# GuMNet: A high altitude Monitoring Network in the Guadarrama mountains, Madrid (Spain)


http://www.ucm.es/gumnet/

GuMNet Team *


## 1. Infrastructure:

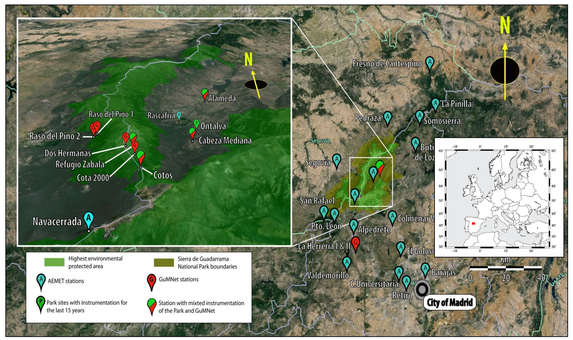



*Fig. 1. Spatial distribution of GuMNet automatic weather stations across the Sierra de Guadarrama and other meteorological stations in the area.*

GuMNet (**Guadarrama Monitoring Network**) is a joint initiative to build up an **observational meteorological and sub-surface infrastructure** in the Sierra de Madrid, central Spain. The resulting network consists of the following instrumentation:

- **10 complete WMO standard meteorological stations**.
- **15 experimental boreholes** for monitoring the **subsurface temperature evolution**, distributed over the 8 WMO-typesites. **8 trenches** for direct monitoring of **temperature and humidity of the soil**, at each station.
- **2 anemometric stations** including an WMO standard set ups as well as **$CO_2$ and $H_2O$ vapor flux** trace analyzers and **eddy covariance measurements** .

These high altitude locations are within the **National Park Sierra de Guadarrama** (PNSG), an environmentally protected area (Figure 1). The GuMNet initiative will be complemented by locations endorsed by the **Spanish National Meteorological Agency** (AEMET, see blue icons). GuMNet builds upon a network of 5 sites (green icons) including meteorological instrumentation within the PNSG that have been operational over 10 to 15 years. 4 of these sites have been updated and extended with new meteorological instrumentation and also incorporated soil and subsurface monitoring infrastructure (green/red icons). This region is characterized by a complex topography and heterogeneous vegetation cover offering a variety of different micro-climate setups, e.g. pine forest, scrub, pastures, or bare soil/rock areas. The GuMNet initiative is supported by research groups and funded by the **Moncloa Campus of Excellence** with additional infrastructure and collaboration support by the PNSG and AEMET (see *GuMNet team). The goal of GuMNet is to create a meeting point to develop educational and research synergies between diverse institutions and research groups of wide range of disciplines.

## 2. Subsurface observations

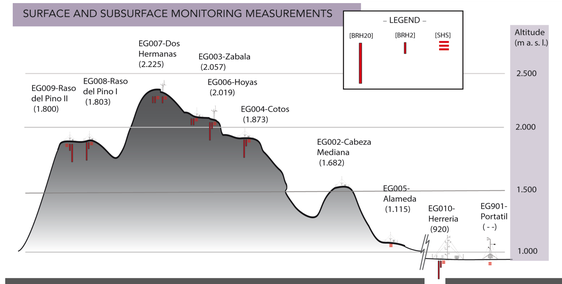



*Fig. 2. Altitude distribution of GuMNet automatic weather stations **including the surface and subsurface infraestructure** over the Peñalara orography. **Note the coverage on North and South sides above 1.500 m a. s. l.** GuMNet also provides two valley sites and a portable station.*

### MONITORING BOREHOLES: Temperature [BRH20, BRH2]

The mayority of GuMNet sites include subsurface temperature monitoring infraestructure. Boreholes are drilled and shaped casings installed to easily place and replace temperature sensors at **14 different depths** at each station. This is done at two monitored **experimental boreholes of 2 (BRH2) and 20 meters depth (BRH20).**

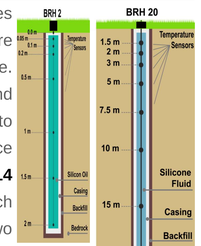



*Fig. 3.Scheme of the 20 m **(BRH20)** and 2 m **(BRH2)** borehole showing the casing of PVC and silicone oil filling where 8 temperature sensors (pt1000) are immersed at different depths in each borehole. Note that the density of measurement points is higher close to the surface to improve the resolution of the subsurface temperature evolution.*
*Fig. 4. The Core Rock extracted during borehole drilling.*

### TRENCHES: Temperature and humidity [SHS]

Trenches (SHS) are daug in the first layers (1-2 m) of sediment to introduce **temperature and humidity sensors**. This allows to establish and document the soil horizons at each site.

*Fig. 5. Once the spectroscopy analysis is done, a set of samples are taken in order to rmake subsequent **analysis in the laboratory**.*

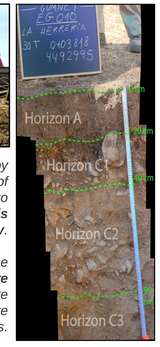



*Fig. 6. Before covering the trench, **soil horizonts are determined** and temperature and humidity sensors are placed at different depths.*

## 3. Eddy covariance $CO_2$ flux

**EG008-La Herreria I is a fixed anemometric tower** with wind speed (VV) and air temperature (TA) sensors at three different heights. This configuration is complemented with an in-situ **open-path mid-infrared absorption gas analyzer** integrated with a three dimensional **sonic anemometer** (CO2+AS3). Likewise, the station includes the standard WMO meteorological sensors, the two experimental boreholes (BRH20, BRH2) and a trench (SHS).

A complementary **twin portable station, EG009-La Herreria II** is also operational for comparison purposes at this site or for use in intensive measurement campaigns elsewhere. It includes subsurface sensors: temperature (TS), humidity (SHS) and heat flux (FCS) measurements for soil monitoring.

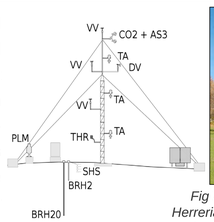



*Fig 7. (left scheme, right picture) EG010- La Herreria automatic weather station is located in the municipality of El Escorial at 920 m.a.s.l. Atmospheric instrumentation have been design to study boundary layer evolution and CO2 fluxes.*

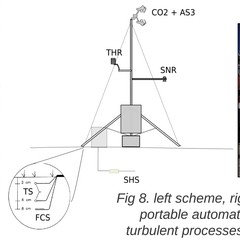



*Fig 8. left scheme, right picture) The EG901- Portatil is a portable automatic weather station design to monitor turbulent processes responsible for soil respiration and gas exchange, such as turbulence CO2 and H2O vapor fluxes, take place in this range.*

## 4. Atmosphere observations.

The standard WMO GuMNet station includes also: an **alpine wind monitor** (DVV), an **air temperature and humidity** sensor (THR), **ultrasonic snow height** sensor (SAN), a **4 component net radiation** sensor (SNR) and **a rain gauge** (PLM) specially designed for snow measurements. A GPRS connection is established between all the remote stations and a central server. This configuration allows to download the recorded data once a day and to verify the health status of the instrumentation, hence **minimizing the loss of data,** like after a snowstorm (Fig 9).

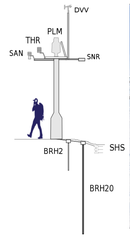



*Fig 10. EG006-Hoyas automatic weather station is located in the cirque valley of Peñalara at 2.019 m.a.s.l. Abounding in tall grass and wetlands the designe of the station amis to minimal impact without perimeter security fence. A single mast houses all atmopheric instrumentation. Since it is located in an area of high accumulation of snow during the winter season, the mast is configured to be over the snow cover and high visible to avoid ski activities.*

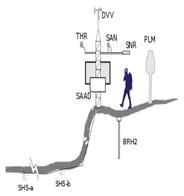
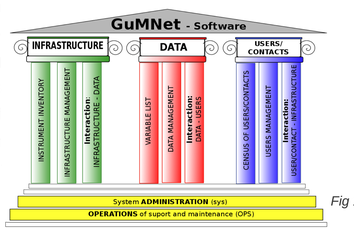



*Fig 9. EG007-Dos Hermanas automatic weather station after a snowstorm. The stations is anchored in the wall of the glacier circus of Peñalara at 2.225 m.a.s.l. It has standard atmospheric instrumentation. The subsurface instrumentation consists of three temperature monitoring boreholes, one of them designed for skin temperature measurements. Besides, two trenches measure temperature and humidity, near the station and another one is located 30 m downslope below an area where snow tends to accumulate until the summer.*

## 5. Software management system

The different parts of the GuMNet infrastructure and the communication system are wrapped up under a **software management tool**. The GuMNet-Software will help to track and maintain instrumentation as well as **managing data observations and data-users** in order to registries all the interactions that may be **relevant to facilitate data interpretation** and management of the system. The vision of GuMNet is to **serve as a high mountain laboratory by providing high quality data and derived products** for research, teaching and leisure users of the Guadarrama mountains.



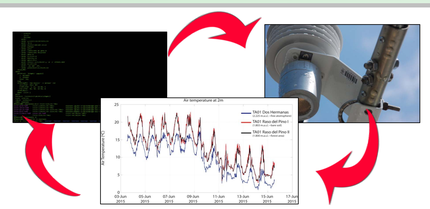



*Fig 11. The relations between **data acquisitions**, **infrastructure operating conditions** and **user/contacts activity** is handled through a **management software** .*

## * 6. GuMNet team (institutions and research groups)

- **PalMA** (UCM), *Paleoclimate Modeling and Analysis*
- **MicroVAR** (UCM), *Micrometeorology and climate Variability*
- **GFAM** (UCM), *Geografía Física de Alta Montaña*
- **CEI** (UCM, UPM), *Campus de Excelencia Internacional*
- **PDC** (UCM), Plataforma de Divulgación Científica
- **CPD** (UCM), *Centro de Procesamiento de Datos*
- **CEIGRAM** (UPM), *Centro de Estudios e Investigación para la Gestion de Riesgos Agrarios y Medioambientales*
- *Departamento* ***Energías Renovables*** (CIEMAT)
- *Departamento* ***Medio Ambiente*** (CIEMAT)
- **IGEO** (UCM-CSIC), *Instituto de Geociencias*
- **AEMET,** *Agencia Estatal de Meteorología*

**PNSG**, *Parque Nacional Sierra de Guadarrama*
**PN,** *Patrimonio Nacional*
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