National Conference

on

Land-Atmosphere Interactions Controlling Weather & Climate: Applications of Numerical Models and Observations

(LAI-2023)

09-12 January 2023

SOUVENIR

Table of Contents

About

The overarching aim of the seminar is to bring together the experts in the field of land surface and atmosphere interactions to discuss and share knowledge for the benefit of society with a special emphasis to complex orography regions, such as the Himalayas.

NIT Rourkela

National Institute of Technology (NIT) Rourkela is an institute of national importance under the Ministry of Education, Government of India. The main objective of the Institute is to produce quality Engineers and Scientists in Graduate and Post-Graduate levels in various branches of Engineering and Science. It promotes advanced research across the disciplines.

Department of Earth and Atmospheric Sciences

The Department of Earth and Atmospheric Sciences is set up to provide state of the art education and research in earth, climate, ocean, and planetary sciences. The department promotes interdisciplinary research linking geological processes, natural hazards, environmental issues, weather and climate. The department is completing ten years of its existence in 2023. Currently, the department offers MSc (Applied Geology Atmospheric Science), M.Tech (Atmosphere and Ocean Science), and PhD.

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Massage from the Director

It is my immense pleasure to welcome you all to the National Conference on Land-Atmosphere Interactions Controlling Weather Climate: Applications of Numerical models and Observations (LAI-2023) organized by the department of Earth and Atmospheric Sciences of the National Institute of Technology Rourkela during 9-12 January 2023.

This event provides a common platform for meeting national-level researchers, scientists, and academicians working in the weather and climate field with a specific focus on land-atmosphere interactions. I firmly believe that the conference would be able to deliberate on advancements in land-atmosphere interactions with a specific interest in complex orography regions to provide better weather and climate guidance. The gathering will also delve into the role of atmosphere-land processes in weather extremes with remote sensing data, artificial intelligence, and machine learning techniques.

I convey my warm greetings and congratulations to the organizers and delegates and extend my wishes for the success of the conference.

Dr. K. Umamaheshwar Rao

Director NIT Rourkela

Patron of LAI-2023

Massage from the Head of the Department

The Department of Earth and Atmospheric Sciences was set up in the year 2013 at National Institute of Technology Rourkela to provide state of the art education and research in Earth, Climate, Ocean, and Planetary Sciences. However, it had its humble beginning in 2014 with only ten students, but today, has come a long way with more than 150 students and nine faculty members on roll. The goal is to inculcate a sense of deep understanding and fundamental knowledge in the student and also to provide a research oriented Environment that encourages inquiry and rewards hard work so that the students can think of innovative ideas and nurture their curiosity to learn even outside the classroom. The Department has been playing a vital role in providing resourceful man power through interdisciplinary way of teaching and research programs. The academic activities are oriented towards achieving fundamental understanding of the interaction among lithosphere, hydrosphere, and atmosphere. The Department would focus on the exploration of economically important mineral and energy resources, evolution and internal dynamics of Earth, surficial processes, natural and human–induced hazards, groundwater, environmental issues, weather, climate, air quality modelling, planetary research (both atmosphere and geological perspectives). Notably, the department continues to take dramatic steps forward, advancing the quality of research education, and engagement with the world. The national conference organized on 'Land-Atmosphere Interactions' is one the efforts from the department side to provide a platform to researchers for disseminating their works, wherein participants from several organizations around the country would be gathering to discuss scientific outcomes in this specific area of research. I would like to congratulate the organizers for taking such a step first time in a decade long history of the department. I wish the conference to be successful and beneficial to all.

Dr. Jagabandhu Panda

Head, Dept. of Earth and Atmospheric Sciences

Massage from the Convener

It is with great pleasure that I welcome you to the national conference on 'Land-Atmosphere Interactions Controlling Weather Climate: Applications of Numerical models and Observations', or LAI-2023. As an assistant professor at the Department of Earth and Atmospheric Sciences at NIT Rourkela, I am honored to serve as the convener for this conference, which is being held in collaboration with the G.B. Pant National Institute of Himalayan Environment in Almora, Uttarakhand and the Indian Institute of Geomagnetism, Mumbai.

The theme of this conference is the study of land-atmosphere interactions and their role in controlling weather and climate. Our goal is to bring together experts from various fields to discuss the latest research and developments in this area, with a focus on the use of numerical models and observations.

Throughout the interactive workshop, we will have invited and plenary lectures on a range of themes related to this topic. These include the role of land surface processes in weather and climate predictions, the influence of water and biodiversity on regional weather and climate, and the use of field and satellite observations in understanding land surface processes. We will also delve into the role of atmosphere-land processes in extreme weather events, and the application of remote sensing, artificial intelligence, and machine learning in the study of weather and climate.

I am confident that the abstracts included in this book reflect the high-quality research being presented at this conference. The abstracts cover a wide range of topics, and I believe that they will provide valuable insights and stimulate meaningful discussions throughout the conference.

I would like to express my gratitude to all of the authors who submitted abstracts. I would also like to thank the organizing committee, sponsors, and all of the attendees for their support and participation in this conference.

I hope that you will make the most of your time at this conference by networking with your colleagues and engaging in discussions.

Dr. Krishna Kishore Osuri

Convener, LAI-2023

Abstracts

Diversity of Indian summer monsoon circulation and rainfall during the super El Niño years

Nagaraju Chilukoti [1]**, *Mahendra N.***

[1]NIT ROURKELA

In It is generally true that the Indian Summer Monsoon (ISM) rainfall tends to be deficit (excess) during El Nino (La Nina) years, but this may not always be the case. The spatial patterns of rainfall over the Indian region show variations from one El Niño event to another. An investigation of the diversity of ISM circulation and the variations in rainfall during the super El Nio years is presented in this novel research paper. Super El Niño years such as 1982, 1997, and 2015 are considered for the study based on Niño 3.4 Index SST exceeding a threshold (value >2°C). It is also noted that these events co-occurred with positive Indian Ocean Dipole (IOD) and show different evolution in their anomalous Sea Surface Temperature (SSTA) patterns over Indo-Western Pacific (IWP) and IOD strength as well. Strong southeast-northwest tilted cold SSTA was seen in 1982 and 1997 from southwest Pacific to the southeast Indian Ocean (SEIO) across the Indonesia islands, which was weak in 2015 and is associated with asymmetric equatorial circulation over IWP. A significant influence on monsoon circulation can be attributed to anomalous easterlies emanating from the maritime continent across SEIO as they interact with synoptic events developing in the southern hemisphere (SH). It summarizes the fact that El Nino and SH synoptic events affect the ISM circulation and rainfall. As a result of this diversity, there were more frequent and organized northward propagating convective events over Central India (CI) that modulated the strength of IOD. years 1982 and 1997. While in 2015, there are scattered patches without any organized northward propagation. It was evident that there was intraseasonal variability linked to northward propagation with corresponding rainfall peaks. Even in deficit monsoon years associated with El Nino, the influence of WNP convection on active and break signals of ISM can be observed in 10 to 20-day oscillations. A super El Nino years have significantly altered the characteristics of Intraseasonal Oscillations (ISOs), which affect monsoon rainfall. Based on this analysis, it is observed that even though there will be a super El Niño in the future, the background conditions over the IWP can determine the characteristics of the ISOs, which can determine the rainfall changes over India.

Abstracts

Retrieval of LULC changes from Tasseled cap transformation by machine learning techniques and LST analysis

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The rapid urbanization will lead to a significant change in LST and causes thermal discomfort over the Spatio-temporal pattern. So there is a need to assess the land cover changes with more precision, especially where field data is absent. In this study, the tasseled cap transformations of Landsat 8 TM imagery and LST were clubbed to SVM (support vector machine) technique, and LULC changes are plotted over the city of Hyderabad. The results are compared to the conventional supervised maximum likelihood method. The results of the ML-based algorithm showed consistency over seasons and achieved better accuracy than the maximum likelihood method. The built-up was over-estimated in Machine learning methods, and lesser built-up LST was predicted with SVM. BUT water bodies are well resolved in SVM than MLE method. As the data set is large better performance in SVM and the same data points are enough for seasonal variations also, but in conventional methods, the training data set should vary according to the season. The mean LST resoled from maximum likelihood method are vegetation(30.2),barren(31.8), water(27.3), and built-up(31.9) and mean LST from SVM are vegetation(30.2),barren(32.8), water(23.5), and built-up(30.4). From LST patterns the, Northen Hyderabad is colder than southern Hyderabad because of the presence of vegetation cover. The schools and hospital points in Hyderabad are identified, and corresponding LST at those places are presented to ease the policymakers to plan the cooling systems in the buildings.

Abstracts

Evaluation of WRF-ARW model performance for the monsoon season extreme rainfall event over central Himalaya emphasizing land-atmosphere feedbacks

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Indian summer monsoon season extreme rainfall events are well known for disastrous floods and landslides over the central and northwestern Himalayan region resulting loss of human lives and property. These extreme events are mostly noted to be due to moisture convection, mid latitude Rossby wave breaking or ageostrophic motion within the complex terrain. However, due to occasional very small scale occurrences of such events, high-resolution model predictions of these events remain elusive. Additionally, the role of land-atmosphere interactions during the genesis of such events is seldom studied. In view of this knowledge gap, this study primarily aims to assess whether performance of WRF-ARW model physics depends on imitating land-atmosphere feedback processes. Subsequently, a monsoon season extreme rainfall event over central Himalaya, during 16-20 July, 2014, was studied. The event resulted daily total precipitations of 100.8, 77.8, 307.7, 127.4, 48.9 mm at the Kosi-Katarmal, Almora, (29.639N, 79.622E, 1213 m above sea level) station in Uttarakhand. To evaluate performances of WRF-ARW model physics, the high-resolution model was simulated during 14-21 July, 2014, having 09, 03 and 01 km domain centered over the Kosi-Katarmal, Almora. A total of 36 experiments that included 06 numbers of cloud microphysics and cumulus convections, respectively, were conducted. The generic model performance simulating station rainfall was evaluated by computing statistical cumulative index (C.I) wherein model accuracy, bias, probability of detection, threat score, correlation coefficient and false alarm rate was included. The hourly, 3-hourly and 6-hourly cumulative heavy rainfall observations at Kosi-Katarmal were used to evaluate the model sensitivity at three nested domains. Subsequently, best experiment was identified, irrespective of each domain and time resolution, based on the highest C.I. Once the best experiment was identified, the land-atmosphere feedback was evaluated using bi-directional Granger Causality tests, at a confidence interval of 95%, amongst model simulated rainfall, convective potential energy (CAPE), convective inhibition energy (CIN) and soil moisture (SM). We found that the best model performance, i. e. highest C. I. = 0.67 inclusive of all the domains and rainfall duration, was for the combination of Betts-Miller-Janjic cumulus and Kessler cloud microphysics parameterisations (i.e. BK experiment). Similarly, highest C. I. was noted during 6-hourly prediction over domain 3, i.e. when the model spatial integrating scale was finest (1 x 1 km) for the BK experiment. Finally, when the bi-directional Granger Causality tests were carried out, we found that the BK experiment was best performing as it could identify the soil moisture resulting rainfall at a lead time period of 01-02 hours before the initiation of extreme rain over all the domains. Our study clearly indicates that along with the regional scale changes in the monsoon circulations, local scale soil-moisture rainfall feedback plays an important role in the extreme rainfall over Himalaya, and WRF-ARW model performance, while predicting extreme rainfall over Himalaya, improves with better physical representation of soil-moisture rainfall feedback.

Abstracts

Surface PM2.5 concentrations and MODIS AOD at the rural site (Annaram) and its comparison with the urban area (Hyderabad) measurements

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Exposure to the high Particulate Matter (PM2.5) concentrations leads to adverse health impacts such as cardiovascular and respiratory diseases in humans. Surface PM2.5 monitoring stations are mostly located in urban areas and there is no air quality information to the people living in the rural areas. The present study is an attempt to quantify the PM 2.5 levels over a rural site and compare it with the urban area. Moderate Resolution Imaging Spectroradiometer (MODIS) derived aerosol optical depth (AOD) data (at 550 nm) at 3 km resolutions from both Terra and Aqua satellites is also used to understand the variations of observed surface PM2.5 in relation to AOD which is a columnar measurement. The study area is located near Annaram Village (Lat: 17.03°, Lon: 78.21° E) which is located about 50km south of Hyderabad. A gravimetric based High Volume sampler (HVS) model DHA-80 is used along with the high quality quartz filters for measurement of PM2.5 for the entire study period (2018-2021). In this study, Central Pollution Control Board (CPCB) in-situ data for PM2.5 for IDA Bolaram and IDA Zoo park stations located in Hyderabad city is also used. From the mean monthly average PM2.5 concentrations at rural site it is seen that concentrations are high (55 g/m3) during the winter season (Dec-Feb) in comparison to the concentrations observed (35 g/m3) during the Pre-monsoon/summer season (Mar-May). This can be understood interms of shallower boundary layer height inhibiting the convection during the winter season leading to high surface PM2.5 concentrations. The observation period covers the COVID-19 lockdown phases and it is observed that the PM2.5 concentration levels during the lockdown phase (10-40 g/m3) are lowest in comparison to pre and post lockdown phases (25-60 g/m3). During the period under consideration, it is observed that the PM2.5 concentrations are higher at urban measurement stations compared to rural site. MODIS AOD is observed to infer the day to day variations in PM2.5. The study also investigates a statistical relation between the AOD and PM2.5 including the meteorological parameters and the boundary layer height.

Keywords: PM2.5; AOD; High Volume Sampler; CPCB

Abstracts

Assimilation of ASCAT Soil Moisture in High Resolution NCUM-R NWP System and Its Impact

Ashish Routray*[1], *Abhishek Lodh*, *Devajyoti Dutta*, *John P. George* , *A. K. Mitra

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The present study attempted to evaluate the impact of assimilation of satellite derived soil wetness data from Advanced Scatterometer (ASCAT) in the soil moisture analysis on the simulation of three inland moving monsoon depressions (MDs) and three tropical cyclones (TCs). The study used NCUM-R high resolution regional NWP system. The simplified Extended Kalman Filter (sEKF) based Land Surface Data Assimilation (LSDA) system is used to create soil moisture (SM) initial condition for the NCUM-R model. In the eEKF system, ASCAT Soil Moisture (SM) along with near surface meteorological observations are used to create the soil moisture analysis. The ASCAT SM products are estimated from the backscatter measurements from C-band microwave active sensor (5.255 GHz) on board MetOp satellites. Various quality control steps were performed before assimilating the ASCAT SM observations in the LSDA system. In this Observing System Experiment, two numerical experiments, namely CTL (incorporating only screen level observations in LSDA) and ASCAT (assimilating both ASCAT SM and screen level observations in LSDA) were carried out to understand the impact of ASCAT SM. The atmospheric initial conditions for both the experiments were prepared using 4DVAR assimilation technique. The results of this study clearly show that high-resolution regional model initialized with SM initial conditions created using satellite observations improved the structure, intensity, track and evolution of the MDs/TCs and associated precipitation. The analysis increment of fluxes from ASCAT experiment clearly shows the coupled positive feedback between land and atmosphere. The positive values of Jacobians of humidity are noticed over the regions affected by the storms mainly in the ASCAT experiment. The root mean square error of top layer SM is decreased by 5 to 15% in ASCAT analyses compared to CTL analyses. The land-atmosphere coupling feedback is investigated by using Dirmeyer's indices, it is noticed that the precipitation modulated by the latent heat flux is higher in ASCAT simulation than in the CTL simulation. Overall, this study indicates that the use of ASCAT SM in the preparation of soil moisture initial condition helps to improve the forecast of high impact weather events like MDs and TCs in the high resolution NWP system.

Abstracts

Meteorological Conditions of Extremely Heavy Rainfall events over Mumbai

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The city of Mumbai frequently receives extreme heavy rainfall (gt;204.5 mm/day) during the summer monsoonal period (June - September), causing flash floods and other hazards. An assessment of the meteorological precursors that lead to these rain events is carried out for 15 previous cases from 1980 to 2020. The moisture source for such rain events over Mumbai is associated with mid-tropospheric cyclones, or off-shore troughs or Bay of Bengal depression. The analysis shows that almost all the extreme rain events are associated with each of these conditions co-occurring. The presence of a narrow zone of high sea surface temperature approximately along the latitude of Mumbai over the Arabian Sea can favor mesoscale convergence and is observed at least three days before the event. Anomalous wind remotely supplying copious moisture from the Bay of Bengal adds to the intensity of the rain event. The presence of mid-tropospheric circulation and off-shore trough, along with the orographic lifting of the moisture, set a unique meteorological set up to bring about highly localized catastrophic extreme rainfall events over Mumbai. The approach adopted in this study can be utilized for other such locales to develop location-specific guidance that can aid the local forecasting and emergency response communities. Further, they also provide a promise for using data-driven/machine learning-based pattern analysis for developing warning triggers.

Abstracts

Impact of very high-resolution urban fraction in simulating severe convection over megacities of India

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Augmented numbers of severe convective systems over urban areas pose serious threats to the life and property of the citizens in the metropolitan region. A reliable urban weather forecasting system for the city scale rainfall prediction with considerable accuracy is the primary requirement, as in recent times it has been a challenge to operational meteorologists to predict the urban flood. Most of the time the urban weather prediction models fail to predict the urban rainfall mainly due to the lack of adequate representation of land use/ land cover changes (LULCC). Coupled urban-atmospheric models are widely used to comprehend urban agglomeration and its impact on meteorological processes. A communal prerequisite of these models is the detailed information about the “urban fraction” (fraction of model grid covered by impervious surface area [ISA]).

The European Space Agency (ESA) WorldCover product provides a global land cover map for the base year of 2020 at a spatial resolution of 10 m. The dataset is built on Sentinel-1 and Sentinel-2 data with an overall accuracy of 74.4%. In this study, ESA WorldCover-derived urban fraction at 100 m horizontal resolution is utilized that is consequently incorporated into the advanced research version of the weather research and forecast (WRF-ARW) modeling system for the simulation and prediction of severe convections over Indian cities. The results of urban-scale weather modeling have been assessed against ground-based observations and remotely sensed datasets from satellites and radars. Furthermore, diagnostic analyses with model simulations are carried out to understand the impact of urbanization on the characteristics of urban severe weather patterns.

Keywords: Severe convective systems, Urbanization, WRF-ARW, Urban scale weather modeling.

Abstracts

Application of Machine Learning Algorithms for Regional Flood Frequency Analysis of Ungauged Watersheds in India

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Estimates of the flood quantile for ungauged watersheds are crucial for water resources management but challenging due to the nonlinear complex hydrological system. In the absence of the observed streamflow, the estimated flood quantiles depend on many interdependent physio-meteorological variables, many of which are not yet adequately considered in regional flood frequency analysis (RFFA). The objective of the present study is to estimate flood quantiles for ungauged watersheds using Random Forest (RF) and Support Vector Machine (SVM) algorithms that can learn the nonlinear relationship between the physio-meteorological variables and flood quantiles. A total of eight physio-meteorological variables, which are watershed area, mean elevation, surface water storage area, urban area, average annual rainfall, mean temperature, mean solar radiation, and Gravelius Index, were used to estimate the 100-year, 50-year, and 10-year return period flood quantiles (Q100, Q50, and Q10, respectively). A total of 39 watersheds spread across India were considered in the study based on data availability. The RF and SVM were trained for 29 watersheds to estimate individual flood quantiles and were tested on the remaining ten watersheds, which are considered ungauged. The R2 achieved by RF is 0.854, 0.881, and 0.887, and by SVM is 0.923, 0.916, and 0.913 for Q10, Q50, and Q100, respectively. The result shows that RF and SVM can effectively apply to the RFFA, considering appropriate physio-meteorological predictors. The study also shows that the ML algorithms can be used for flood quantile estimates even in the sparse data region.

Abstracts

IMPACT OF WRFDA ON PREDICTIONS OF VERY HEAVY RAINFALL

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Background Error Covariance Matrix (B) is one of the important parameters in the governing equations of Weather Research and Forecasting (WRF) Data Assimilation (DA) system. This study examines the sensitivity of numerical weather prediction model analyses and subsequent very heavy precipitation forecasts quality on the formulation of B. The numerical DA experiments are performed using 3DVAR, 4DVAR, 3DENVAR and 4ENVAR techniques in the WRFDA-4.3.3, at 30-km horizontal grid spacing for the ten latest (2022 to 2018) very heavy rainfall events during South West (SW) monsoon season, associated with Depression or more intense weather systems formed over Bay of Bengal (BOB) region. Four different B's are formulated, first with National Meteorological Center (NMC) method named in the study as B-CLIM, second with 45 ensembles by varying microphysics (mp) and cumulus (cu) schemes named here as B-MPCU, third by varying mp, cu, short and long wave radiation named here as B-RAD and lastly by perturbing initial conditions while formulating 45 ensembles, named here as B-PERT. Surface, Upper air and GPS radio occultation data are assimilated in the six hours forecast from previous analysis. Performance of the model is evaluated over the regions where weather systems are prevailing and over hilly (elevation > 1Km) regions. Comparison of model analysis with radio sonde , metar observations and European Centre for Medium-Range Weather Forecast reanalysis (ERA-5) and model forecast with GPM 0.1 X 0.1 rainfall estimator has showed that combination of 3DEnVAR technique with B-MPCU has performed consistently better in all the ten cases.

Abstracts

Understanding the Indian Summer monsoon variability in the warm mid-Pliocene period

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Indian Summer Monsoon Rainfall (ISMR) plays a critical role in agriculture and in turn affects the economy of India. Accurate and timely prediction of ISMR and its variability is necessary to mitigate its adverse effects.Understanding the variability of ISMR through past climates is necessary to predict the ISMR under the future warmer scenario with improved skill. To achieve this, we have selected the warm mid-Pliocene (3.0-3.3 Ma) period which has Carbon dioxide (CO2) concentration comparable to the end of the century and orbital parameters were the same as the present period. To evaluate the ISMR variability during the mid-Pliocene, we have used five Coupled Model Intercomparison Project 6 (CMIP6) models simulation datasets. All the model's skill in predicting the ISMR is evaluated using available observations and reanalysis datasets during the historical period. During the mid-Pliocene, we find an increase in the seasonal rainfall over most parts of India than the recent period . The enhanced CO2 forcing in the mid-Pliocene led to increase in both Surface air temperature (SAT) over the Indian landmass and SST over the Indian Ocean which favors more evaporation and increased convective activity. In combination, the enhanced temperature gradient between the Indian landmass and Arabian Sea (TGIA) during the recent period strengthened the ISM circulation. It is also observed that synoptic scale features like heat low, monsoon trough and the wind circulation at lower (850 hPa, cross equatorial jet observed along the Somalia coast and over the Arabian Sea) and upper levels (at 200 hPa, tropical easterly jet over the southern peninsula) are intensified and found to be consistent with the higher precipitation observed over the Indian subcontinent. These results are also consistent with the proxy records-based study.

Abstracts

Evaluation of the prediction of Heat Waves using WRF model coupled with PBL Parameterization schemes over Bhubaneswar city of East coast of India

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The current study is primarily concerned with the role of Planetary boundary layer (PBL) schemes in modeling heat waves over Bhubaneswar city using the high-resolution (500m) Weather Research and Forecasting model (WRF) model. WRF model coupled with the Yonsei University (YSU), Mellor-Yamada-Janjic (MYJ), Asymmetric convection model 2 (ACM2), Bougeault Lacarrere (Boulac), and Medium Range Forecast (MRF) Schemes. The Spatial variability of temperature at the peak (0800UTC) period of a heat wave ACM2 (Root mean square error: 1.67°C) and night time (0000UTC) is well predicted by Boulac (1.25°C) scheme with less error. The MYJ scheme well captures the temporal variability of temperature. But, it varies more during day time over Bhubaneswar city. During the peak time of a heat wave for zonal wind, ACM2 (Mean Absolute error: 1.47m/s) and Boulac (1.79) and for Meridional wind, Boulac (2.81m/s) and ACM2 (2.86m/s) are predicted better. Planetary boundary layer height and relative humidity is good agreement with the Boulac and ACM2 compared to the IMDAA reanalysis datasets. Furthermore, human comfort indices and surface heat fluxes have been computed to understand the feedback of the PBL schemes and their response during a heat wave. MYJ scheme acts as positive feedback, which explains overestimating the temperature over Bhubaneswar city. Boulac scheme have well-predicted discomfort and Heat Index against the IMDAA reanalysis datasets.

Abstracts

Comparative Analysis of Classification Techniques of Aerosols

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It is a well-established fact that aerosols play a crucial role in the radiation budget of the earth's system. Each aerosol type has a specific radiative influence on the earth's system; thus, even a small change in their composition could significantly change their radiative effects. The most aerosol characterization is the chemical analysis, but it is not feasible due to logistical and cost limitations. Remote sensing technique has come up as an alternative method. The researchers have used various techniques for the classification of the aerosols, which are based on the Aerosol Optical Depth (AOD), Angstrom Exponent (AE), Single Scattering Albedo (SSA), Fine Mode Fraction (FMF), and Sphericity Fraction (SF). In the present work, we used the remotely sensed aerosol physical properties at AERONET (Aerosol Robotic Network) ground observation sites over the Indian continent. Seven sites were selected for this work. Three techniques are used to classify the aerosols, and results are compared to observe the change in aerosol classification based on the type of parameters used. First classification technique for aerosol classification was based on the AOD-AE relation; the second was based on size distribution of aerosols and radiation absorptivity; and in the third, we used aerosol SF and FMF for classification. The notable changes are noticed in the type of aerosols from one technique to other. But it will be too early to claim which approach performed better. We also used the backward trajectory for aerosols to understand their origin and relate with the results found.

Abstracts

Drought forecasting using Long short-term memory neural networks and Explainable AI

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[1]Indian Institute of Technology Mandi

Droughts have caused millions of deaths since 1900s and have affected billions of people. Droughts are considered one of the costliest hazards and have baneful impact on economy, agriculture, environment and societal development. In order to be able to mitigate negative impacts of droughts, we need to shift from the traditional way of providing an emergency assistance to a proactive approach that builds resilience. Drought-forecasting systems play a crucial role in drought management. The present study proposes an advanced approach based on deep learning to predicts droughts in Indian parts of Indus River basin at a lead time of ninety days. A Long Short-Term Memory (LSTM) based deep learning architecture has been used in the study to improve the drought prediction accuracy. It has been known for a very long time that ENSO parameters have a significant relationship with Indian drought incidents hence a good understanding of the role of each variable behind the prediction is the key to build an efficient forecasting model. The study uses an Explainable AI technique, SHAP (Shapley Additive Explanations) to understand the effect of various features such as Rainfall, NINO, IOD, SOI and Temperature values on the predictions. The data was split into two parts, training data (1979- 2010) and testing data (2010-2020). R-Squared error (R2) and Root Mean Square Error (RMSE) has been used to measure the model's performance. Results shows that LSTM is a promising tool while predicting droughts in the region and the interpretation of the forecasting model facilitates comprehension of the effect of climate variables in governing drought dynamics.

Abstracts

ESTIMATING REFERENCE EVAPOTRANSPIRATION BASED ON LIMITED HYDROMETEOROLOGICAL DATA USING NEURAL NETWORK MODELS

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Accurate estimation of reference evapotranspiration (ETo) is beneficial for hydrological studies, water resources allocation, and agricultural water management. The most reliable method for estimating ETo, the FAO Penman-Monteith (PM) equation, is a complex approach due to extensive data (location, solar radiation, temperature, humidity and wind speed) requirements for combination of energy balance and mass transfer models. In this study, we demonstrate a methodology for ETo estimation for data-scarce regions with tropical savanna (tropical wet and dry) climate, utilizing feed-forward back-propagation neural network (BPNN) machine learning technique. In this way, it is proposed to develop a lower-dimensional model using combinations of maximum and minimum temperature, precipitation, soil moisture, and wind speed variables to estimate monthly ETo, and is calibrated using PM-based values. Hydrometeorological data for the 1980-2021 period collected from 132 meteorological stations around the globe with tropical savanna climate are used. BPNN is trained on a wide range of input combinations to identify a parsimonious model for ETo estimation. Performance metrics (mean absolute error, root mean square error, and coefficient of determination) are computed to assess the suitability of the different BPNN models, to select the best parsimonious model. Additionally, we used a deep learning technique in this study; performance of a long short-term memory (LSTM) recurrent neural network (RNN)-based model is compared with the best BPNN model for parsimonious ETo modeling. Development of such optimal ETo models in the tropical savannas can be useful for water budgeting under data scarce conditions.

Keywords: Reference Evapotranspiration, Tropical Savanna Climate, Neural Networks, FAO-Penman Monteith Method, Long Short-Term Memory (LSTM)

Abstracts

Developing Machine Learning based parameterization of Cloud Microphysics for Climate Models

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Numerical weather prediction (NWP) models and General circulation models (GCMs) apply parameterization schemes and sometimes rely on heuristic justifications to depict subgrid phenomena (e.g., cloud microphysics, radiation, convection, etc). Often the traditional physical parameterizations of these complex and poorly understood phenomena used in models are inaccurate, which causes biases in models and significant uncertainty in climate forecasts. Climate simulations with explicitly resolved deep convection globally are too expensive because the computational cost for directly resolving important low cloud feedbacks will be too high. Therefore, novel and computationally effective methods for subgrid parameterizations are immediately required and are the focus of climate research. Using machine learning algorithms trained on an existing parametrization scheme, we may replace parametrization with an artificial intelligence method that won't be any more accurate but will be substantially less expensive to implement than the original method. We will develop atmospheric models combined with ensembles of computationally cheap microphysics parametrization approaches based on machine learning to replace the highly expensive conventional parameterization schemes. We have trained multiple Random Forest Regressors with the output from Kessler warm rain microphysics scheme using the MPAS-Atmosphere model. The trained model shows significant value of R^2 and very less value of root mean square error. Also, the predicted values by the Random Forest based microphysics scheme shows good agreement with the true output in the test data. We have also investigated different combinations by changing the number of estimators and the maximum number of leaf nodes to estimate the improvement in model accuracy.

Abstracts

Monitoring Land Use Land Cover Changes and its impact on Surface Energy Balance: A case study of Bhubaneswar, India

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Changes in Land Use Land Cover (LULC) modulates the climate and Surface Energy Balance (SEB) of a region. The present study attempts to establish the inter-relationship of LULC with changes in Normalized Difference Vegetation Index (NDVI) and SEB of Bhubaneswar, India. The study was conducted for 3 years (2009, 2015 and 2020) for pre-monsoon (April) and post-monsoon (November) periods. LULC and NDVI were obtained from Landsat 8 Optical Land Imager scenes. ECMWF Reanalysis v5 Relative Humidity (RH) and Precipitation (TP) datasets were considered for the meteorological forcings. The LULC change analysis showed around 11% increase in urban areas during 2009 to 2020. The forest and vegetation cover decreased by around 6%, and 7% of the total area, respectively. NDVI values exhibited a decrease from 2009 to 2015, followed by an increase from 2015 to 2020. An increase in RH and TP values were observed in 2020, resulting in denser vegetation and consequently, a higher NDVI. Analysis of SEB components showed net all-wave radiation (NAR) and the storage heat flux (StHF) to have high increasing values in April. However, November showed a decreasing trend for both terms. The latent heat flux (LHF) values showed decreasing trend in April and increasing trend in November, linked to an increase in TP and presence of dense vegetation in the region. The sensible heat flux (SHF) also showed an overall decreasing trend in April and November. Further analysis is being carried out to characterize the influence of varying urbanization scenarios on regional climate systems.

Abstracts

Ecological impact of Ageratina adenophora and Mikania micrantha in protected natural forests of Mizoram, an Indo-Burma Biodiversity hotspot

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Invasion by alien plants in protected natural forest areas has appeared as a serious concern globally and one of the most important topics for conservation initiatives. Impact of alien plant invasion constitutes a significant and pressing threat to the ability of protected areas to provide conservation of native species. The ecological status of prioritized noxious invasives facilitate in evaluating the potential threats to the natural plant diversity in the protected landscapes. The present case study identifies the most prioritized noxious invasives and neo-invasive plants in protected areas of Mizoram evaluating their altitude-wise ecological impact on the natural forests. The study was carried out during July, 2018 to September, 2021 in Murlen and Phawngpui national park in Mizoram. Results revealed occurrence of most noxious invasive alien plants, Ageratina adenophora, Chromolaena odorata, Mikania micrantha under Asteraceae family in shrub layer and herb layer of the natural forests. Most of these invasive alien plants were from American origin. Chromolaena odorata (Max. IVI- 64.74) and Mikania micrantha (Max. IVI- 41.72) were the most noxious invasive alien plants in shrub layer whereas Ageratina adenophora (Max. IVI-72.51) and Ageratum houstonianum (Max. IVI-28.51) were the most noxious invasive alien plants in herb layer. The phytosociological data (importance value index) also helped to identify the neo-invasive plants namely Ageratina riparia, Tithonia diversifolia, Crassocephalum crepidioides and Galinsoga parviflora spread in these national parks. The noxious invasives and the neo-invasives gregariously invaded the disturbed natural forest areas in the lower and middle altitudes of the national parks in Mizoram.

Abstracts

Intraseasonal Oscillation of Land Surface Moisture and its link with the active phases of the Indian Summer Monsoon

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The monsoon rainfall inherently exhibits quasiperiodic intraseasonal oscillations (ISO) that are evident in the sub-seasonal active and break spells of monsoon rainfall over the Indian region Rajeevan et al. (2010). It is generally accepted that such low-frequency variabilities in the land-ocean-atmosphere system can be generated through interaction between its components. The land surface influences the climate system at various time and spatial scales. Firstly, the atmosphere is in direct contact with the surface, and the surface conditions act as regulators for important feedback cycles in the climate system. Secondly, the partitioning of net radiation at the surface into sensible and latent heat fluxes determines the soil wetness evolution, which acts as a forcing. In fact, after the sea surface temperature, soil moisture and snow mass are the most essential "memory" mechanisms for time scales ranging from weeks to season. To analyze the observed relationship between rainfall and land surface parameters, ERA5 datasets have been used from the period (1989-2019). Results from the analysis suggest that, like the rainfall, the soil parameter (soil -moisture and soil temperature) also shows the maximum variance in the low-frequency band (30-60 days). And as we go deeper into the soil layer, maximum variance is observed in the lower frequency band. Also, it is moderately correlated with the rainfall during JJAS, and maximum correlation occurs in the first two layers of the soil moisture (i.e.layer 1 and layer 2). North of IGP shows a strong correlation at lag 0. The same is observed in soil temperature. We also found that during the active phase of monsoon, soil moisture act as preconditioning to the rainfall. Spatially separated maxima of soil–Moisture and rainfall at the top layer same is true for the next layer also. The bottom two layers are responding inadequately as compared to the top layers. It is also clear from the analysis that the propagation of intraseasonal oscillations provides a spatially inhomogeneous response in terms of rainfall and surface moisture, and it could be related to the soil type

Abstracts

Correlation analysis between LST and LULC changes in Bathinda City by using GEE and CE

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Unchecked rapid urban expansion and LULC transformations have the potential to alter the thermodynamic, and radiative activities of the earth surface. Changes in land use/land cover (LULC) exacerbate climate alteration and generates the urban heat island (UHI) consequence in cities by raising the land surface temperature (LST). LST is a radiative skin temperature of land derived from solar radiation. Land surface temperature is a crucial climate variable having its significance across scales local to global. LST can be estimated mainly by Thermal infrared radiation (TIR) remote sensing. The high-performance computing feature of Google Earth Engine (GEE) and Climate Engine (CE) are used to compute the LST and LULC data. This study aims to estimate the changes in LULC classes and identify their impacts on LST in Bathinda city, India using Landsat satellite images from 2000 to 2022. Efforts have been made to study the LST in correlation with LULC changes in order to investigate the temporal variations of the UHI phenomenon.

Keywords- Google Earth Engine, Land surface temperature, Land use land cover, Remote sensing Urban Heat Island, Urban Climate.

Abstracts

A Non stationary Standardized Precipitation Evapotranspiration Index (NSPEI) for changing climate.

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Droughts are slow-moving natural disasters that cause devastation over large areas. In India, meteorological drought has a negative impact on agriculture, environment, economy, and food security. The meteorological drought index based on precipitation and temperature, such as the Standardized Precipitation Evapotranspiration Index (SPEI), is based on the concept of stationarity (i.e., the statistical parameters do not change with time). This highlights the need for developing a drought index that can provide robust and reliable quantification of meteorological drought under a changing climate. Hence, in this study, a non-stationary Standardized Precipitation Evapotranspiration Index (NSPEI) was developed using time as a covariate. The NSPEI was calculated on a 3-month time scale using monthly precipitation and temperature data from 341 grid points in the Krishna basin, India, for a period of 40 years, i.e., from 1980 to 2019. A time-sliding window approach was adopted to determine non-stationarity in the data. Numerous distribution fits, including Gamma, Weibull, Log Normal, and Generalized Extreme Value (GEV), were used to fit the data. However, the K-S test reveals that the GEV distribution provides the best fit. Using the Mann-Kendall test, a monthly trend analysis of the distribution parameter series was examined to identify the changing parameter in each grid. Moreover, shape, scale, and location parameters were obtained in R software using the Maximum Likelihood Estimator (MLE). The results of this study indicated that the NSPEI, using time as a covariate, could capture drought characteristics in the Krishna River basin more effectively than the SPEI. As a result, the new meteorological drought index (NSPEI) offers robust monitoring of drought that can effectively adapt to a changing climate.

Abstracts

Assessment of Wind Power Potential over Eastern India sites using Weibull Distribution

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Wind energy is a primary renewable energy source and plays an essential role in the energy industry. Wind power estimation is valuable for various climatic numerical simulations. Assessing the wind power density at a particular site is necessary to explore the feasibility of wind power generation. Modeling the wind speed distribution is critical for evaluating wind energy potential and the efficiency of wind energy systems. In the present work, we explored the possibility of wind energy generation over two sites in the Eastern India region: Ranchi and Kolkata, with the Weibull distribution function with two parameters. The shape parameter (k) and the scale parameter (c) values of the Weibull distribution were estimated with graphical and numerical methods. The mean wind, maximum wind, wind with maximum frequency, the standard deviation of wind, wind power density, and available wind power are estimated using the Weibull parameters. The lowest standard deviation was observed for the winter months, indicating that wind speed values were close to the mean value, while the highest during the pre-monsoon months showed widespread out over a large range of values. Wind power density variation shows a gradual increase till June, after which a drastic decrease could be seen in this value. These investigative studies are essential, and the findings from this work help us to quantify the sites for wind power generation. We also explored how the k and c parameter determination approaches affected the Weibull distribution's capacity to estimate wind potential accurately.

Abstracts

Radiative Impact of Anthropogenic-induced Land Cover Changes: Case Study Over Hyderabad, India

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Rapid urbanisation is expected to lead to almost 40% of India's population residing in urban areas by 2040. The urban sprawl is accompanied by conversion of native land cover to impervious built-up cover, whose extent is widely accepted as an indicator for assessing urbanisation. The mapping and monitoring of impervious surfaces is critical due to their contrasting thermal and radiative properties relative to natural surfaces. In-depth studies are necessary considering the potential impact of the radiation balance and associated warming/cooling. In the present study, we focus on land cover changes over Hyderabad city and examine the concomitant changes in surface radiative properties. The recent LULC dataset from University of Maryland is used to examine land cover changes at 30m resolution during 2000–2020, over the region bounded by Hyderabad's Outer Ring Road. The area under cropland increased from 15.3% (2003) to 18.6% (2019) while forest cover increased from 5.7% (2000) to 7.65% (2020). Seasonal water bodies expanded from 0.47% (2000) of area to 1.15% (2020), semi-permanent water bodies increased from 0.37% to 0.43%, and permanent water bodies increased from 0.64% to 0.93% by 2020. These land cover changes contributed to a regional (17°–18°N, 78°–79° E) lowering of surface albedo. Trends in surface albedo, derived from the CERES sensor, indicate a monotonic decrease by about 0.0012/year over the annual period and upto 0.002/year over the pre-monsoon/winter seasons. Radiative impact of impervious area expansion for 2000-2020 is examined, considering predictions from a global urban land expansion product for 2015–2100.

Abstracts

Evaluation of CMIP6 model skill in Predicting the decadal variability of Tropical Biennial Oscillations

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Indian Summer monsoon and Australian monsoon are tightly linked and varies on biennial time scale this phenomena is known as Tropical Biennial Oscillations (TBO). The tropical air-sea interaction variations plays a critical role in varying the TBO and its decadal variability. Understanding the role of air-sea interactions and physical process in modulating the TBO will be helpful to improve the forecast. In this study we aim to evaluate the Coupled Model Inter comparison Project Phase 6 (CMIP6) models skill in predicting the TBO variability. We have evaluated the long-term modulation in the relation between Indian summer monsoon rainfall (ISMR) and Australian summer monsoon rainfall (ASMR), we have also verified the impact of the Pacific Ocean (ENSO). Some models are able to simulate the relation between Indian summer monsoon and Australian summer monsoon reasonably, others are failed to simulate the decadal variability in the relationship. In the observations we have identified decadal variability in the relationship between ISMR and ENSO, similar variability in ASMR and ENSO. However, most of the models failed to capture these variability. The model inability to capture the decadal variation of ISMR and ASMR may be attributed to the failed to simulate the observed variability ISMR – ENSO as well as ASMR – ENSO relationship. The SST biases in the Indo – Pacific region in the model may be attributed to poor skill of the models

Keywords: Indian summer Monsoon, Australian Summer Monsoon, ENSO, Tropical Biennial Oscillations

Abstracts

Evaluation of extreme precipitation climate indices and their projected changes over Uttarakhand

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It is well known that Uttarakhand, India, has witnessed floods and landslides in the past, and these extremities are challenged in the future. This study examined the projected changes in precipitation extremes by using state-of-the-art high-resolution statistically downscaled NASA Earth Exchange Global Daily Downscaled Projections (NEX–GDDP) during southwest monsoon season (June to September) under RCP 4.5 and RCP 8.5 scenarios. The spatial variations of mean precipitation, as well as the extremes obtained from the Multi-Model Mean (MMM) from NEX–GDDP simulations, showed a good agreement with Asian Precipitation–Highly–Resolved Observational Data Integration Toward Evaluation of Water Resources (APHRODITE) observational data for the baseline period (1976-2005) over the Uttarakhand state. In response to global warming, the monsoon precipitation may increase by 13% and 16% under RCP 4.5 and RCP 8.5 emission scenarios, respectively, in the near-future (2021-2050), and further increased by 23% and 36% in the far-future (2070-2099). The results show that all extreme precipitation indices are expected to increase except consecutive dry days (CDD) over the Uttarakhand, both in the near-future and far-future of the 21st century, under both the emission scenarios. The RCP 4.5 and RCP 8.5 scenarios exhibited noticeable increase in the highest ONE-day rainfall (by 1.4 and 3.3 mm decade-1), highest FIVE days rainfall (by 2.7 and 7 mm decade-1), and consecutive wet days become more frequent during monsoon season, respectively. This study alarms an increasing rainfall activity over Uttarakhand towards the end of the century and helps to improve policymaking, adaptation, and mitigation strategies.

Abstracts

Characterization of ecohydrological indicators (EHIs) at multi-spatial scales in India

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The biogeochemical source and sink dynamics of terrestrial ecosystems play an important role in balance of carbon in the atmosphere. These biogeochemical processes such as carbon, water and energy cycles were affected by climate change and hydroclimatic disturbances. Hence, it is essential to understand the spatiotemporal variations and drivers of different ecohydrological indicators (EHIs) which links the carbon, water and energy cycles. This study assesses the three EHIs, namely water use efficiency (WUEe), rain use efficiency (RUEe), and light use efficiency (LUEe), as well as their drives based on Net Primary Productivity (NPP) in India from 2002 to 2017 at river basin, climatic zone, and land cover scales. All the three EHIs were found to be higher in forest ecosystems which are high productive regions. The mean annual WUEe and RUEe showed a slightly decreasing trend, and the mean annual LUEe experienced a slightly increasing trend. The ecosystem-based study shown that WUEe and LUEe in semi-arid zones and shrubland ecosystems experienced a positive trend. A similar trend was observed in RUEe for arid and shrubland ecosystems. The drivers investigated includes 11variables, CO2 concentrations, evapotranspiration (ET), humidity, leaf area index (LAI), normalized difference vegetation index (NDVI), precipitation (PRECIP), soil moisture (SM), solar radiation (SR), temperature (TEMP), vapor pressure deficit (VPD), and wind speed (WS). TEMP and SR were found to be more sensitive drivers of EHIs. Other drivers such as VOD, SM and humidity also played a significant role in local scales. This study will enhance our understanding of variations in EHIs and their mechanisms which can be a reference in predicting the ecosystem responses and resilience to changing climate and climate extremes.

Abstracts

Evaluating the Carbon Sequestration Potential of OAK and PINE-dominated Ecosystems of Himalaya

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Nowadays, the ecosystems of the Himalayas are experiencing weather extremes, which drastically impact their structure, function, and dynamics. These temporary and permanent changes influence the net ecosystem exchange (NEE) of Himalayan ecosystems and their dependence on meteorological conditions. The present study aims to investigate the carbon sequestration potential of two eminent Oak and Pine-dominated ecosystems of Himalaya. The study used the half-hourly temporal resolution flux tower data obtained from G. B. Pant National Institute of Himalayan Environment, Almora, Uttarakhand, India. The analysis is conducted with the information theory-based Temporal Information Partitioning Network (TIPNet) approach to generate the weekly process networks with a memory of 6 hours. The weekly networks are generated for the monsoon and post-monsoon seasons of 2016 and 2017. In both ecosystems, the sub-daily scale variations among the eco-hydro-meteorological variables are responsible for the fluctuations in NEE. The Pine ecosystem is found to be more sensitive to air temperature and sequestrates more carbon as compared to the Oak ecosystem. The consistent (>60%) transfer entropy links show that the Oak is moisture-driven (precipitation and relative humidity) whereas Pine is heat dominating ecosystem (air temperature and net solar radiation). The moisture-stressed periods are noted to have more causal links from meteorological variables to NEE. Overall, the precipitation is not the influencing variable in the Pine ecosystem at the memory of 6 hours as the root depth of Pine is higher as compared to Oak.

Keywords: Ecohydrology, Process networks, Oak, Pine, Himalayan

Abstracts

Groundwater quality assessment using water quality index (WQI) with Health risk assessment from Nellikal watershed of Nalgonda district, Telangana, India.

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This study described the assessment of groundwater quality using a water quality index (W.Q.I.) and non-carcinogenic health risk due to Nitrate in groundwater from rural habitats of Nellikal watershed of Nalgonda district. Groundwater samples are collected and measured for pH, E.C., T.D.S., T.H., and major anions and cations. Results revealed that T.D.S., HCO3- and NO3 concentrations are beyond the WHO permissible limits among the various parameters determined. The groundwater of the study area falls in poor water quality accounts for 35% of samples, and 5.9% of samples are in the very poor category, according to W.Q.I. The risk assessment demonstrated that hazardous quotient (H.Q.) values are in the range of 0.01-105.70; 0.01-99.10; 0.01-37.75 concerning infants, children and adults, respectively. These data demonstrated that most of the samples (71%) showed HQ>1 together for infants and children suggests a severe health effect on infants and children due to groundwater ingestion from the Nellikal watershed. This investigation recommended that water has to treated before supply for drinking in the study region.

Abstracts

Extreme Rainfall Events in Indian Himalayas

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Extreme precipitation events (EPEs) and associated flash flooding is one of the most pervasive weather-related natural hazards during the winter season over the north Indian region, owing to the interplay of western disturbances (WDs) and regional orography. The occurrence of such EPEs in this region can be catastrophic, particularly in terms of damages to life, infrastructure, environment and agricultural sustainability. In this study, an investigation of winter EPEs and associated dynamical processes has been conducted using gauge-based (IMD), satellite (TRMM) and the recently released high resolution reanalysis (IMDAA) datasets over the north Indian region from 1979-2019. EPEs have been identified using percentile approach from IMD and IMDAA and composite analysis for EPEs and non-EPEs in IMDAA and ERA5 has been carried out to understand the underlying physical mechanisms. An increasing trend of EPEs over the region has been observed. Furthermore, the composite analysis of various dynamical features and circulation patterns during EPEs and non-EPEs has been used to explain the conducive conditions developed during the occurrence of EPEs in comparison to non-EPE days. Our analysis suggests that the development of an intensified subtropical westerly jet (SWJ) during EPEs induces baroclinic instability over the region which favors the proclivity of such extreme events. Moreover, a southward shift of SWJ has been identified during EPEs which suggests an increased frequency for passage of WDs and therefore, enhanced contribution to winter precipitation over the region during EPEs. Detailed results will be discussed.

Abstracts

Assessment of Groundwater Recharge Variability under Climate Change Scenarios in the Gomti Basin, India

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The SWAT hydrological model was used in this study to assess the influence of changing climate on groundwater in the Gomti basin. Sensitivity analysis, calibration, and validation were used to assess model performance. The most critical/sensitive parameter is the initial SCS runoff curve number for moisture condition II (CN2). The R2 values obtained throughout the calibration and validation periods were 0.86, and 0.83, respectively. Four GCMs, MIROC-ESM, MIROC-ESM-CHEM, MIROC MIROC5, and MOHC HADGEM2 ES, were used to the calibrated SWAT model to examine the future climate change impact on groundwater under RCP 4.5 and 8.5 scenarios, and the following results are observed. Rainfall is decreasing by -29.17% (-29.65%), -28.69% (-28.88%), and -23.82% (-20.11%) under RCP 4.5 (8.5). Groundwater recharge is decreasing by -17.96% (-20.72%), - 18.96% (-21.35%), and -19.37% (-21.77%) under RCP 4.5 (RCP 8.5), correspondingly in near, mid, and end century. The research findings are beneficial for long-term water resource management in the region.

Abstracts

Cluster Analysis of Tropical Cyclones in the Bay of Bengal and Arabian Sea

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Tropical cyclones (TC) are extreme weather events, posing serious threat to life and property in the coastal regions of India. There is a large spread in the spatial distribution of cyclogenesis locations in the North Indian Ocean (NIO) basin. The current study attempts to identify distinct clusters in these cyclogenesis locations and characteristics of TCs in such clusters using machine learning techniques. Cyclogenesis location of 169 TCs (56 in Arabian sea (AS) and 113 in the Bay of Bengal (BoB)) has been obtained from International Best Track Archive for Climate Stewardship (IBTrACS) for 1991 to 2020 period. K-means clustering technique was employed to identify clusters in the cyclogenesis locations of TCs in the BoB and AS. Silhouette coefficient was used to detect the optimal number of clusters, which identified three clusters in both BoB and AS with fairly good separation. In BoB, Cluster-2 in the northern part contained more TCs which occurred in the 2005-2020 period, compared to Cluster-3 in the southeast with more activity during 1995-2000. Cluster-2 region was also observed to be most active during the month of October and Cluster-3 during November. Cluster-1 in the southwest BoB showed moderate TC activity during 1991-2020 period. In AS, Cluster-1 in the central part of the basin showed higher activity during 2010-2020 period. Cluster-2 and 3, located in the north-eastern and south-eastern coastal AS, respectively, showed higher activity during 1991-2001 period. Further analysis is being carried out to probe into the track and intensity characteristics of TCs in these clusters.

Abstracts

Probing into Indo-Pacific Ocean Heat Content Anomaly to validate its role on deviation of ISM Onset.

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The tropical oceans, particularly the Indo-Pacific region plays a significant role in the establishment and maintenance of the Indian Summer Monsoon (ISM). The changes in tropical rainfall correlate to weather patterns across the world. Using Empirical orthogonal function (EOF) analysis we have tried to depict large scale processes like ENSO, El Nino, La Nina, IOD and IOT condition with change in upper layer Ocean Heat Content (OHC) over the Indo-Pacific Ocean and find its relation with the deviation of ISM Onset. The onset of the ISM and its withdrawal exhibit significant variations from year to year. The climatological onset date for the ISM is 1st June, with a standard deviation of eight days. A delay in the onset of the monsoon is associated with a lowering of levels in hydroelectric reservoirs resulting reduction in generation of hydroelectricity that critically affect the country's economy yearly. Analyses of the Indo-Pacific OHC are conducted for a sufficient amount of time to take ENSO fluctuation into account. The central-eastern Pacific region, where the magnitude of OHC anomalies was found to be the largest, exhibits strongest signals at the ENSO time scale. Areas of strongest correlation significant up to 95% confidence interval between IndoPacific OHC and ISM Onset are identified. It is possible to conduct more research to determine how the IndoPacific Ocean heat content is related to the ISM onset variability.

Abstracts

Relation between the urbanization and temperature over inland and coastal regions of India using mesoscale model

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Since 2000, the major cities in India have witnessed rapid urbanization due to the migration of a large number of people. Increasing built-up areas will result in higher surface air temperatures in urban than rural areas, resulting in human discomfort and heat stroke. Therefore, a comprehensive study on the impact of urbanization on temperatures is required in the modern era. In this regard, we investigated the impact of urbanization on the diurnal variability of surface, air, and soil temperatures in inland and coastal cities such as Hyderabad and Bhubaneswar, India, using the WRF model. For this analysis, we consider four heat wave events over each city (a total 8 events), and conducted the sensitivity experiments by changing the old (USGS) and latest (ISRO) land-use and land-cover datasets. Our preliminary observational analysis shows that the maximum and minimum temperature anomalies and frequency of the 90th percentile of heat wave days have significantly increased. In addition, there has been a significant expansion of urbanization in these two cities. Our model analysis demonstrates that urbanization raises the maximum and minimum temperatures of the soil, surface, and air. Furthermore, urbanization has a greater impact on the minimum (night-time) temperature than the maximum (day-time) temperature on the surface and air temperatures, and vice versa for soil temperatures regardless of the inland and coastal areas. Additionally, due to urbanization, the urban heat island (UHI) effect is much more prominent at night-time than during the day-time. The higher sensible and lower latent heat flux over urban areas could be a reason for rises in maximum and minimum temperatures over the study regions.

Abstracts

Day-Ahead Forecast of Surface Reaching Solar Radiation under All-Sky Conditions over India Using WRF-Solar Model

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The Paris Agreement for climate change targeted reductions of global emission through intended nationally determined contributions are unique steps for holding global warming below 2°C or 1.5°C above pre-industrial levels. Towards achieving greater energy security and reducing the carbon footprint, India has renewed efforts to increase the share of solar energy in national energy generation systems. Due to the rapid penetration and increase in deployment of solar power in electricity grids, solar power forecasting has become critical to power management. Forecasts of surface reaching solar radiation result from different methodologies depending on the temporal scales starting from intra-hour to horizons beyond 24hrs. Numerical weather prediction (NWP) models are found to be an appropriate and accurate approach for the forecast beyond 6hrs to day-ahead. In this study WRF-Solar model, a version of the Weather Research and Forecasting (WRF) NWP model optimized for solar irradiance prediction, is used. Here, we evaluating day-ahead forecast of surface reaching solar radiation under all-sky conditions by integrating WRF-Solar. The model incorporates satellite observations of ISRO's AWiFS land-use land-cover, near real-time aerosol properties and is initialized using Global Forecast System data to generate a day-ahead forecast at 15-min interval. From the analysis of model forecasted surface reaching solar radiation against ground based measurements is understand that model able to forecast the surface reaching solar radiation within a difference of 30-50 W/m2 under cloud-free condition and within a difference of 50-250 W/m2 under partial cloudy and overcast conditions. Model is also able to forecast surface reaching solar radiation under cloudy-sky conditions within 200 W/m2 from 85 to 62 % of time from scatter clouds to overcast conditions of ground-based flux measurements. Results show that WRF-Solar can be operationalized at solar power stations to generate day-ahead forecast of site specific radiation and high-resolution maps of solar irradiation.

Abstracts

Understanding the role of Land Use Land Cover Change on the Indian Summer monsoon variability and extreme rainfall characteristics over India.

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The revival of the Indian summer monsoon (ISM) in recent decades has been associated with an increase in heavy to extremely heavy rainfall occurrences across most of India. Extreme rainfall events' frequency and ISM rainfall variability are tightly related. The impact of Land Use Land Cover Change (LULCC) on monsoon and extreme events is investigated. In four meteorological sub-divisions, such as Southern Peninsular India (SPI), Central India (CI), Northwest India (NWI), and Northeast India (NEI), extreme rainfall is classified as (ER; 99 percentile) and very extreme rainfall (VER; 99.9 percentile) during the summer monsoon season for the period of 1901 to 2021. In this work, the European Centre for Medium-Range Weather Forecast (ECMRF) Re-Analysis (ERA-Interim) (0.25°x0.25°), and the Indian Meteorological Department (IMD) high-resolution (0.25°x0.25°) gridded rainfall data have been used.

Abstracts

Partitioning of rainfall into throughfall and stemflow in Pine and Oak-dominated forest stands of the Western Himalayas

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Pinus roxburghii and Quercus sp. are two dominant tree species in the mid-altitudes of the Western and Central Himalayas. Driven by anthropogenic disturbances in recent decades, the Pinus sp. has been encroaching upon the Quercus sp. forests and surviving, resulting in the loss of Oak forests and the spread of Pine forests. The changing Himalayan landscape has implications for partitioning between various components of the land-surface water budget. In this study, rainfall partitioning into throughfall and stemflow is quantified under forest stands in two watersheds of similar elevation, aspect, and close aerial proximity but contrasting dominant forest canopies, i.e., Pinus roxburghii and Quercus leucotrichophora. Throughfall and stemflow were measured for the observational period, August 2021 - October 2022. For periodic totals of throughfall and stemflow, the average stemflow (%) for the Pine-dominated forest is 0.3 ± 0.4 (13 observations) and for the Oak-dominated forest is 0.7 ± 0.6 (12 observations), while the average throughfall (%) is 67.4 ± 43.2 (11 observations) and 71.6 ± 36.0 (10 observations), respectively. The effect of rainfall intensity, represented by the maximum 30-minute rainfall spell (I_30) in the observation period, on throughfall is evident only for the Pine forest stand, in which higher I_30 results in a higher proportion of throughfall. The lower variability of throughfall between periods and a weaker positive relationship between through fall and rainfall intensity for the Oak forest stand indicate higher canopy storage and interception loss for Oak canopies even at high-intensity spells during the observation period.

Abstracts

Assessing the severity of thunderstorms in Eastern India through downscaled high-resolution using supervised machine learning land use and land cover map

Priya Kumari[1]***, Sasanka Talukdar, Krishna Kishore Osuri***

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In this study, sensitivity experiments have been conducted using model horizontal resolution using three different domains, two nested (DD2 - 6km (outer):2km(inner) km and DD3- 9km(outer):3km(inner)), and one single domain (3 km). The use of finer resolutions leads to improvement in surface parameters and rainfall. In the DD2 experiment, the average mean error of temperature (T2) and relative humidity (RH2) is 0.7℃, -6% during the mature stage, and 0.2℃, -4% during the dissipating stage. For T2 and RH2, respectively, the inaccuracy in SD3 and DD3 is larger (9-17% and 20–60%, respectively). In 8 and 12 of the DD2 run's rainfall cases, respectively, the timing and amount of rain were improved. It is noticed that land use land cover(LULC) changes feedback to local atmospheric processes that promote TS formation and longevity. An attempt has been made on the sensitivity of LULC over Bhubaneswar(a rapid growth city). The LULC map was generated using three different machine learning Classifications and Regression Trees (CART), Naive Bayes (NB), and Support Vector Machine(SVM) on the Google Earth Engine platform using Landsat-8 for 2014. CART experiments exhibited high accuracy with a high kappa coefficient (87%) and Overall accuracy (84%). CART experiment exhibits relatively less bias in RH2 (– 10% to – 5%) and T2 (2.5 ℃ to 0 ℃) up to the peak stage of the TS compare to other experiments. In the current situation of increasing urbanization, the study emphasizes the sensitivity of LULC information to the performance of high-resolution models.

Abstracts

Effect of extreme marine heat wave events on chlorophyll variability over the tropical Indian Ocean using satellite data

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One of the main concerns of scientists and decision-makers worldwide is climate change and its effects on various facets of human life. Marine heat waves (MHW) are one such less investigated but highly devastating consequence of climate change. MHWs are characterized by an abnormally high sea surface temperature over a region for days or even months. These events have detrimental effects on several marine ecological sectors, including mass extinctions of various species, a decline in biodiversity, changes in genetic diversity, etc. In this study, we aim to understand the effect of MHW events on phytoplankton biomass by studying the variation of chlorophyll content after the occurrence of such an event. The study area is mainly the tropical Indian Ocean and MODIS-Aqua dataset has been used to study chlorophyll variation. The 2015- 2016 MHW event over the south-eastern tropical Indian Ocean which lasted for more than 300 days resulted in a significant decrease in chlorophyll-a during the months of June, July, August, and September. Similar results were observed in September 2015, over the Somali coast after the occurrence of a MHW event. According to IPCC, MHW events are expected to increase in the upcoming decades. Therefore, it is important to study the impact of MHW events on the marine ecosystem over various sectors of global ocean.

Abstracts

Comparitive analysis of WRF Parameterisation schemes in simulation of heavy rainfall event over Jammu and Kashmir, a mountainous region in Indian subcontinent

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India has been facing extreme weather events like droughts, flash floods, cyclones, etc. The severity and number of such events have increased over the last decades. The latest IPCC (Intergovernmental panel for climate change) report (IPCC-AR6) has concluded that climate change is a reality and which might be the reason for such extreme events. With the advancement of science and technology, Various techniques/methods have been used for the prediction of these events and one of the most accepted methods for weather prediction in today's scenario is climate/weather modeling. In this study, heavy precipitation events over Jammu (JK), were simulated using the Weather Research and Forecast (WRF) model. Performance and physics options in the model were analyzed through a series of simulations. All the simulations use the same initial and boundary conditions as derived from NCEP 6-hourly FNL (final) data. The simulations have been done using the combination of various physical schemes which include the Microphysics scheme, Cumulus schemes, Surface layer physics, planetary boundary layer schemes. The parameters which has been included for analysis are Atmospheric boundary layer height (ABLH) , Specific humidity, Convective available potential energy (CAPE) , t2 temperature and precipitation. Model results has been validated against IMD data and reanalysis data. Results reveal that Physical schemes are performing differently over Srinagar and Jammu. The reason behind this might be because of topographic and climatic conditions. Also the altitude differences in both the places are responsible for varying results.

Keywords: WRF, planetary boundary layer height, CAPE, IMD

Abstracts

Impact of Cyclone Titli on Vegetation Damage

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Due to climate variability, the intensity and frequency of the tropical cyclones (TC) are increasing and causing severe damage to coastal regions. TC's environmental and socioeconomic consequences might be mitigated through a variety of management strategies. In this study, the cyclone Titli was taken as a case study to analyze the impact on vegetation that happened on 11th October 2018. This study investigates the Land use and land cover (LULC) and Normalized Vegetation Index (NDVI) changes using high-resolution Sentinel-2 data. The production of a digital elevation model (DEM) map from ALOS PALSAR and a buffer zoning map processing are also carried out. The results showed that the substantial changes in LULC before and after landfall, the dense vegetation has decreased by 413.93%, less dense vegetation has increased by 48.79% and water bodies have increased by 49%. Most of the dense vegetation is converted into less dense vegetation and fallow land over the study area. The pre and post-image comparison showed that mean NDVI values decreased from 0.72 to 0.65 after landfall. The vegetation damage has no obvious relationship to elevation or distance. This study looks at the need for more geospatial technology in disaster effect assessments and the need to implement efficient, suitable, and long-term disaster management and mitigation approaches to avoid future disasters.

Abstracts

Influence of elevation and aspect on plant species diversity and soil properties on mountain summits - a Himalayan view on preferences of alpine plants

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Under the current global climate warming scenario, mountain ecosystems are experiencing some of the highest rates of warming, which may lead to degradation of their biodiversity. Numerous reports of species redistribution towards summits, and warming-induced range shifts of species suggest that mountain biota are highly sensitive to increasing temperatures. However, such corroborations are lesser known for the Himalayas, the youngest globally recognized biodiversity hotspot. Here, we studied vegetation dynamics on the alpine summits of west Himalaya using standard multi-summit approach to assess the transformation of plant communities with respect to elevation and aspect and its relation with climatic and edaphic factors. While plant species richness and diversity were highest at low elevation summits, among aspects it was higher in east and south facing slopes. Spatial patterns in beta diversity at multiple-sites revealed very low Sørensen dissimilarity among all the studied summits. The nestedness component (sne) was found to be the largest contributor to the overall dissimilarity. Cluster analysis from the dissimilarity matrices of turnover revealed that east and west aspect of is highly dissimilar from rest of the aspects. A significant correlation ($p<0.05$) was observed between soil parameters and elevation, indicating that summits with distinct pool of species possess distinct soil properties. Moreover, soil temperature clearly determined the aspect-wise distribution of soil parameters and species richness. The present study, therefore, enhances understanding of the spatial patterns of variation in soil and plant diversity of mountain summits, which will help to monitor, model and predict how these ecologically unique ecosystems will respond to climate warming.

Abstracts

A Meteorological Perspective of the 6th August 2020 Kerala and the 7th February 2021 Uttarakhand Disaster

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This study aims to identify the possible meteorological factors during two disaster events that occurred at Pettimudi, Kerala, India, on 6th August 2020 and in the Chamoli region of Uttarakhand on 7th February 2021. These events resulted in a disastrous landslide/rock-ice avalanche, leading to major loss of life and infrastructure damage. A detailed analysis of meteorological and geological features as causes of these disasters is presented using multiple in-situ and satellite observations. A high-resolution numerical modelling approach based on Weather Research and Forecast (WRF) model is used to simulate the distribution of hourly precipitation along with the near-surface and upper atmospheric features. The numerical simulations are carried out with two fine-resolution nested domains covering the Kerala region and around the Chamoli region of Uttarakhand, India, over a period of 15 days starting from 1st August and 1st February 2021, respectively. An optimal set of surface/boundary layer and microphysical parameterization schemes and initial/boundary conditions have been identified through the comparison of model outputs with in-situ observations from a network of automatic weather stations, various reanalysis products and satellite datasets. Recommendations are made for real-time precipitation-induced landslide early warning systems in the Indian subcontinent.

Abstracts

Atmospheric Conditions Conducive to Forest Fire Events in Uttarakhand

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During the last decade, there has been a dramatic rise in Forest Fire incidents over the Indian Himalayan region, leading to a huge loss of life and property. To mitigate and manage the impact of forest fires through a Forest Fire Early Warning System a better understanding of both small- and large-scale atmospheric processes conducive to the spread of forest fires is needed. Although significant progress has been made in disseminating forest fire danger information, most of the operational methodologies still do not consider real-time weather forecasts from atmospheric numerical models an input to the fire module. The objective of this work is to systematically analyze the meteorological conditions during two major forest fire events that occurred over the Uttarakhand region in 2016 and 2020. Forest fire events in 2016 and 2020 coincides with El-Nino, La-Nina and cycles of Indian Ocean Dipole (IOD). A detailed analysis of the 2016 and 2020 fire events shows the increased frequency of fire events and burnt area in 2016 whereas the area burnt was considerably low in the 2020 event. A normal year without significant influences from ENSO and IOD shows relatively low spread of fires and burnt areas. Such Impenetrable correlation of atmospheric oscillations and fire events result in vast damage over the Indian Himalayan region. The implementation of real-time weather forecasts with numerical weather prediction models could tackle this existing gap in the Forest Fire Early Warning System and possibly mitigate the further casualties caused by increased acceleration of fire spread induced by atmospheric oscillation over the Indian Himalayan region.

Abstracts

Long-Term High-Resolution IMD Gauge Adjusted Satellite Rainfall Product

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This study aims to create a 21-year, high spatiotemporal resolution Global Satellite Mapping of Precipitation (GSMaP) rainfall product adjusted by rain gauge measurements over the Indian mainland. The targeted resolutions of the GSMaP are hourly and 0.1°× 0.1°. The National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center (CPC) daily gauge analysis (0.5° × 0.5°) and Indian Meteorological Department (IMD) daily gridded rainfall product (0.25° × 0.25°) were utilized to generate two long-term rainfall products, GSMaP_CPC and GSMaP_IMD rainfall, respectively. After preliminary verification of the GSMaP_CPC and GSMaP_IMD rainfalls with IMD gauges, these rainfall products are evaluated for the Indian Summer Monsoon (ISM) periods of 2000–2020 with comparisons of other merged rainfall products such as the Integrated Multi-satellitE Retrievals for Global Precipitation Measurement (IMERG). The results suggest GSMaP_IMD has a smaller root-mean-square difference (RMSD) and higher correlation than GSMaP_CPC, evaluated against independent rainfall products. In the three-hour mean analysis with spaceborne precipitation radar data, it is found that the value of RMSD decreases in GSMaP_IMD with respect to GSMaP_CPC throughout the day. The statistics against the hourly dense rain gauge network in Karnataka suggests that the GSMaP_IMD is more effective in capturing large spatiotemporal rainfall variation over India. Thus, validation results with the independent sources suggest that GSMaP_IMD rainfall generally improved over GSMaP_CPC rainfall. These improvements are significant in orographic regions with high rainfall amounts, mainly the western Ghats and northeastern parts of India.

Abstracts

Extremely Severe Cyclonic Storm ‘Taukte’(2021): Causes of its intensification and its role in re-distribution of aerosols over Western coast

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As a coastal nation, India is highly susceptible to tropical cyclones. During pre-and-post monsoon seasons of the country, tropical cyclones form annually over the North Indian Ocean (NIO) region (i.e. the Arabian Sea and Bay of Bengal). The country’s western state of ‘Gujarat ‘experienced devastation in May 2021as a result of the extremely severely cyclonic storm (ESCS) ‘Taukte’, which formed over the Arabian sea and made landfall in the state’s ‘Saurashtra’ region. The present study seeks to identify the causes of the cyclone’s extreme nature utilising satellite and remote sensing data sets available for the region. The sea surface temperature (SST), tropical cyclone heat potential (TCHP) and ocean currents data provided by Indian National Centre for Ocean Information services (INCOIS) are analysed. Our in-depth analysis reveals that the cyclone’s intensification process was fuelled up by warmer SST and higher TCHP values. Further, the role of the TC in re-distributing oceanic and anthropogenic aerosols (like sulphate, black carbon etc.) is studied. It is found that in addition to Gujarat, the ESCS ‘Taukte’ played a crucial role in the re-distribution of anthropogenic aerosols over inner parts of the country.

Abstracts

Study of Heat Wave Characteristics over East Coast of India using High-Resolution IMDAA Reanalysis

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Heat waves mostly occur in the spring and summer seasons , affect human health and cause mortality and morbidity. Heat wave characteristics over the East Coast of India (ECI) particularly 79°E–83°E and 15°N–19°N is studied using high-resolution IMDAA reanalysis data. This study involves (1) Representing number of heat wave days in the ECI.(2) Understand the heat wave features over the ECI. (3) To obtain the variability between IMD observational maximum temperature and IMDAA reanalysis maximum temperature. We found a total 57 heat wave days over the ECI during 2011 to 2020 with 2012 as the high intensified heat wave. The presence of anomalous anticyclone over southwestern part of central India. In which air descends and compresses and leads to surface warming. The presence of north-westerly wind flow advects hot air from central India to the study region, which is also responsible to abate the onset of sea breeze and leads to heat waves. Depleted soil moisture leads to a positive feedback between land and atmosphere, amplifying the sensible heat and causing high surface temperature. The correlation between soil moisture and maximum temperature is -0.27, this indicates the importance of soil moisture in regulating heat waves.

Abstracts

Assessment of historic storm surges induced flooding and their future projections along west coast of India

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The Indian coasts bordered by the Bay of Bengal Arabian Sea are regularly traversed by tropical cyclones that cause storm surges during their landfall. Despite several studies on the effects of tropical storms on the coastal regions, the detailed study on their impact especially the coastal inundation remains limited, and comprehensive research on this aspect is still lacking. Improvement in the coastal inundation warning measures can help in reducing the time needed to prepare for necessary emergencies. This study aims to analyze the several aspects of storm surges and associated coastal inundation along the east and west coasts of India. The current study utilizes historical cyclone tracks over the past five decades to generate synthetic tracks projected for the next hundred years to develop a comprehensive analysis of the storm surges in India in view of the climate change impact. The impact of climate change on cyclone path and intensity is also considered while generating synthetic tracks. The Advanced Circulation (ADCIRC) model is used to compute storm surge heights and associated coastal inundation for historical and future cyclone tracks. An in-depth analysis is carried out using composite maps explaining the storm surge characteristics at various coastal locations. The novelty of this study lies in the comprehensive analysis of storm surge heights and associated coastal flooding using historical and synthetic tracks. This study also creates potential storm surges and associated coastal floods related to exaggerated cyclones that are expected in a changing climate scenario. This study also provides an improved understanding of role of coastal morphology in inundation computations. The outcome of current study will be useful in monitoring and prediction of tropical cyclone-induced storm surge as well as climatology of storm surge and inundation for disaster management applications.

Abstracts

Comparison of water use efficiencies of Pine and Oak dominated ecosystems of western Himalaya

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Water use efficiency (WUE) is an important parameter for quantifying metabolism of the terrestrial ecosystems, and can be represented as carbon uptake per unit of water loss. In general, WUE at the ecosystem level is typically controlled by micro-climatic parameters, primarily precipitation, air temperature, vapor pressure deficit (VPD) and radiation while their coupling mechanism is complex. Under the changing climate scenarios, assessment of relationships between WUE and microclimate for different forest types is expected to be beneficial for targeted forest plantation policies. Although the western Himalayan Pine (Pinus roxburghii) and Oak (Quercus leucotrichophora) dominated forest ecosystems, having different vegetation dynamics, exceptionally contributes to the region's carbon and water cycles, role of microclimate on the sub-daily to seasonal scale variation of WUEs of these systems remained unaddressed. In order to address this knowledge gap, this study presents the comparative assessment of WUEs of Pine-Oak dominated ecosystems over western Himalaya measured using eddy covariance systems. Efforts are also made to establish numerical relationships amongst WUEs and selected micro-climatic parameters, i.e. VPD, photosynthetic photon flux densities (PPFD), surface air-temperature and rainfall, at various seasonal scales. Continuous daily flux and micro-climatic parameters during 2016-2017 from eddy covariance flux towers of Uttarakhand, India, are used for this purpose. Results of the analyses indicate that both Pine and Oak dominated ecosystems efficiently use water during photosynthesis activity. However, the Pine dominated ecosystem has marginally higher annual WUE (1.35 ±3.18 gC.Kg-1H2O) than Oak (1.10 ± 2.08 gC.Kg-1H2O) dominated ecosystem. Statistically significant relationship between WUE and air-temperature and PPFD are also observed for both Pine and Oak dominated ecosystems during pre-monsoon and monsoon seasons; whereas a positive relationship is observed between WUE and VPD for Pine dominated ecosystems during post-monsoon, and Oak dominated ecosystem during pre-monsoon seasons. Furthermore, WUEs of both Pine and Oak dominated ecosystems decreases with increasing rainy days of monsoon period and the decreasing rate is higher for the Oak dominated ecosystem. The general inference of the study indicates that Oak has higher resilience to micro-climatic fluctuations than Pine dominated ecosystem.

Abstracts

PM estimation across the city of Kolkata: A regression modelling approach

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Particulate Matter (PM) has emerged as a matter of concern in air quality monitoring sector. The study here is a prospect to analyse and observe trend of PM concentration over city of Kolkata using data archived from combined Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua and Terra C6 daily product at 550 nm over a period of three years (2019-2021). The ground level concentration of the PM was collected through seven different CPCB ground station across the city of Kolkata. The MODIS AOD data product at 1-km spatial resolution and the meteorological parameters are taken from Modern-Era Retrospective analysis for Research and Application version 2 (MERRA-2) for the analysis. Four statistical regression models (Model 1 – Model IV) were derived for estimation of the PM2.5 using satellite AOD. Daily estimated concentrations of PM2.5 compared with respective ground observations to evaluate the performance using descriptive statistics. The results suggest Model II as best fit model which is multi-linear regression model with a strong positive correlation (R=0.814) and RMSE (Root Mean Square Error) of 22.54 µg/m3. The Normalized Mean Bias (NMB) value is found to be -0.315 with the mean absolute error of around 12.30. The mean absolute percent error is also estimated at around 5.14. The detailed statistical analysis thus infers that the Model II can be utilised to study particulate pollution over regions where ground level data is missing or scarce.

Keywords: Air Quality, MODIS, AOD, Regression model, PM2.5

Abstracts

Assessment of linkage between UAPI and UHI over Indian Megacity

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The present research work focuses on determining the Urban Aerosol Pollution Island (UAPI) intensity and spatial variability in particulate matter (PM) concentration over Indian megacity. The hourly concentration of PM2.5 and PM10 dataset from January 2019 to December 2020 obtained from air quality monitoring stations maintained by CPCB have been utilised to find the interconnection between particulate pollution and heat island. For analysis, Moderate Resolution Imaging Spectroradiometer (MODIS) Aerosol Optical Depth at 550 nm (1-km) and Land Surface Temperature datasets have been acquired from Level-1 and Atmosphere Archive Distribution System (LAADS) Distributed Active Archive Center (DAAC). The daily, monthly, and annual variations of PM along with related meteorological parameters have been studied to analyse PM trends. The highest concentration of PM10 observed to be 426.77 µg/m3 while that of PM2.5 was found around 301.91 µg/m3 in January 2019 over Delhi. For both years, diurnal variation of PM10 and PM2.5 showed a bimodal distribution. Over Delhi, higher AOD have been observed in the closer proximity of increased temperature. The results indicate a significant correlation between temperature and PM concentration. The results will aid researchers and policy makers to deliver solutions towards a more advantageous urban design.

Keywords: UAPI, PM, Air pollution, Heat Islands, Urban climate, Aerosols

Abstracts

Assessment of Land Use/Land cover Change over Dehradun City using Remote Sensing and GIS Techniques

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Dehradun is surrounded by protected areas, national parks, and wildlife sanctuaries; making it an ecologically sensitive zone. Degradation of forest cover is one of the major threats in this area. Land use Land cover (LULC) mapping would be a vital tool for evaluating the landscape dynamics over the area. The aim of present study is to detect the LULC change over the Dehradun District of Uttarakhand during time period of 2000 to 2020. The analysis was conducted at an interval of 5 years that is 2000, 2005, 2010, 2015 and 2020. Changes in urban - and forest area are detected using remote sensing and GIS techniques. The multi – temporal images are extracted from the Land Remote Sensing Satellite System (LANDSAT) satellite (5,7 and 8). The supervised classification is used to classify the images and to extract the LULC maps. These classification reveals change in area from 2000 to 2020, it was found that there was a decline in dense vegetation by 9.00% and increase in built up area by 2.32% which may be due to the increase in urbanization and industrialization across 20 years. This study can play prime role in planning further development activities over the study region.

Keywords: Land use, Land cover, LANDSAT Satellite, Remote sensing, Supervised classification.

Abstracts

Understanding the recent Land Surface Temperature (LST) trend over Kolkata: A Remote Sensing Approach

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Population growth and the growing economy have boosted urbanization. Urbanization has led to the prominence of impervious surfaces and deprived land of vegetation. This has triggered heat accumulation within the urban perimeter, making the urban region relatively warmer than the surrounding rural areas. This pocket of heat is called an Urban Heat Island (UHI). Monitoring the LST changes will be useful for understanding the impact of LULC changes and the associated UHI. This study captures the spatio-temporal trend of LST over Kolkata for the period March 2000 to February 2022 using MODIS Terra 1 km daily LST product. Preparation of the dataset has been done using the Google Earth Engine (GEE) platform. The annual, seasonal, and monthly analysis is performed using the daily observations by considering the median value. Modified Mann-Kendall (MMK) test has been employed to check the LST trend at a 95% confidence level and Theil-Sens slope to estimate the magnitude of the monotonic trend. The results obtained from this study would be highlighted through the presentation.

Keywords: MODIS LST, Google Earth Engine, MMK test

Abstracts

Urban heat and cool island signatures over eight major cities of India witnessed through LANDSAT observations

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Urbanization results in the rise of temperature over urban centres having a general trend of warmer cores compared to its periphery, thus forming an urban heat island (UHI). The UHI effect is typically confined to urban climates worldwide, characteristic of land-atmospheric interaction. UHI intensity is recorded to reach a maximum of 12°C internationally and 9°C over Indian cities. Numerical simulations in this direction demonstrate UHI intensity of up to 5°C over medium to large-size Indian cities. The Land Surface Temperature (LST) values over the currently considered eight major cities of India derived from Landsat observations also indicate the same. It gave an overall outlook of the Surface Urban Heat Island (SUHI) phenomenon experienced by these cities. The temporal variation of LST of urban impervious surfaces in both summer and winter indicated spatial LST increase over the years, exhibiting both UHI and Urban Cool Island scenarios. Maximum LST rise is observed in Delhi (9°C) during summer and in Jaipur (6°C) during winter over a certain period illustrating prominent UHI signatures while urban cool island phenomenon is observed in cities like Bengaluru. The current study highlights the correlation between the rise in LST and the corresponding urban growth and helps to understand the urban landscapes concerning the alleviation of the UHI effect.

Abstracts

Tree diversity and distribution in Kosi watershed, Uttarakhand, India

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Altitude causes significant variation in the diversity and distribution of biodiversity over a region. In forest ecosystem trees constitute a major structural component and regulate climatic conditions for proper ecosystem functioning. Quantification of diversity and distribution along the altitudinal gradient is important for overall assessment of biogeochemical cycle and forest policy and management. Therefore, this study investigates the current diversity, distribution patterns regeneration status of tree species along the altitudinal gradient under Kosi-watershed area in Uttarakhand. A grid-based approach was used to analyse the diversity of tree species along the altitudinal gradient lying between 1000m-2400 m asl. We recorded 33 tree species belonging to 23 genera and 18 families. In terms of distribution the most abundant species recorded was Pinus roxburghii showing dominance at all altitudinal range except 2000-2200m which was found to be dominated by Quercus spp. Species richness shows a dissimilar pattern ranging from 11 to 20 indicating low to moderate level of richness over the area, the lowest species richness (11) was recorded for two altitudinal range 1400-1600m and 2200-2400m and highest (20) was recorded in mixed-broad leaves forest type growing between 2000-2200m asl. Across the forest type, the highest density 807 (ind/ha1) was recorded for the altitude zone 2000-2200 m while the lowest density was observed for 1200-1400 m (201ind/ha1). The study indicated good regeneration of some species in the study area that will facilitate better monitoring and management of the forest ecosystems in the respective region and can help in developing sustainable management strategies for ecologically healthy forest areas in the region.

Abstracts

Review of Possible applications of Quantum Computing in the field of Climate Change and Energy Sector

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Many critical concerns addressing the Earth's climate and energy efficiency need extremely complicated computations. Simulating the delicate impacts of moving clouds on climate and analyzing a wide range of energy efficient materials to maximize production or energy storage fall under this area. Traditional computers executing bit-based binary-code programs find it harder to deal with such issues, especially as the volume of the associated computations grows exponentially. As a result, many problems are thought to be addressed using models that rely on approximate solutions to save computational costs. Even with these assumptions, supercomputers are reaching classical processing computational capacity limits. Researchers have recently recognized possible high-impact applications for quantum computing technology in the fields such as climate change, renewable energy, and the creation of efficient energy-generating and storage systems.

As simulation and forecasting model complexity and precision grow, significant computing capacity is required for climate modeling and weather forecasting. In this aspect, quantum computers are more potent in tackling fluid dynamics-based simulations. It might help model improvements by providing a more accurate view of future circumstances and boosting mitigation and adaptation strategy. Grid safety and resilience are critical in the energy industry, as they are essential for the future robustness and reliability of power-producing facilities.

Refined weather and climate models may enable safer infrastructure deployment, while quantum optimization may improve the design of new resources like wind farms. By enhancing operational circumstances, quantum optimization might contribute to the creation of cost-effective management solutions as well as the lowering of consumer costs.

Abstracts

Aerosols and associated effects on atmosphere over Major Cities of Gujarat due to shutdown during Covid-19 pandemic

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In order to explore impact of aerosols on atmospheric conditions due to pandemic shutdown, thorough study specially over urban population may help to understand it better. Hence Gujarat, being one of the most industrialized state with a rapid growing economy in India suits best for the purpose. Based on zonal division by Central Pollution Control Board, four major cities Surat, Ahmedabad, Rajkot and Bhuj have been selected for present study. The approach utilizes long term satellite data (2010-2021) related to aerosol, cloud and meteorological parameters in identifying the effect with pre-covid and post-covid monitoring. Aerosol Optical Depth (AOD) shows a decreasing trend during April (-28% to -17%) and May (-54% to -18%) in 2020 with respect to average of decadal data over all cities. More drop in Ahmedabad than Bhuj show dominance of anthropogenic sources over natural generation of aerosols. A noticeable change has also been observed in Cloud Fraction (CF) over Rajkot (-38% to -38%) and Surat (-22% to -17%) with respect to the average of selected decadal data during April-May of 2020. Correlation study of AOD-CF (0.6 to 0.8) and CF-RH (0.9) show high positive values, which signifies sufficient amount of hygroscopic nuclei and moisture content for cloud formation. Further detailed analysis will be presented for each city along with other cloud and meteorological parameters. Such studies may be useful to understand heterogeneity at regional level during lockdown period supporting our approach in upcoming future towards clean atmosphere by turning down the anthropogenic activities to a certain level.

Abstracts

Assessment of seasonal extreme rainfall over India in current seasonal coupled models during the recent period

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In the present study, we have assessed the seasonal prediction coupled models fidelity to simulate the seasonal extremes (June through September; JJAS) over the Indian region during 1981-2018. For this, we have obtained retrospective state/re-forecast/hindcast simulations (10 ensembles mean) with February and May initial conditions from Northern American Multimodel Ensemble (NMME) and Climate Forecast System version 2 (CFSv2) models. It is noticed that all models show significant seasonal dry bias over the Northern and west coast of Indian regions (associated with northerly wind bias at lower troposphere), whereas strong wet bias over the southeastern Indian region which is associated with cyclonic circulation (at 850 hPa) over the central Bay of Bengal in both lead times. From February hindcasts, CFSv2 has more dry bias over India compared to the other NMME models due to strong northerly wind bias over the Northern Indian region and strong cyclonic circulation over the North West Pacific region, whereas, that dry bias is reduced significantly over the Northern Indian region in all models except GEM_NEMO in May simulations. All NMME models are not able to reproduce orographic (i.e., west coast and northeastern parts of India) rainfall over the Indian sub-continent compared to the CFSv2 in both initial conditions. It is noticed that many models are not able to estimate the deficient and excess years of rainfall over the Indian region mainly due to the misrepresentation of ascending and descending branches of Walker circulation over the tropical region during the extreme years. Majority of the models are not able to capture the extreme years that are associated with El Nino southern osciallation, Indian Ocean dipole mode and Atlantic Nino boundary forcings, while the observed normal years which co-occure with these boundary forcings are reperesnted as excess years in the models. Different categorical skill scores suggest that, all models can capture the normal years only as similar to observations whereas deficient and excess years have more false alarms. Overall, this study reveals that the CFSv2 model is better performed/slightly improved to observed deficient and excess year's rainfall (seasonal extremes) over the Indian region compared to the NMME models with February simulation during the summer season whereas NMME models are better to simulate mean features and seasonal extremes of ISMR with May simulation than February.

Keywords: summer monsoon, excess and deficient years, ISMR, CFSV2, and NMME models

Abstracts

Impact of ENSO and IOD on Tropical Cyclone activity in the North Indian Ocean Using Wavelet Coherence

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This paper focuses on the impact of the El Niño southern oscillation (ENSO) and Indian Ocean Dipole (IOD) phenomena on tropical cyclone (TC) activities in the Bay of Bengal (BoB) and the Arabian Sea (AS). These are examined on the basis of the observed and reanalysed data from 1891-2020 using the cyclone e-Atlas of the Indian Meteorological Department, Niño 3.4 Index, Oceanic Niño Index and Dipole Mode Index (DMI). A total of 657 TCs are observed over BoB and AS during a 130 years study period at the rate of 5.05 TC per year. This 130-year study period is divided into years of ENSO (El Niño, La Niña and neutral ENSO) and IOD (+ve IOD, -ve IOD and no IOD) categories. It is observed that a total of 195, 215 and 247 TCs occurred during El Niño, La Niña and neutral ENSO years respectively. To Analyse the genesis location of TC, BoB is divided into three sections specified as: (i) Southern (5-10°N) (R_1), (ii) Central (10-15°N) (R_2), and (iii) Northern (15-20°N) (R_3). Genesis location of TCs over BoB indicates that during El Niño and La Niña years, maximum (minimum) number of TCs are formed in R_2 (R_3). The technique of wavelet coherence analysis (WTC) is used to examine the possible relationship between the time series of Niño 3.4 index/DMI, and frequency of TCs. Also, WTC analysis is made to find the possible linkage in time-frequency space between DMI and Niño 3.4 Index. 95 percent significance level has been observed through Monte Carlo simulation. Furthermore, the relative phase relationship has been analysed through arrows, where the pointing left arrow represents anti-phase, pointing right arrow denotes in phase, and pointing straight down indicates the leading phase. Multiple Linear Regression Analysis (MLRA) is also used for trend analysis and dependency with these climate forcing. The analysis reveals a statistically significant relationship between frequency of TCs and DMI with p - value 0.0133 (< 0.05), while it is insignificant with Niño 3.4. Also, strong dependence between the two meteorological parameters DMI and Niño 3.4 index were found.

Abstracts

Assessment of present seasonal prediction models' ability to simulate the association between ISMR and SAH

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In the present study, we use four present seasonal prediction models such as ., CANCM4, NEMO, CANSIP (from the NMME Project), and the CFSv2 model's hindcast runs which are initialized by May month to simulate the association between Indian summer monsoon (June through August; JJA) and South Asian High (SAH) during 1982-2016. It is noticed that the SAH index (defined by NWSE index is strongly associated with Indian summer monsoon rainfall (ISMR) during JJA season (Correlation between ISMR and SAH 0.62) whereas SAH (defined by EW index) is negatively correlated with ISMR in the observations. All models reasonably capture the relation between ISMR and SAH (both cases (SAHI and SAH_EW)) with slight variation in magnitude. Many models have better skill for SAHI, while less skill for the SAH_EW index. The positive regressed rainfall anomalies (significant) are seen over the monsoon trough region in the SAHI due to strong La Nina and positive vorticity associated with strong cyclonic circulation over the monsoon trough region, whereas negative rainfall anomalies are identified in the SAH_EW because of El Nino like pattern in eastern Pacific and negative vorticity anomalies (means divergence) is related with anti-cyclonic circulation over monsoon trough region in the observations during SAH years. But, all NMME models shows very strong rainfall anomalies over the entire Indian land mass in both cases unlike in the observations except CFSv2. This is due to SAH strongly associated with ENSO and IOD than observations. Overall, all models are able to reproduce the relation between ISMR and SAH slight variations, CFSv2 is slightly better than other NMME models during the JJA season.

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