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Early Evolution of the 23–26 September 2012 UK Floods: Tropical Storm Nadine and Diabatic Heating

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Major river flooding affected the UK in late September 2012 as a slow-moving extratropical cyclone brought over 100 mm of rain to a large swathe of northern England and north Wales, with local accumulations approaching 200 mm. The cyclone first developed on 21–22 September following the interaction between an equatorward-moving potential vorticity (PV) streamer and Tropical Storm Nadine, near the Azores. A plume of tropical moisture was drawn poleward ahead of the PV streamer over a low-level baroclinic zone, allowing deep convection to develop. Convectively driven latent heat release reduced upper-tropospheric PV near the streamer, causing it to fracture and cut off.

Convection-permitting (4-km grid spacing) simulations using the Weather Research and Forecasting (WRF) model investigate the importance of microphysical processes to the cyclone's evolution by setting the associated heating and cooling tendencies to zero. Both deposition (vapour to solid) and condensation heating play vital roles in reducing upper-tropospheric PV and allowing the streamer to cut off, whereas other microphysical processes such as sublimation, melting and evaporation have much less of an impact. Calculation of instantaneous diabatic heating and PV tendencies, in conjunction with Lagrangian trajectory analysis, confirms that deposition heating is as important as condensation heating to the cyclone's early development, but as the cyclone matures, condensation again becomes the dominant microphysical process in changing the PV.

The cyclone deepened further over the UK on 23–25 September, ahead of an approaching upper-tropospheric PV anomaly. Additional WRF simulations are designed in which the strength of the approaching PV anomaly is altered using PV surgery. These simulations allow quantification of the PV anomaly's importance to the UK floods, in conjunction with the cyclone's deepening over the UK. Preliminary results are at first glance counterintuitive, with the cyclone deepening more rapidly when the PV anomaly is removed and remaining weaker when the anomaly is doubled in strength. Further simulations will alter the position of the PV anomaly relative to the cyclone in order to investigate the role of phasing between the two systems on the cyclone's final intensity.

Keywords: PV surgery, Nadine, tropical storm, latent heat release, deposition, microphysics