Severe Storm in the metropolitan region of Belém: A Case Study
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1 – INTRODUCTION

The advent of weather radar came to filling in a gap opened by information with better spatial and temporal resolutions, which are essential in the detection and monitoring of severe storms. Thus, the nowcasting is essential for generating weather alerts in a timely manner for decision making and propose mitigation actions.

With 11 weather radar installed in the legal Amazon, SIPAM through the divisions of meteorology (DivMet) of the three RC – Regional Centers (Belém, Manaus and Porto Velho) invests in training and improving your body's operational, aimed at forecasting and warning of severe events time, posing potential threat to any human activity with a significant socioeconomic impact.

The object of study is the storm which occurred on January 15, 2010 that generated a maximum rainfall of 72 mm showing the first 2 hours standard convective rain in the remaining three hours that followed the rain decreased from stratiform to submit feature. This severe event left nearly submerged the city of Belém on several points. In addition to the points of flooding, some trees did not survive the high winds that prevailed heavy rains.

2 - MATERIALS AND METHODS

Were used for the production of case study satellite images (GOES 10) and products of the S-band weather radar located in the town of Belém (lat 01º24’ S - long 48º 27’ W).

The software used to analyze the data collected by weather radar was the TITAN (Thunderstorm Identification Tracking Analysis and Nowcasting). The TITAN has routines for identifying and qualifying storms among them;

VIL (Vertically Integrated Liquid) - Calculation of the contents of vertically integrated liquid water;
VIL_overhang - VIL calculated from a threshold up and down, subtracting the top of the bottom. This parameter identifies areas of upward flow. As the TITAN also estimates the height of the top, this allows the derivation of the parameter DVIL, VIL density, another important parameter for quantifying the degree of severity.

DVIL density (VIL) - Estimates the severity of storms. DVIL The parameter is calculated by the equation:

\[ \text{DVIL} = \frac{\text{VIL}(\text{kg/m}^3) / \text{TOP(m)}}{1000} \]

Finally parameter SSS (Storm Severity Structure) which is a parameter calculated according to the reflectivity (dBZ_{max}) at the bottom, middle and top of the cell, and a value is distributed throughout the cell is not a point value (Visser 2001).
3 - RESULTS AND DISCUSSION

1.3 Analysis of the environment that the storm surge

The satellite images (Figure 1) show very cloudy over the region, and in time of 19 UTC (Fig. 1-a) the north shore has a small active cell, one hour later (Fig. 1-b) this cloudy already has line format and intensifies. The growth of this line Cumulonimbus (CB) is coming very fast, its top temperature of-80°C in the cells near Belém (Fig.1-c and 1-d).

![Figure 1 – Satellite images GOES-12 - 15/01/2010; a) 1900 UTC, b) 2000 UTC; c) 2030 UTC; e d) 2100 UTC. The green arrow indicates the location of Belém. Source: CPTEC/INPE (Centro de Previsão de Tempo e Estudos Climáticos – Instituto Nacional de Pesquisas Espaciais)](image)

3.2 - The storm weather radar with a view of Belém

The weather radar of Belém located in the 1º 24' S 48º 27' W within the metropolitan area. The Figure 2 shows the reflectivity data (dBZ), the entire sequence of the storm, which includes the time 19:21 to 21:09, when it begins to dissipate; The 19:21 UTC the storm begins to intensify while the 40km east of the radar (Fig. 2a), 20:09 from the line arrives in Belém where to start precipitation and winds gust at the surface, the cell east of the radar has around 60 DBZ height reaching 13.4 km, the torrential rains are (Fig. 2b). At the time of 20:33 UTC, the gust front moves to the west of the radar, but the city is still under the influence of convective cell but shows lowering winds at the surface, however following intense rain (Fig. 2c) . The following image (Fig. 2d) shows a continuation of the storm rainfall without significant surface winds, radar already shows a large area west of the capital convective and stratiform extensive area over Belém.
The Figure 3 shows, for the hours of 19:45 UTC, some parameters that TITAN software provides. Was made a cross-sectional line storm (shown in phantom). This line was 40km east of the radar. In the central part are shown the values of the top of various cells with values between 12.6 and 14.9 km. In the above right side of the figure is a cross section about the line 70 km and below two histograms, one with the parameters VII, mass flow area and volume of precipitation and the last rising the parameters for the probability of occurrence of hail. When calculating the parameter settings of the storm area, volume and flow of precipitation showed the same trend intensified as the histogram shown in figure 3. The storm vertical development cannot be well represented because the storm has occurred very close to the radar, still the right of the graph Figure 5 shows the vertical Development also a few cells. It is noteworthy that the red line that represents the parameter estimation of cell movement (tracking) showed the direction of the storm south of the radar in the region of the neighborhoods most affected (Marco, São Braz and Terra Firme) by storm.
3.2.1 - Analysis of the severity indexes calculated by TITAN

The severity of the storm can be seen with the data of Table 1, where are recorded the values of VIL, TOP, DVIL, maximum reflectivity index and SSS severity, throughout its development. Given these data, it appears that the parameter SSS was the best qualified the severity of storms in their various stages of development. VIL values range from 50.9 to 66.2 moving to 19:33 UTC 20:09 UTC when the storm reached its peak decreasing to 26.8 to 21 UTC. The findings corroborate Greene and Clark (1972) who concluded that the rapid development of values of VIL is a strong indicator of "explosive development".

DVIL values calculated for this storm (Table 1), ranging from 4.94 at the peak of the storm to 2.68 in its decay. Paxton and Shepherd (1993) proposed the use of this parameter to estimate the severity of storms. The same parameter was used by Gomes and Held (2004) in the central part of the state of Sao Paulo. DVIL These values are above the values found by Gomes & Held (2004) for the central area of São Paulo, where DVIL between 2.3 and 3.3 were considered indication of high winds, deserving a severe storm warning and also above those found by Queiroz (2009) who studied severe storms using radar data from Bauru and the São Roque DVIL found values between 1.8 and 3.8. Another relevant parameter is the SSS (Storm Severity Structure), which represented the best variations in several volumes considered, as shown in Table 1.
Table 1: Evolution of Parameters: VIL, TOP, DVIL, Maximum reflectivity and Storm Severity Structure (SSS).

<table>
<thead>
<tr>
<th>Tempo (UTC)</th>
<th>19:33:06</th>
<th>20:09:05</th>
<th>20:33:05</th>
<th>21:09:09</th>
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</thead>
<tbody>
<tr>
<td>VIL (Kg/m²)</td>
<td>50,9</td>
<td>66,2</td>
<td>47,7</td>
<td>26,8</td>
</tr>
<tr>
<td>TOP (Km)</td>
<td>11,9</td>
<td>13,4</td>
<td>10,4</td>
<td>10,10</td>
</tr>
<tr>
<td>DVIL (g/m³)</td>
<td>4,2</td>
<td>4,94</td>
<td>4,55</td>
<td>2,68</td>
</tr>
<tr>
<td>dBZ</td>
<td>64</td>
<td>65</td>
<td>65</td>
<td>56</td>
</tr>
<tr>
<td>SSS</td>
<td>2-5</td>
<td>7-8</td>
<td>4-5</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2 shows the comparison of the values of rainfall in 24 h in which the event occurred, with values recorded for two seasons INMET and the values estimated by TITAN. The automatic station located at Almirante Barroso Avenue recorded 50.4 mm while the conventional station located southeast recorded rainfall of 76.2 mm. The precipitation rate calculated by the radar showed values close to those observed in the two stations of INMET.

Table 2: Values of rainfall

<table>
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<tr>
<td>INMET automatic station (Almirante Barroso -48,3 x -1,41)</td>
<td>50,40</td>
</tr>
<tr>
<td>TITAN</td>
<td>48,80</td>
</tr>
<tr>
<td>INMET conventional station (CEASA -48,4 x -1,43)</td>
<td>76,20</td>
</tr>
<tr>
<td>TITAN</td>
<td>63,14</td>
</tr>
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</table>

4 - CONCLUSIONS

The storm occurred on January 15, 2010 had a fast development and reached a wide area allowed to be viewed by GOES satellite image 10. The weather radar located in the city of Belem was used to analyze the same. The TITAN software allowed the calculation of various parameters including parameters indicative of severe storm such as VIL and DVIL, both showed higher values than those found for other regions of the country. The Titan was a good predictor to track and predict the progress of the storm cells to neighborhoods south of the radar where the damage was greatest. The parameter SSS, this storm proved to be very sensitive in monitoring the severity of the storm.

5-REFERENCES


