



EG010 - La Herrería: design, construction and installation of a hydrometeorological station

GuMNet Team *

1. GuMnet - Guadarrama Monitoring Network (overview)

GuMNet is an infrastructure project of the Campus de Excelencia Internacional Moncloa which aims to create a long-term monitoring network to observe the atmosphere and the subsurface in the Guadarrama mountains, north of Madrid. The GuMNet network is being installed mostly within the range of the Parque Nacional Sierra de Guadarrama (PNSG). The GuMNet observational infrastructure is generating a valuable framework of research confluence between a wide spectrum of scientific investigations such as biology, ecology, meteorology, hydrology, geomorphology, agriculture, climate change, soil sciences, education, divulgation, big data, remote sensing and leisure information among others. The deployment of instrumentation has been optimized to satisfy as many research-line types as possible and it will continue growing in the future. The network and its web site server will be fully operational in 2016.

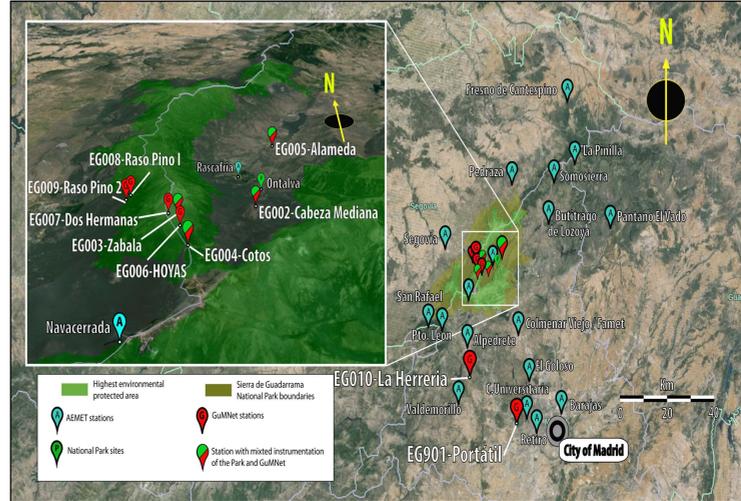


Fig. 1. Spatial distribution of GuMNet stations across the Sierra de Guadarrama and other meteorological stations of the area. The GuMNet infrastructure includes:

- 9 complete meteorological stations with WMO standards.
- 2 anemometric towers jointly with CO₂ and H₂O vapor flux trace analyzers and eddy-covariance measurements.
- 14 boreholes for monitoring subsurface temperature evolution on 8 different levels, distributed over the 9 WMO type sites.
- 8 trenches for direct monitorization of temperature and humidity of the soil.

All this instrumentation is founded on the basis of a meteorological network installed in the area around Peñalara 15 years ago.

2. Set up of a GuMNet station

Selecting an appropriate site for the installation of a weather station is critical for obtaining an accurate meteorological data witch represents the area of interest. Each measurement variable has a different needs, so the site must satisfy in a reasonable and workable way the compromise between all the measurement requirements. The following scheme summarizes the 6 steps taken for the installation of the EG010-La Herrería station.

1. Firstly, geophysical measurements were made in the area of interest to detect water-pipes and other sources of humidity. An Electric Resistivity Tomography (ERT) was performed for imaging subsurface structures from electrical resistivity measurements made at the surface (Fig. 2).
2. Build the foundation and structures for the meteorological tower, anchorages, rain gauge base and perimeter fence.
3. Install meteorological instrumentation on the parcel of land and on the 10 meter high assembled tower (Fig. 3a).
4. Drill two borehole wells, extract core rocks (Fig. 3b) to analyze the physical properties of the subsurface and place temperature sensors in the boreholes at 8 different depth levels.
5. Dig a trench, establish and document the soil horizons (Fig. 4 and Fig. 6) to take samples at different depths and introduce temperature and humidity sensors.
6. Connect all the sensors to the data acquisition system and program the datalogger. Check the behaviour of the power system, data record, data transfer and the automation of the whole system via GPRS.

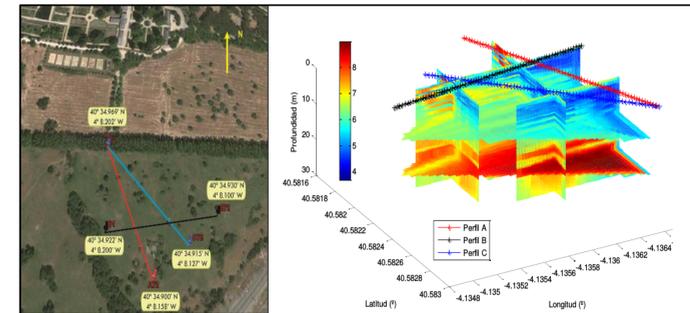


Fig. 2. Left: profiles made in the area of study and GPS coordinates of extreme electrodes. Right: Inversion of the three electric profiles. The color scale represents the natural logarithm of the resistivity.



Fig. 3. (a) Left: Uprising of the meteorological tower. (b) Right: A set of core rocks. Note that the first 1.5 meters are encased in PVC to preserve the soil structure and composition.



Fig. 4. The use of reflectant spectroscopy allows to characterize the chemical composition, as well as the water content, of the different layers of the subsurface. Once the spectroscopy analysis is done, a set of samples are taken in order to realize future analysis in the laboratory. And finally before covering the trench, the temperature and humidity sensors are placed at different depths.

3. Instrumentation installed on the EG010-Herrería site

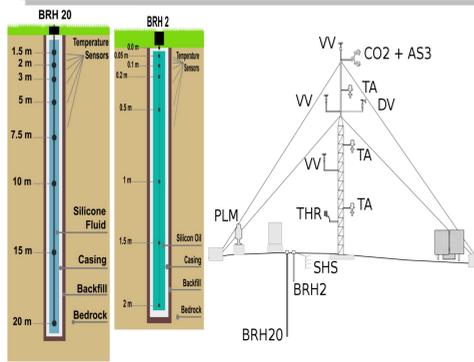


Fig. 5. (a) Left: Scheme of the 20 (BRH20) and 2 (BRH2) meters borehole installed. They include a casing of PVC and silicone oil filling where 8 temperature sensors (pt1000) are immersed at different depths in each borehole. Note that the density of measurements points is higher close to the surface to improve the resolution of the subsurface temperature evolution influenced by the atmospheric forcing. (b) Right: Sketch with the position and height of the installed instrumentation on the EG010-La Herrería station.

EG010-La Herrería station has been designed along three distinct objectives:

1. Being an observation point of the atmosphere following the WMO requirements, representative of high- and mid- mountain climate area. To carry out this issue the standard meteorological variables are being recorded: air temperature (TA), air humidity (THR), precipitation (PLM), wind module (VV) and direction (DV).
2. Monitor the dynamics of the air between 0 and 10 meters high. Turbulent processes responsible for soil respiration and gas exchange, such as turbulence CO₂ and H₂O vapor fluxes, take place in this range. To accomplish this issue, temperature (TA) and wind (VV) are measured at different heights and an integrated CO₂/H₂O Open-Path Gas Analyzer and a 3D Sonic Anemometer IRGASON® (CO₂ + AS3) is placed at 10 meters high (Fig. 5b). Thanks to the precision of the 3D sonic anemometer, high-frequency (20Hz) variations in the wind field will be available.
3. Monitor the evolution of the temperature and humidity of the subsurface. Two boreholes of 2 (BRH2) and 20 meters (BRH20) depth have been drilled in the field to allow the placement of 16 temperature sensors at different depths (Fig. 5a). With the aim of complementing these measurements a trench has been dug in the first meters of the ground, to take samples to determine the composition of the subsurface, to identify the various horizons present and to place temperature and humidity sensors at different heights: 15, 50 and 100 cm (Fig. 6) (SHS).

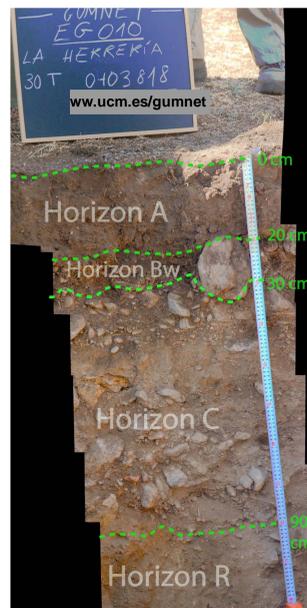
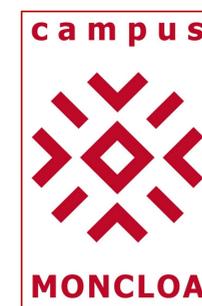


Fig. 6. Detail of the different soil horizons characterized in the EG010-La Herrería trench. The first layer (Horizon A) is the result of biological alteration due to roots activity resulting in fertile soil. Second layer (Horizon Bw) is a deposit of medium-sized boulders due to river floods of little intense character. The third layer (Horizon C) is the result of deposits of boulder of larger size from river due to avalanches stronger character. Finally the fourth layer (Horizon R) reveals fragments and remains of weathering of bedrock (granite) which produces jabres with less mechanical consistency. Future analyzes of collected samples, will provide more information on the thermomechanical properties of each layer. This information will be crucial for interpreting monitoring data of temperature and humidity.

4. Applicability of observational data

Climate is crucial in driving or regulating many biological and physical processes at the landscape level. Rainfall and temperature are the primary factors that limit an ecosystem's structure and function. Secondary limiting factors include long term climate patterns: the duration, intensity and seasonality of intense weather events and their interannual variability. In turn, these dynamics greatly influence the types of plant species that grow, the ways in which nutrients are cycled and the relationships between soil, plants, and water availability. Climate can also affect the susceptibility of an ecosystem to disturbance. Information from long-term weather data will provide park managers an historic perspective invaluable for natural resource management, aid in detecting trends in other vital signs monitoring efforts, and document long-term climate change at the Sierra de Guadarrama National Park and at many municipalities in its area of influence, including their natural resources. With this extensive monitoring program, the Sierra de Guadarrama is well suited to address local, regional and globally important questions with weather and other monitoring data. Weather data plays a key role in interpreting the legacy of past management practices as well as providing information about trends in temperature and precipitation essential for future management decisions. On a broader scale, experts predict that mountain climate will change significantly during the next century. Data collected today will provide baseline information about the rate and magnitude of climate change in this type of areas.

* 5. GuMNet team (institutions and research groups)



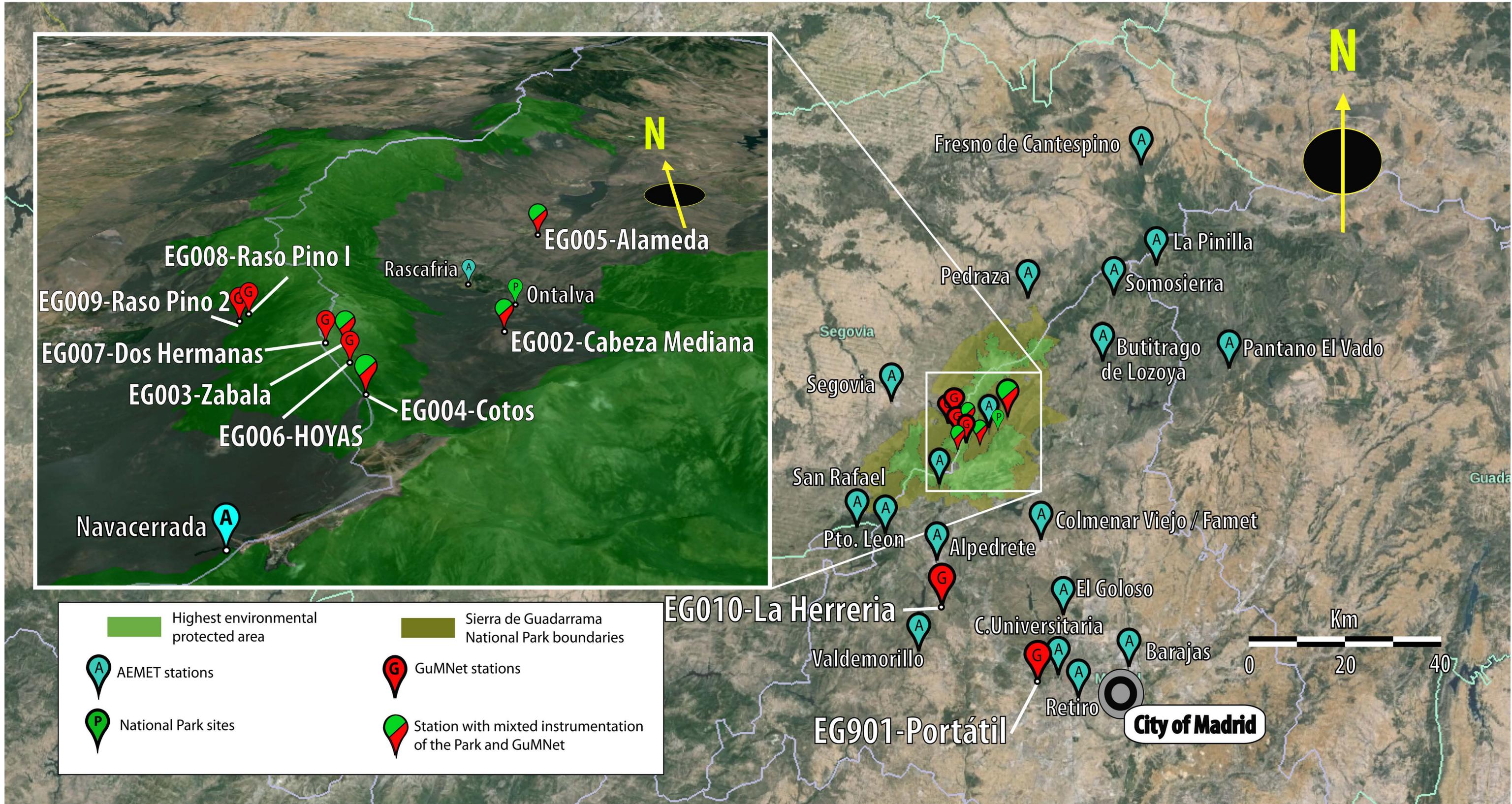
- PalMA (UCM), Paleoclimate Modeling and Analysis
- MicroVAR (UCM), Micrometeorology and climate Variability
- GFAM (UCM), Geografía Física de Alta Montaña
- CEI (UCM, UPM), Campus de Excelencia Internacional
- PDC (UCM), Plataforma de Divulgación Científica
- CPD (UCM), Centro de Procesamiento de Datos
- 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
- DIAS, Dublin Institute for Advanced Studies



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Mapa de las estaciones de la red **GuMNet** – **Guadarrama Monitoring Network**



Esperamos que hayas disfrutado con esta actividad ;)

www.ucm.es/gumnet