Historical Assessment of Compound Summer Drought and Heatwave Events in Southeast Brazil

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Abstract

Positive trends of droughts and heatwaves' frequency and severity have been reported for several regions, namely for Southeast Brazil (SEB). Nevertheless, this region still lacks a comprehensive assessment of compound drought and heatwave (CDH) events. This study aims to (1) analyse the historical evolution of CDH events in SEB, to (2) characterize the land and atmosphere conditions as well as to (3) disentangle the physical mechanisms behind the observed record-breaking dry and hot events recorded during the 2013/14 and 2014/15 austral summer seasons.

Meteorological data, including maximum temperature (Tmax) and precipitation records were extracted from the ERA5 reanalysis datasets. Soil moisture data were obtained from Global Land Evaporation Amsterdam Model (GLEAM v3.3a). Drought conditions were defined at a monthly scale, using the ERA5 precipitation records, and considering 3-month Standardized Precipitation Index (SPI) values <–1. Heatwaves were defined as periods of consecutive days with daily Tmax values above a climatological calendar day Tmax percentile (80⁰, 90⁰, 95⁰ percentile). A compound event was defined as a heatwave period occurring during a month under drought conditions.

Our results confirm that the São Paulo, Rio de Janeiro and Minas Gerais states have recorded pronounced and statistically significant increases in the number of compound summer drought and heatwave episodes. The recent summer seasons of 2013/14 and 2014/15 were examples of an association between outstanding drought and heatwave conditions stemmed by severe precipitation deficits and a higher-than-average occurrence of atmospheric blocking patterns. This inter-relationship was controlled by two soil–atmosphere coupling regimes. The first regime (energy-limited) occurred during the first half of both summer seasons, in which consecutive hot periods coupled with a long-term precipitation deficit induced drought conditions. The absence of precipitation and the clear sky conditions maintained. Consequently, the severe dryness of the surface was enhanced, until a second high coupling regime (water-limited) was imposed, in which the hot events were amplified by the simultaneously drought conditions. At this stage, the surface started to disproportionally dissipate the incoming radiation as sensible heat, yielding the mega-
heatwaves recorded over SEB during this period.

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