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Influence of Warm Conveyor Belts on the Predictability of Downstream High-Impact Weather

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We explore the sensitivity and predictability of warm conveyor belts (WCBs) within extratropical cyclones that were observed intensively during the North Atlantic Waveguide and Downstream Impact Experiment (NAWDEX) in the fall of 2016. We utilize the moist adjoint for the Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS) to quantify the initial state and forecast sensitivity, as well as identify predictability barriers associated with moist and diabatic processes within WCBs. The adjoint modeling system is used to understand how perturbations of moisture, winds and temperature, of similar magnitude as analysis errors, impact WCBs and the cyclones, and subsequently grow rapidly as they propagate downstream as they interact with the waveguide.

The first case we focus on is the extratropical transition (ET) of Karl (2016) and its interaction with the waveguide and subsequent downstream impact. Karl is a unique storm in that it was observed as a tropical cyclone during two flights of the NASA Global Hawk (22-23 Sept. and 24-25 Sept.) as part of the NOAA Sensing Hazards with Operational Unmanned Technology (SHOUT) program. The subsequent extratropical transition (ET) of ex-Karl was observed by the European HALO G-V aircraft (26 Sept.) during NAWDEX. The adjoint sensitivity results underscore the importance of the inflow to the WCB during the ET stage of ex-Karl. The adjoint diagnostics indicate that the intensity of the WCB in ex-Karl following ET was especially sensitive to the northeast of Karl in a corridor of moisture prior to ET, and approximately 48-h earlier when the Global Hawk was observing the storm. We also find that the intensity of diabatic heating in the WCB influences the downstream ridge development. We use the Global Hawk dropsondes in the vicinity of Karl, as well as HALO dropsondes and the WALES DIAL Lidar to characterize the regions of strong sensitivity including those within the WCB.

Immediately following the ex-Karl ET case, extratropical cyclone 'Walpurga'developed and featured strong water vapor transport. This cyclone and associated atmospheric river were observed by a HALO flight on 27 September. The adjoint sensitivity highlights regions of enhanced sensitivity filaments of water vapor and temperature located in the low- to mid-levels within the ascending portion of an atmospheric river that have a strong impact on a high-impact precipitation event in Scandinavia that resulted in more than 100 mm in 72 h. Additionally, the adjoint results connect the high-impact precipitation event to the WCB associated with ex-Karl. The results of this study underscore the need for higher-fidelity moisture observations particularly within WCBs along with data assimilation systems that can adequately assimilate these mesoscale observations in order to reduce the forecast uncertainties for cyclones and their associated downstream impact.

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