Intra-ACP Climate Services and Related Applications Programme – ClimSA

WORKSHOP - SADC Region

WEFE NEXUS, Climate Variability, and Environmental Monitoring

South Africa, Johannesburg, June 10th – 13th 2024

Climate Variability module – Practical session

Estimation of CV indicators

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South Africa, Johannesburg, June 11th 2024

Joint Research Centre

Climate Variability module – Practical session

- **The following climate variability index can be calculated using E-Nexus tool – Climate Variability Module**

	TEMPORAL AGGREGATION	INDEX
PRECIPITATION	Daily [mm/d]	Drought
	Monthly Maximum[mm/d]	Return period (mm, yy, user defined)
	Monthly cumulative[mm/m]	Excess/Deficit (annual, monthly) SPI User defined Return periods
	Annual maximum[mm/d]	Annual return period
TEMPERATURE	Daily	HEAT WAVES
	Monthly maximum	Return period (monthly, annual, user defined)
	Annual maximum	Annual return period

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Excess/Deficit/Return periods

Excess or Deficit precipitation refers to the amount of rainfall that exceeds or is below to what is **typically expected (average)** for a given location and **time frame** (simulated period)

- Excess rainfall occurs when actual daily or cumulative rainfall exceeds a specified trigger value

- Rainfall deficit refers to a situation where the actual total rainfall during a reference period is lower than the normal rainfall index → Essentially, it's when there's less rain than expected.

In summary, **excess rainfall** represents the surplus, while **rainfall deficit** indicates a shortfall in precipitation. **Both concepts play a crucial role in understanding water availability and managing water resources**

Excess/Deficit/Return periods

PRACTICE WITH E-NEXUS

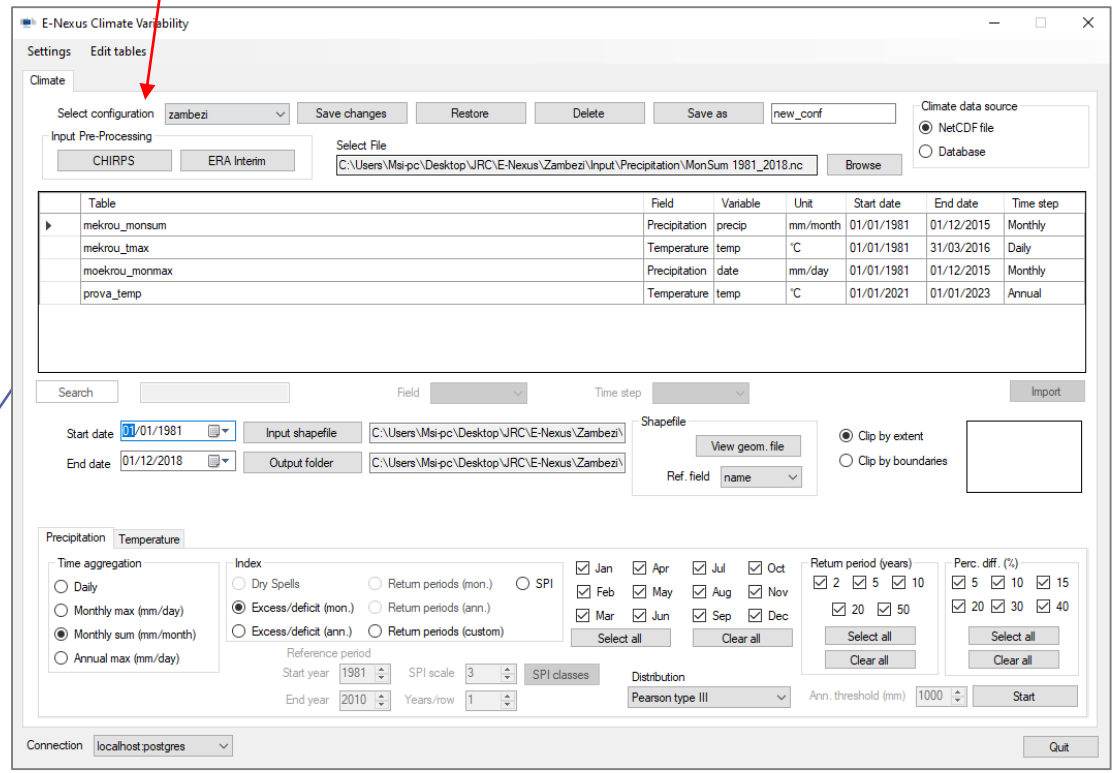
Precipitation indices

- The temporal aggregation of input data induces the types of indices that can be calculated.
- In case of monthly data, it is possible to choose particular months on which(s) to focus the process.
- The indices to calculate are Drought, Return Time, and Excess deficit (annual or monthly).

Specific Parameters

- Temporal aggregation of input values
- Index to calculate
- Month to choose for index evaluation
- Desired return time for index calculation
- Diff. Cent. (%) (excess/deficit percentages) desired for return period evaluation (excess/deficit indices)
- Statistical distribution for return period and SPI evaluation
- Ann. precipitation threshold desired for evaluation of custom return times

Input Setup



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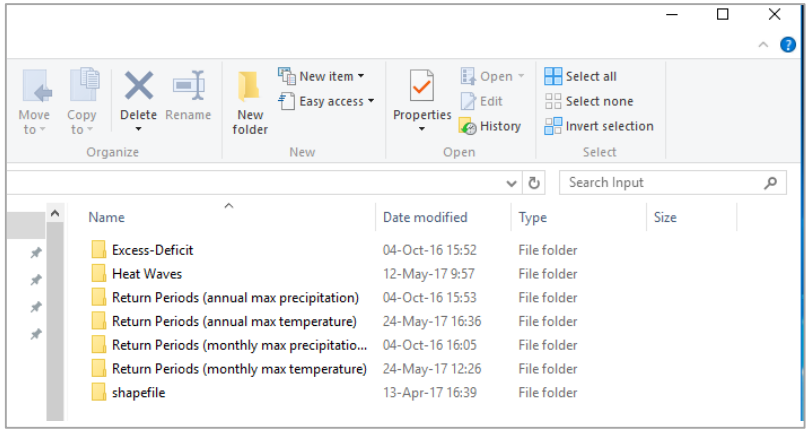
Excess/Deficit/Return periods

Precipitation indices

All required input data are stored into ***Input*** folder. More in detail, inputs are located in folders named after the specific process to execute. ***Shapefile*** folder contains *.shp* files related to available geographical domains.



Precipitation source: CHIRPS
https://data.chc.ucsb.edu/products/CHIRPS-2.0/

Temperature source : ERA5 re-analysis
https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=form

Process duration*

Short (<1 minute)

Average (5:10 minutes)

Long (>10 minutes)

* Performances affected by hardware specifics

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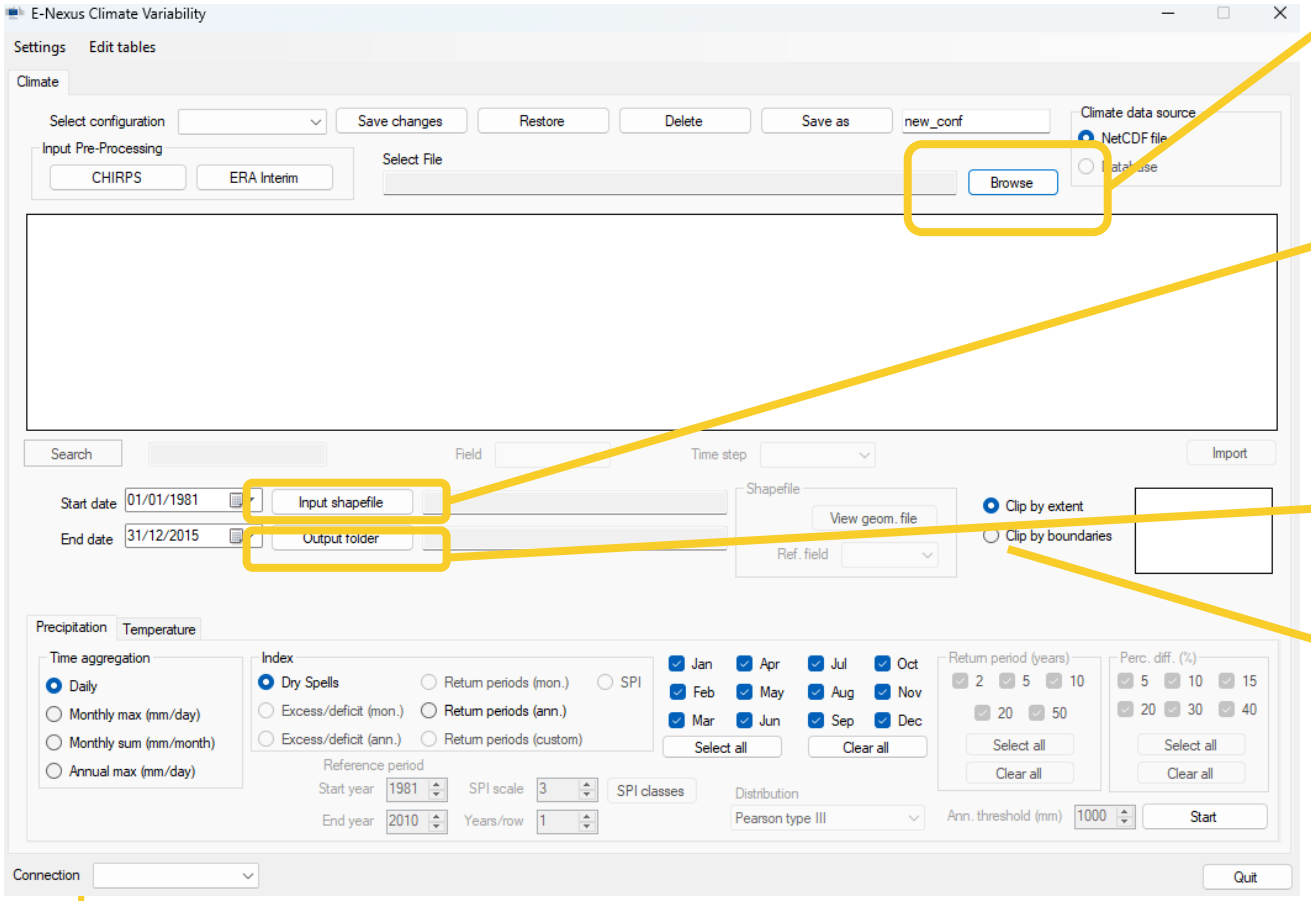
Excess/Deficit/Return periods

Precipitation indices



NOTE VALID FOR ALL INDEX AND EXCERCISES

BROWST TO LOAD INPUT DATA SPECIFIC TO THE ANALYSIS

All required input data are stored into *Input* folder.

The folder where you copied or downloaded the Harmonized DATA

***Shapefile*: LOAD the Shapefile that contains geographical delimitation of the domain of interest**

Path:..<localuser>\Documents\E-NexusCV\Shapefiles\ Sample_areas_GADM_Lev4_ForBox1\Gadm26_L4_SampleArea_Box1.shp

USER CHOICE: OUTPUT FOLDER

OPTIONAL: CLIP BY BOUNDARIES

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Climate Variability module – Practical session

Precipitation indices

ECERCISE 1.1

ANNUAL
Excess/deficit

Excess/Deficit/Return periods

Summary of parameters to be entered in the interface

Ex 1.1 - **Annual** precipitation **deficit and excess** values

The aim is to assess the annual precipitation deficit and excess values for several return times and the percentage differences in the period 1981-2019 (including all months).

Duration:

General parameters →

- **Folder**: *Exercices\Input\Precipitations\ CHIRPS_monsum_1981_2023.nc*

InputShapefile:*Documents\E-Nexus CV\Shapefiles\Sample_areas_GADM_Lev4_ForBox1\Gadm26_L4_SampleArea_Box1.shp*

- **Output folder**: free choiche
- **Start time**: 01 Jan 1981
- **End time**: 31 Dec 2023

Specific parameters (tab **Precipitations**) →

- **Temporal aggregation: cumulative monthly**
- **Index**: excess/deficit (annual)
- **Month**: all
- **Return period**: all
- **Diff. Cent (%):** all
- **Distribution**: *Pearson Type III*

→ **Run** ←

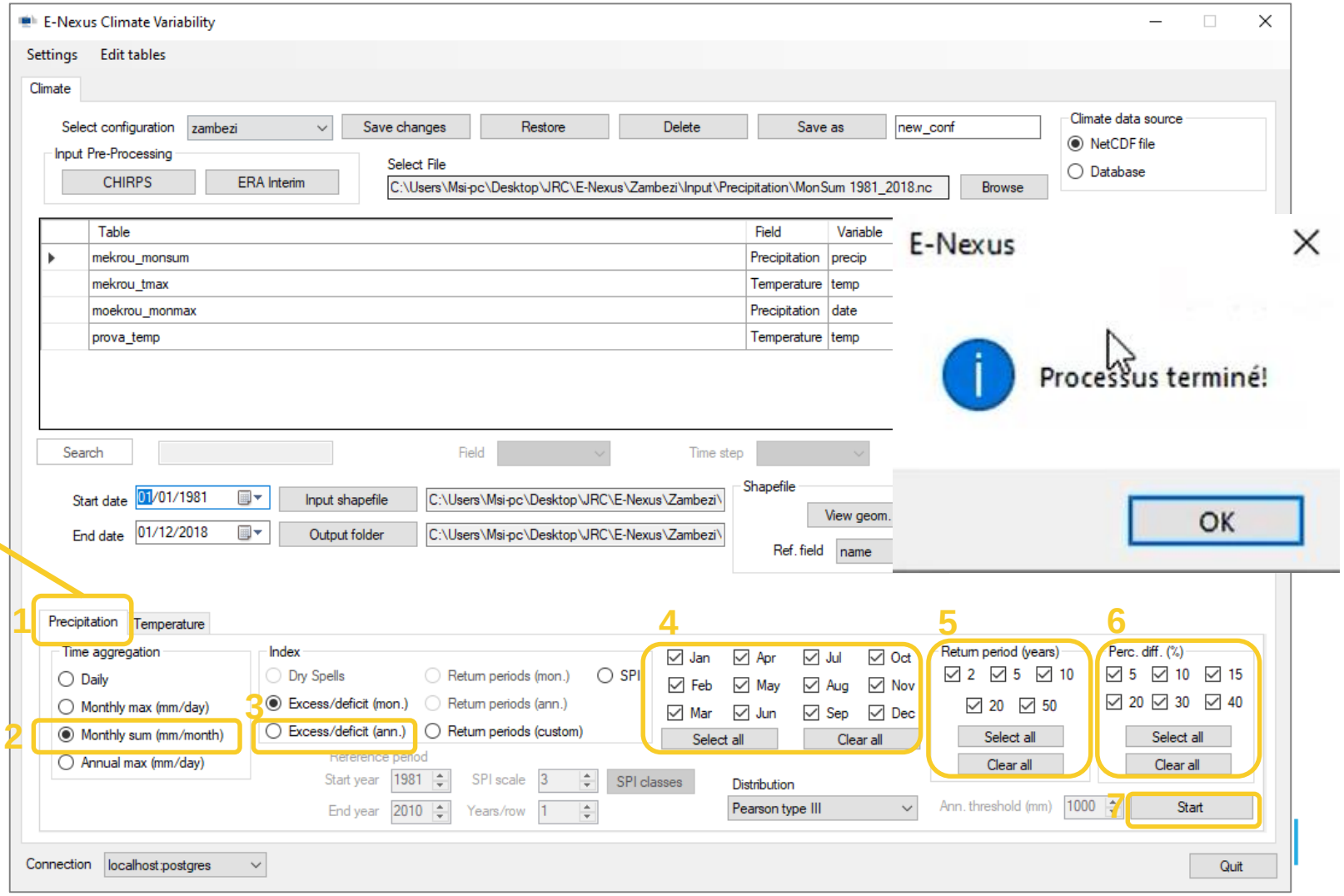
Excess/Deficit/Return periods

Precipitation indices

Specific parameters
(tab **Precipitations**)

1. Variable = Precipitation
2. Aggregation = Monthly sum
3. Index = Excess/deficit (ann.)
4. Months to be used = all
5. Return Period = all
6. % differences = all

7. Start the tool



Excess/Deficit/Return periods

Ex 1.1 - **Annual** precipitation **deficit and excess** values

RESULTS

For each process, the results are generated in the selected output folder as :

1. images (.png)
2. vector files (.tif) that can be analysed in any GIS environment.

Note that the outputs are sorted into a set of sub-folders. For example, the results for the monthly indices calculated, the outputs are placed in several folders sorted by month - from JAN to DEC.

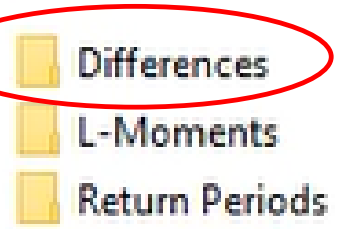
All files created at the end of the process will be placed in the following sub-folder:

Differences/JUN: annual excess and deficit of monthly precipitation calculated in percentage (%) and absolute values (mm) of monthly precipitation for 10 and 20 year return periods in June (16 files)
Return Periods/JUN: return periods relative to the excess and deficit of 15 and 30% of monthly precipitation (8 files)
L-Moments/JUN: the 4 main L-Moments of monthly precipitation (8 files)

If you are interested exclusively in the total amount of precipitation in particular months, excluding the others, select them from the Months section (they are all selected by default).

Excess/Deficit/Return periods - OUTPUTS

Precipitation indices



FOLDER CONTENT

- Annual Rainfall Excess/deficit: % and absolute values
- 4 L-Moments values (mean, …)
- Return periods for the chosen excess and deficit estimated

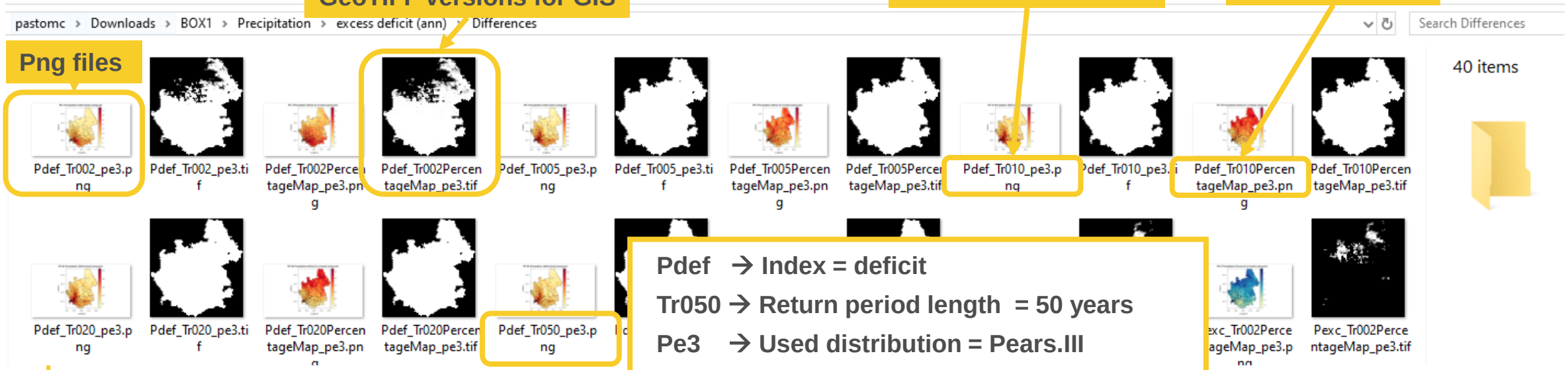
File name coding

GeoTIFF versions for GIS

ABSOLUTE VALUES

PERCENTAGES

Png files



Pdef → Index = deficit

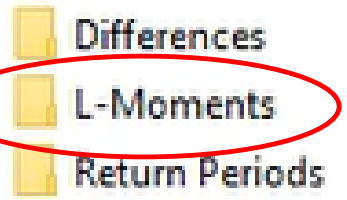
Tr050 → Return period length = 50 years

Pe3 → Used distribution = Pears.III

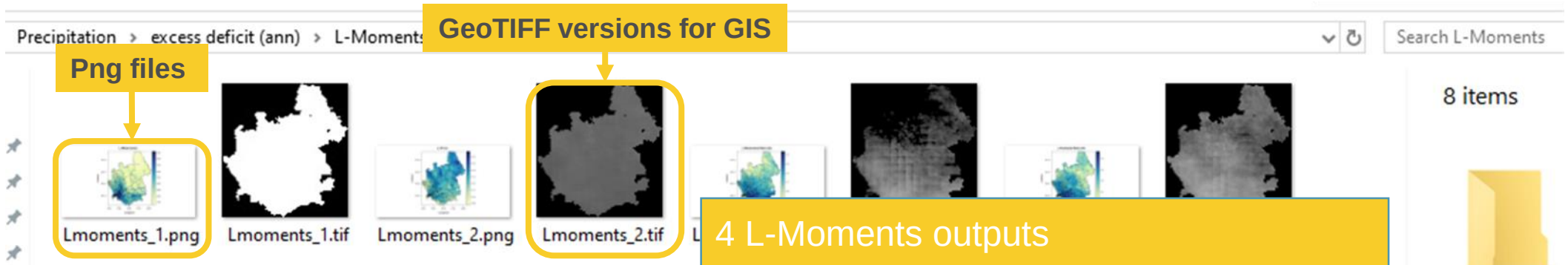
Excess/Deficit/Return periods - OUTPUTS

Precipitation indices

FOLDER CONTENT



File name coding



Png files

GeoTIFF versions for GIS

4 L-Moments outputs

L-moment 1: Average
L-moment 1: variation (L-CV)
L-moment 1: skew coeff. (L-Skewness)
L-moment 1: Kurtosid coeff. (L-Kurtosis)

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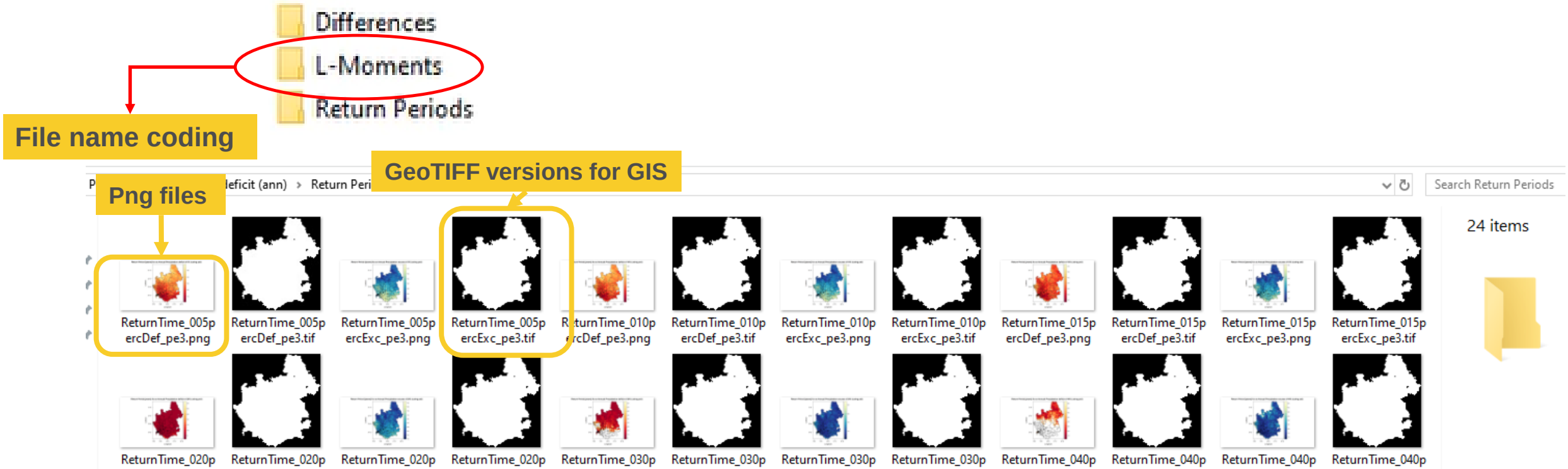
Excess/Deficit/Return periods - OUTPUTS

Precipitation indices

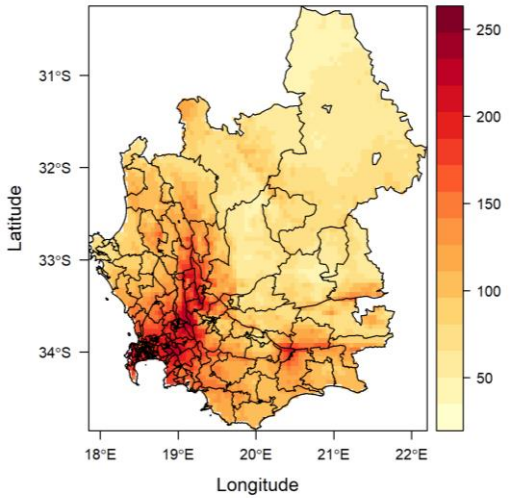


ReturnTime_xxx → Period = Ex. 30 years
Def = for Deficit
Exc = for the Excess

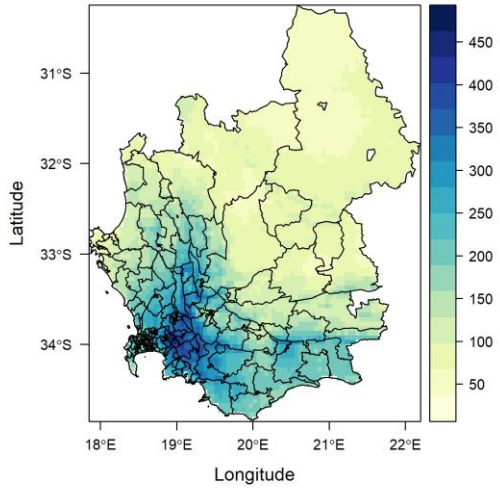
RESULTS – ANNUAL PRECIPITATION EXCESS DEFICITS

OUTPUTS INTERPRETATION

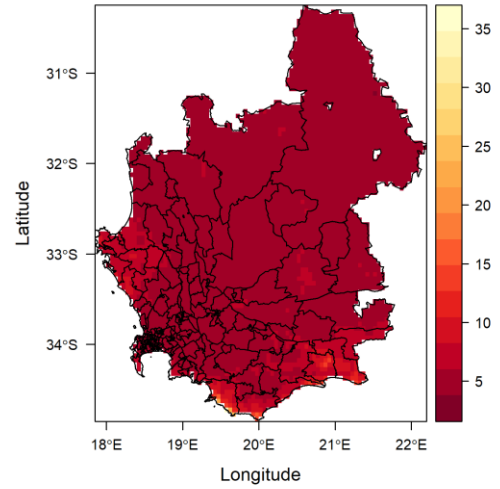
RP 20 Precipitation Deficit [mm] (using pe3)



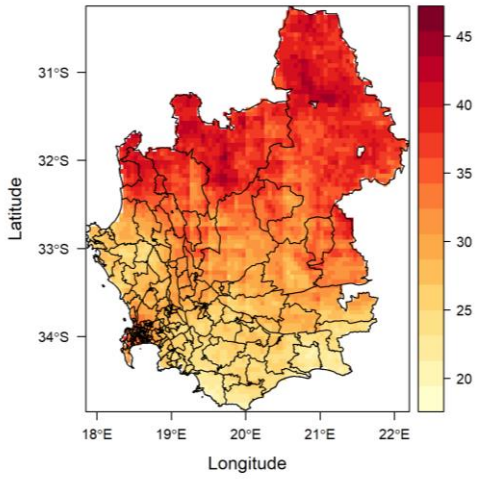
RP 20 Precipitation Excess [mm] (using pe3)



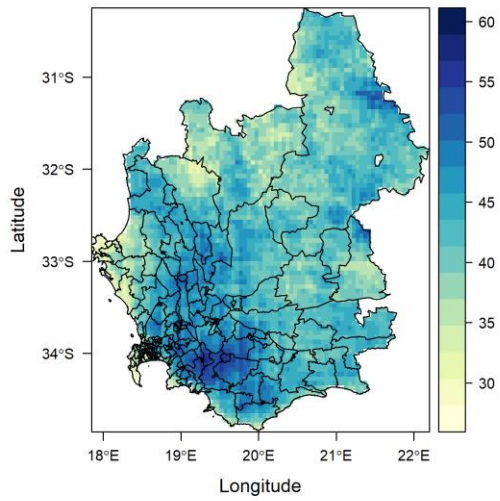
Return Period [years] for an Annual Precipitation deficit of 20% (using pe3)



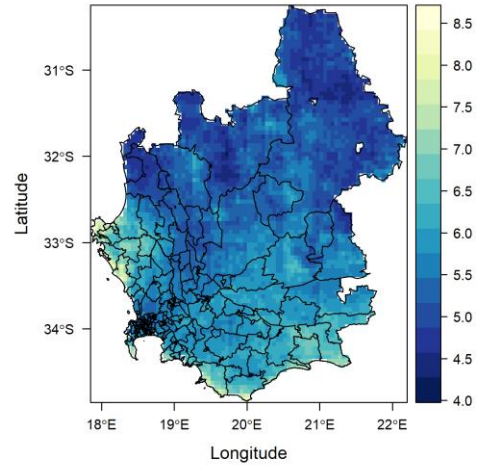
RP 20 Precipitation Deficit [% of mean] (using pe3)



RP 20 Precipitation Excess [% of mean] (using pe3)



Return Period [years] for an Annual Precipitation excess of 20% (using pe3)



FOLDER: Differences

FOLDER: Return Periods

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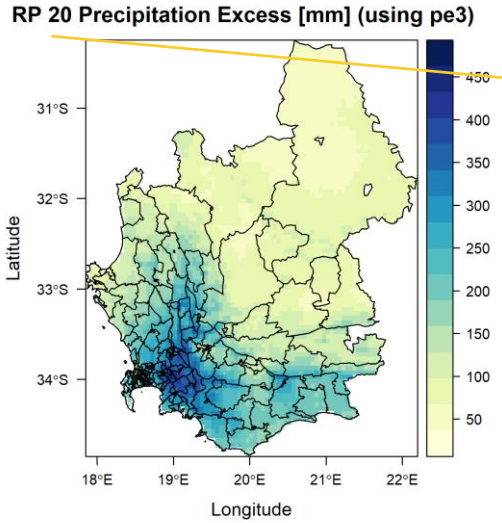
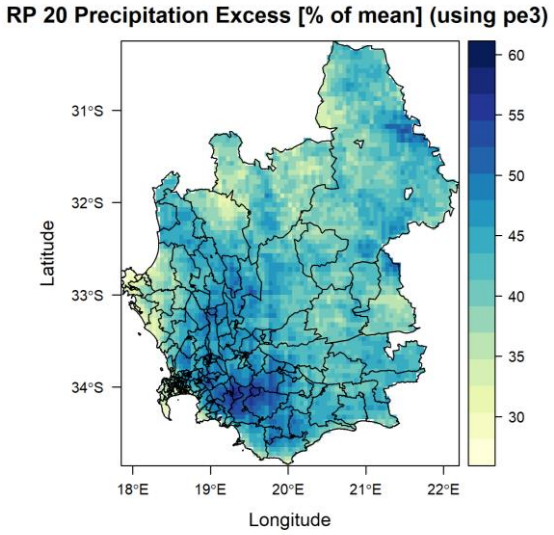
RESULTS – ANNUAL PRECIPITATION EXCESS DEFICITS

OUTPUTS INTERPRETATION





In this case, we're considering a **20-year return period**, meaning we're interested in extreme precipitation events that occur, **on average**, once **every 20 years**

Excess precipitation refers to the amount of rainfall that exceeds what is typically expected (average) for a given location and time frame (simulated period)

For a 20-year return period, we're looking at extreme events that go beyond the usual annual precipitation levels

Understanding annual precipitation excess with a return period helps assess flood risks, design infrastructure (such as drainage systems), and plan for extreme weather events

It's crucial for managing water resources, flood control, and disaster preparedness

NOTE: 1. return periods provide valuable insights for risk management, but they do not guarantee precise timing or predictability of specific events
2. this approach considers extreme events, so it focuses on deviations from the norm rather than typical yearly rainfall

Files in FOLDER: Differences

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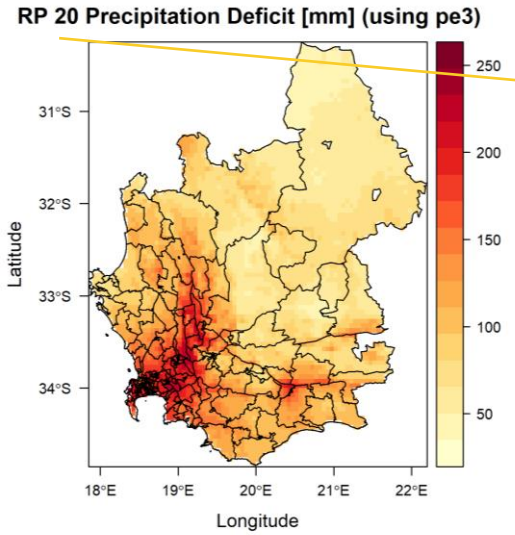
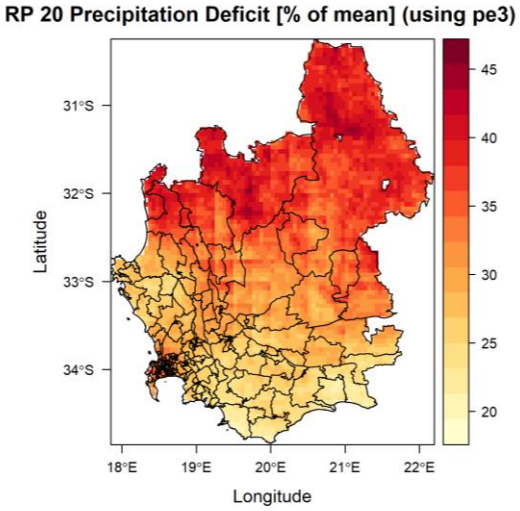
RESULTS – ANNUAL PRECIPITATION EXCESS DEFICITS

OUTPUTS INTERPRETATION





In the same way we can refer to **Deficit, both in mm differences or %**

we're interested in extreme cases where the annual precipitation falls significantly below the long-term average)

For a 20-year return period, we're looking extreme cases where the annual precipitation falls significantly below the long-term average

It helps assess the **severity of drought conditions** and informs water resource management

Understanding annual precipitation deficits is crucial for **agriculture, water supply planning, and ecosystem health**.

Droughts associated with deficits can have significant economic and environmental impacts

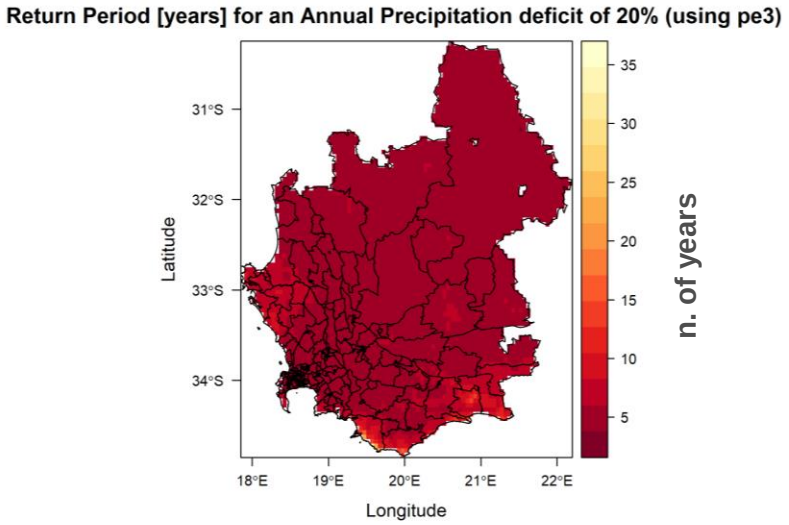
NOTE: 1. return periods provide valuable insights for risk management, but they do not guarantee precise timing or predictability of specific events
2. this approach considers extreme events, so it focuses on deviations from the norm rather than typical yearly rainfall

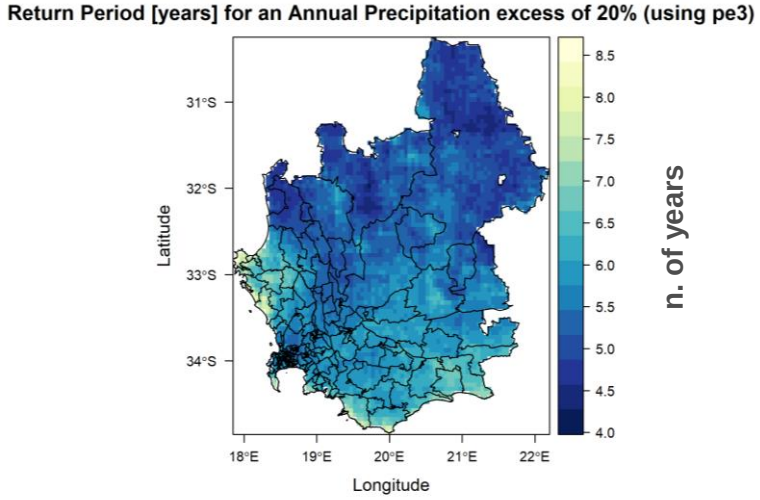
Files in FOLDER: Differences

European Commission

RESULTS – ANNUAL PRECIPITATION EXCESS DEFICITS

OUTPUTS INTERPRETATION





With those outputs we are focusing on the assessment of a specific deficit/excess of rainfall (see for example 20% more or less of the expected average)

We’re interested in how often this deficit/excess precipitation occurs

The 20% excess threshold means that we’re looking at years where the precipitation exceeds the expected average by 20%

The return period helps us understand the frequency of extreme precipitation events beyond the usual average

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Excess/Deficit/Return periods

Precipitation indices

ECERCISE 1.2

Monthly Excess/deficit

Excess/Deficit/Return periods

Ex 1.2 - **Monthly** precipitation **deficit and excess** values → **DIFFERENT TEMPORAL SCALE FOCUS ON A SPECIFIC MONTH**

The calculation of this index is similar to the previous process, except that you need to determine the month(s) on which the analysis will focus. For example, **to obtain the indices for June, August and November**.

Duration: 

General parameters →

- **Folder**: *Exercices\Input\HIRPS_monsum_1981_2023.nc*
- **Input Shapefile** : *Documents\E-Nexus CV\Shapefiles\Sample_areas_GADM_Lev4_ForBox1\Gadm26_L4_SampleArea_Box1.shp*
- **Output folder**: free choiche
- **Start time**: 01 Jan 1981
- **End time**: 31 Dec 2023

Specific parameters (tab **Precipitations**) →

- **Temporal aggregation: cumulative monthly**
- **Index**: excess/deficit (monthly)
- **Month**: Select the ones to be specifically analysed (June, August, November, December)
- **Return period**: 10, 20, 50
- **Diff. Cent (%):** 15, 30
- **Distribution**: *Pearson Type III*

→ **Run** ←

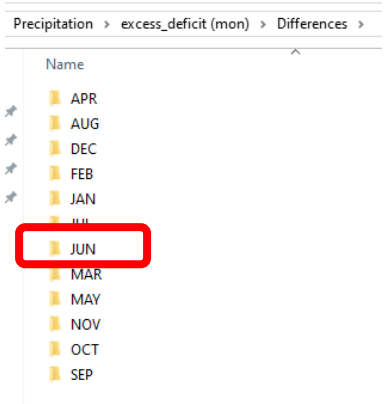
Excess/Deficit/Return periods

RESULTS

Differences/JUN: monthly excess and deficit of monthly precipitation calculated in percentage (%) and absolute values (mm) of monthly precipitation for 10 and 20 year return periods in June (16 files)
Return Periods/JUN: return periods relative to the excess and deficit of 15 and 30% of monthly precipitation (8 files)
L-Moments/JUN: the 4 main L-Moments of monthly precipitation (8 files)

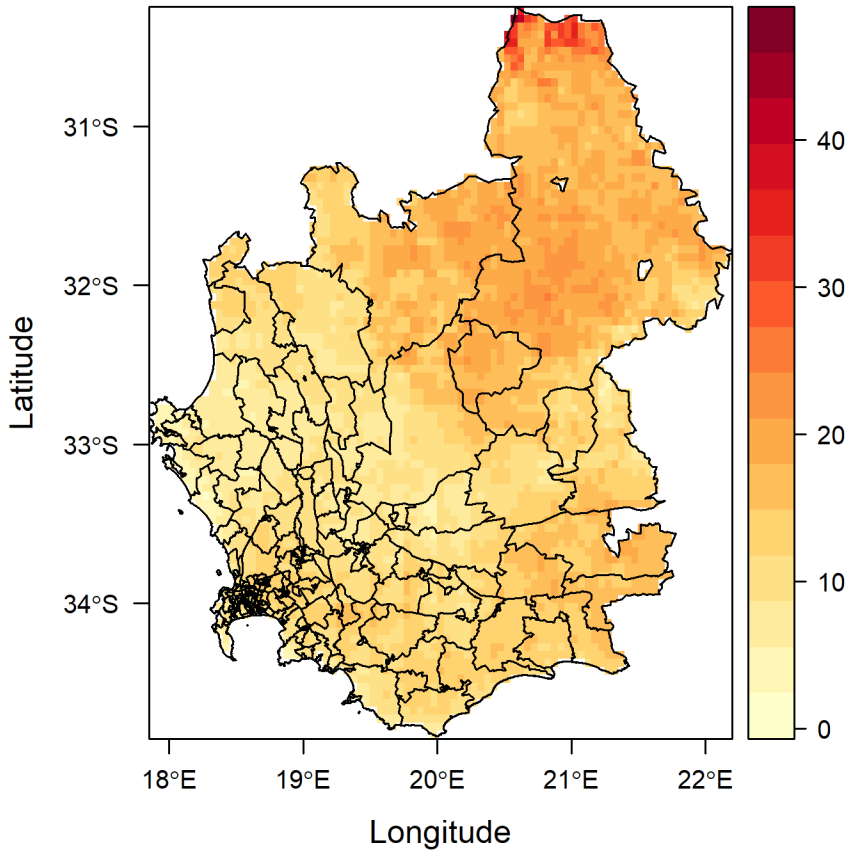
The same for all selected months

RESULTS – MONTHLY PRECIPITATION EXCESS DEFICITS

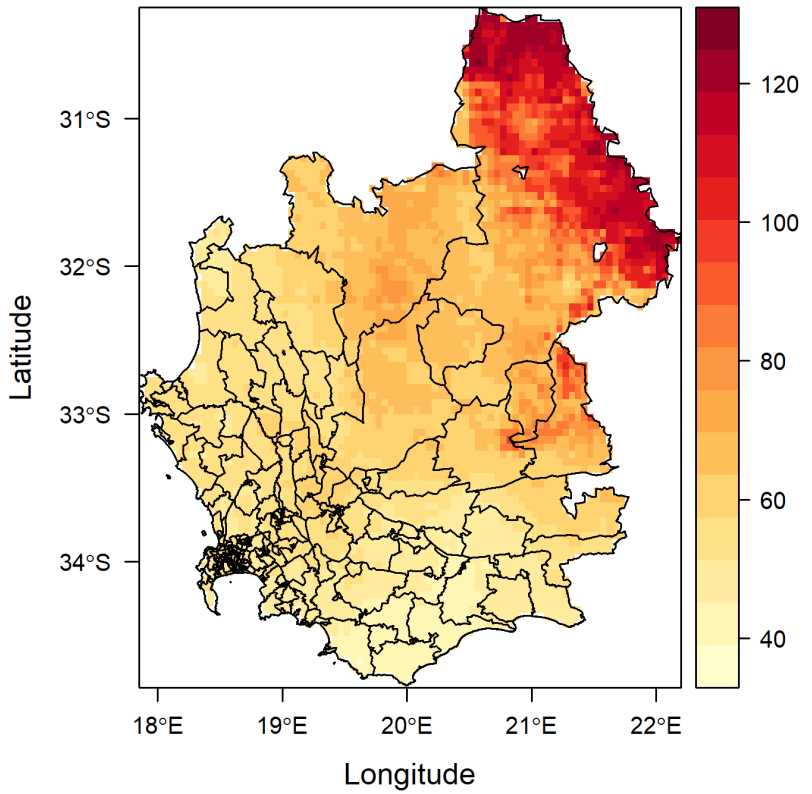


DEFICIT IN JUNE for a return period of 20 years

JUN RP 2 Precipitation Deficit [% of mean] (using pe3)



JUN RP 20 Precipitation Deficit [% of mean] (using pe3)



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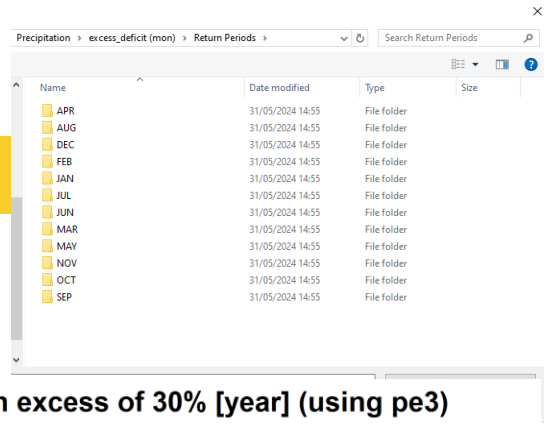
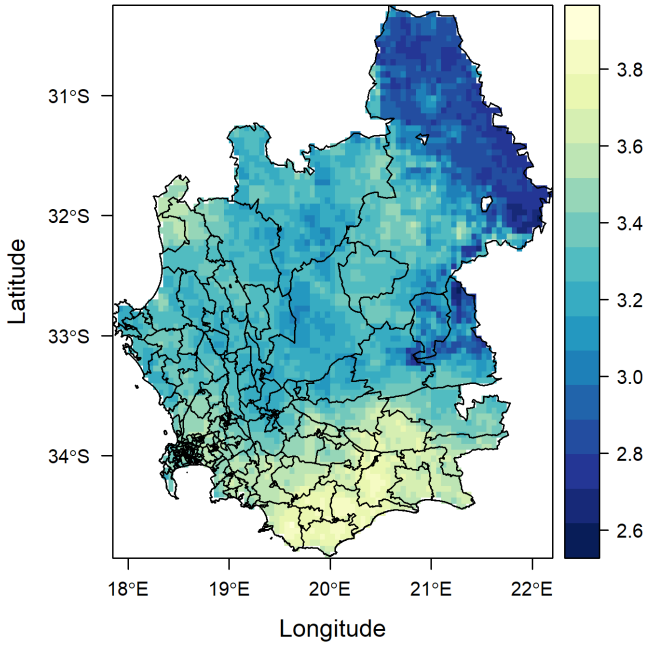
RESULTS – MONTHLY PRECIPITATION EXCESS DEFICITS

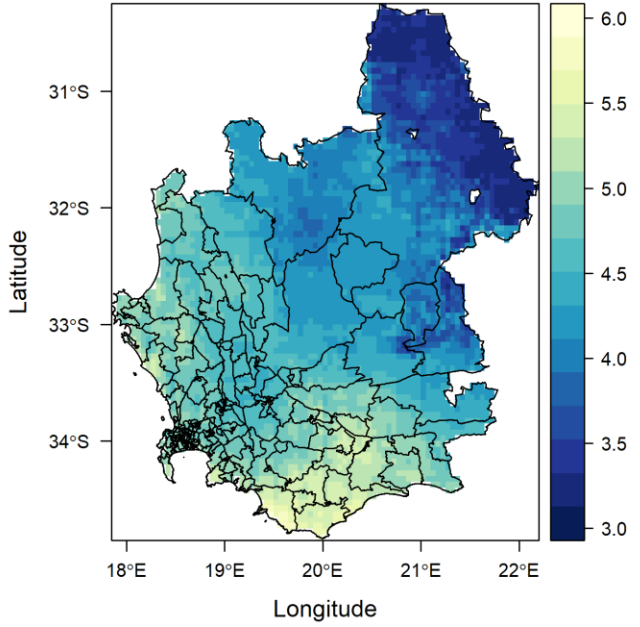
RETURN PERIOD IN JUNE for an EXCESS RAINFALL OF 15 AND 30%



Return Period [years] for JUN Monthly Precipitation excess of 15% [year] (using pe3)



Return Period [years] for JUN Monthly Precipitation excess of 30% [year] (using pe3)



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RESULTS – MONTHLY PRECIPITATION EXCESS DEFICITS

OUTPUTS INTERPRETATION

Interpretation is the same of ANNUAL OUTPUTS.

Here the temporal focus is more precise and **we can identify specific months or seasons; this can be key when it is required to monitor more precisely the impact of extreme events (excess/deficit) in specific periods.**

These can have significant implications across various domains:

Flooding and Infrastructure Damage (Intense rainfall can overwhelm drainage systems, leading to urban flooding. Roads, bridges, and buildings may suffer damage due to excessive water flow, human health, including waterborne diseases)

Economic Impact (Flood-related property damage can result in substantial financial losses. Businesses, agriculture, and transportation networks)

Water Quality and Erosion (Heavy rainfall can wash pollutants into water bodies, affecting water quality. Soil erosion increases)

Ecological Effects (alter habitats, affecting plant and animal species. Stream ecosystems may experience changes in flow dynamics)

Here we focus on historical data to detect anomalies. A further step would be to consider Climate Change impact

Excess/Deficit/Return periods

Precipitation indices

ECERCISE 1.3

Monthly MAX PRECIPITATION RETURN PERIODS

Excess/Deficit/Return periods

Ex 1.3 - Monthly MAX precipitation RETURN PERIODS → FOCUS ON MAXIMUM VALUES

This exercise involves calculating the **10- and 20-year monthly return periods for maximum monthly rainfall (mm/day)** for the months of **August and November** over the period **1981-22**.

Duration: 

General parameters →

- **Folder**: *Exercices\Input\Precipitations\ExcesDeficit_ReturnPeriod - SPI\CHIRPS_monsum_1981_2019_senegal.nc*
- **Input Shapefile** : *Documents\E-Nexus\Shapefiles\WEFE Senegal\Wefe Senegal.shp*
- **Output folder**: free choiche
- **Start time**: 01 Jan 1981
- **End time**: 31 Dec 2023

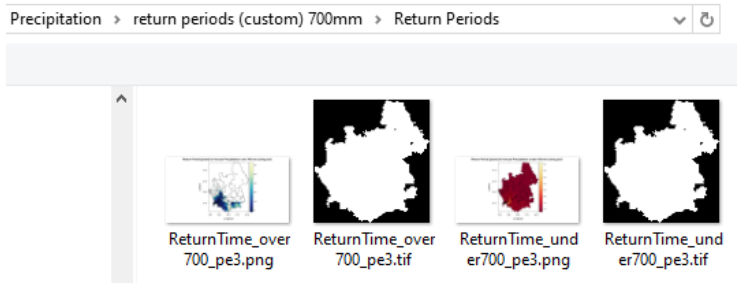
Specific parameters (tab **Precipitations**) →

- **Temporal aggregation: MONTHLY MAXIMUM**
- **Index**: Return period (monthly)
- **Month**: Select the ones to be specifically analysed (August, November)
- **Return period**: 10, 20

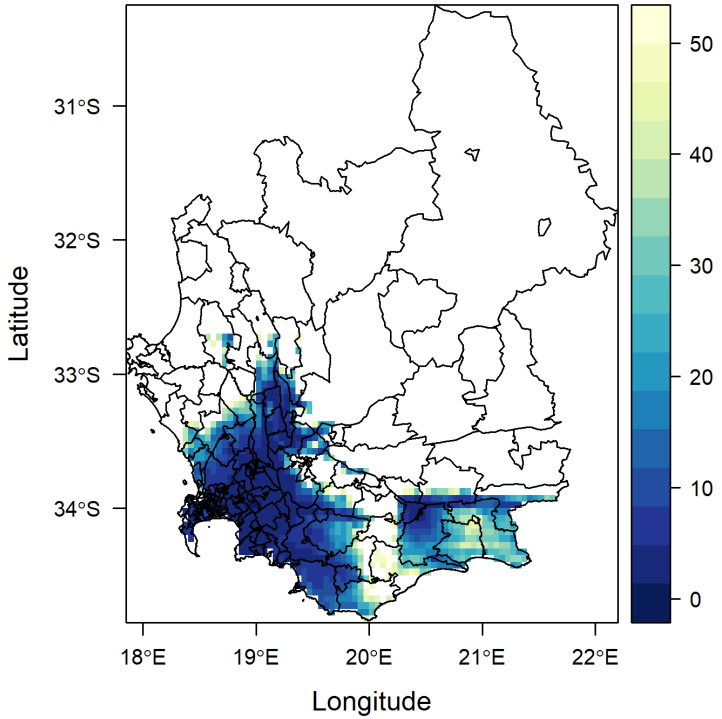
→ **Run** ←

RESULTS – MONTHLY MAX PRECIPITATION RETURN PERIODS

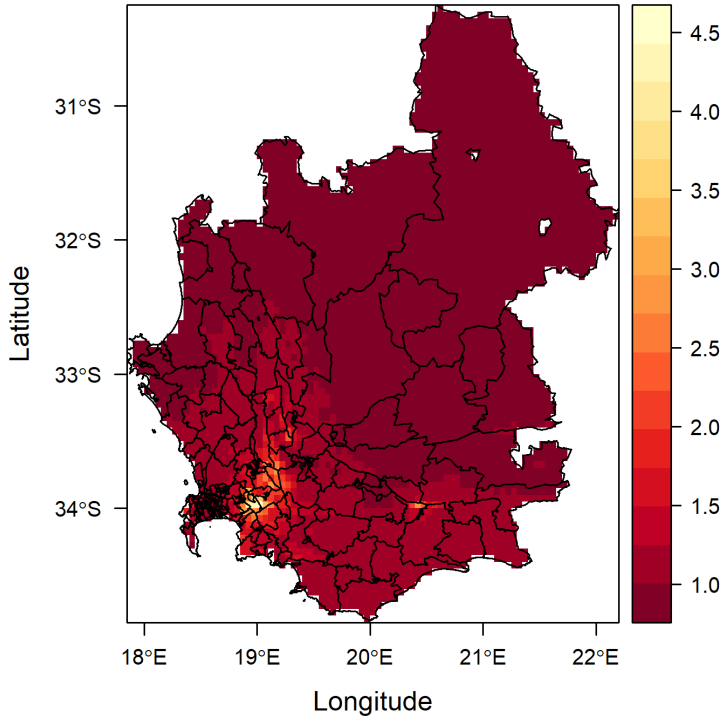
RETURN PERIOD FOR ANNUAL RAINFALL > 700 mm from April to November



Return Period [years] for Annual Precipitation over 700 mm (using pe3)



Return Period [years] for Annual Precipitation under 700 mm (using pe3)



Thank you

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