1. The Infrastructure

GuMNet (Guadarrama Monitoring Network) is a joint initiative to build up a high mountain meteorological and sub-surface observational infrastructure in the Sierra de Guadarrama in Madrid, central Spain. The resulting network consists of the following instrumentation: 10 complete WMO standards-fulfilling meteorological stations, 12 boreholes for monitoring the subsurface temperature evolution (distributed over 6 of the WMO type sites) and 8 trenches for direct monitoring of temperature and humidity of the soil (distributed over 7 stations). Moreover, 2 of the stations include anemometric instrumentation, as well as CO2 and H2O vapor flux traces analyzers and eddy covariance measurements.

These high altitude locations are within the Sierra de Guadarrama National Park (SGNP), an environmentally protected area (Figure 1). The region where the SGNP is situated is characterized by a complex topography and a heterogeneous vegetation cover, offering a variety of different micro-climate setups, such as pine forest, scrub, pastures or boreal oak trees. The GuMNet initiative, funded by the Moncloa Campus of Excellence (UAM) supported by research groups with additional infrastructure and the cooperation from the SGNP and the Spanish National Meteorological Agency (AEMet) [see ‘GuMNet Team’] . GuMNet is also part of several networks whose efforts are devoted to the investigation and research in high mountain environments, such as the Mountain Research Initiative (MRI), the Iberian Mountain Research Network (RIM) or the Network for European Mountain Research (NEMOR).

All the information about the GuMNet initiative, the participants institutions, the international partnership with other networks, those related to the network and requests of available observational data can be found on the initiative website, which can be accessed from the attached QR code or the following link: http://www.ucm.es/gumnet

2. Observational Data Examples

Thanks to the altitudinal distribution of stations (spanning from 920 to 2,225 m a.s.l.), meteorological and subsurface variables are measured on sites located at different heights so that the high mountain environment of the Sierra de Guadarrama can be evaluated (Figures 2, 3, 8 and 9). The recorded data can help observe, amongst other things, the evolution of some phenomena in the lower atmosphere, such as thermal inversions (Figure 4).

3. Subsurface Observations

Most of the GuMNet sites include subsurface temperature monitoring instrumentation. Boreholes are drilled and cylinder-shaped casings installed to easily place and replace temperature sensors at 16 different depths at each station, distributed in two monitored boreholes of 2 (BRH2) and 20 meters depth (BRH20), respectively (Figure 6). Trenches (SHS) are dug in the first layer (1 – 2 m) of sediment to introduce temperature, humidity and electrical conductivity sensors. This allows to establish and document the soil thermal evolution (Figure 7).

4. Atmospheric Observations

The standard WMO GuMNet station includes: an alpine wind monitor (OVI), an air temperature and humidity sensor (THI), ultrasonic snow height sensor (SBN), a 4 component net radiation sensor (SNR) and a rain gauge (PLM) especially designed for snow measurements. A GPR6 connection is established between all the stations and a central sensor. This configuration allows the downloading of 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 (Figure 10).

5. Eddy Covariance CO2 Flux

EGO10-La Herreria (Figure 12) is a fixed anemometric tower with wind speed (V) and air temperature (T) 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, two boreholes (BRH20, BRH20) and two trenches (SHS).

As a complementary twin passive site, EGO10-La Herreria/Portillo (Figure 13) is also operational for comparison purposes at this site and for use in intensive measurement campaigns elsewhere. It includes subsurface sensors: temperature (T), humidity (HIS) and heat flux (FC8) measurements for soil monitoring.

6. Modeling at the Sierra de Guadarrama

The existence of a meteorological and subsurface/solid database like GuMNet in the Sierra de Guadarrama has permitted the comparison between observational data and simulated data in order to evaluate the capability of a high resolution (1 Km) WRF model simulation during the period 2000 - 2015 (Figures 14, 15 and 16).

As far as air temperature is concerned, this comparison proved the model to be representative of the observations, which led to a first analysis of temperature variability in this region (Figures 17 and 18).

7. GuMNet Team (Institutions and Research Groups)

- Patika (UCM), Paleoclimate Monitoring and Analysis.
- MicroVAR (UAM), Ultrasonic technology and Variable Density.
- GAFAM (UCM), Geografia Fisica de Alta Montafia.
- CEI (UCM, UPF), Campus de Excelencia Internacional.
- PDC (UAM), Plataforma de Disipacion Cientifica.
- CDP (UCM), Centro de Procesamiento de Datos.
- EGEAM (UPM), Centro de Estudios e Investigacion para la Gestion de Recursos Hidraulicos y Ambientales.
- Departamento Energias Renovables (CIEMAT).
- Departamento Medio Ambiente (CIEMAT).
- IOC/E (UAM-CICyT), Instituto de Oceanografias.
- AEMET, Agencia Estatal de Meteorologia.
- PNSG, Parque Nacional Sierra de Guadarrama.
- FN, Patrimonio Nacional.

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