Use of the multiple time scales SPI index for monitoring and forecasting drought events over Mediterranean Basin

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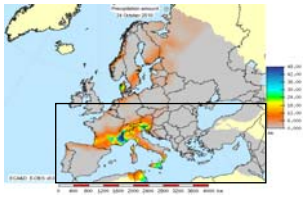
INTRODUCTION

Since last decade, water availability has been identified as one of the main problem affecting earth population. Some areas within the Mediterranean Basin, are interested by an increasing reduction of available water resources that caused a progressive enhancement vulnerability of those zones especially caused by dry events. For this reason, the study and the monitoring of climatic situation and its evolution over those areas is of primary importance in order to reach a sustainable management of the natural resources. Drought, in particular, is a recurrent feature of climate and can affects areas with different climate regimes; its impacts depend on the duration, intensity and extent of precipitation deficiency and on the interaction between this extreme event and water demand for several purposes.
In this study the SPI-Standardized Precipitation Index (McKee et al., 1993) is computed in order to evaluate trends of drought events over the Mediterranean Basin, interested by an increasing reduction of available water resources, for multiple time scales (3, 6, 12 months). This index is particularly suitable both because it requires only precipitation data and the standardization of the values permits a comparison between areas climatically and geographically different. The number of drought occurrences over a long period is investigated for each SPI time scale, giving information on the distribution and evolution of these extreme events.
Moreover the SPI_3 is used for seasonal forecasts that try to predict, in a statistical framework, the spatial and temporal distribution of weather anomalies a few months into the future. Even though the detailed dynamical evolution of atmospheric systems is not predictable on those time scales, some of their statistical features and behaviors can be predicted. In particular it is possible to infer on the average behavior over a month or season, and how much the probability distribution of such averages, or anomalies, differs from the "climatology".

SPI COMPUTATION

To obtain a spatiotemporal homogeneity of the SPI-Standardized Precipitation Index, the analysis is carried out using daily E-OBS (Ensamble Observational) gridded precipitation dataset from the ECA&D (European Climate Assessment & Dataset) project (Haylock et al., 2008), covering the period from 1950 to February 2012, with a spatial resolution of 0.25 degree lat-lon grid (http://eca.knmi.nl) and focused over Mediterranean Basin.
The 3, 6, and 12 months SPI is computed, in order to highlight the evolution of drought events from season to year level.



SPI FREQUENCIES ANALYSIS

Step 1

Negative values of SPI (3-6-12 months) are extracted and grouped in its three intensity classes: moderately dry (-1>SPI>-1.5), severely dry (-1.5>SPI>-2), extremely dry (SPI< -2).
The number of drought events found in each class represent the frequency of occurrences.
As first step, the whole study period is divided in 4 sub-periods of 30 years, with a 10 years moving window method. For each sub-period and intensity class we calculate the number of occurrences.
A linear trend analysis is made computing Pearson correlation coefficient, "r".
To define the significance of correlation we identify a threshold based on the number of sub-periods. In our case, if |1| > "r" Pearson > |0.8114| the correlation is significative.
Hence, the "r" correlation coefficient map is reclassified in three classes, indicating a positive significance (1), a negative significance (-1) or not significance (0).

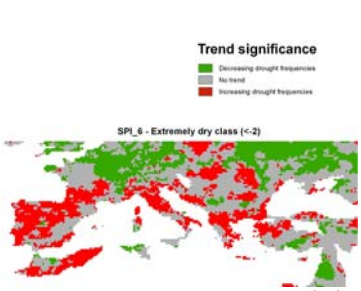


Fig. 1 b

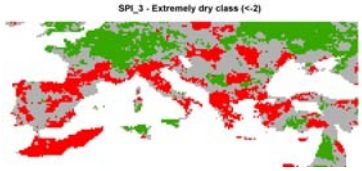


Fig. 1 a

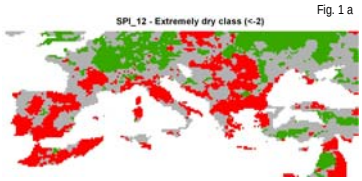


Fig. 1 c

RESULTS 1

This first statistical analysis reveals that, for all SPI time scales, large areas of Mediterranean Basin and central Europe are affected by an increase of drought events, specially those of highest intensity (extremely dry class), as shown in Fig. 1a (SPI_3), Fig. 1b (SPI_6) and Fig. 1c (SPI_12).

Step 2

As a second step, an intra-annual analysis is done for assessing if the intensification of drought phenomenon is focused on seasons of groundwater recharge or during hottest seasons.
To this aim we select, from the SPI_3 months time series, months that cover each season (February, May, August and November).
For each seasonal series we repeat the frequency statistical analysis using the reclassified Pearson correlation coefficient.

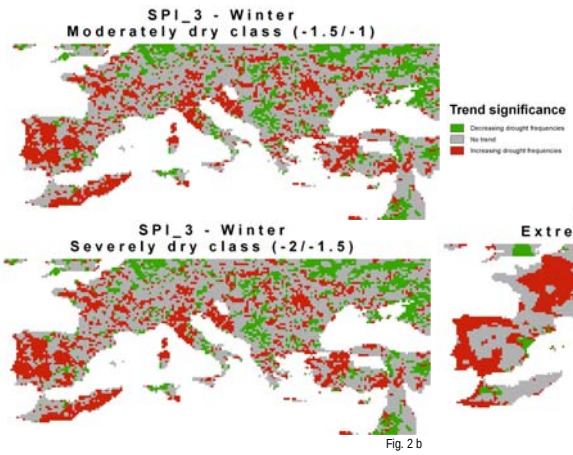


Fig. 2 b

Fig. 2 c

RESULTS 2

At seasonal level winter results the most affected period, revealing a significant increase of dry events over large part of Mediterranean Basin (Figg. 2 a-b-c), once again particularly for the extremely dry class (Fig. 2c).

SPI FORECAST

The Institute of Biometeorology developed a simple, physically–based, statistical approach to obtain monthly outlooks, regarding rainfall anomalies over the Mediterranean basin based on the ECAD-OBS dataset, and in particular on the SPI_3 index. The forecasting strategy is a multi-regressive method based on physical atmospheric indices and sea surface anomalies.
The SPI can be used as a tool for drought forecast; after calculating the 1-month and 3-month SPI, an "adaptive multi-regressive method" is applied to obtain monthly outlooks for the next 1-6 months, selecting potential predictors among a list of physical atmospheric indices and Sea Surface Temperature (SST) anomalies.
Figure 3 shows the SPI_3 forecast for January 2012, based on the 1971-2000 reference period.

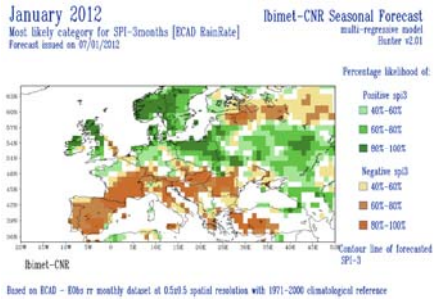


Fig. 3

SUPPORT FOR DROUGHT PREPAREDNESS

Climatological analysis, monitoring and forecast are three crucial elements of a more complex system that should be implemented to support planners and policy-makers to prepare proactive action plans in order to rapidly respond to drought events and SPI can be a good indicator to this aim, due to its applicability to past and present analysis and future outlooks.

REFERENCES

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