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Baroclinic development within zonally varying flow

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Previous idealized modeling studies have shown the importance of across-jet barotropic shear to the resulting evolution of cyclones, anticyclones, surface-based fronts, and upper-level fronts. In contrast, many observational studies of cyclones have shown the importance of along-jet variations in the horizontal wind speed (i.e., confluence and diffluence). This study investigates the importance of these along-jet (zonal, for zonally oriented jets) variations in the horizontal wind speed to the resulting structures and evolutions of baroclinic waves using idealized models of growing baroclinic waves. An idealized primitive-equation channel model is configured with growing baroclinic perturbations embedded within confluent and diffluent background flows. When the baroclinic perturbations are placed in background confluence, the lower-tropospheric frontal structure and evolution initially resembles that of the Shapiro–Keyser cyclone model with a zonally oriented cyclone, strong warm front, and bent-back warm front. Later, as the baroclinic wave amplifies in the stronger downstream baroclinicity, the warm sector of the cyclone narrows, becoming more reminscent of the Norwegian cyclone model. The upper-level frontal structure develops with a southwest–northeast-orientation and becomes strongest at the base of the trough where geostrophic cold advection is occurring. In contrast, when the baroclinic perturbations are placed in background diffluence, the lower-tropospheric frontal structure and evolution resembles that of the Norwegian cyclone model with a meridionally oriented cyclone, strong cold front, and occluded front. The upper-level frontal structure is initially oriented northwest–southeast on the west side of the trough before becoming zonally oriented. Weak geostrophic temperature advection occurs along its length. These results are compared to those from previous observational and idealized modeling studies.