SIMEPAR
Tecnologia e Informações ambientais

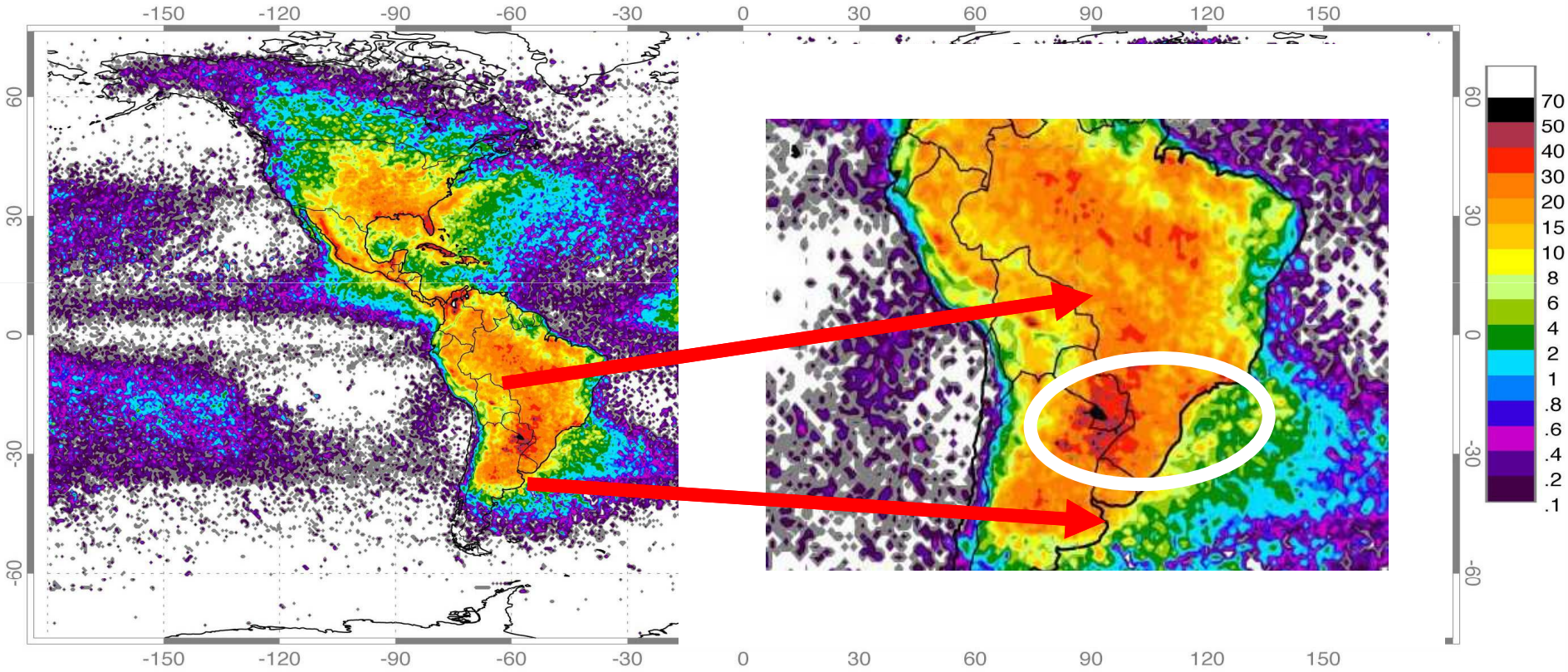
Weather Radar and Lightning Observations of Mesoscale Convective Systems in the South of Brazil

Cesar Beneti, Augusto Pereira Filho, Eloa Damian Lenardo Calvetti

WSN 12
Rio de Janeiro - Brasil

SIMEPAR
Tecnologia e Informações ambientais

Lightning Incidence in Southeastern South America



High Resolution Full Climatology Annual Flash Rate

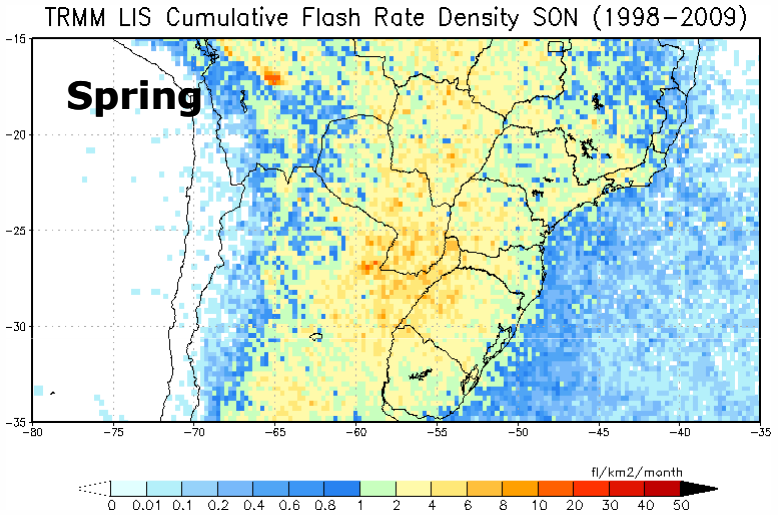
Global distribution of lightning April 1995-February 2003 from the combined observations of the NASA OTD (4/95-3/00) and LIS (1/98-2/03) instruments
(Adapted from Goodman & Cecil 2002)

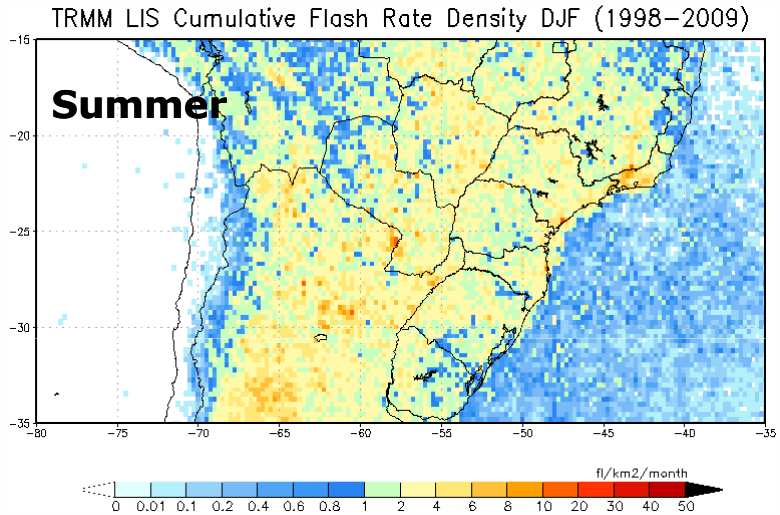
WSN 12
Rio de Janeiro - Brasil

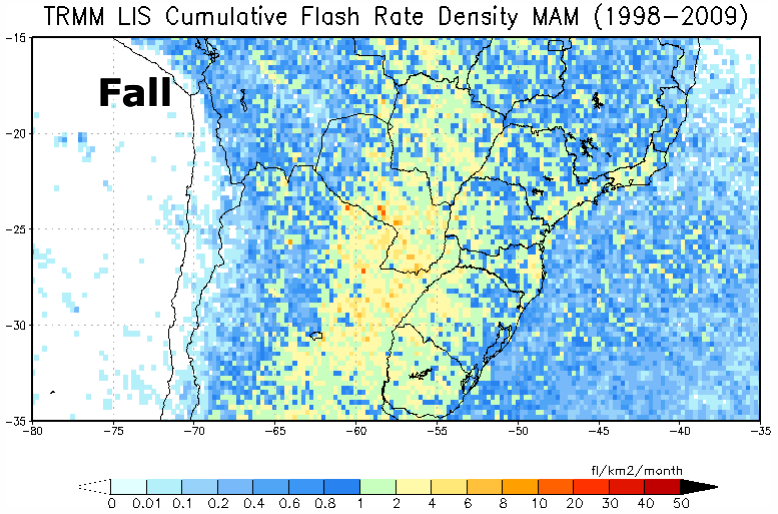
SIMEPAR
Tecnologia e Informações ambientais

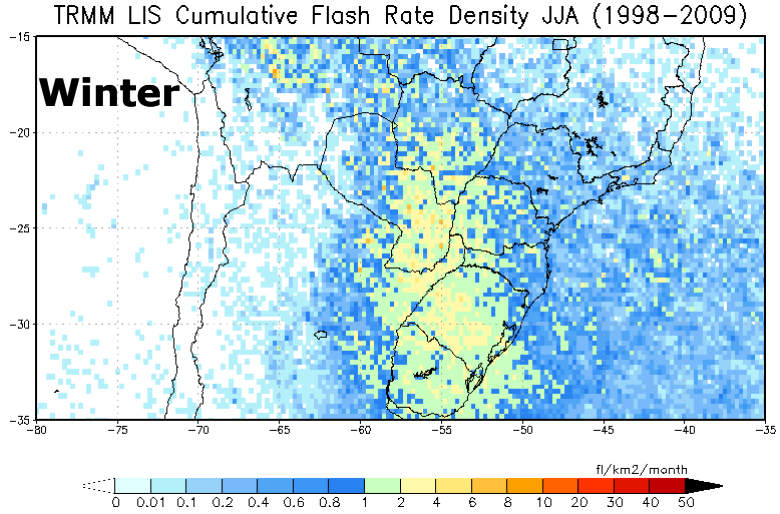
Lightning Incidence in Southeastern South America

Seazonal Variation







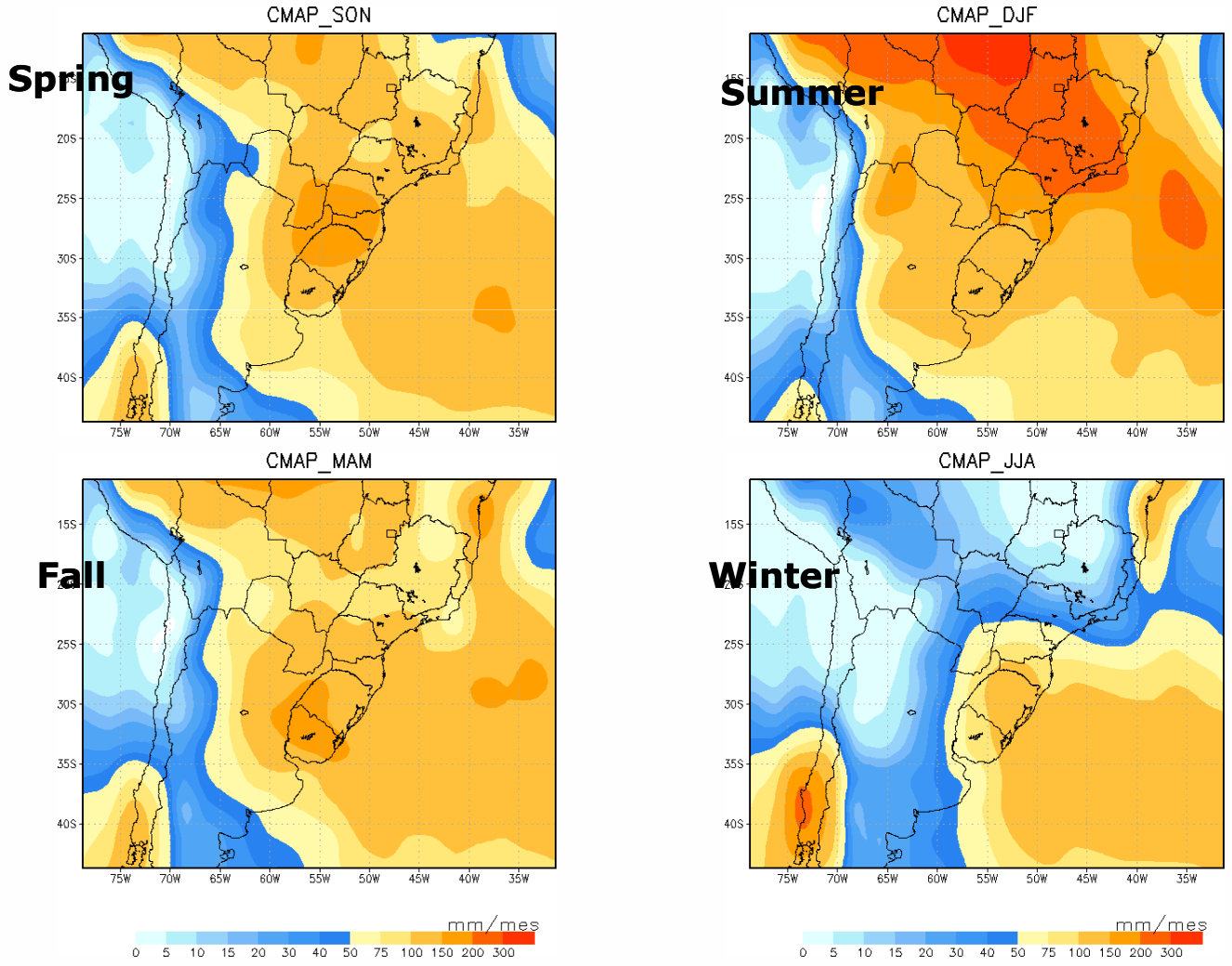


WSN 12
Rio de Janeiro - Brasil

SIMEPAR
Tecnologia e Informações ambientais

Precipitation Distribution in Southeastern South America

Seazonal Variation

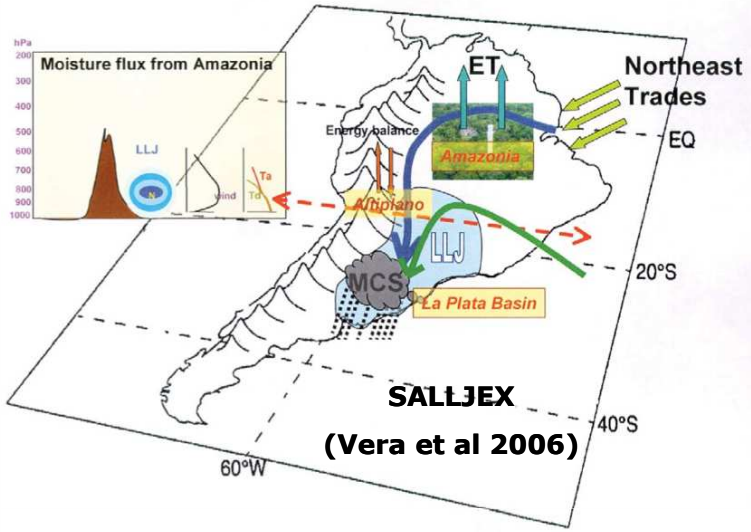


WSN 12
Rio de Janeiro - Brasil

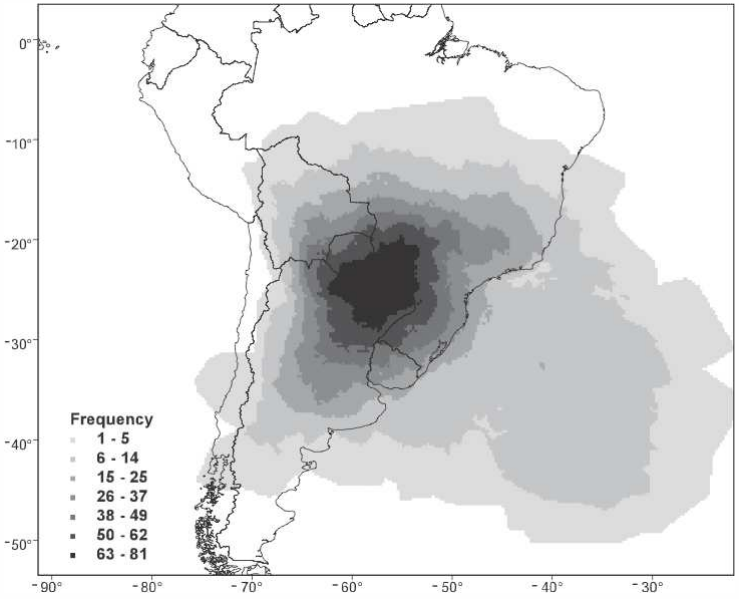
SIMEPAR
Tecnologia e Informações ambientais

Synoptic Influence for MCS Occurrence in Southeastern South America

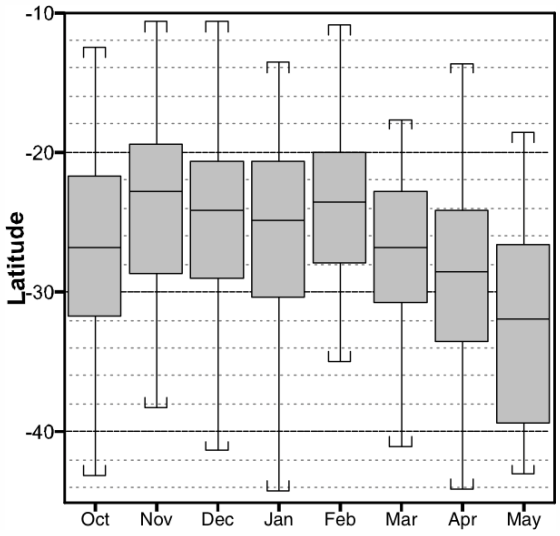
- ✓ South American Low Level Jet



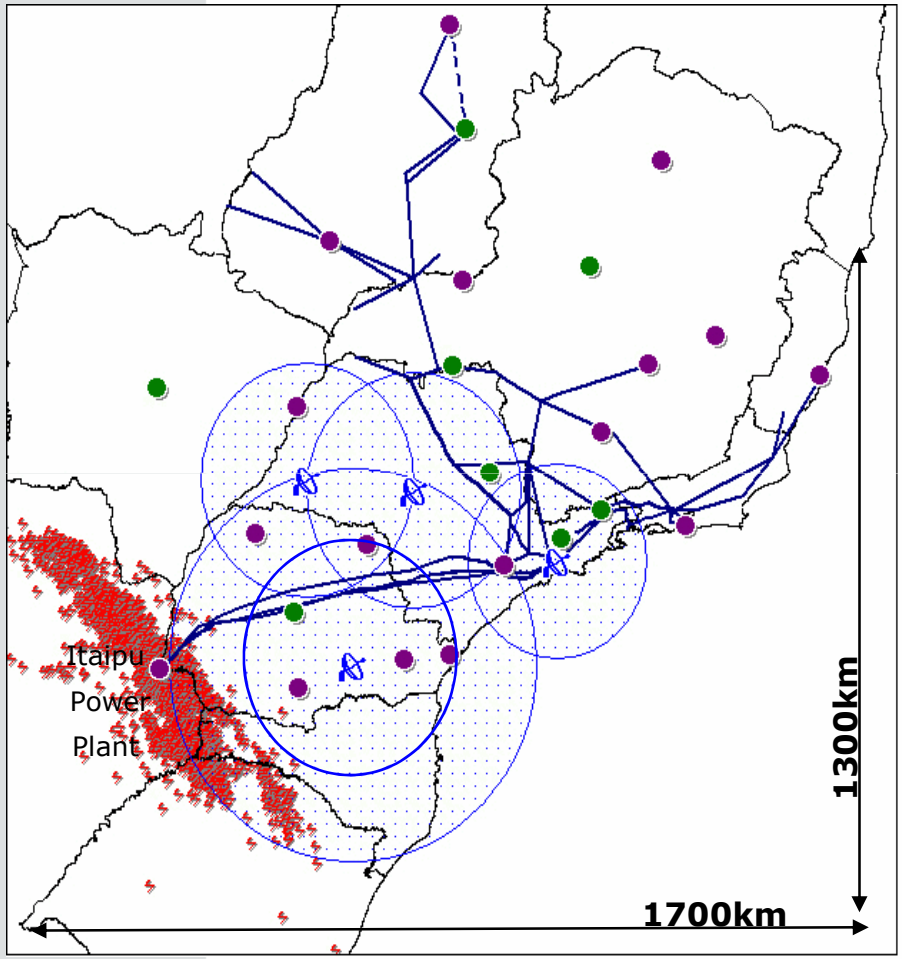
MCC frequency during warm season (1998-2007)



Durkee et al. (2009)



WSN 12
Rio de Janeiro - Brasil



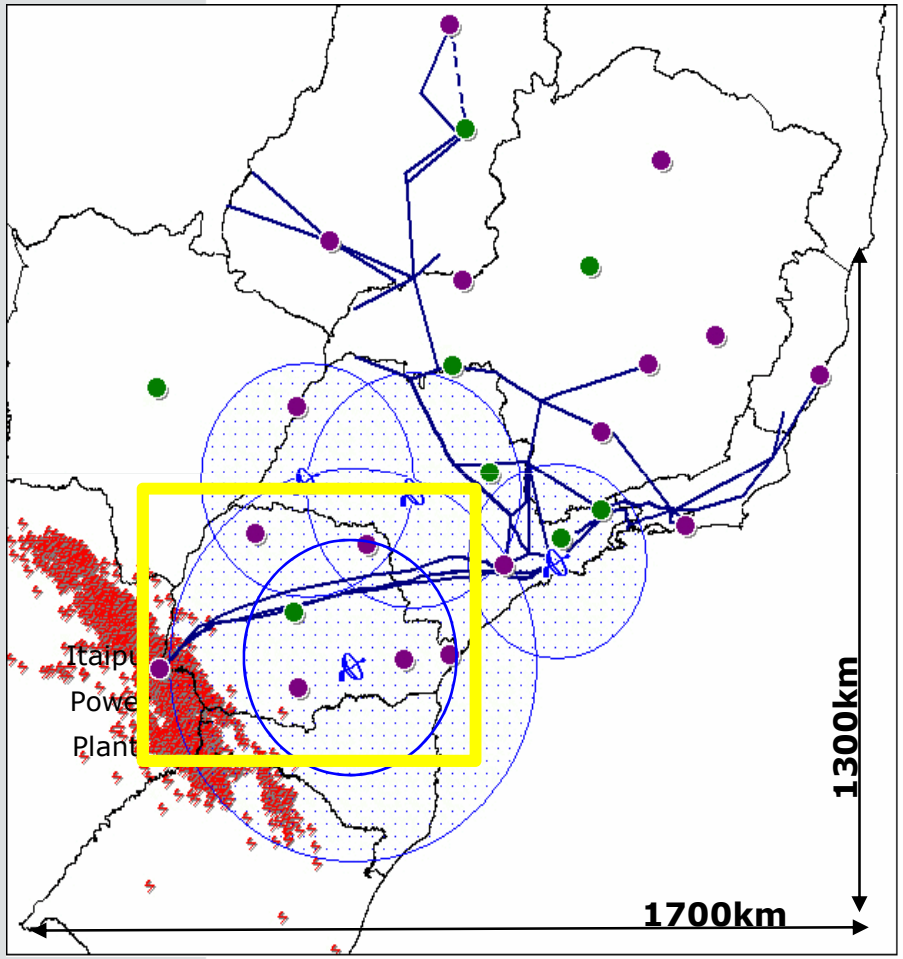
Southeastern Brazil

More than 70% of GDP
(Gross Domestic Product)

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

Power generation, Agriculture, Petrol refineries, Industries

Integrated National Power Transmission Lines

In Parana State:
- 6.8% GDP

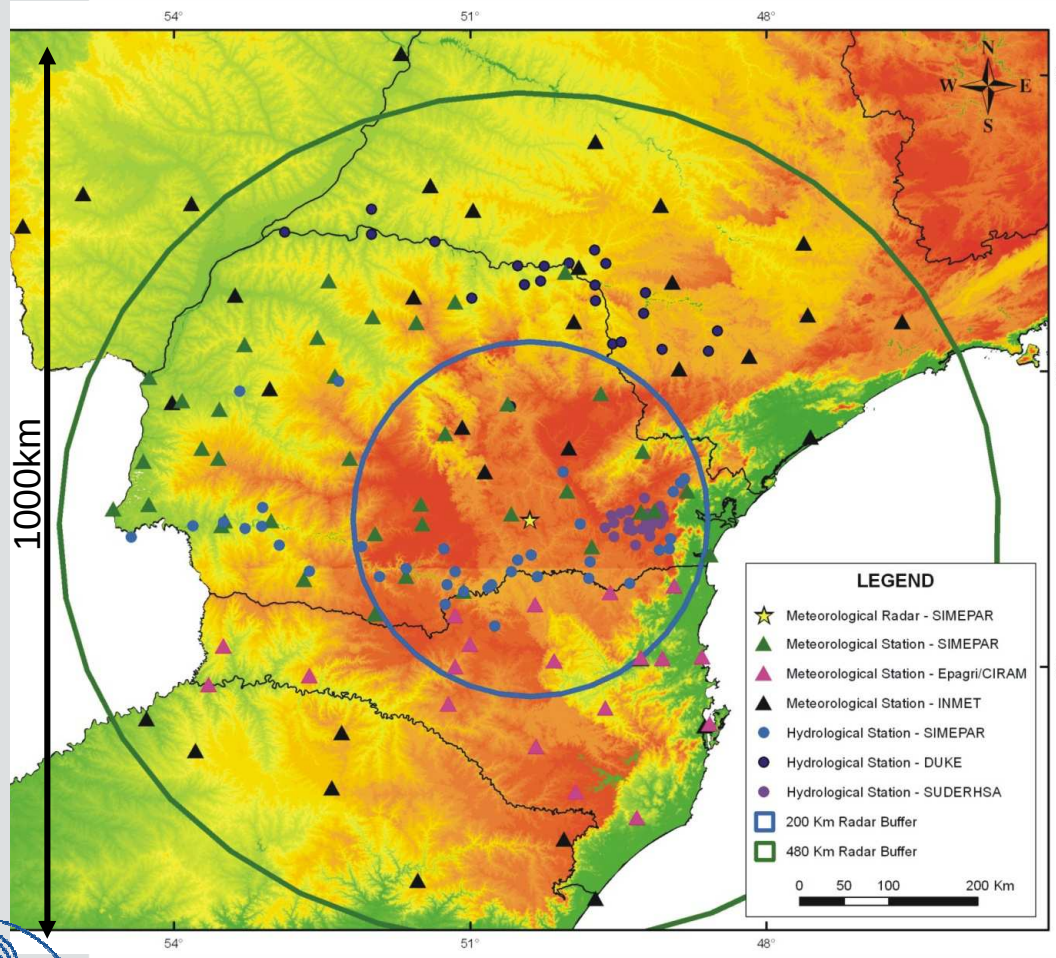
- Largest Grain Production
(55% Wheat, 25% Beans)

- Hidropower Generation
35% Brazil 95% Paraguay

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

SIMEPAR
Tecnologia e Informações ambientais

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)**

WSN 12
Rio de Janeiro - Brasil

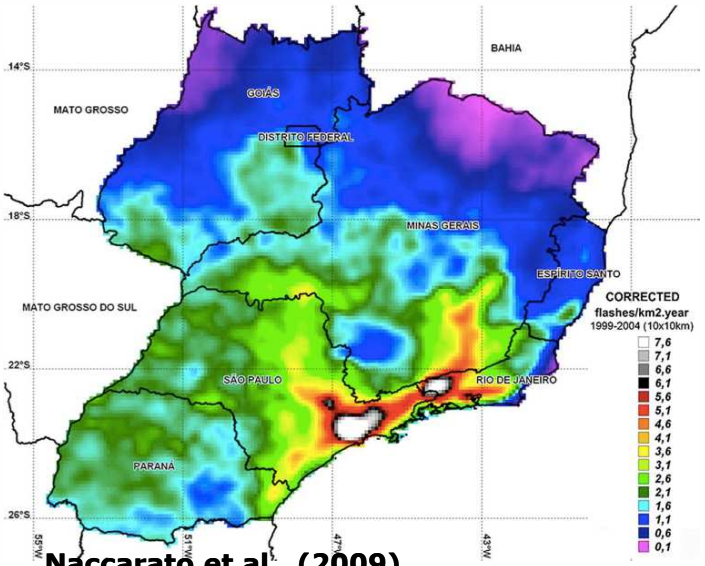
Methodology – Lightning Data (Jan2000-Dec2010)

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

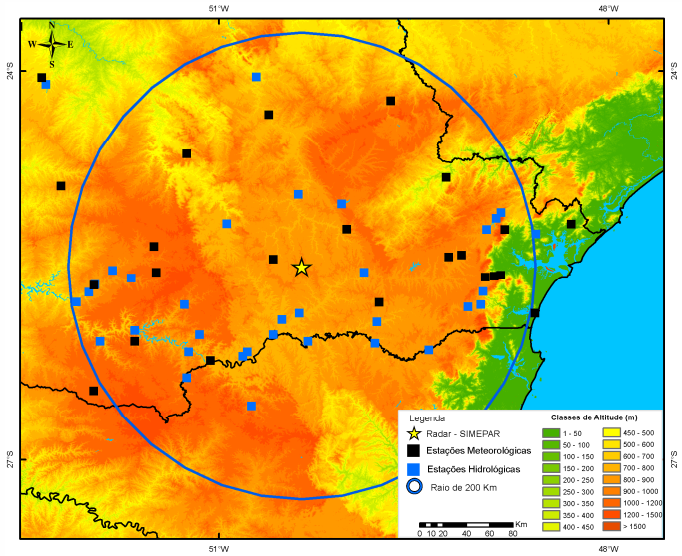


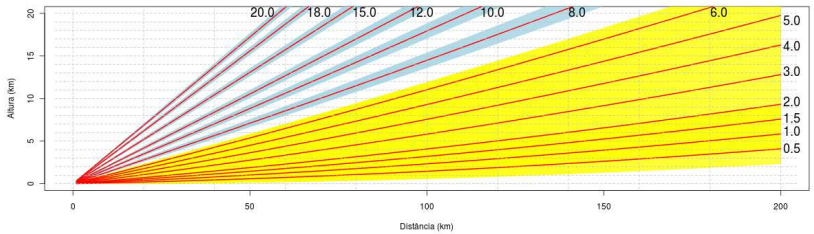
Naccarato et al. (2009)

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**



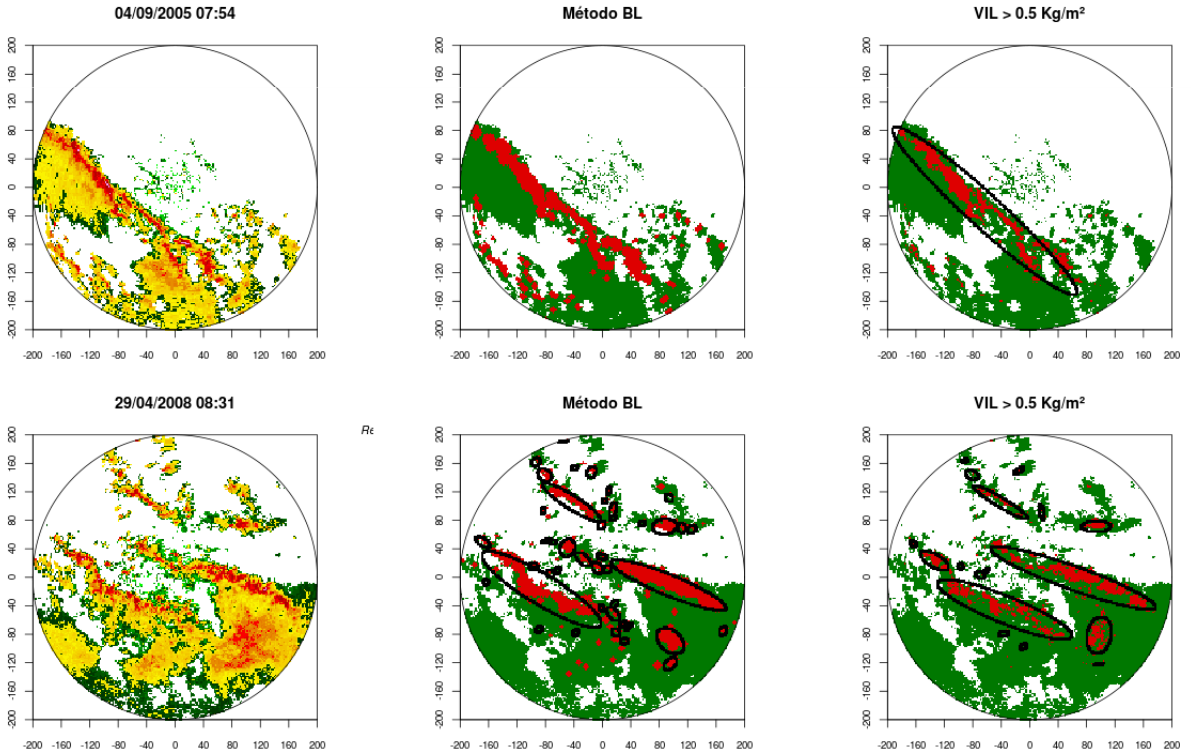


WSN 12
Rio de Janeiro - Brasil

Methodology – Radar Data (Jan2000-Dec2010)

Doppler Weather Radar in Parana:

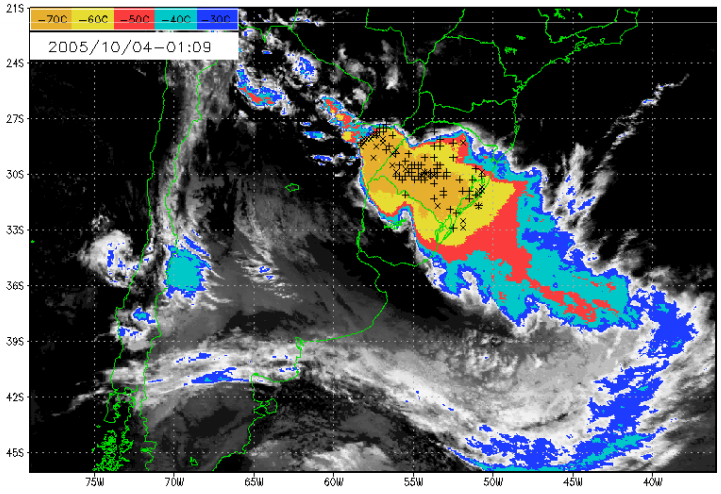
- **Convective – Stratiform partitioning using VIL (Vertically Integraded Liquid)**
- **Ellipsis fitting**
- **Lighting flashes identified in stratiform/convective regions**

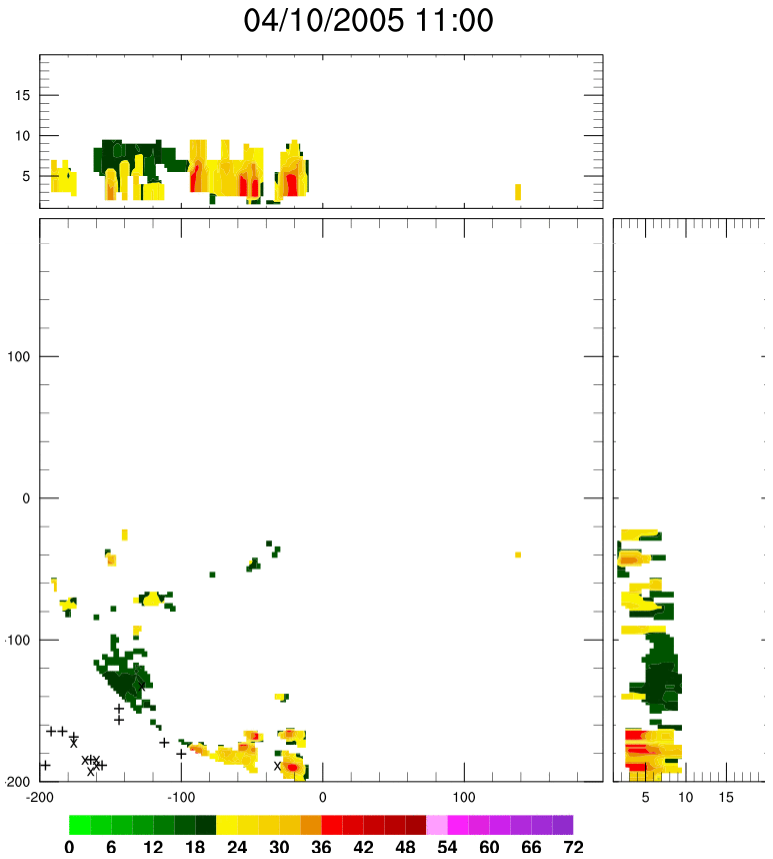


MCS Example – 04/Oct/2005

Cold Front displacement through the area:

- **hail and strong precipitation in Parana,**
- **intense lightning activity,**
- **wind gust > 15m/s,**
- **5 transmission towers collapsed.**

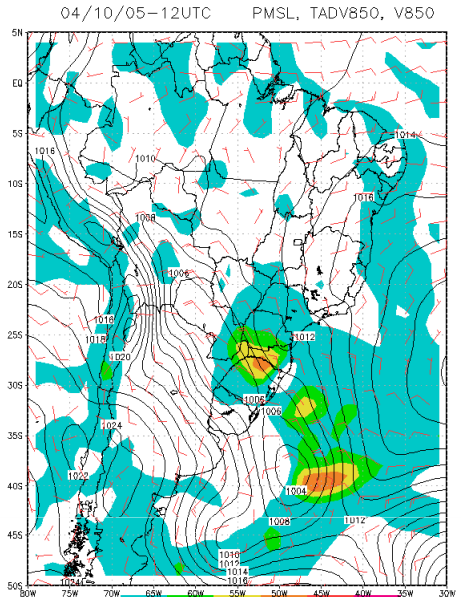


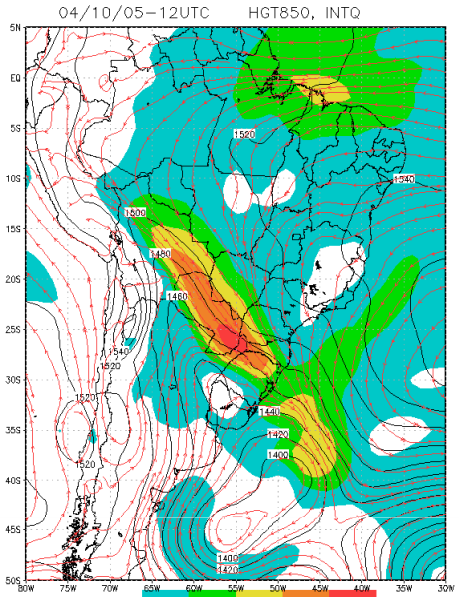


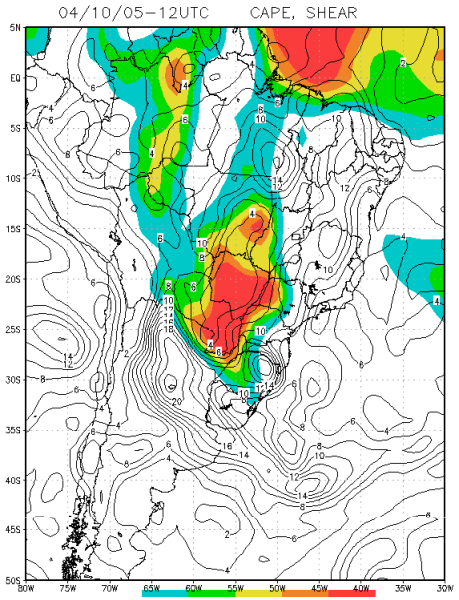
SIMEPAR
Tecnologia e Informações ambientais

MCS Example – 04/Oct/2005

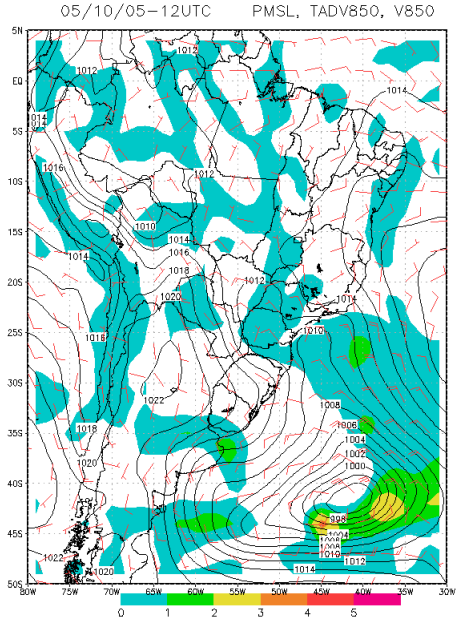
GFS - Analysis 04/Oct/2005 – 12UTC

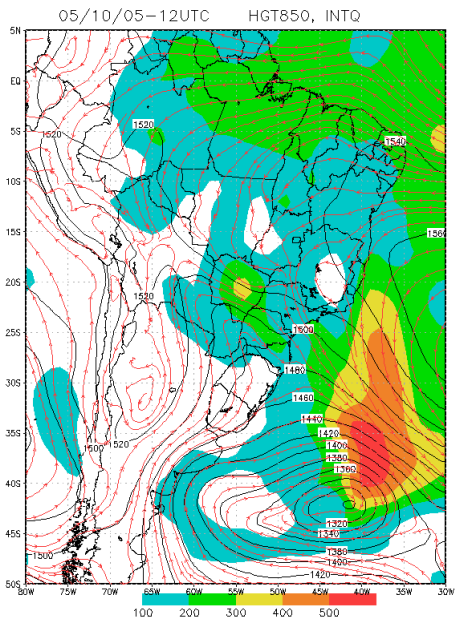


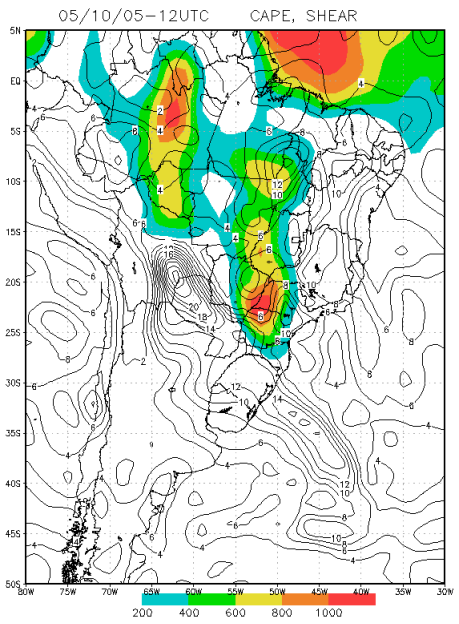




GFS – Analysis 05/Oct/2005 – 12UTC



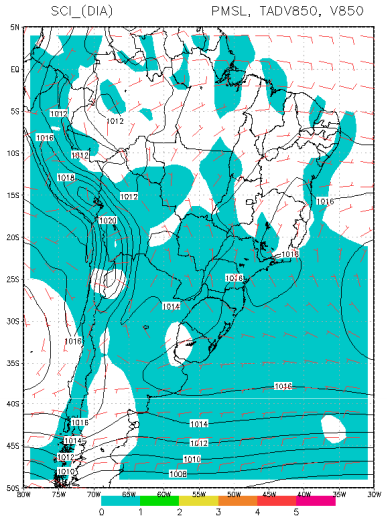


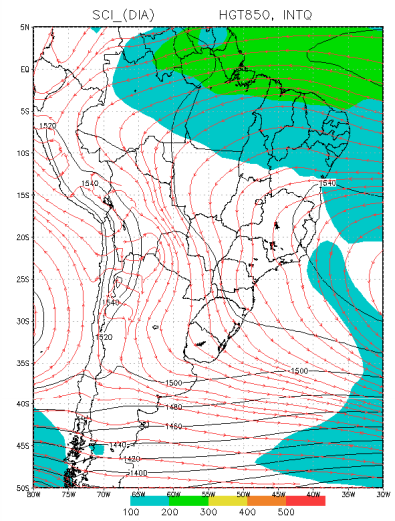


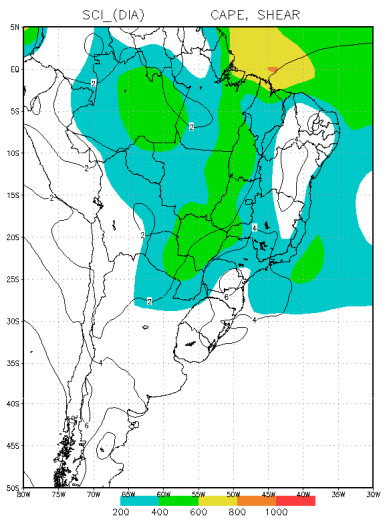
MCS Synoptic Characteristics

GFS-Analysis Mean Fields

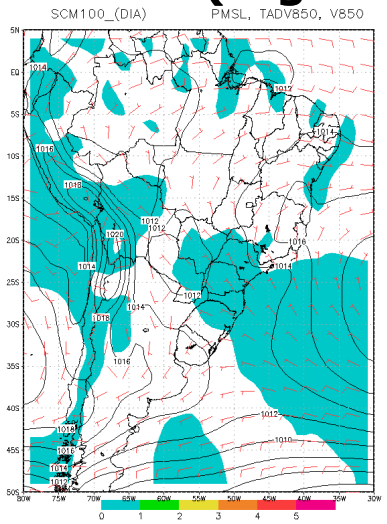
❑ Isolated Convection

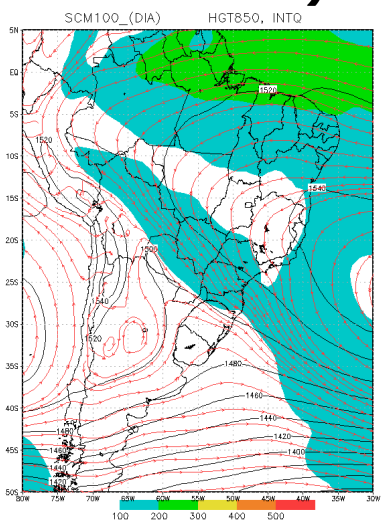


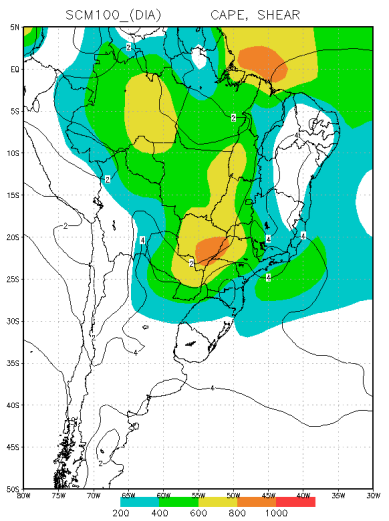




❑ MCS (organized, size>100km)

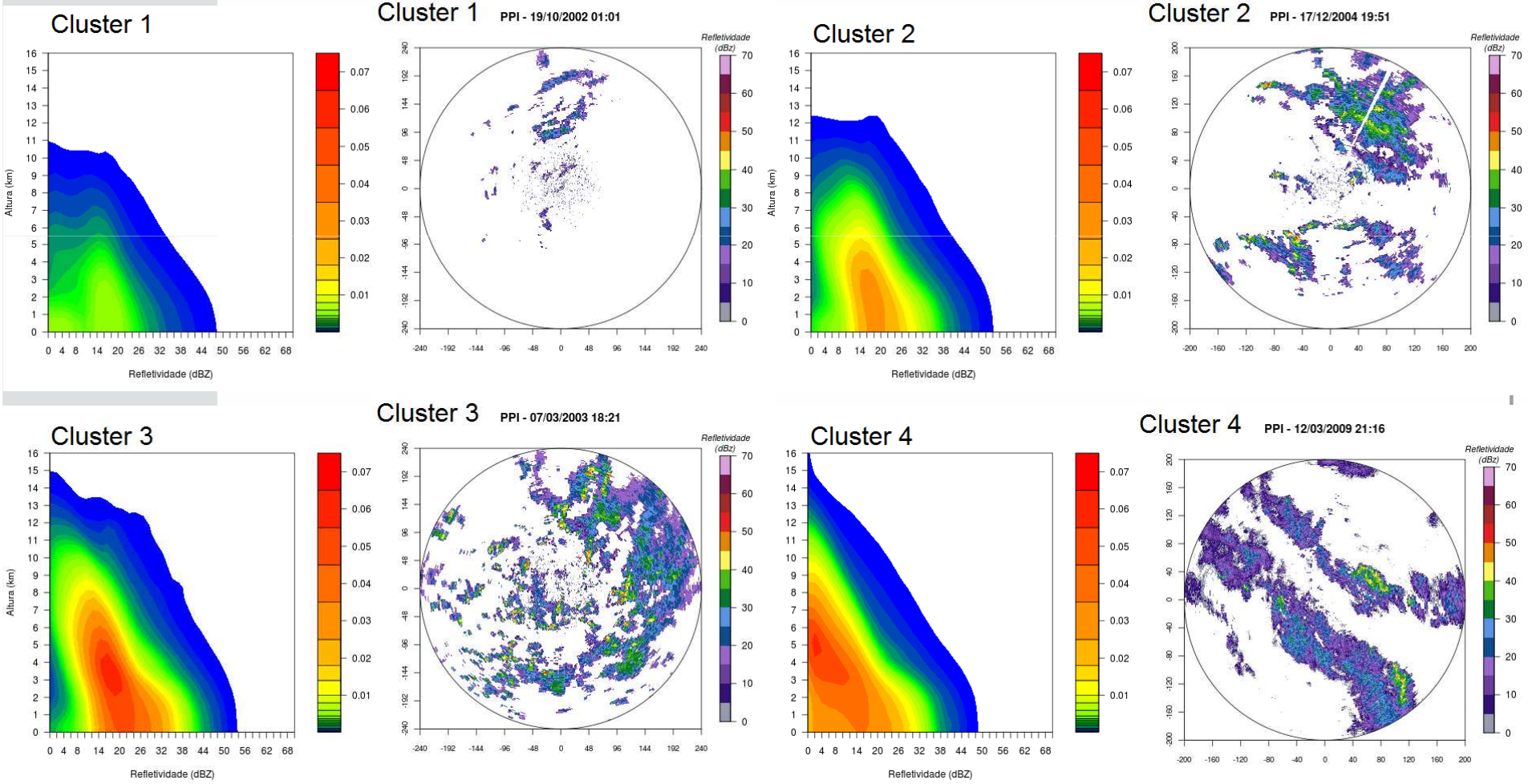




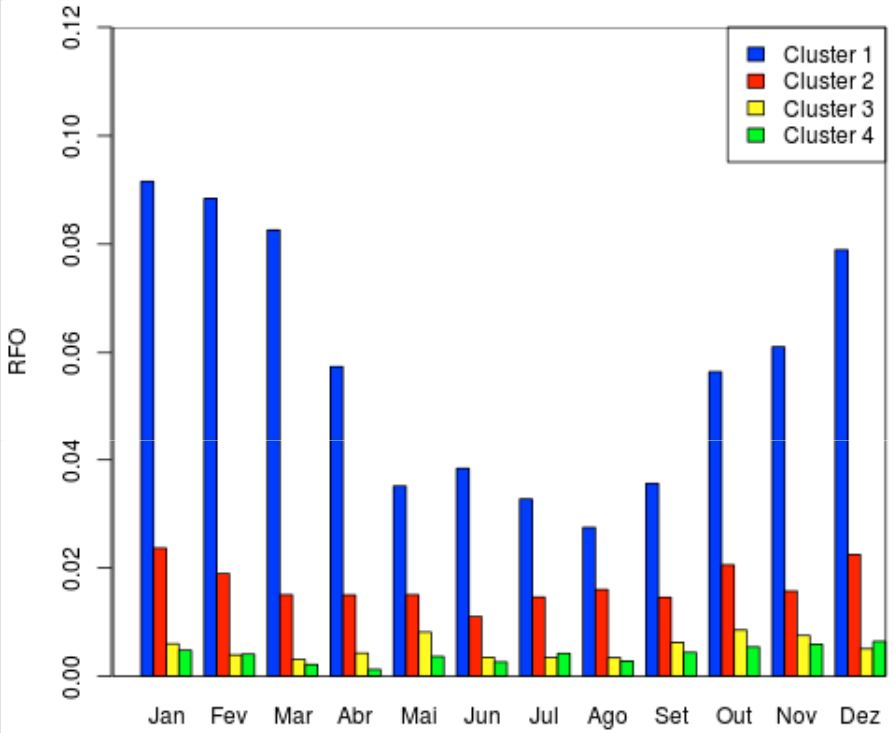


MCS Precipitation Regimes

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



MCS Precipitation Regimes



Radar Cell Organization:

Isolated Convection:
Cluster1 – 76%
Cluster2 – 19%

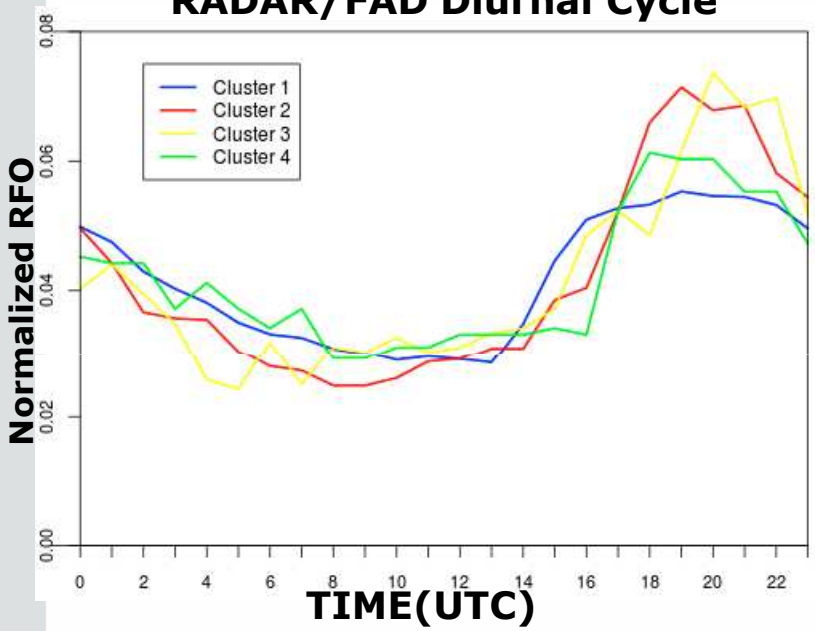
MCS (>100km):
Cluster2 – 32%
Cluster3 – 54%

LLTS (>200km):
Cluster2 – 27%
Cluster3 – 54%

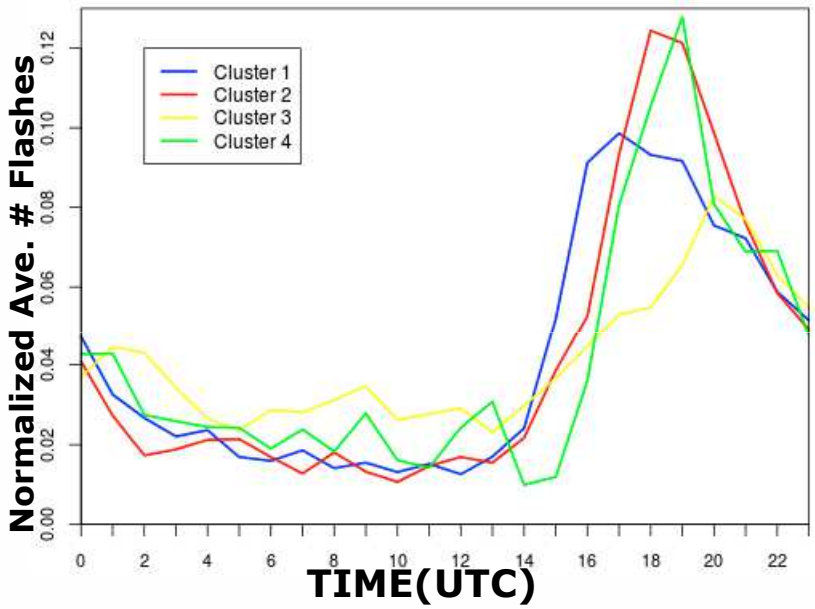
Precipitation Regime	Relative Frequency of Occurrence (RFO)	Total Volume Coverage (TVC)	Average # Negative Flashes	Average # Positive Flashes
Zeroth	27.3%	-	-	-
Cluster 1	49.8%	1%	5	3
Cluster 2	14.7%	8%	43	23
Cluster 3	4.7%	17%	145	34
Cluster 4	3.4%	17%	333	57

MCS Precipitation Regimes

RADAR/FAD Diurnal Cycle



LIGHTNING Diurnal Cycle

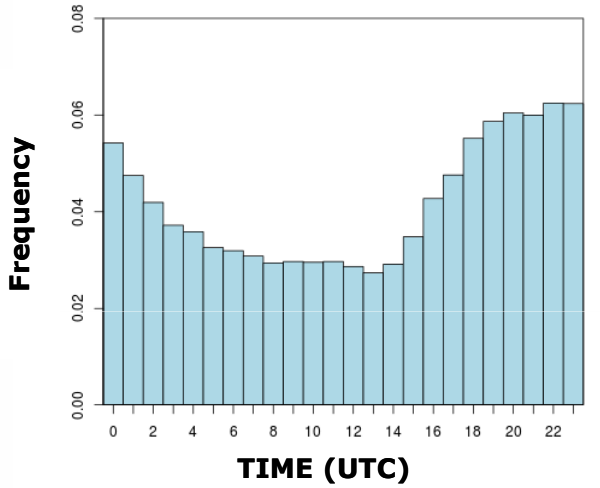


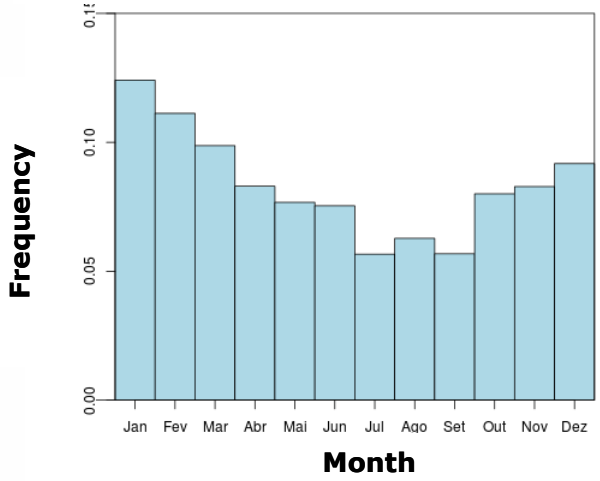
Precipitation Regime	Relative Frequency of Occurrence (RFO)	Total Volume Coverage (TVC)	Average # Negative Flashes	Average # Positive Flashes
Zeroth	27.3%	-	-	-
Cluster 1	49.8%	1%	5	3
Cluster 2	14.7%	8%	43	23
Cluster 3	4.7%	17%	145	34
Cluster 4	3.4%	17%	333	57

MCS Radar Characteristics

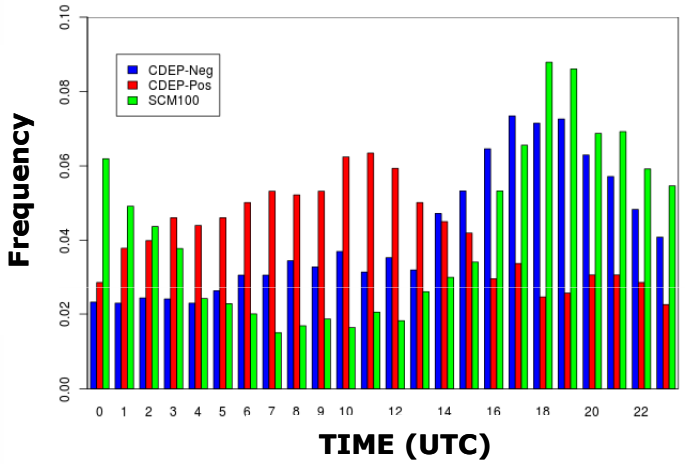
Diurnal and Annual Cycles

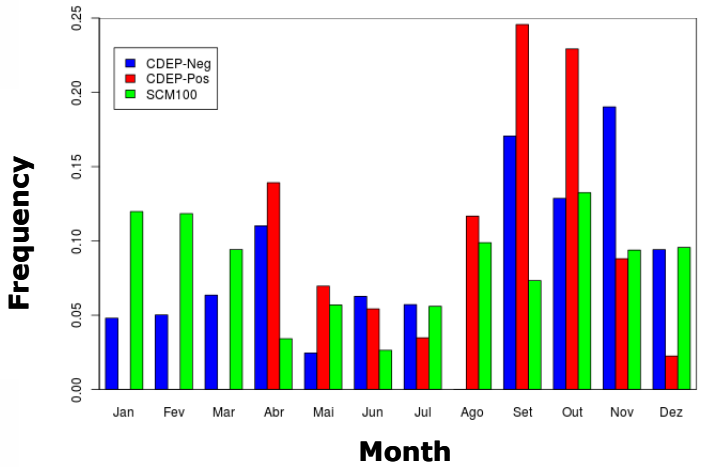
❑ **Isolated Convection**





❑ **MCS (organized, size>100km)**



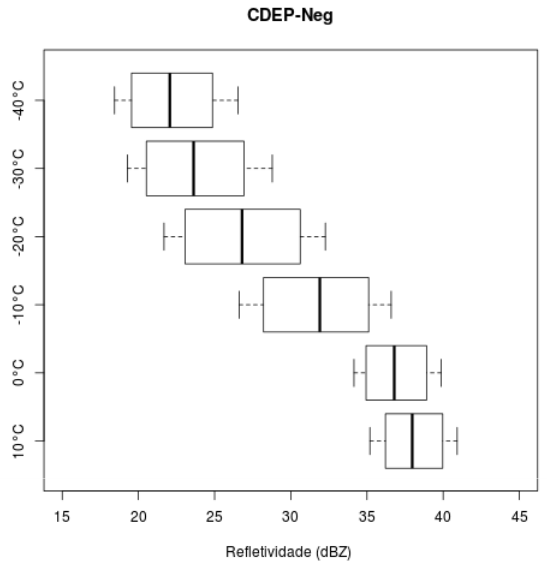


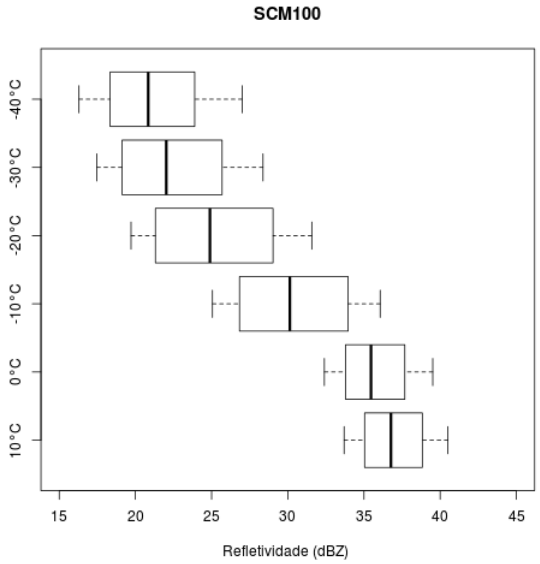
WSN 12
Rio de Janeiro - Brasil

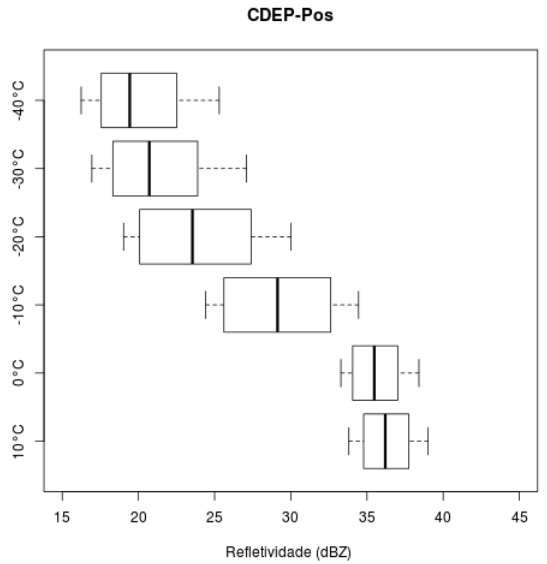
MCS Radar Characteristics

Mean Vertical Reflectivity Profile

- ✓ 30-35dBZ in mixed phase layer (~0C to -10C)
- ✗ >40dBZ above -10C



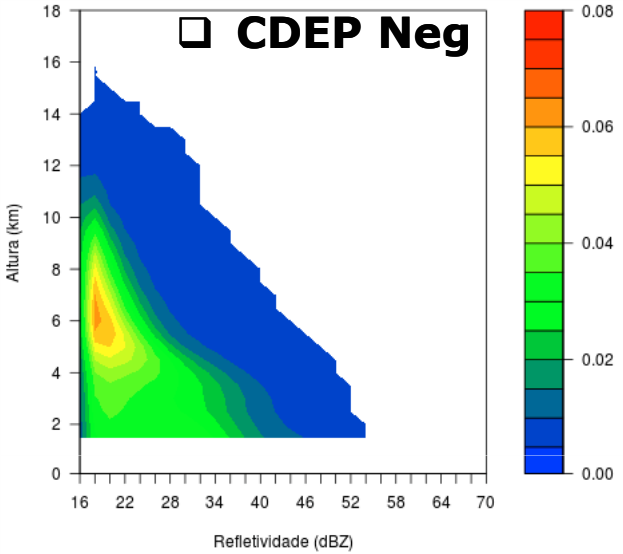




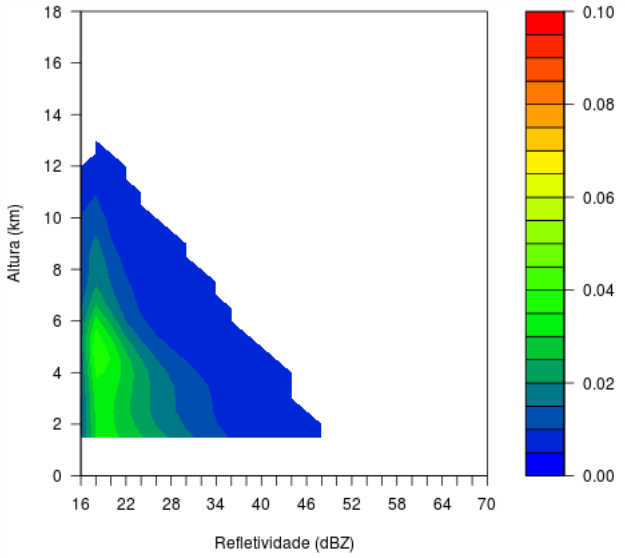
MCS Radar Characteristics

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

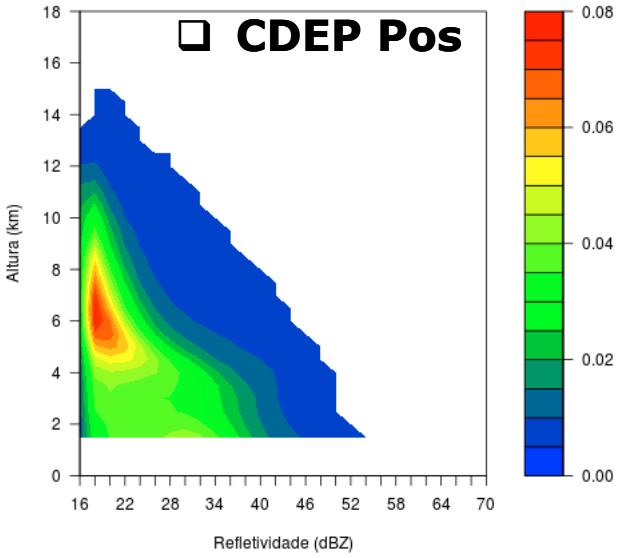
❑ **CDEP Neg**



❑ **Isolated Convection**

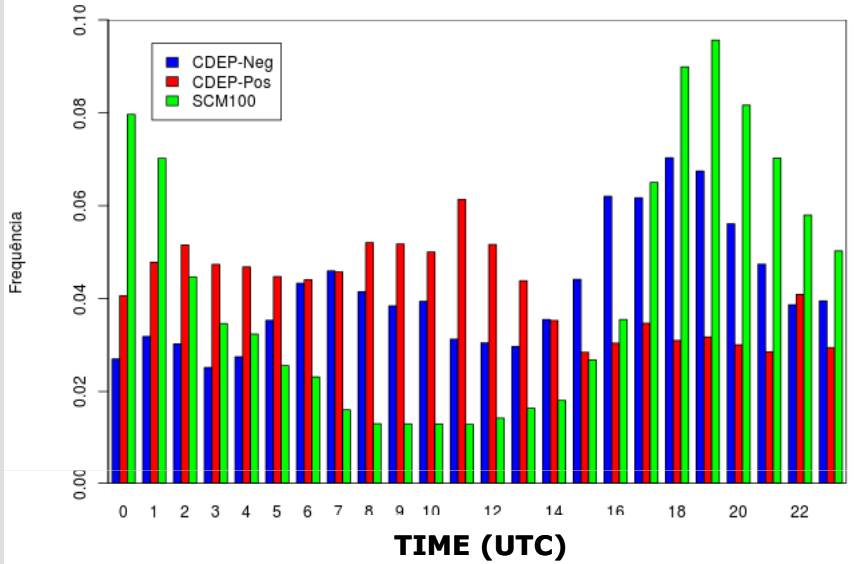


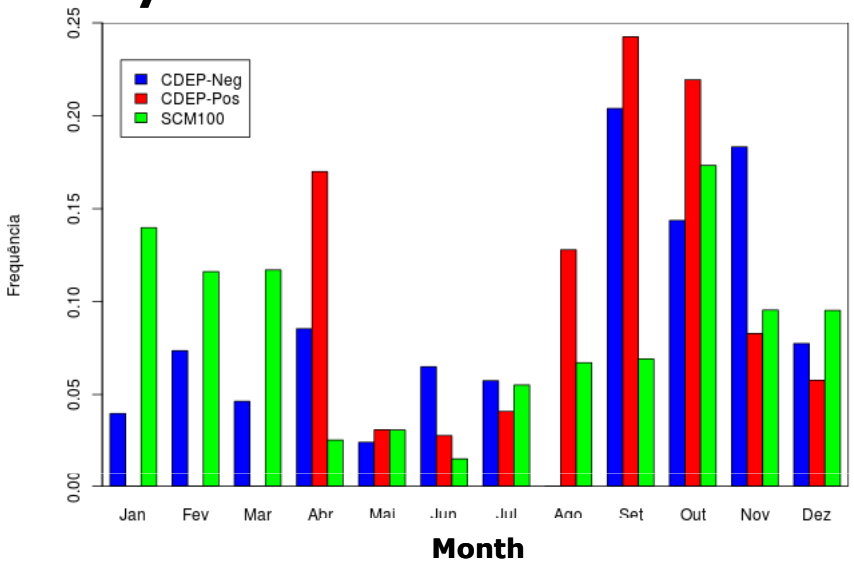
❑ **CDEP Pos**

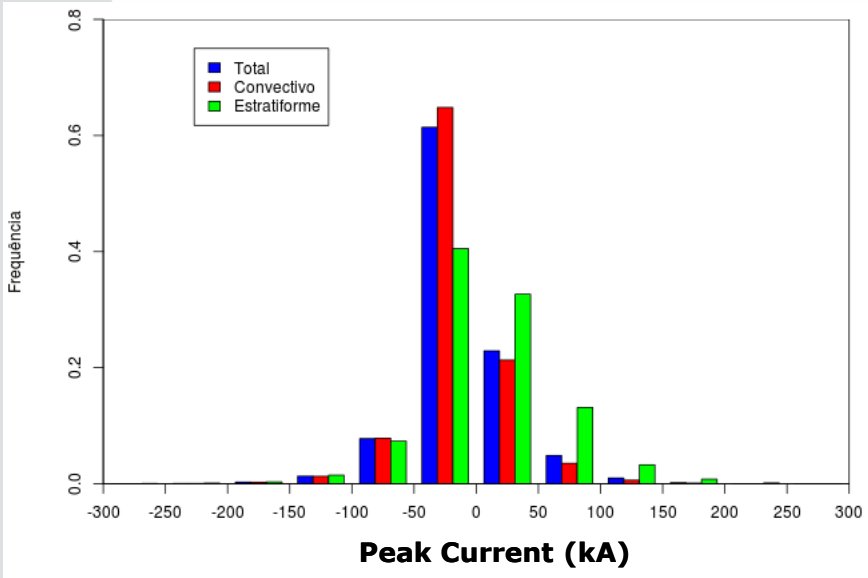


MCS Lightning Characteristics

Diurnal and Annual Cycles for MCS



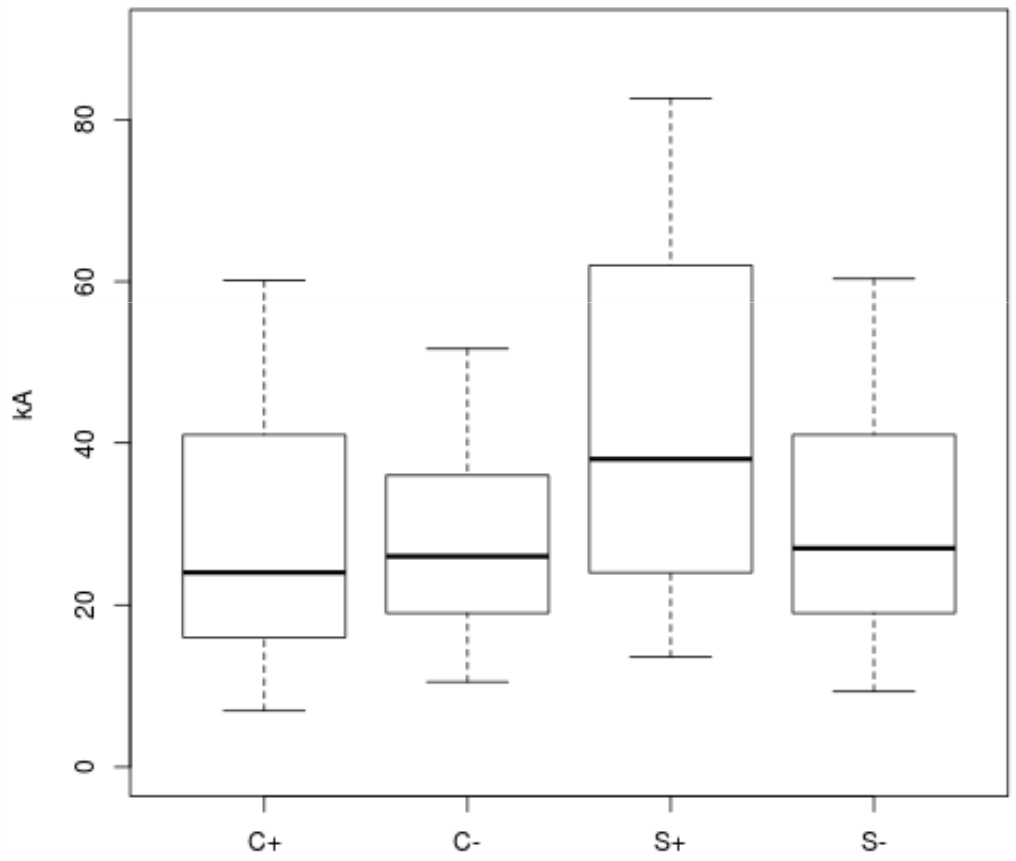




Lightning Flash Peak Current (kA) observed within the MCS clusters

MCS Lightning Characteristics

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

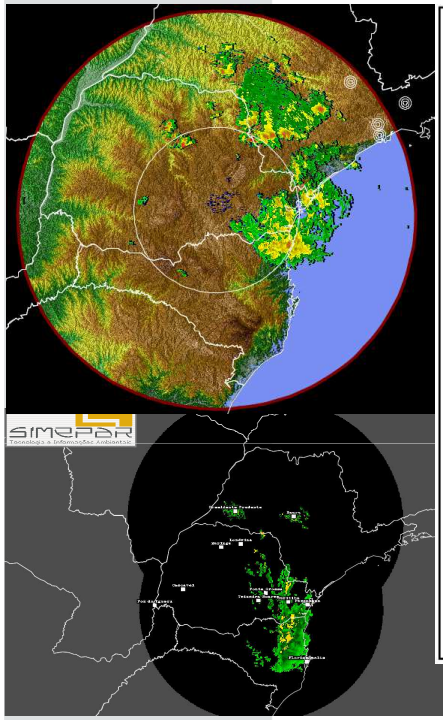


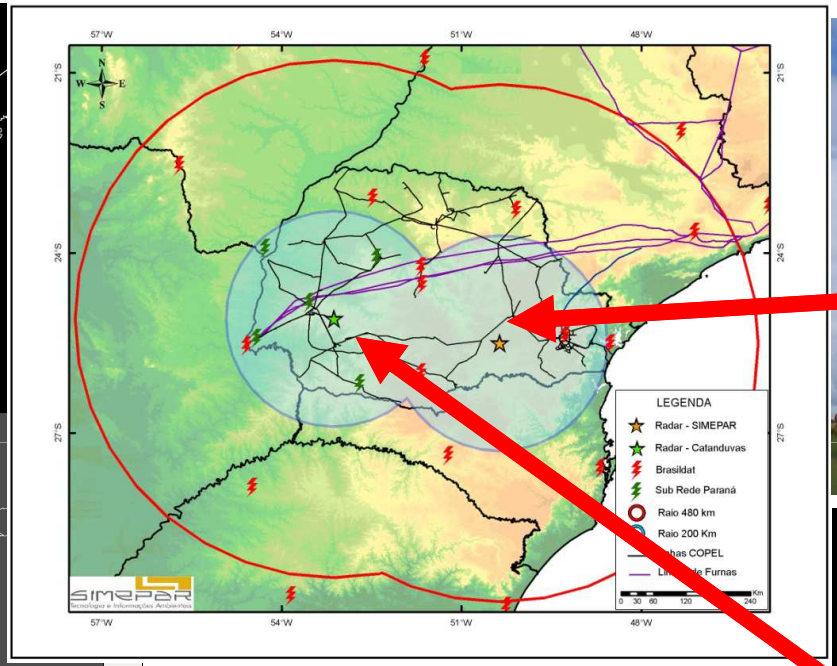
Boxplot for lightning flashes identified in the convective and stratiform areas of the MCS.

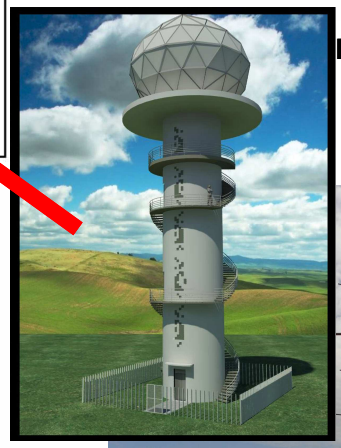
C convective region

S stratiform region

PARANA WEATHER RADAR NETWORK EXPANSION







RADAR CASCAVEL (WEST)
S-Band Dual-Pol
2013 -

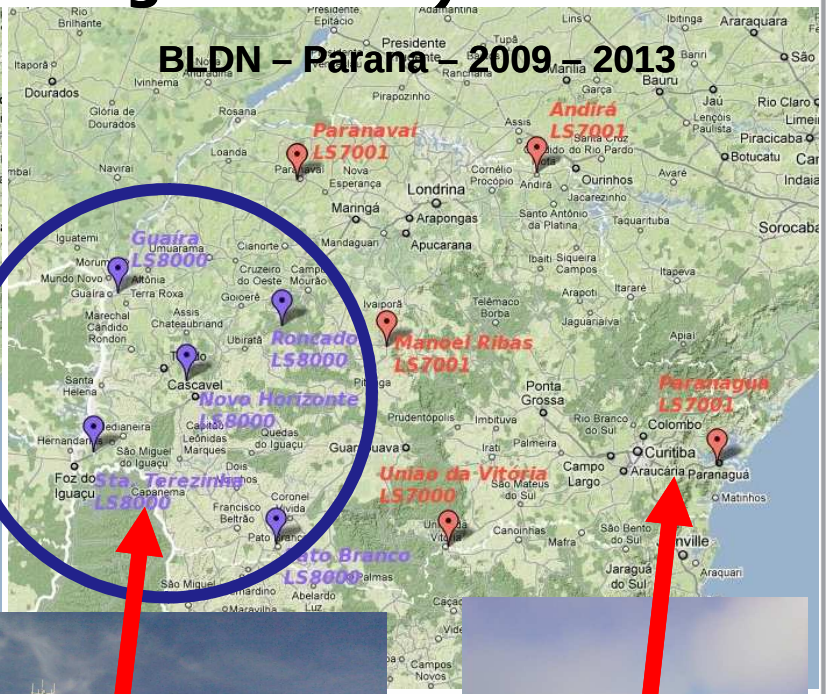
TXS Radar (East) – S-Band, Doppler, 1.0deg beam width, since 1998.

Cascavel Radar (West) - S-Band Dual–Polarization, 1.0deg beam width, in operation mid-2013

WSN 12
Rio de Janeiro - Brasil

BRAZILIAN LIGHTNING DETECTION NETWORK / Parana Upgrade

Upgrade of Lightning Detection Sensors ('Total Lightning' sensors)



WSN 12
Rio de Janeiro - Brasil

SIMEPAR
Tecnologia e Informações ambientais

Thank You!

WSN 12
Rio de Janeiro - Brasil