

THE URBAN HEAT ISLAND IN LAS PALMAS DE GRAN CANARIA: INTENSITY, DISTRIBUTION AND CONDITIONING FACTORS

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Studies have already been conducted on the urban climate of Santa Cruz de Tenerife and Las Palmas de Gran Canaria, the two largest and most dynamic Canary Island cities in demographic and economic terms. The pioneering works by Dorta *et al* (1990) and Marzol *et al* (1992) on Santa Cruz de Tenerife highlight the impact of the sea breezes and weather types on the thermal behaviour of Santa Cruz de Tenerife and confirm the existence of considerable differences between the coastal areas, higher altitudes and the city centre. In the case of Las Palmas de Gran Canaria, the first studies, by Hernández *et al* (2001) and Romero *et al* (2005-2006), determined the existence of a nocturnal urban heat island of moderate intensity with two focal points.

This study, whose objective is to provide new data on the hygrothermal regime of Las Palmas de Gran Canaria, includes identification of the intensity and morphology of the urban heat island, in addition to its seasonal variation and relation to a number of environmental and human variables.

The coastal city of Las Palmas de Gran Canaria, capital of the island of Gran Canaria, has undergone spectacular growth in recent decades. It is the municipality with the largest urbanised area in all of the Canary Islands and the eighth most populated city in Spain (377,056). The city also has one of the highest levels of demographic density in the country, with 3,627.14 persons per km². It has an area of 9 km², consisting of gentle slopes on the coastal platform, where the area of Ciudad Baja is located, and more pronounced slopes in Ciudad Alta. The marked topographical contrast between the two areas has conditioned the process of occupation and use of the areas, firstly with the building up of Ciudad Baja, followed by the urbanisation of Ciudad Alta. In terms of the type of human occupation and land use, a major contrast exists between the two zones. While in Ciudad Baja there is a combination of residential, administrative, economic, sports, recreational and commercial uses, in Ciudad Alta the use is primarily residential. From a urban planning point of view, the two sectors show considerable morphological differences. In Ciudad Baja there is a

predominance of built-up areas, while in Ciudad Alta there is a combination of built-up areas on relatively flat land and open areas with major height differences in the terrain.

The location of Las Palmas de Gran Canaria in the northern part of the Island, which is constantly influenced by the trade winds, combined with the fact that it is a low-altitude coastal city, are the factors which determine the principal features of its climate. The average annual temperature is 21° C, with the highest temperatures in September (24.3° C) and the lowest in January and February (18.4° C). The average annual rainfall is barely 112 mm and precipitation usually occurs on just a few days of the year. The average annual relative air humidity is 73%. It is a well ventilated city with a low number of cloudless days (7.1%). In 2003, the number of motor vehicles was 225,720 and the average daily traffic flow throughout the city was 15,000 vehicles.

The information presented in this study comes from the thermohygrometric readings taken in Las Palmas de Gran Canaria throughout 2004. The data was taken following two urban transects, in Ciudad Baja and Ciudad Alta, respectively. The 42 sample sites were chosen by taking into consideration the heterogeneity of the building morphology, the land-use type and the intervals of traffic flow recorded, using a previously compiled map of homogeneous urban areas. At each site, temperature and relative air humidity data was recorded using a Hanna digital thermohygrometer, model HI 8564, with a resolution of 0.1°C (temperature) and 0.1% (humidity) and a precision of $\pm 0.4^\circ\text{C}$ and $\pm 2.0\%$ respectively. Because the transect routes made it impossible to position cross points as a control, an attempt was made to mitigate this with parallel outward and return paths. The data was recorded every two weeks.

INTENSITY AND MORPHOLOGY OF THE NOCTURNAL URBAN HEAT ISLAND

The results confirm the existence of a moderate urban heat island (annual average of 3.4° C) with slightly higher values in the winter months, when the average temperature range is 3.8° C. The absolute maximum intensity was in December 2001, at 5.3° C, and the minimum in June, at just 2.1° C. In general, the maximum intensities of the urban heat island normally coincide with anticyclones and, to a lesser extent, low relative pressures. They are also accompanied by lower wind speed readings and high cloud levels. Ciudad Baja always behaves as a warm spot in contrast to the greater coolness of the sites in Ciudad Alta.

According to the annual data, the highest thermal index of the city is in San Bernardo, a zone in Ciudad Baja with a well established commercial tradition, where residential use is combined with a compact urban area and moderate traffic flow. The coldest site is in the park known as Parque de los Músicos, a well ventilated region in Ciudad Alta at an altitude of 150 m.

There are also significant differences between the two urban levels, in that Ciudad Baja is always warmer than Ciudad Alta. In Ciudad Baja two large warm regions are interspersed with three relatively cool sectors throughout the seasons. In addition, within the warm regions higher temperature air pockets exist, which change position inside these regions as the seasons change. In Ciudad Alta the thermal map is more complex due to the abrupt topography and the heterogeneity of the built-up urban sector and the building types.

CONDITIONING FACTORS OF THE NOCTURNAL URBAN TEMPERATURES

The influence of some of the environmental and urban factors in the distribution of temperatures in the city centre was determined by means of an analysis of variance. Altitude is the variable with most influence, as an obvious decrease in temperature occurs as the altitude increases. The areas closest to the coast up to an altitude of 15 m have above average temperatures which decrease at higher altitudes, dropping to below average at sites above 100 m.

In terms of land use, the highest temperatures are found in commercial areas with a high influx of visitors during the day. Both the residential and industrial areas have below average temperatures, with quite low values in the case of the latter. The industrial areas are characterised by the presence of large industrial buildings and are located at higher altitudes on well ventilated ridges away from the main concentrated commercial areas, which explains this differentiating factor in relation to most Spanish cities. In general, the small parks and gardens do not seem capable of cooling the temperatures, although this is not so in the case of extensive green areas such as Parque Doramas. In addition to the cool urban areas there are all the sites in the proximity of the beach in Las Canteras, in small alleys between buildings, which accentuate the breezes and cool the temperatures.

The traffic also influences the temperature distribution. Areas with less daytime traffic show temperatures below the average annual values. However, greater traffic density coincides with the lowest temperatures of the transect paths as a result of the configuration of these types of areas, as they consist of wide avenues right by the coast or very near to it and roads built on what were once city watercourses and now serve as connections between Ciudad Baja and Ciudad Alta.

ATMOSPHERIC HUMIDITY

Due to the operating deficiencies detected in the sensor used in Ciudad Alta, it was only possible to establish with any certainty the general humidity characteristics in the sectors at lower altitudes. In Ciudad Baja at altitudes from 0 to 15 m the average annual humidity is 62%. The highest values observed were in autumn (66.2%) and summer (64%) and the lowest were in spring (57.6%), although the variations throughout the year are not pronounced.

The relative humidity drops to its minimum value in the afternoon and tends to increase over night. In terms of the spatial distribution, the importance of the proximity to the coast is worth noting, as this is the location of sites with higher humidity.

CONCLUSIONS

The observations made by means of the urban transects reveal the existence of major contrasts in temperature and humidity in the city of Las Palmas de Gran Canaria. In general, the temperatures are higher in the urban sectors built on the former wave-cut platform (Ciudad Baja) than in the urban sectors of Ciudad Alta. In addition, the existence of pockets of warm air in Ciudad Baja means it is possible to affirm the existence of a nocturnal urban heat island with two focal points. The intensity is on average 3.4°C and

the maximum (5.3°C) occurs during the winter months, coinciding with anticyclones and calm winds.

This data and the statistical analysis carried out make it possible to suggest that the spatial distribution of the urban temperatures is due to two criteria. Broadly speaking, the altitude and the topographical variations, in this case due to more or less well ventilated ridges and ravines, are two of the factors responsible. This explains why Ciudad Alta acts as a cool sector while the warmer areas are located in Ciudad Baja. However, a more detailed analysis makes it possible to state that the distribution is mainly due to the built-up urban area, land use and traffic flow, which is why the warmer sites in Ciudad Baja correspond to totally built-up areas where green areas are scarce, with highly patronised commercial centres and high traffic density.

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