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Groundwater storage in the Horn of Africa drylands dominated by seasonal rainfall extremes

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Rural communities in the Horn of Africa Drylands (HAD) rely on the availability of soil moisture for crop growth and groundwater for drinking water supply for people and livestock. Recent negative trends in March-May rainfall ('long rains') have decreased soil moisture with negative consequences for the livelihoods in HAD communities, who have become increasingly vulnerable to multi-season droughts affecting crops and livestock. These increasingly common failed 'long rains', propagate into agricultural drought, causing famines, and lead to major humanitarian intervention across HAD. However, the links between seasonal rainfall ('long rains' and 'short rains' in October-December) and regional groundwater storage in HAD have not been explored. We examined trends in seasonal rainfall from various gridded datasets alongside an analysis of total water storage (TWS) from GRACE satellite data. Multiple rainfall datasets corroborate declining 'long rains' and increasing 'short rains', and a 3-hr (MSWEP) dataset reveals the disproportionate contribution of extreme rainfall to totals within both seasons. We also found that TWS generally increased across the HAD region between 2002 and 2017, and that the GRACE TWS signal is primarily composed of groundwater storage changes for this region, rather than trends in soil moisture. We then found that groundwater storage variability correlates strongly with seasonal rainfall on interannual and decadal scales, and it is particularly correlated with extreme rainfall in both rainy seasons. We highlight the importance of increasingly large Indian Ocean Dipole events in dominating extreme rainfall and correspondingly high TWS and groundwater recharge within the October-December rainy season. While groundwater recharge in HAD by high-intensity rainfall is generally high for the March-May rainy season, it is increasing for the 'short rains' season. These findings raise the possibility that increasing groundwater availability across HAD could be exploited to offset the 'long rains' decline, potentially mitigating their climate change impacts on soil moisture, crops, and drinking water supplies.