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Sudden Ionospheric Disturbance (SID) Monitor

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Solar flares and ionosphere
SID Monitor

SID monitor (the improved version is called SuperSID) originally developed by Stanford University is used to track changes in the amplitude of VLF signals. VLF signals (3-30kHz) are transmitted by VLF transmitters installed worldwide by different nations and propagated through Earth-ionosphere waveguide.

SID monitor consists of:
I. Antenna
II. Preamplifier
III. Computer with a soundcard

A loop antenna pick up radio signals reflected from ionosphere and a preamplifier boost the signal about thousand times to the level that can be captured with a PC soundcard. The program on PC, tracks the VLF transmission signal strength and process the data.
International Space Weather Initiative (ISWI) is a follow-up activity to the successful IHY 2007, but focusing exclusively on space weather. SID is one instrument among an array of instruments installed under ISWI.
Different nations have installed VLF transmitters used for time signals and radio navigation beacons. We have selected six VLF stations for data recording.

<table>
<thead>
<tr>
<th>Country</th>
<th>Station</th>
<th>Frequency</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>German</td>
<td>DHO</td>
<td>23.4</td>
<td>53.16 N, 33 E</td>
</tr>
<tr>
<td>UK (NATO)</td>
<td>GQD</td>
<td>22.1</td>
<td>52 N, -1.2 W</td>
</tr>
<tr>
<td>Italy</td>
<td>ICV</td>
<td>20.27</td>
<td>40.88 N, 9.68 E</td>
</tr>
<tr>
<td>Japan</td>
<td>JJI</td>
<td>22.2</td>
<td>32.04, 130.81</td>
</tr>
<tr>
<td>Australia</td>
<td>NWC</td>
<td>19.8</td>
<td>-21.8, 114.2E</td>
</tr>
<tr>
<td>Turkey</td>
<td>TBB</td>
<td>26.7</td>
<td>37.43, 27.55</td>
</tr>
</tbody>
</table>

Aerial view of 19.8kHz frequency transmitter, installed in Australia near North West Cape (NWC).
Quiet day graph (DHO and TBB)
Quiet day graph (ICV and JJI)

Continued...
Sunrise and sunset terminator

Day/night cycle is an important factor affecting the propagation of VLF signals. D-region of ionosphere is produced at daytime, causing absorption of VLF signals therefore intensity of signal decreases. At night time D-region disappears and reflection happens from E-region therefore signal intensity increases.

The two figures are showing day and night paths of signals from NWC-transmitter to receiver installed at Sonmiani.
Comparison of our SID data and of Khatav, India (Proceedings of the 10\textsuperscript{th} Australian Space Science Conference, Brisbane 20-30 Sep. 2010) showing typical one day variations of NWC signal strength (19.8 kHz).
Solar flare-1

<table>
<thead>
<tr>
<th>Flare Type (03 Feb 2013)</th>
<th>Begin (UTC)</th>
<th>Max (UTC)</th>
<th>End (UTC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C8.4</td>
<td>0556</td>
<td>0610</td>
<td>0615</td>
</tr>
</tbody>
</table>
Comparison with Quiet day
## Solar flare-2

<table>
<thead>
<tr>
<th>Flare Type (05 Mar 2013)</th>
<th>Begin (UTC)</th>
<th>Max (UTC)</th>
<th>End (UTC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1.2</td>
<td>0747</td>
<td>0754</td>
<td>0759</td>
</tr>
</tbody>
</table>

### NWC data plot (05 Mar 2013)

The diagram shows a plot of solar flare intensity from 00:00 to 23:59 UTC on 05 Mar 2013. The x-axis represents UTC time, and the y-axis shows relative strength. The legend indicates:
- **C** - minor flare (class C)
- **M** - moderate flare (class M)
- **X** - large flare (class X)

The plot indicates a significant flare event around 0747 UTC, peaking at 0754 UTC, and lasting until 0759 UTC.
Continued...

Comparison with Quiet day
### Solar flare-3

<table>
<thead>
<tr>
<th>Flare Type (15 Mar 2013)</th>
<th>Begin (UTC)</th>
<th>Max (UTC)</th>
<th>End (UTC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1.1</td>
<td>0546</td>
<td>0658</td>
<td>0835</td>
</tr>
</tbody>
</table>

**NWC data plot (15 Mar 2013)**
Comparison with Quiet day

Continued...
Thunderstorm activity

Thunderstorms are huge source of VLF waves and appears as vertical lines in SID data. VLF observations of thunderstorms are useful for prediction purpose.
Solar flare data enhancement

<table>
<thead>
<tr>
<th>Flare Type (17 May 2013)</th>
<th>Begin (UTC)</th>
<th>Max (UTC)</th>
<th>End (UTC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M3.2</td>
<td>0843</td>
<td>0857</td>
<td>0919</td>
</tr>
</tbody>
</table>
Same day data (17 May 2013) of another station, Sudden Ionospheric Disturbances Monitoring Station A118 has given in next slide. This station is an amateur observatory located in France.
This station is an amateur observatory located in France. Operational since early 2006, it has received the AAVSO observer code A118 in July 2006 and provides data to a coordinated network of observers around the world.
1. Very Low Frequencies (3-30 kHz) can propagate over very long distances (many thousands of kilometers) through the Earth-ionosphere waveguide (EIWG).

2. The most prominent change in the Earth-ionosphere waveguide is the day/night change.

3. However, significant modifications of the propagating conditions happen due to severe changes in the lower ionosphere electron density, induced by solar X-ray flares.

4. The changes in the waveguide medium (i.e. Earth-ionosphere duct in this case) cause to change VLF signal amplitude/phase.

5. SID monitor is very useful in monitoring such changes.

6. There are many other sources of VLF e.g. thunderstorm activity, meteor showers, Earthquake etc.

7. Therefore VLF data is very useful for modeling lower ionosphere and studying other Geophysical phenomenon.
Thanks for your attention...