

# MODELLING OF THE ESTUARINE BREEZE OF LISBON (PORTUGAL): PRELIMINARY RESULTS

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## RESUMEN

Se sabe que las brisas pueden beneficiar el clima urbano de Lisboa. La brisa del estuario en Lisboa parece ser un fenómeno que ocurre cuando el viento del norte es más débil y cuando las diferencias de la temperatura de la ciudad y el estuario son grandes. La modelización de la brisa del estuario permitió un mejor conocimiento de la extensión de la brisa en Lisboa. El objetivo principal de esta comunicación es entender de qué forma las brisas del estuario penetran en la ciudad de Lisboa, contribuir al conocimiento de los campos del viento en Lisboa y ayudar a definir los principios climáticos para el planeamiento urbano.

**Palabras clave:** Brisa de estuario, clima urbano, modelización.

## ABSTRACT

*Thermal induced winds are known to greatly benefit the urban climate of Lisbon. The estuarine breeze in Lisbon seems to be a phenomenon that occurs when the north wind weakens and when the temperature differences between the city and the estuary are the greatest. Modelling the estuarine breeze has permitted a better knowledge of the breeze penetration in Lisbon. The main objective of this paper is to understand the way the estuarine breezes expand into Lisbon's city and to contribute to the knowledge of the wind fields in Lisbon and to help defining climatic guidelines for the planning authorities.*

**Key words:** *Estuarine breeze, urban climate, modelling.*

## 1. INTRODUCTION

The summer wind regime in the city of Lisbon is dominated by the *Nortada*, a relatively strong north wind that occurs near the western coast of the Iberian Peninsula. When this North wind weakens, a second type of regime starts to develop: the sea and the estuarine breeze. The main focus of this paper is to understand the way the estuarine breezes expand into Lisbon's city.

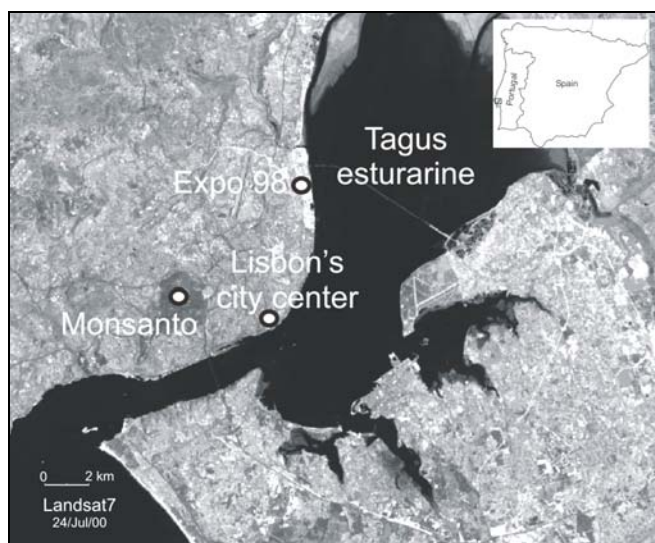


Fig. 1. Lisbon and its environment

## 2. METHODS

In order to identify the breeze, wind directions and temperatures were analysed. Temperature data was obtained from the National Meteorological Institute for Gago Coutinho (Airport) for the period of August and September of 2000, and also for the Geophysical Institute (Instituto Geofísico do Infante D. Luís) for the same period (Fig. 2).

Wind speed and direction data was also obtained with an anemometer equipped with a data-logger set on a mast 8 m high located in the *Expo 98* site. 10 minute average was taken, in the Marina site, during August and September 2000.

The breeze simulation was performed with the Meso-NH atmospheric model. The model is based upon the LIPPS AND HEMLER (1982) anelastic system of equations and is able to simulate all scales ranging from turbulent large eddies to the synoptic scale.

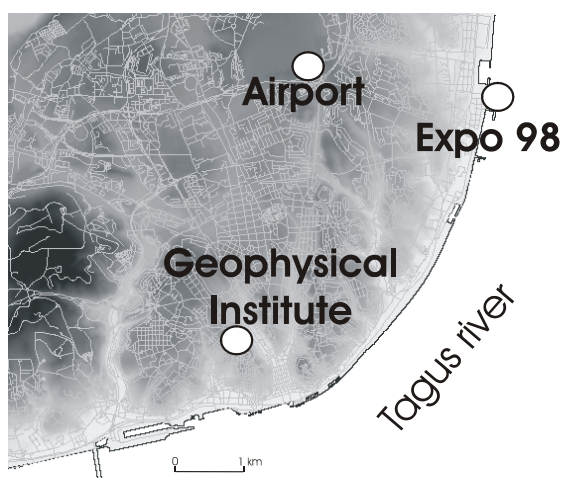


Fig. 2. Sites location

### 3. RESULTS

#### 3.1. Breeze observation

From 10 minutes average data of August of 2000 (22 days), hourly wind roses were drawn and four of them are presented here (Fig. 3). Early in the morning, at 6 h, NNW, N and NNE winds together reach 60% of the total frequency. At 10 h, the NNE wind is still dominant, followed by N winds, but SSE begin to appear going up to 10% followed by S (8%) and SE (8%) winds. In the early afternoon, at 14 h, N wind frequency diminishes: S, SSW, SW and winds correspond to 45 % of wind direction. Later during the afternoon, at 17 h, NW, N and NE wind corresponds to 85% of the cases. At sunset and even later, WSW winds still blow, but NNW, N and mainly NNE winds are the more frequent as calm situations do not occur.

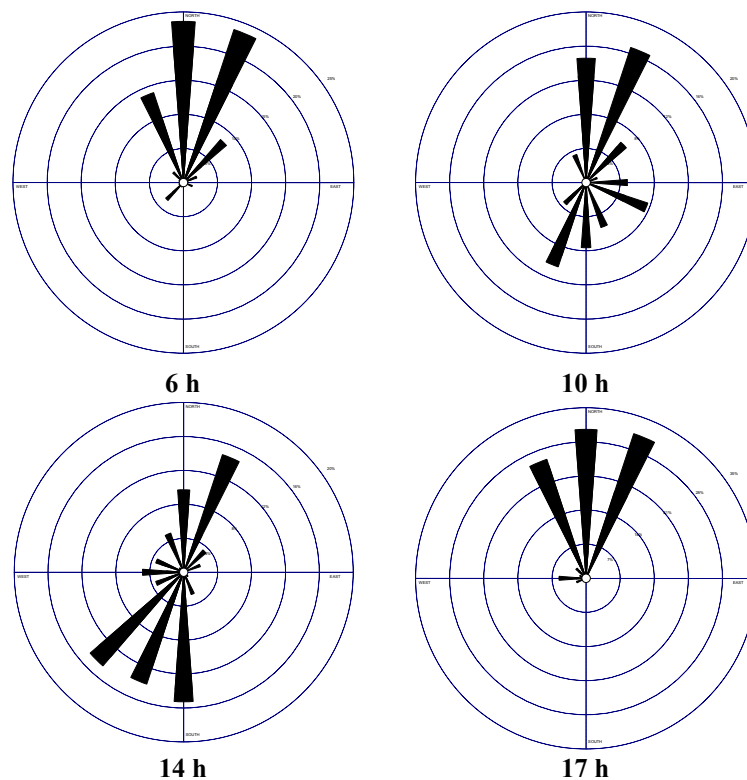


Fig.3. Hourly wind frequency and direction measured at *Expo98* site during the month of august 2000

#### 3.2. Breeze modelling

The preliminary results show the patterns of the estuarine breeze over Lisbon, penetrating over the urban areas. The decrease of the frequent north, northwest and northeast winds that allows the occurrence of the breezes, and the return of the dominant wind direction at the end of the breeze period, was also observed in Expo 98 and is clear on the figures 4, 5 and 6.

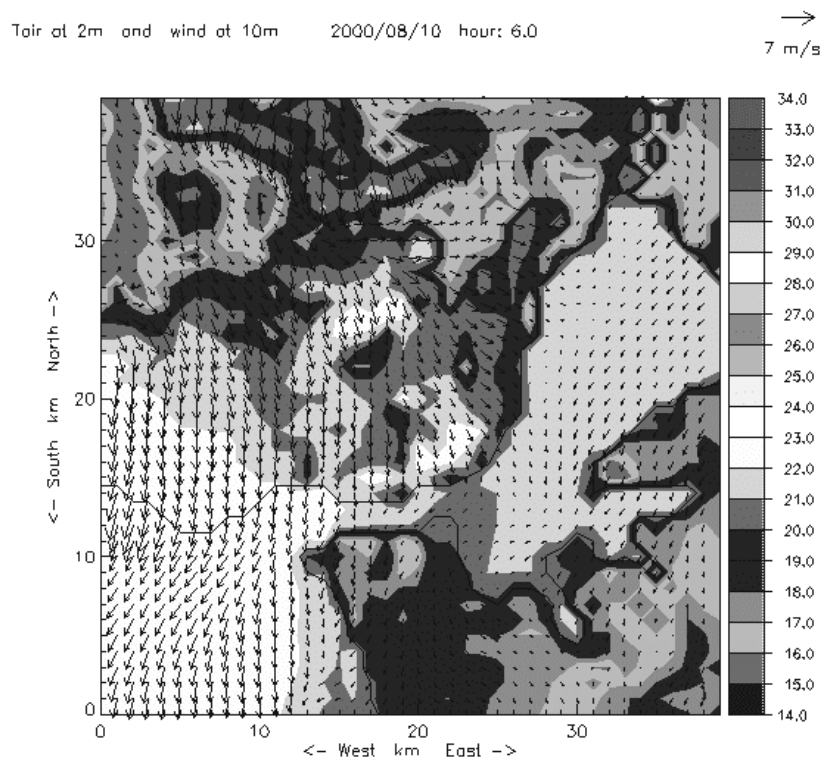


Fig. 4. Wind and temperature modelling for the 10<sup>th</sup> of August of 2000 at 6.A.M.

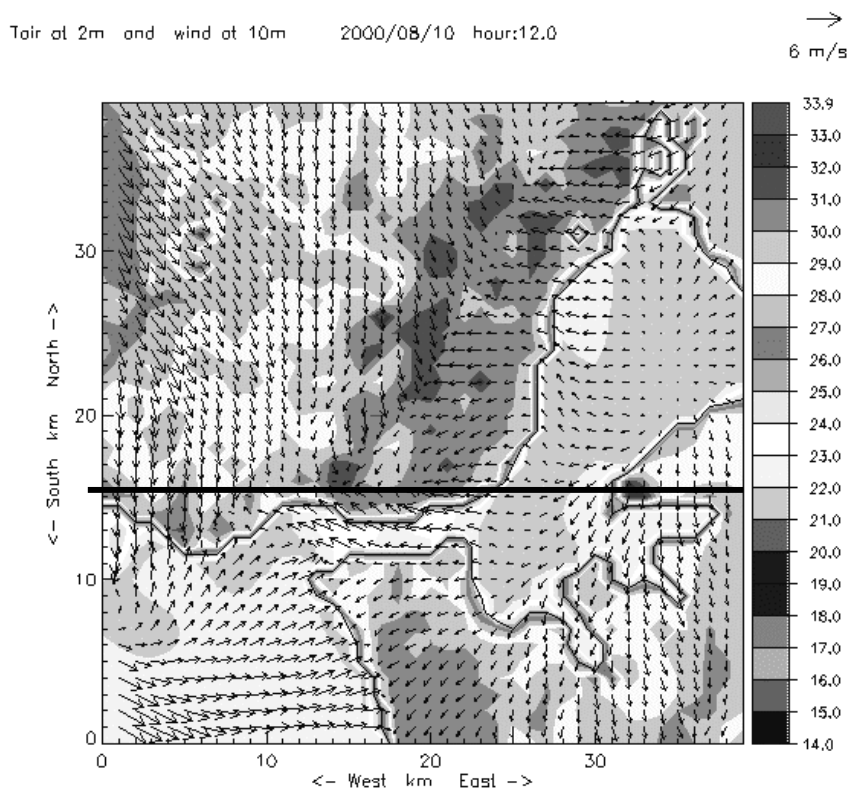


Fig. 5. Wind and temperature modelling for the 10<sup>th</sup> of August of 2000 at 12.A.M.

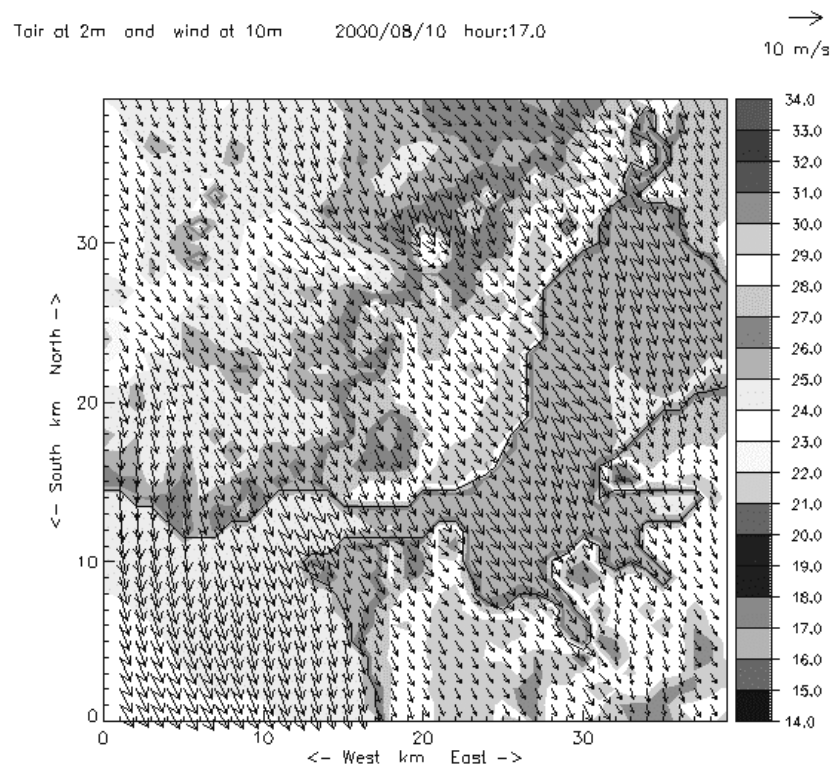


Fig. 6. Wind and temperature modelling for the 10<sup>th</sup> of August of 2000 at 5 p.m.

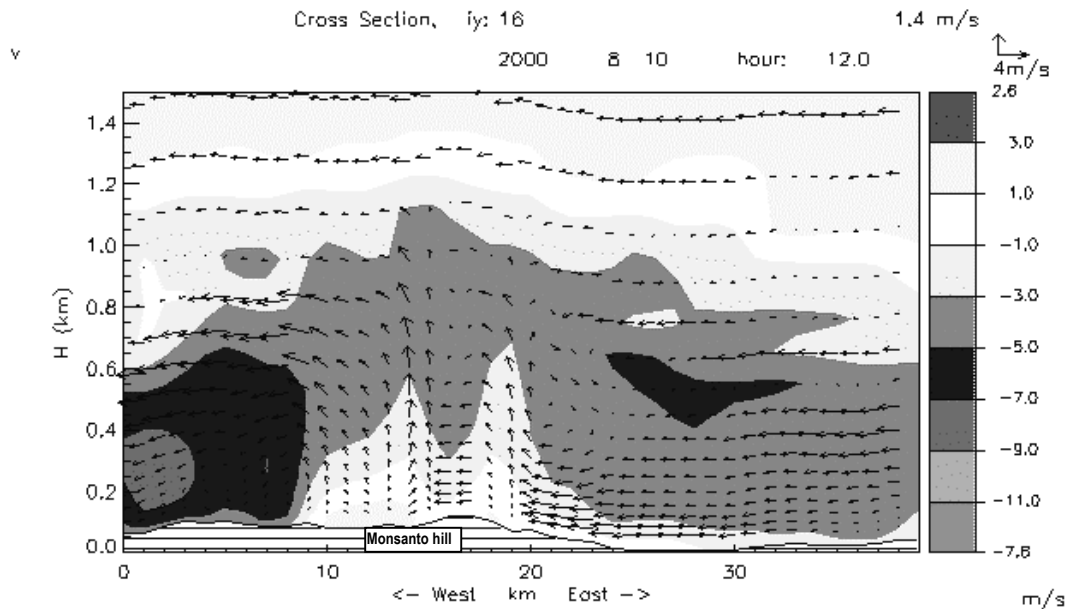


Fig. 7. Vertical structure modelled for the 10<sup>th</sup> of August of 2000 at 12:00 h.

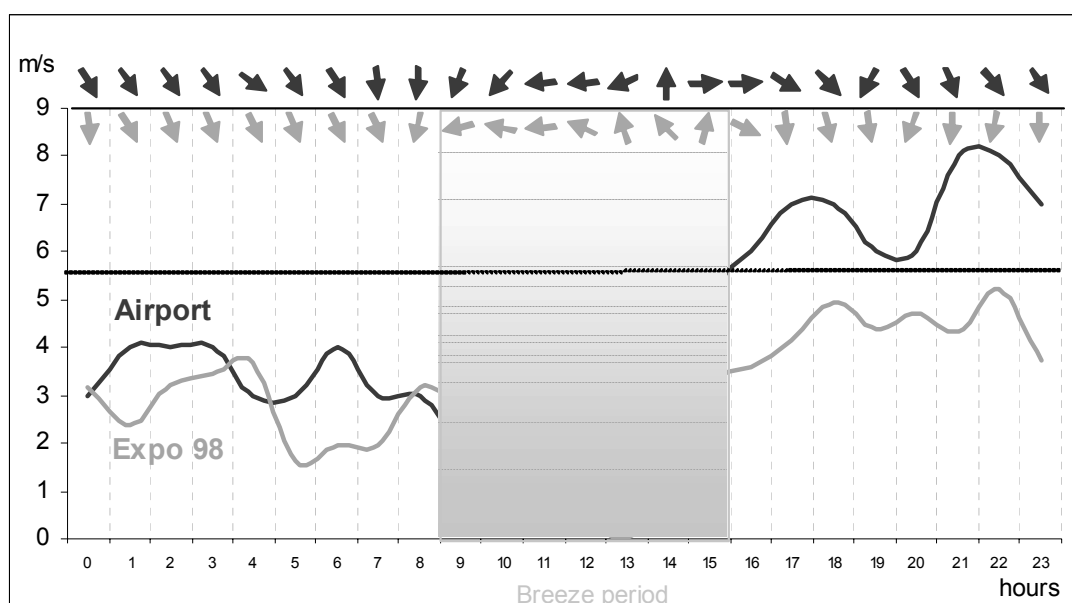


Fig. 8. Wind speed and direction for two sites in Lisbon, 10<sup>th</sup> of August of 2000.

#### 4. CONCLUSION

New data provided from the anemometer in Expo 98 confirm what has been previously mentioned by ALCOFORADO (1987) and ALCOFORADO *et al.*, (2004). Through the use of model it is now possible to understand the breeze penetration of the breeze in Lisbon.

The further step on this research is to understand the main cause of the estuarine breezes in Lisbon through the calculation of the energy balance both in the city and in the estuary. For this purpose, several temperature and humidity dataloggers will be installed in different sites of Lisbon and radiance measurements will take place on the summer of 2004.

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