Annual Report 2015-16

Indian Institute of Geomagnetism

New Panvel, Navi Mumbai

Indian Institute of Geomagnetism

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AUTONOMOUS RESEARCH INSTITUTE
UNDER
DEPARTMENT OF SCIENCE AND TECHNOLOGY
GOVERNMENT OF INDIA

PUBLICATION COMMITTEE
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Cover page : Newly inaugurated Shillong Geophysical Research Centre, Shillong, Meghalaya.

INDIAN INSTITUTE OF GEOMAGNETISM

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From the Director's Desk.....

IIG's dream to establish its scientific reach and activities in Northeast India fructified this year with the inauguration of its third regional centre at Shillong by our Honourable Union Minister of Science & Technology and Earth Sciences, Dr. Harsh Vardhan Ji on January 18, 2016. It is indeed a proud and historic moment for us. The Shillong Geophysical Research Centre (SGRC) is founded to focus on the seismically vulnerable Northeast India with the ultimate objective to build a precursor hierarchy related to large magnitude earthquake occurrence through in-depth understanding of the coupled nature of the dynamic Lithosphere-Atmosphere-Ionosphere system. The launch of this ambitious program was also graced by dignitaries from IIG and Northeast region. This newly formed centre would embark on cutting edge research to decipher the pre- and co- seismic signatures in various Atmospheric-Ionospheric regions over the Northeast India using a variety of state-of-art observational techniques aided by numerical modelling tools.

This year IIG witnessed a quantum growth in terms of research and scientific output. The effects of a geomagnetic storm on the variation of the atmospheric electric field over Maitri, Dome C, and Vostok Antarctic research stations have been established for the first time. Deformation fields distilled from GPS observations and GRACE satellite measurements revealed that maximum uplift and horizontal movement dominate Peninsular Antarctica and West Antarctica, while low rate of horizontal movement and subsidence is observed over eastern Antarctica. Studies concerning the ice sheet dynamics involving both velocity and strain field are in progress for the Polar Regions.

Entropy-based modelling of geomagnetic data from the Indian observatories unambiguously established a clear connection of day-to-day variability between the equatorial electrojet (EEJ) and solar quiet (Sq) currents. This novel approach revealed that both EEJ and Sq are indeed coupled systems and exchange significant information between them through cross-talk.

Under the program "Integrated studies on the earth's upper atmosphere using ground and space-based instrumentation and numerical modeling tools" scientists at IIG are devoted to study the Mesosphere-lower Thermosphere (MLT) region, which is a very important transition region of the atmosphere that acts as an interface between the lower, middle and the upper atmosphere. Neural network approach has been used to derive the vertical E x B drift from the ionosonde Doppler drift data. These results suggest that even the daytime ionosonde measurements of vertical E x B drift can be relied upon, provided adequate corrections are applied.

The recently developed L–band scintillation technique is applied to evolve the spatio-temporal map of scintillation patches over low latitude regions of India. In order to make the forecast mechanism more robust, the local time variation of the zonal velocity of the perturbations will be estimated by combining the two geo-stationary satellites (GSAT-8 and GSAT-10). The uncommon evolution of fresh and intense field aligned irregularities (FAI) near sunrise terminator which sustained for more than 90 minutes of post-sunrise period was observed by Equatorial Atmosphere Radar (EAR) at Kototabang during a minor geomagnetic storm period. In order to profile the horizontal gradient of ionosphere and ionospheric electron density, an improved and self-contained global ionospheric maps (GIM)-aided Abel retrieval procedure was adopted that can justify spherical non-uniformity along the radio wave path in the vicinity of the radio occultation (RO) region. This procedure drastically reduced the computational complexity and is suitable when the number of occultations increased by many times in the future when other RO missions become operational.

Theoretical and numerical simulation studies of space plasma processes based on spacecraft observations are rigorously being carried out by IIG scientists. Cassini spacecraft detected electromagnetic ion (proton) cyclotron (EMIC) waves and whistler mode chorus in the Earth's dayside sub-solar outer magnetosphere during the Earth flyby. The results suggest that the EMIC waves are coherent to quasi-coherent in nature. Further, coherent wave structures such as electrostatic solitary waves, double layers and ULF/VLF waves have been observed in the Earth's magnetosphere, which play an important role in the transfer of mass and energy across different boundary layer regions of the Earth's magnetosphere. These results provide clues to identify particle acceleration processes in the Earth's magnetosphere.

Several super intense geomagnetic storms that occurred prior to 1900 have been revisited to understand the probable interplanetary conditions leading to such intense geomagnetic storms. In recent times, a major geomagnetic storm occurred on 17 March 2015 wherein Dst reached its minimum of -228 nT, thus making it the largest geomagnetic storm ever occurred in current solar cycle-24. A remarkable observation derived from this storm is that the Traveling Ionospheric Disturbances (TIDs) associated with disturbance meridional wind flow during recovery phase of the storm, which is usually excited due to particle precipitation at high latitude and their subsequent propagation to low latitudes.

Electromagnetic imaging over selected profiles in Cambay basin indicates very high conductive sediments (Tertiary) with deepest part at the centre of the Cambay basin. The demarcation of Cambay basin is obvious with western margin of the basin steeply dipping to vertical while eastern margin of the basin gently dipping towards SW. However the trap thickness below Tertiary sediments is not clear due to presence of low resistivity. The correlation of magnetic anomaly signatures with surface geology of the Andaman Islands was undertaken under a DST sponsored project. This study, a first of its kind in Andaman Islands, revealed ophiolite bodies up to depth of about 5-8 km which spatially correlated with the mapped fault/thrust zones. These ophiolites were emplaced as a result of subduction.

Palaeomagnetic, rock magnetic, AMS and petrographic studies were carried out over the doleritic dykes in and around Keonjhar district of Odisha, Southern Singhbhum craton, India. The mean magnetic susceptibility and the mean NRM intensity for the collected rock samples indicate strong magnetite component. Based on the analysis, the dolerite dykes ages were assigned to 2200 Ma. The petrological studies suggest low grade metamorphism.

Environmental magnetic measurements `were undertaken along Tirna, Girna and Anjani river sediments of western Maharashtra, for studying the palaeoclimate and palaeomagnetic characteristics, the variations in anisotropy of magnetic susceptibility, determination of palaeointensity, rock magnetic, particle size and geochemical characteristics. It is observed that the magnetic mineral particles are dominated by ferrimagnetic minerals and titanomagnetite, apart from few anti-ferromagnetic minerals. Anisotropy of magnetic susceptibility measurements suggests the shape of the AMS fabric is oblate and fluvial flow current is weak to moderate. Sediment samples collected from Gad river estuary revealed that both mineral magnetic and non magnetic variations are controlled by the concentration of magnetite, which can be used as a proxy for rainfall dependent catchment erosion. Pre-Monsoon, monsoon and post-monsoon seasons heavy metal monitoring of beach sands of Vengurla and Aravali suggest presence of antiferromagnetic minerals during all the three seasons.

To delineate the structural framework and to look below the traps, ground magnetic data in conjunction with gravity and GPS data revealed NW-SE Dharwarian trends continue below the Deccan traps. It is also observed that the Kaladgi and Bhima sediments and the Schist belts continue northward below the Deccan traps.

It is imperative to protect and manage coastal aquifers, which serve as important sources of fresh water to major population in any region. Contamination of groundwater due to saline water intrusion has become another major concern for coastal communities, which rely on groundwater as their principal source of drinking water. Both geophysical and geochemical studies are being carried out in coastal regions of Sindhudurg district, Maharashtra by the researchers at IIG in order to determine the extent of saline water intrusion into coastal aquifers and to evaluate the water quality. Elsewhere, in drought-prone regions of Maharashtra, hydrogeophysical studies are being carried out for aquifer mapping, which eventually will lead to a development of watershed management program.

Ground-based rainfall data, satellite-measured total rainfall, surface precipitation, convective precipitation rate and cloud top temperature were evaluated to look into the June 16-17, 2013 Kedarnath catastrophe, where there was huge loss of life and property due to the flash floods. The results advocate that convective heavy rainfall was responsible for this catastrophic event. Also the convergence of southwest monsoon trough and westerly disturbances over the region was observed.

The 25th April Gorkha Nepal earthquake was studied for coseismic and early post-seismic deformation from InSAR and GPS measurements. It is inferred that the shallow portion of the Main Himalayan Thrust (MHT) towards south neither ruptured during the earthquake, nor did it slip aseismically after the earthquake. This suggests the possibility of MHT playing host to future large events.

The instrumentation group at IIG, in its effort to modernize equipments, has developed in-house a low cost proton precession magnetometer (PM7) which has an accuracy of 0.1nT.

Research carried out by IIG scientists culminated in 83 SCI publications with a cumulative impact factor of 158.523 besides 50 papers presented in national and international conferences. Kudos to all my colleagues for maintaining a healthy *per capita* paper of 2 for the second successive year. IIG continues to receive a large number of good students for summer projects and dissertation. A total of 41 were trained by IIG during the current year.

Under the Science Outreach program, the institute has been promoting several scientific exhibitions for students and has participated in several state and national level scientific expositions during the year besides sponsoring a few. During the year, two research scholars were awarded Ph.D. degree and several accolades were also bestowed on students at numerous conferences.

We thank the Governing Council of IIG and the Research Advisory Committee for their constant support and guidance in our endeavour to perform higher pursuing excellence in science. All the staff members of IIG stood up admirably to several academic, administrative and technical challenges during the year and have contributed significantly towards the success of the new initiatives reported here.

D.S. Ramesh
Director

September 19, 2016.

GEOMAGNETIC DATA BASED RESEARCH

GEOMAGNETIC OBSERVATORIES, DATA ANALYSIS & RESEARCH

Chief Coordinator : **Satyavir Singh**

Coordinator : **Gopi Krishna Seemala**
Network of Geomagnetic observatories & data analysis

Coordinator : **Geeta Vichare**
Geomagnetic field variations due to internal and external origin

Coordinator : **B. Veenadhari**
IIG World Data Center

Members : **A.T. Deshmukh, B.D. Kadam, S.K. Bharadwaj, S. Mukherjee, M.M. Jadhav, P.K. Birthare, R. Rawat, A.S. Kulkarni, R. Nimje, M. Doiphode, P. Patro, and All observatory staff.**

Under this program, day-to-day, latitudinal, longitudinal and seasonal variations in the ionospheric Sq current system using variations in D, H and Z components of magnetic field measured at the Indian and worldwide geomagnetic observatories have been studied. Principal component analysis technique was used to study the variability during the normal and abnormal quiet days.

Abnormal Quiet Day (AQD) variations occur occasionally on normal Sq pattern showing abnormal features in the day to day variability. The exact cause of these AQDs, whether it is due to ionospheric origin or extra-terrestrial origin is still unknown. Generally, most of these AQDs occur during minimum solar activity period. To study the abnormal features in its day to day variability pattern, hourly mean of D and H components were used at Indian observatories along 75° E meridian during minimum solar activity period. The technique of Principal Component Analysis (PCA) has been applied to the data sets for presenting a quantitative estimate of the influence of day to day variability in the Sq current system on normal (NQD) and abnormal quiet (AQD) days. AQDs observed at the Indian stations are reflected in the second Principal Component PC-2. Anomalous changes in day to day variations (H and D) are interpreted as an influence of high latitude magnetospheric current systems as well as due to single current vortex (SCV) located in the ionosphere whose focus lie between 10° to 15° N geomagnetic latitude for the northern hemisphere winter AQDs ***(Fig.1)***.To find the source of these variations

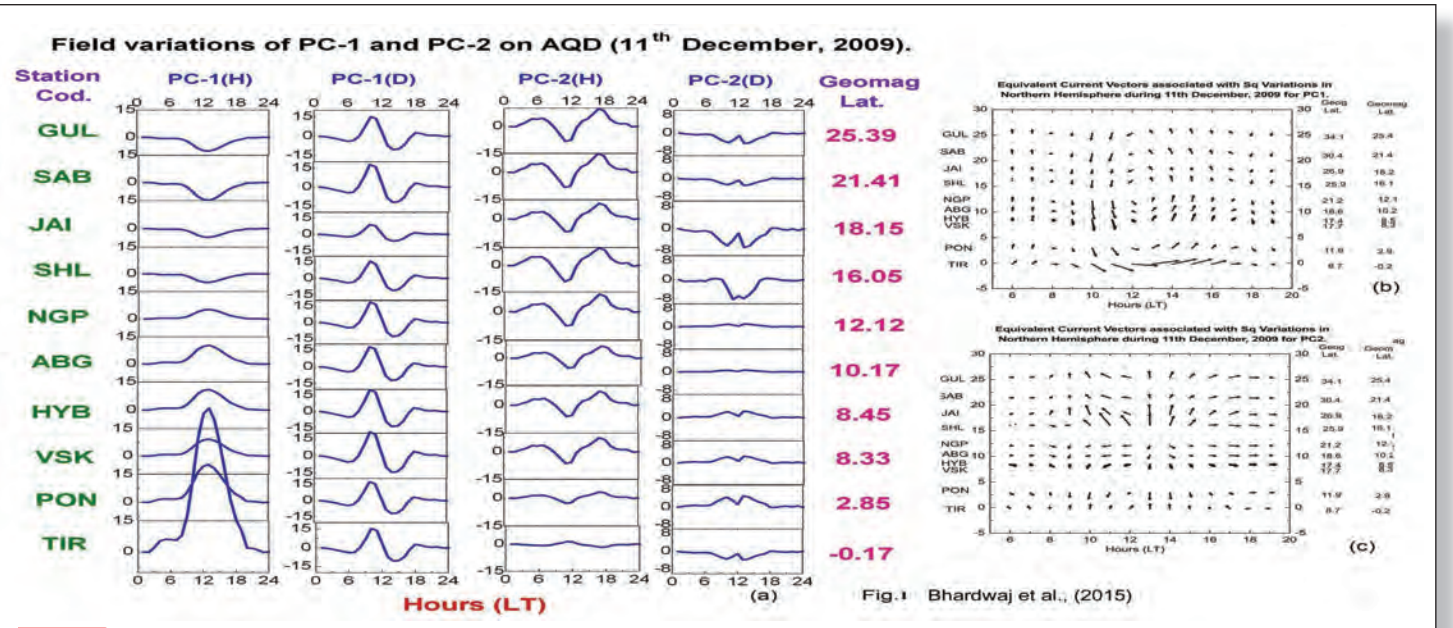


Figure 1 (a) Field variations of first and second principal components of H and D during winter (11 December 2009) month for abnormal quiet day. Figure 1(b) shows the feature of AQD current system along 75° E meridian, determined by equivalent current vector plots on 11th December 2009 and indicates an anti-clock wise Sq loop with focus somewhere around NGP (12.1° N) and SHL (16.1° N geomagnetic latitude) and around 12 hour local time. Figure 1(c) shows the plots equivalent current vectors on the local time-latitude sector for PC-2 that do not show any type of loop on abnormal quiet days.

due to extra-terrestrial (magnetospheric) origin, data set is also compared with Interplanetary Magnetic Field (IMF) parameters ***(Fig. 2)***.

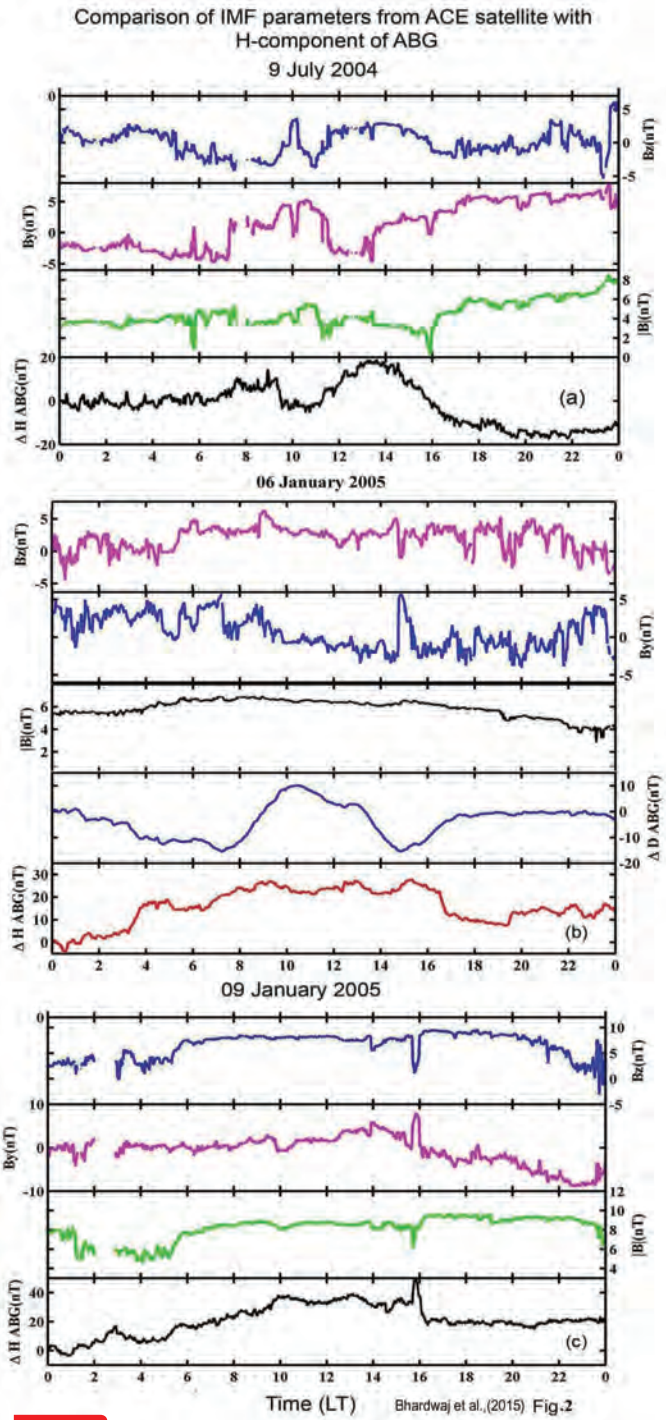


Figure 2 Comparison of Interplanetary Magnetic Field (IMF) parameters (B, By and Bz) download from ACE Satellite with H-component of geomagnetic field at Alibag during (a) 09 July 2004, (b) 06 January 2005 (with D-component) and (c) 09 January 2005 suggests that AQD's is due to extra-terrestrial or magnetospheric origin whereas for event recorded on 11th December 2009 is due to ionospheric origin.

INFORMATION THEORETIC APPROACHES TO MODEL GEOMAGNETIC PROCESSES

Chief Coordinator : Geeta Vichare
Entropy based modelling of Geomagnetism, Current systems and Climate Change

Members : D.S. Ramesh, S. Gurubaran Ashwini K. Sinha, S. Sripathi, B. Kakad, M. Bagiya, A. Bhaskar, A.S. Sunil, Jayanta K. Behera.

Cause-effect relationship has been studied by applying information theory-based stochastic methods that revolve around the concept of entropy in many diverse fields including neuroscience, climate changes, magnetospheric dynamics etc. Likewise in the Geomagnetism and allied fields, there exist ambiguities regarding the inter-connectivity and prominent drivers between coupled systems. The technique can be applied to the systems involved in atmosphere-ionosphere-magnetosphere-solar wind coupling, climate change and seismic activities.

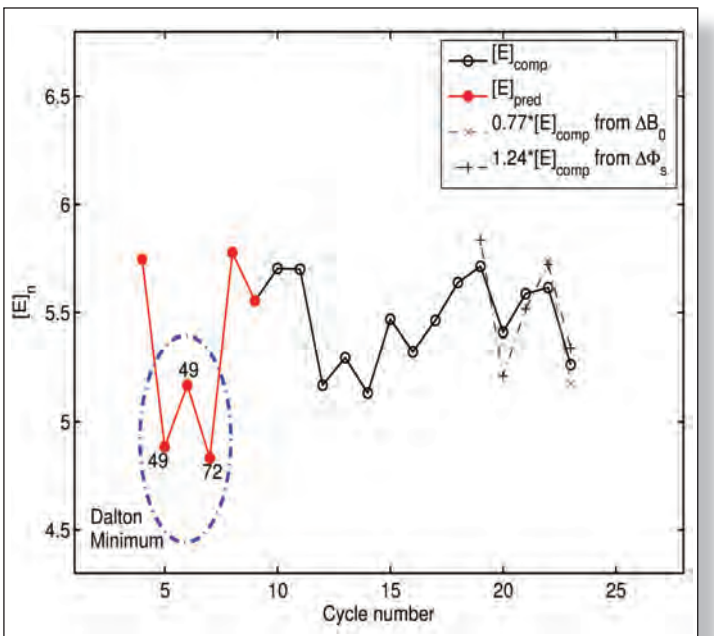


Figure 3 Entropy of SCs 4–23. The entropy estimates for SCs 10–23 (black dots) are based on daily sunspot number data, whereas those for SCs 4–9 (red dots) are obtained from modelled prediction equation. Note the coincidence of the least entropy values with the well-known Dalton minimum. The entropy values obtained from the F10.7 flux and solar magnetic field for SCs 19–23 (black plus symbol) and SCs 22– 23 (magenta cross) are shown. The entropy values obtained from the solar magnetic field (B0) and F10.7 flux (Us) are respectively multiplied by 0.77 and 1.24 to view them on a common scale.

Forecasting of the solar cycle characteristics is an important aspect of space weather studies. IIG scientists have developed a new model to predict the descent time of forthcoming solar cycle (SC), based on the estimation of the Shannon entropy. Prediction of an extended solar minimum is extremely important due to its severe impact on near earth space. The important feature of the model is that the prediction equation enunciates the possible criteria for occurrence of unusually longer solar minimum/Daltaon minimum ***(Fig. 3)***.

A method based on transfer entropy is employed to examine the relationship between day-to-day variability in the equatorial electrojet (EEJ) and solar quiet (Sq) currents. The analyses clearly demonstrate that significant information is exchanged between EEJ and Sq variations, and hence they are in a cross-talk with each other, indicating EEJ and Sq are coupled systems. Variations of time scales less than 4 hrs appear at the equatorial station before Sq stations. The atmospheric gravity waves (periodicities between 1-4 hr) driving the variations at EEJ can take few tens of minutes to affect the variations at Sq. It is also found that the variations of longer periodicities (>4 hr) do not exchange significant information. Similar analyses carried out for the African sector also validate the above results ***(Fig. 4)***.

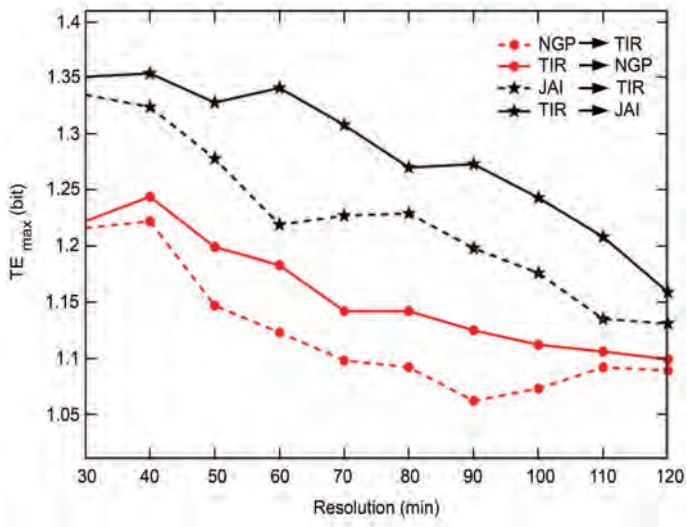


Figure 4 Maximum value of Transfer Entropy (TE) plotted against the varying sampling interval of the time series.

UPPER ATMOSPHERIC SCIENCE

INTEGRATED STUDIES ON THE EARTH'S UPPER ATMOSPHERE USING GROUND AND SPACE-BASED INSTRUMENTATION AND NUMERICAL MODELING TOOLS

Chief Coordinator : **S. Gurubaran**

Coordinator : **S. Sripati**

Members : **C.P. Anil Kumar, G. Vichare, S. Tulasiram, B. Kakad, N. Parihar, R. Ghodpage, M. Bagiya, P. Mahavarkar, M. Lal, B. Veenadhari, K. Vijaykumar, P. Tiwari, L.M. Joshi, R. Singh, V. Yadav, P. Gurram, S. Sreekumar, K.K. Ajith**

Vertical EXB drift measured using the ionosonde Doppler sounding during the daytime suffers from an underestimation of the actual EXB drift due to the photochemistry that determines the height of the F layer during the daytime, in addition to the zonal electric field. Using C/NOFS satellite drifts and EEJ strength data, systematic investigations suggested a correction factor for the ionosonde Doppler vertical drift during daytime. A detailed analysis, however, indicated that the linear relation between the ionosonde Doppler drift and C/NOFS EXB drift varied with seasons. Thus, solar, seasonal and also geomagnetic variables were included in the Doppler drift correction, using the artificial neural network based approach. The RMS error in the neural network was found to be lesser than that in the linear regression analysis ***(Fig. 5)***. Daytime EXB drift was derived using the neural network which was also used to model the ionospheric redistribution in the SAMI2 model. SAMI2 model reproduced strong (/weak) equatorial ionization anomaly (EIA) for cases when neural network corrected daytime vertical EXB drift was high (/low). Similar features were also observed in GIM TEC maps. Thus, the results indicate that neural network can be utilized to derive the vertical EXB drift from its proxies, like the ionosonde Doppler drift. These results indicate that the daytime ionosonde measured vertical EXB drift can be relied upon, provided adequate corrections are applied to it.

The annular solar eclipse of 15 January 2010 over southern India was studied using multi-instruments consisting of magnetometer, ionosonde and GPS receivers. The presence of a counter electrojet during the eclipse and adjacent days suggests the strong gravitational tidal

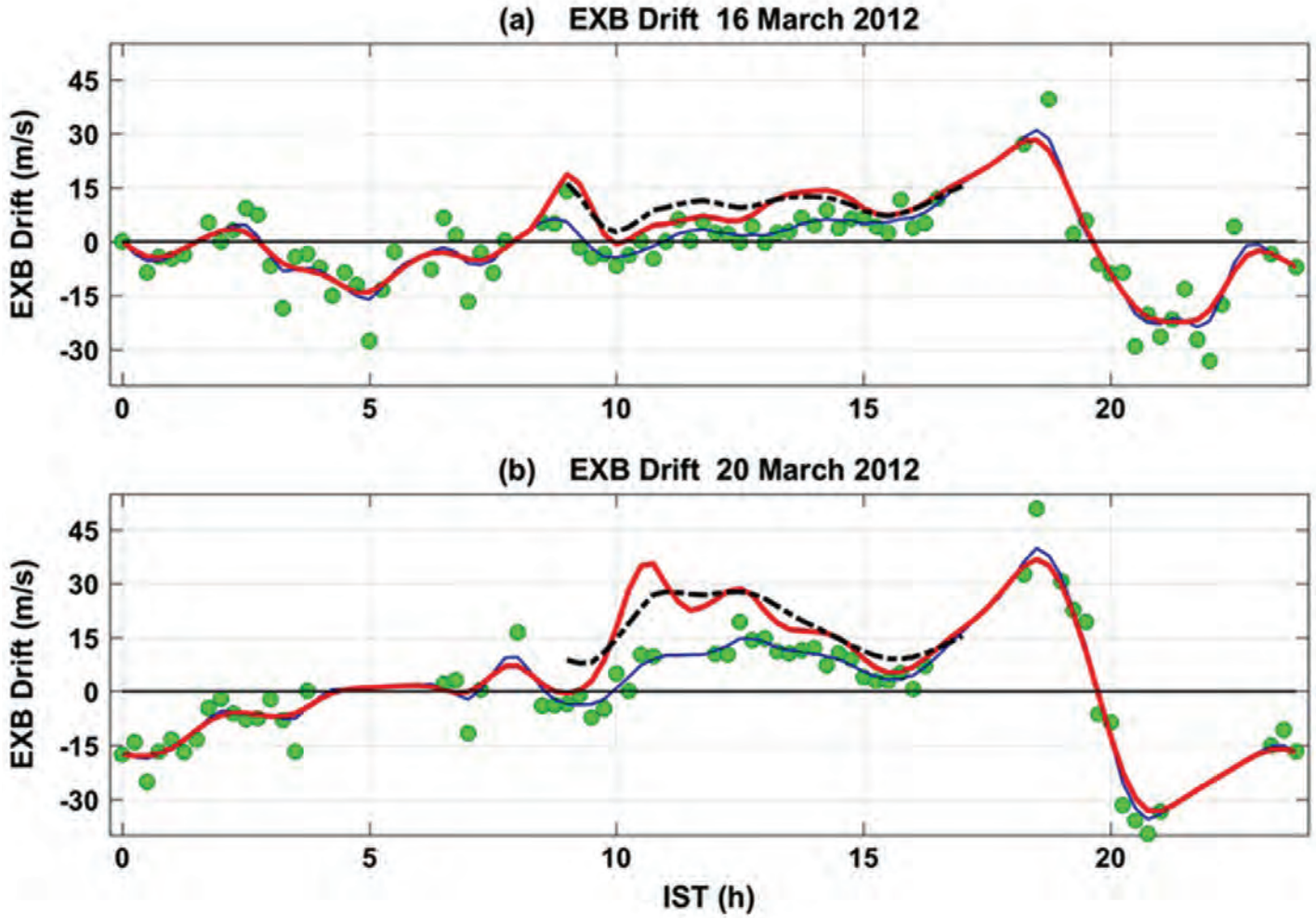


Figure 5 Doppler ExB drift recorded over Tirunelveli (a) on 16 March 2012 and (b) on 20 March 2012. Here each green circle indicates 15 min averaged Doppler EXB drift. Blue line indicates the interpolated and smoothed Doppler EXB drift. Thick red line indicates the corrected Doppler EXB drift (based on linear regression). Black dashed line indicates the EXB drift derived from neural network during the daytime (09:00 to 17:00 IST).

effect around the eclipse day. Based on these results, it is suggested that the electrodynamical consequences were due to the combination of eclipse as well as lunar tides rather than eclipse alone.

The ionospheric response to fast stream solar coronal holes during 2008 deep solar minimum year has been studied using ground-based multi-instruments over Indian region. To examine this, foF2 (MHz) and hpF2 (km) from Canadian Advanced Digital Ionosonde (CADI) and Total Electron Content (TEC) from GPS receiver over Tirunelveli (8.73°N, 77.70°E; Dip 0.5°N) along with Equatorial Electrojet (EEJ) strength have been analysed. The analysis show good correlation between solar wind and foF2/TEC, while hpF2 is poorly correlated. However, moderate correlation exists between EEJ strength. Periodogram analysis revealed 9- and 13-day periods as dominant periods in foF2 and TEC. Interestingly, the occurrence pattern of plasma irregularities also resembles these periodic oscillations. Since it is believed that lower atmospheric waves are dominant forces for ionospheric variabilities during deep solar minimum, the Mesosphere-Lower-Thermosphere (MLT) region temperature using TIMED SABER and winds using Medium Frequency (MF) radar along with Outgoing Long wave Radiation (OLR) in the troposphere altitudes have been examined to rule out the sources for these periodic oscillations in the lower atmosphere. Using cross-wavelet and cross-coherence spectra of both solar wind as well as ionospheric/atmospheric parameters, it is suggested that ionospheric periodicities are similar to that of solar wind ***(Fig. 6)***. Based on these results, it is advocated that while the periodic

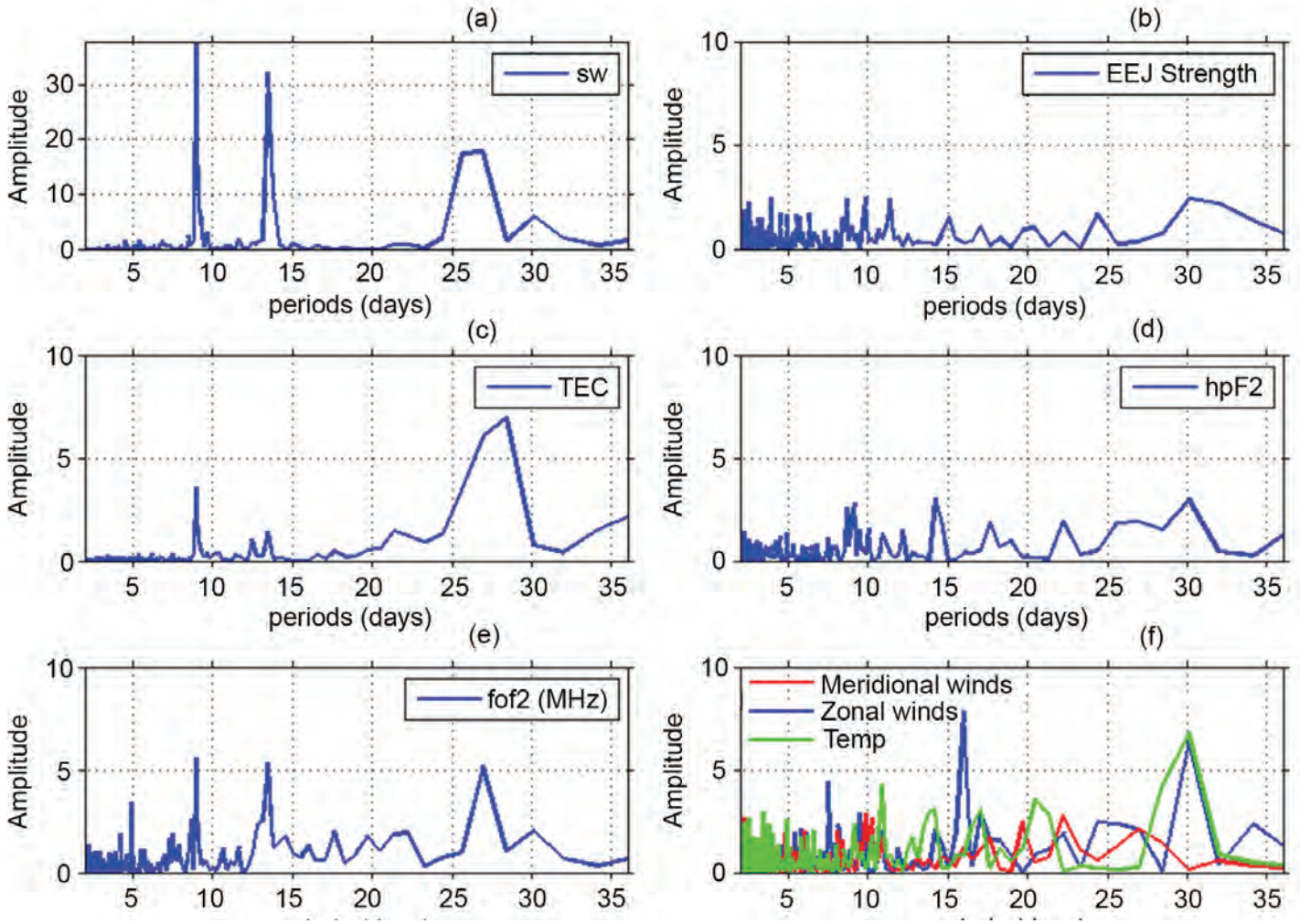


Figure 6 The Lomb-Scargle (L-S) periodograms of (a) solar wind, (b) EEJ strength, (c) TEC, (d) CADI hpF2, (e) CADI foF2, and (f) MLT zonal/ meridional winds at 90 km altitude along with SABER mean Temperature at 97 km altitude, respectively, during the year 2008.

oscillations are associated with the disturbance dynamo winds/electric fields that are propagated to equatorial latitudes, however, the differences in their temporal/ seasonal variations are attributed to the variations in the composition/recombination changes.

Structuring of E-region irregularities was investigated using rare daytime scintillations on the 251 MHz radio signal. It is found that the scale length of irregularities is smaller on CEEJ days as compared to that on non-CEEJ days.

L-band scintillations, one of the manifestations of the medium scale plasma density irregularities in the post sunset equatorial F-region, has a unique place in the overall scenario of the phenomenon of Equatorial Spread-F, mainly because of its significant effect on the ground-satellite-ground communication links. The positional inaccuracies introduced by these scintillations have the potential to become critical in satellite based navigation which incidentally is becoming the order of the day. The recently evolved L–band scintillation forecast mechanism based on the characteristic features of the daytime F-region electron density fluctuations and also on the basic ionospheric conditions had been successful to a reasonable extent in forecasting the spatio-temporal map of scintillation patches ***(Fig. 7)***.There had been a few non-compliances in the expected pattern within or outside the forecast windows. These non-compliances are addressed in two parts : (i) by duly accounting for the local time variation of the zonal velocity of the perturbations and (ii) based on neutral dynamics, especially the local time variations of vertical winds over the magnetic equator, while at the same time refining the earlier stipulated background ionospheric conditions. The unique combination of the two geo-stationary satellites (GSAT-8 and GSAT-10) over the

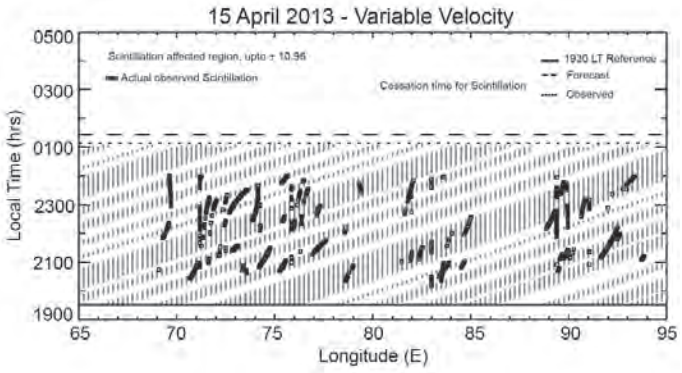


Figure 7 The spatio-temporal occurrence pattern of scintillation generated with time varying velocity. The shaded area with time is the duration when one could expect scintillations in that particular longitude region. The square symbols represent the actual observed scintillation from different locations like Agati (10.83 N 72.2 E), Trivandrum (8.5 N, 76.9 E), Visakhapatnam (17.69 N, 83.22 E) and Portblair (11.61 N, 92.77 E). With the variable drift values, the spatio-temporal forecast of L-band scintillation have become more realistic and is emerging as one of the important tools for satellite based navigation.

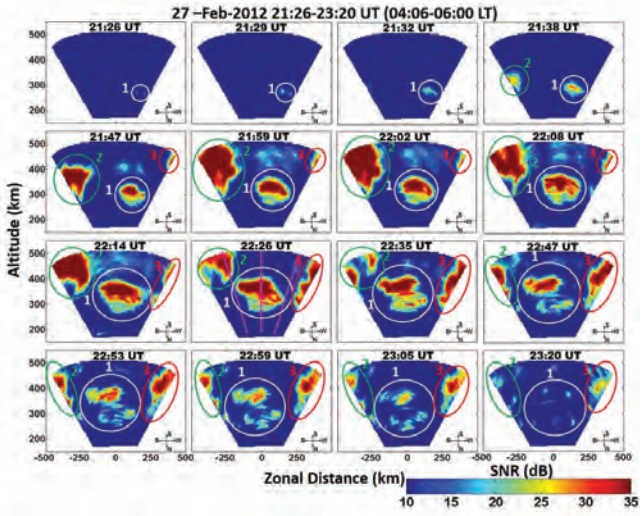
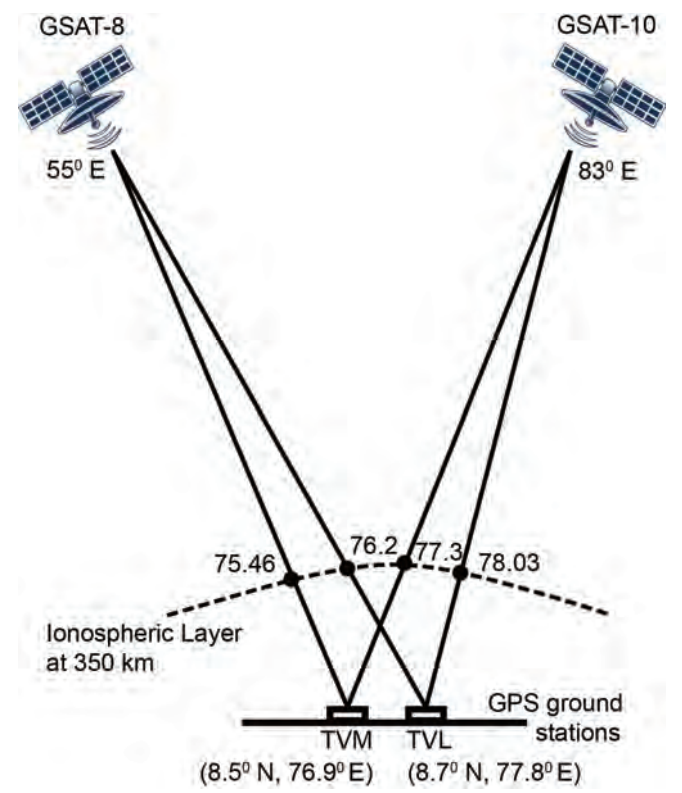


Figure 9 EAR fan sector backscatter echo maps showing the onset and evolution of three fresh EPBs over Indonesian sector during the local predawn hours (2126–2320 UT on 27 February 2012). These EPBs were continued to evolve and sustained for more than ~90 min of post-sunrise period.

Indian zone ***(Fig. 8)*** has been used to estimate the typical local time dependence of the perturbation velocities by closely following identifiable features in the scintillation pattern. It is anticipated that, the above refinements would make the forecast mechanism very robust.



The unusual evolution of fresh and intense field aligned irregularities (FAI) near sunrise terminator which further sustained for more than 90 minutes of post-sunrise period was observed by Equatorial Atmosphere Radar (EAR) at Kototabang during a minor geomagnetic storm period ***(Fig. 9)***.These FAI echoes were initially observed around 250 – 350 km altitudes, growing upward under eastward polarization electric fields indicating the plasma bubbles that are fully depleted along the flux tube. The background low-latitude F-layer dynamics that lead to the development of these dawn-time FAI have been investigated from two ionosondes at near magnetic conjugate low-latitude locations. A minor geomagnetic storm was in progress which did not appear to cause any large electric field perturbations at preceding post-sunset to midnight period over Indonesian sector. However, the prompt penetration of overshielding electric fields associated with sudden northward turning of IMF Bz caused spectacular ascent

Figure 8 Schematic showing the experimental setup to estimate the local time variations of the perturbation velocities by closely following identifiable features in the scintillation pattern. The two Indian geostationary satellites one at 55°E (GSAT-8: PRN 127) and another at 82.98°E (GSAT-10: PRN 128) launched as part of the Indian satellite based augmentation system, GAGAN (GPS Aided Geo Augmented Navigation) are shown in the figure along with the two SBAS enabled GPS receivers, one operated from Trivandrum (8.47°N, 76.92°E; 0.5°S geomagnetic) and the other from Equatorial Geophysical Research Laboratory, Tirunelveli (8.7°N, 77.8°E; 0.13°N geomagnetic). The IPP longitudes for the two Indian GEO satellites over the respective receivers are also depicted.

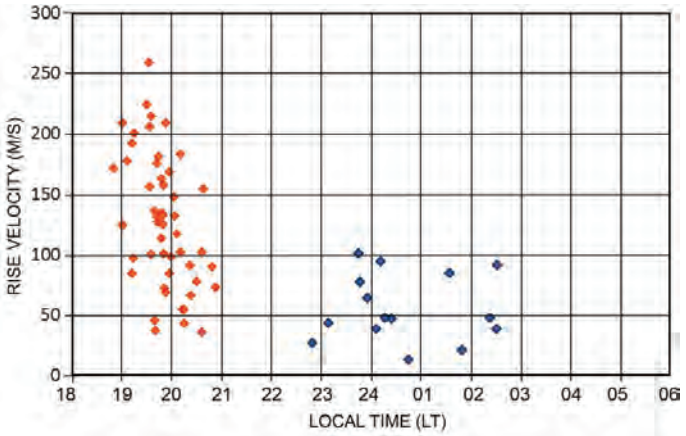


Figure 10 Local time variation of the vertical rise velocity of post-sunset (red triangles) and post-midnight (blue diamonds) EPBs observed with the EAR.

of F layer and development of fresh, intense and upward evolutionary plasma bubbles near sunrise terminator.

The vertical rise velocities of postmidnight field-aligned irregularities (FAIs) at low geomagnetic latitudes have been examined near the June solstice by using two-dimensional maps of F region FAI echoes observed with the Equatorial Atmosphere Radar in Indonesia for 3 years starting in May 2010. About 15 freshly growing FAIs at postmidnight between May and August during the 3years period have been observed. The rise velocities of FAIs are significantly smaller at postmidnight than at postsunset ***(Fig. 10)*** and they are mostly confined to altitudes below 450 km. Based on the rise velocities, a lower limit for the creation time of the postmidnight FAIs is estimated to be between 21:30LT and 02:00LT for 14 of the 15 events, indicating that this class of FAIs is distinct from the postsunset FAIs.

A self-contained global ionospheric maps (GIM)-aided Abel retrieval method is adopted that can account for spherical non-uniformity along the radio wave path in the vicinity of the radio occultation (RO) region using the asymmetry factors derived from global background NmF2 maps. This procedure does not require any supplementary data sources to augment the Abel retrieval in order to represent the horizontal gradients in the ionosphere. The Ne(h) profiles retrieved from this Abel retrieval procedure aided with asymmetry factors provide significant improvement compared to classical Abel retrieval at both F- and E-regions. The artificial large-scale structures, such as wave number-3 latitudinal structure and plasma caves underneath the equatorial ionization anomaly crests, were largely eliminated ***(Fig. 11)***.This improved retrieval procedure also reduces the computational complexity and

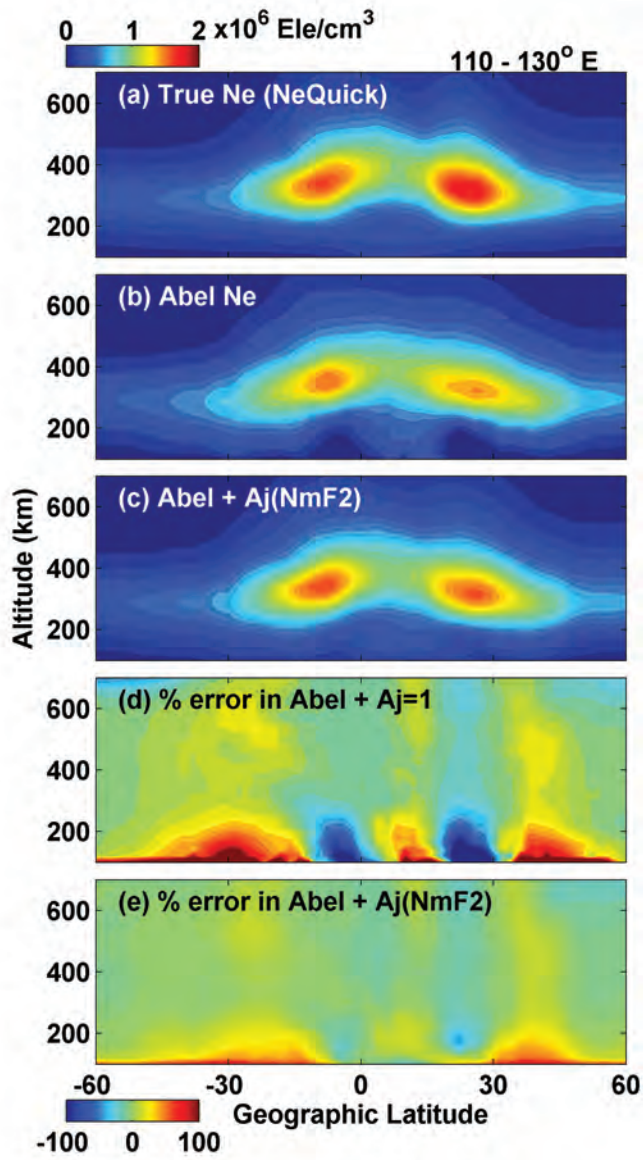


Figure 11 Geographic latitude and altitude variations of (a) simulated true electron density from NeQuick model, (b) classical Abel retrieval with the assumption of spherical symmetry, (c) improved Abel retrieval accounting for spherical non-uniformity [A_j = $f(N_mF_2)$], (d) relative percentage error in classical Abel and (d) relative percentage error in improved Abel along the 110°-130°E longitudinal (noon) sector.

is suitable when the number of occultations increased by many times in the future when FORMOSAT-7/COSMIC-2 (F7/C2) and other RO missions become operational. The computation simplicity in this self-contained GIM-aided Abel retrieval procedure enables more accurate retrieval of Ne(h) profiles in near real time.

The FormoSat-3/COSMIC has been proven to be a successful mission on profiling ionospheric electron density

(Ne) using the radio occultation (RO) technique. A follow-on program (called FS7/COSMIC2) is now in progress. The COSMIC follow-on mission will have six 24°-inclination and 550-km low Earth orbiting (LEO) satellites and six 72°-inclination and 750-km LEO satellites to receive Tri-G (GPS, GLONASS, and Galileo) satellite signals. A compensatory Abel-inversion scheme is proposed to improve vertical Ne profiling and three-dimensional (3D) Ne modeling in this FS7/COSMIC2 simulation study with futuristic real observations. The results show that the root-mean-square (RMS) foF2 and hmF2 difference improvements are 46% (32%) and 21% (4.6%), respectively, in relative percentage over the standard Abel inversion at the TWIM-background (NeQuick-background) simulation experiment ***(Fig. 12)***.The RMS modeling errors are about one order less than those from FS3/COSMIC simulations.

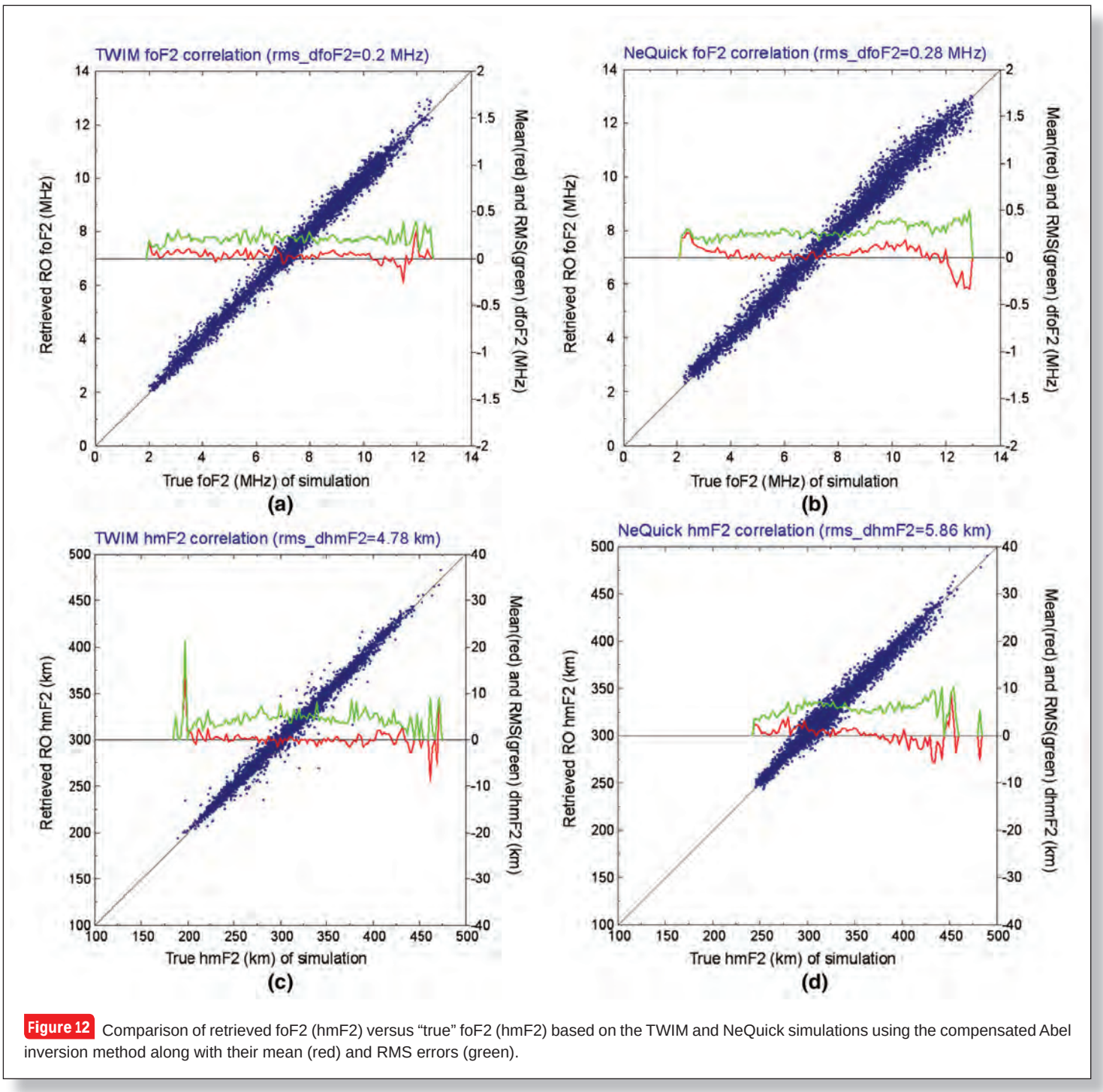


Figure 12 Comparison of retrieved foF2 (hmF2) versus "true" foF2 (hmF2) based on the TWIM and NeQuick simulations using the compensated Abel inversion method along with their mean (red) and RMS errors (green).

Finer features of equatorial plasma bubbles were studied using all-sky airglow imager data from Panhala and Tirunelveli. In particular, one interesting feature reported based on this study was the decrease in the latitudinal extent of the EPBs corresponding to a reduction in their apex altitudes over the magnetic equator indicating shrinking of the bubbles. This is an important phase of the bubble evolution and decay during the post-midnight hours.

Long-period wave features were revealed in the photometric measurements of mesospheric OH and O(1S) emissions obtained from Kolhapur during January-April 2005. Adopting Krassovsky ratio, which is defined as the ratio of normalized intensity perturbations to the associated normalized temperature perturbations of a particular wave, this study demonstrated the utility of Krassovsky parameters in studying the long vertical wavelength atmospheric gravity waves.

THEORETICAL AND NUMERICAL SIMULATION STUDIES OF SPACE PLASMA PROCESSES

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Coordinators : S.S. Ghosh, A.P. Kakad, B. Kakad

Members : Satyavir Singh, B. Remya, S.V. Steffy, T. Sreeraj, B.L. Ajay, R. Rubia, S. Devanandhan

Recent spacecraft observations reveal the role of super-thermal particles in dynamically evolving wave processes in the Earth's and other planetary magnetospheres. As a first step, a one-dimensional electrostatic fluid code for the unmagnetized plasma consisting of superthermal electrons and fluid ions has been developed. It is found that the conventional Poisson solver drives the simulation unstable when modelling the longtime evolution of plasma waves in a large system. The dependency of the superthermal index on the occurrence of the numerical instability has been examined. In this code, different iterative approaches are employed to remove the numerical instability. This fluid simulation is the first to assimilate the superthermal particle distribution in the code. This fluid code will be useful to model various plasma wave processes in the Earth's and other planetary magnetospheres, where the superthermal plasma population is observed.

Cassini spacecraft simultaneously detects electromagnetic ion (proton) cyclotron (EMIC) waves and whistler mode chorus in the Earth's dayside subsolar outer magnetosphere during the Earth flyby. The observations were made near the magnetic equator 3.1°– 1.5° MLAT at 1300 MLT (Magnetic Local Time) from L = 9.9 to 7.0. It is hypothesized that the solar wind external pressure caused pre-existing energetic 10 − 100 keV protons and electrons to be energized in the $T_{\perp}$ component by betatron acceleration and the resultant temperature anisotropy ($T_{\perp} > T_{||}$) formed led to the simultaneous generation of both EMIC (ion) and chorus (electron) waves. The EMIC waves had maximum wave amplitudes of ~ 6 nT in a ~ 60 nT ambient field B_0. The observed EMIC wave amplitudes were about ~ 10 times higher than the usually observed chorus amplitudes (~ 0.1 − 0.5 nT). The EMIC waves are found to be coherent to quasi-coherent in nature. Calculations of relativistic ~ 1 − 2 MeV electron pitch angle transport are made using the measured wave amplitudes and wave packet lengths. Wave coherency was assumed. Calculations show that in a ~ 25 − 50 ms interaction with an EMIC wave packet, relativistic electron can be transported ~ 27° in pitch. Assuming dipole magnetic field lines for a L = 9 case, the cyclotron resonant interaction is terminated ~ ±20° away from the magnetic equator due to lack of resonance at higher latitudes. It is concluded that relativistic electron anomalous cyclotron resonant interactions with coherent EMIC waves near the equatorial plane is an excellent loss mechanism for these particles. It is also shown that E > 1 MeV electrons cyclotron resonating with coherent chorus is an unlikely mechanism for relativistic microbursts. Temporal structures of ~ 30 keV precipitating protons will be ~ 2 − 3 s which will be measurable at the top of the ionosphere ***(Fig. 13)***.

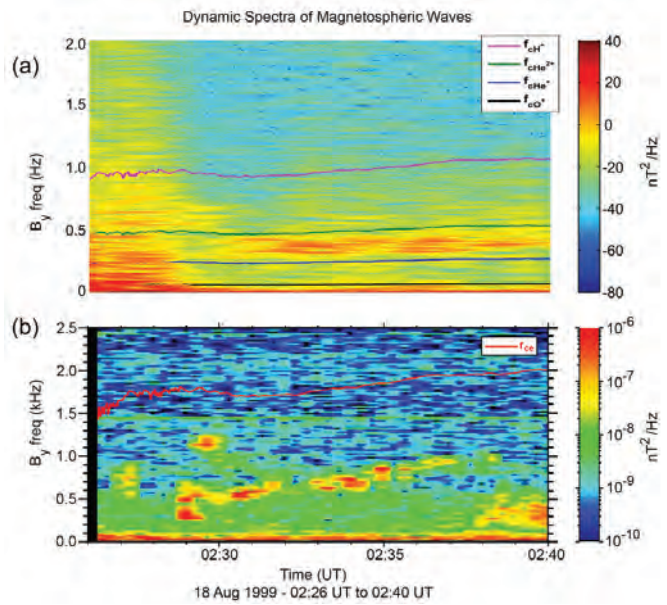

Figure 13 The dynamic power spectra for the magnetospheric magnetic field observed by (a) Cassini MAG and (b) Cassini Radio and Plasma Wave Science (RPWS) during the Earth flyby on 18 August 1999. The interval 0226-0240 UT covers the Earth's outer magnetosphere. The upper panel shows the proton cyclotron waves and the lower panel indicates presence of whistler mode chorus structures.

In recent spacecraft observations, coherent wave structures such as electrostatic solitary waves, double layers and ULF/VLF waves have been observed in the Earth's magnetosphere. These waves play an important role in the transfer of mass and energy across different boundary layer regions of Earth's magnetosphere. The observations of these waves give important clues to identify particle acceleration processes in Earth's magnetosphere. The main objective of this program is to explore some of the wave observations from satellite and ground data to investigate their generation mechanism and their role in particle acceleration processes in the Earth's magnetosphere.

SPACE WEATHER RESPONSE OF MAGNETOSPHERE-IONOSPHERE-THERMOSPHERE SYSTEM TO SOLAR DRIVEN TRANSIENT AND RECURRENT FORCES

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Coordinator : **S. Tulasiram**

Members : **B. Veenadhari, Geeta Vichare, Gopi K. Seemala, S. Sripathi, Ashwini K. Sinha, Rajesh Singh, P.T. Patil, B. Kakad, C.D. Reddy, N. Parihar, L.M. Joshi, Ram Singh, Sreeba Sreekumar, Sukanta Sau, Ankush Bhaskar, Neethal Thomas, A.S. Sunil, S. Gurubaran, D.S. Ramesh**

Ground magnetic measurements provide a unique database in understanding space weather. Colaba-Alibag have the continuous and long history of geomagnetic field observations from1847 to till date, and the study of historical geomagnetic storms can help to create a good database for intense and super intense geomagnetic storms. Further, an approximation of plausible interplanetary conditions that lead to such intense geomagnetic storms may give important clues on the probability of occurrence of intense geomagnetic storms and their impact on modern hi-tech society. Some of the super intense geomagnetic storms that occurred prior to 1900 have been revisited and investigated in order to understand the probable interplanetary conditions. An empirical relationship is derived for estimation of interplanetary electric field (IEFy) from the variations of Dst index and ΔH at Colaba-Alibag observatories. The estimated IEFy values using Dst and ΔHABG variations agree well with the observed IEFy, calculated using Advanced Composition Explorer (ACE)

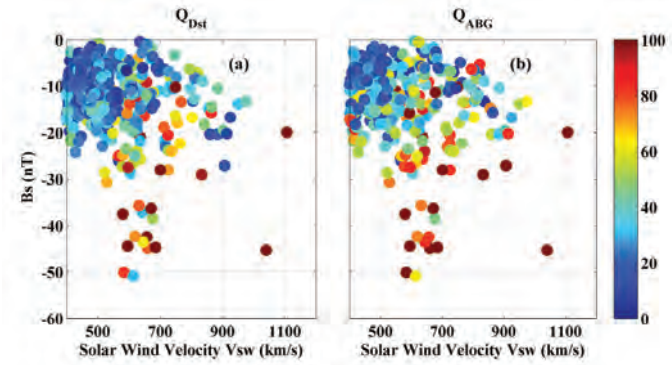

Figure 14 The variation of ring current energy (Q) with IMF Bs and solar wind velocity (Vsw). The variations of (a) QDst and (b) QABG. The color bar shows the strength of Q.

satellite observations for intense geomagnetic storms in solar cycle 23. The variation in ring current rate (Q) is computed using Dst and ΔHABG by analyzing 69 intense geomagnetic storms of solar cycle 23. It is observed that the ring current injection rate variation depends on IMF Bs and Vsw ***(Fig.14)***. Its intensity is more dependable on IMF Bs strength and duration. Based on the empirical analysis of 69 intense magnetic storms, the integrated electric field is estimated for historical geomagnetic storms recorded at Colaba.The IEFy obtained for Carrington event, 1–2 September 1859, is close to the value computed by earlier workers.

Substorm-associated Pi2s are studied at the topside of the ionosphere using CHAMP satellite data. During nighttime, coherent in-phase oscillations are observed at satellite and underneath ground station. The dominant background lower frequencies present at dayside satellite passes are found to modify the Pi2s significantly. Daytime Pi2s identified in the topside ionosphere showed coherent but mostly opposite phase oscillations with underneath ground station, and satellite-to-ground amplitude ratio is less than one. Results indicate that a combination of fast cavity-mode oscillations and an instantaneous transmission of Pi2 electric field from high to low latitude ionosphere is responsible for the observation of daytime Pi2s.

Recently, a major geomagnetic storm occurred on 17 March 2015 where Dst reached its minimum of -228 nT ***(Fig. 15)***. So far, this is the largest geomagnetic storm ever occurred in current solar cycle-24. It is believed that such major storms produce adverse effects at low latitudes including damage to satellites, communication blockages, and biological/ psychological effects on humans through radiation hazards. The important results are as follows:

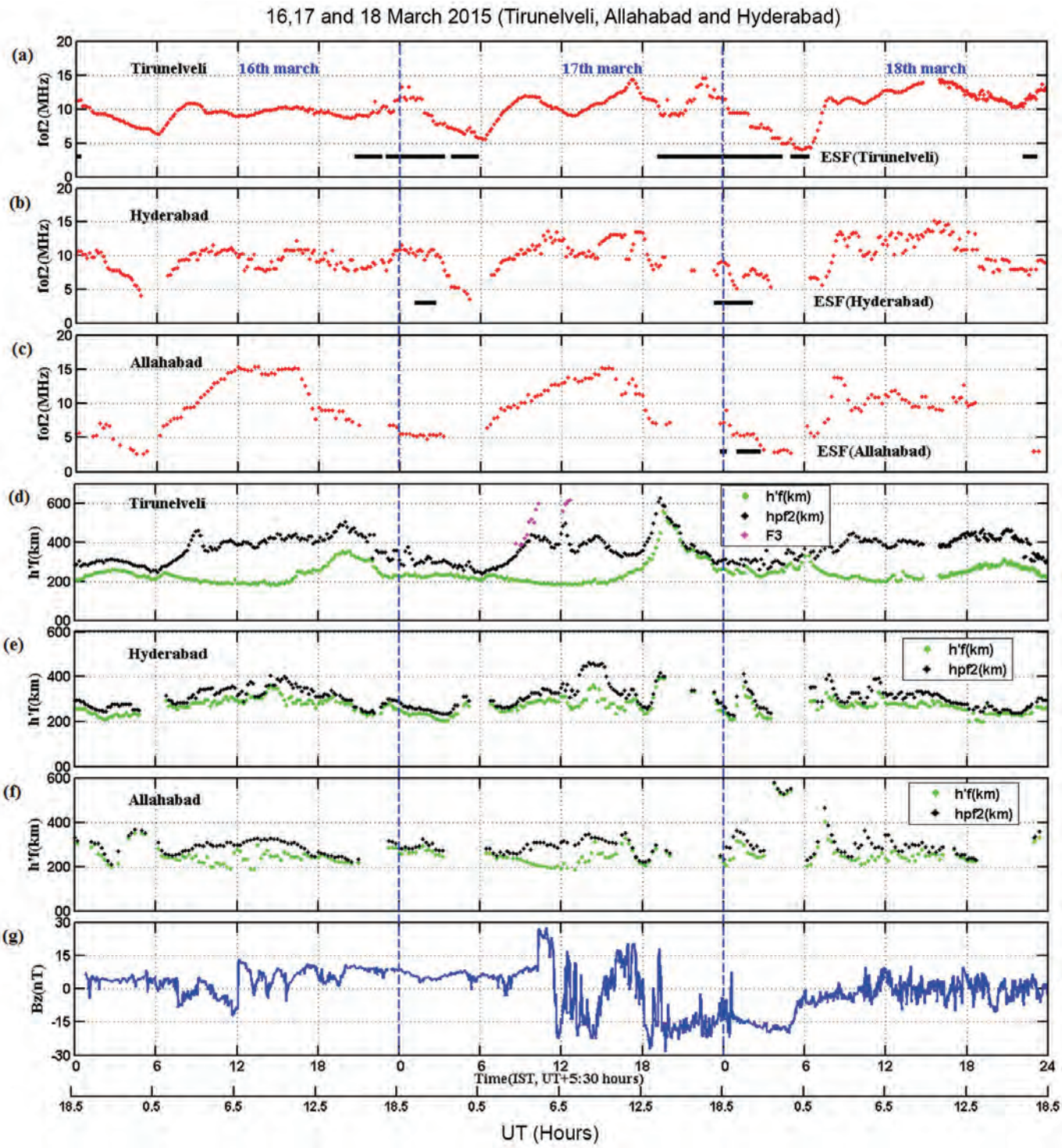

Figure 15 Temporal variations in solar wind pressure, speed, IMF Bz and IEF in GSM co-ordinates for the period of 16th to 18th March 2015 were shown in top 4 panels, while geomagnetic indices namely AE(AU/AL) index, SYM-H, EEJ strength and Kp index for the same period are shown in the bottom 4 panels.

(a) Significant rise in the F layer height of the ionosphere over Tirunelveli (magnetic equator) to as high as ~560 km with vertical drift of ~70 m/s at the time of Pre-Reversal Enhancement (PRE) due to direct penetration of storm time eastward electric fields and caused intense plasma density gradients or irregularities in ionosondes

and TEC gradients, scintillations in GPS receivers at extended latitudes. Plasma irregularities are so intense that their signatures are seen at Allahabad/Lucknow, which is rare. This is quite remarkable as compared to the quiet time F layer height and associated latitudinal extent of these plasma irregularities ***(Figs. 16, 17)***.

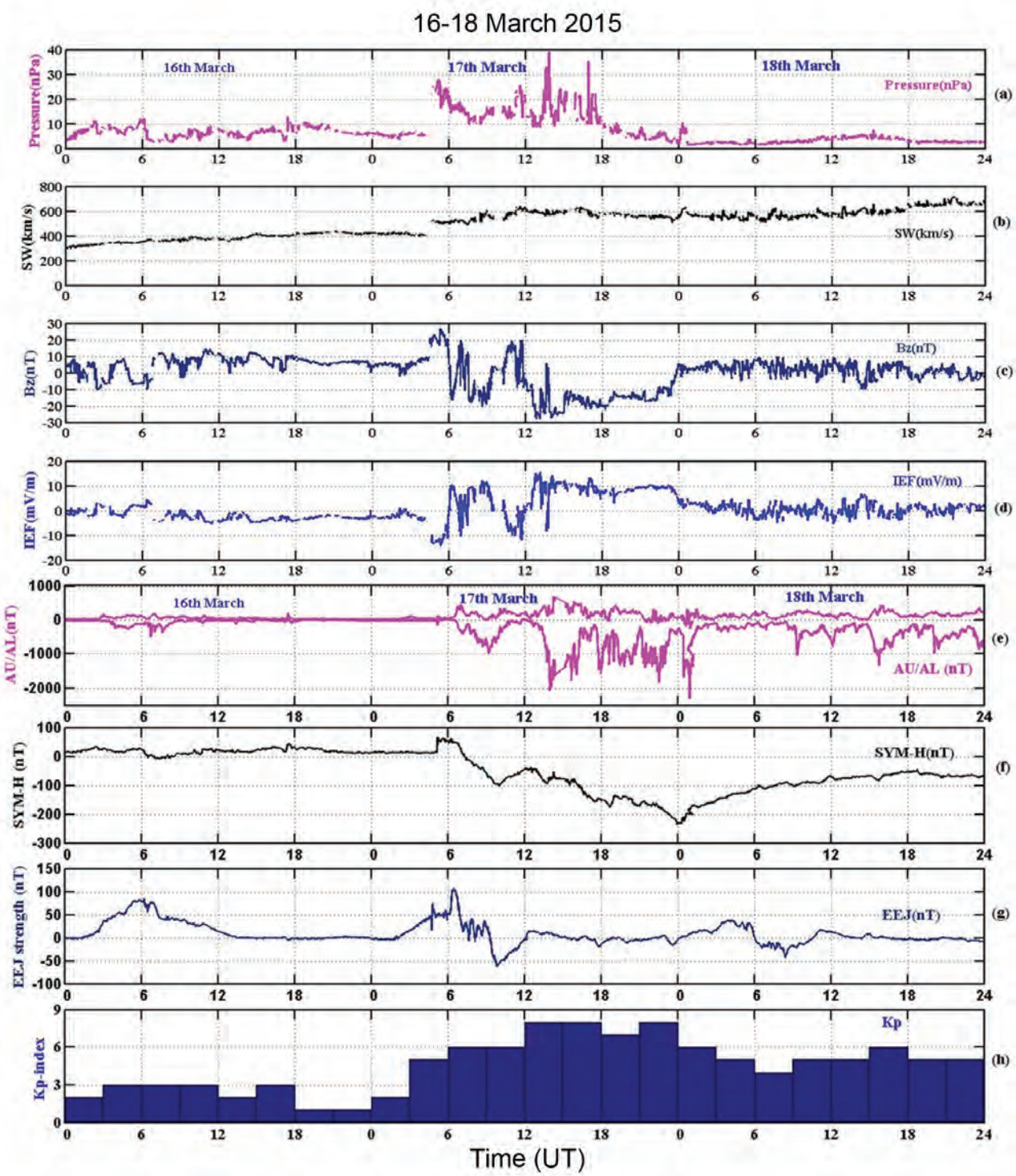

Figure 16 Top three panels (a, b and c) shows the temporal variation of ionospheric F region density in terms of foF2 in MHz (red) for Tirunelveli, Hyderabad and Allahabad. Next three panels (d, e and f) show h'F in km (green) and hpF2 in km (peak height) (black) for Tirunelveli, Hyderabad and Allahabad respectively during 16th to 18th March 2015. F3 layer (Magenta) is also visible in figure (d).These figures are supported by Bz in the bottom panel (g) for comparison.

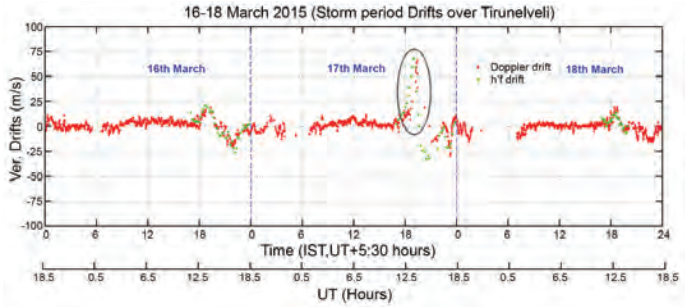

Figure 17 The Doppler vertical drifts over Tirunelveli as obtained from CADI ionosonde during 16-18 March 2015. Also shown is the vertical drift obtained from rate of change of virtual height (h'F (km)) on 17th March 2015 (green). Drifts of ~70 m/s due to PPEF on 17th March is highlighted by oval shape

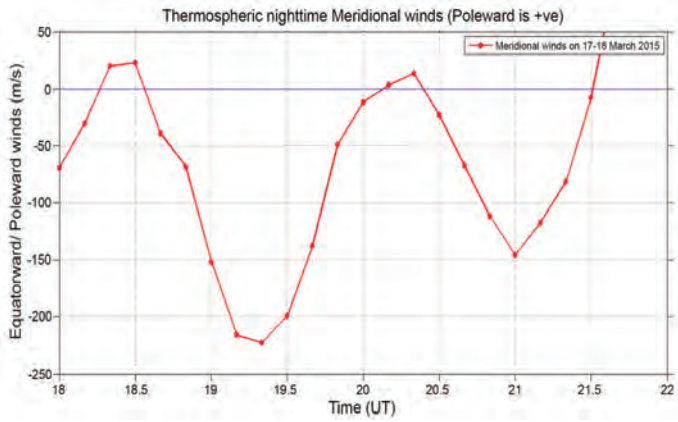

Figure 18 The calculated meridional winds during 18-22 UT on 17th. Blue line represents transition from poleward to equatorward winds

(b) Storm time thermospheric meridional winds during nighttime as estimated using two ionosondes suggest the equatorward surge of gravity waves with period of ~2 hrs. It is believed that these gravity waves are produced due to the Joule heating at auroral latitudes ***(Fig. 18)***.

(c) Suppression of anomaly crest on the next day of the storm suggests the complex role of disturbance dynamo electric fields and disturbance wind effects. Usually anomaly crests are formed at low latitudes due to fountain effect ***(Fig. 19)***.

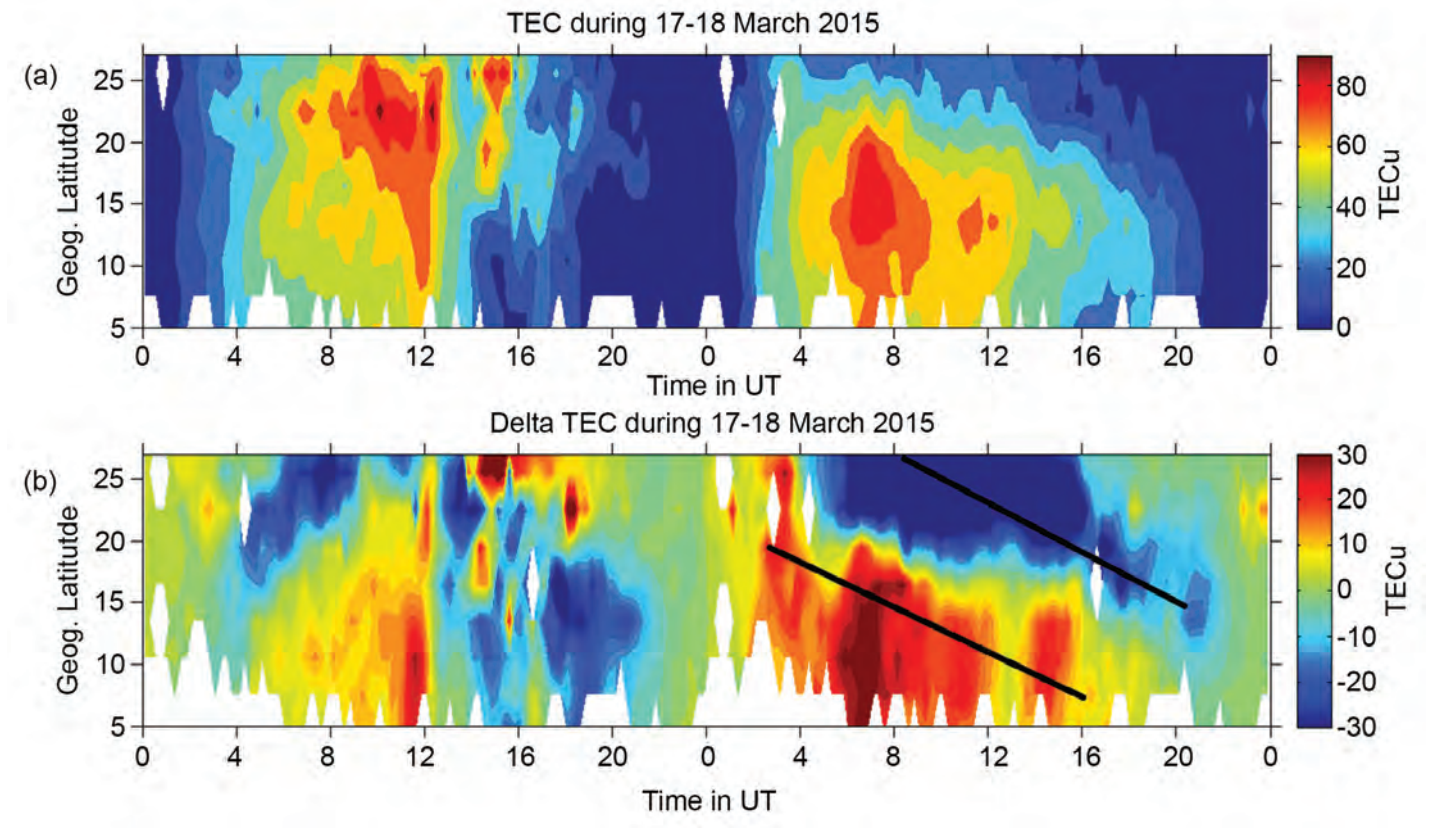

Figure 19 (a) Show the latitudinal and temporal variation of TEC (vertical) during 17-18 March 2015. (b) Show the delta TEC during 17-18 March 2015 after subtracting quiet day TEC (here it is 16th). The black line indicates variation of phase velocity

(d) The results also showed an interesting feature of Traveling Ionospheric Disturbances (TIDs) associated with disturbance meridional wind flow during recovery phase of the storm. Such TIDs are usually excited during major storms like the one reported here due to particle precipitation at high latitude and their subsequent propagation to low latitudes.

(e) In addition, the observations also showed nighttime reversal of zonal drifts during substorm activity at high latitudes and Counter ElectroJet (CEJ) signatures in magnetic records during the recovery phase. Usually, zonal drifts are eastward during nighttime. But due to geomagnetic storm, this drift changed its direction to westward due to Joule heating at high latitude. Similarly, Equatorial Electrojet (EEJ) strength is very high during quiet time periods but due to this storm EEJ strength became very weak due to reversal of primary zonal electric field and produced CEJ signatures in magnetic records.

(f) Lower enhancement in TEC over anomaly crests over Indian longitude for this storm relative to American longitude during other geomagnetic storms may be related to lower geomagnetic strength over American sector than Indian sector.

(g) Using SAMI2 modeling, the geomagnetic storm impact on the ionosphere was reproduced after utilizing vertical E X B drifts from ionosonde over Tirunelveli. The modeled TEC and observed TEC showed similar enhancements indicating model do reproduces storm time enhancements over Indian region ***(Fig. 20)***.

The analytic model of field line oscillations, which was developed for ideal ionosphere, has been extended to realistic ionospheric conditions in which symmetric conjugate ionospheres of finite conductivity were considered. It was concluded that the conductivity effect is pronounced when ionospheric conductance was close to Alfven conductance. In this neighbourhood of Alfven conductance, mode conversion from free-end to rigid-end takes place with an increase in the harmonic number.

The equatorial zonal electric field responses to prompt penetration of eastward convection electric fields (PPEF) were compared at closely spaced longitudinal intervals at dusk to pre-midnight sectors during the intense geomagnetic storm of March 17, 2015. At dusk sector (Indian longitudes), a rapid uplift of equatorial F-layer to >550 km and development of intense equatorial plasma bubbles (EPBs) were observed.These EPBs were found to extend up to 27.13^{o}N and 25.98^{o}S magnetic dip latitudes indicating their altitude development to ~1670 km at apex. In contrast, at few degrees east in the pre-midnight sector (Thailand-Indonesian longitudes), no significant height rise and/or EPB activity has been observed. The eastward electric

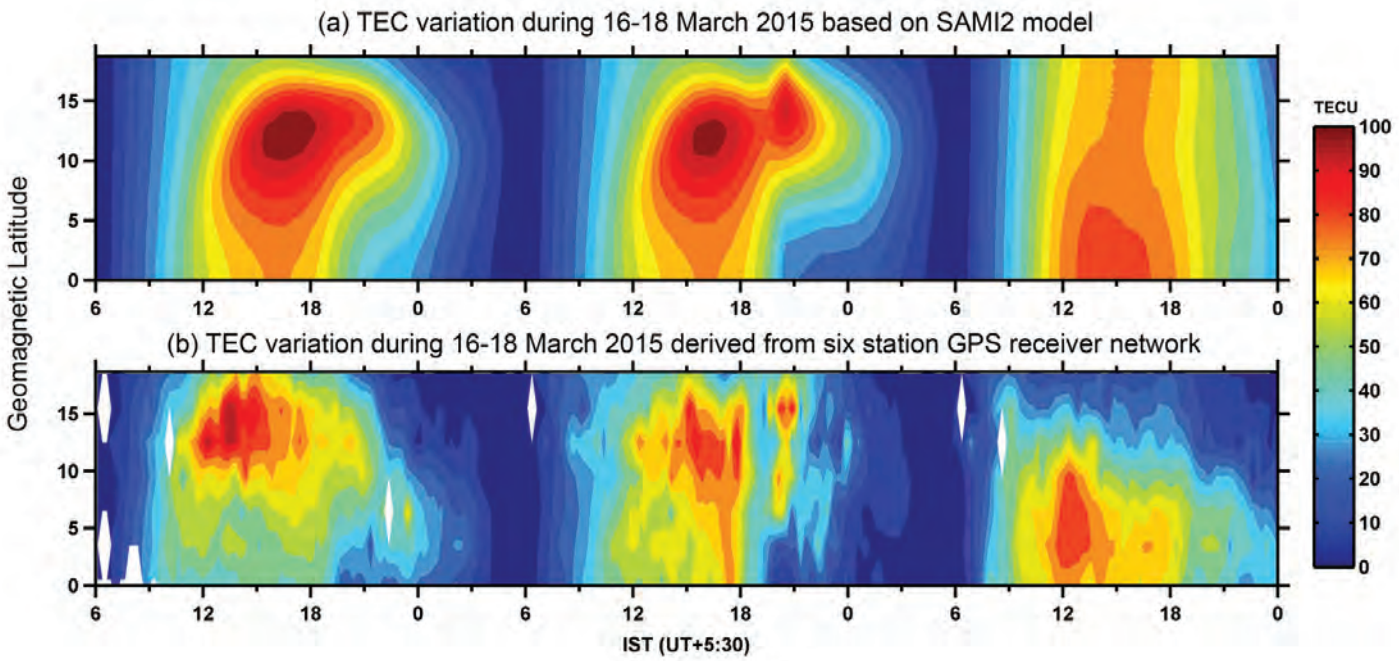

Figure 20 Comparison of the VTEC map derived from SAMI2 model, and six station GPS TEC observations. (a) VTEC map derived by integrating the SAMI2 model plasma density in a vertical column of unit area from 100 km to 1500 km. (b) VTEC map derived from GPS observations from six stations in India

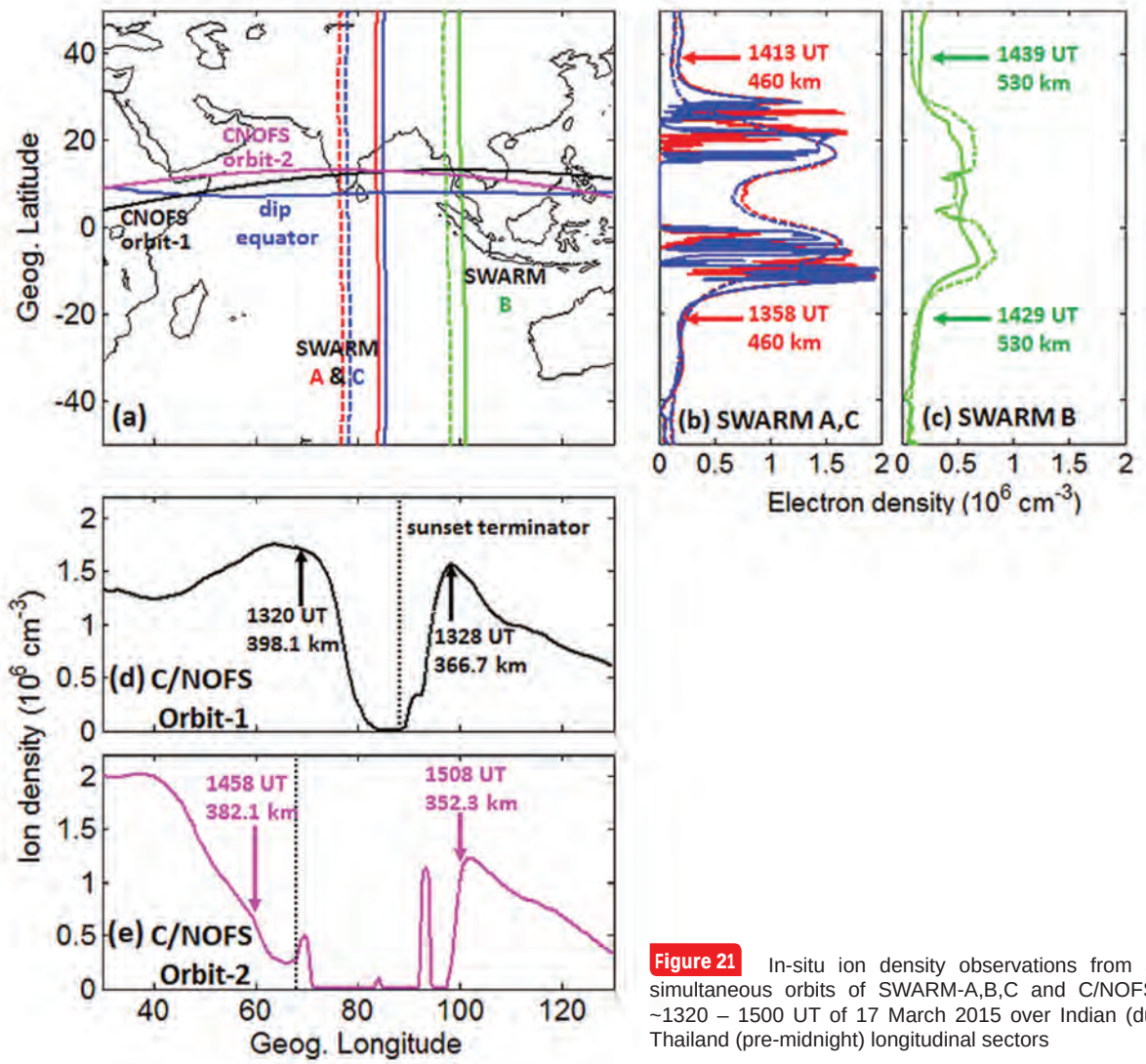

Figure 21 In-situ ion density observations from a nearly simultaneous orbits of SWARM-A,B,C and C/NOFS during ~1320 – 1500 UT of 17 March 2015 over Indian (dusk) and Thailand (pre-midnight) longitudinal sectors

field perturbations due to PPEF are greatly dominated at dusk sector despite the existence of background westward ionospheric disturbance dynamo (IDD) fields, whereas, they were mostly counter-balanced by the IDD fields in the pre-midnight sector. In-situ observations from SWARM-A, C and C/NOFS satellites detected large plasma density depletion near Indian equatorial region due to large electrodynamic uplift of F-layer to higher than satellite altitudes ***(Fig. 21)***. Further, this large uplift is found to confine to a narrow longitudinal sector centered on sunset terminator. This study brings out the significantly enhanced equatorial zonal electric field in response to PPEF that is uniquely confined to dusk sector.

The continuous Dst data available since 1957 and H component data for the Carrington space weather event of 1859 have been analyzed and it is found that the mean value of Dst during the main phase of geomagnetic storms, called mean DstMP, is a unique parameter that can indicate the severity of space weather. All storms having high mean DstMP (≤−250nT), which corresponds to high amount of energy input in the magnetosphere–ionosphere system in short duration,are found associated with severe space weather events that caused all known electric power outages and telegraph system failures ***(Fig. 22)***.

The occurrence of substorm associated Pi2 (6.6-25 mHz) pulsations in the low latitude topside ionosphere is investigated using vector magnetic field measurements from LEO satellite CHAMP. Pi2s are a common phenomenon at ground which occurs in conjunction with substorm activity. Although a night time phenomena, Pi2s are often observed in the low latitude daytime ground stations. Pi2s are also detected in LEO observations during night times. However, its daytime observations at LEO revealed different conclusions about its existence in the topside

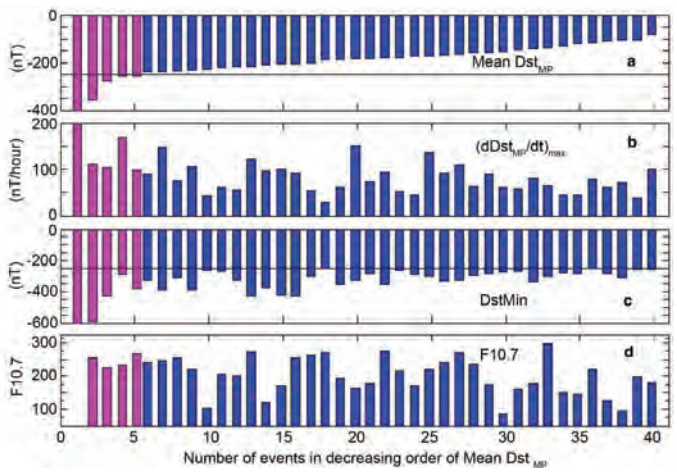

Figure 22 Parameters of super storms (mean Dst MP, (dDstMP/dt) max, and Dst Min) and solar activity index F10.7 arranged in the order of decreasing mean Dst MP. Severe space weather events that caused all known electric power outages and telegraph system failures occurred when the mean Dst MP is below -250 nT indicated by pink bars

ionosphere and remained controversial. The present study examines the simultaneous occurrence of daytime Pi2s in the LEO and underneath ground observations, which are initially identified using high-resolution data from Indian station Shillong. It is shown that the identification of daytime Pi2s at CHAMP (compressional component) depends on the frequency of Pi2 oscillation, i.e., Pi2s with higher frequencies (> 15 mHz) are more suitable for the detection in the topside ionosphere using polar LEO satellites. The presence of a dominant non-Pi2 power in the lower frequencies (< 15 mHz) of Pi2 band, is consistently observed in the CHAMP observations during daytime. These background frequencies which are unique to satellite are found to modify the Pi2 oscillations having frequencies < 15 mHz at CHAMP, whereas Pi2s having frequencies > 15 mHz are less affected by these background frequencies. This study clearly demonstrates that the signatures of daytime Pi2s are possible to observe at CHAMP, provided that contribution from background frequencies at satellite is eliminated. The night time Pi2s identified at CHAMP are in accordance with the previous reports, suggesting cavity as a viable mechanism. However, the characteristics of daytime Pi2s observed at satellite and ground are found to be different from that of night time ones indicating an additional mechanism responsible for the occurrence of Pi2s in the day side. The results indicate that apart from fast cavity-mode oscillations, an instantaneous transmission of Pi2 electric field from high to low-latitude ionosphere also plays a major role in the occurrence of daytime Pi2s.

Study of ULF pulsations is very important from the space weather point of view. The investigation of geomagnetic pulsations at the top side of the ionosphere using low earth orbiting satellite data is performed under this project.

DYNAMICAL AND ELECTRODYNAMICAL COUPLING OF NEAR EARTH SPACE ENVIRONMENT

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Members : C.P. Anilkumar, S. Gurubaran, K.U. Nair, K. Jeeva, C. Panneerselvam, K. Jawahar, C. Selvaraj, K. Emperumal

Some salient results emanated from the project are,

- The 2009 SSW event had a stronger wave number 2 whereas 2013 SSW event contribution of both wave number 1 and wave number 2. In addition, 2009 event is centered on Indian sector and American sectors whereas 2013 event is more pronounced in American sector than the Indian sector.
- Morning TEC increase and evening TEC decrease are observed prominently in the Brazilian sector (45°W) than Indian sector (75°E) for SSW 2013 event as a function of local time.
- The mesopause zonal wind at 90 km is clearly decelerated from eastward to westward in the first week of January 2013 over Tirunelveli when the polar stratosphere temperature attains positive temperature gradient. During 2009 event, there were sequence of wind reversal noticed during end of January 2009.

REMOTE SENSING OF FAR AND NEAR EARTH ENVIRONMENT AND CHANGING HUMANOSPHERE

Chief Coordinator : Rajesh Singh

Members : N. Parihar, M. Lal, K. Vijaykumar, S. Sripathi, B. Veenadhari, S. Tulasiram, P. Tiwari

This program addresses the behaviour of Atmosphere-Ionosphere-Magnetosphere system (AIMs) due to the sources and forcing from below (lightning, thunderstorms, cyclones, gravity waves, tides, etc.) and above of geomagnetic-solar-interplanetary origin using active and passive remote sensing techniques.

Collective research using Airglow Imaging, VLF waves observation, Lightning/TLE Imaging, Ionosonde &

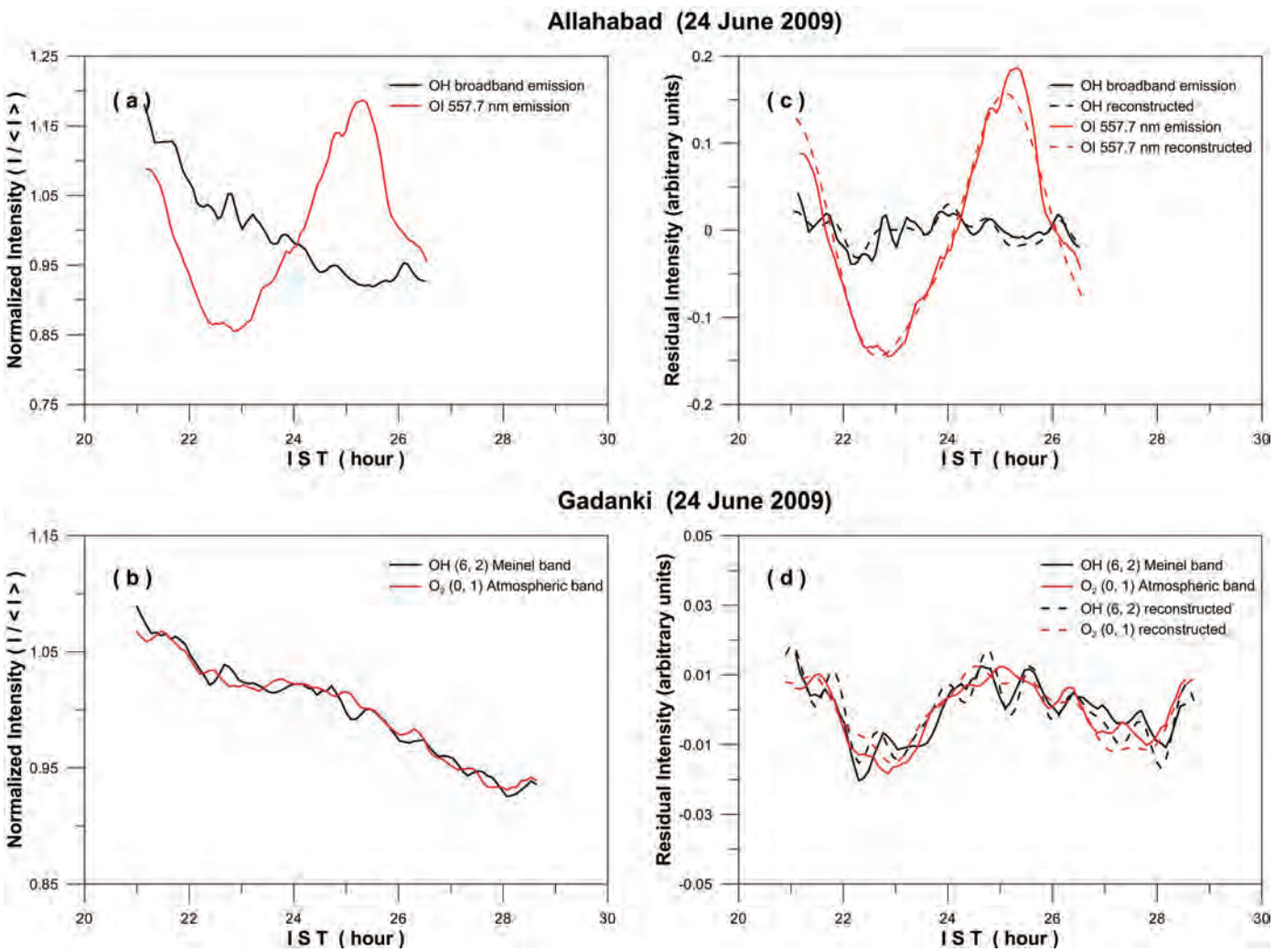

Figure 23 The variation of different emission features over Allahabad and Gadanki on the night of 24–25 June 2009.

Scintillation experiment, GPS and satellite measurements were carried out at KSK GRL, IIG under this program and the salient findings are as below:

Coordinated measurements of airglow features from the mesosphere–lower thermosphere (MLT) region were performed at Allahabad (25.5° N, 81.9° E) and Gadanki (13.5° N, 79.2° E), India to study the propagation of gravity waves in 13 – 27° N latitude range during the period June 2009 to May 2010 under CAWSES (Climate And Weather of Sun Earth System) India Phase II Programme.On 23–24 and 24–25 June 2009 and 23–24 October 2009, an identical wave (period ranging from 2.2 to 4.5 h) was observed at both locations that shared a common source. Typically, the waves had large horizontal wavelength (~ 1194 – 2746 km) and their phase speed lay in the 77 – 331 m/s range. The variation of different emission features over Allahabad and Gadanki on the night of 24–25 June 2009 is shown ***(Fig. 23)***. A 4.5 h common wave was noted at both locations on this night. NOAA Outgoing long-wave radiation contour images and KALPANA-1 infrared images ***(Fig. 24)*** indicate a mesoscale convective system to be the source of the common wave on these nights. The m^2 profile analysis using SABER/TIMED temperature profiles and Horizontal Wind Model (HWM-07) estimates suggests their ducted propagation.

In one study related to lightning discharge radiated whistler waves in Indian low latitude region, the whistlers observed at Indian low latitude station, Allahabad (geographic latitude, 25.40°N; geographic longitude, 81.93°E; L = 1.081) were correlated with the lightning activity at the conjugate point (geographic latitude, 9.87°S; geographic longitude, 83.59°E). About 2000 whistlers were identified

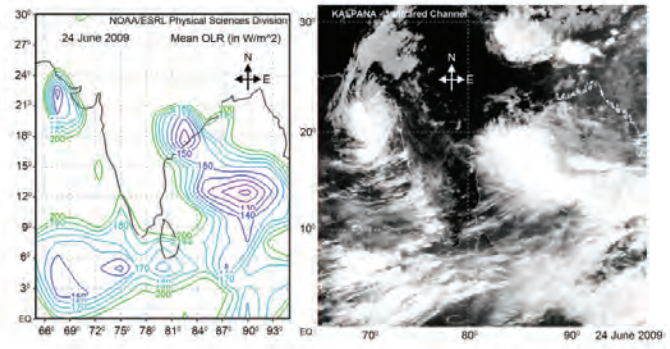

Figure 24 NOAA Outgoing long-wave radiation contour images and KALPANA-1 infrared images for 24 June 2009

with the help of Automatic Whistler Detector employed at Allahabad in tandem with AWESOME VLF receiver. Total of 15 days were masked with whistler activity in one year period from December, 2010 to November, 2011. The correlation is carried out by matching arrival time of whistler causative sferic with that of WWLLN detected lightning discharges. About 63% whistlers are observed to associate with the lightning discharges generated in the conjugate area. The total lightning activity (during whistler activity period) for the 15 days is grouped according to different seasons ***(Fig. 25)***. WWLLN detected lightning discharges are shown with cyan circles. WWLLN lightning events that are correlated with the whistlers are indicated with circles of other colors. It is found that, the most probable region of lightning events that produce whistlers is situated around the conjugate point within a radius of ~1000 km. The properties of causative lightning discharges such as type, energy, the distance of its occurrence with respect to the conjugate point and the thunderstorm alignment are found to play an important role in triggering and trapping the whistler wave energy. The statistical study on diurnal

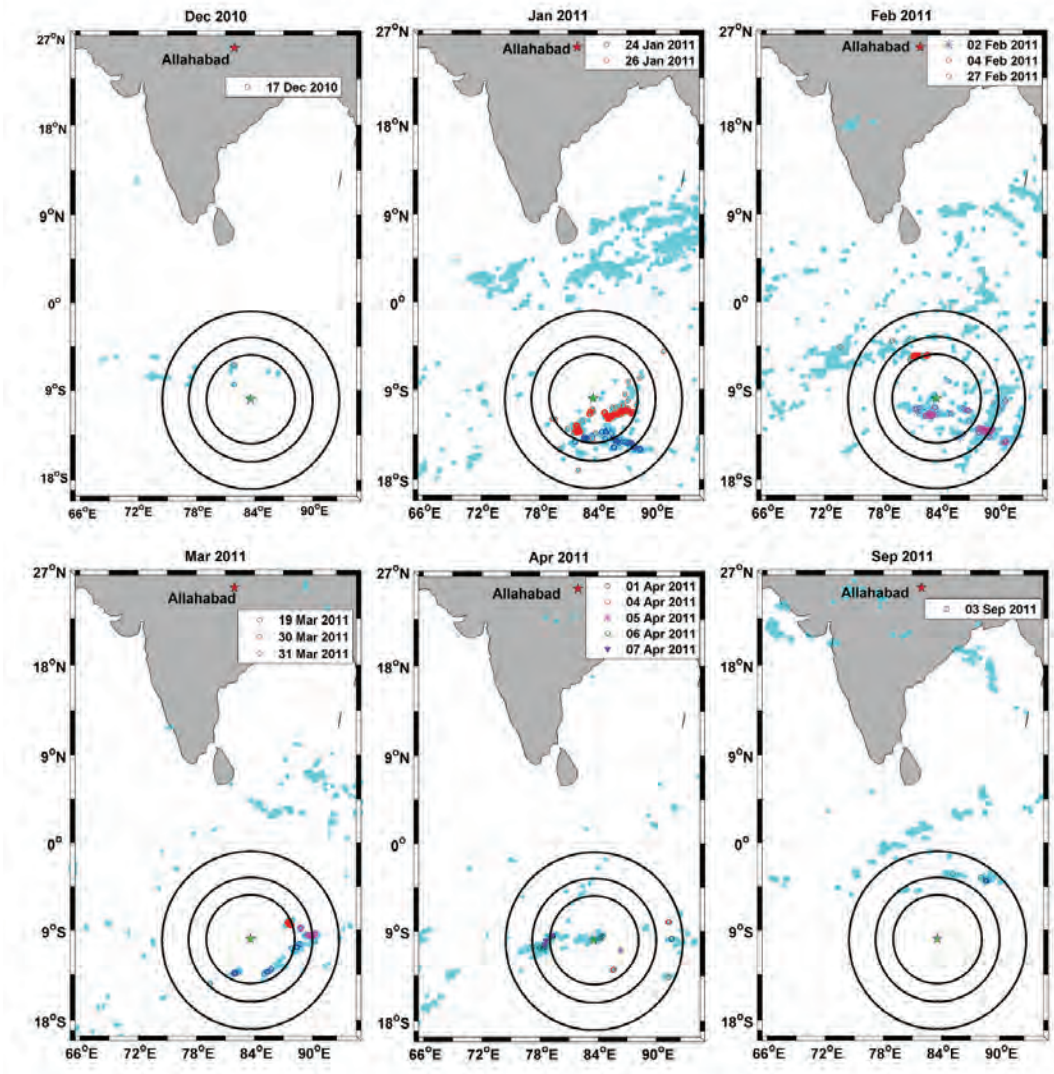

Figure 25 Maps showing lightning activity in the vicinity of conjugate region within circles of radii 500 km, 700 km and 1000 km, with the conjugate point of Allahabad as the centre, for different seasons. DJF represents, December, January, February; MAM, March, April, May; JJA June July August and SON, September, October, November.

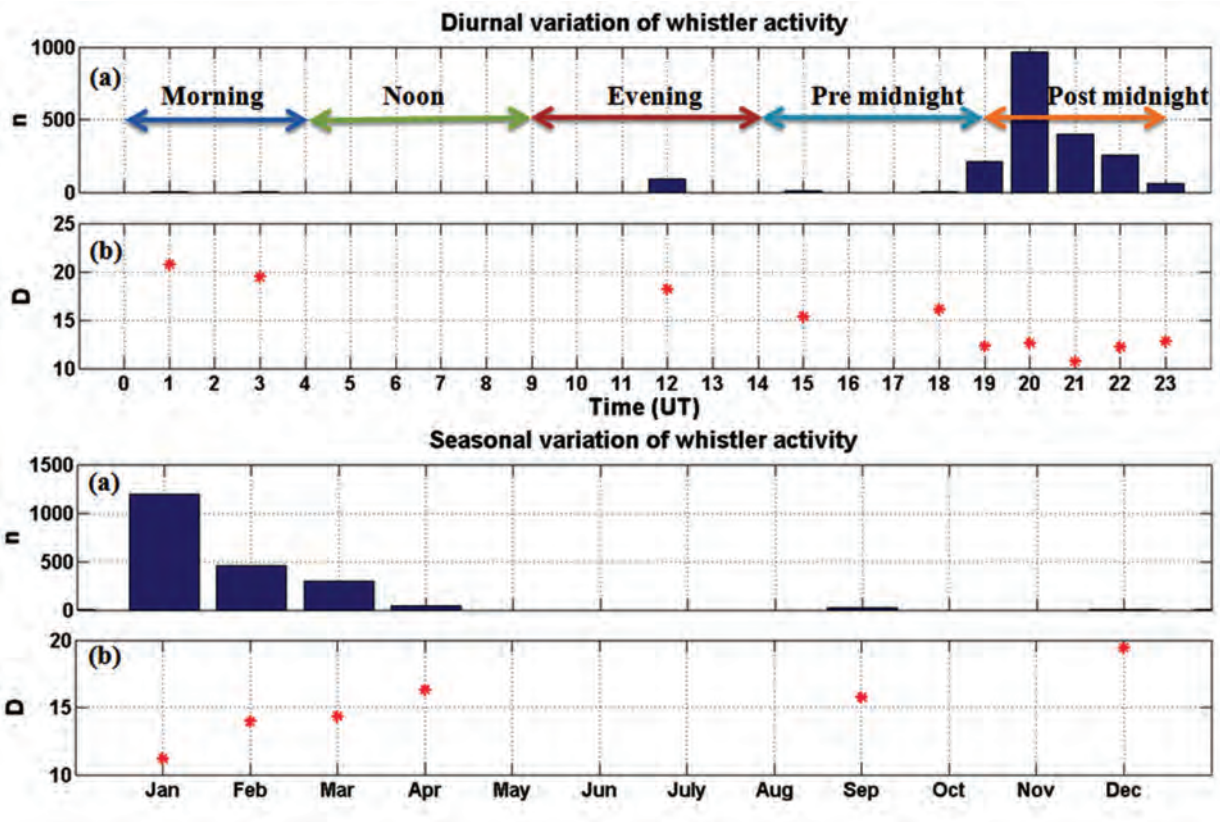

Figure 26 Diurnal and seasonal variation of whistler parameters: occurrence number (*n*) and dispersion (*D*).

and seasonal variations of various whistler parameters such as, whistler occurrence (n), whistler dispersion (D) and sferic identification factor (C) is also carried out. The diurnal and seasonal variations of n and D are shown ***(Fig. 26)***. The occurrence of whistlers is clustered in the post midnight hours. The diurnal variation of D suggests that the ionospheric conditions during whistler activity period are controlling factors for whistler occurrence along with the lightning discharges. The winter months (December, January and February) showed relatively high whistler occurrence due to high availability of source lightning discharges in the conjugate region and low atmospheric noise at receiving site. The results obtained from diurnal and seasonal variations along with L values of causative lightning discharges suggest that the propagation path of observed low latitude whistlers was embedded in the topside ionosphere.

An investigation was carried out to look into the climatic, meteorological and topographical causes of the 16–17 June 2013 Kedarnath (India) natural disaster. This devastating flood episode, caused huge loss of lives and physical/material wealth. The Uttarakhand region in the Himalayas normally experiences heavy rainfall during July and August months of the Indian monsoon season, and is normally associated with landslides and flash floods. The Southwest (SW) monsoon of 2013 over the Indian region was very unique in terms of the time of its onset, and its rapid advancement. The Charobari lake (located about 2 km upstream of Kedarnath town was over flooded due to continuous heavy rain during 10–17 June 2013 and enhanced ice melt, in 3 days. Water gushed out as the lake burst and flooded Saraswati and Mandakini Rivers. Both the banks of Mandakini River were washed away, causing massive devastation to Kedarnath town and downstream areas. Flood water and debris from Saraswati River added to this devastation. Many houses, along with other civil structures in Kedarnath, Rambara and Gaurikund, were completely washed away. This occurred in the early morning of 17 June 2013. As a result, hundreds of people and animals lost their lives, in addition to huge damage to property. To understand this catastrophic event, rainfall/convective data and associated climate meteorological parameters are investigated. In ***Fig. 27a***, ground-based rainfall data, satellite-measured total rainfall, surface precipitation, convective precipitation rate and cloud top temperature are shown, for both day and night hours during 10–20

June 2013. There was considerable rainfall during 15–17 June, with a maximum on 16 June. ***Figure 27b*** shows 6 hourly variations of wind velocity, pressure, cloud cover (%), surface temperature and relative humidity for the period 10–20 June 2013. Daily mean variation is also shown in each plot. The analysis shows that cloud cover reached almost 90% (on 16 June 2013) and wind speed was low (< 4 m/s). In addition to this, relative humidity reached ~100 %. These factors support convective heavy rainfall which was observed during 15–17 June 2013. The convergence of the Southwest monsoon trough and westerly disturbances over the region was observed. The monsoon advanced by almost a month and coincided with the peak period of pilgrimage and tourism. Due to heavy rain and ice melt from the nearby mountains, much loss of human life, animals and property occurred.

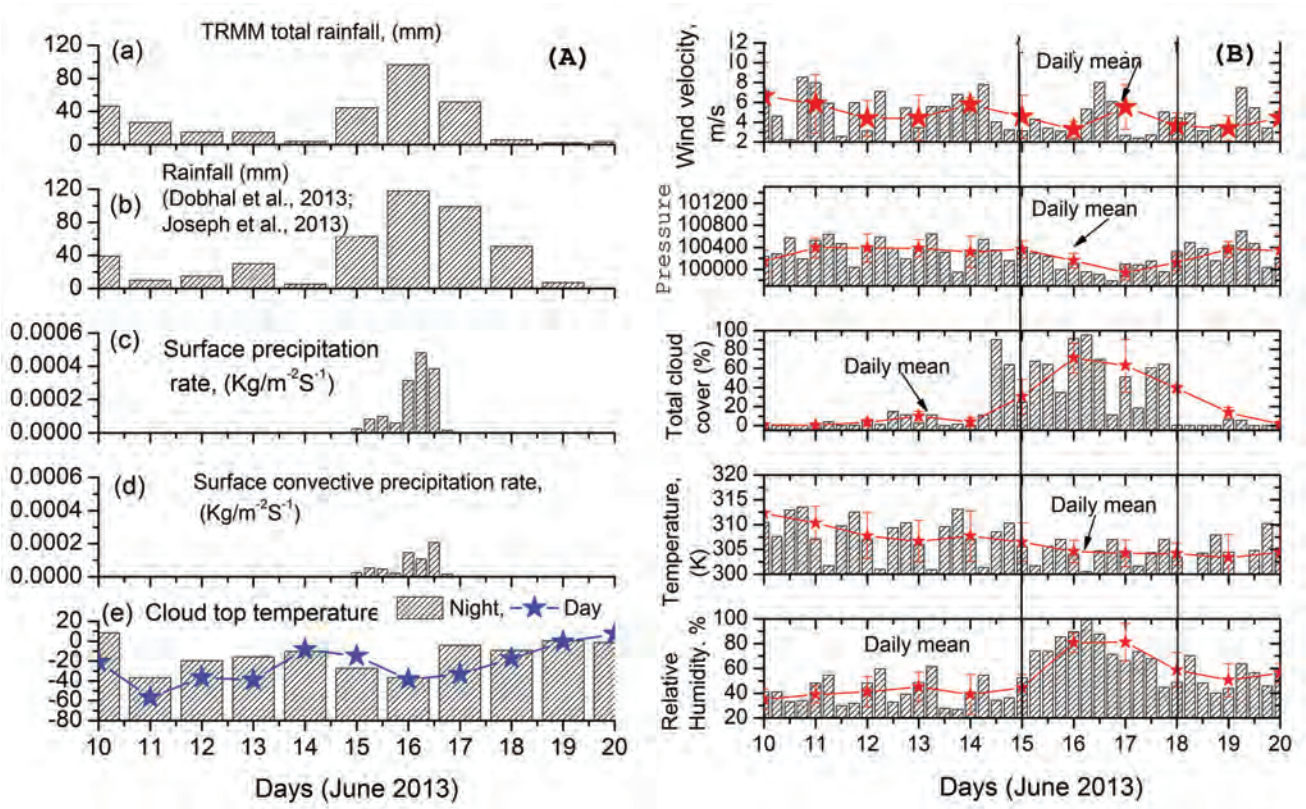

Figure 27 Variation of daily mean of **(a)** TRMM total rainfall (b) rainfall (Dobhal et al., 2013), (c) surface precipitation rate, (d) surface convective precipitation rate, and (e) cloud-top temperature (day/night) for the period 10–20 June 2013. **(b)** Variation meteorological parameters such as wind velocity, atmospheric pressure, total cloud cover percentage, surface temperature and relative humidity for the period 10–20 June 2013 for the selected region.

SOLID EARTH RESEARCH

INTEGRATED APPROACH TO SOLID EARTH STUDIES- DATA & MODELLING

Chief Coordinator : N. Basavaiah

An overview

Laboratory-based rock magnetic measurements are vital for studying palaeoclimate of lacustrine, fluvial, fluvio-lacustrine, glacio-fluvial, and marine sediments; contemporary and historical pollution records (sediments, soils, road dust and vegetation); impact shock evidences preserved in shocked basalts, and dating of archaeological artifacts and seismic deformation structures. The focus of research is over Deccan Traps, viz., Lonar impact crater and west and east coast deltaic and lake sediments, where the fluctuations in fluvial erosion will be explored. Also archaeomagnetic

and palaeomagnetic dating of Deccan dyke system and archaeological artifacts will be undertaken.

Various space borne geodetic techniques viz. GPS, GRACE, InSAR is intended to be employed to know the crustal demormation mechanisms within Deccan Volcanic Province (DVP), e.g. Koyna-Warna belt.

Plume–lithosphere interactions beneath DVP using magnetotelluric/long period magnetotelluric technique will be used to decipher the deep electrical conductivity distribution. These are the places where seismic reflection does not give a true picture. The areas of Saurashtra across the Cambay basin nearby triple junction of the Cambay, Narmada-Tapti rifts and west coast fault will be studied. Some of the research problems that will be addressed are: (a) Magmatic processes originating in the deep mantle and their impact on the lithosphere levels and (b) delineation of underplating material beneath the Saurashtra region and its extension towards Cambay basin.

The geodynamic evolution of the DVP will be deciphered by using gravity and magnetic anomalies, where the anomalies will be interpreted in terms of geological structure and tectonics of DVP and throw light on Western Continental Margin and Sahyadris.

Limited palaeomagnetic data are available on the Proterozoic Newer dolerite dykes (ca 2100 Ma to 1100 Ma) within Singhbhum nucleus rocks. Palaeomagnetic, petrological and geochemical investigations are proposed to study newer dolerite dykes, so that the Precambrian Apparent Polar Wander Path (APWP) for the Indian sub-continent can be defined.

The problem of water scarcity is very acute in Maharashtra, dictating the need for searching auxilliary sources of groundwater in hard rock terrain like DVP. Also, there is no systematic study of geophysical and geochemical techniques to map saline water intrusion and water contamination in DVP. It is thus pertinent to evaluate the geoelectrical and geochemical signatures in the semi-arid and Konkan coastal regions of Maharashtra. The water samples collected from bore wells/dug wells will provide substantiation of saline water intrusion and also the anthropogenic input into groundwater.

ENVIRONMENTAL MAGNETISM STUDIES

Coordinator : **B.V. Lakshmi**

Members : **N. Basavaiah, K. Deenadayalan, K.V.V. Satyanarayana , P.B. Gawali, Md. Arif, P.K. Das, J.L.V. Mahesh Babu, K. Abilash**

Environmental magnetic measurements were carried out along Tirna River in Latur-Osmanabad district to study the palaeoclimate and palaeomagnetic characteristics

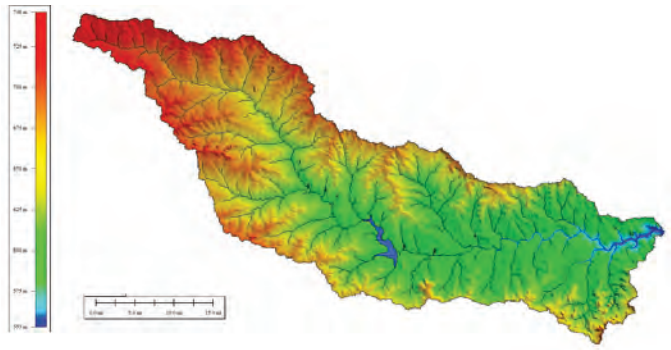

Figure 28a Location map of study area along Tirna river, Latur-Osmanabad.1-9 are studied profiles

and to observe the variations in anisotropy of magnetic susceptibility, environmental magnetic and geochemical properties of sediments from the nine profiles along Tirna River ***(Fig. 28a)***. Magnetic susceptibility studies along with the IRM acquisition curves, Bcr, χ_{ARM}, SIRM and S-ratio reveal the magnetic mineral particles are dominated by ferrimagnetic magnetite and titanomagnetite, apart from few anti-ferromagnetic minerals. χfd%, SIRM/χlf and χ_{ARM} /SIRM illustrate that magnetic mineral particles are dominated by super-paramagnetic particles (SP), in addition to fine and coarse particles. The detrital geochemical elements are seen to dominate the profiles under investigation wherein Ca is seen to be the main indicator of onset of arid and semi-arid climatic conditions in Latur and its adjoining area ***(Fig. 28b)***. There are a few theories as to the type of drainage system prevalent in the past and in recent times which have undergone radical changes on account of climatic and environmental conditions that are being now deciphered in the study undertaken in this area. Anisotropy of magnetic susceptibility measurements suggests the shape of the AMS fabric is oblate and fluvial flow current is weak to moderate.

The pseudo-Thellier technique was applied to obtain relative palaeointensity determinations using sediments from Ter, Latur. Measurements of intensity of natural palaeointensity, remanent magnetization left (NRM left) after AF demagnetization versus intensity of anhysteric remanent magnetization gained (ARM gained) at the same peak were carried out on a set of samples ***(Fig. 28c)***. Jackknife resampling scheme was used to get error estimates on the palaeointensity. The pseudo-Thellier palaeointensity records were compared with the conventional method results where the remanent magnetization at 25mT (NRM25mT) has been normalized using the anhysteretic remanent magnetization at 100mT (ARMmax).The pseudo-

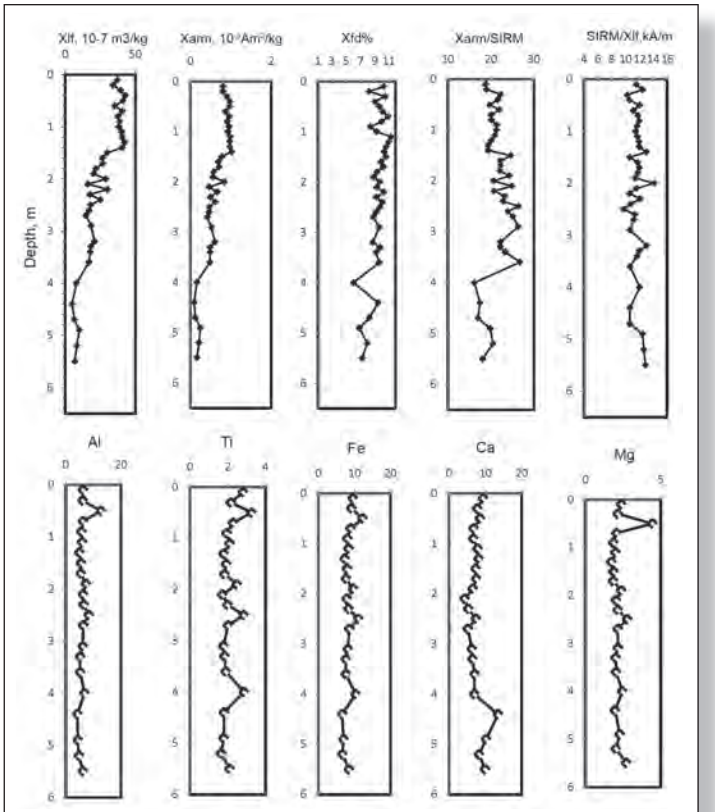

Figure 28b Magnetic (χ_{lf},χ_{arm},χ_{fd}%, χ_{arm}/SIRM and SIRM/χ_{lf}) and Geochemical parameters of studied profile along Tirna river.

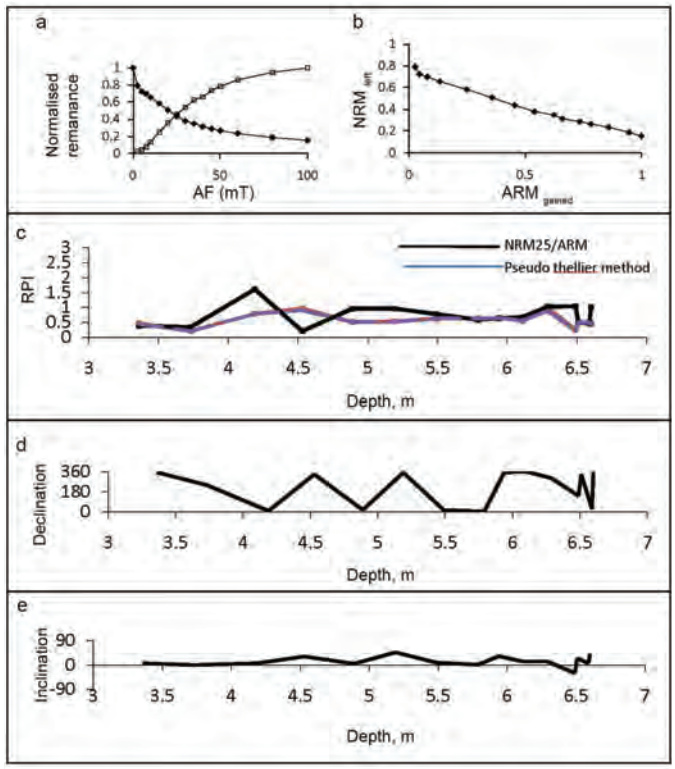

Figure 28c Pseudo-Thellier method for a sample (a) Stepwise AF demagnetization of NRM and acquisition of ARM; intensities are normalized by their maximum values. (b) NRM intensity left after demagnetization to a given peak field versus ARM intensity gained at the same peak field. (c) Comparison of Relative paleointensity estimate using a conventional method: NRM25mT/ARMmax vs. Depth with Pseudo-Thellier paleointensity estimate ma (d) Declination and (e) Inclination of the studied section plotted with depth.

Thellier record shows a reasonable agreement with the standard method of normalization (NRM25mT/ARMmax).

Sediment samples collected from Gad river estuary in Maharashtra state was analyzed to understand rock magnetic, particle size and geochemical characteristics which reflect local environmental climate-induced changes. In the studied profile, mineral magnetic (χ_{lf}, χ_{ARM}, SIRM, χ_{ARM}/χ_{lf}, SIRM/χ_{lf}, χ_{ARM}/χ_{fd}, S-ratio and soft IRM) and other non-magnetic measurements indicate variations are controlled by the concentration of magnetite. The magnetic grain size also plays a major role. The rock magnetic results indicate low-coercivity magnetite is the main magnetic mineral within the sediments ***(Fig. 29)***. The magnetic parameters and geochemical indicators, when seen in conjunction, reveal terrigenous origin of Gad river sediments. The variations encountered in rock magnetic, geochemical and particle size data of the studied sediments reveal their deposition in wetter and drier climates. Thus, variation in sediment properties encountered in the study area can be used as a proxy for rainfall dependent catchment erosion.

Mineral magnetic studies were carried out along Girna and Anjani rivers, Maharashtra wherein a total of 15 surface samples were collected at an approximate 500 m interval along Girna (at 10 stations) and Anjani River beds (at 5 stations). Different grain sizes (600,300,250,150,125, 90, 63 and 44 µm) were used according to the Wentworth scale for this analysis. A standard range of magnetic parameters was measured on all samples. No correlation was observed in magnetic concentration and magnetic grain size in Girna river sediments, whereas the Anjani river sediments displayed increase in magnetic concentration with increase in grain size. The Girna and Anjani river sediment samples are dominated by ferrimagnetic minerals corresponding to magnetite–like minerals and also small contribution of greigite in Anjani river sediments. IRM acquisition and Hcr shows that magnetite is the primary magnetic mineral present in the sediments. The percentage of frequency dependent magnetic susceptibility reflects the presence of single domain magnetic minerals in Girna and Anjani river sediments with small contribution from super-paramagnetic grains (SP).

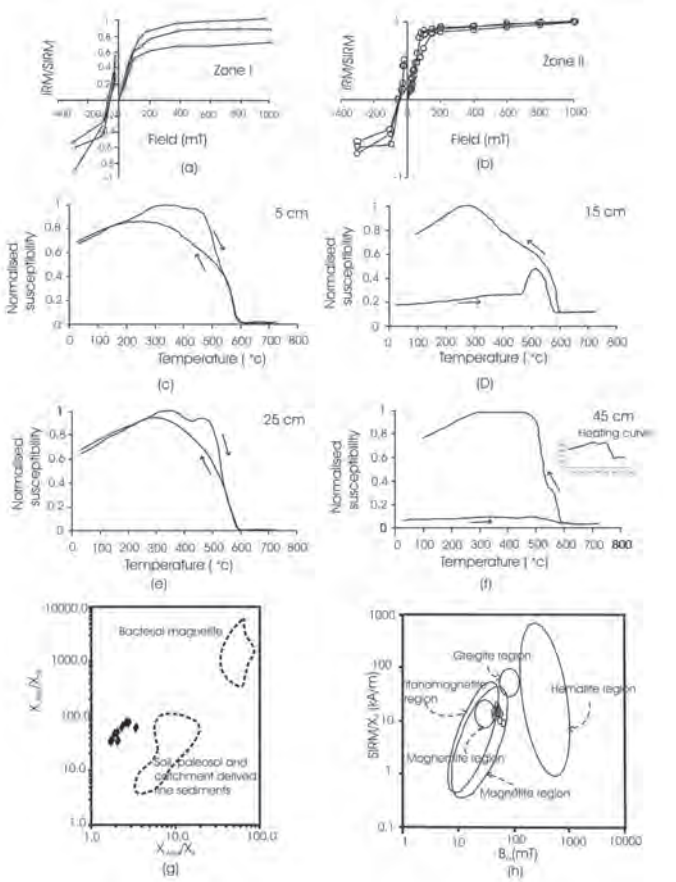

Figure 29 **(a-b)** IRM acquisition and backfield curves from representative samples **(c-f)** χ-T curves from different depths for representative samples; **(g)** Bi-logarithmic plot of χ_{ARM}/χ_{lf} *vs.* χ_{ARM}/χ_{fd} **(h)** SIRM/ χ_{lf} versus B_{CR}, most of the samples are located in the region for magnetite as main carrier.

Heavy metal monitoring of beach sands were carried on sediments collected from Vengurla and Aravali beaches of Sindhudurg district, Maharashtra. Mineral magnetic, geochemical and statistical analyses were carried on surface sediments for preMonsoon (PreM), monsoon (M) and postmonsoon (PM) seasons. Magnetic concentration parameters (χlf, ARM, SIRM and HIRM) are strongly correlated within themselves during PreM, M and PM. Low S-ratio and high HIRM indicates presence of antiferromagnetic minerals during all the three seasons. Strong correlation was deciphered between magnetic parameters and heavy metal (Cu, Cr, Zn and Ni) PreM and PM which obliterated in M ***(Fig. 30)***. This shows influx of magnetic minerals and heavy metals is more in M than PreM and PM. The monsoonal influx is more haphazard and random in M because of enhanced weathering resulting in weak correlation between different mineralogical and geochemical entities.

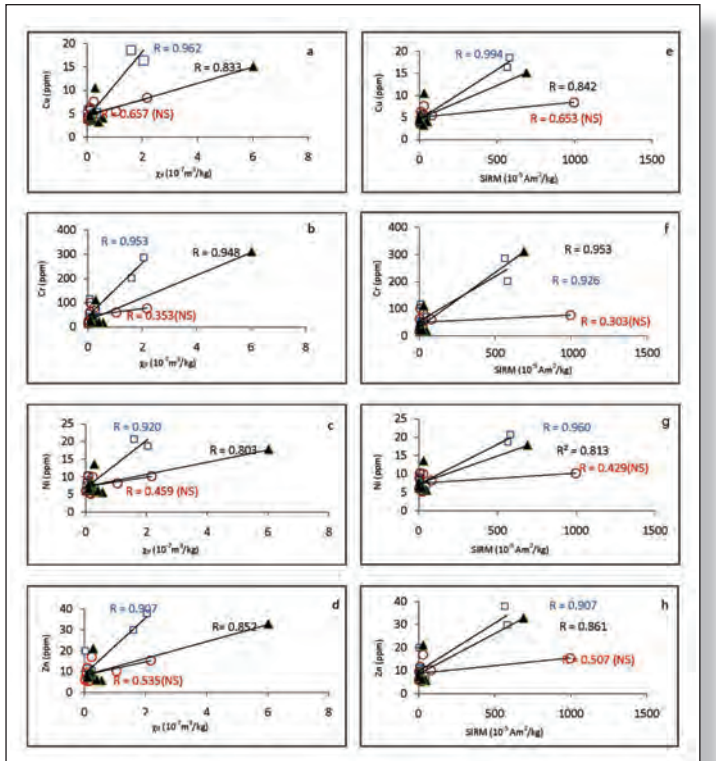

Figure 30 Variation of Copper (Cu), Chromium (Cr), Nickel (Ni) and Zink (Zn) versus magnetic mineral concentration parameters: magnetic susceptibility (v) and saturation isothermal remanent magnetization (SIRM). a–d Cu, Cr, Ni and Zn versus vlf; e– h Cu, Cr, Ni and Zn versus SIRM. Squares, open circles and filled triangles represent PreM, M and PM, respectively. NS-not significant

Archaeological samples were collected from Ter, in Latur district, and Junnar, from Pune district of Maharashtra for deriving archaeointensity of ancient geomagnetic field. The natural remanent magnetization and thermal demagnetized data generates archaeointensity estimates by employing Thellier-Thellier double heating method. All intensities were corrected for cooling rate effects. Archaeointensity values for Ter (Junnar) $_{Banc}$= 40.79 ± 3.6 mT ($_{Banc}$= 37.01 ± 2.1 mT) are superimposed on the Indian secular variation curve.

ELECTROMAGNETIC INDUCTION STUDIES

Coordinator : **Ajay K. Singh**

Members : **C.K. Rao, P.B.V. Subba Rao, Amit Kumar, D. Nagarjuna, Vijay Kumar, Santu Ghoshal**

Under the MoES sponsored project entitled ***"Lithospheric studies in Cambay basin using Magnetotelluric technique"*** undertaken by Prof. C.K. Rao as the Principal Investigator, magnetotelluric data were collected across North Cambay basin ***(Fig. 31)*** along four east-west trending

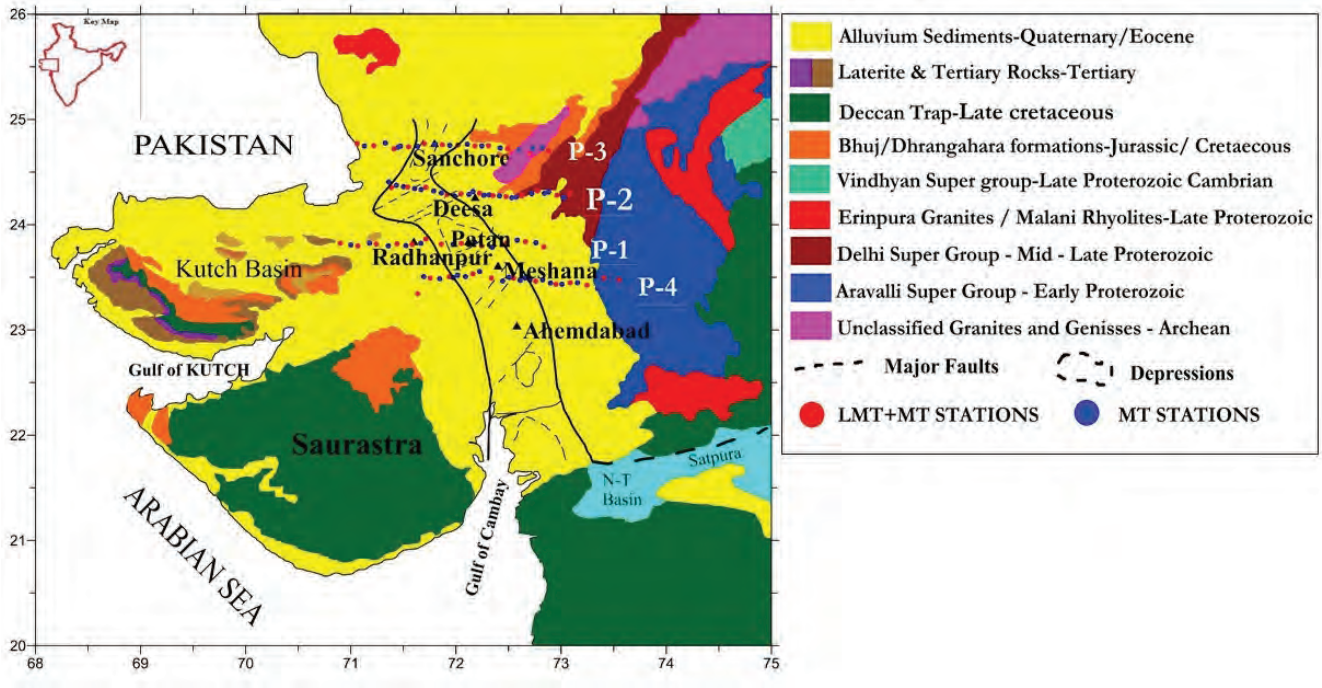

Figure 31 Location map showing the LMT and MT stations.

profiles of length approximately 200 km each. Considering local logistics and availability of sites for Broad band MT (BBMT) and Long period MT (LMT), data were collected at about 24 BBMT stations with inter-station spacing of 8-10 km in the period range of 0.003 - 3000 s and 12 LMT stations with spacing 15-20 km and period range 1- 10000+ seconds along each profile. The five component MT data (2 electric, 3 magnetic components) were acquired using two different instruments, MTU-05 (BBMT, Phoenix Geophysics Ltd., Canada) and LEMI-417 (LMT, LVIV Ukraine). At all locations, electric field variations in north-south and east-west directions were measured using non-polarizable Ag/AgCl or Pb/PbCl electrodes in an + configuration with typically 70 m arms. The magnetic field sensors used for BBMT acquisition were Phoenix MTC-50 induction coil magnetometers, and for the LMT systems were ring-core fluxgate magnetometers.

The BBMT and LEMI time series data were processed using robust remote reference techniques (LEMI software). Where LEMI data were available, their responses were merged with the corresponding BBMT response estimates. The responses were then subjected to galvanic distortion identification and correction with a tensor decomposition approach using the multi-site, multi-frequency analysis code on subsets of sites. The analysis has brought out two distinct strike angles for Cambay rift (varying from N12º W to N5º E) for profiles I to III and Aravalli strike angle varying from N50-59º E. where as in profile IV, the strike direction indicate only Aravalli direction (N59º E). In both cases the strike directions are consistent with major geological strike directions in the study region.

The magnetotelluric data (TE, TM modes and vertical magnetic Hz tipper) from three profiles were inverted using the two-dimensional (2-D) RLM2-DI algorithm, as implemented within the WinGLink package of Geosystem Srl. (now Schlumberger/Western Geco). The 2D geoelectric models ***(Fig. 32)*** indicate very high conductive

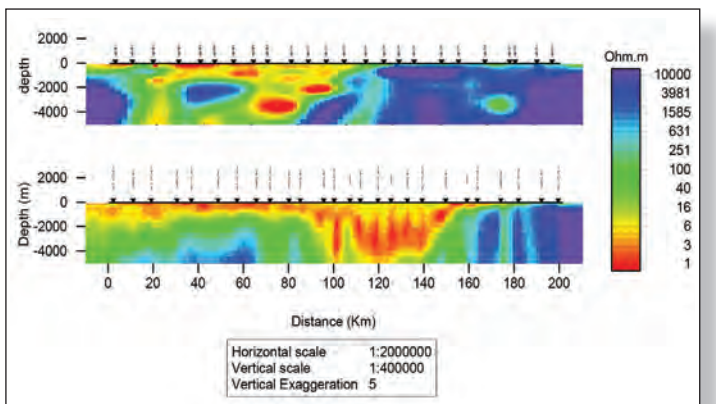

Figure 32 Two-dimensional geoelectric models obtained over Cambay basin.

sediments (Tertiary) with resistivity of 5-10 ohm-m and thickness varying from 1-5 km with deepest part at the centre of the Cambay basin. The demarcation of Cambay basin is clearly visible with western margin of the basin steeply dipping to vertical and whereas eastern margin of the basin gently dipping towards SW. The presence of trap and its thickness below Tertiary sediments is not clear due to low resistivity present in the study region. West of the Cambay basin indicate Kutch basin with 1-2 km sedimentary thickness, whereas eastern part indicate Aravalli rocks with high resistivity. A mid to lower crustal conductor is delineated outside Cambay basin and its signatures within Cambay basin is not clear due to non availability of resistivity contrast of the formations within the Cambay basin. Although many explanations are available for high conductivity at mid-lower crustal conductor, presence of fluids may be the possible explanation for high conductivity observed here.

A DST sponsored project titled ***"Geological and Geophysical studies over Andaman Islands and surrounding region"*** was undertaken by Dr. P.B.V. Subba Rao in collaboration with IIT Mumbai. The aim of the study, which is first of its kind over Andaman Islands, was to understand the correlation of magnetic anomaly signatures with surface geology of the Islands. Magnetic anomalies

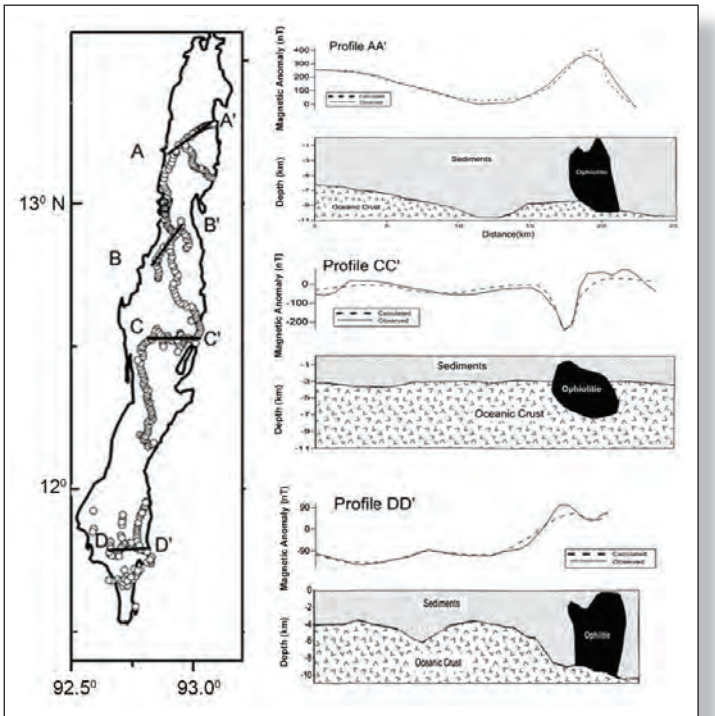

Figure 33 The 2-D modelling of magnetic anomalies along selected E-W profiles across the islands indicate that the ophiolite bodies extend to a depth of about 5-8 km and spatially correlate with the mapped fault/thrust zones.

are in general smooth in the sedimentary region, however, along the east coast of north, middle and south Andaman Islands, significantly high amplitude magnetic anomalies occur over the mafic/ultramafic cumulates of ophiolite bodies. The 2-D modeling of magnetic anomalies along selected E-W profiles ***(Fig. 33)*** across the Islands indicate that the ophiolite bodies extend to a depth of about 5-8 km and spatially correlate with the mapped fault/thrust zones. Below the Andaman Islands, the basement is composed of oceanic crust with ophiolite suite of rocks emplaced along the faults or thrust sheets within the outer arc accretionary prism. It is suggested that these ophiolites were emplaced as a result of subduction; ocean crust (ophiolite) of the subducting slab was scraped off and emplaced as a thrust slice.

PALAEOMAGNETIC & PETROLOGIC STUDIES

Coordinator : **S.K. Patil**

Members : **Anup K. Sinha, R. Nishad, K. Vijayakumar, V. Purushotham Rao, Sujit K. Pradhan**

A palaeomagnetic, rock magnetic, AMS and petrographic studies were carried out over the doleritic dykes in and around Keonjhar district of Odisha, Southern Singhbhum craton, India. Total 91 oriented block samples of dolerite dykes have been collected from 17 sites/locations. Another 16 oriented block samples of granites have also been collected from 6 sites at the contact between the country rocks and dykes. A total of about 440 standard specimens have been prepared for palaeomagnetic measurements. AF pilot study for a set of 30 specimens from representative dykes has been carried out for characterizing the dyke samples. AF blanket study for 51 specimens has been carried out to accumulate the ChRm directions. AMS study on around 800 specimens has been carried out from different dykes of Singhbhum craton. Petrological investigations on around 20 samples have been carried out.

The mean magnetic susceptibility and the mean NRM intensity for the collected rock samples were found as 1275 x 10^{-5} SI units and 9.59 x 10^{-1} A/m respectively indicating strong magnetite component in the samples. From the AF and thermal demagnetization spectra, the primary directions were noticed in the AF fields 200-450 Oe and 400°C-550°C thermal steps. Based on the yielded ChRM directions, dolerite dykes ages were assigned to 2200 Ma. Rock magnetic investigations comprising of isothermal remanent magnetizations curves and high temperature susceptibilities indicated magnetite as the major magnetic mineral in the studied samples.

The petrological studies suggested that Dolerite with variable degrees of alterations is overwhelmingly the dominant member of the dyke system within the Singhbhum granite. Textures, mineral compositions, and other specific observation were observed on the advance polarizing microscope. Most of the thin sections of the collected dyke samples shows low to high clouding in minerals and they contains calcic plagioclase (typically andesite to labrodorite) with lamellar twinning. The main mafic mineral is clinopyroxenes with a distinct ophitic texture and replacement by chlorite and actinolitic, is noticed in many samples. The common accessory mineral in the rocks is magnetite which is associated occasionally with ilmenite. Minor orthopyroxene has been noticed only in patches near WNW of Hata, which may be the second phase of crystallization. The clouding in minerals may suggest possibility of lower grade metamorphism.

ELECTRICAL RESISTIVITY & GROUNDWATER QUALITY STUDIES

Coordinator : **Gautam Gupta**

Members : **V.C. Erram, M. Laxminarayana, G. Shailaja, N. Suneetha**

It is a well known fact that there is severe dearth of groundwater in hard rock terrains. The fracturing, faulting etc within these hard rocks trap limited amount of groundwater. Some districts of Maharashtra are no exception to groundwater scarcity. However not much information is available on the role of dykes, lineaments, conduits, joints and fractures in the hydrogeological set up as well as their role in the occurrence and movement of groundwater in the semi-arid regions of Maharashtra. To this effect, electrical resistivity sounding and tomography was undertaken in Nandurbar region, north Maharashtra, which is a part of the semi-arid region and is infested by dykes ***(Fig. 34)***. 2D resistivity imaging and 1D Vertical Electrical Sounding (VES) data analysis, over the dykes suggests that these are continuous to the depth limit of detection and are characterized by very high apparent resistivity values (> 200 ohm-m) ***(Fig. 35)***. Longitudinal geoelectrical sections along the dykes demonstrated carrier as well as barrier stretches which identified potential aquifers up to depths of 25-30 m below which hard and compact rock exists. These studies also indicated that dykes with sufficient width, length and favorable hydrogeological structure forms potential aquifers for the occurrence and movement of groundwater in the study area.

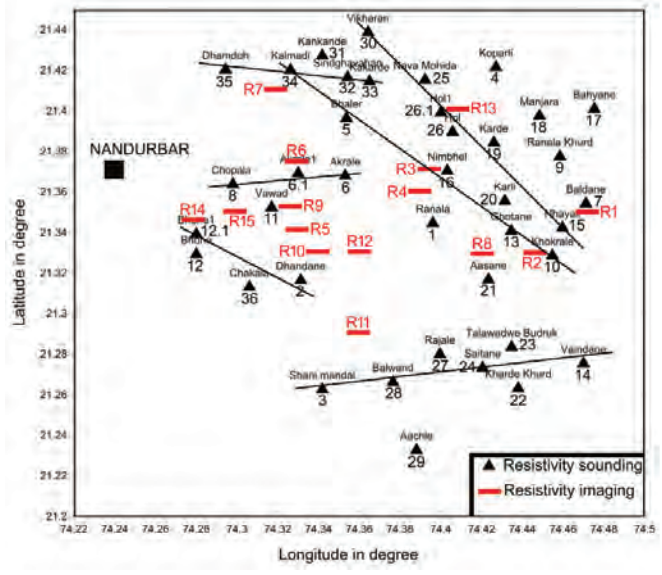

Figure 34 Location of vertical electrical sounding and electrical resistivity tomography points in Nandurbar region.

Similar studies are being carried out in the rain shadow areas of Satara, Sangli and Solapur regions, Maharashtra, in order to demonstrate the capability of high resolution electrical resistivity imaging data coupled with VES, geohydrologic and geomorphometric studies to delineate prospective locations for groundwater exploitation in the drought prone and hard-rock dominated DVP, with specific reference to find scientific and lasting solutions to mitigate recurring droughts at micro level.

Another interesting research problem is the intrusion of saline water in coastal aquifers of Maharashtra thereby depleting and contaminating the available fresh groundwater. Geoelectrical studies carried out in Sindhudurg district of coastal Maharashtra helped in delineating the zones and extent of saline water ingress and also in locating fresh groundwater pockets to meet the water demands of society. Furthermore, aquifer parameters such as hydraulic conductivity, formation factor, porosity and transmissivity is evaluated by utilizing electrical conductivity values analysed via hydro-geochemical analysis of existing wells and the respective vertical electrical sounding (VES) points. These results suggest that there are relatively high value of hydraulic conductivity, porosity and transmissivity at Sagareshwar and Shiroda (the coastal stations) which would be useful to characterize the aquifer system over western Maharashtra.

In the crystalline hard rock terrain, groundwater generally occurs in the weathered basement or regolith and the fractured rock. The presence of weathered and fractured granulites and granites, generally associated with weathered zones may enhance the chances of high yielding boreholes.

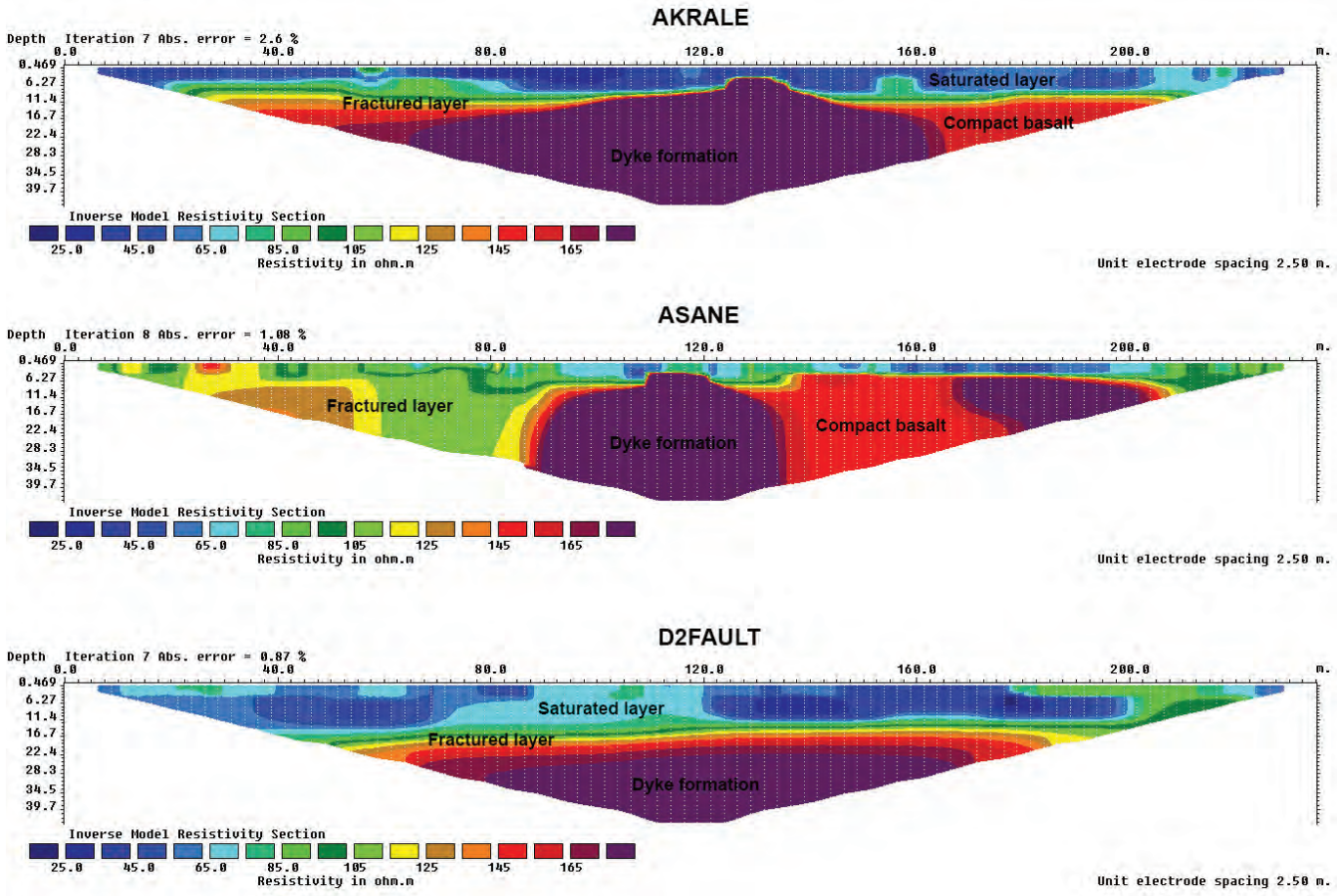

Figure 35 Resistivity tomographs obtained in the dyke infested Nandurbar region.

Therefore, the delineation of geologically weak zones such as fractures is of considerable societal importance. In view of this fact, VES data acquired over Raver basin (Jalgaon), Chikotra basin (Kolhapur) and southern Konkan block (Sindhudurg) have been analysed using secondary geophysical indicators like longitudinal conductance, transverse resistance, electrical anisotropy and electrical reflection coefficient along with numerical factor analysis in order to delineate the subsurface fractures which might be favourable zones for groundwater exploration. These results are also compared with the available litho-log data near the stations. It is generally seen that stations with low reflection coefficient revealed higher electrical anisotropy, suggesting an inverse correlation between these two parameters. The longitudinal conductance (S) value suggest that several locations in these study areas reveals good to weak aquifer protective capacity rating. The low value of the protective capacity is due to the absence of significant amount of clay as an overburden impermeable material, thereby enhancing the percolation of contaminants into the aquifer. The large variation in the coefficient of anisotropy suggests the anisotropic disposition of the aquifers in basaltic region. The fracture porosity inferred from the geophysical parameters and specific conductance of groundwater signifies different degrees of water saturation within the basaltic layers. The high-porosity zones corroborate with the high anisotropy values, indicating significant reserves of exploitable groundwater.

GEOPOTENTIAL STUDIES

Coordinator : **S.P. Anand**

Members : **M. Ravikumar, B.N. Shinde, Awdesh K. Prasad, K. Priyesh, P. Radhika**

The Deccan Volcanic Province (DVP) in the central part of Peninsular India covering an area of 500,000 sq km is

one of the largest flood basalt provinces in the world. The flood basalts are of tholeiitic composition and consist of different flows, which mainly comprise massive, vesicular, amygdoloidal basalt, tuff and breccia. In the recent past, occurrences of two major earthquakes, the Koyna earthquake (M= 6.1) of 1967 and the Latur earthquake (M =6.3) of 1993 with epicentre at Killari have focused attention on the subsurface structure and tectonics of this region. The continued seismic activity in Koyna over the last 35 years, or so, is considered to be reservoir induced, whereas the Latur earthquake is believed to be due to reactivation of weak zones. A better knowledge of the structure and density inhomogeneities in the region may provide an improved understanding of the nature of the crust and the tectonic processes. Since the entire area is blanketed with lava flows, the nature of the underlying pre-volcanic geology and tectonics remains speculative. Although a gravity anomaly map of the DVP is existing, a magnetic anomaly map is not yet available. Hence to understand the structural framework and to look below the traps, ground magnetic data is being acquired over the DVP of Maharashtra. A crustal anomaly map generated from the ground data in conjunction with the available aeromagnetic maps over Peninsular India and gravity map over DVP should help in deciphering structures below the traps. In addition, ground magnetic, gravity and GPS data are being collected along few profiles to understand the crustal, basement configuration and also to map the blind and locked faults, if any, in these regions to understand the seismicity.

Geophysical mapping of the Deccan Volcanic Province of Maharashtra

Ground magnetic data was acquired over a period of several years at an average data spacing of 5 km over a significant part of the Deccan trap covered region of Maharashtra mainly to look at the long wavelength features in the region. A total of around 4000 data points were acquired over ten field surveys (different epochs) spanning a period from 2005 to 2013. Data acquired from each survey is first corrected for diurnal variations; the International Geomagnetic Reference Field (IGRF) corresponding to the year of data collection is then removed and finally a base value corresponding to the mean value representative of the survey area is removed. The data from all the survey areas are then merged after removal of a general base and gridded to produce, for the first time, a total field magnetic anomaly image map of the Deccan Volcanic Province. Analysis of the data revealed NW-SE Dharwarian trends continue below the Deccan traps. In conjunction with earlier published composite magnetic anomaly map, six NW-SE lineaments (Ln1-Ln6) and a NE-SW lineament (Ln7) were delineated in the trap covered region ***(Fig. 36)***. Bouguer gravity data over this

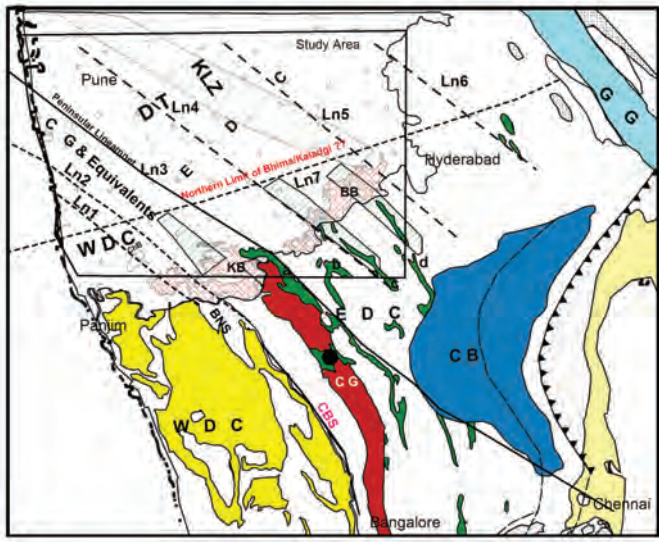

Figure 36 Interpreted lineament and lithological map of the Deccan Volcanic Province from the integrated analysis of gravity and magnetic data superimposed on regional-scale geologic and tectonic map of peninsular India (redrawn from Ramakrishnan & Vaidyanadhan 2008; GSI 2001, 2010), showing the sub-trap continuation of the Dharwar Craton and the associated schist belts. Hatched areas represent the interpreted NW extension of the schist belts (the width is arbitrary). Although it is shown as continuous, it may be present in patches. The dashed lines are the lineaments interpreted from this study. Ln1& Ln2 represents the northward continuation of Bababudan-Nallor Shear and Chitradurga-Boundary shear, respectively. Schist belts are in green. WDC, Western Dharwar Craton; EDC, Eastern Dharwar Craton; CG, Closepet Granite; CB, Proterozoic Cuddapah Basin; KB, Proterozoic Kaladgi Basin; BB, Proterozoic Bhima Basin; ChB, Chikotra Basin; DT, Deccan Traps; GG, Gondwana Godavari Graben, KLZ, Kurdwadi Lineament Zone (from Peshwa & Kale 1997). a–d are schists/greenstone belts: a-Hungund–Kushtagi; b-Hutti–Muski; c-Raichur–Deodurg; d-Gadwal. The study area is demarcated by the black rectangle.

region was further analysed by filtering the data to study the sources at different depth levels within the crust. From combined analysis it is observed that Ln1 coincides with the continuation of Bababudan Nallur Shear; the boundary between the western and eastern Dharwars, Chitradurga Boundary Shear, merges with Ln2 and continues into the offshore. Ln3 is part of the peninsular lineament running from Chennai to the West coast, perhaps, marks a major lithologic boundary. Ln4 coincides with the Bhima River (southward extension of the Ghod Lineament); Ln5 passes through the epicentre of the Killari earthquake and has been reactivated from time to time. Ln6 probably marks the contact between Traps and the crystalline basement. The region between Ln4 and Ln5 is related to the Kurduwadi lineament zone. Further, it is observed that the Kaladgi and Bhima sediments and the Schist belts continue

northwards below the Deccan traps and are constrained to lie to the south of NE-SW lineament Ln7.

Lithospheric structures and crustal flow rheology of eastern Himalaya region from geodetic and geophysical measurements

Several geophysical studies facilitate examining the crustal flow, and GPS and gravity observations in tandem provide an excellent tool. While the direction and magnitude of the GPS derived strain rate are sensitive to crustal dynamics, the space borne gravimetric data from GRACE and GOCE with EGM models are found to be extremely useful in delineating the large scale structures pertinent to crust and lithosphere, further construing the crustal flow in the eastern Himalaya region. Electrical conductivity, density, susceptibility, earthquake distribution, the horizontal velocity along the selected profiles cutting across the crustal flow regions facilitates conceptualizing and imaging the crustal flow. The intriguing tectonic scenario is examined in terms of Lithospheric structures and crustal flow rheology of south east Tibetan and Eastern Himalaya Syntaxes (EHS) bounded regions of eastern Himalaya and their geodynamic implications are being studied.

GLOBAL POSITIONING SYSTEM AND GEODESY STUDIES

Coordinator : **C.D. Reddy**

Members : **P.S. Sunil, K. Vijay Kumar, M. Ponraj, S. Amirtharaj, A.S. Sunil Kumar, Ajish P. Saji**

During last 2.5 decades, the greatly improved precision, spatial and temporal resolution, relatively low cost of space geodetic measurements like Global Positioning System (GPS) and Interferometric Synthetic Aperture Radar (InSAR) led to a revolution in crustal deformation measurements in respect of tectonic and related earthquake process. In a seismic plate boundary and intra-plate regions, the crustal deformation is characterized with a cyclic pattern by the development and release of elastic strain due to the relative plate motions. Considering the importance of Indian plate's geographic location, current motion towards northeast direction, rapid collision with Eurasian plate, active inter-plate and intra-plate deformation and related earthquake, estimation of the present-day motion of the Indian plate from GPS and InSAR data is of great importance for earthquake and related crustal deformation studies.

The main research interest of this group focuses on the application of GPS and InSAR techniques to understand (a) plate kinematics and crustal deformation; (b) pre-, co- and post- seismic crustal deformation and ionospheric responses due to earthquake occurrences; (c) seismic hazard; (d) rheology of the Earth's mantle and (e) Total Electron Content ice sheet dynamics of the Arctic and Antarctic regions. To augment and facilitate these studies, About 21 permanent GPS stations all over India and 2 permanent GPS stations at Antarctica have been established and initiative is being taken to establish more permanent stations. A number of semi-permanent/campaign stations have also been established at different parts of seismically active regions of India. Several field campaigns are being carried out in western Maharashtra, Kutch, Andaman-Nicobar Islands, Himalaya, northeast India and Polar regions.

Two-mode ionospheric response and Rayleigh wave group velocity distribution reckoned from GPS measurement following M_w 7.8 Nepal earthquake on 25 April 2015

Following M_w 7.8 Nepal earthquake on 25 April 2015, the coseismic-induced ionospheric total electron content (TEC) perturbations were analyzed. It is observed that the ionospheric response is due to both the modes, i.e., shock acoustic waves (slow mode) and Rayleigh wave induced (fast mode). The maximum coseismic-induced peak-to-peak TEC amplitude is ~1.2 total electron content unit, $1\,TECU = 10^{16}\,el\,m^{-2}$. The ionospheric response distribution seen is mainly depending on the epicentral distance, satellite geometry, directivity of radiation pattern, and the upper crustal heterogeneity ***(Fig. 37)***.

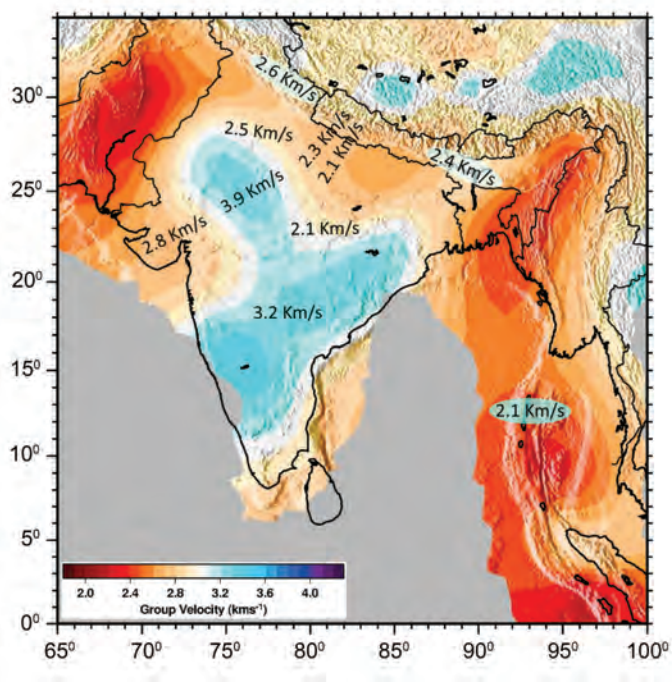

Figure 37 The Rayleigh velocities calculated from Total Electron Content (TEC) wave forms are marked on the corresponding region for comparison with Rayleigh wave fundamental group velocity for 10 s obtained by Acton et al., JGR, 2010.

Near-field co-seismic ionospheric response due to the northern Chile M_w 8.1 Pisagua earthquake on April 1, 2014 from GPS observations

To analyze the co-seismic induced ionospheric TEC perturbations following the northern Chile M_w 8.1 Pisagua earthquake occurred on April 1, 2014, the GPS data at 15 sites from Integrated Plate Boundary Observatory Chile (IPOC) and International GPS Service (IGS) GPS networks have been used. It is observed that the maximum co-seismic induced peak-to-peak TEC amplitude is ~1.25 TECU (1TECU=10^{16} electrons/m^2), and the perturbations are confined to less than 1000 km radius around the epicenter. The observed horizontal velocity of TEC perturbations has been determined as ~1180 m/s ***(Fig. 38)***. The ionospheric signal components due to Rayleigh and/or Tsunami waves however could not be observed.

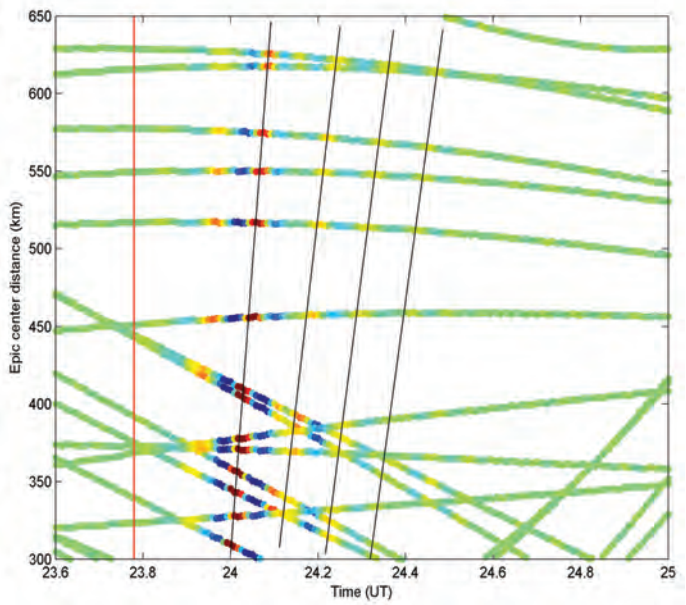

Figure 38 Hodochron plot showing variation in vertical TEC at various GPS sites as a function of time and epicentral distance of Chile M_w 8.1 Pisagua earthquake on April 1, 2014, obtained from PRN 01, 11 and 20. Slope of the slant line gives the average horizontal propogation velocity of the acoustic wave and estimated as 1180 m/s. The three parallel lines (on the right) correspond to AGW wave with velocity ~650 m/s with frequency ~2 mHz.

Coseismic and early postseismic deformation due to the 25 April 2015, M_w 7.8 Gorkha, Nepal, earthquake from InSAR and GPS measurements

Analysis of Interferometric Synthetic Aperture Radar (InSAR) and Global Positioning System (GPS) data reveals coseismic and early postseismic (4–88 days) surface displacements associated with the April 25, 2015, **M_w** 7.8 Gorkha, Nepal, earthquake. The pattern of early postseismic surface uplift and subsidence is found to be opposite to that of the coseismic motion. InSAR and GPS data were jointly inverted for coseismic and postseismic slip on the Main Himalayan Thrust (MHT). The analysis revealed early postseismic afterslip (4–16 days) of 0.2–0.47 m towards downdip of the coseismic slip asperity and another patch with 0.1–0.2 m slip toward east ***(Fig. 39)***. The shallow portion of the MHT towards south neither ruptured during the earthquake, nor did it slip aseismically after the earthquake, thus increasing the potential of MHT to host large earthquakes in the future.

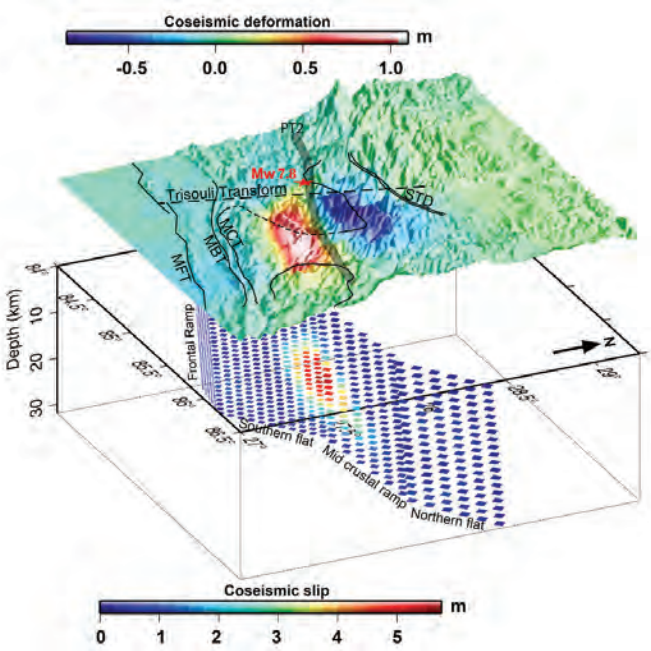

Figure 39 Three-dimensional illustration of the coseismic slip and related surface deformation due to the 25 April 2015, M_w 7.8 Gorkha, Nepal, earthquake from InSAR and GPS measurements.

POLAR SCIENCE RESEARCH

GEOPHYSICAL STUDIES IN POLAR REGIONS

Chief Coordinator : **Ashwini K. Sinha**

Coordinators : **S. Gurubaran, C.D. Reddy**

Members : **C.P. Anil Kumar, S.S.Ghosh, P.S. Sunil, Geeta Vichare, Mala Bagiya, M. Ravikumar, A. Dhar, A. Hanchinal, K. Jeeva, C. Panneerselvam, K.U. Nair, C. Selvaraj, Rahul Rawat, S. Labde, Jeni Victor, Jayanta K. Behra**

Geophysical Studies in Polar Regions has following three key components:

i. **Multi-technique investigation of substorm processes:** In this component, the dynamics of particle precipitation in the sub-auroral ionosphere is studied. This study has direct bearings on Space Weather because particle precipitation responds to varying geomagnetic environments such as storms and substorms.

ii. **Study of DC and AC components of Global Electric Circuit (GEC):** This component is devoted to understand magnetospheric-ionospheric-atmospheric coupling by studying the influence of ionospheric and magnetospheric disturbances on global atmospheric electrical parameters by monitoring Air-earth currents at Maitri.

iii. **Plate kinematics, Isostatic rebound and Glacier motion investigations in Antarctic:** This part of the project performs studies on crustal deformation, glacier movement and kinematics of the Antarctica and adjacent plates from GPS and GRACE observations.

Study of Antarctic Plate Vertical deformation from GPS and GRACE revealed that maximum upliftment and horizontal movement dominate Peninsular Antarctica and West Antarctica, whereas low rate of horizontal movement and subsidence observed in eastern Antarctica. The study also shows that regardless of the origin of disagreement, elastically adjusted vertical GPS rate correlate very well with the latest Antarctic Elastic deformation model ***(Fig. 40)***.

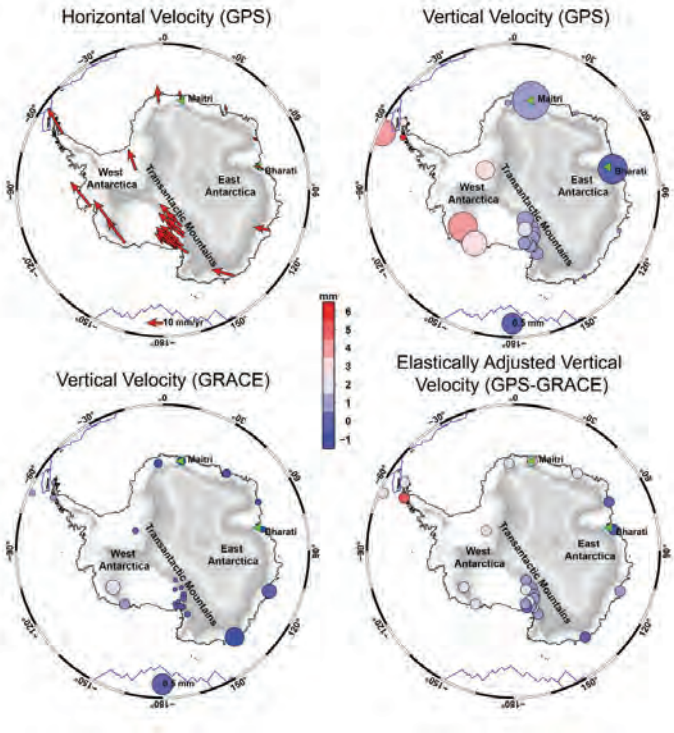

Figure 40 Horizontal and vertical velocity fields due to elastically adjusted deformation of Antarctic plate estimated from GPS and GRACE data.

It was envisaged that dayside cosmic noise absorption as observed by imaging riometer at Maitri can be attributed to energetic particles being pushed across the field line and getting azimuthally trapped in L-shell depending upon the energy of particles and drift in the dayside. Due to wave particle interaction these particles can fall in the loss cone and precipitate up to D-region of the ionosphere, resulting into the cosmic noise absorption (CNA) in the dayside. For the similar value of AL excursion whether the dayside CNA will occur or not, depends on the magnitude of interplanetary electric field (IEF) and the duration up to which this enhanced IEF is sustained ***(Fig. 41)***.

For the first time, the effects of a geomagnetic storm on the variation of the atmospheric electric field over Maitri (70°45′S, 11°44′E), Dome C (75°06′S, 123°20′E), and Vostok (78°27′S, 106°52′E) Antarctic research stations have been extensively analyzed. During strong substorm activity, significant variations are observed on PG from the three observatories. Observations clearly depict the

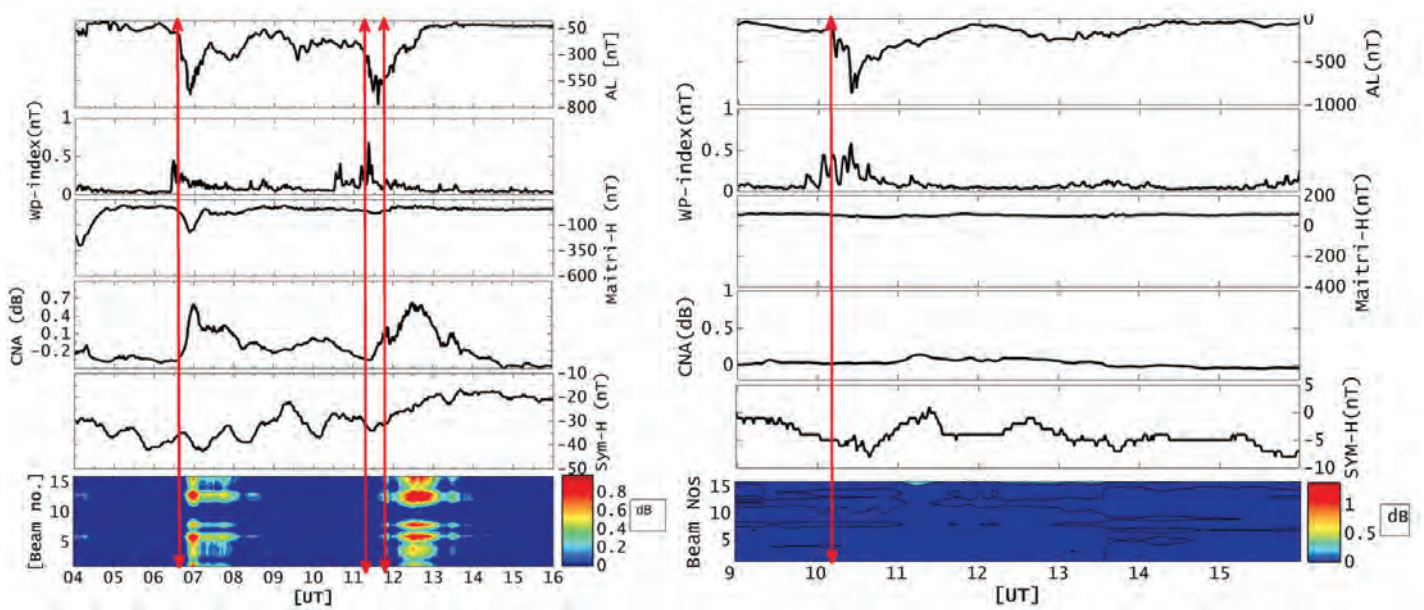

Figure 41 No day side CNA even though the all the criteria were fulfilled.

effect of geomagnetic conditions on atmospheric electrical parameters ***(Fig. 42)***.

Some new initiatives under this program are as follows,

In the Earth's magnetosphere, several types of ultralow-frequency (ULF) waves are generated. Most of them can penetrate the atmosphere, while propagating along magnetic field lines, and they can be detected on the ground by induction coil magnetometers (ICMs) at high latitudes. Spacecraft observations referenced with ground observations help in understanding the sources of these waves, and the role of the waves in particle acceleration/ precipitation. Thus, in addition to spacecraft observations, high-latitude ground observations with ICMs are important to understand the radiation belt dynamics. Recently the first observation of EMIC from Maitri is reported ***(Fig. 43)***. It is now planned to examine and explore characteristics and generation mechanism of these waves using multi-instrument data from Maitri in corroboration with other ground and satellite observations.

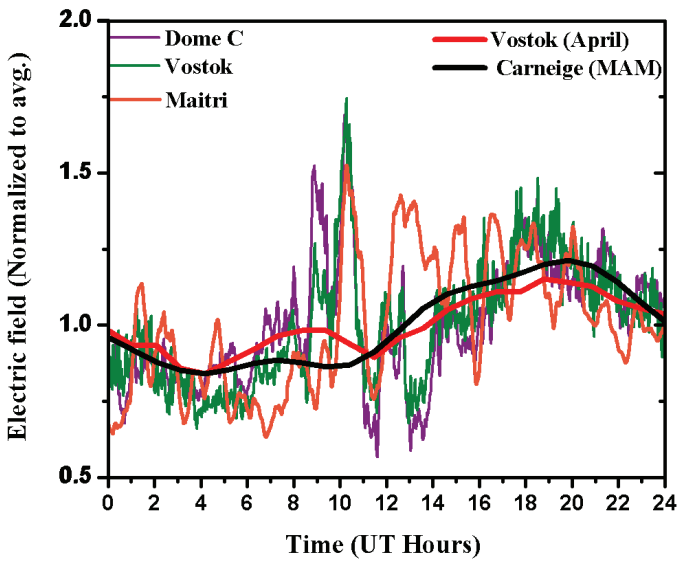

Figure 42 Variation of the atmospheric electric field over Maitri, Dome C, and Vostok Antarctic research stations showing the effects of geomagmetic storms.

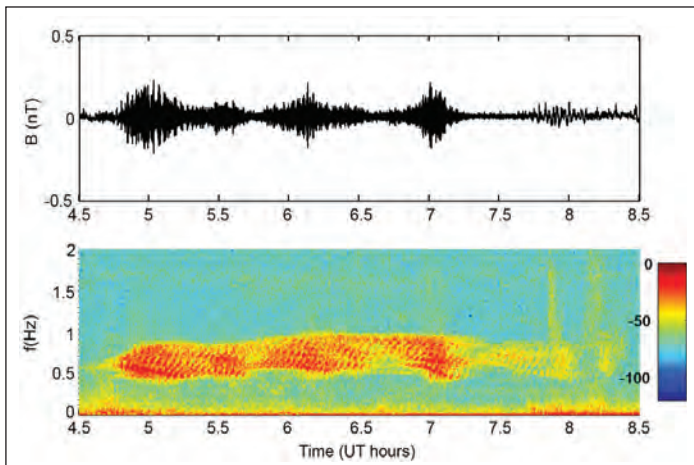

Figure 43 First electromagnetic ion cyclotron (EMIC) wave observations at Maitri (17 September 2011)

OBSERVATORY SYSTEM AND DATA ANALYSIS

INTERMAGNET *(International Real-time Magnetic Observatory Network)*

INTERMAGNET is a global network of observatories, monitoring the Earth's magnetic field, adopting modern standard specifications for measuring and recording equipment in order to facilitate high resolution data exchanges in close to real time. IIG is a participating institute in this programme. Near real time data received from INTERMAGNET System (at Alibag and Jaipur magnetic observatories) are processed on daily basis and these one minute observations of the Earth's magnetic field are emailed to Kyoto GIN which can be viewed as Quick-Look plots at the Kyoto website. Final one minute absolute values for the year **2014** are computed and sent to Paris GIN for inclusion in the annual DVD-ROM published by INTERMAGNET.

Scientists/Researchers downloaded digital data of **Alibag** from web: IAGA Day files: **65,120 days**

WORLD DATA CENTRE FOR GEOMAGNETISM (WDC, Mumbai)

World Data Centre (WDC) for geomagnetism, Mumbai has become regular member ICSU WDS after following various norms of this international scientific community.

The total number of registered users with the WDC website (http://wdciig.res.in) is now 700. This year around 50 new users registered. From all over the globe, around 750 data files have been accessed/downloaded from the WDC website by the end scientific users.

In continuation of long term preservation project, the conservation work of old Colaba observatory magnetograms is completed and Digital Imaging of various observatories is also completed. A software is prepared to get the ASCII value from these digitized images.

The regular updation of WDC website with latest release of datasets (i.e. new dataset from Indian observatories) is added to the web site for the year 2013 and 2014. Also one minute absolute data is added for the year 2010 to 2012 of Alibag, Jaipur and Nagpur observatories and soon other station data will also be added in the website for this period as per the IIG Data Policy.

Center also fulfilled various data request received through online data service portal and by email as per new IIG data policy**.**

DFM-1 data of Gulmarg and Pondicherry observatories for the year 2014 were processed with adopted base line values. The DFM-1 data of Gulmarg and Pondicherry observatories for the years 2013 & 2014 was published in CD with all stations data in regular volume. Presently the processing of 2015 data sets of Gulmarg and Pondicherry is underway.

INSTRUMENTATION DIVISION

DEVELOPMENT OF DIFFERENT TYPE OF MAGNETOMETERS, INSTALLATION AND MAINTENANCE OF OBSERVATORY INSTRUMENTS

Chief Coordinator : V.J. Jacob

Coordinators : Prasanna Mahavarkar

Members : All personnel working in the Instrumentation division

Proton Precession Magnetometers (Accuracy: 0.1 nT)

With the primary purpose of generating the ground-based magnetic data, the Instrumentation division has been developing low cost Proton Precession Magnetometers (PPM) for the last three decades. Beginning with the 1 nT PPM which has undergone several changes in design, the successor PM7 ***(Fig. 44)*** the advanced version has

Figure 44 Newly developed IIG make PM7.

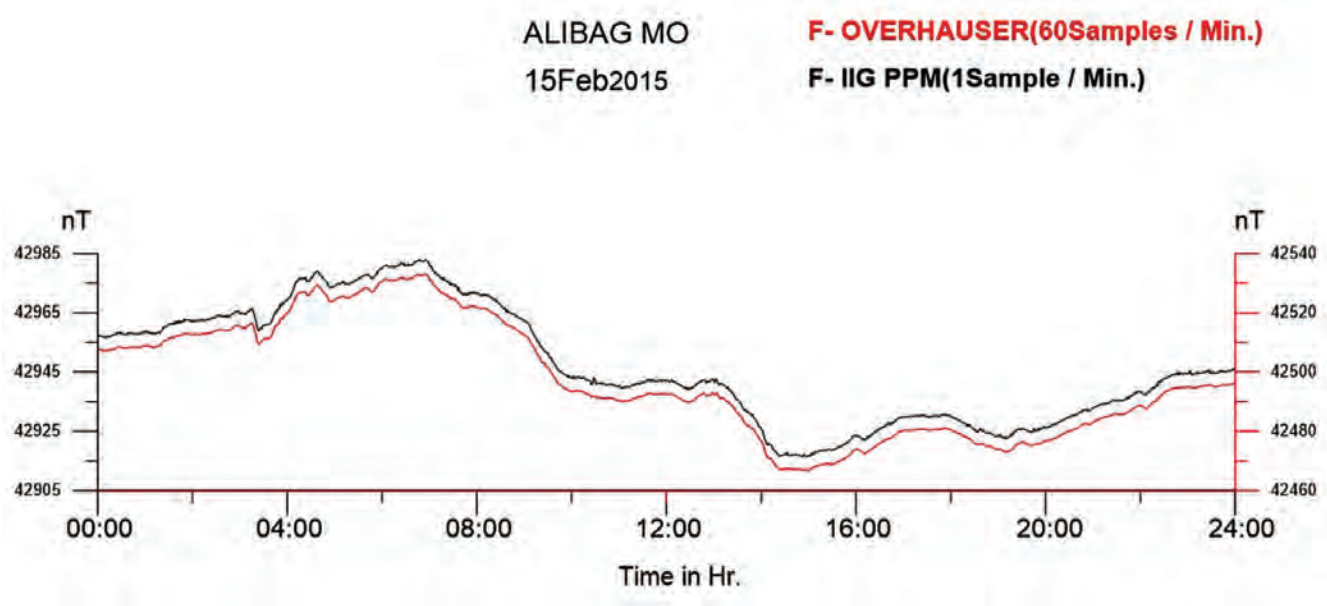

Figure 45 Data comparison of PM7 with commercially available Overhauser magnetometer.

been successfully developed by the institute. This year the Division has fabricated 5 numbers of these PPM's out of which 3 are tested. Further these PPM's are installed at various observatories of the institute. PM7 records the total field `F' with an accuracy of 0.1 nT and a sampling rate of 10 samples/second. The quality of data recorded by IIG make PM7 has been compared with the data recorded by one of the commercially available Overhauser magnetometer in the world market, and is found to be in excellent agreement with the Overhauser magnetometer ***(Fig. 45)***. With the superior quality of data generated by this instrument, PM7 is an affordable magnetometer for scientific institutions, University departments and colleges intending to carry out geomagnetic studies. The commercial cost of PM7 is ~20% of the cost of Overhauser available in market. These PPM's on demand are sold to various scientific institutions in India. A technical paper entitled "*The low cost Proton Precession Magnetometer developed at the Indian Institute of Geomagnetism: An affordable instrument for every laboratory*" is under review in Current Science.

Calibration of magnetometers at Alibag Magnetic Observatory

A Tri-axial Square Helmholtz Coil system for the study of palaeomagnetic studies was successfully commissioned at the Alibag magnetic observatory in the year 1985. This system was used for few years after which it encountered technical problems with the control unit. Rectification of the same could not be undertaken as the information document related to this system was not available and as a result the said system had been lying in an un-used state for a long time until 2015 when the system was re-commissioned and upgraded as a test facility for calibrating the magnetometer sensors. The system was upgraded with a constant current source and a data logging unit. Both these units have been designed and developed in the institute's laboratory. Also re-measurements of the existing system have been made thoroughly. The upgraded system is semi-automatic, enabling non-specialists to operate it. This facility ***(Fig. 46)*** is now in broad use for the parent institute and external

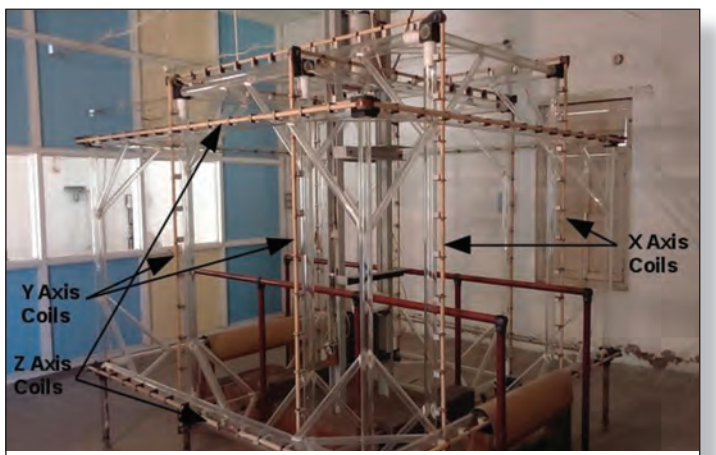

Figure 46 Tri-axial Square Helmholtz Coil system installed at Alibag Magnetic Observatory.

institutions to calibrate their magnetometers and also serves as a national facility. This facility was recently used by VSSC ISRO to calibrate their Fluxgate magnetometers for rocket experiments. "*Tri Axial Square Helmholtz Coil system at the Alibag Magnetic Observatory* highlighting the calibration results for the H, D and Z Field measurements are shown in ***Figs. 47a, b, c***.

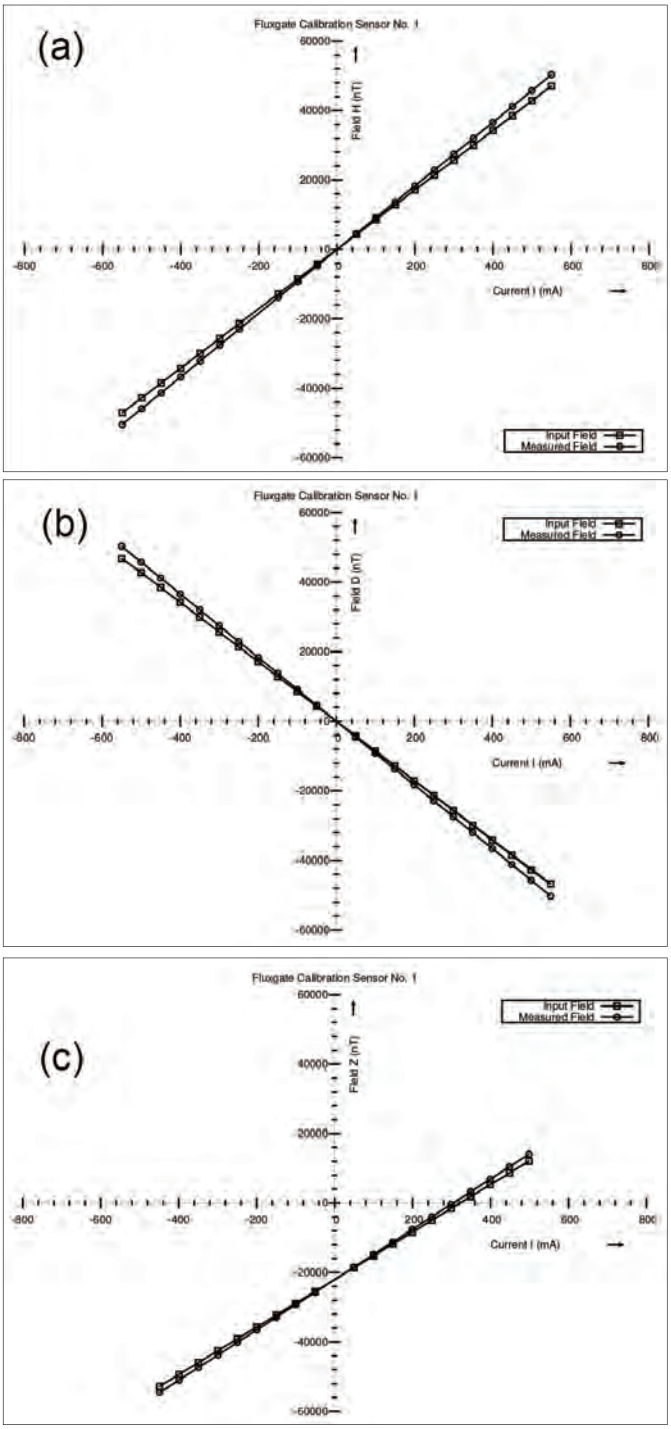

Figure 47 Calibration results for the H, D and Z field measurements

Software for Network of Geomagnetic Observatories

IIG magnetic observatories are networked to Panvel (HQ) server with real time data which is displayed at different locations within the institute viz. the Director's Cabin, Lobby and ODA Rooms etc. Until last year this activity was outsourced to a private external agency on AMC basis. This external agency is now discontinued and the task of technical trouble shooting of software was assigned to the Instrumentation section. Engineers from IIG HQ and EGRL worked in a collaborative mode and delivered user friendly software which caters to the day to day linking of real time observatory data with the institute HQ. This software plots real time observatory data and communicates to the institute HQ. A snapshot of the data in action is shown in ***Fig. 48***.

Scientific Project: PC Based dIdD Vector Proton Precession Magnetometer

PC based dIdD Vector Proton Precession Magnetometer was developed in the institute. This system was installed at Pondicherry Magnetic Observatory and is in continuous operation till date. It measures the instantaneous variation of Inclination and Declination and also the Total field F on a continuous basis.

Development of nT Logger

Developed a windows-based data logging system (nT LOGGER) for log and acquire data for magnetic observatories as import substitutes. One such unit is installed at Pondicherry MO and two units will be installed at Nagpur and Shillong.

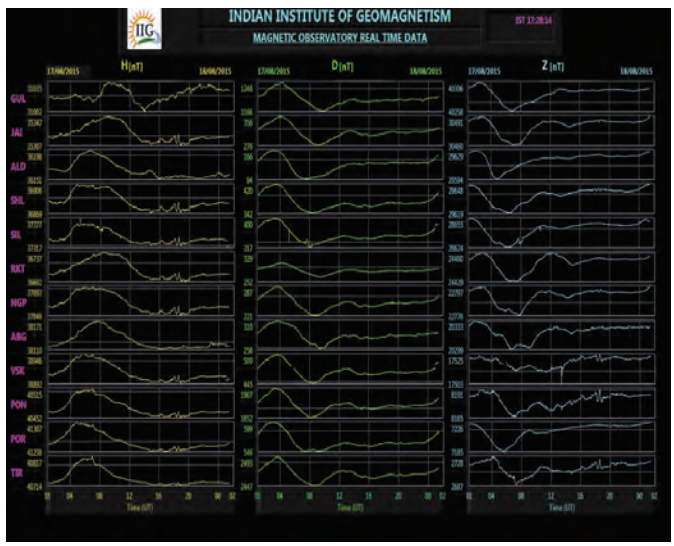

Figure 48 Magnetic observatory real time data.

COLLABORATIONS

Collaboration between NIT Warangal and IIG was finalized on November 23, 2015 with the signing of MoU. The scope of MoU covers collaborative R&D academic interaction leading to higher qualifications. The linkage involves collaboration in research projects and academic interaction in the areas of Mathematical Modeling, Computational Fluid Dynamics, Geophysical Modeling, Numerical Methods, Optimization, Operations Research, Coding Theory and all other relevant areas to both NIT Warangal and IIG.

MoU between Scientific Committee on Solar Terrestrial Physics (SCOSTEP) and IIG was inked on January 6, 2016 with an objective to provide training to young students from developing countries by scientists from IIG to enable the students to put the training in use for further development of their career.

FIELD SURVEYS

1. Electrical resistivity imaging (ERI) and vertical electrical sounding studies were carried out over the dyke swarm region of Nandurbar in north Maharashtra during April, 2015 to decipher potential groundwater aquifer zones within the dykes and also to understand the groundwater flow.
2. Carried out vertical electrical soundings in the rain-shadow regions of Satara-Sangli-Solapur in order to delineate shallow and deep aquifers. Also soil samples were collected to study the quality for agricultural purpose. These surveys were carried out in September-October, 2015 and December, 2015-January 2016.
3. Vertical electrical sounding data were acquired in Malwan-Aachra-Kankavli-Kharepatan-Vijaydurg in Sindhudurg district, Maharashtra. The aim of this study is to identify the extent of saline water ingress and to delineate zones of potential freshwater aquifers. This survey was conducted in February-March 2016.
4. Samples for archaeo, environmental magnetic and palaeoseismic studies were collected from Terna River, Sangamner, Maharashtra during May 18-28, 2015. The areas surveyed were Latur, Ter, Killari, Sangamner and Junnar.
5. Oriented block samples for the palaeomagnetic, rock magnetic, AMS and petrographic studies over the dolerite dykes of Singhbhum craton were collected from Keonjhar, Odisha during July 10-24, 2015.
6. Ground magnetic data was acquired in the region bounded by 19°- 20°N and 75° - 76°E covering areas of Aurangabad, Jalna and surrounding regions during the period November 16, 2015 to December 1, 2015. The objective of this study is to prepare a crustal magnetic anomaly map of the Deccan Volcanic Province of Maharashtra.
7. Ground magnetic, gravity and GPS data were acquired along an approximately 200 km long EW profile from east of Khanapur up to Guhaghar during September 21, 2015 to October 15, 2015 and March 10-24, 2016, with an objective to understand the density and magnetization inhomogeneities below the Deccan trap covered region of Maharashtra.
8. Magnetotelluric and Long period magnetotelluric survey was undertaken across north Cambay Basin across Mehsana and surrounding regions in Gujarat with total profile coverage of 200 km. The main objectives of this study were (a) to determine the thickness of sediments with hidden faults in the Cambay basin (b) to establish the Lithosphere-Asthenosphere boundary across all the profiles in the study region and (c) to identify the conductive zones (low velocity zones) at upper mantle depths due to Reunion plume activity. The data acquisition was accomplished in two campaigns during April 29 to June 6, 2015 and during February 25 to March 10, 2016.
9. To understand the contemporary kinematics and related active deformation across the main Himalayan thrust zones due to India-Eurasia collision, the 3rd GPS campaign survey was carried out during 1st May 2015 to 15th June 2015 at Himachal-Garhwal-Kumaun Himalayas.
10. To give an insight into the motion, related mass balance and future behavior of the Vestre Broggerbreen Glacier, Svalbard, Arctic, the 2nd GPS campaign survey was carried out during 3rd September 2015 to 1st November 2015.

PUBLICATIONS

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IMPACT FACTOR OF PUBLICATIONS DURING 2015-2016

Journal Name	Impact Factor
Advances Space Research	1.358
Ann. Geophysicae	1.709
Astrophys. Space Sci.	2.263
Commun. Nonlinear Sci. Numer. Simulat.	2.866
Curr. Sci.	0.926
Earth Planet Space	1.328
Environmental Earth Science	1.765
Geophys. Res. Lett.	4.196
GPS Solutions	2.991
History Geo Space Sci.	0.550
J. Atmos. Solar-Terr. Phys.	1.474
J. Earth System Sci.	1.040

Journal Name	Impact Factor
J. Geophys. Res.	3.426
J. Space Weather and Space Climate	2.558
J. Plasma Physics	0.864
J. Geodesy	2.699
Lithosphere	3.013
Natural Hazard Earth Syst. Sci.	1.735
Phys. Plasmas	2.142
Pure and Applied Geophysics	1.618
Quaternary International	2.062
Solar Physics	4.039
Space Weather	2.149

INVITED TALKS AND LECTURES

Dr. Mita Rajaram (Emeritus Scientist) was invited to present a talk on *"Imaging the earth's interior through geomagnetic data analysis"* at the Geophysics Department, Andhra University, Vishakhapatnam on December 22, 2015.

Dr. D.S. Ramesh was invited to deliver lectures at Department of Geophysics, Andhra University, Visakhaptnam on May 1, 2015.

Dr. D.S. Ramesh was invited to deliver a lecture at Department of Mathematics and Statistics, R.B.V.R.R Women's College, Hyderabad during the Diamond Jubilee celebration on August 17, 2015.

Dr. D.S. Ramesh was invited to address the Research Scholars & PG students at NIT, Warangal on the topic *"Is Research a forgotten option"* during January 21-23, 2016.

Dr. Amar Kakad was invited to present a talk on *"Wavebreaking of ion acoustic solitary wave in thermal plasmas"* (**Bharati Kakad** and Yoshiharu Omura**)** at 2nd URSI Regional Conference on Radio Science 2015, November 16-19, 2015, New Delhi.

Dr.C.P. Anil Kumar was invited to give a talk on *"Recent trends in Materials Science"* at Dept. of Physics, Sadakathullah Appa College, Tirunelveli, on January 11, 2016.

Dr. Gopi K. Seemala was invited to give a talk on *"Communication and Navigation using Satellites"* in a workshop under DST-SERB project held at BVC College, Amalapuram, India, during March 18-19, 2016.

Dr. Gopi K. Seemala was invited to give a talk on *"Application of NeQuick model in validation of 3D ionospheric tomography"* at Workshop and Conference on NeQuick Latest Developments and Advanced Uses, May 4-8, 2015, ICTP, Trieste, Italy.

Dr. Gopi K. Seemala was invited to give a talk on *"Using GPS data for Ionospheric studies and GPS-TEC derivation"* at 2015 African Geophysical Society conference September 21-25, 2015, Nairobi, Kenya.

Dr. Navin Parihar was invited to give a talk on *"Optical Study of Mesosphere-Lower Thermosphere-Ionosphere Region Using Airglow Phenomenon"* at National Centre of Experimental Mineralogy & Petrology, University of Allahabad on February 22, 2016 in the workshop *"Material Synthesis, HP-HT technique and use of Electron Microscopy"* held between February 16-22, 2016.

Dr. Navin Parihar was invited to give a talk on *"Airglow observations of the mesosphere-lower thermosphere region and climate change"* at K. Banerjee Center of Atmospheric and Ocean Studies, Department of Physics, University

of Allahabad under the auspices of UGC Academic Staff College conducted UGC refresher course on March 13, 2016..

Dr. Ravikumar. M was invited to give a talk *on "Deformation due to hydrological loading: inference from GPS and Grace"* at Discussion meeting on "GRACE Mission - Opportunities for India" on January 28, 2016 at National Centre for Earth Science Studies (NCESS), Thiruvananthapuram.

Dr. Rajesh Singh was invited to give a talk on *"ELF-VLF studies in India: Search for transient luminous events and earthquake precursors"* at IPER, Moscow, Russia on October 12, 2015.

Dr. Rajesh Singh invited to give a talk on *"Transient Luminous Events - an Overview"* at National Centre of Experimental Mineralogy & Petrology, University of Allahabad on February 22, 2016 in the workshop "Material Synthesis, HP-HT technique and use of Electron Microscopy", between February 16-22, 2016.

Dr. Rajesh Singh was invited to give a talk on *"Giant Lightning to the Edge of Space"* at K. Banerjee Center of Atmospheric and Ocean Studies, Department of Physics, University of Allahabad on March 16, 2016 under the auspices of UGC Academic Staff College conducted UGC refresher course.

Dr. Satyavir Singh was invited to give a talk on *"Electromagnetic ion cyclotron waves with losscone distribution of protons",* RISH, Kyoto University, Kyoto, Japan on February 18, 2016.

Dr. Satyavir Singh was invited to give a talk on *"Electromagnetic ion cyclotron waves in the Earth's magnetosphere",* HESA/IBSA workshop on *"Mathematical Modelling of Fluctuations in Space Plasmas",* SANSA Space Science Directorate, Hermanus, South Africa during October 15-16, 2015.

Dr. S. Gurubaran was invited to give a talk on *"A high altitude balloon experiment to probe stratospheric electric fields from low latitudes"* (**Manu, S., and K. Jawahar)** at the 14th International Symposium on Equatorial Aeronomy during October 19-23, 2015 at Bahir Dar, Ethiopia.

Dr. S. Tulasiram was invited to give a talk on *"Dusk side enhancement of convection electric field response – a case study on recent 17 March 2015 storm"* at Solar Terrestrial Environment Laboratory (STEL), Nagoya University, Nagoya, Japan, on July 3, 2015.

Dr. Ashwini K. Sinha delivered a talk on *"An analytical approach to geomagnetic pulsations"* on October 13, 2015 at Space Research Institute, Moscow, Russia.

PARTICIPATIONS IN CONFERENCES/MEETINGS/SEMINARS

NATIONAL

UGC Sponsored National Seminar on "Estuaries of India: Past, Present & Future", July 24 -25, 2015, Department of Geology, Govindram Seksaria Science College, Belagavi

Lakshmi, B.V., P.B. Gawali and P.T.Hanamgond

Mineral magnetic and trace element characterization of Gad river sediments, Maharashtra: source weathering implications.

37th Annual Convention Seminar and Exhibition on "Recent Advances in Geoexploration of Mineral Resources: Present Practices and Future Challenges", October 15-17, 2015, Jaipur, Rajasthan

Erram, V.C., G. Gupta, M. Laxminarayana, Suneetha Naidu and **G. Shailaja**

Hydro-geochemical assessment to evaluate the suitability of groundwater for domestic and irrigation purpose in parts of Sindhudurg district, Maharashtra.

52nd IGU Annual Convention and Meeting on "Near Surface Earth System Sciences", November 3-5, 2015, National Centre for Antarctic and Ocean Research (NCAOR), Goa

Anand, S.P., V.C. Erram and **G. Gupta**

Can magnetic data image sub-basalt structures? A case study from Chikotra River Basin in the Deccan Volcanic Province of Maharashtra.

Das, A., S. Maiti, **G. Gupta** and **V.C. Erram**

Estimation of aquifer parameters from surface geo-electrical method.

Maiti, S., M.K. Sen, A. Das, **G. Gupta** and **V.C. Erram**

Groundwater quality index forecasting using automatic relevance determination model.

Vijay Kumar, P.V., P.B.V. Subba Rao, C.K. Rao, Ajay K. Singh and P. Rama Rao

Frequency characteristics of geomagnetic induction anomalies in Saurashtra region.

2nd URSI Regional Conference on Radio Science 2015, November 16-19, 2015, New Delhi

Ajith K. K., and **S. Tulasiram**

Characteristics of evolutionary-type plasma bubbles and its rise velocities observed from Equatorial Atmosphere Radar.

Dube, A., A.K. Maurya, R. Singh and Morris B. Cohen

Cyclone/thunderstorm induced ionospheric disturbances.

Kakad, B., P. Gurram, P.N.B. Tripura Sundari and **A. Bhattacharyya**

Structuring of Equatorial spread-F irregularities during intense recent geomagnetic storm of solar cycle 24.

Ram Singh, S. Sripathi and **Sreeba Sreekumar**

Low latitude ionospheric response to a super geomagnetic storm of the current solar cycle occurred on 17 March 2015 over Indian region.

30th National Symposium on Plasma Science & Technology (PLASMA-2015), Dec 1-4, 2015, SINP Kolkata

Devanandhan, S., T. Sreeraj, S.V. Singh and **G.S. Lakhina**

The Effects of Electron Beam and Heavier Ions on Ion-Acoustic Solitary Waves.

Joshi, L. M. and **S. Sripathi**

Reliable measurement of F region vertical plasma drift during the daytime using ionosonde Doppler technique.

Rubia, R., S.V. Singh and **G.S. Lakhina**

Arbitrary amplitude ion acoustic solitons in the solar wind plasma.

LAIM Workshop, January 18, 2016, North East Hill University, Shillong

Tulasi Ram, S.

Dusk-side enhancement of Convection Electric field response during St.Patrick's day storm.

Kakad, B., P. Gurram, V. Yadav, M. Ravi Kumar, D. S. Ramesh and **A. Bhattacharyya**

Earthquake linked signatures in the equatorial ionosphere.

Science for Space Weather (SSW) Workshop/CCMC school, January 24 - 29, 2016, Goa, India

Pandya, M., R. Selvakumaran, Sandeep Kumar and **B. Veenadhari**

Investigation of Major Solar Eruptions of Solar Cycle 23 & 24 and their geoeffectiveness.

Ram Singh, S. Sripathi and **Sreeba Sreekumar**

Equatorial and low latitude Ionospheric Response to Some of the Space Weather Events over Indian region.

Discussion meeting on "GRACE Mission - Opportunities for India", January 28, 2016, National Centre for Earth Science Studies (NCESS), Thiruvananthapuram

Ravikumar, M.

Deformation due to hydrological loading: inference from GPS and Grace. (Invited)

19th National Space Science Symposium, February 9-12, 2016, Thiruvananthapuram

Lotekar, A., A.P. Kakad and **B. Kakad**

A new fluid code for modeling the evolution of plasma wave processes in the Earth's and other planetary magnetosphere.

Parihar, N.

Optical study of Mesosphere-Lower Thermosphere-Ionosphere region using airglow phenomenon.

Sathishkumar, S., P.V. Muhammed Kutty, S. Gurubaran, P.T. Patil and **R. Ghodpage**

Mean winds and planetary waves in the mesosphere and lower thermosphere over Kolhapur (16.8^{o}N, 74.2^{o}E).

INTERNATIONAL

International Symposium on Arctic / Antarctic Science summit week (ISAR-4), April 23-30, 2015, National Institute of Polar Research, Tachikawa, Tokyo, Japan,

Anil Kumar, C.P., N.Balan, **C. Panneerselvam, N. Jeni Victor, C. Selvaraj, K.U. Nair, P. Elango, K. Jeeva, A. Dhar, S. Gurubaran, B.M. Pathan** and C.Venugopal

Effects of Cosmic rays on clouds and snow-fall in Antarctica.

Japan Geoscience Union (JpGU) International Symposium, May 22-26, 2015, Makuhari, Messe, Japan

Tulasi Ram, S., K. K. Ajith, M. Yamamoto, T. Yokoyama, Y. Otsuka and T. Tsugawa

Long term observations of Equatorial Plasma Bubbles (EPBs) from EAR – New aspects.

Mbuli, L.N., R. Bharuthram, **S.V. Singh** and **G.S. Lakhina**

Slow and fast electron-acoustic solitons in three-electron temperature space plasmas.

Rufai, O.R., R. Bharuthram, **S.V. Singh** and **G.S. Lakhina.**

Auroral electrostatic super-acoustic structures in a magnetized three-component plasma.

Geospace Environment Modeling (GEM) workshop, June 14-19, 2015, Aspen, USA

Bhaskar, A. and **G. Vichare**

Forecasting geomagnetic field variations: Artificial Neural Network approach.

26th IUGG 2015 General Assembly, June 22 – July 2, 2015, Prague, Czech Republic

Sathishkumar, S., P.V. Muhammed Kutty and **S. Gurubaran**

Mesospheric and ionospheric responses during sudden stratospheric warming events at low and high solar activity.

Sau, S., V. Lakshmi Narayanan and **S. Gurubaran**

Simultaneous observation of large scale nightglow intensity perturbation and equatorial spread-F over the Indian dip equatorial station, Tirunelveli.

Vichare, G., N. Thomas, Ashwini K. Sinha and **Rahul Rawat**

Study of daytime Pi2 pulsations using CHAMP and ground observations.

12th International School/Symposium for Space Simulations (ISSS-11), July 3-10, 2015, Prague

Remya, B., B. T. Tsurutani, **R. V. Reddy, G. S. Lakhina** and R. Hajra

Cyclotron waves and pitch angle scattering in the magnetosphere.

12th International Symposium on Antarctic Earth Sciences, July 13-17, 2015, Goa, India

Behera, Jayanta K., Ashwini K. Sinha, Rahul Rawat and **A. Dhar**

Investigation of polar atmospheric response to the intense Geo-space activities.

Jeeva, K., A.K. Tiwari, **Jayanta K. Behera, S. Gurubaran, Mala Bagiya** and **Ashwini K. Sinha**

Physical and chemical coupling between the stratosphere and troposphere: A plausible mechanism to understand the solar-terrestrial-weather relationship.

Rahul Rawat, S. Manu, Ashwini K.Sinha and **S. Gurubran**

Seasonal and interhemispheric differences in the diurnal variation of Schumann resonance parameters.

Sunil, P.S., Ajish P. Saji, C.D. Reddy and **A. Dhar**

GPS and GRACE constrains on present day Antarctic glacial isostatic adjustment.

12th Annual Meeting, Asia Oceania Geosciences Society (AOGS), August 2-7, 2015, Singapore

Ajish P. Saji, P.S. Sunil, C.D. Reddy and P.K.R. Gautam

Effect of seasonal hydrological loading over Indian sub-continent and Himalaya from GPS and GRACE observations.

Balan, N., R. Skoug, **S. Tulasiram,** P.K. Rajesh, K. Shiokawa, Y. Otsuka, I. Batista, Y. Ebihara, Y. Omura and T. Nakamura

Severe Space Weather including historical events.

Behera, Jayanta K., Ashwini K. Sinha, Anand K. Singh, **Rahut Rawat** and **A. Dhar**

Day side cosmic noise absorption (CNA) at sub-auroral latitude (L=5, CGM -63^0 59' S, 53^0 59' E).

Lakshmi Narayanan, V., **Sukanta Sau**, **S. Gurubaran**, N. Balan, K. Shiokawa, **S. Sripathi** and **K. Emperumal**

Implications of different ionogram signatures of equatorial spread- F.

WDS-SCOSTEP Workshop on Global data activities on the study of Solar -Terrestrial variability, September 27-30, 2015, Tokyo, Japan

Veenadhari, B., Sandeep Kumar, S. Tulasiram, R. Selvakumaran, S. Mukherjee, R. Singh and **B. D. Kadam**

Extreme space weather events as seen in the historical geomagnetic records of Colaba, India and their estimation of interplanetary conditions.

HESA/IBSA workshop on "Mathematical Modelling of Fluctuations in Space Plasmas", SANSA Space Science Directorate, October 15-16, 2015, Hermanus, South Africa

Lakhina, G.S. and **S. V. Singh**

Generation of weak double layers and low-frequency electrostatic waves in the solar wind.

14th International Symposium on Equatorial Aeronomy, 19-23 October 2015, Bahir Dar, Ethiopia

Singh, Dupinder and **S. Gurubaran**

Long term tidal variability as observed from satellite and ground based observations.

Sreeba Sreekumar, S. Sripathi, K. Emperumal and B. Suneel Kumar

Role of thermospheric meridional winds in controlling the Equatorial Spread F (ESF) irregularities: A comparative study using h'F and hpF2 data.

2nd COSPAR Symposium, Water and Life in the Universe, November 9-13, 2015, Foz do Iguacu, Brazil

Anil Kumar, C.P. and N Balan

Effects of cosmic rays on clouds.

American Geophysical Union, AGU-2015, December 13-20, 2015, San Francisco, CA, USA

Maurya, A.K., M. B Cohen, **A. Dube** and **R. Singh**

Response of Ionosphere to the Tropospheric disturbances.

AGU Fall Meeting, December 14-18, 2015, San Francisco, USA

Devanandhan, S., T. Sreeraj, S.V. Singh and **G.S. Lakhina**

Oblique propagation of ion acoustic solitons in magnetized superthermal plasmas.

Joshi, L.M., S. Sripathi and **Ram Singh**

Low latitude Ionospheric response to the recent super storm of 17 March 2015: Modeling perspectives and recent findings.

U.S. National Committee for URSI meeting, January 6-9, 2016, Boulder, CO, USA

Maurya, A.K., M. B. Cohen, **Rajesh Singh**, T. Neubert and O. Chanrion

Morphology of TLEs producing thunderstorm over Indian region.

6th International Ground Water Conference, Association of Global Groundwater Scientists, February 11-13, 2016, SRM University, Chennai

Shailaja, G., G. Gupta, V.C. Erram and **M. Laxminarayana**

Identification of water bearing fractured zones in trap covered hard rock area of southern Maharashtra using vertical electrical sounding data.

Suneetha, N., M. Laxminarayana, V.C. Erram and **G. Gupta**

Geoeletrical studies for delineating seawater intrusion in west coast Maharashtra.

International Symposium on GPS – Radio Occultation, March 9-11, 2016, Taipei, Taiwan

Gowtham, V.S. and **S. Tulasi Ram**

Hemispheric and annual asymmetry of NmF2 observed by FORMOSAT-3/COSMIC radio occultation observations.

STUDENTS CORNER

Ms. G. Shailaja and **Ms. Suneetha Naidu** attended a training cum familiarization ***Workshop on "Surface Geophysics for Groundwater"*** organized by National Geophysical Research Institute, Hyderabad during December 14-19, 2015. During the week long training program they were introduced to groundwater geophysics, electrical and electromagnetic methods for groundwater exploration and data analysis techniques. A field work was also organized and different surficial geophysical techniques were demonstrated.

Ms. G. Shailaja and **Ms. Suneetha Naidu** also attended the ***6th International Groundwater Conference*** at SRM University, Chennal during February 11-13, 2016 and presented papers.

Dr. Ajeet K. Maurya (RA) was awarded Fulbright-Nehru Postdoctoral Research Fellowship for the year 2015-16 by United States - India Educational Foundation (USIEF), New Delhi, to carry out postdoctoral research at Georgia Institute of Technology, Atlanta, USA.

Ms. Neethal Thomas received SCOSTEP's Visiting Scholar (SVS) scholarship 2015.

Mr. R. Selvakumaran visited Goddard Space Flight Center (GSFC), NASA under SCOSTEP Visiting Scholar Program - 2015 for a period of 3 months (October 2015 to January 2016). He worked on Identification of source location of Coronal mass ejections (CMEs), ICME magnetic structures corresponding to the geomagnetic storm occurred in solar cycle 24 under Dr. Nat Gopalawamy and his team at GSFC, NASA. He also investigated the dependence of solar source (CME) and interplanetary parameters for moderate geomagnetic storms occurred in solar cycle 23 and 24.

Ms. Nisha Nair was awarded Ph.D. degree in Geophysics by Andhra University, Visakhapatnam based on her thesis entitled *"Geophysical characterization of tectonic elements along the Western Continental Margin of India and the Andaman-Sumatra Arc-Trench system"* under the supervison of **Prof. Mita Rajaram** (IIG) and Prof. P. Rama Rao (Andhra University).

Manu, S. was awarded Ph.D. degree for his thesis titled *"Investigation of near Earth space environment"* by M.S. University, Tirunelveli, under the supervision of **Prof. S Gurubaran.**

DEPUTATIONS/VISITS ABROAD

Name	Country visited	Duration	Conference/workshop/symposium
Dr. Navin Parihar	Italy	May 3-9, 2015	The Abdus Salam International Centre for Theoretical Physics
Dr. G.K. Seemala	Italy	May 4-8, 2015	International Center for Theoretical Physics(ICTP), Italy
Ankush Bhaskar	United States	May 14- June 13, 2015	Goddard Space Flight Center, NASA. ''Understanding radiation belt dynamics during geomagnetic storms''
Dr. S. Tulasiram	Japan	May 22- July 25, 2015	Solar Terrestrial Environment Laboratory (STEL), Nagoya University, Nagoya, Japan, ''Collaborative research under STEL International Joint research program''
Dr. B. Veenadhari Dr. S. Satishkumar	Prague	June 22-27, 2015	26th IUGG 2015 General Assembly, held in Prague, Czech Republic
Ajay Lotekar	Prague	July 3-10, 2015	12th International School/Symposium for Space Simulations, Czech Republic
Virendra Yadav K.Venkatesham	Peru	July 19-25, 2015	Jicamarca Radio observatory, Peru
Ajish P. Saji	Singapore	August 2-7, 2015	12th Annual Meeting, Asia Oceania Geosciences Society (AOGS)

Name	Country visited	Duration	Conference/workshop/symposium
Dr. G.K. Seemala	Kenya	September 21-25, 2015	Technical University of Kenya, Kenya
Dr. Satyavir Singh	South Africa	September 22-October 21, 2015	Visiting Scientist, University of the Western Cape, Bellville and Hermanus Magnetic Observatory, Hermanus, South Africa
Dr. B.Veenadhari	Japan	September 27-30, 2015	National Institute of Information and communications Technology (NICT), World Data System (WDS), Tokyo
Dr. Rajesh Singh	Denmark	September 27-October 8, 2015	National Space Institute, Technical University of Denmark (DTU Space), Copenhagen
Dr. B.Veenadhari	Japan	October 1-3, 2015	Research Institute for Sustainable Humanosphere (RISH), Kyoto University, Kyoto
Dr. Ashwini K. Sinha	Russia	October 5-17, 2015	Indo-Russian Project, Institute of the Physics of the Earth (IPER), Moscow, Russia
Dr. Rajesh Singh	Russia	October 9-17, 2015	Indo-Russian Project, Institute of the Physics of the Earth (IPER), Moscow, Russia
Dr. Satyavir Singh	Japan	February 15-March 14, 2016	Indo-Japan Project "Comprehensive study of particle acceleration processes in Earth's magnetosphere during extreme space weather events".
Dr. Amar Kakad	Japan	February 15-March 16, 2016	Research Institute for Sustainable Humanosphere, Kyoto University, Kyoto
Antarctic/Arctic Expeditions			
Dr. P.S. Sunil	Norway, Arctic	Arctic Expedition, September 3-November 1, 2015	Scientific Expedition to Himadri, Ny-Alesund, Svalbard
P. Elango	Maitri, Antarctica	34th ISEA	Winter member and Station Commander, Maitri
Varun Dongre	Maitri, Antarctica	34th ISEA	Summer member, Maitri

DISTINGUISHED VISITORS

Dr. N. Satyavani

Principal Scientist, NGRI, Hyderabad, visited the Institute on April 9, 2015 and gave a lecture on *"Role of Seismics in Hydrocarbon Exploration"*.

Dr. Hemali J. Tanna

National Institute of Technology, Surat, Gujarat, visited IIG on May 7, 2015 and gave a talk on *"A study of Ionospheric fluctuations through the time-series analysis methods"*.

Dr. Shobha R. Surve

Physics Department, University of Mumbai, Mumbai visited the Institute on May 15, 2015 and gave a lecture on "*Study of the presence of dust grains effect on the wave particle interaction in the near Earth space environment*".

Prof. Y. N. Reddy

Department of Mathematics, National Institute of Technology, Warangal, visited IIG on June 15, 2015 and enlightened the scientists and students on *"Numerical treatment of singularly perturbed differential difference equations"*.

Dr. Amod Anandkumar

Visited the Institute on July 15, 2015 to teach *"Signal processing using MATLAB"*.

Dr. R. Gopichandran

Director, Vigyan Prasar, New Delhi, visited the Environmental Magnetism laboratory on July 16, 2015.

Dr. T.V. Venkateswaran

Scientist "F", Vigyan Prasar, New Delhi, visited the Environmental Magnetism laboratory on July 16, 2015.

Prof. Yoshiharu Omura

Research Institute for Sustainable Humanosphere (RISH), Kyoto University, Japan, visited IIG during the period September 6-11, 2015 and gave a colloquium on the topic entitled *"Generation mechanism of whistler-mode chorus emissions"*.

Olga Kozyreva and **Ekaterina Vorontsova**

IPER, Russian Academy of Sciences, Moscow, visited IIG under Indo-Russian project and gave lectures on December 1, 2015 on the topics *"Global Pc5 pulsations during magnetic storms"* and *"The complex analysis variations of the natural electromagnetic fields, total electron content and recordings of the seismic waves"*.

Prof. Vikas S.Sonwalkar

University of Alaska Fairbanks, visited IIG and gave a lecture on January 13, 2016 on the topic *"Variation of Plasmaspheric (90-4000 km) Field-aligned Electron Density and Ion Composition as a Function of Geomagnetic Storm Activity"*.

Professors Shin-Yi Su and **Lung Chi Tsai**

National Central University, Chung Li, Taiwan, visited IIG during January 21-28, 2016 under the India-Taiwan Science and Technology cooperation project. During their stay, they gave a lecture on January 25, 2016 on the topic entitled *"Longitudinal distributions of nighttime equatorial irregularity occurrences and the vertical drift velocity and density variations during solstices"*.

Dr. Bijendra Singh

Chief Scientist (Retd.), National Geophysical Research Institute, Hyderabad, visited IIG and delivered a talk on *"Long wavelength gravity anomalies over Indian subcontinent and its geotectonic interpretation"*.

Dr. Aniket Sule

Homi Bhabha Center for Science Education, TIFR visited the Environmental Magnetism laboratory on February, February 26, 2016.

B.T. Tsurutani

Jet Propulsion Laboratory, California Institute of Technology visited the Institute on February 16, 2016 and gave a lecture on *"Space weather"*.

HONOURS AND AWARDS

Dr. D.S. Ramesh was conferred **Fellow**, Andhra Pradesh Akademi of Sciences, 2015.

Dr. D.S. Ramesh was invited as Chief Guest at St. Pious X Degree & PG College for Women, Hyderabad at the valedictory session of National Seminar on *"Impact of scientific Advances on Society"* during August 18-19, 2015.

Dr. D.S. Ramesh was invited to Co-chair the seminar on *"Learning from Nepal Earthquake for Indian Himalayas and Gangetic Plains"* at INSA Bhavan, New Delhi on August 20, 2015.

Dr. P.S. Sunil was selected as a Member in the Board of Studies**,** Dept. of Marine Geology & Geophysics, Cochin University of Science and Technology, Kochi, Kerala for a term of 4 years from July, 2015.

Dr. S.K. Bhardwaj received the *"24th Ashirwad Rajbhasha Samman".*

Dr. S. Gurubaran was elected as Chair, Interdivisional Commission on Developing Countries (ICDC), International Association of Geomagnetism and Aeronomy (IAGA), for the period 2015-2019.

Dr. Satyavir Singh chaired a session at HESA/IBSA workshop on *"Mathematical Modelling of Fluctuations in Space Plasmas"*, SANSA Space Science Directorate, Hermanus, South Africa during October 15–16, 2015.

TRAINING IMPARTED

Dr. Gautam Gupta

Guided the project work entitled ***"Dykes as potential groundwater locale in semi-arid areas of Nandurbar region, Maharashtra: a geophysical perspective"*** by Mr. Ajinkya R. Yadav, G.K.G. College, Kolhapur during the period November 16-December 23, 2015 in the partial fulfillment of the requirements for the award of M.Sc. in Geology of Gopal Krishna Gokhale College, affiliated to Shivaji University, Kolhapur.

Dr. P.S. Sunil

Supervised the following students to carry out dissertation / summer training

Komal Sharma, M. Tech., Department of Applied Geophysics, Kurukshetra University, Kurukshetra, Haryana on the topic ***"A 3D moho depth model for the Himalaya-Tibet from EIGEN-6C4 Satellite Gravity data,"*** during February-April 2015.

Shikha K. Sajeev, M. Sc., Department of Marine Geology & Geophysics, Cochin University of Science and Technology, Kochi, Kerala on the topic ***"Imaging the b-value anomalies within the Pamir- Hindu Kush Subduction Zone using earthquake data,"*** during December, 2015-February, 2016.

Vishnu K. Raji, M. Sc., Department of Applied Geophysics, Manonmaniam Sundaranar University, Tirunelveli, Tamilnadu, entitled ***"Present-day tectonic regime and stress patterns from inversion of focal mechanism data, in the Pamir-Hindu Kush Subduction Zone,"*** January-March 2016.

Dr. S.P. Anand

Guided the following students for dissertation / summer training,

Himanshu Gupta, Department of Earth Science, Indian Institute of Technology, Bombay on the topic "***Depth to magnetic sources using Euler Deconvolution - A review"***, during June-July 2015.

Zeba Nazren, Department of Geology and Geophysics, Cochin University of Science and Technology on the topic ***"Aeromagnetic Data analysis and interpretation over the seismically active Koyna Region"***, during December, 2015-February, 2016.

Abhijit Patil, Nowrosjee Wadia College, Pune on the topic ***"Role of gravity and magnetic method in hydrocarbon exploration: A comprehensive report"***, during January-February 2016.

Alex Antony, Department of Geotechnology, M.S. University, Tirunelveli on the topic ***"Free air gravity studies over the aseismic Comorin Ridge with emphasis on Energy Spectral Analysis"***, during January-March 2016.

Dr. P.B.V. Subba Rao

Guided Mr. S. Eswara Rao towards the partial fulfillment of the M. Sc. Degree in Geophysics, Andhra University, Visakhapatnam on the topic ***"Geomagnetic Depth Sounding in Shillong Plateau and surrounding regions"*** during May-June 2015.

Guided Mr S. Sajan, from integrated geophysics course from Department of Applied Geophysics, ISM, Dhanbad towards summer training in ***"MT techniques"*** during May-June 2015.

Dr. Vinit C. Erram and Dr. Gautam Gupta

Guided the dissertation of Ms. Aditi Singh, M.Sc. (Tech.) Geophysics, B.H.U. Varanasi, on the topic***"Geophysical techniques over Konkan coastal belt of Maharashtra"*** towards the partial fulfillment of M.Sc. degree in Geophysics during May 27-July 13, 2015.

Guided the dissertation of Ms. Afrin Shaikh, G.K.G. College, Kolhapur on the topic ***"Delineation of subsurface structure and basement surface of Chikotra basin, Kolhapur, Maharashtra using ground magnetic data"***, during the period November 16-December 23, 2015.

Dr. B.V. Lakshmi

Guided Mr. Sumit B. Bhavsar, M.Sc. Applied Geology, from North Maharashtra University, Jalgaon, Maharashtra, on his internship project entitled ***"Distinguishing sediments from the Girna, Anjani and Tirna rivers, Maharashtra: a mineral magnetic approach"*** during his internship from May 15-June 30, 2015.

Supervised the internship of Mr. Allwin Shrisundar, M.Sc. Applied Geology from, Gopal Krishna Gokhale College,Shivaji University, Kolhapur, on the project ***"Mineral magnetic properties of sediments from Sastur and Killari along Tirna River, Maharashtra"*** from November 26-December 26,2015.

Guided Ms. Kanika Lalwani, M.Sc. Applied Petroleum Technology, from Nowrosjee Wadia College, Pune, during her internship project on ***"Paleoenvironmental changes in sediments of Ujani, Tirna river, Maharashtra: insights from Environmental Magnetism and Geochemistry"*** from January 4-February 4, 2016.

Guided the internship project of Mr. Shinto Raju, M.Sc. Applied Geophysics, Manonmaniam Sundaranar University, Tirunelveli, Tamilnadu, on ***"Integrated anisotropy of magnetic susceptibility, mineral magnetic and geochemical studies to delineate the sediment source in Sawari sediments along Tirna river, Latur-Osmanabad, Maharashtra, India"*** during the period January, 2016 to March, 2016.

Guided Mr. Dhananjay, M.Sc. Applied Geophysics, from, Ambedkar University, Srikakulam, Andhra Pradesh, for completing his internship project on ***"Changing characteristics of river sediments deciphered from magnetic and geochemical studies on Makni sediments, Tirna River, Latur, Maharashtra, India"*** during the period January-March, 2016.

Dr. K. Deenadayalan

Guided Mr.Sanket Kumar, M.Sc. Geology from Central University of Karnataka, for the completion of the project on ***"Mineral Magnetic studies of archaeological artefacts from Ter and Junnar, Maharashtra historical sites"*** during June 2015.

Supervised the project of Mr. Ajith, K.M., M.Sc. Geophysics from Manonmaniam Sundaranar University, Tirunelveli, Tamilnadu, on ***"Variations in magnetic parameters and Geochemical Characteristics in sediments from Dutta, Latur, Maharashtra, India"***, during January-March, 2016.

Guided Mr. Jinkala Saidulu, M.Sc. Applied Geophysics, from, Ambedkar University, Srikakulam, Andhra Pradesh, on the project topic ***"Mineral magnetic and Geochemical studies on Boargon sediments of Tirna river, Latur, Maharashtra"*** during January-March, 2016.

Shri P.B. Gawali

Mr. Sushil Mudabe, pursuing M.Sc. Applied Petroleum Technology, from Nowrosjee Wadia College, Pune, completed his internship project on ***"Distinguishing sediments from the Chandanpuri, Sangamner, Maharashtra: A mineral magnetic approach"*** from January 4-February 4, 2016.

Mr. Akshay Yadav, pursuing M.Sc. Applied Petroleum Technology, from Nowrosjee Wadia College, Pune, completed his internship project on ***"Variations in magnetic parameters and geochemical characteristics in sediments from Palsap, district Latur, Maharashtra, India"*** from January 4-February 4, 2016.

Mr. Rohan R. Jadhav, pursuing M.Sc. Applied Petroleum Technology, from Nowrosjee Wadia College, Pune, completed his internship project on ***"Petrogenetic fundamentals and variations in magnetic and geochemical characteristics in sediments from Harwadi, Manjra River valley, Latur, Maharashtra, India"*** from January 4-February 4, 2016.

Dr. M. Ravi Kumar

Guided the M.Sc. dissertation of Mr. Chonde Shivling Vankatrao, School of Earth Science, S.R.T.M. University, Nanded on the topic ***"Isostatic anomaly beneath the NW Himalayan region"*** during May- July 2015.

Dr. Amar Kakad

Guided the Pre-Ph.D. project of Mr. Ajay Lotekar entitled ***"Numerical methods and their applications to simulate differential equations"***.

Dr. Bharati Kakad

Supervised the M.Sc. Project work of Ms. Tripura Sundari from Andhra University, Visakhapatnam, during June 2015.

Dr. Gopi Krishna Seemala

Guided the project work done by K. Rama Tarisha entitled ***"Study of Sporadic E characteristics during high, low solar period (2001, 2004, 2006)"***.

Dr. Navin Parihar

Guided the M.Sc. dissertation of Mr. G. Satya Phani Charan of Department of Physics, Andhra Univeristy, Vishakhapatnam, on the topic ***"Measurements of near mesopause temperatures using OH nightglow over Allahabad (25° N), India"*** during May-June 2015.

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Dr. S. Sripathi

Mr. Harikrishnan from Madras Christian College, Madras did his summer project work under summer trainee program.

Dr. C.P. Anil Kumar guided the following students for dissertation / summer training,

Ms. Ananthalakshmi for the award of M.Sc. (Space Physics), Andhra University entitled ***"Numerical computation of ionospheric electric potential"***.

T. Balachandran M. Tech, (Environmental Science), Anna University, Tirunelveli, on the topic ***"A study of Inter annual variation of northeast monsoon rainfall (NEMR) observed from 1990-2006 Tamil Nadu and Pondichery"***, and hands-on training and data analysis of EFM-100.

Dr. Manohar Lal

Supervised the M.Sc. Project work of Mr. M. Ram Prasad on the topic entitled ***"Geomagnetic storm induced ionospheric current"*** during May-June 2015.

Dr. Rajesh Singh

Supervised the M.Sc. Project work of Ms. P Nymisha on the topic ***"Ionosphere Radio sounding by Very Low Frequency (VLF) Whistler waves"*** during May-June 2015.

A batch of 6 M.Sc. students (Ms. Pratigya Pathak, Ms. Shraddha Srivastava, Ms. Anamika Pandey, Mr. IrjeshSonker, Mr. Mohan Kumar, and Mr. Shyam Sharma) from Department of Earth and Planetary Sciences, University of Allahabad completed one month summer internship/training on the science experiment facilities at KSK GRL, IIG, Allahabad during July 2015. The title of their report is ***"Exposure to the Science, Expertise and Facilities available at KSK GRL, IIG, Allahabad".***

Dr. Rajesh Singh and Mr. Prabhakar Tiwari

Supervised the M.Sc. Project work of Ms. B. Lakshmi on the topic entitled ***"Ionosphere Radio Sounding by Ionosonde"*** during May-June 2015.

Dr. S. Satishkumar

Imparted training to Research Scholar from Shivaji University, Kolhapur in the topic "***Data analysis technique in the middle atmosphere dynamics"***.

PARTICIPATION IN SPECIALIZED WORKSHOPS/ TRAINING COURSES

Drs. S.P. Anand and **M. Ravikumar** participated in the two day intensive training on "COMSOL Multiphysics" held at Pune on June 25-26, 2015 conducted by COMSOL India.

Dr. S. Sripathi attended a two weeks general management program (GMP) for scientists at Administrative Staff College of India (ASCI), Hyderabad during July 6-17, 2015.

Mr. M. Ponraj participated in the training school on Glacial Isostatic Modeling at Stone Laboratory, Ohio State University, Gibralter Island, Lake Erie, US during September 13-19, 2015.

Dr. Navin Parihar participated in the Workshop and Conference on NeQuick Latest Developments and Advanced Uses during May 4-8, 2015 at ICTP, Trieste, Italy.

OFFICIAL LANGUAGE (HINDI)

Rajbhasha Adhikari	:	**S.K. Bhardwaj**
Asst. Director (Official Language)	:	**J. Kamra**
Senior Hindi Translator	:	**Manju J. Singh**
Hindi Typist	:	**K. Shelatkar**

In compliance with the provisions of the Official Languages Act, Rules, Annual Programme and other directives issued from time to time by the Department of Official Language, the Institute regularly undertakes some important routine and special activities to increase the progressive use of official language Hindi among its members.

The Institute organized Hindi Mah during September-October, 2015. The Hindi competitions organized during this period included Computer Typing, General Knowledge, Crossword, Essay Writing and Word Construction, which were well attended by the members. Hindi Mah concluded with a prize distribution function organized on October 27, 2015, in which Chief Guest Shri Nandlal Sachdev, General Manager, MTNL, Navi Mumbai addressed the gathering. He said that it was beyond his imagination that a specialized scientific research institute like IIG can also easily undertake its scientific and technical activities in Rajbhasha Hindi. He appreciated the concerted efforts from each and every member of the Institute towards progressive use of official language Hindi in all the activities. He also stated that the subordinate staff should always be encouraged to do official work in Hindi. Prof. D.S. Ramesh, Director gave a brief speech regarding the inspection of the Institute by the Committee of Parliament on Official Language on June 27, 2015 and told that barring some shortfalls the Parliamentary Committee was well satisfied with the institute's performance with regard to implementation of Official Language Policy. He told that the Institute has bagged a number of coveted shields and awards for religiously implementing the Official Language Policy of the Union. He urged the staff of the

Institute to do maximum work in Hindi and thereby achieve the targets set by the Government. He also gave away prizes to the winners of the various competitions.

Dr. S.K. Bhardwaj, Rajbhasha Adhikari briefing about the activities of Hindi Mah celebrations at the institute.

Chief Guest Shri Nandlal Sachdev addressing the staff during the concluding session of Hindi Mah celebrations.

Director Dr. D.S. Ramesh giving away prizes to the winners of the various competitions held during Hindi Mah celebrations.

The Committee of Parliament on Official Languages visited Mumbai during June 25-27, 2015 for inspection of six organizations. During the inspection on June 27, 2015, six members of the Institute and three members from the Dept. of Science & Technology were present before the Committee. At the outset, Dr. D.S. Ramesh, Director, presented a brief overview on the functions and achievements of the Institute. Hon'ble Member of Parliament Dr. Satyanarayan Jatia, Dy. Chairman, presided over the meeting. The inspection concluded in a cordial atmosphere and measures to increase the progressive use of Hindi were also discussed. During the inspection, apart from Hindi and bilingual publications, some scientific posters in Hindi were also displayed. The Committee of Parliament appreciated the efforts put in by the Institute for the implementation of the Official Language.

Hindi House Magazine "SPANDAN" was published as a regular activity, which includes scientific and technical articles also. The magazine is sent to all the scientific and educational institutes of the country.

During the year, four Hindi Workshops were organized on different topics, in which a total of 82 members participated.

Staff members attending a workshop in Hindi.

Geetanjali Shirke, Cyberspace Multimedia Ltd., visited the Institute on December 29, 2015 to give a tutorial on *"Use of Akruti Hindi Software - An Introduction"*.

Under the incentive scheme, 16 staff members of the Institute were awarded with cash prize for doing their official work in Hindi during the Annual Day Celebrations.

Asstt.Director (O.L.) and Sr. Hindi Translator continued as members of the editorial board of Hindi Magazine 'Samanvaya', being jointly brought out by the member organizations of TOLIC, Navi Mumbai.

Rajbhasha Adhikari, Asstt.Director (O.L.) and Sr. Hindi Translator of the Institute attended various meetings/ seminars held under the aegis of TOLIC, Navi Mumbai and other voluntary organizations. Some of the staff members participated in the competitions organized by TOLIC.

The Institute bagged appreciation award from TOLIC, Navi Mumbai for the implementation of Official Language Policy.

Dr. Sandeep Kumar Bhardwaj, Rajbhasha Adhikari, was felicitated by Mumbai based cultural organization 'Ashirwad' for his contribution towards implementation of official language policy in the Institute.

SCIENCE OUTREACH ACTIVITIES

The Institute has been actively promoting Science Outreach Program by holding various programmes for the students and participating in Science Exhibitions held at state and national level for the benefit of student community.

In the year 2015-16, the Institute carried out following activities:

i. Students from 14 Schools/Colleges visited the Institute and Magnetic Observatory Alibag to get acquainted with the Science of Geomagnetism and allied fields.

ii. A total of 25 talks were delivered by IIG Scientists at various forums and on various topics for the benefit of students.

iii. IIG participated in Indian Science Congress – 2016, BVS Science Sammelan and Expo- 2015 (held at Goa), Science Expo- 2015, held at Nehru Science Centre, Mumbai.

iv. Week long open house celebrations were held during Science Day Celebrations from 22-26 February 2016 at IIG. 3-Day open house celebrations were also held at IIG Regional Centres KSKGRL, Allahabad and one day open house exhibition at EGRL, Tirunelveli.

v. DAV Public School, New Panvel celebrated late Dr. A.P.J. Abdul Kalam's birthday on 15 October 2015, by organizing special lectures on the topic "Late Dr. A.P.J. Abdul Kalam and his Mission and Vision". Shri Ajay Dhar was Chief Guest at the function and delivered two talks on (i) "Late Dr. A.P.J. Abdul Kalam and his Mission and Vision" and (ii) Antarctica – The frozen continent.

vi. The Institute on the request of Maharashtra State Council of Educational Research and Training (Regional Office) and Institute of Vocational Guidance and Selection, Government of Maharashtra held a one day training session for their teachers working in secondary schools on "Vocational Guidance" on 30 June 2015. Forty five teachers and five vocational guidance officers attended the session.

The following schools/colleges visited the Institute to get acquainted with the science of geomagnetism and allied fields:

i. Two batches of 70 Students each of 2nd and 3rd year Electronics and Telecommunication and Computers Branches of Don Bosco Institute of Technology, Mumbai visited the Institute on a study tour during the year. Shri Ajay Dhar delivered two talks on "Basics of Geomagnetism" to the students.

ii. 25 Students accompanied by 2 Professors of D.Y. Patil College of Engineering & Technology (Civil Branch), Kolhapur, visited the Institute on a study tour on October 20, 2015. The students were explained the science of Geomagnetism & Allied Fields through talks and colorful posters. They were also explained the importance of Geomagnetic Observatories. Prof. C.K. Rao, Dr. S.P. Anand and Shri Pravin B. Gawali delivered talks to the students.

iii. A batch of 60 Students of 1st and 2nd year B. Sc. Science of Rajiv Gandhi College of Arts, Science & Commerce, Navi Mumbai visited the Institute on September 14, 2015 for a study tour. Shri Ajay Dhar delivered two talks on "Introduction to IIG" and "Basics of Geomagnetism" to the students.

iv. Two batches of 120 students each from Rustomjee Academy for Global Careers (A Rustomjee Group CSR initiative) visited Magnetic Observatory, Alibag on an educational tour. They were explained in detail the working of Magnetic Observatory and its importance.

v. 40 Students and 3 teachers of Horizon Discovery Academy, Nanded, Maharashtra were hosted by the Institute during August 24-25, 2015 on their study tour. Local hospitality for their visit and stay was provided free by the Institute. Shri Ajay Dhar delivered three talks on "Introduction to IIG", "Basics of Geomagnetism" and "Antarctica – The Frozen Continent" to the students. The students also had a question – answer session with IIG research scholars.

vi. Second year girl students of B. Sc. Physics and Maths of NSC Science College, Nashik Road, Maharashtra visited Institute on a study tour on August 26, 2015.

vii. 45 Students and 5 teachers of Anant Pandurang Bhoir Vidyalya, Dapoli Pargaon, Panvel visited the Institute on a study tour on September 8, 2015. The students were explained the research work carried out at the Institute.

viii. A batch of 80 Students of 2nd year B. Sc. Science of Rajiv Gandhi College of Arts, Science & Commerce, Navi Mumbai visited Magnetic Observatory, Alibag for a study tour.

ix. Dr. S. Sathishkumar and Shri K. Jeeva delivered two talks on "Introduction to Earth's atmospheric physics and its application" in Kamaraj College, Thoothukudi during November 26-30, 2015.

INDIA INTERNATIONAL SCIENCE FESTIVAL – 2015

Ministry of Science and Technology and the Ministry of Earth Sciences jointly held India International Science Festival (IISF) at IIT, New Delhi from December 4-8, 2015. The Institute participated in IISF by putting up an exhibition of posters depicting the science of geomagnetism and allied fields and the impact it has on society. Solar telescope and different scientific models were also put on display. The stall was visited by the Hon'ble Minister for Science & Technology and Earth Sciences, Dr. Harsh Vardhan, who lauded the displays and appreciated the work carried out by the Institute.

103rd INDIAN SCIENCE CONGRESS

The Institute participated in the 103rd Indian Science Congress held at Mysore University, Mysore from January 3-7, 2016 with a group consisting of four faculty members and four research scholars. IIG participated in the Science Expo as a part of Department of Science and Technology (DST) pavilion. The focal theme of the Indian Science Congress – 2016 was "Make in India- S & T Innovations".

The "Pride of India" science pavilion was inaugurated by the Hon'ble Minister for Science & Technology and Earth Sciences, Dr. Harsh Vardhan in the presence of Secretary, Department of Science & Technology and other dignitaries. The Institute put up an exhibition of colorful posters depicting Geophysics, Geomagnetism and its applications. A few posters on the theme of the Science Congress were specially made and displayed for the public. In addition, a few equipments used for collecting magnetic field data and various science models were also put on display for the benefit of students. The scientific models of IIG's research activities such as Earth's Magnetosphere, Plasma Sphere, Seismometer, etc. were exhibited along with illustrating posters to create scientific awareness in common public including school/college students. IIG participants in the DST pavilion and at Solar telescope were constantly engaged in demonstrating the scientific models and their working principles in a lucid manner so as to reach out to a large audience and create awareness amongst common public. IIG also distributed science comic books and other literature to visitors. The participation and demonstrations of IIG's exhibits received huge applause and wide coverage in the national/ local print and electronic media. The main attraction for students and other visitors was the Solar Telescope put up by the Institute. The students and public at large could have a view of the solar corona, sun spots, solar flares and prominences with the help of this state-of-the-art solar telescope.

Enlightenment of posters and scientific models at the IIG stall during Indian Science Congress.

The DST pavilion as a whole was awarded the "Best Innovative Pavilion" in the Science Expo at 103rd Indian Science Congress.

NATIONAL SCIENCE DAY CELEBRATIONS

In order to bring scientific awareness among the students and public, the National Science Day- 2016 celebrations started with various competitions held for students and teachers. The focal theme for this year's National Science Day was **"Make in India: S & T driven innovations"**.

The following programs were arranged for the students and teachers during this Science Day celebrations:

"**Essay Writing**" competition was held on January 11, 2016 for the students. 110 students from 12 Schools and 3 Junior Colleges participated in this competition. The participants were divided into three different categories as junior, senior and college students. A separate competition was held for vernacular language (Marathi Medium) Schools/Junior College and had more than 50 participants. The topic for the Essay was "**How to develop science relevant to India's growth"**

The "**Elocution**" competition for the students was held on January 12-13, 2016 for English Medium and vernacular language Schools and Junior Colleges. 75 Students from 15 schools and 3 Junior Colleges participated in the Elocution competition. The participants were divided into three different categories as junior, senior and college students. The topic of Elocution this year was "**Make in India: Its relevance"** for junior students and **"Make in India: Can the World accept it**" for senior and college students.

The "**Sit & Draw**" competition for the students attracts large participation and was held on January 14, 2016 on the topic "**APJ Abdul Kalam – The Dreamer**". Nearly 130 Students from 15 different schools participated in this competition, which was again divided into three categories as sub-junior, junior and senior standards.

School children participating in the Sit & Draw competition during National Science Week celebrations.

The "**Power Point Presentation**" competition for the students was held on January 15 and 18, 2016 on the topic "**Make in India: Development of Indian Industry"** for English Medium and vernacular language schools and junior colleges respectively. 57 students from schools and junior colleges from English and Vernacular languages participated in the competition.

Power point presentation competition was held for Teachers on February 19, 2016 on the topic "**Make in India: S&T driven innovations".** Twenty teachers from 10 Schools and two Junior colleges made a Power Point presentation on the above mentioned topic.

A school teacher participating in PowerPoint presentation during National Science Week celebrations.

The main exhibition of colorful posters depicting the "**Science of Geomagnetism and Allied Fields**" was held from February 22-26, 2016. A few posters depicting the theme of the National Science Day were specially prepared and displayed. Various instruments used for Geomagnetic studies were displayed for the benefit of students. More than 1500 students and a large number of people from all walks of life visited the exhibition. Transport arrangements were made for schools expressing inability to bring the students to the Institute. Various audio-visuals on science related topics were highlighted and a number of popular talks were delivered during this period. Hands on experiments on "**what can you do with a Magnet**" and various science models were also displayed. Science Quiz was held daily during the exhibition and spot prizes given to students. The main attraction for students and common public was the Solar Telescope. The students and public could have a view of the solar corona, sun spots, solar flares and prominences with the help of this solar telescope.

School students deeply engrossed in learning the science of geomagnetism.

School students having a glimpse of the Sun through a solar telescope.

The valediction function was held on February 26, 2016 with popular science talk on "**Indian Astronomy in the era of Mega Projects**" by **Dr. Aniket Sule, Homi Bhabha Centre for Science Education, TIFR**. Dr. Sule was the Chief Guest for the valediction function and distributed Awards and Certificates to winners of the competitions.

Prof. S. Gurubaran felicitating the Chief Guest Dr. Ankit Sule.

A student winner being felicitated by the Chief Guest Dr. Ankit Sule.

Science Day was also celebrated at IIG regional Centre's "**Equatorial Geophysical Research Laboratory (EGRL), Tirunelveli"** and **"Dr. KS Krishnan Geomagnetic Research Laboratory (KSKGRL), Allahabad".**

As part of the National Science Day celebrations, EGRL organized a 1-day open house on February 25, 2016, primarily targeting school and college students with the aim of motivating them to pursue science and research in frontier areas of Science and Technology. The celebration included scientific / technical talks on EGRL Research activities and different themes of current innovations in Science. 45 Physics students from the local University interacted with scientists and engineers for mutual benefits at EGRL. Dr. C.P. Anil Kumar greeted and welcomed the galaxy of creative young minds and teachers during the occasion and Dr. C. Panneerselvam explained about experimental research activities of EGRL. After the scientific talks, the students were taken to the experimental site; viz., Optical experiments, Ionosonde, Atmospheric Electricity Laboratory, Magnetic Observatory, and P.R. Radar and explained in detail the principles and technical aspects by the concerned Technical Officials and Scholars. More than 500 students from various schools/colleges in Tirunelveli and surrounding districts participated in this programme.

Dr. K.S. Krishnan Geomagnetic Research Laboratory (KSKGRL) Allahabad, a regional centre of Indian Institute of Geomagnetism, organized the 3-day celebrations during February 24-26, 2016 with theme **Make in India: S & T Driven Innovations**. The main attractions in the schedule of celebrations were the audio-visual presentation, poster display of institute's activities and demonstration of scientific instruments. In order to create awareness about scientific research, (i) A powerpoint presentation featuring Space weather and Sun-earth connections, Geomagnetism: its measurement and instrumentation, Magnetospheric studies using ULF/VLF waves, Lightning/TLE studies, Ionospheric studies using Ionosonde - Scintillation experiments, Airglow studies, Paleomagnetic research, Petrological studies, GPS based tectonic research and IIG's participation in Antarctica Expedition was delivered on each day; (ii) Popular lectures on Energy (in Hindi), Space Weather (bilingual) and Genesis of Rocks (bilingual) were also arranged. Over 18 Posters were also displayed and explained to visitors.

The overall response for the function was overwhelming. More than 500 school and college students and 50 teachers from local schools and colleges and a large number of public participated in the celebrations. The academicians/teachers from schools/colleges and the local community had shown keen interest in knowing the activities of KSKGRL and the organization. The students were very enthusiastic and the feedback received from them indicated the celebrations were quite informative and interesting to all the cadre of participants.

To generate curiosity among young students, elocution, science quiz and science model competition were organized. Prizes and gifts were also distributed to the winners.

Participation of KSKGRL in the Science Express – Climate Action Special (SECAS)

Science Express is an exhibition train that runs across India with an objective of creating scientific awareness among folks (http://www.sciencexpress.in/allahabad.html). Its current theme is **Climate Action Special**. At Allahabad,

SECAS exhibition was during **December 21 – 24, 2015** in Platform No. 1 of Allahabad City Railway Station. In coordination of SECAS, Indian Institute of Geomagnetism actively participated in the exhibition. Nearly a dozen Posters depicting Scientific Research carried out by IIG in the field of Space weather and Sun-earth connections, Geomagnetism, Magnetosphere-Ionosphere-Atmospheric studies, Paleomagnetic-Petrology studies and GPS based research were displayed. Our stall was equipped with a whiteboard. IIG gallery in Platform No. 1 received an overwhelming response of over 10000 visitors in these four days (mostly high-school and inter-college students apart from college/university goers and general public). KSKGRL Staff members were phenomenal in explaining the research activity and their basics to the curious ones through Posters and Whiteboard.

COMPUTER FACILITIES

Chief Coordinator : R.V. Reddy

Coordinator : Mahendra Doiphode

Member : Nanda S. Shah

Computer center has carried out various activities to provide uninterrupted internet, networking and high performance computing services to the end users during the year. Some of these activities are listed below.

- **Inauguration of IIG HPC center:** Hon'ble Union Minister, Ministry of Science and Technology & Earth Sciences, Dr. Harsh Vardhan inaugurated state of the art IIG HPC center during his visit on January 9, 2016. Currently, about 10 scientists and research scholars are using this high end computing facility for their simulation and modeling work.

- **Implementation of the central UPS backup supply setup:** As a part of major drive to revamp computer center facilities, and improve IT facilities and services to end users, the computer center installed central 40 KVA parallel UPS system for the East wing of main building.

- **Network assessment:** For the first time, computer center has taken up self-evaluation of current network architecture to find out technical issues, if any, which may affect the architecture, security and efficiency for the institute's network. This network assessment is also useful in technical terms to understand the current shortcoming of the network. This will be helpful to resolve the existing issues and to improve IT services, security, storage, end user bandwidth, and minimize the downtime of email, and web services, etc.

- **The Central storage and backup facility**: Institute has recently implemented the data policy based on the DST data policy guidelines, and extended the storage and backup services for long series of valuable scientific data-sets. In view of this, center has initiated the process to procure central storage and backup unit, which will extend the existing central storage backup capacity with more secured access privileges.

- **Printer policy:** This year Computer center has introduced common printing policy to promote ecofriendly working environment to save papers, and control the expenses on individual ink cartridges. In this context, the section has introduced rental multifunctional printers.

- **RF Local lead connectivity:** The computer section has implemented RF local lead connectivity for 10 mbps STPI internet leased line to avoid downtime or total internet blackout, in case the MTNL and NKN ISP's optical fibre local leads fails.

- **Scientific softwares:** The centre has changed the license policy of MATLAB scientific software from network licenses to TAH license. Under this, the scientists and research students can install latest MATLAB software version with 50 numbers of toolboxes to their office desktops and laptops to increase flexibility and minimize dependency on the local network.

- **Data transfer from the Antarctica stations:** Considering the urgent requirement for remote data transfer from Indian Antarctic stations (Bharati and Maitri), the computer section has provided facility to transfer data remotely with secured access.

LIBRARY AND DOCUMENTATION

Chief Coordinator : Sukti S. Ghosh

Coordinator : Smita Chandra

Members : Neetesh Dubey, A. Selvarajeshwari, Satish B. Waknis, B.I. Panchal

Library

The library was committed to meeting the needs of staff and students by providing timely user service, supporting research, learning and teaching, and ensuring that our facilities and services are accessible to everyone. The services were extended to outside users from universities and other organizations.

During the year, the library added 71 books on areas of research within the institute, and 199 reprints and conference papers. 58 Hindi books were acquired. From the year 2016 onwards, the library subscribes to online copies of all international journals. Hard copies of only the journals from Indian publishers were subscribed to. The library had an excellent usage statistics of the online library resources. It also procured documents on inter-library loan for its users and also provided documents to other libraries under this service. 42 new students from across the country visited and used the library for their various project and/or internship work.

The library streamlined the past book and journal acquisition procedure, and developed and implemented new policy regarding the empanelment of book and journal agents for a period of two years. The ongoing conservation work at Alibag was completed.

The Library continued subscribing to “Georef” database, via Geoscience World. Metadata was regularly updated to the Institutional Repository (IR) being made available at http://library.iigm.res.in:8080/jspui. This repository was linked to the National Digital Library (NDL) at IIT Kharagpur and its contents were harvested by the NDL. Access to online resources to scientists and IIG regional centers and observatories was extended via the upgraded VPN-IP software by the computer center, Accelpro. The library website further enhanced services by providing access to all resources, via the library website (http://library.iigm.res.in). Through the NKRC (library consortium of DST-CSIR laboratories), users have full text access to more than 20 publisher resources. Access to online copies of journals was given to all observatories and regional centers via the Accelpro. The library continued to train new library interns in all aspects of library work.

Documentation

Documentation continued all their support services to the scientists. During the past year, the work of scanning and digitizing the Ph.D. thesis by IIG staff and students started. This work is still going on along with other routine services like, rendering help in preparation of posters, editing of photographs, designing/ layout of institute publications and photography of magnetograms.

SPECIAL EVENTS

Visit of Hon'ble Union Minister for Science and Technology and Earth Sciences, Dr. Harsh Vardhan to IIG Panvel and Colaba campus, January 9, 2016

The Hon'ble Union Minister for Science and Technology and Earth Sciences, Dr. Harsh Vardhan, visited the Indian Institute of Geomagnetism (IIG), Navi Mumbai on January 9, 2016. The Hon'ble Minister was given a traditional welcome upon his arrival.

A floral welcome by Director Dr. D.S. Ramesh to Hon'ble Minister Dr. Harsh Vardhan during his visit to IIG.

Hon'ble Minister Dr. Harsh Vardhan inaugurating the HPC facility at IIG, Panvel.

An overview of the activities of IIG with significant contributions made by the institute was presented by the Director to the Hon'ble Minister. The new initiatives of IIG with direct societal relevance received special appreciation by the Hon'ble Minister.

The Hon'ble Minister interacted with the researchers, students and staff from all research areas of IIG. The Hon'ble Minister went through the posters, instruments pertaining to the theme 'Make in India' and other scientific exhibits kept on display.

During his visit, the Hon'ble Minister inaugurated the newly established High Performing Computing Centre. This centre will provide in-house parallel computing environment for the scientists of IIG to develop and run the more realistic simulation models to understand the Sun-Earth processes.

Scientific deliberations with Hon'ble Minister Dr. Harsh Vardhan.

Later during the afternoon, the Hon'ble Minister visited the Heritage Colaba Observatory complex and was impressed by the century old collection of books, journals and magnetic recordings preserved at Colaba. The Hon'ble Minister inaugurated the renovated office block of the World Data Centre for Geomagnetism, Mumbai. This centre is the only data repository centre, representing the Indian subcontinent at the International Council for Science – World Data System (ICSU-WDS).

Hon'ble Minister Dr. Harsh Vardhan inaugurating the World Data Centre for Geomagnetism at IIG, Colaba.

Hon'ble Minister Dr. Harsh Vardhan taking a look at the old collection of books, journals and magnetic recordings preserved at IIG Colaba.

Inauguration of the Shillong Geophysical Research Centre at Shillong, Meghalaya, January 18, 2016

IIG's third regional centre at Shillong was inaugurated by the Honourable Union Minister of Science & Technology and Earth Sciences, Dr. Harsh Vardhan on January 18, 2016, which was graced by the presence of Chairman, IIG Governing Council, Padmashree Dr. V. P. Dimri, Director IIG, Dr. D.S. Ramesh, besides a good number of dignitaries and general public. Christened as "Shillong Geophysical Research Centre" (SGRC) of IIG, this centre will be dedicated for detailed research on earthquakes in the north eastern region of the country. Speaking on the occasion, the Hon'ble Minister said that with the setting up of the state of the art research facility, the changes in the electrical field and the variation in temperatures occurring at different times including modulation in very high or low frequency can be observed consistently for years and can be related to occurrence of earthquake with time. The North-eastern part of India is vulnerable when it comes to occurrence of earthquakes and thus this research centre will be of immense help to the people of the region in terms of avoiding the damage caused by earthquakes. Referring to a common question on whether earthquakes can be predicted, the Hon'ble Minister said, "With the type of research that they are going to do in the centre, there will be a time in the foreseeable future when we should be able to predict an earthquake." The Union Minister informed that the government is thoroughly committed to take science forward in a proactive and dynamic manner.

Hon'ble Minister Dr. Harsh Vardhan along with other dignitaries during the inauguration of Shillong Geophysical Research Centre.

Hon'ble Minister Dr. Harsh Vardhan emphasizing the significance of Shillong Geophysical Research Centre.

Hon'ble Minister Dr. Harsh Vardhan unveiling the plaque at Shillong Geophysical Research Centre.

Prior to the inauguration of SGRC, a half day workshop was organized on the topic *"Lithosphere-Atmosphere-Ionosphere-Magnetosphere coupling and dynamics: New paradigms in earthquake monitoring and precursors"* to sensitize the dignitaries on the importance of an integrated approach to study the dynamics of earthquakes. Several eminent earth and space scientists deliberated and illuminated the gathering on the subject.

An eminent Earth Scientist delivering a lecture during the workshop on "Lithosphere-Atmosphere-Ionosphere-Magnetosphere coupling and dynamics: New paradigms in earthquake monitoring and precursors".

After the inauguration of SGRC, the annual **IMPRESS** program was organized during January 19-21, 2016. This program essentially is aimed at inspiring the minds of post graduate students from all over the country to persue research in earth sciences. A total of about 50 students were selected from various universities of India to attend this program. A wide spectrum of faculties was drawn from both IIG and different research institutes of the country to motivate the students in different aspects of earth science problems and prospects.

Students attending the IMPRESS program lecture series.

IIG STAFF WELFARE AND RECREATION CLUB

IIG Staff Welfare and Recreation Club organized IIG's 44th Annual Day celebration on April 1, 2015. The morning session commenced with the Director presenting a brief account of the Institute's activities and achievements. Dr. K.S. Hosalikar, Deputy Director General, India Meteorological Department, Mumbai, was the Chief Guest. He delivered the Foundation Day lecture on "***Emerging new Sectors and Challenges in Meteorology***". Employees contributing a major portion of their official work in Hindi were felicitated. Also, employees who rendered 25 years of service were presented a memento and a certificate.

The second session comprised entertainment involving individual and group performances by Staff and their family members. Celebrations for the day concluded with the Director handing over prizes to the winners of sporting events organized during the months from January to March 2015. The Club succeeded in making the Annual Day 2015 a successful event.

Chief Guest Dr. Hosalikar lighting the traditional lamp during IIG Annual Day.

Dr. Hosalikar delivering the foundation day lecture.

Staff member being felicitated for promoting Hindi through official work.

Dr. Hosalikar presenting mementos to staff for long-time service awards.

Annual General Body Meeting of the Club was held on November 27, 2015, which transacted all the business of the agenda in a genial manner.

The Club Library bought magazines and newspapers for the benefit of the staff during the year.

The Club, on behalf of the Institute, bid farewell on superannuation to Shri K.B. Rohara on May 31, 2015, Shri D.K. Meshram and Shri R.S. Udare on September 30, 2015, Mr. G. Jayakumar and Shri A.G. Patil on November 30, 2015, and Shri R.L. Asinkar on March 31, 2016.

The club continued to provide recreational facilities to staff members during the allotted time. The co-operation and support extended by staff is gratefully acknowledged.

STAFF WELFARE MEASURES

Various staff welfare measure, such as, visit of a Resident Doctor twice a week, transport facilities from the nearest railway station, Benevolent Fund Scheme, Canteen facility etc. were provided to the staff members. Hindi and Marathi magazines and books were made available for the staff.

Dr. Kranti Jejurkar, Chairperson, University Women Development Cell (WDC), Mumbai University, Mumbai, visited IIG on December 11, 2015 and enlightened the staff members on the topic *"Sexual harassment act 2013 - Prevention, Prohibition, Redressal"*. This awareness talk was arranged by **Internal Complaint Committee (ICC)**.

Dr. Kranti Jejurkar sensitizing the staff members about harassment at workplace.

Shri Vinayak Parab, Senior Editor, Loksatta & Indian Express, visited IIG and gave a lecture on *"Dr. A.P.J. Abdul Kalam and his achievements"* on October 15, 2015. He also visited the Environmental Magnetism laboratory. This special talk was arranged by **Staff Welfare & Recreation Club** as a mark of respect on the birth anniversary of Dr. Kalam.

Shri Vinayak Parab's reminiscences with Dr. A.P.J. Abdul Kalam.

Vigilance awareness week was observed in IIG during October 26-31, 2015. Vigilance Officer Dr. Satyavir Singh highlighted the importance of vigilance in day to day work and requested to maintain integrity as responsible citizens of the country. During this occasion, the Director and staff members took the vigilance oath on October 26, 2015.

Staff members during the Vigilance awareness week oath-taking.

CORPORATE SOCIAL RESPONSIBILITIES

RIGHT TO INFORMATION ACT 2005

The Institute has operationalised the Act and the following authorities have been appointed under the act:

1. Chief Public Information Officer:
   Dr. R.V. Reddy, Professor F
   Indian Institute of Geomagnetism
   Kalamboli Highway, New Panvel.
2. Appellate Authority :
   Dr. S. Gurubaran, Professor G
   Indian Institute of Geomagnetism
   Kalamboli Highway, New Panvel.

PUBLIC GRIEVANCES REDRESSAL MECHANISM

The General Public having any grievance can approach Prof. R.V. Reddy at the Institute. Director shall be the Appellate Authority.

CITIZEN CHARTER

Information / suggestion on the functioning of the Institute can be obtained / given by the public. The following nodal officers have been nominated for this purpose:

Dr. R.V. Reddy, Prof. F
Indian Institute of Geomagnetism
Kalamboli Highway, New Panvel.

Head
E.G.R.L.
Vittalapuram, Tirunelveli
Tamil Nadu.

Head
Dr. KSKGRL
Jhusi, Allahabad.

Head
Shillong Geophysical Research Center (SGRC)
Shillong, Meghalaya.

RESERVATION POLICY

The Institute has been implementing the reservation policy of the Govt. of India from time to time.

STAFF PROFILE

Academic	●	41
	*	41
Technical	●	84
	*	82
Administration	●	41
	*	35
Maintenance	●	37
	*	11

● Sanctioned staff strength
* Staff strength as on March 31, 2016

ACTION TAKEN NOTE ON AUDITORS REPORT

No serious adverse comments have been received. However, replies to some of the observations made are appended with the Audit Report of the Institute for the year 2015–2016

MOBILIZATION OF RESOURCES

The Institute has been constantly making endeavors to mobilize resources by extending its scientific and technical expertise to organizations like DRDO, NHPC Ltd., ONGC and by selling magnetic data to outside organizations. During the year 2015–2016, the Institute received funds for carrying out the objectives of various sponsored projects. The gains from sponsored projects in terms of academic activity are immense.

The Instrumentation section is in the process of obtaining an Indian patent for the 0.1 nT PPM. Since this activity involves know-about of the techno-legal knowledge, a patent attorney has been appointed who will guide in every step of the patent filing procedures till the final document is generated and is submitted to the patent office. As per the guidelines of the patent filing procedures, a detailed technical report has been generated which describes the design and working of the said PPM. Towards the sensor design, all the necessary specifications were re-calculated and it was ensured that the theoretical calculations agree with the experimental results. Also the mechanical drawings of the instrument were generated. This detailed draft document has undergone several corrections under the expert guidance of the appointed patent attorney office. The final document is now complete in all respects and awaiting some legal formalities to be completed after which it is planned to file the patent.

IN SERVICE OF THE NATION.....

The Indian Institute of Geomagnetism (IIG) is a leading research centre of the country, actively engaged in basic and applied research in Geomagnetism and allied areas of Geophysics, Atmospheric & Space Physics and Plasma Physics. It started out as a successor to the Colaba Magnetic Observatory, set up in 1826, where the first regular magnetic observatory in the country was established in 1841. In 1971 IIG became autonomous and is now under the Department of Science & Technology, Government of India. The study of Geomagnetism encompasses the entire Heliosphere starting from the centre of the Earth extending to all the planets and the Sun itself.

The vision of the institute is to enable India become a global knowledge centre by promoting, guiding and conducting basic and applied research in Geomagnetism and associated fields of earth science. The Institute's mandate is also to maintain and modernize the magnetic observatories under its magnetometer network, establish new observatories and publish high quality data as Indian Magnetic Data volumes. The magnetic records from these observatories serve as useful tools for the study of electrical current systems flowing in the near space environment, the understanding of whose drivers has a bearing on monitoring and assessing the health of satellite navigation systems.

IIG operates 12 geomagnetic observatories and two regional centres. It is indeed a historic moment that very recently, a third regional centre was inaugurated at Shillong, Meghalaya by the Honourable Union Minister of Science & Technology and Earth Sciences, Dr. Harsh Vardhan. Christened as "Shillong Geophysical Research Centre" of IIG, this centre will be dedicated for detailed research on earthquake occurrence in the north eastern region of the country. This research centre will offer a unique opportunity to comprehend and decipher the coupled nature of the lithosphere-atmosphere-ionosphere-magnetosphere system leading towards development of an **I**ntegrated **P**recursory **S**ignals **S**ystem (**IPSS**) to mitigate natural disasters of varied origin. The North-eastern part of India is vulnerable when it comes to occurrence of earthquakes, and the centre will be of great help to the people of this region in terms of mitigation of hazards.

With advances in science and technology, the institution widened its research programs to understand the Geophysical processes including Sun-Earth interactions. However, at the same time, it opens many new scientific questions and challenges that need to be addressed, especially, in Space Weather and Geo-seismic phenomena which can have potential implications in modern society and technological systems. Short and long term anomalies in geomagnetic field are being studied through ground based magnetometer network. While the upper atmosphere and magnetospheric processes are being studied through observations, theory and numerical simulations.

The Earth's interior is being probed on various time scales using a variety of sophisticated geophysical tools like (a) electrical and electromagnetic imaging of shallow and deep Earth, (b) mapping of geopotential fields, (c) use of GPS and InSAR to understand lithospheric deformation and (d) environmental and rock magnetic investigations to understand the Earth's past climate and tectonics. Geophysical and environmental studies are of considerable significance in terms of societal issues like groundwater exploration and protection from contamination and scientific aspects ranging from past climate to present pollution levels which have a direct societal impact.

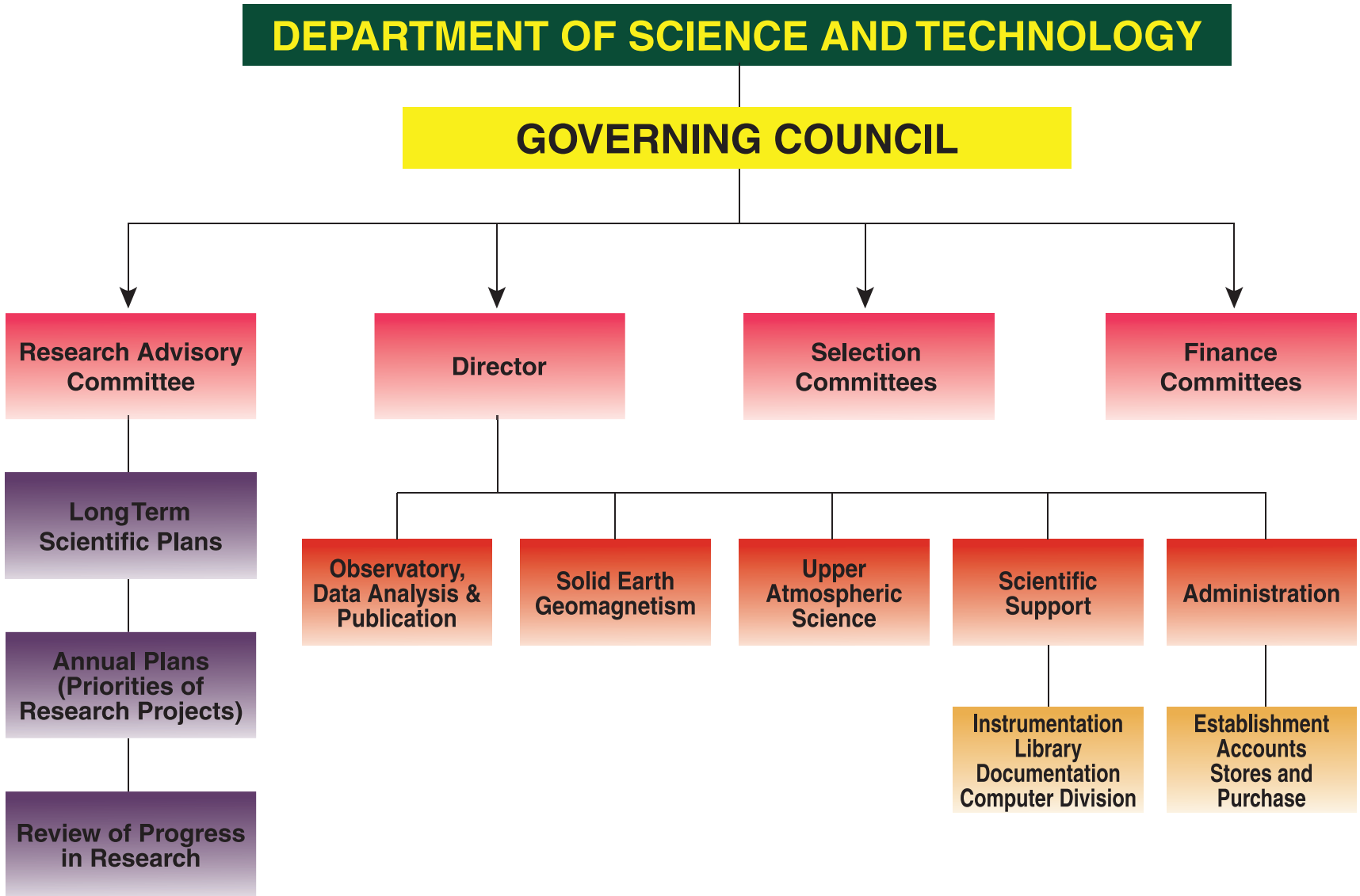
The instrumentation division caters to the need of the scientists in the development and maintenance of the instruments used in the Institute's observatories. Further it is heartening to note that this division is in the process of obtaining an Indian patent for the 0.1 nT PPM. The state-of-the art high performance computational facility has been formally established for scientific studies and numerical simulations with 256 core HPC cluster to meet current and future needs of parallel processing on big data sets. It is loaded with latest Linux OS environment, and scientific software like MATLAB, COMSOL, FORTRAN, etc.

The Institute is exploring all the possibilities for generating the revenue by utilizing the expertise to extend the possible geomagnetic based services to civil and industries. As a part of Consultancies and Services, IIG strives to provide scientific services to ONGC, DoS, NHPC, DRDO etc. These scientific studies are essential to decipher several types of energy resources in the nation. Also, the paid services of this Institute include supply of geomagnetic data to the private firms using the data for commercial purpose. Other services such as calibration of magnetic compasses and other magnetic instruments, magnetic surveys for preparations of anomaly maps and airport geomagnetic and GEOID surveys are levied at appropriate rates. IIG plays a major role in disseminating training programs to researchers from both national and international Universities, with an objective of building individuals who would make long-term contributions to the advancement of society. Under this initiative, a half day workshop

was arranged on the topic "Lithosphere-Atmosphere-Ionosphere-Magnetosphere coupling and dynamics: New paradigms in earthquake monitoring and precursors" to sensitize the students on the importance of an integrated approach to study the dynamics of earthquakes. Also the annual 'Inspiring Minds of Post-graduates for Research in Earth and Space Sciences' (IMPRESS) program was arranged for post graduate students from all over the country to pursue research in earth sciences. Dr. Nanabhai Moos postdoctoral research fellowship is being continued in order to retain brilliant young researchers in India by offering better terms to pursue high quality research at IIG.

To this effect, the vision of Indian Institute of Geomagnetism has been to enable India to become a global knowledge power by promoting, guiding and conducting basic and applied research in Geomagnetism and allied fields; with a mission to build infrastructural support (using state-of-the-art technology) for acquisition of high quality data, leading to cutting edge research; to maintain / modernized magnetic observatory network of India and establish new observatories and facilities at existing centers for other observations related to geomagnetism and allied fields; and to attract, motivate and train young, talent to undertake research in geomagnetism.

ORGANIZATIONAL CHART OF THE INSTITUTE



Auditor Report 2015-2016

Narendra Samar
B.Com., F.C.A.

NARENDRA SAMAR & CO.
Chartered Accountants

AUDITORS' REPORT
TRUST REGISTRATION NO. AF/2375
SOCIETY REGISTRATION NO. 91 / 71. GBBS

To,
The Governing Council,
Indian Institute of Geomagnetism,
Panvel, Navi Mumbai.

We have audited the attached Balance Sheet of **Indian Institute of Geomagnetism** as at 31st March 2016, and also the Income and Expenditure Account of the Institute for the year ended on that date, annexed thereto. These financial statements are the responsibility of the management of the Institute. Our responsibility is to express an opinion on these financial statements based on our audit and report that –

1. We conducted our audit in accordance with auditing standards generally accepted in India. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statement. An audit also includes assessing the accounting principles used and significant estimates made by the management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.
2. Further to our comments referred to in paragraph 1 above, we state that –

a. We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purpose of our audit.

b. In our opinion, proper books of account, as required by law have been kept by the Institute, so far as it appears from our examination of the books of accounts.

c. The Balance Sheet and the Income and Expenditure account dealt with by this report are in agreement with the Books of Accounts.

d. IIG should maintain their observatories bank accounts and record with the name of IIG.

e. All bank accounts in the name of observatories should be close down and all payment to vendors and employees should be paid directly from IIG head office bank account only to keep better control on banking activities and payments.

f. Inventories Stock should be maintained in Tally Software.

g. IIG is operating bank accounts at Triunelvallei and Allahabad observatories for convenience purpose in the name of observatories but they have no control over withdrawal and deposit. They must have control over all accounts of observatories.

h. IIG has deducted Works Contract TDS under MVAT Act of Rs.1,42,713/- which is to be remitted to the MVAT Authorities and the return for same is to be filed but the said amount is not yet paid and the Works Contract Return under MVAT Act is not yet filed. WCT form 402 and 405 is not maintained.

5, Ground Floor, Amfotech Park, Opp. MIDC Office, Road No.16, Wagle Estate, Thane (W) - 400604.
022 2582 7712 / 093 2430 9929 n.samar2005@gmail.com cansamarandco@gmail.com

i. Advance received against write off account represent amount received from sale of scrap assets still not adjusted fixed assets should be adjusted in respective a/c.

j. Security deposit Payment a/c is more than two years old is to be require full scrutiny.

k. EMD is pending from the last two years. Status report required whether work is completed or not if not then action to be taken and remaining work to whom so ever is allotted and difference bill should be raised.

l. Labour cess amounting to Rs. 1,11,514/- still not paid and it is not filed the return to particular authority. Amount should be paid & return to be filed to respective authority.

m. TDS on contractor for F.Y. 14-15 should be reconcile with 26Q file also there is outstanding of Rs34,313/-

n. TDS on professional charges payable for F.Y. 15-16 should be reconcile with 26Q file.

o. IIG should get Non deduction certificate from Income tax department. Some of parties deducted TDS on interest & Other Income by not availing non deduction certificate from ITD.

p. All TDS a/c should be reconcile & rectify with TDS return & Challans.

q. As per the income tax department website default in TDS total Rs.2,17,720/-.

r. For F.Y. 15-16 tax deducted by other authorities Rs.9,349/- & F.Y. 14-15 Rs.7,024/- respectively these are not booked in the books of accounts.

s. Securities deposits / EMD / Performance guarantee are taken / deducted from suppliers/ contractors towards performance of the work lying with IIG from years, management are required to scrutinize the relevant documents to refund / write off deposits. Before written off necessary approval sanction to be taken from governing council / DST.

t. In our opinion, and to the best of our information and according to the explanations given to us, the said accounts, read together with the notes on Accounts **subject to non-transfer of property, Note No. 2 for accounting of government grants related to fixed assets, Note No. 9 for non-provision of doubtful advances,** gives a true and fair view :

   i. In the case of the Balance Sheet of the state of affairs of the Institute as 31st March 2016 and

   ii. In the case of the Income & Expenditure Account, of the Surplus for the financial year ended 31st March 2016.

For M/s. Narendra Samar & Co.
Chartered Accountants,
Firm No. 126415W

Narendra Samar & Co. Partner Chartered Accountants

Narendra Samar
Membership No.119521
Partner

Place: Thane
Date: 17/09/2016

INDIAN INSTITUTE OF GEOMAGNETISM, MUMBAI
TRUST REGISTRATION NO. AF/2375
SOCIETY REGISTRATION NO. 91/71 GBBS

SIGNIFICANT ACCOUNTING POLICIES AND NOTES ON ACCOUNTS

A: SIGNIFICANT ACCOUNTING POLICIES:

1) ACCOUNTING CONVENTION:

a) The Financial Statements are prepared under the historical cost convention on the basis of going concern and in accordance with the applicable Accounting Standards issued by ICAI except AS-11, AS-15.

b) The Institute generally follows the mixed system of accounting and recognizes income and expenditure on accrual basis except Government grants and those with significant uncertainties are accounted as cash basis.

2) FIXED ASSETS:

Fixed Assets are stated at their original cost acquisition / installation. Fixed assets are shown net of accumulated depreciation without any adjustment of foreign exchange fluctuation gain (loss).

3) DEPRECIATION

a) Depreciation has been provided on written down value method corresponding to the rates prescribed under Section 32 of Income Tax Act 1961.

b) Assets costing Rs.5000/- or less each is fully expenses out in the year of acquisition.

4) CAPITAL WORK IN PROGRESS

Capital Work-in-progress is stated at the amount spent up to the date & Advances made to respective parties of the Balance Sheet, in case the same is backed by asset. In case if the expenditure is not backed by asset the same is recorded as Pre-Operative Expenses (Project) under the head Miscellaneous Expenditure.
Leasehold land is amortized over the period of lease.

5) GRANT

Government grants are accounted on Receipt basis.

6) INVENTORIES

Closing Stock was valued at cost or market price whichever is less on FIFO basis.

7) RETIREMENT BENEFITS:

Contribution for various retirement benefit Debited to Income and Expenditure Account AS-15 is not followed in the case of gratuity & leave encashment.

8) CONTINGENT LIABILITIES & PROVISIONS :

No provision is made for liabilities, which are contingent in nature, but, if material, the same are disclosed by way of notes to the accounts & accounted on payment basis.

K. Kumar D.S Rawat

Naveen Samar & Co. Partner Chartered Accountants

9) **GENERAL:**

Accounting policies not specifically referred to above are consistent with generally accepted accounting principles.

B. NOTES TO ACCOUNTS

1. Previous year's figures have been regrouped, wherever necessary.

2. Properties worth Rs. 113,18,789.00 (moveable Rs. 8,83,000.00 and immovable Rs. 104,34,989.00) previously belonging to IMD and in occupation of the Institute have not been accounted for in the Balance Sheet as the same have not yet been conveyed to the Institute worth Rs.8.83.000/- is in occupation of IIG previously belong to IMD still not conveyed to IIG is now NIL.

3. Contingent Advances –
   Contingent Advances balance as on 31.03.2016 is Rs. 56,98.486/- Out of the above amount, Rs. 25,15,084/- has been settled up to 16.09.2016.

4. As per notification no. BPI 1390/317/(75)-6 dated 5th March 1991 issued by the Government of Maharashtra, this Institute has been exempted from all provisions of the Bombay Public Trust act 1950, except those relating to registration contained in Chapter IV of the said Act.

5. The management has carried out Physical verification of closing stock.

6. Physical Verification & reconciliation of fixed assets with books was not carried out by management.

7. Capital work in progress as on 31.03.2016 is verified and certified by management / respective authorities.

8. During the previous year capital grant received from Government of India was credited to Income & Expenditure A/c but in current year Government Grant of Rs. 83,12,5000/- received is transferred to Capital Fund A/c.

9. Advance for movable property capital works includes Rs. 6,03,900 (paid in 2002-03) represents the cost of Lab equipment lost in transit. The amount has been included under the head Advance for Lab Equipment. No provision has been made in the books for the same.

10. Retirement fund of the employee is solely managed by IIG only in their proprietary account & all contribution of employee & employer is kept by IIG in separate bank account, it should be kept separate from business of IIG in different trust.

11. IIG is operating different Bank Accounts for convenience purpose in the name of observatories like bank of India, Triunelvelli & Bank of India, Allahabad. These accounts are showing as Bank Account but IIG have no control over withdrawal and depositing of money.

12. Inventory stores are not maintained in Tally Software.

K. Kumar D.S Ramesh

13. Advance received against written off account represent amount received from sale of scrap assets still not adjusted against fixed assets.

14. Payment received as Security deposit is showing more than two years old and no any action was taken.

15. EMD is pending from the last two years. Status report of work is not available on record.

As per our Report of even dated

For M/s. Narendra Samar & Co.
Chartered Accountants,
Firm No. 126415W

Narendra Samar
Membership No. 119521
Partner

Place: Thane
Date: 17/09/2016

For Indian Institute of Gemomagnetism

Accounts Officer

The Director for Trustee

FORM OF FINANCIAL STATEMENTS (NON – PROFIT ORGANISATIONS)
Name of Entity : Indian Institute of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

BALANCE SHEET AS AT 31ST MARCH 2016

(Amount – Rs.)

CAPITAL FUND AND LIABILITIES	Schedule	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
CAPITAL FUND	1	644055987	629801962
RESERVES AND SURPLUS	2	0	0
EARMARKED / ENDOWMENT FUNDS	3	0	0
SECURED LOANS AND BORROWINGS	4	0	0
UNSECURED LOANS AND BORROWINGS	5	0	0
DEFERRED CREDIT LIABILITIES	6	0	0
CURRENT LIABILITIES AND PROVISIONS	7	19648390	28307457
TOTAL		**663704377**	**658109419**
ASSETS			
FIXED ASSETS	8	607874368	635037102
INVESTMENTS – FROM EARMARKED / ENDOWMENT FUNDS	9	2750	2750
INVESTMENTS – OTHERS	10		
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	55827259	23069567
MISCELLANEOUS EXPENDITURE (TO THE EXTENT NOT WRITTEN OFF OR ADJUSTED)			
TOTAL		**663704377**	**658109419**

See accompanying Notes to Accounts - Schedule 24

As per our Report of even dated.As per our Report of even dated.

For M/s. NARENDRA SAMAR & CO.
Chartered Accountants
Firm No. 126415W

Narendra Samar
Membership No. : 119521
Partner

Place : Thane
Dated : 17 SEP 2016

The above Balance Sheet to the best of my knowledge and belief contains a true and fair account of the funds and liabilities and property assets of the Trust.

For INDIAN INSTITUTE OF GEOMAGNETISM

K. Kumar
ACCOUNTS OFFICER

D. S. Ramesh
THE DIRECTOR FOR TRUSTEE

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

INCOME AND EXPENDITURE ACCOUNT FOR THE PERIOD / YEAR ENDED 31ST MARCH 2016

(Amount – Rs.)

INCOME	Schedule	Current Year Ended 31st March-2016	Previous Year Ended 31st March-2015
Income from Sales / Services	12	0	0
Grants / Subsidies	13	256875000	257500000
Fees / Subscriptions	14	363524	360526
Income from Investments (Income on Invest. from earmarked/endow. Funds transferred to Funds)	15	0	0
Income from Royalty, Publication etc.	16	0	0
Interest Earned	17	3973005	6929591
Other Income / Profit on sale of assets	18	4576937	4693552
Increase / (decrease) in stock of Finished goods and works-in-progress	19		0
TOTAL (A)		265788466	269483669

K. Kumar

D. S. Ramesh

Cont...II

Narendra Bamer & Co. Partner Chartered Accountants

(Amount – Rs.)

EXPENDITURE	Schedule	Current Year Ended 31st March-2016	Previous Year Ended 31st March-2015
Establishment Expenses	20	190194178	168262366
Other Administrative Expenses etc.	21	82057159	100210336
Expenditure on Grants, Subsidies etc.	22	605600	1002140
Interest	23	0	0
Loss on sale of Asset			18138
Depreciation	8	61802504	67500681
TOTAL (B)		**334659441**	**336993661**
Balance being excess of Income over Expenditure (A-B)		-68870975	-67509992
Transfer to Special Reserve (Specify each)			
Transfer to / from Income and Expenditure A/c			0
Balance being deficit carried to Corpus / Capital Fund		**-68870975**	**-67509992**

See accompanying Notes to Accounts - Schedule 24

The above Income and Expenditure A/c to the best of my knowledge and belief contains a true and fair account of the Income and Expenditure of the Trust.

As per our Report of even dated.

For M/s. NARENDRA SAMAR & CO.
Chartered Accountants
Firm No. 126415W

Membership No. : 119521
Partner

Place : Thane
Dated : 17 SEP 2016

For INDIAN INSTITUTE OF GEOMAGNETISM

K. Kumar
ACCOUNTS OFFICER

D. S. Ramesh
THE DIRECTOR FOR TRUSTEE

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)
Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.
SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 1 : CAPITAL FUND	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
Balance as at the beginning of the year	629801962	697311954
Add : Contributions towards capital Fund	83125000	0
Add : Balance of net income transferred from the Income and Expenditure Account	-68870975.36	-67509992
BALANCE AS AT THE END OF THE YEAR	**644055987**	**629801962**

K. Kumar

D. S. Ramesh

Partner

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)
Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.
SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 2 : RESERVES AND SURPLUS	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 3 : EARMARKED/ENDOWMENT FUNDS	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 4 : SECURED LOANS AND BORROWINGS	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 5 : UNSECURED LOANS AND BORROWINGS	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 6 : DEFERRED CREDIT LIABILITIES	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
	NIL	NIL
TOTAL	NIL	NIL

SHEDULE 9 : INVESTMENTS FROM FARMARKED/ENDOWMENT FUNDS	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
	NIL	NIL
TOTAL	NIL	NIL

K. Kumar

D. S. Ramesh

Narendra Sumar & Co. Partner

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

SCHEDULE FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 12 : INCOME FROM SALES / SERVICES	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 15 : INCOME FROM INVESTMENTS (Income on Invest. From Earmarked/Endowment Funds transferred to Funds)	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 16 : INCOME FROM ROYALTY, PUBLICATION ETC. (Income on Invest. From Earmarked/Endowment Funds transferred to Funds)	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 19 : INCREASE/(DECREASE) IN STOCK OF FINISHED GOODS & WORK IN PROGRESS	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 23 : INTEREST	Current Year as on 31/03/2016	Previous Year as on 31/03/2015
	NIL	NIL
TOTAL	NIL	NIL

K. Kumar

D. S. Ramesh

Harendra Samar & Co. Chartered Accountants Partner

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 7 – CURRENT LIABILITIES AND PROVISIONS			Current Year as at 31st March-2016	Previous Year as at 31st March-2015
A. CURRENT LIABILITIES				
1	Acceptances		0	0
2	Sundry Creditors:			
	a)	For Goods	37303	37303
	b)	Others	5748819	11601657
3	Securiy Depsoit Payable		1445625	678808
4	Interest accrued but not due on:			
	a)	Secured Loans/borrowings	0	0
	b)	Unsecured Loans/borrowings	0	0
5	Statutory Liabilities:			
	a)	Overdue	0	0
	b)	Others	0	0
6	Other current Liabilities (other Projects)			0
TOTAL (A)			7231747	12317768
B. PROVISIONS				
1	Loss on interest for GPF			0
2	Gratuity		4562716	6363080
3	Superannuation / Pension		3611587	4601554
4	Accumulated Leave Encashment		4242340	4938746
5	Trade Warranties/Claims			0
6	Others current Liabilities (for expenses on telephone, electricity, water charges etc.)		0	86309
TOTAL (B)			12416643	15989689
TOTAL (A + B)			**19648390**	**28307457**

K. Kumar

D S Ramesh

Narendra Samar & Co. Partner Chartered Accountants

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 8 : FIXED ASSETS		GROSS BLOCK				DEPRECIATION					NET BLOCK	
DESCRIPTION		Cost / valuation as at beginning of the year 01/04/2015	Additions during the year	Deductions during the year	Cost/valuation at the year-end 31/03/2016	As at the beginning of the year 01/04/2015	On additions during the year	For the year 2015-16	On deductions during the year	Total up to the year – end 31/03/2016	As at the current year-end 31/03/2016	As at the previous year-end 31/03/2015
A. FIXED ASSETS												
1	LAND :											
a)	Freehold	3493366	0	0	3493366	0	0	0	0	0	3493366	3493366
b)	Leasehold	56466353	0	0	56466353	22510538	0	0	0	22510538	33955815	33955815
2	BUILDINGS:											
a)	On freehold Land	210391921	0	0	210391921	82451304	0	6397031.00	0	88848335	121543586	127940617
b)	On Leasehold Land	249797605	199000	0	249996605	72216478	4961	8879056	0	81100495	168896110	177581127
d)	Ownership Flats/Premises	0		0	0	0		0	0	0	0	0
e)	Superstructures on Land Not belonging to the entity	0		0	0	0		0	0	0	0	0
3	LABORATORY EQUIPMENT	465843624	14195714	0	480039338	277092604	1034742	28312653	0	306439999	173599339	188751020
4	MOTOR CAR VEHICLE	4402883	1466924	0	5869807	3167570	132809	185297	0	3485676	2384131	1235313
5	FURNITURE, FIXTURES	24932305	252611	0	25184916	15959622	66029	897268	0	16922919	8261997	8972683
6	OFFICE EQUIPMENT	27577421	408142	0	27985563	16772415	49860	1620751	0	18443026	9542537	10805006
7	COMPUTER & SOFTWARE	127979020	1164862		129143882	110886892	492196	10255277	0	121634365	7509517	17092128
9	ELECTRIC INSTALLATIONS	4370060	0	0	4370060	3073762	0	194445	0	3268207	1101853	1296298
10	LIBRARY BOOKS	37246600	3280129	0	40526729	37246600	0	3280129	0	40526729	0	0
TOTAL OF CURRENT YEAR		1212501158	20967382	0	1233468540	641377785	1780597	60021907	0	703180289	530288251	571123373
PREVIOUS YEAR		95843756	5220295	37150322	63913729						0	0
B. CAPITAL WORK IN PROGRESS		63913729	14293604	621216	77586117						77586117	63913729
TOTAL											607874368	635037102

(Note to be given as to cost of assets on hire purchase basis included above)

K. Kumar

D S Ramesh

Partner

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2016

(Amount – Rs.)

SHEDULE 10 – INVESTMENTS – OTHERS		Current Year as at 31st March-2016	Previous Year as at 31st March-2015
1)	In Government Securities	0	0
2)	Other approved Securities	0	0
3)	Shares (no. of shares of Rs.....)	2750	2750
4)	Debentures and Bonds	0	0
5)	Subsidiaries and Joint Ventures	0	0
6)	SDR with Bank	0	0
TOTAL		2750	2750

K. Kumar

D. S. Ramesh

Partner

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 11 : CURRENT ASSETS, LOANS, ADVANCES ETC.				Current Year as at 31st March-2016	Previous Year as at 31st March-2015
A. CURRENT ASSESTS					
1)	Inventories				
	a)	Stores and spares (closing bal. in stores)		439728	569299
	b)	Loose Tools			
	c)	Stock-in-Trade			
		Finished Goods			
		Work-in-Progress			
		Raw Materials			
2)	Sundry Debtors:				
	a)	Debts Outstanding for a period exceeding six months			
	b)	Others		22039	
	c)	Smt.Nirupama Tiwari		1185654	
3)	Cash Balances in hand (including cheques / drafts and imprest)			39017.00	39017
	Head Office		---		
	Sub Office		9017.00		
	Cash for emergency		25000.00		
	Petty Cash		5000.00		
4)	Bank Balances:				
	a)	With Scheduled Banks:			
		-- On Current Accounts – Bank of India, Panvel		3621673.88	3700264
		-- Union Bank of India, Panvel		16886.37	64606
		-- Bank of India, Allhabad		27828	0
		-- Bank of India, Tirunelvelli		0	159433
		-- Bank of India, LC A/c. 365		32953398.66	679903
		SDR against purchase of equipment		4305000	9527000
5)	Advance for Franking Machine (Stamp in hand)			22336	45036
6)	Prepaid Expenses			0	0
	TOTAL (A)			42633561	14784558

K. Kumar

D. S. Ramesh

Narendra Sarmar & Co. Partner Accountants

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 11 : CURRENT ASSETS, LOANS, ADVANCES ETC.(CONTD.)			Current Year as at 31st March-2016	Previous Year as at 31st March-2015
B. LOANS, ADVANCES AND OTHER ASSETS				
1)	Loans			
	a)	Staff	4080141	2864130
	b)	Other entities engaged in activities / objectives similar to that of the entity	59950	0
	c)	Other (specify)- Contingent Advances	5698486	1602100
2)	Advances and other amounts recoverable in cash or in kind for value to be			
	a)	On Capital A/c	0	0
	b)	Pre-payments	0	0
	c)	Others	1943682	1704073
3)	Income Accrued			
	a)	On Investments from earmarked / endowment funds	0	0
	b)	On Investments – Others Accrued interest of SDR on LC	0	0
	c)	On investment in SDR	0	0
	d)	Others (includes income due unrealized Rs.....) Accrued interest on HBA & interest receivable	1411439	2114706
4)	Claims Receivable		0	0
TOTAL (B)			13193698	8285009
TOTAL (A + B)			**55827259**	**23069567**

K. Kumar

D. S. Ramesh

Narendra Samar & Co. Partner Chartered Accountants

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)
Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.
SCHEDULE FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 13 : GRANTS/SUBSIDIES (Irrevocable Grants & Subsidies Received)		Current Year Ended 31st March-2016		Previous Year Ended 31st March-2015
1)	Central Government - Received from Department of Science & Technology	340000000		
	Less : Grant-in-Aid Capital Transferred to Capital Account	83125000	256875000	257500000
2)	State Government		0	0
3)	Government Agencies		0	0
4)	Institutions/welfare Bodies		0	0
5)	International Organizations		0	0
6)	Others (Specify)		0	0
TOTAL			256875000	257500000

K. Kumar

D. S. Ramesh

Partner

FORM OF FINANCIAL STATEMENTS (NON-PROFT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

SCHEDULE FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 14 : FEES / SUBSCRIPTION			Current Year Ended 31st March-2016	Previous Year Ended 31st March-2015
1)	Entrance Fees		0	0
2)	Annual Fees / Subscriptions		0	0
3)	Seminar / Program Fees		0	0
4)	Consultancy Fees		0	0
5)	Others (Specify)		0	0
	a)	CGHS contribution	0	0
	b)	Service charges – IIG	20729	18001
	c)	License fees – IIG	342795	342525
TOTAL			**363524**	**360526**
Note : Accounting Policies towards each item are to be disclosed				

K. Kumar

D. S. Ramesh

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

SCHEDULE FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2016

SCHEDULE 17 : INTEREST EARNED			Current Year Ended 31st March-2016	Previous Year Ended 31st March-2015
1)	On Term Deposits:			
	a)	With Scheduled Banks	0	0
	b)	**With Scheduled Banks (Bank of India) - From investment in SDR */LC**	**2951336**	3549179
	c)	With Institutions	0	0
2)	On Savings Accounts		0	0
	a)	With Scheduled Banks	0	0
	b)	With Non-Scheduled Banks	0	0
	c)	Post office Savings A/cs	0	0
	d)	Others	0	0
3)	On Loans		0	0
	a)	**Staff Members**	**1021669**	3380412
	b)	Others	0	0
4)	Interest on Debtors and Other Receivables		0	0
	TOTAL		**3973005**	**6929591**
Note : Tax deducted at source to be indicated				

K. Kumar

D.S. Ramesh

Narendra Sarwar & Co. Partner Chartered Accountants

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

SCHEDULE FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 18 : OTHER INCOME			Current Year Ended 31st March-2016	Previous Year Ended 31st March-2015
1)	Profit on Sale / disposal of Assets:			
	a)	**Owned assets**	**1100**	3937
	b)	Assets acquired out of grants, or received free of cost	0	0
2)	**Income from Project**		**0**	160000
3)	**Sale of data, PPM & Caliberation of equipment**		**249094**	601328
4)	Miscellaneous Income			
	a)	**Income from hostel / Guest house**	**402092**	855859
	b)	**Miscellaneous receipt**	**3924651**	3072428
TOTAL			**4576937**	**4693552**

K. Kumar

D. S. Ramesh

Narendra Sarnaa & Co. Partner Chartered Accountants

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

SCHEDULE FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 20 : ESTTABLISHMENT EXPENSES		Current Year Ended 31st March-2016	Previous Year Ended 31st March-2015
a)	Salaries	146417988	138174481
b)	Allowances and Bonus	2210277	1303832
c)	Employers Contribution to CPF	32824	28930
d)	Employers contribution to Other Fund (specify) – IIG Pension A/C	23489056	5713254
e)	Employers Contribution to Benevolent Fund	33300	29270
f)	Expenses on Employees Retirement and Terminal Benefits	11777403	17337014
g)	Others (specify) (Medical Expenses)	2784595	2648601
h)	Employers contribution to Recreation Club	72080	102443
I)	Employers contribution to New Contributory Pension Fund	3376655	2924541
TOTAL		**190194178**	**168262366**

K. Kumar

D. S. Ramesh

Partner

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

SCHEDULE FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 21 : OTHER ADMINISTRATIVE EXPENSES		Current Year	Previous Year
1	Advertisement and Publicity	68404	2606508
2	Audit Fees	31050	34151
3	Bank charges	26108	10862
4	Binding charges	5175	57570
5	Canteen Subsidy	366024	302325
6	Conservation of old volumes	0	3191589
7	Design & Fabrication	65000	159965
8	Electricity and power / Charges	11803726	13447565
9	Entertainment / Hospitality	179660	449567
10	Garden Expenses	767408	1574579
11	Guest house maintenance / ChargesGueste house items	564620	882140
12	Hindi expenses / awards	203931	166685
13	House keeping expenses	4064722	2418057
14	IIG Annual Day A/c	131932	188008
15	Insurance	113676	138681
16	Journals	656015	5760603
17	Liveries	12370	15100
18	Meeting expenses	350057	411261
19	Miscellaneous expenses	743868	651362
20	MPLS-Communication Link Charges	1320957	1469267
21	Postage, Telephone and Communication Charges / Internet charges	4074895	3821823
22	Printing and Publication	1576063	962112
	Balance c/f	**27125661**	**38719780**

K. Kumar

D. S. Ramesh

Harendra Sarkar & Co. Partner Chartered Accountants

SCHEDULE 21-OTHER ADMINISTRATIVE EXPENSES		Current Year	Previous Year
	Brought Forward	**27125661**	**38719780**
23	Professional Charges / Consultancy Charges	16723	1254549
29	Registration fees	447380	471444
30	Rent, Rates and Taxes	130150	168874
31	Repairs and Maintenance	12122542	10445139
34	Science week celebration / Exhibition	65982	83503
35	Scientific Expenses	597559	1189941
36	Security services	18050388	15272894
38	Staff welfare	92431	268870
39	Stores consumed	2763377	4913426
40	Survey expenses	401889	359391
41	Traveling and Conveyance Expenses	8445023	16177741
42	Vehicle maintenance	1137245	1028278
43	Visiting scientist / seminar / fees etc.	0	953000
44	Water charges	528025	677217
45	Wages to Contingent Mazdoors	7110915	7140650
46	EGRL Impress	193624	588143
47	Moos Fellowship	0	245498
48	Silchar Workshop	0	251995
49	AMC Maintenance	2569163	0
50	INAUGURAL FUNTION PORTBLAIR	259082	0
	TOTAL	**82057159**	**100210333**

K. Kumar

INDIAN INSTITUTE OF GEOMAGNETISM

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INDIAN INSTITUTE OF GEOMAGNETISM

D. S. Ramesh

Narendra Sarnaa & Co.
Partner
Chartered Accountants

FORM OF FINANCIAL STATEMENTS (NON-PROFIT ORGANISATIONS)

Name Of Entity : Indian Institute Of Geomagnetism, New Panvel, Navi Mumbai – 410 218.

SCHEDULE FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2016

(Amount – Rs.)

SCHEDULE 22 : EXPENDITURE ON GRANTS,SUBSIDIES ETC	Current Year Ended 31st March-2016	Previous Year Ended 31st March-2015
a) Grants given to Institutions / Organizations	605600	1002140
b) Subsidies given to Institutions / Organizations	0	0
TOTAL	**605600**	**1002140**
Note : Name of the Entities, their Activities along with the amount of Grants/subsidies are to be disclosed .		

K. Kumar

D. S. Ramesh

Partner

INDIAN INSTITUTE OF GEOMAGNETISM-2014-2015

Kalamboli Highway,
New Panvel
Navi Mumbai

Current Liabilities

Group Summary

1-Apr-2015 to 31-Mar-2016

Particulars	Opening Balance	Transactions Debit	Transactions Credit	Closing Balance
Duties & Taxes	**53,800.00 Cr**	*2,09,93,858.00*	*2,09,40,058.00*	
Provisions	**1,59,89,689.00 Cr**	*1,60,45,538.00*	*1,24,72,492.00*	**1,24,16,643.00 Cr**
Sundry Creditors	**1,12,61,762.00 Cr**	*15,55,95,446.78*	*14,95,98,358.78*	**52,64,674.00 Cr**
BENEVOLENT FUND PAYABLE		*42,900.00*	*42,900.00*	
GPF PAYABLE		*1,21,17,777.00*	*1,21,17,777.00*	
IIG NPS PAYABLE		*33,70,915.00*	*33,70,915.00*	
IIG RECREATION & WELFARE FUND PAYABLE		*44,200.00*	*44,200.00*	
Performance Guarantee(CL)			*3,01,815.00*	**3,01,815.00 Cr**
RETENTION MONEY	**37,303.00 Cr**			**37,303.00 Cr**
SALARY-PAYABLE	**7,734.00 Cr**	*9,67,11,402.00*	*9,67,03,668.00*	
Security Deposit From Others	**2,01,192.00 Cr**	*9,400.00*	*2,85,264.00*	**4,77,056.00 Cr**
Benevolent Fund (CONTR:435,VOL:5)		*42,900.00*	*42,900.00*	
B.K.ENTERPRISES-PERFORMANCE GUARANTEE	12,060.00 Cr		*11,027.00*	23,087.00 Cr
EPF EMPLOYER'S CONTRIBUTION-PAYABLE		*32,824.00*	*32,824.00*	
GPF-DIRECTOR		*3,00,000.00*	*3,00,000.00*	
GPF- IIG		*1,24,17,777.00*	*1,24,17,777.00*	
IIG NPS		*33,70,915.00*	*33,70,915.00*	
INCOME TAX-OTHERS-PAYABLE		*1,00,000.00*	*1,00,000.00*	
K. LYNGDOH - SD			*16,440.00*	16,440.00 Cr
LIC PREMIUM		*5,78,492.00*	*5,78,492.00*	
MAHENDRA SASAWANEKAR-EMD		*7,300.00*	*7,300.00*	
PT-Others-Payable	500.00 Dr	*8,200.00*	*8,700.00*	
Recreation and Welfare Fund		*44,200.00*	*44,200.00*	
REIMBURSEMENT OF TUTION FEE-PAYABLE	1,67,812.00 Cr	*1,67,812.00*		
Research Scholarship and Others-Payables		*1,34,24,595.00*	*1,34,24,685.00*	90.00 Cr
SAL.-REC - GPF		*8,19,025.00*	*8,19,025.00*	
SECURITY DEPOSIT (5%) ON CONTRACTOR	4,40,905.00 Cr		*5,03,013.00*	9,43,918.00 Cr
SECURITY DEPOST 10% FOR CONTRACTOR	24,651.00 Cr			24,651.00 Cr
Society		*58,16,741.00*	*58,16,741.00*	
TDS ON CONTRCTOR-PAYABLE-2015-16		*5,75,933.00*	*5,75,933.00*	
TDS ON PROFESSIONAL CHARGES-PAYABLE-2014-15	7,889.00 Cr	*7,889.00*		
TDS ON PROFESSIONAL CHARGES PAYABLE-2015-16		*1,21,613.00*	*1,21,613.00*	
Wages-Payable	85,748.00 Cr	*3,76,625.00*	*2,90,877.00*	
WCT-PAYABLE	17,412.00 Cr	*1,40,676.00*	*2,65,977.00*	1,42,713.00 Cr
Grand Total	**2,83,07,457.00 Cr**	***34,32,84,953.78***	***33,46,25,886.78***	**1,96,48,390.00 Cr**

K. Kumar

D S Ramesh

Partner

INDIAN INSTITUTE OF GEOMAGNETISM
NEW PANVEL, NAVI MUMBAI – 410 218.

SCHEDULE – 8A(1a)

YEAR ENDING 31/03/2016

FREEHOLD LAND

AS ON 31/03/15		PARTICULARS	AS ON 31/03/16	
Rs	Ps		Rs	Ps
1000000.00		Land for Regional Centre at Allahabad	1000000.00	
628726.00		Land for E.G.R.L., Tirunelvelli	628726.00	
1864640.00		Land at Portblair	1864640.00	
3493366.00		**TOTAL**	**3493366.00**	

K. Kumar

INDIAN INSTITUTE OF GEOMAGNETISM KALAMBOLI

INDIAN INSTITUTE OF GEOMAGNETISM

D. S. Ramesh

Narendra Samar & Co. Partner Chartered Accountants

INDIAN INSTITUTE OF GEOMAGNETISM
NEW PANVEL NAVI MUMBAI
YEAR ENDED 31-03-2016

Land And Building

Fix Assests - Immovable Property (On Freehold land)

Schedule : 8A 2(a)

Sr No	Particulars Of Assests	Gross Block				Depreciation					Net Block	
		Cost/Value at 31-03-15	Additions during the year	Deduction during the	Cost/Value at 31-03-16	On Value 01/04/15	On addition during the year	For the year 2015-16	On deduction	Deduction during the year	Upto 31-03-16	Cost as at 31-03-15
1	Building - Capital Works	10730609.87	0.00	0.00	10730609.87	5994439.87	0.00	236809	0.00	6231248.87	4499361.00	4736170.00
2	Building - Belapur Quarters	19661930.13	0.00	0.00	19661930.13	11873414.13	0.00	389426	0.00	12262840.13	7399090.00	7788516.00
3	Building - Gulmarg	170337.27	0.00	0.00	170337.27	148194.27	0.00	1107	0.00	149301.27	21036.00	22143.00
4	Building - Nagpur	2052175.12	0.00	0.00	2052175.12	1086497.12	0.00	48284	0.00	1134781.12	917394.00	965678.00
5	Building - Alibag Mavacs	225000.00	0.00	0.00	225000.00	162761.00	0.00	3112	0.00	165873.00	59127.00	62239.00
6	Building - Prefabricated Structure	155235.00	0.00	0.00	155235.00	120734.00	0.00	1725	0.00	122459.00	32776.00	34501.00
7	Building - Space Sci.Lab. Kolhapur	153338.00	0.00	0.00	153338.00	110921.00	0.00	2121	0.00	113042.00	40296.00	42417.00
8	Building - Wilton Hall	531374.51	0.00	0.00	531374.51	474565.51	0.00	2840	0.00	477405.51	53969.00	56809.00
9	Building - P.R. Radar Tower Kolhapur	972012.00	0.00	0.00	972012.00	571242.00	0.00	20039	0.00	591281.00	380731.00	400770.00
10	Building - Pondicherry	2459332.56	0.00	0.00	2459332.56	1311036.56	0.00	57415	0.00	1368451.56	1090881.00	1148296.00
11	Building & Quarters - EGRL	8327194.00	0.00	0.00	8327194.00	4809359.00	0.00	175892	0.00	4985251.00	3341943.00	3517835.00
12	Building - Alibag Quarters	7454672.00	0.00	0.00	7454672.00	4495149.00	0.00	147976	0.00	4643125.00	2811547.00	2959523.00
13	Building - Vishakhapatnam	907924.00	0.00	0.00	907924.00	525383.00	0.00	19127	0.00	544510.00	363414.00	382541.00
14	Building - Jaipur	5646974.00	0.00	0.00	5646974.00	2927384.00	0.00	135980	0.00	3063364.00	2583610.00	2719590.00
15	Building - GRL Allahabad	75546986.23	0.00	0.00	75546986.23	27735549.23	0.00	2390572	0.00	30126121.23	45420865.00	47811437.00
16	Building - Rajkot	4280804.00	0.00	0.00	4280804.00	1595516.00	0.00	134264	0.00	1729780.00	2551024.00	2685288.00
17	Building - Shillong (Boundry Wall)	6916354.00	0.00	0.00	6916354.00	2411444.00	0.00	225246	0.00	2636690.00	4279664.00	4504910.00
18	Building, Guest House, Hostel-EGRL	48252012.00	0.00	0.00	48252012.00	13771335.00	0.00	1724034	0.00	15495369.00	32756643.00	34480677.00
19	Building - Silchar	14715046.00	0.00	0.00	14715046.00	2242452.00	0.00	623630	0.00	2866082.00	11848964.00	12472594.00
20	Building – Colaba (WDC)	1232610.00	0.00	0.00	1232610.00	83927.00	0.00	57432	0.00	141359.00	1091251.00	1148683.00
	TOTAL	**210391920.69**	**0.00**	**0.00**	**210391920.69**	**82451303.69**	**0.00**	**6397031.00**	**0.00**	**88848334.69**	**121543586.00**	**127940617.00**

K. Kumar

D. S Ramesh

Narendra Sarwar & Co. Partner Chartered Accountants

INDIAN INSTITUTE OF GEOMAGNETISM
NEW PANVEL NAVI MUMBAI
YEAR ENDED 31-03-2016

Land And Building

Fix Assests - Immovable Property (On Leasehold Land)

Sr No	Particulars Of Assests	Gross Block				Depreciation					Net Block	
		Cost/Value at 31-03-15	Additions during the year	Deduction during the	Cost/Value at 31-03-16	On Value 01/04/15	On addition during the year	For the year 2015-16	On deduction	Deduction during the year	Upto 31-03-16	Cost as at 31-03-15
1	Building - Panvel	77703355.00	0.00	0.00	77703355.00	38272675.00	0.00	1971534.00	0.00	40244209.00	37459146.00	39430680.00
2	Research Scholar Hostel	18362223.00	0.00	0.00	18362223.00	7411344.00	0.00	547544.00	0.00	7958888.00	10403335.00	10950879.00
3	Guest House at Panvel	35240411.00	0.00	0.00	35240411.00	11701231.00	0.00	1176959.00	0.00	12878190.00	22362221.00	23539180.00
4	Building - Auditorium & Canteen at Panvel	75876172.00	0.00	0.00	75876172.00	10475543.00	0.00	3270031	0.00	13745574.00	62130598.00	65400629.00
5	Building Director Bunglow Flatlets & Staff Quarters	42615444.00	199000.00	0.00	42814444.00	4355685.00	4961.00	1912988	0.00	6273634.00	36540810.00	38259759.00
	TOTAL	**249797605.00**	**199000.00**	**0.00**	**249996605.00**	**72216478.00**	**4961.00**	**8879056.00**	**0.00**	**81100495.00**	**168896110.00**	**177581127.00**

K. Kumar

D. S. Ramesh

Narendra Samar & Co. Partner Chartered Accountants

INDIAN INSTITUTE OF GEOMAGNETISM
NEW PANVEL, NAVI MUMBAI – 410 218.

YEAR ENDING 31/03/2016

ADVANCES FOR IMMOVABLE PROPERTIES CAPITAL WORKS IN PROGRESS (A)

Particulars	As on 31/03/15	Additions during the year	Deduction during the year	As on 31/03/16
Capital work in progress – Nagpur	289514	0	0	289514
Capital work in progress – Rajkot (CPWD)	1049315	0	0	1049315
Capital work in progress – Jaipur	468774	0	372216	96558
Capital work in progress – Kolhapur	303796	0	0	303796
Capital work in progress – CPWD Alibag	1700000	1239980	0	2939980
Capital work in progress – Allahabad	12240100	3335424	0	15575524
Capital work in progress – EGRL	809428	0	0	809428
Capital work in progress – Portblair	27664204	0		27664204
Capital work in progress – Flatlets/Dir Bung, Staff Qtrs	400000	0	199000	201000
Capital work in progress – Pondicherry	3365296	1310400		4675696
Capital work in progress – Shilong	4364948	2503315	0	6868263
Capital work in progress – Belapur	1621656	0	0	1621656
Capital work in progress – Vishakapatnam	6388	1635000	0	1641388
Capital work in progress – Panvel	5948564	0	0	5948564
Capital Work in progress - Hostel	834466	0	0	834466
Capital Work in progress - Silchar	2094250	0	0	2094250
Capital Work in progress - Colaba	0	4269485	0	4269485
TOTAL	**63160699**	**14293604**	**571216**	**76883087**

K. Kumar

D. S. Ramesh

Narendra Samar & Co. Partner Chartered Accountants

INDIAN INSTITUTE OF GEOMAGNETISM
NEW PANVEL, NAVI MUMBAI – 410 218.

YEAR ENDING 31/03/2016

SCHEDULE – 8(B)

ADVANCES FOR MOVABLE PROPERTIES CAPITAL WORKS IN PROGRESS (B)

Particulars	As on 31-03-15	Additions during the year	Deduction during the year	As on 31-03-16
Advances for Laboratory Equipment (Exp.)	753030.00	0.00	50000.00	703030.00
Margin Money	0.00	0.00	0.00	0.00
TOTAL	**753030.00**	**0.00**	**50000.00**	**703030.00**

CAPITAL WORKS IN PROGRESS

A) ADVANCES FOR IMMOVABLE PROPERTIES	76883087.00
B) ADVANCES FOR MOVABLE PROPERTIES	703030.00
TOTAL	77586117.00

K. Kumar

D. S. Rawat

Narendra Sarsar & Co. Patna Chartered Accountants

INDIAN INSTITUTE OF GEOMAGNETISM

NEW PANVEL NAVI MUMBAI

YEAR ENDED 31-03-2015

INVENTORIES

Sch :11 A (1)

Particulars	Opening Balance	Purchases	Closing Balance	Consumption
Computer Stationery	143080	815344	103445	854979
Stationery / Chart Rolls & Printing of stationery : 1) Stationery / Chart Rolls 2) Pringing of stationery	182997	404013	144844	442166
Electrical Goods & Electronic Components	201843	1372987	151314	1423516
Photo Goods	41379	41462	40125	42716
TOTAL	569299	2633806	439728	2763377

K. Kumar

D. S. Ramesh

Partner

INDIAN INSTITUTE OF GEOMAGNETISM

NEW PANVEL, NAVI MUMBAI – 410 218.

SCHEDULE – 11A(2b)

YEAR ENDING 31/03/2016

ADVANCE AND DEPOSITS WITH OTHERS

AS ON 31/03/15		PARTICULARS	AS ON 31/03/16	
RS.	PS.		RS.	PS.
	74387	Deposit Tele / Telex MTNL		74387
	47730	Deposit MSEB, Alibag		47730
	14200	Deposit LPG Gas (Mumbai & Panvel)		14200
	72100	Deposit Telephones (All outstations)		62708
	3470	Deposit BEST Security		3470
	5560	Deposit BEST for Residential Qtrs.		5560
	16510	Deposit Security Deposit MSEB & MSED, Nagpur		16510
	19420	Deposit Tamilnadu Electricity Board		19420
	294300	Deposit MSEB, Belapur		294300
	40000	Deposit Internet (VSNL)		0
	384000	Deposit MSEB, Panvel		0
	23920	Deposit Electricity Tirunelveli		23920
	950	Deposit LPG Gas (All Outstations)		950
	32090	Deposit CIDCO Land		32090
	9747	Deposit Electric Connection GRL		9747
	500	Deposit Telephone Rajkot		500
	8555	Deposit Rajasthan Electricity (Board) Jaipur		8555
	0	GSILI Recoverable		0
	550	Deposit HP Gas, Panvel		550
	1000	Deposit MTNL, Panvel (Guest House)		0
	700	Deposit BSNL Jaipur		700
	1000	Deposit BSNL Port Blair		1000
	3000	Deposit BSNL Rajkot		3000
	48000	Deposit CIDCO (DIR BUNG & FLAT)		48000
	11000	Deposit UPPCL (Allahabad)		11000
	64333	Deposit Elect. Portblair		64333
	2200	Deposit Security MSED Alibag		2200
	3150	Deposit Pushpak Gas Rajkot		3150
	1850	Deposit LPG Gas Portblair		1850
	1900	Deposit LPG GAS Silchar		1900
	320	Deposit Mobile Vodafone		0

K. Kumar

D. S Ramesh

100000	Deposit Security at Assam Silchar	100000
0	Foreuign TA receivable	0
1000	Deposit Bank A/c. Rajkot	1000
1000	Deposit Bank A/c. Alibag	1000
1000	Deposit Bank A/c. Vishakhapatnam	1000
1000	Deposit Bank A/c. Silchar	1000
500	Deposit Bank A/c. Nagpur	500
3430	Deposit Electric MSEDCL, Alibag	3430
5170	Deposit Electric Vishakhapatnam	5170
52857	Deposit Nalanda Decor	52857
500	Deposit Reliance Telephone	0
25000	Deposit Victory Automobiles	25000
1060	Deposit MSEDCL Belapur quarters	1060
3480	Deposit MSEDCL Kolhapur	3480
71300	Deposit MSEDCL Panvel	773100
152175	NHPC A/c.	152175
66890	NMRL/DRDO Project	66890
31269	ALLAHABAD BANK OF INDIA	0
0	Security Deposit of Electric Meter Colaba	2620
0	Security Deposit of Electric Meter Kolhapur	1670
1704073	**TOTAL**	**1943682**

K. Kumar

D S. Rawat

INDIAN INSTITUTE OF GEOMAGNETISM

NEW PANVEL, NAVI MUMBAI – 410 218.

SCHEDULE 11B(1)

YEAR ENDING 31/03/2016

ADVANCE TO STAFF

AS ON 31/03/15	PARTICULARS	AS ON 31/03/16
RS. PS.		RS. PS.
74391	Travelling Allowance	112320
64875	Festival	42750
46178	Leave travel concession	470671
104500	Scooter	103000
1446575	House Building	707795
0	Foreign T.A.	465510
177150	Computer	338700
950461	Motor Car	689409
0	Hard Duty Allowance	1130000
0	Medical Advance	19986
0	TA on Transfer	0
2864130	**TOTAL**	**4080141**

K. Kumar

D. S. Ramesh

INDIAN INSTITUTE OF GEOMAGNETISM

NEW PANVEL, NAVI MUMBAI – 410 218.

SCHEDULE – 20A

YEAR ENDING 31/03/2016

A. SALARIES

PARTICULARS	AS ON 31/03/16	
	RS.	PS.
Pay and Allowances	132253381	
Research Scholarship / Stipend to Res. students	14164607	
TOTAL	146417988	

K. Kumar

D. S. Ramesh

Harendra Sonar & Co. Chartered Accountants

INDIAN INSTITUTE OF GEOMAGNETISM
NEW PANVEL, NAVI MUMBAI – 410 218.

SCHEDULE – 20B

YEAR ENDING 31/03/2016

ALLOWANCES & BONUS

PARTICULARS	AS ON 31/03/16	
	RS.	PS.
Bonus	191696	
Honorarium	848657	
Overtime	16295	
Hard Duty Allowance	0	
Mess Allowances	113692	
Children Education Allowance/Reimbursement of Tution Fees	1039937	
TOTAL	2210277	

K. Kumar

D. S Ram

Nirendra Samar & Co.
Partner
Chartered Accountants

Artistic Effects-
Research Scholars performing dance sequences on the occasion of the 44th Foundation Day celebrations.

Hon'ble Minister Dr. Harsh Vardhan viewing the Sun through solar viewing glass.

Geodetic studies being carried out by IIG scientists at Vestre Broggerbreen Glacier, Svalbard, Arctic