# Disentangling the contribution of precipitation and temperature to Chilean "megadrought" (2010-2015)


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## 1) Motivation

Central Chile (30-40°S) has experienced a rainfall decline since the early 80s. Such long-term drying has been accentuated by an intense rainfall deficit from 2010 to date. Moreover, the maximum air temperatures have risen since the late 70s, with warm anomalies between 0.5° and 1°C relative to the past 30 years, resulting in the use of the term **megadrougth** for the 2010-2015 period.

## 2) Aim

To analyze the contribution of precipitation and temperature on recent droughts of Central Chile, and to improve our understanding about the onset, duration and magnitude thereof.

## 3) Data

- **Precipitation** (*PCP*): daily data in **781** stations (1940-2015).
- **Extreme temperature**: daily data of maximum (*Tmx*) and minimum (*Tmn*) temperature in **281** stations (1950-2015).
- Period of analysis: 01/Jan/1981 – 31/Dec/2015.
- Only stations with **98%** or more days with information in the period of analysis → *PCP*: **134** ; *Tmn*/*Tmx*: **27**
- Simultaneous *PCP* and *Tmn*/*Tmx* → **15** stations.
- Potential evapotranspiration (*PET*):

  Hargreaves method: $f(Tmx, Tmn, Lat)$

## 4) Drought analysis

- The traditional Standardized Precipitation Index (**SPI**) is used to describe the effect of lack of precipitation on drought conditions.
- The Standardized Precipitation-Evapotranspiration Index (**SPEI,** Vicente-Serrano et al. 2010), based on a simple climatic water balance (precipitation minus reference evapotranspiration), is used to assess the effect of temperature -throughout changes in evaporation- on drought severity at different time scales.
- SPI and SPEI at 12-month scale (SPI-12 and SPEI-12, respectively) were selected as representative of the long-term effects of meteorological droughts on hydrology.
- Thresholds used to classify drought severity (Agnew, 2000):

  SPI/SPEI ≥ -0.84: no drought
  SPI/SPEI < -0.84: moderate drought (20% pbb of exceedance)
  SPI/SPEI < -1.28: severe drought (10% pbb of exceedance)
  SPI/SPEI < -1.65: extreme drought ( 5% pbb of exceedance)

## 5) Results

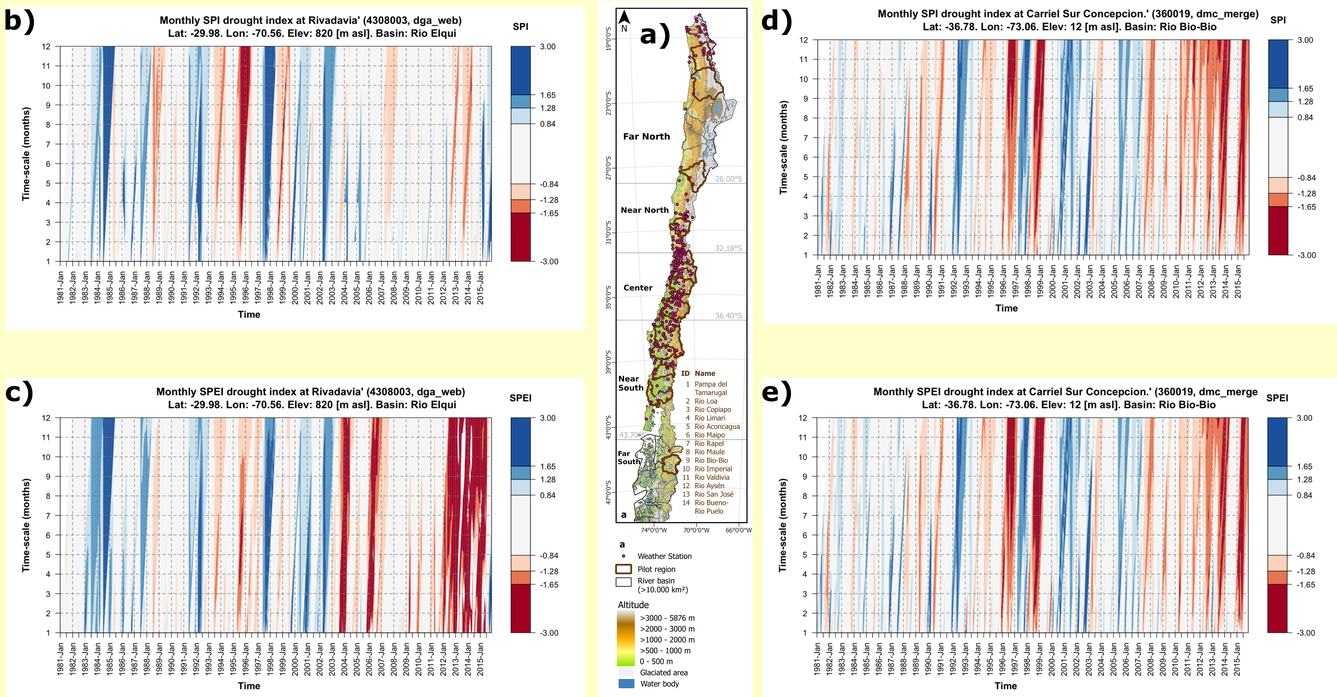


**Figure 1.** Panel a) shows the map of the study area, including digital elevation model, main Chilean basins, and location of selected rain gauges. (Adapted from Zambrano-Bigiarini et al., 2016). Panels b) and c) represent monthly values of SPI and SPEI, respectively, for different time scales at Station Rivadavia (Near North macroarea). Panels d) and e) represent monthly values of SPI and SPEI, respectively, for different time scales at Station Carriel Sur Concepción (Near South macroarea).

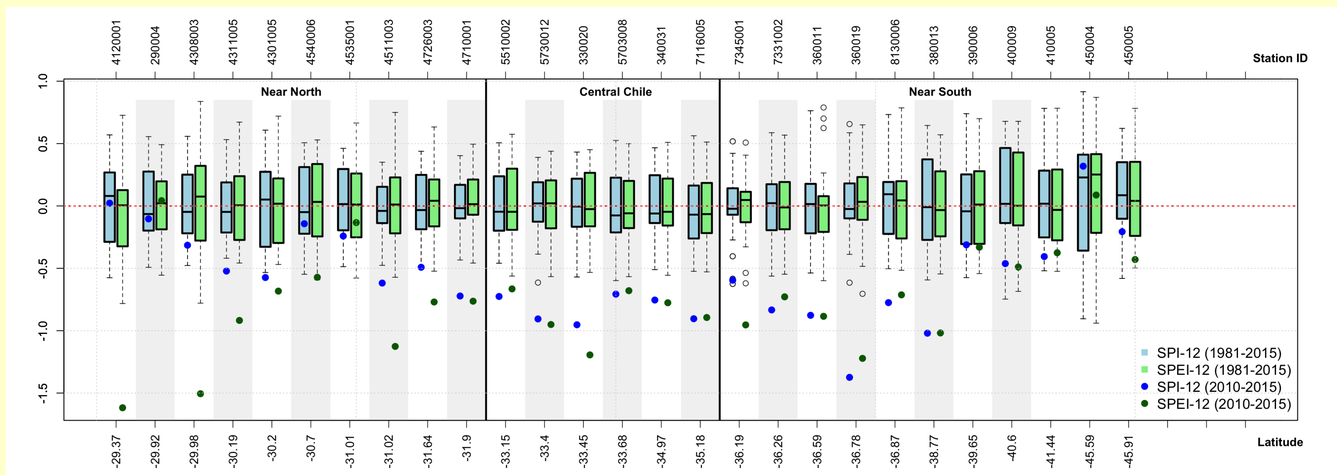


**Figure 2.** Boxplots with 6-year moving averages of monthly values of SPI-12 and SPEI-12 for the period 1981-2010. Dots represent 6-year moving averages of monthly values of SPI-12 and SEPI-12 only for the *megadrought* period 2010-2015.

## 6) Conclusions

- Moderate and severe drought conditions are currently ongoing: both the SPI-12 and SPEI-12 were below zero since 2010 onwards in almost all the analysed stations.
- The SPEI index allowed to effectively take into account the effect of temperature on drought conditions. It was able to detect droughts events even after the occurrence of some above-normal rainfall periods.
- Fluctuations of maximum temperature exert a strong effect on the SPEI index, being more important than fluctuations of minimum temperature, for the analyzed stations.
- In the arid north the increase in temperature has worsened the rainfall deficit by increasing evaporation: the SPI-12 was low but not extraordinary, whilst the SPEI-12 was well beyond the historical distribution.
- In the humid south, we found little difference between SPI-12 and SPEI-12 during the megadrought, but both values were extraordinary in their historical context.

## 7) Future work

- To investigate the use of satellite estimations of precipitation (Zambrano-Bigiarini et al., 2016) and potential evapotranspiration, in order to obtain spatial fields of the SPI and SPEI indices, for different time scales.
- To investigate the propagation of the ongoing meteorological droughts into the land component of the hydrological cycle (streamflows, reservoirs, snow, groundwater)

## References


- Agnew, C. T., Using the SPI to Identify Drought (2000). Drought Network News (1994-2001). Paper 1. http://digitalcommons.unl.edu/droughtnetnews/1.
- Vicente-Serrano, S. M., Beguería, S., & López-Moreno, J. I. (2010). A multiscalar drought index sensitive to global warming: the standardized precipitation evapotranspiration index. Journal of Climate, 23(7), 1696-1718.
- Zambrano-Bigiarini, M., Nauditt, A., Birkel, C., Verbist, K., and Ribbe, L.: Temporal and spatial evaluation of satellite-based rainfall estimates across the complex topographical and climatic gradients of Chile, Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-453, in review, 2016.



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