Damage under strong winds in the NE of Argentina: Three case studies

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1 INTRODUCTION

Continental Argentina stretches approximately from 22º to 55º S latitudes. It is a large country with areas dominated by different climate mechanisms. Schwarzkopf [1] characterised five main synoptic features causing strong winds:

a) the southern part of the country (Patagonia), between 35º an 55º S, is dominated by large extra-tropical cyclones that move from west to east;
b) in the Andes range, the cyclones are perturbed by the mountains and downslope winds occur frequently;
c) the north-west is dominated by a persistent steady depression with a warm nucleus known as "baja térmica del noroeste argentino";
d) over the north-central area, dynamic depressions form, mainly in winter and early spring, and move toward south-west; and
e) squall lines sweep the centre and the north-east of the country from south to north. Apart from these large scale phenomena, all the country further north than 45º S is affected by severe storms caused by convective cells.

Occurrence of severe storms in Argentina has been exhaustively studied by Schwarzkopf [2], who since early '70s conducts systematic field surveys to quantify the magnitude of the storms. Schwarzkopf and Rosso [3] developed a model to assess the risk that downburst and tornados hit either point or linear targets, which is based in a Twisdale and Dunn's [4] model.

Since 2008, damage caused by strong winds on civil structures is being surveyed at Chaco and neighbouring areas. Chaco is a province of the north-east of the country (Fig. 1). The more frequent strong wind events in the NE are related to severe convective storms. Chaco has an area of 99.633 km² and a population of nearly 1 million inhabitants, of which about 20% are settled in rural areas. The field surveys are complemented with analysis of the synoptic conditions through NCEP/NCAR Reanalysis and a Global Data Assimilation System (GDA) model. In this work, some preliminary findings about damage and prevailing meteorological conditions are presented with emphasis on three particular cases.

2 SOME FEATURES OF THE OBSERVED DAMAGE

Twenty two storms causing damage were observed at Chaco in the period January 2007-June 2010. Field surveys were conducted after ten events. Information from secondary sources, mainly the local press, are available in the remaining twelve cases.

Eleven storms took place in summer, nine in spring, one in autumn and one in winter. Clearly, there is a seasonal influence. There is information about duration of the storms in nine cases, where damage occurred during periods of strong winds that lasted from 4 minutes to half an hour. For some events, the strong winds corresponded to a more intense phase of a longer storm and for other events the phenomenon was an intense short-lived storm.

Damage occured between midnight and dawn in 60% of the cases and in the evening in 25% of the cases.

Fig. 1: Left, location of Argentina and the Chaco province. Right, detail of the north-eastern area.

With regard with the extension and destructivity of the cases, only two were widespread destructive events, that is, events after which the government had to assist the population to a significant extent. In nine cases, only isolated structures were damaged while the surrounding area was not affected. Between these two extremes, there are eleven cases in which the damage was widespread but it was mainly background damage (damage to poorly built structures or to structures with poor maintenance). At this point, it must be noted that what is called background damage has different meanings in rich and poor countries, because the structures in bad condition (deterioration) or poorly built, in the last case, make up a significant part of the full building stock.

The structures more frequently affected were residential dwellings. Four storms caused damage to homes involving 460 families that had to be assisted by the government. Damage to dwellings is reported in fourteen cases (63%). Warehouses and canopies with structures made of a peculiar feeble lattice, which is characteristic of the local building culture, were damaged in nine events (40%). High voltage electricity transmission lines were damaged in four cases, and low voltage lines in ten cases.

The number of victims was surprisingly low: only 11 people with minor injuries in three cases. Nineteen events produced no casualties.

3 THREE STORMS

In this section, three study cases corresponding to different scales of damage are presented. The first one occurred in Chaco, while the other two occurred in the nearby province of Formosa.

3.1 1st case: a storm causing localized damage in a suburb of Resistencia

On 22nd of October, 2008, at 4:30 a.m. local time (07:30 UTC), seven supporting towers of a 132 KV electrical transmission line collapsed in Fontana, a western suburb of Resistencia (Fig. 1)(about 400,000 inhabitants), when a cold front was passing from S to N. The storm caused little damage in the surrounding area, where only auxiliary structures such as signboards, marquees and carports were affected. The electricity line runs east/west and the towers fell towards the north. Gust speeds around 23 m/s where recorded at the airport, which is 4.5 km to the S. These gust speeds were in agreement with the level of damage in the city but could not explain the failure of the towers.

The synoptic analysis shows that the area was affected by severe convective activity produced by the instability associated to the passage of a frontal wave with strong spatial gradients of humidity and temperature. This frontal wave came from the SW and was related to a strong discontinuity in the mass of air: there was moist warm air further north the front. A low-pressure area developed on the zone of the discontinuity. Fig. 2 shows that there was convergence of masses of air at levels close to the ground. At 06 UTC, this zone laid approximately 100 km to the south of Fontana. The surface wind field presented a maximum over 15 m/s. This maximum was related to the polar jet stream that came along the frontal system. Above the centre of the country, the maximum was over 40 m/s (level of 250 hPa). The index of instability revealed the probability of formation of severe convective storms (Standard Lifted Index reached -5.3°C in previous hours). From the available information, it was inferred the presence of strong vertical movements with velocities about 50.9 hPa/h, at the level of 850 hPa (06 UTC). At the same time, the low layers of the atmosphere had high horizontal wind velocities; for instance, 24.6 m/s at 900 hpa (909 m above ground level) and 20.1 m/s at 200 m.

3.2 2nd case: a storm causing widespread damage in a city

Formosa city is the capital of Formosa province (see Fig. 1). It has a population over 200,000. On 21st of July, 2008, at 18:40 local time (21:40 UTC) a storm caused widespread damage in a strip of approximately 200 m wide x 5000 m long in the urban area. The strip was oriented NW/SE in coincidence with the predominant wind direction at the moment.

Unroofing of dwellings, fallen trees and failure of electricity line poles were the most common types of damage. A 70 m deep x 40 m wide vaulted canopy roof and a few dwellings were utterly destroyed. Seven hundred families were assisted by the government.

In this case, the origin of the strong wind was the formation and development of a low-pressure system (cyclogenesis on surface [5]). This process caused a circulation from the north that contributed with warm moist air. At the 21UTC the system was extended, covering N and NE of the country as it can be seen in Fig. 3. At that time, the city of Formosa laid in the equatorial side of the jet stream, which contributed to the upward movements of the mass of air. This dynamic pattern plus the convergence on surface produced severe convective activity.

3.3 3rd case: a storm causing widespread damage in more than one urban centre

On 9^{th} of November, 2008, at 5:00 a.m. local time (08UTC) a storm fell upon the village of Estanislao del Campo (population about 4,000, see Fig. 1) and shortly afterward passed over Pozo del Tigre (population about 4,000) and then over Las Lomitas (population about 10,000). It caused widespread damage in Estanislao del Campo and Pozo del Tigre and some isolated damage in Las Lomitas. Earlier that day (at 2 a.m.), there was a storm causing some isolated damage in Formosa city. Unroofing of dwellings, major damage in public buildings and fallen electricity poles were the predominant types of damage. Defensa Civil estimated that one out of two families of Estanislao del Campo and Pozo del Tigre was affected (about 1100 families).

The synoptic analysis identified a mesoscale convective complex (MCC) over the area. These systems are defined as a complex of storms whose cloud top cover more than 50,000 km^2 in the infrared satellite images for T_{IR} of < -52 °C. The MCC are systems predominantly deep and barotropic [6, 7]. One of the two most intense convective centres of the MCC was established in the Pozo del Tigre area. The Standard Lifted Index was less than -3 °C. Two hours before the event, a barotropic atmosphere with a warm nucleus was observed. The MCC developed on the east edge of the depression by the persistent advection of humid, warm air. In Fig. 4, the satellite image shows the cloudiness associated to the MCC, with temperatures in the edges of the system less than -52 °C. Besides, it can be observed that one of the most intense convective cells was located on Pozo del Tigre.

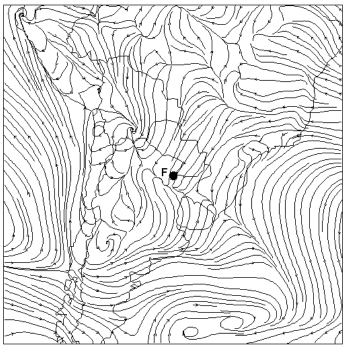

Fig. 2: Case 1: Streamlines (KNTS) at 1000 hPa, 06UTC.

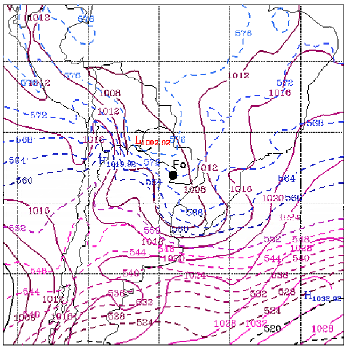

Fig. 3: Case 2: mean sea-level pressure (hPa) and thickness1000hPa/500hPa (dm), 21UTC.

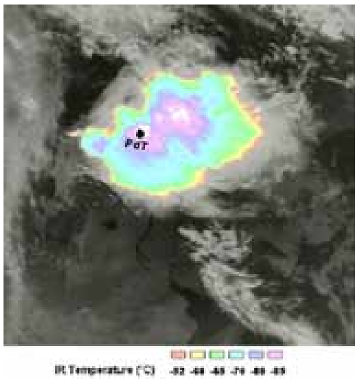

Fig.4: Case 3: thermal scene, c4 AVHRR/NOAA15, 08UTC.

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