APPENDIX

```
#Importing libraries
import xarray as xr
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import cartopy.crs as ccrs
import cartopy.feature as cfeature
# Opening dataset
Mali_data = xr.open_mfdataset('/home/benedict/julitta/mali/*.nc')
Mali_data
# Slicing the longitude and latitude
Mali = Mali_data.sel(datetime=slice("2001","2011"),lon=(-6.75),lat=(14.25))
Mali
Mali_precip = Mali['precip']
Mali_precip
monthly_rainfall_total = Mali_precip.resample(datetime='1M').sum('datetime')
monthly_rainfall_total
monthly_longterm_climatology = monthly_rainfall_total.groupby('datetime.month').mean()
monthly_longterm_climatology
QUESTION 2
annual_rainfall_total = Mali_precip.resample(datetime='1Y').sum()
annual_rainfall_total
annual_rainfall_average = annual_rainfall_total.groupby('datetime.month').mean()
annual_rainfall_average
fig, ax = plt.subplots(figsize = (12,6))
plt.subplots_adjust(hspace = 0.6, wspace = 0.4)
annual_rainfall_total.plot(color = 'blue', lw = 1.5, marker = '*', markersize =
'6',label='Precipitation')
ax.set_title('Timeseries Of Annual Precipitation Variability (2002-2011)',fontweight = 'bold',
fontsize = 15,color = 'blue')
ax.set_xlabel('Year', fontweight = 'bold', fontsize = 15,color = 'blue')
ax.set_ylabel('Precip(mm)', fontweight = 'bold', fontsize = 15,color = 'blue')
plt.legend()
plt.show()

QUESTION 3
Mali_series_data = xr.open_mfdataset('/home/benedict/julitta/mali/*.nc')
Mali_series_data
Mali_series = Mali_series_data.sel(datetime=slice("2002","2011"),lon=(-6.75),lat=(14.25))
Mali_series
Mali_precip_series = Mali_series_data['precip']
Mali_precip_series
NUMBER OF DRY DAYS PER YEAR
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```
dryd = Mali_precip_series
dry_days_year = (dryd < 1).groupby('datetime.year').sum(dim='datetime')
dry_days_year
fig,ax=plt.subplots(5,2,figsize=(20,18),subplot_kw={'projection': ccrs.PlateCarree()})
ax=ax.flatten()
month_names=['2001','2002','2003','2004','2005','2006','2007','2008','2009','2010']
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.OCEAN)
    ax[i].add_feature(cfeature.LAKES, color='blue')
    ax[i].add_feature(cfeature.RIVERS)
    ax[i].set_extent([-12.25,3.75,10.75,24.75], crs=ccrs.PlateCarree())
    ax[i].set_title(month_names[i])
    cb= ax[i].contourf(dry_days_year.lon,dry_days_year.lat,dry_days_year[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(mm)')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('TOTAL ANNUAL DRY DAYS INDICES (<1MM)', fontweight='bold');

NUMBER OF WET DAYS PER YEAR
wet = Mali_precip_series
wet_days_year = (wet >= 1).groupby('datetime.year').sum(dim='datetime')
wet_days_year
fig,ax=plt.subplots(5,2,figsize=(20,18),subplot_kw={'projection': ccrs.PlateCarree()})
ax=ax.flatten()
month_names=['2001','2002','2003','2004','2005','2006','2007','2008','2009','2010']
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.OCEAN)
    ax[i].add_feature(cfeature.LAKES, color='blue')
    ax[i].add_feature(cfeature.RIVERS)
    ax[i].set_extent([-12.25,3.75,10.75,24.75], crs=ccrs.PlateCarree())
    ax[i].set_title(month_names[i])
    cb= ax[i].contourf(wet_days_year.lon,wet_days_year.lat,wet_days_year[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(mm)')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('TOTAL ANNUAL WET DAYS(>=1MM)', fontweight='bold');

NUMBER OF DRY DAYS PER MONTH <1MM
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```
dry_days_month = (dryd<1).groupby('datetime.month').sum(dim='datetime')
dry_days_month
fig,ax=plt.subplots(3,4,figsize=(16,8),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.OCEAN)
    ax[i].add_feature(cfeature.LAKES, color='blue')
    ax[i].add_feature(cfeature.RIVERS)
    ax[i].set_extent([-12.25,3.75,10.75,24.75], crs=ccrs.PlateCarree())
    ax[i].set_title(month_names[i])
    cb= ax[i].contourf(dry_days_month.lon,dry_days_month.lat,dry_days_month[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(mm)')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('MONTHLY DRY DAYS INDICES OVER(<1MM)', fontweight='bold');

NUMBER OF WET DAYS PER MONTH
wet_days_month = (wet>1).groupby('datetime.month').sum(dim='datetime')
wet_days_month
fig,ax=plt.subplots(3,4,figsize=(16,8),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.OCEAN)
    ax[i].add_feature(cfeature.LAKES, color='blue')
    ax[i].add_feature(cfeature.RIVERS)
    ax[i].set_extent([-12.25,3.75,10.75,24.75], crs=ccrs.PlateCarree())
    ax[i].set_title(month_names[i])
    cb= ax[i].contourf(dry_days_month.lon,dry_days_month.lat,dry_days_month[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(mm)')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('MONTHLY WET DAYS INDICES OVER(>1MM)', fontweight='bold');

TIMESERIES PLOTTING
Mali_data = xr.open_mfdataset('/home/benedict/julitta/mali/*.nc')
Mali_data
```

```
Mali = Mali_data.sel(datetime=slice("2001","2011"),lon=(-6.75),lat=(14.25))
Mali
dry_days_annual = (Mali['precip']< 1).resample(datetime='1Y').sum()
wet_days_annual = (Mali['precip']>=1).resample(datetime='1Y').sum()
DRY DAYS PER YEAR TIMESERIES
fig, ax = plt.subplots(figsize = (12,6))
plt.subplots_adjust(hspace = 0.6, wspace = 0.4)
dry_days_annual.plot(color = 'red', lw = 1.5, marker = '*', markersize = '6',label='Precipitation')
ax.set_title('Annual Precipitation Variability (2001-2011)',fontweight = 'bold', fontsize = 15,color =
'red')
ax.set_xlabel('Year', fontweight = 'bold', fontsize = 15,color = 'red')
ax.set_ylabel('Precip(mm)', fontweight = 'bold', fontsize = 15,color = 'red')
plt.legend()
plt.show()

WET DAYS PER YEAR TIMESERIES
fig, ax = plt.subplots(figsize = (12,6))
plt.subplots_adjust(hspace = 0.6, wspace = 0.4)
wet_days_annual.plot(color = 'blue', lw = 1.5, marker = '*', markersize = '6',label='Precipitation')
ax.set_title('Annual Precipitation Variability (2001-2011)',fontweight = 'bold', fontsize = 15,color =
'blue')
ax.set_xlabel('Year', fontweight = 'bold', fontsize = 15,color = 'blue')
ax.set_ylabel('Precip(mm)', fontweight = 'bold', fontsize = 15,color = 'blue')
plt.legend()
plt.show()

Q.4 EXTREME RAINFALL INDICES
WET DAYS PER YEAR
wet_days_year_extreme = (wet>10).groupby('datetime.year').sum(dim='datetime')
wet_days_year_extreme
fig,ax=plt.subplots(5,2,figsize=(20,18),subplot_kw={'projection': ccrs.PlateCarree()})
ax=ax.flatten()
month_names=['2001','2002','2003','2004','2005','2006','2007','2008','2009','2010']
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.OCEAN)
    ax[i].add_feature(cfeature.LAKES, color='blue')
    ax[i].add_feature(cfeature.RIVERS)
    ax[i].set_extent([-12.25,3.75,10.75,24.75], crs=ccrs.PlateCarree())
    ax[i].set_title(month_names[i])
  cb=
ax[i].contourf(wet_days_year_extreme.lon,wet_days_year_extreme.lat,wet_days_year_extreme[
i],
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```
                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(mm)')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('TOTAL ANNUAL WET DAYS INDICES (>10MM)', fontweight='bold');

wet_days_year_extreme2 = (wet>20).groupby('datetime.year').sum(dim='datetime')
wet_days_year_extreme2

WET DAYS PER MONTH
wet_days_month_extreme = (wet>10).groupby('datetime.month').sum(dim='datetime')
wet_days_month_extreme
fig,ax=plt.subplots(3,4,figsize=(16,8),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.OCEAN)
    ax[i].add_feature(cfeature.LAKES, color='blue')
    ax[i].add_feature(cfeature.RIVERS)
    ax[i].set_extent([-12.25,3.75,10.75,24.75], crs=ccrs.PlateCarree())
    ax[i].set_title(month_names[i])
    cb=
ax[i].contourf(wet_days_month_extreme.lon,wet_days_month_extreme.lat,wet_days_month_ext
reme[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(mm)')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('MONTHLY WET DAYS INDICES OVER(>10MM)', fontweight='bold');

WET DAYS PER MONTH FOR >20MM
wet_days_month_extreme2 = (wet>20).groupby('datetime.month').sum(dim='datetime')
wet_days_month_extreme2
fig,ax=plt.subplots(3,4,figsize=(16,8),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.OCEAN)
    ax[i].add_feature(cfeature.LAKES, color='blue')
    ax[i].add_feature(cfeature.RIVERS)
```

```
    ax[i].set_extent([-12.25,3.75,10.75,24.75], crs=ccrs.PlateCarree())
    ax[i].set_title(month_names[i])
    cb=
ax[i].contourf(wet_days_month_extreme2.lon,wet_days_month_extreme2.lat,wet_days_month_
extreme2[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(mm)')
fig.subplots_adjust(wspace=-0.55, top=0.93)
plt.suptitle('MONTHLY WET DAYS INDICES OVER(>20MM)', fontweight='bold');
```