PRAVEEN KUMAR, Ph.D.

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EDUCATION

Ph.D. *Environmental Science* Nov, 2017
Central University of South Bihar, India.
Ph.D. Title: Future Projections of Rainfall & Temperature and its Impact on Transmission of Malaria, Japanese Encephalitis and Acute Encephalitis Syndrome
Subject Studied during course work: Earth System Modeling, Computational Technique

M.Tech. *Modeling and Simulation* 2013
University of Pune, India.
(***Major Subject***: Stochastic and Deterministic Modeling, Computer Programming)

B.Tech. *Bioinformatics* 2011
D.Y. Patil Vidyapeeth, Pune, India .
(***Major Subject***: Mathematics, Bioinformatics, Computer Programming, Computer Algorithm)

RESEARCH AND WORKING (TEACHING) EXPERIENCE

- Project Scientist-C May, 2020 – Current
  India Meteorological Department, New Delhi (**Pay Level - 11**)

- Research Associate Sep, 2017 – Jan, 2020
  Department of Environmental Science, Central University of South Bihar, India

- Scientist C-Project June-Sep, 2017
  Division of Environmental Epidemiology, ICMR-National Institute of Malaria Research, New Delhi In **Centre of Excellence for Climate and Health (Grade Pay: 6600)**

- Project Research Fellow 2016- 2017
  DST-Project, Govt. of India, Central University of South Bihar, India

- Senior and Junior Research Fellow 2013-2016
  DST-Project, Govt. of India, Central University of South Bihar, India

- Invited Lecture April, 2013
  School of Environment, Biological and Earth Sciences, Central University of South Bihar, India

WORK EXPERIENCE WITH MODELS AND PACKAGES INSTALLATIONS

- **Extended hydrological Prediction in the capacity of operational forecast**

The forecasted rainfall for extended hydrological prediction being provided over particular reservoir or dam are of India. Further, to assess the model's skill in extended and medium range forecast.

- Data Processing and Scientific Visualization Packages

Analysed large volumes of atmospheric (outputs from model simulations) and reanalysis data products. Used advanced meteorological packages and visualization tools such as GrADS, MATLAB, QGIS, ArcGIS, NCL, R and Python.

- Data Formats and Data Extraction

Used Reanalysis and model (GCM/RCM) simulations data with formats e.g. self-describing files (GRIB1 and 2, HDF4 and 5, NetCDF3 and 4) in the research work.

- Model and Package Installation, upgrade and maintenance

Installed and upgraded various software packages and utilities on Windows and Unix operating systems to handle various data formats and their visualization. Proficient in mathematical models and graphical packages such as GrADS, XCONV, HDFView, Panoply and MS-Office.

- Statistical modelling for Climate Driven Vector borne Diseases

Developed statistical model in association with climate and Vector Borne disease (Japanese Encephalitis and Malaria) for district of Bihar and Orissa in India. The **SPSS, R software** used for model analysis and evaluation. The Poisson regression model and Bayesian Gaussian time series regression modeling performed.

- Teaching to Master students and assisting M.Sc. and M.Tech. students in their dissertation

PUBLICATIONS IN PEER-REVIEWED JOURNALS (SCI)

1. **Kumar P**, Vatsa R, Sarthi PP, et al (2020) Modeling an association between malaria cases and climate variables for Keonjhar district of Odisha, India: a Bayesian approach. J Parasit Dis. doi: 10.1007/s12639-020-01210-y

2. **Kumar P**., Sarthi P.P., Kumar S, Barat A, and Sinha A.K. (2020): Evaluation of CORDEX-RCMS and their driving GCMS in simulation of Indian Summer Monsoon Rainfall and its future projections. Arab. J. Geosci. https://doi.org/10.1007/s12517-020-5081-x.

3. Barat A, Sarthi PP, Kumar S, et al (2020) Observed and simulated winter temperature over Gurudongmar area , North Sikkim , India. Mausam. 1:115–124

4. **Kumar P**, Sarthi PP (2019) Surface Temperature Evaluation and Future Projections Over India Using CMIP5 Models. Pure Appl Geophys. doi: 10.1007/s00024-019-02203-6

5. **Kumar P.** Sarthi P.P., Kumar S, Barat A, and Sinha A.K. (2019): Evaluation of NASA's NEX-GDDP Simulated Summer Monsoon Rainfall over Homogeneous Monsoon Region of India. Theor Appl Climatol doi: https://doi: 10.1007/s00704-020-03188-2

6. Sarthi PP, Kumar S, Barat A, **Kumar P** et al (2019) Linkage of aerosol optical depth with rainfall and circulation parameters over the Eastern Gangetic Plains of India. J Earth Syst Sci. doi: 10.1007/s12040-019-1204-8

7. Kumar S, **Kumar P**, Barat A, et al (2019) Characteristics of Observed Meteorological Drought and its Linkage with Low-Level Easterly Wind Over India. Pure Appl Geophys. doi: 10.1007/s00024-019-02118-2

8. Deshmukh P, Narang R, Jain J, **Kumar P**, et al (2019) Leptospirosis in Wardha District, Central India—Analysis

of hospital based surveillance data. Clin Epidemiol Glob Heal 7:102–106. doi: 10.1016/j.cegh.2018.02.005

9. **Kumar P**, Kshirsagar A, Shil P (2018) Estimation of epidemiological parameters for historical ship outbreaks of influenza. Biomed Res J 5:28. doi: 10.4103/2349-3666.240299

10. Barat A, Kumar S, **Kumar P**, Parth Sarthi P (2018) Characteristics of Surface Urban Heat Island (SUHI) over the Gangetic Plain of Bihar, India. Asia-Pacific J Atmos Sci 54:205–214. doi: 10.1007/s13143-018-0004-4

11. Pisudde PM, **Kumar P**, Sarthi PP, Deshmukh PR (2017) Climatic Determinants of Japanese Encephalitis in Bihar State of India : A Time-Series Poisson Regression Analysis. 49:13–18

12. **Kumar P**, Pisudde PM, Sarthi PP, et al (2017) Acute encephalitis syndrome and Japanese Encephalitis, status and trends in Bihar State, India. Natl Med J INDIA 30:317–320. doi: 10.4103/0970-258X.239070

13. Parth Sarthi P, **Kumar P**, Ghosh S (2016) Possible future rainfall over Gangetic Plains (GP), India, in multi-model simulations of CMIP3 and CMIP5. Theor Appl Climatol 124:691–701. doi: 10.1007/s00704-015-1447-5

14. **Kumar P**, Pisudde PM, Sarthi PP, et al (2016) Acute encephalitis syndrome and Japanese Encephalitis, status and trends in Bihar State, India. Int J Infect Dis 45:306–307. doi: 10.1016/j.ijid.2016.02.671

15. Parth Sarthi P, Ghosh S, **Kumar P** (2015) Possible future projection of Indian Summer Monsoon Rainfall (ISMR) with the evaluation of model performance in Coupled Model Inter-comparison Project Phase 5 (CMIP5). Glob Planet Change 129:92–106. doi: 10.1016/j.gloplacha.2015.03.005

Report/Book Chapter

1. **EXTENDED RANGE FORECAST (ERF) DURING SOUTHWEST MONSOON 2020,** D.R. Pattanaik, Satendra Kumar, **Praveen Kumar**, Ashish Alone, Raju Mandal, Avijit Dey, R. Phani, M. Mohapatra, and A. K. Sahai, Published by India Meteorological Department, India.

Manuscript (with journal)

1. **Kumar P** and Sarthi PP. (2020): Evaluation of ISMR variability in coupled model Intercomparison project phase 6 (CMIP6). In revision, **Theoretical and Applied Climatology** (Springer)

2. **Kumar P**, Sarthi PP,…..(2020): Statistical Modeling of Meteorological Association to Acute Encephalitis Syndrome at Gorakhpur, India" Submitted.

3. Sinha A. K., **Kumar P**, Sarthi PP and Mohapatra M. (2020): Tropical Cyclonic Disturbances over the Bay of Bengal in observation and climate model's simulation. Submitted to **Pure and Applied Geophysics (Springer)**.

4. Barat A, Sarthi PP, ……, **Kumar P**; Ashutosh K Sinha (2020): Surface Urban Heat Island (SUHI) over Riverside Cities along the Gangetic Plain of India. In revision, **Pure and Applied Geophysics** (Springer)

INTERNATIONAL VISIT

Attended the school themed "Integrated Environmental Health Impact Assessment (IEHIA) of Air Pollution and Climate Change in Mediterranean Areas", International Centre for Theoretical Physics (ICTP), **Trieste, Italy**. 23-27 April, 2018

CONFERENCES/WORKSHOP/TRAINING AND SCHOOL ATTENDED

- Talk in Annual Monsoon E-Workshop and National E-Workshop on Cloud and Precipitation

Processes, 18-20th January 2021, "Medium to Extended Forecast over River Basins During Monsoon-2020. Jan-2021

- Attended International Conference on Climate Services-6, Feb 11 – 13, 2020, Pune, India
- Abstract selected for poster presentation in American Monsoons: progress and future plans at ICTP South American Institute for Fundamental Research in São Paulo. **Aug-2019**
- Statistical Analysis using R Software in Indian Institute of Technology (IIT), Kanpur, India. **June-2019**
- Attended two weeks' school organized by Science and Engineering Research Board (SERB) on Numerical Modelling and Forecasting of Desert Storm and Cloudburst. **Feb, 2019**
- Special Lecture Series on Cloud Convection Parametrization, IITM Pune, India **Dec, 2017**
- Short Course on Dynamic Data Assimilation: Theory and Applications, IITM Pune, India **July, 2017**
- Indo-US Workshop on Development and Applications of Downscaling Climate Projections, IITM, Pune (CCCR Division) **March, 2017**
- Regional Training program on Post Disaster Needs Assessment (PDNA) Tools for India, Organized by ADPC, World Bank Group, BSDMA and NIDM **Sep, 2015**

PROFESSIONAL AFFILIATIONS AND SERVICES

- **HONORARY ROSALIND MEMBER OF LONDON JOURNALS PRESS (ID#GB24652)**
- **Reviewer for** Current Journal of Applied Science and Technology
- **Reviewer** for PLOSONE (Public Library of Science)
- **Reviewer** for International Journal of Biometeorology (Springer)
- **Reviewer** for Arabian Journal of Geosciences (Springer)
- **Reviewer** for Biomedical Research Journal (Medknow)
- **Executive council Member**: India Meteorological Society (IMS, India)-Patna Chapter
- **Member (Annual):** Indian Science Congress
- **Advisor**: Gangeya (A Not for Profit Organization), Patna, India
- **Expert**: Policy Change Initiative ((A Not for Profit Organization), New Delhi, India
- https://scholar.google.co.in/citations?user=mvgcN1FlQBAC&hl=en

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ORIGINAL ARTICLE

JPD

Modeling an association between malaria cases and climate variables for Keonjhar district of Odisha, India: a Bayesian approach

Praveen Kumar[1] · Richa Vatsa[2] · P. Parth Sarthi[1] · Mukesh Kumar[1] · Vinay Gangare[3]

Received: 5 December 2019 / Accepted: 3 March 2020 / Published online: 19 March 2020

Abstract Malaria, a vector-borne disease, is a significant public health problem in Keonjhar district of Odisha (the malaria capital of India). Prediction of malaria, in advance, is an urgent need for reporting rolling cases of disease throughout the year. The climate condition do play an essential role in the transmission of malaria. Hence, the current study aims to develop and assess a simple and straightforward statistical model of an association between malaria cases and climate variates. It may help in accurate predictions of malaria cases given future climate conditions. For this purpose, a Bayesian Gaussian time series regression model is adopted to fit a relationship of the square root of malaria cases with climate variables with practical lag effects. The model fitting is assessed using a Bayesian version of R^2 (RsqB). Whereas, the predictive ability of the model is measured using a cross-validation technique. As a result, it is found that the square root of malaria cases with lag 1, maximum temperature, and relative humidity with lag 3 and 0 (respectively), are significantly positively associated with the square root of the cases. However, the minimum and average temperatures with lag 2, respectively, are observed as negatively (significantly) related. The considered model accounts for moderate amount of variation in the square root of malaria cases as received through the results for RsqB. We also present Absolute Percentage Errors (APE) for each of the 12 months (January–December) for a better understanding of the seasonal pattern of the predicted (square root of) malaria cases. Most of the APEs obtained corresponding to test data points is reasonably low. Further, the analysis shows that the considered model closely predicted the actual (square root of) malaria cases, except for some peak cases during the particular months. The output of the current research might help the district to develop and strengthen early warning prediction of malaria cases for proper mitigation, eradication, and prevention in similar settings.

Keywords Malaria · Forecasting · Climate · Bayesian statistical modeling · Gaussian time series regression · MCMC · Odisha

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Introduction

Malaria (vector-borne disease), has a substantial public health concern in most of the tropical countries of the world. It is the most prevalent vector-borne disease, as nine out of ten malaria deaths occur in Africa, Latin America, and Asia. In India itself, approximately 225 million cases, and nearly one million deaths occur every year due to malaria disease (Kant 2011; Hay et al. 2008, 2011). However, it is the fourth leading cause of death in children and pregnant women in developing nations (Martens and Hall 2000; Rowe et al. 2013). World Health Organisation (WHO) estimated millions of malaria cases and

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ORIGINAL PAPER

Evaluation of NASA's NEX-GDDP-simulated summer monsoon rainfall over homogeneous monsoon regions of India

Praveen Kumar[1] · Sunny Kumar[1] · Archisman Barat[1] · P. Parth Sarthi[1] · Ashutosh K. Sinha[1]

Received: 24 May 2019 / Accepted: 19 March 2020

Abstract

The current research aimed to evaluate the predictive skill of statistically downscaled National Aeronautics Space Administration (NASA) Earth Exchange Global Daily Downscaled Projection (NEX-GDDP) data in simulating the Indian summer monsoon rainfall (ISMR) for the period of 1961–2005 over the individual homogeneous monsoon regions of India (HMRI). For the purpose, five models are selected, as these models (in GCM) have shown better performance in the simulation of ISMR by the researcher. The spatial characteristics and statistical scores (annual cycle, percentage bias, Taylor score, probability distribution function) are used to evaluate the performance of each model in simulating rainfall over land points of individual HMRI. In the spatial analysis, it seems that models of NEX-GDDP can simulate the ISMR, pretty well in comparison to APHRODITE (observation), and show a moderate to significantly high correlation (grid point) over each of the HMRI particularly to core monsoon region, except over few parts of PI. The Taylor statistics suggest that the model CanESM performs very well over the regions of PI, NWI, and WCI. The models MPI-ESM-LR and NorESM perform well in simulating the ISMR over CNI, followed by ACCESS, CanESM, and CCSM4. The models have varying bias in predicting the rainfall; however, ACCESS does perform well and shows the minimum bias (ranges from ~ 1 to ~ 14% only) among others. The models CanESM and NorESM (except over CNI) performed relatively better. The NEX-GDDP models overcome the global climate models (GCMs) in the retrospective simulation of ISMR over the land points of India. It is concluded that the models have good predictability of JJAS rainfall but unable to catch daily rainfall variability.

1 Introduction

The summer monsoon rainfall is an essential parameter for agricultural production, water supply, and livelihood in India. However, relatively accurate quantification of summer monsoon rainfall for future periods at the regional and local scale is a challenging task owing to its erratic behavior and skewed statistics (Meher et al. 2017). The varying orography and land-sea contrast make the uneven distribution of rainfall over landmasses of India, and therefore, the predictability of rainfall is always a challenging task. Global climate models (GCMs) are used to predict the rainfall but unable to provide information on regional/smaller scales (Solomon et al. 2007). To improve prediction, in the 1990s, World Climate Research Programme (WCRP) coordinated Coupled Model Intercomparison Project (CMIP) has been carried out on control experiment and variety of sensitivity experiments (Meehl et al.2000), and further additional phases of the CMIP, termed as CMIP2, CMIP2+, CMIP3, CMIP5, and recently CMIP6, have been performed. There are numerous studies on validation and future projection of rainfall in CMIP3 and CMIP5 model experiments over the land points of India (Sarthi et al. 2015, 2016); however, projection of summer monsoon rainfall under changing climate using GCMs is still challenging for the researchers (Pattnaik and Kumar 2010; Turner and Annamalai 2012). In addition to that, uncertainties are associated with GCMs in the prediction of monsoon rainfall due to the vastness of GCMs, coarse resolution, and not proper inclusion of local or regional factors (Christensen et al. 2008; Saini et al. 2015).

To provide information on regional scales for agricultural planning, water resources management, power industry, and environmental policymaking, the prediction of rainfall through coarse resolution GCMs is not sufficient (Maraun et al. 2010). In general, the globally available GCMs outputs at coarser resolution (varying resolution of 1.0–2.5°) (Pepler

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Status and trend of acute encephalitis syndrome and Japanese encephalitis in Bihar, India

PRAVEEN KUMAR, P.M. PISUDDE, P.P. SARTHI, M.P. SHARMA, V.R. KESHRI

ABSTRACT

Background. Acute encephalitis syndrome (AES) is a clinical condition, of which the most common cause is Japanese encephalitis (JE). Though there is deficiency of data on AES and JE from Bihar, the state ranks third in the reporting of JE cases after Uttar Pradesh and Assam. We aimed to assess the status and trends of AES and JE cases in Bihar and to know the status of the disease in the districts.

Methods. We collected monthly epidemiological data for AES and JE for the period 2009–2014.

Results. A total of 4400 cases (733 cases/year) with an average case fatality rate (CFR) of 30% for AES for the entire study period. A total of 396 cases of JE were reported with approximately 14% CFR. The disease peaks were during the start and end of the Indian summer and monsoon months for AES and JE, respectively. Districts such as Patna, Jehanabad, Nawada, Gaya and East Champaran reported the maximum number of AES and JE cases with annual incidence rates of 4.7–25.0 and 0.546–1.78 per 100 000 population, respectively.

Conclusion. Since 2009, the incidence of AES and JE cases has been increasing in Bihar.

Natl Med J India 2017;30:317–20

INTRODUCTION

Acute encephalitis syndrome (AES) is a multifactorial clinical condition, the most common cause being Japanese encephalitis (JE). JE is a vector-borne viral disease caused by the JE virus of group B arbovirus (Flavivirus) and is transmitted to humans by the Culicine mosquito. JE affects the central nervous system (CNS), and can cause serious complications and death. The case fatality rate (CFR) is high and those who survive may suffer from neurological sequelae such as convulsions, episodic headache, autonomic disturbance, abnormal behaviour, mood disorder, intellectual deficit, paresis, incoordination of movements, jerky limb movements, speech disorder, cranial nerve palsy, gaze palsy, parkinsonian features, impaired hearing, etc.[1] An estimated 25% of affected children die from the disease, and among those who survive, 30%–40% suffer from physical and mental impairment. Children suffer the highest attack rate due to lack of cumulative immunity from natural infections.[2] JE was first recognized in Japan in 1924. Since the late 1960s, the extent of epidemics in Japan and China has steadily declined. It is estimated that 3 billion people are at risk, and the disease has spread to new territories.[3]

According to WHO, JE is endemic in large parts of the Asia and Pacific regions, especially in the South Asian and Western Pacific regions. According to WHO statistics, 3187 cases of JE were reported in 2013 from all over the world; of these, 42% were from countries in the South-East Asia region, and of these 80% were from India.[4] According to a systematic review by Campbell in 2011, India falls in the medium-to-high incidence areas with an expanding vaccination programme and shares its place with Sri Lanka, Thailand and Vietnam. The population of these endemic areas is about 538.1 million.[5] A fatality rate of 30%–50% has been attributed to JE in southern and eastern Asia.[6]

The first case of JE was reported in India in 1955 from Vellore, Tamil Nadu and the first major outbreak was reported in 1973 from Burdwan district of West Bengal. Since then, in India, AES and JE have been reported from 171 districts of 19 states. In India, the JE virus has been isolated from more than 15 species of mosquitos belonging to genera Culex, Aedes and Anopheles; *Culex tritaeniorhynchus* and *Culex vishnui* are considered the main vectors.[7] A major outbreak of JE was reported from eastern Uttar Pradesh (UP) during 2005 with more than 6000 cases and 1500 deaths. This led to the introduction of the JE vaccine in endemic areas. Bihar, which is adjacent to eastern UP, has also reported a rise in the number of patients with AES and JE with periodic epidemics in some districts, including Muzaffarpur district.[8]

The outbreaks of JE in Gorakhpur and Basti divisions in eastern UP during 2005, led to the development of surveillance guidelines for AES and JE by the National Vector Borne Disease Control Programme (NVBDCP). These guidelines required JE to be reported as an AES and after confirmation from the sentinel sites, a line-list of JE cases needed to be drawn and sent in prescribed formats.[9]

There is deficiency of data on AES and JE from Bihar. We aimed to ascertain the status and trends of AES and JE in Bihar to suggest measures for prevention and control.

METHODS

The Bihar plain is divided into two unequal halves by the river Ganga which flows from west to east. With a population of 10.38 crore (103.8 million), 17% of the state population is in the 0–6 years age group. The literacy rate of Bihar is 63.8% and decadal

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M.P. SHARMA State Programme Officer (Malaria)

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ORIGINAL PAPER

Evaluation of CORDEX-RCMS and their driving GCMs of CMIP5 in simulation of Indian summer monsoon rainfall and its future projections

Praveen Kumar[1] · Pradhan Parth Sarthi[1] · Sunny Kumar[1] · Archisman Barat[1] · Ashutosh K. Sinha[1]

Received: 24 January 2019 / Accepted: 7 January 2020

Abstract

Climate models are widely used for global and regional assessment of climate change. The present study aims to assess the ability of regional climate models (RCMs) of the Coordinated Regional Climate Downscaling Experiment (CORDEX) and their driving global climate models (GCMs) of Coupled Models Intercomparison Project phase 5 (CMIP5) in simulating the Indian summer monsoon rainfall (ISMR) over India (1979–2005). The assessment of CORDEX-RCMs driven by the boundary conditions from GCMs is necessary to know the capability of RCMs in the simulation of ISMR over India. The spatiotemporal analysis of ISMR is performed for past periods to understand its characteristics while attempt is made for future projected changes over the homogeneous rainfall region of India. The study reveals that RCM REMO2009 (MPI) and its driving GCM MPI-ESM-LR are close to the observed rainfall of Global Precipitation Climatology Centre (GPCC). Further, it is noticed that the biases in REMO2009 (MPI) and GCMs viz. MPI-ESM-LR and GFDL-CM3 are of comparable amplitude making them suitable for future projection of ISMR for 2016–2045 under Representative Concentration Pathways (RCPs) 4.5 and 8.5 at 99% and 95% confidence levels. In the simulation of REMO2009 (MPI) and its driving GCM (MPI-ESM-LR) under RCPs 4.5 and 8.5, an excess of rainfall is possible over the parts of Peninsular India (PI) and West Central India (WCI) while a deficit over the North West India (NWI). The simulation of the GCM, GFDL-CM3 depicts an excess of rainfall over NWI, PI, and deficit over WCI under both emission scenarios.

Keywords CORDEX · Regional climate models · Indian summer monsoon rainfall · Evaluation · Future projection

Highlights

- The study highlights performance of the CORDEX-RCMs and their driving GCMs in the simulation of ISMR over land points of India.
- More biases are observed in CORDEX-RCMs except few, while the driving GCMs simulate close to observations.
- RCM REMO2009 (MPI) and its driving GCM MPI-ESM-LR and along with another GCM GFDL-CM3 simulate the ISMR fairly well.
- Under RCPs 4.5 and 8.5, an excess of rainfall is possible over PI and WCI while a deficit over NWI in REMO2009 (MPI) and MPI-ESM-LR.

Responsible Editor: Zhihua Zhang

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Introduction

The ocean-land-atmospheric systems and their dynamic processes in South Asia are highly complex. Any change in external or internal processes of the system alters the rainfall pattern on regional scale over India (Goswami 2012) which has a large impact on sectors such as agriculture and water resources. Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report (AR4) has clearly reported changes in rainfall pattern over the region with increased risks of climate extremes (droughts, floods, storm surge, cyclone etc.). To assess the changes in climatic variables in past and future time periods, climate models at various spatial and temporal scales have emerged as viable tools. The global climate models (GCMs) at resolution of 100–250 km are able to simulate the climatic variables at continental scale (Shongwe et al. 2009), but do not capture the associated processes on regional scale which is required for regional climate change

Published online: 26 February 2020

Research Article

Climatic Determinants of Japanese Encephalitis in Bihar State of India: A Time-Series Poisson Regression Analysis

Pravin M Pisudde[1], Praveen Kumar[2], Pradhan Parth Sarthi[3], Pradeep R Deshmukh[4]

Abstract

World's 60% population lives in regions endemic for Japanese Encephalitis (JE), which affects approximately three billion people. Southeast Asia, especially India, is also not an exception to JE. The present study was carried out to know about the climatic determinants that affect occurrence and transmission of JE cases. The data on maximum temperature, minimum temperature, average temperature, relative humidity, and rainfall was retrieved for the period from 2009 to 2014. Similarly, JE surveillance data was also retrieved for the same period. Time-series Poisson regression analysis was used to quantify the association between climatic conditions and JE incidences. Among the predictors, time was negatively associated, number of JE cases during last month, relative humidity (1-month lag) and rainfall (2-month lag) were positively associated while average temperature (3-month lag) has no significant association with JE incidence. This will help in early forecasting of the JE incidences, if future climate over the area are known in advance.

Keywords: Rainfall, Temperature, Relative humidity, Climate, Japanese Encephalitis, Bihar, Poisson regression analysis

Highlights

- The optimal lag for climatic variables with JE cases in Bihar is analyzed
- Number of JE cases during last month, relative humidity (1-month lag) and rainfall (2-month lag) were positively associated
- The Poisson regression model fits well, as the predicted and observed and number of JE cases match significantly during reporting months

Introduction

World's 60% population lives in regions endemic for Japanese Encephalitis (JE), which affects approximately three billion people. It is estimated that approximately 68,000 people suffer from this disease every year, causing approximately 10,000–15,000 deaths in more than 20 countries, including Asia and the Pacific region.[1,2] Rural and suburban areas are more affected.[3-5] It also poses a great threat to human beings in Southeast Asia and the Western Pacific region, with case fatality rate up to 30%. According to annual (2014-15) report of National Vector Borne Disease Control Program (NVBDCP), India has reported 3600 cases of JE in years 2010 to 2013 with mortality of approximately 18%. Bihar State

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Linkage of aerosol optical depth with rainfall and circulation parameters over the Eastern Gangetic Plains of India

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The aerosol optical depth (AOD) is an important physical parameter and dimensionless number. The possible link between AOD and variability of summer monsoon rainfall and surface temperature over the densely populated Gangetic Plain may be used to assess change in weather and climate over the Plain. For examining the impact of AOD on summer monsoon rainfall and surface temperature, monthly data of AOD for the period of 2000–2015 are obtained from a remotely sensed moderate resolution imaging spectro-radiometer sensor at 550 nm and at a surface resolution of $1^\circ \times 1^\circ$. For the period of 2000–2015, rainfall and surface temperature data at a resolution of $1^\circ \times 1^\circ$ are obtained from Indian Meteorological Department (IMD) and surface wind data are obtained from National Centers for Environmental Prediction (NCEP). Summer monsoon rainfall and AOD are inversely related during 2000–2015. On an average, a difference in the mean monthly surface maximum and minimum temperatures increases (decreases) with a decrease (increase) of AOD. The high degree of correlation exists between AOD and a difference in $T_{\max}$ and $T_{\min}$ during January to June–July. In winter months, relative strength of negative vorticity over the Gangetic Plain and positive vorticity in the adjacent area may be cause of more dispersion of AOD in February in comparison with that in December and January and therefore more AOD is noticed in January and December.

Keywords. Aerosol optical depth (AOD); Indian Gangetic Plain; temperature; vorticity; MODIS.

1. Introduction

Aerosols originating from natural and anthropogenic sources have been influencing air quality, Earth's radiation budget (through scattering and absorbing the incoming solar and outgoing terrestrial radiation) and consequently changing regional and global climate. The variability in aerosol concentration has been significantly impacting the regional scale. The anthropogenic aerosols (sulphate and carbonaceous aerosols) have increased substantially in recent decades, especially over urban's industrial regions and have direct impact on cloud formation and the rainfall distribution because aerosols act as cloud condensation nuclei (CCN) and influences cloud formation, rainfall and climate through radiative forcing and microphysical effects (Rosenfeld 2000; Li 2004; Li *et al.* 2007, 2011a, b; Nakajima *et al.* 2007; Huang *et al.* 2014; Guo *et al.* 2016). For assessing changes in weather and climate due to aerosol concentration, aerosol optical depth (AOD) is an important physical

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Characteristics of Surface Urban Heat Island (SUHI) over the Gangetic Plain of Bihar, India

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Abstract: The rapid urbanisation impacts on environment, climate, agriculture, water resources trigger several problems to human beings. The present study is carried out to estimate intensity and trend of Urban Heat Island (UHI) as Surface UHI (SUHI) over towns/cities of the Gangetic plain of the state of Bihar, India, in which urban areas show relatively greater Land Surface Temperature (LST) than its rural surroundings especially during night times. The LST data (2001-14) of Moderate Resolution Imaging Spectroradiometer (MODIS) is used for five major towns/cities of Bihar namely, Bhagalpur, Gaya, Patna, Purnea and Muzzaffarpur. Each city is classified into Urban, Suburban and Rural zones as per land cover of the area. During winter months (January, February, November and December), UHI is more intense over all towns/cities. Mann-Kendall Test is applied on Surface Urban Heat Island Intensity (SUHII) in which MK-Test Statistic (S) shows a significant increasing trend. This trend would alarm a risk to increase in air pollution, heat related biohazards, energy demand in the region. This study shows the need of urban greening and proper town planning over the considered areas to mitigate the changes.

Key words: Surface Urban Heat Island (SUHI), Land Use Land Cover (LULC), Mann-Kendall Test, Bihar

1. Introduction

The fast urbanisation has been impacting water resources, agriculture, environment (micro and meso scale) and created several problems to human beings. Changes in urbanisation through expansion (vertical and horizontal) of the city alter surface temperature over that area. Due to fast rate of urbanisation, suburbs of cities is expected to decrease in vegetation cover and rise in surface temperature. Such Changes in surface temperature lead to phenomena known as Urban Heat Island (UHI) and are generally associated with changes in Land Use Land Cover (LULC) over the area (Kalnay and Cai, 2003; Ding and Shi, 2013; Meng and Liu, 2013). LULC changes may be responsible for changes in heat fluxes, albedo, evapotranspiration rate, biogeochemical cycles (Tian et al., 2014), moisture exchange (Kharol et al., 2013), cyclone track (Badrinath et al., 2012), ecosystems (Hyman et al., 2000; Gupta and Roy, 2012; Karwariya and Tripathi, 2012; Mishra et al., 2014), hydrological cycles and water resources (Aggarwal et al., 2012; Garg et al., 2012), and increase run off (Carlson and Arthur, 2000). LULC changes are influencing the formation of UHI (Nesarikar-Patki and Raykar-Alange, 2012). Researchers (Kalnay and Cai, 2003; Voogt and Oke, 2003; Meng and Liu, 2013; Bahi et al., 2016) suggested that LULC and Land Surface Temperature (LST) are important parameters for the study of UHI.

The profound effect of urbanisation is changes in LST profile and formation of UHI (Ding and Shi, 2013) in which urban areas show relatively greater temperature than its rural surroundings (Zhou et al., 2013), especially during night time (Tam et al., 2015). UHI, particularly after sunset, can have intensity of as much as 12°C (USEPA, 2015), or between 10-15°C during night (Lokoshchenko et al., 2015). In general, UHI is either determined by station data (Jiang et al., 2006; Meng and Liu, 2013) or by remote sensing data (Rao, 1972; Meng and Liu, 2013). Quantification of Intensity of UHI is important and LST difference is an indicator for UHI Intensity (UHII) (Voogt and Oke, 2003; Singh et al., 2014). The LST depends upon surface albedo, moisture content and most importantly LULC Changes (LULCC) (Xian, 2008). The formation of UHI takes place due to dense building structure in the urban area which receives large amount of solar radiation in the daytime. The surface undergoes nocturnal irradiative cooling, and thus retarding the rate of decrease in air temperature, whereas in rural areas nocturnal cooling occurs more rapidly (Lee and Baik, 2010). This difference in surface energy balance causes a markedly difference between urban and rural LST, resulting in formation of UHI. The UHII varies with morphology and size of the city (Oke, 1973; Sakakibara and Matsui, 2005; Hoffmann et al., 2012). The land cover also has a major influence on the extension and geometry of the UHI (Cheval and Dumitrescu, 2009). Decrease in Urban Greens can intensify the UHII while increase in greenery can mitigate its impact (Chen et al., 2014). UHI has strong impact on air quality (Sarrat et al., 2006; Davies et al., 2007; Sarkar and Ridder, 2011). UHI may trigger heat related illness, affect urban air quality (Qi et al., 2007), induce heat waves (Holderness et al., 2013) and adversely affect local climate (Van Weverberg et al., 2008; Sarkar and Ridder, 2011). Tan et al., (2010) found that heat related mortality is higher in city than in suburbs and 3°C UHI may cause increase in hospital

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