Highest wind gusts in Uruguay: characteristics and associated meteorological events

Valeria Durañona[1]

[1]*Institute of Fluid Mechanics and Environmental Engineering (IMFIA), School of Engineering, Universidad de la República, Montevideo, Uruguay,* valeriad@fing.edu.uy

INTRODUCTION

Wind gusts in Uruguay started to be systematically recorded in open terrain in 2008, when a network of automatic weather stations began to be installed for wind resources purposes [1]. At present there are around 25 stations measuring wind and other meteorological parameters in open and level terrain, without significant obstacles in their surroundings that could influence their wind measurements. Although the lengths of these wind records are not enough to obtain reliable wind gust extreme statistics, they are a source of relevant information to describe the main characteristics of the wind gusts that occur in Uruguay, as their temporal and spatial scale, wind speed evolution with time, correlation among different heights, etc., as well as the associated meteorological mechanisms that produce them.

Uruguay is located in the southeastern part of South America, between 30 and 34.5º south latitude, in an area that concentrates intense weather episodes associated with the occurrence of severe convective storms, which produce intense localized winds, as downbursts and tornadoes ([2], [3], [4]). It also belongs to a region of the southern hemisphere that experiences one of the most significant cyclogenesis activities ([5], [6]), where intense extra-tropical cyclones occasionally develop and generate intense winds in the country. Due to these facts, it was expected that a systematic analysis of the wind gust data made recently available could help to describe and characterize both types of wind extreme events, which are responsible for most of the wind damage that occurs in Uruguay ([7]).

METHODOLOGY

The weather stations used for this work register the mean, standard deviation, maximum and minimum values of wind speed, wind direction and temperature every 10 minutes, with some of them also measuring humidity and solar radiation. Every station measures wind speed at two or three heights, wind direction at two heights, temperature at one or two heights, and in the cases where humidity and/or solar radiation are also recorded, they are measured at one height. The heights of measurements vary among the different stations, spanning 10 to 100m heights, but as all of them have anemometers below and above 45m, wind speed values were interpolated at this height when comparison along the country was needed. As the stations network has been gradually installed, the lengths of the available records vary from around four years to just a few months. Altogether they represent 850 months of 10 minutes measurements of each meteorological parameter. When homogenization was needed to compare results, only complete years were used in the analysis, in order to take into account possible seasonality in the occurrence of high wind gusts.

The locations of the weather stations were chosen in order to cover most of the country. As Uruguay has an area of approximately 175.000 km^2, with the maximum distance between two points of the country being around 600km, the density of these stations allow an adequate analysis of the trajectories and behavior of the storms that cause the highest wind gusts.

A search for wind events that caused gusts higher than 80km/h in any anemometer was performed in the database described above. This value of wind speed had been previously found to be a threshold for the start of wind damage in Uruguay ([7]). When a gust was found that surpassed that threshold, the temporal evolution of all the available meteorological variables for that particular station was analyzed and plotted 5 hours before and after the highest wind gust was recorded. In many cases, synoptic charts

and satellite imagery were collected around the time the gust occurred, in order to describe the meteorological mechanism behind it.

RESULTS

A high correlation between the most intense wind gusts (as high as 160 km/h) and drops in temperature was found in all the stations, indicating the importance of the passage of cold fronts in the generation of high wind gusts in Uruguay. These cold fronts drive warm humid air upwards and in the presence of an unstable atmosphere, conditions for Cumulonimbus clouds to form and produce intense downbursts, and therefore high gusts, are met. As cold fronts can span hundreds of kilometers, they usually produce high wind gusts in more than one station, and the passage of a cold front over Uruguay is easily detected analyzing how wind speed, direction and temperature change along time on the network.

Most of the cases that presented high wind gusts with intense convective activity could be classified into four general categories according to their wind speed evolution with time, all of them showing very high correlation between the different measurement heights at a particular site. These categories are: 1- very pronounced spikes, lasting less than half an hour, generally associated with drops in temperature and changes in wind direction; 2- pronounced spikes, lasting less than one hour, also generally associated with drops in temperature and changes in wind direction; 3- sudden increments in wind speed, which decreases during several hours afterwards and 4- wind speeds increasing and decreasing more gradually, during three to four hours.

Looking at all the generated data, it could be concluded that the highest wind gusts in Uruguay are caused by severe convective mechanisms, in particular due to the passage or stationarity over the country of cold fronts, but also due to the passage of warm fronts and isolated storms with a lesser degree of importance. Larger temporal events also cause high wind gusts, principally due to the passage of intense extra-tropical cyclones, but also due to the presence of high and low pressure systems in different particular combinations near Uruguay. Although distinct from a meteorological point of view, both convective events and extra-tropical cyclones generate the highest gusts from the southwest quadrant.

The center of the country was the region that presented more cases with gusts higher than the selected threshold, followed in order by the southeast. Additionally, a tendency for the northwest of the country to have a higher percentage of intense gusts caused by convection than the southeast was found, with more events of larger temporal scales recorded in the southeast.

Mean wind speeds were also studied, and it was found that convective activity was also significant in the production of the highest 10 min wind speeds.

REFERENCES

[1] Cataldo, J., 11th Report for the Wind Energy Program in Uruguay (in Spanish), School of Engineering, UDELAR, Montevideo, 2011.

[2] Durañona, V., Wind extreme events in Uruguay, in: Proc. of the 14th Australasian Wind Eng. Society and Southern Hemisphere Extreme Winds Workshops (Canberra, 2010), Geoscience Australia, Canberra, 2010. pp. 142- 145.

[3] Nascimento, E.L., Doswell C. A., The need for an improved documentation of severe thunderstorms and tornadoes, in: South America. Severe Local Storms Special Symposium, 86th AMS Annual Meeting, Atlanta/USA, paper P1.18, in CD-ROM, 2006.

[4] Schwarzkopf, M.L., Rosso, L.C., Downbursts and tornadoes risk in Argentina. Biblioteca de apoyo CIRSOC, Fac. Cs.Exactas y Naturales, Univ. de Bs.As., Argentina, 1993.

[5] Gan, A.M., Rao, B. V., Surface cyclogenesis over South America. Mon. Weather Rev. 119, 5, (1991), 1293-1302.

[6] Seluchi, M., Diagnóstico y pronóstico de situaciones sinópticas conducentes a ciclogénesis sobre el este de Sudamérica. Geofísica Internacional 34, 2, 1995. pp. 171-186.

[7] Durañona, V., Wind impact on Uruguay: vulnerability to extreme winds and estimation of their risk, 13th International Conference on Wind Engineering, Amsterdam, 2011.