GPS Scintillation over Vietnam on April 2006

Lu. Alfonsi, L. Spogli, J. R. Tong, G. De Franceschi, V. Romano, A. Bourdillon, M. L. Huy, C. N. Mitchell

EGU General Assembly 2010
Outline

- Introduction
- Geomagnetic condition on April 2006
- Data
  - GISTM
  - MIDAS
- Method
- Discussion of the results
- Summary and conclusions
Introduction

- SW-magnetosphere coupling → ionosphere turbulence
  - Scintillation of trans-ionospheric signals (GPS)
- Severe effects at equatorial latitudes
  - Fountain effect
- Pre-reversal enhancement → formation of irregularities
- $\mathbf{E} \times \mathbf{B}$ conditions leading to scintillation scenarios are not still clear
- Scintillation inhibition phenomena during geomagnetic storms are here described
Introduction

- Vietnamese ionosphere shows particular sensitivity to the Equatorial Electrojet
- Region poorly described in the open literature
- Two GISTM receivers
  - Hue (near the crest)
  - Hoc Mon (close to the equator)

<table>
<thead>
<tr>
<th>Location</th>
<th>ID</th>
<th>Latitude (°N)</th>
<th>Longitude (°E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hue</td>
<td>HUE</td>
<td>16.4</td>
<td>107.6</td>
</tr>
<tr>
<td>Hoc Mon</td>
<td>HOC</td>
<td>10.9</td>
<td>106.6</td>
</tr>
</tbody>
</table>
Geomagnetic conditions

- 2006: year of solar minimum
- Moderate storm from 4\textsuperscript{th} to 7\textsuperscript{th}
- SSC on 4\textsuperscript{th}
- DST reaches -87 nT under southward IMF conditions
- Substorms
- April 1\textsuperscript{st} is used as quiet day of reference
Data and Method

- **GISTM (GPS Ionospheric Scintillation and TEC Monitor)**
  - High sampling rate (50 Hz)
  - $S_4$ and $\sigma_\phi$ (1, 3, 10, 30 and 60 s)
  - TEC and ROT (15 s)
- **MIDAS (Multi – Instrument Data Analysis System)**
  - Ionospheric tomography to support the identification of irregularities
  - Dual frequency measurements from IGS network
  - Vertical TEC maps
- **ROT (30 s), ROTI and Amplitude Scintillation index ($S_4$) are used**
  - ROTI is the std. dev. of ROT (5 minutes intervals)
- **$S_4$, ROT and ROTI gives information on the dimension of the irregularities**
  - $S_4$ is sensitive to scale below the Fresnel scale
  - ROTI $>$ 0.5 corresponds to scale lengths of few km
- No meaningful phase scintillation (as expected)
Results

PRN 30

- Scintillation between 1200 and 1400 (local sunset)
  - 1\textsuperscript{st}, 5\textsuperscript{th} and 7\textsuperscript{th}
  - Pre-reversal activity
- Inhibition on 4\textsuperscript{th} and 6\textsuperscript{th}.
- vTEC
  - Smooth during inhibited days
  - Steep changes during scintillating days
Results

PRN 30

- ROT and ROTI
  - Stable values during inhibited days
- ROTI > 0.5 for 4th (HUE @ 1200 UT)
  - Irregularity scale < few km
  - BUT not sufficient to produce scintillation
Results (II)

- vTEC time evolution
- Scintillation 1000-1200 UT
- Dots indicates S4
  - Scint. co-located with TEC gradients
  - Crests recognizable on 1\textsuperscript{st}, 5\textsuperscript{th} and 7\textsuperscript{th}
- 4\textsuperscript{th} and 6\textsuperscript{th} crest approaches equatorial lat.
- No sufficient fragmentation
Results

- vTEC profiles (MIDAS)
- Scintillation 1000-1200 UT
- Dots indicates S4
  - Scint. co-located with TEC gradients
- Crests recognizable on 1\textsuperscript{st}, 5\textsuperscript{th} and 7\textsuperscript{th}
- 4\textsuperscript{th} and 6\textsuperscript{th} crest approaches equatorial lat.
  - No sufficient fragmentation
Results

Possible explanation

- IMF:
  - southward on early 4\textsuperscript{th}
  - northward on late 5\textsuperscript{th}
- Turnings are associated with intense AE activity
- Suppression of spread F
- On 7\textsuperscript{th} the F layer goes back to the unstable conditions
  - Expected local sunset scintillation enhancement
Summary

- Identification of scintillation inhibition during different phases of the storm development (PRN 30)
- vTEC, ROT and ROTI indicates that amplitude scintillation is due to steep changes in vTEC
- vTEC time evolution is smooth under inhibited conditions
- The MIDAS maps indicate that the crest configuration is lost on 4th and 6th
  - IMF turn to southward on 4th and come back to northward on 5th
    - Associated with AE activity intensification (penetrating E fields?)
- IMF Bz and AE critically contribute to the suppression of the spread F generating ionospheric scintillations.
- Similar inhibitions has been found for a storm occurred few days after (dedicated study)

Thanks for your attention!