Droughts in Southern Minas Gerais, Southeastern Brazil: Understanding the Last 100 Years

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The hydrological years of 2013-2014 and 2014-2015 in southeastern Brazil have people, governments, and scientists concerned due to a much lower than expected amount of rainfall. Drought has affected eastern South America with catastrophic effects for the economy, the water availability for human consumption, agriculture, and electric energy production (more than 70% of Brazilian energy comes from hydropower plants, and most of them are in operation in southern Minas Gerais State). In a recent study, Coelho et al. (2015) studied eastern São Paulo State, focusing on the São Paulo metropolitan region, where they characterized 2014-2015 as the driest year ever recorded. However, these authors addressed the study taking into account the records only from 1961 to 2010, which are not long enough to make a significant conclusion. Thus, a number of doubts remain: are these droughts normal? What is the expected frequency of them? Were the 2013-2014 and 2014-2015 hydrological years really the worst droughts recorded? A longer monthly rainfall dataset would be indispensable to answer these questions.

The Standard Precipitation Index (SPI) was calculated for the hydrological years (from October to March in southeastern Brazil) providing a historical series of this drought index as long as 101 years (1915-2015), for Lavras, Southern Minas Gerais State. From this dataset, we characterized: the SPI-6M (from October to March) and SPI-4M (December to March); a long-term rainfall accumulated in five hydrological years; a 5-year moving long-term average for both indexes studied; and basic statistics for the monthly series (median and quartiles). This data set is one of the longest existing in Minas Gerais State and is very rare for other regions in Brazil. The SPI was calculated based on the Gamma Probability Distribution fitted to the historical series. From the estimated frequency, the correspondent z value, which corresponds to SPI, from a Standard Normal Distribution (e.g., mean = 0 and variance = 1) was determined. This index was proposed by the National Climatic Data Center/National Oceanic and Atmospheric Administration (NOAA) and is classified according to the boundaries: SPI < -2 "exceptionally dry"; -2 ≤ SPI < -1.60 "severely dry"; -1.60 ≤ SPI < -1.30 "very dry"; -1.30 ≤ SPI < -0.80 "moderately dry"; and -0.80 ≤ SPI < -0.51 "abnormally dry".

Figure 1 (a and b) shows, respectively, the temporal distribution of SPI-6M and SPI-4M throughout the last 101 years for the studied rain-gauge station, which can be extended for most of southern Minas Gerais State. The 5-year moving averages for both SPI series are also presented. Drought periods were common, since we observed 20 and 22 years, respectively, with SPI-6M and SPI-4M characterized as "moderately dry" or "very dry". However, "exceptionally dry" years were very rare, and were observed only 2 times for SPI-6M and just once for SPI-4M. For SPI-6M, this anomaly was detected for the hydrological years of 1949-1950 and 2013-1014. Coelho et al. (2015) observed that 2014-2015 was the driest recorded for São Paulo; however, they did not evaluate earlier hydrological years (before 1961). Regarding this point, the 1950's decade should be highlighted, as there were a number of consecutive years with negative SPIs (lower than -1) detected, and the moving averages demonstrated that this

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decade was one of the driest ever recorded.

Analyzing the hydrological years grouped into 5 years (Figure 1c), we can observe 5 occurrences below the $P_{25\%}$ quartile, indicating strong drought occurrence in the regional climate in the last 101 years. However, from these data, we can also see that in the last 15 years the region has experienced continuous precipitation below the $P_{25\%}$ quartile, meaning that the current drought (2013-2014; 2014-2015) has been preceded by consecutive drier years, which was not observed during the 1949-1950 hydrological year.

Figure 1d depicts, statistically, the monthly rainfall behavior, given by the median and quartiles based on the last 101 years, along with the observed monthly data of 1949, 2014 and 2015. We can see the acute reduction (lower than the $P_{25\%}$ quartile) on monthly rainfall for the summer/spring months for all these years, which explains the SPI values lower than -2. In 1949 the rainfall values were much lower than the $P_{25\%}$ quartile from September to December, which produced an "exceptionally dry" rating for the 1949-1950 hydrological year. The same features are valid for the other hydrological years even with January and December presenting values closer to the median. Much of that rain was concentrated in a few convective events, with high intensity and short duration.

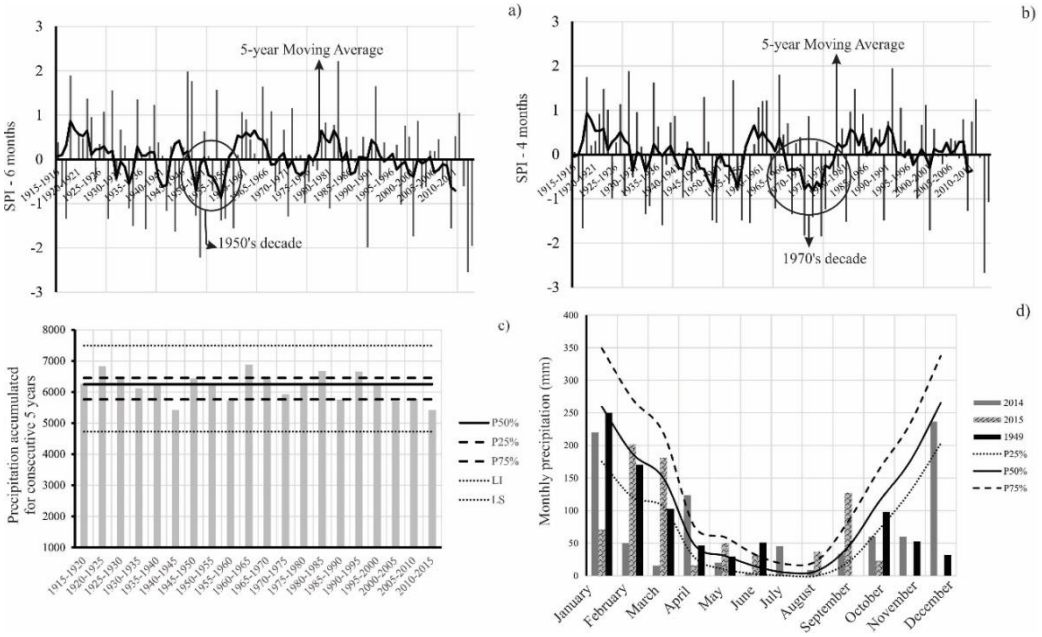

Figure 1. Precipitation records from Lavras, Minas Gerais State, Brazil: (a) SPI–6M, (b) SPI–4M, (c) Five hydrological years' precipitation accumulation, and (d) Monthly precipitation behavior and monthly precipitation for 1949, 2014 and 2015.

Thus, we can conclude that drought occurrence is common in southern Minas Gerais State, and, by extent, in southeastern Brazil. The hydrological period between 2010 and 2015 has been the most severe in the last 101 years; however, the 1950's decade was another historical drought episode and seemingly, there may be a 50-60 years periodicity.

References

Coelho, C.A.S., D.H.F. Cardoso, and M.A.F. Firpo. 2015. Precipitation diagnostics of an exceptionally dry event in São Paulo, Brazil. Theor. Appl. Climatol. DOI 10.1007/s00704-015-1540-9.