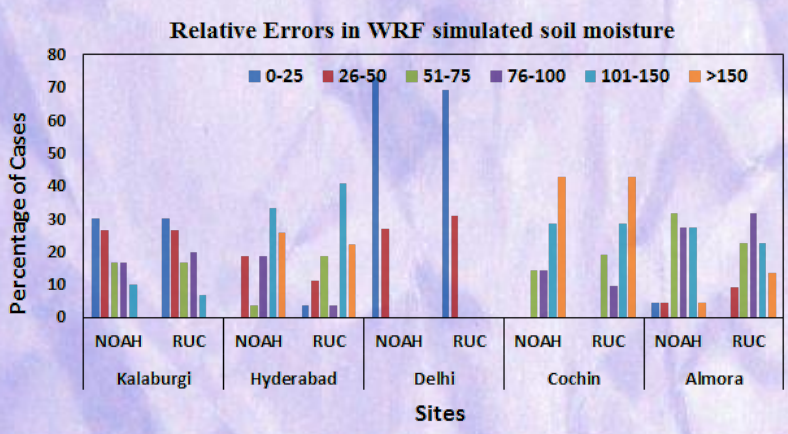
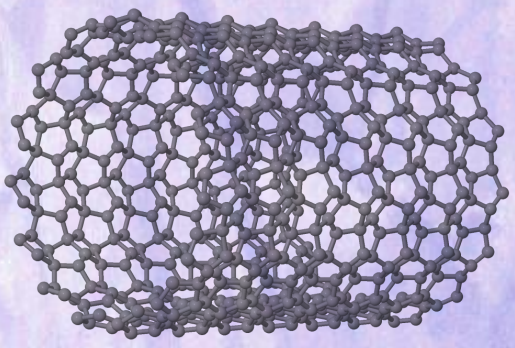
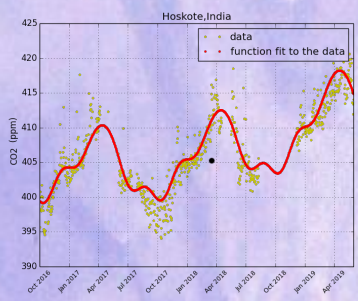
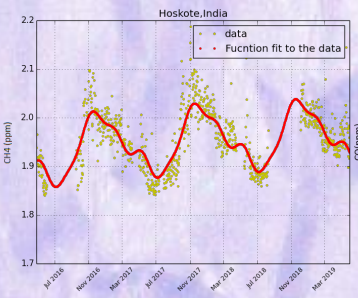
CSIR Fourth Paradigm Institute Annual Report 2018 - 2019

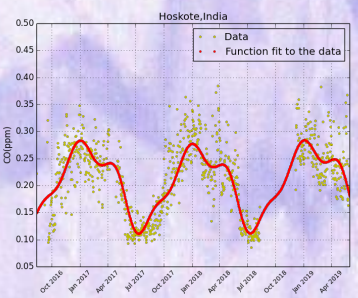
CSIR-4PI

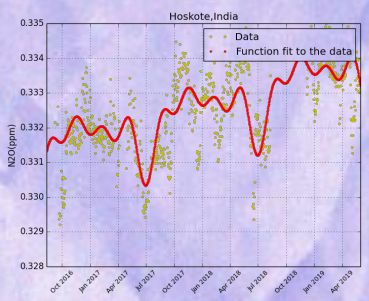


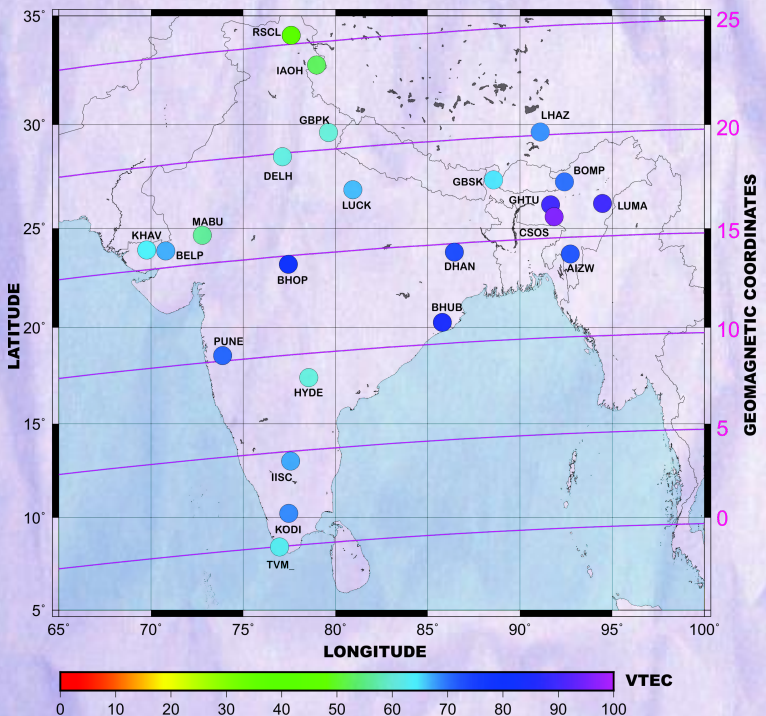


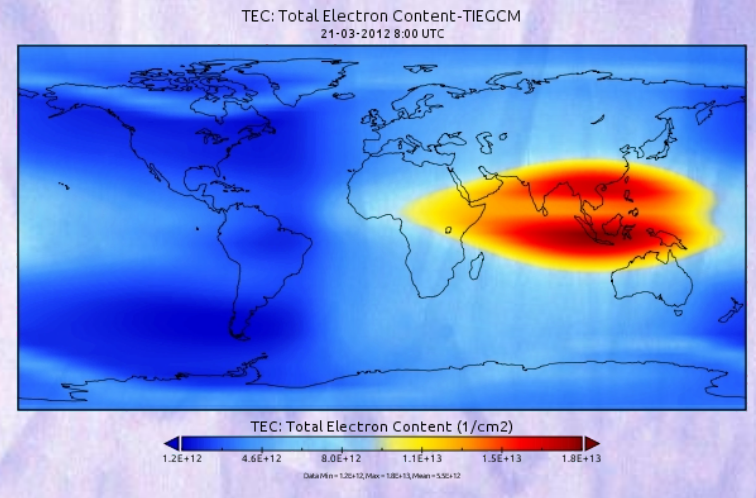




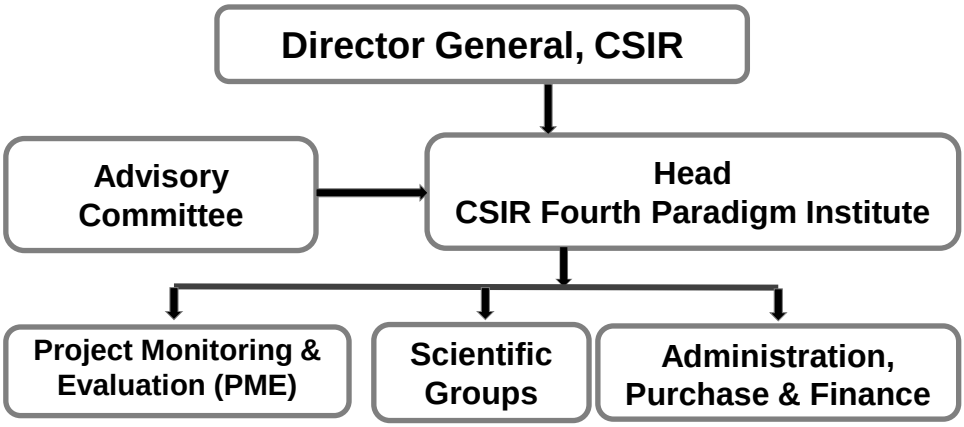








ORGANIZATION CHART



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CSIR FOURTH PARADIGM INSTITUTE

Annual Report 2018-2019

CONTENTS

Vision

To provide modelling, simulation and data intensive capability powered by high performance computing and informatics research.

Mission

Develop knowledge products in earth system and information sciences for societal benefit by exploiting modelling, simulation and data science capabilities.

The mission statement thus encompasses continuation of existing modelling and simulation work in earth sciences and places emphasis on exploiting data science capabilities across domains.

Mandate

To develop reliable knowledge products for decision support in Earth, Engineering and Information Sciences.

To be the national leader in High Performance Computing as service that will power modelling and informatics across CSIR.

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Acknowledgements
To all staff members of CSIR-4PI for inputs to the Annual Report.

Preface

Year 2018 marks an important milestone as far as CSIR Fourth Paradigm Institute (CSIR-4PI) is concerned. On June 21, 2018, a meeting was held under the chairmanship of Shri Narayana Murthy, Founder Infosys, wherein the roadmap for CSIR-4PI was presented before a committee consisting of experts and thought-leaders around the country. The committee appreciated past achievements of the Institute in the area of Earth Sciences and high performance computing and the role it has thus far played in CSIR. With the advent of data science, the committee was of the opinion that CSIR-4PI has a much larger role to play in the new theme-based CSIR and suggested that all mechanisms be put in place to move forward. Following this, much needed Advisory Committee (AC) was formed with Shri Narayana Murthy as its Chair.

The Advisory Committee met in December 2018 and made many recommendations. A call to tackle urgent issues in Agriculture and Healthcare were given. Much needed approval to initiate hiring of manpower to build data science group was also given. Following this, steps have been taken to formulate multi-institutional precision agriculture project to develop an AI/Drone based system to assist marginal/small farmer.

An important step in establishing a data-driven scientific institution is to establish AI infrastructure. The existing HPC platform, Ananta, is undergoing enhancement of compute power with addition of new Skylake nodes. More importantly, Data Cloud will now be established which help us infuse AI capability in CSIR and also fulfill our mandate as a new Institute focused on the fourth paradigm.

Existing groups working in the area of earth sciences have made significant progress during this year.

Solid earth modeling research work on Indian reference frame published in Scientific Reports, Nature is recognized in the Top 100 earth science papers. Research article published on ionosphere variability specific to Indian subcontinent has attracted much attention. The Institute is running and maintaining 12 broadband seismic stations in Kashmir Himalayas which has provided data over 2628 source-receiver path contributing to surface wave disperison data from 8 to 60 seconds period. This data set along with the data from the international agencies like IRIS, RESIF and GEOFON were used to produce shear wave velocity structure at a regular grid of 0.5° x 0.5° in northwestern Himalaya and at 1°×1° in the surrounding areas.

On the climate modeling front, we continue to perform high resolution long-range dynamical forecasting of Indian monsoon. Use of WRF model for simulation of multi-level soil moisture and other parameters will be used for various applications including proposed cloud seeding activities of Government of Karnataka. Efforts have also been made to develop new rain based index for Indian summer monsoon. Significant efforts have also been made to simulate climate change effects on monsoon rainfall. We have also used temperature dependent model to predict Chikungunya epidemic and studied land use change in mega-cities with a view to understand impact on heavy rainfall.

Carbon cycling and ocean modeling are important areas with unique strength in the Institute. We continue to gather data from the four WMO compliant GHG stations. These efforts have also resulted in continued collaboration with IIA, Bangalore,

Pondicherry University and NIOT in Chennai. Hanle station data provides background GHG concentration which, is essential for modeling purpose. We have also studied effect of Iron on specific growth rate of phytoplankton and influence of physical processes on biological and chemical processes in north Indian Ocean.

Cyber-security is yet another unique capability developed at the Institute. Our efforts have resulted in important projects sponsored by MEITy and industry.

These are significant societal contributions by the Institute and these efforts will continue in the future by the modeling and simulation group.

Among other things, we signed an MoU with IIA Bangalore, VIT Vellore and Berhampur University. These collaborations are expected to enhance our reach and capability.

The past year also saw good scientific publications. There were 11 journal publications, 4 books/proceedings and around 20 presentations in various conferences. One patent was also granted.

Two major projects are presently being sponsored by MoEF&CC. CSIR-4PI is playing nodal role in the Intelligent Systems Mission project that has major industry involvement. One scientist was awarded CSIR Raman Research Fellowship and 8 scientists were promoted during the year gone by.

It is now time for us to take concrete steps towards building capacity in data sciences. Once established, this capability will provide impetus to several domains across CSIR. Already, CCMB, Hyderabad, IGIB, Delhi, NEERI, Nagpur, NEIST, Jorhat and IIP, Dehradun laboratories have come forward to work with CSIR-4PI to set up joint teams at their locations to tackle problems in their domain using Big Data, AI and Machine Learning techniques. Thus, CSIR-4PI is poised to play a central role in the CSIR system and thereby provide much needed leadership in AI which has now come to stay as a major force in science and technology.

Dr. V Y Mudkavi
Head

1

CARBON CYCLING AND OCEAN MODELLING

The importance of the cycling of carbon and nitrogen as a major influence on global climate has been recognized for the past few decades, starting with the pioneering work of Keeling, Tans, Bryan, Manabe and others (IPCC 1992-2017). At CSIR-4PI, we have continued our intense research on modelling and simulation of the global carbon cycle as well as state-of-the-art measurements of greenhouse gases. These measurements are being assimilated into inverse transport models to yield robust fluxes of carbon. CSIR has funded a major project "Carbon Nitrogen Cycling in the Earth System (CNCES)" to enable us to continue our research in this important area.

Sensitivity of one of the parameters related to iron limitation $(Fe:N)_{irr}$ (which alters light utilization efficiency by phytoplankton) on primary productivity, chlorophyll, nitrate, pCO_2 and carbon flux in the Arabian Sea has been investigated. Numerical simulations of a marine biogeochemical model at a resolution of 0.25 degree is set up in the global domain for the estimation of marine productivity.

From the measurement side, we have been able to resume operations at our stations in Hanle and Pondicherry. The former has the potential of being a baseline station for monitoring the secular increase in GHG concentration. The station at Hoskote, which is also a primary reference calibration station has been operational and its stability has been demonstrated.

Inside

1.1 Effect of iron limitation on the specific growth rate of phytoplankton

Sensitivity of one of the parameters related to iron limitation $(Fe:N)_{irr}$ (which alters light utilization efficiency by phytoplankton) on primary productivity, chlorophyll, nitrate, pCO_2 and carbon flux in the Arabian Sea has been investigated using a 3-D coupled Biogeochemical Model (TOPAZ) embedded in Modular Ocean Model (MOM4P1) in the global domain for climatology and interannual variability. Initially the model results are evaluated for many of the biogeochemical components using data from World Ocean Atlas, satellites and cruises in the Arabian Sea. It is noticed that model results capture seasonal and interannual variations of some of the biogeochemical components and fluxes in the Arabian Sea.

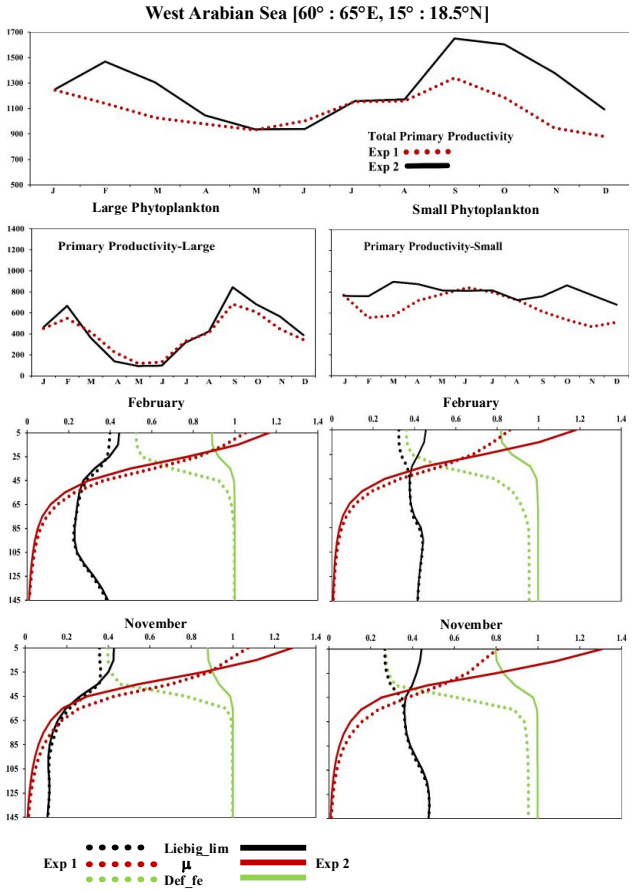


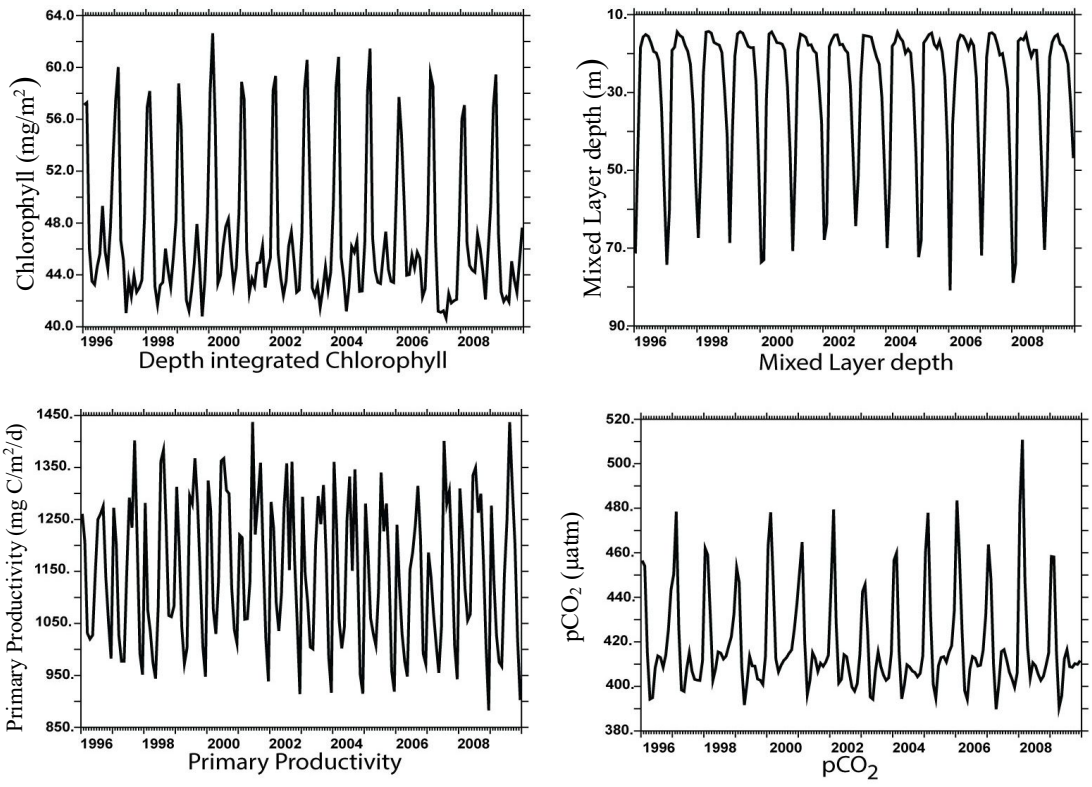
Figure 1.1 Comparison of Primary Productivity (mgC/m²/d) and Terms related to Specific Growth Rates of Large and Small Phytoplankton from model simulations Exp (1) and Exp (2) in the west Arabian Sea

To understand the effect of iron limitation parameter on the primary productivity, detailed analysis of the deficiency of Iron (through chlorosis factor which is a function of Fe:N ratio, which modulates Chl:N ratio), Leibig Limitation for nutrient uptake, Specific Growth rates for Large and Small Phytoplankton are carried out. It is noted that if $(Fe:N)_{irr}$ is decreased, Chlorosis is increased (i.e., iron limitation is reduced), specific growth rate for large and small phytoplankton are increased during some months and at some regions in the Arabian Sea which is reflected in the increase of primary productivity for both large and small phytoplankton. Figure 1.1 shows the terms which are responsible for determining the

Specific Growth Rate of Phytoplankton for two numerical simulations with different values of $(Fe:N)_{irr}$ namely, Exp(1) and Exp(2) for one region in the west Arabian Sea. It is clearly seen that when primary productivity is higher for Exp(2) compared to Exp(1) in west Arabian Sea, specific growth rate and chlorosis are higher for both large and small phytoplankton and also, the effect of iron parameter is higher for small phytoplankton compared to large phytoplankton. It is also noted that there is no change in primary productivity when $(Fe:N)_{irr}$ is decreased in the east of 65° E in the Arabian Sea. This study has shown that primary productivity and chlorophyll increase, nitrate and pCO_2 decrease during January-March and September-December, when iron limitation is reduced in the north and north-west regions of the Arabian Sea. But in the east Arabian Sea and regions of Arabian Sea south of 10º N, primary productivity, chlorophyll, nitrate, pCO_2 and carbon flux did not show any change when iron limitation is varied (figure not shown). Further analysis on the parameters and processes related to primary productivity of large and small phytoplankton need to be carried out to understand the limitations due to different micro and macro nutrients.

1.2 Carbon cycle studies of the Indian Ocean using ocean biogeochemical model simulations and observations

Simulations of global ocean biogeochemical model (TOPAZ) is used to study the influence of ocean physics on various biological and chemical processes in the north Indian Ocean. The model is integrated using different sets of forcing products to study the effect of thermal structure and ocean circulation on seasonal variations of productivity, nutrient transport and pCO_2 in the north Indian Ocean. Results of the simulations have been validated against available data (ARGO, MODIS, SeaWiFS, World Ocean Atlas etc.) on temperature, salinity, mixed layer depth, pCO_2, chlorophyll, primary productivity, nitrate and oxygen, for seasonal, interannual and annual variations to ascertain the model's capability to reproduce many of the significant features in the Arabian Sea (AS) and Bay of Bengal. Figure 1.2 shows the monthly variations of depth integrated chlorophyll, mixed layer depth, primary productivity and pCO_2 in the North Arabian Sea (Region:60°-66°E Longitude, 22.5°-24.5° N Latitude) for the period 1996 to 2009. It is observed that the mixed layer is deep in the north Arabian Sea, and influences the distribution of phytoplankton biomass and primary production. Also, the variations of depth integrated chlorophyll, primary productivity alters pCO_2 in this region.



Region: 60°-66°E, 22.5°-24.5°N

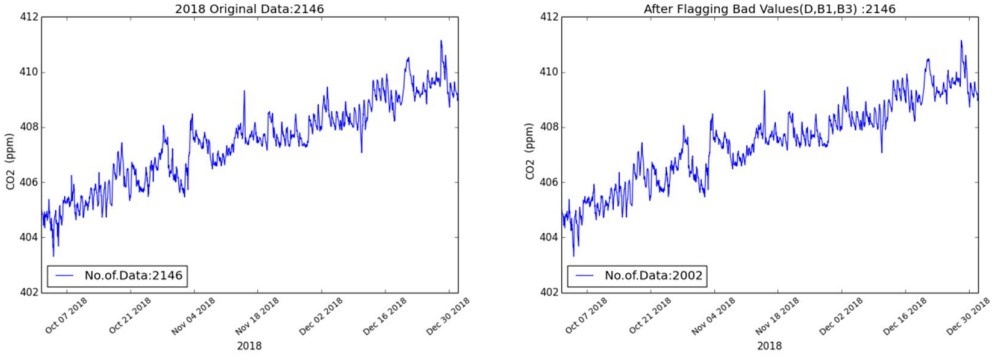
Figure 1.2 Monthly variations of Depth Integrated Chlorophyll (mg/m^2), Mixed Layer Depth (m), Primary Productivity (mgC/m^2/d) and pCO$_2$ (µatm) in the North Arabian Sea (Region: 60°-66°E Longitude, 22.5°-24.5° N Latitude) during 1996 to 2009

1.3 Greenhouse Gases (GHG) Data Collection and Processing

Data collection at Hanle was resumed in Oct 2018 after the installation of the repaired Picarro G2301 instrument. The station is at a height of 4500 m and its elevation and surroundings (dry desert) are quite comparable to Mauna Loa, which is at a height of 3400m surrounded by volcanic lava with very little vegetation. The station is ideally suited to be a baseline station where the background GHG concentration can be monitored. We have applied the same technique that NOAA applies to process the data to extract the background signal. If two adjacent hourly averages differ more than 0.25 ppm, they are both discarded. Daily averages are computed for each month and a least squares spline is fit through this data. Outliers (2sigma) of hourly data from this curve are omitted and the process is iterated till no more data is excluded. Figure 1.3 shows the processing of CO_2 data for three months from October to December 2018.

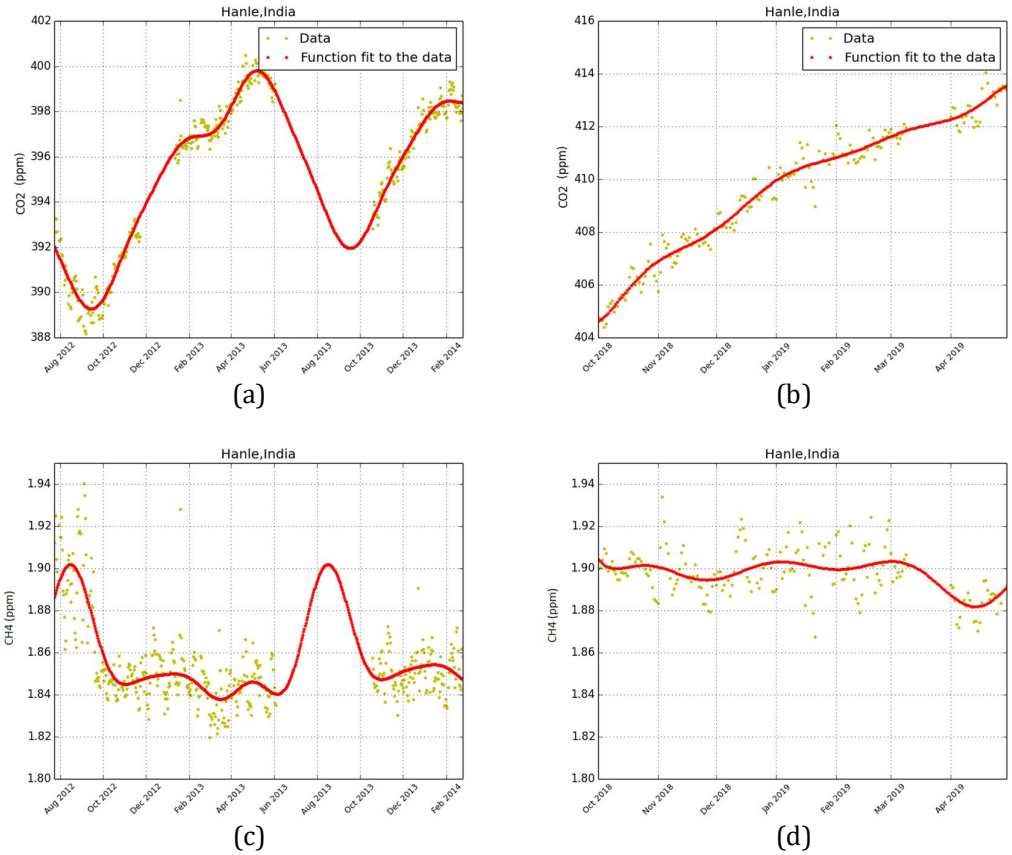
The data points that survive this data selection are considered in the next step where a curve of a quadratic polynomial and two harmonics is fitted. Around 93% of the data survive after the data selection in Hanle after removal of local effects. The residuals from this fit are band pass filtered using FFT and its inverse is added to the least squares curve. This final

signal is taken to represent the baseline CO_2 values at Hanle. The processing of methane (CH_4) data is similar but the cut-offs are much smaller. Figure 1.4 shows daily averages of CO_2 and CH_4 data selected after the above procedure and the final curve fit.



(a) (b)

Figure 1.3 (a) Values before the data selection (b) Selected data after considering hour to hour difference and standard deviation cutoff for further processing



(a) (b)

(c) (d)

Figure 1.4 (a) Past data fit of CO_2 for 2012-2014 (b) CO_2 data fit from October 2018 onwards (c) CH_4 data fit for 2012-2014 (d) CH_4 data fit from October 2018 onwards

The GHG station at Hoskote has been operating since Nov. 2016 and we have a continuous record for nearly the whole period. However, the station is not isolated from local influences as Hanle. The extraction of background signals at Hoskote is much more complicated as we

try to exclude the effects of local sources and sinks. Figure 1.5 shows processing of CO_2 data in Hoskote for 2017 as a representative.

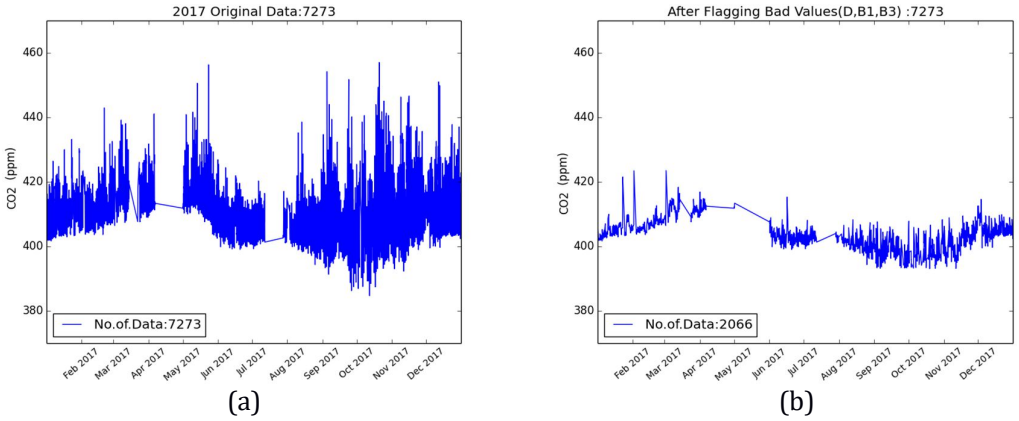


Figure 1.5 (a) Data before the selection (b) Data selected after considering hour to hour difference and standard deviation cutoff for further processing.

Further the CO_2 data processed in Hoskote is represented in Figure 1.6 to show different criteria for flagging values viz. Night time data, hourly variability, standard deviation cutoff, outliers. After applying the selection process described earlier, less than 20 percent of the data survive for further processing.

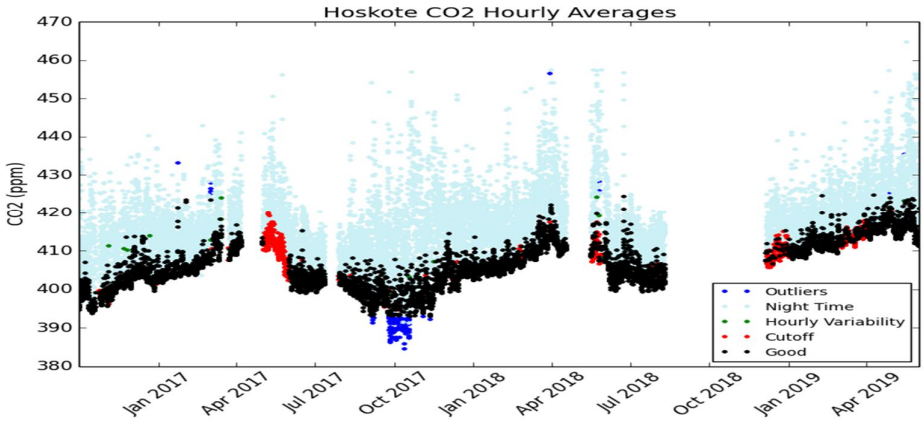


Figure 1.6 Representation of CO_2 data in different categories

In Hoskote, Methane (CH_4) is also measured by the same instrument whereas Carbon monoxide (CO) and Nitrous oxide (N_2O) are measured by another instrument LGR. A similar procedure for data selection and curve fit is applied to these data as well. Figure 1.7 shows the daily averages of the selected data of CO_2, CH_4, CO and N_2O and the final curve fit obtained by the procedure as explained earlier for the processed data for 2016-19.

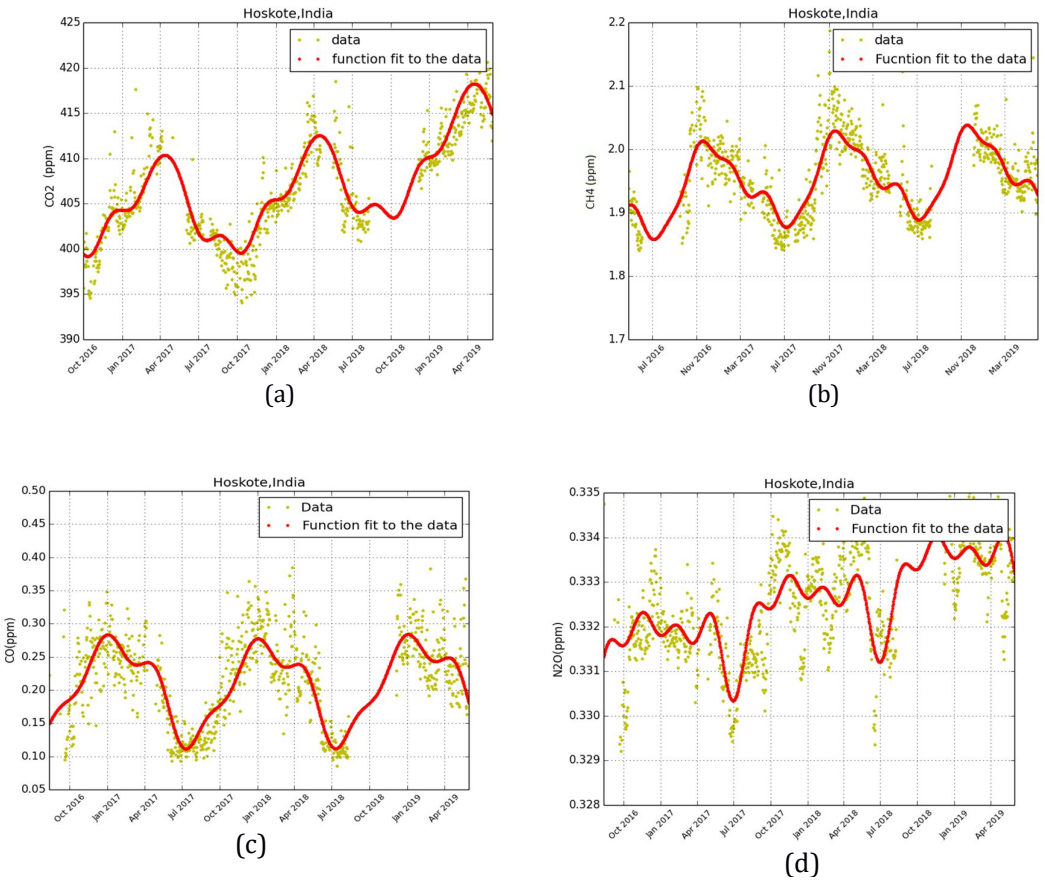


Figure 1.7 (a) CO_2 data is represented with the function fit (b) CH_4 data is represented with the function fit (c) CO data is represented with the function fit (d) N_2O data is represented with the function fit

Data collection at Pondicherry was resumed in March 2019 after the Picarro instrument was replaced with a new repaired one. The CO_2 and CH_4 data are under process.

The GHG station at Hoskote is also equipped with primary cylinders supplied from NOAA. The two instruments measuring these GHGs are calibrated with a set of secondary cylinders which are called working standards. These secondary cylinders are calibrated with the NOAA primary cylinders once a year.

Table 1.1 gives the comparison between the calibrated values for all the six secondary cylinders in 2017 and 2018 for each of the four species that are measured. It is seen that the cylinders are very stable as there has been very little drift in the values between the two years.

Using the short target values measured by the instrument after every measurement cycle of the ambient air, it is interesting to see that the measurement is very stable and the instrument has not drifted.

Table 1.1 Comparison of the calibrated values of secondary cylinders done in 2017 and 2018

Species : CO2 (ppm)

TANK	CYLINDER	Calibrated value 2017	Calibrated Value 2018
		CO2 (ppm)	CO2 (ppm)
CAL 1	D300571	372.11175198	372.101360041
CAL 2	D300560	402.345977102	402.33697978
CAL 3	D300567	423.088349966	423.091939458
CAL 4	D300559	483.357980321	483.366888558
TGT_LG	D300572	461.189882606	461.197281736
TGT_ST	D300562	402.404705726	402.418704366

Species : CH4 (ppb)

TANK	CYLINDER	Calibrated value 2017	Calibrated Value 2018
		CH4 (ppb)	CH4 (ppb)
CAL 1	D300571	1831.46671208	1831.77964386
CAL 2	D300560	1926.54621005	1926.74516346
CAL 3	D300567	2127.15906146	2127.32374738
CAL 4	D300559	2424.27975298	2424.62790278
TGT_LG	D300572	2322.28630188	2322.10150743
TGT_ST	D300562	1926.75812441	1926.92472519

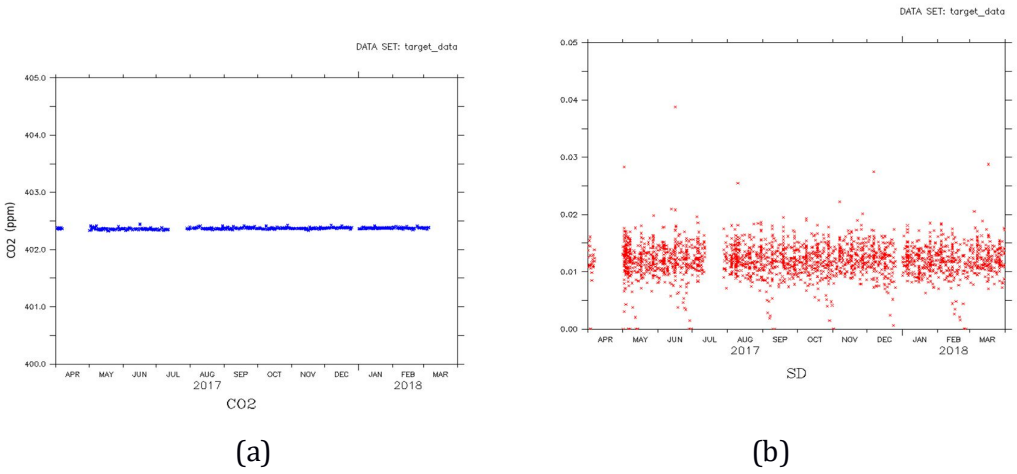
Species : CO (ppb)

TANK	CYLINDER	Calibrated value 2017	Calibrated Value 2018
		CO (ppb)	CO (ppb)
CAL 1	D300571	52.653245716	53.5441083586
CAL 2	D300560	100.529999052	101.11639529
CAL 3	D300567	250.977132704	251.193593545
CAL 4	D300559	496.340578348	494.997452872
TGT_LG	D300572	496.713380831	494.89882726
TGT_ST	D300562	153.615536353	154.748998853

Species : N2O (ppb)

TANK	CYLINDER	Calibrated value 2017	Calibrated Value 2018
		N2O (ppb)	N2O (ppb)
CAL 1	D300571	318.179357735	318.328337649
CAL 2	D300560	337.761495567	337.173362327
CAL 3	D300567	342.93842041	342.346346422
CAL 4	D300559	358.68563159	358.292213299
TGT_LG	D300572	349.373881061	348.789229332
TGT_ST	D300562	336.528950158	336.061861005

Figure 1.8 shows the instrument measuring CO_2 for the short target cylinder, having 402.4 ppm of concentration of CO_2, over three months is very stable. The same is true for all the other three species and hence both the instruments are very stable.



(a) (b)

Figure. 1.8 (a) Short Target of CO_2 in Hoskote (b) Standard deviation of minute means of CO_2 for short target

2

CLIMATE & ENVIRONMENTAL MODELLING

The research activities of Climate and Environmental Modeling Programme (CEMP) have been aimed at providing solutions to weather and climate-related problems to minimize their adverse impact on the environment and public. Major research activities of CEMP are: Monsoon, Climate and Weather Informatics, Smart Agriculture, Modelling the impact of climate and weather on epidemiological diseases (Malaria and Chikungunya), and hydro-meteorological disasters. Group activities are also aligned with missions of Government of India such as Samarth Bharat and Swasthya Bharat. The team carries out its research and analysis through open-source codes, state-of-the-art models (LAMs, GCMs, and NWPs), in-house algorithms and visualization tools, field and satellite data sets.

Inside

2.1 Evaluation of WRF simulated multi-level soil moisture, 2m air temperature and relative humidity with in-situ observations over India

The skill of Weather Research and Forecasting (WRF) model in simulating multi-level soil moisture, 2m-air temperature (T_{2m}) and 2m-relative humidity (RH_{2m}) is evaluated over five different locations in India. The WRF model simulations were carried out for 30 cases during different seasons with two different land surface schemes (Noah and RUC). The simulations were compared with in-situ observations which were deployed to routinely measure at 30-minute time interval over the selected five locations. Statistical evaluation showed that though the model could simulate soil moisture reasonably well (majority of the cases fall in <25% relative error (RE) category) at different depths over Delhi and Gulbarga, the model errors were high (most of the cases fall in >50% RE category) over Almora, Hyderabad and Cochin (Figure 2.1). In case of T_{2m}, model errors were high (RE > 15%) over the hilly terrain like Almora, while errors were relatively less (RE < 10%) for plane areas like Hyderabad, Gulbarga, Delhi, and Cochin. In general, the diurnal variation showed that the model underestimated (overestimated) afternoon temperatures during non-rainy (rainy) days. The RH_{2m} were also well simulated by the model over the locations Hyderabad, Gulbarga, and Cochin, though it underestimated RH_{2m} during morning hours over the locations of Almora and Delhi.

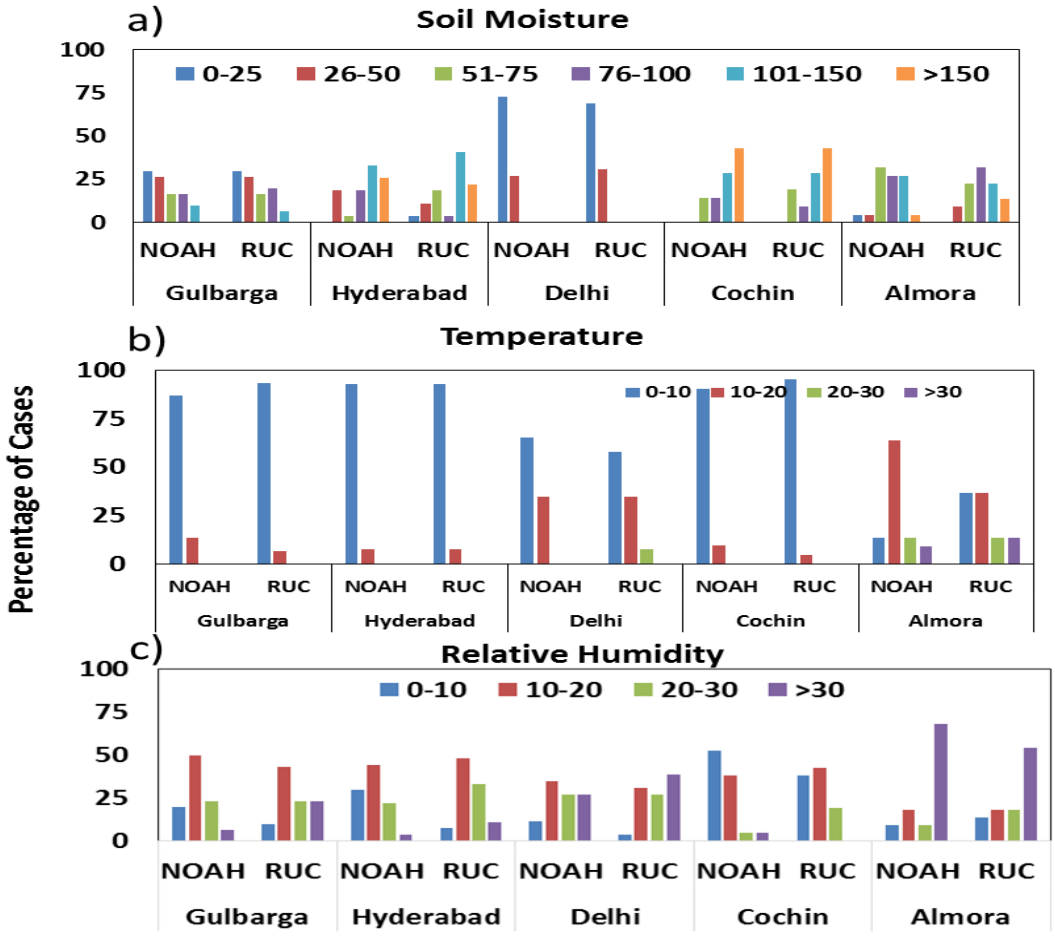


Figure 2.1 Percentage of cases in different error bins for the parameter surface soil (a) moisture, (b) temperature, and (c) relative humidity

2.2 Sensitivity of WRF model simulated urban thermodynamic features to microphysical parameterizations

In this study, the sensitivity of the WRF model simulated thermodynamic features associated with extreme rainfall events to mycrophysical parameterizations in the model are examined over the Bengaluru city. The thermodynamic indices like CAPE (Convective Available Potential Energy) and K-Index are calculated from the model at 0600 UTC (11:30) IST and 1200 UTC (17:30 IST) for each case over Bengaluru city from domain 4 (1 km resolution) and are verified against observations from the FNL data. For the evaluation of forecasted thermodynamic indices, a number of standard evaluation parameters such as bias and relative error of forecasts with respect to FNL observations were computed. Analyses showed that while the model could reproduce the observed distribution of stability indices and thereby the rainfall for non-localized EREs, it differed from observation for many localized ERE cases. We have also examined the sensitivity of model results to different microphysical parameterization schemes in WRF model and results showed that in the case of CAPE, among the schemes tested, the MP16 and MP7 schemes showed lower bias and relative error. For CAPE, all the schemes, particularly MP10 and MP7, showed lower percentage errors in case of local EREs (06 Hr) (Figure 2.2), while the MP7 and MP10 schemes produced better results (12Hr) for local EREs.

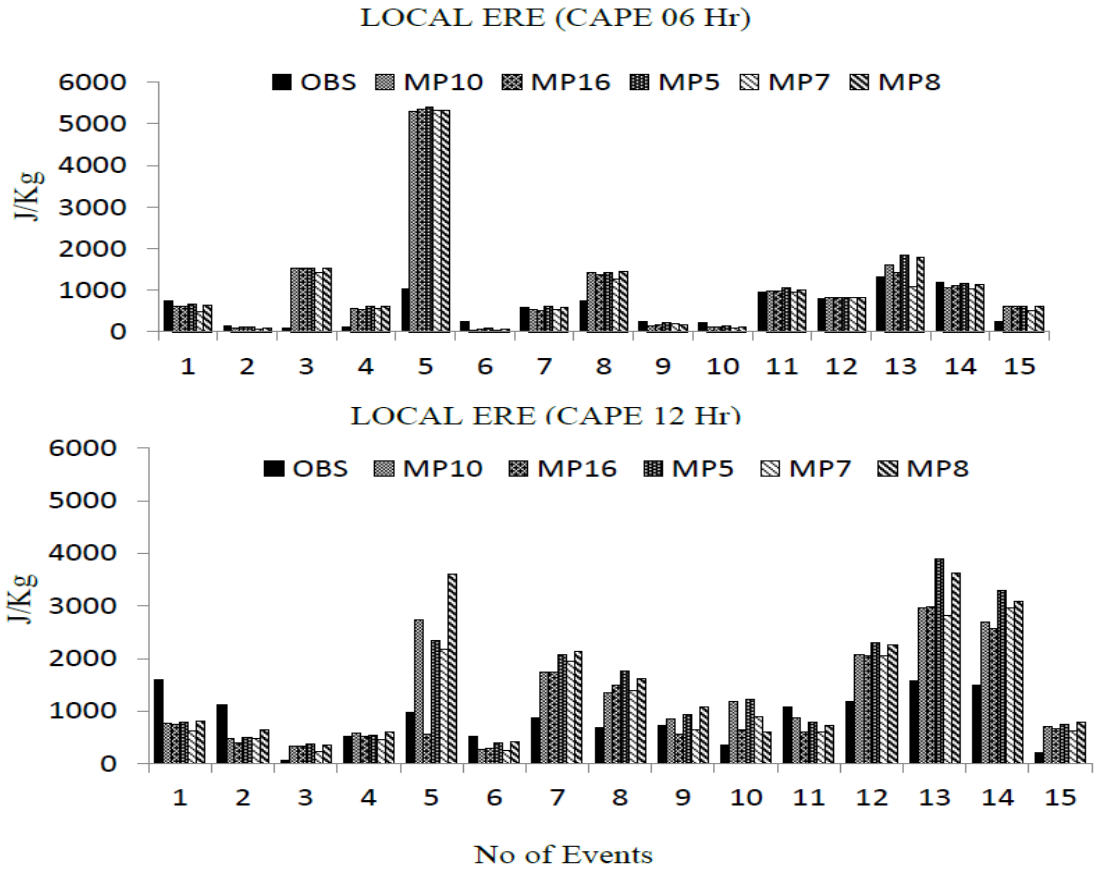


Figure 2.2: Observed and model simulated Convective Availability of Potential Energy (CAPE in J/Kg) for 06 hour (top) and 12 hour (bottom) averaged over Bengaluru city with different micro-physics scheme.

2.3 Temperature dependent model to predict Chikungunya epidemic in India.

The risk of Chikungunya transmission in recent years of climate is gradually increasing in India. This work has been carried out in collaboration with CSIR-IICT, Hyderabad to develop a mathematical model to predict the Chikungunya epidemic in India. During 2016, Delhi experienced an epidemic caused by Chikungunya virus with more than 12,000 cases. Similarly, other parts of India also reported a large number of Chikungunya cases, the highest incidence rate was observed during 2016 in comparison with the last 10 years of epidemiological data (Figure 2.3). The model developed in the present study using empirical estimates the effects of the temperature range for optimal transmission of Chikungunya by predicting pathogen traits and entomological factors. This temperature-driven model provides regions risk for Chikungunya transmission and regions predicted for likely occurrence of disease outbreaks in India. The model described here helps in public health preparedness and vector management operations in predicted risk zones of Chikungunya well in advance.

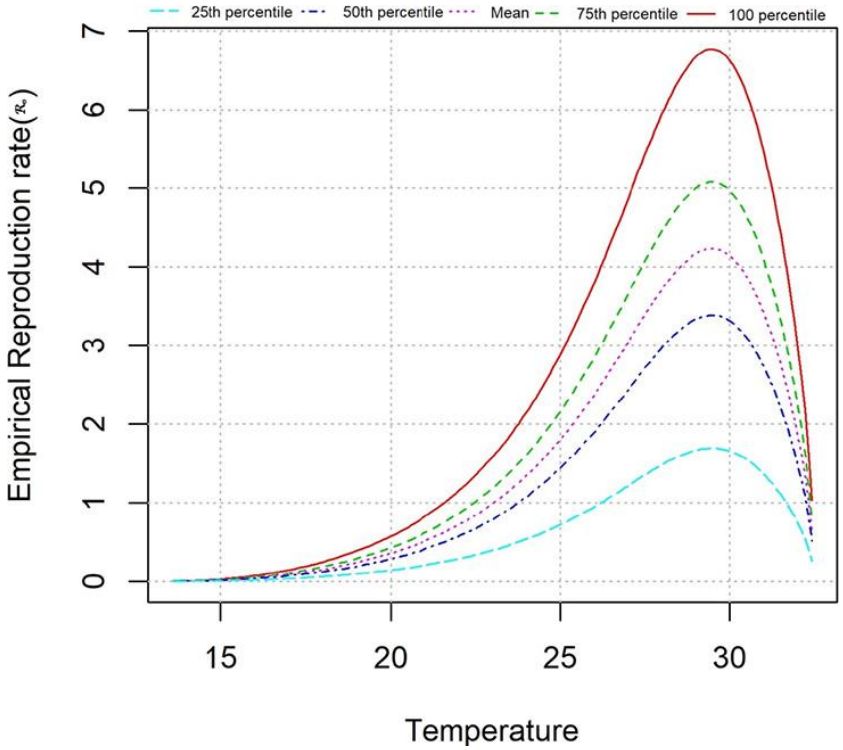


Figure 2.3 Variation of Empirical reproduction rate with temperature for Chikungunya

2.4 Land-use changes in megacities and their impact on the dynamics of heavy rainfall

This is one of the case studies of the impact of land-use changes and urbanization on the processes and mechanisms of a heavy rainfall event that occurred over Bengaluru. The analysis is based on high resolution (2 km), time-ensemble simulation of one of the heaviest rainfall events that occurred on 27th May 2017. The simulations are carried out using Weather Research and Forecasting (WRF4) model that is coupled with a single-layer urban

canopy model (UCM). The high resolution (30s) land use data derived from Indian Space Research Organization (ISRO) with the reference date of 2017 is shown to be realistic in representing the current land-use scenario with a three-fold increase in urbanization when compared to USGS land-use data which has the reference date of 1992 as shown in Figure 2.4. Simulation and analysis of large-scale circulation pattern revealed that the event was triggered and sustained by the low-pressure system and cyclonic circulation over the Bay of Bengal. Simulated rainfall was found to be remarkably sensitive to land-use changes as shown by control (USGS) and test (ISRO) simulations. The simulated rainfall intensity and spatial distribution are close to observation in test simulations with relatively less error in 24-hr averaged rainfall (9%) when compared to control simulations (32%), indicating the importance of realistic representation of land-use in the model and its impact on rainfall processes. The surface energy fluxes and thermodynamic indices as shown by test simulations are consistent with the current land-use scenario with increased urbanization and found to be favorable for heavy rainfall events. This study has clearly demonstrated and quantified the impact of urbanization on land surface processes (latent heat flux, sensible heat flux, surface temperature, diurnal temperature), on circulation (horizontal & vertical draft), and rainfall. Urbanization is found to significantly contribute to the intensification of rainfall, urban heat island effect, and increase in diurnal temperature change. It is also shown that a realistic representation of the current land-use pattern is crucial in improving model skill and forecast reliability of heavy rainfall events over megacities.

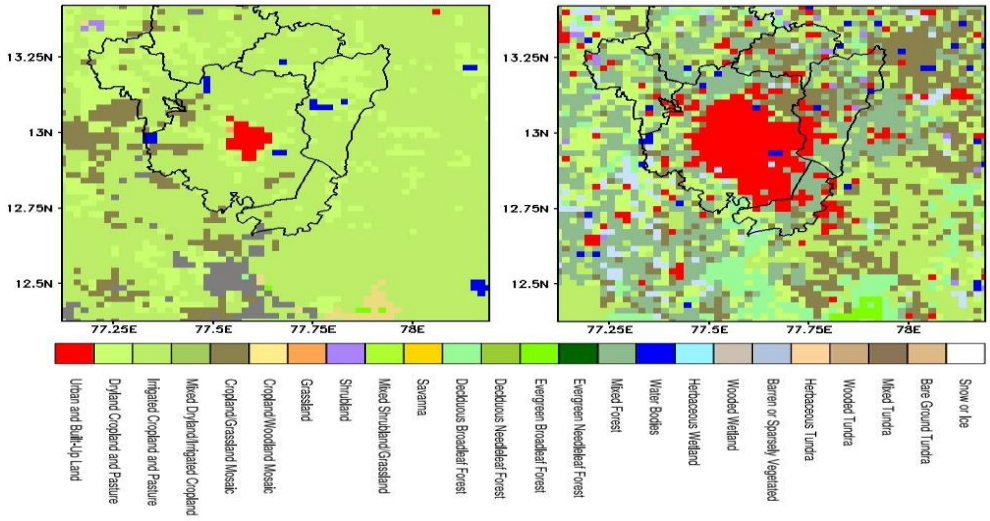


Figure 2.4 High resolution land-use pattern over Bengaluru; USGS (left) and ISRO (right) used in WRF-UCM for rainfall simulation. A three-fold increase in urbanization over the central region of Bengaluru between 1992 and 2017 is evident in the right panel

2.5 High resolution long-range dynamical forecasting of Indian monsoon 2018

The date of onset of monsoon (DOM) with the first sustained and significant rainfall over Kerala signifies the arrival of the main agricultural season in India. Thus, accurate and advance prediction of DOM can help agricultural planning like preparation of land and sowing schedule. However, advance dynamical prediction had been traditionally considered unfeasible as DOM involves highly chaotic rainfall variability. For 2018, the CSIR-4PI forecast of the date of Onset of Monsoon matched exactly with the date announcement by IMD i.e. 29th May 2018.

Following its standard procedure, CSIR-4PI issued its experimental forecasts of monsoon 2018 in early April, 2018. There is very good agreement between distribution of monthly and seasonal rainfall from forecast and observation; there are only a few regions of errors. Out of the 24 cases (six sectors, three months and one season for each), the categories (Excess/Normal/Deficit) forecasts match observations for almost 15 cases as presented in Table 2.1.

Table 2.1: Comparison of the forecast and observation of 2018 monsoon rainfall both at monthly and seasonal scale for the different regions over India

Region	Extent	June		July		August		Jun-Aug	
		Model	Obs	Model	Obs	Model	Obs	Model	Obs
All India	Continental land	N	N	N	N	D	N	N	N
North India	(72-84°E, 24-30°N)	N	N	N	N	D	D	D	N
South India	(75-78°E, 8-12°N)	N	N	D	N	N	N	N	N
Central India	(72-84°E, 20-28°N)	D	N	N	N	D	D	N	N
North-East India	(92-96°E, 24-30°N)	D	D	E	D	D	D	D	D
North-West India	(68-75°E, 24-30°N)	D	N	E	N	N	D	N	D

3

HIGH PERFORMANCE COMPUTING & CYBER SECURTY

CSIR-4PI has been providing state-of-the-art High Performance Computing (HPC) facility to the computational scientists and researchers of CSIR to address significant problems in their frontier areas of science and engineering. The centralized HPC facility located at CSIR-4PI is operational on a 24x7 basis with high uptime efficiency. The facility at CSIR-4PI is one of the top supercomputers in the country and provides a computing platform suitable for multiple domain specific applications. All the CSIR laboratories access the facility through the high speed, National Knowledge Network with redundant path. In addition to providing the HPC facility, the group is also actively involved in research on various aspects of cyber security and cryptography. Extending the research carried out under the 12th Five Year Plan of CSIR, the team is participating in a Mission Mode Project of CSIR on Intelligent Systems in which the team is concentrating on the security and privacy issues in connected vehicles and biometric based transactions.

Inside

3.1 Cryptojacking in HTTP/2 Framework

Cryptojacking is a malicious activity in which compute resources are used for mining crypto currency without the consent of the owner of the resources. As the popularity and usage of crypto currency has been increasing rapidly, the resource requirement for mining them is also increasing proportionately. Consequently, Cryptojacking has emerged as a new security threat on the cyberspace. Identifying novel means of exploitations and countermeasures have become a topic of interest to cyber security community.

Typically, an adversary performs Cryptojacking either by hacking into the victim computer or by injecting malware with Cryptojacking code into the victim computer for auto-execution. Once injected, the code runs on the victim computer in the background and mine the currency silently.

In this work, we focus on an alternate way of performing Cryptojacking. In particular, we explore the feasibility of exploiting Internet middle-boxes (like open proxies, ToR exit points, etc.) for injecting Cryptojacking code. Note that the usage of open proxies for accessing the Internet has been increasing because of anonymity reasons. Many users, who prefer to use such services to hide his/her identity like Internet Protocol (IP) Address and physical location may become a victim of Cryptojacking.

We used a relatively simple experimental setup consisting of three entity: A client machine that acts as a base user; an anonymous open proxy server through which all the client communications passes; and an HTTP/2 web server that provides HTTP/2 service to the client machine. The proxy component was modified to inject the Cryptojacking code into the client in a seamless manner. For this, the proxy intercepts the response from the HTTP/2 webserver, modify the html page and insert the java script containing the malicious code. Neither the client nor the server is aware of the code injection process. The client browser just displays the original html page served by the HTTP/2 webserver, and the Cryptojacking code execution is not visible on the browser.

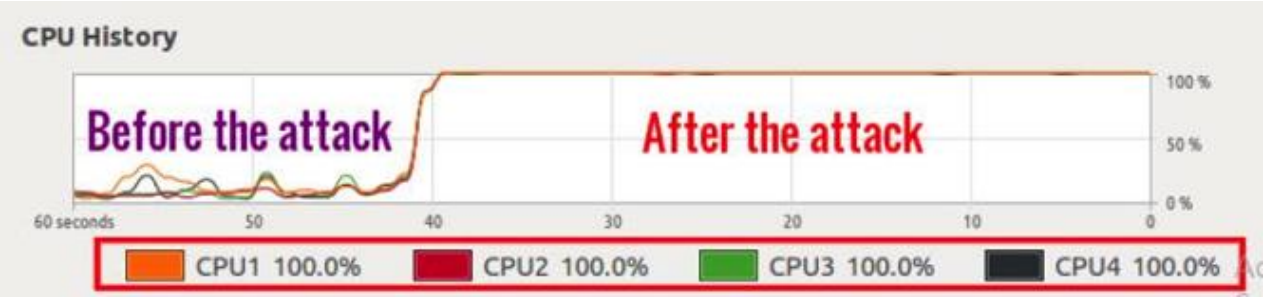


Figure 3.1 CPU Utilization of the client before and after the Cryptojacking Attack. The axes X and Y, respectively, show the running time and percentage of CPU utilization

In Figure 3.1, we capture a running screen-shot of the CPU utilization of the client. As seen in the Figure, before the code execution, the CPU utilization was small and mainly used by the Operating System and some default daemons. Once the Cryptomining is started, the CPU utilization of all the four CPUs has gone to 100%. The only indication that a careful user will have is that the system response is relatively slow.

3.2 Tree parity machine based group key agreement protocol

There are large number of network applications that involve multiple users and demand security. Hence, there is a need to develop multi-party key exchange that can provide secure communication among parties. In this work we have extended Tree Parity Machine (TPM) based key exchange to group based key exchange. Here, each participant is treated as a node of a binary tree, holding his or her own TPM. Each participant starts a synchronization/learning process, with his or her sibling partner at the lowest layer. At the end of synchronization, the siblings act as the parent and again participate in synchronization with their sibling in the next upper layer. The synchronization process moves upwards in the binary tree, till the root is reached. This indicates that all the participants have the same synchronized key to participate in the multi party application. Figure 3.2 shows the mean synchronization step for different number of participants. The figure shows the difference between, the traditional ring structures with our proposed binary tree structure. It is clear that the tree based mechanism takes less learning steps to generate a group key.

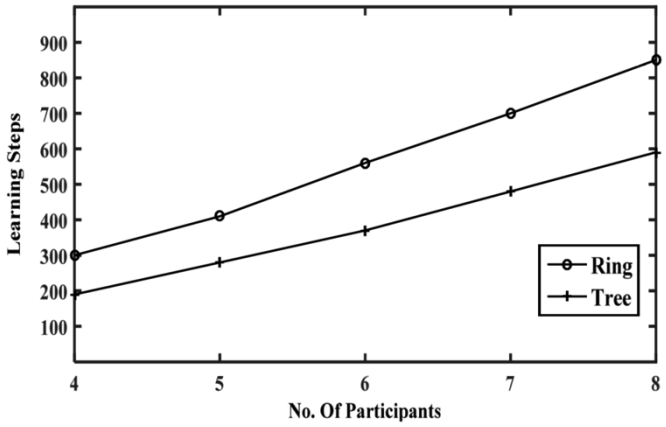


Figure 3.2 The mean synchronization steps with different number of participants between ring and tree based group key agreement for same TPM structure

3.3 High Performance Computing

The “Ananta” Supercomputer (Figure 3.3) continues to serve the CSIR computational science community tirelessly for the 6th year in a row as the centralized facility. The computational workforce got a major boost with the addition of 127 TF of additional computational capability powered by 48 numbers of Intel Skylake processor based nodes.

Figure 3.3 CSIR centralized 489 TF High Performance Computing Facility

With this upgrade, the system currently has the capability to carry out about 489 Tera floating-point operations in a second. The sustained performance using a High Performance LINPACK (HPL) is about 334 TF for the original system and 84 TF for the additional nodes and the system continues to be the largest Supercomputer of CSIR. In addition, the centre also hosts an Altix-ICE medium range HPC along with a hierarchical storage infrastructure.

Currently listed as the 9th fastest system in the country, the supercomputer Ananta, is a cluster consisting of 1088 computing nodes (two numbers of Intel Xeon E5 2670, 8 core processors each) and 48 numbers of upgraded nodes

(two numbers of Intel Xeon Gold 6140, 18 core processors per node), distributed over 18 racks. While the original system has 64 GB per node, the upgraded nodes have 192GB memory per node. This amounts to about 77TB of distributed memory for the total system. The inter-node communication is powered by high speed FDR (for original nodes) and EDR (in the upgraded nodes) infiniband providing a dedicated 56 and 100 Gbps interconnect bandwidth respectively. However, both the set of nodes access the common LUSTRE parallel file system of about 2.1 Peta Byte of usable capacity, which is capable of providing a minimum of 20 GB/s simultaneous read and write performance. PBS Pro workload manager ensures efficient usage of the system.

One of the reasons of “Ananta” Supercomputer providing un-interrupted service for more than 6 years is due the Tier-3 equivalent state-of-the-art data center along with the state-of-the-art energy farm. The highlight of the datacenter is the water based cooling mechanism called Rear Door Heat Exchangers (RDHx) that has resulted in providing one of the best power efficient and high-density datacenter (Power Usage Efficiency (PUE) of less than 1.5) in the country. The energy farm consists of two numbers of redundant compact substations of 1.25MVA, three numbers of 1010 KVA diesel generators, an underground diesel yard (more than 15000 liters) and three numbers of UPS with battery backup for ensuring 24x7 power supply to the datacenter.

4

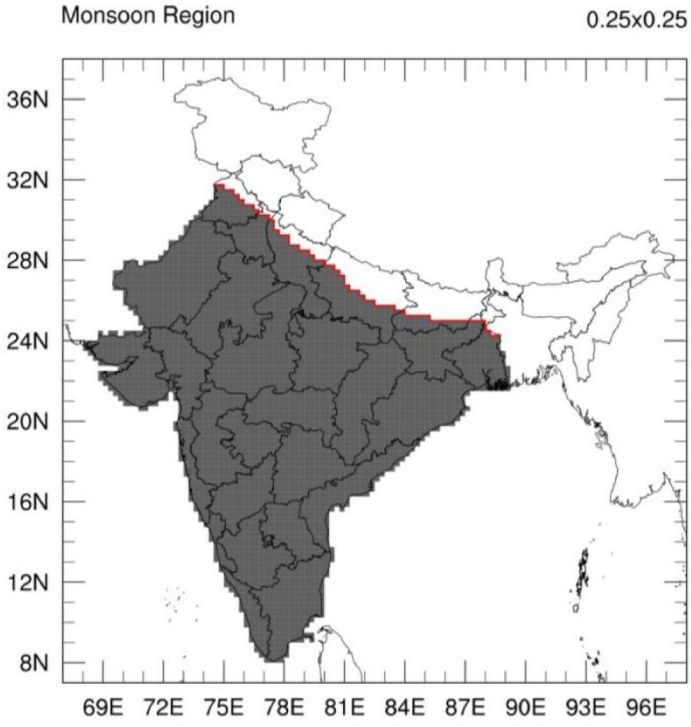
MULTI-SCALE MODELING PROGRAMME

This is a data intensive paradigm which addresses multiscale problems ranging from weather and climate, century-scale climate projections, space-based geodesy, computational geodynamics, surface processes and climate aspects from surface to ionosphere. Development of system models and carrying out the simulations, formulation of algorithms for analysis of simulations and deriving inferences in the field of climate sciences, lithosphere-hydrosphere-atmosphere-ionosphere interactions and computational geodynamics, are the major foci of the group. In weather and climate studies, General Circulation Models (GCMs), coupled ocean-atmosphere climate model and earth system model with emphasis on processes such as multiscale organization of organized convection and aerosol-cloud-radiation feedbacks, are employed. Computational geodynamics and space-based geodesy research are on multi-scale earthquake dynamics, land-form evolution processes, multi-scale modelling of deformation processes and seismo-ionospheric coupling.

Inside

4.1 A new rain-based index for the Indian summer monsoon rainfall

Most of the studies of the observed variability of the Indian summer monsoon rainfall (ISMR), have involved analysis of an index for ISMR. In 2006 India Meteorological Department (IMD) derived a gridded rainfall data set at a resolution of 1^0 for the Indian region and subsequently in 2014, IMD has derived a finer resolution (0.25^0) rainfall data set for the same region. At present, these data sets are widely used by modelers to generate the 'observed' ISMR for assessment of the skill of their models. However, in different studies, different regions are used for averaging the grid data to obtain the 'observed' ISMR. For proper assessment and standardized comparison of the skill of the simulations/predictions by different models/versions, it is important that a standard region under the sway of Indian summer monsoon system be used for averaging the rainfall to obtain the observed ISMR.



We suggest what we consider as the appropriate regions for averaging the rainfall in terms of the 1° and 0.25° (Figure 4.1) to derive/represent ISMR, on the basis of the present understanding of the monsoonal regions and the Indian summer monsoon. We show that the interannual variation of the ISMR thus derived (by averaging rainfall over the regions identified in this study) from gridded data sets is largely consistent with the interannual variation of the indices used earlier studies.

Figure 4.1 Newly defined seasonal rainfall based Indian summer monsoon region for monsoon variability studies, at 0.25° resolution (shaded)

4.2 Future projections of Indian Summer Monsoon under multiple RCPs using a high resolution global climate model multiforcing ensemble simulations

Greenhouse gases (GHGs) act as an external factor that affects Indian summer monsoon climate. Different Representative Concentration Pathways (RCPs) introduced in the Inter-governmental Panel for Climate Change Assessment Report 5 (IPCC AR5) viz. RCP 2.6, 4.5, 6.0 and 8.5 based on the emissions of GHGs in the atmosphere. Present climate simulations (1983-2003) of the model with three deep convection schemes and three initial conditions are analysed to choose the best scheme for simulating the mean ISM rainfall (ISMR) and its

variability. Multiforcing ensemble projections are carried out with the selected convection scheme, forced with four spatial patterns in future sea surface temperature (SST) changes under each scenarios. Further, multiforcing ensemble simulations of a global climate model at 60km horizontal resolution, under future (2079-2099) scenarios corresponding to RCP 2.6, 4.5, 6.0 and 8.5, are examined for ISM projections. Future changes in surface air temperature and rainfall show an overall increase over India (although with some spatial inhomogeneity for rainfall).

4.3 Aerosol-monsoon relationship on subseasonal timescales

Over India, low rainfall amounts during the droughts are found to be associated with high AOD as compared to decreased AOD in excess monsoon years. This is consistent with the understanding that increased wash out of aerosols occurs in wet regions, and aerosol life times are longer in dry regions. Given the rather short life time of aerosols, it is imperative to understand how the aerosols can possibly impact the prominent component of Indian summer monsoon (ISM) intraseasonal variability (ISV) by analyzing recent ground-based and satellite observations of aerosol and cloud properties, and India Meteorology Department (IMD) rainfall. Our analysis confirms the indirect effect of dust aerosols on intraseasonal time scales. These results are crucial and it is required to incorporate aerosol induced heating in models for proper simulation of ISV and thereby improved prediction of ISM.

4.4 Indian summer monsoon climate change projections: CSIR-4PI WRF RCM for dynamical downscaling versus CORDEX-SA RCMs

The high-resolution regional climate model (RCM) simulations are found to be an important to provide realistic climate change information at regional scale, which is useful for climate change impact assessments. We use the high-resolution dynamical downscaled simulations from CORDEX South Asia (SAS) domain to assess their skill in reproducing present-day mean and extremes of Indian summer monsoon (ISM). Although a few CORDEX RCM simulations exhibit improved regional characteristics of mean ISM, many fail to outperform their parent CMIP5 GCM and could be due to the low skill of the parent GCM. The climate change projection of mean ISM rainfall at the end of 21st century is estimated using RCP8.5 scenario simulations of CORDEX RCMs. Along with consistent surface temperature increase, the models project a future increase in ISM rainfall with large inter-model spread, which is similar to that seen CMIP5 models. The CORDEX RCMs are of the order of 50 km resolution, which still is not sufficient to resolve the small-scale features especially at highly complex orographic areas such as Western Ghats (WG) over the southern peninsular India.

4.5 Forecast of monsoon-2018 using CFSv2

Indian summer monsoon (ISM) forecasting has always been associated with sensitivity to initial conditions pertaining to the capricious behavior of climate system. This can be regarded as a classic example of prediction problem as first pointed out by E N Lorenz. Given the fact that

high resolution can take care of sub-grid scale processes which include the cloud and convection genesis within a climate model, it is imperative to look into the prediction with the right choice of initial condition as well. At CSIR-4PI, we took into account these factors and did an experimental forecast for the summer monsoon season of 2018 using the available computing facility at CSIR-4PI. A total of 14 initial conditions were derived and forecasts were carried out at a resolution which corresponds to a grid resolution of approximately 40km. A prediction is useful if it has sufficient lead time in predicting the monsoon season and so we took May initial conditions. Figure 4.2 shows the ensemble mean of 14 runs, June to September (summer monsoon) predicted rainfall (top panel) and the seasonal mean departure of monsoon rainfall (bottom panel). Forecast indicates below normal monsoon.

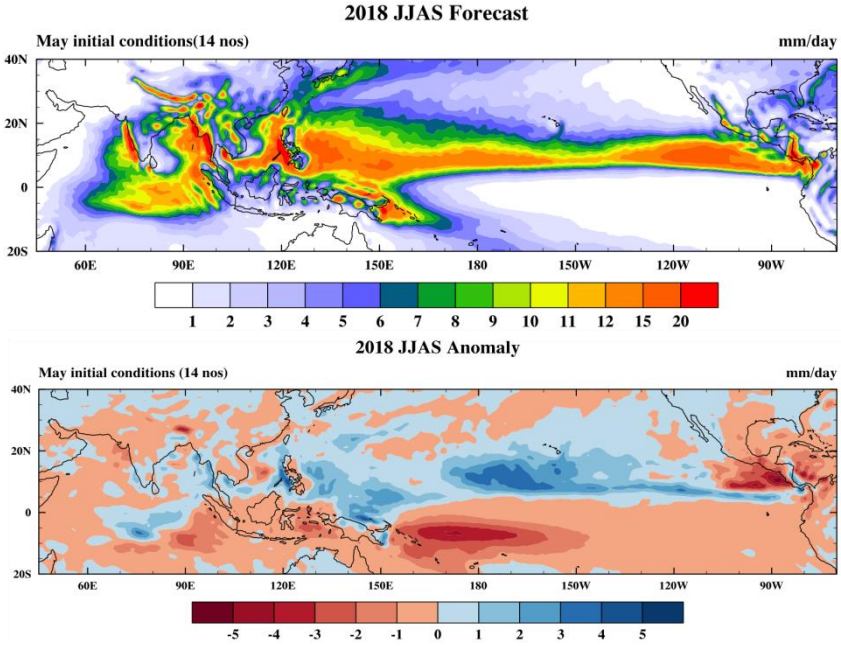


Figure 4.2 June to September mean (JJAS, summer monsoon) rainfall (top panel) and the seasonal (JJAS) mean departure of rainfall (bottom panel) for 2018, as predicted by the ensemble mean of runs with 14 May initial conditions

4.6 Global spread of ionospheric irregularities during the 17th March 2015 the St. Patrick's day geomagnetic storm

The St. Patricks day geomagnetic storm was triggered by an Earth directed Interplanetary Coronal Mass Ejection (ICME) associated with c9.1 class solar flare erupted from the active region of the Sun (AR 2297 at S22W29) on 11/03/2015 between 00:45 UT and 02:00 UT. This was the first geomagnetic storm of the 24th Solar cycle which reached a level of G4 on the NOAA scale (severe).

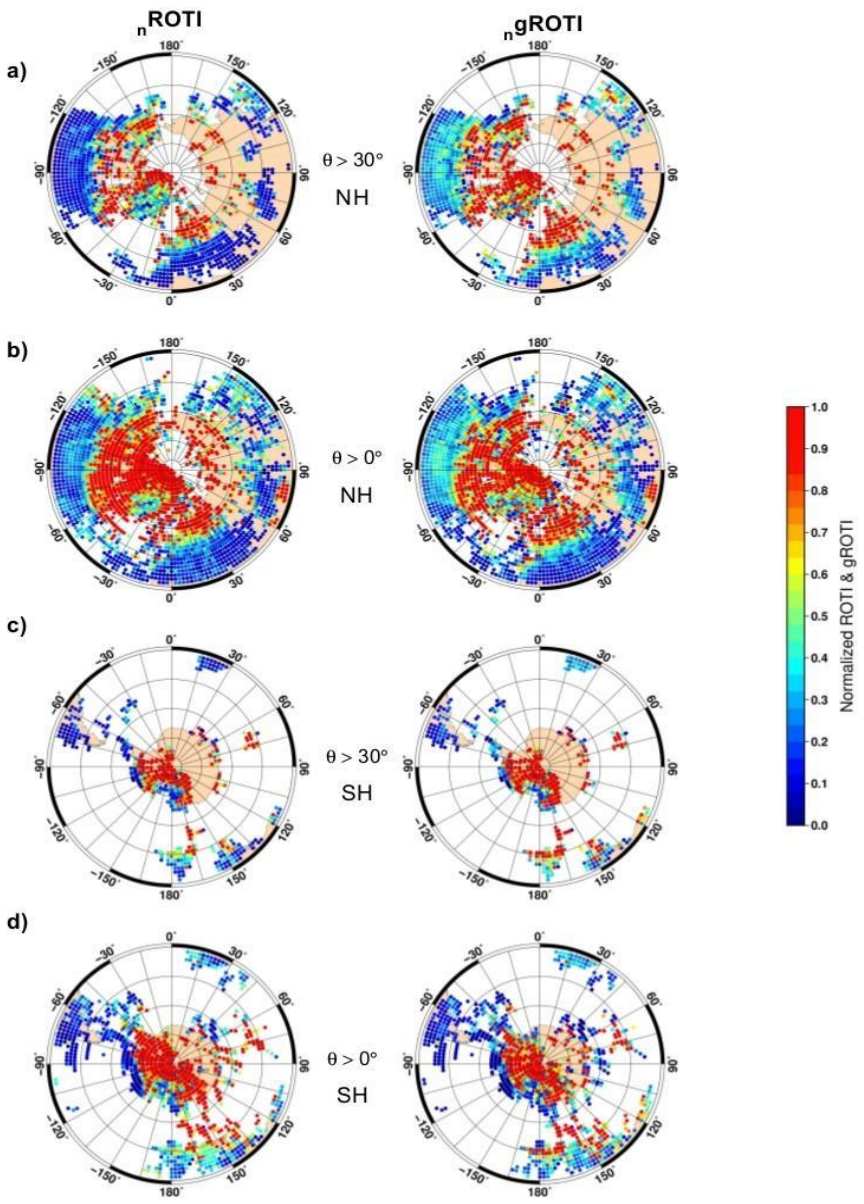


Figure 4.3 The variation of normalized value of ROT and gROT in the northern and southern hemisphere for a latitude range of 30° - 90° gridded with 1°x1° at 17-18hr of St. Patrick's day storm

The impact of the ionospheric irregularities caused by the St. Patrick's day storm was studied using dual frequency microwave soundings at ~13.7 million Ionospheric Pierce Points (IPP), which are intersections of GPS signals observed by 2,365 ground based dual frequency GPS receivers spread across the globe as part of IGS, CORS, and Australian networks during the St. Patrick's storm. De-aliased ROTI (Rate of TEC Index) maps were prepared using the gradient Rate of change of TEC (gROT) and conventional ROT (Rate change of TEC). The comparison of ROTI and gROTI shows that de-aliased ROTI maps can be used to increase the area of

coverage by >60% by including observations from all elevations without altering the signal. The de-aliased gROT map (Figure 4.3) with 1 degree x 1 degree resolution during 17-18 UTC on St' Patrick's day, the 17th March 2015, shows the strong ionospheric irregularities in both southern and northern hemisphere. The irregularities were intense at 17-18 UTC and it spread beyond the mid-latitude.

4.7 Establishing multi-scale modeling frame work for LAIC studies: Ionospheric General Circulation Model

The TIEGCM (Thermosphere Ionosphere Electrodynamics General Circulation Model) developed by High Altitude Observatory at the National Center for Atmospheric Research, USA was installed at CSIR-4PI MSMP computing platform as part of the Multi-scale modelling frame work for LAIC (Lithosphere-Atmosphere-Ionosphere Coupling) studies. TIEGCM is a three dimensional, time-dependent numerical simulation model of the Earth's upper atmosphere, including the upper Stratosphere, Mesosphere, Thermosphere and Ionosphere. This also includes a self-consistent aeronomic scheme for the coupled Thermosphere/Ionosphere system. The performance of the model was assessed by carrying out standard tests and benchmarking. The global ionospheric Total Electron Content (TEC) on 21st March 2012 simulated using TIEGCM with a spatial resolution of 0.25x0.25 degrees is given in Figure 2. The Equatorial Ionization Anomaly spread over the Indian region is well captured by the TIEGCM simulation (Figure 4.4). This newly established computing facility will enhance the capability to study the ionospheric coupling processes in detail.

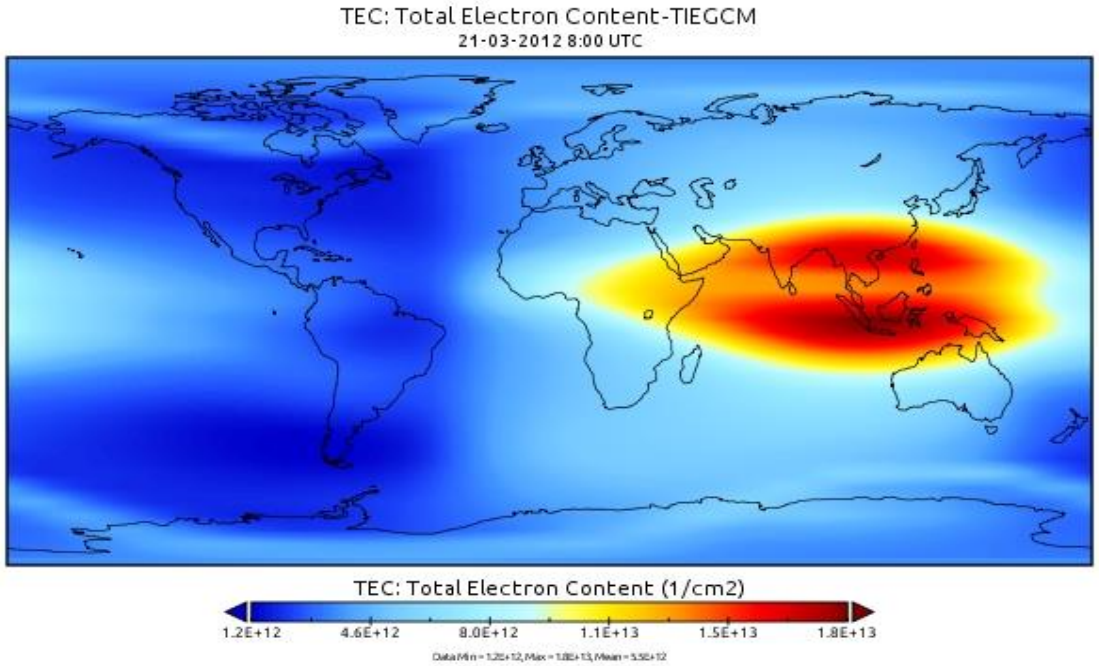


Figure 4.4 Total Electron Content on 21st March 2012 at 8 UTC simulated by TIEGCM

4.8 Noise characteristics of GPS time series and their influence on velocity uncertainties

Accurate geodetic crustal deformation estimates with realistic uncertainties are essential to constrain geophysical models. A selection of appropriate noise model in geodetic data processing based on the characteristics of the geodetic time series being studied is the key to achieving realistic uncertainties. The noise characteristics of a 12-yr long global positioning system (GPS) geodetic time series (2002–2013) obtained from 22 continuous mode GPS stations situated in north-east India, Nepal and Bhutan Himalayas, which are one of the most complex tectonic regimes influenced by the largest hydrological loading and impacted with a load of the largest inland glaciers, were studied. A comparison of the maximum log likelihood estimates of three different noise models – (i) white plus power law (WPL), (ii) white plus flicker law (WFL) and (iii) white plus random walk noise – adopted to process the GPS time series reveals that among the three models, ~74% of the time series can be better described either by WPL or WFL model. The results further showed that the horizontals in Nepal Himalayas and verticals in north-east India are highly correlated with time. The impact analysis of noise models on velocity estimation (Figure 4.5) shows that the conventional way of assuming time uncorrelated noise models (white noise) for constraining the crustal deformation of this region severely underestimates rate uncertainty up to 14 times. Such simplistic assumption, being adopted in many geodetic crustal deformation studies, will completely mislead the geophysical interpretations and has the potential danger of identifying any inter/intra-plate tectonic quiescence as active tectonic deformation. Furthermore, the analysis on the effect of the time span of observations on velocity uncertainties suggests 3 years of continuous observations as a minimum requirement to estimate the horizontal velocities with realistic uncertainties for constraining the tectonics of this region.

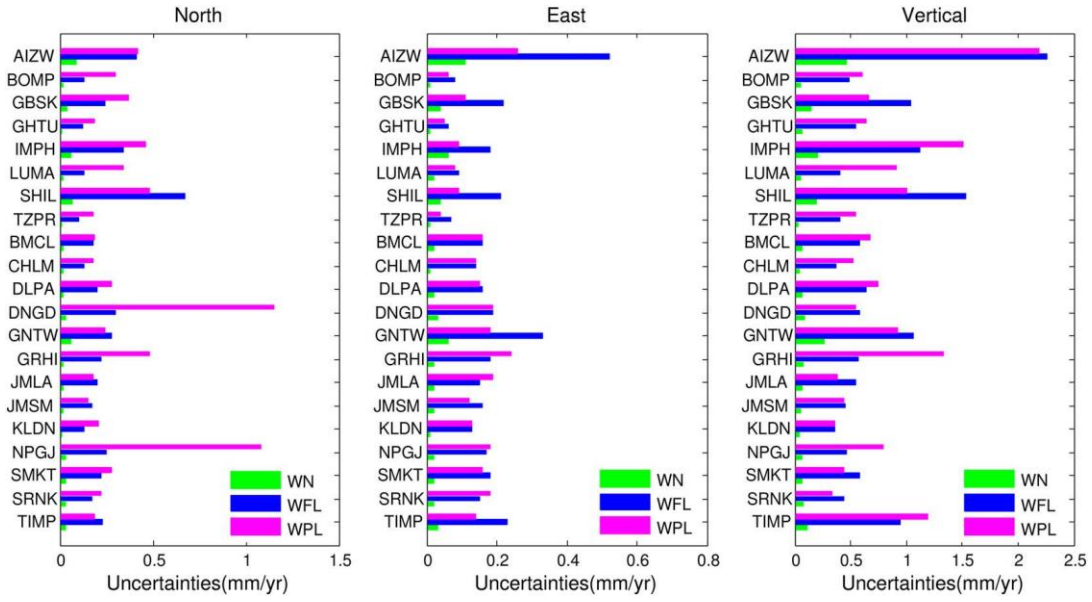


Figure 4.5 Velocity uncertainties obtained when adopting WN (white noise), WFL and WPL noise models

4.9 A reappraisal on the present-day stress field of the Indo-Burmese ranges: seismo-tectonic insights from faulting mechanisms

Contentious arguments are present in the available literature on the Indo-Burmese arc tectonics, which places the subduction there as relict, ceased, a seismically creeping or even fully locked. This leaves large uncertainties on the associated seismic hazard. Through this work, we re-examine the state of stress-field using available faulting mechanism data from this region. These data mostly represent the slab deformation of the sinking Indian lithosphere and the slip partitioning along the Sagaing fault. Our results show that the shallower slab features NNE compression, concurrent with the Indian plate convergent direction. Whereas, an EW active subduction can be observed at the southern segments. Over all, our results favour a weakly coupled active subduction, which could be capable of generating segmented plate boundary ruptures.

5

SOLID EARTH MODELLING PROGRAMME

Data from broadband seismic stations have been used to estimate Rayleigh wave dispersion maps for periods 8-60 sec for NW Himalaya and adjacent regions. The dispersion maps were inverted for 1-D Vs structure beneath each grid point, which were collected to form a 3-D Vs model for the region. A 3-D shear wave velocity model is presented for NW Himalaya for depths up to 100 km. The uncertainty analysis performed at both surface wave map generation and shear wave inversion to have higher confidence in the resulted model. First high resolution map (0.5 x 0.5 degrees) in the northwestern Himalaya around the syntaxial bend, providing improved estimates of the S wave structure corroborated by a) correlations with higher velocity gneissic domes and crystallines (Vs 3.8-4.0 km/s), b) by receiver function inversions and c) by convergence with velocities determined by other authors in the region surrounding the NW Himalaya.

Research article on Indian angular plate velocity published in Scientific Reports, Nature is recognized in the Top 100 earth science papers. GPS signals passing through atmosphere give valuable information on atmospheric water vapor and the Total Electron Content (TEC) in ionosphere. For the first time, TEC estimated using two decades of GPS data gave significant insights in to the ionosphere variability at low and mid latitudes of India and its relation to solar cycle 23 and 24. Research article published on ionosphere variability specific to Indian subcontinent has the distinction of 200 downloads within 6 months of publication. Observation network of cGNSS (continuous Global Navigation Satellite System) stations in Kashmir valley, Ladakh Himalaya and Peninsular India gave valuable insights on the accuracy of GNSS position estimates and uncertainties.

Inside

- Shear wave velocity structure beneath North-Western Himalaya
- GNSS and its impact on position estimates

5.1 Shear wave velocity structure beneath North-Western Himalaya

Shear wave velocity structure, together with Moho depths have been estimated beneath a regular grid of 0.5°× 0.5° in northwestern Himalaya, Hindu Kush and the Pamirs and at 1°×1° in the surrounding area, by inverting fundamental mode Rayleigh wave group velocities calculated from regional earthquake (Δ ≤ 2500 km) data, and also from their joint inversions with teleseismic receiver functions at 38 of the 59 broadband stations in the region that provided the data. Dispersion maps clearly mark the low velocity enclaves of western Tarim, Tadjik and the Himalayan foreland basins, showing strong correlation (-0.76 to -0.99) with the sediment thickness map. Shallower dispersion maps (10-20 sec) also delineate the high velocity southeastern margin of the Hindu Kush (V_{Rg} ~3.3 km/s) extending to the slightly lower velocity northwestern Himalaya (~3.1 -3.2 km/s). Tibet and northeastern regions are marked with low (~2.7-3.0 km/s) velocities in dispersion maps of higher than 30 sec, apparently representing the thicker crust underneath. The inverted shear wave velocity maps clearly demarcate the shallower structures, which have strong geomorphic signatures (as shown in Figure 5.1).

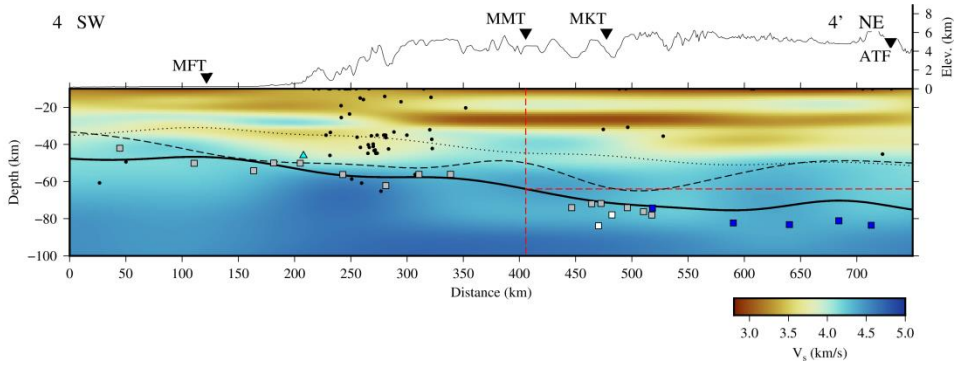


Figure 5.1 Posterior Vs cross-section and Moho depths marked by dotted, dashed and solid black lines, respectively estimated from 3 different initial a-priori models identifying the Moho surface with velocities of 4.0, 4.2 and 4.4 km/s. This NE-SW profile is same as of Rai et al. (2006). Gray squares represent the Moho estimates from Rai et al. (2006), blue from Wittlinger et al. (2004), and white from two stations further east of the profile, all constrained by joint inversions of receiver functions and surface wave dispersion data. This profile crosses the Himalayan foreland basin, Zanskar, and Ladakh Himalaya. The Moho depth beneath the MMT, marked by red dashed line, is ~64 km. Note the pervasive low velocity layer (~3.0 km/s) at depth of ~30 km beneath the Himalaya and a shallow high velocity (~4.0 km/s) at depth of 20 km beneath the Ladakh which correspond to the surface location of the Greater Himalayan Crystalline complexes.

For example, at 10 km, high shear velocities (~3.4 km/s) mark out the Hindu Kush subduction zone, the Pamirs and the northwestern Himalaya, while low velocities mark the sedimentary basins of Tadjik, western Tarim, and Himalayan foreland basin (~3.1 km/s). The high velocities correspond to surface location of high grade crystallines in the Nanga Parbat, gneiss domes in the Pamirs, the obducted Tethys ocean crust in the Hindu Kush, and subduction of the Neo-Tethyan oceanic crust beneath the Eurasian plate in Ladakh. The entire northwestern Himalaya

and Hindu Kush is characterized by low velocities (~3.2 km/s) at 30 km depth except for the Pamir (~3.7 km/s). Another notable result is the distinctly shallower Moho beneath the Himalayan arc apparently segmented by arc-normal shear zones that cross the rupture zones of the 1905 Kangra and the 2005 Kashmir earthquakes, in turn, marked by the current epoch seismicity.

5.2 GNSS and its impact on position estimates

Global Navigation Satellite System (GNSS) is a space based radio positioning system with one or more satellite constellations which provide three dimensional position, velocity and time information to users on or near the surface of the earth. At present GNSS consists of global (GPS, Glonass, Galileo, BeiDou) and regional Quasi Zenith Satellite System (QZSS), Indian Regional Navigation Satellite System (IRNSS)/Navigation with Indian Constellation (NavIC) navigation systems. Even though satellite systems are similar at fundamental levels, differences exist in the reference frames, timing standards and signal structures. Multi-GNSS can improve start-up time, performance, satellite visibility, accuracy, spatial geometry and reliability compared to standalone GPS but on the flip side multi-GNSS can increase the noise, signal interference, hardware complexity of the receiver, inter-system interference and computation complexity which may degrade the performance.

Currently GPS and Glonass are only fully operational with global coverage and comparable precision to estimate the positions. Glonass satellite constellation, signal structure, epoch time and reference frame are different compared to GPS. For crustal deformation studies using static post processing, combined solution may degrade the accuracy, if these differences are not handled carefully. Combined GPS-Glonass solution may significantly improve the accuracy in navigation applications with increased satellite signal observations and spatial distribution of visible satellites. Currently only GPS observations are mostly used for crustal deformation studies. Computation of daily precise position estimates using static post processing with only GPS, Glonass as well as combined GPS-Glonass is being carried out.

6

OTHER RESEARCH ACTIVITIES

An Indigenous software for generating “Penta-Graphene Sheet” and “Penta-Graphene Nanotube” has been developed for the first time. The “lattice parameter” used for analyzing carbon nanostructures in nonlocal continuum mechanics has been precisely identified. Noise is ubiquitous to both the observational and experimental data. Improper handling of noise could potentially skew the conclusions drawn from the data analyses. These aspects had been examined in the context of two modern data analysis algorithms.

Inside

- Indigenous Software for Penta-Graphene Nanotube Structure Generator
- Nonlocal bi-Helmholtz Stress Gradient Theory and Carbon Nanostructures
- Impacts of noise on the modes extracted by two data analysis algorithms

6.1 Indigenous software for penta-graphene nanotube structure generator

Using in-house code, the Penta-Graphene Nanotube Structure Generator Software has been developed for the first time. The Penta-Graphene structure consists of five carbon atoms in different planes. In open source platform, there exists no such software to generate the penta-graphene structure. The Penta-Graphene Sheet and Penta-Graphene Nanotube are shown in Figure 6.1 and Figure 6.2, respectively.

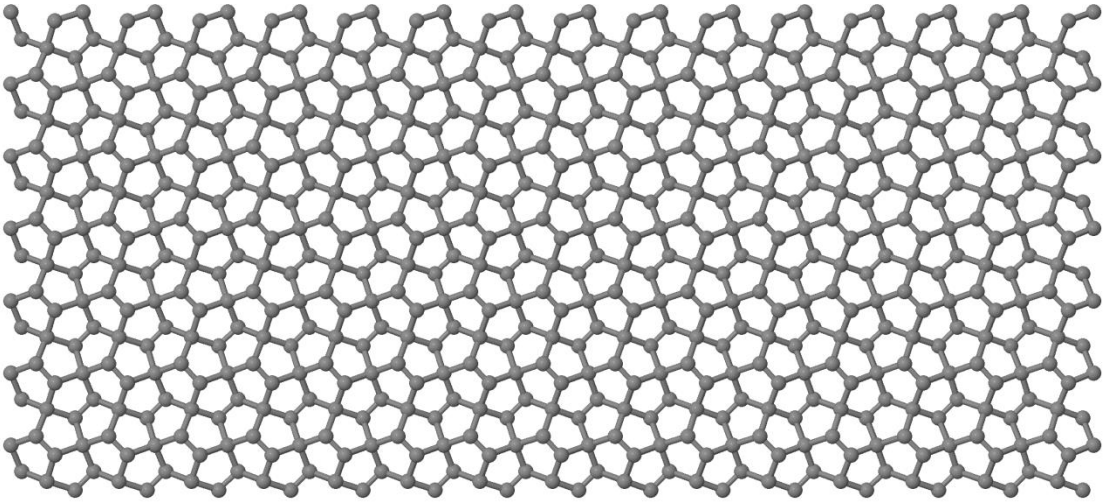


Figure 6.1 Penta-Graphene Sheet with Chirality as (15,0)

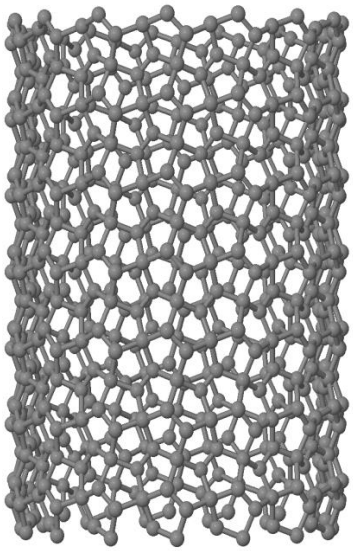


Figure 6.2 Penta-Graphene Nanotube with Chirality as (15,0)

6.2 Nonlocal bi-Helmholtz stress gradient theory and carbon nanostructures

The group velocity of nonlocal continuum model failed to capture the atomic-model behavior. For the first time, the complex conjugate numbers have been proposed in the continuum stress-gradient model using nonlocal elasticity. The nonlocal bi-Helmholtz stress gradient theory has been proposed with two nonlocal parameters. The “lattice parameter” value used in “nonlocal continuum models” is 0.142 nm for analyzing nanostructures like Carbon Nanowire, Carbon Nanorod, and Graphene. The atomic distance between two-carbon atoms is 0.142 nm. Many researchers misconceived that the “lattice parameter” value as a carbon-carbon bond length. It has been observed that the correct value for “lattice parameter” is 0.246 nm.

6.3 Impacts of noise on the modes extracted by two data analysis algorithms

We report, here, the prominent oscillations in the Indian Ocean SST extracted by Dynamic Mode Decomposition (DMD) and Non-linear Laplacian Spectral Analysis (NLSA). In addition, the sensitivities of their modes to random noise are presented. The latter aspect is important to understand, as the characteristics of noise can vary from one batch of data set to another, even when these batches originate from an identical model simulation or an experiment. The results obtained are based on the monthly observations of Indian Ocean SST from the Extended Reconstructed Sea Surface Temperature dataset. The two versions of datasets, which differ only in terms of the realization of random noise have been analyzed to examine the impacts of noise.

In general, the characteristics of DMD modes extracted from the two versions of SST are almost identical. Thus, it is clear that the structures and periods of weakly damped DMD-modes are not impacted by random noises. Nevertheless, it does change the decay/growth rates of these seasonal oscillations. Apart from the well-known annual and semi-annual cycles, the DMD analysis also could extract a few additional modes having the interannual periods. A comparison of the characteristics of inter-annual DMD-modes extracted from the two datasets reveals that their spatial-structures, periods and decay rates are very different. This suggests that, unlike the seasonal DMD-modes, the fundamental properties of the inter-annual DMD-modes are dictated by the instantaneous noise. In short, the findings emerged from these exercises imply that a prediction based on a fixed set of inter-annual modes can potentially be erroneous since the characters of inter-annual DMD-modes of Indian Ocean change with the noise. However, the noise depends in turn on the input data and the number of leading SVD-modes used to reduce the dimensionality. Therefore, the quest for reduced order models for the inter-annual predictions needs to be more attentive to the neglected components.

A comparison of the eigen spectra, time series, and spatial structures of the leading NLSA-modes extracted from the two versions of datasets had brought out the following facts. Like in DMD, the first NLSA-mode has the spatial structures of long-term monthly mean of Indian Ocean SST. The annual and semi-annual cycles are captured by the mode-pairs (2, 3) and (4, 5) respectively. However, in both cases, NLSA algorithm failed to detect in the inter-annual

modes. There exist considerable disagreements, in terms of magnitudes and phases, between the sums of 25 leading NLSA-modes (i.e., the reconstruction) extracted from the two datasets. Hence, these two reconstructions are not the accurate representations of the signals embedded in the inputs. Apart from the noise-sensitivities reported here, the sensitivity of NLSA-modes to the in-built parameters like ‘number of neighbors’ (used in the estimation of transition probability matrix) is also a matter of concern.

7

KNOWLEDGE PRODUCTS: PUBLICATIONS, PRESENTATIONS…

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, brain storming sessions, etc.

Inside

- Publications in Journals
- Patent Filed
- Publications in Books/Proceedings
- Presentations in Conferences/Symposia/Workshops/Seminars
- Participation in Conferences/Symposia/Workshops/Training Programmes
- Conference/Workshops/Seminars/Scientific Meetings at CSIR-4PI
- Invited Talks
- Visitors at CSIR-4PI

Publications in journals

Gouda K C, Nahak S and Goswami P, Evaluation of a GCM in seasonal forecasting of extreme rainfall events over continental India, Weather and Climate Extremes, 21, 10-16, 2018.

Himesh S, Rao E V S P, Gouda K C, Ramesh K V, Rakesh V, Mohapatra G N, Kantha Rao B, Sahoo S K, and Ajilesh P, Digital revolution and Big Data: a new revolution in agriculture, CAB Reviews, 13, 21, 1-7, 2018.

Kantha Rao B and **Rakesh V**, Evaluation of WRF-simulated multilevel soil moisture, 2-m air temperature, and 2-m relative humidity against in situ observations in India, Pure and Applied Geophysics, 176(4) 1807-1826, 2019.

Kakarla, Satya Ganesh, Rajasekhar Mopuri, Srinivasa Rao Mutheneni, **Kantha Rao B**, Sriram Kumaraswamy, Madhusudhan Rao Kadiri**, Gouda K C**, and Suryanaryana Murty Upadhyayula, Temperature dependent transmission potential model for chikungunya in India, Science of the Total Environment, 647, 66-74, 2019.

Mohapatra G N, Rakesh V, Mohanty P K and **Himesh S**, Comparative evaluation of the skill of a Global Circulation Model and a Limited Area Model in simulating tropical cyclones in the North Indian Ocean, Meteorol Appl., 25, 523–533, 2018.

Neethu C, Ramesh K V and **Shafeer K B,** Understanding the spatio-temporal structure of recent heat waves over India, 1-16, Natural Hazards, Online: 04 March 2019.

Dhananjay A Sant, **Parvez, I A**, Govindan Rangarajan, Satish J Patel, Madhuri N Bhatt, Sanoop Salam T A, Subsurface imaging of brown coal bearing Tertiary sedimentaries-Deccan Trap interface using microtremor method, Journal of Applied Geophysics, 159, 362-373, doi:https://doi.org/10.1016/j.jappgeo.2018.09.008, 2018.

Chandra R, Dar J A, Romshoo S A, Rashid I, **Parvez I A**, Mir S A, Fayaz M, Seismic hazard and probability assessment of Kashmir valley, northwest Himalaya, India, Natural Hazards 93(3), 1451-1477, 2018.

Rajendran K, Sulochana Gadgil, **Sajani Surendran**, Monsoon season local control on precipitation over warm tropical oceans, Meteorology and Atmospheric Physics, doi:10.1007/s00703-018-0649-7, 2018.

Esack Edwin Raj, **Ramesh K V**, Rajagobal Rajkumar Modelling the impact of agrometeorological variables on regional tea yield variability in South Indian tea-growing regions, 1981-2015, Cogent Food & Agriculture, Taylor & Francis publications, 2019.

Sunilkumar T C, **Earnest A**, **Silpa K**, Andrews R, Rupture of the Indian slab in the 2011 Mw 6.9 Sikkim Himalaya earthquake and its tectonic implications, Journal of Geophysical Research: Solid Earth, 124(3), 2623-2637, 2019.

Patent Filed

Anil Kumar V and D Das "Method and Device for Categorizing a Stream Control Transmission Protocol (SCTP) Receiver Terminal as a Malicious SCTP Receiver Terminal", US Patent No. 10129294, date of Issue 13 November 2018, Issuing Authority, US Patent and Trademark Office.

Publications in Books/Proceedings

Shrungeshwara T S, **Chiranjeevi Vivek G**, Anil Kumar Maletha, Shantanu Sarkar, **Sridevi Jade**, Landslides studies using Global Positioning System (GPS), Sustainable development of natural resources, R.K. Books, New Delhi, 2018.

Sridevi Jade and Shrungeshwara T S, Ionosphere variability in low and mid-latitudes of Indian using GPS-TEC estimates from 2002 to 2016, Chapter 9, Multifunctional Operation and Application of GPS, IntechOpen, http://dx.doi.org/10.5772/intechopen, 74172, 2018

Sunilkumar T C, Anil Earnest, Silpa K and Ronia Andrews, Rupture of the Indian slab in the 2011 Mw 6.9 Sikkim Himalaya earthquake and its tectonic implications, Deep structure and dynamics of the Himalaya – Tibet orogen and global collision zones, International Symposium on Deep Earth Exploration and Practices Beijing, China, October 24-26, 2018.

Presentations in Conferences/Symposia/Workshops/Seminars

Anil Kumar V, DDoS Attacks on Cyberspace and Mitigation Technologies, National Workshop on Technology Trends in Cyber Security (WorTICS 2018), Society for Electronics Transaction and Security (SETS), Chennai.

Apoorva D L, **Mohapatra G N** and Ratnoji S S, Strategic framework for integrated flood disaster management and modelling over Bangalore city, TROPMET-2018, October, 24-27, 2018, BHU, Varanasi.

Rachna Deshpande, **Ashapurna Marndi**, Occupancy Detection using Machine Learning Approach,11th National Women's Science Congress, 9-11November, 2018, Mysore.

Gouda K C, Modelling Vector Borne Disease over India, Proceedings of TROPMET-2018, National Symposium on Understanding Weather and Climate Variability: Research for Society, Banaras Hindu University, 24 to 27 October, 2018.

Nagaraj Bhat and **Gouda K C**, Assessment of Signature of Climate Change over Bengaluru, Proceedings of TROPMET-2018, National Symposium on Understanding Weather and Climate Variability: Research for Society, Banaras Hindu University, 24 to 27 October, 2018.

Majumdar Sharanya J, Sun J, Dudhia J, Golding B. W, **Gouda K C,** Joe P, Steinle P, Vincendon B, and Wang J, Nowcasting and Forecasting High-Impact Weather: Current Status and Future Challenges, Proceedings of American Meteorological Society Special Symposium on catalyzing weather science internationally, Phoenix, Arizona, USA, 6-10 Jan 2019.

Lokoshchenko M.A., Elansky N.F , Alekseeva L., Bogdanovich A.Yu., and **Gouda K C**, Thunderstorms in Russian and Indian cities, Proceedings of International conference on Thunderstorms and Lightning in Tropics, SoA University, Bhubaneswar, 17-19 Jan 2019.

Gouda K C, Sahoo S K, Samantray P, Nahak S and **Himesh S**, Evaluation of WRF configuration for Thunderstorm simulation over Odisha, Proceedings of International conference on Thunderstorms and Lightning in Tropics, SoA University, Bhubaneswar, 17-19 Jan 2019.

Jayasankar C B, Rajendran K, Sajani Surendran, High-resolution climate change projection of Indian Summer Monsoon: A dynamical downscaling approach, Scenarios Forum 2019 (Forum on Scenarios for Climate and Societal Futures), 11-13 March, Denver, Colorado, USA.

Kalyani Devasena C, Sharada M K and **Swathi P S**, Study of Oxygen and Nutrients in the Arabian Sea using Model Simulations and Observations, 4th International Symposium on the effects of climate change on the world's oceans, June 4-8 2018, Washington DC, USA.

Kalyani Devasena C, Sharada M K and **Swathi P S**, Study of Primary Productivity and Chlorophyll variations in the North Indian Ocean using Global Biogeochemical model Simulations and Observations, AGU Fall meeting-2019, December 10-14 2018, Washington DC, USA.

Mohapatra G N, Rakesh V and **Ajay Bankar**, Configuration and Validation of mesoscale model for urban extreme rainfall events for major metro cities in India, Proceeding of TROPMET 2018, Understanding Weather and Climate, Variability Research for Society, 24-27 October 2018, BHU, Varanasi.

Nahak S and **Gouda K C** and P Goswami, Seasonal Prediction of Extreme Rainfall episodes over India, Proceedings of TROPMET-2018, National Symposium on Understanding Weather and Climate Variability: Research for Society,Banaras Hindu University, 24 to 27 October, 2018.

Rekha B Gogoi, Govindan Kutty, Arup Borgohain, and **Rakesh V**, Impact of flow - dependent ensemble error covariance in the three – dimensional variational data assimilation method in a limited area model over the month of July 2013, Proceeding of TROPMET 2018, Understanding Weather and Climate, Variability Research for Society, BHU, Varanasi, 24-27, October, 2018.

Rakesh V and **Ramesh K V,** Crop and application specific high resolution weather and climate informatics, Workshop on Modeling and ICT Applications in Forecasting Pest and Diseases: Current Status and Emerging Needs, funded by World Bank funded project CAAST- NGT for forecasting pest and disease outbreak for effective management, GKVK Campus, University of Agricultural Sciences, Bengaluru, 12 February – 2019.

Ramesh K V and **Rakesh V**, Design and development of pest and disease forecasting and management system for increasing farmer's income. Workshop on Modeling and ICT Applications in Forecasting Pest and Diseases: Current Status and Emerging Needs, funded by World Bank funded project CAAST- NGT for forecasting pest and disease outbreak for effective management, GKVK Campus, University of Agricultural Sciences, Bengaluru, 12 February – 2019.

Rakesh V and **Ramesh K V**, A quantitative assessment of the potential of weather and climate informatics in efficient agricultural management, Proceedings of XIV Agricultural Science Congress, New Delhi, February 20-23, 2019

Ramesh K V and **Rakesh V**, Integrated system dynamical model (SDM) for sustainable utilization of natural resources to enhance farm productivity in agro-ecosystems., Proceedings of XIV Agricultural Science Congress, New Delhi, February 20-23, 2019

Sahoo S K, Himesh S and **Gouda K C**, High resolution Simulation study of Heat wave and Cold Wave over Odisha, Proceedings of TROPMET-2018, National Symposium on Understanding Weather and Climate Variability: Research for Society, Banaras Hindu University, 24 to 27 October, 2018.

Samantray P and **Gouda K C,** Analysis of Extreme Rainfall Event due to Cloud burst using Multiscale Observation and Non Hydrostatic Model, Proceedings of TROPMET-2018, National Symposium on Understanding Weather and Climate Variability: Research for Society, Banaras Hindu University, 24 to 27 October, 2018.

Sahoo S K, Gouda K C and **Himesh S**, Forecasting Analysis of pre-monsoon Thunderstorm over South India, Proceedings of International conference on Thunderstorms and Lightning in Tropics, SoA University, Bhubaneswar, 17-19 Jan 2019.

Senthilkumar V, Keynote Speaker, Engineering Technology in the Digital Era, International Conference on Engineering, Technology and Management in the Digital Era (ICETMDE-2019), Dayananda Sagar Academy of Technology and Management, Bangalore, 25 February 2019

Silpa K, **Anil Earnest,** Source process of outer arc earthquakes after the Mw 9.2, 2004 Sumatra-Andaman megathrust rupture, SCOR InterRidge Workshop Mid ocean ridges and other geological features of the Indian Ocean, 14-16 November 2018, CSIR-NIO, Goa, India.

Sunilkumar T C, Anil Earnest, A reappraisal on the present-day lithospheric stress field of the Indo-Burmese arc and its seismo-tectonic implications, SCOR-Inter Ridge Workshop Mid ocean ridges and other geological features of the Indian Ocean, 14-16 November 2018, CSIR-NIO, Goa, India.

Conferences/Symposia/Workshops/Seminars attended

Anil Kumar V

104th Internet Engineering Task Force (IETF) Meeting at Prague, Czech Republic

National Workshop on Technology Trends in Cyber Security (WorTICS 2018), Society for Electronics Transaction and Security (SETS), Chennai.

Chiranjeevi Vivek G

Modelling & Simulation workshop initiated by CSIR-RAB, CSIR-4PI, Bengaluru, 19-21 June, 2018

Pavithra N R

Modelling & Simulation workshop initiated by CSIR-RAB, CSIR-4PI, Bengaluru, 19-21 June, 2018

Rajendran K

National Round Table Discussion on Geoengineering and India: Science and Policy, DST, Indian Institute of Science, 26 July 2018.

Invited Talks

Anil Earnest

Sinking slab deformation at the Himalayas, National Workshop on Present-day Advancements in Geoscience – PAGe – 2019, Department of Marine Geology and Geophysics, Cochin University of Science and Technology, 17-18 January, 2019.

Anil Kumar V

Watching Dark IP Address Space: The Gain and Pain, C-DAC Technology Conclave 2019, C-DAC, Pune.

Gouda K C

Malaria Simulation over Indian regions, 6 July 2018, University of Liverpool, UK

Multi-scale Simulation of Indian Monsoon, 11 July 2018, UK Met Office, Exeter, UK

Climate-disease modeling, 13 July 2018, University of East Anglia, Norwich, UK

Chief Guest, Freshers day at Sapthagiri College on 16 August 2018

Modelling Vector Borne Disease over India, TROPMET-2018, National Symposium on Understanding Weather and Climate Variability: Research for Society, 24 to 27 October, 2018, Banaras Hindu University.

Evaluation of WRF configuration for Thunderstorm simulation over Odisha, International conference on Thunderstorms and Lightning in Tropics, 17-19 Jan 2019, SoA University, Bhubaneswar.

Chief Guest, World Meteorology day celebration at IMD-Regional centre, Bangalore held on 22 March 2019

Patra G K

Blockchain: The Innovation that is Transforming the Society, International Conference on Multimedia Processing, Communication and Information Technology – MPCIT 2018" organised by IEAE at JNN College of Engineering at Shimoga, 8-9 June 2018.

IPBC India, Bengaluru, 14thMarch 2019

NetApp @ CEERI's Industry Day, 12th October 2018

Role of Adaptive Learning in Security, Safety and Efficiency of Intelligent Transportation System, CSIR Sponsered Two Days WorkshoponSoft Computing based Data Driven Self Adaptive Systems (SC-DDSAS), Velore Institute of Technology, 18-19 January 2019.

Cyber Security: Skills, Work Cultures and Regulatory Frameworks for Building Sustainable Digital Enterprises, 2nd International Conference On Digital Entrepreneurship 2019 Platform, Process, People And Technology, Presidency University, Bangalore February 8-9, 2019.

Rajendran K

Monsoon Climate Change Projection for the Orographic West Coast of India using High Resolution Dynamical Downscaling Model, Meteorological Research Institute (MRI), Tsukuba, Japan, 8 May 2018.

CFSv2 Forecast 2018, Monsoon Café 2018, Indian Institute of Science, Bangalore, 27 June 2018.

High resolution climate change projection for the Western Ghats using regional climate model, National Symposium on Physics-Dynamics interactions in Climate in Connection with 80th Anniversary of the School of Marine Sciences, Cochin University of Science and Technology (CUSAT), Kerala, 21-22 February 2019.

Rakesh V

Crop and application specific high resolution weather and climate informatics, Workshop on Modeling and ICT Applications in Forecasting Pest and Diseases: Current Status and Emerging Needs 12th& 13thFebruary – 2019 jointly organized by GKVK, University of Agricultural Sciences, Bengaluru & Indian Council of Agricultural Research funded by World Bank.

Ramesh K V

Applications of Calculus and Differential Equations in Design and Development of System Dynamics Modelling", 01st September 2018 (Saturday), VIT, Vellore.

Design and development of pest and disease forecasting and management system for increasing farmer's income, Workshop on Modeling and ICT Applications in Forecasting Pest and Diseases: Current Status and Emerging Needs 12th& 13thFebruary – 2019 jointly organized by GKVK, University of Agricultural Sciences, Bengaluru & Indian Council of Agricultural Research funded by World Bank.

Sridevi Jade

Invited for Lead Tech Talk in IGC 2018 as Eminent Woman Geotechnical Engineer of Indian Origin, 14December 2018, JN Tata Auditorium, IISc, Bangalore

Invited as a Chief Guest for Women's Day, 12 March 2019, Central Manufacturing Technology Institute (CMTI), Tumkur Road, Bangalore

Senthilkumar V

Applications of Linear Systems and Numerical Methods in Engineering Problems", 01.09.2018, VIT, Vellore, Tamil Nadu

Applications of Numerical Methods in Engineering Science, VIT, Vellore, Tamil Nadu, 05 October 2018

Applications of Statistical Methods in Realistic Engineering Problems, VIT, Vellore Tamil Nadu, 18 March 2019.

Advanced Statistical Applications in Data Analysis", VIT, Vellore, Tamil Nadu, 18 March 2019.

Applications of Numerical Methods in Realistic Engineering Problems, VIT, Vellore, Tamil Nadu, 18 March 2019.

Thangavleu R P

The Road to Exascale…, Altair Technology Conference (ATCx 2018), Bangalore, 23 July 2018

The Road to Exascale…, Altair Technology Conference (ATCx 2018), Pune, 27 July 2018

Participation in Conferences/Symposia/Workshops/Training Programmes

Rakesh V

Remote Sensing Data User Interaction Meet (UIM) – 2019 22-23, Jan 2019 at NRSC, Hyderabad

Stakeholder Meeting at the Department of Civil Engineering at Indian Institute of Science, Bangalore on 19 April 2018, as a part of the Upscaling Catchment Processes in Peninsular India (UPSCAPE) programme

Seminar titled "Sensors and cyberphysical sensing networks for water and agriculture" at Ashoka trust for research in ecology and the environment auditorium by Supratik Guha, Argonne National Laboratory and the University of Chicago and subsequent discussions on 2 April 2018.

Ramesh K V

Seminar titled "Sensors and cyberphysical sensing networks for water and agriculture" at Ashoka trust for research in ecology and the environment auditorium by Supratik Guha, Argonne National Laboratory and the University of Chicago and subsequent discussions on 2 April 2018.

Remote Sensing Data User Interaction Meet (UIM) – 2019 22-23, Jan 2019 at NRSC, Hyderabad

Stakeholder Meeting at the Department of Civil Engineering at Indian Institute of Science, Bangalore on 19 April 2018, as a part of the Upscaling Catchment Processes in Peninsular India (UPSCAPE), programme

National Mission on Himalayan Studies-SD project workshop at Almora, Uttrakand, 19-22 Nov 2018

Conference/Workshops/Seminars at CSIR-4PI

Workshop on Modelling and Simulation with emphasis on Engineering and Physical Sciences including Earth & Environmental Sciences, 19-21 June, 2018

A three days' workshop on Modelling and Simulation with emphasis on Engineering and Physical Sciences including Earth & Environmental Sciences was organized during June 19-21, 2018 at CSIR 4PI, Bangalore. It had been initiated by the Recruitment and Assessment Board RAB), CSIR and organized by CSIR Fourth Paradigm Institute (CSIR 4PI). A total of twenty-two participants from various laboratories of CSIR including CSIR NEERI, CSIR SERC, CSIR NML, CSIR CEERI, CSIR CRRI, CSIR CBRI, CSIR CSIO, CSIR CIMFR, CSIR CGCRI and CSIR 4PI participated as nominees by their respective labs.

CSIR-4PI Foundation day, 31st October 2018

CSIR-4PI foundation day was celebrated on 31st October 2018. Chief Guest for the event was Prof Sanghamitra Bandyopadhyay, Director, ISI, Kolkata. She delivered the Foundation Day talk on "Harnessing of power of the Fourth Paradigm". She also released CSIR-4PI Annual Report for 2017-18.

VANET Security, Kickoff Meeting, Dec 10-14, 2018

The meeting was organized to discuss, deliberate and brainstorm on the implementation of the VANET Security project funded by Cognizant. The meeting was attended by 4 participants from Cognizant and 10 participants from CSIR 4PI. The meeting discussed the different activities, implementation strategies and guiding principles related to the VANET Security project.

Kick start meeting of the Indo-Russia joint project

Dr. Mikhail A. Lokoshchenko and Dr L I Alekseeva of Department of Meteorology and Climatology, Lomonosov Moscow State University (LMSU), Russia visited CSIR 4PI during 10-15 January 2019. The visit was part of the Indo-Russia collaborative project between CSIR 4PI and LMSU. On 11th Jan 2019 the kick start of the joint project on "Analysis of urban 'heat islands', air pollution dynamics and extreme weather phenomena in India and Russia" was held at CSIR 4PI being inaugurated by Dr V Y Mudkavi, Head CSIR 4PI.Dr K C Gouda, Senior Scientist and PI of the project briefed about the joint DST-RFBR project followed by scientific talk on "urban heat island" by Dr Mikhail and Dr Alekseeva. The visitors participated in the project discussion meeting and interacted with the scientists and researchers of CSIR 4PI.

Guest Lectures

R K Dutta, former Special Director, CBI and former DGP, Bangalore, 02 November 2018
A valedictory lecture of Vigilance Awareness Week

Mitra S, Professor, IISER, Kolkata, 15 February, 2019
Crustal Structure and Evolution of the Eastern Himalayan Plate Boundary System

Arjun Datta, Postdoctoral Fellow, TIFR, Mumbai, 28 March 2019
Beyond Conventional Methods and Applications with Seismic Surface Waves

In-house seminars/lectures

Bhogle S, Honorary Scientist, CSIR-4PI, 21 May 2018
Monsoon Prediction: Data from Models, or Models from Data?

Visitors at CSIR-4PI

Amitava Bandopadhyay, Head, RAB, New Delhi 07 June 2018

Govindankutty M, Assistant Professor, Department of Earth and Space Sciences (IIST), Kerala on 26 - 28 June 2018

Yasuhiro Inoue, DPH Practice Head, NEC, Japan, 17 July 2018

Deepak San, Anurag San, Manish K Kadam, Sai Madhukar, Sidhu Singh, Girisha Hassan, NEC Bangalore, 17 July 2018

Subrahmanya V R K Rao, Head, R&D, Cognizant Tech. Solution, Chennai, 21 August 2018

Ramesh V, Viswanath Durbha, Cognizant, Bangalore, 23 October 2018

Moriyama Yuki, Dy General Manager for data platform for Hadoop on 04 December 2018

Yasuhiro Inoue, Sr Manager for data platform for Hadoop, Japan, 04 December 2018

Harshal Ganpatrao Hayatnagar, Computer Scientist, Bhimsen Padalkar, Research Engg, ThoughtWorks Tech, Pune, 03 December 2018

Mohanram, AC Member, 14 December 2018

Liubov Alekseeva, Professor Lomonsov Moscow State University, Moscow, Russia, 10-14 January 2019

Mikhail Lokoshchenko, Professor, Lomonsov Moscow State University, Moscow, Russia, 10-14 January 2019

Anil Koul, Director, CSIR-IMTECH, Chandigarh, 19 January 2019

Kumaran S, Principal Scientist, CSIR-IMTECH, Chandigarh, 19 January 2019

Brahmachari S K, Former DG, CSIR, 19 January 2019

Srinivas Kaveri, Director, CNRS, India 23 January 2019

Bove Jerome Francois, Attaché for Science and Technology, French Embassy in India, 23 January 2019

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CSIR-4PI ACADEMIC PROGRAMME

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 a unique opportunity to bright and motivated students of reputed Universities to carry out 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 Science, Physical Science and Engineering Science.

Inside

- Ph D Programme
- Thesis/Project by M. Tech/BE/MCA students
- Research Fellowship Programme
- Faculty Participation
- Industrial Visit to HPC

Ph D Programme

Anil Earnest

Sunilkumar T C (AcSIR), A study on characterization of seismogenesis along the plate boundary zones of Himalayan and Indo-Burmese arcs

Silpa K, (AcSIR), A study of Indian plate seismogenesis using kinematic slip distribution models of selected earthquakes.

Goswami P and **Gouda K C (Co-guide)**

Shaktidhar Nayak (AcSIR), Development and evaluation of a model configuration for local climate projection over India

Gouda K C

Nagaraj Bhat (VTU), Weather Informatics using Remote Sensing & GIS

Payoshni Samantray (VTU), Study of Extreme Rainfall Events due to Cloud Burst using Observation and Model Simulation

Radhika TV (VTU), Efficient and Large-Scale Climate Simulation Analysis in Cloud Computing Cluster

Himesh S (Guide) and Rakesh V (Co-guide)

Ajilesh P (VTU), Charecterstics of Urban Extreme Rainfall Events over the Indian Cities: An Observational and Modelling Study

Himesh S (Guide) and Gouda K C (Co-guide)

Sanjeeb Kumar Sahoo (VTU), Impact of Urbanization on High Impact Weather Events & Local Climate

Kantha Rao Bhimala (Guide) and G K Patra (Co-guide)

Prasad Babu Kanike (AcSIR), Data Analytics to Identify the Relationship between the Land Surface Meteorological Parameters and Indian Summer Monsoon Rainfall

Mohapatra G N (Guide) and Rakesh V (Co-guide)

Smrati Purwar (AcSIR), Modelling of spatio-temporal variation in urban extreme rainfall events with special focus on localised versus large-scale impacts

Parvez I A

Ramiz Raja Mir (AcSIR), The study of crustal evolution and earthquake hazard in Kashmir Himalayas

Vishal Gupta (ISM Dhanbad), Site specific seismic hazard study in Kashmir Valley, NW Himalayas

Patra G K

Ashapurna Marndi (AcSIR), Development of Deep Learning Techniques for multi-dimensional time series data analysis

Iraganeni Rajasekhar Reddy (AcSIR), Block chain for sensitive data storage.

Sangeeta K and **Patra G K (Co-guide)**

Santhanalakshmi S **(**Amrita School of Engineering), Design of cryptographic protocols using computational intelligence techniques

Rajendran K

Ipsita Putatunda (AcSIR), Satellite data analysis in the context of short range numerical weather prediction

Jayasankar C B (AcSIR), Reliable climate change projections over India through dynamical downscaling using very high resolution regional climate model.

Rakesh V

Ajay Bankar (AcSIR) Impact of data assimilation in mesoscale models

Praveen S (VTU), Role of background error statistics in mesoscale data assimilation

Ramesh KV

Alfred Johny (AcSIR), Simulation of Indian Summer Monsoon using CMIP5 Climate Simulations

Edwin Raj E, (UPASI TRF TRI), Climate Impact Assessment on Tea Production over South India

Neethu C V (VTU), Modelling the role of land-atmosphere interaction during heatwaves

Safeer K B (AcSIR), Evaluation of Upper Ocean Variability Simulated by IPCC Climate Simulations

Sajani Surendran

Arya V B, (AcSIR), The impact of regional and remote aerosols on Indian summer monsoon variability

Sajani Surendran (Guide), Rajendran K (Co-guide)

Stella Jes Varghese, (AcSIR), Impact of resolution and deep convection parameterization on simulation and projection of Indian summer monsoon and variability

Sridevi Jade

Chiranjeevi Vivek G, (AcSIR), GNSS signal processing and analysis to study impact on position estimates.

Vidyadhar Mudkavi

Kanaka Muthu, CSIR-NAL, (NIT), Experimental and computational investigation of diffuser augmented small wind turbine.

Rinku A, CSIR-NAL, (IISc, Bangalore), Modular design of ribs in aircraft wings using topology and size optimization and non-dimensional analysis

Vijayan M S M

Shimna K, (AcSIR), Seismo-ionospheric coupling and upper atmospheric perturbations induced by acoustic gravity waves

M. Tech/BE/MCA students' Thesis/Project

Anil Kumar V

Gowtham R, (M.Tech), Amrita School of Engineering, Coimbatore, Proof of Concept on Dark net Sensor Implementation in Linux Kernel.

Meenakshi Suresh, (M.Tech), Amrita School of Engineering, Coimbatore, Exploitation of HTTP/2 Proxies for Cryptojacking.

Niranjana R, (Integrated MSc) , PSG College of Technology, Coimbatore, Anna University, Darknet Traffic Analysis using Clustering Techniques.

Srikanth Reddy D, (M.Tech), Amrita School of Engineering, Coimbatore, ACK spoofing at Kernel Level and TCP sender Behaviour Analysis.

Gouda K C

Amar C, (M.Tech), Karnataka Remote Sensing Application Centre (VTU), Bengaluru, Surface Temperature Analysis using Remote Sensing and GIS techniques.

Manjunath T N , (M.Tech), Karnataka Remote Sensing Application Centre (VTU), Bengaluru, Impact of cyclones on Chlorophyll-a concentration in north Indian Ocean using OCM data.

Kantha Rao B

Mrinal (M.Tech), Manipal Institute of Technology, Evaluation of WRF skill in simulation of urban rainfall events with high density rain-gauge network over Bangalore region.

Marndi Ashapurna

Rachna Sunilkumar Deshpande, (BE Internship), RNS Institute of Technology, Occu pancy Detection using Machine Learning Approach,July- August 2018.

Mohapatra G N

Apoorva DL, M Tech Environmental Science, Strategic Framework For Integrated Flood Disaster Management And Modelling Over Bengaluru, Manipal Institute of Technology, 06 August 2018

Parvez I A

Nazia Hassan, (M Tech), Indian Institute of Science Education and Research (IISER), Kolkata, A probabilistic approach to assess the seismic hazards in North-East India by estimating the parameters for recurrence models of earthquakes

Patra G K

Kasalanati Pavan, Kasalanati Sricharan, VIT, Deep Reinforcement Learning and Block Chain technology.

Dhikshitha S and Ria George, REVA University, Artificial Intelligence with Connected Vehicles.

Shreyas Titnus, Dr Ambedkar Institute of Technology, Vehicle localization based on particle filter.

Ashank D'souza, REVA University, Traffic Optimization for load differing traffic.

Apurva S, BNMIT, Deep Reinforciment learning algorithm for control in SUMO.

Madhuri K, Sushmitha K, Meghavarshini, Veda R Babu, Global Academy of Technology, Number Plate detection system.

Keshav S and Kaliki Poojasri, New Horizon College of Engineering, Traffic Signal Automation for Ambulances.

Nikhil Udgata, NMIMS, Securing Vehicular Communication with Block Chain

Devu B, Amrita School of Engineering, Solving Computational Physics Problems using Python

Rakesh V

Arun V S, (M.Sc), Cochin University of Science and Technology, Urban extreme rainfall simulation using wrf model: sensitivity of model results to microphysical schemes.

Adithya Samanth, (M.Tech), Manipal institute of Technology Crop viability over Karnataka: integration of crop-weather model outputs using arc-GIS.

Dhishana P R (M.Sc), Cochin University of Science and Technology, Simulation of thermodynamic features associated with urban extreme rainfall using weather research and forecasting model and validation against observations

Ramesh K V

S Ayisha (M.Sc), Pondicherry University, System dynamic macroeconomic model.

Senthilkumar V

Aditya Sreekumar, (BE Internship), Peridynamics and its Numerical Implementation on a finite bar, M.Visvesvaraya Institute of Technology, Bangalore.

Jai Kumar, (BS-MS Internship), Modelling of Graphene and Pentagraphene Structures, Indian Institute of Science Education and Research, Bhopal.

Roshan Kumar Singh, (M.Tech), Mechanical properties analysis of Pentagraphene nanowire through Molecular Dynamics Simulation, Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal.

Research Internship Programme

Gouda KC

Libujashree, Priyanak Kumari, Manisha Sharma, Rainfall prediction using machine learn ing, M V J Engineering College (VTU), Bangalore, March 2019

Nandan Nayak, Nithin H A, Gautham P, Nithesh S, SMV Institute of Technology and Management (VTU), Udupi, Machine Learning for climate data analysis, March 2019

Faculty Participation

Gouda K C

Data mining techniques and Big data analytics for MOSPI-Indian Statistical Service (ISS) Probationers at C R Rao AIMSCS, University of Hyderabad, 27-28, December 2018.

G K Patra

Advance Mathematical Tools in Engineering Applications Interdisciplinary modelling approach for designing cryptographic primitives, Department of Mathematics, Malnad College of Engineering, Hassan. 2 July 2018

Academy of Scientific and Innovative Research (AcSIR)

Gouda K C

Analysis of Meteorology and Climate Data, January 2019 session

Industrial Visit to HPC at CSIR-4PI

Presentation and Contribution: Prabhu N

Valliammai Engineering college, Dept. of Civil Engineering, SRM Nagar, Kattankulathur, Chennai, on 10 August, 2018, around 30 students and 2 faculties.

MVJ college of Engineering, Dept. Computer Science, near ITPB, Bangalore, on 30 August 2018, around 60 students and 2 faculties.

CMRIT Institute of Technology, Bangalore, on 11 October 2018 around 40 students and 2 faculties

MVJ college of Engineering, Dept. of Information Science and Engineering, near ITPB, Bangalore, on 15th March 2019, around 50 students and 2 faculties

MVJ college of Engineering, Dept. Computer Science and Engineering, near ITPB, Bangalore, on 26th March 2019, around 50 students and 2 faculties

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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

- CSIR Projects
- Grant-in-aid Projects
- In-House Projects

CSIR Projects

CSIR Mission Mode Project: Intelligent Systems (IS) - Intelligent technologies and solutions- *PI:* G K Patra

CSIR Young Scientist Scheme: Assessment and forecasting of extreme weather events over the Indian Region using Mesoscale Model- *PI: Rakesh V*

CSIR Niche Creating High Science Project: Carbon and nitrogen cycling in the earth system (CNCES) -*PI: Sharada M K*

Grant-in-aid Projects

Investigation of relative roles of local and large-scale circulation in the dynamics of cloudburst using simulation with a non-hydrostatic model, DST - *PI*: *Gouda K C*

Carbon cycle studies of the Indian Ocean using ocean biogeochemical model simulation and observations, DST, Women Scientist Scheme A - *PI: C Kalyani Devasena, Swathi PS*

National carbonaceous aersolsprogramme (NCAP): Working Group III - Carbonaceous aersols emissions, source appointment and climate effects, Ministry of Environment, Forest and Climate Change (MoEFCC) GOI - *PI: Sajani Surendran*

Geological characterization of the Kashmir valley with the objective of quantifying probabilistic hazard and risk in the high risk areas of the valley using a logically integrated set of GEO-Scientific Investigation, Department of Earth Science, GOI- *PI: Imtiyaz A Parvez*

Integrated system dynamical model to design and testing alternative intervention strategies for effective remediation & sustainable water management for two selected river basins of Indian Himalaya, *MOEFCC - PI: Ramesh K V.*

Enhancement of the quality of livelihood opportunities and resilience for the people in the Indian Himalayas, through design of intervention strategies aimed at maximizing resource potential and minimizing risks in urban-rural ecosystem, *MOEFCC - PI: Ramesh K V.*

Improving the prediction of the extremes of the interannual variation of the Indian Summer Monsoon Rainfall (ISMR) by CFSv2, *IITM, Pune and MOES - PI: Rajendran K*

Hyperspectral Imaging for sharper definitions of Himalayan Ecosystems and its high value plant species under climate uncertainties, *BHU and MOEFCC - PI: Ramesh K V.*

Analysis of urban 'heat islands', air pollution dynamics and extreme Heat wave phenomena in India and Russia, DST - *PI*: *Gouda K C*

Collaborative Project

Collaborative Research Project on Climate Change for Patna and its Agglomeration, NEERI, Nagpur - *PI*: *Gouda K C*

In-House Projects

Monitoring continuously operating CSIR-4PI GNSS station located in the IISC Campus and real-time operational data hub at CSIR-4PI - *PI: Sridevi Jade*

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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, CSIR-4PI today is a young and vibrant institution of research.

Inside

- Staff List
- Awards/Honours/Recognition
- Services on External Committees/Membership of Professional Bodies
- Deputations

CSIR-4PI Staff List

Head
Vidyadhar Y Mudkavi

Honorary Emeritus Scientist
Gaur V K
Dutt H N V
Indira N K
Ravichandran K S
Sinha U N
Srinivas Bhogle
Swathi P S
Yajnik K S

Scientist
Anil Earnest
Anil Kumar V
Ashapurna Marndi
Ashish
Chiranjeevi Vivek
Gouda K C
Gyanendranath Mohapatra
Himesh S
Kantha Rao Bhimala
Parvez I A
Patra G K
Pavithra N R
Rajendran K
Rakesh V
Ramesh K V
Rameshan K
Sajani Surendran
Senthilkumar V
Sharada M K
Sridevi Jade
Thangavelu R P
Vijayan M S M

Project Monitoring and Evaluation
Sharada M K (additional charge)
Suchanda Ray

Technical Officer
Prabhu
Suchanda Ray

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

Administration
Anilkumar Angadi
Balakrishna K R
Sathyanarayana K

Stores & Purchase
Mary Suneetha William

DST Women Scientist
Chikka Kalyani Devasena

SRF/JRF
Ajay Vijay Bankar
Arya V B
Bandesh
Dhananjay Kumar C
Iraganeni Rajasekhar Reddy
Jayasankar C B
Jayashree S
Kanike Raghavendra Prasad Babu
Kiran Kumar V
Shimna K
Silpa K
Smrati Purwar
Stella Jes Varghese

Project Assistants
Ajay Anand K V
Anjali Thomas
Ankit
Chaithra S T
Dilip Babu Loganathan
Payoshini Samantray
Pradeep Kumar Jha
Praveen S
Sanjeeb Kumar Sahoo
Shruti S
Shyamasundar
Sunena Rose
Suraj Ravindran
Vishal Gupta S

Awards/Honours/Recognition

Honours/Recognition

Anil Kumar V
Received Indian Internet Research and Engineering Forum (IIREF) Fellowship for participation in the Internet Engineering Task Force (IETF) meeting at Prague, Czech Republic.

Gouda K C

Awarded with CSIR Raman Research Fellowship

Silpa K won the best student poster award, felicitation and cash prize, SCOR-InterRidge Workshop Mid ocean ridges and other geological features

Services on External Committees/Membership of Professional Bodies

Anil Earnest
Member, American Geophysical Union (AGU)
Member, Society of Exploration Geophysicists (SEG)
Member, Society of Earth Scientists (SES), India
Associate Member, International GNSS Service (IGS)
Member, Asia Oceania Geosciences Society (AOGS)
Member, Seismological Society of America (SSA)

Anil Kumar V
Invited Member, Advisory Committee for Society for Electronics Transaction and Security (SETS) Chennai.
Member, Project Review and Steering Group (PRSG), Ministry of Electronics and Information Technology (MeitY), Government of India.
Mentor, Network Protocol Analysis Group, C R Rao Advanced Institute for Mathematics, Statistics and Computer Science (AIMSCS), Hyderabad.
Member, Technical Expert Group for IT Infrastructure Procurement and Implementation, Kidwai Memorial Institute of Oncology, Bangalore.
Member, Expert Committee for Supercomputing Facility for Cryptanalysis at CR Rao Advanced Institute of Mathematics, Statistics and Computer Science
Member, Internet Society (ISOC)
Member, Program Committee, National Conference on Parallel Computing Technologies, PARCOMPTECH- 2017
Life Member, Computer Society of India
Member Assessment Committee, CSIR-NAL
Member Assessment Committee, CSIR-NIO, Goa
Member, Selection committee C-DAC, Bangalore
Member, Thesis Evaluation Committee, Center for Cyber Security, Amrita VishwaVidyapeetham, Coimbatore.
Member, Assessment Committee, C-DAC, Bangalore
Nodal Officer, CSIR wide private IP scheme implementation
Nodal Officer, National Knowledge Network

Himesh S
Life Member, Indian Meteorological Society
Life Member, IAEM
Life Member, Institution of Engineers
Member, ACSIR DAC Committees

Gouda K C
Life Member, Indian Meteorological Society
Life Member, Indian Society of Remote sensing
Member, High-Weather Project of World Meteorological Organization
Executive member, India Meteorological Society, Bangalore Chapter
Member, Indo-Africa group on Research on Vector Borne Disease
Member, MoES Committee for Long Range Forecast of Monsoon
Member, Advisory Board, Dept. of CSE, Dayananda Sagar college of Engineering, Bangalore
Member, Board of Studies, Dept. of MCA, Dayananda Sagar University, Bangalore
Member, Board of Studies, School of Computer Science, Jain University, Bangalore
Member, M.Tech, Thesis Evaluation Committee, VTU, Belagavi
Member, Doctoral Committee, VTU, Belgavi
Member, Doctoral Committee, Jain University
Member, Project review committee (PRC), DSIR-PRISM
Member, CSIR 4PI Grievance committee
Coordinator, Healthcare theme of CSIR at CSIR 4PI

Indira N K
Member, Board of studies, Dayananda Sagar University, Bangalore

Parvez I A
PhD Examiner, Indian School of Mines, Dhanbad, Indian Institute of Technology, Kanpur.
Member, Advisory Committee, Reviewing Committee of Scientific Projects, National Institute of Rock Mechanics (NIRM), Kolar
Member, Hindi Technical Advisory Committee (HTAC) of NAL.
Member, Technical Expert Committee of Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Department of Science and Technology, Government of Karnataka.
Life Member, Indian Society of Earthquake Technology
Life Member, Indian Society of Earthquake Science

Patra G K
Associate Dean, Mathematical & Information Sciences of AcSIR
Member, Senate of Academy of Scientific and Innovative Research
Member, Empowered Technical Committee, Centre for Modelling Simulation and Design, University of Hyderabad
Member, Industrial Advisory Board, School of Computer Science and Engineering, Vellore Institute of Technology.
Member, Selection Committee, National Centre for Disease Informatics and Research, Indian Council of Medical Research.
Member, Technical Expert Group for IT Infrastructure Procurement and Implementation, Kidwai Memorial Institute of Oncology, Bangalore.
Member, Board of Studies, Government Science College, Bangalore.
Member Assessment Committee, for Technical Officers (IT) at CSIR Head Quarter
Member Assessment Committee, CSIR-NAL

Member, Technical Committee, International Conference on Intelligent Computing 2018 (ICIC 2018)
Member, Advisory Committee, International Conference on Multimedia Processing, Communication and Information Technology – MPCIT 2018

Rajendran K
Associate Editor, Journal of Earth System Sciences, Indian Academy of Science
Member, Working Group on Climate Change, Kerala State Planning Commission, Govt. of Kerala
Member, Board of Studies in Atmospheric Sciences, Cochin University of Science & Technology, Cochin, Kerala.
Member, Scientific and Academic Council, Institute for Climate Change Studies, Department of Environment, Govt. of Kerala.
Executive Council Member, Indian Meteorological Society
Life Member, Indian Meteorological Society

Rakesh V
Life Member, Indian Meteorological Society
Member, AcSIR Academic Committee
Member, AcSIR DAC Committees
Coordinator, Agriculture theme of CSIR at CSIR 4PI

Sajani Surendran
Life Member, Indian Meteorological Society
Member, Working Group III, National Carbonaceous Aerosol Project, Ministry of Environment and Forests

Senthilkumar V
Nodal Scientist, CSIR 4PI, Micro Small & Medium Enterprises (MSME)
Nodal Scientist, CSIR 4PI, of CSIR Theme, Mining, Minerals and Materials (4M)
Associate Professor, Academy of Scientific and Innovative Research (AcSIR)
Life Member, Indian Association of Computational Mechanics (IndACM)
Life Member, Indian Society for Advancement of Materials and Processing Engineering (ISAMPE)
Associate Member, Institute of Nanotechnology, UK

Sridevi Jade
Life Member, Indian Geotechnical Society
Life member, Indian Geological Congress
Member, Indian Science Congress
Member, International Society of Soil Mechanics and Foundation Engineering
Founder Life Member, Indian Society of rock mechanics and tunneling technology
Associate Member, International GNSS Service (IGS)

Thangavelu R P
Life Member, Computer Society of India
Life Member, Cryptology Research Society of India
Member, Cloud Computing Innovation Council of India
Member, Expert Group on Infrastructure, National Supercomputing Mission, GoI
Member, Executive Committee, Karnataka State Natural Disaster Monitoring Centre, Bangalore

Member, Technical Expert Group for IT Infrastructure Procurement and Implementation, Kidwai Memorial Institute of Oncology, Bangalore
Member, Technical Evaluation Committee for procurement of Supercomputers under NSM, Indian Institute of Science, Bangalore
Member, Technical Evaluation Committee for procurement of HPC system for Indian Institute of Technology, Dharwad
Member, Technical Evaluation Committee for procurement of HPC system for Gas Turbine Research Establishment, Bangalore
Member, Technical Expert Committee for procurement of HPC cluster, Aeronautical Development Agency, Bangalore
Member, Technical Evaluation Committee for Augmentation and upgradation of the shore station facility in Ocean Observation Systems, National Institute of Ocean Technology, Chennai
Member, Selection Committee, Karnataka State Natural Disaster Monitoring Centre, Bangalore
Member, Assessment Board, Ministry of Earth Science, GoI

Vidyadhar Y Mudkavi
Member, Executive Board, National Supercomputing Mission (NSM).
Chairman, Technical Evaluation Committee (TEC), Cloud Aerosol Interaction and Precipitation Enhancement Experiment (CAIPEEX), Indian Institute of Tropical Meteorology (IITM), Pune.
Chairman, Technical Advisory Committee (TAC), UAV Development for Atmospheric Measurements, IITM Pune.
Co-Chairman, Interdisciplinary Committee for Tejas Wake Clearance, Aeronautical Development Agency (ADA), Bengaluru.
Secretary, Trust for Advancement of Aerodynamics in India (TAAI), Bengaluru.
Member, National Advisory Committee, CAIPEEX, IITM, Pune.
Member, Technical Advisory Panel (TAP) for various departments of Government of Karnataka.
Member, Expert Committee, eVidhana, Government of Karnataka
Life member, Aeronautical Society of India (AeSI)
Member, Indian Academy for Mathematical Modeling and Simulation (IAMMS)
Member, Computer Society of India
Fellow, The Institution of Engineers (India)

Vijayan M S M
Member, American Geophysical Union (AGU)
Member, European Geophysical Union (EGU)
Associate Member, International GNSS Service (IGS)

Deputations

Anil Kumar V
Deputed for participation in 104th Internet Engineering Task Force (IETF) Meeting, Prague, Czech Republic, 23-29 March 2019

Rajendran K
Invited for formulating collaborative project, Japan Meteorological Business Support Center, Meteorological Research Institute (MRI), Tsukuba, Japan, 7 May- 1 June 2018.

Gouda K C
Deputed to University of Liverpool to work under CSIR Raman Research Fellowship(April 208-July 2018)

Visited China to deliver talk in the WMO sponsored HIWeather Workshop on increasing the value of weather-related warnings, Chinese Academy of Meteorological Sciences, Beijing, China, 20-22 November 2018

Mudkavi V Y
Visited institutes of Fraunhofer Gesellschaft (FhG) Stuttgart, Germany. To meet the top management researchers, National Centre for Scientific Research (CNRS), Paris. To interact with Director and researchers and visiting research facilities of Pasteur Institute, Paris, Germany & France, 3-8 March 2019

Jayashankar C B, awarded Foreign Travel Grant (full support) by DST, Scenario Forum 2019 (Forum on Scenarios for Climate and Societal Futures), Denver, Colorado, USA, 11-13 March 2019.

Shimna Kannoth, awarded CSIR Foreign Travel Grant (full support) to present her papers in COSPAR2018, Pasadena, California, USA

Promotions

Thangavelu R P: Promoted as Chief Scientist

Sridevi Jade: Promoted as Chief Scientist

Parvez I A: Promoted to Senior Principal Scientist.

Anil Kumar V: Promoted to Senior Principal Scientist.

Rajendran K: Promoted to Senior Principal Scientist

Sajani Surendran: Promoted to Principal Scientist

Anil Earnest: Promoted to Senior Scientist

Mohapatra G N: Promoted to Senior Scientist

CSIR RAB Workshop on Modelling & Simulation, June 19-21, 2018, Bengaluru

CSIR- 4PI Foundation Day, 31ST October 2018

CSIR- 4PI Advisory Committee Meeting, 21ST December 2018

CSIR- 4PI Advisory Committee Meeting, 21ST December 2018


DG SET 1
DG SET 2
DG SET 3