# The CHUVA project: The contribution to GPM

Presenter: Daniel Vila

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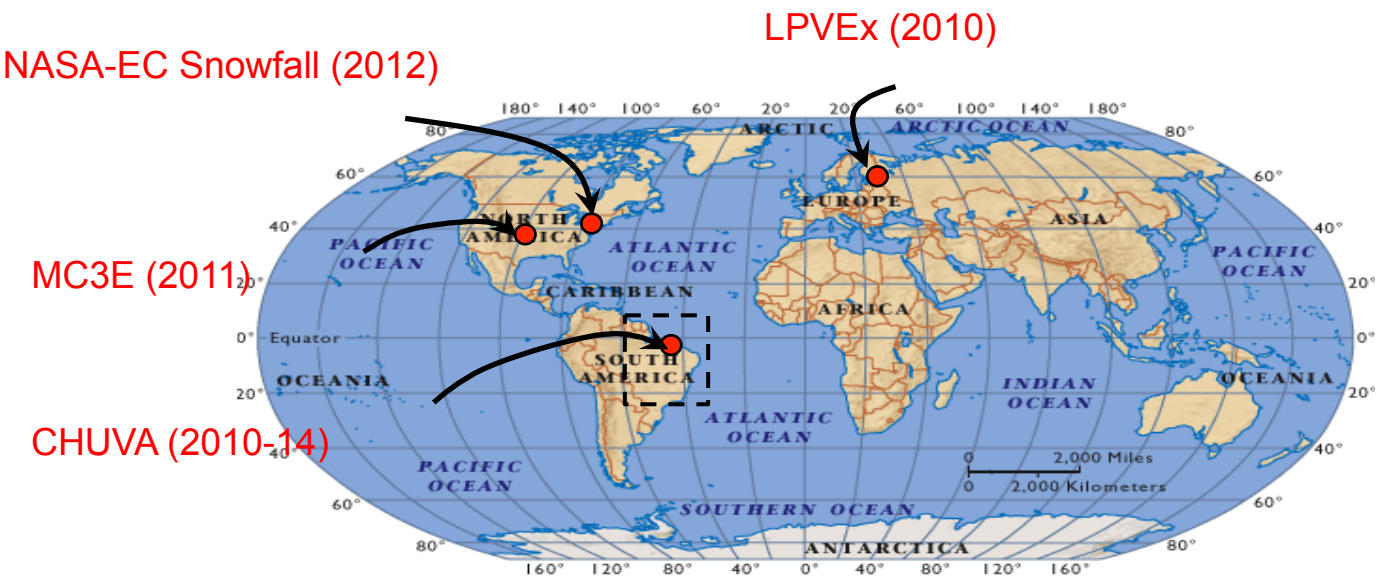
2015 PMM Science Team Meeting
Embassy Suites, Baltimore, MD
13 – 17 July 2015

# INTERNATIONAL COLLABORATIONS ON GPM GV

- *Joint field campaigns*
- *National networks and other ground assets (radar, gauges, etc.)*
- *Hydrological validation sites (streamflow gauges, etc.)*

*15 Active International Projects*



# ROLE OF GPM GROUND VALIDATION

*Pre-launch algorithm development & post-launch product evaluation*

- Refine algorithm assumptions & parameters - Characterize uncertainties in satellite retrievals & GV measurements

"Truth" is estimated through the convergence of satellite and ground-based estimates

## Three complementary approaches:

- *Direct statistical validation (surface):*

  - Leveraging off operational networks to identify and resolve first-order discrepancies between satellite and ground-based precipitation estimates

- *Physical process validation (vertical column):*

  - Cloud system and microphysical studies geared toward testing and refinement of physically-based retrieval algorithms

- *Integrated hydrologic validation/applications (4-dimensional):*

  - Identify space-time scales at which satellite precipitation data are useful to water budget studies and hydrological applications; characterization of model and observation errors

Selecione

Data: 2014-10 Setor: Norte Buscar

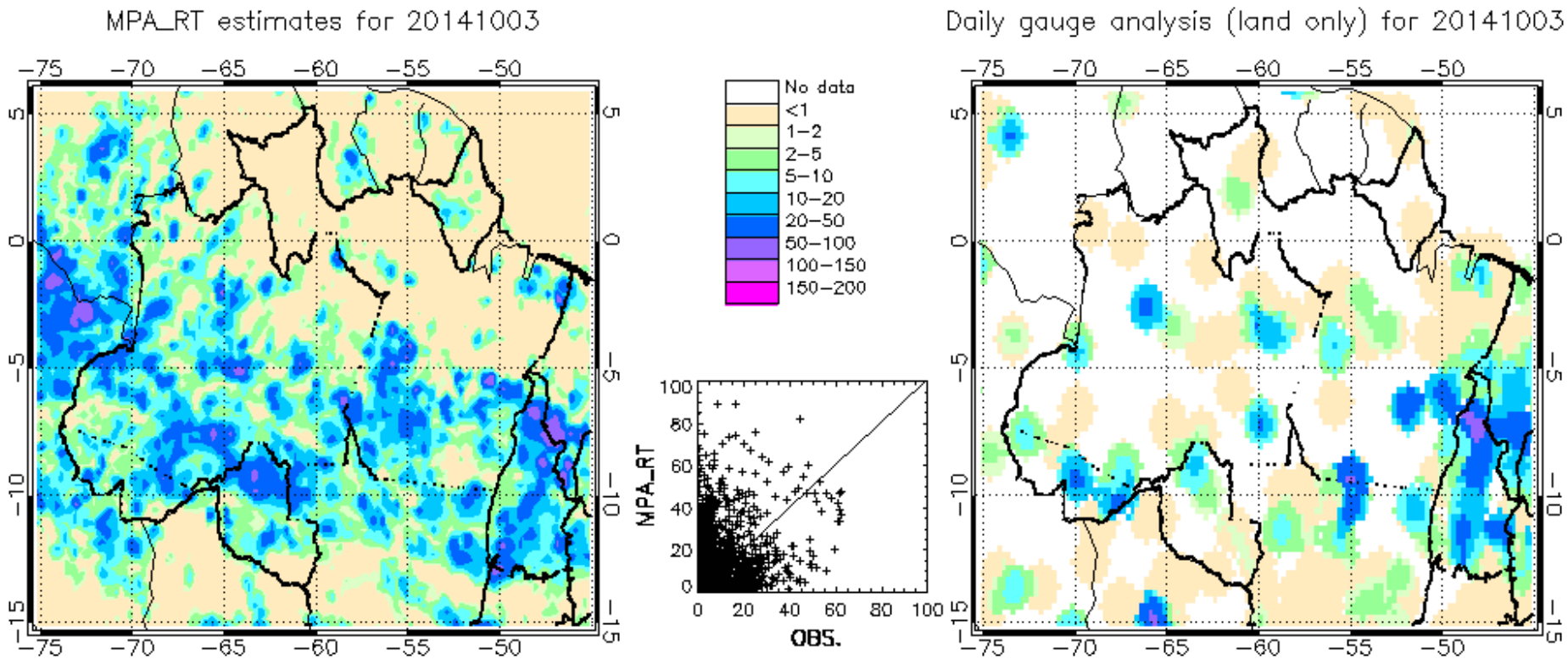
Validação - Norte

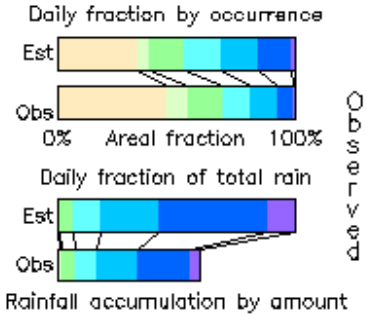
| Hidroestimador | 3B42RT | CMORPH | GSMAP | ETA |
|---|---|---|---|---|
| 2014-10-31 | 2014-10-30 | 2014-10-31 | | 2014-10-30 |
| 2014-10-30 | 2014-10-29 | 2014-10-30 | | 2014-10-29 |
| 2014-10-29 | 2014-10-28 | 2014-10-29 | | 2014-10-2[illegible] |
| 2014-10-28 | 2014-10-27 | 2014-10-28 | | 2014-10-26 |
| 2014-10-27 | 2014-10-26 | 2014-10-27 | | |
| 2014-10-26 | 2014-10-25 | 2014-10-26 | | |
| 2014-10-25 | 2014-10-24 | 2014-10-25 | | |
| 2014-10-24 | 2014-10-23 | 2014-10-21 | | |
| 2014-10-23 | 2014-10-22 | 2014-10-20 | | |
| 2014-10-22 | 2014-10-21 | 2014-10-19 | | |
| 2014-10-21 | 2014-10-20 | 2014-10-18 | | |
| 2014-10-20 | 2014-10-19 | 2014-10-17 | | |
| 2014-10-19 | 2014-10-18 | 2014-10-16 | | |
| 2014-10-18 | 2014-10-17 | 2014-10-15 | | |
| 2014-10-17 | 2014-10-16 | 2014-10-14 | | |
| 2014-10-16 | 2014-10-15 | 2014-10-13 | | |
| 2014-10-15 | 2014-10-14 | 2014-10-12 | | |
| 2014-10-14 | 2014-10-13 | 2014-10-11 | | |
| 2014-10-13 | 2014-10-12 | 2014-10-10 | | |
| 2014-10-12 | 2014-10-11 | 2014-10-09 | | |
| 2014-10-11 | 2014-10-10 | 2014-10-08 | | |
| 2014-10-10 | 2014-10-09 | 2014-10-07 | | |
| 2014-10-09 | 2014-10-08 | 2014-10-06 | | |
| 2014-10-08 | 2014-10-07 | 2014-10-05 | | |
| 2014-10-07 | 2014-10-06 | 2014-10-04 | | |
| 2014-10-06 | 2014-10-05 | 2014-10-03 | | |
| 2014-10-05 | 2014-10-04 | 2014-10-02 | | |
| 2014-10-04 | 2014-10-03 | 2014-10-01 | | |
| 2014-10-03 | 2014-10-02 | | | |
| 2014-10-02 | 2014-10-01 | | | |
| 2014-10-01 | | | | |

http://sigma.cptec.inpe.br/prec_sat/validacao.lista.logic?i=br

CGMG IPWG International Precipitation Working Group | National Oceanic and Atmospheric Admonistration | Cooperative Institute For Climate Studies | Instituto Nacional de Pesquisas Espaciais | Centro de Previsão de Tempo e Estudos Climáticos

# DAILY GROUND VALIDATION




| Observed | MPA_RT <1 | MPA_RT ≧1 |
|---|---|---|
| <1 | 592 | 623 |
| ≧1 | 289 | 1111 |

Verification statistics for 20141003 n=2615 Verif. grid=0.25° Units=mm/d

| | Observed | MPA_RT |
|---|---|---|
| # gridpoints raining | 1400 | 1734 |
| Average rain | 5.5 | 9.2 |
| Conditional rain | 10.3 | 13.9 |
| Rain volume (mm*km²x10⁶) | 10.3 | 17.1 |
| Maximum rain | 62.7 | 89.6 |

Mean abs error = 8.2
RMS error = 13.5
Correlation coeff = 0.342
Frequency bias = 1.239
Probability of detection = 0.794
False alarm ratio = 0.359
Hanssen & Kuipers score = 0.281
Equitable threat score= 0.167

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Volume 95 Number 9 September 2014

# BAMS

Bulletin of the American Meteorological Society

SMARTPHONE OBSERVING

MAKING NASA MORE RESILIENT

FLOODS FROM TROPICAL CYCLONES

## Storms over Brazil

### CHUVA and the Science of Tropical Clouds

# CHUVA PROJECT – THE GOAMAZON CAMPAIGN

## THE CHUVA PROJECT

### How Does Convection Vary across Brazil?

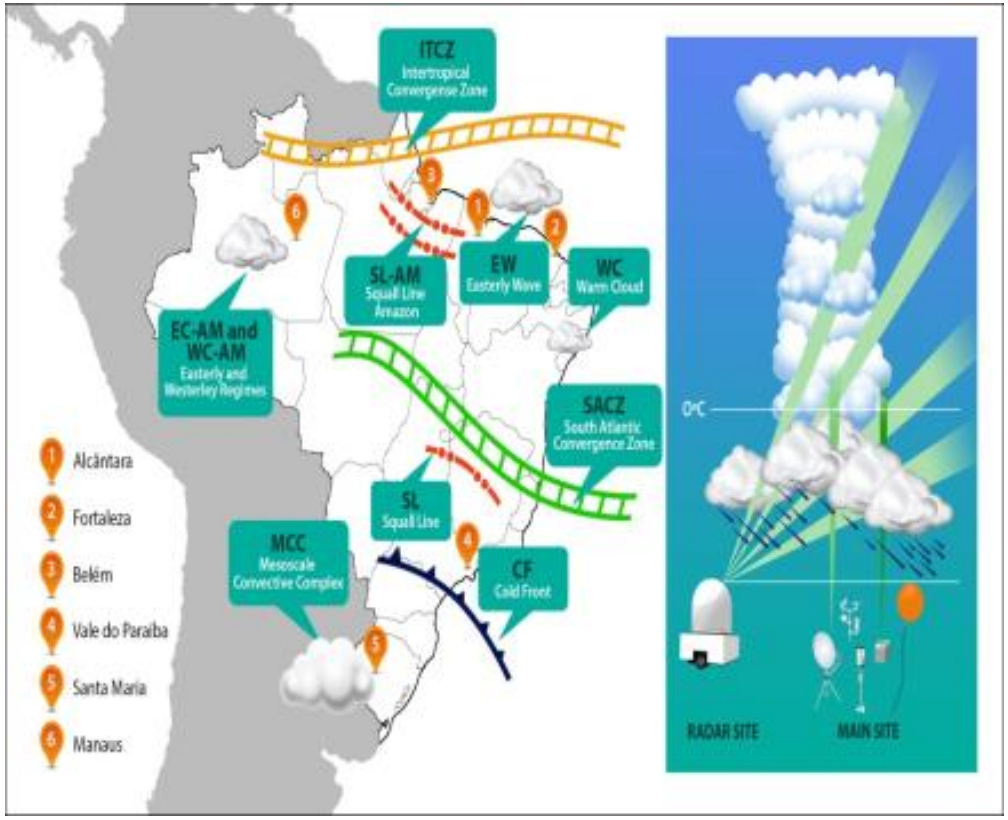
*by Luiz A. T. Machado, Maria A. F. Silva Dias, Carlos Morales, Gilberto Fisch, Daniel Vila, Rachel Albrecht, Steven J. Goodman, Alan J. P. Calheiros, Thiago Biscaro, Christian Kummerow, Julia Cohen, David Fitzjarrald, Ernani L. Nascimento, Meiry S. Sakamoto, Christopher Cunningham, Jean-Pierre Chaboureau, Walter A. Petersen, David K. Adams, Luca Baldini, Carlos F. Angelis, Luiz F. Sapucci, Paola Salio, Henrique M. J. Barbosa, Eduardo Landulfo, Rodrigo A. F. Souza, Richard J. Blakeslee, Jeffrey Bailey, Saulo Freitas, Wagner F. A. Lima, and Ali Tokay*

CHUVA reveals very diverse cloud processes in tropical continental regions and contributes to improving satellite precipitation estimation, nowcasting, cloud-resolving models, and the understanding of cloud electrification.

The CHUVA project—CHUVA, meaning "rain" in Portuguese, is the acronym for the Cloud Processes of the Main Precipitation Systems in Brazil: A Contribution to Cloud-Resolving Modeling and to the Global Precipitation Measurement (GPM)—began in 2010 and has conducted five field campaigns; the last experiment will be held in Manaus as part of the Green Ocean Amazon (GoAmazon) experiment in 2014 (see http://campaign.arm.gov/goamazon2014/ for a detailed description). CHUVA's main scientific motivation is to contribute to the understanding of cloud processes, which represent one of the least understood components of the climate system.

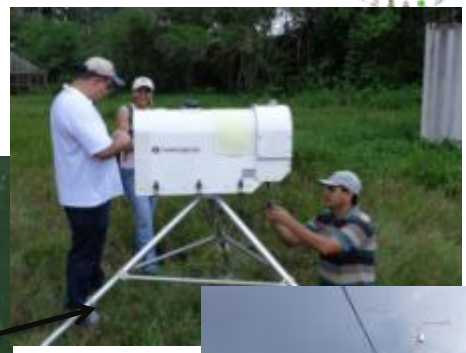
Brazil has an area of 8.5 million square kilometers and lies primarily south of the equator and within the tropics. Therefore, Brazil is ideally situated for studying tropical continental convection over a broad range of precipitation regimes within a single country. In northeastern Brazil, a semiarid region, the CHUVA project was designed to characterize warm clouds (Costa et al. 2000) and the organized convection influenced by the intertropical convergence zone and easterly waves (Kouadio et al. 2012). Cotton (1982) defines warm clouds as clouds in which the ice phase

# CHUVA Project – Main goals



**CHUVA, meaning "rain" in Portuguese, is the acronym for the C*loud processes of tHe main precipitation systems in Brazil: A contribUtion to cloud resolVing modeling and to the GPM (GlobAl Precipitation Measurement)*. The CHUVA project has conducted six field campaigns. CHUVA's main scientific motivation is to improve remote sensing precipitation estimation, rainfall ground validation and microphysical parameterizations of the tri-dimensional characteristics of the precipitating clouds over Brazil.**

# CHUVA Project – The GoAmazon Campaign – IOP #2
# ACRIDICON-CHUVA



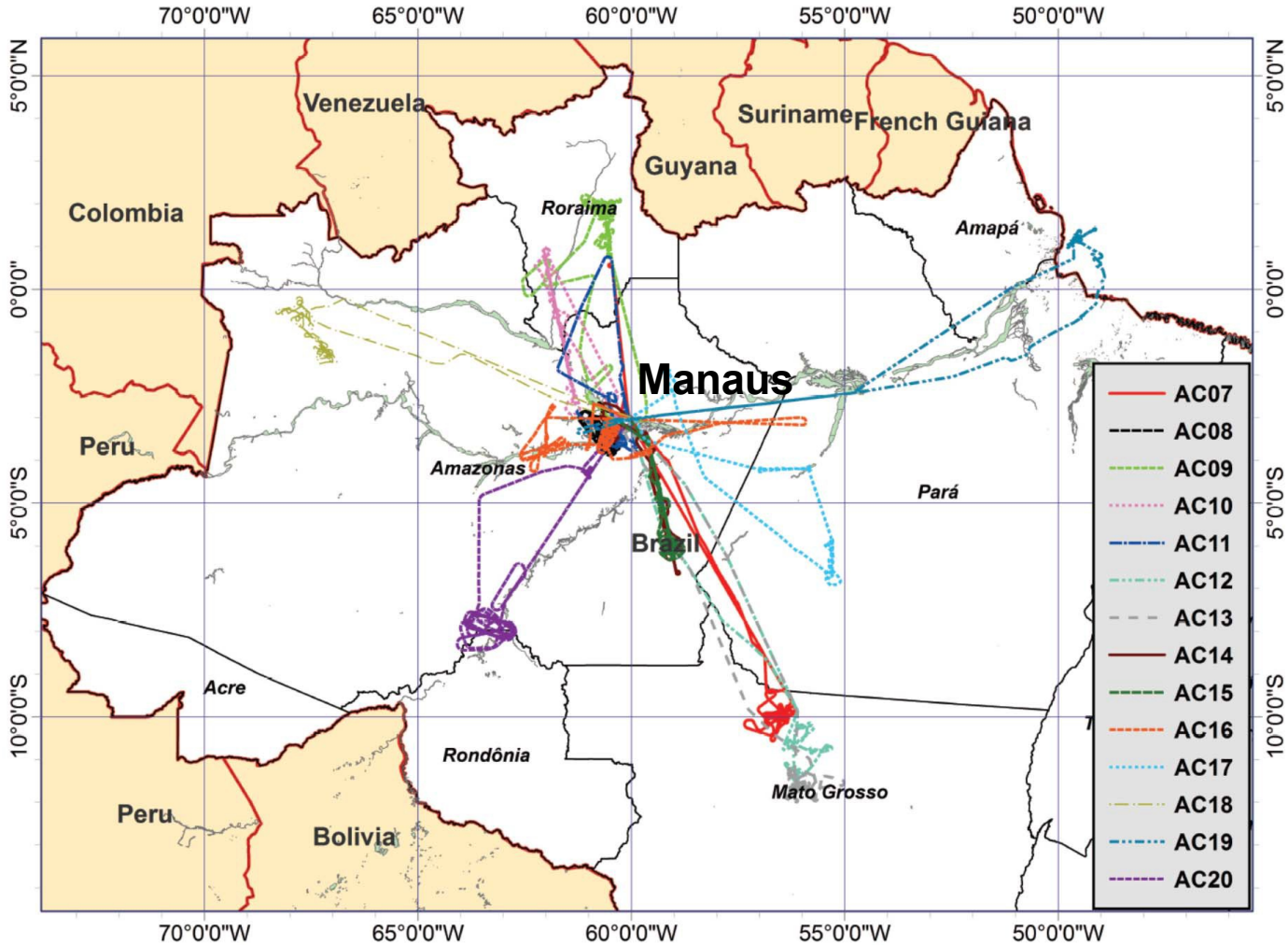
# HALO: High Altitude and Long Range Research Aircraft

**Ultra Long Range Business Jet G 550, Gulfstream**

| | |
|---|---|
| Ceiling: | 15 km |
| Payload: | 3 t |
| Endurance | 8 hours |

Partly Coordinated with Gulfstream-1 (GoAmazon 2014/5)

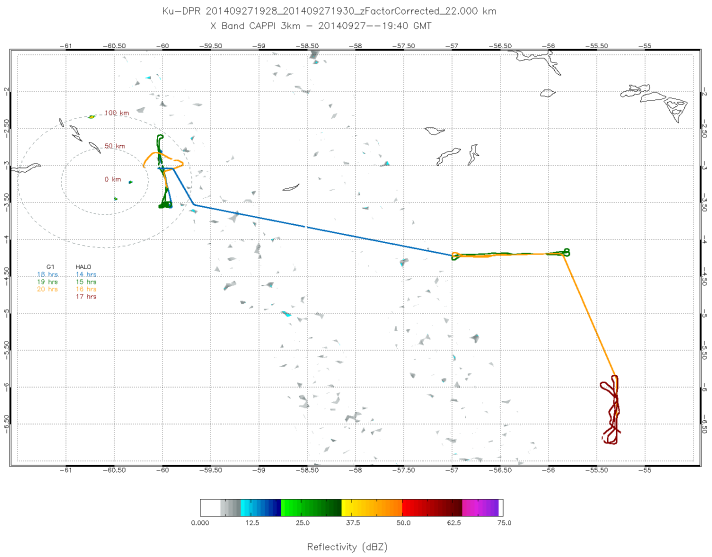
# 1 September — 3 October 2014, 14 Flights, 96 Hours

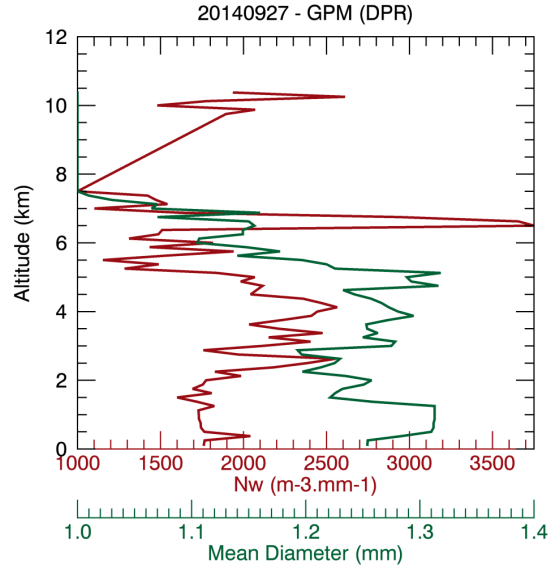



2. Campaign Overview

Wendisch et al., submitted to BAMS

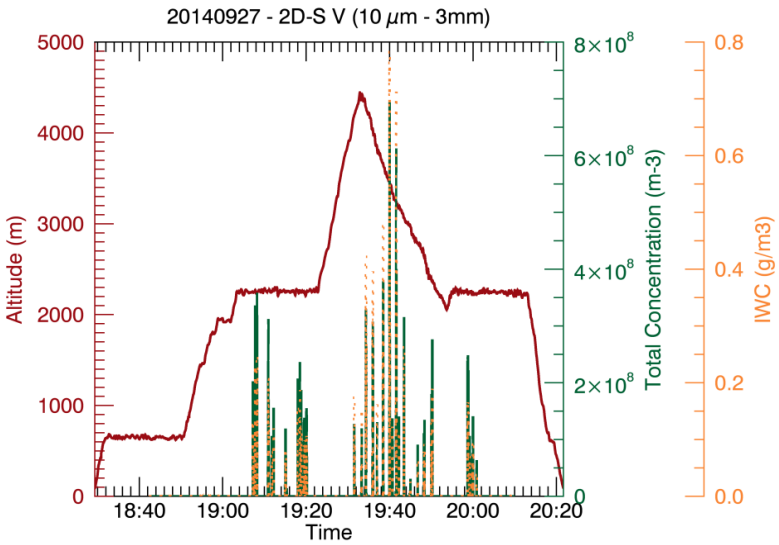
# Mission Type 3: Satellite Validation



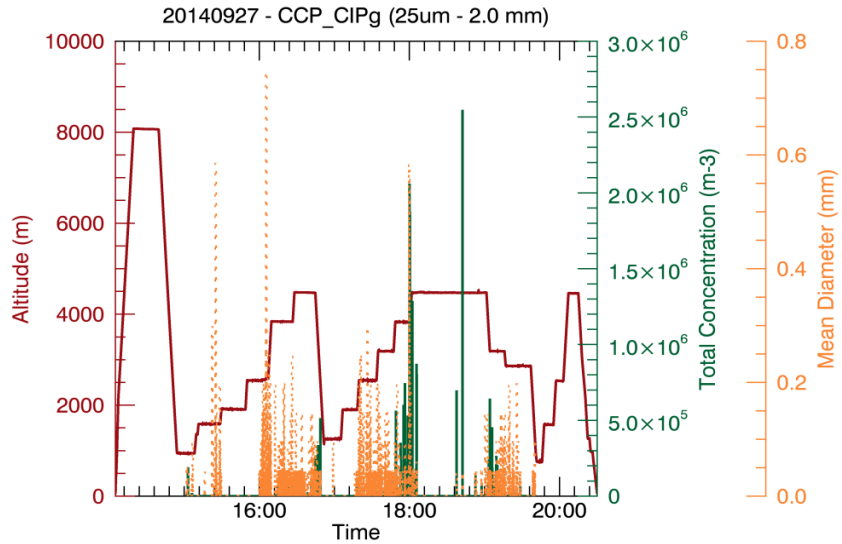




Nw and Dm parameters are means in each level for the selected area.

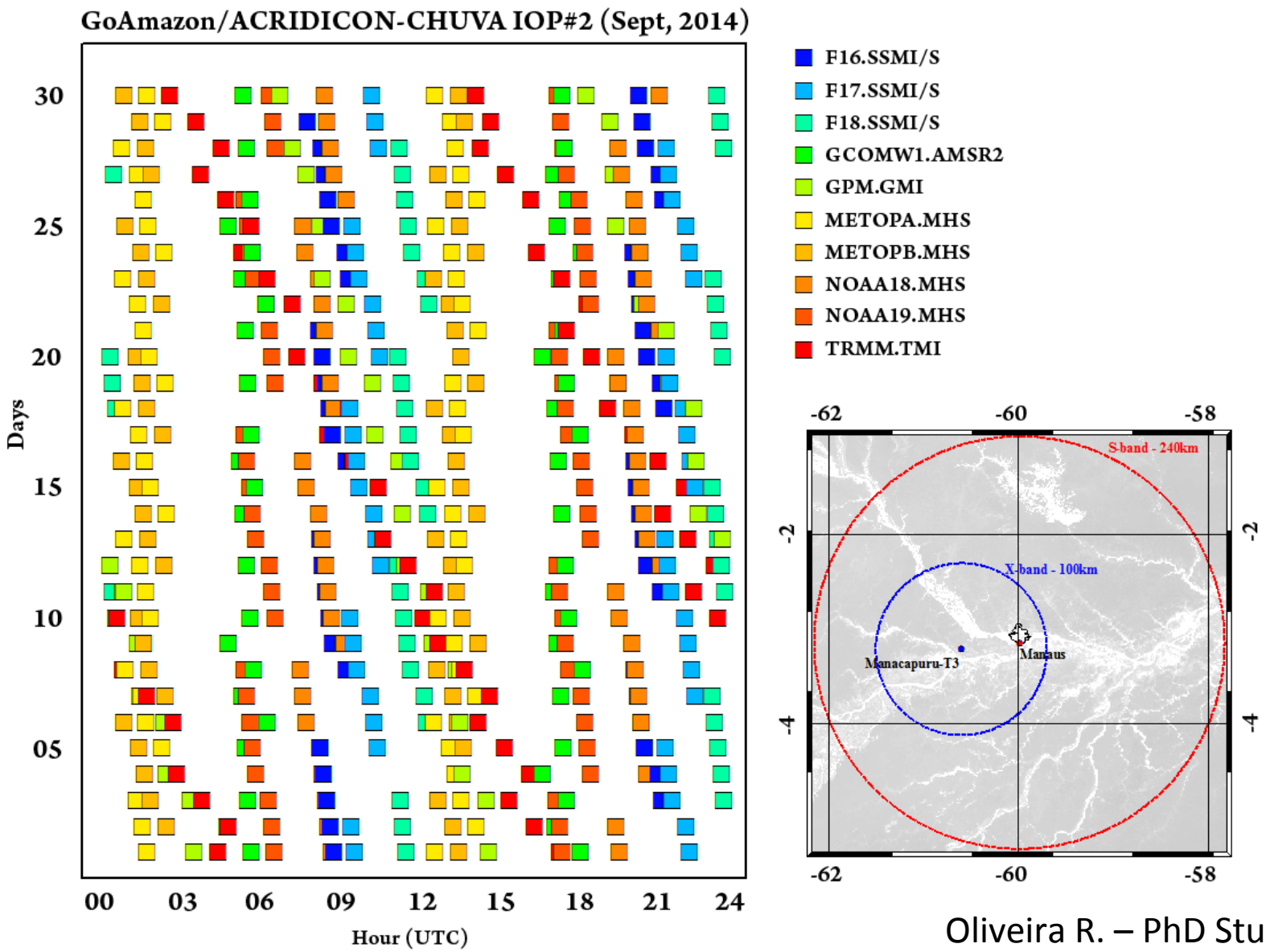
G1




HALO



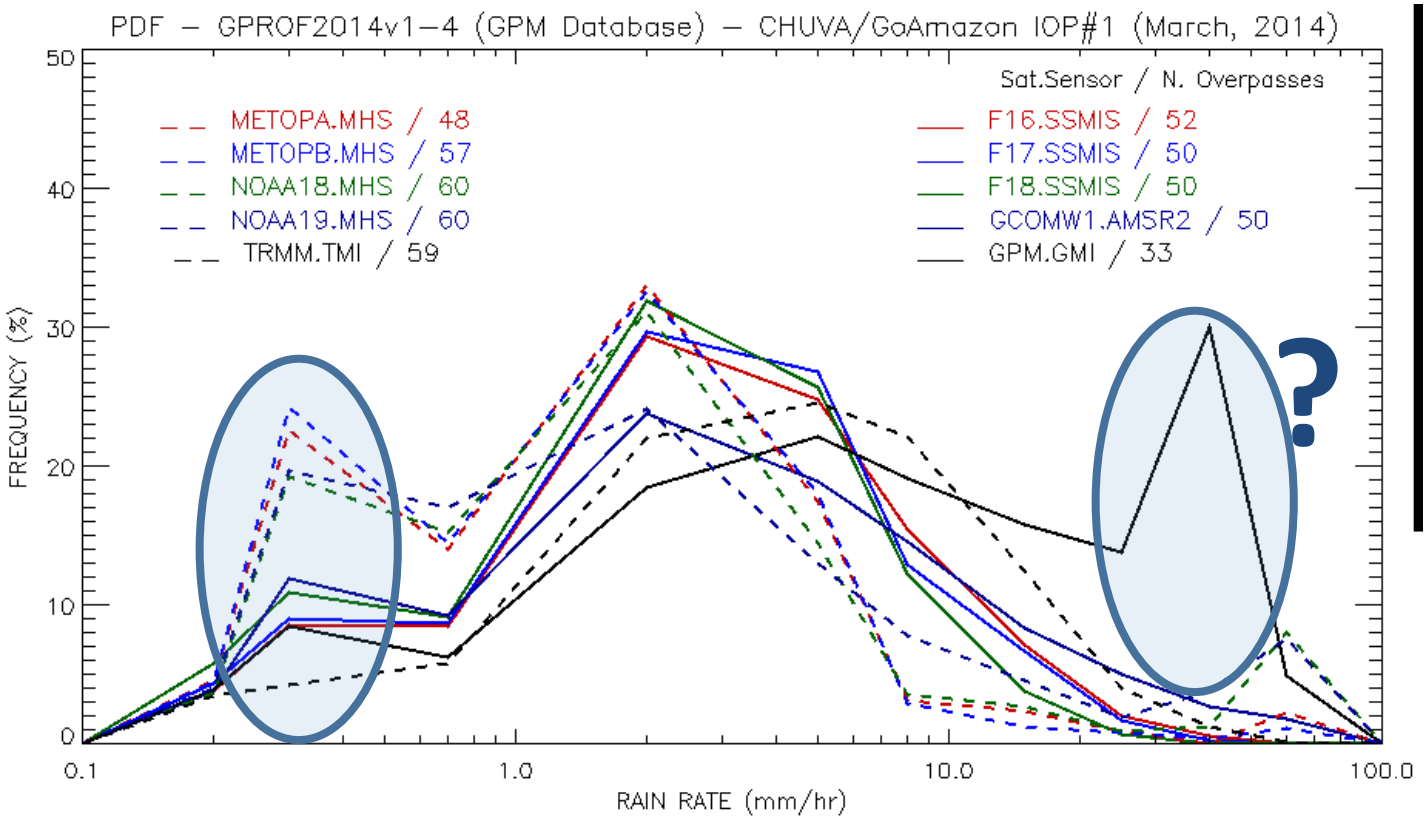
# Preliminary results of GPROF2014 and IMERG for Amazon-Brazil




Oliveira R. – PhD Student

# Preliminary results of GPROF2014 and IMERG for Amazon-Brazil

- **GPROF2014v1-4 : [-51, -41 ; -28, -18] – March, 2014**



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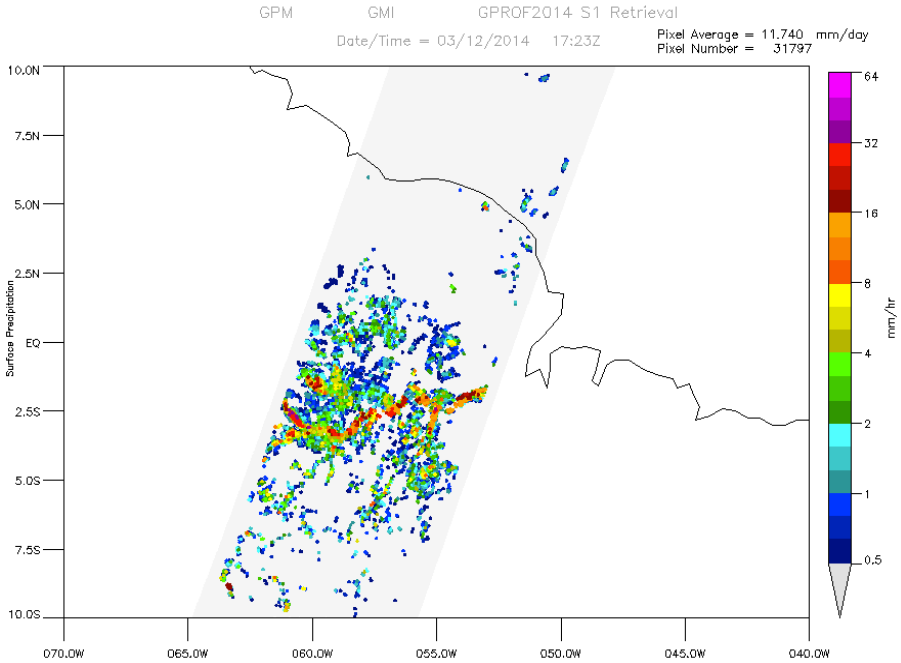
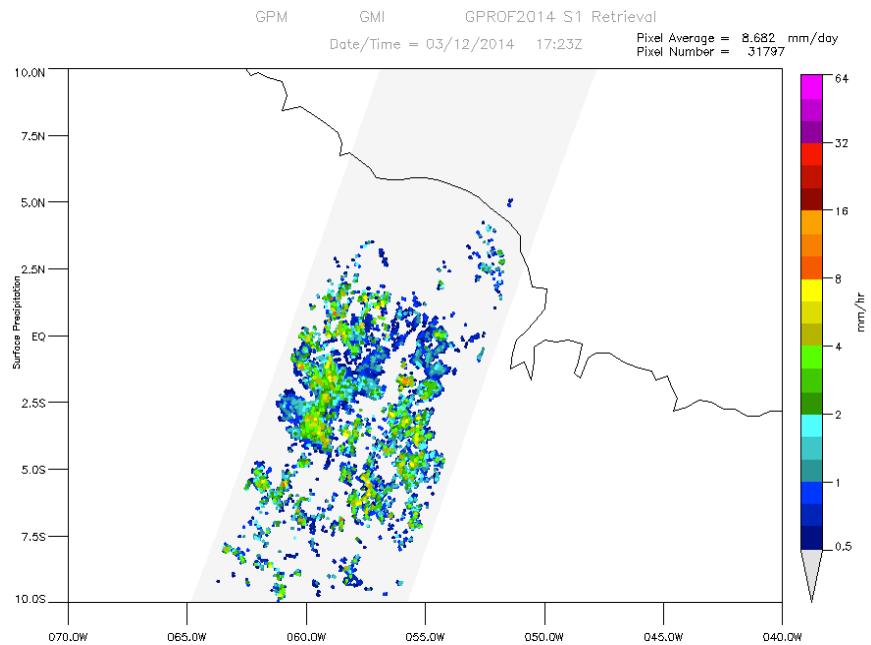
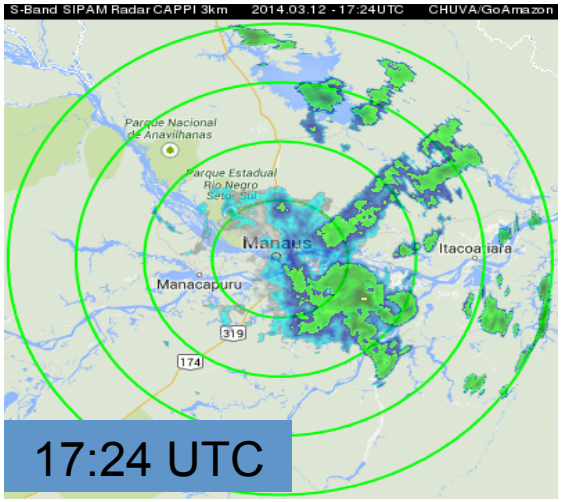



V1-4 (operational)

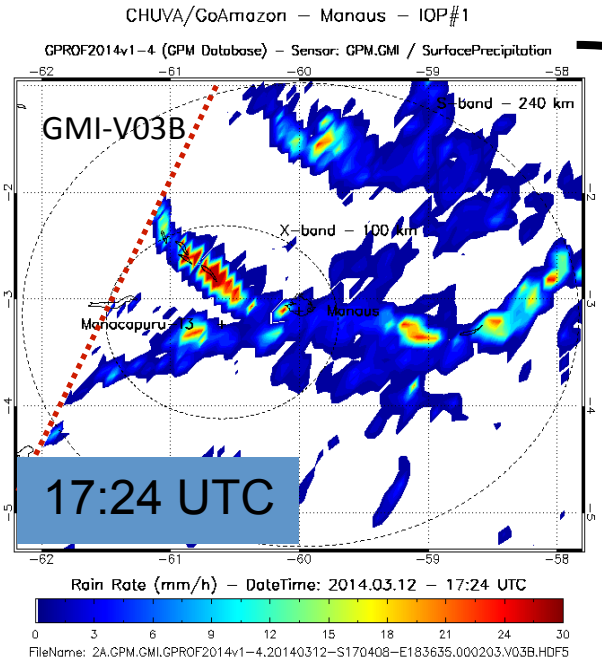


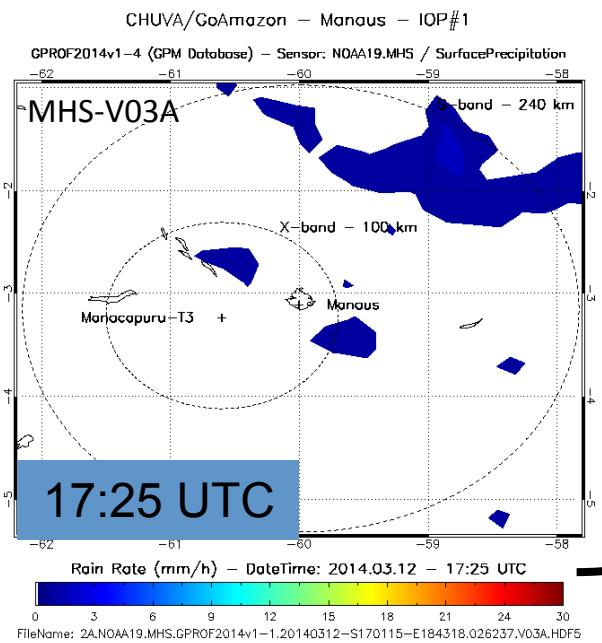

V1-4 (empirical) (11 months of matchups)

## S-band radar



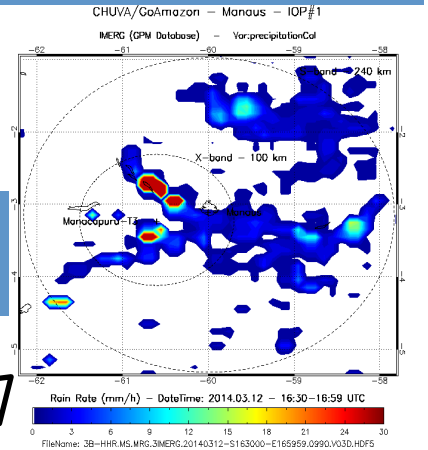

## GPROF2014v1-4



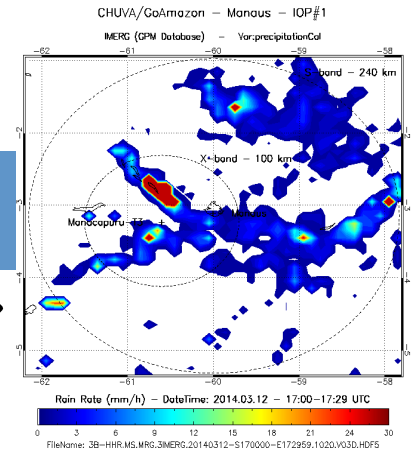

## IMERG HHR - V03D

16:30 – 16:59 UTC



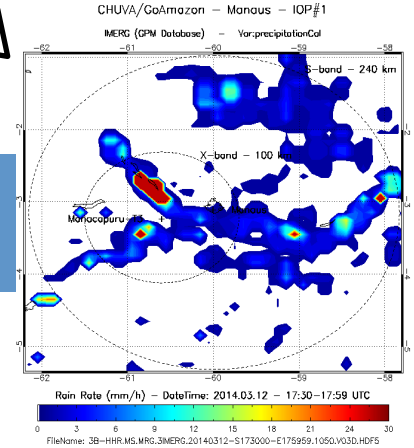

backward

17:00 – 17:29 UTC




forward

17:30 – 17:59 UTC

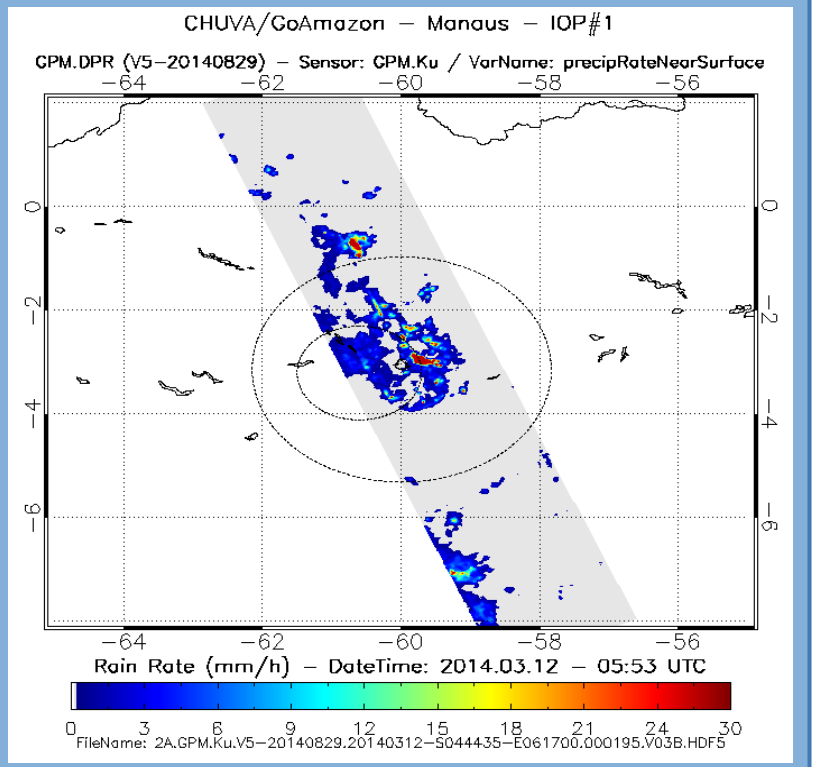


# Reference Database Avaliable/processing

**2014 CHUVA/GoAmazon Campaigns**

## GPM / DPR-Ku (rainfall estimation)

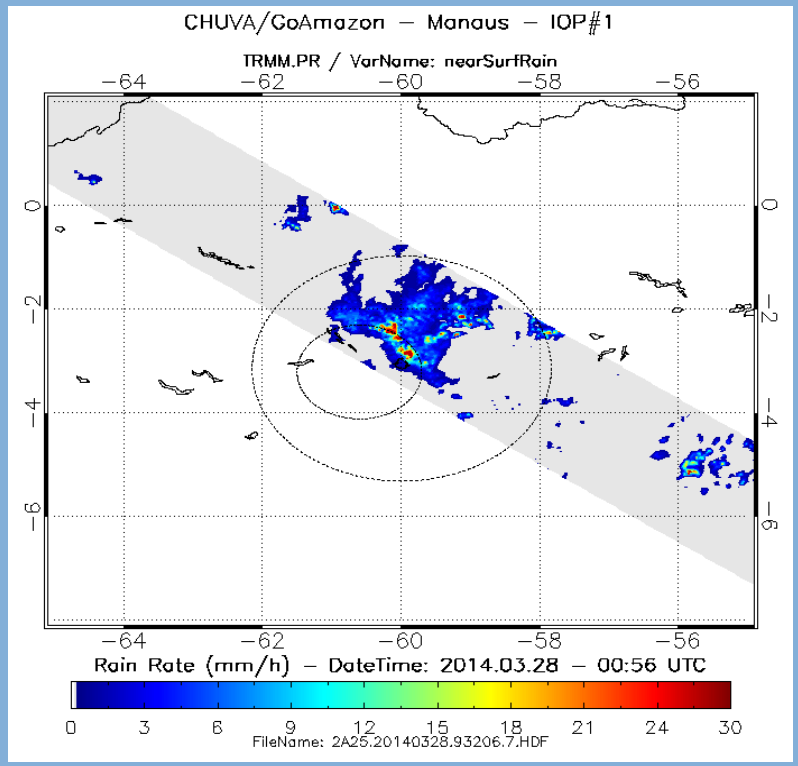
**Ex.: 2014.03.12 – 05:53UTC**




**From MAR,2014 to Now**

## TRMM / PR-Ku (rainfall estimation)

**Ex.: 2014.03.28 – 00:56UTC**



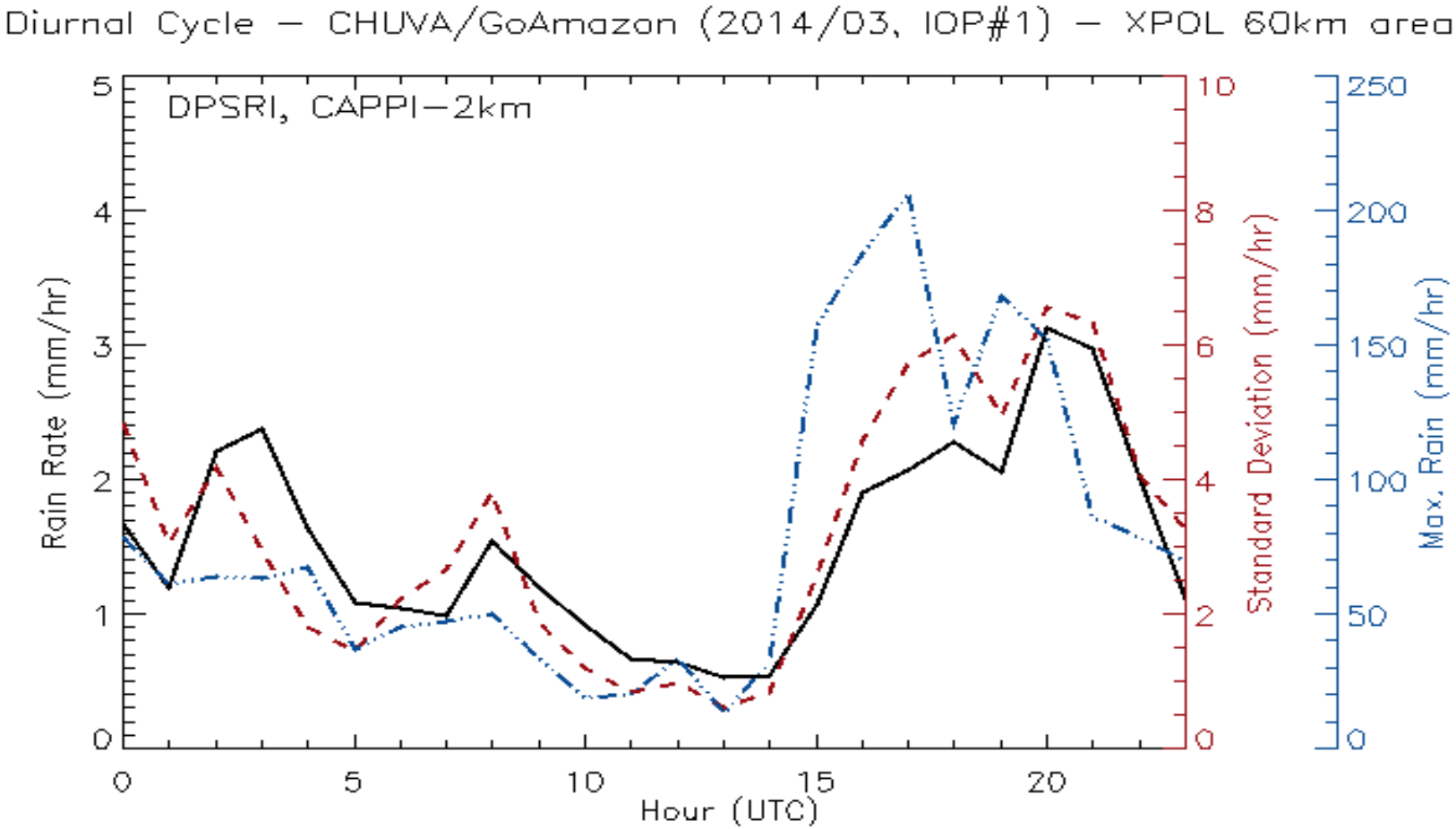

**From JAN to MAR, 2014**

# X-band Dual Polarization Radar (XPOL)

**Dual Polarization Surface Rainfall Intensity (DPSRI) algorithm**

**Native spatio-temporal resolution: 0.2km-10min**

**Conditional average: Rainfall ≥ 0.2 mm.hr$^{-1}$**

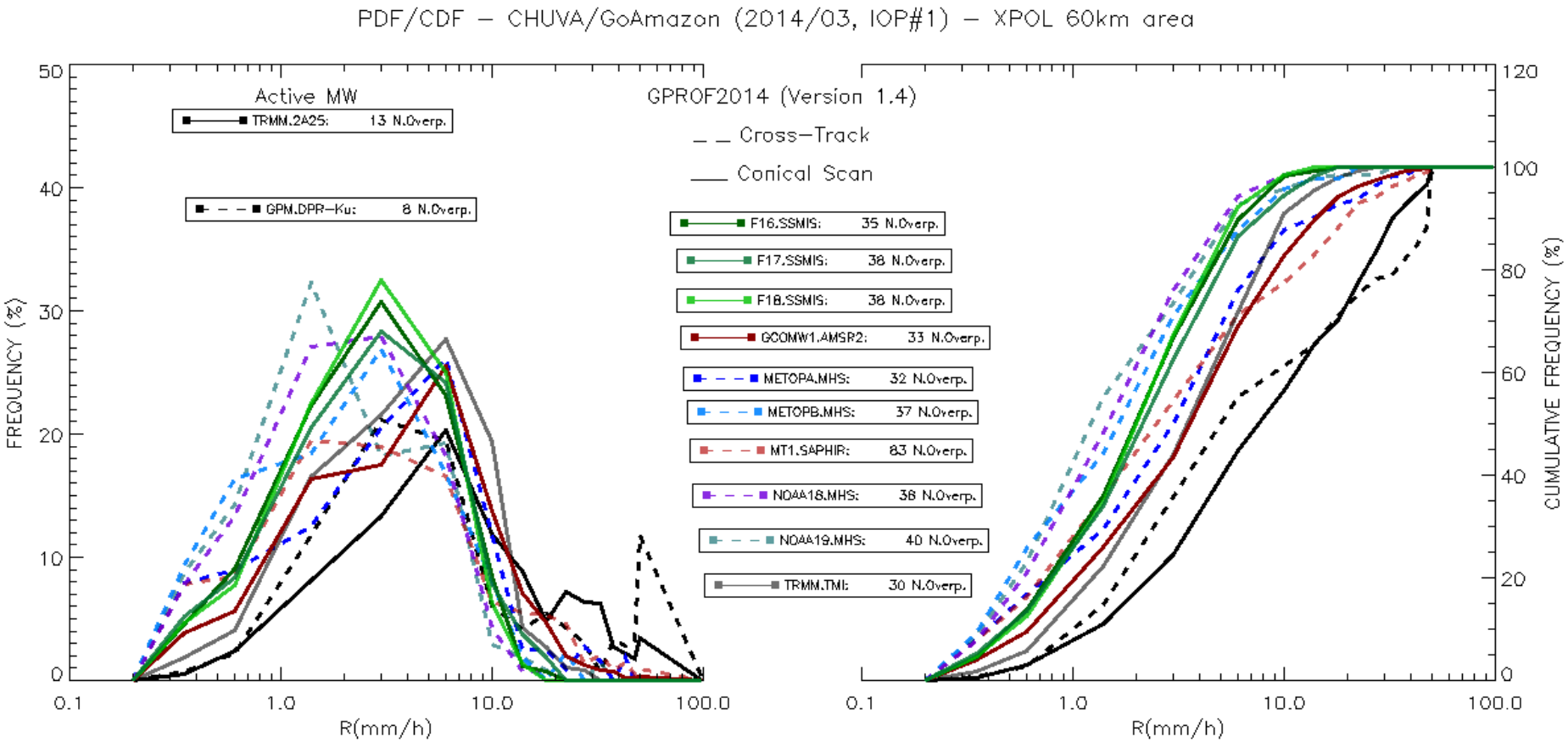


# Satellite- / Radar-based Precipitation Estimates

**PMW: GPROF2014 Version 1.4**
**Active MW: PR.TRMM and DPR.GPM**

**Native spatial resolution: 12.5km (GPROF) / 5km (PR and DPR)**

**Conditional average: Rainfall ≥ 0.2 mm.hr$^{-1}$**



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**PMW: GPROF2014 Version 1.4**
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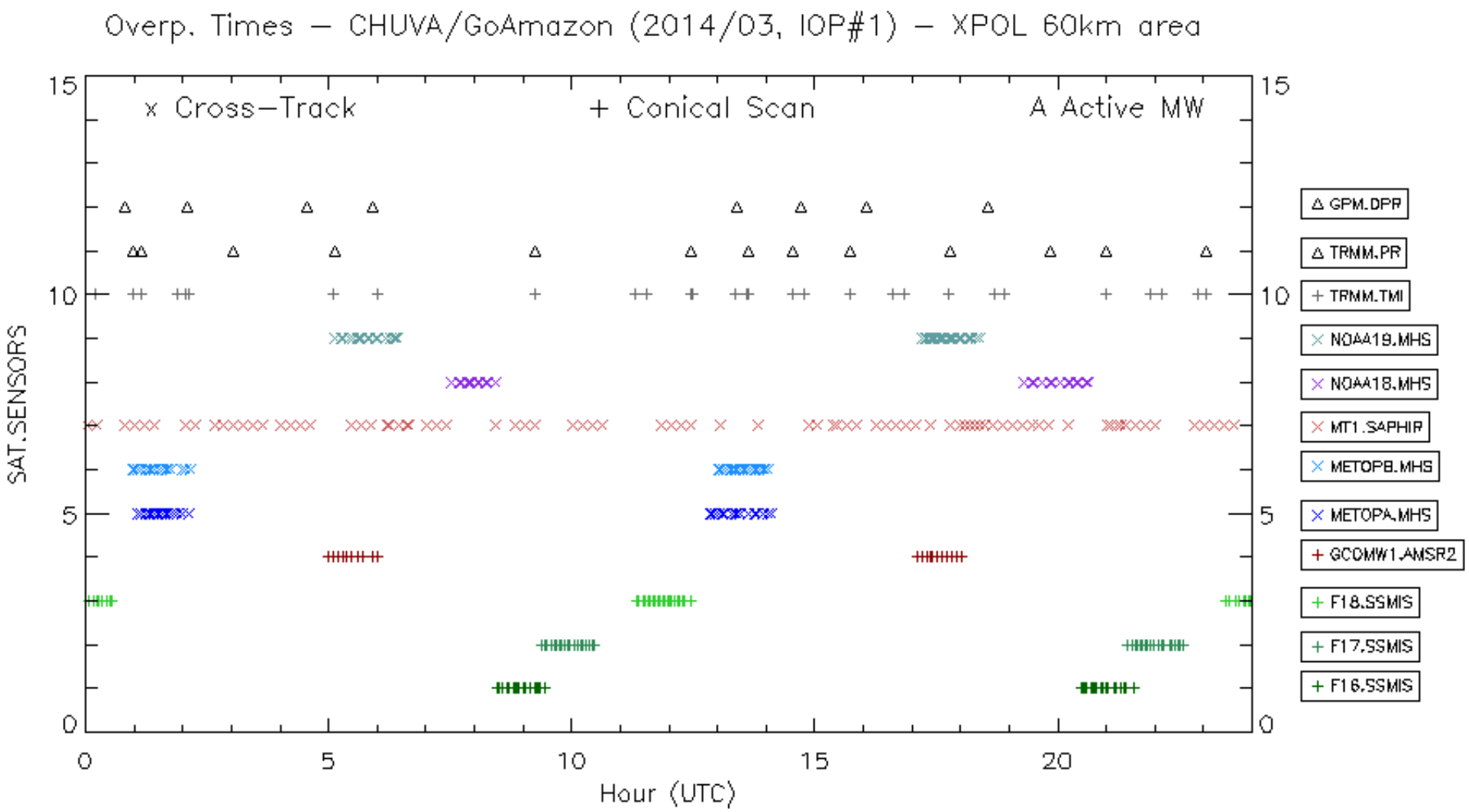
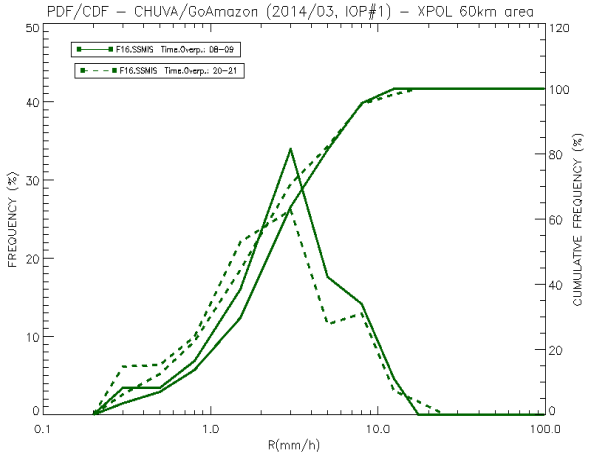
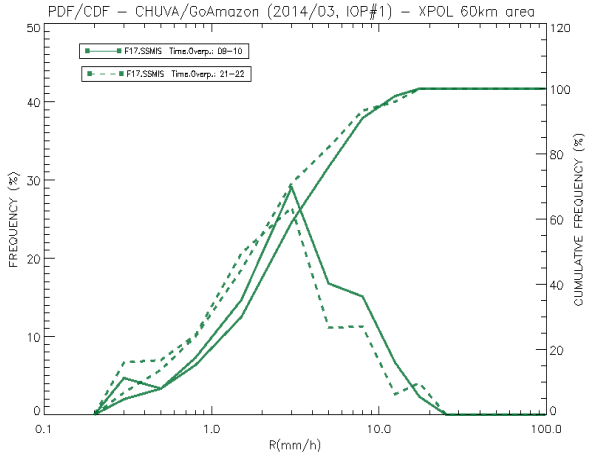
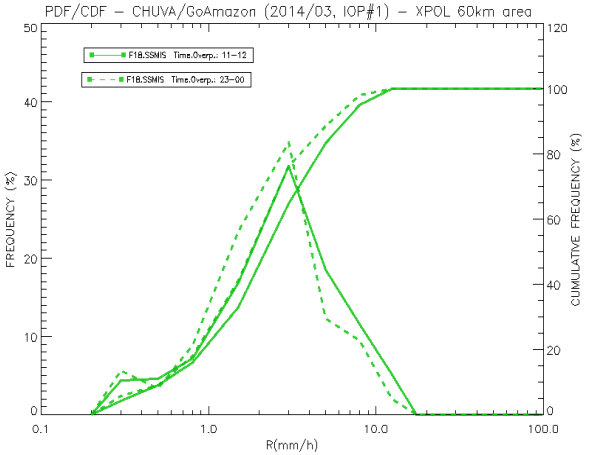
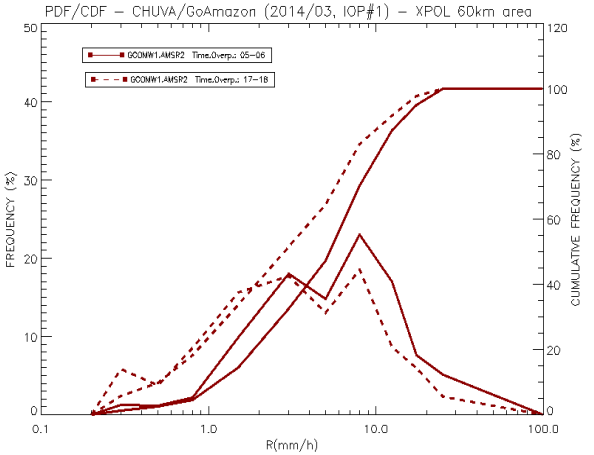
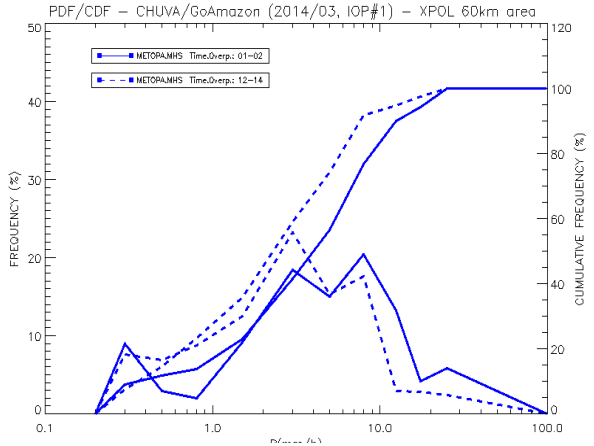


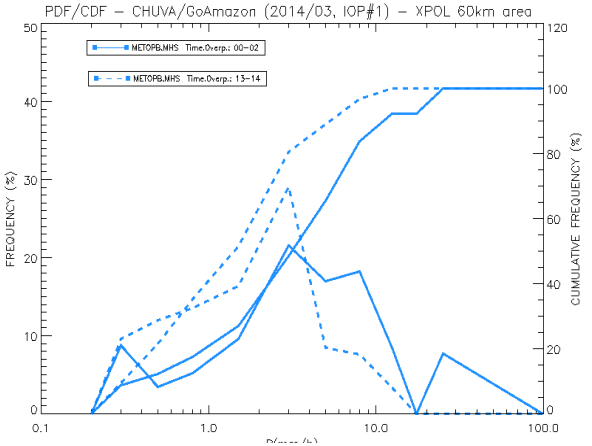

PDF/CDF – CHUVA/GoAmazon (2014/03, IOP#1) – XPOL 60km area
F16.SSMIS Time.Overp.: 08–09
F16.SSMIS Time.Overp.: 20–21
FREQUENCY (%)
CUMULATIVE FREQUENCY (%)
R(mm/h)

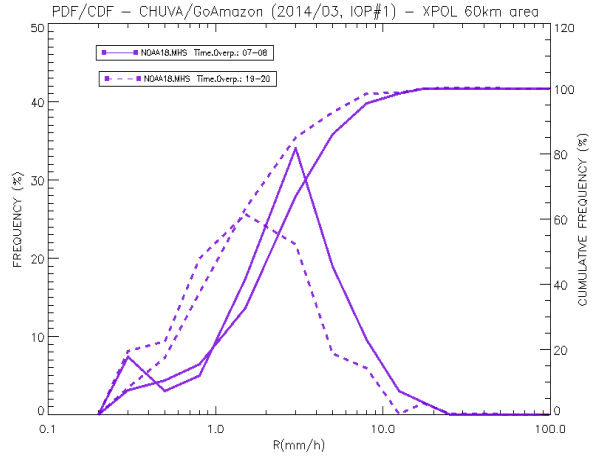

PDF/CDF – CHUVA/GoAmazon (2014/03, IOP#1) – XPOL 60km area
F17.SSMIS Time.Overp.: 09–10
F17.SSMIS Time.Overp.: 21–22
FREQUENCY (%)
CUMULATIVE FREQUENCY (%)
R(mm/h)

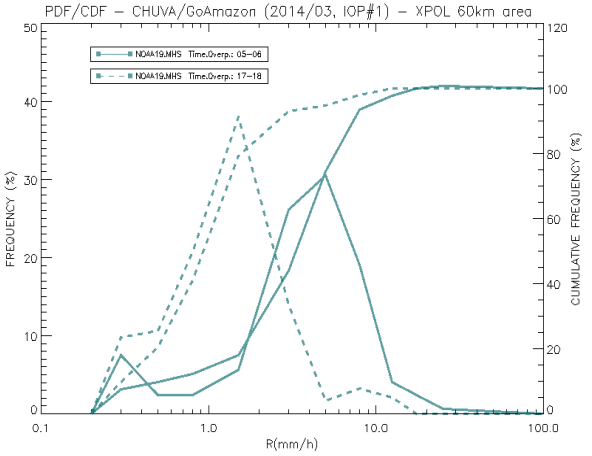

PDF/CDF – CHUVA/GoAmazon (2014/03, IOP#1) – XPOL 60km area
F18.SSMIS Time.Overp.: 11–12
F18.SSMIS Time.Overp.: 23–00
FREQUENCY (%)
CUMULATIVE FREQUENCY (%)
R(mm/h)


PDF/CDF – CHUVA/GoAmazon (2014/03, IOP#1) – XPOL 60km area
GCOMW1.AMSR2 Time.Overp.: 05–06
GCOMW1.AMSR2 Time.Overp.: 17–18
FREQUENCY (%)
CUMULATIVE FREQUENCY (%)
R(mm/h)

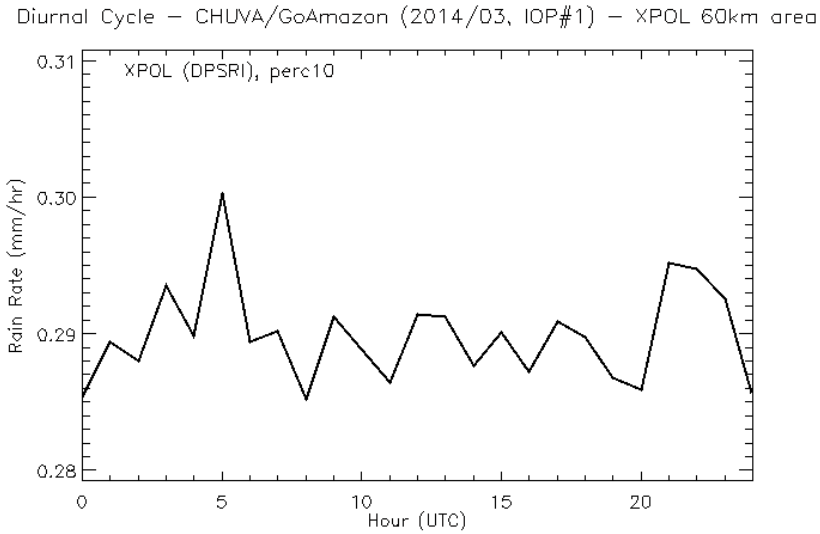

PDF/CDF – CHUVA/GoAmazon (2014/03, IOP#1) – XPOL 60km area
METOPA.MHS Time.Overp.: 01–02
METOPA.MHS Time.Overp.: 12–14
FREQUENCY (%)
CUMULATIVE FREQUENCY (%)

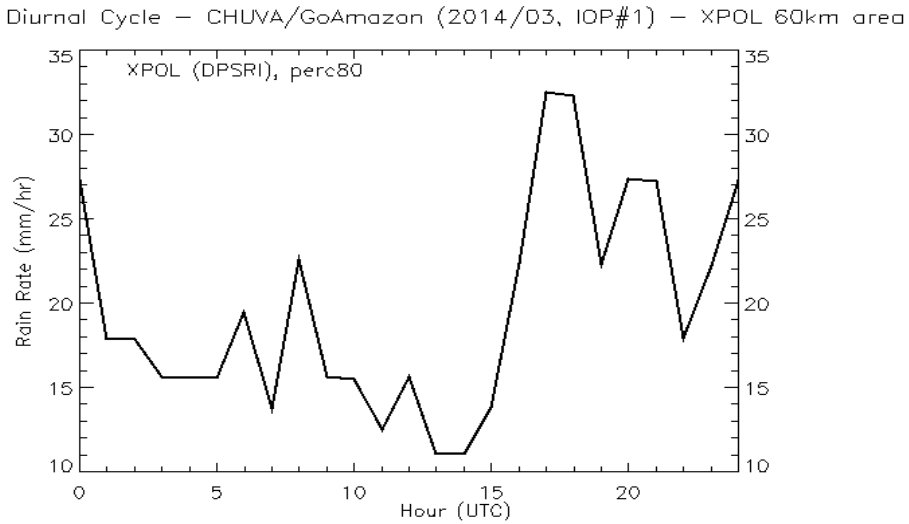

PDF/CDF – CHUVA/GoAmazon (2014/03, IOP#1) – XPOL 60km area
METOPB.MHS Time.Overp.: 00–02
METOPB.MHS Time.Overp.: 13–14
FREQUENCY (%)
CUMULATIVE FREQUENCY (%)


PDF/CDF – CHUVA/GoAmazon (2014/03, IOP#1) – XPOL 60km area
NOAA18.MHS Time.Overp.: 07–08
NOAA18.MHS Time.Overp.: 19–20
FREQUENCY (%)
CUMULATIVE FREQUENCY (%)
R(mm/h)


PDF/CDF – CHUVA/GoAmazon (2014/03, IOP#1) – XPOL 60km area
NOAA19.MHS Time.Overp.: 05–06
NOAA19.MHS Time.Overp.: 17–18
FREQUENCY (%)
CUMULATIVE FREQUENCY (%)
R(mm/h)

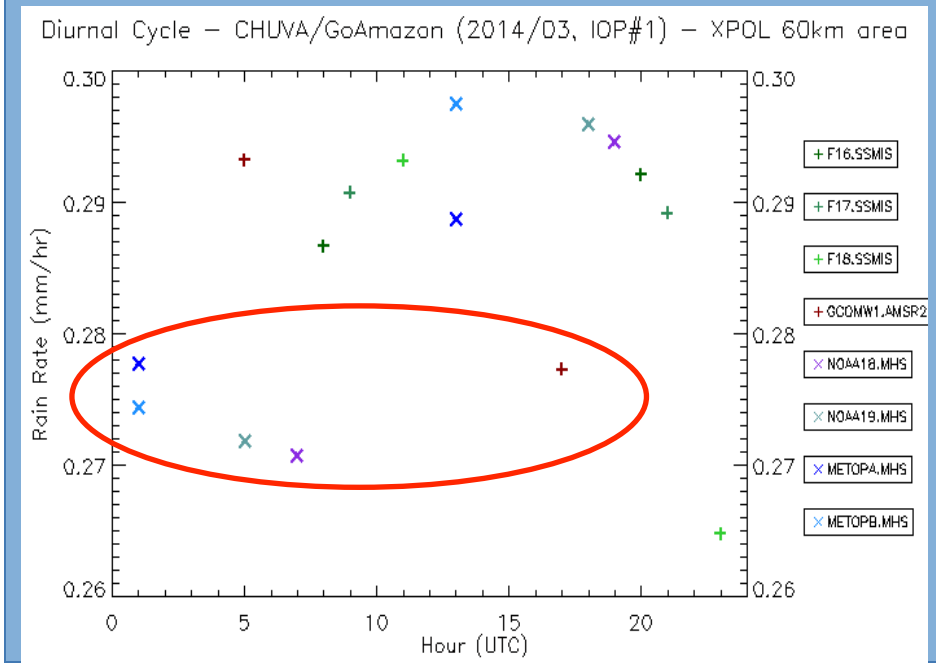
# X-band Dual Polarization Radar (XPOL)



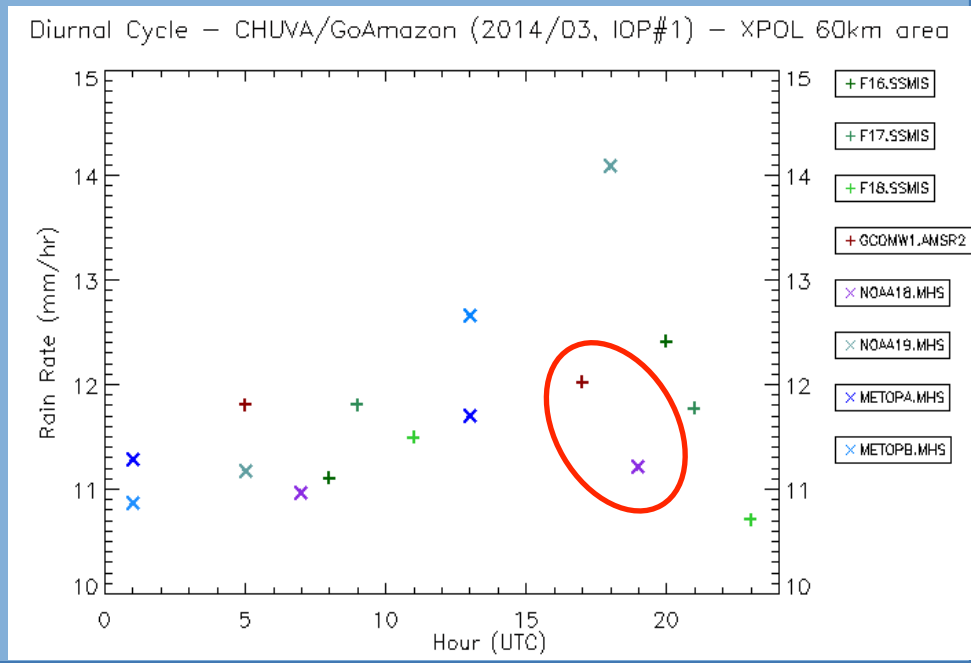




## GPROF 2014 (Version 1.4)

### Class 1 (10% in CDF)



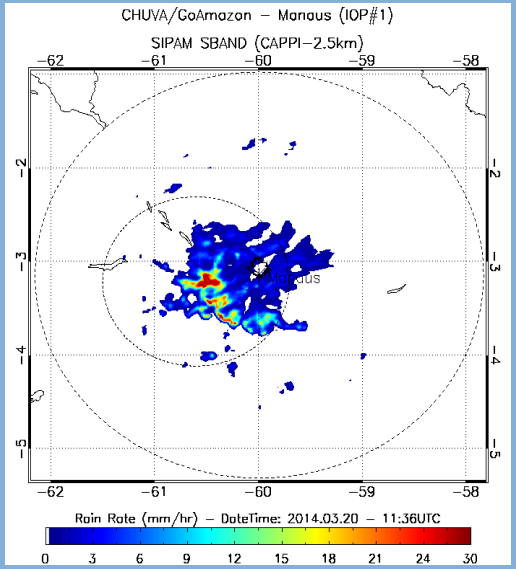

### Class 8 (80% in CDF)



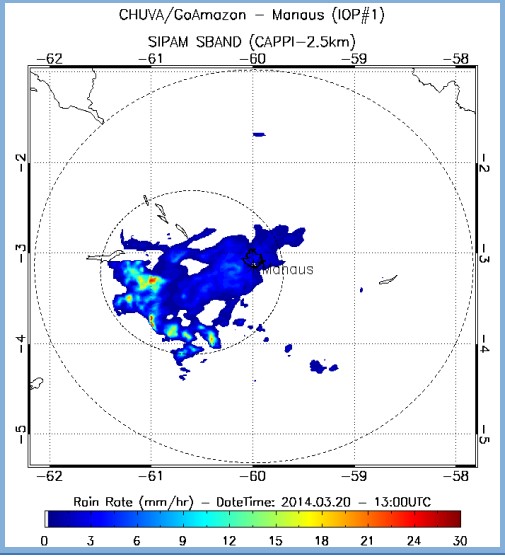
# 2014.03.20

## S-Band radar

### 11:36 UTC

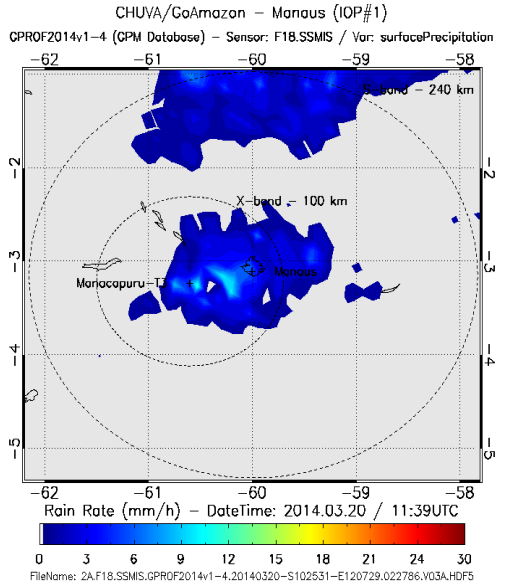



### 13:00 UTC

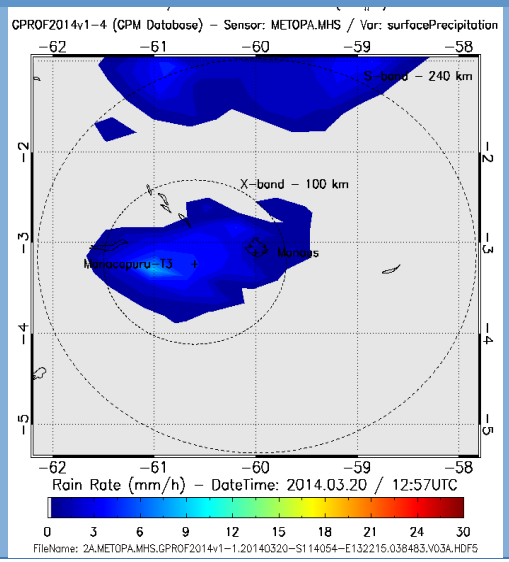



## GPROF2014

### 11:39 UTC

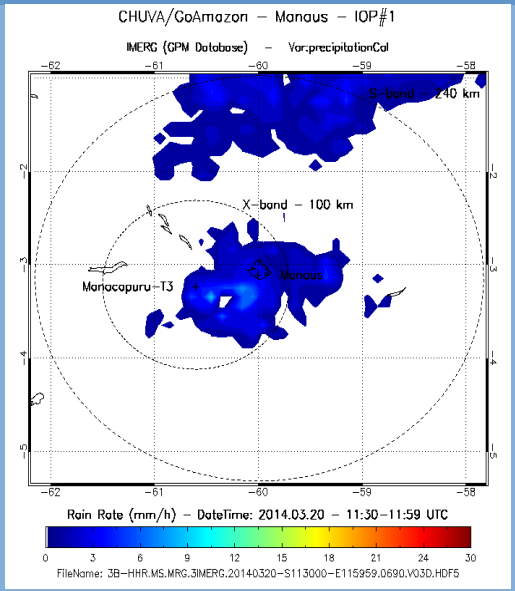



### 12:57 UTC

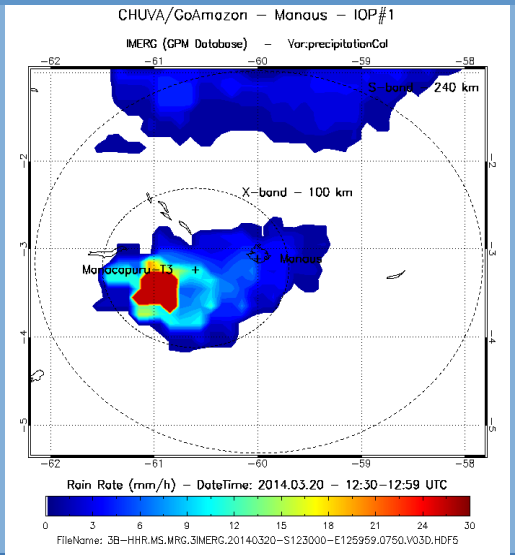



## IMERG HHR - V03D

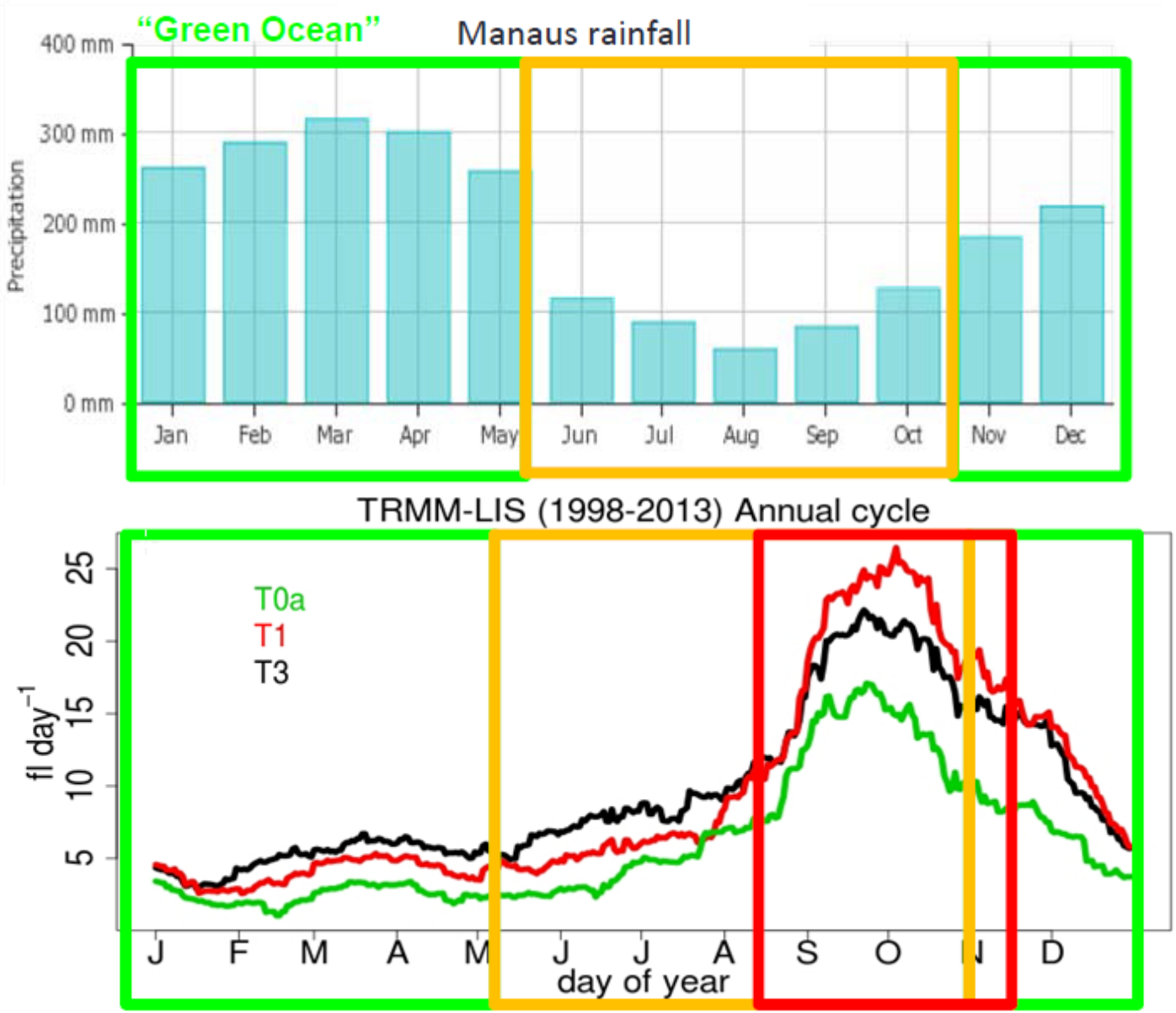
### 11:30 - 12:00 UTC




### 12:00 - 12:30 UTC



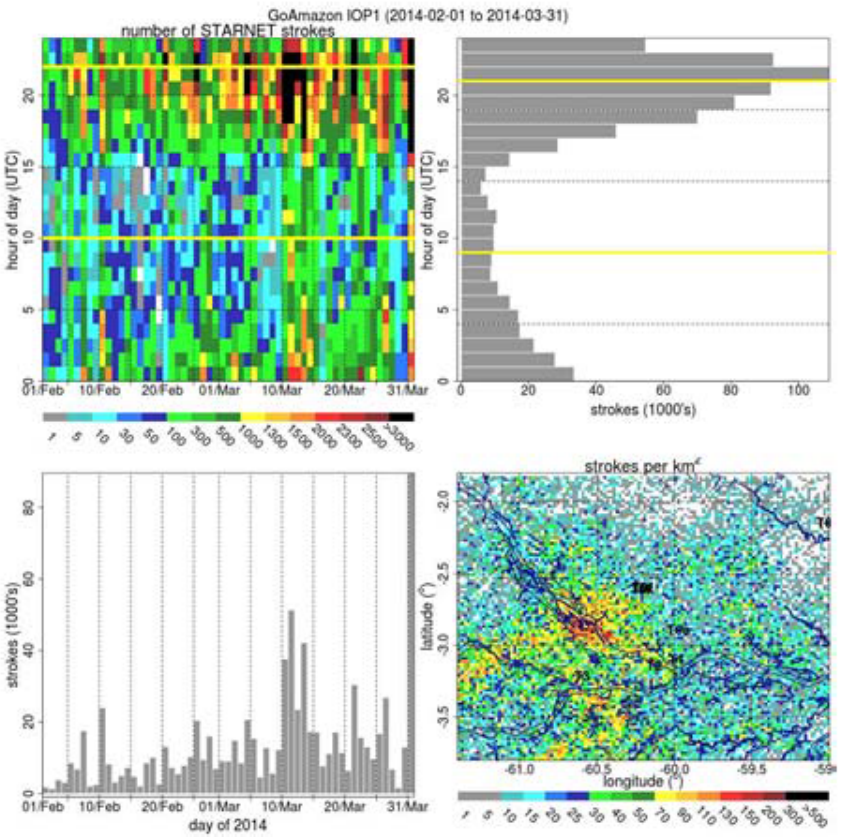
# Electrification Processes over the Amazonian Region



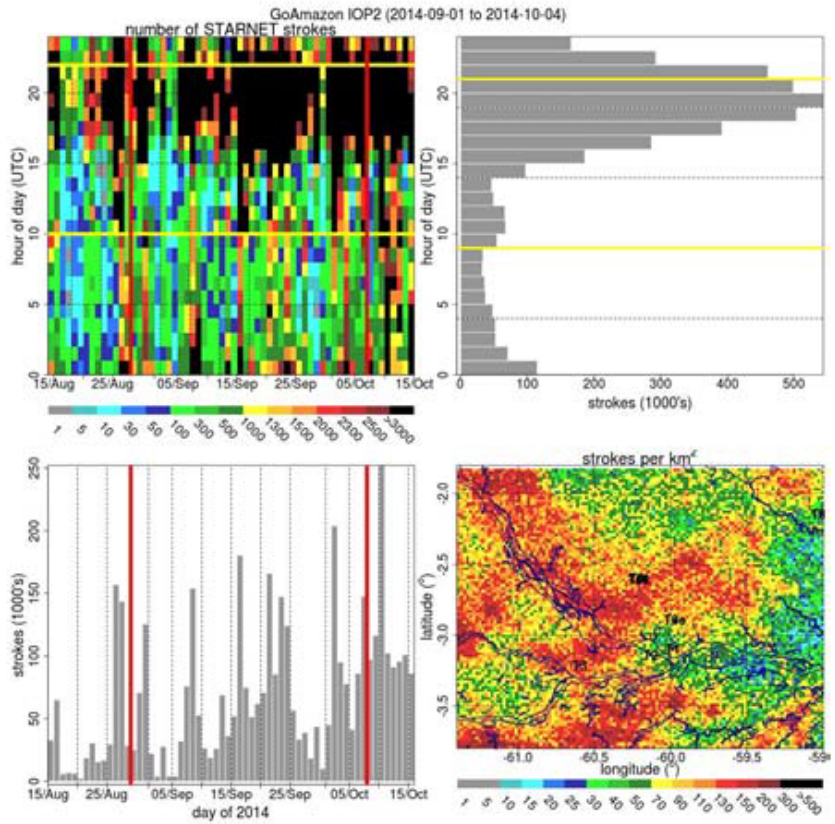

Albrecht et al. (2015)

# Electrification Processes over the Amazonian Region

IOP #1 Feb-Mar

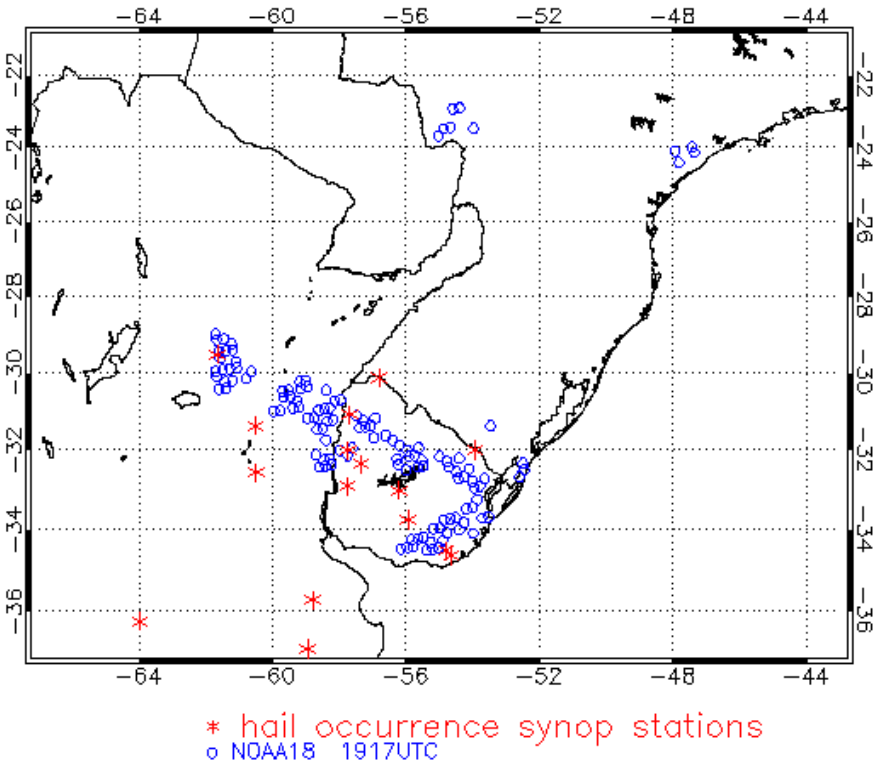


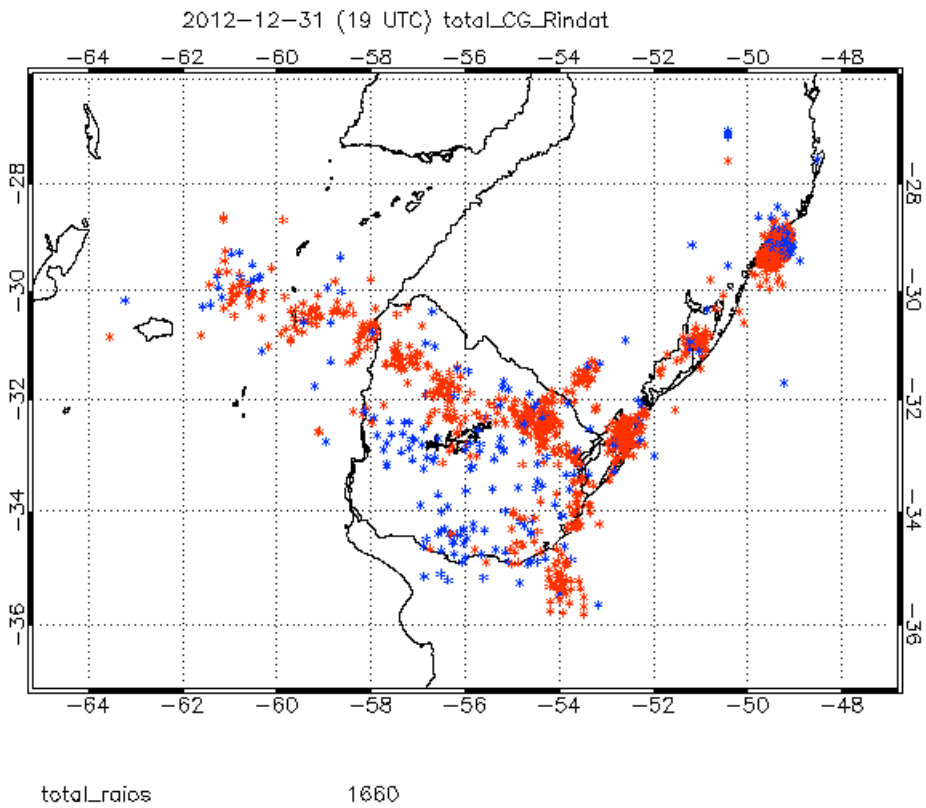

IOP#2 Sep-Oct




Albrecht et al. (2015)

# Hail Detection using GPM Constellation




red = +CG
blue = -CG

# ROLE OF GPM GROUND VALIDATION

*Pre-launch algorithm development & post-launch product evaluation*

- Refine algorithm assumptions & parameters - Characterize uncertainties in satellite retrievals & GV measurements

"Truth" is estimated through the convergence of satellite and ground-based estimates

## Three complementary approaches:

- *Direct statistical validation (surface):*

  - Leveraging off operational networks to identify and resolve first-order discrepancies between satellite and ground-based precipitation estimates

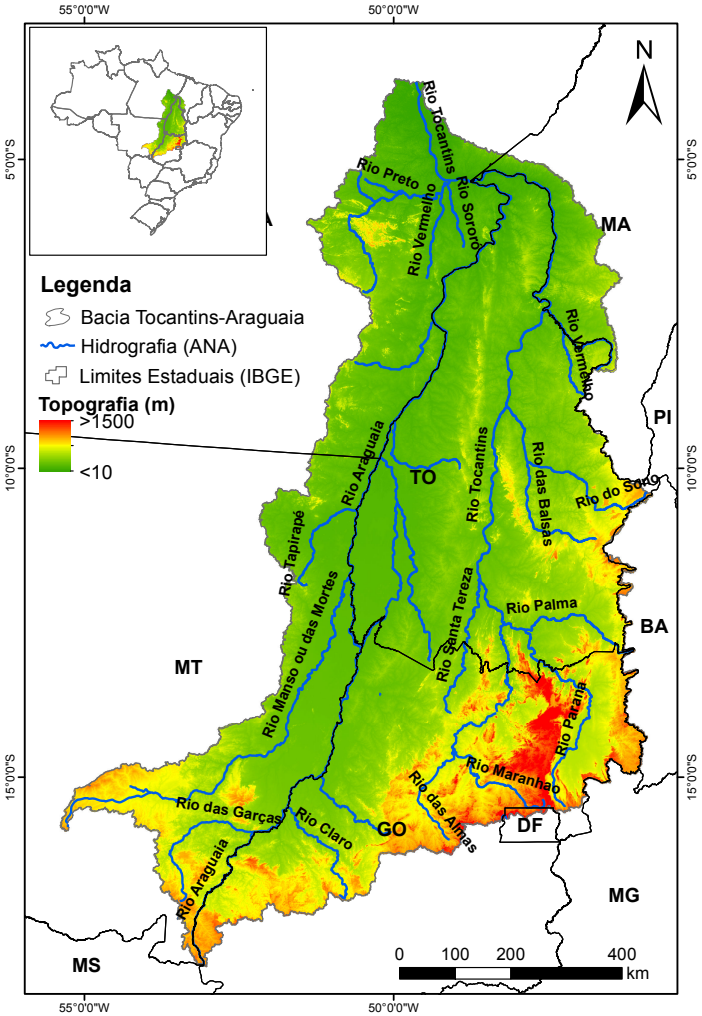
- *Physical process validation (vertical column):*

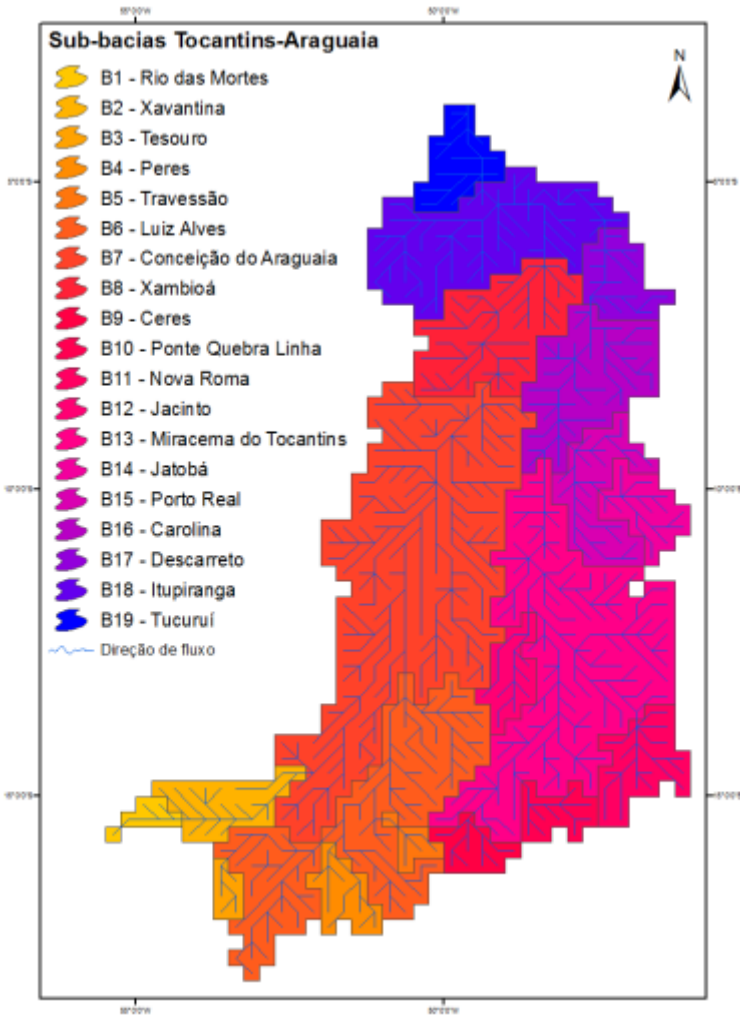
  - Cloud system and microphysical studies geared toward testing and refinement of physically-based retrieval algorithms

- *Integrated hydrologic validation/applications (4-dimensional):*

  - Identify space-time scales at which satellite precipitation data are useful to water budget studies and hydrological applications; characterization of model and observation errors

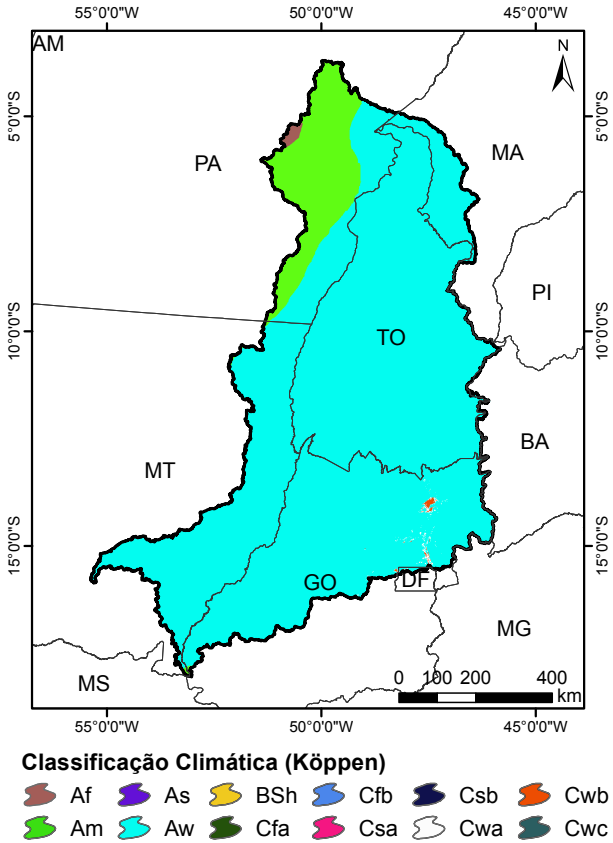
# Evaluation of satellite rainfall estimates on hydrological modeling of Tocantins-Araguaia basin



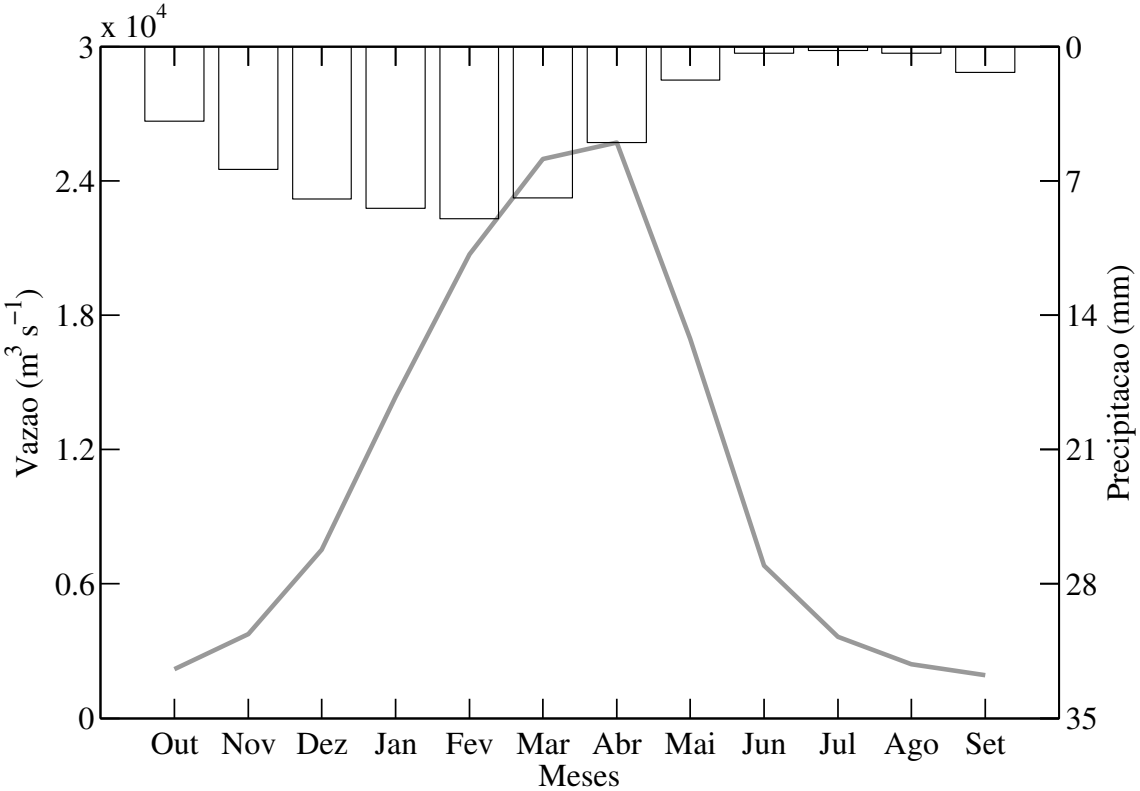




Localization of Tocantins river basin
Area: ~800,000 km$^2$

# Evaluation of satellite rainfall estimates on hydrological modeling of Tocantins-Araguaia basin



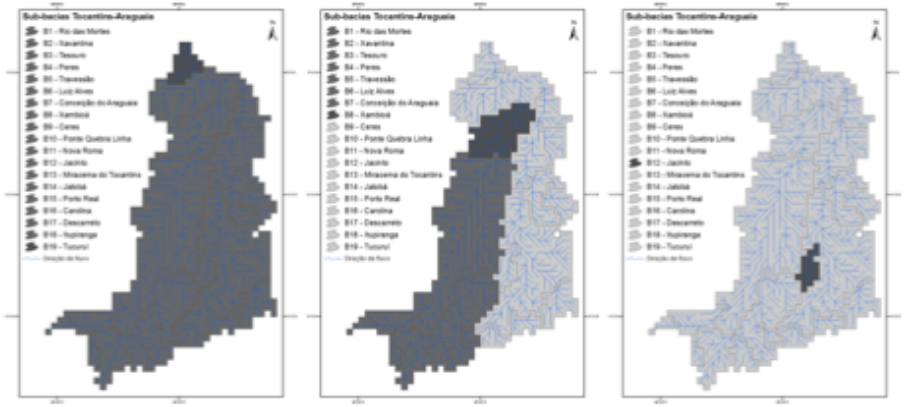

**Regimes climáticos (Alvares et al., 2013)**




**Mean rainfall and discharge at Tocantins-Araguaia basin (Estação Tucuruí; 2000-2011)**

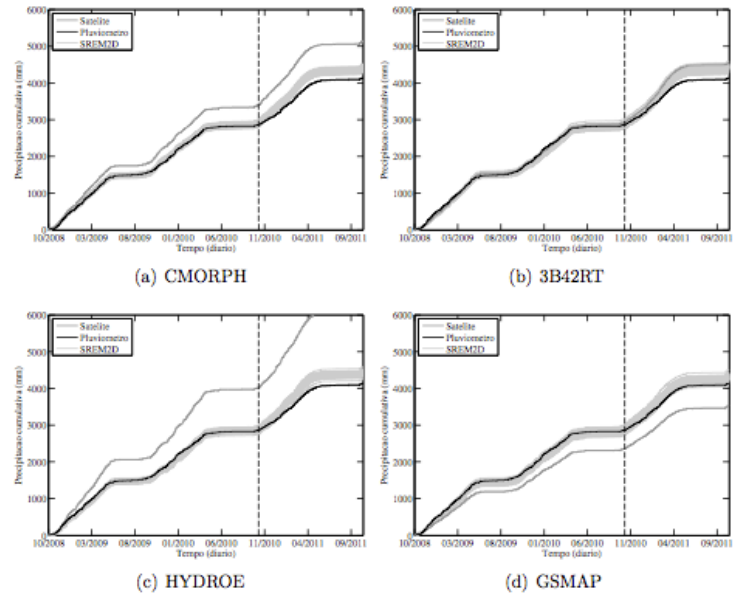
# Evaluation of satellite rainfall estimates on hydrological modeling of Tocantins-Araguaia basin

B19 - Tucuruí | B08 - Xambioá | B12 - Jacinto



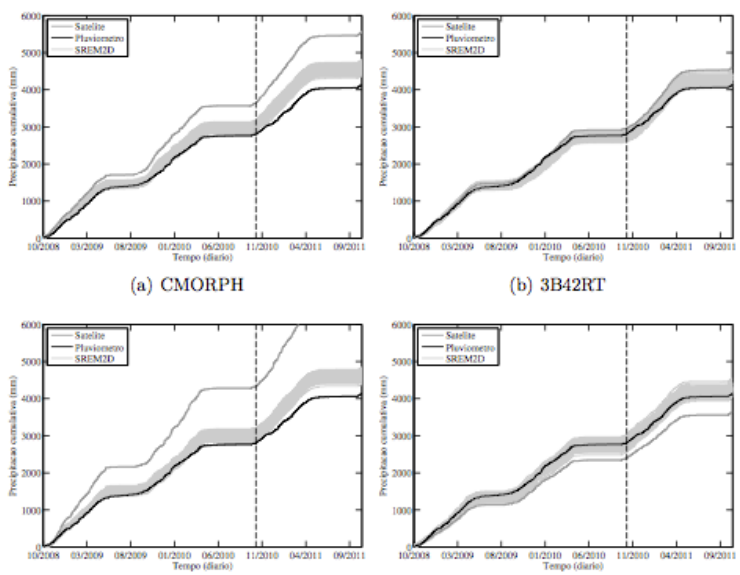
(a) B19 764.000 km$^2$ (b) B8 377.000 km$^2$ (c) B12 13.900 km$^2$

B19



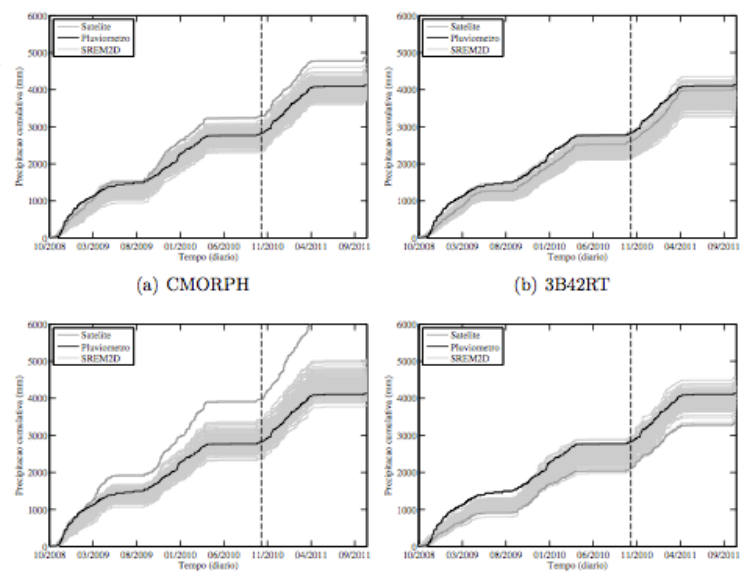

(a) CMORPH (b) 3B42RT (c) HYDROE (d) GSMAP

B08




(a) CMORPH (b) 3B42RT (c) HYDROE (d) GSMAP

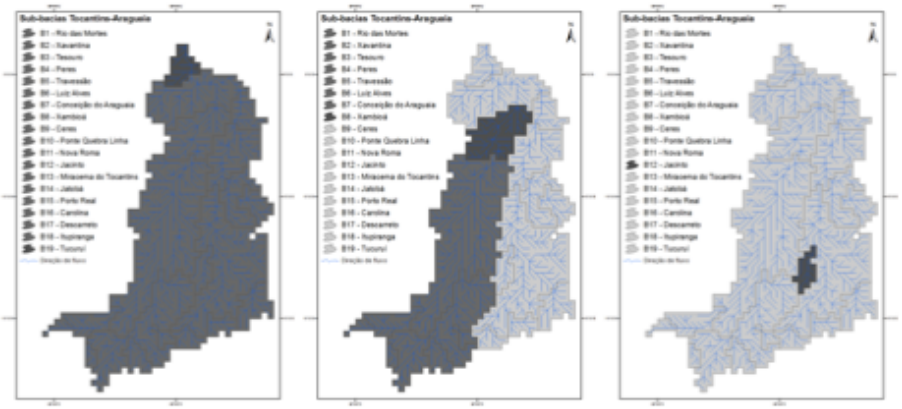
B12




(a) CMORPH (b) 3B42RT (c) HYDROE (d) GSMAP

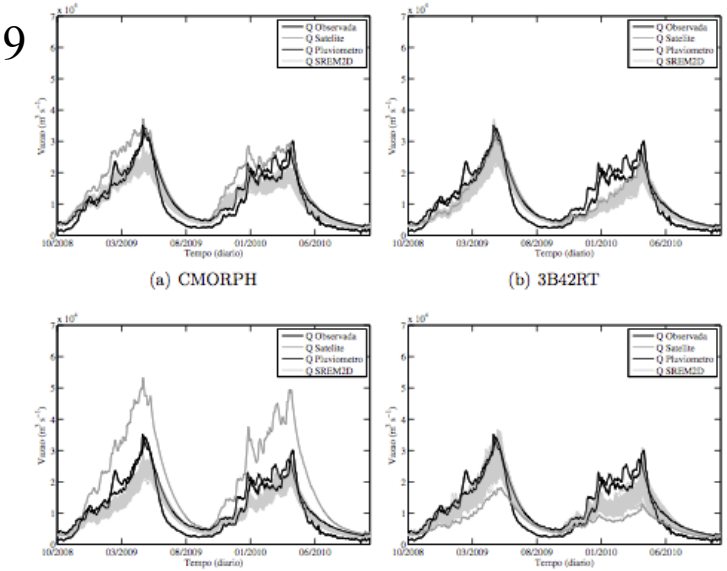
# Evaluation of satellite rainfall estimates on hydrological modeling of Tocantins-Araguaia basin

B19 - Tucuruí | B08 - Xambioá | B12 - Jacinto



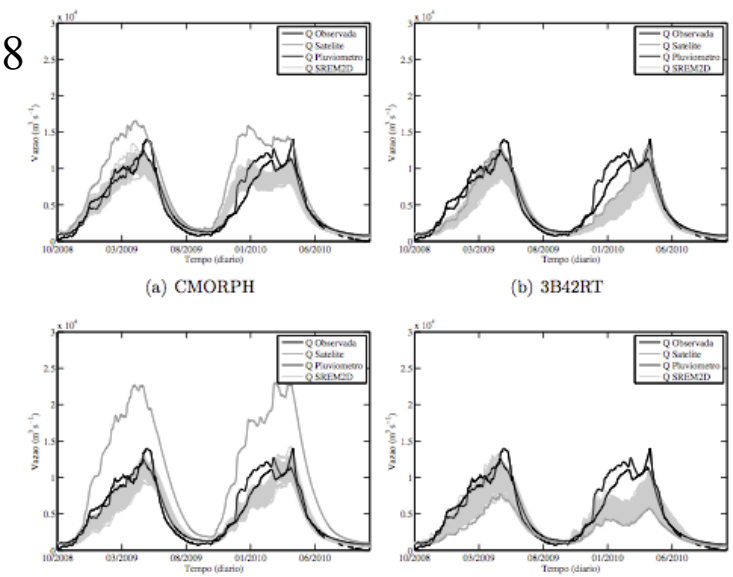
(a) B19 764.000 km$^2$ | (b) B8 377.000 km$^2$ | (c) B12 13.900 km$^2$

B19



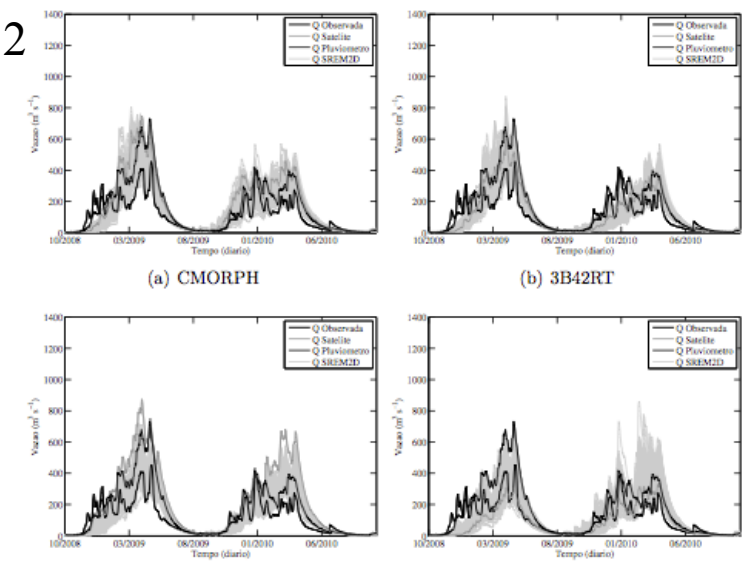

(a) CMORPH (b) 3B42RT (c) HYDROE (d) GSMAP

B08




(a) CMORPH (b) 3B42RT (c) HYDROE (d) GSMAP

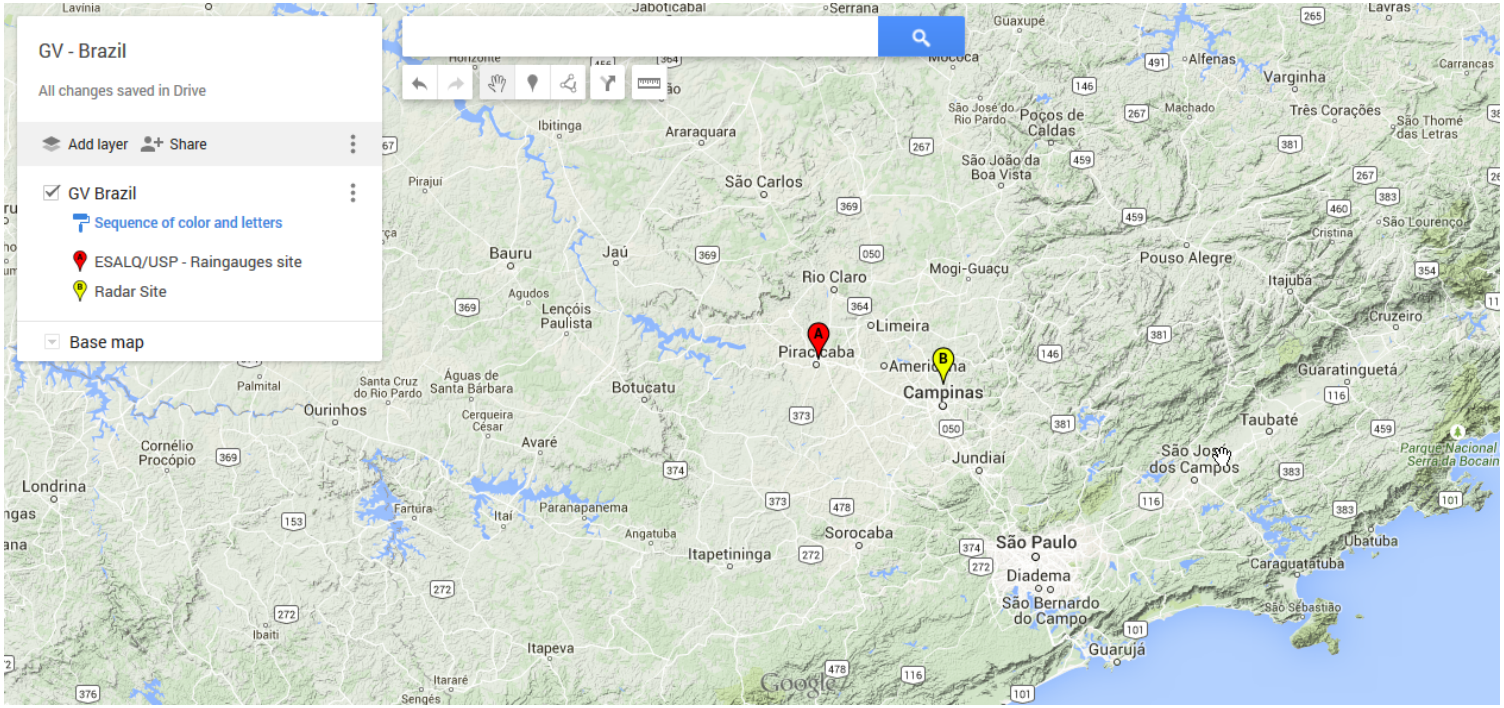
B12




(a) CMORPH (b) 3B42RT (c) HYDROE (d) GSMAP

# New Ground Validation Sites in Brazil

Severe Weather Nowcasting and Microphysical Process inside the Clouds (to be submitted at NASA as GPM proposal at no-cost)

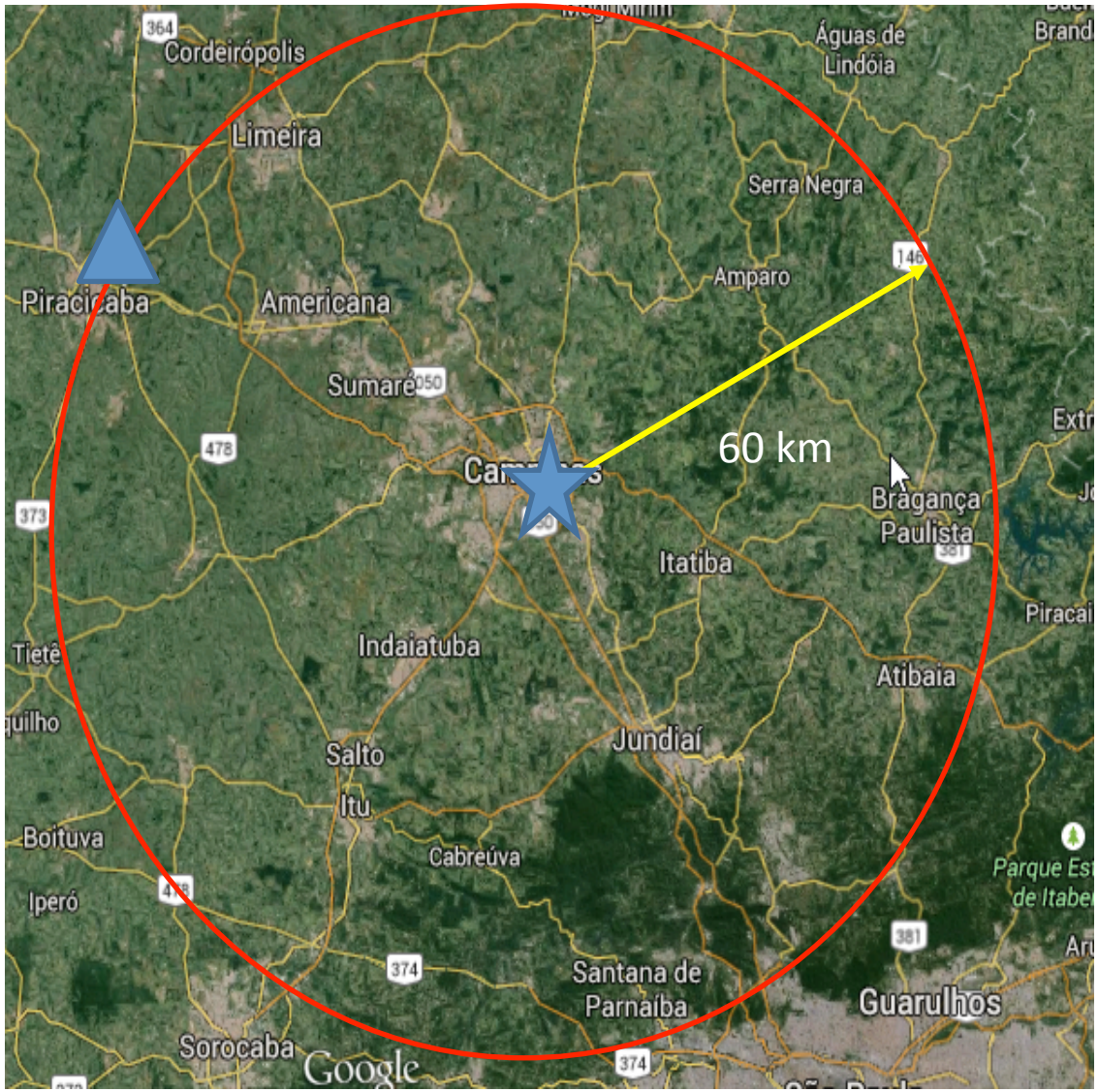


# New Ground Validation Sites in Brazil

Radar Site – X Band
– dual polarization

# New Ground Validation Sites in Brazil

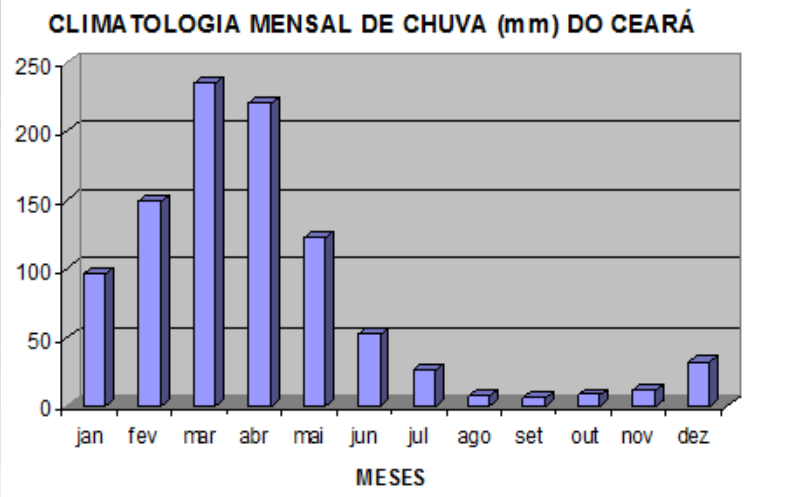
# New Ground Validation Sites in Brazil

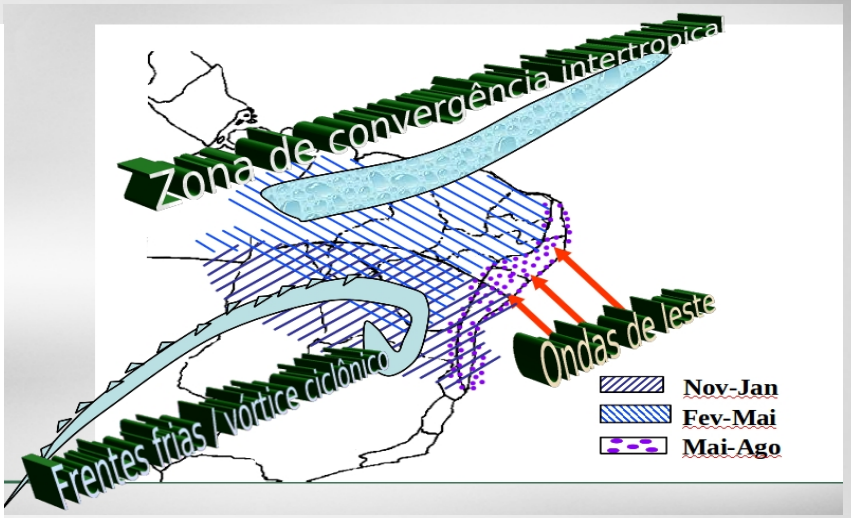


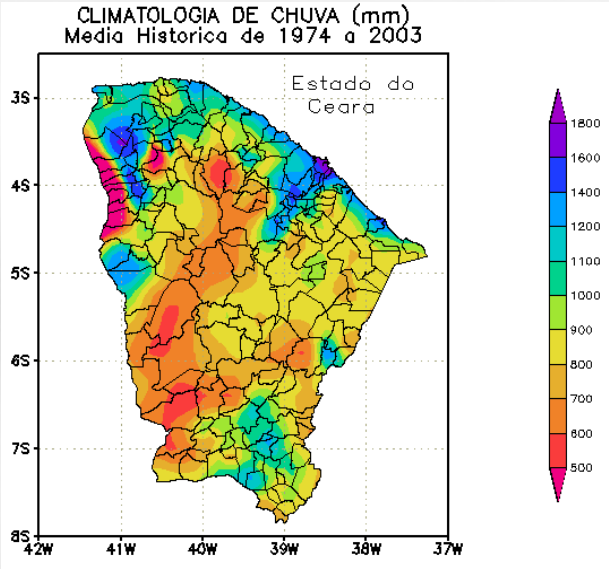

## Experiment Overview

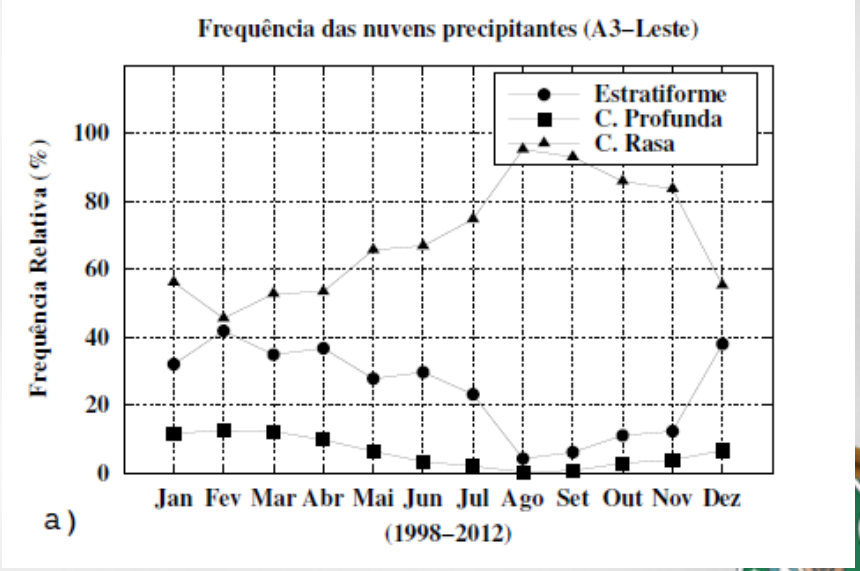
- 10-minutes VolScan and RHI w/GPM overpasses
- Radar calibration using gauge network --> ~ same resolution.
- 3 disdrometers at radar site, 10km and gauge site
- Hail-pads
- 6 field mills and GPS network
- Brasildat Lighting Network data
- 2-years continuous operation experiment (Oct 2015 – Sep 2017)

# Climatologia do Ceará



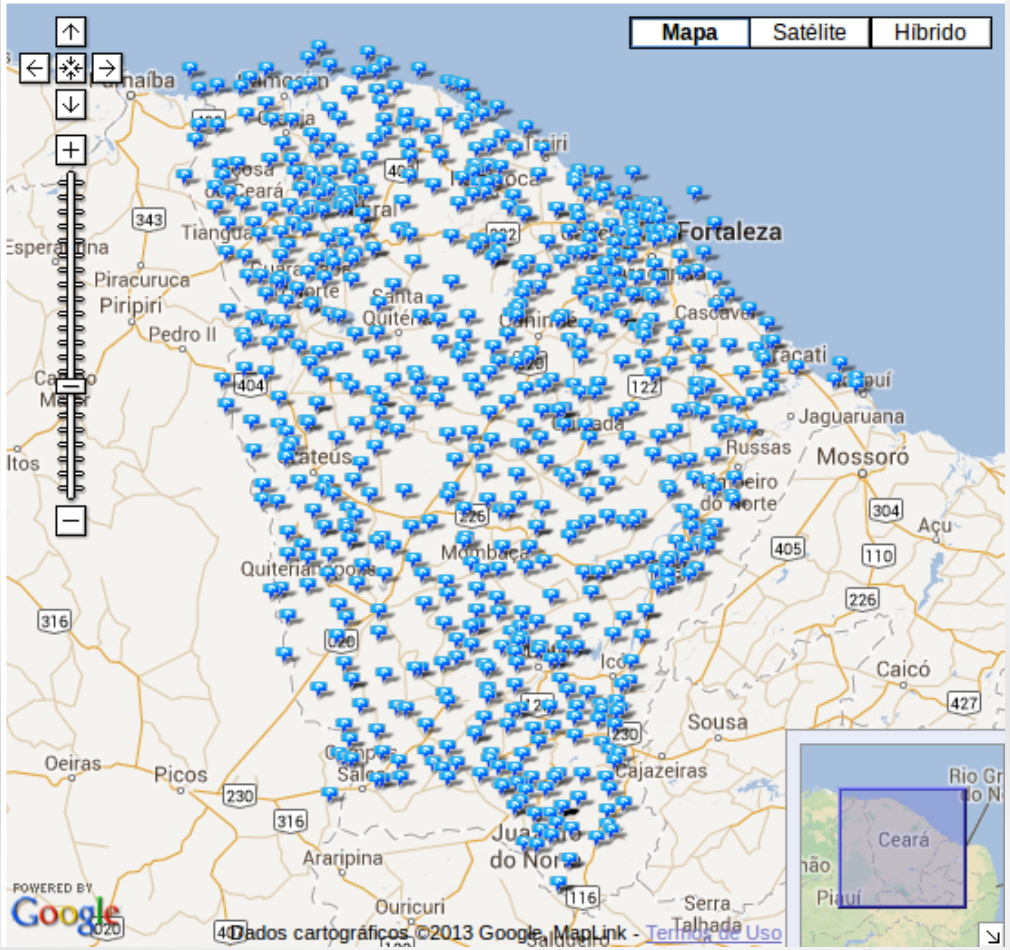



# UNIDADE DE MONITORAMENTO / NÚCLEO DE METEOROLOGIA

## REDE DE PLUVIÔMETROS CONVENCIONAIS DO ESTADO DO CEARÁ




Mapa com Localização dos Pluviômetros

Leitura da chuva no pluviômetro

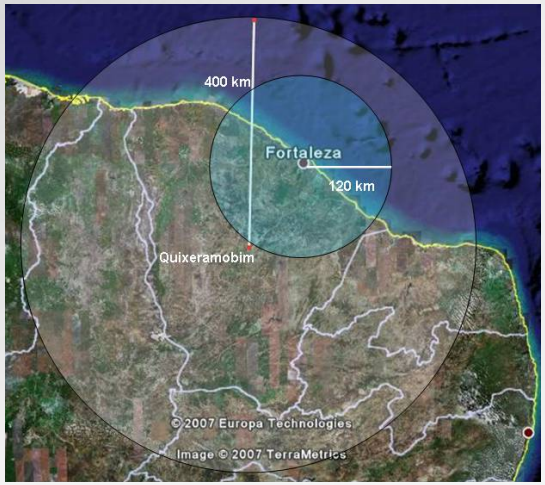
FUNCEME

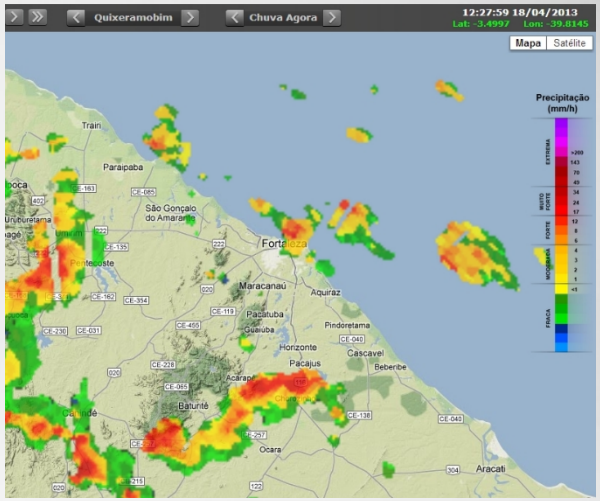
Governo do
Estado do Ceará
Secretaria de Recursos Hídricos

# UNIDADE DE MONITORAMENTO / NÚCLEO DE METEOROLOGIA

## Rede Cearense de Radares Meteorológicos

Área de Cobertura




Banda-S

Banda-X (Fortaleza)

Banda-S (Quixeramobim)

Banda-X

Governo do
Estado do Ceará
Secretaria de Recursos Hídricos

CHUVA PROJECT

CPTEC

# Thanks