

Thunderstorm activity over South
America as inferred from the **S**ferics
Timing **A**nd **R**anging **NET**work –
STARNET

<http://www.zeus.iag.usp.br>

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Introduction

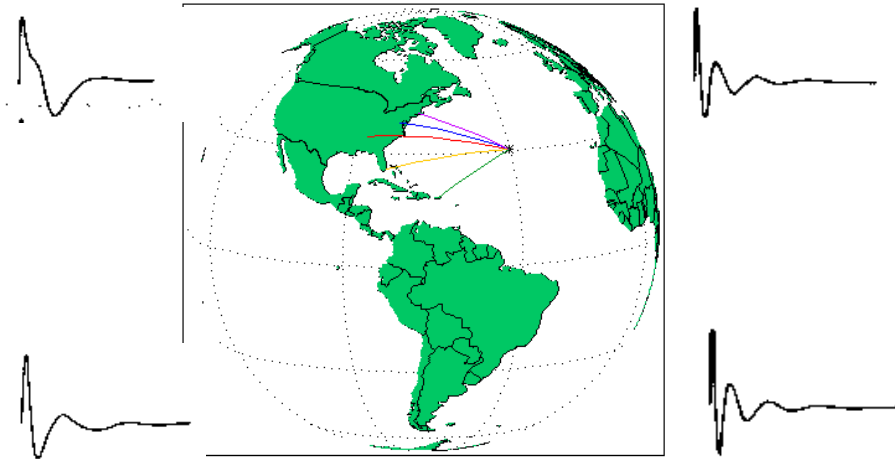
- STARNET is a long range lightning network that uses Very Low Frequency (VLF) receivers to measure the radio noise emitted by lightning discharges in the frequency range of 7-15 kHz. STARNET network receivers were manufactured by Resolution Displays, Inc and employ the Arrival Time Difference (ATD) method to locate the sferics (Lee, 1986). The present VLF receivers are capable to measure up to 100 sferics per second and identify the lightning polarity (Morales et al., 2007).
- STARNET was deployed in 2006 with the installation of 3 antennas (Guadeloupe, Fortaleza and São Paulo) that were integrated with African receivers (Nigeria, Ethiopia, Tanzania, and South Africa) of World-ZEUS. During 2007-2009, four more antennas were installed in Brazil (Campo Grande, São Martinho da Serra, Brasilia and Manaus).
- In the present study, we evaluate the STARNET performance during year of 2009 by comparing its observations with the ones measured by the Brazilian Lightning Detection Network – RINDAT and the Lightning Imaging Sensor – LIS

Locations of STARNET VLF antennas

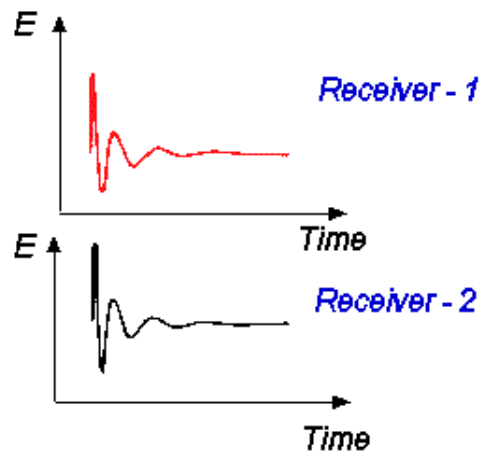


Since 2009, 8 VLF antennas are operating, i.e., 1 Guadeloupe, 6 in Brazil (Fortaleza, Manaus, Brasilia, Campo Grande, Sao Martinho da Serra and Sao Paulo), and 1 in Halmilton (South Africa)

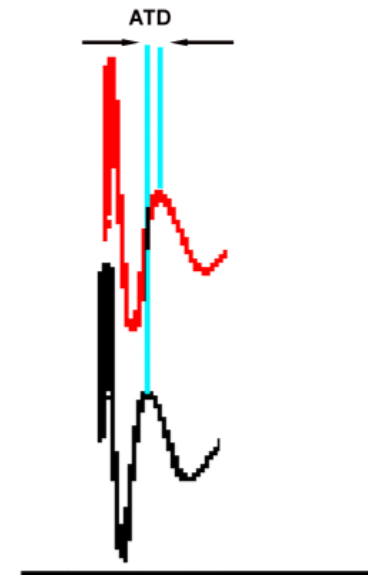
Arrival Time Difference – ATD technique (Lee, 1986)



Continuous measurement of E_z

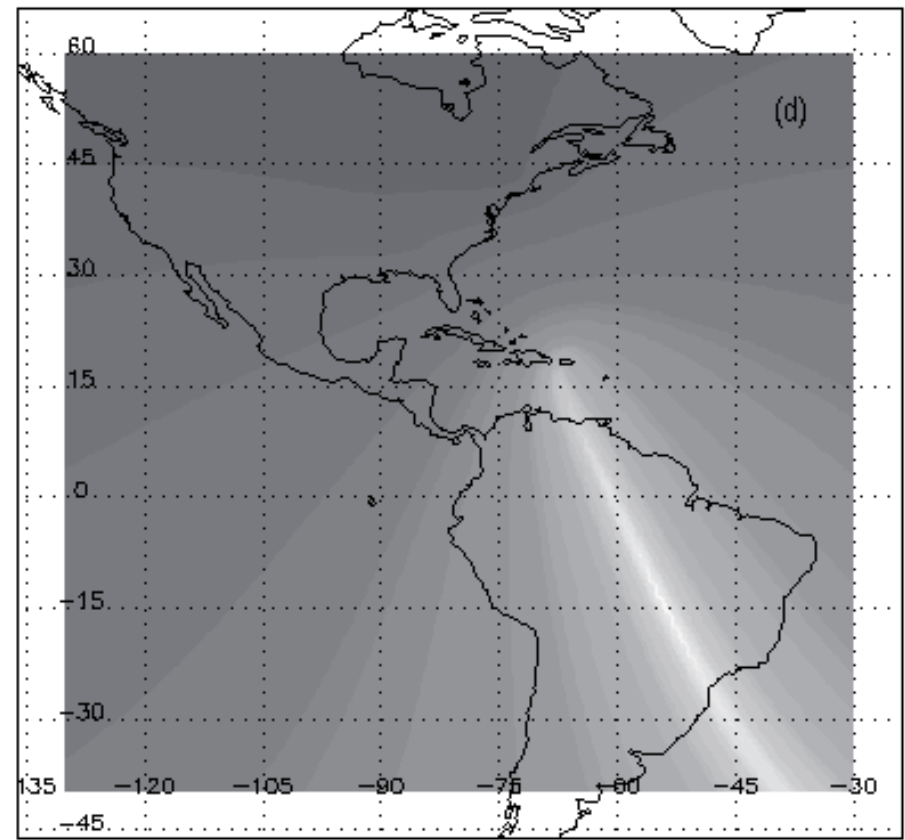
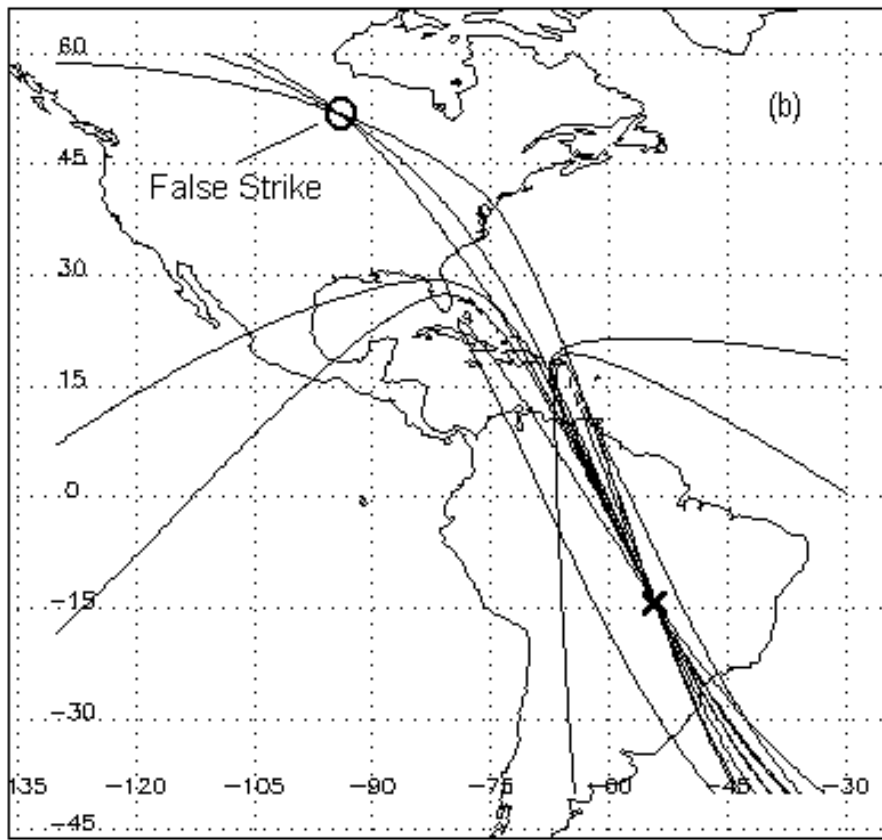


Time Correlation between 2
sferics waveforms define an
ATD

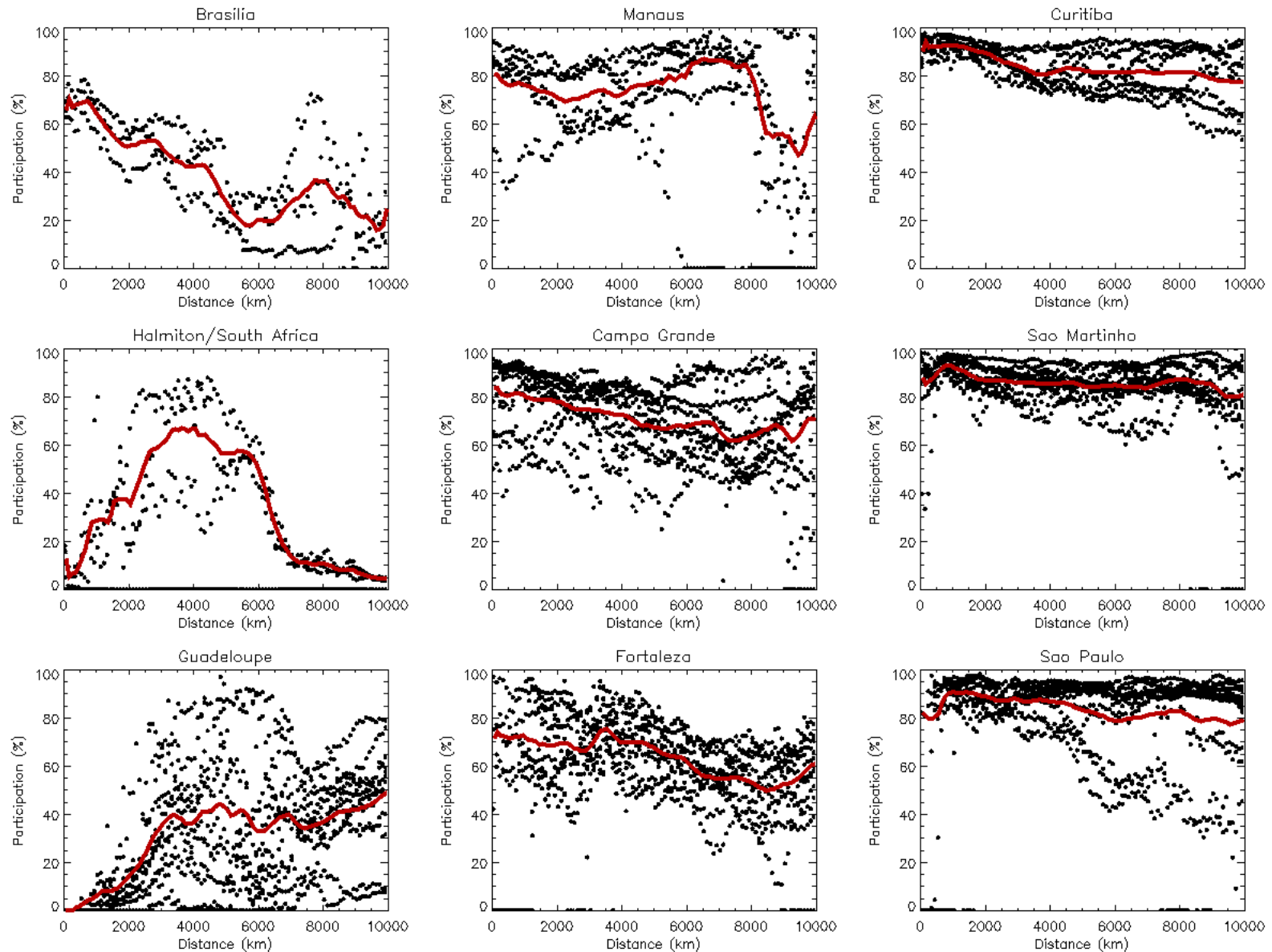


Sferics position, Lee (1986)

$$\chi^2 = \frac{1}{N-2} \sum_{i=1}^{N_{ATD}} \left\{ \frac{ATD_i^{simulated} - ATD_i^{measured}}{\sigma_i} \right\}^2$$

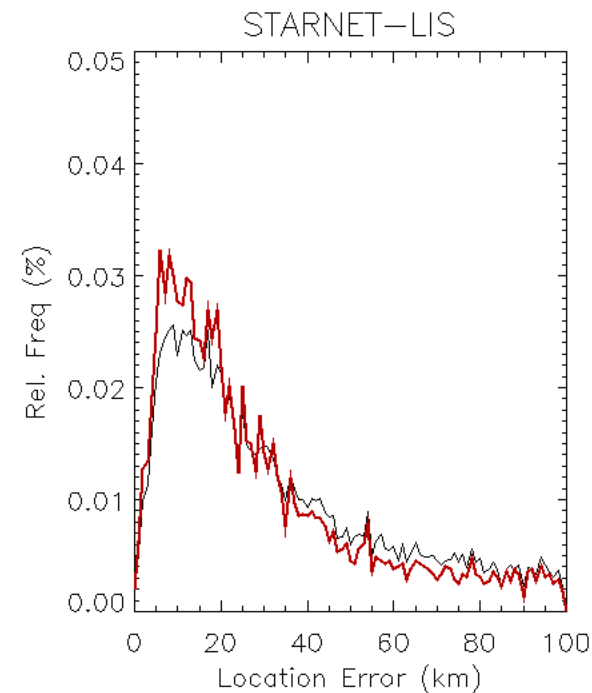
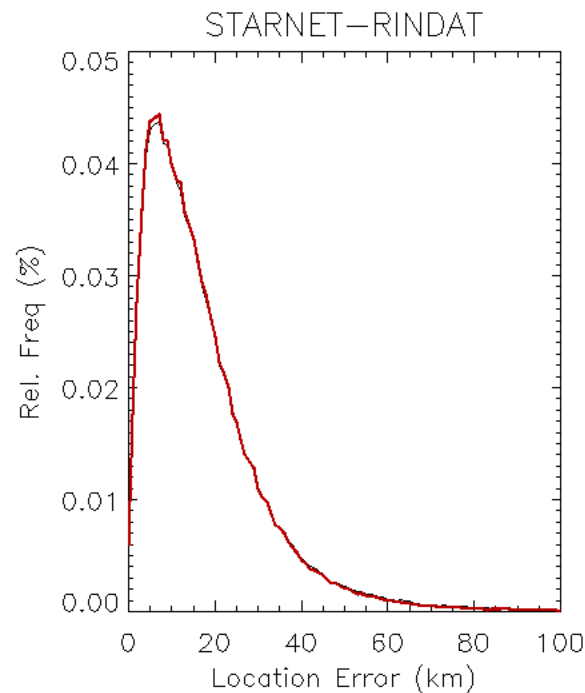


Antenna participation

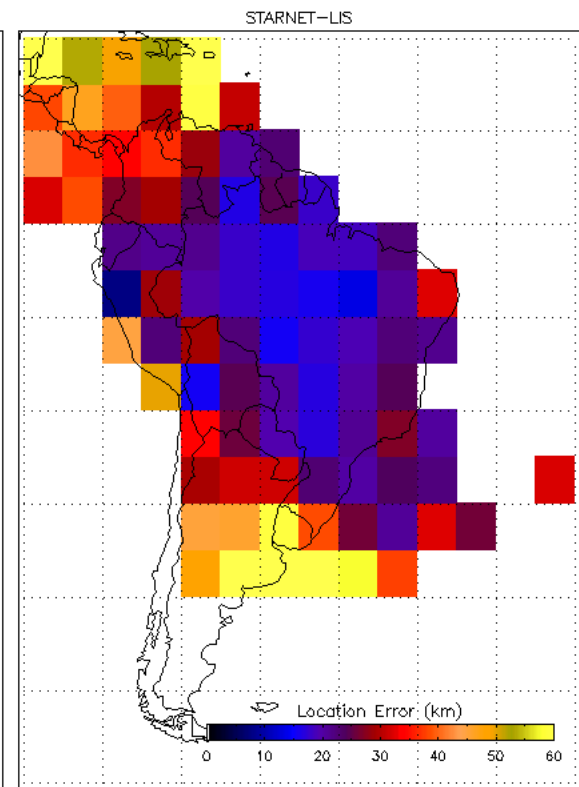
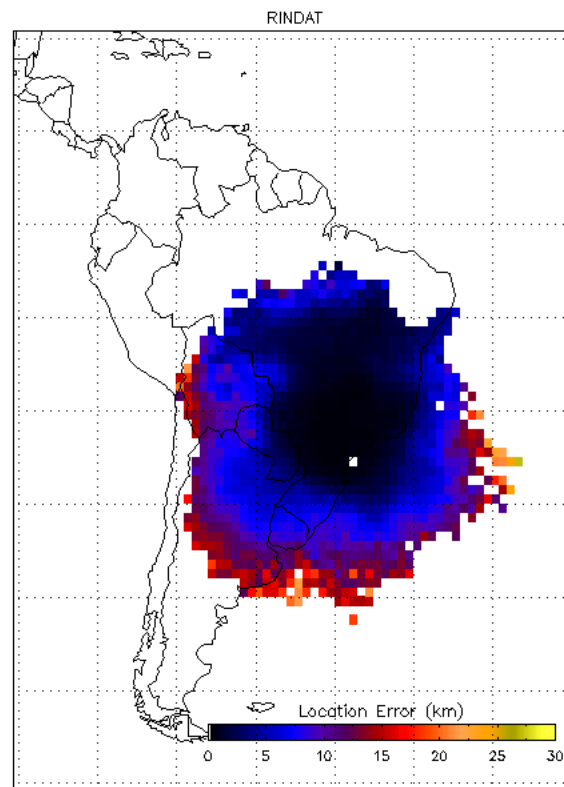
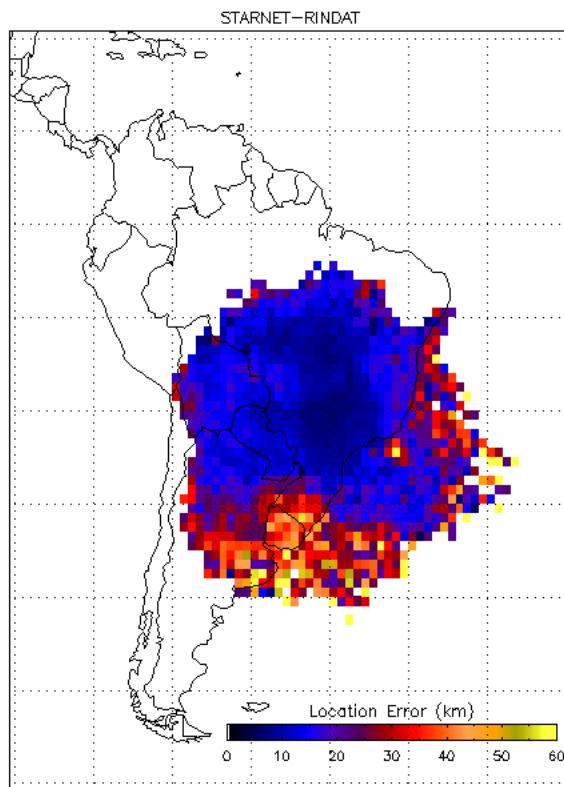


Location Errors

- Data employed as our consolidated “ground truth”:
Brazilian Lightning Detection Network – **RINDAT**. 47 LPATS/IMPACT antennas that cover most of the South, Southeast and Center of Brazil.
Accuracy: 0.5-2 km.
Lightning Imaging Sensor – **LIS** – Accuracy: ~ 10km
- Coincident matches
Time constrain of 0.001 second for STARNET/RINDAT - Sferics/Strokes
Time constrain of 0.33 seconds for STARNET/LIS – Sferics/Events
- Period: **2009**



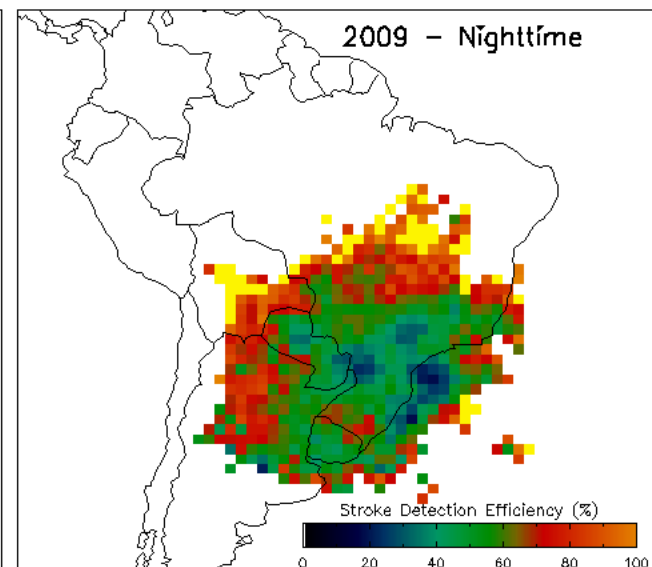
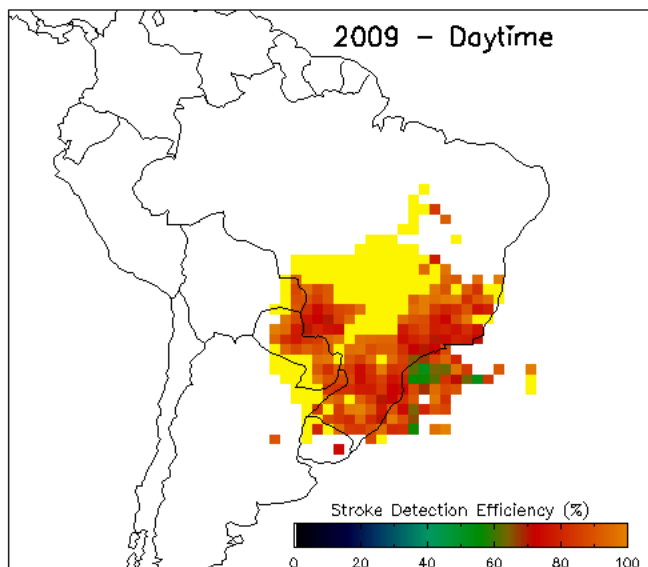
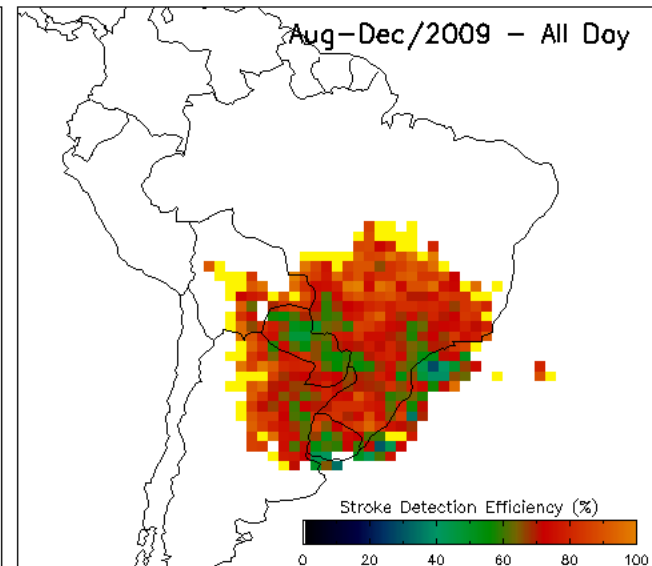
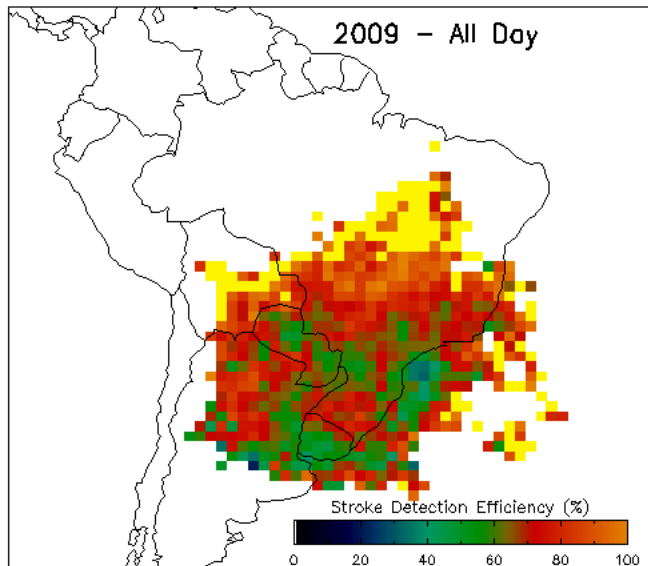
Mean Errors (km)	RINDAT	LIS All Domain	LIS Brazil
Arithmetic	17.7	86.32	82.41
Harmonic	8.43	22.08	19.23
Geometric	12.97	47.57	42.15
# of Matches	306,875	22,956	6,538



Detection Efficiency

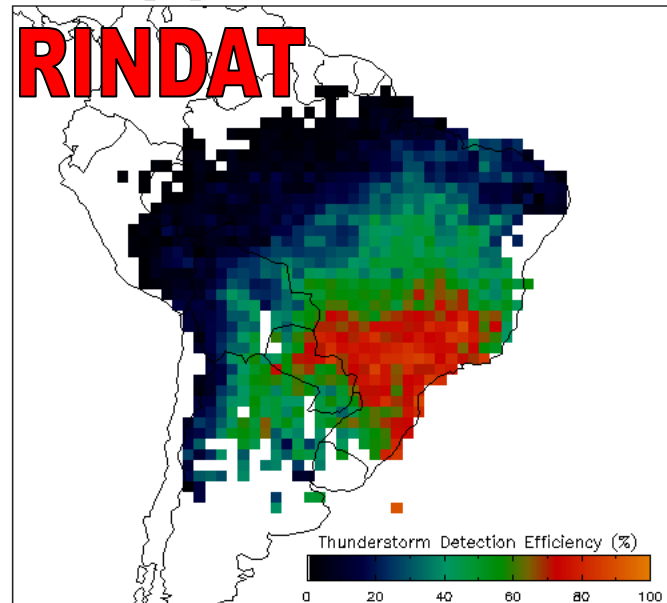
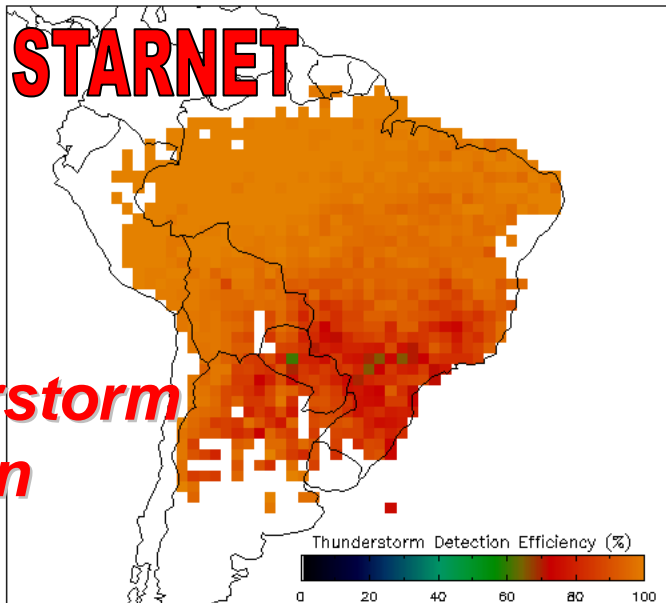
- To evaluate the detection efficiency we have employed 2 approaches
 - a) **Grid/Temporal:** Both STARNET and RINDAT are binned in grids of 1x1 degree with 15 minutes time interval. For each grid that has at least 10 strokes from RINDAT, we compute the ratio between the number of sferics occurrences (STARNET) by the number of observed strokes (RINDAT). Later, we compute the mean value for the hour and for each grid box.
 - b) **Thunderstorm:** Evaluation of the ratio between the lightning occurrences observed by STARNET and RINDAT for each thunderstorm. For each GOES-IR image, we delineate all the cloud clusters that have brightness temperature (T_b) lower than 258 K. Then, we collocate the observed lightning observations in a time window of ± 15 min of the IR image and count how many sferics/strokes were observed in each thunderstorm. For the calculations, only Thunderstorms clusters with radius less than 70 km were considered. Finally, we compute the thunderstorm detection and the mean thunderstorm lightning detection efficiency for each 1 x 1 grid box.

Grid/Temporal Approach:

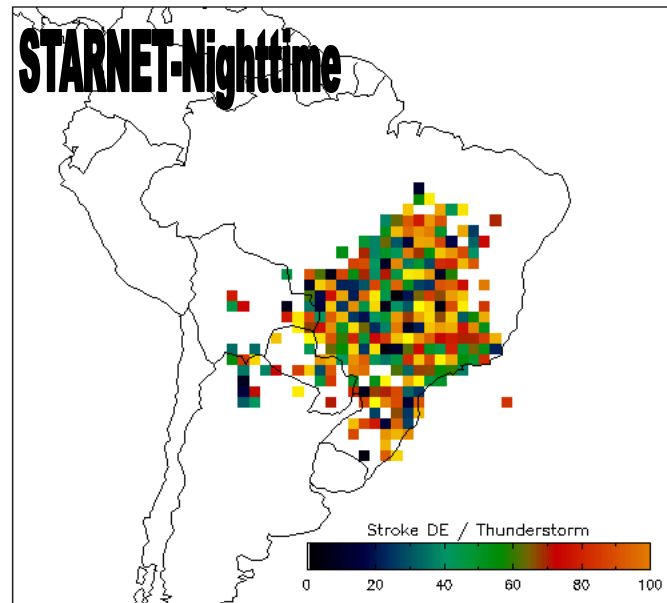
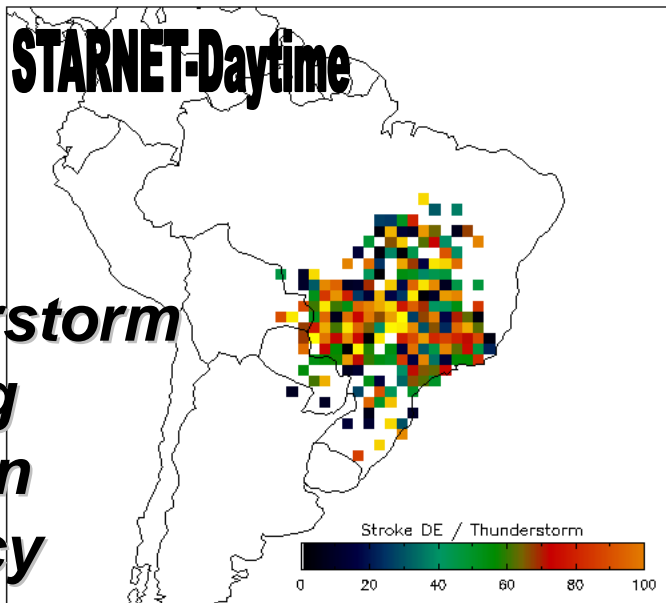


Thunderstorm Approach:

**Thunderstorm
detection**



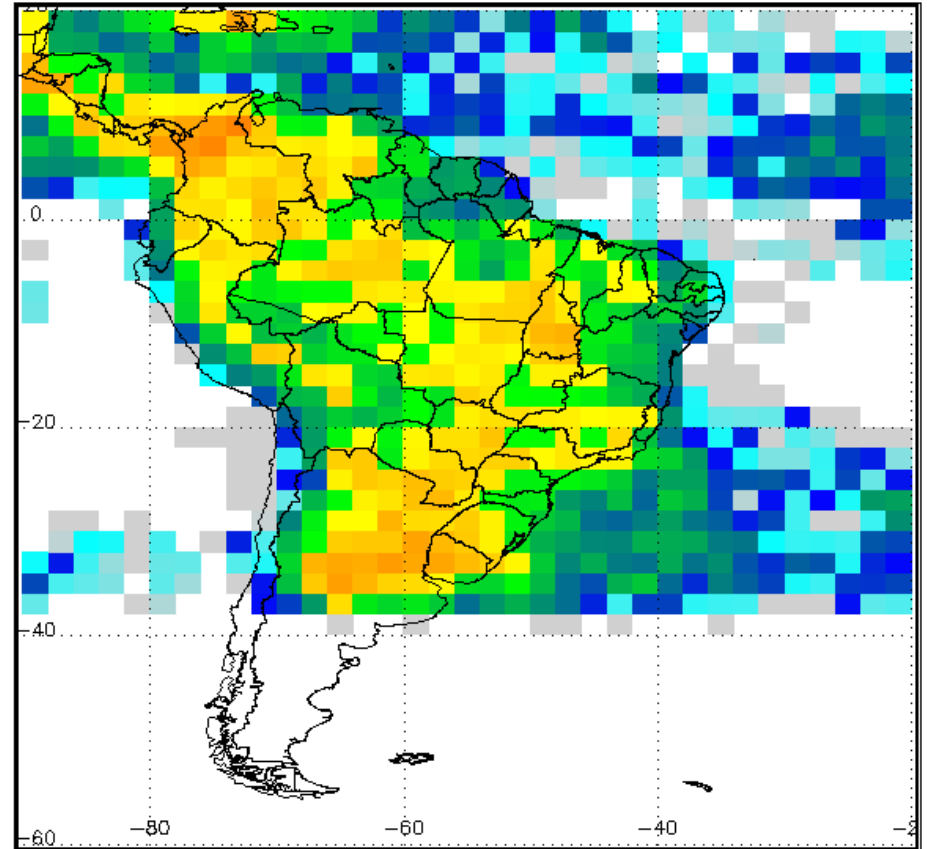
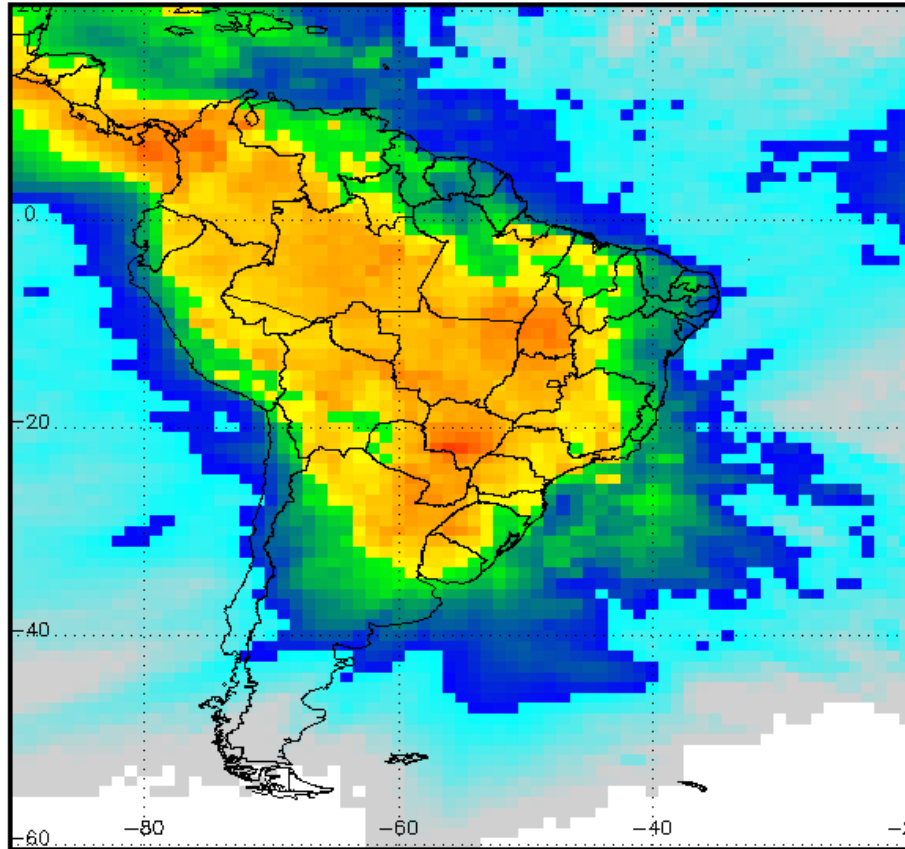
**Thunderstorm
lightning
detection
efficiency**



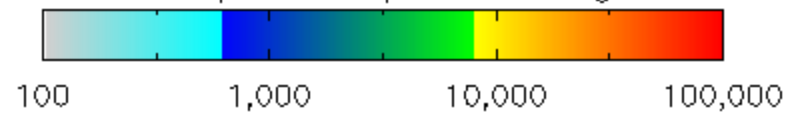
Annual activity

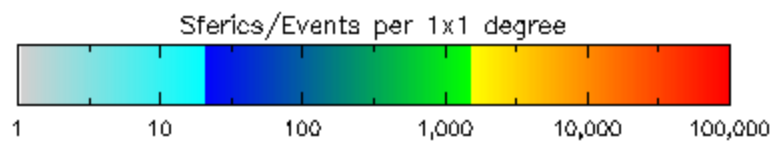
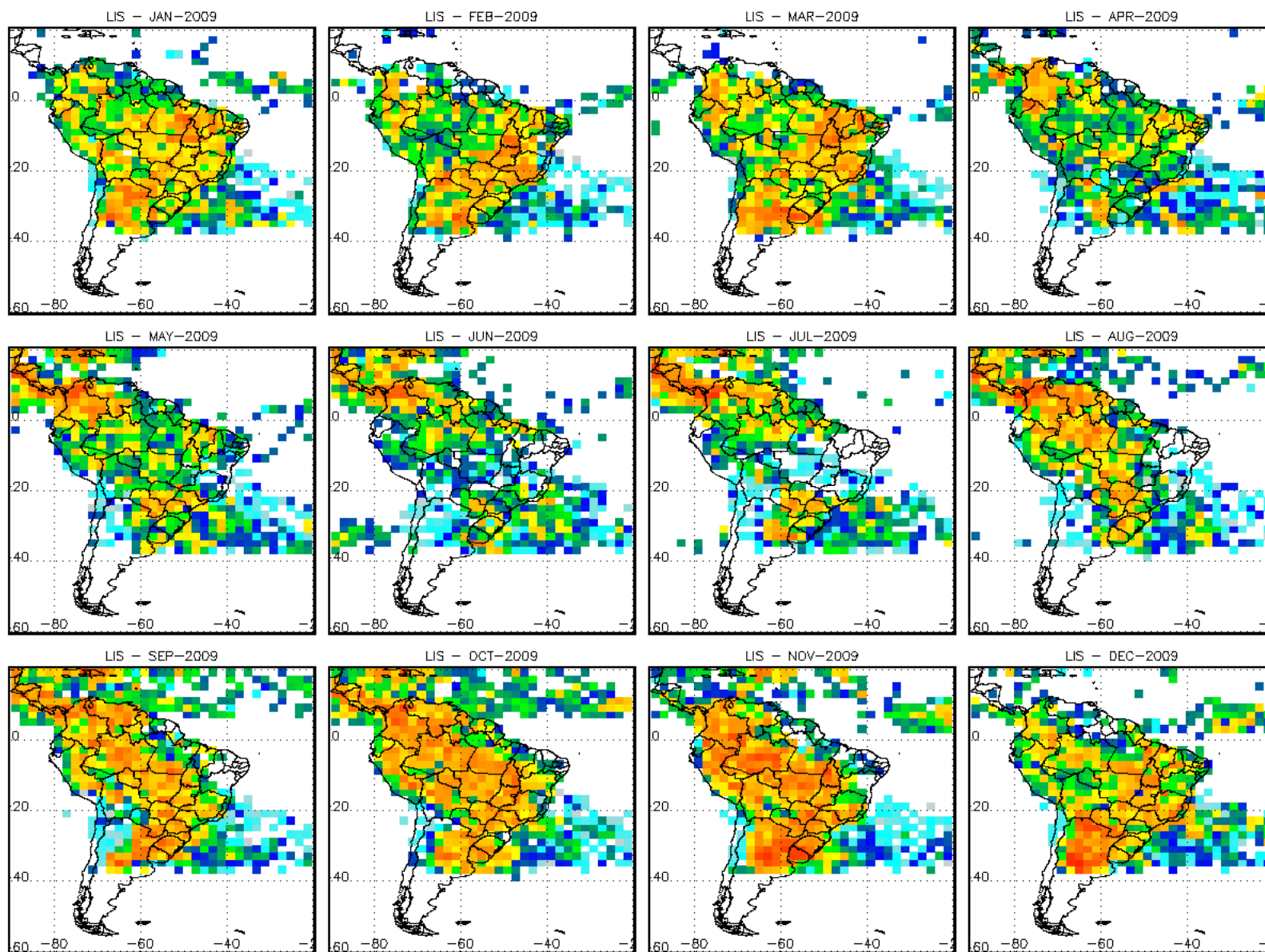
STARNET/2009

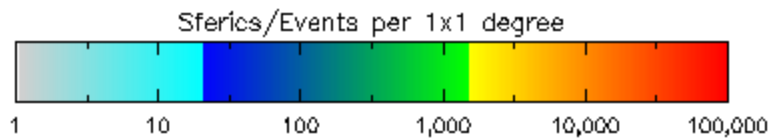
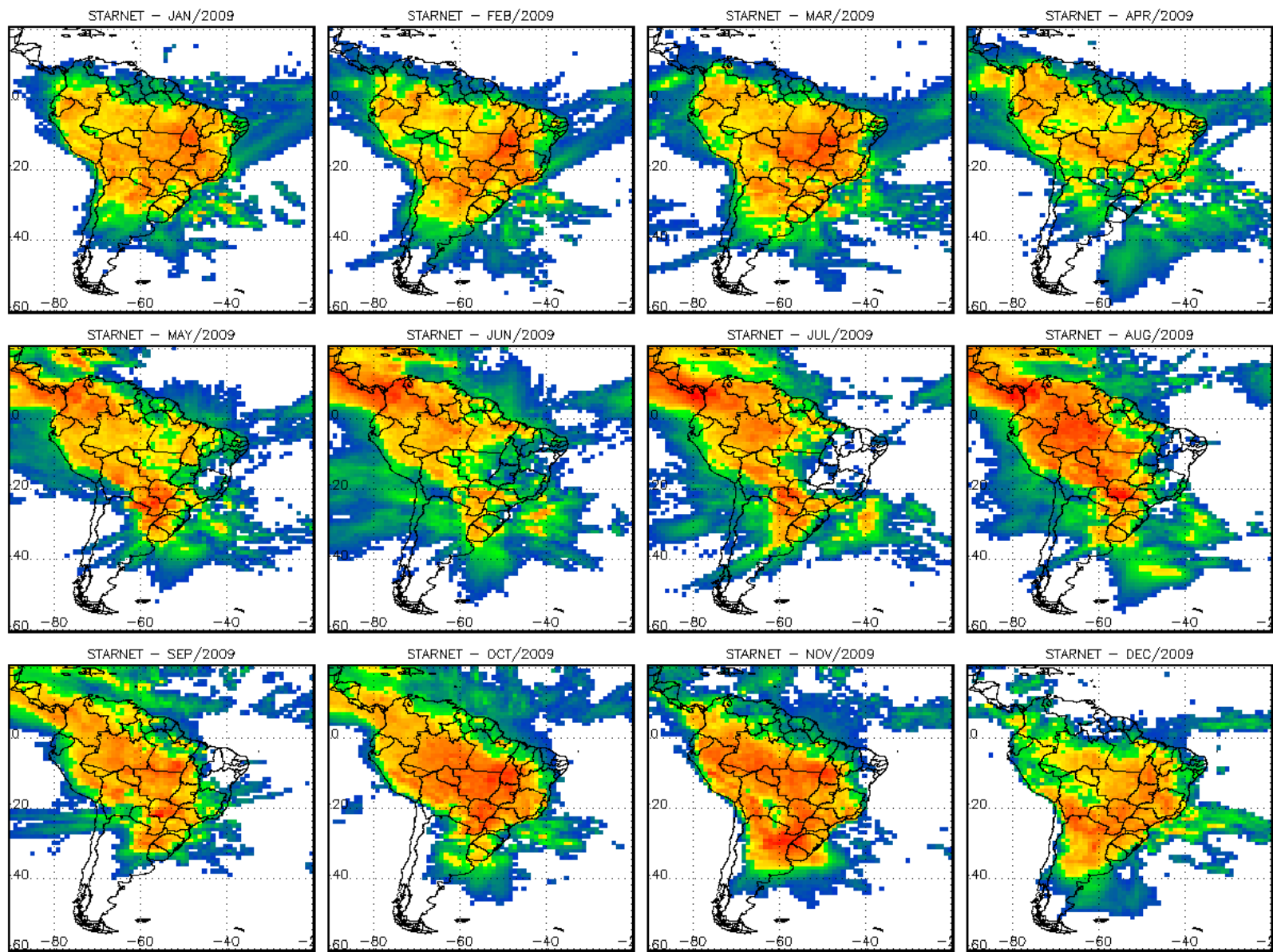
LIS/2009



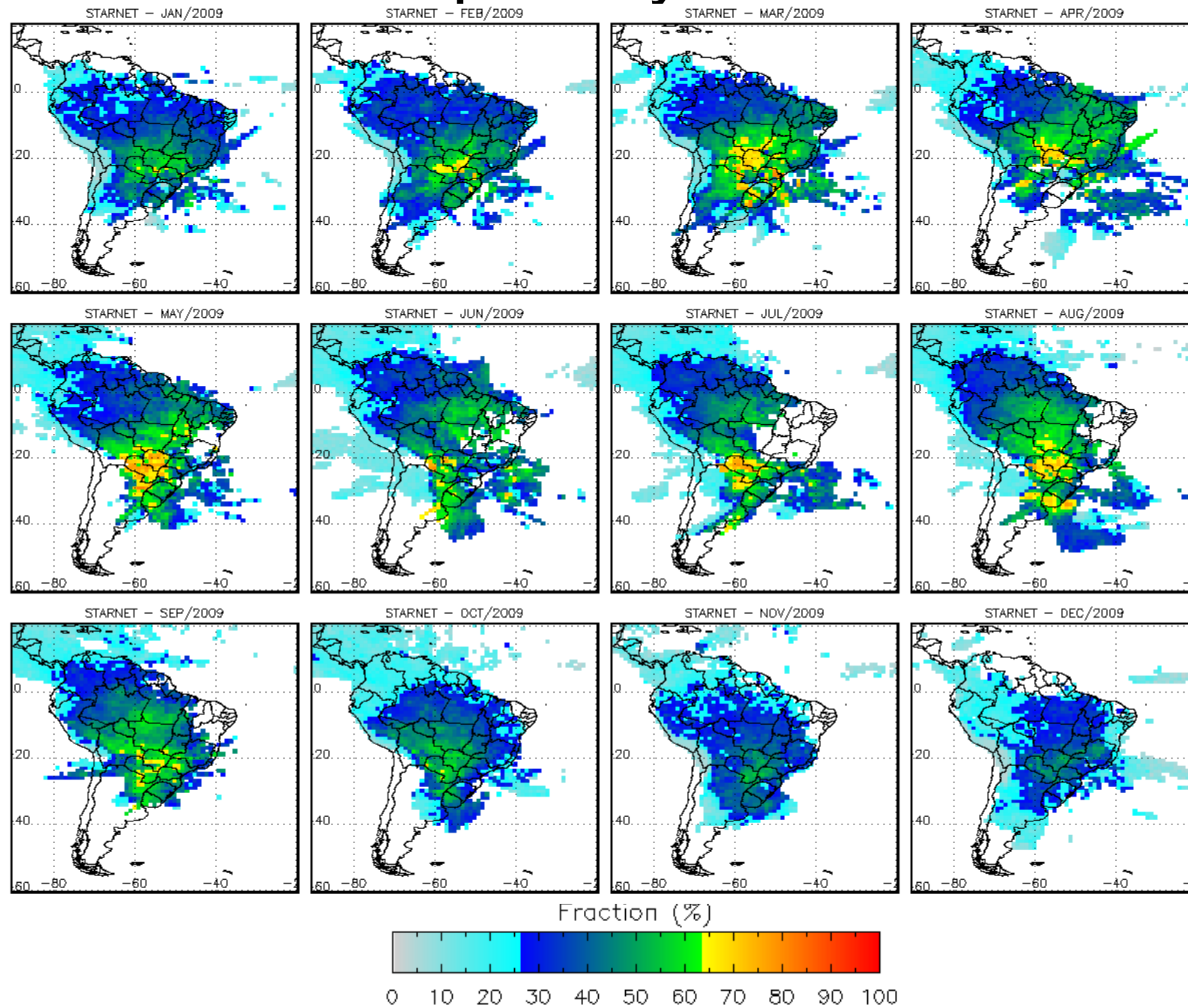
Sferics/Events per 1x1 degree

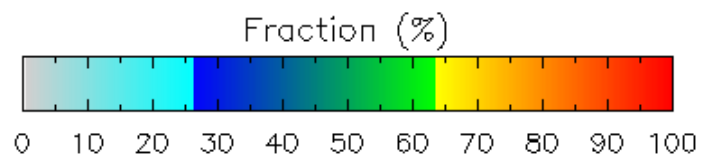
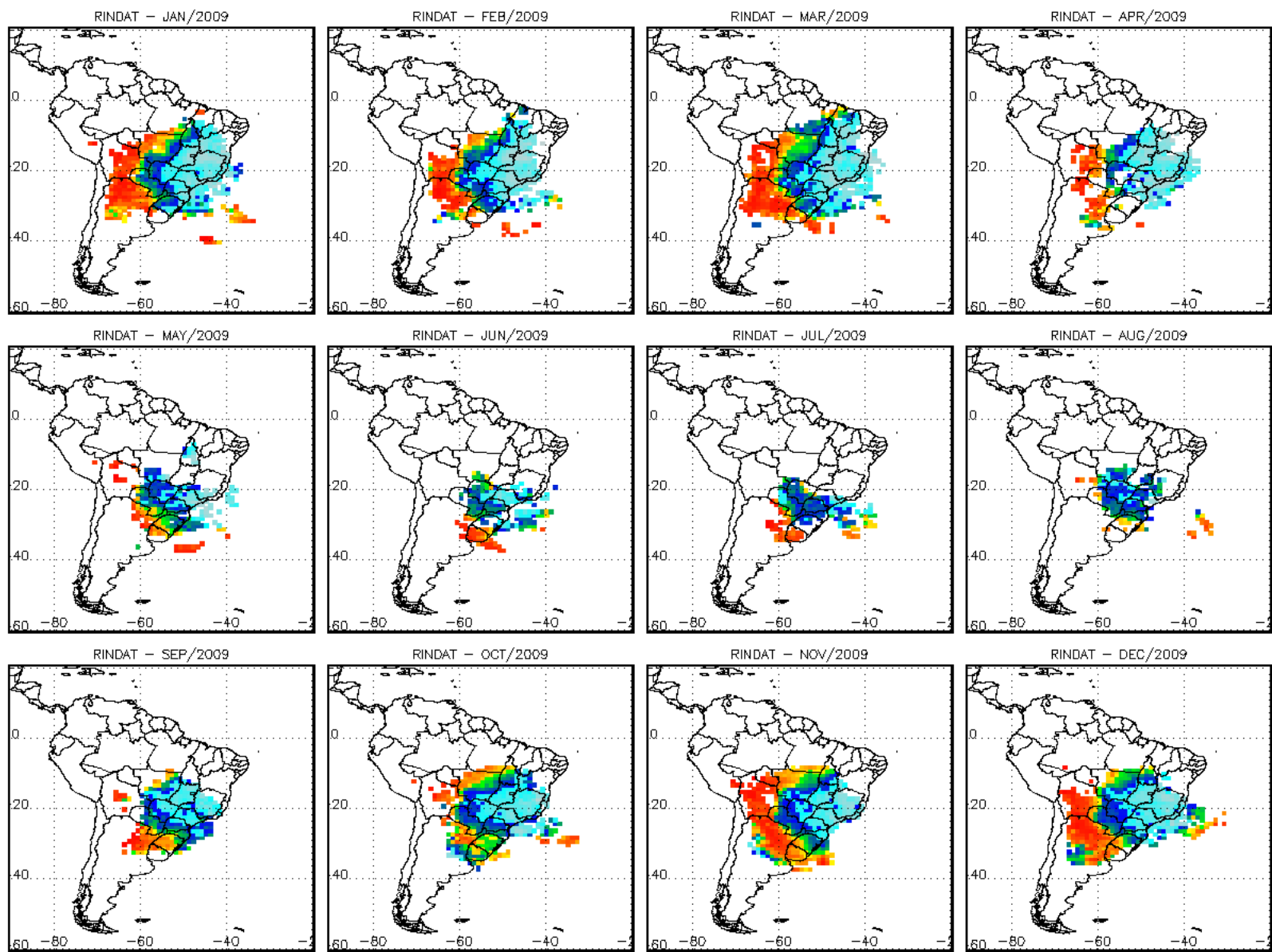






Positive polarity contribution





STARNET web interface

<http://www.zeus.iag.usp.br>

Realtime data

Re-processed data

Google interface

Thunderstorm Alerts

Rainfall Estimation – SIRT

FTP area



STARNET - SFERICS TIMING AND RANGING NETWORK

Em 1997 nasce a rede experimental de detecção de descargas atmosféricas a longa distância, "Sferics Timing And Ranging NETWORK (STARNET)". A STARNET foi concebida pela Resolution Display Inc (RDI) a partir do programa de desenvolvimento inovativo de pequenas empresas da NASA. A RDI desenvolveu um sistema que consistia de cinco antenas rádio receptoras na faixa de frequência de VLF (7-15 kHz) que estavam situadas ao longo da costa leste dos EUA e em Porto Rico. Sferics é o ruído de rádio emitido por descargas atmosféricas dentro de uma grande faixa do espectro eletromagnético. Na faixa de frequência do VLF, este sinal pode se propagar a milhares de quilômetros de distância dentro do guia-de-onda formado pela ionosfera e a superfície terrestre. Esta rede experimental operou até 1998.

Em 2003, a National Science Foundation através do programa de Ciclo da Água financiou a compra e a operação de 4 receptores de rádio sobre o continente Africano. Estes receptores foram integrados com a rede de descargas atmosféricas - ZEUS do Observatório Nacional de Atenas (NOA). Esta configuração possibilitou um contínuo monitoramento das tempestades sobre os continentes Europeu e Africano até 2005.

Através de um projeto de Pesquisa e Desenvolvimento (P&D) da Companhia Energética do Ceará (COELCE) em 2006, a Universidade Estadual do Ceará (UECE) e a Universidade de São Paulo (USP) instalaram duas estações de VLF no Brasil. No mesmo ano, a Universidade de Nevada em Las Vegas financiou uma outra antena que foi instalada no Caribe. Estas 3 novas antenas foram integradas com os quatro sensores da África em uma tentativa de incorporar todos os receptores que dispunham da tecnologia de VLF-Sferics.

A partir de projetos de pesquisa da Universidade de São Paulo e Universidade Estadual do Ceará, do Sistema de Proteção da Amazônia (SIPAM) e do Sistema Meteorológico do Paraná (SIMEPAR) foram adquirido mais 3 antenas de VLF em 2008. Em Agosto de 2008 foi instalada uma antena em São Martinho da Serra (RS) enquanto que em Dezembro de 2008 foi a vez de Curitiba (PR).

Dessa maneira, a rede STARNET está operando no momento 7 sensores de VLF que estão instalados em Bethlehem (África do Sul), Guadeloupe (Caribe), Fortaleza (Brasil), São Paulo (Brasil), Campo Grande (Brasil), São Martinho da Serra (Brasil) e Curitiba (Brasil) enquanto que no primeiro semestre de 2009 a rede irá aumentar para 8 receptores de rádio, sendo que a nova antena será instalada em Manaus (Brasil). As antenas instaladas em Addis Ababa (Etiópia) e Dar es Salaam (Tanzânia) serão transferidas para localidades no oceano Atlântico de forma a auxiliar a formação dos furacões.

Desde o lançamento da STARNET, a atividade de descargas atmosféricas sobre as Américas, Caribe, oceano Atlântico e parte do continente Africano tem sido monitoradas continuamente em diferentes resoluções espaciais (ex: 5-20 km dentro da área de cobertura e > 50 km fora da área de cobertura dos sensores) e com uma alta resolução temporal (1 mili-segundo).

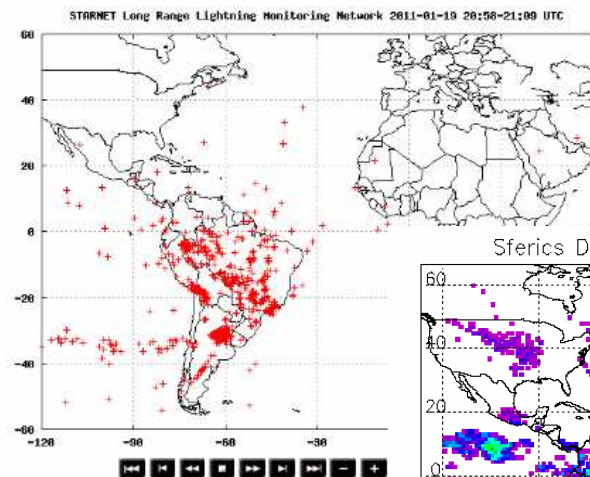
Esta série de dados sem precedentes no estudo da convecção, apresenta uma oportunidade original de avançar a pesquisa do ciclo da hidrológico nas regiões mais ativas da terra (África, Amazônia e ZCIT). A disponibilidade de monitoramento contínuo da atividade elétrica em uma área tão extensa, possibilitará aplicações em tempo real para as áreas de recursos hídricos (melhora da estimativa de precipitação), meteorologia (melhora da previsão quantitativa de tempestades convectivas com a assimilação contínua dos dados de descargas atmosféricas) e na segurança da aviação (prever regiões com movimento vertical intenso em nuvens, onde um avião deve evitar).



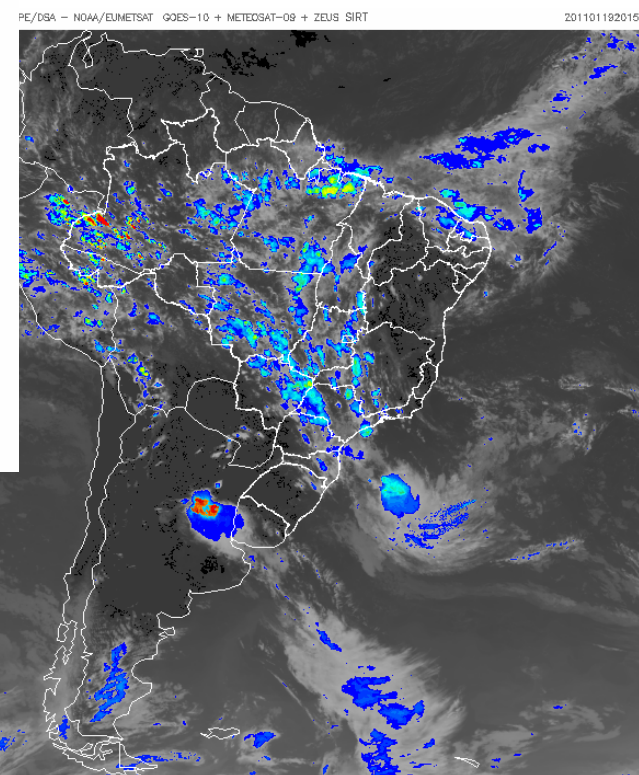
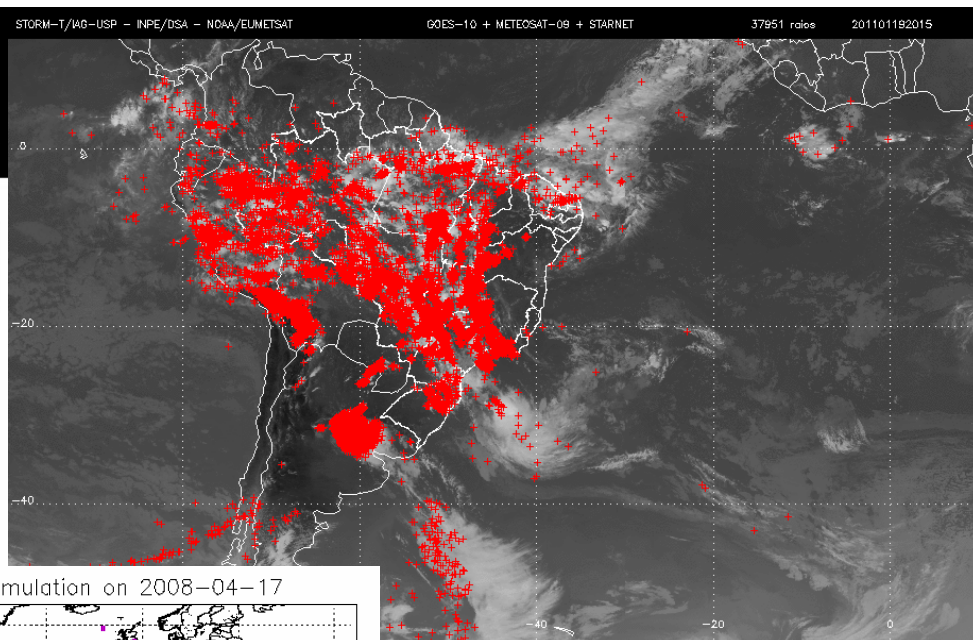
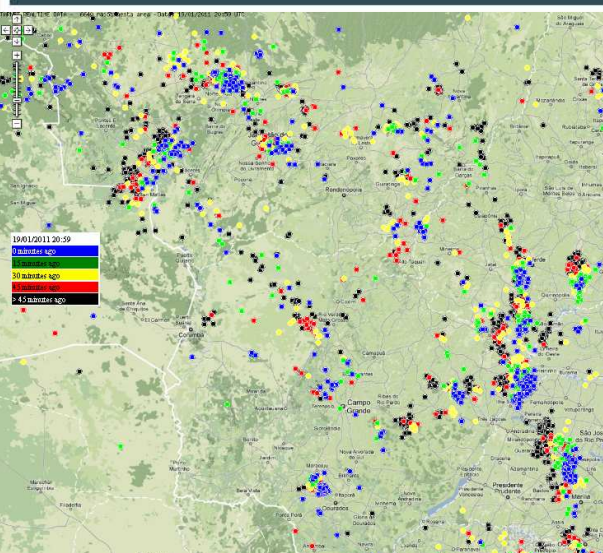
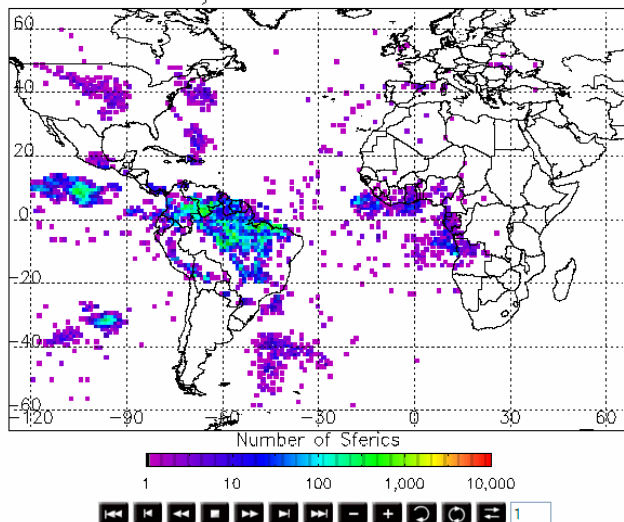
- Privacidade
- Descrição do Sistema
- Localização das Estações
- Publicações
- Contatos
- Agradecimentos
- Links
- DADOS EM TEMPO REAL**
- Tempo Real
- GOOGLE MAPS - Brasil
- Estações**
- Acumulação Horária
- Acumulação Diária
- Acumulação Mensal
- WSJ GLW**
- DADOS DE SATÉLITES**
- GOES + METEOSAT + STARNET
- Estimativa de Precipitação SIRT
- DOWNLOAD DE DADOS**
- FTP
- DADOS REPROCESSADOS**
- Dados de 2011-2009
- 15 minutos
- Acumulação Diária
- Acumulação Mensal
- Dados Arquivo
- DADOS DO AHMA**
- 15 minutos
- Acumulação Diária
- FTP

STARNET Sferics - Medições em Tempo Real

Initial Date: Day: 15, Month: 01, Year: 2006, Hour: 00, Minute: 00. Final Date: Day: 15, Month: 01, Year: 2006, Hour: 00, Minute: 00. Search: [Imagens da última hora]



Sferics Daily Accumulation on 2008-04-17



Conclusions

- STARNET has location difference of approximately 8-12 km when compared to RINDAT, while when it is compared to LIS it varies from 19-22 km. Taking into account that LIS has an accuracy of 10 km and RINDAT less than 2 km, ***the location accuracy of STARNET would be between 6 and 12 km.***
- In terms of **strokes detection efficiency**, STARNET measures **mainly 50%** of the RINDAT strokes in their best coverage area.
- For the **thunderstorm activity**, it is possible to state that STARNET measures more than **80% of them over South America**, i.e., clouds that have at least one sferic or stroke.
- The STARNET lightning distribution for 2009 is very similar to LIS, where both regions with high and low lightning activity are well represented.
- The polarity spatial distribution shows an increase on positive polarity over Mato Grosso do Sul, Paraguay and northern Argentina, coincident with the MCS activity.
- ***All STARNET sferics measurement are public released into our website, <http://www.zeus.iag.usp.br> (link ftp)***

Acknowledgments

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