Rossby wave breaking and extreme precipitation in the central and eastern U.S.

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Climatological and dynamical linkages between Rossby wave breaking (RWB) and extreme precipitation events (EPEs) over portions of the central and eastern U.S. are examined. A climatology of breaking Rossby waves within a domain over North America is constructed for 1979–2015 by identifying potential vorticity (PV) streamers on tropopause-intersecting isentropic surfaces in the NCEP Climate Forecast System Reanalysis. Streamers are categorized as "anticyclonic," "cyclonic," or "neutral" based on the streamer tilt. A concurrent climatology of exceptionally widespread EPEs not associated with tropical cyclones is constructed within a domain encompassing the south-central and southeastern U.S. using daily gauge-based precipitation analyses. Composite analysis of all EPEs in the climatology demonstrates the formation of a robust Rossby wave train across the North Pacific and North America that culminates in EPE occurrence in conjunction with the formation of a high-amplitude slow-moving upper-level trough over the western U.S. This trough formation in the composites is found to be associated with significantly elevated PV streamer frequency relative to climatology, particularly for the anticyclonic streamer category. A comparison of the PV streamer and EPE climatologies reveals that ~80% of EPEs occurred in conjunction with a PV streamer. Of those EPEs, ~66% were associated with anticyclonic streamers, ~24% were associated with cyclonic streamers, and ~10% were associated with neutral streamers.

Dynamical linkages between RWB and EPEs are examined in a composite framework for two groups of EPEs associated with anticyclonic and cyclonic PV streamers, respectively. The composites for the two groups are found to exhibit differences with respect to the structure and evolution of the flow over North America. Despite these differences, the composites for both groups feature the formation of a meridionally elongated and slow-moving PV streamer over the western U.S. coincident with the development and equatorward progression of a surface low east of the Rocky Mountains. The surface low is linked to the formation and maintenance of an atmospheric river-like corridor of strong water vapor transport extending from low latitudes into the EPE region. Trajectory calculations demonstrate that this corridor is associated with direct transports of moist air from over the Caribbean Sea and the Gulf of Mexico into the EPE region.