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# Flash droughts in southern South America as captured by ERA5 reanalysis data

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This study investigates the frequency of occurrence of two types of flash droughts in southern South America: heatwave flash droughts (HWFD) and precipitation deficit flash droughts (PDFD). To this end, we employ ERA5 products at 0.25° horizontal resolution under the assumption that they add valuable information in regions of scarce observations. The analysis is based on 1979-2019 ERA5 pentad data of precipitation (P), 2-m air mean temperature (T), evapotranspiration (ET), and root-zone soil moisture (SM). HWFD and PDFD exhibit different functional mechanisms related to surface moisture and surface energy fluxes. In HWFD, high T causes ET to increase and lead to decreases of SM. When combined with negative P anomalies before a drought's onset, there is a significant increase in the magnitude of negative SM anomalies. The mechanism of PDFD formation starts with a precipitation deficit prior to the drought onset. The lack of precipitation causes a reduction in SM and ET, which results in increased T (the Bowen ratio and T increase in response to the decreased ET).

HWFDs at each grid point and each pentad are identified as those that meet the following conditions: (a) T anomalies are larger than one standard deviation (SD) computed from the 1979-2019 period for that pentad, (b) ET anomalies are positive, (c) P anomalies are negative, and (d) the SM is below the 40$^{th}$ percentile. PDFDs are identified when (a) P is below the 40$^{th}$ percentile, (b) SM% < 40, (c) ET anomalies are negative, and (d) T anomalies > 1 SD. The frequency of occurrence (FOC) of HWFD or PDFD is defined as the percentage of pentads exceeding those thresholds. Composites of all variables for pentads under HWFD or PDFD were prepared to determine such droughts' spatial structure.

Our results indicate that cases of HWFD are more common than those of PDFD. HWFDs are more likely to occur over the arid western region and central-eastern Brazil. HWFDs are more common in both areas in spring (SON) and summer (DJF), reaching FOC values of 14-16% over each season. On the other hand, PDFDs can occur almost everywhere but less frequently. The maximum annual FOC for PDFD (4 - 6%) is located towards Brazil's center. Composite maps show that the most frequent HWFDs occur in regions of highest T and ET anomalies, with a SM decrease to the 10-20$^{th}$ percentile range.

In contrast, the most frequent PDFDs do not occur in regions of highest P deficit, i.e., northeastern Argentina and southern Brazil. However, the precipitation deficit towards the center of Brazil, the area with the highest frequency of PDFD, is significant ( -3 mm / day). This P deficit leads to decreased soil moisture to the 20-30th percentile range and mean ET anomalies between -0.2 and -0.5 mm/day.