Joint IAGA IASPEI Symposia

J1 Earth and planetary core structure and evolution from observations and modelling

Conveners: **Christopher Davies** (C.Davies@leeds.ac.uk)
Swarandeep Sahoo (swarandeep.iitk@gmail.com)
Kimberly Moore (kmmoore@caltech.edu)
Christine Thomas (cthom_01@uni-muenster.de)

Recent advances in the theory and observation of planetary cores is providing profound insight into these remote and enigmatic regions. The Juno and Cassini missions have revealed the properties of Jupiter's magnetic and gravity fields in unprecedented detail, while results from forthcoming missions such as BepiColombo and InSight promise a step change in our knowledge of the interior structure and dynamics of terrestrial bodies within our solar system. Complementary theoretical developments have advanced our understanding of nucleation and crystallization of solids within planetary cores and how these processes influence the generation of global magnetic fields over geological timescales. Numerical simulations of the dynamo process are pushing towards the extreme conditions of rapidly rotating magnetic turbulence that are thought to characterize many planetary cores, promising new insights into the field generation process and the origin of observed magnetic secular variation. On Earth, novel seismic data processing techniques are being combined with vast datasets to illuminate core-mantle interactions and anomalous structures in the liquid and solid cores, while mineral physics calculations and experiments are now capable of estimating transport properties at the extreme pressure-temperature conditions of the core-mantle boundary. Observations of Earth's magnetic field magnitude and its secular variation have been used to infer various physical processes such as core flow patterns, inner core growth, thermal and compositional evolution of the core, and their fundamental origin.
This session focuses on recent cutting-edge and interdisciplinary activities that advance our understanding of Earth and planetary core structure, dynamics and evolution. We invite submissions from disciplines including, but not limited to: Earth and planetary chemistry, core dynamics, magnetism, mineral physics, seismology, planetary science, and geodesy.

J2 Application of geophysical studies for understanding lithospheric structure and properties

Conveners: **Jerome Dyment** (jdy@ipgp.fr)
Vincent Lesur (lesur@ipgp.fr)
Munukutla Radhakrishna (mradhakrishna@iitb.ac.in)
Anand. P. Singh (apsingh@ngri.res.in)

The main objective of the session is to bring together researchers specialized in geophysical studies, both in potential fields (involving terrestrial, marine, airborne and satellite-based datasets) and in seismology, to present and discuss their new results related to the crustal and lithospheric structure, properties, and geodynamic evolution in both the continental and oceanic realms. Papers involved in regional investigations and/or the development of new methodologies are therefore encouraged.
Considering the original meeting location and host, a special emphasis will be given to the Indian Plate. The plate is bounded by a collision boundary along the Himalayan arc, an active subduction along the Indonesian arc, and a slow to intermediate spreading center along the Carlsberg, Central and Southeast Indian ridges. It comprises of the continental lithosphere of the Indian subcontinent made of an assemblage of several cratons and mobile belts, and the oceanic lithosphere of the northern Indian Ocean. The passive margins of the Indian subcontinent acted as huge sediment depocenters and provide valuable clues on the Himalayan orogeny as well as the ongoing deformation within the Indian plate. A

deeper understanding of the continental lithosphere sheds light on the early crust formation as well as the evolution of sub-continental lithospheric mantle. Potential fields and seismology provide images that can be used to delineate lithospheric structures at different spatial scales and, in turn, geodynamic evolution models at different temporal scales.

J3 Lithosphere-Atmosphere-Ionosphere Coupling: Seismo Ionospheric and Electromagnetic anomalies

Conveners: **Mala S. Bagiya** (bagiyamala@gmail.com, mala.bagiya@iigm.res.in)
Elvira Astafyeva (e.astafyeva@gmail.com, astafyeva@ipgp.fr)
Yasuhide Hobara (hobara@ee.uec.ac.jp)

This session plans to discuss and understand the "unexplored" characteristics of co- and pre-seismic ionospheric and electromagnetic anomalies and their origin within the framework of lithosphere-atmosphere-ionosphere coupling. A brainstorming discussion towards the advancement of new insights in realizing the pre-seismic imprints in the near space environment is proposed. Observations from ground as well as from space and their validation through model simulations adopting both empirical and physical approaches may assist in understanding the physical mechanisms responsible for these anomalies. This session seeks papers on seismo-ionospheric and electromagnetic anomalies and signatures before and/or after strong earthquakes, tsunamis and volcanic eruptions.

J4 Joint Inversion Methods and Other Interpretation Strategies to Integrate Multidisciplinary Geophysical Data

Conveners: **Max Moorkamp** (moorkamp@geophysik.uni-muenchen.de)
Gesa Franz (gfranz@geomar.de)
Alan Jones (alan.jones.geophysics@gmail.com)
Ulrich Achauer (ulrich.achauer@unistra.fr)

Combining complimentary data sets typically reduces the ambiguity of inversion results and facilitates subsequent interpretation. Hence, integration of multi-disciplinary data has become popular in many disciplines including near-surface geophysics, mineral exploration, sub-basalt and sub-salt problems, gas hydrate investigations, and studies involving deep crustal and mantle structures. Still, many questions remain: Which types of data should be inverted together? How to balance their influence in the inversion? How can we assess the differences between joint inversion, cooperative inversion and other integrated interpretation strategies? This session welcomes research using joint inversion or other approaches to combine different types of geophysical data. Both case studies and technical contributions are welcome.

J5 Cratons & Mineral Exploration

Conveners: **Stephan Thiel** (stephan.thiel@sa.gov.au)
Fiona Darbyshire (darbyshire.fiona_ann@uqam.ca)
Prasanta Patro (patrobpk@ngri.res.in)

We seek contributions pertinent to exploration of cratons and the mapping of mineral systems using electromagnetic and seismic techniques. Contributions that characterize cratons across scales from lithospheric mapping to camp size using array and profile data are invited for this symposium. It includes multi-disciplinary interpretations using other geophysical (e.g. gravity, magnetics, electrical,

geoid, heat flow) and geochemical (e.g. xenolith, isotope, geochronology) data, which are able to infer mantle and crustal fertility. We encourage submissions that highlight the importance of lithospheric architecture on position and genesis of mineral systems, including but not limited to iron-oxide-copper-gold (IOCG), sediment-hosted deposits, porphyry deposits, gold and diamond deposits.

J6 Marine Geophysics

Conveners: **Amir Haroon** (aharoon@geomar.de)
Vera Schlindwein (Vera.Schlindwein@awi.de)

More than 70% of the Earth surface is covered by ocean. Yet, a high percentage of the ocean or the subsurface below the seafloor remains unexplored. This session invites all contributions of marine geophysical research ranging from small to large scales aimed at characterizing various structures of the Earth's interior from water column investigations to deep mantle studies. Fields of research include, but are not limited to synthetic modelling, instrumentation, survey design, data acquisition and novel data processing, visualization, and interpretation procedures. We invite contributions from various fields of geophysical investigations including seismological, electromagnetic, geochemical, magnetic, gravity, and multi-beam surveying. A particular focus will lie on multi-disciplinary interpretation of different data sets, and multi-dimensional imaging of the Earth's interior.

J7 New knowledge of intraplate earthquakes using ground and satellite observations: marking two decades of the deadly 2001 Bhuj Earthquake

Conveners: **Ramesh P. Singh** (rsingh@chapman.edu)
Vineet Gahalaut (vkgahalaut@yahoo.com)

Though earthquakes in the plate interior regions are not frequent, the loss of lives and property in such earthquakes is almost comparable to that in the plate boundary regions. This is mainly due to higher population density and lower hazard perception amongst people living in the plate interior regions. The 2001 Bhuj earthquake in Gujarat state of the western part of India is the most damaging plate interior region earthquake in the past few decades. The mechanism and processes of earthquakes occurring in the plate boundary regions is well understood, but our understanding is limited for the plate interior earthquakes. In these regions the process of strain accumulation is extremely slow, and evidence of earthquakes, are generally masked by the seasonal and anthropogenic changes and also by the noise in the observations. It is important to have long term in-situ, ground and satellite observations at a very local scale to understand the deformation characteristics. The multi-satellite observations of various physical parameters (e.g., temperature, TEC, strain, etc.) provide both spatial and temporal coverage to understand the neotectonic activities that may provide information about seismically active regions in the plate boundary and in the plate interior regions. This session is proposed to review the geological, geophysical, hydrological and satellite data to understand the characteristics and contrast between earthquakes occurring "in the plate interior" and "in the plate boundary" regions. The session has special focus on papers giving an overview about all the aspects related to seismic and geodetic network, geological/geophysical/hydrological and remote sensing studies in the last two decades of the Bhuj earthquake.

J8 FAIR data and TRUST repositories in the Geosciences: licensing, data publication, citation

Conveners: **Simon Flower** (smf@bgs.ac.uk)
Masahito Nosé (nose.masahito@isee.nagoya-u.ac.jp)

Anatoly Soloviev (a.soloviev@gcras.ru)
Aude Chambodut (aude.chambodut@unistra.fr)
Helle Pedersen (helle.pedersen@univ-grenoble-alpes.fr)
Florian Haslinger (florian.haslinger@sed.ethz.ch)

Researchers in all areas strive to make the results of their work widely used: by their fellow workers; by people working in different knowledge domains; by policy makers; and by the general public. What tools and techniques can help us to achieve this goal? The concepts of FAIR[1] data and the TRUST[2] repository principles help guide managers towards ways of presenting data that help enhance re-use. While some communities in Earth Sciences have a long tradition of open science and interoperable data, formalisation of these concepts via the FAIR and TRUST principles is relatively recent. It has had wide uptake at the highest levels, including endorsement by the G20 forum for international economic cooperation. The four major international data organisations (WDS[3], CODATA[4], GOFAIR[5] and RDA[6]) have come together in an articulation of their collaboration, called "Data Together". Through this collaboration they will support the implementation of FAIR data with a view to optimising the global research data ecosystem, particularly focusing on cross-domain science to enable new discoveries that are driven by data. In this session we welcome descriptions of problems, solutions and best practice relating to the management of data and data repositories. How is data licensed and published? How are metadata and related thesauri used to set up efficient harvesting protocols? How we can further encourage use and citation of data within our own communities and beyond?
Notes:
1.) FAIR = Findable, Accessible, Interoperable, Reusable (https://www.go-fair.org/fair-principles/)
2.) TRUST = Transparency, Responsibility, User focus, Sustainability and Technology (https://www.rd-alliance.org/trust-principles-rda-community-effort)
3.) WDS = the World Data System
4.) CODATA = the Committee on Data
5.) GOFAIR = Global Open FAIR
6.) RDA = the Research Data Alliance

J9 Analogue Data for the Future: Preservation and Present-Day Utilization of Historical Data in the Geosciences

Conveners: **Josep Batlló Ortiz** (josep.batllo@icgc.cat)
Edward Cliver (ecliver@nso.edu)
Justin Mabie (Justin.mabie@noaa.gov)
Anna Skorkina (anna@mitp.ru)
Masahito Nosé (nose.masahito@isee.nagoya-u.ac.jp)

Started on the second part of the 19th century, the 20th century brought several fold increase in recorded data in the geosciences. These analogue records, largely consisting of seismograms and magnetograms form the basis of climatology and scientific discovery and study in their related fields.
Maintenance of a complete time series of environmental data is necessary for the comprehensive study of a changing world. Availability and usability of old analogue records are needed for understanding of our Earth systems. Historic environmental data in analogue form are, many times, contained in unique formats, difficult to interpret, and at risk of loss. A comprehensive effort on historical data preservation and modernization is needed. Data discovery, availability, interpretation and use for scientific study are necessary for understanding of the changing Earth and extreme events. The sharing of the IASPEI and IAGA accumulated experience is an important step toward comprehensive historical data preservation and modernization. This joint-session symposium welcomes contributions on:

(a) Locating, assessing, preserving, and disseminating historical data mainly obtained from analogue magnetograms and seismograms.
(b) Solutions for batch digitization, recognition and conversion of analog data into digital numerical arrays.
(c) Methodologies and study cases using these historical data to advance our understanding of the Earth system.

J10 Innovation in Geoscience Education and Outreach

Conveners: **Manoj Nair** (manoj.c.nair@noaa.gov)
Edgar Bering (spacephy@Central.UH.EDU)
Raju Sakar (rajusarkar.cst@rub.edu.bt)
Hannah Rogers (h.f.rogers@sms.ed.ac.uk)
Tereza Kameníková (kamenitka@gmail.com)

This symposium calls for papers describing innovations in geoscience instruction methods, citizen science initiatives and community learning efforts. Papers are welcome on all aspects of education and citizen-science including methodology, data collection, data analysis, non-traditional areas of curriculum, case studies etc. In particular we invite contributions related to the use of machine learning, big data analysis and virtual reality (VR) applications in citizen science and education. We also encourage submissions that describe ways to broaden the public understanding and appreciation of science and to attract non-traditional and under-represented students into the sciences. Papers are welcome describing advances in all levels of instruction, including secondary and higher education. We are particularly interested in papers about inventive approaches to inquiry based learning in all geosciences. Involving students and the public in designing experiments and collecting data has been shown to foster a scientific identity, to increase overall interest in science, and to improve the perceived value of scientific research.

Diamond Jubilee Symposium (by invitation)

DJ Advancing Geophysical Science - 60 Years of CSIR-NGRI, India

Conveners: **V. M. Tiwari** (vmtiwari@ngri.res.in)

CSIR-NGRI was established in 1961 with the mission to carry out basic research in geosciences and to develop the knowledge base for making informed decisions about use of geo-resources sustainably and improve preparedness and resilience to natural hazards. CSIR-NGRI has evolved in scientific vigor over the decades and has carved its niche on the global map of geo-science research organizations with its vibrant and outstanding contributions. The researchers of CSIR-NGRI have published more than 100 books, encyclopedia and ~ 5000 papers in the SCI journals, which have remarkably advanced both within the core disciplines of geophysics and across the many Earth science fields. CSIR-NGRI has also taken up a good number of research programs of global interest in collaboration involving many countries through bilateral programs as well as supports from IUGS, IUGG, IGCP, IAHS, etc. This session is planned to celebrate 60 glorious years of institute's journey and to discuss potential scientific issues that can be pursued through international collaboration in the view of global scientific challenges.

Joint IAGA Division Symposia

D1 Exploring Earth's magnetic field from space

Conveners: **Ciaran Beggan** (ciar@bgs.ac.uk)
Gauthier Hulot (gh@ipgp.fr)
Patrick Alken (patrick.alken@noaa.gov)
Yanyan Yang (youngyany@163.com)

The magnetic field is a fundamental geophysical characteristic of the Earth, which provides information on a range of processes from core to space. Research related to elucidating these sources is greatly aided by data collected from a fleet of satellite systems around the Earth. Recent years have seen the continued operation of the Swarm constellation with improvements to the quality of the magnetic field measurements, as well as the inclusion of the Cassiope/ePoP mission as Swarm-E. There has also been the successful launch of the CSES mission and the investigation of data from platform magnetometers on other scientific missions. Together these represent new data streams to investigate core, mantle, crust, tidal, ionospheric and magnetospheric sources of the magnetic field. This symposium wishes to combine ideas in modelling, observations and theory applied to Earth's magnetic field as measured primarily from space, also inviting ideas for maintaining and improving observational strategies on the long-term.

D2 Planetary magnetic fields and geomagnetic secular variation

Conveners: **William Brown** (wb@bgs.ac.uk)
Ingo Wardinski (wardinski@unistra.fr)
Christopher Finlay (cfinlay@space.dtu.dk)
Swarandeep Sahoo (swarandeep.iitk@gmail.com)
Katia Pinheiro (kpinheirogeomag@gmail.com)
Sanja Panovska (panovska@gfz-potsdam.de)

Magnetic fields are an intrinsic part of many planetary bodies, including Earth, the study of which informs us of an array of processes and properties. These fields may influence studies of planetary cores, mantles, crusts, oceans, ionospheres and magnetospheres. Planetary magnetic fields operate across a wide range of temporal and spatial scales, of which the secular variations generated by dynamo processes are of particular interest, past, present and future. Observations of these magnetic fields may be contemporaneously observed at the surface, within the atmosphere, or by satellite orbit or fly-by, or derived historically from analysis of various materials. This session aims to cover studies of observations of planetary magnetic fields and their time changes, the incorporation of these data into models, and the theory underpinning these phenomena. A particular focus will be geomagnetic secular variation throughout Earth history and the pressing questions being raised by the wealth of recent observations of Earth and other bodies, as well as rapidly improving geodynamo models.

D3 Coupling Processes in the Atmosphere-Ionosphere System

Conveners: **Christina Arras** (arras@gfz-potsdam.de)
Subramanian Gurubaran (gurubara@iigm.res.in)
Loren Chang (loren@jupiter.ss.ncu.edu.tw)
Petra Koucka Knizova (pkn@ufa.cas.cz)

The objective of this symposium is to bring new insights into the understanding of the coupling processes in the atmosphere-ionosphere system. The symposium will address fundamental physical, chemical, and electrodynamical processes covering whole atmosphere system. The coupled effects can be expressed in terms of the modulation of waves from the lower to the upper atmosphere as well as from low- to high-latitudes, electrodynamic and compositional changes, plasma drifts, electric fields and plasma irregularities at different latitudinal regions of the globe due to the varying energy inputs.
The manner in which the couplings take place due to varying energy inputs from the Sun and from the lower atmosphere is a question that is not completely understood. This symposium solicits papers dealing with experiments, observations, modelling and data analysis that describe the effects of atmospheric coupling processes within the whole atmosphere-ionosphere system.

D4 Advances in Mid, Low Latitude and Equatorial Aeronomy

Conveners: **Paulo Roberto Fagundes** (fagundes@univap.br)
Geeta Vichare (geeta.vichare@iigm.res.in)
Venkatesh Kavutarapu (venkatkau@gmail.com)
Michael Pezzopane (michael.pezzopane@ingv.it)
Yosuke Yamazaki (yamazaki@gfz-potsdam.de)

Ionospheric electrodynamics at equatorial and low latitudes is controlled by the forcing from the lower atmosphere including the effects of SSW, tidal, planetary, and gravity waves; and by the forcing from the magnetosphere through penetration of disturbed time electric fields and neutral winds. The session focuses on the behavior of ionospheric phenomena occurring at equatorial to low latitudes including equatorial ionization anomaly, plasma irregularities, plasma bubbles and blobs, F3-layer, pre-reversal enhancement, etc., with the particular emphasis on the electric fields and current systems associated with solar quiet (Sq) and equatorial electrojet. Recent multi-instrument and multi-site observations, as well as, theoretical and simulation studies have advanced our understanding of these phenomena. Although this has substantially improved our current understanding of the ionospheric electrodynamics during quiet and disturbed periods, solar eclipse, solar flare, and sudden stratospheric warming events, there are still some outstanding questions and challenges, which need to be addressed. Presentations are solicited that focus on the physical understanding of these processes through observations and numerical simulation modeling, and unresolved problems therein.

D5 Relativistic electrons: Their emergence and loss in geospace, their impact on the upper atmosphere and the role of the cold plasma background

Conveners: **Ioannis A. Daglis** (iadaglis@phys.uoa.gr)
János Lichtenberger (lityi@sas.elte.hu)
Jacob Bortnik (jbortnik@atmos.ucla.edu)
Yoshizumi Miyoshi (miyoshi@isee.nagoya-u.ac.jp)
Gurbax Lakhina (gslakhina@gmail.com)
Rajesh Singh (rajesh.singh@iigm.res.in)

Relativistic electrons in geospace form the Van Allen radiation belts and are a major space weather agent, as they pose a significant threat to space assets. Their emergence and loss are driven, to a large extent, by magnetospheric plasma waves of various frequencies. These processes are mediated by the cold plasma density through wave-particle interactions over a large scale of spatial extent. Loss of relativistic electrons occurs through the magnetopause to interplanetary space and through precipitation

to the Earth's atmosphere. Precipitating relativistic electrons have a significant impact on the dynamics of the upper atmosphere, which can cause catalytic destruction of mesospheric ozone and feed back into space affecting the convection electric field.
This session invites studies of the emergence, loss, precipitation and atmospheric impacts of relativistic electrons in geospace, as well as the dynamic behaviour of the plasmasphere and the radiation belt using in-situ and ground based observations, physics-based models, machine learning and/or numerical simulations.

D6 Geomagnetic observations for space science, space weather and space climate applications

Conveners: **Pierdavide Coïsson** (coisson@ipgp.fr)
Miquel Torta (jmtorta@obsebre.es)
Ellen Clarke (ecla@bgs.ac.uk)

Magnetic field observations, both from ground and from space, provide information on the current state of space weather and are the corner stone for both scientific understanding and practical applications. Providing timely and accurate geomagnetic measurements is key to generating space weather information in general, and to producing nowcasts and forecasts, in particular. Current and historical geomagnetic data are also relevant for space science studies, including space climate, the long term variation in solar activity and their effects in the near Earth environment. Solar cycle 24 has been relatively weak, but several geomagnetic storms occurred. The complexity of the phenomena occurring during such events still requires significant research efforts to understand the interactions between the various regions of Earth space environment and the induced effects on ground. Space weather events can severely impact modern technologies by disrupting essential services, making it critical to improve their understanding and predictability. Better understanding of the role of longer term changes in the heliosphere and geomagnetic field interactions is also an important factor. Contributions that make use of magnetic field measurements to demonstrate recent advances in the understanding of the space weather hazard and impact are welcome. This could include, but is not limited to, models of both the space environment and the solid earth, to quantify how rapid magnetic variations and sub-surface conductivity impact conducting infrastructures on the ground and improve our physical understanding of electromagnetic fields on, and near, Earth. This session aims to present recent updates in the use of magnetic measurements in space science, space weather and space climate applications.

D7 Remarkable geomagnetic events and indices: Derivation, history, and applications for space weather

Conveners: **Juan José Curto** (jjcurto@obsebre.es)
Anna Naemi Willer (anna@space.dtu.dk)
Hisashi Hayakawa (hisashi@nagoya-u.jp)

This symposium is dedicated to the production, prediction and application of geomagnetic indices and remarkable events. About 50 years ago, the Working Group of 'Geophysical Indices' was placed in Division V and Ebro Observatory was entrusted with the activity of the Service of Rapid Magnetic Variations. Also, P. N. Mayaud published a list of 100 years of SSCs measured by himself. Indices and remarkable events data provide clear evidence of the links between solar activity and earth space environment. They are therefore of great importance for Space Weather analysis and required as input in many predictive models. Long term space climate studies benefit from the availability of long time-series of these well-defined indices and remarkable events.

D8 Space weather services: New scientific research to address future needs

Conveners: **Terry Onsager** (terry.onsager@noaa.gov)
Heikki Vanhamäki (heikki.vanhamaki@oulu.fi)

The demand for space weather services is continuing to grow as space activities expand. Space traffic management, space tourism, and human space exploration are among the areas where the expected increase in the utilization of space will require new scientific understanding and new space weather services. This session encourages presentations on advances in modeling and data analysis techniques and scientific understanding that will facilitate space based activities. Of particular interest are efforts to improve the understanding and modeling of neutral atmosphere dynamics impacting satellite orbits and the specification and prediction of the plasma and radiation environment impacting satellites and humans from low-Earth orbit to interplanetary space.

D9 Geomagnetic disturbance (GMD) benchmarks, case studies and new results in geomagnetically induced currents (GIC) and hazard assessments

Conveners: **Stefan Lotz** (slotz@sansa.org.za)
Antti Pulkkinen (antti.a.pulkkinen@nasa.gov)

Space weather related GMD can drive GIC in various technological systems such as railways, fuel pipelines and power grid infrastructure, all of which are critical to the activities of modern societies. In order to protect these systems against solar activity, risk planning and hazard assessment efforts need to address a variety of damage modes manifesting at different time scales and in different geomagnetic regions. One critical aspect of this is the identification and design of benchmark events that capture these effects. Accurate benchmarks enable effective vulnerability assessments, assist in the development of mitigation procedures, and help to provide sober risk quantification. Therefore, we invite presentations on (i) assessment of currently proposed or existing benchmarks, (ii) the analysis and design of benchmarks, (iii) case studies of interesting events, and (iv) novel ideas for hazard assessment related to GIC-related effects on the relevant industries.

IAGA Division I

1.1 Open session on paleo, rock, and environmental magnetism

Conveners: **Mathew Domeier** (mathew.domeier@geo.uio.no)
Ramon Egli (ramon.egli@zamg.ac.at)

The magnetism of Earth materials presents one of the richest information archives on our planet, with dimensions that extend through time (e.g. geomagnetism to archeomagnetism and paleomagnetism), space (e.g. nanoscale magnetic microscopy to planetary scale satellite surveys) and discipline (e.g. biomagnetism, environmental magnetism and tectonics). Often developments and discoveries in some of these dimensions are highly relevant to others, but the sheer size and complexity of our research community means that these important insights are often not well disseminated. In this general session, we highlight the richness of this community and aim to foster information-sharing across time, space and discipline, by inviting contributions from across the spectrum of paleo-, rock-, bio- and environmental magnetism.

1.2 Magnetic record of tectonic, geologic and volcanic processes

Conveners: **Satria Bijaksana** (satria@fi.itb.ac.id)
Mamilla Venkateshwarlu (mvwarlu@ngri.res.in)
Uwe Kirscher (uwe.kirscher@uni-tuebingen.de)

Tectonic as well as volcanic processes shape not only the morphology of the Earth but also affect the history of mankind. These processes also change climate as well as environment. These processes might be dated, recorded, or associated with magnetic records in rocks and sediments. This session welcomes contributions, not only, on all types of magnetic record (secular variations, excursions to magnetic stratigraphy) related to tectonic and volcanic processes, but also on changes of magnetic mineralogy and granulometry associated with these processes. We especially welcome contributions that develop new models, simulations, instruments, experimental techniques and analytical approaches to help us better use magnetic methods in understanding tectonic and volcanic processes. Complementary approaches to magnetic methods that help us understand the magnetic record of tectonic and volcanic processes are also welcome.

1.3 Paleo- and rock-magnetic mysteries – quest for solutions

Conveners: **Maodu Yan** (maoduyan@itpcas.ac.cn)
Xiaoqiang Yang (eesyxq@mail.sysu.edu.cn)

Paleo- and rock-magnetism have played key roles in understanding the geomagnetic field, plate tectonics, and the past and recent environment. However, despite of many great efforts, some fundamental properties of the geomagnetic field and rock magnetic remanence, average strength and its spatial and temporal short and long term variations, inclination bias in sedimentary rocks, remagnetization, etc., remain debated, leading to some ambiguities in the evolution of Earth's interior, plate kinematics, dynamics of the core and mantle, long term climate change, and true polar wander. This inclusive session brings together diverse studies that make use of paleo-, rock, and environmental magnetic data in relation to geological, geomagnetic, and environmental processes. We welcome presentations of innovative studies from both experimental and theoretical aspects of paleo- and rock-magnetism that highlights how the geomagnetic field changes and rock remanence behaves.

1.4 Earth's magnetic field and secular variation on all temporal and spatial scales

Conveners: **Arnaud Chulliat** (arnaud.chulliat@noaa.gov)
Gelvam Hartmann (gelvam@unicamp.br)
Phil Livermore (P.W.Livermore@leeds.ac.uk)
Yoichi Usui (yoichi@jamstec.go.jp)

The Earth's magnetic field varies on a wide range of temporal and spatial scales. Geodynamo processes and waves in the Earth's outer core generate magnetic field variations on subdecadal to geological time scales. Some variations are global (e.g., magnetic reversals, the dipole decay) while others have a smaller spatial foot print (e.g., the evolution of the South Atlantic Anomaly, the drift of the North magnetic dip pole). This session aims at bringing together researchers investigating geomagnetic field variations on all temporal and spatial scales, and using a broad range of methods. We welcome observational studies based on paleomagnetic and archeomagnetic records, cosmogenic isotopes, ground-based and satellite geomagnetic measurements, as well as theoretical studies, numerical simulations and laboratory experiments.

1.5 The theory and applications of rock and environmental magnetism

Conveners: **Liao Chang** (liao.chang@pku.edu.cn)
Joshua M. Feinberg (feinberg@umn.edu)

Fundamental rock magnetic properties and magnetic recording processes underpin our understanding of magnetic signals encoded in terrestrial and extraterrestrial materials. Advances in rock magnetic theories and analytical methods expand our ability to obtain important information in Earth, environmental and planetary research, including reconstructing past geomagnetic field variations and environmental parameters, and understanding a wide range of geological and geophysical processes. This session focuses on recent advances in fundamental rock magnetism and environmental magnetism across all scales, from theories to experiments. We welcome a range of contributions, including new rock magnetic theories, analytical methods, anisotropy, fundamental investigations of magnetic minerals and their grain size/domain state dependent properties, magnetic mineral unmixing, and magnetic modelling. We also welcome studies establishing links between rock and mineral magnetic properties and environmental variables, and those that apply magnetic proxies to environmental issues related to climatic, geochemical and biological processes on Earth.

1.6 Paleo- and rock-magnetic data: archiving, mining, (re)use

Conveners: **Lisa Tauxe** (ltauxe@ucsd.edu)
Sergei Pisarevsky (Sergei.Pisarevskiy@curtin.edu.au)
Patrick Arneitz (patrick.arneitz@zamg.ac.at)

Paleo- and rock-magnetic data have been generated since the early 1900s and many data sets remain beyond the reach of modern paleomagnetists. Discovering and preserving legacy data is urgently needed, particularly for materials that can no longer be sampled (e.g., archaeological sites or outcrops that have been destroyed or are no longer accessible). The data may be in paper or outmoded digital format (floppy disks) and their retrieval requires considerable effort. This session will be devoted to the general topic of identifying, digitizing and archiving of legacy data. Topics will include populating databases with rescued legacy data, examples of how to amalgamate large data sets of geomagnetism and paleomagnetism data and/or re-interpreting archived data with new methods/ideas.

IAGA Division II

2.1 Electrodynamics of the ionosphere-atmosphere system and its coupling to the space environment

Conveners: **Irina Mironova** (i.a.mironova@spbu.ru)
Martin Fullekrug (M.Fullekrug@bath.ac.uk)
Andrei Demekhov (andrei@ipfran.ru)

Electrodynamics of the global electrical circuit and the polar ionosphere-atmosphere system depends on solar wind magnetosphere interaction from above as well as the thunderstorm activity maintaining a time varying, globally uniform electrical potential difference between the ionosphere and the Earth as well as downward electric currents in the fair weather regions. The symposium solicits contributions on interdisciplinary studies that emphasize the electrodynamic connection between the ionosphere-atmosphere system and the magnetosphere, as well as the coupling between atmospheric layers, ionospheric potential, electrical currents, lightning physics, energetic radiation, energetic particles, and their impact on the Earth's atmosphere, ionosphere and the magnetosphere. In particular, we welcome

reports on the impact of energetic particle precipitation on the Earth's ionosphere and atmosphere, the formation of ionospheric potential, electrical currents and conductivity, meteorological effects of the global atmospheric electric circuit, lightning physics, and energetic radiation. This symposium is focused on both satellite and ground based observations, as well as modeling studies of electrodynamics of the ionosphere-atmosphere system and its coupling to the space environment.

2.2 Solar Influence on the Atmosphere and Climate

Conveners: **Christoph Jacobi** (jacobi@uni-leipzig.de)
Nicholas Pedatella (nickp@ucar.edu)
Luc Damé (luc.dame@latmos.ipsl.fr)

Solar influence on climate keeps attracting much interest presently. This includes in particular the role of the Sun both in the past climate as in future climate variability as an important aspect. State-of the art climate models include a well resolved stratosphere and mesosphere. This allows the prediction of global climate and its changes, taking into account expected solar related variability at short to long time scales.
In the middle and upper atmosphere solar related electromagnetic and particle variability is one dominant forcing mechanism for atmospheric variability at time scales from days to decades. From available datasets it is not always straightforward to distinguish between solar and meteorological influences. Time series are often too short to clearly identify, e.g., the 11- and 22- year solar cycles in the presence of nonlinear trends owing to lower atmospheric variability. The effect of planetary waves at time scales of days to weeks is difficult to extract from time series in the presence of the solar rotation effect and harmonics.
Results from observations, including observation and modeling solar forcing, theoretical work and modeling efforts to quantify meteorological and solar effects on the lower, middle, and upper atmosphere are welcome. Reports on progress in reconstructing past climate and future climate projections and the role of extraterrestrial forcing in these are desired.

2.3 Stratosphere-Mesosphere-Thermosphere-Ionosphere System – Long-Term Changes

Conveners: **Liying Qian** (lqian@ucar.edu)
Jan Lastovicka (jla@ufa.cas.cz)

Long term changes of greenhouse gas concentrations and other drivers, such as the long term change of the Earth’s magnetic field, cause long term changes in the upper atmosphere, which are often much larger than tropospheric trends. Note that in atmospheric science, long term changes, or trends, refer to changes on a time scale longer than one solar cycle (~ 11 years). We welcome papers on investigating trends in the stratosphere, mesosphere, thermosphere and ionosphere, dealing with ground based as well as satellite borne observations, model simulations, theoretical analyses, long term data quality issues, methods of determination of trends, and related laboratory experiments.

IAGA Division III

3.1 Reporter review for Div III

Conveners: **Simon Wing** (simon.wing@jhuapl.edu)
George Balasis (gbalasis@noa.gr)

This session presents reviews of the scientific progress in the Div III in the last few years.

3.2 The expanding regimes of ULF wave research

Conveners: **Jayashree Bulusu** (bulusujayashree@gmail.com),
Kazue Takahashi (Kazue.Takahashi@jhuapl.edu)
Masahito Nose (nose.masahito@isee.nagoya-u.ac.jp)

ULF wave research has a long-standing history and equally significant ongoing efforts in explaining some of the fundamental problems of magnetospheric research viz: energy transport during dynamic coupling of solar wind-magnetosphere, wave particle interaction, flux rope disruptions during active geomagnetic conditions. The research has a far-reaching implication in modelling the mass densities using field line resonances and extends to higher frequencies covering the IAR (Ionospheric Alfven resonator) and ELF bands in probing the lowest ionospheric layers. This ULF session focuses on the advancement in the understanding of ULF wave propagation and transport of energy in the geospace and other planetary environments. Papers are invited from observations of ULF waves with satellites and ground based experiments depicting transmission of energy from the solar wind, internal ULF instabilities, magnetosphere-ionosphere coupling, field line resonances, investigations of IAR and SR (Schumann Resonances) and their relation to ULF waves. Papers depicting the developments in analytic, numerical, and machine learning techniques are also encouraged regarding generation and propagation of ULF waves and the role of the waves in probing the magnetosphere.

3.3 Recent advances in the system level understanding of solar wind – magnetopshere – ionosphere – thermosphere coupling

Conveners: **Jone Peter Reistad** (jone.reistad@uib.no)
Kazuo Shiokawa (shiokawa@nagoya-u.jp)
Geeta Vichare (geeta.vichare@iigm.res.in)

The amount of available data describing the electrodynamics in geospace has significantly increased during the past decades. In addition, the improved physical understanding, computing power, and efforts to optimize numerical methods, has vastly improved the capabilities of modern physics-based models to describe in great detail the interactions taking place in this huge and complex system. This session welcomes presentations on all aspects of recent advances in our system level description of the coupled solar wind – magnetosphere – ionosphere – thermosphere system, including their evaluation using observations.

3.4 Magnetic reconnection and its impact on geospace

Conveners: **Matthew Argall** (Matthew.Argall@unh.edu)
Kevin Genestreti (Kevin.genestreti@swri.org)

Magnetic reconnection is a universal process of plasmas by which magnetic energy is converted to particle kinetic energy via a topological change in the magnetic field. Reconnection has a profound impact on the geospace environment as it often explosively develops and redistributes mass and energy over a variety of scale sizes. Rapid progress in understanding the micro-physics of reconnection in space has been largely enabled by NASA's Magnetospheric Multiscale (MMS) mission and the development of computational resources required to describe complex systems with physics-based

models. Multi-spacecraft conjunctions, data-driven and theoretical models are often used to advance our understanding of how the micro-physics impacts and/or is impacted by the large-scale magnetosphere.
This session will focus on the micro-physical aspects of reconnection and the impact of reconnection on geospace.

3.5 Magnetospheric Boundary Layers

Conveners: **Steve Petrinec** (steven.m.petrinec@lmco.com)
Karlheinz J. Trattner (karlheinz.trattner@lasp.colorado.edu)

Planetary magnetospheres have long been known to be spatially bounded by the fast solar wind, such that plasmas and fields observed earthward of the boundary (magnetopause) are distinct from plasmas and fields outside the boundary. Additional boundaries associated with the presence of a magnetosphere are at the outer edge of the magnetotail plasmasheet, the upstream bow shock, and other places. These boundaries topologically and spatially separate the different regions from one another and are of finite thickness. Recent spacecraft missions and ground-based observatories have made it possible to make observations from multiple vantage points, at varying spatial scales, and at high temporal resolution. This has enabled important new insights into the operating physical phenomena associated with boundary layers. In this session we focus on recent advances in the understanding of magnetospheric boundary layers. Contributions from data analysis studies, numerical model runs, and theory that address the physics of magnetospheric boundary layers and their influence on magnetospheric dynamics are encouraged.

3.6 Magnetotail dynamic processes

Conveners: **Jay Johnson** (jrj@andrews.edu)
Xuzhi Zhou(xzhou@igpp.ucla.edu)
Meng Zhou (monmentum82@gmail.com)

Decades of space explorations have shown that plasma and energy transport processes in the magnetotails of Earth and other planets play a critical role in the dynamics of their magnetospheres. These processes occur over a diverse range of spatial and temporal scales, involving steady and/or intermittent mass loading, momentum, and energy transport often culminating in explosive events that completely reorganize the plasma sheet and drive processes in the inner magnetosphere, ionosphere, and boundary layer. Multipoint observations within the boundary layers, the plasma sheet and the ionosphere have been key to developing a more comprehensive view of the role of various transport processes. However, many unsolved questions remain about the underlying transport mechanisms and their coupling to the inner magnetosphere and ionosphere, which can only be resolved using multiple approaches that include theory, simulation, and observation. This session provides a forum to present the latest results on magnetotail processes at earth and other planets.

3.7 Current challenges and future directions of magnetospheric research

Conveners: **Larry Kepko** (larry.kepko@nasa.gov)
Rumi Nakamura (Rumi.Nakamura@oeaw.ac.at)

Magnetospheric research utilizes a broad array of measurements, including in situ plasma, remote sensing, ground magnetometers, auroral imagers, and ionospheric radars, as well as global and local

numerical models. While tremendous progress has been made with these data and programs, there still remain major outstanding questions of magnetospheric dynamics. In particular, the next thrusts of magnetospheric research involve system science, and the cross-scale coupling and energization of space plasmas. In this context, cross-scale can mean across plasma regimes (i.e, Micro <-> Meso <-> Global) and across magnetospheric regions (e.g., tail -> ring current, Ionosphere <-> magnetosphere). We invite papers that summarize the current state-of-the-art of our understanding of magnetospheric dynamics while outlining current challenges and major open questions. In addition, we seek papers that offer future pathways that can lead to breakthrough science, including new simulation efforts, new research techniques applied to space physics datasets such as data mining and data assimilation, or measurement concepts, particularly those that take advantage of new frontiers of spacecraft technology, such as constellations.

3.8 Recent Advances in Observations and Modeling of the Ring Current System

Conveners: **Vania Jordanova** (vania@lanl.gov)
Ioannis Daglis (iadaglis@phys.uoa.gr)
Yoshizumi Miyoshi (miyoshi@isee.nagoya-u.ac.jp)
Yiqun Yu (yiqunyu17@gmail.com)

The dynamics of energetic particles forming the ring current populations, the main signature of a geomagnetic storm, have been studied for many decades. However, the development of predictive ring current models and the forecast of severe geomagnetic storms remain challenging due to gaps in our understanding of the complex and strongly coupled magnetosphere-ionosphere system. The ring current populations interact with the surrounding plasmasphere and radiation belts and with the outer magnetosphere and ionosphere through a variety of physical processes leading to particle injections, acceleration, and loss. Coordinated multi-satellite and ground based observations combined with numerical modeling are essential to understand these processes. This session invites presentations on research advancing our knowledge of ring current dynamics and its coupling with the magnetosphere and ionosphere, as well as capabilities for their nowcast and forecast.

3.9 Understanding the Causes and Consequences of Space Weather Phenomena in the Earth Magnetosphere

Conveners: **Suiyan Fu** (suiyanfu@pku.edu.cn)
Drew Turner (drew.turner@jhuapl.edu)
Qiugang Zong (qgzong@pku.edu.cn)
Yoshizumi Miyoshi (miyoshi@isee.nagoya-u.ac.jp)

The interaction between transient solar wind events, e.g. CMEs, CIRs, and the Earth's magnetosphere would excite various types of geomagnetic phenomena, which is of great importance for the space weather research in the past several decades. Based on coordinate observations of satellites and high time resolution data obtained in recent years, progress has been made on the magnetosphere response to solar wind forcing in many aspects covered by radiation belt physics, magnetic storms and magnetospheric substorm mechanism, etc. Knowledge on the relationship between wave activities (e.g. ULF/VLF waves) and the variations of energetic particle flux in the inner magnetosphere has been greatly improved. Extensive attempts also have been made to further understand how the solar wind energy couples into the magnetosphere, leading to space weather phenomena.
This session invites presentations on progress from space-borne and ground-based observations, theoretical modeling and simulation studies to understand the causes and consequences of space

weather phenomena in the Earth magnetosphere. Various energetic particle processes in Geospace are especially encouraged.

3.10 Machine learning in space physics

Conveners: **Peter Wintoft** (peter@lund.irf.se)
Irina Zhelavskaya (irina.zhelavskaya@gfz-potsdam.de)

Over the past decades there has been a tremendous increase in the amount of data from ground based and space based measurements and observations. The data enables us to explore our solar-terrestrial environment and other planets, and to develop and verify models with increasing accuracy and detail. Due to the large datasets, the large number of variables, and the complex interactions between different physical regions in the heliosphere, the exploration and modelling is a great challenge. The past decades have also seen great development and maturity in the area of machine learning (ML) driven by performance increase in hardware, increased availability of ML software, and theoretical development. In this session we invite contributions on ML in space physics which may include, but are not limited to, aspects of: data mining; data preprocessing; supervised, unsupervised, and reinforcement learning; feature selection; physics-informed ML; predictions and verification. Both theoretical and applications-oriented presentations are welcome. Theoretical aspects should primarily be focused on the incorporation of prior knowledge (physics) into the ML process and the interpretation of the derived ML relations. On the application aspect, we invite presentations concerned with practical challenges related to preprocessing of data, ML algorithms and frameworks, and validation.

3.11 Magnetospheric processes

Conveners: **Simon Wing** (simon.wing@jhuapl.edu)
George Balasis (gbalasis@noa.gr)

The magnetosphere is the outermost layer of the atmosphere where the primary physical processes involve plasma, waves, electric currents, electric and magnetic fields. At its outer boundary, the magnetosphere interacts with the solar wind, forming a bow shock and magnetopause boundary. Electric currents flow within the magnetosphere and between magnetosphere and ionosphere, providing a fundamental link for the magnetosphere-ionosphere coupling. Mass and energy are transported between the solar wind and magnetosphere and between magnetosphere and ionosphere. This session welcomes contributions that highlight processes within the magnetosphere, solar wind-magnetosphere interactions, and magnetosphere-ionosphere interactions. Studies that involve satellite and ground observations, modeling and simulations, theory, and laboratory experiments are welcomed.

Division IV

4.1 Advances and Upcoming Developments in Solar and Heliospheric Physics

Conveners: **Mari Paz Miralles** (mmiralles@cfa.harvard.edu)
Spiros Patsourakos (spatsour@uoi.gr)
Jin-YI Lee (jlee@khu.ac.kr)
Xochitl Blanco-Cano (xbc@geofisica.unam.mx)
John Richardson (jdr@space.mit.edu)
Cynthia Lopez Portela (cynthialp@igeofisica.unam.mx)
Stefano Livi (slivi@swri.edu)

Continuous observations have advanced our knowledge of the physical and dynamical properties of the Sun, the heliosphere, and the interstellar medium. These observations, along with theory and models, continue to pose challenges to our understanding of the relevant physical processes. This session invites contributions covering new results from space- and ground-based observations, theory, and modeling of different aspects of the Sun and the heliosphere, including the solar interior, magnetic field, atmosphere, solar wind, and interstellar medium. This session will stimulate exchange and promote discussion of upcoming developments from the latest research and instrumentation in the field. In addition, we also invite contributions from the SCOSTEP/PRESTO program (Pillar 1: Sun, interplanetary space, and geospace).

4.2 Magnetic Ejecta and Flux Ropes from the Sun to Geospace

Conveners: **Noé Lugaz** (noe.lugaz@unh.edu)
Anna Malanushenko (anny@ucar.edu)
Emilia Kilpua (emilia.kilpua@helsinki.fi)
Dibyendu Nandi (dnandi@iiserkol.ac.in)

Magnetic fields play a prominent role in driving solar activity and space weather from Sun to Earth. In the solar atmosphere, when these magnetic fields become twisted, they form twisted magnetic flux ropes, a coherent, self-confining structure, which allows them to store energy. This coherence is often invoked as a reason why bundles of magnetic flux can rise buoyantly to the solar surface to form active regions. This coherence has also been proposed as a means for storing eruptive capacity in coronal magnetic fields, and then driving solar eruptions such as flares and coronal mass ejections (CMEs). This underlying flux rope structure is used to explain the commonly observed coherence of CMEs when observed in the outer corona. As interplanetary CMEs pass over spacecraft in the heliosphere, single-spacecraft measurements are often consistent with this coherence, and have been traditionally considered evidence of twisted magnetic field structure. Flux ropes are also believed to form both at magnetopauses and in magnetotails as a consequence of the solar wind magnetic field interacting with planetary magnetospheres, and they play a key role in the transmission of mass energy and momentum within magnetospheres. In this symposium, we will explore these various phases of flux rope formation and evolution from the Sun to geospace and planetary space environments, and we will explore ways in which a better understanding of this behavior can lead to improved insights into solar activity and space weather.

4.3 Space Weather and Climate Throughout the Solar System: Bringing Data and Models Together

Conveners: **Laure Lefevre** (laure.lefevre@oma.be)
Baptiste Cecconi (baptiste.cecconi@obspm.fr)
Mateja Dumbovic (mateja.dumbovic@geof.unizg.hr)
Phillip Hess (phillip.hess@nrl.navy.mil)

With the growing human technology and space exploration, understanding and modelling of space weather and climate driven by the solar activity is becoming exceedingly important. Accordingly, the amount of scientific data from numerous missions in the heliosphere is growing rapidly, as is the number and variety of models. The availability of the large amount of data evokes novel, data driven forecasting methods and techniques. In order to use these novel methods for space weather applications, a rigorous examination of the available data, the applied techniques, and the statistical

properties of the system are necessary. We solicit contributions related to recent progress in handling data sources, data quality issues, forecasting techniques and modelling of space weather and space climate at any point along the chain from the Sun to planets. Especially, but not exclusively, we encourage contributions describing novel approaches based on data assimilation techniques and machine learning. Contributions regarding data collection, data formats, metadata standards, distribution interfaces and any issues associated to these are also encouraged.

4.4 Waves and Turbulence in the Solar Corona and Wind

Conveners: **Valery M Nakariakov** (V.Nakariakov@warwick.ac.uk)
Bo Li (bbl@sdu.edu.cn)
Raffaella D'Amicis (raffaella.damicis@inaf.it)

Waves and turbulence in the solar corona and solar wind are a critical topic on both theoretical and observational grounds. Remote-sensing observations have recently revealed magnetohydrodynamic (MHD) waves in the solar corona. Meanwhile, sophisticated numerical MHD simulations become available that shed light on how these waves are generated and dissipated, as well as the possible role of kinetic effects. Solar wind turbulence in interplanetary space remains a hot topic, with remarkable observational and theoretical progresses in terms of wave-vector anisotropy, nature of turbulence at kinetic scales, intermittent heating, and so on. Solar wind models are also improved to incorporate important effects of wave and turbulence. In this symposium, we solicit contributions on both the observational analysis and theoretical modelling of waves and turbulence in the solar corona and wind. We look forward to get a comprehensive overview of what we have known about waves and turbulence in this context, and discuss recent results and anticipated future breakthroughs.

Division V

5.1 Current developments of Geomagnetic observatories and integration of ground and space-based measurements

Conveners: **Achim Morschhauser** (mors@gfz-potsdam.de)
Kusumita Arora (kusumita.arora@gmail.com)
Katia Pinheiro (kpinheirogeomag@gmail.com)
Roman Krasnoperov (r.krasnoperov@gcras.ru)

Ground geomagnetic observatories play a crucial role in generating high quality and consistent long term data. On the other hand, satellites generate high quality data with global coverage. The combination of ground and satellite data has the power to open new possibilities in studying space weather, space physics, magnetosphere-ionosphere coupling, secular variation, and in geomagnetic field modeling. This session aims to bring together the most recent results from experimental and theoretical improvements of observatory and satellite data acquisition, and is also open to applications and models using these data. We invite contributions on all aspects of advances in development of new techniques and in derivation of new results from the combination of satellite and observatory data, but also from observatory data alone, in the global as well as regional context.

Division VI

6.1 Electromagnetic induction in Earth

Conveners: **Alexander Grayver** (agrayver@ethz.ch)
Alison Kirkby (alison.kirkby@ga.gov.au)
Oliver Ritter (oritter@gfz-potsdam.de)
Lindsey Heagy (lindseyheagy@gmail.com)

Electromagnetic (EM) geophysical methods are applied on scales ranging from the near surface to the deep mantle. Aspects of EM induction in geophysics include new instrumentation and data acquisition methods, mathematical and numerical improvements to data processing, modelling, and inversion, ground-based and measurements in the marine environment, airborne and satellite missions. We are interested in studies of EM applied to global induction, imaging regional scale tectonic, magmatic, or volcanic systems, in the search for hydrocarbon, geothermal, or mineral resources, and the investigation of near surface structure relevant to environmental, urban, and hydrological systems. Results from EM methods are often part of multi-disciplinary studies integrating data from rock physics and other geophysical, geochemical, and geological methods to investigate complex subsurface structures and their temporal evolution. Neighbouring fields of research encompass the study of natural and controlled EM sources, geomagnetically induced currents, or geomagnetic field studies based on observatory data. This session welcomes contributions on all aspects of EM induction in geophysics.

6.2 EM & MT DATA: Acquisition, Processing, Analysis and Archiving

Conveners: **Adam Schultz** (Adam.Schultz@oregonstate.edu)
Maxim Smirnov (maxim.smirnov@ltu.se)
Jared Peacock (jpeacock@usgs.gov)
Ute Weckmann (uweck@gfz-potsdam.de)

Fundamental to all experimental geophysical applications is a sensible, reliable and modern data acquisition and handling. More than anything else, these topics are subject to technical, statistical and numerical innovations and developments. Within the last years even concepts of machine learning and artificial intelligence are discussed and tested for electromagnetic (EM) and Magnetotelluric (MT) data. Therefore, we invite contributions in the field of EM instruments development, novel and advanced concepts of experimental design, EM and MT data processing and any sort of analyses that are applied before modelling and inversion. Finally, innovative concepts for data archiving are required and need to be introduced and discussed, to make data available and usable in the future.

IASPEI Symposia

S1 CoSOI **Observational seismology - open session seismology**

Conveners: **Torsten Dahm** (Germany), torsten.dahm@gfz-potsdam.de
Johannes Schweitzer (Norway), iaspei@norsar.no

The commission of seismological observation and interpretation (CoSOI) covers a broad and diverse field of developments, approaches and application. We invite presentations from all field of CoSOI including also new developments of integrating non-seismological data into seismic observations.

S2 CoSOI & CoESM **Standardization and automatic procedures in source studies**

Conveners: **Simone Cesca**, (Germany), simone.cesca@gfz-potsdam.de
Domenico Di Giacomo (UK), domenico@isc.ac.uk
Kristin Pankow (USA), pankow@seis.utah.edu, pankowseis2@gmail.com

Routine and automatic earthquake source parameter and moment tensor inversion methods are ever evolving and are used by several agencies, universities and surveys. Systematic global and regional services are becoming a standard in many countries, and different catalogues developed from temporal and permanent deployments are provided for the community. Software toolboxes offer standard source parameter tools – but results depend very much on the data pre-processing, data selection and implementation methods. Often, quality criteria for the processing and implementation methods are not easily available or are not provided. Therefore, a systematic comparison between parameters retrieved from different tools and procedures is not always straight forward. The session invites both contributions focusing on scientists developing tools, and working towards automated source parameter estimation, as well as case studies where source inversion methods are applied to earthquakes, seismic sequences or large datasets. We aim to collect contributions based on a broad variety of approaches, from traditional methods to new concepts of massive data and machine learning, including uncertainty quantification and testing platforms to calibrate and compare automated methods and their robustness.

S3 CoSOI & CoESM **Anthropogenic seismicity**

Conveners: **Stanislaw Lasocki** (Poland), lasocki@igf.edu.pl
Harsh K. Gupta (India), harshkoyna@gmail.com
Beata Orlecka-Sikora (Poland), orlecka@igf.edu.pl

Under suitable geological conditions, anthropic activities such as the creation of the artificial water reservoirs, underground coal and metal mining, hydrocarbon production, underground storage of CO2, geothermal energy production, etc. can trigger/induce earthquakes. The socio-economic impact of the triggered and induced seismicity is very significant. On the one hand, the anthropogenic seismic events, though being small compared to tectonic earthquakes, are often damaging and occasionally even devastating because of their shallowness. The accurate assessment of the hazards associated with triggered earthquakes is of paramount importance. Due to anthropogenic seismic processes' relation to technological activity, which usually varies in time, this hazard assessment problem is inherently time-dependent. But the existence of this relation also opens a possibility to mitigate the related hazards through adequate modifications of the inducing industrial operations.
This symposium takes a global perspective to recognize the severity of the anthropogenic seismicity and to survey recent progress in understanding this phenomenon. We welcome both cross-sectional multi-aspect theoretical, methodological, and experimental studies as well as case histories linked to particular inducing technologies. The session will help identify cross-technology common denominators of the induced seismic processes, with specific attention devoted to approaches to hazard assessment and mitigation.

S4 CoSOI **Seismic scattering and absorption, ambient noise, and monitoring Earth's structure**

Conveners: **Hisashi Nakahara** (Japan), naka134@tohoku.ac.jp
Ulrich Wegler (Germany), ulrich.wegler@uni-jena.de
Jayant N. Tripathi (India), jntripathi@gmail.com

Seismic scattered waves or coda waves carry rich information on heterogeneities within the Earth. Amplitude information from coda waves has been used to estimate the spatial distribution and the frequency dependence of the strength of scattering attenuation and intrinsic absorption in the Earth. Recently, ambient noise cross-correlation has also been used to study seismic structure in the Earth thanks to the development of seismic interferometry. Time-lapse imaging or monitoring of the Earth has been conducted using tiny changes in phase information of cross-correlation functions of ambient noise and coda waves. Increasing the spatial and temporal resolutions of the imaging will help to understand the Earth's heterogeneities and dynamics. In this session, we would like to widely invite presentations related to theoretical and observational studies of attenuation, coda waves, ambient noise, and their applications to the imaging and monitoring Earth's heterogeneous structure.

S5 CoSOI **Advancements in observation, processing and interpretation of seismological data**

Conveners: **Francesco Grigoli** (Switzerland), francesco.grigoli@sed.ethz.ch
S. Mostafa Mousavi (USA), mmousavi@stanford.edu
Aitaro Kato (Japan), akato@eri.u-tokyo.ac.jp

Freely available large datasets, including both Large-N nodal arrays and continental arrays, have greatly advanced our understanding of tectonic and earthquake processes. Combination of the big datasets, new monitoring instrumentations and novel processing methods, including improvements in rapid communication of scientific results, has led to breakthroughs in many subfields of seismology. For instance, earthquake location and large earthquake rupture processes are now routinely resolved within a few days by multiple agencies, which have led to new developments in damage impact assessment. Moreover, high performance computing has enabled machine learning being applied to massive datasets to identify previously unknown patterns. However, results of these automatized processing approaches may have errors when their uncertainties are not carefully evaluated, suggesting future research focus directions. The session invites contributions from both structural and earthquake seismology studies with large datasets. In particular, we solicit studies tackling result uncertainty issues associated with big datasets from theoretical, modeling, and observational aspects.

S6 CoSOI **Collection, interpretation and publication of paleo and historical earthquake data**

Conveners: **Paola Albini** (Italy), paola.albini@ingv.it
Kenji Satake (Japan), satake@eri.u-tokyo.ac.jp
Jian Wang (China), wangjian@cea-igp.ac.cn
Javed N. Malik (India), javed@iitk.ac.in

Evidence of global seismic activity from instrumental records covers about one century, too short a period to catch the recurrence interval of large earthquakes. Historical seismological studies and macroseismic intensity data have significantly expanded backwards in time our knowledge of the seismic behaviour of many areas in the world. Paleoseismological studies of inland active faults, as well as coastal geological studies on tsunami deposits or marine terraces, and marine geological studies on deep-ocean turbidites, have provided important information for the past occurrence of pre-instrumental earthquakes, too.
The combination of data deriving from these three domains would result in a better vision of the long-term seismicity, which may be utilized for long-term forecast. However, challenges are still posed to researchers on how to best derive earthquake parameters from originally non-seismological observations of earthquake effects, as it is the case of both macroseismic and geological data.

This session welcomes contributions suggesting new prospects related to these topics, such as case studies of historical and paleoseismological records, their unfiltered association to specific events as well as their usual parameterization in seismological terms, or their combination with modern instrumental data, or any further issue on long term seismicity analysis and forecast of moderate and especially of large earthquakes.

S7 CoSOI **National and Regional Earthquake Data Centers: Highlights and Challenges**

Conveners: **D. Srinagesh** (India), srinagesh@ngri.res.in
Dmitry Storchak (UK), dmitry@isc.ac.uk

National and regional seismic operational centers play an important role in monitoring for natural earthquakes, volcanic eruptions, and other phenomena, such as induced seismicity. The products generated by these centres, from raw waveforms to earthquake catalogues are used by a wide variety of stakeholders, including researchers, emergency management agencies, policy makers, educators, regulators, and the general public.
This session focuses on the important role that earthquake centres play in advancing scientific study, especially as it relates to local and regional hazard; integrating new technological advances in data acquisition and processing; and communicating earthquake hazard and risk.
We welcome contributions describing new and evolving networks, data policies and data sharing, new processing algorithms, hazard assessments, and novel education and outreach initiatives. Other topics that highlight current advances and challenges for earthquake operation centres are also of interest.
Potential outcomes of the session may include summary publications, organized advocacy, and frameworks for closer collaboration

S8 CoSOI **Advances in geophysics, atmospheric science, and signal analysis for monitoring the CTBT**

Conveners: **Keith L. McLaughlin** (USA), KEITH.L.MCLAUGHLIN@leidos.com
Inna Sokolova (Kazakhstan), sokolova@kndc.kz
Alexander Smirnov (Kazakhstan), smirnoff@kndc.kz

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) distinguishes itself from other international agreements by establishing a verification regime that includes the International Monitoring System (IMS) and the International Data Centre (IDC). The IMS is a global, multi-physics network of sensors that record seismic, hydro-acoustic, infrasound, and radionuclide signals that are generated by nuclear explosions. The first two decades of the CTBT focused on installation of the IMS network and implementation of robust IDC processing for detection and characterization of signals recorded on the IMS.
This symposium calls for contributions of state-of-the art methods and observational studies that advance CTBT verification science across all geophysical sensor technologies. For example, recent remote sensing INSAR observations have contributed insight into deformation by underground explosions. We seek contributions in the areas of source physics, signal propagation, and signal analysis. Source physics studies improve understanding of the nuclear explosion source and features that distinguish them from non-nuclear anthropogenic sources and natural sources. Signal propagation studies include characterization of Earth's interior, the oceans, and the dynamic atmosphere. Of particular interest are advances in predictive propagation of infrasound signals in the dynamic atmosphere, acoustic-seismic conversion, and hydroacoustic-seismic conversion. Analysis includes methods to detect, characterize, and associate signals generated by common sources. Of particular

interest are methods to simultaneously analyse and fuse observations across multi-physics data sets. Additionally, we invite reports on efforts to collect and analyse the wealth of historical data.

S9 CoSOI **Cryoseismology**

Conveners: **Myrto Pirli** (Norway), myrto.pirli@gmail.com
Masaki Kanao, (Japan), kanao@nipr.ac.jp
Paul Winberry (USA), paul.winberry@gmail.com
Douglas Wiens (USA), doug@wustl.edu

Insight into cryospheric dynamics is of utmost importance to a wide spectrum of scientific fields, from glaciology and polar climate research to projections of sea level rise. During the last decade, a growing volume of literature has been establishing cryoseismology as a very appropriate interdisciplinary tool to answer questions on diverse dynamic processes in the cryosphere, from ice-shelf crevassing and iceberg detachment, to glacier surging, basal stick-slip and tidally induced grounding-line migration, as well as phenomena related to subglacial water flow. In addition, techniques such as seismic interferometry and H/V spectral ratios of ambient noise have been emerging as potent tools to gain knowledge on the structure of shallow ice layers and changes in the permafrost.
We invite contributions on all topics of cryoseismological research, covering both the Arctic and Antarctica, as well as mountain glaciers in temperate climates.

S10 CoSHRSGM **Site and Source Modeling for Urban Seismic Microzonation Studies**

Conveners: **Prantik Mandal** (India), prantikmandal62@gmail.com
Utpal Dutta (USA), udutta2@alaska.edu

During the last two decades, the world had witnessed several devastating earthquakes at various places, e.g., 2001 Mw7.7 Bhuj (India), 2004 Mw9.3 Sumatra (India), 2005 Mw7.6 Kashmir (India), 2008 Mw7.9 Wenchuan (China), 2010 Mw7.1 Canterbury (New Zealand), 2011 Mw9.0 Tohoku (Japan), and 2015 Mw7.9 Kathmandu (Nepal). These earthquakes caused not only substantial damages to buildings, dwellings, and other critical infrastructural facilities due to poor construction practices but also were responsible for the loss of thousands of human lives. With the rapid growth in seismic instrumentation and advancement in data communication, the dense seismic monitoring at many high-risk urban areas is currently in operation to minimize infrastructural losses and casualties by adopting better engineering practices based on knowledge gained from the analysis of recorded seismic data. The seismic microzonation of these urban areas is studied using accurate assessment of the site and local source characteristics, which form the basis of the preparedness to mitigate the earthquake hazard and help to develop an earthquake resilient society. To reflect the modern advancements in the modeling of earthquake data for rapid assessment of the site and, source processes associated with large devastating earthquakes, and to foster inter-disciplinary and international exchange and cooperation, this session focuses on, but not limited to, the following topics:
1) Seismogenesis of devastating large earthquakes, 2) Evaluation of seismic hazards associated with large earthquakes, 3) Study of source scaling of earthquakes, 4) Microzonation studies including site response, shallow Vs30m and hazard mapping at a local scale, 5) Impact of soil non-linearity during large earthquakes.

S11 CoEGP **Earthquake Generation Process & Forecasting Models**

Conveners: **Eleftheria Papadimitriou** (Greece), ritsa@geo.auth.gr
Alexey Zavyalov (Russia), zavyalov@ifz.ru
David Rhoades (New Zealand), d.rhoades@gns.cri.nz
Rajender Kumar Chadha (India), rajen0555@gmail.com
Petr N. Shebalin (Russia), p.n.shebalin@gmail.com)

It is known that the process of destruction is not a momentary act, but there is a process taking place in time and space. In preparation of macro-destruction destruction process is going through a number of levels (stages), starting with the micro-scale and ending on macro-scale, including earthquake focal area. In this symposium, we invite researchers to discuss the results and directions for further research on the physics of seismic process - from experiments in laboratory conditions, rock bursts in mines and in seismically active regions during the preparation of strong earthquakes.
Special emphasis will be given to quantitative physical models of the seismic process at different scales, describing the origin of the future earthquake source and its evolution in time and space, observations on earthquake triggering by other earthquakes or nearby faults, and synchronization between nearby faults with positive stress coupling, fault system interactions controlling earthquake occurrence, the connection of smaller magnitude seismicity with stress changes as expressed through the Rate/State model, calculation of stress changes from changes in earthquake occurrence. Modeling and simulations across a wide range of spatial and temporal scales provide a better understanding source processes and interactions, and advance predictive capabilities.
Contributions are invited on all aspects of models designed to forecast earthquake occurrence in time and/or space. The development of earthquake forecasting models is being facilitated by the improvement of data and modelling inputs. Some modeling efforts are focussed on short term clustering of earthquakes, others on the time-varying probability of rupture of major fault sources, and others on the space-time-magnitude variation of the rate of earthquake occurrence in extended regions. Models can be statistical or physics based. Data inputs include the past earthquake catalogue, known or inferred dates of previous fault ruptures, modeled physical variables such as stress accumulation and strain rates, and proposed precursory phenomena. Improved methods to test the performance of forecasting models are being developed. Reports on the application of forecasts to inform the public or in support of earthquake counter measures planning are welcome.

S12 CoEGP **Interdisciplinary observations of Pre-Earthquake processes: A new approach towards Earthquake prediction studies**

Conveners: **Dimitar Ouzounov** (USA), ouzounov@chapman.edu
Sergey Pulinets (Russia), pulse1549@gmail.com
Katsumi Hattori (Japan), hattori@earth.s.chiba-u.ac.jp
Patrick Taylor (USA), patrick.taylor@nasa.gov

This session concerns the multi-disciplinary observations related to earthquakes, which would lead to an understanding of the physical processes preceding earthquakes. Some new results were obtained from modeling of the atmosphere-ionosphere connection and analyses of seismic records (foreshocks /aftershocks), geochemical, electromagnetic, and thermodynamic processes related to stress changes in the lithosphere, along with their statistical and physical validation. Recent large magnitude earthquakes in Asia, Central America and Europe have shown the importance of these various studies in the search for earthquake precursors either for short-term forecasting or predictions. This session will provide the next development of the topics presented in the new AGU Geophysical Monograph published this year. Presentations will include but are not limited to: observations; modeling and analyses; seismic, geochemical and electromagnetic thermodynamic processes; and case histories related to stress changes

in the lithosphere along with their statistical and physical validation. Presentations on the latest developments in earthquake predictability and prospective testing associated with major earthquakes are welcomed.

S13 CoESG & SEDI **Seismic structures in the mantle**

Conveners: **Christine Thomas** (Germany), tine@earth.uni-muenster.de
Barbara Romanowicz, (France/USA), barbara.romanowicz@gmail.com
Sebastian Rost (UK), s.rost@leeds.ac.uk
Stéphane Rondenay (Norway), rondenay@uib.no

Dynamic processes and mineralogical changes generate seismic observables that can be used to infer the current state of the mantle. Seismic studies of interfaces in the mantle provide constraints on composition, temperature and flow. Seismic tomography provides evidence for regional and local changes of temperature and composition and images dynamic processes driven by convection and plate tectonics. Combinations of global, regional and local studies of Earth's mantle highlight differences and connections between different tectonic regimes in the mantle. Together with constraints from mineral physics, geochemistry and geodynamics, seismological studies contribute to our understanding of the dynamics and evolution of the deep Earth shaping our planet. This session invites contributions from all areas of seismology investigating the structure of the Earth's mantle from the lithosphere to the core-mantle boundary aiming to image the dynamics and structure of the planet.

S14 CoESM & CoSOI **Earthquake Source Mechanics**

Conveners: **Satoshi IDE** (Japan), ide@eps.s.u-tokyo.ac.jp
Keisuke ARIYOSHI (Japan) ariyoshi@jamstec.go.jp
Daniela KÜHN (Norway), daniela@norsar.no
Seok Goo SONG (Korea) sgsong@kigam.re.kr
Anna SKORKINA (Russia), anna@mitp.ru

Recent high quality seismic and geodetic observations provide large volumes of broadband data, which enable accurate determination of earthquake source parameters (locations, magnitudes, durations, moment tensors, etc.) and detailed imaging of rupture processes emerging from slow background processes. Further, techniques for solving inverse problems have improved substantially in the recent past. Abundant information from these analyses is the basis for studying a variety of earthquakes including swarms, tectonic and volcanic events as well as induced events, and to seek the governing laws and conditions for rupture initiation, growth, and arrest. It also provides useful input to estimate the stress state, fault geometry, and fluid movement around seismic regions. The entire earthquake process from long-term tectonic loading and slow nucleation to rapid rupture propagation with strong motion radiation is now studied using numerical simulations. The validity of assumptions in these simulations is tested by data analysis and laboratory experiments supported by several drilling projects. In this symposium, we invite contributions on data analysis and interpretation of earthquake parameters and source processes, on improvement and validation of routine analysis techniques, on theoretical and numerical modeling of dynamic ruptures and earthquake sequences, and observational and experimental studies on the physics of earthquakes.

S15 CoTCS **Fine structure of the lithosphere**

Conveners: **Prakash KUMAR** (India), prakashk@ngri.res.in
Ulrich ACHAUER (France), ulrich.achauer@unistra.fr

The relatively strong lithosphere that constitutes the tectonic plate which moves coherently atop the softer asthenosphere, originally evolved in a mechanical sense to explain the post-glacial rebound phenomenon. The lithosphere-asthenosphere boundary is of fundamental importance in understanding the mantle dynamic processes. However, there is no general consensus on its nature in various geological units and its relation with the crust-mantle and mid-lithospheric discontinuities. In the recent past, numerous geophysical and geological studies provided the 'fine-scale' structure of the Earth's lithosphere, revealing important insights but complex and varied interpretations, as reflected in seismic-wave velocities, seismic anisotropy, attenuation, electrical conductivity and compositions of mantle-rock samples. We welcome research contributions from various fields to understand the lithospheric structure and lithosphere-asthenosphere system.

S16 CoTCS & ILP **More than 40 years of seismological research within ILP**
Conveners: **Michael Weber** (Germany), mhw@gfz-potsdam.de
Magdalena Scheck-Wenderoth (Germany), leni@gfz-potsdam.de
Uli Achauer (France), ulrich.achauer@unistra.fr

The International Lithosphere Program (ILP) has since 1980 been initiating major international, multi-disciplinary research programmes to elucidate the nature, dynamics, origin and evolution of the lithosphere. ILP has taken initiative for more than 70 programs within its four research themes: (1) Geoscience of Global Change, (2) Contemporary Dynamics and Deep Processes, (3) Continental Lithosphere and (4) Oceanic Lithosphere. Present programmes focus on integrated mapping of lithosphere physical parameters, lithosphere dynamics including the fate of subducted lithosphere and deformation of continental lithosphere, response of the lithosphere to surface processes including changes in climate and erosion/deposition dynamics, mineral resources, and seismic risk. One example programme initiated by ILP is dedicated to the Global Geoscience Transects based on large deep seismic experiments such as LITHOPROBE, DEKORP, ECORS, MONA LISA, BABEL and many more. Meanwhile the number of both methods employed, and regions investigated have grown and we aim at fostering scientific exchange between the different groups working on those.
Therefore, we invite, in particular multi-disciplinary contributions, which focus on the structure and evolution of the continental crust and upper mantle and on the nature of mantle discontinuities based on seismic methods. The latter include, but are not limited to, the mid-lithosphere discontinuity (MLD), the lithosphere asthenosphere boundary (LAB), and the mantle transition zone, as imaged by various geophysical techniques and interpreted within interdisciplinary approaches. Papers with focus on the structure of the crust and the nature of the Moho are also welcome. We also invite studies integrating seismic methods with thermal, gravity, petrological, and/or electromagnetic data interpretations.

S17 CoTCS **The Crust of Oceans, Margins and Continents - From regional to global context**
Conveners: **Gabi Laske** (USA), glaske@ucsd.edu
Walter Mooney (USA), mooney@usgs.gov

The crust has preserved a record of the evolution of a multitude of Earth systems. Advances in seismology have resulted in much richer and more complex picture of the crust than ever before. But ever new images and models also generate many new questions. A partial list of questions includes the

process of crustal formation and modification, the presence of deep crustal fluids and/or partial melt, the geometry of crustal faults at depth, crustal modification by lateral crustal flow, the existence and origin of crustal seismic anisotropy and the age and physical properties of the Moho and mid-crustal discontinuities. This session welcomes seismic and non-seismic studies of the Earth's crust on regional and global scales, particularly those with a multi-disciplinary perspective.

S18 CoTCS & ILP Task Force CoLiBrI **Integrated seismological studies of the continental lithosphere - what we can learn from seismic anisotropy and other geophysical methods about the (micro-) plate structure and fabrics**

Conveners: **Jaroslava Plomerova** (Czech Republic), jpl@ig.cas.cz
Juan Carlos Afonso (Australia), juan.afonso@mq.edu.au
Nicola Piana Agostinetti (Austria), nicola.piana.agostinetti@univie.ac.at

Seismology tools help to decipher complex structure and fabrics of continental lithosphere, which was formed in different geological cycles and plate forming processes, including accretion of plate fragments, collisions, subductions, break off, spreading of micro-plates and their consequent amalgamation into new continents. Seismic tomography snap shots of the present lithosphere state, in combinations with results from other seismological results, e.g., from seismic anisotropy at different scales or modelling mantle dynamics, and inevitably in interdisciplinary approach considering, e.g., gravity, petrology, GPS and other measurements in integrated geophysical modelling, allow us to image the current detailed structure of the continental lithosphere and to improve our understanding evolution and history of the continental lithosphere. Contributions on integrated seismological studies of the continental lithosphere are welcome.

S19 CoTCS **Intraplate Seismicity: Distribution, properties and causes**

Conveners: **D. Srinagesh** (India), srinagesh@ngri.res.in
Won-Young Kim (S. Korea / USA), wykim@ldeo.columbia.edu
Lars Ottemöller (Norway), lars.ottemoller@uib.no
Stéphane Rondenay (Norway), rondenay@uib.no

Intraplate seismicity in many parts of the world significantly contributes to seismic hazard. While intraplate seismicity today is well monitored by permanent and temporary seismic networks to observe its spatial and temporal distribution, low activity rates prevent us from obtaining a more complete picture, especially when it comes to large earthquakes. And while source studies provide mechanisms and other physical parameters, the exact causes for intraplate earthquakes can be difficult to identify as often one deals with a combination of different processes. In this session, we invite for presentations on state-of-the-art studies on different aspects of intraplate seismicity. We anticipate contributions from different parts of the world and complementary disciplines (e.g., seismology, geodynamics, rock physics) that will allow us to discuss differences and similarities with the aim to get a better understanding of intraplate seismicity overall.

S20 CoEO **Seismology Education, Citizen Science, and Global Resilience to Earthquakes**

Conveners: **Raju Sarkar** (Bhutan), rajusarkar.iaspei@gmail.com
Aaron Velasco (USA), aavelasco@utep.edu
Xyoli Pérez-Campos (Mexico), xyolipc@sismologico.unam.mx

Worldwide, earthquakes represent a substantial hazard, especially to underdeveloped countries. Social preparedness, community response, and resilience can be advanced through awareness and understanding of seismology. Earthquakes represent a global challenge to resilience that can be overcome by improving education in seismology, and new initiatives continue to improve seismology awareness through education and citizen participation in various countries around the world. For many countries, resources and infrastructure for preparedness are a limitation; however, creative, low-cost strategies, such citizen science, can be implemented. Research on the following topics is welcome, but not limited:

a) Educational programs in seismology
b) Strategies on public outreach in seismology
c) Citizen science in seismology
d) Studies on the impact of communication in seismology awareness
e) Products that contribute to seismicity understanding

S21 CoEO & CoSHRSGM **Role of Seismologists and Earthquake Engineers in Community Development**

Conveners: **Ramesh P. Singh** (USA), rsingh@chapman.edu
Rajib Shaw (Japan), shaw@sfc.keio.ac.jp
Raju Sarkar (Bhutan) rajusarkar.iaspei@gmail.com

This symposium sets out to discuss the possible ways/ explore in which seismologists and engineer's joints hand to deal with earthquakes for infrastructure development leading to community development. As it is well known, the approach and ability to recover from a damaging earthquake differ greatly across the communities. Considering 2015 Nepal earthquake were a striking reminder of this of fatalities almost 9000, when the death toll from the 2010 Haïti earthquake was at least 100,000; in the much larger earthquake of same year in Chile, killed just 525 people. In a narrow perception, the difference can be interpreted in terms of the approach of design and construction along with the engineering properties of locally available materials used for construction to withstand the strong ground shaking. When seismologists joint hand with engineers, the greater the chance that the community affected can be recovered quickly. In this symposium it will try to explore from the researchers whether the ability of communities to deal with this natural disaster is only limiting to the technical factors, or it has gone beyond. Research on the following topics is welcome, but not limited:

a) New seismic engineering approach for earthquake risk reduction
b) Hazard estimates and vulnerabilities of structures
c) Seismological and engineering challenges with social and economic importance
d) Strategies for improvement of new infrastructure codes
e) Case Studies
f) Product that contributes to community for better dealing with earthquake

S22 ASC & CoSHRSGM **Seismicity and seismic induced hazards in Asia**

Conveners: **Harsh K. GUPTA** (India), harshg123@gmail.com

Zhongliang WU (China), wuzl@ief.ac.cn
Ruben Tatevossian (Russia), ruben@ifz.ru
Gary Gibson (Australia), gary@earthquake.net.au

In the first 20 years of the 21st Century, the number of human lives lost and quantum of economic losses due to earthquakes and the resultant tsunamis have far exceeded the similar losses in the entire 20th Century. This in spite of all the technological and scientific developments. Asia is particularly vulnerable to such losses, accounting for more than 70% human lives lost globally to earthquakes and tsunamis. Short term earthquake forecasts are not yet available. Even if such a forecast becomes possible, can the entire population of a major city be evacuated? We therefore need to develop earthquake resilient societies by spreading awareness including creating earthquake scenarios, carrying out mock-drills, involving government and public participation. Excellent tsunami warning facilities have been created following the disastrous 2004 Mw 9.2 Sumatra earthquake. Contributions are invited to address the issue of making Asian societies resilient to earthquakes and tsunamis and suggestions for future work.

S23 ASC & CoSOI **New technology for earthquake observation and data explanation in Asia**

Conveners: **Parameshb Banerjee** (Singapore), parameshb@hotmail.com
Toshiaki Yokoi (Japan), tyokoi@kenken.go.jp
Li Li (China), lilygrace@cea-igp.ac.cn

In the past 10 years, new technologies have been injected into earthquake observation and data analysis. New instrument, based on optical fiber demodulation are used to note down the ground motion and strain of the crust. New parameters such as rotational components of seismic waves, are being recorded by unconventional seismographs. AI, machine learning and big data techniques are used to deal with earthquake recordings. Contributions are invited to address the issue of new technology in observation and new method in data processing.

S24 IHFC **Towards 60 years of activity of the International Heat Flow Commission**
Conveners: **Sukanta Roy** (India), sukantaroy@yahoo.com
Robert N. Harris (USA), robert.harris@oregonstate.edu
Sven Fuchs (Germany), fuchs@gfz-potsdam.de
Massimo Verdoya (Italy), massimo.verdoya@unige.it

The International Heat Flow Commission, constituted under the IASPEI in 1963, will celebrate its 60th anniversary at the next IUGG General Assembly in 2023. The activities of the Commission span all aspects of geothermal studies and linkages to the Earth sciences. Initially, the focus of the IHFC was on the acquisition of heat-flow data through temperature-depth measurements and thermal properties of rocks in a variety of geologic and tectonic regimes to constrain the thermal structure of the Earth. Since that time heat-flow studies have become fundamental for a number of applications in seismology, volcanology, geodynamics, geothermal energy, past climate change, hydrology and other fields. The goal of this symposium is to highlight the accomplishments of heat-flow studies and their role in understanding a wide range of Earth processes. The contributions to the symposium will include critical reviews identifying key-knowledge gaps as well as recent work in all aspects of geothermal investigations.