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

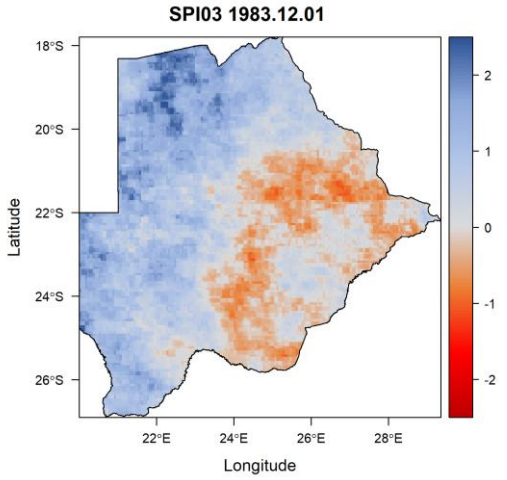
European Commission

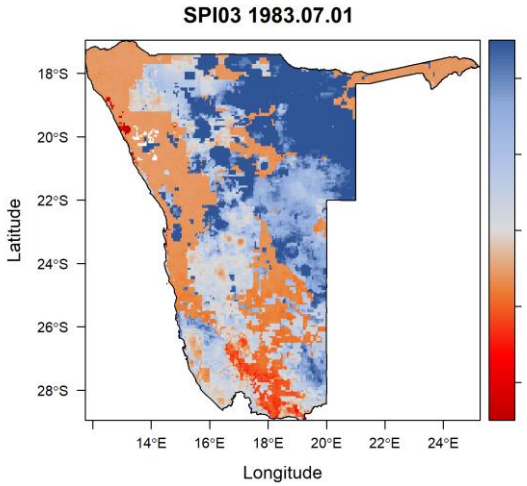
Joint Research Centre

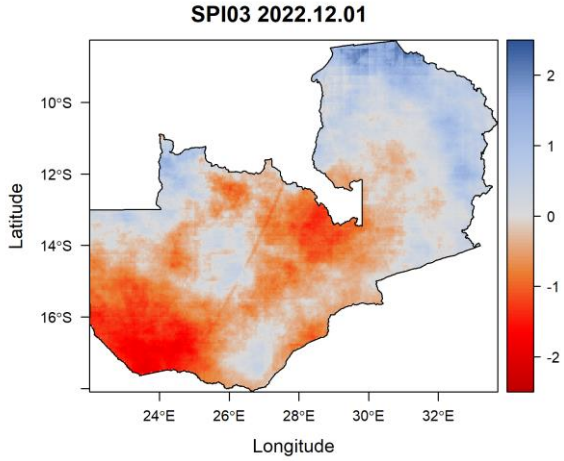
Climate Variability module – Practical session

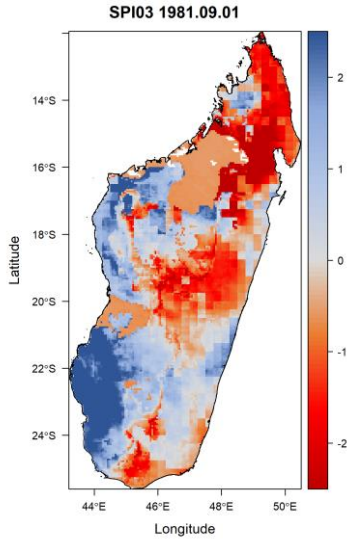
SPI

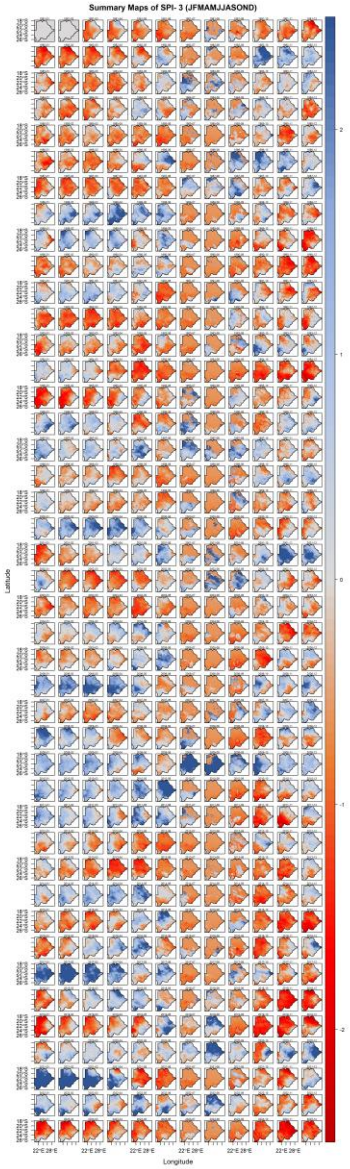
Standard Precipitation Index











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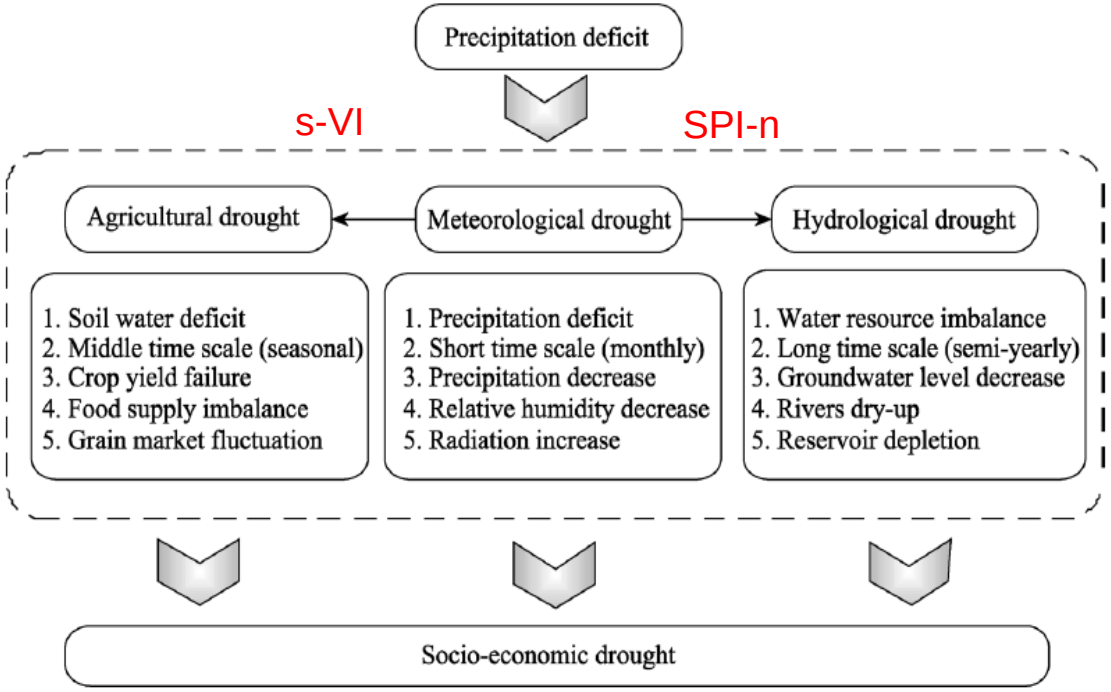
SPI - Standard Precipitation Index

Why ?

Detecting Meteorological Droughts

- The SPI can be used to assess areas affected by rainfall anomalies or meteorological drought.
- It can be analysed in combination with other indices to assess agricultural drought and hydrological drought.



Drought transfer processes and interactions, Xianfeng L. et.al 2016

SPI - Standard Precipitation Index

Introduction

- The Standardized Precipitation Index (SPI) is an index of the **probability of precipitation occurrence** that provides a representation of **moisture and drought anomalies** over a certain period of time in a region
- **flexible** and simple to calculate: **rainfall is the only input parameter required** (ideally, at least 20 to 30 years of monthly values should be available, with 50 to 60 years (or more) being optimal and preferred)
- It has the advantages of **simple calculation and stability**, and **eliminates the temporal and spatial difference** in rainfall → **It can be compared across distinctly different climatic regions**.
- It is **sensitive to drought change** and applicable to drought monitoring and assessment of climatic conditions above the monthly scale.
- By standardising the SPI, the index can be used to **determine the rarity of a current meteorological drought**.

SPI - Standard Precipitation Index

Introduction

- The SPI has an intensity scale in which positive and negative values are calculated, which correlate directly with wet and dry events. For drought, there is great interest in the ‘tails’ of the precipitation distribution, and in particular in extreme dry events, which are events considered rare on the basis of the climate of the region studied.

- Standardisation of the SPI enables the index to determine the rarity of a current meteorological drought. Can be calculated on any time scale, from 1 month to 48 months or more.

- The SPI can be calculated for different periods (n = generally from 1 to 36 months) using monthly input data..

SPI - Standard Precipitation Index

APPLICATIONS

- The ability of the SPI to be calculated on different time scales means that it can be used for a wide range of applications.

- Soil moisture responds to precipitation anomalies on a relatively short time scale. Groundwater, river flow and reservoir storage reflect longer-term precipitation anomalies → Depending on the impact of the drought in question:
  - SPI values for 3 months or less may be useful for basic drought monitoring,
  - values for 6 months or less for monitoring agricultural impacts and
  - values for 12 months or more for hydrological impacts.

- The SPI index can also be calculated on gridded precipitation datasets, broadening the scope of users compared to those working solely with station data.

SPI - Standard Precipitation Index

Anomaly intensity classes based on SPI (McKee et al, 1995 et Agnew et al, 2000)

extreme event

Wet/dry class	SPI values [McKee et al]	SPI values [Agnew et al]
Extremely Dry	<-2	<-1.64
Severely Dry	[-2,-1.5)	[-1.64,-1.28)
Moderately Dry	[-1.5,-1)	[-1.28,-0.84)
Moderate	[-1,1)	[-0.84,0.84)
Moderately Wet	[1,1.5)	[0.84,1.28)
Severely Wet	[1.5,2]	[1.28,1.64]
Extremely Wet	>2	>1.64

SPI	Category	Number of times in 100 years	Severity of event
0 to -0.99	Mild dryness	33	1 in 3 yrs.
-1.00 to -1.49	Moderate dryness	10	1 in 10 yrs.
-1.5 to -1.99	Severe dryness	5	1 in 20 yrs.
< -2.0	Extreme dryness	2.5	1 in 50 yrs.

- A drought episode occurs whenever the SPI is continuously negative and reaches an intensity of -1.0 or less.
- Each drought episode therefore has a duration defined by its start and end, and an intensity for each month in which the episode continues.
- The positive sum of the SPI index for all the months of a drought episode can be called the ‘magnitude’ of the drought.

SPI - Standard Precipitation Index

EXERCISE

EXAMPLE ON HOW TO PRODUCE OPTPUTS

SPI INDEX

IN SADC REGION

SPI - Standard Precipitation Index

The aim is to evaluate the SPI values for monthly precipitation over the period 1981-2023 (with a reference from 1981 to 2010), focusing on the months from August to November with a 3-month SPI scale and a Pearson III type probability distribution. The SPI classification according to Agnew et al. 2000 will be used

Duration: 

General parameters →

- **Folder**: : *Exercices\Input\Precipitations\ CHIRPS_monsum_1981_2023.nc*
- **Input Shapefile** : *Shapefiles\Gadm36_L4_SampleArea_Box1.shp*
- **Output folder**: free choiche
- **Start time**: 01 Jan 1981
- **End time**: 31 Dec 2023
- **Reference field name**: GId4 (Shapefile unique identifier column)

Specific parameters (tab **Precipitation**) →

- Select **Precipitation**
- **Temporal aggregation:** monthly
- **Index**: SPI
- **Months**: Aug-Nov
- **Reference period** -> **Start**: 1981 **End**: 2010
- **SPI scale (n. of months)** : 3
- **N° row/cols for output summary**: 2

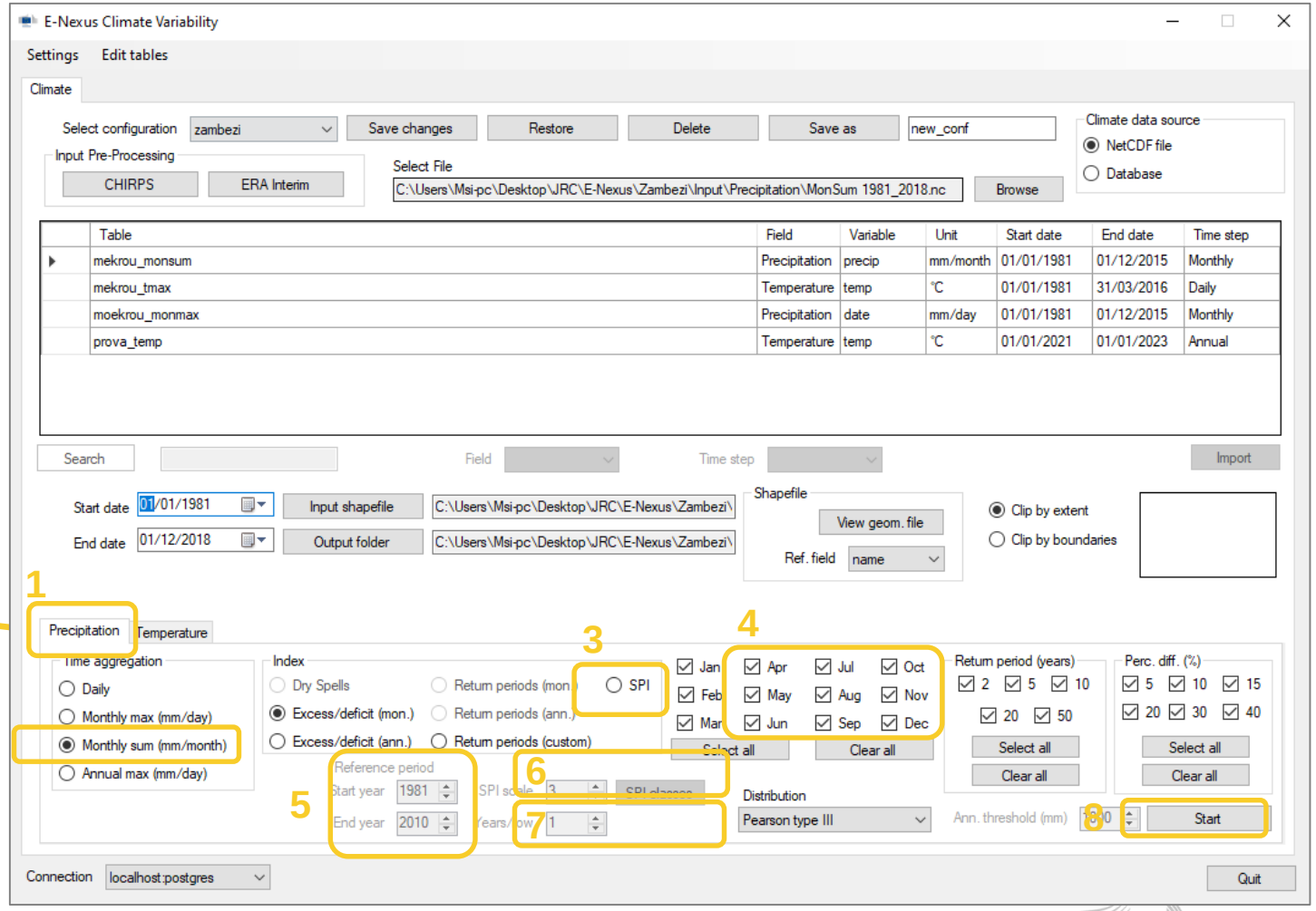
→ **Start** ←

SPI - Standard Precipitation Index

Precipitation Index - SPI

Specific parameters
(tab **Precipitation**)

1. Variable = Precipitation
2. Aggregation = Monthly
3. Index = SPI
4. Months: Aug-Nov
5. Reference period = 1981-2010
6. SPI scale (n. of months) : 3
7. N° row/cols for output summary: 2
8. Start the tool



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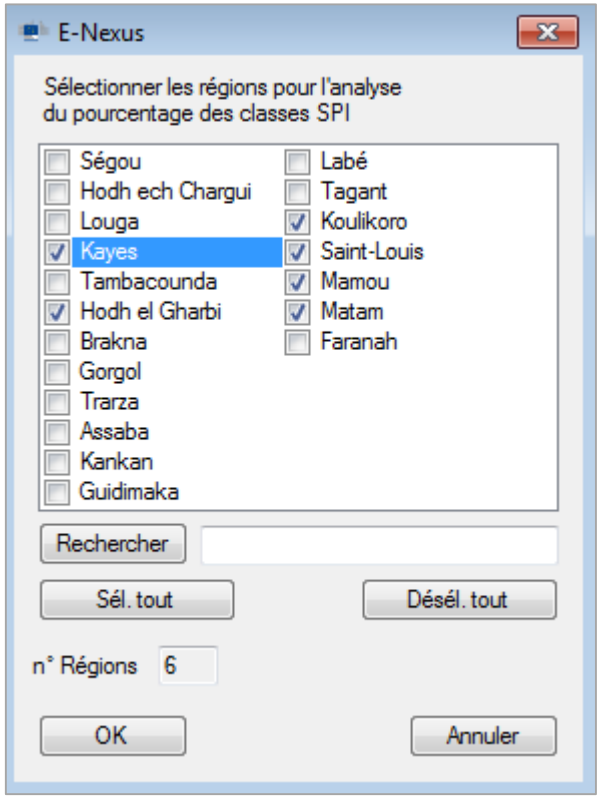
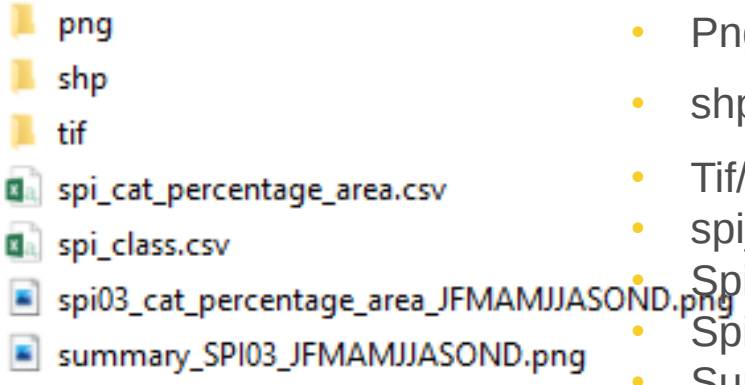
SPI - Standard Precipitation Index



Just after starting the process, select the regions

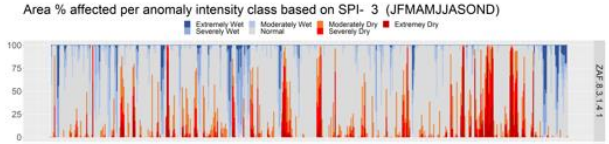
SPI - Standard Precipitation Index

MAIN FOLDER CONTENT



- Png/: Maps of SPI-x for each month
- shp/: shapefile with geographical limits with time % and affected zone
- Tif/: GeoTIFF layers for SPI-x for each month simulated
- spi_cat_percentage_area.csv: % of affected surface
- Spi_class.csv : Classification scale
- Spi<class>cat_percentage_area_<months>: summary
- Summary for all time series simulated

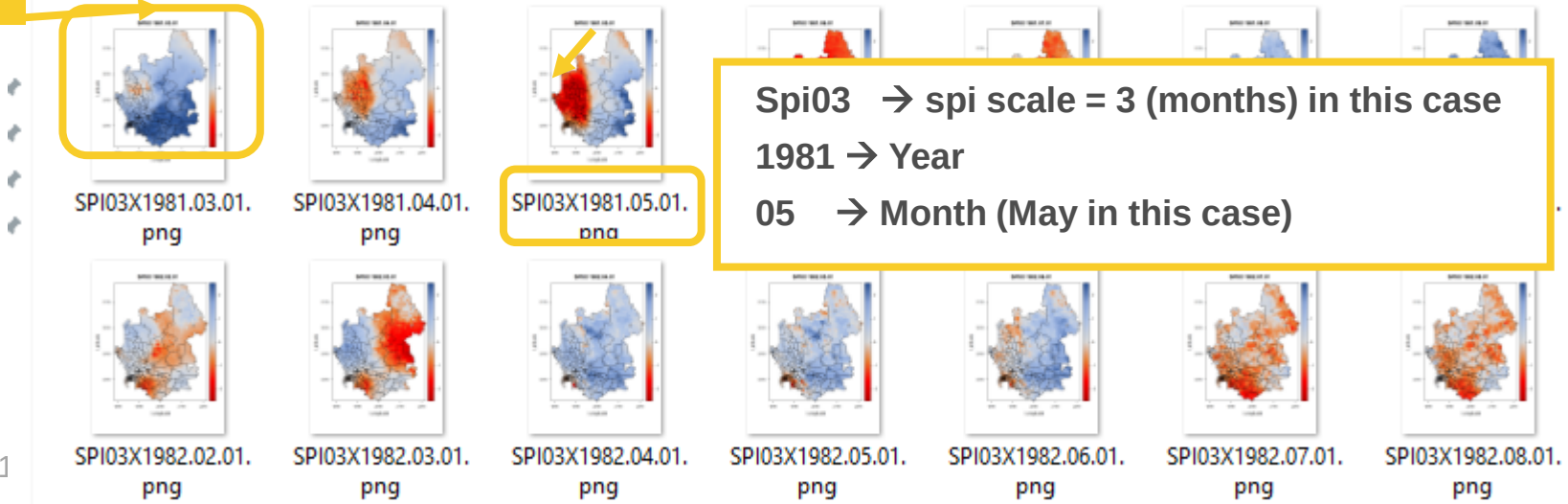
name	spi_cat	time	value	month
ZAF.8.3.1.4_1	007 Extremey Dry	01/04/2023	0.00	Apr
ZAF.8.3.1.4_1	006 Severely Dry	01/04/2023	0.22	Apr
ZAF.8.3.1.4_1	005 Moderately Dry	01/04/2023	0.00	Apr
ZAF.8.3.1.4_1	004 Normal	01/04/2023	69.08	Apr
ZAF.8.3.1.4_1	003 Moderately Wet	01/04/2023	24.34	Apr
ZAF.8.3.1.4_1	002 Severely Wet	01/04/2023	5.92	Apr
ZAF.8.3.1.4_1	001 Extremely Wet	01/04/2023	0.44	Apr



File name coding

SUB FOLDER \PNG

Png files



Spi03 → spi scale = 3 (months) in this case

1981 → Year

05 → Month (May in this case)

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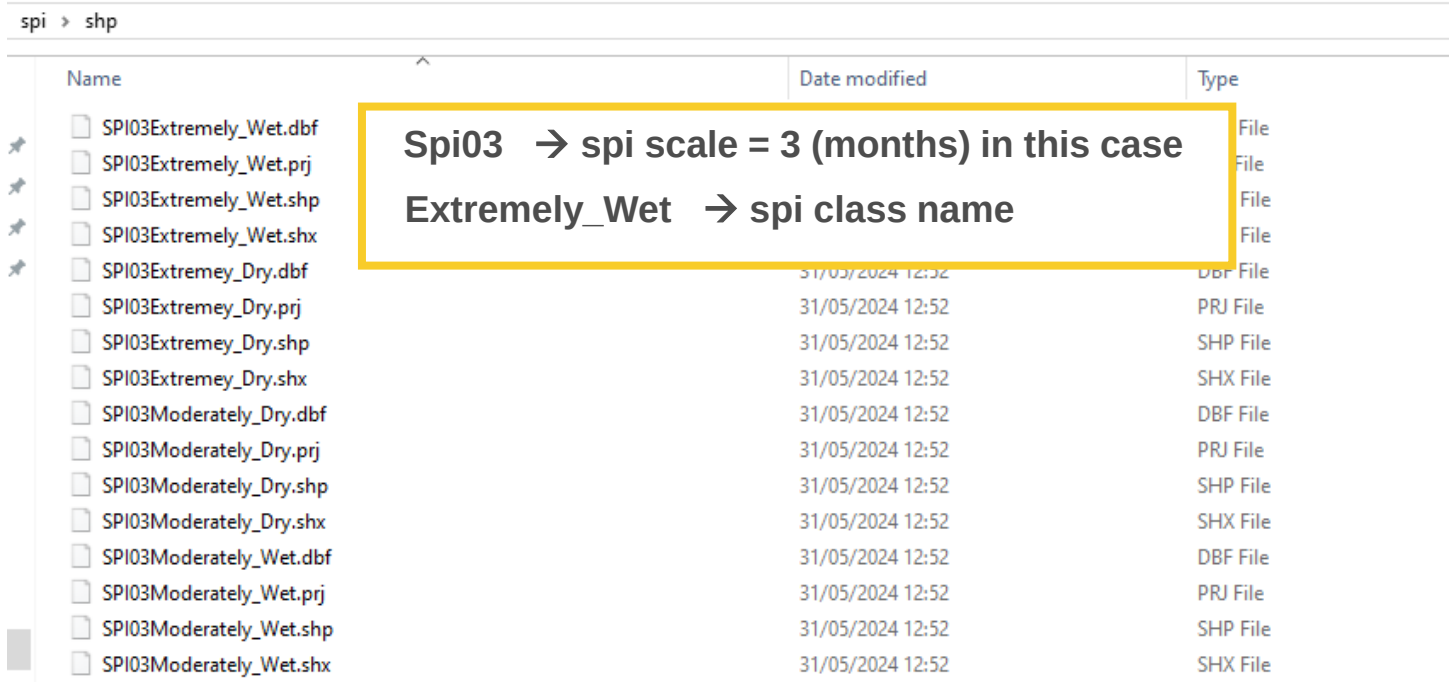
SPI - Standard Precipitation Index

SUB FOLDER \SHP



Shape file (for GIS Apps) with anomaly classes % for each administrative spatial unit used in the analysis

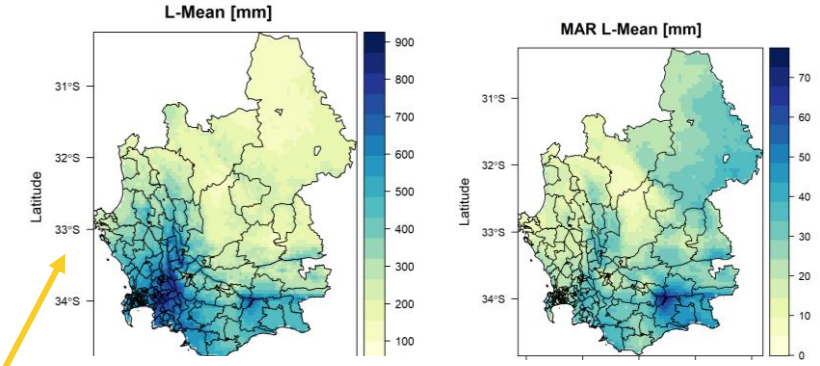
SPI - Standard Precipitation Index

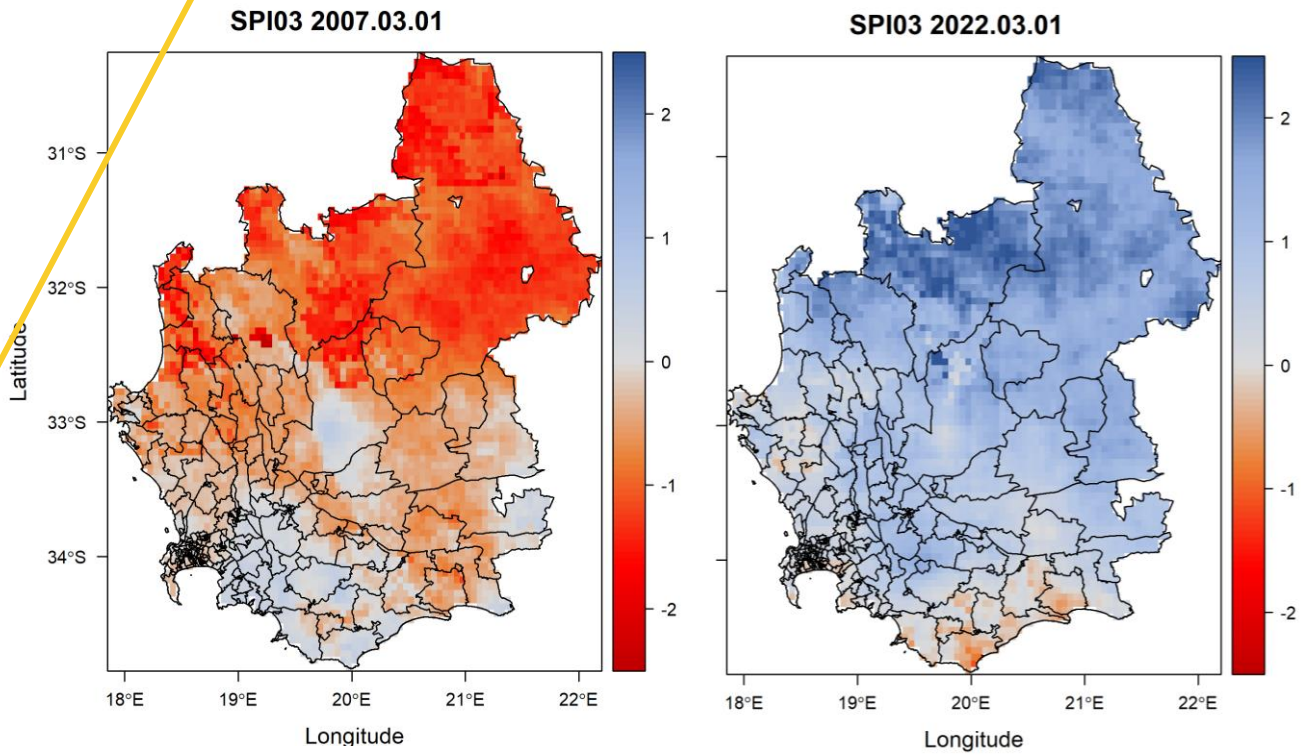
OUTPUTS - INTERPRETATION

SPI value = standard deviation from the long-term mean (normal distribution of the variable).

SPI < -1 indicates dry conditions (the more negative the value, the more severe the situation).
SPI > 1 indicates very wet conditions.
SPI between -1 and + 1 indicates a normal situation.

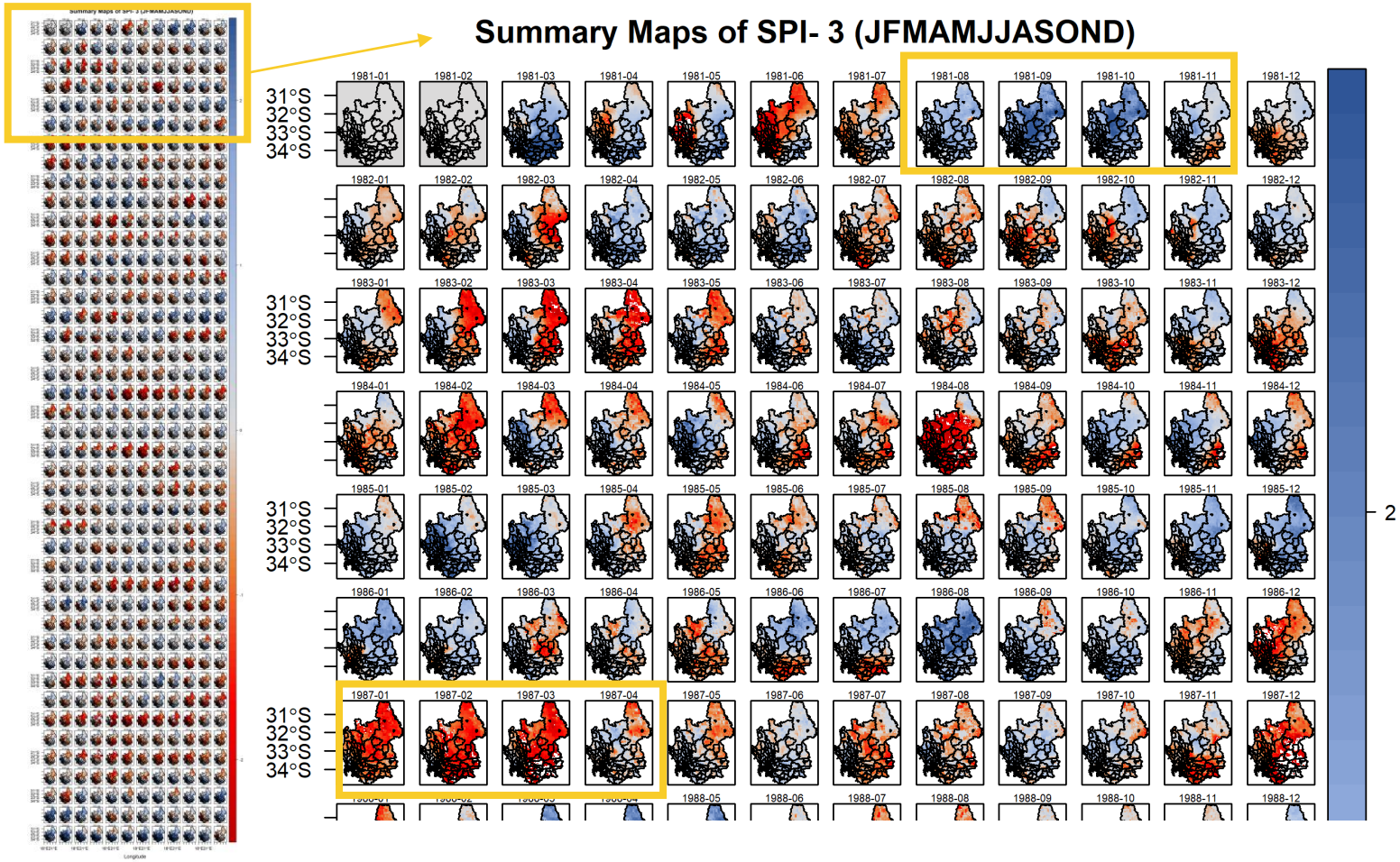
The images show examples of **SPI-3** results for the periods relative to **March** (**including two previous months**) of the years 2007 and 2022.
The first (SPI03 2007.03.01) shows **strong negative anomalies over most of the communes in the area**: the more intense the **red colour**, the more **severe** the **drought**.
The map for **March 2022** shows the **opposite behaviour** (very wet) when compared with the long-term average rainfall.





SPI - Standard Precipitation Index

OUTPUTS - INTERPRETATION



This image is a summary of the SPI-3 images generated by E-Nexus.
Users can select the number of months (for example focusing on regional period of rainy seasons) of their interest and quickly see the pattern of droughts over the period 1981 to 2023.
Objective → to quickly see positive or negative anomalies.

In this example, the **SPI 3** is showed for all months
1981 is highlighted with negative anomalies, **drier than normal, while 1987 starting months are characterized by a positive anomaly, with more abundant precipitation.**

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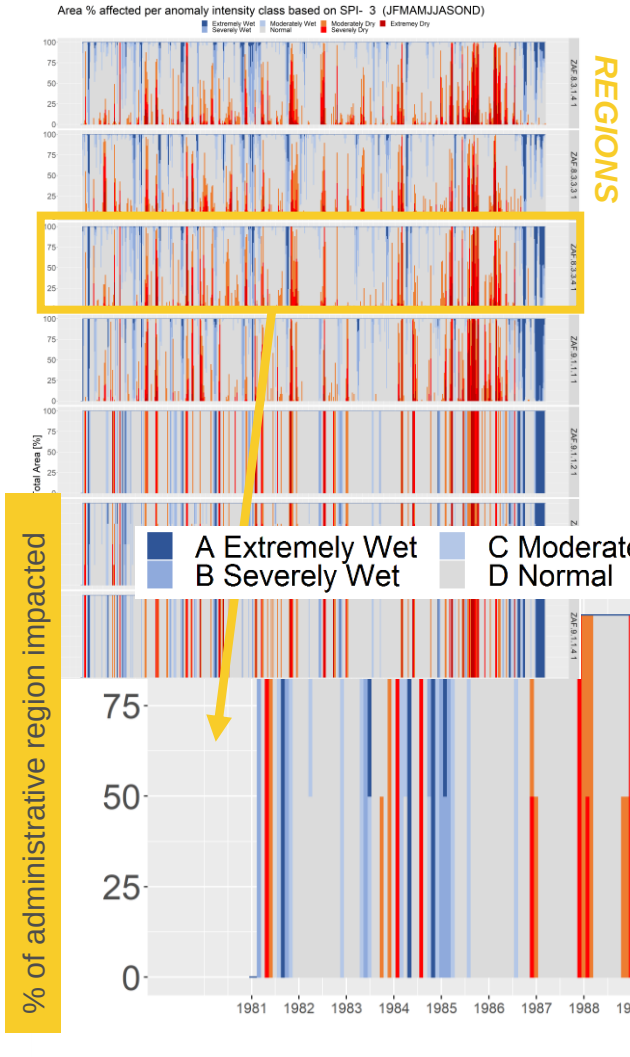
SPI - Standard Precipitation Index

OUTPUTS - INTERPRETATION



Objective: This graph shows the **sensitivity of selected regions of the area to precipitation anomalies** (SPI3).

This image represents the same SPI3, giving an overall view of the **percentage of the surface of each region affected by each category of anomaly**.

The example of GADM lev4 region in South Africa (ZAF.91171 – Breede Valley) is shown.
In 1998, the **majority of this region was affected by general drought conditions** throughout the period analysed, with extremely severe peaks. Conversely, there was a particularly **abundant rainfall recurrence in 1990 (and 2022)**, when a large part of the area experienced extremely wet conditions (2).

Thank you

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