DROUGHT MONITORING

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Material for practical on Drought monitoring

Introduction:

The goal of this exercise is to introduce some methods in drought analysis and drought monitoring. In the first part of this exercise, you will first analyze the spatial and seasonal variation in precipitation. Afterwards, you will analyze the Standardized Precipitation Index (SPI) variations to investigate droughts on a global scale. In the second part, you will use the given precipitation (P), soil moisture (SM) and evapotranspiration (ET) data to calculate the anomalies to analyze the trends in monthly P, SM, ET times series. This analysis gives you an idea on how these data sets can be used for drought analysis.

Exercise steps:

Part 1.

- Analyze the spatial and seasonal variation in time series of precipitation.
- Analyze droughts using SPI indices on a global scale.

Part 2.

- Calculate soil moisture and precipitation anomalies.
- Analyze trends in time series of P, SM, ET.

Data sets

a) Precipitation from GPCP (Global Precipitation Climatology Project (version 2018)

- Monthly total precipitation
- Spatial coverage: global
- Temporal coverage: January 1987 to December 2016
- Spatial resolution:2.5°
- Unit: mm/month

b) **Pre-processed SPI for various time scales (1,3,6 and 12 months)**
SPI was calculated using the GPCP data (1987 – 2010) based on the algorithm developed by (McKee, Doesken et al. 1993).

SPI =(P-P(mean))/P(std)

P = *precipitation of a specific month.*
P(mean) = *mean long term precipitation of a specific month*
P(std) = standard deviation of long term precipitation of a specific month

The monthly precipitation P for a certain time scale was initially normalized using the Gamma distribution function. The SPI was calculated for each of the time scales (1,3,6,12 months) for the period 1987-2016.

According to McKee, a drought event occurs any time the SPI is continuously negative and reaches an intensity of -1.0 or less, and the event ends when the SPI becomes positive.

c) Soil moisture data simulated by GLDAS Noah land surface model

- Monthly average layer 1 (0-10cm) soil moisture data

- Spatial coverage: China
- Temporal coverage: January 2003 to December 2010
- Temporal resolution: monthly average
- Spatial resolution: 0.25°
- Unit: mm

d) SEBS-based evapotranspiration time series
- Monthly total evapotranspiration time series estimated by SEBS model
- Spatial coverage: China
- Temporal coverage: January 2003 to December 2010
- Spatial resolution: 0.1°
- Format: an image list with 96 bands/maps, one for each month. Floating points.
- Unit: cm/month

Software

- ILWIS
- Excel

Exercise Steps

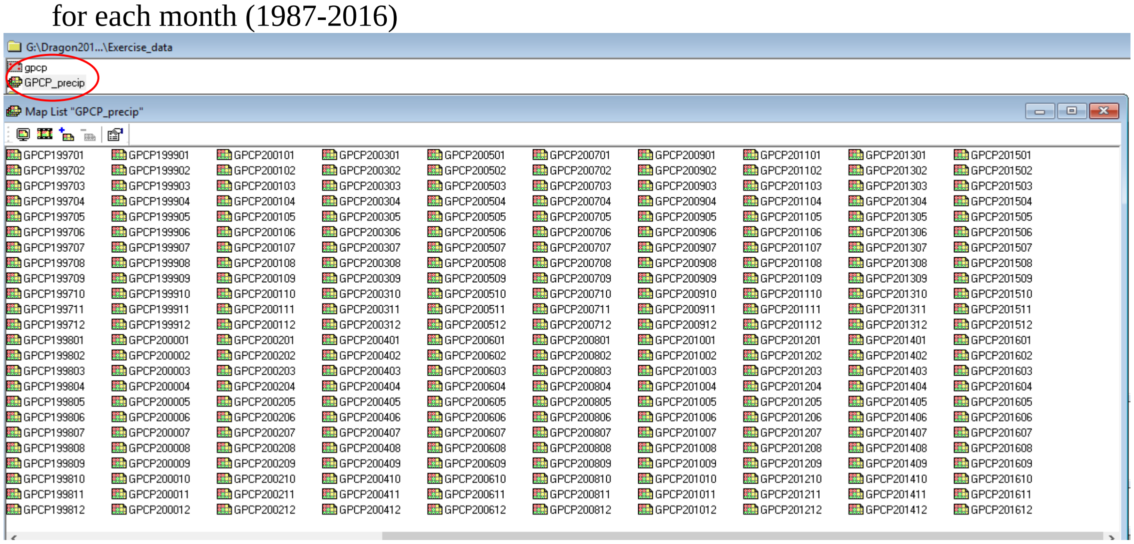
Part 1.

Start ILWIS and navigate to the exercise folder (e.g. D:\data\exercise_data).
Note that always use this folder as your working directory for the exercise.

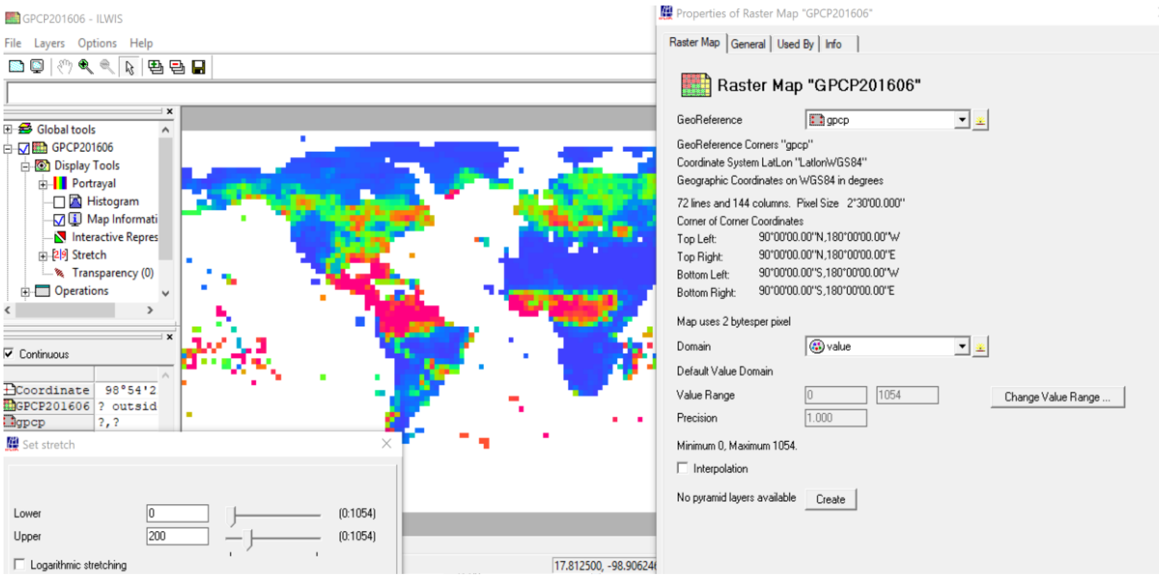
1.1) Analyze the spatial and seasonal variation in time series of precipitation

Data: P monthly from GPCP (1987-2016)

a) Open the GPCP_precip maplist, there will be 360 precipitation monthly images, one image for each month (1987-2016)

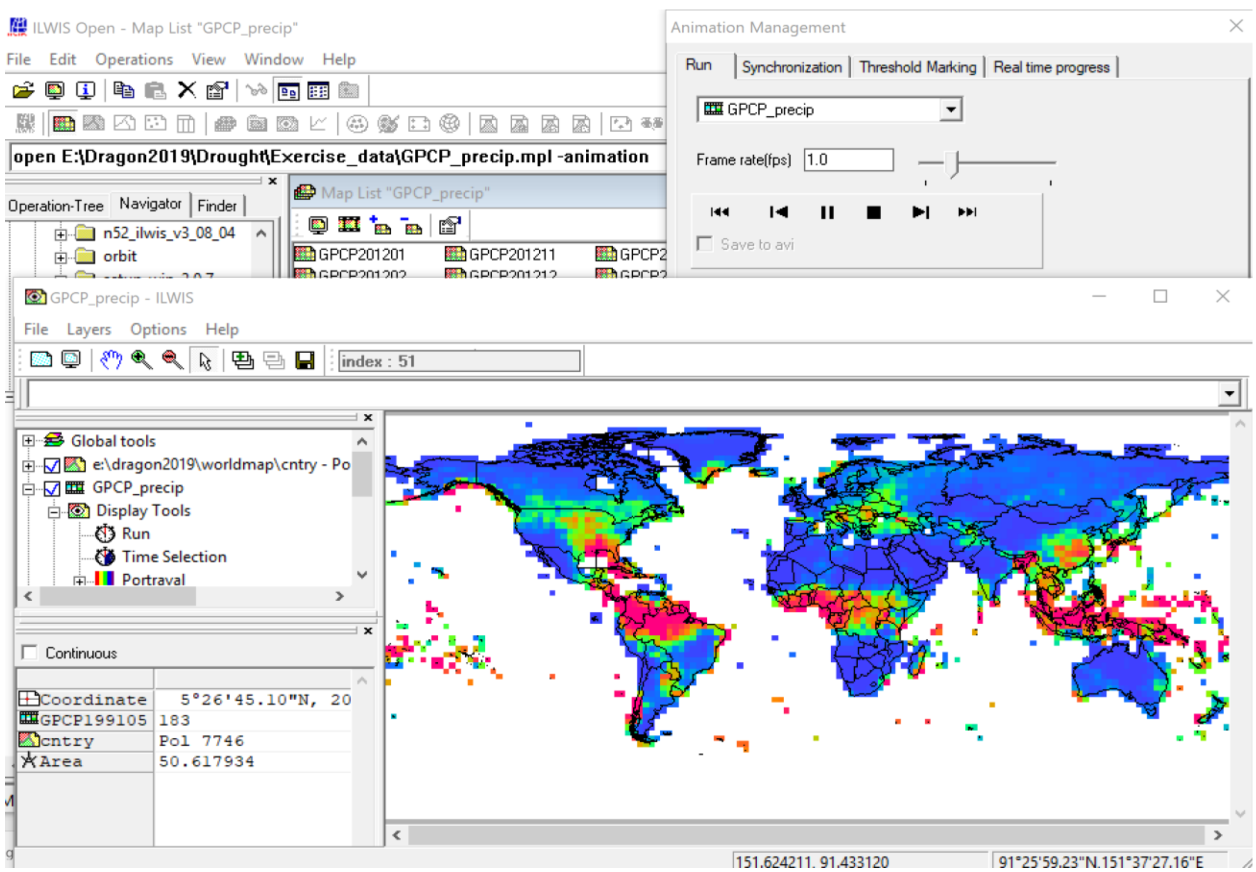


b) Open at least one image to understand value ranges, image size and resolution.



c) Display the time series as animation and examine the spatial and temporal variations of precipitation.

- Right on maplist GPCP_precip. Go to Open as animation.
- Click on "Run ". Animation Manage window will appear, leave the settings as they are and click "Run".
- Now examine the spatial and temporal variations of precipitation in different areas carefully.

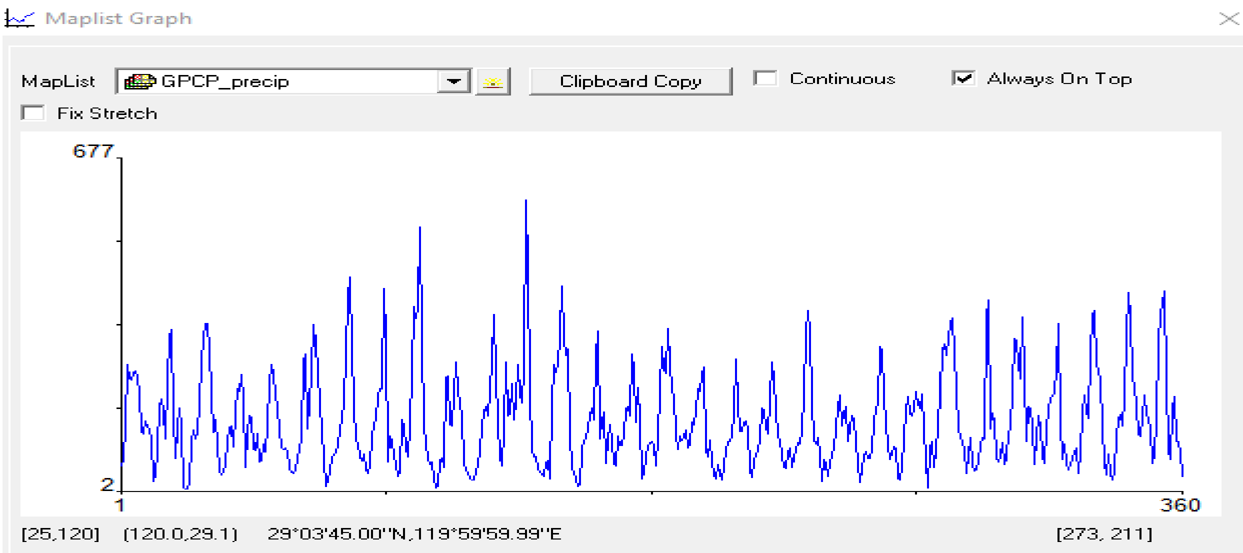


d) Analyze seasonal variation of precipitation (Maplist > Statistics > Maplist Graph)

- Open one of the monthly precipitation (P) maps.
- Move the cursor over the P monthly map.
- Plot the precipitation time series for specific different areas.
- Examine the changes carefully in Maplist Graph. The maplist graph shows the temporal behavior in P for pixel/area you click.

At the bottom right of the display window, you can read the image coordinates and the geographic coordinates of the pixel. Take note of them (as you are going to use these data also for the successive steps).

⇒ Can you explain the different precipitation behaviour taking into account the different geographic locations?



Rainfall distribution for a selected location (1987-2016)

- Select Clipboard Copy and copy all the information in to an Excel file.
- Plot the precipitation values and determine the trend.

⇒ Does the product shows a seasonal trend?

- Choose different locations, then plot the temporal behavior, and compare them.

⇒ Is there a variation in the trend when you change the observation area?

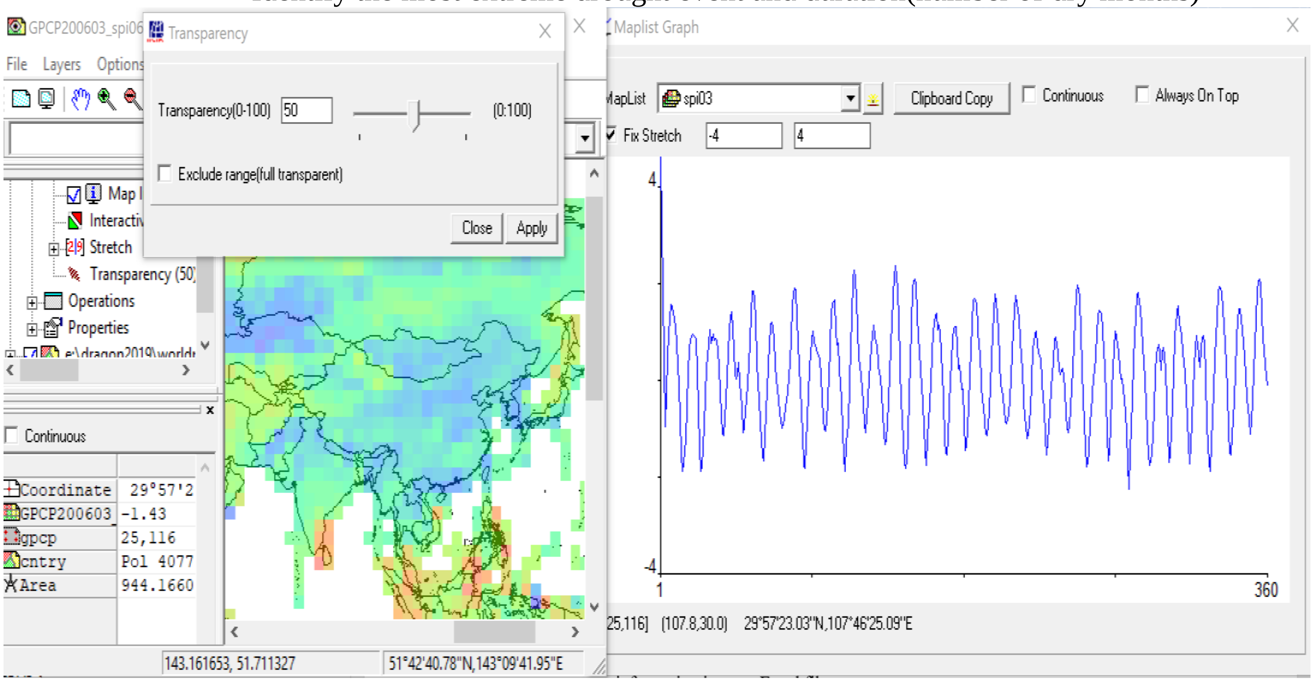
1.2) Analyze SPI indices for drought analysis (1987-2016)

Data: SPI for 4 time scales (1,3,6 and 12 months), spi01, spi03,spi06,spi12.

According to McKee, a drought event occurs any time the SPI is continuously negative and reaches an intensity of -1.0 or less, and the event ends when the SPI becomes positive.

a) Observe the spatial and temporal variations of the SPI06, using time series show, maplist graphs for two specific locations (e.g. places you suspect to have drought).

- Plot the SPI06 time series
- Investigate drought occurrence
- Identify the most extreme drought event and duration(number of dry months)



Monthly SPI (spi06) temporal behavior

b) Linear trend analysis for the SPI06 time series

- In the maplist graph window, click on "Clipboard Copy" and copy all the information in to an Excel file.
- Plot the linear trend and the temporal SPI06 values over time

⇒ Is the slope of the linear trend significant different from zero?

⇒ What can you conclude from these trends?

- Repeat the same steps for spi01, spi03,spi12, for the same pixel, plot them together with the temporal trend of the SPI06 and compare them.
- Compute the linear trend for the SPI data sets.

SPI	*Linear trend equation*	*R^2*
1-month		
3-months		
6-months		
12-months		

⇒ Do you see significant differences between the SPIs (1,3,6,12 months)?

⇒ What can you conclude from these trends?

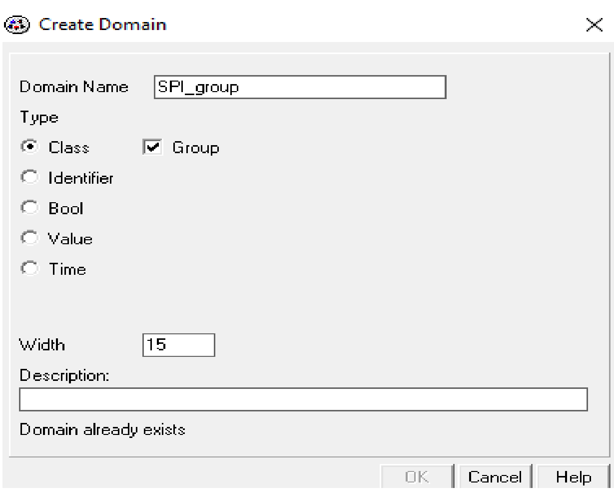
⇒ If you repeat the same comparison of different places, can you arrive at the same conclusion?

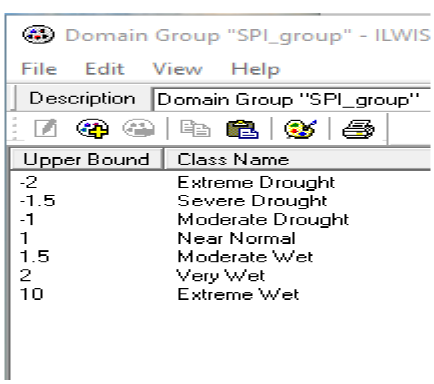
c) Classify SPI values and identify the spatial extent of drought
In this exercise, drought intensity is divided into seven classes :

SPI values	*Drought Class*
-2 or less	*extreme drought*
-2 – -1.5	*severe drought*
-1.5 – -1	*moderate drought*
-1 – 1	*near normal*
1 – 1.5	*moderate wet*
1.5 – 2	*very wet*
2 and above	*extremely moist*

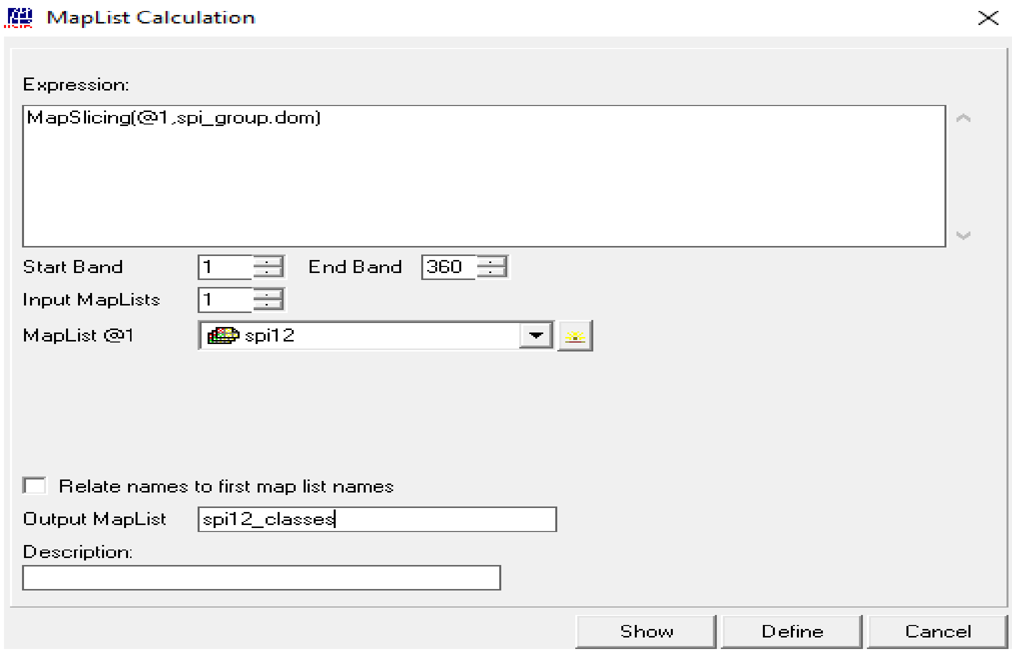
You will classify the SPI values using the Slicing function. Slicing classifies the values of a raster map. Ranges of values of the input map are grouped together into one output class. A domain Group should be created beforehand; it lists the upper boundaries of the groups and the group names.

- Create a domain (File > Create > Domain)
- Set up the parameters as shown in the figure below

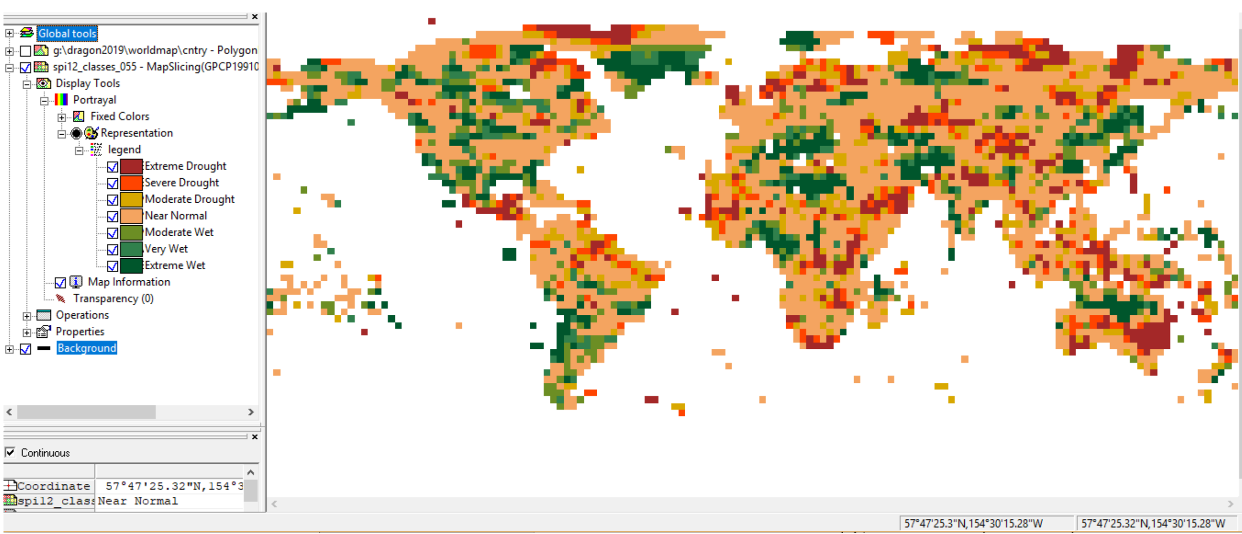




- Go to Operations > Raster operations > Maplist Calculation
- Specify the parameters as shown in the figure below and click on "Show"



- After these steps, a list of the classified maps will appear. Open the newly created image to understand the values.
- Display the time series as animation and identify the drought areas. observe the spatial extent of drought.



Example the classified SPI (SPI12) values

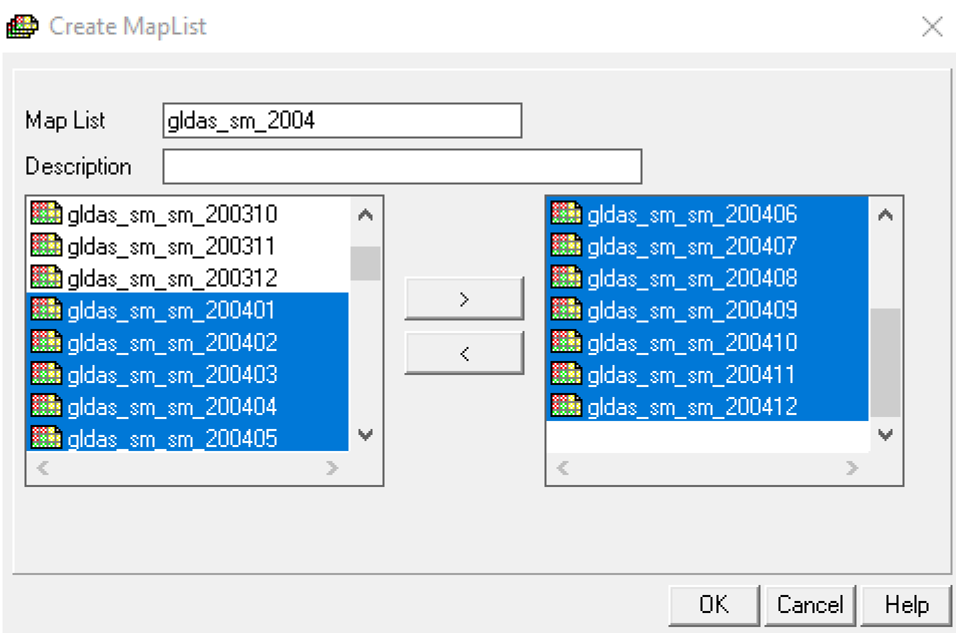
- Repeat the same steps for the classification of the SPI with other time scales (1,3,6-months) and compare the results.

Part 2.

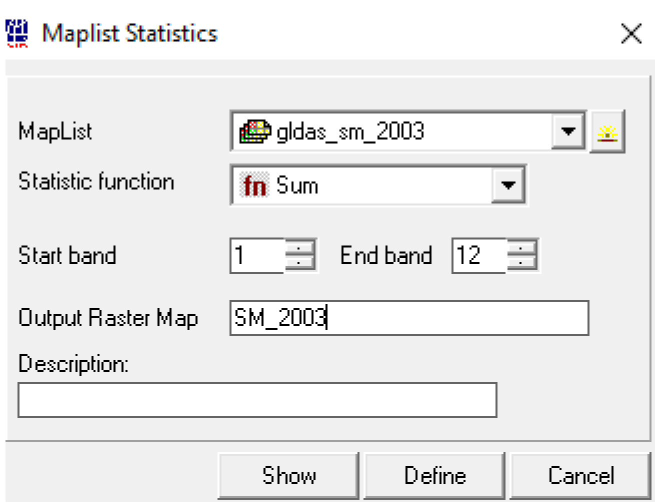
2.1) Compute anomalies

Data : Precipitation (P) monthly from GPCP (2003-2010)
Soil moisture (SM) monthly from GLDAS (GLDAS_SM 2003-2010)

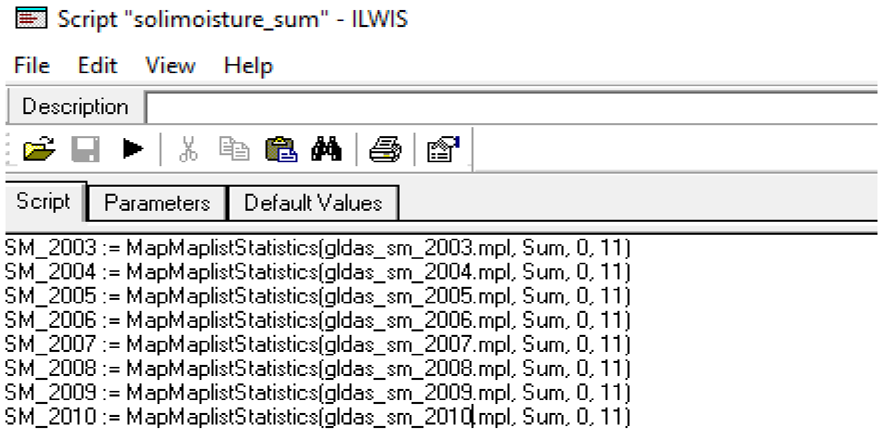
a) Compute the yearly average and anomalies of the SM from 2003 to 2010 (each year)
   - Create SM maplists separately for each year from the monthly SM maps.
     File menu > Create menu > Script …



   - Calculate the yearly SM for each year (Operations>Statistics>Maplist>Maplist Statistics)



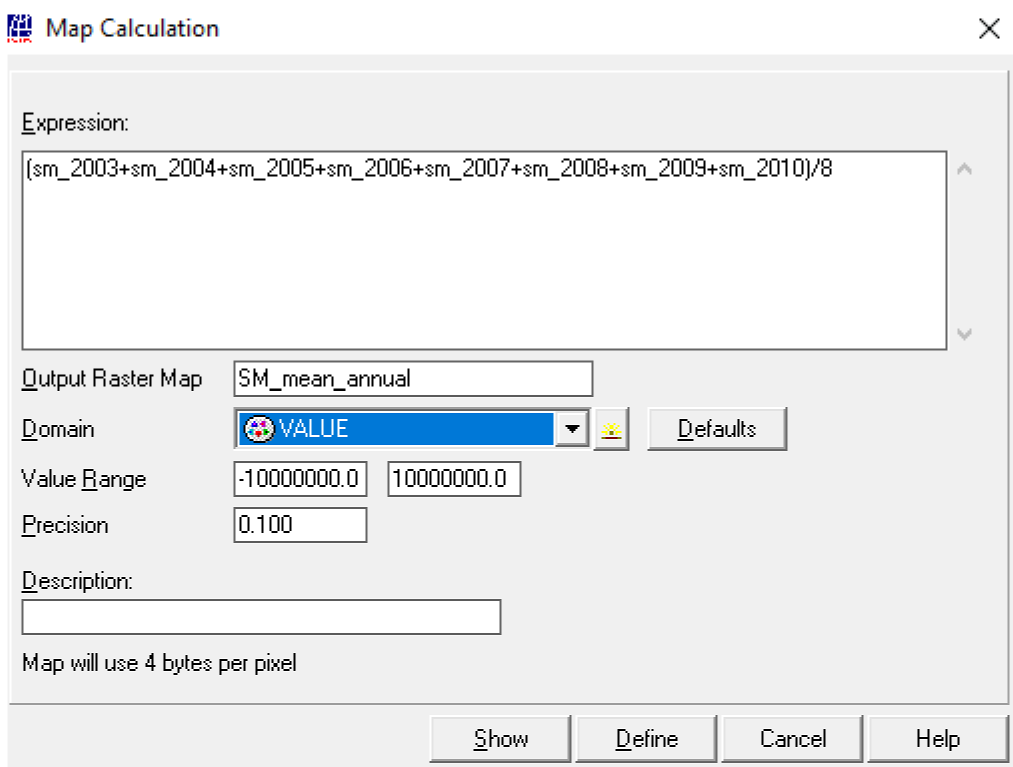
Hint: you can create scripts as below to make it faster!



- Compute the average of all the yearly values(2003-2010)
  Using ILWIS command line

  SM_mean_annual= (sm_2003+sm_2004+sm_2005+sm_2006+sm_2007+sm_2008+sm_2009+sm_2010)/8

  Or using ILWIS “Map Calculation”

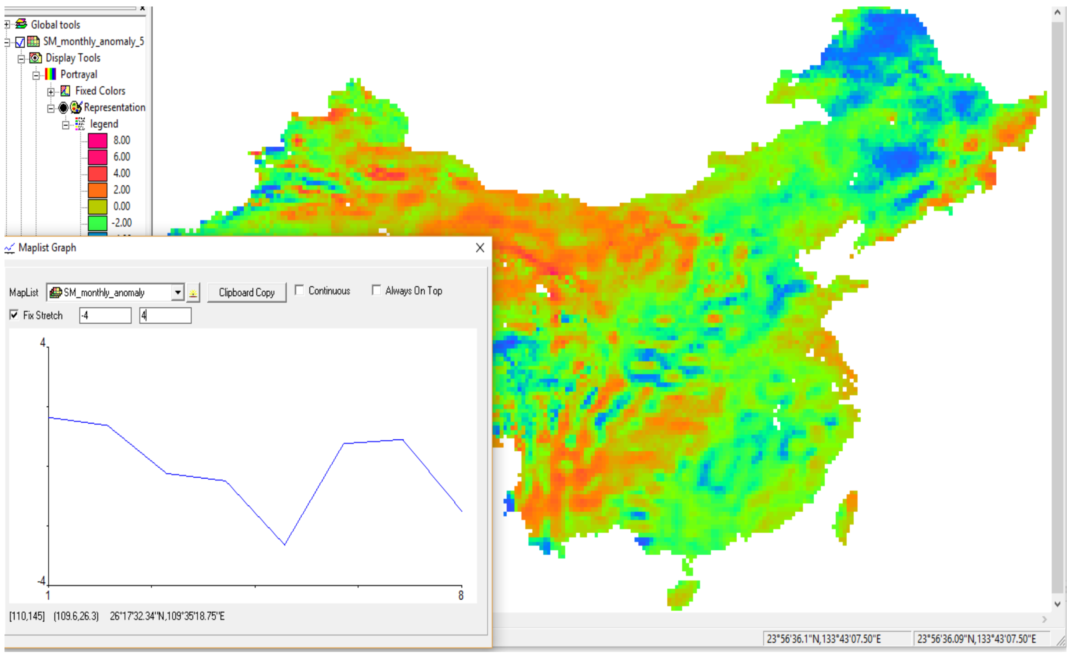


- Compute the anomalies subtracting the yearly average from each yearly image (using ILWIS command line)

SM_anomaly_2003 = SM_2003 - SM_mean_annual
SM_anomaly_2004 = SM_2004 - SM_mean_annual
…
…
Hint: you can make scripts to make it fast!

- Create an image list containing all the SM anomaly maps calculated (named for example, SM_anomaly.mpl).

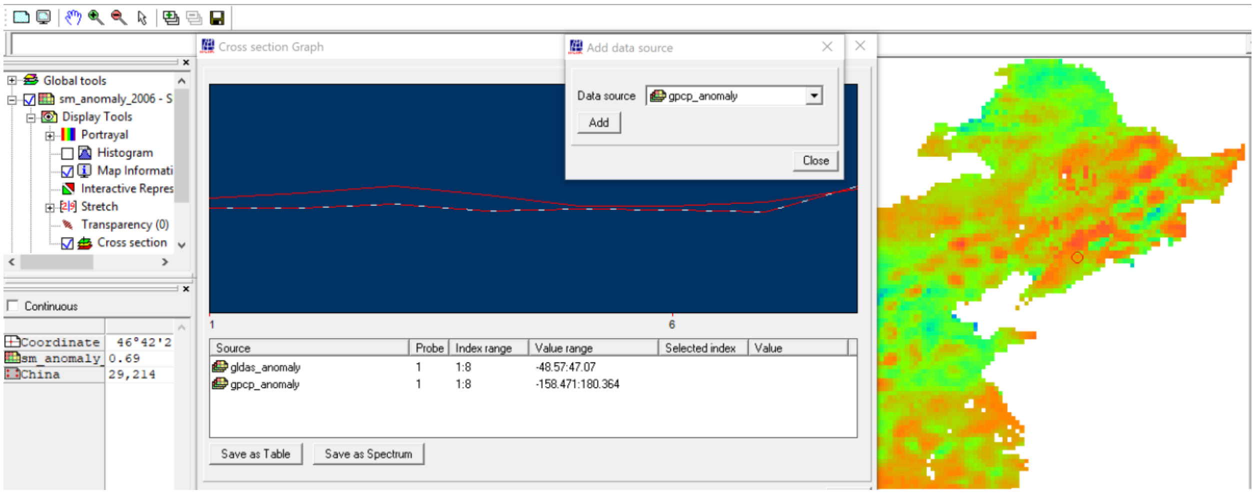
- Plot the SM anomalies time series and observe the spatial and temporal changes.



b) Compute the year average and anomalies of precipitation, as done for SM time series in step 3.a) (named P anomalies for example, P_anomaly.mpl)

2.2) Analyze trends in time series of P, SM, ET

- Open one of the SM anomaly map, right click on the Display Tools in the left panel of the display window and select the Cross Section.
- Add the maplists SM_anomaly.mpl, and maplist P_anomaly.mpl in the "Add data source" window that appears.
- Move the cursor over the SM map, observe the changes in Cross section graph window. The Cross section graph shows the temporal behavior of SM anomalies together with the P anomalies.



- In the cross section graph, click on Save as Table, and plot the graph as shown in figure below

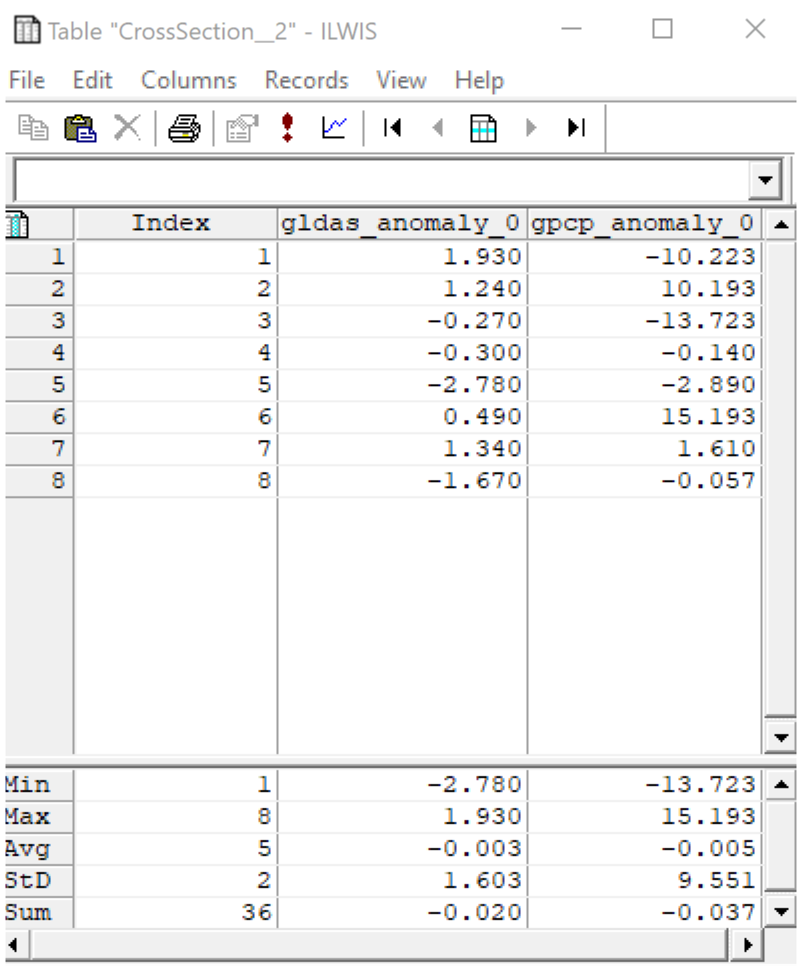
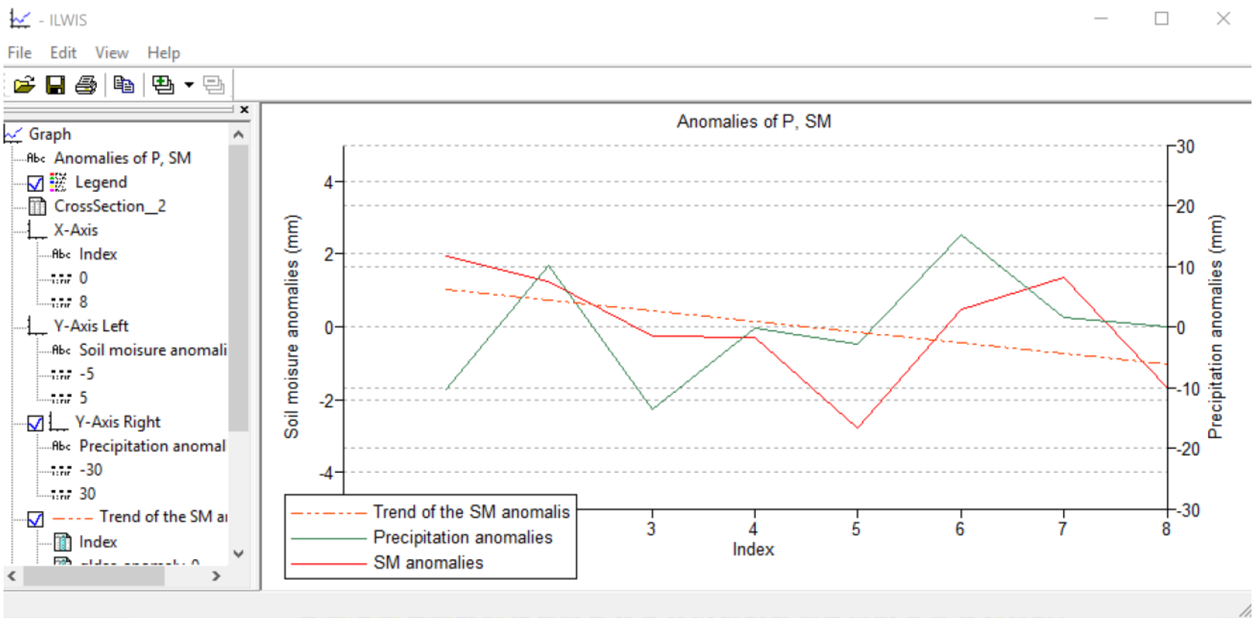


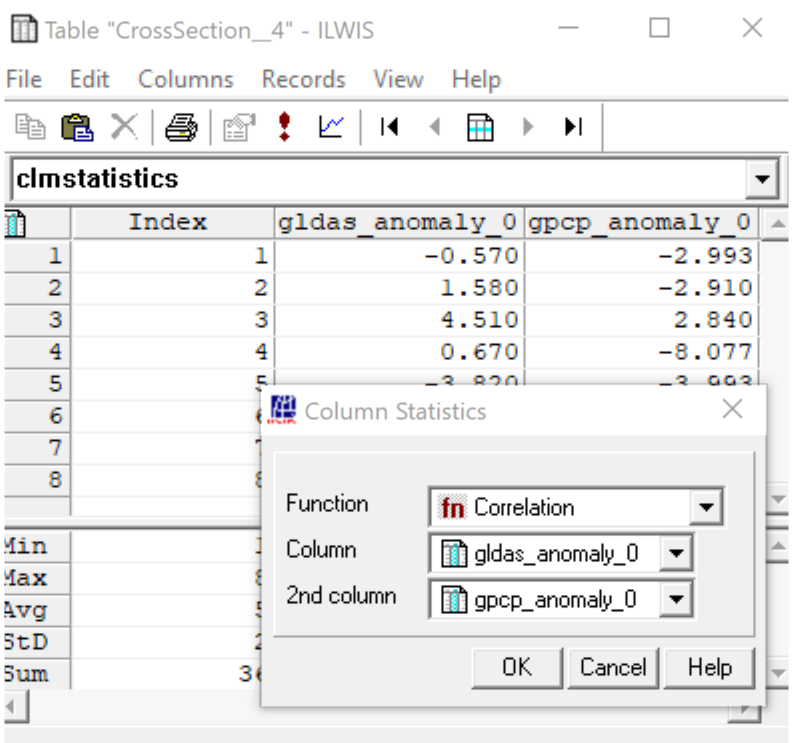
Table "CrossSection__2" - ILWIS

File Edit Columns Records View Help

	Index	gldas_anomaly_0	gpcp_anomaly_0
1	1	1.930	-10.223
2	2	1.240	10.193
3	3	-0.270	-13.723
4	4	-0.300	-0.140
5	5	-2.780	-2.890
6	6	0.490	15.193
7	7	1.340	1.610
8	8	-1.670	-0.057
Min	1	-2.780	-13.723
Max	8	1.930	15.193
Avg	5	-0.003	-0.005
StD	2	1.603	9.551
Sum	36	-0.020	-0.037



- Compute correlation between SM an P data (Column > Statistics



⇒ Do you see a correlation between GLDAS soil moisture and precipitation data?

⇒ Is there a variation in the trend when you change the observation area?

Note
In addition SEBE based ET time series are available in case that you want to correlate this to P and SM.