Space Weather Monitoring in Pakistan

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Space Science Dte
SUPARCO
Activities in the context of SWx

- Monitoring and study of ionosphere
- Monitoring of geomagnetic field
- Monitoring of solar activity
Purpose of SWx Operation/ Research

- Provision of SWx data and services to help mitigate risks to technological systems, operations and applications
- Provision of timely alerts and advisory regarding SWx to national agencies
- Sharing of data for carrying out scientific studies
- Collaboration with international SWx forecast centres for improvement of assimilative models and services
Services

- MUF/ FOT Predictions
- Ionospheric data
- HF advisory
- Geomagnetic data
- Solar Flares/ Geomagnetic storm warning
- Training & Educational support
Services

Daily space weather summary (SUPARCO)

Tuesday, October 29, 2013, 11:25 PST

**LOCAL CURRENT IONOSPHERIC CONDITIONS**

<table>
<thead>
<tr>
<th>F2</th>
<th>123.45 nsf</th>
</tr>
</thead>
<tbody>
<tr>
<td>nF2</td>
<td>234.56 km</td>
</tr>
<tr>
<td>nMUF</td>
<td>123.45 kHz</td>
</tr>
</tbody>
</table>

Local ionospheric conditions are nominal. HF radio comm expected to slightly disturbed with possibilities of shortwave breakdowns. In case of HF comm difficulty, try higher frequency bands.

**LOCAL GEOMAGNETIC CONDITIONS**

<table>
<thead>
<tr>
<th>kp</th>
<th>2 (max value in 24 hrs: 3, no effect)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ap</td>
<td>1 (max value in 24 hrs: 3, no effect)</td>
</tr>
<tr>
<td>P2</td>
<td>45540 nT (54400 nT)</td>
</tr>
<tr>
<td>P3</td>
<td>45905 nT (49700 nT)</td>
</tr>
</tbody>
</table>

The local geomagnetic field is quiet now (as shown in graph).

**LATEST SOLAR CONDITIONS**

<table>
<thead>
<tr>
<th>S/N</th>
<th>151/185</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar radio flux</td>
<td>165/180 sfu</td>
</tr>
<tr>
<td>Solar wind speed</td>
<td>31.8 km/s (varied in the past 12 hrs between 314 &amp; 254 km/s)</td>
</tr>
<tr>
<td>Solar X-ray flux (11:20 PST)</td>
<td>1.8 (1057 UT/1015 PST: M1.5)</td>
</tr>
<tr>
<td>Dst</td>
<td>-1.65 nT (varied in the past 12 hrs between -3.15 &amp; -1.7 nT)</td>
</tr>
</tbody>
</table>

Solar activity: active with background X-ray flux at C-class levels. Local geomagnetic conditions are at quiet levels. Local HF working frequencies are slightly shifted compared to monthly average predicted values.

This data and information is taken from the National Geophysical Data Center (NGDC) at <https://www.ngdc.noaa.gov/seg/nowcast/nowcast.html> and <https://wwbweb3.nssdc.gsfc.nasa.gov/STP/Solar.html>.

**DEFINITIONS**

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>F2</td>
<td>Maximum frequency of F2-layer of the ionosphere</td>
</tr>
<tr>
<td>Ns</td>
<td>Normal season or F2-layer state</td>
</tr>
<tr>
<td>F1</td>
<td>Maximum usable frequency for 2000-3000m</td>
</tr>
<tr>
<td>P2</td>
<td>Planetary index defining geomagnetic conditions, predicted value during geomagnetic quiet conditions</td>
</tr>
<tr>
<td>P3</td>
<td>Planetary X index defining geomagnetic conditions, predicted value during geomagnetic storm conditions</td>
</tr>
<tr>
<td>Dst</td>
<td>Composite of the total geomagnetic field vector</td>
</tr>
<tr>
<td>Kp</td>
<td>24-hour average of the magnetic field component of which is y-axis</td>
</tr>
<tr>
<td>Ap</td>
<td>Total Dst</td>
</tr>
<tr>
<td>AS</td>
<td>Total Ap</td>
</tr>
<tr>
<td>AR</td>
<td>Active Region on the sun currently in view</td>
</tr>
<tr>
<td>CR5</td>
<td>Coronal mass ejection</td>
</tr>
<tr>
<td>CH</td>
<td>Coronal hole</td>
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</tbody>
</table>

**Actual Condition**

For more information, visit the 3rd AOSWA Workshop at www.aoswa.org.
## History

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>Establishment of ionospheric station at Karachi and installation of British Ionosonde Mark II</td>
</tr>
<tr>
<td>1975</td>
<td>Replacement of British Ionosonde Mark II by analogue Japanese Ionosonde PIR-9 (Panoramic Ionospheric Recorder-9) at Karachi</td>
</tr>
<tr>
<td>1978</td>
<td>Establishment of ionospheric station at Islamabad and installation of PIR-9B</td>
</tr>
<tr>
<td>1983</td>
<td>Establishment of geomagnetic observatory (AMOS-III), EDA Canada at Karachi</td>
</tr>
<tr>
<td>1987</td>
<td>Replacement of PIR-9 by Digisonde DGS-256 at Karachi, establishment of ionospheric station at Multan and shifting of PIR 9 from Karachi to Multan</td>
</tr>
<tr>
<td>1992</td>
<td>Replacement of PIR-9 by Digisonde DGS-256 at Islamabad</td>
</tr>
<tr>
<td>2008</td>
<td>Installation of DPS-4 at Multan</td>
</tr>
<tr>
<td>2008</td>
<td>Establishment of Islamabad geomagnetic observatory and shifting of Karachi geomagnetic observatory to Sonmiani</td>
</tr>
<tr>
<td>2013</td>
<td>Installation of Sudden Ionospheric Disturbance (SID) Monitors</td>
</tr>
<tr>
<td>2014</td>
<td>Installation of GNSS TEC Scintillation Receiver and CALLISTO at Sonmiani</td>
</tr>
<tr>
<td>2015</td>
<td>Installation of GNSS TEC Scintillation Receiver and CALLISTO at Multan</td>
</tr>
</tbody>
</table>
Infrastructure

- Ionosondes
- Magnetometers
- Variometers
- SID monitors
- CALLISTO
- Riometers
- Optical telescope
- GNSS TEC
- Scintillation receivers
Ground Based Sensors (Ionosphere)

- DGS-256 at Sonmiani (geog: 24.95°N, 66.45°E) & Islamabad (geog: 33.75°N, 73.13°E)
- DPS-4 at Multan (geog: 30.18°N, 71.48°E)
Ground Based Sensors (Ionosphere)

- GNSS TEC/ Scintillation receivers at Sonmiani & Multan
- SID monitors at Sonmiani, Multan & Islamabad
Ground Based Sensors (Geomag)

- Variometers/ magnetometers at Sonmiani (geom: 17.26°N, 141.33°E) & Islamabad (geom: 25.42°N, 148.73°E)
Ground Based Sensors (Solar)

- CALLISTO at Sonmiani & Multan
- Sunspot Observation Telescope at Karachi
- Solar activity monitoring softwares
Available Resources (contd)

Observation Data

- Ionosonde data at 15 min interval
- Geomagnetic data at 1 min and 2.5 sec interval
- Absolute geomagnetic field data 2-3 times in a week
- Solar radio burst data at 800 measurements/sec
- SID data at 5 sec sampling rate
- Scintillation data at 1 sec interval & TEC data at 15 sec interval
- K – index

Model codes

- Near real time K-index codes
- Regional model codes using EOFs (Empirical Orthogonal Functions)
Available Resources

Measurement/Analysis Techniques

- SAO Explorer – Ionospheric data
- Absolute/ Turbo basic routines – geomagnetic data
- KASM – k-index
- Spectrum Lab – VLF signals
- Python routines – Solar Radio Bursts

Human Resources

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Researchers</td>
<td>5</td>
</tr>
<tr>
<td>Technicians</td>
<td>9</td>
</tr>
</tbody>
</table>
International Cooperation (contd)

Membership:

- Asia-Oceania Space Weather Alliance (AOSWA)
- Inter program Coordination Team on Space Weather (ICTSW)
- International Real-time Magnetic Network (INTERMAGNET)
International Cooperation (contd)

APSCO studies:

- Atmospheric effects on ionospheric modeling through study of radio wave propagation and solar activity
- Research on determining precursors ionospheric signatures of Earthquake by ground based ionospheric
International Cooperation (contd)

SUPARCO shares its data with:

- WDC – Solar and Terrestrial Science
- INTERMAGNET
- APSCO

SUPARCO also contributed in:

- COSMIC Campaign – USA
- Oersted mission – Denmark
SUPARCO benefits from:

- Space Weather Software/Models
  - SWB
  - WSA-ENLIL
  - ASSA
  - PropLab, SWIM & SWARM
  - IGRF
  - IRI
International Cooperation (contd)

- Satellite Based Data/ Information
  - GOES, ACE, SOHO, SDO

- Web based data/ information
  - Solar Indices (SSN, F10.7cm, T-index)
  - Geomagnetic Indices (Kp, Ap & Dst)
  - IQD & IDD
The 1st Workshop on “Geomagnetic Observatories and their Applications” was held for OIC member countries, 03-13 April, 2012 at the Geomagnetic Observatory, Islamabad with the collaboration of IRM, Belgium, ISNET & NCP. About 24 participants attended the Workshop among whom 09 were locals and 15 were foreigners.
Training and Short Courses

- Space Weather Challenges of Solar Cycle 24, Karachi
- Solar Radiation and modern technologies, Islamabad
- Space weather monitoring, Karachi
- Impact of Solar Radiation on Earth, Ionosphere and Geomagnetic Field, Karachi
Scientific Studies

- Geomagnetic activities in Pakistan since 2006-to date, Earth Science and Technology, 2012
- Study of maximum electron density NmF2 at Karachi and Islamabad during solar minimum (1996) and solar maximum (2000) and its comparison with IRI, Advances in Space Research, 2009
- Comparing IRI and a regional model with ionosonde measurements in Pakistan, Advances in Space Research, 2008
Future Plans

- Setup of collaborative Oblique Sounding hardware
- Development of professional skills necessitated for space weather predictions
- Joining as one of the regional centers of international network
Near Future Targets

Space Weather Monitoring Center

Pakistan is currently working towards the establishment of a Space Weather Monitoring Centre. The centre aims to integrate and upgrade the existing facilities at remote sites, and to install new ground based instrument for monitoring SWx.

Human Resource Development

- Higher studies
- Short trainings

Collaborative studies/ projects under:

- APSCO (in progress)
- AOSWA (planned)
Resources Required

- Flare Monitoring Telescope (FMT) in Pakistan
- Upgrading of ionosondes (DGS 256 & DPS-4)
- Collaborative studies in plasma and solar physics with any AOSWA members willing to undertake collaborative work. Requirement of data would depend on need basis.
- Accurate Models / codes for forecasting space weather
Higher studies (MS, PhD) along with scholarships

Short trainings on:
- Scientific data analysis
- Installation and calibration of instruments

International cooperation to establish Space Weather Monitoring Centre
THANK YOU
Collaborative Future Studies (planned)

We are working on the following studies/titles and desire to publish these:

1. Variations in F2-layer parameters and comparison with IRI over Pakistan for deep solar minimum
2. Ionospheric variability of low and mid latitude for solar cycle 22 and 23 (under preparation)
3. Solar cycle effect on coupling of neutral and ionized species at F2 altitude
4. A study of the relationship between the critical frequency of the F2 layer of the ionosphere and the GPS total electron content in the equatorial anomaly region
5. Use of Pakistani and MAGDAS geomagnetic data to investigate EEJ
Collaborative Future Studies (planned)

We are working on the following studies/titles and desire to publish these:

- Development of Asia Oceania Reference Ionosphere model
- Ionospheric variability of low and mid latitude for solar cycle 22 and 23
- Use of Pakistani and MAGDAS geomagnetic data to investigate EEJ
- Development of Pakistani TEC map (EOF, SHA, Neural network)
- Study of effects of Solar Wind on the morphology of ionosphere