Hydrological response to meteorological drought: a case study in La Plata Basin
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Summary
The quantitative knowledge of the properties of droughts in a region is an important aspect of the planning and management of water resources. This work analyzes the relationship between meteorological droughts and hydrological droughts for a specific location over Uruguay River, belonging to La Plata Basin (LPB), one of the largest basins in the world. The basin generates around 70% of the Gross National Product of Argentina, Brazil, Paraguay and Uruguay, and has a population of over 180 million inhabitants. The LPB is also one of the major producers of hydroelectric power in the world, therefore, extreme flow events are crucial for hydroelectric power generation and water resources management in this region.

Database and methodology
Streamflow data are subjected to human interference, which can result in errors for low flow conditions. Therefore, we selected an unregulated station to ensure an unbiased analysis. Daily precipitation and streamflow data from Paso de los Arcos station (Figure 1) for the period 1941-2007 were used in this study. The Standardized Precipitation Index (SPI; O'Gorman et al., 1993), which is the most widely used drought index, was chosen to characterize meteorological droughts at different time scales, in order to define the streamflow drought events in the region. We consider SPI negative, the flow is reduced or exceeded by 70% of the time (Middleton et al., 2001).

Since the SPI is a daily index, we selected the monthly average values between the streamflow index (SPI) and the monthly average values of the SPI at different time scales as a monthly average for the whole time series, considering one month as a criterion, also averaging, considering the seasonal Southern Hemisphere seasons. For comparison we used the Pearson correlation coefficient.

B. Comparison between precipitation and streamflow deficits

1. Annual approach
Higher correlation have been obtained with the SPI on shorter time scales (3-4 months) (Figure 2). The maximum correlation found is around the time scale of 3 months (SPI-1993.3-0.56).
This indicates that river discharges are more determined by precipitation of the current month and the previous two months than considering wider periods.

2. Seasonal approach
The highest correlation between SPI values and the deficit volume were obtained in summer (June), which is the low flow season, for the time scales of 2 to 3 months.
During summer the evolution of a drought from precipitation to streamflow better responds to larger time scales.

The behavior during winter is similar to the findings for the annual approach.
In the spring months we find the lowest correlations between SPI and GPTI values for time scales longer than 3 months.

A. Comparison during the drought of 1982-83
We made a comparison of the two series for the historical drought episode of 1982-83, which is the extreme drought event we record coinciding both SPI’s and GPTI’s (Figure 2).

The general behavior of these indices are similar for the illustrated drought event (Figure 7), demonstrating their validity for studying time scales of runoff and streamflow (Penaiba and Rivera, 2010). This suggests that our methodology was suitable for identifying the drought trends.

Results
A. Drought evolution in the middle part of the Uruguay River

The analysis of the 3-month SPI and 8-month SPI time series for the period 1960-2007 indicates that the record minimum SPI was observed in July 1996 and October 1962 respectively.
As the time period is lengthened to 12 and 18 months, the SPI responds more slowly to changes in precipitation.

The 12-month SPI time series indicated that during this period no weather was unusually wet or dry. The first period (1960-1962) was the extreme drought as record. The largest decreases occurred during 2001-2004 and it is characterized by the longest dry event.

B. Streamflow deficiency

The streamflow deficiency during 2004, with 209 dry days, caused the largest amount of energy generated at La Grande Dam, located downstream of Paso de los Arcos station.

Discussion

In several, different studies indicate that there is a considerable time lag between departures of precipitation and the point at which these deficiencies become evident in surface components of the hydrologic system. Our findings prove that the surface runoff responds to years four time series (4-6 months), the maximum correlation is reached on the time scale of 3 months (R1=1). The seasonal corrections show that the highest correlations were obtained in summer, which is the low flow season. Results could be useful for forecasting and monitoring hydrological drought severity and in developing a drought prevention plan in the region.

References

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