

I Workshop da RBMC

Mapas da ionosfera com dados da RBMC: *comparação de modelos*

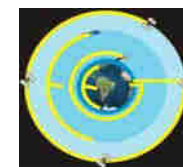
Fabricio S. Prol – *Mestrando PPGCC*

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FCT/UNESP – Presidente Prudente, SP

São Paulo, 19 de junho de 2013



SUMÁRIO

- Posicionamento GNSS
- GNSS x Ionosfera
- Comparação entre modelos da ionosfera
 - Mapas
 - Análises estatísticas
- Considerações finais

SUMÁRIO

- Posicionamento GNSS

- GNSS x Ionosfera

- **Comparação entre modelos da ionosfera**

- Mapas
- Análises estatísticas

- Considerações finais

Qual a discrepância dos valores de TEC entre os modelos que utilizam dados da RBMC?



SUMÁRIO

- Posicionamento GNSS

- GNSS x Ionosfera

- **Comparação entre modelos da ionosfera**
 - Mapas
 - Análises estatísticas

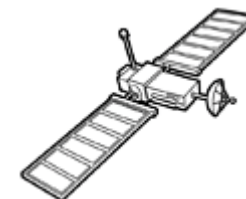
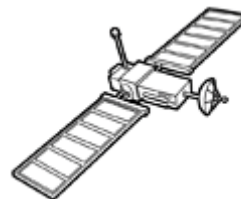
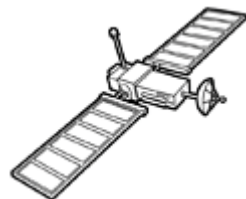
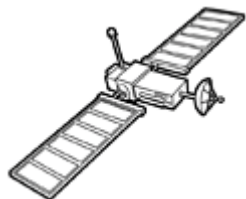
- Considerações finais

Qual a compatibilidade destes modelos com um modelo climatológico?



Posicionamento GNSS

- Densificação nos sistemas GNSS
 - GPS, GLONASS, GALILEU, BEIDOU
 - Densificação nos Sistemas de Controle Ativo (SCA)
 - RBMC/RIBaC, IGS, rede GNSS-SP
- Levantamentos geodésicos mais acurados.
- A acurácia obtida depende das observáveis do sistema (fase da onda portadora e pseudodistância), que são afetadas diretamente por diversos erros sistemáticos.

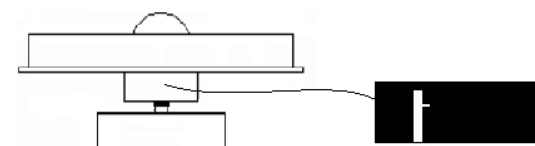


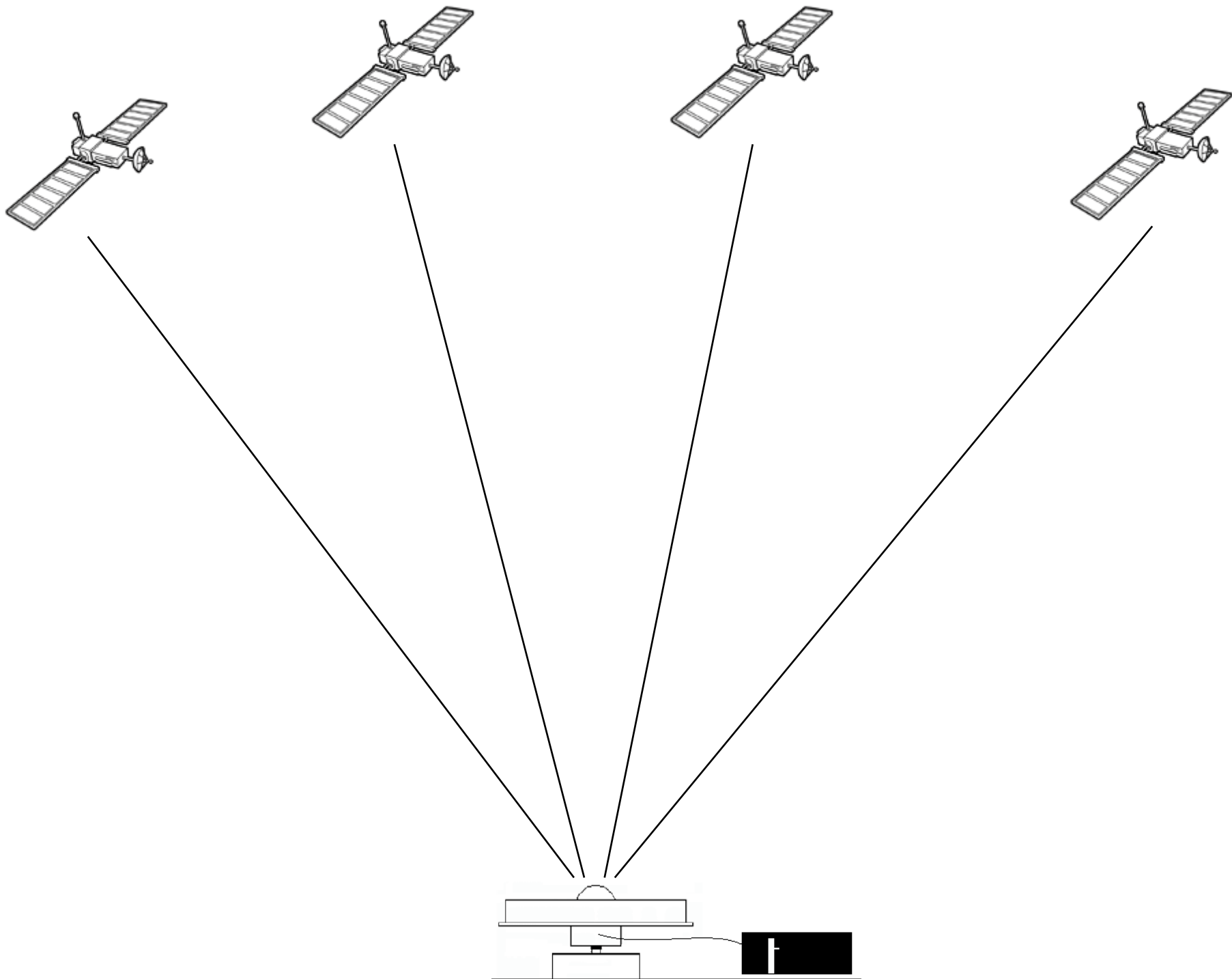
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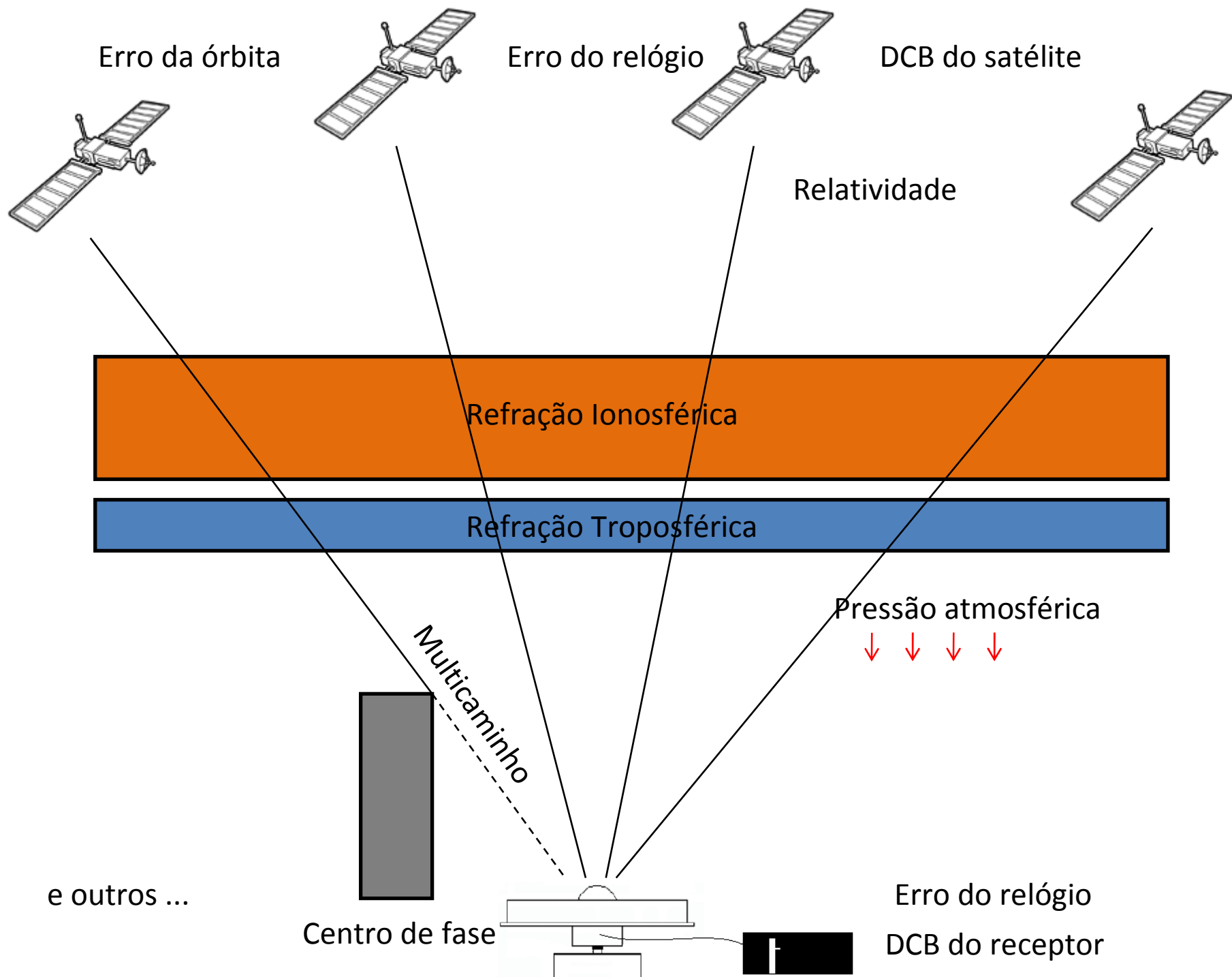
Estações de referências
permitem modelar os
erros sistemáticos

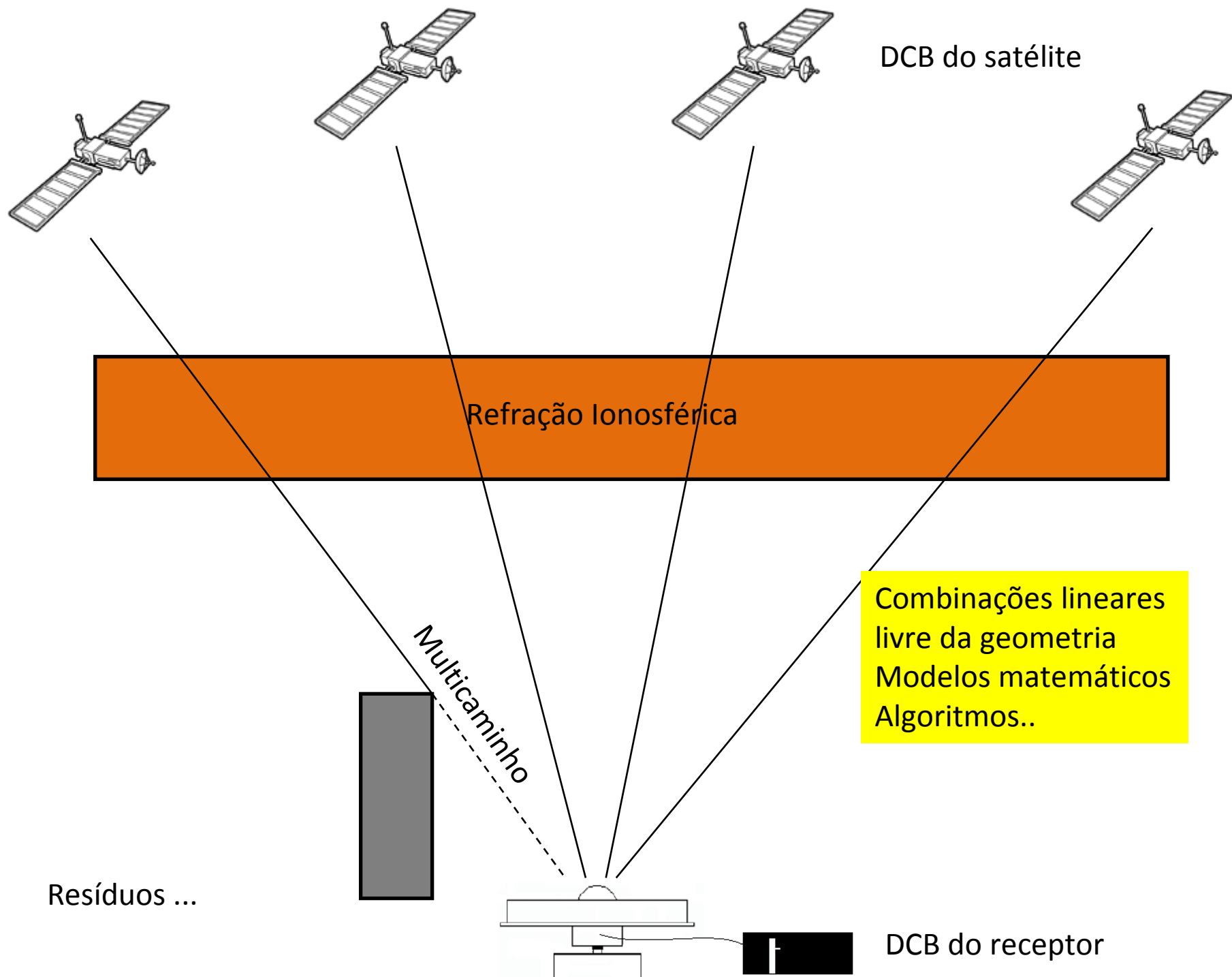
SCA

Coordenadas Conhecidas









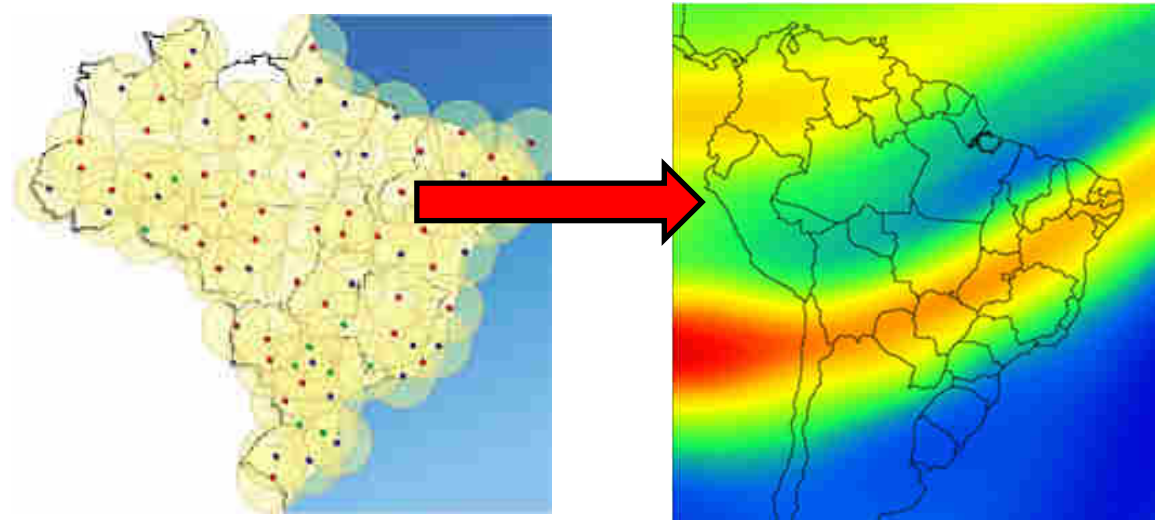
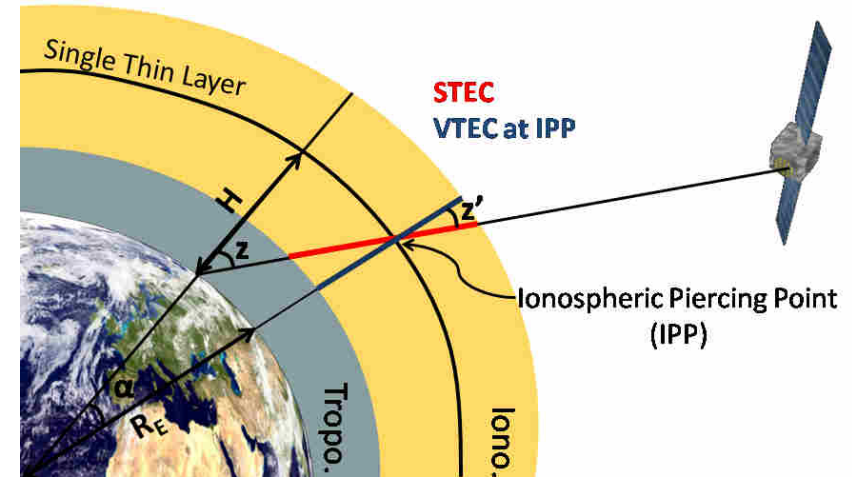
GNSS x Ionosfera

O erro devido à ionosfera é proporcional ao TEC. Receptores de dupla frequência permitem efetuar combinações lineares e calcular o TEC.

$$1 \text{ TECU} = 1 \times 10^{16} \text{ el/m}^2$$

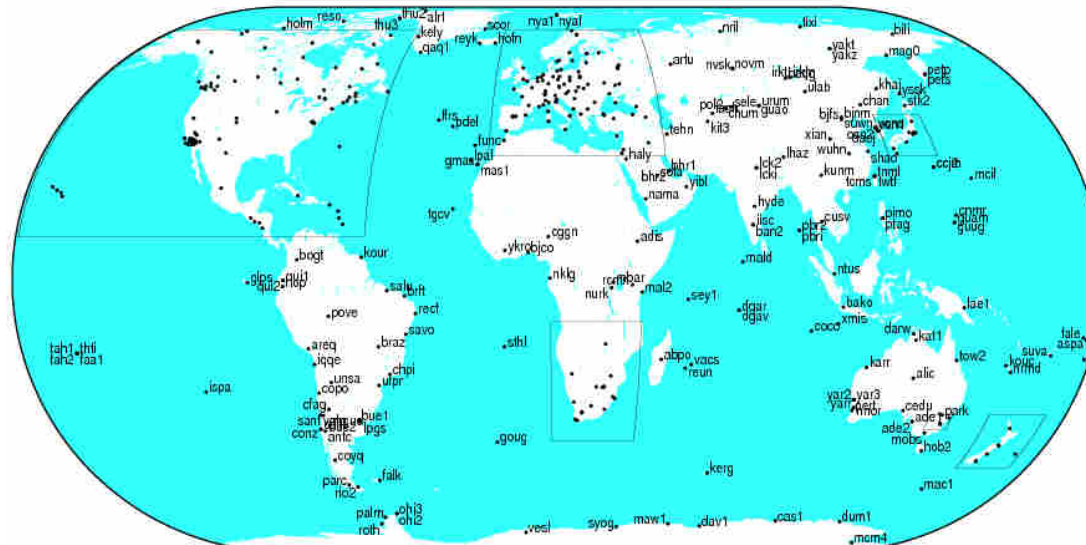
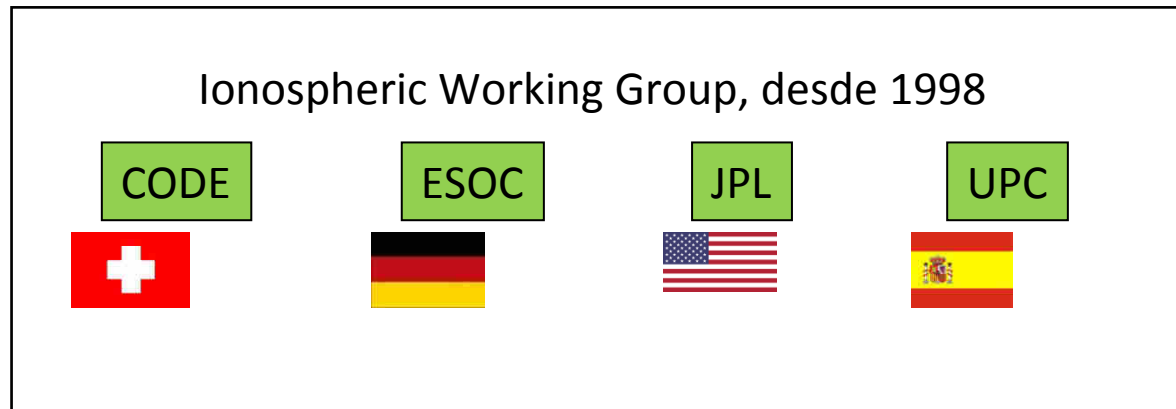
$$L1 \cong 0,16\text{m}$$

$$L2 \cong 0,27\text{m}$$



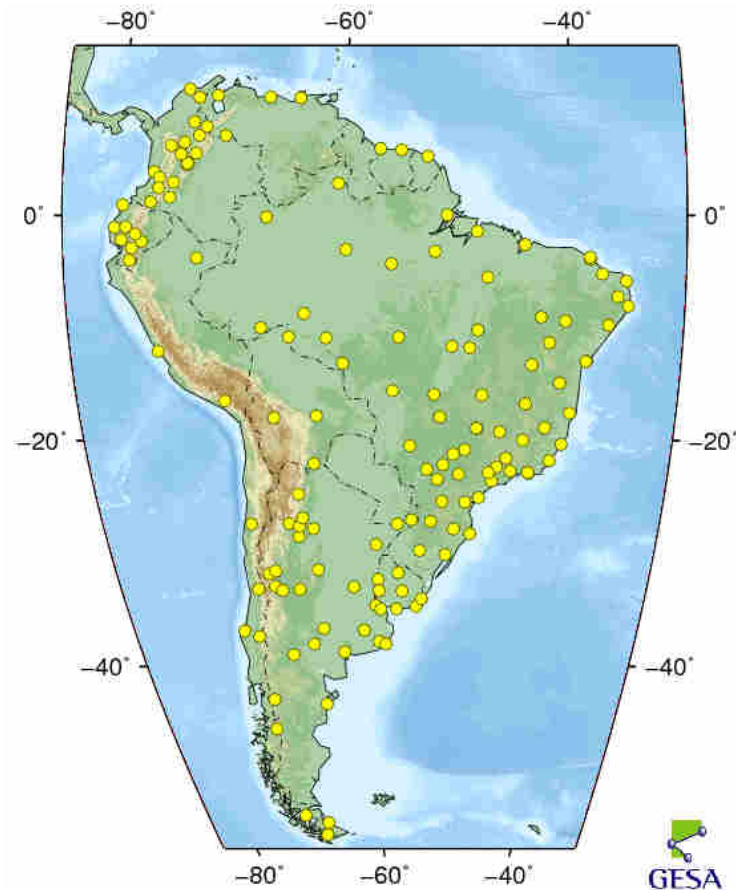
Mapas Avaliados

- IGS → International GNSS Service



Mapas Avaliados

- LPIM → La Plata Ionospheric Model
- Desenvolvido na Universidade de La Plata e é utilizado pelo Centro de Análise Ionosférica do SIRGAS para produzir mapas de VTEC para a América do Sul



Mapas Avaliados

- MODION → Modelo regional da Ionosfera
- Desenvolvido na FCT/UNESP



Mapas Avaliados

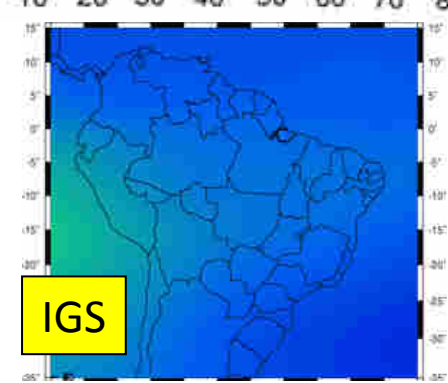
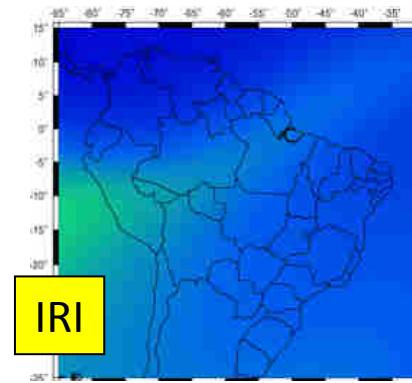
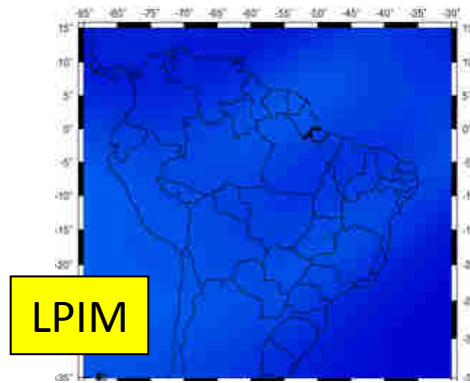
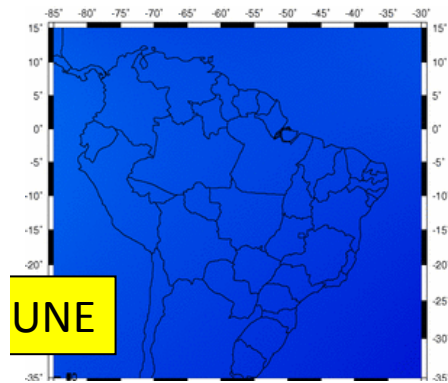
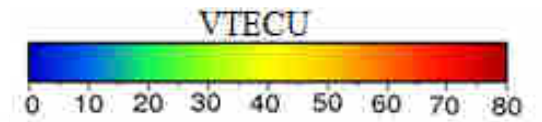
- IRI → International Reference Ionosphere
- Mantido pela COSPAR e URSI
- As principais fontes de dados provêm de uma rede mundial de ionossondas, radares de espalhamento incoerente, as sondas ISIS e Alouette e instrumentos acoplados em satélites e foguetes espaciais
- Descreve a ionosfera em função da densidade de elétrons, íons, temperatura, composição iônica e velocidade do plasma

Experimentos

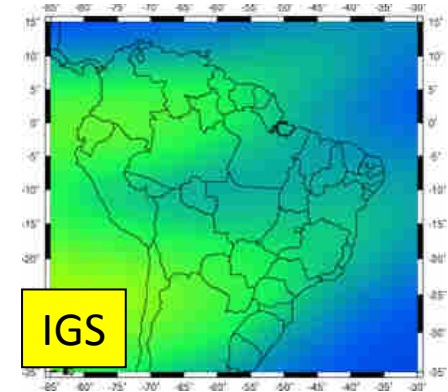
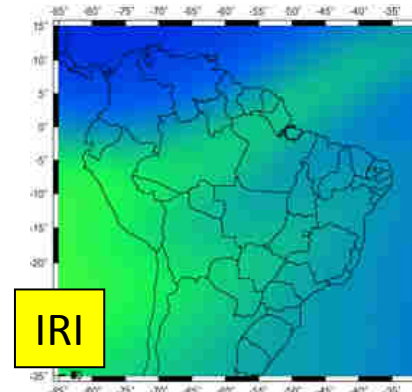
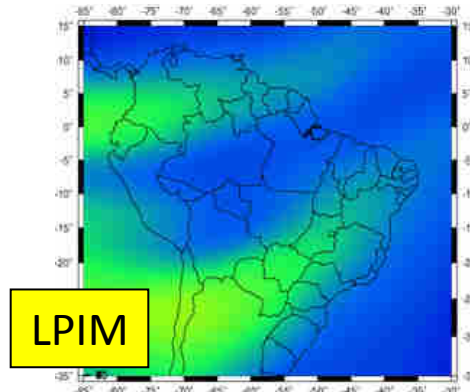
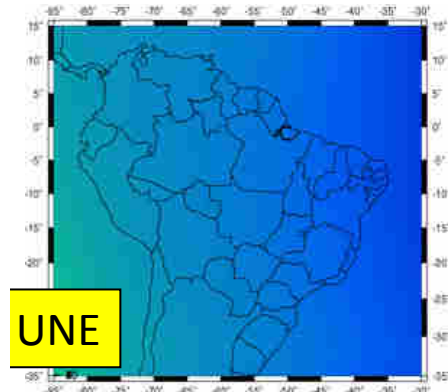
Três épocas de interesse:

- **Baixa Atividade Ionosférica** → 04/01/2009
- **Moderada Atividade Ionosférica** → 28/01/2011
- **Alta Atividade Ionosférica** → 07/01/2013

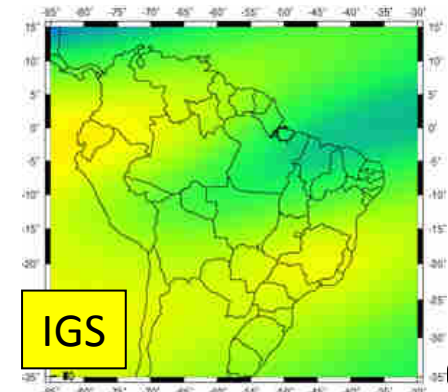
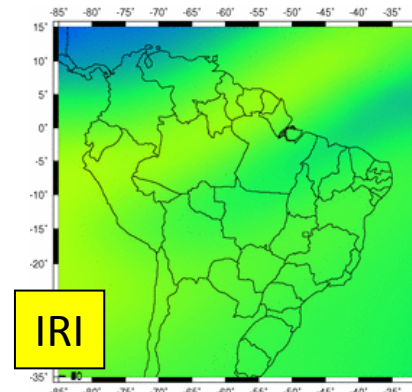
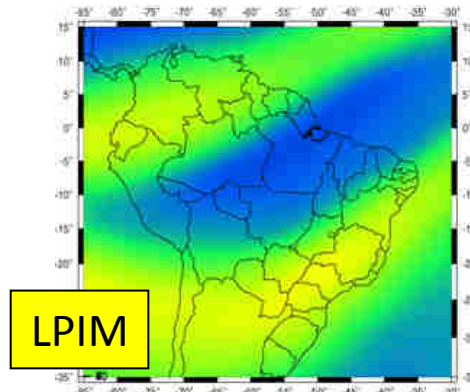
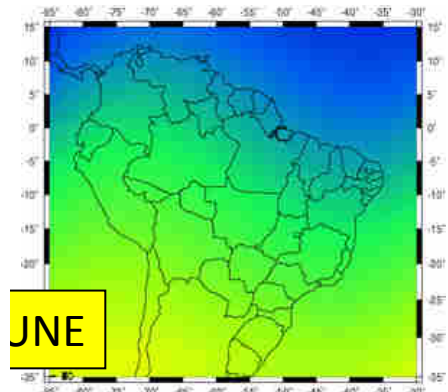
04/01/2009 - BAIXA ATIVIDADE



28/01/2011 - MODERADA ATIVIDADE



07/01/2013 - ALTA ATIVIDADE



04/01/2009

LPIM

BAIXA ATIVIDADE

TECU

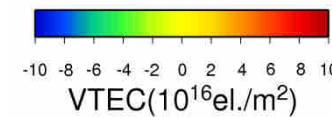
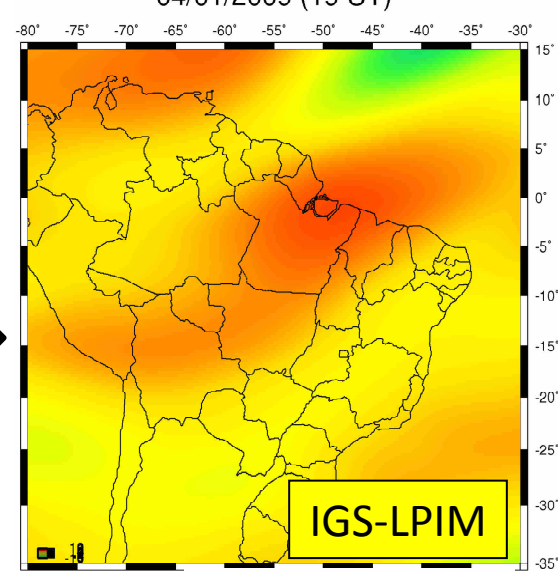
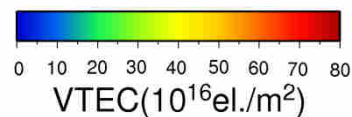
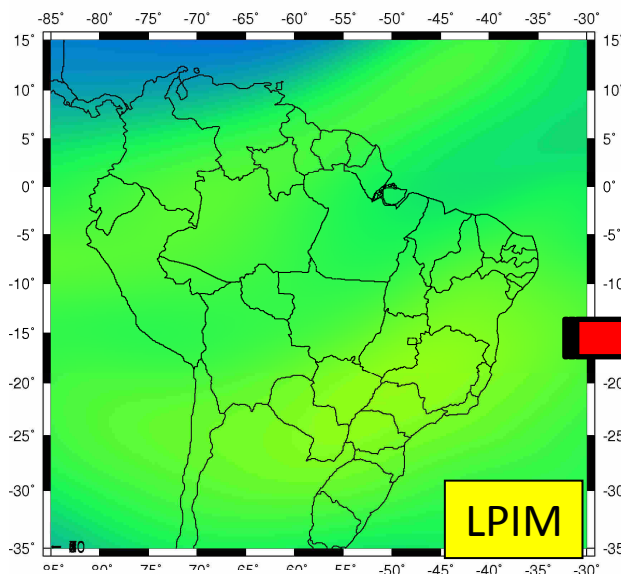
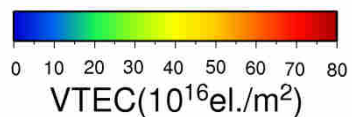
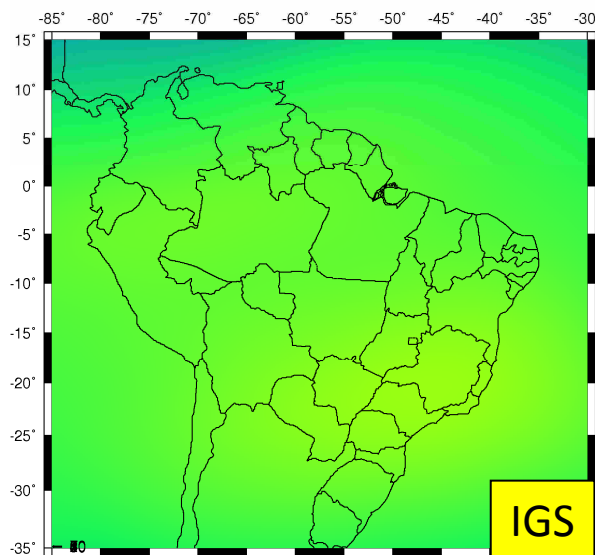
MAX
MIN
RMSC

UT

04/01/2009 (19 UT)

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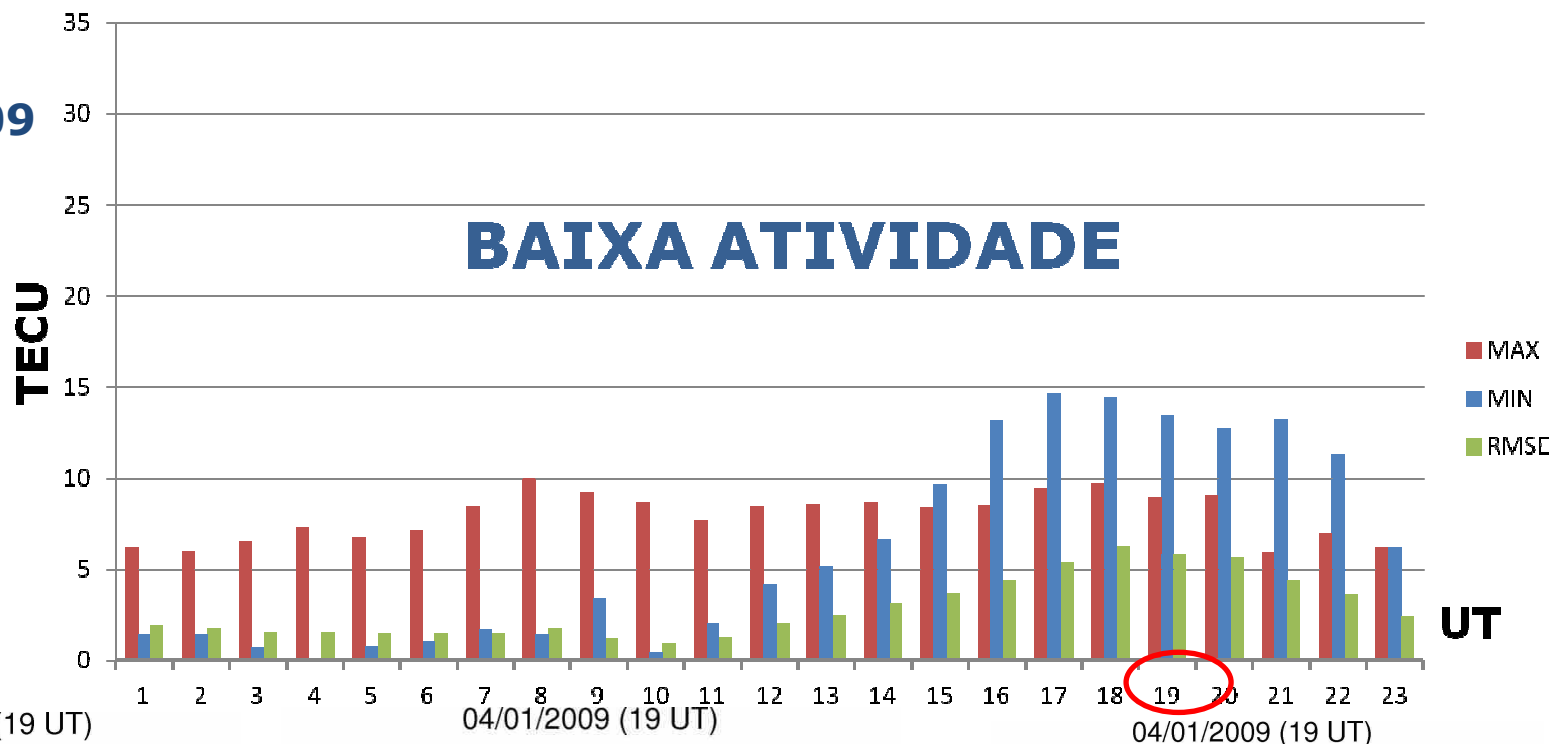
04/01/2009 (19 UT)



04/01/2009

MODION

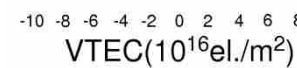
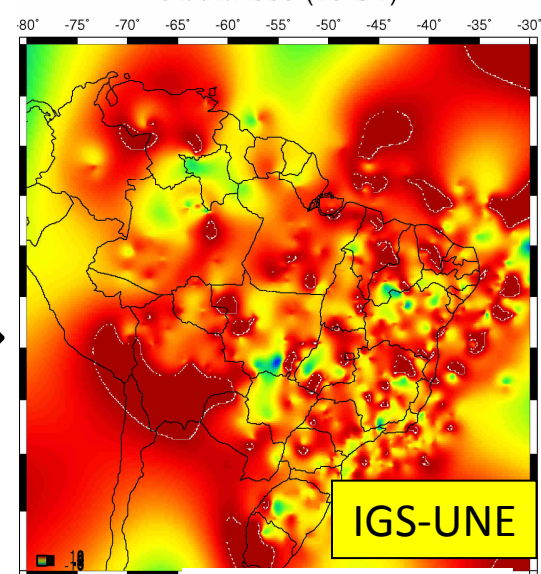
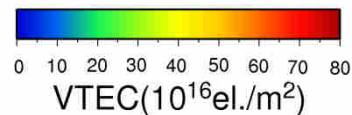
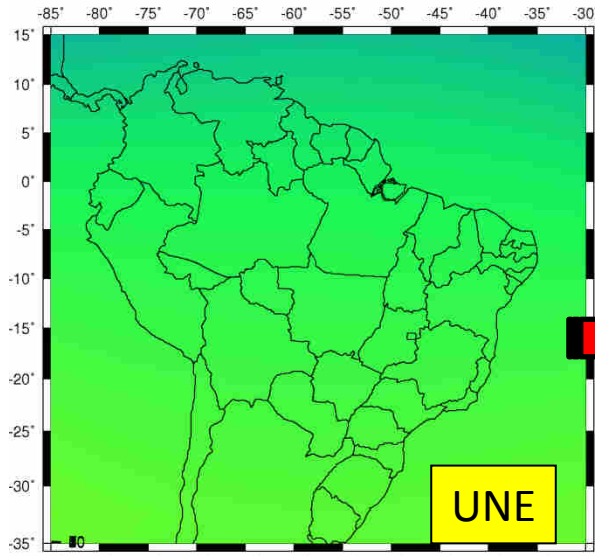
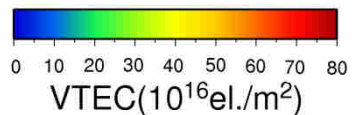
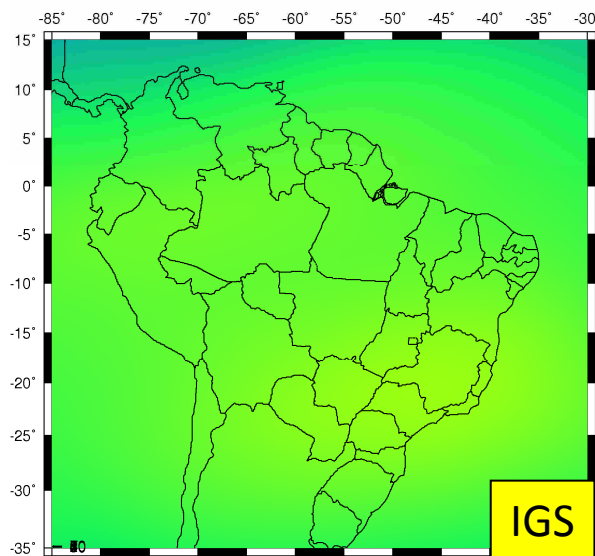
BAIXA ATIVIDADE



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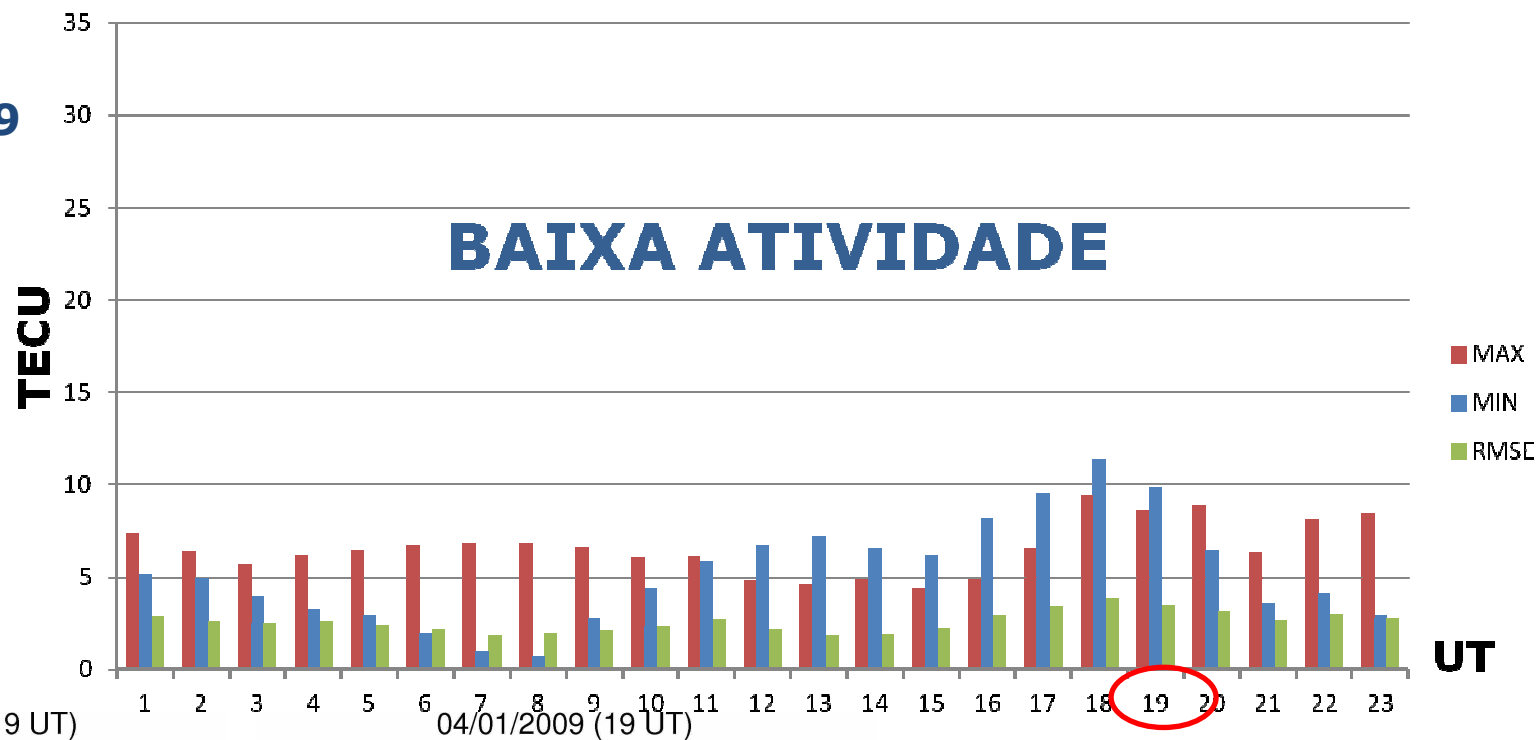
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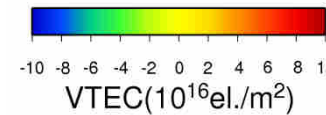
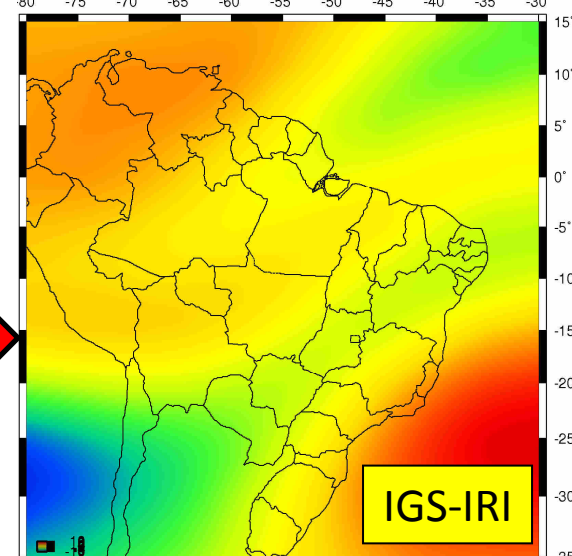
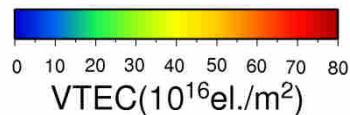
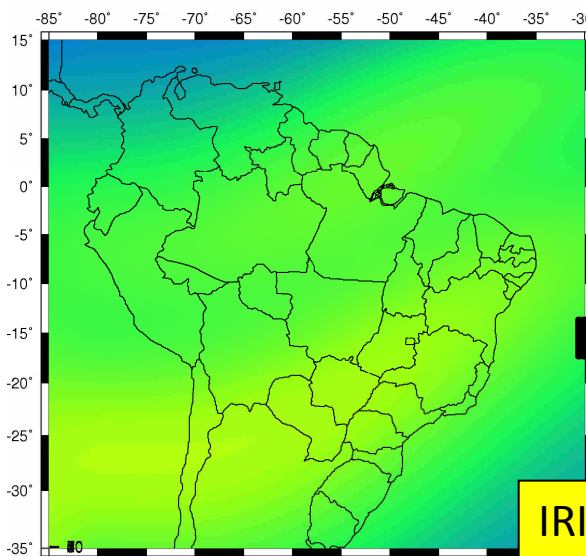
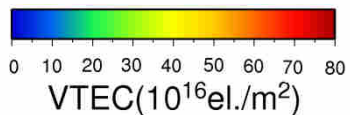
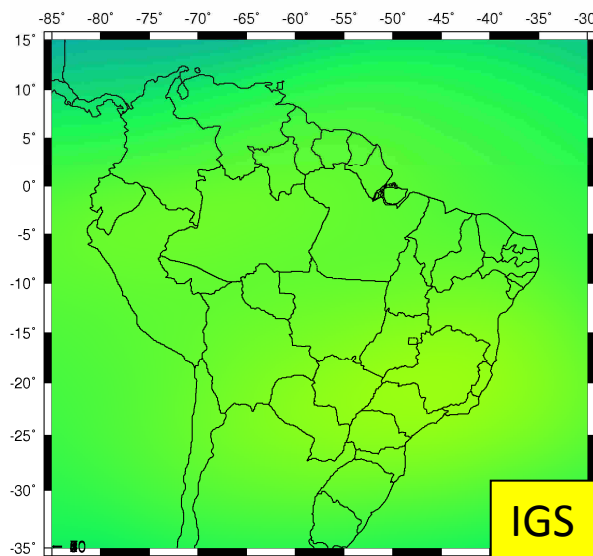
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BAIXA ATIVIDADE



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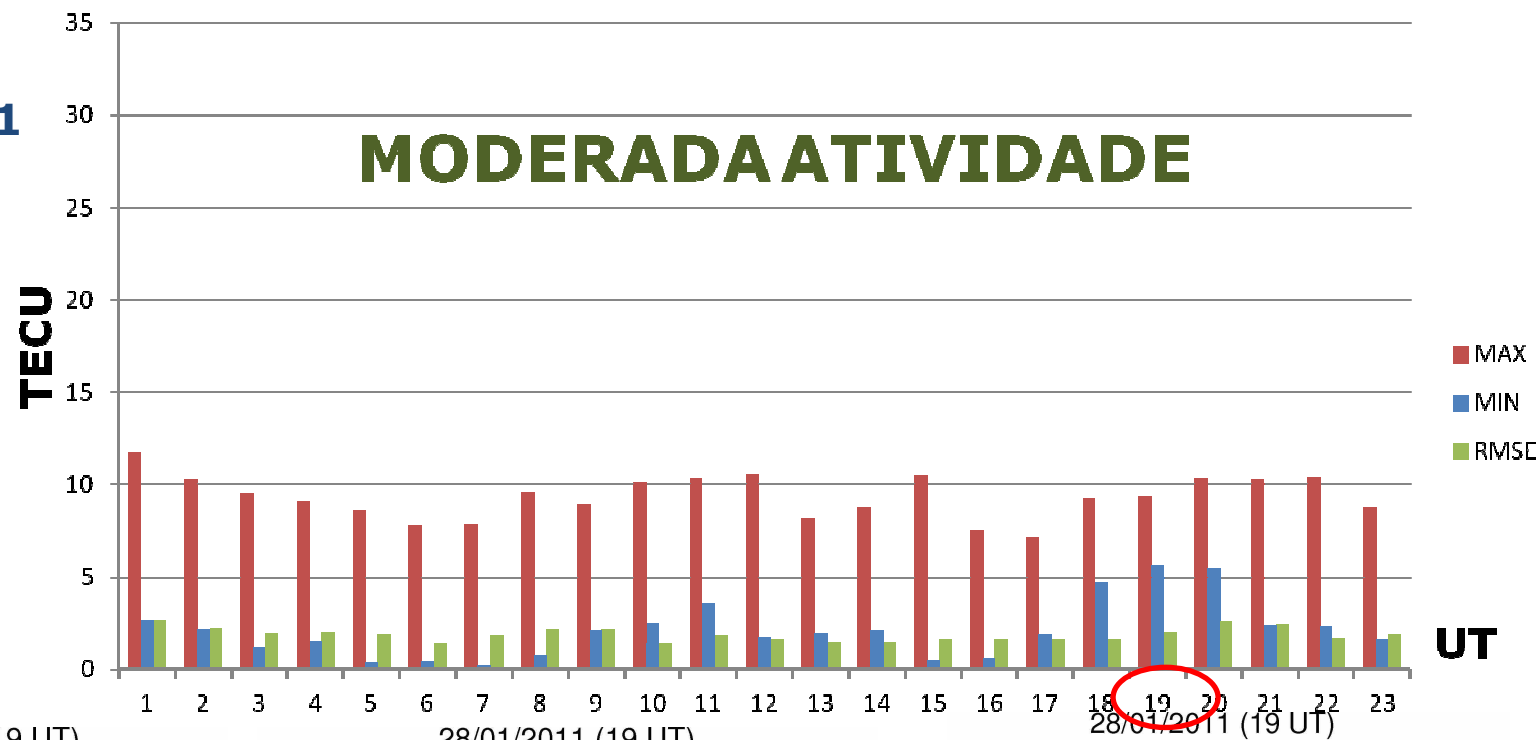


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28/01/2011

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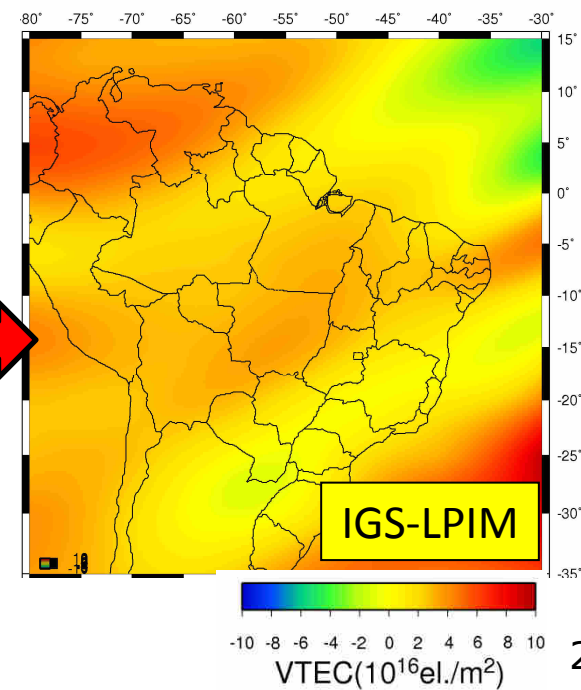
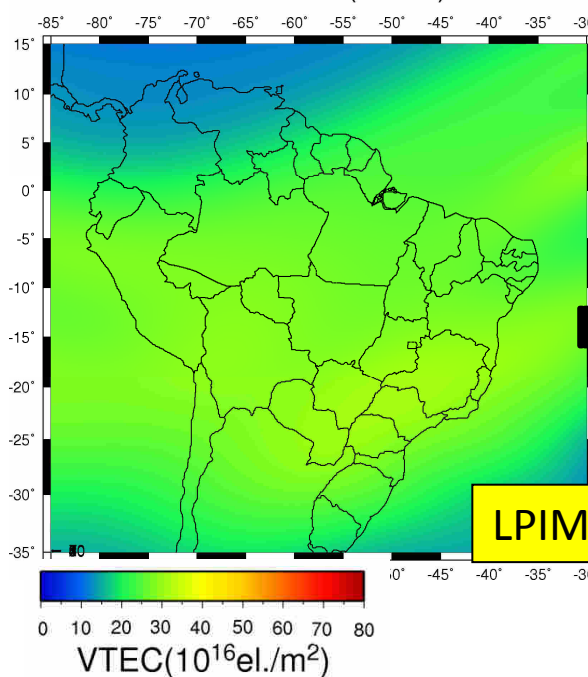
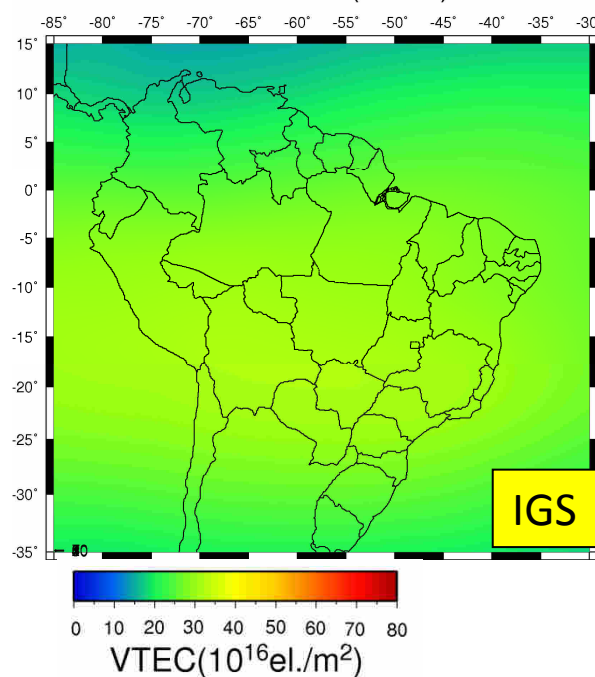
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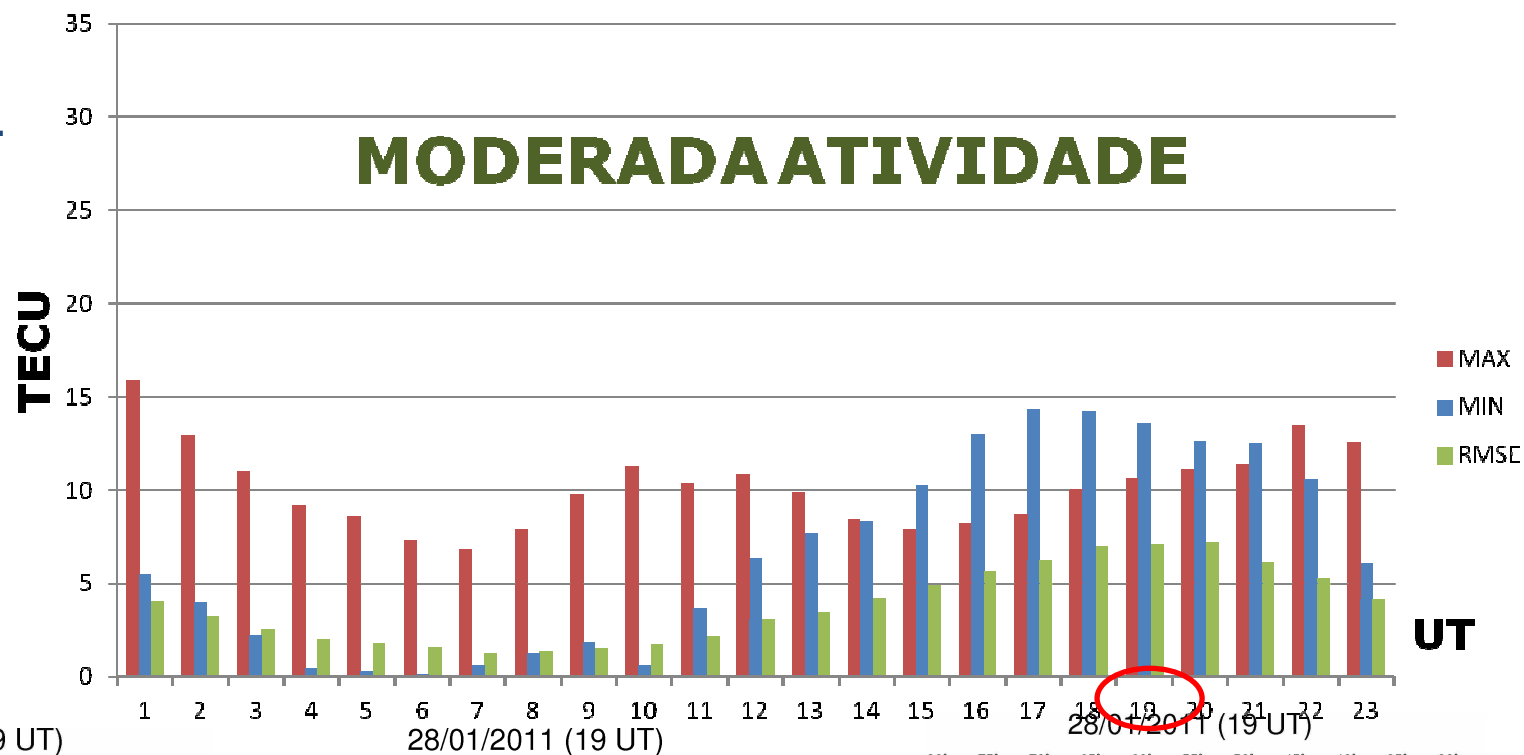
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28/01/2011

MODION

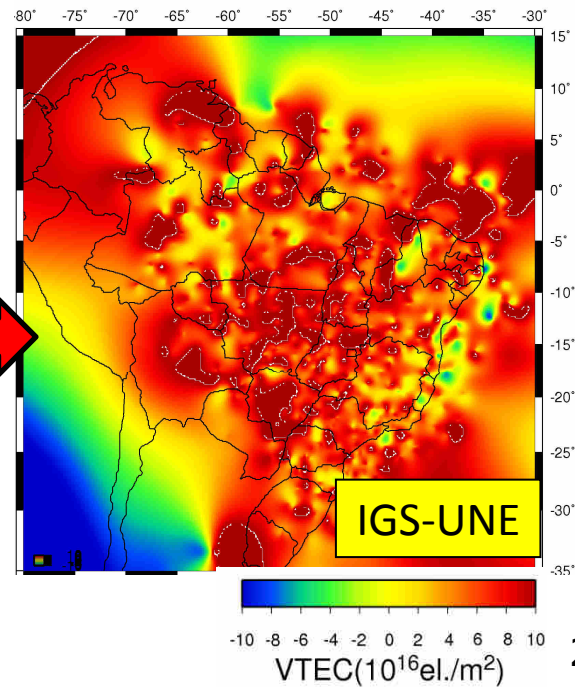
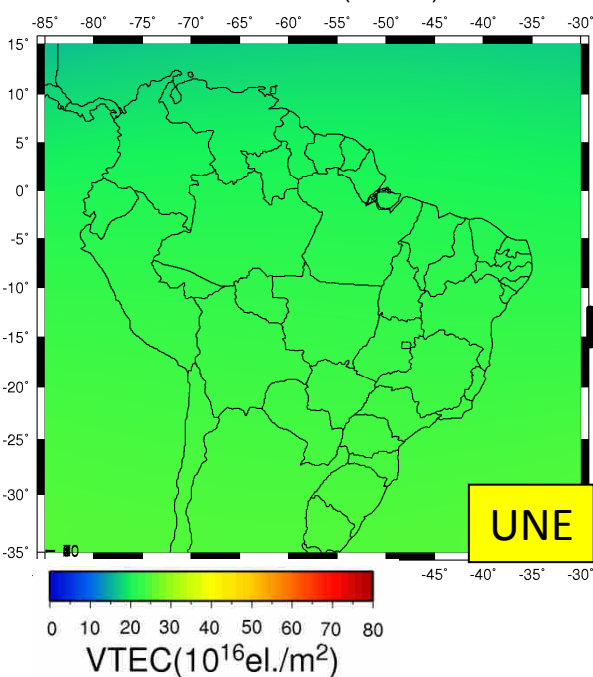
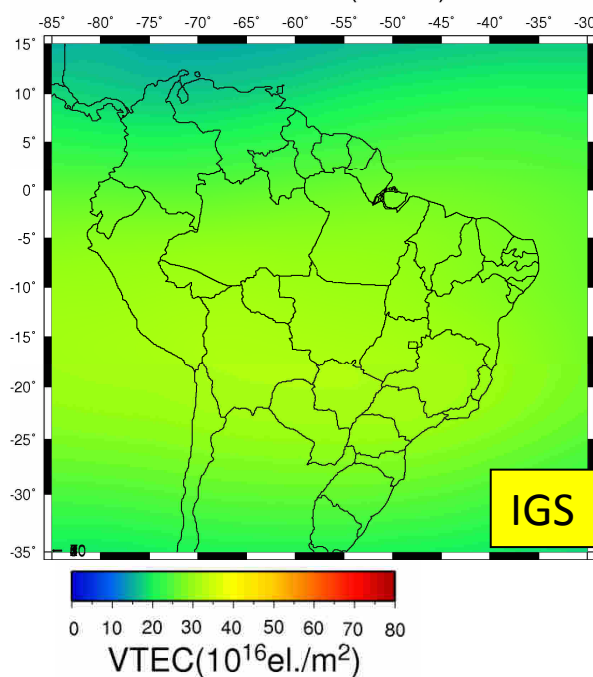
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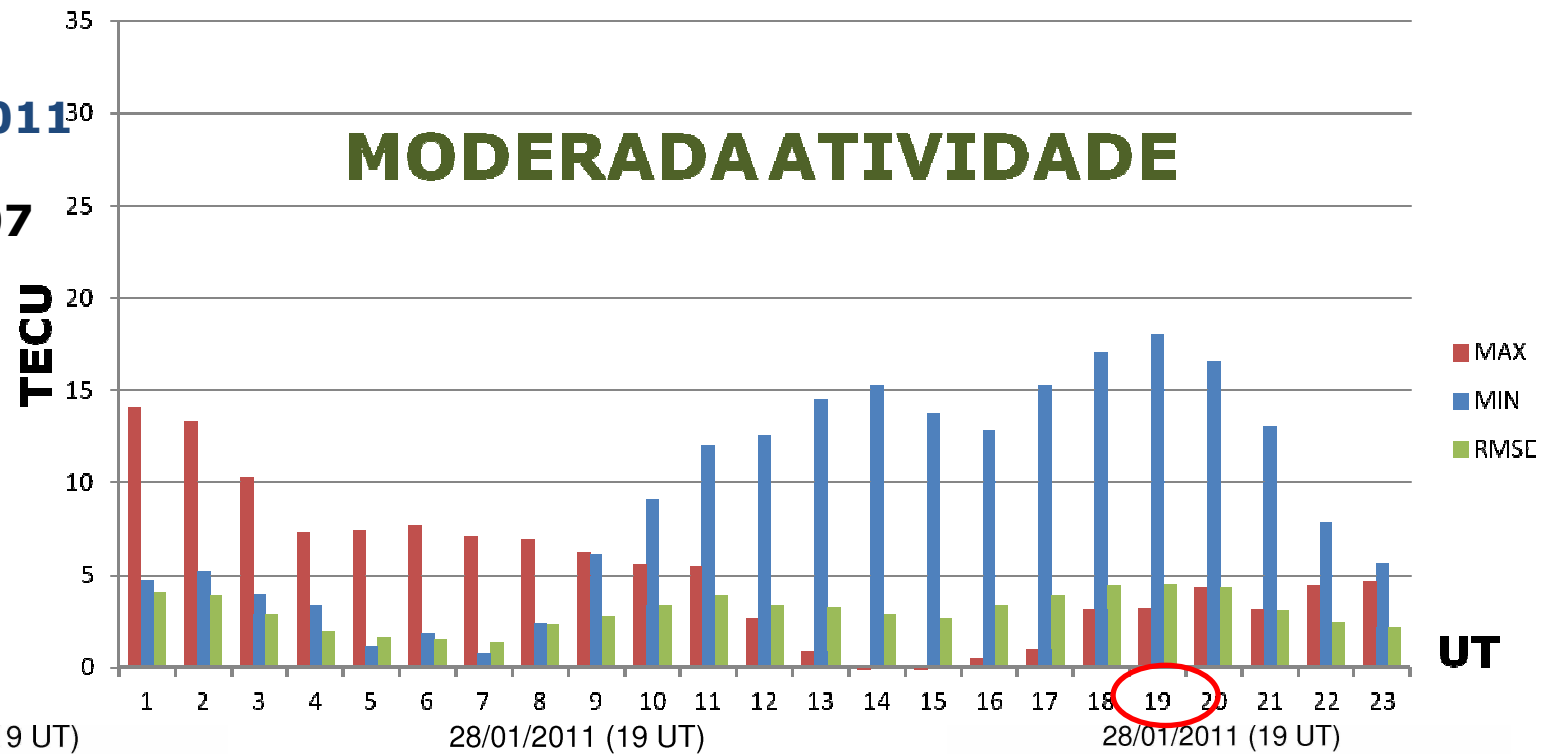
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IRI-2007

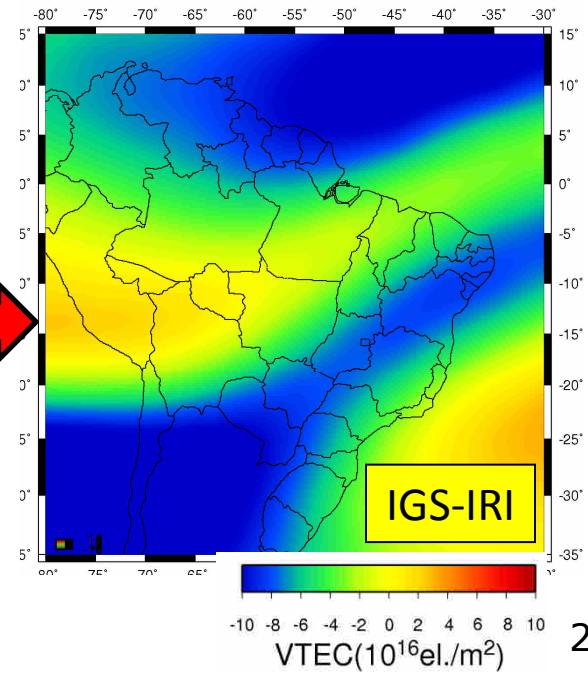
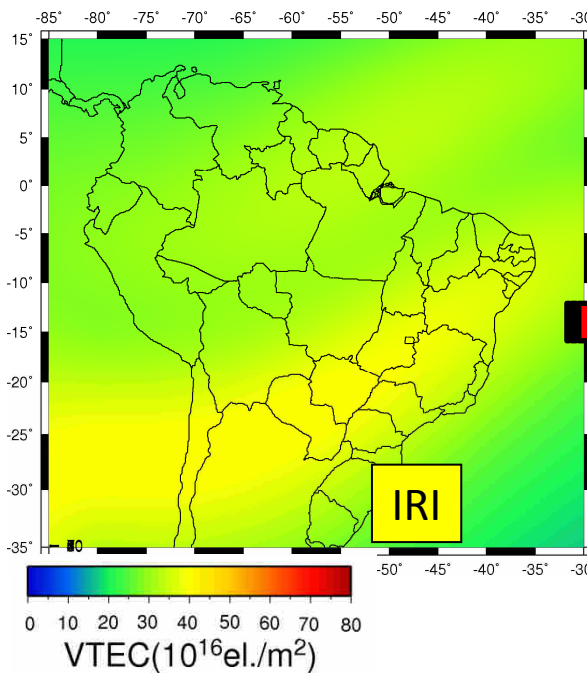
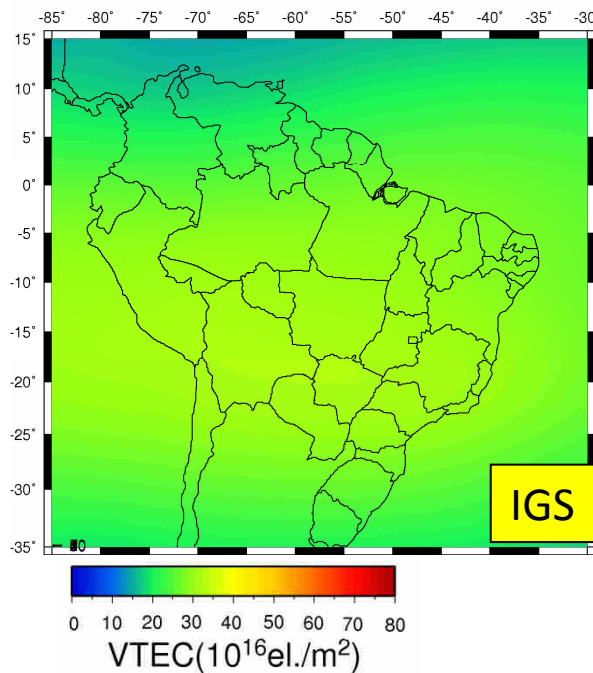
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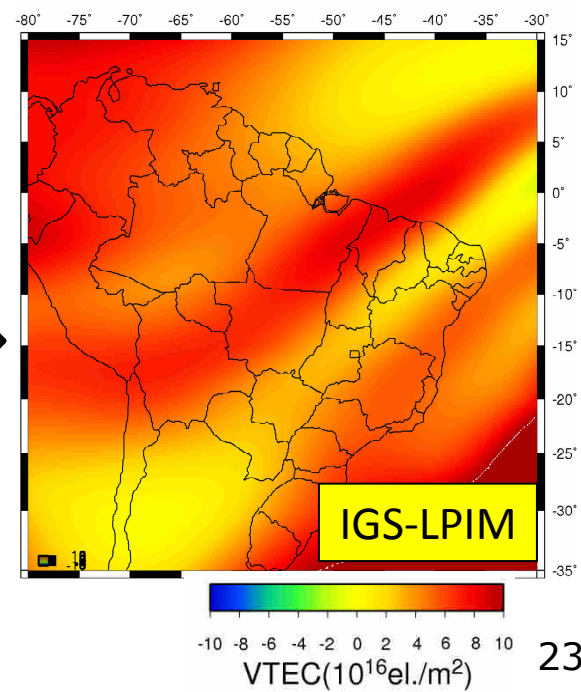
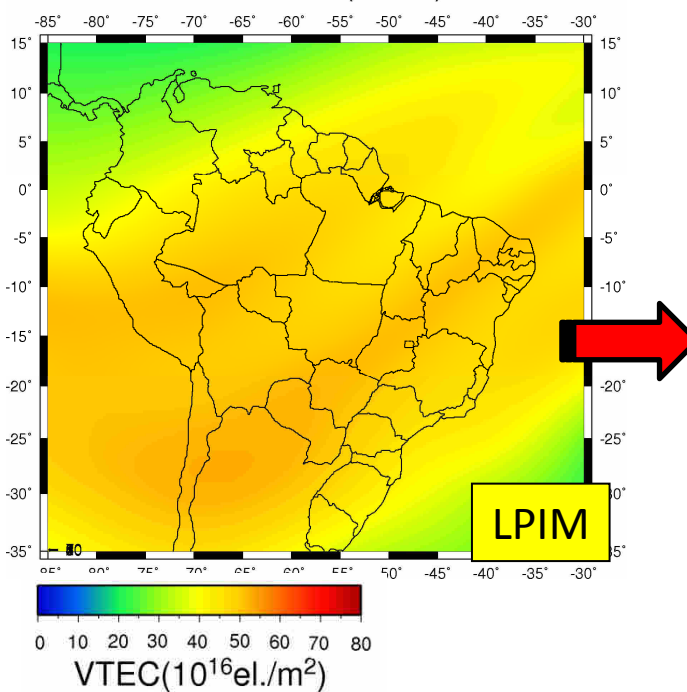
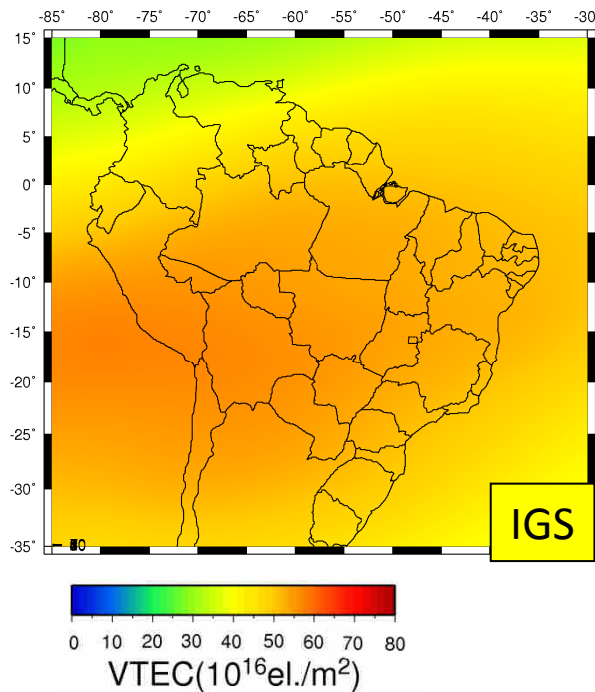
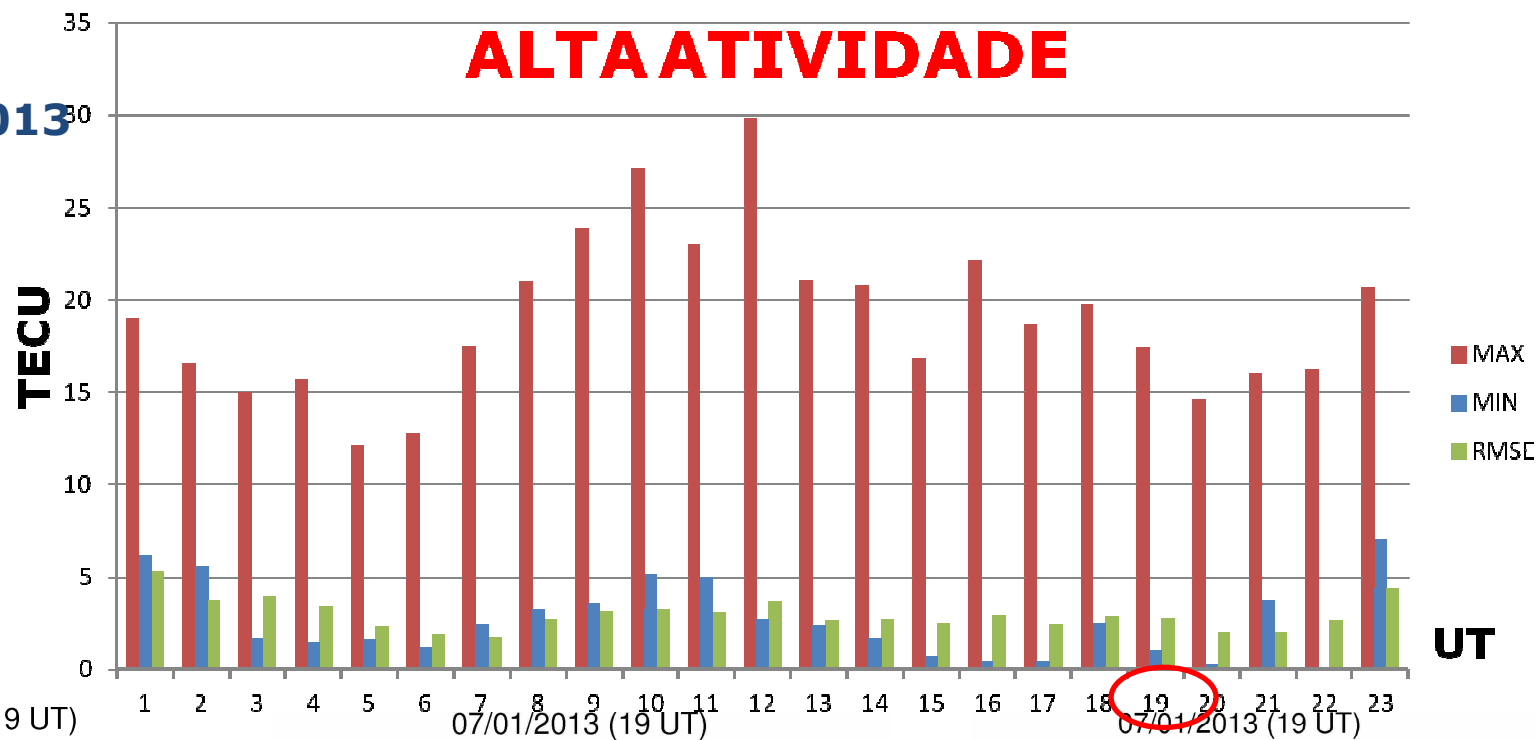
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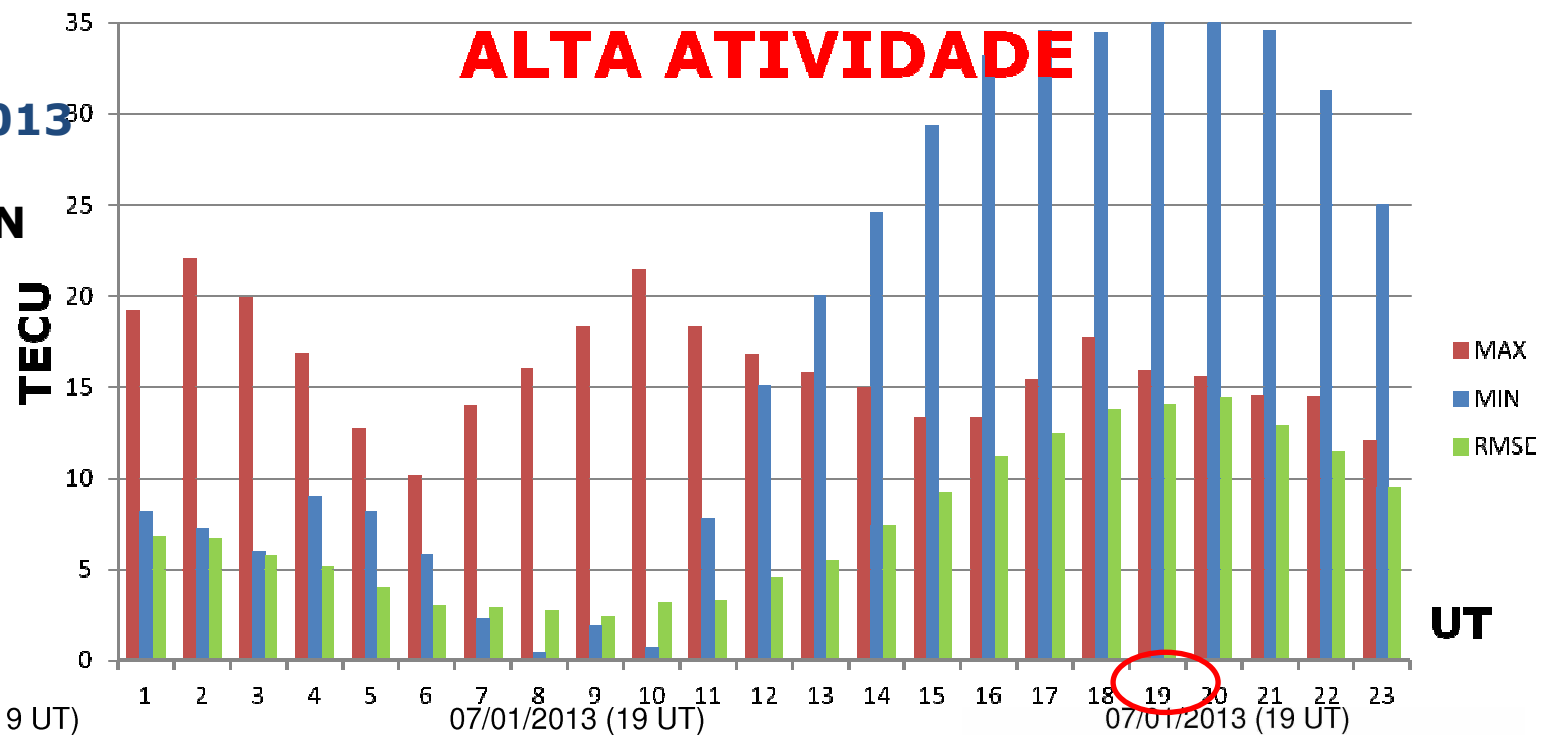
LPIM

ALTA ATIVIDADE



07/01/2013

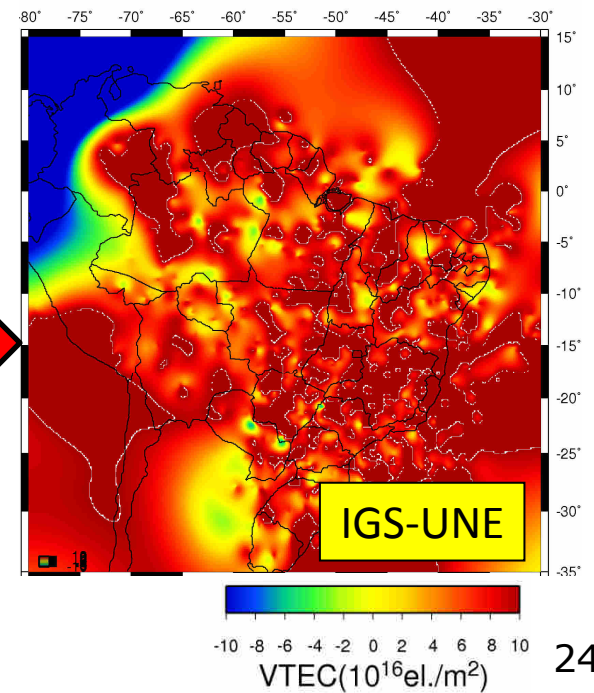
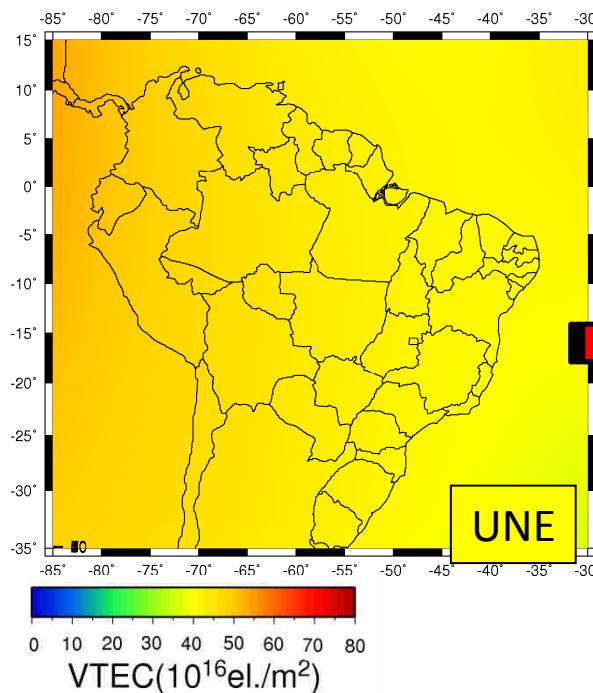
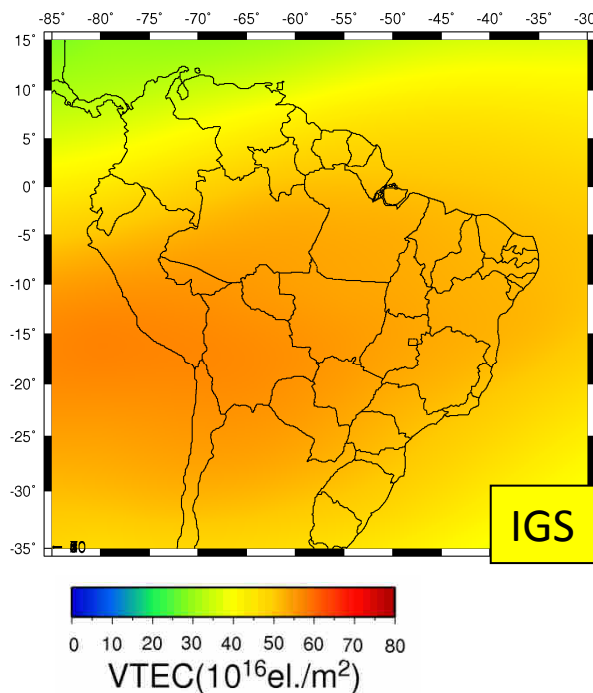
MODION



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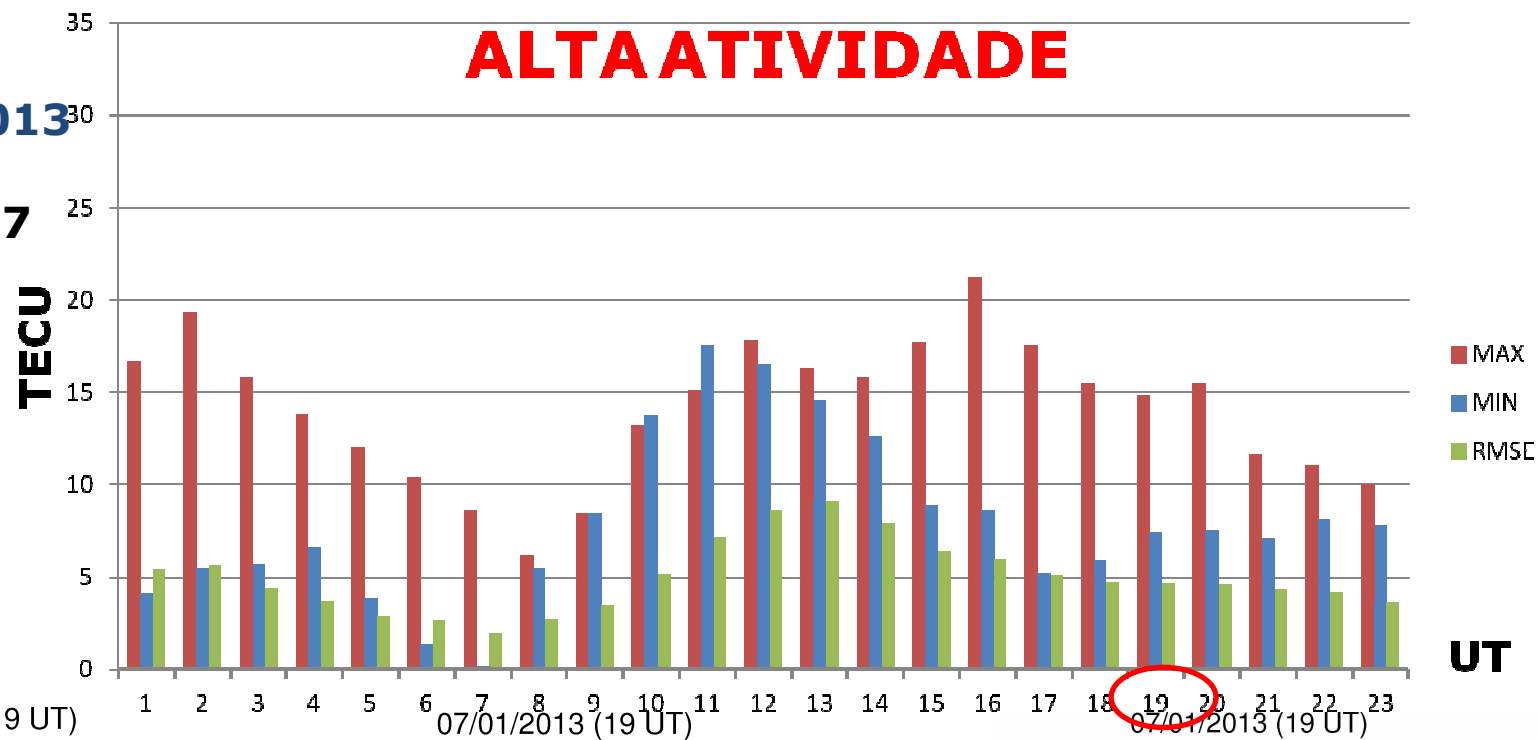


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ALTA ATIVIDADE

TECU

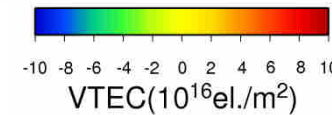
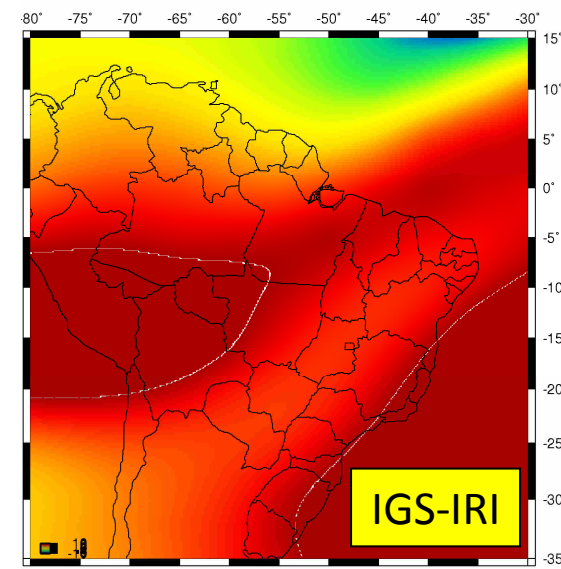
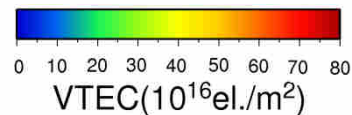
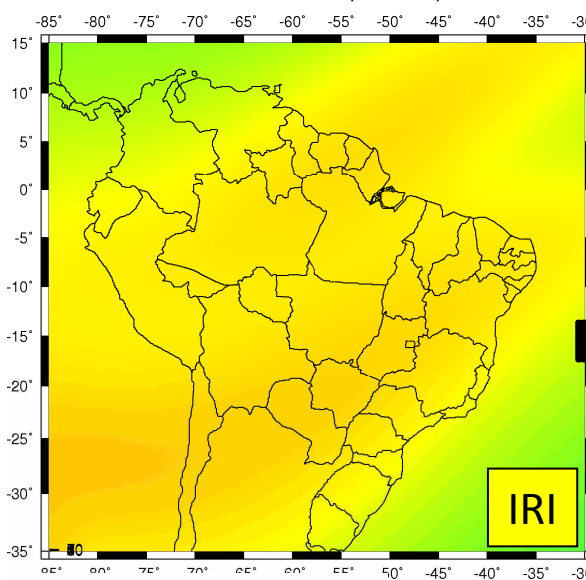
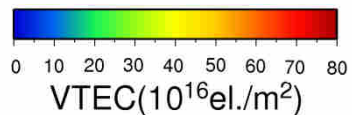
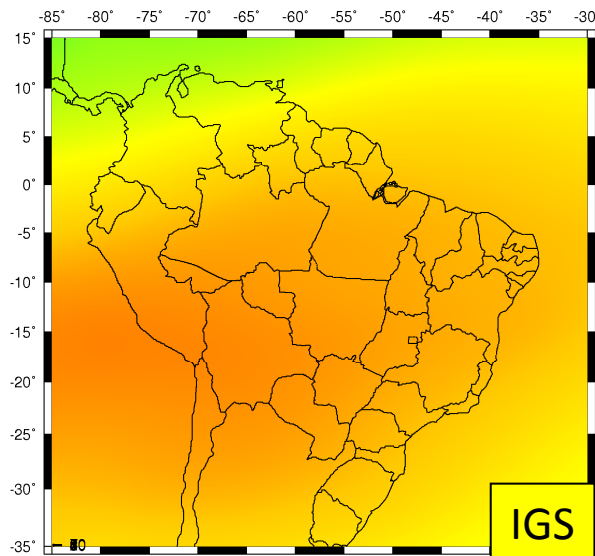


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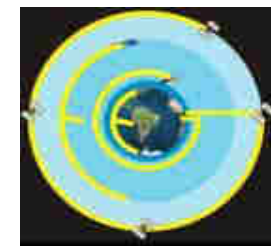
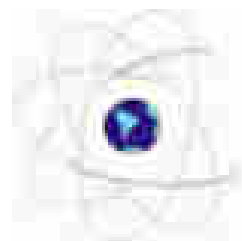


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Considerações Finais

- Tendo os GIM's do IGS como modelo de referência, conclui-se:
- LPIM →
 - RMSE menor que 5 TECU
 - Sub-estima os valores de TECU em todas as épocas do experimento
 - Representa a Anomalia Equatorial (AE)
- MODION →
 - RMSE menor que 15 TECU
 - Sub-estima os valores de TECU para a região brasileira
 - Suaviza a AE
- IRI →
 - RMSE menor que 10 TECU
 - Super-estima os valores de TECU em Baixa e Média Atividade, Super-estima em alta atividade ionosférica
 - Representa a AE

Agradecimentos





"We went to explore the Moon, and in fact discovered the Earth." Eugene Cernan