SWIM and Horizon 2020 Support Mechanism

Working for a Sustainable Mediterranean, Caring for our Future

REG-7: Training Session #1: Drought Hazard Monitoring Example from real data from the Republic of Cyprus. Plenary: Explanation of the Breakout Sessions

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Objectives of the Training

- **Rainfall data quality assessment.**
- **Introduction to DrinC and WMO software programs.**
- **Drought Hazard indices based on precipitation and evapotranspiration.**
- **Drought Hazard indices based on runoff series.**
- **Drought identification and characterization.**

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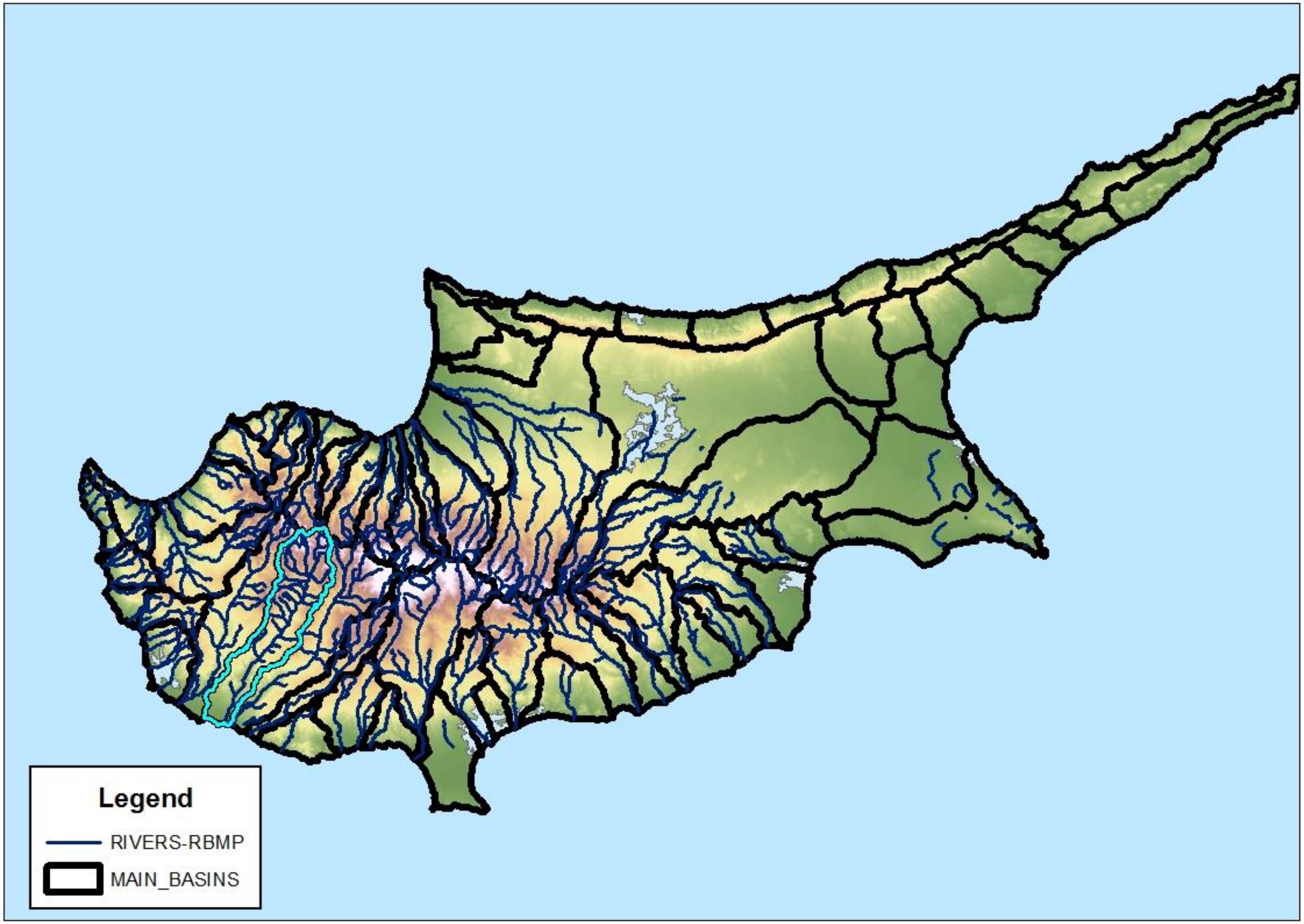
Geographical Area: Xeros Catchment in the Republic of Cyprus



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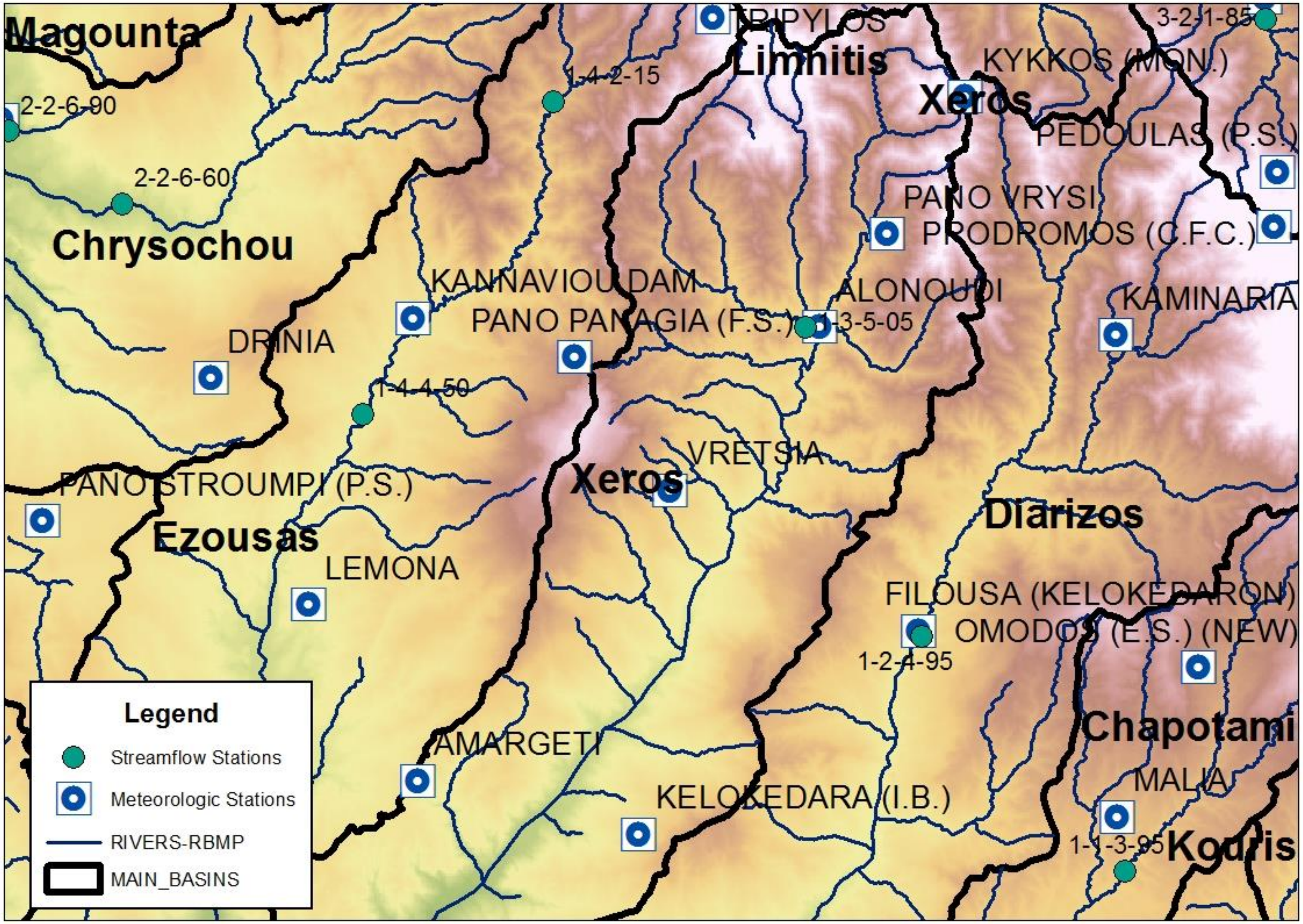

QUALITY CHECK FOR RAINFALL DATA

Level of aggregation: Understand your primary data. The original time step (daily, accumulated across days with rainfall) and construct monthly timeseries. Decide on the time frame duration according to data availability.

- Outliers: Outliers are data that are higher than the value defined as the average plus (often) two times the standard deviation of the sample. The outliers are not necessary erroneous, check for data.
- Correlation matrix: Correlation matrix between all annual and monthly rainfall values between all stations. Check for rainfall stations with constant low correlation values especially with the adjacent stations.

QUALITY CHECK FOR RAINFALL DATA (cont.)

- Correlation matrix: Correlation matrix between all annual rainfall and monthly values between all stations. Define rainfall stations with constant high correlation values especially with the adjacent stations. Select the ones as base stations.
- Double Mass Curves: Perform double mass curves analysis to further evaluate data consistency in rainfall stations.
- Understand reasons for inconsistency: For rainfall station with certain fashion of inconsistency, check the station’s log for certain changes (e.g. change of the rain recorder).

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QUALITY CHECK FOR RAINFALL DATA (cont.)

- Data gap filling: The base stations should have all datasets filled for all months of the finally selected time analysis. Certain, sparse, gaps can be filled according the correlation equation.
- Data extension: Reliable rainfall station with time of operation less than the defined one can be extended to the required one according to the correlation analyses.
- Define the altitude rainfall lapse rate: For the computation of the surface rainfall, the rate of change between rainfall and elevation must be defined with satisfactory correlation coefficients.

ASSIGNMENT RAINFALL DATA

- TASK #1: Analyze rainfall data for both rainfall stations (outliers, double mass curve, correlation analysis, etc.).
- TASK #2: Gap filling of AMARGETI station for hydrologic years 2008-09 to 2013-14 based on PANAYIA PANO data.

Potential Evapotranspiration

COMPUTATION OF THE POTENTIAL EVAPOTRANSPIRATION

- Quality Check of the associated data: Data for PET are often vast and demanding. Temperatures, relative humidity, wind speed (height of 2m) and sunshine duration, for a satisfactory meteorological stations number for a time duration is rare even in developed countries.
- Variety of Methods: According to necessary data, methods of computing PET can be very complex (e.g. the Penman-Monteith) to very simple (e.g. Blaney-Criddle).

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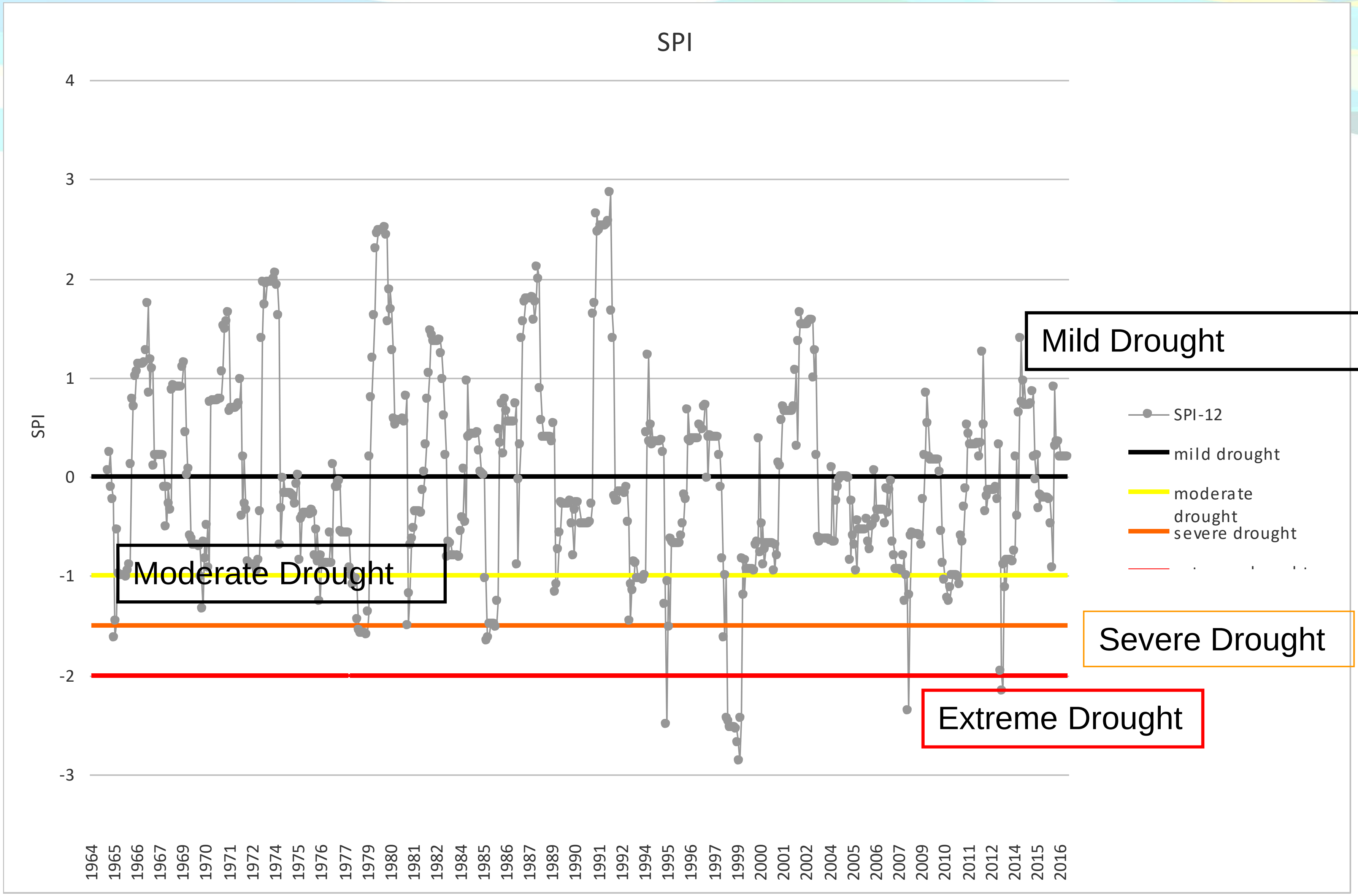
Drought Hazard Indicator based on Rainfall (Standardized Precipitation Index, SPI*n*)

1. Drought Classification according to SPI

SPI values	Classification
2.0 or more	Extremely Wet
1.5 to 1.99	Very Wet
1.0 to 1.49	Moderately Wet
-.99 to .99	Near Normal
-1.0 to -1.49	Moderately Dry
-1.5 to -1.99	Severely Dry
-2 or less	Extremely Dry


SPI
4
3
2
1
0
-1
-2
-3
SPI
1964
1965
1966
1967
1969
1970
1971
1972
1974
1975
1976
1977
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1996
1997
1999
2000
2001
2002
2004
2005
2006
2007
2009
2010
2011
2012
2014
2015
2016
SPI-12
mild drought
moderate drought
severe drought
Mild Drought
Moderate Drought
Severe Drought
Extreme Drought

Drought Hazard Indicator based on Rainfall (Standardized Precipitation Index, SPI*n*

2. Main characteristics of SPI

The SPI calculated in this way has the following desirable traits:

- Soil moisture conditions respond to precipitation anomalies on a relatively short timescale. Groundwater, streamflow and reservoir storage reflect the longer-term precipitation anomalies. So, for example, one may want to look at a 1- or 2-month SPI for meteorological drought, anywhere from 1-month to 6-month SPI for agricultural drought, and something **like 6-month up to 24-month SPI or more for hydrological drought analyses and applications**.
- 1-month SPI: A 1-month SPI map is very similar to a map displaying the percentage of normal precipitation for a 30-day period. In fact, the derived SPI is a more accurate representation of monthly precipitation because the distribution has been normalized. For example, a 1-month SPI at the end of November compares the 1-month precipitation total for November in that particular year with the November precipitation totals of all the years on record. Because the **1-month SPI reflects short-term conditions, its application can be related closely to meteorological types of drought along with short-term soil moisture and crop stress, especially during the growing season.**

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Drought Hazard Indicator based on Rainfall (Standardized Precipitation Index, SPI*n*

3. Main characteristics of SPI

The SPI calculated in this way has the following desirable traits:

• 3-month SPI: The 3-month SPI provides a comparison of the precipitation over a specific 3-month period with the precipitation totals from the same 3-month period for all the years included in the historical record. In other words, a 3-month SPI at the end of February compares the December–January–February precipitation total in that particular year with the December–February precipitation totals of all the years on record for that location. Each year data is added, another year is added to the period of record, thus the values from all years are used again. The values can and will change as the current year is compared historically and statistically to all prior years in the record of observation. A **3-month SPI reflects short- and medium-term moisture conditions and provides a seasonal estimation of precipitation.** In primary agricultural regions, a 3-month SPI might be more effective in highlighting available moisture conditions

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Drought Hazard Indicator based on Rainfall (Standardized Precipitation Index, SPI*n*

4. Main characteristics of SPI

The SPI calculated in this way has the following desirable traits:

- 6-month SPI: The 6-month SPI compares the precipitation for that period with the same 6-month period over the historical record. For example, a 6-month SPI at the end of September compares the precipitation total for the April–September period with all the past totals for that same period.

The 6-month SPI indicates seasonal to medium-term trends in precipitation and is still considered to be more sensitive to conditions at this scale than the Palmer Index. A 6-month SPI can be very effective in showing the precipitation over distinct seasons. For example, a 6-month SPI at the end of March would give a very good indication of the amount of precipitation that has fallen during the very important wet season period from October through March for certain Mediterranean locales. **Information from a 6-month SPI may also begin to be associated with anomalous streamflows and reservoir levels, depending on the region and time of year.**

Drought Hazard Indicator based on Rainfall (Standardized Precipitation Index, SPI*n*

5. Drought definition according to SPI

According to the SPI, **a drought event occurs when the index continuously reaches an intensity of -1.0 or less**. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and intensity for each month that the event continues.

Drought magnitude is the positive sum of the SPI for each month during the drought event.

ASSIGNMENT ON SPI ANALYSIS

- TASK #1: Analyze SPI (SPI1, 3, 6, 12) for Pano Panayia Rainfall Station with the WMO model from the hydrologic year 1916-17. Search for the drought periods and compute the drought severity and magnitude. Compare different drought periods.
- TASK #2: Analyze SPI (SPI1, 3, 6, 12) for Pano Panayia Rainfall Station with the WMO model from the hydrologic year 1972-73. Compare the results with the previous task.

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Reconnaissance Drought Index (RDI)

2. Calculation

The values of α_k follow satisfactorily both the lognormal and the gamma distributions in a wide range of locations and different time scales, in which they were tested (Tigkas 2008; Tsakiris et al. 2008). By assuming that the lognormal distribution is applied, the following equation can be used for the calculation of RDIst:

$$RDI_{st}^{(i)} = \frac{y^{(i)} - \bar{y}}{\hat{\sigma}_y}$$

in which $y^{(i)}$ is the $\ln(\alpha_k^{(i)})$, y is its arithmetic mean and σ_y is its standard deviation.

In case the gamma distribution is applied, the RDIst can be calculated by fitting the gamma probability density function (pdf) to the given frequency distribution of αk (Tsakiris et al. 2008; Tigkas 2008). For short reference periods (e.g. monthly or 3-months) which may include zero values for the cumulative precipitation of the period, the RDIst can be calculated based on a composite cumulative distribution function including the probability of zero precipitation and the gamma cumulative probability.

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Reconnaissance Drought Index (RDI)

3. Categorization

Positive values of RDIst indicate wet periods, while negative values indicate dry periods compared with the normal conditions of the area. Drought severity can be categorised in mild, moderate, severe and extreme classes, with corresponding boundary values of RDIst (-0.5 to -1.0), (-1.0 to -1.5), (-1.5 to -2.0) and (< -2.0), respectively.

RDI values	Classification
2.0 or more	Extremely Wet
1.5 to 1.99	Very Wet
1.0 to 1.49	Moderately Wet
-.99 to .99	Near Normal
-1.0 to -1.49	Moderately Dry
-1.5 to -1.99	Severely Dry
-2 or less	Extremely Dry

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ASSIGNMENT ON RDI ANALYSIS

TASK #1: Analyze RDI (RDI1, 3, 6, 12) for AMARGETI Rainfall Station with the DrinC model from the hydrologic years 1991-92 to 2007-08. Search for the drought periods and compute the drought magnitude. Compare different periods with droughts.

- TASK #2: Analyze SPI (SPI1, 3, 6, 12) for AMARGETI Rainfall Station with the DrinC model for the hydrologic years 1991-92 to 2007-08. Compare the results with the previous task.

Streamflow Drought Index (SDI)

1. Introduction

According to Nalbantis (2008), if a time series of monthly streamflow volumes $Q_{i,j}$ is available, in which i denotes the hydrological year and j the month within that hydrological year (j = 1 for October and j = 12 for September), $V_{i,k}$ can be obtained based on the equation:

2. Calculation

$$V_{i,k} = \sum_{j=1}^{3k} Q_{i,j} \quad i = 1, 2, \ldots \quad j = 1, 2, \ldots, 12 \quad k = 1, 2, 3, 4$$

in which Vi,k is the cumulative streamflow volume for the i-th hydrological year and the k-th reference period, k = 1 for October-December, k = 2 for October-March, k = 3 for October-June, and k = 4 for October-September.

Based on the cumulative streamflow volumes Vi,k, the Streamflow Drought Index (SDI) is defined for each reference period k of the i-th hydrological year as follows:

Streamflow Drought Index (SDI)

2. Calculation

$$\mathrm{SDI}_{i,k} = \frac{V_{i,k} - \overline{V}_k}{s_k} \quad \mathrm{i} = 1, 2, \ldots, \quad \mathrm{k} = 1, 2, 3, 4$$

in which V_k and s_k are respectively the mean and the standard deviation of cumulative streamflow volumes of the reference period *k* as these are estimated over a long period of time.

According to Nalbantis and Tsakiris (2009), states (classes) of hydrological drought are defined for SDI in an identical way to those used in the meteorological drought indices SPI and RDI. Five states are considered, which are denoted by an integer number ranging from 0 (non-drought) to 4 (extreme drought) and are defined through the criteria

State	Description	Criterion
0	Non-drought	SDI $\geq$ 0.0
1	Mild drought	- 1.0 $\leq$ SDI < 0.0
2	Moderate drought	- 1.5 $\leq$ SDI < - 1.0
3	Severe drought	- 2.0 $\leq$ SDI < - 1.5
4	Extreme drought	SDI < - 2.0

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Measures within a Drought Risk Management Plan (DRMP)

ASSIGNMENT ON SDI ANALYSIS

•TASK #1: Analyze SDI (SDI1, 3, 6, 12) for r1-3-5-05_ Xeros Station with the DrinC model from the hydrologic year 1970-71. Search for the drought periods. Compare different periods with droughts. Compare the results with the meteorological drought indices.

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Thank you for your attention.

This Project is funded by the European Union