Spatial and temporal changes and variations of different threshold-based precipitation indices in the Southeastern United States

GY570: Web-GIS for Remote Sensing Analytics | Final Project Report

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I. Objectives and description

Extreme weather events like floods and droughts are increasing in the continental United States significantly (NOAA/NCEI, 2021). Extreme events are more frequent in the Southeastern United States than any other parts of the country (Powell & Keim, 2015), and they are increasing in both frequency and in magnitude in the United States (Wuebbles et al., 2014). In this study, the Southeastern United States was defined as the 9 adjacent states, respectively, Alabama, Louisiana, Mississippi, Georgia, South Carolina, North Carolina, Florida, Arkansas, and Tennessee. Because of its closeness to the Atlantic Ocean, this region gets a very good amount of precipitation throughout the year (Powell & Keim, 2015). As this region experiences a lot of hurricane events, and they are increasing rapidly (NOAA/NCEI, 2021), heavy precipitation is a very common phenomenon in the Southeastern United States. With slide changes in heavy precipitation, this region faces severe flash floods, floods and other hydrological hazards and disasters (Bartels et al., 2020).

Considering this region's strong vulnerability to heavy precipitation change, this study plans to conduct analysis of change detection in three different precipitation indices namely moderate heavy precipitation amount (total of 12.7 to 25.4 mm/day precipitation events), heavy precipitation amount (total of 25.4 to 76.2 mm/day precipitation events), and very heavy precipitation amount (greater than 76.2 mm/day precipitation total). The rationale behind taking this threshold selection is that in many precipitation data sources the measurement unit is inches instead of millimeters. Precipitation classification in this study can be easily replicable in inches. Also, in the Central and the Southeastern United States, other studies used this exact threshold approach to conduct research on precipitation days event changes using different precipitation dataset (Groisman et al., 2012; Dourte et al., 2015). Taking the exact threshold is a good way to make comparison with other studies conducted in that region. Therefore, this study aims to study decadal variation of three different types of precipitation indices in the last four decades and how these extreme precipitation indices vary spatiotemporally in the Southeastern United States.

II. Research question(s)

- How extreme precipitation indices changed spatiotemporally in the Southeastern United States?
- How was the variation of the three different precipitation indices in the study area in different decades?
- Is there any noticeable spatial shifting of precipitation extreme indices in the Southeastern United States?

III. Background and justification

Previous studies in the United States mainly focused on precipitation frequency and intensity using station observed precipitation dataset and reported changes in different extreme precipitation indices. For example, Bartels et al., (2020) studied the changing trend of precipitation days indices in the United

States. Findings from this study indicate that Southeastern parts of the United States are experiencing a decreasing trend of precipitation days indices. If the total precipitation amount remains same but precipitation days decreased, then total precipitation distributed in fewer precipitation days than before. Which can result in more extreme hydrological events. Brown et al., (2020) explored the changing regime of hourly precipitation in the Southeastern United States. This study took 50 first order stations across the Southeastern United States to conduct research. Findings from this study reported that 18 stations among 50 stations showed a significant increasing trend in 90th percentile precipitation in the study area. This study found no significant decreasing trend in 90th percentile precipitation in the study area. Powel & Keim, (2015) studied different precipitation and temperature indices in the Southeastern United States. This study also reported significant changes in frequency and magnitude of precipitation, which is also aligned with the findings of Brown et al., (2020). Findings of the above studies clearly indicate a decreasing trend of precipitation days and increasing trend in precipitation amount indices. But no study still reports how different heavy precipitation indices are changing in the study area. Specially, how has the moderate heavy precipitation amount, heavy precipitation amount, and very heavy precipitation amount changed in the study area in the last four decades?

In the Central United States (Groisman et al., 2012), conducted one research to detect changes in different categories of precipitation days indices. They divided extreme precipitation in three different categories to identify changes in those categories based on precipitation distribution. Dourte et al., (2015) conducted another research on the Southeastern United States to understand the changing behavior of precipitation days based on threshold recommended by Groisman et al., (2012). This study found significant changes in precipitation days indices in the study area. Precipitation is categorized in different ways in different parts of the world. In the Southeastern United States these threshold-based categories are recommended, and this study tends to take this recommendation and plan to study total precipitation amounts in three different heavy precipitation indices to identify the changes in precipitation amount. Above mentioned studies reported changes in precipitation days indices in the Southeastern United States using station observed daily precipitation dataset. This study plans to study total precipitation in three different categories instead of total precipitation days using the CHIRPS dataset for the Southeastern United States.

Considering all these, I am proposing this project because heavy precipitation change is one of the major causes of frequent floods and droughts in different parts of the world. Increasing heavy precipitation is the probable reason for flash floods, floods, in wet seasons and droughts in dry seasons. With sparse ground-based stations for precipitation measurement, CHIRPS dataset can be a great alternative for heavy precipitation change detection.

IV. Methods and data

To identify change in various precipitation types, this study divided precipitation based on previous research that categorized precipitation in the Southeastern region of the United States. Precipitation category recommended by Groisman et al., (2012) and Dourte et al., (2020) taken to this study for calculating total precipitation in three heavy precipitation categories. For moderate precipitation amounts, I took precipitation events that are greater than equal 12.7 and less than equal 25.4 and so on, as described below.

(1) Moderate heavy precipitation amount (total precipitation amount range from 12.7 to 25.4 mm/day)

(2) Heavy precipitation amount (total precipitation amount range from 25.4 to 76.2 mm/day)

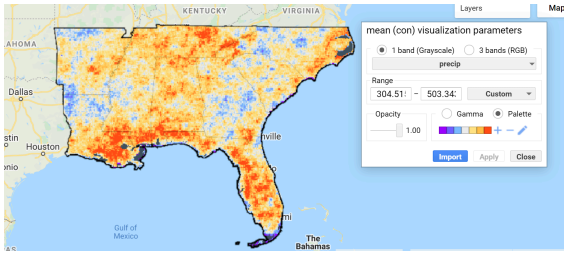
(3) Very heavy precipitation amount (total precipitation amount greater than76.2 mm/day)

I am planning to include the CHIRPS dataset to conduct this project because of two reasons. First, this dataset has long temporal coverage. Second, this dataset is a daily precipitation dataset produced using both satellite and ground observed satellite dataset.

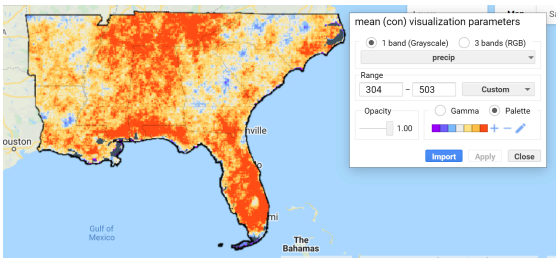
PERSIANN-CDR is another daily quasi-global precipitation dataset produced using a machine learning algorithm and satellite precipitation dataset that spans the period from 1983-01-01 to present. Two problems I faced when considering this dataset for my purpose. First, this dataset is available from 1983, which means this dataset still needs a few more years to acquire four decades coverage. Another one is this dataset has spatial resolution of 27830 meters, which is much coarser than CHIRPS dataset with spatial resolution of 5566 meters.

V. Expected maps and results

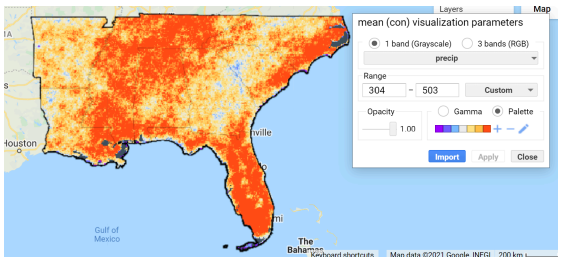
Moderate heavy precipitation yearly average from 1981-2020 divided into four different decades, shown in four panel figures.



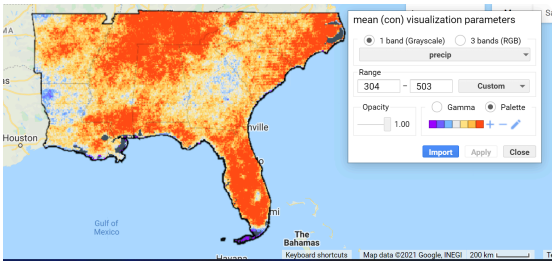
(1981-1990)



(1991-2000)



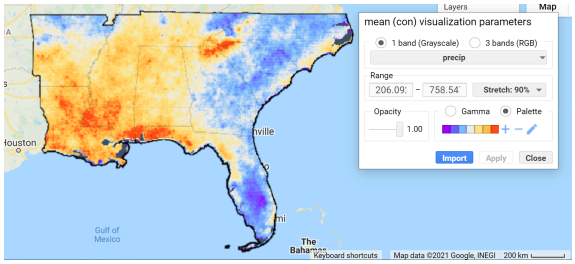
(2000-2010)



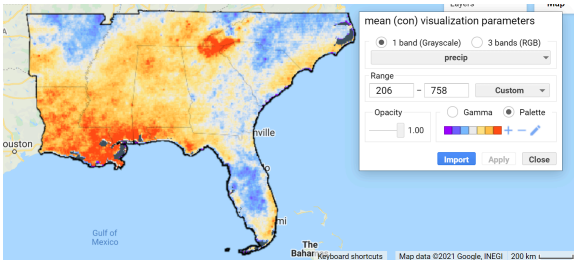
(2011-2020)

In the last four decades there is a clear spatial shift in moderate heavy precipitation in the Southeastern United States. First two decades of the observation period delineate that the gulf coast region is only getting more moderate heavy precipitation but in the last two decades moderate heavy precipitation increased in the North Carolina coast region and also in the upper Tennessee region. Overall, moderate heavy precipitation is increasing in the gulf coast region and Florida-Georgia coastline.

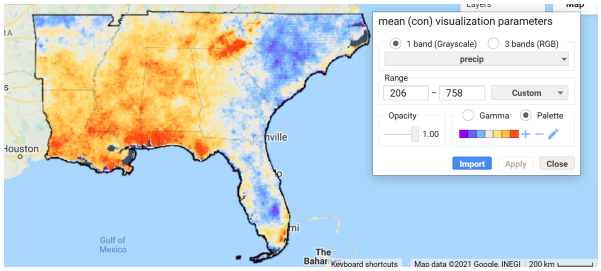
Heavy precipitation has also increased in the last four decades. But the spatial extent of heavy precipitation is different from moderate heavy precipitation.



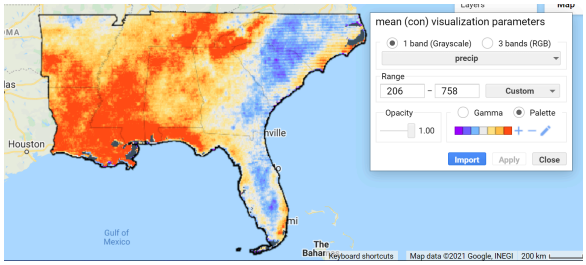
1981-1990



1991-2000



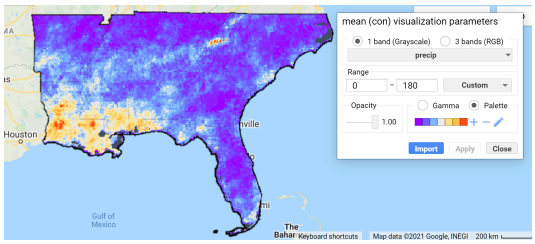
2001-2010



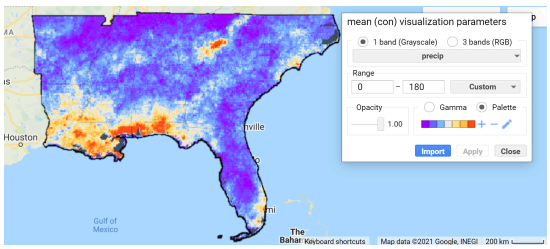
2011-2020

With time heavy precipitation increased in Louisiana, Mississippi, Alabama, and some parts of Tennessee. The average decadal precipitation change mostly happened in the last decade at the study area. As seen in the image, some part of the study area becomes darker than previous decades.

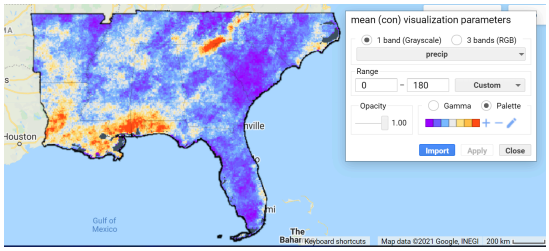
Very heavy precipitation is not that frequent like moderate and heavy precipitation events. The gulf coast region of the Southeastern United States has received most of the heavy precipitation events. The gulf coast region of Louisiana, Mississippi, and Alabama was the region that got the most very heavy precipitation. But in the last two decades, especially in the last decade, very heavy precipitation increased in this region and now it covers most of Louisiana, and Mississippi and some part of Alabama. Now this every precipitation event is shifting toward inland in these three states.



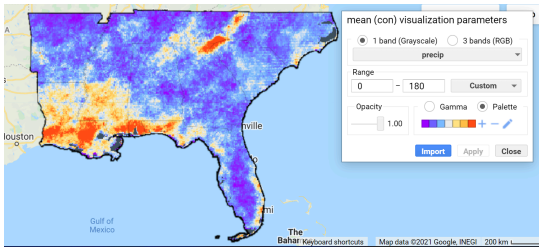
1981-1990



1991-2000



2001-2010



2011-2020

Temporal changes of moderate precipitation show huge and frequent fluctuation still we can observe an increasing trend.

Fig: moderate precipitation annual total

Heavy precipitation also changes temporally. Though the increasing trend is not linear but with many fluctuations of heavy precipitation, the temporal graph shows an increasing trend in the study area.

Fig: heavy precipitation annual total

Very heavy precipitation change may be more increasing than other two types and show a clear increasing trend. These three figures have many possible MAUP, and MTUP problems. I took this figure for demonstration to get a clear idea about the temporal changes of precipitation in the study area.

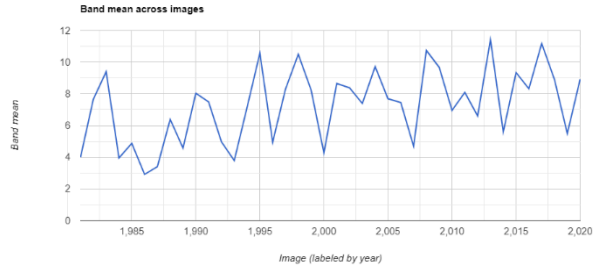


Fig: very heavy precipitation annual total

VI. References

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