During October 2009, the central and eastern U.S. experienced multiple high-impact extreme weather events, including cold-air outbreaks and widespread flood-producing heavy rain events. Integrated over the U.S., October 2009 currently ranks as the third coldest and the wettest October on record. This study examines a particularly high-impact heavy rain event over the central U.S. during 29–31 October that was preceded by a strong perturbation to the North Pacific jet stream associated with the extratropical transition (ET) of western North Pacific Tropical Cyclone (TC) Lupit and the concomitant formation of a high-amplitude Rossby wave train extending into North America. The heavy rain event in the central U.S. occurred in conjunction with prolonged water vapor transport from the tropics linked to the formation of an elongated potential vorticity (PV) streamer over the western U.S. The flow response downstream of TC Lupit was associated with rapid error growth in medium-range ensemble forecasts across the eastern North Pacific and North America, corresponding to exceptionally large errors and uncertainty in precipitation forecasts during the central U.S. heavy rain event.

The dynamical linkage between the forecast errors related to the heavy rain event over the central U.S. and the forecast errors related to the ET of TC Lupit is examined using an ECMWF ensemble forecast that was initialized 5 days prior to the onset of the heavy rain event. A procedure involving principal component analysis paired with a fuzzy clustering technique is applied to the ensemble to identify distinct clusters of members with respect to the forecast tropopause-level flow configuration over North America during the heavy rain event. This procedure identifies two clusters of members in the ensemble corresponding to distinct forecast scenarios: one featuring a westward displacement of the PV streamer over the western U.S. (cluster 1), and one completely lacking a PV streamer and instead featuring a progressive trough over the central U.S. (cluster 2). Although both clusters are associated with large errors with respect to the placement and intensity of precipitation over the central U.S., the members in cluster 1 are characterized by greater forecast skill than those in cluster 2.

The dynamical processes contributing to the development and growth of differences between the two aforementioned clusters of ensemble members are diagnosed from a PV perspective. In both clusters, TC Lupit undergoes ET and induces pronounced ridge amplification, leading to the downstream development of a meridionally elongated trough and concomitant ridge amplification over the eastern North Pacific. In cluster 2, the ridge amplification directly linked to the ET of TC Lupit is found to be significantly stronger than that in cluster 1 and results in anticyclonic wave breaking (AWB) over the central North Pacific. In conjunction with this AWB, the southern portion of the trough downstream of TC Lupit becomes cut off, the northern portion of the trough becomes progressive, and ridge amplification ceases over the eastern North Pacific. Consequently, a more progressive and less amplified wave pattern develops across the eastern North Pacific and North America in cluster 2 relative to cluster 1. In cluster 1, which features weaker ridge amplification directly linked to the ET of TC Lupit, AWB does not occur, the trough over the central North Pacific remains meridionally elongated, and ridge amplification persists over the eastern North Pacific, culminating in the formation of an elongated PV streamer over the western U.S. The results of this study highlight the sensitivity of forecasts of the flow pattern and precipitation over the U.S. to the downstream flow response linked to the ET of TC Lupit.