Characteristics of the X-Band Polarimetric Radar Associated With the Lightning Electrical Activity

Doctoral Thesis in Meteorology - INPE
Student: Msc. Enrique Vieira Mattos
Advisor: Dr. Luiz Augusto Toledo Machado

IAG-USP São Paulo - May 10, 2013
Characteristics of the X-Band Polarimetric Radar Associated With the Lightning Electrical Activity: Enrique MATTOS and Luiz MACHADO
This work have the objective of the evaluate the impact of cloud microphysics on the intensity of lightning electrical activity.
DATA DESCRIPTION:

XPOL RADAR

EXPERIMENT: CHUVA-GLM-VALE
(Nov/2011 to Mar/2012)
**DATA: RADAR**

(1) Radar xpol:

(a) dBZ  ➔  LEVEL 1B  
(b) ZDR  ➔  LEVEL 1B  
(c) CORR  ➔  LEVEL 1A  
(d) KDP  ➔  LEVEL 1A

**Correction #1: Wet radome**

(a) dBZ (Bechini et al. (2010))

\[ L_{rad} = 2(-0.34 + 1.61(r \times R)^{1/3}) \]

**Correction #2:**

(a) ZDR (Sakuragi and Biscaro (2012))

<table>
<thead>
<tr>
<th>Initial Period</th>
<th>Final Period</th>
<th>Offset (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/11/2011</td>
<td>11/12/2011</td>
<td>-0.271</td>
</tr>
<tr>
<td>12/12/2011</td>
<td>27/01/2012</td>
<td>-0.328</td>
</tr>
<tr>
<td>28/01/2012</td>
<td>31/03/2012</td>
<td>-0.587</td>
</tr>
<tr>
<td>15/05/2013</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PPI for Second Elevation**

 characteristics of the X-Band Polarimetric Radar Associated With the Lightning Electrical Activity: Enrique MATTOS and Luiz MACHADO
DATA: LIGHTNING

(2a) LMA (*sources VHF) ➔ LEVEL 1B
(2b) Rindat (*CG,*PC) ➔ LEVEL 1A
(2c) BrasilDat (*IC,*CG,*PC) ➔ LEVEL 1B

Example: Flash propagation using LMA data

Courtesy from Rachel

ICAE Newsletter

15/05/2013

Characteristics of the X-Band Polarimetric Radar Associated With the Lightning Electrical Activity: Enrique MATTOS and Luiz MACHADO
RESULTS: LMA Distribution

Histogram of VHF Sources by Pixel

- 1-4 LMA Sources
- 5-34 LMA Sources
- 35-215 LMA Sources

Characteristics of the X-Band Polarmetric Radar Associated With the Lightning Electrical Activity: Enrique MATTOS and Luiz MACHADO
### RESULTS: Amount of Lightning by LMA Sets

<table>
<thead>
<tr>
<th>LMA Sets Intensity Namely</th>
<th>Sets Profile</th>
<th>#Sources</th>
<th>-CG</th>
<th>+CG</th>
<th>IN</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Wit. Activity</td>
<td>24389612</td>
<td>0</td>
<td>2484</td>
<td>320</td>
</tr>
<tr>
<td>1-4</td>
<td>Low</td>
<td>563543</td>
<td>1015778</td>
<td>3243</td>
<td>642</td>
</tr>
<tr>
<td>5-34</td>
<td>Moderate</td>
<td>244342</td>
<td>2659489</td>
<td>6466</td>
<td>1994</td>
</tr>
<tr>
<td>35-215</td>
<td>High</td>
<td>20356</td>
<td>1231596</td>
<td>3081</td>
<td>1185</td>
</tr>
</tbody>
</table>

Characteristics of the X-Band Polarimetric Radar Associated With the Lightning Electrical Activity: Enrique MATTOS and Luiz MACHADO
RESULTS: CFADS - DBZ

Distribution Shifts toward higher concentration of droplets
RESULTS: CFADS - ZDR

Distribution shifts toward negative ZDR and close ~7 Km
RESULTS: CFADS - KDP

Higher Electrical Activity is associated with distribution of KDP with more negative values.
High Electrical Activity happens for highest values of Correlation Factor
RESULTS: Vertical Profile of Polarimetric Variables

- **ZDR**: Higher Occurrence associated with Ice Aligned vertically
- **DBZ**: Higher Occurrence associated with Convective Profile
- **KDP**: Electrical Activity associated with Oblatos hydrometeors
- **CORR**: Warm Phase of cloud is very clear for Different steps of LMA. Cold Phase is more moderate
RESULTS: Electrical Charge Center

VHF Sources Average Occurrence by Height

Despersion by Electrical Charge Center and LMA Steps

Characteristics of the X-Band Polarimetric Radar Associated With the Lightning Electrical Activity: Enrique MATTOS and Luiz MACHADO
1) Distribution of VHF Sources has an logarithmic form

2) Convective Profile has a good signature for differentiate electrical activity

3) Higher Electrical Activity is more correlated with ice crystal aligned vertically or with the conical graupel

4) Eletrification is correlated for an kind of hydrometeoror and has not good relatianship with mix of ice/water together.

5) Polarimetrics variables has a good signature for indentifie the Negative and Positive Center of Electrical Charge
WORK IN PROGRESS:

Analysis for Polarimetrics Variables for intra-cloud lightning, Negative CG and Positive CG strokes

Create an Conceptual Model that describe to the four “kind” of activity electrical in terms of Cloud Polarimetric Characteristics
ACKNOWLEDGEMENTS
This research was supported by FAPESP Grant 2009/15235-8 and 2011/18217-0.