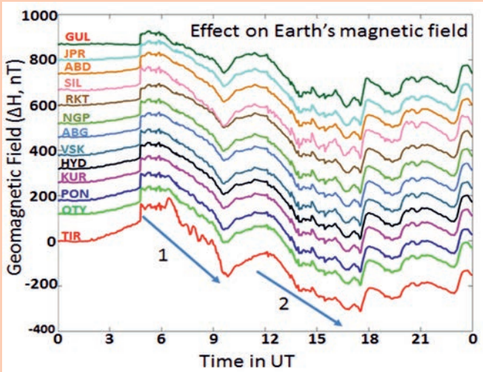
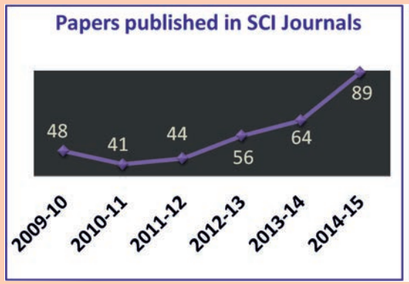
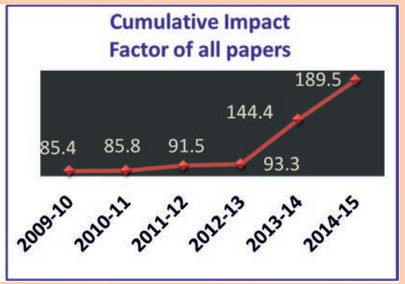


Disturbed Geomagnetic field during double strom
(IIG's Magnetometer Network)

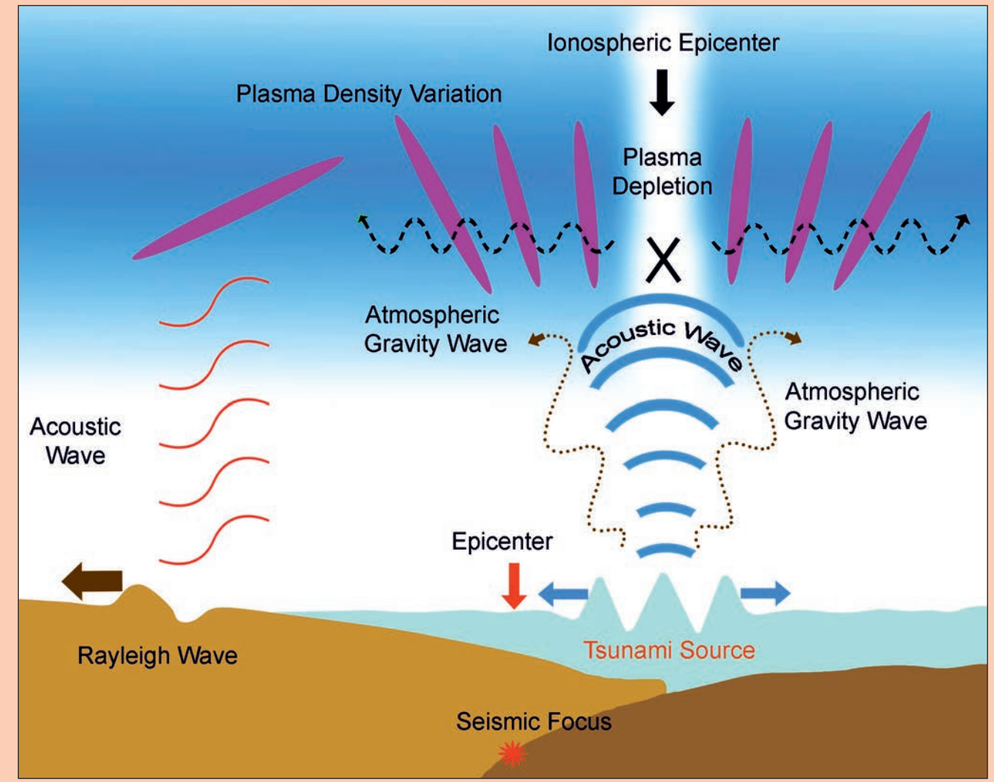
BEENS Experiment





Swachh Bharat campaign at IIG

Annual Report 2014-2015



Indian Institute of Geomagnetism

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Indian Institute of Geomagnetism

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PUBLICATION COMMITTEE
Ashwini K. Sinha, Gautam Gupta, Gopi Krishna Seemala, B.I. Panchal and Samir Parab

Cover page : Remote sensing of natural disasters using GPS and InSAR technology

Education Leadership Award
was conferred on IIG by ABP News

Performance by a Research student in the
cultural program on IIG's foundation day

IIG house magazine 'SPANDAN'
bagged coveted ICE
(In-house Communication Excellence)
Award instituted by
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INDIAN INSTITUTE OF GEOMAGNETISM

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From the Director's Desk.....

History was created by IIG with the inauguration of a Multi-parametric Geophysical Observatory (MPGO) at Shoal Bay-8, South Andamans on March 30, 2015. The Honourable Union Minister of Science & Technology and Earth Sciences, Dr. Harsh Vardhan formally dedicated this state-of-art most modern prognostic facility of natural disasters to the nation. It was indeed heartening to note that a good number of general public and school students were present on this auspicious occasion. This centre in Port Blair hosts a variety of sophisticated instruments to monitor both long and short term excursions in the Earth's Magnetic field at varied frequencies using state-of-the-art Overhauser, Induction coil and Fluxgate magnetometers. It would also house modern instruments by way of a Very Broad Band Seismometer, Ground Accelerometer and GPS to record both vertical and horizontal components of the ground deformation. In addition, various meteorological parameters are proposed to be recorded at the MPGO. This Multi-Parametric Geophysical Observatory offers a unique opportunity to comprehend and decipher the coupled nature of the lithosphere-atmosphere-ionosphere-magnetosphere system leading towards development of an Integrated Precursory Signals System (IPSS) to mitigate natural disasters of varied origin. These results would complement the information gleaned from the already established multi-parametric observatory at Shillong, under a mission mode project of DST on seismicity. This MPGO is expected to attract many researchers, particularly from universities/institutes of India, to carry out collaborative research on the possible precursory mechanisms.

To present important advances on other academic research, observations from imaging riometer installed at India's permanent Antarctica base, Maitri, suggest that dayside Cosmic Noise Absorption (CNA) at Maitri accompanied with Pc5 oscillations is the consequence of magnetospheric drift of energetic particles from night side to dayside during severe geomagnetic storms. These results are first of their kind in the area of space weather research.

Role of linear and non linear waves in magnetospheric and interplanetary plasma forms an important research component to understand the solar wind, magnetosphere and ionosphere coupled system. To provide a clear view on the application of the fluid and kinetic treatments in modeling the electrostatic solitary waves in space plasmas, both fluid and particle-in-cell (PIC) simulations of ion acoustic solitary waves (IASW) are performed. The simulation results suggests that the fluid treatment is appropriate when the magnitude of phase velocity of IASW is less than the ion acoustic (IA) speed obtained from their linear dispersion relation, whereas when it exceeds IA speed, it is necessary to include the kinetic effects in the model.

The growth rates of the two competing plasma instabilities- mirror and ion cyclotron instability in the space plasma has been studied, and the dominance regime for each is explained in the case of magnetosheath plasma using linear kinetic theory. An unusual event of ion cyclotron mode dominance in the magnetosheath has been reported using Cassini and WIND satellites. An unusually low plasma beta in the magnetosheath during this interval could have possibly favoured the ion cyclotron mode dominance during the period.

As far as global electric circuit (GEC) studies are concerned, the first observations of Transient Luminous Events (TLE's) at Allahabad have reported "Sprites" over the thunder clouds in the Indo-Gangetic plain. These optical emissions above thunderstorms are considered to be very energetic and more powerful than terrestrial lightning discharges. Their detailed study will be useful in characterizing Indian thunderstorms, their contribution to GEC and other related meteorological phenomena. The study would also open a new window for TLE's research in India with a quest for observing other TLE's such as Elves, Blue Jets, Gigantic Jets etc.

Ionospheric irregularities in the equatorial ionosphere have damaging effects on satellite based communication and navigation systems and are being studied by examining their effects on trans-ionospheric propagation of radio waves. A sharp transition in h'F was noticed during the progressive period of the 30–31 Oct 2003 Halloween storm, though it was relatively lower at the equator.

VHF and L-band radio wave signals transmitted from a geostationary and GPS satellites respectively, and radio wave signals backscattered by irregularities as seen from the Indian MST radar data, were effectively used to study the evolution of the Rayleigh- Taylor instability on the bottom side of the post-sunset equatorial F region during magnetically quiet periods. The spatial and temporal evolution of equatorial plasma bubbles (EPBs) during the low to moderate solar activity years (2010–2012) were deciphered using Equatorial Atmosphere Radar (EAR) and the responsible mechanisms for the genesis of fresh EPBs during post midnight hours were envisaged in light of equator-ward meridional winds in the presence of weak westward electric fields.

Using VLF observations, occurrence of periodic wave-like signatures (WLS) in the D-region ionosphere during 22 July 2009 total solar eclipse has been reported. These could be generated by sudden cut-off of the photo-ionization creating night-time like conditions in the D-region ionosphere and solar eclipse induced gravity waves coming to ionosphere from below and above.

The Mesosphere-lower Thermosphere (MLT) region (80-100 km) is a vital transition zone of the atmosphere which provides an interface between the lower, middle and the upper atmosphere. The advent of new satellite missions, ground-based instrumentation networks, and the development of whole atmosphere models over the past decade resulted in a paradigm shift in understanding the variability of geospace. It has now been realized that conditions in geospace are linked strongly to terrestrial weather and climate below. An integrated approach will play an important role in understanding the vertical and lateral coupling of different regions of the atmosphere.

IIG is engaged in understanding the processes of the Earth's interior on various spatial and temporal scales using a variety of observational tools, namely, electromagnetic induction, resistivity imaging, geomagnetic depth sounding, rock and mineral magnetism, petrology, gravity and magnetic anomalies and space geodetics. Synthesizing the results obtained from joint 2D modeling of ship-borne gravity-magnetic data and 3D modeling of satellite derived free air gravity data using modified form of Energy Spectral Analysis, it is inferred that the EW and NW-SE segments of the Laxmi ridge are characteristically different. The region to the north of Laxmi ridge, between Laxmi and Gop basins, is composed of volcanic / basaltic flows having Deccan affinity which may have been emplaced during the passage of India over the Reunion hotspot.

Electrical conductance map for the Kachchh Rift Basin has been prepared using an array of magnetometers spread across the basin. The results indicate that the imaged conductivity anomalies can be related to the sediment-filled structural lows in between the fault bounded uplifts. Presence of metamorphosed graphite schist clasts in shale dominated Mesozoic sequence and/or thin films of carbon resulting from the thermal influence of Deccan activity on Carbonate-rich formations can account for the high electrical conductivity anomalies seen in the thick Mesozoic and Tertiary sediments. Additionally two high conductivity zones are imaged encompassing a resistive block, related to volcanic plugs, defined by the 2001 Bhuj earthquake which perturbs the regional stress concentrations to produce frequent and low magnitude aftershocks.

GPS observations are used to ascertain the causative source in the generation of the September 18, 2011 Sikkim–Nepal border earthquake. It is surmised that the competent and strong eclogitic layer in the lower crust serves as a repository of high stresses during an earthquake build-up cycle, wherein the fluid pressure in the fractured rock matrix above plays a key role in the earthquake generating process. The 11 April 2012 East Indian Ocean doublet earthquake occurred with a magnitude of 8.6 Mw and was followed by a strong aftershock (8.2 Mw). The

estimated propagation velocities of the post-seismic TEC disturbances during the main shock and aftershock confirm the presence of an acoustic frequency as the generative mode for the observed TEC fluctuations.

Environmental magnetism deals with the measurement and analysis of magnetic properties of sediments, soil and dust. As human kind faces the threat of global climate change, researchers at IIG are engaged in the multi-proxy reconstruction of past climate by analyzing several sediment cores from the Indian monsoon region. Such studies provide clues to identifying major environmental factors affecting human settlements in the recent geological past. Results of anisotropy of magnetic susceptibility (AMS) of deformed and undeformed unconsolidated clay samples of Deccan Trap terrain from the ~2000-year-old palaeo-earthquake site of Ther village, Maharashtra, India, suggests these deposits to be rare in this region and gives an excellent prospect to test the efficacy of AMS in the Deccan Trap region, which can potentially throw up new results to build the chronology of past earthquakes.

Groundwater being a natural and renewable resource plays a vital role in the socio-economic development of any region. The resistivity group of IIG routinely carry out electrical resistivity imaging investigations to identify potential aquifer zones and assess the quality of groundwater from different hard rock, semi-arid regions of the Deccan Volcanic Province of Maharashtra. It is our constant endeavour to assess the quality of air and water, which is a prerequisite for sustenance of human life. At the same time our scientific efforts such as above are directed towards the adherence of **Swastha Bharat Abhiyaan**.

The instrumentation division of IIG, in its effort to modernize equipments, has designed an nT Logger which to continuously monitors and records variations in various geomagnetic field components. This division is now actively engaged in developing various in-house equipments and accessories (both hardware and software) required for geomagnetic studies, thereby complying with the National Mission **Make in India**.

Research work carried out by IIG scientists has culminated in the publication of 105 papers during the year, of which 89 were in SCI journals with a cumulative impact factor of 189.5. IIG scientists participated in a large number of national and international conferences held during this period, and presented more than 54 papers.

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. IIG got the distinction in organizing a special session on the “Dynamic Earth and its near and far Environment: new paradigms”, at the 102nd Indian Science Congress at Mumbai. Also a National workshop on “Geomagnetic Research and upgradation of Observational Skills of Staff” was held at Magnetic Observatory, Silchar. IIG jointly hosted the XVIth IAGA Workshop on ‘Geomagnetic Observatory Instruments, Data Acquisition and Processing’ with NGRI at Hyderabad. The Institute formally launched the Dr. Nanabhoy Moos Research Fellowship on the 156th birthday of Dr. Nanabhoy Moos on October 29, 2014. In pursuit of igniting young minds to take up research as their career, IIG again conducted IMPRESS programme at EGRL, Tirunelveli. In its endeavour towards the service of the nation, IIG is committed to provide consultancy and technical services to various national agencies and public sectors in the area of resource prospecting and calibration of different magnetic instruments.

IIG continued to receive a good number of applications from students for summer projects and dissertation. Thirty two M.Sc. students worked on summer projects at IIG. Several researchers were given training on AMS studies in the environmental magnetism laboratory at IIG and palaeomagnetic laboratory at KSKGRL, Allahabad. During the year, three research scholars were awarded Ph.D. degree and several accolades were also bestowed on students at numerous conferences.

The valued contributions of each member of the IIG family and their support made it possible to surmount the challenges stemming from various new initiatives reported here. We thank the Governing Council of IIG and the Research Advisory Committee for their illuminating guidance and generous support to strengthen our commitment towards ushering cutting-edge science at IIG.

D.S. Ramesh
Director

September 01, 2015

GEOMAGNETIC DATA BASED RESEARCH

QUIET TIME VARIATIONS

Relationship between the equatorial electrojet and global Sq currents at the dip equator region

The equatorial electrojet (EEJ) is a strong eastward ionospheric current flowing in a narrow band along the dip equator. In this study, the EEJ-Sq relationship is examined by using observations at six stations in the South American, Indian, and Southeast Asian sectors. The analysis was carried out with data on geomagnetically quiet days with Kp ≤3 from 2005 to 2011. A normalization approach was used because it yields more accurate results by overcoming the uncertainties due to latitudinal variation of the EEJ and Sq. A weak positive correlation between the EEJ and Sq was obtained in the Southeast Asian sector, while weak negative correlations were obtained in the South American and Indian sectors. EEJ-Sq relationship is found to be independent of the hemispheric configuration of stations used to calculate their magnetic perturbations, and it also only changed slightly during low and moderate solar activity levels. These results demonstrate that the Southeast Asian sector is indeed different from the Indian and South American sectors, which is indicative of unique physical processes particularly related to the electro-dynamo. Furthermore, it can also be demonstrated that the definition of the EEJ, that is, the total current or enhanced current, can significantly affect the conclusions drawn from EEJ-Sq correlations *(Nurul Shazana, Abdul Hamid, Huixin Liu, Teiji Uozumi, Kiyohumi Yumoto (Kyushu University, Japan); **B. Veenadhari**; Akimasa Yoshikawa (Kyushu University, Japan); Jairo Avendaño Sanchez (Geographic Institute Agustin Codazzi, Colombia)).*

Gravity, GPS and Geomagnetic data in India

Gravity, Global Positioning System (GPS) and geomagnetic data sets in India are acquired by different research, academic and government institutions, under various projects. These data sets have extensively been utilized for natural resources and lithopsheric explorations, earthquake studies, atmospheric and ionospheric studies, control surveys, aircraft navigation, etc. The data are archived at individual institutions and have different modes of procurement considering some of the data, e.g., gravity data are classified in nature. Some of these data sets are contributed to the international observational network for example IGS and INTERMAGNET and are available as open source for the scientific communities. Present article provides information about different types of available Gravity, GPS and Geomagnetic data, their archival and mode of availability to the user community *(Tiwari, V.M. (NGRI, Hyderabad); **B. Veenadhari**; V.K. Gahalaut (NGRI, Hyderabad); **S. Mukherjee**; V.P. Dimri (NGRI, Hyderabad)).*

Solar flares induced D-region ionospheric and geomagnetic perturbations

The D-region ionospheric perturbations caused by solar flares occurred during January 2010 to February 2011, a low solar activity period of current solar cycle 24, have been studied on NWC transmitter signal (19.8 kHz) recorded at an Indian low latitude station, Allahabad (Geographic lat. 25.75°N, long. 81.85°E). A total of 41 solar flare events including 21 C-class, 19 M-class and 01 X-class flares occurred during the daylight part of NWC-Allahabad transmitter receiver great circle path. The local time dependence of solar flare effect on the change in the VLF amplitude (ΔA), time delay (Δt) between VLF peak amplitude and X-ray flux peak have been studied during three different period of local daytime. Using the Long Wave Propagation Capability code V 2.1, the D-region reference height (H/) and sharpness factor (β) for each class of solar flare (C, M and X) have been examined. It is found that D-region ionospheric parameters strongly depend on the local time of flares occurrence and their classes. The electron density estimated by using H/ and β shows highest increase of the order of ~80 as compared to normal day values for X- class flare. Electron density found to increase exponentially with increase in the solar flux intensity. Solar flare effects on horizontal component (H) of the Earth's magnetic field over an equatorial station Tirunelveli (Geographic lat., 8.7 °N, long., 77.8 °E, dip lat., 0.4 ºN) have also been studied. The maximum increase in H of ~ 8.5% was found for M class solar flares due to the additional magnetic field produced by the ionospheric electrojet currents over the equatorial stations *(**R. Selvakumaran, Ajeet K. Maurya, Sneha A. Gokani, B. Veenadhari**; Sushil Kumar, K. (The University of South Pacific, Fiji); **K. Venkatesham;** D. V. Phanikumar, (Aryabhatta Research Institute of Observational Sciences, Nainital); Abhay K. Singh (Banaras Hindu University, Varanasi); Devendraa Siingh, (Indian Institute of Tropical Meteorology, Pune); **Rajesh Singh**).*

EFFECT OF GEOMAGNETIC DISTURBANCES

Ionospheric current contribution to the main impulse of a negative sudden impulse

The geomagnetic field response to a moderate-amplitude negative sudden impulse (SI−) that occurred on 14 May

2009 at 10:30 UT was examined at 97 geomagnetic observatories situated all over the globe. The response signature contains a contribution from magnetospheric as well as ionospheric currents. The main impulse (MI) is defined as the maximum depression in the observed geomagnetic field. It is observed that for low-to-high latitudes, the amplitude of the MI is larger in the afternoon to post-dusk sector than in the dawn-noon sector, indicating asymmetry in the MI amplitude. It is estimated that the contribution at various observatories due to the Chapman-Ferraro magnetopause currents using the Tsyganenko model (T01) and subtracted this from the observed MI amplitude to obtain the contribution due to ionospheric currents. It is found that the ionospheric currents contribute significantly to the MI amplitude of moderate SI− even at low-to-mid latitudes and that the contribution is in the same direction as that from the magnetopause currents near dusk and in the opposite direction near dawn. The equivalent current vectors reveal a clockwise (anticlockwise) ionospheric current loop in the afternoon (morning) sector during the MI of the negative pressure impulse. This evidences an ionospheric twin-cell-vortex current system (DP2) due to field-aligned currents (FACs) associated with the dusk-to-dawn convection electric field during the MI of an SI−. The estimated magnetic field variation due to prompt penetration electric fields is found to be very small at low latitudes in the present case. The studied SI− is not associated with shock, and hence no preliminary reverse impulse was evident. In addition, the summer hemisphere reveals larger MI amplitudes than the winter hemisphere, indicating once again the role of ionospheric currents *(**Geeta Vichare, Rahul Rawat, Ankush Bhaskar**; B.M. Pathan).*

Quantitative understanding of Forbush decrease drivers based on shock-only and CME-only models using global signature of February 14, 1978 event

The Forbush decrease (FD) event that occurred on February 14, 1978 using 43 neutron monitor observatories have been studied to understand the global signature of FD. The rigidity dependence of shock amplitude and total FD amplitude has been studies. It is found that almost the same power law index for both shock phase amplitude and total FD amplitude. Local time variation of shock phase amplitude and maximum depression time of FD have been investigated which indicate possible effect of shock/CME orientation. The rigidity dependence of time constants of two phase recovery has been analysed. Time constants of slow component of recovery phase show rigidity dependence and imply possible effect of diffusion. Solar wind speed was observed to be well correlated with slow component of FD recovery phase. This indicates solar wind speed as possible driver of recovery phase. To investigate the contribution of interplanetary drivers, shock and CME in FD, shock-only and CME-only models have been used. These models have been applied separately to shock phase and main phase amplitudes respectively. This confirms presently accepted physical scenario that the first step of FD is due to propagating shock barrier and second step is due to flux rope of CME/magnetic cloud *(Anil Raghav (University of Mumbai, Mumbai); **Ankush Bhaskar**; Ajay Lotekar (University of Mumbai, Mumbai); **Geeta Vichare, Virendra Yadav**).*

Effects of prolonged southward interplanetary magnetic field on low-latitude ionospheric electron density

The present work describes the low-latitude ionospheric variability during an unusually prolonged (~33 h) geomagnetically disturbed condition that prevailed during 15–16 July 2012. The low-latitude electron density in summer hemisphere, investigated using ground- and satellite-based observations, responded to this by generating strong negative ionospheric storm on 16 July. The maximum electron density on 16 July over Indian low latitudes was reduced by more than 50% compared to that on a geomagnetically quiet day (14 July 2012). In contrast to the extreme reduction in total electron content (TEC) in the Northern Hemisphere, TEC from a winter hemispheric station revealed substantial (~23 TEC units, 1 TECU = 10^{16} el/m^2) enhancements on the same day. This contrasting hemispherical response in TEC is suggested to be due to the combined effects of strong interhemispheric and solar-driven day-night winds. Further, very weak equatorial electrojet (EEJ) strength on 16 July indicated that the westward electric field perturbations in the low-latitude ionosphere were possibly due to the disturbance dynamo effect associated with meridional circulation from polar to equatorial latitudes. Interestingly, despite reduction in the integrated EEJ strength on 15 July, the low-latitude electron density showed substantial enhancement, highlighting the significant effect of the positive ionospheric storm on the low-latitude ionosphere. The roles of electrodynamical / neutral-dynamical and compositional disturbances are discussed in view of these observations to understand low-latitude ionospheric response when geomagnetic disturbance persists for longer duration. *(**Mala S. Bagiya**; Rumajyoti Hazarika (Dibrugarh University, Dibrugarh); Fazlul I. Laskar (Physical Research Laboratory, Ahmedabad); Surendra Sunda (Space Application Centre, Ahmedabad); **S. Gurubaran**; D. Chakrabarty (Physical Research Laboratory, Ahmedabad); P. K. Bhuyan (Dibrugarh University, Dibrugarh); R. Sridharan (Physical Research*

Laboratory, Ahmedabad); B. Veenadhari; D. Pallamraju (Physical Research Laboratory, Ahmedabad)).

Low energy secondary cosmic ray flux (gamma rays) monitoring and its constrains

Temporal variation of secondary cosmic rays (SCR) flux was measured during the full and new moon and days close to them at Department of Physics, University of Mumbai, Mumbai (Geomagnetic latitude: 10.6°N), India. The measurements were done by using NaI (Tl) scintillation detector with energy threshold of 200 keV. The SCR flux showed sudden enhancement for approximately about 2 hour during few days out of all observations. The maximum enhancement in SCR flux is about 200 % as compared to the diurnal trend of SCR temporal variations. Weather parameters (temperature and relative humidity) were continuously monitored during all observations. The influences of geomagnetic field, interplanetary parameters and tidal effect on SCR flux have been considered. Summed spectra corresponding to enhancement duration indicates appearance of atmospheric radioactivity which shows single gamma ray line. Detail investigation revealed the presence of radioactive AR^{41} . Present study indicates origin of Ar^{41} could be due to anthropogenic source or due to gravitational tidal forces. This measurements point out limitations on low energy SCR flux monitoring. This study will help many researchers in measurements of SCR flux during eclipses and to find unknown mechanism behind decrease/increase in SCR flux during solar/lunar eclipse *(Anil Raghav (University of Mumbai, Mumbai); **Ankush Bhaskar**, **Virendra Yadav**; Nitinkumar Bijewar (University of Mumbai, Mumbai)).*

Substorm related CNA near equatorward boundary of the auroral oval in relation to interplanetary conditions

Cosmic noise absorption (CNA) at high latitudes is a typical manifestation of enhanced precipitation of energetic charged particles during the course of a magnetospheric substorm. Present analysis demonstrates the energetic particles precipitate to the high latitude ionosphere during substorms, affecting upper and lower regions of the ionosphere simultaneously. Previous studies have reported that intense and short-lived CNA events associated with substorms are mostly observed in the midnight sector of the auroral oval. The current study examines such type of CNA events predominantly occurring during 0000–0600 UT (2300–0500 MLT) at an Indian Antarctic station Maitri (corrected geomagnetic (CGM) coordinates 62.59 ^{0}S, 53.59 ^{0}E), which is located at the equatorward edge of the auroral oval. Absorption events related to isolated substorm and storm-time substorms exhibit distinct features in terms of their intensity and extent in latitude and longitude. This study suggests that the maximum intensity of CNAs depends on the interplanetary conditions, such as, the solar wind speed, southward component of IMF Bz, and duskward component of IEF Ey. Moreover, the role of duskward component of IEF Ey is more noteworthy than other interplanetary parameters ***(Fig.1)*** *(**Jayanta K. Behera,***

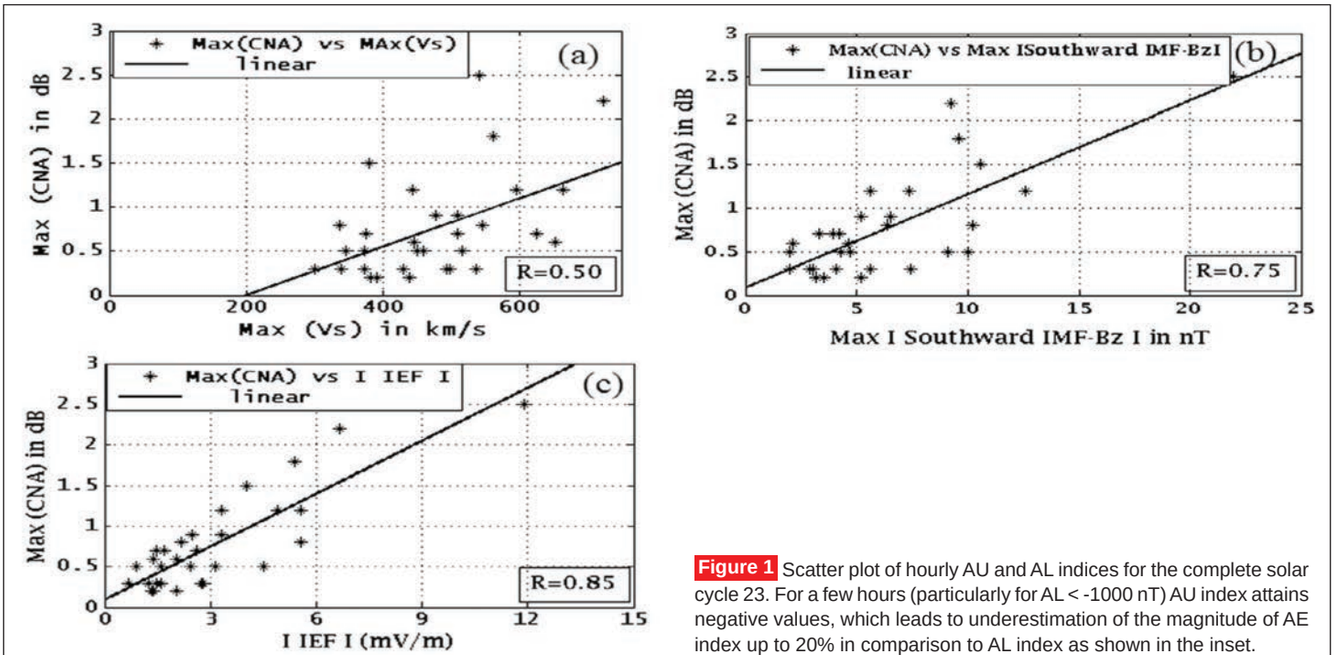


Figure 1 Scatter plot of hourly AU and AL indices for the complete solar cycle 23. For a few hours (particularly for AL < -1000 nT) AU index attains negative values, which leads to underestimation of the magnitude of AE index up to 20% in comparison to AL index as shown in the inset.

***Ashwini K. Sinha**; Anand K. Singh (NCAOR, Goa); **Geeta Vichare, Ajay Dhar, Sachin Labde, K. Jeeva**).*

Auroral electrojets during severely disturbed geomagnetic condition on 24 August 2005

Very intense and highly dynamic eastward and westward currents flowing in the auroral ionosphere are traditionally monitored by the auroral electrojet indices – AU and AL, respectively. In this study we show that on occasions of intense magnetic activity, entire auroral oval could be dominated by the westward flowing currents, which lead to depression not only in AL index but also in supposedly positive AU index ***(Fig.2)***. During negative AU intervals, there could be up to ~20% underestimation of the total maximum intensity of the auroral electrojet represented by AE index defined as AU-AL). A detailed investigation of a well-studied extremely intense event of 24 August 2005 has been carried out. Global prevalence of the westward auroral electrojet was clearly observed at the auroral latitudes during the unusually intense substorm (AL ~ -4000 nT) on the day. Moreover, along the noon meridian westward electrojet appeared in the auroral region whereas eastward electrojet shifted towards lower latitudes. This paper emphasizes that intense substorms are represented better by AL index than AE index *(Anand K. Singh (NCAOR, Goa); **Ashwini K. Sinha**; S. Saini (NCAOR, Goa); **Rahul Rawat**).*

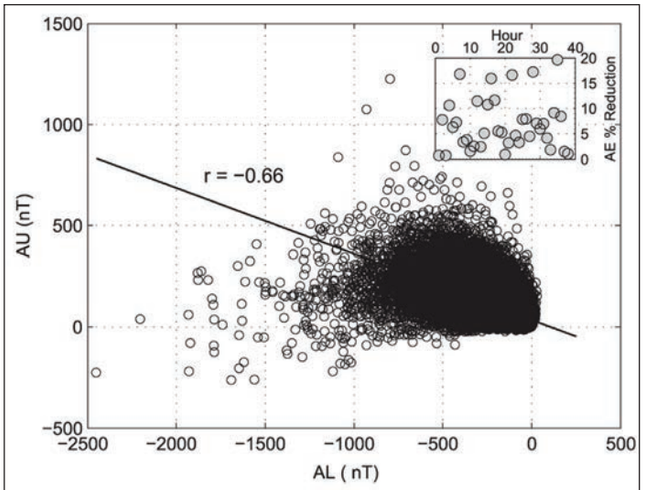


Figure 2 Scatter plot of the maximum intensities of (a) Vsw vs CNA (correlation coefficient, r = 0.5), (b) southward IMF Bz vs CNA (r = 0.75) and (c) duskward IEF Ey vs CNA (r = 0.85) for selected events. CNA intensity at Maitri has strong dependence on IEF Ey.

UPPER ATMOSPHERIC RESEARCH

MESOSPHERE-LOWER THERMOSPHERE STUDIES

The geospace response to variable inputs from the lower atmosphere: a review of the progress made by Task Group 4 of CAWSES-II, Progress

The advent of new satellite missions, ground-based instrumentation networks, and the development of whole atmosphere models over the past decade resulted in a paradigm shift in understanding the variability of geospace, that is, the region of the atmosphere between the stratosphere and several thousand kilometers above ground where atmosphere-ionosphere-magnetosphere interactions occur. It has now been realized that conditions in geospace are linked strongly to terrestrial weather and climate below, contradicting previous textbook knowledge that the space weather of Earth's near space environment is driven by energy injections at high latitudes connected with magnetosphere-ionosphere coupling and solar radiation variation at extreme ultraviolet wavelengths alone. The primary mechanism through which energy and momentum are transferred from the lower atmosphere is through the generation, propagation, and dissipation of atmospheric waves over a wide range of spatial and temporal scales including electrodynamic coupling through dynamo processes and plasma bubble seeding. The main task of Task Group 4 of SCOSTEP's CAWSES-II program, 2009 to 2013, was to study the geospace response to waves generated by meteorological events, their interaction with the mean flow, and their impact on the ionosphere and their relation to competing thermospheric disturbances generated by energy inputs from above, such as auroral processes at high latitudes. This paper reviews the progress made during the CAWSES-II time period, emphasizing the role of gravity waves, planetary waves and tides, and their ionospheric impacts. Specific campaign contributions from Task Group 4 are highlighted, and future research directions are discussed *(J. Oberheide (Clemson University, USA); K. Shiokawa (Solar-Terrestrial Environment Laboratory, Nagoya University, Japan); **S. Gurubaran**; W.E. Ward (University of New Brunswick, Canada); H. Fujiwara (Seikei University, Japan); M.J. Kosch (South African National Space Agency, South Africa); J.J. Makela (University of Illinois, USA); H. Takahashi (Instituto Nacional de Pesquisas espaciais, Brazil)).*

Advanced meteor radar installed at Tirupati: System details and comparison with different radars

An advanced meteor radar, viz, Sri Venkateswara University (SVU) meteor radar (SVU MR) operating at 35.25 MHz, was installed at Sri Venkateswara University (SVU), Tirupati (13.63°N, 79.4°E), India, in August 2013 for continuous observations of horizontal winds in the mesosphere and lower thermosphere (MLT). This study describes the purpose of the meteor radar, system configuration, measurement techniques, its data products, and operating parameters, as well as a comparison of measured mean winds in the MLT with contemporary radars over the Indian region. It is installed close to the Gadanki (13.5°N, 79.2°E) Mesosphere-Strastosphere-Troposphere (MST) radar to fill the region between 85 and 100 km where this radar does not measure winds. The present radar provides additional information due to its high meteor detection rate, which results in accurate wind information from 70 to 110 km. As a first step, a comparison of SVU MR-derived horizontal winds in the MLT region is made with those measured by similar and different (MST and MF radars) techniques over the Indian region, as well as model (horizontal wind model 2007) data sets. The comparison showed an exquisite agreement between the overlapping altitudes (82–98 km) of different radars. Zonal winds compared very well, as did the meridional winds. The observed discrepancies and limitations in the wind measurement are discussed in the light of different measuring techniques and the effects of small-scale processes like gravity waves. This new radar is expected to play an important role in our understanding of the vertical and lateral coupling of different regions of the atmosphere that will be possible when measurements from nearby locations are combined *(S. Vijaya Bhaskara Rao, S. Eswaraiah, E. Kosalendra (Sri Venkateswara University, Tirupati); M. Venkat Ratnam (National Atmospheric Research Laboratory, Gadanki); K. Kishore Kumar (Space Physics Laboratory, Trivandrum);* ***S. Sathishkumar, P. T. Patil, S. Gurubaran****).*

Mesosphere and lower thermosphere zonal wind variations over low latitudes: Relation to local stratospheric zonal winds and global circulation anomalies

Long-term observations from medium-frequency and meteor radars (1993–2012) and rocket soundings (1979–1990 and 2002–2007) are used to study mesosphere and lower thermosphere (MLT) zonal wind variations in relation to the stratospheric winds over northern low latitudes. The combined data set provides a complete height profile of amplitude of semiannual oscillation (SAO) up to 100 km, with an exception around 75–80 km. The SAO signal has maxima around 50 km and 82 km and a minimum around 65 km. The MLT zonal winds show remarkable interannual variability during northern hemispheric spring equinox and much less during fall equinox. Zonal wind mesospheric spring equinox enhancements (MSEE) appear with a periodicity of 2–3 years, suggesting a modulation by the quasi-biennial oscillation, which is identified with the strength of stratospheric westward winds. Out of 20 years of observations, the stratospheric westward winds are strong during 11 years (non-MSEE) and weak during 9 years. Six of these 9 years show large MLT winds (MSEE), and 3 years (1999, 2004, and 2006) show small MLT winds (missing MSEE). These unexpected small winds occur in years with global circulation anomalies associated with strong sudden stratospheric warmings and an early spring transition of zonal winds. With the proposed three MSEE classes, local and global forcing factors are taken into account *(G. Kishore Kumar, C. Zulicke, G. Baumgarten (Leibniz-Institute of Atmospheric Physics, Kuhlungsborn, Germany); K. Kishore Kumar, G. Ramkumar (Space Physics Laboratory, Trivandrum);* ***S. Gurubaran, S. Sathishkumar****; M. Rapp (German Aerospace Center Institute of Atmospheric Physics, Operfaffenhofen, Germany)).*

Gravity waves in the thermosphere: Solar activity dependence

A statistical study of the thermospheric gravity waves has been carried out using multiwavelength daytime oxygen airglow emission intensity and equatorial electrojet (EEJ) strength data, which originate from four different altitude regions of the thermosphere. The thermospheric daytime oxygen airglow emission intensities at wavelengths 557.7, 630.0, and 777.4 nm, obtained during the January to March period in the three years 2011–2013, have been used. The percentage number of days in which waves with spectral periods in the gravity wave range have occurred are found to be greater for the relatively higher solar activity duration (in 2013) compared to that of low solar activity (in 2011). This observation is explained to be due to the altering background atmospheric density and temperature (that vary with solar activity), which, in turn, influences the propagation and dissipation of waves. Moreover, the higher frequency gravity waves (of periods Brunt-Vaisala to 30 min) have been found to be present in greater numbers in the thermosphere compared to that of low-and-moderate frequency gravity waves (of periods 30–60 min). This behavior in the frequency selection by ambient conditions at thermospheric altitude is in accordance with earlier

theoretical and simulation works. The ratios of high- to low-frequency occurrences have also been found to be greater in higher solar activity period of 2013 compared to that of the relatively low solar activity period of 2011. These results thus provide experimental evidence to the earlier simulation works suggesting similar behavior, as found here, for thermospheric gravity waves *(Fazlul I. Laskar, D. Pallamraju (Physical Research Laboratory, Ahmedabad);* ***B. Veenadhari****; T. Vijaya Lakshmi, M. Anji Reddy (Jawaharlal Nehru Technological University, Hyderabad); Supriya Chakrabarti (University of Massachusetts, USA)).*

STUDY OF GLOBAL ELECTRIC CIRCUIT

First Observations of Transient Luminous Events (TLE's) in Indian Sub-Continent

The first 'Sprites' observed in the Indian subcontinent on 11 April 2012 is reported. The optical measurements were conducted at Allahabad (Geographic lat 29.360 N, long 79.460 E)) over the thunder clouds of Indo-Gangatic plan. Transient Luminous Events (TLE's) are short lived flashes of light observed above large thunderstorms in the stratosphere and mesosphere regions of Earth's atmosphere. The TLE's depending on their geometrical shape and luminosity are mainly classified as: Sprites, Halos, Blue Starters, Blue Jets, Gigantic Jets, Elves, etc. These optical emissions above thunderstorms are considered to be very energetic and more powerful than terrestrial lightning discharges. Studies in this filed are being carried out since last two decades but despite much advancement in technology and scientific understanding many questions still remains unanswered. TLE's have special significant in Indian scenario, their observation and detailed study will be help full in characterizing Indian thunderstorms, contribution to GEC and other related meteorological phenomenon. The observed sprite has open new window for TLE's research in India and quest for observing other TLE's such as Elves, Blue Jets, Gigantic Jets etc *(****Rajesh Singh, A.K. Maurya, B. Veenadhari, S.A. Gokani, R. Selvakumaran****; Morris B. Cohen (Georgia Tech., USA); Olivier Chanrion, Torsten Neubert (DTU Space, Denmark)).*

Lightning and convective rain over Indian peninsula and Indo-China peninsula

The impact of surface temperature, CAPE, convective cloud cover, outgoing long wave radiation and aerosol concentrations on lightning flashes and convective rainfall in the Indian peninsular and Indo-China peninsular regions were compared. Results showed that the observed relationships between lightning, precipitation and considered parameters are very complicated. An attempt is made to tie these observed results with physical considerations. For better understanding of involved processes, regional scale simulations to replicate the observed features are required. The results clearly suggest the need of regional modeling studies along with more observations at regional basis in order to understand physical processes involved and to quantify interdependence of various parameters and their impact on convective process leading to lightning flashes and precipitation *(D. Siingh, P.S. Buchunde (IITM, Pune); H. Gandhi (BHU, Varanasi);* ***Rajesh Singh****; S. Singh (UPES, Dheradun); M.N. Patil (IITM, Pune); R.P. Singh (BHU, Varanasi)).*

IONOSPHERIC IRREGULARITIES: SCINTILLATION STUDIES

Fast and ultrafast Kelvin wave modulations of the equatorial evening F region vertical drift and spread F development.

The role of eastward and upward propagating fast (FK) and ultrafast Kelvin (UFK) waves in the day-to-day variability of equatorial evening prereversal vertical drift and post sunset generation of spread F/plasma bubble irregularities is investigated. Meteor wind data from Cariri and Cachoeira Paulista (Brazil) and medium frequency (MF) radar wind data from Tirunelveli (India) are analyzed together with Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics/Sounding of the Atmosphere using Broadband Emission Radiometry (TIMED/SABER) temperature in the 40- to 100-km region to characterize the zonal and vertical propagations of these waves. Also analyzed are the F region evening vertical drift and spread F (ESF) development features as diagnosed by Digisonde (Lowell Digisonde International, LLC, Lowell, MA, USA) operated at Fortaleza and Sao Luis in Brazil. The SABER temperature data permitted determination of the upward propagation characteristics of the FK (E1) waves with propagation speed in the range of 4 km/day. The radar mesosphere and lower thermosphere (MLT) winds in the widely separated longitude sectors have yielded the eastward phase velocity of both the FK and UFK waves. The vertical propagation of these waves cause strong oscillation in the F region evening prereversal vertical drift, observed for the first time at both FK and UFK periodicities. A delay of a few (approximately 10) days is observed in the F region vertical drift perturbation with respect to the corresponding FK/UFK zonal wind

oscillations, or temperature oscillations in the MLT region, which has permitted a direct identification of the sunset electrodynamic coupling process as being responsible for the generation of the FK/UFK-induced vertical drift oscillation. The vertical drift oscillations are found to cause significant modulation in the spread F/plasma bubble irregularity development. The overall results highlight the role of FK/UFK waves in the day-to-day variability of the ESF in its occurrence season *(M.A. Abdu, P.P. Batista, J.V. Bageston, I.S. Batista, H. Takahashi (Instituto Nacional de Pesquisas Espaciais, Brazil); C.G.M. Brum (Arecibo Observatory, Puerto Rico);* ***S. Gurubaran****; D. Pancheva (Geophysical Institute, Bulgarian Academy of Sciences, Bulgaria)).*

On the pre-midnight ascent of F layer in the June solstice during the deep solar minimum in 2008 over the Indian sector

Investigations on the variations of the virtual height (h'F) of the base of the F-layer over Thumba (8.5°N, 77°E, dip lat 0.5°N) in 2002 (high solar activity) and 2008 (very low solar activity) under quiet geomagnetic conditions show characteristic pre-midnight rise of h'F in the June solstice of 2008. Comparison of the h'F variations in 2008 over Thumba and Fortaleza (3.9°S, 38.4°W, dip lat 1.8°S), Brazil, reveals that the pre-midnight rise of h'F is significantly more over Thumba during the June solstice. Drift measurements on-board the Communication/Navigation Outage Forecasting System (C/NOFS) satellite elicit that the midnight upward drift over the Indian sector during the northern summer months of 2009 is the largest, a feature that significantly weakens in 2010. C/NOFS measurements also confirm the electro-dynamical nature of the pre-midnight h'F rise over the Indian sector in the June solstice during the low solar activity. As the equatorial F-region vertical drifts during nighttime are controlled by E-region dynamo driven by tidal wind system, systematic wind measurements at upper mesospheric heights by an MF radar (1.98 MHz) from Tirunelveli (8.7°N, 77.8°E, dip lat 0.5°S), India, during 2000–2011 are used to derive the tidal components. This reveals that the phases of both the meridional and zonal components of the diurnal tide regress while the phase of the meridional component of the semidiurnal tide significantly advances with decreasing solar activity with concomitant increases in amplitudes during the summer months. These observations suggest the possible semidiurnal tidal influence on the pre-midnight h'F rise over the Indian sector in the June solstice during low solar activity *(D. Chakrabarty, R. Sekar (Physical Research Laboratory, Ahmedabad); B.G. Fejer (Utah State University, USA);* ***S. Gurubaran****; T.K. Pant (Space Physics Laboratory, Trivandum), M.A. Abdu (Instituto Nacional de Pesquisas Espaciais, Brazil)).*

A statistical study of satellite traces and evolution of equatorial spread F

The ionosonde observations made at 5-min intervals at the Indian dip equatorial station Tirunelveli (8.7°N, 77.8°E geographic; 1.1°N dip latitude) from March 2008 to February 2009 during the extended solar minimum period are used to study the interlink between equatorial spread F (ESF) and satellite traces (STs) which are assumed to represent tilts in the bottomside iso-electron density surfaces probably caused by large-scale wave-like structures (LSWS). The data show different patterns of ESF onset in the bottomside F region, which are illustrated through examples. In addition, the statistics of occurrence of ST and its relation to the formation of ESF are studied. The results indicate that (1) the zonally drifting ESF irregularities can be differentiated from those forming over the observing station. (2) Nearly half of the ESF events were preceded by ST. (3) In about 30% of the cases of occurrence of ST, ESF was not formed afterwards implying that LSWS may not always lead to ESF. (4) The percentage of ESF following ST was high in summer and increased with the time of the night. (5) Following the first occurrence of ST, the ESF onset was delayed by about 30 min on the average suggesting that ST may be used as a precursor of ESF. (6) Pre-reversal enhancement (PRE) of upward plasma drift was found insignificant during the period of study. The trapping of high-frequency radio waves between the E and F regions during intense sporadic E is also illustrated *(V. Lakshmi Narayanan (Indian Institute of Science Education and Research Mohali);* ***Sukanta Sau, S. Gurubaran, K. Emperumal, S. Sripathi****; N. Balan (Solar-Terrestrial Environment Laboratory, Nagoya University, Japan)).*

Development of intermediate scale structure near the peak of the F region within an equatorial plasma bubble

Scintillation observations are used to study the evolution of intermediate scale (~100 m–few kilometers) irregularities through growth of the Rayleigh-Taylor (R-T) instability on the bottom side of the post-sunset equatorial F region during magnetically quiet periods. Amplitude scintillations on a VHF signal from a geostationary satellite, recorded by spaced receivers at an equatorial station, are used to compute as a function of local time: (1) the coherence scale length for spatial variations of intensity in the ground scintillation pattern, which is linked with the spectrum of the intermediate scale irregularities near the peak of the equatorial F region that contribute the most to the observed

scintillations; and (2) the "random velocity", which accounts for the decorrelation of the spaced receiver signals. The relationship between the coherence scale length and the random velocity for saturated scintillations at different local times suggests that (1) the random velocity is linked with fluctuations in the drift velocity of the irregularities caused by the perturbation electric fields associated with the R-T instability rather than structural changes in the intermediate scale irregularities, (2) the spectrum of intermediate scale irregularities in the equatorial F peak region tends to be shallowest after the decay of the perturbation electric fields associated with the R-T instability, and (3) evolution of intermediate-scale irregularity spectrum in the equatorial plasma bubble near the equatorial F region peak depends on season and solar flux. These have implications for observation of low-latitude L-band scintillations ***(Bhattacharyya, A., B. Kakad, S. Sripathi, K. Jeeva, K.U. Nair)***.

Occurrence of blanketing E_s layer (Esb) over the equatorial region during the peculiar minimum of solar cycle 24

A thin and highly dense sporadic E layer, which can occasionally block the upper ionospheric layers, is called blanketing sporadic E (E_{sb}). The statistical seasonal local time occurrence pattern of Esb at equatorial station Tirunelveli (8.7°N, 77.8° E, dip latitude 0.7°N) during the extended minimum of solar cycle 24 (2007–2009) is presented. In spite of nearly the same average solar activity during both 2007 and 2009, considerable differences are noticed in the seasonal occurrence of E_{sb} during this period. The percentage of E_{sb} occurrence is found to be the highest during the summer solstice (≥50 %) for both 2007 and 2009, which is in general accordance with the earlier studies. The occurrences of E_{sb} during the vernal equinox (~33 %) and January–February (~28 %) are substantial in 2009 as compared to those during the same seasons in 2007. It is found that, during winter (January–February), ~75% of E_{sb} occurred during or just after the period of sudden stratospheric warming (SSW). It is suggested that enhanced E_{sb} occurrence during winter (January–February) and the vernal equinox of 2009 could be associated with SSW-driven changes in the E region ambient conditions. Furthermore, the close association of E_{sb} with counter equatorial electrojet (CEEJ) suggested by earlier studies is re-examined carefully using the scenario of E_{sb} occurrence on non-CEEJ days. Such an exercise is crucial as it is unaware whether the physical mechanisms driving E_{sb} and CEEJ are linked or not. It is found that, of all the seasons, the association of E_{sb} and CEEJ is strongest during winter

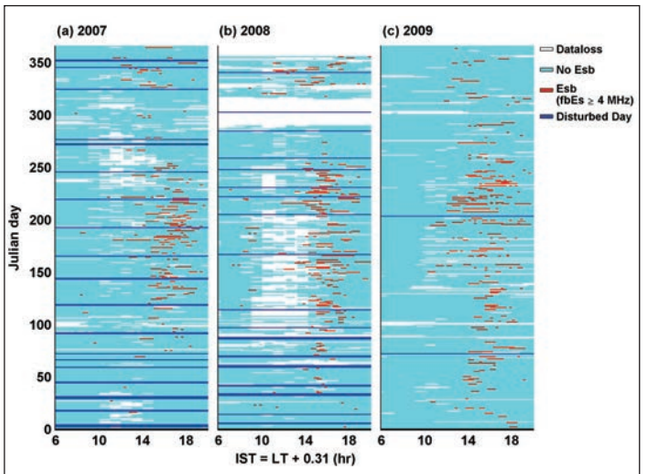


Figure 3 Occurrence of blanketing Es (Esb) as a function of IST during **(a)** 2007, **(b)** 2008 and **(c)** 2009. Disturbed days (Kp =24) and data loss are shown by blue and white colour respectively

(November–December) ***(Fig. 3)*** ***(Yadav, V., B. Kakad, C.K. Nayak, G. Surve, K. Emperumel)***.

Climatology of GPS amplitude scintillations over equatorial Africa during the minimum and ascending phases of solar cycle 24

This study characterizes African equatorial scintillations at L-band frequency during the minimum and ascending phases of solar cycle 24. Three years (2009–2011) of amplitude scintillation data from three African equatorial GPS stations, namely; Lagos (6.48°N, 3.27°E, dip: 4.95°S), Nigeria; Nairobi (1.16°S, 36.80°E, dip: 10.65°S), Kenya; and Kampala (0.30°N, 32.50°E, dip: 11.12°S), Uganda were used for this investigation. The data is grouped into daily, monthly, seasonal, and yearly scales, at elevation angles greater than or equal to 30°. Scintillations exhibit daily trend of occurrences during the hours of 1900 - 0200 LT, with higher occurrence levels being localized within the hours of 2000–2300 LT. Generally, highest scintillation occurrences were recorded during equinoxes and the least during June solstice. Intriguingly, over equatorial Africa, January was observed to be a non-scintillation month, and post-midnight scintillations were observed during June solstice months, although at weak intensities. Scintillations were also observed to increase with solar and geomagnetic activities. These results would support the development of future African equatorial scintillation models, which could also be of support to the implementation of global navigation satellite system (GNSS)-based navigation in Africa *(Akala, A.O., L.L.N. Amaeshi (University of Lagos, Nigeria); E.O. Somoye (Lagos State University, Nigeria); R.O. Idolor, E.*

Okoro (University of Lagos, Nigeria); P.H. Doherty, K.M. Groves, C.S. Carrano, C.T. Bridgwood (Boston College, USA); P. Baki (Technical University of Kenya, Kenya); F.M. D'ujanga (Makerere University, Uganda); ***G.K. Seemala****).*

IONOSPHERIC IRREGULARITIES: RADAR STUDIES

Explicit characteristics of evolutionary-type plasma bubbles observed from Equatorial Atmosphere Radar during the low to moderate solar activity years 2010–2012

Using the fan sector backscatter maps of 47 MHz Equatorial Atmosphere Radar (EAR) at Kototabang (0.2°S geographic latitude, 100.3°E geographic longitude, and 10.4°S geomagnetic latitude), Indonesia, the spatial and temporal evolution of equatorial plasma bubbles (EPBs) were examined to classify the evolutionary-type EPBs from those which formed elsewhere and drifted into the field of view of radar. A total of 535 EPBs were observed during the low to moderate solar activity years 2010–2012, out of which about 210 (~39%) are of evolving type and the remaining 325 (~61%) are drifting-in EPBs. In general, both the evolving-type and drifting-in EPBs exhibit predominance during the postsunset hours of equinoxes and December solstices. Interestingly, a large number of EPBs were found to develop even a few minutes prior to the apex sunset during equinoxes. Further, the occurrence of evolving-type EPBs exhibits a clear secondary peak around midnight (2300–0100 LT), primarily, due to higher rate of occurrence during the postmidnight hours of June solstices. A significant number (~33%) of postmidnight EPBs generated during June solstices did not exhibited any clear zonal drift, while about 14% of EPBs drifted westward. Also, the westward drifting EPBs are confined only to June solstices. The responsible mechanisms for the genesis of fresh EPBs during postmidnight hours were discussed in light of equatorward meridional winds in the presence of weak westward electric fields ***(Fig. 4, 5)*** *(**Ajith, K. K., S. Tulasi Ram**; M. Yamamoto (RISH, Japan); T. Yokoyama (NICT, Japan); **V. S. Gowtham**; Y. Otsuka (Nagoya University, Japan); T. Tsugawa (NICT, Japan); K. Niranjan (AU, Visakhapatnam)).*

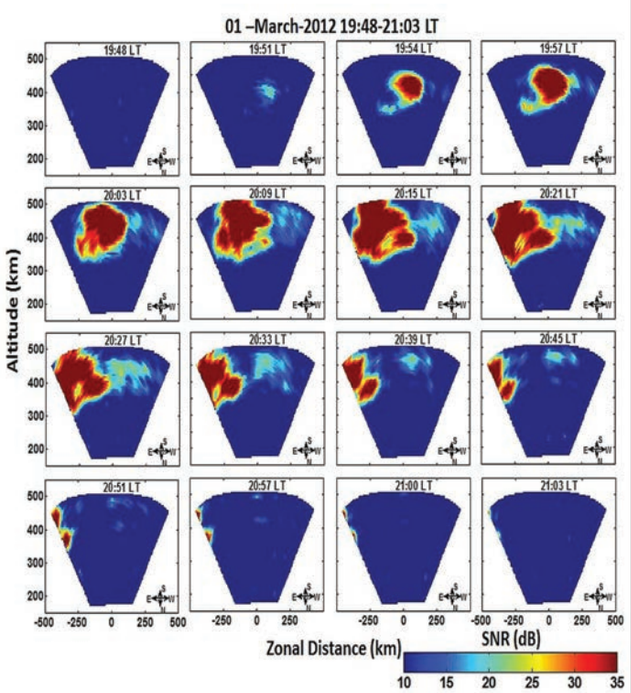


Figure 4 The temporal and spatial evolution of equatorial plasma bubble observed from multi-beam (16 beams) probing of Equatorial Atmosphere Radar (EAR) over Kototabang.

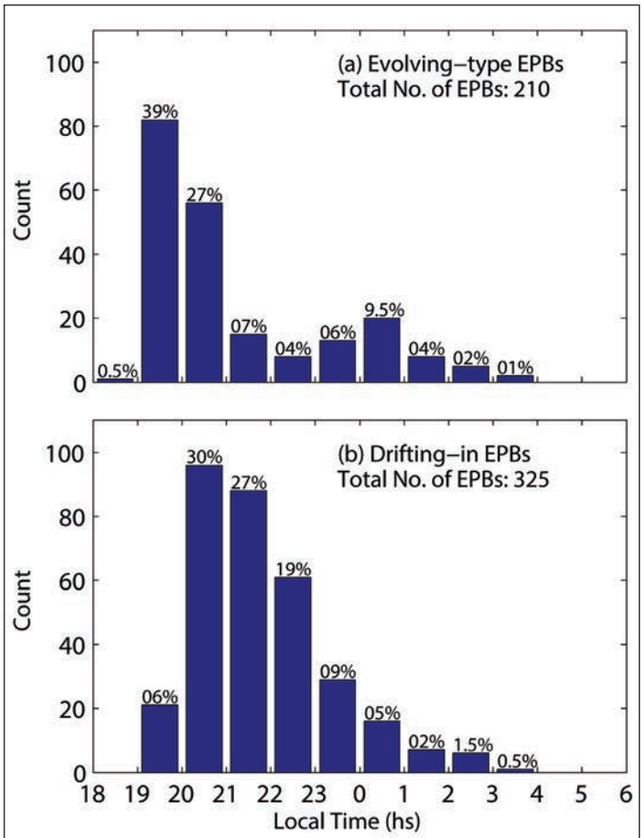


Figure 5 Histograms showing the nocturnal occurrence of evolving-type EPBs and drifting-in EPBs during the ascending phase of solar cycle 24 (2010-2012). The numbers shown on top of histogram bars indicate the percentage of occurrence.

IONOSPHERIC IRREGULARITIES: AIRGLOW STUDIES

Simultaneous optical measurements of equatorial plasma bubble (EPB) from Kolhapur (16.8˚ N, 74.2˚E) and Gadanki (13.5˚ N, 79.2˚ E)

The Equatorial Plasma Bubble (EPB) features using All sky imager (ASI) observations of O(1D) 630.0 nm night airglow emission from Kolhapur (16.8°N, 74.2°E, 10.6°N dip lat.) and Gadanki (13.5°N, 79.2°E, 6.5°N dip lat.) during March 2012 is studied. The optical data was supported by the ionosonde measurements from Tirunelveli (8.7°N, 77.8°E,0.5°N dip lat.) which revealed the occurrence of equatorial spread-F. The EPBs were monitored at both locations as nearly north–south aligned intensity depleted regions. The east–west plasma drift velocity over Kolhapur and Gadanki for the nights having coordinated measurements is computed. Also, the observed plasma bubble drift velocities are compared with the zonal neutral wind velocities obtained from the HWM-07 model and the empirical drift model of England and Immel (2012). It is observed that, generally, the mean zonal drift velocities of the plasma bubbles tend to decrease with local time (after midnight). These results reveal the drift velocity noted in Kolhapur data varies from 124 m/s to 181.8 m/s, while from the Gadanki data show the drift velocity to range from 116.3 m/s to 160.3 m/s *(**Ghodpage, R.N.**; A. Taori (NARL, Gadanki); **P.T. Patil, S. Gurubaran, S. Sripathi, S. Banola**; A.K. Sharma (Shivaji University, Kolhapur)).*

Airglow Measurements of Gravity Wave Propagation and Damping over Kolhapur (16.8° N, 74.2° E)

Simultaneous mesospheric OH and O (1S) night airglow intensity measurements from Kolhapur (16.8°N, 74.2°E) reveal unambiguous gravity wave signatures with periods varying from 01 hr to 9 hr with upward propagation. The amplitudes growth of these waves is found to vary from 0.4 to 2.2 while propagating from the OH layer (~87 km) to the O (1S) layer (~97 km). It is observed that the vertical wavelength of the observed wave's increases with the wave period. The damping factors calculated for the observed waves show large variations and that most of these waves were damped while traveling from the OH emission layer to the O(1S) emissionlayer. The damping factors for the waves show a positive correlation at vertical wavelengths shorter than 40 km, while a negative correlation at higher vertical wavelengths. It is noted that the damping factors have stronger positive correlation with meridional wind shears compared to the zonal wind shears *(**Ghodpage, R.N.,** A. Taori (NARL, Gadank); **P.T. Patil, S. Gurubaran**; A. K. Sharma, S. Nikte, D. Nade (Shivaji University, Kolhapur)).*

Star Detection and Removal in Night Airglow Images

Image Processing is technique by which any image can be processed to extract the real information i.e. useful information from the image. The study of the Earth's upper atmosphere by using All-Sky Imager (ASI) technique the image processing is to be done on the captured images. Noise is an important factor that influences image quality which is mainly produced in the processes of image acquirement. The stars in images act as a noise, they can cause streaking when scanning images for analysis and when images are averaged for flat fielding. Stars in the sky are, first of all, a local increase in the amount of light over the ambient night sky intensity. Most star detection and removal methods are based on image analysis. However, some factors will affect the detection of stars due to the complexity of the interpretation, e.g. high intensity in the sky over horizon due to city lights and other structures like Milky Way in sky as they are easily mistaken as stars. A simple effective algorithm is developed for removing stars while leaving the remainder of the image data essentially untouched. The results are satisfactory and show that the developed star removal technique is better as compared to the other methods *(Rohit P. Patil, S. B. Patil (Patil College of Engineering and Technology, Kolhapur); **R.N. Ghodpage, P.T. Patil**).*

Observations of Plasma Blobs by OI 630 nm Using ASI and Photometer over Kolhapur, India

This study presents observations of plasma blobs by nightglow OI 630.0 nm emissions using ground-based techniques, all sky imager and photometer from Kolhapur. The nightglow observations have been made at low latitude station, Kolhapur (16.42°N, 74.2°E, and 10.6°N dip lat.) during clear moonless nights for period of October 2011–April 2012. Generally, these occur 3 h after sunset (18:00 IST). Here in the velocities of plasma blobs are calculated using scanning method. The average zonal drift velocity (eastward) of the plasma blobs were found to be 133 ms^{-1} and vary between 100 and 200 ms^{-1}. Their mean width and length were in the range of 70–180 and 500–950 km respectively. The study shows that localized eastward polarization electric field plays an important role in the generation of plasma blobs *(D.P. Nade, A.K. Sharma, S.S. Nikte, G.A. Chavan (Shivaji University, Kolhapur); **R.N. Ghodpage, P. T. Patil, S. Gurubaran**).*

On the vertical wavelength estimates using the Krassovsky parameters of OH airglow monitoring

The photometric measurements of mesospheric OH and O(1S) emission, carried out from Kolhapur (16.8°N, 74.2°E), Maharashtra during January–April 2005 are used to study the wave characteristics. The nocturnal variability reveals the dominant long-period wave signatures with significant

amplitudes of embedded short-period waves. The vertical wavelength (VW) derived with the help of Krassovsky parameters of the OH data, reveals VW to vary from 38.9 to 110.2 km. This was compared with the VW estimates using the phase difference of the simultaneously observed waves in both OH and O(1S) emission intensities. Results reveal that in the absence of attitudinally resolved measurements, the VW estimated using Krassovsky method can be used *(**Ghodpage, R.N.;** A. Taori (NARL, Gadanki)**; P.T. Patil, S. Gurubaran**; D. Siingh (IITM, Pune); A.K. Sharma (Shivaji University, Kolhapur)).*

Geographical analysis of equatorial plasma bubbles by GPS and nightglow measurements

This work is about the zonal drift velocity and signature of equatorial plasma bubbles (EPBs) by measurements of global positioning system (GPS) receiver and all sky imager (ASI) operating in India, at the low latitude region. The optical and radio observations have been made from Kolhapur (16.8° N, 74.2° E) and Hyderabad (17.37°N, 78.48°E), respectively. The zonal drift velocity of EPBs has estimated using images of nightglow OI 630.0 nm emission recorded by ASI at Kolhapur. The measurements of total electron content (TEC) using the GPS have carried from the nearby station, Hyderabad. When depletions occurred about 00:37 h (IST) in TEC, the EPBs were found to occur about 5:30 h in optical data of OI 630.0 nm emission. This work focuses on simultaneous measurements of TEC and intensity of OI 630.0 nm emissions for EPBs during nighttime. The occurrence period of EPBs in TEC and OI 630.0 nm has found to be different. To study this difference, the zonal drift velocity of EPBs has established. The averaged eastward velocity of EPBs was found to be 138 m/s. The calculated values of zonal drift velocities are well correlated with that of the empirical model values. This work may be helpful in finding the growth of EPBs over low latitude *(Nade, D.P.(Shivaji University, Kolhapur); D. J. Shetti (Smt. Kasturbai Walchand College, Sangli); A.K. Sharma (Shivaji University, Kolhapur); A. Taori (NARL, Gadanki); G.A. Chavan (Shivaji University, Kolhapur); **P.T. Patil, R.N. Ghodpage**; O.B. Gurav, S.S. Nikte (Shivaji University, Kolhapur)).*

Field of View Determination and Spatial Calibration of Night Airglow All-Sky Images

The various phenomenon and structures observed in night airglow all-sky imager (ASI) images (such as, drift motions of gravity waves and plasma bubbles) are accurately measured only after the spatial calibration of the images. While spatial calibration is a process of computing pixel to real-world unit transformations although accounting for many errors inherent to the imaging setup. Calibration of image is important when accurate measurements required in real-world units. Spatial calibration includes the alignment to true north and measurement of field of view (FOV) of captured ASI images. For the spatial calibration the stars in the (ASI) image are used as a reference points which is then compared and calibrated with star catalogue image to find true north and FOV of ASI image. The spatial calibration and FOV measurement of an image is useful when the imaging setup is not stationary. This study presents developed simple but accurate methodology for spatial calibration and FOV measurement of ASI image. The software is developed for the FOV measurement and spatial calibration by using Mat Lab 7.0 *(**Patil, P.T.**; R. P. Patil (Shivaji University, Kolhapur); **R. N. Ghodpage**; S. B. Patil, D. P. Nade (Shivaji University, Kolhapur)).*

IONOSPHERIC TEC & MODELLING

On the performance of the IRI-2012 and NeQuick2 models during the increasing phase of the unusual 24th solar cycle in the Brazilian equatorial and low-latitude sectors

It is known that the equatorial and low-latitude ionosphere is characterized with typical dynamical phenomena namely, the equatorial ionization anomaly (EIA). Accurate modeling of the characteristic variations of the EIA is more important to arrive at the correct estimation of range delays required for the communication and navigation applications. The total electron content (TEC) data from a chain of Global Positioning System (GPS) receivers at seven identified locations from equator to the anomaly crest and beyond along 315°E geographic longitude in the Brazilian sector are considered. The performances of the latest available IRI-2012 and NeQuick2 models have been investigated during 2010–2013 in the increasing phase of the 24th solar cycle. A comparative study on the morphological variations of the GPS measured and modeled TEC revealed that the performances of the models are improved during low solar activity periods compared to that during the increased solar activity years. The strength and the locations of the EIA crest are nearly well represented by both the models during the low solar activity while the models underestimate the peak TEC at the EIA during the increased solar activity conditions. The deviations between the GPS-measured and model-derived TEC are more during equinoctial and summer months at and around the anomaly crest locations. Significant differences have also been observed in between the TEC values derived from both the models. The causes for the discrepancies in the modeled TEC values are discussed based on themodel-derived and ionosonde-measured vertical electron density profiles variations *(Venkatesh, K., P. R. Fagundes (Universidade do Vale do Paraiba, Brazil); **G. K. Seemala**; R. de Jesus, A. J. de Abreu, V. G. Pillat (Universidade do Vale do Paraiba, Brazil)).*

Unique latitudinal shape of ion upper transition height (H_T) surface during deep solar minimum (2008-2009)

The ionospheric upper transition height (H_T) is found to increase dramatically by ~100 km from 2008 - 2009 to 2010 only for a marginal increase in solar activity (F10.7) by 11.76 solar flux units. The latitudinal variation of H_T surface during 2008-2009 period exhibits a local minimum at equatorial latitudes and increase at low latitudes. Further, the H_T at equatorial latitudes exhibits slower rate of increase than at low-latitudes. These interesting features are new and different from those reported in literature. A quick loss of O^+ and increase in H^+ ions is observed around ~550 to 650 km indicating that the charge exchange reaction is responsible for the slower rate of increase and lowered H_T at equatorial latitudes. These new aspects of H_T are more conspicuously observed during this deep solar minimum period where the resonant charge exchange reaction is taking place at altitudes as low as ~550 km ***(Fig. 6)*** *(**S. Tulasi Ram**; R. Heelis (Univ. of Texas, USA); **V. S. Gowtham, K. K. Ajith**; S.-Y. Su (NCU, Taiwan)).*

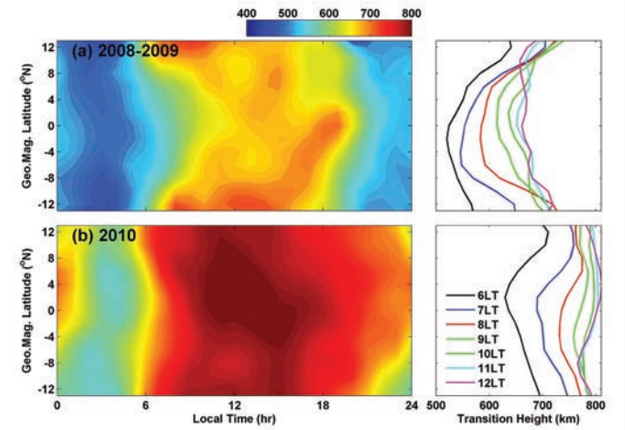


Figure 6 The local time and geomagnetic latitudinal variations of $O^+/(H^+ + He^+)$ transition height (H_T) surface during equinoctial months of (a) the extreme low-solar activity period 2008 – 2009 and (b) slightly higher solar activity period 2010. The right hand side panels show the line plots of magnetic latitude variation of H_T during 06 – 12 LT.

An ensemble average method to estimate absolute TEC using radio beacon-based differential phase measurements: Applicability to regions of large latitudinal gradients in plasma density

A GNU Radio Beacon Receiver (GRBR) system for total electron content (TEC) measurements using 150 and 400MHz transmissions from Low-Earth Orbiting Satellites (LEOS) is fabricated in house and made operational at Ahmedabad (23.04°N, 72.54°E geographic, dip latitude 17°N) since May 2013. This system receives the 150 and 400MHz transmissions from high-inclination LEOS. The first few days of observations are presented in this work to bring out the efficacy of an ensemble average method to convert the relative TECs to absolute TECs. This method is a modified version of the differential Doppler-based method proposed by de Mendonca 1962) and suitable even for ionospheric regions with large spatial gradients. Comparison of TECs derived from a collocated GPS receiver shows that the absolute TECs estimated by this method are reliable estimates over regions with large spatial gradient. This method is useful even when only one receiving station is available. The differences between these observations are discussed to bring out the importance of the spatial differences between the ionospheric pierce points of these satellites. A few examples of the latitudinal variation of TEC during different local times using GRBR measurements are also presented, which demonstrates the potential of radio beacon measurements in capturing the large-scale plasma transport processes in the low-latitude ionosphere. *(Thampi S. V. (Physical Research Laboratory, Ahmedabad); **Mala S. Bagiya**; D. Chakrabarty, Y.B. Acharya (Physical Research Laboratory, Ahmedabad); M. Yamamoto (RISH, Kyoto University, Japan)).*

Peculiar features of ionospheric F3 layer during prolonged solar minimum (2007–2009)

The seasonal and local time occurrence of ionospheric F3 layer over Tirunelveli (geographic longitude 77.8°E, geographic latitude 8.7°N, dip 0.7°) during extremely low and prolonged solar activity period (2007–2009) are presented. Canadian Advanced Digital Ionosonde observations from this station are used in the present study. We find that the occurrence of F3 layer is nearly 3 times higher during 2009 (~48%) as compared to that during 2007 (~16%). The increase of this order just within the low solar activity period is unusual. In earlier studies similar increase in F3 occurrence has been reported when solar activity changes from high (F10.7=182) to low (F10.7=72). The other important feature is the presence of post-noon F3 layers which are observed dominantly during summer solstice of 2009. Such occurrence of post-noon F3 layers was nearly absent during summer solstice of the previous solar minimum (1996) over nearby dip equatorial station Trivandrum. Equatorial electrojet (EEJ) as a proxy for eastward electric field. It is noticed that the EEJ strength and the maximum rate of change of EEJ are higher for F3 days as compared to those on non-F3 days. The peak occurrence of prenoon F3 layer closely coincides with the time of maximum rate of change of EEJ. It is in general accordance with the theory proposed by Balan et al. (1998) that suggests the formation of F3 through vertically upward E × B drift in presence of equatorward neutral wind. The present study reveals that the rate of change of eastward electric field (dE/dt) as well plays an important role in the formation of F3 layer *(**Nayak, C.K., V. Yadav, B. Kakad, S. Sripathi, K. Emperumal**; T.K. Pant (VSSC, Trivandrum); **A. Bhattacharyya**; Shuanggen Jin (Shanghai Astronomical Observatory, China)).*

SPACE WEATHER

The influence of Corotating Interaction Region (CIR) driven geomagnetic storms on the development of equatorial plasma bubbles (EPBs) over wide range of longitudes

Recurrent high speed solar wind streams from coronal holes on the Sun are more frequent and Geoeffective during the declining phase of solar cycle which interact with the ambient solar wind leading the formation of Corotating Interaction Regions (CIRs) in the interplanetary medium. These CIR-High Speed Stream (HSS) structures of enhanced density and magnetic fields, when they impinge up on the Earth's magnetosphere, can cause recurrent geomagnetic storms in the Geospace environment. In this study, we investigate the influence of two CIR-driven recurrent geomagnetic storms on the equatorial and low-latitude ionosphere in the context of the development of equatorial plasma bubbles over Indian and Asian longitudes. The results consistently indicate that prompt penetration of eastward electric fields into equatorial and low-latitudes under southward IMF Bz can occur even during the CIR-driven storms. Further, the penetration of eastward electric fields augments the evening pre-reversal enhancement and triggers the development of EPBs over wide longitudinal sectors where the local post-sunset hours coincide with the main phase of the storm. Similar results that are consistently observed during both the CIR-driven geomagnetic storms are reported and discussed ***(Fig. 7)*** (***S. Tulasi Ram***, ***Sandeep Kumar***; *S.-Y. Su (NCU, Taiwan);* ***B. Veenadhari***; *Sudha Ravindran (SPL, VSSC, India)).*

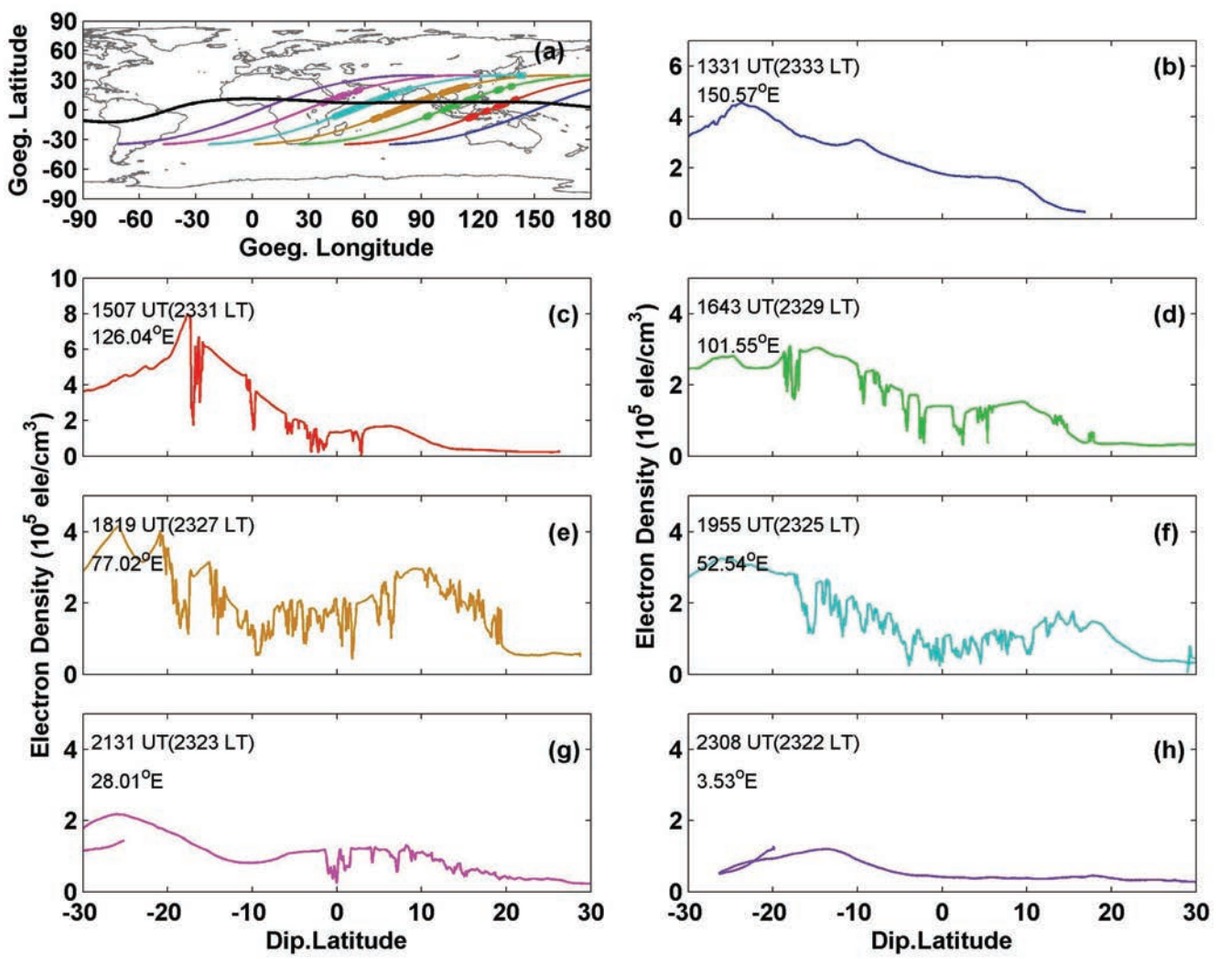


Figure 7 Successive development of EPBs over a wide longitudinal (~92°) sector due to continuous penetration of convection electric fields during a CIR-driven moderate geomagnetic storm on February 11, 2004.

A multi-technique study of the 29–31 October 2003 geomagnetic storm effect on low latitude ionosphere over Indian region with magnetometer, ionosonde, and GPS observations

The present study demonstrates the ionospheric response to the extreme geomagnetic storms during 29–31 Oct 2003 (the Halloween storm), in the low latitude anomaly Indian region, based on multi-instrument measurements namely magnetometer, ionosonde, and GPS observations. Unlike earlier reports, the best quiet days (CQ-Days) are chosen amongst 10 international quiet days (Q-Days), on the basis of equatorial electrojet strength and pattern, that drives the distribution of plasma over the low latitude. Arbitrarily selecting the Control/Q-Days may lead to erroneous interpretations and will not yield a clearer understanding of the equatorial electrodynamics. The analysis confirms the anomalous increase in TEC at all stations on 29 Oct 2003 and suppressed TEC across anomaly crest latitudes during 30–31 Oct 2003. The sharp transition in h'F is noticed during the progressive period of the storm, though it was relatively lower at the equator. The respective foF2 remained subordinate at Trivandrum. However, we did not notice such foF2 changes at Delhi. Observations at various latitudes confirm the maximum positive deviation of TEC at mid-latitude POL2 (140 %), followed by the low latitude Jodhpur (108 %), and the rest of the stations showing relatively lower enhancements with deviations ranging between 60–90 %. However, at Ahmedabad, the lowest divergence from the mean CQ-Days, attribute the typical quiet day formation of crest at this latitude. Although the results are well agreeing with earlier reports, miniature differences is noticeable due to the way of choosing the best reference days in the analysis *(Panda, S. K., Gedam, S. S., Rajaram, G. (IIT Bombay, Mumbai);* ***Sripathi, S.;*** *Pant, T. K. (VSSC, Trivandrum); Das, R. M.(NPL, Delhi)).*

CME front and severe space weather

Thanks to the works of a number of scientists it is known that severe space weather can cause extensive social and economic disruptions in the modern high-tech society. It is therefore important to understand what determines the severity of space weather, and whether it can be predicted. Results from the analysis of the coronal mass ejections (CME), solar energetic particle (SEP) events, interplanetary magnetic field (IMF), CME-magnetosphere coupling and geomagnetic storms associated with the major space weather events since 1998 are presented by combining data from the ACE and GOES satellites with geomagnetic parameters, and the Carrington event of 1859, Quebec event of 1989 and an event in 1958. The results seem to indicate that (1) it is the impulsive energy mainly due to the impulsive velocity and orientation of IMF Bz at the leading edge of the CMEs (or CME front) that determine the severity of space weather. (2) CMEs having high impulsive velocity (sudden non-fluctuating increase by over 275 km s^{-1} over the background) caused severe space weather (SvSW) in the heliosphere (failure of the SWI mode of SWEPAM in ACE) probably by suddenly accelerating the high energy particles in the SEPs ahead directly or through the shocks. (3) The impact of such CMEs which also show the IMF Bz southward from the leading edge caused SvSW at the Earth including electric power outage and extreme geomagnetic storms of mean Dst_{MP}< -250 nT during main phases. (4) The higher the impulsive velocity, the more severe the space weather, like faster weather front and tsunami front causing more severe damages through impulsive action. (5) The CMEs having the IMF Bz northward at the leading edge do not seem to cause SvSW on Earth though, later when the IMF Bz turns southward, they can lead to super geomagnetic storms of intensity (Dst) less than even -400 nT ***(Fig. 8)*** *(N. Balan (STEL, Nagoya Univ., Japan); R. Skoug (LANL, USA);* ***S. Tulasi Ram****; P. K. Rajesh (NCKU, Taiwan); K. Shiokawa, Y. Otsuka (STEL, Nagoya Univ., Japan); I. S. Batista (INPE, Brazil); T. Nakamura (NIPR, Japan)).*

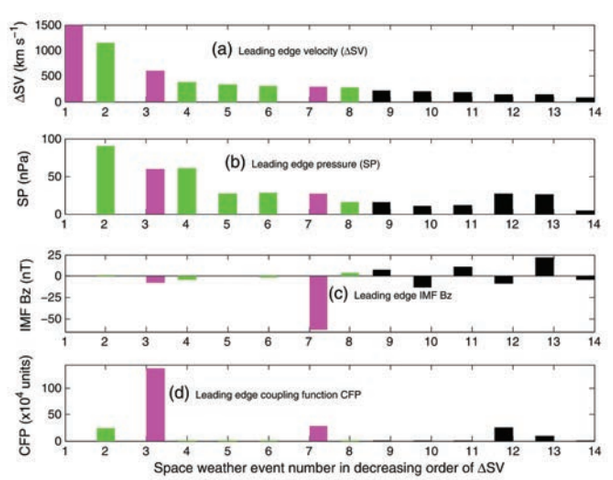


Figure 8 The mean leading edge velocity ΔSV (limited to 1500 km/s), dynamic pressure SP, IMF Bz, and coupling function CFP for 2 hours from the leading edge of the CMEs corresponding to the 16 major space weather events, arranged in decreasing order of ΔSV. The pink color represents severe space weather in space and Earth, green color represents severe space weather in space and normal space weather on Earth and black color indicates the normal space weather in space and Earth.

ULF/ELF/VLF WAVES

An Analytic Model of Toroidal Half Wave Oscillations: Implication on Plasma Density Estimates

The developed analytic model for toroidal oscillations under infinitely conducting ionosphere ("Rigid-end") has been extended to "Free-end" case when the conjugate ionospheres are infinitely resistive. The present direct analytic model (DAM) is the only analytic model that provides the field line structures of electric and magnetic field oscillations associated with the "Free-end" toroidal wave for generalized plasma distribution characterized by the power law $\rho = \rho_o (r_o/r)^m$, where m is the density index and r is the geocentric distance to the position of interest on the field line. This is important because different regions in the magnetosphere are characterized by different m. Significant improvement over standard WKB solution and an excellent agreement with the numerical exact solution (NES) affirms validity and advancement of DAM. In addition, the equatorial ion number density (assuming H+ atom as the only species) is estimated using DAM, NES, and standard WKB for Rigid-end as well as Free-end case and illustrate their respective implications in computing ion number density. It is seen that WKB method overestimates the equatorial ion density under Rigid-end condition and underestimates the same under Free-end condition. The density estimates through DAM are far more accurate than those computed through WKB. The earlier analytic estimates of ion number density were restricted to m = 6, whereas DAM can account for generalized m while reproducing the density for m = 6 as envisaged by earlier models. Using observed magnetospheric pulsations the developed analytic model could also delineate plasma pause boundary ***(Fig.9)*** (***Jayashree, B., Ashwini K. Sinha, G. Vichare***).

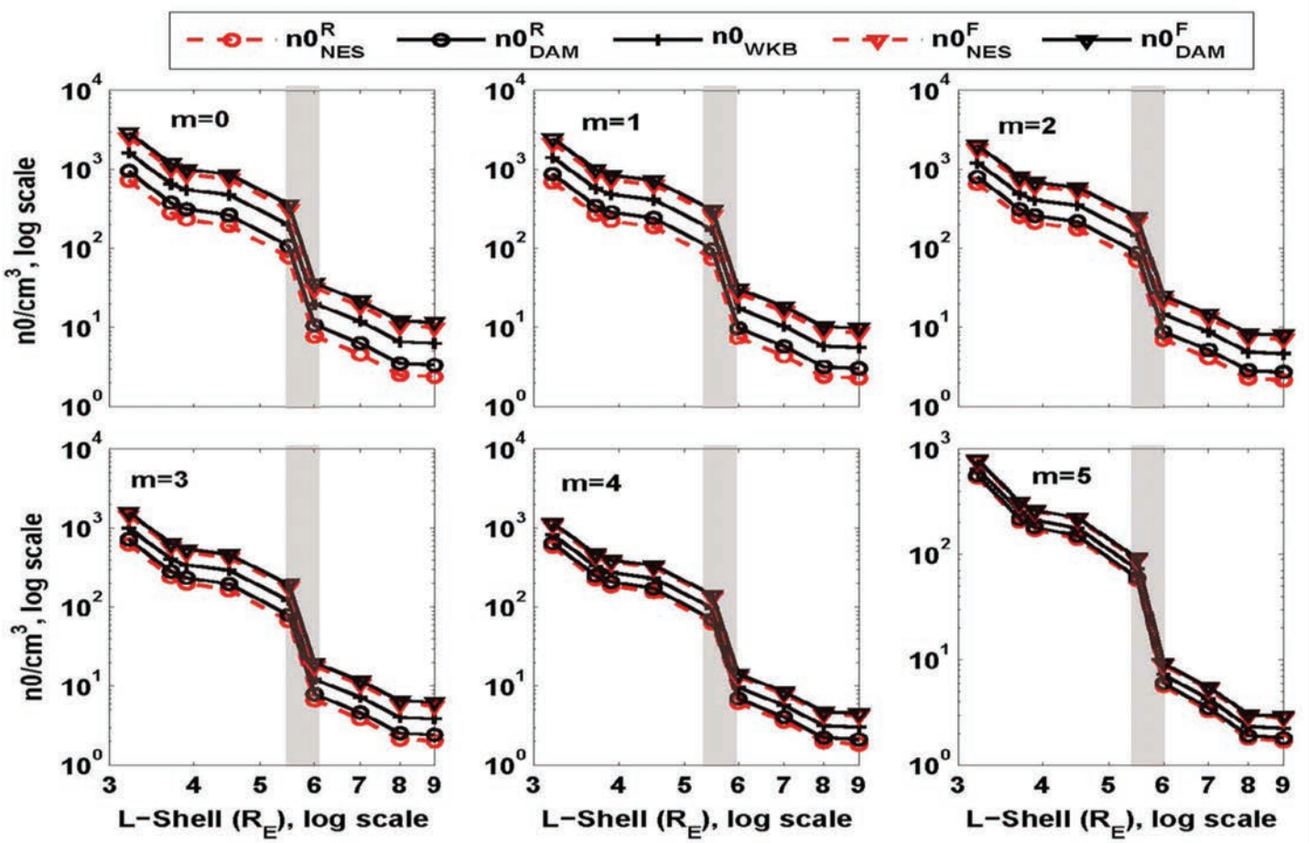


Figure 9 Variation of equatorial ion number density estimated using NES, DAM, and WKB with density indices under Rigid-end and Free-end boundary conditions for L shells ranging from 3 to 9. The parameter $n0$ denotes the equatorial ion number density. Both $n0$ and L are expressed in log scale. Superscripts R and F represent the Rigid-end and Free-end conditions. Subscripts DAM, NES, and WKB denote the respective methods used in computing the ion number densities. Each panel denotes the variation of $n0$ with L, for a given density variation. Vertical grey area denotes the location of plasmapause.

Toroidal quarter waves in the Earth's magnetosphere: theoretical studies

An analytic model has been developed for toroidal quarter wave (QW) oscillations in the Earth's magnetosphere using idealistic and highly asymmetric ionospheric boundary condition. The background magnetic field is dipolar and plasma density distribution is governed by a power law $1/r^m$ where r is the geocentric distance of any point along the field line and m is the density index. The solution thus obtained has been compared with the numerical solutions. Earlier workers had developed the analytic model for trivial $1/r^6$ (m = 6) type of plasma density distribution along the field line for which the period of the fundamental is twice that of corresponding half wave (i.e. toroidal oscillation in the symmetric ionospheric boundary). The present analytic model does reproduce this feature. In addition, it is seen that this ratio decreases for lower values of m. Moreover, for a particular value of m, this ratio shows a decreasing trend with increased harmonic number. The spatial characteristics of QW obtained from present analytic model are in excellent agreement with those computed numerically, thereby validating the model ***(Fig 10).*** The departure of frequency computed analytically from that obtained numerically is significant only for the fundamental and this departure reduces sharply with the increased harmonic number. It should be noted that there is no such departure for $1/r^6$ type of plasma density distribution and spatial structures as well as frequency computed from the present analytic model match perfectly with those computed numerically (***Jayashree, B., Ashwini K. Sinha, G. Vichare***).

Response of the low-latitude D region ionosphere to extreme space weather event of 14–16 December 2006

The response of the D region low-latitude ionosphere has been examined for extreme space weather event of 14–16 December 2006 associated with a X1.5 solar flare and an intense geomagnetic storm (Dst =-146 nT) using VLF signals from Northwest Cape, Australia (NWC) (19.8 kHz) and Lualualei, Hawaii (callsign NPM) (21.4 kHz) transmitters monitored at Suva (Geographic Coordinates, 18.10°S, 178.40°E), Fiji. Modeling of flare associated amplitude and phase enhancements of NWC (3.6 dB, 223°) and NPM (5 dB, 153°) using Long-Wave Propagation Capability code shows reduction in the D region reflection height (H′) by 11.1 km and 9.4 km, and enhancement in ionization

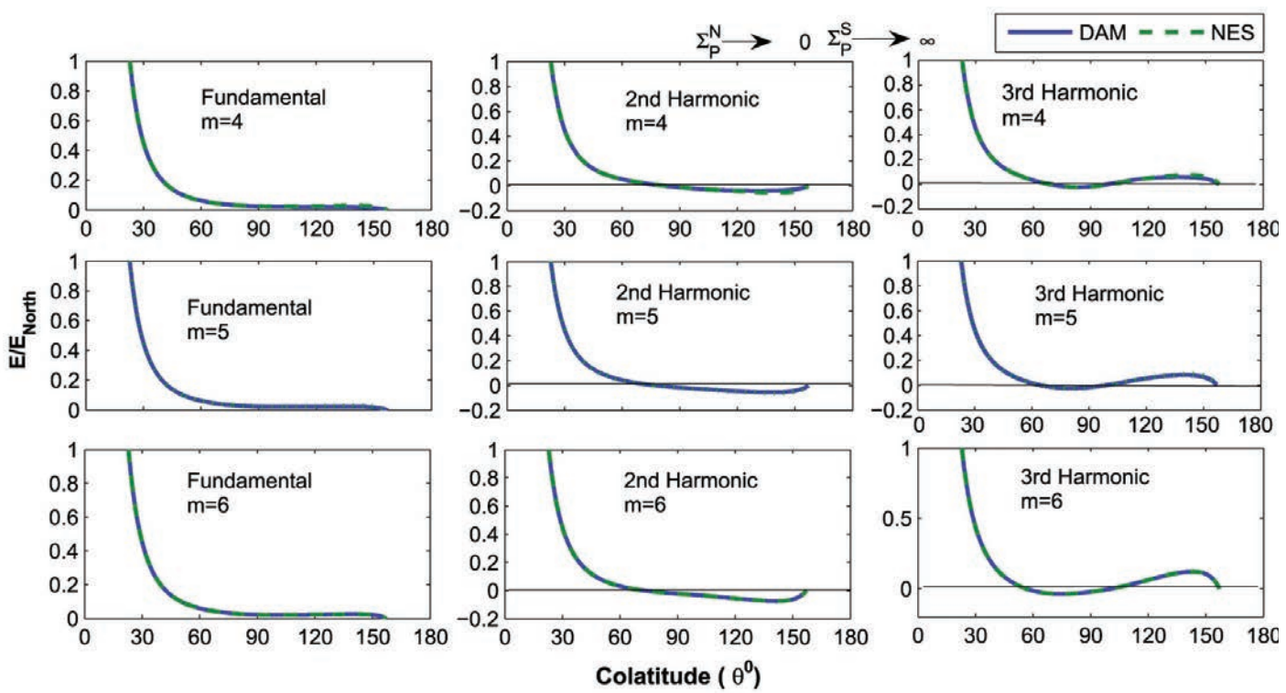


Figure 10 Latitudinal structures of electric field for quarter wave toroidal oscillation for the first three harmonics obtained from DAM and numerical exact solution at L = 6.6. The ionopsheric conductivities were considered as $\Sigma^N_P \rightarrow 0$ and $\Sigma^S_P \rightarrow \infty$. The top, middle and bottom panels show the electric field variation along the field line for density indices m = 4, m = 5 and m = 6 respectively. The magnitude of electric field at any point can be obtained by multiplying with the indicated factor. E_{North} represents the value of electric field at northern conjugate point.

gradients described by increases in the exponential sharpness factor (β) by 0.122 and 0.126 km^{-1}, for the NWC and NPM paths, respectively. During the storm the daytime signal strengths of the NWC and NPM signals were reduced by 3.2 dB on 15 and 16 December (for about 46 h) and recovered by 17 December. Modeling for the NWC path shows that storm time values of H′ and β were reduced by 1.2 km and 0.06 km^{-1}, respectively. Morlet wavelet analysis of signal amplitudes shows no clearly strong signatures of gravity wave propagation to low latitudes during the main and recovery phases. The reduction in VLF signal strength is due to increased signal attenuation and absorption by the Earth-ionosphere waveguide due to storm-induced D region ionization changes and hence changes in D region parameters. The long duration of the storm effect results from the slow diffusion of changed composition/ionization at D-region altitudes compared with higher altitudes in the ionosphere *(S. Kumar, A. Kumar (University of South Pacific, Fiji); F. Menk (University of Newcastle, Australia);* ***A.K. Maurya, Rajesh Singh, B. Veenadhari****).*

Low-mid latitude D-region ionospheric perturbations associated with 22 July 2009 Total Solar Eclipse: Wave-like signatures inferred from VLF observations

The study reported the first Periodic wave-like signatures (WLS) in the D-region ionosphere during 22 July 2009 total solar eclipse using JJI, Japan, VLF navigational transmitter signal (22.2 kHz) observations at stations, Allahabad, Varanasi and Nainital in Indian Sector, Busan in Korea and Suva in Fiji ***(Fig. 11)***. The signal amplitude increased on 22 July by about 6 and 7 dB at Allahabad and Varanasi and

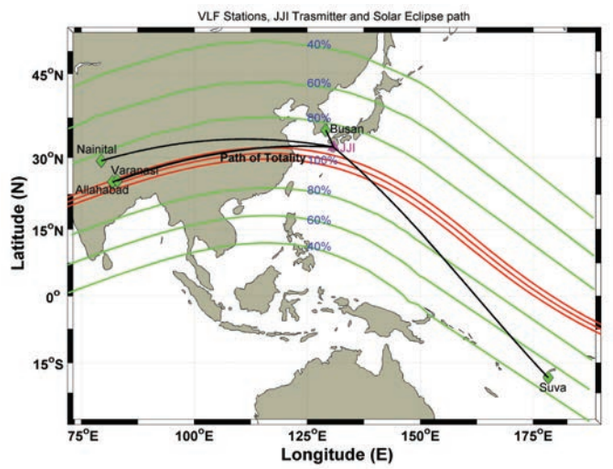


Figure 11 The 22 July 2009 solar eclipse totality path in the Indian and Asia-Oceania regions. The locations of VLF receiving sites (Allahabad, Varanasi, Nainital, Busan, and Suva) are represented by green diamonds and location of JJI transmitter by pink triangle.

decreased by about 2.7, 3.5, and 0.5 dB at Nainital, Busan and Suva, respectively, as compared to 24 July 2009 (normal day) ***(Fig. 12)***. The increase/decrease in the amplitude can be understood in terms of modal interference at the sites of modes converted at the discontinuity created by the eclipse intercepting the different transmitter-receiver great circle paths. The wavelet analysis shows the presence of WLS of period ~16-40 minutes at stations under total eclipse and of period ~30-80 minutes at stations under partial eclipse (~85-54 % totality) with delay times between ~50-100 minutes at different stations ***(Fig. 13)***. The intensity

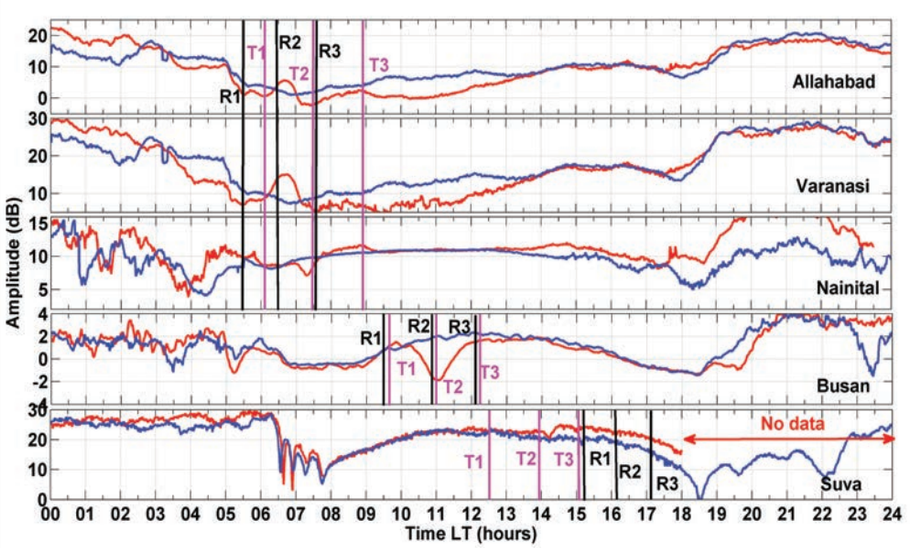


Figure 12 The JJI signal amplitude variation for 24 hours local time (LT) observed at the VLF stations on 22 July eclipse day (red line) and on a normal day (24 July 2009) (blue line). The vertical lines R1, R2, R3 (pink line) and T1, T2, T3 (black line) represent begin, maximum and end times of eclipse at receivers and transmitter, respectively. The Local Time (LT) for Allahabad, Varanasi and Nainital=Universal Time (UT) + 5.5hr, for Busan = UT + 9 hr and for Suva =UT + 12 hr.

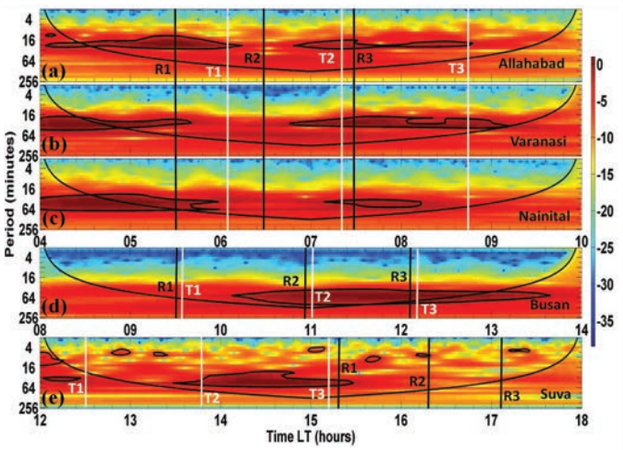


Figure 13 The wavelet spectra based on the Morlet wavelet of JJI filtered amplitude signal in two period ranges 10-50 minutes for totality stations (Allahabad and Varanasi) and 30-80 minutes for partially eclipsed stations (Nainital, Busan and Suva) observed on 22 July 2009 eclipse day for six hour at each stations. The vertical lines R1, R3 and T1, T3 represents the eclipse begins and end time at receivers and transmitter, respectively.

of WLS was maximum for paths in the partially eclipsed region and minimum in the fully eclipsed region. The features of WLS on eclipse day seem almost similar to WLS observed in the nighttime of normal days (e.g., 24 July 2009). The WLS could be generated by sudden cutoff of the photo-ionization creating nighttime like conditions in the D-region ionosphere and solar eclipse induced gravity waves coming to ionosphere from below and above. The present observations shed additional light on the current understanding of wave induced D-region ionospheric perturbations *(**Maurya, A.K.**; D.V. Phani Kumar (ARIES, Nainital); **Rajesh Singh**; Sushil Kumar (University of South Pacific, Fiji); **B. Veenadhari**; Y.-S. Kwak (KASI, South Korea); Abhikesh Kumar (University of South Pacific, Fiji); Abhay K. Singh (BHU, Varansi); K. Niranjan Kumar (MIST, UAE)).*

Response of the mid-latitude D-region ionosphere to the Total Solar Eclipse of 22 July 2009 studied using VLF signals in South Korean peninsula

VLF signals received at Busan is analysed to study the the D-region changes linked with the solar eclipse event of 22 July 2009 for very short (~390 km) transmitter-receiver great circle path (TRGCP) during local noon time 00:36 – 03:13 UT (09:36 – 12:13 KST). The eclipse crossed south of Busan with a maximum obscuration of ~84%. Observations clearly show a reduction of ~ 6.2 dB in the VLF signal strength at the time of maximum solar obscuration (84% at 01:53 UT) as compared to those observed on the control days. Estimated values of change in Wait ionospheric parameters: reflection height (h') in km and inverse scale height parameter (β) in km^{-1} from Long Wave Propagation Capability (LWPC) model during the maximum eclipse phase as compared to unperturbed ionosphere are 7 km and 0.055 km^{-1}, respectively. Moreover, the D-region electron density estimated from model computation shows 95% depletion in electron density at the height of ~ 71 km. The reflection height is found to increase by ~ 7 km in the D-region during the eclipse as compared to those on the control days, implying a depletion in the Lyman-α flux by a factor of ~ 7. The present observations are discussed in the light of current understanding on the solar eclipse induced D-region dynamics *(D.V. Phanikumar (ARIES, Nainital); Y.-S. Kwak (KASI, S. Korea); A.K. Patra (NARL, Gadanki); **A. K. Maurya, Rajesh Singh**; and S.-M. Park (KASI, S. Korea)).*

Subionospheric VLF perturbations observed at a low latitude station Varanasi (L = 1.07)

Subionospheric very low frequency (VLF) perturbations observed on NWC (19.8 kHz) and NPM (21.4 kHz) transmitter signals at low latitude ground station Varanasi, India, during the period January–June 2010 were studied. Characteristics and occurrence rates of these events mainly observed during nighttime are studied. Most of the early VLF events had slow recovery with amplitude perturbations of 0.5–4.5 dB and phase changes of 3–120. Temporal variation of the events is studied. World Wide Lightning Location Network data along with the broadband VLF data are analyzed to find the location of causative lightning discharge and/or the sferics associated with these early VLF events. Lightning induced changes in D-region ionospheric conductivity are attributed to the perturbations in the VLF signals *(As. K. Singh, A.K. Singh (BHU, Varanasi); **Rajesh Singh**; R.P. Singh (BHU, Varanasi); K. Adams, R.L. Dowden (LFER, New Zealand)).*

LINEAR AND NON-LINEAR WAVES

Nonlinear evolution of ion acoustic solitary waves in space plasmas: Fluid and particle-in-cell simulations

Spacecraft observations revealed the presence of electrostatic solitary waves (ESWs) in various regions of the Earth's magnetosphere. Over the years, many researchers have attempted to model these observations in terms of electron/ion acoustic solitary waves by using nonlinear fluid theory/simulations. The ESW structures predicted by fluid models can be inadequate due to its inability in handling kinetic effects. To provide clear view on the application of the fluid and kinetic treatments in modeling

the ESWs, both fluid and particle-in-cell (PIC) simulations of ion acoustic solitary waves (IASWs) are performed and the quantitative differences in their characteristics like speed, amplitude, and width. The number of trapped electrons in the wave potential is higher for the IASW, which are generated by large-amplitude initial density perturbation (IDP). The present fluid and PIC simulation results are in close agreement for small amplitude IDPs, whereas for large IDPs they show discrepancy in the amplitude, width, and speed of the IASW, which is attributed to negligence of kinetic effects in the former approach. The speed of IASW in the fluid simulations increases with the increase of IASW amplitude, while the reverse tendency is seen in the PIC simulation (as shown in ***Fig. 14***). The present study suggests that the fluid treatment is appropriate when the magnitude of phase velocity of IASW is less than the ion acoustic (IA) speed obtained from their linear dispersion relation, whereas when it exceeds IA speed, it is necessary to include the kinetic effects in the model *(**B. Kakad, A. Kakad**; Y. Omura (Kyoto University, Japan)).*

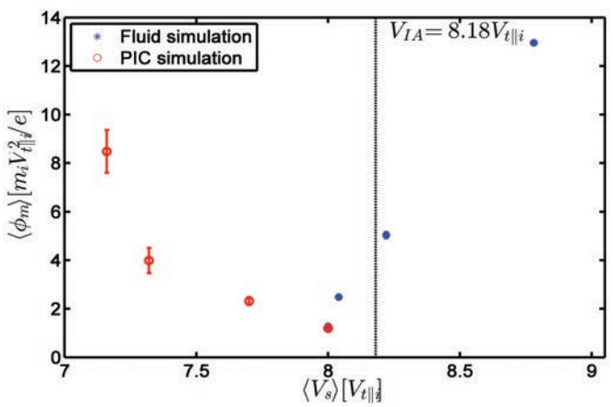


Figure 14 Average peak amplitude of IASW as a function of its phase velocity for both fluid and PIC simulations. The vertical dotted line represents the speed of IASW obtained from their linear dispersion relation, i.e., $V_{IA}=8.18V_{t\|i}$. For $Vs < V_{IA}$, the characteristics of IASW from the fluid simulation are in close agreement with those obtained from the PIC simulation and they are associated with the IDP with less than 15% perturbations. For density perturbations greater than 15%, the Vs exceeds V_{IA} and the IASW characteristics obtained from the fluid and PIC simulations are considerably different.

Existence domains of slow and fast ion-acoustic solitons in two-ion space plasmas

A study of large amplitude ion-acoustic solitons is conducted for a model composed of cool and hot ions and cool and hot electrons. Using the Sagdeev pseudo-potential formalism, the scope of earlier studies is extended to consider why upper Mach number limitations arise for slow and fast ion-acoustic solitons. Treating all plasma constituents as adiabatic fluids, slow ion-acoustic solitons are limited in the order of increasing cool ion concentrations by the number densities of the cool, and then the hot ions becoming complex valued, followed by positive and then negative potential double layer regions. Only positive potentials are found for fast ion-acoustic solitons which are limited only by the hot ion number density having to remain real valued. The effect of neglecting as opposed to including inertial effects of the hot electrons is found to induce only minor quantitative changes in the existence regions of slow and fast ion-acoustic solitons *(Maharaj, S.K. (SANSA, South Africa); R. Bharuthram (University of Western cape, South Africa); **S.V. Singh, G. S. Lakhina**).*

Do nonlinear waves evolve in a universal manner in dusty and other plasma environments?

Using a fluid theory approach, this article provides a comparative study on the evolution of nonlinear waves in dusty plasmas, as well as other plasma environments, viz electron-ion, and electron-positron plasmas. Where applicable, relevance to satellite measurements is pointed out. A range of nonlinear waves from low frequency (ion acoustic and ion cyclotron waves), high frequency (electron acoustic and electron cyclotron waves) in electron-ion plasmas, ultra-low frequency (dust acoustic and dust cyclotron waves) in dusty plasmas and in electron-positron plasmas are discussed. Depending upon the plasma parameters, saw-tooth and bipolar structures are shown to evolve *(Bharuthram, R. (University of Western cape, South Africa); **S. V. Singh**; S. K. Maharaj (SANSA, South Africa); S. Moolla (University of KwaZulu-Natal, South Africa); I. J. Lazarus (Durban University of Technology, South Africa); **R. V. Reddy**, **G. S. Lakhina**).*

Ion acoustic solitons and supersolitons in a magnetized plasma with nonthermal hot electrons andBoltzmann cool electrons

Arbitrary amplitude, ion acoustic solitons, and supersolitons are studied in a magnetized plasma with two distinct groups of electrons at different temperatures. The plasma consists of a cold ion fluid, cool Boltzmann electrons, and nonthermal energetic hot electrons. Using the Sagdeev pseudo-potential technique, the effect of nonthermal hot electrons on soliton structures with other plasma parameters is studied. Numerical computation shows that negative potential ion-acoustic solitons and double layers can exist both in the subsonic and supersonic Mach number regimes, unlike the case of an unmagnetized plasma where they can only exist in the supersonic Mach number regime. For the

first time, it is reported here that in addition to solitions and double layers, the ion-acoustic supersoliton solutions are also obtained for certain range of parameters in a magnetized three-component plasma model. The results show good agreement with Viking satellite observations of the solitary structures with density depletions in the auroral region of the Earth's magnetosphere *(Rufai, O. R., R. Bharuthram (University of Western cape, South Africa);* ***S. V. Singh****,* ***G. S. Lakhina****).*

Ion acoustic solitons/double layers in two-ion plasma revisited

Ion acoustic solitons and double layers are studied in a collisionless plasma consisting of cold heavier ion species, a warm lighter ion species, and hot electrons having Boltzmann distributions by Sagdeev pseudo-potential technique. In contrast to the previous results, no double layers and supersolitons are found when both the heavy and lighter ion species are treated as cold. Only the positive potential solitons are found in this case. When the thermal effects of the lighter ion species are included, in addition to the usual ion-acoustic solitons occurring at M>1 (where the Mach number, M, is defined as the ratio of the speed of the solitary wave and the ion-acoustic speed considering temperature of hot electrons and mass of the heavier ion species), slow ion-acoustic solitons/double layers are found to occur at low Mach number (M<1). The slow ion-acoustic mode is actually a new ion-ion hybrid acoustic mode which disappears when the normalized number density of lighter ion species tends to 1 (i.e., no heavier species). An interesting property of the new slow ion-acoustic mode is that at low number density of the lighter ion species, only negative potential solitons/double layers are found whereas for increasing densities there is a transition first to positive solitons/double layers, and then only positive solitons. The model can be easily applicable to the dusty plasmas having positively charged dust grains by replacing the heavier ion species by the dust mass and doing a simple normalization to take account of the dust charge ***(Lakhina, G. S****.,* ***S. V. Singh, A. P. Kakad****).*

Ion-acoustic supersolitons in presence of non-thermal electrons

A great deal of interest has been generated in the literature to study the newly found structures known as supersolitons. Theoretical models are being developed to understand these unusual electric field structures which have wiggle on their wings. The current understanding of these structures require at least three-component plasma model. In this work, ion-acoustic supersolitons are studied in three-component unmagnetized plasmas comprising of Boltzmann electrons, nonthermal (Cairn's distribution) electrons and fluid cold ions. The supersoliton solutions are obtained for Mach number values beyond the existence of double layers. The effect of nonthermality, cold electron density and cold to hot electron temperature ratio is examined on ion-acoustic supersolitons. It is found that presence of nonthermal electrons significantly affect the existence of the supersolitons. The amplitude of the supersolitons decreases with the increase in the nonthermality for the fixed value of Mach number. Results show that electric field and electrostatic potential of the supersolitons are more distorted which are obtained for Mach numbers closer to the double layer solutions than the far away solutions. Due to the lack of observations of these structures, either in space or laboratory plasmas, the present theoretical model predictions can not to be compared directly. However, it is worth investigating the data on the electrostatic solitary structures observed by several satellites in the various region of the Earth's magnetosphere ***(Singh, S.V., G. S. Lakhina****).*

Nonlinear ion--acoustic waves in an inhomogeneous plasma with non-thermal distribution of electrons

In the Earth's magnetosphere, the boundary layer regions are the sources for inhomogeneous plasmas and are natural laboratories to study wave phenomena. In these regions, particles distributions also differ from Maxwellian and are found to be non-thermal. Therefore, amplitude of the waves propagating through these regions can vary differently compared to the homogeneous plasmas. In this study, propagation of ion–acoustic waves (IAWs) in an inhomogeneous, warm electron-ion plasma is examined. The electrons are considered to be having non-thermal Cairn's type distribution and ions follow the fluid dynamical equations. Further, inhomogeneity is assumed in equilibrium density of the electrons and ions. The evolution of the nonlinear IAWs is governed by the Korteweg–de Vries (KdV) equation with variable coefficients. Analytical solution of the KdV equation shows that for a cold ion plasma and non-thermal electrons, the amplitude and the width of the nonlinear IAWs decreases and increases, respectively with the inclusion of the non-thermal distribution of electrons. It is interesting to note that nonlinear IAWs in this model can not propagate for whole range of non-thermal parameter, α. The novel result of this study is that for nonlinear IAWs to propagate in the inhomogeneous two component plasma with ions and non-thermal electrons, the non-thermal parameter, $\alpha \leq 0.155$. Results from this study may have impact on the propagation of the IAWs in the boundary layer

regions of the Earth's magnetosphere where density inhomogeneities are appreciable *(**Singh, S.V.**).*

Small amplitude electron acoustic solitary waves in a magnetized superthermal plasma

The propagation of electron acoustic solitary waves in a magnetized plasma consisting of fluid cold electrons, electron beam and superthermal hot electrons (obeying kappa velocity distribution function) and ion is investigated in a small amplitude limit using reductive perturbation theory. The Korteweg–de-Vries–Zakharov–Kuznetsov (KdV–ZK) equation governing the dynamics of electron acoustic solitary waves is derived. The solution of the KdV–ZK equation predicts the existence of negative potential solitary structures. The new results are: (1) increase of either the beam speed or temperature of beam electrons tends to reduce both the amplitude and width of the electron acoustic solitons, (2) the inclusion of beam speed and temperature pushes the allowed Mach number regime upwards and (3) the soliton width maximizes at certain angle of propagation (am) and then decreases for $\alpha > \alpha m$. In addition, increasing the superthermality of the hot electrons also results in reduction of soliton amplitude and width. For auroral plasma parameters observed by Viking, the obliquely propagating electron-acoustic solitary waves have electric field amplitudes in the range (7.8–45) mV/m and pulse widths (0.29–0.44) ms. The Fourier transform of these electron acoustic solitons would result in a broadband frequency spectra with peaks near 2.3–3.5 kHz, thus providing a possible explanation of the broadband electrostatic noise observed during the Burst. *(**Devanandhan, S., S.V. Singh, G. S. Lakhina**; R. Bharuthram (University of Western cape, South Africa)).*

Extremely intense ELF magnetosonic waves: A survey of polar observations

A Polar magnetosonic wave (MSW) study was conducted using 1 year of 1996–1997 data (during solar minimum). Waves at and inside the plasmasphere were detected at all local times with a slight preference for occurrence in the midnight-postmidnight sector. Wave occurrence (and intensities) peaked within ~±5° of the magnetic equator, with half maxima at ~±10°. However, MSWs were also detected as far from the equator as +20° and 60° MLAT but with lower intensities. An extreme MSW intensity event of amplitude Bw = ~± 1 nT and Ew = ~± 25 mV/m was detected. This event occurred near local midnight, at the plasmapause, at the magnetic equator, during an intense substorm event, e.g., a perfect occurrence. These results support the idea of generation by protons injected from the plasma sheet into the midnight sector magnetosphere by substorm electric fields. MSWs were also detected near noon (1259 MLT) during relative geomagnetic quiet (low AE). A possible generation mechanism is a recovering/expanding plasmasphere engulfing preexisting energetic ions, in turn leading to ion instability. The wave magnetic field components are aligned along the ambient magnetic field direction, with the wave electric components orthogonal, indicating linear wave polarization. The MSW amplitudes decreased at locations further from the magnetic equator, while transverse whistler mode wave amplitudes (hiss) increased. Intense MSWs are always present somewhere in the magnetosphere during strong substorm/convection events. It is suggested that modelers use dynamic particle tracing codes and the maximum (rather than average) wave amplitudes to simulate wave-particle interactions *(Tsurutani, B. T., B. J. Falkowski (JPL, USA); J. S. Pickett (University of Iowa, USA); O. P. Verkhoglyadova (JPL, USA); O. Santolik (Institute of Atmospheric Physics, Czech Republic); **G.S. Lakhina**).*

An extreme coronal mass ejection and consequences for the magnetosphere and Earth

A "perfect" interplanetary coronal mass ejection could create a magnetic storm with intensity up to the saturation limit (Dst ~ −2500 nT), a value greater than the Carrington storm. Many of the other space weather effects will not be limited by saturation effects, however. The interplanetary shock would arrive at Earth within ~12 h with a magnetosonic Mach number ~45. The shock impingement onto the magnetosphere will create a sudden impulse of ~234 nT, the magnetic pulse duration in the magnetosphere will be ~22 s with a dB/dt of ~30 nT s^{-1}, and the magnetospheric electric field associated with the dB/dt ~1.9 V m^{-1}, creating a new relativistic electron radiation belt. The magnetopause location of 4 Re from the Earth's surface will allow expose of orbiting satellites to extreme levels of flare and ICME shock-accelerated particle radiation. Calculations are compared with current observational records. Comments are made concerning further data analysis and numerical modeling needed for the field of space weather *(Tsurutani, B. T., B. J. Falkowski (JPL, USA); **G.S. Lakhina**).*

No electrostatic supersolitons in two-component plasmas

The concept of acoustic supersolitons was introduced for a very specific plasma with five constituents, and discussed only for a single set of plasma parameters. Supersolitons are characterized by having subsidiary extrema on the

sides of a typical bipolar electric field signature, or by association with a root beyond double layers in the fully nonlinear Sagdeev pseudopotential description. It was subsequently found that supersolitons could exist in several plasma models having three constituent species, rather than four or five. In the present paper, it is proved that standard two-component plasma models cannot generate supersolitons, by recalling and extending results already in the literature, and by establishing the necessary properties of a more recent model *(Verheest, F. (Universiteit Gent, Belgium);* ***G. S. Lakhina****; M. A. Hellberg (University of KwaZulu-Natal, South Africa)).*

SOLID EARTH RESEARCH

CRUSTAL AND DEEP CONTINENTAL RESEARCH

GEOPOTENTIAL STUDIES

A relook into the crustal architecture of Laxmi Ridge, northeastern Arabian Sea from geopotential data

In this study, analysis of ship-borne gravity-magnetic and satellite-derived free-air gravity (FAG) data is undertaken to derive the crustal structure of Laxmi Ridge and adjacent areas. 2D and 3D crustal modelling suggests that the high resolution FAG low associated with the ridge is due to underplating and that it is of continental nature. From Energy Spectral Analysis, five-depth horizons representing interface between different layers are demarcated that match those derived from 2D models. Magnetic sources from EMAG2 data, various filtered maps and absence of underplating in the EW section suggest that the EW and NW–SE segment of the Laxmi Ridge is divided by the Girnar fracture zone and probably associated with different stages of evolution. From the derived inclination parameters, it is inferred that the region to the north of Laxmi Ridge, between Laxmi and Gop Basins, is composed of volcanic/basaltic flows having Deccan affinity, which might have been emplaced in an already existing crust. The calculated inclination parameters derived from the best fit 2D model suggests that the rifting in the Gop Basin preceded the emplacement of the volcanics in the region between Laxmi and Gop Basins. The emplacement of volcanic/basaltic flows may be associated with the passage of India over the Reunion hotspot ***(****Nisha Nair (NCAOR, Goa)****; S.P. Anand, M. Rajaram****).***

ELECTROMAGNETIC INDUCTION STUDIES

Electrical Conductance Map for the Kachchh Rift Basin: Constraint on Tectonic Evolution and Seismotectonic Implications

Geomagnetic field variations recorded by an array of magnetometers spread across the Kachchh Rift basin are reduced to a set of induction arrows as a diagnostic of lateral electrical conductivity variations. A non-uniform thin-sheet electrical conductance model is developed to account for the salient induction patterns. It indicates that the imaged conductivity anomalies can be related to the sediment-filled structural lows in between the fault bounded uplifts. It is suggested that sagging structural lows preserved the marine sediments deposited during the Mesozoic sea transgression and later developed into first order embayment basins for the deposition of sediments in association with Late Eocene transgression. Depth integrated electrical conductance helped in mapping two depo-centres: along the ENE-WSW trending Banni half-Graben bounded by the Kachchh Main fault on the south, and second, along the Vinjan depression formed in response to the subsidence between the Vigodi fault and westward extension of the Katrol Hill fault together with the westward bending of the Median High. Presence of metamorphosed graphite schist clasts in shale dominated Mesozoic sequence and/or thin films of carbon resulting from the thermal influence of Deccan activity on Carbonate-rich formations can account for the high electrical conductivity anomalies seen in the depo-centres of thick Mesozoic and Tertiary sediments. Additionally two high conductivity zones are imaged encompassing a block defined by the 2001 Bhuj earthquake and its aftershocks. In agreement with gravity, magnetic and seismic velocity signatures, aqueous fluids released by recrystallizing magmatic bodies intruded in association with Deccan trap activity account for mapped high conductivity zones. High fluid pressure in such a fractured domain, surrounding the intruded magmatic plugs, perturb the regional stress concentrations to produce frequent and low magnitude aftershocks in the shallow section of the epicentral track of the 2001 Bhuj earthquake ***(Fig. 15)*** ***(P.B.V. Subba Rao;*** *B.R. Arora (Geoscience Division, MOES, New Delhi);* ***A.K. Singh)****.*

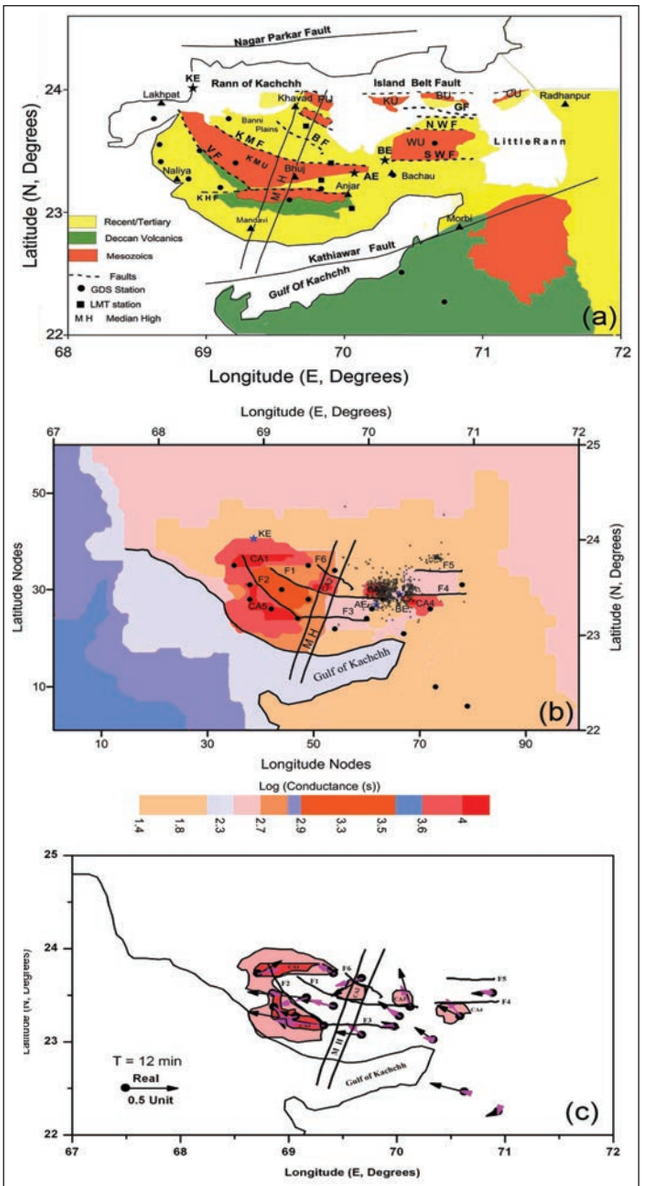


Figure 15 **(a)** Map of the Kachchh Rift Basin showing geology and major faults (modified from BISWAS 1987; MISHRA et al. 2005). Bounded to the north by the Nagar Parkar Fault and the Kathiawar Fault to the south, The KRB is dominated by several uplands (KMU Kachchh mainland uplift, WU Wagad uplift, and a chain of small uplands along the Island Band fault (IBF). Major faults are KMF Kachchh Mainland fault, VF Vigodi fault, KHF Katrol Hill fault, SWF, NWF South and North Wagad faults, BF Banni fault, GF Gedi fault). The epicentres of the 2001 Bhuj (BE), 1956 Anjar (AE) and 1819 Kachchh (KE) earthquakes are also marked. Black circles and squares mark GDS and LMT sites covered under the present study. **(b)** Spatial distribution in depth-integrated conductance in and around the KRB together with the mapped high conductivity anomalies, referred to as CA1, CA2,…, CA5. Different colour codes used to represent conductance values are in logarithms scale. The grey dots denote earthquakes recorded since 2001 Bhuj earthquake. **(c)** Comparison of observed and modelled real induction corresponding to period of 12 min in the background of mapped high conductance anomalous zones.

GLOBAL POSITIONING SYSTEM AND GEODESY STUDIES

Geophysical constraints on the seismotectonics of the Sikkim Himalaya

The role of transverse lineaments is often invoked in strain partitioning to generate strike-slip-dominated earthquakes in the Sikkim Himalaya, including the recent M_w 6.9 earthquake of September 18, 2011. An integration of seismicity clusters and crustal structures in conjunction with gravity modeling helps to develop a unified seismotectonic model for the Sikkim Himalaya, where transverse lineaments appear to have little role in strain concentration. Instead, deflection of the arc normal slips by rigid eclogitized Indian crust in the 40–60 km depth range is the primary source to generate strike-slip-dominated, large-magnitude earthquakes. The clustering of relatively deep aftershocks and main event near the southern edge of the eclogitized lower crust is a clear manifestation of this deformation. This transcurrent deformation also re-orients foliation planes in the low-velocity block immediately above to inflict anisotropy and promote strike-slip-dominated moderate-magnitude earthquakes in the 20–40 km depth range. The low-angle northeast-dipping detachment in the 10–12 km depth range forms a localized asperity that produces low-magnitude earthquakes beneath the Lesser Himalayan duplex. It is surmised that the competent and strong eclogitic layer in the lower crust serves as a repository of high stresses during an earthquake buildup cycle, wherein the fluid pressure in the fractured rock matrix above plays a key role in the earthquake generating process ***(****B.R. Arora, S.K. Prajapati (Geoscience Division, MOES, New Delhi);* ***C.D. Reddy)***.

Post-seismic ionospheric response to the 11 April 2012 East Indian Ocean doublet earthquake

The 11 April 2012 East Indian Ocean earthquake is unique because of its largest ever recorded aftershock. The main earthquake occurred with a magnitude of 8.6 Mw and was followed by a strong aftershock (8.2 Mw). Analysis of the main shock indicates that the rupture was a mixture of strike-slip and thrust faults, and significant vertical surface displacements were observed during the event. The prime interest here is to study the post-seismic ionospheric disturbances, along with their characteristics. As both earthquakes had large magnitudes, they provided an opportunity to minimize the ambiguity in identifying the corresponding seismic-induced ionospheric disturbances. Approximately 10 min after both seismic events, the nearby ionosphere started to manifest electron density perturbations

that were investigated using GPS-TEC measurements. The epicenters of both events were located south of the magnetic equator, and it is believed that the varying magnetic field inclination might be responsible for the observed north-south asymmetry in the post-seismic total electron content (TEC) disturbances. These disturbances are observed to propagate up to approximately 1,500 km towards the north side of the epicenter and up to only a few hundred kilometers on the south side. The frequency analysis of the post-seismic TEC disturbances after both earthquakes exhibits the dominant presence of acoustic frequencies varying between approximately 4.0 to 6.0 mHz. The estimated propagation velocities of the post-seismic TEC disturbances during the main shock (0.89 km/s) and aftershock (0.77 km/s) confirm the presence of an acoustic frequency as the generative mode for the observed TEC fluctuations ***(Sunil, A. S., Mala Bagiya, C. D. Reddy, Manish Kumar, D. S. Ramesh)***.

ENVIRONMENTAL AND HYDROGEOPHYSICAL RESEARCH

ENVIRONMENTAL MAGNETISM STUDIES

Analysis of vegetation and climate change during Late Pleistocene from Ziro Valley, Arunachal Pradesh, Eastern Himalaya region

Vegetation and climate during later part of Late Pleistocene have been reconstructed from Ziro valley, Arunachal Pradesh, Eastern Himalaya based on pollen data along with carbon isotope and magnetic susceptibility data. The study reveals that the area and the vicinity is occupied by mixed broad leaved – conifer forest and pine grass savanah at variable densities at least since 66,000yr BP. The phases of expansions and declines of Oaks with decline and increase of Pines and grasses probably occurred under increase (warm–moist) and decrease (cool–dry) of southwest monsoon precipitation respectively. The increasing trend of southwest monsoon and temperature is recorded during ~44,000 to 34,000 cal yr BP synchronizing with the peat development, and which peaked at around 35,000 cal yr BP. This may link to the interstadial phase during the last major glacial cycle in the Himalayan region. It is also reflected in the decline of $\delta^{13}C$ value indicating dominance of C-3 type of vegetation. The increased values of ChiFD%, and lower values χLF magnetic susceptibility, recorded during the phase of the peat deposit, further advocate's higher monsoon intensity. Impact of expansion of glacier felt with peak (LGM) around 20,000 cal yr BP is perceived. Tree line had moved to lower altitudes due to increased aridity and low temperature. During this time existence of savannah type of vegetation is also evident by the increase of C4 taxa. Decreased FD% and increased ChiLF susceptibility also indicate reduced southwest monsoon intensity (*A. Bhattacharyya, N. Mehrotra, S.K. Shah (BISP, Lucknow); **N. Basavaiah;** V. Chaudhary (MoES, New Delhi); Indra Bir Singh (CASG, Lucknow University)).*

Magnetic properties of LiZnCu ferrite synthesized by the microwave sintering method

Lithium ferrites have attracted considerable attention because they have been used as replacements for garnets due to their low cost. A series of polycrystalline ferrite samples were prepared with the composition of $Li_xZn_{(0.6-2x)}Cu_{0.4}Fe_2O_4$(**X**=0.05, 0.1, 0.15, 0.2, 0.25, 0.3) at chemical reaction temperature 150 °C by sintering with microwave assisted combustion method. The characterization shows the formation of single phase cubic structure when carried out by using the X-rays technique and **I–R** technique. Magnetization parameters such as saturation magnetization, coercivity, magnetic moment were calculated by using the Hysteresis graph. The Curie temperature obtained using the susceptibility data are found to be in the range 350–700 °C. Anhysteric remanent magnetization is used for estimating the grain size and domain structure of the composition. An attempt has been made to synthesis the nano-particles at lower reaction temperature by using non-conventional microwave sintering method. The advantage of this method is its lower sintering temperature and time compared to the conventional ceramic technique and direct formation of nano-ferrites without ball-milling ***(****S.S. Khot (Smt. Chandibai Himathmal Mansukhani College, Ulhasnagar); N.S. Shinde(D. B. J. College, Chiplun); B.B. Kale (P.D. Karkhanis College, Ambernath); **N. Basavaiah;** S.C. Watawe (P.D. Karkhanis College, Ambernath); M.M. Vaidya (Vedanta College of Management and Information Technology, Vitthalvadi****)).***

Anisotropy of magnetic susceptibility of earthquake-affected soft sediments: example from Ther village, Latur, Maharashtra, India

Anisotropy of magnetic susceptibility (AMS) of deformed and undeformed unconsolidated clay samples of Deccan Trap terrain from the ~2000-year-old palaeoearthquake site of Ther village, Maharashtra, India, was studied. Such deposits are rare in this region and give an exceptional opportunity to test the efficacy of AMS and other magneto petrofabric studies, which can have a bearing on magnetic granularity ellipsoids,inclination and declination directions impacting palaeomagnetic studies. The undeformed clay samples exhibit typical sedimentary fabric with an oblate AMS ellipsoid, whereas the deformed samples are tightly

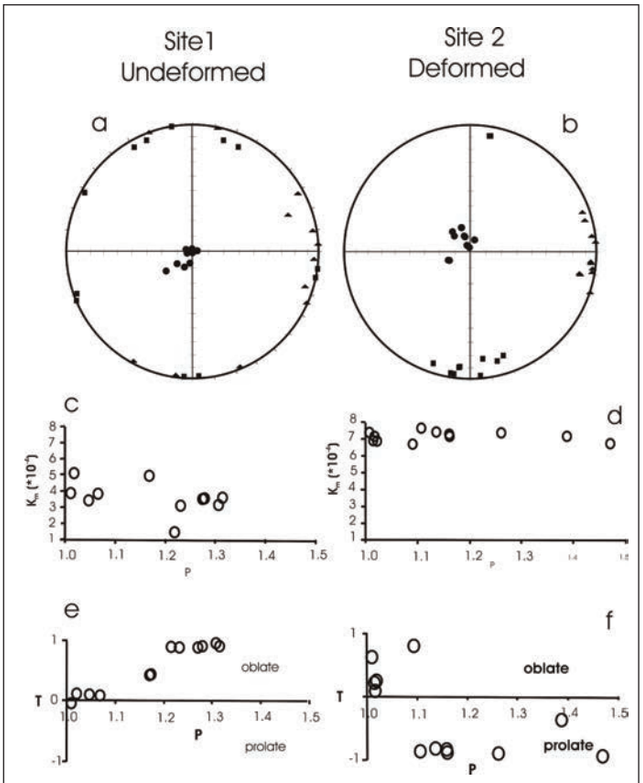


Figure 16 AMS data for two sites. a-b: Lower-hemisphere, equal area projections of AMS principal axes (squares: K1, triangles: K2 and circles: K3). c,d: degree of anisotropy (P) versus mean susceptibility (Km) e,f: P versus Shape parameter (T).

grouped in the inferred compression direction, probably effected by an earthquake, exhibiting prolate as well as oblate AMS ellipsoids ***(Fig.16)***. The temperature dependent magnetic susceptibility revealed the occurrence of titanomagnetite and magnetite in both the deformed and undeformed samples signifying similar sedimentmaterial. The site mean ChRM direction for undeformed clay samples is D = 3 and I = 44.7 (k = 92.7, a_{95}= 4.5), whereas for deformed samples D = 336 and I = 39 (k = 39, a_{95} = 8). The present study reveals that sediments can be severely deformed without deflecting minimum susceptibility directions. AMS methodology can be effective in the DT region and can throw up new results to build the chronology of past earthquakes ***(B.V. Lakshmi, K.V.V. Satyanarayana, N. Basavaiah, P.B. Gawali).***

The use of amino acid analyses in (palaeo-) limnological investigations: A comparative study of four Indian lakes in different climate regimes

The present study demonstrates the results of comprehensive amino acid (AA) analyses of four Indian lakes from different climate regimes. The focus is on the investigation of sediment cores retrieved from the lakes but data of modern sediment as well as vascular plant, soil, and suspended particulate matter samples from individual lakes are also presented. Commonly used degradation and organic matter source indices are tested for their applicability to the lake sediments, and potential reasons for possible limitations are discussed. A principal component analysis including the monomeric AA composition of organic matter of all analysed samples indicates that differences in organic matter sources and the environmental properties of the individual lakes are responsible for the major variability in monomeric AA distribution of the different samples. However, the PCA also gives a factor that most probably separates the samples according to their state of organic matter degradation. Using the factor loadings of the individual AA monomers, a lake sediment degradation index (LI) is calculated that might be applicable to other palaeo-lake investigations ***(****P. Menzel(Institute of Geology, University of Hamburg, Germany); K. Anupama (French Institute of Pondicherry, Pondicherry);* ***N. Basavaiah;*** *B.K. Das (Centre of Advanced Study in Geology, Panjab University, Chandigarh); B. Gaye, N. Herrmann (Institute of Geology, University of Hamburg, Germany); S. Prasad (Institute of Earth- and Environmental Science, University of Potsdam, Germany****)).***

Effect of Chemical Reaction Temperature on Magnetic Properties of NiCuZn Ferrites, Magnetics

Ni0.5Cu*x*/2Zn(0.5−*x*/2)Fe_2O_4 (where *x* = 0.3, 0.4, 0.5, and 0.6) ferrites were prepared at different chemical reaction temperatures (100 °C, 125 °C, and 150 °C) and then were further sintered using domestic microwave oven. X-ray diffraction revealed the ferrite phase formation and proved that chemical reaction temperature affects the structural properties. Magnetic properties, such as saturation magnetization, coercivity, Curie temperature, and normalized susceptibility were found to be dependent not only on composition, but also on chemical reaction temperature. Grain size was found to be in range of 41.866–200.909 nm ***(****N.S. Shinde (D. B. J. College, Chiplun); S.S. Khot (Smt. Chandibai Himathmal Mansukhani College, Ulhasnagar);* ***N. Basavaiah;*** *S.C. Watawe (P.D. Karkhanis College, Ambernath); M.M. Vaidya (Vedanta College of Management and Information Technology, Vitthalvadi****)).***

Late Quaternary environmental and sea level changes from Kolleru Lake, SE India: Inferences from mineral magnetic, geochemical and textural analyses

The present study employs mineral magnetic, geochemical, and textural parameters to elucidate the climate and sea

level change signatures from Kolleru lake sediments representing the inter-deltaic part of the Krishna–Godavari sedimentary basin (KG basin). For this purpose, four cores were obtained which included significant peat. The conventional radiocarbon dating suggested that the peat formation took place during 9 ka–6 ka with an average sedimentation rate of 0.31 cm/y. Thermomagnetic analysis identifies titanomagnetite, magnetite and hematite as the dominant magnetic mineralogy of the KG basin sediments. The variation in magnetic mineralogy is related to paleoclimatic and paleoenvironmental processes; the transitions between (titano) magnetite and hematite coincide with peat layers of the cores as indicated by SIRM/χ (Saturation Isothermal Remanent Magnetization/Magnetic Susceptibility) and S-ratio defined by $IRM_{-0.3T}$/SIRM values. The various mineral magnetic parameters, χ and S-ratio along with major elemental concentrations of Ti, Al, Fe and Zr show signatures of an arid event before 10 ka, between 9 ka–8 ka periods and during the last 5.5 ka. The overall climate of warm and humid type was inferred from 10 ka to 9 ka, which correlates with Early Holocene Optima and 6 ka to 5.5 ka of Middle Holocene. The presence of evaporite crystals in the lowermost part of the cores corroborated by mineral magnetic and geochemical proxies indicates sub-aerially weathered facies of the arid Late Pleistocene. Similarly, the peat layers rich in mangrove pollen indicate sea level changes between 10 ka and 6 ka. The sub-surface position of the Pleistocene weathered layer and the Holocene peat layer suggests tectonic subsidence of the area, which is situated over the basement graben, known as Gudiwada sub-basin ***(N. Basavaiah,J.L.V. Mahesh Babu, P.B. Gawali****; K.Ch.V. Naga Kumar, G. Demudu (Department of Geo-Engineering, Andhra University, Visakhapatnam); P. Siddharth Prizomwala (Institute of Seismological Research, Raisan, Gandhinagar); P.T. Hanamgond (G.S.Science College, Belgaum); K. Nageswara Rao (Department of Geo-Engineering, Andhra University, Visakhapatnam****)).***

Modern pollen vegetation relationships in a dry deciduous monsoon forest: A case study from Lonar Crater Lake, central India

As part of ongoing research on Holocene lacustrine sediments of Lonar Crater Lake (central India), pollen assemblages in lake surface sediment and soil samples were studied to unravel pollen–vegetation relationships, including pollen transport processes in tropical dry deciduous forest vegetation. Furthermore, palynological results were compared with geochemical proxies and spatial features of the lake sediments and the vegetation. The obtained data reveal strong differences in pollen assemblages and pollen concentrations between and within the studied trapping media. Local arboreal vegetation is adequately represented in the soil samples, but is less represented in the lake surface sediment samples. The composition of the lacustrine pollen assemblages is mainly influenced by patterns of transport through surface and channel runoff. Besides the relevance of the new data for reliable interpretation of fossil pollen spectra extracted from Lonar sediment cores, the results of this study are of general importance for the understanding of Quaternary pollen assemblages from tropical lacustrine archives, as well as for the implementation and selection of suitable approaches for quantitative pollen based environmental reconstructions in south Asia and beyond *(N. Riedel (Senckenberg Research Institute, Research Station of Quaternary Palaeontology, Germany); M. Stebich (Senckenberg Research Institute and Natural History Museum, Germany); A. Anoop (GFZ German Research Centre for Geosciences, Potsdam, Germany);* ***N. Basavaiah****; P. Menzel (Universität Hamburg, Institute of Biogeochemistry and Marine Chemistry, Hamburg, Germany); S. Prasad, D. Sachse, S. Sarkar (Institute for Earth and Environmental Science, University of Potsdam, Potsdam, Germany); M. Weisn (University of Hamburg, Institute of Biogeochemistry and Marine Chemistry, Hamburg, Germany)).*

Reconstructed late Quaternary hydrological changes from Lake Tso Moriri, NW

The results of investigations on the radiocarbon dated core sediments from the Lake Tso Moriri, NW Himalaya are presented which is aimed at reconstructing palaeohydrological changes in this climatically sensitive region. Based on the detailed geochemical, mineralogical and sedimentological analysis, several short-term fluctuations are recognized superimposed upon seven major palaeohydrological stages identified in this lake since ~26 cal ka. Stage I (>20.2 cal ka): shallow lake characterised by input of coarse-grained detrital sediments; Stage II (20.2–16.4 cal ka): lake deepening and intensification of this trend ca. 18 cal ka; Stage III (16.4–11.2 cal ka): rising lake levels with a short term wet phase (13.1–11.7 cal ka); Stage IV (11.2–8.5 cal ka): early Holocene hydrological maxima and highest lake levels inferred to have resulted from early Holocene Indian monsoon intensification, as records from central Asia indicate weaker westerlies during this interval; Stage V (8.5–5.5 cal ka): mid-Holocene climate deterioration; Stage VI (5.5–2.7 cal ka): progressive lowering of lake level; Stage VII (2.7–0 cal ka): onset of modern conditions. The reconstructed hydrological

variability in Lake Tso Moriri is governed by temperature changes (meltwater inflow) and monsoon precipitation (increased runoff). A regional comparison shows considerable differences with other palaeorecords from peninsular India during late Holocene *(P.K. Mishra (Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Potsdam, Germany); A. Anoop (Department of Earth Sciences, Indian Institute of Science Education and Research, Kolkata); G. Schettler (Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Potsdam, Germany);S. Prasad (Institute for Earth- and Environmental Science, University of Potsdam, Potsdam, Germany); A. Jehangir (Limnology and Fisheries Laboratory, Centre of Research for Development, University of Kashmir); P. Menzel (Universität Hamburg, Institute of Biogeochemistry and Marine Chemistry, Hamburg, Germany); R. Naumann (Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Potsdam, Germany); A.R. Yousuf (Limnology and Fisheries Laboratory, Centre of Research for Development, University of Kashmir);* ***N. Basavaiah, K. Deenadayalan****; M.G.Wiesner, B.Gay (Universität Hamburg, Institute of Biogeochemistry and Marine Chemistry, Hamburg, Germany)).*

ELECTRICAL RESISTIVITY STUDIES

Geoelectrical investigation for potential groundwater zones in parts of Ratnagiri and Kolhapur districts, Maharashtra

Study of significant variations in nature and extent of weathering due to the presence of fractures and lineaments at depth and the geomorphological features at the surface is vital for groundwater exploration in a hard rock terrain. An attempt is made here to understand the vertical distribution of water bearing zones in the shallow formations over Devrukh-Ganapati Pule and Malkapur-Ratnagiri sections through geoelectrical studies. Two-dimensional geoelectrical cross-sections along five profiles reveal potential aquifer zones at a few sounding locations viz. 1, 2, 4, 5, 6, 7, 17, 18, 20, 21 and 22 with resistivities varying from 22-36 Ω-m over Devrukh- Ganapati Pule profile. Potential aquifer zones are also revealed at sounding points 24, 25, 34,37, 39, 40, 41 and 42 in the eastern part of the Malkapur-Ratnagiri profile in the resistivity range of 22-37Ω-m. Several lineaments cris-crossing this region play a significant role in the occurrence and movement of groundwater as revealed by low resistivities near VES 6, 5, 4, 16 and 17 over Devrukh-Ganapati Pule profile and VES 24, 25, 34 and 37 over Malkapur-Ratnagiri profile ***(Gautam Gupta, Vinit C. Erram;*** *Saumen Maiti (Dept. of Applied Geophysics, ISM Dhanbad****)).***

Electrical resistivity imaging for aquifer mapping over Chikotra basin, Kolhapur district, Maharashtra

Electrical resistivity study assumes a special significance for mapping aquifers in hard rock areas. A two-dimensional (2D) resistivity survey of Chikotra basin, southern part of Kolhapur district in the Deccan Volcanic Province of Maharashtra was conducted ***(Fig. 17)***. The aim of this work was to determine the aquifer zones of the study area using electrical resistivity imaging technique. The hydrogeological section derived from the available dug well/borehole lithology suggests that the top layer comprises red bole, laterite or black soil followed by weathered/fractured rock grading into compact basalts. The sources of groundwater appear to be available in weathered and fractured basalt trapped between weathered over-burden and hard rock. Results from the 2D inverted models of resistivity variation with depth suggest the occurrence of aquifers mostly in weathered/fractured zones within the traps or beneath it ***(Fig. 18)***. The resistivity models suggest that the northern part of the study area represents a promising aquifer zone with reasonable thickness of weathered basement. The models further indicate that there are several locations throughout the basin for possible groundwater exploration as it exhibited strong water-bearing potential in the subsurface rocks ***(Gautam Gupta;*** *J.D. Patil (D.Y. Patil College of Engineering and Technology, Kolhapur); Saumen Maiti (Dept. of Applied Geophysics, ISM Dhanbad);* ***Vinit C.***

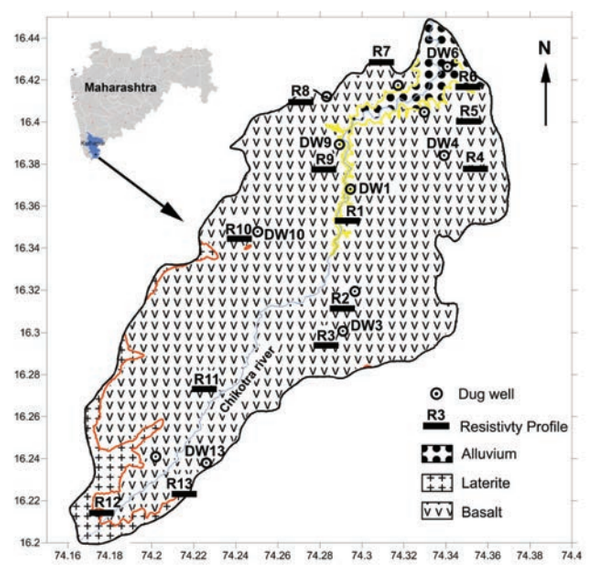


Figure 17 Geological map of the study area showing the location of electrical resistivity imaging profiles as well as the dug wells.

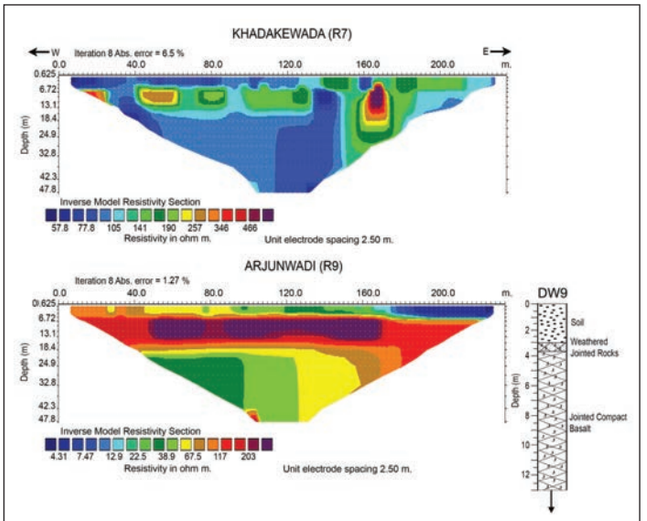


Figure 18 Inverted resistivity models of profile Khadakewada (R7) and Arjunwadi (R9). Also shown is the dug well lithology (DW9).

Erram; *N.J. Pawar (Shivaji University, Kolhapur);* ***S.H. Mahajan****; R.A. Suryawanshi (Yashwantrao Chavan College of Science, Karad)).*

PETROLOGIC AND PALAEOMAGNETIC RESEARCH

PALAEOMAGNETIC STUDIES

Monitoring of spatial variations of particulate matter (PM) pollution through bio-magnetic aspects of roadside plant leaves in an Indo-Burma hot spot region

Particulate matter (PM) is an important air pollutant because of its adverse impacts on human health. Existing and conventional methods of PMs monitoring were found to be inadequate in terms of feasibility, which paved the way of magnetic bio-monitoring approach. Magnetic measurement carried through the plant leaves is a useful means in assessing the PM pollution. Plant species are found to be an effective biomonitors and may act as natural filters by trapping and retaining the PM on their leaf surfaces. Therefore, the aim of this communication is to demonstrate the magnetic properties [Magnetic susceptibility (χ), Anhysteretic remanent magnetization (ARM) and Saturation isothermal remanent magnetization (SIRM)] of two roadside plant leaves (*Hibiscus rosa-sinesis* and *Mangifera indica*) at four spatially distant sites. The study measures and compares the capabilities of these plants to accumulate and retain the PMs. The study also assesses the PM pollution at selected sites and establishes the relationship between magnetic properties and PM in the city of an Indo-Burma hot spot region. The results indicated a significant correlation between the concentration of ambient PM and magnetic measurement (χ, ARM and SIRM) of both the roadside plant leaves. Similarly, reasonably good correlations are obtained between magnetic parameters (χ, ARM and SIRM) and Fe content in PMs. Present study is, perhaps, a novel contribution in the area of bio-magnetic monitoring studied with several magnetic parameters viz., χ, ARM and SIRM. Results indicated that the bio-magnetic monitoring is applied for environmental geomagnetism which act as proxy for ambient PM pollution and further employed as an eco-sustainable tool for environmental management in urban and peri-urban regions *(Prabhat Kumar Rai, Biku Moni Chutia (Department of Environmental Science, Mizoram University, Mizoram);* ***S.K. Patil****).*

OBSERVATORY SYSTEM AND DATA ANALYSIS

OBSERVATORY DATA PROCESSING

All the magnetic observatories operated by the Institute namely, Tirunelveli, Pondicherry, Visakhapatnam, Alibag, Rajkot, Nagpur, Jaipur, Allahabad, Silchar, Shillong, Port Blair and Gulmarg covering latitudes ranging from equator to Sq focus are equipped with two Digital Fluxgate Magnetometer (DFM) systems recording one minute/ second variation data. One DFM system is used as a standard and the other as a back-up support, additionally having an OverHauser system recording one minute total field values attached to it.

In a change from traditional setups, year 2014 witnessed closing up of analog recordings using IZMIRAN system at most observatories barring Tirunelveli and Alibag.

One minute digital data from the DFM system are received at H.Q via e-mail in near real time and can be viewed as Quick-look plots of multi-station data of HDZ components.

Absolute measurements recorded at all the stations are carried out by using high precision Declination Inclination Magnetometer (DIM) and Proton Precision Magnetometer (PPM) in addition to classical instruments. These absolute measurements in conjunction with variation data (Minute/

Hourly) are used to compute H, D and Z baselines. Computation of one minute and hourly Definitive data are done at H.Q., Navi Mumbai. Dedicated visual software and digital outputs of inter-comparison of HDZ components of different stations are used as check points in maintaining the data quality.

Confirmation of AZIMUTH

Using GNSS method, confirmation of Azimuth is initiated at all observatories which was earlier determined by astronomical or sun observations. Magnetic gradient survey in the observatory campus is also undertaken.

Following papers are published by scientists, based on the geomagnetic data from IIG:

Seven Papers are published with author/Co-authorship of IIG scientists.

(JGR 119, 1250-1261, Feb 2014; JGR 119, 4044-4061, May 2014; JGR 119, 5764-5776, Jul 2014; EPS 66:94, Aug 2014; EPS 66:92, 18 Aug 2014; EPS 66-146, Oct 2014; JGR 119, 8685-8697, Oct 2014;)

Fourteen papers are published by scientists of other Organization/Universities based on the geomagnetic data from IIG

(JGR 119, 2229-2242, Mar 2014; JGR 119, 4544-4555 Jun2014; JGR 119, 5049-5059, Jun 2014;; JASTP 114, 19-29, Jul 2014; JASTP 114, 58-65, Jul 2014; Adv.Space Res 54, 425-434, Aug 2014; Adv.Space Res 54, 456-462, Aug 2014; JASTP 117, pp 71-80, Sep 2014; JGR 119, 7243-7263, Sep 2014; IJRSP 43, 274-283, Aug-Oct 2014;; Adv. Space Res , In Press, Nov 2014; Adv.Space Res 54, 1751-1767, Nov 2014; JASTP 119, pp 138-146, Nov 2014; JASTP 121 Part B, pp 206-220, Dec 2014)

PUBLICATION OF MAGNETIC DATA

'INDIAN MAGNETIC DATA' for 2012 are published on a DVD from Ten magnetic observatories. These annually published DVD's are dispatched to several universities and institutions in India and abroad. Hourly values deduced from one minute magnetic field variations of the three components of the earth's magnetic field at Institute's observatories have been deposited to World Data Centre, Mumbai.

The magnetic storm sudden commencement amplitudes and ranges computed every month for magnetic observatories managed by IIG are deposited to World Data Centre, Colorado for inclusion in *Geophysical Data Bulletin.*

INTERMAGNET (*Int*ernational *R*eal-time *Mag*netic Observatory *Net*work)

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) are processed on daily basis and these one minute observations of the Earth's magnetic field are emailed to Kyoto GIN. Final one minute absolute values for the year 2013 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: **58503 days**

SERVICE TO INDIAN NAVY AND OTHER ORGANISATIONS

- Prime magnetic observatory at Alibag serves as a calibration centre for magnetic instruments from organizations like SOI and NGRI. Calibration of Magnetic compasses received from Indian Navy, Indian Coast Guard, Naval Air Stations, Indian Naval Ships and Pawan Hans Helicopter Ltd. are also undertaken. The Calibration work for a total of 37 magnetic compasses (Landing , Datum, Theodolite etc.) was carried out at Alibag Magnetic Observatory (Calibration charges per compass is ₹3000/-).
- Calibration Certificates are prepared and issued to the respective naval departments to incorporate the correction factors as a measure to maintain higher degree precision in compass readings.
- High resolution Digital magnetic data, hourly values and Magnetogram copies were supplied on requests to scientists and research students from Universities and research institutes in India and abroad for their investigational work.
- Absolute Hourly values of Alibag 'H' component are sent on a monthly basis to WDC, Kyoto (Japan) for the compution of Dst Index.
- Using magnetic data of the 'H' component of Tirunelveli and low latitude station Alibag, equatorial electrojet strength is computed both in hourly and one minute resolution and are provided to scientists for use in their investigational work.

- One minute definitive data of Alibag are supplied to national and international agencies which is used to supplement their geodetic, gravity and marine magnetic survey work.
- On request from Cochin University regarding fixing of geomagnetic coordinates for marking the magnetic North-South direction and providing the geomagnetic co-ordinates for the installation of ST RADAR, observations using DIM instrument were made and the geomagnetic coordinates were supplied to them.

WORLD DATA CENTRE FOR GEOMAGNETISM (WDC, Mumbai)

WDC for geomagnetism, Mumbai has become regular member ICSU WDS after following various norms of this international scientific community. WDC Mumbai Members attended the International Conference on Data Sharing and Integration for Global Sustainability (SciData Conference), November, 02-06, 2014, INSA, New Delhi and presented the oral and poster paper.

The total no. of registered users with the WDC website (http://wdciig.res.in) are now 650. This year around 70 new users registered. From all over the globe, around 800 data files accessed/downloaded from the WDC website by the end scientific users. As a part of standardization of IT facilities at the center, installed new Rittal make precision cooling racks for WDC server rooms.

In continuation of long term preservation project, the conservation work of old Colaba observatory magnetograms is completed for the period of 1871- 1904 and Digital Imaging of various observatories Magnetograms for the period of 60 years is also completed.

The regular updation of WDC website with latest release of datasets. Center also fulfilled various time to time data request received through online data service portal and by email as per new IIG data policy.

ICSU WDS System Delegates visited the WDC for geomagnetism, Mumbai Center

INSTRUMENTATION DIVISION

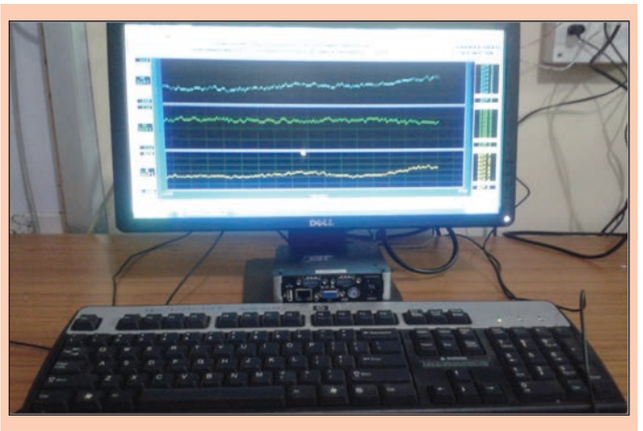
USRP PRE-AMPLIFIER

A RF coax cable (RG-213, 100 meter in length) wide band pre-amplifier electronic circuit design has been developed to be used as input signal booster to newly procured USRP model-2920. The test results are as follows: Frequency: 250 MHz, Bandwidth: +/- 10 MHz, Gain: 5 dB and Sensitivity: 800 Nano-Volt (A.M.).

nT Logger has been developed by the Indian Institute of Geomagnetism (IIG), New Panvel, Navi Mumbai. These loggers are being used at IIG magnetic observatories to log the geomagnetic data from one or more magnetometers like three component fluxgate magnetometers and Proton precession magnetometers. It is an automatic system which runs with a minimum operator intervention. It is designed to continuously monitor and record variations in horizontal intensity (H), magnetic declination (D), vertical intensity (Z) from a fluxgate magnetometer and from an absolute total field (F) from a proton precession magnetometer. The accurate atomic clock time is derived from a GPS synchronized clock.

Firmware for nTLOGGER is developed using Labview 8.5. This is a data logger program for magnetic data measurement synchronized with GPS time. We implemented a menu driven program under Windows Operating System. There are many menus to monitor the status of the particular operation. This is made to facilitate interface ADAM 4017 8 channel 16 bit ADC. DFM output (HDZ, Sensor Temp. Electronics Temp.) are fed to the input of 4017. The Program sends the command to ADAM 4017 through serial port. This help in digitizing and reading the data for the above mentioned channel on every second and plots the corresponding data online. The program also has the facility to connect the PPM through serial port so as to read, plot and store the data. Gauss filter is applied to the second's data to obtain the minute data. The program saves both seconds and minutes data in separate file daily. Thus the compatibility is maintained with existing system. Configuration setting file is used to set the parameter like Station name, file extension name for minute data file, data storage path, GPS sync interval, serial port settings for

ADAM 4017, GPS and PPM, gauss co-efficiency etc.. The config.ini file can be edited in any notepad/WordPad so that the software can be configured for different station as per the user requirements. Remote data transfer is being implemented by using winscp tool with the associated script so that the data can be transferred to the IIG server at desired interval automatically.



nTLogger is Dual-Core Intel® Atom™ processor is based on industrial computer with 1 GB or more RAM and with 500GB or higher hard disk storage capacity. It runs from 12 VDC (+/- 10%) low power consumption: 5-15 Watts (typically 6...7 Watts at normal load). It is fan less Embedded computer, noiseless and small size: 133.8 x 43.1 x 94.2 mm (5.27" x 1.70" x 3.71"), weight: 1.2 kg with cast aluminum housing. It has 4x USB, 1x RS232 (COM1), 2x RS232/RS485/RS422 port (COM3&COM4, port type selected in BIOS setup), 1x RS-485 and 1x RS-232, VGA, 10/100/1000 Mbps Ethernet, SMA or MCX type GPS antenna connector. It has hardware watchdog and auto start on power and Built-in GPS for GPS time synchronization and for real-time time stamping of data records coming on RS232 and RS485 peripheral ports. GPS antenna is included, default cable length is 5 meter, but shorter or longer cables. Once GPS time is acquired, the GPS module can keep the clock accurate for several hours even after satellite signal reception stopped.

NEW SCIENCE RESEARCH PROGRAMS

GEOPHYSICAL STUDIES IN POLAR REGIONS

There are several unresolved issues with regard to the instantaneous flow pattern of magnetospheric potential and how the ground level electric field respond to transients of magnetospheric origin. Past atmospheric electricity observations, correlated with geomagnetic variations and solar events have suggested that extraterrestrial sources modulate the GEC in the polar region. IIG has been pursuing GEC studies from Antarctica since 19th Indian Antarctic Expedition.

The Antarctica continent embedded in Antarctica plate came to its existence when Pangea broke up about 175 million years ago. The Antarctic plate is the fifth biggest tectonic plate (~ 17 x 10^6 sq km) having a boundary with the Nazca Plate, the South American Plate, the African Plate, the Indo-Australian Plate, the Scotia Plate and a divergent boundary with the Pacific Plate forming the Pacific-Antarctic Ridge. All these plates are grouped around Antarctica as a central core. The Institute is involved in monitoring crustal deformation in Antarctica, which is key in understanding the present ongoing tectonic, past- and present-day ice sheet history and environment of the continent. Crustal deformation within Antarctica and kinematics of the Antarctica plate has important regional and global implications respectively.

Methods to accurately determine mass balance are of great interest for studying the history of glacial advance and retreat and also for predicting future glacier behavior. The recent advent of Global Positioning Systems (GPS) and Interferometric Synthetic Aperture Radar (InSAR) have created an effective means by which the acquired data from Arctic regions are analyzed for the effective monitoring and mapping of temporal dynamics of glaciers.

Substorm occurrence lead to ionopsheric particle precipitation at the auroral latitudes causing enhanced absorption of cosmic noise signal that can be monitored by riometer. The role of interplanetary conditions over the substorm processes and related particle precipitation is well established. However, there is no complete understanding of drift of energetic charged particles during substorms. Though ionospheric drifts at different altitudes have been explored recently, magnetospheric drift is more complicated and demands detailed examination. With the conjunction study of satellites data and advanced ground instruments such as Imaging Riometer and magnetometer, it could be possible to address this aspect.

THEORETICAL AND NUMERICAL SIMULATION STUDIES OF SPACE PLASMA PROCESSES

Development and application of new fluid and kinetic simulation codes to study micro- and macro-scale wave phenomenon in plasma

One-dimensional fluid code has been developed on Intel FORTRAN platform. In this code, OpenMP (Open Multi Processing) technique is used to reduce computational time of simulation job. Fourth order central finite difference scheme is used to solve spatial derivatives of the quantities and a Leapfrog method is used for time integration of fluid equations. The fluid code is general and can handle multispecies plasma. The localized perturbation in the plasma densities are required to initialized the code. The code is used to study and understand the evolution of initial density perturbation into different structures such as IA solitons, IA oscillations, and Langmuir waves. Based on the Kyoto University Electro Magnetic Particle Code (KEMPO), one-dimensional electromagnetic Particle In-Cell (PIC) code is developed. In this code, Maxwell equations and equations of motion are solved by using finite difference time domain technique for large number of super particles. The initial velocity distributions of electrons and ions are assumed to be drifted- Maxwellian distributions. The code is developed on the Intel FORTRAN platform and it uses Message Passing Interface (MPI) technique to reduce computational time.

Study of solar wind-magnetosphere-ionosphere system

The solar wind, magnetosphere and ionosphere form a single system driven by the transfer of energy and momentum from the solar wind to the magnetosphere and ionosphere. The plasma dynamics in this coupled system is quite complex in nature and depend on many parameters. It is necessary to understand how small-scale processes control large-scale phenomena, for example, magnetosphere - solar wind coupling, plasma entry through the magnetopause and cusp, magneto-tail dynamics, magnetosphere-ionosphere coupling, field-aligned currents and substorm dynamics, etc. To understand these physical processes, broad range of analytical and computer simulation methods are used. A project has been undertaken to study the microscopic plasma processes in the magnetosphere and ionosphere using electrostatic particle simulation. The simulation code is being used to study the mulit-species plasma dynamics and the evolution of nonlinear electric field structures in the auroral acceleration region. The study is also being undertaken to understand the dynamics of low frequency waves in the solar wind and Earth's magneto sheath using linear theory and numerical simulations.

Theoretical investigations of solar wind-magnetosphere ionosphere interactions have been conducted using several analytical and computational methods. Generation of ion- and electron-acoustic solitons is being carried out in different regions of the Earth's magnetosphere. Low-frequency waves are being studied using the loss-cone and other non-thermal distribution of energetic ions in the Earth's magnetosphere.

Theoretical Modeling of low latitude current system

An atmospheric tidal model based on classical tidal theory has been developed. The tidal structure due to conventional ozone and water vapor heating in conjunction with the O_2 absorption could be obtained without considering mean wind and dissipation mechanisms. The present tidal model reveals that the diurnal amplitude peaks in mid to low latitudes, whereas semidiurnal component is stronger at higher latitudes. The semidiurnal tide is about an order of magnitude weaker than the diurnal tide. Also, semidiurnal wave has longer vertical wavelength than diurnal tide. The results of present model are qualitatively in good agreement with the other tidal models, which utilize more sophisticated parameterization. Thus, the salient features of the tidal structure are obtained using basic computations without considering the effects of background winds and dissipation processes.

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

Ionospheric plasma irregularities are generated in the nighttime F region owing to the unique geometry over dip equator. These irregularities map to low latitudes as they rise to higher altitudes. These irregularities pose severe threat to Indian SBAS system known as GAGAN. So, there is a need to examine the role of equatorial and low latitude ionospheric electrodynamics that produces the day-to-day, longitudinal and seasonal variability in the occurrence of ionospheric irregularities and scintillations on the radio signal. The operational forecasting of key ionospheric parameters such as ionospheric TEC, GPS range errors, probability of EPB/scintillation occurrence and their location, intensity, duration and dynamics were not yet realized due to complex spatio- temporal variability of equatorial and

low-latitude region and its coupled response to various forces from lower atmosphere and space weather events

The present project proposes to undertake an investigation into the evolution of ionospheric irregularities at different scale sizes and their day-to-day, seasonal and longitudinal variabilities under different ambient conditions. It is also proposed to use network of ionosondes and GPS receivers along with geomagnetic and EEJ strength data. The present project also proposes to use observations like COSMIC density profiles. It is intended to examine the ionospheric models such as IRI and SAMI2 models to understand the different ionospheric processes that produce ionospheric irregularities. The equatorial and low-latitude ionosphere is a complex system where a number of neutral and electro-dynamical couplings take place leading to the large scale phenomena such as EEJ/ CEJ, EIA and ESF irregularities. These processes are studied at wide locations across globe as they produce navigational effects. While general morphological features such as diurnal, seasonal and solar cycle variations were fairly understood, however, their day-to-day and longitudinal variability and their response to forces from lower atmosphere and space weather events still needs to be investigated. Several scientific groups across the globe are working on this enigmatic problem. Several countries including USA had flown several satellites to understand this issue. Recent C/NOFS satellite launched by NASA was one of the best examples to show its importance internationally.

Objectives:

- Investigation of growth rate of the plasma irregularities using the field line integrated geometry of RT instability for different background ambient conditions and its comparison with ionospheric scintillations.
- Retrieve the nighttime thermospheric meridional neutral winds using ionosondes (one located at equator and other located at low latitude) and examine the wind effect on the scintillations.
- Investigation of day-to-day variability of ionospheric scintillations and TEC depletions.
- Investigation of source mechanisms for the occurrence and the variability of descending tidal ion layers over Allahabad with reference to atmospheric tides
- In this project, contributions shall be made to quantify the variability of the irregularities that are caused due to lower atmospheric forcing using both observations and modeling.
- Sudden Stratospheric Warming (SSW) events in the polar stratosphere and their coupling to the equatorial MLT and ionosphere that leading to the variability in the ionosphere needs further understanding as their propagation mechanisms to equator are not clear. In this project, attempts shall be made to understand the variability of the equatorial and low latitude ionosphere caused due to SSW related electrodynamics.
- Investigate the response of equatorial and low latitude ionosphere to geomagnetic storms.

ULF/ELF/VLF STUDIES

Under the project VLF receivers and Transient Luminous Events (TLE) monitoring experiment are maintained for continuous operation to collect quality data. The scientific objective of the study is the studies of far and near Earth environment with electromagnetic signals in very low frequency (VLF) range in conjunction with various upper atmosphere experiment run at KSKGRL and IIG. The main science questions addressed are: Modeling and Theoretical approach to understand the propagation mechanism of VLF waves in low latitude ionosphere and Low latitude VLF phenomena and its relationship with Geomagnetic Activity and Ionospheric irregularities. Lower ionosphere studies include D-region ionosphere perturbation studies due to events like solar flares, cosmic gamma ray flares, terrestrial gamma ray flashes, lightning discharges and thunderstorms. Investigation of extreme cases of events related to climate change and characterization of Transient Luminous Events (TLE's) and studies its effect on near-earth space environment. The Transient Luminous Events (TLE) generated by terrestrial lightning discharge has been discovered two decades ago and has become one of the most investigated areas of among sub-ionospheric phenomena. The project aims to answer these science questions and address to above mentioned scientific questions.

CAWSES INDIA PHASE II PROGRAMME

Variabilities of the ionosphere due to forcing from top and bottom

It is known that ionosphere responds differently to solar originated forces as well as wave forcing originated from the lower atmosphere. Under CAWSES India project, variabilities of the ionosphere due to forcing from top and bottom are being studied. It is known that solar originated forces such as geomagnetic storms and solar flares do affect the equatorial and low latitude ionosphere. In addition,

present results also suggest that equatorial ionosphere do respond to forcing from lower atmospheric waves. Present study indicates that both forcing are to be taken into account in order to understand the equatorial ionosphere. It is suggested that the quiet-time variabilities seen in the GPS TEC over EIA could be caused due to the non-linear interaction of upward propagating planetary waves (PWs) with atmospheric tides. Presence of similar periods in the EEJ strength and TEC observations near the EIA crest region, supports the view that the large-scale wave like structures seen in TEC near the EIA crest are associated with atmospheric planetary scale waves. Attempts are being made to study these two using case studies over Indian region.

Role of wave-particle interactions in storm time ring current dynamics

During the main phase of the storms, the fractional concentration of the oxygen ions increases significantly and can influence the generation of low-frequency instabilities in the ring current. Oxygen and protons can be highly anisotropic. The objective of the project is to study the low frequency waves excited by the anisotropic and kappa-type distributions of energetic oxygen ions and protons in the ring current region through wave-particle interaction and also estimate the decay time of the ring current during magnetic storms.

INTEGRATED APPROACH TO SOLID EARTH STUDIES- DATA & MODELLING

CRUSTAL AND DEEP CONTINENTAL RESEARCH

GEOPOTENTIAL STUDIES

The geodynamic evolution of the DVP will be deciphered by using the 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.

ELECTROMAGNETIC INDUCTION STUDIES

Deep electrical conductivity distribution will be used in deciphering the plume–lithosphere interactions beneath DVP using MT surveys, since seismic reflection won't work. Around 3 MT/LMT profiles will be proposed over Deccan basalt covered areas of Saurashtra across the Cambay basin nearby triple junction of the Cambay, Narmada-Tapti rifts and west coast fault. Some of the issues that will be addressed are: (a) Magmatic processes originating in the deep mantle and their impact on the lithosphere levels. (b) Delineation of underplating material beneath the Saurashtra region and its extension towards Cambay basin.

GLOBAL POSITIONING SYSTEM AND GEODESY STUDIES

Crustal deformation will be monitored by using various space borne geodetic techniques viz. GPS, GRACE, InSAR. Extensive GPS studies will be undertaken to include new sites within DVP, e.g. Koyna-Warna belt.

ENVIRONMENTAL AND HYDROGEOPHYSICAL RESEARCH

ENVIRONMENTAL MAGNETISM STUDIES

Laboratory-based rock magnetic measurements are proposed 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 is on the study areas of Deccan Traps, viz., Lonar impact crater and lake sediments. Also archaeomagnetic and paleomagnetic dating of Deccan dyke system and archaeological artifacts will be undertaken

ELECTRICAL RESISTIVITY STUDIES

The problem of water scarcity is more acute in Maharashtra, dictating the need for searching additional sources of water supply 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. Thus, it is proposed at evaluating the geoelectrical signatures, and geothermal manifestations in the Dhule, Nandurbar and Satara districts, and Konkan coastal region 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.

PETROLOGIC AND PALAEOMAGNETIC RESEARCH

PALAEOMAGNETIC, PETROLOGICAL AND GEOCHRONOLOGICAL STUDIES

Limited paleomagnetic 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 be carried out on newer dolerite dykes, so that the Precambrian Apparent Polar Wander Path (APWP) for the Indian sub-continent can be defined.

Earlier, palaeomagnetic and rock magnetic investigations have been carried out on 60 oriented block samples belonging to 9 dolerite dikes situated at Haludpukar and Onlajorito regions (south of Jamshedpur town), Singhbhum Craton. 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 the 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. Petrographically, most of the thin sections (90 thin sections) contain calcic plagioclase and clinopyroxene with a distinct ophitic texture. Replacement of clinopyroxenes by chlorite and actinolitic amphibole is noticed in many samples. Coarser, relatively less altered rocks reveal subsequent clinopyroxene (augite) partly enclosing plagioclase laths. The common accessory mineral in the rocks is magnetite which is associated occasionally with ilmenite. The field studies reveal that these dolerite rocks have been affected by hydrothermal alteration under lower green schist facies metamorphism.

FIELD SURVEYS

1. Electrical resistivity imaging (ERI) and vertical electrical sounding studies were carried out at Magnetic Observatory Jaipur during August, 2014 to decipher potential groundwater aquifer zones in the Observatory campus.
2. Carried out resistivity imaging studies at potential and saline water intruded locations in Malwan-Oras-Kudal-Sawantwadi-Vengurla-Redi in Konkan region of Maharashtra to understand the two-dimensional extent and effects of saline water intrusion during November 2014.
3. MT and LMT surveys were conducted in Dhrol – Bagadora area in the northern part of Saurashtra region during March-April 2014.The objective of these studies was to determine the electrical conductivity of the sub-surface.
4. Ground magnetic data were acquired over the Deccan trap covered regions of Maharashtra in the districts of Thane, Ahmednagar, Nasik etc to generate the magnetic anomaly map of the region. The survey was conducted in two phases during November-December 2014 and February-March 2015.
5. Ground magnetic data was also acquired over dykes of Nandurbar and Dhule region in order to assess the role of dykes and lineaments for the occurrence and movement of groundwater during April 2014 and January 2015.
6. To understand the contemporary kinematics and related active deformation across the main Himalayan thrust zones due to India-Eurasia collision, the GPS geodesy group initiated and carried out 2nd GPS campaign in Himachal and Garhwal Himalayan region from 10-04-2014 to 20-05-2014.
7. To give an insight into the motion and related mass balance and future behavior of the Vestre Broggerbreen Glacier, Svalbard, Arctic, the second GPS campaign has been carried out during the expedition from 08-09-2014 to 13-10-2014.
8. Site visit and interaction with archaeologists of Archaeological Survey of India, Mumbai Circle, Sion regarding archaeomagnetic studies and to gather information about recent archaeological excavations from Mumbai during 8-9 May, 2014.
9. Collected archaeological samples from historical sites at Nalasopara, Kanheri Caves and around Mumbai during 10-15 June, 2014.
10. To collect oriented block samples from Singhbhum Craton dolerite dykes, two field surveys were conducted during June 25-July 10, 2014 and February 24-March 5, 2015 in Tatanagar, Jharkhand.

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Modern pollen vegetation relationships in a dry deciduous monsoon forest: A case study fromLonar Crater Lake, central India, *Quaternary International*, 2015.

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

Ion-acoustic supersolitons in presence of non-thermal electrons, *Commun. Nonlinear Sci. Numer. Simulat*., 2014.

Singh, S.V.

Nonlinear ion--acoustic waves in an inhomogeneous plasma with non-thermal distribution of electrons, *J. Plasma Phys.*, 2015.

Watitemsu Imchen, **S.K. Patil**, V. Rino, Glenn T. Thong, T. Pongen and B.V. Rao

Geochemistry, Petrography and rock magnetism of basalts of Phek district, Nagland, *Curr. Sci.*, 2015.

IMPACT FACTOR OF PUBLICATIONS DURING 2014-2015

Journal Name	Impact Factor
Advances Space Research	1.238
Ann. Geophys.	1.676
Astrophys. J.	6.28
Astrophys. Space Sci.	2.401
Bull. Seismol. Soc. America	1.964
Commun. Nonlinear Sci. Numer. Simulat.	2.569
Curr. Sci.	0.833
Earth Moon Planets	0.438
Earth Planet Space	3.056
Environmental Earth Science	1.572
Geochimica et Cosmochimica Acta	4.25
Geophys. Res. Lett.	4.456
Indian Natn. Sci. Acad.	N/A
IEEE Transactions on Magnetics	1.213
International J. Geophys.	N/A
International J.Scientific Res. Development	2.39

Journal Name	Impact Factor
International J. Innovative Res. Sci., Engg. Tech.	5.442
J. Atmos. Solar-Terr. Phys.	1.751
J. Cosmology Astroparticle Physics	5.877
J. Earth System Sci.	0.794
J. Geophys. Res.	3.44
J. Geol. Soc. India	0.513
J. Magnetism and Magnetic Materials	2.002
J. Plasma Physics	0.739
Nonlin. Processes Geophys.	1.692
Phys. Plasmas	2.04
Progress Earth Planet. Sci.	N/A
Pure and Applied Geophysics	1.854
Quaternary International	2.128
Quaternary Science Reviews	4.571
Urban Forestry & Urban Greening	2.133

INVITED TALKS AND LECTURES

Erram, V.C.

Invited Guest lectures for B.Sc. (Final) and M.Sc. students on *Exploration geophysics- Scope and applications*, Department of Geology, Gopal Krishna Gokhale College, Kolhapur during July 25-26, 2014.

Invited lecture for B.Sc. students on *Geomagnetism*, Department of Geology, Yashwantrao Chavan College of Science, Karad during July 27, 2014.

Geochronology, Age of the Earth, magnetic method of prospecting and thermal history of the Earth, (Guest lectures on these topics) delivered to the 1st year M.Sc. (Applied Geology& Geography) students at School of Environmental & Earth Sciences, North Maharashtra University, Jalgaon, October 8-10, 2014.

Gupta, G.

Invited to School of Environmental & Earth Sciences, North Maharashtra University, Jalgaon as a Visiting Faculty to impart lectures on the topics, *Physics & Chemistry of the Earth, Seismology and earth processes, and Geophysical techniques* to the 1st year M.Sc. (Applied Geology and Geography) students during October 8-10, 2014.

Gopi K. Seemala

Invited lecture at DACGSM, Kyoto University, Japan on "*Equatorial and low latitude ionosphere characteristics over the Indian region*" on July 23, 2014

Ankush Bhaskar

Talk on *Science of Space Weather* at Department of Physics, Bandodkar College, Thane on July 19, 2014.

Talk on *Journey through Cosmos* at Utkarsh Mandir School, Malad, January 2015.

Satyavir Singh

Invited talk on *Motivation & Inspiration for higher studies in research,* at Sri Vijay Vidyalaya College of arts and science, Nallampalli, Dharmparuri, on February 25, 2015.

Reddy, C.D.

Delivered a keynote address at national seminar 'GPS Technology in Earth Science and Rural Development' held at National Institute of Rural Development (NIRD) on March 26, 2015.

Rajesh Singh

Delivered one lecture as 'Resource Person' under the auspices of UGC Academic Staff College in "Refresher Course on Climate Change" at K. Banerjee Center of Atmospheric and Ocean Sciences, Allahabad University on January 21, 2015.

Delivered two lectures as 'Resource Person' under the auspices of UGC Academic Staff College in "Refresher Course in Physics" at University of Lucknow on February 10, 2015.

PARTICIPATIONS IN CONFERENCES/MEETINGS/SEMINARS

NATIONAL

ISRO-CNES meet on "Geodynamics of Himalaya" June 12-13, 2014, Dehradun

Ravi Kumar, M. and **Susheel Kumar**

Long wavelength gravity anomalies over Himalaya-Tibet and adjoining region based on space borne gravimetric technique.

STARP meeting, November 3-5, 2014, ISRO, Bangalore

Singh, S. and **B. Kakad**

Comprehensive Study of Earth's Magnetosphere during Extreme Space Weather Events.

51st IGU Annual Convention and Meeting on "Earth Sciences and Society" 2014, November 19-21, 2014, Kurukshetra University, Kurukshetra

Banola, S., R.N. Maurya and **S. Sripathi**

Characteristics of ionospheric scintillation and its relation to post sunset height rise using CADI Ionosonde at Tirunelveli.

Bhardwaj, S.K., P. B. V. Subba Rao and **B. Veenadhari**

Role of main field vertical component in the deformation of Sq current system.

29th National Symposium on Plasma Science & Technology (PLASMA-2014), December 8-11, 2014, Mahatma Gandhi University, Kottayam, Kerala

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

Influence of superthermal electrons on obliquely propagating Ion-Acoustic solitary waves in space plasmas.

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

Ion cyclotron and ion acoustic waves in magnetised plasma with kappa distribution of electrons.

Sreeba Sreekumar, S.Sripathi, and **K. Emperumal**

Effect of Post Sunset Vertical Drift & Thermospheric meridional Winds on the Occurrence of ESF.

Prabhakar Tiwari, Ajeet K. Maurya, Rajesh Singh, S. Sripathi and **B. Veenadhari**

The impact of 22 July 2009 Total Solar Eclipse on Sporadic E-layer near the equatorial ionization anomaly (EIA) crest region, Allahabad.

Vijay Kumar, K., Prabhakar Tiwari, Ajeet K. Maurya, B. Veenadhari, S. Sripathi, C.D. Reddy and **Rajesh Singh**

Ionospheric TEC variations over Allahabad due to Solar Flares of Solar cycle 24.

Maurya, Ajeet K., Rajesh Singh and **B. Veenadhari**

On the characteristics of Transient Luminous Events (Sprite) producing thundercloud/storm over Indian region: a case study.

Sneha A. Gokani, Rajesh Singh and **B. Veenadhari**

Features of Very Low Latitude (L=1.08) Whistlers.

Venkatesham, K., Rajesh Singh, Ajeet K. Maurya and **B. Veenadhari**

Modeling of 22 July 2009 total solar eclipse effects on the D-region ionosphere using narrowband VLF signal recorded at Indian low latitude stations.

National Conference on Recent advances in astrophysics and space science December 19-20, 2014, G.I. Bagewadi Arts, Science, Commerce & PG College, Nipani

Naniwadekar, G.P., **R.N. Ghodpage, P.T. Patil** and **S. Gurubaran**.

Atmospheric tides and its effects on the mesospheric winds.

Patil, R.P., S.B. Patil, **R.N. Ghodpage** and **P.T. Patil**

Spatial calibration of Night Airglow All-Sky Images.

National Workshop on "Continental crust and cover sequences in the evoluation of Indian subcontinent", January 20-21, 2015, Thiruvananthapuram

Ravi Kumar, M., V.M.Tiwari and D.C.Mishra

Long wavelength gravity anomalies over Indian subcontinent: Implications on Deep Lithospheric structures.

Sandeep Sathian, P. S. Sunil and S. K. Arora

Contemporary stress regime characterization in Himalaya-Tibetan collision zone by inversion of earthquake fault plane solutions.

National Conference on Emerging Trends in Engineering, Technology and Architecture, January 23-24, 2015, D.Y. Patil Engineering College, Kolhapur

Patil, R.P., S. B. Patil, **R N. Ghodpage** and **P.T. Patil**

Gravity Wave Parameter Estimation by Using Image Processing and Simple Wave Formulae in Matlab.

The 33rd Meeting of the Astronomical Society of India (ASI), February 17-20, 2015, National Centre for Radio Astrophysics (NCRA), Tata Institute of Fundamental Research (TIFR), Pune

Nade, D.P., A.K. Sharma, A. Taori, S.S. Nikte, **P.T. Patil**, G.A. Chavan, O.B. Gurav, **R.N. Ghodpage** and **S. Gurubaran**

Influence of the Milky Way Galaxy on nightglow OI 630 nm emissions.

Nikte, S.S., A.K. Sharma, D.P. Nade , G.A. Chavan, O.B. Gurav , M.P. Yadav, **P.T. Patil, R.N. Ghodpage**, M.V. Rokade and R.V. Bhonsle

Study of signal strength of cosmic radio noise using Riometer.

Chavan, G.A., A.K. Sharma, S.S. Nikte, D.P. Nade , **R.N. Ghodpage, P.T. Patil**, M.A. Yewale, and O.B. Gurav.

Effect of Magnetic Activity on Ionospheric Irregularity.

INTERNATIONAL

2nd TEA – IS Summer School, June 23–27, 2014, Collioure, France

Rajesh Singh, Ajeet K Maurya, B. Veendhari, Torsten Neubert and Olivier Chanrion

Ground based support for ASIM and TARANIS space missions over Indian region.

Ajeet K Maurya, Rajesh Singh, B. Veendhari, R. Selvakumaran, Sneha A. Gokani, Morris B. Cohen, Torsten Neubert and Olivier Chanrion

Observations of first TLE's events over Indian Sub-continent.

International Symposium on Geodesy for earthquake Natural Hazards, GENAH-2014, July 22-26, 2014, Japan

Ravi Kumar, M., and **C.D.Reddy**

Long wavelength gravity anomalies over Japan and adjoining regions: Implications on deep Lithospheric structures.

Asia Oceania Geosciences Society (AOGS) conference, July 28- August 1, 2014, Sapporo, Japan

Gopi Seemala, Selvakumaran, Geeta Vichare, and **B. Veenadhari**

Ionospheric and geomagnetic response to space weather events.

Kakad, B., G. Surve, P. Tiwari, S. Sripathi and **A. Bhattacharyya**

Extent of disturbance dynamo effects over low latitude F-region: A study by network of VHF spaced receivers.

40th COSPAR Scientific Assembly, August 2-10, 2014, Moscow, Russia

Yadav, V., B. Kakad, T. K. Pant and **A. Bhattacharyya**

Study of Blanketing Es-Layer (Esb) Using VHF Scintillation over Equatorial Region.

Devanandhan, S., Satyavir Singh, and **G.S. Lakhina**

Small amplitude electron acoustic solitons in a magnetoplasma with non-thermal electrons.

Tsurutani, B. T., **G. S. Lakhina**, and O. P. Verkhoglyadova

Energetic Electron (greater than 10keV) Microburst and about 5-15s Pulsations, Chorus and Wave-Particle Interactions.

Tsurutani, B. T., E. Echer, **G. S. Lakhina**, W. D. Gonzalez, O. Verkhoglyadova, A. J. Mannucci, and J. U. Kozyra

Solar wind structures and their effect upon the Magnetosphere and Ionosphere during the modern era.

Parihar, N., Taori, A.,**Ghodpage, R.,** and Patil, P.

"Bi-station Observations of Plasma Depletions in OI 630 nm imaging over Allahabad (25.50N, 81.90E) and Gadanki (13.50 N, 79.20E), India.

Taori Alok; **Parihar, N.,Gurubaran, S., Sripathi, S**., **Ghodpage, R.** and **Patil, P.T.**

First tri-station airglow imaging of plasma depletions with MSTID signatures from Indian sector.

Taori Alok, **Gurubaran, S., Ghodpage, R**., **Patil, P.T.**, and Siingh, D.

On the vertical wavelength estimates using the Krassovsky parameters of OH airglow monitoring.

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

Extreme Historic and Solar cycle 23 Geomagnetic Storm events and their interplanetary characteristics over Indian Sector.

AGU Chapman Conference on Low Frequency Waves in Space Plasmas, August 31- September 5, 2014, Jeju Island, Republic of South Korea

Sneha A. Gokani, Rajesh Singh, Ajeet K. Maurya, B. Veenadhari, Morris B. Cohen and J. Lichtenberger

Low Latitude whistlers: Correlation with conjugate region lightning activity and arrival azimuth determination.

Geospace Revisited Conference, September 15-20, 2014, Rhodes, Greece

Ankush Bhaskar, Geeta Vichare and **Neethal Thomas**

Storm time penetration electric field observed by SWARM and Ground based magnetometers.

XVI IAGA Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing, October 7-16, 2014, Hyderabad

Geeta Vichare, Rahul Rawat, and **Ankush Bhaskar**

Role of geomagnetic observatories in understanding the magnetospheric-ionospheric electrodynamics.

Gurubaran, S. and **S. Sathishkumar**

Upper atmospheric tides and their role in the day-to-day variabilities of equatorial electrojet.

Malini Aggarwal, Ananna Bardhan, and D. K. Sharma

Study of Co-seismic observations of ionospheric behavior.

Anil Iype, M.S., A.T. Deshmukh and **B. Veenadhari**

The necessity of applying the F drifts correction for the long term stability of baseline for ground magnetic observatories.

Anil Iype, M.S., A.S. Kulkarni, V.J. Jacob, M.G. Doiphode, P.S. Sunil, C.D.Reddy and **B. Veenadhari**

The method and the procedural details of determining the azimuth of a datum point by the use of GNSS.

Veenadhari, B., S. Mukherjee, B.D. Kadam and **A. T. Deshmukh** (Invited)

Historical geomagnetic records at Colaba, India – A fresh perspective.

Veenadhari, B., M. Doiphode, R.N. Nimje, S. Mukherjee, G.K. Seemala and **D.S. Ramesh**

Long geomagnetic data series and WDC-Geomagnetism, Mumbai.

Veenadhari, B., S. Mukherjee, B.D. Kadam and **A. S. Kulkarni**

Colaba-Alibag observatories: Long data series since 1841.

13th Quadrennial Solar Terrestrial Physics Symposium 2014, October 12-18, 2014, Xi'An, Shanxi, China

Neethal Thomas, Geeta Vichare, Ashwini K. Sinha, and **Rahul Rawat**

Study of daytime Pi2 pulsations.

International Conference on Data Sharing and Integration for Global Sustainability (SciDataCon), November 2-6, 2014, INSA, New Delhi

Veenadhari, B., S. Mukherjee and **D.S. Ramesh** (Invited)

Investigation of Historical geomagnetic records at Colaba, India and its utility for use in Space weather research.

Veenadhari, B., M.G. Doiphode, R.N. Nimje, S. Mukherjee and **D.S. Ramesh**

Long Term Geomagnetic Data Series in the Indian Longitude Chain.

The 12th International Conference on Substorms (ICS-12), November 10-14, 2014, Ise-Shima Royal Hotel, Japan

Victor, N. J., C. Panneerselvam, and **C. P. Anil Kumar**

Field aligned current study during the solar declining-extreme minimum of 23 solar cycle.

Victor, N. J., C. Panneerselvam, S. Manu, and **C. P. Anil Kumar**

Investigation of post-geomagnetic storm effect on atmospheric electricity at high latitude.

AGU fall meeting, December 15-19, 2014, San Francisco, USA

Jayashree, B., Ravi Chandra, Ashwini K.Sinha, Geeta Vichare, and **Neethal Thomas**

Low latitude pulsations associated with different phases of geomagnetic storms

Kakad, A., B. Kakad, and Y. Omura

Nonlinear Evolution of Ion Acoustic Solitary Waves in Earth's Magnetosphere: Fluid and Particle-In-Cell Simulations.

Malini Aggarwal, Ananna Bardhan, and D. K. Sharma

Ionospheric disturbances during a strong earthquake (M=5.5) event.

Satyavir Singh, Hajime Sugiyama, Yoshiharu Omura, Masafumi Shoji, David Nunn and Danny Summers

Electromagnetic ion cyclotron waves in the inner magnetosphere with a kappa-Maxwellian proton distribution.

International School on Equatorial and Low Latitude Ionosphere (ISELION), March 16-20, 2015, Bandung, Indonesia

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

EPBs observed from EAR radar: A comparison between Evolutionary-type and Drifting-in.

STUDENTS CORNER

Dr.Prasant K. Das attended ***14th Castle international conference on new trends on Palaeo, Rock and Environmental Magnetism***, August 31 – September 6, 2014, Evora, Portugal.

He also presented a poster paper entitled "Evaluation of rock-magnetic properties for the determination of metal pollution in the sedimentary core of the Kolleru Lake, East coast of India", co-authored by N. Basavaiah.

Dr. Das also attended a short course on magnetic susceptibility at Evora, Portugal, August 28-30, 2014.

Shri Ajith K.K. attended The International school on Equatorial and low latitude Ionosphere held at Bandung, Indonesia during March 16-20, 2015. He was conferred with best poster presentation award for the paper titled "EPB's observed from EAR radar : A comparison between evolution and drifiting".


ISELION
International School on Equatorial and Low Latitude Ionosphere
Certificate of Appreciation
SCOSTEP

BEST POSTER AWARD
to
Ajith K.Kuriakose
for the poster entitled
" EPBs OBSERVED FROM EAR RADAR :
A COMPARISON BETWEEN EVOLUTIONAY-TYPE AND DRIFTING IN "
International School on Equatorial and Low Latitude Ionosphere
on 16-20 March 2015
in Bandung, West Java - INDONESIA
Bandung, 20 March 2015

Prashant K. Das was awarded Ph.D. degree from University of Mumbai on the topic ***"Magnetic investigations of urban pollution at Mumbai and Nashik, Maharashtra, India: mineral magnetic method as a pollution proxy"***, during September, 2014. He has carried out this work under the supervision of Prof. N. Basavaiah.

Remya B. was awarded Ph.D. degree from University of Mumbai on the topic "***Beam and temperature anisotropy driven plasma instabilities in the solar wind and the Earth's magnetosphere system***" during May 2014. She has carried out this work under the supervision of Prof. R.V. Reddy.

S. Devanadhan was awarded Ph.D. degree from Mumbai University on the topic "**Study of some linear and nonlinear phenomena in space plasmas**" under the supervision of Prof. Satyavir Singh.

(L-R) Md. Arif, P.K. Das, S. Devanandhan, Chinmaya Kumar Nayak and B. Remya were awarded Ph.D. degree during convocation ceremony at University of Mumbai

Ph.D. Thesis Synopsis

B. Remya

Beam and temperature anisotropy driven plasma instabilities in the solar wind and the Earth's magnetosphere system

The bow shock heating and acceleration processes at the Earth lead to deviation of spatial or thermal equilibrium of the magnetosheath plasma which in turn drive various free energy sources such as particle temperature anisotropies, field-aligned beams, unequal species temperatures, non-equilibrium spatial distributions, etc. This free energy in the system is then relieved off or redistributed in the form of waves and instabilities in planetary magnetosheaths. These disturbances carry energy and momentum from the bow shock to the magnetopause and vice versa.

The present study aims at understanding the low frequency plasma turbulence at the Earth's magnetosheath region arising due to ion beams and ion temperature anisotropy. Behind the quasiperpendicular bow shock, the heating of the plasma and magnetic field line draping around the magnetosheath causes anisotropic ion distributions with its perpendicular temperature greater than the parallel temperature, $T_{\perp_i} > T_{\parallel_i}$, where parallel and perpendicular is with reference to the ambient magnetic field. Apart from this, the acceleration processes at the bow shock subject energetic ions to stream along the ambient magnetic field. These anisotropic distributions act as source of free energy to drive various low frequency instabilities. The study focuses on three such instabilities that compete with each other: the ion cyclotron instability, mirror instability and ion beam driven instability.

Linear theory and computational studies till date show that the ion cyclotron instability has a higher growth rate compared to the mirror instability for a given set of plasma parameters in an electron-proton plasma. Contradictorily, most of the observations in the planetary magnetosheaths and other space plasma regions show mirror instability dominance over ion cyclotron instability. A wide parametric regime is explored to model planetary magnetosheaths based on observations and studies the linear growth rates of these instabilities to determine which mode dominates in a particular region. This study assumes multi-component plasma model with anisotropic protons, anisotropic heavy ions like helium (He^{2+}) and oxygen (O^{6+}) and isotropic as well as anisotropic electrons. Electron anisotropy effects on the low frequency instabilities are studied for the first time. It is shown that anisotropic electrons reduce the ion cyclotron growth rate and increases the growth of mirror modes significantly thereby enhancing the chances of mirror mode occurrences in planetary magnetosheaths. The parameters proton plasma beta (β_p), ion temperature anisotropy ($T_{\perp i}/T_{\parallel i}$), concentration of heavy ions and electron temperature anisotropy can determine whether ion cyclotron or mirror modes dominate in a given plasma regime. For $T_{\perp e}/T_{\parallel e}$ = 1.2 mirror mode growth exceeds the ion cyclotron growth at a beta value β_p = 0.5 with a helium concentration n_α = 0.10n_p, where n_p is the proton concentration. An increase in electron temperature anisotropy to $T_{\perp e}/T_{\parallel e}$ = 1.8 further brings down the growth rate of ion cyclotron mode; mirror modes dominate for helium ion concentration n_α = 0.01n_p. The presence of anisotropic electrons, perhaps due to bow-shock heating and magnetic field line draping effects, can explain the growth of mirror mode waves when the magnetosheath plasma beta is as low as 0.5.

Presence of heavy ion beams in the plasma model showed a significant effect on the wave growth in the mirror regime. The heavy ion beams with velocities higher than the beam thermal velocities were found to modify the dispersion curves of the mirror mode. A beam driven mode is found to get excited in this parametric regime which was found to couple with the mirror wave and alter its wave characteristics. The linearly polarized mirror wave showed a transition to a right hand elliptically polarized wave, which is the beam driven mode. At the same time, the ion cyclotron modes did not show much alteration in their wave characteristics in the presence of heavy ion beams. This leads to a possibility that the presence of a strong ion beam in the plasma model could possibly rule out the existence of the mirror modes. In such cases, the competition is between the left hand polarized ion cyclotron mode and the right hand polarized beam driven mode. Whichever has a higher growth rate will prevail in a given region. All the parameters for the magnetosheath plasma model are based on the satellite observations.

Another aspect of the study examines the magnetic field fluctuations observed by Cassini and WIND in the Earth's magnetosheath on 18th August, 1999, while Cassini had its Earth flyby on its way to Saturn. An elaborate picture is given on the plasma wave properties and characterizes them statistically for the interval when Cassini and WIND were in the Earth's subsolar and dusk side magnetosheath, respectively. The standard technique of minimum variance analysis was found to result in errors in determining high amplitude wave properties and hence a new technique called Rosetta Automatic Wave Analysis (RAWA) has been developed based on the method initiated by Tsurutani et. al., 2013 and applied to analyze the wave cycles. The frequency, ellipticity, polarization and angle of propagation of each wave cycle are determined and are characterized statistically to show prominent waves in this region. Cassini and WIND wave cycle analysis suggest that almost all the waves (> 90%) were left hand circularly polarized waves with frequencies lying at or below the proton cyclotron frequency. This indicates abundance of ion (proton) cyclotron mode propagation in the Earth's magnetosheath for the aforementioned interval. No obvious mirror mode indications were found as there were no linearly polarized waves detected. The waves which were either right hand polarized or had frequencies greater than the proton cyclotron frequency were consistent with their being left hand waves with frequencies less than proton cyclotron frequency in the plasma frame. It is thus concluded that the waves detected at both Cassini and WIND are electromagnetic left hand polarized proton cyclotron waves. Plasma data from WIND showed unusually low value of ion beta which would have possibly favored ion cyclotron dominance in the magnetosheath during this period. A theoretical explanation is also given for this unusual observation.

Prasanta Kumar Das

Magnetic investigations of urban pollution at Mumbai and Nashik, Maharashtra, India: Mineral magnetic method as a pollution proxy

Environmental pollution due to anthropogenic sources of vehicular exhausts and industrial emissions is rapidly becoming a critical issue of public concern worldwide. The increasing pollution level day-by-day has prompted policy makers, scientists, environmental organizations to opt for fast, cost effective, complimentary yet reliable tools against the time consuming, cost intensive and destructive

geochemical practises. Environmental magnetism is one such tool which has been widely used to investigate the degree, source, scope and spatio-temporal evolution of anthropogenic pollution related to industrial and other human activities in this thesis.

The work reported in this thesis covers two case studies where the validity of magnetic technique is tested for its suitability as pollution proxy while dealing with high magnetic background geology of Deccan Traps. For the first time, environmental magnetic techniques are applied in the areas of highly magnetic basaltic backgrounds for assessment of heavy metal pollution screening. It led to the development of an advanced magnetic monitoring technique to successfully separate the magnetic signature of anthropogenic combustion (industrial and vehicular) particulate from natural inputs to produce a pollution signal into soils and surface dusts. Specifically, mineral magnetic techniques are effectively used to reveal a steady decrease of the anthropogenic particulate matter loadings from the Nashik Thermal Power Plant and the adjacent ash pond up to a distance of 12 km. Evaluation of magnetic and chemical data including pollution load indices (PLIS) of Pb, Zn and Cu reveals close relationship of magnetic susceptibility with the metal contents, enabling the application of magnetic screening methods in highly magnetic soils. In another study, mineral magnetic technique is applied to assess environmental pollution in megacity of Mumbai using the road dust materials. The MS patterns clearly show that road traffic has the most significant impact on the enhancement of values within “The Bombay Arc”. PCA analysis helped in identification of the various metal inputs as vehicular traffic emissions, high temperature combustion processes, paint and metallurgical units and natural weathering of bedrocks.

The outcome of the road dust analysis could serve as a basis for future planning of the city, as well as in providing precedence for other coastal cities to follow. Results of topsoil pollution monitoring around NTPS identified both the power plant and its ash pond as the major soil pollution source, and hence regulation regarding the emission of fly ash and its safe disposal should further be tightened/ strengthened in view of the large public and the farm lands in the vicinity.

Devanandhan, S.

Study of some linear and nonlinear phenomena in space plasmas

In this thesis, various theoretical models for the generation and propagation of linear and nonlinear electron and ion-acoustic waves in multi-component unmagnetized and magnetized space plasmas have been developed by considering superthermal electrons/ions which are described by the nonthermal kappa distributions. The effect of various plasma parameters such as superthermality, density, temperature and beam speed on the propagation of these waves has been investigated in detail. The results of the study have been applied to satellite observations in the various regions of the Earth’s magnetosphere. Here, summary of the results obtained in the thesis are presented.

Firstly, the theoretical model for electron-acoustic waves in three component unmagnetized plasma consisting of cold electrons, hot superthermal electrons and fluid ions is investigated. The theoretical results show that the superthermal distribution function is accountable for higher electric field amplitude than the Maxwellian or non-thermal (Cairn’s type) distribution function and temperature effects play an important role. The inclusion of cold electron temperature significantly reduces the regime for the existence of the electron-acoustic solitons and their electric field amplitudes. Similarly, the maximum soliton velocity, width and pulse duration are significantly reduced with the inclusion of finite cold electron temperature. Further, the ranges of soliton velocity, electric field, soliton width and pulse duration decreases with an increase in the cold electron temperature.

Three component model described above is extended to include electron beam to study a four component plasma model of electron acoustic solitary waves. The results show that inclusion of an electron beam alters the minimum value of spectral index, k, of the superthermal electron distribution and Mach number for which electron-acoustic solitons can exist and also changes their width and electric field amplitude. It is found that the electric field amplitudes in a four component model is lower than the three component model of electron acoustic waves. The range of kappa values also widens due to the presence of electron beam and minimum value of kappa for which soliton solutions are obtained are higher as compared to three component model.

The characteristics of linear and nonlinear electron acoustic solitary waves in a two component electron-ion magnetoplasma are discussed. Linear analysis of this study shows cyclotron wave modified with thermal effects at perpendicular propagation and for parallel propagation, we get two modes namely, electron-acoustic wave and cyclotron wave. In nonlinear regime, we have focused on electron acoustic waves and it is found that only negative

solitary potential structures can be generated through this model. It is worth mentioning that only critical Mach number gets affected by the angle of propagation but not the upper limit of the Mach number for which soliton solution exist. The electric field amplitude is reduced by the inclusion of thermal effects. Also, kappa distribution accounts for higher electric field values than the Maxwellian. The electric field amplitude increases with the increase in magnetic field, whereas soliton width as well as pulse duration decreases. This model is very restrictive in space plasmas and requires the ion temperature much higher than the electron temperature. The results from this study were found to be in good agreement of the wind spacecraft observations in the bow shock region.

The propagation of electron acoustic solitary waves in a magnetized plasma consisting of fluid cold electrons, electron beam and superthermal hot electrons having kappa velocity distribution and ions is investigated in the small amplitude limit using reductive perturbation theory. The Korteweg-de-Vries-Zakharov-Kuznetsov (KdV-ZK) equation governing the dynamics of electron acoustic solitary waves is derived. The solution of the KdV-ZK equation predicts the existence of negative potential solitary structures. It is found that increasing either the speed or temperature of beam electrons tend to reduce both amplitude and width of the electron acoustic solitons. Increasing the superthermality of the hot electrons also results in reduction of soliton amplitude and width. Furthermore, higher soliton amplitude are found at larger angle of propagation for auroral plasma parameters. The results may be helpful in explaining the broadband electrostatic noise observed in the auroral region of the Earth's magnetosphere.

In the low frequency regime, obliquely propagating ion-acoustic solitary waves have been examined in a magnetized plasma composed of kappa distributed electrons and fluid ions with finite temperature. The Sagdeev potential approach is used to study the properties of finite amplitude solitary waves. Using a quasi-neutrality condition, it is possible to reduce the set of equations to a single equation (energy integral equation), which describes the evolution of ion-acoustic solitary waves in magnetized plasmas. The temperature of warm ions affects the speed, amplitude, width, and pulse duration of solitons. Both the critical and the upper Mach numbers are increased by an increase in the ion temperature. The ion-acoustic soliton amplitude increases with the increase in superthermality of electrons. For auroral region plasma parameters, the soliton speed, amplitude, width, and pulse duration obtained from the model are in good agreement with Viking observations.

DEPUTATIONS/VISITS ABROAD

Name	Country visited	Duration	Conference/workshop/symposium
Amar Kakad	South Africa	May 10-19, 2014	Indo-South Africa Bilateral Project
Rajesh Singh Ajeet K Maurya	France	June 23-27, 2014	2nd TEA – IS Summer School
Ajeet K Maurya	USA	July 9-16, 2014	2014 Heliophysics Summer School
Ravi Kumar	Japan	July 22 - 26, 2014	International Symposium on Geodesy for earthquake Natural Hazards, GENAH-2014
Gopi Seemala	Japan	July 28 – August 1, 2014	Asia Oceania Geosciences Society (AOGS) conference
Devanandan S Sandeep Kumar Virendra Yadav	Russia	August 2-10, 2014	40th COSPAR Scientific Assembly
Prashant Kumar Das	Portugal	August 28- September 6, 2014	14th Castle international conference on new trends on Paleo, Rock and Environmental Magnetism, Evora. & Short course on magnetic susceptibility, Evora.
Sneha A. Gokani	South Korea	August 31- September 5, 2014	AGU Chapman Conference on Low Frequency Waves in Space Plasmas

Name	Country visited	Duration	Conference/workshop/symposium
Satyavir Singh	South Africa	September 1-October 1, 2014	Indo-South Africa Bilateral project
Ankush Bhaskar	Greece	September 15-20, 2014	Geospace Revisited Conference
Neethal Thomas	China	October 12–18, 2014	13th Quadrennial Solar Terrestrial Physics Symposium 2014
Navin Parihar	Italy	October 13 – December 22, 2014	Junior Associateship at ICTP
Jeni Victor	Japan	November 10-14, 2014	International conference on substorms 2014
Satyavir Singh Amar Kakad Chinmay K Nayak Remya B Jayashree B	USA	December 15-19, 2014	AGU Fall meeting in San Francisco
Nagarjuna D	Japan	March 3-10, 2015	KAGI 21 International Spring School (ISS)
Ajith, K. K.	Indonesia	March 16-20, 2015	International School on Equatorial and Low Latitude Ionosphere (ISELION)
Antarctic/Arctic Expeditions			
Dr. Sunil P.S.	Norway (Arctic)	September 8-October 13, 2014	Participation in Scientific Expedition to Svalbard, Arctic region. Visit to Indian Scientific Research Station "Himadri", Ny-Alesund, Svalbard, Norway
P. Elango	Maitri, Antarctica	34th ISEA	Winter member and Station Commander, Maitri
Varun Dongre	Maitri, Antarctica	34th ISEA	Summer member, Maitri

DISTINGUISHED VISITORS

Prof. Anil K. Gupta, Director, Wadia Institute of Himalayan Geology, Dehradun visited the Environmental Magnetism laboratory on September 12, 2014.

The following scientists from Wadia Institute of Himalayan Geology, Dehradun visited the Environmental Magnetism laboratory on December 23, 2014, **Dr. Sushil Kumar, Dr.Gautam Rawat,** and **Dr. N. Suresh**

Prof. Dhanajay Rawat, Chair and Professor of Geophysics, Department of Earth and Environmental Sciences, University of Kentucky, USA visited IIG on June, 2014 and delivered a lecture on "A New method of Constraining Geotherms deep inside the Crust – steady state Geotherms constrained with Curie depths".

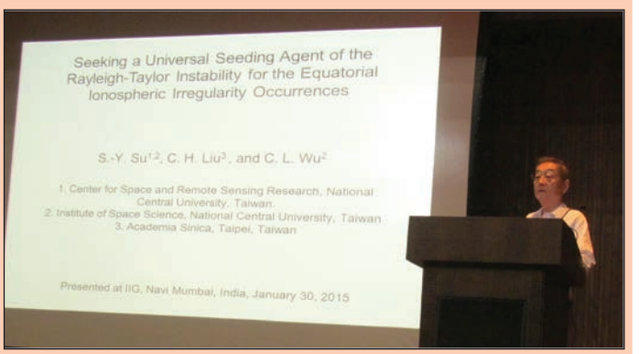
Prof. Jaydeep Mukherjee, Director, NASA Florida Space Grant Consortium, USA, visited IIG on December 11, 2014 and delivered a lecture on "MAVEN: Exploring Mars Climate History"

Prof. Jaydeep Mukherjee, Director, NASA Florida Space Grant Consortium, USA

Dr Esfhan Alam Kherani, Researcher, Aeronomy division, National Instiute of Space Research (INPE)São José dos Campos, Brasil visited IIG from January 6-10, 2015 and delivered a seminar on "Travelling ionosphere disturbances excited ahead of the Tohoku-Oki tsunami: A case study" on January 9, 2015.

Dr. Dilip Haldar, Dept. of Radio Physics and Electronics, University of Kolkata visited IIG on January 21, 2015 and delivered a talk on "Studies on climate forecasting and earthquake precursors using ULF/ELF/VLF measurements".

Prof. S. –Y. Su and **L.C. Tsai**, Center for Space and Remote Sensing Reseach, National Central University, Taiwan, visited IIG during January 30, 2015 and delivered a lecture on Seeking a Univeral Seeding Agent of the Rayleigh-Taylor Instability for the Equatorial Ionospheric Irregularity Occurrences.



Prof. S. –Y. Su, Center for Space and Remote Sensing Reseach, National Central University, Taiwan

Dr. Uwamahoro Jean of Kigali Institute of Education, Department of Maths & Physics, Kigali REMERA – RWANDA visited Indian Institute of Geomagnetism, New Panvel from January 5-February 5, 2015 under **CV Raman International Fellowship for African Researchers programme** of Federation of Indian Chambers of Commerce and Industry (FICCI) New Delhi, India. He gave a seminar on February 4, 2015 on "**A contribution to space weather research: recent past and current interests** "

Prof. G. Yellaiah (Retd.) from Osmaniya University visited IIG during 11-13 Feb 2015 and delivered a lecture.

Prof. Bruce Tsurutani, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA visited the Institute on August 14, 2014. He also delivered a lecture on "Space weather phenomena during the modern era".

Dr. Rajesh Tiwari, Research Associate, School of Electrical and Electronic Engineering, New Castle University, UK visited the Institute on May 2, 2015 and delivered a lecture on "Software GPS Receiver Approach to Mitigate Scintillation".

Dr. Kamal, Department of Earth Science, Center of Excellence for Disaster, Mitigation and Management, Indian Institute of Technology, Roorkee visited IIG on May 23, 2015 and delivered a talk on "Earthquakes – Everything you want to know but were afraid to ask".

Dr. Monika Korte, Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences visited IIG on October 20, 2014. She gave a detailed lecture on the research activities at GFZ entitled "From Earth's core to space-geomagnetism research at GFZ".

Dr. Rorie Edmunds and **Dr. Takashi Watanabe**, WDS, Japan visited the Institute on November 11, 2014 and gave a talk on "The ICSU World Data System: Trusted Data Services for Global Science".

Dr. M. Nose, Data Analysis Center for Geomagnetism, Graduate School of Science, Kyoto University visited IIG on November 11, 2014 and gave a lecture on "Van Allen Probes observation of oxygen torus in the inner magnetosphere".

HONOURS AND AWARDS

Anand, S.P.

Recognized as Ph.D. guide by SRTM University, Nanded.

Elango, P.

Was selected as Station Commander of Maitri station in Antarctica. This is the second time that this honour is bestowed upon him.

Lakhina, G.S.

Received the 2014 COSPAR Vikram Sarabhai Medal by COSPAR and ISRO, India in person during the Inauguration and Award Ceremony of COSPAR 2014 in Moscow, Russia on August 4, 2014.

Deputy Organizer (DO) for the special session D3.1 Multiscale Magnetospheric Processes: Theory, Simulations,

and Multipoint observations, of COSPAR2014, Moscow, Russia (Philippe Escoubet and G. S. Lakhina) August 2-10, 2014.

Co-convened AOGS 2014 special session ST07 Structures and dynamics of the inner/outer frontiers of terrestrial magnetosphere and of magnetized /unmagnetized planets, Sapporo, Japan (B. Lembege, G. S. Lakhina and I. Shinohara), July 28-August 1, 2014.

Co-convened URSI GA 2014 special session H06: Boundary layers in terrestrial and planetary environments: Macro/ micro-scale kinetic processes, Beijing, China (B. Lembège, G. S. Lakhina, I. Shinohara), August 16-23, 2014.

Sinha, Ashwini Kumar

Appointed by University of Mumbai as Examiner for M.Sc. (part-II) in Astronomy and Space Physics for the academic year 2013-2014.

Appointed by Tripura University as examiner for Ph.D. thesis " Studies of various features of geophysical and solar events using subionospheric propagation" submitted by Mr. Abhijit Choudhury.

Sripathi, S.

Awarded Regular Associate of the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy.

TRAINING IMPARTED

Dr. Gautam Gupta

Guided the dissertation of Ms. Bhagyashree P. Darp, a student of School of Environmental & Earth Sciences, North Maharashtra University, Jalgaon on the topic***"Assessment of electrical resistivity sounding data by curve matching technique in parts of Konkan coast, Maharashtra"***towards the partial fulfillment of M.Sc. degree in Geology during December 2014-January, 2015.

Supervised a project work entitled ***"Electrical Methods-DC Resistivity"*** done by Rhythm Shah of Department of Applied Geophysics, Indian School of Mines, Dhanbad during December, 2014-January, 2015, in partial fulfillment of the requirements for the award of Master of Science and Technology in Applied Geophysics.

Guided the dissertation of Ms. G. Saroja, from Centre for Geo Technology, Manonmaniam Sundaranar University, Tirunelveli on the topic ***"Delineation of shallow resistivity structure in Chikotra basin, southern Maharashtra by vertical electrical sounding measurements"*** towards the partial fulfillment of M.Sc. degree in Applied Geophysics during January-March, 2015.

Guided Ms. G. Shailaja for her dissertation on ***"Identification of water bearing fractured zones in trap covered hard rock area of southern Maharashtra using vertical electrical sounding data"*** as a part of IIG course work for research scholars.

Guided Mr. Pankaj Das for his dissertation on "***Delineation of groundwater from hard rock terrain of southern Maharashtra using electrical resistivity method: interpretation by various techniques"*** as a part of IIG course work for research scholars.

Supervised Ms. Suneetha Naidu for her dissertation on ***"Analysis of D.C. resistivity data using Dar Zarrouk parameters in some parts of West Coast of Maharashtra"*** as a part of IIG course work for research scholars.

Dr. Ashwini K. Sinha

Guided an M. Sc. student Mr. Ravi Chandra from Andhra University for his dissertation on ***"Identification of Geomagnetic Pulsations during Geomagnetic Storms"*** towards the partial fulfillment of M.Sc. degree in Physiscs (Space Science).

Dr. S.P. Anand

Guided Mr. E. Krathikeyan of M.S. University Tirunelveli for summer training on ***"Crustal heat flow – methods and techniques and crustal magnetic anomalies"*** during May-June 2014.

Supervised Ms. Sayalee S. Bhosle of North Maharashtra University Jalgaon, towards completionof dissertation on ***"Aeromagnetic data analysis over a part of eastern Dharwar craton"*** during December 2014-January 2015.

Guided Ms. Sruthi.M. of M.S. University Tirunelveli, for thye completion of her dissertation on ***"Processing and interpretation of aeromagnetic data over a part of the Archean-Greenstone terrain"*** during January-March,2015.

Dr. P.B.V. Subba Rao

Guided Mr. K. Santha Rao of Department of Geophysics, Andhra University, Visakhapatnam for completion of summer training on the topic ***"Geomagnetic Depth Sounding in Andaman Nicobar Islands"*** during May-June, 2014.

Guided Ms. Kalpana from Department of Applied Geophysics, ISM, Dhanbad for completion of summer training on the topic ***"Geomagnetic Depth Sounding in northern part of Saurashtra region"***, during May 6-June 20, 2014.

Dr. P. S. Sunil

Guided Mr. Kaja Hussain Fazil from Cochin University of Science and Technology towards the partial fulfillment of the M. Sc. Degree in Marine Geophysics on the topic titled ***"Stress and strain pattern of the Sikkim Himalayan region, inferred from the inversion of Focal Mechanism Solutions and Global Positioning System Data"*** from December 1, 2014 to February 10, 2015.

Dr. V.C. Erram

Guided a student Miss. Sheetal Satish More from Dept of Environmental and Earth Science, North Maharashtra University, Jalgaon for M.Sc. project work entitled ***"Magnetic Method of Geophysical Exploration, A case Study From Saurashtra Basin, Gujarat"*** during the period December 15, 2014 to January 26, 2015.

Guided Mr. Gaurav Thakare and Mr. Darshan Bodhe from Wadia College, Pune for their M. Sc. Dissertation work on ***"Geophysical Methods of Exploration"*** during December 8-26, 2014.

Prof. N. Basavaiah

Guided a student, Pitchika V. N. S. Vinay Kumar from Geophysics Department, Andhra University for M.Sc. dissertation on the topic ***"Environmental magnetic properties of Krishna-Godavari basin sedimentary core samples"***, during July 2014.

Dr. S.K. Patil

One Research scholar of CEG, Osmania University was trained in "***Environmental magnetism to monitor the magnetic pollution in the dusts of Hyderabad region"***, during January 2015.

Dr. B.V. Lakshmi

Guided a student Ms. Jerusha Bonu from Dr.B.R. Ambedkar University, Andhra Pradesh, for M.Sc. dissertation on the topic ***"Environmental magnetic properties of sediments from Gad River, Sindhudurg, Maharashtra"*** during the period December 2014-March, 2015.

Dr. K. Deenadayalan

Guided a student Yadla Prasada Rao from Dr. B.R. Ambedkar University, Andhra Pradesh for M.Sc. dissertation on the topic ***"Mineral magnetic studies on archaeological artefacts from Mumbai Buddhist sites"*** during December 2014-March, 2015.

Shri P.B.Gawali

Guided two students from NMU, Jalgaon and Andhra University for M.Sc. dissertation on the topic ***"Changing characteristics of beach sands deciphered from magnetic, geochemical and textural studies on beach samples of Vengurla, Aravalli and Redi beaches of Sindhudurg district, Maharashtra, India"***during the period May-June, 2014.

Guided a student Mr. Sama V.A. Phani Khishan from Ambedkar University, Andhra Pradesh, for M.Sc. dissertation on the topic ***"Mineral magnetic properties of Beach sediments, Achra-Tondavali Coast, Maharashtra"***during the period December 2014-March, 2015.

Guided a student Mr. Vivek Suresh Patel from Northern Maharashtra University, Jalgaon, for M.Sc. dissertation on the topic ***"Seasonal variations in textural and magnetic susceptibility characteristics of Vengurla, Aravalli and Redi beaches of Sindhudurg district, Maharashtra, India"***during the period December 2014-January, 2015.

Shri M. Ravi Kumar

Guided the M.Sc.dissertation of Mr. Abhinav Mittal, Department of Geophysics, Banaras Hindu University, Varanasi on the topic ***"Gravity Anomalies, Isostasy over Himalaya-Tibet"*** during the period May 26 to July 2, 2014.

Dr. Amar Kakad

Guided the M. Sc. dissertation of Ms. G. Padma, Andhra University on topic ***"Two stream instability in space plasmas"*** during June, 2014.

Dr. Bharati Kakad

Guided the M. Sc. dissertation project of Ms. A. Kalpana, Andhra University on topic ***"Scintillations: A tool to study the ionosphere"*** during June, 2014.

Guided a student Mr. A. Sharma, Institute of Science, Mumbai on the topic ***"Study of solar activity and Earth's atmosphere"*** during May 2014.

Dr. S Sripathi

Guided a student, Mr. Aniket Shigwan, Mumbai University for his summer project work as summer trainee.

Rajesh Singh

One B.Sc.-IInd year student from Nehru Gram Bharati University, Allahabad, U.P. did summer dissertation.

Two M.Sc.-IInd year students from Andhra University, Visakhapatanam did summer dissertation.

PARTICIPATION IN SPECIALIZED WORKSHOPS/ TRAINING COURSES

Dr. Amar Kakad attended Fujitsu's one-day workshop on "Latest trends in Datacenter Technology, Mobility, Cloud and Big Data" at Mumbai on September 2, 2014.

Mr. Ankush Bhaskar has attended "COMSOL Multiphysics Modeling Workshop" at Mumbai on November 27, 2014.

Dr. B.V. Lakshmi participated in winter school on "Quaternary Geology and Palaeoenvironment" at Department of Archaeology, Deccan College, Post-graduate and Research Institute, Pune during December 8-14, 2014.

Dr. Vinit C. Erram participated in the 7th International Congress of Environmental Research held at R.V. College of Engineering Bangalore, India during December 26-28, 2014.

OFFICIAL LANGUAGE (HINDI)

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 important and special activities to enhance the progressive use of official language Hindi among its members.

The Institute organized 'Hindi Mah' during September-October, 2014. The Hindi competitions organized during this period included Computer Typing, General Knowledge, Crossword, Essay Writing and Sentence Construction, which were well attended by the members. 'Hindi Mah' concluded with a prize distribution function, in which Chief Guest Dr. Ram Veer Sharma, Rtd. Dy. Director General, Indian Meteorological Deptt., Ministry of Earth Sciences, gave away the prizes to the winners and addressed the gathering. He appreciated the determined efforts from each and every member of the Institute towards intensive use of

Director IIG, welcoming the Chief Guest Dr. R.V. Sharma

Chief Guest giving away prizes to winners of Hindi competitions

Director giving away prizes to winners of Hindi competitions

official language Hindi. He also stated that there are a number of incentive schemes for doing official work in Hindi. Therefore, the staff should always be informed and encouraged regarding such schemes, so that overwhelming participation is ensured at all levels and in all schemes. Prof. D.S. Ramesh, Director told that the Institute has a lot of resources like Hindi books, software loaded on computers and Hindi Section's Staff. He emphasized the need of optimum utilization of such resources, so that the staff can put in maximum efforts in doing their day-to-day official work in Hindi and thereby achieve the targets set by the Government. He also gave away prizes to some staff.

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 76 members participated.

IIG staff members taking part in Hindi workshop

Under the incentive scheme, during the Annual Day Celebrations, 9 staff members of the Institute were awarded with cash prize for doing their official work in Hindi.

Hindi Officer and Sr. Hindi Translator continued as member of the editorial board of Hindi Magazine 'Samanvaya' being jointly brought out by the member organizations of TOLIC, Navi Mumbai.

Rajbhasha Adhikari, Hindi Officer and Sr. Hindi Translator of the Institute attended various meetings/seminars held under the aegis of TOLIC, Navi Mumbai and other voluntary organizations. Shri Varun Dongre of the Institute received consolation prize in Essay Competition organized by TOLIC.

The Institute's house magazine 'SPANDAN'bagged coveted ICE (In-house Communication Excellence) Award (1st Runner up) instituted by Shailaja Nair Foundation, Mumbai.

Shri Jeetendra Kamra, Hindi Officer was felicitated by Mumbai based cultural organization 'Ashirwad' for his contribution towards implementation of official language policy in the Institute.

PUBLIC OUTREACH PROGRAM

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 central level for the benefit of student community.

In the year 2014-15, the Institute carried out following activities:

i. Students from 11 Schools/Colleges visited the Institute and Magnetic Observatory Alibag to get acquainted with the Science of Geomagnetism and Allied Fields.

ii. Institute participated in the Regional Level Science Fest – 2014 held at DAV Institutions, Panvel, Navi Mumbai. The Regional level CBSE Science Exhibition was held at DAV Public School, Panvel on June 26-28, 2014. Shri Ajay Dhar, Dr. Amar Kakad and Dr. S. Tulasiram were selected by CBSE, New Delhi to judge the exhibits.

iii. 25 Talks were delivered by IIG Scientists on various topics for the benefit of students.

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

v. Week long open house celebrations were held during Science Day Celebrations from February 19-27, 2015 at IIG. Three-day open house celebrations were also held at the Regional Centre KSKGRL, Allahabad and one day open house exhibition at EGRL, Tirunelveli.

vi. A special popular science Lecture on “Maven-Solving Mar’s Climate Mystery” by Dr. Jaydeep Mukherjee, Director NASA Florida Space Grant Consortium, Florida, USA was organized at the Institute on December 11, 2014. The lecture was attended by a large number of students from the schools of Navi Mumbai area in addition to staff members.

vii. Prof. D.S. Ramesh, Director, IIG was requested to inaugurate a science documentary film titled “Antarctica” at Nehru Science Centre, Mumbai on October 13, 2014. Prof. Ramesh was the Chief Guest at the function. Shri Ajay Dhar was the Guest of Honor at the function and delivered a talk on “Indian Antarctic Expeditions”.

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

i. Three 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.

ii. A group of 40 Students of BNN College of Science and Arts, Bhiwandi visited Magnetic Observatory, Alibag on December 18, 2014 on a study tour. The students were explained science of Geomagnetism through colorful posters and explained the importance of Observatory.

iii. A batch of 40 Students of 2nd year B.Sc. Physics of Vikas College of Arts, Science & Commerce, Mumbai visited the Institute on August 8, 2014 for a study tour.

iv. Three batches of 120 students each from Rustomjee Academy for Global Careers (A Rustomjee Group CSR initiative) visited Magnetic Observatory, Alibag on an educational tour.

v. Students of K.J. Somaiya Polytechnic, Mumbai visited Alibag Observatory on a study tour.

vi. Students of 1st year B.Sc. Physics and Maths of Rajiv Gandhi College of Arts, Science and Commerce, Vashi, Navi Mumbai visited Magnetic Observatory, Alibag on a study tour.

vii. Students of Sri Rawatpura Sarkar Institute of Technology & Sciences, Datia M.P. affiliated to Rajiv Gandhi Technical University, Bhopal visited KSKGRL on a study tour.

viii. A batch of 50 students of 2nd year B.Sc. Physics from G. M. Vedak College of Science, Mangaon, Dist. Raigad, visited the Institute on February 23, 2015 on a study visit.

102nd INDIAN SCIENCE CONGRESS, MUMBAI

The Institute participated in the 102nd Indian Science Congress held at Mumbai University, Kalina Campus from January 3-7, 2015. The focal theme of the Indian Science Congress – 2015 was “Science & Technology for Human

Development". The Institute put up an exhibition of colorful posters depicting the "Science of Geomagnetism and Allied Fields". In addition, a few equipment used for collecting magnetic field data and various science Models were also put on display for students benefit.

The main attraction for students and common public was the Solar Telescope put up by the Institute. 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.

IIG doctoral students demonstrating the dynamo theory to school children through experiment at the Indian Science Congress Exhibition

IIG doctoral students showing live Sun through solar telescope to enthusiasts in Indian Science Congress Exhibition.

SCIENCE EXPO-2015, NEHRU SCIENCE CENTRE, MUMBAI

An Interface of Science & Society was organized at the Nehru Science Centre during February 4-7, 2015. A total of 13 Scientific, Research & Development institutes including IIG participated in the expo to show-case the scientific achievements. The main objective of the exhibition was to create awareness among the masses, especially school students, and to bring them face to face with practicing scientists and also to motivate them in pursuing science as their career of choice which is so essential in the modern knowledge based society.

The Expo was inaugurated by Dr. R. K. Sinha, Chairman, Atomic Energy Commission and Secretary, Dept. of Atomic Energy, Mumbai. Around 15000 students, teachers and general visitors visited the expo and participated in the programmes. During the expo, "Meet the Scientist" programme was also organized in which 12 scientist from the participating institutes interacted with about 2500 visitors including students, teachers and general public. Prof. S. Gurubaran was invited from IIG to interact with the students, teachers and general public. Dr. Mala Bagiya was invited to deliver a popular lecture to the visitors during the Expo. In addition to this exhibition, several competitions, Science Shows, Sky Observations, Science Demonstration Lectures, Astronomy Slide Shows, Quizzes, etc., were organized in which large number of students participated. The event concluded on 7th February 2015 with a valediction & prize distribution Function. Shri A.K. Jain, Additional Chief Engineer (Corporate Communication) Nuclear Power Corporation of India Ltd. was the Chief Guest of Function.

The Institute participated in this Science Expo – 2015 and put up an exhibition of colorful posters depicting the "Science of Geomagnetism and Allied Fields". In addition, various equipment used for data collection and science Models were put on display.

IIG doctoral students demonstrating the dynamo theory to school children through experiment in Science Expo - 2015 at Nehru Science Centre, Mumbai.

IIG faculty delivering a lecture on Satellite Navigation System to school students during Meet the Scientists program in Science Expo - 2015 at Nehru Science Centre, Mumbai.

PARTICIPATION IN BVS SYMPOSIUM, GOA

Vigyan Bharati, India's biggest society working for noble cause of human prosperity and development by using Science & Technology organized the 4th Bharatiya Vigyan Sammelan & Expo-2015 during February 5-8, 2015 at Kala Academy, Panaji, Goa.

The Institute participated in the event to showcase their achievements in "Geomagnetism and Allied Fields". Colorful posters depicting the Science of Geomagnetism and allied fields were displayed during the science exhibition. Short science films were also displayed for the benefit of students. The exhibition was visited by a large number of students from Schools/Colleges and Universities and people from all walks of life. Various lectures by eminent scientists were also arranged during the sammelan.

IIG Pavellian of scientific exhibition during 4th Vigyan Sammelan and Expo 2015 at Kala Academy, Panji, Goa

NATIONAL SCIENCE DAY CELEBRATIONS AT INDIAN INSTITUTE OF GEOMAGNETISM

In order to bring scientific awareness among the students and public, the National Science Day- 2015 celebrations started with various competitions held for students and teachers. The theme for this year National Science Day was **"Science for Nation Building"**. The Science exhibition was held during February 19-27, 2015 with colorful posters depicting the "Science of Geomagnetism and Allied Fields". Various Models and instruments were displayed during the exhibition for the benefit of students and public. Nearly 1000 school and college students participated in these events.

During this period several competitions were arranged for the students and teachers. In the "**Essay Writing**" 150 students from 12 Schools and 3 Junior Colleges participated. The topic for the Essay was "**How to use Science to eradicate poverty**".

175 students from 15 schools and 3 Junior Colleges (English Medium and vernacular language schools and junior colleges) participated in the **Elocution competition**. The topic of Elocution this year was "**Why do I like/dislike Science"** for junior students and **"Mobile Phone – Boon or Nuisance**" for senior and college students.

"**Sit & Draw**" competition on the topic "**Science & Humanity**" attracted a large number of students. Nearly 150 students from 15 different schools participated in this competition.

Students and teachers **power point presentation competition** was arranged on the topics **"Science – Destructive or Constructive**" and **"Science for Nation Building"** respectively. About 50 students and eleven teachers from 7 Schools and two Junior colleges participated.

The science exhibition portrayed colourful posters on "**Science of Geomagnetism and Allied Fields**". Various instruments used for Geomagnetism and Allied studies were displayed for the benefit of students and teachers. 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.

The valediction function was held on February 27, 2015. The Science Day lecture was delivered by **Dr. S. M.**

Khened, Director, Nehru Science Centre, and **National Gallery of Modern Art, Mumbai** and was the **Chief Guest** for valediction function. Dr. Khened delivered a talk on ***"Internet & Cloud Computing – A Historical Perspective"***, which was attended by a large gathering.

Students participating in the elocution competition during National Science Week 2015

Large number of school children participating in the sit and draw competition during National Science Week 2015

Geological samples on display during National Science Week 2015

A Research Scholar explaining a scientific poster during National Science Week 2015

A school teacher participating in power point presentation competition during National Science Week 2015

Chief Guest Dr. S.M. Khened delivering science day lecture at IIG

Prize distribution during valedictory function of science day competition

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

EGRL, as part of the National Science Day celebrations, organized a 1-day open house on February 28, 2015, primarily targeting school and college students with the aim of motivating them to pursue science and research in frontier areas of Science and Technology. More than 500 students from various schools/colleges in Tirunelveli and surrounding districts participated in this programme. As part of this activity, the participants were taken to various field sites of EGRL and were briefed about the experimental activities pursued here. An Open House Science Exhibition of colorful posters and some of the instruments used for the scientific studies were also organized.

Dr. K.S. Krishnan Geomagnetic Research Laboratory (KSKGRL) Allahabad, a regional centre of Indian Institute of Geomagnetism, organized the 3-day celebrations during February 26-28, 2015. The main attractions in the schedule of celebrations were the audio-visual presentation, poster display of Institute's activities and demonstration of scientific instruments.

Seven schools participated in various science related programs arranged for the school students, which were Science Models, Science Quiz and Elocution. The enthusiasm shown by the students in the science model competition, organized for the first time at KSKGRL, was overwhelming. Science quiz and elocution competitions were held on 26th and 28th February 2015. The open questions put forth to the general audience brought more life into the event. The winners of individual event and team events were gifted with mementos. Certificates were distributed to all the participants of competitions.

More than 600 students and 50 teachers from local schools 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.

A number of talks on topics related to geo-science and space science were covered during the two day celebrations. All efforts were made to encourage the usage of Hindi in the celebrations, which facilitated the local audiences in understating and popularization of science among common people.

COMPUTER FACILITIES

During last academic year, computer center has taken up various institute level projects and completed successfully as a part of IT infrastructure revamping drive to provide best possible IT environment to the scientists of the institute.

Brief information about various major projects is as follows:

- **Development of IIG HPC center**: The computer center procured FUJITSU make 256 core High Performance Computing (HPC) cluster and developed HPC center with standard data center practices to provide quality HPC services. To maintain cluster in ideal working environment, the computer section has procured a precision cooling system of EMERSON make SMART-ROW server racks, server cabin. The HPC center is connected with two 20 KVA parallel UPS backup setup. The HPC center is under 24x7 remote monitoring for various parameters like power supply, temperature, humidity, fire, water, CCTV surveillance, etc. This new HPC center became one of the major milestones in IIG history and scientists have started use of this HPC facility for their High-end computation requirements.

Testing of 256 core HPC system

- **Implementation of central UPS backup supply setup**: The computer center has taken up project to remove individual small UPS units and successfully installed single central USP of two parallel 40 KVA capacity UPS units for all the users in newly constructed central UPS room at the ground floor. This setup is successfully implemented. Currently, all the floors of North wing side of the IIG's main building are under single central UPS power backup and procurement of another UPS is under process.
- **Network architecture assessment:** The computer center assessed the current network architecture to investigate technical issues that may effect on institutes network architecture, security and efficiency. This network assessment was very useful in technical terms to understand current shortcoming of the network. This would improve IT services, security, storage and end user bandwidth and also will help in reducing the downtime of email and web services, etc. Institute has prepared its own data policy for central data storage at computer center. Provided access to scientific users to store their datasets at the central storage at computer center with proper access and also prepared roadmap for future central data storage facility and initiated procurement of new 80 TB unified storage/backup solution.
- The Computer center has introduced common printing policy to promote ecofriendly working environment. This would reduce wastage of papers, and will control expenditures on individual ink cartridges.
- Acquired new 30 mbps MTNL internet leased line and switched over both email and web server on this link. This has improved uptime of these services.

LIBRARY AND DOCUMENTATION

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 206 books on areas of research within the institute, and 101 reprints and conference papers. 87 bound volumes were added. 32 Hindi books were acquired. The library had an excellent usage statistics of the online library resources. It also procured 36 documents on inter-library loan for its users and also provided documents to other libraries under this service. 72 new students from across the country visited and used the library for their various project and/or internship work.

The library developed new procedures to ease Xerox facilities. A policy to address the publication charge for papers published by our scientists was developed and implemented. A new acquisition policy for book and e-book was also developed and implemented.

The Library started subscribing to "Georef" database, via Geoscience World. The Institutional Repository (IR) was implemented using the Dspace Open Source software. It has been made available at http://library.iigm.res.in:8080/jspui. Currently the repository is being populated with publications by the institute scientists. Access to online resources to scientists and IIG centers and observatories was extended via the Ezproxy server. Users were given three tiered access to all the publications by our institute scientists using the Ezproxy server, the Institutional Repository and the Web-OPAC. The library website further enhanced our services by provided access to all our resources, as the library acquired a new domain name that is, 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. All foreign journals were subscribed to in the online version and access to all these journals was given to all our observatories and centers via the Ezproxy server. Print copies of only Indian journals were subscribed to. The new conservation work of old journal volumes completed its first year. The library continued to train new library interns in all aspects of library work.

Documentation

Documentation section continued all their support services to the scientists and students. During the past year, the work of scanning and digitizing the Ph.D. thesis by our institute was 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

NGROSS - 2014 - National workshop on Geomagnetic Research and upgradation of Observational Skills of Staff held at Magnetic Observatory, Silchar during June 17-20, 2014

The workshop was inaugurated by Prof. Somnath Dasgupta, Honourable Vice Chancellor, Assam University and Guest of honour, Padmashri V.P. Dimri, Chairman, Governing Council, IIG in the presence of Dr. Sailendra Choudhary, Director (S&T) North Eastern Council and Dr. D S Ramesh, Director, IIG at B N Goswami Hall, Assam University. In his inaugural speech Prof. Somnath Dasgupta talked about the importance of Science. Dr. V P Dimri stressed upon the importance of data and particularly mentioned the legacy of having long series of data both in terms of quality and quantity by IIG. Dr. Sailendra Choudhary assured us of co-operation by NEC for new projects in the North Eastern region. Dr. D S Ramesh elaborated the work of our Institute and talked about the importance of the magnetic observatories internationally.

One staff member from each of the twelve magnetic observatories operated by IIG and a five member team of Scientists and technical staff members from H.Q., Navi Mumbai participated in the workshop. Scientists gave talks on the basics of upper atmospheric current systems and its effects on geomagnetic field variations and few sessions on the calibration of DIM Instruments were also held during the Workshop.

Dignitaries engrossed in discussion during NGROSS 2014

XVIth IAGA Workshop on 'Geomagnetic Observatory Instruments, Data Acquisition and Processing' during October 2-16, 2014, jointly hosted with NGRI at NGRI, Hyderabad

The Workshop was formally inaugurated by Prof. Harsh Gupta, President IUGG on October 13, 2014. The representation of delegates were from 31 countries viz. Germany, USA, Belgium, UK, S Korea, Hungary, Japan, Russia, Kazakhstan, Austria, Australia, Czech, South Africa, Ireland, Canada, Denmark, Israel, France, Switzerland, Spain, W Samoa, Maldives, Sri Lanka, Russia, Syria, Romania, Slovenia, Poland and Ukraine. About 90 delegates participated in the Workshop of which 65 members attended the measurement sessions. Standard DIM Instruments of Tirunelveli and Alibag magnetic observatories were calibrated during this workshop. 45 Oral and 35 poster presentations were made at the scientific sessions. A wide range of topics were covered related to measurements and Scientific applications of observatory data to diverse phenomena viz. Earthquake and tsunami signatures, historical geomagnetic events, equatorial electrojet, equatorial plasma bubbles and application to GPS signals and modelling of Sudden Impulse events.

Azimuth determination with GNSS method at Choutuppal observatory, NGRI was carried out before the commencement of the IAGA workshop by staff members from ODAR-OBD division.

Dr. Nanabhoy Moos Research Fellowship Awards, October 29, 2014

To promote its research activities, the Institute has been conducting Research Scholarship programme every year attracting young post-graduates from Physics and Geophysics streams. A new Post-Doctoral Fellowship scheme was instituted during this year under the name of Dr. Nanabhoy Moos Research Fellowship (NMRF) whose aim is to further enrich and create scientific talent in a variety of disciplines in this Institute.

Dr. Nanabhoy Ardesher Framji Moos (1859-1936) was the first Director of Indian origin to head the Magnetic Observatory at Colaba, Mumbai and he held the prestigious Directorship for an eventful 23 years. Soon after his taking over as Director in 1896, electric trams were about to be introduced at the then Bombay. While appreciating the deleterious effects of the tram operation, Dr. Moos led the efforts to shift the instruments from the Colaba Observatory to Alibag, an alternate site situated about 30 km south-south east facing the Arabian Sea. Thanks to his leadership, Alibag Magnetic Observatory became operational from April 1904. Together with the recordings at Colaba, the Colaba-Alibag magnetic observatory data form a long series of more than 170 years.

The 156th birthday of Dr. Nanabhoy Moos, the first Indian Director of the Colaba-Alibag Observatories, falls on October 29, 2014. The Institute formally launched the Dr. Nanabhoy Moos Research Fellowship on the same day. This occasion was made special by the presence of Mrs. Silla Ardeshir, the granddaughter of Dr. Nanabhoy Moos and a few other members of Moos family who could make it for the award ceremony. The function was graced by Dr. V.P. Dimri, Chairman, Governing Council and Prof. Abhijit Sen, Chairman, Research Advisory Council. Former Directors of IIG, Prof. G.S. Lakhina and Prof. Archana Bhattacharyya were the special invitees. Adding flavour to the event, a special Coffee Table Book was released that captures the works and accomplishments of Dr. Nanabhoy Moos that were indeed time immemorial. As a tribute to the first Indian Director of the Colaba Observatory, the entire family tree of Moos descendants was traced out with valuable inputs from Mrs. Dhun Irani (who sat on the dais along with Mrs. Silla Ardeshir) and Mrs. Myrna Dalal, the great granddaughters of Dr. Nanabhoy Moos. The bio-sketch of Dr. Moos (Coffee Table Book) specially edited for this occasion lists out the various members of this tree. A few pictures of Dr. Moos and the instruments he handled are included in the Coffee Table Book. Those pictures depicting the past glory of Dr. Moos are ever to be treasured by the IIG community.

The candidates for the Dr. Nanahoy Moos Research Fellowship were carefully selected by an Expert Panel comprising of eminent scientists. The awardees of the first Fellowship were Dr. B. Remya, Dr. Lalit Joshi and Dr. Devanandan, who each received a plaque and the award letter from the hands of Mrs. Silla Ardeshir.

Director, IIG addressing the august gathering during inaugural function of NMRF

Release of Dr. Nanabhoy Moos's Bio-sketch

NMR Fellows along with the Director and a descendent of Dr. Nanabhoy Moos

Special session on the Dynamic Earth and its near and far Environment: new paradigms organized by Indian Institute of Geomagnetism at the 102nd Indian Science Congress, University of Mumbai, January 6, 2015

The focal theme of the session organized by IIG was on the Dynamic Earth and its near and far environment, particularly on the new paradigms that have emerged in recent years.

Eminent scientists from India and abroad deliberated upon various topics of relevance pertaining to the theme of the session.

Prof. V.K. Gaur, an Indian seismologist of international repute dealt with earthquake prediction in the short term and the hazard assessment. Earthquake hazard assessment of probable region and magnitude in the future can help quantify risks and suitable knowledge guided actions can be directed to minimize them. The lecture dealt with the hazard assessment using a Bayesian probabilistic estimate that takes into account all faults within a few hundred km that are capable of producing significant ground acceleration at the site. With the probabilities estimated for every location, an earthquake hazard map is generated for the whole region.

He concluded with the remarks that the theory of the precursory seismic signals needs to be rigorously researched. Rigorous experimental design and information theoretic approaches to signal detection and attribution and projection will have great potential in capturing genuine precursory signals for short term predictions.

Dr. Lucie Rolland from University of Nice, France, introduced ionospheric seismology. Rolland began with the remark that the ionosphere at altitudes of a few hundred kilometres from ground is sensitive to ground shaking. An acoustic wave generated during an earthquake can be enhanced in amplitude by 4 to 5 orders of magnitude when it reaches the maximum of ionization of the ionosphere, 7-8 minutes after the event. Using radio sounding techniques, one can detect several kilometres displacement of the ionosphere responding to one mm displacement of the ground. Measurements of total electron content are a powerful tool for monitoring such signals in the ionosphere. Rolland showed the post-seismic signatures within the ionosphere at the time of the great Japan earthquake of 2011. Dr. Rolland later proceeded to describe a typical modelling scheme that incorporated the neutral atmospheric motion first and then the electron density perturbation through an MHD model, to finally reconstruct the TEC perturbation. The speaker then summarized the development of 3D models that account for the seismic source (solid Earth/ atmosphere coupling), the propagation (winds, viscous attenuation), the state of the atmosphere and ionosphere and the geomagnetic field.

Prof. S.K. Tandon, a renowned Indian geologist touched upon the ongoing debate on CCGS and the means for it to be widely accepted and adopted. He explained the rationale behind opting for CCGS. The speaker placed the debate on the following issues: (i) Whether CCGS should be part of the technological mix in moving toward developing a non-fossil fuel low-carbon energy system, (ii) Including CCGS in

the technological mix that is supposed to lessen the fossil fuel impacts has the potential to bog us down even deeper, (iii) Might CCGS technologies simply deepen the current carbon and fossil fuel lock-in or does their inclusion 'in the mix' allow a breathing space whilst the longer term transition to a new low-carbon pathway is engineered.

The need to distinguish natural from anthropogenic causes of climate change places significant emphasis on quantifying and understanding the impact of the Sun. In her lecture, Prof. Joanna Haigh from Imperial College, London outlined what is known about variations in solar radiative output and reviewed the evidence for solar influences on climate. The global average temperature response is modest, but detectable, on century timescales. There is, however, increasingly robust evidence for somewhat larger solar signals on regional climate, particularly in mid-latitudes with influence on the positions of the jet streams and storm-tracks. An important factor driving this response appears to be the absorption in the stratosphere of solar ultraviolet radiation, followed by a dynamical coupling which transfers a solar signal to the atmosphere and surface below.

Life on our planet is crucially dependent upon the behavior of our Sun, both by way of long-term changes pertaining to its magnetic cycle and by way of short-term transients in its corona.

Dr. Prasad Subramanian, a solar physicist from IISER, Pune laid emphasis on coronal mass ejections (CMEs) from the Sun, which are the typical progenitors of space weather disturbances. Apart from causing a variety of disruptions in both space-based and ground-based technologies, the transients of solar origin affect astronaut safety, satellite drag, disruptions to space (radio) communications, GPS, etc. The speaker narrated the past large space weather events that resulted in major power grid blackouts, disabling of satellites, airline flight diversion, GPS outage, etc.

He also pointed out that precursors to Forbush decreases in galactic cosmic rays at the Earth provide advance information about parameters of the CME-associated shock, and hence the impending geomagnetic storm.

Dr. Nat Gopalaswamy from NASA dealt extensively with the properties of CMEs that affect Earth, how we observe them, and the difficulties in predicting their space weather consequences. Noting that the current solar cycle (24) is the weakest in the Space Age, the speaker noticed ccertain peculiarities like very late onset of storm activity, drop in major storms by 70% and sunspot number by 44% and there have been only 11 CMEs so far during the current cycle (compare this with solar cycle 23 wherein there were 36 CMEs).

The session organized by IIG was well attended. A large number of students and faculties from IIG participated in the deliberations. The convener arranged a separate discussion session at the end. Young scholars greatly benefited by interacting with the distinguished speakers.

Director with the convenor and distinguished national and international scientists

NASA senior scientist delivering his talk

Interaction of a student with an eminent French scientist

IMPRESS 2015 – Inspiring the Minds of Post-graduates for Research in Earth and Space Sciences

To attract, motivate and train young talent to undertake research in geomagnetism and allied fields, the institute has conceived the **"IMPRESS"** programme for post-graduate students from Indian universities during the year 2014. IMPRESS-2015 was organised at Equatorial Geophysical Research Laboratory (EGRL), Tirunelveli, a regional centre of the Indian Institute of Geomagnetism, Navi Mumbai) during February 16-20, 2015. A total of 18 participants from various Institutes/Universities across India and 41 internal participants (research scholars including RA and PDF's) from IIG HQ and two regional centres, KSKGR and EGRL participated.

The program consisted of research presentations by eminent scientists from earth sciences, atmospheric and space sciences during forenoon session. The afternoon sessions were devoted to the experimental setup/Laboratory procedures to explain the various techniques, instruments and applications by staff/Research Scholars. Actual working of the instruments, processing techniques and processed results were demonstrated during the course of the program.

A presentation on current Antarctic/Polar Research and IIG's contribution therein was organised during a pre-dinner session on February 16, 2015. Sunspot viewing and sky gazing was arranged on February 17, 2015 to excite and also de-stress the participants. An overview of IIG's research activities was presented on February 18, 2015, followed by a question-answer/quiz session, which was well received.

An excursion to Vivekananda Rock Memorial in Kanyakumari was organized for the participants on February 19, 2015.

The concluding day, February 20, 2015, comprised of IIG's current research activities in space, atmospheric and Earth sciences presented by researchers from IIG followed by an interactive feedback session and valedictory function. Written feedback and suggestions were received from the participants. The programme was very much appreciated from all the participants.

An IIG Scientist involved in discussion with potential young researchers

Demonstration of a magnetic instrument.

Handing out certificates to participating students

Inauguration of the Multi-parametric Geophysical Observatory at Shoal Bay-8 in South Andaman, March 30, 2015

The December 26, 2004 tsunami caused by an earthquake in the west coast of Sumatra, Indonesia wreaked havoc and resulted in unprecedented loss of lives and property in the islands of Andaman & Nicobar and elsewhere. Taking note of the immense magnitude of such natural hazards, the Department of Science and Technology, Govt. of India entrusted the Indian Institute of Geomagnetism (IIG) with the responsibility of setting up a Multi-Parametric Geophysical Observatory (MPGO) in this region and Shillong in the Northeast to monitor these disasters and also conduct research on the possible precursory mechanisms. It is believed that earthquakes leave precursory signatures in different seismogenic parameters prior to their occurrence. Thus, monitoring of electromagnetic emissions in varied frequency bands, variations in GPS

signals, water table fluctuations, and radon gas emissions from micro-fractures etc. during an earthquake preparatory phase has conceptualised the establishment of the MPGO at Port Blair.

The Honourable Union Minister of Science & Technology and Earth Sciences, Dr. Harsh Vardhan inaugurated the Multi-Parametric Geophysical Observatory (MPGO) at Port Blair, Andaman and Nicobar Islands, on 30 March 2015. The inaugural event of MPGO, Port Blair, was graced by the presence of the Honourable Lt. Governor of A&N Islands, Lt. Gen. A.K. Singh (Retd.), Honourable Member of Parliament, Shri Bishnu Pada Ray, Chief Secretary, Shri Anand Prakash, Adhyaksha, Zila Parishad, Mrs. V.K. Mariam Bibi and other officials of Andaman and Nicobar Islands administration, besides a good number of general public and school students. The inaugural function commenced with a welcome address by the Chairman, IIG Governing Council, Padmashree Dr. V. P. Dimri. The Honourable Union Minister presented mementos to the heads of the various departments of the Island administration who have contributed towards the setting up of the MPGO at Port Blair. The function concluded with the vote of thanks proposed by the Director, IIG, Prof. D. S. Ramesh.

This Multi-Parametric Geophysical Observatory (MPGO) at Shoal Bay, Port Blair hosts a variety of sophisticated instruments to monitor both long and short term excursions in the Earth's Magnetic field at varied frequencies using state-of-the-art Overhauser, Induction coil and Fluxgate magnetometers. These equipment record signals related to processes of the Earth's interior and the ionospheric phenomena. The MPGO would house hi-fidelity instruments by way of Very Broad Band Seismometer, Ground Accelerometer and GPS to document both vertical and horizontal components of the seismic disturbances. The attendant or induced water level changes and Radon Gas emissions will also be monitored continuously. In addition, various meteorological parameters are proposed to be recorded at the MPGO. Based on analyses of these observations, several precursory seismogenic signals can be distilled.

This Multi-Parametric Geophysical Observatory offers 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.

Lighting of lamp by dignitaries

All the dignitaries on the dias during inaugural function of MPGO, Port Blair

Hon'ble Minister Dr. Harsh Vardhan addressing the gathering

IIG STAFF WELFARE AND RECREATION CLUB

IIG Staff Welfare and Recreation Club started the year 2014-15 by organizing IIG's 42nd Annual Day celebration on April 1, 2014. The festivities spanned over two sessions. The morning session commenced with the Director presenting a brief account of the Institute's activities and achievements. Dr. Rajan Sivaramkrishnan, Director, National Centre for Antarctic and Ocean Research, Goa, was the Chief Guest. He delivered the Foundation Day lecture on "India's Scientific Endeavors in the Polar Regions". Employees contributing a major portion of their official work in Hindi were felicitated.

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 2014. The Club succeeded in making the Annual Day 2014 a successful event.

Annual General Body Meeting of the Club was held on November 17, 2014, which transacted all the business of the agenda in a cordial 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 Mrs. Annie George on November 30, 2014.

The Club organised a picnic to the serene Kihim beach on January 17, 2015 for the staff and their family members. There was an overwhelming response and everyone had a day full of fun, food and frolic.

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.

Chief Guest addressing the IIG staff on the Institute's foundation day

Mrs. Manju Singh, Senior Hindi translator of IIG receiving the Long Service Award from the Chief Guest

Chief Guest Dr. Rajan Sivaramkrishnan, Director, NCAOR, Goa along with the Director-in-charge and President, Welfare and Recreation Club, IIG

Performance by Research students in the cultural program on IIG's foundation day

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.

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 F
   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
Equatorial Geophysical Research Laboratory
Vittalapuram, Tirunelveli,
Tamil Nadu.

Head
Dr. K.S. Krishnan Geophysical Research Laboratory
Jhusi, Allahabad.

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, 2015

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 2014–2015.

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 2014–2015, 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.

No patent was filed nor technology transferred for commercial use.

IN SERVICE OF THE NATION.....

Since its inception in 1841, geomagnetic research pursued from the Colaba-Alibag observatories has travelled a long journey. Today, Geomagnetism is an area of study that is truly multidisciplinary encompassing such disciplines like physics, mathematics, geology, geophysics, atmospheric physics, plasma physics, fluid dynamics, geochemistry and non-linear dynamics, to name a few. 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 Colaba-Alibag Observatory has been producing high quality of photographic geomagnetic records for more than 150 years. The Institute currently operates 12 geomagnetic observatories and two regional centres. The Institute regularly participates in the Indian Expeditions to Arctic and Antarctic.

The vision of IIG is to enable India become a global knowledge centre by promoting, guiding and conducting basic and applied research in Geomagnetism and allied fields. 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. The World Data Center (WDC)-Geomagnetism, Mumbai, is now a member of the International Council for Science-World Data System. IIG is also involved in the calibration of magnetic compasses of Indian Navy, Indian Coast Guard, Naval Air Stations, etc. besides providing high resolution digital magnetic data to several research and other government organizations.

On the research front, IIG is engaged in understanding the processes occurring in the Earth's interior on various time scales using a variety of geophysical tools. In the areas of space geomagnetism and plasma physics, radio and optical remote sensing tools are used to probe the Earth's near space environment along with geomagnetic field variations as diagnostic tools. Several theoretical studies are being carried out on charged particles, electric fields and currents in the space environment comprising of the solar wind, magnetosphere and ionosphere. An instrumentation group caters to the need of the scientists in the development and maintenance of the instruments used in the Institute's observatories.

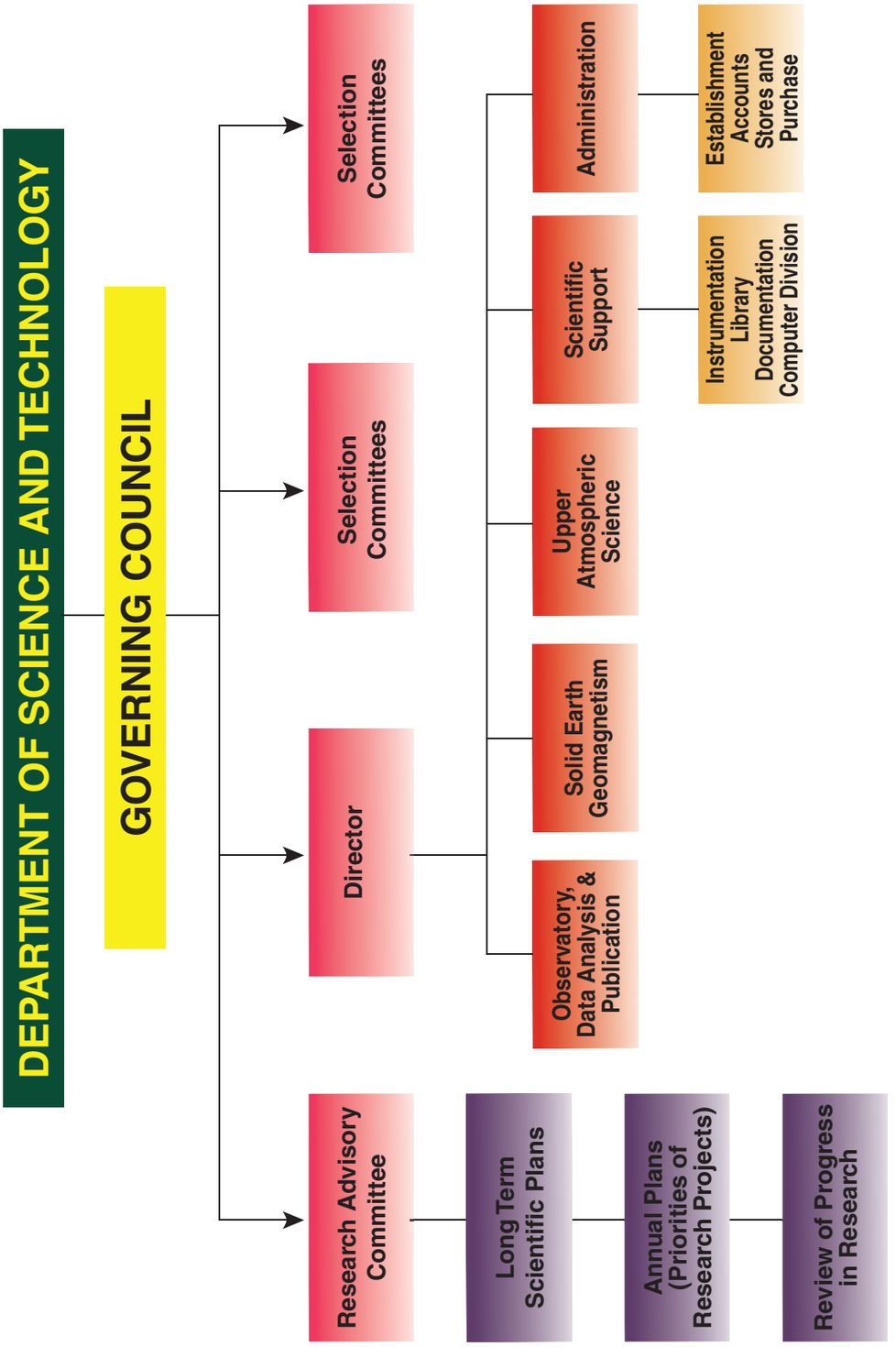
The Institute has been constantly making endeavours to mobilize its resources by extending its scientific and technical expertise as a part of Technology Development program, Consultancies and Services. To state a few, IIG partakes in national capacity building by imparting training/ courses to researchers from national and international Universities, with an aim of attaining higher goal of building individuals who would make lasting contributions to the progress of society. A National workshop on Geomagnetic Research and upgradation of Observational Skills of Staff was held at Magnetic Observatory, Silchar. Geophysical studies are carried as part of consultancy projects with DRDO, NHPC ONGC etc. Such research studies provide an opportunity to evaluate the potential of several types of energy resources in the country.

Groundwater being a natural and renewable resource plays a vital role in the socio-economic development of any region. IIG scientists routinely carry out electrical resistivity tomography investigations to identify potential aquifer zones and assess the quality of groundwater. As human kind faces the threat of global climate change, researchers at IIG are engaged in the multi-proxy reconstruction of past climate by analyzing several sediment cores from the Indian monsoon region. Such studies provide clues to identifying major environmental factors affecting human settlements in the recent geological past. Ionospheric seismology is an emerging discipline that links atmospheric and ionospheric disturbances with sources in earthquakes and tsunamis. In this context, IIG's new Multi-parametric Geophysical Observatory (MPGO) started functioning at Shoal Bay-8 in South Andaman. IIG proposes to upgrade the multi-parametric geophysical observatory at its Shillong observatory with the introduction of a variety of geophysical components.

Capacity building for scientific research is a major mission of the Institute. To attract, motivate and train young talent to undertake research in geomagnetism and allied areas, new initiatives have been made, such as 'Inspiring Minds of Post-graduates for Research in Earth and Space Sciences' (IMPRESS) and Dr. Nanabhoy Moos Post-Doctoral Fellowship to research scientists.

To conclude, it is the vision of IIG to make India innovative and add value to India's outstanding traditional knowledge base by acquisition and exploitation of high quality geophysical data leading to frontline research, impart training as a measure of capacity building, provide scientific facilities to scientists from within and outside the country and disseminate relevant information through public outreach programs.

ORGANIZATIONAL CHART OF THE INSTITUTE



Auditor Report
2014-2015

Item-wise replies to the Auditors observations in respect of the Audit Report for the year ended 31/03/2015

B

1) No action is required.
2) The materials under the head of margin money in the form of FDR of ₹95.27 lakhs, have already been received and accounted in Books of Accounts.
3) The movable and immovable properties previously belonging to IMD and in occupation of the Institute: Since the land belongs to the Government of India, the matter has been taken up at highest level with parent Ministry.
4) Out of the outstanding contingent advances of ₹16,02,100/-, a sum of ₹10,86,446/- has already been adjusted. The balance of ₹5,15,654/- will be adjusted soon.
5) No action is required.
6) No action is required.
7) The physical verification of fixed assets was carried out by the Institute. Loss of value due to depreciation etc. has also been worked out and proposal for write off of the loss is being submitted. On completion of this process, reconciliation of fixed assets with books will be carried out.
8) No action is required.
9) The Grant-in-aid received from the government and utilized for acquisition of immovable properties has been taken in the Books of Accounts. For some of the buildings, constructed out of these funds, the finalization of accounts have not been received. After completion of these processes, the value will be transferred to the Trust Fund.
10) Proposal for write off of an amount of ₹6,03,900/- have been sent to Department of Science & Technology for approval. The necessity for procurement of the Laboratory Equipment will be examined and based on this, decision will be taken as to whether provision have to be made or not.
11) Interest earned on advances to staff is accounted on accrual basis from current year.
12) The retirement fund is being managed by the Institute in a separate Bank Account and it is kept separately from business of IIG.
13) The In-charges of the two Regional Centers at Tirunelveli and Allahabad are vested with the power of operating Accounts, and the funds transferred to these Accounts are treated as advances till final settlement.
14) Inventory of stores, henceforth, will be maintained in Tally software.

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 2015, 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.

H.O.: 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

Branch Off.: 115, Shastri Nagar, Chittorgarh (Rajasthan) - 312001.

g. IIG is operating bank accounts at Tirunelvallei 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. 17,412/- 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.

i. 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 Note No.3 for non transfer of property, Note No.9 for accounting of government grants related to fixed assets, Note No.10 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 at 31st March 2015 and

   ii) In the case of the Income & Expenditure Account, of the Surplus for the financial year ended 31st March 2015.

For **NARENDRA SAMAR & Co.**
Chartered Accountants
Firm No. 126415W

Partner

Narendra Samar
Membership No.119521
Partner

Place: Thane
Date: 27/08/2015

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 2015

(Amount – Rs.)

CAPITAL FUND AND LIABILITIES	Schedule	Current Year	Previous Year
CAPITAL FUND	1	629801962	697311954
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	28307457	13077916
TOTAL		**658109419**	**710389870**
ASSETS			
FIXED ASSETS	8	635037102	678919541
INVESTMENTS – FROM EARMARKED / ENDOWMENT FUNDS	9	2750	2750
INVESTMENTS – OTHERS	10		
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	23069567	31467579
MISCELLANEOUS EXPENDITURE (TO THE EXTENT NOT WRITTEN OFF OR ADJUSTED)			
TOTAL		**658109419**	**710389870**

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 : 27/08/2015

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

R. Vinod Reddy
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 2015

(Amount – Rs.)

INCOME	Schedule	Current Year	Previous Year
Income from Sales / Services	12	0	0
Grants / Subsidies	13	257500000	251580000
Fees / Subscriptions	14	360526	223693
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	6929591	8751286
Other Income / Profit on sale of assets	18	4693552	1700025
Increase / (decrease) in stock of Finished goods and works-in-progress	19	0	0
TOTAL (A)		**269483669**	**262255004**

K. Kumar

R. Vinay Reddy

Cont...II

EXPENDITURE	Schedule	Current Year	Previous Year
Establishment Expenses	20	168262366	146560338
Other Administrative Expenses etc.	21	100210336	84459340
Expenditure on Grants, Subsidies etc.	22	1002140	490000
Interest	23	0	0
Loss on sale of Asset		18138	25292
Depreciation	8	67500681	61109552
TOTAL (B)		**336993661**	**292644522**
Balance being excess of Income over Expenditure (A-B) Transfer to Special Reserve (Specify each)		-67509992	-30389518
Transfer to / from Income and Expenditure A/c		0	0
Balance being deficit carried to Corpus / Capital Fund		**-67509992**	**-30389518**

See accompanying Notes to Accounts - Schedule 24

As per our Report of even dated 2014

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

For M/s. NARENDRA SAMAR & CO.

Chartered Accountants

Firm No. 126415W

Partner

Narendra Samar

Membership No. : 119521

Partner

Place : Thane

Dated : 27/08/2015

For INDIAN INSTITUTE OF GEOMAGNETISM

K. Kumar

ACCOUNTS OFFICER

R. Vinod Reddy

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 2015

(Amount – Rs.)

SCHEDULE 1 : CAPITAL FUND	Current Year as on 31/03/2015	Previous Year as on 31/03/2014
Balance as at the beginning of the year	697311954	727701472
Add : Contributions towards capital Fund		0
Add : Balance of net income transferred from the Income and Expenditure Account	-67509992	-30389518
BALANCE AS AT THE END OF THE YEAR	**629801962**	**697311954**

K. Kumar

R. Vinay Reddy

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 2015

(Amount – Rs.)

SCHEDULE 2 : RESERVES AND SURPLUS	Current Year as on 31/03/2015	Previous Year as on 31/03/2014
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 3 : EARMARKED/ENDOWMENT FUNDS	Current Year as on 31/03/2015	Previous Year as on 31/03/2014
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 4 : SECURED LOANS AND BORROWINGS	Current Year as on 31/03/2015	Previous Year as on 31/03/2014
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 5 : UNSECURED LOANS AND BORROWINGS	Current Year as on 31/03/2015	Previous Year as on 31/03/2014
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 6 : DEFERRED CREDIT LIABILITIES	Current Year as on 31/03/2015	Previous Year as on 31/03/2014
	NIL	NIL
TOTAL	NIL	NIL

SHEDULE 9 : INVESTMENTS FROM FARMARKED/ENDOWMENT FUNDS	Current Year as on 31/03/2015	Previous Year as on 31/03/2014
	NIL	NIL
TOTAL	NIL	NIL

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 2015

(Amount – Rs.)

SCHEDULE 7 – CURRENT LIABILITIES AND PROVISIONS			Current Year	Previous Year
A. CURRENT LIABILITIES				
1	Acceptances		0	0
2	Sundry Creditors:			
	a)	For Goods	37303	428597
	b)	Others	11601657	1007022
3	Securiy Depsoit Payable		678808	2649450
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	305116
TOTAL (A)			12317768	4390185
B. PROVISIONS				
1	Loss on interest for GPF		0	0
2	Gratuity		6363080	2407845
3	Superannuation / Pension		4601554	1952402
4	Accumulated Leave Encashment		4938746	1660080
5	Trade Warranties/Claims		0	0
6	Others current Liabilities (for expenses on telephone, electricity, water charges etc.)		86309	2667404
TOTAL (B)			15989689	8687731
TOTAL (A + B)			**28307457**	**13077916**

K. Kumar

R. Vinod Reddy

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 2015

(Amount – Rs.)

SCHEDULE 8 : FIXED ASSETS	GROSS BLOCK				DEPRECIATION					NET BLOCK	
DESCRIPTION	Cost / valuation as at beginning of the year 01/04/2014	Additions during the year	Deductions during the year	Cost/valuation at the year-end 31/03/2015	As at the beginning of the year 01/04/2014	On additions during the year	For the year 2014-15	On deductions during the year	Total up to the year-end 31/03/2015	As at the current year-end 31/03/2015	As at the previous year-end 31/03/2014
A. FIXED ASSETS											
1 LAND :											
a) Freehold	3493366	0	0	3493366	0	0	0	0	0	3493366	3493366
b) Leasehold	56466353	0	0	56466353	21720858	0	789670	0	22510538	33955815	34745485
2 BUILDINGS:											
a) On freehold Land	210391921	0	0	210391921	75717589	0	6733715.00	0	82451304	127940617	134674332
b) On Leasehold Land :	248509489	1288116	0	249797605	62892948	42702	9280828	0	72216478	177581127	185616541
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	439779761	26063863	0	465843624	245258398	2656002	29178204	0	277092604	188751020	194521363
4 MOTOR CAR VEHICLE	4402883	0	0	4402883	2949573	0	217997	0	3167570	1235313	1453310
5 FURNITURE, FIXTURES	23944257	988048	0	24932305	14942123	117286	900213	0	15959622	8972683	9002134
6 OFFICE EQUIPMENT	25607947	2321613	352139	27577421	15124479	121945	1525991	0	16772415	10805006	10173272
7 COMPUTER & SOFTWARE	105123206	22860174	4360	127979020	96279586	9303217	5304089	0	110886892	17092128	8840148
9 ELECTRIC INSTALLATIONS	3517974	852086	0	4370060	2962140	28247	83375	0	3073762	1296298	555834
10 LIBRARY BOOKS	36029400	1217200	0	37246600	36029400	0	1217200	0	37246600	0	0
TOTAL OF CURRENT YEAR	1157266557	55591100	356499	1212501158	573877104	12269399	55231282	0	641377785	571123373	583075785
PREVIOUS YEAR	93538962	26760007	24455213	95843756						0	0
B. CAPITAL WORK IN PROGRESS	95843756	5220295	37150322	63913729						63913729	95843756
TOTAL										635037102	678919541

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

K. Kumar

R. Vinay

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 2015

SHEDULE 10 – INVESTMENTS – OTHERS		Current Year	Previous Year
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

R. Vinod Reddy

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 2015

(Amount – Rs.)

SCHEDULE 11 : CURRENT ASSETS, LOANS, ADVANCES ETC.			Current Year	Previous Year
A. CURRENT ASSESTS				
1)	Inventories			
	a)	Stores and spares (closing bal. in stores)	569299	539748
	b)	Loose Tools		0
	c)	Stock-in-Trade		0
		Finished Goods		0
		Work-in-Progress		0
		Raw Materials		0
2)	Sundry Debtors:			0
	a)	Debts Outstanding for a period exceeding six months		0
	b)	Others		
3)	Cash Balances in hand (including cheques / drafts and imprest)			
	Head Office	----		
	Sub Office	9017.00	39017	39017
	Cash for emergency	25000.00		
	Petty Cash	5000.00		
4)	Bank Balances:			
	a)	With Scheduled Banks:		
		-- On Current Accounts – Bank of India, Panvel	3700264	3682106
		-- Union Bank of India, Panvel	64606	216044
		-- Bank of India, Allhabad	0	10000
		-- Bank of India, Tirunelvelli	159433	204334
		-- Bank of India, LC A/c. 365	679903	16865660
		SDR against purchase of equipment	9527000	0
5)	Advance for Franking Machine (Stamp in hand)		45036	38095
6)	Prepaid Expenses		0	62110
		TOTAL (A)	14784558	21657114

K. Kumar

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 2015

(Amount – Rs.)

SCHEDULE 11 : CURRENT ASSETS, LOANS, ADVANCES ETC.(CONTD.)			Current Year	Previous Year
B. LOANS, ADVANCES AND OTHER ASSETS				
1)	Loans			
	a)	Staff	2864130	4492821
	b)	Other entities engaged in activities / objectives similar to that of the entity		0
	c)	Other (specify)- Contingent Advances	1602100	2842530
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	1704073	2405528
3)	Income Accrued			
	a)	On Investments from earmarked / endowment funds	0	0
	b)	On Investments -- Others Accrued interest of SDR on LC	0	69586
	c)	On investment in SDR	0	0
	d)	Others (includes income due unrealized Rs.....) Accrued interest on HBA & interest receivable	2114706	0
4)	Claims Receivable		0	0
		TOTAL (B)	8285009	9810465
		TOTAL (A + B)	**23069567**	**31467579**

K. Kumar

R. Vinod Reddy

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 2015

(Amount – Rs.)

SCHEDULE 12 : INCOME FROM SALES / SERVICES	Current Year as on 31/03/2015	Previous Year as on 31/03/2014
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 15 : INCOME FROM INVESTMENTS (Income on Invest. From Earmarked/Endowment Funds transferred to Funds)	Current Year as on 31/03/2015	Previous Year as on 31/03/2014
	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 31/03/2015	Previous Year as on 31/03/2014
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 19 : INCREASE/(DECREASE) IN STOCK OF FINISHED GOODS & WORK IN PROGRESS	Current Year as on 31/03/2015	Previous Year as on 31/03/2014
	NIL	NIL
TOTAL	NIL	NIL

SCHEDULE 23 : INTEREST	Current Year as on 31/03/2015	Previous Year as on 31/03/2014
	NIL	NIL
TOTAL	NIL	NIL

K. Kumar

R. Vinod Reddy

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 2015

(Amount – Rs.)

SCHEDULE 13 : GRANTS/SUBSIDIES (Irrevocable Grants & Subsidies Received)		Current Year	Previous Year
1)	Central Government - Received from Department of Science & Technology	257500000	251580000
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	257500000	251580000

K. Kumar

R. Vinay Reddy

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 2015

(Amount – Rs.)

SCHEDULE 14 : FEES / SUBSCRIPTION			Current Year	Previous Year
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	18001	20510
	c)	License fees -- IIG	342525	203183
TOTAL			360526	223693

Note : Accounting Policies towards each item are to be disclosed

K. Kumar

R. Vinay Reddy

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 2015

SCHEDULE 17 : INTEREST EARNED			Current Year	Previous Year
1)	On Term Deposits:			
	a)	With Scheduled Banks	0	0
	b)	With Scheduled Banks (Bank of India) - From investment in SDR */LC	3549179	8157604
	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	3380412	593682
	b)	Others	0	0
4)	Interest on Debtors and Other Receivables		0	0
		TOTAL	6929591	8751286

Note : Tax deducted at source to be indicated

K. Kumar

R. Vin

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 2015

(Amount – Rs.)

SCHEDULE 18 : OTHER INCOME			Current Year	Previous Year
1)	Profit on Sale / disposal of Assets:			
	a)	**Owned assets**	3937	30735
	b)	Assets acquired out of grants, or received free of cost		
2)	**Income from Project**		160000	254001
3)	**Sale of data, PPM & Caliberation of equipment**		601328	0
4)	Miscellaneous Income			
	a)	**Income from hostel / Guest house**	855859	797127
	b)	**Miscellaneous receipt**	3072428	618162
TOTAL			**4693552**	**1700025**

K. Kumar

R. Vish

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 2015

(Amount – Rs.)

SCHEDULE 20 : ESTTABLISHMENT EXPENSES		Current Year	Previous Year
a)	Salaries	138174481	117829789
b)	Allowances and Bonus	1303832	1605556
c)	Employers Contribution to CPF	28930	26201
d)	Employers contribution to Other Fund (specify) – IIG Pension A/C	5713254	11303351
e)	Employers Contribution to Benevolent Fund	29270	25350
f)	Expenses on Employees Retirement and Terminal Benefits	17337014	11820306
g)	Others (specify) (Medical Expenses)	2648601	1960371
h)	Employers contribution to Recreation Club	102443	60325
I)	Employers contribution to New Contributory Pension Fund	2924541	1929089
	TOTAL	**168262366**	**146560338**

K. Kumar

R. Vinay Reddy

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 2015

(Amount – Rs.)

SCHEDULE 21 : OTHER ADMINISTRATIVE EXPENSES		Current Year	Previous Year
1	Advertisement and Publicity	2606508	1738854
2	Audit Fees	34151	50562
3	Bank charges	10862	8271
4	Binding charges	57570	58580
5	Canteen Subsidy	302325	659391
6	Conservation of old volumes	3191589	4533630
7	Design & Fabrication	159965	149494
8	Electricity and power / Charges	13447565	11702412
9	Entertainment / Hospitality	449567	380981
10	Garden Expenses	1574579	638677
11	Guest house maintenance / ChargesGueste house items	882140	889712
12	Hindi expenses / awards	166685	75616
13	House keeping expenses	2418057	2440868
14	IIG Annual Day A/c	188008	126290
15	Insurance	138681	87085
16	Journals	5760603	4001726
17	Liveries	15100	35359
18	Meeting expenses	411261	504659
19	Miscellaneous expenses	651362	626761
20	MPLS-Communication Link Charges	1469267	1640340
21	NGRI A/c.	0	64698
22	Postage, Telephone and Communication Charges / Internet charges	3821823	5174483
23	Printing and Publication	962112	578638
	Balance c/f	**38719780**	**36167087**

SCHEDULE 21-OTHER ADMINISTRATIVE EXPENSES		Current Year	Previous Year
	Brought Forward	**38719780**	**36167087**
24	Professional Charges / Consultancy Charges	1254549	884317
25	Registration fees	471444	146208
26	Rent, Rates and Taxes	168874	258796
27	Repairs and Maintenance	10445139	7353824
28	Science week celebration / Exhibition	83503	278834
29	Scientific Expenses	1189941	1803600
30	Security services	15272894	14532666
31	Staff welfare	268870	523029
32	Stores consumed	4913426	5364088
33	Survey expenses	359391	1050187
34	Traveling and Conveyance Expenses	16177741	12696292
35	Vehicle maintenance	1028278	552825
36	Visiting scientist / seminar / fees etc.	953000	0
37	Water charges	677217	746570
38	Wages to Contingent Mazdoors	7140650	2101017
39	EGRL Impress	588143	0
40	Moos Fellowship	245498	0
41	Silchar Workshop	251995	0
	TOTAL	**100210333**	**84459340**

K. Kumar

R. Vinod Reddy

INDIAN INSTITUTE OF GEOMAGNETISM ★ KALAMBOLI, NAVI MUMBAI ★

15

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 2015

(Amount – Rs.)

SCHEDULE 22 : EXPENDITURE ON GRANTS,SUBSIDIES ETC	Current Year	Previous Year
a) Grants given to Institutions / Organizations	1002140	490000
b) Subsidies given to Institutions / Organizations	0	0
TOTAL	1002140	490000
Note : Name of the Entities, their Activities along with the amount of Grants/subsidies are to be disclosed .		

K. Kumar

R. Vinay Reddy

INDIAN INSTITUTE OF GEOMAGNETISM-2014-2015

Kalamboli Highway,
New Panvel
Navi Mumbai

Current Liabilities

Group Summary

1-Apr-2014 to 31-Mar-2015

Page 1

Particulars	Opening Balance	Transactions Debit	Transactions Credit	Closing Balance
Duties & Taxes		*1,95,69,825.00*	*1,96,23,625.00*	**53,800.00 Cr**
INCOME TAX-PAYABLE		89,37,195.00	89,37,195.00	
PROFESSIONAL TAX-PAYABLE		3,03,700.00	3,03,900.00	200.00 Cr
TDS		9,78,210.00	9,78,210.00	
INCOME TAX-(TDS ON OTHERS)		77,063.00	77,063.00	
Income Tax (TDS ON SALARIES)		89,37,195.00	89,37,195.00	
PERFORMANCE GURRANTE			49,189.00	*49,189.00 Cr*
Professional Tax		3,03,900.00	3,03,900.00	
Professional.Tax-Others		15,150.00	15,150.00	
WCT 2%		17,412.00	21,823.00	*4,411.00 Cr*
Provisions	**86,87,731.00 Cr**	*77,28,108.00*	*1,50,30,066.00*	**1,59,89,689.00 Cr**
Other Current Liabilities	26,67,404.00 Cr	25,81,095.00		86,309.00 Cr
PROVISION FOR PENSION,GRATUITY & LEAVE ENCASHMENT	60,20,327.00 Cr	51,47,013.00	1,50,30,066.00	1,59,03,380.00 Cr
Sundry Creditors	**43,90,185.00 Cr**	*18,57,88,044.00*	*19,26,59,621.00*	**1,12,61,762.00 Cr**
BENEVOLENT FUND PAYABLE		*27,120.00*	*27,120.00*	
BENEVOLENT FUND PAYABLE-CLASS II & IV STAFF		4,215.00	4,215.00	
BENEVOLENT FUND PAYABLE-OFFICER STAFF		14,325.00	14,325.00	
BENEVOLENT FUND PAYABLE-OUTSTATION STAFF		8,580.00	8,580.00	
GPF PAYABLE		*1,06,01,210.00*	*1,06,01,210.00*	
GPF PAYABLE-CLASS III & IV STAFF		8,82,142.00	8,82,142.00	
GPF PAYABLE-OFFICER STAFF		77,50,613.00	77,50,613.00	
GPF PAYABLE-OUTSTATION STAFF		19,68,455.00	19,68,455.00	
IIG NPS PAYABLE		*28,98,439.00*	*28,98,439.00*	
IIG NPS PAYABLE-CLASS III & IV STAFF		2,34,407.00	2,34,407.00	
IIG NPS PAYABLE-OFFICER STAFF		12,93,660.00	12,93,660.00	
IIG NPS PAYABLE-OUTSTATION STAFF		13,70,372.00	13,70,372.00	
IIG RECREATION & WELFARE FUND PAYABLE		*45,000.00*	*45,000.00*	
R & W CLUB FUND PAYABLE-CLASS III & IV		7,125.00	7,125.00	
R & W CLUB FUND PAYABLE-OFFICER STAFF		26,675.00	26,675.00	
R & W FUND RESEARCH SCHLOAR AND OTHERS-PAYABLE		11,200.00	11,200.00	
RETENTION MONEY		*2,18,859.00*	*2,56,162.00*	**37,303.00 Cr**
RETENTION MONEY-LOCUZ		2,18,859.00	2,18,859.00	
RETIONTION MONEY-KARAN BUILDERS			37,303.00	*37,303.00 Cr*
SALARY-PAYABLE		*9,34,22,676.00*	*9,34,30,410.00*	**7,734.00 Cr**
SALARY-PAYABLE-CLASS III & IV		70,39,321.00	70,39,321.00	
SALARY PAYABLE-OFFICER		5,87,68,769.00	5,87,76,503.00	7,734.00 Cr
SALARY PAYABLE-OUTSTATION		2,76,14,586.00	2,76,14,586.00	
Security Deposit From Others			*2,01,192.00*	**2,01,192.00 Cr**
Intelligent Integration-Security Deposit			9,400.00	*9,400.00 Cr*
SD-MAHARASHTRA SECURITY SERVICES,KOLHAPUR			92,000.00	*92,000.00 Cr*
SD-R.NONGDHAR SHILLONG			12,751.00	*12,751.00 Cr*
SD-SCOTLAND SECURITY SERVICES,WALTAIR			75,000.00	*75,000.00 Cr*
SD-SWASTIK ENTERPRISES,NAGPUR			12,041.00	*12,041.00 Cr*
Benevolent Fund (CONTR:435,VOL:5)		*27,120.00*	*27,120.00*	
B.K.ENTERPRISES-PERFORMANCE GUARANTEE			*12,060.00*	12,060.00 Cr
EPF EMPLOYER'S CONTRIBUTION-PAYABLE		*28,930.00*	*28,930.00*	
GPF-DIRECTOR		*3,00,000.00*	*3,00,000.00*	
GPF- IIG		*1,09,01,210.00*	*1,09,01,210.00*	
Carried Over	**1,30,77,916.00 Cr**	***33,15,56,541.00***	***34,60,42,165.00***	**2,75,63,540.00 Cr**

R. Vimala Reddy

K. Kumar

continued ...

INDIAN INSTITUTE OF GEOMAGNETISM-2014-2015

Current Liabilities Group Summary : 1-Apr-2014 to 31-Mar-2015 Page 2

Particulars	Opening Balance	Transactions Debit	Transactions Credit	Closing Balance
Brought Forward	**1,30,77,916.00 Cr**	***33,15,56,541.00***	***34,60,42,165.00***	**2,75,63,540.00 Cr**
IIG NPS		*28,98,439.00*	*28,98,439.00*	
IIG PENSION ACCOUNT NO.12144		*56,87,236.00*	*56,87,236.00*	
INCOME TAX-OTHERS-PAYABLE		*82,113.00*	*82,113.00*	
LIC PREMIUM		*5,74,318.00*	*5,74,318.00*	
Prof.Tax-Others-Payable		*15,650.00*	*15,150.00*	500.00 Dr
Recreation and Welfare Fund		*45,000.00*	*45,000.00*	
REIMBURSEMENT OF TUTION FEE-PAYABLE			*1,67,812.00*	1,67,812.00 Cr
Research Scholarship and Others-Payables		*1,12,85,878.00*	*1,12,85,878.00*	
SECURITY DEPOSIT (5%) ON CONTRACTOR			*4,40,905.00*	4,40,905.00 Cr
SECURITY DEPOST 10% FOR CONTRACTOR			*24,651.00*	24,651.00 Cr
SHREEM ASSOCIATES-PERFORMANCE GUARNTEE		*10,820.00*	*10,820.00*	
Society		*52,39,750.00*	*52,39,750.00*	
TDS ON PROFESSIONAL CHARGES-PAYABLE-2014-15		*5,29,792.00*	*5,37,681.00*	7,889.00 Cr
Wages-Payable		*4,61,625.00*	*5,47,373.00*	85,748.00 Cr
WCT-PAYABLE			*17,412.00*	17,412.00 Cr
Grand Total	**1,30,77,916.00 Cr**	***35,83,87,162.00***	***37,36,16,703.00***	**2,83,07,457.00 Cr**

2

K. Kumar

R. Vinay Reddy

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

SCHEDULE – 8A(1a)

YEAR ENDING 31/03/2015

FREEHOLD LAND

AS ON 31/03/14	PARTICULARS	AS ON 31/03/15
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

R. Vinod Reddy

INDIAN INSTITUTE OF GEOMAGNETISM
NEW PANVEL NAVI MUMBAI
YEAR ENDED 31-03-2015

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 31-03-14	Additions during the year	Deduction during the	Cost/Value at 31-03-15	On Value 01/04/14	On addition during the year	For the year 2014-15	On deduction	Deduction during the year	Upto 31-03-15	Cost as at 31-03-14
1	Building - Capital Works	10730609.87	0.00	0.00	10730609.87	5745167.87	0.00	249272	0.00	5994439.87	4736170.00	4985442.00
2	Building - Belapur Quarters	19661930.13	0.00	0.00	19661930.13	11463492.13	0.00	409922	0.00	11873414.13	7788516.00	8198438.00
3	Building - Gulmarg	170337.27	0.00	0.00	170337.27	147029.27	0.00	1165	0.00	148194.27	22143.00	23308.00
4	Building - Nagpur	2052175.12	0.00	0.00	2052175.12	1035672.12	0.00	50825	0.00	1086497.12	965678.00	1016503.00
5	Building - Alibag Mavacs	225000.00	0.00	0.00	225000.00	159485.00	0.00	3276	0.00	162761.00	62239.00	65515.00
6	Building - Prefabricated Structure	155235.00	0.00	0.00	155235.00	118918.00	0.00	1816	0.00	120734.00	34501.00	36317.00
7	Building - Space Sci.Lab. Kolhapur	153338.00	0.00	0.00	153338.00	108689.00	0.00	2232	0.00	110921.00	42417.00	44649.00
8	Building - Wilton Hall	531374.51	0.00	0.00	531374.51	471575.51	0.00	2990	0.00	474565.51	56809.00	59799.00
9	Building - P.R. Radar Tower Kolhapur	972012.00	0.00	0.00	972012.00	550149.00	0.00	21093	0.00	571242.00	400770.00	421863.00
10	Building - Pondicherry	2459332.56	0.00	0.00	2459332.56	1250599.56	0.00	60437	0.00	1311036.56	1148296.00	1208733.00
11	Building & Quarters - EGRL	8327194.00	0.00	0.00	8327194.00	4624210.00	0.00	185149	0.00	4809359.00	3517835.00	3702984.00
12	Building - Alibag Quarters	7454672.00	0.00	0.00	7454672.00	4339385.00	0.00	155764	0.00	4495149.00	2959523.00	3115287.00
13	Building - Vishakhapatnam	907924.00	0.00	0.00	907924.00	505249.00	0.00	20134	0.00	525383.00	382541.00	402675.00
14	Building - Jaipur	5646974.00	0.00	0.00	5646974.00	2784248.00	0.00	143136	0.00	2927384.00	2719590.00	2862726.00
15	Building - GRL Allahabad	75546986.23	0.00	0.00	75546986.23	25219158.23	0.00	2516391	0.00	27735549.23	47811437.00	50327828.00
16	Building - Rajkot	4280804.00	0.00	0.00	4280804.00	1454185.00	0.00	141331	0.00	1595516.00	2685288.00	2826619.00
17	Building - Shillong (Boundry Wall)	6916354.00	0.00	0.00	6916354.00	2174343.00	0.00	237101	0.00	2411444.00	4504910.00	4742011.00
18	Building, Guest House, Hostel-EGRL	48252012.00	0.00	0.00	48252012.00	11956563.00	0.00	1814772	0.00	13771335.00	34480677.00	36295449.00
19	Building - Silchar	14715046.00	0.00	0.00	14715046.00	1586000.00	0.00	656452	0.00	2242452.00	12472594.00	13129046.00
20	Building - Colaba (WDC)	1232610.00	0.00	0.00	1232610.00	23470.00	0.00	60457	0.00	83927.00	1148683.00	1209140.00
	TOTAL	**210391920.69**	**0.00**	**0.00**	**210391920.69**	**75717588.69**	**0.00**	**6733715.00**	**0.00**	**82451303.69**	**127940617.00**	**134674332.00**

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

YEAR ENDING 31/03/2015

SCHEDULE – 8(B)

ADVANCES FOR IMMOVABLE PROPERTIES CAPITAL WORKS IN PROGRESS (A)

Particulars	As on 31/03/14	Additions during the year	Deduction during the year	As on 31/03/15
Capital work in progress – Nagpur	289514	0	0	289514
Capital work in progress – Rajkot (CPWD)	1049315	0	0	1049315
Capital work in progress – Jaipur	29026	439748	0	468774
Capital work in progress – Kolhapur	5219391	0	4915595	303796
Capital work in progress – CPWD Alibag	1700000	0	0	1700000
Capital work in progress – Allahabad	12240100	0	0	12240100
Capital work in progress – EGRL	490528	318900	0	809428
Capital work in progress – Portblair	27241807	422397		27664204
Capital work in progress – Flatlets/Dir Bung, Staff Qtrs	400000	0		400000
Capital work in progress – Pondicherry	3365296			3365296
Capital work in progress – Shilong	2419948	1945000	0	4364948
Capital work in progress – Belapur	1621656	0	0	1621656
Capital work in progress – Vishakapatnam	6388	0	0	6388
Capital work in progress – Panvel	5948564	0	0	5948564
Capital Work in progress - Hostel	834466	0	0	834466
Capital Work in progress - Silchar	0	2094250	0	2094250
TOTAL	**62855999**	**5220295**	**4915595**	**63160699**

K. Kumar

R Vimp Rally

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

YEAR ENDING 31/03/2015

SCHEDULE – 8(B)

ADVANCES FOR MOVABLE PROPERTIES CAPITAL WORKS IN PROGRESS (B)

Particulars	As on 31-03-14	Additions during the year	Deduction during the year	As on 31-03-15
Advances for Laboratory Equipment (Exp.)	850305.00	0.00	97275.00	753030.00
Margin Money	32137452.00	0.00	32137452.00	0.00
TOTAL	**32987757.00**	**0.00**	**32234727.00**	**753030.00**

CAPITAL WORKS IN PROGRESS

A) ADVANCES FOR IMMOVABLE PROPERTIES	**63160699.00**
B) ADVANCES FOR MOVABLE PROPERTIES	**753030.00**
TOTAL	**63913729.00**

K. Kumar

R. Vinay Reddy

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	129718	1661391	143080	1648029
Stationery / Chart Rolls & Printing of stationery : 1) Stationery / Chart Rolls 2) Pringing of stationery	215717	516535	182997	549255
Electrical Goods & Electronic Components	108424	2679645	201843	2586226
Photo Goods	85889	85406	41379	129916
TOTAL	539748	4942977	569299	4913426

K. Kumar

R. Vinay Reddy

INDIAN INSTITUTE OF GEOMAGNETISM

NEW PANVEL, NAVI MUMBAI – 410 218.

SCHEDULE – 11A(2b)

YEAR ENDING 31/03/2015

ADVANCE AND DEPOSITS WITH OTHERS

AS ON 31/03/14		PARTICULARS	AS ON 31/03/15	
RS.	PS.		RS.	PS.
76040		Deposit Tele / Telex MTNL	74387	
47730		Deposit MSEB, Alibag	47730	
14200		Deposit LPG Gas (Mumbai & Panvel)	14200	
72100		Deposit Telephones (All outstations)	72100	
2590		Deposit BEST Security	3470	
4700		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)	40000	
384000		Deposit MSEB, Panvel	384000	
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	
775		GSILI Recoverable	0	
550		Deposit HP Gas, Panvel	550	
1000		Deposit MTNL, Panvel (Guest House)	1000	
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	
0		TDS Receivable	0	
1850		Deposit LPG Gas Portblair	1850	
1900		Deposit LPG GAS Silchar	1900	
320		Deposit Mobile Vodafone	320	

100000	Deposit Security at Assam Silchar	100000
773136	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
5000	Deposit Profession Tax A/c.	0
500	Deposit Reliance Telephone	500
25000	Deposit Victory Automobiles	25000
1060	Deposit MSEDCL Belapur quarters	1060
3480	Deposit MSEDCL Kolhapur	3480
25200	Profession Tax	0
0	Deposit MSEDCL Panvel	71300
152175	NHPC A/c.	152175
66890	NMRL/DRDO Project	66890
0	ALLAHABAD BANK OF INDIA	31269
2405528	**TOTAL**	**1704073**

K. Kumar

R. Vimal Reddy

INDIAN INSTITUTE OF GEOMAGNETISM

NEW PANVEL, NAVI MUMBAI – 410 218.

SCHEDULE 11B(1)

YEAR ENDING 31/03/2015

ADVANCE TO STAFF

AS ON 31/03/14	PARTICULARS	AS ON 31/03/15
RS. PS.		RS. PS.
371113	Travelling Allowance	74391
37500	Festival	64875
742677	Leave travel concession	46178
151500	Scooter	104500
2085541	House Building	1446575
66647	Foreign T.A.	0
198250	Computer	177150
839593	Motor Car	950461
0	TA on Transfer	0
4492821	**TOTAL**	**2864130**

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

Schedule – 24
SIGNIFICANT ACCOUNTING POLICIES AND NOTES ON ACCOUNTS FORMING THE PART OF BALANCE SHEET & INCOME & EXPENDITURE 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 payment basis except those expenses/income outstanding as on 31/03/2013 are accounted on accrual basis and Government grant 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.

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. Margin money in form of FDR Rs.95.27lacs
3. Properties worth Rs.113,18,789.00 (movable 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 by the Government of India. Realizable value of movable properties worth Rs.8, 83,000/- is in occupation of IIG previously belong to IMD still not conveyed to IIG is now NIL.
4. Contingent Advances –

   Contingent Advances balance as on 31.03.2015 is Rs.16,02,100/-. Out of the above amount, Rs.10,86,446/- has been settled up to 26.08.2015.
5. 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.
6. The management has carried out Physical verification of closing stock.
7. Physical Verification & reconciliation of fixed assets with books was not carried out by management.
8. Capital work in progress as on 31.03.15 is verified and certified by management / respective authorities.
9. Income & Expenditure Account credit balances include a substantial major portion of Grants-in-Aid received from Government of India and utilized for acquisition of immovable properties and advances made to purchase of immovable properties. The same, however, is not transferred to Trust Fund or Corpus Account, nor is the account ascertained.
10. Advance for Movable property Capital works includes Rs.6,03,900 (paid in 2002-03) represents the cost of Lab equipments 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.
11. In previous year the Interest on Staff Advances is accounted on Receipt basis but from the current year Interest on Staff Advance is accounted on Accrual basis.

12. 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.

13. IIG is operating different Bank Accounts for convenience purpose in the name of observatories like Bank of India, Tirunelvelli & Bank of India, Allahabad. Bank of India, Tirunelvelli is accounted as a Bank Account but Bank of India, Allahabad is shown in Loans & Advances in the name of observatories. IIG have no control over withdrawal and depositing of money

14. Inventory stores are not maintained in tally software.

As per our Report of even dated

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

Partner

Narendra Samar
Membership No.119521
Partner

Place: Thane
Date: 27/08/2015

For Indian Institute of Geomagnetism

K. Kumar
Accounts Officer

R. Vinod Reddy
The Director for Trustee