Are precipitation and snowfall droughts concomitant in semiarid mountainous areas?

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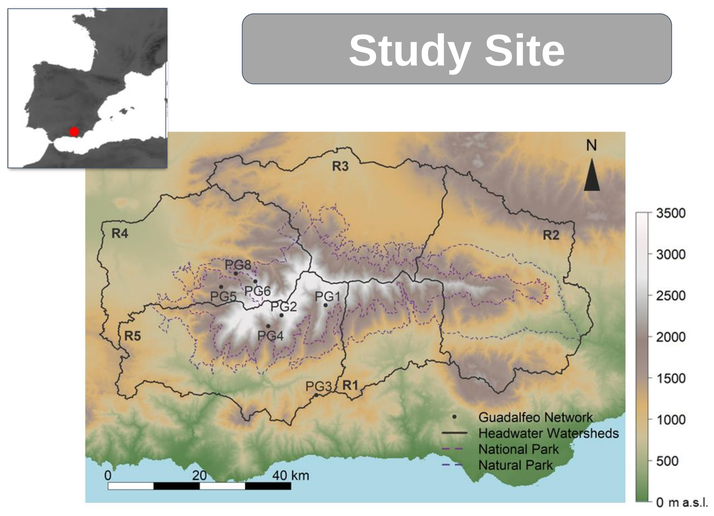
INARCH 2022

Introduction

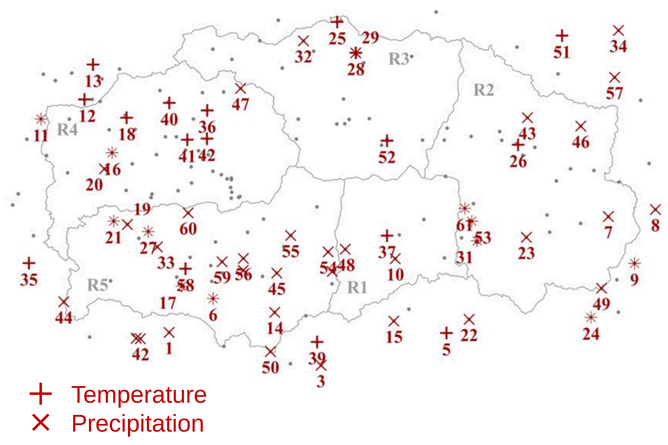
The current meteorological drought situation we have been facing in the Mediterranean regions during last years has also resulted in a shift in snowfall seasonal patterns. Particularly, in the Sierra Nevada mountain range, an alpine-climate area in the semiarid southern Spain very close to the Mediterranean, this has been also translated in very different snowpack evolution on an annual basis. For instance, shallow snowpacks with several clear accumulation-ablation cycles, thicker snowpacks but with a shorter duration, or first big accumulation cycles taking place in March. Traditionally, meteorological droughts have been defined using the whole precipitation amount, without discriminating between rainfall or snowfall. However, snowfall is the main determinant of snowpack evolution and should be used for defining "snowfall droughts", whose hydrological impacts can be amplified throughout the watershed in mountain areas.

AIM: This work proposed to analyze the connection between precipitation and snowfall droughts. For that, the Standardized Precipitation Index (SPI), widely used in hydrology, and the Standardized Snowfall Index (SSI, defined as SPI but using snowfall data) are calculated in the study area on different time scales for a reference period of 50 years (1960-2020), establishing connection patterns among them.

Study Site



Available Data



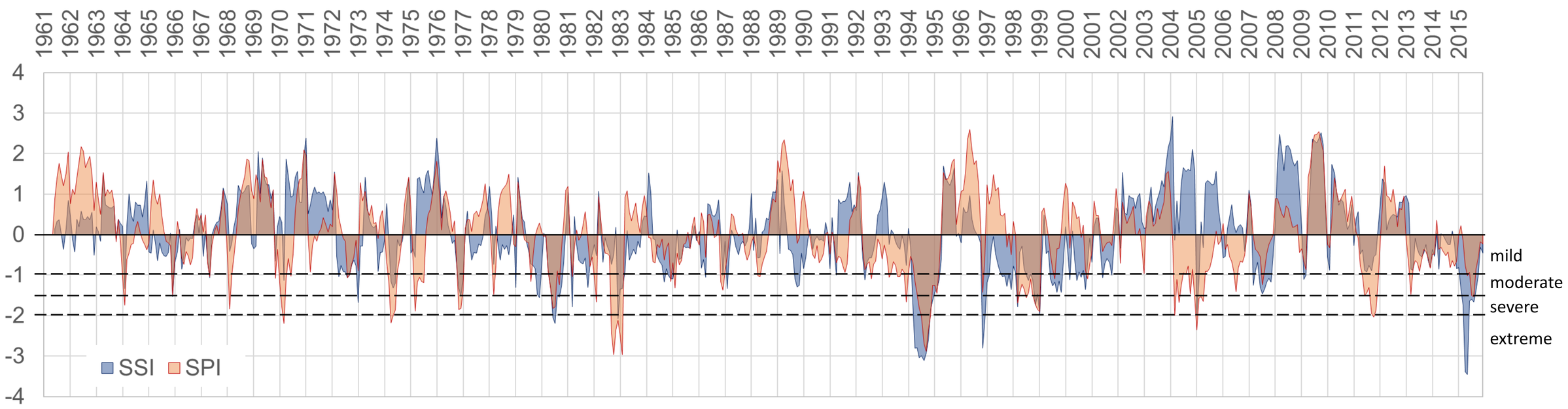
Methodology

The SPI calculation is based on the long-term precipitation **(1961-2015)** for a desired period **(6 months).** This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution. Values lower than zero indicate a drought period. Moreover, the absolute value indicate the severity.

Distributed Precipitation / Snowfall Data → Fit to Gamma Distribution → Normalize SPI / SSI

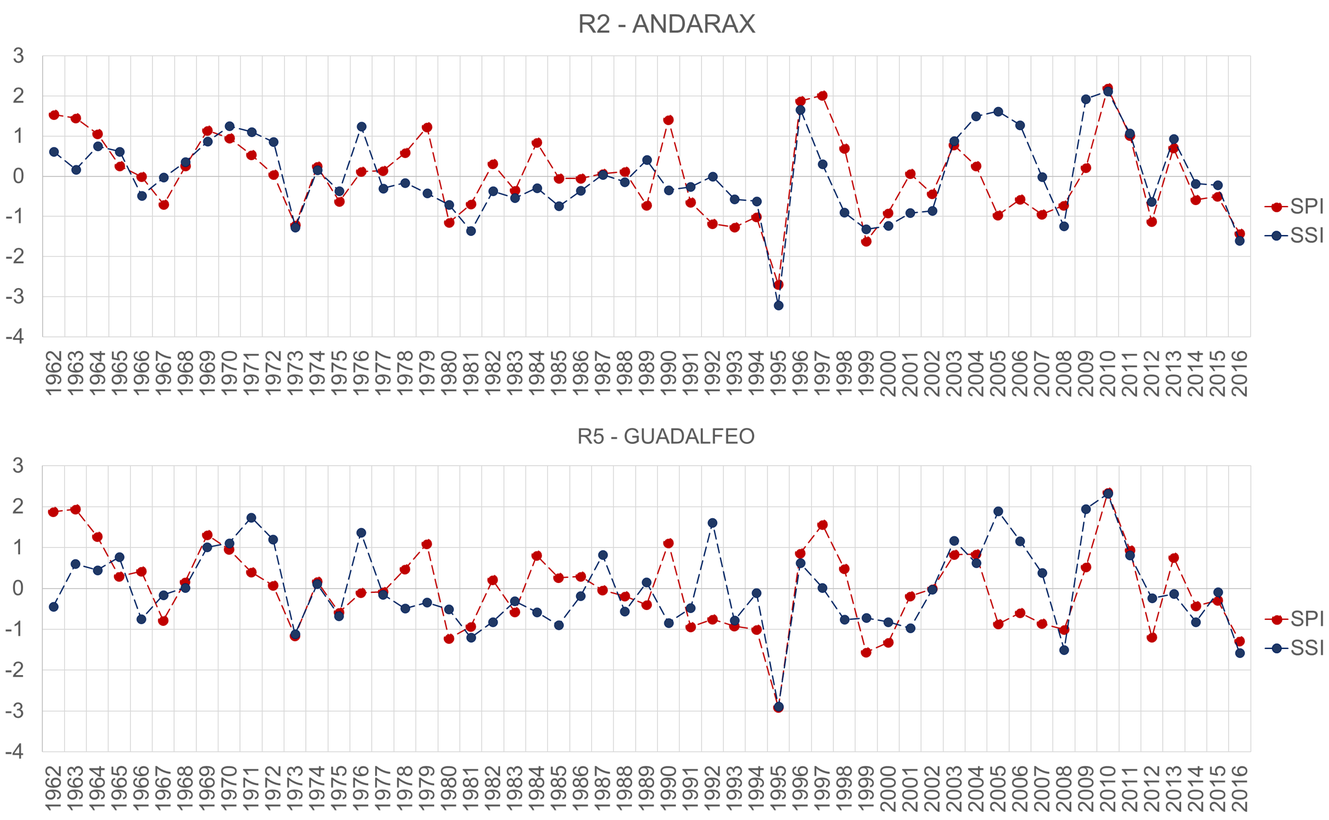
Results

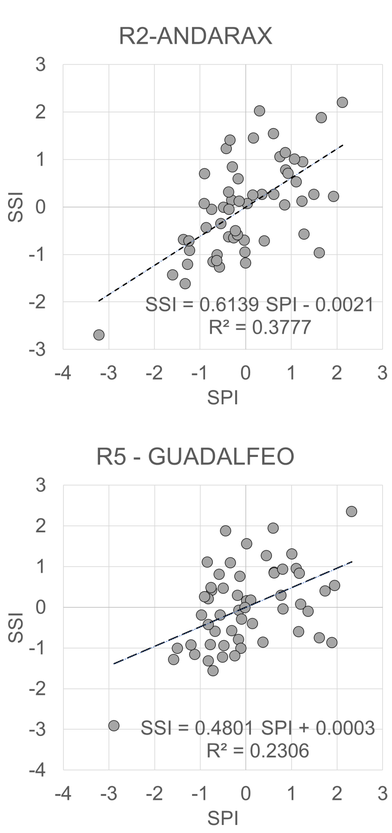
(A) Sierra Nevada 6 months'SPI and SSI evolution



			SNOW DROUGTH					
			YES				∑	NO
PRECIPITATION DROUGTH			Mild	Mod	Sev	Ext		
	YES	Mild	113 (17.2%)	31 (4.7%)	5 (0.8%)	2 (0.3%)	151 (23.0%)	84 (12.8%)
		Mod	23 (3.5%)	12 (1.8%)	5 (0.8%)	4 (0.3%)	44 (2.0%)	13 (2%)
		Sev	9 (1.4%)	6 (0.9%)	5 (0.8%)	3 (0.5%)	23 (0.6%)	4 (0.6%)
		Ext	3 (0.5%)	4 (0.6%)	3 (0.5 %)	5 (0.8%)	15 (0.2%)	1 (0.2%)
	∑		148 (22.6%)	53 (8.1%)	18 (2.7%)	14 (2.1%)	**233 (35.5%)**	**102 (15.5%)**
	NO		94 (14.3%)	10 (1.5%)	1 (0.2%)	0 (0.0%)	**105 (16.0%)**	**216 (32.9%)**

(B) The April 6-months'SPI and SSI evolution. Snowfall usually take place between November and April. Therefore, the 6-months' SPI/SSI in April is a good indicator of snowfall condition within the year. The two more extreme catchments R5-GUADALFEO (wettest) and R2-ANDARAX (driest) are compared.





Conclusions

- Both precipitation' and snow' droughts are recurrent in Sierra Nevada, with 440 of the analysed months (67%) with at least one type of drought. In most of the cases both droughts are concomitant, being the most common situation a mild drought for both types.
- The April 6-months' SPI and SSI evolution shows similar pattern for both, the wettest and the driest catchments, with a slightly higher values for the wettest catchment.
- The relation between the April 6-months' SPI and SSI show for both cases a linear relation, which is stronger for the driest catchment.

Acknowledgements: This study was supported and partially funded by the Spanish Ministry of Science and Innovation (research project RTI2018-099043-B-I00, "Operability in hydrological management under snow torrentiality/drought conditions in high mountain in semiarid watersheds") and by the project MONADA - "Hydrometeorological trends in mountainous protected areas in Andalusia: examples of co-development of climatic services for strategies of adaptation to climatic change", with the economic collaboration of the European Funding for Rural Development (FEDER) and the Andalusian Ministry of Economic Transformation, Industry, Knowledge and Universities. R+D+i project 2020. Moreover, the present work was partially developed within the framework of the Panta Rhei Research Initiative of the International Association of Hydrological Sciences (IAHS) (working groups Water and energy fluxes in a changing environment and Mountain Hydrology). Rafael Pimentel acknowledges funding by the Modality 5.2 of the Programa Propio-2018 of the University of Cordoba and the Juan de la Cierva Incorporación program of the Ministry of Science and Innovation (IJC2018-038093-I).