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Characterising thermal anomalies during Amazon droughts using multiple satellite observations

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Abstract: The Amazon rainforest experienced three major droughts in 2005, 2010, and 2015. Large-scale positive thermal anomalies were observed in the southern Amazon during the dry seasons (i.e., August and September) of these three droughts. Here we utilized a series of satellite-observed hydro-meteorological variables, including land surface temperature (LST), precipitation (P), incoming solar radiation (SW↓) and terrestrial water storage (TWS), to examine whether the thermal anomalies during these droughts were caused by the same reason. Despite similar negative precipitation anomaly magnitudes, we found that the radiation and water storage conditions were different between these three droughts. SW↓ and TWS were both below average during the dry seasons of 2005 and 2010, but both above average in 2015. To explain the dry-season thermal anomalies we analysed satellite-based LST, P, SW↓ and TWS from 2003 to 2015 with tri-variate linear regression using of P, SW↓ and TWS anomalies able to reasonably explain the thermal anomalies (i.e., average R = 0.71). Next, we investigated why the anomalies in dry-season SW↓ and TWS were opposite during different droughts and found this was caused by opposite hydro-meteorological conditions prior to dry seasons (i.e., during the wet-to-dry transition seasons from May to July). In 2005 and 2010, the southern Amazon had below average P during the wet-to-dry seasons, leading to very low level of dry-season water storage. Because of this, more fires that average occurred resulting in greater atmospheric aerosols so SW↓ decreased. In contrast, precipitation was above average in the wet-to-dry season in 2015, leading to both TWS and SW↓ being above average. Finally, we explored the impact of the drought severity, including thermal stress and water shortage, by comparing the dry-season LST (and TWS) against the maximum LST (and minimum TWS) across the non-drought years, with regions affected by concurrent thermal and water stress found in the 2005 to 2010 droughts. However, dry-season TWS in 2015 was higher than the minimum TWS during the non-drought years, therefore no region had simultaneous thermal and water stress during the 2015 drought. This research highlights the various mechanisms and preceding hydrological processes of severe droughts in the southern Amazon. It is important to understand the development of droughts for a thorough estimation of their influence on rainforests.

Keywords: *Drought, remote sensing, temperature, radiation, water storage*