Project : Short-Term Climate Variability and Prediction

Sub-Project : Climate Variability, Predictability and Applications

Project Director : Dr. Ashwini Kulkarni, Scientist-F

OBJECTIVES

The main objective of this project is to understand mechanisms responsible for the Indian monsoon variability on intra-seasonal, inter-annual and inter-decadal time scales which can be achieved through diagnostic studies as well as modelling and simulation studies.

In particular,

- To continue ongoing efforts in identifying regional and global climate drivers for monsoon inter-annual variability and to identify useful predictors.
- To examine the teleconnections of Indian monsoon rainfall on intra-seasonal , inter-annual to decadal scale.
- To develop forecast models for relevant climatic parameters over India on different spatio-temporal scales using empirical/statistical methods as well as downscaling of seasonal forecasts from General Circulation Models (GCMs) with high-resolution regional models.
- To develop regional climate data products such as daily temperature, rainfall etc. on district, state and homogeneous regional scales using latest interpolation techniques for improved climate change detection and attribution.
- To understand the role of aerosol loading over the Indian region in monsoon inter-annual variability and its possible implications on the predictability on inter-annual as well as on intra-seasonal time scales.
- To quantify the various aspects of climate change and variability on intra-seasonal, inter-annual, decadal and century time scales over India and the neighbouring countries, particularly related to the southwest and northeast monsoons.

DEVELOPMENTAL ACTIVITIES

A web portal CLIMINFO (*http://www.tropmet.res.in/~lip/climvar/rainfall.php*) is being developed at the Institute which will provide all the information on rainfall and temperature variability over a region in one click. The products are being prepared on the spatial scale of sub-divisions, cities and districts and on the time scale of daily , monthly to seasonal. The products will also be prepared for the time scales of nakshatras, especially for farmers. The products being developed which involve empirical distributions, rainfall limits, excess/deficit events etc. The products are so designed as to be used by general public as well as farmers. These products would be very useful as inputs to impact assessment groups.

Developing a dashboard for projections of rainfall and temperature over various regions of India using NEX-GDDP data in collaboration with EPTRI, Hyderabad, NOAA,NCEI and North Carolina State University, USA.

RESEARCH ACHIEVEMENTS

Projected changes in rainfall and temperature over homogeneous regions of India

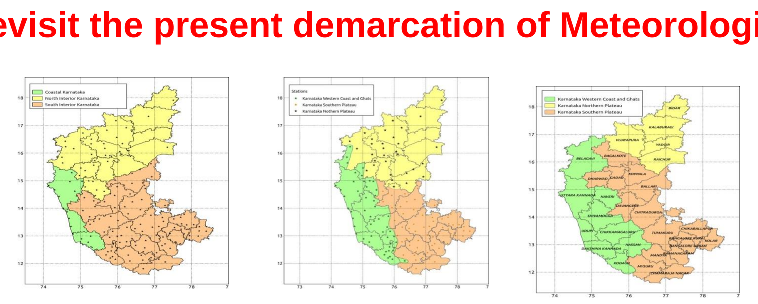
The impact of climate change is assessed on the characteristics of seasonal maximum and minimum temperature and seasonal summer monsoon rainfall over five homogeneous regions of India using a high-resolution regional climate model. Providing REgional Climate for Climate Studies (PRECIS) is developed at Hadley Centre for Climate Prediction and Research, UK. The model simulations are carried out over South Asian domain for the continuous period of 1961-2098 at 50-km horizontal resolution. Here, three simulations from a 17-member perturbed physics ensemble (PPE) produced using HadCM3 under the Quantifying Model Uncertainties in Model Predictions (QUMP) project of Hadley Centre, Met. Office, UK, have been used as lateral boundary conditions (LBCs) for the 138-year simulations of the regional climate model under Intergovernmental Panel on Climate Change (IPCC) A1B scenario. The regional climate model projections indicate the increase in the summer monsoon rainfall, towards the end of the present century, over all the homogeneous regions (15 to 19%) except peninsular India (~5%). There may be marginal change in the frequency of medium and heavy rainfall events (>20 mm) towards the end of the present century. The analysis over five homogeneous regions indicates that the mean maximum surface air temperatures for the pre-monsoon season (March–April–May) as well as the mean minimum surface air temperature for winter season (January–February) may be warmer by around 4°C towards the end of the twenty-first century.

	JJAS RAINFALL % CHANGE		
REGION	2020s	2050s	2080s
NORTH WEST	15.3 (6 TO 23%)	9 (4 TO 13%)	18.7 (15 TO 21%)
CENTRAL NE	2.7 (2 TO 4%)	10 (8 TO 13%)	19 (16 TO 22%)
NORTH EAST	5 (0 TO 10%)	8.3 (5 TO 10%)	14.7 (10 TO 17%)
WEST CENTRAL	5.7 (1 TO 9%)	13.7 (5 TO 12%)	16.7 (15 TO 20%)
PENINSULAR	4.7 (4 TO 6%)	2.3 (-7 TO 14%)	4.7 (1 TO 9%)

Table : Average % change simulated in summer monsoon (JJAS) precipitation for 2020s, 2050s and 2080s with respect to 1970s. The figures in the bracket indicate the range of future projections.

(Patwardhan S., Kulkarni Ashwini and Koteswara Rao K,Theoretical and Applied Climatology, 131, January 2018, DOI:10.1007/s00704-016-1999-z,581-592)

Revisit the present demarcation of Meteorological Sub-divisions



(a) (b) (c)

Fig.1 : (a) Existing subdivisions of the state of Karnataka and proposed subdivisions (b) based on station mean rainfall and (c) district average rainfall

A Committee under the chairmanship of Prof S Gadgil has been set up in May 2016 by Secretary, MOES to revisit the present delineation of meteorological subdivisions. The clusters have been formed using the objective method of k-means clustering algorithm to seasonal rainfall over present meteorological subdivisions. The analysis for subdivisions over south peninsular India has been completed. The present demarcation of Karnataka and Maharashtra show some changes (e.g. Fig.1). However, present subdivisions of the states of Andhra Pradesh, Telangana, Kerala and Tamil Nadu are coherent and homogeneous. The report has been prepared.

(Kulkarni, Guhathakurta, Patwardhan, Gadgil)

Temporal and Spatial Analysis of Rainfall and Associated Normalized Difference Vegetation Index (NDVI) over the Pune district, India

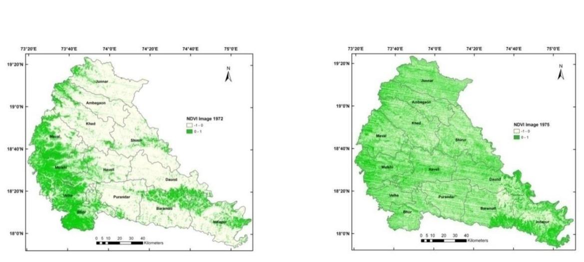


Fig.2 : NDVI Image for drought year of 1972 and during good rainfall year 1975

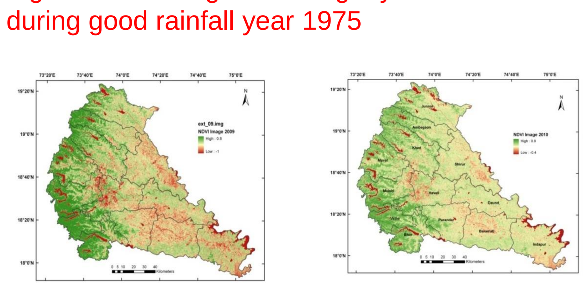


Fig.3 : NDVI Image for drought year of 2009 and during good rainfall year of 2010

Pune district (Maharashtra state) is having slightly lower mean monsoon or annual rainfall having high intra-seasonal and spatial variability of rainfall over different talukas. An attempt has been made to present daily rainfall series for 23 stations in all the 14 talukas of Pune district for the period 1971- 2012. The mean monthly rainfall pattern and the variability of four seasons and annual and decadal rainfall for each of 14 talukas of Pune district are presented and are very useful information to the agriculture and water sectors of this district. The study aims to find the changing pattern of rainfall over Pune at the taluka scale which may have impact on increasing extreme rainfall events and droughts/floods over the region.

To understand a detailed relationship between rainfall variability and vegetation dynamics, an attempt has been made to study the distribution of rainfall over the Pune district and its impact on NDVI during 1971-2012. The results indicated that the NDVI values changed in relation to different amount of precipitation, showing that about 54% and 13% of area remained barren during 1972 and 2009 drought years respectively (Figs.2 and 3).

(Nandargi S.S. and Kamble A.S., 2018, Focus on Science International Journal, 3(4): 9-16, DOI: 10.21859/fosci-03041452)

Analysis of Trends and Variability in Rainfall over West Bengal

The trends and variability in the rainfall pattern over the West Bengal using non parametric Mann-Kendall test, Sen's slope estimator has been carried out for monthly, seasonal and annual rainfall series of 19 districts in the two meteorological sub-divisions by using monthly rainfall data of 117 years (1901-2017). It was found that except Darjeeling district, all the other districts in Sub-Himalayan West Bengal (SHWB) showed decreasing trend. On the other hand nine districts in the Gangetic West Bengal (GWB) showed increasing trend in the rainfall pattern and four districts showed slightly decreasing trend. Percentage change in annual rainfall series showed > -10% change in Dinajpur S. (SHWB), Nadia and Hoogly (GWB) districts. Positive increase >10% is seen in Birbhum, Midnapore E, 24 Pargana S and Kolkata districts of GWB. Seasonal rainfall series showed negative percentage change >-10% in Jalpaiguri and Dinajpur S districts of SHWB and positive increase >10% Midnapore E, Midnapore W, 24 Pargana S and Kolkata districts of GWB. As the state is situated in close vicinity of Bay of Bengal and due to increase in Sea Surface Temperature (SST) in recent past, the results obtained from the present analysis would be meaningful in water resource management, proper agricultural planning, marine life, flood management and economy of the West Bengal.

(Nandargi S.S. And Barman K., 2018, International Journal of Current Advanced Research, 7(7E):14223-14229, Index Copernicus IC value:ICV-2016:83.75.)

Spatial and Temporal Distribution of Rainfall and Rainy Days over the Goa State

Planning for water resources development in a basin or over a region requires careful assessment of the available water resources and reasonable needs of the basin/region in foreseeable future for various purposes such as drinking water, irrigation, hydro-power, navigation, etc. There are several ongoing river water disputes between different states of India, especially in the peninsular region due to decrease in rainfall during the past 15 years or so. The sharing of water of the Mondovi River is a cause of dispute between the Governments of Maharashtra, Karnataka and Goa states. An attempt has therefore been made to study the characteristics of rainfall distribution over the Goa state using daily and monthly rainfall data. The study mostly comprises of spatial distribution of rainfall, seasonal and annual rainfall trend, relationship between rainfall and rainy days, mean daily rainfall intensity (MDI) and yearly variation of rainfall as well. The results of this study would form basis for various studies in administrating fresh water sources, projecting the investments to prevent the urban areas from the flood and proper planning of the agricultural activities in the State. (Paper published in International J. of Energy Resources and Conversion, Virginia, U.S.)

(Nandargi S.S. and Gupta V.K., 2018, Journal of Energy Resources and Conversion, 1, November 2018, 1-17)

Statistical characteristics of cloud burst and mini-cloud burst events during monsoon season in India

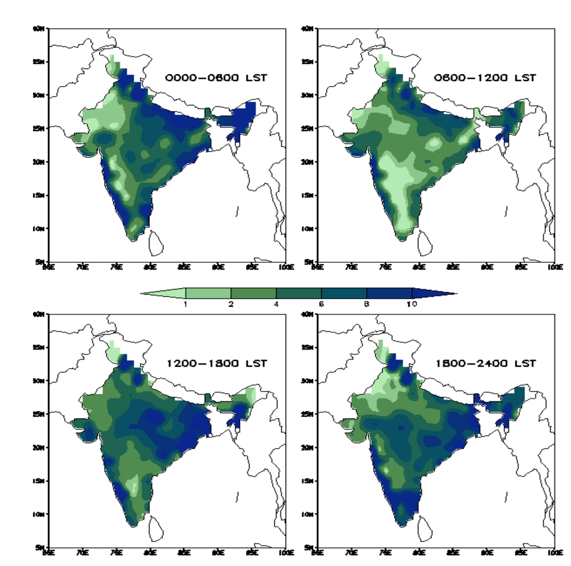


Fig.4 : MCB distribution as per their time of occurrence during a monsoon day

The study analyses short duration heavy rainfall events namely cloud burst (CB) associated with heavy rainfall in the steep slope mountainous regions of Himalayas irrespective of the rainfall amount. Other category of cloud burst events as defined by IMD associated with rainfall > 10 cm/hr. These are found to occur over different parts of India. A new category of short-term heavy rainfall events has been defined as "mini-cloud burst" (MCB). It is an event in which rainfall in two consecutive rain-hours is 5 cm or more. MCB occurs in June over Western Ghats, over central India and foot hills of Himalayas in July and August. The frequency is low in the month of September. These events generally found to occur in the early morning hours at foot hills of Himalayas and along the west coast of India. In the interior of the land mass these are observe in the afternoon hours while in southern peninsula during night hours. Trend analyses indicate significant increase in these events at many places, except over northeast India. (Fig.4)

(Deshpande, N.R., Kothawale D.R., Vinay Kumar, Kulkarni J.R., 2018, International Journal of Climatology, DOI: 10.1002/joc.5560)

Atlantic Nino modulation of the Indian summer monsoon

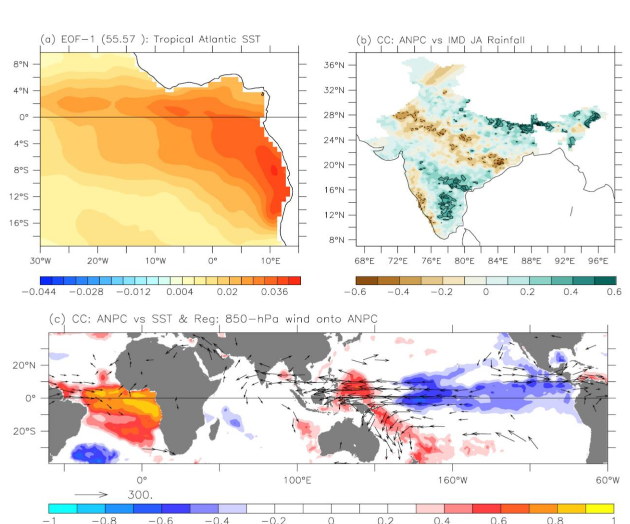


Fig.5: (a) The first mode of Empirical orthogonal function (EOF1) of SST anomalies (oC; shaded) over the equatorial Atlantic region. (b) Correlation between ANPC and IMD rainfall during JA. (c) ANPC correlation with tropical SST anomalies (shaded) and regression of ANPC upon 850-hPa winds (vectors, m/s).

The Indian rainfall and the Atlantic Niño peaks during summer month and have inverse relationship. This relationship has been revisited and it is found that the Atlantic Niño significantly influences a dipole pattern of rainfall in the north–east and the north-western parts of India. The positive phase of the Atlantic Niño intensifies the inter-tropical convergence zone, owing to the enlargement of the upper-troposphere divergence and local tropospheric warming, over the equatorial east Atlantic and West Africa. This provokes meridional stationary wave owing to the stronger meridional transfer of energy, as the influences of background jet-streams are minimal over North Africa and Europe. This results in the consecutive anomalous negative, positive and negative geopotential heights (GPHs) over the tropical east Atlantic, Mediterranean and north–west Europe respectively. The north–west Europe acts as the center of action for the propagation of a Rossby wave train zonally oriented toward central Asia reinforcing positive GPH anomaly over there. The positive GPH anomaly reduces the Asian subtropical westerly jet stream east of the Caspian Sea, owing to the reduction in the upper-troposphere divergence toward the Indian subcontinent and caused for above (below) normal north–east (north–west) Indian summer monsoon rainfall. The atmospheric general circulation model captures general characteristics of wave pattern and changes in the Asian jet when correlated with Atlantic Niño with considerable skill. (Fig.5)

(Yadav R.K., Srinivas G., Chowdary J.S., npj Climate and Atmospheric Science, 1:23, DOI:10.1038/s41612-018-0029-5,1-11)

PUBLICATIONS

IN SCIENTIFIC JOURNALS

Deshpande N.R., Kothawale D.R., Vinay Kumar, Kulkarni J.R., 2018, Statistical characteristics of cloud burst and mini-cloud burst events during monsoon season in India, International Journal of Climatology, 38, September 2018, DOI:10.1002/joc.5560, 4172-4188.

Nandargi S.S. and Barman K., 2018, Evaluation of Climate Change Impact on Rainfall Variation in West Bengal, Acta Scientific Agriculture, 2(7), 74-82.

Nandargi S.S., Gupta V.K., 2018, Spatial and temporal distribution of rainfall and rainy days over the Goa State, Journal of Energy Resources and Conversion, 1, 1-17.

Nandargi S.S. and Barman K., 2018, Analysis of Trends and Variability in Rainfall over West Bengal, International Journal of Current Advanced Research, 7(7E):14223-14229, Index Copernicus IC value :ICV-2016:83.75.

Nandargi S.S. and Kamble A.S., 2018. Temporal and Spatial Analysis of Rainfall and Associated Normalized Difference Vegetation Index (NDVI) over the Pune district, India, Focus on Science International Journal, 3(4): 9-16, DOI: 10.21859/fosci-03041452.

Patwardhan S., Kulkarni Ashwini, Koteswara Rao K., 2018, Projected changes in rainfall and temperature over homogeneous regions of India, Theoretical and Applied Climatology, 131, DOI:10.1007/s00704-016-1999-z, 581-592.

Raj Deepak S.N., Chowdary J.S., Dandi Ramu A., Srinivas G., Parekh A., Gnanaseelan C., Yadav R.K., 2018, Impact of multiyear La Niña events on the South and East Asian summer monsoon rainfall in observations and CMIP5 models, Climate Dynamics, online, DOI:10.1007/s00382-018-4561-0,1-23.

Raju Attada, Ramesh Kumar Yadav, Ravi Kumar Kunchala, Hari Prasad Dasari, Omar Knio and Ibrahim Hoteit, 2018, "Prominent mode of summer surface air temperature variability and associated circulation anomalies over the Arabian Peninsula". Atmospheric Science Letters, Published Online, October 2018. DOI: 10.1002/asl.860.

Raju Attada, Hari Prasad Dasari, J. S. Chowdary, Ramesh Kumar Yadav, Omar Knio and Ibrahim Hoteit, 2018 "Surface Air Temperature Variability over the Arabian Peninsula and its Links to Circulation Patterns", International Journal of Climatology; Published Online, August 2018; DOI: 10.1002/joc.5821.*

* Paper selected for King Abdullah University of Science and Technology (KAUST) "Discovery"

Shil P., Kothawale D.R., Sudeep A.B., 2018, Rainfall and Chikungunya incidences in India during 2010-2014, VirusDisease, online, DOI:10.1007/s13337-018- 0428-6, 1- 8.

Somaru Ram, Singh, H.N., Yadav R.K., Srivastava M.K., 2018, "Climatic response of '*Cedrusdeodara*' tree-ring width records from Jangla region of western Himalaya in India: A case study", The Journal of Indian Geophysical Union (JIGU); 22 (6): 632-639.

Yadav R.K., Relationship between Iran Surface Pressure and India Summer Monsoon, Vayu Mandal, 44, June 2018, 23-30.

Yadav R.K., Srinivas G., Chowdary J.S., Atlantic Niño modulation of the Indian summer monsoon through Asian jet, npj Climate and Atmospheric Science, 1:23, August 2018, DOI:10.1038/s41612-018-0029-5,1-11.