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Meteorological Patterns and fog water in Morocco and the Canary Islands

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Abstract

There are large monthly differences in the daily average amounts of fog water collected in Morocco (Boutmezguida) and in the Canary Islands (Anaga), from June 2006 to December 2009, which can be explained by the organization of the air pressure in the north-west Atlantic and the Sahara. Two different models of fog behavior can be identified, *the Moroccan* and *the Canary* models. The former is efficient in the winter while the latter is efficient in the summer.

1. Introduction

The stratocumulus cloud formation is very common in the Canary Islands (Spain) and on the Atlantic coast of Morocco, which are locally referred to as *mar de nubes* (sea of clouds) and *tagut* respectively. In both cases, the clouds behave like fog when they hit the mountainous relief and it is possible to collect some of their liquid content using artificial systems. This water can then be used in areas of water shortages to meet daily requirements. The source of this cloud formation is connected to the Azores anticyclone and anomalous structure of the atmosphere caused by a subsistence thermal inversion.

It is, therefore, useful to know what the organization of the surface air pressure is like (localization, frequency and intensity) in the low atmosphere of this part of the Atlantic as this would explain how this efficient natural resource providing the Canary and Moroccan ecosystems with water develops.

The University of La Laguna has been collaborating, since June 2006, with the Si Hmad Derham Foundation on a study about the viability of providing drinking water, via the construction of Large Fog Collectors (LFC)[1,2], to rural communities in areas around Mount Boutmezguida (Ifni) which are 30 km from the Atlantic coast of Morocco at the same latitude as the Canaries.

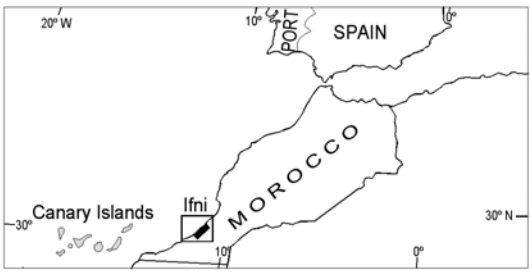

Figure 1: Location of the Ifni region where the Boutmezguida site is.

To date, the volume of the potential water that can be collected, the monthly differences and their relationship with the meteorological variables of relative humidity, wind speed and direction have been analyzed. This stage of the study has been carried out using a Standard Fog Collector (SFC) [3] and a Quarter Fog Collector (QFC) [4] connected to a Davis model automatic meteorological station, providing information on all the variables, every ten minutes, which will be used to determine the most favourable conditions for collecting the fog water with the greatest efficiency (figure 2).

The Si Hmad Derham Foundation has surveyed the local population, made up of twenty rural communities (1,547 people and 5,451 animals) about their water needs. The results of the survey show that the people in charge of looking for water are basically children (53%) and women (21%), the distance covered is more than one kilometre, this task is performed every day, only 3 out of 217 families treat the water with bleach and that the average daily consumption is very low, less than 50 litres per family per day. All these data can explain the low level of schooling of the children, the difficulty the women have in dedicating their time to more productive tasks, health problems associated with the bad quality of the water making it the main vector of diseases, etc.

Figure 2: Equipment used in the study (Morocco)

The possibility of providing these communities with drinking water via LFCs will, without doubt, improve the quality of life and contribute to sustainable development for the rural populations who have started to abandon the countryside and their roots, by emigrating to the towns and cities, as a result of the great difficulties they face in making a living in rural areas [5,6].

2. Aims and Methodology

The aim of this article is to geographically locate the areas of surface pressure on the days when there was fog in Boutmezguida (Morocco), from 6th June 2006 (starting date of the study) to 31st December 2009, and to see if there is a model of the meteorological and atmospheric conditions in the Atlantic and the Sahara which may explain seasonal differences in water fog water collection between Morocco and the Canaries.

Two SFCs with different orientations (nº3 with 300° and nº4 with 340°) were installed in Boutmezguida (1,225 m a.s.l., 29°12'30"N - 10° 01'30"W) in June 2006; the SFC nº3 was replaced by a QFC connected to a meteorological station in September 2009; the SFC nº4 was kept to fix the correlations resulting from the size of the meshes. The information collected was compared with the data, from the same period, from the station in Anaga (842 m a.s.l., 28°32'09"N - 16°14'11"W), on the island of Tenerife (the Canary Islands).

The methodology used[7] here is based on dividing the space in the Atlantic into 80 squares, 5° longitude by 5º latitude, between the longitudes 40°W and 20°E and latitudes 25° to 70°N (figure 3). This method can georeference the type of pressure centre (high and low pressure) and its values. The information is taken from daily synoptic surface maps from the Spanish National Meteorological Agency which is then introduced into a daily data base with synoptic information from the maps and data on the water from the SFC and QFC in Boutmezguida and Anaga.

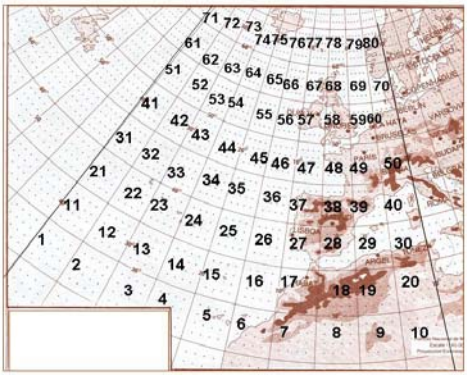

Figure 3: Grid used to take the information from the surface weather maps

3. Results

3.1 The cloud phenomenon frequency

Out of the total of 1,297 analyzed days (from 12/06/2006 to 31/12/2009, there was only fog on 33% of the days (427) in Morocco and on 381 of these 427 days there was also fog in the Canaries, i.e. 89% of the days. However, an analysis of the data for the same period in Anaga shows that there was a total of 1,250 days with fog (97%), thus the difference between Morocco and the Canaries does not mean there was a lower frequency of the cloud phenomenon but rather a lack of coincidence of the phenomenon in both places, basically in the spring and autumn.

The "interference" that rainwater can exert in determining the collection efficiency of the screens only occurs on 4% of the days of the year in Morocco and on 8% of the days of the year in the Canaries, and this only affects the months between October and March. In the case of Morocco there are very few rainy days which is why they were taken into account, whereas, in the Canaries, the fact that information is taken every 10 minutes means that rainy days can be discriminated (table 1).

3. 2 The volume of collected water

The obtained results, both in Morocco and the Canaries, support the viability of artificially

collecting part of the liquid content of the clouds because an average of 10 L/m^2/day is assured. Table 1 shows the daily amount of collected water from the screens irrespective of origin, rain and fog (1), and the fog water collected exclusively (2).
The most outstanding feature is that there are monthly models of how the efficiency of fog water collection behaves. A daily collection of 10.5 L/m^2 is assured for seven months from December to June, and only 4.8 L/m^2 per day in the other five months, whereas in the case of the Canaries, the vertical development of the clouds predominates in the winter months and reduces the efficiency of the screens as only an average of 6.5 L/m^2 /day is assured from September to May compared to 19.1 L/m^2/day in the three summer months. This volume of summer water is important from an ecological perspective because it provides the ecosystem with humidity and water at a time of greatest water stress.

Table 1: Daily mean amount of fog water at Morocco and Canary Islands (June 2006 at December 2009)

	Morocco	Canary Islands	
	(1)	(1)	(2)
	L/m^2/day	L/m^2/day	L/m^2/day
J	12.2	7.0	5.2
F	12.5	7.1	5.2
M	14.8	6.5	4.3
A	16.3	12.0	10.8
M	14.4	10.8	9.9
J	17.7	13.2	13.0
Jl	0.0	23.9	23.9
A	2.3	20.7	20.4
S	5.5	7.1	6.9
O	7.0	7.8	6.4
N	9.0	5.8	3.2
D	14.5	7.1	4.3
Mean	**10.5**	**10.7**	**9.5**

3.3 Organization of the surface pressure fields

There is a high pressure area in the eastern Atlantic on 88% of fog days in Morocco; on 60% of those days the centre of the anticyclone is between Morocco and the Canaries, with an average pressure of 1030 hPa. With less frequency (40% of days with fog) there is a relative depression over the Sahara of 1008 hPa. In addition, 5% of fog events in Morocco coincide with an area of low pressure between the Iberian Peninsula and the Canaries which corresponds to a talweg or cold advection on 500 hPa chart (figure 4).

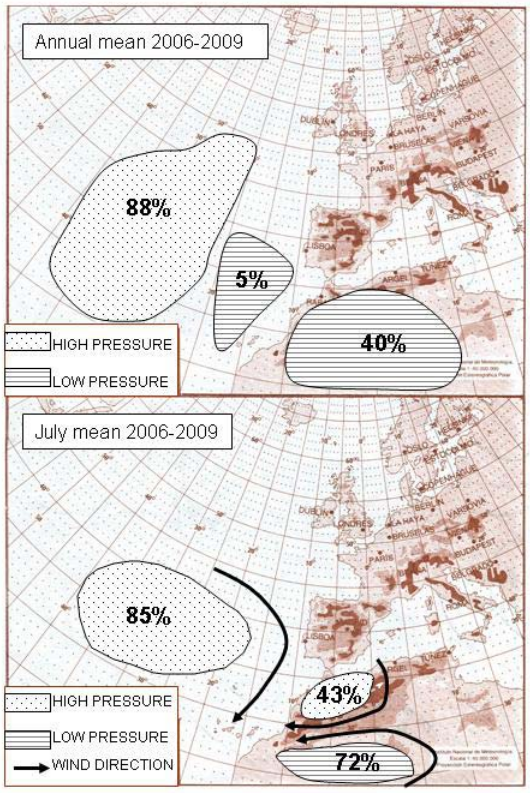

Figure 4: Location of pressure centres in the North Atlantic on fog days in Morocco (Dec-June) and on fog free days (July) in the period from 2006-2009.

3.4 July: A very dry month in Morocco and very humid in the Canaries

There is no fog water in Morocco in July in any of the four years of the study, whereas in the Canaries water is collected on 90% of days in July with a daily average of 23 L/m^2. The explanation for this large difference lies in the simplification of the regional pressure fields. The most outstanding features are:

a) The centre of the Atlantic anticyclone is nearer the Canaries on more days (85% of days in July) (figure 2). Average pressure is somewhat lower than the rest of the year (1028 hPa).
b) A greater frequency of the thermal depression over the Western Sahara (72% of days in July) with an average pressure of 1008 hPa. Its geographical location is only to be found to the south of the Atlas Mountains.

c) The appearance of a surface anticyclone over the Atlas Mountains on 43% of the days in July with an average value of 1019 hPa.

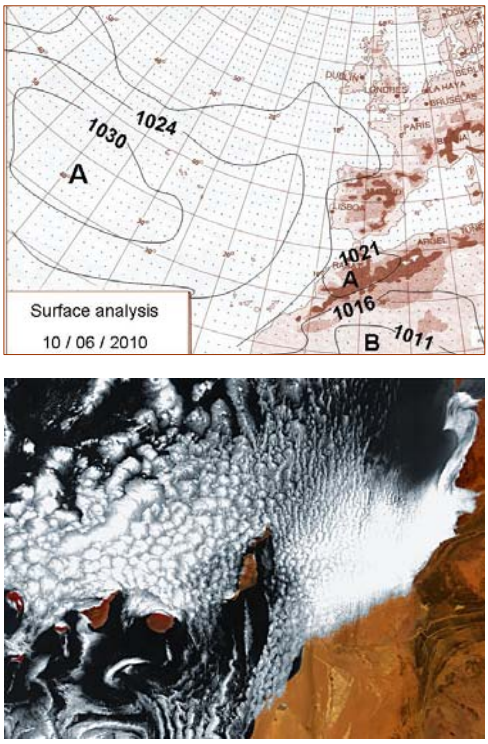

Figure 5: The surface chart and the satellite image (ENVISAT) of 6 June 2010 show the best atmospheric conditions for collecting large amounts of fog water in Boutmezguida

The three pressure centres create a steep barometric gradient giving rise to moderate NE trade winds, parallel to the Moroccan coast or from the Atlas Mountains towards the coast, which impede the Atlantic cloud from penetrating into Moroccan territory but do favour its path over the Canary Archipelago (figures 4 and 5).
However, when the winds are from the north there is a greater probability of fog on the Moroccan coast, which is what happened on 6 June 2010 (figure 5).

4. Conclusions

There is fog in Morocco on one out of every three days and in 89% of the cases this coincides with fog in the Canaries. However, the cloud phenomenon is much more common in the Islands given that it occurs on 97% of the days of the year.

There are two models of fog behavior: the *Moroccan* model which is very efficient from December to June with more than 15 L/m^2/daily and deficiency of water in July and August; and the *Canary* model which behaves inversely with a deficiency of water from September to March and an excess of water from April to August.
Finally, the organization of surface pressure systems on fog days in Morocco clearly differs to the dominating organizations on the days when there is no fog and the direction of the isobar lines is also different.

Acknowledgement

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