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Trend of drought conditions based on meteorological index detection in the Upper Rhone River Basin, Valais, Switzerland

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Drought is a phenomenon resulting from persistent low precipitations that generally affects larger areas and more people than any other natural catastrophes. It is commonly classified as meteorological (rainfall deficiency), agricultural (insufficient soil moisture) and hydrological (deficient surface and subsurface water supply) droughts. Comprehensive hydro-meteorological monitoring of drought requires a variety of indicators and indices that accurately reflect and represent the impacts being experienced during drought events.

Among different available meteorological indices, the Standardized Precipitation Index (SPI) stands out. The SPI (McKee et al. 1993) uses historical precipitation records for a given location and can be easily computed for various timescales, from 1 to 48 months or longer, with different available tools (e.g. Travaglini et al. 2016). Its analysis enables the detection of drought events, thus leading to effective monitoring (Hayes 2011). SPI can be used to identify short periods of precipitation deficiency –related to meteorological droughts– as well as long periods –related to agricultural or hydrological droughts (WMO 2012).

This approach was applied to the Upper Rhone River Basin, located in the Alps upstream of Lake Geneva, in Switzerland. Covering a surface of 5'524 km^2 with 658 km^2 of glaciers, this basin is characterized by elevations varying from 372 to 4'634 meters. Using historical rainfall data from 1981 to 2015, the SPI was calculated for 13 meteorological stations situated within and to the proximity of the basin and for timescales of 1, 6 ,12 and 24 months.

The analysis of the 24 month SPI helped identifying two main consistent dry periods throughout the studied area in 2004-2005 and 2010-2011 (see example of Zermatt in Figure 1). In addition, a trend analysis using the Mann-Kendall test was performed (Figure 2) and showed a general decreasing trend of the SPI values, which indicate the worsening of dryness conditions over the study period. A Mann-Kendall test applied to the meteorological data set also indicates general decreasing of rainfall and increasing of temperature.

Based on meteorological data, the present study reveals a deterioration of climatic conditions from 1981 to 2015 in the Upper Rhone River Basin that may result in drier periods, and even in drought events, in the future. Moreover, demographic, agricultural and climate change may lead to a reduction and over-exploitation of water resources, and further threat of water supply with expected socio-economic and environmental consequences.

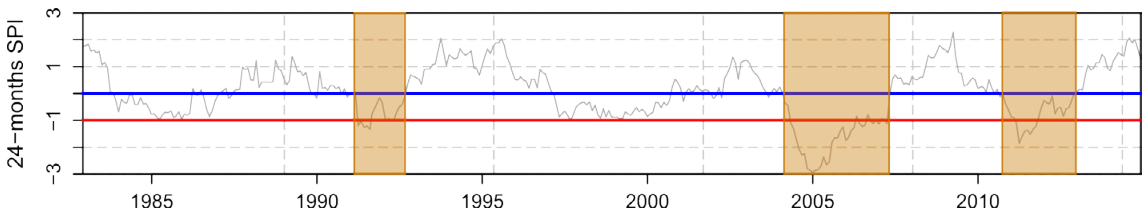

Figure 1. Evolution of SPI values resulting from the Zermatt meteorological station. Red/blue thresholds (McKee et al. 1993) used for the detection of SPI-based droughts (in orange).

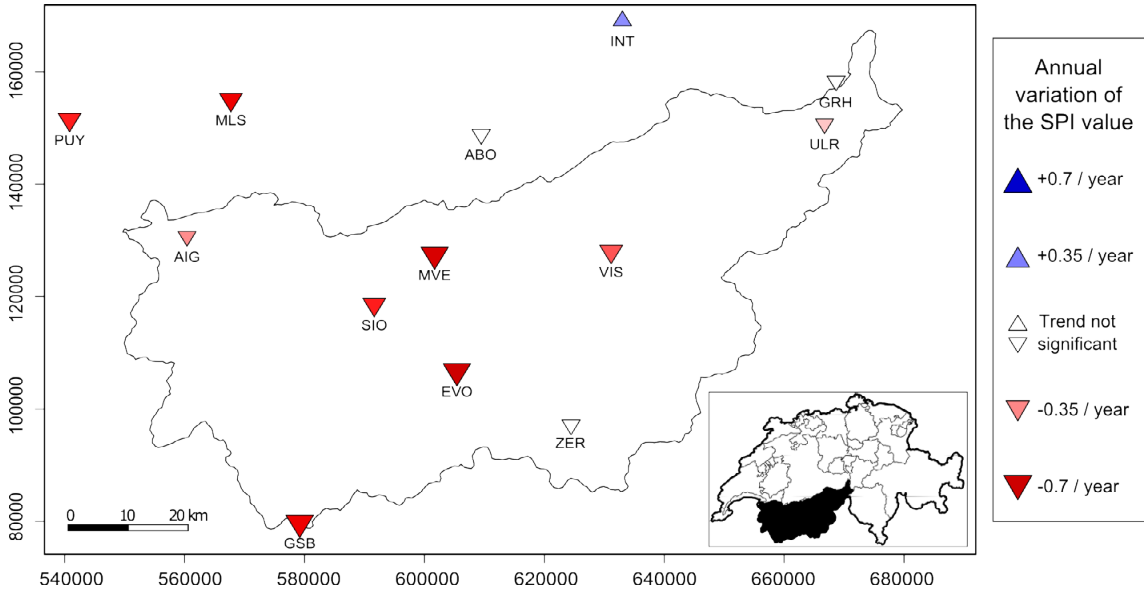

Figure 2. Trends in the SPI values between 1981 and 2015, with a 95% level of significance.

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