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Future changes in North Atlantic winter cyclones in CESM-LE simulations from a Lagrangian-composite perspective

Edgar Dolores-Tesillos[1,2] and Stephan Pfahl[1]
[1]Freie Universität Berlin, Institut für Meteorologie, Berlin, Germany (stephan.pfahl@met.fu-berlin.de)
[2]Universität Bern, Geographisches Institut, Bern, Switzerland (edgar.dolores@giub.unibe.ch)

Extratropical cyclone airstreams, such as warm conveyor belts (WCBs), are linked to strong precipitation along with latent heat release at low levels and, thus, changes in the low-level PV distribution. Previous studies have shown significant changes in PV anomalies in a future climate under the RCP8.5 scenario, which are also associated with changes in strong near-surface winds. However, the source of these PV anomalies is still unclear, especially at upper levels. Based on the 1% strongest winter-cyclones in the North Atlantic (NA) region over the two periods 1990-2000 and 2091-2100, we adopt a Lagrangian perspective to investigate such changes in CESM Large Ensemble simulations.
Backward trajectories are computed to explicitly identify the contributions of diabatic processes to future changes in cyclone-associated PV anomalies. Moreover, the role of specific airstreams in PV generation/destruction is examined with Lagrangian composites.
The results show a sinificant change in the mean trajectory properties 24 hours before the maximum cyclone intensity at low and upper levels. This period of 24 hours is taken to construct Lagrangian composites at 700 hPa and 250 hPa, which provide insights into changes in WCB and dry intrusion (DI) airstreams. We further analyze these airstrem changes by constructing cross sections downstream (WCB regime) and at the equatorward side (DI regime) of the cyclone center.
In general, increased diabatic heating along backward trajectories amplifies positive PV anomalies near the cyclone center at both lower and upper levels in a warmer future climate. More specifically, a poleward and upward shift of the WCBs with a larger PV production at middle levels are is found. DIs near the cyclone center are projected to be responsible for stronger PV production at low levels to the south of the cyclone center. At upper levels, the decreased PV anomaly to the south of the cyclone center results from a combined effect of a decreased climatological PV in the NA region and a shift in the origin of the air masses. The increasing importance of diabatic processes in a wamer climate suggests that a better representation of these processes in climate models is necessary to reduce uncertainties.