A Fog Collection Network in the Valencia Region (Western Mediterranean Basin)

José A. Valiente, María J. Estrela, David Corell

Fundación CEAM (Fundación Centro de Estudios Ambientales del Mediterráneo), Parque Tecnológico, C/ Charles R. Darwin 14, 46980 Paterna (Valencia), Spain, josean@ceam.es

ABSTRACT

A small network of eight passive fog water collectors installed at several mountain sites in the Valencia region, Spain, has been providing high quality data on a daily basis since August 2005. Data measurements are obtained by means of an instrument ensemble consisting essentially of a passive cylindrical fog water collector, a rain gauge, a wind direction and velocity sensor and a temperature and humidity probe. Six of the stations are at coastal locations, and the remaining two are at inland sites around 40 km from the coastline. The highest station is located at 1300 m a.s.l. and the lowest at only 400 m a.s.l. Fog water volumes are sampled using a handmade cylindrical fog collector which is based on the ASRC (Atmospheric Science Research Center, State University of New York) string collector and yields an omnidirectional collection efficiency. Results in terms of monthly water rates and wind statistics are obtained for the two-year period 2005-2006 and then compared and discussed.

1. **INTRODUCTION**

The fog collection network maintained by the Fundacion CEAM began in 2003 with the installation of three collectors at different points in the Valencian Community (Estrela *et al*., 2004). At that time, its purpose was to obtain collection rates at a few mountainous sites above 600 m a.s.l. that were very few kilometers from the coast and covered the region from North to South. Although the number of locations was small, interesting results were expected as a consequence of the high quality of the ancillary data acquired by the instrument ensemble. Two new collectors were added to the network in 2004 during a second stage. Both were installed on inland sites –in contrast with the coastal sites chosen previously- at the North and the South of the Community. In early 2005, another three collectors were installed in the southern part of the region to complete the network. These latter sites are all coastal and only a few kilometers from each other. The spatial arrangement of these three locations was based on a supposition that local gradients could be gathered from the data, which was not exactly the case due to the different site altitudes for each of the fog collectors.

From North to South, the network is composed of the following mountainous locations (see Figure 1):

- Mt Bartolo, the northernmost site with an altitude of 736 m a.s.l., is a ridge with a long crest line, which is only 6 km from the coastline.
- Mt. Peñaroya, at 1193 m a.s.l. and 50 km inland, is a distinctive cliff that drops approximately 400 m over a distance of 4 km, constituting the apex of a valley that leads perpendicularly to the coastline.
- Mt. Moduver, in the south-central part of the Community, is an isolated and almost pyramidal mountain 843 m high and only 7 km inland from the coast.
- Mt. Montgo, a very coastal site with an altitude of 670 m a.s.l., stands alone as a massive rock lying on a land mass that stretches out to the sea and is only 4 km from the nearest coastline.
- Mt. Mariola, the other inland site at 1256 m a.s.l. and only 40 km from two coastlines at the NE and SE, is a cliff dominating the southern side of a wide valley that connects the interior with the coastal lowlands.
- Mt. Bernia, a coastal site at 845 m a.s.l. and 7 km from the coast, is the top of a steep hill at one end of a small mountain range that borders on a short and rounded valley.

- Mt. Puig Campana, the network´s highest location at 1319 m a.s.l. and only 9 km from the coast, is a massive rounded mountain with huge slopes and cliffs, with the station being located on its southern side.
- Mt. Helada, at a modest altitude of 428 m a.s.l. but on top of a cliff that drops directly into the sea, is the most coastal location in the network and is located at the entrance of a small valley that is also monitored by the two latter stations described.

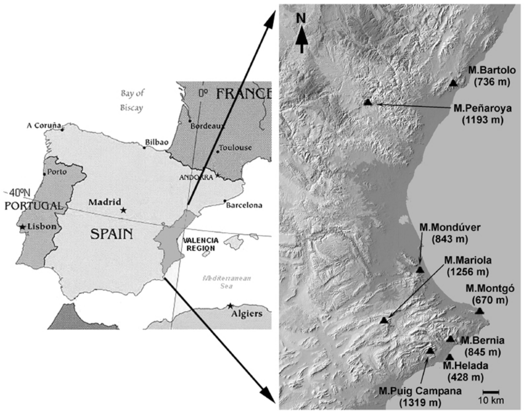

Figure 1. Geographical distribution of the network stations and their orographic altitudes.

2. **METHODOLOGY**

Each of the stations uses an identical instrument ensemble which has already been described in detail by Estrela *et al.* (2004) and Estrela *et al.* (2007). Essentially, the ensemble consists of several instruments attached to a mast at different heights. The sensors are: an integrated vane-anemometer at the top, two tipping-bucket raingauges: one used for rainfall and the other for fog sampling, four wetness-sensing grids to detect suspended water droplets, an air temperature and relative humidity probe and a handmade cylindrical fog collector based on the ASRC (Atmospheric Science Research Center, State University of New York) string collector (Falconer and Falconer, 1980). The handmade collector consists of a cylinder, 26 cm in diameter and 46 cm in height, strung with five concentric rows of 0.8 mm thick nylon line. Because of the cylindrical design of the device, collection efficiency does not depend on wind direction. Automatic data acquisition is carried out by a data logger that, once a day, transmits stored data by means of a GMS modem. Data are recorded as 10-minute averages of 6-second samplings and the whole ensemble is designed to work completely unattended.

Results presented here correspond to a two-year period (2005-2006) during which the network was fully operational and data gaps were limited. Fog water volumes were sampled by a tipping bucket raingauge and the measured values divided by the effective collection surface of the cylindrical collector to obtain collection volumes per unit area (l/m2). Monthly rates of rainfall and fog collection are calculated respectively as the average of daily collection volumes for the number of days in a month with available precipitation or fog data. The most common situation is to have around 30 days of available data in a month.

As indicated by Schemenauer and Cereceda (1994 and 1995), simultaneous fog and rainfall values are very hard to separate, especially if a passive collector is being used. Raindrop trajectories are wind-driven, hence the greater the wind speed, the more likely that rain drops will enter the fog collector. Consequently, some rainfall component is generally present in the fog volume samples, unless no rainfall is recorded. An estimate of the rainfall component has been computed for each of the monthly rates following the parameterizations described in Estrela *et al.* (2007). This component is then removed from the directly measured fog volume samples to yield the monthly fog rates without the rain water contribution. If the total water volumes collected by the passive collector are sought, the sum of the monthly fog rate and its associated rainfall component will yield the required quantity. The reduction technique, on which the parameterizations are based, is simply inferred by exposing the instrument ensemble to only rainfall conditions and then fitting the collected water volumes against wind velocity and rainfall intensity.

Annual wind statistics in the form of wind roses are also calculated for each of the network stations. Using the entire set of wind data gives a common wind rose. However, if only the set of wind data that are simultaneous with fog water collection is used, the resulting wind rose will show the most frequent winds yielding fog water. Moreover, if the latter statistic uses the fog water volumes as statistical weighs, the subsequent wind rose will indicate the percentage of fog water over the total annual volume that was collected at a certain wind direction and velocity.

3. **RESULTS**

For each year of the period, Figures 2 and 3 show monthly rates of rainfall and fog and associated rainfall component derived as the methodology section describes.

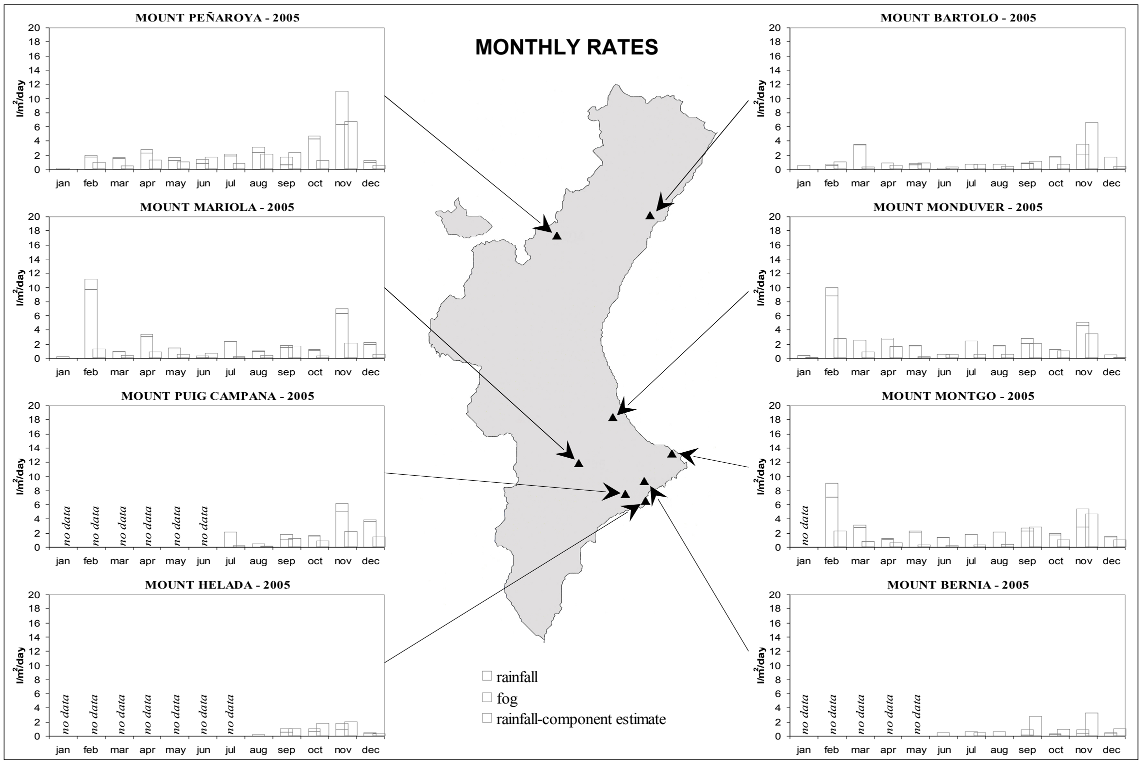

Figure 2. Monthly rates (l/m^2/day) of rainfall and fog with its estimated rainfall component for 2005.

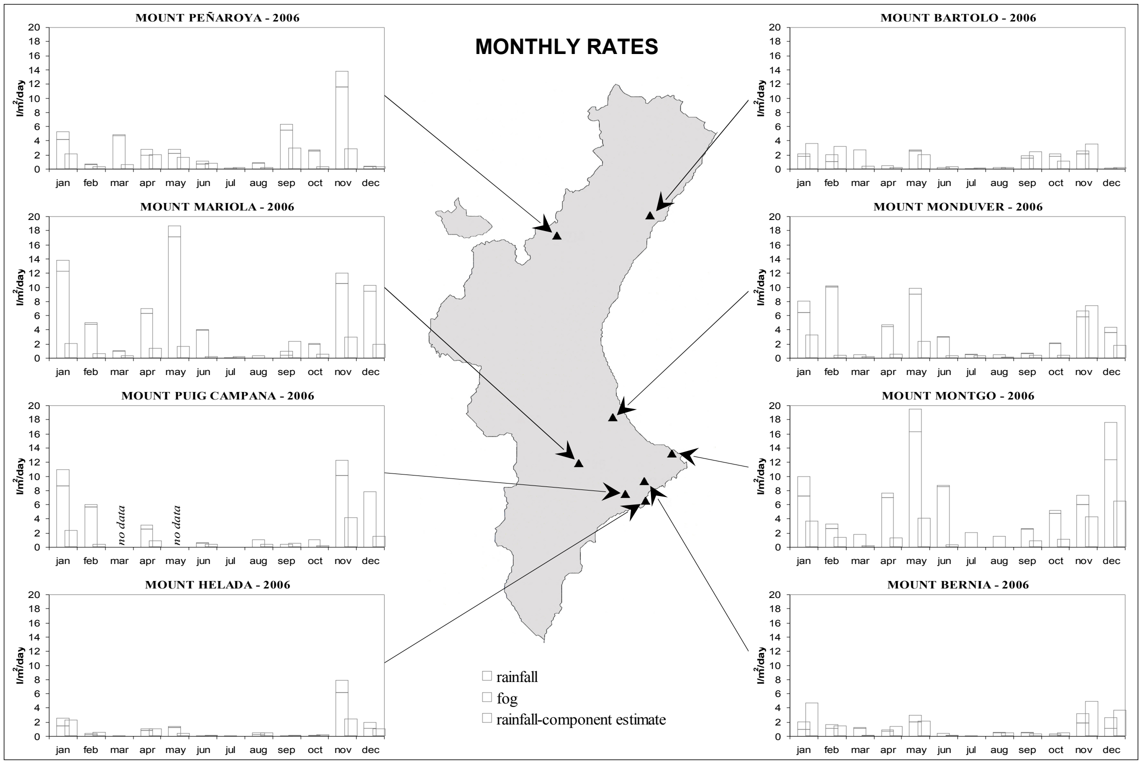

Figure 3. Monthly rates (l/m^2/day) of rainfall and fog with its estimated rainfall component for 2006.

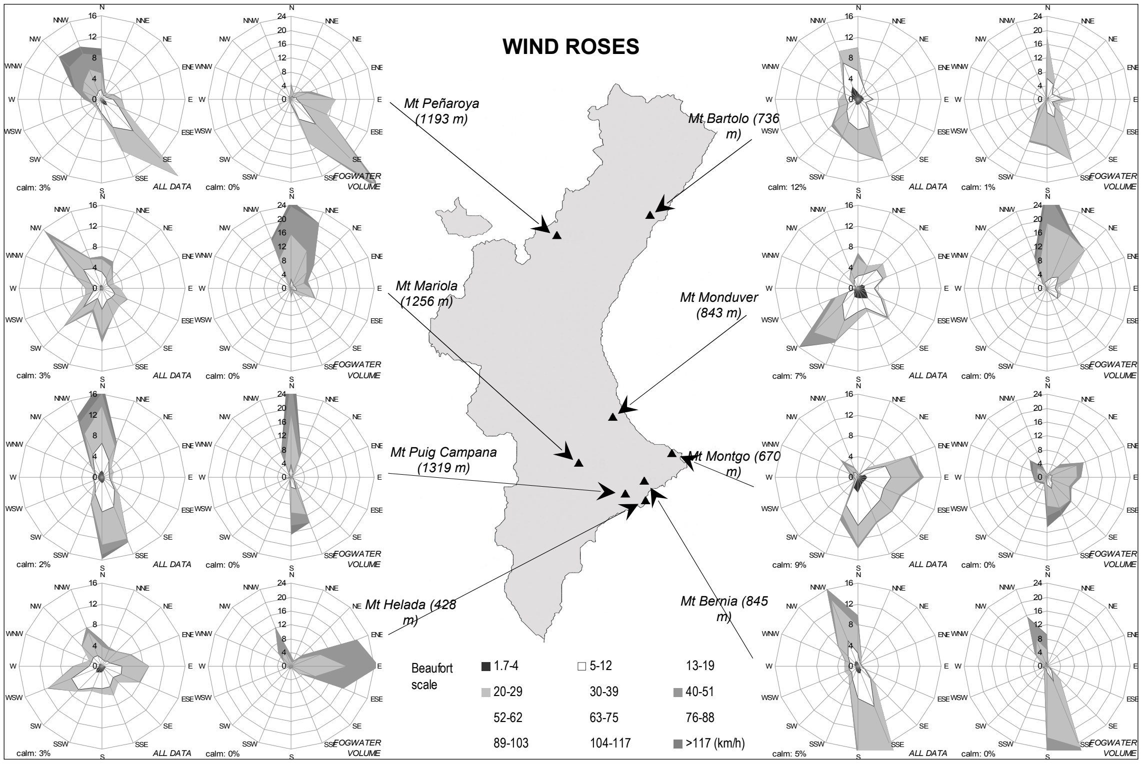

Figure 4. Wind roses obtained for the 2006 winds using all available data unrestrictedly (*ALL DATA*) and statistically weighed by the simultaneous fog water collected volumes (*FOGWATER VOLUME*).

A straightforward result is the large difference between the years 2005 and 2006, the former being classified as dry and the latter as normal. This difference is even more marked for the fog collection rates at the most productive stations. The rainfall component is minimal during the drier months, and fog yields are also small but significant at some stations. The rest of the year is quite variable in terms of both month of the year and location. Even though it is an inland site, Mount Mariola is the second most productive station after the coastal site of Mount Montgo. Spatial gradients are hard to ascertain, with the local characteristics of each station being the most likely explanation. Wind roses (Figure 4) show similar results in terms of particular local conditions. The most frequent winds do not usually coincide with the most productive winds for fog collection. The latter are generally distributed in only one angle sector that determines the most efficient direction for installing flat fog-collection panels.

4. **ACKNOWLEDGEMENTS**

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