ELSEVIER

Journal of Wind Engineering
and Industrial Aerodynamics 95 (2007) 1007–1027

JOURNAL OF wind engineering AND industrial aerodynamics

www.elsevier.com/locate/jweia

An analysis of extreme non-synoptic winds

Valeria Durañona[a,*], Mark Sterling[b], Christopher J. Baker[b]

[a]*Institute of Fluid Mechanics and Environmental Engineering, School of Engineering, University of the Republic, Julio Herrera y Reissig 565, CP 11200 Montevideo, Uruguay*
[b]*School of Engineering, The University of Birmingham, Edgbaston, Birmingham B15 2TT, UK*

Available online 23 March 2007

Abstract

This paper presents an analysis of wind velocity data relating to 11 extreme non-synoptic events obtained from velocity time series pertaining to flow over rural and coastal terrain. For the purposes of the current analysis, an extreme event is deemed to have occurred when the local velocity increases rapidly by 50% or more and decreases within a relatively short time. The data were measured at a number of locations within Northern Europe and in all cases a sufficient array of anemometry was present to obtain an indication of the velocity profile. The velocity profile is shown to alter significantly during such events with three different trends identified. Despite the large variations in wind speed and velocity profile, wavelet analysis is used to illustrate that the underlying turbulent structures exhibit similar behaviour to those expected to occur during extreme wind speed events in boundary layer flow.

Keywords: Non-synoptic; Extreme winds; Conditional sampling

1. Introduction

In general, the calculation of wind loads on structures usually considers the effects of synoptic winds or tropical cyclones. However, in recent years it has come to be realised that the wind loads caused by a variety of other weather systems can be important. Holmes (2003) writes:

> Until recently there was a tendency to assume that we understood all that we need to know about windstorms, their origins and characteristics. In fact, it was assumed

*Corresponding author. Tel.: +598 27115276; fax: +598 27115277.
E-mail address: valeriad@fing.edu.uy (V. Durañona).

0167-6105/$ - see front matter © 2007 Published by Elsevier Ltd.
doi:10.1016/j.jweia.2007.01.014

that all the extreme winds were large-scale synoptic winds, with boundary-layer characteristics remarkably similar to those found in boundary-layer wind tunnels! This is far from the truth. A good example is extreme winds produced by thunderstorms.

There is considerable ongoing activity to measure the characteristics of thunderstorm winds at low levels (<100 m above the ground) in Texas (Gast and Schroeder, 2003) and in Singapore (Choi and Hidayat, 2003). Letchford has pioneered numerous approaches in order to physically simulate the turbulence characteristics (Letchford and Chay, 2002; Letchford et al., 2002; Chen and Letchford, 2004) and has suggested ways in which this knowledge can be used for design (Chen and Letchford, 2005). Numerous other researchers have focused attention on the simulation of thunderstorm winds both physically and numerically (e.g. see Chay et al., 2006; Hangan et al., 2003 for further details).

Whilst it is acknowledged that in many cases it is possible that thunderstorm activity is responsible for an extreme wind event, it should be noted that not all extreme events are downbursts. It is also worth noting that the remaining extreme events (i.e. those that are not thunderstorm related) are not necessarily well understood and cannot necessarily be attributed to a particular weather system. It is with this issue that the current work is concerned. Eleven extreme events from coastal and rural sites have been identified and are analysed in detail. It is shown that adopting common threshold criteria to indicate deviations from the norm can capture a series of events whose statistical properties can be significantly different.

Section 2 of the paper outlines the experimental data and the threshold criteria that have been used to identify the events. Section 3 analyses a number of the peak events using traditional analysis while Section 4 interprets the identified peak events using wavelet analysis. Finally, Section 5 of the paper presents some concluding remarks relating to the importance of the analysis undertaken.

2. Experimental data

2.1. Wind velocity database

The following analysis is concerned with full-scale data which has been collected at a variety of rural and costal sites throughout Europe at various heights above the ground using cup and sonic anemometry. The data used in this study were obtained from a unique and extensive database, WindData.com (2004). This database contains four different categories of wind-related data: extensive velocity time series, time series corresponding to wind turbine responses, wind resource data and other measurements of relevance to wind energy. These data have been compiled from a number of different locations across the world (Europe, Japan, Egypt and Central and North America) and as such encompasses a wide variety of conditions and different terrains; more than 162,600 h of wind speed measurements are contained in the database.

Although this database has data relating to 74 sites, attention was restricted to locations with a relatively flat orography, to avoid the influence of hills and mountains on the wind measurements as well as the presence of nearby upwind obstacles, which could affect the atmospheric boundary layer characteristics under normal wind conditions. Attention was