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Rainfall Deviation of India from the Last 40 Years Data Using Remote Sensing

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Abstract- This research investigates precipitation deviations using the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) dataset within the Google Earth Engine (GEE) platform. CHIRPS, developed by the Climate Hazards Group at the University of California, Santa Barbara, in collaboration with the U.S. Geological Survey, provides high-resolution daily precipitation data from 1981 to the present. Leveraging its spatial resolution of 0.05 degrees, we analyzed precipitation patterns over a specified region from 1982 to 2022. The methodology involves comprehensive data preprocessing, including loading, subsetting, and handling missing values using JavaScript in GEE. Climatology was calculated by aggregating the data monthly to establish a baseline of expected precipitation patterns. Deviations from this baseline were computed to identify anomalies. The CHIRPS dataset's integration into GEE enabled robust spatial and temporal visualization and statistical analysis of precipitation anomalies. This study underscores CHIRPS's crucial role in enhancing our understanding of precipitation variability, informing climate adaptation strategies, and improving hydrological, agricultural, and disaster risk management practices. The findings contribute valuable insights into precipitation trends and their implications in the context of global climate change.

Introduction-

The Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) satellite is a widely utilized tool for monitoring global precipitation. Developed by the Climate Hazards Group at the University of California, Santa Barbara, in collaboration with the U.S. Geological Survey (USGS), CHIRPS provides high-resolution, daily precipitation data starting from 1981. This dataset is instrumental for research in climatology, agriculture, hydrology, and disaster risk management.

CHIRPS data is available at a spatial resolution of 0.05 degrees (~5.5 km), making it suitable for detailed local and regional studies. The dataset spans from 1981 to the present, offering a long-term perspective on precipitation trends and variability. CHIRPS combines satellite observations with in-situ station data, enhancing the accuracy and reliability of precipitation estimates. The dataset covers all land areas between 50°S and 50°N, making it applicable for global studies, particularly in regions where ground-based observations are sparse. Over the past decade, CHIRPS has been employed in numerous studies and applications, reflecting its versatility and importance in various fields such as climate and weather studies, agricultural monitoring and food security, hydrological modeling, disaster risk reduction, environmental and ecological studies and many more fields of remote sensing.

CHIRPS has been used to analyze long-term precipitation trends, variability, and extremes. Studies have investigated how precipitation patterns have changed over time and the potential impacts of climate change on future precipitation. Researchers have utilized CHIRPS data to assess drought conditions, crop performance, and food security, particularly in developing regions. For instance, the Famine Early Warning Systems Network (FEWS NET) relies on CHIRPS for drought monitoring and food security assessments. CHIRPS data has been integrated into hydrological models to simulate river flows, flood risks, and water availability. These models are crucial for water resource management and planning. The dataset supports disaster risk management by providing critical information for early warning systems and post-event assessments. CHIRPS data has been used to monitor and predict the impacts of extreme weather events such as hurricanes, floods, and droughts. Researchers have applied CHIRPS to study the impacts of precipitation on ecosystems, biodiversity, and soil moisture. These studies help in understanding how changes in precipitation influence ecological dynamics. In humanitarian assistance and policy making CHIRPS data informs humanitarian interventions and policy decisions. It helps in allocating resources for disaster response and planning long-term strategies for climate adaptation and resilience building.

Studies using CHIRPS have identified significant trends and patterns in global precipitation, contributing to the understanding of how climate change is affecting rainfall distribution and intensity. CHIRPS has been pivotal in drought monitoring across Africa, aiding in the development of early warning systems that help mitigate the impacts of drought on vulnerable populations. Research has demonstrated the utility of CHIRPS in flood risk assessment, particularly in regions with limited ground-based observations, enhancing the capability to predict and manage flood events. Analyses using CHIRPS data have improved the understanding of the relationship between precipitation and crop yields, informing agricultural practices and policies to enhance food security. The CHIRPS satellite and its extensive dataset have revolutionized the way scientists and policymakers monitor and understand precipitation patterns and their impacts. Over the past decade, the integration of CHIRPS data into various fields has significantly advanced research and practical applications in climatology, agriculture, hydrology, and disaster management. As climate change continues to pose challenges, the role of CHIRPS in providing reliable and high-resolution precipitation data will remain crucial for global efforts in climate adaptation and resilience.

Related Works-

Over the past decade, the CHIRPS dataset has been instrumental in a wide range of research areas and practical applications, highlighting its versatility and importance in climatology, agriculture, hydrology, and disaster risk management. Numerous studies have utilized CHIRPS to analyze long-term precipitation trends and variability, providing insights into how climate change impacts rainfall patterns (Funk et al., 2015; Dinku et al., 2018). In the realm of agricultural monitoring and food security, CHIRPS has been extensively used to monitor drought conditions and assess their impact on crop performance. Shukla et al. (2014) demonstrated the application of CHIRPS in drought monitoring within the Famine Early Warning Systems Network (FEWS NET), and Toté et al. (2015) used the dataset to evaluate agricultural drought in Mozambique. The integration of CHIRPS data into hydrological models has enhanced flood risk assessment and water resource management. For instance, Awange et al. (2016) employed CHIRPS for hydrological simulations in the Nile Basin, while Tongul and Hobson (2013) used the dataset for flood modeling in Ethiopia. Furthermore, CHIRPS supports disaster risk management by providing critical information for early warning systems. Cattani et al. (2016) used the dataset for flood risk mapping in West Africa, and Nicholson (2014) applied CHIRPS data in drought early warning systems across sub-Saharan Africa. Researchers have also applied CHIRPS to study the impacts of precipitation on ecosystems and biodiversity. For example, Herrero et al. (2016) utilized the dataset to analyze soil moisture dynamics in Kenya, and Masih et al. (2014) assessed the relationship between rainfall and river flow in the Upper Indus Basin. In humanitarian assistance and policy-making, CHIRPS data informs interventions and decisions by providing reliable precipitation estimates. Anderson et al. (2018) used CHIRPS to support drought relief efforts in East Africa, while Funk et al. (2019) employed the dataset to develop climate resilience strategies in the Horn of Africa. Studies using CHIRPS have identified significant trends in global precipitation, such as changes in rainfall distribution in southern Africa (Maidment et al., 2015) and precipitation patterns in the Sahel region (Rowell et al., 2015). In Africa, CHIRPS has been pivotal in drought monitoring, with Pohl et al. (2017) evaluating drought severity in West Africa and Gebrechorkos et al. (2019) assessing drought trends in East Africa. The utility of CHIRPS in flood risk assessment has also been demonstrated, with Dinku et al. (2016) utilizing the dataset for flood mapping in the Blue Nile Basin and Berhane et al. (2014) applying it for flood prediction in Ethiopia. Analyses using CHIRPS data have improved the understanding of the relationship between precipitation and crop yields, as illustrated by Vrieling et al. (2016) studying the impact of rainfall on maize yields in Kenya and Barlow et al. (2015) exploring the effects of precipitation variability on agricultural productivity in the Sahel. These studies underscore the critical role of CHIRPS in enhancing our understanding of precipitation patterns and their wide-ranging impacts, thereby informing effective strategies for climate adaptation and resilience.

Methodology

The methodology outlined in this research paper for analyzing precipitation deviations utilizing the CHIRPS dataset entails a meticulous process designed to offer comprehensive insights into climate dynamics within the Google Earth Engine (GEE) platform. Initially, the CHIRPS dataset is acquired from the Earth Engine Data Catalog, specifying the study period spanning from 1982 to 2022 and delineating the geographical region of India using GEE's spatial filtering capabilities. Subsequently, data preprocessing is conducted within the GEE environment, leveraging JavaScript to facilitate tasks such as data loading, subsetting to the specified region and time period, and addressing missing values through interpolation or filling methods.

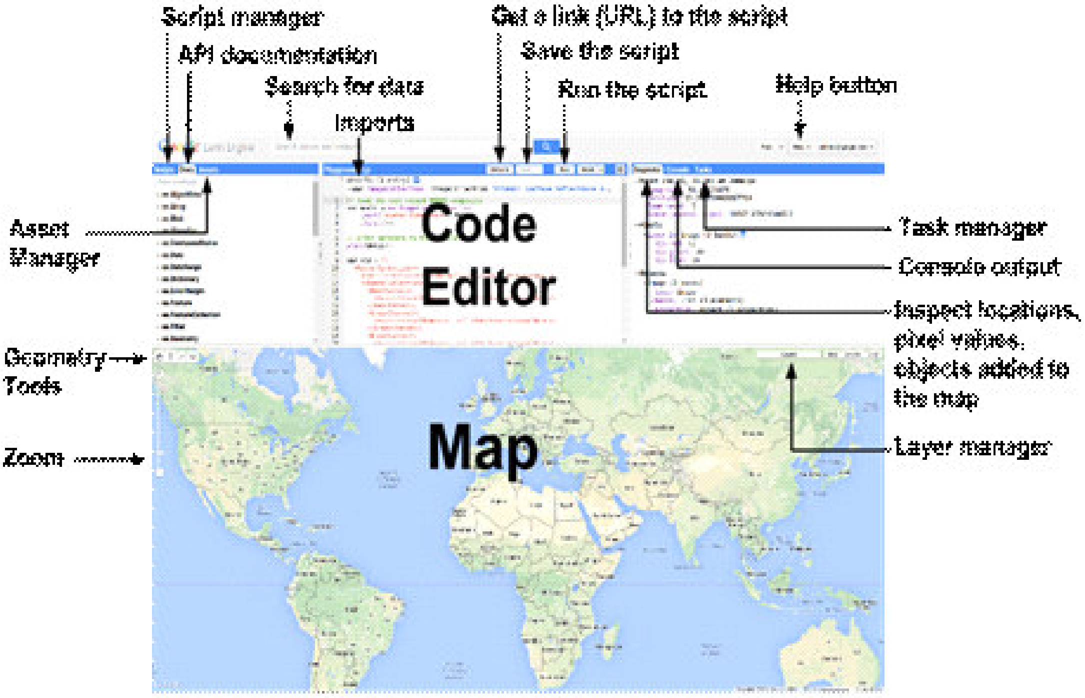

Figure 1

Following data preparation, the calculation of climatology is executed by aggregating the precipitation data temporally, typically by month, and computing the mean precipitation for each respective month across the entire study period, thereby establishing a baseline representation of expected precipitation patterns. Subsequently, deviations from this established climatological baseline are computed within GEE by subtracting the climatological mean from the observed precipitation data for each corresponding month or season. This facilitates the identification and characterization of anomalies, representing deviations from expected precipitation patterns. These computed deviations can then be visualized through spatial and temporal animations or interactive maps within the GEE platform, providing a comprehensive understanding of the spatial distribution and temporal variability of precipitation anomalies. Additionally, statistical analyses, such as hypothesis testing or trend analysis, may be performed using GEE's analytical capabilities to assess the significance of observed deviations and identify any underlying patterns or trends. By employing this rigorous methodology within the GEE platform, this research paper aims to contribute valuable insights into precipitation variability and its implications for various sectors, including hydrology, agriculture, and disaster management, thereby informing evidence-based decision-making and enhancing our understanding of climate dynamics in the studied region.

Results and Discussion-

The analysis of rainfall deviations for the year 2023, compared to the historical averages from 1982 to 2022, reveals significant anomalies across various states of India. The findings are based on data extracted from the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) pentad dataset, processed and analyzed using Google Earth Engine (GEE). The results indicate substantial variations in monthly precipitation, with both positive and negative deviations.

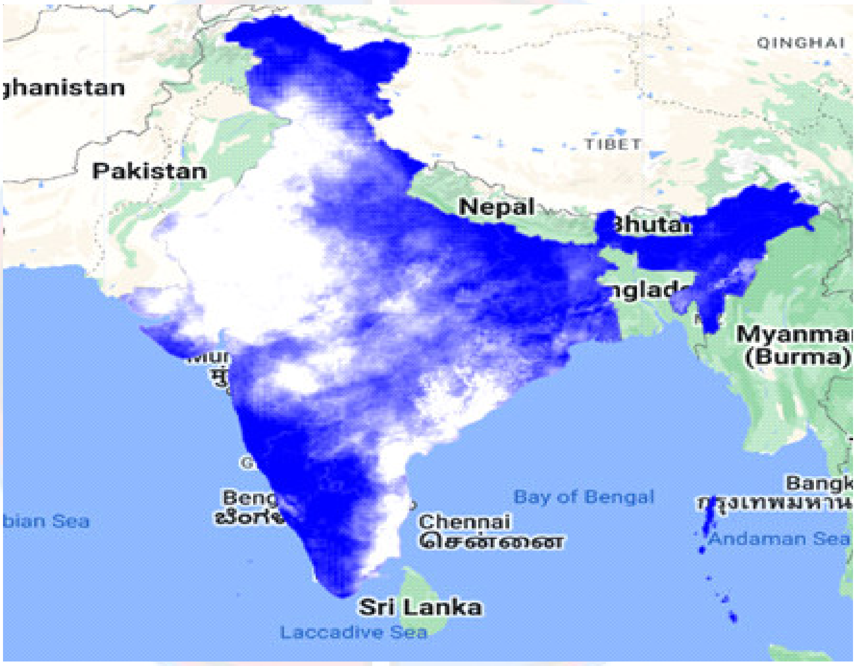

Figure 2

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