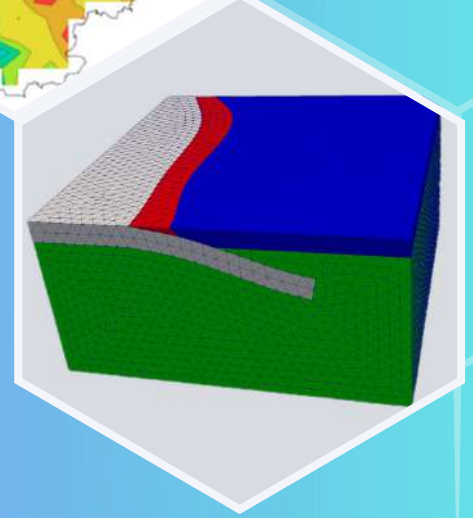
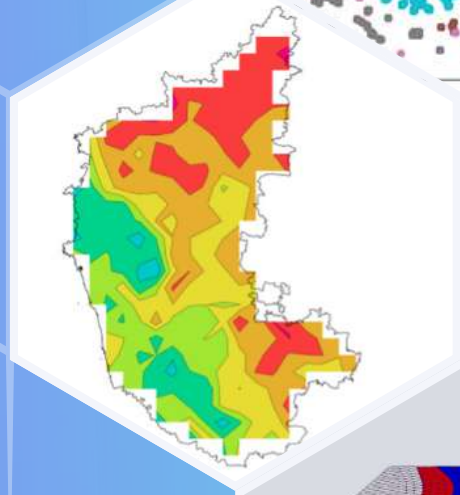
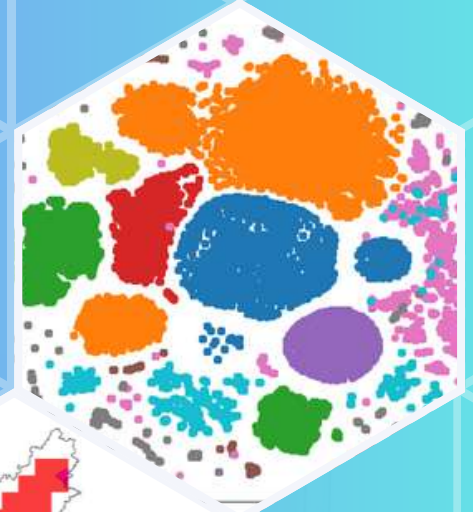


ANNUAL REPORT

2023-2024



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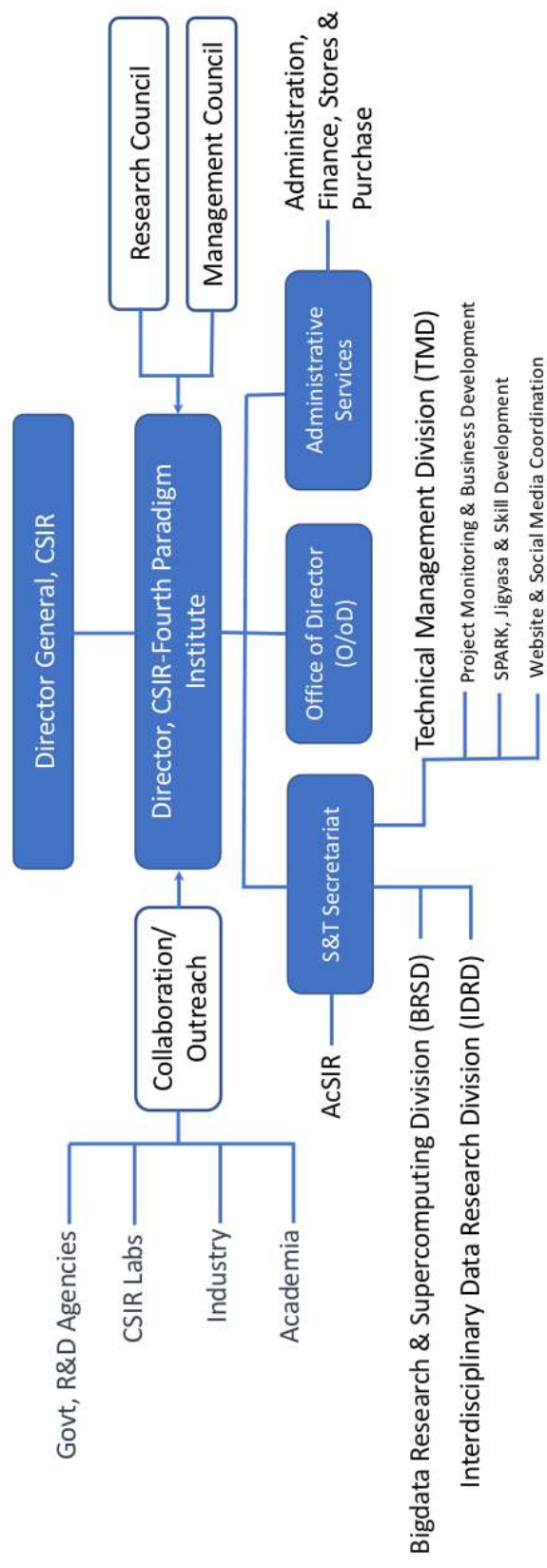
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CSIR - FOURTH PARADIGM INSTITUTE

WIND TUNNEL ROAD, BENGALURU-560037



CSIR-Fourth Paradigm Institute



VISION

To synergize the Transdisciplinary Pan-CSIR expertise and build a unified platform that embodies a rich set of big data enabling technologies and services with optimized performance to facilitate data intensive scientific discovery in the country.

MISSION

To Pioneer data driven interdisciplinary research in diverse fields through state-of-the-art data science ecosystem and impactful industrial partnerships for the betterment of Society.

MANDATE

To develop cutting edge data science products as a horizontal across the CSIR Themes and position as an Institute of Excellence in Bigdata and Artificial Intelligence.

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Released on, 15 July 2024

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ACKNOWLEDGEMENTS

We extend our gratitude to all the scientists and staff of the CSIR-Fourth Paradigm Institute for their invaluable contributions to this report. Special thanks go to Dr. G. K. Patra and Dr. K. C. Gouda for their time and insightful suggestions, which were crucial for the timely completion of this report. We also acknowledge the photography section of CSIR-NAL for providing some of the event photos. This report was typeset using $\text{\LaTeX}$ collaborative authoring tools available at www.overleaf.com.

Preface



Year 2023-24 marked a significant milestone in the three and half decades journey of CSIR Fourth Paradigm Institute (CSIR-4PI) with the approval of Governing Body of CSIR on 7 March 2023 to the proposal of “National Laboratory Status” and ‘Director’ for CSIR-4PI. This approval, uniquely positions CSIR-4PI as the one and only Data Science lab of CSIR and gave it wings to launch itself in to the future and contribute to data intensive scientific discovery.

CSIR HPC, AI & ML Platform (CHAMP) centralized supercomputing facility was inaugurated by Dr. N. Kalaiselvi, DG-CSIR and Secretary, DSIR. This facility consists of 410 nodes of CPU only computing and 12 nodes with 48 GPUs for AI applications with a combined computing power of about 3 PetaFlops. Further, with the existing GPU system of 1.2 PetaFlops, the total available computational capability stands at 4.2 PetaFlops. CSIR-4PI has established "MEGHA a scalable cloud storage for CSIR with an initial capacity of about 4 Petabyte and scalable to about 22 Petabyte. The storage for the first time provides a seamless access capability through sync and share facility to researchers across CSIR.

Advisory Committee (AC) of CSIR-4PI met twice during this year with Smt. Nivruti Rai, CEO and MD, Invest India as chairperson along with highly acclaimed expert members with diverse expertise. AC commended the team for their continued and sustained research output along with several outreach activities with sub-critical manpower. We completed recruitment for 16 scientific positions during this year.

“One Week One Lab” (OWOL) is a countrywide initiative of CSIR following the suggestion of Dr Jitendra Singh, Honble Union Minister of Science and Technology to showcase the technological breakthroughs and scientific innovations of the Council of Scientific & Industrial Research (CSIR) laboratories. CSIR Fourth paradigm Institute (CSIR-4PI), a constituent laboratory of CSIR has organised this campaign during July 10-15, 2023, that culminated with the Foundation Day celebrations on July 15, 2023. We conducted Press meet, Curtain raiser to launch our OWOL program. Each day of OWOL covered Jigyasa, Skill Initiative, Stakeholders Meet, Academia-Industry-Student-Scientist Interaction, Farmers Meet, Scientific Outreach and Roadshow.

Bigdata research and supercomputing division (BRSD) marked this year with CSIR AI initiative for Industry with a two-day brain storming between the CSIR labs represented by their Directors and team followed by Industry and stakeholders meet. The main motive of this initiative is to “Ensure AI Leadership for India”, “Create an AI enabled CSIR” and “Enable manifestation of AI for Industry” by harnessing the power of AI to accelerate industrial growth, innovation, and competitiveness.

Our AI Mission mode and the domain agnostic AI projects continue to deliver as per targeted schedule with the scope being enhanced to include health care, agritech and so on. Cyber security vertical gave insights in to hierarchical clustering of malicious http payloads, retrospective analysis of Internet background radiation and advanced cyber-security inferences.

Interdisciplinary data research division added a feather to their cap with sanction of CSIR mission mode project “Region Specific Smart Agro-technologies for Soil and Plant Health” with CSIR-4PI as Nodal lab. The budget outlay of this project is about Rs. 25 Cr. with participation of 10 CSIR labs spread across the country. This division is globally recognised for their world class research in climate modelling, impact of climate change on various sectors, computational seismology, GNSS and GHG.

Advanced Climate research gave insights in to Indo-pacific warm pool frequency, new pacific decadal oscillation, impact of nutrient availability on primary productivity in Indian ocean, hypersensitivity of Indian summer monsoon, impact of climate change on extreme rainfall events, complex dynamical systems and their implications for climate data analysis. Further, research on dynamics of Indian summer monsoon, extreme weather events, storm water modelling platform for Bengaluru, rainfall variability over Karnataka, impact of climate parameters to malaria spread in northeast India, AI models for crop yield prediction, AI applications to climate and weather data, measurement and analysis of GHG are some notable contributions during this year.

Geoscience research activity made significant contributions related to GPS crustal deformation and earthquakes in 2500km Himalayan arc, probable magnitude and recurrence interval of earthquakes in seismically active Himachal, Kashmir and Ladakh Himalaya. Further, fine imaging of crustal and upper mantle structure beneath Northwest Himalaya, Ionosphere studies using GPS data, noise estimates of GNSS signals, geodetic and seismic strain in Nepal Himalaya and a 3D FEM mesh for Andaman subduction zone are some notable contributions.

Our Skill Initiative program, conducted a five-day intensive course in data science followed by advanced course on ocean science and modelling which saw enthusiastic participation of students from across the country. As part of Industrial visit programme, several institutions participated in one day workshop on HPC, Cybersecurity, GNSS, GHG and Agritech. Spark program resulted in training 147 students across the country. For the first time, week long summer training on HPC, climate modelling, GNSS+Seismology, GHG and five day winter workshop on GHG for high school students was conducted under Jigyasa. Several science competitions, webinars, training and visits for school students were also conducted. Our Institute’s Jigyasa and Skill initiative programs saw more than 500 school and college students participation.

We conducted several events throughout the year which are listed in the events section of the report. Notable events being the Hindi week celebrations, observance of Hindi Day and Vishwa Hindi Divas giving impetus to Rajbhasa implementation at our Institute.

Our doctoral students who are the backbone of our research activities continue to contribute to high impact research of global relevance. 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 privileged to be given an opportunity to lead the only data science institute of CSIR and continue to strive hard to reach our goal of being recognised as ‘Institute of Excellence in Bigdata and Artificial Intelligence’.

Dr Sridevi Jade
Director



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I Bigdata Research & Supercomputing

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Bigdata Research & Supercomputing

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1. Domain Agnostic AI, Cyber Security & Infrastructure

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 pursue 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:

- 1.1 CSIR HPC, AI & ML Platform (CHAMP)
- 1.2 HPC cloud resource at CSIR for COVID-19 research support for Indian researchers
- 1.3 Ananta Supercomputer with Skylake
- 1.4 Energy Farm: HPC Support Infrastructure
- 1.5 Operating System Fingerprinting of Malicious Network Traffic for Cybersecurity Inference
- 1.6 TCP Destination Port Evolution of Internet Background Radiations: Retrospective Analysis
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- 1.10 Enhancing Breast Cancer Diagnosis: A Comprehensive Study of Deep Learning Techniques
- 1.11 Creation of Multi-View Traffic Dataset

1.1 CSIR HPC, AI & ML Platform (CHAMP)

The CSIR centralized HPC facility, known as CHAMP (Figure 1.1), is designed to support both CPU and GPU workloads. The new system includes 410 dual CPU nodes, each equipped with AMD 7763 processors, featuring 128 cores and 512 GB of memory per node. In total, the system boasts 52,480 processor cores and 205 TB of RAM, capable of achieving a peak computing power of approximately 2 PF with sustained performance of about 1.4 PF on HPL benchmarks.

In addition to the CPU nodes, the system includes 12 compute nodes equipped with 4 GPUs each, providing a peak performance of 960 TF and sustaining approximately 600 TF on HPL benchmarks (equivalent to about 30 AI Peta FLOPS). For storage, the supercomputer utilizes an online LUSTRE parallel file system with a usable capacity of approximately 8 PiB. The inter-node communication within the HPC system is facilitated by high-speed HDR 200 InfiniBand switches, utilizing HDR 100 InfiniBand links to each node in a fully non-blocking FAT tree topology configuration. The usage pattern of CHAMP supercomputer is given in the Figure 1.2.



Figure 1.1: CSIR HPC, AI & ML Platform (CHAMP).

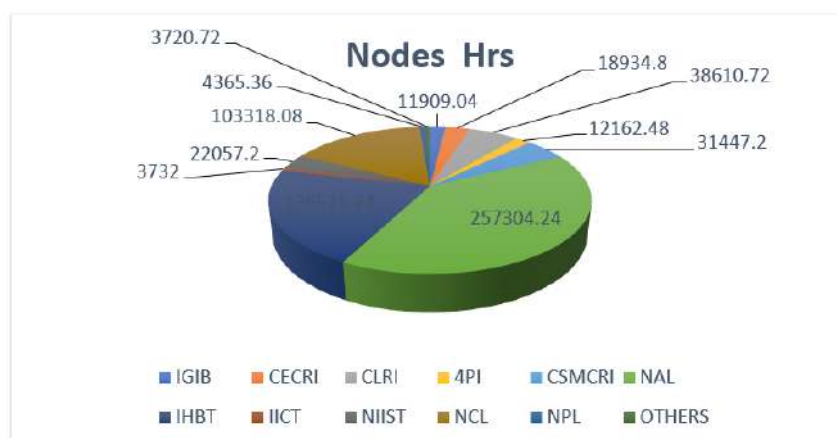


Figure 1.2: Usage of CHAMP cluster in Jan 2024- Mar 24.

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

1.2 CSIR-AMD Research Engagement

The CSIR AMD Research Engagement Network was established in collaboration between CSIR and AMD as an initiative as part of AMDs COVID-19 HPC Global Fund. AMD designed and deployed a GPU-based compute infrastructure capable of delivering over one PetaFLOPS of compute power. This system is accessed remotely by researchers via the high-speed national knowledge network.

This HPC (Figure 1.3) consists of 24 nodes based on AMD EPYC processors, each equipped with 8 AMD Radeon Instinct MI-50 GPUs, 48 GB of CPU memory, and 128 GB of GPU memory. Additionally, DDN India donated a 250 TB parallel file system for use as a scratch file system. The goal of this initiative is to find deployable solutions by leveraging the high-performance computing platform at CSIR-4PI, guided by the principles of Open-Source Innovation and Data Sharing Policy. A large number of GPU enabled software in the field of data science, molecular simulations, AI ML are available on the system.



Figure 1.3: HPC cloud resource at CSIR for COVID-19 research.

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1.3 Ananta Supercomputer with Skylake

The Ananta Supercomputer, is retained with Skylake based 48 computing nodes with peak performance of 489TF. Each skylake based computing node comprised of two numbers of eighteen core Intel Xeon Gold 6140 processors, 192 GB memory, 100 Gbps EDR infiniband. Usage of Skylake nodes is about 82 thousand node hours in the reporting period. The usage pattern of the Skylake nodes is given in the Figure 1.4.

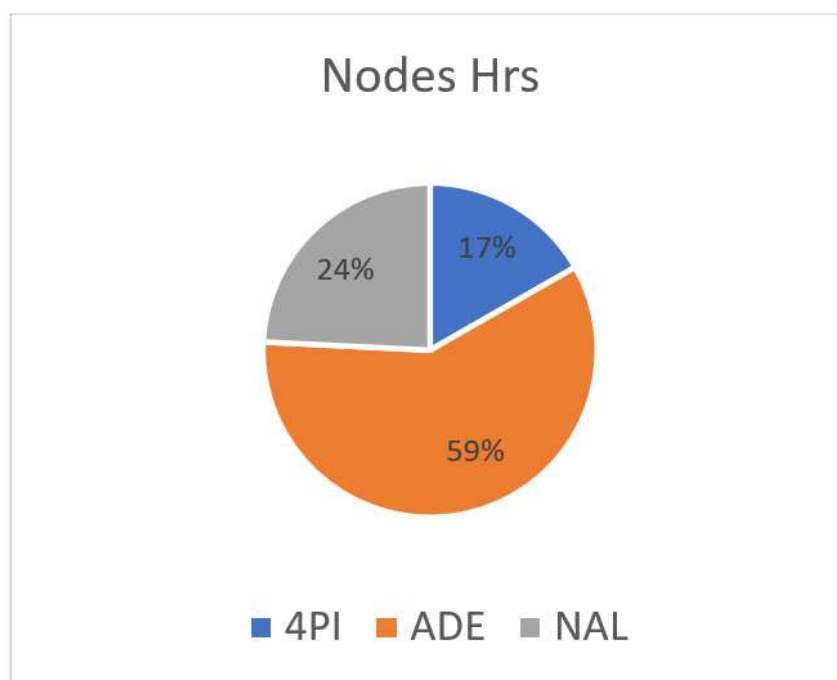


Figure 1.4: Usage of skylake nodes in Aug 2023- March 24.

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1.4 Energy Farm: HPC Support Infrastructure

The support infrastructure is crucial for ensuring the smooth operation of the HPC system. The data center, equivalent to Tier-3 standards, is supported by a state-of-the-art energy farm, essential for maintaining continuous production mode.

For the CHAMP Supercomputer, cooling is managed through a combination of liquid (Direct Contact Liquid Cooling - DCLC), water, and air-cooling methods. DCLC handles 60% of the cooling for the CPU nodes, while air-cooling manages the remaining 40%. GPU-based compute systems are cooled using active Rear Door Heat Exchangers (RDHx). This combination of cooling technologies aims to achieve a Power Usage Efficiency (PUE) of approximately 1.258.

The energy farm includes redundant compact substations totalling 1.25 MVA, three 1010 KVA diesel generators for backup power, and an underground diesel yard with a capacity of 15 KL (Figure 1.5). To ensure uninterrupted power supply, three 400 KVA UPS units have been replaced with two 600 KVA modular UPS systems (each with 4x300 KVA modules) along with adequate battery backup, ensuring continuous 24x7 power supply to the data center.

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



Figure 1.5: CSIR centralized HPC support infrastructure.

1.5 Operating System Fingerprinting of Malicious Network Traffic for Cybersecurity Inference

Operating System (OS) fingerprinting is the process of remotely identify the OS of hosts/devices on the network without having physical or administrative access to these devices. The process, if applied to malicious traffic, would enable to gain better insight on the devices responsible for malicious activities on the Internet and take possible preventive steps. In this work, we explored the feasibility of OS fingerprinting of raw TCP connections observed in malicious traffic from various part of the Internet. The traffic consists of not only the TCP three-way handshake (SYN, SYN/ACK and ACK) observed, but also some of the post connection hypertext transfer protocol (http) payloads extracted from packets.

The overall methodology can be broadly divided into two modules, the Operating System prediction model and the auto updating database. The former makes use of the TCP/IP header information present in the SYN packet of a client to predict its Operating System information, while the latter extracts the Operating System information from the HTTP user-agent present in the PUSH+ACK packets of a client to establish the ground truth for model retraining process. As the model takes the TCP/IP information from SYN packet and yields the OS information, the ground truth extracted from the PUSH+ACK needs to be tagged with the corresponding TCP/IP information of the client SYN packet. This is done using a cache-based approach wherein the latest SYN packets are stored and when the PUSH+ACK packet containing the OS information, for a particular IP address present in the cache, is encountered the necessary fields are combined and then inserted into the database.

Figure 1.6 shows a representative results when a 10 lakh packet subset of the network traffic was analysed and processed to extract the database for the initial model training. Out of these packets, 8 thousand PUSH+ACK packets containing the Operating System information were encountered. These belonged to 1589 unique IP addresses, and their OS distribution is shown in Figure 1.6.

Parth Dhole*, V Anil Kumar, Priyadarshini, HNV Dutt and Aswani Kumar Cherukuri*

* - Vellore Institute of Technology

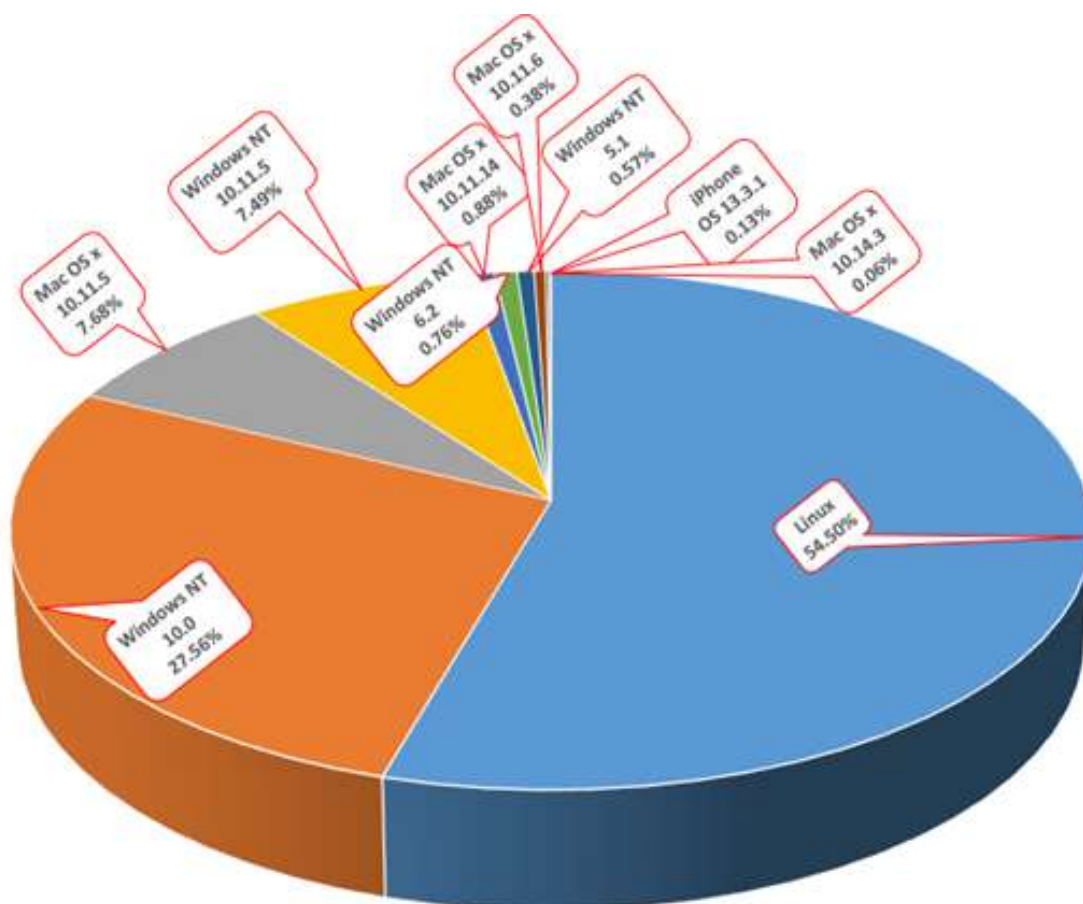


Figure 1.6: Operating System Distribution.

1.6 TCP Destination Port Evolution of Internet Background Radiations: A Retrospective Analysis

TCP continues to be one of the most popular and widely used transport protocols on the Internet. A sizable portion of the malicious traffic (e.g., port-scan, worm propagation, brute-force password cracking attempts, etc.) in the cyberspace is by default transported over TCP. By large, the 16-bit TCP destination port number is a good representation of the application that triggers the malicious traffic. Hence, macroscopic analysis of TCP destination ports of malicious traffic can indicate the trend on how new services are being exploited or targeted in the cyberspace. For better understanding of the evolution of malicious activity on the cyberspace, we studied various aspects of TCP destination ports observed in malicious traffic over a period of time.

Figure 1.7 show the number of unique TCP destination ports seen on specific dates during an extended period of 5 years, spanning from the year January 2019 to August 2023. These dates for each year are selected from our database based on the availability of malicious traffic on a specific day for all the years.

The plateauing behavior during the years 2019 to 2021 is attributable to the pandemic induced sluggishness across the globe. It is evident from the plot that post pandemic period, viz., years 2022 and 2023, the number of unique TCP destination ports observed

has further increased. On the specific days mentioned for year 2023, the unique port count has reached about 40,000 out of the maximum possible value of 65535 (216-1).

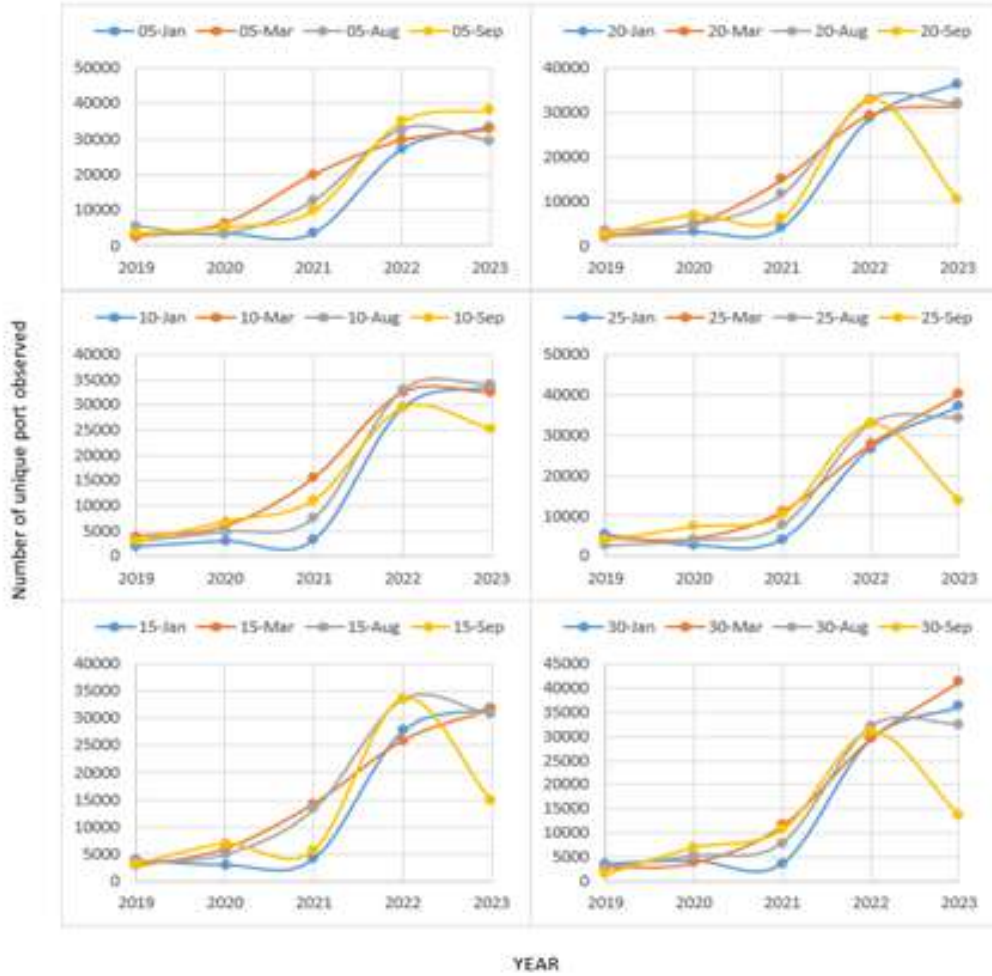


Figure 1.7: TCP destination ports observed in malicious traffic.

V Anil Kumar, Madhvee Kori, H N V Dutt and Aravind Raj A.

1.7 Hierarchical Clustering of malicious http payloads

In this work, we applied hierarchical clustering, an unsupervised technique, to malicious http payload observed soon after TCP three-way handshake process. As these payloads are textual in nature, including some non-ascii characters, our research delves into the transformative realm of natural language processing (NLP), specifically focusing on the word embedding process and subsequent hierarchical clustering of embeddings generated by the Sentence-BERT (SBERT) model. Word embeddings serve as a foundational element, facilitating the conversion of textual information into continuous vector representations. SBERT, chosen for its superior semantic understanding, pretrained models, and demonstrated performance, plays a pivotal role in the text to vector conversion process.

Figure 1.8 provides a representative result by clustering malicious http payload observed for a continuous period of 90 days from July 6 to October 3, 2023.

As seen in Figure 1.8 (left), the payload forms a number of well-defined clusters. Our further analysis shows that each cluster represents certain malicious events being attempted using http as the applying protocol. Figure 1.8 (right) maps these clusters into more realistic attack scenarios. The analysis reveals the multifaceted nature of network behaviours within http traffic, encompassing activities such as Ethereum blockchain operations, websocket handshake attempts, malicious directory traversal attacks and many other diverse array of attack patterns and exploitations attempts.

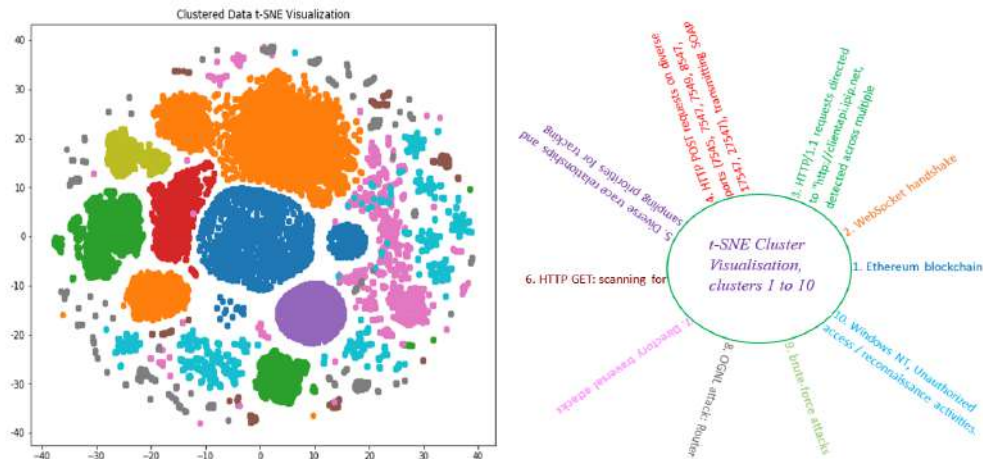


Figure 1.8: (left) t-SNE visualization of http payload after clustering and (right) mapping of the clusters to realistic network events.

**Arun Prasath S*, V Anil Kumar, Prajwal H S, HNV Dutt, Akash Deep Dixit and
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*PSG College of Technology

1.8 Image Fusion using Gaussian Filter-Based Image Fusion Algorithm

Image fusion plays a pivotal role in many fields like medical imaging, military and surveillance remote sensing etc. to enhance the quality and utility of visual information. Especially, fusion of infrared and visible images has high importance in every scenario from computer vision to medical sector. The objective of this work is to develop an effective method for producing clear objects with high spatial resolution along with background information by fusing infrared (IR) and visible (VIS) images. This integrated image can be efficiently utilized by humans or machines. To achieve this objective, we propose the use of Multi-Layer Bilateral Filtering (BF) and Gaussian Filtering (GF) techniques, which improves the skewness and kurtosis of fused images. While the BF technique consistently produces higher quality images, the GF approach outperforms it by 86% in terms of statistical measures such as skewness and kurtosis. The findings demonstrate that the GF technique yields outputs with reduced noise and improved visual appeal. As depicted

in Figure 1.9(a), VIS images possess more detailed spatial information and Figure 1.9(b) illustrates the distinct edges and structural features present in IR images. Consequently, before performing the fusion process, the key characteristics of the two distinct channels of the layers must be extracted. The purpose of fusing infrared (IR) and visible (VIS) images is to integrate essential information from the IR image into the VIS image. The fused images resulting from their approach are shown in Figure 1.9(c) and (d). To demonstrate the effectiveness of the proposed technique, this work compares the values of skewness, kurtosis, peak signal-to-noise ratio (PSNR), and image similarity ratio.



Figure 1.9: The images of “Ship” and the fused outcomes achieved by different algorithms. (a) VIS, (b) IR, (c) Fused Image using Bilateral Filtering Method, (d) Fused Image using Gaussian Filtering Method.

A Marndi

1.9 Synthetic Image Generation using Generative AI

Generative Adversarial Networks (GANs) have revolutionized image generation by allowing creation of highly realistic and diverse images. With the advancement of these capabilities, there is chances of security concerns increasingly coming to the forefront. It is one of the pressing priorities to examine the complex landscape of privacy preservation in GAN-based image generation. Simultaneously, it addresses significant privacy concerns, such as the potential misuse of GANs for creating deepfakes, committing identity

theft, and engaging in other malicious activities. To address these issues, we explore various techniques and strategies incorporated within GAN models to preserve privacy. These include differential privacy methods and innovative architectural designs that emphasize data protection while maintaining GANs robust generative abilities.

A Marndi & GK Patra

1.10 Enhancing Breast Cancer Diagnosis: A Comprehensive Study of Deep Learning Techniques

Breast cancer remains one of the most common cancers affecting women worldwide, with critical factors such as tumour stage, size, grade, lymph node status, histological type, and hormone receptor status influencing patient risk and treatment decisions. Histologic grading, which pathologists perform using the Nottingham histologic grading system, plays a crucial role in this process. Traditionally, pathologists analyse histology slides through microscopes to grade cancer, but digital pathology has revolutionized this field. By scanning physical histology slides to obtain whole slide images, digital pathology reduces the burden on pathologists. It introduces the potential for AI technologies to aid in cancer diagnostics and prognostics. Despite advancements in deep learning technologies producing promising results in medical image analysis, the black-box nature of AI models has hindered their adoption in clinical settings. The decision-making process in tumour grading is critical for treatment planning and prognostic analysis, necessitating explainable and interpretable AI applications. Our study explores the trans-

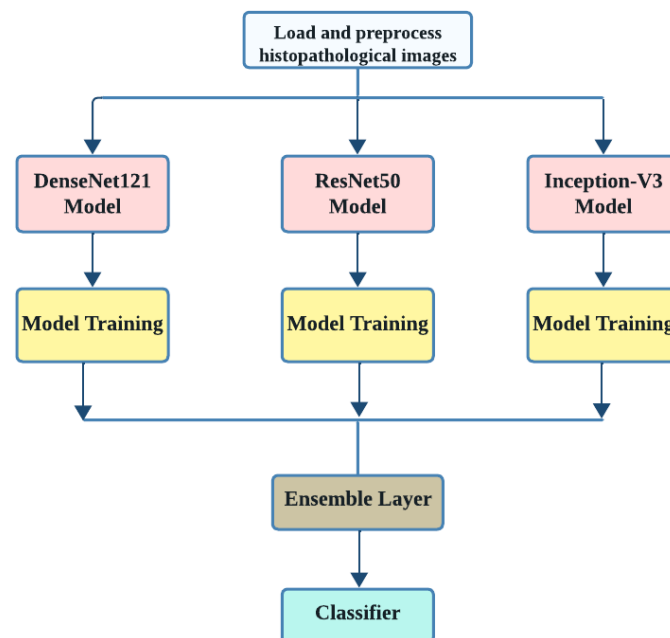


Figure 1.10: Ensemble Learning Approach.

formative potential of deep learning in breast cancer diagnosis, focusing on classifying

publicly available histopathology slide images into Normal, Benign, In Situ, and Invasive categories. Various deep-learning models, including DenseNet121, ResNet50, Inception-v3, and VGG19, are evaluated for their effectiveness. An ensemble model combining DenseNet121, ResNet50, and Inception-v3 is also explored. The evaluation employs standard metrics, revealing DenseNet121's superior accuracy of 81.67% and F1 score of 0.8143. ResNet50 and Inception-v3 show balanced performance, while the ensemble model demonstrates promising results. Notably, the ensemble model's exploration adds a unique dimension, showcasing an enhanced accuracy of 90%, indicating its potential in clinical settings. Research findings underscore the significant potential of deep learn-

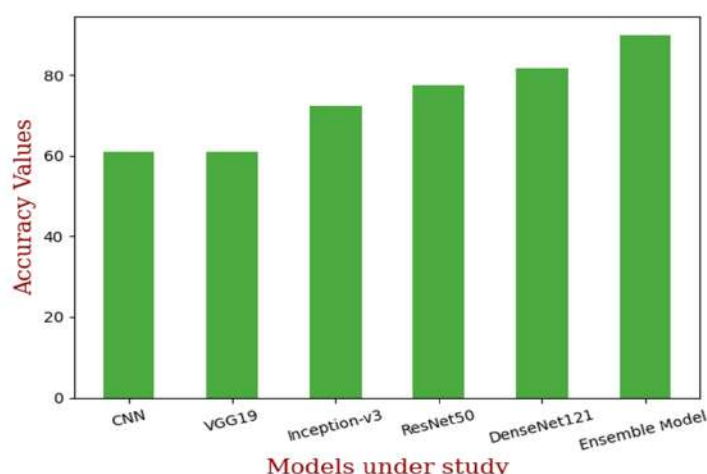


Figure 1.11: Results of comprehensive study.

ing, with ensemble learning emerging as a promising avenue for improving breast cancer diagnosis accuracy. Further research is encouraged to refine and optimize these models, paving the way for their integration into clinical workflows and empowering pathologists for more efficient and accurate diagnoses. The study contributes to the growing knowledge in deep learning for breast cancer diagnosis, emphasizing the need for continued exploration and refinement of ensemble learning techniques. Our research is centred around the dataset from the 2018 Challenge of Breast Cancer Histopathology (BACH) within the International Conference on Image Analysis and Recognition (ICIAIR). This dataset is particularly pertinent for classifying breast cancer subtypes and serves as a benchmark in medical image analysis. To gain insight into how deep learning algorithms manage the intricacies of breast cancer subtype classification, we meticulously scrutinize these algorithms based on various performance metrics.

A Marndi & Rashmi KS

1.11 Creation of Multi-View Traffic Dataset

A comprehensive dataset of approximately 12,000 minutes of video data and 1.2 million images has been created, focusing on Bengaluru traffic. This data was collected using three vehicles, including two cars and one minibus. Each vehicle was equipped with two front-mounted cameras, one on the left and one on the right, positioned at a height of

1.7 meters from the ground. Data collection was conducted over five different routes, ranging from 7 km to 20 km (See Figure 1.12). For each route, data was gathered over 15 consecutive days, with recordings made during six different time periods each day. This extensive dataset provides valuable insights into traffic patterns and behaviors in Bengaluru.

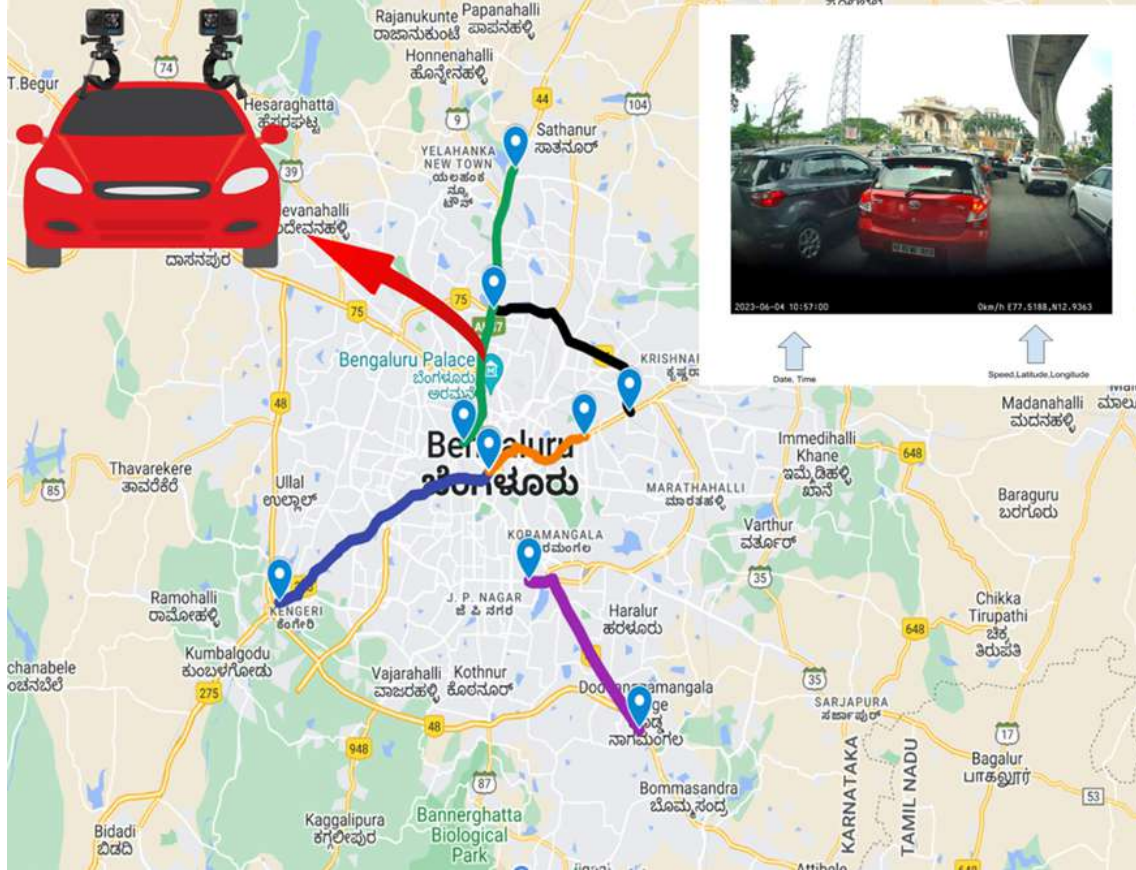
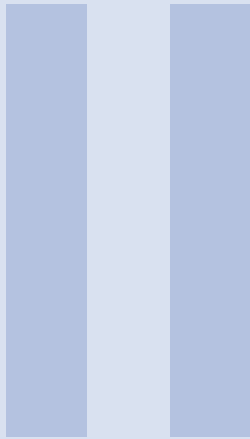


Figure 1.12: Identified Bangalore routes with sample traffic image.

Gaurav Melkani, A Marndi, G K Patra



Interdisciplinary Data Research

2	Advanced Weather & Climate Research	27
3	Geosciences & Engineering Research	59

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:

- 2.1 Warm Pool Frequency and High Frequency Region
- 2.2 Impact of Nutrient availability on Primary Productivity using Biogeochemical Model Simulations
- 2.3 Measurements and Analysis of Greenhouse Gases (GHG)
- 2.4 Understanding Complex Dynamical Systems and Their Implications for Climate Data Analysis
- 2.5 New Pacific Decadal Oscillation: Low-Frequency Imprints of Amplitude-Modulated Seasonal Cycles
- 2.6 Do clouds become more convective during very Extreme Rainfall Events (vEREs) due to the impact of climate change in global model projection?
- 2.7 Hypersensitivity of Indian summer monsoon to moisture exchange with the Pacific Ocean in CFSv2
- 2.8 The role of ensemble averaging in ENSO-monsoon relationship in CFSv2 model
- 2.9 Optimizing LSTM and Bi-LSTM models for crop yield prediction and comparison of their performance with traditional machine learning techniques
- 2.10 Improved learning by using a modified activation function of a Convolutional Neural Network in multi-spectral image classification
- 2.11 Development of stormwater modelling platform for Bengaluru city of India
- 2.12 Dynamics of Indian summer monsoon in different phases
- 2.13 Intensity duration and frequency of Heat wave in different phases of MJO over India

- 2.14 Intensity-Duration-Frequency analysis of Indian Summer Monsoon
- 2.15 Analysis of heat wave over different physiographical regions in India
- 2.16 Climate parameter and malaria association in north-east India
- 2.17 Extreme Rainfall Event analysis in India
- 2.18 Assessment of Rainfall Variability over Karnataka state in India
- 2.19 Spatio-temporal analysis of air pollution dynamics over Bangalore city during second wave of COVID-19
- 2.20 Estimation of Vegetation Index over the State of Sikkim
- 2.21 Dynamical influence of MJO phases on the onset of Indian monsoon
- 2.22 Multi-source soil moisture data for efficient water management in agriculture

2.1 Warm Pool Frequency and High Frequency Region

Indo-Pacific warm pool (monthly sea surface temperature (SST) $> 28^{\circ}\text{C}$), due its size, has considerable influence on precipitation over vast areas in tropics and extra-tropics and, hence, on global climate.

Two new ideas have been developed to get insight into the interconnected variations in space and time of normal (30-year average) annual cycle of the Indo-Pacific warm pool. Warm pool frequency is defined as the frequency (0:1) of SST crossing the threshold ($= 28^{\circ}\text{C}$) for a given month and a given 30-year period. High Frequency Region (HFR) is defined as the region where warm pool frequency exceeds 0.5. The Figure 2.1 shows that the normal area (a) of Indo-Pacific warm pool (in black) and its normal mean latitude (b) are well approximated by the area and mean latitude of HFR (in green), while there is reasonable agreement between normal mean longitude of the warm pool and mean longitude of HFR (c).

A manuscript is under preparation.

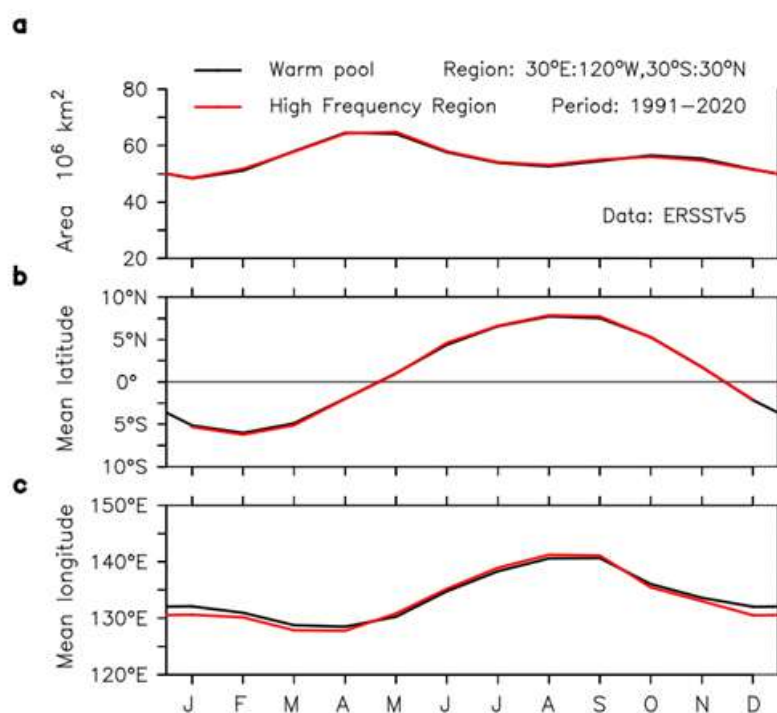


Figure 2.1: The Figure shows that the normal area (a) of Indo-Pacific warm pool (in black) and its normal mean latitude (b) are well approximated by the area and mean latitude of HFR (in green), while there is reasonable agreement between normal mean longitude of the warm pool and mean longitude of HFR (c).

2.2 Impact of Nutrient availability on Primary Productivity using Biogeochemical Model Simulations

Numerical Simulations of the three-dimensional prognostic marine biogeochemical model (TOPAZ having more than 25 tracers) are carried out at CSIR-4PI in the global domain for climatological and interannual variability. It is essential to understand the seasonal and spatial variations of different nutrients like Nitrate, Ammonium, Silicate, Iron and Phosphorus to determine the variations in Primary Productivity. As we are aware, the distribution of nutrients in the oceans will vary due to climate change and hence there is an impact on primary productivity. Spatial variation of one of the nutrients Silicate

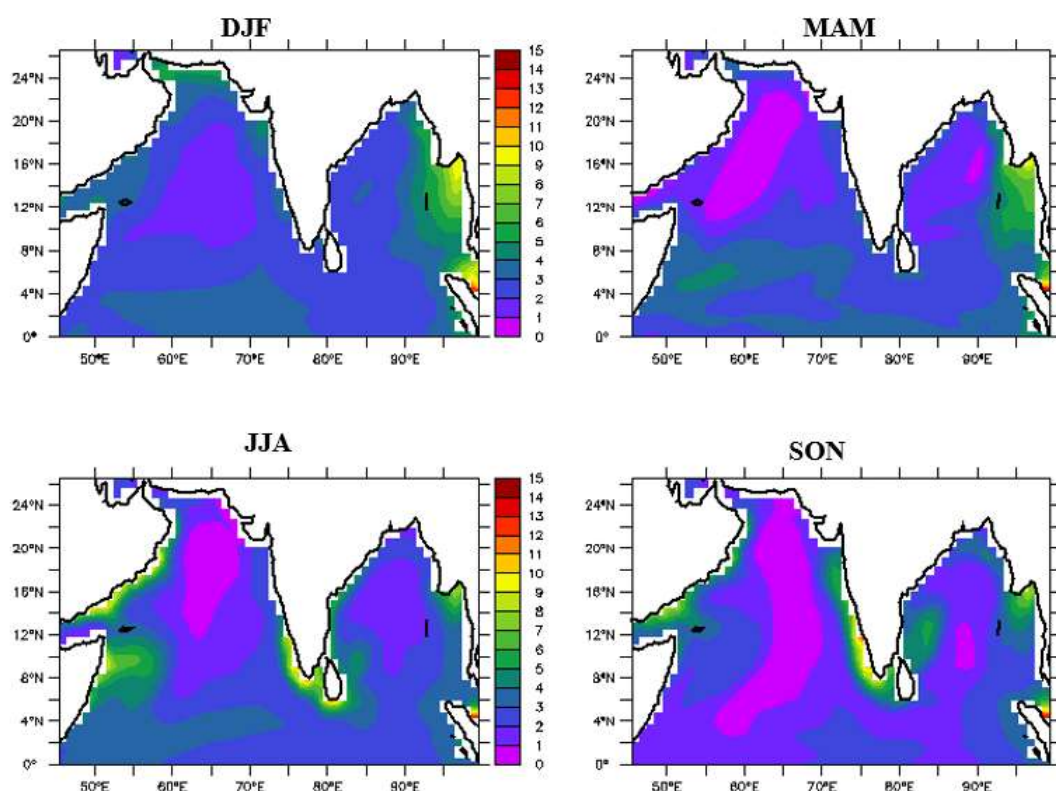


Figure 2.2: Spatial variation of Silicate (mMol/m^3) for four seasons in the North Indian Ocean.

(mMol/m^3) for four seasons is shown in Figure 2.2. It is noted from model simulation results that Silicate concentration is very low in the east and central Arabian Sea (AS), and whole of Bay of Bengal.

Primary productivity (PP) of different phytoplankton (Large, Small and Diazotrophs) due to all nutrients (Nitrate, Ammonium, Silicate and Iron) are analysed in detail for spatial seasonal variations in the north Indian Ocean. Monthly variation of Primary Productivity of Large, Small, Diazotrophs, and Total productivity is shown in Figures 2.3 & 2.4 for two regions in the AS. It is observed that Primary Productivity of Large Phytoplankton is very less in the East AS compared to West AS since the significant nutrient

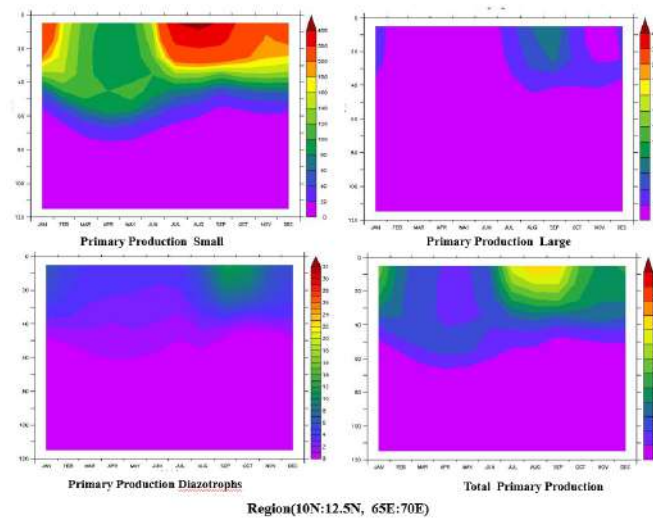


Figure 2.3: Monthly variation of Primary Productivity of Large, Small Phytoplankton and Diazotrophs, Total Primary Productivity with respect to depth for two regions (Region-10°N:12.5°N, 65°E:70°E and 15°N:18°N, 60°E:65°E)

required for PP of Large Phytoplankton, Silicate is very low in East AS. Therefore, it is essential to analyse the spatial and seasonal distribution of nutrients to understand the impact of climate change on PP.

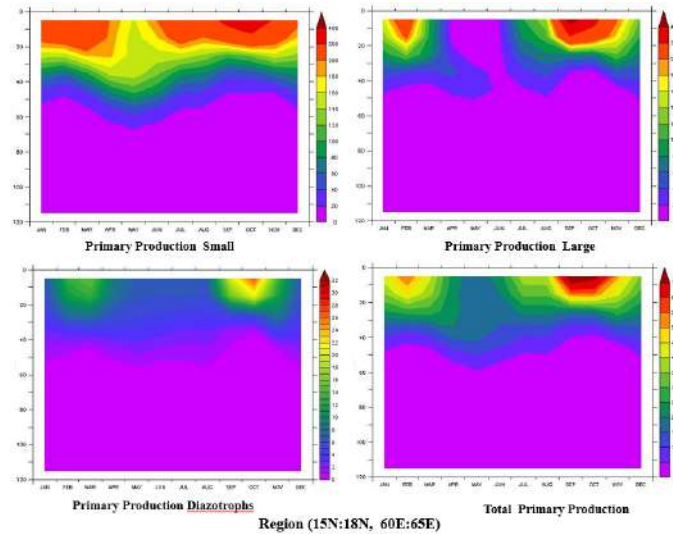


Figure 2.4: Monthly variation of Primary Productivity of Large, Small Phytoplankton and Diazotrophs, Total Primary Productivity with respect to depth for two regions (Region-10°N:12.5°N, 65°E:70°E and 15°N:18°N, 60°E:65°E)

Sharada M K, Kalyani Chika Devasena and Lakshmikanthan P

2.3 Measurements and Analysis of Greenhouse Gases (GHG)

The network of GHG monitoring stations established by CSIR-Fourth Paradigm Institute across India have been operational for more than a decade now and are being monitored by CSIR-4PI. These stations continuously measure GHGs like Carbon dioxide (CO_2) and Methane (CH_4) using high-precision analyzers installed in Hanle, Pondicherry, Port Blair and Hoskote at World Meteorological Organisation (WMO) standards. Along with GHG measurements, the weather sensors track parameters such as wind speed and direction, air temperature, humidity, pressure, and precipitation to correlate the meteorological conditions with GHG concentrations. Both Hanle (HLE) and Hoskote (HSK) stations consistently measure CO_2 and CH_4 with additional flask sampling i.e. discrete measurements being carried out at these sites. HLE (32.78°N , 78.96°E , 4517 m a.s.l.) is situated in the western Indian Himalayas at high an altitude featuring clean background air due to low population density. Its CO_2 concentration is comparable to NOAA's Mauna Loa (MLO) data. HSK (13.07°N 77.79°E , 891 m a.s.l.) is a tropical surface station located near Bangalore, Karnataka, surrounded by industrial and agricultural activities that impact background air quality. GHG concentration data are filtered according to Integrated Carbon Observation System (ICOS) standards and other established protocols.

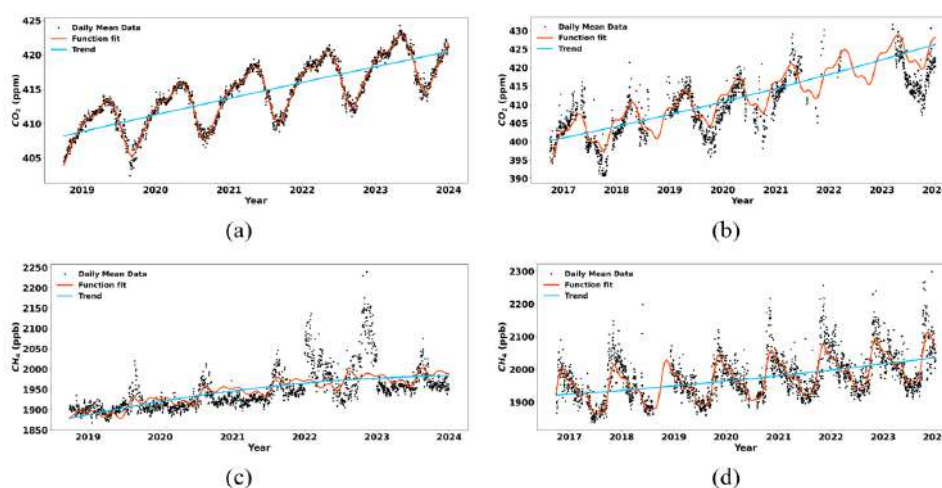


Figure 2.5: CO_2 daily concentration with function fit at (a) HLE (Oct 2018–Dec 2023) (b) HSK (Oct 2016–Dec 2023); CH_4 daily concentration of HLE with function fit at (c) HLE (Oct 2016–Dec 2023) (d) HSK (Oct 2016–Dec 2023).

The analyzer records data for each of species at 3-second intervals. Raw data undergo careful filtration to isolate the background signal and calibration corrections are applied to the ambient air. At HLE, all time background air is processed, whereas only daytime data is utilized at HSK due to elevated CO_2 emissions from vegetation at night. The NOAA/CMDL curve fitting method <https://gml.noaa.gov/aftp/user/thoning/ccgcrv/>, employing three polynomial terms to depict long-term growth and four harmonics for annual oscillations is used for data analysis. Discrete flask measurements are incorporated when continuous data is unavailable. The resulting smoothed concentration from this procedure serves as the baseline CO_2 and CH_4 concentration for the region. Continuous observation of data at HLE has been carried out since October 2018. Approximately 76% of the raw data from 2023 is utilized after filtration. The highest recorded CO_2 level was 422.86

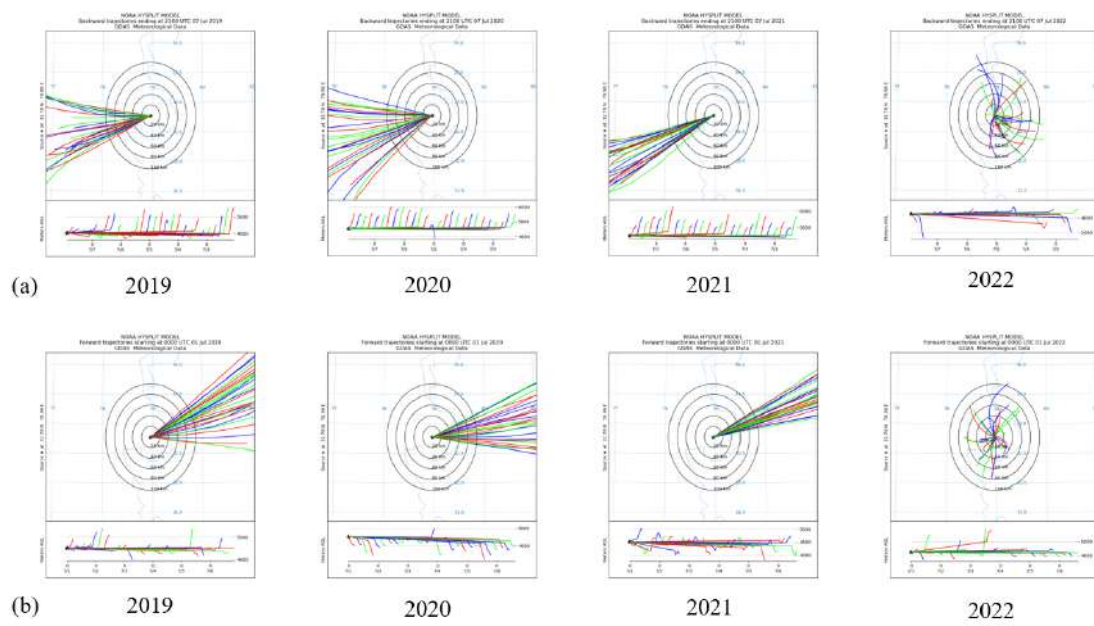


Figure 2.6: Backward trajectories at HLE during monsoons (b) Forward trajectories at HLE during monsoons.

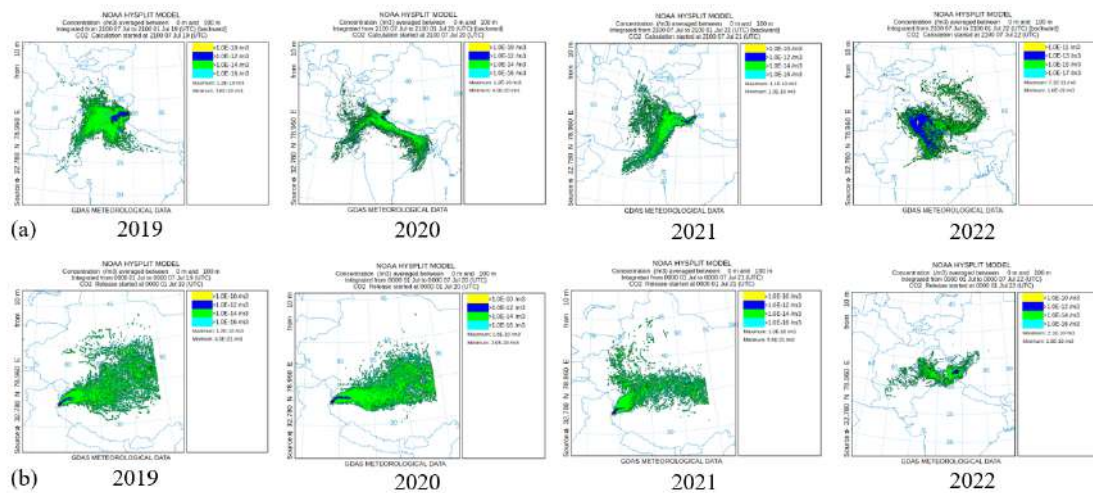


Figure 2.7: CO₂ concentration using HYSPLIT at HLE (a) Backward (b) Forward

ppm in May 2023, while the lowest was 415 ppm in September 2023. The annual mean CO₂ mole fraction at HLE is 419.4 ± 0.76 ppm showing a 2.26 ppm increase from the previous year. The average annual increase in CO₂ at HLE is approximately 2.3 ppm. The CH₄ levels at HLE varied from a minimum of 1948.34 ppb in February 2023 to a maximum of 2007.82 ppb in August 2023. On average, CH₄ concentrations at HLE increased by 14 ppb annually. The average CH₄ concentration in 2023 was 1964.1 ± 11 ppb as shown in the Figure 2.5. HSK data has been recorded since October 2016. The annual mean CO₂ level in 2023 was 419.06 ± 1.92 ppm, with minimum readings of 411

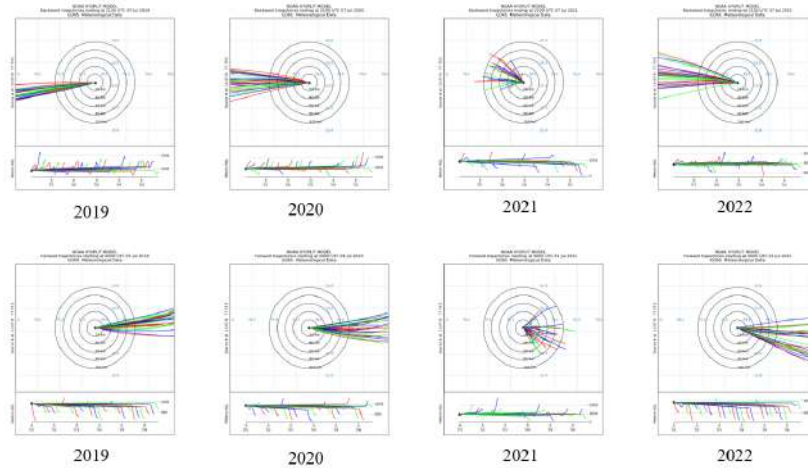


Figure 2.8: (a) Backward trajectories at HSK during monsoons (b) Forward trajectories at HSK during monsoons.

ppm in October and maximum readings of 430 ppm in February. At HSK, the annual increase in CO_2 is roughly 2.5 ppm. The average CH_4 measurement at HSK in 2023 is 2018.633 ppb. July experienced the lowest CH_4 concentration at 1942 ppb, and October recorded the highest concentration at 2144 ppb. The concentration of CH_4 grew by around 16 parts per billion a year. Seasonal trajectory plots are generated for the Hoskote and Hanle regions using NOAA's Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model, which utilizes global meteorological data. During the monsoon season, Hanle typically experiences predominantly south and southwest winds transitioning towards the east, except for in 2022 when wind directions were more varied. Throughout the monsoon season, Hoskote consistently receives westerly winds. In the pre-monsoon and post-monsoon periods, most winds originate from the east. The trajectory plots depict westward winds affecting the Hanle region during the pre-monsoon, which then shift towards the south. In the post-monsoon period, wind patterns display a mix of westerly and southwesterly directions, eventually moving towards the east and northeast as shown in Figures 2.6, 2.7, 2.8 & 2.9.

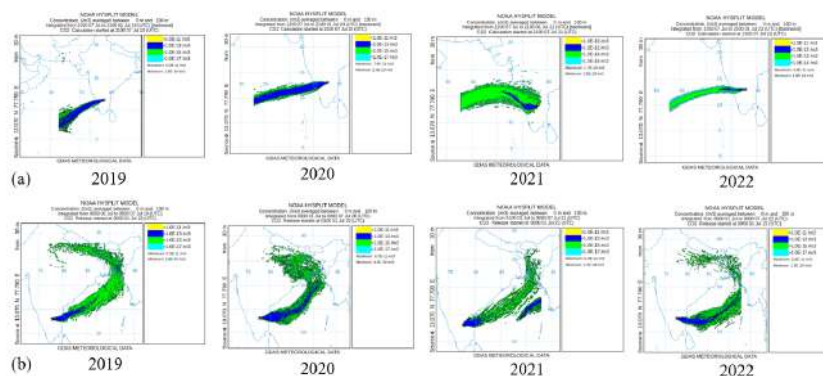


Figure 2.9: CO_2 concentration using HYSPLIT at HSK (a) Backward (b) Forward

2.4 Understanding Complex Dynamical Systems and Their Implications for Climate Data Analysis

Complex dynamical systems possess several attributes that make them intricate and challenging to analyze. They are inherently nonlinear, meaning their behavior is not proportionate; small changes can result in significant and sometimes unexpected effects. These systems consist of multiple interacting components that influence each other, creating feedback loops and emergent behaviors that cannot be understood by examining individual parts in isolation. They operate across a broad spectrum of spatial and temporal scales, from local to global and from minutes to millennia, which adds to their complexity. Additionally, they exhibit non-stationary behavior, where their statistical properties evolve over time due to internal dynamics or external influences, complicating their prediction and modeling. Two notable examples from the climate system are the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). ENSO is a coupled ocean-atmosphere phenomenon characterized by aperiodic variations in sea surface temperatures and atmospheric pressure in the equatorial Pacific. It demonstrates non-stationarity and complexity, lacking a fixed periodicity and interacting with various climatic regions, leading to significant impacts on global weather patterns. PDO, on the other hand, is a long-term fluctuation of surface temperatures of the North Pacific Ocean, with phases lasting 20 to 30 years. It influences weather patterns in the North Pacific and interacts with other climate modes like ENSO, potentially amplifying or dampening their effects. These systems exemplify the dynamic and interdependent nature of climate phenomena, highlighting the need for comprehensive models to capture their complexities. Traditional climate data analyses often rely on simplified assumptions that overlook the complexities and non-stationary behaviors of the climate system. These analyses typically fail to account for the interplay of multiple coupled ocean-atmosphere modes with complex waveforms. A common but flawed approach is to treat the amplitudes of annual cycles as stationary and to assume that low-frequency phenomena like ENSO and PDO are governed by a different set of processes, independent of those driving the seasonal cycles. This approach forces an artificial separation of these low-frequency phenomena, which are inherently interrelated. By defining anomalies as deviations from a long-term mean annual cycle with fixed amplitude, traditional methods constrain the ability to capture the true dynamics of multiple seasonal cycles and their interactions. This simplification also ignores the possibility of low-frequency amplitude-modulations of these seasonal cycles, and treats all variations outside the annual timescale as external. To improve the understanding of climate variability, we need to move beyond these restrictive assumptions. Our approach involves a diagnostic procedure that allows for the extraction of fundamental climate modes without assuming a static amplitude for the annual cycle. This facilitates a more accurate analysis of prominent low-frequency variations in the tropical Pacific by acknowledging and capturing the inherent dependencies between these modes. This uncovers four distinct sets of coupled annual modes and reveals how three of them are independently linked to secular warming, Eastern Pacific ENSO, and Central Pacific ENSO. As a result, this investigation achieves: (1) a more distinct separation between secular warming and ENSO-related interannual variation, (2) a clearer classification of both types of ENSO events based on their spatial patterns and intensity, (3) a new direction to explore the seasonal synchronization of ENSOs, (4) a more systematic reproduction of ENSO features highlighted in many earlier studies, and (5) an exposition of the precise nature of secular warming.

The reported findings also cast doubt on suggestions implying that global warming has influenced ENSO. Finally, we propose a new dynamical framework: the secular warming of the ocean surface and ENSO are essentially the interannual modulations of the amplitudes of three non-sinusoidal annual cycles. By embracing the natural complexities and dynamic interactions of the climate system, we can achieve a more accurate representation of climate variability.

Rameshan Kallummall

2.5 New Pacific Decadal Oscillation: Low-Frequency Imprints of Amplitude-Modulated Seasonal Cycles

The canonical Pacific Decadal Oscillation (PDO) is defined as the leading empirical orthogonal function of North Pacific (NP; 20°–70°N) sea surface temperature (SST) monthly averaged anomalies, which are departures from the climatological annual cycle after removing the global mean SST. During a warm (positive) phase, the west Pacific cools and parts of the eastern ocean warm, while the opposite occurs during a cool (negative) phase. These patterns have substantial impacts on weather and extreme events in the Americas and Asia, and they also cause significant transitions in marine ecosystems, leading to large-amplitude changes. Initial research suggested that the PDO might represent a distinct physical mode of North Pacific variability. However, more recent studies indicate that the PDO is a mix of physical processes, including remote tropical forcing and local North Pacific atmosphere-ocean interactions, contributing to similar SST anomaly patterns. Our approach involves a diagnostic procedure that allows for the extraction of fundamental climate modes without assuming a static amplitude for the annual cycle. Several statistical modes, exhibiting interannually modulating amplitudes, have been derived from observed monthly SST, surface pressure, and wind data. The leading statistical modes show their largest spectral powers on seasonal timescales. A triplet of modes combining these three variables, where co-variations are consistent with physical principles, provides a close representation of a physical mode. This study examines low-frequency variations in NP in the context of interannual modulations of leading coupled seasonal modes. The total interannual modulations of the seasonal cycles of SST exhibit distinct spatial patterns, temporal changes, and spectral peaks compared to the canonical PDO (see Figure 2.10). The cumulative low-frequency changes in the seasonal modes of SST representing a slowly varying component with episodic changes in sign on a decadal timescale capture the key spatial features of a new PDO. Understanding the implications of these new decadal changes on regional and global climate patterns through teleconnections is essential for improving climate forecasting and mitigating climate-related hazards.

Canonical Pacific Decadal Oscillation .Vs. Total Interannual Amplitude Modulations

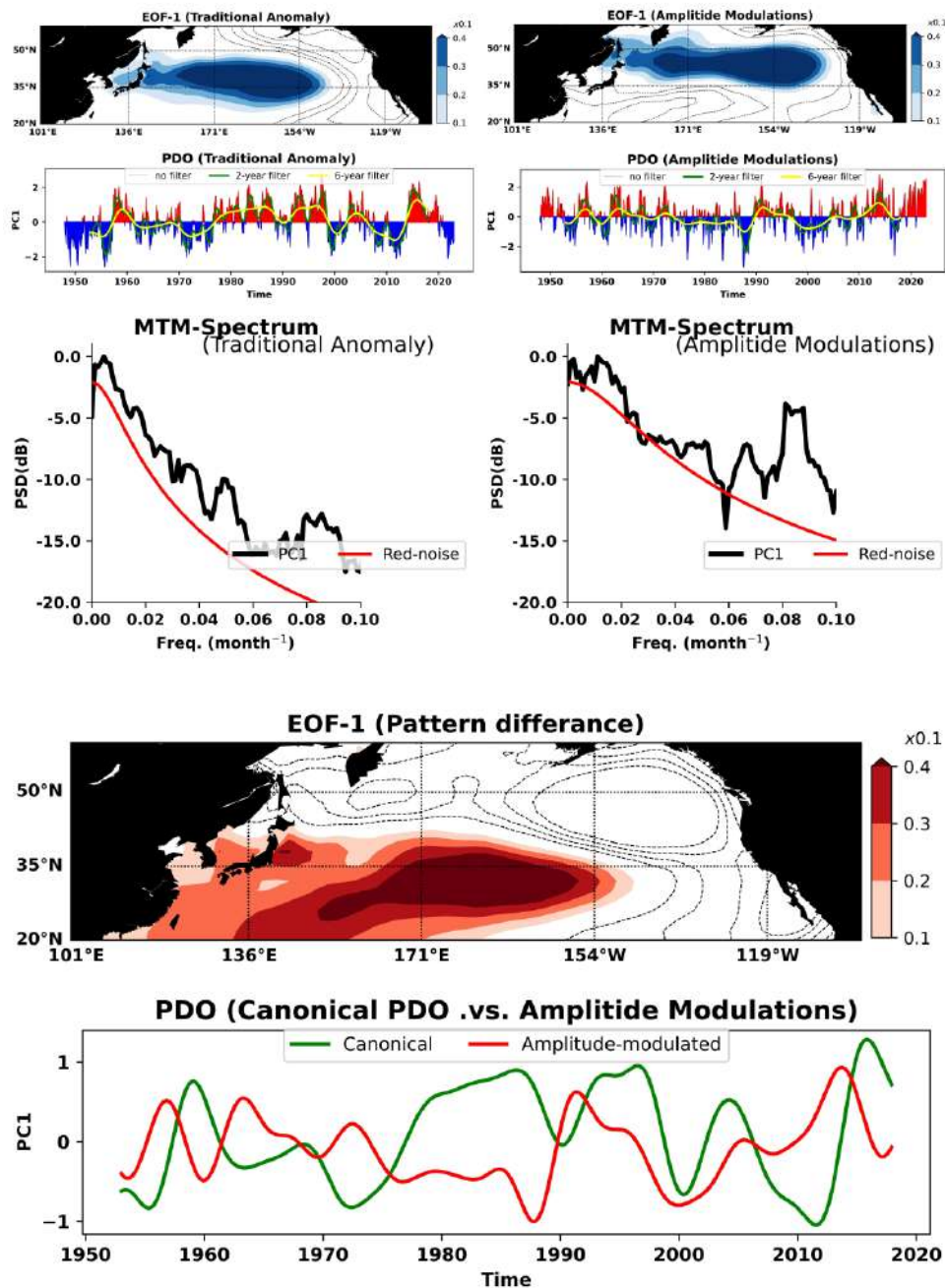


Figure 2.10: Spatial Patterns (top row), temporal changes (second row) and MTM spectral density (third row) estimated from traditional anomaly (left) and Interannual Amplitude Modulations (right). EOF difference (penultimate row) and PDO and AM indices are also shown (last row); both are smoothed via 72-month moving window.

2.6 Do clouds become more convective during very Extreme Rainfall Events (vEREs) due to the impact of climate change in global model projection?

This study investigates the impact of climate change on Indian Summer Monsoon Rainfall (ISMR) and analyses the characteristics of extreme rainfall events (EREs) across India. Utilizing multiforcing ensemble projections from a high-resolution global climate model (MRI 20-km model), we examine various global warming scenarios. Under each scenario, the model is forced with four patterns of future sea surface temperature (SST) change, derived from a combination of mean SST changes projected by approximately 28 coupled ocean-atmosphere models and subgroups identified through cluster analysis of tropical SST changes. Our findings indicate a projected increase in surface air temperature and rainfall across India, with the exception of a reduction in rainfall over the Western Ghats (WG) region. We identify enhanced atmospheric water vapor content and increased low-level moisture transport as primary contributors to the intensification of ISMR.

The projected reduction in rainfall over WG is associated with a drastic reduction in southwesterly winds and moisture transport into the region. This reduction is accompanied by a weakening of the summer mean meridional circulation and diminished vertical velocities. Our analysis indicates that these changes result from greater warming in the upper troposphere relative to the surface and lower levels, leading to a decrease in the lapse rate. Consequently, there is an increase in vertical moist static stability, which inhibits vertical ascent in response to global warming. The increased stability weakens vertical velocities ultimately reducing large-scale precipitation- a major contributor to summer mean rainfall over the WG orographic region.

This is further corroborated by a significant decrease in the frequency of moderate-to-heavy rainfall days over the WG, indicative of the decrease in large-scale precipitation in this area. Therefore, the drastic reduction in vertical ascent and weakening of circulation due to the upper tropospheric warming effect, predominates over the moisture build-up effect in reducing the rainfall over this narrow orographic region. This analysis illustrates that monsoon rainfall over mountainous regions is strongly controlled by processes and parameterized physics that need to be resolved with adequately high resolution for accurate assessment of local and regional-scale climate change.

Analysis of extreme events indicates a rise in both warm days and nights, accompanied by a steady increase in extreme rainfall events from low to high emission scenarios. Furthermore, utilizing a high-resolution model allows for a detailed examination of projected changes across homogeneous zones across India. Consistent with the overall increase in rainfall, extreme rainfall events also show a uniform rise across these zones.

Changes in extreme rainfall intensities can be attributed to the Clausius-Clapeyron relationship, which highlights the influence of warmer atmospheric states. Particularly, very extreme rainfall events (vEREs) exhibit significant sensitivity to enhanced temperatures, suggesting potential implications for future climate scenarios. The shift in severe rainfall intensities in warmer atmospheric states is explained by the Clausius-Clapeyron (CC) relation, which shows how the atmosphere's ability to hold water increases with temperature. The Clausius-Clapeyron (CC) equation is: $de_s/e_s = LdT/(RT^2)$, where e_s is the saturation vapor pressure at temperature T , L is the latent heat of vaporization and R is the gas constant. Hence, it is natural to express changes in moisture as a percentage of

the current value. Linear CC scaling is estimated to be approximately 7% per Kelvin (K). Very extreme Rainfall Event (vERE) intensities (R99p) tend to exhibit super-CC scaling for precipitation (Figure 2.11), where future scenarios show much higher scaling compared to present-day values. Interestingly, although the temperature change is uniform

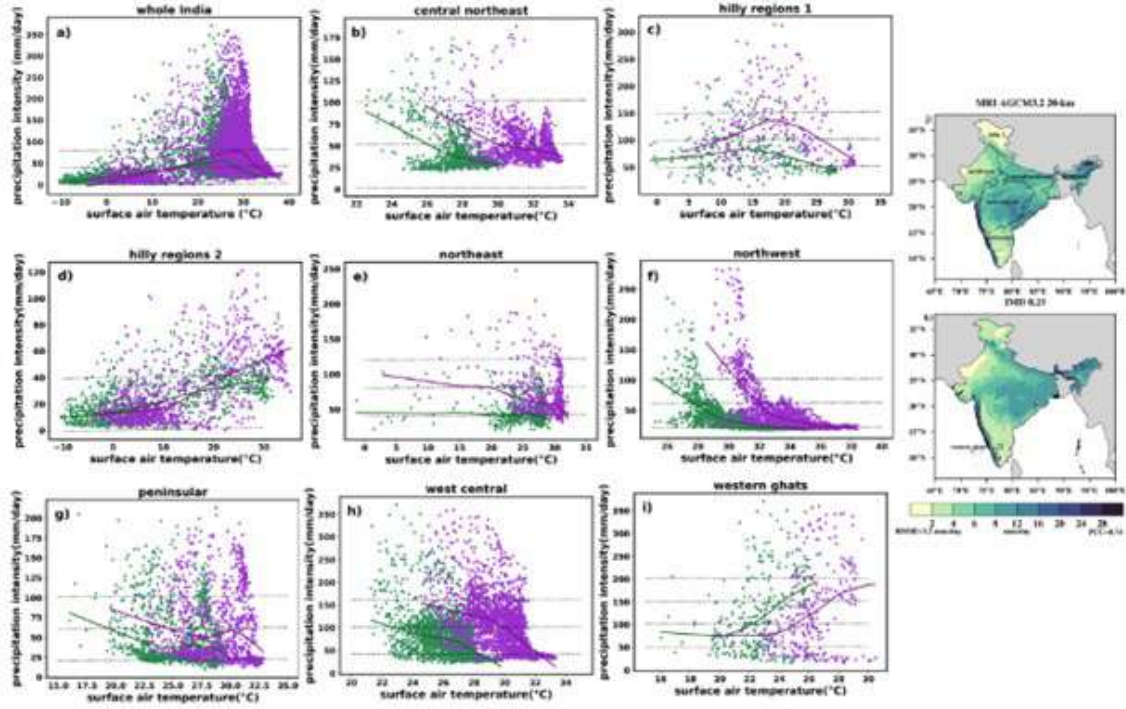


Figure 2.11: Variation of daily R99p (rainfall above 99th percentile) to surface air temperature (°C) for (a) India and seven homogeneous rainfall zones of India: (b) central northeast, (c) hilly regions-1, (d) hilly regions-2, (e) northeast, (f) northwest (g) peninsular India, (h) west-central India, and (i) Western Ghats. Green and purple scatter points correspond to present-day and future scenarios, respectively. Green and purple solid lines show their respective non-parametric fitting using LOWESS smoothing. Black dotted lines illustrate CC scaling (7%/°C) for reference. (j) Climatological mean monsoon rainfall from MRI 20-km model present-day simulation and (k) IMD observation. The homogeneous rainfall zones are demarcated inside (j) and Western Ghats in (k). The pattern correlation (PCC) and root-mean-square-error (RMSE) are written at the bottom-right and bottom-left of (k), respectively.

throughout the monsoon region, the precipitation patterns are not. This difference arises from the interplay with the dynamic aspects. Due to altered radiative forcing, the upper atmosphere gets heated, stabilizing the atmosphere and ultimately offsetting the effect of increasing humidity on the precipitation intensity. This can be gleaned from the vertical profiles of pressure velocity and cloud water content in Figure 2.12. The cloud cover is reduced, whereas a slight increase in cloud water content is seen in the future. This suggests that the clouds will be more convective supporting extreme rainfall. A latitudinally uniform decrease of cloud water content at 500 hPa is likely due to the tendency for the level of maximum cloud water content to rise in the future. Thus, our analysis underscores the

complex interplay between altered radiative forcing, atmospheric stability, and moisture content on precipitation intensity. We anticipate a shift towards more convective clouds and alterations in circulation patterns, contributing to future changes in vEREs during the Indian summer monsoon season.

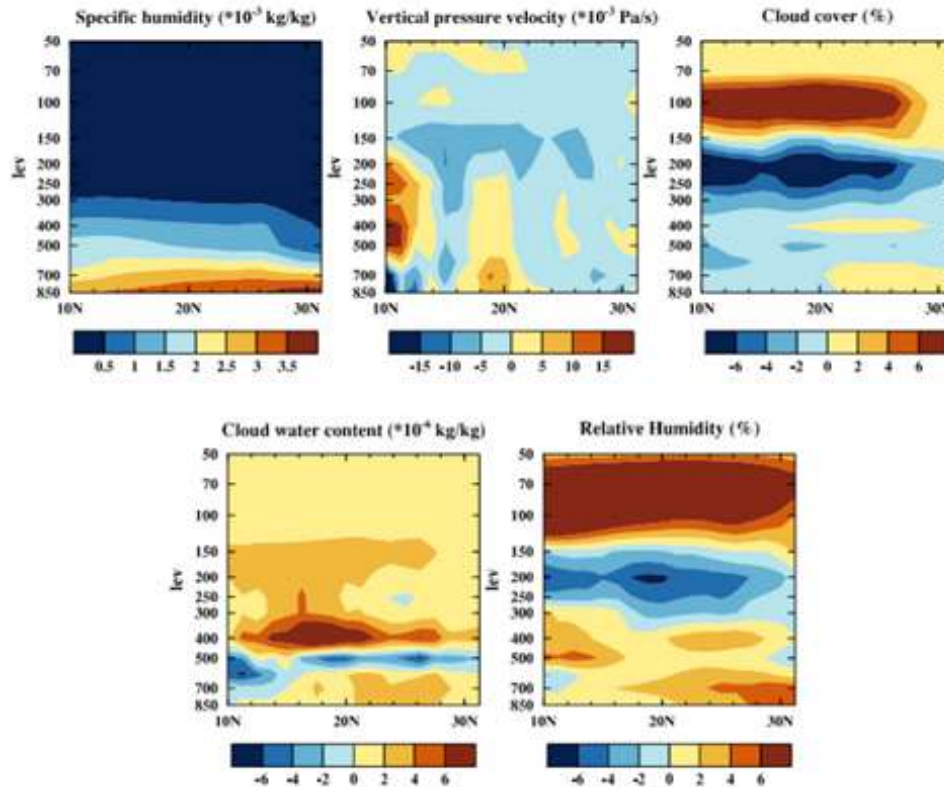


Figure 2.12: Vertical profiles of zonally averaged projected future changes in JJAS (June, July, August, September) over the Indian land region (as shown in Figure 1j) for (a) specific humidity, (b) vertical pressure velocity, (c) cloud cover, (d) cloud water content and (e) relative humidity.

The convective organization can induce dynamic changes in extreme precipitation. The degree and extent of any such convective organization can affect the tropospheric state through their interaction with atmospheric temperature, humidity and circulation. The intensity of extreme precipitation can sometimes exceed the thermodynamic scaling, indicating the dominance of such convective aggregations. Studies have identified an increased frequency of these regimes as a result of global warming. However, over some regions where the extreme precipitation has exceeded the thermodynamic scaling (e.g., Figure 2.11), we find that the upward vertical velocity does not increase much relatively, in comparison to a few positive regions (Figure 2.12). This invariably suggests that beyond convective aggregations, it is the interplay of increased large-scale atmospheric moisture content and circulation, or the moisture convergence, that is responsible for the changes in the extreme events over these regions.

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2.7 Hypersensitivity of Indian summer monsoon to moisture exchange with the Pacific Ocean in CFSv2

Interannual variability of the Indian summer monsoon rainfall (ISMR) is explained through the total column water vapor in the atmosphere, primarily controlled by the incoming zonal moisture flux over the Arabian Sea (F_W) and outgoing flux over the Bay of Bengal (F_E). In this study, we investigate the underlying mechanisms driving F_W and F_E leading to ISMR droughts in the observations and seasonal hindcasts by the Climate Forecast System version 2 (CFSv2) model.

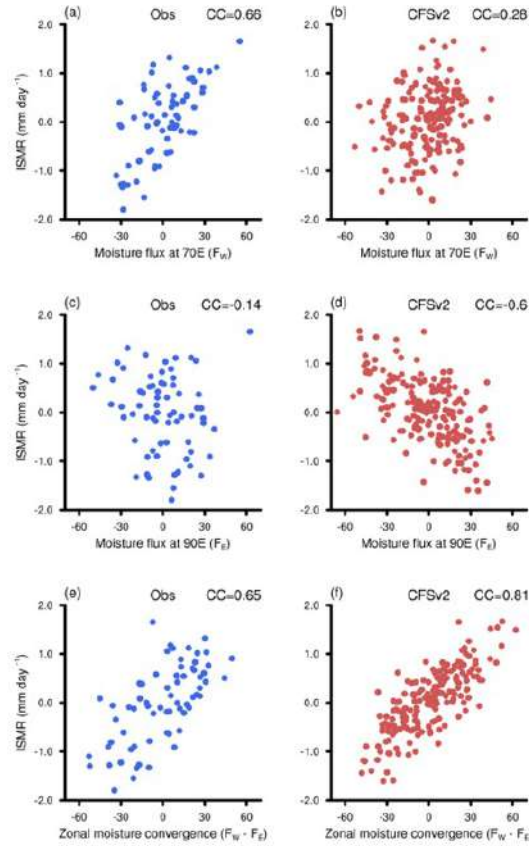


Figure 2.13: The scatter plot shows the relationship between ISMR and vertically integrated moisture flux along the western boundary at 70°E (F_W), vertically integrated moisture flux along the eastern side at 90°E (F_E), and zonal moisture convergence ($F_W - F_E$) over the Indian region for both observation and CFSv2. The correlation between these variables is indicated at the top of the plots.

The moisture flux is computed using the moisture budget equation (1). The year-to-year variation of rainfall (P) can be expressed in terms of net moisture convergence (F_{Net}) over the given domain. On interannual time scale, the variation of evaporation (E) and change in total column water vapour (P_{wat}) does not vary much compared to P and F_{Net} .

$$\frac{1}{A}(F_W - F_E + F_S - F_N) = \bar{P} - \bar{E} + \frac{\partial P_{\text{wat}}}{\partial t} \quad (2.1)$$

$$\frac{1}{A}(F_{NET}) = \bar{P} - \bar{E} + \frac{\partial P_{wat}}{\partial t} \quad (2.2)$$

The vertically integrated boundary flux at the western (F_W), eastern (F_E), southern (F_S), and northern (F_N) boundaries is calculated as follows:

$$F = \int_{p_{sfc}}^{p_{top}} (q \cdot u) \frac{dp}{g} \quad (2.3)$$

Where, q and u represent the specific humidity (kg/kg) and winds vector (m/s) at the respective boundaries. The integration is from pressure at the surface (p_{sfc}) to the top of the atmosphere (p_{top}), which is taken as 100 hPa. All variables are considered departures from the monthly mean and detrended over the entire period.

In observations, a reduction in F_W is essential for droughts to occur. Additionally, an increase in F_E results in a severe drought. On the contrary, droughts in CFSv2 primarily occur due to an enhancement in F_E , seldom accompanied by a decrease in F_W . This hypersensitivity of the CFSv2 ISMR to F_E (Figure 2.13) is further explained using Matsuno-Gill response to moist convection.

During El Nino droughts, precipitation decreases over the equatorial western Pacific and eastern Indian Oceans. The resulting anomalous diabatic cooling increases local surface pressure (SP), intensifying meridional SP gradient, and thus, F_E . The reduction in F_W , however, is associated with a cooling of the central north Pacific Ocean in tandem with El Nino. During non-El Nino droughts, frequent occurrences of cold sea surface temperature over the western north Pacific Ocean are noticed. This cooling decreases SP over east Asia, resulting in an increase in F_E . To summarize, droughts in CFSv2 are controlled by the pan-Pacific climate, significantly increasing F_E but weakly decreasing F_W . But in observations, a strong decrease in F_W and a moderate increase in F_E together lead to droughts.

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2.8 The role of ensemble averaging in ENSO-monsoon relationship in CFSv2 model

An ensemble of forecasts is necessary to identify the uncertainty in predicting a nonlinear system like climate. While ensemble averages are often used to represent the mean state and diagnose physical mechanisms, they can lead to information loss and inaccurate assessment of the models characteristics. We highlight an intriguing case in the seasonal hindcasts of the Climate Forecast System version 2 (CFSv2). While all ensemble members often agree on the sign of predicted El Nino Southern Oscillation (ENSO) for a particular season, non-ENSO climate forcings, although present in some of the individual members, are disparate. As a result, an ensemble mean retains ENSO anomalies while diminishing non-ENSO signals. This difference between ENSO and non-ENSO predictions and a more decisive impact of ENSO on seasonal predictions increases the ensemble mean ENSO-Indian summer monsoon rainfall correlation. Therefore, adequate care should be

taken while evaluating physical mechanisms of teleconnection in ensemble mean predictions that can often be skewed due to constructive or destructive superposition of different impacts.

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2.9 Optimizing LSTM and Bi-LSTM models for crop yield prediction and comparison of their performance with traditional machine learning techniques

This study presents a generic methodology to configure and fine tune the state-of-the-art Long Short-Term Memory (LSTM) based Deep Learning (DL) model through hyperparameter optimization for prediction of yield (annual crop production) in Wheat, Groundnut and Barely over India based on multiple independent input variables identified using multicollinearity test. The Monte Carlo cross-validation method is used to validate the optimized LSTM models. Results from the LSTM model tuning showed that among the 4 optimizers tested, Adam was found to perform better irrespective of the crop and Bi-LSTM outperformed sLSTM in terms of prediction accuracy (Figure ??v1). The percentage reduction in error with Bi-LSTM compared to sLSTM in predicting wheat and groundnut crop yield was 39% and 13% respectively while in case of barley crop, error reduction was marginal (0.34%). The performance of optimized Bi-LSTM model is compared with the performance of traditional machine learning (ML) models such as support vector regression (SVR) and SVR polynomial 2nd and 3rd order, Auto Regressive Integrated Moving Average (ARIMA) and ARIMAX (ARIMA with exogenous variables) and Vector Auto-regression (VAR). The Bi-LSTM model is found to be superior to ML models; the percentage reduction in mean absolute scaled error with the Bi-LSTM compared to the best performing ML model was 94%, 72%, and 71% in predicting wheat, groundnut and barley yield respectively.

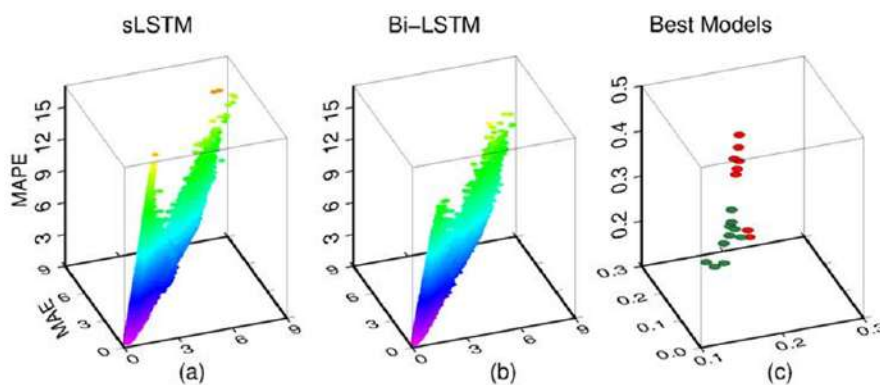


Figure 2.14: Primary error metrics (RMSE on X-axis, MAPE on Y-axis & MAE on Z-axis) for different combinations of sLSTM (a), and Bi-LSTM (b) model simulations in predicting crop production for wheat. The best LSTM models (red dots for sLSTM and green dots for Bi-LSTM) identified is also shown (c).

V. Kiran Kumar, K.V. Ramesh and V. Rakesh

2.10 Improved learning by using a modified activation function of a Convolutional Neural Network in multi-spectral image classification

The Convolutional Neural Network (CNN) algorithm is used to classify multispectral images of labelled EuroSAT data from Sentinel-2 satellite. The main objective of this study to examine the role of newly proposed activation function, Modified Rectified Linear Unit (MReLU) in improving multi-spectral image classification accuracy. The experimental design deployed a 5-layer CNN with activation function Rectified Linear Unit (ReLU) and the MReLU having 27 learning rates ranged from 0.0001 to 0.01 with 10% increment and 8 optimizers (Figure 2.15). ReLU has a diminishing gradient problem since it does not consider the significant information present in the negative values of the convolution layer for different spectral bands. In order to overcome this short coming, we have designed the MReLU which allows the absolute values of the small negative gradient and thereby introducing higher nonlinearity in the output. The experimental results show that the image classification accuracy of the CNN with ReLU and MReLU activation functions is definitely higher than the pre-trained ResNet-50 model which is a complex and computationally expensive architecture. The MReLU has advantage over ReLU in land use classification, particularly in the Industrial, Herbaceous Vegetation, and Permanent Crop classes where accuracies were typically low.

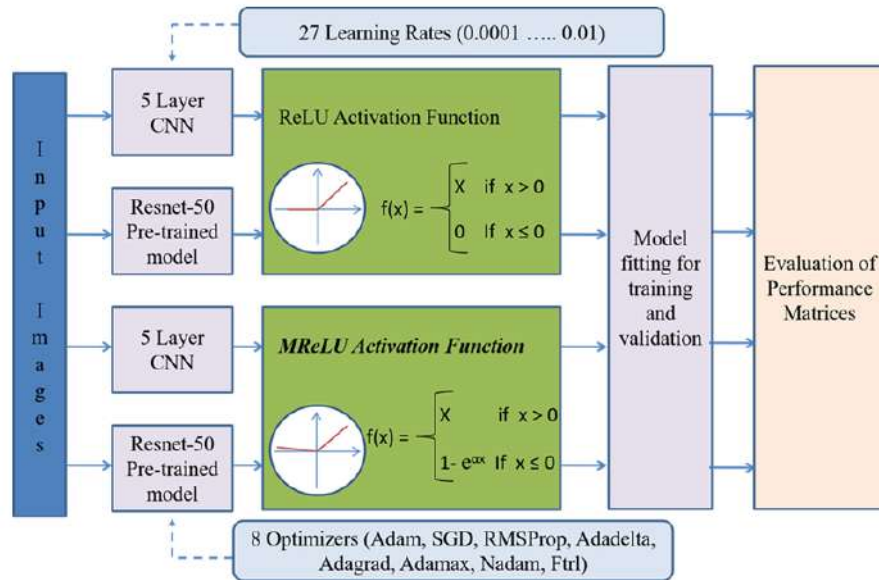


Figure 2.15: Experimental setup adopted in this study describing step by step processing of images.

2.11 Development of stormwater modelling platform for Bengaluru city of India

Bangalore city witnessed many flash floods associated with extreme rainfall events (EREs) in the recent past. Our analysis showed an increasing trend in the annual and monthly average rainfall over major valleys in Bengaluru Urban from 1971 to 2020 which indicated the possibility of rise in the frequency of urban flooding in recent decades. The digital elevation map (DEM) is examined to understand the topography of high elevation and low-lying areas, enabling the assessment of flood impacts of EREs in various areas of Bengaluru Urban. We have selected four flash flood events associated with EREs over one of the critically low laying Koramangala-Challaghatta watershed valley (KC valley) in the city for our simulation study. To understand the flood pattern, timing and volume during these flood events, stormwater management model (SWMM) simulations were conducted with observed rainfall from rain gauge stations. The model simulations could capture the inundation prone regions of KC valley for the flood events of different rainfall intensity. The hyetograph of the rainfall runoff with elapsed time demonstrates the model capability to calculate the runoff amount for different intensity of EREs. The bias in simulated storm water discharge range from +4 to -4 cubic meter per second (CMS) at different time scales and intensities within specific areas of stormwater drainage network system. The flood modeling systems like the one presented in this study can serve as valuable decision support system for management of urban floods associated with EREs and planning of mitigation strategies (See Figure 2.16).

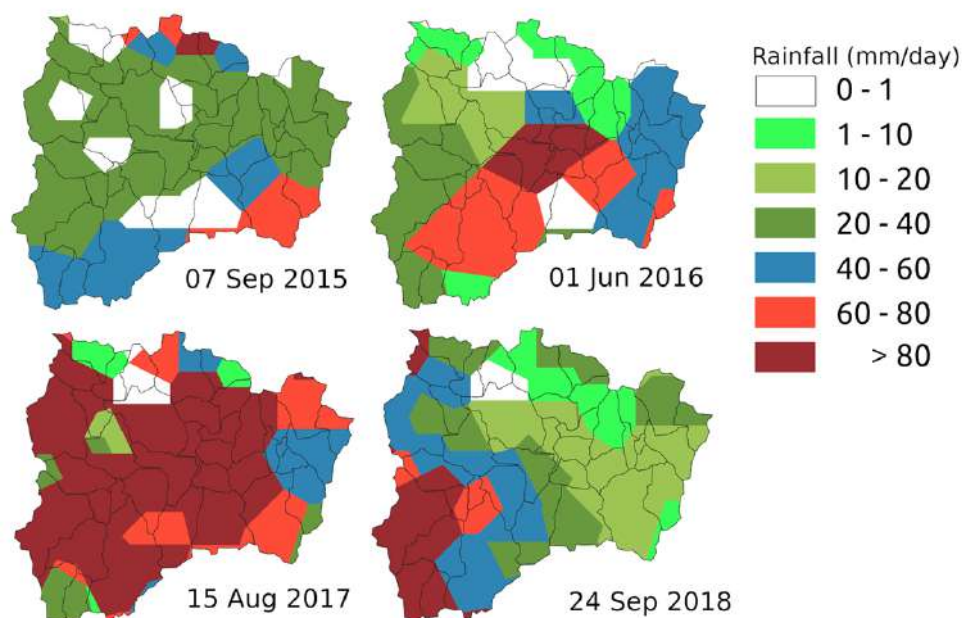


Figure 2.16: The spatial map shows 24 hours accumulated rainfall(mm) for four EREs at KC valley catchment area simulated in SWMM model.

2.12 Dynamics of Indian summer monsoon in different phases

Better understanding on the phases of Indian summer monsoon i.e., onset, progress and withdrawal helps in the decision making and proper management. In this paper, date of onset of monsoon (DOM) and date of withdrawal of monsoon (DWM) is estimated using the long-term daily rainfall data observed by the India Meteorological Department (IMD) and cumulative rainfall anomaly concept, as the onset/withdrawal represents a signature of rainfall transition. The results are promising with a better match between the estimated DOM and IMD announced DOM over Kerala. The length of monsoon season variability is also analysed. The concept of onset at grid point (OGP) in India is also evaluated and progress of monsoon is monitored by considering the latitudinal variation, persistent & strength of rainfall in the continental India. The impact of ENSO on the OGP is brought out, which clearly shows that DOM, DWM and progress is almost influenced by the largescale processes. Figure 2.17 represents the climatological values of DOM, DWM and trend in length of monsoon season in continental India. This study will help modellers in better understanding of onset and progress of monsoon dynamics in India and can be integrated with NWP for the accurate and advance prediction of DOM and the progress.

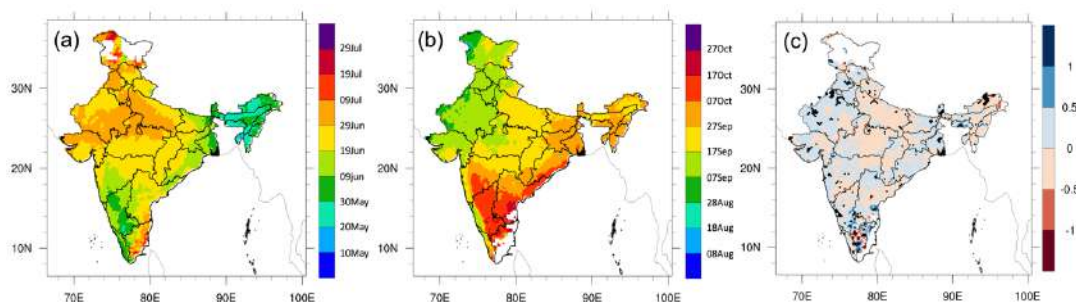


Figure 2.17: Climatology (1951-2018) of (a) date of onset, (b) withdrawal and (c) the trend in length of monsoon (dots represents the 95% significance) over all the locations in India.

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2.13 Intensity duration and frequency of Heat wave in different phases of MJO over India

The Madden-Julian Oscillation (MJO) stands as a prominent driver of tropical intra-seasonal variability, exerting influence on worldwide weather patterns. It is characterized by the eastward propagation of large-scale atmospheric convection and upper circulation anomalies. The innovation of this study is the modulation of spatial characteristics (in terms of the frequency, intensity and duration) of HW over India by the strength and 8 phases of MJO using RMM index data. Figure 2.18 represents the spatial distribution of change in the probability of heat wave occurrence during all phases of MJO over India. The maximum likelihood of HW occurrence over most of the parts of India has been noted in MJO phase 2 and 3. The climatological probability of HW occurrence over India rise by more

than 1-fold in the MJO inactive phase than the active phase over corresponding location in the wet phase. Overall, significantly, the wet (dry) phase leads to the doubling (total suppression) of HW occurrence probability over most of the parts of India. The HW maximum duration decreases by 2 days on average over northern MP, NW and north central parts of India in the MJO active than inactive phase. The maximum average duration (5-9) days has been observed in inactive dry and active wet phase. The HW intensity found to be reduced by 0.5°C in the active wet phase over NW parts than inactive wet phase whereas during active dry phase increment of 0.5°C have been noticed over northern MP and Vidarbha region. The differential dynamics of change in HW occurrence probability over eastern, SE and NW India are also supported by the elevated GPH accompanied by anticyclonic (cyclonic) wind circulation over Indian landmass (Indian ocean) in the wet (dry) phase. The elevated GPH in Arabian sea, northern India and south China sea representing the presence of quasi stationary Rossby waves train which mediates the impact of MJO on HW. Analysis of VP indicates that the subsidence of warm air into India from the upper to lower tropospheric levels in MJO phases during HW also supports the intensification of HW in inactive wet phase. This dynamical study mechanism can be prescribed in the numerical weather prediction models for the improved prediction of such extreme weather events during summer for proactive disaster management.

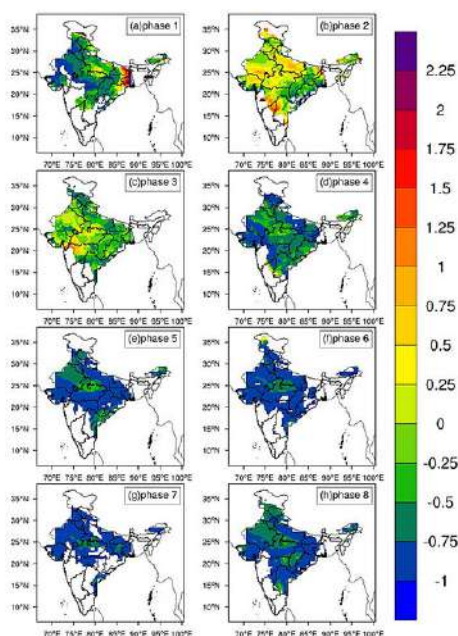


Figure 2.18: Spatial distribution of change in probability of Heat Wave occurrence during all phases of MJO (phase 1 to 8) over the Indian region for the period 1979-2022.

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2.14 Intensity-Duration-Frequency analysis of Indian Summer Monsoon

The ratio of the total amount of rainfall received during the given period to the duration of the particular period is known as the rainfall intensity of the particular region. The duration is considered as ISM length (date of monsoon withdrawal – date of monsoon onset) at each grid point using the proposed algorithm. The intensity of rainfall at the grid point (Figure 2.19a) presents the total amount of rainfall received at the grid point during the ISM period (Figure 2.19b) observed at the same point. The rainfall frequency is calculated by counting the number of rainy days (Figure 2.19c) at each grid point as mentioned. The IDF analysis shows that the North-East region of the country receives high-frequency rainfall during the rainy season, and the ISM length is also longer in this region as compared to all other parts of the country. By taking the Karnataka region into consideration, it is observed that although the ISM length is longer but it receives lower amounts of rainfall because of less rainy days. Similarly, in eastern India, Odisha state witnesses about 1400 mm of rainfall during the rainy season with high frequency in the rainy days. The comparison of the rainy-day frequency in ISM at each grid (Figure 2.19c) and JJAS (Figure 2.19d) indicates that the patterns are almost the same, but the south peninsula, including the eastern part, gets more rainy days in JJAS.

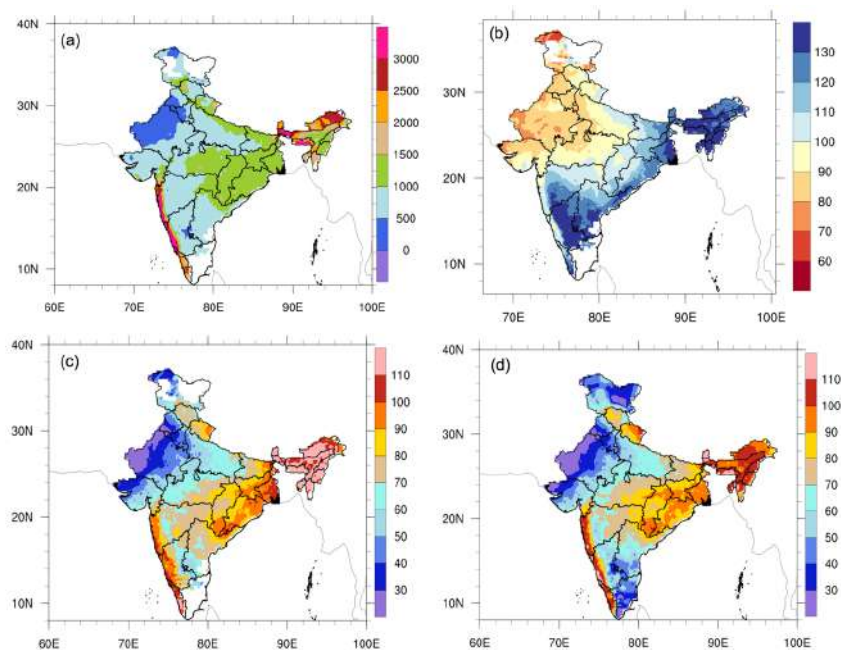


Figure 2.19: Intensity-duration-frequency (IDF) analysis of the ISM represented as (a) Intensity of total rainfall in mm/day during (b) the duration (in days) or length of the monsoon season. Frequency of rainy days (c) during the estimated ISM season and (d) during June 01-September 30 period. The analysis represents average over 1951-2018.

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2.15 Analysis of heat wave over different physiographical regions in India

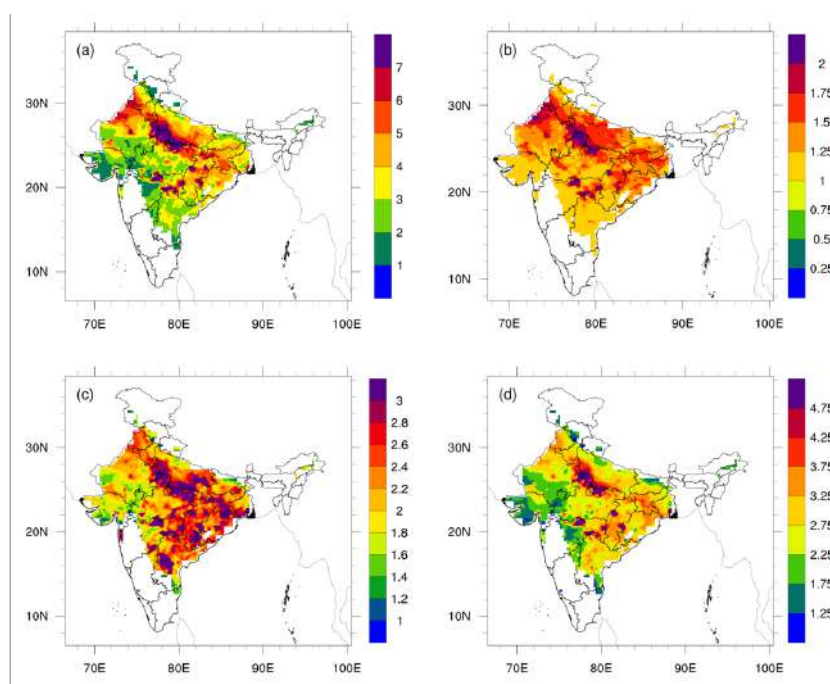


Figure 2.20: CMIP-6 model projected spatial distribution of (a) long-term climatology of number of HW days during the HW events, (b) annual frequency of HW (c) average duration of HW events and (d) average maximum HW duration over India for the period (2025-2100). The results are obtained using the ensemble mean under SSP126.

Heat waves (HW) is the less explored and hazardous natural extreme weather event as compared to other hydro-meteorological disaster events particularly in India. The global warming and climate change effects on HW occurrence are clearly seen in the form of increasing trend of duration, intensity and frequency. This study has shown the recent past and future characteristics of HW based on the physiology of the region in India. Based on the IMD HW criterion in hilly plain and coastal region, HW average duration, HW maximum duration, HW days and HW events has been increasing in spatial extent as well as in temporal extent over the larger parts of India. The future HW characteristics have been projected using the CMIP6 ensemble (MPI LR & EC Earth3) output with equal weightage under SSP126 and SSP 585 emission scenarios. Some key finding of this study indicates that the maximum HW are observed in North West, central and Eastern part of the Indian region. The projected results like the spatio-temporal distribution of HW days, average total duration, maximum duration and event frequency are presented in figures 2.20 which will be useful for future strategy. There is significant positive trend in all HW parameters over plains (NW, eastern), coastal (eastern) and hilly (northern) parts of the country. MPI LR (EC Earth3) model overestimated (underestimated) all the HW parameters in eastern and coastal parts and underestimated (overestimated) in NW parts of India. The ensemble mean of the models MPI LR & EC Earth3 shows the spatial extent of HW over new hotspots in southern India and in existing HW locations, HW duration (average, maximum), HW events, HW days will be more under SSP 585 scenarios as

compared to SSP 126. It is projected that 2050 onwards, there will be rapid increase in all HW parameters in hilly, plains and coastal regions of India. The findings of this study suggest the need of high resolution regional modelling and impact based analysis of HW.

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2.16 Climate parameter and malaria association in north-east India

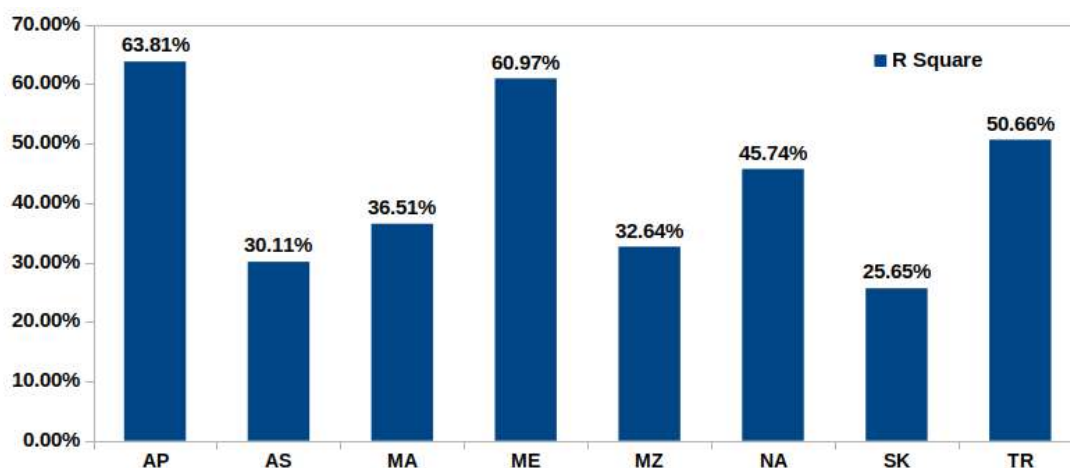


Figure 2.21: Represents the % of variance in malaria cases because of the impact of weather parameters in each state.

This study was performed in order to understand the effect of climatological variables on the malaria situation in the north-east region of India, which is prolonged by the disease. Time-series analysis of major climate parameters like rainfall, maximum temperature, minimum temperature, mean temperature, relative humidity, and soil moisture distributions is carried out, and their correlation with the malaria incidence is quantified state-wise, which is the unique part of the study. The correlation analysis reveals that malaria is significantly related with the maximum temperature and soil moisture in three out of eight states in NE India. To assess the climate variability, the inter-dependency between the meteorological parameters is obtained and the state wise correlation matrix for all states are reported. The analysis shows that maximum and mean temperature has highest positive correlation whereas minimum temperature and relative humidity has negative correlation. The climate-malaria relation is being carried out in the study region using the regression analysis and the results revealed that the regional climate has the most impact for the malaria incidence in the state of Arunachal Pradesh, Meghalaya, Tripura and Nagaland and in other states the impact is moderate. The variation in the number of malaria cases because of the combined impact of all the climate parameters are classified for each of the states in NE India in terms of the coefficient of determination i.e. R^2 (Figure 2.21). Analysis of variance modelling in the regions also indicates the degree of the fitment of

both the data sets with the regression model and it is observed that the relation is also significant in the same 4 states. As a case study the impact of large-scale oscillations like El Niño-Southern Oscillation on the malaria load is also assessed which can be a good indicator in the prediction of the climate and in turn the malaria incidences over the region.

K. C. Gouda, Nikhilasuma Pernaje & Mahendra Benke

2.17 Extreme Rainfall Event analysis in India

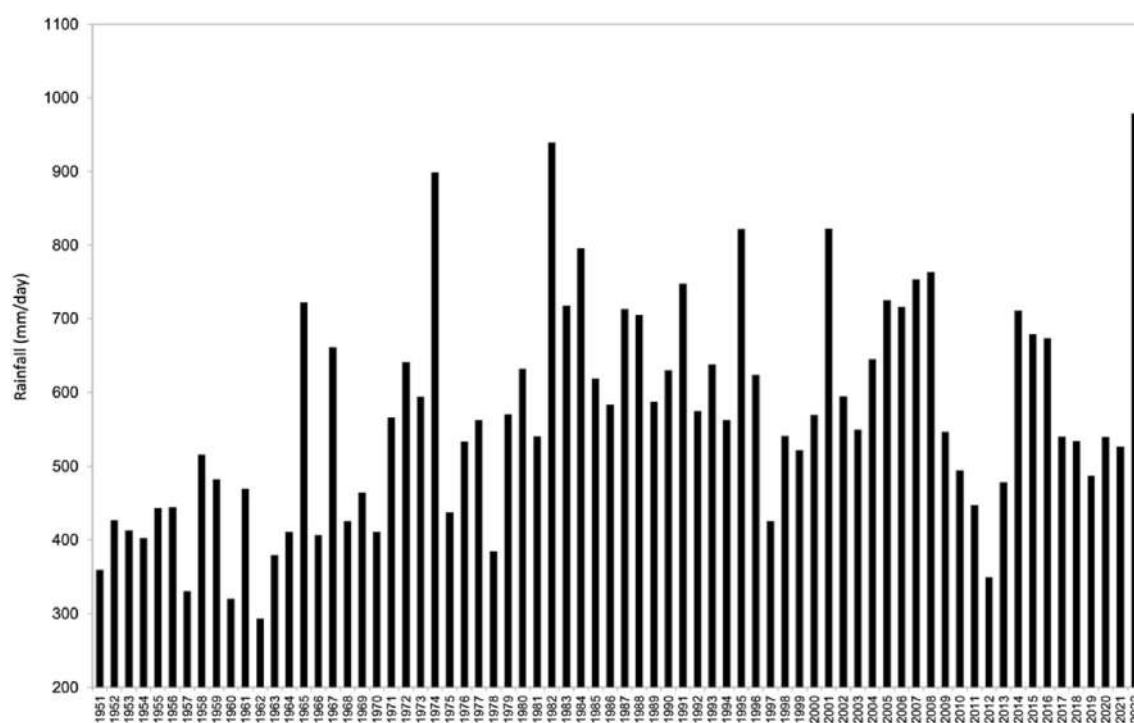


Figure 2.22: Interannual variability of the maximum daily rainfall (mm/day) observed at any location in continental India.

Climate vulnerability in the Indian region becomes a major concern due to the frequent hydro-meteorological extreme events throughout the year. The number of extreme rainfall events (ERE) associated with monsoon, thunderstorms and short-spanned local cloudbursts which are mainly ranges from a few hours to a few days, has increased in recent decades over the subcontinent. There is a need to quantify these high impact weather events and to understand the spatio-temporal dynamics and associated physical processes for the real time prediction for pro-active disaster management. This review paper highlights the various research works carried out and suggests the need of observation, modelling efforts for simulation/prediction of the EREs in the continental India. The works starting from cloudburst in the Himalayan region (Leh, Uttarakhand, Himachal Pradesh) to the heavy rainfall in Kerala, Bangalore, Mumbai, Chennai etc. as presented by earlier researchers are being reported in this compilation. The ERE intensity and frequency distribution in India are being analyzed using IMD gridded rainfall observation for 72 years

(Figure 2.22) . The analysis indicates the increasing trend in the intensity of daily rainfall during the ERE in the subcontinent. The current state of research in the multi-scale study of the ERE as well as their future changes based on climate model outputs are reviewed and the challenges are also reviewed. Evaluation of the capability of the state of art meso scale models like Weather Research and Forecasting (WRF) model for the simulation of such events at high resolution using the high-performance computing and the assimilation techniques are also emphasized in the recent research in this field. Along with the impact of large-scale physical processes like El Nino Southern Oscillations (ENSO), also the sensitivity of the urbanization, topography in the simulation of the convective meso-scale events is being presented and which indicated the down-scaled data are the best tool for the ERE research. This review will surely help the interdisciplinary researchers for the extreme analysis of the high impact hydro-meteorological disaster events.

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2.18 Assessment of Rainfall Variability over Karnataka state in India

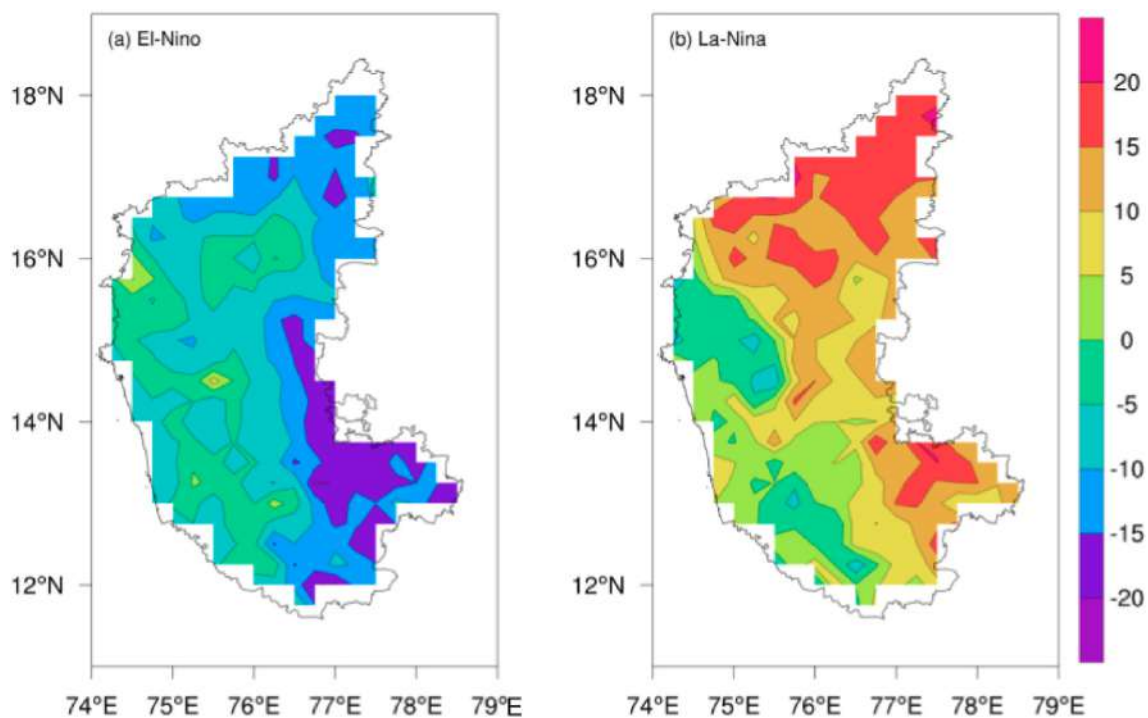


Figure 2.23: Distribution of spatial trend of monsoon rainfall anomaly (normalised to long term mean) over Karnataka composite over the (a) El-Niño and (b) La-Niña years during 19012020.

Karnataka state situated in the southern part of India is surrounded by a long coast line and western ghat mountain regions on the western side. The rainfall distribution shows a large variability in different parts of the state. North interior part in the state receives less rainfall as compared to the south interior region, which receives moderate

rainfall. Although coastal Karnataka witnesses a high rainfall and is one of the most important regions in the country, in recent years the state has faced drought because of less rainfall which may be attributed to the regional climate change. Because of the decreasing trend in rainfall almost all the important sectors like agriculture and water resources have been affected a lot in Karnataka. In this work, assessment of the spatial and temporal distribution of monsoon rainfall is presented in terms of the climatology, variability, trend etc. The time series analysis also indicated the increasing trend of rainfall as a whole but the trend in recent decades is very less as compared to the long term. The El-Niño Southern Oscillation (ENSO) and the regional rainfall pattern relation is also explored. The increase in heavy rainfall in recent times is observed from the analysis. This study can be useful in addressing regional climate change, understanding the local and large scale variability impacts and in can be a good input for preparing the policy formulation and pro-active disaster management (See Figure 2.23).

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2.19 Spatio-temporal analysis of air pollution dynamics over Bangalore city during second wave of COVID-19

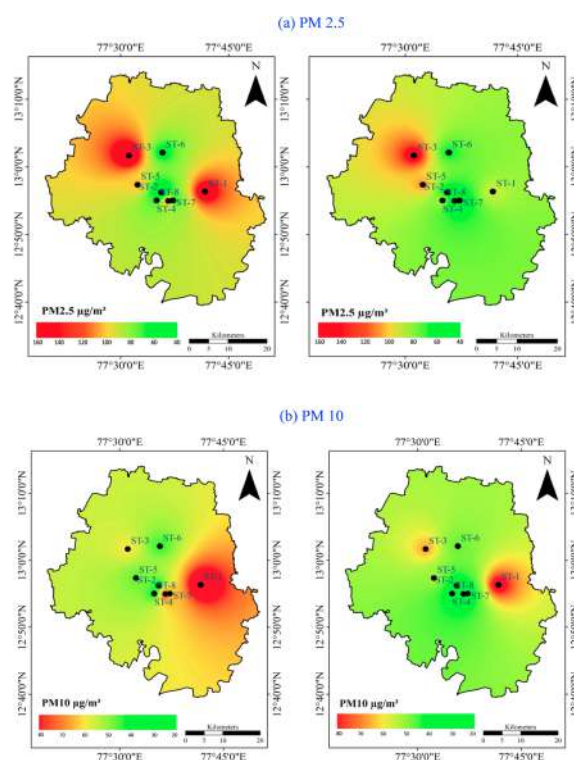


Figure 2.24: Comparison of the spatial variation of the air pollutants i.e. (a) PM2.5 and (b) PM10 across Bangalore city during pre-lockdown (left panels) and COVID-19 lockdown (right panels).

The country wide lockdown implemented during 27th April to 14th June 2021 in order to prevent the spread of COVID-19 during the second wave in India. Effect of the

restricted lockdown resulted in improved air quality. This study focuses on analyzing the spatio-temporal distribution analysis of major air pollutant concentration over Bangalore city in India. The inverse distance weighting (IDW) method is implemented for the spatial analysis in order to quantify the distribution of the pollutant concentrations at each location in the Urban city of Bangalore. The research considers the distinct periods of pre-lockdown and lockdown during the second wave of COVID-19 pandemic in 2021 to investigate the impact of reduced human activities on air quality over the city. The study mainly utilizes the air pollution data collected from Central Pollution Control Board (CPCB) monitoring stations across Bangalore, including measurements of pollutants such as PM_{2.5}, PM₁₀, O₃, NO₂, SO₂, and CO. The IDW method is implemented to create the high-resolution pollution concentration maps for both the pre-lockdown and lockdown periods. This spatial distribution provides valuable insights into the variations in the pollution levels throughout the Bangalore city. The comparative analysis of the concentration maps reveals significant changes in air pollution levels between the two periods; similarly, the temporal weekly average analysis also witnessed negative anomalies during the lockdown weeks. The results in Figure 2.24 indicate substantial reductions in pollutant concentrations during the second wave COVID-19 lockdown, attributed to decreased vehicular emissions, industrial activities, and construction operations. The pre-lockdown period serves as a baseline for assessing the improvements in air quality during the lockdown. The spatio-temporal modeling approach enhances our understanding of the distribution patterns of air pollutants across the Bangalore metropolitan city. The findings underscore the potential benefits of implementing sustainable strategies to maintain improved air quality even after the pandemic subsides.

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2.20 Estimation of Vegetation Index over the State of Sikkim

Processing and evaluating remote sensing data from available satellite images are software dependent and space consuming tasks. This work represents a recent widely used method for processing of satellite data at an online platform named Google Earth Engine (GEE). In this platform the task can be done individually as well as a team can work in collaboration mode. GEE platform allows the various remote sensing data processing and plotting without downloading remote sensing data to the users system (which are mainly space constraints). Motivation of this work is to perform remote sensing time series data analysis to study the vegetation index over Sikkim state in north east part of India in the GEE platform as a case study. In this work the normalized difference vegetation index (NDVI) is estimated at regional scale using the Landsat-8 data. The index generally detects the plant canopies green pigmentation in the remote sensing data of multi-spectral nature. This is also helped in quantifying the photosynthetic strength of green vegetation. The time span is selected from 2015 to 2020 according to the availability of Landsat8 data having 30m of spatial resolution to process the NDVI. For NDVI calculation, May month period of each year has been selected because of minimum cloud cover in the data for Sikkim region and the spatial distribution of the index is generated which clearly indicates the year to year variability in the state of Sikkim. Result of this work shows that Temporal variation of vegetation cover over Sikkim region has increased in the year

of 2017 and 2018. Vegetation cover has started to decrease again in 2019 (Figure 2.25). The changes are direct dependent on the the weather variations like rainfall, humidity, temperature etc.

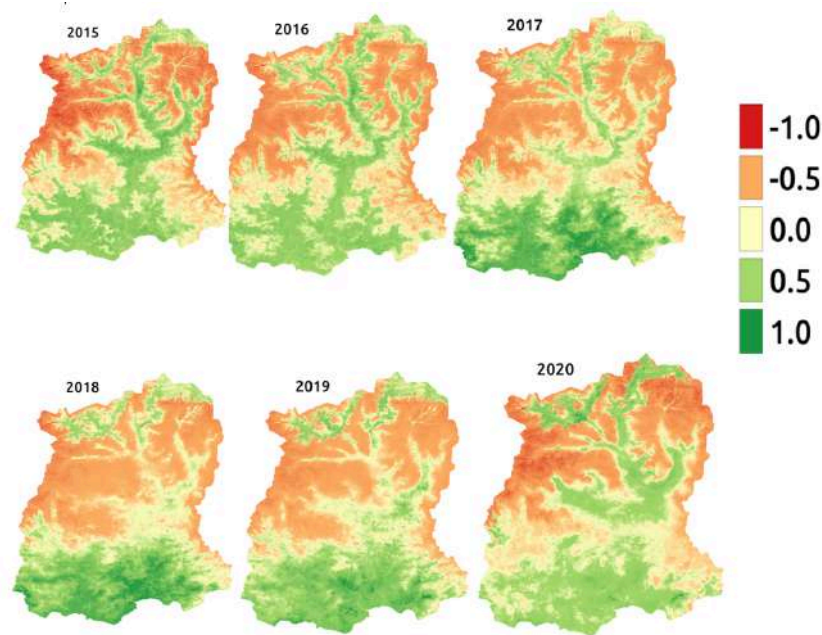


Figure 2.25: Raster image of vegetation index from 2015 to 2020.

K C Gouda, Reshma Kumari

2.21 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 78 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. 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) in this research. 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. To address the progress of monsoon the DOM in Rajasthan (MOR) is considered and the rainfall anomalies during MOK - MOR period are linked to the MJO phases (Figure 2.26) . It

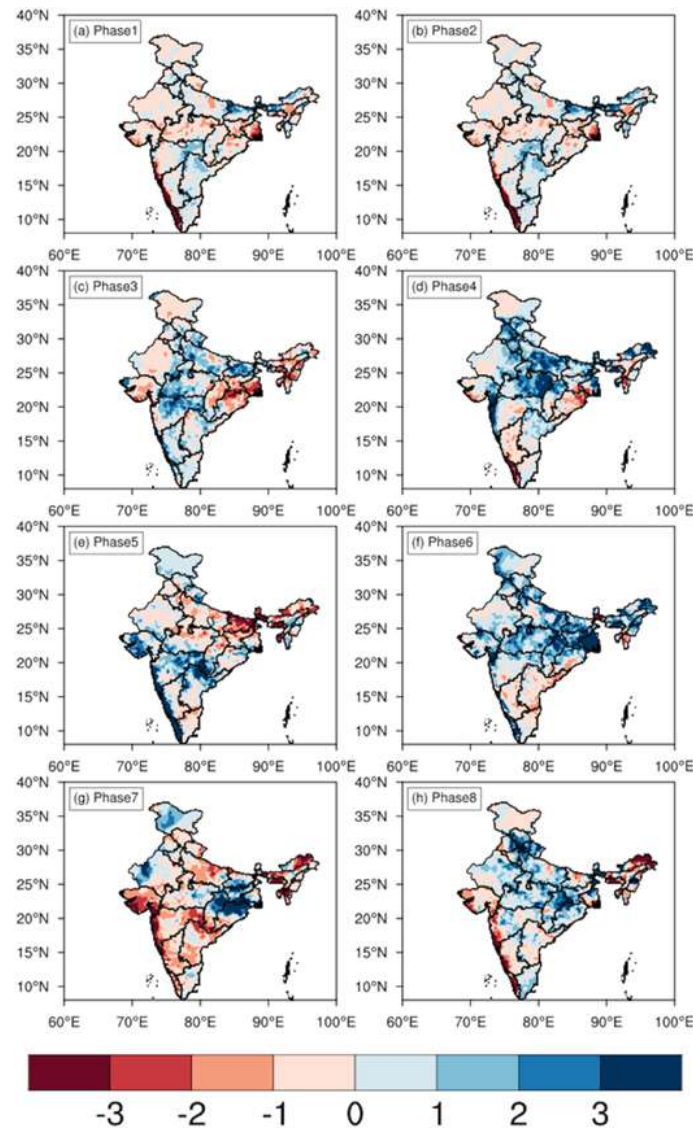


Figure 2.26: Rainfall anomaly (mm) analysis for the period of MOK to MOR, composite over different phases (18) of MJO. The results represent the analysis over the years 19802018.

is inferred that the wet MJO phase with negative OLR anomaly triggers the fast progress of monsoon over India. This understanding will surely help operational researchers and the NWP modellers for improving the methodologies for the advanced and accurate prediction of DOM. Result of this work shows that Temporal variation of vegetation cover over Sikkim region has increased in the year of 2017 and 2018. Vegetation cover has started to decrease again in 2019 (Figure 2.26). The changes are direct dependent on the the weather variations like rainfall, humidity, temperature etc.

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2.22 Multi-source soil moisture data for efficient water management in agriculture

The development of an efficient water management system for the agricultural sector is a growing demand in arid and semi-arid regions of India due to the limited sources of surface and groundwater. Precision water management based on advanced irrigation technologies (drip or sprinkler) saves a lot of water and has the potential to bring more crop area under irrigation. Identification of farm-level surface and root zone soil moisture deficits plays a key role in the automation of irrigation systems. The present study aims to review the multi-source (sensors, models, satellites, and AI/ML) soil moisture measuring methods and their advantages for crop water use efficiency (WUE). There is

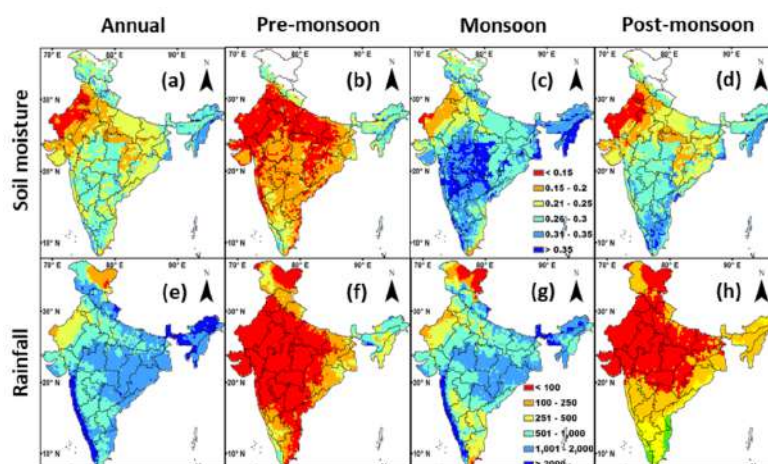


Figure 2.27: Spatial distribution of soil moisture and rainfall for annual, pre-monsoon, monsoon, and post-monsoon seasons over India during the period 2018-2022.

tremendous growth in Internet-of-Things (IoT) based wireless sensor networks to monitor soil moisture deficits at the farm level. Advancements in satellite remote sensing with the capabilities of microwave remote sensing (L and S band) and SAR (Synthetic Aperture Radar) applications show promising results for developing very high-resolution soil moisture data. The data-driven algorithms also develop reliable soil moisture products based on various machine learning (ML) and deep learning (DL) techniques. The synthesis of these multi-source soil moisture measurements can improve the WUE of different crops and enhance the scope of conducting the On-Farm-Agronomy Research (OFAR) efficiently in India. This review article gives policymakers more insights into incorporating multi-source soil moisture products into agro-advisories for precision crop water management (See Figure 2.27).

Kantha Rao Bhimala, E.V.S. Prakasa Rao, K.R. Prasad Babu And Himesh S



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:

- 3.1 Open science practices relevant to Earth Sciences & Agri-Tech
- 3.2 GPS deformation studies in the Himalayan Arc
- 3.3 Impact of two severe geomagnetic storms on the ionosphere over Indian longitude sector during March-April 2023
- 3.4 Seismic and GNSS strain rates in Himachal Pradesh, Kashmir, and Ladakh
- 3.5 Integration and comparison of seismic and geodetic strain rates to estimate seismic potential in Nepal Himalaya
- 3.6 Noise analysis and impact of noise on velocity uncertainties using multi-GNSS time series
- 3.7 Coseismic Ionospheric Disturbances Controlled by Rupture Dynamics of 6th February 2023 Turkey-Syria Doublet Earthquakes
- 3.8 Fine Imaging of the Crustal and Upper Mantle structure beneath north western Himalaya using receiver functions and Surface wave dispersion
- 3.9 A 3D FEM mesh for the Andaman Subduction Zone Using CUBIT
- 3.10 Fractional derivative analysis of axial wave propagation study in nanorod using nonlocal strain gradient theory with elastic medium support
- 3.11 Flexural wave propagation studies of carbon nanotube with nonlocal strain gradient theory using fractional derivative approach supported by Winkler and Pasternak medium

3.1 Open science practices relevant to Earth Sciences & Agri-Tech

CSIR with its 37 labs is a Pan-India scientific and industrial organization covering wide spectrum ranging from oceanography, geophysics, chemicals, drugs, genomics, biotechnology and nanotechnology to mining, aeronautics, instrumentation, environmental engineering, information technology and so on for the past 80+ years generating significant amounts of data across varied wide disciplines. CSIR-Fourth Paradigm Institute addresses the data science and super computing needs of CSIR with niche domain expertise in Earth and Engineering Sciences. Data Science research involves Data and science involving both the domain as well as data expertise supported by the computing and data visualization platform. Hence, the interdisciplinary nature of the data science and challenges needs to be addressed i.e the five Vs of data such as Volume, Velocity, Value, Veracity and Variety; associated with large-scale open scientific data. This is quantifiable in terms of the exponential growth, performance, scalability, security and observability of the BIG data. Best practices for open and FAIR data specific to scientific domain includes providing ample metadata about scientific data, adopting open standards and formats for scientific data sharing, and possible inclusion of codes (computer programs) and tools used for generation of data and scientific results. It should be noted that due to rapid increase in data generation and consumption rate in the domain of earth science, the open data framework of this domain would demand more sophistication in future. Some of the evolving challenges are Seamless and real-time handling of missing data, realizing a more pervasive framework for open data leading to open science, catering to the needs of real-time replication of massive open data and disaster recovery framework and so on. Apart from the above, specific aspects associated with promoting and practicing open data for Agri-Tech need to be carefully considered. Further, concerns on exposing traditional farming knowledge, which is predominantly considered as a proprietary property of farmers need to be addressed (See Figure 3.1).

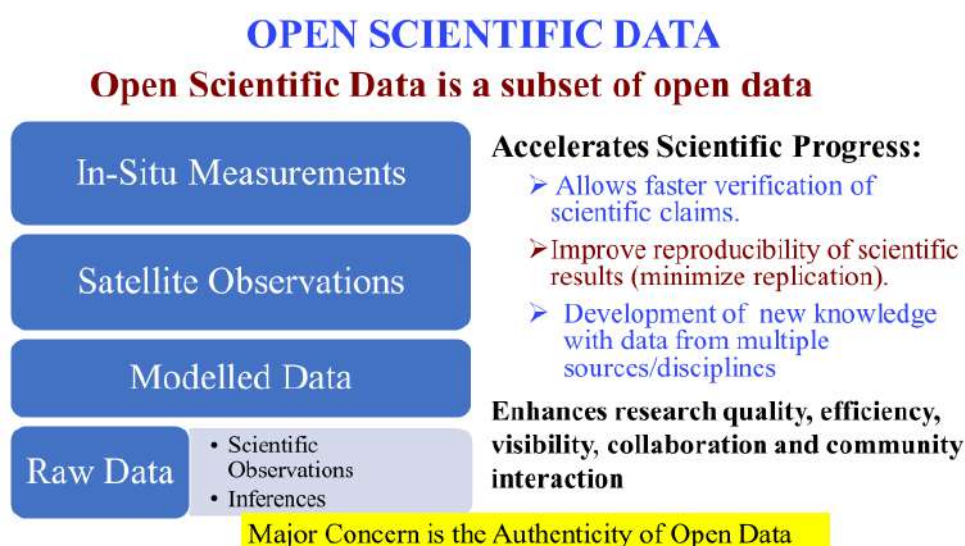


Figure 3.1: Best practices for open and FAIR data specific to scientific domains.

3.2 GPS deformation studies in the Himalayan Arc

Himalayan arc of 2500 km which stretches from Kashmir, Ladakh in the west to Eastern syntaxis in the east is tectonically complex and seismically active northern convergent boundary of Indian plate. Kashmir, Ladakh, Himachal, Garhwal, Kumaun, Nepal, Sikkim, Bhutan, Arunachal, Eastern Syntaxis segments of Himalaya are studied using three decades of GNSS/GPS observational data. Seismicity, tectonics and surface deformation are different for each segment; hence an in-depth study is required to understand the complex Himalayan region. GPS data sets yielded well-constrained surface convergence rates of 10 to 26 mm/year (Figure 3.2). Inverse modelling of India fixed velocities is carried out using Okada dislocation theory and weighted least square for determining subsurface decollement parameters along with the associated slip. Indian plate subducts below the Eurasian plate along the Main Himalayan Thrust (MHT) at a depth of 15 to 20 km and width of 100 to 150 km with a slip rate of 13 to 20 mm/year indicating high strain accumulation in different segments of Himalaya. Geodetic strain rates are calculated using GPS velocities and covering Kangra 1905, Muzaffarabad 2005 earthquakes, Kashmir seismic gap, Himachal, Garhwal, Kumaun and Nepal suggest active compression with NNE orientation and increasing strain rates from frontal Himalaya to northern edge of MHT which is consistent with micro-seismicity of the region. Seismic strain rates are calculated using instrumental period and historical earthquake catalogue using Kostrov 1974 formulations. Combined analysis of geodetic and seismic strain rates and the corresponding moment rates of each segment of Himalaya suggests uniform stress regime. Recurrence interval along with the probable magnitude of likely to occur earthquake in each segment of Himalaya is estimated using strain budget and accumulated slip, since the last devastating earthquake.

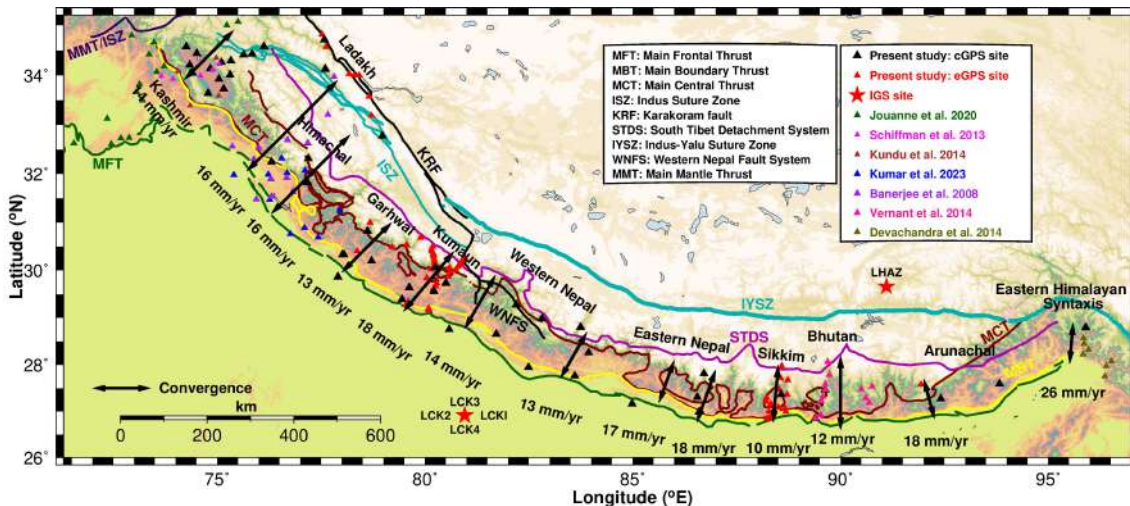


Figure 3.2: GPS derived arc-normal surface convergence rates along with the GPS stations and major faults across the Himalayan arc.

3.3 Impact of two severe geomagnetic storms on the ionosphere over Indian longitude sector during March-April 2023

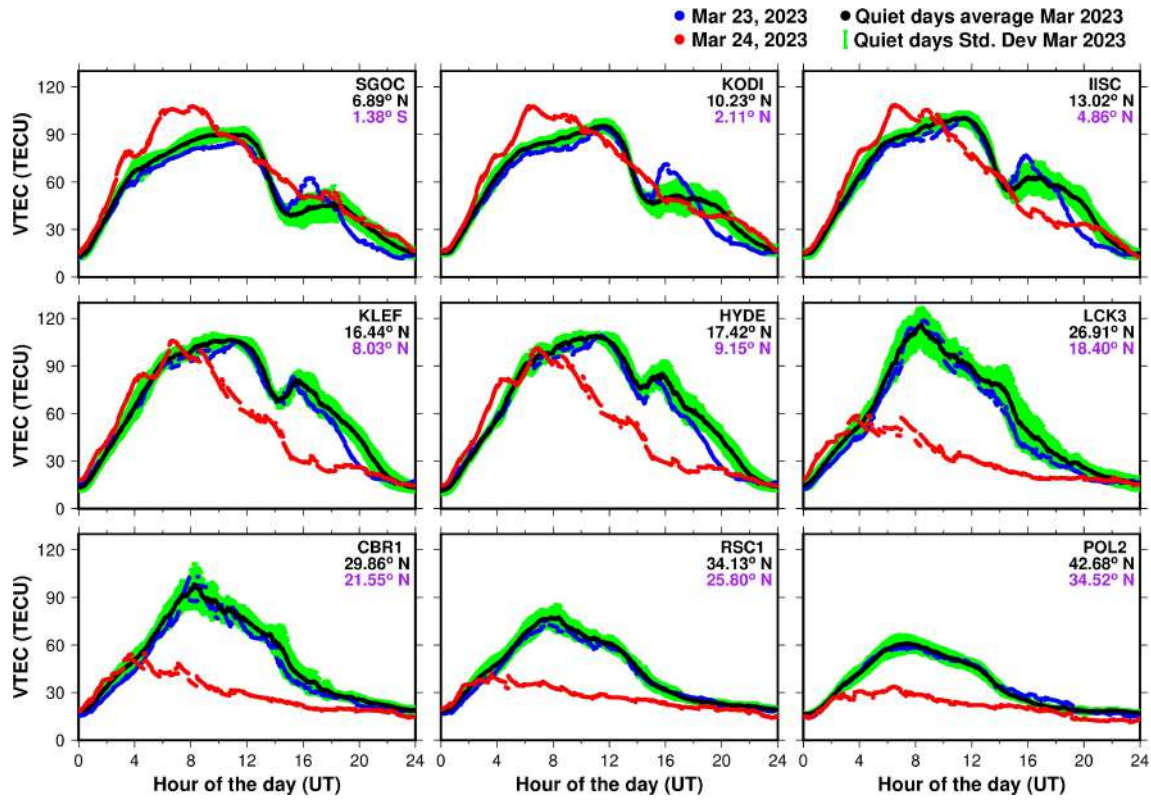


Figure 3.3: Diurnal variation of VTEC at various latitudinal stations within the Indian longitude sector on March 23 and 24, 2023 along with the quiet days mean and standard deviation of March. Geographic latitude is represented in black, and geomagnetic latitude is represented in purple.

The Ionosphere response to two severe geomagnetic storms in the ascending phase of solar cycle 25, which occurred during the 23-24 March 2023 and 23-24 April 2023 are studied using the multi-instrument observations. Significant fluctuations in GPS-TEC are observed during the main and recovery phases of both storms, primarily due to the influence of westward directed Disturbance Dynamo Electric Fields (DDEFs). During the main phase of March 23-24 storm, the development of Pre-Reversal Enhancement (PRE) and post-sunset ionospheric irregularities are suppressed after approximately two hours, due to the zonal plasma drift transitioning from eastward to westward direction under the influence of DDEFs. Diurnal variations of Vertical TEC (VTEC) in Figure 3.3 shows the pronounced negative ionospheric storm effect during the recovery phase of 23-24 March 2023 geomagnetic storm, indicating a reduction in latitude-dependent variability of GPS-TEC from mid-latitudes to low latitudes. This negative effect is attributed to the strong daytime westward DDEFs. Additionally, these DDEFs inhibited the equinoctial manifestation of PRE-effects and post-sunset ionospheric irregularities during the recovery phase of both storms. These findings are further supported by data from TEC measurements by Swarm satellites, model-derived ionospheric electric fields, and thermospheric O/N₂. The

results from this study may contribute to the deeper understanding of how the ionosphere responds to severe geomagnetic storms in the presence of westward DDEFs during the dayside recovery phase, thereby enhancing global efforts in space weather modeling and prediction services.

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3.4 Seismic and GNSS strain rates in Himachal Pradesh, Kashmir, and Ladakh

Himachal Pradesh, Kashmir and Ladakh Himalaya is seismically active and tectonically complex which includes rupture zones of 1905 Kangra and 2005 Kashmir (Muzaffarabad) earthquakes. The kinematics and active tectonics of the plate boundaries are mostly determined by seismic and geodetic data. Geodetic strain rates are calculated using two decades of about 58 GNSS stations in this region. When fault is ruptured, focal mechanism solutions of the earthquake give the directions in which the current tectonic stress acts. Magnitude completeness (M_c) and seismogenic thickness of the crust estimated based on the reported events from 1964 to 2021 from ISC catalog is computed using ZMAP. Figure 3.4a, c shows the number of events with magnitude and depth respectively during the instrumental period. During this period, the magnitude completeness M_c of the catalog is 3.9 (Figure 3.4b). Figure 3.4d shows total release of seismic moment during the instrumental period. Hence, principal seismic strain rates are estimated using available focal mechanism solutions of earthquakes $M_w \geq 3.9$ reported in the GCMT catalog. Estimated seismic strain for the instrumental period indicates a mean compression rate of -28.1 ns/year and it slightly decreases to -21.7 ns/year after including the historical earthquakes of the past 520 years. In the present region of the Northwest Himalaya, a composite study of geodetic and seismic strain rates and the corresponding moments estimate the accumulated strain budget of approximately $1E+21$ Nm over the previous 520 years, which has the potential to cause future earthquakes with a magnitude of $M_w > 8$.

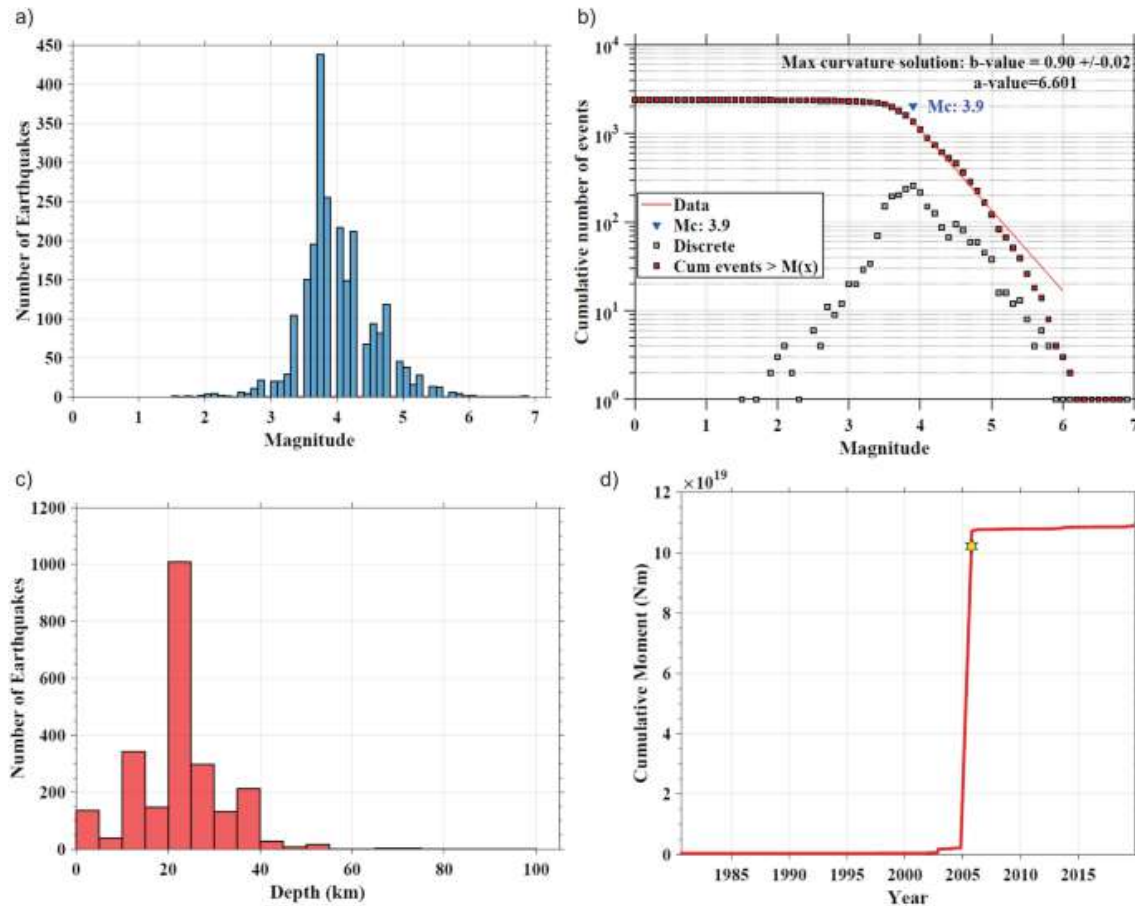


Figure 3.4: Characteristics of seismicity from 1964 to 2021 in the study region. (a) Magnitude - frequency distribution curve. (b) Maximum Likelihood solution. (c) Average Seismogenic depth. (d) Total release of cumulative seismic moment (Yellow star indicates 2005 Muzaffarabad earthquake).

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3.5 Integration and comparison of seismic and geodetic strain rates to estimate seismic potential in Nepal Himalaya

Nepal lies along the active collision belt of the Indian and Eurasian plates. In Nepal, over 16 earthquakes have occurred since 1223. The most disastrous occurred in 1833 with Mw 7.7 and 1934 with Mw 8.1. An earthquake of magnitude Mw 7.8 occurred on 25 April 2015, which is the first major earthquake in the Nepal Himalaya after the 1934 Nepal-Bihar earthquake (Figure 3.5). The central Himalayan seismic gap, which is named because there has never been a significant earthquake between Kathmandu in the east and Dehradun in the west. An important indicator for seismic hazard mitigation

and seismic potential estimation is the comparison of the strain rates derived from the seismic and geodetic datasets, which provides more knowledge on the extent to which an area is impacted by seismic deformation. The International Seismological Centre (ISC) provides an earthquake database for the instrumental period spanning from 1964 to 2023. This set of data helps in the ZMAP tool for the estimation of seismic moment cumulative, seismogenic thickness, and magnitude completeness. Kostrov formulations have been used to calculate seismic strain rates and GPS data to calculate the continuously varying geodetic strain rate fields for the region. Then seismic and geodetic strain rate results are compared to identify regions with seismic moment deficits and also calculate the expected recurrence intervals from the geodetic moment rates.

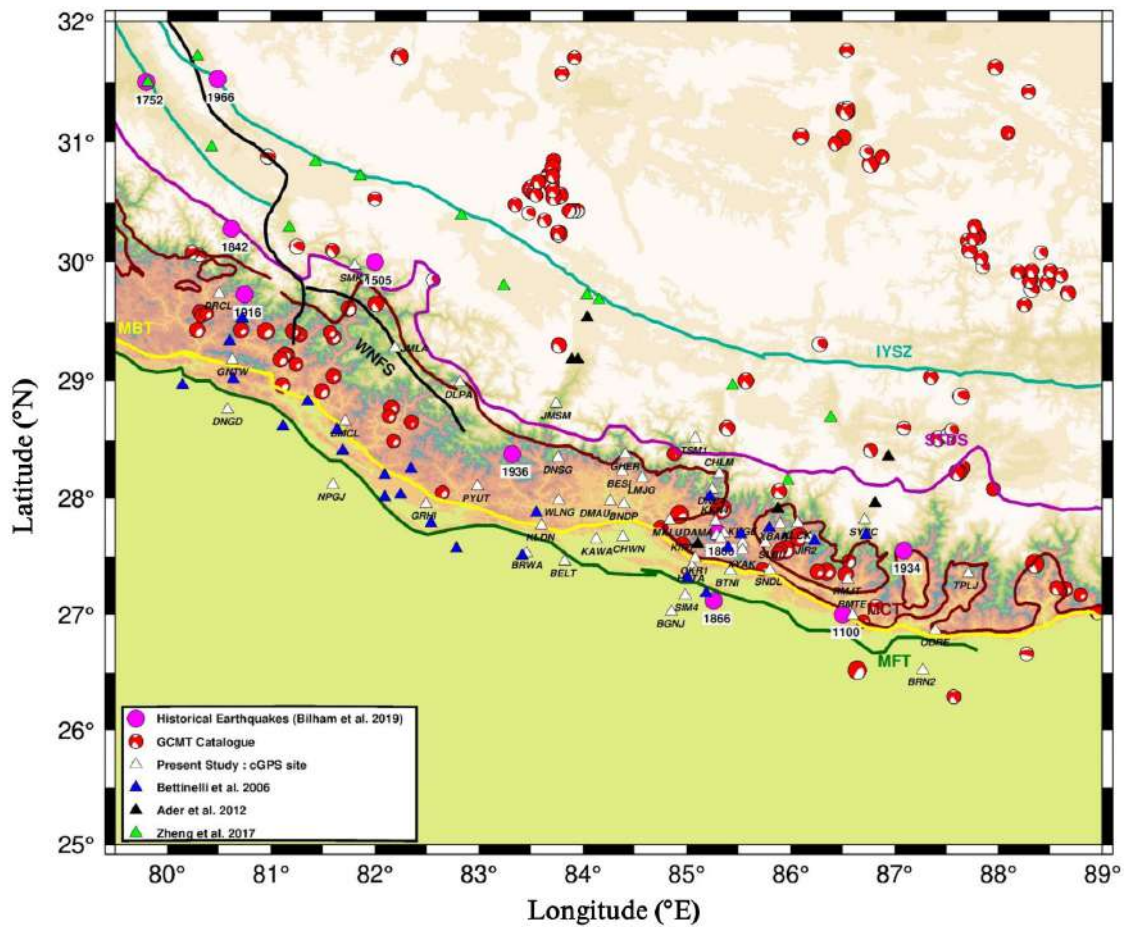


Figure 3.5: Seismicity, cGPS sites and major faults of the study region.

Bhavani Narukula, Sridevi Jade

3.6 Noise analysis and impact of noise on velocity uncertainties using multi-GNSS time series

Comprehensive noise analysis is carried out using stand-alone GPS, Glonass (GLO) and GPS+Glonass (GGL) time series of continuous mode Global Navigation Satellite System

(cGNSS) stations to identify the preferred noise model, noise amplitude and velocity uncertainties. Spectral analysis and Maximum Likelihood Estimation (MLE) techniques are used to recognize the noise model which showed that flicker noise plus white noise is dominant in north, east and up components of the time series. Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) also confirmed that color noise is the dominant noise model. It is observed that flicker noise is the best model for all stations, except southern hemisphere sites which exhibited intrusive white noise. Noise amplitudes and velocity estimates with associated uncertainties are computed by assuming flicker noise as the preferred model. Noise amplitudes are less in East component compared to north and up components of GPS, GLO and GGL time series (Figure 3.6). GGL time series have higher amplitudes and associated uncertainties which shows that combined analysis does not benefit in case of geodetic studies. Uncertainties are less for the stations with ~ 5 years of data, but noise analysis need to be carried out with more data span to ascertain the dominant noise model for each constellation. Southern hemisphere sites are not notably noisier compared to northern hemisphere.

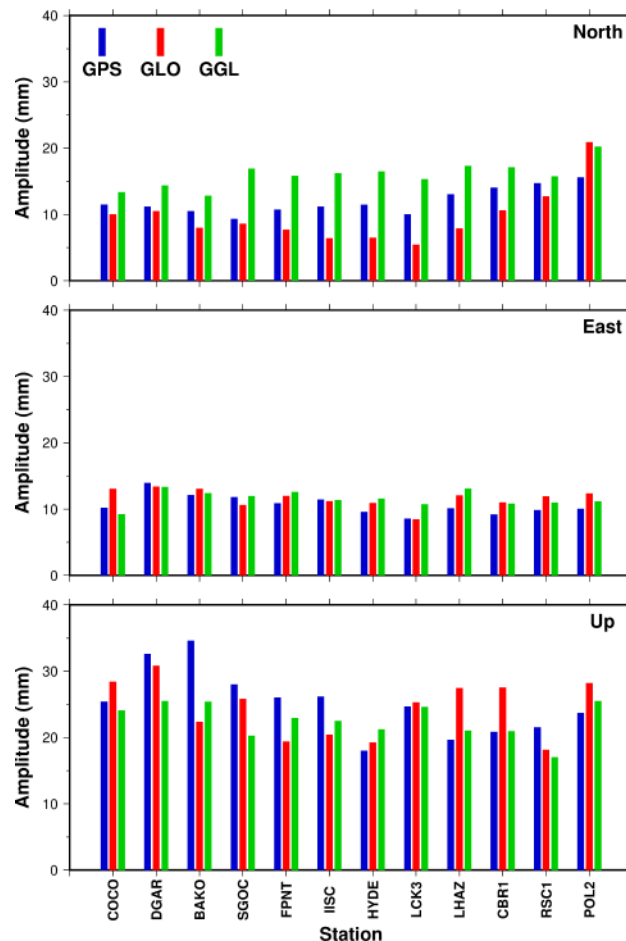


Figure 3.6: Flicker noise amplitudes in North, East and Up components.

3.7 Coseismic Ionospheric Disturbances Controlled by Rupture Dynamics of 6th February 2023 Turkey-Syria Doublet Earthquakes

Two strike-slip earthquakes, with magnitudes Mw7.8 and Mw7.5, devastated regions of Turkey and Syria on February 6th, 2023. The first event, Mw7.8, occurred near the Syrian border (37.174°N, 37.032°E) at 01:17:35 (UTC) (4:17 am local time). The second event, Mw7.5, occurred on the same day at 10:24:48 (UTC) (1:24 pm local time) along the Surgu fault (38.024°N, 37.203°E) located west of the East Anatolian plate. A small portion of seismic energy released during major earthquakes leaks into the atmosphere and triggers significant disturbances in the ionosphere. Recent studies analyzing the characteristics of such Coseismic Ionospheric Disturbances (CIDs) point to the potential use of CIDs in geophysical investigations. Following this lead, we explored the CIDs caused by these two nearly simultaneous earthquakes one occurring in the early morning and the other at local noon using total electron content derived from dual-frequency Global Positioning System (GPS) signals observed at 74 GPS stations across the Turkey region. The results show, contrary to current knowledge, that the CIDs associated with the daytime event (Mw7.5) are stronger and more widespread than those of the nighttime event (Mw7.8). Although the magnitudes, focal depths, and slip patterns of these two earthquakes are similar and comparable, the main differences are the time of occurrence and the dynamics of their rupture. Hence, we investigated the factors responsible for this counterintuitive difference in the CIDs observed during the two earthquakes. Comparison of the CIDs obtained after removing the influence of nocturnal and diurnal background ionospheric electron densities with the spatiotemporal pattern of fault rupture obtained from seismic studies reveals that in addition to the magnitude of the earthquakes, the nature of fault rupture also plays a major role in controlling the characteristics of the CIDs (See Figure 3.7).

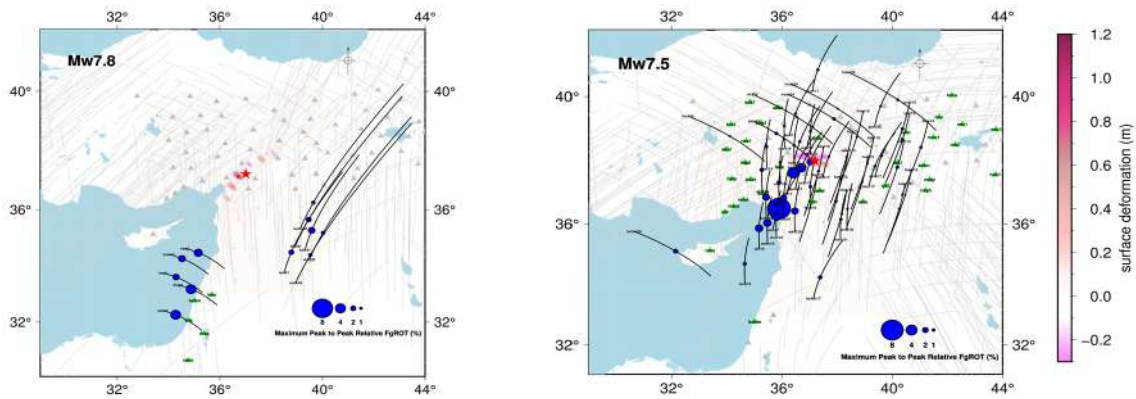


Figure 3.7: CIDs induced by the 6th February 2023 Turkey-Syria doublet strike-slip earthquakes. Triangles are location of GPS stations and the lines are ground tracks of the Ionospheric Pierce Points (IPP) of GPS satellites tracked by the GPS stations during the events. Location of the earthquakes are marked with red stars. Blue circles represent location and amplitude of the CIDs.

3.8 Fine Imaging of the Crustal and Upper Mantle structure beneath north western Himalaya using receiver functions and Surface wave dispersion

The Himalayas, extending for ~ 2500 km from west to east, are defined by four distinct and broadly strike sub-parallel litho-tectonic units. From north to south are the Tethys, the Great, the Lesser, and the sub-Himalaya, separated by thrusts that apparently root in a shallow (10-15 km) decollement formed by the upper surface of the underthrusting Indian plate. Despite a nearly unbroken continental scale continuity, however, the four units show notable variations along the strike. We analysed and modelled earthquake waveform recorded at 22 seismic stations in the North Western Himalaya and adjoining region (Figure 3.8).

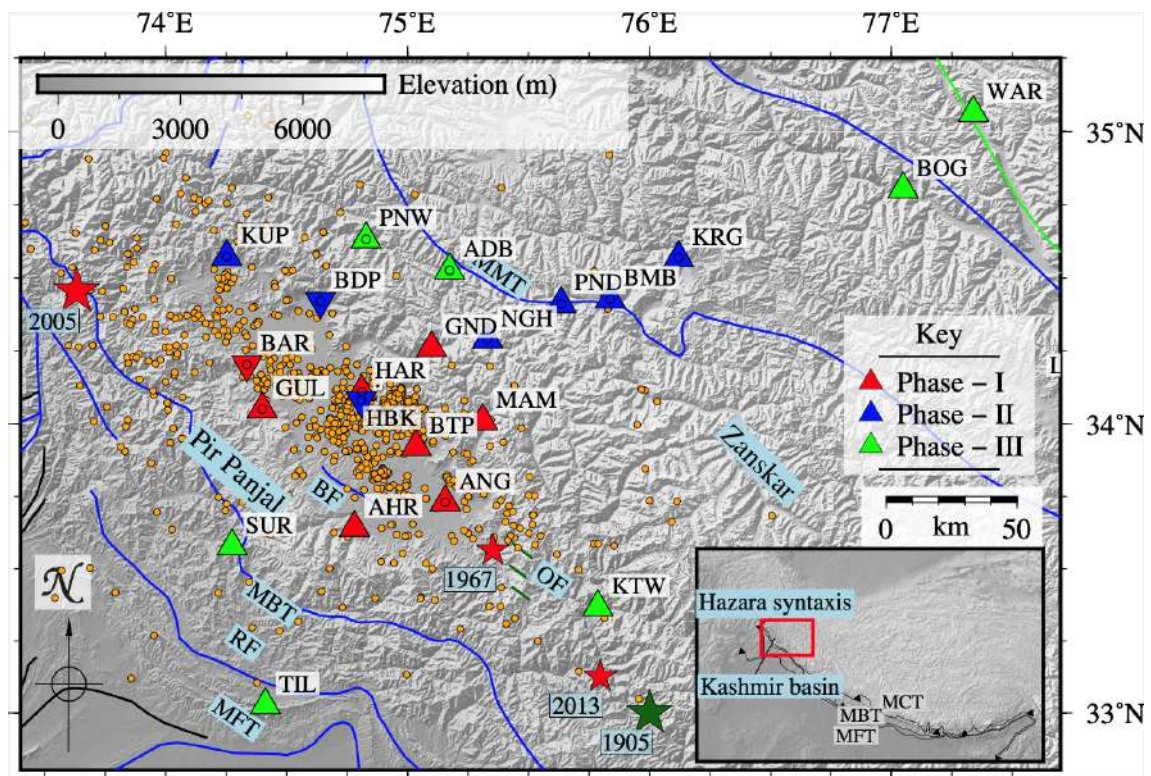


Figure 3.8: A topographic map of the north western Himalaya and surrounding area showing 22 broadband stations along with major tectonic features.

Information on S-wave velocities (V_s) has been obtained using Receiver Functions (RFs) analysis exploiting P-to-S converted waves generated across the seismic discontinuity during the propagation of a teleseismic wavefield. To compute RFs at locations (Figure 3.8), we selected earthquakes with magnitude above 5.5 and epicentral distances between 30° and 95° . The earthquake waveform data with clean P-wave arrival (Signal-to-noise ratio ≥ 15) has been used for further analysis. The P-arrival of the waveforms has been picked initially by Taup-toolkit and are corrected after visual inspection. A 2nd order Butterworth filter having cut of frequency between 0.03 to 4 Hz is used to filter the earthquake waveform after demeaning and detrending. RFs were computed by time

domain deconvolving the vertical component of the seismogram from the corresponding radial and transverse components. The RFs reproducing at least 90% of the original waveform, when convolved back with the vertical trace, were retained for further analysis. To examine the data quality and identify a few robust phases, we plot the RFs for stations ANG and AHR as a function of distance. We observe a positive phase at ~ 7.5 -8s (corresponding to Moho) and its multiples at 22s and 24s. The S wave velocity-depth profile

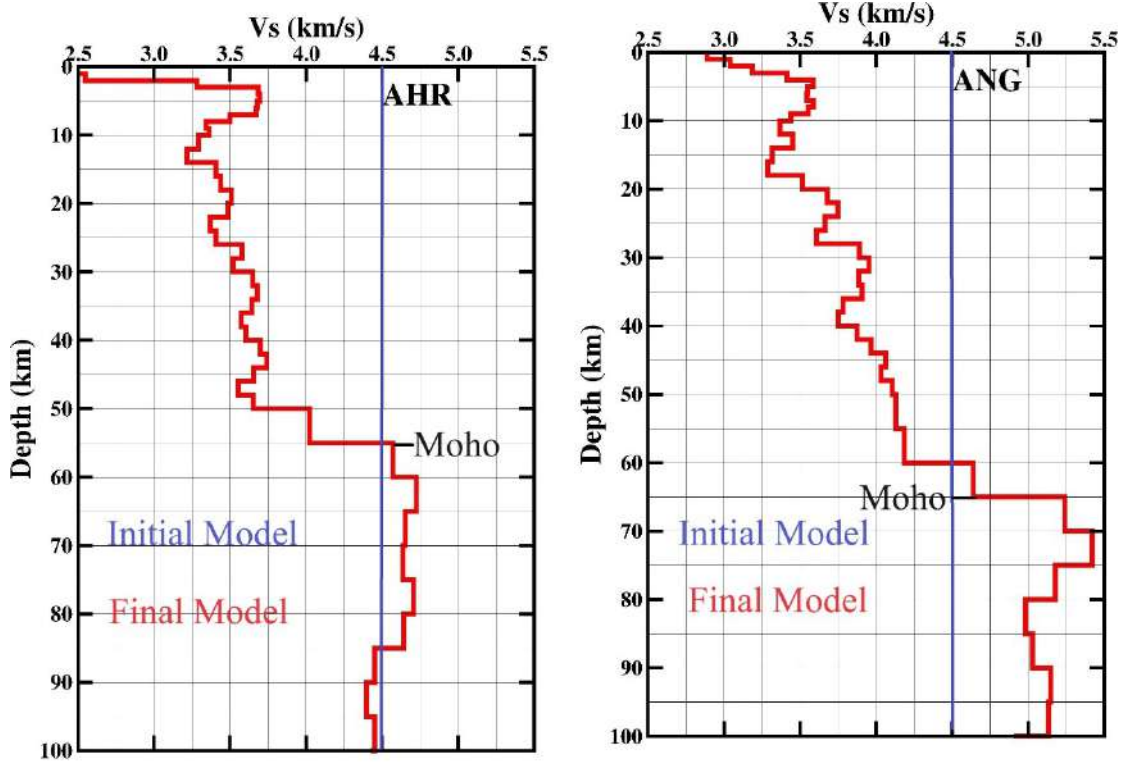


Figure 3.9: Joint inversion of RFs and surface wave dispersion for stations AHR and ANG using an initial velocity model with a half-space of V_s 4.5 km/s and a variable depth parameterization.

has been obtained by jointly inverting the RFs with surface wave dispersion following the linearized inversion procedure. We consider the initial model of Earth as layers with constant S-velocity 4.5 km/s. The layer has a thickness of 1 km up to 10 km depth, followed by 2 km at a depth of 10-50 km and 5 km at a depth of 50-200 km. The thin-layered near-surface model helps in mapping rapid variation in velocity. The weightage between the surface wave and RF data during the inversion is controlled by the influence parameter, and its value lies between 0 and 1. Inversion is performed using weights of 0.9 and 0.1 to the RFs and surface wave dispersion. The resulting velocity model from inversion and the initial model is shown in Figure 3.9.

Gokul Kumar Saha and Imtiyaz A. Parvez

3.9 A 3D FEM mesh for the Andaman Subduction Zone Using CUBIT

The Andaman Subduction Zone, part of the complex tectonic boundary between the Indo-Australian and Eurasian plates, presents unique challenges for geological modeling. Creating a detailed 3D finite element mesh of this region is crucial for understanding its seismic behavior and geological characteristics. Through this work we generated a 3D finite element mesh of the Andaman Subduction Zone using CUBIT, a robust meshing tool. The first step involved gathering geospatial and geological data for the Andaman Subduction Zone including Bathymetric and Topographic Maps for surface topography. Cross-sectional images were generated from seismic survey profile which reveal subsurface structural orientations. Detailed maps indicating rock types, fault lines, and other geological features were also used. Further, we used Geophysical Data like; gravitational, magnetic, and thermal properties to define the rheological variations. We generated a 3D mesh geometry by defining the volumes that represent different geological layers and fault structures. We used various available DEM's to create the surface topography. This surface was extruded downward to create a volume representing the Earth's crust and subducting plate. We used seismic data to delineate boundaries between these layers and introduced faults and discontinuities using boolean operations to cut and modify volumes. Mesh sizes were specified based on the required ample resolution and computational constraints. This mesh serves as a foundational tool for simulating and understanding the tectonic and seismic behavior of this complex geological region (See Figure 3.10). Further improvements in the mesh geometry based on arcuate geometry of the subduction interface, dip of Benniof zone, near trench structures, slab penetration depth, material models and along-strike mega-thrust as well as sliver variations etc. are being included in forthcoming versions for better geophysical and geospatial matching. With accurate geological data and careful meshing practices, researchers can gain insights into the dynamics of subduction zones and their associated hazards.

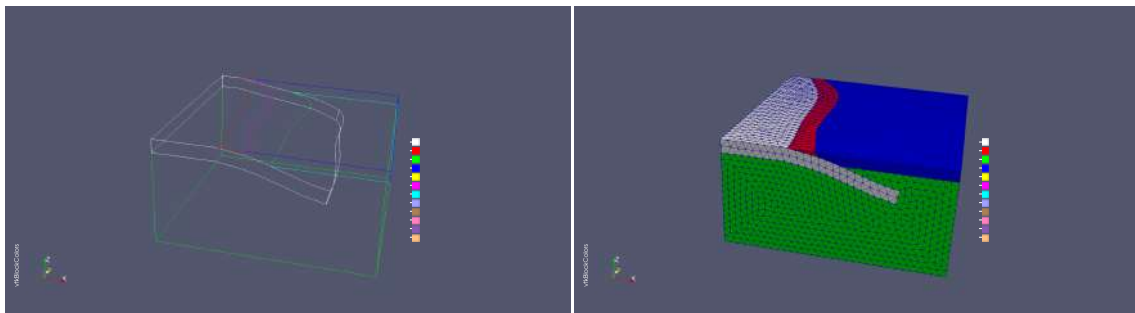


Figure 3.10: Left Panel: Shows the visualization of feature edges created for the Andaman Subduction interface. Right Panel: Shows the finer scales meshes for respective rheological features like the subducting plate, Over riding plate and the Andaman tectonic sliver.

3.10 Flexural wave propagation studies of carbon nanotube with nonlocal strain gradient theory using fractional derivative approach supported by Winkler and Pasternak medium

The present investigation considers the modeling of Euler-Bernoulli's theory for carbon nanotubes using nonlocal strain gradient theory by utilizing the Caputo fractional derivative approach to study flexural wave propagation. As concluded in the previous work about carbon nanorods with a fractional derivative approach for axial waves, four length scales occur in the present model in terms of irrational number π for effectively predicting the group speed. In addition, the linear elastic support model by Winkler and the shearable elastic support model developed by Pasternak attract their roles in influencing wave propagation studies of the present model, like frequency curve, phase speed, and group speed. Further, the escape frequency, cut-off frequency, etc., shows the entire behavior of this model for flexural waves. The carbon nanorod considers axial waves with the drawback of not understanding shearable elastic support in the literature, the present work included the Pasternak medium support to model the flexural waves.

Senthilkumar V

3.11 Fractional derivative analysis of axial wave propagation study in nanorod using nonlocal strain gradient theory with elastic medium support

The nonlocal continuum model proposed by Eringen to analyze the small-sized effects in structures failed to satisfy the group speed boundary conditions at the end of the first Brillouin zone comparison with the lattice dynamics model (Born-Karman). Eringen's single-length scale fails to model the entire group speed phenomena, particularly at the higher wave numbers. It necessitates the inclusion of more than one length scale in the nonlocal continuum models. Subsequently, many other nonlocal continuum models seen in the literature by researchers to improve the group speed showed some promising results. However, these models fail to satisfy the criteria of group speed value reaching zero at the end of the first Brillouin zone. The fractional derivative approach attracted researchers because it introduces additional fractional length scales for different nonlocal length scales. The present work considers the nonlocal strain gradient theory (FC NSGT) that allows two length scales to model the stress and strain gradient phenomena. The Caputo fractional derivative approach converts the one-dimensional model based on nonlocal strain gradient theory containing two length scales into a four-length scale model by adding two fractional length scales. As reported by Senthilkumar in a previous study, the length-scale parameters after the conversion of the Caputo fractional derivative form should be in irrational numbers (FC Challamel). In the present study, all four length scales are in the form of irrational numbers (function of π). The study of dispersion curves and phase speed shows excellent matching of results with lattice dynamics models. Interestingly, the group speed (Figure 3.11) showed excellent results in comparison to the lattice dynamics model and it is better than other existing nonlocal continuum models. Though the group speed didn't approach zero value at the end of the first Brillouin zone, it reached nearby zero value with a minor error percentage. So this model shows confidence in analyzing

further wave phenomena like critical wave number, cut-off frequency, critical group speed, etc. Further, the effect of elastic support over the frequency, phase speed, and group speed is the key focus of this study. One of the major observations is that choosing the correct range of length-scale values provides reliable results and, all the length scales have to be in irrational number form (function of π).

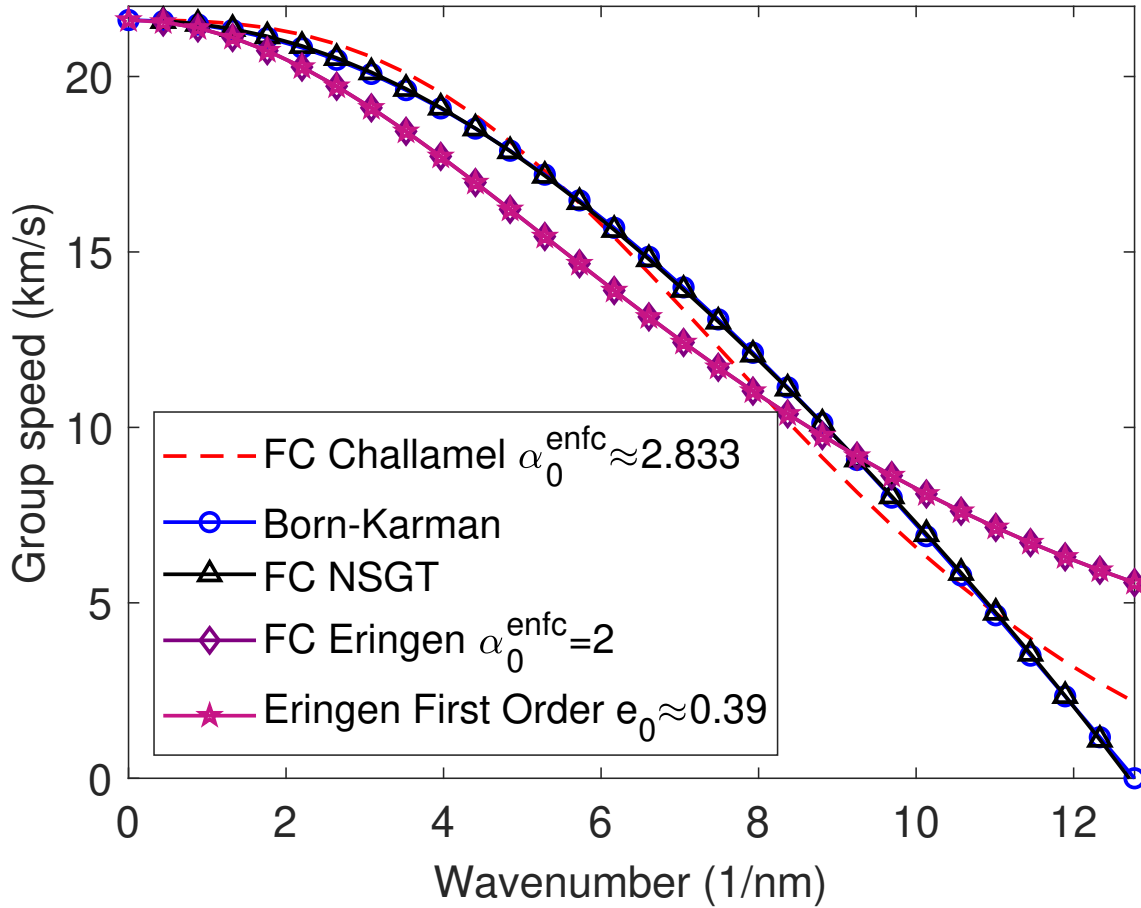
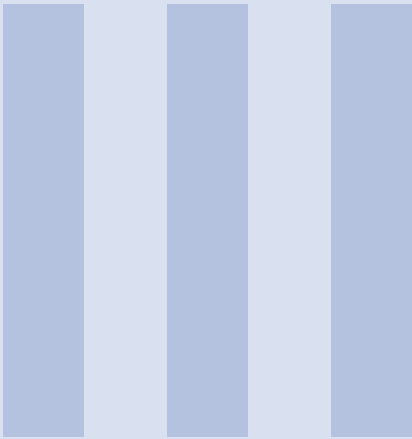


Figure 3.11: Group speed criteria at the end of first Brillouin zone.

Senthilkumar V



Knowledge & Technical Management

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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:

- 4.1 Academy of Scientific and Innovative Research (AcSIR)
- 4.2 Doctoral Guidance
- 4.3 CSIR-Integrated Skill Initiative Programme at CSIR-4PI
- 4.4 CSIR Jigyasa
- 4.5 CSIR-4PI Student Programme for Advancement of Research Knowledge (SPARK)
- 4.6 Faculty Participation

4.1 Academy of Scientific and Innovative Research (AcSIR)

The Academy of Scientific & Innovative Research (AcSIR) is established with the goal of maximizing the number of qualified researchers and professionals in the domains of science and engineering, equipped with skills in innovation and interdisciplinary integration. AcSIR imparts course instruction and awards degrees in frontier areas of science and technology. At CSIR-4PI, the AcSIR PhD program is offered in three disciplines: Physical Sciences (PS), Engineering Science (EE), and Mathematical and Information Sciences (MIS). Our program targets students intending to pursue research careers in interdisciplinary and multidisciplinary areas, both within and outside academia. Our primary objective is to provide students with a strong technical background, enhance their capacity for analytical thinking, and tackle new challenges for advancing science and society.

The PhD program is typically completed within 5 years. During the first year, students undergo coursework covering basic and advanced topics, with encouragement to take courses in interdisciplinary fields. They also participate in computational training tutorials and develop a research proposal on topics of high relevance and novelty, which includes a state-of-the-art review, methodologies, and recommendations, demonstrating a high level of scientific ability. Additionally, students are required to undertake a 6-8 week project related to rural areas, aligned with the themes of the CSIR-800 program. The aim of this project is to engage with rural communities, understand their challenges, and propose improvements in areas such as energy, education, environment, agriculture, health, food, and water. Students must pass a comprehensive examination designed to assess their overall comprehension of various subjects. This is followed by advanced research leading to a PhD thesis on a specific topic. To date, CSIR-4PI has produced 13 PhD graduates since its inception.

All academic activities related to PhD students, including screening and selection of students in two sessions every year, scheduling of coursework offered by faculty (open to AcSIR students of all CSIR labs), allocation of supervisors, coordination of Doctoral Advisory Committee (DAC) meetings and Comprehensive Examinations, and management of PhD thesis submissions and oral examinations, are overseen by the AcSIR coordinator. The coordinator also maintains records of students' performance in coursework, progress reports of PhD work, and all AcSIR-related information and documents pertaining to doctoral students.

In the academic year 2023-2024, one student joined the PhD (MIS) program in the August 2023 session, and two students joined in the January 2024 session. As of March 2024, there are 16 PhD students on roll. RANI DEVI (Reg. No. 10MP19A45001) completed her PhD PTOC on 18/01/2024. Smarti Purwar (Reg. No. 10MM18A45001) and Kanike Raghavendra Prasad Babu (Reg. No. 20EE18A45002) submitted their PhD theses on 15/12/2023 and 23/01/2024 respectively. Ajay Vijay Bankar (Reg. No. 10PP17J45001), under the guidance of Dr V Rakesh, was awarded PhD degree for his thesis titled Impact of assimilation of multi-source observations in prediction of extreme rainfall events with different data assimilation techniques using WRF model by AcSIR on 27.02.2024.

Sajani Surendran
AcSIR Coordinator, CSIR-4PI

4.2 Doctoral Guidance

- **Anilkumar V**
 1. Tarun Pandey, AcSIR- 20EE22J45001, PhD (Engg.).
 2. Akash Deep Dixit, AcSIR- 10MM23A45002, PhD (MIS).
- **Ashapurna Marndi**
 1. Rashmi K S, AcSIR- 20EE22A45001, PhD (Engg.).
- **Gouda K C**
 1. Rani Devi, AcSIR-10MP19A45001, PhD (PS).
 2. Irranna Gogeri, AcSIR-20EE21A45002, PhD (Engg.).
 3. Swadesh Mohapatra, AcSIR- 10PP24J45002, PhD (PS).
 4. Radhika TV, VTU.
 5. Payoshni Samantray, VTU.
 6. Smrutishree Lenka VTU.
- **Himesh S (Guide), Gouda K C (Co-guide)**
 1. Sanjeeb Kumar Sahoo VTU.
- **Kantha Rao B (Guide) and Patra G K (Co-Guide)**
 1. Kanike Raghavendra Prasad Babu, AcSIR-20EE18A45002, PhD (Engg.)
- **Kantha Rao B (Guide) and Gouda K C (Co-Guide)**
 1. Pankaj Sharma, AcSIR- 10MM24J45001, PhD (MIS).
- **Lakshmikanthan P**
 1. Deepak Singh Baghel, AcSIR- 20EE18J45003, PhD (Engg.).
 2. Manjunatha G S, AcSIR- 20EE22J45002, PhD (Engg.).
- **Mohapatra G N (Guide), Rakesh V (Co-guide)**
 1. Smrati Purwar, AcSIR-10MM18A45001, PhD (MIS).
- **Patra G K**
 1. S Gunasekaran, AcSIR-10MM20A45003, PhD (MIS).
 2. Manmohan Brahma, AcSIR 20EE20A45001, PhD (Engg.).
 3. Anju Sharma, Multi-sensor data fusion strategies and algorithms for health assessment of Mechanical systems (joined in January 2021)
 4. Shranappa V Sajjan, Simulation of dynamic stability derivatives of an aircraft using CFD (joined in January 2023)
- **Rakesh V**
 1. Ajay Vijay Bankar, AcSIR-, PhD (MIS).
 2. Rakhi, AcSIR (10MM23J45001), PhD (MIS).
- **Ramesh K V(Guide), Rakesh V (Co-guide)**
 1. Swetha S, AcSIR-10MM20A45002, PhD (MIS).
- **Sridevi Jade**
 1. Chiranjeevi Vivek Ganapa, AcSIR-20EE16J45001, PhD (Engg.).
 2. Siva Sai Kumar Rajana., KLEF University, Vijayawada.
- **V Senthilkumar**
 1. Shivaprasad, M V, AcSIR, Raja, S., CSIR-NAL (Supervisor) and V. Senthilkumar (Co-Supervisor) from January 2023.
 2. Mutturaj H Medar, AcSIR, Raja, S., CSIR-NAL (Supervisor) and V. Senthilkumar (Co-Supervisor) from January 2023.
 3. Sivaranjani, T, AcSIR, Pavan Kumar, D V T G., CSIR-NAL (Supervisor) Raja, S., CSIR-NAL (Co-Supervisor) and V. Senthilkumar (Co-Supervisor).

4.3 CSIR-Integrated Skill Initiative Programme at CSIR-4PI

The Council of Scientific and Industrial Research (CSIR) launched the CSIR-Integrated Skill Initiative in alignment with the national "Skill India" mission. This initiative aims to enhance the skill sets of students, researchers, and professionals across various scientific domains. CSIR-4PI (Fourth Paradigm Institute) has been an active participant in this programme, offering comprehensive training and development opportunities through three key programmes: Advanced Training Programmes, Industrial Visits, and the Student Programme in Advancement in Knowledge (SPARK).

Advanced Training Programmes

CSIR-4PI conducted two advanced training programmes under the CSIR-Integrated Skill Initiative. The first programme, titled "From Data to Decision Support System: A Data Science Hands-on Workshop," was held from December 11th to 15th, 2023. This workshop trained 27 participants, including undergraduate, postgraduate, and Ph.D. students from various institutes and CSIR laboratories. The workshop focused on equipping trainees with hands-on skills in data science, enabling them to transition from data collection to decision support systems.

The second advanced training programme, "Ocean Science & Modelling: Energy, Environment and Living Resources," took place from January 16th to 20th, 2024. Esteemed speakers from CSIR and other prestigious Indian institutes served as faculty members. Over 25 students participated in this programme, including undergraduate, postgraduate, and Ph.D. students, and professionals from various institutes and universities across India. The training provided in-depth knowledge of ocean science and modelling, addressing critical issues related to energy, the environment, and living resources.

Industrial Visits

As part of the Industrial Visit programme, CSIR-4PI organized two one-day workshops focused on High-Performance Computing (HPC) and its applications. These workshops were attended by students from CMR Institute of Technology, Bangalore; Cambridge Institute of Technology, Bangalore; GSS Institute of Engineering and Technology for Women, Mysore; and Er. Perumal Manimekalai College of Engineering (PMCTECH). A total of 142 students participated in these workshops, gaining valuable insights into recent trends in HPC, cyber security, and earth system sciences.

Overall Impact

Under the CSIR-Integrated Skill Initiative Programme, CSIR-4PI has trained a total of 341 individuals across its advanced training programmes, industrial visits, and SPARK. This comprehensive approach to skill development aligns with the mission of "Skill India," empowering students, researchers, and professionals with the knowledge and skills necessary to excel in their respective fields.

Ashish, Prabhu N & Pavithra N R

4.4 CSIR Jigyasa program at CSIR-4PI

CSIR Jigyasa program, an initiative taken during the Platinum Jubilee year of CSIR under the vision of Honorable PM Narendra Modi for a new India with Scientific Social Responsibility (SSR) for CSIR. The objective of Jigyasa is to extend classroom learning by focusing on well-planned research laboratory-based learning for school students. More details about the program can be found at Jigyasa-CSIR. Under the JIGYASA program, we conduct various science-integrated activities such as: Scientist-Student Interaction Program: Students visit our CSIR-4PI campus, where they are briefed about the R&D work carried out in the lab and are taken on tours of various lab facilities.

Co-curricular Activities: Including doodle art contests, essay writing, drawing competitions, and more. Workshops: Lectures on critical subjects like calculus, physics, and introductions to computer science subjects like AI & ML, along with hands-on sessions. YouTube Webinars: Engaging online sessions covering a variety of scientific topics.

As part of this Initiative, Vismaya Vigyana Summer Training and YouTube webinar series, Doodle Competition, Student-Scientist Interaction, Workshops and field visits are conducted throughout the year. Details are given in the events section 5.10.

Pavithra N R, Ashish & Prabhu N

4.5 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. The Student Programme in Advancement in Knowledge (SPARK) is a dedicated academic initiative designed to foster collaboration between CSIR-4PI scientists and students from various universities and academic institutions. 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. Through SPARK, 147 students completed their internship or thesis work, benefiting from the mentorship and expertise of CSIR-4PI scientists. This initiative strengthens the connection between academia and research, promoting the advancement of knowledge and skills among young scholars.

V Anil Kumar, Ashish, Sajani Surendran and Stella Margeret

M.Tech/BE/MCA student thesis/projects supervised by**• Anil Kumar V**

1. Arun Prasath S, Exploring Payload Similarity and Domain Matches in Telescope Data, M. Sc Data Science, Feb. 2024, PSG College of Technology, Coimbatore.
2. V Sivani, M. Sc Cybersecurity, Application of DL and ML Techniques Towards a Prediction Framework of Telescope Data, Feb. 2024, PSG College of Technology, Coimbatore.

• Ashapurna Marndi

1. Pooja P Synthetic Fingerprint Generation using PrintsGAN
2. Nihaal Anupoju, Differentially Private Hybrid Federated and Centralized Learning with BigGAN: A Comprehensive Framework for Privacy Preserving Generative Adversarial Networks
3. Arun Francis Tellis, Generative AI for Secure Synthetic Image Generation (BTech project)
4. Sivani U Application of DL and ML Techniques towards a prediction Framework of Active Network Telescope Data
5. Arathi Hembram, Ananya P Raj Development of Graphical User Interface for Scientific Applications
6. Lakshmi Rajeev Synthetic Image Generation using ViT-GAN

• Kantha Rao Bhimala

1. K. Bhavitha, Jawaharlal Nehru Technological University, Kakinada
2. P. Nagalakshmi, Jawaharlal Nehru Technological University, Kakinada
3. S. Nagababu, Jawaharlal Nehru Technological University, Kakinada
4. S. Varun Sai Srinivas, Jawaharlal Nehru Technological University, Kakinada

• Rakesh V

1. Fathima Anan, Kerala University of Fisheries and Ocean Studies (KUFOS), Kerala
2. Shahid Anwar, KUFOS, Kerala
3. Anandhu M S Cochin University of Science and Technology, Kerala

• G N Mohapatra

1. Nidhi Santosh Gajankar, Visvesvaraya Technological University

• Gouda K C

1. Aman Prakash, M.Tech., CORAL, IIT-Kharagpur
2. Anitesh Singh, M.Tech., CORAL, IIT-Kharagpur
3. Gurupreet Singh, M.Tech., CORAL, IIT-Kharagpur
4. Jyoti Ranjan Sau, M.Sc., Berhampur University
5. Shankar Das, M.Sc., Berhampur University
6. Shobhana Nayak, M.Sc., Berhampur University
7. Preeti Priyadarshinee, M.Sc., Berhampur University
8. Ramesh Sahu, M.Sc., Berhampur University
9. Debanshu Sekhar Dash, B.E., Hindustan Institution of Technology and Science, Chennai

• Gaurav Melkani & G K Patra

1. Satyajit Sahu, Anomaly Detection of Images using Autoencoder Model IIT Kharagpur, 1st June to 29th July

-
2. Bibhudatta bhanja, Image and Text Based Anomaly Detection in Vehicular Ad-hoc Networks IIT Kharagpur, 8-05-2023 to 30-07-2023
 - **Ashapurna Marndi & G K Patra**
 1. Shivpreet Padhi, Secure Synthetic Face Image Generation Kalinga Institute of Technology, 16th May 2023-28th June 2023
 2. Ekta Mishra, Analysis on Student Knowledge and Proficiency Mapping, Dibrugarh University , 4th Jan 2024 to 2nd Feb 2024
 3. Chaitany Patange, 1/6/2023 to 31/07/2023

4.6 Faculty Participation

1. **Gouda K C**, National Level Symposium on "Futuristic Innovation Technology for Sustainable IT Solutions" on 7th, 8th and 9th of December 2023 (Panelist) Talk: AI for achieving Sustainable Development Goals
2. **Gouda K C**, FDP on Mathematical Foundation on Data Science, BMS College of Engineering, 20th May 2023 Talk: Mathematics for AI/ML
3. **Rakesh V**, "Overview of Atmospheric Modeling" in Pre-Conference Lecture Series 2nd International Conference on Asian Summer Monsoon Anticyclone (ASMA 2023) organized by Department of Physics and Nanotechnology, SRM IST, Kattankulathur, India
4. **G K Patra**, "High Performance Computing and Its Applications" 23rd September 2023, NMIT Bangalore.
5. **G K Patra**, Lecture Series By Industry Experts (LSIE)", CSE Department, MIT Manipal.
 - Introduction to High Performance Computing & Parallel Computer Architecture, 31st July 2023
 - Developing Models on HPC from Scratch Basics; 4th November 2023
 - Panel discussion: Recent Trends in HPC and its Applications



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:

- 5.1 Publications in Journals
- 5.2 Publications in Books/Proceedings
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- 5.4 Participation in Conferences/Workshops/Training Programmes
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- 5.6 Invited Talks
- 5.7 Conference/Workshops/Seminars at CSIR-4PI
- 5.8 In-house seminars/lectures
- 5.9 Visitors at CSIR-4PI
- 5.10 Events at CSIR-4PI

5.1 Publications in Journals

1. Madhvee Kori, V. Anil Kumar, Rajneesh Pachouri, Anurag Jain, and H. N. V. Dutt, Quantitative and qualitative evaluation of TCP target ports through active network telescope, *International Journal of Information Technology*, Springer, Volume 16, pp. 31773191 (2024), <https://doi.org/10.1007/s41870-024-01816-y>
2. Gogeri, Iranna, K. C. Gouda, and S. T. Aruna., Spatio-temporal analysis of air pollution dynamics over Bangalore city during second wave of COVID-19." *Natural Hazards Research* (2023)., <https://doi.org/10.1016/j.nhres.2023.10.002>
3. Gouda, K. C., Nikhilasuma, P., Benke, M., & Agnihotri, G. (2023). Assessment of Rainfall Variability over Karnataka state in India. *Natural Hazards Research*, <https://doi.org/10.1016/j.nhres.2023.08.004>
4. Gouda, K.C., Pernaje, N. & Benke, M. Climate parameter and malaria association in north-east India. *J Parasit Dis* 47, 501512 (2023). <https://doi.org/10.1007/s12639-023-01585-8>
5. Gogeri, I., Gouda, K. C., & ThippaReddy, A. S. (2024). Unravelling Bangalore's air quality during the second wave: Multifaceted analysis of COVID-19 lockdown impact. *Natural Hazards Research*. <https://doi.org/10.1016/j.nhres.2024.01.008>
6. Anju Sharma, G K Patra and V P S Naidu, (2023) Bispectral analysis and information fusion technique for bearing fault classification, *IOP Science, Meas. Sci. Technol.* 35 (2024) 015124 (12pp), DOI10.1088/1361-6501/acffe4, Oct 2023.
7. Kantha Rao, Prakasa Rao, Prasad Babu, and Himesh. Multi-source soil moisture data analytics for efficient water management in agriculture. *Indian Journal of Agronomy*, (XXII Biennial National Symposium Special issue), 2023.
8. Prasad K R, Bhimala K R, Patra G K, Himesh S & 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*, Vol 152, Issue 5, 999-1017, Impact Factor 3.1, <https://link.springer.com/article/10.1007/s00704-023-04436-x>
9. Singhai P, Chakraborty A, Rajendran K & Sajani S (2023) "Why Is The Indian Summer Monsoon In Cfsv2 Hypersensitive To Moisture Exchange With The Pacific Ocean?", *Climate Dynamics*, Vol 61, Issue 9-10, 4515-4531, Impact Factor 4.4, <https://doi.org/10.1007/s00382-023-06815-6>
10. Ipsita P, Rakesh V, Singh R & Mohapatra G N (2023) "Impact Of Different Land Use Data On WRF Model Short Range Forecasts During Pre-Monsoon And Monsoon Seasons In India", *Urban Climate*, Vol 49, 101558, Impact Factor 6.0, <https://doi.org/10.1016/j.uclim.2023.101558>
11. Lenka S, Gouda K C, Devi R & Joseph C M (2023) "Dynamical Influence Of MJO Phases On The Onset Of Indian Monsoon", *Environmental Research Communications*, Vol 5, Issue 6, Impact Factor 2.5, 10.1088/2515-7620/acde3a
12. Ipsita P, Rakesh V & Mohapatra G N (2023) "Role Of OceanAtmosphere Interactions On Contrasting Characteristics Of Two Cyclones Over The Arabian Sea", *Meteorology and Atmospheric Physics*, Vol 135, Issue 5, Article 50, Impact Factor 2.0, <https://doi.org/10.1007/s00703-023-00987-w>
13. Devi R, Gouda K C & Lenka S (2023) "Analysis Of Heat Wave Over Different Physiological Regions In India", *Theoretical and Applied Climatology*, Vol 154, Issue 3-4, 1343-1356, Impact Factor 3.1, <https://doi.org/10.1007/s00704-023-04639-2>

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15. Kakkanattu S P, Mehta S K, Subrahmanyam D B, Rakesh V & Kesarkar A P (2023) "Thermodynamic Structure Of The Atmospheric Boundary Layer Over A Coastal Station In India For Contrasting Sky Conditions During Different Seasons", *Atmospheric Research*, Vol 293, 106915, Impact Factor 4.5, <https://doi.org/10.1016/j.atmosres.2023.106915>
16. Kumar V K, Ramesh K V & Rakesh V (2023) Optimizing LSTM And Bi-LSTM Models For Crop Yield Prediction And Comparison Of Their Performance With Traditional Machine Learning Techniques, *Applied Intelligence*, Vol 53, Issue 6, 28291-28309, Impact Factor 3.9, <https://doi.org/10.1007/s10489-023-05005-5>
17. Neethu C & Ramesh K V (2023) Projected Changes In Heat Wave Characteristics Over India, *Climatic Change*, Vol 176, Issue 10, Article 144, Impact Factor 5.4, <https://doi.org/10.1007/s10584-023-03618-w>
18. Senthilkumar V (2023) Fractional Derivative Analysis Of Wave Propagation Studies Using Eringens Nonlocal Model With Elastic Medium Support, *Journal of Vibration Engineering & Technologies*, Vol 11, Issue 4, Impact Factor 2.2, <https://doi.org/10.1007/s42417-022-00775-7>
19. Shrungeshwara T S, Narukula B, Jade S, Ghavri S, Vivek C G & Parvez I A (2023) Implications Of Seismic And GNSS Strain Rates In Himachal, Kashmir And Ladakh, *Scientific Reports*, Vol 13, Issue 1, Article 21652, Impact Factor 5.5, <https://doi.org/10.1038/s41598-023-48997-3>
20. Ramesh K V, Rakesh V & Krishnappa V G (2023) "Improved Learning By Using A Modified Activation Function Of A Convolutional Neural Network In Multi-Spectral Image Classification", *Machine Learning with Applications*, Vol 14, Impact Factor 5.8, <https://doi.org/10.1016/j.mlwa.2023.100502>
21. Gogeri I, Gouda K C & Sumathy T (2023) Modeling And Forecasting Atmospheric Carbon Dioxide Concentrations At Bengaluru City In India, *Stochastic Environmental Research and Risk Assessment*, Vol 38, Issue 5, 1297-1312, Impact Factor 3.6, <https://doi.org/10.1007/s00477-023-02629-4>
22. Varghese S J, Surendran S, Rajendran K, Ghosh S, Kitoh A & Ashok K (2024) "Precipitation Scaling In Extreme Rainfall Events And The Implications For Future Indian Monsoon: Analysis Of High-Resolution Global Climate Model Simulations", *Geophysical Research Letters*, Vol 51, issue 1, Impact Factor 4.9, <https://doi.org/10.1029/2023GL105680>
23. Singh P, Anand A, Rana S, Kumar A, Kumar S, Goel P, Gouda K C & Singh H (2024) "Impact Of COVID-19 Vaccination: A Global Perspective", *Frontiers in Public Health*, Vol 11, Impact Factor 5.2, <https://doi.org/10.3389/fpubh.2023.1272961>
24. Rajana S S K, Panda S K, Jade S, Vivek C G, Upadhayaya A K, Bhardwaj A, Jorphail S & Seemala G K (2024) "Impact of Two Severe Geomagnetic Storms On the Ionosphere Over Indian Longitude Sector During March-April 2023, *As-trophysics and Space Science*, Vol 369, Article No 3, Impact Factor 1.6, <https://doi.org/10.1007/s10509-024-04268-9>
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5.2 Publications in Books/Proceedings

1. Bhageerath, K.E., Marndi, A., Harini, D.N.D. (2024). Performance Assessment of Gaussian Filter-Based Image Fusion Algorithm. In: Kumar, S., K., B., Kim, J.H., Bansal, J.C. (eds) Fourth Congress on Intelligent Systems. CIS 2023. Lecture Notes in Networks and Systems, vol 868. Springer, Singapore. https://doi.org/10.1007/978-981-99-9037-5_4
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3. Sithartha Muthu Vijayan M, and Dhanya Thomas, (2023) Coseismic Ionospheric Disturbances Controlled by Rupture Dynamics of 6th February 2023 Turkey-Syria Doublet Earthquakes, MedGU Annual Meeting, Oral presentation, 26th - 30th November 2023, Istanbul, Turkey.
4. Dhanya Thomas and Sithartha Muthu Vijayan M (2023) Challenges and effectiveness of imaging the earthquake source region using first arrivals of coseismic iono-

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 10. Lenka S, Gouda KC, Devi R, Joseph CM. Impact of Pre-monsoon Tropical Cyclones on the Onset Dynamics of Indian Summer Monsoon. AGU23, A53J-2375, San Francisco, CA, 11-15 Dec 2023
 11. Samantray, P & Gouda, K C, Comparative Analysis of Large Scale and Local Scale Dynamics Associated with Extreme Rainfall Events in the Indian Himalayan States. AGU23, A31G-2459, San Francisco, CA, 11-15 Dec 2023
 12. Ghosh, S., Lata, R., & Gouda, K. C. Assessing the Correlation of Anomalies and Temporal Variation of Major Climatic Parameters with Extreme Hydro-Meteorological Events in Beas Valley, Himachal Pradesh, AGU23, NH31D-0794, San Francisco, CA, 11-15 Dec 2023
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 21. Shobhana Nayak, KC Gouda, Sankar Das and Jyoti Ranjan Sau, SST dynamics for analyzing tropical cyclones in Bay of Bengal, Tropmet-2023, National Symposium on Changing Dynamics of Arid Region and Impact on Weather and Climate over Indian Subcontinent, Birla Institute of Scientific Research, Statue Circle, Jaipur, Rajasthan, 22-24 Nov 2023.

5.3 Presentations in Conferences/Workshops/Seminars

1. V Anil Kumar (India), Joshua (Saint Lucia), Jose Carlos (Philippines), Esteban (Colombia), Suleiman (Somaliland), Nur (Indonesia), How to address the complex security problems in the Cyberspace, White Team presentation on Information Security Policy Workshop of Taiwan International Development and Cooperation Fund, Taipei, Taiwan.
2. Rameshan Kallummal, Pacific Decadal Oscillation: Low-frequency Imprints of Amplitude modulated Seasonal Cycles, AGU Fall Meeting 2023 (25-01-2024), <https://agu.confex.com/agu/fm23/meetingapp.cgi/Paper/1257955>
3. Chiranjeevi G Vivek, Noise analysis and velocity uncertainties of Multi-GNSS time series, 2023 IEEE India Geoscience and Remote Sensing Symposium (InGARSS) at IIT Bangalore, India, 10-13 December, 2023.
4. Sithartha Muthu Vijayan M, and Dhanya Thomas, (2023) Coseismic Ionospheric Disturbances Controlled by Rupture Dynamics of 6th February 2023 Turkey-Syria Doublet Earthquakes, MedGU Annual Meeting, Oral presentation, 26th - 30th November 2023, Istanbul, Turkey
5. P. Singhai, A. Chakraborty, K. Jana, K. Rajendran, Sajani Surendran, " Suppressing non-ENSO forcing with ensemble mean", 104th AMS Annual Meeting, Joint

Session-J16B, Baltimore, MD, USA, <https://ams.confex.com/ams/104ANNUAL/meetingapp.cgi/Paper/433755>, 28 January – 1 February 2024.

6. Medar M H, Raja S and Senthilkumar V, Mechanical Characterization of Glass Fibre Shape Memory Polymer (GFSMP) Composites, ISAMPE National Conference on Composites: INCCOM 18, 08-09 February 2024.
7. Senthilkumar V, Kumar J and Singh R K, Modelling of Pentagraphene Nanostructures, 2nd Conference on Conjectures to Consilience through Computation (Virtual Conference), Book of Abstracts, Page No: 14, 30th September 2023.
8. Senthilkumar V, Indigenous Efforts in Modelling and Simulation in Engineering Science, Science Outreach and Road Show on the occasion of CSIR-4PIs OWOL celebration at Vemana Institute of Technology, Bangalore, 14th July 2023.
9. Sridevi Jade, Keynote presentation “Open Science Practices Relevant to Earth Sciences & Agri-Tech”, “International Conference on Open and FAIR Data Ecosystem Principles, Policies, and Platforms”, India International Centre, New Delhi, September 11-13, 2023.
10. Sridevi Jade, CSIR League for AI based Industrial Manifestation, CSIR Directors Conference, 2 December 2023, Puri, Orissa.
11. Sridevi Jade, Supercomputing and Scientific Cloud Infrastructure of CSIR, CSIR Directors Conference, 2 December 2023, Puri, Orissa.
12. Lenka, Smrutishree, Krushna Chandra Gouda, Rani Devi, and C. M. Joseph. Exploring the Synergy between MJO in Shapping Pre-Monsoon Heatwaves and Monsoon Onset, National Symposium on Heat wave, IITM, Pune, 18-19 March 2024.

5.4 Participation in Conferences/Workshops/Training Programmes

• Anil Kumar V

1. V Anil Kumar, Information Security Policy Workshop of Taiwan International Development and Cooperation Fund, Taipei, Taiwan, May 24- June 06 2023.
2. Rashmi KS, Ashapura Marndi, “Enhancing Breast Cancer Diagnosis: A Comprehensive Study of Deep Learning Techniques”, 14th National Women’s Science Congress, 16-17 Dec 2023, Tumkur University, Tumkur.

• Ashish

1. Participated in Conclave-cum-Workshop for CSIR-Integrated Skill Initiative Programme Organized by CSIR-HRDC at HRDC, Ghaziabad from 16th – 17th February 2023.
2. Represented CSIR-4PI and showcase CSIR-4PI activities at prestigious CFD event ACFD 2023 from 30th October to 2nd November 2023.
3. Represented CSIR-4PI in the exhibition on the occasion of CSIR Foundation Day, showcasing our Institute’s decadal achievement from 26 – 27 September 2023 at Bharat Mantap, Delhi.

• Chiranjeevi G Vivek

1. 2023 IEEE India Geoscience and Remote Sensing Symposium (InGARSS) at IIIT Bangalore, India, 10-13 December, 2023.
2. National Symposium on Earthquake, Landslide and Glacial Hazards and 7th annual convention on Advances in Earthquake Science (AES-2023) jointly organized by Indian Society of Earthquake Science (ISES) & University of

Kashmir and sponsored by Ministry of Earth Science & CSIR-4PI during 25-27, May 2023.

3. 1-day workshop on NavIC: Development, Scope and Applications, organized by Indian Radio Science Society (InRaSS), sponsored by Commission-C, International Union of Radio Science (URSI), 25 January, 2024 (Virtual).

- **G K Patra**

1. “Securing Sustainable Mobility: Safeguarding the Future of Cities with VANET Security” at Indo-German joint scientific workshop on, “Computational Intelligence for Sustainable Energy and Mobility Systems (CI-SEMS): Advancing Efficiency and Environmental Impact” at CSIR-CSIO, Chandigarh (India), 21-23 February 2024.
2. “Data Analytics-1 Linear regression, Time series analysis, and model building”, From data to decision support system: a data science hands-on workshop, 11-15, December 2023, Skill Development Program, CSIR-4PI.
3. “Data Driven Approaches to Understanding Ocean Processes”, CSIR-4PI Skill Development program on Ocean Science and Modelling: Energy, Environment and Living resources 16-20 January 2024

- **K Rajendran**

1. 104th AMS Annual Meeting, Joint Session-J16B, Baltimore, MD, USA

- **Sridevi Jade**

1. National Symposium on Earthquake, Landslide and Glacial Hazards and 7th annual convention on Advances in Earthquake Science (AES-2023) jointly organized by Indian Society of Earthquake Science (ISES) & University of Kashmir and sponsored by Ministry of Earth Science & CSIR-4PI during 25-27, May 2023.

- **Sithartha Muthu Vijayan M**

1. MedGU23 Mediterranean Geosciences Union Annual Meeting, 26th - 30th November 2023, Istanbul, Turkey (online)
2. AGU23 American Geophysical Union Fall Meeting, 11-15 December 2023, San Francisco, CA, USA (online)

- **Sajani Surendran**

1. 104th AMS Annual Meeting, Joint Session-J16B, Baltimore, MD, USA

5.5 Guest Lectures

- **Gouda K C**

- Delivered a talk "Ethics in R&D" in c/w observance of Vigilance Awareness Week jointly by CSIR-NAL and CSIR-4PI at CSIR NAL, Bangalore on 31 Oct 2023.
- Guest lecture on Mathematics in Science and Technology and Club activity "Math Mastery", MVJ College of Engineering, Bangalore, 27th Nov 2023.
- 14th Asian Computational Fluid Dynamics Conference (ACFD2023) held at HAL Management Academy, Bangalore, 30th October-02nd November 2023.

- **Senthilkumar V**

- Participated in 14th Asian Computational Fluid Dynamics Conference (ACFD2023) held at HAL Management Academy, Bangalore, 30th October-02nd Novem-

ber 2023.

5.6 Invited Talks

- **Anil Kumar V**
 - “Packets, Protocols and Attacks in Cyberspace”, ACM-India Winter School on Cryptography and Cybersecurity, VIT Vellore, 27 Nov to 7 Dec. 2023.
 - “Packets, Protocols and Attacks in Cyberspace”, ACM-India Winter School on Cryptography and Cybersecurity, VIT Vellore, 27 Nov to 7 Dec. 2023.
 - “Intellectual Property Rights: An Introduction to College Students”, Dayanand Sagar University, Bangalore, July 13, 2023.
 - “Cybersecurity Opportunities: An academia Industry Perspective”, Academia, Industry R&D Connect, 13 July, 2023.
- **Chiranjeevi G Vivek**
 - Talk on Global Navigation Satellite Systems and its applications in Earth Science, organized by Electronics & Communication Engineering Dept., KL university, Vijayawada in association with IEEE MTT-S & communication society, 01 December, 2023.
- **G K Patra**
 - Mathematics in Emerging Technologies National Mathematics Day Celebration, School of Applied Sciences, Department of Mathematics, REVA University, 20th December 2023.
 - VANET to FANET: Convergence of IT and Mobility for Sustainable Development, National Level Symposium on "Futuristic Innovation Technology for Sustainable IT Solutions" 7-9, December 2023. Dayananda Sagar College of Engineering.
 - Connecting the Road to Sustainability: Harnessing VANET for a Greener Future, International Conference on Recent Advances in Information Technology for Sustainable Development, 6 - 7 November 2023, MIT, Manipal.
 - "Cryptography Unravelling: From Enigma to Everyday", Global encryption day celebrations organized by Internet Society Bengaluru section in collaboration with IEEE COMSOC, 21st October 2023.
 - Artificial Intelligence in Food Technologies, the OWOL of CFTRI, Mysore on 3-7 July 2023.
 - AI and Its Applications to COVID Related Studies, Workshop on Mathematical Foundation on Data Science, BMS College of Engineering, 15-20 May 2023.
- **K Rajendran**
 - Invited talk on "Monsoon Teleconnection in CFSv2, Brainstorming Workshop of Monsoon Mission-II, NIAS, Bengaluru, 25 January 2024.
 - Invited talk on “Unravelling Climate Change through Numerical Modelling”, College of Engineering, Thiruvananthapuram, 5 February 2024.
 - Invited talk on “Modelling of Climate Change Projection and its Applications”, College of Engineering, Thiruvananthapuram, 6 February 2024.
- **Sajani Surendran**
 - Invited talk on “Pertinence of interacting aerosols in monsoon breaks”, Brain-

storming Workshop of Monsoon Mission-II, NIAS, Bengaluru, 24 January 2024.

- **Rakesh, V**

- Invited talk “Modelling Rainfall extremes and Floods during Indian summer monsoon” in 2nd International Conference on Asian Summer Monsoon Anticyclone (ASMA 2023) organized by Department of Physics and Nanotechnology, SRM IST, Kattankulathur, India
- Key note Talk on “Weather and Climate Informatics for Multi-sector Application” in the conference Modelling Resilience: Mathematical & Data Science Applications in Multi-sector Ecosystems organized by Department of Mathematics & Information Technology, Sri Krishna Arts & Science college, Coimbatore

- **G. N. Mohapatra**

- Invited talk on Recent trend of data science in modern day applications", CM-RIT Bengaluru, 9th December 2023 (Saturday).
- Invited Speaker for National Symposium On "Futuristic Innovation Technology for Sustainable IT Solutions" 7th-9th December 2023, DSCE, Bangalore
- Panel discussion on 7th December, 2023, from 2.30Pm to 3.30Pm with the theme of the panel discussion being "Generative AI Dynamics: Shaping the Future of Intelligent Generations" Dayananda Sagar College of Engineering Shavige Malleshwara Hills, Kumaraswamy Layout, Bengaluru-560078
- NMHS project meeting, field work and meeting at Kullu and Palampur from 26th to 30th Oct, 2023
- Presented a talk on Framework for integrated flood Management and modeling over Bangalore city in one day workshop on flooding in cities warning and dissemination Venue: Golden Jubilee Hall, Civil Engineering Department, IISc Bangalore on 9th October, 2023
- Delivered a talk on Applications of Numerical Methods in Engineering Department of Mathematics, MVJ College of Engineering (An Autonomous Institute), Whitefield, Bangalore, Karnataka.on 20th July 2023.

- **Gouda K C**

- Delivered invited talk and chaired a session in the international conference on Mountain Ecosystem Processes and sustainable livelihood, scheduled to be held during 5-7 March 2024 in Himachal Regional Centre-GBPNIHE, Kullu, H.P.
- Delivered invited talk and panelist in the National conference on Blue Economy: Navigating Marine Ecosystem Value Chain on 19-20 February 2024 at KIIT, Bhubaneswar organized by KIIT, ILS, IMMT, NIO and BCKIC.
- Delivered invited talk in the National Seminar on Artificial Intelligence (AI) and Climate - Role of AI for Smart Sustainable Future on January 20th 2024 at CHRIST Deemed to be university, Bangalore.
- Delivered invited talk and chaired a session in the National Symposium on Changing Dynamics of Arid Region and Impact on Weather and Climate over Indian Subcontinent (TROPMET-2023) held at Birla Institute of Scientific Research, Statue Circle, Jaipur, Rajasthan during 22-24 Nov 2023.
- Delivered invited talk in the the Brainstorming Meeting on Monsoon Mission

of MoES at NIAS Bengaluru, 24-25 Jan 2024.

- **Kantha Rao**
 - Kantha Rao, CSIR-4PI: CSIR-Knowledge products, Vemana Institute of Technology, OWOL (One Week One Lab) program Bangalore, 10-15 July, 2023.
 - Kantha Rao, CSIR-4PI: The Role of Mathematics in Artificial Intelligence and Big Data, Department of Mathematics, MVJ College of Engineering, Bangalore, 19th Feb, 2024.
- **Sithartha Muthu Vijayan M**
 - Indigenous Technologies for Viksit Bharat: Towards Liberating People through Science & Technology, Keynote Address, National Science day-2024, Jyoti Nivas College, 26th February, 2024
 - Down to the Earth, Keynote Address, National Science day 2024, St. Francis Xavier Girls' High School, Frazer Town, Bangalore, 01st March 2024
- **Sridevi Jade**
 - Invited talk on “GPS deformation and Earthquakes in Himalaya”, National Symposium on Earthquake, Landslide and Glacial Hazards and 7th annual convention on “Advances in Earthquake Science (AES-2023)” jointly organized by Indian Society of Earthquake Science (ISES) & University of Kashmir and sponsored by Ministry of Earth Science & CSIR-4PI during 25-27, May 2023.
 - Invited talk on AI application in Food Research and technologies, followed by Panel discussion, 7 July 2023. One Week One Lab (OWOL) event, CSIR-CFTRI, Mysore.
 - Invited talk on “CSIR AI Initiative for Industry”, MAFAT x CSIR Meeting: AI, Semi-Conductors, Chip Design, Manufacturing, Lasers, Automation of Processes, 4 September 2023.
 - Valedictory talk “Data Science and Super Computing at CSIR-4PI” Asian Computational Fluid Dynamics Conference (ACFD-2023), 2 November 2023, Bangalore
 - Invited talk, “AI-based tools and software to monitor and map the skills and competency of school students”, Brain Storming Session, 9 November 2023, Jigyasa Chintan Shivir, INSA, New Delhi.
 - Foundation Day Talk, “Importance of Data + Science”, 10 Feb 2024, CSIR-CBRI Foundation Day, Roorkee, Uttarakhand.
 - Invited Talk, “Responsibilities and Challenges of Science Leaders”, Panel discussion on Visionary leadership, 23 February 2024, Bangalore.
 - Womans Day Talk, “Paradigms of Science”, Chief Guest, International Womans Day, 11 March 2024, CSIR-CGCRI, Kolkata

5.7 Conference/Workshops/Seminars at CSIR-4PI

- **Ashapura Marndi**
 - Delivered two lectures and hands-on sessions in From Data to Decision Support System: A Data Science Hands on workshop under skill Development Programme of CSIR-4PI.
- **Ashish**

- A 5-day workshop was organized titled " From Data to Decision Support System: A Data Science Hands-on Workshop from 10h - 15th December 2023 as a part of Skill India, a flagship GOI programme.
- A 5-day workshop was organized titled " Ocean Science and Modelling: Energy, Environment and Living Resources from 16th - 20th January 2024 as a part of Skill India, a flagship GOI programme.
- **Sajani Surendran**
 - Hands-on Training Sessions on “Climate Modeling and Climate Change” under the Jigyasa Winter Workshop at CSIR-4PI on 19 December 2023.
 - Hands-on Training Sessions on “Climate Modeling” under the Jigyasa Vismaya Vigyana Summer Training at CSIR-4PI on 18 April 2023.
- **Gouda K C**
 - Organized the “ACADEMIA, INDUSTRY R&D CONNECT” event as part of the ONE WEEK ONE LAB program of CSIR at CSIR-4PI in 13th July 2023. About 200 participants participated and the event was a huge success one.
 - Organized the “Science Outreach and Roadshow” at Dayananda Sagar College of Engineering and Vemana Institute of Technology, Bangalore as part of the ONE WEEK ONE LAB program of CSIR at CSIR-4PI in 14th July 2023. About 200 participants participated and the event was a huge success one.
 - Organized a conference as part of NMHS (Himalayan mission) project work, along with capacity building training workshop and meeting different parts in Kullu region in Himachal Pradesh during 27-30 Oct 2023

5.8 In-house seminars/lectures

- **Sajani Surendran**, Lecture on weather and Climate Forecasting: Approaches of the thinkers versus the tinkerers at CSIR-4PI on 13 March 2024.
- **Parvez I A** Lets talk about Earth and Earthquakes , CSIR 4PI Jigyasa: Vismaya Vigyana Summer Training 2023 on April 17, 2023.
- **Parvez I A** Broadband Seismology and Earthquake Hazard Assessment, One Week One Lab Academia, Industry R & D Connect, July 13, 2023

5.9 Visitors at CSIR-4PI

- Prof. Samir K. Brahmachari, Former DG CSIR, New Delhi, 19 May 2023.
- Dr. N Kalaiselvi, DG CSIR and Secretary, DSIR, New Delhi, 21 June 2023.
- Dr. Manoj Rajan, IFS, Commissioner KSDMA, Director, KSNDMC, and Special Secretary to Government of Karnataka (Food processing) Bangalore, 21 June 2023.
- Dr. G Narahari Sastry, Director, NEIST, Jorhat, 11 July 2023.
- Ms Sireesha Sangha, AMD, Bangalore, 11 July 2023.
- Raghesh Aloor, AMD, Bangalore, 11 July 2023.
- Mr. Manmohan Brahma, AMD, Bangalore, 11 July 2023.
- Dr V S Prasad, Head, MoES-NCMRWF, Noida, 13 July 2023.
- Prof R V Ravikrishna, IISc., Bangalore, 13 July 2023.
- Dr Manish Modani, NVIDIA, Pune, 13 July 2023.
- Prof D S Rao, CSIR-IMMT & Dean, AcSIR, Bhubaneswar, 13 July 2023.

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- Dr V S Prasad, NCMRWF, Noida, 14th July, 2023
 - Prof R V Ravi Krishna, IISc, Bangalore, 14th July, 2023
 - Prof D S Rao, IMMT-AcSIR, Bhubneswar, 14th July, 2023
 - Prof Shrikantha Rao, NIT-K, Suratkal, 14th July, 2023
 - Dr Ashish Routray, NCMRWF, Noida, 14th July, 2023
 - Dr. Pruthviraj U, NIT-K, Suratkal, 14th July, 2023
 - Dr Dilip Kumar Jha, NIOT, Chennai, 14th July, 2023
 - Dr Govindan Kutty, ISST-ISRO, Trivandrum, 14th July, 2023
 - Dr Kishore Natte, IIT-Hyd, Hyderabad, 14th July, 2023
 - Dr Somashekara M A, IIT-Dharwad, Dharwad, 14th July, 2023
 - Dr Uma Shankar Panda, NCCR, Chennai, 14th July, 2023
 - Dr Santhosh R, IIT-BHU, Banaras, 14th July, 2023
 - Dr Suresh S, TNAU, Coimbatore, 14th July, 2023
 - Dr Swarna Priya, TNAU, Coimbatore, 14th July, 2023
 - Dr. Manish Modani, NVIDIA, Pune, 14th July, 2023
 - Shri. Naren Nayak, Armtronix, Hubli, 14th July, 2023
 - Shri. Pavan Kumar Hugar, Armtronix, Hubli, 14th July, 2023
 - Shri. Bhavesh Jangir, Radio2pir, Ahmedabad, 14th July, 2023
 - Shri. Mohit Bebart, Research Realm, Noida, 14th July, 2023
 - Shri. Deepak Murugan, Cropin, Bangalore, 14th July, 2023
 - Shri. Jeetendra, Cropin, Bangalore, 14th July, 2023
 - Shri. Lingaraj Patnaik, Ranjita Encons, Bangalore, 14th July, 2023
 - Shri. Udayabhanu Das, Medvise Futurekare, Bangalore, 14th July, 2023
 - Shri. Barada P Pattnaik, Medvise Futurekare, Bangalore, 14th July, 2023
 - Shri, Ganesh P Kumble, MoI, Bangalore, 14th July, 2023
 - Shri. Bhardwaj, MoI, Bangalore, 14th July, 2023
 - Shri. Debashish Patra, Cognigant, Bangalore, 14th July, 2023
 - Dr Geeta Agnihotri, IMD, Bangalore, 14th July, 2023
 - Dr Aruna S T , NAL, Bangalore, 14th July, 2023
 - Shri. Karthikeyan T, NAL, Bangalore, 14th July, 2023
 - Prof Suma, DSCE, Bangalore, 14th July, 2023
 - Mr. M N Guruvenkatesh, DSCE, Bangalore, 14th July, 2023
 - Dr C M Joseph, DSCE, Bangalore, 14th July, 2023
 - Dr Chandrika M, DSCE, Bangalore, 14th July, 2023
 - Dr Radhika T V, DSCE, Bangalore, 14th July, 2023
 - Dr Pandurangappa, RNSIT, Bangalore, 14th July, 2023
 - Dr Narasimha Murty, BIT, Bangalore, 14th July, 2023
 - Prof Nagaraj K, Bangalore Uni., Bangalore, 14th July, 2023
 - Dr Dodmani Shashidhar, CARI, Min of AyUSH, Bangalore, 14th July, 2023
 - Prof Vijayasimha Reddy. B. G, Vemna Inst of Technology, Bangalore, 14th July, 2023
 - Prof Suresh M, Vemna Inst of Technology, Bangalore, 14th July, 2023
 - Dr. Annapurni Subramaniam, Director, Indian Institute of Astrophysics, Bangalore on 15th July, 2023
 - Dr. Purnima Rupal, Head, DGED, CSIR-HQ on 15th July, 2023
 - Shri. Mahendra Kumar Gupta, Joint Secretary (Admin.), CSIR, New Delhi, 15 July

2023

- Dr. Mahendra P. Darokar, Chief Scientist, CSIR-HQ, New Delhi, 15 July 2023.
- Prof. K. K. Aggarwal, Former Chairman, National Board of Accreditation, 15 July 2023.
- Dr. Shanmuga Sundaram, Sr. Gen. Manager R&D, EID Parry, 28th July, 2023.
- Dr A R Upadhyaya, Former Head, CSIR-4PI and Former Director, CSIR-NAL, Bangalore, 2 August 2023.
- Dr Avinash, Director, CSIR-AMPRI, Bhopal, 2 August 2023.
- Prof P Seshu, IIT-Bombay & Former Head CSIR-4PI, Bangalore, on 8 September 2023
- Dr. Alok Kumar Srivastava, Associate Director, URSC, Bangalore, 22 September 2023.
- Mrs. Jaya Jagadish, AMD, Bangalore, 3 October 2023.
- Shri. Bhasker Murthy, Joint Secretary Vanvasi Kalyanna, 23 November 2023.
- Dr. Ram Chandra Rao, Vice Chairman, VIBHA, Bangalore, 18 December 2023.
- Dr. V Shubha, Former Distinguished Scientist and member of Internal Complaints Committee (ICC), CSIR-NAL, Bangalore, 7 December 2023.
- Prof. Arvind Kumar Mishra, Director, CSIR-CIMFR, Dhanbad, 10th January, 2024
- Dr. Abhisek Chatterjee, Indian National Centre for Ocean Information Services (INCOIS), Hyderabad ,16 January 2024
- Dr. Sarma VVSS, National Institute of Oceanography (CSIR-NIO) Panaji, Goa, 18 January 2024.
- Dr. Neeraj Agarwal, Space Applications Centre Jodhpur Tekra, Ambawadi Vistar Ahmedabad, 19 January 2024.
- Dr. Debasis Sengupta, Indian Institute of Science (IISC), Bangalore, 20 January 2024
- Dr. R. Krishnan, Indian Institute of Tropical Meteorology (IITM) Pune, 20 January 2024
- Dr. Isha Garg, MD, Adjunct Professor of Pathology Former Prof. & Head - Dept. of Pathology, St. John's Medical College, Bangalore & Digital Vision Fellow (2006-07)- Stanford University, 6th February, 2024.
- Dr. S Vidyadhara, Chairman & HOD - Spine Surgery, Consultant Robotic Spine Surgeon, Manipal Hospital, Old Airport Road, Bangalore, 26th Feb 2024.
- Dr Madhava Pai, Associate Professor, Department of Orthopedics, Manipal Hospital, , 26th Feb 2024.
- Dr Mitesh Shetty, HOD of Dept of Genetics, Manipal Hospital, Old Airport Road, Bangalore, 26th Feb 2024.
- Sh. Roop Kishor, Chief Vigilance Officer, CSIR on 29th February 2024.
- Dr. Vinay K. Nandicoori, Director, CSIR-Centre for Cellular and Molecular Biology, 5th March 2024.
- Dr. Anjan Ray, Former Director, CSIR-Indian Institute of Petroleum on 6th March 2024.
- Dr. Shantanu Sarkar, Director, Uttarakhand Landslide Mitigation & Management Center Former Chief Scientist at CSIR- Central Building Research Institute, Roorkee, India on 13th March 2024.
- Dr. (Ms.) Jyoti Yadav, Head, CSIR-RAB on 13th March 2024

5.10 Events at CSIR-4PI

Vismaya Vigyana Summer Training

CSIR-4PI organized "Vismaya Vigyana Summer Training" from April 17-22, 2023. Seventeen students participated, gaining exposure to High Performance Computing, Climate Modeling, Seismology, GPS, GHG measurements, and energy literacy training from Energy Swaraj Foundation.



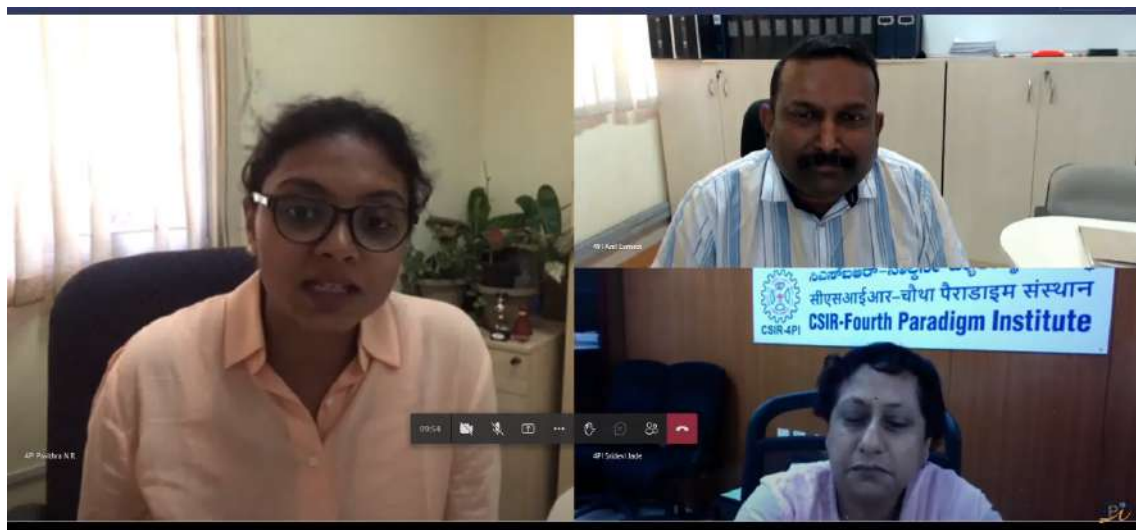
Vismaya Vigyana You-Tube Webinar Series On "Big Data Seismology"

CSIR-4PI also organized VISMAYA VIGYANA YOU-TUBE WEBINAR SERIES on "BIG DATA SEISMOLOGY" by Dr. Anil Earnest on 13th, 20th & 27th April 2023.

Day 01: <https://www.youtube.com/watch?v=87AiW>

Day 02: <https://www.youtube.com/watch?v=zfTgK>

Day 03: <https://www.youtube.com/watch?v=QyuB31M-asg>



CSIR-4PI Jigyasa: Moda Bittaney Ondu Vyagnika Prayoga

CSIR-4PI JIGYASA presents Vismaya Vigyana YOU-TUBE webinars: "Moda Bittaney Ondu Vyagnika Prayoga" (cloud seeding) webinar on 3-4, May 2023.



CSIR-4PI Logo Launch event

Dr. Kalaiselvi N, Director General, CSIR, unveiled the new logo of CSIR-4PI in virtual mode, while Dr. Sridevi Jade, Head of CSIR-4PI, launched the physical mode logo - on May 8, 2023.



Dr B R Ambedkar's Birth Anniversary

CSIR-4PI and CSIR-NAL jointly celebrated Dr. B R Ambedkar's Birth Anniversary at S R Valluri Auditorium, NAL Campus on June 6, 2023



Inauguration of AcSIR Complex

Independent AcSIR complex was inaugurated at CSIR-4PI on 15th June 2023 by Dr Sridevi Jade, Head CSIR-4PI.



One Week One Lab - Preliminary Press Meet

Preliminary Press Meet was held at CSIR-4PI regarding One Week One Lab curtain raiser program, on 19th June 2023.



Curtain raiser event for “One Week One Lab” (OWOL)

Inauguration of Curtain raiser event for One Week One Lab & CSIR-4PI video was released by Dr. N. Kalaiselvi, DG-CSIR and Dr. Manoj Rajan, Commissioner, KSDMA, on 21st June 2023.



Inauguration of CSIR CHAMP HPC facility on 21st June 2023

One Week One Lab (OWOL)

On 10 July 2023, CSIR Fourth Paradigm Institute (CSIR-4PI), Bangalore launched its One Week One Lab (OWOL) campaign. Dr. Sridevi Jade, Head, CSIR 4PI, welcomed attendees, including Chief Guest Dr. K S Yajnik, Founder Head, and Prof. Annapurni Subramaniam, Director of Indian Institute of Astrophysics. Dr. K S Yajnik Conference Hall was inaugurated along with the release of the OWOL video, followed by Dr. Parvez outlining the week's activities.



OWOL - Day 1, (July 10, 2023)

Following the inauguration, school children from three schools engaged in the “Scientist-Student Connect” on the first day. Dr. V Mudkavi introduced them to AI, while Mr. Chiranjeevi Vivek discussed GNSS applications in earth sciences. The children toured Cybersecurity test bed, CHAMP facility for High-Performance Computing, and witnessed Greenhouse Gases data acquisition. The day closed with a keynote by Dr. Narahari Shastry, Director of CSIR NEIST, Jorhat, marking an enriching start to the event.



OWOL - Day 2, (July 11, 2023)

On 11 July 2023, the second day, Dr. Parvez, Chief Scientist, CSIR-4PI, inaugurated the "College Youth Interaction". Dr. Narahari Shastry, Director, CSIR-NEIST, Jorhat, delivered an inspiring lecture on the future role of students in Indian technology. Dr. Jade, Head, CSIR-4PI, emphasized the authenticity of social media data. The event featured students from CMRIT, Cambridge Institute of Technology from Bengaluru and GSSS Institute of Engineering and Technology for Women, Mysuru, and showcased CSIR-4PI's OWOL video and High-Performance Computing initiatives. Mr. Manmohan Brahma and his team from AMD India Pvt Ltd conducted a workshop featuring Mr. Raghes Aloor on Compiler Optimization with AOCC and Ms. Sireesha Sanga on AMD's CPU libraries. Dr. Anilkumar V discussed Intellectual Property Rights. Students explored the CHAMP facility, Cybersecurity R&D Lab, and witnessed a Greenhouse Gases data demo. The event concluded with a keynote by Dr. Parvez, followed by students from various colleges sharing their event experiences.



OWOL - Day 3, (July 12, 2023)

On July 12, 2023, third day, OWOL campaign took place at Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Yelahanka, Bengaluru. Dr. Jade chaired the session, welcoming attendees, including Shri Karee Gowda, IAS, Co-Chair Director of KSNDMC, and Dr. Sridevi Annapurna Singh, Director, CFTRI, Mysore, as Chief Guest. The day focused on engaging stakeholders from Karnataka State, featuring technical presentations by Dr. V Rakesh and Dr. K V Ramesh on CSIR 4PI's R&D activities relevant to Karnataka. KSNDMC presented areas for potential research collaborations, followed by presentations from experts in government agencies and academia. Afternoon sessions included theme-based round table discussions on topics like natural disaster forecasting, hydrology, geospatial crop monitoring, and smart agro-technologies. The meeting concluded with recommendations, identification of new collaboration areas, and the formulation of MoUs to enhance scientific partnerships and research initiatives in the region.

**OWOL - Day 4, (July 13, 2023)**

On July 13, 2023, the event aimed to enhance collaboration between Industry, Academia, and R&D. Dr. V S Prasad from MoES inaugurated the event, with Prof. R V Ravikrishna delivering a keynote on fostering Industry-Academia connections. Dr. Sridevi Jade emphasized collaborations importance, while Dr. K C Gouda outlined the day's program. Dr. Manish Modani discussed modern computing applications, and MoUs were signed between CSIR 4PI, NCMRWF, and NIT-K Surathkal, facilitated by Dr. Parvez. The technical sessions featured distinguished speakers sharing case studies and success stories in applied science, engineering research, and industry collaborations. Research scholars and post-doctoral fellows presented papers, with Prof. D S Rao highlighting industry-academic research partnerships for technological advancement and publications. MSMEs and startups like Ranjita Encons, Cropin, Armtronix, and Medvise Futurekare engaged with scientists and scholars. Karthikeyan from CSIR-NAL discussed funding opportunities. Dr. Parvez moderated a panel discussion focusing on enhancing synergy between research labs, industry, and academia. Dr. Gouda summarized the session with suggestions for societal betterment through collaborative efforts.



OWOL - Day 5 (July 14, 2023)

The Science Outreach and Roadshow event at Vemna Institute of Technology, Bangalore, was inaugurated by Sri S. Jayram Reddy and attended by Dr. Parvez, Dr. K C Gouda, and Dr. Vijayasimha Reddy. Dr. Parvez introduced the OWOL program, emphasizing interdisciplinary collaborations. CSIR 4PI scientists presented expert talks, and research scholars demonstrated technologies. Faculty and students commended the program for its insightful research insights and exposure to advanced facilities. At Dayananda Sagar College of Engineering, Bangalore, Principal Dr. Prasad, Vice Principal Dr. Ramesh, Chief Scientist Dr. V Anil Kumar, Mr. Chiranjeevi, and Ms. Pavithra inaugurated the event. Dr. Prasad commended Team CSIR-4PI for their interdisciplinary research and the OWOL initiative, expressing satisfaction with their existing MoU for collaborative research. Dr. Anil Kumar discussed Intellectual Property and advanced cyber security research at CSIR-4PI. Ms. Pavithra, Mr. Chiranjeevi, and Mr. Iranna G interacted with students, while research scholars demonstrated technologies. Dr. K C Gouda highlighted data science for societal development. Dr. Parvez thanked the college for hosting the successful event, with active participation from DSCE faculties including Prof. Joseph, Dr. Vindhya, Dr. Mohammed Tajuddin, Dr. Rashmi S, Dr. Vinod, Dr. Rajeshwari, and Ms. Radhika in discussions with CSIR-4PI's scientific team.



OWOL - Day 6 (July 15, 2023)

On July 15, 2023, CSIR-4PI hosted a special event to promote smart agro-technologies, fostering interaction among Farmers, Students, and Scientists. Dr. Jade chaired the event, with Shri. Mahendra Kumar Gupta, Joint Secretary (Admin), CSIR, as Chief Guest. Dr. Mahendra P. Darokar, Chief Scientist at CSIR Headquarters, highlighted CSIRs agricultural contributions. Dr. K V Ramesh outlined the event's objectives, stressing its impact on farming practices. Shri Prabhudev, a farmer from Hosahalli, Vijayanagar District, Karnataka, lauded CSIR 4PIs R&D in improving paddy yields. Interactive sessions involving Farmers, PG & PhD students from UAS Bangalore, and Scientists addressed farming challenges, followed by practical demonstrations of agricultural instruments. In the afternoon, CSIR 4PI celebrated its 35th Foundation Day, concluding the One Week One Lab campaign. Prof. K K Aggrawal discussed data's importance and the institute's evolving role. A recap of OWOL activities led to Shri. Mahendra Kumar Gupta's address as Guest of Honor, underscoring the event's success and future CSIR 4PI initiatives. This event was dedicated to Farmer-Student-Scientist interaction to create awareness on smart agro-technology.



National Intellectual Property Festival

Dr. Anilkumar V, Chief Scientist specialist in Intellectual Property Rights, interacted with students during the National Intellectual Property Festival to raise awareness about intellectual property rights.



Yoga Day

CSIR-4PI and CSIR-NAL Jointly Celebrated “Yoga Day” on 21st June, 2023 at SR Valluri Auditorium, NAL Campus.



CSIR-4PI JIGYASA team has opened a Doodle Competition for Bengaluru residents students on 27th June 2023.



The winners of CSIR-4PI's JIGYASA doodle competition were felicitated on Independence Day First Prize Winner: S. Tushitha Devi, 10th standard, Young Scholars Academy
Second prize winner: Sahnaina Vishal, 9th standard, Kendriya Vidyalaya, NAL



77th Independence Day

CSIR-4PI celebrated 77th Independence Day. Dr Sridevi Jade, Head CSI- 4PI hoisted the National Flag on August 15, 2023.



Hindi Pakhwada

Hindi Pakhwada was observed at CSIR-4PI from September 14-21, 2023, featuring a variety of competitions such as Swarachit Hindi Kavita Lekhan, Essay writing, Dumb Charades, Antakshari, and Hindi Solo song. The celebrations culminated on Hindi Day, September 22, 2023, chaired by Dr. Sridevi Jade, Outstanding Scientist and Head of CSIR-4PI. The event's chief guest was Dr. Alok Kumar Srivastava, Associate Director of URSC, Bangalore. Winners of the competitions were awarded cash prizes during the Hindi Day celebrations, marking a vibrant tribute to the language and its cultural significance at the institute.



CSIR-4PI Jigyasa: Scientists-Students interaction

On September 21, 2023, 82 students and 6 teachers from Narayan e-Techno School, Bengaluru participated in the Jigyasa: Scientists-Students interaction. The students were briefed in the areas of GHG, GNSS & HPC.



CSIR Foundation Day

CSIR-4PI participated in CSIR Decadal Achievements Exhibition on the occasion of CSIR Foundation Day on 26 September 2023 held at CSIR, New Delhi



82nd CSIR Foundation Day

CSIR Foundation Day was celebrated on 3rd October 2023 at CSIR-4PI. The inaugural day concluded with a lecture on “Principles of Leadership” by Chief Guest Mrs. Jaya Jagadish, AMD.



Swachhata Pakhwada

Under special swachhata campaign Nodal Officer & Head, CSIR-4PI along with staff participated in cleaning the dark spots in the office premises to boost the staff on October 12, 2023.



CSIR-4PI Jigyasa: Workshop on Statistics and Game Psychology

CSIR-4PI organised a Workshop during 16-17 October 2023 in Statistics and Game Psychology. 30 Students and 15 Teachers from Jai Gopalagarodia Rashtrorothana Vidyalaya School participated in the event.



Kannada Rajyotsava

Kannada Rajyotsava was Celebrated on November 1, 2023 jointly by CSIR-4PI and CSIR-NAL, Bhubaneswari Devi Puja and flag hoisting were performed.



Asian Computational Fluid Dynamics (ACFD)

CSIR-4PI at the prestigious Asian Computational Fluid Dynamics (ACFD) 2023 in Bangalore held during October 30 - November 2, 2023.



FIT India Swachhata Freedom Run 4.0

FIT India Swachhata Freedom Run 4.0 was organised on November 3, 2023 by CSIR-4PI and CSIR-NAL. Government of India initiative to encourage fitness.



Vigilance Awareness Event

Vigilance Awareness Event of CSIR-4PI was jointly organised with CSIR-NAL. Integrity Pledge and Vigilance Awareness Address were held.



Ayurveda Day

CSIR-4PI celebrated Ayurveda Day on 8 Nov 2023. A team of doctors from Central Ayurveda Research Institute (CARI), Bangalore conducted Ayurveda awareness programme, health check-up, on-site medicine distribution.



Janajatiya Gaurav Diwas Celebration

On November 23, 2023, a group of students from 8th to 10th standard and faculty members from Yerahalli Government High School, located in Yerehalli, Ramanagara District, Karnataka, visited CSIR Fourth Paradigm Institute to celebrate Janajatiya Gaurav Diwas. The inaugural event saw the participation of 64 students and 5 faculty members, along with regular and non-regular staff of CSIR 4PI. During the visit, the students were introduced to various facilities including High-Performance Computing (HPC), the Cyber Security Lab, Global Navigation Satellite System set-up, and the Energy Farm.



Prevention of Sexual Harassment at Workplace

As part of the “Sexual Harassment at Workplace Prevention Week,” a lecture with an interactive session was held on December 7, 2023. Dr. V Shubha, Former Distinguished Scientist at CSIR-NAL and member of the Internal Complaints Committee (ICC) at CSIR-4PI, delivered the lecture titled “Prevention & Tackling of Women Harassment at Workplace.” She provided a comprehensive explanation of sexual harassment at the workplace, emphasizing prevention strategies and methods for addressing such issues both organizationally and individually. The session concluded with participants engaging in discussions on effective prevention and management of workplace harassment.



Hindi Diwas

Hindi workshop for Scientists, technicians and officers of CSIR-4PI was conducted on 1st December 2023, CSIR-4PI.



Data Science Workshop

CSIR-4PI organized a Data Science workshop, “From Data to Decision Support System: A Data Science Hands-on Workshop,” from December 8-12, 2023, as part of the CSIR Integrated Skill Initiative in line with Institute’s mandate. Dr. Sridevi Jade, Head of CSIR-4PI, inaugurated the event on December 8, and an insightful inaugural lecture was delivered by Prof V K Gaur. The workshop drew 25 participants, predominantly PhD students eager to acquire and apply data science skills for research problem-solving. During the workshop, total 10 lectures were delivered by eminent faculties, from basics (Maths and Statistics) to advance machine learning techniques followed by Hands-on sessions with real world scientific issues using data science tools. This workshop reflects CSIR-4PI’s commitment to fostering skill development in cutting-edge technologies.



India International Science Festival (IISF)

As part of the outreach program of India International Science Festival (IISF) 2023, CSIR-4PI has conducted IISF Outreach Program on December 18, 2023 at CSIR-4PI with Dr. Ram Chandra Rao, Vice Chairman, VIBHA, Bengaluru unit, presenting the details of IISF 2023 to college students along with Open Day for family members.



CSIR-4PI Jigyasa: Workshop on Green House Gases

CSIR Fourth Paradigm Institute also conducted Jigyasa Winter Workshop from December 19 to December 21, 2023 on the topic of Green Houses Gases. Many lectures and hands-on sessions were conducted to provide the basic concept of GHG and field visit to the GHG station of India Institute of Astrophysics, Hoskote campus was arranged to show them real time GHG flux measurements.



Vishwa Hindi Diwas

World Hindi Day is celebrated every year on 10 January. Its purpose is to create awareness for the promotion of Hindi in the world and to present Hindi as an international language. As part of this Vishwa Hindi Diwas celebrations were held at CSIR-4PI on 10 January 2024.



75th Republic Day

Celebration of 75th Republic Day at CSIR-4PI and flag hoisting.



Intensive Course on Ocean Science and Modelling: Energy, Environment and Living Resources

CSIR-4PI conducted an intensive course titled "Ocean Science and Modelling: Energy, Environment, and Living Resources" from January 16-20, 2024, as part of its Skill Development Programme.



Mathrubhasha Diwas

CSIR- National Aerospace Laboratories and CSIR-Fourth Paradigm Institute, jointly celebrated "Mathrubhasha Diwas" on 21st Feb 2024, at CSIR-NAL Campus.



National Science Day

On February 28, 2024, CSIR-National Aerospace Laboratories and CSIR-Fourth Paradigm Institute collaborated to celebrate “National Science Day” at the S R Valluri Auditorium. Dr. M.K. Kokila, Chairperson of the Department of Physics at Bangalore University, honored the event as the Chief Guest. She delivered a lecture titled “Crystal Science and Its Relevance” emphasizing the critical role of crystal science in modern research and practical applications.



Women's Day Celebration

Celebrated Women's Day at CSIR-4PI with an outstanding presentation by our very own women achievers: Dr. Sajani Surendran, Senior Principal Scientist and Dr. Kalyani, a woman scientist and concluded the program with some fun and frolic.



CSIR-4PI Jigyasa: Scientist-Student Interaction

On March 6, 2024, 50 children and 4 instructors from Morarji Desai Residential School in Anumanahalli, Ramanagar District attended a Scientist-Student Interaction event hosted at CSIR-4PI. They were briefed on the CSIR-4PI's High Performance Supercomputing, Satellite Geodesy, and Climate Change Research and Development activities.



Hindi Workshop

Hindi Workshop for all Admin/F&A/S&P employees on March 22, 2024. A power point presentation on Conduct Rules & Recording data in Sparrow in Hindi was also conducted during the program.



5.11 Some major events organized by CSIR-4PI

Discussion Meeting of Directors & Heads for formulating CSIR League for AI based Industrial Manifestation (CLAIM) project on 7-8 August 2023 at CSIR-IICT, Hyderabad

There was a meeting for two days to discuss on formulating the detailed project report on upcoming AI Mission project “CSIR League for AI based Industrial Manifestation (CLAIM)” on 7-8 August 2023 at CSIR-IICT, Hyderabad. The Directors and Heads of all 37 labs participated in this meeting in physical and online mode. Technical Presentations of the Directors & Heads were scheduled for DPR preparation on 7th August. On the second day, another discussion session was scheduled with respective Industry Partners, Line Ministry Representatives and Data Partners through online/in person for their involvement in the project.



Capacity building workshop on Himalayan High Impact weather events 28-30 October 2023

From October 28-30, 2023, the NMHS project organized a capacity-building workshop at GBPNIHE, Kullu, HP, in collaboration with CSIR 4PI and GBPNIHE. The workshop began with a scientific team visiting sites affected by recent cloud bursts, heavy rains, and landslides in the Kullu-Manali region, specifically focusing on the Beas river basin. Engaging with local stakeholders and affected individuals, the team gathered insights and discussed mitigation strategies for these disasters, emphasizing their connection to climate change and changes in land use/land cover (LULC). The second day featured field trips to disaster-affected areas for workshop participants, while the third day included interactive sessions. Dr. R K Singh highlighted GBPNIHE's environmental research, followed by Dr. K C Gouda presenting outcomes and prototypes of the NMHS project for predicting high-impact weather events in the Beas basin. Discussions led by experts such as Dr. Ashish Routray on high-resolution modeling and Dr. Sudhansu Sekhar on mountain meteorology underscored the workshop's focus on disaster studies. Dr. G N Mohapatra discussed regional disaster modeling for advanced simulation of extreme rainfall. Brainstorming sessions yielded recommendations for further studies submitted to NMHS, MoEFCC, GoI, aimed at enhancing disaster preparedness and management strategies.



One-to-One meeting with Chairman, ISRO

A one-to-one meeting with Shri. S Somanath, Chairman ISRO being the mentor of CSIR-4PI, as per suggestions of the Hon'ble President CSIR & Hon'ble PM to adopt one CSIR lab by the CSIR society members for regular interactions. The meeting was held on 20th June, 2023 at Antriksh Bhavan, ISRO HQ. Head, CSIR-4PI made a brief presentation of the laboratory activities and the road-map. Chairman, ISRO was very keen on the institute activities, especially on domain related to cyber-security, AI & ML and Climate change.

Industry interaction meeting with M/s EID Parry

A discussion meeting was held on 28th July, 2023 at CSIR-4PI with Dr. Shanmuga Sundaram, Sr. Gen. Manager R&D, EID Parry and team along with the domain scientists of 4PI. Various research problems of mutual interest were discussed related to smart agriculture and weather informatics. Dr. Kantha Rao coordinated the meeting from CSIR-4PI side.



Meeting between CSIR-4PI & KSNDMC to take-up collaborative research

A high level meeting of KSNDMC & CSIR-4PI scientists and researchers was held on 18th April 2023, at 4PI. The meeting was conducted under the chairmanship of Dr. Manoj Ranjan, Commissioner KSNDMC and Dr. Sridevi Jade, Head CSIR-4PI. The following areas emerged as important topics for collaboration.

- Developing a modelling system for urban flood forecasting
- Urban Heat Islands simulations Lighting & Thunderstorm predictions
- Predictions of extreme weather events over state
- Sesimic prediction over Karnataka



Discussion meeting on AcSIR proposal to host NSM systems at CSIR-4PI

A meeting was held on 26 March 2024 at Knowledge Park, CDAC, Bengaluru. The meeting was attended by Dr S D Sudarshan, Executive Director, Bengaluru, Ms. Divya M, Scientist-F and Mr P Soundararajan, Joint Director from NSM/C-DAC, Bengaluru and CSIR-4PI was represented by Dr Sridevi Jade, Head, 4PI and Dr G K Patra, Chief Scientist, 4PI. Dr Vidyadhar Mudkavi, Distinguished Emeritus Professor of AcSIR was also present. The discussion resulted in a decision to provide immediate access of NSM systems to AcSIR scholars and to conduct a HPC training programme to the students. An important outcome of the meeting was to work towards hosting NSM supercomputing system at CSIR-4PI by the end of 2024 for AcSIR research activities.





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:

- 6.1 Grant-in-Aid Projects
- 6.2 Other Lab Projects (OLP)
- 6.3 Headquarter Controlled Projects (HCP)
- 6.4 Network Projects (NWP)
- 6.5 MOUs Signed

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. 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, Govt, Department of Science and Technology, Ministry of Science and Technology, PI- Dr. K C Gouda
3. 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
4. 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
5. 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
6. 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
7. Improving the prediction of Thunderstorms using Dual-Resolution Hybrid Ensemble-Variational Data Assimilation System using WRF Model, Ministry of Earth Sciences (MoES), PI- Dr. V Rakesh
8. 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
9. Ionospheric Imagery of Earthquake Source Region using the Co-seismic Ionospheric Perturbations (CIPs), Science and Engineering Research Board (SERB), Department of Science and Technology, PI- Dr. Dhanya Thomas
10. Impact Assessment of New and Emerging Waste Management Technology on Human Life, Ministry of Science & Technology, Department of Science and Technology, PI-Dr. Lakshmikanthan P
11. 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 River Basins of India, Women Scientist Scheme A (WOS-A), Department of Science & Technology, PI- Dr. Sumana Sarkar
12. Analysis and Modeling of Thunderstorm Events in India, Ministry of Science & Technology, Department of Science and Technology, PI- Ms. Payoshni Samantray
13. Network Telescope Feed for Threat Intelligence Generation, Ministry of Electronics and Information Technology, PI- Dr. V Anil Kumar
14. Architecture and Dynamics of Magma Reservoir in Deccan Volcanic Province: Seismological-Geochemical Synthesis, Science and Engineering Research Board (SERB), DST, PI- Dr. Imtiyaz A Parvez

15. Development of Privacy Preserving Machine Learning Framework for Healthcare Data, Ministry of Science & Technology, PI- Ms. Shruthi S Deepak

6.2 Other Lab Projects (OLP)

1. Development of High Precision Green House Gases (GHG) Database in Indian Context, PI-Dr. Lakshmikanthan P, Co- PI M. K Sharada
2. GNSS & Seismic Network in the Indian Subcontinent, PI- Dr. Sridevi Jade, Co-PI Dr. Imtiyaz A Parvez & Shri Chiranjeevi Vivek G
3. Vehicular Platform for Algorithm Testing and Traffic Data Collection, PI- Dr. G.K Patra

6.3 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
3. CSIR JIGYASA 2.0 Virtual Laboratory Integrated Project (CJVL), PI- Smt. Pavithra N R, Co- PI: Dr. Ashish
4. Region Specific Smart Agrotechnologies for Enhancing Soil and Plant Health (RSSA), PI- Dr. V Rakesh, Co-PI- Dr. G N Mohapatra

6.4 Network Projects (NWP)

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

6.5 MOU's Signed

1. MoU signed on 13 July 2023 between CSIR-4PI and National Centre for Medium Range Weather Forecasting, (NCMRWF) Earth System Sciences Organisation, Ministry of Earth Sciences, Noida, Academic Collaboration for the Promotion of Academic Cooperation and Exchange of Research Personnel and Students.
2. MoU signed on 13 July 2023 between CSIR-4PI and National Institute of Technology (NIT) Karnataka, Surathkal Academic Collaboration for the Promotion of Academic Cooperation and Exchange of Research Personnel and Students.
3. Addendum between CSIR-4PI and National Institute of Ocean Technology (NIOT) on 26 May 2023, Agreement for the financial arrangement towards operation and maintenance of Green House Gases (GHG) station.
4. MoU signed on 02 January 2024 between CSIR-4PI and Kerala Agricultural University (KAU) to collaborate in the CSIR project on Region Specific Smart Agriculture to facilitate/ help CSIR project team in conducting regular field observations, IoT measurements, drone survey and experiments in coordination with local farmers and jointly develop disease prediction models.



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.

Inside:

- 7.1 Staff List
- 7.2 Services on External Committees/Membership of Professional Bodies
- 7.3 Newly Joined Staff
- 7.4 Promotions
- 7.5 Foreign Deputations
- 7.6 Superannuation
- 7.7 Staff relieved from CSIR-4PI

7.1 Staff List

Director

Sridevi Jade

Veeresh

Dileep Kumar P

Honorary Emeritus Scientists

Gaur V K

Yajnik K S

H N V Dutt

Srinivas Bhogle

Rao E V S P

Distinguished Emeritus Professor

Mudkavi V Y

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

Stella Margaret A

Administration

Mangala S

Vikash Chandra Mishra

Rajesh V

Abhimanyu Kumar Tiwary

Geetha S

Radha Ramani

Nirmala Bai SP

Abhijna

Ved Prakash

Narayana Murthy Pulla SVS

Kishore RPN

Rajalakshmi V

Jitakala D

Sujatha Keshava Murthy

Vinod M Sharma

Aiswarya P Venkitesh

Kishan Kumar Singh

Lakshmi Priya

Archa RS

Arvind Kumar J

Juliya John

Dhanya Dharman D

Santhiya T

Priya L

Finance and Accounts

Rajesh V

Abhimanyu Kumar Tiwary

Narayana Murthy Pulla

Aravind Kumar J

Stores & Purchase

Vikash Chandra Mishra

Kishan Kumar Singh

Research Fellows, Project Staff, Women

Scientists

Kalyani Devasena C

Dhananjay Kumar C

Dhanya Thomas	Arvind Raj A
Ipsita Putatunda	Prajwal H S
Madhvee Kori	E Sarath Kumar
Neethu C	Bhagyashree Narayana Hegde
Nikhilasuma	Hemanth Kumar M
Priyadharshini	Prasanth S V
Rajendra Kumar Dash	Sujisha C S
Smrathi Purwar	Vivek R
Smruthishree Lenka	Prema
Gaurav Melkani	Sreejaya T
Amit Umesh Patil	Katta Hari Charan
Ajay Vijay Bankar	Apoorva Jangir
Sumana Sarkar	Shubha A S
Payoshini Samantray	Shruthi S Deepak
Bhargavi B	Lekhana K
Dipti Singh	Rajitha R
Manjunatha G S	Sharath L R
Prescila Raj	Akash Deep Dixit
Lekshmi M S	Swadesh Mohapatra
Sushanti Vijaykumar Lade	Pankaj Sharma
Swetha S	Rani Devi
Rakhi	Kanike Raghavendra Prasad
Priyadharshini	

7.2 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, Seismological Society of America (SSA)

- **Anilkumar V**

1. Member Project Review and Stering Group (PRSG) of Ministry of Electronics and Information Technology (MeitY) on project Enhancing Security using Lightweight Cryptography in IoT with one M2M as the service Platform and 3GPP-5G as the underlying Communication Network.
2. Special Invitee, Advisory Board meeting, Society for Electronics Transaction and Security, Chennai.
3. Member, Advisory Committee for Information, Communication and Technology Division, CSIR-NAL
4. Member Project Review and Stering Group (PRSG) of Ministry of Electronics and Information Technology (MeitY) on project Establishment of a National

Facility for Security Testing, Evaluation and Certification of IoT Devices & Embedded Systems leading to Security Assurance".

5. Member, search committee for Engagement of Mentors at Society for Electronics Transaction and Security, Chennai.
6. Member, Scientist Selection Committee, Center for Development of Advanced Computing (C-DAC), Pune.
7. Member, Assessment and Promotion Committee for Scientists at Society for Electronics Transaction and Security, Chennai.
8. Expert member, Committee for Regulation, Scheme and Syllabus for Post graduate diploma in cyber security, Kannur University.
9. Member, Selection Committee for AcSIR Ph.D Admission of CSIR-NAL.
10. Member, Board of Studies, Coimbatore Institute of Technology (CIT)
11. Member, Internet Society (ISOC)
12. Life Member, Computer Society of India
13. Member, Review committee for patent renewal recommendation, CSIR-NAL

• **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, Board of Studies, School of Computer Science, Jain University, Bangalore
7. Member, Board of Studies, Department of Meteorology and Oceanography, Andhra University, Vishakhapatnam, Andhra Pradesh
8. Member, Advisory Board, Dept. of CSE, Dayananda Sagar college of Engineering, Bangalore.
9. Member, Board of Studies, Dept. of MCA, Dayananda Sagar University, Bangalore
10. Member, Board of Studies, School of Computer Science, Jain University, Bangalore
11. Mentor in the ATAL Innovation Centre of SoA University, Bhubaneswar
12. Member, M.Tech. Thesis Evaluation Committee, VTU.
13. Member, M.Tech. Examiner, VTU.
14. Member, Doctoral Committee, VTU.
15. Member, Doctoral Committee, Jain University.
16. Member, PhD thesis Evaluation Committee, Andhra University, AP
17. Member, M.Sc. examiner, Berhampur University, Odisha
18. Member, Project review committee (PRC), DSIR-PRISM
19. Member, Assessment Committee, CSIR NAL

• **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

- **Kantha Rao Bhimala**

1. Board of Studies Member: Dept. of. Mathematics, Dravidian University, Kuppam.

- **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, Expert Evaluation Committee of VIABHAV proposals for ICT theme.
4. Member, Data management sharing policy committee: PI-CHeCK CSIR.
5. Member Advisory Committee International Conference on Computations and Data Science IIT, Roorkee.

- **Rajendran K**

1. Member, Board of Studies in Atmospheric Sciences, Cochin University of Science & Technology, Cochin, Kerala.
2. Executive Council Member, Indian Meteorological Society
3. 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. Member, CSIR Advisory Board
2. CSIR Nominee, Executive Board Member, National Supercomputing Mission (NSM-EB)
3. CSIR Nominee, Member, Scientific Advisory Committee, National Mission on Interdisciplinary Cyber Physical Systems (NM-ICPS)

4. Senate Member, AcSIR
 5. Expert Member, Committee for CSIR Emeritus Scientist Schemes 2021-2023
 6. Expert Member ASPIRE Engineering Science Committee 2023-2025
 7. Executive Committee Member, Karnataka State Natural Disaster Monitoring Agency, Government of Karnataka.
 8. Expert Member, International panel for GNSS Remote Sensing for future missions and sciences.
 9. Expert member, Technical Advisory Committee, Government of Karnataka
 10. Life Member, Indian Geotechnical Society
 11. Life member, Indian Geological Congress
 12. Member, International Society of Soil Mechanics and Foundation Engineering
 13. Founder Life Member, Indian Society of rock mechanics and tunneling technology
 14. Associate Member, International GNSS Service (IGS)
 15. Reviewer, for Several International and National SCI Journal
- **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 Implementation, 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)
 4. Elected as a Member of International GNSS Service (IGS) Ionosphere Committee (Formerly IGS Ionospheric Working Group).

7.3 Newly Joined Staff

- **Abhimanyu Kumar Tiwary**, FAO
- **Radha Ramani**, Principal Private Secretary
- **Nirmala Bai SP**, Hindi Officer
- **Kishore RPBN**, Section Officer (F&A)
- **Jitakala D**, Private Secretary
- **Juliya John**, JSA (Gen.)
- **Dhanya Dharman D**, JSA (F&A)
- **Santhiya T**, Jr. Stenographer
- **Priya L**, Jr. Stenographer

7.4 Promotions

- **Senthilkumar, V.**, as Sr. Principal Scientist
- **Chiranjeevi Vivek, G.**, as Principal Scientist
- **P Lakshmikanthan** , as Senior Scientist

7.5 Foreign Deputations

- **V Anil Kumar**, Information Security Policy Workshop of Taiwan International Development and Cooperation Fund, Taipei and Tainan, Taiwan, May 24-June 06.
- **C Kalyani Devasena**, International Ocean Colour Science Meeting on Advancing Global Ocean colour observations, 14-17 November 2023 St. Petersburg, FL, USA.

7.6 Superannuations

Staff superannuated from CSIR-4PI during the period from 01.04.2023 to 31.03.2024

Smt. Sharada MK, Chief Scientist superannuated on 31.01.2024



Figure 7.1: Smt. Sharada MK, Chief Scientist superannuated on 31.01.2024.
Watch the farewell function on <https://www.youtube.com/watch?v=pSQ4m9yiyCI>.

Dr. Himesh S, Sr.Principal Scientist superannuated on 31.05.2023



Figure 7.2: Dr. Himesh S, Sr. Principal Scientist superannuated on 31.05.2023.
Watch the farewell function on <https://www.youtube.com/watch?v=uTjj8SsYi9o>

Shri. Chandrashekara Bhat, Sr.Technician-2 superannuated on 30.06.2023



Figure 7.3: Shri. Chandrashekara Bhat, Sr.Technician-2 superannuated on 30.06.2023.
Watch the farewell function on <https://www.youtube.com/watch?v=YZ76gqy8t28>

7.7 Staff relieved from CSIR-4PI

List of staff relieved from CSIR-4PI on Resignation/ Transfer for the period from 01.04.2023 to 31.03.2024

- **Ramesh K V Dr.**, Chief Scientist Transferred to CSIR-NIIST
- **Iranna Gogeri**, Sr.Scientist Transferred to CSIR-NAL
- **Rajesh V**, FAO Transferred to CSIR-CFTRI
- **Geetha S**, Principal Private Secretary Transferred to CSIR-CFTRI
- **Narayana Murthy Pulla SVS**, Section Officer (F&A) Transferred to CSIR-IICT
- **Lakshmi Priya**, JST Resignation
- **Archa RS**, JST Resignation
- **Arvind Kumar J**, JSA (F&A) Resignation

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 its 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, Principal Scientist
2. Shri. R P Thangavelu, FAA, Chief Scientist
3. Smt. S Mangala, Transparency Officer, COA

