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Predicting NCAR Climate Change Data Using GIS Techniques

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Abstract: ***The present paper is an attempt to study the predicting NCAR climate change data using Geographic Information System (GIS) techniques. For this study used climate datasets generated by the Community Climate System Model (CCSM) for the Intergovernmental Panel for Climate Change (IPCC) 4th Assessment Report and distributed through the National Center for Atmospheric Research (NCAR) GIS Initiative Climate Change Scenarios portal in a GIS format. From this is study it was found that GIS is a time effective tool for analyzing large scale climatic data and it can easily identify the locations where the effect of climate change will be maximum in future.***

Keywords: NCAR Climate Change data, Community Climate System Model (CCSM), GIS

1. Introduction

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It is a geographic problem, and we believe solving it takes a geographic solution. GIS users represent a vast reservoir of knowledge, expertise, and best practices in applying this cornerstone technology to the science of climate change and understanding its impact on natural and human systems.

Reducing the risks caused by climate change is an immense challenge. Scientists, policy makers, developers, engineers, and many others have used geographic information system (GIS) technology to better understand a complex situation and offer some tangible solutions. A GIS-based framework helps us gain a scientific understanding of earth systems at a truly global scale and leads to more thoughtful, informed decision making.

This paper is a demonstration of how to analyze climate projections from a Global Climate Model (GCM) in a Geographic Information System (GIS). This study used climate datasets generated by the Community Climate System Model (CCSM) for the Intergovernmental Panel for Climate Change (IPCC) 4th Assessment Report and distributed through the National Center for Atmospheric Research (NCAR) GIS Initiative Climate Change Scenarios portal in a GIS format. In this paper, we compare model output of a present day climate with future climate projections.

2. Objectives

1. To demonstrate GIS-based analysis of the Northern hemisphere summer months (June, July and August) temperature anomaly in 2040 with respect to the average summer temperatures of present-day climate.
2. To compare the most current climatic data available from the CCSM runs with an ensemble average, the 20th Century (1980-1999) Experiment to the SRES A2 scenario ensemble average for 2040.
3. To create anomaly map to highlight areas around the globe that will experience either air temperature increase or decrease in 2040 relative to 1980.

Database Software Used: ESRI ArcGIS 9.3
Region: Global
Data: NCAR GIS climate change portal.
Data set -1
CCSM Model Run: 20th Century Experiment, Ensemble Average
Dates of Interest:
June: Start Year: 1980, End Year: 1999
July: Start Year: 1980, End Year: 1999
August: Start Year: 1980, End Year: 1999
Dataset: Atmospheric
Atmospheric Variable: Air Temperature (Degree Kelvin)
Download: Download shapes file Region

Data set-2
Global CCSM Model Run: Scenario A2, Ensemble Average
Dates of Interest:
June: Start Year: 2021, End Year: 2040
July: Start Year: 2021, End Year: 2040
August: Start Year: 2021, End Year: 2040
Dataset: Atmospheric
Data Atmospheric Variable: Air Temperature (Degree Kelvin)
Download: Download shapes file Region

3. Methodology

In the present study predicting NCAR Climate Change Data Using GIS techniques has been carried out using data is distributed through the National Center for Atmospheric Research (NCAR) GIS Initiative Climate Change Scenarios portal in a GIS format. The methodology adopted in the present study is shown in the figure number 01.

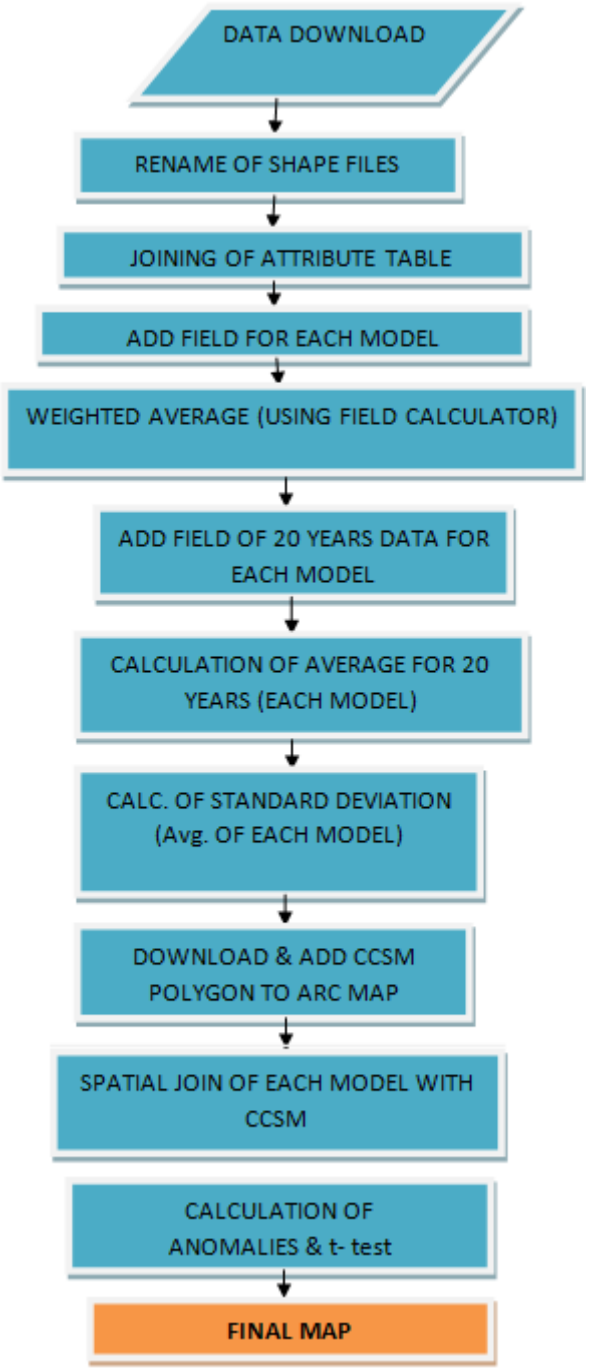

Figure 1

4. Methodology Adopted

Part 1 – Download Data
Download data from NCAR Climate Change Portal.

Part 2 – Calculate Summer Air Temperature Averages 1980-1999
Calculate summer average temperatures during the growing season (June, July, and August) using simulated, present day climate modeled output (1980 to 1999).

Part 3 – Calculate Summer Air Temperature Averages 2021-2040
Calculate summer average temperatures during the growing season (June, July, and August) using projected, future climate modeled output (2021 to 2040).

$$2021\text{Avg JJA} = \frac{((30*202106)+(31*202107)+(31*20210))}{92}$$

20th Century Ensemble Average, JJA, 1980 – 1999								
ID	JJA1980Avg*	JJA1981Avg*	JJA1982Avg*	…	…	JJA1999Avg*	JJA20YearAvg	Std

Scenario A2 Ensemble Average, JJA, 2021 – 2040								
ID	JJA2021Avg*	JJA2022Avg*	JJA2023Avg*	…	…	JJA2040Avg*	JJA20YearAvg	Std

* Values are weighted averages

Calculation of the JJA 20 year average for each model run year (1980-1999 & 2021-2040)

([tas_JJA_2021_2040_SRESA2.JJA2021avg] +
[tas_JJA_2021_2040_SRESA2.JJA2022avg] +
[tas_JJA_2021_2040_SRESA2.JJA2023avg] +
[tas_JJA_2021_2040_SRESA2.JJA2024avg] +
[tas_JJA_2021_2040_SRESA2.JJA2025avg] +
[tas_JJA_2021_2040_SRESA2.JJA2026avg] +
[tas_JJA_2021_2040_SRESA2.JJA2027avg] +
[tas_JJA_2021_2040_SRESA2.JJA2028avg] +
[tas_JJA_2021_2040_SRESA2.JJA2029avg] +
[tas_JJA_2021_2040_SRESA2.JJA2030avg] +
[tas_JJA_2021_2040_SRESA2.JJA2031avg] +
[tas_JJA_2021_2040_SRESA2.JJA2032avg] +
[tas_JJA_2021_2040_SRESA2.JJA2033avg] +
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[tas_JJA_2021_2040_SRESA2.JJA2035avg] +
[tas_JJA_2021_2040_SRESA2.JJA2036avg] +
[tas_JJA_2021_2040_SRESA2.JJA2037avg] +
[tas_JJA_2021_2040_SRESA2.JJA2038avg] +
[tas_JJA_2021_2040_SRESA2.JJA2039avg] +
[tas_JJA_2021_2040_SRESA2.JJA2040avg]) / 20

Calculation of standard deviation using field calculator

$$\sigma_{N-1} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

Part 4 – Compare Average JJA Temperatures for both Model Runs
Visually compare the temperature differences for the (1980 to 1999) and the (2021 to 2040) model runs.

Part 5 – Create a Temperature Anomaly Map
Create a temperature anomaly map to highlight areas around the globe that will experience either air temperature increases or decreases in 2040 relative to 1990.

Part-6- Student's t-test calculations were derived from the general formula

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{\sigma_1^2 + \sigma_2^2}{N}}}$$

5. Analysis and Result

We analyzed and compared CCSM model runs, available through the GIS Climate Change Scenarios portal, in a GIS environment. We used one variable, air temperature, and compared simulations of a present-day climate to a projected climate of 2040. Same method can be applied to other, scenarios, variables and time periods that are available from the CCSM and the GIS portal. In addition, within a GIS framework, additional spatial information such as land use/land cover change detection, population projections, or any other environmental and social spatial data of interest can be used for climate change impacts studies.

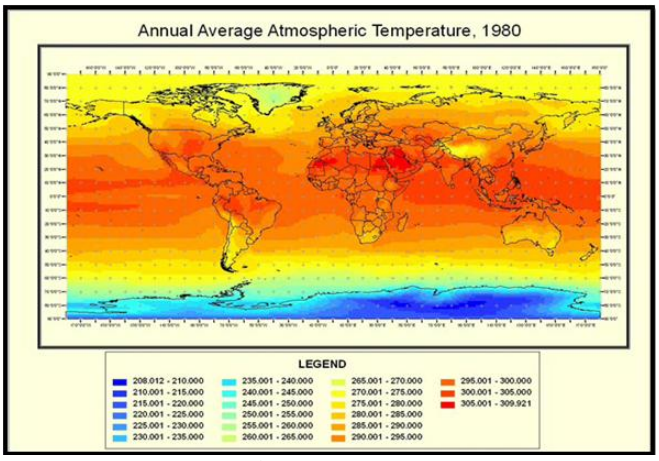

Figure No.02

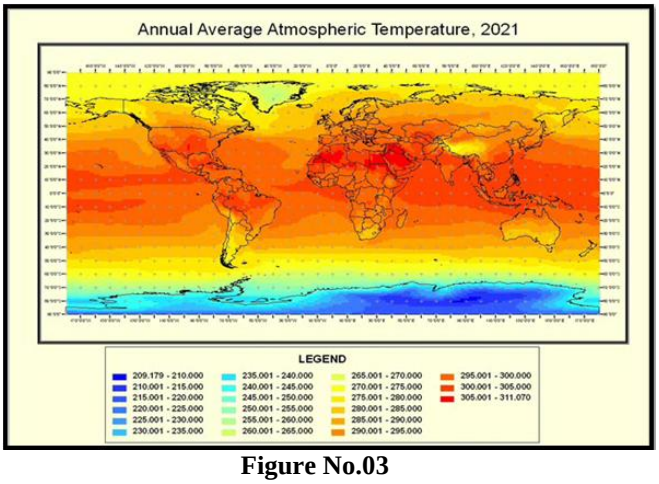

Figure No.03

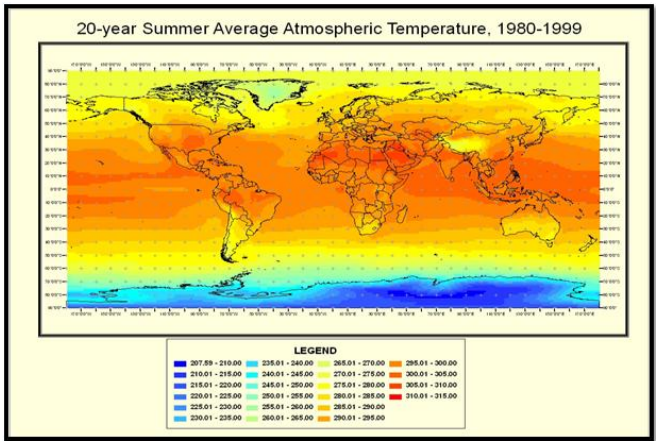

Figure No.04

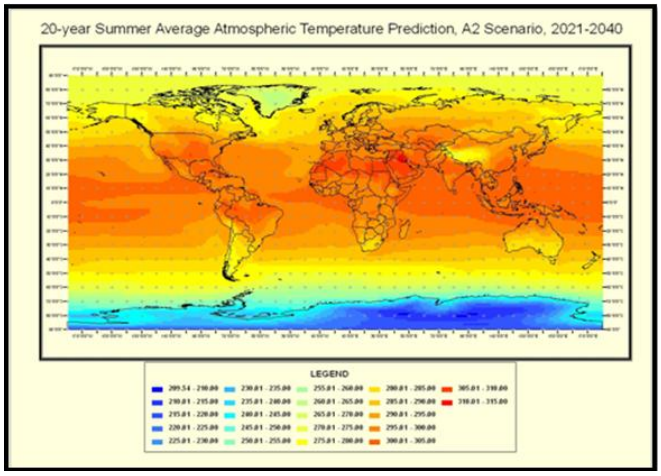

Figure No.05

Finally we understand the meaning and uncertainties of climate model projections. The data available through the NCAR Climate Change Portal are from one of many GCMs, (i.e., the Community Climate System Model), that contributed to the current understanding of the global Climate System. IPCC climate change projections were based on multi-model results from a world-wide climate modeling effort. As indicated in the final map the areas that are warming most dramatically are over land they are colored in red. The areas that are colored in blue show the temperature decreases (Figure no.06).

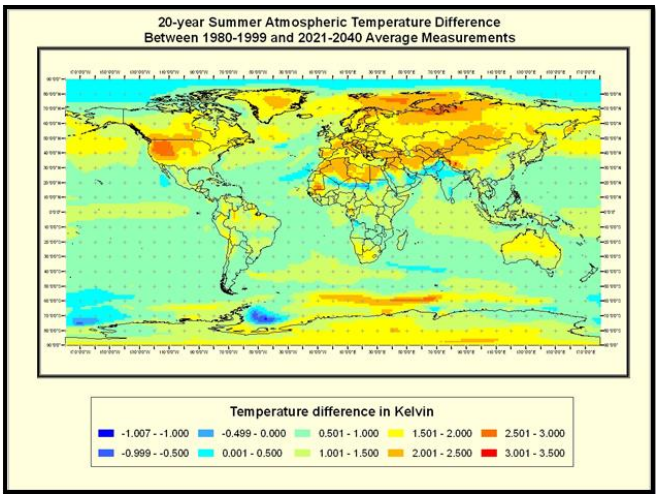

Figure No.06

6. Conclusion

Based on this study it may finally conclude that the GIS technique is useful in long term qualitative monitoring of the global climate change. Further GIS is a time effective tool for analyzing large scale climatic data and it can easily identify the locations where the effect of climate change will be maximum in future. On the basis of the final temperature anomaly map generated with the help of GIS one can go for proper policy plan to mitigate the problems of global climatic change.

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