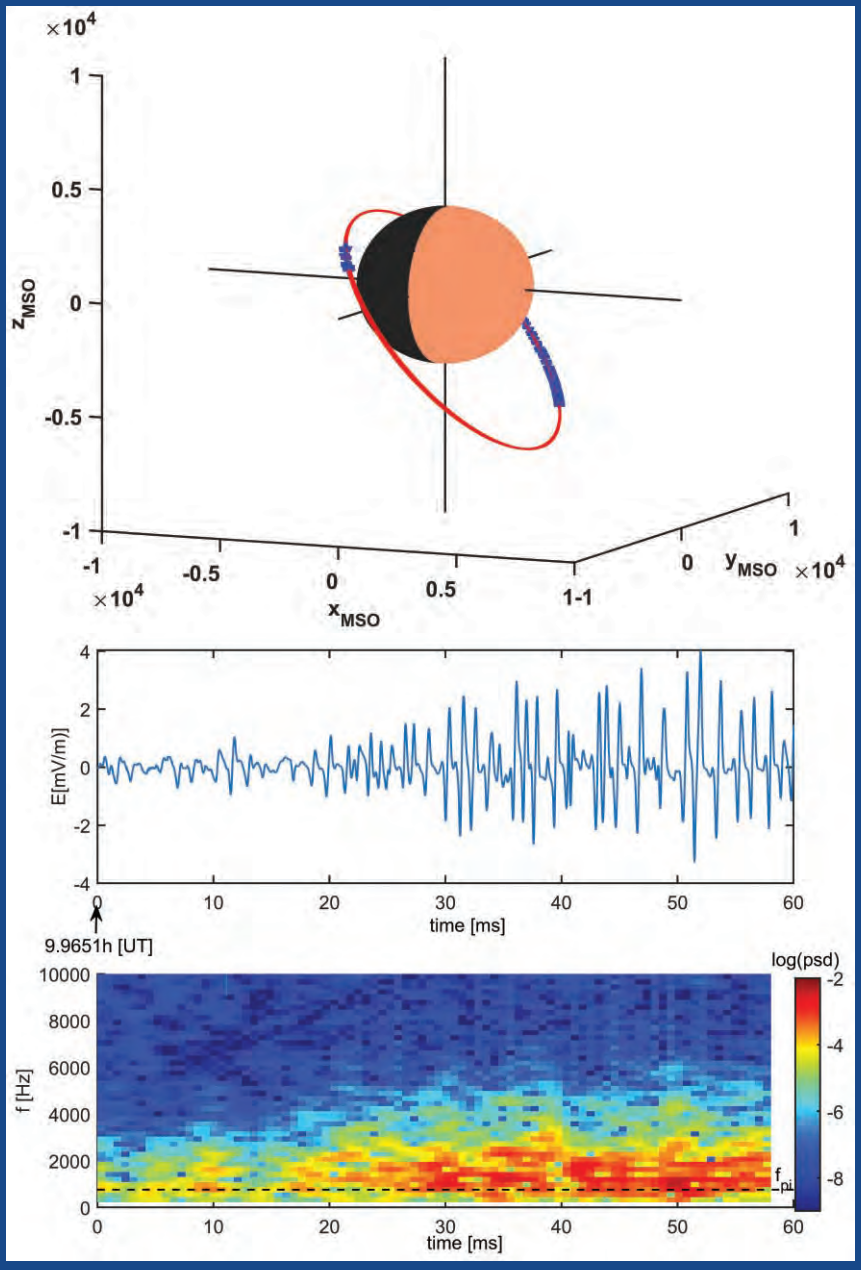
Annual Report 2022-23



Indian Institute of Geomagnetism

New Panvel, Navi Mumbai

INDIAN INSTITUTE OF GEOMAGNETISM

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

PUBLICATION COMMITTEE

Satyavir Singh, B. Veenadhari, Gautam Gupta, Remya Bhanu, Smita Chandra, B. I. Panchal, Jeetendra Kamra

COVER PAGE:

Upper panel shows the orbit (red color) of Mars Atmosphere and Volatile Evolution (MAVEN) satellite around Mars on 9 February 2015. The occurrences of bipolar electric field pulses are marked in blue along the path of MAVEN. An example of a series of bipolar electric field pulses observed by the MAVEN is shown in the middle panel and its spectrogram is shown in the lower panel. The plotted electric field is the y-component of the electric field recorded in the spacecraft coordinate system. The ion plasma frequency is shown by the black dotted horizontal line in the lower panel. The power spectral density (PSD) is in units of square millivolts per meter per hertz.

INDIAN INSTITUTE OF GEOMAGNETISM

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From the Director's Desk…..

Director's Foreword

I am delighted to present the report for the year 2022-2023. This is my first annual report since assuming the charge of Director of IIG, and what a challenging year it has been. It is our endeavour to understand the past, inform the present and improve the future. Our focus is on advancing fundamental research aimed at comprehending human and other impacts on our planet and developing future-oriented technologies and solutions. The achievements in various significant categories have acknowledged the excellence and societal impact of our research programs. We have experienced continued success in expanding our diverse research activities, engaging in knowledge translation initiatives, and fostering collaboration and expertise with other academic and professional institutions.

IIG primarily operates as an observatory-based institute, having 12 facilities across India. Our magnetometer network, equipped with cutting-edge GEM Overhauser, PPMs, and Magson DFM instruments, ensured uninterrupted data collection at our magnetic observatories. These crucial datasets play a pivotal role in upholding high standards amidst advancements in technology. IIG takes pride in its strategically developed research areas, which are highly interdisciplinary and address emerging challenges in lithospheric, atmospheric, ionospheric, and magnetospheric sciences. Embracing inherent complexities, our research tackles the most important challenges we anticipate in the future.

On the research front, Spectral Resonance Structures (SRS) in Shillong's magnetic field power spectrum (0.1-10 Hz) display multiple maxima and minima. Two simultaneous SRS with different frequency separations are seen which is more prevalent in winter (47% occurrence). These events relate to the ionosphere's refractive index variability, particularly in the Bx magnetic field component.
The St. Patrick's Day storm in 2015 caused significant plasma depletion near the sunset terminator. Simulations indicate an equatorial vertical drift at sunset as the cause, strengthening the Equatorial Ionization Anomaly. Such active space weather events can disturb plasma density in the equatorial and low latitude ionosphere, impacting HF radio wave communication. Another weak geomagnetic storm on 24 December 2014, observed unusual penetration electric field perturbations in the Indian dip equatorial sector after sunset, which is a deviation from existing understanding. Measurements from the CADI ionosonde at Tirunelveli showed unexpected vertical drifts, influenced by interplanetary magnetic field (By) and substorm effects.

The GPS-TEC observations near the Equatorial Ionization Anomaly (EIA) crest from 2005 to 2019 were analyzed and compared with IRI-2016 model predictions. The model tends to overestimate TEC at noon

and underestimate it at night, with biases varying based on solar activity and seasons, highlighting the need for improvements in low latitude regions.

The mesospheric bores at northern high and mid latitudes using data from ISEE's OMTI network were analyzed with five years of airglow imager data from Tromso, Norway, during winter. A total of 10 bore events were identified out of 172 clear sky nights, indicating low occurrence at northern high latitudes. Such a study on mesospheric bores at Rikubetsu, Japan (mid-latitude site), is ongoing.

Additional evidence supporting the role of gravity waves in equatorial plasma bubble (EPB) formation was examined. Analysis of air glow and ionosonde data from Kolhapur and Tirunelveli respectively for two nights with distinct EPB structures under similar geomagnetic and ionospheric conditions suggested a close relationship between EPBs and upper mesospheric gravity waves. Investigating precursor circumstances and seeding of EPBs is crucial, considering day-to-day variability, a challenging aspect of EPB research.

On 31 March 2001, a rare and notably large Geomagnetically Induced Current (GIC) event occurred at the geomagnetic equator. The magnetic field at Tirunelveli station experienced a rapid drop of about 350 nT in 5 minutes, with a concerning peak change of 136 nT/min. Simulations attributed this to strong westward electric fields and ionospheric currents, emphasizing the potential impact of density reduction in magnetic clouds on electric power grids.

Alfvénic fluctuations in space and astrophysical plasma were examined for their role in heating and work done. Polytopic analysis of Wind spacecraft data indicated super-adiabatic behavior and the transfer of energy from the Alfvénic zone to the surrounding plasma.

Ion fluxes of O+, He+, and H+ ions during geomagnetic storms were studied using Van Allen Probes data. Differences in ion flux enhancement and response to solar wind parameters were observed at different energies and L-values, with longer durations for Corotating Interaction Region (CIR)-driven storms. The influence of prompt penetration electric fields on the East Asian sector ionosphere was investigated during a space weather event in November 2021. Oscillations in ionospheric electrodynamics and wavelet spectra analysis suggested a relationship with prompt penetration electric fields.

Geomagnetic storm effects and Prompt Penetration of Electric Field (PPEF) over the Indian region were examined. PPEF signatures were identified using correlation coefficients, consistency across magnetic stations, and model confirmation. The intensity of geomagnetic storms impacted plasma distribution and equatorial ionization anomaly (EIA) patterns. A minor geomagnetic storm activity in February 2022 caused unexpected ionospheric variations over the American sector. Loss of SpaceX satellites and changes in thermospheric composition and temperature were observed. Storm-induced thermospheric wind and disturbance dynamo electric field contributed to the ionospheric variations.

MAVEN observed bipolar electric field pulses in the Martian magnetosheath, modeled as ion-acoustic solitary wave structures. Saturn's plasma environment generated ion Bernstein-Greene-Kruskal (BGK) modes, and dusty plasma environments affected dust-acoustic electrostatic solitary waves in Saturn's magnetosphere. EMIC waves were studied through ground and spacecraft observations, showing spatial and temporal variations during geomagnetic storms. Crustal magnetic fields on Mars were found to enhance electron density in the ionosphere.

Research focused on plasma processes in solar wind-magnetosphere energy exchange, chorus properties, and electrostatic solitary waves in Earth's magnetosphere and Lunar wake. Optical remote

sensing of the MLTI region was used to study dynamical and electrodynamical processes.
A theoretical model has been developed to study the middle region of Jupiter's magnetosphere, which is applied to the magnetosphere of Ganymede, a natural satellite with an intrinsic dipole magnetic field opposite to Jupiter's. The model calculates the spatial and temporal structures of field line eigen modes within Ganymede's mini-magnetosphere.

In solid earth research, several geophysical investigations were undertaken with emphasis on the Deccan Volcanic Province. A comparative study of the VGP's of dykes of Singhbhum and Bundelkhand Cratons, shows that the dykes of both regions are of the same age group. Urban traffic-related atmospheric pollution in Prayagraj is a major health concern due to urbanization and population growth. 118 samples from tree leaves, bark, and topsoil in the eastern part revealed two hot spots with magnetite-like particles, originating from particulate emissions caused by urban activities, including traffic. These emissions likely contribute to higher aerosol levels in Prayagraj, potentially impacting the local climate. Another study was conducted in the Purna River Basin sediments to investigate the area's palaeoclimate and palaeoenvironmental conditions. The sediments and soil in the basin is uninvestigated and are potential archives for understanding the past neotectonic and Late Quaternary evolutionary history. 112 sediment samples from the Parad section of the basin were collected and the results reveal that the sediments contain strongly ferrimagnetic based minerals. Indian archaeological artefacts have been used to explain the pre-historic geomagnetic field variations for estimating the absolute geomagnetic field intensity, because the long-term variation of past Earth magnetic field components is virtually unknown for the region.

A societal study was aimed to evaluate the corrosion severity due to groundwater usage by analyzing 43 water samples' chemical composition in the Mann River Basin, Maharashtra. Majority of the groundwater samples show high corrosion and tendency to deposit calcium carbonate whereas some of the samples indicate the alternate scenario. A study on geothermal prefectures in western Maharashtra explains the use of the very low frequency (VLF) electromagnetic method and delineated the lateral conductivity distribution of fracture zones in and around geothermal springs. 2D inversion of AMT data deciphered conductivity anomalies at a shallow depth of about 1-2 km beneath the southern part of the Rajapur profile and its thickness reduces as one move from south to north and acts as a source for Rajapur geothermal spring. This has been attributed to the accumulation of fluids (probably meteoric water) and acts as a reservoir for hot water spring. A Lithospheric Anomaly Map of the Indian (LAMI-1) sub-continent, was created using almost seven years of Swarm satellite data. A subsequent model LAMI-2, showed improved amplitude and wavelength. Both LAMI-1 and LAMI-2 revealed enhanced lithospheric anomaly resolution compared to MAGSAT data, highlighting magnetic signatures in various tectonic provinces like Deccan Volcanic Province, Himalayan Belt, and Archean cratonic areas. Using an aeromagnetic map of central India at 1.5 km elevation, the depth to the bottom of the magnetic source (DBMS) was determined for the Bastar craton and surrounding areas, which shows significant variation due to complex geology and past high thermo-tectonic activity, affecting the region's heat flow.

GPS survey has been carried out in the Palghar and the adjoining region of Maharashtra since October 2018, where micro-seismic activities from micro to minor magnitude have been occurring. Another study was carried out at understanding crustal deformation in and around the MFT, MBT, and MCT along the western and central parts of Arunachal Pradesh and bordering upper Assam. Yet another study explains that Precipitable Water Vapour (PWV) or Integrated Water Vapour (IWV) is an essential component of the atmosphere that significantly influences many atmospheric processes.

A new project has been initiated with an aim to understand solar variability's impact on Earth's climate across different temporal and spatial scales. Objectives include investigating geomagnetic effects on Northern Atlantic oscillations, studying solar variability's influence on tropical cyclone activity, assessing long-term solar activity effects on Outgoing Longwave Radiation (OLR), and exploring potential links between CIR-driven storms and flash floods. Initial findings reveal a strong anti-correlation between solar activity and TC occurrence in the North Atlantic region. Extreme TC events are more likely during

the declining and minimum phases of the solar cycle, particularly under low solar activity conditions (SSN < 50).

This annual report serves as comprehensive evidence of a challenging and innovative year. The research findings are reflected in this year's 56 research papers by IIG scientists, resulting in a cumulative impact factor of 185.714. Additionally, 71 papers were presented in national and international conferences. This year, four research scholars successfully obtained their Ph.D. degrees, and many awards and recognitions were conferred upon both staff and students. As part of the capacity building program, IIG scientists trained summer interns/dissertation students during the current year. Notably,the annual IMPRESS program took place at IIG HQ, Panvel, attracting 54 students from different parts of the country. As part of the Science Outreach program, the institute implemented a new program called as “Reach the Unreached”, wherein a large number of students could be reached. IIG was actively engaged in various state and national level scientific expositions, including the Indian Science Congress and the India International Science Festival.

As always, the entire staff at IIG extends their sincere gratitude to the Governing Council of IIG, the Research Advisory Committee, and the Finance Committee for their unwavering support and exceptional cooperation, enabling us to achieve our objectives during this pivotal year.
I deeply appreciate the positive, vigorous, and selfless contributions of my colleagues throughout the past year. The commitment and dedication of the IIG staff remained unwavering. Lastly, the institute’s growth heavily relies on teamwork, and close collaboration with academic partners. The exchange of skills and ideas is a crucial prerequisite for further advancement. We are presented with a momentous chance to preserve and foster IIG's distinct expertise, global mandate, reach, and legitimacy for the benefit of future generations.

A. P. Dimri
Director

July 25, 2023

GEOMAGNETIC DATA-BASED RESEARCH

MAGNETIC OBSERVATORIES AND GEOMAGNETISM FROM THE INDIAN SUBCONTINENT AND POLAR REGIONS (MOGPR)

Chief Coordinator : Geeta Vichare

Members : All technical staff of ODA at HQ and other Magnetic Observatories; All instrumentation division staff at HQ and EGRL; All WDC staff, Gopi K. Seemala

Spectral Resonance Structures (SRS) Observed from Shillong

Spectral Resonance Structures (SRS) are manifested in the form of multiple maxima and minima in the power spectrum of magnetic field variations, in the frequency range of 0.1-10 Hz (Figure 1). They are investigated by analyzing the magnetic field data of a high sampling frequency induction coil magnetometer, installed at Shillong (L = 1.08). One of the distinguishing features of the resonance structure observed at this latitude is the excitation of two spectral resonance structures simultaneously, one with a small frequency separation and the other with a large frequency separation of subsequent harmonics. The seasonal variation shows that the occurrence of double SRS is more favoured during winter, where, out of the total IAR events observed during winter, about 47% shows clear signatures of double SRS and no double SRS are observed during summer (Figure 2). In order to study the ionospheric cavity in which the SRS are excited, the altitudinal variation of refractive index have been examined, using IRI 2016 model to understand the role of local ionospheric conditions in the formation of double spectral resonance structures. The study reveals that the excitation of double SRS is related to the E-region to F-region variability of refractive index of the ionosphere. It is also reported that the double spectral resonance structures at Shillong are always observed only in the B_x component of the magnetic field variation.

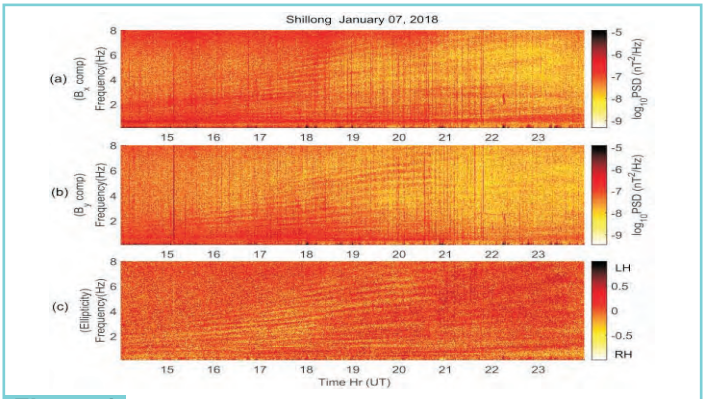

Figure 1 Dynamic spectra of B_x (a), B_y (b) components and ellipticity (?) (c) as an example of IAR observed at Shillong station.

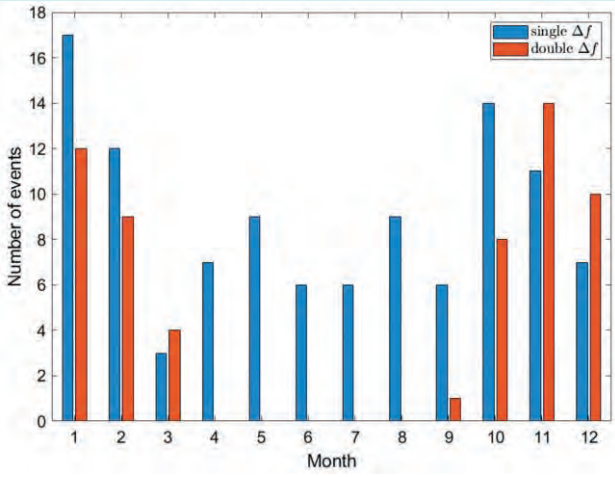

Figure 2 Seasonal variation of occurrence of IAR with single as well as double Spectral Resonance Structures for the year 2018.

POLAR SCIENCE RESEARCH

Indian Scientific Expedition to Antarctica

Two winter members i.e., one each for Maitri and Bharati and one summer member for Maitri were deputed for the 42nd Scientific Expedition to Antarctica. All the experiments at both stations are running uninterrupted. Measurements of total magnetic field at Maitri in campaigns and by IGRF model had indicated large decline in magnetic field (~ 110 nT/year) at Maitri during the last few decades. However, the continuous monitoring of geomagnetic field at Maitri indicates that recently it is reducing at a rate of approximately 65 nT/year. A systematic rapid decline in the Earth's complex main magnetic field is important for monitoring the evolution of reverse magnetic flux patches due to physical processes occurring in the outer core of the Earth.

Global Electric Circuit

The Global Electric Circuit (GEC) studies were started to understand the solar-terrestrial relationship and associated changes in surface weather and the near-earth electrical environment. The observed diurnal variation is explained in terms of the dominant thunderstorm activity centered over the three convectively active regions, viz. Asia/Maritime Continent (Indonesia), South America and Africa. Atmospheric electric field variations during fair weather days in Maitri do not follow Carnegie Curve during summer time, rather they are influenced by wind speed and direction. Initially it is presumed that the Antarctic continent is the most suitable location for this study. Investigations reveal that this

is true as far as the Antarctic Plateauis concerned. The coastal Antarctic regions has some in-situ electrical signals pertaining to the regional issues.

Measurements of the Bipolar Air Ion Concentration (BAIC) have been carried out regularly since December 2018 at Maitri. Figure 3 shows the location of the Maitri station, and campaign sites, in the Schirmacher Oasis in the Dronning Maud Land, East Antarctica. The Oasis is surrounded by a thick polar ice sheet on the southern, western, and eastern sides. The ice sheet's slope is from the SE quadrant, which is the direction of the prevailing katabatic winds. The shelf ice that extends for ~80 km is on the northern side. In the summer season, greater solar heating of the land surface melts the ice and snow over the land surface and the polar ice sheet and feeds about a hundred lakes in the Oasis. Greater convective and mechanical turbulence is present in the summer than in the winter season as the Sun is then below the horizon. The measurements of 222Rn and its daughter products suggest that their level (0.02 to 0.03 Bq m^{-3}) at Maitri is not much different from those observed over the oceans. Figure 4 shows the hourly mean diurnal curves of the BAIC for the months of December 2018 to November 2019. The number of fair-weather days considered for the average is mentioned in the parenthesis in each panel. The concentration of negative ions demonstrates a systematic diurnal variation in the months of December 2018 to April 2019 and November 2019. During the months of May 2019 to October 2019, the diurnal variation is absent. Random Forest Regression technique and Principal Component Analysis reveal that ~80% of the variation in the BAIC is attributed to surface winds and temperature variations. Radon and thoron have a very minimal ionization contribution of about 7.7% and 3.9% respectively as the exhalation rate is considerably low. The maximum concentration of negative ions is ~1100 cm^{-3} and positive ions ~800 cm^{-3} as observed in the peak austral summer at local noon and the minimum, (~below 200 cm^{-3}) is observed during the night hours. The diurnal cycle is largely absent in the winter months and the concentrations of negative and positive ions are nearly steady at ~200 cm^{-3} and ~400 cm^{-3} respectively. The concentration of negative ions in three consecutive summer seasons suggests that it is more when the summer is warmer. The effect of kinetic molecular theory through the Lenard effect and electrostatic interface effects is inferred to be the source of the excess negative ions.

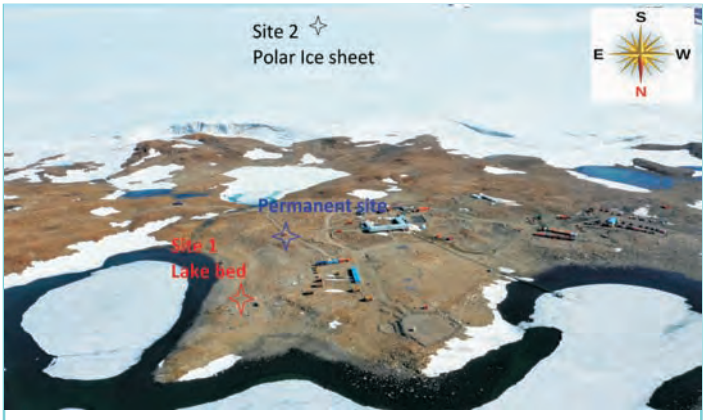

Figure 3 Location of observation sites of the BAIC at Maitri in Schirmacher Oasis. In the permanent site, the ion counter experiment is conducted throughout the year. Site 1 is very close to the lake and site 2 is over the Polar ice sheet. Site 1 and 2 are operated in campaign mode in the summer season.

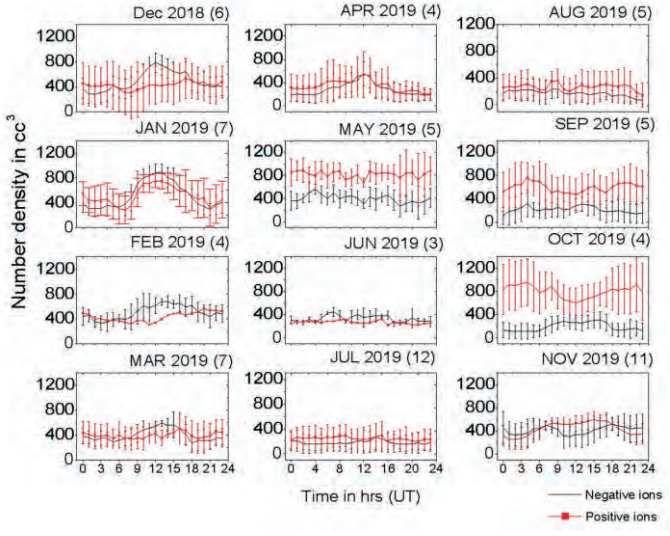

Figure 4 Monthly mean diurnal variation of bipolar cluster ion concentration for the period December 2018 to November 2019. The diurnal variation of BAIC is clearly seen during the months of December to April. It is absent from the month's May to September.

Installation of GRism-based Spectrograph for Airglow and Auroral studies at Maitri, Antarctica

Naturally occurring luminescent phenomenon airglow and aurora are the characteristic features of few planetary atmospheres in the solar system. Aurora appears as diffused, continuous luminous oval-shaped bands near the geomagnetic poles and represents the interaction between energetic plasma from the solar wind and the ionosphere. Airglow is the emission of photons from atmospheric species excited directly or indirectly by the solar radiation.

When compared to aurora, airglow is relatively fainter and occurs globally and at all the times. Ground-based photometric and imaging measurements of these phenomena have immensely contributed to the understanding of the Solar Wind-Magnetosphere-Ionosphere coupling. Being located in sub-auroral zone, Maitri occupies a unique position to understand the auroral dynamics.

A Grating-cum-prism (GRism) based Airglow and Auroral Spectrograph (GRAAS) was installed during February 2023. GRAAS is a CCD based ultra-fast f/2.8 optics spectrograph having field-of-view ~180° and spectral coverage from visible to far-infrared wavelengths. Physical installation of GRAAS was done during February 8-25, 2023. GRAAS is primarily meant for Nightglow observations and the experimental settings for the best exposure and image acquisition were done subsequently. Figure 5 presents a snapshot of installed GRAAS. Figure 6 shows the Control Unit of GRAAS. GRAAS has been set and tested for continuous automated operations during nighttime and is expected to run flawlessly.

A typical raw spectral recorded by GRAAS is shown in Figure 7. Under normal operations (i.e. in absence of aurora), GRAAS will provide the intensity information of several airglow lines that can be analyzed to understand the Mesosphere-Lower Thermosphere-Ionosphere region in context of wave processes and its response to geomagnetic activity over Maitri. During auroral activity, GRAAS in coordination with All-sky imaging is expected to reveal a wealth of information about different auroras, to understand the Solar Wind-Magnetosphere-Ionosphere coupling and to study traveling ionospheric disturbances.

Figure 5 Left Panel: Fisheye lens of GRAAS covered by Optical grade BK7 Glass dome. Right Panel: Coupled Optical Assembly and CCD detector of GRAAS.

Figure 6 Control Unit of GRAAS.

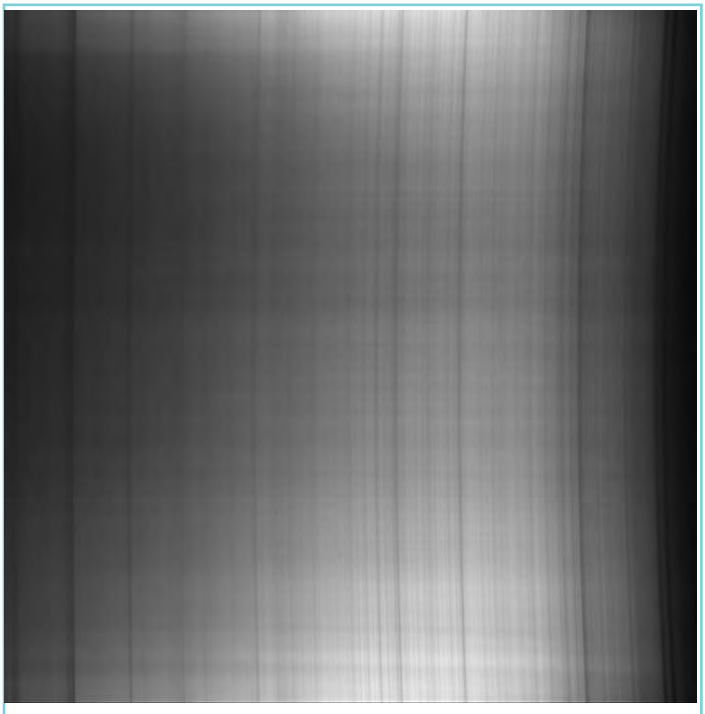

Figure 7 A typical raw spectra of sky captured by GRAAS on 07 March 2023.

Installation of Secondary Cosmic Ray Experiment at Maitri, Antarctica

Secondary Cosmic Ray (SCR) particle detector (NaI(Tl)) was installed at Maitri. As incident flux of cosmic rays depends upon the solar and geomagnetic activity, this experiment will significantly contribute to the Space Weather and Solar-Terrestrial relationship. Figure 8 displays the SCR set up at Maitri in Vindhya hut.

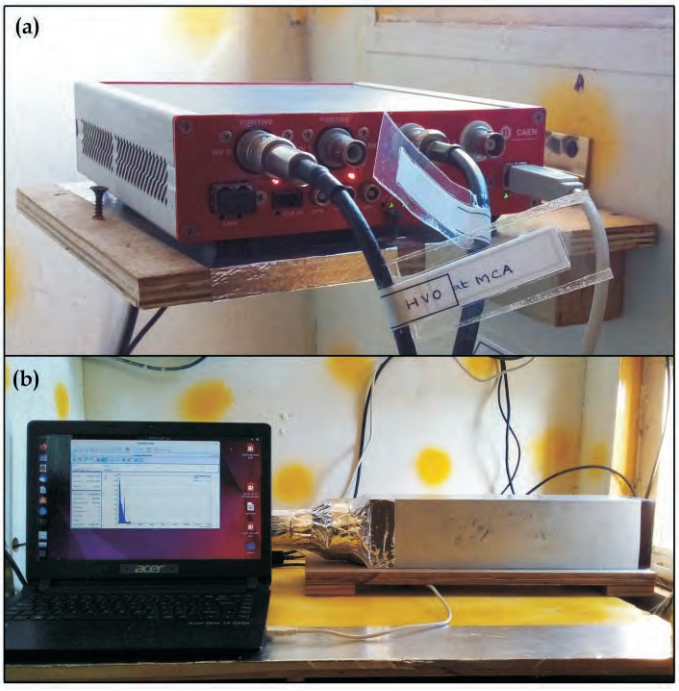

Figure 8 Top Panel: Multi-Channel Analyzer to measure the energy of each individual particles. Bottom Panel: NaI scintillation detector along with Laptop interface.

OBSERVATORY MAINTENANCE AND INSTALLATION

Institute's magnetic observatories house various instruments such as DFM, DIM, PPM and Overhauser magnetometer for magnetic field measurements. Indigenously developed 0.1 nT PPMs for absolute magnetic field observations are used at all the IIG observatories. IIG have supplied these PPMs to many Universities and Institutes. This year, on order, two such PPMs were supplied to Sacred Heart College, Kochi, and Presidency University, Kolkata.

IIG-make Windows based data logger is installed at most of the observatories and running well for last 5 to 6 years. Survey of India (SoI) has purchased one IIG-make windows-based data logger. The data logger was installed and is running well at Sabhawala Observatory. On observing the performance for few months, SoI has placed an order for a second data logger. The second data logger was assembled and successfully installed at Sabhawala Observatory in January 2023.

The data logger installed at M.O. Jaipur was replaced after it was damaged due to lightning. The old data logger at Shillong Observatory was upgraded to IIG-make datalogger.

Many of the instruments failed at Pondicherry Observatory due to heavy lightening during August 2022. After maintenance/repair and installation of new instruments, the instruments at the Observatory were made functional in a shortspan of time.

Routine maintenance activities of observatory instrumentation were carried out from time to time for continuous operation of observatory setup.

INTERMAGNET

INTERMAGNET is a global network of observatories, monitoring the Earth's magnetic field, adopting modern standards for measuring and recording equipment in order to facilitate high resolution data exchange in near real time. IIG is a participating Institute in this programme. Earth's magnetic field data received from Alibag and Jaipur Magnetic Observatories are processed and emailed to Kyoto GIN in near real time. These data can be viewed as Quick-Look plots at the Kyoto website (http://wdc.kugi.kyoto-u.ac.jp/plot_realtime/intermagnet/index.html).

DEVELOPMENT OF INSTRUMENTATION

Overhauser Magnetometer

The Overhauser Magnetometer is a type of nuclear magnetic resonance (NMR) instrument that is used for detecting the magnetic field of materials. It is an important tool for measuring magnetic fields in a variety of applications, including geology, mineral exploration, and medical imaging. Over the past year, the instrumentation team has focused on improving the sensitivity and higher sampling rate of Overhauser Magnetometer. This has been achieved through a combination of hardware and software improvements. Earlier an experimental setup of indigenously made Overhauser Magnetometer with 5 second sampling rate was installed at Alibag M.O. for continuous operation. The progress made during the past year in the development of the Overhauser Magnetometer is as follows.

Hardware Improvements

The hardware improvements have included upgrades to the magnetometer's signal processing electronics as well as improvements to the polarization and detection subsystems. The upgrades to the signal processing electronics have resulted in a significant reduction in noise levels, which has in turn improved the sensitivity of the magnetometer. The upgrades to the RF amplifier stage polarization and detection subsystems have improved the polarization efficiency, resulting in a higher signal-to-noise ratio. These improvements enabled to achieve 1 second sampling rate of the magnetic field measurement with accuracy better than 1nT.

Software Improvements

The software improvements have focused on improving the signal processing capabilities of the magnetometer. A new software algorithm has been developed to improve the accuracy of magnetic measurements. The new algorithmincorporates corrections for environmental noise and interference, resulting in more accurate measurements of the magnetic field, particularly in high-noise environments.

Mechanical Improvements

To fit all the components efficiently and compactly, the mechanical enclosure of the sensor and its electronics console were designed. To make the instrument aesthetically pleasant and readable, a new bright and clear HMI LCD is being interfaced.

The improved magnetometer is again installed to Alibag M.O. for continuous operation and testing.

Proton Precession Magnetometer

With the addition of new components and microcontroller boards, PPM now provides a variety of interface options and enhanced measurement accuracy. A new feature of the upgraded PPM is onboard data storage, a 3.5" TFT LCD interface, and USB data retrieval.

Magnetometer Coil Calibration Facility

There has been significant progress made during the past year in the development of the Magnetometer Coil Calibration Facility. The facility is being designed to provide precise and accurate calibration of various magnetometers.

An effort has been made to simulate and develop the proposed coil system in 3D, and to look for Indian fabricators who can precisely build such a coil system. The team visited the URSC in Bengaluru to look at potential upgrades and safety precautions required to be takenwhen developing the proposed facility in comparison to their analogous system.

UPPER ATMOSPHERIC RESEARCH

NEUTRAL AND ELECTRODYNAMICAL COUPLING OF THE ATMOSPHERE-IONOSPHERE SYSTEM (NECLAS)

Chief Coordinator : S. Sripathi

Coordinator : B. Veenadhari and S. Tulasiram

Members : S. Gurubaran, S.Tulasi Ram, B. Veenadhari, Geeta Vichare, Mala S. Bagiya, R. Ghodpage, Manohar Lal, Technical staff at EGRL/KSKGRL/MF Radar Facility and Research Scholars

Impact of severe space weather on HF radio wave (Skywave) communications

The plasma density distribution in the equatorial and low latitude ionosphere can often be severely disturbed during active space weather events that can have paramount impacts on the long-distance HF radio wave (Skywave) communications through the ionosphere. On the St. Patrick's Day storm of 17th March 2015, a deep depletion of plasma with more than two orders of magnitude was observed over a narrow longitudinal sector near the sunset terminator. The controlled SAMI2 simulations indicate that a large equatorial vertical drift around sunset terminator can produce such a deep electron density depletion and strong reinforcement of Equatorial Ionization Anomaly. The impacts of these ionospheric density disturbances on the Skywave communication systems have been investigated using an HF propagation simulator that solves the propagation path of radio waves under given background ionospheric conditions. The results clearly demonstrate that the usable HF spectrum for Skywave communications is reduced by more than 50% over the region of depletion. Further, large areas of skip zones, where the Skywave signals are not receivable, are produced due to low ionospheric densities over this region. (Figure 9). This study can have important applications in the planning and operation of Skywave systems during the active space weather periods.

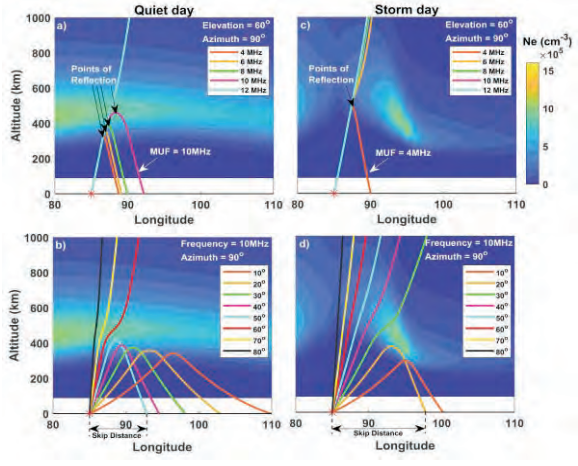

Figure 9 (a-d) Reduction of usable HF spectrum (MUF) and increase in skip-zone due to electron density depletion on the storm day (right panels) compared to quiet day (left panels).

Impact of solar eclipse on the electrodynamics of the equatorial ionosphere

The impact of a solar eclipse on the equatorial and low-latitude ionosphere has been a subject of interest for several years. Understanding the response of the ionosphere to gravity wave disturbances during a solar eclipse can provide important insights into the dynamics of the Earth's atmosphere-ionosphere coupled system. To this end, two case studies have been conducted, utilizing both ground-based and space-based observations. In the first study, a rare Annular Solar Eclipse (ASE) observed on 15 January 2010 was investigated. The study utilized data from ground-based instruments, including ionosondes, GPS receivers, and magnetometers, as well as data from space-based instruments such as the ICON, TIMED-SABER, and COSMIC satellites. The results indicated a reduction of approximately 33% in the lower ionosphere, with no change observed near the F layer peak on the eclipse day. This reduction in ion density was attributed to a temporary change in solar radiation due to the solar eclipse. Further analysis revealed the presence of gravity waves with dominant periods in the range of 5-30 minutes. These waves propagated from below, as indicated by the altitude variation of group and phase velocities, which showed opposite propagation (Figure 10). The simultaneous presence of gravity waves in the fmin, TEC, and EEJ strength on eclipse day supports the finding that these waves were propagated from the lower atmosphere. The isoheight analysis further confirmed the presence of gravity waves. The second study also investigated the impact of a solar eclipse on the ionosphere using ground-based and space-based observations. The observations showed a tremendous increase and decrease in the base height of the F-layer, resembling the nighttime Pre-Reversal Enhancement (PRE). Near the eclipse maximum, a strong blanketing sporadic E layer was observed at Tirunelveli with a top frequency of approximately 18 MHz for 1 hour and 26 minutes. Satellite traces (STs) and "U" shaped ionograms were noticed for the first time over Tirunelveli during the eclipse maximum and end phases, indicating the presence of short-period gravity waves or TID type of wave perturbations over the Indian region. A maximum of approximately 5-7 TECU (30%-40%) decrease in TEC was observed on the eclipse day for Bengaluru (iisc), Hyderabad (hyde), and Tirunelveli (tiru) stations. Periodogram analyses of TEC data showed the presence of wavelike structures with periodicities of 18-24 minutes for different stations (Figure 11). Simultaneous observations from the ICON satellite showed an increase and decrease in hmF2 and NmF2, which matched well with the ionosonde observations from Tirunelveli. The temperature profiles from TIMED-SABER and ICON satellites showed a reduction and enhancement in the lower and upper E regions, respectively. The findings of these two events provided important insights into the impact of solar eclipses on the equatorial and low-latitude ionosphere and its electrodynamics. The results demonstrate the occurrence of gravity wave disturbances and density reduction due to temporary changes in solar radiation during solar eclipses. This information is significant for understanding the dynamics of the Earth's atmosphere-ionosphere system and its response to external factors such as solar eclipses.

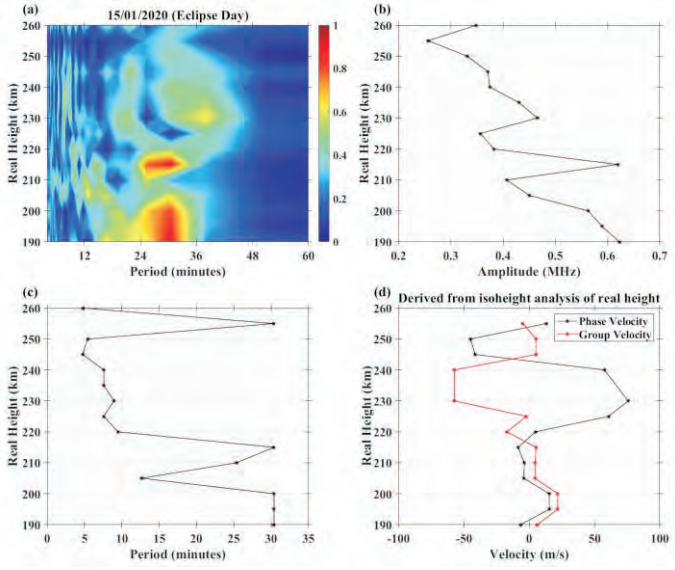

Figure 10 Altitude variation of (a) amplitude after FFT analysis on isoheight variations, (b, c) peak amplitude and corresponding periods, and (d) group and phase velocity of the gravity wave in isoheight variations for eclipse day on 15 January 2010.

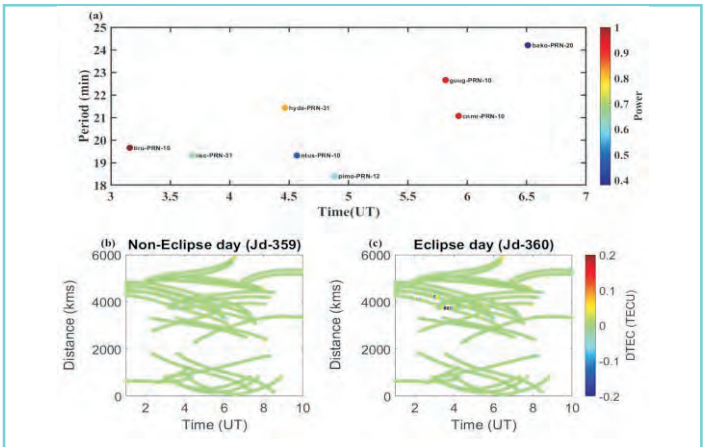

Figure 11 (a) shows the variation of dominant periods at different stations which are normalized to maximum power (amplitude) across different stations, the TEC fluctuations for PRN-10, 12, 20, and 31 for all the stations on (b) non-eclipse day (25 December 2019), and (c) eclipse day (26 December 2019) respectively.

Impact of IMF By for anomalous electric field perturbations in the equatorial ionosphere

During a weak geomagnetic storm (Ap = 15) on 24 December 2014, the penetration electric field perturbations over the Indian dip equatorial sector are found to be anomalous on a number of occasions during post sunset hours. The event is anomalous as the magnitude and polarity of penetration electric fields do not obey the existing paradigm. The penetration electric field perturbations are investigated using the vertical drifts derived from the CADI (Canadian Advanced Digital Ionosonde) measurements at Tirunelveli (8.7°N, 77.7°E, dip angle: 1.7°). During this event, post sunset vertical drift of ~42 ms^{-1} not only at 18:10 LT but also ~36 ms^{-1} at ~21:00 LT which is anomalous, was observed. Interestingly, the dawn-dusk component of interplanetary electric field (IEFy) is relatively less (<2 mV/m) at ~21:00 LT compared to the interval 19:30–20:30 LT (IEFy ~3 mV/m). Despite that, the vertical drift observed over Tirunelveli is very close to zero or nominally upward during 19:30–20:30 LT. In addition, the downward drift just after 21:30 LT on this night is found to be exceptionally large (~ –60 ms^{-1}). By combining vertical total electron content over the Indian sector with the OI 630.0 nm airglow intensity from Mt. Abu chain of magnetometer and Los Alamos National Laboratory geosynchronous satellite particle measurements, it is suggested that the anomalous penetration electric field perturbations on this night arise from the effects of interplanetary magnetic field By and substorm.

Comparison of long - term GPS TEC (observed) with IRI-2016 model

When Global Navigation Satellite System (GNSS) signals propagate through the ionosphere, the carrier experiences a phase advance and the code experiences a group delay due to total number of free electrons along the signal path from satellite to the receiver. This results in the degradation of the positional accuracy provided by a GNSS receiver. To minimise the ionospheric errors in GNSS based positioning and navigation, near precise ionospheric model should be provided. To verify the model accuracy, it is desirable to compare the model derived ionospheric variability with that of the actual observations. Ionospheric variability near the EIA crest region using Global Positioning System (GPS) – Total Electron Content (TEC) observations over 2005 to 2019 encompassing the descending phase of solar cycle 23, deep solar minimum between solar cycle 23 and 24, ascending, maximum, and descending phases of the solar cycle 24 were examined (Figure 12). International Reference Ionosphere (IRI-2016) predicted total electron content (TEC) during the same period (2005 to 2019) were extracted and compared with actual GPS-TEC observations. The model bias for various phases of solar activity 23-24 has been investigated. The statistical analysis results show that: (i) diurnal variation of TEC predicted by the IRI-2016 model mostly overestimates GPS-TEC during noon hours and underestimates at the nighttime. (ii) The seasonal comparison shows that model fits best during the summer months with the least bias. In winter, noon time overestimation by the model was found irrespective of solar activity. Further, in equinoctial months, noontime bias varies with the solar activity; i.e., the model overestimates (underestimates) the observed ionospheric variations during low (high) solar activity. (iii) GPS-TEC for the high solar activity year of 2014 shows a winter anomaly prominently. It is believed that the nature of the IRI-2016 model bias assessed for more than one solar cycle period, in the present study, may assist in improvising the model for the low latitude regions.

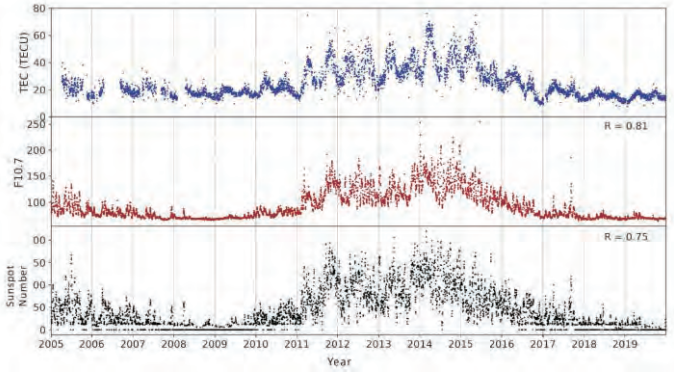

Figure 12 (a-c) Time series of daily mean GPS-TEC in comparison with F10.7 solar flux and sunspot numbers during solar cycles 23 and 24 (2005–2019).The correlation of GPS-TECvariations with those of theF10.7 and sunspot numbers are shown with R values in respective subplot.

Ducting of Mesospheric bores at high latitudes

Study of mesospheric bores from northern high and mid latitudes was carried out using optical instrument network (OMTI) operated by the Institute of Space Earth Environmental Research (ISEE), Japan. Five years (2011-2015) of all-sky airglow imager data from the high latitude site Tromso, Norway (69.6° N, 19.2° E) for northern winter months from October to March were utilized. Wind measurements from MF Radar and temperature measurements from lidar datasets were used to probe the background atmospheric conditions during the passage of mesospheric bores. On 24 February 2011, an undulating

(a bore front followed by wave-train) mesospheric bore in OI 557.7 nm, Na 589.3 nm, and OH emission images were observed. The temperature data suggest presence of thermal inversion layer which acts as a duct or channel for the bore to propagate. Ten bore events were obtained from 172 nights of clear sky observation which suggest that the occurrence of mesospheric bore at Northern high latitude is low. A separate study to investigate mesospheric bores from the mid-latitude site, Rikubetsu (45° N, 148° E), Japan is currently being undertaken.

Mesospheric gravity waves and seeding of the Equatorial Plasma Bubbles

In the current investigation, additional evidences were looked upon to substantiate the contribution of gravity waves to the observed EPB features using airglow data from Kolhapur and ionosonde data from Tirunelveli. Two nights from the same season and year were chosen when the EPB structuring is noticeably different. Furthermore, the dates were selected when quiet conditions prevailed in order to exclude waves that are propagating horizontally from high latitudes during geomagnetic disturbances. Additionally, the nights were chosen where the background ionospheric parameters (foF2 and h'F) are comparable, so that no other influence is prominent. The analysis showed that the EPB structures seen in the O (1D) 630nm emission variability demonstrate a close relationship with the gravity waves visible in the upper mesospheric O (1S) 557.7nm pictures. As both cases are during geomagnetic quiet conditions and that no structure is evident in the images suggest absence of large-scale wave structures on both the days. Therefore, the most viable reason for the observed differences may be the seed perturbation of lower atmospheric origin. EPB has a high degree of variability at medium (seasonal), long (solar cycle), and short (day-to-day) scales. The day-to-day variability of EPB is the least known and is the most difficult problem for current EPB investigations. In this regard, it is critical to thoroughly explore the precursor circumstances (or seeding) of EPB growth. The station at Kolhapur is well-equipped with all-sky imager optical studies at various altitudes ranging from the mesosphere to the lower thermosphere. This data set is being analysed further to investigate the role of lower atmospheric forces such as gravity waves in seeding of EPBs.

SPACE WEATHER: OBSERVATIONS AND MODELING (SWOM)

Chief Coordinator : Mala S. Bagiya
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Members : B. Veenadhari, Geeta Vichare, S. Sripathi, S. Tulasiram, Gopi Seemala, Rahul Rawat, S. Banola and Research Scholars

Large geomagnetically induced currents at equator caused by interplanetary magnetic cloud

A rare and extremely large GIC (Geomagnetically Induced Currents) is found to occur at the geomagnetic equator due to a sudden drop in solar wind density at the front boundary of a magnetic cloud (MC) during the great 31 March 2001 storm (Figure 13). The horizontal component at the Indian equatorial station, Tirunelveli, recorded a sharp decline of ~350 nT in just 5 minutes with a peak change in magnetic field $\left(\frac{dB}{dt}\right)$ exhibiting a concerning value of 136 nT/min, a risk factor to the electric power systems. The responsible physical mechanisms were examined through mageneto-hydrodynamic model simulations and found that prompt penetration of strong westward overshielding electric fields and ionospheric currents at equator play the dominant role (Figure 14). This work provide new insights on the extent of extreme changes at equatorial region can be caused by density reduction at MC which can have potential impacts on electric power grid systems.

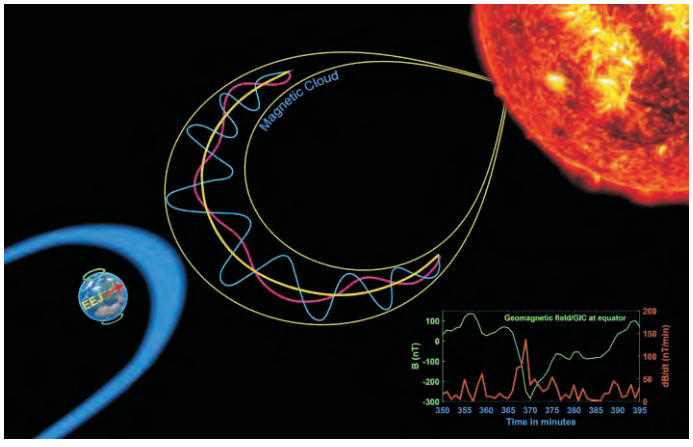

Figure 13 Interplanetary Magnetic Cloud causing rapid decrease of geomagnetic field at the geomagnetic equator causing GIC.

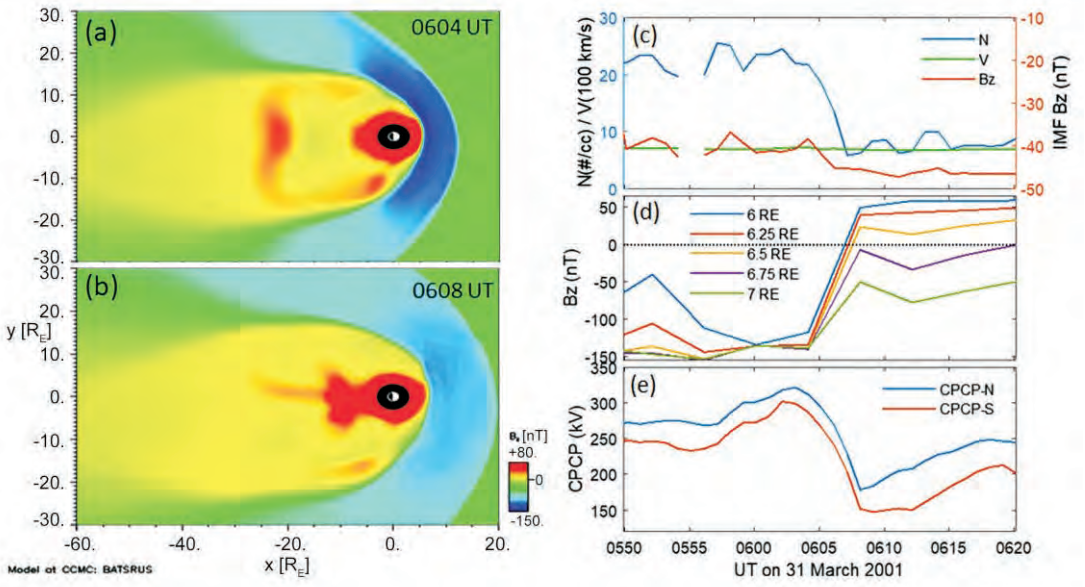

Figure 14 MHD model simulations showing the sudden expansion of magnetosheath region and strong westward overshielding electric fields.

Evidence for Super-adiabatic Heating and Cooling of Alfvénic Solar Wind

Alfvénic fluctuations are widespread and crucial in various physical processes of space and astrophysical plasma. However, their role in heating and work done remains unexplored. Wind spacecraft's data situated at 1 AU distance has been used to examine 12 distinct Alfvénic regions using polytropic analysis. The study finds an average polytropic index value that is consistent with a super-adiabatic behaviour for plasma particles with three effective degrees of freedom. Moreover, several scenarios for plasma particles with different degrees of freedom were examined. It is noted that the investigated Alfvénic region could be adiabatic only for plasma particles with f = 1.26 degrees of freedom. In addition, analysis suggests that 68% of the total supplied heat is utilized to accomplish work by the system on the surrounding (expansion phenomena), and the remaining is used to increase the internal energy of the system. As a result, it is hypothesized that the Alfvénic plasma region is cooling more than the adiabatic expectation, resulting in super-cooling phenomena. Therefore, it is proposed that the discovered possible super-adiabatic process would be critical in understanding the energy transfer from the Alfvénic zone to the surrounding plasma.

L-Value and Energy Dependence of 0.1–50 keV O^+, He^+, and H^+ Ions for CME and CIR Storms over the Entire Van Allen Probes Era

O^+, He^+, and H^+ ions having energies ranging from ~ 10 eV to 50 keV contribute to a majority of the ring current density that provides significant information about the important processes in the inner magnetosphere. The high-resolution data over the entire Van Allen Probes era have been acquired to understand the storm time dynamics of ion fluxes for the two different categories of solar wind drivers. A characteristic difference is observed upon correlating the ion flux enhancement during the storm main phase with the solar wind parameters and strength of the magnetic storm at different L-values and energies for both the category of solar wind drivers. Not all the energies and L-values respond in a similar manner. Moreover, O^+, He^+, and H^+ do not appear at the spacecraft location for the same duration of time. The time duration for which the ion fluxes remain at high is more for Corotating Interaction Region (CIR)-driven storms than Coronal Mass Ejection (CME) ones. The present studies give a comprehensive overview of spatio-temporal characteristics of the inner magnetospheric O^+, He^+, and H^+ ions at different energies using a long-term data set for CME and CIR-driven geomagnetic storms.

Ionospheric density oscillations associated with recurrent prompt penetration electric fields during the space weather event of 4 November 2021 over the East-Asian sector

Attempts are being made to identify the signatures of the multiple prompt penetration electric fields and the disturbance dynamo electric field having impacts on the East Asian sector ionosphere along the meridional chain thoroughly from the equator, low-mid to high latitudes during the space weather event of 3-5 November 2021. The observation is made on global positioning system-total electron content (GPS-TEC), digisonde, and magnetometer stations. In the main phase of the storm, intense modulations of VTEC and critical frequency (foF2) are observed as coherently fluctuating with interplanetary electric field (IEF) and IMF Bz reorientations. It is diagnosed that the oscillations in the disturbance polar current 2 (DP2) current system directly penetrate meridianally from high to equatorial latitudes, leading to the significant changes in ionospheric electrodynamics that governs the density fluctuations. The wavelet spectra of VTEC, foF2, h'F (virtual height), H-components and IEF give a result of common and dominant periodicity occurring at ~1 hr. The VTEC diurnal variations (red solid lines) over the East Asian sector during the 03-05 November are shown in Figure 15. The grey shaded region and solid black lines show IQDs mean and the averaged standard deviation. The vertical dotted blue color lines indicate the VTEC enhancements. This result suggests that the wavelike oscillations of VTEC, foF2 and H component are associated with prompt penetration electric fields.

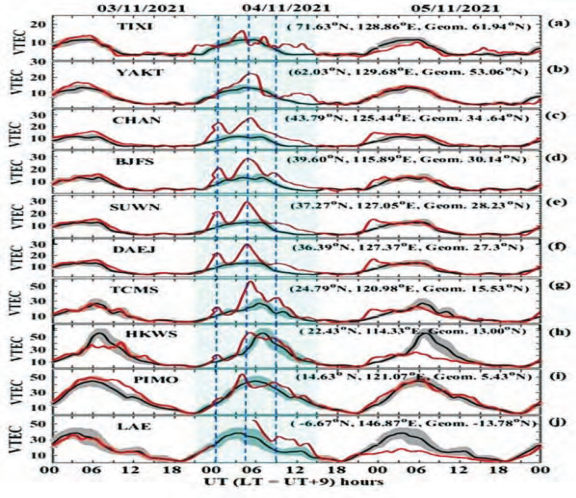

Figure 15 VTEC diurnal variations (red solid lines) over the East Asian sector during the 03-05 November. The grey shaded region and solid black lines show IQDs mean and the averaged standard deviation. The vertical dotted blue color lines indicate the VTEC enhancements.

Classification of geomagnetic storms effects and the associated PPEF over the Indian region

Low latitude ionosphere is strongly affected by the space weather events. Prompt Penetration of Electric Field (PPEF) associated with geomagnetic storms redistribute low latitude ionospheric electron density which can disrupt the satellite and radio communications. PPEF effects on Indian ionosphere are investigated during geomagnetic storms of March 17, 2015 (G4) and June 8, 2014 (G2). To identify PPEF signatures, three criteria were used. First, a correlation coefficient greater than 0.75 with a 90 percent overlap in a 5-minute bin between the equatorial electrojet (EEJ) and the interplanetary magnetic field (IMF) Ey is looked at, second, it is verified that the PPEF signatures were consistent across all Indian magnetic stations, in addition to two Russian stations at the same longitude. Finally, the PPEF signatures were confirmed using the PPEEFM1 model. Based on the variations of equatorial electrojet (EEJ) and its influence on equatorial ionization anomaly (EIA) over the Indian region, the study found that the intensity of geomagnetic storms can have a significant impact on the plasma distribution in low-latitude regions, leading to variations in the pattern and strength of the EIA (Figure 16). The findings emphasize the importance of understanding the effects of different types of geomagnetic storms on the ionosphere and the need for continued monitoring of space weather.

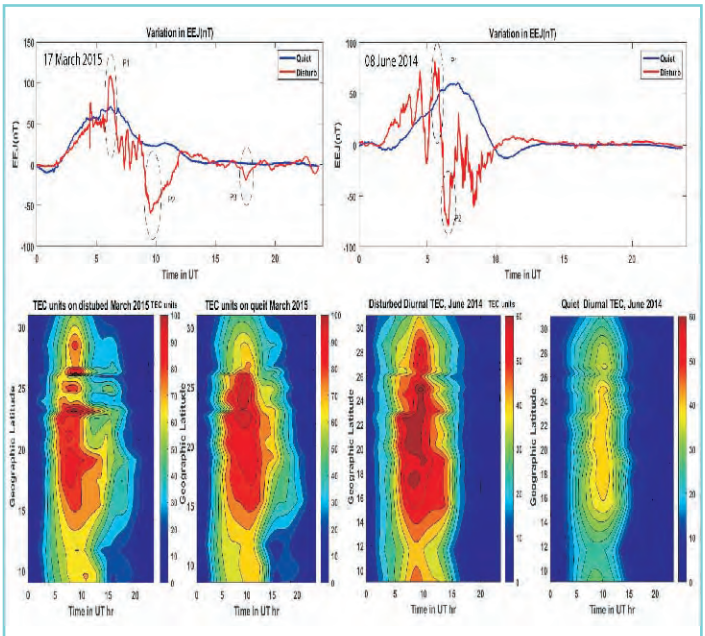

Figure 16 Variations of equatorial electrojet (EEJ) and its influence on equatorial ionization anomaly (EIA) over the Indian region during March 17, 2015 (G4) and June 8, 2014 (G2) geomagnetic storms.

The dayside ionospheric-thermospheric changes during minor geomagnetic storm activity of 3-4 February 2022

A minor geomagnetic storm occurred on 3-4 February 2022, causing the loss of 38 SpaceX Starlink satellites during their launch, resulting in significant technical and economic consequences. The storm-time neutral dynamic and electrodynamic changes over the American sector during this minor storm activity has been investigated using GPS–TEC and Global-scale Observations of the Limb and Disk (GOLD) measured thermospheric composition and temperature. Results revealed an unexpected feature in terms of increase in O/N_2 and depletion in the TEC over the American low-latitudes (Figure 17). This feature is in addition to the classic storm time ionospheric variations of enhancement in ionospheric electron density in presence of enhanced O/N_2 and an intense Equatorial Electrojet EEJ. Results from Multiscale Atmosphere-Geospace Environment (MAGE) model simulations elucidated that strong morning CEJ caused by the disturbance dynamo electric (DDE) field generated by the storm-induced equatorward thermospheric wind which further explains the morning TEC depletion at low-latitudes despite an increase in O/N_2. Sub-storm related magnetospheric convection gave significant noon-time peak in EEJ on 4 February 2022. Observation and modelling approaches together suggested that combined effects of storm-time neutral dynamic and electrodynamic forcing resulted in significant ionospheric variations over the American sector during minor geomagnetic storm.

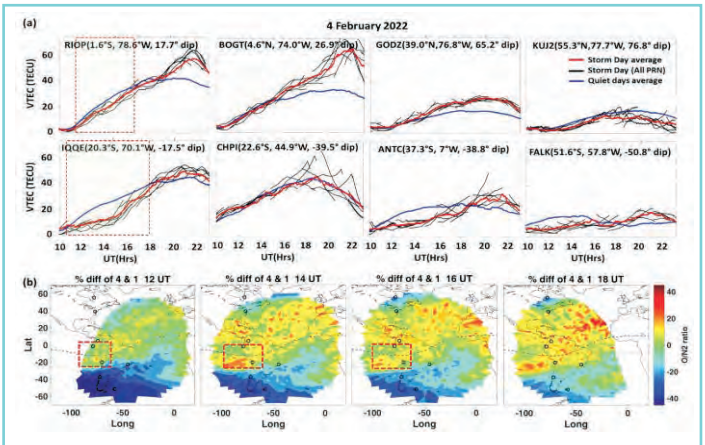

Figure 17 (a) TEC variations during 10:00-23:00 UT over northern hemisphere (NH) (upper panel) and Southern hemisphere (SH) (lower panel) low, mid and high latitude stations on 4 February 2022. (b) ÓO/N_2 changes (%Diff) from GOLD observations on 4 February from 1 February. Coloured circles indicate the GPS-TEC stations. Red dashed box indicates the unexpected feature i.e. increase in O/N_2 was accompanied by depletion in TEC during the morning.

EARTH MAGNETOSPHERE, SOLAR WIND INTERACTION WITH PLANETARY MAGNETOSPHERE & IONOSPHERES – THEORY, OBSERVATIONS & SIMULATIONS (EPTOS)

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The MAVEN observations of bipolar electric field pulses associated with the solitary waves at an altitude of 1000–3500 km in the Martian magnetosheath have been reported (Figure 18). The magnitude and duration of these pulses vary between 1 and 25 mVm^{-1} and 0.2^{-1}.7 ms, respectively. The ambient plasma conditions suggest that these pulses are quasi-parallel to the ambient magnetic field and can be considered electrostatic. These pulses were modelled by using both nonlinear fluid theory and simulations, which confirms that the observed bipolar pulses are ion-acoustic solitary wave structures with a propagation speed close to the ion-acoustic speed.

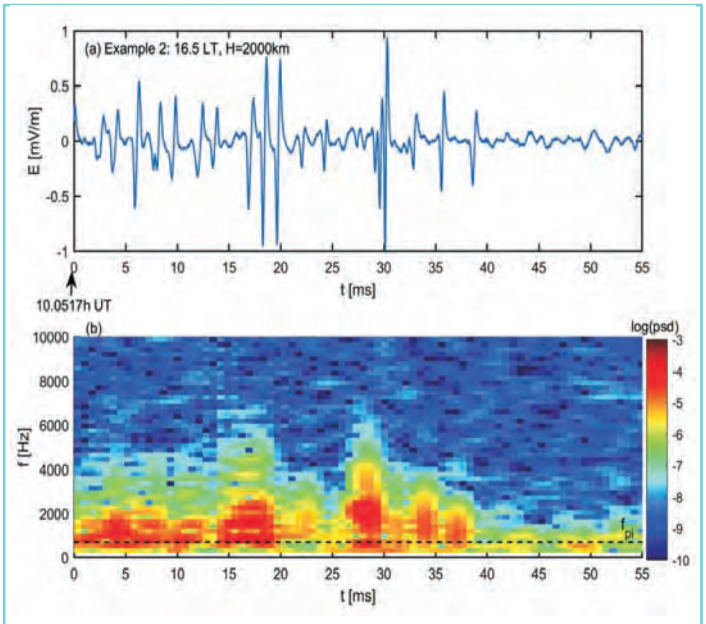

Figure 18 An example of a series of bipolar electric field pulses associated with the solitary waves observed by MAVEN spacecraft on February 9, 2015, is shown in panel (a), and its spectrogram is shown in panel (b).

Frequent observations of ion beams moving out from Saturn's plasma environment hint at the generation of ion Bernstein–Greene–Kruskal (BGK) modes. As the plasma environments of Saturn and its moon Enceladus are characterized by the ubiquitous presence of massive negatively charged dust particles, the existing BGK theory for electron-ion plasma models cannot address this scenario. In this context, a theoretical model for Bernstein–Greene–Kruskal (BGK) ion modes in a dusty plasma environment is developed. As this model considers electrons and ions with superthermal distribution, it can be used to predict and study the ion-hole structures (Figure 19) that formed in any space/astrophysical plasmas. The theory revealed that the ion BGK modes are more physically plausible in a dusty plasma environment than in a typical plasma environment.

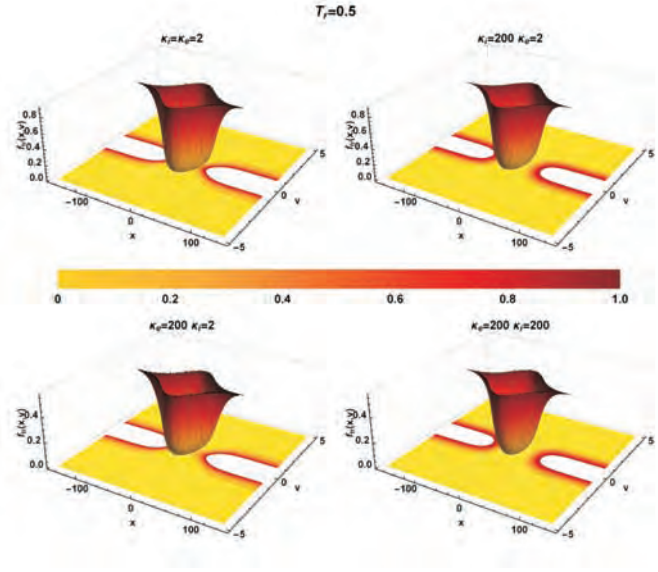

Figure 19 Panels show the trapped ion distribution function associated with the BGK ion holes for various kappa indices. These combinations of kappa indices essentially constitute different space plasma scenarios. At the bottom, the contour plot of the passing ion distribution function is also given.

The observation of dust in the rings of Saturn by the Voyager 1, Voyager 2, and Cassini missions triggered the interest in exploring the evolution of electrostatic dust acoustic waves (DAWs) in the Saturnian magnetospheric dusty plasma. The salient features of dust-acoustic electrostatic solitary waves have been examined by means of numerical simulations that adopted a fluid algorithm. At equilibrium, the initial density perturbation in the dust density was used to trigger the evolution of DASWs propagating in non-Maxwellian dusty plasma (Figure 20). These simulation results are thought to be relevant for (and applicable in) existing experimental data in space, not only in the magnetosphere of Saturn, but also in other planetary plasma environments that are presumably characterized by the presence of charged dust.

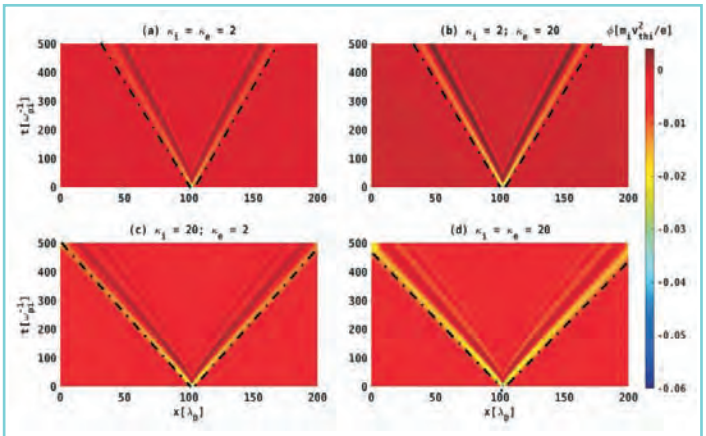

Figure 20 Spatio-temporal evolution of the electrostatic potential associated with the dust acoustic solitary waves (DASW) in the presence of suprathermal particles for different values of the spectral index of electrons and ions. A comparison of panels a and d suggests that highly suprathermal electrons and/or ions (i.e., for lower values of ê) correspond to smaller amplitude DASW pulses, in comparison with weakly suprathermal (e.g., quasi-Maxwellian) electrons and/or ions.

The modulation of electromagnetic ion cyclotron (EMIC) waves by different geomagnetic pulsations is known from both ground and satellite observations. However, their dependence on the EMIC wave characteristics is not well explored. A statistical analysis of modulation of EMIC waves by short and long periodicities at the Indian Antarctic station, Maitri is examined to reveal its effect on the EMIC wave characteristics viz. start time, end time, peak frequency, frequency extent, maximum power, and dominant short and long periodicities. The study shows the dominant short and long periodicities in the EMIC waves in the range of 1.5–3 min and 10–60 min, respectively (Figure 21). The short period decreases with an increase in the peak frequency of the EMIC wave, which is attributed to the decrease in the magnetic field line oscillation period at lower L-shells. Additionally, it is noticed that the stronger EMIC wave events are likely to have a higher peak frequency. All these observed tendencies are examined in light of nonlinear theory, and they are found to be in good agreement.

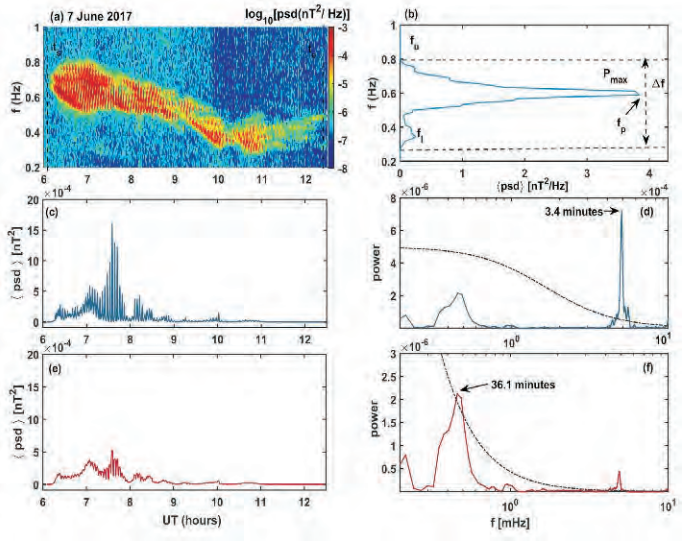

Figure 21 : Example of an EMIC wave event with both short and long periodicities at Maitri. (a) Spectrogram of magnetic field recorded at Maitri, on 7 June 2017. The start and end times for the event are marked with a black dashed line. (b) Shows the average power as a function of frequency. (c) The spectrogram power is averaged from frequency fl to fu and plotted as a function of time. The signal in panel-c is subjected to Fourier transform and its spectrum is plotted as a function of frequency in panel (d). (e) The signal in panel-c is smoothed by applying a 15-point average and plotted as a function of time, and its Fourier-transformed spectra is shown in panel-f.

In general, the interplanetary solar wind conditions and geomagnetic activity control the generation of EMIC waves by modifying the ambient plasma conditions in the generation region. Therefore, EMIC wave occurrence patterns observed both in space and on the ground are influenced by variations in the parameters like auroral electrojet (AE index), solar wind dynamic pressure, and Dst index, which represents the magnetospheric conditions. Detailed local time distribution of EMIC waves observed at the Antarctic station, Maitri for 2011–2017 is presented. This analysis reveals that at Maitri, the occurrence of EMIC waves is dominated in the lower frequency range (0.12-1 Hz) with lower occurrence in the higher frequency range (>1 Hz). It is found that the EMIC waves having frequencies > 1 Hz occurs dominantly in the early morning hours with a peak close to 5.7 LT hours, and they are linked to the magnetic activity that occurred in the preceding days, whereas the effect of solar wind dynamic pressure and AE index on the local time occurrence of EMIC waves is unambiguously seen for the waves with < 1 Hz.

The long-lasting, persistence EMIC waves can have a profound effect on the dynamics of the relativistic electrons in the Earth's radiation belt. With spacecraft measurements, it is difficult to determine their spatio-temporal extent and sustainability. In this context, in addition to the spacecraft observations, the ground observations can give better insights into these features. For this, a total of 12 EMIC wave events that are steadily observed for >10 hours at Maitri during 2011–2017 are identified and examined (Figure 22). All these events are dominantly seen during the recovery phase of the weak-moderate geomagnetic storm. Comparison with spacecraft observations indicates the simultaneous EMIC waves in the magnetosphere within L-shell 4-6 with wider longitudinal coverage, and sufficiently long-time presence in the magnetosphere. Simultaneous differential electron flux observations from Van Allen Probes indicate that approximately 90% of these EMIC waves were accompanied by a decrease in relativistic (2.6-4.2 MeV) electrons in the outer radiation belts.

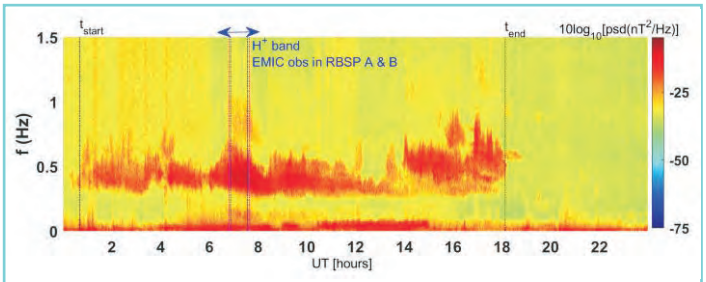

Figure 22 Example of long-duration EMIC wave event observed at ground station Maitri on 12 April 2015. Spectrogram of the horizontal component of magnetic field variation recorded by ICM.The time duration for which the EMIC wave activity observed in space by RBSP-A (magenta color) and RBSP-B (blue color) in the band is marked by dashed-dotted lines.

A statistical study of Electro Magnetic Ion Cyclotron (EMIC) waves is carried out to understand their spatial occurrence pattern with respect to different geomagnetic conditions. The wave events are separated into non-storm, storm-time and storm-phases and identify that geomagnetic indices alone cannot describe the EMIC wave occurrences well, rather, coupling indices with storm phases illustrate complete picture of EMIC wave occurrences. This study is performed using ~7 years of measurements from Van Allen Probes mission. It is found that EMIC waves are 2.9 times more likely to be observed during geomagnetic storms than non-storm times. Highest occurrence rates were found to be during the pre-onset phase of the storm, followed by main phase and recovery phase, respectively. The wave amplitudes were not found to have any storm phase dependence but high amplitude EMIC waves were found to occur as often during quiet conditions as during storm times. These events will be further studied to understand the quiet time drivers of the waves.

Mars does not possess a global magnetic field unlike Earth. However, it does have sporadic but clustered crustal magnetic fields in the southern hemisphere. Even though the fields themselves are very small (as compared to that of Earth), it has great implications in large scale distribution of plasma around the planet. To quantify the crustal magnetic field (B) and its subsequent effects on the ionospheric plasma distribution, in-situ observations from NASA's MAVEN (Mars Atmosphere and Volatile Evolution) have been used. Six years (3 Martian years) of magnetic field and electron density data is used to construct global maps of magnetic field and electric density. The results show a clear enhancement in electron density (Ne) over the regions of crustal magnetic fields in the southern hemisphere. The enhancement is prominent above a height of approximately 250 km and is mostly a daytime phenomenon. Additionally, the effect is absent in neutral densities confirming the fact that it is a plasma effect caused due to presence of the crustal fields. An exactly opposite effect can be observed in the northern hemisphere in the longitudes corresponding to the crustal fields. Further analysis is being carried to understand the phenomenon.

Research efforts were directed towards understanding the role of plasma processes in solar wind-magnetosphere energy exchange and the causes of the Carrington super magnetic storm. Properties of chorus and their role in radiation belt dynamaics/auroral plasma were studied. Nonlinear fluid models for ion-and electron-acoustic solitons and double layers were developed to explain the properties of electrostatic solitary waves observed in at the Earth's magnetopause and in the Lunar wake.

Investigations of Planetary magnetosphere and ionosphere

A theoretical model has been developed for characterizing the Jovian's middle (6-20 RJ) magnetosphere. The model is examined in the magnetosphere of the natural satellite Ganymede which has an intrinsic dipole magnetic field, directed opposite to the Jovian magnetosphere. The spatial and temporal structures of field line eigen modes are computed within this mini-magnetosphere.

Observation of field line eigen modes in magnetosphere of Jupiter

A rare pass of JUNO around Ganymede is investigated on 07 June 2021 (34th Orbit of JUNO). Strong fluctuations of 10-25 mHz frequency are observed in the azimuthal component of the magnetic field. This event is modelled using adequate scale size and plasma parameters from JUNO. This observation is reproduced using the developed theoretical model.

COUPLED LITHOSPHERE-ATMOSPHERE-IONOSPHERE-MAGNETOSPHERE SYSTEM(CLAIMs)

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Earthquake induced liquefaction features in the meizoseismal area of 1943 Hojai and 1950 Assam earthquakes, NE India

Since earthquakes occur repeatedly in the region undergoing active deformation and produce predictable ground deformation features in the contemporary sediment column, paleoseismic investigations are carried out in the meizosesmal area of 1950 Assam earthquake, 1943 Hojai earthquake and 1869 Cachar earthquake, to explore the possibility of identifying and dating past seismic events using liquefaction features (Figure 23). Sites that liquefied during large modern earthquakes and historic earthquakes furnish good target for paleoliquefaction studies because liquefaction often reoccur where susceptible sediments are present. Therefore, investigation for liquefaction features is being carried out along the BurhiDihing, Disang and Dhansiri rivers in the meizoseismal area of 1950 earthquakeand along the Kolang, Pokriyar and Barak Rivers in the meizoseismal area of 1943 and 1869 earthquakes.

The methods employed for identifying earthquake induced liquefaction include reconnaissance of open ground and river/stream cut-offs, investigation of sand-blow/sand dyke features by making trenches, documentation of liquefactionfeatures by logging and river exposures. The strata here are susceptible to liquefaction, because the riverine sand beds with confining clay layers are better situated for increased pore pressure, under shallow water table conditions. Field survey in and around the study sites resulted in observation of multiple sand dykes, sand blows and flame like intrusion (Figure 24). The studied sections comprise of unconsolidated sand and mud deposited in the point bar of the growing meander loop in region with shallow water table. Such water saturated sediments are highly susceptible to liquefaction during an earthquake forming

sand dykes and lateral spreads/fissures. The sand dykes of varying thickness (5 cm - up to 60 cm and length of 1 m-20 m) and geometry are mostly tabular form. Sediment samples representing the upper and lower bound ages for this section were collected to bracket the earthquake events responsible for the liquefaction and growth of the sand dykes.

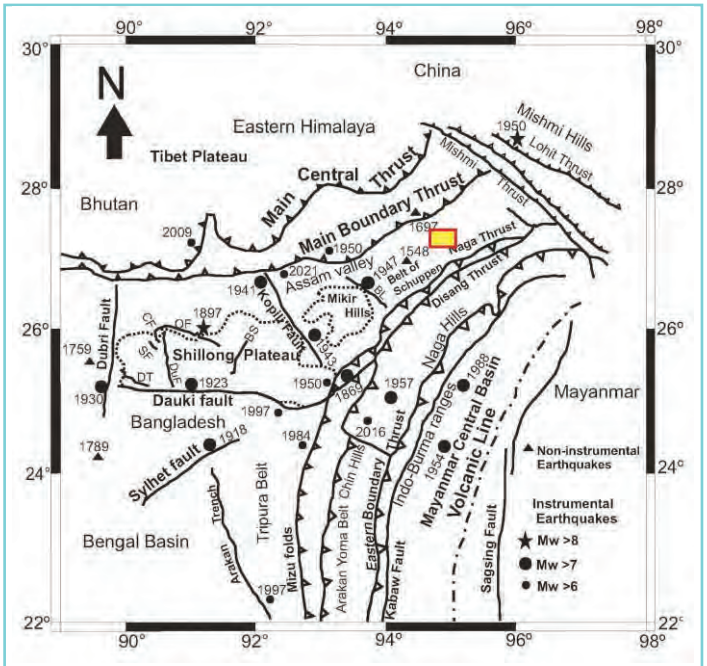

Figure 23 Location map showing studied section

Figure 24
A view of deformational features in the form of Liquefaction sand dykes of 2 to 20 m height and 5-50cm thick, at Hojai

Anisotropy of magnetic susceptibility of earthquake induced liquefaction features in the meizoseismal area of 1869 Hojai earthquake

Anisotropy of low-field magnetic susceptibility (AMS) analysis is a rapid and sensitive technique for measuring preferred orientations of magnetic grains and, therefore holds great potential for acquiring fabric information. Theoretical and field data show that an idealized suite of AMS ellipsoids develops as primary sedimentary fabrics and are progressively overprinted by tectonic fabrics. In an undeformed condition, primary sedimentary fabrics are controlled by depositional and diagenetic processes and are characterized by oblate AMS ellipsoids with Kmax ≈ Kint within the bedding plane and Kmin perpendicular to beddingplane. More than 221 samples from 5 sites of 1869 Hojai earthquake were collected and subjected to AMS to explore whether palaeomagnetic studies can aid in obtaining a time constraint on deformation liquefaction features. For each specimen, three principal axes and their magnitudes (referred to as Kmax, Kint and Kmin) describe the ellipsoid of AMS. Orientations of the three principal axes of AMS and its corresponding magnitudes are calculated. The degree of orientation and ordering of the AMS generating particles in the liquefaction and host strata are compared. The host strata exhibit depositional fabric and the liquefaction features have quite randomly distributed AMS values. The degree of anisotropy which provides information about the degree of deformation is high for liquefaction, whilst for the host strata it is low. The new application of AMS provides a petrofabric tool to identify dikes as seismites, which, with good age constraints, may provide an important addition to palaeoseismic records. Remanent magnetic directions data analysis is under progress.

3D Seismic velocity models

Surface wave analysis of seismic ambient noise-based investigation allows to focusprimarily on crustal and uppermost mantle structures ranging from global to local scales (depending on network design), which is hard to achieve in surface wave dispersion method due to scattering and attenuation. The fundamental mode of Rayleigh waves in Green's functions between adjacent stations can be successfully extracted from sufficiently long recordings of seismic ambient noise, providing input to structural analysis with tomographic methods. This ambient noise tomography (ANT) analysis is underway for the database generated atseismic stations in the North-East India. At present the work of refiningthe final 3D velocity model is in progress.

Further, P- and S- wave travel time tomography for north-east Indian region has been performed which shows strong velocity heterogeneities beneath the study region at different

depth levels. The anomalies of high P- and S-velocity dipping structures beneath the Himalayas as well as below the Indo-Burma Ranges were evident.

Apart from this, a full waveform tomography for the Rayleigh waves has been performed. The study area is located inSouth Africa which is mainly comprised of two Archean craton namely Congo and Kalahari carton. The Walvis ridge area used to overly the Tristan da Cunha mantle plume in the Early Cretaceous at the time of the Gondwana break-up.

All-sky imaging observations of mesospheric fronts from Silchar (24.68°N, 92.76°E)

A mesospheric front is marked by an extensive step-like onset of enhanced or depleted airglow intensity, which divides the night sky into dark and bright regions followed by alternating crests and troughs of intensity (categorised as waves) or turbulence. An All-Sky Airglow Imager was operated at Silchar (24.68°N, 92.76°E), India from 9 to 11 December 2018, during a special observational campaign. The presence of two simultaneous mesospheric fronts observed in OH airglow emission propagating orthogonal to each other on the night of 9 December 2018 is reported, which was a rare and unique observational feature. A third mesospheric front was observed on 11 December 2018. Temperature and OH intensity measurements from SABER instrument onboard TIMED satellite were used to characterise the environment of the frontal propagation. Though one of the frontal structures resembled a mesospheric bore, the other frontal events do not satisfy a few of the requirements to be met for a bore. It is also reported the modulation of the OH emission layer by the passage of the mesospheric front on the night of 11 December 2018.

Slow Fault Slip Signatures in Coseismic Ionospheric Disturbances

Rapidly moving objects excite short-period waves, and slow objects excite long-period waves. Rise times of earthquake moment release influence the spectra of seismic waves. For example, slow fault movements in tsunami earthquakes excite larger tsunamis than expected from intensities of short-period seismic waves. The amplitudes of two different atmospheric waves, long-period internal gravity waves (IGW) and short-period acoustic waves (AW), excited by coseismic vertical crustal movements are compared. These are observed as coseismic ionospheric disturbances by measuring ionospheric electrons using global navigation satellite systems. Four regular megathrust earthquakes (Mw 8.0–9.0) showed that the IGW become ten times stronger as the magnitude increases by one. The IGW have a larger magnitude dependence than AW, that is, a larger earthquake has a larger IGW/AW ratio. This suggests that the time constants of faulting may play a larger role in exciting IGW than AW. It is further found that the 2010 Mentawai earthquake, a typical tsunami earthquake, excited abnormally large IGW from ionospheric observations (Figure 25). On the other hand, amplitudes of acoustic waves excited by tsunami earthquakes were normal. This further suggests that slow fault ruptures excite long-period atmospheric waves efficiently, leaving a slow earthquake signature in ionospheric disturbances. This is the first slow earthquake signature found in space.

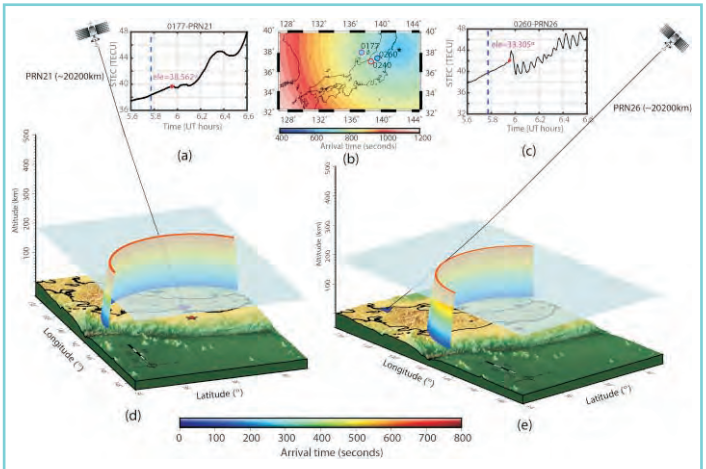

Figure 25 AW (blue circles) and IGW (red triangles) amplitudes as a function of Mw of earthquakes. Symbols for the tsunami earthquakes are enlarged (no clear IGW signals for the 2006 Java event). A pink triangle corresponds to the wave indicated as "IGW?",might be a hybrid wave, i.e., IGW excited by AW that reached the ionosphere. (b) Compares coseismic ionospheric disturbance records in slant TEC for the six earthquakes studied.

On the Rayleigh Wave Induced Ionospheric Perturbations During the Mw 9.0 11 March 2011 Tohoku-Oki Earthquake

Spatial and temporal characteristics of Rayleigh wave generated ionospheric perturbations are well documented based on the ionospheric measurements using Global Positioning System (GPS)-Total Electron Content (TEC) technique. However, due to integrated nature of the GPS recorded TEC, the actual detection altitudes of these perturbations could not be determined. In general, the maximum electron density altitude (hmF2) is assumed as the perturbation detection altitude in GPS-TEC. To validate this assumption, case studies focusing on the early detection of ionospheric perturbations induced by direct epicentral waves during the Mw 7.4 March 9, 2011 Sanriku-Oki and Mw 9.0 March 11, 2011 Tohoku-Oki earthquakes were performed. Moving a step forward, estimation of actual detection altitudes of Rayleigh wave generated ionospheric

perturbations has been attempted during the Tohoku-Oki earthquake. The average Rayleigh wave velocity over Japan region was estimated based on the seismic waveform data. Using the 3D ray tracing of Rayleigh wave generated acoustic waves in the atmosphere and realistic GPS station-satellite LOS geometry, the detection altitudes of Rayleigh wave generated coseismic ionospheric perturbations (CIPs) are computed efficaciously **(Figure 26).** It is further demonstrated the possibility of detecting specific CIP at different ionospheric altitudes, based on the distinct satellite geometries.

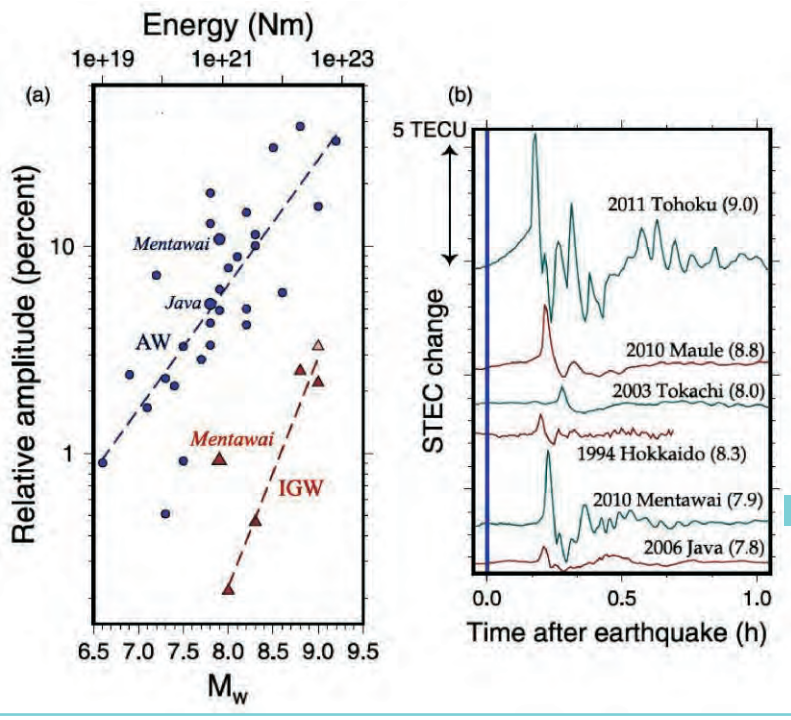

Figure 26 Estimation of the actual detection altitudes of Rayleigh wave generated coseismic ionospheric perturbations (CIPs) based on 3D ray tracing of Rayleigh wave generated acoustic waves in the atmosphere and realistic GPS station-satellite line of sight geometry during the Tohoku-Oki earthquake.

SOLID EARTH RESEARCH

GEOLOGICAL AND GEOPHYSICAL STUDIES OVER DECCAN TRAPS (GGDT)

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Comparative study of the VGP's of dykes of Singhbhum and Bundelkhand Cratons

A comparative study of the VGP's of dykes of Singhbhum and Bundelkhand craton were carried out to find any tectonic linkage between these two cratons through palaeomagnetic study. For the palaeomagnetic study, a total of 38 dykes (oriented block samples = 181 and specimens = 1862) from the Singhbhum craton and 6 dykes (specimens = 202) from the Bundelkhand craton have been re-analyzed. Through detailed AF and thermal demagnetizations, the Singhbhum craton dykes suggests two groups of ChRM directions (Group-I: Dec=241.25°; Inc=40.22°; N=9 dykes and Group-II: Dec=226.2°; I= -42.29°; N=7 dykes). The VGPs of the two groups of ChRM directions were calculated and the VGPs for the Group-I was found as Lat: 15.28°S; Long: 29.38°E and Group-II VGP Lat: 48.1°S; Long: 343°E. The Bundelkhand craton dykes show one group of ChRM directions as Dec=126°; I= -33° and corresponding VGP as Lat: 44.97°N; Long: 350.15°E for the 6 dykes. From the above

palaeomagnetic study for the two cratons, it is revealed that Group II dykes of Singhbhum craton and Bundelkhand dykes shows almost similar VGPs and belongs to almost similar age groups.

A pilot project to study the pollution hot-spots in and around Prayagraj

Atmospheric pollution resulting from urban traffic is now fully recognized as a major health issue in cities of any size. The rapid urbanization and population growth in Prayagraj city has resulted in a significant increase in the emission of pollutants. Biocollectors-based environmental magnetism is a rapid and non-destructive way to monitor emitted particle dispersion in various environments. Tree leaves and, to a lesser extent, tree bark, and top soil have been extensively used as bio-monitors. A total of 118 samples comprising roadside dust and leaf dust were collected in and around eastern part of Prayagraj city during the month of February 2023, with an objective to identify quantitatively and qualitatively the pollution hotspots related to traffic intensity during Magh mela month. All the samples were collected at approximately 500 meter interval on the traverses (1) Shastri bridge to Hanumanganj (2) Andawa to Sahson (3) Chakk to Leelapur road. These traverses were categorized on the basis of respiratory to heavy, moderate and low traffic zones. Few samples were also collected in and around KSKGRL campus with very low traffic activity. All the collected samples were prepared with equal weight for the measurements in the laboratory. High and low frequency magnetic susceptibility measurements of all the samples is in progress.

Magnetic mineralogy of sediments from Parad section of Purna River Basin, Maharashtra

In the study area of Purna alluvial basin, the present concern is to study the palaeoclimate/ palaeoenvironmental conditions from the sediments that are exposed in the Purna River Basin. The Quaternary sediments and soil occurring along Purna River Basin have remained uninvestigated so far, which are potential archives for delineating past neotectonic and Late Quaternary evolutionary history.

A total of ~112 loose sediment samples were collected in 7.65 m sediment section from Parad, Purna basin (Figure 27), which were exposed to different magnetic experiments to reveal their magnetic properties which in turn is useful to palaeoclimatic interpretation. The universal presence of magnetic minerals in environmental materials, including sediments, and their high sensitivity to climate change allow the use of environmental magnetism as a useful tool for high-resolution palaeoenvironment reconstruction in diverse environmental settings.

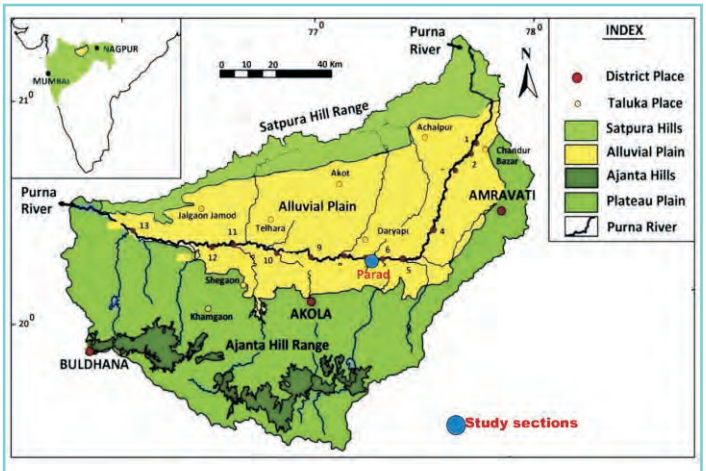

Figure 27 Location map showing studied sediment section, Parad, in Purna river Basin

The iron oxide minerals are mainly terrigenous. There is no overprinting of the magnetic signal by the formation of bacterial magnetite, anthropogenic magnetite, and authigenic greigite. It is essential to find out the sources of magnetic minerals in sediments before attempting to decipher the mineral magnetic proxies for palaeo-environmental reconstruction. The possibility of authigenic formation of greigite in sediments is ruled out as the SIRM/÷If ratio values of the samples are much lower (~8 to 12 kA/m) than those assigned to its presence (~70 kA/m). Magnetic minerals produced by bacterial activity may also contribute to the mineral magnetic properties of sediments and the diameter of bacterial magnetite varies from 0.02 to 0.1 ì m (stable single domain; SSD). Hence, inter-parametric ratios like χ_{ARM}/χ, χ_{ARM}/χ_{fd} and χ_{ARM}/SIRM may be used to qualitatively evaluate the presence of biogenic magnetite; for example, χ_{ARM}/SIRM values >200; and bi-logarithmic plot of χ_{ARM}/χ(>40) vs. χ_{ARM}/χ_{fd}(>1000). The bacterial magnetite is not documented in sediments deposited as these ratio values are lower than the assigned values.

The iron oxide minerals do not show any signs of dissolution. Magnetic mineralogy is identified from IRM acquisition curves, 3 IRM and S-ratio. The IRM curves saturate at low fields such as 300 mT and indicate that (titano) magnetite as the main magnetic mineral carrying the remanent magnetization (Figure 28a). An IRM was given along three perpendicular directions: the Z-axis at 2.5 T, the Y-axis at 0.6T, and X-axis at 0.1T. The thermal demagnetization in air of the three IRMs of samples suggests that most of the remanence is held by a soft blocking temperature fraction. The contribution of hard fraction is negligible. The curves are dominated by a mineral with a maximum blocking

temperature between 250, 350, 450°C and 580°C, characteristic of magnetite with different Ti contents (Figure 28c). The S-ratio values of the Parad section sediments are > 0.90, except at top of the section, suggesting the presence of softer ferrimagnets like magnetite/titanomagnetite. ÷-T curves indicate presence of titanomagnetite as the magnetic mineral carrier (Figure 28b).

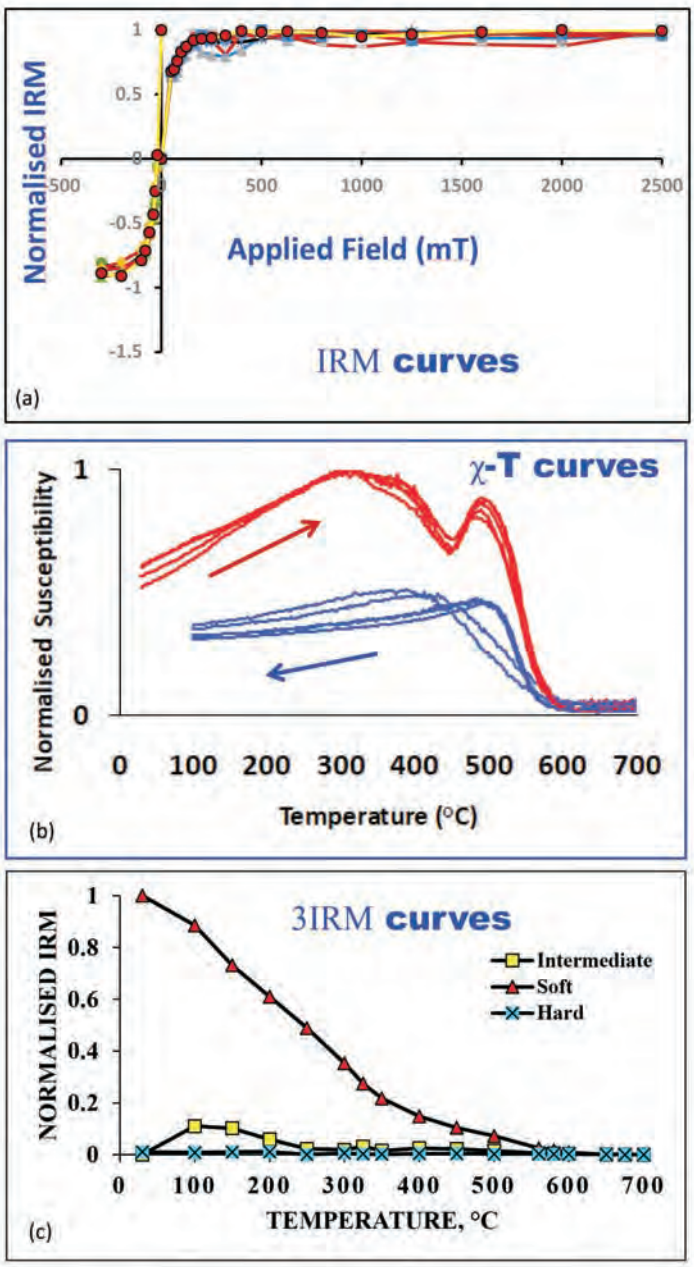

Figure 28 Magnetic mineralogy of Parad section sediments (a) Isothermal remanent magnetisation curves (IRM), (b) Temperature dependent magnetic susceptibility variation (χ-T curves) and (c) 3IRM curves

Environmental magnetic properties of sediments from Parad section, Purna basin

Magnetic susceptibility ($÷_{lf}$), Saturation isothermal remanent magnetization (SIRM) and anhystereticremanent magnetization (ARM) are considered to be the concentration dependent parameters of magnetic mineral accumulation in sediments. $÷_{lf}$ reflects sum of magnetic susceptibilities comprising ferrimagnets, canted antiferromagnets, paramagnets and diamagnets. Ferrimagnetic minerals are strongly magnetic whereas para- and dia-magnetic minerals are not. SIRM relates to the presence of all remanence-carrying magnetic minerals suggesting total magnetic mineral content. ARM is seen to reveal stable single domain (SSD) grains. $÷_{lf}$, ARM and SIRM of Parad section sediments are seen to exhibit similar trends suggesting they are mainly controlled by concentration of the magnetic minerals (Figure 29). In this study, the high $÷_{lf}$, ARM and SIRM values observed in the samples suggest the presence of strongly ferrimagnetic minerals. High $÷_{lf}$ and SIRM values indicate a high magnetic mineral concentration in the sediments, main contribution to which is by ferrimagnetic minerals (high S-ratio values) like titanomagnetite / magnetite. The parameter ÷fd% provides hints on the occurrence of ultrafine superparamagnetic (SP) grains in the sediments. High ÷fd% values > 10 suggest significant concentrations (> 75%) of superparamagnetic grains in the sediments, whereas low ÷fd% values < 2% indicate the absence of SP grains. The mean ÷fd% value for this study is 1.04% indicating a negligible proportion of SP grains in the Parad sediments. $_{ARM}$/÷lf, SIRM/÷lf and $÷_{ARM}$/÷fd ratio has been used to identify relative changes in grain size. Since ARM is sensitive to magnetic grains in stable single domain (SSD, 0.04-0.06 µm) range in ferrimagnetic minerals, the ratio ARM/$÷_{lf}$ can be used to indicate their grain size, with higher values reflecting fine grained SSD particles and lower values as multi-domain (MD) or SP particles.

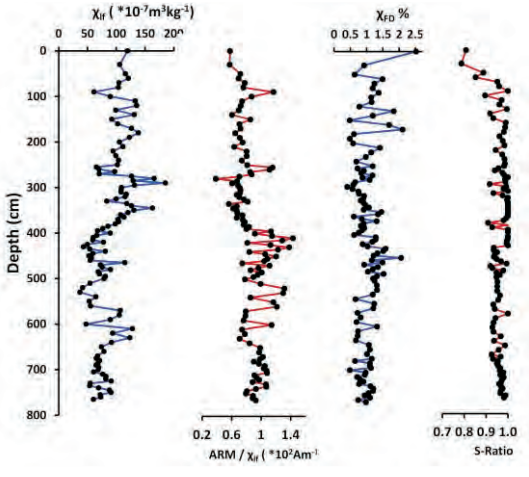

Figure 29 Environmental magnetic properties (magnetic concentration, grain size and composition) of Parad section sediments

Pre - historic geomagnetic field variations using archaeological artifacts

The estimations of absolute geomagnetic field intensity from Indian archaeological artefacts are essential because long-term variation of the past Earth magnetic field components is virtually unknown for the region. India is a large subcontinent with a glorious history and rich archaeological heritage spanning thousands of years. It is therefore important to generate and increase the pool of India-specific archaeomagnetic data, to help build and improve upon the Indian secular variation curve. The detailed rock-magnetic investigations were undertaken on baked clay artefacts from Parad in the Purna River Basin, Maharashtra and Vadnagar, Mehsana district of Gujarat. Rock-magnetic studies offered critical information about the magnetic-concentration, grain size, and thermal stability of the archaeological artefacts. The detailed rock magnetic investigations are seldom employed in archaeointensity studies and however such investigations can be useful to screen the samples before the archaeointensity measurements are performed.

Archaeomagnetic studies were undertaken on 80 individual artefacts from the historical site of Vadnagar. Vadnagar town of western India possess continuous human habitation record from 200 BCE to 1900 CE with seven periods. The Koenigsberger ratio (Q-ratio) is a direct measure of the ratio of remanent magnetization to induced magnetization. All Q-ratio values are greater than one, such high Q-ratio values indicate a stable thermoremanent origin of natural remanent magnetization for all samples. Isothermal remanent magnetization acquisition curves confirmed the presence of ferrimagnetic (magnetite) and antiferromagnetism (hematite) minerals in mixture form (Figure 30). This is confirmed by thermal demagnetization of orthogonal three-component IRM and thermal stability test (Figure 31). These rock-magnetic studies will help to find the suitable artefacts for reliable ancient geomagnetic field intensity investigation.

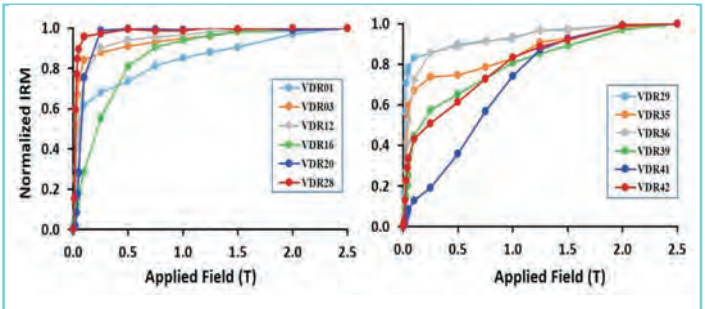

Figure 30 Representative isothermal remanent magnetization acquisition curves for Vadnagar archaeological artefacts.

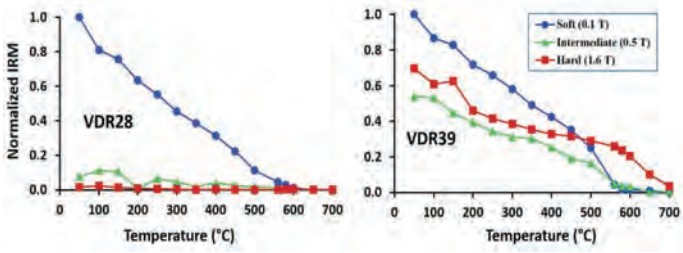

Figure 31 Progressive thermal demagnetization of orthogonal three-component IRM.

Groundwater quality and corrosion severity in Mann River Basin, Maharashtra

The groundwater quality study is aimed to evaluate the corrosion severity due to groundwater usage, based on the chemical analyses of 43 samples collected from the Mann River basin, Maharashtra. Corrosivity of groundwater would cause leaching of the materials used in drinking water supply pipes contaminating it causing the health risk of the habitants since the same is used for household activities and drinking purpose. The analytical results of physicochemical parameters such as pH, TDS, EC, Calcium, Magnesium, Sodium, Potassium, Chloride, Bicarbonate, Sulphate etc. were used in computing the corrosion indices like Langelier Saturation Index (LSI), Aggressive Index (AI) and Ryznar Stability Index (RSI). Drinking water quality index based on these parameters has also been computed to check whether the concentrations of major ions are within the permissible limit (WHO, BIS). Also, irrigation water suitability was evaluated by computing the parameters like Sodium Adsorption Ratio, percentage of Sodium, SSP, Permeability Index and Kelly's Ratio. Overall, majority of the groundwater samples show high corrosion and tendency to deposit calcium carbonate whereas some of the samples indicate the alternate scenario. GIS based maps were generated for the calculated indices for accurate decisions on corrosion of water in the study area.

Very Low-Frequency Electromagnetic studies over geothermal prefecture in western Maharashtra, India

The very low frequency (VLF) electromagnetic method was employed to delineate the lateral conductivity distribution of fracture zones in and around the geothermal springs of western Maharashtra. Four VLF traverses have been conducted at two geothermal springs (Tural and Rajawadi). The traverse (T-1) at Rajawadi hot spring revealed broad conductive features and extended from the surface to the depth of 12m. The broad conductive feature is identified as fracture zone which is marked as F-F in the second traverse (T-2) at Rajawadi hot spring (Figure 32). The boundaries of

these fracture zones are having high resistivity contrasts. The traverse 3 at Tural hot spring revealed one broader conductive feature beyond the lateral distance of 32 m to 65 m. This conductive feature is the signature of thermal spring and it extended up to the depths of 12.5 m. Traverse 4 at Tural suggests conductive zones at shallow levels at a lateral distance of 22 m, 60 m, and beyond.

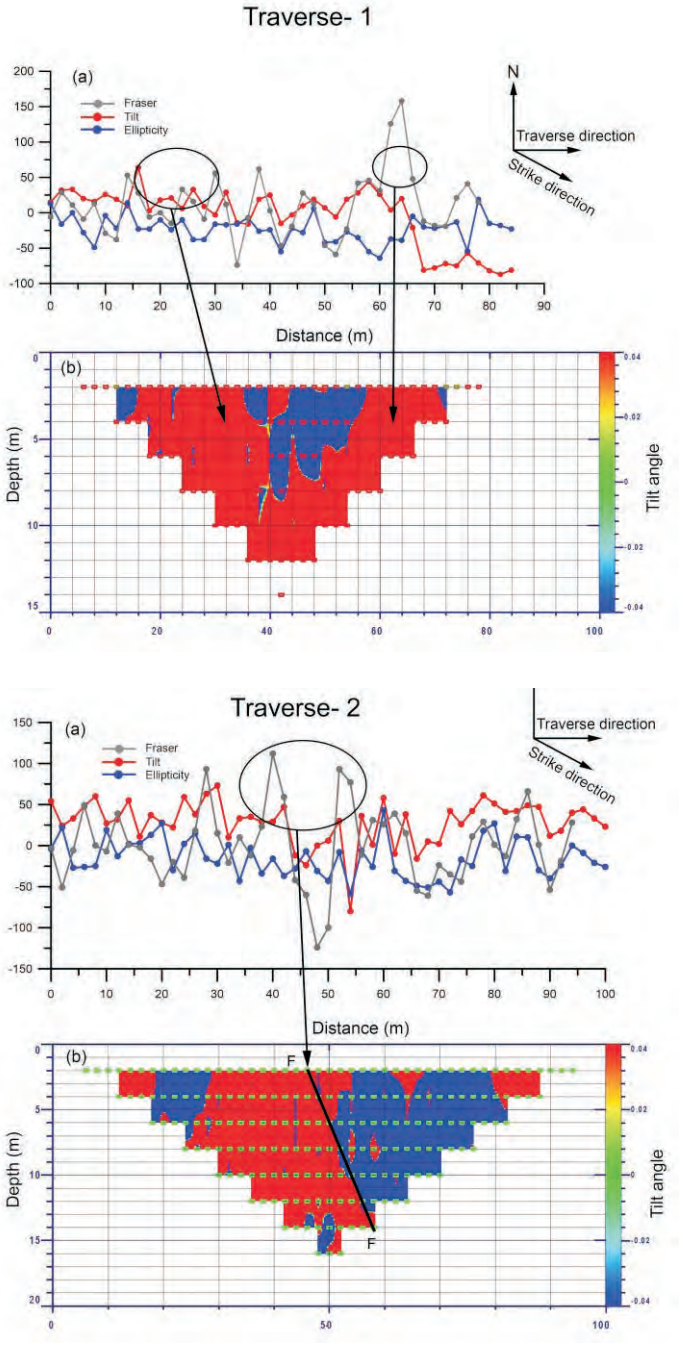

Figure 32 Plot of (a) tilt, ellipticity, and Fraser filter; (b) Karous-Hjelt pseudo depth section over Traverses 1 and 2.

AMT / MT studies across Rajapur geothermal zones, western Maharashtra, India

Several hot springs are located along the west coast of India and grouped under west coast geothermal province and are related to deep-seated fault/lineament category. These hot springs extend from Kokener of Maharashtra state in the north, to Irde of Karnataka state in the south. Rajapur hot spring is located along the west coast of India and emerges through Deccan volcanics. Even though this spring is discharged through volcanics, it is believed that Precambrian gneisses and granitic basement have played a major role in heating the meteoric water and hot water has been gushed up to surface through faults/fracture zones that resulted in hot springs.

In order to understand geo-electrical structure across Rajapur geothermal zone, 3D audio Magnetotelluric (AMT) survey was carried across geothermal zone. Dimensionality analysis denotes 2D nature and strike angle obtained from Groom-Bailey (GB) analysis is about N35ºE. Thus, the impedance tensors at each site are rotated for all frequencies for TE and TM modes and inverted by using NLCG (non-linear conjugate gradient) algorithm.

2D inversion of AMT data brings out conductivity anomalies at a shallow depth of about 1-2 km beneath southern part of the Rajapur profile and its thickness reduces as one move from south to north and acts as a source for Rajapur geothermal spring. This has been attributed to the accumulation of fluids (probably meteoric water) and acts as a reservoir for hot water spring. May be these fluids are gushed up to the surface through faults/fractures and reflected as hot-springs in this region.

Lithospheric anomaly map over the Indian subcontinent

A preliminary Lithospheric Anomaly Map of the Indian sub-continent (LAMI-1) was generated, from almost seven years of Swarm satellite data using Legendre polynomial of order n=6-50 directly by the inversion of residual data, obtained by removing the main field and external field variation from satellite observations using the Chaos model. The lithospheric signal-to noise ratio can be improved by applying proper corrections to the residual data, some of which are associated with the improper and cross cutting track lines, selection of data from satellite altitude with maximum passes and data points etc. These corrections were applied which considerably improved the resolution of the residual data, following which the model coefficient could be expanded upto 65 using the damped least square method. The resulting modelled lithospheric anomaly (LAMI-2) showed improvement in both amplitude and wavelength compared to

LAMI-1. LAMI-1 and LAMI-2 shows considerable improvement in the lithospheric anomalies in comparison with the magnetic anomaly map generated from MAGSAT data which had a smaller number of passes over the Indian region. The Satellite derived crustal anomalies thus generated mainly reflects the long wavelength features over the Indian sub-continent with the various tectonic provinces showing distinct magnetic signatures. These include distinct low over the Deccan Volcanic Province (Large Igneous Province), the Himalayan Belt etc and highs over the Saurashtra-Marwar block, Shillong Massif and over Archean cratonic areas like Eastern Dharwar, Bastar etc

Estimation of depth to the bottom of the magnetic source (DBMS) over the Bastar craton and adjoining regions from aeromagnetic map of central India

The depth to the bottom of the magnetic source (DBMS) over the Bastar craton and adjoining regions were estimated from the aeromagnetic map of the central India generated at an elevation of 1.5 km. For estimating the depth to the bottom of the magnetic sources, the region bounded by 16 to 22°N latitude and 78 to 85°E longitude was divided into 29 blocks of dimension 200 km × 200 km with 50% overlapping cells. The aeromagnetic data was upward continued to a height of 4 km to remove the effect of shallow sources before estimating the bottom depths. For estimating the bottom depth values, modified centroid and de-fractal methods that are based on the scaling distribution of magnetic sources are used. The DBMS estimated in this region on an average varies from 24 km to 41km. This larger variation in depth represents the complex nature of the sub-crustal levels within the Bastar craton and adjoining regions. The shallowest value of 24 km is found over the Indravati basin of Bastar craton and the deepest value of 41 km is found adjacent to the eastern flank of Godavari graben. The DBMS may indicate either a thermal, compositional or petrological boundary. Comparison of the estimated DBMS with the Moho depth along the Deep Seismic Sounding (DSS) profile over the central Indian region suggested that the bottom of the magnetized crust is shallower than the Moho depth in most of the regions and hence represent a thermal boundary, along the profile. The DBMS estimated for Bastar craton and adjoining regions varies over a larger range which can be attributed to the complex geology of the region and the high thermo-tectonic activity in the past, altering the heat flow of the region.

Crustal deformation study in the Palghar and adjoining region

Recent micro-seismic activities have been identified in Palghar and adjoining region of Maharashtra from October 2018.Several earthquakes have occurred in the region, in the range of micro to minor magnitude. There are two major faults in vicinity, namely, Ghod andupper Godavari. This, along with the lineaments and dykes trending dominantly in the N-S and NW-SE direction and Panvel flexure running parallel to the coast makes the tectonicstructure of the region more complex. Recent seismic study concluded that the swarms were related to the monsoon,and were attributable to a phenomenon called “hydro-seismicity”.Some studies have attributed the micro-seismicactivity in this region to a tectonically disturbed zone of weakness. Further, INSAR observation sreveal that there is are gionof uplift and subsidence near Talasari. In order to understand the deformation caused by the induced seismicity/ hydroseismicity, it is necessary to monitor ground deformation susing GPS geodesy technique. Three stations of Palghar, Talasari and Silvassa datasets were checked and processed in Gamit/Globk post processing software. Detailed analysis will be taken after acquisition of more data to get the deformation parameters. Time series of three stations have been computed to understand the north-south component variation.

Crustal deformation study in the Arunachal Himalaya

To study the crustal deformation in and around the MFT, MBT and MCT along western and central part of Arunachal Pradesh and bordering upper Assam, two transects were selected between latitude 26º to 28º Nand longitude 92º to 94ºE.This study is also aimed to understand the convergence between India and Eurasia plates as well as variation of slip ratea long the Himalayan arc.To meet this goal,10 sets of GNSS receivers JAVADAlpha -3N were sponsored by the SAC - ISRO Ahmedabad. Team members were trained in operational procedure and collected GPS data. Seven GPS receivers were installed as continuous and seven as campaign mode GPS stations, which are scattered over the two transects.

Estimation of Precipitable Water Vapour in the atmosphere over India

Precipitable Water Vapour (PWV) / Integrated Water Vapour (IWV) are an important component of the atmosphere and significantly influence many atmospheric processes. PWV is the vertically integrated amount of water vapour in the atmosphere, and it is a valuable predictor for weather forecasting. PWV is estimated from the Zenith Total delay of GPS signals. PWV is estimated using the continuously operated GNSS receiver data from permanent stations as well as from the continuous operating reference station (CORS) from International GNSS service. Meteorological parameters are required for PWV estimation which is downloaded from the NOAA/NCEP website for validating theestimated results. Estimated PWV for two stations (IISC and PANV) for three years have been acquired. The estimated PWV is validated using satellite and ERA5 data. This work will be extended to other station datasets also.

Development of Geophysical instruments

Development of indigenously user-friendly electrical resistivity tomography (ERT) instrument for groundwater and mineral exploration is underway. To provide sufficient current, a power supply unit with a maximum voltage sourcing capability of 200V is replaced in the existing circuit. High input impedance amplifier LF411 in potential sensing circuit is implemented. To limit the current, a current limiter circuit is designed and deployed. To increase the immunity against noise, an averaging concept with multiple samples is introduced in potential measurement calculation in microcontroller program. Sequential delays in LABVIEW and Microcontroller program were optimized for better synchronization of current server and main server. Also included provision in application to customized delay between each probe configuration. Calculations for resistance from measured electrical parameters are embedded in application. To isolate current server from main server during offset potential measurement, a double pole double through relay is replaced in existing circuit. Separate access point is added for flawless communication between computer, current server and main server. Resistance values acquired with commercial earth resistivity tester (DDR3) and IIG-ERTsystemhave been compared for ensuring the reliability of measurements. Multiple field tests were performed at same location to check the repeatability of resistivity data from IIG-ERT system.

DIRECTOR'S RESEARCH GROUP

Chief Coordinator : Geeta Vichare

Members : A. P. Dimri, Jayashree Bulusu, Chinmaya Nayak, Aditi Upadhyay, T. Sreeraj, Vasundhara Barde

A new project is taken up in the Institute to understand the impact of solar variability on the Earth's climate, over various temporal (days to decades) and spatial (regional to global) scales. Few objectives are being deliberated under this project viz. to investigate the possible impacts of active geomagnetic conditions on Northern Atlantic oscillations, to study the possible effects of solar variability on tropical cyclone (TC) activity over various time scales, Long term influence of solar activity on the Outgoing Longwave Radiation (OLR), effects of CIR-driven storms on flash floods, if any linkages between the stratospheric warming, atmospheric tides and Indian summer monsoon rainfall etc. The current work investigates possible effects of the solar variability on tropical cyclone activity using IBTrACS (International Best Track Archive for Climate Stewardship) data set. The initial results show strong anti-correlation between TC occurrence and solar activity in the North Atlantic region. However, a similar behavior is not clearly observed in other sectors. Additionally, extreme events (category and above TCs) are less favoured during the ascending phase of a solar cycle. They are more favoured during the declining phase and minimum phases. More importantly, extreme TC are highly probable under low solar activity (SSN < 50) conditions.

FIELD SURVEYS

1. Field survey for the acquisition of electrical resistivity imaging (ERI), VLF, and hydro-geochemical data was carried out in and around the thermal springs in Jalgaon

2. Field survey for the acquisition of electrical resistivity imaging (ERI), and VLF was carried out in Ratnagiri district, Maharashtra during January 2023 to assess the saline water intrusion and freshwater aquifers.

3. GPS field work was conducted during March 15 to April 6, 2022, in the Palghar and surrounding area. During the field work 3 continuous operating GPS station was installed at Talasari, Palghar and Silvassa. Further 6 campaign mode GPS stations were installed at Daman, Bordi, Udwa, Wada, Vickram Gad and Tarapur. At every site, 72 hours data were collected.

4. Five permanent stations were installed at Vedanta Medical College, Rubber Research Institute, Udwa, Ambesari and Ashagad during August 10-30, 2022.

5. One malfunctioning GNSS receiver was replaced at Vedanta Medical College and checked the status of the receiver at other places during September 6-7, 2022.

6. GPS field work was conducted in western and central part of Arunachal Pradesh and bordering upper Assam during November 1-19, 2022. Installed two permanent GPS stations at Bhalukpong and Kimi. Six campaign mode GPS stations were installed at Balipara, Biswanath Charali, Gophur, North Lakhimpur, Doimukh -Mani and Yazali. 72 hours GPS data were collecte dat each site.

7. Carried out archaeological artefacts collection in Lothal and Vadnagar historical sites, Gujarat, during June 10-14, 2022.

8. Palaeomagnetic rock sample collection was carried out in Silvassa, Maharashtra and Gujarat states, with IIT Bombay team during October 11-12, 2022.

9. Archaeological artefacts collection was carried out in and around the Mumbai Region (Elephanta Caves, Kondivite Caves, Vasai Fort,Bahrot Caves, Kolaba Fort, Nizam Shahi Mosque, Nagothane Bridge, Raigad Fort) during March 5-28, 2023.

10. A total of 118 samples comprising roadside dust and leaf dust samples were collected in and around eastern part of Prayagraj city in the month of February 2023, with an objective to identify quantitatively and qualitatively the pollution hotspots related to traffic intensity during Magh mela month. All the samples were collected at approximately 500 m interval on the traverses (1) Shastri bridge to Hanumanganj (2) Andawa to Sahson (3) Chakk to Leelapur road.

11. Ground magnetic survey was carried out in Vansada, Vapi, Daman and Dadra & Nagar Haveli, Nasik, Lonar, Chikli, Manmad, Mehkaretc regions of Gujarat, Maharashtra and UT's, to understand the magnetization variations within the Deccan trap, map the lineaments and prepare a crustal magnetic anomaly map of the Deccan Volcanic Province of Maharashtra. The said surveys were carried out during January 5- February 2, 2023 and February 27- March 20, 2023.

12. Servicing/data retrieval of the seismic instruments and servicing/data retrieval /dismantling of AEFM/ METPAK/ GNSS instruments was carried out in North-East India, from June 27 to July 06, 2022.

13. Field work was carried out for finalization of a site for the installation of broadband seismograph (BBS) at Imphal, Manipur, during July 2022.

14. Installation of BBS at the Lamdeng Forest Nursery campus, Imphal, Manipur, has been done during March 2023.

15. Field work was conducted for the maintenance and data retrieval of BBS stations at Imphal, Agartala and Aizawl during June 27 – July 7, 2022 and February 23 – March 13, 2023.

16. In order to select a suitable site to revive magnetic observations at Hanle, a magnetic survey had been successfully competed on a hillock nearby Hanle Observatory on September 29, 2022, which is also a geomagnetically quiet day. The magnetic survey resulted in the identification of site having low magnetic gradient suitable for the installation of fluxgate magnetometer on the eastern side of the hillock for the observations of earth's magnetic field.

17. Site survey and Radio Noise survey has been conducted from February 28 to March 3, 2023 for the installation of new advanced digital ionosonde system (ADIS) at KSKGRL, Prayagraj, UP (Figure 33).

Figure 33 Loop Antenna Setup used for Noise Survey by SAMEER team at KSKGRL, Prayagraj, UP

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55. Yadav, S., D. Singh and **M. Lal.** Spatiotemporal variability of rainfall over Jharkhand (India).*Disaster Advances,***15(4)**, 2022.

56. Zou, D.D., Q.Z. Ji, Y. Zhang, O.V. Kravchenko, **J.K. Atul** and K. Ostrikov. Electric properties of Chiral Plasma Plumes without external magnetic field. *IEEE Trans. Plasma Sci.*, **50 (12),** 2022.

CHAPTERS IN BOOKS/ BOOKS EDITED

1. **Anil Kumar, C.P**., A. SherinAnn and J. C. K. Akhila. Investigation of Joule heating in polar region -Antarctic. Editor(s) Dr. Abbas Mohammed, *New Frontiers in Physical Science,* **6**, 70-80, 2023, B.P.International, https://doi.org/10.9734/bpi/nfpsr/v6/ 17736D.

2. Maurya, A. K., G. Tripathi, S. B. Singh, **Rajesh Singh** and A. K. Singh. Low-latitude upper atmosphere remote sensing using very low frequency (VLF) waves. *Atmospheric Remote Sensing – Principles and Application*'; 283-306, 2023, doi:https://doi.org/10.1016 / B978-0-323-99262-6.00002-X, Elsevier.

3. Resmi, T. R., G. Gopinath, P. S. Sunil, M. Praveenbabu and **R. Rawat.** Isotope hydrochemistry of lakes and transient ponds of east antarctica with varying degree of environmental condition, In: Climate Change and Geodynamics in Polar Regions, 1st Edition, 2022, CRC Press, eBook ISBN9781003284413

4. **Seemala, G.K**. Estimation of ionospheric total electron content (TEC) from GNSS observations, In: Atmospheric Remote Sensing: Principles and Applications, 63-84, 2023.

5. **Varghese, S. S.** and **S.S. Ghosh.** Offset bipolar pulses in magnetospheric plasma systems In: Banerjee, S., Saha, A. (eds) Nonlinear Dynamics and Applications. Springer Proceedings in Complexity. Springer, Cham. https://doi.org/10.1007/978-3-030-99792-2_1.

IMPACT FACTOR OF PUBLICATIONS DURING 2022-2023

Journal Name	Impact Factor	No. of Papers
Advances Space Research	2.611	6
Asian Journal of Research and Reviews in Physics	–	1
Atmosphere	3.11	1
Astrophys. Space Sci.	1.9	1
Astronomy Astrophys.	6.24	1
Disaster Advances	0.33	1
Earth Planet. Phys.	3.362	1
Frontiers in Astronomy and Space Sciences	4.055	3
Geoscience Frontiers	7.483	1
Geophysical Research Letters	5.576	1
IEEE Transactions on Plasma Science	1.5	2
Inorg. Chem. Commu.	3.428	1
Int. J. Environ. Res. Public Health	4.614	1
Internat. Res. J. Engg. Tech.	7.529	1
J. Atmos. Solar-Terr. Phys.	2.119	2
J. Earth System Sci.	1.912	2
J. Geophys. Res. (Space Physics)	3.111	10
J. Geophys. Res. (Atmospheres)	5.217	1
J. Geosci. Res.	1.778	1
J. Phys. Chem. A	2.9	1
J. Phys. Chem. B	3.3	1
Journal of Pure & Applied Physics	0.846	1
Monthly Notices Royal Astron. Soc.:Letters	5.235	1
Natural Hazards	3.7	1
Phys. Plasmas	2.2	1
Physica Scripta	2.9	1
Pure Appl. Geophys.	2.0	1
Solar Physics	2.8	1
Space Weather	4.288	2
Tectonophysics	3.66	1
The Astrophysical Journal	5.521	4
Theoretical and Applied Climatology	3.4	1
Turkish J. Earth Sci.	1.543	1

INVITED TALKS AND LECTURES

Dr. Amar P. Kakad

Gave a talk on *"Solitary Waves in Martian Plasma Environment",* at Research Institute for Sustainable Humanosphere, Kyoto University, on September 8, 2022.

Dr. Anand, S.P.

On an invitation from Marine & Coastal Survey Division (M & CD), Geological Survey of India, delivered an e-lecture as a part of their online training course entitled "Course on Marine Geology and Marine Geophysics" on the topic *´Crustal Structure of Asesimic Ridges in the Northwestern Indian Ocean-A Geopotential Appraisal"*,on June 19, 2021.

On invitation from Geological Survey of India Training Institute Hyderabad, delivered one day lecture on *"Processing and interpretation of Magnetic data with case histories"* as a part of their workshop entitled "Basic course on integrated marine gravity, magnetic and shallow and deep seismic surveys to explore sub-seafloor geological features" conducted at MCSD, Manguluru, on August 26, 2022.

Dr. Anup K. Sinha

Delivered a series of lectures on *"Introduction to Geology, Structural Geology, Petrology (igneous, metamorphic and sedimentary rocks), Texture & Mineralogy, and Stratigrahy"* as part of Research Scholar course work during November 14-18, 2022 at IIG Panvel.

Dr. B. Jayashree

Delivered two lectures in the meeting as a member of project under International Space Science Institute titled *"CSES and Swarm investigation of the generation mechanisms of low latitude Pi2 waves"* (ISSI/ISSI-BJ Joint proposal (2022) during November 1-2, 2022

Dr. Bharati Kakad

Gave atalk on *"Solitary wave structures in the Mars Magnetosheath region"*, at Space plasma planetary group, Khalifa University, on November 22, 2022.

Dr. B. Veenadhari
Gave a talk on *"Space weather and Geomagnetism"*, at SRM Institute of Science and Technology, Delhi-NCR Campus, Ghaziabad, October 8-9, 2021.

Dr. Vasundhara Barde
Gave an invited talk on *"India's major drought-prone area: from the past to the future"*, during a one-day National Workshop at Centre for Climate Smart Agriculture, SOA University, Bhubaneswar Odisha, on March 23, 2023.

Dr. Gautam Gupta
Delivered a lecture at MRS School & College, Prayagraj, on *"Overview of scientific research at KSKGRL, Prayagraj"*, on August 8, 2022.

Delivered an invited lecture during IMPRESS 2023 at IIG, Panvel, on the topic *"Application of Electrical Geophysics: Challenges"*, on February 14, 2023.

Delivered an invited talk at Zulal Bhilajirao Patil College, Dhule, on the topic *"Earth and Human"*, on March 1, 2023.

Dr. G.S. Lakhina
Delivered the 2nd A. K. SUNDARAM MEMORIAL LECTURE on *"Magnetic Reconnection, Magnetospheric Substroms, Magnetic Storms and Society"*, at Institute for Plasma Research, Gandhinagar, on January 17, 2023.

Dr. Geeta Vichare
Was invited at National conference on *"Akash for life"* held during November 4-6,2022 at Uttaranchal University, Dehradun to deliver a talk on "Impact of Extreme Space weather events on Geospace".

Dr. G.K.Seemala
Has given an online invited talk on *"Space weather: effects on Satellite communication and navigation systems"* at Koneru Lakshmiah Deemed to be University on 30 April 2022.

Ms. Khan Tahama
Delivered a guest lecture at School of Earth & Environmental Science, KBC North Maharashtra University, Jalgaon on the topic *"Hydrology and Geoelectrics: A Perspective"*, on April 19, 2022.

Dr. S. Gurubaran
Participated as a Panelist in Panel Discussion on the theme Environment & Climate Change: Role of Akash, during Akash for Life Conference, held at Dehradun during November 5-6, 2022.

Dr. S.Sripathi
Was invited to deliver alecture at SAMEER on *"HF radar probing of the ionosphere for space weather applications"* in a National Workshop on Advance Observation Systems for Atmospheric & Space Weather Monitoring during February 23-24, 2023 conducted at SAMEER, IIT campus, Mumbai.

Dr. S.Tulasiram
was invited to give alecture on *"Space Weather monitoring with magnetometers"* at Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP)SAC, Ahmedabad on March 16,2023.

PARTICIPATION IN CONFERENCES/MEETINGS/SEMINARS

NATIONAL

One-day National Meet on Venusian Science - Outstanding Scientific Problems on Venus: Need for Space-based Studies (Virtual meet) conducted by Science Programme Office, (SPO), ISRO Headquarters, Bengaluru, May 4, 2022

Devanandhan, S., B. Jayashree, Chinmaya K. Nayak and B. Remya, Venusian ionosphere.

National Meet on Aeronomy (online) conducted by ISRO Headquarters, Bengaluru, May 10, 2022

Gurubaran, S., Current understanding of ionosphere-thermosphere system.

Two-day workshop at Cosmic Ray Laboratory (CRL), Ooty, May 17-18, 2022

Vichare, Geeta, Studies using NaI (Tl) scintillation detector at Tirunelveli.

Brainstorming Meeting on Middle Atmosphere Research using Lidars (online) conducted by NARL, Gadanki, May 24, 2022

Gurubaran, S., Middle atmospheric research using lidars and other collocated facilities.

6th National Geo-Research Scholars Meet 2022, organized by Wadia Institute of Himalayan Geology & University of Ladakh, Leh Campus, June 7-10, 2022

Khan, Tabish, Anand, S.P. and D. Chandrashekaram, Estimation of depth to bottom of magnetic sources and proxy heat flow map through spectral analysis of aeromagnetic data.

Rawat, M. and **Anand, S.P.**, Comparative study of lithospheric models derived from MAGSAT, Champ and Swarm satellite data over the Indian sub-continent.

7th National Conference on Rock Deformation and Structure (RDS VII), Department of Geology, BHU, Varanasi, October13-15, 2022

Nishad, R. K., Anup K. Sinha, S. K. Pradhan and **S. K. Patil,** A comparative analysis for the identification and distribution of magnetic mineral grains in the mafic dykes of Singhbhum and Bundelkhand cratons: Constraints from AMS study.

Sinha, Anup K., R. K. Nishad and **S. K. Patil,** Status of palaeomagnetic, rock magnetic and geochronology investigations on the Proterozoic dykes of Bundelkhand craton, central India.

3rd Triennial Congress of Federation of Indian Geosciences Association on Geosciences of Himalaya for Sustainable Development, Wadia Institute of Himalayan Geology, Dehradun, November 16-18, 2022

Deshmukh, V., P. V. Vijaya Kumar, **P. B.V. Subba Rao** and **A. K. Singh**, MT and AMT studies across thermal springs in SW part of Maharashtra.

Md. Mujahed Baba, B.V. Lakshmi and **K. Deenadayalan,** Characteristic of magnetic fabrics of sediments along Kolang River, Kopili fault zone, Assam, India.

Pathan, S., **K. Tahama**, T. Arora, **G. Gupta** and T. Vijay Kumar, Hydro-Geophysical investigation to demarcate groundwater potential zone and assessment of aquifer protective capacity in hard rock terrain using Dar-Zarrouk parameters, Tapi River Basin, India.

Frontiers in Geosciences Research Conference, 2nd Annual Conference, Physical Research Laboratory, Ahmedabad, February 1-3, 2023

Bagiya, Mala S., Observing the earthquakes and tsunamis from the space: Applications and limitations.

Bagiya, Mala S., A. P. Dimri, K. Heki, and **Srinivas Nayak**, Tracing the tsunami generated ionospheric signatures: An early warning system on the anvil.

Mohite, P., P. Rajapandy, K. Deenadayalan and **B.V. Lakshmi,** Archaeomagnetic studies on ancient artefacts from Parad, Purna River Basin, Maharashtra.

Tiwari, S.H., Mala S. Bagiya, S. Maurya, K. Heki, **A. P. Dimri,** On the lithospheric-atmospheric-ionospheric coupling during the 15 January 2022 Hunga Tonga-HungaHa'apai Volcanic eruption.

National Workshop on Advance Observation Systems for Atmospheric & Space Weather Monitoring, SAMEER, Mumbai, February 24, 2023

Gurubaran, S., Probing the mesosphere-lower thermosphere (MLT) region (80-100 km) using medium frequency (MF) partial reflection radars.

Two-day workshop on "Deccan Magmatism and its Implications to the Evolution of the Western Continental Margin of India", Indian Institute of Technology, Bombay, March 29-30, 2023

Anand, S.P., Can geopotential data image sub-basalt structures – case studies from Deccan Volcanic Province.

INTERNATIONAL

EGU General Assembly-2022 Vienna (Austria), April 23-28,2022

Jadhav, A. and **S. Gurubaran**, Planetary wave coupling of Atmosphere-Ionosphere system at low to mid-latitudes.

3rd Eddy Cross Disciplinary Symposium: Sun, Earth, Planet, Space, Atmosphere andOcean organized by NASA at Vail, Colorado, USA, June 6-10, 2022

Shaikh, Z.I., A. Raghav, **Geeta Vichare**, R.D'Amicis, D. Telloni, Super-adiabatic heating and cooling of alfvenic solar wind plasma.

Energetics and Dynamics of Atmospheric Regions (CEDAR) workshop held at Austin, Texas, USA, June 19-24, 2022

Sreelakshmi, J., A. Maute, **Geeta Vichare** and B. Harding, Study of zonal wind effect on the equatorial return currents using ICON/MIGHTI and Swarm Observations in the Coupling.

44th COSPAR Scientific Assembly, July 16-24,2022 (Online)

Sinha, S.,Geeta Vichare and A.K. Sinha, Categorization of substorm triggering mechanism based on the ground observations.

19th Annual Meeting Asia Oceania Geoscience Society (AOGS) Virtual Conference, August 1-5, 2022

Adhitya P., B. Jayashree, Geeta Vichare, M.Nosé and A.K. Sinha, Observation of upper extent of ionospheric alfven resonator frequencies at low latitudes.

10th SCAR Open Science Conference, August 1-10, 2022 (virtual platform)

Sinha, S., Geeta Vichare, A.K. Sinha and **R. Rawat**, Hemispheric asymmetry in the cosmic noise absorption response during intense solar flare events.

16th International Symposium on Equatorial Aeronomy, September 12-16, 2022 (Online)

Chauhan, N., V. Lakshmi Narayanan and **S. Gurubaran**, Sources of gravity waves observed over indian equatorial region using reverse ray-tracing.

Kakoti, G., Mala S. Bagiya, and F.I. Laskar, The dayside ionospheric-thermospheric changes during minor geomagnetic storm activity of 3-4 February 2022.

Saha, S., D. Pallamraju, **R. N. Ghodpage**, Characteristics Gravity wave scale sizes present in the plasma bubbles as seen in in the OI 630 nm night glow emissions over low latitudes.

Sreelakshmi J., A.Maute, **Geeta Vichare**, A.D. Richmond and B. Harding, Zonal winds in the lower ionosphere and their effects on EEJ return currents: An observational study using ICON/MIGHTI and Swarm.

Tulasi Ram, **S.**,K.K. Ajith, T. Yokoyama, M. Yamamoto and K. Hozumi, Early development of 3-meter scale irregularities in the topside region of an equatorial plasma bubble.

10th VERSIM meeting at Sodankila, November 7-11, 2022

Singh, Rajesh, Role of mesoscale convective system (MCS) generated gravity waves (GWs) in atmosphere-ionosphere coupling (INVITED).

The 5th ISEE Symposium, Nagoya, Japan, November 15-17, 2022

Veenadhari, B., Y. Miyoshi, M. Pandya, **T. Shah,** Y. Ebihara,T. Hori, K. Asamura, S. Yokota, S. Kasahara, K. Keika, A. Matsuoka and I. Shinohara, Variation of energetic ions during magnetic storm and substorm time: ERG (Arase) and Van Allen probe observations.

International Conference on Advances in Science of Earth: Relevance to the Society, SRTM University, Nanded, November 24-26, 2022

Anand, S.P. and P. Kunnummal, Crustal architecture of greater Maldive ridge in the west-central Indian ocean.

Bagiya, Mala S., A. P. Dimri and **Srinivas Nayak**, On the tsunami generated ionospheric disturbances over the Indian ocean: An early warning perspective.

Jayan, J.R., C.J. Kiran, **Anand, S.P.** and B. Longhinos, Subsurface characterization of rock gully exposure using Magnetotelluric scanning in Kollam, Kerala.

Tiwari, S.H., Mala S. Bagiya, S. Maurya, K. Heki, A.P. Dimri and **Srinivas Nayak,** Seismic spheroidal modes excited by atmospheric oscillations during the 2022 Hunga Tonga-HungaHa'apaivolcanic eruption.

5th URSI Regional Conference on Radio Science (URSI-RCRS 2022)" held at IIT, Indore, December 1-4, 2022

Shaikh, Z.I. and **Geeta Vichare**, Super-adiabatic cooling of small-scale magnetic flux-ropes in inner heliosphere: PSP observation.

Sripathi, S., S.Tulasiram, A.Khandare, P. Shrivastava and A. Kulkarni, Development of Advanced Digital Ionosonde System (ADIS) under IIG-SAMEER collaborative project for ionospheric and space weather applications.

American Geophysical Union (AGU) Fall Meeting, December 12-16, 2022, Chicago, USA (Virtual)

Jayashree, B., A. Upadhyay, C. Nayak, Geeta Vichare and **A.P. Dimri**, Influence of geomagnetic activity on the Northern Atlantic Oscillations (NAO).

Maute, A. I., **J.Sreelakshmi, Geeta Vichare**, A. D. Richmond, B.J. Harding and P. Alken, Connection between daytime vertical zonal wind gradient and zonal current at low latitude using ICON and Swarm observations.

Nayak, C., B. Jayashree, A. Upadhyay, Geeta Vichare and **A. P. Dimri**, An investigation into possible effects of solar variability on tropical cyclone activity.

Rawat, M. and **Anand, S.P.**, Lithospheric anomaly map of Indian region derived from Swarm and Champ satellite data.

Upadhyay, A., B. Jayashree, C. Nayak, Geeta Vichare and **A.P. Dimri**, Understanding the influence of the solar forcing on the global climate.

STUDENTS CORNER

Ms. Dhanya Thomas was awarded Ph.D. degree in Geophysics by Andhra University on the thesis entitled "Lithospheric deformation and associated manifestation in Ionosphere using GNSS observations", under **Dr. Mala Bagiya** and Dr P. S. Sunil (CUSAT, Kochi).

Shri Krushna Chandra Barik was awarded Ph.D. degree in Physicson the thesis entitled "Generation of low-frequency electromagnetic waves in the magnetosphere", Mumbai University, under the guidance of **Prof. Satyavir Singh.**

Shri Biswajit Ojha was awarded Ph.D. degree in Physics on the thesis entitled "Solar wind control of wave activity in the magnetosphere",Mumbai University, under the guidance of **Prof. Satyavir Singh.**

Shri Zubair I. Shaikh was awarded Ph. D. degree in Physics on the thesis entitled "Solar transients and associated space weather effects", Mumbai University, under the guidance of **Prof. Geeta Vichare.**

Ms. Trunali Shah virtually attended the following

1. Sixteenth Heliophysics Summer School on "Connecting the Heliopshere", August 1-12, 2022.
2. Symposium on "The Future of Heliopsheric Science from Geotail and Beyond", Tokyo, Japan, March 28-31, 2023.

DEPUTATIONS/VISITS ABROAD

Name	Country visited	Duration	Conference/workshop/symposium
Dr. Amar Kakad	Japan	July 1- September 30, 2022	Visiting Professor at Research Institute for Sustainable Humanosphere, Kyoto University, Kyoto,Japan.
Dr. B. Veenadhari	Japan	October 6, 2022 to February 7, 2023	Visiting Professor, Research Institute for Sustainable Humanosphere (RISH), Kyoto University, Kyoto, Japan.
Dr. Geeta Vichare	USA	June 28, 2022 to July 10, 2022	Visited High Altitude Observatory (HAO), Boulder, Colorado, for scientific discussions with Dr. Astrid Maute, under Newkirk Fellowship program.
Shri Nilesh Chauhan	Japan	November 1, 2022 to January 31, 2023	Scostep Visiting Scholar at Institute for Space Earth Environmental Research (ISEE), Nagoya, Japan.
Dr. Bharati Kakad	UAE	November 5 to December 5, 2022	Collaborative research work with the space plasma group, Khalifa University, Abu Dhabi.
Dr. Chinmaya Nayak	USA	December 12-16, 2022	AGU Fall Meeting, Chicago, USA.
Dr. Gopi K.Seemala	South Africa	March 26 to April 15, 2023	Visited for scientific discussions at South African National Space Agency (SANSA), and to understand their ongoing implementation of space weather forecast, & regional magnetic model, South Africa.

Antarctic/Arctic Expeditions

Name	Country visited	Duration	Expedition
Dr. M. Laxminarayana	Maitri, Antarctica	42nd ISEA	Winter member
Shri Pranjal Saikia	Bharati, Antarctica	42nd ISEA	Station Leader & Winter member
Dr. Navin Parihar	Maitri, Antarctica	42nd ISEA	Summer member

DISTINGUISHED VISITORS

Prof. B. R. Arora, ex-Director (Retd.),Wadia Institute of Himalayan Geology, Dehradun, visited IIG on April 12, 2022 and January 25, 2023,and interacted with scientists and students. He gave a talk on “Multi-Geophysical Imaging of the Himalayan Collision Zone: Constraints on Tectonics and Seismogensis”.

Mr. Amol Thute, Technology Lead - HPC & LinuxLocuz Enterprise Solutions Ltd.,visted IIG on April 25, 2022and gave a talk on “Introduction to High Performance Computing System”.

Mr. S. Sriram, Indian Institute of Astrophysics, Bengaluru, visited iig on April 29, 2022, and gave talk on “India’s contribution to the Thirty Meter Telescope”.

Prof. Ramana Murthy, NIT, Warangal, visited IIG on April 26, 2022,and gave a talk on“Numerical solutions of Non-linear Differential Equations”.

Mr. Arghyadeep Paul, IIT, Indore, visited IIG and gave a talk on June 23, 2022“A Volumetric study of Flux Transfer Events at the Dayside Magnetopause”.

Dr. P.T. Jayachandran, Chair and Professor, Department of Physics, University of New Brunswick, Canada, visited IIG during September 13-17,2022. He also delivered a lecture on "Effect of Scintillation on GNSS-based TEC Metrology"and interacted with students and faculties.

Prof. Devesh K. Sinha, Director, Delhi School of Climate Change & Sustainability, visited on October 17, 2022 and gave a talk on "Integrated Neogene-Quaternary Oceanic Biostratigraphy & Magnetostratigraphy: Global Correlations and Scope for Indian Marine Neogene Sequences".

A team of faculties from Jawaharlal Nehru University (JNU), New Delhi, visited IIG on November 11, 2022, to discuss the Memorandum of Understanding between JNU and IIG, to facilitate the academic collaboration.

Faculty members from Jawaharlal Nehru University (JNU), New Delhi and IIG discussing the Memorandum of Understanding between JNU and IIG, to facilitate the academic collaboration. (Bottom: Group Photo)

Dr. Anil Bhardwaj, Director, PRL, Ahmedabad, and Member, Governing Council IIG, visited KSKGRL, Prayagraj on December 4, 2022. Dr. Gautam Gupta, Head, KSKGRL, accorded a floral welcome to Dr. Anil Bhardwaj on his arrival. Post lunch, Dr. Bhardwaj was taken to the Magnetic Observatory to show the magnetic instruments in operation. He visited the Petrology and Palaeomagnetic laboratories and showed keen interest in their operation and applications. He was taken around the Upper Atmospheric laboratory, wherein he was shown the real-time plots acquired from the Observatory instruments, the Canadian Advanced Digital Ionosonde (CADI) and from VLF receiver. Dr. Anil Bhardwaj interacted with the staff and student members and expressed his interest to set-up some experiments within the KSKGRL campus. His advice and invaluable guidance will immensely help the Center to move ahead in terms of scientific research. Dr. Anil Bhardwaj was felicitated with a flower bouquet and shawl. As a mark of remembrance, a tree plantation was also organized during his visit.

Dr. Anil Bhardwaj, Director, PRL, Ahmedabad and Member Governing Council IIG, visiting the research facilities at KSKGRL (IIG), Prayagraj.

Dr. Vipin K. Yadav, Space Physics Laboratory (SPL), VSSC, Trivandrum, visted IIG on December 5, 2022, and gave a talk on "Magnetic field measurements at L-1 point using Fluxgate Magnetometer (MAG) onboard Aditya-L1 Spacecraft".

Prof. Dev Niyogi, Department of Geological Sciences, Jackson School of Geosciences, USA, visited IIG on December 19, 2022, and gave a talk on "Ongoing select research and engagement activities at Jackson School of Geosciences".

Dr. Fazlul I. Laskar, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA, visited IIG on December 30, 2022, and gave a talk on "How SpaceX lost 38 out of the 49 Starlink satellites launched on 3rd February 2022?".

Dr. Suryachandra A. Rao, Indian Institute of Tropical Meteorology, Pune,visted IIG on January 24, 2023, and gave a talk on "High Performance Computing in Meteorology and Oceanography: Achievements and Challenges".

Dr. Nat Gopalswamy, NASA, USA,visted IIG on February 27,2023, and gave apopular talk on "The Dark Side of the Sun".

Shri K.N. Rai, Former Chief Executive (Civil Works & Estate), DRDO, visited KSKGRL, Prayagraj on March 6, 2023. Dr. Gautam Gupta, Head, and Dr. Rajesh Singh, AIC, KSKGRL, accorded a warm welcome to Shri K.N. Rai on his arrival. Shri Rai was briefed about KSKGRL campus and the developmental activities planned. He enquired about the water and power supply and the sewage facility in the campus. He suggested that the earlier surveillance pathway around the campus to be repaired with a track of 1.5 m. He also advised to put up barbed-wire fence above the compound wall for safety purposes. Shri Rai also stressed upon the leakage and seepage issues and other procedures. The advice and invaluable guidance of Shri Rai will immensely help the Center to move ahead in terms of infrastructural development.

The Environmental Magnetism Laboratory (EML) was visited by the following distinguished scientists:

1. Prof. J.K. Tripathi, JNU, New Delhi, visited in June 2022.
2. Geologists from Geological Survey of India, Nagpur, visited in the month of July 2022.
3. Dr. Anupam Sharma and Dr. S. Nawaz Ali, Scientists from BSIP, Lucknow, visited during August 28- September 1, 2022.
4. Prof. Devesh K. Sinha, Director, Delhi School of Climate Change & Sustainability, visited on October 17, 2022.
5. Interaction with Dr. A.K. Pandey, Scientist, NGRI, Hyderabad.
6. Dr. Y.Giri, IIT Mumbai, visited during October 25-29, 2022.
7. Dr. Saumitra Misra, Geologist,University of KwaZulu -Natal, Durban, South Africa, visited during October 27-28, 2022.
8. Prof. M. Radhakrishna, IIT, Mumbai and Dr. Radha Seinivasan, Mumbai University visited on December 2, 2022.
9. Dr. B.R. Arora, WIHG, Dehradun, visited on January 25, 2023.
10. Dr. Tyson Sebastian, Project Scientist, NCPOR, Goa, visited during March 6-10, 2023.
11. Smt. Sugandhi Suresh, Scientific Officer/F, BARC, Mumbai, visited on March 13, 2023.

Dr. Manoranjan Mohanty Head, Autonomous Institution Division, Department of Science and Technology, New Delhi visted IIG on 3rd December 2022 and interacted with faculty members

Dr. Manoranjan Mohanty, Head, Autonomous Institution Division, Department of Science and Technology, New Delhi, interacting with faculty members and visiting various research facilities at IIG.

HONOURS AND AWARDS

Dr. Amar P. Kakad
Buti Foundation Award-2021, for outstanding contributions in the field of Plasma Science and Technology.

Member of Scientific Program Committee, 37th National Symposium on Plasma Science & Technology (PLASMA-2022) organized by IIT Jodhpur, in association with Plasma Science Society of India (PSSI) during December 12-14, 2022.

Dr. Gautam Gupta
Chief Guest during the National Science Day Celebrations, 2023, at School of Environmental and Earth Sciences, KBC North Maharashtra University, Jalgaon, on March 3, 2023.

Member, Board of Studies, Department of Geotechnology, Manonmaniam Sundaranar University, Tirunelveli, 2023.

Associate Editor, Journal of Ground Water Research, ISSN Number (ISSN 2321-4783), 2023.

Member, Editorial Board, Bulletin of Pure & Applied Sciences (Geology), eISSN: 2320-3234, 2023.

Dr. Mala S. Bagiya
Convened following two Sessions at International Conference on Advances in Science of the Earth: Relevance to Society (ASERS-2022)held at Swami Ramanand Teerth Marathwada (SRTM) University, Nanded, during November 24-26,2022.

(i) Natural Hazards: Prediction and Mitigation
(ii)Application of AI and ML in Earth Sciences

Represented IIG during concluding session of International Conference on Advances in Science of the Earth: Relevance to Society (ASERS-2022) held at Swami Ramanand Teerth Marathwada (SRTM) University, Nanded, during November 24-26, 2022

Dr. Geeta Vichare appointed as an examiner for the Ph.D. thesis entitled "Studies on the Electron Velocity Distributions in the Solar Wind at 1AU during Solar Transient Events", of Cochin University of Science and Technology, Kochi.

Dr. Geeta Vichare appointed as an examiner for the evaluation and final defense of the Ph.D. thesis entitled "Investigations on Low Latitude Ionosphere under Varying Space Weather Conditions", of IITGandhinagar.

Dr. Zubair I. Shaikh received Young Scientist Award (YSA) in Commission-H in the URSI-RCRS 2022 conference, held at IIT Indore, during December 1-4,2022.

Dr. Anand S. P. was nominated as Member of Executive Council of Indian Geophysical Union (IGU) for the period 2022-2024.

Dr. Satyavir Singh
Life member of in Rass.
Member, American Geophysical Union 2022.

Dr. S. Tulasiram
Session Convener, Session 3: Atmosphere-ionosphere vertical coupling at low- and mid-latitudes at 16th International Symposium on Equatorial Aeronomy (ISEA-16) during September 12–16, 2022 held at RISH, Kyoto University, Japan.

Guest Editor, Special Issue on "Recent advances in the study of Equatorial Plasma Bubbles and Ionospheric Scintillation" in the international journal Earth Planet Physics.

TRAINING IMPARTED

Dr. Anand, S.P.

Ms. Anjali Suresh, M.Sc. student from Department of Marine Geology and Geophysics, Cochin University of Science and Technology, Kochi, completed her M.Sc. dissertation work on the topic "Depth to the Bottom of the Magnetic Sources in the Bastar craton and adjoining regions", from March to June 2022.

Dr. Anup K. Sinha

A total of 5 M.Sc. students from Department of Geology, Central University of Punjab, are undergoing their dissertation work as part of M.Sc. curriculum, in the paleomagnetic and petrological laboratory since March 2023. They are working on Environmental study of the roadside dust samples, Palaeomagnetic and Petrological studies on the dykes and granites samples of Singhbhum and Bundelkhand Craton.

Dr. B. V. Lakshmi

Mr. Vishnu K. Nambiar, Department of Marine Geophysics, Cochin University of Science and Technology, Kochi, has done his M.Sc. Project work on "Mineral magnetic and geochemical properties of sediments from Dudhnai River, Assam", during April-June 2022.

Mr. Munde Newton Annarao, School of Earth Science, Swami Ramanand Teerth Marathwada (SRTM) University, Nanded, has done his M.Sc. dissertation work on "Mineral magnetic properties of sediments from Khoridhara section along Krishnai River, Assam", during April 25-May 18, 2022.

Dr. Gautam Gupta

Ms. S. Aswathy, Department of Marine Geology and Geophysics, Cochin University of Science and Technology, Kochi, has completed her dissertation in the partial fulfillment of the requirements for the Master of Science in Marine Geophysics on the topic"Appraisal of groundwater quality based on Integrated Water Quality Index and GIS in coastal Sindhudurg district, Maharashtra", during March-June, 2022.

Mr. Sohelkhan Pathan, School of Earth Science, SRTM University, Nanded, completed his dissertation in the partial fulfillment of the requirements for the Master of Science in Geophysics on the topic"Evaluation of aquifer hydraulic parameters from geo-electrical sounding and hydro-geochemical data of Suki River basin, Raver Taluka, Jalgaon Dist., Maharashtra", during May, 2022.

Dr. C.P. Anil Kumar

Ms. Manju S.,Integrated M.Sc. (Physics), Dept. of Physics, M.S. University, Vadodara, received training for "External magnetic field periodicities and their signature in the terrestrial environment".

Dr. S.Sripathi

Ms. Sreelaxmi Purushothaman Nair has done her M.Sc. (Physics) dissertation work entitled "Estimation of bottom side electron density profiles using real height analysis (POLAN) under quiet and disturbed periods over Tirunelveli" during February 24-May 24,2022 for the partial fulfillment of award of M.Sc. in Physics, K.J. Somaiya College of Science and Commerce, Mumbai.

Ms. Muskan Ansari has done her M.Sc. (Physics) dissertation work entitled "A study on winds and wind shears for the occurrence of blanketing Es layers and Counter Electrojet (CEJ) events over Indian region", as a part of her Postgraduate degree curriculum during July 11 to September 23, 2022.

Dr. Navin Parihar

Internship guidance rendered to Ms. K. Anusiya M.Sc. (Integrated) Student, Department of Physics, M.S. University, Tirunelveli.

Dr. Satyavir Singh

Ms. Prajakta Mahesh Mhatre of Department of Physics, K.B. Patil College, Vashi, Navi Mumbai, carried out her M.Sc. project on "Linear Dispersion of Kinetic Alfven Waves" from July 11-September 29, 2022.

Dr. B. Remya

Ms. Tisa John, student from Department of Physics, Vellore Institute of Technology (VIT), Chennai, carried out her M.Sc. dissertation on the title "Study of high amplitude EMIC waves during quiet geomagnetic conditions". from January 5-April 21, 2023.

PARTICIPATION IN SPECIALIZED WORKSHOPS/TRAINING COURSES

Dr. Amar P. Kakad
Attended a training program in Administrative Vigilance conducted by the Department of Science and Technology, New Delhi, during June 15-17, 2022 for Vigilance Officers.

Attended a two-day Online Training on "Advance Course on Preventive Vigilance" from May 18-19, 2022 organized by National Productivity Council, Delhi.

Dr. K. Deenadayalan
Participated in Brainstorming workshop on "Deccan Magmatism and its Implications on the Evolution of Western Continental Margin of India" held at Department of Earth Sciences, IIT, Bombay, during March 29-30, 2023.

Dr. B. V. Lakshmi
Participated in Brainstorming workshop on "Deccan Magmatism and its Implications on the Evolution of Western Continental Margin of India" held at Department of Earth sciences, IIT, Mumbai, during March 29-30, 2023.

Participated (Nominated) in Brainstorming meeting on the "Geophysical aspects of Geological Exploration of Amery Ice Shelf (GeoEAIS)" held at NCPOR, Goa, on March 11, 2023.

Dr. Veenadhari, B., attended the 10th VERSIM meeting at Sodankila, during November 7-11, 2022 in virtual mode.

Dr. Geeta Vichare participated in NIAS-DST Programme on "Policy for Science and Science for Policies" during August 22-26, 2022 at NIAS, Bangalore.

Dr. Rabin Das participated in the 3rd International Virtual Workshop on Global Seismology & Tectonics (IVWGST-2022), Geoscience & Technology Division, North East Institute of Science & Technology, Jorhat, Assam, September 20-30, 2022.

Drs Nava Kumar Hazarika, Ganpat Surve, Ajish P Saji participated and put IIG exhibits in PHD Chamber of Commerce and Industry (PHD CCI) 2nd Edition MOMENTUM – North East 2023, Guwahati, January 20-22, 2023

NEGRL-IIG team at 2nd Edition MOMENTUM, North East 2023, Guwahati

OFFICIAL LANGUAGE (HINDI)

Rajbhasha Adhikari	:	Amar P. Kakad
Asst. Director (Official Language)	:	J. Kamra
Hindi Advisor	:	Manju J. Singh
L. D. C	:	K. Shelatkar

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

The Institute has organized 'Hindi Mah' during September-October, 2022. The Hindi competitions organized during this period included Essay Writing, General Knowledge, Crossword, Sentence Construction and Typing competition on computer, which were well attended by the staff members & research scholars. A total of 40 prizes were given to the winners in these competitions.

The Institute celebrated World Hindi Day on January 10, 2023 and organized 'Review Writing' competition on Hindi books available in the library. A total of 10 participants participated and 6 prizes were awarded for the same.

During the year, the Institute actively participated in various competitions organized by Navi Mumbai Town Official Language Implementation Committee (TOLIC). The institute also participated in the best house magazine competition of TOLIC and bagged first prize for its six-monthly house magazine 'SPANDAN' in the central government offices category.

The Hindi House Magazine "SPANDAN" is being published on a six-monthly basis (2 issues annually), which includes both scientific & technical articles. The magazine is being sent to various scientific and educational institutes/ universities in the country.

Institute bagged the Navi Mumbai TOLIC's first prize the best magazine award for the house magazine SPANDAN.

During the year, four Hindi Workshops (1 in virtual mode and 3 in-person) were organized on different topics for the staff of the Institute, in which around 85 members participated. Two workshops were conducted by Asstt. Director (OL) of the Institute for the technical/academic staff and one workshop was conducted byDr. Rakesh Kumar Parashar, Dy. Director, Hindi Teaching Scheme, Deptt. of Official Language, Belapur, Navi Mumbai, who was invited to provide guidance for typing/translating in Hindi on the computers to all the staff of the Institute.

Dr. Rakesh Kumar Parashar, Dy. Director, Hindi Teaching Scheme, Deptt. of Official Language, Belapur, Navi Mumbai providing guidance for typing/translating in Hindi on the computers to all the staff of the Institute.

Staff members attending Hindi workshop at IIG, Panvel.

Under the annual incentive scheme, during the Annual Day Celebrations 2022, 10 staff members of the Institute were awarded with cash prizes for doing their official work in Hindi throughout the year. Apart from this, 4 children of employees were awarded with cash prizes for scoring very good marks in the Hindi/Sanskrit subjects in10th Class examination

Director, Rajbhasha Adhikari, and Asstt.Director (Official Language) of the Institute attended various meetings/ seminars held under the aegis of TOLIC, Navi Mumbai and other organizations.

Staff members awarded with cash prizes for performing their day-to-day official work in Hindi.

SCIENCE OUTREACH ACTIVITIES

Indian Institute of Geomagnetism, a premier institute, conducting basic and applied research in the field of Space Science and Geomagnetism, is regularly conducting various public outreach activities for the students and common people. The science outreach activities are regularly conducted at IIG's regional Centers and Magnetic Observatories across the nation. Under this program, during 2022-2023 over 5500 students were benefited. The various challenges encountered post-COVID were overcome by implementing new program called as "Reach the Unreached". The new program implemented by IIG in the Post-COVID period to attract more students was successful and appreciated by many schools. With this program, large number of students could be reached. Particularly, it could reach and motivate minds of the young students coming from the grassroots level by arranging programs in their native languages. Real-time observations of solar surface and sunspots via telescope, quiz and slogan competitions, comic books, rock display, audio-video shows were in high demand during the science outreach activities. The public outreach team work tirelessly to make common people and students aware about the Earth and space science related research carried out at IIG.

Students being explained the concepts of geomagnetism and allied fields through instruments and lectures during various outreach programs organized by IIG.

NATIONAL SCIENCE DAY 2023

National Science Day is being celebrated on February 28 every year in commemoration of Sir C.V. Raman's discovery of the Raman Effect on February 28, 1927. The theme for National Science Day 2023 is 'Global Science for Global Wellbeing'. A popular talk on "The Dark Side of the Sun" was given by Dr. Nat Gopalswamy, NASA, USA, on February 27, 2023.

School students participating in the sit and draw competition during the Science Week 2023 celebrations at IIG.

Prof. A. P. Dimri, Director, IIG addressing Students and visitors at IIG during Science Day

Dr. Nat Gopalswamy delivering a popular science lecture during Science Day 2023 celebrations at IIG.

Science Week 2023 being celebrated at Magnetic Observatories and Regional Centers of IIG.

Seminar / workshop / events conducted by IIG under outreach activities:

1. On January 13, 2023, Indian Institute of Geomagnetism conducted a curtain raiser event for IISF 2022 to be held at Bhopal from 21-24 January 2023. Over 170 students enjoyed various science outreach activities like talks, rock display, comic books, solar observations, 3D globe, quiz, crosswords etc. Students also visited the Alibag Magnetic Observatory.

Participants of the curtain raiser event of India International Science Festival (IISF) at IIG.

2. One day seminar series organized at IIG on November 9, 2022 under "Akash for Life National event" on the theme "Strategic aspects of disturbances in Akash Tatva".

3.Indian Institute of Geomagnetism participated in the longest running coastal cleanup campaign, "Swachh Sagar Surakshit Sagar campaign". Scientists and students organized beach cleaning activity at Murud in Raigad district, Maharashtra on August 29,2022

Scientists and students participated in the longest running coastal cleanup drive, "Swachh Sagar Surakshit Sagar campaign" at Murud in Raigad district, Maharashtra on August 29, 2022.

ERP & COMPUTER SERVICES

Chief Coordinator : Ajay K. Singh
Member : Susheel Kumar, Mahendra Doiphode, Sayali Nalawade, Tejashri Bari, Nanda S. Shah

Computer Centre

During this year, the computer center has got upgraded central data-center infrastructure. The implementation of the smart server rack unit was carried out as part of enabling the standard data center environment for the critical server, storage, and network equipments. The new Video Conference room is also made operational. As routine practice, uninterrupted IT services are provided to the staff members and students. The network security at H.Q. network setup is improved and to bring all regional centers and observatories under single central security management. The VPN tunnels are also established between all centers and major observatory locations. Increased internet bandwidth and campus Wi-Fi services at H.Q. and other regional centers are initiated.

ERP

ERP System started in IIG since January 2019, with the vision of computerization, automating the existing

and streamlining systems. In this year all the modules related to HRD are made live and are being successfully used by all IIG staff and students. Leave module is live since 2019 and along with this, during this year tour advance, LTC advance, CEA, property declaration, Medical Reimbursement etc. are made live. The dispatch processes are digitized through Dak Seva module of ERP. During the year, one of the successful outcomes of ERP system was to conduct the Staff Recruitment completely in online mode with integration of payment gateway. The recruitment for various academic and administrative posts was conducted through Staff recruitment module. For temporary posts recruitment the NIC forms platform provided by NIC is also successfully used.

ERP portal being used is ensured with Data and Application security. For Data security, routine backups and server for Disaster recovery is set up. This will ensure the availability of latest data in case of any disaster. For application security, Security Audit of the portal from certified empaneled auditor is completed. SSL certification of the portal is also completed.

For achieving the milestone of paperless office and support the concept of work from anywhere, steps have been taken towards implementing the e-Office system in IIG.

LIBRARY AND DOCUMENTATION

Chief Coordinator : Satyavir Singh

Coordinator : Smita Chandra

Members : B.I. Panchal, Sachin Jadhav

Library

The IIG Library continued to render its services of knowledge dissemination to the scientists, students, and technical staff at its headquarters, regional centers, and observatories by means of acquisition, collection management, and dissemination of the library resources. The library staff with the help of the IIG management delivered quality services both via the online medium and offline physically. The collections added during the period is as follows:

Sr.No.	Collection	Added during 2022-2023
1.	Books, Thesis, Hindi Books, Project Reports	175
2.	*Journals/e-Journals subscribed by Library	83
3.	Scientific Publications of IIG	79
4.	**Total**	**337**

***(The above list excludes the list of more than 1400 e-journals + Databases subscribed by the CSIR/DST-NKRC Libraries consortia for the IIG library)**

Besides rendering library help on a daily basis, some of the important activities and services carried out by the library during this period are as follows:

1. The library began the task of data cleaning and enriching metadata. The same was completed for approximately 12000 records of English Books, Hindi Books, and E books, using Open-Sourcetools like Open Refine.

2. New server was acquired and configured for migration to the open-sourcelibrary management software KOHA. Tests were carried out and are on-going with the server for the successful migration of the first batch of records.

3. The institutional repository server and software were upgraded and bugs were identified. Work is going on for cleaning the data within the repository. Efforts are on to increase the functionality of the Dspace IR software, using outsourced technical support.

4. Profiles of Scientists were created via the Indian Research Information Network System (IRINS), INFLIBNET program. The IRINS not only give the research metrics for the individual scientists but also for the group they belong to and the institute as a whole.

5. Generation of Research metrics figures related to the number of publications, the impact factor, the h-index, citations of papers produced during the year, etc. The trends analyzed for the top authors of the institute, the top publishers the scientists chose to publish their article with, and the top journals the scientists chose to publish in for the year were collected, the number of Open Access articles published, etc was prepared by the library using tools like the Web of Science and in-house data collected by the library.

6. Library orientation to new students covered topics like the collection, services, facilities, etc both online as well as physically.

7. An awareness was raised for better usage of campus subscribed resources via technologies enabled by Google, for the IIG library users, anywhere, anytime, any day, and on any device of their preference.

8. Library contributed to the Hindi Mah (September 14 -October 13, 2022) by displaying books in the library on various topics. In efforts to further enhance the usage of Hindi books and the implementation of Rajbhasha, events like writing about the contents of a book as an abstract, etc were organized.

9. The library carried out the Stock-Verification including physical verification and re-arrangement of books and bound journals within the premises and compactor area to make more space for books/bound volumes in the future.

Library Usage during 2022-2023

1. Following are the figures of usage of the library and some of the other services by the HQ library:

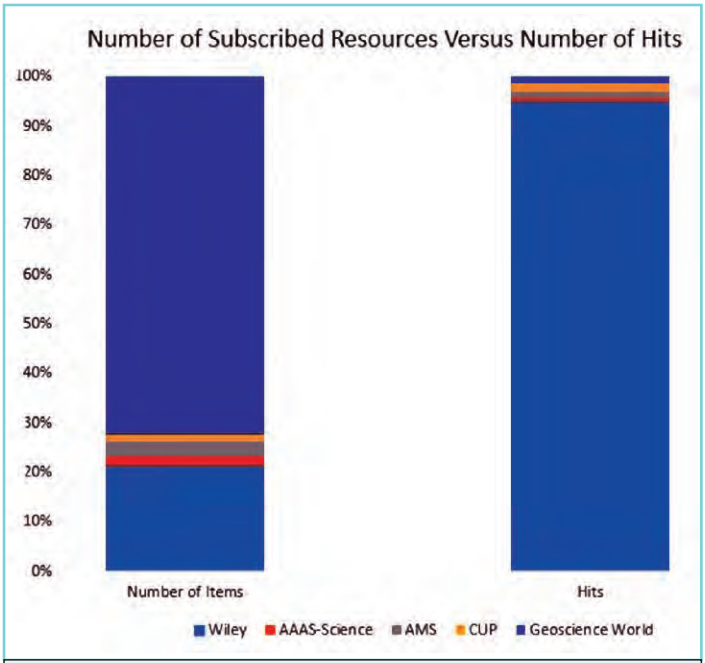
Sr.No.	Library Service	Usage Figures
1.	Average Daily HQ Library Footfall	36
2.	Issue/Return Transactions or Circulation Desk Transactions	1380
3.	Number of Xerox copies provided	2135
4.	Number of binding work done	209
5.	Number of Abstracts Processed and Displayed	161
6	Number of ILL Article requests handled	12

Head Count at HQ Library: 118 (For Sr.Nos.1-6)

2. The library usage for the e-resources facilities provided by the library to the HQ, regional centers and observatories are as follows:

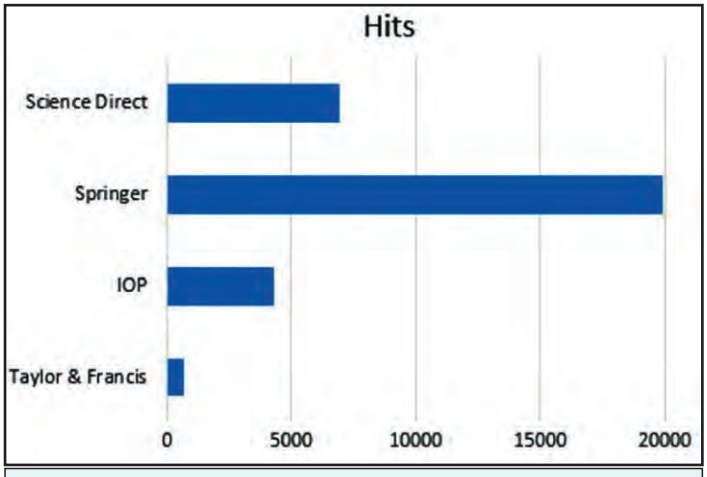
Sr.No.	E-resource service provided	Usage Figures
1.	RemoteXs services for e-resources (Data available : Apr-Dec 2022)	Logins : 166 Downloads : 143
2.	Daily Average Web-OPAC Hits	49
3.	i-Thenticate Plagiarism Checks	344 document count

3. Usage Statistics of e-Journals Subscribed by the library for the period :



Some of the Subscribed Resources by Library Versus Online Usage

4. Usage Statistics of some of the Publishers subscribed by the CSIR/DST-NKRC Libraries Consortium for the IIG Library



Usage Statistics of some of the Resources by NKRC-DST-CSIR-Libraries Consortium

[It may be noted that the Head Count for Points 2, 3 & 4 is 160 (approx.)]

Documentation

The Documentation department provides services like designing, printing, photography, editing, scanning and digitizing etc. to the Institute.

Science Outreach Activities

- In house designing and printing of Scientific posters and banners for Seminars/ Symposium / Workshop and Science Outreach Activities.
- Designed scientific posters to display permanently outside the Dr. B.P. Singh Auditorium of the Institute.
- Designing and printing certificates for prize winning children of various competitions.
- Designing and printing posters in Marathi language for Marathi medium school.
- In the year 2022-23, new brochures and bookmarks showing the achievements of the institute were designed and printed in Hindi and English languages.

IIG Website

- Photographing all programs in the Institute and giving it to the computer department for uploading on the website.
- Providing photographs (in proper format) of all employees for the IIG website.

Seminars/ Symposium/Workshop

- Designing and in-house printing of banners, tags, certificates etc. for IMPRESS 2023.
- Flyer Making for Plasma Bubble Workshop to be held in 2023.

Rajbhasha Hindi

- Preparing scientific posters (with image editing) in Hindi language during the visit of Hindi Parliamentary Inspection Committee 2023 and providing all other necessary support.
- Designing and in-house printing of coffee table book "आईआईजीके 50 गौरवशाली वर्ष" in Hindi.
- Photography and banner preparation for Hindi mah and International Hindi Day celebration at Institute.

IIG Publication

- Specifically involved in Annual Report Publication e.g. scientific images and photos editing (setting proper resolution) as per publication standards.
- Regular updating of the network map showing the activities of the Institute's work.
- Designing and in-house printing of coffee table book "50 Glorious years of IIG" in English.

Scientific Publication and Field Survey

- Editing and designing new scientific figures for scientific and technical staff as per their requirement.
- Scanning and printing of topographic maps in multiple parts to facilitate Scientific fieldwork.

SPECIAL EVENTS

Brain storming meeting on "Development of Advanced Digital Ionosonde System (ADIS)", May 25, 2022

A one-day brain storming meeting was held on May 25, 2022 at IIG with SAMEER Engineering team to discuss various scientific and technical aspects of the proposed development of the new ionosonde system. Nearly 20 participants including students have participated in this brain storming meeting. Director, IIG chaired the session and welcomed the participants for the meeting. He appreciated the importance of this MoU between IIG and SAMEER, leading to the development of hardware and software required for the ionosonde project. The meeting has been conducted through hybrid mode. Several presentations were made from both sides in addition to interactive discussions

The following members attended the meeting:

1. Prof. S.Gurubaran, IIG
2. Dr. S.Sripathi, IIG
3. Dr S.Tulasi Ram, IIG
4. Dr Gopi K. Seemala, IIG
5. Dr Mala S.Bagiya, IIG
6. Mr. Anil Kulkarni, SAMEER
7. Mr. Ajay Khandare, SAMEER
8. Mr. Saurav Pandey, SAMEER
9. Mrs. Poornima Srivastava, SAMEER (online)
10. Ph.D. Students (Rajesh K. Barad, Ankita Manjrekar, Nilesh Chauhan, Ashish Jhadav, B. Gayathri, P. Rajapandy, Satyamesh Tiwari)
11. Few technical staff attended the meeting through online (Mr. Subrata Moulik, (MO Silchar), Mr. N Venkatesh / Mr. Selvaraj (EGRL, Tirunelveli) and Prabhakar Tiwari (KSKGRL, Prayagraj)

The following are the main points that emerged from the meeting:

1. Discussed the need for transmission/reception of O-mode and X-mode separately at low latitudes to improve the detection of polarized echoes. While linear polarization of radio wave may be sufficient for transmission at the dip Equator, transmission of circularly polarized waves may play an important role in generating a quality ionograms. Accordingly, SAMEER Engineering team have agreed for dual polarization for transmission /reception for echo identification.

2. Also discussed the need to identify O/X polarization tagging in the software algorithms.

3. It is suggested to integrate the auto scaling algorithms/real height analysis algorithms as developed by IIG scientists with the proposed system.

4. HF radio wave propagation in the ionosphere using single transmitter but its reception using multiple receiving antennas and its advantages and applications are discussed.

The program ended at 18:00 Hrs.

World Environment Day – June 5, 2022

Indian Institute of Geomagnetism (IIG) celebrated World Environment Day with cleanliness drive and tree plantation in and around IIG campuses on June 6, 2022. Regional Centers and Magnetic Observatories of IIG also participated very actively during this celebration. IIG Research Scholars contributed significantly in cleanliness drive and tree plantation. Prof. V.S. Kale, Former Professor and Head, Department of Geography, S.P. Pune University, delivered guest lecture on 'Climate Change: Present, Past and Future' on June 7, 2022. The lecture was followed by tree plantation in IIG Panvel campus. The Deputy Commissioner of Panvel Municipal Corporation, Shri VitthalDake, also participated in tree plantation drive at IIG on June 7, 2022.

Prof. V. S. Kale, Former Professor and Head, Department of Geography, S. P. Pune University, delivering a guest lecture during World Environment Day at IIG.

Planting of sapling by Prof. V. S. Kale, Former Professor and Head, Department of Geography, S. P. Pune University, during World Environment Day at IIG.

Planting of sapling by Prof. A.P. Dimri, Director, IIG during World Environment Day.

International Day of Yoga –June 21, 2022

The 8th International Day of Yoga (IDY) was celebrated at IIG on 21st June 2022 with a Yoga session on various Asanas as per the guidelines by Ministry of Ayush. During the recent pandemic time, all probably realised the importance of mental health. The mental health care is as important as physical health care. A lecture on mental health awareness and importance of Yoga in stress management was also organised at IIG on 21st June as part of the celebration of 8th IDY. Regional Centers and magnetic observatories of IIG participated in this celebration with great enthusiasm.

8th IDY was celebrated at IIG on June 21, 2022. On this occasion, a lecture on mental health awareness and importance of Yoga in stress management was also organised.

'Har Ghar Tiranga' Campaign –August 12, 2022 and Independence Day –August 15, 2022

IIG celebrated 76th Independence Day of India on August 15, 2022 with patriotic fervor. As part of these celebrations, Har GharTiranga campaign was organised at IIG on August 12, 2022. A Rangoli competition was also conducted on August 12, 2022. The flag hoisting ceremony was performed at IIG, Panvel, its regional centres and observatories. The flag hosting was followed by singing of national anthem and cultural program. The research students, staff and their families participated enthusiastically in cultural program by singing patriotic songs, dance and deshbhakti speech.

`Har Ghar Tiranga' campaign, under the aegis of Azadi Ka Amrit Mahotsav, was celebrated with enthusiasm by members of IIG to mark the 75th year of India's independence.

Memorandum of understanding (MoU) between Indian Institute of Geomagnetism (IIG), Navi Mumbai and Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow, September 7, 2022

The Memorandum of Understanding (MoU) was signed between Indian Institute of Geomagnetism (IIG), Navi Mumbai and Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow on September 7, 2022. The signing of MoU was attended by Prof. A. P. Dimri, Director, Dr. B.V. Lakshmi, Dr. K. Deenadayalan and Shri Ashutosh Shukla, Registrar, apart from faculties from BSIP. The MoU, signed for five years, was established to provide collaborative research programs in specific fields of interest, student training programs, sharing of instrumentation facility and submission of joint projects.

Scientists from Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow and IIG signing the Memorandum of Understanding between BSIP and IIG, to facilitate the academic collaboration.

Run for Unity – October 31, 2022

National Unity Day is celebrated on October 31 to mark the birth anniversary of Sardar Vallabhbhai Patel. IIG celebrated the day by conducting Run for Unity event in which Ph.D. Research Scholars, Research Associates along with the entire staff of IIG participated enthusiastically. A Rashtriya Ekta Diwas Pledge was also read out collectively.

The Vigilance Awareness Week 2022

The Vigilance Awareness Week 2022 was observed by Indian Institute of Geomagnetism during October 31-November 6, 2022. The CVC's theme for this year was "Corruption free India for a developed Nation". The week began with administering the pledge on October 31, 2022 at 11:00 am in Dr. B.P. Singh Auditorium of Headquarters, New Panvel, along with the staff connected through video conferencing from three Regional Centres and ten Magnetic Observatories of IIG situated across the country, in its true spirit and sense. An essay writing competition was held for employees and their families in Hindi and English languages on the theme "Corruption free India for a developed Nation". As a Vigilance Awareness event, a talk by the Commissioner of Panvel City Municipal Corporation Shri Ganesh Deshmukh was organized at IIG HQ on the theme "Corruption free India for a developed Nation". This talk was broadcasted to IIG's regional centers and observatories.

Oath being observed by all the members of IIG on account of Vigilance Awareness week .

Commissioner of Panvel City Municipal Corporation Shri Ganesh Deshmukh delivering a talk on the theme "Corruption free India for a developed Nation" at IIG.

"Akash for life" national event regional seminar: "Strategic aspects of disturbances in Akasha Tatva", November 9, 2022

To shape the solutions to the challenge of climate change and associated environmental concerns based on the synergy of Indian philosophical tradition and modern science, a National Conference on "Akash for Life" was organised by Vijnana Bharati in association with various science Ministries and Departments and Uttarakhand State during November 5-6, 2022, at Uttaranchal University, Dehradun, Uttarakhand.

As a part of "Akash for life" national event, Indian Institute of Geomagnetism (IIG) hosted a one-day seminar on the theme "Strategic aspects of disturbances in Akasha Tatva, like weather modification, space warfare, and climate migration" on November 9, 2022.The seminar was conducted in hybrid mode (both offline and online) to reach a large number of participants. Subject experts from various national institute were invited. The first talk was on "Space and climate: a palaeoclimate perspective" by Prof. Anupam Sharma, BSIP, Lucknow. The second talk was delivered by Prof. Anand Kumar Pandey, NGRI, Hyderabad, and the topic was "Erosion vs tectonic variability for the evolving landscape and associated hazards". Afternoon talks were delivered by IIG scientists. Prof. S. Gurubaran spoke on "Impact of energetic particle precipitation at high latitudes on atmospheric chemistry and climate". Prof Geeta Vichare delivered a talk on "Extreme space weather events-effects on geospace". The seminar series was concluded with remarks by Director IIG, Prof. A.P. Dimri. Many students and researchers were benefited by this seminar. Dr Chinmaya Nayak proposed the vote of thanks.

Dignitaries' deliberating during the one-day seminar on the theme "Strategic aspects of disturbances in Akash Tatva, like weather modification, space warfare, and climate migration" as a part of "Akash for life" national event on November 9, 2022.

One-day workshop in the Environmental Magnetism Laboratory (EML), November 11, 2022

A one-day workshop was arrangedin the Environmental Magnetism Laboratory (EML), Indian Institute of Geomagnetism (IIG) on November 11, 2022. Dr. Anupam Sharma, Scientist-G, BSIP, Lucknow, discussed about Geochemical and palaeoclimate studies of lake sediments in India. EML Research Scholars interacted with Dr. Anupam Sharma and discussed about their research areas.

Janbhagidari program

Dr. S.T. Mehetre, Nuclear Agriculture and Biotechnology Division, BARC, Mumbai, delivered a popular invited talk under Janbhagidari program on December 30, 2022. The title of the talk was "BARC technologies for sustainable Management of biodegradable waste".

International Woman's Day – March 8, 2023

Ms. Aparna Ranadive delivered a talk on "Innovation & Gender Equality, A Mantra for Thriving in the New Reality" at IIG, New Panvel campus on the occasion of International Woman's Day.

Ms. Aparna Ranadive delivering a talk on "Innovation & Gender Equality, A Mantra for Thriving in the New Reality" on the occasion of International Woman's Day.

Inspiring the Minds of Post - Graduatesfor Research in Earthand Space Sciences (IMPRESS)

For any research organization, one major responsibility is to attract, train and develop skilled manpower in the field of science and technology. The annual IMPRESS program of IIG is specially designed to inspire the minds of young students to take up research in the field of Earth and Space Science. The goal of IMPRESS is to motivate young minds towards selecting research as a career; to make them experience the joy of discovery. IMPRESS would strive to make post-graduate students realise that research is indeed an exciting and sublime experience and an exclusive preserve of the chosen. This programme provides a rare opportunity for young students in India to learn about current areas of research in Earth and Space Sciences, through interaction and exposition sessions with IIG scientists and young researchers. During the meet, they are exposed to state-of-art observation tools which provide them glimpses of inner-working of the Earth's interior and enable them grasp the processes in the atmosphere, which are so vital for very survival on this planet. A programme is considered successful when the young minds are ignited.

This year, IMPRESS was conducted during February13-16, 2023 at IIG Panvel, after a gap of 2 years because of COVID pandemic. Reaching out to more institutions helped IIG to double the participants than usually used to attend. There were 54 participants from all corners of India who had participated in this event. More than 20 speakers covered various aspects of Earth, Atmospheric and Space Sciences. From earth to atmosphere to near and far space environment, the deliberations ranged from a more general to intermediate to advanced discourse into the various subjects.

It was inaugurated by, Dr. M. Rajeevan, former MoES Secretary on February 13,2023. The participants had many lively interactions with the guest speakers. A separate 30-min open-for-all wrap-up session was arranged on the last day, wherein four of very senior scientists responded to participants' questions and clarified their doubts on the scientific content deliberated upon during the entire programme.

The participants also had the opportunity to listen to Dr. S. Chandrasekhar, Secretary, DST, who was the Chief Guest for the Valedictory Session on the concluding day. The Secretary, DST, in his valedictory address, spoke briefly about the history of science and then went on to deliberate on some of the recent advances in science including those in medicine. The participants were urged to keep in mind that the research they would choose to pursue should meet the needs of the society.

Welcome of Dr. M. Rajeevan, former MoES Secretary , during IMPRESS 2023.

Prof. A. P. Dimri, Director, IIG addressing the participants of IMPRESS 2023.

Dr. M. Rajeevan, former MoES Secretary, addressing the participants during IMPRESS 2023.

Valedictory cum open-for-all wrap-up session of IMPRESS 2023

Secretary DST, Dr. S. Chandrasekhar Faculties and participants of IMPRESS 2023

Eminent guests and faculties deliberating on various aspects of Earth, Atmospheric and Space Sciences during the IMPRESS 2023.

DST Secretary Dr. S. Chandrasekhar addressing during IMPRESS 2023.

E

Prof. A.P. Dimri, Director, IIG, felicitating Dr. S. Chandrasekhar during his visit to IIG.

DST Secretary Dr. S. Chandrasekhar visiting the Environmental Magnetism Laboratory.

DST Secretary Dr. S. Chandrasekhar visiting the Instrumentation Section.

DST Secretary Dr. S. Chandrasekhar inaugurating the Computational Fluid Dynamics Lab & Video Conference room at IIG.

Planting of sapling by DST Secretary Dr. S. Chandrasekhar at IIG.

IIG STAFF WELFARE AND RECREATION CLUB

IIG celebrated its glorious 51st Annual Day on April 1, 2022 coinciding with the Nation's Azadi ka Amrit Mahotsav celebrations. Due to Covid -19 pandemic situation, the 50th Annual day could not be celebrated in 2021.

The 51st Annual Day was celebrated in a grand manner. Prof. Ranjan R. Kelkar, former Director-General of India Meteorological Department, New Delhi, was the Chief Guest, while Dr. Anil Kulkarni, Program Director, SAMEER, IIT Mumbai, and Dr. Sunil Gitte, Director, NIPHTR, Navi Mumbai,were the special guests on this occasion. Staff members and their families and former employees of IIG were invited to be part of this special occasion. The IIG's scientific progress and achievements made during the last five decades were on display through posters, models, and scientific instruments for the invitees. The event was inaugurated with a welcome address by Prof. S.Gurubaran, Director-in-Charge, IIG, by briefing the Annual progress of scientific achievements and milestones of IIG's magnificent journey. It was followed by the Foundation Day lecture on "Geomagnetism and Meteorology in India: History & Outlook" delivered by the Chief Guest. The Chief Guest presented long service awards to four IIG employees who have completed 25 years of distinguished service. Rajbhasha awards were also presented to staff members. The event concluded with a vote of thanks and recitation of the national anthem. The afternoon session comprised of colourful cultural activities by employees, students, and their family members.

Chief Guest Prof. Ranjan R. Kelkar, being explained the geomagnetic instruments of IIG.

Lighting the traditional lamp by Prof. Ranjan R. Kelkar, former Director-General of India Meteorological Department, New Delhi, during IIG Foundation Day.

Prof. S. Gurubaran, Director-in-Charge, delivering the Annual Progress report of IIG.

Chief Guest Prof. Ranjan R. Kelkar delivering the Foundation Day lecture.

Chief Guest Prof. Ranjan R. Kelkar presenting the Long Service award to staff members.

Prof. S. Gurubaran, Director-in-Charge, felicitating Chief Guest Prof. Ranjan R. Kelkar during IIG Foundation Day.

Haldi Kumkum function was arranged by the club on January 16, 2023, for the female staff and students of Institute.

A one-day picnic to Alibaug, was arranged on March 18, 2023. Staff members and students with families participated in the picnic with great fervor and made it a grand success.

The Club, on behalf of the Institute, bid farewell on superannuation to Dr. S.K. Bhardwaj and Shri Vinod Chauhan on June 30, 2022, Dr. Vinit C. Erram (under VRS) on October 31, 2022 and Shri S. Amirthraj on March 3, 2023.

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

CORPORATE SOCIAL RESPONSIBILITIES

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:

Central Public Information Officer (CPIO):

Prof.A.K. Singh, (Professor E)
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E-mail:ajaykishore.s@iigm.res.in

Appellate Authority:

Prof. S. Gurubaran, (Professor G)
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New Panvel (W), Navi Mumbai-410218
Maharashtra
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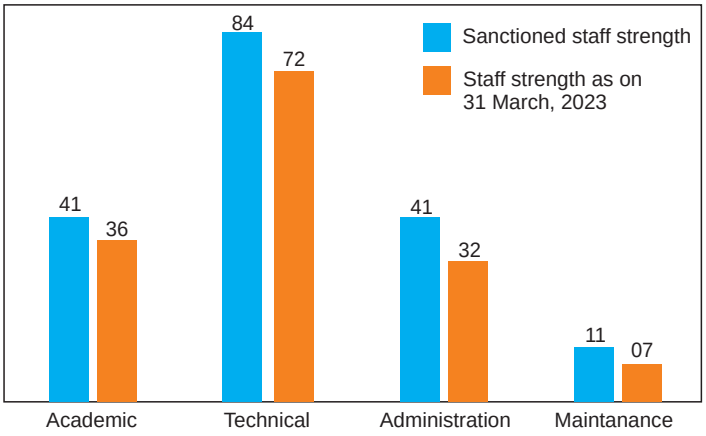
E-mail:gurubaran.s@iigm.res.in

RESERVATION POLICY

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

STAFF PROFILE

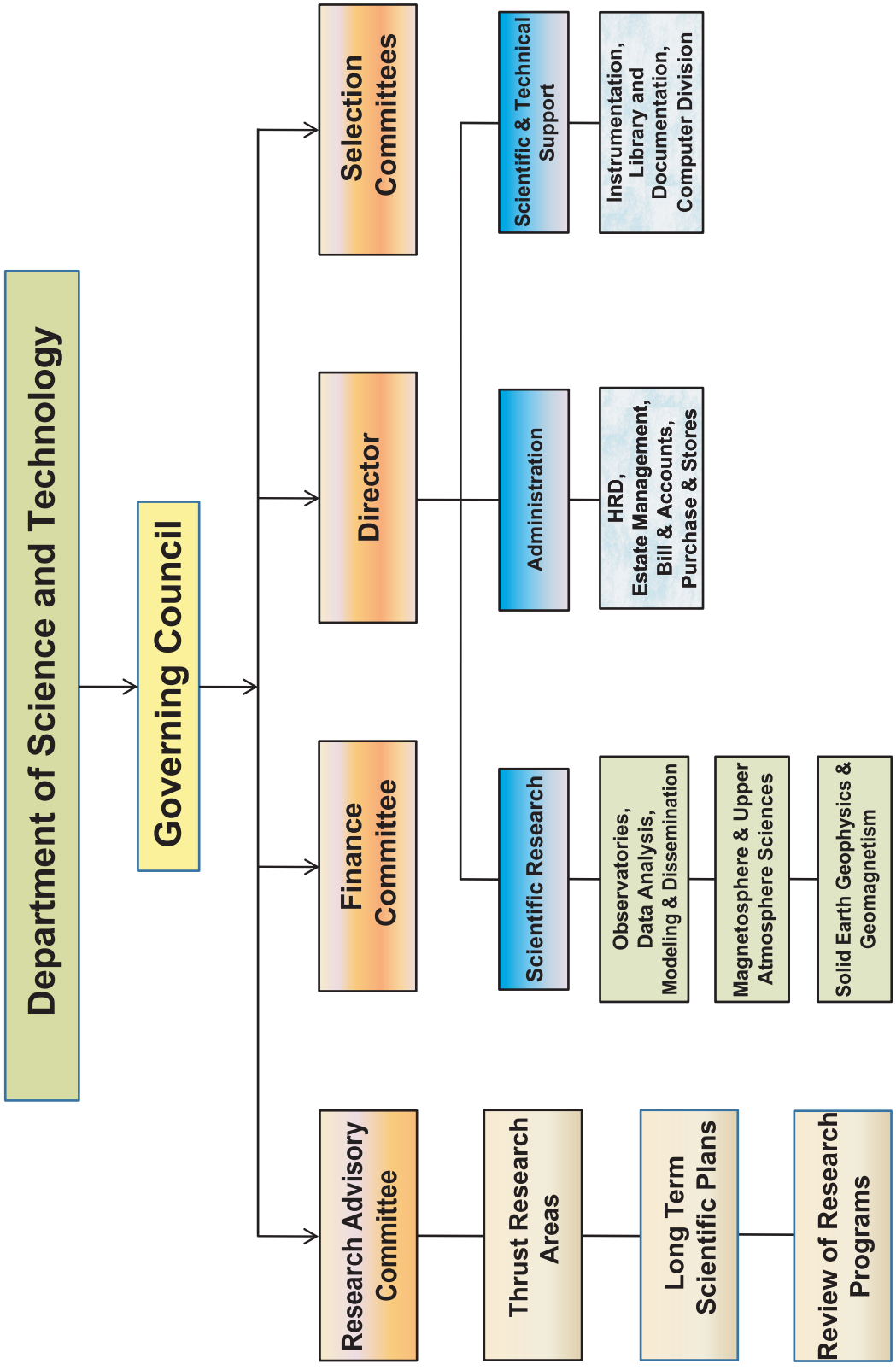


ACTION TAKEN NOTE ON AUDITORS REPORT

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 2022–2023.

MOBILIZATION OF RESOURCES

The Institute has been constantly making endeavors to mobilize resources by extending its scientific and technical expertise to organizations like ISRO, DRDO, AAI etc, and by selling magnetometers and magnetic data to outside organizations. During the year 2022–2023, 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.


Department of Science and Technology
Governing Council
Selection Committees
Director
Finance Committee
Research Advisory Committee
Scientific & Technical Support
Instrumentation, Library and Documentation, Computer Division
Administration
HRD, Estate Management, Bill & Accounts, Purchase & Stores
Scientific Research
Observatories, Data Analysis, Modeling & Dissemination
Magnetosphere & Upper Atmosphere Sciences
Solid Earth Geophysics & Geomagnetism
Thrust Research Areas
Long Term Scientific Plans
Review of Research Programs

Cultural events being performed by staff and students during the IIG Foundation Day celebrations.

"Hemispheric observing dome of the Grism-based Spectrograph for Airglow & Auroral Studies installed at Maitri, Antarctica.

Rashtriya Ekta Diwas was celebrated in a befitting manner with great enthusiasm by IIG staff and students by participating in the “Run for Unity”

New BBS setup at the Lamdeng Forest Nursery campus, Imphal, Manipur