IMPACT OF TWO SEVERE STORM SYSTEMS OVER SÃO PAULO STATE, BRAZIL

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I. INTRODUCTION

On 4 May 2001 a tornado hit 5 different cities in the state of Sao Paulo, Brazil, impacting the areas significantly. On 24 May 2005 another tornado struck a nearby area, causing again severe damages. It is worth mentioning that both storm systems occurred in autumn.

This study aims to determine the physical conditions that triggered the two systems, evaluating the impacts on the local population.

II. DISCUSSION

The State of São Paulo, Southeastern Brazil, encompasses approximately 249,000 km^2 and it is the most developed and populated state of the country. At the western edge of the Atlantic Ocean, along with the variations in its topography, São Paulo presents a variety of atmospheric conditions that cause heavy precipitation episodes (Candido and Nunes, 2009). The area is affected by tropical, subtropical and mid-latitude controls and during summer the South Atlantic Convergence Zone (ZCAS) enhances the convective activity, connecting humidity from the Amazonian basin to the Atlantic coast. The region is also influenced by the negative phase of ENSO as well as occasional Mesoscale Convective Complexes. These atmospheric conditions are associated with high instability and development of storm cells and because of the high density of population and economic activities, these situations can adversely affect the area. Southern South America is ranked as the second area of higher risk to tornadoes in the world (Vesilind, 2004). FIG 1 shows the core area of tornadoes in South America and FIG 2, the episodes recorded in the state of Sao Paulo, southeastern Brazil.

The study evaluated the development of two storm systems over the state: on 4 May 2001 a powerful tornado hit five municipalities in the Metropolitan Region of Campinas, a densely populated and economically important area. Wind speeds of around 300 km/h were recorded, and caused severe damages. The second event, on 24 May 2005, was dominated by a strong cold front that moved fast north-eastward to the centre of the state, with high instability sustaining severe storms, and one of them spawned a multi-vortex tornado (F3) that hit three cities. Satellite composite and radar images were used to evaluate the storm systems. Both were associated with a conflict between dry cold and hot humid air masses, favouring the development of storms in the western sector of the State, moving south-eastward, following the River Tiete, which provided additional humidity and intensified the storm systems.

The episodes heavily impacted the areas, causing severe damages. The first episode (2001) registered wind speeds over 300 km/h according to CEPAGRI-UNICAMP (Center of Agricultural Research of the University of Campinas). The damage was consistent with winds of major proportions, as trees and electric poles were twisted.

The city of Sumaré was particularly affected by the storm: besides the infrastructure damages and economic losses, one person died as a result of the collapse of a wall and a 9-year old child was seriously injured. Because the tornado track extended over 50 km, the damages caused could be extensively recorded. Among the consequences one can quote brick building destructions and power outages in dozens of cities, since high-voltage towers were hit, forcing the power distribution stations in the region to disrupt operations (Folha de São Paulo, May, 05, 2001).

Concerning the episode of 2005, the strong winds caused the collapse of numerous houses, left 110 homeless and .destroyed roofs on 400 other buildings. The overturning of 18 railroad cars testifies the high speed of winds in the city of Indaiatuba., where the impact was particularly severe since the tornado hit the poor neighbourhoods, where local population presents higher degree of social vulnerability.

FIG 1: Area of higher occurrence of tornadoes in South America.

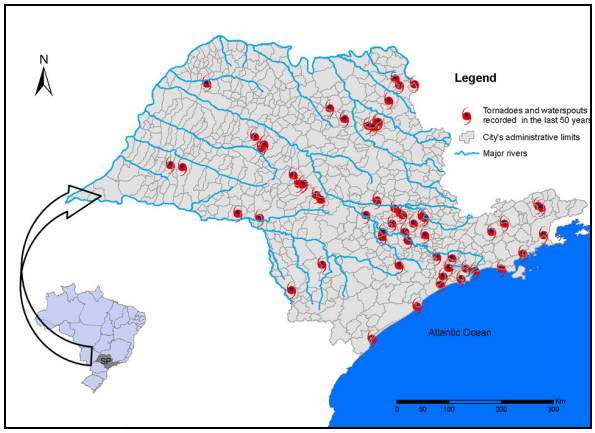

FIG. 2: Tornadoes and waterspouts recorded in the the State of São Paulo, Brazil, from 1957 to 2007.

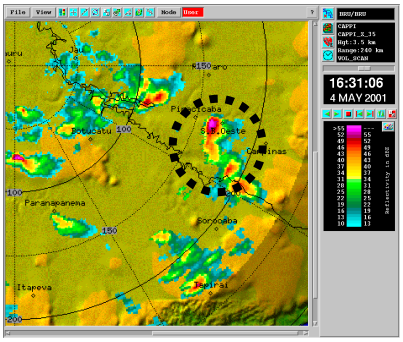

FIG. 3: Supercell of May 04, 2001 near Campinas, SP

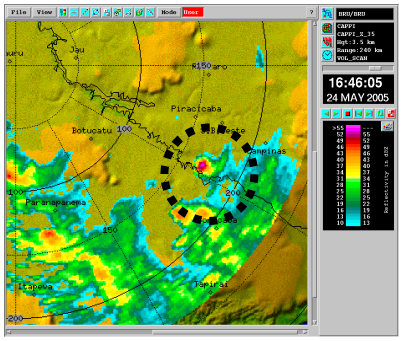

FIG. 4: Supercell of May 24, 2005 near Campinas, SP

III. RESULTS AND CONCLUSIONS

The two selected episodes of severe storms associated with tornadoes presented similarities: both were registered in the same period of the year (May) and followed a northwest-southeast path. Radar and satellite analysis showed that in both cases the storms were associated with an enhanced ZCAS. Some hours before the storm clouds were formed as the convergence zone was intensified, in response to the contrast between the warm and moist air of ZCAS and a polar air mass.

During the event of 2001, winds exceeding 300 km/h were recorded, as could be attested by the kind of damages to the structures (Blessmann, 2002). Power poles and transmission lines collapsed and many of them presented torsional loads consistent with critical wind exposure to tornadoes. However, to the best knowledge of the authors, no photographic record of the funnel exists, a fact that might be associated with the high humidity levels that caused mist and sudden visibility loss.

Unlike the first case, the episode of 2005 was filmed by several video cameras. A particular good recording was registered by the surveillance system of a local highway. This was the first record of a video in South America that clearly showed an F3 tornado with multiple vortices. The tornado moved through an industrial district causing severe damages to machinery and equipments. Economical losses were significant, about US$ 50 million (Folha de São Paulo, May, 30 2005). The same cell storm spawned tornadoes in other cities during its advance: Capivari, for instance, was hit by multiple tornadoes and among other damages, one person died and 40% of the sugarcane planted was lost.

III. FINAL REMARKS

The "Tornado Alley" in the USA and a sector of South America that encompasses the state of São Paulo are the two areas that present the highest threat to tornadoes in the world (Vesilind, 2004; Antonio et al, 2005). As can be seen in FIG. 2, tornadoes are far from being an uncommon feature in São Paulo state (Silva-Dias and Grammelsbacher, 1991; Held et al, 2004; Held et al, 2005), due to the combination of complex atmospheric mechanisms that lead to high instabilities and the morphological and hydrological characteristics of the area. However, no tornado action plan exists either in São Paulo or in any other Brazilian state, a fact that contributes to increase the risk to this hazardous phenomenon.

The study compared two tornadoes recorded in the state of São Paulo, Brazil. Great similarity in the atmospheric conditions leading to the formation of supercells in both cases, was found. Interestingly, even the timing of the events was similar: the two storms reached maturity at around 16:00 (FIG 3 and FIG 4). Radar and satellite composition showed that in both cases systems advanced from northwest, associated with atmospheric disturbances arising from the ZCAS. The episode of 2005 was particularly well publicised, since it was recorded on video and its losses were higher, since the tornado hit a large and modern industrial park. But the 2001 event was also significant and caused one death.

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