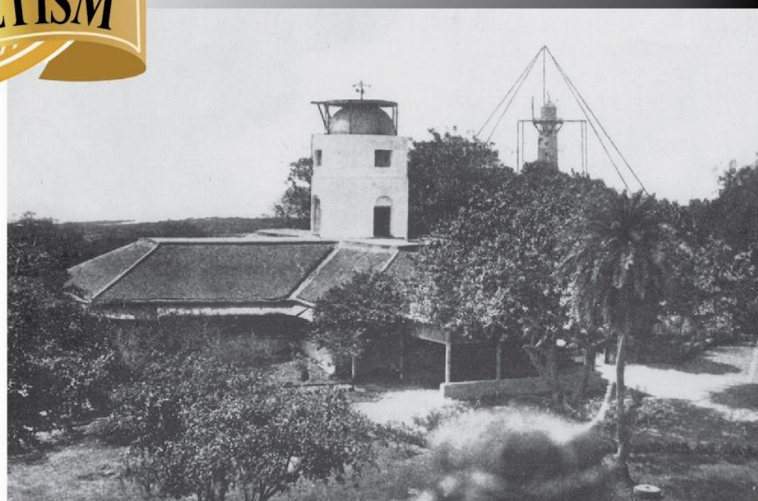
175 YEARS OF GEOMAGNETISM

Proceedings of
Geomagnetism, Earth, Moon & Sun

GEMS



भारतीय भूचुम्बकत्व संस्थान
IIG
Indian Institute of Geomagnetism

Indian Institute of Geomagnetism
New Panvel, Navi Mumbai

Geomagnetism, Earth, Moon & Sun (GEMS)

Indian Institute of Geomagnetism

New Panvel, Navi Mumbai – 410 218

Chairman
Prof. D. S. Ramesh

Convener
Prof. Satyavir Singh

Distinguished Speakers

Dr. B.N. Goswami, IISER, Pune, India
Dr. G.S. Lakhina, IIG, Navi Mumbai, India
Dr. A.Bhattacharyya, IIG, Navi Mumbai, India
Dr. T. Radhakrishna, NCESS, Trivandrum, India
Dr. K.Shiokawa, Nagoya University, Japan
Dr. S.G. Kanekal, GFSC, NASA, USA
Dr. N.Gopalswamy, GFSC, NASA, USA
Dr. J. Brestensky, Comenius Univ. Bratislava, Slovakia
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Dr. S. Y. Su, National Central University, Taiwan
Dr. B. T. Tsurutani, Jet Propulsion Laboratory, USA
Dr. D. Pallamraju, PRL, Ahmedabad, India
Dr. A. Kherani, INPE, Brazil
Dr. M.A. Abdu, INPE, Brazil

Chief guest Dr. B.N. Goswami inaugurating the GEMS workshop at IIG, Panvel

Chief guest Sheetal Teli-Ugale, District Collector of Raigad inaugurating the workshop at Alibag

Edited by
Dr. S. Tulasiram & Dr. Amar Kakad

Designed by
B. I. Panchal

Contents

Preface

Institutions propagate science and are the cradle of advancement and progression. Indian Institute of Geomagnetism (IIG) is such an institution that spawned the science of Geomagnetism not only in India but throughout the world. Geomagnetism has played a key role in unraveling the intricate processes operative in space and on Earth. This would not be possible if the long term magnetic field records are not available. Therefore, the magnetic observatories have incredible place among the scientific fraternity. IIG is fortunate to have Colaba-Alibag pair of Geomagnetic observatories which form a long chain of continuous observations since 1841. Initially, eye observations were taken from the year 1841 to 1872 and thereafter continuous photographic recordings were carried out. In the year 1900 electric trams were proposed to be introduced in Bombay. Then, the Director Dr. Nanabhoy A.F. Moos could envisage its delirious effects on the accuracy of magnetic measurements and hence it was decided to shift the geomagnetic observatory from Colaba to Alibag, a site free from all the magnetic noises and in close proximity to Colaba. It was only after analysing the data of Colaba and Alibag simultaneously for two years (1904 – 1906), the observatory was completely shifted to Alibag. Thus, Colaba-Alibag pair of Geomagnetic observatories completed 175years of Geomagnetic observations in India. On this uniquely joyous occasion, several festivities have been organized during 2016-2017.

As a curtain raiser to the 175th year celebrations, IIG organized a Workshop titled **"175 Years of Geomagnetism in India"** with the theme "**G**eomagnetism, **E**arth, **M**oon & **S**un (**GEMS**)" on **22nd September 2016 (Thursday)** at IIG New Panvel Campus. Also, a one day function was organized at the world renowned Alibag Magnetic Observatory. Subsequently, the GEMS seminar series was organized starting November 2016 which continued until February 2017. The immense success of GEMS workshop and the seminar series is attributed to the contribution of eminent scientists from India and abroad. As part of ongoing celebrations, a two day programme is organized to motivate and train young talent, post-graduate students from Indian universities, during February 22-23, 2017 at IIG New Panvel to undertake research in geomagnetism and allied fields. . The wide range of topics broadly covered during the year long celebrations are: solar eruptions, magnetic storm and space weather, wave-particle interaction in the inner magnetosphere, radiation belt dynamics, particle precipitation, irregularities in the low latitude ionosphere, whistler mode radio sounding, climate, palaeomagnetism and geospheric disturbances during seismic weathers. Nuggets from the talks of invited distinguished speakers at the GEMS series of lectures are recorded in this volume for the benefit of researchers and students.

These year long celebrations concluded with a Valedictory function organized on 24th February, 2017 at the Colaba observatory complex. A fitting tribute indeed to the historic Colaba-Alibag pair of observatories. Dr. Ashutosh Sharma, Secretary Department of Science and Technology, New Delhi was chief guest at the Valedictory function. He released the abstract book and gave away the mementoes to the distinguished luminaries. The Valedictory function was a success due to the active participation of one and all.

Satyavir Singh
Convener

Dr. Bhupendra Nath Goswami
Pisharoty Professor, Ministry of Earth Sciences
Indian Institute of Science Education and Research, Pune, India

Research Interests: Indian summer monsoon variability, predictability of the tropical coupled Ocean-Atmosphere system, climate modelling, modelling of large scale Air-Sea interactions in the tropics, theoretical study of large scale tropical dynamics using simple models

Significant Scientific Achievements:

- A new mode of variability discovered in the Indian ocean, namely the Indian Ocean Dipole Mode.
- Identification of a new extratropical teleconnection pathway through which ENSO influences the Indian monsoon rainfall via modification of meridional gradient of tropospheric temperature.
- Unraveling of a physical mechanism of how north Atlantic SST influences Indian monsoon on interdecadal and longer time scales.
- The first evidence of a significant rising trend in the frequency and intensity of heavy rain events and decreasing trend in the frequency of light to moderate rain events over central India in the monsoon season during 1951-2000 is produced.

Honors and Awards:

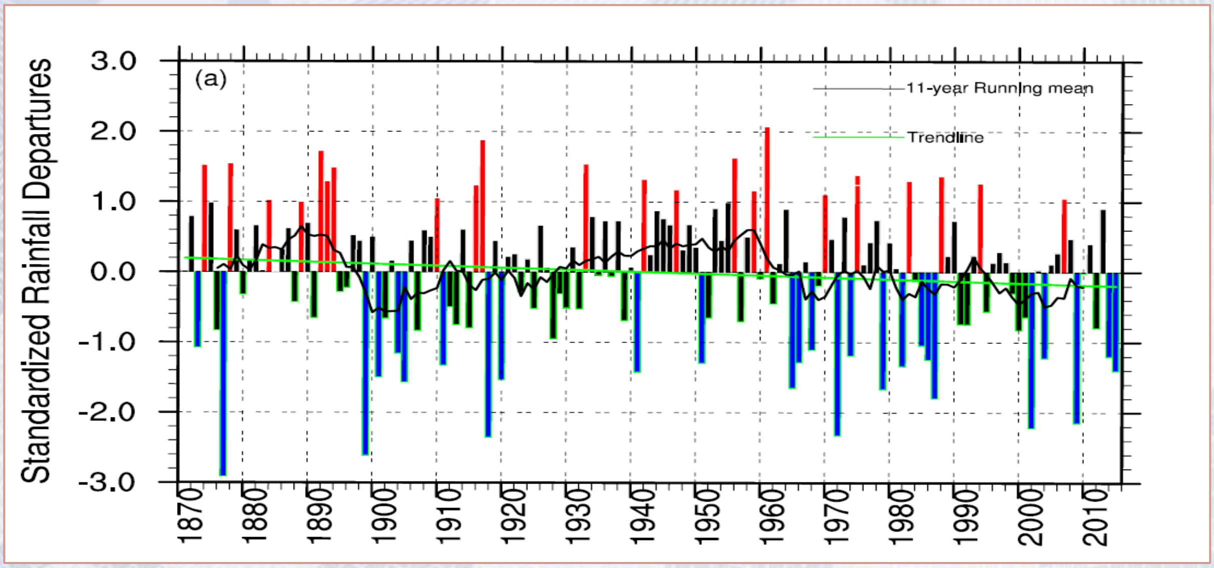
- Shanti Swarup Bhatnagar Award, in Earth, Atmosphere, Ocean and Planetary Sciences, 1995 by Council of Scientific and Industrial Research, India
- Hari Om Ashram Prerit Vikram Sarabhai Award in Space Science including Atmospheric Science, 1994, Physical Research Laboratory, Ahmedabad
- The Kalpathi Ramakrishna Ramanathan Medal, for the year 2008 by Indian National Science Academy, India
- Fellow of Indian Academy of Sciences, Indian National Science Academy, National Academy of Sciences, TWAS
- Associate, International Centre for Science and High Technology of ICTP, Trieste, Italy
- Ex-officio Member, Expert Committee set up by Prime Minister on Impacts of Climate Change – 3 years from May 2008

Dr. B. N. Goswami

Has the Indian summer monsoon reached a tipping point for collapse?

Some paleoclimate records indicate that Indian Summer Monsoon (ISM) had abrupt transitions in the past from a wet monsoon to a dry monsoon. Two consecutive years of drought in 2014 and 2015 has caused a serious scarcity in the country. The average rainfall during the June to September period is ~12 % less than the normal in 2014 and ~14 % less than the normal in 2015. This has caused serious concerns because of its potential and direct influence on the living and agriculture. The multi-decadal variability of ISM is actually showing a decreasing trend since 1955 and below the normal phase of multi-decadal variability since 1960. This decrease in ISM is highly significant (~7% of mean) and extensive (6 decades long) raising the serious questions that this decreasing trend of monsoon would continue and lead to a collapse of monsoon?

It is shown that the current decreasing trend of ISM rainfall results from a positive feedback between monsoon winds and Indian Ocean sea surface temperature (IO SST). The monsoon is mainly driven by the north-south gradient in the tropospheric temperature; and the variations in the ISM are partly driven by local air-sea-land interactions and partly by teleconnections with the Pacific Ocean through ENSO and North Atlantic Ocean through AMO. The warming of Indian Ocean is the driver for the weakening of the Indian monsoon due to decrease in tropospheric temperature gradient. Further, the decrease in monsoon in turn leads to the increasing trend of IO SST giving rise to a positive feedback. If there is no mechanism to counter this positive feedback, the Indian summer monsoon may indeed face a runaway collapse. However, the multi-decadal variability observed from tree-ring analysis shows an evidence for an extended spell of weak monsoon like the present one had also occurred in the past. Hence, the present scenario of decreasing trend of monsoon likely to be a part of 50 - 80 year multi-decadal mode. However, the "negative feedback" mechanism that would counter the present "positive feedback" between IO SST and ISM needs to be identified.



Normalized departure of rain fall during June - September over India showing the multi-decadal variability of Indian Summer Monsoon.

Dr. Gurbax Singh Lakhina

NASI-Senior Scientist Platinum Jubilee Fellow
Indian Institute of Geomagnetism, Navi Mumbai, India

Research Interests: Nonlinear waves in space plasmas, solar wind interaction with magnetosphere, magnetic storms and Space Weather.

Significant scientific achievements:

- Development of a theory for a nonlinear coherent cyclotron interaction between electromagnetic whistler mode chorus and energetic electrons.
- Generation mechanism for electrostatic solitary waves (ESWs) in terms of ion- and electron-acoustic solitons and double layers.
- Identifying the interplanetary causes of intense and super-intense magnetic storms, including the classic work on the 1859 Carrington superstorm.
- Clarifying physics of the mirror mode (MM) structures occurring in planetary magnetosheaths and the magnetic decreases (MDs) that occur in the interplanetary space.

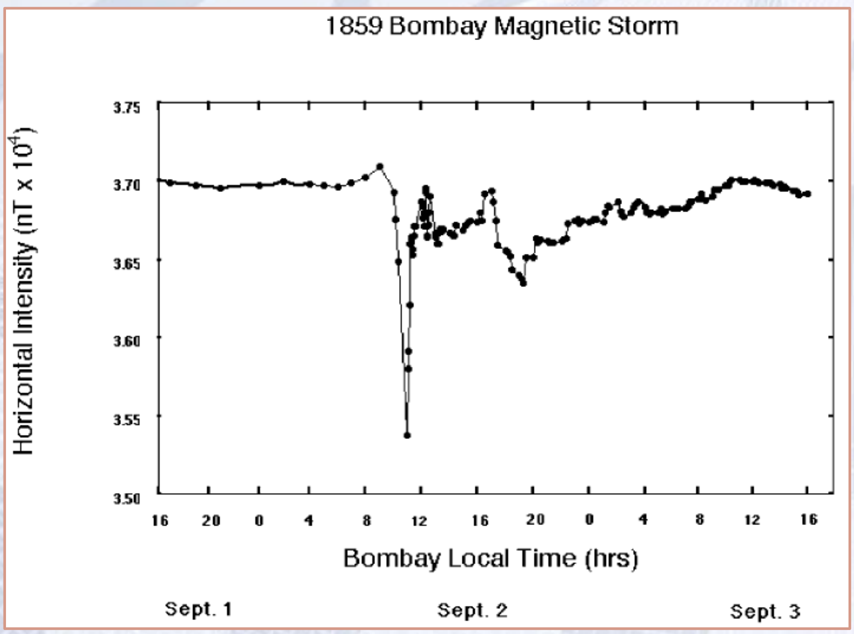
Honors and Awards:

- 2015 AGU Space Weather and Nonlinear Waves and Processes Prize, AGU Fall Meeting, San Francisco, December 2015.
- 2014 COSPAR Vikram Sarabhai Medal by COSPAR and ISRO, India.
- Fellow of Indian National Science Academy, National Academy of Sciences, and Indian Geophysical Union.
- The Kalpathi Ramakrishna Ramanathan Medal (2005) of Indian National Science Academy (INSA), New Delhi
- Group Achievement Award (2005) from European Space Agency (ESA) for the contribution to Plasma Wave Team's experiment on CLUSTER spacecraft.
- NASA Cluster Science Team Group Achievement Award, 2004.
- Decennial Award-Gold Medal 2000, Indian Geophysical Union, Hyderabad, India

Dr. G. S. Lakhina

Super geomagnetic storms: Past, Present and Future

The history of geomagnetism is more than 400 years old. There has been keen interest in understanding Sun-Earth connection events, such as solar flares, CMEs and concomitant magnetic storms in recent times. Magnetic storms are the most important component of space weather effects on Earth. Geomagnetic storms were discovered about 200 years ago. Geomagnetic storms are large scale disturbances in the Earth's magnetic field due to orders of magnitude increases in trapped energetic ~10 to 300 keV particle fluxes in the Earth's magnetosphere. During geomagnetic storms, the horizontal component of the low-latitude magnetic fields are significantly depressed over a time span of one to a few hours from the diamagnetic effect from the enhanced ring current fluxes. This is known as the Main Phase of the storm, and is followed by the recovery phase where the particles are lost. This latter phase may extend over several days. The strength of magnetic storms is measured by the Disturbance Storm Time (Dst) index. Super-intense magnetic storms (defined here as those with Dst < -500 nT) although relatively rare in occurrence, have the largest societal and technological impacts. Such storms can cause life-threatening power outages, satellite damage, satellite communication failures, navigational problems, and loss of low Earth orbiting (LEO) satellites. Geomagnetically induced currents (GICs) produced during super magnetic storm and super substorms can harm ground-based technologies, like power grids and long pipe lines, etc. This talk gives a review the present knowledge about super magnetic storms. Starting with the super storms that had occurred in the past, the case history of the Carrington storm (1-2 September 1859 event) as a representative example is described. This is followed by a discussion on present day (space-age era) super magnetic storms, and those that can occur in the future. Finally, the occurrence probability of super storms having intensities equal to the Carrington storm or higher is discussed.



The most intense geomagnetic storm recorded in the history, the Carrington storm, from the Grubb magnetometer at Bombay (Colaba) observatory [Tsurutani et al., 2003].

Dr. Archana Bhattacharyya

INSA Senior Scientist

Indian Institute of Geomagnetism, Navi Mumbai, India

Research Interests: Ionospheric scintillations, Plasma instabilities in the ionosphere, Variability of the low latitude ionosphere, geomagnetic field variations.

Significant scientific achievements:

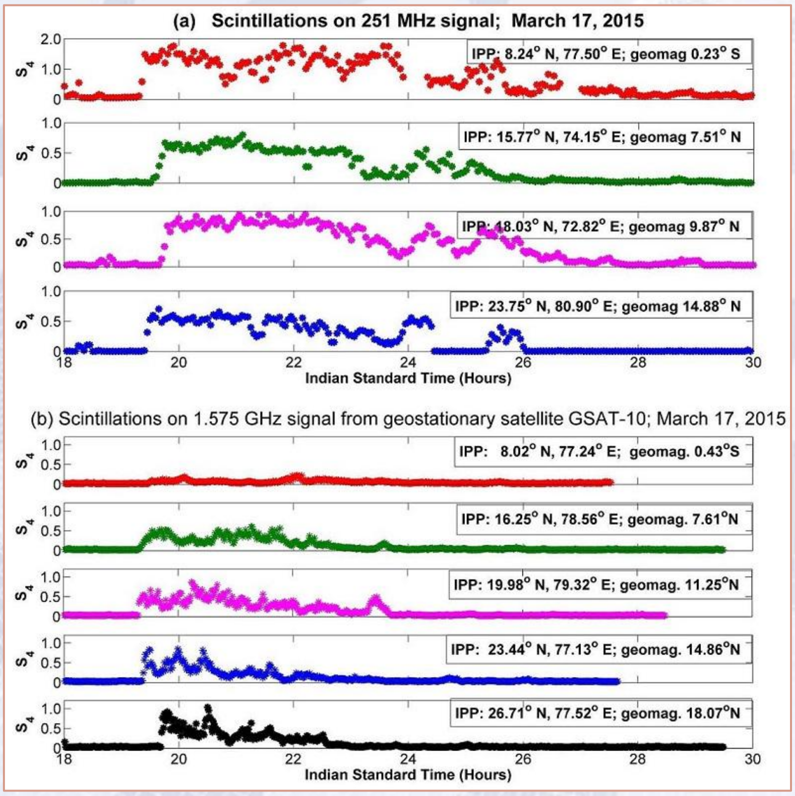
- Modeling strong scintillations due to thick ionospheric irregularity layer.
- Identification of fresh plasma bubbles generated in the equatorial ionosphere due to magnetic storms using spaced receiver measurements of ionospheric scintillations.
- Development of model to delineate phase scintillations from TEC fluctuations in GPS data.
- Theory for development of equatorial plasma bubble (EPB) by an electromagnetic Rayleigh-Taylor instability, and use of this model to quantify the influence of E-region on the evolution of EPBs.
- First evidence from scintillation observations that the EPB is more structured on the topside of the equatorial F region than near its peak, which has implications for prediction of L-band scintillations.

Honors and Awards:

- Fellow of Indian National Science Academy; Indian Academy of Sciences; National Academy of Sciences, India; and Indian Geophysical Union.
- K. R. Ramanathan Memorial Lecture and Gold Medal, Indian Geophysical Union, 2008.
- Senior Resident Research Associateship, National Research Council, USA, 1998-2000.
- J. C. Bose National Fellowship, Science and Engineering Research Board, Government of India, 2013 – 2016.

Large and small scale structures in the low latitude ionosphere: Role of the geomagnetic field

An important component of space weather in the low latitude ionosphere is the equatorial plasma bubble (EPB) formed by the growth of the Rayleigh-Taylor instability on the bottom-side of the post-sunset equatorial F region. The EPB grows non-linearly to the topside of the equatorial F region and also develops structure over a wide range of scale sizes. Irregularities of scale sizes in the range of 100m – few km give rise to fluctuations or scintillations in the amplitude and phase of VHF and higher frequency transionospheric radio waves. The EPBs involve whole flux tubes, and are thus aligned with the geomagnetic field lines so that the irregularities at different altitudes over the magnetic equator map down along the geomagnetic field lines to different latitudes. In numerous efforts to predict scintillations on L-band signals transmitted by GNSS satellites, it has been assumed that the irregularity spectrum is the same at different altitudes over the magnetic equator. Using observations of scintillations on VHF and L-band signals recorded by a network of ground stations at different locations in India, and modelling them using different irregularity models, we have shown that as an EPB develops over the magnetic equator, it becomes more structured on the topside of the F region than near the equatorial F region peak. This contributes to strong L–band scintillations near the crest of the equatorial ionization anomaly when weak or no L-band scintillations are recorded near the magnetic equator. This picture of the evolution of EPB irregularities is now seen in simulations of the development of EPBs, which at present do not have adequate resolution to forecast scintillations.



Variation of S_4-index with time for scintillations on (a) a 251 MHz signal transmitted from a geostationary satellite and recorded at four stations; (b) the 1.575 GHz signal transmitted from geostationary satellite GSAT-10 and recorded at five stations for which the signal path elevation angle was not less than 55°. Coordinates of ionospheric penetration points at 300 km are given.

Dr. Tallavajhala Radhakrishna

Retired Scientist, National Centre for Earth Science Studies, Trivandrum, India

Research Interests: Palaeomagnetism, igneous geochemistry and geodynamics of the Indian subcontinent

Significant Scientific Achievements:

Made fundamental contributions for effectively integrating palaeomagnetism, petrology and isotopic dating; notable are

- Providing an authentic apparent polar wander path for Palaeoproterozoic India
- Positioning India in pre-Gondwana global supercontinental cycles
- Identifying two petrologically distinct igneous events derived of contrasting mantle sources in a short time span (~85-65 Ma) on the west coast and establishing geodynamic linkage to the Reunion and Marion mantle plumes
- Palaeomagnetically demonstrating southward motion for the Marion plume in the Indian Ocean region for the first time lending support to numerical model predictions from Global Mantle Circulation
- Providing fundamental evidences for involvement of Archaean (c. 3 Ga) lithospheric mantle in the petrogenesis of Proterozoic magmas in India.
- His doctoral work is one among the earliest works to document island arc tectonic setting along the Indus suture in the Himalaya

Honors and Awards:

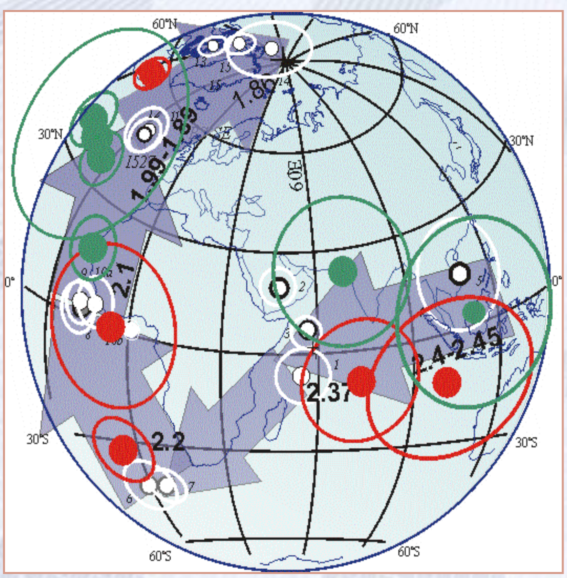
- Palaeomagnetism and Igneous petrology Expert in IODP Expedition 355 in the Arabian Sea (2015)
- INSA-Royal Society Exchange Fellow (2002)
- National Mineral award, the Ministry of Coal and Mines, Government of India (2001)
- Fellow of the Indian Academy of Sciences (FASc) (2000)
- Commission of European Communities (Marie Curie) Fellow (1995)
- BOYSCAST Fellow (1990)
- Young Scientist award, Indian National Science Academy, New Delhi. (1985)

Dr. T. Radhakrishna

Geodynamics of the Indian shield deep in time: palaeomagnetic perspective

The dynamic distribution and evolution of tectonic plates/blocks on Earth through time has immense relevance to comprehend the Earth resources and environments. Evolution of the present continent-ocean architecture from Pangaea through late Phanerozoic (~250 Ma) is fairly well documented. In this approach, palaeomagnetic results have been used in combination with kinematics of relative plate motion modeled using marine magnetic anomalies, trends of fracture zones in the world's ocean basins and reference frames for absolute plate motion based on the use of hot spot tracks. These developments also paved way to characterise and distinguish different tectonic environments.

The Indian Peninsular comprises of at least five of the oldest cratons of the world and becomes a natural choice for probing into the Precambrian geodynamics. Mafic dykes that represent magmatic intrusive rocks of discrete ages of Plalaeoproterozoic (2500-1600 Ma) are profusely distributed across these cratons and are potential targets for palaeomagnetism investigations. Studies have been carried out in Dharwar, Bundelkhand and Bastar cratons at the National Centre for Earth Science Studies to determine distinct reliable palaeomagnetic directions and palaeopoles and linked them to high precision age determinations. The results permitted to propose a more acceptable APWP for India combining the data from all three cratons (figure 1). Such a unified APW curve indicate that quasi-integrity between the cratons of India was achieved by 2.5 Ga. Between 2.45 and 2.37 Ga, the Indian shield was situated at higher latitudes and subsequently was located near the equator at 2.22, 2.18, 1.99 and 1.86 Ga. A comparison with pole data from other cratons across the world indicate an India–Australia connection during the early Palaeoproterozoic times, but other tectonic linkages with cratons of Africa, China or north America are inconsistent with Indian data and do not render support for the supercontinental reconstructions of Columbia. The present palaeomagnetic database is yet unable to produce an unequivocal drift record for Precambrian India and therefore study of several key Precambrian rock formations in India is imperative. The Indian Institute of Geomagnetism, with its glorious service to the nation for the past 175 years, is hoped to exploit the geomagnetic principles to this area of geodynamics and becomes one of the major contributing institute to the solid earth geosciences research.



Summary of Palaeoproterozoic poles of South India depicting possible apparent polar wander path in a Schmidt projection. Poles from Dharwar, Bundelkhand and Bastar are shown in white, red and green respectively.

Dr. Kazuo Shiokawa

Professor, Institute for Sun-Earth Environment Research (ISEE)
Nagoya University, Japan

Research Interests: Space science and Aeronomy, dynamical coupling of the solar wind-magnetosphere-ionosphere-thermosphere, ground-based optical and electromagnetic measurements related to aurora and airglow

Significant Scientific Achievements:

- Braking of high-speed flows in the near-Earth tail
- Development of optical mesosphere - thermosphere imagers (OMTI)
- Ground and satellite observations of nighttime medium-scale traveling ionospheric disturbances

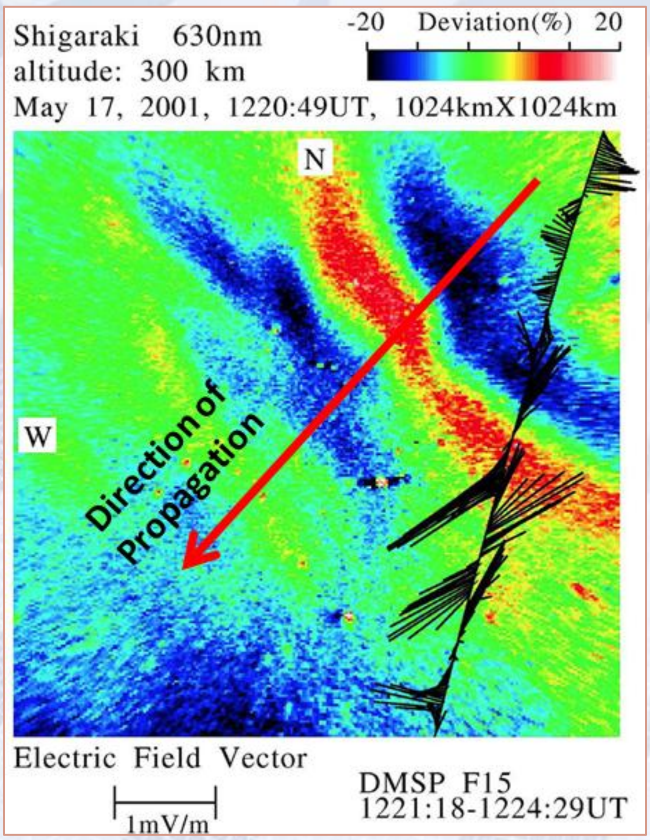
Honors and Awards:

- Obayashi Early Career Scientist Award, Society of Geomagnetism, and Earth, Planetary, and Space Physics, November, 1999
- Tanakadate Award: Society of Geomagnetism, and Earth, Planetary, and Space Physics, May, 2009
- 2010 Editors‘ Citation for Excellence in Refereeing for JGR – Space Physics, American Geophysical Union, 2011
- First Place Winner, AGU Geophysical Images Contest (photography section), May 1993

Dr. K. Shiokawa

Imaging observations of night-time Medium Scale Traveling Ionospheric Disturbances (MSTIDs) - a review

The night time medium scale traveling ionospheric disturbances (MSTIDs) are the wave-like perturbations in the ionospheric plasma, a prevailing feature in the ionosphere at middle and sub-auroral latitudes, say, 20 – 60 geomagnetic latitudes. The MSTIDs in the northern mid-latitudes preferably occur during solstices with their phase fronts inclined in Northwest – Southeast direction. The night time MSTIDs found to have preferable propagation in Southwest direction in the northern hemisphere and Northwest direction in the southern hemisphere. The horizontal wavelengths of MSTIDs were typically 150 – 250 km and propagate with velocities of the order of 50-150 m/s. The development of night time MSTIDs can be explained by Perkins instability mechanism seeded by sporadic E-layer and the amplification of instability process in the F-layer. The MSTIDs are found to couple between the conjugate locations in northern and southern mid-latitudes. The night time mid-latitude MSTIDs are seem to have a low-latitude boundary around the equatorial ionization anomaly crest region. The other class of MSTIDs observed over equatorial region (below 10^{o} geomagnetic latitudes) exhibit gravity wave features, propagating away from the highly convective tropospheric origin. Also, some night time MSTIDs observed at subauroral latitudes, show the effect of penetrating electric field and gravity waves generated by auroral energy input.



Nighttime MSTIDs observed from Shigaraki, a mid-latitude station in Japan and the simultaneous observations of Electric field oscillations from an over pass DMSP satellite supporting the Perkins instability mechanism for the generation of MSTIDs [Shiokawa et al. 2003]

Dr. Shrikanth G Kanekal

Research Astrophysicist, NASA's Goddard Flight Space Centre, USA

Research Interests: Energization and loss processes of relativistic electrons in the Earth's magnetosphere, solar energetic particles, Jovian electrons, magnetospheric energetic particle boundary dynamics, space instrumentation and space weather.

Significant Scientific Achievements:

- Developed the Compact Relativistic Electron and Proton Telescope (CREPT)
- Involved in the design and calibration of Relativistic Electron Proton Telescope (REPT) for Van Allen probes mission
- Designed and is currently building the MERiT (Miniaturized Electron Proton Telescope) for CeREs mission

Honors and Awards:

- NASA Scientific Group Achievement Award, 2013
- NASA Scientific Group Achievement Award, 1994
- National Science Talent Search Scholarship, 1974, Government of India

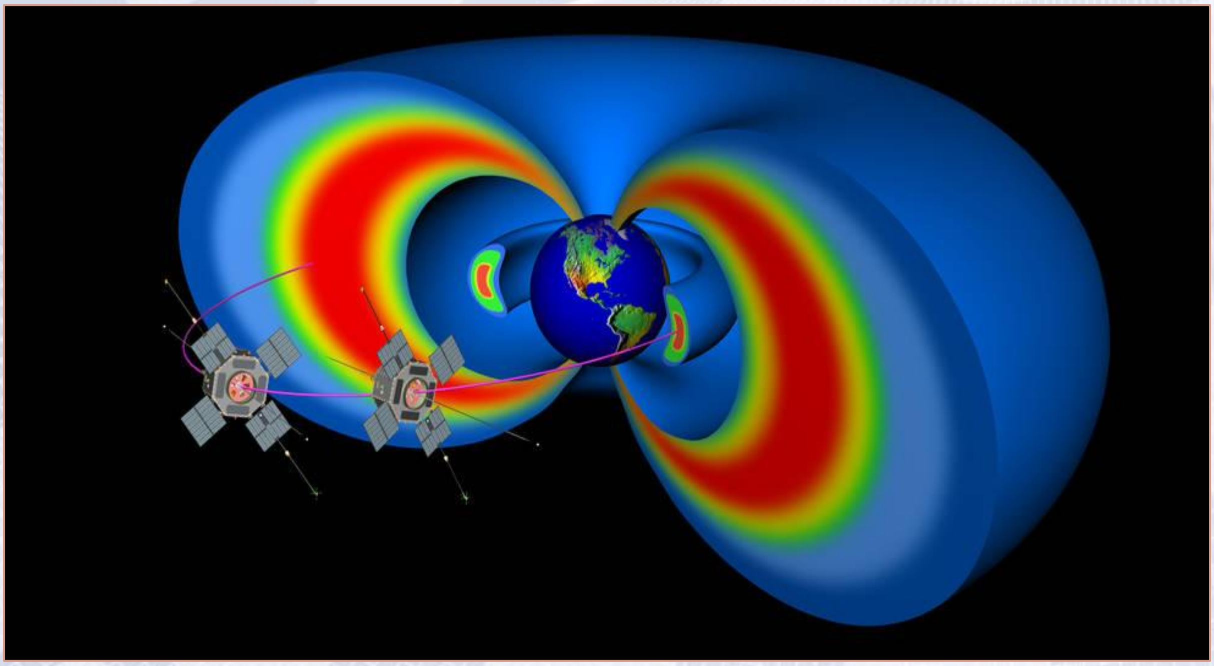
Dr. S. G. Kanekal

Electron dynamics in the Earth's radiation belts: Van Allen Probes contributions and future directions

The Earth's radiation belts were discovered by James Van Allen in the 1950s. The Van Allen belts comprise charged particles trapped in the geomagnetic field, usually confined to two distinct regions, the inner and the outer belt separated by the so-called slot region. The outer belt containing chiefly electrons, is very dynamic and a number of physical processes operate there which affect their intensities via energization and loss mechanisms.

The Van Allen Probes, a major NASA mission was launched late August 2012 to study the radiation belts in a comprehensive manner. The mission comprises two identically instrumented spacecrafts carrying a comprehensive suite of instruments that characterize charged particles, electric and magnetic fields, and plasma waves in the Earth's radiation belts. In particular, the ECT suite of instruments comprising of HOPE, MagEIS and REPT instruments measure electrons, protons and ions and their angular distributions over energies ranging from a few eV to several tens of MeV. Measurements from Van Allen Probes have made significant and paradigm-shifting contributions towards the understanding of the physics of charged particles in the Earth's radiation belts.

The Van Allen Probes mission is described with emphases on the REPT and MagEIS instruments and highlighted some of the recent science results regarding electron energization and loss in the outer radiation belt. Further, the recent advances in miniaturizing space platforms have enabled small CubeSats to make significant contributions to radiation belt physics. The overview of the Compact Radiation belt Explorer (CeREs) CubeSat mission, currently being built at Goddard to be launched July-2017 and its science goals are presented.



NASA's Van Allen Probes orbit through two giant radiation belts that surround the Earth. The observations help to improve computer simulations of various processes in the belts that can affect the space based technology . ***Credit: JHU/APL, NASA***

Dr. Nat Gopalswamy

Astrophysicist, NASA Goddard Space Flight Center, USA

Research Interests: Solar Physics, Solar Terrestrial Physics, Space Weather, Radioastronomy

Significant Scientific Achievements:

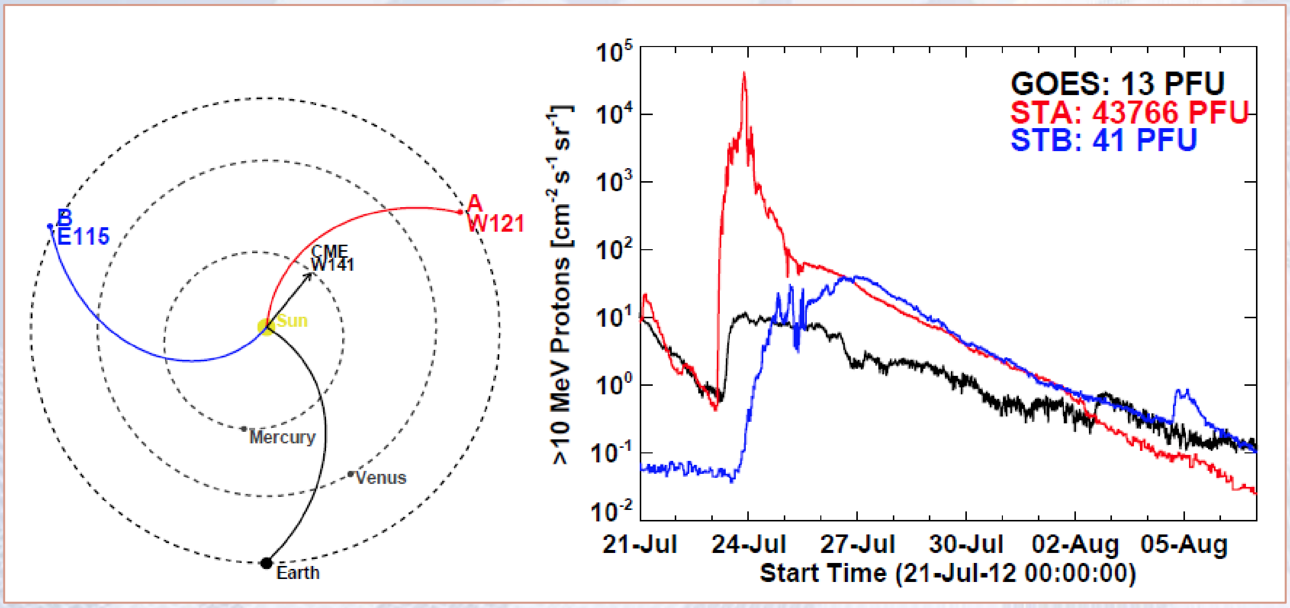
- First detection of radio CME
- Effective interplanetary acceleration
- Empirical Shock Arrival Model
- Anomalous expansion of CMEs
- North-south asymmetry switch in solar polarity reversal

Honors and Awards:

- G. Ramaswamy Naidu Memorial Prize, University of Madras, 1977
- Prof. P. E. Subramani Ayyar Commemoration Medal, University of Madras, 1977
- Dr. K. S. Krishnan Gold Medal, University of Madras, 1977
- Dr. K.S. Krishnan Memorial Prize, University of Madras, 1977
- Jagirdar of Arni Medal, University of Madras, 1977
- Fellow of the Science and Technology Agency of Japan, 1996
- Senior Research Associate, US National Academy of Sciences 1998 – 2000
- NASA GSFC NATIONAL RESOURCE Group Achievement Award, 2000
- NASA GSFC Solar System Exploration Division Peer Award, 2006
- NASA Goddard Space Flight Center Special Act Award in recognition of superior service, 2006
- NASA GSFC New Business Capture Award, 2006
- Robert H. Goddard Honor Award for Science 2008
- AOGS Distinguished Lecturer, 2010
- NASA GSFC Heliophysics Division Peer Award, 2012
- NASA Outstanding Leadership Medal, 2013
- American Geophysical Union Fellow 2016

The July 23 extreme solar eruption on the backside of the Sun: A Carrington-class event?

A massive cloud of solar material (coronal mass ejection, CME) erupted on the backside of the Sun spanning into the interplanetary space on July 23, 2012. The speed of the CME front is estimated to vary between 1800 and 2200 miles per second (~2896 – 3540 km/s), one the fastest CMEs ever recorded. This outstanding event has received considerable attention because many of its characteristics place it among the historical extreme solar events. The CME has been deemed to be of Carrington class based on its magnetic content. The energetic particle observations have shown that the CME is also extreme from the particle acceleration perspective: not only are the particle intensities very high, the fluence spectrum of the event is consistent with acceleration of GeV particles. The associated solar energetic particle (SEP) event had a >10 MeV proton flux peaking at ~5000 pfu, and the energetic storm particle (ESP) event was an order of magnitude larger, making it the most intense event in the space era at these energies. By a detailed analysis of the CME, shock, and SEP characteristics, it is found that the July 23 event is consistent with a high-energy SEP event (accelerating particles to GeV energies).



The direction of the CME (W141) with respect to Earth along with the locations of STEREO-A (W121), STEREO-B (E115) spacecraft (left). The solar energetic particles (SEPs) with energies >10 MeV detected by STEREO-A, STEREO-B and GOES spacecraft (right) [Gopalswamy et al., 2016].

Dr. Jozef Brestenský

Associate Professor, Comenius University in Bratislava (CU)
Bratislava, Slovakia

Research Interests: Rotating Magnetoconvection, Cosmic Magnetohydrodynamics, Solar Physics, Geophysics, Geophysical Fluid Dynamics, Planetary Magnetic Fields and Physics of everyday life.

Significant Scientific Achievements:

- Magnetoconvection in a plane layer rotating about the horizontal axis: The effect of anisotropic diffusivities.
- Rotating magnetoconvection with anisotropic diffusivities in the Earth's core.
- Nonlinear Magneto-convection due to Compositional and Thermal buoyancy with Soret effect.
- Compositional and thermal convection in Earth's rotating outer core.

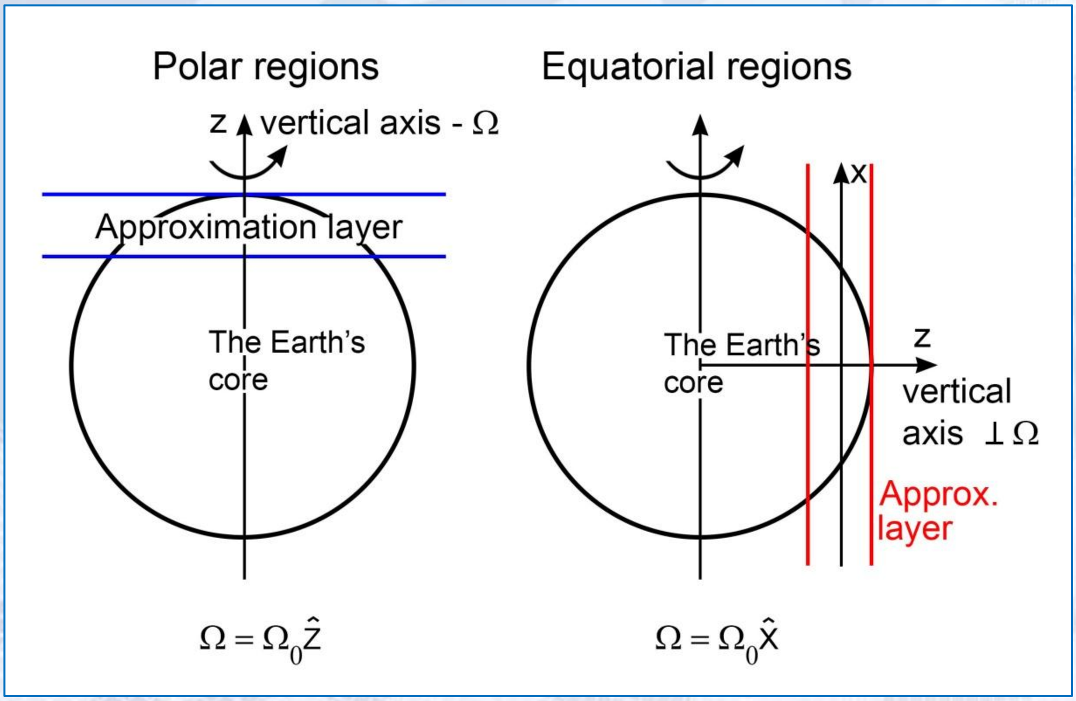
Honors and Awards:

- Member of Slovak National Committee for Geodesy and Geophysics – National Representative of IUGG (International Union of Geodesy and Geophysics) (2001 – February 2016)
- National correspondent to IAGA (International Association for Geomagnetismus and Aeronomy) at IUGG (2001 – February 2016)
- Editorial Board Member of Contribution to Geophysics and Geodesy, GFÚ SAV (1997 – 2005)
- Editorial Board Member of AAGUC–Acta Astronomica et GeophysicaUniversitatis Comenianae (1993– 2005)
- Guest Editor of GAFD (Geophysical and Astrophysical Fluid Dynamics) for Special Issue "Natural Dynamos", Taylor & Francis Group (Sept 2009 –2010)
- Chair of Scientific and Local Organisation Committee of "Natural Dynamos" Conference, Stará Lesná, High Tatras (30th August–5th September 2009)
- Co-Chair of Division I: "Planetary dynamos: theory, models, observations and experiments" in frame of Committee of IAGA - International Association for Geomagnetismus and Aeronomy IUGG (2007 – 2011)

Dr. J. Brestenský

Influence of anisotropic diffusivities on hydromagnetic instabilities in rotating plane layer

The rotating magnetoconvection models are distinguished by different basic magnetic fields with respect to different orientations of rotation axes and also based on anisotropic diffusivities. The instabilities in the Earth's core due to the turbulence as a source of anisotropy will be highlighted. The basic governing equations and the method of solution will be elucidated for all models. It can be noted that in all these cases, the developing instabilities are strongly sensitive to anisotropic diffusivities. There are instabilities which do not exist in isotropic diffusivities' cases, i.e. the instabilities which necessarily need any case of anisotropic diffusive coefficients, viscosity and thermal diffusivity, for their existence. The magnetostrophic balance of forces is confirmed for very large Elsasser number, $\Lambda >> 1$, as well as for $\Lambda = O(1)$. The anisotropy of diffusive coefficients influences the arising instabilities, but only weakly from the dynamic point of view. The analysis is related to parameters typical for the Earth's outer core. Anisotropy of diffusive coefficients due to turbulence and their influence on the RMC.



Models of rotating magnetoconvection

Dr. Vikas S Sonwalkar

Professor, University of Alaska Fairbanks, USA.

Research Interests: Space physics, plasma waves, VLF, radio sounding

Significant scientific achievements:

- Pioneered whistler mode radio sounding from space
- Explained ground observations of auroral hiss
- Hot plasma diagnostics using VLF waves injected from ground
- Proposed lightning as an embryonic source of hiss
- First measurement of an effective length of a dipole antenna in space plasmas
- First observations of trans-ionospheric multipath propagation at VLF

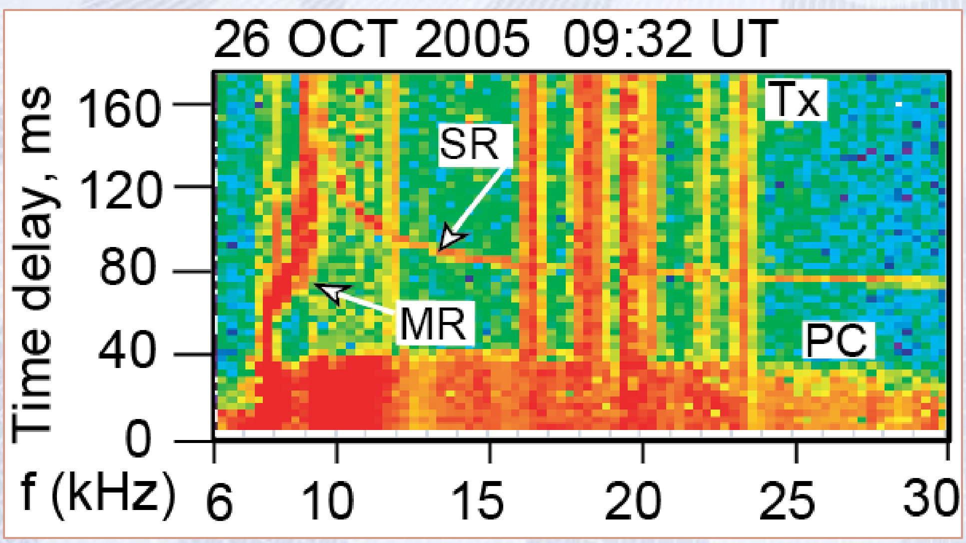
Honors and Awards:

- URSI best student paper award (1986)
- URSI young scientist award (1987)
- Los Alamos achievement award (1997)
- Outstanding graduate student advising, College of Science, Engineering and Mathematics, University of Alaska Fairbanks, 2004

Dr. V. S. Sonwalkar

Evolution of quiet time field aligned electron and ion densities from whistler mode radio sounding: comparison of observations with SAMI2 simulations

The temporal evolution of field aligned electron (N_e) and ion densities (N_{H+}, N_{He+}, N_{O+}) obtained from whistler mode (WM) radio sounding is compared with the SAMI2 (SAMI2 is Another Model of the Ionosphere) model predictions during 21-27 Nov 2005 quiet period, preceded by a minor storm [Reddy, Sonwalkar, Huba, 2016 AGU Fall meeting, San Francisco, CA]. The comparisons were made along L~2 and L~3, for altitude <3000 km, and ~10 MLT. SAMI2 simulations were performed for ~30 hours with input parameters (F10.7 flux, Ap, scaling factors for neutral density and wind and electric field) such that the model calculations of electron density and O+/H+ transition height agreed within 10% and 15%, respectively, with those measured by WM sounding on 21 November at L~2. SAMI2 simulations were run for another 145 hours, using same scaling factors, to obtain electron and ion densities on 24 November and 27 November when WM sounding data were available on the same flux tube and MLT. The important findings from this study reveals that, (1) WM sounding showed electron density decrease with time while SAMI2 predicted increase, the changes in both cases being more pronounced at altitudes above O+/H+ transition height. (2) Relative to WM sounding results, on all three days, SAMI2 predicted greater F2 peak densities, and above O+/H+ transition height, greater He+ and O+ densities. (3) WM sounding gave roughly the same O+/H+ transition height on all three days, while SAMI2 predicted decrease in transition height with time. (4) Simultaneous in-situ measurements from CHAMP (350 km) and DMSP (850 km) agreed better with that from WM sounding than they did with that predicted by SAMI2. Similar results were noted for L~3 WM sounding results and SAMI2 predictions. These results indicate: (1) Improved models of neutral densities, temperature, and electric fields or observational inputs to SAMI2 simulations are needed for better predictions. (2) The scaling factors used to obtain the fit on the first day may not be appropriate for subsequent days. Further, the results indicate that WM sounding measurements combined with SAMI2 simulations provide a novel approach to study the role of thermospheric winds and storm time electric fields in modifying the ionosphere and magnetosphere during storm time.



Examples of Whistler mode echoes observed on the IMAGE satellite [Sonwalkar, et al., JGR 2011].

Dr. Yoshiharu Omura

Professor, Research Institute for Sustainable Humanosphere (RISH)
Kyoto University, Japan

Research Interests: Space plasma physics and simulations

Significant scientific achievements:

- Particle simulations and theoretical analysis of electrostatic solitary waves
- Nonlinear theory and simulations of chorus and ion cyclotron emissions and the associated acceleration and precipitation of radiation belt electrons.

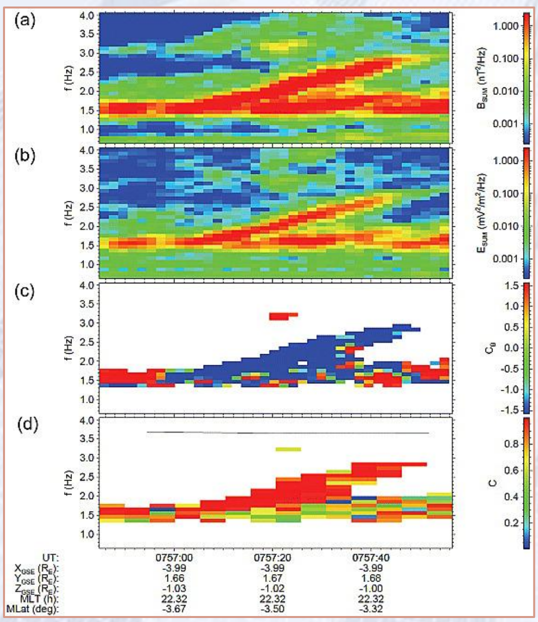
Honors and Awards:

- Zeldovich Award of Committee on Space Research (COSPAR), Commission D, 1992.
- Tanakadate Award of Society of Geomagnetism and Earth, Planetary and Space Sciences (SGEPSS), 1996.
- Science and Technology Award presented by Minister of Culture, Sports, Science, and Technology in Japan, 2006.

Dr. Y. Omura

Wave-particle interaction processes in Earth’s inner magnetosphere

In recent years, a series of spacecraft, Cluster, THEMIS, Van Allen Probes, and ERG have been launched into the Earth’s inner magnetosphere, and they have functions to record wave forms with high time resolutions, enabling us to understand coherent structures in waves such as whistler mode chorus, hiss, and electromagnetic ion cyclotron (EMIC) emissions frequently observed in the radiation belts. Successful reproductions of these waves by particle simulations have resulted in significant progress in theory on their generation mechanisms and associated acceleration and precipitations of energetic particles. We give a brief account of the nonlinear theory of the generation mechanism of chorus emissions. We describe the nonlinear dynamics of resonant electrons, and the formation of the electromagnetic electron “hole” that results in resonant currents generating rising-tone emissions. We have theoretically derived threshold and optimum wave amplitudes for the nonlinear wave growth of rising-tone emissions. The profiles of these wave amplitudes as functions of frequencies agree well with those from observations and simulations. In contrast, falling-tone emissions are generated through the formation of electron “hills.” We also describe the mechanism of nonlinear wave damping due to quasi-oblique propagation, which results in the formation of a gap at half the electron cyclotron frequency. The nonlinear wave growth theory of chorus emissions can be applied to the generation mechanism of electromagnetic ion cyclotron emissions. Hybrid code simulations have confirmed that coherent rising-tone emissions are generated by energetic protons at frequencies below the proton cyclotron frequency through formation of electromagnetic ion holes. Electromagnetic ion cyclotron waves can also interact with relativistic electrons. Both chorus emissions and electromagnetic ion cyclotron rising-tone emissions play important roles in controlling radiation-belt particle dynamics. Coherent structures recently found in the plasmaspheric hiss emissions are also interpreted by the nonlinear wave growth theory. Good agreement between the observation and the theory confirms local generation of the hiss emissions in the equatorial region just inside the plasmapause.



Dynamic power spectra of (a) magnetic, (b) electric field in a frequency range of 0.5–4.0 Hz, observed by Cluster 4 during the time 07:56:44.795–07:57:56.475 on 30 March 2002. (c) Polarization and (d) coherency analyses. The spectra are from the STAFF-SC and EFW instruments and the magnetic field measurements from the FGM instrument [Omura et al., J. Geophys. Res., 2010].

Dr. Yoshiharu Omura
Professor, Research Institute for Sustainable Humanosphere (RISH)
Kyoto University, Japan

Research Interests: Space plasma physics and simulations

Significant scientific achievements:

- Particle simulations and theoretical analysis of electrostatic solitary waves
- Nonlinear theory and simulations of chorus and ion cyclotron emissions and the associated acceleration and precipitation of radiation belt electrons.

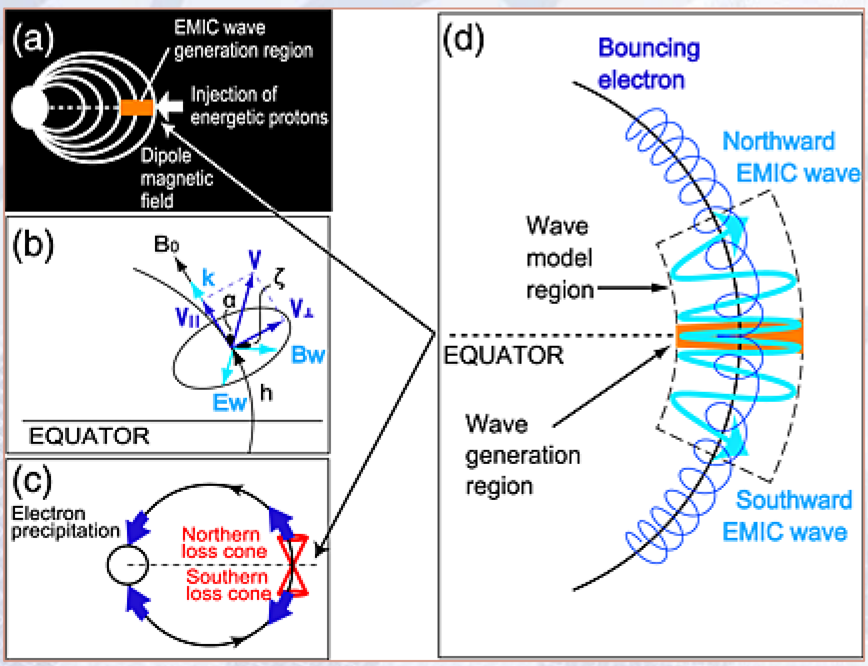
Honors and Awards:

- Zeldovich Award of Committee on Space Research (COSPAR), Commission D, 1992.
- Tanakadate Award of Society of Geomagnetism and Earth, Planetary and Space Sciences (SGEPSS), 1996.
- Science and Technology Award presented by Minister of Culture, Sports, Science, and Technology in Japan, 2006.

Dr. Y. Omura

Dynamic variation of Earth's outer radiation belt due to whistler-mode chorus and EMIC waves

During space weather events, energetic particles are injected from the magnetotail to the inner magnetosphere, and various kinds of wave-particle interactions take place. Whistler-mode chorus emissions are one of the most important waves for the dynamics of relativistic electrons forming the outer radiation belt. Chorus emissions are excited via interaction with 10 - 100 keV electrons outside the plasmasphere, and they can accelerate a fraction of resonant electrons to MeV energy through nonlinear wave trapping mechanisms called relativistic turning acceleration (RTA) and ultra-relativistic acceleration (URA). The time scale of acceleration is much shorter than that predicted by the quasi-linear theory. Effective acceleration of electrons through Landau resonance with obliquely propagating chorus emissions can also take place. Another kind of waves important for the radiation belt dynamics is EMIC rising-tone emissions excited by nonlinear interaction with 10 -100 keV protons both inside and outside the plasmasphere. The EMIC emissions can interact with relativistic electrons (> 0.5 MeV) and scatter them to lower pitch angles efficiently by nonlinear wave trapping, resulting in significant precipitation of radiation belt electrons as well as energetic protons. In these nonlinear wave-particle interactions, the rising-tone frequencies of the emissions and the gradient of the magnetic field play essential roles in particle acceleration and pitch angle scattering. We review recent development of nonlinear theory and simulations that can describe dynamic nature of the radiation belts under intense space weather events.



A schematic illustration of the generation of EMIC-triggered emissions and interaction with relativistic electrons. (a) EMIC wave generation around the equator by injected energetic protons in a dipole magnetic field. (b) Vector components of an EMIC wave and velocity components of a test electron. (c) Electron precipitation due to scattering induced by EMIC waves. (d) Mirror motion of relativistic electrons interacting with the wave packets repeatedly [Kubota, Omura, and Summers, J. Geophys. Res., 2015]

Dr. Nanan Balan

Senior Scientist/Professor, University of Sheffield, UK

Research Interests: Space weather, geomagnetic storms and Ionosphere-Thermosphere response, severity of space weather and its relevance to the high-tech society.

Significant Scientific Achievements:

- Involved in the development of first HF Doppler Radar at Trivandrum
- Involved in the development of Sheffield University Plasmasphere Ionosphere Model (SUPIM)
- Explained the mechanisms behind the formation of F3-layer

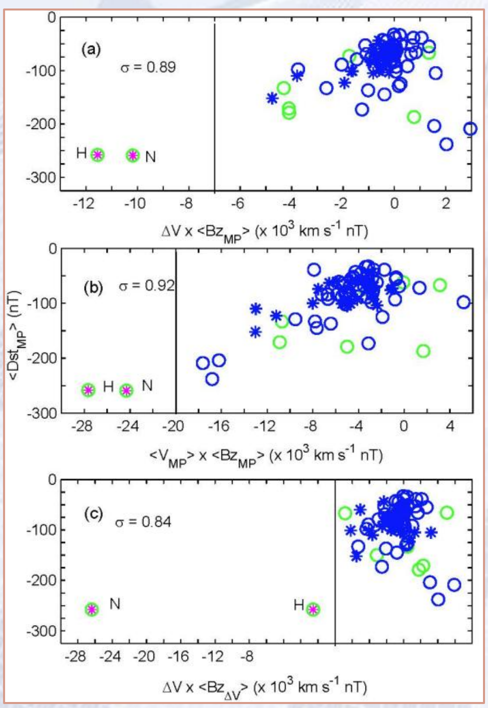
Honors and Awards:

- Berkner Award of AGU for Young Scientists in 1984
- Young scientist awards from URSI and INSA
- Exceptional Performance Award of University of Sheffield in 1992
- Professorship of the Center of Excellence of Kyoto University in 2000
- Served as Associate Editor for JGR-Space Physics, Earth, Planets and Space (EPS) and Geoscience Letters
- Guest editor for JGR-Space physics, JASTP and IJRSP
- Excellence in reviewing for JGR in 2012
- President, ST Section of AOGS

Dr. N. Balan

Severe space weather and its relevance to the high-tech society

Like Earth's weather space weather sometimes become severe. When it becomes severe it can cause extensive social and economic disturbances in the high-tech society by damaging satellite systems and ground systems. For example, an event such as the Carrington event of 1859 at present times can cause damages costing up to 1 to 2 trillion US Dollars. It is therefore important to understand what determines the severity of space weather and whether it can be predicted. An analysis of the solar-geophysical data indicates that the impulsive energy and orientation of the IMF Bz at the leading edge of the CMEs (or CME front) that determine the severity of space weather. The CMEs having high impulsive leading edge velocity (sudden non-fluctuating increase by over 275 km s^{-1} over the background) and the IMF Bz southward from the leading edge caused SvSW at the Earth including extreme geomagnetic storms of mean DstMP<-250 nT during main phases. The known electric power outages happened during some of these SvSW events. A scheme is suggested and tested for forecasting severe space weather (SvSW) using solar wind velocity (V) and the north-south component (Bz) of the interplanetary magnetic field (IMF) measured using the ACE (Advanced Composition Explorer) satellite from 1998 to 2016. The coincidence of high CME front (or CME shock) velocity ΔV (sudden increase in V over the background by over 275 km/s) and sufficiently large Bz southward at the time of the ΔV increase is associated with SvSW; and their product (ΔV x Bz) is found to exhibit a large negative spike at the speed increase. Such a product (ΔV x Bz) exceeding a threshold seems suitable for forecasting SvSW. However, the coincidence of high V (not containing ΔV) and large Bz southward does not correspond to SvSW, indicating the importance of the impulsive action of large Bz southward and high ΔV coming through when they coincide. The need for the coincidence is verified using the CRCM (Comprehensive Ring Current Model) model, that produces extreme Dst storms ($\langle Dst_{MP} \rangle < -250$ nT) characterizing SvSW when there is coincidence.



The relationship between the mean Dst value during the mainphase ($\langle Dst_{MP} \rangle$) and the product of CME front velocity (ΔV) and IMF Bz. The product of ΔV and the mean southward Bz is a better index for the severity of space weather.

Dr. Nanan Balan

Senior Scientist/Professor, University of Sheffield, UK

Research Interests: Space Weather, Geomagnetic storms and Ionosphere-Thermosphere Response, Severity of space weather and its relevance to the High-tech society.

Significant Scientific Achievements:

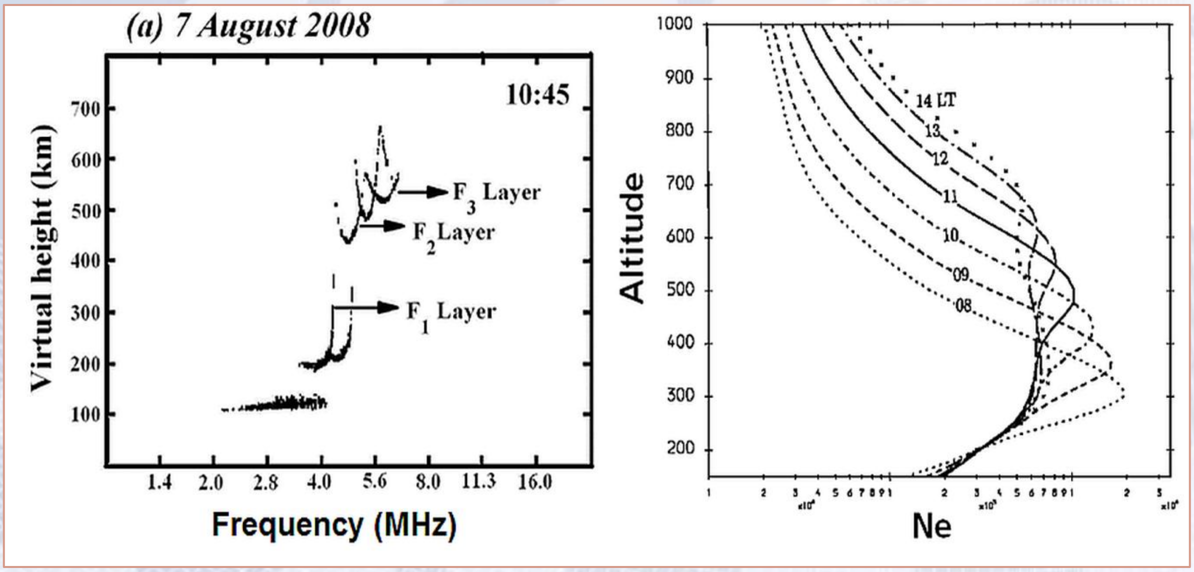
- Involved in the development of first HF Doppler Radar at Trivandrum
- Involved in the development of Sheffield University Plasmasphere Ionosphere Model (SUPIM)
- Explained the mechanisms behind the formation of F3-layer

Honors and Awards:

- Berkner Award of AGU for Young Scientists in 1984
- Young scientist awards from URSI and INSA
- Exceptional Performance Award of University of Sheffield in 1992
- Professorship of the Center of Excellence of Kyoto University in 2000
- Served as Associate Editor for JGR-Space Physics, Earth, Planets and Space (EPS) and Geoscience Letters
- Guest editor for JGR-Space physics, JASTP and IJRSP
- Excellence in reviewing for JGR in 2012
- President, ST Section of AOGS

Recent developments in the understanding of the behaviour of low latitude ionosphere-thermosphere system

Low latitude ionosphere-thermosphere system is characterized by several special features basically due to the horizontal orientation of the geomagnetic field at the geomagnetic equator. The special features include the equatorial electrojet, equatorial plasma fountain, equatorial ionization anomaly (EIA), equatorial plasma temperature anomaly (EPTA), equatorial wind and temperature anomaly (EWTA), plasma bubbles and spread F and F_3 layer. The upward field perpendicular **E**x**B** drift and field-aligned diffusion act together all along the field lines, and plasma flows in the direction of the resultant. The EIA arises mainly from the removal of plasma from around the equator (by **E**x**B** drift), with very little accumulation at the crests when the crests are within ~±15° mag. lat. and no accumulation when they are beyond ~±25°. EIA can become very strong during early main phase of daytime super storms due to the simultaneous action of strong eastward PPEF and storm time equatorward neutral wind. The additional stratification of F-layer often occurs in low-latitude ionosphere during day times. The existing F2 layer drifts upward and forms F3 layer while a new F2 layer develops at lower heights. The upward velocity is provided mainly by **E**x**B** drift and partly by neutral wind (and waves). The layer is formed centered on that (summer) side of the equator where the net upward velocity is vertical. When $foF_3 > foF_2$, F3 layer can be observed by bottomside sounders; and later when $foF_3 < foF_2$, F3 layer becomes a topside ledge, which can be observed by topside sounders. The incoherent scatter radars can observe F2 and F3 layers and topside ledge.



The formation of F3 layer and modelled electron density profiles under the condition of strongest F3 layer from SUPIM model.

Dr. Shin-Yi Su
Retired Professor, Institute of Space Science
National Central University (NCU), Taiwan.

Research Interests: Orbital Debris, Ionospheric Physics, and Solar Wind Interaction with Magnetosphere

Significant Scientific Achievements:

- Principal investigator of the Ionospheric Plasma and Electrodynamics Instrument (IPEI) on board the ROCSAT-1 satellite. IPEI data provided more than one hundred scientific publications.
- Published about 120 scientific papers and technical reports

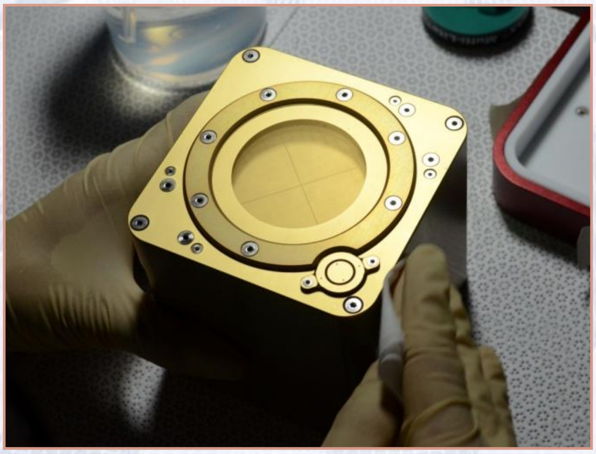
Honors and Awards:

- Director of NCU Instrument Center for National Science Counsel (Taiwan) (1990-2001)
- Director of Space Science Institute of NCU (1989-1992)
- Associate Editor for Terrestrial, Atmospheric and Oceanic Sciences (TAO) journal
- Executive Member and Scientific Secretary of National SCOSTEP Committee of ROC (Taiwan) (1996-2002).

Dr. S.Y. Su

Taiwan's space (ionospheric) exploration (Past and Future)

The first Taiwan's space exploration is carried out by a scientific satellite "ROCSAT-1 (FORMOSAT-1)" launched on January 27, 1999 from Cape Canaveral, Florida, USA. The ionospheric payload is the "Ionospheric Plasma and Electrodynamics Instrument" (IPEI). The significance of IPEI payload is three-fold: (1) First low-to-mid latitude ionosphere exploration from 1999 to 2004 during high solar activity years since the ends of US Atmospheric Explorer E in 1981 and Japanese Hinotori in 1982. Equatorial C/NOFS satellite was followed on April 16, 2008 and ended on Nov 28, 2015, but was operated during low solar activity years. (2) 100% duty cycle operation so that global, seasonal, and solar activity effects have been studied, and it has the only complete set of low-to-mid latitude ionospheric data taken during high solar activity years of cycle 23. (3) IPEI has operated at1024 Hz (~15-m scale) to take high resolution data to study the equatorial spread-F (ESF) irregularity structure. Following the heritage of IPEI, an Advanced Ionospheric Probe (AIP) has been developed to put on the upcoming FORMOSAT-5 satellite scheduled for launched in 2017. AIP is an all-in-one thermal plasma sensor to measure ionospheric plasma concentrations (N_i), velocity ($\boldsymbol{V}_i$), and temperatures (T_i and T_e) in a time sharing way for Ion Trap (IT), Ion Drift Meter (IDM), Retarding Potential Analyzer (RPA), and Planar Langmuir Probe (PLP). The AIP is capable of measuring ionospheric plasma irregularities with a sampling rate up to 8,192 Hz. Electro-formed gold grids used in the AIP can reduce quasi-hysteresis effect on I-V curves and obtain the ideal equal potential surfaces for accurate measuring geophysical parameters. The second phase of FORMOSAT-7/COSMIC-II mission that will carry (expected) payloads of GOX, AIP, ISUAL, and GPS-R is still under planning, and may be realized in 2020.



The Ionospheric Electrodynamics and Plasma Instrument (IPEI) on board the Formosat-1 satellite (left) and the all-in-one miniature Advanced Ionospheric Probe (AIP) on board the upcoming Formosat-5 mission (right).

Dr. Bruce T Tsurutani

Senior Scientist and Principal Scientist, Jet Propulsion Laboratory (JPL)
Pasadena, Calif. USA

Research Interests: Plasma waves and instabilities, nonlinear waves, wave-particle interactions, magnetic storms and substorms, auroras, solar flares, space weather, extreme events, chaos and climate change.

Significant Scientific Achievements:

- Published ~700 articles in refereed scientific journals
- H-index of 77, i10-index 360, number of citations 29,204
- Published 9 NASA tech briefs (patents)
- Elected President of AGU SPA Section (1988-1992)
- Elected Secretary for Solar and Interplanetary Physics AGU (1982-1986)
- Edited 8 books on space plasma science topics
- Organized 4 AGU Chapman Conferences
- Organized many science sessions and meetings
- Organized or edited many JGR, GRL, NPG, EOS special issues

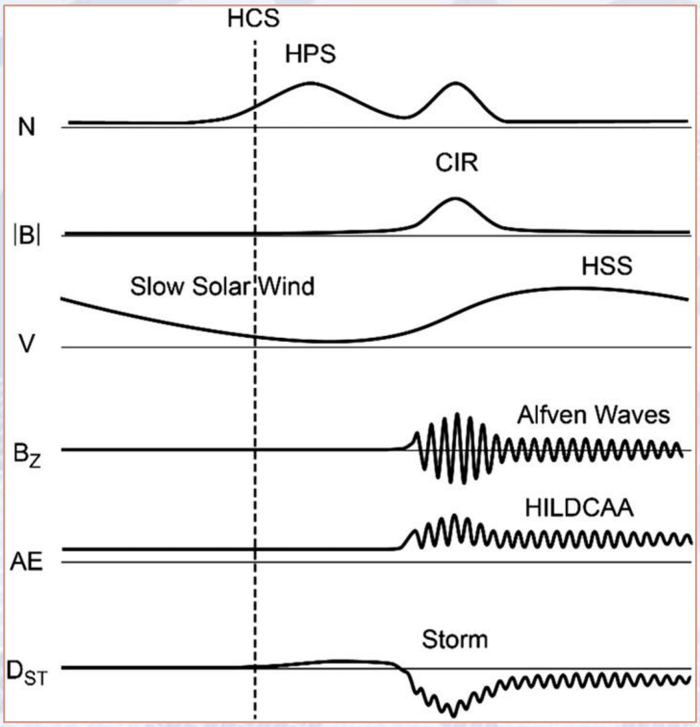
Honors and Awards:

- ESA and Chinese NSSC Cluster and Double Star award, 2015
- Excellence in Refereeing by JGR-Space Physics (2015, 2014, 2007), Solar Physics (2015), JASTP (2014) and GRL (2003, 1984)
- AGU John Adam Fleming Medal, 2009
- AGU Fellow, 2009
- ALAGE (Latin America Geophysical Society) inaugural Gold Medal, 2001
- NASA Exceptional Service Medal, 1985 and 2001
- Brazilian National Space (W. Von Braun) Medal, 1992
- ESA Ulysses achievement, 1990

Dr. B. T. Tsurutani

Heliospheric Plasma Sheet (HPS) impingement onto the magnetosphere as a cause of Relativistic Electron Dropouts (REDs) via coherent EMIC wave scattering with possible consequences for climate change mechanisms

A new scenario is presented for the cause of magnetospheric relativistic electron decreases (REDs) and potential effects in the atmosphere and on climate. High density solar wind heliospheric plasmasheet (HPS) events impinge onto the magnetosphere, compressing it along with remnant noon-sector outer-zone magnetospheric ~10-100 keV protons. The betatron accelerated protons generate coherent EMIC waves through a temperature anisotropy ($T_\perp/T_\parallel > 1$) instability. The waves in turn interact with relativistic electrons and cause the rapid loss of these particles to a small region of the atmosphere. A peak total energy deposition of 3 x 10^{20} ergs is derived for the precipitating electrons. Maximum energy deposition and creation of electron-ion pairs at 30-50 km and at < 30 km altitude are quantified. We focus attention on the relevance of this present work on two climate change mechanisms. Wilcox et al. [1973] noted correlation between solar wind heliospheric current sheet (HCS) crossings and high atmospheric vorticity centers at 300 mb altitude. Tinsley et al. [1994] has constructed global circuit model which depends on particle precipitation into the atmosphere. Other possible scenarios potentially affecting weather/climate change are also discussed



A schematic of the region near the slow stream-high-speed stream interaction. (first panel) The solar wind density N, (second panel) the interplanetary magnetic field magnitude |B|, (third panel) the solar wind velocity V, (fourth panel) the interplanetary magnetic field B_z component, and the (fifth panel) geomagnetic AE and (sixth panel) Dst indices. The dashed vertical line is the heliospheric current sheet (HCS), and the density associated with it (asymmetrically on the right side) is the heliospheric plasma sheet (HPS). A corotating active region (CIR) and HSS HILDCAAs are shown for context. They are present sunward of the HPS and impact the Earth's magnetosphere after the HPS impact in time [Tsurutani et al., 2016].

Dr. Duggirala Pallamraju

Professor, Space and Atmospheric Sciences Division
Physical Research Laboratory (PRL), Ahmedabad, India.

Research Interests: Solar terrestrial interactions in the ionosphere and thermosphere, space weather, atmospheric coupling, daytime wave dynamics,

Significant Scientific Achievements:

- Resolved controversies with regard to the contribution of Ring (scattering) effect in Fraunhofer spectrum.
- Developed innovative technique for simultaneous daytime airglow emission measurements at multiple wavelengths.
- Obtained the first signatures of magnetospheric cusps in the daytime upper atmosphere.
- Obtained the first three dimensional wave structure in the upper atmosphere that exists in the daytime.
- Along with Ph.D. students: (1) discovered a new meridional circulation cell in winds that gets set up during Stratospheric Sudden Warming events, (2) characterized the relative role lower atmospheric wave effects and those of solar activity in the upper atmosphere, (3) obtained experimental evidence for the effects of tropospheric cyclonic storms in the mesosphere, (4) unearthed the imprint of equatorial electrodynamics in the neutral dayglow emissions.

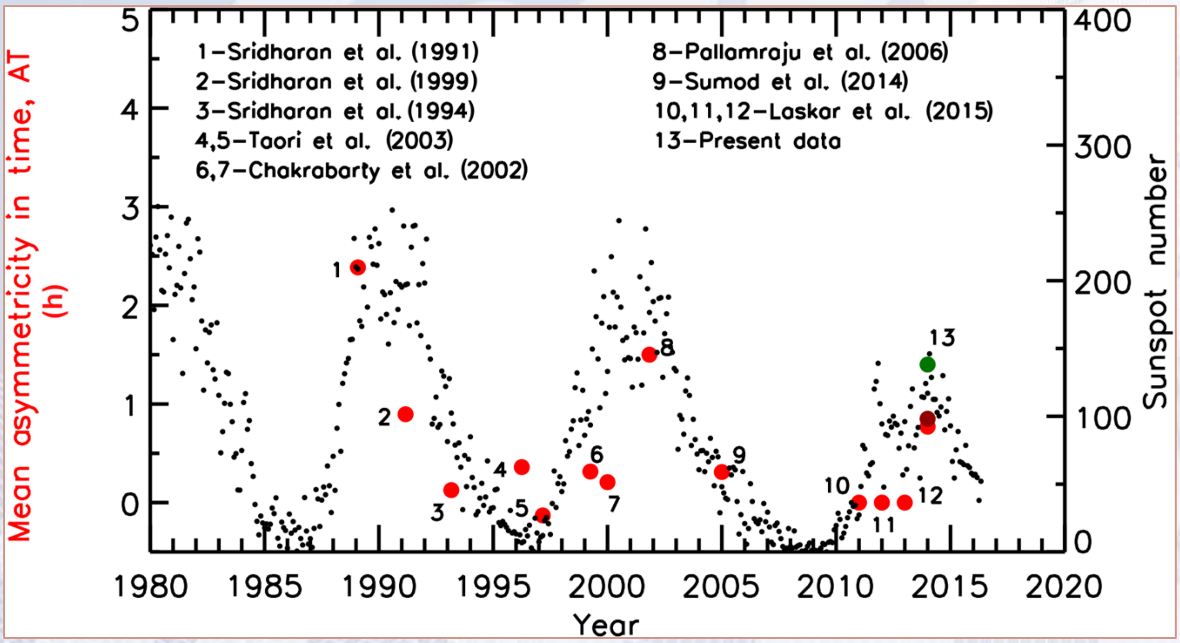
Honors and Awards:

- **Scientific Coordinator**, Climate and Weather of the Sun-Earth System (CAWSES) (2004 - 2008)
- **Member,** Board of Studies on Atmospheric Sciences, Pune University, Pune (2010 – 2012)
- **Elected Secretary** of Solar Terrestrial (ST) Section, AOGS (2011 – 2015)
- **Science Discipline Representative** (SDR) for SCOSTEP (2011 – present)
- **Member Secretary**, Board of Studies, Centre for Space Science Technology Education in Asia Pacific (CSSTEAP), Affiliated to United Nations (2011 – present)
- **Elected Vice-Chair** for Commission C1 of COSPAR (2012 – 2020)
- **Working group leader** of ROSMIC project of VarSITI (2014 – 2018)
- **Member**, Editorial Board, Indian Journal of Radio and Space Physics (2015 – 2017)

Dr. D. Pallamraju

Influence of equatorial electrodynamics on low-latitude neutral optical dayglow emissions

Equatorial electrodynamics plays a significant role in the redistribution of plasma and neutral densities in the low- and equatorial latitude regions. The daytime airglow emission intensity measurements at three wavelengths OI 777.4 nm, OI 630.0 nm, and OI 557.7 nm made from a low-latitude location, Hyderabad (17.5° N, 78.4° E; 8.9° N MLAT) showed both symmetric and asymmetric behaviour in their respective diurnal variability with respect to local noon. The asymmetric diurnal behaviour is not expected considering the photochemical nature of the production mechanisms. The reason for this observed asymmetric diurnal behaviour has been found to be predominantly the temporal variation in the equatorial electrodynamics. The plasma that is transported across latitudes due to the action of varying electric field strengths over the magnetic equator in the daytime contributes to the asymmetric diurnal behaviour in the neutral daytime airglow emissions. It is also noted that this asymmetric diurnal behaviour in the neutral emission intensities has a solar cycle dependence with a greater number of days during high solar activity period showing asymmetric diurnal behaviour compared to those during a low solar activity epoch.



Variation of mean asymmetricity in time (AT) at OI 630.0 nm emissions in different years as obtained from the published literature is shown. The monthly averaged sunspot number is also plotted. A striking similarity between them indicates that the equatorial electric field has a direct role in the observed diurnal pattern of the neutral optical dayglow emission intensities [from Karan et al., Electrodynamic influence on the diurnal behaviour of neutral daytime airglow emissions, Ann. Geophys., 34, 1019-1030, 2016].

Dr. Esfhan Alam Kherani

Researcher, National Institute for Space Research, Brazil

Research Interests: Space plasma physics, Atmospheric-Ionospheric coupling and dynamics

Significant Scientific Achievements:

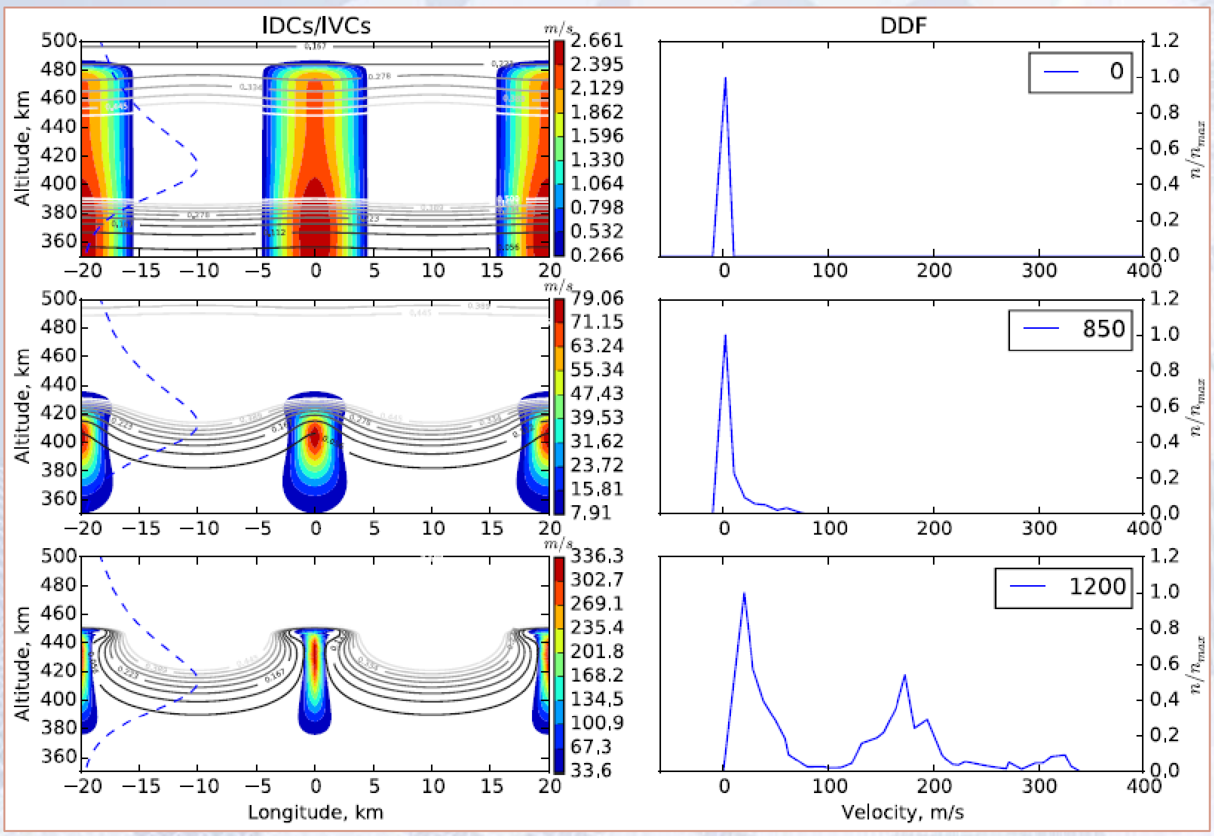
- Development of vertical coupling simulation model of atmosphere-ionosphere system involving acoustic gravity wave and travelling ionosppheric disturbances
- Development of three dimensional plasma bubble simulation model
- Development of tsunami early warning methodology based on identification and simulation of new kind of tsunamigenic traveling ionospheric disturbances
- Development of short term forecasting methodology of plasma bubble and scintillation, based on simultaneous observation and simulation approach
- Construction of distribution function inside the simulated equatorial plasma bubble
- 40 publications with 25 as first or second author, in the peer reviewed journals
- Thesis advisors of 2 master and 5 doctoral students

Dr. A. Kherani

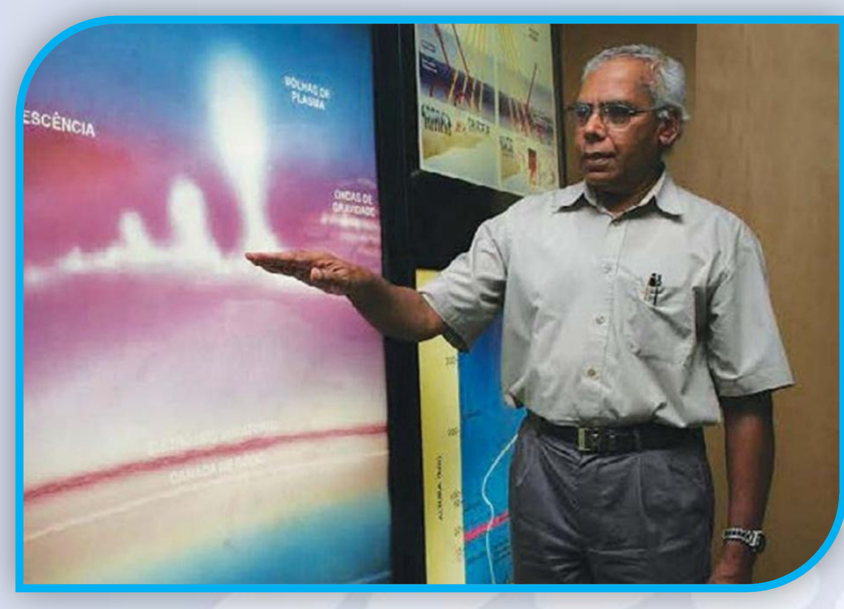
Geospheric disturbances during convective and seismic weathers

The geospheric disturbance is referred to the disturbance in the atmosphere ionosphere over the globe. They are in abundance and in varieties but special attentions are given to the disturbances during meteorological anomalies such as the tropospheric convection and during the seismic anomalies such as earthquakes/tsunamis. Adopting the terminology from space weather, these phenomena are referred as the convective and seismic weathers, respectively.

The presentation is broadly focused on the recent developments at INPE on these subjects and also the collaborative activities currently undertaken with IIG. In particular, the following aspects were discussed, (1) plasma bubble simulation and associated unstable distribution function, (2) observations of geospheric disturbances during Tahoku-Oki tsunami and very recent Chile tsunami, (3) Simulations of some of these disturbances, (4) Observations of MSTIDs during the convective weather, (5) simulations of the mesospheric ripples and QP disturbances during the convective weather.



Evolution of CII: Left-panels show the longitude-altitude distribution of (n, v), in the form of IDCs and IVCs, at three chosen times, t = 0, 850, and 1200 s. IDCs and IVCs are represented by contours and color-pixmaps. In the right-panel, the corresponding DDFs are plotted. The DDF is constructed by counting the number density encountered within a narrow-middle part of EPB in each 10 m/s window of v ranging between -10 and 400 m/s. The DDF is normalized to the maximum density (n_{max}) which is 10^{14}, 5 x 10^{13}, 10^{12} m^{-3} at three chosen times. In the left panels, the dashed blue curve represents the ionospheric number density and t = 0 s [Kherani et al., 2016].



Dr. Mangalathayali Ali Abdu
Senior researcher and CNPq research fellow
National Institute for Space Research (INPE), Sao Jose dos Campos, Brazil

Research Interests: Interactive processes in the Earth's atmosphere-ionosphere-magnetosphere system; the electrodynamics and plasma structuring of the equatorial-low latitude ionosphere including the generation and dynamics of plasma bubble irregularities; atmosphere-ionosphere responses under space weather disturbances; vertical coupling in the atmosphere-ionosphere system due to atmospheric waves; South Atlantic Magnetic Anomaly impact on the electrodynamics of the equatorial ionosphere.

Significant Scientific Achievements:

- Explained mechanisms for the space-time distribution of the plasma structuring of the earth's equatorial ionosphere arising from direct solar forcing and forcing from wave disturbances from lower atmosphere
- Explained the unique nature of the ionospheric changes due to magnetosphere-atmosphere interaction in the region of South Atlantic (or South American) Magnetic Anomaly
- Coordinated the establishment of several ionospheric observatories in Brazil (Cachoeira Paulista, Fortaleza, and Sao Luis)
- Published about 290 research papers, authored several book chapters and edited one book by Springer

Honors and Awards:

- Vikram Sarabhai Medal by COSPAR/ISRO (2008) for excellence in promoting Space Research in Developing Countries
- Excellence in reviewing by American Geophysical Union (AGU)
- Outstanding researcher award by INPE
- Consultant to Brazilian national council for research and development (CNPq), Sao Paulo State Foundation for Promotion of Research (FAPESP), National Aeronautics and Space Administration (NASA), National Science Academy (NSF)
- Member of the Science Academy of the State of Sao Paulo, Brazil

Dr. M. A. Abdu

Electric Fields and Plasma Transport in Quiet and Disturbed Equatorial-Low Latitude Ionosphere

Equatorial and low latitude ionospheric plasma structuring, dynamics and related phenomenology are primarily controlled by dynamo electric fields. Disturbance electric fields, i.e., penetration electric fields and disturbance dynamo electric filed, associated with magnetic storms can cause drastic modifications to this phenomenology. Depending upon the longitude sector and local time, large changes in ionospheric conductivities, especially, in the relative values of the field line integrated Hall and Pedersen conductivities, that is, the ratio $\sum_H / \sum_P$, can occur due to (1) storm induced extra *E* layer ionization by energetic particle precipitation and/or by (2) *F* layer modification by storm time thermospheric winds. While the item (1) is known to dominate the South Atlantic Magnetic Anomaly (SAMA) longitude region, the item (2) can dominate any longitude region. As a result, storm time prompt penetration electric fields may produce, (1) large Hall conduction effects in the form of vertical electric fields, (2) plasma bubble zonal drift velocity reversal to westward, or acceleration to eastward (3) large/abnormal *F* layer plasma uplift, (4) sporadic *E* layer formation with instabilities, or disruption of an *Es* layer during its development, etc. An overview of some recent results highlighting these effects based on observational and modeling studies will be presented and discussed.

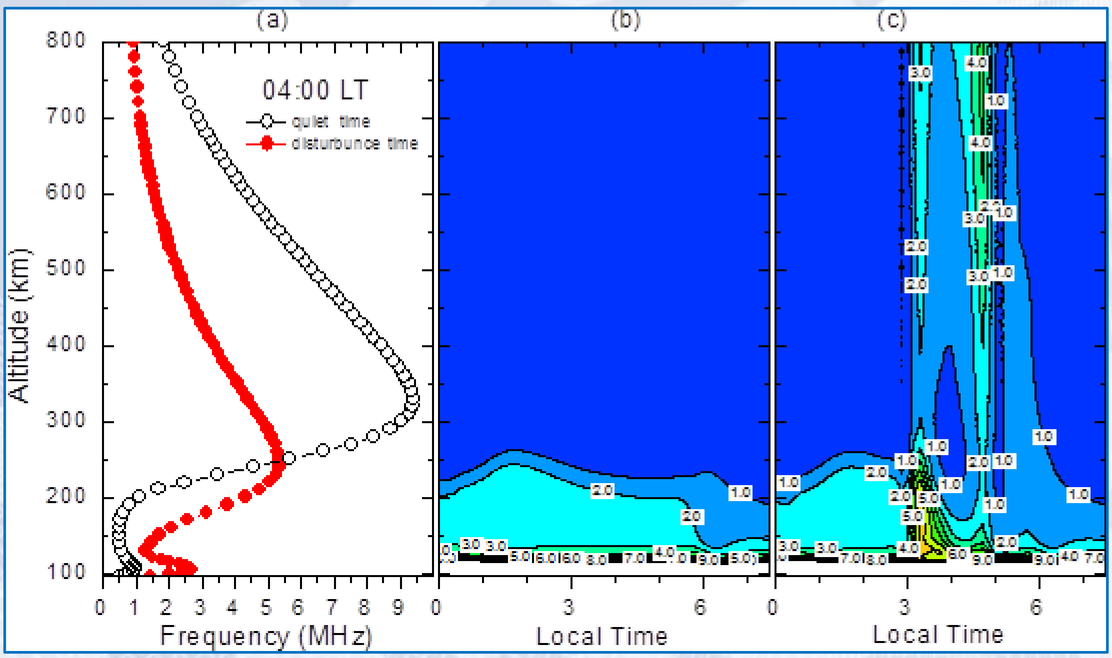


Figure: Storm time enhancement in the ratio $\sum_H / \sum_P$ (left panel) due to energetic particle precipitation in the post-midnight E region that is necessary to explain sporadic E layer formation by prompt penetration electric field of westward polarity. Quiet time behavior of the conductivity ratio (middle panel). Electron density profiles at 04 LT over Fortaleza representative of the two cases simulated by the SUPIM-INPE (right panel) [Abdu et al., 2013].