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Rainfall Screening Methodology For Salem Hill Using TRMM Method

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Abstract

The aim of this study is to present a rather complete picture about the current (1961-1990) and future (2010-2080) projection of the pattern of rainfall and temperature for the period. For the assessment of the future climate projection over Ponnaiyar River basin, Tamil Nadu, India, the 21st century the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment. Report (AR4) A1B (CO_2 Concentration 720 ppm until 2100) forcing scenario is used with the climate model of the National Centre for Atmospheric Research (NCAR) and the Community Climate System Model (CCSM-3). The obtained results were developed using dynamical downscaling approach to a model grid of 30 second. Baseline of 1961-1990 was used to calculate changes for precipitation, maximum temperature and minimum temperature. The IPCC AR4 climate model datasets of the 20th century experiments, forced by the Special Report on Emissions Scenarios (SRES), as well as those for the climate baseline simulations, are available through the Research Program on Climate Change, Agriculture and Food Security (CCAFS).A regionalized rain/no-rain classification (RNC) based on scattering index methodology is developed for detecting rainfall signature over the land regions of ponnaiyar river basin, using data products from Tropical Rainfall Measuring Mission (TRMM) namely, Microwave Imager (TMI) and Precipitation Radar (PR).

Keywords: Rainfall, Screening Methodology, Salem Hill, TRMM Method

1.INTRODUCTION

Rainfall is the most important forcing data for hydrological models and prime necessity of life on Earth. It is very difficult for hydrologists to simulate the water cycles over regions with no or sparse precipitation gauge station networks, especially over complex terrain or remote areas. Microwave radiometers have taken unprecedented satellite images of Earth’s weather proving to be a valuable source for quantitative estimation of precipitation from space. Significant contributions in this regard have been extended by the microwave instruments on board the Tropical Rainfall Measuring Mission (TRMM) satellite namely the TRMM. Majority of the instantaneous passive microwave rain retrieval algorithms, make use of a Database constructed by cloud model simulation that associates calculated microwave brightness Temperatures to physically plausible sample rain events. Delineation of rainfall signature from Microwave footprints, also known as rain/no-rain classification (RNC) is an essential preprocessing step which assists in the succeeding rainfall retrieval technique (using the database).The physically based overland rainfall retrieval algorithms using microwave data incorporate rainfall screening as an integral part before applying the succeeding overland rain retrieval Techniques.RNC algorithms developed globally might not perform well for regional catchments of small areal extent. This can be attributed to the spatio-temporal variations of land surface emissivity values. Hence, global RNC methods cannot be efficiently applied for rainfall pre-processing and weather related studies over such areas. Keeping these in mind, the present study proposes a regionalized RNC classification algorithm over the land regions of Mahanadi basin in India. In the present study, the best value is modeled using a combination of microwave low-frequency channels that are least sensitive to scattering and which better represent the emissivity variations of the study region. With the launch of successor missions to study precipitation measurement on a global scale, several microwave sensors have either recently or will soon be launched into orbit. Water runoff into the sea has been received substantial attention in several coastal zones worldwide, in time many of these zones experience water shortage. This is well pronounced in arid and semi-arid regions, like the case of the Middle East. The Eastern Mediterranean is typical example for this the hydrologic phenomenon. Hence, studies carried out in this regard include the coast of Lebanon, Arabian Sea and the Arabian Gulf The discharged freshwater into the sea occurs either as direct surface runoff (i.e., from rivers and streams), or as groundwater discharge, which is commonly called “submarine springs ” and sometime as “invisible rivers”. In India, high precipitation rate (i.e., averaging 950-1100 mm) results large amounts of surface water that rapidly flows towards the sea due to steep terrain. Also, there is groundwater seeps from coastal aquifers to the sea along the bedding planes of rocks, which encompass often with acute dip. Additionally, the intensive fracture systems increase the flow regime of groundwater seaward. The main objective of our study is to use remote sensing data as a monitoring system between rainfall and water flow from rivers, thus applying comparative analyses for each river basin separately. Also, assuring the creditability of remotely sensed data as a supporting tool to ground measuring stations. It is a cost-effective approach to monitor and assess the hydrologic regime of rivers and the relation to their basins. Also, it interprets a number of hydrologic criteria, such as the existing of small-scale

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plumes (i.e. low discharge) from river basins with high rainfall and vise versa. The used approach also reflects the hydrologic characteristics of basin terrain.

2.METHODOLOGY

2.1 Data Collocation

As the spatial resolution of TMI channels vary with respect to one another as well as with respect to PR data, collocation was performed as the initial step. Several studies have approached collocation by spatial resolution enhancement. In the present study, the resolution of low-frequency channels (10V, 10H, 19V, 19H, 21V, 37V and 37H) was increased by linear interpolation technique to match with the resolution of 85V channels. Collocation is performed by using the geolocation information from TRMM PR and TMI dataset In this process, the pixels tagged as “coast” are excluded from the analysis. The rainfall type (convective and stratiform) represented by each of these collocated overland pixels was estimated by utilizing the storm type information present in TRMM 2A23 data product. This initial data processing procedure comprising of data collocation and extraction of overland footprints was adopted for all the orbits passing over the study region during the four year period of 2014 to 2015.

2.2 Rain/No-Rain Classification Based On Scattering Index

The present study uses collocated data over the land regions of the study area to develop a region specific SI, using the synergistic use of low-frequency TMI channels. The key idea in this technique is that Tb at 85V channel is affected by frozen ice particles and rain drops in the atmosphere. As overland rainfall retrieval from passive sensor relies on ice scattering at 85V.

2.3 Categorical Statistics

This study analyses the performance of proposed RNC method using a total of 10 performance statistics. RNC classification is a typical example of dichotomous classification having just two possibilities, either zero or unity.

3.STUDY AREA

Ponnaiyar river basin extends over approximately of 11,441 sq. km, VES area covers 9119km 2 and Hill area covers 23.49km 2 and lies between 11 0 35’ and 12 0 35’ N latitudes and 77 0 45’ and 79 0 55’ E longitudes. This river basin is drained by ponnaiyar as well as its tributaries Pambar, Vaniar, Turinjalar etc.,(Figure.1) Triuvannamalai is situated in the northern side, Cuddalore and Villupuram in east and Dharmapuri and Hosur in western side.The Ponnaiyar (South Pennar) is a river in southern India. It rises on the hill of Nandidurg in Chikkaballapur District of Karnataka state, flowing south and then east for 400 km through Karnataka and Tamil Nadu, emptying into the Bay of Bengal at Cuddalore. Tirukkovilur is the largest city in the path of Ponnaiyar River.The South Pennar River is known as DakshinaPinakini in Kannada and Thenpennai in Tamil. It is also referred as Ponnaiyar.The river originates in the Nandi Hills in the Chikkaballapur district of Karnataka and flows through Tamil Nadu before emptying into the Bay of Bengal. It has a catchment area of 1,424 square miles (3,690 km^2) located in Karnataka, Tamil Nadu and Andhra Pradeshstates. Kelavarapalli dam is built across this river near Hosur. The Krishnagiri dam and Sathanur Dam are also built across this river. Moongilthuraipattu Sugar Factory is situated on the bank of river.Figure.2 and Figure.3 shows the study area and location map.

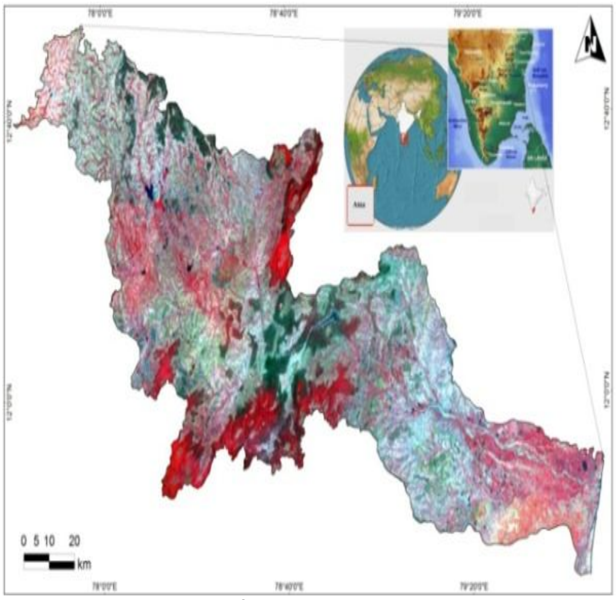

Figure. 1 Location of Ponnaiyar river basin shows IRS P6 LISS III satellite data

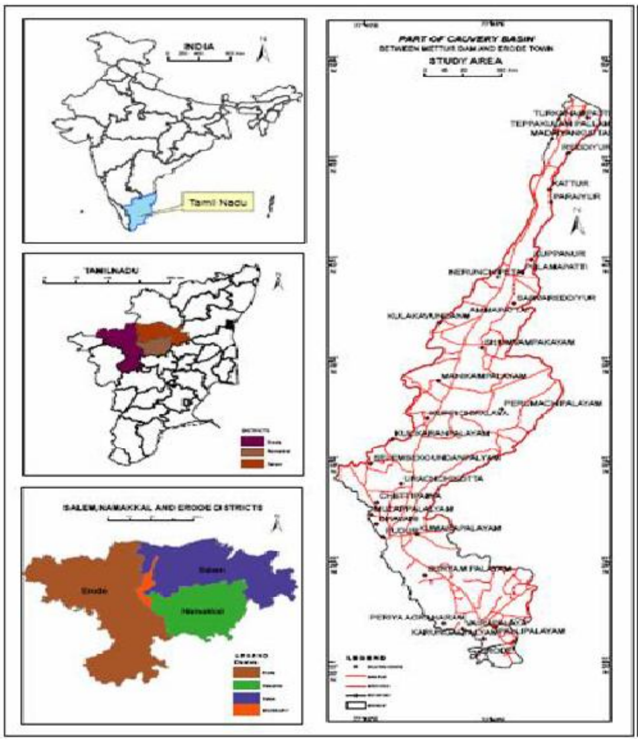

Figure. 2 Map Showing the Study Area

Figure. 3 Location Map

3.1 Rainfall/Water Flow Responses

TRMM and MODIS data were prepared and the obtained results were tabulated for the selected period. This was a perquisite step for data correlations to assess the rainfall/ water-flow relationship, the scope of this study. Consequently, a number of hydrologic relations were obtained as shown in Figure.4. As a first step, the amount of rainfall as extracted from TRMM data was measured in millimeters (mm), and then it was multiplied by the area of the catchment (i.e., km^2) to convert it to million m3 per day. The extent of water plumes into the sea was measured in km^2. Units were standardized for all calculations. This was applied to all studied rivers for the selected period.

Five key elements were utilized for quantitative analysis. These are:

1) Rainfall peaks, which represent torrential rain events and intensity and their behavior (i.e. ascending or descending trends),
2) The coincidence between the plume area (PA) and recorded rivers discharge from gauging stations (Qm). It can be obtained by interpolating both parameters, and this enables recognizing rivers discharge from the areal extent of the plume as it appears in satellite image,3) Lag time (τ) between precipitated water and the existence of water plumes into the sea, which is indicative to several terrain parameters including mainly, recharge, geology, slope and land cover/use,
4) The spatial extent of plumes into the sea (PA) after each rainfall peak, and this is related to water flow energy as well as the terrain parameters mentioned in point 3,
5) The ratio between the area of plumes with respect to the recorded discharge (Rpd).

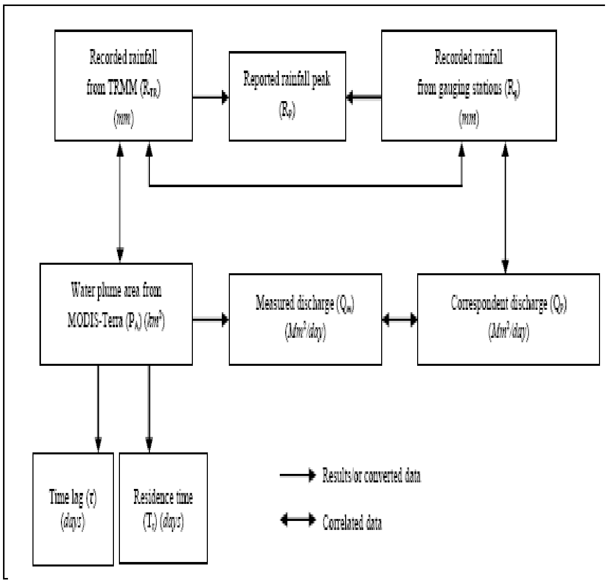

Figure 4 Schematic diagram showing the relationships of different hydrologic elements

4.2 Rainfall Gauges (Rg) And Trmm Data (Rtr)

Several worldwide studies have used TRMM data as a reliable source of rainfall information (examples are: In this study, rainfall records from available gauging stations were compared with TRMM data as an verifying approach for TRMM data. Thus, both almost show similar results in a clear coincidence in the trend of rainfall amounts (i.e., ascending and descending), though the recorded amounts of rainfall from gauging station were found to be a little bit exceeded. In average, the ratio of TRMM values for all rivers to the recorded data is 1:1.35. This often exists with peaks (main rainfall events). The lower values of rainfall appears in TRMM data is attributed to a distortion in the satellite images that may might occur during torrential events, thus creates error in data simulation. In general, the use of TRMM data is a capable tool to acquire rainfall information, notably in a time ground data is lacking.

4.SOFTWARE USED

4.1 GIS

A geographic information system (GIS) is a computer-based tool for mapping and analyzing feature events on earth. GIS technology integrates common database operations, such as query and statistical analysis, with maps. GIS manages location-based information and provides tools for display and analysis of various statistics, including population characteristics, economic development opportunities, and vegetation types. GIS allows you to link databases and maps to create dynamic displays. Additionally, it provides tools to visualize, query, and overlay those databases in ways not possible with traditional spreadsheets. These abilities distinguish GIS from other information systems, and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies.At the national and local level, possible GIS applications are endless. For example, agricultural planners might use geographical data to decide on the best zones for a cash crop, combining data on soils, topography, and rainfall to determine the size and location of biologically suitable areas. The final output could include overlays with land ownership, transport, infrastructure, labour availability, and distance to market centres. The ultimate use of GIS lies in its modelling capability, using real world data to represent natural behaviour and to simulate the effect of specific processes. Modelling is a powerful tool for analyzing trends and identifying factors that affect them, or for displaying the possible consequences of human activities that affect the resource availability.In agrometeorology, to describe a specific situation, we use all the information available on the territory: water availability, soil types, forest and grasslands, climatic data, geology, population, land-use, administrative boundaries and infrastructure (highways, railroads, electricity or communication systems). Within a GIS, each informative layer provides to the operator the possibility to consider its influence to the final result. However more than the overlap of the different themes, the relationship of the numerous layers is reproduced with simple formulas or with complex models. The final information is extracted using graphical representation or precise descriptive indexes.

5.ANALYSIS DATA

5.1 Data Sets And Methodology

Datasets that describe the baseline climate and the plausible future climate conditions forced with the SRES of AR4 of the IPCC at a local or regional scale and obtained throughout a dynamical downscaling from General Circulation Models (GCM) are available on the CCAFS website. The datasets contains a large range of Regional Climate Models (RCM), developed by different countries and climate modeling communities with different spatial resolutions. The datasets are available in ARC GRID, and ARC ASCII format, in decimal degrees and datum WGS84. This data format facilitates their integration in GIS environment for processing. The climate model downscaling data of the NCAR-CCSM-3 was selected for this investigation due to its fine space scale (30 second). The fine space resolution is a very important for this investigation due to the complex topography and land surface of Oman, which contribute to the emergence of varieties of local climate. The climatic baseline over 1961-1990 was used to compare and calculate projected changes (anomalies) for the average annual maximum temperature, average annual minimum temperature, and annual precipitation. Figure. 5 shows Base Map of the Ponnaiyar River.

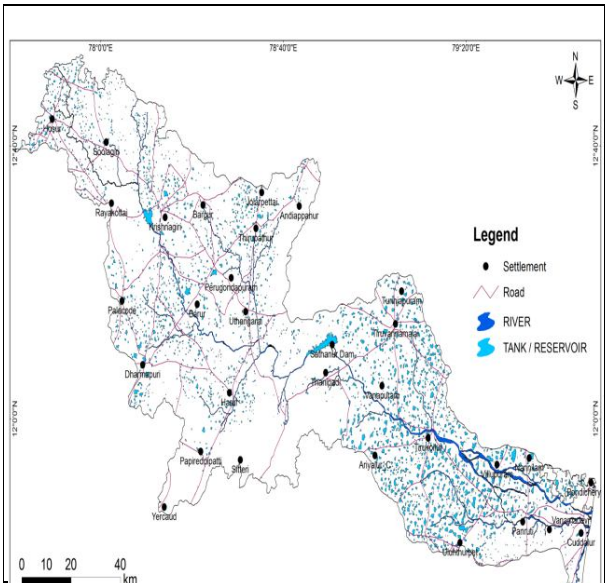

Figure. 5 Base Map of the Ponnaiyar River

The pattern of temperature and rainfall anomalies was calculated for each raster cell grid using Arc-Map software for short term (2011-2040) and medium term (2041-2080). Future climate simulation related to the IPCC's A1B Greenhouse Gas (GHG) emissions scenario was chosen, to assess future temperature and rainfall projections. This scenario provides an intermediate level of warming by the end of the century and predicts a future where technology is shared between developed and developing nations in order to reduce regional economic disparities. Figure.6 shows the Elevation with contour of ponnaiyar river.

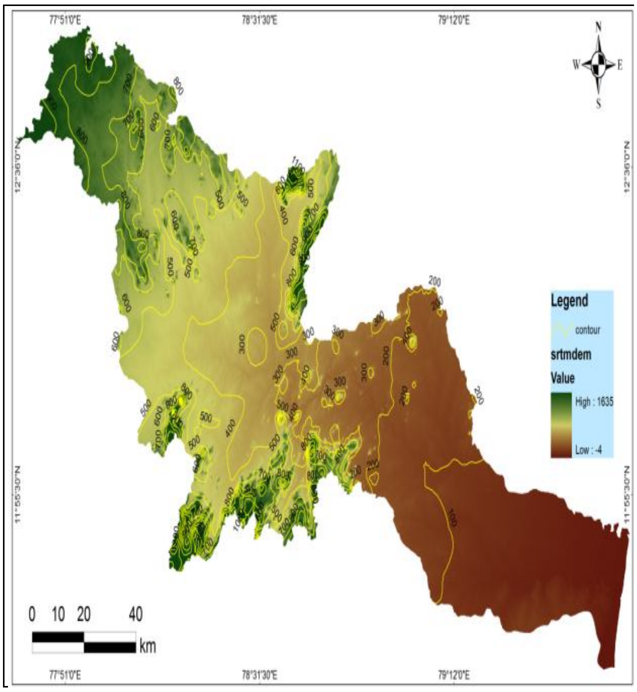

Figure.6 Elevation with contour of ponnaiyar river

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5.2 Baseline Climate

Average Annual Rainfall

Overall, rainfall fluctuates between 597 and 1528 mm/year. The lowest average annual rainfall is found in the interior plains and coastal areas along the Bay of Bengal. The highest average annual rainfall is found around peaks in the coastal plains. Figure7 shows Rainfall data

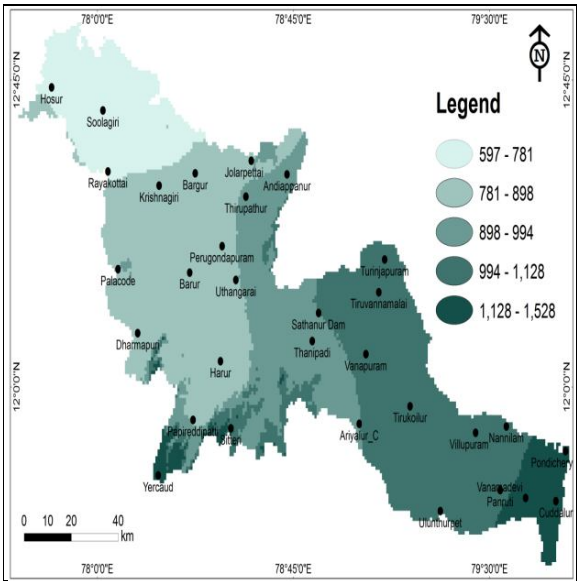

Figure7 Rainfall data

Annual average rainfall patterns in Ponnaiyar River for the period 1961-1990

Average Minimum Temperature

Figure. 8 shows Minimum temperature (january) patterns of ponnaiyar river for the period 1961-1990

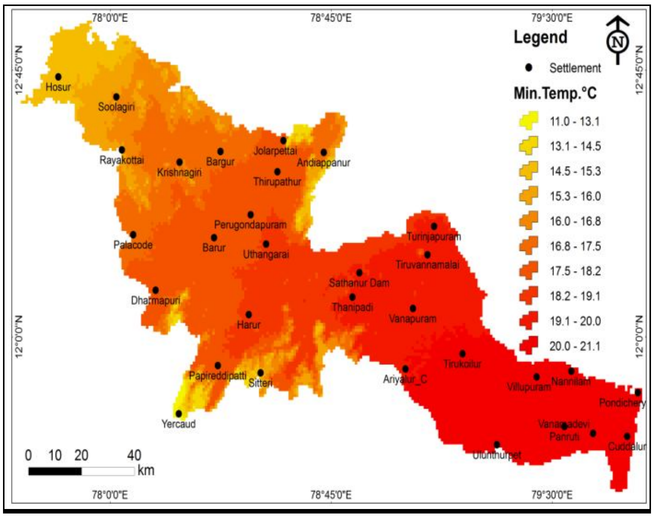

Figure. 8 Minimum temperature (january) patterns of ponnaiyar river for the period 1961-1990

Average Maximum Temperature

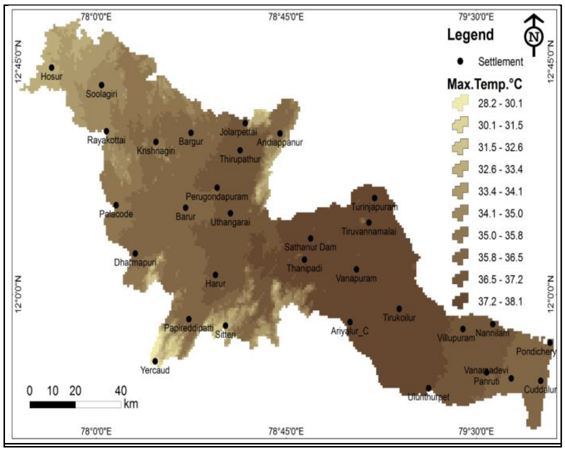

Figure.9 Maximum temperature (may) patterns of ponnaiyar river for the period 1961-1990

Future Climate

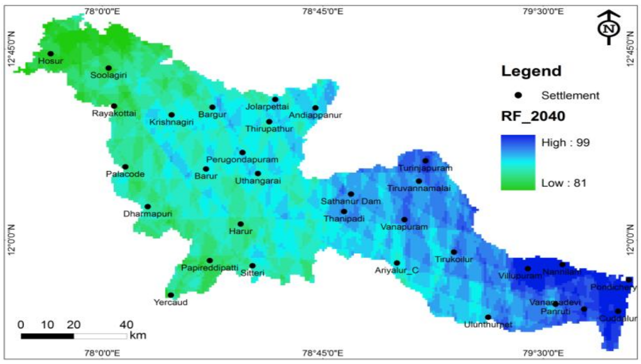

Figure. 10 The simulated average annual rainfall changes during the periods 2011-2040

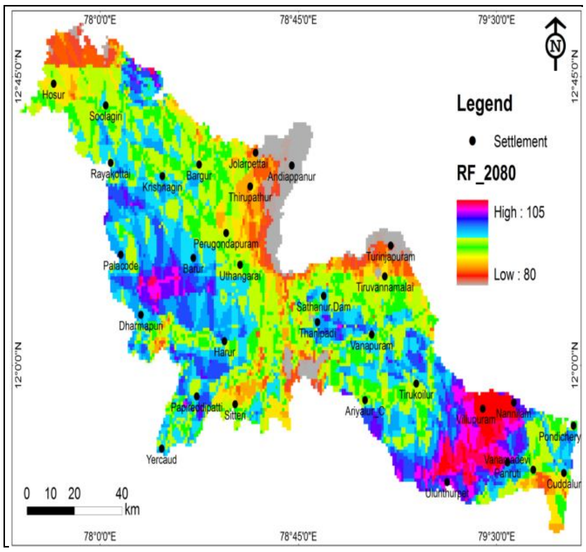

Figure.11 The simulated average annual rainfall changes during the periods 2041-2080

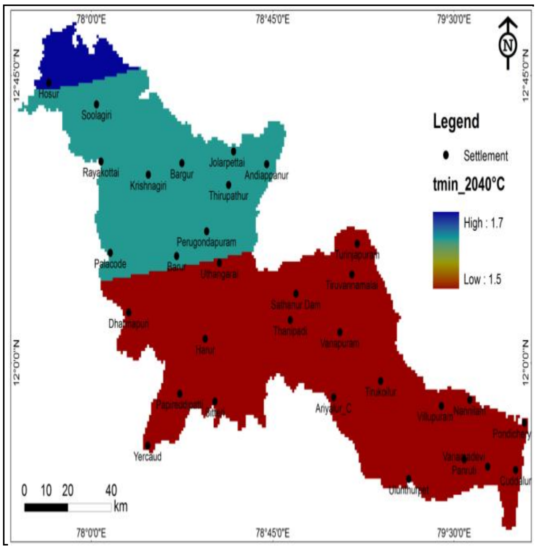

Figure.12 The simulated average minimum temperature change during the periods 2011-2040

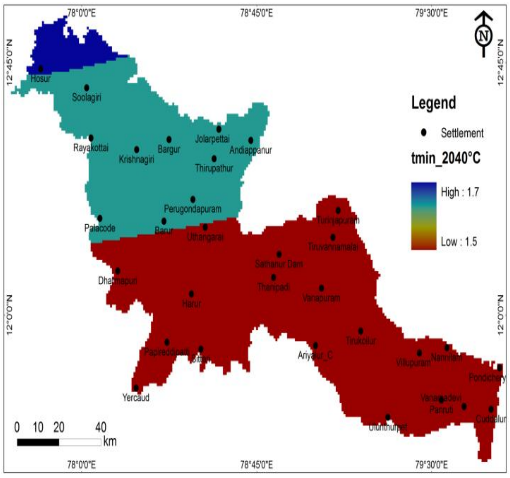

Figure. 13 The simulated average minimum temperature change during the periods 2041-2080

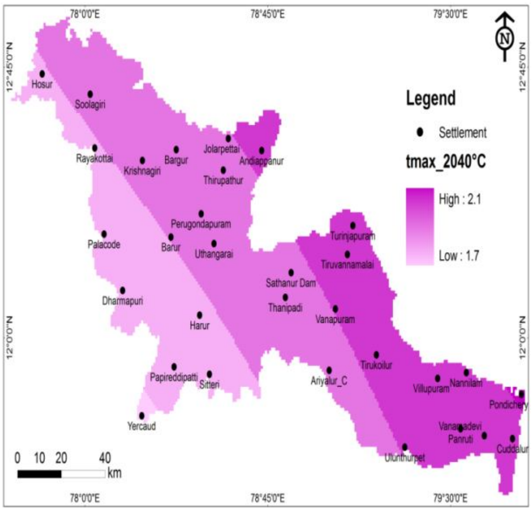

Figure. 14 The simulated average maximum temperature change during the periods 2011-2040

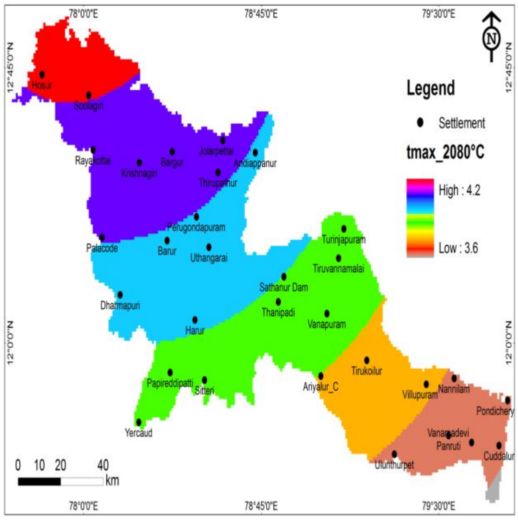

Figure. 15 The simulated average maximum temperature change during the periods 2041-2080

Figure.9,10,11,12,13,14 & 15 shows the Maximum temperature (may) patterns of ponnaiyar river for the different periods, the simulated average annual rainfall changes during the different periods and the simulated average minimum temperature change during the different periods

6..CONCLUSION

Action on climate change is required across all sectors. A national strategy for climate change adaptation is a necessary course of actions. This strategy should integrate and applies the best and most applicable approaches, tools and technologies. The involvement of policymakers, researchers, the private sector and civil society in the elaboration of the strategy and actions plan is vital. The PR 2A25 product rain flag provides the “rain” and “no rain” definitions for each pixel. The usual practice to evaluate rain/no-rain (RNC) algorithms of TMI is by assuming RNC classification given by PR to be “true” or near perfect. This assumption is acceptable in evaluating RNC by TMI over land, because PR detects precipitation. The present study utilizes the vertical polarization as it is known to be less affected by aliasing effect with change in land use/land cover. Also, with increasing biomass density, the vertical polarization is known to comparatively increase with respect to the horizontal polarization.

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