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Mechanisms controlling the spatial structure of mid-latitude storm tracks and their variation under climate change

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Abstract The Atlantic and Pacific storm tracks in the northern hemisphere are characterized by a downstream poleward deflection, which has important consequences for the distribution of heat, wind and precipitation in the midlatitudes. In this study, the spatial structure of the storm tracks is examined by tracking transient cyclonic eddies in an idealized GCM with a localized ocean heat flux. The localized atmospheric response is decomposed in terms of a time-zonal mean background flow, a stationary wave and a transient eddy field. The Lagrangian tracks are used to construct cyclone composites and perform a spatially varying PV budget. Three distinct mechanisms that contribute to the poleward tilt emerge: transient nonlinear advection, latent heat release and stationary advection. The downstream evolution of the PV composites shows the different role played by the stationary wave in each region. Our results imply that in the region where the tilt is maximized, all three mechanisms contribute to the poleward propagation of the low level PV anomaly associated with cyclones. Upstream of that region, the stationary wave is opposing the former two and the poleward tendency is therefore reduced. Through repeated experiments with enhanced strength of the heating source, it is shown that the poleward deflection of the storms enhances when the amplitude of the stationary wave increases. For a global warming scenario, we find that poleward deflection due to transient nonlinear advection and latent heating will strengthen, meaning that the poleward motion of individual cyclones increases with increasing global mean temperatures. Our results imply that for a 4K rise in the global mean surface temperature, the averaged poleward drift of cyclones will increase by approximately 1 degree of latitude. This will have significant impact on midlatitude climate, and implies that localized storm tracks, such as the Atlantic and Pacific storm tracks, will exhibit a more poleward deflected shape under global warming.