Monthly variations of cloud-to-ground lightning in Brazil based on high-resolution lightning imaging sensor data

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TRMM Satellite

- Launched in Nov 1997
  Still operational
- 35° inclination, 350 km altitude
  Detects until ~38° latitude
- 49 days required to sample the entire diurnal cycle
- Sensors of Interest:
  Lightning Imaging Sensor (LIS)
  Precipitation Radar (PR)
  Microwave Imager (TMI)

- Data for this study:
  Jan 1998 - Dec 2010 (13 years)

- More information:
  - http://thunder.nsstc.nasa.gov/lis/
Motivation

- Oceanic systems have more rainfall per lightning flash ($R_{YF} = 1.96 \times 10^9 \text{ kg.fl}^{-1}$), while continental (land) systems presented relatively more lighting flash for the same amount of rainfall ($R_{YF} = 3.94 \times 10^8 \text{ kg.fl}^{-1}$) 

*Takayabu, GRL, 2006*
Methodology

- **CG Lightning Flash Rate Density (FRD)**
  - \([\text{FRD}] = \text{fl} \cdot \text{km}^{-2} \cdot \text{yr}^{-1}\);

- **Rainfall Rate (RR)**
  - \([\text{RR}] = \text{mm} \cdot \text{yr}^{-1}\)

- **Rain Yield Per Flash (RYF)**
  - \(\text{RYF} = \frac{\text{RR}}{\text{FRD}} \times 10^6\)
  - \([\text{RYF}] = \left(\frac{\text{mm}}{\text{yr}}\right) \times \left(\frac{\text{km}^2 \cdot \text{yr}}{\text{fl}}\right) = \ldots = 10^6 \times \text{kg} \cdot \text{fl}^{-1}\)

  - **large RYF --> more rain per flash**
  - **small RYF --> less rain per flash**
Methodology

• Individual LIS orbits were tracked in 0.1° grid to compute the total view time of the sensor and the total number of flashes detected.

• LIS flashes were corrected by the instrument detection efficiency $Boccippio \ et \ al., \ 2002$

• The number of CG flashes was estimated assuming the average IC/CG ratio of 1.5 (60% IC and 40% CG) for Brazil $Pinto \ et \ al. \ 2003$
Basic Meteorological Systems

- Sea breeze, coastal squall lines, easterly waves;
- Amazonian convection (local, squall lines, MCS, SACZ, ITCZ);
- MCS, local convection;
- MCS originated in Argentina;
- Sea breeze, SACZ, local topography
Results

LIS estimated cloud-to-ground lightning flash rate density

TRMM 4B43 mean annual rainfall
Results

• RYF > 4 up to 100
  High RR, Low FRD

• RYF < 5
  High RR, Moderate FRD

• RYF < 0.7
  Low RR, High FRD

• RYF < 2
  Low RR, High FRD

• RYF > 1 up to 15
  Moderate RR & FRD
Results

North Brazil

Dry-to-wet

Monsoon

Northeast Brazil

Midwest branch

Midwest Brazil

MCS

South Brazil

MCS

MCS

Cold Fronts

Southeast Brazil

Local Convection

SACZ

SACZ

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Conclusions

• It was found that precipitation and lightning activity at five political macro-regions of Brazil (North, Northeast, Midwest, Southeast and South) were well correlated to the known meteorological systems of each region.

• The RYF variations were able to capture the physical nature (convective regime) of these systems, such as deeper convection (like MCS) or more stratiform precipitation (like the SACZ).