KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KNUST)

FACULTY OF PHYSICAL AND COMPUTATIONAL SCIENCES

DEPARTMENT OF METEOROLOGY AND CLIMATE SCIENCE

MET 359: ATMOSPHERIC FIELD WORK

AMPONSAH DANIEL

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SUPERVISOR: DR. JEFFREY ARYEE

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INTRODUCTION

Precipitation is a crucial component of the Earth's water cycle, which involves the continuous movement of water between the atmosphere, land, and oceans. Precipitation refers to any form of water that falls from the atmosphere and reaches the Earth's surface, including rain, snow, sleet, and hail.

There are several factors that influence precipitation, including temperature, humidity, air pressure, and wind patterns. In general, areas with high humidity and low pressure tend to experience more precipitation, while areas with low humidity and high pressure tend to be drier.

Precipitation can occur in a variety of forms, depending on the temperature and other atmospheric conditions. Rain is the most common form of precipitation, and it occurs when water droplets in the atmosphere become large enough to fall to the ground. Snow occurs when the temperature is below freezing and water vapor in the atmosphere freezes into ice crystals, which then fall to the ground. Sleet occurs when raindrops freeze into ice pellets before reaching the ground, while hail occurs when strong updrafts in thunderstorms carry raindrops high into the atmosphere, where they freeze and grow into large, heavy balls of ice.

In order to measure precipitation, scientists use a variety of tools and techniques, including rain gauges, radar systems, and satellite imagery. These measurements are used to track precipitation patterns over time and to develop models that can help predict future precipitation levels.

Overall, precipitation is a complex and important phenomenon that plays a critical role in the Earth's water cycle and ecosystems. Meteorologists continue to study precipitation in order to better understand its behavior and to develop models that can help predict future weather patterns and mitigate the impacts of natural disasters.

MAIN OBJECTIVE

- Assessment of rainfall climatic indices over CHILE

SPECIFIC OBJECTIVES

- Determine the rainfall total and Climatology over Chile on a monthly and yearly basis.
- Assess the number of dry and wet days on monthly and yearly basis and providing a time series and spatial plots for the variations.
- Assess extreme rainfall indices over Chile on a monthly and yearly basis and time series and spatial plots depicting the variations

RESEARCH QUESTIONS

1. What is the rainfall Climatology over Chile on a monthly and yearly basis?
2. What are the number of wet and dry days on monthly and yearly basis over Chile?
3. What are the number of extreme rainfall days over Chile on monthly and yearly basis?

<u>**DESCRIPTION OF STUDY AREA**</u>

Chile is a long, narrow country located along the western coast of South America, stretching over 4,300 km (2,670 miles) from north to south bordered by Peru to the north, Bolivia to the northeast, Argentina to the east, and the Pacific Ocean to the west and south. Due to its unique geography, the northernmost point of Chile is located at approximately 18 degrees south latitude, while the southernmost point is located at approximately 56 degrees south latitude.

Climate of Chile: Chile's climate varies widely depending on the region. The northern desert regions are extremely dry, while the central regions have a Mediterranean climate with mild, wet winters and hot, dry summers. The southern regions are cooler and wetter, with heavy rainfall and snow in the winter.

Chile's precipitation patterns vary greatly from north to south and are influenced by factors such as the Andes Mountains, the Pacific Ocean, and the country's unique geography. From the extremely arid Atacama Desert in the north to the wet and temperate regions of southern Chile, the country offers a diverse range of climates and precipitation patterns.

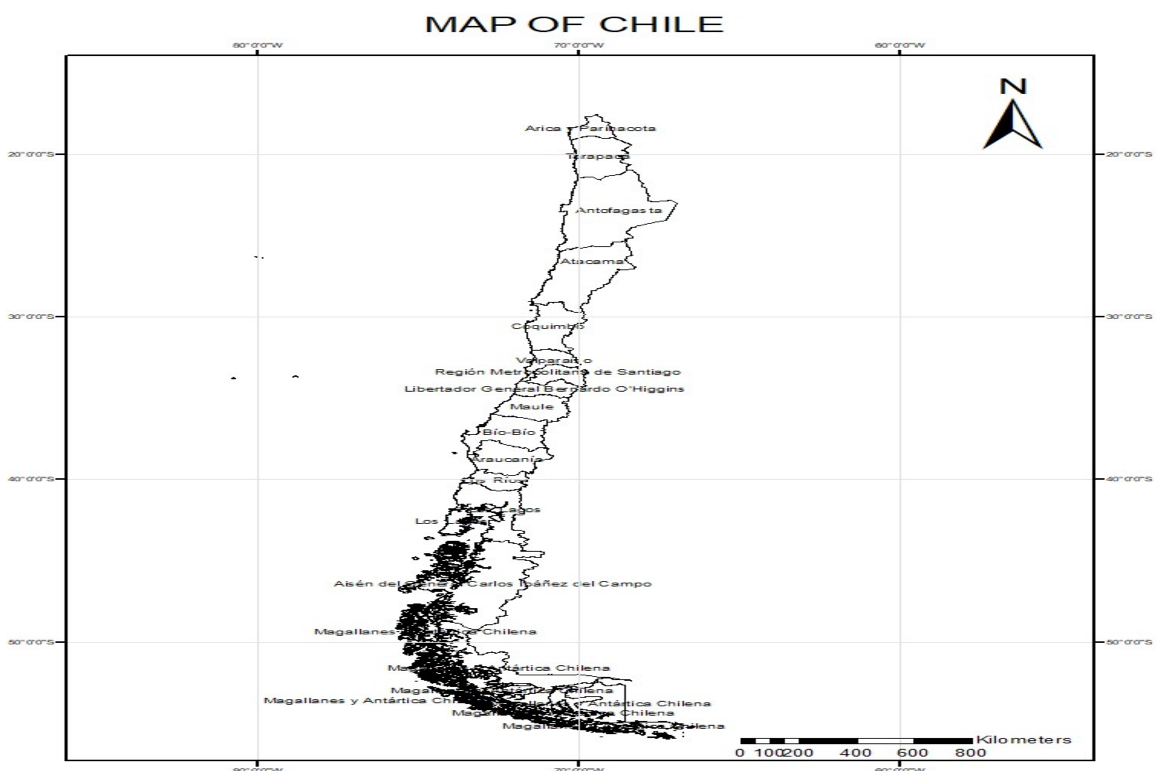


Fig 1.0 showing an image of the study area generated by ARCGIS interpolation software

DATASET

The data for this work was downloaded from Center for Hydrometeorology and Remote Sensing (CHRS).

Center for Hydrometeorology and Remote Sensing (CHRS) at the University of California, Irvine, provides rainfall data derived from satellite observations. The data is available through their Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN) system. PERSIANN uses artificial neural networks to estimate precipitation from satellite infrared imagery.

Here's an overview of the rainfall data provided by CHRS:

PERSIANN: Provides precipitation estimates at a 0.25-degree spatial resolution and 3-hourly temporal resolution.

PERSIANN-CCS (Cloud Classification System): Offers precipitation estimates at a 0.04-degree spatial resolution and hourly temporal resolution.

PERSIANN-CDR (Climate Data Record): Contains daily and monthly precipitation estimates at a 0.25-degree spatial resolution, available from 1983 to the present.

The data is typically provided in NetCDF (Network Common Data Form) format, which is a widely used format for storing and sharing large, multi-dimensional scientific data.

PERSIANN data product was selected and a daily data of precipitation for my study area (CHILE) was downloaded for a period of ten years.

METHODOLOGY

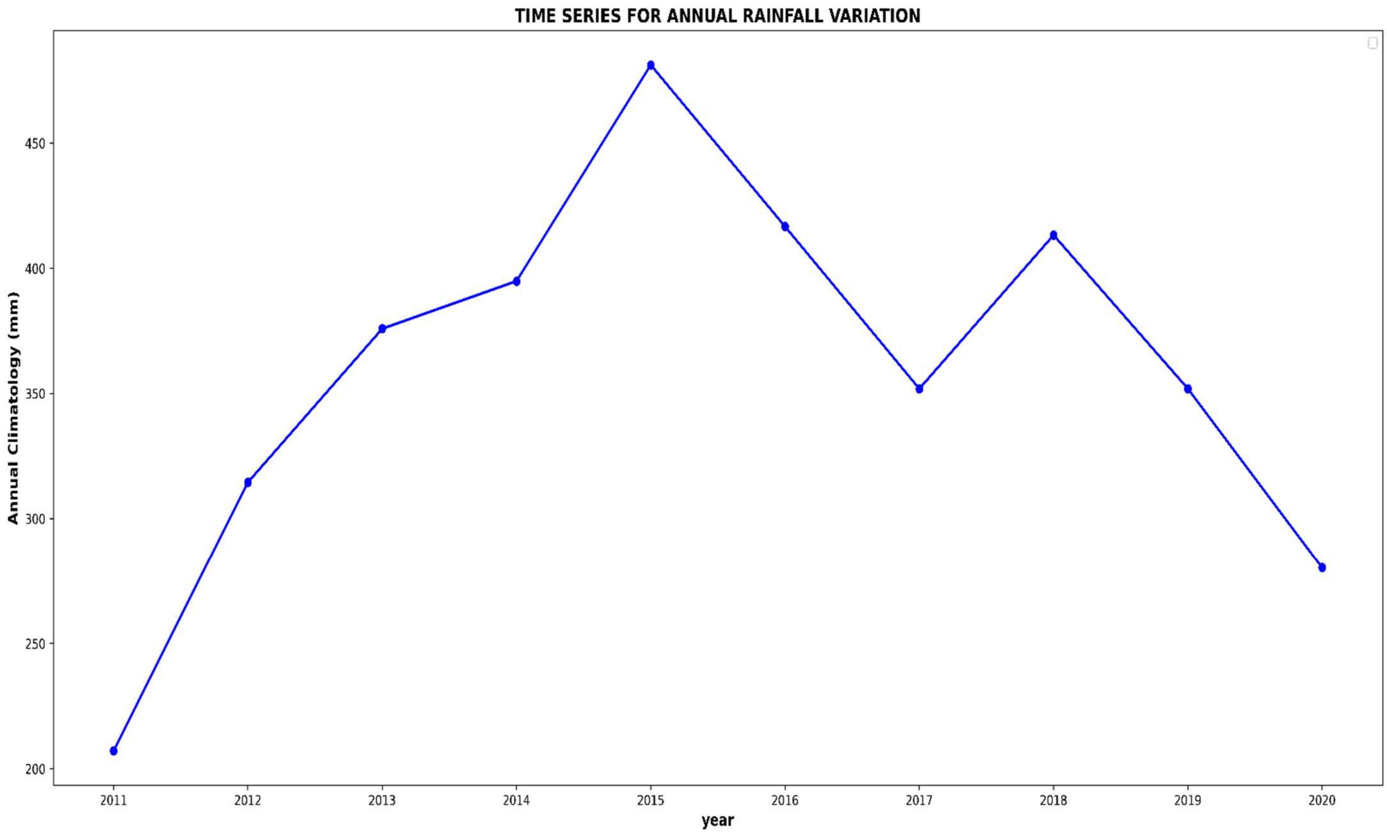
Daily precipitation data from Center for Hydrometeorology and Remote Sensing was downloaded for a period of ten years. All computations were done using python programming language and jupyter notebook was used. All libraries needed for the work such as ; xarray, matplotlib, cartopy, pandas, NumPy etc were imported .The data was opened using xarray (a library for opening netcdf files) and since the data was in individual years and not combined, xr.open_mfdataset was used to open the multiple files and then later converted into a single file containing all data for the period of ten years. After opening the data and selecting the parameter(precip), it was realized that the nan values recorded by the satellite were represented by -99.0 and hence had to be removed using data.where(data != -99.0 , np.nan) to prevent them from interfering in any computations that were done. The -99.0's were converted into nan values after the computation was done.

Monthly totals and its climatology as well as annual totals and its average was calculated using resample and a time series plot depicting the year-to-year trends was displayed using a python script.

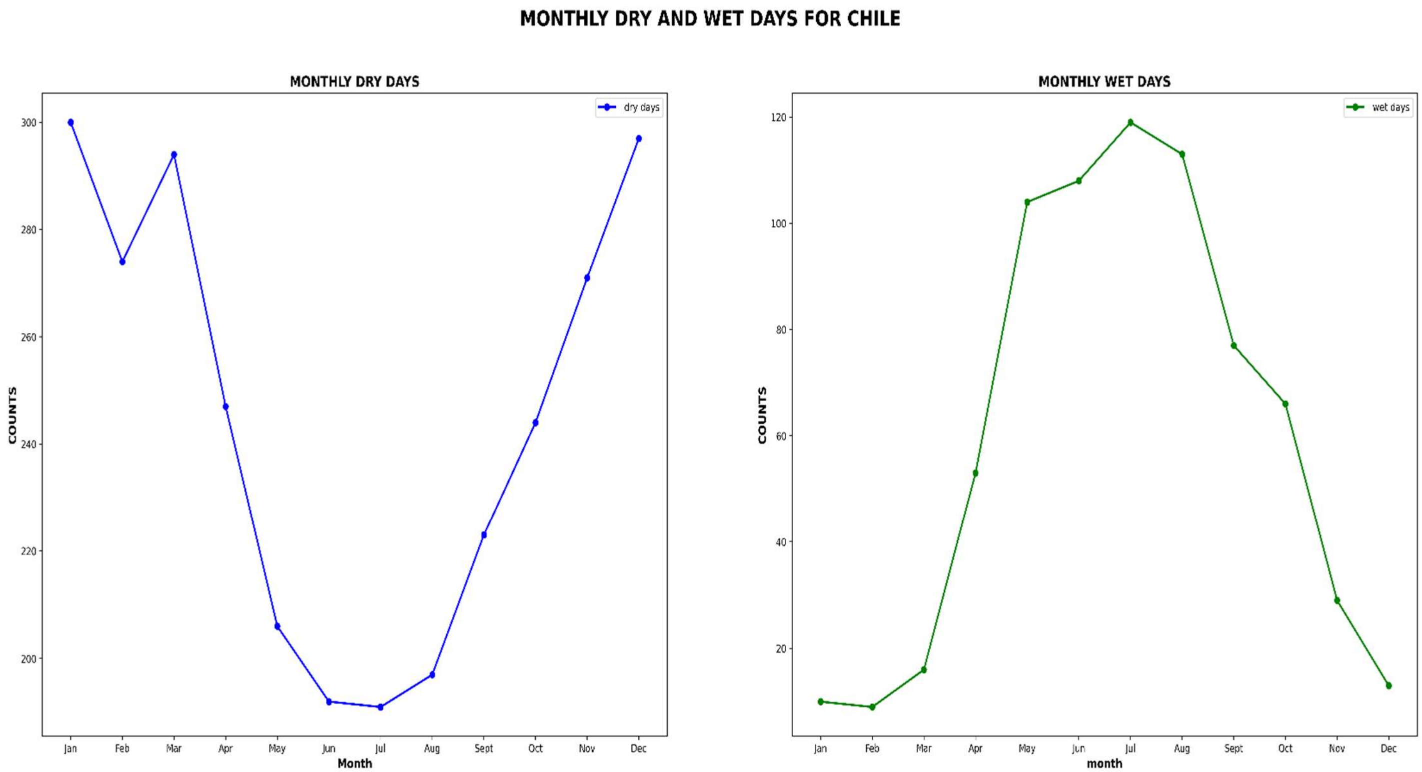
Rainfall indices for number of dry RR< 1mm and number of wet R>= 1mm days were computed using groupby for months and year and then counted to be able to determine the number of times in a month or year that recorded number of dry or wet days for the period 2011 to 2020. A time series and spatial plot(cartopy) were developed using a python script to be able to view the outcome of the computations of the number of dry and wet days over the country for that period.

Similar computations were made for extreme rainfall indices for RR> 10mm and RR> 20mm and time series and spatial plot were displayed depicting the outcome of the computations.

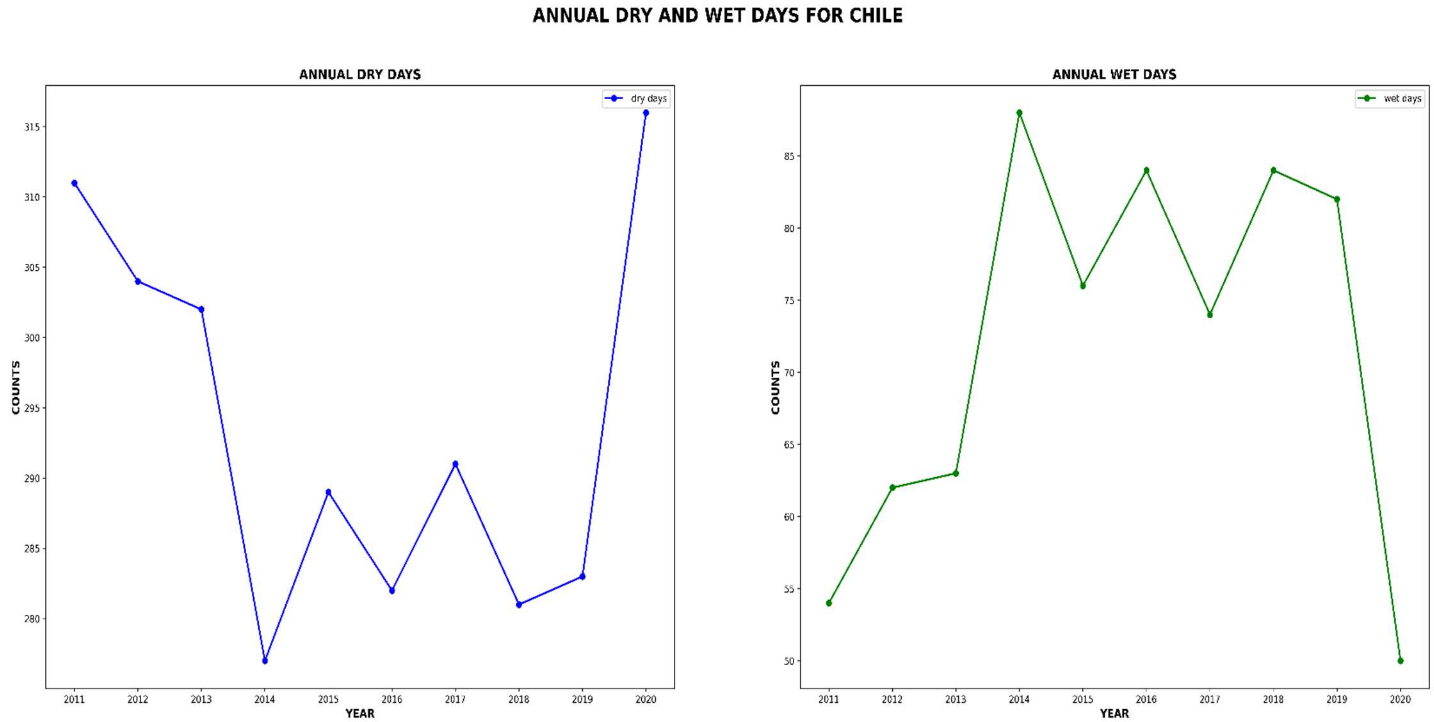
RESULTS AND DISCUSSION



The above diagram depicting the annual average precipitation variation over Chile shows a sharp increment in the precipitation from 2011 to 2015 recorded over the region having the highest value of 490 mm recorded for 2015 and after it shows a decrement in annual precipitation for subsequent years ending at 2020. The lowest and highest annual precipitation were recorded as 210 mm and 490 mm for 2011 and 2015 respectively. This simply means that in the year 2015 Chile recorded the highest amount of rainfall and recorded lowest for 2011 in that decade.

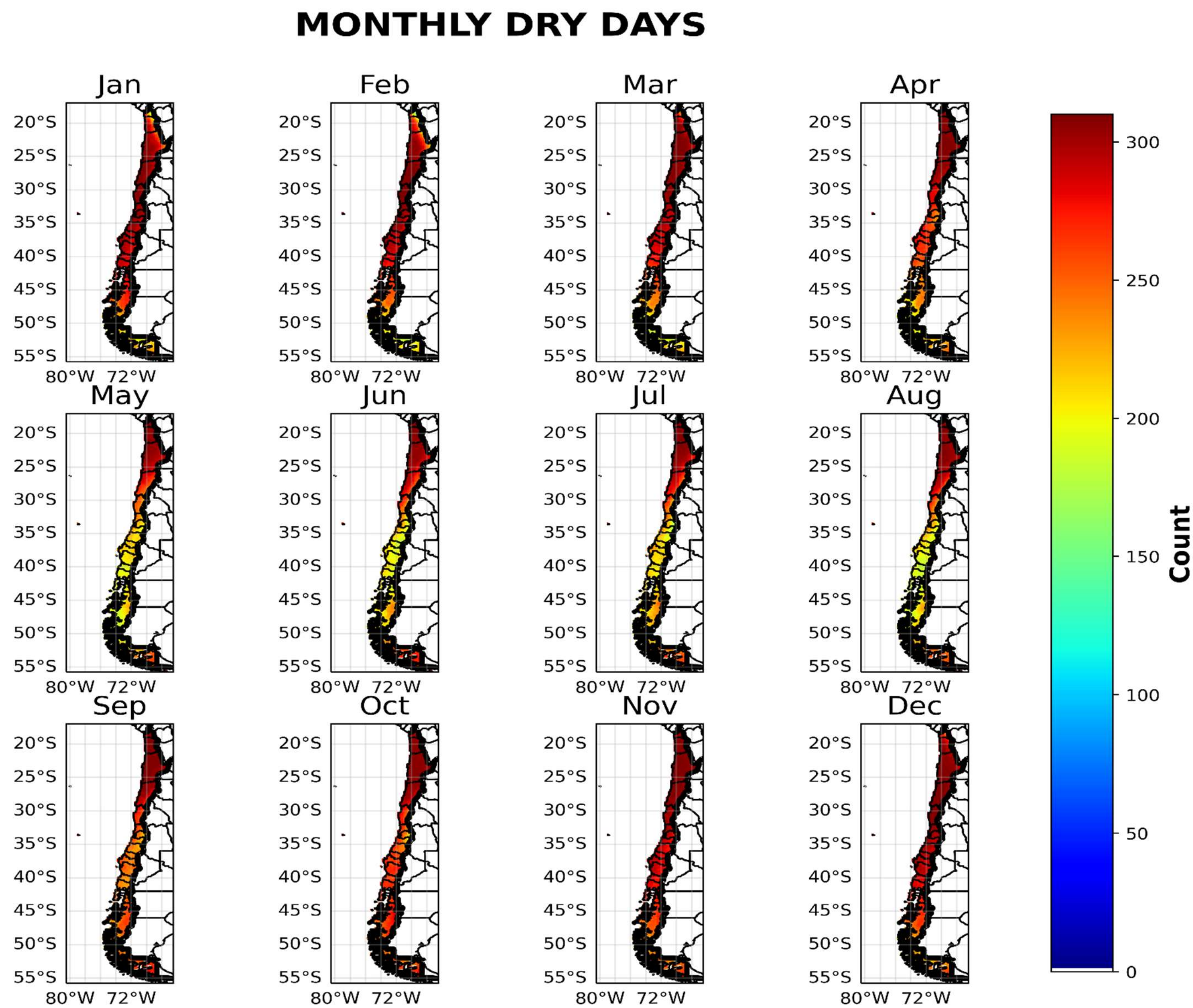


The above figure depicts the monthly dry and wet days for Chile for a decade. For monthly dry days it was observed that both January and December recorded higher amounts of dry days which mean that both months recorded higher amounts of rainfall less than 1mm for the entire period with June and July also recording relatively lower dry days as compared to January and December. For wet days it was observed that months that recorded lower dry days had the highest counts for wet days which implies that June, July, August recorded higher amount of rainfall values greater or equal to 1mm for the entire period.

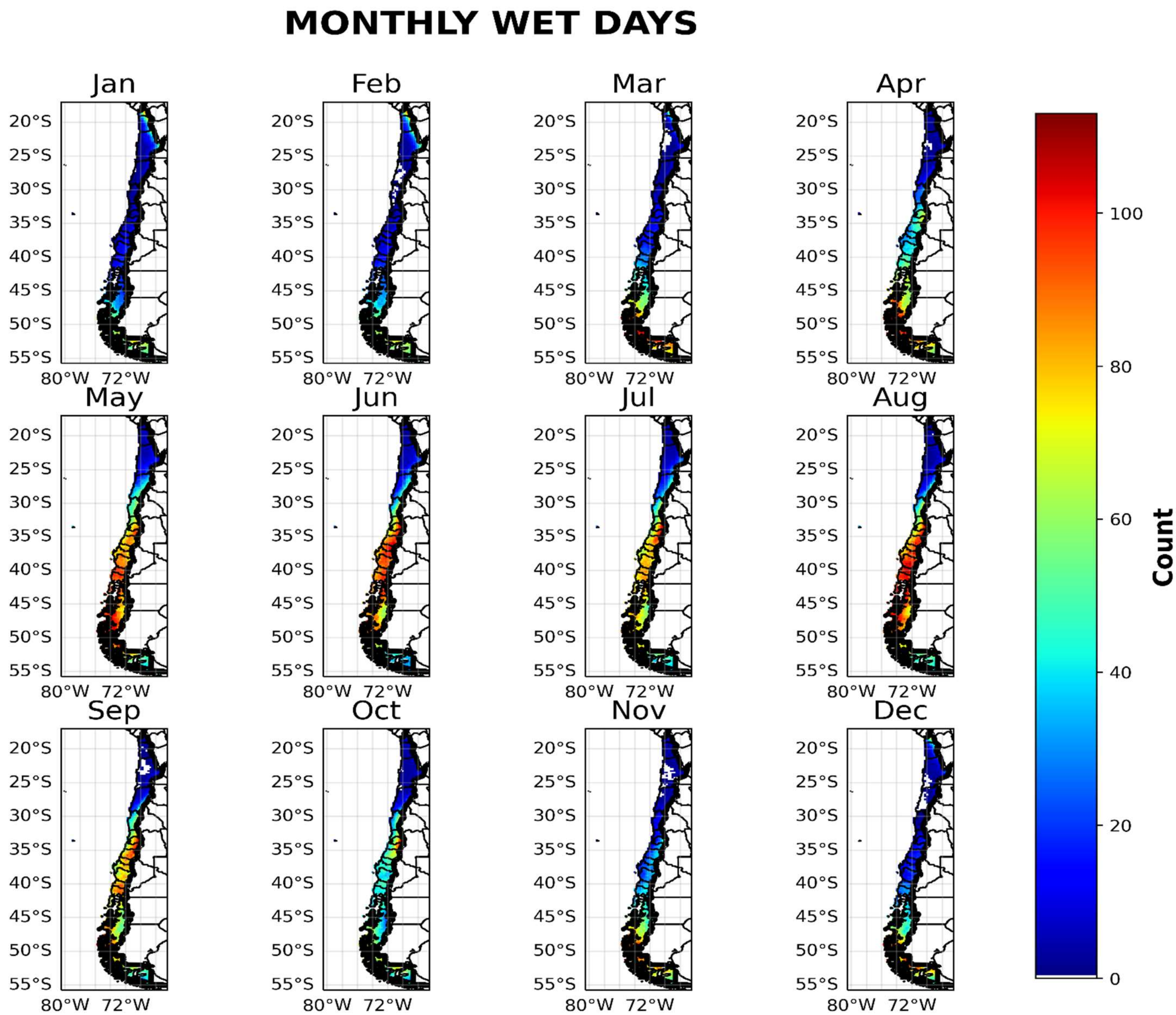


The above figure depicts the annual dry and wet days for Chile for a decade. For annual dry days it was observed that both 2011 and 2020 recorded higher amounts of dry days which mean that both years recorded higher amounts of rainfall less than 1mm for the entire period with 2014 and 2016 also recording relatively lower dry days as compared to 2011 and 2020. For wet days it was observed that years that recorded lower dry days had the highest counts for wet days which implies that 2014, 2016 and 2018 recorded higher amount of rainfall values greater or equal to 1mm for the entire period.

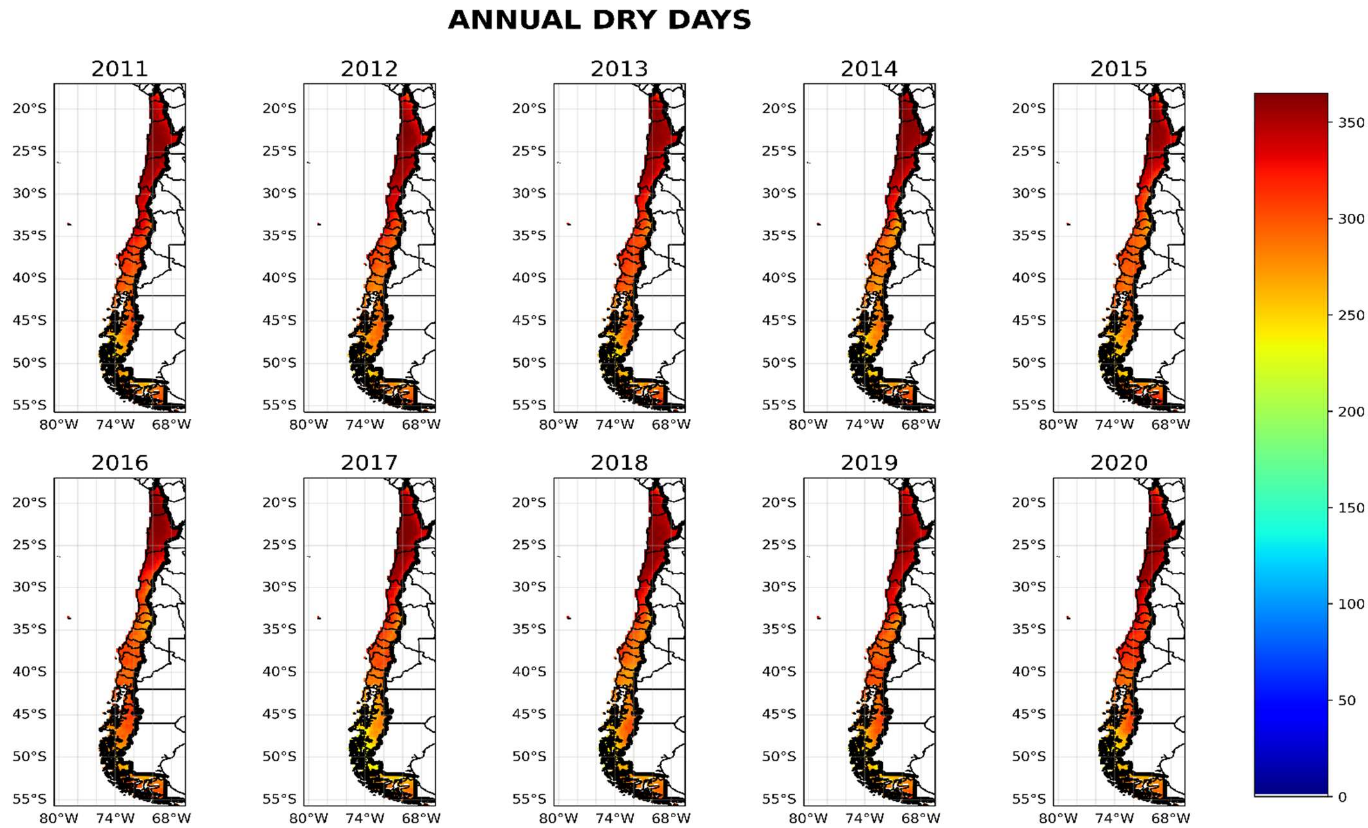
For spatial plots of the monthly dry and wets days also depicts the same variations given in the time series and it is the same for the annual dry and wet days over the decade, however the spatial plots show each month and year individually with its either wet days or dry days(counts)



The above figure shows monthly dry days for the entire period for the country. With some months recording higher amounts of dry days that is rainfall less than 1mm and the variation can be seen from the color bar by the plots. December and January recording counts of about 300 implying that rainfall values less than 1mm were recorded mostly during those months.

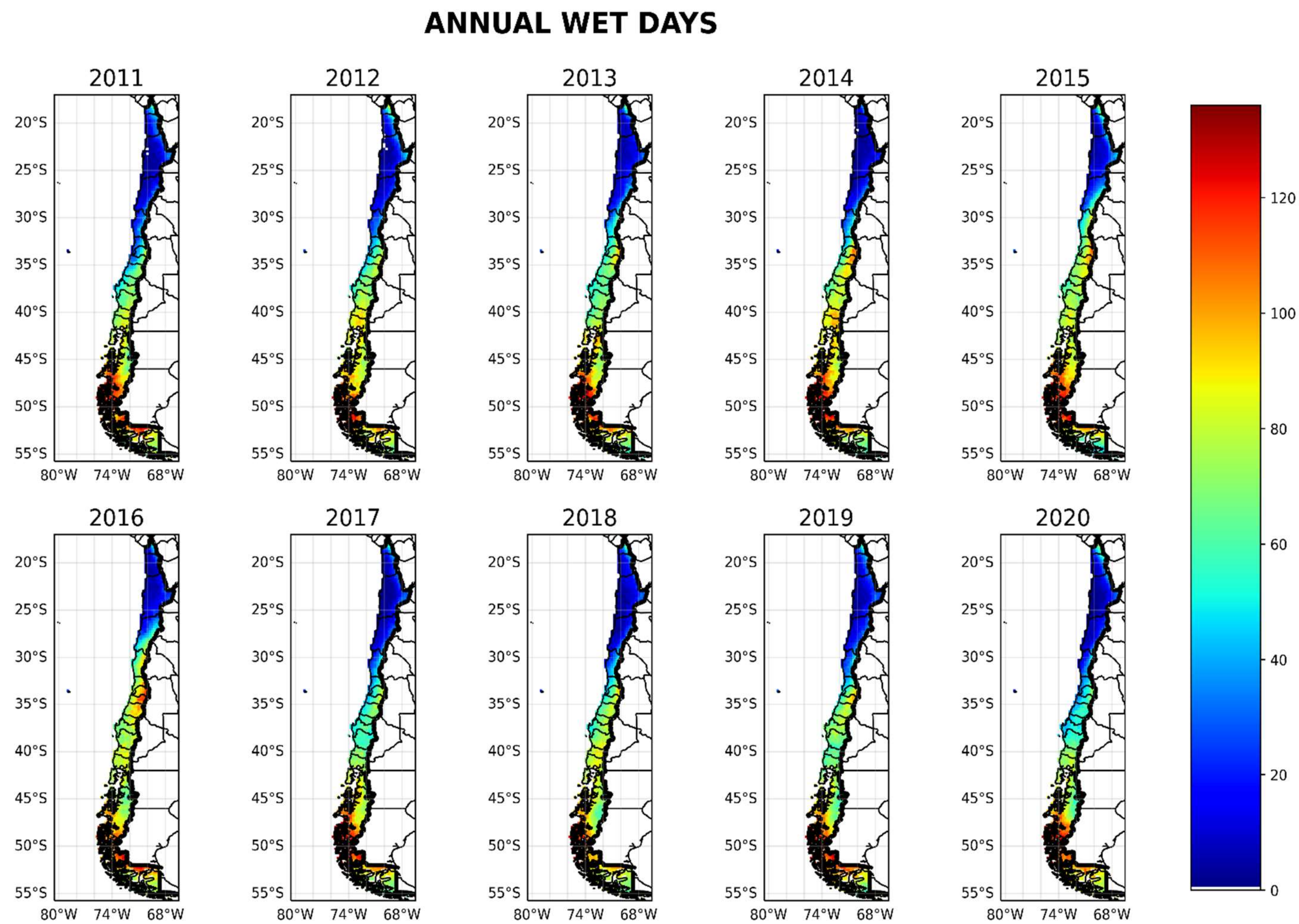


The above figure shows monthly wet days for the entire period for the country. With some months recording higher amounts of wet days that is rainfall greater than or equal to 1mm and the variation can be seen from the color bar by the plots. December and January recording counts of about 0 to 40 implying that rainfall values greater than 1mm were recorded less during those months, but vice versa for May, June, July and August.

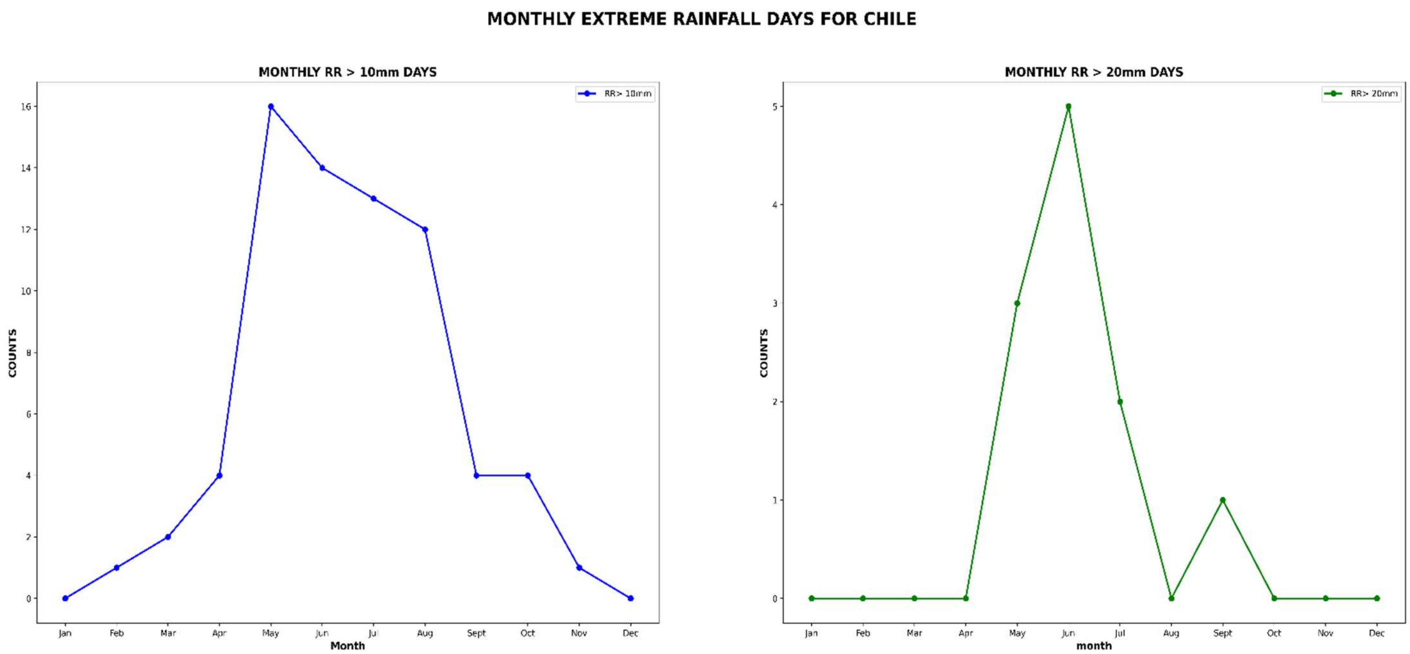


The above figure depicts the number of dry days recorded annually for the period with most years recording higher number of rainfall amount less than 1mm for the period in Chile.

Some parts of the southern part of the country recorded relatively high values than the ones at the north implying that there were more dryness counts recorded at the north for that decade.

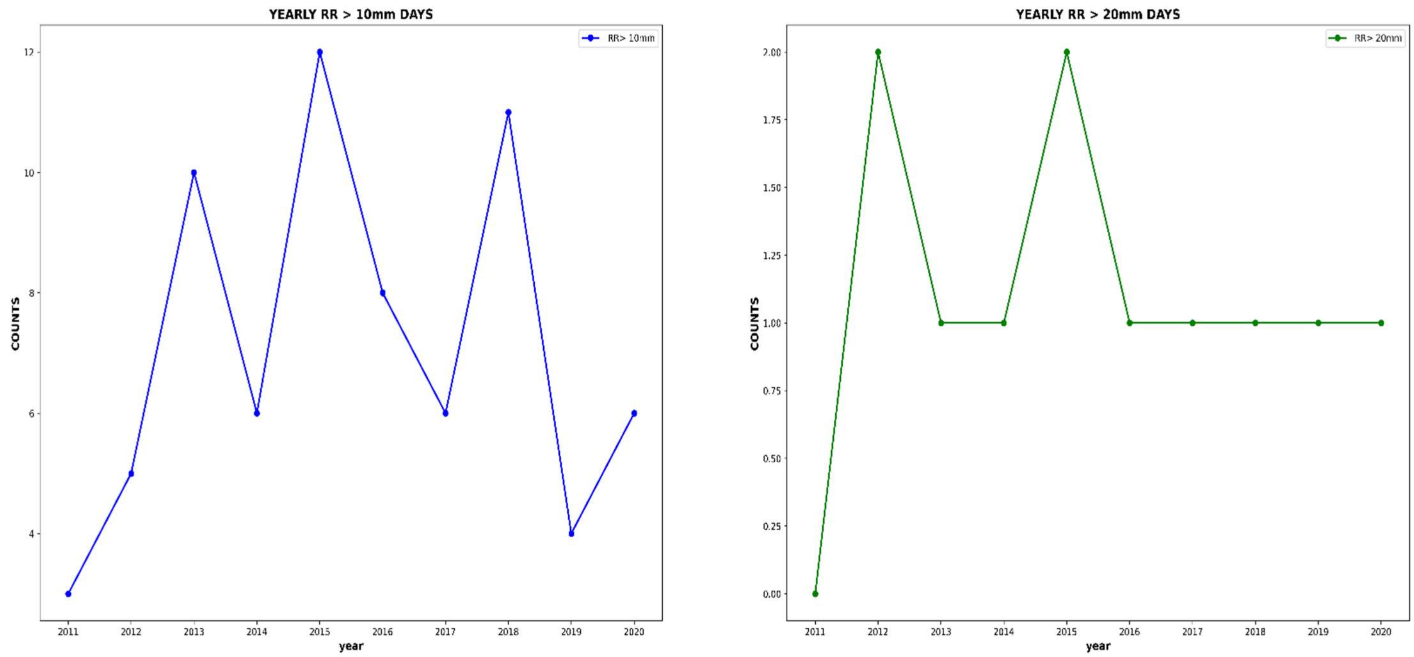


The figure above shows the number of wet days per year and from the spatial plots and the color bar it can be seen that less counts ranging from 0 to 20 were recorded for the northern part of Chile implying that the place recorded less amount of rainfall and hence the less numbers resulting in much more dryness over the region. With some parts recording relatively higher counts for rainfall greater than 1mm.

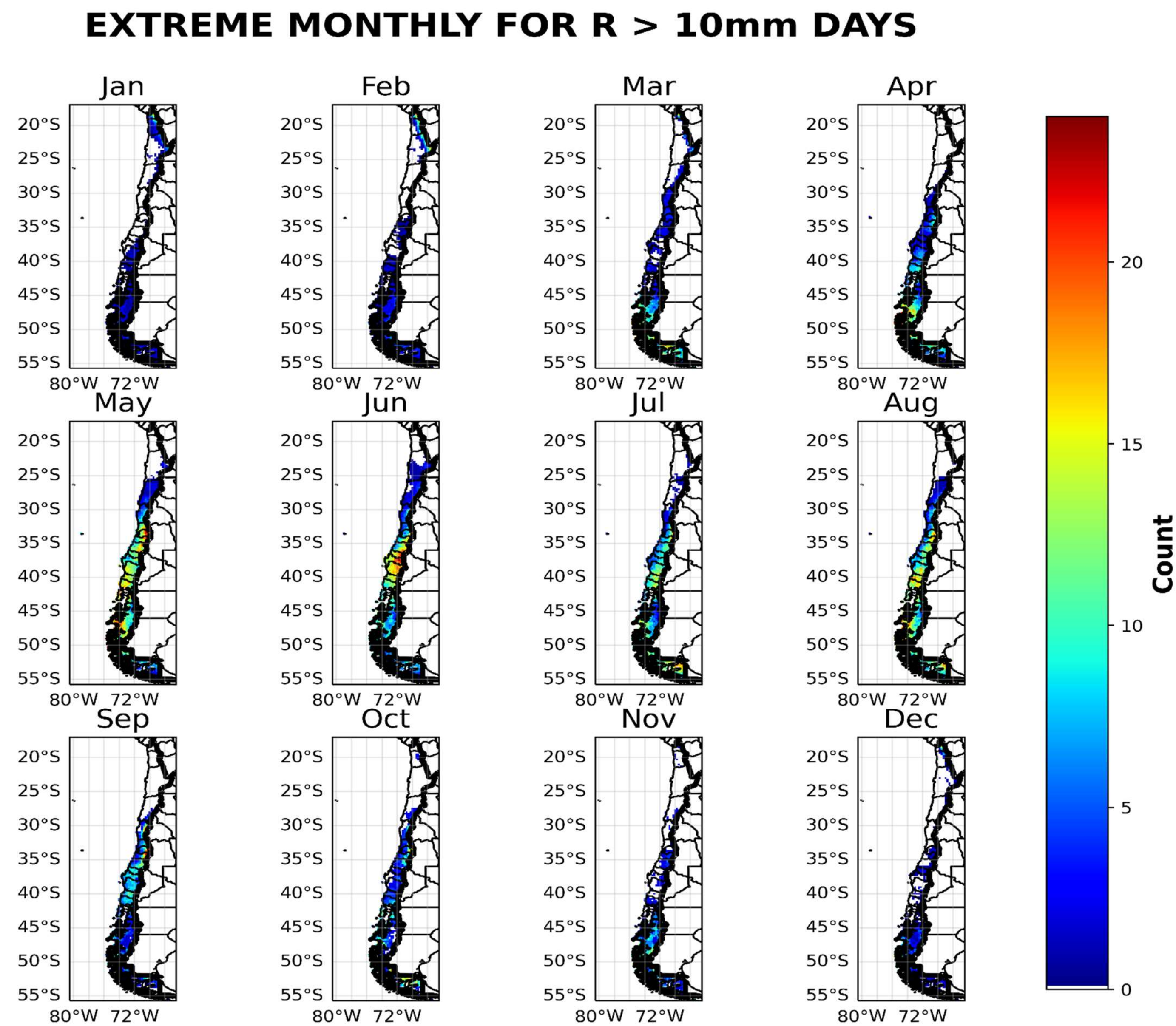


The diagram above shows the variation for extreme annual rainfall indices for RR> 10mm and RR> 20mm. From the time series it was observed higher number of counts recorded were found when the precipitation was set to a threshold of 10mm, indicating that most months recorded more counts for RR > 10mm than RR> 20mm. This also shows that the number of wet days for precipitation greater that 20mm were less.

ANNUAL EXTREME RAINFALL DAYS FOR CHILE



The diagram above shows the variation for extreme annual rainfall indices for RR> 10mm and RR> 20mm. From the time series it was observed higher number of counts recorded were found when the precipitation was set to a threshold of 10mm, indicating that most months recorded more counts for RR > 10mm than RR> 20mm. This also shows that the number of wet days for precipitation greater that 20mm were less with some precipitation greater than 20mm having zero counts.



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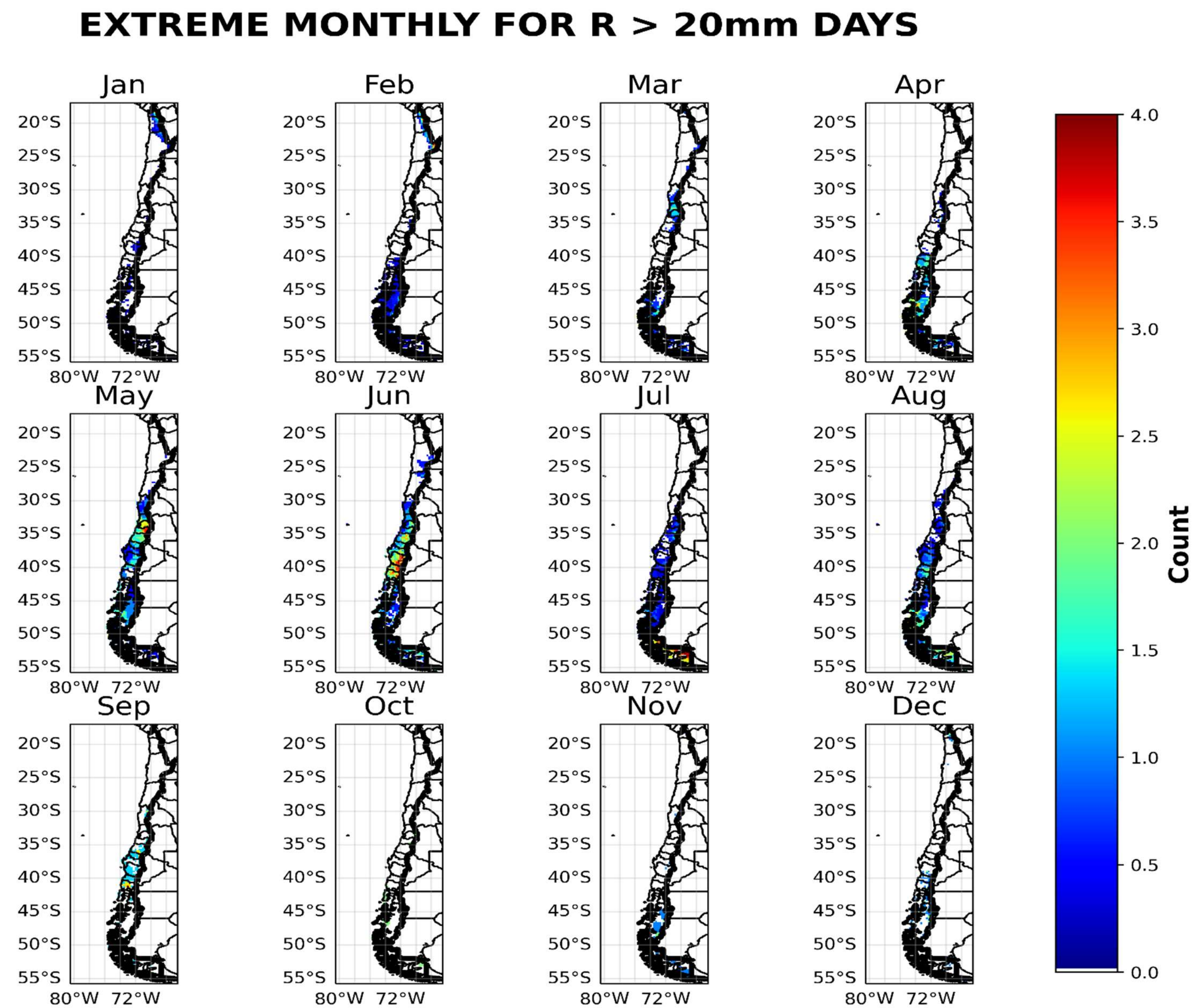
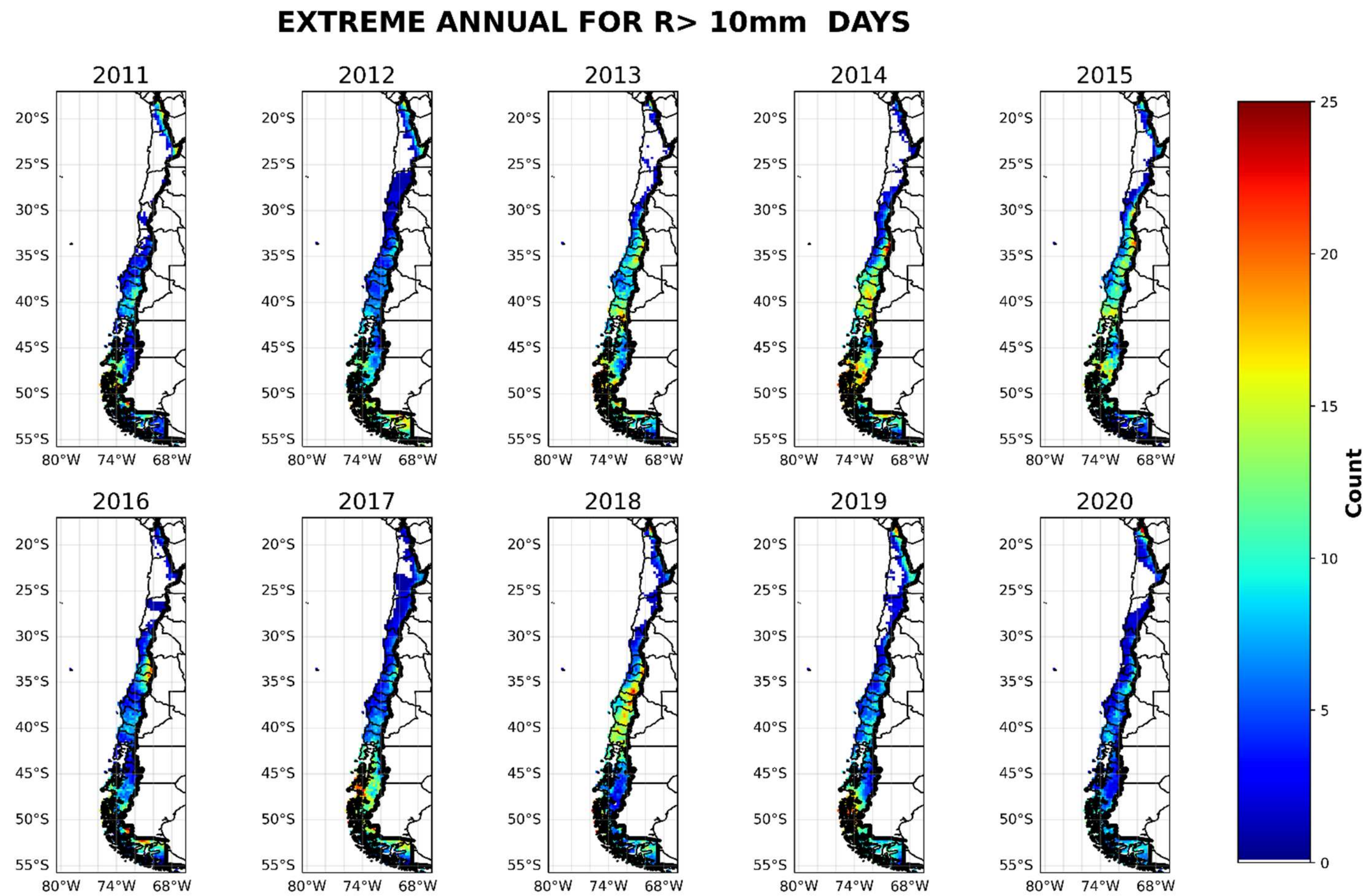
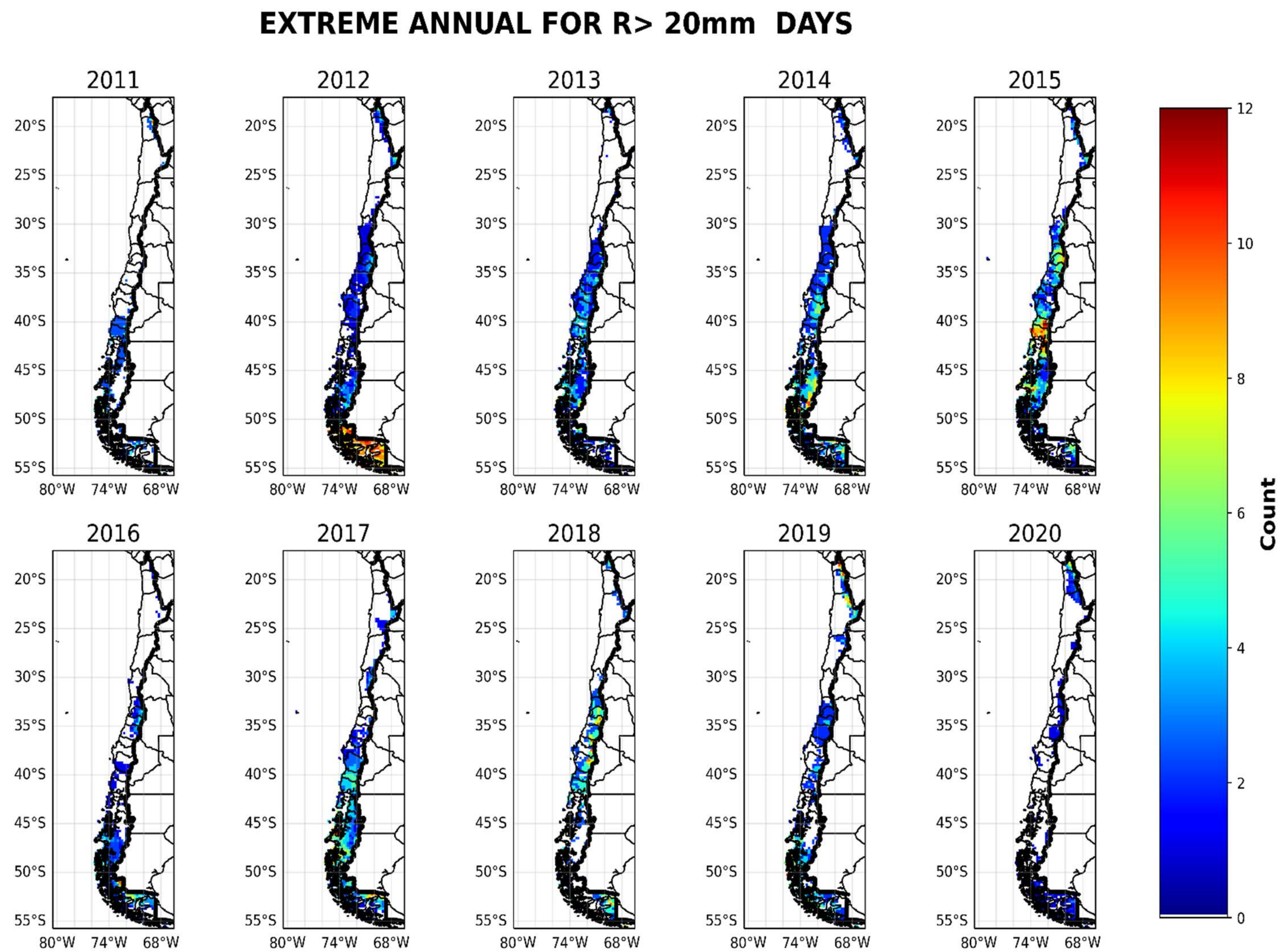
The above spatial shows the number of wet days recorded for extreme rainfall indices and can be seen that some of the regions in the country recorded less or no number of counts for when precipitation was greater than 10mm. Some parts of the middle belt of the country recorded relatively smaller amounts of count in May, June, July and August. This shows that some parts of Chile recorded no precipitation for 10mm and hence might lead to higher dry days over the country.



The spatial plot shows that in most parts of the region no rainfall values greater than 20mm was recorded for the month over the entire period, fewer counts were observed for the southern sector of the country and none at the northern sector of the country except for January which recorded a minute number of counts for precipitation greater than 20mm.



The figure depicts extreme annual precipitation greater than 10mm counts for Chile over the period of ten years. It is observed that most parts of the regions recorded relatively smaller counts indicating that fewer wet days were observed during the period and with some parts of the northern sector recording no counts for precipitation greater than 10mm and all the southern sector recording an amount of count for the period.



The spatial plot above depicts the number of extreme rainfall indices for precipitation greater than 20mm days. From the diagram, most parts of the northern sector recorded relatively smaller or no number of counts for the period, however the southern sector recorded some counts depicting fewer dry days as compared to the northern sector of the country during the period.

CONCLUSION

In the assessment of the rainfall climatic indices over Chile, it was observed from the spatial plots that the northern desert regions are extremely dry, while the central regions have a Mediterranean climate with mild, wet winters and hot, dry summers. The southern regions are cooler and wetter, with heavy rainfall.

For the annual average of precipitation over the region it was observed that the maximum rainfall recorded was in the year 2015 with a value of 490mm which depicts the year with the most precipitation and this was influenced by the many factors such as the effects of the El Nino and Andes mountains. The time series also showed that during the month of July higher counts of precipitation were recorded indicating that July is the wettest month over the country and would be favorable for some agricultural activities. January and December were also found to have higher counts of dry days which is an indication of drought and changes in energy balances.

Months such as December through to January were related to drier conditions and depicts fewer wet days which results in loss in volume of water bodies, and not favorable to some agricultural activities and also excessive exposure to the condition may results in some skin diseases whereas months such as June, July and August are related to wetter conditions which replenishes water bodies and favor most agricultural conditions.

Extreme precipitation had higher counts when R> 10mm than R> 20mm for both monthly and yearly basis which means less values of precipitation greater than 20mm are recorded over the country.

APPENDIX

https://github.com/damponsah20/ATMOSPHERIC-PHYSICS.git