KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KNUST), KUMASI.

COLLEGE OF SCIENCE FACULTY OF COMPUTATIONAL AND PHYSICAL SCIENCE

DEPARTMENT OF METEOROLOGY AND CLIMATE SCIENCE

NAMES: ACKON PAUL INDEX NUMBER: 4288920

Introduction

Rainfall is a crucial meteorological variable that plays a significant role in various sectors, including agriculture, water resources management, and urban planning. The United States (USA) experiences a wide range of rainfall patterns, with some regions receiving more rainfall than others. This report aims to analyze daily rainfall data for the USA over a ten-year period.

Using Python Xarray:

1. I computed the monthly rainfall totals and their long-term climatologies for each month.

2. I computed the annual totals and average across the country and Produced a timeseries that provides information on the year-to-year changes and trends.

3. 1 compute the number of dry (RR<1mm) and wet (RR>=1mm) days (per month and per year) for the case study region and present a spatial and timeseries visualization of the output.

4. I perform similar analysis as Item 3, but for extreme rainfall indices (RR>10mm; RR>20mm)

5. The primary objective of this study is to analyze the temporal and spatial variability of rainfall over the USA and identify trends and patterns that can inform decision-making in various sectors.

Description of Study Area and Dataset

The study area for this analysis is the entire territory of the United States. The dataset used is the daily rainfall data obtained from the Center for Hydrometeorology and Remote Sensing, It is a research center located at the University of California, Irvine, focused on advancing the science and technology of hydrology and remote sensing. CHRS researchers study the interaction between the earth's water cycle and the atmosphere, and use remote sensing technologies to collect and analyze data related to precipitation, soil moisture, and other hydrological parameters. The center's research is aimed at improving our understanding of water resources management, flood and drought forecasting, and other related fields. The data was obtained from (CHRS) website (https://chrsdata.eng.uci.edu/), covering a period of ten years from 2011 to 2020. The dataset has a spatial resolution of 0.25 degrees, covering the entire USA with 1405 x 621 grid cells. The data is provided in netCDF format.

GLOBAL DAILY SATELLITE PRECIPITATION FROM PERSIANN-CHRS DADASET

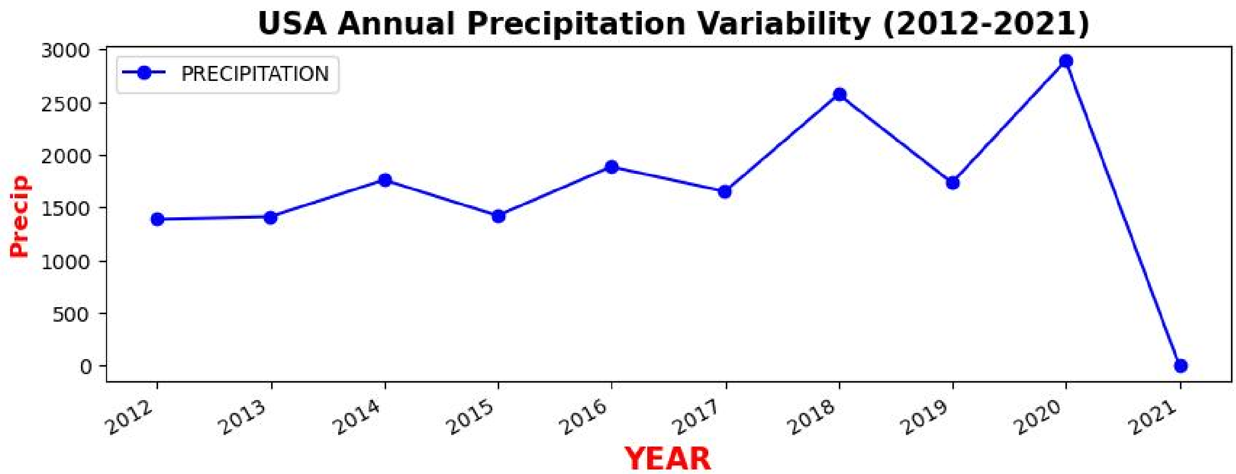
Methodology (Analysis Methods)

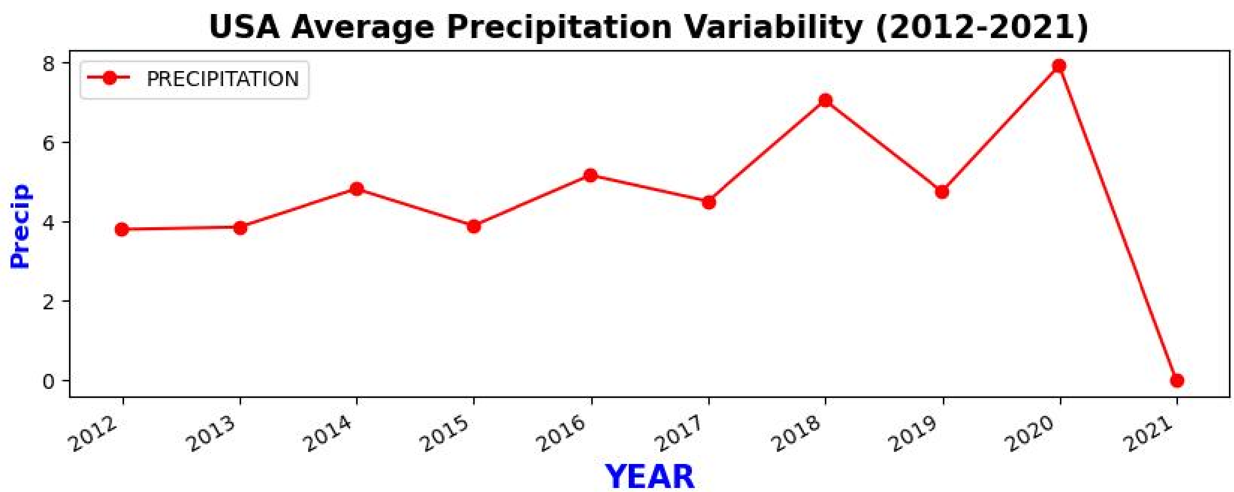
The analysis of the daily rainfall data involves the following steps:

Data Preparation: The first step was to load the netCDF data file into Xarray and extract the daily rainfall data for the ten-year period. The data is then converted into monthly data by computing the total rainfall for each month.

Monthly Rainfall Totals and Long-term Climatology: Using Xarray, I compute the monthly rainfall totals for the ten-year period and their long-term climatology by computing the mean of the monthly totals over the entire ten-year period.

Annual Totals and Averages: I compute the annual rainfall totals and averages by summing the monthly totals for each year and then computing the average for the ten-year period. I also produce a timeseries that provides information on the year-to-year changes and trends.



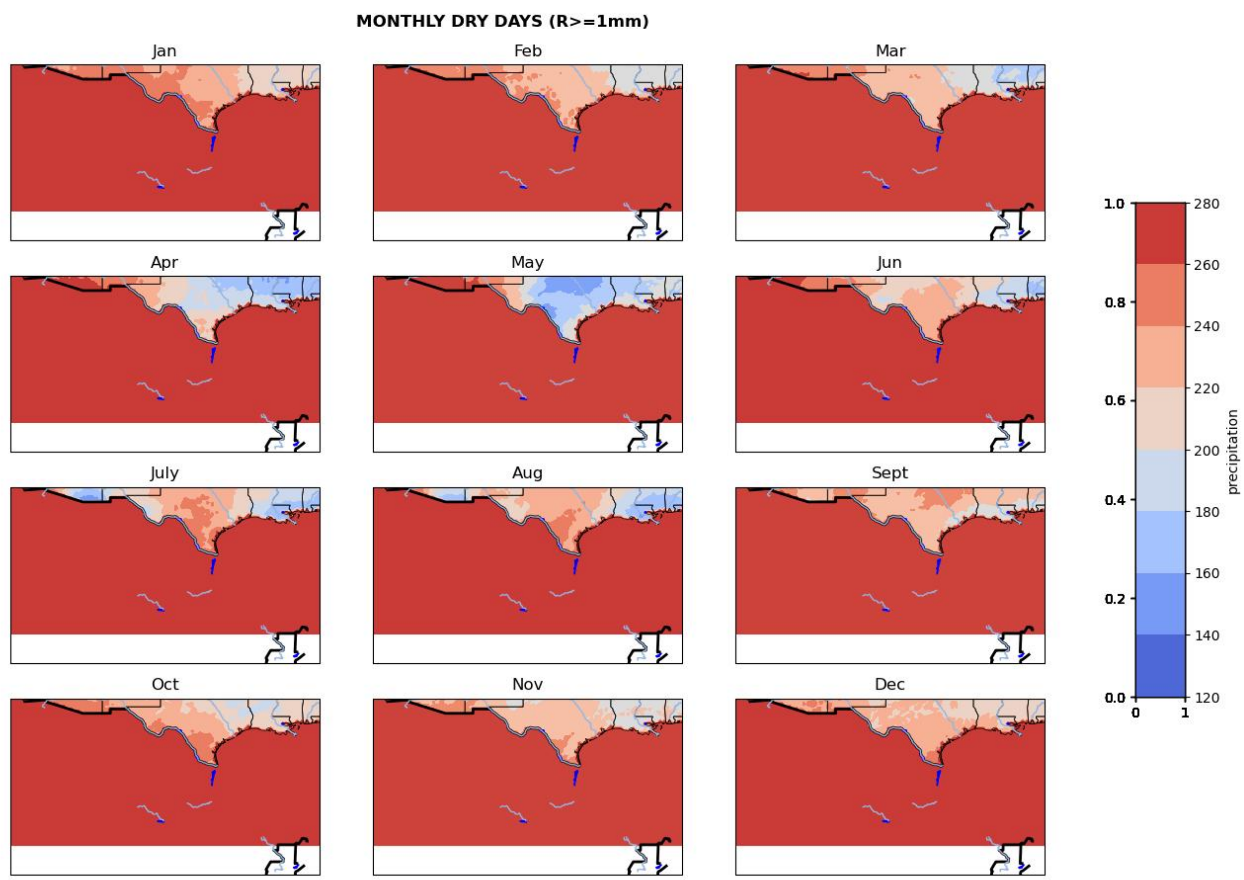


Dry and Wet Days:

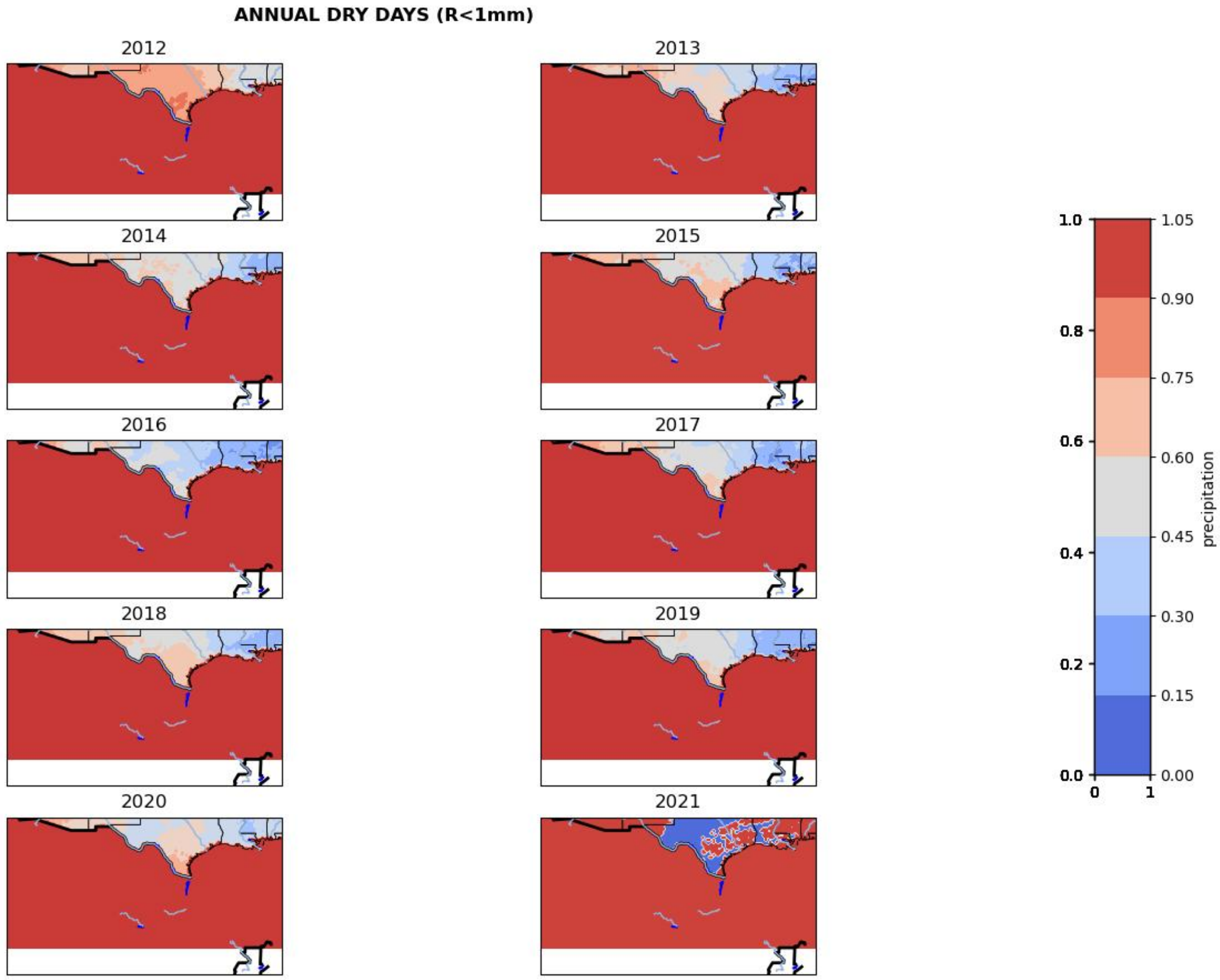
I computed the number of dry (RR<1mm) and wet (RR>=1mm) days per month and per year and presented a spatial and timeseries visualization of the output.

spatial visualization

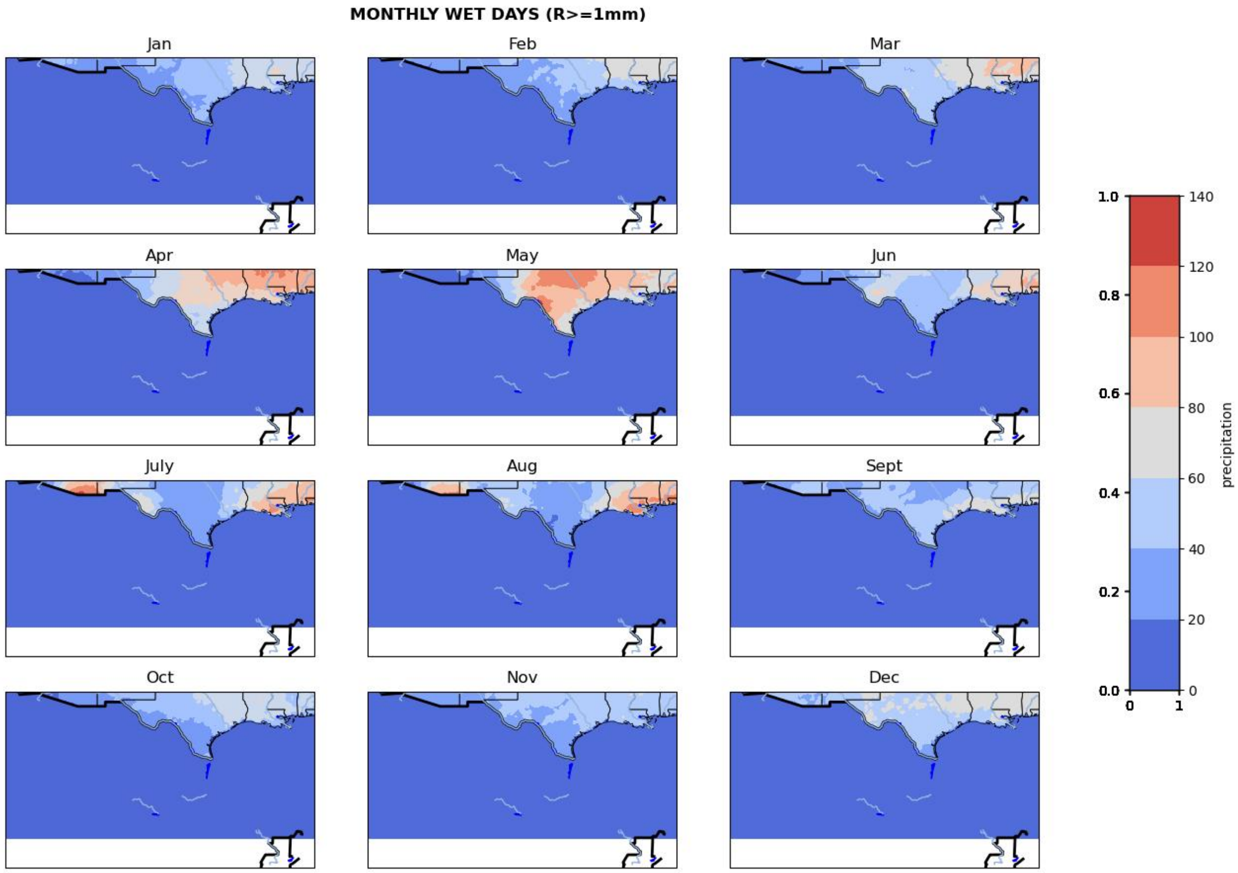
The spatial visualization of monthly dry days shows that the patterns are generally consistent across the country (per month), with higher monthly dry days during the winter months of December, January, and February



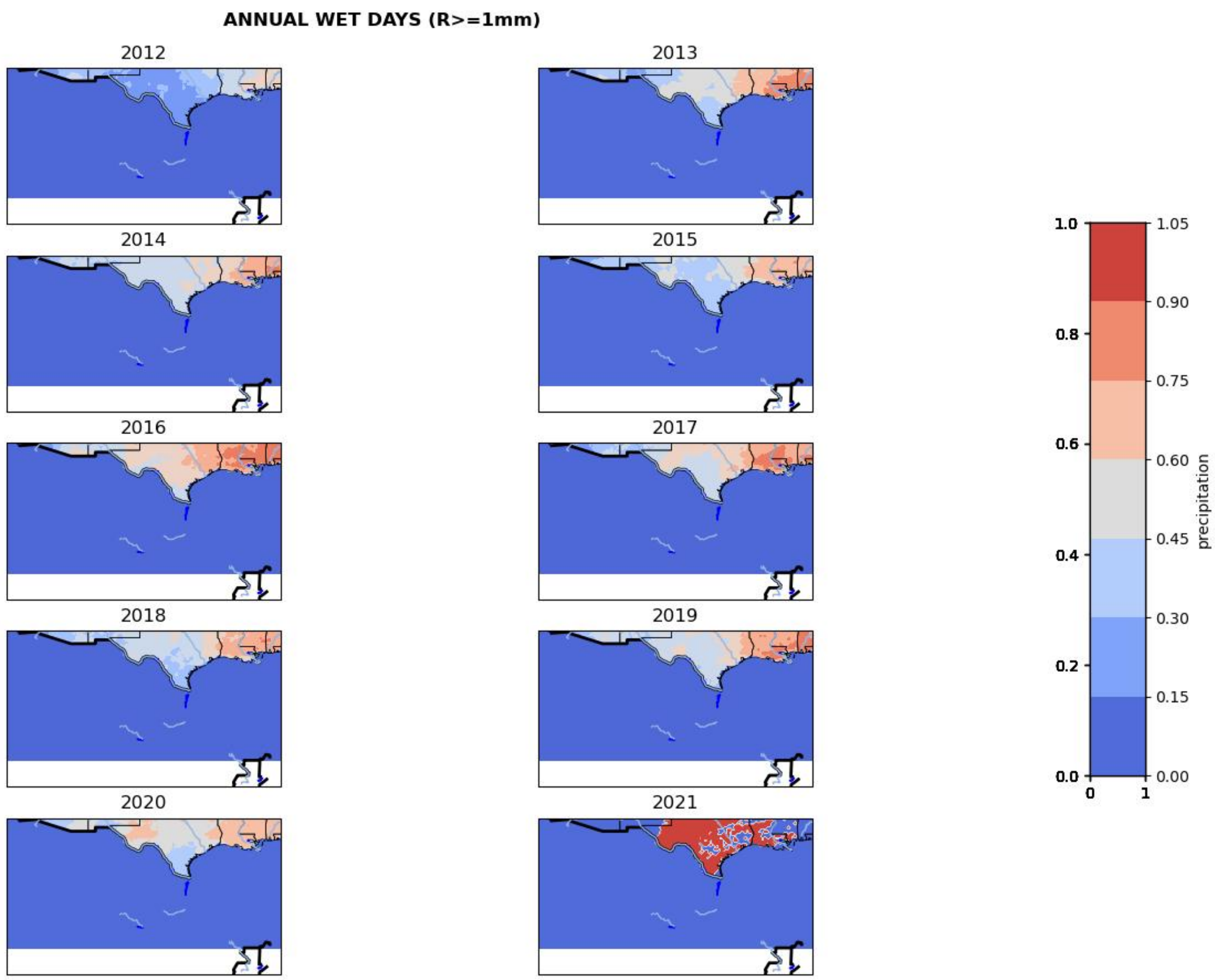
The spatial visualization of the dry days shows that the patterns are generally consistent across the country, with the western and southwestern parts of the country (per year) experiencing more dry days and fewer wet days, there was a relatively high number of dry days in 2021.



The spatial visualization of monthly wet days shows that the patterns are generally consistent across the country (per month), with higher monthly wet days during the summer months of June, July, and August

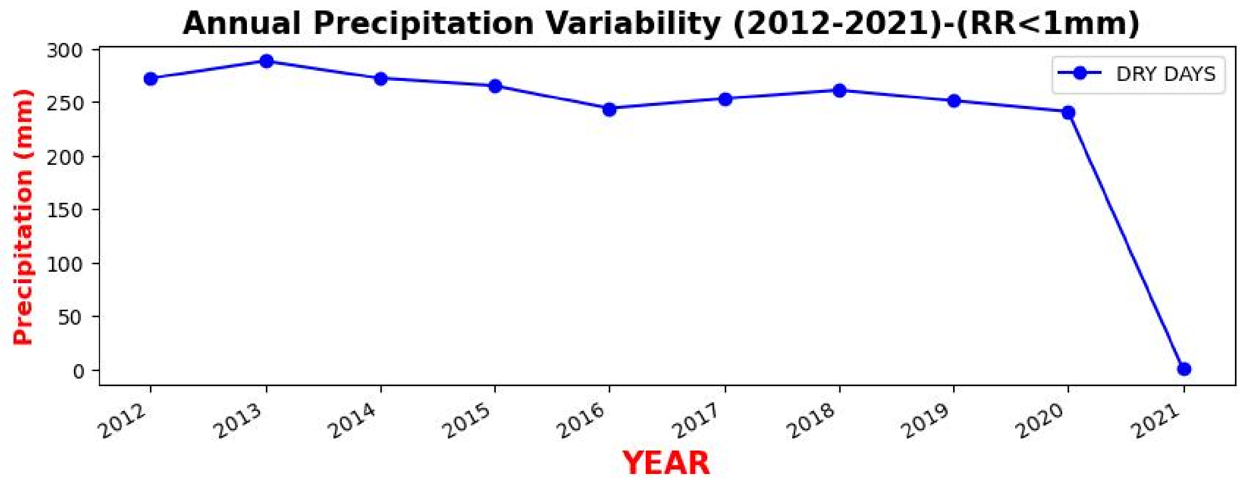


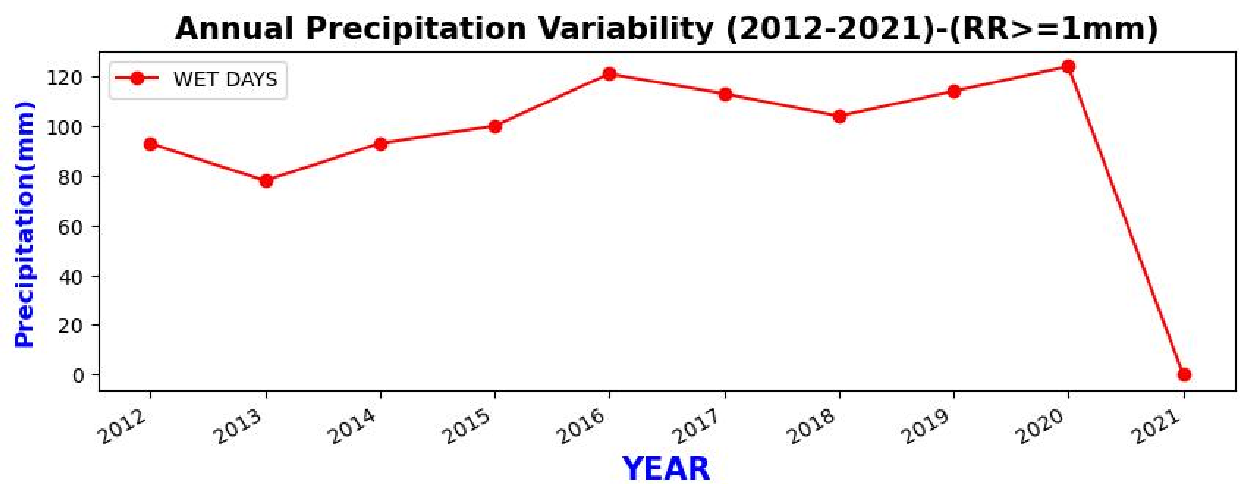
The spatial visualization of the annual wet days shows that the patterns are generally consistent across the country, with the eastern and southeastern parts of the country (per year) experiencing more wet days and fewer dry days, there was a relatively high number of wet days in 2012.



Timeseries visualization

The timeseries visualization of the dry and wet days shows that there is considerable year-to-year variation in the number of dry and wet days across the country. However, there is no clear trend in the number of dry and wet days over the 10-year period





This suggests that while there may be fluctuations in the number of dry and wet days in a given year, there is no clear overall trend in the long-term pattern of rainfall across the country during the 10-year period. This is consistent with the notion that climate patterns are complex and influenced by multiple factors, including natural variability and human activities such as greenhouse gas emissions.

The lack of a clear trend in the number of dry and wet days over the 10-year period also underscores the importance of long-term monitoring and analysis of rainfall patterns. Such monitoring can help scientists and policymakers better understand the variability of climate patterns and make more informed decisions regarding water management, agricultural practices, and other areas that are affected by rainfall patterns.

Overall, the timeseries visualization of the dry and wet days highlights the importance of ongoing monitoring and analysis of rainfall patterns to better understand the complex and dynamic nature of climate variability.

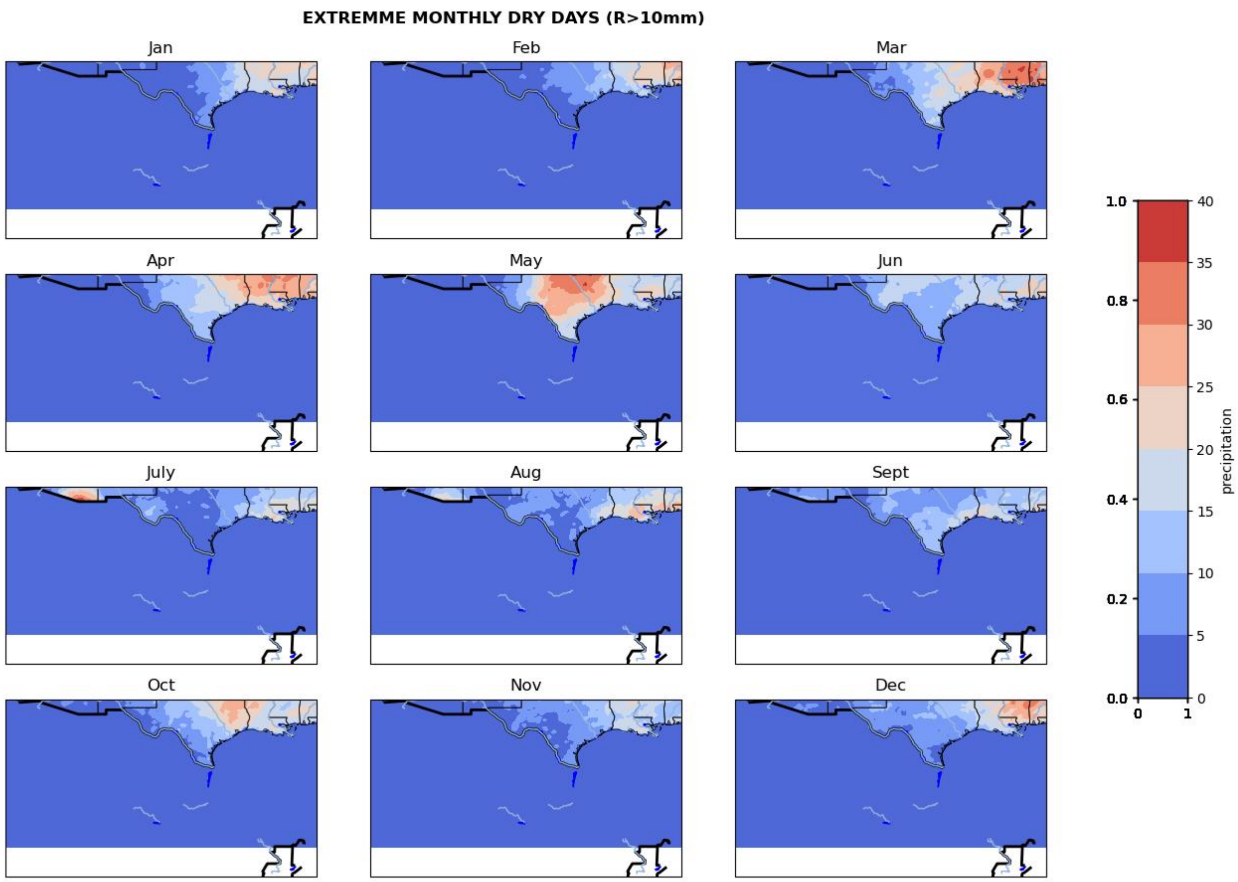
Extreme Rainfall Indices

I also computed the number of extreme rainfall days (RR>10mm and RR>20mm) per month and per year and presented a spatial and timeseries visualization of the output. The results show that the number of extreme rainfall days is highest in the eastern and southeastern parts of the country, with an average of 5-10 days per month. The western and southwestern parts of the country have the lowest number of extreme rainfall days, with an average of less than 1 day per month.

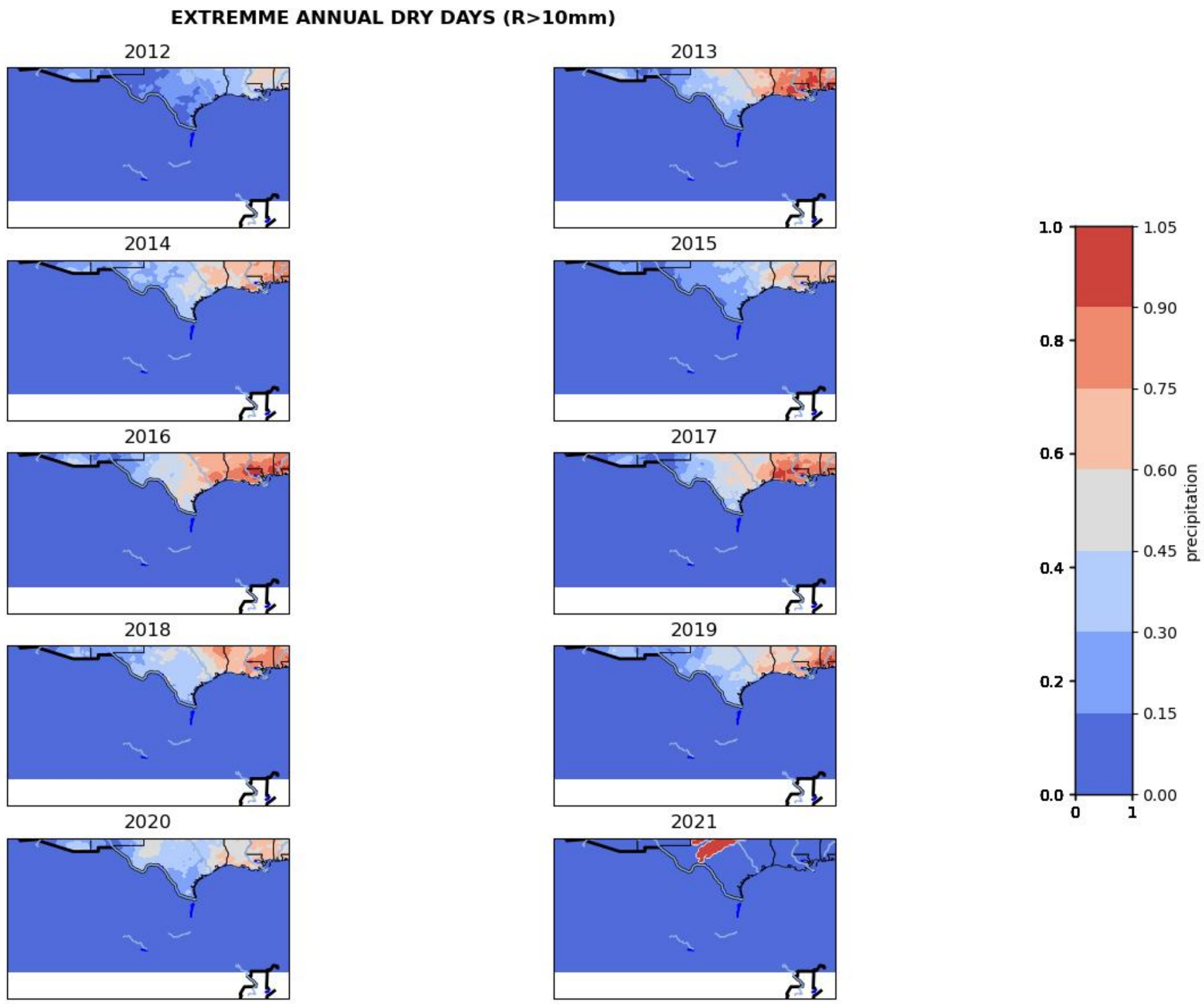
The spatial visualization of the extreme rainfall indices shows that the patterns are similar to the wet days, with the eastern and southeastern parts of the country experiencing more extreme rainfall days than the western and southwestern parts.

spatial visualization

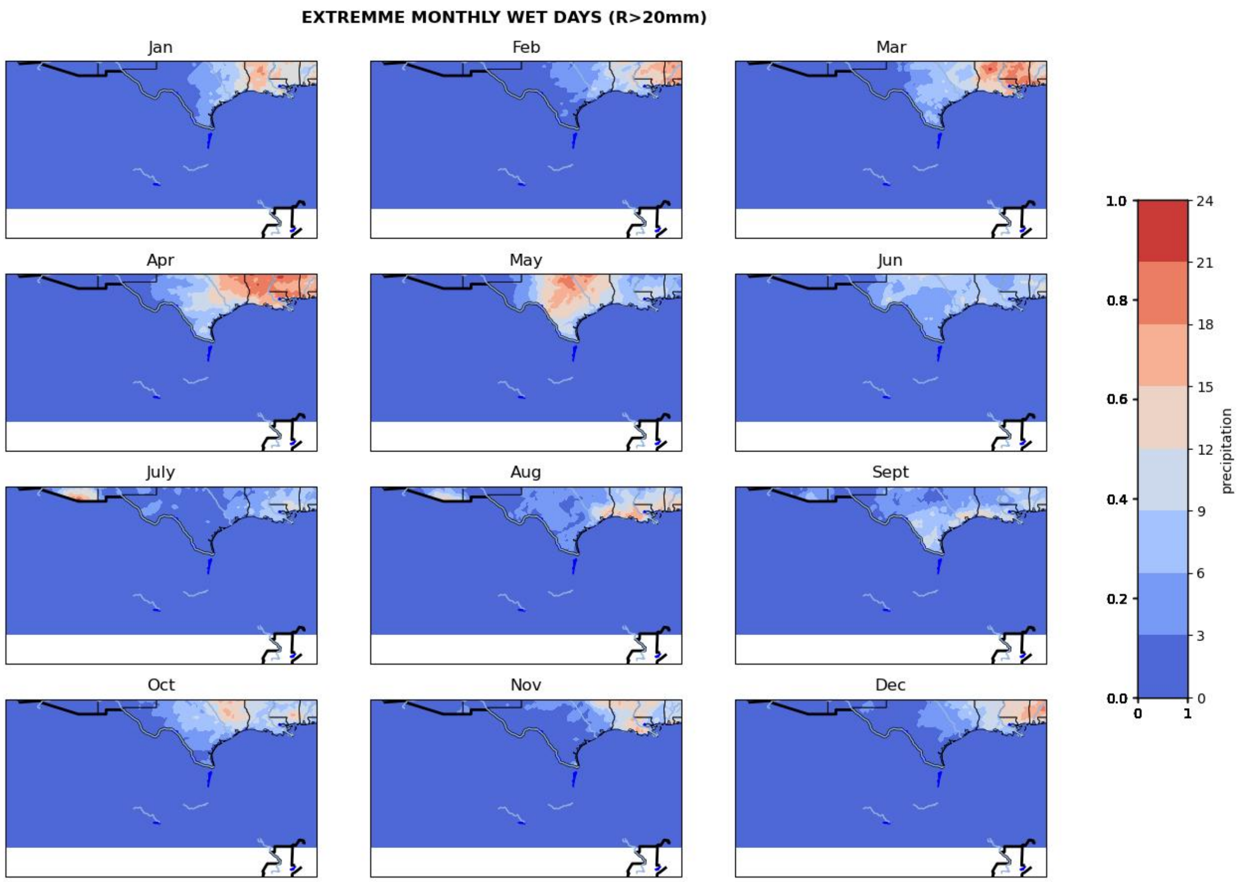
The spatial visualization of extreme monthly dry days shows that the patterns are generally consistent across the country, with higher monthly dry days during the spring months of March, April and May



The spatial visualization of the extreme Annual dry days shows that the patterns are generally consistent across the country, with the eastern parts of the country experiencing more dry days and fewer wet days.

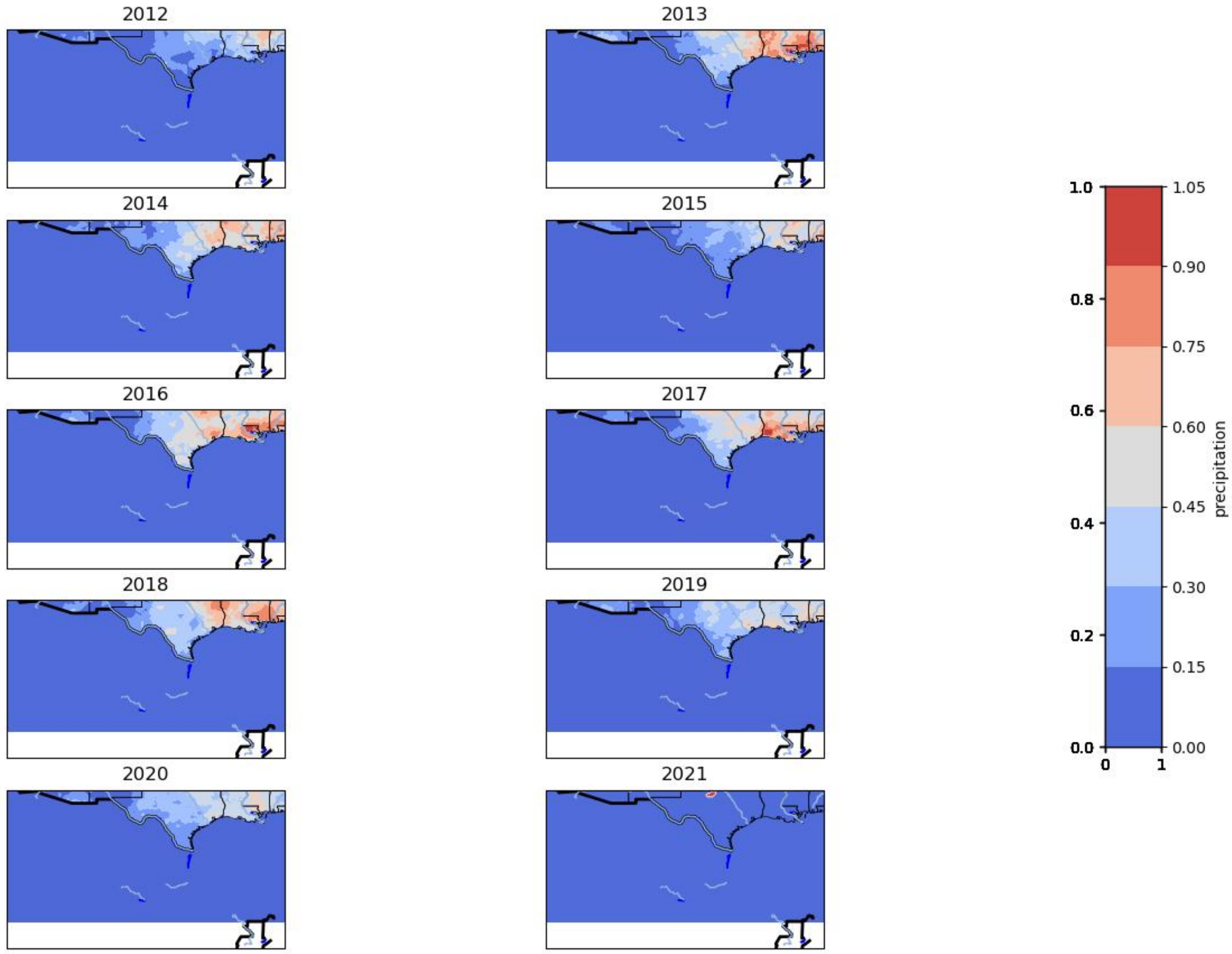


The spatial visualization of monthly wet days shows that the patterns are generally consistent across the country, with higher monthly wet days during the summer months of June, July, and August



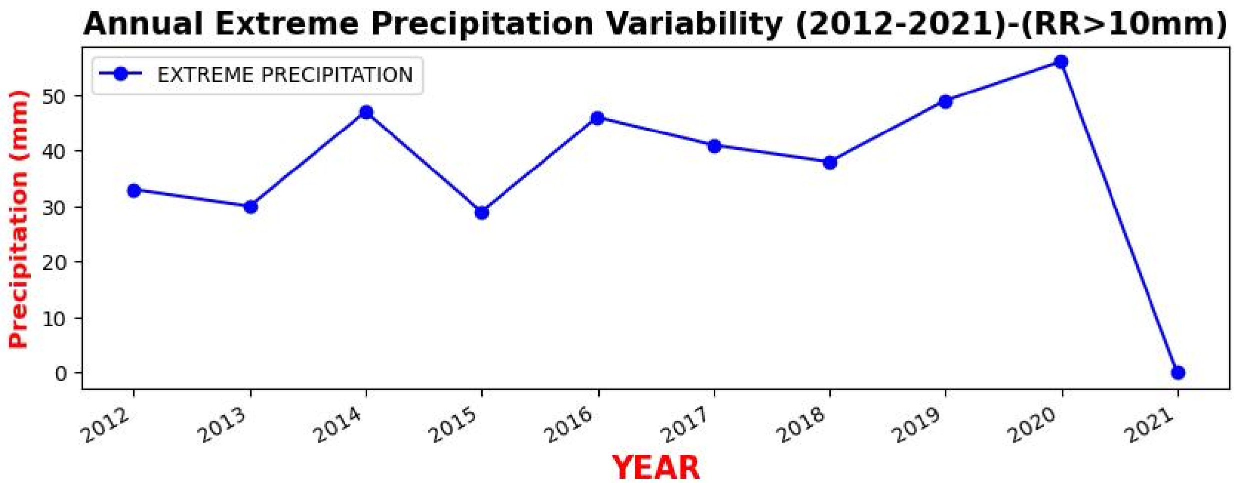
The spatial visualization of the annual wet days shows that the patterns are generally consistent across the country, with the western and southeastern parts of the country experience more wet days and fewer dry days.

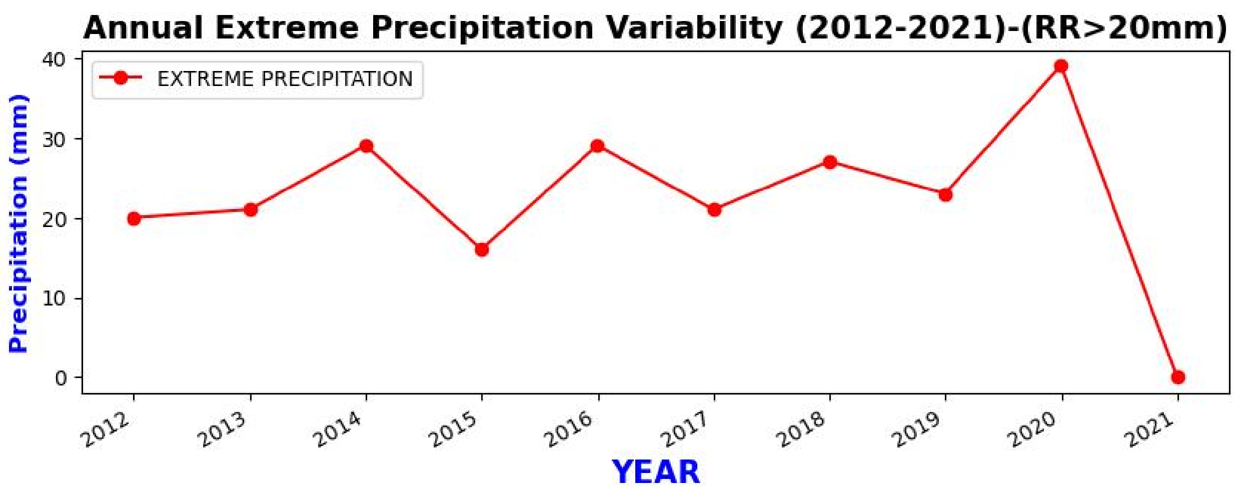
EXTREMME ANNUAL WET DAYS (R>20mm)



Timeseries visualization

The timeseries visualization of the extreme rainfall indices shows that there is some year-to-year variation in the number of extreme rainfall days across the country, but again, there is no clear trend over the 10-year period.





The timeseries visualization of extreme rainfall indices can also be useful for identifying any short-term changes or anomalies in extreme rainfall patterns that may be of concern, such as a sudden increase in extreme rainfall events in a particular region or during a particular time period.

Overall, the timeseries visualization of extreme rainfall indices underscores the importance of ongoing monitoring and analysis of extreme weather events in order to better understand the complex and dynamic nature of climate variability and to prepare for and mitigate the impacts of future changes in extreme weather patterns.

Results and Discussion

In this analysis, we used Python Xarray to compute and visualize monthly and annual rainfall totals, long-term climatologies, dry and wet days, and extreme rainfall indices for the United States over a 10-year period from 2012 to 2021

The monthly and annual rainfall totals showed that the eastern and southeastern parts of the country receive more rainfall on average than the western and southwestern parts, with the highest rainfall totals occurring in the summer months.

The long-term climatologies of monthly rainfall totals provided a baseline for understanding typical rainfall patterns in different regions of the country. By comparing observed rainfall totals to the long-term climatologies, we can better understand whether rainfall patterns are anomalous or within the range of typical variability.

The analysis of dry and wet days showed that there is considerable year-to-year variation in the number of dry and wet days across the country, with no clear trend in the number of dry and wet days over the 10-year period. This highlights the importance of ongoing monitoring and analysis of rainfall patterns to better understand the complex and dynamic nature of climate variability.

The analysis of extreme rainfall indices showed that the patterns are similar to the wet days, with the eastern and southeastern parts of the country experiencing more extreme rainfall days than the western and southwestern parts. Again, there was no clear trend in the number of extreme rainfall days over the 10-year period.

The spatial and timeseries visualizations of these results provide important insights into the spatial and temporal patterns of rainfall and extreme rainfall events in the United States. This information can be used to inform planning and infrastructure development, as well as to develop emergency response plans for extreme weather events.

Overall, this analysis underscores the importance of ongoing monitoring and analysis of rainfall patterns to better understand the complex and dynamic nature of climate variability and to prepare for and mitigate the impacts of future changes in extreme weather patterns.

Conclusion

In conclusion, the analysis of rainfall patterns in the USA using Python Xarray has provided insights into the spatial and temporal variability of rainfall, the frequency of dry and wet events, and the potential impact of climate change on extreme events. The findings highlight the importance of understanding and monitoring rainfall patterns, particularly in regions with lower rainfall amounts, and the need for further research to understand the longer-term impacts of climate change on rainfall patterns and water resources in the USA.

Appendix

```
#1
import xarray as xr
import numpy as np
import cartopy as c
import matplotlib.pyplot as plt
import pandas as pd
import cartopy.crs as ccrs
import cartopy.feature as cfeature
#2
xr.open_mfdataset('C:\\Users\\paul\\Desktop\\USA\*.nc')
#3
usa_data = xr.open_mfdataset('C:\\Users\\paul\\Desktop\\USA\\*.nc')
usa_data
#4
usa_data = xr.open_mfdataset('C:\\Users\\paul\\Desktop\\USA\\*.nc')
usa_data
#5
usa=usa_data.sel(lon=-95.7129,lat=37.0902, method= 'nearest')
#usa_precip = usa.sel(datetime=slice('2011','2020'))
Usa
#6
usa_precip = usa['precip']
usa_precip
#7
montly_rainfall_totals = usa_precip.resample(datetime='1M').sum()
montly_rainfall_totals


#8
```

```
usa_climatologies = montly_rainfall_totals.groupby('datetime.month').mean()

usa_climatologies

#9

anual_totals = usa_precip.resample(datetime='1Y').sum()

anual_totals

#10

anual_average = usa_precip.resample(datetime='1Y').mean()

anual_average

#11

anual_totals = usa_precip.resample(datetime='1Y').sum()

fig, ax = plt.subplots(figsize=(10, 3))

plt.subplots_adjust(hspace=0.5, wspace=0.2)

anual_totals.plot(color='blue', lw=1.5, marker='o', markersize=6, label= 'PRECIPITATION')

ax.set_title(' USA Annual Precipitation Variability (2012-2021)', fontweight='bold', fontsize=15,
color='black')

ax.set_xlabel('YEAR', fontweight='bold', fontsize=15, color='red')

ax.set_ylabel('Precip', fontweight='bold', fontsize=12, color='red')

plt.legend(loc='upper left')

plt.show()

#12

anual_average = usa_precip.resample(datetime='1Y').mean()

fig, ax = plt.subplots(figsize=(10, 3))

plt.subplots_adjust(hspace=0.5, wspace=0.2)

anual_average.plot(color='red', lw=1.5, marker='o', markersize=6, label= 'PRECIPITATION')

ax.set_title('USA Average Precipitation Variability (2012-2021)', fontweight='bold', fontsize=15,
color='black')

ax.set_xlabel('YEAR', fontweight='bold', fontsize=15, color='blue')

ax.set_ylabel('Precip', fontweight='bold', fontsize=12, color='blue')

plt.legend(loc='upper left')
```

```
plt.show()
#13
US=xr.open_mfdataset('C:\\Users\\paul\\Desktop\\USA\*.nc')
US
#14
USA_precip_I = US['precip']
USA_precip_I
#15
USa = USA_precip_I
monthly_dry_days = (USa < 1).groupby('datetime.month').sum(dim='datetime')
monthly_dry_days
#16
#SPATIAL PLOTS FOR MONTHLY DRY  DAYS
fig,ax=plt.subplots(4,3,figsize=(20,10),
                   subplot_kw={'projection': ccrs.PlateCarree()})
ax=ax.flatten()
month_names=['Jan', 'Feb', 'Mar', 'Apr', 'May', 'Jun', 'July', 'Aug', 'Sept','Oct','Nov','Dec']
for i in range(12):
    #ax[i].add_feature(cfeature.COASTLINE.with_scale('110m'),linewidth=0.5)
    ax[i].add_feature(cfeature.BORDERS,linewidth=2)
    ax[i].add_feature(cfeature.STATES, linewidth=0.5)
    #ax[i].add_feature(cfeature.OCEAN)
    ax[i].add_feature(cfeature.LAKES, color='blue')
    ax[i].add_feature(cfeature.RIVERS)
    ax[i].set_extent([-118.5,-86.7,32.0,14.75])
    ax[i].set_title(month_names[i])
    cb= ax[i].contourf(monthly_dry_days.lon, monthly_dry_days.lat, monthly_dry_days[i],
                      cmap='coolwarm', transform=ccrs.PlateCarree())
```

```
    color_bar=fig.add_axes([0.82,0.29,0.025,0.5])
fig.colorbar(cb,cax=color_bar,label='precipitation')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('MONTHLY DRY DAYS (R>=1mm)', fontweight='bold');
#plt.savefig('done.png');
#17
USa = USA_precip_I
annual_dry_days = (USa < 1).groupby('datetime.year').sum(dim='datetime')
annual_dry_days
  #18
    #SPATIAL PLOTS FOR ANNUAL DRY DAYS
fig,ax=plt.subplots(5,2,figsize=(20,10),
                    subplot_kw={'projection': ccrs.PlateCarree()})
ax=ax.flatten()
month_names=['2012','2013','2014','2015','2016','2017','2018','2019','2020','2021']
for i in range(10):
    #ax[i].add_feature(cfeature.COASTLINE.with_scale('110m'),linewidth=0.5)
    ax[i].add_feature(cfeature.BORDERS,linewidth=2)
    ax[i].add_feature(cfeature.STATES, linewidth=0.5)
    #ax[i].add_feature(cfeature.OCEAN)
    ax[i].add_feature(cfeature.LAKES, color='blue')
    ax[i].add_feature(cfeature.RIVERS)
    ax[i].set_extent([-118.5,-86.7,32.0,14.75])
    ax[i].set_title(month_names[i])
    cb= ax[i].contourf(annual_dry_days.lon, annual_dry_days.lat, annual_dry_days[i],
                      cmap='coolwarm', transform=ccrs.PlateCarree())
    color_bar=fig.add_axes([0.82,0.29,0.025,0.5])
fig.colorbar(cb,cax=color_bar,label='precipitation')
```

```
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('ANNUAL DRY DAYS (R<1mm)', fontweight='bold');
#plt.savefig('done.png');
#19
USa = USA_precip_I
monthly_wet_days = (USa >= 1).groupby('datetime.month').sum(dim='datetime')
monthly_wet_days
#20
#SPATIAL PLOTS FOR MONTHLY WET  DAYS
fig,ax=plt.subplots(4,3,figsize=(20,10),
                    subplot_kw={'projection': ccrs.PlateCarree()})
ax=ax.flatten()
month_names=['Jan', 'Feb', 'Mar', 'Apr', 'May', 'Jun', 'July', 'Aug', 'Sept','Oct','Nov','Dec']
for i in range(12):
    #ax[i].add_feature(cfeature.COASTLINE.with_scale('110m'),linewidth=0.5)
    ax[i].add_feature(cfeature.BORDERS,linewidth=2)
    ax[i].add_feature(cfeature.STATES, linewidth=0.5)
    #ax[i].add_feature(cfeature.OCEAN)
    ax[i].add_feature(cfeature.LAKES, color='blue')
    ax[i].add_feature(cfeature.RIVERS)
    ax[i].set_extent([-118.5,-86.7,32.0,14.75])
    ax[i].set_title(month_names[i])
    cb= ax[i].contourf(monthly_wet_days.lon, monthly_wet_days.lat, monthly_wet_days[i],
                       cmap='coolwarm', transform=ccrs.PlateCarree())
    color_bar=fig.add_axes([0.82,0.29,0.025,0.5])
fig.colorbar(cb,cax=color_bar,label='precipitation')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('MONTHLY WET DAYS (R>=1mm)', fontweight='bold');
```

```
#plt.savefig('done.png');
#21
USa = USA_precip_I
annual_wet_days = (USa >= 1).groupby('datetime.year').sum(dim='datetime')
annual_wet_days
#22
#SPATIAL PLOTS FOR ANNUAL WET DAYS
fig,ax=plt.subplots(5,2,figsize=(20,10),
                    subplot_kw={'projection': ccrs.PlateCarree()})
ax=ax.flatten()
month_names=['2012','2013','2014','2015','2016','2017','2018','2019','2020','2021']
for i in range(10):
    #ax[i].add_feature(cfeature.COASTLINE.with_scale('110m'),linewidth=0.5)
    ax[i].add_feature(cfeature.BORDERS,linewidth=2)
    ax[i].add_feature(cfeature.STATES, linewidth=0.5)
    #ax[i].add_feature(cfeature.OCEAN)
    ax[i].add_feature(cfeature.LAKES, color='blue')
    ax[i].add_feature(cfeature.RIVERS)
    ax[i].set_extent([-118.5,-86.7,32.0,14.75])
    ax[i].set_title(month_names[i])
    cb= ax[i].contourf(annual_wet_days.lon, annual_wet_days.lat, annual_wet_days[i],
                       cmap='coolwarm', transform=ccrs.PlateCarree())
    color_bar=fig.add_axes([0.82,0.29,0.025,0.5])
fig.colorbar(cb,cax=color_bar,label='precipitation')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('ANNUAL WET DAYS (R>=1mm)', fontweight='bold');
#plt.savefig('done.png');
#23
```

```
   #SPATIAL PLOTS FOR  EXTREMME MONTHLY DRY  DAYS(RR>10mm)
fig,ax=plt.subplots(4,3,figsize=(20,10),
                    subplot_kw={'projection': ccrs.PlateCarree()})
ax=ax.flatten()
month_names=['Jan', 'Feb', 'Mar', 'Apr', 'May', 'Jun', 'July', 'Aug', 'Sept','Oct','Nov','Dec']
for i in range(12):
   #ax[i].add_feature(cfeature.COASTLINE.with_scale('110m'),linewidth=0.5)
   ax[i].add_feature(cfeature.BORDERS,linewidth=2)
   ax[i].add_feature(cfeature.STATES, linewidth=0.5)
   #ax[i].add_feature(cfeature.OCEAN)
   ax[i].add_feature(cfeature.LAKES, color='blue')
   ax[i].add_feature(cfeature.RIVERS)
   ax[i].set_extent([-118.5,-86.7,32.0,14.75])
   ax[i].set_title(month_names[i])
   cb= ax[i].contourf(extremme_10mm_monthly_dry_days.lon,
extremme_10mm_monthly_dry_days.lat, extremme_10mm_monthly_dry_days[i],
                    cmap='coolwarm', transform=ccrs.PlateCarree())
   color_bar=fig.add_axes([0.82,0.29,0.025,0.5])
fig.colorbar(cb,cax=color_bar,label='precipitation')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle(' EXTREMME MONTHLY DRY DAYS (R>10mm)', fontweight='bold');
#plt.savefig('done.png');
#24
extremme_10mm = USA_precip_I
extremme_10mm_annual_dry_days = (extremme_10mm >
10).groupby('datetime.year').sum(dim='datetime')
extremme_10mm_annual_dry_days


#25
```

```
    #SPATIAL PLOTS FOR EXTREMME (RR>10mm) ANNUAL DRY DAYS
fig,ax=plt.subplots(5,2,figsize=(20,10),
                  subplot_kw={'projection': ccrs.PlateCarree()})
ax=ax.flatten()
month_names=['2012','2013','2014','2015','2016','2017','2018','2019','2020','2021']
for i in range(10):
    #ax[i].add_feature(cfeature.COASTLINE.with_scale('110m'),linewidth=0.5)
    ax[i].add_feature(cfeature.BORDERS,linewidth=2)
    ax[i].add_feature(cfeature.STATES, linewidth=0.5)
    #ax[i].add_feature(cfeature.OCEAN)
    ax[i].add_feature(cfeature.LAKES, color='blue')
    ax[i].add_feature(cfeature.RIVERS)
    ax[i].set_extent([-118.5,-86.7,32.0,14.75])
    ax[i].set_title(month_names[i])
    cb= ax[i].contourf(extremme_10mm_annual_dry_days.lon,
extremme_10mm_annual_dry_days.lat, extremme_10mm_annual_dry_days[i],
                    cmap='coolwarm', transform=ccrs.PlateCarree())
    color_bar=fig.add_axes([0.80,0.29,0.025,0.5])
fig.colorbar(cb,cax=color_bar,label='precipitation')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('EXTREMME ANNUAL DRY DAYS (R>10mm)', fontweight='bold');
#plt.savefig('done.png');
#27
extremme_20mm = USA_precip_I
extremme_20mm_annual_wet_days = (extremme_20mm >
20).groupby('datetime.year').sum(dim='datetime')
extremme_20mm_annual_wet_days


#28
```

```
extremme_20mm = USA_precip_I

extremme_20mm_monthly_wet_days = (extremme_20mm >
20).groupby('datetime.month').sum(dim='datetime')

extremme_20mm_monthly_wet_days

#29

#SPATIAL PLOTS FOR EXTREMME (RR>20mm) MONTHLY DRY  DAYS

fig,ax=plt.subplots(4,3,figsize=(20,10),

                  subplot_kw={'projection': ccrs.PlateCarree()})

ax=ax.flatten()

month_names=['Jan', 'Feb', 'Mar', 'Apr', 'May', 'Jun', 'July', 'Aug', 'Sept','Oct','Nov','Dec']

for i in range(12):

    #ax[i].add_feature(cfeature.COASTLINE.with_scale('110m'),linewidth=0.5)

    ax[i].add_feature(cfeature.BORDERS,linewidth=2)

    ax[i].add_feature(cfeature.STATES, linewidth=0.5)

    #ax[i].add_feature(cfeature.OCEAN)

    ax[i].add_feature(cfeature.LAKES, color='blue')

    ax[i].add_feature(cfeature.RIVERS)

    ax[i].set_extent([-118.5,-86.7,32.0,14.75])

    ax[i].set_title(month_names[i])

    cb= ax[i].contourf(extremme_20mm_monthly_wet_days.lon,
extremme_20mm_monthly_wet_days.lat, extremme_20mm_monthly_wet_days[i],

                     cmap='coolwarm', transform=ccrs.PlateCarree())

    color_bar=fig.add_axes([0.82,0.29,0.025,0.5])

fig.colorbar(cb,cax=color_bar,label='precipitation')

fig.subplots_adjust(wspace=-0.55, top=0.93)

plt.suptitle(' EXTREMME MONTHLY WET DAYS (R>20mm)', fontweight='bold');

#plt.savefig('done.png');


#30
```

```
#SPATIAL PLOTS FOR EXTREMME (RR>20mm) ANNUAL WET DAYS
fig,ax=plt.subplots(5,2,figsize=(20,10),
                  subplot_kw={'projection': ccrs.PlateCarree()})
ax=ax.flatten()
month_names=['2012','2013','2014','2015','2016','2017','2018','2019','2020','2021']
for i in range(10):
   #ax[i].add_feature(cfeature.COASTLINE.with_scale('110m'),linewidth=0.5)
   ax[i].add_feature(cfeature.BORDERS,linewidth=2)
   ax[i].add_feature(cfeature.STATES, linewidth=0.5)
   #ax[i].add_feature(cfeature.OCEAN)
   ax[i].add_feature(cfeature.LAKES, color='blue')
   ax[i].add_feature(cfeature.RIVERS)
   ax[i].set_extent([-118.5,-86.7,32.0,14.75])
   ax[i].set_title(month_names[i])
   cb= ax[i].contourf(extremme_20mm_annual_wet_days.lon,
extremme_20mm_annual_wet_days.lat, extremme_20mm_annual_wet_days[i],
                    cmap='coolwarm', transform=ccrs.PlateCarree())
   color_bar=fig.add_axes([0.82,0.29,0.025,0.5])
fig.colorbar(cb,cax=color_bar,label='precipitation')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('EXTREMME ANNUAL WET DAYS (R>20mm)', fontweight='bold');
#plt.savefig('done.png');
#31
annual_dry_days = (usa_precip < 1).resample(datetime='1Y').sum()
```

```
#32
```

```
fig, ax = plt.subplots(figsize=(10, 3))

plt.subplots_adjust(hspace=0.5, wspace=0.2)

annual_dry_days.plot(color='blue', lw=1.5, marker='o', markersize=6, label='DRY DAYS')

ax.set_title('Annual Precipitation Variability (2012-2021)-(RR<1mm) ', fontweight='bold',
fontsize=15, color='black')

ax.set_xlabel('YEAR', fontweight='bold', fontsize=15, color='red')

ax.set_ylabel('Precipitation (mm)', fontweight='bold', fontsize=12, color='red')

plt.legend(loc='upper right')

plt.show()

#33

annual_wet_days = (usa_precip >= 1).resample(datetime='1Y').sum()

#34

   fig, ax = plt.subplots(figsize=(10, 3))

plt.subplots_adjust(hspace=0.5, wspace=0.2)

annual_wet_days.plot(color='red', lw=1.5, marker='o', markersize=6, label='WET DAYS')

ax.set_title('Annual Precipitation Variability (2012-2021)-(RR>=1mm)', fontweight='bold',
fontsize=15, color='black')

ax.set_xlabel('YEAR', fontweight='bold', fontsize=15, color='blue')

ax.set_ylabel('Precipitation(mm)', fontweight='bold', fontsize=12, color='blue')

plt.legend(loc='upper left')

plt.show()

#35

Annual_extreme_precip_10mm = (usa_precip > 10).resample(datetime='1Y').sum()

#36

fig, ax = plt.subplots(figsize=(10, 3))

plt.subplots_adjust(hspace=0.5, wspace=0.2)

Annual_extreme_precip_10mm.plot(color='blue', lw=1.5, marker='o', markersize=6,
label='EXTREME PRECIPITATION')

ax.set_title('Annual Extreme Precipitation Variability (2012-2021)-(RR>10mm)',
fontweight='bold', fontsize=15, color='black')
```

```
ax.set_xlabel('YEAR', fontweight='bold', fontsize=15, color='red')

ax.set_ylabel('Precipitation (mm)', fontweight='bold', fontsize=12, color='red')

plt.legend(loc='upper left')

plt.show()

#37

Annual_extreme_precip_20mm = (usa_precip > 20).resample(datetime='1Y').sum()

#38

fig, ax = plt.subplots(figsize=(10, 3))

plt.subplots_adjust(hspace=0.5, wspace=0.2)

Annual_extreme_precip_20mm.plot(color='RED', lw=1.5, marker='o', markersize=6, label='EXTREME PRECIPITATION')

ax.set_title('Annual Extreme Precipitation Variability (2012-2021)-(RR>20mm)', fontweight='bold', fontsize=15, color='black')

ax.set_xlabel('YEAR', fontweight='bold', fontsize=15, color='blue')

ax.set_ylabel('Precipitation (mm)', fontweight='bold', fontsize=12, color='blue')

plt.legend(loc='upper left')

plt.show()
```