Weather Radar and Lightning Observations of Mesoscale Convective Systems in the South of Brazil

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Lightning Incidence in Southeastern South America

High Resolution Full Climatology Annual Flash Rate

Global distribution of lightning April 1995-February 2003 from the combined observations of the NASA OTD (4/95-3/00) and LIS (1/98-2/03) instruments
(Adapted from Goodman & Cecil 2002)
Lightning Incidence in Southeastern South America
Seazonal Variation

TRMM LIS Cumulative Flash Rate Density SON (1998–2009)

Spring

TRMM LIS Cumulative Flash Rate Density DJF (1998–2009)

Summer

TRMM LIS Cumulative Flash Rate Density MAM (1998–2009)

Fall

TRMM LIS Cumulative Flash Rate Density JJJA (1998–2009)

Winter
Precipitation Distribution in Southeastern South America
Seazonal Variation
Synoptic Influence for MCS Occurrence in Southeastern South America

✓ South American Low Level Jet

MCC frequency during warm season (1998-2007)

Durkee et al. (2009)
Southeastern Brazil

More than 70% of GDP (Gross Domestic Product)

Major cities: Sao Paulo, Rio de Janeiro, Curitiba (> 80 million people)

Power generation, Agriculture, Petrol refineries, Industries

Integrated National Power Transmission Lines
Southeastern Brazil

More than 70% of GDP (Gross Domestic Product)

Major cities: Sao Paulo, Rio de Janeiro, Curitiba (> 80 million people)

Power generation, Agriculture, Petrol refineries, Industries

Integrated National Power Transmission Lines

In Parana State:
- 6.8% GDP
- Largest Grain Production (55% Wheat, 25% Beans)
- Hidropower Generation
  35% Brazil 95% Paraguay

(Electric Energy in Brazil is 80% Hydro-generation)
Hydrometeorological System in Parana

S-Band Doppler Weather Radar

45 automatic weather stations

47 automatic hydrological stations

Satellite processing

Lightning Sensors: LPATS, IMPACT, LS7000, LS8000

Integration with 60 AWS

50 Hydrological Automatic Stations (INMET, EPAGRI, and others)
Methodology – Lightning Data (Jan2000-Dec2010)

Brazilian Lightning Detection Network Data in Parana:
- Cloud-to-Ground detection sensors
- Lightning flashes (group individual strokes)
- Peak Current Intensity (kA)
- Lightning Flash Polarity
- Time and Location of individual flashes within the storms

Sensor Location

Flash Density Distribution

Naccarato et al. (2009)
Methodology – Radar Data (Jan2000-Dec2010)

Doppler Weather Radar in Parana:
- S-Band
- 1.0deg beamwidth
- Volumetric data every 10-15minutes
- Reflectivity, Doppler Velocity, Spectral Width
- Quality controlled data
- Interpolation 2km x 2km x 0.5km
Methodology – Radar Data (Jan2000-Dec2010)

Doppler Weather Radar in Parana:
- Convective – Stratiform partitioning using VIL (Vertically Integrated Liquid)
- Ellipses fitting
- Lighting flashes identified in stratiform/convective regions
MCS Example – 04/Oct/2005

Cold Front displacement through the area:
- hail and strong precipitation in Parana,
- intense lightning activity,
- wind gust > 15m/s,
- 5 transmission towers collapsed.
MCS Example – 04/Oct/2005

GFS - Analysis
04/Oct/2005 – 12UTC

GFS - Analysis
05/Oct/2005 – 12UTC
MCS Synoptic Characteristics

GFS-Analysis Mean Fields

- Isolated Convection

- MCS (organized, size > 100km)
MCS Precipitation Regimes

Clustering Algorithm (KMEANS) applied to the radar data as FAD (Frequency with Altitude Diagrams):
**MCS Precipitation Regimes**

**Radar Cell Organization:**

**Isolated Convection:**
- Cluster 1 – 76%
- Cluster 2 – 19%

**MCS (>100km):**
- Cluster 2 – 32%
- Cluster 3 – 54%

**LLTS (>200km):**
- Cluster 2 – 27%
- Cluster 3 – 54%

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<thead>
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<th>Precipitation Regime</th>
<th>Relative Frequency of Occurrence (RFO)</th>
<th>Total Volume Coverage (TVC)</th>
<th>Average # Negative Flashes</th>
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MCS Precipitation Regimes

### Radar/FAD Diurnal Cycle

- **Normalized RFO**
  - Cluster 1
  - Cluster 2
  - Cluster 3
  - Cluster 4

### Lightning Diurnal Cycle

- **Normalized Avg. # Flashes**
  - Cluster 1
  - Cluster 2
  - Cluster 3
  - Cluster 4

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MCS Radar Characteristics

Diurnal and Annual Cycles

- **Isolated Convection**
- **MCS (organized, size > 100km)**

![Graphs showing frequency over time and month for isolated convection and MCS (organized, size > 100km).](image)
MCS Radar Characteristics

Mean Vertical Reflectivity Profile

- 30-35 dBZ in mixed phase layer (~0°C to -10°C)
- >40 dBZ above -10°C
MCS Radar Characteristics

FAD for Isolated Convection and Leading Line, Trailing Stratiform (CDEP) MCS events:

- Isolated Convection
- CDEP Neg
- CDEP Pos
MCS Lightning Characteristics

Diurnal and Annual Cycles for MCS

Lightning Flash Peak Current (kA) observed within the MCS clusters
MCS Lightning Characteristics

Lightning Flash Peak Current (kA) observed within the MCS clusters

Boxplot for lightning flashes identified in the convective and stratiform areas of the MCS.

C  convective region

S  stratiform region
TXS Radar (East) – S-Band, Doppler, 1.0deg beam width, since 1998.

Cascavel Radar (West) - S-Band Dual–Polarization, 1.0deg beam width, in operation mid-2013
Upgrade of Lightning Detection Sensors
(‘Total Lightning’ sensors)
Thank You!