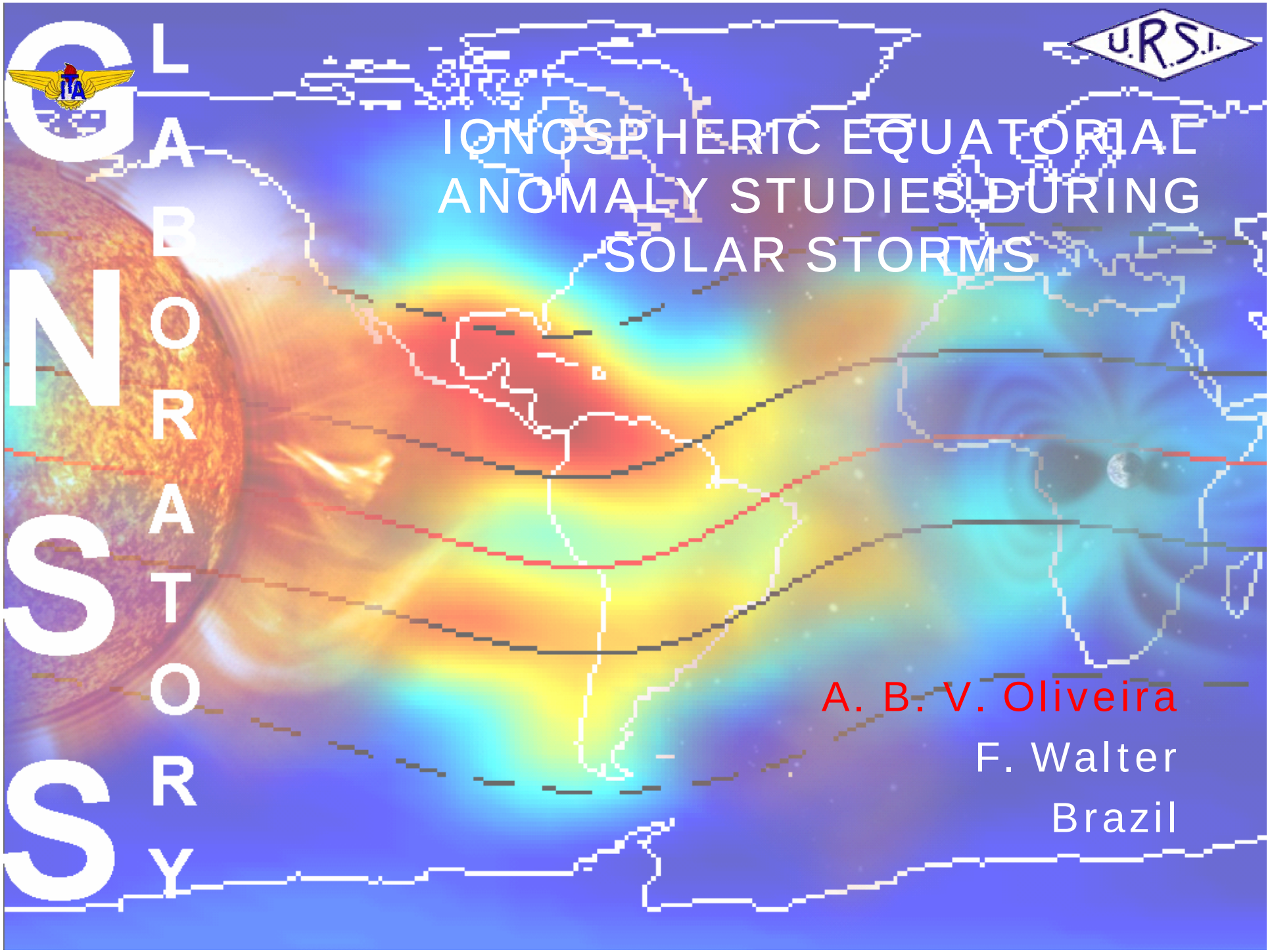

LABORATORY
SUNSS
U.R.S.I.
IONOSPHERIC EQUATORIAL ANOMALY STUDIES DURING SOLAR STORMS
A. B. V. Oliveira
F. Walter
Brazil

Summary

- Objective
- Magnetic storms
- VTEC evaluation
- Global VTEC maps developed
- Periods of magnetic storms analyzed and IEA behavior
- Conclusions and results

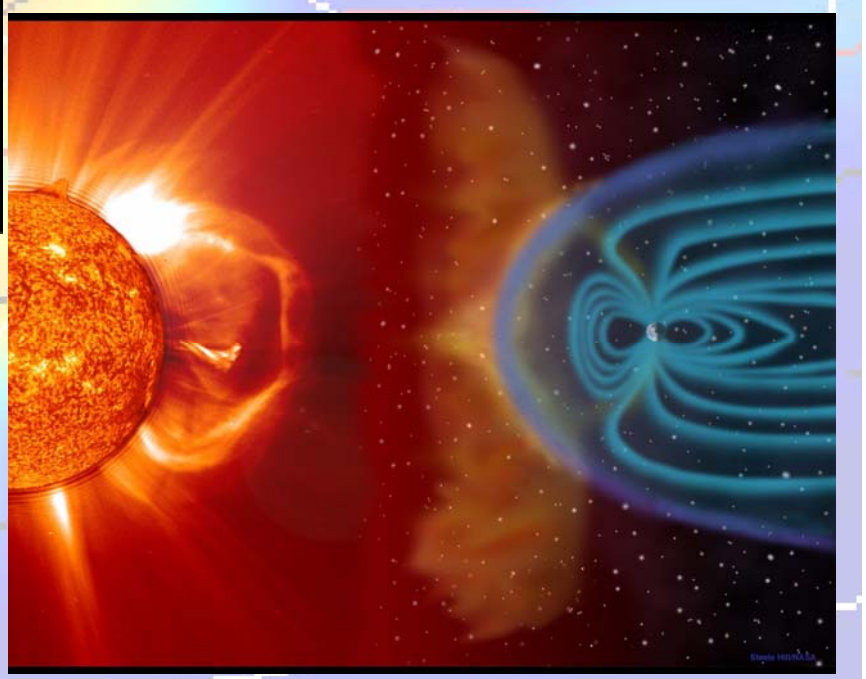
Objective

- In order to study the global behavior of the Ionospheric Equatorial Anomaly, dynamic maps based on IONEX data have been generated.
- In this way the effects of the solar and geomagnetic activity on the Ionospheric Equatorial Anomaly can be easily correlated.

Coronal Mass Ejection (CME)

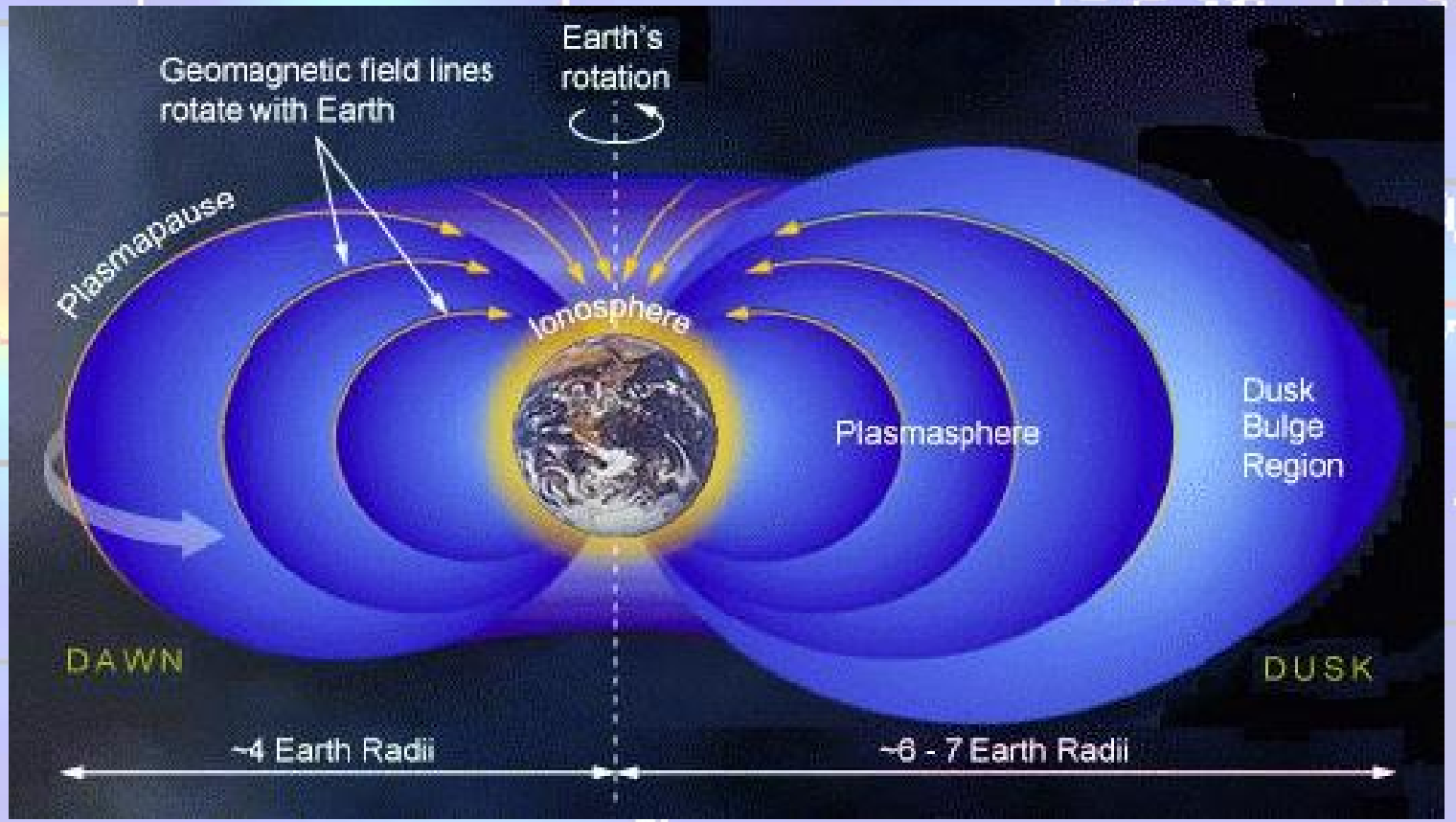
The Sun regularly sends massive solar explosions of radioactive plasma (coronal mass ejection - CME) with the intensity of a billion megaton bombs going through the solar system directly towards the Earth.

Credit: University of Colorado



Credit: Nasa

Ionosphere and Plasmasphere



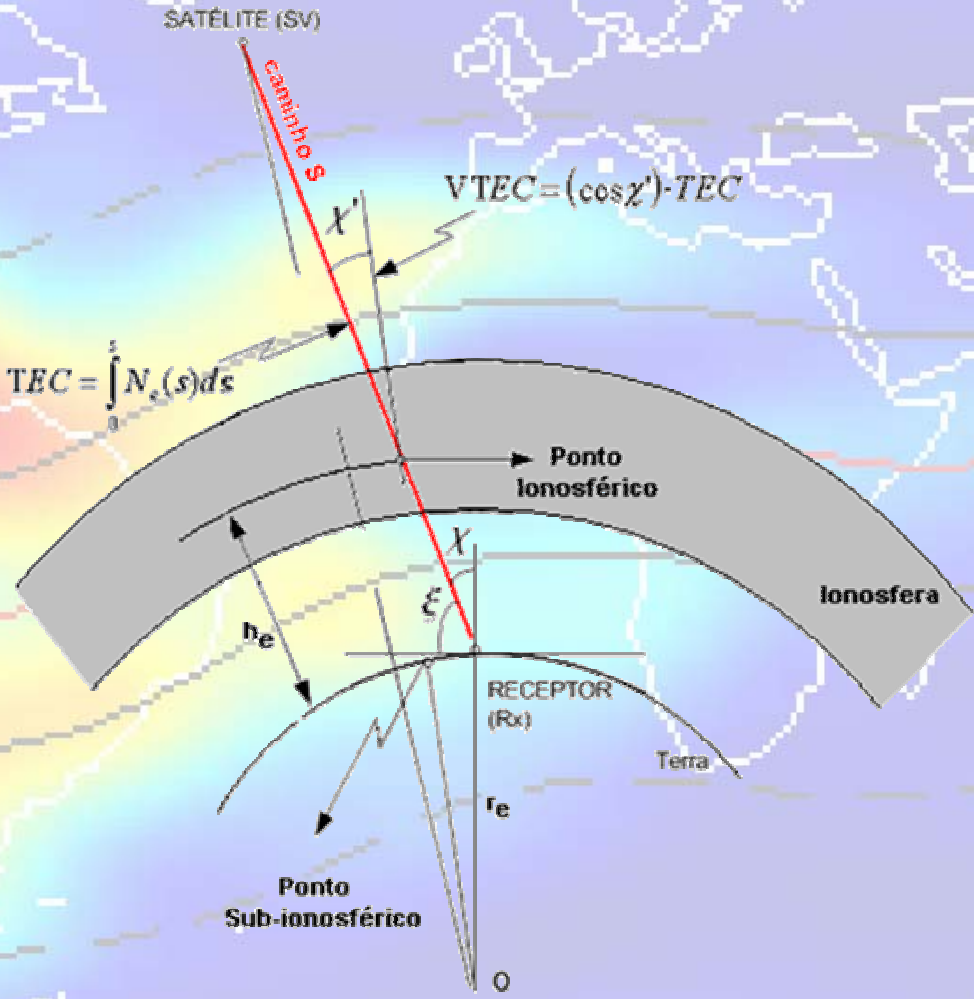
Magnetic Storms

Can cause effects like:

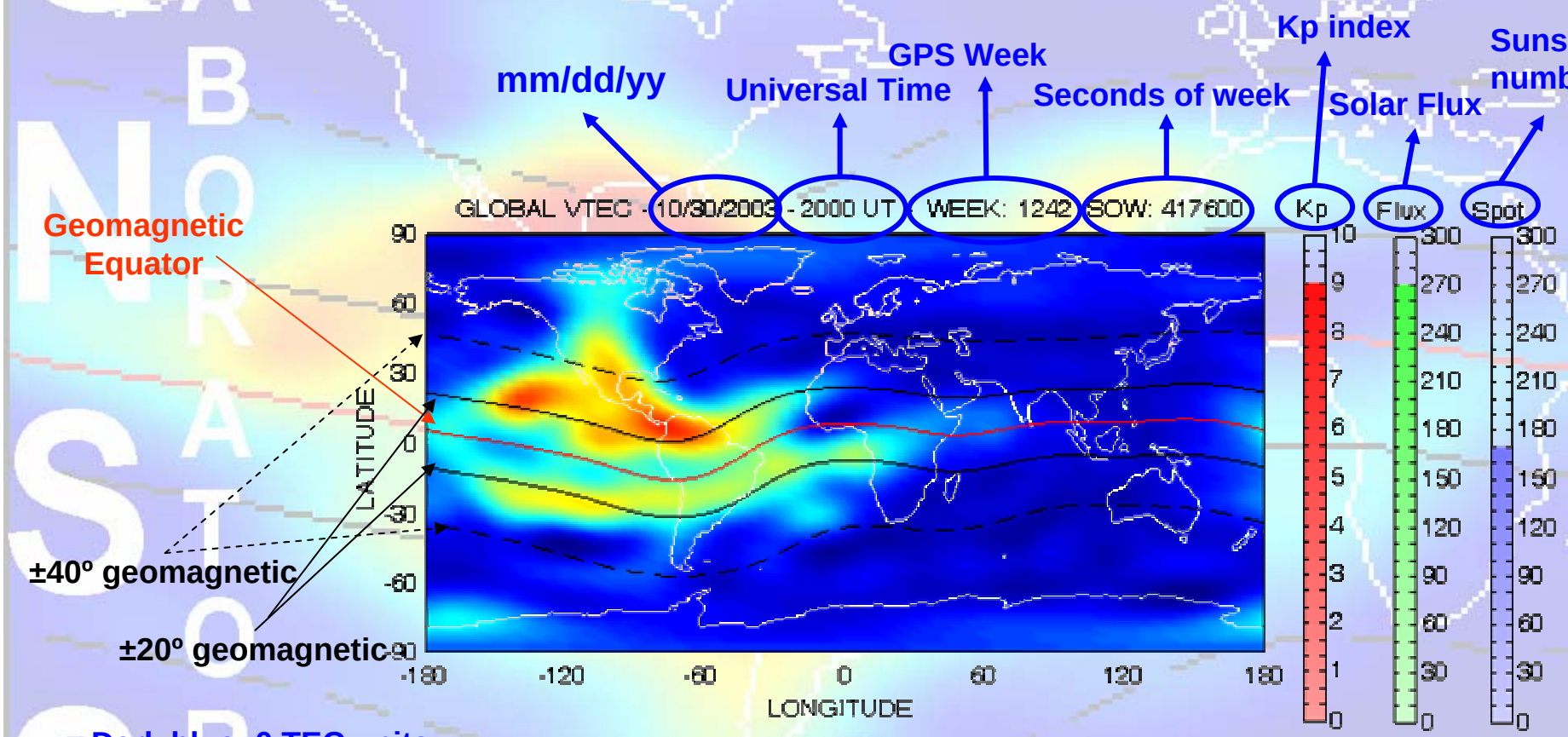
- bright auroras visible at more southern latitudes than usual; and
- even short out orbiting satellites, rendering them permanently inoperable.

Vertical Total Electron Content (VTEC)

Ionosphere is the major source of error in the user positioning determination by GNSS, mainly at low geomagnetic latitude regions (±20º) which are affected by the Ionospheric Equatorial Anomaly (IEA).

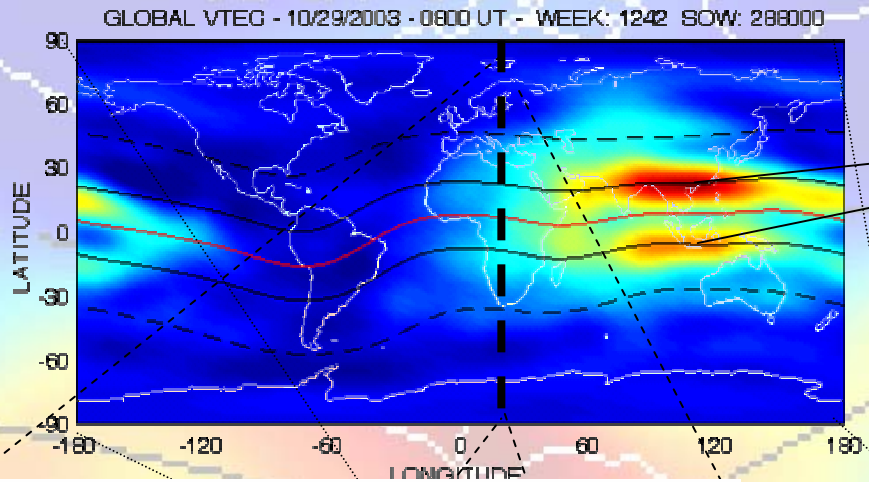


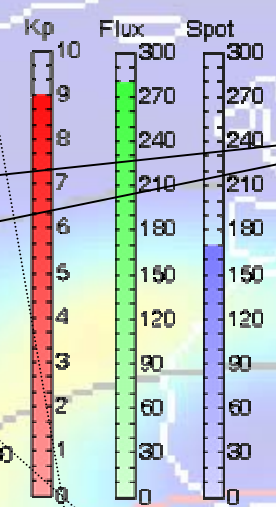
Global VTEC Maps



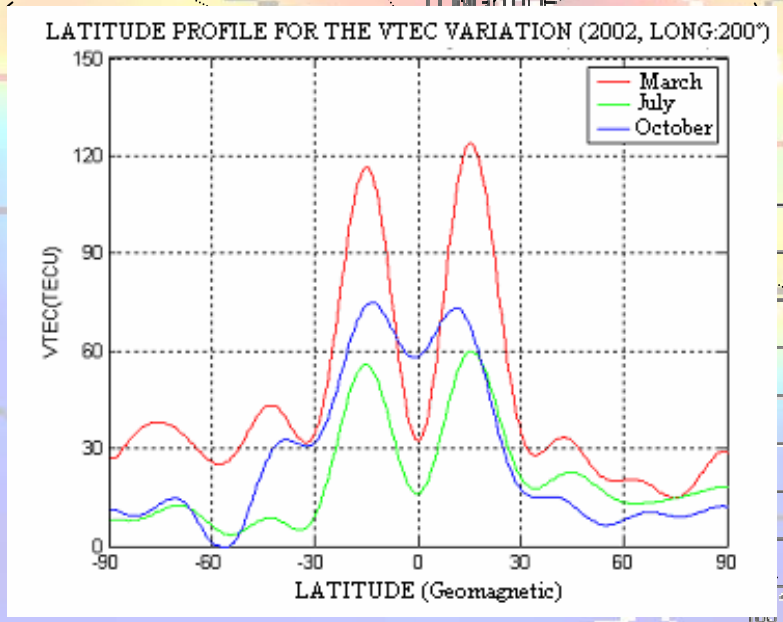
1 TECU = 10^{16} ele/m^2

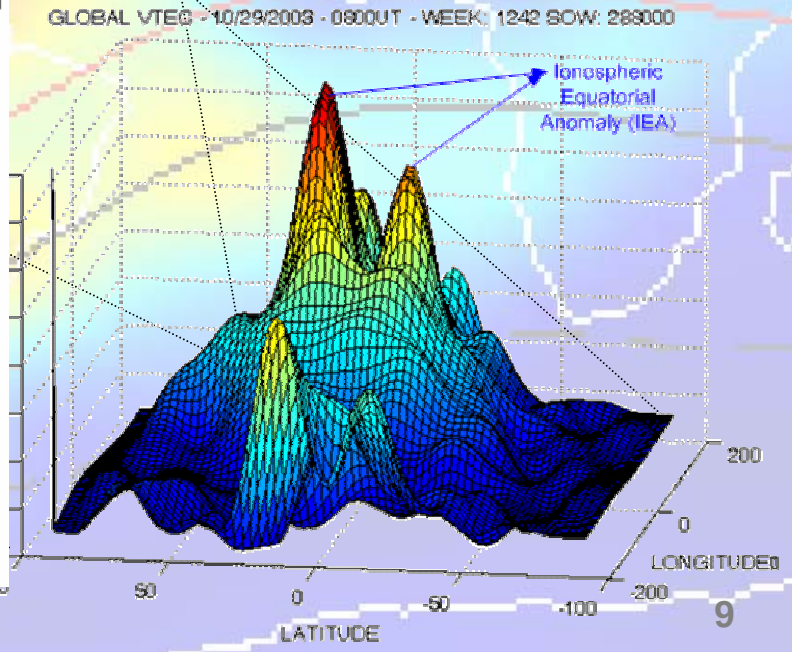
Ionospheric Equatorial Anomaly (IEA)





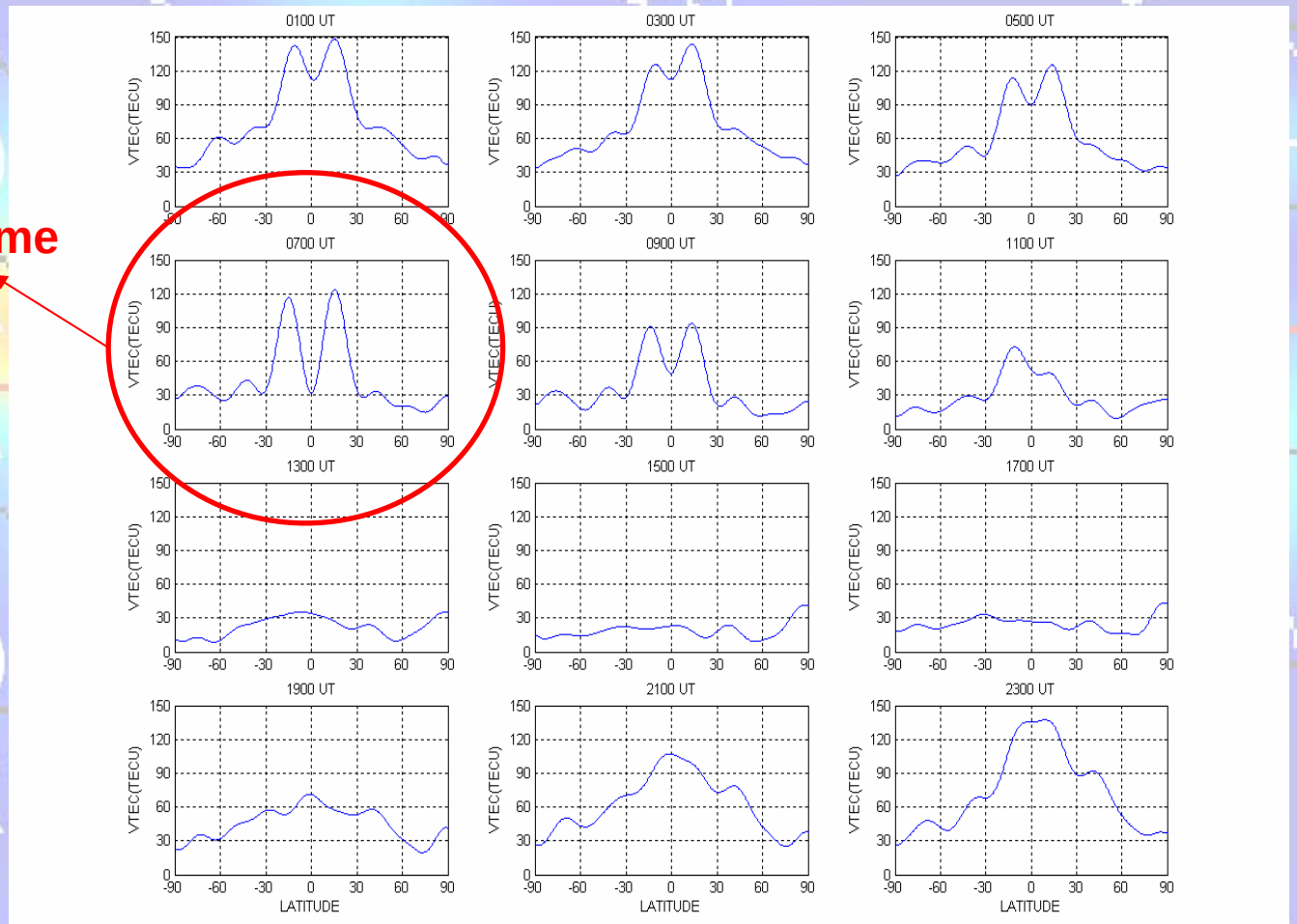
IEA (±20º)





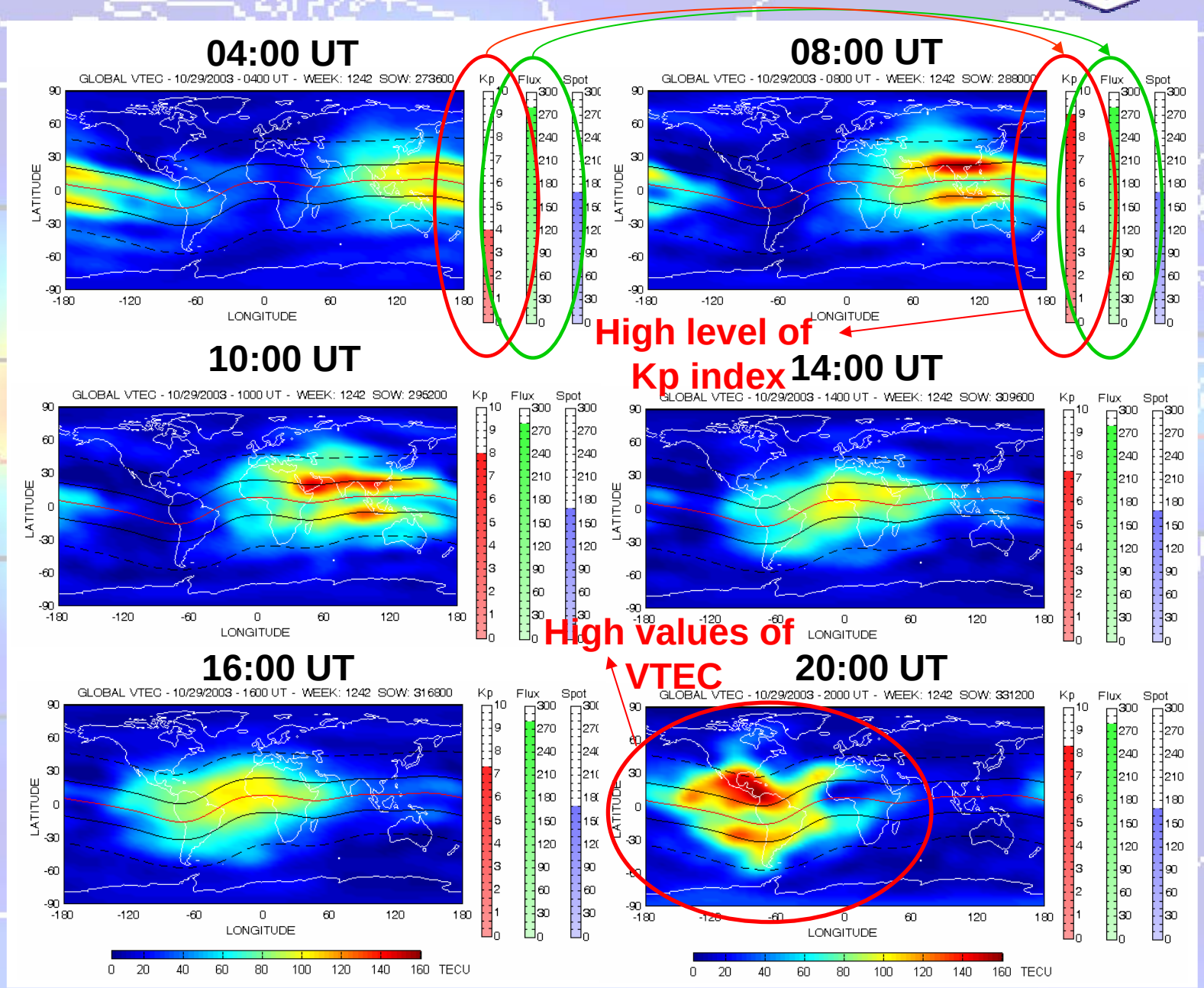
IEA variation along the day (Long. 200º)

3 pm Local Time



Periods of magnetic storms

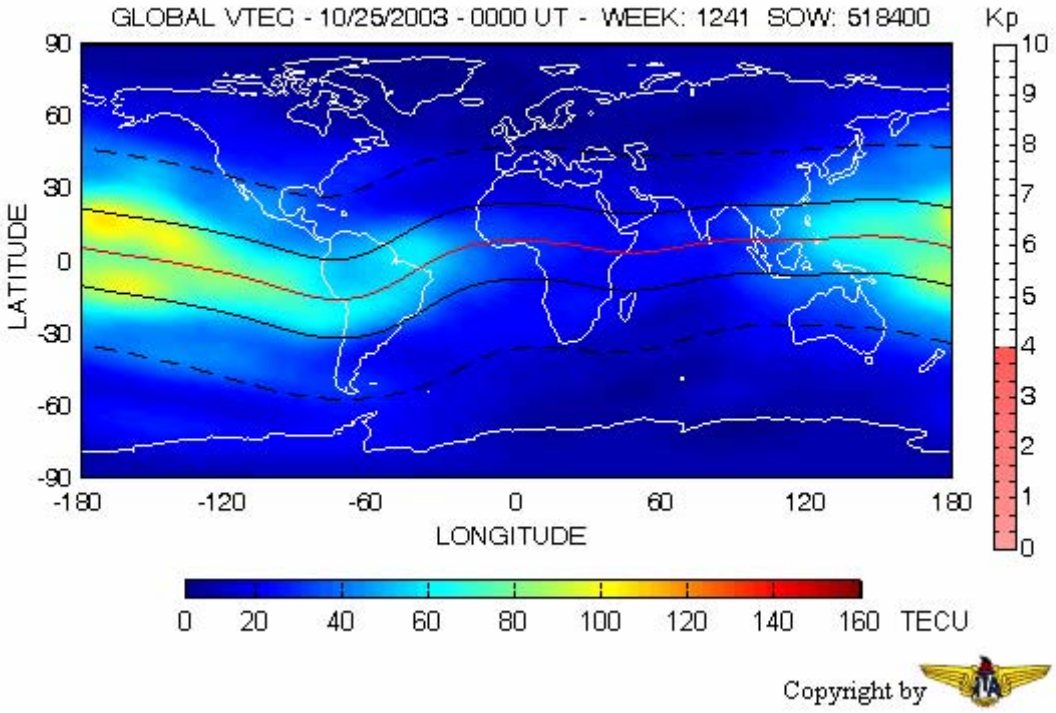
Periods of magnetic storms (October 29, 2003)

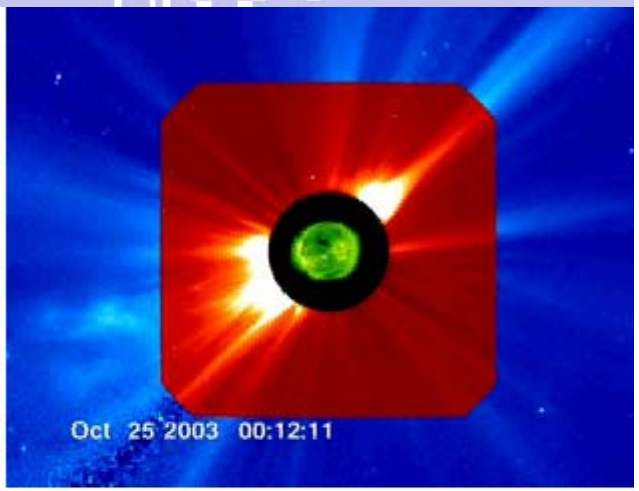


27/1/2006

Periods of magnetic storms (October, 2003)

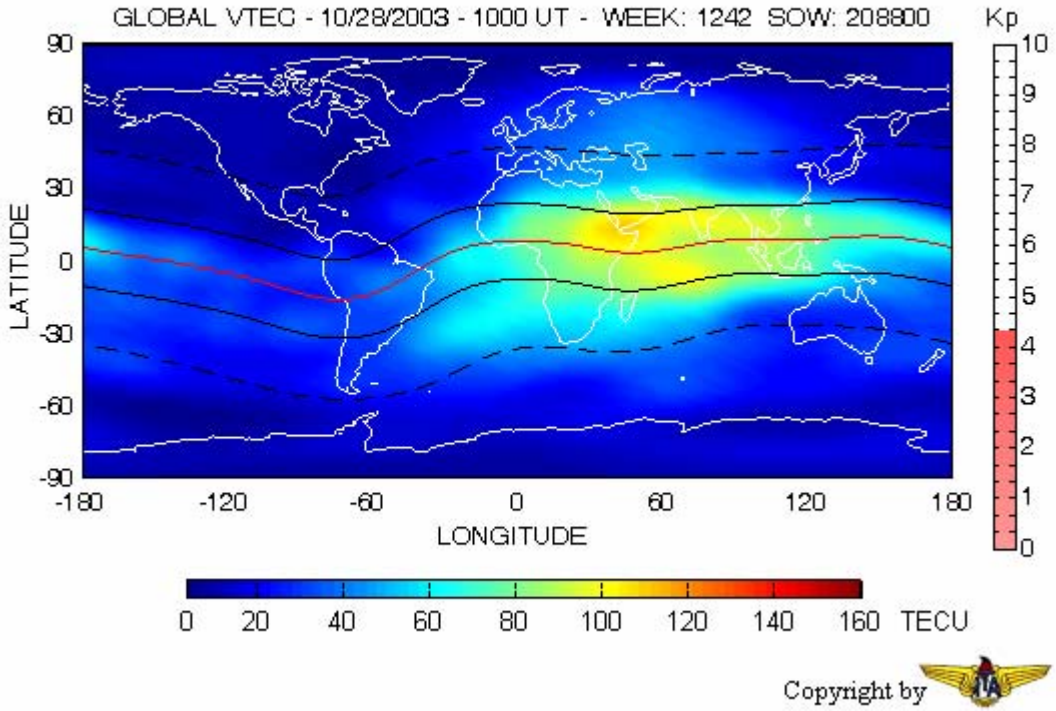
Credit: Nasa

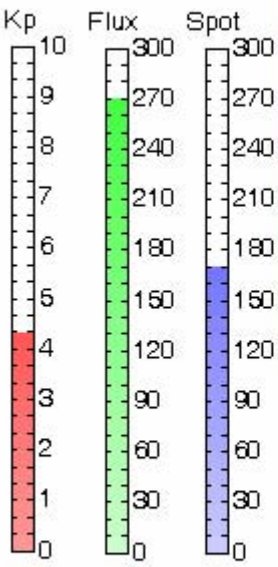


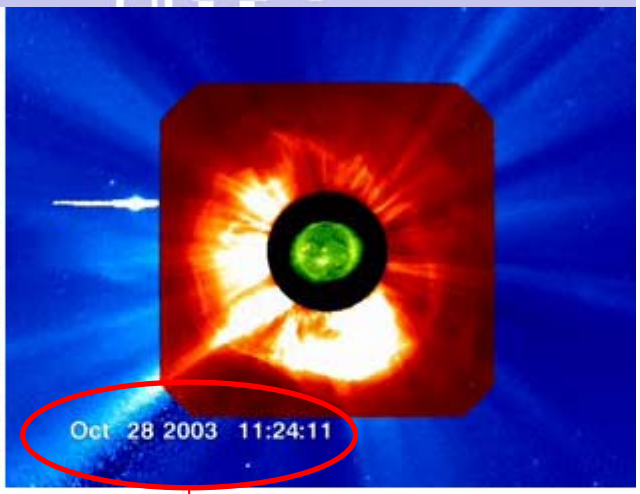


Periods of magnetic storms (October, 2003)

Credit: Nasa



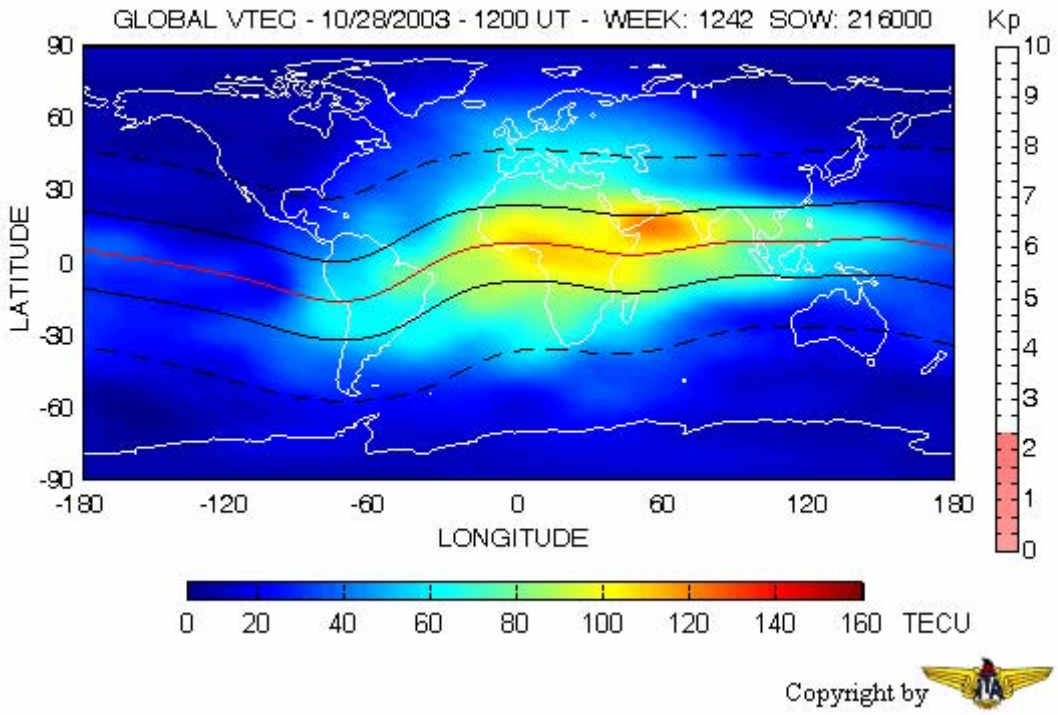


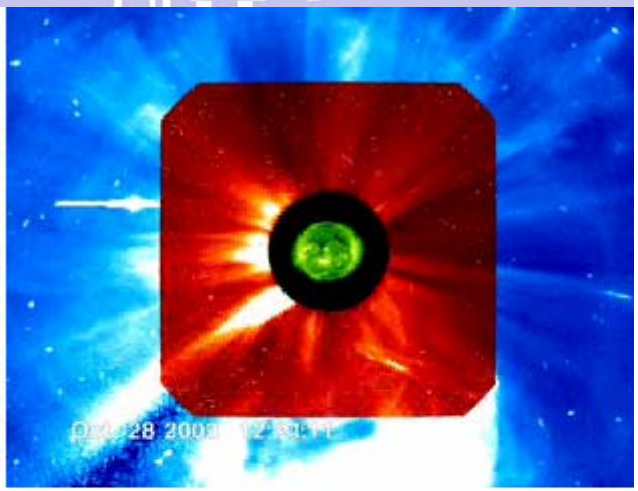


October 28, 2003
11:24 UT

Periods of magnetic storms (October, 2003)

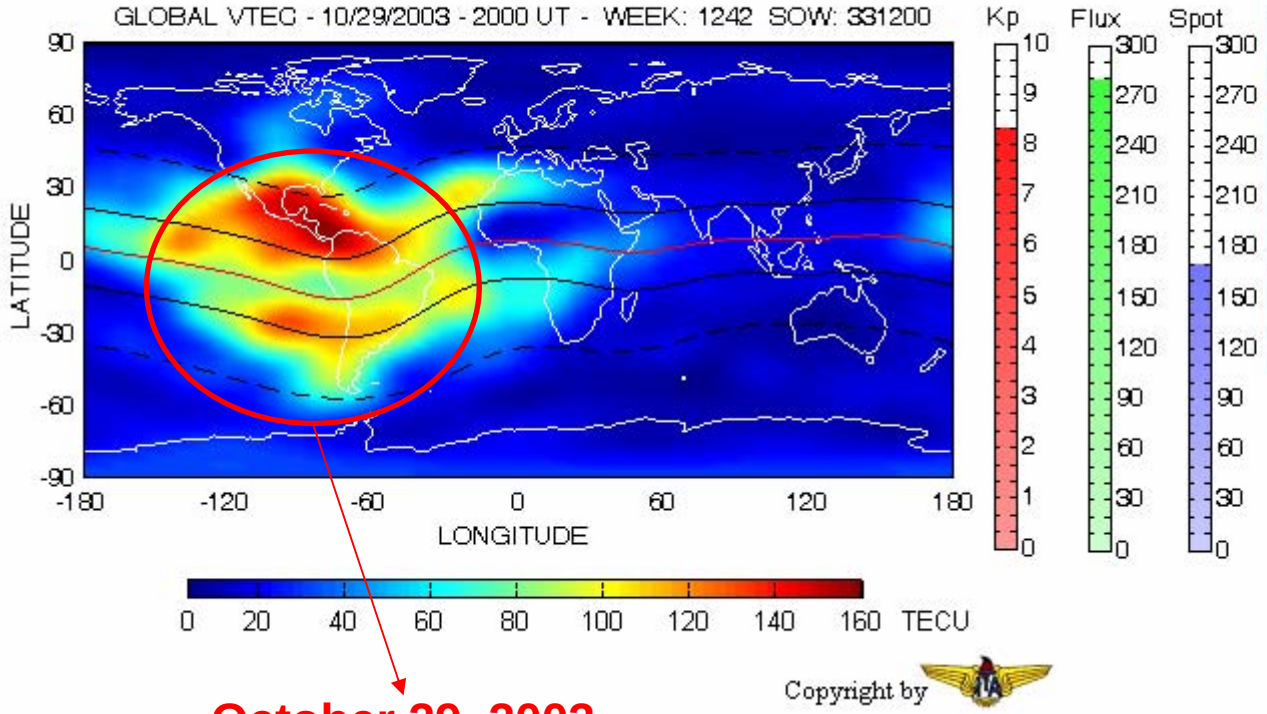
Credit: Nasa

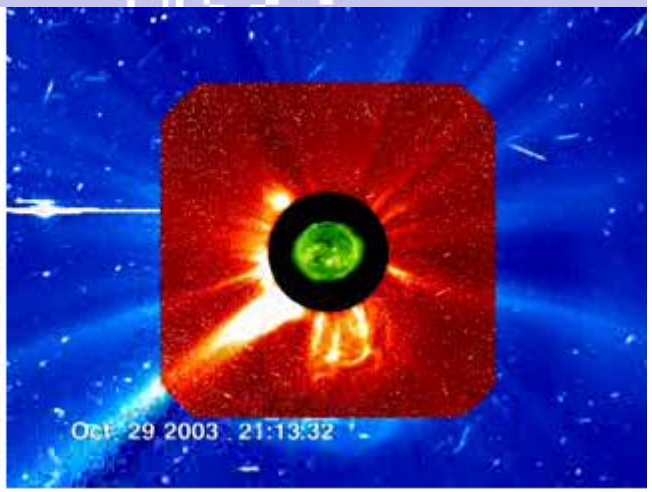




Periods of magnetic storms (October, 2003)

Credit: Nasa

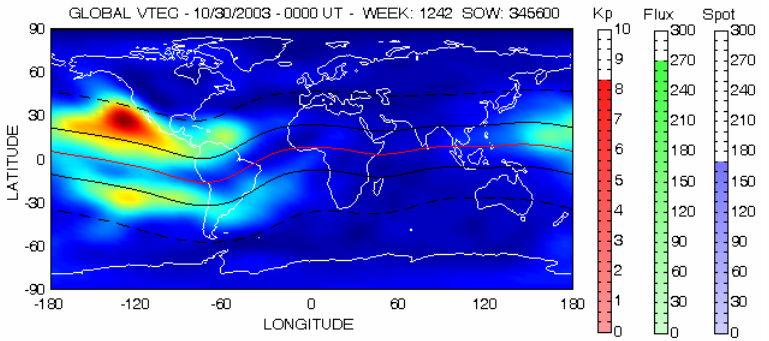




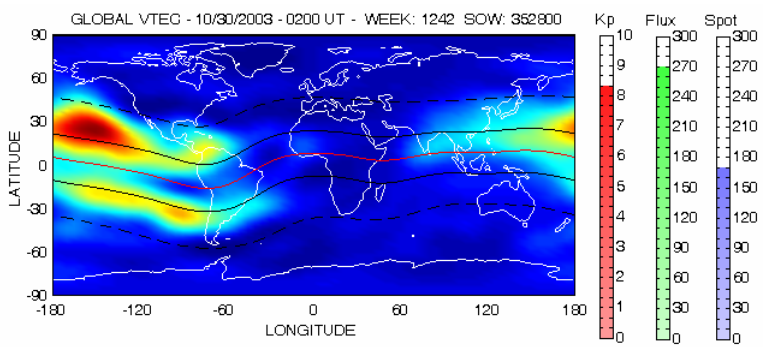
October 29, 2003
20:00 UT

Periods of magnetic storms (October 30, 2003)

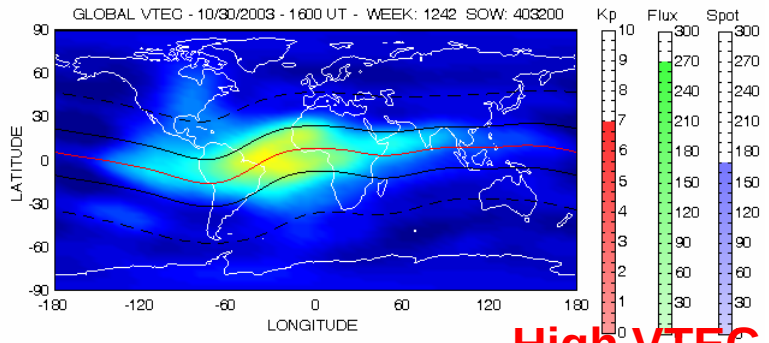
00:00 UT



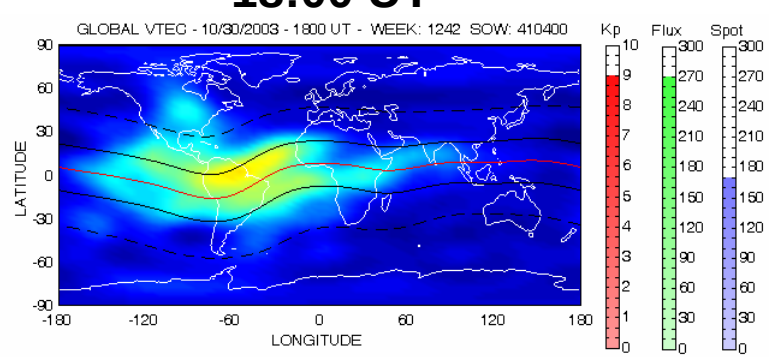
02:00 UT



16:00 UT

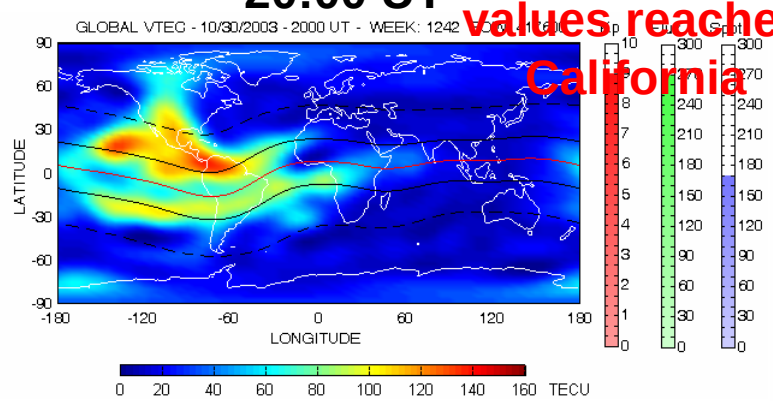


18:00 UT

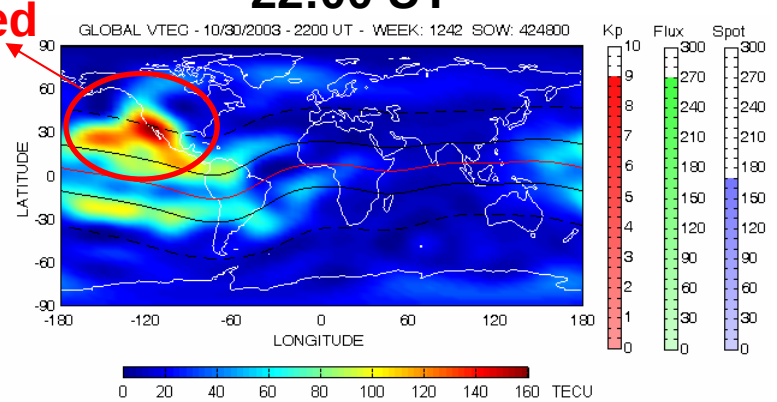


High VTEC values reached California

20:00 UT



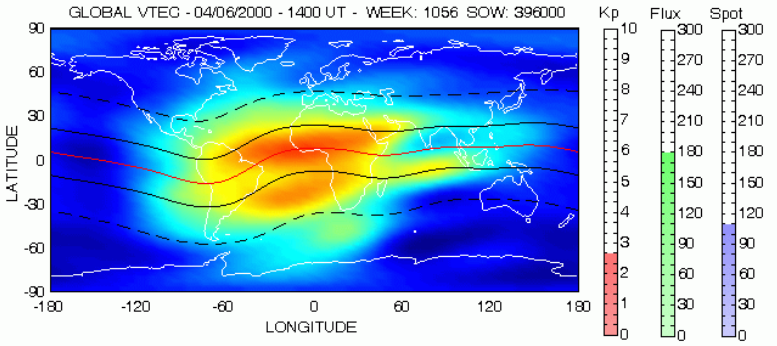
22:00 UT



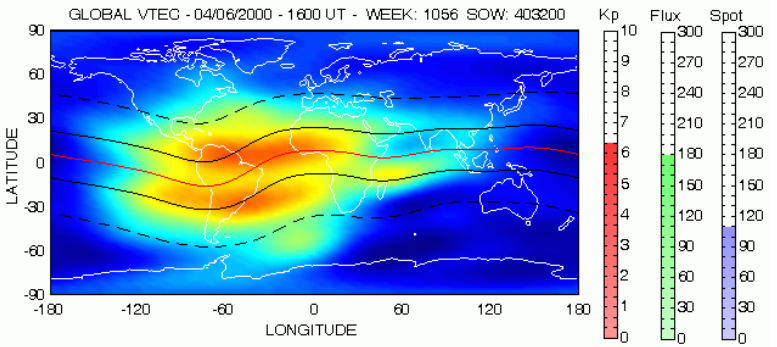
27/1/2006

Periods of magnetic storms (April 06, 2000)

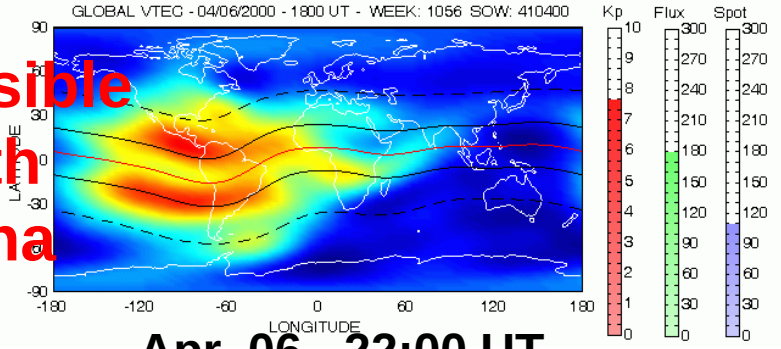
Apr. 06 - 14:00 UT



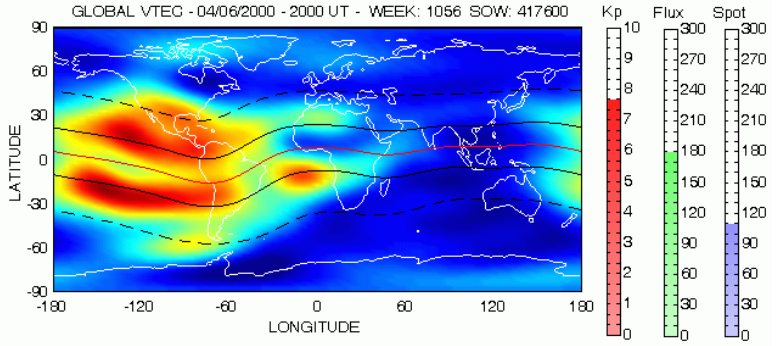
Apr. 06 - 20:00 UT



Apr. 06 - 18:00 UT

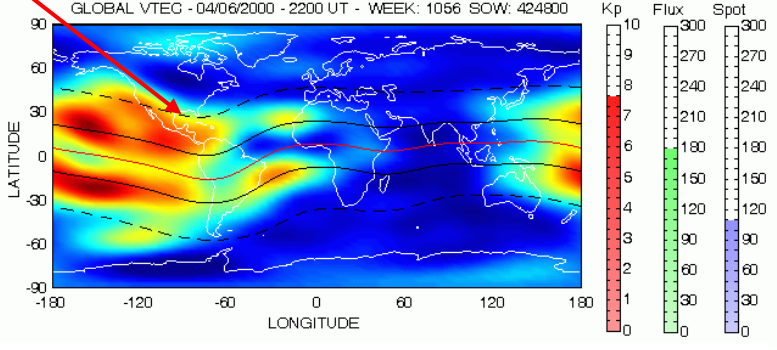


Apr. 06 - 20:00 UT

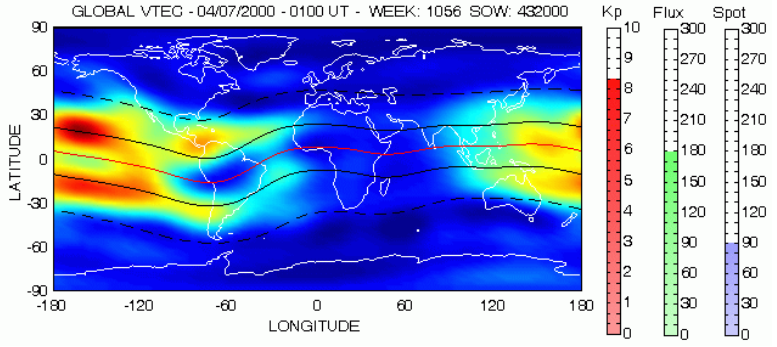


Aurora visible in North Carolina

Apr. 06 - 22:00 UT

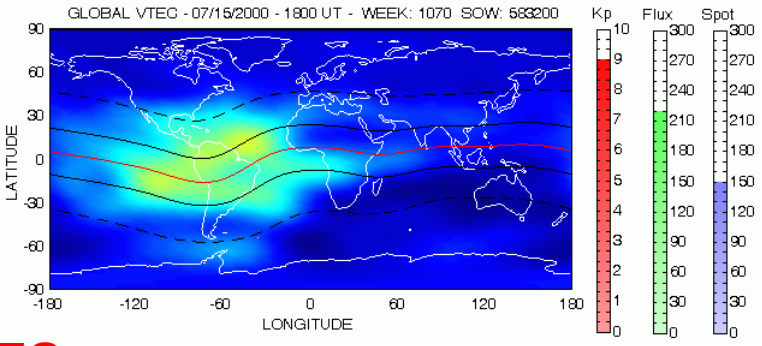


Apr. 07 - 01:00 UT

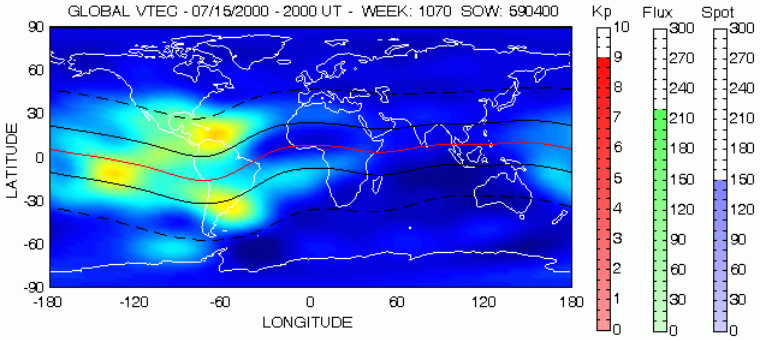


Periods of magnetic storms (July 15, 2000)

Jul. 15 - 18:00 UT

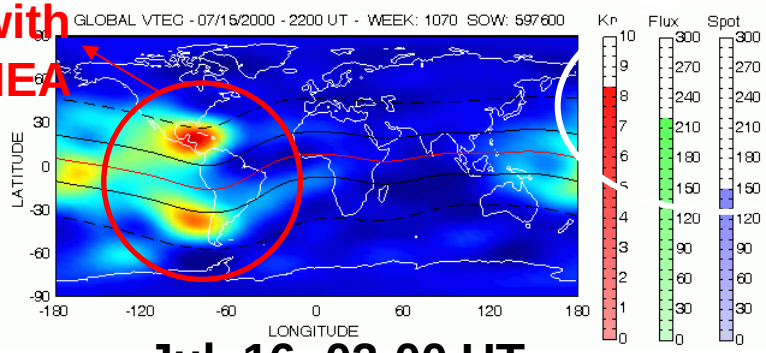


Jul. 15 - 20:00 UT

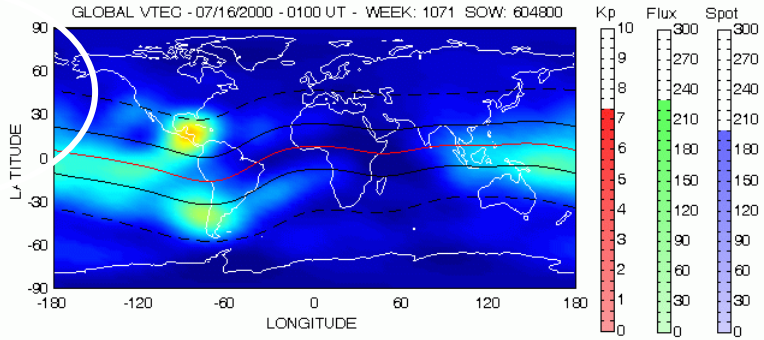


High VTEC values with intense IEA

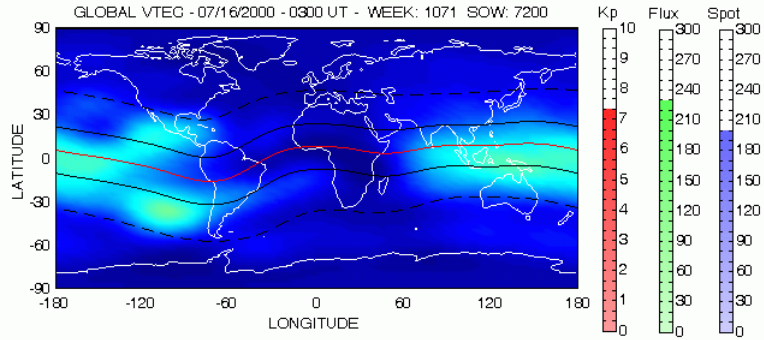
Jul. 15 - 22:00 UT



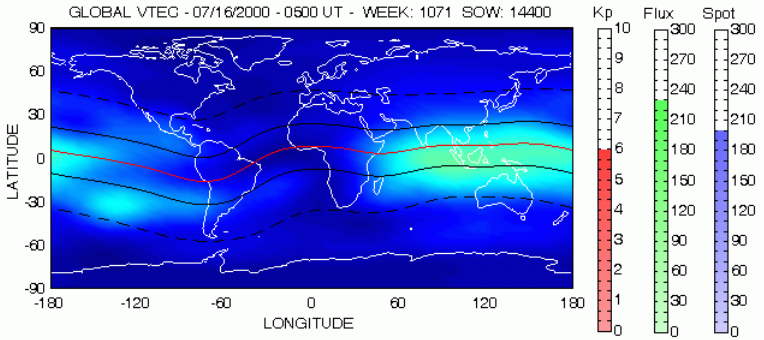
Jul. 16 - 01:00 UT



Jul. 16- 03:00 UT



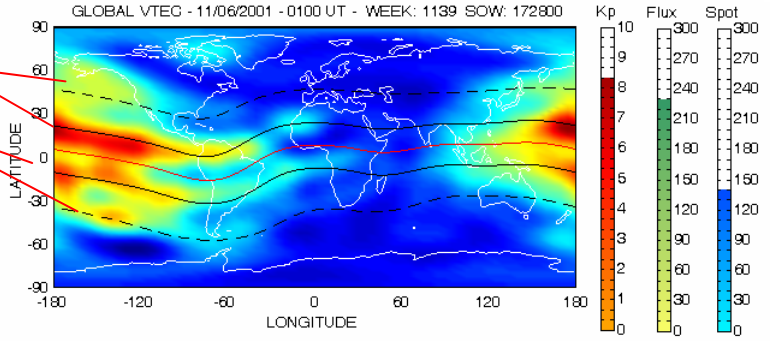
Jul. 16- 05:00 UT



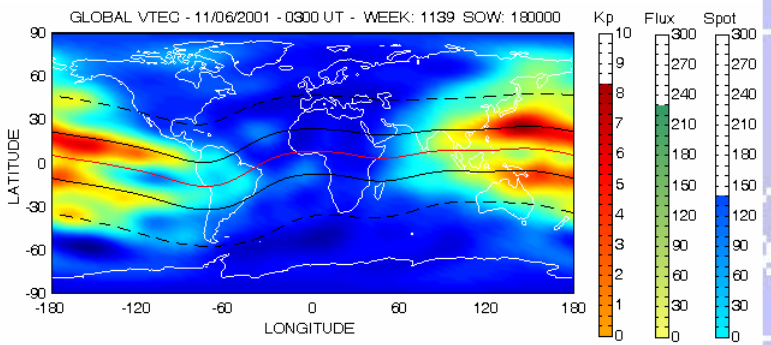
Periods of magnetic storms (November 06, 2001)

IEA intense
(±20º e ±40º)

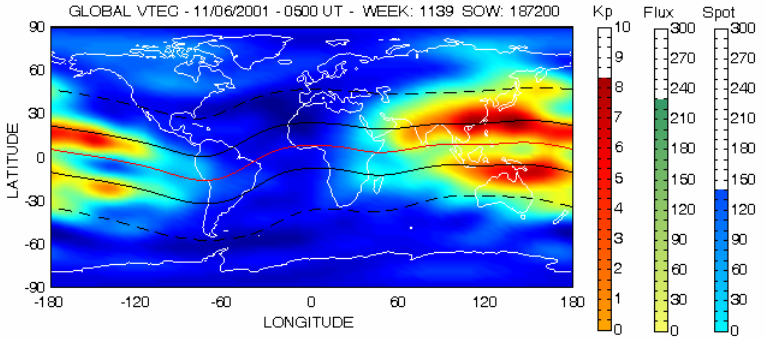
01:00 UT



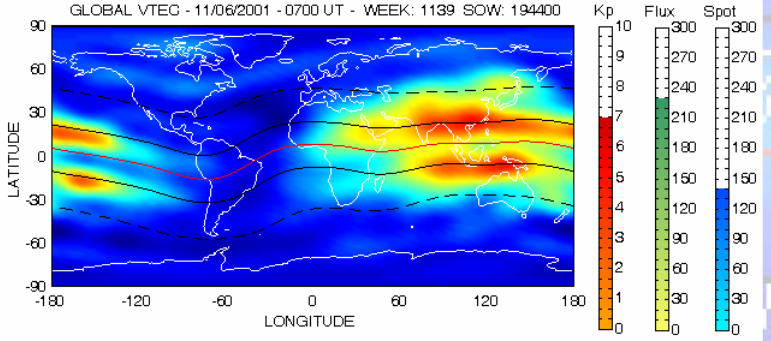
03:00 UT



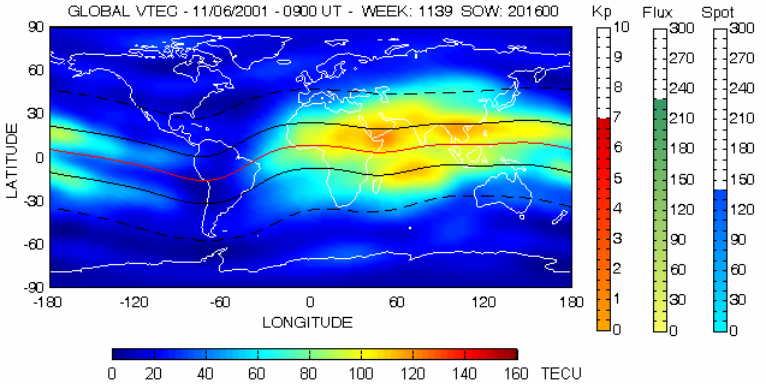
05:00 UT



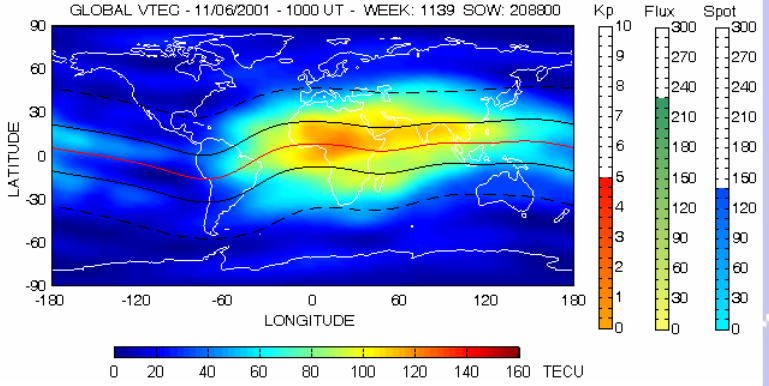
07:00 UT



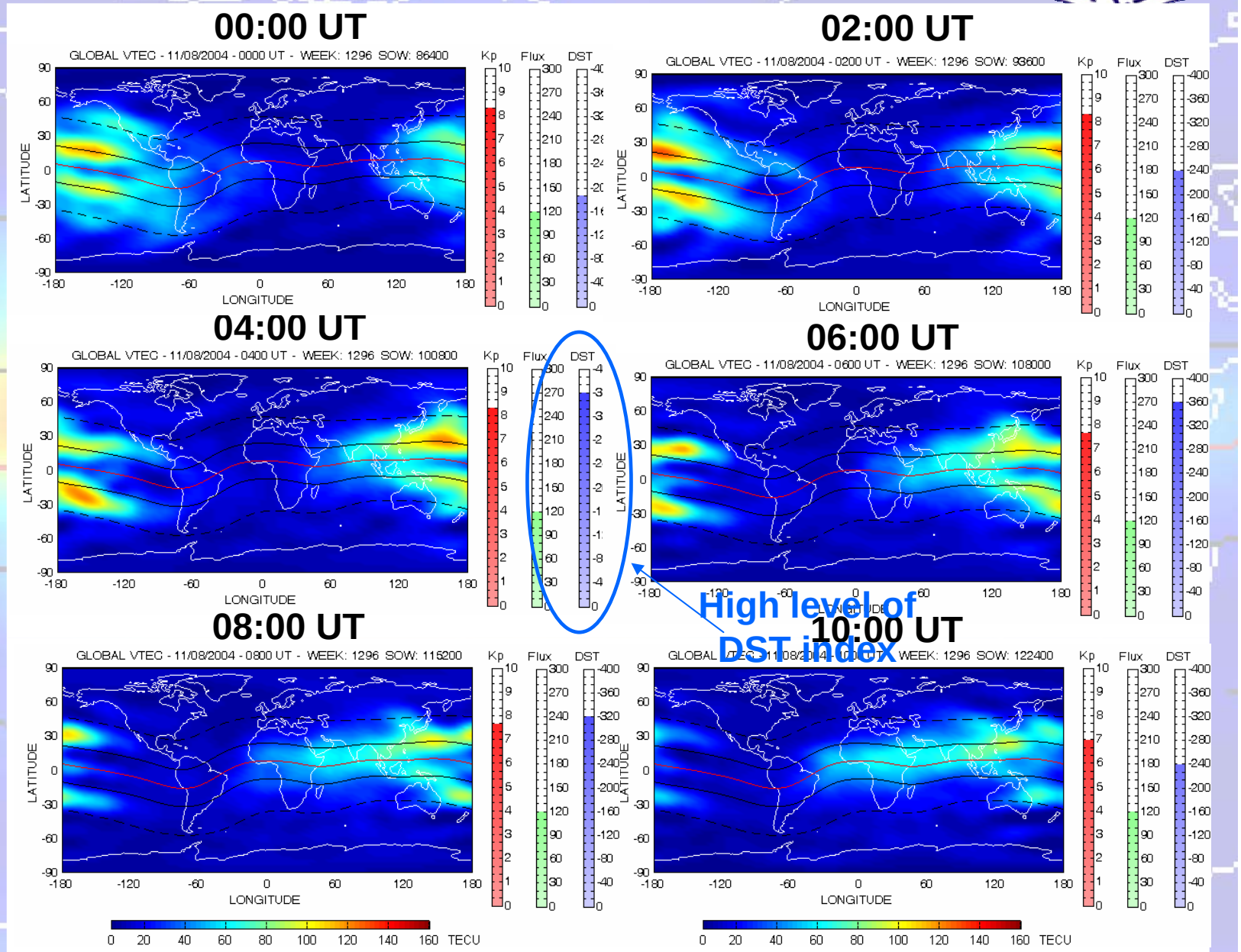
09:00 UT



10:00 UT

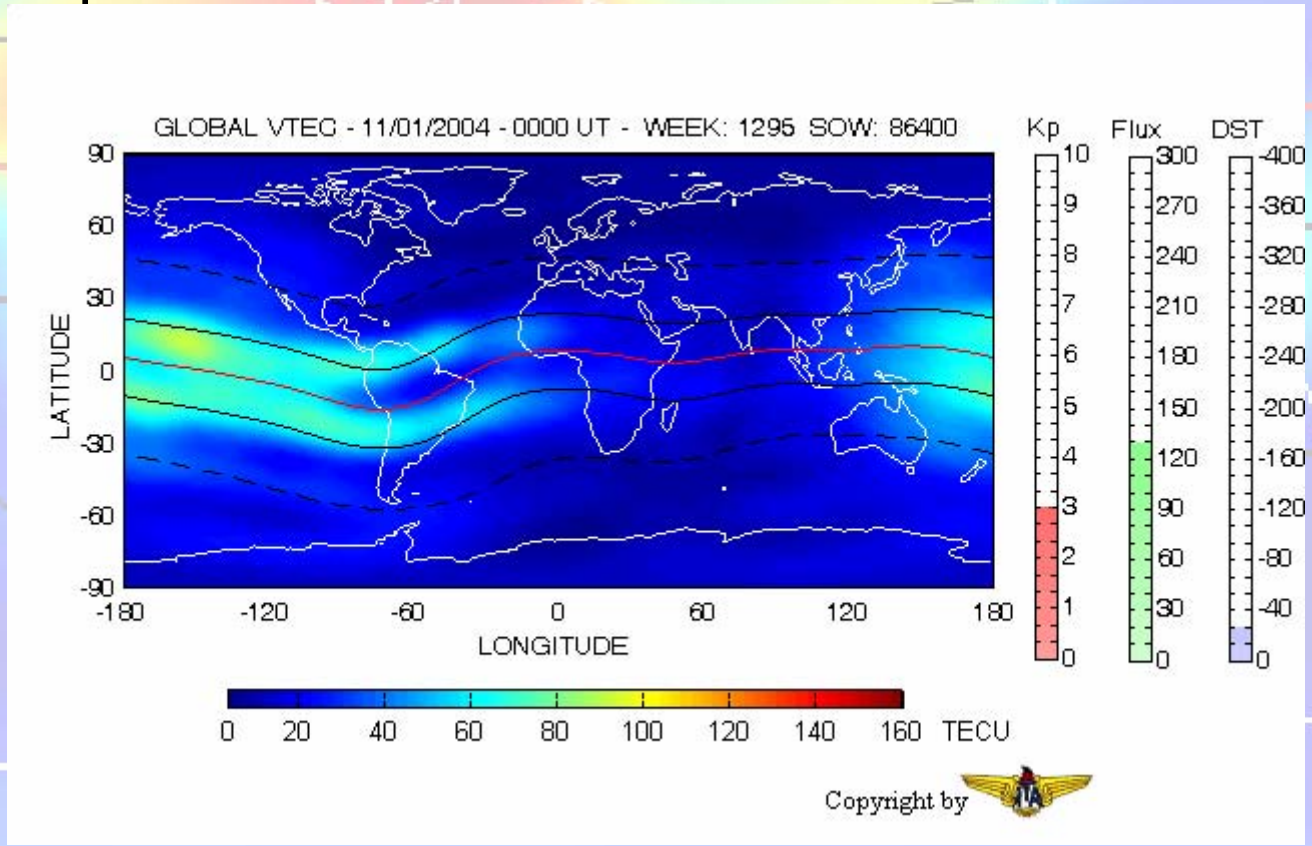


Periods of magnetic storms (November 08, 2004)



Conclusions and Results

- This work has as a final product a database composed by VTEC maps since January 1999 which allows making comparisons with the geomagnetic activity, and the ionosphere behavior visualization during magnetic storms periods.



Conclusions and Results

- This work has as a final product a database composed by VTEC maps since January 1999 which allows making comparisons with the geomagnetic activity, and the ionosphere behavior visualization during magnetic storms periods.
- Since we know, in at least two hours in advance, that what happens in region will affect another one, a global alarm system can be used.
- In order to study the GNSS error, it is necessary to take into account the ionospheric effects, mainly in the Equatorial Anomaly region or under high solar activity.
- The data analyzed show a delay of 20 to 30 hours (~1300 km/h) to the solar storm to affect the TEC. More data needs to be analyzed.
- A new data are starting to be used: the Dst.

FURTHER RESULTS

- Since some discussion between IRI model and TEC were under taking during this meeting we show some preliminary results were the IRI gave us a guidance to model the global VTEC.
- (The following results are an extension of this work, it is only an advance of results getting by Thiago Morais, a student of the GNSS Laboratory, as part of his Master Theses)

Modelamento da densidade eletronica

PERFIL DA DENSIDADE ELETRONICA EM FUNÇAO DA LATITUDE

Epoca

Ano 2001

Mes Out

30

Hora 17 UT

Plotar dados IONEX

Plotar Perfil Dens Eletronica

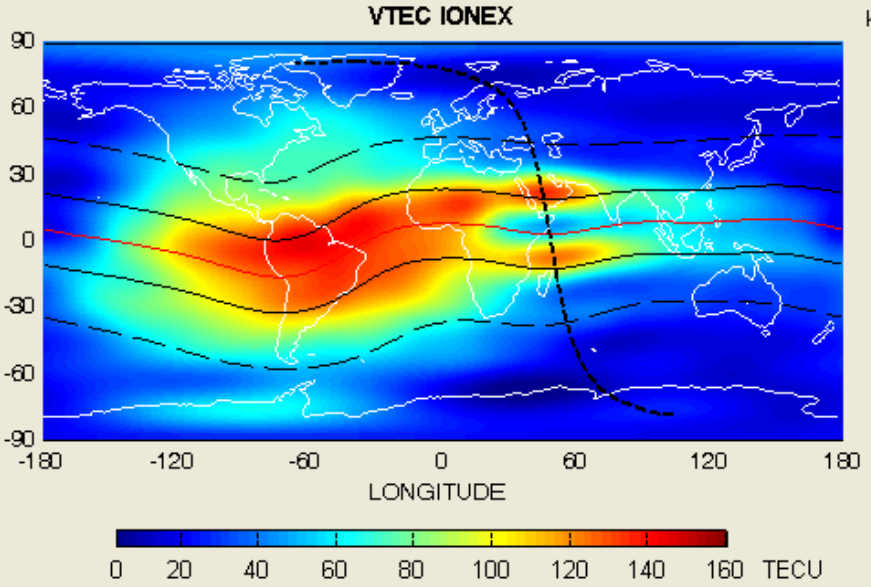
Sair

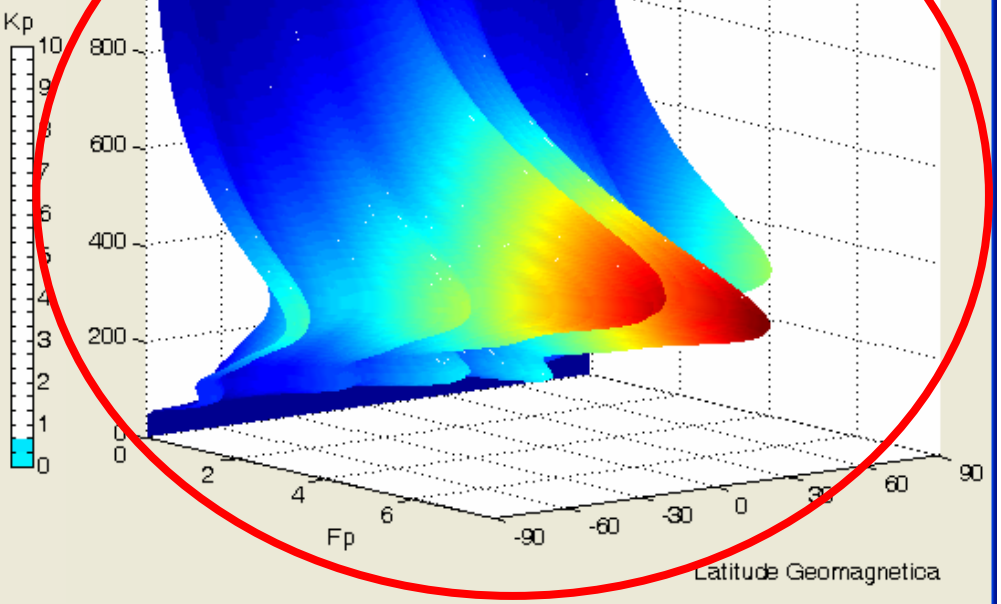
Coordenadas geograficas

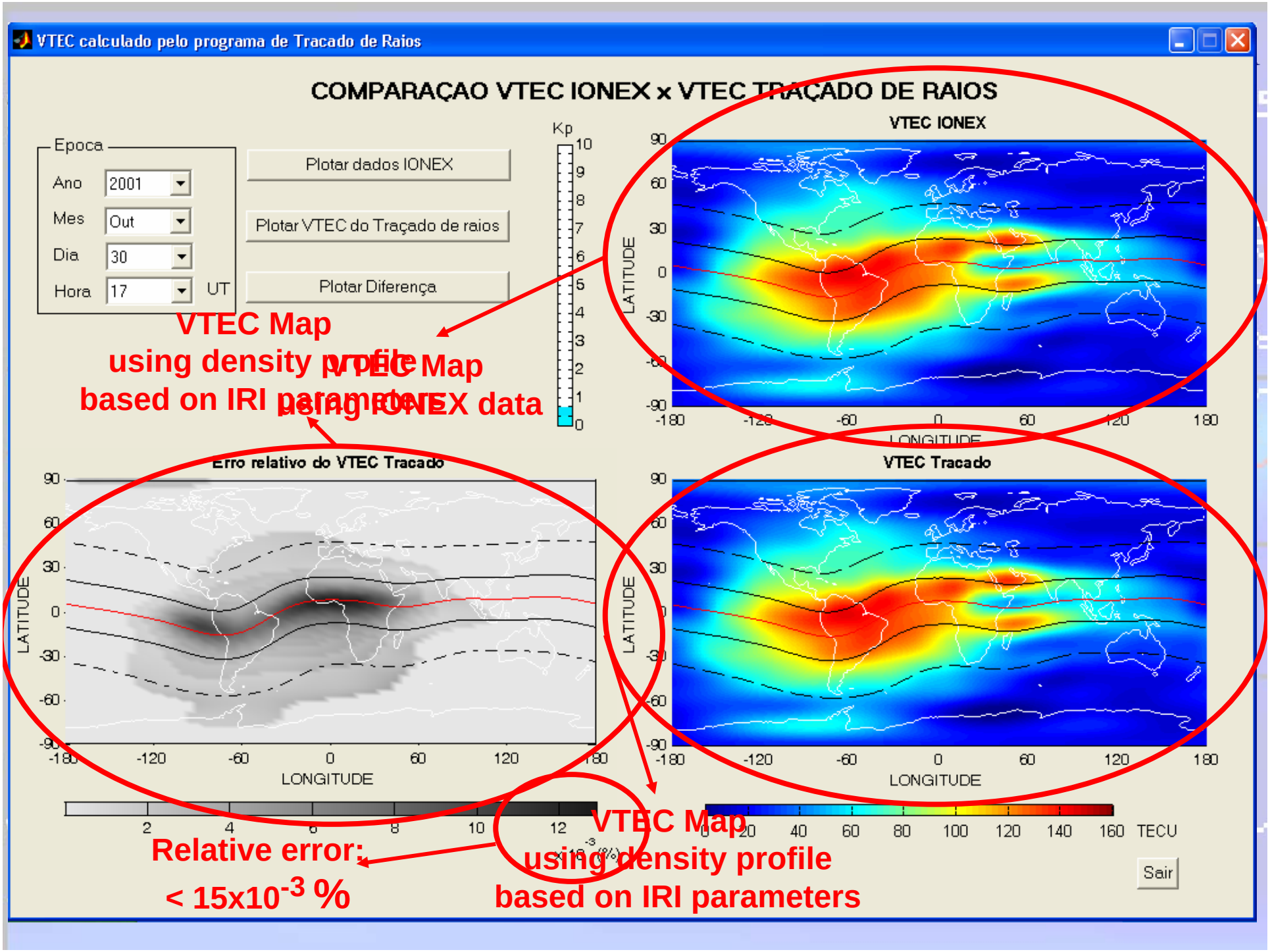
Latitude: 6.61

Longitude: 48.19

Atualizar interface






VTEC calculado pelo programa de Tracado de Raios
COMPARAÇAO VTEC IONEX x VTEC TRAÇADO DE RAIOS
Epoca
Ano 2001
Mes Out
Dia 30
Hora 17 UT
Plotar dados IONEX
Plotar VTEC do Traçado de raios
Plotar Diferença
Kp
VTEC IONEX
LATITUDE
LONGITUDE
VTEC Map
using density profile
based on IRI parameters
VTEC Map
using IONEX data
Erro relativo do VTEC Tracado
VTEC Tracado
TECU
Relative error:
< 15x10-3 %
VTEC Map
using density profile
based on IRI parameters
Sair

Modelamento da densidade eletronica

PERFIL DA DENSIDADE ELETRONICA EM FUNÇAO DA LATITUDE

Epoca

Ano 2003

Mes

Dia 30

Hora 22 UT

Plotar dados IONEX

Plotar Perfil Dens Eletronica

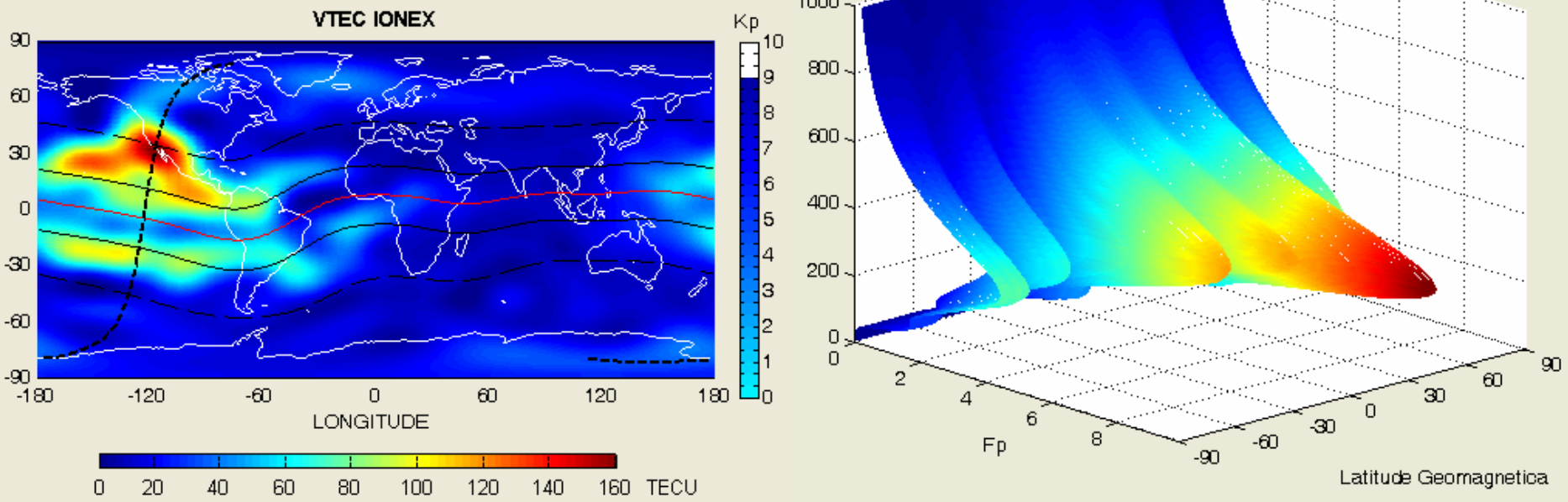
Sair

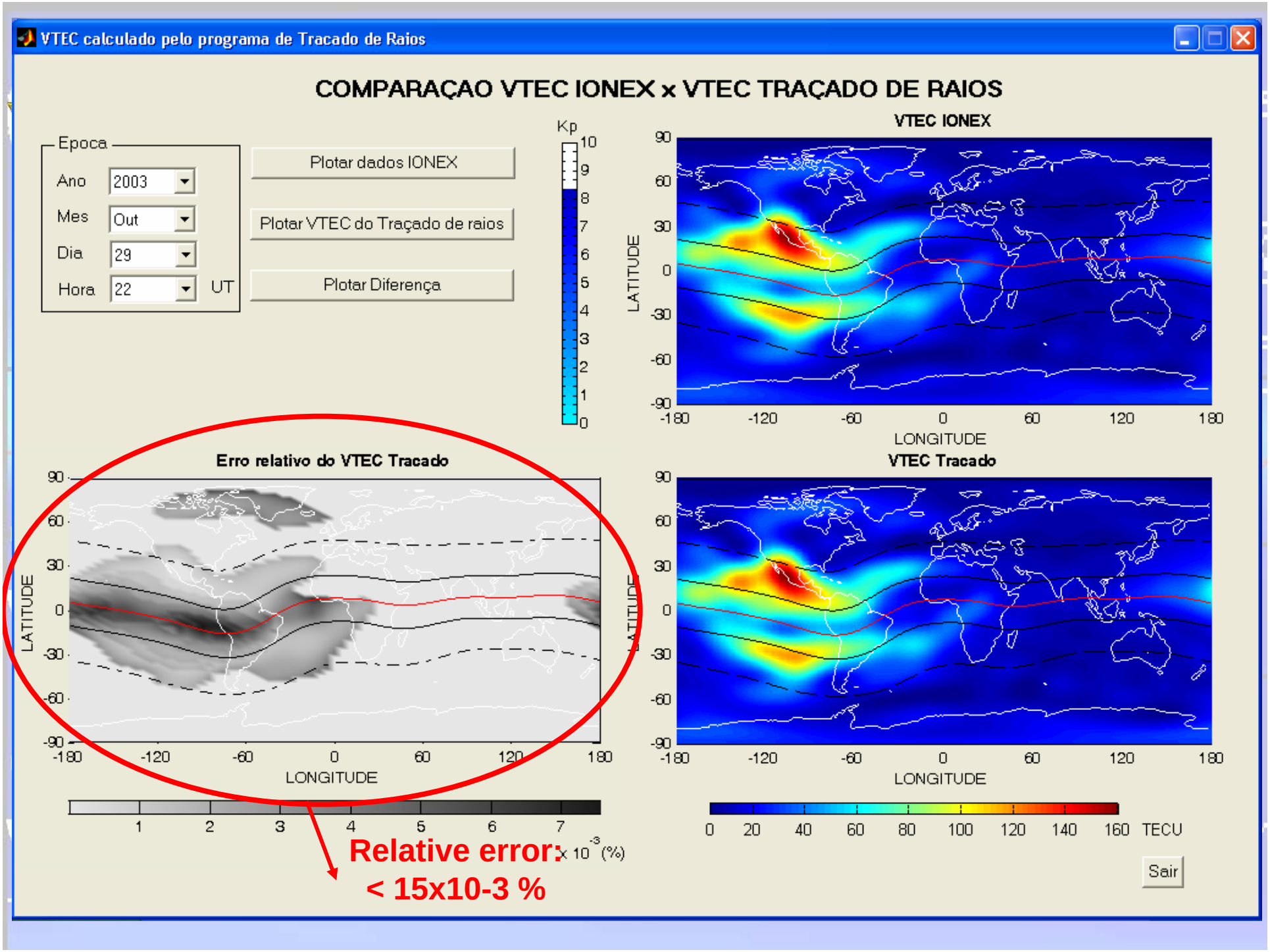
Coordenadas geograficas

Latitude: 29.72

Longitude: -117.39

Atualizar interface




VTEC calculado pelo programa de Tracado de Raios
COMPARAÇAO VTEC IONEX x VTEC TRAÇADO DE RAIOS
Epoca
Ano 2003
Mes Out
Dia 29
Hora 22 UT
Plotar dados IONEX
Plotar VTEC do Traçado de raios
Plotar Diferença
Kp
VTEC IONEX
LATITUDE
LONGITUDE
Erro relativo do VTEC Tracado
VTEC Tracado
TECU
Relative error:
< 15x10-3 %
Sair

Acknowledgments

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THANK YOU

FOR YOUR ATTENTION


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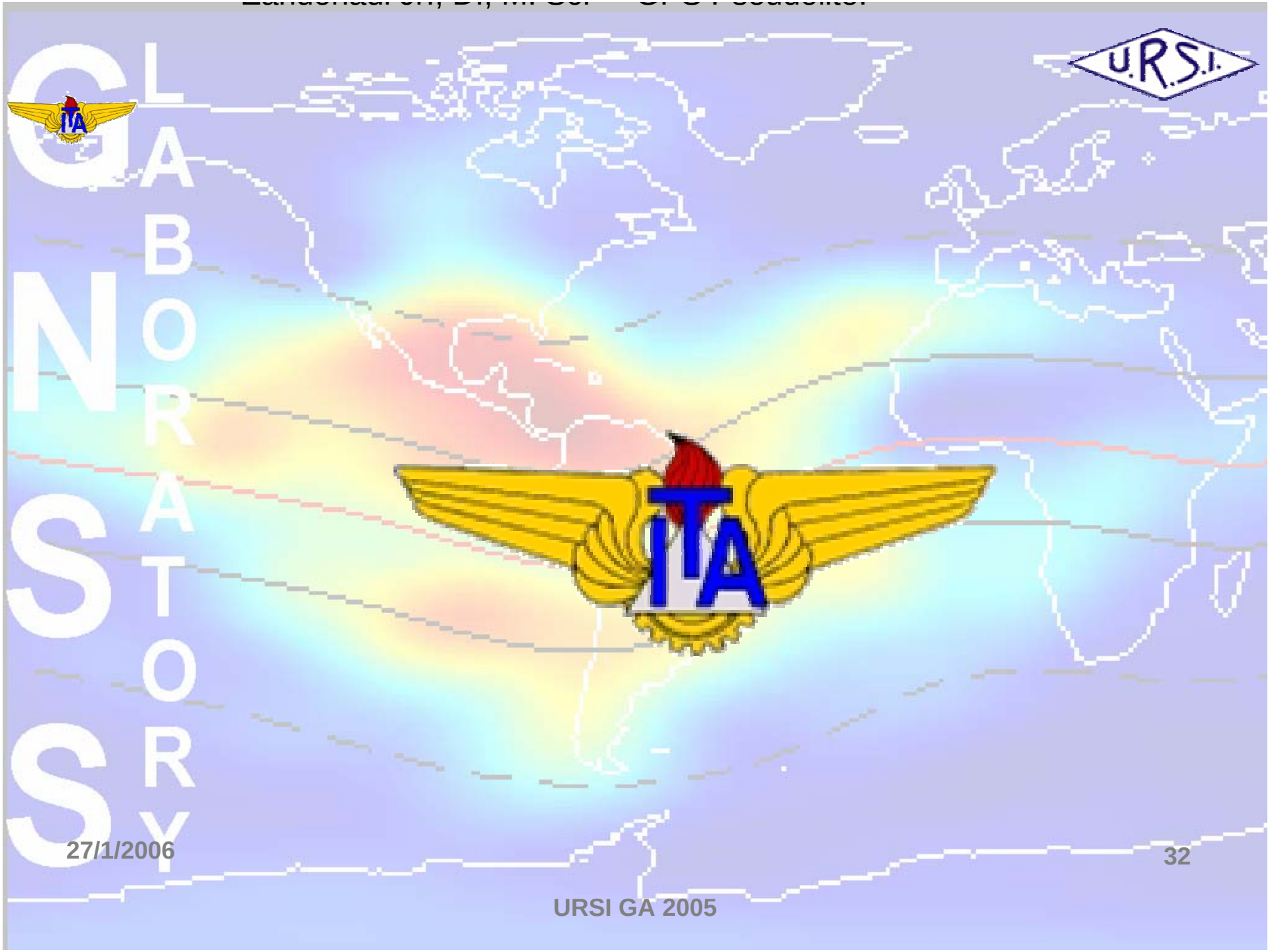
THE END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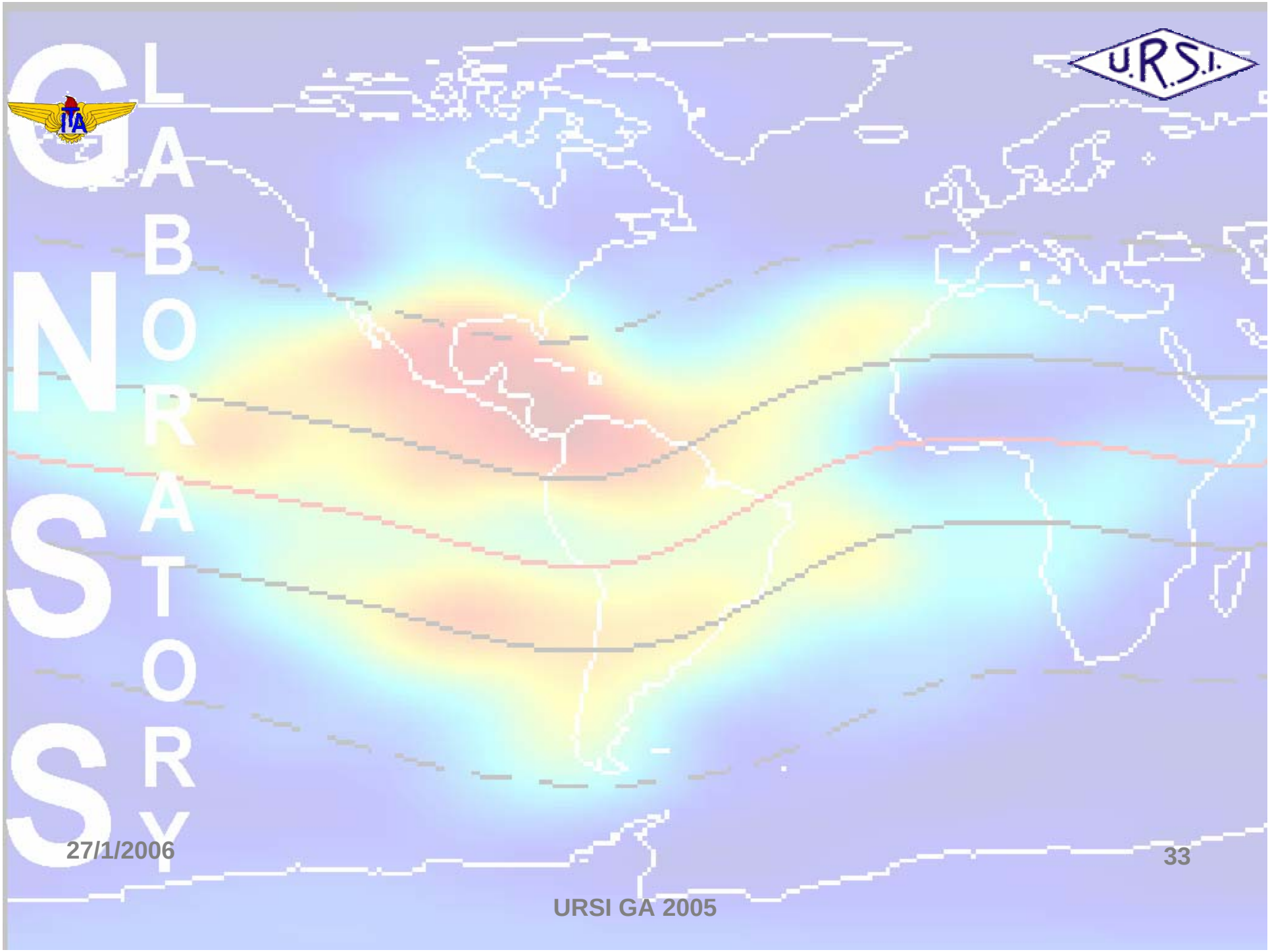
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