Report of Regional Warning Centre INDIA, 2013- 2014 Annual Report

A.K Upadhayaya
Radio and Atmospheric Sciences Division, National Physical Laboratory,
New Delhi-110012, India
Email: upadhayayaak@nplindia.org & rwcindia@nplindia.ernet.in
Website: http://cgc.nplindia.org/atul/cgc/rwc/INTRUDUCTION4_BuIn.htm

National Physical Laboratory, New Delhi a premier laboratory under council of scientific and industrial research(CSIR), operates Indian RWC as a part of International Space Environment Services [ISES] chain and is responsible for collection and dissemination of a wide variety of near-real-time and recent data on solar geophysical conditions to various users in India and neighboring countries. In addition, the center is also responsible for providing forecasts on solar and geophysical conditions based on the data collected from other centers located around the globe and also from observatories within India. RWC [Boulder] and RWC [Sydney] are two major sources of near-real-time data and provide a variety of observational information which includes, detailed reports on solar active regions, magnetic activity, Coronal Holes, CMEs, X-ray events, Radio bursts, Proton events. etc.

I. Recent Accomplishments:

(a)Digital Ionosonde System at NPL, New Delhi :

Lowell Digisonde portable sounder (DPS4D) was installed on 26th June 2014 for real time monitoring of ionospheric critical layer parameters (frequencies and height). The system is replacing an older KEL Ionosonde which was not operational since 2009.

(b)Ionospheric Monitoring lab at Antarctica.

Space Physics Laboratory:

Radio & Atmospheric Sciences Division, CSIR-NPL takes a herculean task to develop first Indian Space Physics laboratory at Maitri, Antarctica during the International Polar year. The task has been successfully completed by commissioning of a new Space Physics Laboratory at Maitri, Antarctica along with phase-wise deployment of three major most advanced real time ionospheric monitoring instruments i.e. Global Scintillation and Total Electron Content Monitoring (GISTM) system and most advanced Canadian Advanced Digital Ionosonde system during 27th to 29th Indian Scientific Expeditions to Antarctica (InSEA).

Advanced Digital Ionosonde:

The CADI Digital Ionosonde system installed at Maitri, Antarctica by CSIR-National Physical Laboratory is capable acquire high - resolution ionospheric data for scientific study of structure and dynamics of Polar region ionosphere.

Indian New station "BHARATI" (Lat.69.24 south, Long.76.11 east) Larsemann Hills, Antarctica.

Global Ionospheric Scintillation & Total Electron Content Monitoring System

A Novatel make dual frequency 12 channel GISTM system (see figure-3) is installed for real time round the clock monitoring and study of L-band scintillation characteristics due to various irregularities generated over the polar region ionosphere. The system is so advanced that it also directly provided the ionospheric total electron content of the ray-path by which the signal is pass through the ionosphere. The system is also enable find out the accurate position of the location of the monitoring station with a maximum error of 1 meter.

II. Highest priority product goals

- Data assimilation of ionosphere/magnetosphere to address space weather issues for scientific research.

III. Highest priority data needs

- Operational observation data of ionosphere with ionosonde, GPS in India.

ACTIVITIES OF RWC - INDIA:

- **DAILY RWC FORCAST**

  Solar geophysical observed data and next 24-48 hrs predictions which is broadcast by IMD

- **SOLAR CYCLE & ACTIVITY PREDICTIONS**

  Complete solar cycle predictions & R12 predictions 6 months in advance

- **IONOSPHERIC PREDICTIONS**

a) Second Degree model - for long term HF Link predictions
b) Multi-Regression Analysis Model - for storm time prediction of F-region parameters
c) TEC model for Indian zone for navigational corrections
d) Morphology, signal statistics of Spread-F/ Scintillation for the Indian zone and their possible predictions etc

- **MONTHLY REPORT**

  Monthly summary of solar geophysical data, Sunspot Predictions, Monthly foF2, hmF2, MUF(4000)F2 and TEC maps for Indian region and Spread-F information on request

DATA SERVICES

1. Information on Solar and Magnetic conditions

- Indian Institute of Astrophysics, Kodaikanal and Udaipur Solar Observatory, Udaipur provide solar data; which includes information on sunspots, active regions, solar flares, eruptive prominences etc.)

- RWC (Boulder) is major contributor to our RWC and provide valuable information on radio and X ray events, coronal holes, CMEs, Solar wind parameters, IMF etc.

- Indian Institute of Geomagnetism (IIG), Mumbai and National Geophysical Research Institute (NGRI), Hyderabad operating chain of Geomagnetic Observatories provides information on local K indices, magnetic storms and EEJ strength.

2. Ionospheric Data

- India now has an impressive chain of Ionosondes covering almost the entire country, which provides critical data to long term planning as well as for short-term frequency updates for HF links operating in the country.

- RWC-India has set three digital ionosondes, one at Bhopal, near Anomaly Crest , at Delhi and one at Maitri Antarctica. The data is also being used in a number of nationally coordinated research programs to study the equatorial ionosphere and its dynamics.

3. Ionospheric Scintillation Data

- VHF and 4 GHz Scintllation data from some selected locations - Morphology and Signal Statistics.

- **PRODUCTS AND SERVICES RWC INDIA**

1. NPL Ionospheric Prediction Models
   (a) Point-to-point HF Link Prediction Model
   (b) Multiple Regression Analysis (MRA) Model for storm time prediction of F-region ionospheric parameters
   (c) TEC Prediction Model for Indian zone
2. Solar Cycle and Solar Activity Predictions
3. Radio reftractivity Atlas for India zone (Surface Refractivity and Initial Gradients) and Ray Tracing Model for Radar Tracking Errors (Range and Elevation Angle Errors).
4. L and C Band Scintillation Morphology and Signal Statistics (Fade Rate, CDF, Bit Error Rates etc.) for Equatorial and Low Latitude Regions of India.
5. Long Series of Ionosonde Data for Indian zone.
6. Conduct Courses on Radio Environment and its Impact on Radio Communication (HF to Microwaves Bands) and Navigation Services for the Users - on request only

USER SERVICES

RWC [New Delhi] caters to the needs of a large number of users in India. Some of the important user organizations include.

i) Air India
ii) Indian Space Research organization
iii) Three Wings of Defense
iv) Scientific Community.
v) Radio Communication Organizations

Apart from this we have undertaken some research bound project with different agencies in India. Some details of work carried out during this period are listed below.

(a) Upadhayaya A.K and Sumedha Gupta (2014), A statistical analysis of occurrence characteristics of Spread-F irregularities over Indian region, JASTP, 112, 1-9 ,doi: 10.1016/j.jastp.2014.01.019.

We have investigated the regularities of a change in spread F probability during day-to-day, under varying solar variability, latitudinal behavior and their response to geomagnetic storm in equatorial and low-mid latitude stations. The occurrence characteristics of spread-F irregularities, is obtained from daily hourly ionosonde data from a low-mid latitude station,

Delhi (28.6°N, 77.2° E), for more than half a solar cycle (2001 to 2007). The latitudinal behavior of spread-F is studied using ionosonde data from anomaly crest station, Ahmedabad (23.01°N, 72.36°E) and equatorial station, Kodaikanal (10.2° N, 77.5°E) for low, moderate and high solar activity periods. The maximum percentage occurrences of spread-F were observed during the low solar activity year 2007, we believe, the low plasma and neutral density during 23/24 solar cycle minimum could be an important factor leading to the generation and propagation of TIDs and gravity waves. An anti-solar activity correlation to Spread F occurrence is reported during all the seasons at different stations which are because of instability generated by the trans-equatorial meridional winds. There is a substantial variation during pre and post midnight hours in F layer height from equatorial to low latititudes in response to magnetic disturbances. Concurrence was observed in the occurrence time of spread-F to different storm events during different storm phases. The established irregularities and their behavior in Indian region are qualitatively interpreted and discussed.

(b) Upadhayaya, A. K., and K. K. Mahajan (2013), Ionospheric F_2 region: Variability and sudden stratospheric warmings, J. Geophys. Res. Space Physics, 118, 6736–6750, doi:10.1002/jgra.50570.

The ionospheric F_2 region is known to show a large day-to-day and hour-to-hour variability. Some of this variability has recently being linked to sudden stratospheric warmings (SSWs). We therefore investigate the extent of ionospheric changes following SSWs of 2007, 2008, and 2009 using ionosonde data from six different stations in the Asian zone, thus covering a broad latitudinal range from 23.2°N to 45.1°N. We find that ionospheric F_2 region shows some significant perturbations soon after the start of the warming. However, characteristics of these perturbations vary from event to event and from station to station. We also examine the data on

equatorial electrojet strength (EEJ) during these warmings and find that there are significant changes in the EEJ strength during the SSW events. A counter electrojet coincident with the start of warming was observed for the SSW event of 2008. We then compare this SSW-linked variability observed by us to the normal day-to-day and hour-to-hour variability seen in the ionospheric data. We find that even during times when there are no SSWs and solar and magnetic indices are quite stable and close to their minimum values, the ionospheric variability is comparable to the variability attributed to these warmings. Further, it seems to us that it is difficult to quantify with precision the changes in f_oF2, as well as in the ionospheric response times involved, following these events.

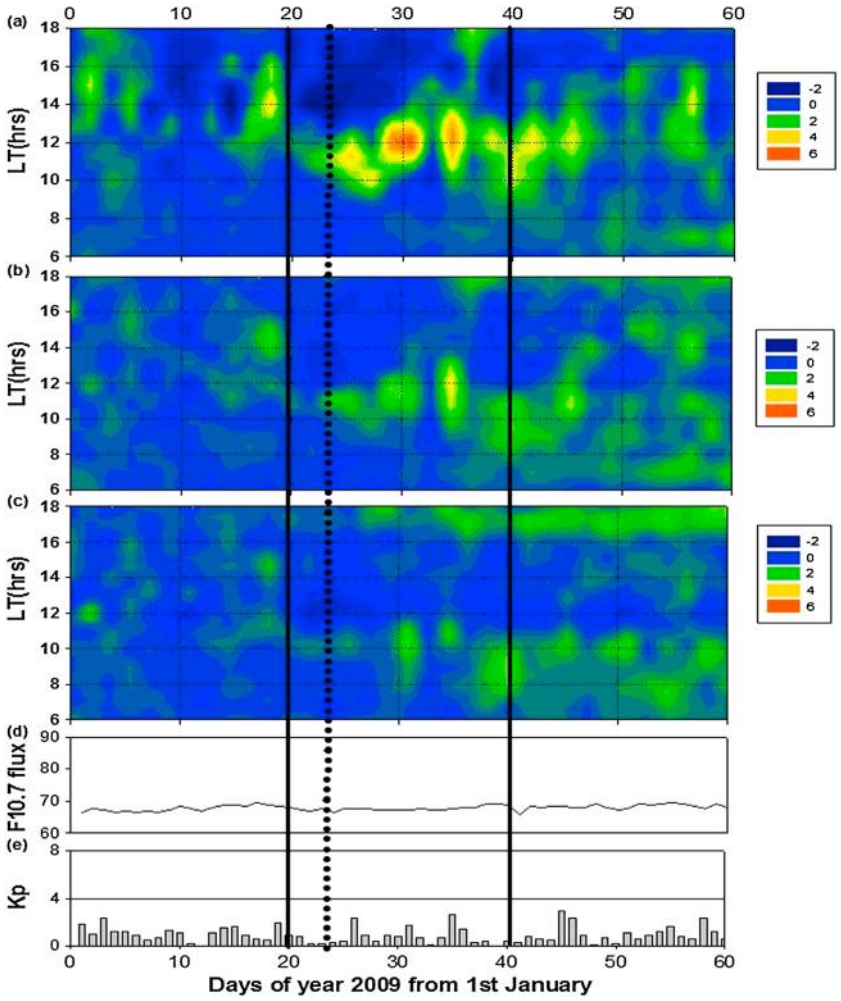
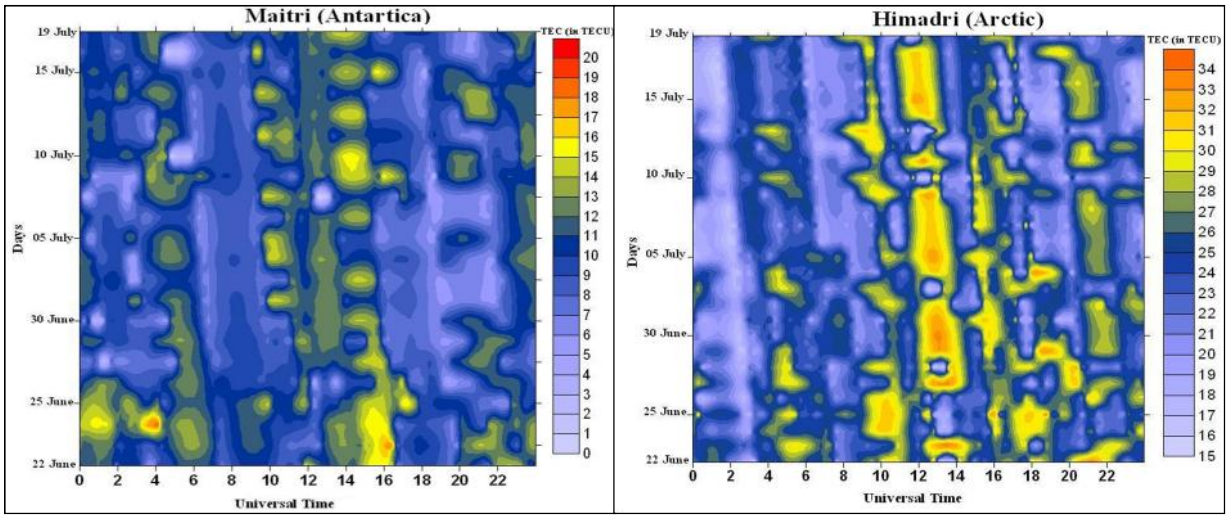


Figure: Plots of deviation ($\Delta f_o F2$) in critical F_2 layer frequency from average of prewarming period (3–12 January 2009) at (a) Okinawa, (b) Yamagawa, and (c) Kokubunji. Plots of (d) $F10.7$ and (e) Kp indices with days of the year 2009. Dark black lines denote the SSW period, and the dotted lines denote the dates of peak warming.

iii) To investigate the ionospheric scintillation and Total Electron Content over inter-hemispheric polar region during solar minimum conditions.

The auroral region ionosphere is highly structured and varied owing to the existence of open magnetic field line arrangement which allows the direct precipitation of high energetic particles. This causes polar region to experience increased scintillation events under geomagnetically disturbed conditions. The presence of ionospheric scintillation can cause cycle slips, degrade the positioning accuracy and often leads to the complete loss of signal lock situation in the Global Positioning Systems (GPS) receivers. Thus, ionospheric scintillations have an adverse effect on the performance of communication and navigation systems. High latitude scintillation events are frequently observed during the solar maximum period in association with increased disturbed magnetic conditions, but are rarely observed during solar minimum conditions when there is low magnetic activity. We have investigated the behavior of TEC and scintillation activity over the inter-hemispheric polar region during quiet or moderately disturbed geomagnetic conditions of solar minimum period.

The study was based on the GPS Ionospheric Scintillation and TEC Monitor (GISTM) observations which are installed at Indian polar research stations Himadri, Arctic and Maitri, Antarctic. This GISTM receivers, model GSV4004, is based on the Novatel dual-frequency receiver model and log raw data on a 50 Hz sampling rate. The receiver computes ionospheric TEC (total electron content) using both GPS L1 and L2 signals. The available dataset during the time period from 22 June to 19 July, 2008 has been used for the study, which represent the extended solar minimum period of 23rd solar cycle and complete day at one region and night at the opposite hemisphere. The geomagnetic activity during the considered period of study represent fairly low to moderate magnetic activity levels.



The values of TEC over Himadri (dayside auroral region) varies from around 15 to 35 TECU, whereas, the values over Maitri (night side auroral region) lies between 5 to 20 TECU.

The peak in the TEC values is observed around 1200-1400 UT over Himadri and 1400-1600 UT over Maitri. The skewed behavior of TEC is observed i.e. shifting in the peak value of TEC on the day-to-day basis.

User-Researcher Interaction through Regional Warning Centre (RWC-India)

User- Researcher Interaction is normally arranged twice a year to learn from user agencies their experience, their needs and views on how the RWC services can be made more useful.

Other Information about Indian Regional Warning Center- RWC-India

Supervisory : Dr. A.K Upadhayaya
Members: Dr**.** MVSN Prasad, Dr. Rupesh M. Das, Ruby Madawat, Sumedha Gupta, Smriti Tiwari Singh.

Mail Address

National Physical Laboratory
Dr. K.S. Krishnan Marg
New Delhi – 110 012
INDIA

Telephone

[91] 11-2572 8241
[91] 11-2574 8299

Telefax:

[91] 11-572 6938
[91] 11-572 6952

Electronic Mail address

rwcindia@nplindia.ernet.in
upadhayayaak@nplindia.org

RWC-India Web-site:

http://www.npl-cgc.ernet.in/atul/cgc/rwc/INTRUDUCTION4_Buln.html