Understanding of GNSS anomalies : Anatolian Bump Signatures

United Nations/Latvia Workshop on the Applications of Global Navigation Satellite Systems 14 – 18 May 2012 Riga, Latvia

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Trever Garner

Applied Research Laboratories, University of Texas at Austin, USA


Small City !
121,300 Students enrolled (2012) in 18 Faculties
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Helwan University


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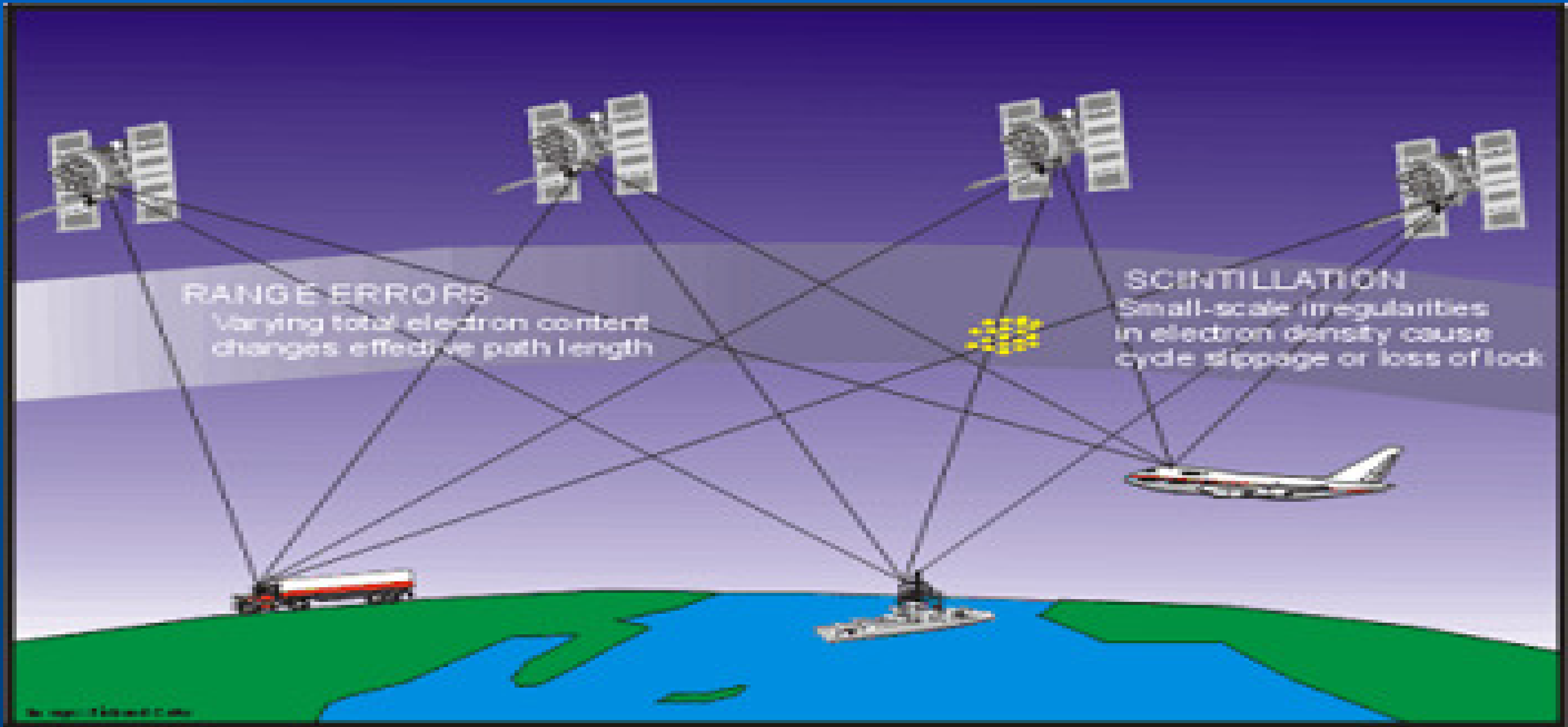
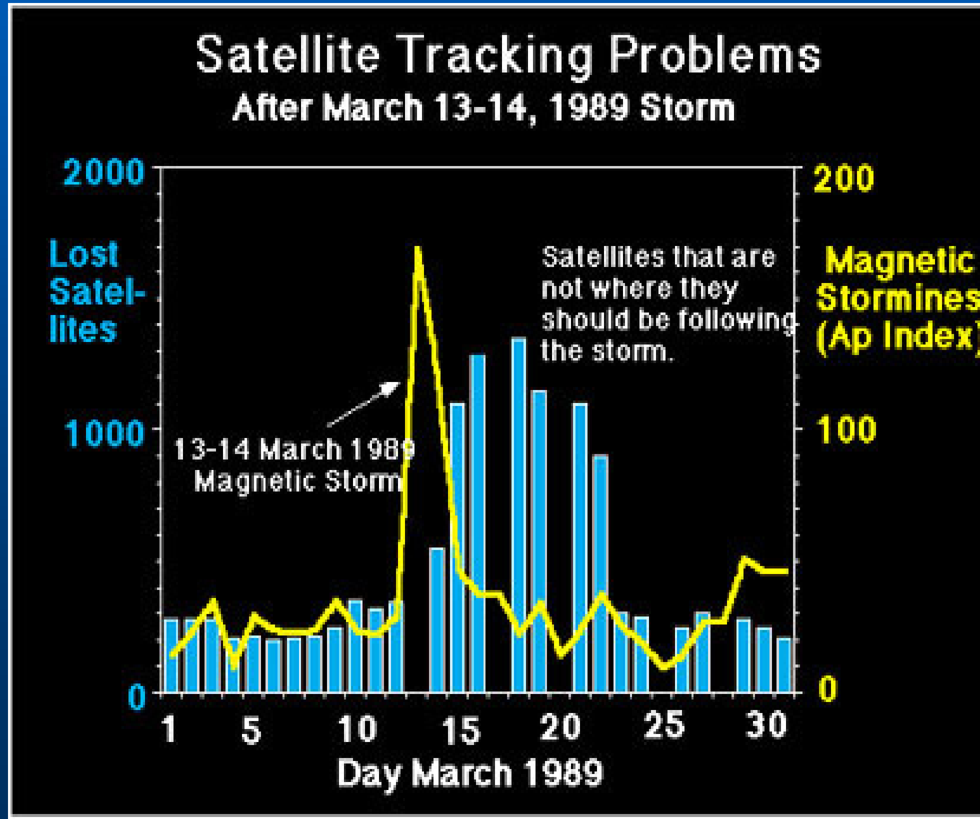
Outlines

- Why we Study Space Weather ?
- Space Weather Monitoring Center (SWMC) at HU
- Research Groups
- CIDR System
- Results
- Conclusions

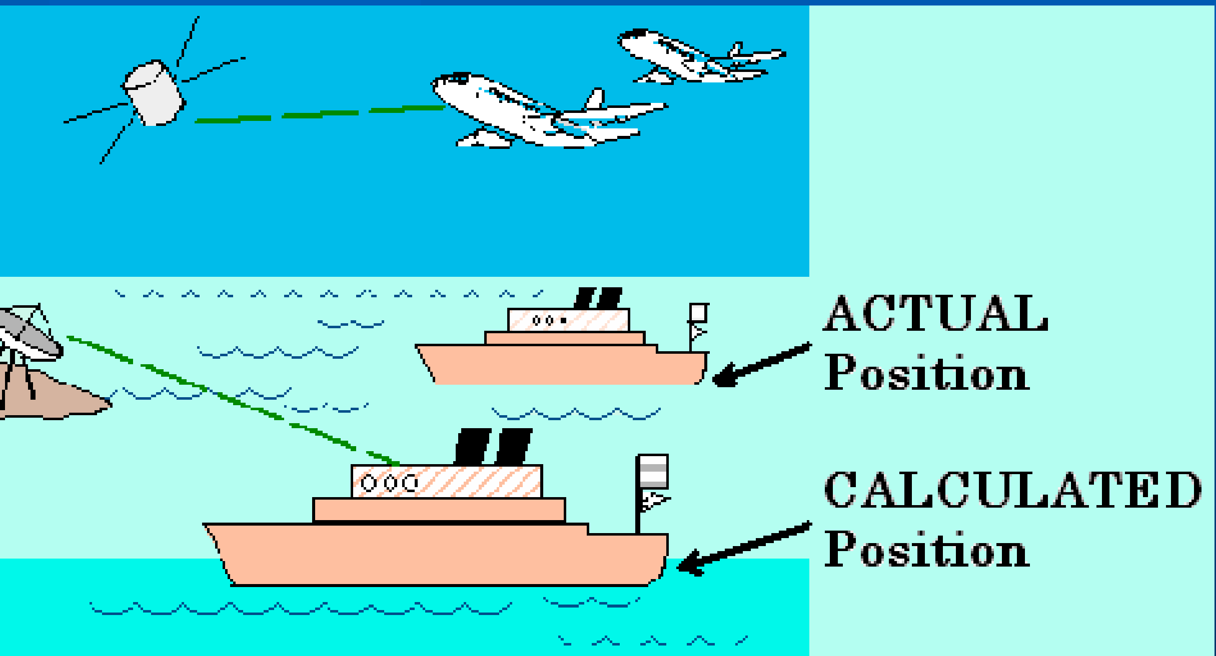
Why we Study Space Weather ?

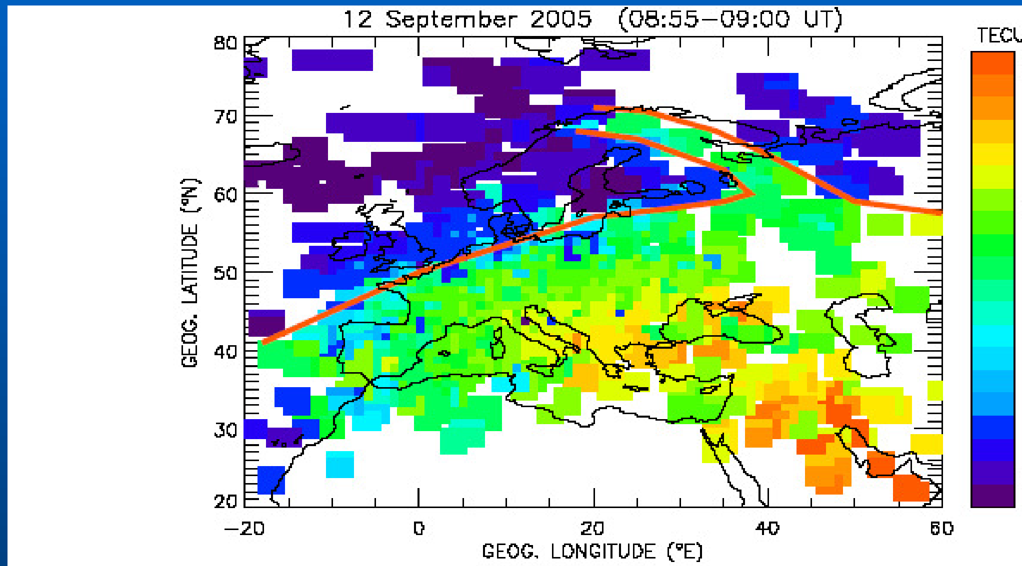


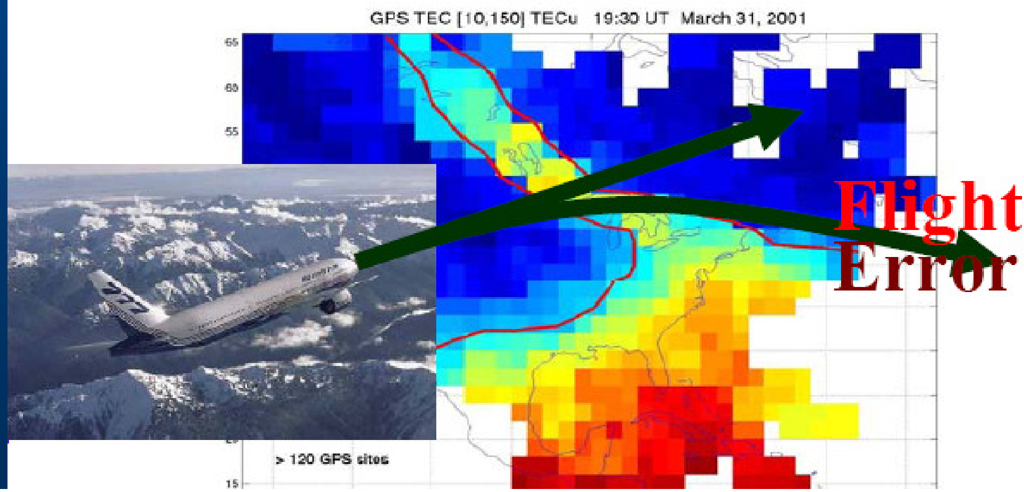
Spacecraft Damage/Loss



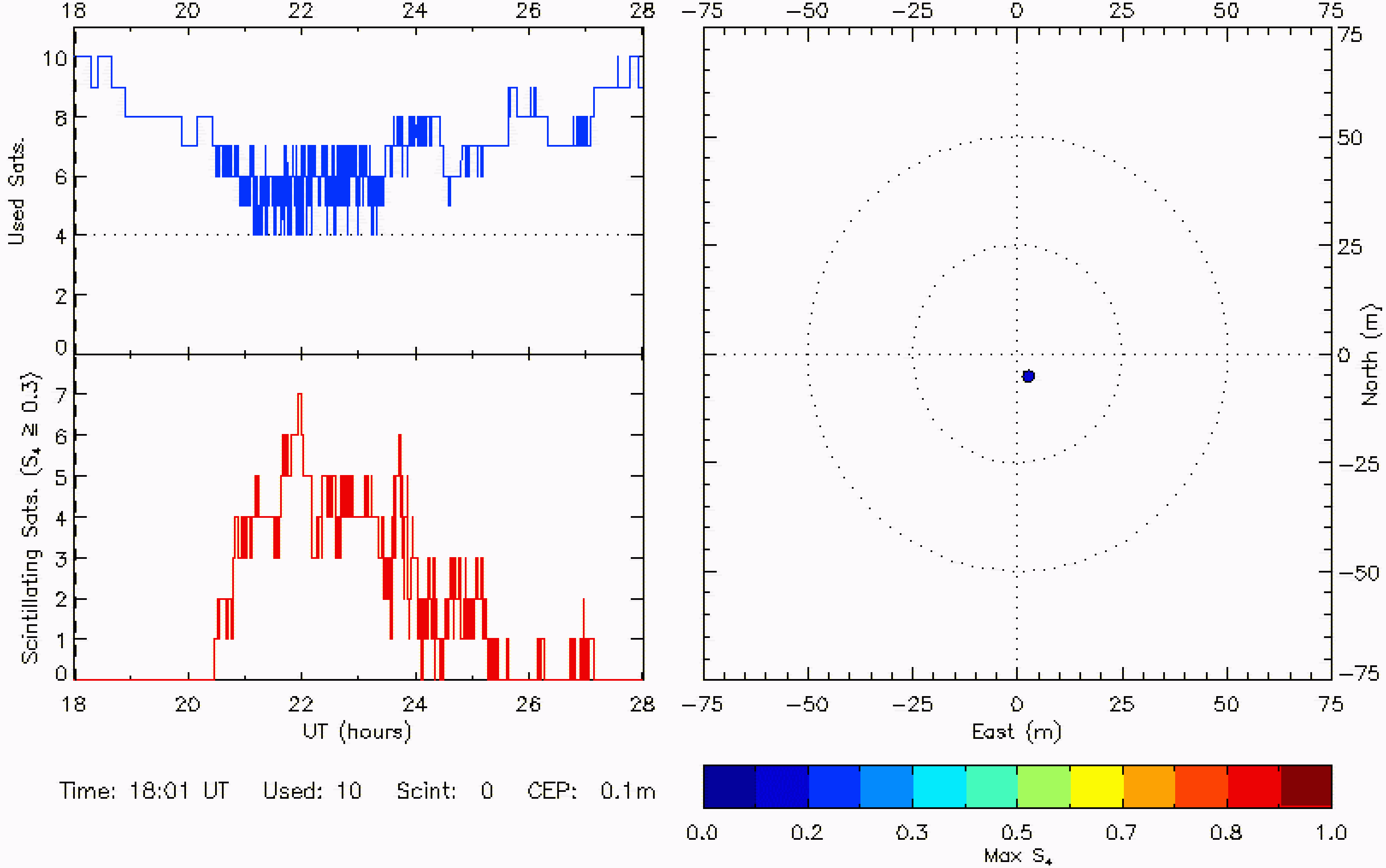
Position Error







GPS Position Error Ascension Island, 03/16/2002



Time: 18:01 UT Used: 10 Scint: 0 CEP: 0.1m

Research Groups in our Center

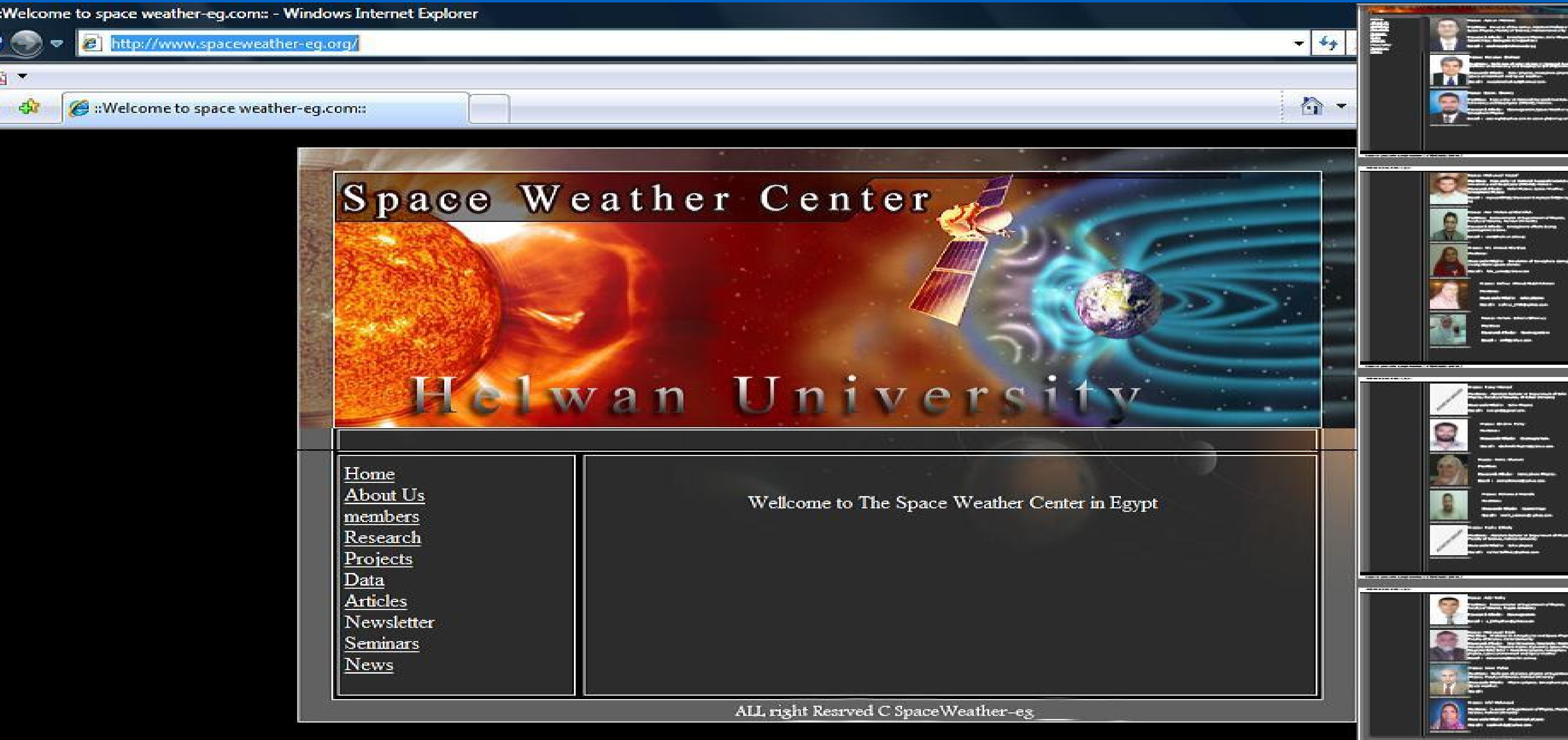
Solar Physics

Cosmic Rays

Geomagnetism

Ionosphere

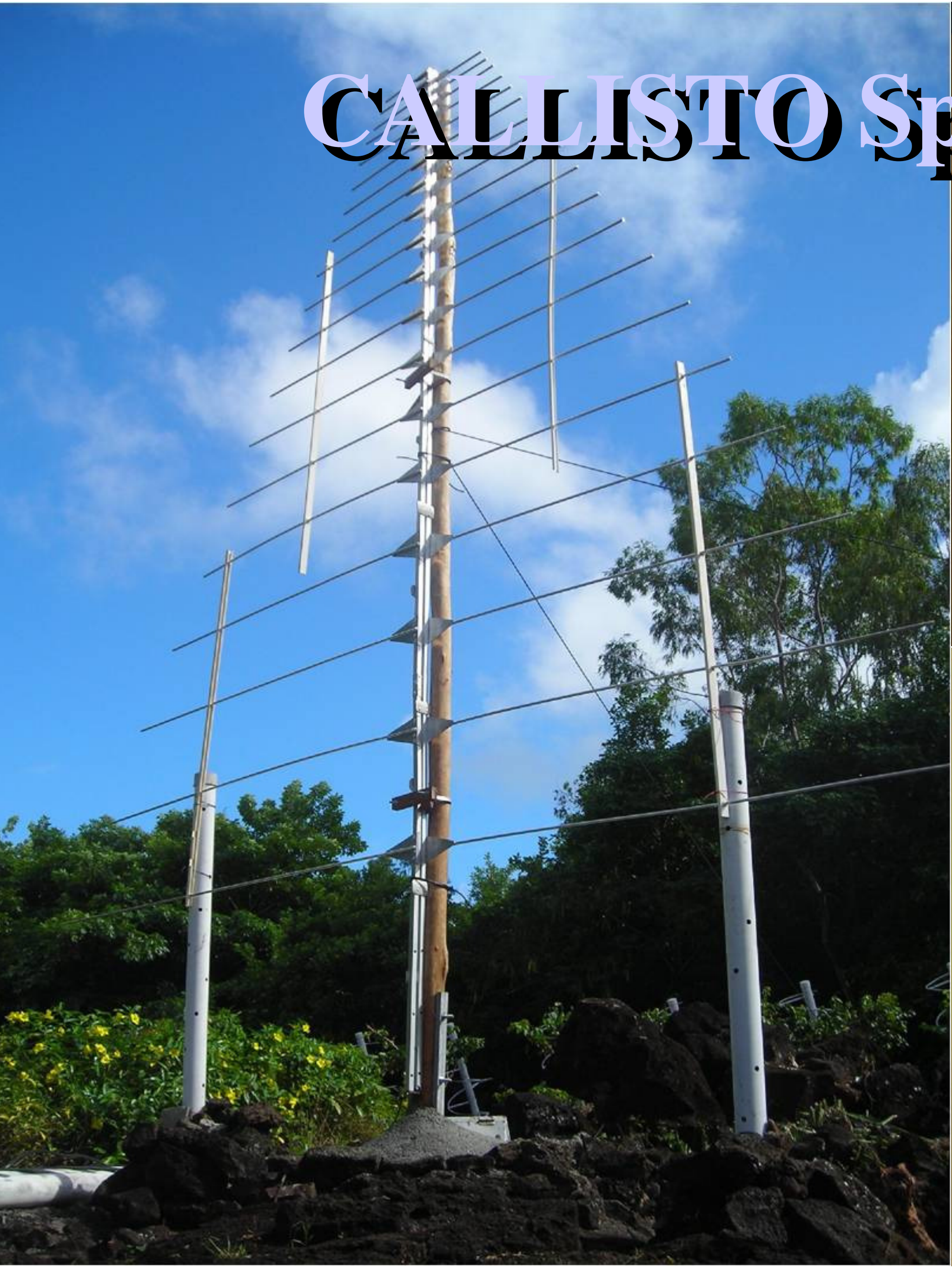
http://www.helwan.edu.eg/english/space

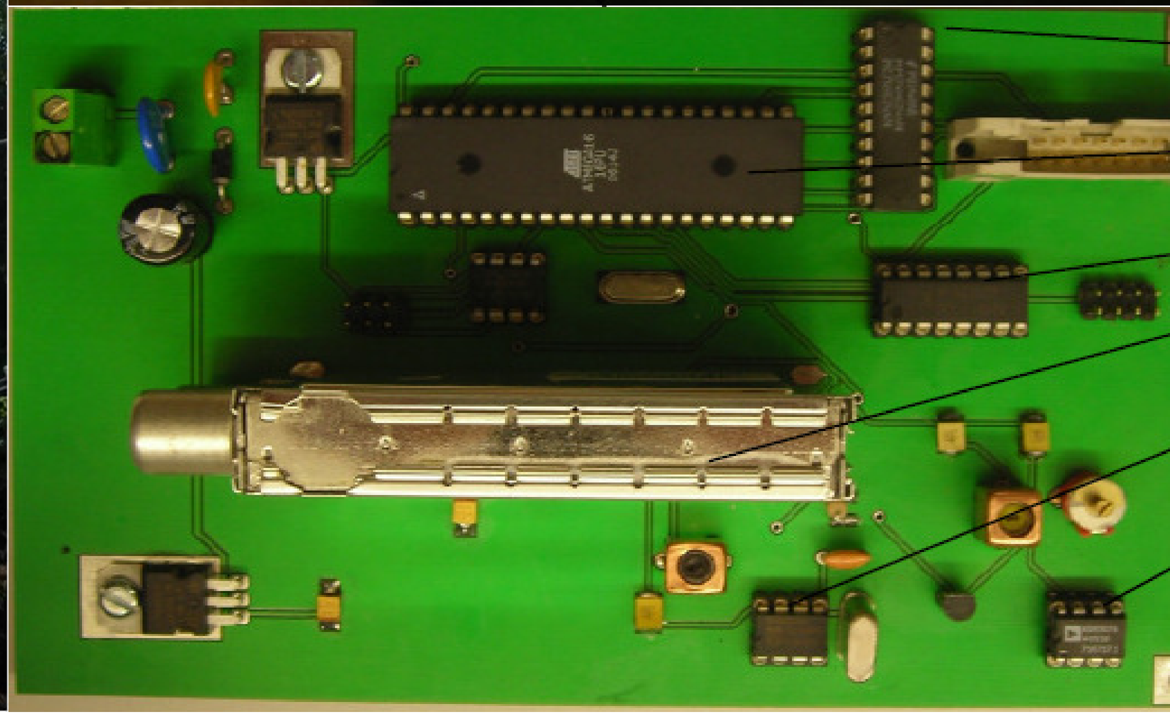


Joint Projects

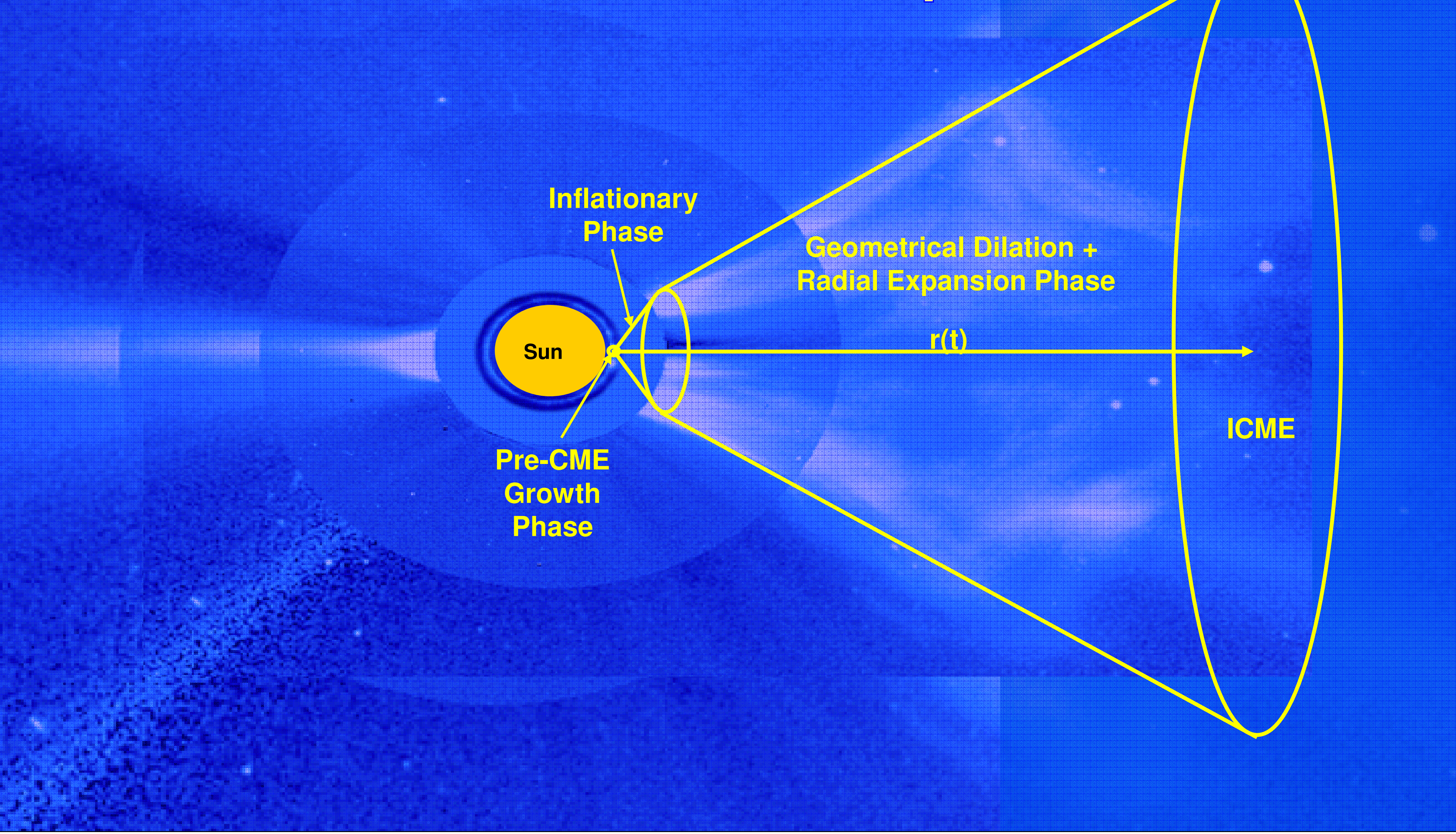
Texas University (USA) CIDR Ionospheric Receiver	Kyusho University (Japan) MAGDAS Magnetometer
Stanford University (USA) AWSOME Ionospheric Receiver	SCINDA Ionospheric Receiver
European Union TEMPUS	US-Egyptian Joint Board
Joining the African Network with European Networks (proposed)	Cyprus-Egyptian Joint Board

CALLISTO Spectrometers

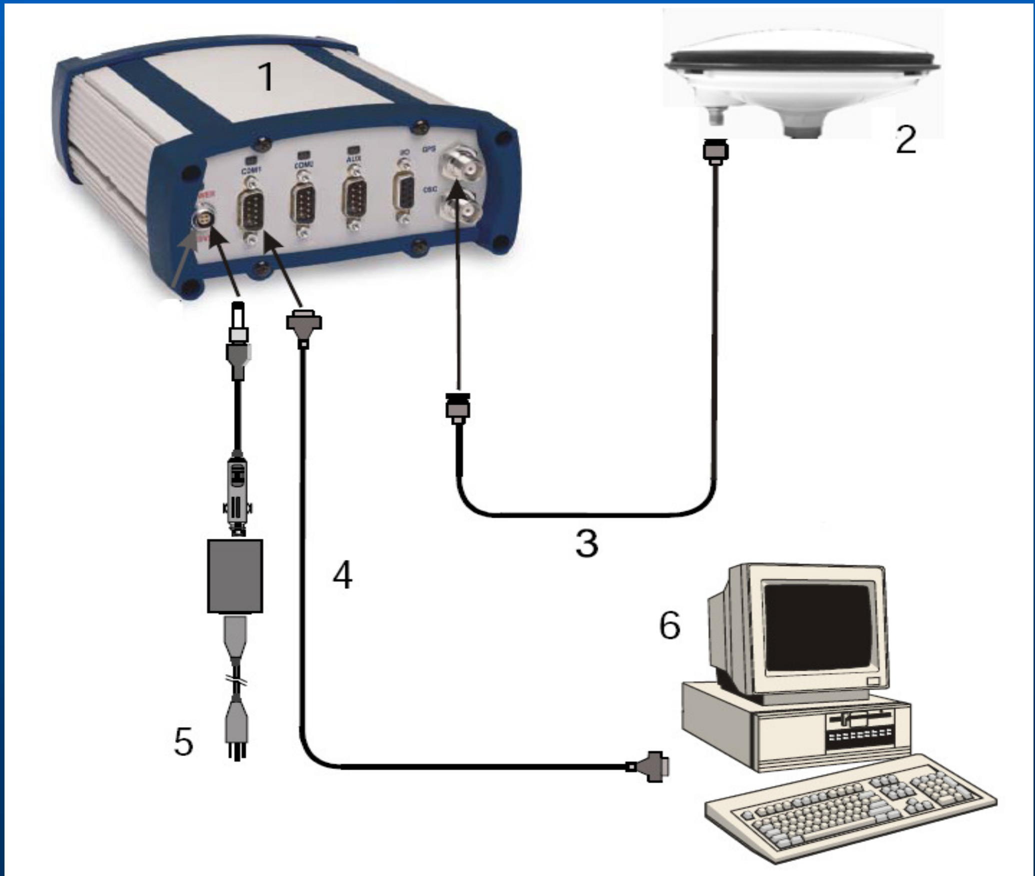




Three Phases of CME Expansion



GPS System at Helwan



1: GPS receiver

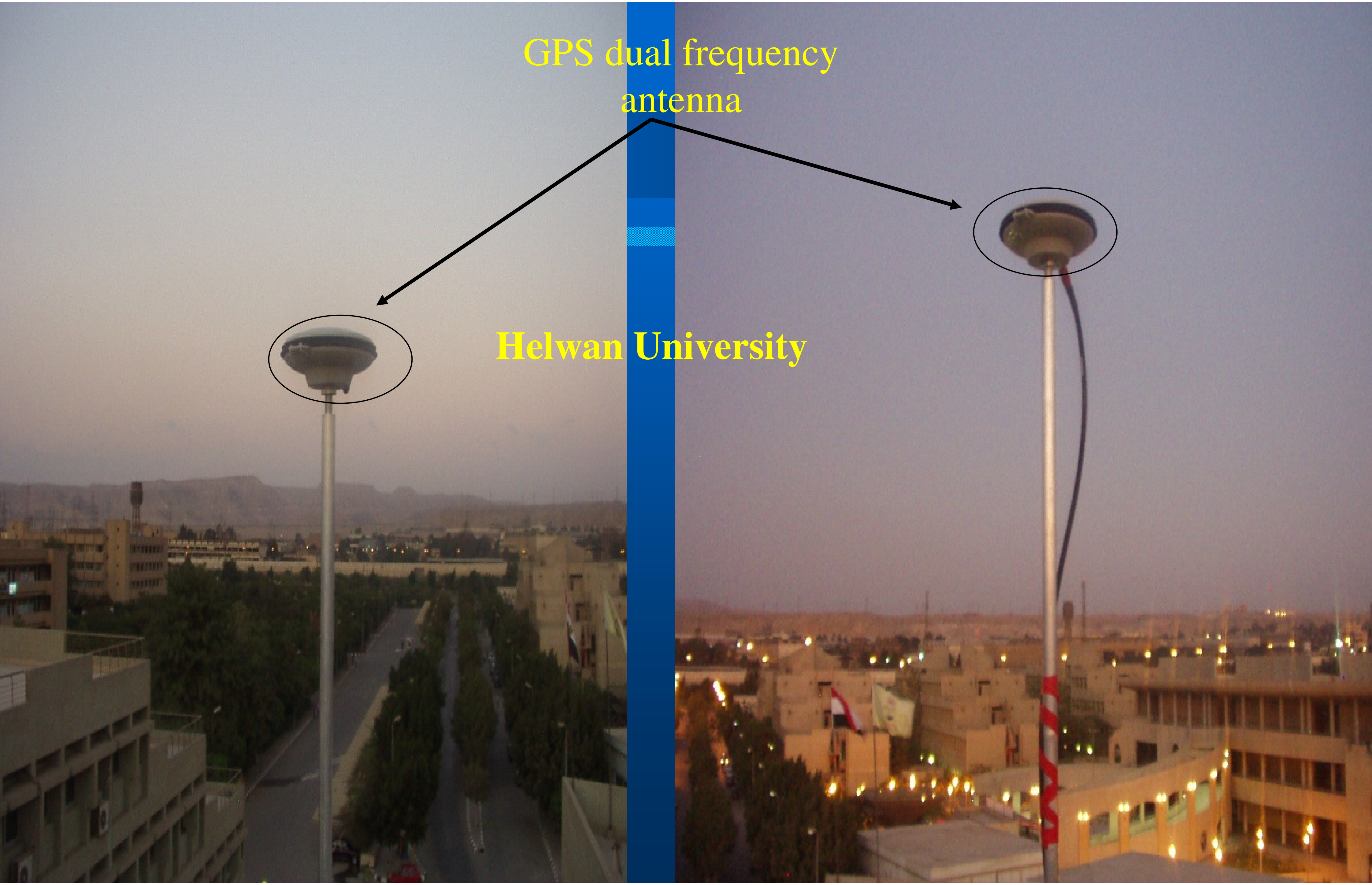
2: GPS dual frequency antenna

3: Antenna cable (30 meter maximum)

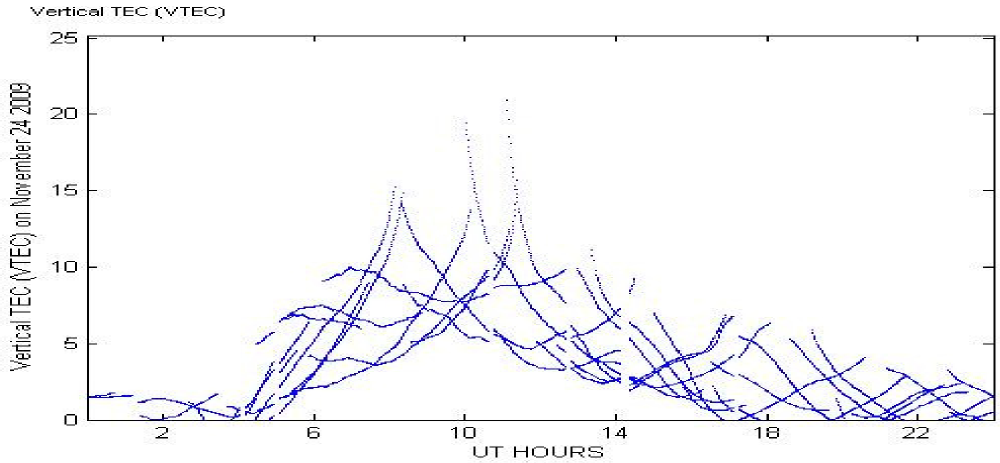
4: Serial cable

5: Power cable

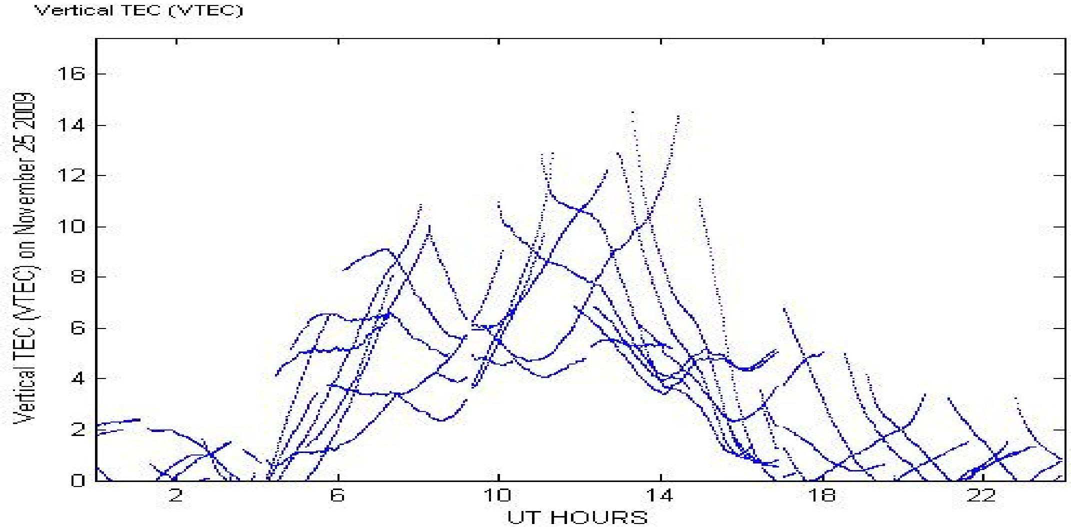
6: Personal computer running Linux


GPS dual frequency antenna
Helwan University

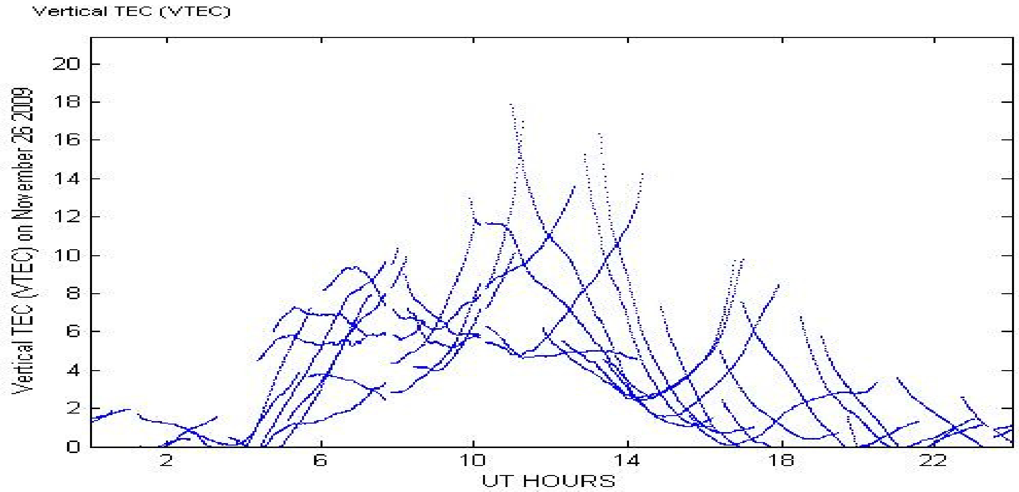
TEC Profile



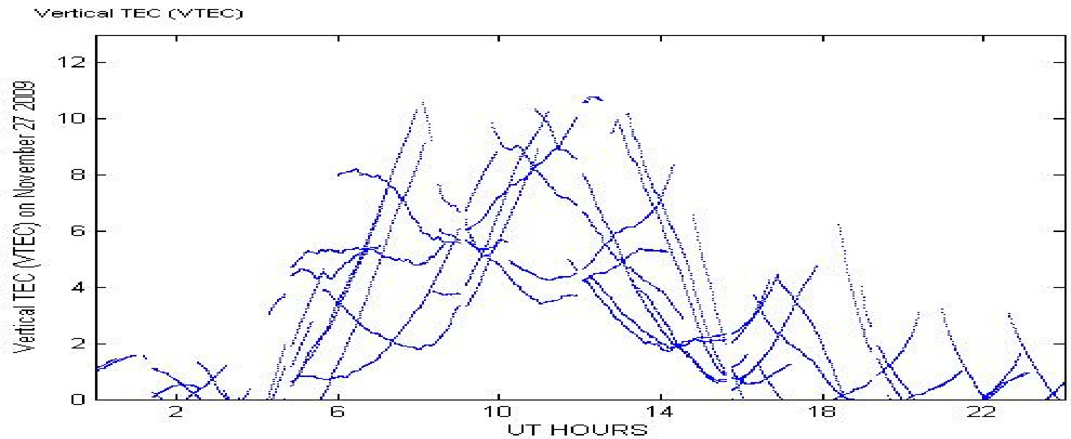
Vertical TEC (VTEC)
Vertical TEC (VTEC) on November 24 2009
UT HOURS



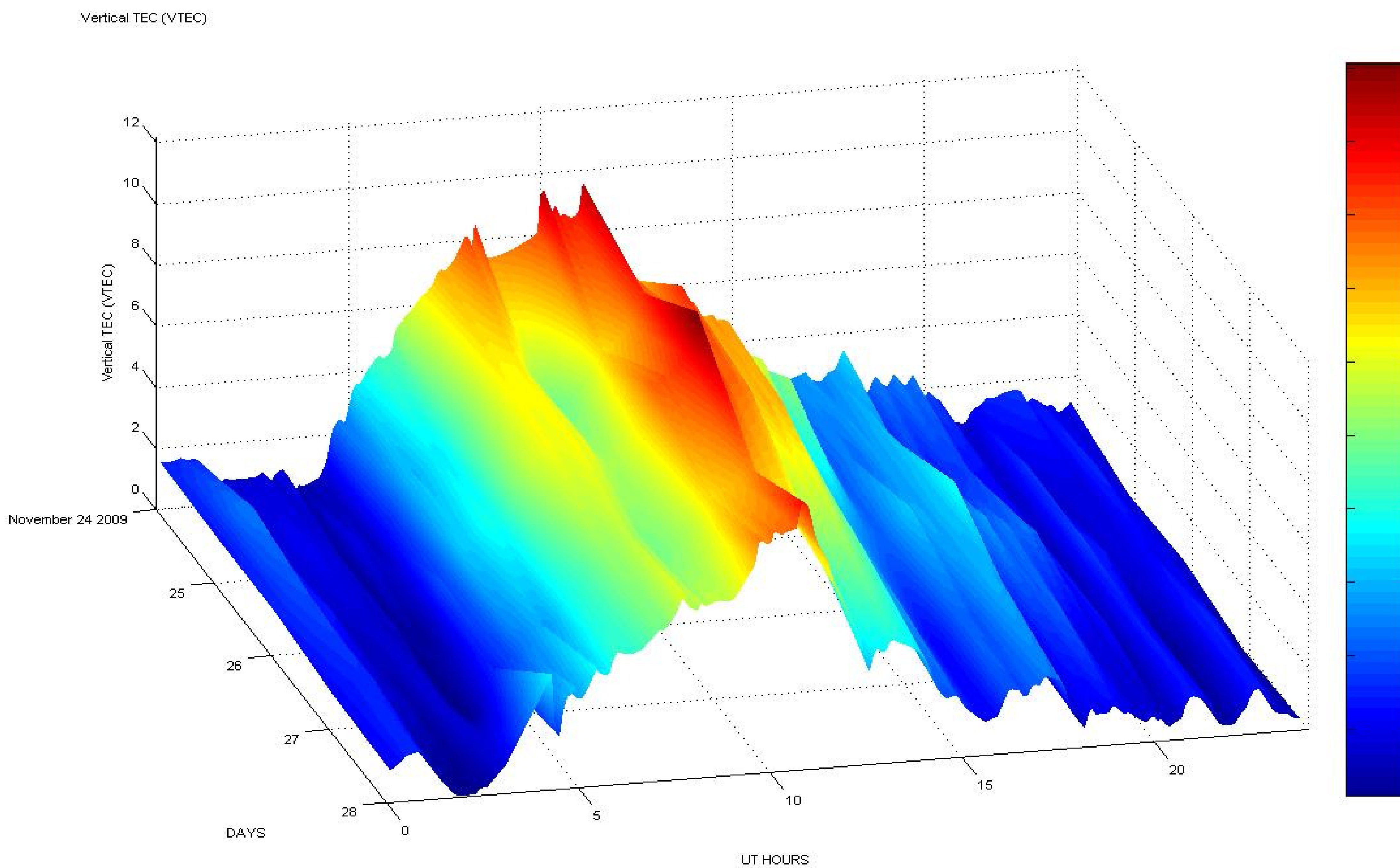
Vertical TEC (VTEC)
Vertical TEC (VTEC) on November 25 2009
UT HOURS



Vertical TEC (VTEC)
Vertical TEC (VTEC) on November 26 2009
UT HOURS

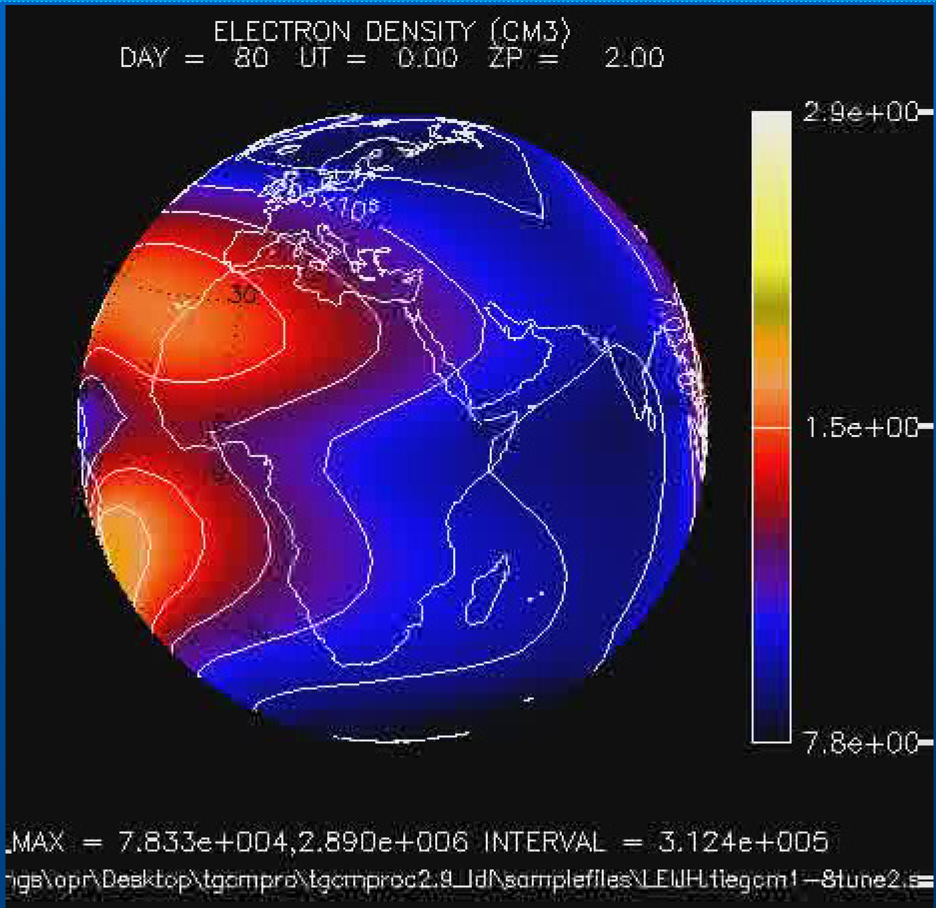


Vertical TEC (VTEC)
Vertical TEC (VTEC) on November 27 2009
UT HOURS

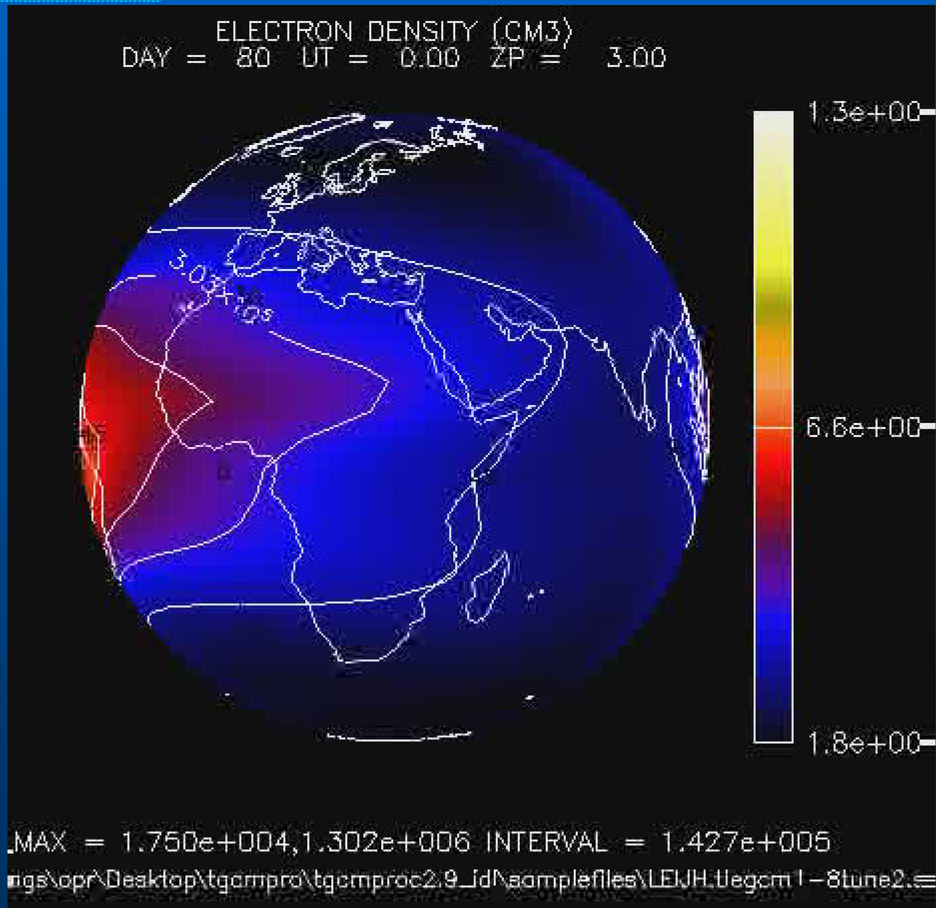


Vertical TEC (VTEC)
Vertical TEC (VTEC)
0
2
4
6
8
10
12
November 24 2009
25
26
27
28
DAYS
0
5
10
15
20
UT HOURS

Simulation Group



Energetic Event

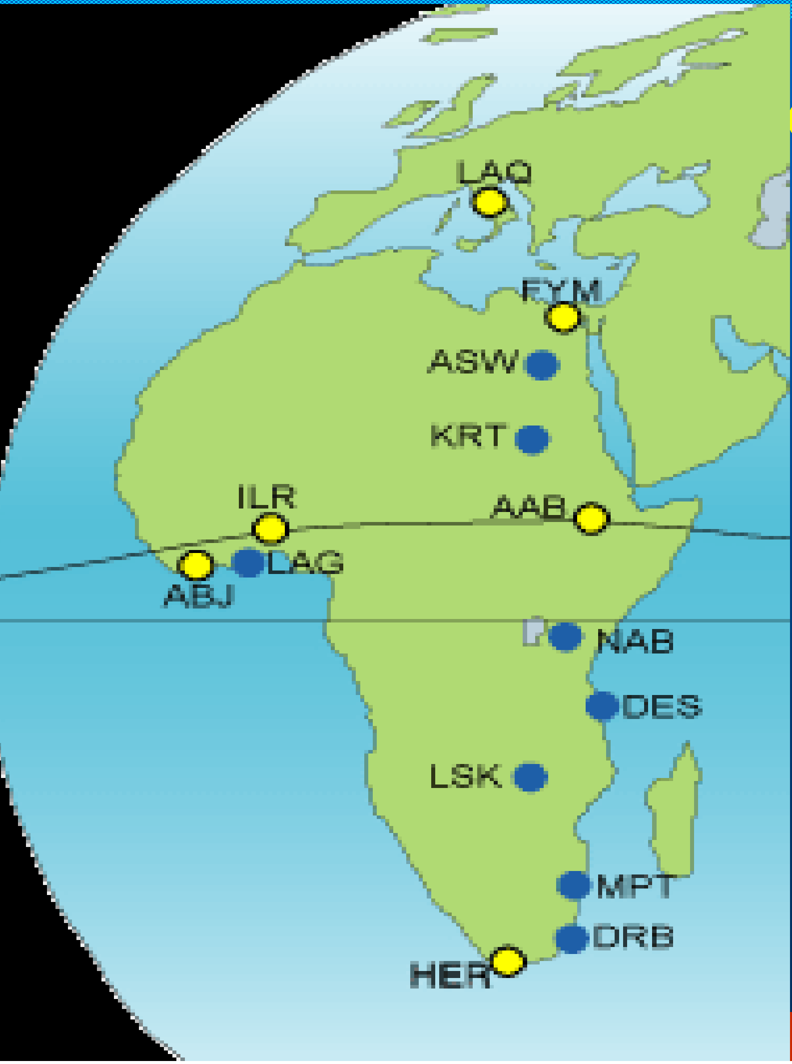


Quite Day

MAGDAS Project 2009

Installation of MAGDAS at FYM

MAGDAS-II installation at ASW & FYM



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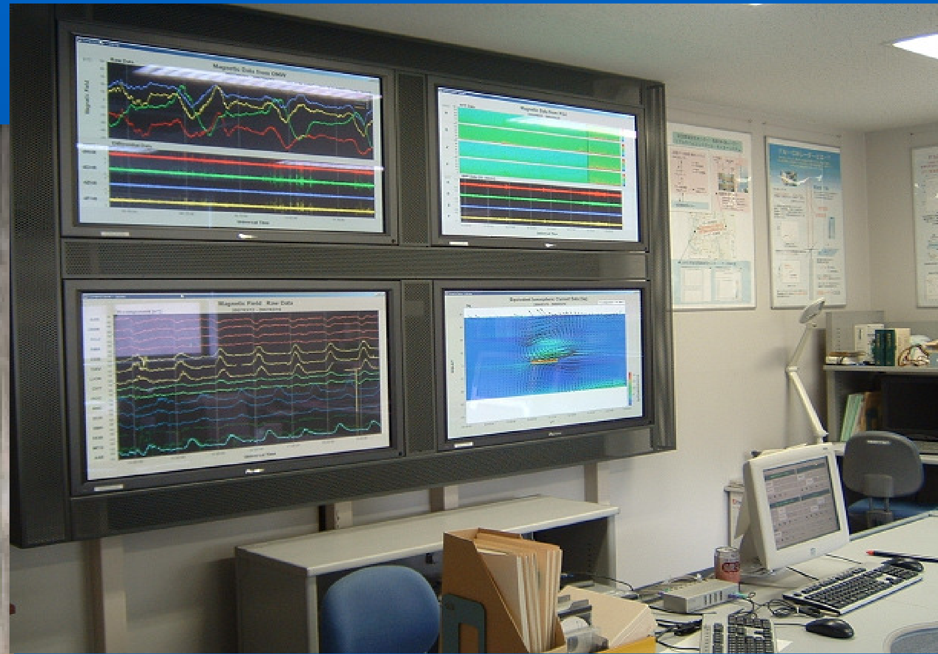
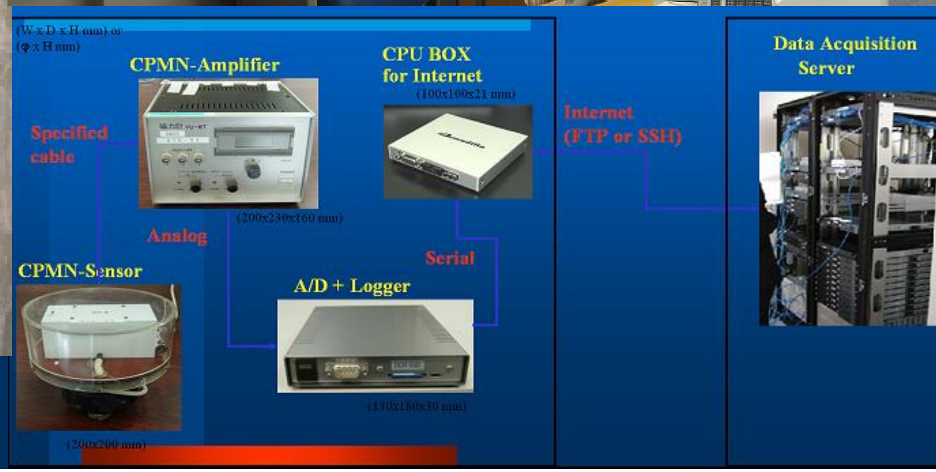


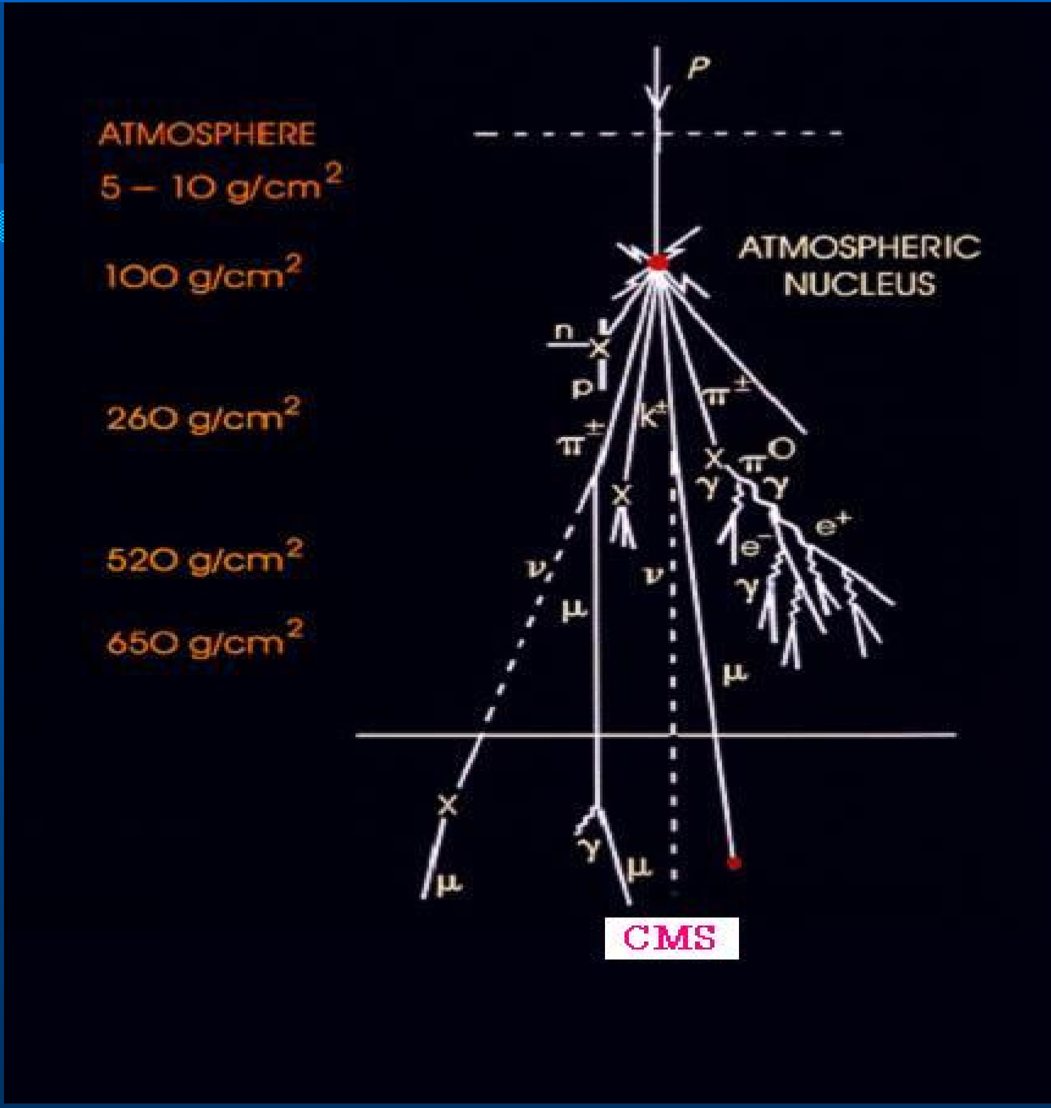


Cosmic Ray Group

The interaction of cosmic ray particles in the upper atmosphere (primarily 9~15 Km above Earth's surface) usually produces pions (Duldig, 2000), a bound state of an up and anti-down quark.

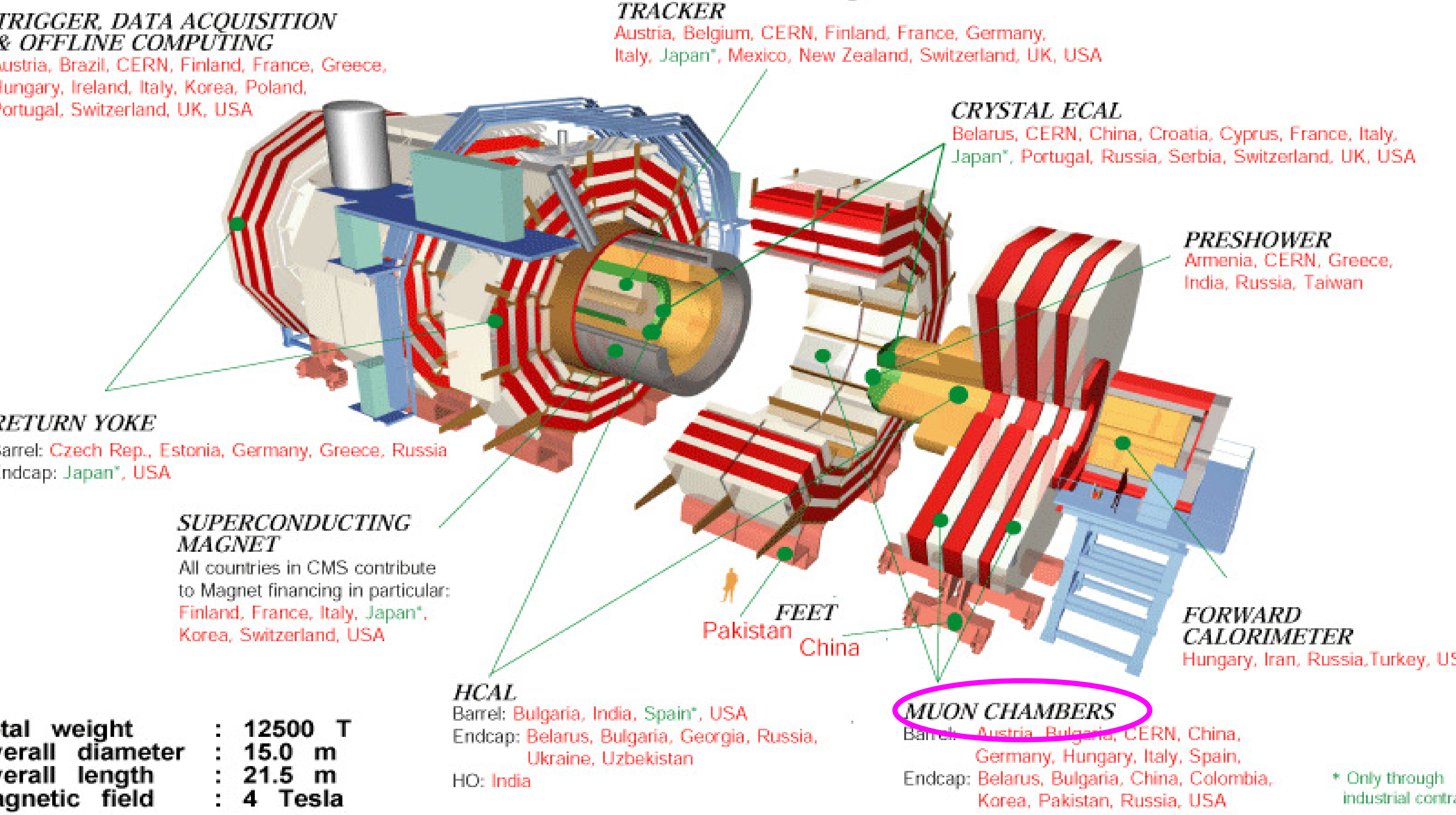
With lifetime of (2.6 x 10^{-8} s), the pion travels only hundreds of meters at velocities between (0.966 C and 0.977 C) before decaying into a muon and mu-neutrino .

The muons produced in that reaction descend to Earth's surface with ample supply of muons at sea level which facilitates the study of these particles (Caso et al., 2000).



CMS Outreach

37 Countries, 155 Institutes, 2000 scientists (including about 400 students) October 2006



tal weight	:	12500	T
erall diameter	:	15.0	m
erall length	:	21.5	m
gnetic field	:	4	Tesla

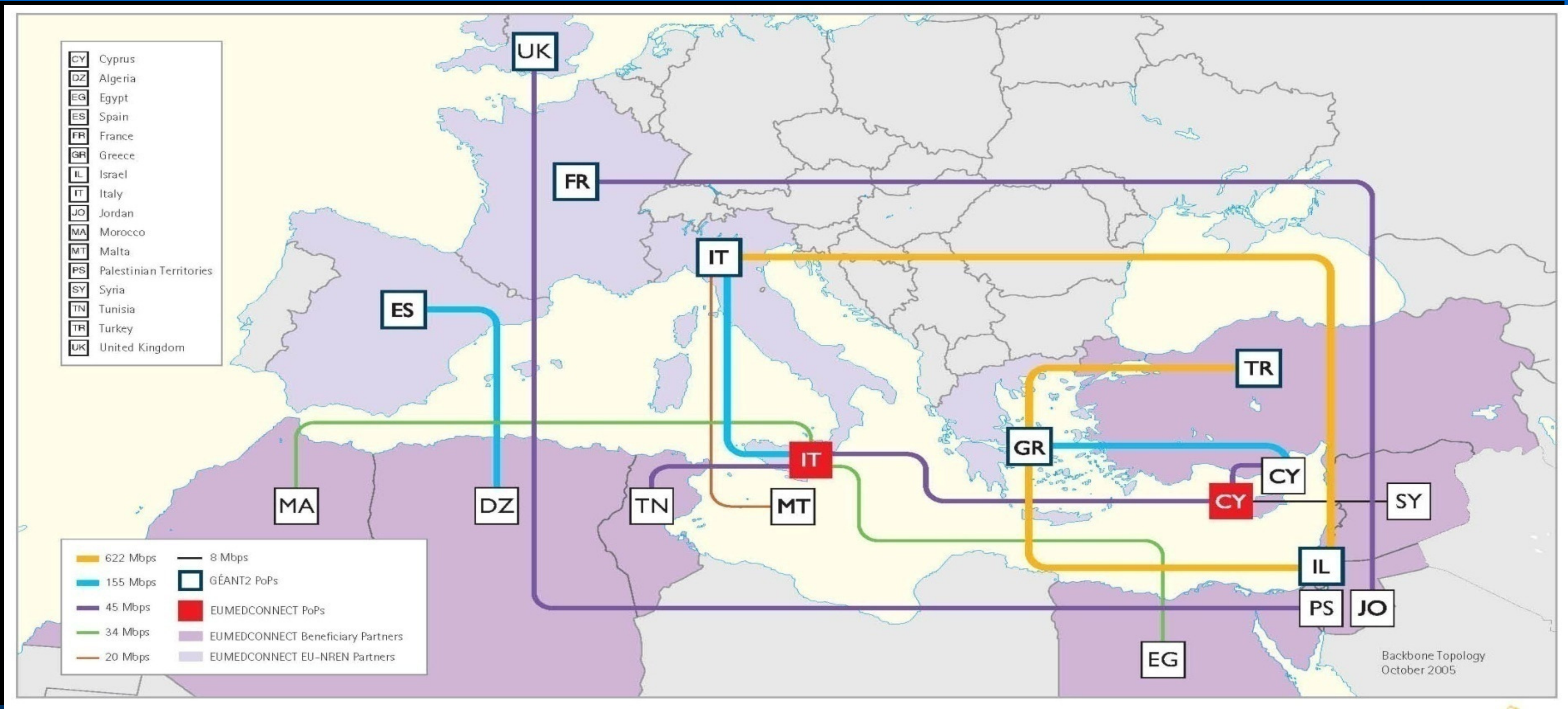
Testing of RPC at SWMC Lab.

4 scintillators
4 scintillation detector boxes
4 Photo Multiplier Tubes PMT
4 electronic boxes to be attached to PMT
Multichannel analyzer
Digital oscilloscope
High voltage power supply

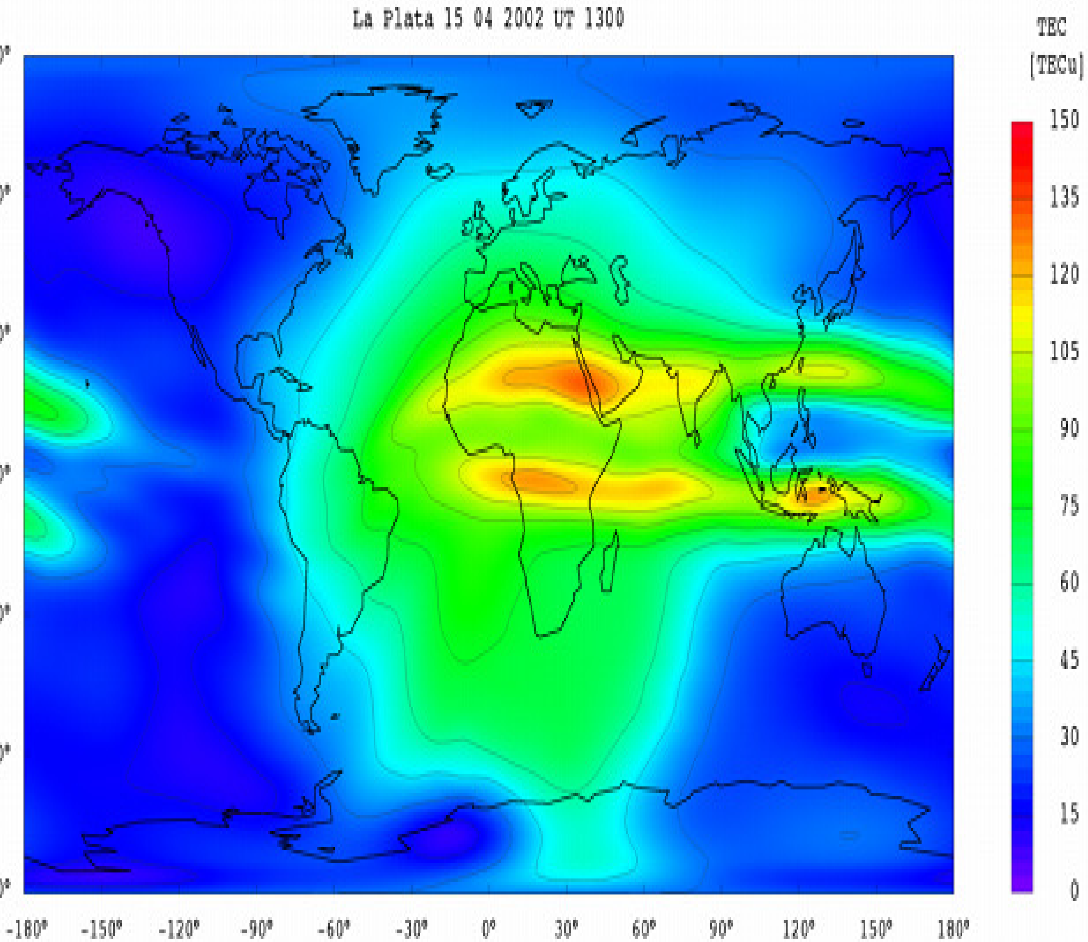
Data Analysis by Cosmic Ray Group

http://www.eumedgrid.org/application/hero.html

EUMED GRID at SWMC



Egypt is Located in Equatorial Anomaly Region (Crest and Trough)



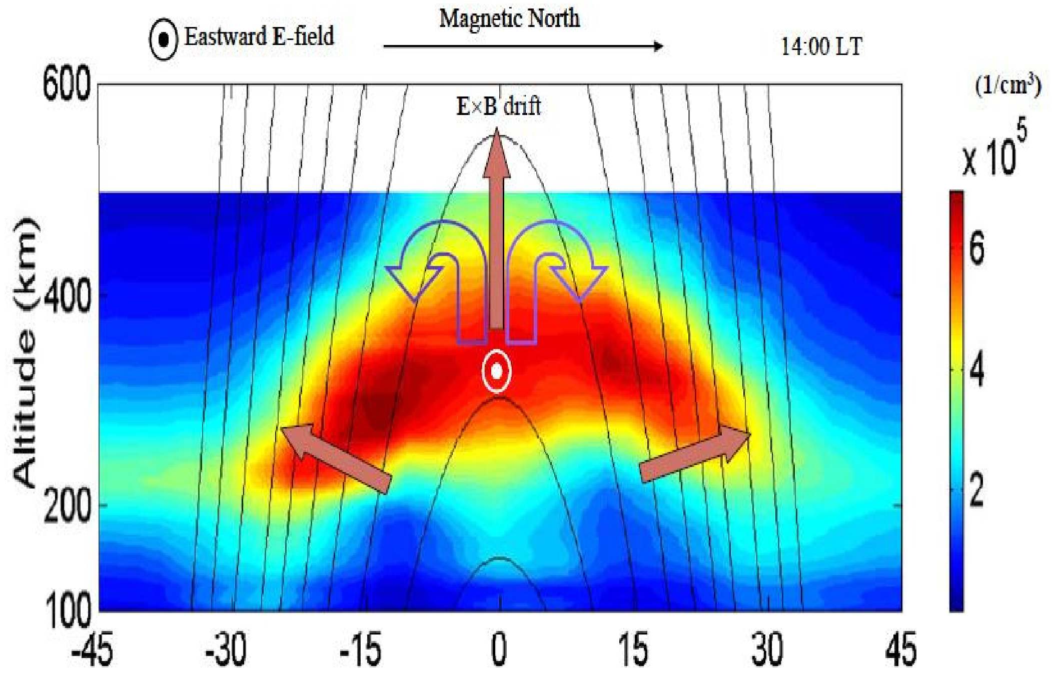
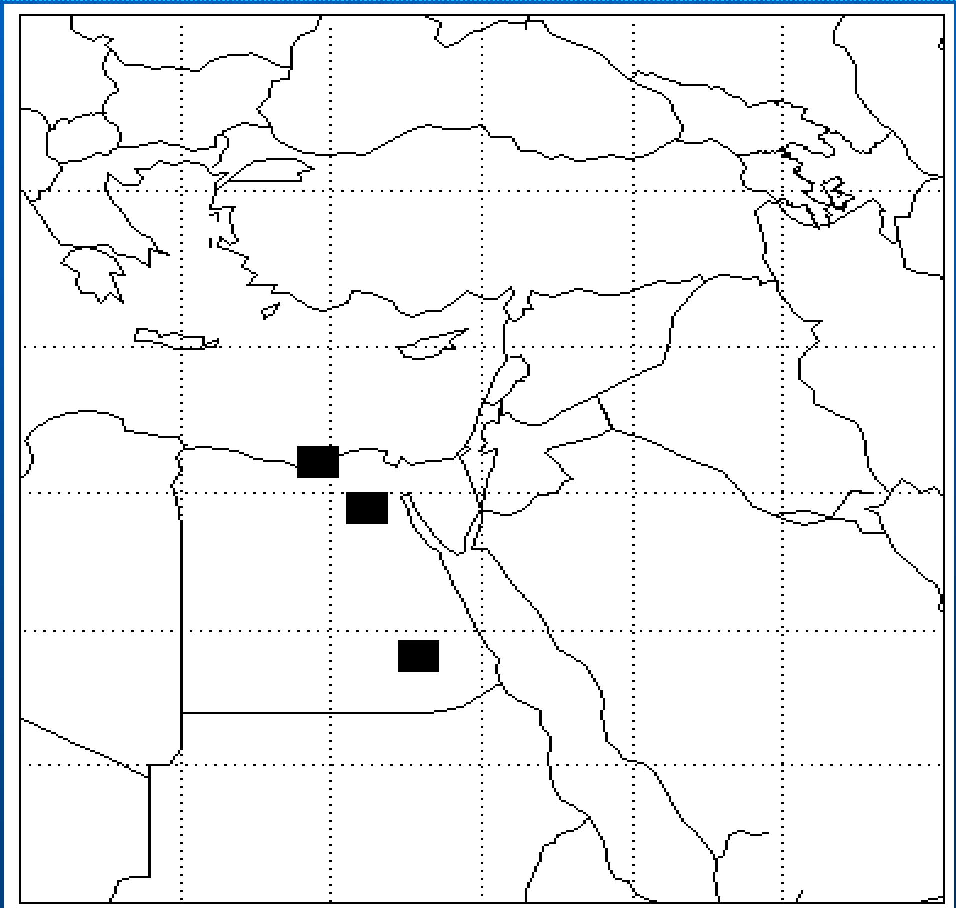


Figure 1.5. Contour is the altitude profile of plasma density at 14LT, black lines are magnetic field lines and arrows stand for the directions of ion drifts [courtesy of Liu and Lin, 2006].

Coherent Ionospheric Doppler Receivers (CIDR) Project 2008

Coherent Ionospheric Doppler Receivers (CIDRs)



Three CIDRs will be deployed to Egypt as part of IHY

- US coordinator (Dr.Trevor Garner), Texas University
- Egyptian coordinator (Dr. Ayman Mahrous), Helwan University.

The CIDR will be operated jointly by :

1- Helwan University

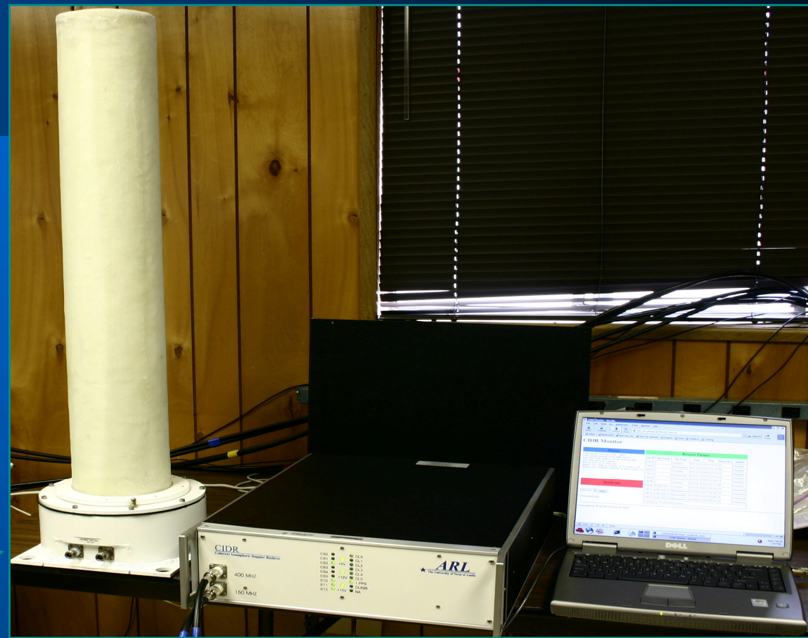
2- South Valley University

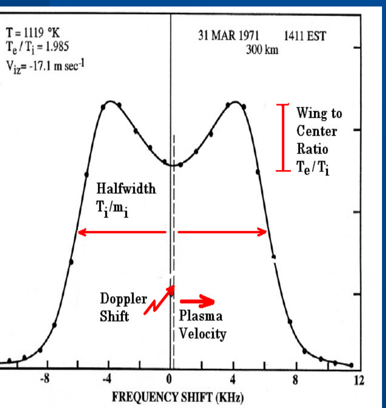
3- Alexandria University

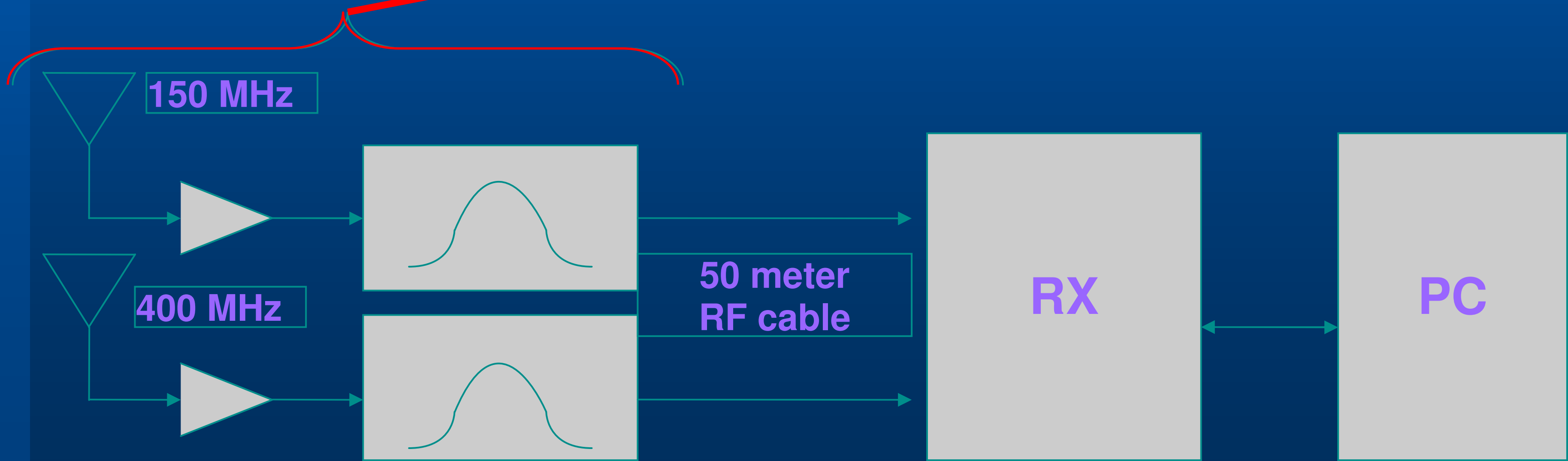
nospheric Tomography Network of Egypt: A New Receiver Network in Support of the International Heliophysical YearT. Garner, Gaussiran, J. York, D. Munton, C. Slack, A. Mahrous, Earth, Moon and Planet, 2009, Vol. 104, pp. 227-235.

Coherent Ionospheric Doppler Receivers (CIDRs)

- Designed to track 150/400MHz LEO beacons (Transit/NIMS, GFO)
- Provides relative TEC and phase scintillation measurements at 50 Hz
- Useful for examining spatial structure with a relatively sparse receiver network and conducting ionospheric tomography







RADCAL/GFO Beacon Satellites

- 3 RADCAL/GFO Satellites
- 20 RADCAL Ground Stations
  - Archived Data 1993 to Present
  - 5 Second Samples
  - Maintained by AF Western Test Range Vandenberg

RADCAL (1993 to Present)

GFO (1998 to Present)

- Radio Altimetry and Ephemeris Satellites
  - 150/400 MHz Radio Beacon
  - Ionospheric TEC Correction Data

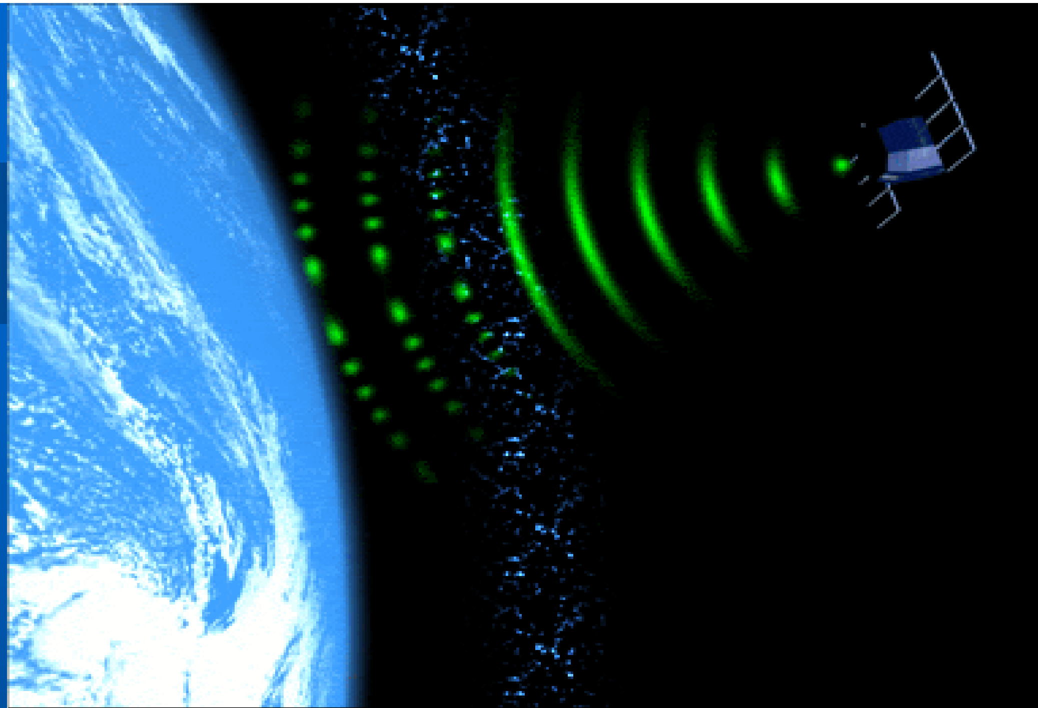
RADCAL on DMSP/F15
(Aug 2006 to Present)

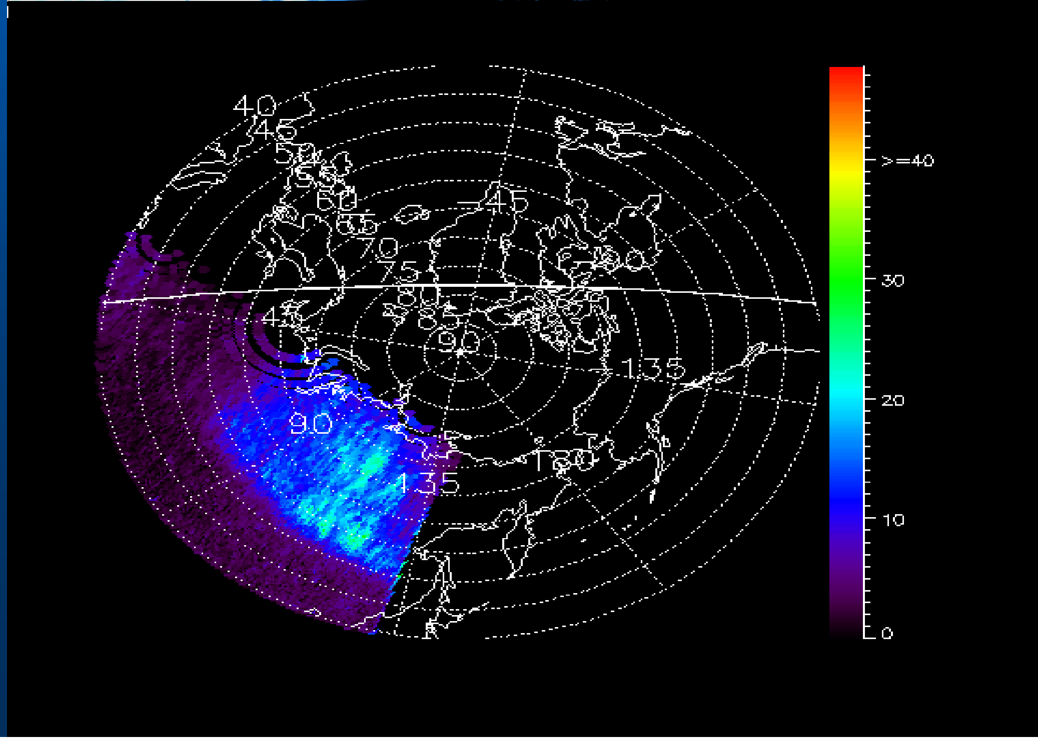
Advantages Over GPS

- More accurate, no need for plasmaspheric corrections by using LEO satellites **(300~1100 km)**, while GPS orbital height **(20,000 Km)**

- Can measure the spatial structure of the ionosphere.

- A powerful tool for topographic image of the ionosphere

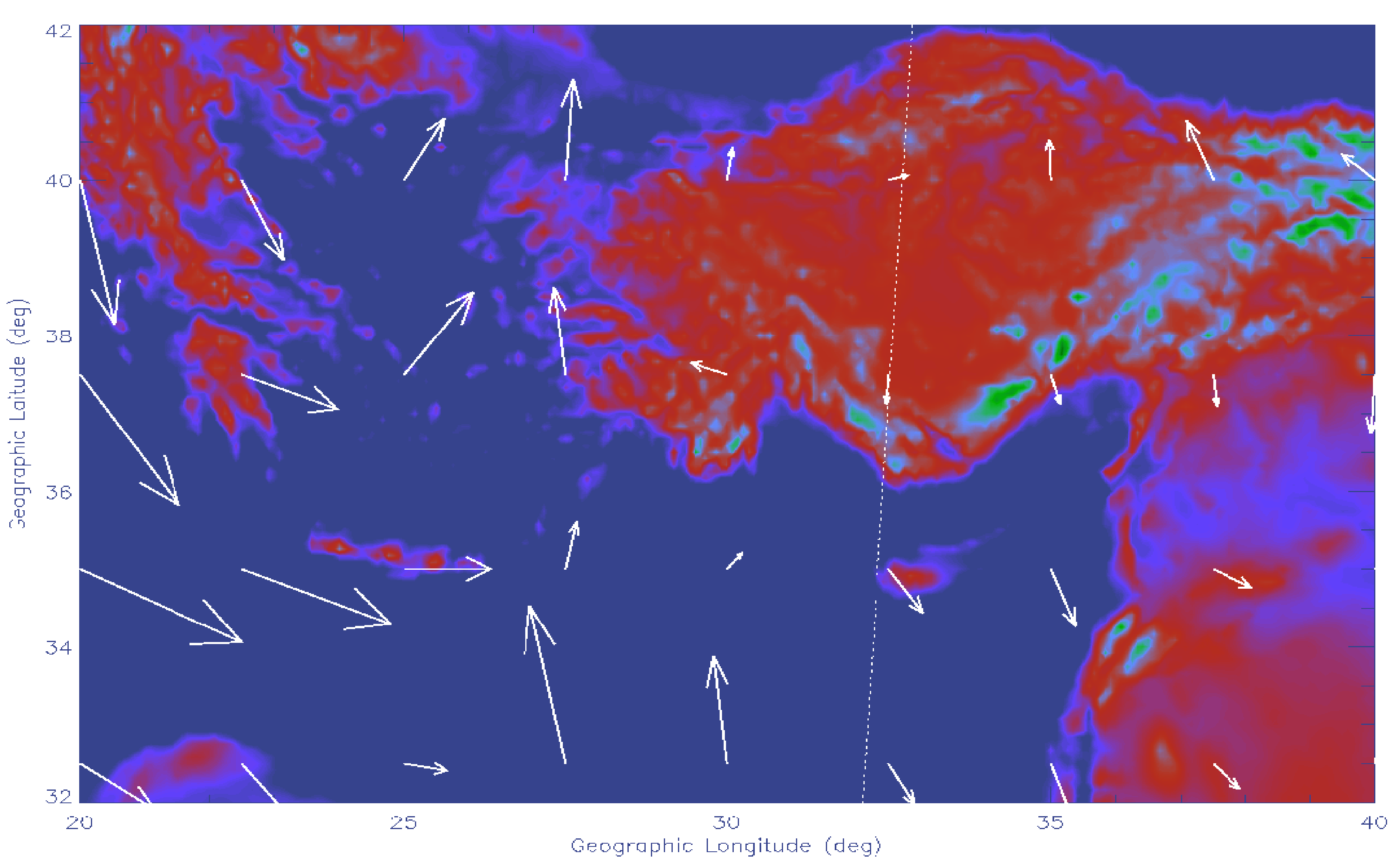




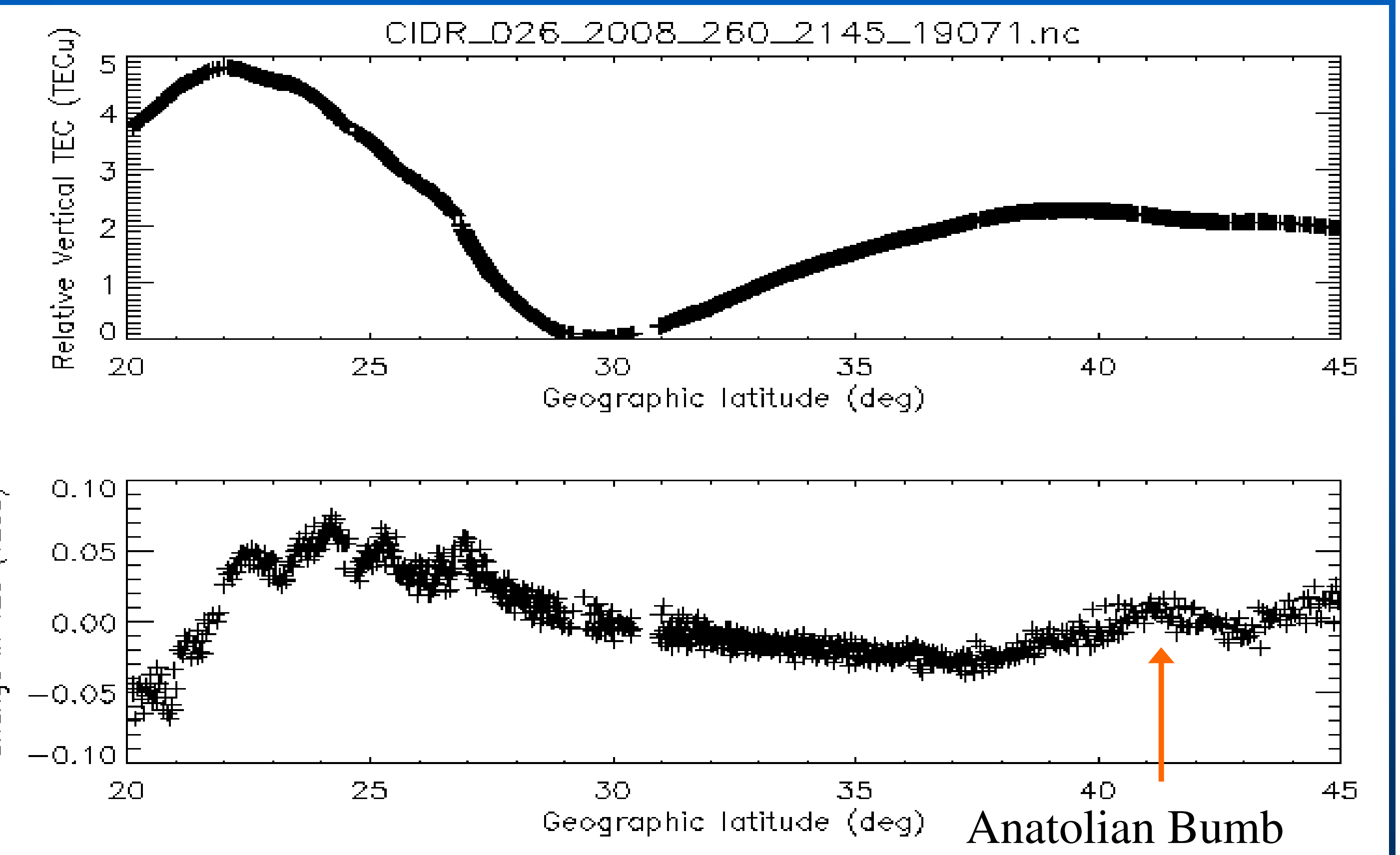
Occurrence of the Anatolian Bump

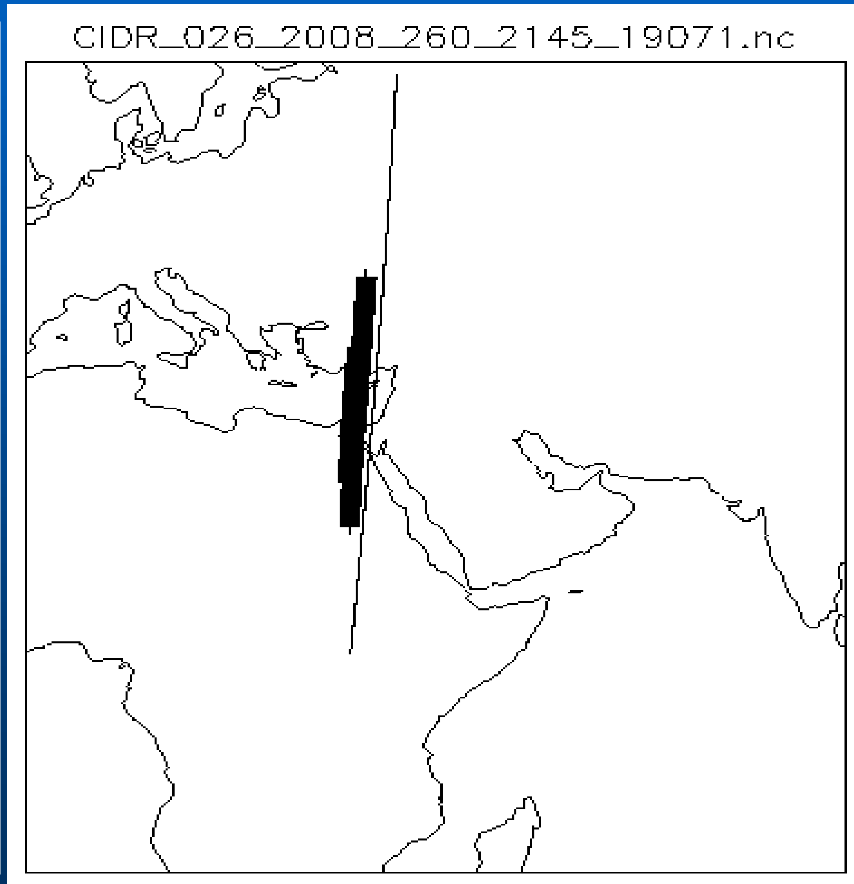
- Examined all data from the Helwan CIDR during 2008.
  - Isolated data over Anatolia
  - 160 good CIDR passes
  - 36.88 % of the passes show no perturbations
- CIDR data presented at the 300 km pierce point

Anatolian Bump Occur Where Atmospheric Gravity Waves are Likely



Initial Observation





Classification of Anatolian Bump Structures

- **Bump**

  A bump is defines as a single spatial DTEC/Dt peak with a peak－to－trough amplitude of at least 0.01TECU/s (1TEC unit (TECu)=1016 electrons/m2) that is at least1°wide in F region latitude.

- **Ripple**

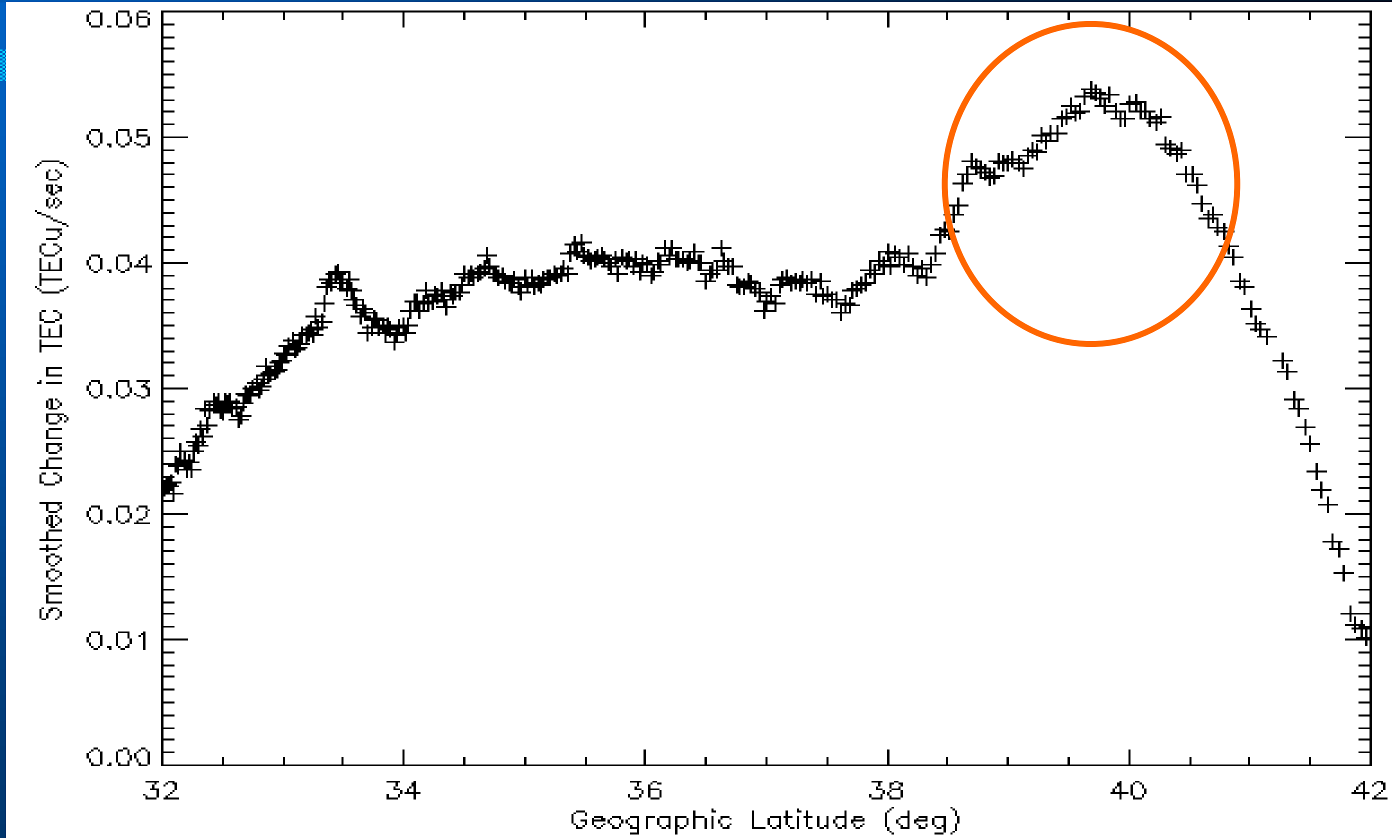
  A ripple is a bump with smaller structures on either side of the central bump.

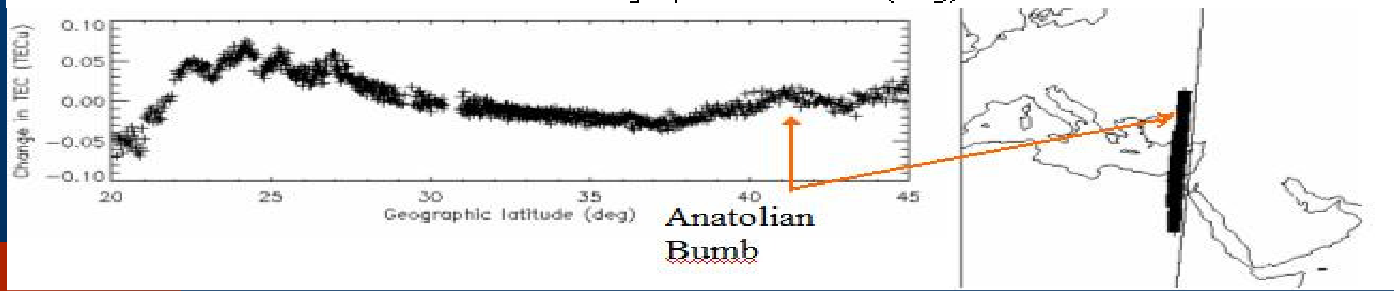
- **Wave**

  waves have amplitudes ≥ 0.01 TECU/s with several roughly equal peaks.

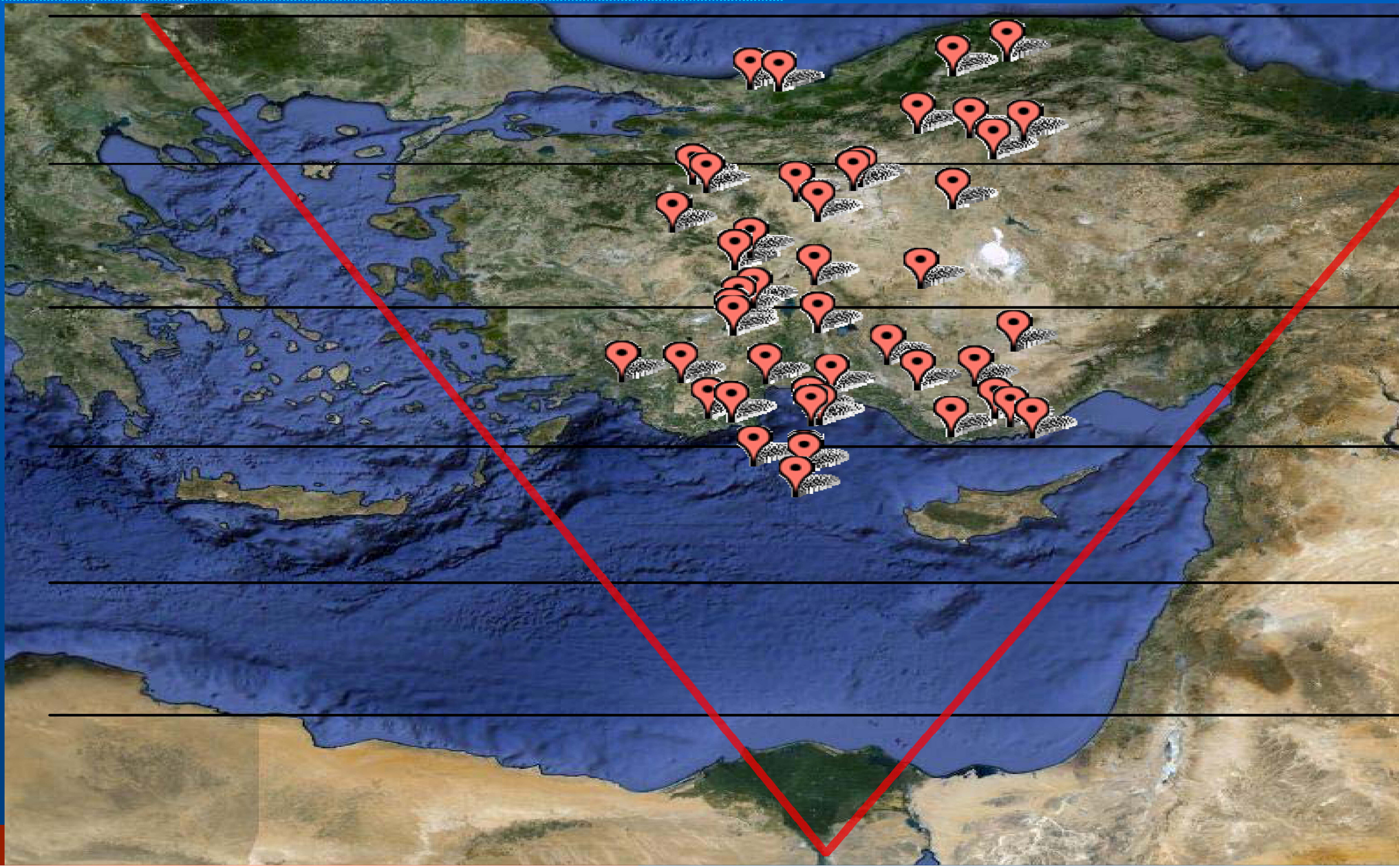
Bump Structure

- Occur on 29.38 % of passes over Anatolia
- Possible response to the gravity waves generated by orographic lift



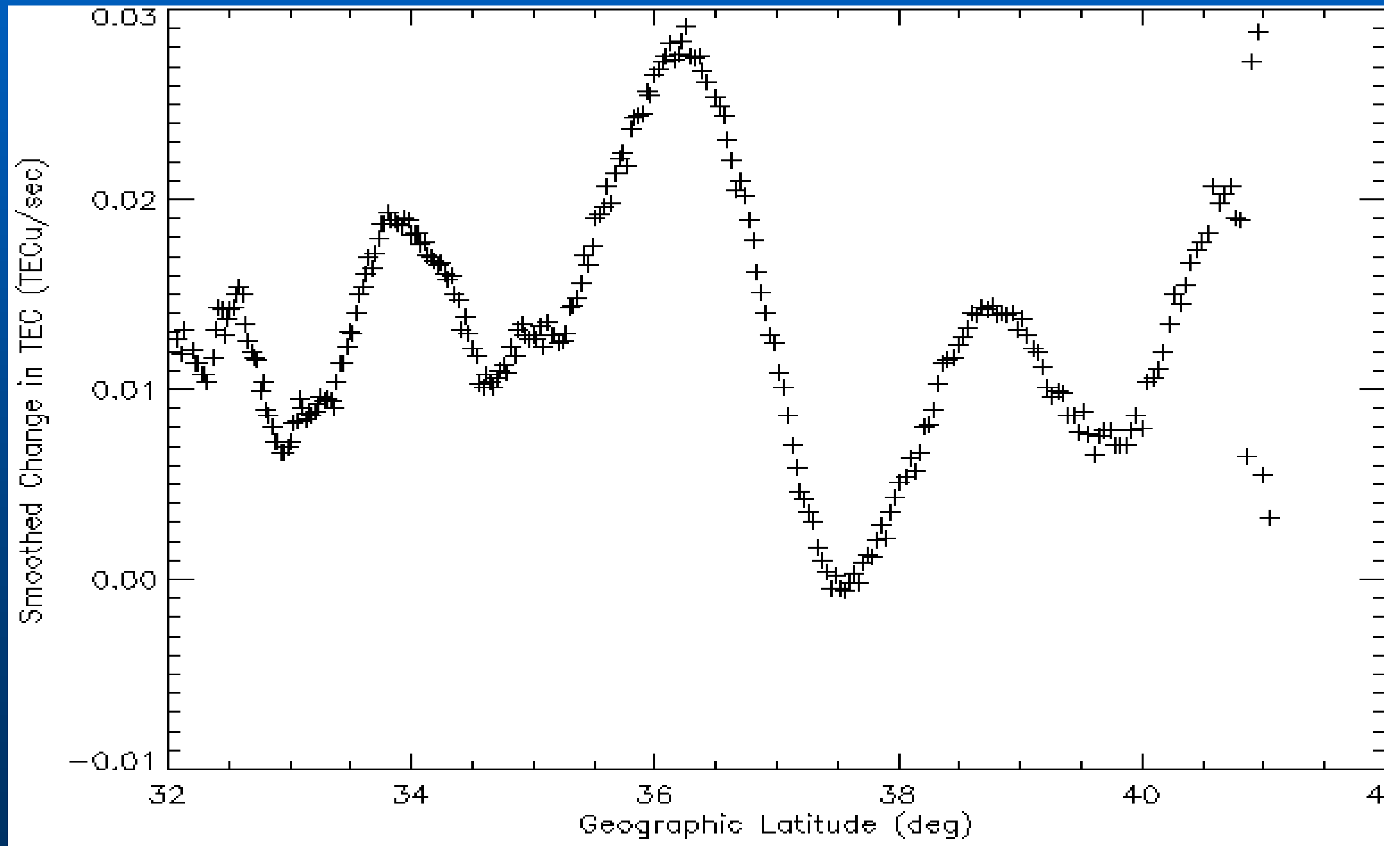


Distribution of Bump Structure



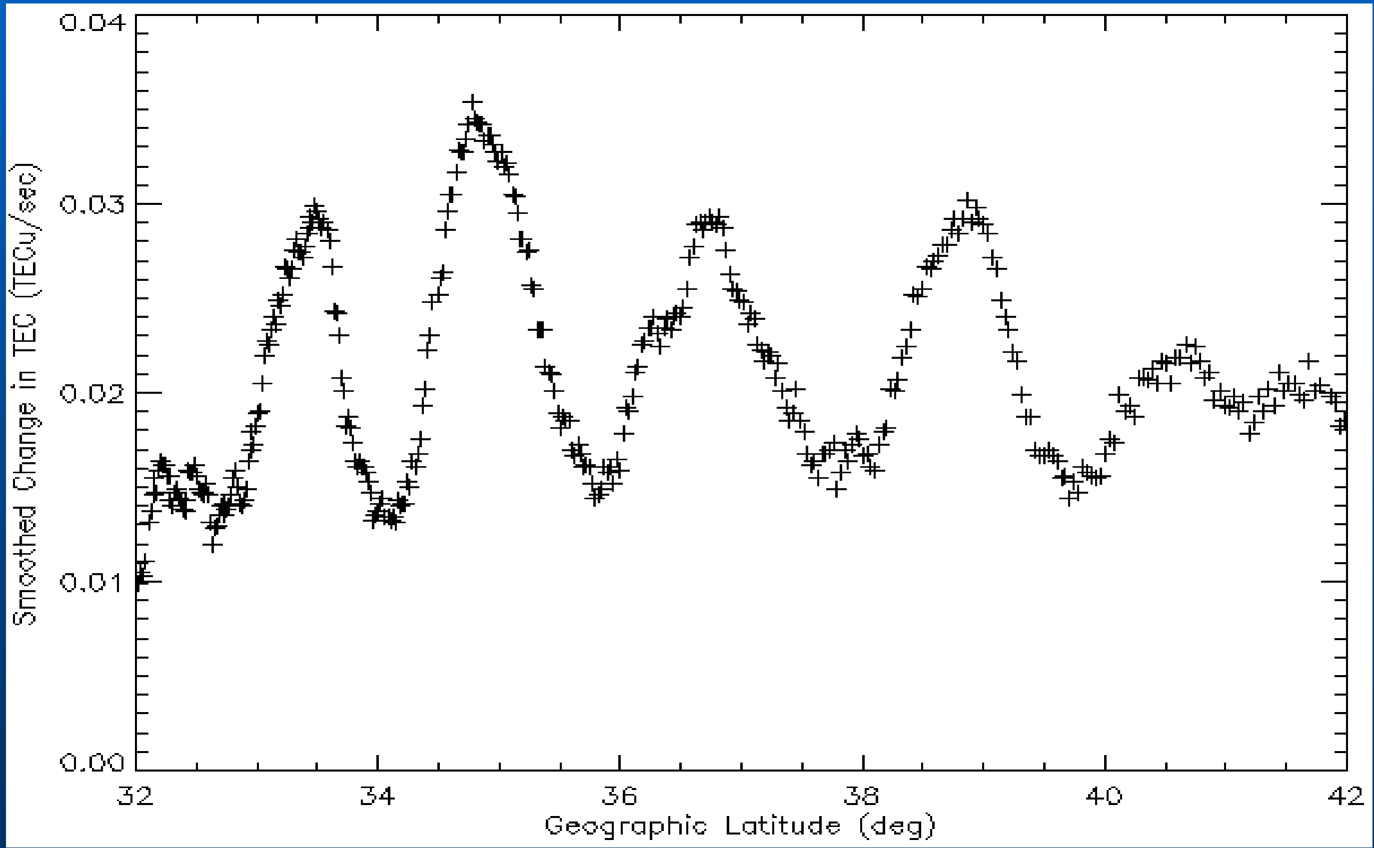
Ripple Structure

- Occur on 16.88 % of passes over Anatolia
- Orographic lift creates ripples that dissipate from the source



Wave Structure

- Occur in 5% of Anatolian passes.
- Gravitational Waves Signature



Conclusions

- Mostly CIDR passes (~60%) during the fall of 2008 showed the **Anatolian Plateau**

- Because of the correlation with steep topographic gradients, **gravity waves and orographic lift** are likely sources of the observed structure

Table 1. The Occurrence Frequency of $\Delta TEC/\Delta t$ Structures Over the Anatolian Plateau During the Fall of 2008

Structure	Count	Occurrence Frequency
None	65	40.9%
Bump	55	34.6%
Ripple	29	18.2%
Wave	10	6.3%


Thank you
SWMC