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The relevance of individual microphysical processes for potential vorticity anomalies in extratropical cyclones

Bas Crezee, Hanna Joos, and Heini Wernli
Institute for Atmospheric and Climate Science, ETH Zürich, Zürich, Switzerland (bas.crezee@env.ethz.ch)

Extratropical cyclones have a large impact on daily weather through their accompanying strong winds and precipitation. The latent heating and cooling associated with microphysical processes like condensation, freezing and melting, sublimation and evaporation leads to the formation of distinct cloud diabatic potential vorticity (CDPV) anomalies. Positive low-level CDPV anomalies - which typically are formed along the fronts and close to the cyclone center - have been shown to interact with upper-level PV anomalies thereby potentially enhancing storm intensification. Here a novel method is applied, which calculates backward trajectories from the mature storm stage, integrates cloud diabatic PV changes due to microphysical processes, and constructs a CDPV budget for each individual anomaly. Thereby we quantify the contributions of, e.g., cloud condensation, depositional growth of snow and melting of snow to the individual anomalies and in turn to the near-surface circulation. First, we apply this method to an idealized mid-latitude cyclone. The formation of the relatively small low-level negative CDPV anomalies is dominated each by one specific process, depending on their location relative to the front. For the large positive PV anomaly we find that the strongest contributions are from in-cloud condensation and below-cloud snow melting and rain evaporation. Although contributions of in-cloud depositional growth of ice are rather small, they cover a very large area and are therefore dynamically significant, i.e. they produce a fairly large-scale but low-amplitude anomaly. In addition the results from the idealized simulations are compared to a wintertime cyclone. It will be discussed how well the method works for real cyclones and how closely the results agree with those from the idealized channel model experiment.