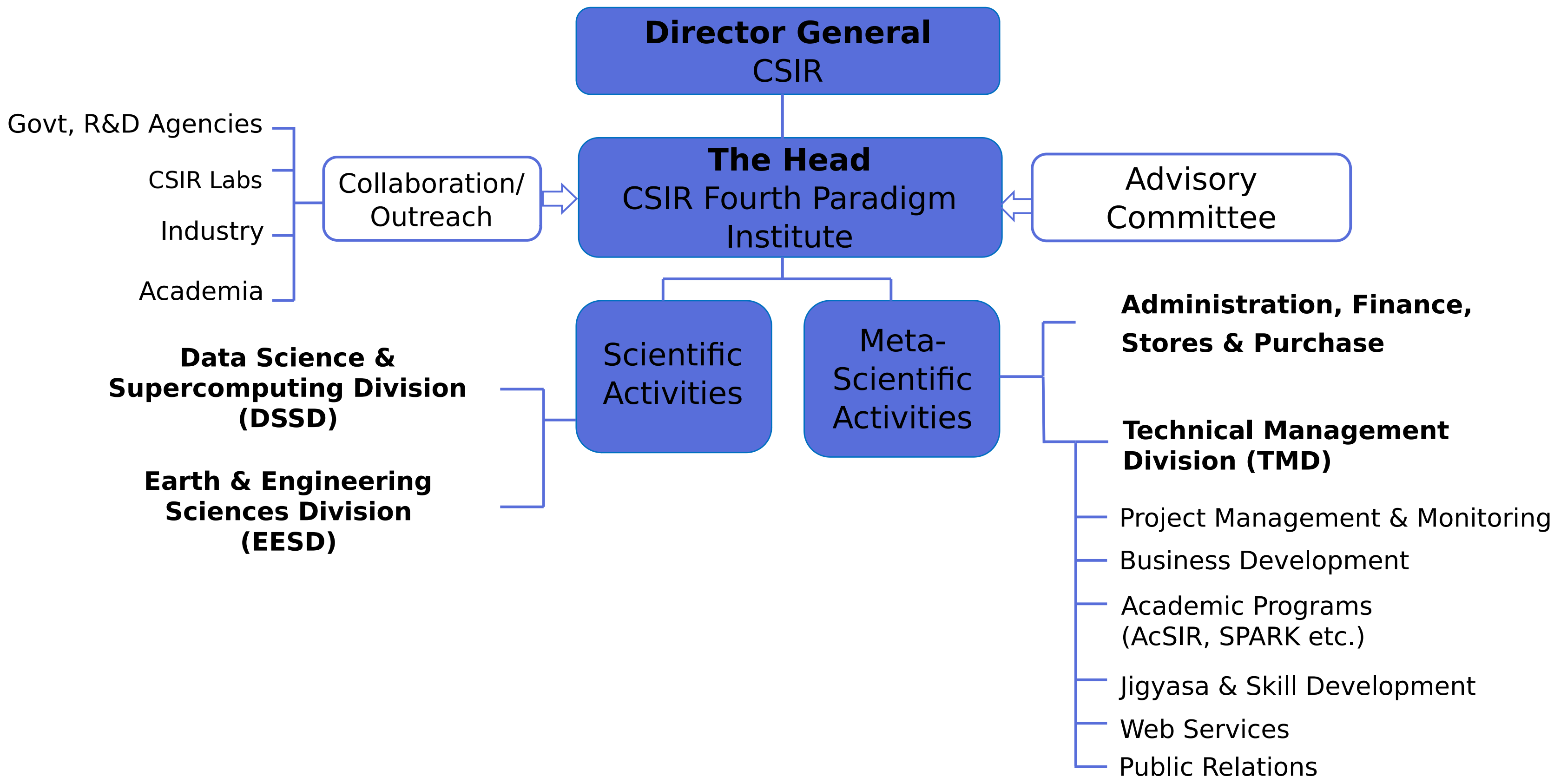
ANNUAL REPORT

2022-23

CSIR FOURTH PARADIGM INSTITUTE

Windtunnel Road, Bengaluru - 560 037
csir4pi.res.in

Organisational Chart



VISION

To synergize the strong expertise in various disciplines across CSIR and build a unified platform that embodies a rich set of big data enabling technologies and services with optimized performance to facilitate research collaboration and scientific discovery.

MISSION

Develop knowledge products in Earth, Engineering and information sciences for societal good by exploiting modeling, simulation and data science capabilities.

MANDATE

To develop reliable knowledge products for decision support in Earth, Engineering and Information sciences as well as to host centralised supercomputing facility for CSIR.

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- **Dr. Sridevi Jade**, CSIR-Fourth Paradigm Institute, Bengaluru
- **Dr. Abhishek Kumar**, Central Planning Directorate (CPD), Council of Scientific & Industrial Research, New Delhi

PUBLISHED BY:
THE HEAD
CSIR FOURTH PARADIGM INSTITUTE
WIND TUNNEL ROAD
BENGALURU - 560 037
KARNATAKA, INDIA
FAX: +91 80 2522-0392
TEL: +91 80 2505-1921
E-MAIL: HEAD@CSIR4PI.IN
Web: www.csir4pi.res.in
Twitter: https://twitter.com/CSIR_4PI
YouTube: https://www.youtube.com/@csir-4pi
Facebook: https://www.facebook.com/csir4pi/

COMPILED BY:
Dr. Anil Earnest

COVER PAGE DESIGN BY:
Shri. Ravichandran C

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0.1 Preface

CSIR Fourth paradigm Institute (CSIR-4PI) is a young and vibrant Institute of CSIR promoting data driven translational research culture across CSIR for the past one decade. We continue to host CSIR centralised Super-Computing facility and fulfil the data science needs of CSIR as a horizontal across CSIR labs. In addition, we are in a process of developing cybersecurity research as a pan-CSIR vertical. Further, we are committed to strengthen existing Earth and Engineering science research activities and earn further accolades.

During this year our Advisory Committee (AC) met twice, chaired by Smt. Nivruti Rai, Country Head of Intel India along with highly distinguished team of expert members from diverse fields. AC commended the research outputs/outcomes in-spite of sub-critical manpower and made recommendations to increase the existing human resources. We completed recruitment of support staff during this year and initiated the process of recruiting scientists.

CSIR AI Mission Phase 2 projects on 'Security and privacy aspects of 5G enabled VANET (Vehicular Ad-hoc Network)' with Cognizant as industrial partner and 'Preserving privacy in AI based Citizen Services involving personal identifiable information' with UIDAI as stakeholder were initiated during this year. Further, we are currently working with CSIR-IIP, CSIR-NIScPR, CSIR-NAL and CSIR-NCL in domain agnostic AI projects.

As part of design, indigenous development and deployment of cyberspace surveillance technology for Indian cyberspace, Network Telescope is deployed in the cybersecurity testbed and daily report is sent to NCCC/CERT-In, GoI. Currently this is being expanded with data driven inference on cybersecurity dynamics. Long term plan is to develop cybersecurity R&D as a separate vertical across CSIR to create an optimal combination of People, Process and Technologies.

During this year, Ananta Supercomputer was decommissioned after a decade of outstanding contribution to pan CSIR projects of national importance. Installation of new centralized Supercomputing facility CHAMP (CSIR HPC, AI & ML Platform) with 3+ PetaFlops peak performance is ongoing and would be made available to CSIR users in August 2023. This facility is capable of both traditional CPU as well as GPU based computing. Existing 1.2 PetaFlops GPU based computing platform donated by AMD, Inc. completed the mandated 2 years usage exclusively for Covid-19 research with outstanding scientific output by Indian researchers.

Our Earth and Engineering Science team continues to make outstanding multidisciplinary research contributions with societal impact in the field of advanced weather & climate, Geoscience and Engineering. Some of the notable contributions are: Study of influence of seasonal cycles on the origin of Indo-Asian monsoons; Advanced Indian monsoon research related to unexpected summer monsoon rainfall, monsoon breaks, relation of monsoon to ENSO, SSTs and so on. We made significant strides on studying the impact of climate change on winter vegetation across Indo-Gangetic plain, heat waves in

Land and Ocean, extreme rainfall in Himalayas, Malaria transmission in North-east India. Further, GHG observation network gave inter comparison of atmospheric CO_2 concentrations in pristine Hanle and polluted Hosakote locations.

Our multidisciplinary geoscience, seismic and engineering research team made significant contribution to Crustal stress distribution of Indian Plate; Seismic potential of Kachchh region; Strain budget in Kashmir Himalaya; Sub-surface shear wave velocity and sedimentation depth beneath Kashmir Basin; Site response analysis beneath Kashmir basin; Imaging sub-surface geological complexity beneath greater Srinagar; Active tectonics of the Bhagirathi River system of the Himalayas. Our GPS based geoscience studies gave insights in to Equatorial F-region irregularities, 3D acoustic ray propagation, delineating seasonal deformation in Himalaya and noise estimates of multi-GNSS signals.

We conducted advanced training on Greenhouse Gases (GHG) measurement and modelling under the CSIR-4PI Skill Initiative Programme. As part of industrial visit programme, several institutions participated in one day workshop on HPC, Cybersecurity, Earth & Engineering research. Spark program resulted in training the Bachelors and Masters students across the country. Our Jigyasa programme conducted world youth skills day, several science competitions, webinars and training to school students. Our Institute's Jigyasa and Skill initiative programs saw more than 500 school and college students participation.

CSIR-4PI organised major event "Science through Games and Toys" at IISF 2022 held at Bhopal to inculcate scientific temper among students through traditional games and toys thus giving a boost to indigenous industry. We conducted several events throughout the year which are listed in the events section of the report.

We continue to excel with several high-impact scientific publications, global citations for our research work, grants for new projects, doctoral degree awards, post-graduate dissertations and training of highly talented scientific workforce and so on. We continue collaborations with several institutes, agencies and industry to achieve new heights in our R&D as well as outreach. I am honoured to be leading our Institute to greater heights and confident of realising our long-term goal of being ONE STOP destination for computational as well as data science needs of CSIR and the country in the coming years.

Dr Sridevi Jade
Head
CSIR Fourth Paradigm Institute

Contents

Data Science & Supercomputing

1. Data Science & Supercomputing

Since its inception, CSIR-4PI provides High Performance Computing (HPC) with state-of-the-art computational facilities and is currently hosting one of the largest supercomputing and Artificial Intelligence (AI) ecosystem for CSIR.

Considering CSIR-4PIs expertise and its mandate to peruse data-intensive research in domains of national importance, the institute intends to take a lead role in data-driven research in cyber & data security research and privacy.

This division also aims to synergize the strong expertise in various disciplines across CSIR including CSIR-4PI and build a unified platform that embodies a rich set of big data enabling technologies and services with optimized performance to facilitate research collaborations and scientific discoveries.

Inside:

- Ananta Supercomputer
- HPC cloud resource at CSIR for COVID-19 research support for Indian researchers
- CSIR HPC, AI & ML Platform (CHAMP)
- Energy Farm: HPC Support Infrastructure
- Network Telescope: Observing post connection behaviour of malicious hosts
- Sea Surface Temperature (SST) prediction using Deep Learning Technique

1.1 Ananta Supercomputer

CSIR-4PI continues to provide High Performance Computing (HPC) resources to the computational scientists and researchers of CSIR Laboratories to enable them to address Grand Challenge problems in the frontier areas of science and engineering. The HPC facility has been operational on 24x7 basis with high uptime efficiency. Remote access from all across CSIR to the facility is provided through a high speed connectivity using National Knowledge Network (NKN).

Figure 1.1: CSIR centralized 489 TF High Performance Computing (HPC) facility.

CSIR centralized High Performance Computing facility the Ananta Supercomputer (Figure 1.1) served the computational scientists for nine years, catering to compute intensive scientific requirement in the areas of Aerospace, Computational Biology, Computational Chemistry, Environmental Science etc. The Ananta Supercomputer is a HPC cluster consisting of Sandy Bridge processor based 1088 computing nodes and Skylake processor based 48 computing nodes with a total peak performance of 489 TF. Each of the Sandy Bridge based compute node consists of two numbers of eight core Intel Xeon E5-2670 processor, 64 GB memory and 56 Gbps FDR InfiniBand interface. Each of the Skylake based computing node is comprised of two numbers of eighteen core Intel Xeon Gold 6140 processors, 192 GB memory, 100 Gbps EDR InfiniBand interface. The total memory of the system is about 77 TB. The supercomputer is supported by an online storage using LUSTRE parallel file system of about 2 Petabytes of useable capacity and is capable of providing a minimum of 20 GB/s simultaneous read and write performance.

PBSPro workload manager ensures efficient usage of the system. The percentage use of the HPC by different CSIR laboratories are given in the Figure 1.2.

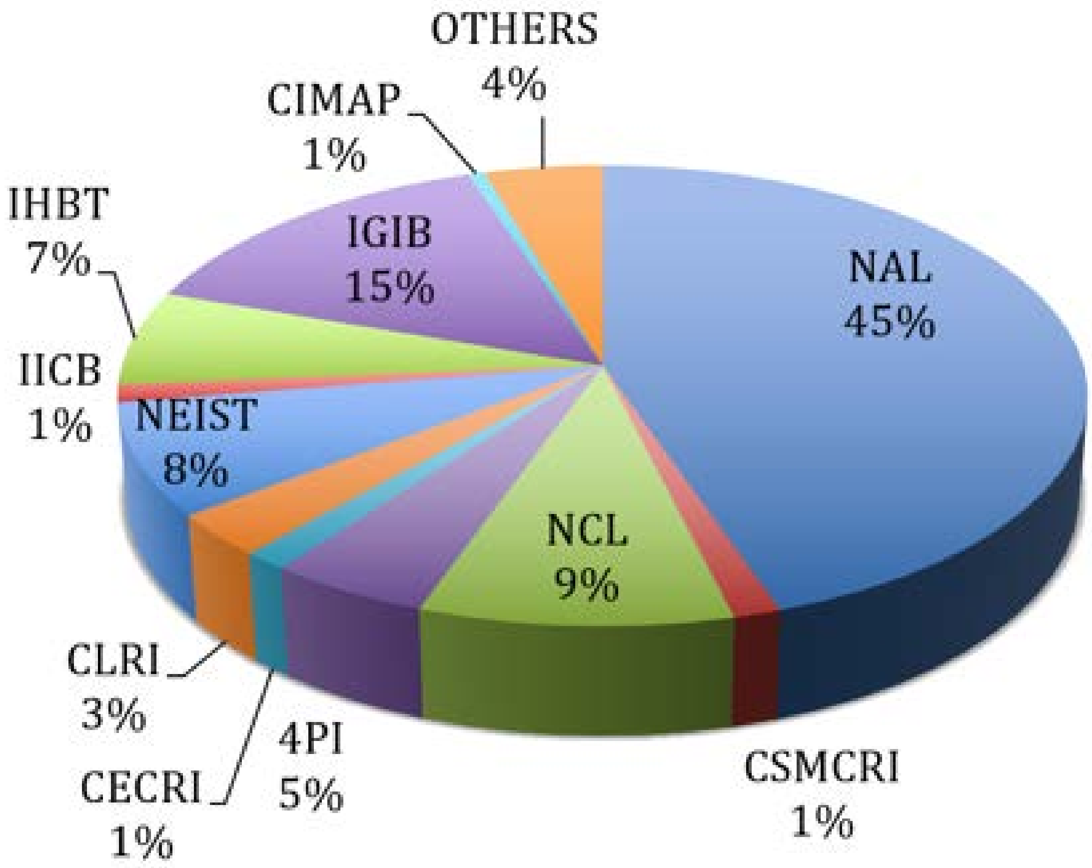


Figure 1.2: Percentage use of Ananta Supercomputing Facility.

R P Thangavelu, G K Patra, Anilkumar V, Ashapurna Marndi, Prabhu N and Veeresh

1.2 HPC cloud resource at CSIR for COVID-19 research support for Indian researchers

COVID CARE (CSIR AMD Research Engagement) Network, GPU based compute infrastructure was established through collaborative effort of CSIR and AMD for carrying out COVID related research exclusively by Indian researchers. The system, built by AMD to deliver more than one Peta Flops of compute power and dedicated for COVID research, is remotely accessed by researchers through high-speed national knowledge network. This is established as a part of AMDs COVID-19 HPC Global fund to understand the various aspects of infectious diseases and develop effective global responses. The system is configured with 24 nodes of AMD EPYC based system, each with 8 AMD Radeon Instinct

MI-50 GP-GPUs, 48 GB CPU Memory and 128 GB GPU memory. In addition DDN, India has also donated a 250 TB parallel file system to be used as a scratch file system. The objective of this collaborative effort is to bring together a wide spectrum of Indian experts with global participation and crowd sourcing of students and citizens in order to address problems posed by COVID-19 and find suitable deployable solutions by effectively utilizing the high-performance computing platform at CSIR-4PI with the basic principle of "Open-Source Innovation and Data Sharing Policy".

Figure 1.3: AMD donated HPC cloud resource for exclusive COVID-19 research.

R P Thangavelu, G K Patra, Anilkumar V, Ashapurna Marndi, Prabhu N and Veeresh

1.3 CSIR HPC, AI & ML Platform (CHAMP)

Ananta supercomputer was decommissioned after a decade of glorious contribution for successfully completing many projects with national importance across CSIR. As a refreshment of CSIR centralized HPC, "CSIR HPC, AI & ML Platform" (CHAMP) was planned.

CSIR centralized HPC facility CHAMP (Figure 1.4) is capable of handling both CPU and GPU workloads. The new system consists of 410 numbers of dual CPU (AMD 7763) compute nodes with each node having 128 cores and 512 GB memory. The system has a total of 52480 processor cores, 205 TB RAM, ∼2 PF peak computing power with a sustained performance of ∼1.4 PF on HPL. The system also has 12 compute nodes with 4 GPUs each with a peak performance of 960 TF and ∼600 TF sustained performance on HPL (∼30 AI Peta FLOPS). The supercomputer is supported by an online storage using LUSTRE parallel file system of about 8 PiB useable capacity. The inter-node communication for the HPC system is powered by high speed HDR 200 InfiniBand switches, with HDR 100 IB links to each node in a fully non blocking FAT tree topology configuration.

Figure 1.4: CSIR HPC, AI & ML Platform (CHAMP)

R P Thangavelu, G K Patra, Anilkumar V, Ashapurna Marndi, Prabhu N and Veeresh

1.4 Energy Farm: HPC Support Infrastructure

The support infrastructure plays an important role in the smooth running of the HPC system. Tier-3 equivalent state-of-the-art data center, supported by the state-of-the-art energy farm is key for the system being in production mode. Cooling of the Ananta supercomputer was carried out using water-based cooling called Rear Door Heat Exchangers (RDHx) which resulted in providing one of the best power and space efficient datacenters (Power Usage Efficiency (PUE) of less than 1.5) in the country a decade ago.

Cooling of the CHAMP Supercomputer is carried out using a combination of liquid, water, and air-cooling. Direct Contact Liquid Cooling (DCLC) will perform 60% cooling of the CHAMP CPU nodes and air-cooling will carry out the remaining 40% cooling. Cooling of GPU based compute system will be performed by active Rear Door Heat Exchangers (RDHx). A combination of DCLC, RDHx and air-cooling promised to achieve Power Usage Efficiency (PUE) of around 1.258.

The energy farm consists of two numbers of redundant compact substations of 1.25 MVA, three numbers of 1010 KVA diesel generators for backup power generation, an underground diesel yard (15 KL). Three numbers of 400 KVA UPS is replaced with two numbers of 600 KVA modular UPS (4x300 KVA modules) with appropriate battery backup for ensuring 24x7 uninterrupted power supply to the datacenter.

Figure 1.5: CSIR centralized HPC support infrastructure.

R P Thangavelu, G K Patra, Anilkumar V, Ashapurna Marndi, Prabhu N and Veeresh

1.5 Network Telescope: Observing post connection behaviour of malicious hosts

A Network Telescope is a framework to extract, validate and analyze a special class of Internet traffic called Internet Background Radiations (IBRs), which can be effectively leveraged for improving cybersecurity inference. CSIR-4PI continues its research in Network Telescope for Cyberspace surveillance under the Cybersecurity Research and Observation (CySeRO) Programme. Our experimental deployment of an improved version of Network Telescope provides important observations and patterns. Figure 1 shows the cumulative number of unique Internet Protocol (IP) addresses interacted, from all over the world, with our Network Telescope during a period of 31 days, i.e., 1 to 31 December 2022.

These IP addresses are validated against possible source IP address spoofing using our active Transmission Control Protocol (TCP) responder through a light-weight interaction process and hence the numbers shown in Figure 1 do not include source IP address spoofed unsuccessful TCP connection attempts. One of our long-term objectives is to focus on Network Telescope centric Threat Intelligence generation. From this perspective, the post connection behaviour of these IP addresses is being analyzed. In particular, attention is paid to the TCP payload portion of these packets, which are received post connection establishment within the initial congestion window (cwnd) of the underlying TCP connection. Figure 2 shows the cumulative number of unique source IP addresses that carried some payload.

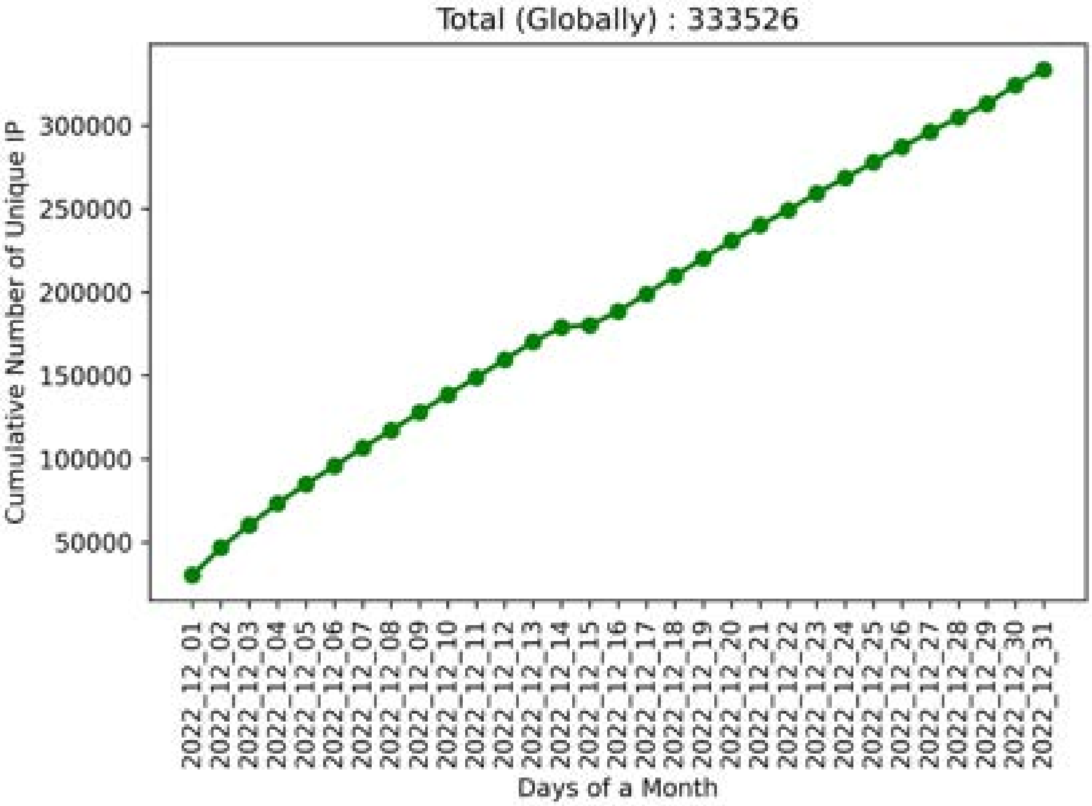


Figure 1.6: Cumulative number of unique IP addresses observed at the Network Telescope.

As observed in Figure 1 and Figure 2, more than 55 % of the unique IP transmitted payload post connection establishment. This indicates that payload observed at Network Telescope is a potential source of information for threat intelligence generation.

An in-depth analysis of the payload is in progress. We observe a wide variety of characteristics and patterns in these payloads. For example, the payload size seen in a single packet varies from one byte, which we call as tiny packet, to the Maximum Segment Size (MSS) restriction of a TCP connection imposed by the end-to-end path. Some dominant patterns in the payload include instructions to connect to third-party botmasters; downloaders like wget, curl and busybox based instructions; shell commands to grant permission to execute malicious scripts and so on. Further analysis of these patterns and extraction of Network Telescope centric threat intelligence from these packets is part of our future work.

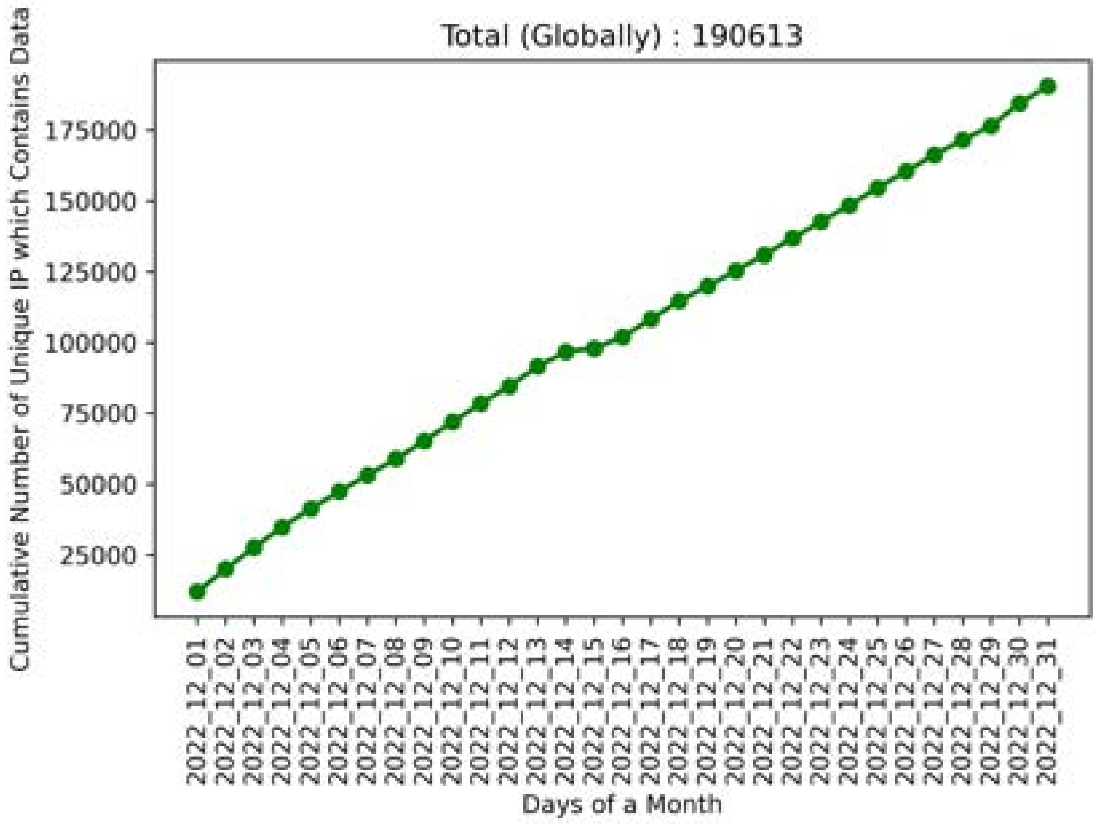


Figure 1.7: Cumulative number of unique IP addresses containing payload/data observed at the Network Telescope.

1.6 Sea Surface Temperature (SST) prediction using Deep Learning Technique

Sea Surface Temperature (SST) is one of the crucial parameters in oceanography study and SST prediction has a significant impact in many applications in the field of forecasting ocean weather and climate, fishing zones identification and also strategic sectors like defense etc. Over the years, many approaches based on dynamic models and statistical models have been used for prediction of sea surface temperature. As dynamic models are compute and time intensive and statistical approaches are lightweight, we have proposed Deep Learning (DL) based technique as shown in Figure 1.6(a) for predicting SST in the Arabian Sea. Sea surface temperature (SST) data used in the experiment was collected from mid IR band of “Moderate Resolution Imaging Spectroradiometer” (MODIS) aqua satellite platform at wavelength of 11 with spatial resolution of 4 km. The data was obtained from NASAs Earth Observing System Data and Information System Physical Oceanography Distributed Active Archive center at the Jet Propulsion Laboratory. These SST data were acquired as Level 3 gridded data product with three dimensions (i.e. latitude, longitude and time) in temporal resolution of one day in Network Common Data Form (NetCDF) format. Data considered for this experiment was collected at Lon-71E, Lat-19 N of Arabian Sea. We have improvised standard LSTM as well as CNN with attention layers and ensemble them to obtain better accuracy compared to standard CNN and LSTM as shown in Figure 1.6(b). The experimental outcome of our proposed technique convincingly justifies the logic behind the enhanced technique.

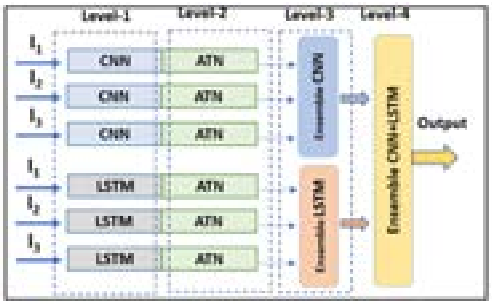


Fig 1(a) Block diagram of AI-based model for SST prediction in Arabian Sea

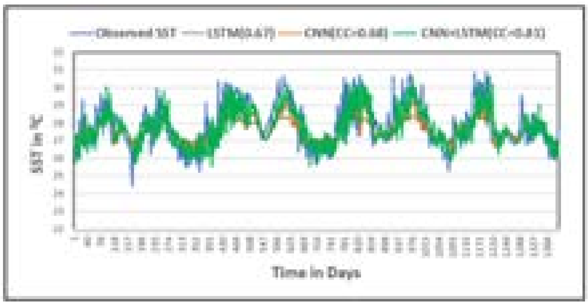


Fig 1(b) Performance of Ensemble Model with CNN and LSTM Models vs standard CNN & LSTM models for predicting 7 days ahead SST in Arabian Sea

Ashapurna Marndi and G K Patra

II Earth & Engineering Sciences

2. Advanced Weather & Climate Research

CSIR-4PI has a unique positioning in CSIR as the only lab for advanced climate modelling and its impact on multiple sectors like agriculture, health, water, energy, disaster management etc. CSIR-4PI has the niche expertise to carry out this inter-disciplinary research and below are some of the major outcomes this year.
Inside:

- Modelling for Biogeochemical Cycles in the north Indian Ocean
- The interannual modes and secular trends in the tropical Atlantic Region: A new dynamical perspective
- A comprehensive perspective on the influence of seasonal cycles on the origins of Indo-Asian monsoons
- Challenging Assumptions: Unveiling the Relationship Between Low-Frequency Variations and Seasonal Cycles in Scientic Literature
- Reconsidering Reynolds Decomposition in Complex Systems: Implications for Time-Invariant Components
- Understanding unexpected evolution of Indian summer monsoon rainfall
- Exacerbation of Indian summer monsoon breaks: Evidence of aerosol indirect effect from an earth system model
- ENSO-monsoon relationship in state-of-the-art global climate models
- Relationship of height and intensity of Low-Level Jet stream with Indian summer monsoon rainfall
- Association of winter vegetation activity across the Indo-Gangetic plain with the subsequent Indian summer monsoon rainfall
- Analysis of actual evapotranspiration over India
- Application of different microphysics parameterization schemes in WRF model in simulating extreme rainfall events over Bangalore city
- Leaf Area Index estimation over the Kosi Watershed in Central Himalaya from

Sentinel-2 using Machine/Deep Learning Models
- Impact of orography and decadal LULC change in simulating streamflow over the Western Indian Himalayan region using SWAT model
- Future Projections of Heat Wave Characteristics over India under CMIP6 Scenarios
- Variability and change in Marine Heatwaves in the Indian ocean
- Investigating the associated dynamics of 2019 Heat wave over India
- Dynamical Inuence of MJO Phases on the Onset of Indian Monsoon
- A comprehensive Study of atmospheric dynamics during Cloudburst over India Himalayan Region
- Inter-comparison of atmospheric CO_2 concentrations measured over mountain region (Hanle) and urban region (Hosakote) in India using high precision instrument
- Trends of seasonal and annual rainfall of semi-arid districts of Karnataka, India: application of innovative trend analysis approach
- Extreme rainfall event analysis over the state of Himachal Pradesh in India
- Impact of comorbidity on patients with COVID-19 in India: A nationwide analysis
- The synergistic effect of climatic factors on malaria transmission: a predictive approach for northeastern states of India
- Weather integrated malaria prediction system using Bayesian structural time series model for northeast states of India
- Estimating the Impact of Spatio-temporal Land Cover Changes on Land Surface Temperature and Air Quality Using Satellite Data in Beas Valley, Himachal Pradesh, India
- Evaluation of ARIMA, Facebook Prophet and a boosting algorithm framework for monthly precipitation prediction of a semi-arid district of north Karnataka, India

2.1 Modelling for Biogeochemical Cycles in the north Indian Ocean

Results of TOPAZ and COBALT (marine biogeochemical models) simulations using CORE and NCEP fluxes are analysed in detail for spatial, seasonal and interannual variations of various biogeochemical components in the north Indian ocean. Model validation studies are carried out using the data from atlases, satellites and cruises including the recent data from World Ocean Circulation Experiment (WOCE) on Nutrients, Primary Productivity, Chlorophyll, Dissolved Inorganic Carbon, Alkalinity, pCO_2, Temperature, Salinity and Mixed Layer Depth for several regions in the Arabian Sea (AS) and the Bay of Bengal (BOB). It is noted that model is able to capture well many of the significant features in spatial, seasonal and interannual variabilities of state variables and fluxes of marine biogeochemical cycles in the AS and BOB.

Spatial and monthly variations of some of the state variables and primary productivity are being analysed in detail in the suboxic (60:66°E, 22.5:24.5°N, 60:68°E, 20:22.5°N, 85:87°E, 17:20°N) and other regions in the AS (60:70°E, 4:8°N) and the BOB (88:92°E, 4:8°N) to understand the carbon and nitrogen cycle in the suboxic zones.

Results of two marine biogeochemical model simulations (TOPAZ and COBALT) are compared for different state variables. It is noted that suboxic zones in the AS and BOB are more intense and at deeper depth for COBALT model simulations compared to TOPAZ.

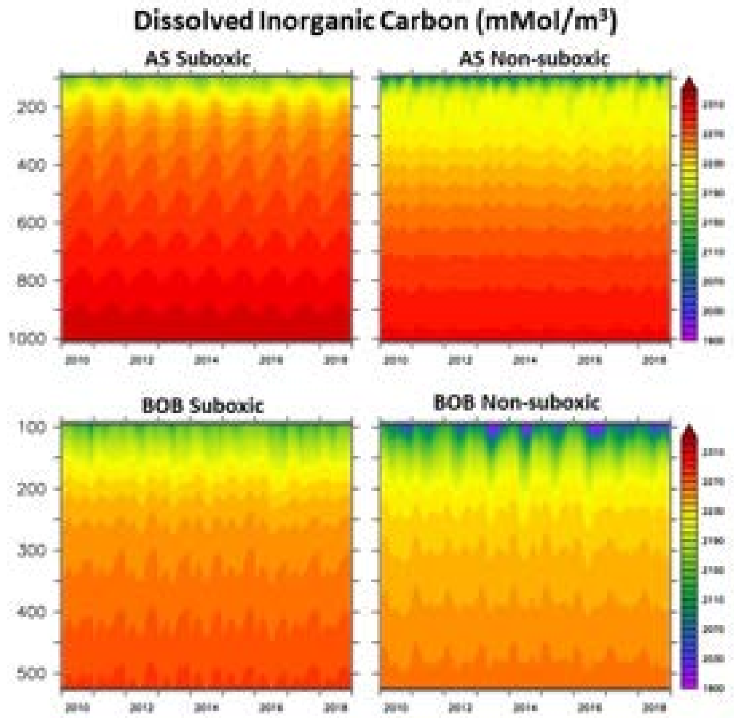


Figure 2.1: Comparison of Dissolved Inorganic Carbon (mMol/m^3) with respect to depth during 2010 to 2018 for suboxic and non-suboxic zones in AS and BOB.

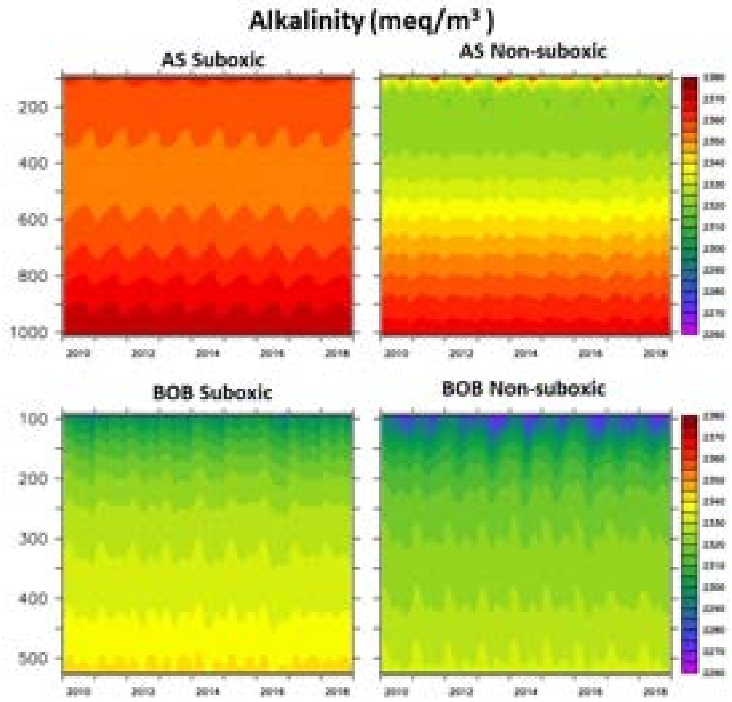


Figure 2.2: Comparison of Alkalinity (meq/m^3) with respect to depth during 2010 to 2018 for suboxic and non-suboxic zones in AS and BOB.

Detailed analysis on the spatial, monthly, seasonal and interannual variations of components (Dissolved Inorganic Carbon (DIC), Alkalinity (ALK), partial pressure of CO_2) and fluxes (carbon flux at the surface of the ocean) related to carbon cycle are done for suboxic and other zones in the AS and BOB. Monthly variations of DIC and ALK with respect to depth for the years 2010-2018 for suboxic and one of the other region in AS and BOB are shown in Figures 2.1 and 2.2. It is noted that DIC & ALK are more at all depths during all months in suboxic zones compared to other regions in the AS and BOB, and also DIC & ALK are less in BOB compared to AS.

Monthly variations of Carbon flux at the surface (mg/m^2/d) in the AS and BOB show that Carbon flux from ocean to atmosphere is higher for suboxic zone in the AS and is lower for the suboxic zone in the BOB, compared to non-suboxic zone. Also, primary productivity (PP) (mg C/m^2/d) in the euphotic zone during 2010 to 2018 in the AS is higher for suboxic zone compared to non-suboxic zone in the AS whereas PP for suboxic and non-suboxic zones in the BOB are almost similar. Detailed analysis on the biogeochemical variables, fluxes and processes are being done using TOPAZ and COBALT model simulations with Core Fluxes and NCEP fluxes, to understand the spatial and temporal variabilities of carbon and nitrogen cycles in the suboxic zones in the AS and BOB, and estimation of impact of climate change on marine ecosystem. Also, model validation studies in different regions of the AS and BOB will be continued using data on physical, biological and chemical variables from cruises, satellites and ARGO floats.

M K Sharada, C Kalyani Devasena and P Lakshmikanthan

2.2 The interannual modes and secular trends in the tropical Atlantic Region: A new dynamical perspective

Weather events, including continental rainfall, Atlantic hurricane activity, biological productivity, and climatic conditions both within and beyond the tropical Atlantic, are significantly influenced by oceanic and atmospheric conditions. To determine the primary seasonal changes in the tropical Atlantic region, an analysis is conducted on the monthly observations of surface temperature of land and sea, surface pressure and wind, and outgoing long wave radiation fields spanning from 1948 to 2021. Each variable's variations are individually broken down to extract multiple seasonal cycles.

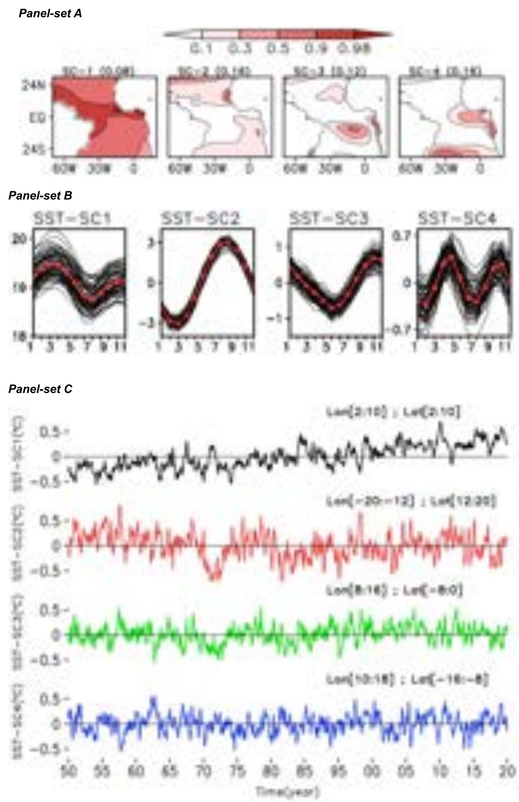


Figure 2.3: Spatio-temporal characteristics of SST-SCs - Panel-set A, normalized variance distributions. The normalization factors are given at the top of each panel. Panel-set B, Sixty-eight domain-averaged season cycles in 12-month windows (i.e., January to December). Panel-set C, The mean seasonal cycles are shown as a red line. Anomaly time series of seasonal modes averaged over their regions of maximum variance (refer A). Anomalies are the deviations from the respective mean seasonal cycle (red lines in B).

The adjustments in pressure due to seasonal temperature changes and the resulting wind responses are effectively captured by each set of seasonal modes. The primary interannual patterns and long-term trends reflect the amplitude fluctuations of these seasonal modes on interannual and decadal time scales.

Rameshan Kallummal

2.3 A comprehensive perspective on the influence of seasonal cycles on the origins of Indo-Asian monsoons

The seasonal and interannual variations of the Indo-Asian monsoon are influenced by numerous interconnected processes involving the atmosphere, oceans, and land. The classical explanation attributed these changes to variations in the amplitude and timing of thermal responses of land and ocean surfaces to solar radiation. However, a recently proposed dynamic framework highlights the significance of the equatorial trough's seasonal movement from north to south. Nevertheless, neither the classical nor the contemporary perspective fully accounts for all aspects of the monsoon phenomenon. Consequently, scientists continue to investigate the fundamental physical mechanisms responsible for the occurrence of monsoons.

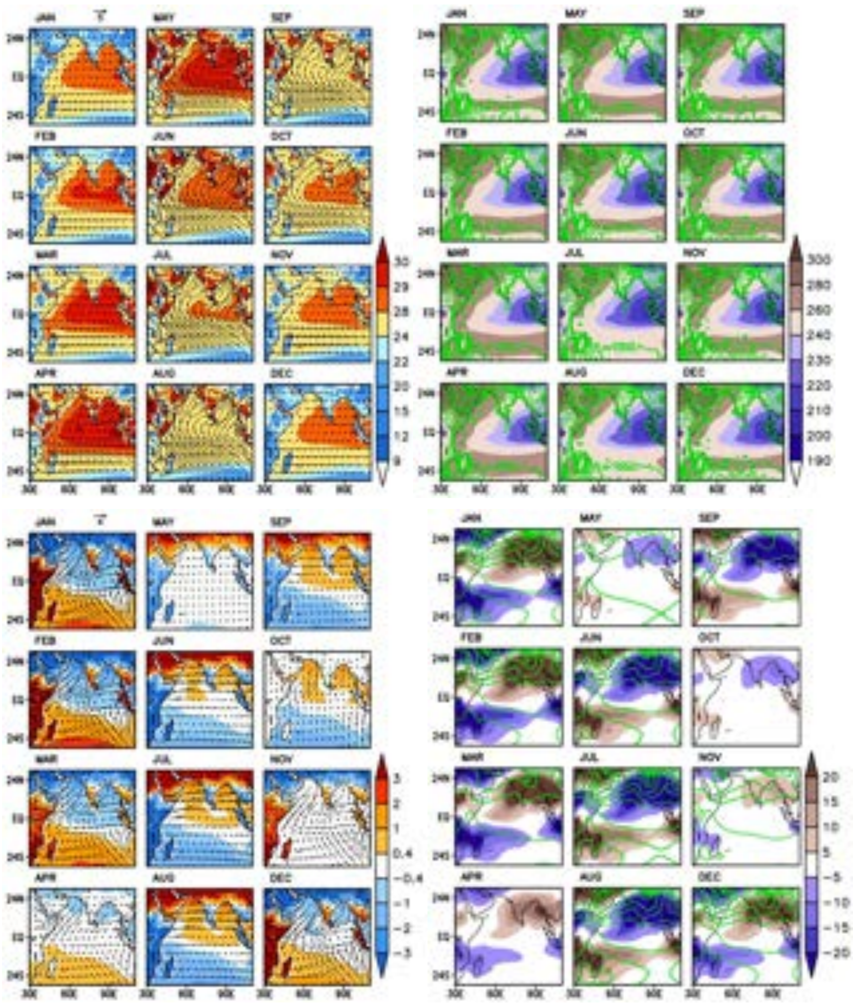


Figure 2.4: Two sets of Seasonal cycles long-term means: SC1 (top panel-sets), SC2 (bottom panel-sets). In the left panels, shades are for SST and land surface temperature (C°) and vectors for wind (m sec^{-1}). In the right panels, shades are for OLR (Watts m^{-1}), and green contours the Surface Pressure (hPa). In the top-right panel, the green contours are the deviations of Surface Pressure from 1000 hPa. The negative values of Surface Pressure are shown as the dashed-contours.

This study aims to reconcile the divergent perspectives mentioned above by employing four distinct sets of multivariate seasonal cycles derived from observations of Sea and Land Surface Temperature, Surface Wind, Outgoing Long Wave Radiations, and Surface Pressure variations. The first set of seasonal cycles captures the annual variations in the ocean-atmosphere system's responses to solar forcing, wherein lower pressure consistently coincides with land masses, aligning with the classical understanding of monsoon circulations based on land-sea thermal contrasts. In contrast, the other three sets of seasonal cycles, either individually or in combination, drive the shifting convection patterns from north to south, supporting the modern viewpoint. It is proposed that the first set of seasonal cycles serves as the baseline state for the other three sets. Furthermore, the analysis emphasizes the need to examine the spatial-temporal distribution of seasonal rainfall in relation to year-to-year changes in the amplitudes of seasonal cycles. However, here we show only the covariations of leading two seasonal cycles.

Rameshan Kallummal

2.4 Challenging Assumptions: Unveiling the Relationship Between Low-Frequency Variations and Seasonal Cycles in Scientific Literature

My recent research has critically examined decades of peer-reviewed scientific articles focusing on low-frequency variations in order to assess low-frequncy events' assumed independent dynamical origin from seasonal cycles. The statistical analyses conducted in my studies have presented compelling evidence that contradicts this long-held assumption. Through the development of a novel dynamical paradigm, I have demonstrated that the interannual amplitude modulations of seasonal cycles effectively exhibit the characteristic features of several prominent low-frequency modes, including IOD, ENSO, PDO, and others. By understanding the relative contributions of local and remote processes, this approach offers a valuable strategy for enhancing the accuracy of modeled seasonal cycles.

Rameshan Kallummal

2.5 Reconsidering Reynolds Decomposition in Complex Systems: Implications for Time-Invariant Components

Reynolds decomposition, a mathematical technique pioneered by Osborne Reynolds (1842-1912), has been widely used to separate the instantaneous variation of a physical process into average (time-independent) and fluctuating components. While this decomposition has proven useful in simplifying the analysis of time-evolving non-linear equations, my research challenges its applicability to complex systems. I have demonstrated that the leading modes of such systems are unlikely to exhibit time-invariant components, rendering the traditional use of Reynolds decomposition questionable in this context. Consequently, caution should be exercised when employing this technique in complex systems.

Rameshan Kallummal

2.6 Understanding unexpected evolution of Indian summer monsoon rainfall

The most important factor determining the year-to-year (interannual) variation of the Indian summer monsoon rainfall (ISMR) is El Niño-Southern Oscillation (ENSO, the interannual variability in the sea surface temperatures (SSTs) over the equatorial central Pacific Ocean). Hence, a major input in understanding the evolution of ISMR on seasonal or monthly scale is the evolution of the ENSO. There has been phenomenal progress in understanding and predicting ENSO since the 90s which made reasonably reliable seasonal predictions of ENSO possible. If the phase of ENSO is predicted to be cold (warm), the expectation is for an excess/normal (deficit/below normal) monsoon rainfall over India. However, considerable variation in ISMR is observed even for the same phase of ENSO. For example, a drought occurred in the summer monsoon of 1985 during a cold event of ENSO, instead of the expected excess rainfall. This warrants deeper understanding of the monsoon-ENSO relationship. Understanding how these unexpected monsoons arise forms the very basis of exploring the possibilities of predicting their evolution in the beginning of the summer monsoon season.

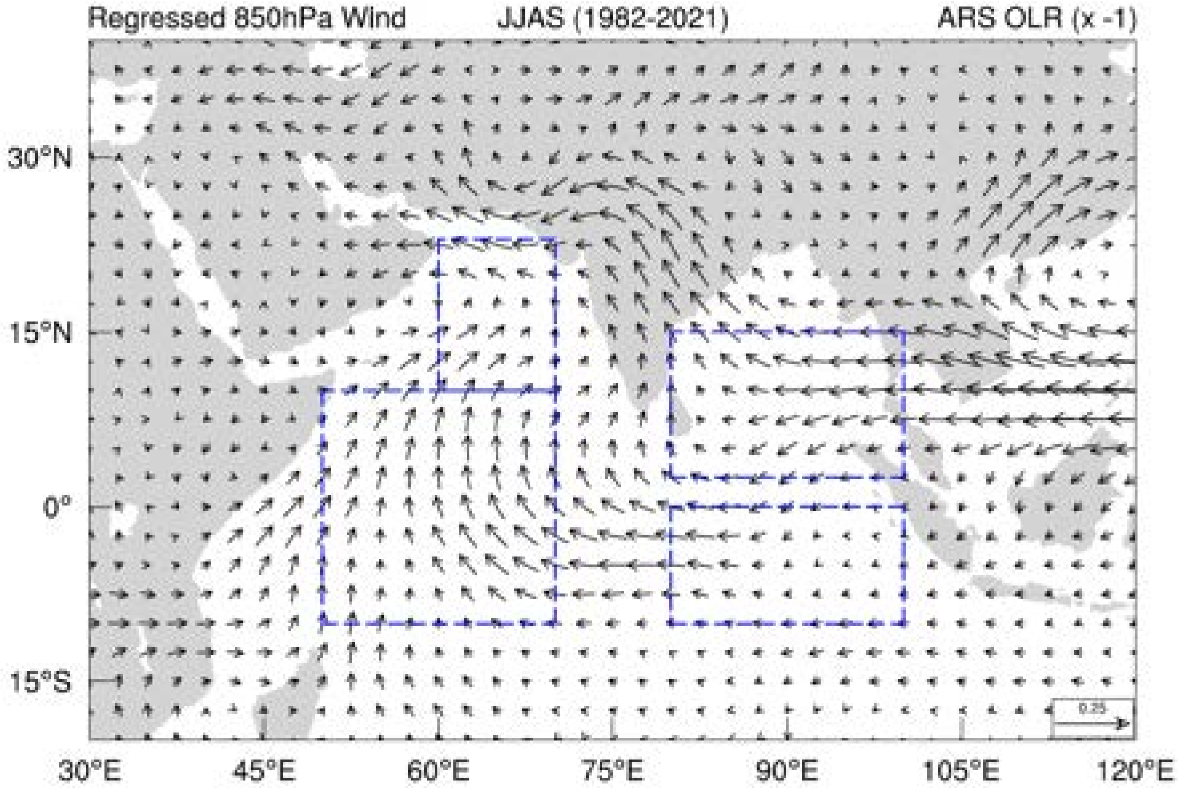


Figure 2.5: Regressed summer season (June to September, JJAS) winds at 850 hPa against the outgoing longwave radiation (OLR) anomalies over the western Arabian Sea (ARS, denoted by blue box).

The influence of ENSO on ISMR could either be through the direct impact of convection anomalies over the equatorial central Pacific Ocean or through the indirect impact of convection anomalies over other regions triggered by the convection anomalies over the equatorial central Pacific. The direct impact is primarily through changes in the Walker circulation in which ascent over the enhanced convection/rainfall over the equatorial central Pacific during the warm phase leads to descent and suppression of convection/rainfall over the regions to the west including the west Pacific, the north and equatorial Indian Ocean and the Indian landmass, and vice versa. The mechanism behind the indirect impact of ENSO is the influence of enhanced convection over the equatorial central Pacific in increasing the vorticity anomalies within the North African-Asian (NAA) jet due to the westward propagating Rossby waves. The teleconnection linking ENSO and the monsoon is mediated by this response of the NAA jet. This would be reflected in the correlation between the monsoon rainfall and the convection anomaly associated with the anomaly of the NAA jet, triggered by the equatorial central Pacific convection. We identified the regions over which ENSO has large impact on the convection/SST anomalies and at the same time show large impact on ISMR. It is found that the evolution of SSTs and convection over the western and eastern equatorial Indian Ocean, southern Bay of Bengal and the western Arabian Sea (ARS) plays the deciding factor (Figure 2.5).

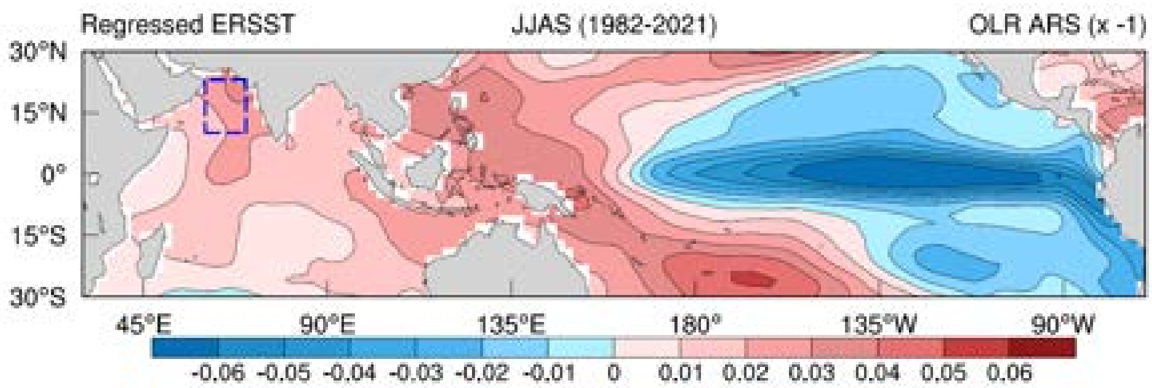


Figure 2.6: Regressed summer season (June to September, JJAS) sea surface temperatures against the outgoing longwave radiation (OLR) anomalies over the western Arabian Sea (ARS, denoted by blue box).

The SSTs are warmer over the entire north Indian Ocean mainly over the selected Arabian Sea region (ARS) during excess monsoon years (Figure 2.6). This implies that cooler Arabian Sea and suppressed convection over the Arabian Sea during JJAS are important attributes of outliers of ENSO

2.7 Exacerbation of Indian summer monsoon breaks: Evidence of aerosol indirect effect from an earth system model

The composite anomalies for active and break spells of Indian summer monsoon show sign reversals (Figure 2.7) for important parameters. During the break (active) spells when dust aerosol loading is anomalously high (low), cloud effective radius (CER) is lower (higher) than the average. This is an evidence for the indirect effect of aerosols on clouds and precipitation. The reversal in anomalies of shortwave flux (SWF_{TOA}) and longwave flux (LWF_{TOA}) at the top of the atmosphere (TOA) implies the semi-direct effect of aerosols. The indirect and semi-direct effects of dust aerosols during the breaks contribute to trap solar radiation and warm the atmosphere. This warming results in exacerbating the severity of monsoon breaks.

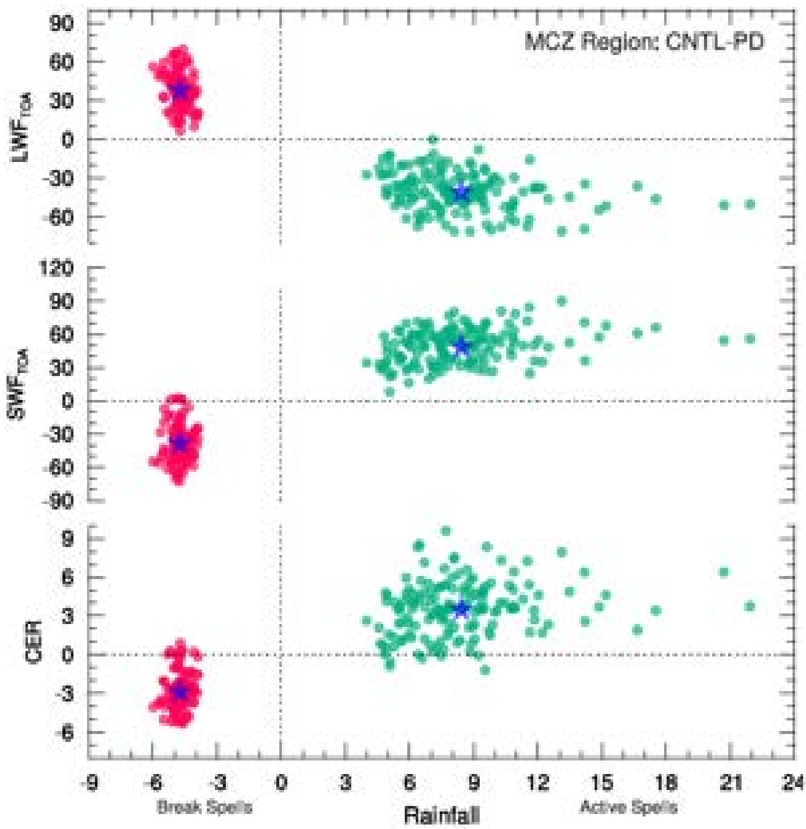


Figure 2.7: Scatterplots of cloud effective radius (CER), shortwave flux and longwave flux (SWF_{TOA} and LWF_{TOA}) at the top of the atmosphere against rainfall over India for active and break spells from a global earth system model (CESM) simulation (CNTL-PD). The blue stars indicate the centroids.

Sajani Surendran, K. V. Ajay Anand[1], Suraj Ravindran[2] and K. Rajendran
[1] - Indian Institute of Science, Bengaluru
[2] - Indian Institute of Technology, Delhi

2.8 ENSO-monsoon relationship in state-of-the-art global climate models

We analysed the performance of sixty one global climate models participated in the 6^{th} generation of Coupled Model Intercomparison Project (CMIP6), in simulating the Indian summer monsoon and its teleconnections with rainfall variability over the equatorial Pacific associated with El Niño-Southern Oscillation (ENSO). Several coupled models successfully capture the evolution and strength of the monsoon-ENSO inverse correlations during summer (Figure 2.8). However, the corresponding atmosphere-only models are not as successful in getting this relationship (Figure 2.8 inset). The improved skill of coupled models is due to the better representation of air-sea interaction in them. This warrants employing global coupled ocean-atmosphere models for the simulation and/or prediction of Indian summer monsoon and its variability, as they are more adept in simulating the important monsoon-ENSO teleconnection relationship.

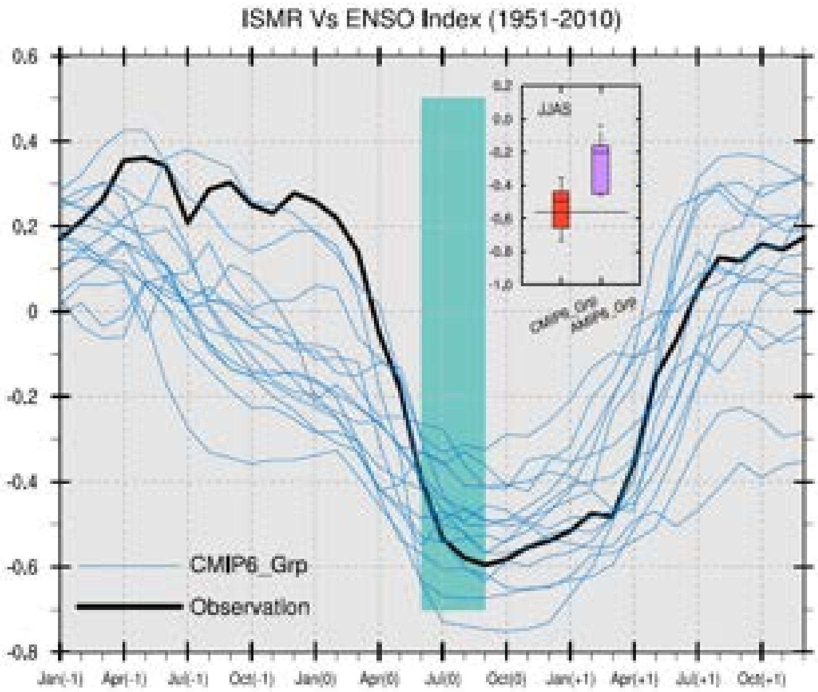


Figure 2.8: Correlation coefficients (CCs) between Indian summer monsoon rainfall (ISMR) anomaly and NINO3.4 SST anomaly (an index for El Nino-Southern Oscillation, ENSO) at monthly lags for observation (black line) and simulations from 15 best CMIP6 (CMIP6_Grp) models (blue lines). June-September (JJAS) season is highlighted in green. Inset: Box and whisker plots showing CCs during JJAS for 15 CMIP6_Grp models and their corresponding atmosphere-only models (AMIP6_Grp). The horizontal black line denotes the observed CC.

K. Rajendran, Sajani Surendran, Stella Jes Varghese[1] and Anjali Sathyanath[2]
[1] - University of Hyderabad
[2] - Indian Institute of Technology, Kharagpur.

2.9 Relationship of height and intensity of Low-Level Jet stream with Indian summer monsoon rainfall

The variability of MLLJ is examined using the fifth generation ECMWF reanalysis ERA-5, (NCEP-CFSR) / CFSv2, MERRA-2 and radiosonde data during 40 years period (1979-2018). The results suggest that there is an increasing trend in MLLJ strength during July and September, but a decreasing trend is observed during August. The MLLJ height showed an increasing trend in all the data sets. Significant interannual oscillations in MLLJ strength and height are observed with a prominent periodicity of 2-3 years (Figure 2.11). The ISMR over Western Ghats region and central India showed strong positive correlation with the MLLJ strength as well as height except during August. It is noted that the influence of the MLLJ on rainfall over the Indian landmass is stronger during the onset and withdrawal phases of monsoon. The increasing trend in MLLJ height indicated the possibility of increase in rainfall over many regions in India especially Western Ghat and Central India.

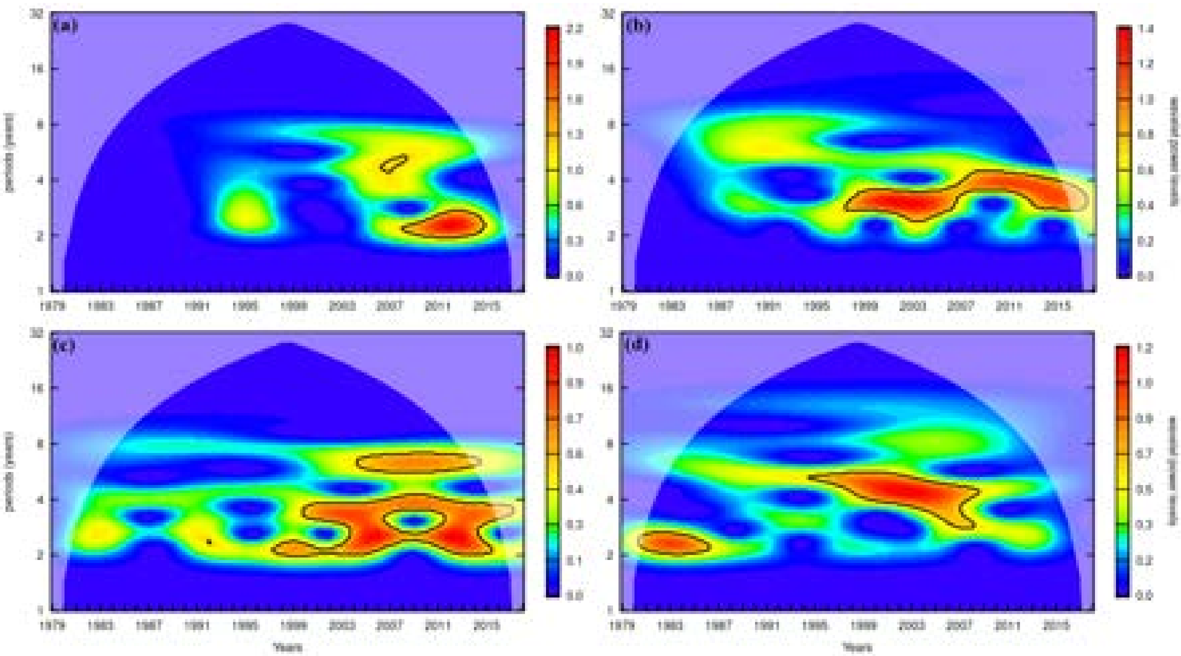
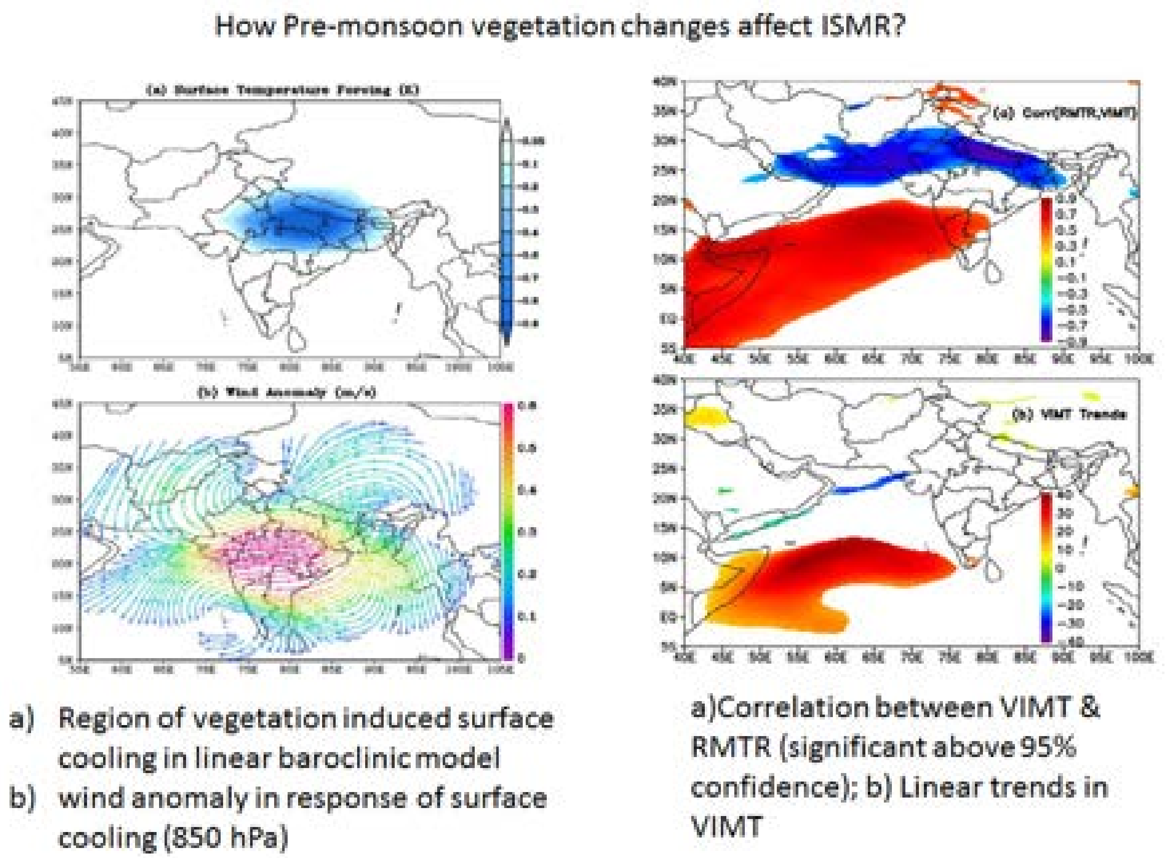


Figure 2.9: Wavelet spectra of MLLJ height from ERA-5 reanalysis data for (a) June, (b) July, (c) August and (d) September (the wavelet spectrum inside black contour showing 95% significance).

Purwar S., Rakesh, V., Bankar, A., and Mohapatra, G. N

2.10 Association of winter vegetation activity across the indo-gangetic plain with the subsequent Indian summer monsoon rainfall

We hypothesized that the January vegetation state affects the ISMR via a delayed hydrological response, in which the wet soil moisture anomaly formed throughout the winter to accommodate the water needs of intensive farming influences the ISMR. The soil moisture anomalies developed in the winter, particularly in the root zone, persisted throughout the summer. Evaporative cooling triggered by increasing soil moisture lowers the summer surface temperature across the IGP. The weakening of monsoon circulation as a result of the reduced intensity of land-sea temperature contrast led in rainfall suppression. Further investigation shows that moisture transport has increased significantly over the past two decades as a result of increasing westerly over the Arabian Sea, promoting rainfall over India (Figure 2.10). Agriculture activities, on the other hand, have resulted in greater vegetation in Indias northwest and IGP during the last two decades, which has a detrimental impact on rainfall processes. Rainfall appears to have been trendless during the last two decades as a result of these competing influences. With a lead time of 5 months, this association between Januarys vegetation and ISMR could be one of the potential predictors of seasonal rainfall variability.



Singh, R., Rakesh, V. and Varma, A.K

2.11 Analysis of actual evapotranspiration over India

Spatio-temporal variability in actual evapotranspiration (ETa) plays a major role in the water and energy budget and is important for irrigation management in India. There is a knowledge gap in the quantitative estimation of ETa due to the sparse in-situ observation data in India. The present study utilized the satellite-based actual evapotranspiration data (GLEAM: Global Land Evaporation Amsterdam Model) to study the annual and seasonal variability over different IMD meteorological sub-divisions in India during the period 1980-2018. The major finding of this study is that the all-India average annual ETa is 573 mm with a standard deviation of 29mm. The transpiration processes (μ = 456 mm; σ = 30 mm) play a major role compared to all other evaporation processes in India. The MannKendall (MK) trend analysis shows that there is an increasing trend (1.33 mm/yr) in annual ETa due to the rising trend in transpiration (1.91 mm/yr) over India. The sub-division-wise analysis shows that there is an increasing trend in actual evapotranspiration over highly irrigated regions which are located in the south, north-west, and foothills of the Himalayas during pre-monsoon (March-May) and monsoon season (June-September). However, the major driving meteorological parameters involved in the actual evapotranspiration process are rainfall, soil moisture, surface net solar radiation, temperature, humidity, and wind speed. The correlation analysis observed a complex relationship between actual evapotranspiration and climatic factors (rainfall (RF), soil moisture (SM), surface temperature (T), relative humidity (RH), surface net solar radiation (SSR), and wind speed (WS)) during monsoon season. The analysis shows that the RF, SM, and RH have a positive association with actual evapotranspiration over water-limited areas (potential evapotranspiration is limited by surface water availability) and a negative correlation with WS, T, and SSR. In the case of energy-limited areas, the actual evapotranspiration showed a positive correlation with SSR and T and a negative correlation with RF. Based on the results it is attributed that the main climatic drivers for the increasing trend of actual evapotranspiration are soil moisture and rainfall over dry regions and SSR and T over densely vegetated regions in India.

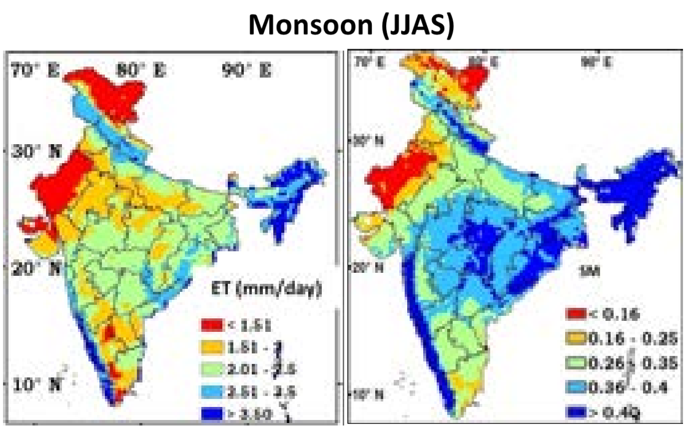


Figure 2.10: Climatological map of actual evapotranspiration and soil moisture during monsoon season in India.

Kanth Rao B, K R Prasad, GK Patra, Himesh S and Goroshi S

2.12 Application of different microphysics parameterization schemes in WRF model in simulating extreme rainfall events over Bangalore city

We explored the impact of distinct microphysics parameterization schemes in weather research and forecast (WRF) model on extreme rainfall events (EREs) simulation over Bangalore city, India. Bangalore city is known as the IT hub of India and the unexpected infrastructure growth to accommodate many livelihoods putting lot of challenges upon climatic condition of the city. The study assessed the impact of five microphysical parameterization schemes of the model (Eta, Goddard, New-Thompson, Morrison double moment, and WDM6) on the prediction of 30 extreme rainfall events (EREs) (15 local and 15 nonlocal events). Model simulations were carried out with four nested domain configurations with horizontal grid resolutions at 36 km, 12 km, 4 km, and 1.3 km. Model skill with different microphysics was assessed by validating against in-situ observations over 34 hoblis (a cluster of adjoining villages) in Bangalore city. The double moment microphysics schemes (MPSs) such as New-Thompson and Morrison2mom outperformed others in quantitative rainfall prediction for majority of cases. In the entire statistical analysis, the performance of Eta MPS was very poor in predicting both nonlocal and local EREs. Analysis of thermodynamic indices such as CAPE and K- index showed that model with different MPS could reproduce thermodynamic conditions leading to EREs; however, there was no clear and consistent advantage observed with a particular MPS.

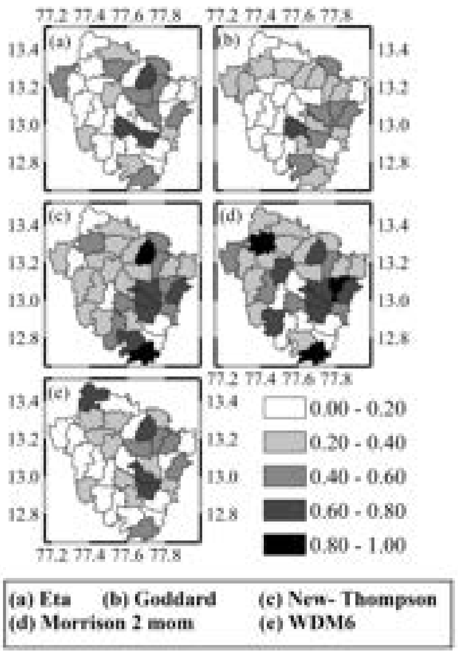


Figure 2.11: Spatial distribution of hit rate in 24 hour accumulated rainfall forecasts with different microphysics schemes for Local ERE Cases.

G. N. Mohapatra Smrati Purwar and V. Rakesh

2.13 Leaf Area Index estimation over the Kosi Watershed in Central Himalaya from Sentinel-2 using Machine/Deep Learning Models

Machine learning (Support Vector Machine; SVM) /deep leaning (Long Short Term Memory; LSTM) based methods are deployed to estimate LAI from Sentinel-2 mutli-spectral imagery over the Kosi watershed in the central Himalayan region based on multiple vegetation indices. Four variants of LSTM models were tested and the Bidirectional LSTM was found to be best in deriving LAI. The performance of Bidirectional LSTM in deriving LAI is compared with SVM and Moderate Resolution Imaging Spectro Radiometer (MODIS) LAI product by validating against in-situ LAI measurements. The in-situ LAI data were collected by random sampling method using Plant canopy analyser LI-COR LAI-2200 for a period of 25 days of continuous field survey. LAI retrieved based on Rendevi index is found to be superior compared to retrieval based in other vegetation indices. The LSTM model outperformed SVM in retrieving LAI in terms all accuracy measures computed. The LAI retrieved using LSTM showed superior agreement with in-situ measurements compared to MODIS LAI product. The seasonal changes in vegetation over the Kosi watershed and interannual variation in LAI are better depicted in high resolution LAI retrieved using LSTM from Sentinel-2 compared to MODIS LAI product (Figure 2.12).

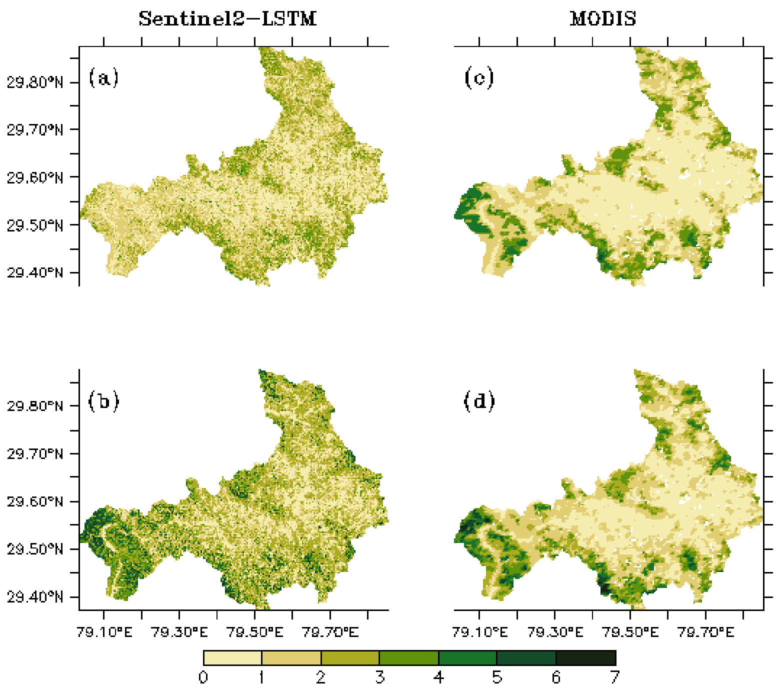


Figure 2.12: Estimated Rendvi based Leaf area index using Bidirectional LSTM from Sentinel-2 image (Left panels) for (a) February and (b) November averaged over the period 2016-2020. The same is compared with MODIS LAI product (Right panel) for February (c) and November (d).

Rakesh V and Ramesh K V

2.14 Impact of orography and decadal LULC change in simulating streamflow over the Western Indian Himalayan region using SWAT model

The main objective of this study is to quantify the decadal changes in LULC and to assess the impact of orography as well as LULC changes in simulating the streamflow in the Upper Jhelum Basin of Western Himalaya for the period 1979 to 2018. The customised and configured version of Soil and Water Assessment Tool (SWAT) model is used to simulate and to understand the climate impact on the streamflow variability in the upper Jhelum basin. Advanced land Observing Satellite Phased Array type L-band Synthetic Aperture Radar (ALOS PALSAR, 12.5m), CARTOSAT (32m) and Shuttle Radar Topography Mission (SRTM, 30m) Digital Elevation Models (DEMs) along with LULCs at intervals of every 5 year from 2001 to 2019 are used to simulate the model. The model simulations are carried out with multisource rainfall from fifth generation ECMWF atmospheric reanalysis (AgERA5 0.1°), India Meteorological Department (IMD 0.25°) and Tropical Rainfall Measuring Mission (TRMM 0.25°). After identifying the streamflow sensitivity parameters to validate the model results using SWAT- Calibration Uncertainty Program (SWAT-CUP) for the period 2004 to 2018. The impact of LULC change was prominent in simulated surface parameters and simulation results were more realistic when ALOS PALSAR and CARTOSAT DEMs were used. Model performance evaluation parameters such as Coefficient of Determination (R2), Nash-Sutcliffe efficiency coefficient (NSE) and percentage bias (PBIAS) were obtained 0.77 (0.80), 0.80 (0.83) and 18.69 (10.69) respectively for ALOS PALSAR (CARTOSAT) DEMs. It is noted that the annual streamflow for the whole watershed is decreased during the monsoon months while snowmelt is found to be increasing in the summer months over the years from 1979 to 2018.

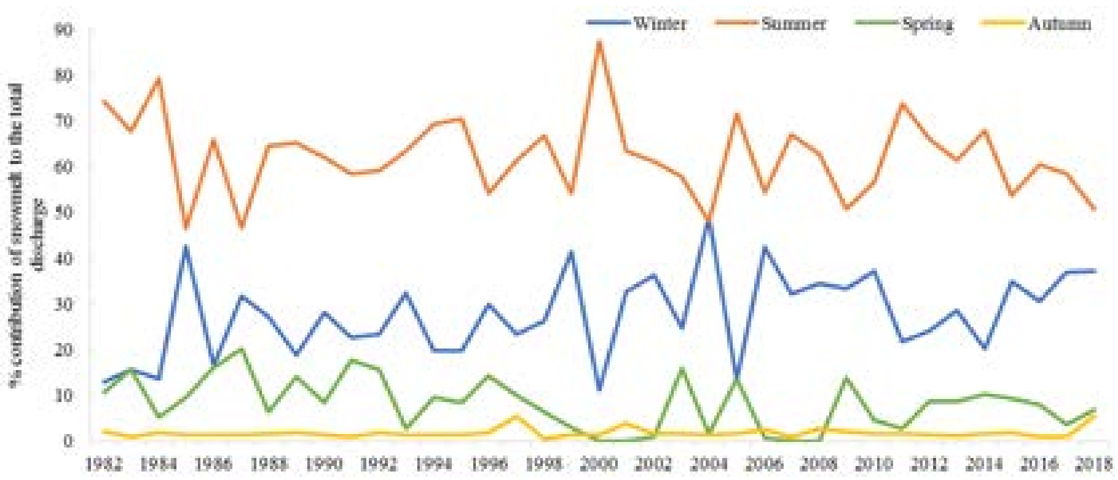


Figure 2.13: Percentage snowmelt contribution to the total discharge during different season over the Upper Jhelum basin over the period of 40 years.

Dhananjaykumar D, Ramesh K V and Rakesh V

2.15 Future Projections of Heat Wave Characteristics over India under CMIP6 Scenarios

Anomalous episodes of extremely high surface temperature are heat waves, observational studies have shown that heat wave characteristics like intensity, frequency, and duration are increasing regionally and globally. As heat waves inflict disastrous impacts on the livelihood of millions of people, it is critical in developing suitable mitigation strategies to curtail socio-economic vulnerability. Future projections at the regional level will be crucial for climate risk management to policymakers. The present study addresses the changes in the heat wave characteristics over the seven temperature homogeneous zones of India, viz. North West, North Central, West Coast, East Coast, Interior Peninsula, Western Himalaya, and North East. We use the historical (1951-2014) and projections (2015-2100) of the Coupled Model Intercomparison Project phase-6 (CMIP6) under different climate change scenarios based on Shared Socioeconomic pathways, SSP126, SSP245, SSP370, and SSP585. The reliability assessment has been carried out and the selected model composite showed good skill than all model composite, in the multiple aspects of observed heat wave features over each zone. The findings show that the projected area of occurrence of extreme daily maximum temperature and long-lasting heat waves (>11 days) are considerably increasing over all zones, where the exacerbating increase is over the West Coast under all climate change scenarios. The heat wave days are likely to increase two times over Western Himalaya and North West, while the warm days are increasing four-fold over the West Coast and double over other zones under SSP370 and SSP585 (Figure 2.14). The projected changes in heat wave characteristics over the North East is below the all-India average. High-intensity heat waves are probably over the coastal zones under the scenario SSP370 and SSP585. Currently, the least heat wave has impa50cted the West Coast, likely to be more vulnerable in the future.

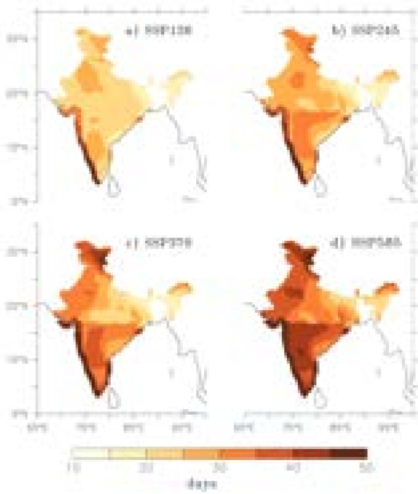


Figure 2.14: The projected warm days (%) in the season April-June of the period 2020-2100 under the climate change scenarios SSP126, SSP245, SSP370, and SSP585.

Neethu C and K V Ramesh

2.16 Variability and change in Marine Heatwaves in the Indian ocean

Marine heatwaves (MHWs) are prolonged periods of unusually warm ocean waters that have a significant impact on the structure and functioning of marine ecosystems. Globally, the frequency of MHWs is increasing at a concerning rate. A heatwave event is declared when the daily sea surface temperature (SST) at a specific location exceeds its 90th percentile for a minimum of five consecutive days. MHWs are categorized based on their intensity: moderate events have a temperature anomaly () between 1◦C and 2◦C, strong events range from 2◦C to 3◦C, severe events span 3◦C to 4◦C, and extreme events have a sea surface temperature anomaly (SSTa) greater than 4◦C. Analyzing the observed occurrences of MHWs during the post-monsoon season, the figure illustrates trends in frequency, duration (measured in days), and intensity (Figure 2). The overall number of MHWs has increased by 0.9 events per year, accompanied by a rise in heatdays of 0.3 days per year. The years with the highest number of heatwave events coincide with the periods of maximum observed heatdays. However, in contrast to frequency and heatdays, there is a decreasing trend in the intensity of MHWs over the past few decades. Interestingly, the last decade has experienced a notable increase in both heatdays and frequency, which aligns with the anthropogenic warming of SSTs. This observation suggests that the warming of sea surface temperatures likely plays a role in the emergence of marine heatwave events.

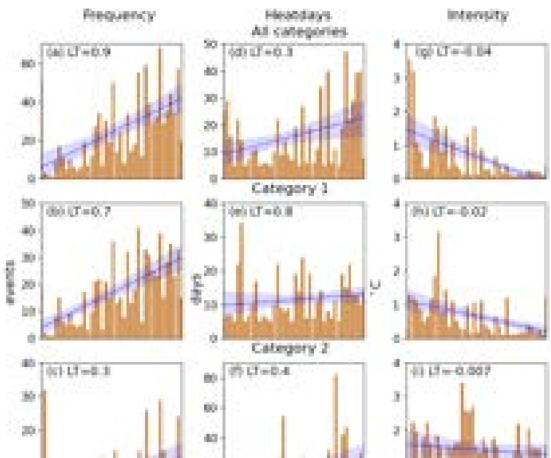


Figure 2.15: Observed trend in frequency (a)-(c) (units-events/year), heatdays (d)-(f) (units- days/year) and intensity (g)-(i) (units- ◦C/year) of detected MHWs in Indian Ocean (1981-2021) 60 during pre-monsoon for all categories of events (top row), category 1 events (middle row) and 61 category 2 events (bottom row). LT denotes the linear trend represented by a blue dashed line 62 and the shaded region represents 95% CI.

Swetha S and K V Ramesh

2.17 Investigating the associated dynamics of 2019 Heat wave over India

India witnessed the second longest recorded heat wave during May-June 2019 causing more human deaths with the maximum temperature recorded was about 51.8°C in a place called Churu in the state of Rajasthan. The present study investigated the spatio-temporal pattern of the maximum temperature and the associate heat waves in the country. The relationship of the heat wave spread and the variables like temperature, humidity, soil moisture as well as the land use and land cover is explored. The dynamics of large scale oceanic and atmospheric features resulting advection and local heating mechanism is found to be the reason of such high intense heat wave in 2019 summer season. The anomaly of all the related weather parameters are linked with the intense maximum temperature and resultant heat wave and the hot spots are identified. The impacts of ENSO (including 'El Niño Modoki') and MJO on the longest and highest heat wave phenomena are also quantified for the year 2019. The role of soil moisture and the evapotranspiration also observed in the analysis which clearly shows lack of these parameters also triggers the intense heat wave events. This study will help in better understanding of the local heat wave dynamics and these informations can be useful for the public health interventions against the intense heat wave situations.

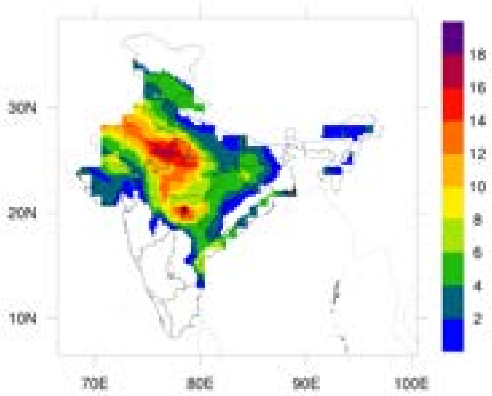


Figure 2.16: Figure shows heat wave days during the summer season in 2019 over Indian region.

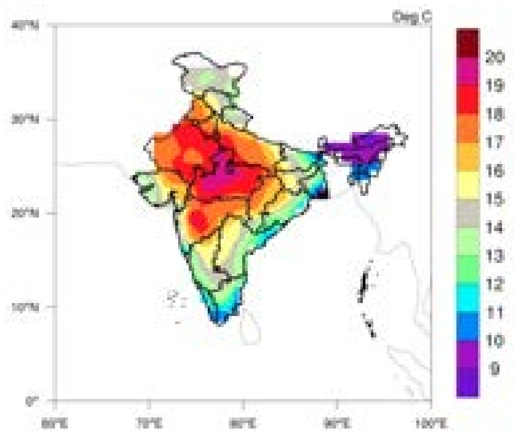


Figure 2.17: Figure shows the average diurnal temperature range during the same season.

Rani Devi, Krushna Chandra Gouda and Smrutishree Lenka

2.18 Dynamical Influence of MJO Phases on the Onset of Indian Monsoon

There is a need to understand the onset of monsoon dynamics as the date of onset of monsoon (DOM) is an important parameter in framing all the policy for the imminent season like crop choice, sowing schedule, disaster management, power distribution etc. It is observed that the interannual variability of the DOM in India is about 7-8 days, making it more challenge to predict this at long lead. The MJO phases are linked with the different convection centres and hence, influences the global circulation process and the rainfall. In this paper the dynamical influence of the different phases of MJO are being quantified on DOM and its progress in continental India by using the multi-source atmospheric and oceanic parameters like wind structure, outgoing longwave radiation (OLR), sea surface temperature (SST). The linkage of the active and inactive phases of MJO along with the favourable conditions for DOM is obtained by using the pentad analysis of associated parameters in different clusters for both the wet and dry phases of MJO along with the strength for the period 1980-2018. Also the dynamics are studied for the early, normal and late onset years separately to understand the relation better. It is inferred that the wet (dry) phase leads to early (late) monsoon onset over Kerala (MOK) in India. The MJO phase wise composite pentad rainfall analysis is presented in figure below.

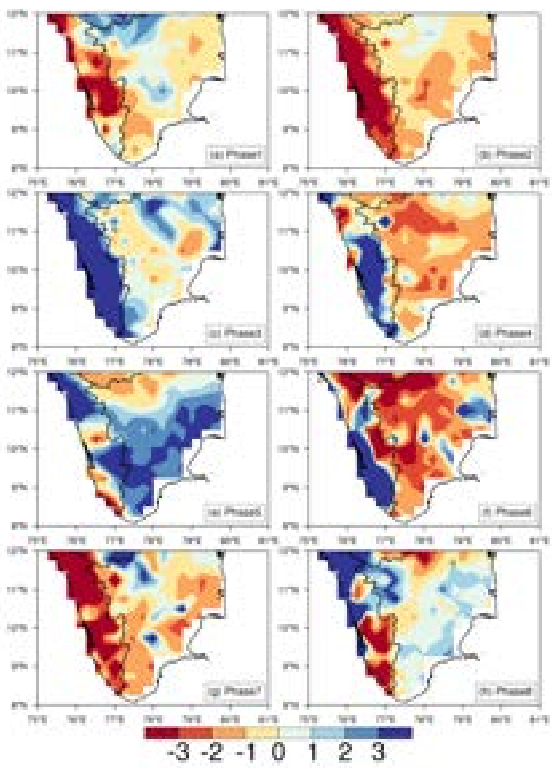


Figure 2.18: Analysis of pentad rainfall anomaly (mm) during MOK. The results are composited

Smrutishree Lenka, Krushna Chandra Gouda, Rani Devi and C M Joseph

2.19 A comprehensive Study of atmospheric dynamics during Cloud-burst over India Himalayan Region

Cloud burst events, characterized by intense rainfall over a short duration, have become increasingly frequent and severe in recent years. These extreme weather phenomena pose significant challenges to various sectors, including urban planning, infrastructure, agriculture, and disaster management. These events are particularly common in hilly and mountain regions like Himachal Pradesh, Uttarakhand, and Jammu & Kashmir. The summer monsoon season, particularly in July and August, is known for sudden torrential downpours in the southern rim of the western Himalayas. These areas are characterized by steep slopes and rugged terrain, which are susceptible to rapid runoff and the accumulation of water. The limited size of these catchment areas contributes to the localized and intense nature of flash floods and lands. Certain atmospheric phenomena, such as humidity, Convective Available Potential Energy, Convective Inhibition, or atmospheric disturbances, can act as triggers for cloud burst events. These triggers help to concentrate and intensify convective activity, resulting in localized heavy rainfall within a limited geographical area. An event 19th Aug 2022, have studied here and explored the atmospheric dynamics associated with it.

Payoshni Samantray and K C Gouda

2.20 Inter-comparison of atmospheric CO_2 concentrations measured over mountain region (Hanle) and urban region (Hosakote) in India using high precision instrument

India's CO_2 emissions have been rising steadily over the years due to economic growth, industrialization, and increased energy consumption,. The primary sources of CO_2 emissions in India include power generation, industry, transportation, and residential and commercial sectors. India's efforts to balance economic growth with environmental sustainability are crucial in addressing climate change and reducing its CO_2 emissions. The monitoring of CO_2 emissions accurately is a complex task that requires comprehensive and widespread measurement networks, data collection, and robust modeling techniques. The lack of sufficient monitoring can lead to uncertainties in assessing the sources and magnitudes of CO_2 emissions, it becomes difficult to track and attribute emissions. To complement the monitoring data, robust modeling techniques are necessary. These models can simulate the transport and dispersion of CO_2 in the atmosphere, enabling researchers to analyze the influence of various factors, such as wind patterns, topography, and emissions from different sources. Models can also help estimate CO2 fluxes between the atmosphere and different types of sinks, such as forests, oceans.

The collected raw data of CO_2 concentrations undergo correction and filtering using standard techniques. The filters include criteria related to cavity temperature, cavity pressure, and outlet valve range. The background air at the Hanle site is considered unpolluted. Around 70% of the data at Hanle exhibit a variability of less than 0.1 parts per million (ppm). Unless there is a substantial variation in concentrations, it is not necessary to exclude night-time hours at the Hanle site. The daily means of GHGs at Hanle, along with a

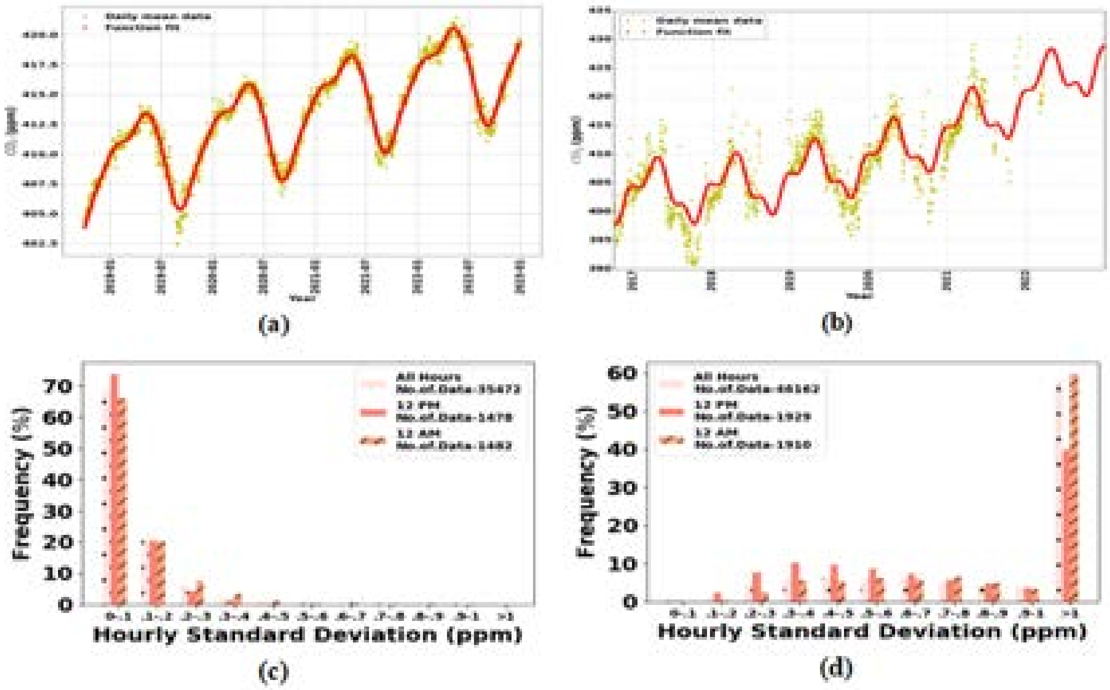


Figure 2.19: Daily mean CO_2 concentrations at (a) Hanle (Oct 2018 to Dec 2022) (b) Hoskote (Oct 2016 to Dec 2022); Hourly standard deviation at (c) Hanle (d) Hoskote.

smooth curve consisting of a constant, linear, quadratic, and four harmonics, show a small deviation between the data and the curve. This suggests that the site is clean and suitable as a background station. The annual mean of CO_2 at the Hanle site is approximately 417 ppm. The CO_2 concentrations at the Hoskote site exhibit significant variability and noise due to local effects. Around 58% of all hourly data at Hoskote show a variability of more than 1 ppm. Only daytime measurements are considered for CO_2 concentration analysis at Hoskote due to its high variability. The year-to-year increase in CO_2 concentrations at Hoskote is similar to that observed at the Hanle site. Combining high-quality monitoring data with advanced modeling techniques allows for a more comprehensive understanding of the CO_2 dynamics over the Indian subcontinent. It can support policymakers in developing effective strategies for mitigating CO_2 emissions, identifying priority areas for emission reduction, and evaluating the potential of natural sinks to sequester CO_2.

Iranna Gogeri and K C Gouda

2.21 Trends of seasonal and annual rainfall of semi-arid districts of Karnataka, India: application of innovative trend analysis approach

The cumulative seasonal and annual rainfall derived from monthly datasets spanning 102 years (19012002) for 11 districts of the semi-arid Karnataka, India, was used for the trend analysis to understand its distribution over a given region. The two-step homogeneous test approach was carried out on all the time series. Then, lag-1 autocorrelation was conducted only on homogeneous time series. Only 78.18% of the total time series data were detected as homogeneous, and 95.35% of time series data were found to have insignificant autocorrelation. Sens slope map of seasonal and annual rainfall (Fig) is presented. The magnitudes of Sens slope for Koppal and Raichur districts are significantly decreasing at 0.0002 and 0.0003 mm/year (Table 4, Fig. 5), respectively. Then, the Innovative Trend Analysis (ITA) method was applied to 43 homogeneous rainfall time series, as well as to 41 time series using the MK and SR tests, and to two time series using the mMK test. The MK and SR tests detected a significant trend in 14.63% of the time series, while the ITA method was able to detect a trend in 93.02% of the total time series data. The MK and SR tests revealed significant trends in winter and post-monsoon season precipitation for two districts, but only for one district in the case of summer and annual rainfall. No trend was identified for monsoon season precipitation. The mMK test showed a positive trend for the post-monsoon season in a district, while the ITA method revealed significant trends for all seasons in most districts. The sub-trend analysis revealed trends that traditional methods were unable to detect.

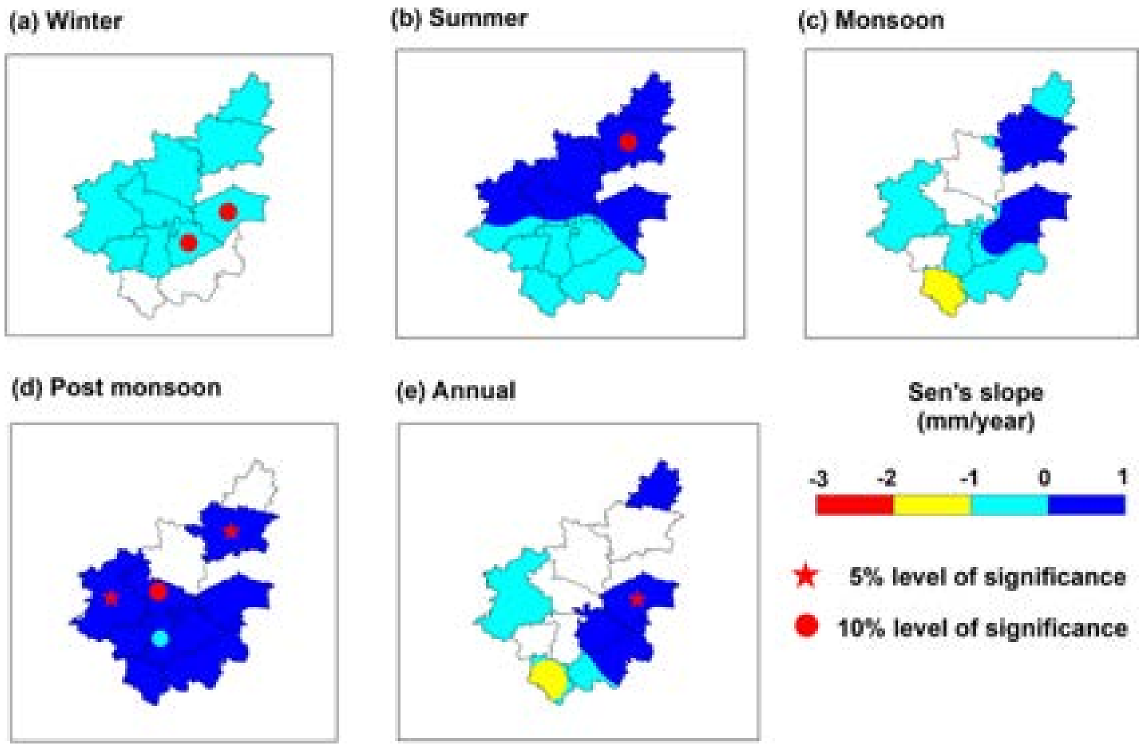


Figure 2.20: Sens slope map of seasonal and annual rainfall.

2.22 Extreme rainfall event analysis over the state of Himachal Pradesh in India

Extreme rainfall events (EREs) are very localized and intense events witnessing heavy rainfall resulting in flash floods and landslides in the Himalayan region. The trend of EREs in the state of Himachal Pradesh shows an increasing trend, so in this study, an attempt is being made for quantifying the climatological feature of these EREs in the state of Himachal Pradesh in the western Himalayan mountain region. Multi-source observed datasets for the long-term period, i.e., 1901 to 2020, are considered for the analysis. The climatology analysis indicates that northern and southern parts of Himachal Pradesh receive comparatively more rainfall, and the state witnessed a decreasing trend of the rainfall in the current decade. The classifications of these EREs in terms of monsoon and non-monsoon with a different threshold of daily rainfall are being analyzed, and it is found that almost 90% of extreme events are observed in the monsoon season. The zone centered around 32.5°N and 76.25°E seems to be the hotspot for the frequent EREs in the mountainous state. The spatial analysis of the ERE trend also indicated that almost 40% of the state witnesses the heavy rainfall throughout the years. This observational study will surely help in understanding the dynamics of these EREs in the higher altitude regions and can be used for hydro-meteorological disaster management and mitigation.

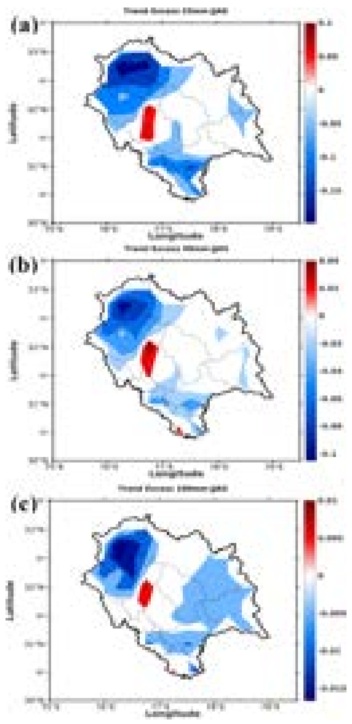


Figure 2.21: a-c: Trend in monsoon rainy days with different thresholds

K. C. Gouda, Sudhansu S. Rath, Nidhi Singh, Sayanta Ghosh and Renu Lata

2.23 Impact of comorbidity on patients with COVID-19 in India: A nationwide analysis

The emergence of coronavirus disease (COVID-19) as a global pandemic has resulted in the loss of many lives and a significant decline in global economic. Thus, for a large country like India, there is a need to comprehend the dynamics of COVID-19 in a clustered way. To evaluate the clinical characteristics of patients with COVID-19 according to age, gender, and pre existing comorbidity. Patients with COVID-19 were categorized according to comorbidity, and the data over a 2-year period (1 January 2020 to 31 January 2022) were considered to analyze the impact of comorbidity on severe COVID-19 outcomes. The results indicated that COVID-19 caused an exponential growth in mortality. In patients over the age of 50, the mortality rate was found to be very high, $\sim$80%. Moreover, based on the estimation of OR, it can be inferred that age and various preexisting comorbidities were found to be predictors of severe COVID-19 outcomes. The proportion of fatal cases among patients positive for COVID-19 increased with the number of comorbidities. This study concluded that elderly patients with preexisting comorbidities were at an increased risk of COVID-19 mortality (Figure 2.22). Patients in the elderly age group with underlying medical conditions are recommended for preventive medical care or medical resources and vaccination against COVID-19.

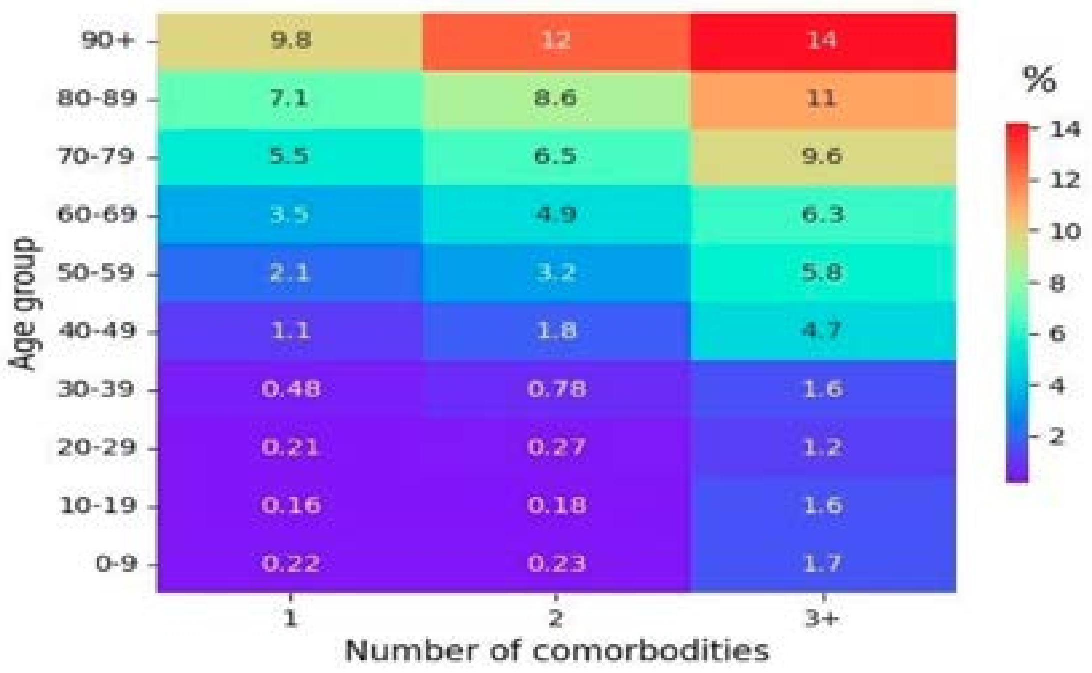


Figure 2.22: The proportion (%) of fatal outcomes in cases of a COVID-19 infection by age groups and the number of comorbidities.

Singh P, Bhaskar Y, Verma P, Rana S, Goel P, Kumar S, Gouda KC and Singh H

2.24 The synergistic effect of climatic factors on malaria transmission: a predictive approach for northeastern states of India

This study attempts to explore the epidemiological profile and quantify the climate-induced influence on malaria cases in the context of tropical states, taking Meghalaya and Tripura as study areas. Monthly malaria cases and meteorological data from 2011 to 2018 and 2013 to 2019 were collected from the states of Meghalaya and Tripura, respectively. The nonlinear associations between individual and synergistic effect of meteorological factors and malaria cases were assessed, and climate-based malaria prediction models were developed using the generalized additive model (GAM) with Gaussian distribution. During the study period, a total of 216,943 and 125,926 cases were recorded in Meghalaya and Tripura, respectively, and majority of the cases occurred due to the infection of Plasmodium falciparum in both the states. The temperature and relative humidity in Meghalaya and temperature, rainfall, relative humidity, and soil moisture in Tripura showed a significant nonlinear effect on malaria; moreover, the synergistic effects of temperature and relative humidity (SI=2.37, RERI=0.58, AP=0.29) and temperature and rainfall (SI=6.09, RERI=2.25, AP=0.61) were found to be the key determinants of malaria transmission in Meghalaya and Tripura, respectively. The developed climate-based malaria prediction models are able to predict the malaria cases accurately in both Meghalaya (RMSE: 0.0889; R2: 0.944) and Tripura (RMSE: 0.0451; R2: 0.884). Figure 6 provides the smoothing components for relative risk of malaria against each climate variable with their corresponding 95% confidence intervals.This reminds the policymakers to pay attention to the control of malaria in situations with high temperature and relative humidity and high temperature and rainfall in Meghalaya and Tripura, respectively.

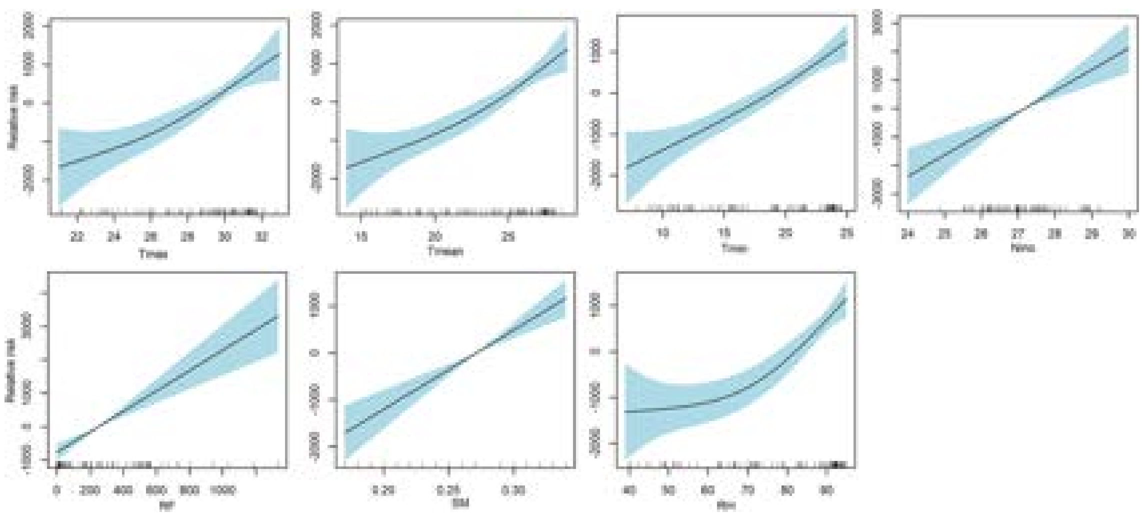


Figure 2.23: Smoothing plots of relationships between climatic variables and malaria prevalence in GAM with 95% confidence bands in Meghalaya (20112018)

Nikhila Yaladanda, Rajasekhar Mopuri, Hariprasad Vavilala, Kantha Rao Bhimala, Krushna Chandra Gouda, Madhusudhan Rao Kadiri, Suryanarayana Murty Upadhyayula and Srinivasa Rao Mutheneni

2.25 Weather integrated malaria prediction system using Bayesian structural time series model for northeast states of India

The present study is aimed at understanding the epidemiological patterns of malaria transmission dynamics in Assam and Arunachal Pradesh followed by the development of a malaria prediction model using monthly climate factors. To predict the malaria incidence, Bayesian structural time series (BSTS) and Seasonal Auto-Regressive Integrated Moving Average with eXogenous factors (SARIMAX) models were implemented. A statistically significant association between malaria cases and climate variables was observed. The most influencing climate factors are found to be maximum and mean temperature with a 6-month lag, and it showed a negative association with malaria incidence. The BSTS model has shown superior performance on the optimal auto-correlated dataset (OAD) which contains auto-correlated malaria cases, cross-correlated climate variables besides malaria cases in both Assam (RMSE, 0.106; MAE, 0.089; and SMAPE, 19.2%) and Arunachal Pradesh (RMSE, 0.128; MAE, 0.122; and SMAPE, 22.6%) than the SARIMAX model. The findings suggest that the predictive performance of the BSTS model is outperformed, and it may be helpful for ongoing intervention strategies by governmental and nongovernmental agencies in the northeast region to combat the disease effectively.

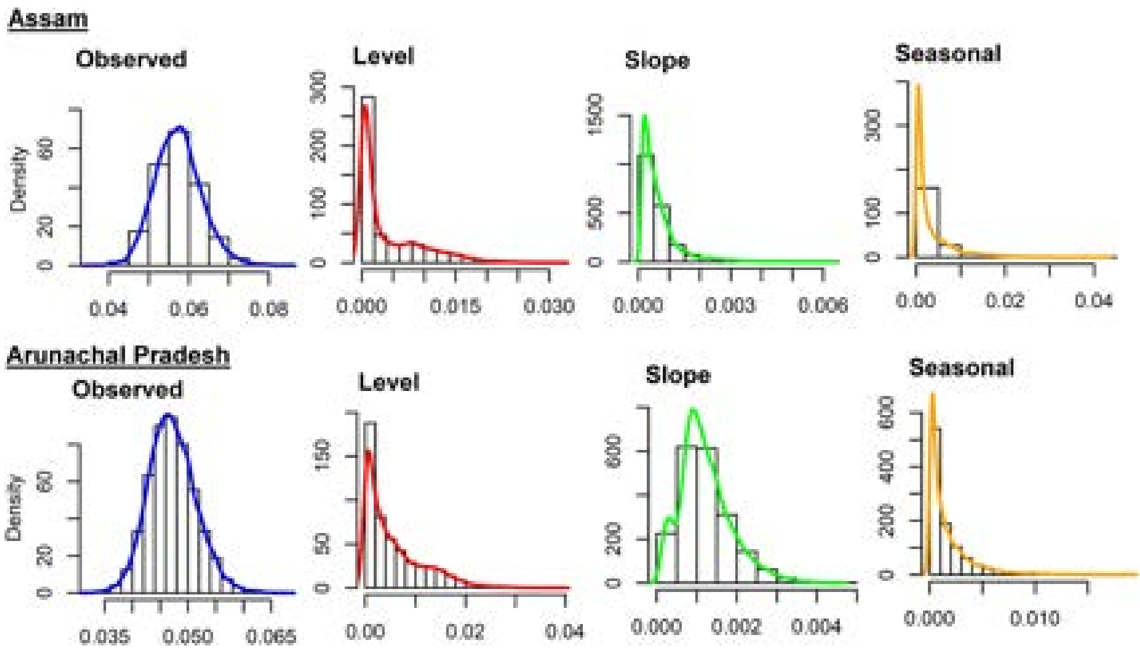


Figure 2.24: Observation, level, slope, and seasonality analysis of climate parameter and malaria incidence over Assam and Arunachal Pradesh states.

Hariprasad Vavilala, Nikhila Yaladanda, Phani Krishna Kondeti, Rafiq Unissa, Rajasekhar Mopuri, Krushna Chandra Gouda, Kantha Rao Bhimala, Madhusudhan Rao Kadiri, Suryanarayana Murty Upadhyayula and Srinivasa Rao Mutheneni

2.26 Evaluation of ARIMA, Facebook Prophet and a boosting algorithm framework for monthly precipitation prediction of a semi-arid district of north Karnataka, India

This study evaluates ARIMA, Facebook Prophet and a new boosting algorithm framework known as ThymeBoost for time series prediction of monthly precipitation of Belagavi district (semi-arid) in Karnataka. The dataset was divided into three periods (19012002, 1951- 2002, and 1971 - 2002). The first 70% of the data for each period was applied for training while the rest for testing. Also, the datasets were used in two different forms for both training and testing. In the first set, raw data was used as it is, and the second set of data was used after normalizing the time series using the min-max concept (between 0 and 1). However, the normalized data were de-normalized for each period for performance metrics estimation. ThymeBoost is the best model for the first period of raw data and the second period of normalized data. In contrast, Prophet outperforms all other models for the normalized data in terms of all four measures. For the second period of raw data, no model emerged as the best model in terms of all performance metrics. Therefore, all three models performed similarly for the third period of raw and normalized data.

Chowdari K K; Surajit Deb Barma; Nagaraj Bhat; R Girisha and K C Gouda

3. Geosciences & Engineering Research

Building on the niche expertise available at CSIR-4PI in GNSS based geoscience research, computational seismology, computational mechanics and the existing capability in modelling and simulation, the following research addresses R&D issues of societal relevance. Inside:

- Seismic Potential of Kachchh region of Western India
- Strain Budget in Kashmir Himalaya and adjoining regions
- Noise estimates of multi-GNSS stations
- Characteristics of Equatorial F-region Irregularities along the 90°E Meridian during High Solar Activity Phase
- Establishment, operation and maintenance of continuous mode GNSS stations
- Imaging subsurface geological complexity beneath Greater Srinagar
- Sub-surface shear wave velocity and sedimentary depth estimation beneath the Kashmir Basin (NW Himalaya) through Ambient Noise Array Measurements
- Site Response Analysis Beneath the Kashmir Basin (NW Himalaya) using microtremor in terms of fundamental frequency and sediment engineering bedrock interface
- Delineating the seasonal deformations of Nepal Himalayas induced by snow and water loading using GPS, GRACE and global climate model simulations
- Modeling 3D acoustic ray propagation triggered by 25 April 2015 Mw7.8 Nepal - Gorkha earthquake
- Crustal stress distribution of the Indian Plate region
- Quantitative river profile analysis to investigate the active tectonics of the Bhagirathi River system of the Himalayas
- A Fractional Derivative Approach for Strain Gradient Nonlocal Models in Wave Propagation Studies
- Prediction of Group Speed Using Peridynamics Model for Phonon

3.1 Seismic Potential of Kachchh region of Western India

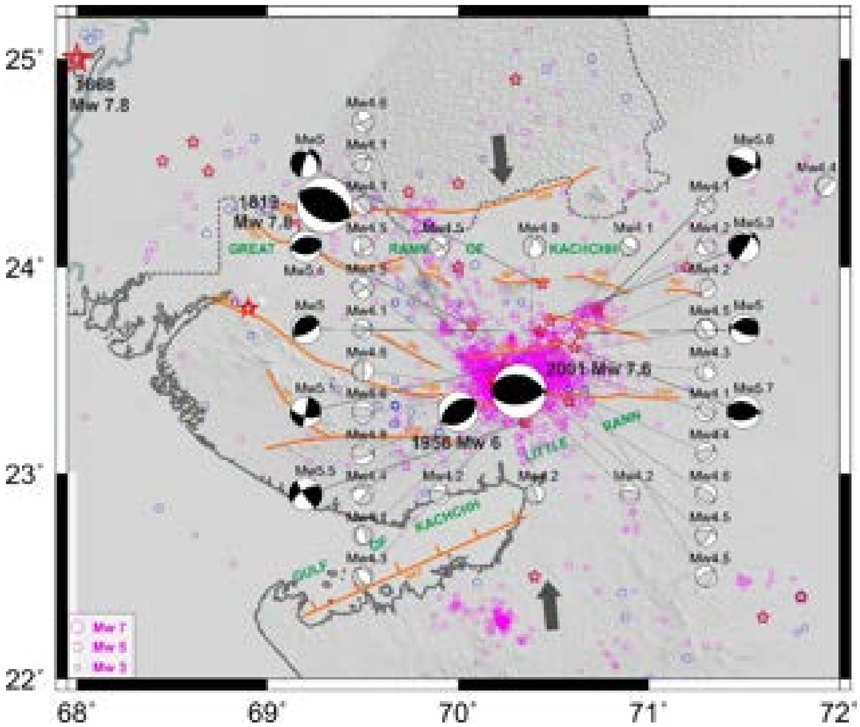


Figure 3.1: Seismic events and Fault mechanisms in Kachchh region.

Bhuj earthquake of Mw 7.6 on 26th January 2001 is the recent earthquake in the Kachchh paleo-rift basin which is classified as seismic zone V, i.e. having potential to produce earthquakes of intensity IX or higher (Figure 3.1). Seismic Potential of this region is estimated from comprehensive analysis of GPS derived geodetic and seismic strain rates. The average geodetic strain rate estimated from GPS data of about eight years (2009 to 2016) is about 16 nano-strain/yr towards N23° resulting in a geodetic moment build-up rate of ∼7E+17 Nm/yr which is equivalent to the rupture volume of 1819 Allah Bund earthquake. Past 350 years of seismic events indicate average released seismic strain rate of about 85 nano-strain/yr mainly contributed by 3 major earthquakes (1668 Mw 7.8; 1819 Mw 7.8 and 2001 Mw 7.6). The mean deviation of about 20° in the orientation of principal axes between the geodetic and seismic strain rates points towards a complex and active tectonic regime. Composite analysis of geodetic and seismic rates gives an estimate of the recurrence interval of >1000 years for events similar to the 1819 Allah Bund earthquake and >500 years for an event similar to the 2001 Bhuj earthquake. Further high rate of strain build-up recorded on the reactivated major faults in this region has a potential to generate Mw ≥6 earthquakes along these faults.

Sapna Ghavri*[1], *Rajeev Kumar Yadav*[2] *and Sridevi Jade
[1] - Bihar Mausam Seva Kendra.
[2] - CSIR-NGRI.

3.2 Strain Budget in Kashmir Himalaya and adjoining regions

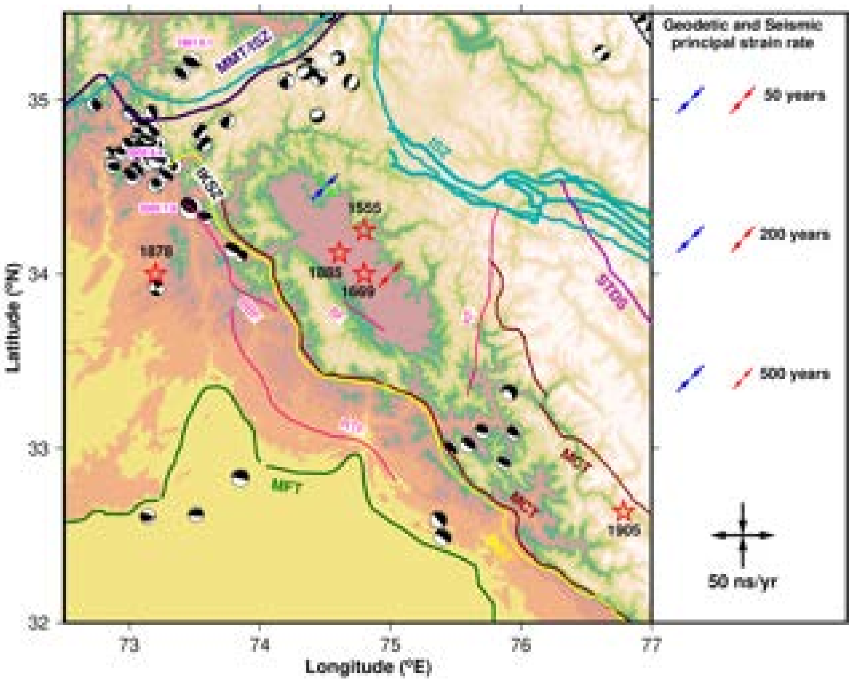


Figure 3.2: GPS derived Geodetic (blue) and seismic (red) strain rates of the study region with historical earthquakes (red star) and focal mechanism of seismic events of M>5.

Geodetic strain rates are estimated using present day GPS velocities (2015-2021) of our continuous observation network along with published velocities spanning last two decades for the region covering the rupture zones of the 2005 Muzaffarabad earthquake and the 1905 Kangra earthquake. The estimated average geodetic strain accumulation rate of about -28.8 ns/yr yields a seismic moment build-up rate of ∼7.0E+18 Nm/yr for the seismogenic volume (∼499.5 Œ 388.5 Œ 20 km^3) of the region (Figure 3.2). Seismic strain rates during the instrumental period of the past 50 years indicate a mean compression rate of -28.1 ns/yr and it slightly decreases to -26.3 ns/yr and -21.5 ns/yr after including the historical earthquakes of the past 200 and 500 years respectively. Azimuth of seismic strain tensor for the instrumental and historic period is about 42°N and is consistent with the azimuth of geodetic strain tensor suggesting uniform compression over a long-time interval justifying combined analysis of strain rate field to determine the seismic potential of the region. Composite analysis of geodetic and seismic strain rates and the associated moments points toward an accumulated strain budget of ∼1E+21 Nm in the past 500 years which has a potential of generating future earthquake of Mw>8 in this region.

TS Shrungeshwara, Bhavani Narukula, Sridevi Jade, Sapna Ghavri*[1]*, Chiranjeevi G Vivek and I. A. Parvez
[1] - Bihar Mausam Seva Kendra.

3.3 Noise estimates of multi-GNSS stations

Mutli-GNSS daily position time series is analyzed to characterize the dominant type of noise models and related amplitudes for their impact on velocity estimates. Amplitudes of Power law noise (flicker noise, random walk noise) and white noise are estimated for stand-alone GPS, Glonass and combined GPS, Glonass using multi-GNSS data of cGNSS stations using Maximum Likelihood Estimation (MLE) method. Figure 3.3 shows the Power Law (PL) noise amplitudes levels for North, East and Up components of multi-GNSS time series. It is observed that PL noise amplitude in North component for Glonass time series is less compared to stand-alone GPS and combined GPS, Glonass time series, while noise amplitudes are more in East and Up components. Also combined GPS, Glonass time series has low noise amplitudes in Up component compared to stand alone time series. Further this study need to be extended to analyze the effect of noise for determination of velocities and associated uncertainties in multi-GNSS time series.

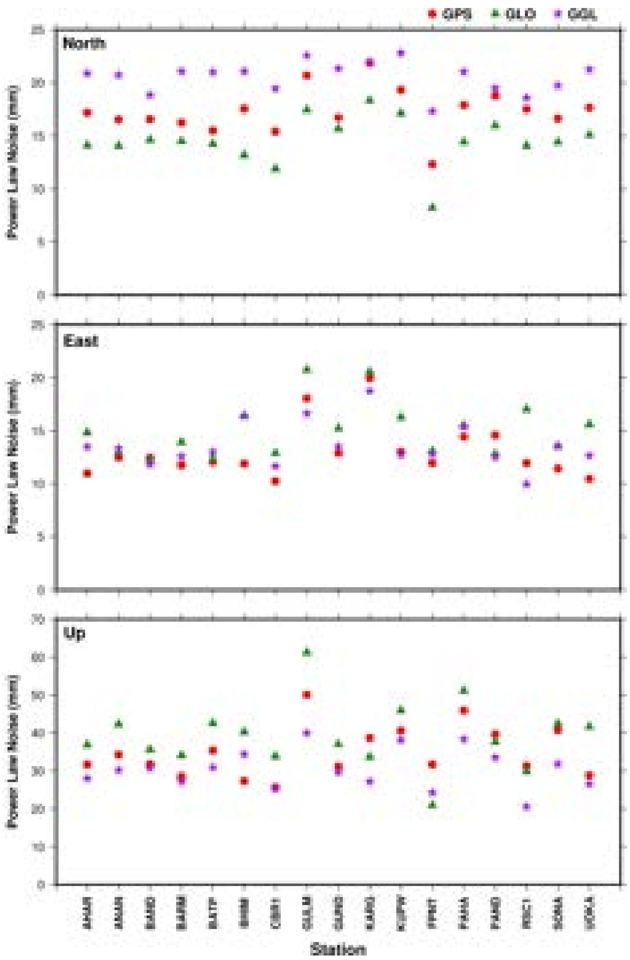


Figure 3.3: Power law noise amplitudes in North, East and Up components of multi-GNSS time series.

3.4 Characteristics of Equatorial F-region Irregularities along the 90°E Meridian during High Solar Activity Phase

We investigated the characteristics of Equatorial ionospheric F-region irregularities (EFIs) along the 90°E meridian using the phase fluctuations of Global Navigation Satellite System (GNSS) signals during the maximum phase of solar activity in solar cycle 24. The contour plots of monthly diurnal average Rate of Total Electron Content Index (ROTI) for the year 2014 (Figure 3.4) occurrence of irregularities. High ROTI values are typically observed between 13:00 UT (18:30 LT) to 19:30 UT (01:00 LT) with peak values around 15:00 UT (20:30 LT) for PBR2 station near the magnetic equator and KHL2 station in low latitude EIA region. This can be attributed to the presence of eastward electric fields during the post-sunset hours and a strong plasma density gradient between the upper and bottom-side of the ionospheric F layer. Additionally, the disappearance of EFIs varies with latitude and season. At KHL2, EFIs vanish earlier compared to the equatorial station PBR2. Moreover, the magnitude and timing of EFI disappearance is more in the spring equinox months compared to the autumn equinox months for PBR2 and KHL2. This confirms significant equinoctial asymmetries in terms of EFIs occurrence frequencies. The findings of this research contribute to the ongoing efforts to mitigate the effects of EFIs in highly precise and dynamic applications that rely on space-based navigation systems, particularly over the equatorial and low latitude Indian longitude sector. Furthermore, this study aims to expand the analysis to other longitudes by utilizing the dense network of geodetic GNSS stations across the Indian region.

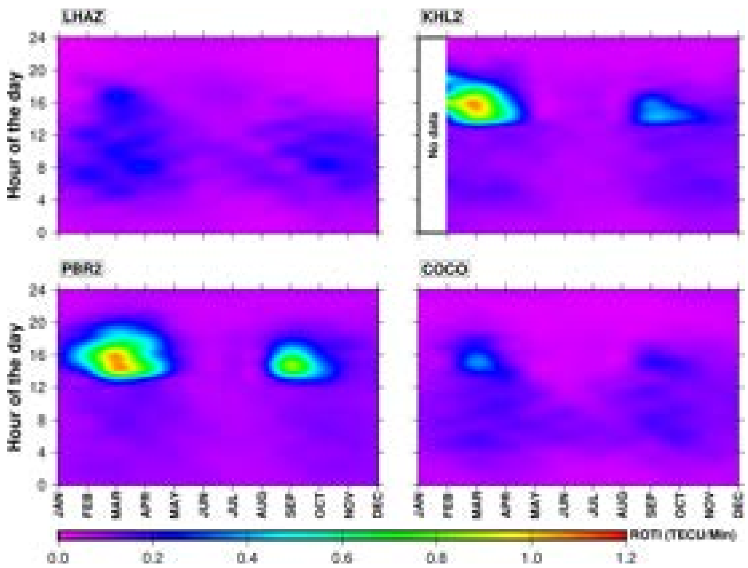


Figure 3.4: Monthly diurnal average ROTI for the stations COCO, PBR2, KHL2 and LHAZ during the year 2014.

Siva Sai Kumar Rajana, Sampad Kumar Panda[1] *and Sridevi Jade*
[1] - Department of ECE, Center for Atmospheric Science, KL Deemed to be University, Guntur, Andhra Pradesh, India.

3.5 Establishment, operation and maintenance of continuous mode GNSS stations

Continuous mode GNSS (Global Navigation Satellite System) stations are established in Badoub and Kishtwar (Jammu & Kashmir UT) (Figure 3.12). Operation and maintenance of twenty-seven stations are carried out. Few stations are remotely accessible and data is transferred in near real-time to CSIR-4PI servers.

Figure 3.5: cGNSS stations established in Jammu and Kashmir region.

Shrungeshwara T S, Ramees Raja Mir, Siva Sai Kumar Rajana, Fayaz Ahmad Bhat, Rushikesh G, Chiranjeevi G Vivek and Sridevi Jade

3.6 Imaging subsurface geological complexity beneath Greater Srinagar

The microtremor data acquired in Srinagar city and its surroundings allow us to study a wide range of subsurface features. We present subsurface shear wave velocity (V_s) structure using the Horizontal to Vertical Spectral Ratio (HVSR) inversion, shear wave velocity for top 30 meters of soil column (V_{S30}), comparison of V_{S30} calculated from HVSR inversion and topographic slope methods and azimuthal behaviour of HVSR peaks, all of which unravel the subsurface spatial heterogeneity and suitability for the building of engineering structures in the study area.

We have estimated shear wave velocity (V_s) of HVSR curves using OpenHVSR that inverts massive HVSR curves dataset simultaneously and constructs layered subsurface models in terms of shear wave velocity. Inversion of HVSR curves is performed leveraging on a Guided Monte Carlo (GMC) approach which allows investigating a wide spectrum of values of the subsurface elastic parameters, such as density (ρ), thickness (h), compressive (V_p) and shear wave velocity (V_s), and corresponding attenuation factors (Q_p, Q_s).

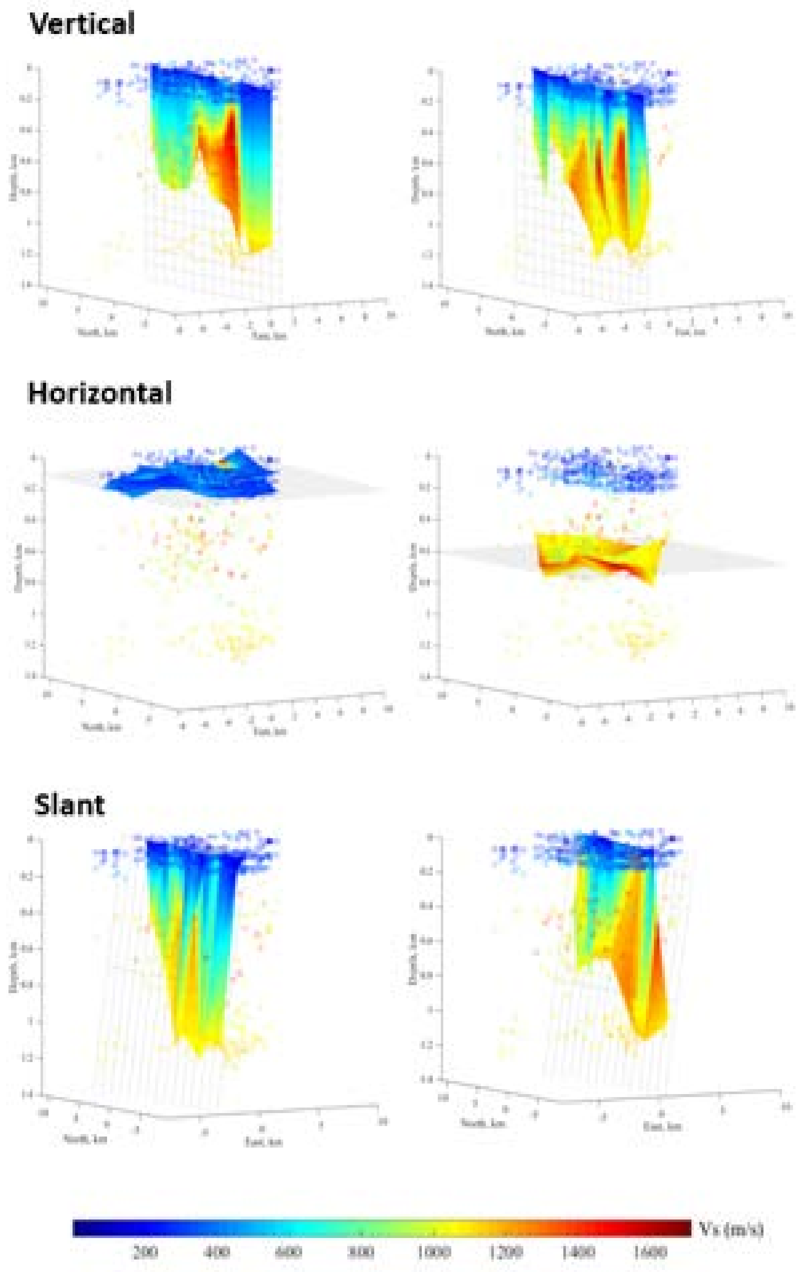


Figure 3.6: Subsurface V_s slices beneath the city for a different direction. Scattered bubbles denote the spatial distribution of velocity contrasts (V_s).

The upper 30 meters of soil column shows a significant influence on local site effects. It is a typical depth of investigation for engineering, geotechnical purposes and building codes and is considered as a key variable in predicting ground motion amplification, classification of sites in building codes and hazard assessment. Thus, we have investigated the shear wave velocity for the upper-most 30-meter soil column (V_{S30}) for the study region.

We also presented the results in 3D as Vs slices beneath Srinagar city (figure 3.6) which reveal that the greater Srinagar region presents a complex structure with irregular 3D distribution of soil deposits, heterogeneity in Vs structure, and azimuthal dependency of site amplification, which in turn, may enhance amplification and increase of irregularity and spatial variability of ground motion in case of a strong seismic event. Further, our findings are not only limited to site effects but will also provide guidance for optimal engineering design of building structures and urban development in the city and adjacent regions. The subsurface investigations over the study area might impart optimal engineering design for civil structures and meaningful formulation of hazard parameters in engineering analyses of ground responses in Srinagar city and its adjacent suburban regions.

S Vishal Gupta, Imtiyaz A. Parvez and Prosanta K. Khan[1]
[1] - Department of Applied Geophysics, Indian Institute of Technology (Indian School of Mines), Dhanbad.

3.7 Sub-surface shear wave velocity and sedimentary depth estimation beneath the Kashmir Basin (NW Himalaya) through Ambient Noise Array Measurements

To get the dispersion characteristics of subsurface sediments of the Kashmir basin, microtremor array measurements were performed throughout the valley covering different lithological set up across the basin. Array set-up was done by installing 7 units of seismic stations at each site. Each recording unit in an array measurement has a combination of a Lennartz LE-3D/5s sensor coupled with a Mini-Shark data logger and a mouse GPS. We mostly preferred equilateral triangular geometry pattern with different subarray apertures but also to cover azimuthal distribution in distinct directions, circular array patterns at few sites with different radii were arrayed in practice. We selected open fields and public grounds for the survey. The minimum subarray aperture was limited to 25m; however, we could achieve upto 140m of maximum array aperture.

The experimental dispersion curve can be extracted from the generated microtremor array data using a variety of processing techniques and is used further for inversion, aiming to get the 1-D V_s profile beneath the array site. The most popular techniques among various array signal analysis tools are Frequency-Wavenumber (F-K) and Spatially autocorrelation (SPAC). Here, we opted conventional Frequency - Wavenumber (CVFK) method to extract the best dispersion curve from generated microtremor array dataset. As such, there is no unique way to transform the dispersion data to get a directly subsurface Vs model, so we opted for the most robust and reliable global search inversion technique that is Neighbourhood Algorithm (NA) implemented in the Dinver tool of Geopsy software. To achieve a realistic subsurface Vs profile from a dispersion curve, a systematic inversion procedure has been carried out.

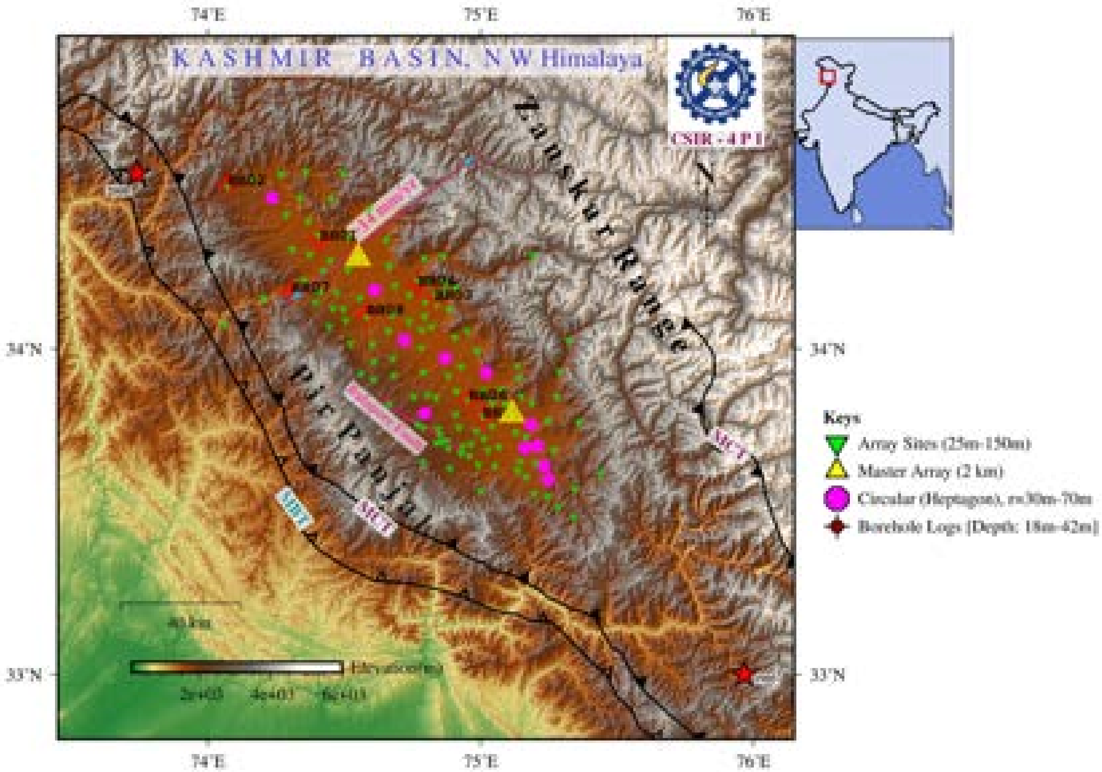


Figure 3.7: Acquisition map of achieved microtremor array experiment. Acquisition key specifies (1) green triangle -campaign mode 1-hour long array recording with different subarray sessions at each site following equilateral triangular geometry pattern; (2) Similarly, circular array setup in pink colour at 11 locations; (3) newly generated subsurface soils logs.

Finally, with multiple distinct inversion runs, we could reach a lowest misfit values to accept a final V_s profile. The assembled all profiles depicts the S-wave velocity of the near surface layer (> 15m) is > 200 m/s which matches with nearby borehole log and below this layer, first velocity contrasts reaches $\sim$ 390 m/s at depth of 40-50m. We restricted the retrieval depth of V_s profile up to the maximum resolvable wavelength that was observed over the associated dispersion curve, which equals almost the same as the maximum array aperture size.

S Vishal Gupta, Imtiyaz A. Parvez and Prosanta K. Khan[1]
[1] - Department of Applied Geophysics,
Indian Institute of Technology (Indian School of Mines), Dhanbad.

3.8 Site Response Analysis Beneath the Kashmir Basin (NW Himalaya) using microtremor in terms of fundamental frequency and sediment-engineering bedrock interface

As we have good coverage of microtremor array sites, we also processed single station microtremor data to estimate fundamental resonance frequency across the entire Kashmir valley and corresponding sedimentary thickness. The map in Figure 3.8 presents a first order fundamental resonant frequency map (varying from 0.21 Hz to 10.19 Hz) of the entire Kashmir valley sedimentary basin. This map was prepared using the nearest neighbourhood interpolation within the boundary enclosed by overall 140 single station sites.

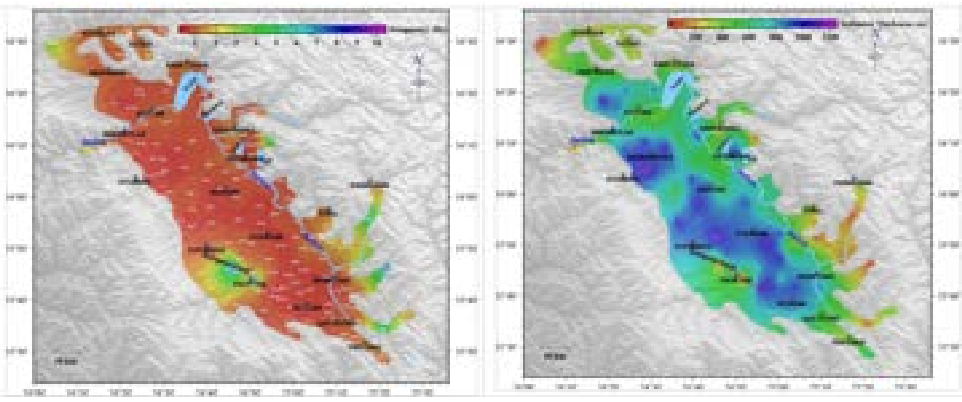


Figure 3.8: Fundamental resonant frequency and Sediment Bedrock Interface map of Kashmir valley.

Figure 3.8 concludes the sediment depth relating to the main stratigraphic unconformities throughout the Kashmir valley. The top of seismic bedrock varies from 7m to 1216m in depth. It increases towards the longitudinal axis of the valley that correlates well with the local geology. The very shallow sediments can be observed at the fringes of the valley directed towards Kupwara, Lolab, Bandipore, Ganderbal, Pahalgam, and Verinag towns of the Kashmir division and the thickest sediment accumulation at sparse locations of Behrampora, Badgam, and Pulwama districts correlates well with exposed soft sedimentary deposits (Karewas plateau), where bedrock depths range from $\sim$ 650m to 1216m. This particular geological feature of exposed Karewas deposition was well observed during the array survey and validated the findings. Our results are not only limited to site effects but will also provide guidance for optimal engineering design of building structures and urban development in the city and adjacent regions. The subsurface investigations over the study area might impart optimal engineering design for civil structures and meaningful formulation of hazard parameters in engineering analyses of ground responses in Srinagar city and its adjacent suburban regions.

S Vishal Gupta, Imtiyaz A. Parvez and Prosanta K. Khan[1]

[1] - Department of Applied Geophysics, Indian Institute of Technology (Indian School of Mines), Dhanbad.

3.9 Delineating the seasonal deformations of Nepal Himalayas induced by snow and water loading using GPS, GRACE and global climate model simulations

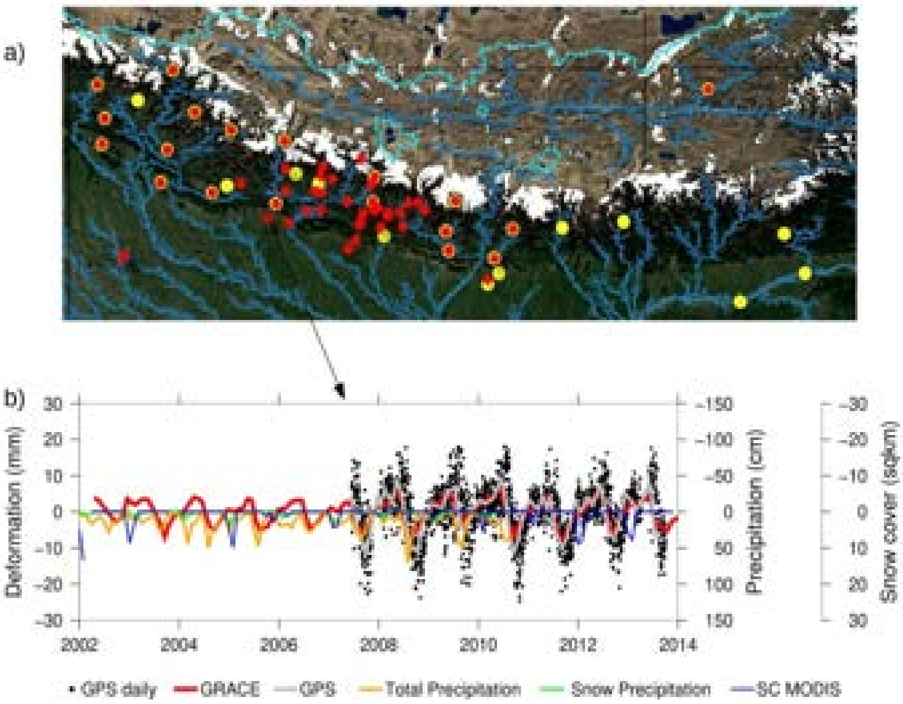


Figure 3.9: (a) Location of GNSS stations in Nepal Himalaya; b) time series of GPS and GRACE derived seasonal deformation at one of the GNSS stations along with MODIS observed snow cover, and precipitations (total and snow) obtained from MRI-GCM simulation.

Monsoon rainfall and melting of the Himalayan glaciers constitute the Ganges-Brahmaputra-Meghna river system as the third largest freshwater outlet next to Amazon and Congo river systems. Unlike other basins, the spatiotemporal variations in precipitation, snow melting, complex topography and active tectonics make the regional hydrology and associated deformation complex. However, observing the response of the Earth's crust to the hydrological loading over the Himalayas can be one of the best proxies to study the impact of climate change on regional hydrology, particularly if we could delineate the effect of snow loading from the water loading. From another geodetic perspective, the region under such complex hydrological and tectonic regimes can also be a very good test bed to study the efficacy of geodetic data processing methods. To test the efficacy of geodetic data processing method and identify the signatures of snow and water loading on the seasonal deformation, we obtained 12 years of seasonal deformation from GPS and GRACE observations over the Nepal Himalayas and then analyzed the results along with the outputs obtained from a global climate model simulations(GCM) and MODIS observed snow cover variations. Spectral analysis of GPS and GRACE derived hydrological deformation time series shows the predominant Annual Cycle (AC) along with a significant Semi-Annual Cycle (SAC). Our analysis revealed that the SAC in GPS and GRACE vertical time series are not processing artifacts arising from the mismodelled parameters but a clear geophysical signature associated with the spatiotemporal variability in precipitation, run-off and snow melt (Figure 3.9). We further established with the help of GCM that the strong AC is associated with annually repeating Indian Summer Monsoon (ISM) precipitation and the SAC is associated with the summer and winter snow precipitation brought by ISM and western disturbance. Similar to loading, the unloading also occurs twice a year associated with the ablation/melting of glaciers during the pre-monsoon period and the draining of groundwater from winter to summer. Both the primary and secondary loading and unloading occur at an interval of 6 months cause the SAC.

Vijayan M.S.M., Ray J.D.[1], Godah W.[2], Vincent A.[3] and Rajendran K
[1] - The Assam Kaziranga University, Jorhat, India
[2] - Institute of Geodesy and Cartography, Warszawa, Poland
[3] - Institute of Geodesy, Schneiderberg, Hannover, Germany.

3.10 Modeling 3D acoustic ray propagation triggered by 25 April 2015 Mw7.8 Nepal - Gorkha earthquake

We modeled the acoustic ray propagation induced by the 2015 Nepal-Gorkha earthquake to study the arrival time characteristics of Coseismic Ionospheric Perturbations (CIPs) at ionospheric heights. The Mw 7.8 Nepal earthquake occurred on 25th April 2015 at 6:11:25 UT. According to the US Geological Survey (USGS), the earthquake was initiated at a latitude of 28.231°N and a longitude of 84.731°E. The rupture propagated southeastward (approximately 140-160 km) with a rupture velocity of 2.5-3.2 km/s. The location of the maximum vertical ground displacement observed during the Nepal earthquake is considered as the source of the acoustic wave in the model. The atmospheric parameters required to model the acoustic propagation through the neutral atmosphere, such as temperature and molecular mass density, were obtained from NRLMSISE-00 atmospheric model. The acoustic source and atmospheric parameters at the corresponding levels were used to model the seismo-acoustic rays at every 1 km altitude in 3D space, ranging from -90° to 90° inclination angle and 0° to 360° azimuthal angle.

In addition, we analysed Global Positioning System (GPS) data observed at 27 GPS ground stations to compare the model arrival times with GPS-observed CIP arrival times at the altitude where the electron density is maximum (hmF2). The slant Total Electron Content (sTEC) along each satellite track traced by the 27 receiver and 31 satellites combination was computed by carrying out phase leveling. The computed sTEC was converted to vertical TEC (vTEC) after correcting the differential code biases associated with GPS satellites and receivers. Furthermore, we employed Spatio-Periodic Leveling Algorithm (SPLA) to remove the errors arising from uncorrected non-uniform spatial sampling and low elevation cut-off and computed the ionospheric perturbations from vTEC. Finally, we obtained the CIPs by subjecting all the ionospheric perturbations computed using SPLA to a bidirectional Butterworth band-pass filter.

To examine the presence of rupture characteristics in the CIP signals, we focused on the onset time of the CIPs. The first arrival time is carefully picked from the GPS-TEC time series for each receiver-satellite pair. Moreover, we compared the arrival time computed from the GPS data with the modeled seismo-acoustic ray traces. From the ray tracing model, it is understood that in the case of Nepal-Gorkha earthquake, the seismo-acoustic rays took more than 12 minutes to reach the altitude of hmF2 (350 km). However, it is interesting to note that arrival time of GPS-CIPs are earlier than the modeled arrival times (see Figure 3.10a and b). At the 350 km ionospheric altitude, the modeled seismo-acoustic rays spread spatially only over a region of approximately 200km by 200km within the 12 minutes timeframe. In contrast, the observed first GPS-CIP signals were spread over an area of 800km by 900km (Figure 3.10a). This indicates that the source responsible for the observed CIPs may not have originated entirely from one location; rather, it might be from multiple sources spread over the rupture region.

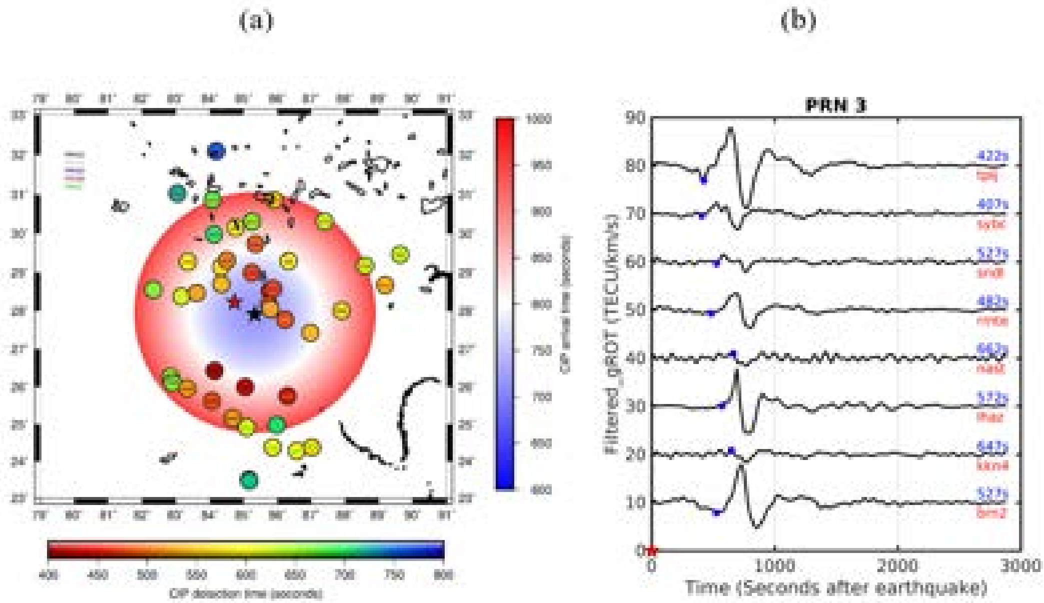


Figure 3.10: (a) Comparison of CIP detection time estimated from GPS-TEC data (coloured disks) along with seismo-acoustic arrival time obtained from the ray tracing model output (coloured background). (b) GPS-TEC time series for the PRN03, each time series is labeled with station name and onset time. The blue dots are the onset time picked from the GPS-TEC time series data.

3.11 Crustal stress distribution of the Indian Plate region

First global compilations of Earth's crustal stress data were published by Hast (1973), Ranalli and Chandler (1975), Brown and Hoek (1978), and Richardson et. al. (1979), employing different stress indicator types and thus providing data sets on global crustal stress with up to 150 data records. These publications started off from the systematic global estimation and compilation of earthquake focal mechanisms and the finding that borehole breakouts can be used as a stress indicator. Similar efforts led to the begging of the World Stress Map (WSM), as a project of the International Lithosphere Program, in 1986. The WSM projects focus in the initial phase was to compile intraplate stress data information to investigate the long wavelength of the crustal stress pattern. Here, in this study, we compiled all the available stress data from the Indian plate region, like the earthquake faulting mechanisms, hydraulic fractures, and borehole breakouts. This compilation gives a comprehensive look at the spatial crustal stress distribution of the Indian plate region.

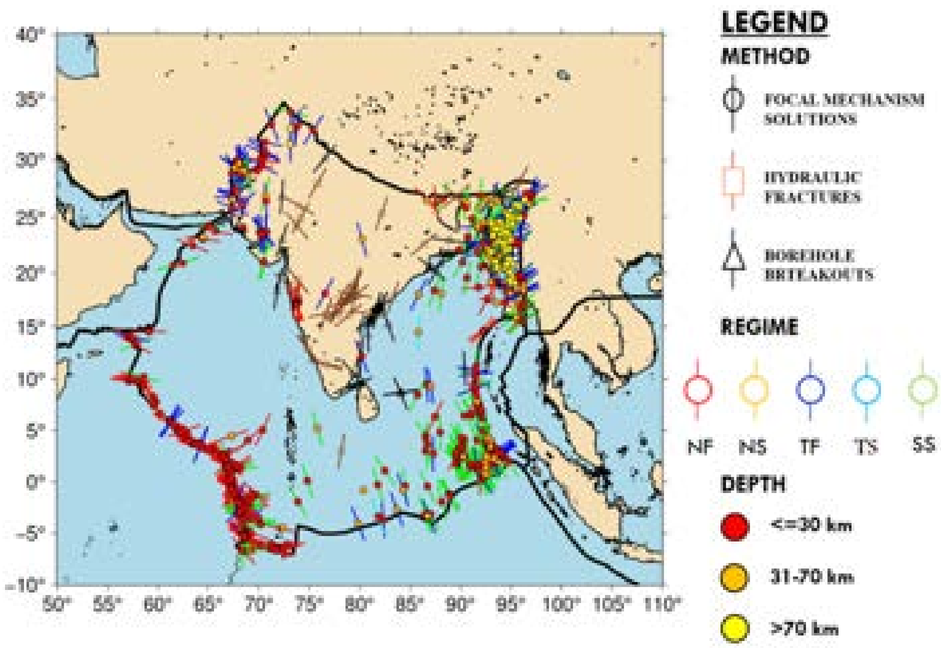


Figure 3.11: Map showing the orientation of azimuths of SHmax from individual focal mechanism solutions, borehole breakout, and hydraulic fracture data within the Indian Plate. Focal Mechanism data is taken from GCMT and other published catalogues. Borehole Breakout and Hydraulic Fracture Data are obtained from WSM Database and also from published articles. Data span 1976 2022. Five general stress regimes are differentiated based on the criteria proposed by Zoback (1992. Stress regimes are differentiated with separate colours and the depth of the earthquakes is also incorporated.

***Richards Nelson*[1]*, Anil Earnest and Sunil P S*[1]**

[1] - Department of Marine Geology and Geophysics, Cochin University of Science and Technology.

3.12 Quantitative river profile analysis to investigate the active tectonics of the Bhagirathi River system of the Himalayas

Generally, in a tectonic active region, there is an immense abnormality in the observed values of the Normalized Steepness Index (ksn), whereas, in tectonically stable regions, the value of ksn remains constant. In the Himalayan thrust belt, where the undergoing differential uplift is reported, ksn may change from one segment to another. Considering that the channel slope is inversely proportional to the drainage basin area, therefore as the drainage area increases, the slope of the river profile decreases. In such regions where differential uplift is going on, the proportionality of the drainage area and slope does not hold because of overstepping the river profile, which can be ascertained by changes in steepness. We did an extensive analysis of the Bhagirathi River channel system of the Himalayas and identified the longitudinal profile of Bhagirathi mainstream showing major and minor knickpoints. The tectonic control over the study area was revealed by the geomorphic parameters like the ksn values and knickpoints. Our results conclude that the active tectonic deformation of the region could possibly be controlled by the three major thrust faults of the Himalayas viz. the Main Central Thrust (MCT), the Main Boundary Thrust (MBT), and the Main Frontal Thrust (MFT).

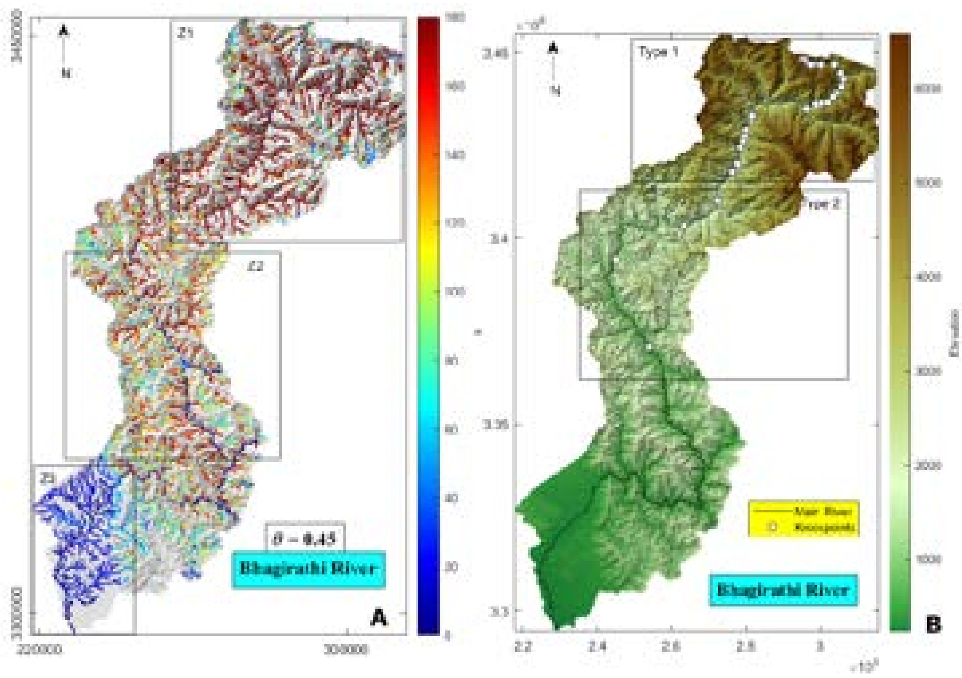


Figure 3.12: a) model of Bhagirathi river. b) Spatial distribution of type 1 and 2 knickpoint zones on relief shaded map of the Bhagirathi river basin.

***Rakesh Kumar Sahoo* [1]*, Anil Earnest and Babu Nalluswamy* [1]**

[1] - Department of Geology, Central University of Karnataka.

3.13 A Fractional Derivative Approach for Strain Gradient Nonlocal Models in Wave Propagation Studies

Unlike the nonlocal stress gradient model proposed by Eringen, the nonlocal strain gradient models are classified into two types: nonlocal stable gradient and nonlocal unstable gradient models. These models captured phonon dispersion and group speed studies reasonably well. Recently, the application of the fractional derivative approach in these models introduced an additional length scale parameter that influences the wave propagation studies better than conventional strain gradient models without a fractional derivative approach. For the dispersion curve prediction, both the nonlocal stress model and the nonlocal strain model show good results. But the real difference between these models appears to be in capturing group speed phenomena. It is interesting to note that the group speed of the nonlocal strain gradient nonlocal model with a fractional derivative approach behaves better in comparison with the strain-based nonlocal model with a fractional derivative approach. So in conclusion, the fractional derivative approach enhances the prediction group speed of the nonlocal strain gradient model for one-dimensional structures with wave propagation in phonon applications.

Senthilkumar V

3.14 Prediction of Group Speed Using Peridynamics Model for Phonon

Peridynamics nonlocal models are strongly dispersive in comparison with weakly nonlocal models like Stress-gradient and Strain-gradient models. Though the Peridynamics approach possesses the supreme capability to model length scale effect for micro-structures, the question remains for its capability in capturing phonon dispersion correctly. Recently there are some attempts to study this behavior. But the group speed study is important to further ascertain the peridynamics model's capability to satisfy the first Brillouin condition. The present study reveals that the Peridynamics models fail to capture the group speed at the end of the first Brillouin zone. It is expected because the dispersion and group speed are in the function of Bessel, Struve, etc.

Senthilkumar V

III Knowledge & Technical Management

4. Academic Programmes

CSIR-4PI maintains an active academic programme, keeping its objective of developing skill and expertise in mathematical modelling & computer simulation, data intensive research in the country. The activities span the entire spectrum from PhD guidance to undergraduate/postgraduate student projects to specialized courses. Student Programme for Advancement of Research Knowledge (SPARK) is intended to provide an unique opportunity to bright and motivated students of reputed Universities to carryout their major project/thesis work and advance their research knowledge in mathematical modelling and simulation of complex systems.Students and professionals from a wide spectrum of organizations including industries across the country have been benefiting from our various academic programmes over the years. CSIR-4PI is very actively engaged with the AcSIR (Academy of Scientific & Innovative Research) PhD program in Mathematical and Information Sciences, Physical Sciences and Engineering Sciences.
Inside:

- Academy of Scientic and Innovative Research (AcSIR)
- CSIR-Integrated Skill Initiative
- CSIR Jigyasa

4.1 Academy of Scientific and Innovative Research (AcSIR)

CSIR-4PI has an active research program leading to Ph.D. degree in a multitude of arenas. It provides a stimulating atmosphere, which fosters creativity and encourages innovative thinking and research. The PhD program consists of flexible course work, computational training tutorials and a research proposal to demonstrate attainment of a high degree of scientific ability which is followed by advanced research leading to a PhD thesis on a specific topic. The PhD program is normally completed in 4-5 years. During the first year, the students have to go through a course work covering basic and advanced topics. The students are encouraged to take courses in inter-disciplinary areas. As part of the PhD program, the PhD student is expected to give at least two seminars.

K C Gouda

PhD Guidance

- **Himesh S (Guide), Gouda K C (Co-Guide)**
  1. Sanjeeb Kumar Sahoo, Impact of urbanization on high impact weather events & local climate, Visvesvaraya Technological University, Belgaum, Karnataka.
- **Himesh S (Guide), Rakesh V (Co-Guide)**
  1. Ajilesh P, Characteristics of urban extreme rainfall events over the indian cities: an observational and modelling study, Visvesvaraya Technological University, Belgaum, Karnataka.
- **Kantha Rao Bhimala** (Guide) and **Patra G K** (Co-Guide)
  1. Raghavendra Prasad Babu Kanike, Identification of relationship between land surface parameters and monsoon rainfall over India.
- **Gouda K C**
  1. Radhika TV, (VTU), Efficient and Large-Scale Climate Simulation Analysis in Cloud Computing Cluster.
  2. Payoshni Samantray, (VTU) Study of Extreme Rainfall Events due to Cloud Burst using Observation and Model Simulation.
  3. Rani Devi (AcSIR), Dynamics High Impact Weather & Climate over India.
  4. Smrutishree Lenka (VTU), Role of air-sea interaction processes on climate system.
  5. Iranna Gogeri (AcSIR).
- **Mohapatra G N (Guide), Rakesh V (Co-guide)**
  1. Smrati Purwar, (AcSIR), Modelling of spatio-temporal variation in urban extreme rainfall events with special focus on localised versus large-scale impacts.
- **Patra G K**
  1. S Gunasekaran, AcSIR, Challenges in Design, development and testing of Autonomous Aerial Refueling capability.
  2. Manmohan Brahma, AcSIR, Optimization of DNN inference on CPU/GPU Platform.
  3. Anju Sharma, AcSIR, Multi-sensor data fusion strategies and algorithms for health assessment of Mechanical systems.

   4. Shranappa V Sajjan (joined in January 2023)
- **Parvez I A**
   1. S Vishal Gupta, IIT(ISM) Dhanbad, Site specific seismic hazard study in Kashmir Valley.
   2. Gopinath Chakkaravarthy, Amrita Vishwa Vidyapeetham, Gravitational waves and it's impact on tectonics and earthquakes.
- **Rakesh V**
   1. Ajay Bankar, AcSIR, Impact of Data Assimilation in Mesoscale model simulations.
- **Ramesh KV**
   1. Neethu C, VTU, Karnataka, Modelling the role of land-atmosphere interaction during heat waves.
   2. Swetha Sivakumar, AcSIR, Modelling the role of air-sea interactions on tropical cyclone intensification and a post cyclone damage assessment using multispectral Remote Sensing observations.
- **Sridevi Jade**
   1. Chiranjeevi G. Vivek, AcSIR, GNSS signal processing and analysis to study impact on position estimates.
   2. Siva Sai Kumar Rajana, KLEF University, Global Navigation Satellite System (GNSS) based remote sensing of long and short-term ionospheric variability over Indian sub-continent.

4.2 CSIR-Integrated Skill Initiative

The Council of Scientific and Industrial Research (CSIR) started a programme CSIR-Integrated skill Initiative in line with the Skill India mission. Under this umbrella, most of the CSIR laboratories have participated and conducted training programs under different domains across India. Under this project, CSIR-Fourth paradigm Institute (CSIR-4PI) is also participating and has conducted three types of training:

- Advance training programme on different science domains of interest.
- Industrial Visit for recent trends in HPC, Cyber Security and Earth & Engineering Science.
- Student programme in Advancement in Knowledge (SPARK).

Under the skill Initiative Programme of CSIR, CSIR-4PI has organized a training programme on Greenhouse Gases (GHG), Measurement, Estimation Modelling from January 9th - 12th 2023. Speakers from both CSIR and other prestigious Institutes in India participated as faculty members of the training programme. The participants of the programme include undergraduate, postgraduate, Ph.D., and professionals from various Institutes/Universities in India. A total of more than 25 trainees were trained as part of this programme. Three one-day workshops were conducted under the Industrial visit programme. Students from Vellore Institute of Technology, CHRIST University and Er. Perumal Manimekalai College of Engineering (PMCTECH) visited CSIR-4PI for one Day workshop on HPC and Its application under the Industrial visit programme. the Student Programme in Advancement in Knowledge (SPARK). SPARK is a student academic programme where students from universities can do their internship and project work in association with CSIR-4PI researchers. A total 197 trainees were trained under the CSIR-

Integrated skill Initiative Programme.

Figure 4.1: Inauguration of advance training on Greenhouse Gases, Estimation, Measurement & Modelling under CSIR-Integrated Skill Initiative Programme at CSIR-4PI.

Figure 4.2: Students from engineering colleges participated in a Workshop on HPC and also visited HPC and Cyber Security facility at the CSIR-4PI.

Ashish

CSIR-4PI Student Programme for Advancement of Research Knowledge (SPARK)

The Student Programme for Advancement of Research Knowledge (SPARK) of CSIR-4PI has been successfully operational for the past ten years. This flagship student programme of the Institute provides a flexible framework for motivated students from all over the country to participate in the research programme of CSIR-4PI and thereby advance their research knowledge. Under SPARK, the students typically carry out their major project/thesis work with the joint guidance of the CSIR-4PI scientists and faculty members of their respective University/Institute. Students are also encouraged to visit CSIR-4PI for internship as well as for short-term exploratory research work. The programme is open to all Indian students who have formally enrolled for higher degrees, like BE/B.Tech/ME/M.Tech/M.Sc/MCA/Ph.D, etc. Applications are being received and processed online throughout the year.

V Anil Kumar, Ashish, Sajani Surendran and Stella Margeret

M.Tech/BE/MCA student thesis/projects supervised by

- **Anil Kumar V**
  1. Anuhya Gangavaram, Amrita VV, Coimbatore, ME (Cyber Security)
  2. Anirudh Srinivas, Amrita VV, Coimbatore, ME (Cyber Security)
  3. Athul Shajan, Karunya University, Coimbatore, B.Sc (Infn Security & Digital Forensics)
- **Ashapurna Marndi**
  1. Swaroop Hebbale, East West Instt of Tech, Bengaluru ME (CSE)
  2. Sravya Yepuri, PES Univ, Bengaluru, BE (CSE)
  3. Kesari Eswar Bhageerath, Gayatri Vidya Parishad College of Engg, Andhra Pradesh, BE (CSE)
  4. Aditya Arun Iyer, Manipal Instt of Tech, Karnataka, BE (CSE)
- **G K Patra**
  1. Ishan Padhy, PES Univ, Bengaluru BE (CSE)
  2. Ishita Erica Pinto, Delhi Technological Univ, Delhi BE (ECE)
  3. Poornashree N, Dayananda Sagar College, Bangalore, BE (CSE)
- **K C Gouda**
  1. Patita Kalyana Sahoo, Berhampur University, Odisha, M.Sc (Marine Science)
  2. Alok Kumar Mandal, Berhampur University, Odisha, M.Sc (Marine Science)
  3. Jyotirmaya Panigrahi, Berhampur University, Odisha, M.Sc (Marine Science)
  4. Swadesh Mohapatra, Berhampur University, Odisha, M.Sc (Marine Science)
  5. Shrutha V Bhat, Shri Madhwa Vadiraja Instt of Tech, Udupi, BE (CSE)
  6. Viswas Prabhu, Shri Madhwa Vadiraja Instt of Tech, Udupi, BE (CSE)
  7. Vikram Girish Thunga, Shri Madhwa Vadiraja Instt of Tech, Udupi, BE (CSE)
  8. Shravya Kamath U, Shri Madhwa Vadiraja Instt of Tech, Udupi, BE (CSE)
  9. Surbhi Tiwari, IIT, Kharagpur, ME (Agr Systems & Mgnt)
- **Imtiyaz Ahmed Parvez**
  1. Mrinal Jyoti Mahanta, Dibrugarh Univ, Assam, M.Sc (Applied Geophysics)
  2. Rikhiraj Dutta, Dibrugarh Univ, Assam, M.Sc (Applied Geophysics)

- **Anil Earnest**
  1. Mariya S Manjaly, Central University, Karnataka, M.Sc (Applied Geology)
  2. Angel Joshy, Central University, Karnataka, M.Sc (Applied Geology)
  3. Rekha Nair MS, Central University, Karnataka, M.Sc (Applied Geology)
  4. Sayandip Das, Central University, Karnataka, M.Sc (Applied Geology)
  5. Richards Nelson, Cochin University of Science & Technology, M.Sc (Marine Geophysics)
- **K V Ramesh**
  1. Nandana Manoj, IASc,
- **K S Yajnik**
  1. Rochan Das, IISER, Mohali

Industrial Visit to HPC at CSIR-4PI from various Institutes

Presentation on "Journey of HPC / Supercomputer evolution of CSIR-4PI" was done before students and faculties of following academic institutions.

1. BE Computers Science & Engineering, Dept. of CSE, around 55 students and 2 faculties on 9th November 2022, from Er. PMCTECH Engineering College Hosur, (Tamil Nadu).
2. M.Tech. Mechanical and Automobile Engineering, around 54 students and 3 faculties, on 10th November 2022, from Christ Deemed to be University, Bengaluru, Karnataka.
3. Around 50 High School students along with their faculties, on 15th July 2022 from JaiGopal Garodia Rastrhtrothan Vidyalaya HRBR Layout Kalyan Nagar, Bangalore
4. Around 40 Girls students with their faculties visited to HPC at CSIR-4PI on 10th January 2023 from Doctor Abdul Kalam Society for Human Awareness (DAKSHA) NGO, Bangalore

Prabhu N

4.3 CSIR Jigyasa

July-2022

On July 15, 2022, CSIR-4PI observed World Youth Skills Day. 50 students and 3 lecturers from the JGRV institution came to the CSIR-4PI campus to witness the research carried out within.




December-2022

On December 26, 2022, the KAMPNASTA team comprising winners of the National Assessment for Scientific Temperament & Aptitude (NASTA) from southern Indian states visited the CSIR-4PI campus. There were a total of 80 students in all who participated the event.



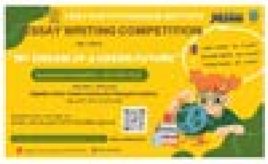
January -2023

About 55 students from NGO Daksha Academy visited CSIR-4PI for " Scientists - Students " interaction. The students were briefed for various topics viz high-performance computing, Green House gases, GNSS application in the field of geodesy and Climate Modelling.



February - 2023

English and Kannada Essay Writing Competition on “My dream of a Green Future”, and “nanna hasiru bhavishyada kanasu”, All the 6 students were invited to CSIR-4PI campus and were felicitated with Cash Awards and Certificates.






Pavithra N R

5. Knowledge Activities & Products

Knowledge creation,knowledge enhancement,knowledge dissemination and knowledge management have been among the core activities of CSIR-4PI. Ever since its inception, CSIR-4PI has maintained a high knowledge output in terms of publications and other scientific programmes, knowledge synthesis and exchange through conferences, workshops, brainstorming sessions,etc.
Inside:

- Publications in Journals
- Publications in Books/Proceedings
- Presentations in Conferences/Workshops/Seminars
- Participation in Conferences/Workshops/Training Programmes
- Guest Lectures
- Invited Talks
- In-house seminars/lectures
- Visitors at CSIR-4PI
- Events at CSIR-4PI
- Some major events organized by CSIR-4PI

5.1 Publications in Journals

1. Ashish, Saha, G., & Rai, S. S. (2023). 3-D crustal structure in Kumaon-Garhwal Himalaya using joint inversion of receiver functions and surface wave group velocity. Geophysical Journal International, 233(3), 21012123.
2. Bhimala, K. R., Patra, G., & Goroshi, S. (2023). Annual and seasonal trends in actual evapotranspiration over different meteorological sub-divisions in india using satellite-based data. Theoretical and Applied Climatology, 152(3-4), 9991017.
3. Chowdari, K., Deb Barma, S., Bhat, N., Girisha, R., Gouda, K., & Mahesha, A. (2023). Trends of seasonal and annual rainfall of semi-arid districts of karnataka, india: Application of innovative trend analysis approach. Theoretical and Applied Climatology, 152(1-2), 241264.
4. Ghavri, S., Yadav, R. K., & Jade, S. (2022). Seismic hazard potential of kachchh paleo-rift basin of indian craton from seismic and geodetic strain rates. Tectonophysics, 837, 229458.
5. Gouda, K. C., Rath, S. S., Singh, N., Ghosh, S., & Lata, R. (2023). Extreme rainfall event analysis over the state of himachal pradesh in india. Theoretical and Applied Climatology, 151(3-4), 11031111.
6. Hebbale, S., Marndi, A., Achyutha, P. N., Manjula, G., Mohan, B., & Jagadeesh, B. (2022). Automated medical image classification using deep learning. International Journal of Health Sciences, 6, 16501667.
7. Hebbale, S., Marndi, A., BH, M. K., Mohan, B., Pareek, P. K. (2022). A survey on automated medical image classification using deep learning. International Journal of Health Sciences, 6, 78507865.
8. Kallummal, R. (2023). Sea surface temperature variations partitioned through multiple seasonal cycles. Climate Dynamics, 60(3-4), 623641.
9. Purwar, S., Rakesh, V., Bankar, A., & Mohapatra, G. (2022). Relationship of height and intensity of low-level jet stream with indian summer monsoon rainfall. Theoretical and Applied Climatology, 115.
10. Rajendran, K., Surendran, S., Varghese, S. J., & Sathyanath, A. (2022). Simulation of indian summer monsoon rainfall, interannual variability and teleconnections: Evaluation of cmip6 models. Climate Dynamics, 58(9-10), 26932723.
11. Samanth, A., Rakesh, V., Purwar, S., Gavaskar, S., Jagadeesha Pai, B., & Mohapatra, G. (2022). Analysis of spatio-temporal variability in observed rainfall over karnataka using different data analytical techniques. Journal of Earth System Science, 131(2), 66.
12. Sarkar, S., & Himesh, S. (2022). Assessing the impact of modified lulc on extreme hydrological event over a complex terrain: A case study for kodagu 2018 flood event. Journal of Atmospheric and Solar-Terrestrial Physics, 240, 105961.
13. Senthilkumar, V. (2022). Some approximate buckling solutions of triple-walled carbon nanotube. Vietnam Journal of Mechanics, 44(3), 212232.
14. Singh, P., Bhaskar, Y., Verma, P., Rana, S., Goel, P., Kumar, S., Gouda, K. C., Singh, H. (2023). Impact of comorbidity on patients with covid-19 in india: A nationwide analysis. Frontiers in Public Health, 10, 1027312.
15. Singh, R., Rakesh, V., Varma, A. (2023). Association of winter vegetation activity across the indo-gangetic plain with the subsequent indian summer monsoon rainfall. Climate Dynamics, 60(7-8), 22452259.

16. Surendran, S., Ajay Anand, K., Ravindran, S., & Rajendran, K. (2022). Exacerbation of indian summer monsoon breaks by the indirect effect of regional dust aerosols. Geophysical Research Letters, 49(20), e2022GL101106.
17. Yaladanda, N., Mopuri, R., Vavilala, H., Bhimala, K. R., Gouda, K. C., Kadiri, M. R., Upadhyayula, S. M., & Mutheneni, S. R. (2023). The synergistic effect of climatic factors on malaria transmission: A predictive approach for northeastern states of india. Environmental Science and Pollution Research, 30(21), 5919459211.

5.2 Publications in Books/Proceedings

1. G.K. Patra, Kantha Rao Bhimala, Ashapurna Marndi, Saikat Chowdhury, Jarjish Rahaman, Sutanu Nandi, Ram Rup Sarkar, K.C. Gouda, K.V. Ramesha, Rajesh P. Barnwal, Siddhartha Raj And Anil Saini, Deep learning methods for scientific and industrial research, In: Venu Govindaraju. Arni S.R. Srinivasa Rao, C.R. Rao (eds) Handbook of Statistics (Deep Learning), Volume 48, Academic Press, Elsevier, USA, Print ISBN 978-0-443-18430-7., 48, 107 - 168 (2023), DOI:10.1016/bs.host.2022.12.002.
2. Marndi, A., Patra, G.K. (2022). Attention-Based Ensemble Deep Learning Technique for Prediction of Sea Surface Temperature. In: Saraswat, M., Sharma, H., Balachandran, K., Kim, J.H., Bansal, J.C. (eds) Congress on Intelligent Systems. Lecture Notes on Data Engineering and Communications Technologies, vol 114. Springer, Singapore. https://doi.org/10.1007/978-981-16-9416-5_30.
3. Siva Sai Kumar Rajana, Sampad Kumar panda, Sridevi Jade, Characteristics of Equatorial F-region Irregularities along the 90°E Meridian during High Solar Activity Phase, Proceedings of 2022 URSI Regional Conference on Radio Science (USRI-RCRS), IIT Indore, India, December 01-04, 2022.
4. P. Singhai, A. Chakraborty, K. Rajendran, Sajani Surendran, "The Role of Diabatic Heating in Influencing Seasonal Extremes in the Indian Summer Monsoon for the CFSv2 Model", 103rd AMS Annual Meeting, 5A.3, Denver, USA, https://ams.confex.com/ams/103ANNUAL/meetingapp.cgi/Paper/420751 , 10 January 2023.
5. P. Singhai, A. Chakraborty, K. Rajendran, Sajani Surendran, "Why do all ENSO Events not lead to Seasonal Extremes in the Indian Summer Monsoon", AGU Fall Meeting, A25E-07, Chicago, USA, https://agu.confex.com/agu/fm22/meetingapp.cgi/Paper/1086792 , 14 Dec 2022.
6. P. Singhai, A. Chakraborty, K. Rajendran, Sajani Surendran, "Are winds and moisture necessary to cause Indian summer monsoon extremes", EGU General Assembly 2022, EGU22-5658, Session AS1.18 (Atmospheric Sciences: Monsoon systems in a changing climate: past, present and future), https://doi.org/10.5194/egusphere-egu22-5658, Vienna, Austria, https://meetingorganizer.copernicus.org/EGU22/EGU22-5658.html , 23-27 May 2022.
7. Putatunda, I., Rakesh, V., and Mohapatra, G. N. (2022, December). Investigation of the role of Ocean-Atmosphere Interactions on Unusual Characteristics of Severe Indian Ocean Cyclone Nisarga. In AGU Fall Meeting Abstracts (Vol. 2022, pp. A21E-09).
8. Bankar, A. and, Rakesh V., (2022) Simulation of Extreme Rainfall Events over Karnataka, Southern state in India: Impact of Lead Time and Data Assimilation,

EGU General Assembly, Vienna, Austria, 2327 May 2022, EGU22-130, https://doi.org/10.5194/egusphere-egu22-130, 2022.

9. Purwar, S., Rakesh V, and Mohapatra, G., (2022), Interannual variability in Monsoon Low Level Jet and Indian summer monsoon rainfall (ISMR), EGU General Assembly, Vienna, Austria, 2327 May 2022, EGU22-171, https://doi.org/10.5194/egusphere-egu22-171, 2022.
10. G N Mohapatra, Smrati Purwar and Rakesh V, Platform for integrated flood disaster modeling for extreme rainfall events over Bangalore city of India August 10-12, 2022 Scope Convention Centre, New Delhi, Organized by Technology Information, Forecasting and Assessment Council (TIFAC), New Delhi and International Institute for Applied Systems Analysis (IIASA), Austria
11. G N Mohapatra, Extreme rainfall events Modelling over major urban cities of India ICCWE - 2022, Department of Water Resources Development and Management, Indian Institute of Technology Roorkee, September 19 -20, 2022
12. Vijayan M.S.M., Ray J.D., Godah W., Vincent A., and Rajendran K. (2022) Delineating the seasonal deformations of Nepal Himalayas induced by snow and water loading using GPS, GRACE and global climate model simulations, AGU Fall Meeting Abstracts 2022, G51A-01, 12-16 December 2022, Chicago, USA
13. Ray, J.D. and Vijayan M.S.M. (2022) Exploring the response of Nepal Himalaya to the hydrological loading during pre and post-seismic phase, AGU Fall Meeting Abstracts 2022, G44A-05, 12-16 December 2022, Chicago, USA
14. Ray, J. D., Godah, W., Devaraju, B., and Vijayan, M. S. M. (2022) Investigating the sources of surface mass loading signals in coastal GNSS permanent stations, EGU General Assembly 2022, Vienna, Austria, 2327 May 2022, EGU22-8682, https://doi.org/10.5194/egusphere-egu22-8682.
15. Sridevi Jade, GNSS based Geoscience Research in Indian subcontinent, Third International Virtual workshop on Global seismology and Tectonics (IVWGST-2022), Keynote Speaker, September 2022.

5.3 Presentations in Conferences/Workshops/Seminars

1. S. Yepuri and A. Marandi, “Classification of Blood Cell Data using Deep Learning Approach”, 2023 International Conference on Intelligent and Innovative Technologies in Computing, Electrical and Electronics (IITCEE), Bengaluru, India, 2023, pp. 9-17, doi: 10.1109/IITCEE57236.2023.10090986.
2. Siva Sai Kumar Rajana, Chiranjeevi G Vivek, Shrungeshwara TS, Sampad Kumar Panda, Ionospheric TEC variations over Ladakh Himalaya during Geomagnetic storm on 8 September 2017, 6th National Geo-Research Scholars Meet (NGRSM-2022), University of Ladakh, Leh Campus, Leh, India, June 7-10, 2022.
3. Siva Sai Kumar Rajana, Sampad Kumar Panda, Sridevi Jade, Characteristics of Equatorial F-region Irregularities along the 90řE Meridian during High Solar Activity Phase, Proceedings of 2022 URSI Regional Conference on Radio Science (USRI-RCRS), IIT Indore, India, December 01-04, 2022.
4. Chiranjeevi Vivek G, Sridevi Jade, Analysis of multi-GNSS data of continuous sites in Indian subcontinent, United Nations International Meeting on the Application of Global Navigation Satellite Systems, Vienna International Centre, Vienna, Austria,

December 05-09, 2022 (Virtual).

5. Babu, K. R. P. and Bhimala, K. R.: Recent trends in root-zone soil moisture over India using the GLEAM data for the period 1980-2020, EGU General Assembly 2022, Vienna, Austria, 2327 May 2022, EGU22-1663, https://doi.org/10.5194/egusphere-egu22-1663, 2022.
6. Gupta S V, Parvez I A and Khan P K (2022) Site Response Analysis and Shallow Shear Wave Velocity (Vs) Distribution beneath Kashmir Basin from microtremor experiments. AGU Fall Meeting Abstracts S41C-08.
7. Kallummal, R,. Drivers of Indo-Asian Monsoons: A Merger of Traditional and Contemporary Explanations, AGU Fall meeting 2022 (2022-12-16), Poster Presentation (Virtual Mode).
8. Kallummal, R,. Seasonal cycles, Interannual Variability, and Secular Trends in the Tropical Atlantic Region, AGU Fall meeting 2022 (2022-12-16), Poster Presentation (Virtual Mode).
9. Anil Earnest, Lithospheric Deformation in the Sumatra-Andaman region poster presentation in "NISAR Science Workshop" organized by SAC, Ahmedabad during 20-21 March 2023.
10. Anirudh Srinivas Balaji, V. Anil Kumar, P. P. Amritha and M. Sethumadhavan, "QUICLORIS: A Slow Denial-of-Service Attack on the QUIC Protocol", International Conference on Signal Processing and Integrated Networks, 25-26, August 2022, SPIN 2022: Advanced IoT Sensors, Networks and Systems, pp 8594.

5.4 Participation in Conferences/Workshops/Training Programmes

- **Anil Earnest**
  1. "NISAR Science Workshop" organized by SAC, Ahmedabad during 20-21 March 2023.
- **Ashapurna Marndi**
  1. Presented talk in I-STEM Tech Management Conclave for Women (ITMC-W): February 21-22, 2023 @ IISc Bangalore.
  2. Presented posters in Bengaluru Tech Summit, India's biggest technology summit held on 29th November to 1st December 2022.
- **Ashish**
  1. Online training on "CSIR ERP Ver 3.0", from 6th - 8th April 2022 (HR Module) and 18th -19th April 2022 (R & D) Module, organized by HRDC, Ghaziabad .
  2. Online training programme on "Emerging trends and best practices in RD project Management", from 17th - 20th May 2022 organized by HRDC, Ghaziabad.
  3. Online training programme on Programme on RTI and Transparency Audit, from 24th - 25th May 2022 organized by HRDC, Ghaziabad.
  4. Participated in Conclave-cum-Workshop for CSIR-Integrated Skill Initiative Programme Organized by CSIR-HRDC, Ghaziabad at NIO, Goa from 16th 17th February 2023.
- **G N Mohapatra**
  1. Organizing committee member in International Workshop on "BIODIVER-

SITY AND CLIMATE CHANGE" (16th19thFebruary 2023) Centre for Ocean, River, Atmosphere and Land Sciences (CORAL) Indian Institute of Technology Kharagpur, India

2. Chaired a session ICCWE -2022, Department of Water Resources Development and Management, Indian Institute of Technology Roorkee, September 19 -20, 2022

- **Chiranjeevi Vivek G**
  1. Space weather annual workshop organized by University Corporation for Atmospheric Research, Boulder, Colorado, USA, April 25-27, 2022 (Virtual).
  2. United Nations International Meeting on the Application of Global Navigation Satellite Systems, Vienna International Centre, Vienna, Austria, December 05-09, 2022 (Virtual).
- **Vijayan M.S.M**
  1. Vijayan M.S.M. AGU Fall meeting 2022, 12-16 December 2022, Chicago, USA, Online.
  2. Vijayan M.S.M. GNSS products NASAs CDDIS for disaster monitoring, crustal deformation, extreme weather and other applications, Earth data webinar, September 28, 2022.

5.5 Guest Lectures

- Senthilkumar V
  - Industrial Expert Lecture delivered on "Numerical Analysis/Simulations using Differential Equations in Engineering Science" at VIT, Vellore, Tamil Nadu (online mode) on 09.06.2022.
- G N Mohapatra
  - Chief Guest and speaker on special lecture, entitled "Artificial intelligence and numerical methods in data science: recent trends and future outlook" 02.7.2022 in Dr M.V. Jayaraman Auditorium, MVJ College of Engineering, Whitefield, Bangalore.

5.6 Invited Talks

- **Anil Earnest**
  1. Invited talk on "Multi-scale lithospheric dynamics" in Solid Earth Break-out session of "NISAR Science Workshop" organized by SAC, Ahmedabad during March 21, 2023.
- **Ashapurna Marndi**
  1. Keynote speaker in the international conference on "Artificial Intelligence, Data Analytics, Internet of Things & Cyber Security (ICAIC22)" held during May 20-21, 2022. Title of talk: Deep Learning and its Applications on Earth Science.
- **G N Mohapatra**
  1. Invited Speaker for International Conference on SYSTEMS ANALYSIS FOR ENABLING INTEGRATED POLICY MAKING entitled Platform for Integrated Flood Disaster Modelling for Extreme Rainfall Events Over Banga-

lore City of India August 10-12, 2022 Scope Convention Centre, New Delhi, Organized by Technology Information, Forecasting and Assessment Council (TIFAC), New Delhi and International Institute for Applied Systems Analysis (IIASA), Austria

2. Invited speaker for Innovative geospatial applications for sustainable development of smart cities (brainstorming-cum-stakeholders meet), School of Earth, Ocean and Climate Sciences, 20th August, 2022 IIT Bhubaneswar
3. Invited lead talk on for 3rdInternationalWorkshoponBiodiversity and Climate ChangeSustainable Development Perspective BDCC-2023,16-19February,2023 IIT Kharagpur
4. Invited key note speaker ICCWE -2022, Modeling of Extreme Rainfall events over major urban cities of India, International Conference on Climate and Weather-related Extremes ICCWE - 2022, Department of Water Resources Development and Management, Indian Institute of Technology Roorkee, September 19 -20, 2022

- **G K Patra**
  1. "Cyber Insecurity: Why? What? And How?", Cyber Security Awareness program, 6th October 2022, Indian Institute of Astrophysics and 11th October 2022, Raman Research Institute
  2. "Applications of ML & DL Algorithms for Addressing Security and Privacy Concerns of Vehicular Ad-hoc Network", DRDO-sponsored two days virtual workshop on "Machine Learning Algorithms for Wireless Communication Networks" Coimbatore Institute of Technology during 04-05th of Nov 2022.
  3. "Digitization & Emerging Technology : Agenda for Cyber Security research" Cybersecurity R&D and Innovation Roadshow 2023 by Data Security Council of India at Bengaluru on 2nd & 3rd February 2023
  4. "Complexity and Challenges of Hosting High Performance Computing Facility: A CSIR-4PI Perspective", Talk to Expert, Indian Science, Technology and Engineering facilities Map (I-STEM) 16th February, 2023
- **Kantha Rao**
  1. Mathematics in Modern Era, Department of Mathematics, MVJ College of Engineering, Bangalore, 11 March, 2023.
- **K Rajendran**
  1. Invited talk on "Climate Change Scenario in the Western Ghats: Past, Present and Future", Expert committee on Notification of Western Ghats Eco-Sensitive Area by Ministry of Environment, Forest and Climate Change, Govt. of India, Indian Institute of Science, Bangalore, 24 September 2022.
  2. Invited course lecture on "State of the art Climate Models and the reliability of Climate Change Projections", One month Certification Course on "Basics of Remote Sensing Application in Climate Change Modelling" during 18 August - 9 September 2022, Amity Institute of Environmental Sciences, Amity University in collaboration with India Meteorological Department (IMD), 01 September 2022.
- **Prabhu N**
  1. CSPARK 2K22 symposium on 17th November 2023, conducted by Department of Computers Science and Engineering, Er. PMCTECH Engineering

College, Hosur (Tamil Nadu)

- **Parvez I A**
  1. Earthquake Hazard Assessment in India and adjacent areas in NDMA and University of Kashmir organized training program on “Earthquake Risk Mitigation and Management” during October 17-21, 2022.
  2. Site-Specific earthquake hazard and microzonation studies a case study for Kashmir Basin in NDMA and University of Kashmir organized training program on “Earthquake Risk Mitigation and Management” during October 17-21, 2022
- **Rakesh V**
  1. Key note speaker at International Conference on Climate and Weather-related Extremes (ICCWE) on the topic “Data assimilation in mesoscale models for improved prediction of Weather Extremes” organized by Department of Water Resources Development and Management, Indian Institute of Technology Roorkee, September 19 -20, 2022
- **Sridevi Jade**
  1. Paradigms of Science, CSIR-IMMT, Bhubaneshwar, February 2022
- **Vijayan M.S.M**
  1. Vijayan M.S.M. IEEE GRSS keynote lecture on “Remote sensing of ionospheric perturbations induced by earthquakes and tsunami using GNSS”, IIT Indore, 8 April 2022.
  2. Vijayan M.S.M. Dr. A. Dhanalakshmi Endowment Lecture on “Physics in the age of AI & ML”, Seethalakshmi Ramaswami College, Tiruchirapalli, 30 August 2022

5.7 In-house seminars/lectures

1. **Sajani Surendran**, Interactive Training Lecture on “Climate Modeling and Climate Change” to 45 students from Darsha Academy, an initiative of Janodaya Trust, under the Jigyasa Programme of CSIR-4PI on 10 January 2023.
2. **G N Mohapatra**, Inhouse training and hands on session training program conducted by DHI Group at CSIR 4PI Network building on MIKE 21 (MIKE+ Model manager and urban flooding) software during 13th and 14th October, 2022.

5.8 Visitors at CSIR-4PI

- **Prof. Samir K Bhramachari**, Former DG, CSIR, 24 May 2022.
- **Dr Debasis Dash**, Chief Scientist, CSIR IGIB, 24 May 2022.
- **Dr Prakash Raghavendra**, Fellow, AMD, 24 May 2022.
- **Mrs Bhanu Sivakumar**, Sc F, CABS, 9 June 2022
- **Mr. Pradeep Raja**, Sc E, CABS, 9 June 2022
- **Ms. Anasuya Sahoo**, Sc E, CABS, 9 June 2022
- **Mr. Saigunaranjan**, Sc E, CABS, 9 June 2022
- **Mr. Samjith**, CABS, 9 June 2022
- **Dr. Shekhar C Mande**, Ex-DG, CSIR and President (VIBHA), 20 June 2022
- **Prof. Malay Mukul**, IIT-Bombay, 15 July 2022

- **Dr. Poornima Rupal**, Head, DGED & SCCD, CSIR-HQ, 15 July 2022
- **Shri. K Venkatasubramanian**, Head, CPD, CSIR-HQ, 15 July 2022
- **Prof. Rajender Singh Sangwan**, Director, AcSIR, 8 August 2022
- **Dr. Vibha Malhotra Sawhney**, Head, Technology Management Directorate (TMD), CSIR-HQ, 25 August 2022
- **Mr Prasad Bhukya**, TMD, CSIR-HQ, 25 August 2022
- **Mr Devendra Singh**, TMD, CSIR-HQ, 25 August 2022
- **Shri Anil Sagar**, Scientist-F, Ministry of Electronics & IT(Meity), 28 September 2022
- **Dr. Yudhishthira Sapru**, Scientist-D, CERT-In, Ministry of Electronics & IT, 28 September 2022
- **Mr. Swarun Nanduri Kameswara**, Scientist-C, CERT-In, Ministry of Electronics & IT, 28 September 2022
- **Ms. Himanshi**, Scientist-C, CERT-In, Ministry of Electronics & IT, 28 September 2022
- **Prof G Rangarajan**, Director, IISc, 21 October 2022
- **Dr. Sulochana Bhat**, Assistant Director (Ayurveda), In-charge of CARI, Bengaluru, 19 October 2022
- **Dr. Srinibash Sahoo**, Research Officer (Ayurveda), 19 October 2022
- **Dr. Kavya N**, Senior Consultant (Ayurveda), 19 October 2022
- **Dr. Monaca K.P**, SRF (Ayurveda), 19 October 2022
- **Dr. Amulya**, SRF (Ayurveda), 19 October 2022
- **Dr. Mahendra Darokar**, Chief Scientist, TMD, 12 November 2022
- **Shri. Amitava Banerjee**, CAG, 18 November 2022
- **Dr. Abhishek Kumar**, Senior Scientist, CSIR-HQ
- **Shri Mahendra Kumar Gupta**, Joint Secretary (Admn), CSIR, 29 Nov 2022
- **Dr. R Krishnan**, Executive Director,IITM, 6 November 2022
- **Dr. T Srinivasa Kumar**, Director, INCOIS, 6 December 2022
- **Dr. Shantanu Sen Gupta** , Chief Scientist, CSIR-IGIB, 19 January 2023
- **Dr. Debasis Dash**, Chief Scientist, CSIR-IGIB, 19 January 2023
- **Dr. Viren Sardan**, Principal Scientist, CSIR-IGIB, 19 January 2023
- **Shri Raj Hans Gautam**, Sr. DFA (IFD), 20 January 2023
- **Prof. Venugopal Achanta**, Director, CSIR- National Physical Laboratory, 24 January 2023
- **Dr. Ranjana Aggarwal**, Director, CSIR-NIScPR, 27 January 2023

5.9 Events at CSIR-4PI

19 April 2022 - Bharat Ratna Dr B R Ambedkar 131st Birth Anniversary Celebrations

Bharat Ratna Dr B R Ambedkar 131st Birth Anniversary Celebrated on 19 April 2022 jointly organised by CSIR-NAL and CSIR-4PI.

20 April 2022 - Ethics in Science & Research: An overview

LECTURE / SEMINAR held on 20 April 2022, Title: "Ethics in Science & Research: An overview"; Speaker: Dr S T Aruna, Senior Principal Scientist, CSIR-NAL, Bengaluru.

11 May 2022 - National Technology Day 2022

Twenty Fourth Technology Day Lecture on "Emerging Aerospace Technology Trends in Post Pandemic Era" by the Chief Guest Shri Dangeti Srinivasa Rao, Sr. Director and Head of Mechanical Systems of Honeywell India, Bengaluru was jointly organised by CSIR-4PI and CSIR-NAL.

21 June 2022 - International Yoga Day 2022 Celebrations

CSIR-4P1 in association with NAL Staff Club organized International Yoga Day program at Indoor Club of CSIR-NAL on 21-06-2022.

15 July 2022 - World Youth Skills Day 2022

Figure 5.1: CSIR-4PI celebrated World Youth Skills day on 15 July 2022 along with student s and teachers of JGR vidyalaya at CSIR-4PI campus.

15 July 2022 - CSIR-4PI 34th Foundation Day

Figure 5.2: CSIR-4PI celebrated 34th Foundation Day on 15 July 2022 with Dr. Vijay Bhatkar, National President, Vibha Chancellor, Nalanda University as Chief guest and Shri. Jitendra J Jadhav, Outstanding Scientist & OSD Aeronautical Development Agency as guest of honour. Shri K,Venkatasubramanian, Head, CPD & Dr. Purnima Rupal, Head, DGED graced the occasion with their presence.

15 July 2022 - Science & Technologies in Aerospace Defense Sectors in Kannada"

Figure 5.3: CSIR 4PI & CSIR-NAL jointly organized National Conference on "Science & Technologies in Aerospace & Defense Sectors in Kannada" on the occasion of 50 years of Kannada Samskritika Sangha on 15th July 2022 at CSIR-NAL campus, Bengaluru. A 10 minutes presentation and Exhibit space was setup to showcase the R&D activities of CSIR-4PI. The event saw a participation of 500+ participants.

21 July 2022 - iCEN-56-"Climate Change through the lens of modelling, artificial intelligence and machine learning"

Figure 5.4: CSIR-4PI organised the Climate Change through the lens of modelling, artificial intelligence and machine learning in the i-CONNECT EVENT iCEN-56 on 21 July 2022.

15 August 2022 - Celebration of 76th Independence Day at CSIR-4PI and flag hoisting

Figure 5.5: Celebration of 76th Independence Day at CSIR-4PI and flag hoisting.

21 October 2022 - 81st CSIR Foundation day

Figure 5.6: 81st CSIR - Foundation day was celebrated on 21st October 2022 and Prof. G. Rangarajan, Director, IISc as the chief guest and delivered a talk on “Detecting Connectivity Patterns in Networks”.

19 October 2022 - Celebration of Ayurveda Day

Figure 5.7: CSIR-4PI in association with CARI celebrated Ayurveda Day on Wednesday, 19 October 2022. A free Ayurvedic medical camp was organized as part of the program and plantation drive was also done. Dr. Kavya N gave a lecture on Methods of Disease Prevention in Ayurveda.

31 October 2022 to 06 November 2022 - Vigilance Awareness week- 2022

Figure 5.8: "Vigilance Awareness week- 2022" was observed from 31-10-2022 to 06-11-2022 by CSIR-4PI jointly with CSIR-National Aerospace Laboratories, Bengaluru (CSIR-NAL)

16 to 18 November 2022 - Bengaluru Tech Summit (BTS)2022

Figure 5.9: CSIR-4PI actively participated in the Bengaluru Tech Summit (BTS) 2022, India's biggest technology summit, which was held from 16th to 18th November 2022 in Bengaluru Palace, Bengaluru, Karnataka along with other CSIR labs like CSIR-NAL, CSIR-CDRI, and CSIR-Imtech. CSIR Pavilion received the Best R&D Exhibition Award at Bengaluru Tech Summit 2022 from the Honble Chief Minister of Karnataka, Shri Basavaraj S Bommai, in the presence of Honble Minister, Shri Piyush Goyal, Ministry of Industries and Commerce, and Shri Dr. Ashwath Narayana C N, Honble Minister for IT, BT and S & T, Govt. of Karnataka.

7 December 2022 - workshop on Prevention of sexual harassment of women at workplace


Figure 5.10: CSIR 4-PI organized workshop on : “Prevention of sexual harassment of women at workplace (POSH)” on 07 Dec 2022, Inaugural Address was given by Smt. M.K. Sharada, Chief Scientist and Chairperson Internal Complaints Committee, while the lecture was given by Smt. Jyothi, Programme Manager, Janodaya Trust, Bengaluru.

9 to 12 January 2023 - Training Program on Greenhouse Gases (GHG)

Training Program on Greenhouse Gases (GHG) : Estimation, Measurement and Modelling under CSIR-Integrated Skill Initiative Program held during 9th-12th Jan 2023.


Figure 5.11: Training Program on Greenhouse Gases (GHG) : Estimation, Measurement and Modelling under CSIR-Integrated Skill Initiative Program

18 to 19 January 2023 - Program on Phenome India CSIR-Cohort during

Figure 5.12: The CSIR-4PI along with CSIR-NAL and CSIR-IGIB conducted an awareness program on Phenome India CSIR-Cohort during 18th - 19th Jan 2023 under PI-CHECK (Phenome India-CSIR Health Cohort Knowledgebase) project.

26 January 2023 - Celebration of 74th Republic Day at CSIR-4PI

Figure 5.13: Celebration of 74th Republic Day at CSIR-4PI and flag hoisting.

5 February 2023 - CSIR-4PI Jigyasa : English & Kannada Essay Writing Competition on My dream of a Green Future

Figure 5.14: Winners of CSIR-4PI Jigyasa : English & Kannada Essay Writing Competition on My dream of a Green Future.

7 February 2023 - Ayurveda Camp conducted at CSIR-4PI

7th February 2023, 10:00 h - 16:00 Ayurveda Camp conducted at CSIR-4PI.

21 February 2023 - Mathrubhasha Diwas

CSIR- National Aerospace Laboratories and CSIR-Fourth Paradigm Institute, Jointly Celebrating “Mathrubhasha Diwas” On 21st Feb 2023, at CSIR-NAL, Cricket Ground.

7 March 2023 - International Women’s Day event

Figure 5.15: On 7th March 2023, CSIR-4PI Organized International Women’s Day event titled "WHERE THERE IS A WOMEN THERE IS A MIRACLE".

8 March 2023 - CSIR-NAL and CSIR-4PI jointly celebrated International Women's Day

Figure 5.16: CSIR-NAL and CSIR-4PI jointly celebrated International Women's Day on March 8, 2023 at CSIR-NAL campus, Bengaluru.

5.10 Some major events organized by CSIR-4PI

CSIR-4PI at India International Science Festival -2022

The 8th edition of IISF is being held in the city of Lakes, Bhopal from January 21-24, 2023. The Ministry of Science and Technology (MoS&T), Ministry of Earth Sciences (MoES), Department of Atomic Energy (DAE), Department of Space (DoS), Government of India and Government of Madhya Pradesh are jointly organising IISF 2022 on the theme 'Marching towards Amrit Kaal with Science, Technology and Innovation'. The Department of Biotechnology, Ministry of Science & Technology is the nodal coordinating department for organising IISF-2022. The Madhya Pradesh Council of Science and Technology (MPCOST) is the local partner and Vijnana Bharati (VIBHA) as Knowledge Partner for IISF 2022. One of the most popular event Science through Games & Toys is coordinated by CSIR-Fourth Paradigm Institute (CSIR-4PI) in support with VIBHA and SAM Global University, Bhopal.

Toys are representations of the cultural, social, economic, and traditional aspects of a region/country. Toys have evolved over 5000 years since the Indus Civilization and with the advancement in science and technology, the toys have also become technically refined. Toys not only act as amusement, and entertainment but also serve the purpose of teaching, learning, recreation, etc. Traditional and educational toys help in the understanding of the basic concepts of math and science which assist in the child's overall improvement

Figure 5.17: Inauguration of the event "Science through Games & Toys" in IISF2022 by Chief Guest Dr. N Kalaiselvi, DG, CSIR presided by Dr. Sridevi Jade, Head, CSIR-4PI on 22nd January 2023.

including physical, mental, logical, and emotional development. Toys also reveal the history, heritage, and lifestyle of the artisans, and craftsmen who have been involved in making these playful models. Toys try to connect the child to nature and make them understand its behavior in a simple way. In the present technologically advanced world of gadgets like mobiles, tablets, etc, there is a dire need to develop the toys industry in order to provide them with a healthy childhood and safeguard their future. IISF provides a platform to showcase traditional, innovative, creative and modern toys by traditional toy makers along with new startups in a spirit of 'Vocal for Local'. This event also invites accomplished speakers and organise creative shows for students to initiate logical thinking and inculcate learning of science through Games and Toys.

The salient feature of IISF2022: GAMES & TOYS were Traditional & creative exhibits and Talk show / Fab-Lab Show. The ultimate goal was to provide global platform for local toys and games. and Inculcation of a scientific attitude among students through games and toys. On 22nd January 2023 the programme was inaugurated by Dr. N Kalaiselvi, Director General, CSIR & Secretory, DSIR as chief guest, Er. Preeti Saluja, Chancellor, SAM Global University, Prof. N K Tiwari, VC, SAM Global University as special guests under presidency of Dr. Sridevi Jade, Head, CSIR-4PI. The event begun with an interactive and live demonstration from Sh. Manish Jain, Director, CCL, IIT Ganndhinagar wherein the topics of Physics and Geometry were dilatory taught using simple newspaper models which were made by students from instructions from IIT-Gandhinagar team members. Day 1 ends with Fab Lab Show by Prateek and Roshni. Day2 started by Dr. Jayant Joshi, (from B.A.R.C. Mumbai) on topic of Science behind toys and followed by a Talk on Bhartiya Khel by Sh. Amitabh Satyam, Chairman, Smart Transformation emphasizing importance on Bhartiya Khel over western sports. Afternoon Session ends with a show on

Figure 5.18: Inauguration of Games & Toys Exhibition by Chief Guest Dr. N Kalaiselvi, DG, CDIR at IISF 2022.

Fun with Flying Things Basic Aerodynamic Made Easy by Rtd. Cdr. T. R. A . Narayanan, an enthusiast and passionate for Aeromodelling from Goa.

Figure 5.19: Experts interaction with students and teachers and learning science using Games & Toys by Sh. Manish Jain, IIT Gandhinagar and Roshni from Fab Lab Show.

Dr. Ashish, Kaustubh Omar, Prof. N K Tiwari [*] ***and Prof. Ganti S. Murthy*** [+]
- Vijnana Bharati, [*] - SAM Global University, Bhopal, [+] - IIT Indore

6. Projects & Collaborative Programmes

Multi-institutional, national and international collaborative research programmes have been the core of CSIR-4PI research. CSIR-4PI today has active collaboration with a number of national and international institutions.
Inside:

- Grant-in-Aid Projects
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6.1 Grant-in-Aid Projects

1. National carbonaceous Aerosols Programme (NCAP): Working Group III-Carbonaceous Aerosol Emissions, Source Apportionment and Climate Effects, Ministry of Environment, Forest and Climate Change (MoEF&CC), PI-Dr. Sajani Surendran
2. Geological Characterization of the Kashmir Valley with the Objective of Quantifying Probabilistic Hazard and Risk in the High-Risk area of the Valley Using a Logically Integrated set of Geo-Scientific Investigation, Ministry of Earth Sciences, Government of India, PI-Dr. Imtiyaz A. Parvez
3. Assessment of regional hydrology using space borne gravity observations: Robust estimation of deformation due to hydrological loading in NE-India and Upper Ganga river basin, Department of Science and Technology, PI-Dr.M. Sithartha Muthu Vijayan, Co-PI-D.K. Rajendran
4. Developing a Public Health Informatics Platform in India for a systems View of Health and Diseases under Epidemiology Data Analytics (EDA) of Interdisciplinary Cyber Physical Systems (ICPS) Programme of DST, Gol, Department of Science and Technology, Ministry of Science and Technology, PI-Dr.K.C. Gouda, Co-PI-Dr. Kantha Rao Bhimala
5. A Darknet/Network Telescope Based Cyber Security Monitoring and Inference Framework, Ministry of Electronics and Information Technology, PI-Dr.V. Anil Kumar
6. Feasibility Evaluation, Impact Quantification and Mitigation of Low Rate Cyber Attacks on Multipath Transmission Control Protocol (MPTCP), Department of Science and Technology, Ministry of Science and Technology, PI-Dr.V. Anil Kumar
7. Modeling and Forecasting of High Impact Weather Events in the Beas basin, and Designing a proto-type Advance Warning System for Mitigating their Adverse Impacts, Ministry of Environment, Forest and Climate Change (MoEF&CC), PI-Dr.K.C. Gouda
8. Design Intervention Strategies for Mitigating the Impacts of heat waves through modified land cover, Department of Science and Technology, Ministry of Science and Technology, PI-C. Neethu
9. Influence of Upper Ocean Physical Processes on the Oxygen and Nutrient Variability in the North Indian Ocean using eddy permitting coupled ecosystem model of global Ocean, Women Scientist Scheme A (WOS-A) Department of Science and Technology, PI-Dr. Chikka Kalyani Devasena
10. Improving the prediction of Thunderstorms using Dual-Resolution Hybrid Ensemble-Variational Data Assimilation System using WRF model, Ministry of Earth Sciences (MoES), Government of India, PI-Dr.V. Rakesh
11. Design and Development of a Hybrid Modeling System for the Management of select horticultural crops in Andhra Pradesh, Dr.Y.S.R. Horticultural University (YSRHU) Andhra Pradesh, PI-Dr.K.V. Ramesh, Co-PI-Dr.V. Rakesh
12. Ionospheric imagery of earthquake source region using the Co-seismic Ionospheric Perturbations (CIPs), Science and Engineering Research Board (SERB), Department of science and Technology, GoI, PI-Dr. Dhanya Thomas
13. Impact Assessment of New and Emerging Waste Management Technology on Human Life, Ministry of Science & Technology, Department of Science and Technology, GoI, Dr. Lakshmikanthan P

14. A physically based Coupled Modeling Testbed for assessing hydrological impact and design of sustainable intervention strategies to mitigate adverse impacts on surface water cycle process under future climate over Monsoon Driven Riven Basins of India, Women Scientist Scheme A (WOS-A), Department of Science & Technology, PI- Dr. Sumana Sarkar
15. Analysis and modeling of thunderstorm events in India, Ministry of Science & Technology, Department of Science and Technology, GoI, PI-Ms. Payoshni Samantray

6.2 Major Lab Projects (MLP)

1. Integrated of GNSS and Board data for high resolution velocity structure and crustal deformation in Jammu, Kashmir and Ladakh Himalaya (IGBHK), PI- Dr. Sridevi Jade, Co-PI- Dr. Imtiyaz A Parvez & Chiranjeevi Vivek G
2. Development of a modelling platform for Hydro-Meterological Disaster early Warning System for major metro cities in India (HDWS), PI-Dr.G.N. Mohanpatra, Co-PI-Dr.V. Rakesh
3. Setting up of CSIR HPC, AI & ML Platform (CHAMP), PI- Shri.R.P. Thangavelu, Co-PI- Dr.Gopal Krishna Patra
4. HPC Cloud Resource at CSIR-19 Research Support for Indian Researchers, PI- Dr. Gopal Krishna Patra, Co-PI- Shri R.P. Thangavelu

6.3 Other Lab Projects (OLP)

1. Development of High Precision Greenhouse Gases (GHG) Database in Indian Context, PI- Dr.K.C. Gouda, Co-PI- Shri Iranna Gogeri
2. GNSS & Seismic Network in the Indian subcontinent, PI- Dr. Sridevi Jade, Co-PI- Dr. Imtiyaz A Parvez & Shri Chiranjeevi Vivek G
3. Vehiclur Platform for Algorithm Testing and Traffic Data Collection, PI- Dr.G.K. Patra

6.4 Headquarter Controlled Projects (HCP)

1. AI-enabled Technologies & Systems (AITS), PI- Dr.G.K. Patra, Co-PI- Dr. Ashapurna Marndi
2. Phenome India-CSIR Health Cohort Knowledge base, PI- Shri Thangavelu R P, Co-PI- Dr. Gopal Krishna Patra

6.5 Network Projects (NWP)

1. CSIR Integrated Skill Initiative-Phase II Programme, PI- Dr. Ashish, Co-PI- Smt.Pavithra

6.6 Industry Sponsored Project

1. VANET Security, Cognizant funded project PI: G K Patra

6.7 MOU's Signed

1. MoU was signed on 05-April-2022 between CSIR Fourth Paradigm Institute, Bengaluru and Karnataka State Natural Disaster Monitoring Centre, Department of Revenue (Disaster Management), Government of Karnataka.
2. MoU signed on 08-06-2022 between CSIR-4PI and Siksha O Anusandhan (SOADU) university, Bhubaneswar. undertaking multi-disciplinary research and joint collaboration.
3. Memorandum of Understanding for "Academic and research Collaboration" between CSIR Fourth Paradigm Institute, Bengaluru, India and Pondicherry University, Pondicherry, India, Greenhouse gas monitoring And Research, to be signed on 30-09-2022.

7. Staff News & Updates

CSIR Centre for Mathematical Modelling and Computer Simulation (CSIR CMMACS) was set up in 1988 with the mandate to develop expertise, excellence and facilities for undertaking major mathematical modelling and simulation problems in identified areas primarily of relevance to CSIR. CSIR CMMACS was repositioned in 2013 as CSIR Fourth Paradigm Institute (CSIR-4PI) to provide the country a unique positioning in the domain of computational and data intensive research powered by high performance computing and informatics research. One of the smallest of CSIR laboratories, CSIR4PI today is a young and vibrant institution of research.

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7.1 Staff List

Head
Sridevi Jade

Honorary Scientists
Gaur V K
Mudkavi V Y
Rao E V S P
Yajnik K S

Scientists
Anil Earnest
Anilkumar V
Ashapurna Marndi
Ashish
Chiranjeevi Vivek
Gouda K C
Gyanendranath Mohapatra
Himesh S
Iranna Gogeri
Kantha Rao Bhimala
Lakshmikanthan P
Parvez I A
Patra G K
Pavithra N R
Rajendran K
Rakesh V
Ramesh K V
Ramashan K
Sajani Surendran
Senthilkumar V
Sharada M K
Thangavelu R P
Vijayan M S M

Technical Officer
Prabhu

Technical Staff
Chandrashekara Bhat
Sita S
Stella Margaret A
Veeresh
Dileep Kumar P

Administration
Ramaprasad,B.S
Mangala S
S. Geetha
Ved Prakash
Sreedevi, KKVSS
Abhijina
Sujatha Keshava Murthy
Rajalakshmi V
Lakshmi Priya
Vinod M Sharma
Archa R S
Aiswarya P Venkitesh

Finance and Accounts
Rajesh V
Abhimanyu Kumar Tiwary
Narayana Murthy Pulla
Aravind Kumar J

Stores & Purchase
Vikash Chandra Mishra
Kishan Kumar Singh

DST Women Scientists
Chikka Kalyani Devasena
Neethu C
Sumana Sarkar
Payoshni Samantray

National Post-Doctoral Fellow
Dhanya Thomas

SRF/JRF/RA
Smruthishree Lenka
Swetha S
Smrati Purwar

Project Assistants/ Project SRF/JRF
Nidhi Singh
Ajay Anand K V
Shruthi S
Venkatesh Gowda
Pratiksha Gopal Krishna Sawant

Rajendra Kumar Dash
Fayaz Ahmad Bhat
Madhvee Kori
Rushikesh Dipak Gudadhe
Josin Sanal Thomas
Janaani Sri R
Athul CP
Amal P Jose
Gaurav Melkani
Vishal Gupta S
Priyadharshini
Aishwarya Pampapathi
Dhananjay Kumar C
Amit Umesh Patil
Sudhansu Sekhar Rath
Ajay Vijay Bankar
Jahnavi Meda
Ipsita Putatunda
Arun Prasad P
Nikhilasuma P
Reshma Kumari
Rakhi
Kanike Raghavendra Prasad Babu
Rani Devi

7.2 Awards/Honours/Recognition

- **Ashish**, Doctoral degree awarded by Osmania University on thesis titled "Crustal Structure in the Central Hiamalaya", December, 2022.

7.3 Services on External Committees/Membership of Professional Bodies

- **Anil Earnest**
  1. Member, American Geophysical Union (AGU)
  2. Member, Society of Exploration Geophysicists (SEG)
  3. Member, Society of Earth Scientists (SES), India
  4. Associate Member, International GNSS Service (IGS)
  5. Member, Asia Oceania Geosciences Society (AOGS)
  6. Member, Seismological Society of America (SSA)
- **Anilkumar V**
  1. Member, Project Review and Steering Group (PRSG), MeitY.
  2. Member (Invitee) Advisory Board of Society for Electronic Transactions and security (SETS), Chennai
  3. Member, Board of Studies, Coimbatore Institute of Technology (CIT).
  4. Member, Expert Committee for preparation of syllabus for Post Graduate Diploma in Cyber security (PGDCS) in the Department of Information Technology, Kannur University
  5. Member, Selection committee, C-DAC.
  6. Member, review committee for patent renewal recommendation, CSIR-NAL
  7. Member, Internet Society (ISOC)
  8. Life Member, Computer Society of India
- **Gouda K C**
  1. Member in the High Impact Weather Project (HIWeather) of the World Meteorological Organization
  2. Life Member, Indian Meteorological Society

3. Life Member, Indian Society of remote sensing
4. Executive member, India Meteorological Society, Bangalore Chapter
5. Member, Indo-Africa group on Research on vector borne disease
6. Member, Advisory Board, Dept. of CSE, Dayananda Sagar college of Engineering, Bangalore
7. Member, Board of Studies, Dept. of MCA, Dayananda Sagar University, Bangalore
8. Member, Board of Studies, School of Computer Science, Jain University, Bangalore
9. Member, M.Tech Thesis Evaluation Committee, VTU
10. Member, M.Tech Examiner, VTU
11. Member, Doctoral Committee, VTU
12. Member, Doctoral Committee, Jain University
13. Member, PhD thesis Evaluation Committee, Andhra University, AP
14. Member, M.Sc examiner, Berhampur University, Odisha
15. Member, Project review committee (PRC), DSIR-PRISM

- **Chiranjeevi G. Vivek**
  1. Associate Member, International GNSS Service (IGS)
- **Himesh S**
  1. Life Member, Indian Society for Technical Education
  2. Life Member, Indian Society for Environmental Management
  3. Life Member, Indian Meteorological Society
- **Parvez I A**
  1. Member, Selection and Assessment Committee of IIT Kanpur
  2. Member, Selection committee for the admission of AcSIR PhD students of CSIR NAL.
  3. Nodal Officer, Disaster Management Cell of CSIR NAL and CSIR 4PI
  4. Member, Hindi Technical Advisory Committee (HTAC) for CSIR NAL
  5. Member, Task Force of Bureau of Indian Standards Map Subcommittee, CED 39:4, Government of India to prepare a Probabilistic Seismic Hazard Map of India.
  6. PhD Examiner, Indian School of Mines, Dhanbad and IIT Roorkee
  7. Member, Hindi Technical Advisory Committee (HTAC) of CSIR NAL.
  8. Life Member: Indian Society of Earthquake Technology
  9. Life Member: Indian Society of Earthquake Science
  10. Member, Editorial Board, Seismic Instruments, Springer Nature Switzerland AG
- **Patra G K**
  1. Member, Industrial Advisory Committee, Computer Stream, Manipal Institute of Technology.
  2. Member Selection Committee, National Centre for Disease Informatics and Research, Indian Council of Medical Research.
  3. Member, Technical Expert Group for IT Infrastructure Procurement and Implementation, Kidwai Memorial Institute of Oncology, Bangalore.
  4. Technical Member, Advisory committee for establishment of Networking Infrastructure and Data center at the new permanent campus of IIT, Dharwad

- **Rajendran K**
  1. 1. Associate Editor, Journal of Earth System Sciences, Indian Academy of Science
  2. Invitee, Expert Committee on Notification of Western Ghats Eco-Sensitive Area by Ministry of Environment, Forest and Climate Change, Govt. of India
  3. Member, Research Proposal Evaluation Committee, KSCSTE & E, Govt. of Kerala
  4. Member, Board of Studies in Atmospheric Sciences, Cochin University of Science & Technology, Cochin, Kerala.
  5. Member, Scientific committee, State Planning Board for Climate Change, Government of Kerala
  6. Executive Council Member, Indian Meteorological Society
  7. Life Member, Indian Meteorological Society
- **Rakesh V**
  1. Life Member of Indian Meteorological Society
  2. Member, Indian Society of Agronomy
- **Sajani Surendran**
  1. Member, Working Group III, National Carbonaceous Aerosol Project, MoE-FCC, GoI.
  2. Life Member, Indian Meteorological Society
- **Sridevi Jade**
  1. Life Member, Indian Geotechnical Society
  2. Life member, Indian Geological Congress
  3. Member, International Society of Soil Mechanics and Foundation Engineering
  4. Founder Life Member, Indian Society of rock mechanics and tunneling technology
  5. Associate Member, International GNSS Service (IGS)
  6. Senate Member, AcSIR
  7. Expert Member, Committee for CSIR Emeritus Scientist Schemes 2021-2023
  8. Executive Committee Member, Karnataka State Natural Disaster Monitoring Agency, Government of Karnataka
  9. DG Nominee, National Supercomputing Mission Executive Board (NSM-EB)
  10. DG Nominee, National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)
  11. Expert member, Technical Advisory Committee, Government of Karnataka
  12. Reviewer, for Several International and National SCI Journals
- **Thangavelu R P**
  1. Life Member, Computer Society of India
  2. Life Member, Cryptology Research Society of India
  3. Member, Cloud Computing Innovation Council of India
  4. Member, Expert Group on Infrastructure, National Supercomputing Mission, GoI
  5. Member, Executive Committee, Karnataka State Natural Disaster Monitoring Centre, Bangalore
  6. Member, Technical Expert Group for IT Infrastructure Procurement and Im-

plementation, Kidwai Memorial Institute of Oncology, Bangalore
7. Member, Technical Evaluation Committee for procurement of HPC system for Gas Turbine Research Establishment, Bangalore.

- **Vijayan M S M**
  1. Member, American Geophysical Union (AGU)
  2. Member, European Geophysical Union (EGU)
  3. Member, International Association of Geodesy (IAG)

7.4 Newly Joined Staff

- Lakshmi Priya, Junior Stenographer
- Vinod M Sharma, JSA (Gen.)
- Archa RS, Junior Stenographer
- Aiswarya P Venkitesh, JSA (Gen.)
- Kishan Kumar Singh, JSA (S&P)
- Aravind Kumar J, JSA (F&A)

7.5 Promotions

- K C Gouda, Sr. Principal Scientist
- Rakesh V., Sr. Principal Scientist
- Anil Earnest, Principal Scientist
- Ashish, Principal Scientist
- Ashapurna Marndi, Principal Scientist
- Iranna Gogeri, Sr.Scientist
- S Mangala, Controller of Administration
- Rajalakshmi V, Private Secretary

7.6 Superannuation

- Sita S, Sr.Technician-2

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Team CSIR-4PI

RIGHT TO INFORMATION (RTI)

CSIR-Fourth Paradigm Institute, Bangalore, is committed towards information transparency under the Right to Information Act 2005. The Institute makes available all the information on it's website www.csir4pi.res.in, in lines with the spirit of the RTI Act 2005.

Details of the officers dealing with RTI's are as follows:

1. Dr. Ashish, CPIO, Senior Scientist
2. Shri. R P Thangavelu, FAA, Chief Scientist
3. Smt. S Mangala, Transparency Officer, COA


DG SET-1
DG SET-2
DG SET-3