Planetary- and synoptic-scale processes contributing to extreme rainfall and flooding in Nashville, Tennessee, and vicinity during 1–2 May 2010

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An analysis of the planetary- and synoptic-scale processes that resulted in extreme two-day rainfall accumulations (200–400 mm; 344.7 mm in Nashville) and devastating flash flooding across western and central Tennessee and Kentucky during 1–2 May 2010 is presented. This analysis reveals that on the planetary scale the rainfall event was preceded during 23 April–1 May by the development and eastward propagation of a Rossby wave train (RWT) across the North Pacific. This RWT was associated with the development of a high-amplitude upper-tropospheric flow pattern extending into North America that featured a persistent ridge over the eastern North Pacific and a deep trough extending into low latitudes over western North America. The development of this high-amplitude flow pattern facilitated, in turn, the formation of a persistent corridor of strong water vapor transport that extended from the tropics into the heavy rainfall region in Tennessee and Kentucky during 1–2 May.

Water vapor flux diagnostics and air parcel trajectory calculations are used to investigate the primary water vapor source regions and transport mechanisms associated with the rainfall event. This investigation reveals that moist air entering the heavy rainfall region originated within two primary tropical source regions: 1) over the Caribbean Sea and 2) over the eastern tropical Pacific near Central America within a region characterized by enhanced convection and highly anomalous precipitable water (PW) values (>65 mm; >4 σ normalized anomaly). While moist air from the former region was transported poleward on the periphery of a broad subtropical anticyclone, moist air originating in the latter region was transported directly poleward on the eastern flank of a stationary lee trough that formed along the eastern Mexico coast in connection with the deep upper-tropospheric trough over western North America. Coincident with the poleward transport of moist air from the eastern tropical Pacific, a narrow plume of water vapor characterized by large PW values (>45 mm) stretched poleward directly from the eastern tropical Pacific into the south-central United States, helping to sustain persistent heavy rainfall across Tennessee and Kentucky. It is suggested that the transport of water vapor from the eastern tropical Pacific, resulting from a direct "tapping" of anomalously moist tropical air by the large-scale flow, may be a key factor that distinguishes this extreme rainfall event from "ordinary" heavy rainfall events.