PREDICTABILITY OF EXTREME STORM EVENTS IN THE STATE OF SÃO PAULO, BRAZIL

Gerhard Held , Ana Maria Gomes, Mateus Teixeira, José Marcio Bassan and Geórgia Pellegrina

Instituto de Pesquisas Meteorológicas-IPMet, São Paulo State University-UNESP, Bauru, Brazil, gerhard@ipmet.unesp.br

(Dated: 15 September 2009)

I. INTRODUCTION

The State of São Paulo is situated in the south-eastern region of Brazil and is characterized by summer rain and relatively dry winter months. However, severe storm events can occur any time of the year, but during summer they have a more tropical character, while from about mid-April to September they are usually associated with baroclinic synoptic situations and cold fronts advancing from southern Brazil in a north-easterly direction into the western and central State of São Paulo.

The Meteorological Research Institute (IPMet) of UNESP operates two S-band Doppler radars, located at Bauru (Lat: 22°21.5' S, Lon: 49°1.7' W, 624 m amsl) and Presidente Prudente (Lat: 22°10.5' S, Lon: 51°22.5'W, 420 m amsl), respectively (Figure 1). The main characteristics of both radars are: 2° beam width, 450 km range for surveillance mode and 240 km in volume scan mode, with 11 (15) elevations from 0.3° to 35°, 1 km (250 m) radial and 1° azimuthal resolution, and a temporal resolution of 15 minutes or less, recording and archiving reflectivity, radial velocity and spectral width (numbers in brackets are applicable from 2007).

FIG. 1: Doppler radar network of IPMet (BRU = Bauru; PPR = Presidente Prudente), showing the 240 and 450 km range rings.

II. PRESENTATION OF RESEARCH

The most severe 7 events during the last five years (2004 – 2008) had been selected to verify their predictability from about 48 hours before the occurrence up to the nowcasting time scale of 30 – 60 min before reaching a town, city or industrial installations, like high-voltage power lines, etc.

IPMet, in collaboration with CPTEC, runs the Meso-Eta model, centered over the Bauru radar, twice daily (initiated at 00 and 12 UT) with a temporal resolution of 3 hours up to 72 hours. Its domain amply covers the State of São Paulo at a resolution of 10x10 km horizontally with 30 levels from 1000 to 100 hPa. This model has been specifically fine-tuned to compute additional convective parameters (SR helicity, BRN Shear, supercell index, etc), as well as the generation of vertical profiles (Skew T – Log P) at any specified grid point (Held et al., 2007). Furthermore, each run of the model is executed twice, using the convection parameterization of Betts & Miller and Kain-Fritsch, respectively (Betts and Miller, 1993; Kain, 2004).

In this paper we shall show which of these new outputs are the most suitable for predicting a severe event up to 48 hours ahead of its possible occurrence, which is then used to alert regional emergency services for the possible need of a standby (especially important before weekends).

On the day of severe thunderstorm development, NCAR´s Software TITAN is deployed (Dixon and Wiener, 1993), utilizing observations from the two S-band Doppler radars, to issue alerts of possible heavy rainfall, probability of hail or extremely strong winds on the time scale of 60 – 30 min.

III. RESULTS AND CONCLUSIONS

The following cases had been selected on the basis of severe damage that had been reported in News Papers, on TV, on Websites or documented by the Civil Defence Organization of the State of São Paulo:

27 February 2004, when heavy rain was accompanied by an extremely severe wind storm, resulting in the destruction of about 30 high-voltage transmission towers, as well as damage to more than 50 houses in several small towns.

25 May 2004, when a supercell, lasting 8,5 hours, and two tornado-spawning cells were tracked by IPMet´s radars, causing the death of 2 and severe injuries to 51 people, as well as great damage to sugar plantations. The tornadoes had a strength of F2-3 and F2, respectively, on the Fujita scale.

24 May 2005 was another day, when an F3 tornado was observed, killing one person and totally destroying an industrial suburb and damaging many buildings and structures in other parts of the town, resulting in a total loss of USD 42 million.

29 March 2006, when a strong frontal event provoked the formation of a bow-echo, which generated extremely strong wind gusts at its leading edge (almost tornado-like), causing enormous damage in two towns in the centre of the State.

19 January 2007 marked the occurrence of a small tornado in the western State during the early hours of the morning. It caused damage to some houses, uprooted large trees and destroyed an electric transmission line.

24 July 2007 was characterized not only by the unseasonal heavy rainfalls over the State, but also by a severe hail swath, destroying the orange crop in the NW regions.

29 October 2008, when a microburst near Bauru destroyed 6 high-voltage transmission towers and caused other damage.

Detailed case studies of some of these storms have already been presented, analyzing the synoptic situations and radar and lightning observations, using TITAN in Archive mode (Held et al., 2006, 2007b; Gomes and Held, 2006, 2009) and simulating a forecast between 30 and 60 minutes, which can then be compared to the actual situation. Therefore, the findings from the synoptic and radar analysis will only be briefly dealt with in this paper, while the emphasis will rather be on the medium-term Meso-Eta forecasts, viz. mostly between 24 and 48 hours for most reliable results.

The severe windstorm, which occurred on 29 March 2006 at the locations P and SB in the central State, as a result of the strong bow echo traversing the State of São Paulo, is used to demonstrate the Meso-Eta medium-term and TITAN nowcasts, as they are being exploited in IPMet´s Operational Center. Figure 2 shows the 39-hour forecast of the CAPE for the Betts-Miller and Kain-Fritsch convection algorithms, respectively. The model was initiated on 27 March, 00 UT and the forecast is valid for 29 March, 15 UT (12 LT), about the time when the wind storm peaked.

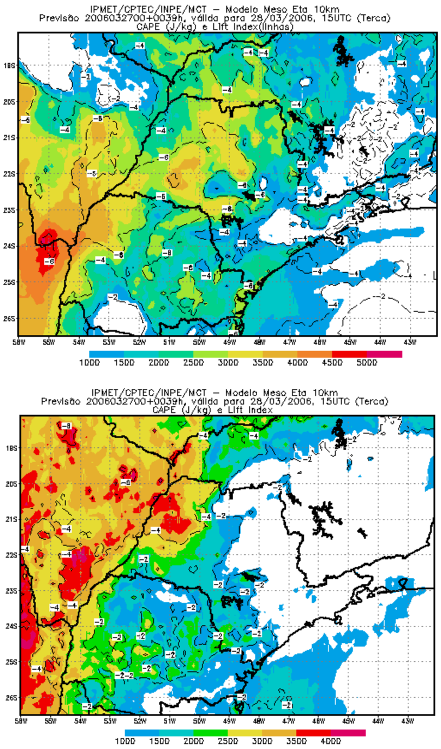

FIG. 2: Meso-Eta run on 27 March 2006, 00 UT with 39 hour forecast for the CAPE, using Betts-Miller (top) and Kain-Fritsch (bottom) convection parameterization

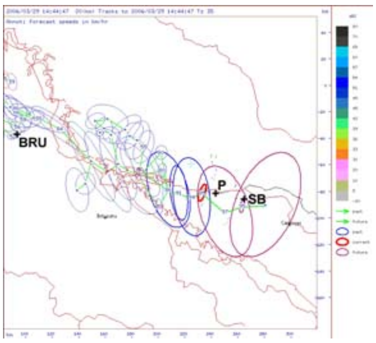

FIG. 3: TITAN storm track on 29 March 2006 at 11:45 LT just west of P, with a 30 min forecast traversing SB. The annotation is cell speed, varying between 80–95km.h^{-1}. Cell envelopes every 15min.

The Betts-Miller output indicates high CAPE values (3000 – 3500 J.kg^{-1}) for the western part of the State with a slightly isolated small high in the region where the wind storm will occur. In contrast, Kain-Fritsch predicts in the same region only up to 1500 J.kg^{-1}, clearly under-estimating the severe storm system that would traverse the State during the morning of 29 March 2006.

Figure 3 shows the TITAN analysis of the storm track at 14:45 UT (11:45 LT, light blue) with the past (yellow) and the future (forecast for 30 min). The predicted cell track at ±90 km.h^{-1} is exactly across the towns P and SB. Figure 4 demonstrates the SSS (Storm-Structure-Severity) Index at 14:22 UT (11:22 LT) with 30 min forecast matching exactly the area where the wind storm occurred.

The onset time of a severe event and the region where it could be expected, is generally well predicted by the Meso-Eta model 24-48 hours ahead, while TITAN captures the nowcast range very well.

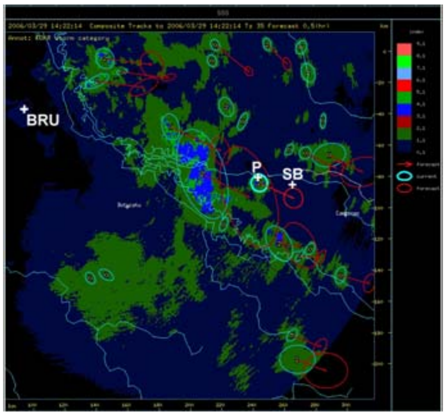

FIG. 4: TITAN SSS Index on 29 March 2006 at 11:22 LT with a 30 min forecast (red arrows). Index 4 (blue) indicates very strong wind.

IV. AKNOWLEDGMENTS

The authors would like to thank J. M. Kokitsu for the implementation of TITAN routines used in the analysis and Drs J. Wilson and M. Dixon of NCAR for facilitating the implementation of TITAN at IPMet/UNESP. J.L. Gomes and G. Sueiro of CPTEC are acknowledged for providing the historic input data sets and for advice on the model installation and occasional upgrading

V. REFERENCES

Betts, A.K. and Miller, M.J. 1993 The Betts-Miller scheme. Chapter in *The representation of cumulus convection in numerical models of the atmosphere*. Eds. K.A. Emanuel and D.J. Raymond. American Meteorological Society.

Dixon M. and Wiener G., 1993: TITAN: Thunderstorm Identification, Tracking, Analysis and Nowcasting - A radar-based methodology. *J. Atmos. Ocean. Technol.*, 10, 785-797.

Gomes A.M. and Held G, 2009: Severe Winter Storms over the Western and Central State of São Paulo, Brazil. *Proceedings, 5th European Conference on Severe Storms*, Landshut, Germany, 12-16 October 2009, 2pp.

Gomes A.M. and Held G, 2006: Identificação, rastreamento e previsão de tempestades severas, Parte II: Evento de ventos intensos. *Proceedings, XIV Congresso Brasileiro de Meteorologia*, (CD ROM), Florianópolis, 27 de novembro – 01 de dezembro de 2006, SBMET, 6pp.

Held G., Gomes A.M., Naccarato K.P. and Pinto O. Jr., Nascimento E., 2006: The Structure of Three Tornado-Generating Storms Based on Doppler Radar and Lightning Observations in the State of São Paulo, Brazil. *Proceedings, 8th International Conference on Southern Hemisphere Meteorology and Oceanography*, Foz do Iguaçu, 24-28 April 2006, 1787-1797.

Held G., Gomes J.L. and Nascimento E.L., 2007a: Forecasting Severe Weather Occurrences in the State of São Paulo, Brazil, Using the Meso-Eta Model. *Proceedings, 4th European Conference on Severe Storms*, Trieste, Italy, 10-14 Sept. 2007.

Held G., Gomes A.M., Naccarato K.P. and Pinto O. Jr., 2007b: Signatures of Severe Thunderstorms for Nowcasting in the State of São Paulo, Brazil.l. *Proceedings, 4th European Conference on Severe Storms*, Trieste, Italy, 10-14 September 2007, 2pp.

Kain J.S., 2004: The Kain-Fritsch convective parameterization: An update. J. Appl. Metor., **43**, 170-181.