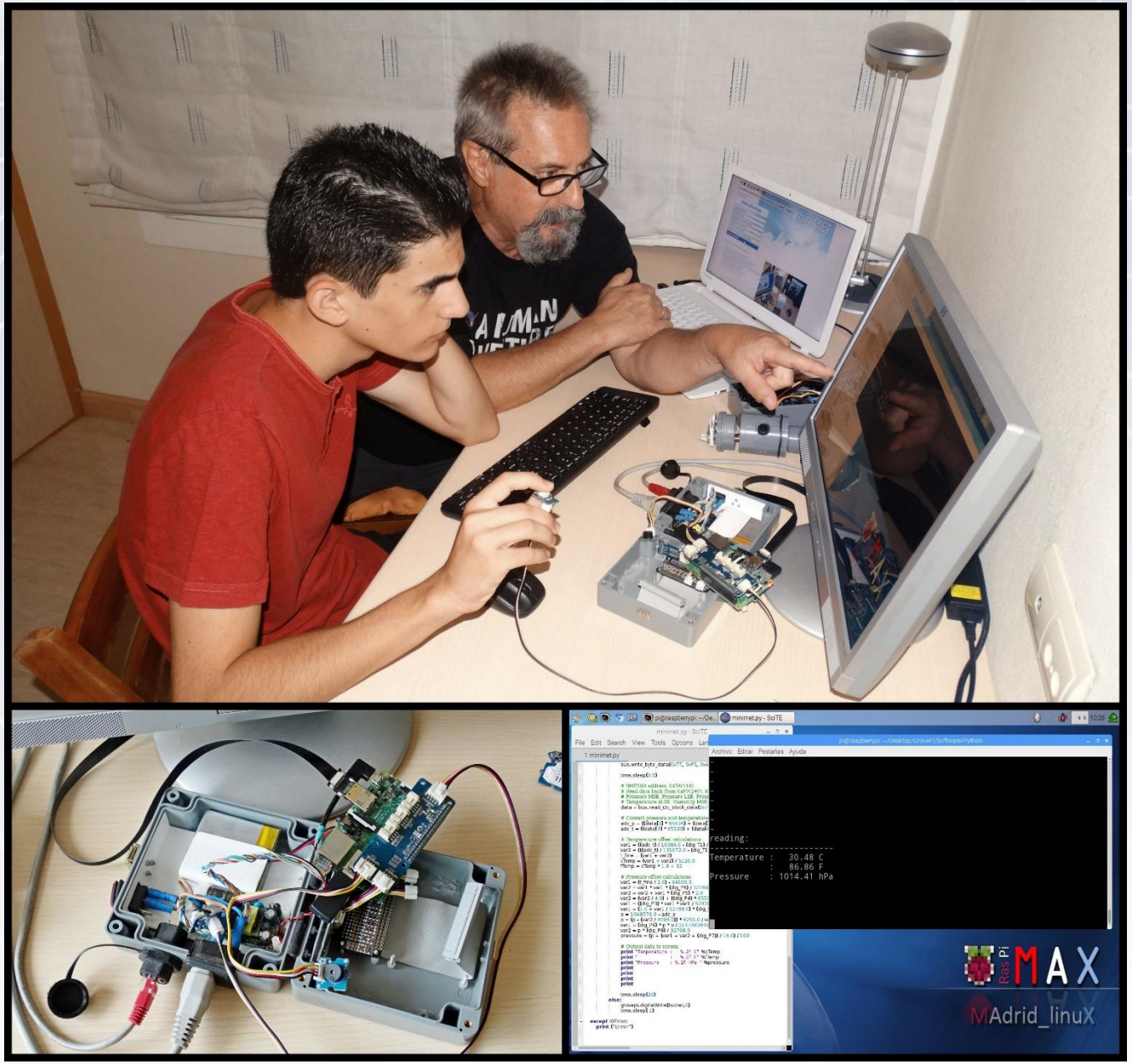
- However, the quality and precision of its measurements are not so far from official stations as one could think regarding these costs…

- AEMET have a network of more than 2000 official collaborators and implementing **miniMET AWAQS**s to those with the necessary connectivity and power supply specifications will be our goal and will require a serial production of stations with a consecuent lowering costs, of course.

"The guys of the RasPiMAX initiative who dreamed up miniMET" were interviewed by **Mara Dambour** in 2017 for **EUMETSAT** educational blog **L-Zone.info**



http://l-zone.info/2017/09/an-interview-with-the-inventors-of-minimet/

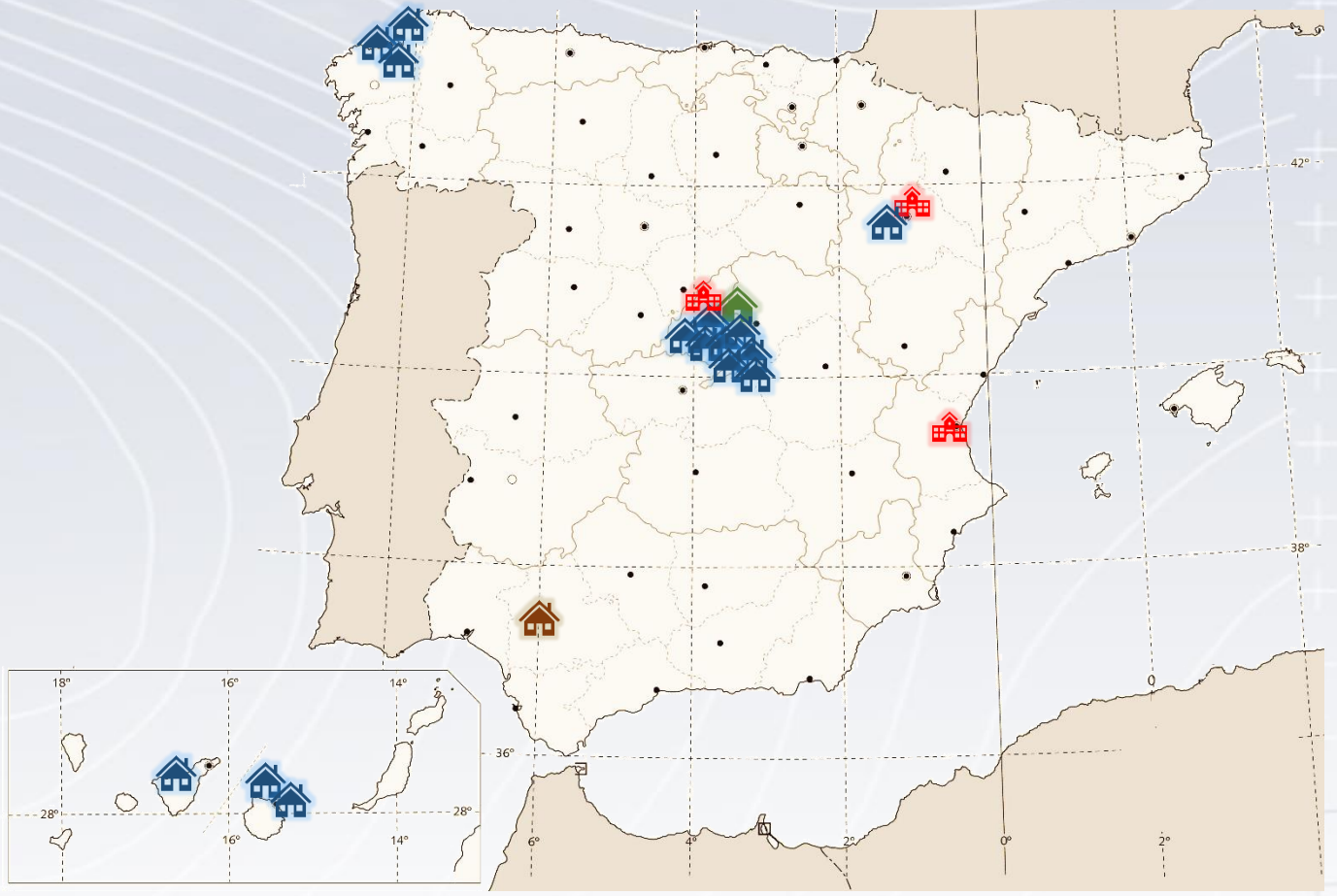

Reading:
Temperature : 30.48 C
: 86.86 F
Pressure : 1014.41 hPa
MAX
MAdrid_linuX

Who can participate in the miniMET Project?

- Schools and colleges of every type, public, private, etc
- Universities
- Environmental educational centres
- Official AEMET collaborators
- Private individuals amateur meteorologists
- Entities promoting citizen science and education

The miniMET Working Group / Pilot Map

- **Open** to everyone willing to participate or informing about core questions and discussion on implementing, funding, etc.
- Using an email distribution list
- To participate ask for it to **minimet@aemet.es**
- More information about this in the blog RasPiMAX: **http://raspimax.es**



Informative Website of miniMET

http://minimet.net > http://es.minimet.net > http://uk.minimet.net

etc

HOW WILL THE DATA BE MANAGED?

Aemet has the necessary operational capacity to handle this project through its OpenData infrastructure and will manage this data network from the **Aemet collaborative OpenData** with a triple function:

1. **Collecting** observations data
2. **Showing** them to the educational community and society through digital maps on the Internet
3. **Sharing** them back as open data because:

Open Science and ***Open Data*** are **inseparable concepts**

AEMET COMMITMENTS I

- ✓ AEMET wil **enable this collaborative opendata input** including the related Aplication Programming Interfaces (APIs), as well as develop the public environment for visualization of received data georeferred in internet **OpenMaps**.
- ✓ Also will develop and freely distribute every prototype station software, mostly written in Python, based entirely in free software within the GNU/Linux Operating System

AEMET COMMITMENTS II

- ✓ AEMET will **define and publish** a **technical specification** of each prototype, as well as the manuals for mounting it
- ✓ **Supervise** and **approve** each of the candidate stations to admit them to this school network
- ✓ **Provide training** through courses and seminars to the ICT managers and teachers of each center enrolled in the project

The final BENEFITS

Finally, the society will benefit from this return data, with an extensive and homogeneous **layer** of environmental measurements throughout the territory, testable with the official measures of AEMET automatic weather stations, providing decisive added information within its **mission** to

"***contribute to the safety of people and goods, and to the welfare and sustainable development of Spanish society***."

Appendix

- **AEMET collaborative OpenData**
- **minimet.net**, Sharing/exporting project
- **AEMET VISOR** internet maps
- **Climatological charts**

AEMET OpenData

opendata.aemet.es

AEMET OpenData is an API REST (Application Programming Interface. REpresentational State Transfer) through which can be downloaded free data listed in Annex II of the resolution of 30 December 2015 of AEMET, in which the public prices that will govern the provision of meteorological and climatological services are established. This resolution has been published in the BOE (Official State Gazette) no. 4, on 5 January 2016.

AEMET OpenData

AEMET OpenData allows two types of access: General access and AEMET OpenData API. Both of them provide access to the same data catalogue and they offer downloading data in reusable formats.

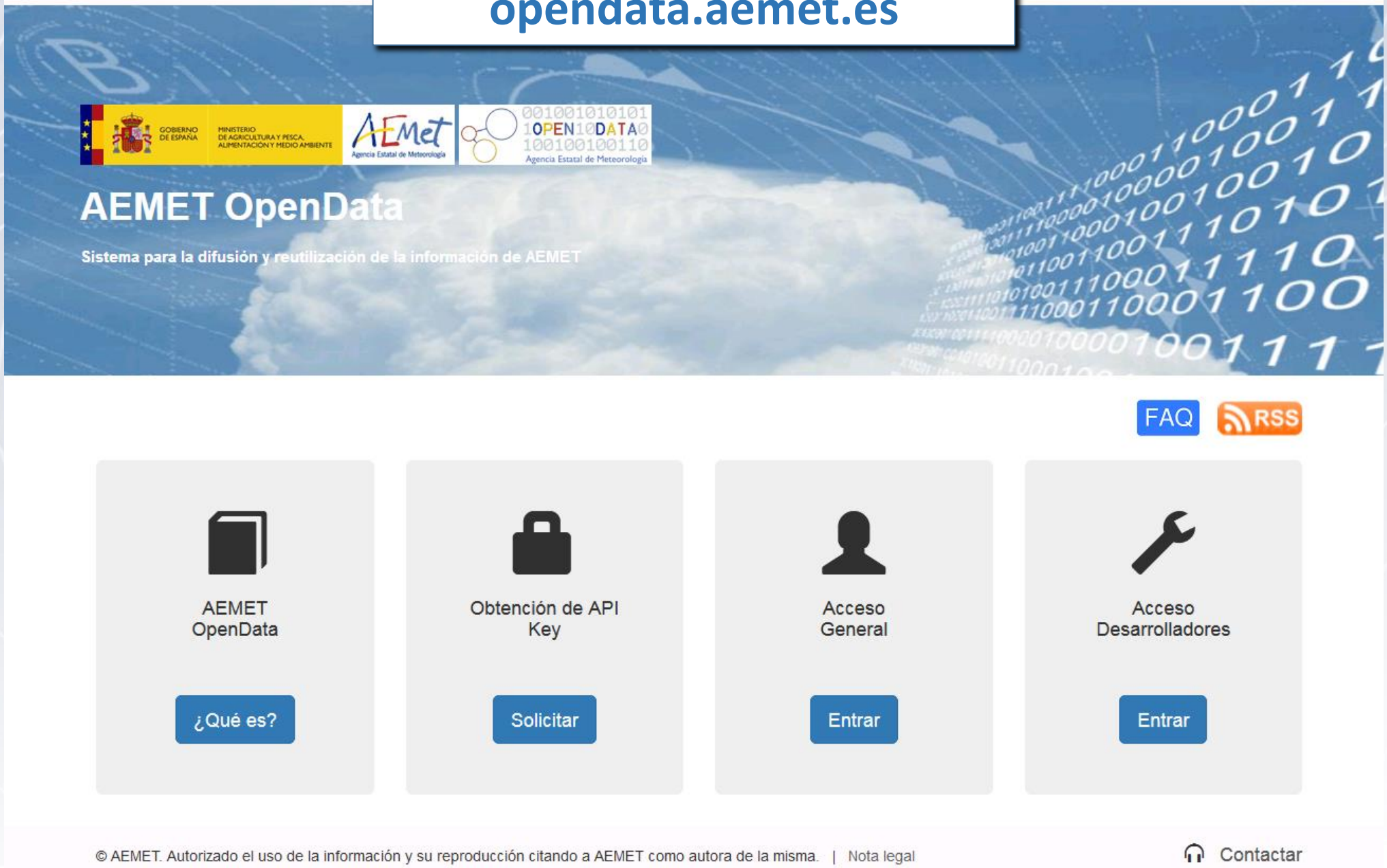
General access

This is a chart access for the general public. It aims to enable user to get access to data in a user-friendly way. Interaction with data is punctual, it's made through a human user-friendly interface, directed step by step and by choosing options.

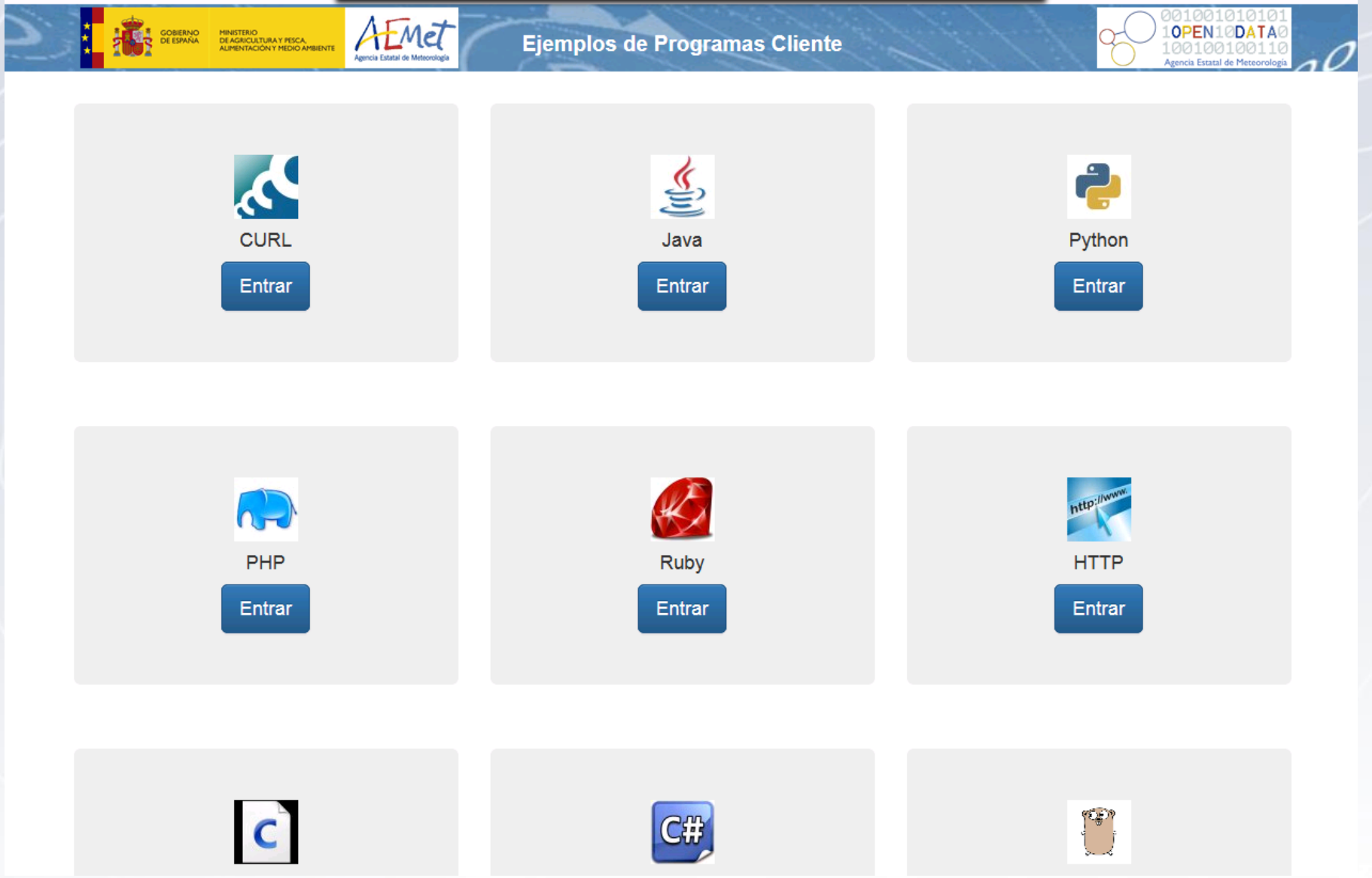
AEM PDF Resolution of 30 December 2015 of the State Meteorological Agency of Spain, in which the public prices that will govern the provision of meteorological and climatological services are established. (522 KB)

AEMET OpenData API allows other interaction way with the data: this interaction can be periodic or programmed, from any programming language, without user-friendly interfaces, with self-discovery option. This make possible that AEMET data can be included by re-users of information in their own information systems.

opendata.aemet.es



opendata.aemet.es



opendata.aemet.es

C

Entrar

C#

Entrar

Go

Entrar

Java Script

Entrar

NodeJS

Entrar

Objective-C

Entrar

OCaml

Entrar

Shell

Entrar

Swift

Entrar

opendata.aemet.es

Ejemplo en Python http.clien (Python 3)

```
import http.client

conn = http.client.HTTPSConnection("opendata.aemet.es")

headers = {
    'cache-control': "no-cache"
    }

conn.request("GET", "/opendata/api/valores/climatologicos/inventarioestaciones/todasestaciones/?api_key=jyJhbGciOiJIUzI1NiJ9.eyJzdWIiOiJqbW9udGVyb2dAYWVtZXQu

res = conn.getresponse()
data = res.read()

print(data.decode("utf-8"))
```

Ejemplo en Python Requests

```
import requests

url = "https://opendata.aemet.es/opendata/api/valores/climatologicos/inventarioestaciones/todasestaciones/"

querystring = {"api_key":"eyJhbGciOiJIUzI1NiJ9.eyJzdWIiOiJqbW9udGVyb2dAYWVtZXQuZXMiLCJqdGkiOiI3NDRiYmVhMy02NDEyLTQxYWMtYmYzOC01MjhlZWJlM2FhMWEiLCJleHAiOjE0Nz

headers = {
    'cache-control': "no-cache"
    }

response = requests.request("GET", url, headers=headers, params=querystring)

print(response.text)
```

Taking the challenge of sharing/exporting

- **Phase I: informative**

  Aemet provides **subdomains** with translations to several languages within the European zone, which explain the basis of the project, launching an **invitation** to participate.

- **Phase II: NMHS supporting initiatives**

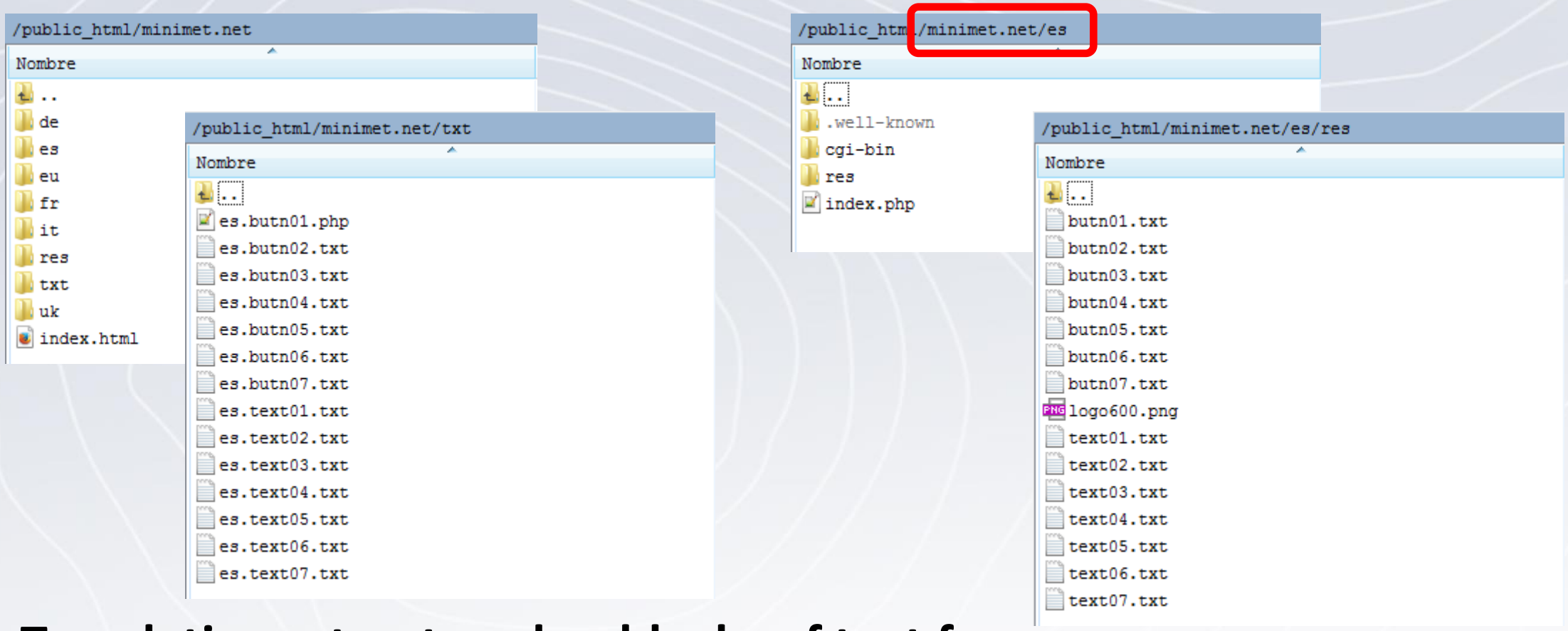
  Interested NMHS's **coordinate efforts** to implement the project in a similar way, taking responsibility for their own stations and country educational commitments, and even creating a **common and shared database**.

Taking the challenge of sharing/exporting

minimet.net

Multi-domain environment using country codes top-level domain, ccTLD

Taking the challenge of sharing/exporting



Translations structured as blocks of text for button labels and contents displayed

Taking the challenge of sharing/exporting

Label texts applied to buttons

Taking the challenge of sharing/exporting

es.minimet.net

Taking the challenge of sharing/exporting

uk.minimet.net

Taking the challenge of sharing/exporting

es.minimet.net

es.minimet.net

[Web prototipo/maqueta no oficial del Proyecto miniMET]

Proyecto miniMET v.beta 4.0 20170525
email: minimet@aemet.es

GOBIERNO DE ESPAÑA · MINISTERIO DE AGRICULTURA Y PESCA, ALIMENTACIÓN Y MEDIO AMBIENTE · AEMet Agencia Estatal de Meteorología

miniMET

- EL MANIFIESTO MINIMET
- EL PROYECTO MINIMET
- CIENCIA CIUDADANA, SOCIENTIZE, RRI/SWAFS
- EL OPENDATA COLABORATIVO
- LA COMUNIDAD EDUCATIVA
- **RasPiMAX: SOFTWARE LIBRE + HARDWARE ABIERTO**
- UN PROYECTO DE TECNOLOGÍA

Para materializar este proyecto aportamos desde la **iniciativa RasPiMAX**, la definición y construcción de una **red de observatorios del aire** para escuelas, colaboradores oficiales de AEMET, y también para aficionados a la meteorología, presentando varios prototipos de **estación meteorológica y de calidad del aire automática (EMCAA)**, de construcción sencilla y bien definida como **proyecto de tecnología** con elementos asequibles de **hardware abierto** y **software libre**.

RasPiMAX, acrónimo de **Ras**pberry **Pi** con GNU/Linux **MAX**, es una iniciativa educativa particular para difundir el uso del software libre y el hardware abierto, proponiendo ideas creativas e innovadoras de las TICs para todas las edades. Se apoya principalmente en **Raspberry Pi**, el miniPC por excelencia, con una amplia difusión en el mundo educativo anglosajón y en **MAX** (de **MA**drid_linu**X**) la versión de GNU/Linux que desarrolla **EducaMadrid** - Consejería de Educación, Juventud y Deporte de la Comunidad de Madrid para sus colegios.

Taking the challenge of sharing/exporting

uk.minimet.net

uk.minimet.net

[Unofficial prototype/model website of miniMET Project]

Proyecto miniMET v.beta 4.0 20170525
email: minimet@aemet.es

NMHS official logo

miniMET

- THE MINIMET MANIFESTO
- THE MINIMET PROJECT
- CITIZEN SCIENCE, SOCIENTIZE, RRI/SWAFS
- THE COLLABORATIVE OPENDATA
- THE EDUCATIONAL COMMUNITY
- RasPiMAX: OPEN SOFTWARE + FREE HARDWARE
- A TECNOLOGY PROJECT

In order to materialize this project, we do contribute, from the **RasPiMAX initiative**, with the definition and building of an **air observatories network** for schools, Aemet official collaborators, as well as for amateur meteorologists, proposing several **automatic weather and air quality station (AWAQS)** prototypes, of simple and well-defined construction as **technology projects** with affordable elements of **open hardware** and **free software**.

RasPiMAX, acronym of **Ras**pberry **Pi** with GNU/Linux **MAX**, is a particular educational initiative to spread the use of free software and open hardware, proposing creative and innovative ideas of ICTs for people of all ages. It relies mainly on **Raspberry Pi**, the miniPC par excellence, with a wide spread in the Anglo-Saxon educational world, and on **MAX** (from **MA**drid_linu**X**) a versión of GNU/Linux developed by **EducaMadrid** - *Consejería de Educación, Juventud y Deporte* of the community of Madrid for his schools.

Taking the challenge of sharing/exporting

es.minimet.net

es.minimet.net

[Web prototipo/maqueta no oficial del Proyecto miniMET]

Proyecto miniMET v.beta 4.0 20170525
email: minimet@aemet.es

GOBIERNO DE ESPAÑA · MINISTERIO DE AGRICULTURA Y PESCA, ALIMENTACIÓN Y MEDIO AMBIENTE · AEMet Agencia Estatal de Meteorología

- EL MANIFIESTO MINIMET
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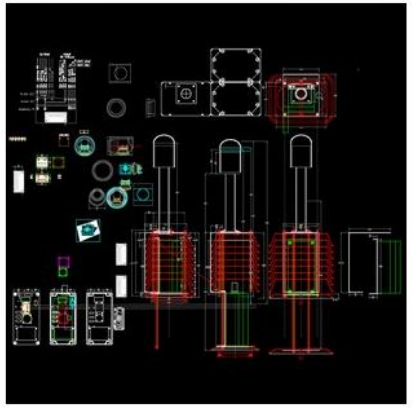
miniMET

El proyecto desarrolla los siguientes aspectos:

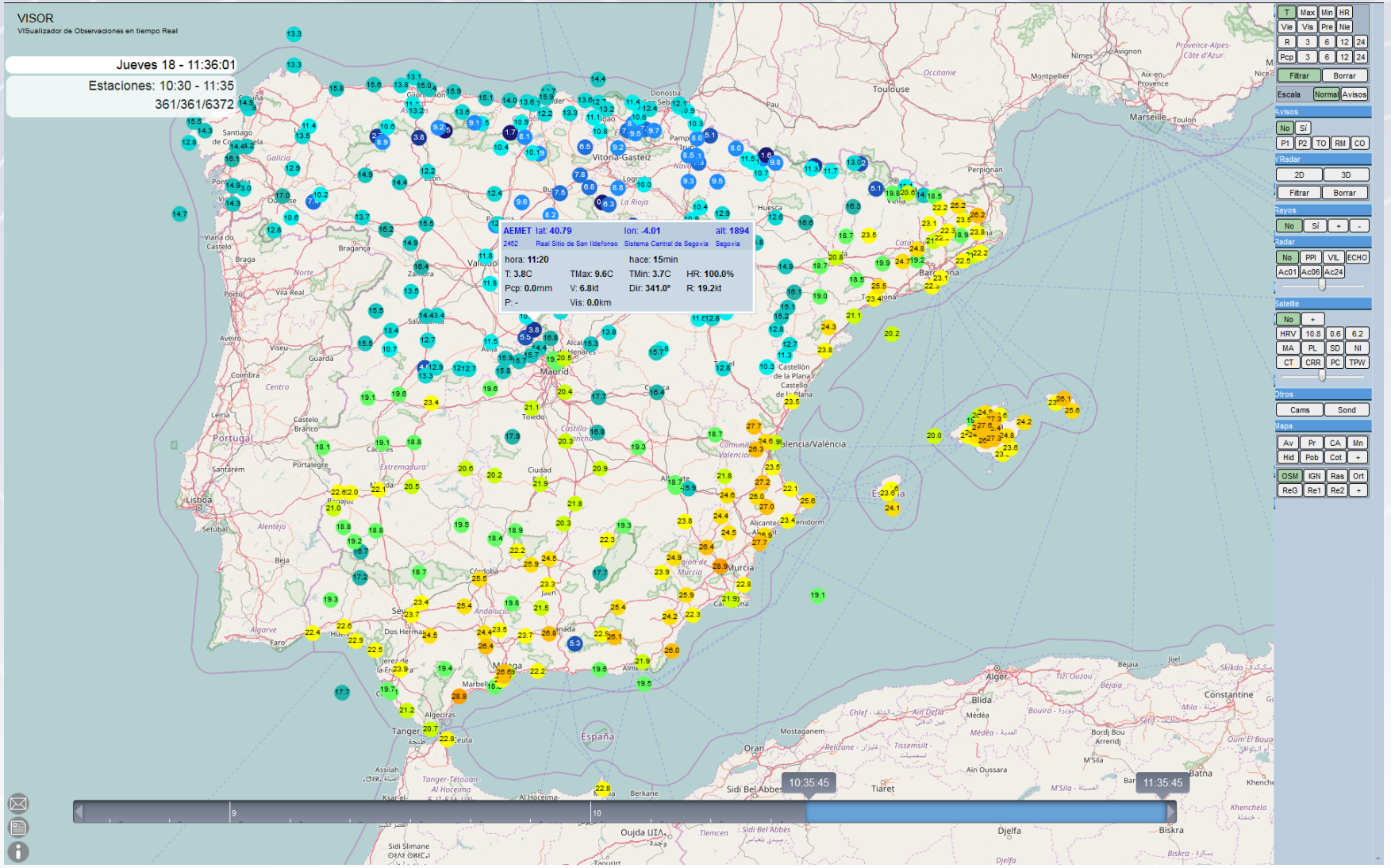
- Bricolaje para construir una garita meteorológica
- Introducción a los miniPCs y tarjetas de desarrollo
- Introducción a los sensores y las comunicaciones
- Iniciación a la programación en Python y otros
- Integración y pruebas de la estación
- Ubicación, instalación y puesta en marcha
- Lectura y análisis de los datos observados
- Transmisión y recuperación de los datos



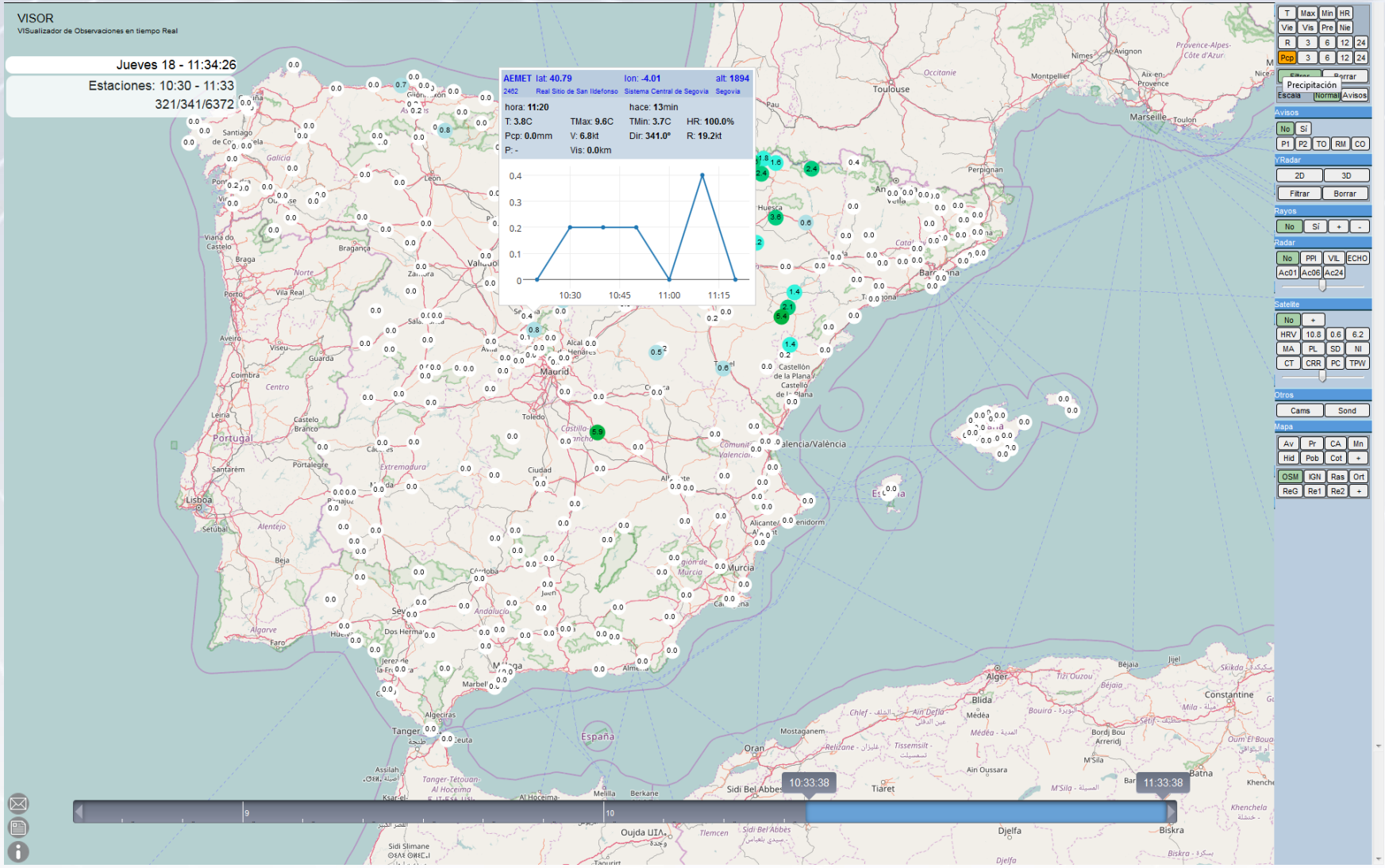
VISOR of AEMET

- **VISOR** (stands for ***VIEWER***) is an AEMET's experimental application for visualizing several types of weather-related information managed in **LAYERS** over an **OpenMaps** base.
- Although at present moment it is an intranet application for our own production work, it is intended to be our candidate for showing publicly on the Internet the **miniMET network**.
- It will locate on the map every registered AWAQS (automatic weather and air quality station), whether it is an official collaborator, a school team or a particular amateur meteorologist.

VISOR of AEMET



VISOR of AEMET



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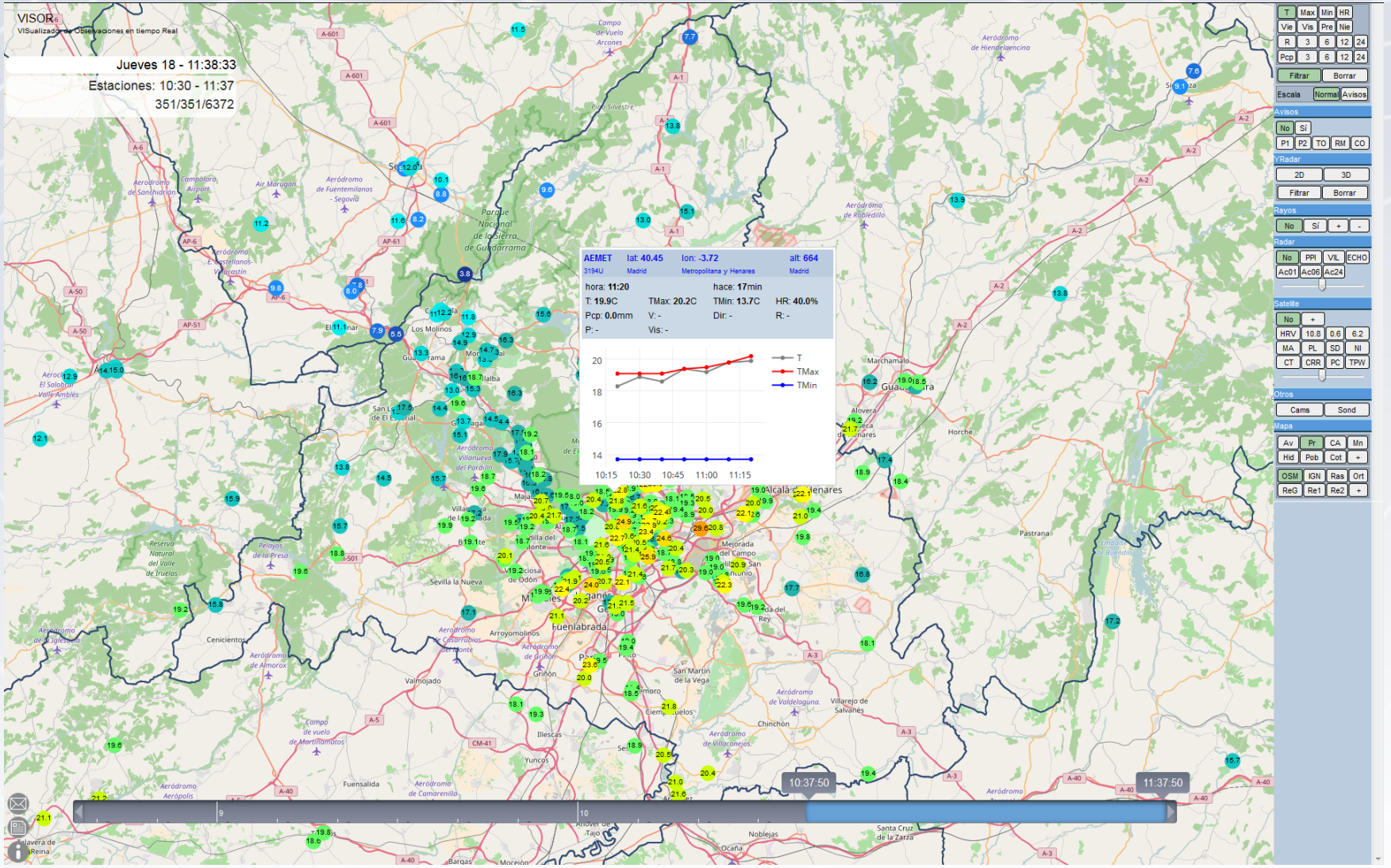
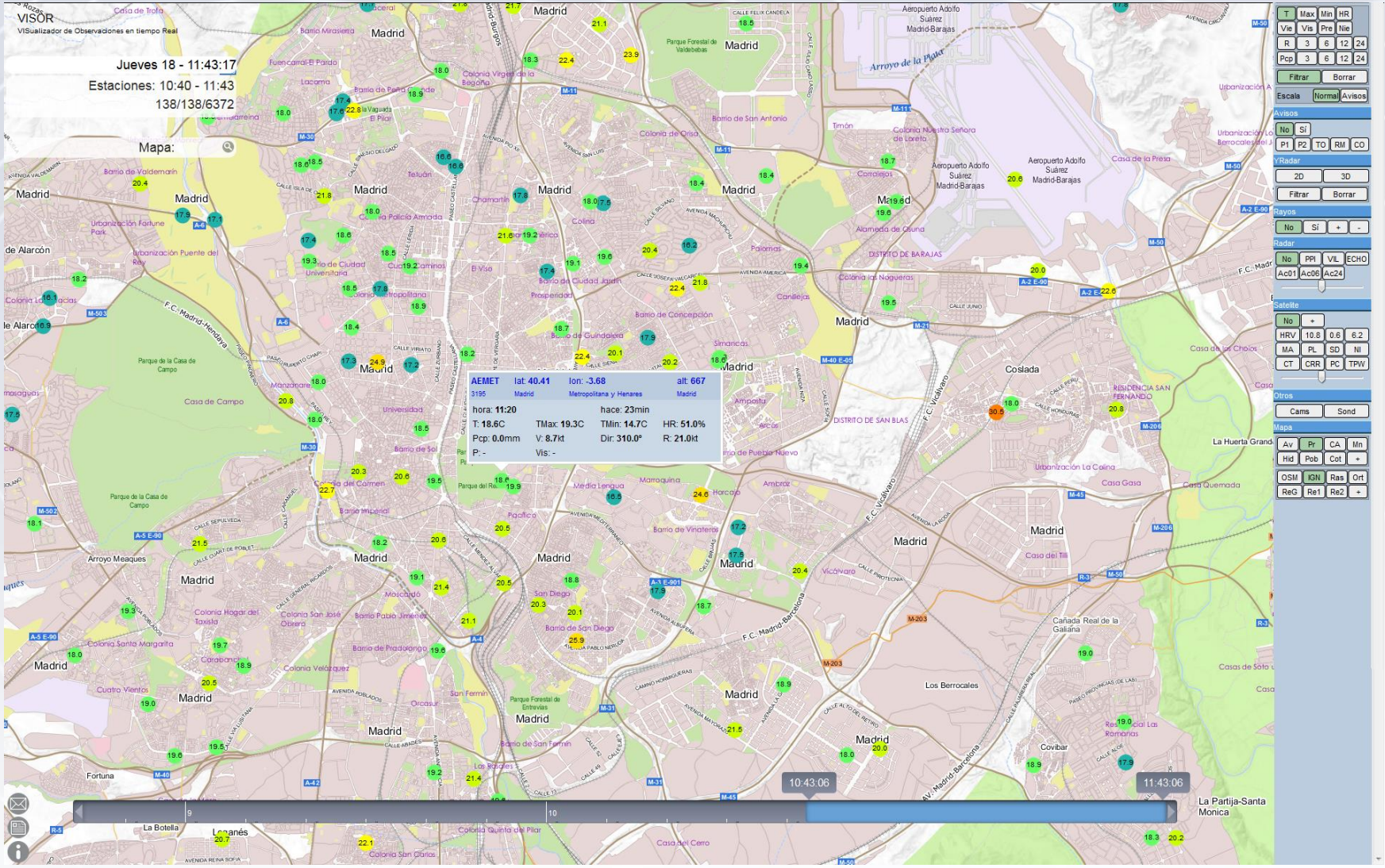


VISOR of AEMET



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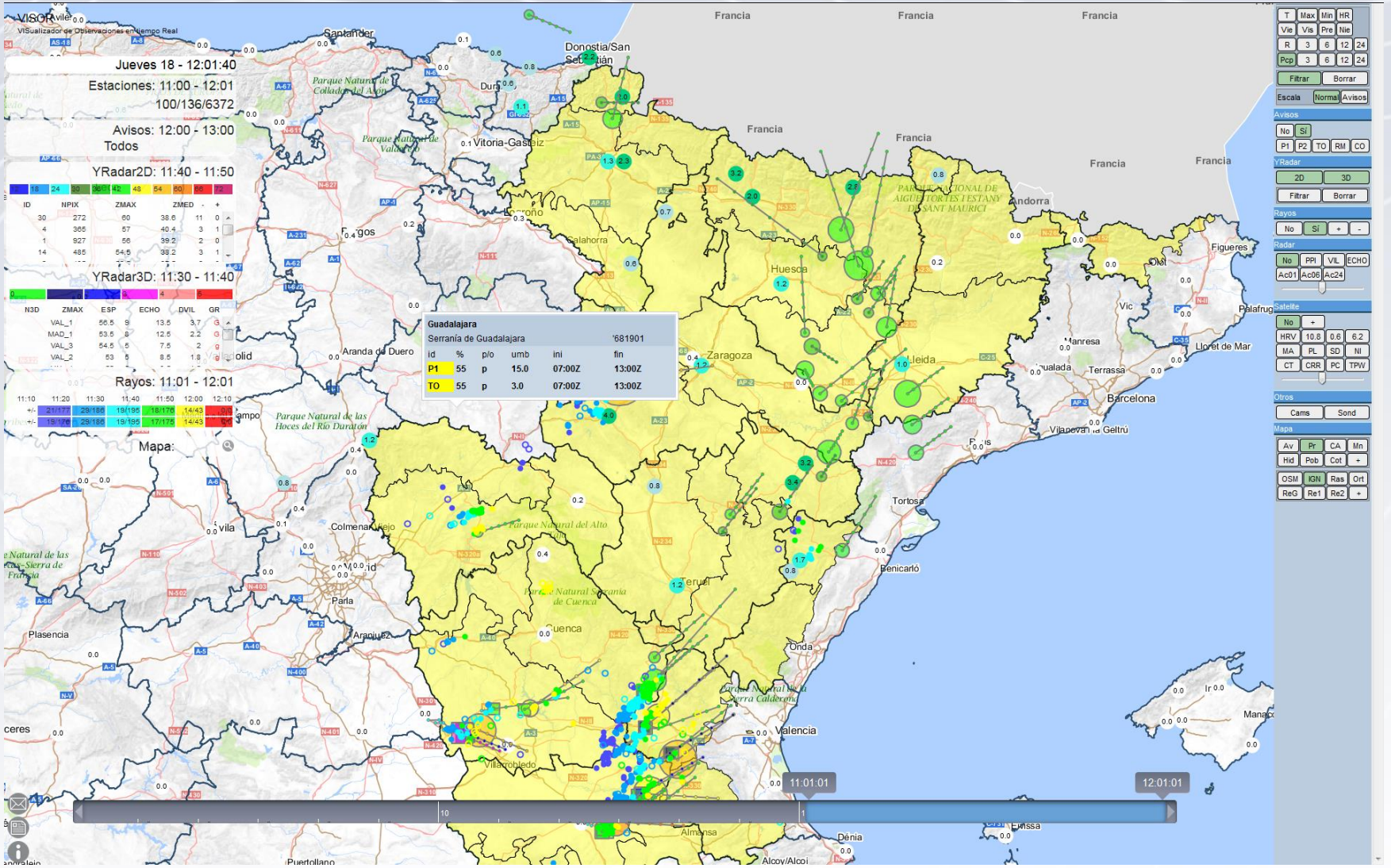
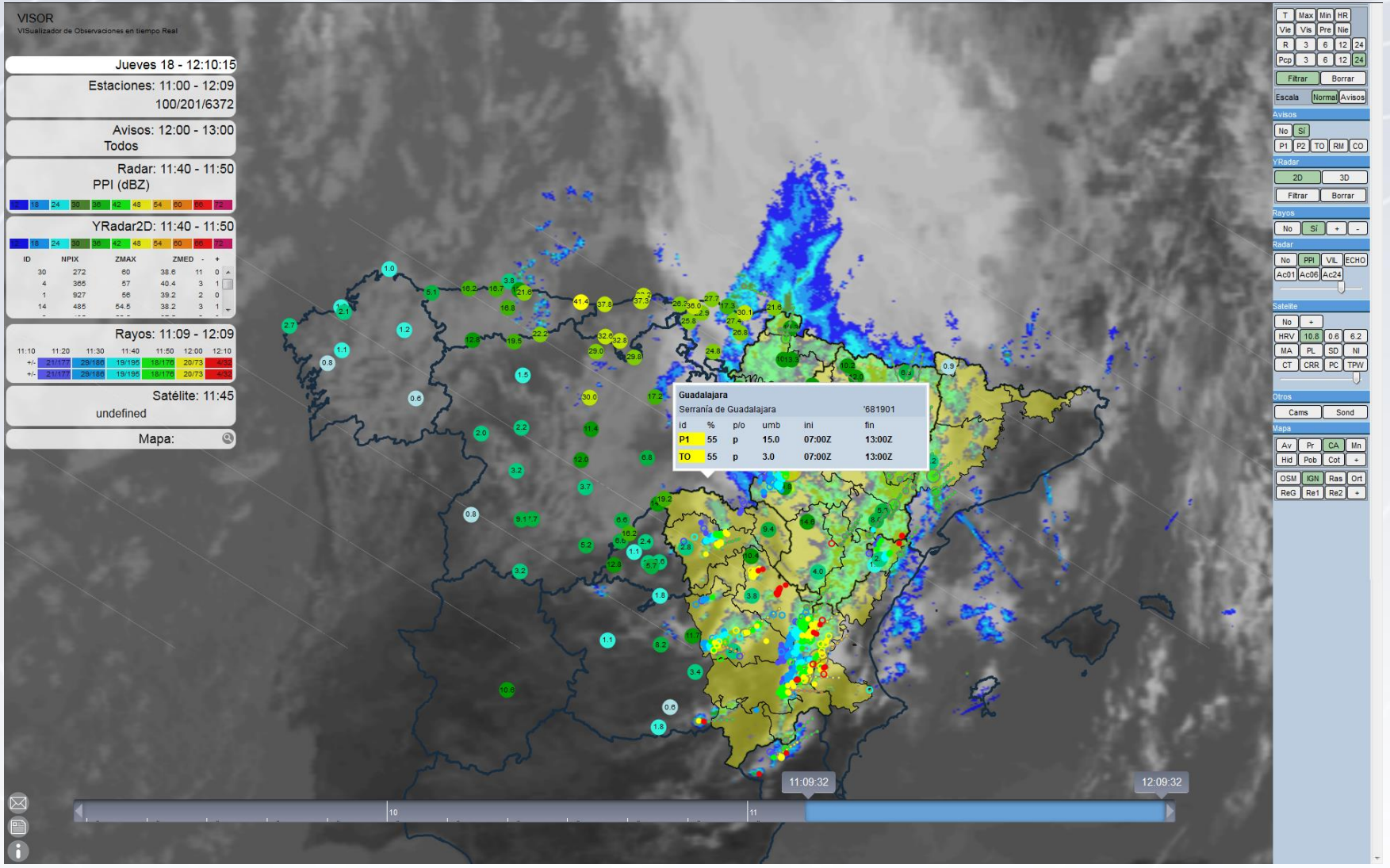


VISOR of AEMET

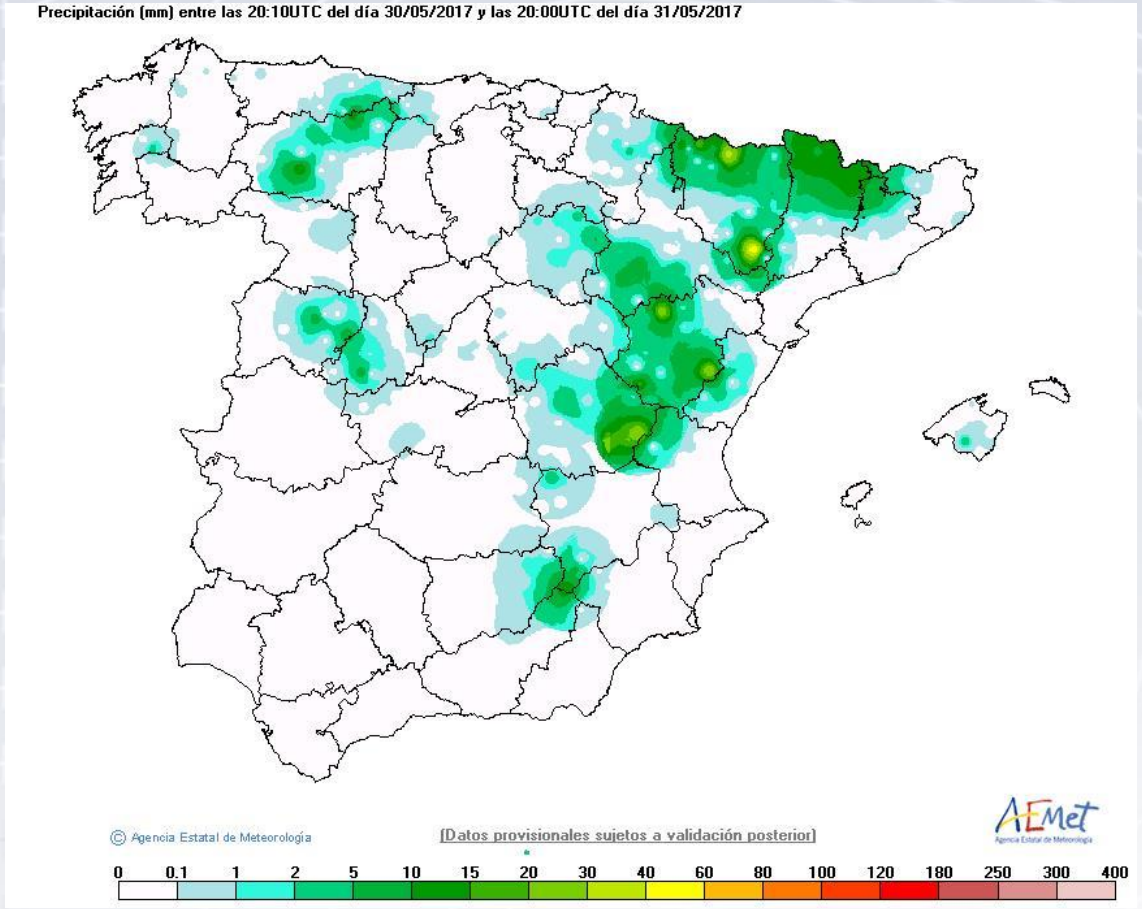


Climatological Charts

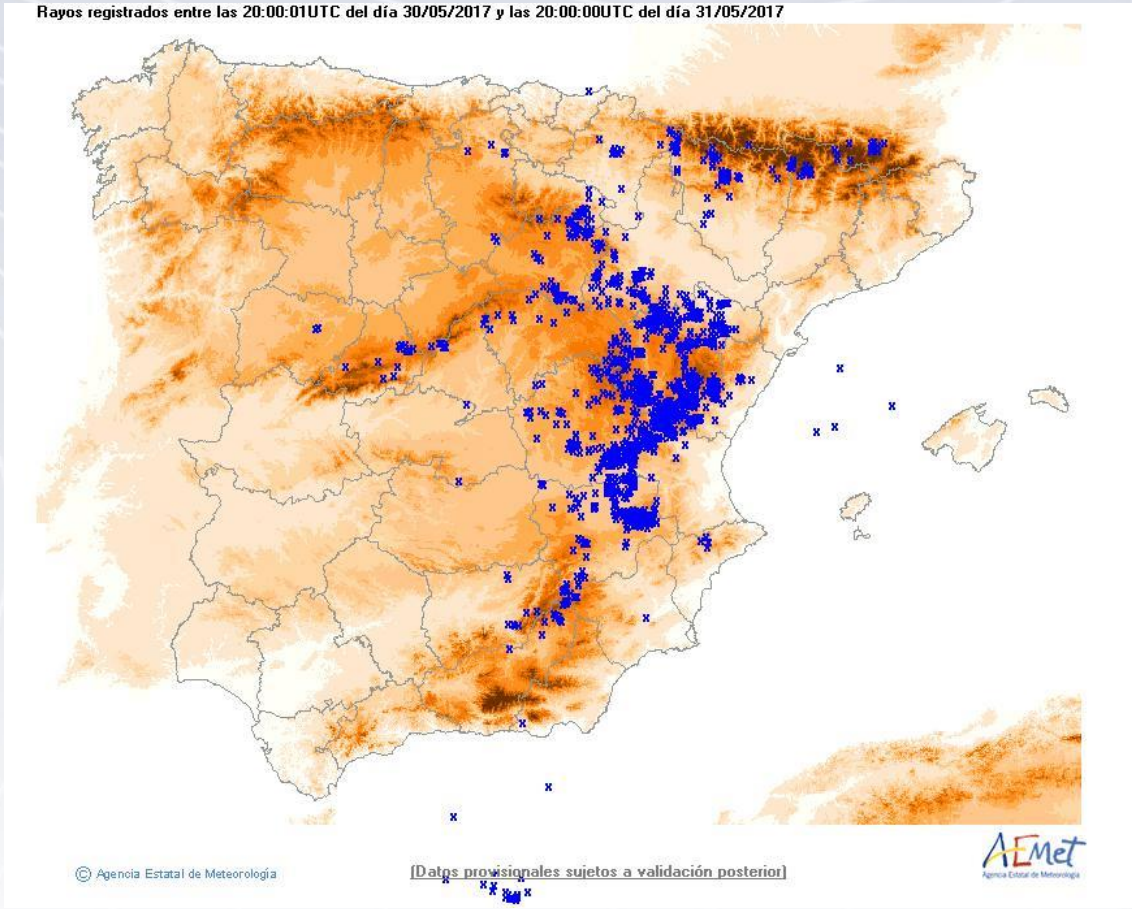
Aemet's **Climatological Data Bank Service** is ready to provide **daily charts** and **monthly summaries** of every layer of data either from his own data bank or from Aemet's **Open Data**, which includes those from the miniMET Project Stations.

Example charts courtesy of **Cesar Rodriguez Ballesteros** (@crballesteros)
from Aemet's Climatological Data Bank
and from his blog http://climaenmapas.blogspot.com.es

Climatological Charts

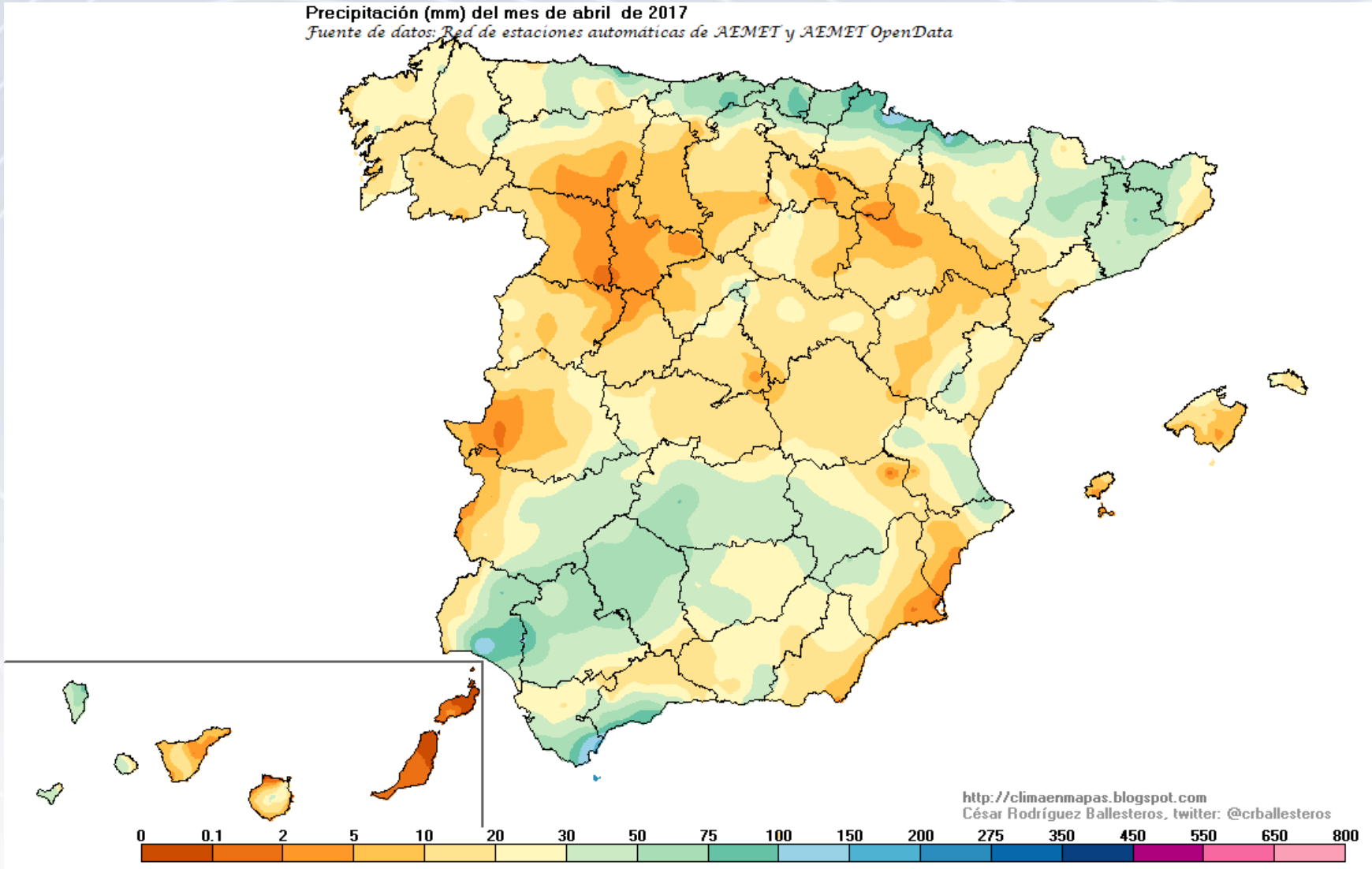


Last 24h rain

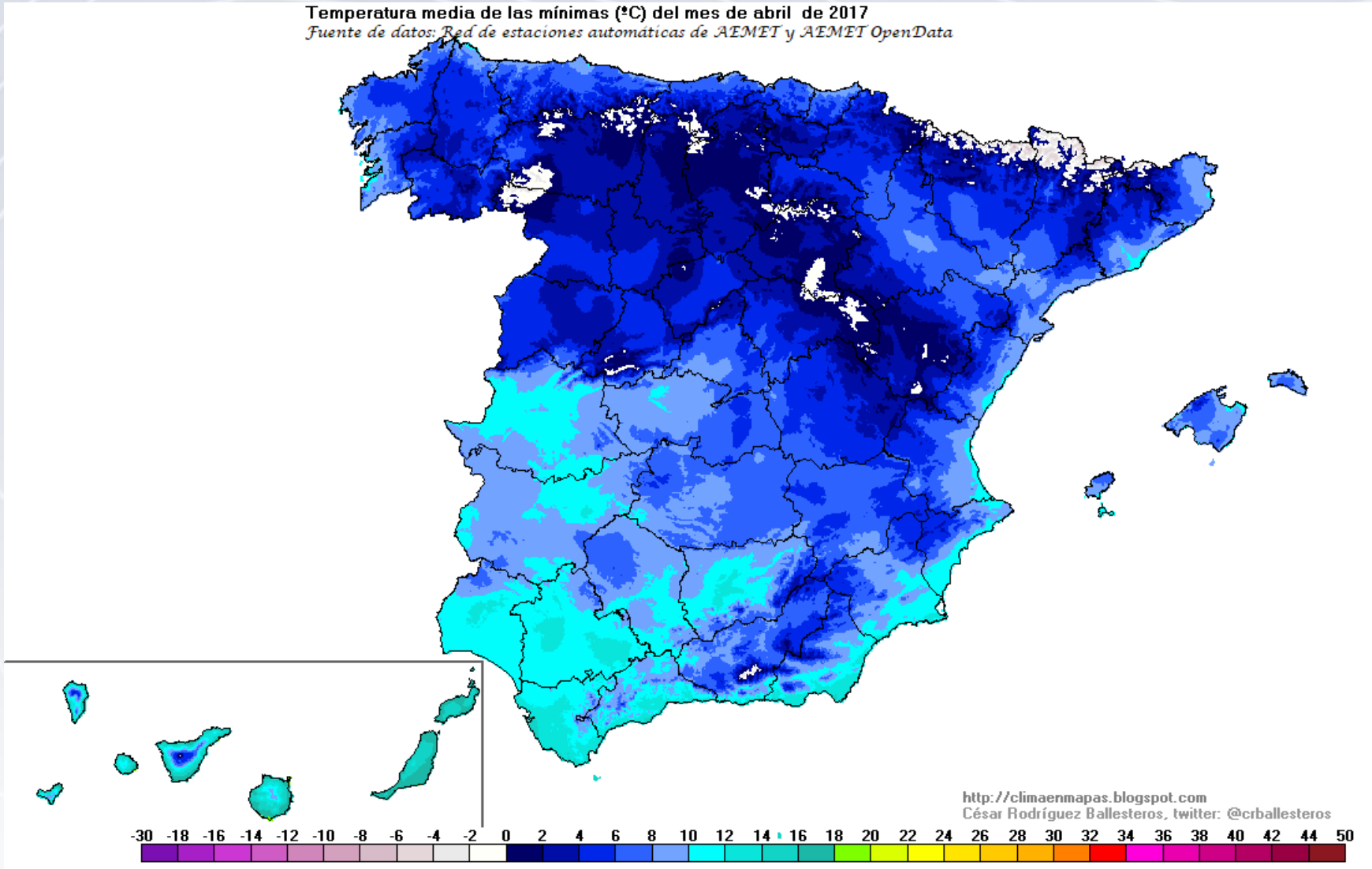


Last 24h lightning

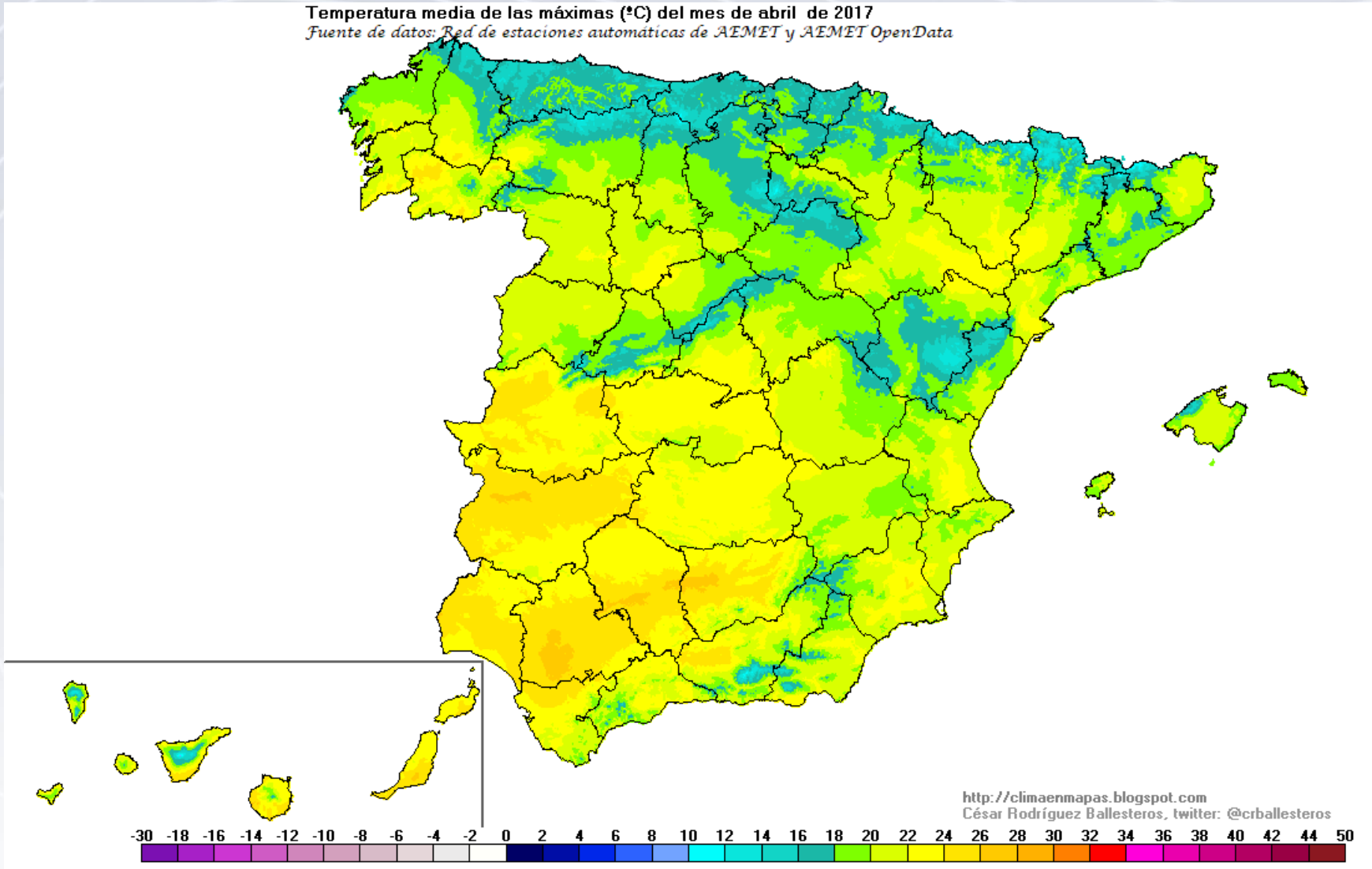
Climatological monthly summary charts



Climatological monthly summary charts



Climatological monthly summary charts



Thank you very much! Questions?