Understanding of GNSS anomalies: Anatolian Bump Signatures


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Small City!

121,300 Students enrolled (2012) in 18 Faculties
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

Satellite Tracking Problems
After March 13-14, 1989 Storm

Lost Satellites

13-14 March 1989 Magnetic Storm

Satellites that are not where they should be following the storm.
Position Error

 ACTUAL Position

 CALCULATED Position

 Flight 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

www.helwan.edu.eg/english/space
http://www.helwan.edu.eg/english/space
<table>
<thead>
<tr>
<th>Texas University (USA) CIDR Ionospheric Receiver</th>
<th>Kyusho University (Japan) MAGDAS Magnetometer</th>
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<tbody>
<tr>
<td>Stanford University (USA) AWSOME Ionospheric Receiver</td>
<td>SCINDA Ionospheric Receiver</td>
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<td>European Union TEMPUS</td>
<td>US-Egyptian Joint Board</td>
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<td>Joining the African Network with European Networks (proposed)</td>
<td>Cyprus-Egyptian Joint Board</td>
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</table>
CALLISTO Spectrometers
Three Phases of CME Expansion

- Pre-CME Growth Phase
- Inflationary Phase
- Geometrical Dilation + Radial Expansion Phase
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
TEC Profile
Simulation Group

Energetic Event

Quite Day
MAGDAS Project 2009
MAGDAS-ll installation at ASW & FYM

Aswan, Egypt, 15.20°N Lat, 104.24°E Long, Installed at 08/12/23
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 $(2.6 \times 10^{-8} \text{ s})$, the pion travels only hundreds of meters at velocities between $(0.966 \text{ C and } 0.977 \text{ C})$ 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

TRIGGER, DATA ACQUISITION & OFFLINE COMPUTING
Austria, Brazil, CERN, Finland, France, Greece, Hungary, Ireland, Italy, Korea, Poland, Portugal, Switzerland, UK, USA

TRACKER
Austria, Belgium, CERN, Finland, France, Germany, Italy, Japan*, Mexico, New Zealand, Switzerland, UK, USA

CRYSTAL ECAL
Belarus, CERN, China, Croatia, Cyprus, France, Italy, Japan*, Portugal, Russia, Serbia, Switzerland, UK, USA

PRESHOWER
Armenia, CERN, Greece, India, Russia, Taiwan

RETURN YOKE
Barrel: Czech Rep., Estonia, Germany, Greece, Russia
Endcap: Japan*, USA

SUPERCONDUCTING MAGNET
All countries in CMS contribute to Magnet financing in particular: Finland, France, Italy, Japan*, Korea, Switzerland, USA

HCAL
Barrel: Bulgaria, India, Spain*, USA
Endcap: Belarus, Bulgaria, Georgia, Russia, Ukraine, Uzbekistan
HO: India

FEET
Pakistan
China

FORWARD CALORIMETER
Hungary, Iran, Russia, Turkey, USA

MUON CHAMBERS
Barrel: Austria, Bulgaria, CERN, China, Germany, Hungary, Italy, Spain,
Endcap: Belarus, Bulgaria, China, Colombia, Korea, Pakistan, Russia, USA

* Only through industrial contract
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 the 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 Lin and Lin, 2006].
Coherent Ionospheric Doppler Receivers (CIDR) Project 2008
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
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

Diagram:
- 150 MHz
- 400 MHz
- 50 meter RF cable
- RX
- PC
**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 on DMSP/F15**
(Aug 2006 to Present)

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

**GFO (1998 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

Anatolian Bump
Classification of Anatolian Bump Structures

- **Bump**
  A bump is defined as a single spatial DTEC/Dt peak with a peak-to-trough amplitude of at least 0.01 TECU/s (1 TEC unit (TECu) = 10^16 electrons/m^2) that is at least 1° 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 $\geq 0.01$ 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
• 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>
<thead>
<tr>
<th>Table 1. The Occurrence Frequency of $\Delta$TEC/$\Delta$t Structures Over the Anatolian Plateau During the Fall of 2008</th>
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</thead>
<tbody>
<tr>
<td>Structure</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Bump</td>
</tr>
<tr>
<td>Ripple</td>
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<td>Wave</td>
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Thank you