TORNADO AND WATERSPOUT CLIMATOLOGY IN BRAZIL

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I. INTRODUCTION

The appropriate conditions for tornadic storms can be found in different places, and although there are more reports for the USA, Canada, northern Europe, Australia and South Africa, southern Brazil has been recognized as a tornado-prone area (http://www.spc.noaa.gov/faq/tornado/).

Some authors have studied specific tornado and waterspout episodes in Brazil, among which Silva Dias and Grammelsbacher (1991), Massambani et al. (1992), Antonio (1996), Held et al. (2004), Marcelino et al. (2006), Nunes et al. (2008) and Candido et al. (2009). However, no consistent information base for these phenomena is kept that could aid identify sites and periods of highest incidence and recognize which characteristics of atmospheric and of other nature are usually associated with tornadoes and waterspouts in Brazil. In order to better understand these atmospheric perturbations that take place mainly in southern Brazil, this study aims to provide an overview of these phenomena during the period 1991 to 2010.

II. DISCUSSION AND RESULTS

Some studies on tornadoes and waterspouts recorded in Brazil stress out that some relief features are fundamental in the formation of tornadoes, such as the hill chains and steeper relief in São Paulo State, and the ridges in the Rio Grande do Sul and Santa Catarina states. Nunes et al. (2008) also observed that the trajectory of many tornadoes in central-southern Brazil follows river courses, from which they obtain energy. Thus, as observed in the United States by Allaby (2004), in sectors of central-southern Brazil the influence of the Subtropical Jet Stream is perceived. It oscillates according to Rossby waves, following the advance of the high-pressure systems associated with the polar masses (Nunes et al., 2008). In these cases, the jets generate wind shear and a more significant atmospheric movement, aspects that favor the formation of potentially tornadic, severe storms.

This analysis focuses on the period between 1991 and 2010, when information became more detailed. For comparison, FIG. 1 presents proven tornadoes and waterspouts occurrences in Brazil between 1967 and 2010. An increasing trend in the number of reported events can be noted, probably due to the facility to document these episodes and to the growth of urbanization and population in many areas of Brazil. Nevertheless, it is important to underline that prior to the 1990s tornadoes and waterspouts were most likely underreported. This raise was more significant from 2005 on, but as no atmospheric alterations occurred that could be associated with this increase, the raise is probably related to the increase of records rather than the events themselves.

In the period of analysis (1991 to 2010) 205 events were identified, 167 being tornadoes and 38 waterspouts. FIG. 2 shows the monthly distribution of the occurrences

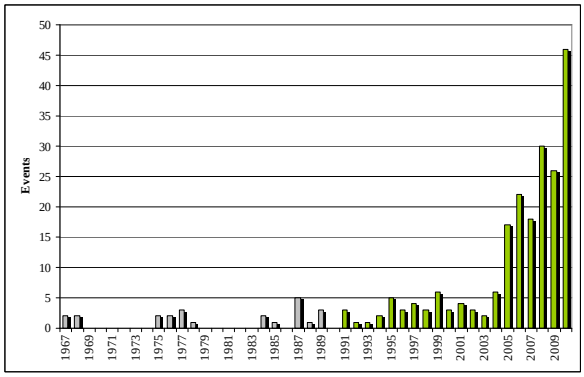

FIG 1: Yearly distribution of events from 1967 to 2010 – in gray, events prior to 1967-2010 (Organized by Laura De Bona)

and that the highest concentration of these phenomena took place in the hottest period of the year, between September and March. The month of May also corresponds to a significant number of episodes, which can be associated with the high instability during this period of atmospheric transition.

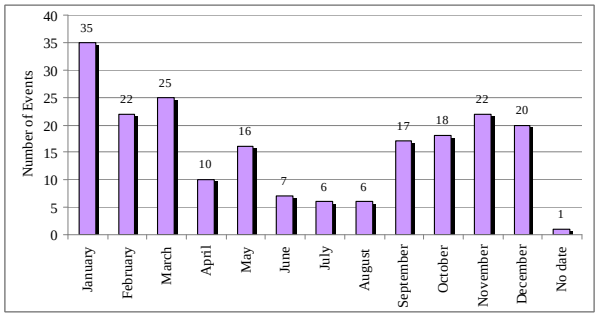

FIG 2: Monthly distribution of events (1991-2010) (Organized by Laura De Bona)

In terms of spatial distribution, 16 Brazilian states recorded tornadoes or waterspouts between 1991 and 2010, a considerable number when taking into account that the federation has 26 states and a Federal District (FIG. 3). The atmospheric conditions in southern Brazil are particularly favorable to the formation of these phenomena, once 81% of the episodes occurred in the southeastern and southern regions. In these sectors the reach of the Jet Stream, the topography, the distribution of the drainage and humidity are decisive contributors to the occurrence of these disturbances. As in the United States, most of them are associated with the meeting of tropical and extra-tropical systems. Besides the favorable physical conditions, southern Brazil states concentrate an important part of the income and population of the country, which aggravates the social-economic consequences generated by these disturbances. Another relevant fact is that in these states tornadoes and waterspouts occurred in different municipalities, signaling that many localities have the conditions to trigger these phenomena.

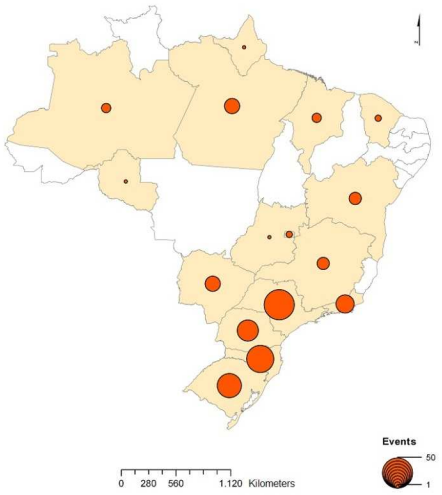

FIG 3: Distribution of the events by state between 1991 and 2010 (Organized by Laura De Bona)

Of the total 205 episodes, 19% were waterspouts. Even if the reduced number makes the recognition of spatial and temporal features difficult, they were predominant over tornadoes in the states more to the north of Brazil, where the contrast between distinct atmospheric systems is less intense. However, the state that recorded more waterspouts was Rio de Janeiro, usually taking place very close to the seashore. Half of the occurrences took place in hotter months, between December and January, but waterspouts occurred in all months of the year.

As in the case of tornadoes and waterspouts, electric discharges are associated with high atmospheric instability conditions. A recent study that examined the density of electric discharges from 2009 to 2010 in municipalities of the central-southern Brazilian states (9 states and the Federal District) pointed that the first 26 in the rank are in São Paulo (14 municipalities) and Rio de Janeiro (12 municipalities), which also presented the highest incidence of tornadoes and waterspouts, respectively (http://www.inpe.br/webelat/home page/menu/infor/ranking.de. municipios.php).

Out of 205 episodes, only 108 record the time of the occurrence of tornadoes or waterspouts, but 80% of these episodes occurred at night or in the afternoon, suggesting the importance of the diurnal heating in the formation of these events.

The degree of detail in the information varies according to the event, which makes the comparison and the pattern recognition difficult. On the other hand, evidences that indicate the occurrence of outbreaks in different cities are frequent. Sixteen reports involve death, totaling 52 casualties. On a single day, 30th September 1991, several cities in São Paulo State were hit, resulting in 15 deaths. Many of the reports mention injured and homeless.

It is of note that the association of the events registered in Brazil with any damage scale like Torro or Fujita is difficult because the assignment of any of these scale rating depends on particular structures being present to be damaged, and Brazilian structures (materials and architectonic patterns) do not correspond to the same ones considered in these scales, fact which pose difficulties for comparisons. However, a simple and not conclusive attempt was done in order to associate the episodes recorded to the Fujita scale, and it was noticed that most of the episodes could be considered weak events (F1 and F2). Notwithstanding, it is possible that 8 episodes were at least a F3 tornado.

III. CONCLUSIONS

The scarce scientific literature on tornadoes and waterspouts in Brazil limits the recognition that the country is an active tornado-prone area, notably in the central-southern region. In this sector a number of aspects such as the meeting of tropical and polar air masses, the position of the Jet Stream and geographic features such as relief and hydrography are fundamental to the occurrence of tornadic storms.

Our survey detected less occurrence of waterspouts, but they were predominant relative to tornadoes in the states more to the north, where low latitudes and large availability of humidity makes the diurnal and seasonal differences of the atmospheric conditions very small.

The frequency of waterspouts and tornadoes was highest in Rio de Janeiro and São Paulo states respectively. Both are localized in southern Brazil and stand out for the economic vitality and high population density. Also in these two states the density of electric discharges has been the highest, when compared to the central-southern states in the last two years. However, as the genesis of these episodes was not analyzed in this study, it is difficult to evaluate the reason for the major incidence of atmospheric disturbances in these states, but the aspects surveyed suggest the necessity of more detailed and comparative evaluations.

Even if the level of detail of the information collected for the 205 events is distinct, it is possible that many of them, taking into consideration their destruction power, were severe. Many occurrences seem to be associated with not only one, but with several, more or less simultaneous tornadoes.

The lack of more information on the patterns of occurrence of these perturbations makes the proposal of standard procedures to diminish damage difficult. Massive investment would be necessary to create centers for the observation of severe events and implant new Doppler radars and alert systems to notify the population on the possibility of occurrence of potentially tornadic storms. All this is linked to the scientific production on the theme, aiming at a better knowledge of the spatial and temporal distribution of these phenomena and case analysis to check the conditions associated with the record of tornadoes and waterspouts.

The association of tornadoes and waterspouts with social-economic parameters is also essential, because in Brazil these phenomena have been frequent in highly-populated areas, bringing to light several issues, such as the aggravation of the severity of their impact, or other issues that should be investigated in more detail and comprehensively.

IV. ACKNOWLEDGEMENT

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