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Delineating the Barotropic and Baroclinic Mechanisms in the Midlatitude Eddy-Driven Jet Response to Lower-Tropospheric Thermal Forcing

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Observations and climate models have shown that the midlatitude eddy-driven jet can exhibit an evident latitudinal shift in response to lower-tropospheric thermal forcing (e.g., the tropical SST warming during El Niño or extratropical SST anomalies associated with the atmosphere–ocean–sea ice coupling). In addition to the direct thermal wind response, the eddy feedbacks—including baroclinic mechanisms, such as lower-level baroclinic eddy generation, and barotropic mechanisms, such as upper-level wave propagation and breaking—can all contribute to the atmospheric circulation response to lower-level thermal forcing, but their individual roles have not been well explained. In this study, using a nonlinear beta-plane multilevel quasigeostrophic channel model, the mechanisms through which the lower-level thermal forcing induces the jet shift are investigated. By diagnosing the finite-amplitude wave activity (FAWA) budget, the baroclinic and barotropic eddy feedbacks to the lower-level thermal forcing are delineated. Particularly, by examining the transient circulation response after thermal forcing is switched on, it is shown that the lower-level thermal forcing affects the eddy-driven jet rapidly by modifying the upper-level zonal thermal wind distribution and the associated meridional wave propagation and breaking. The anomalous baroclinic eddy generation, however, acts to enhance the latitudinal shift of the eddy-driven jet only in the later stage of transient response. Furthermore, the barotropic mechanism is explicated by overriding exper- iments in which the barotropic flow in the vorticity advection is prescribed. Unlike the conventional baroclinic view, the barotropic eddy feedback, particularly the irreversible PV mixing through barotropic vorticity advection and deformation, plays a major role in the atmospheric circulation response to the lower-level thermal forcing.