How to diagnose the horizontal flux of mesoscale / Rossby eddy energy in the extension regions of western boundary currents?

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There have been few studies on the horizontal flux of energy associated with mesoscale eddies and Rossby eddies. (Many studies in the past decade are on either energy conversions or the flux-divergence of eddy energy). This is partly attributed to the fact that, in general, the pressure flux in the traditional eddy energy equation does not look in the direction of the group velocity of Rossby waves. This has been a limitation in the understanding of the maintenance mechanism of the extension of western boundary currents (WBCs). The present study has developed a new eddy energy equation which (is independent of the quasi-geostrophic approximation but) allows us to diagnose the horizontal flux of eddy / wave energy with retaining the direction of the group velocity of a wide-array of Rossby-wave types. The types of Rossby waves include that are associated with both pure and equivalent beta effects, namely variants of Rossby waves concerning the horizontal gradient of (i) planetary vorticity, (ii) relative vorticity associated with mean currents (which is as in atmospheric dynamics), and (iii) the background stratification (which is associated with the slope of thermocline and yields an effect similar to topographic Rossby waves). A diagnosis of an idealized experiment shows that, in the regions of the extension of WBCs, the effects (ii) and (iii) prevail over the effect (i) to yield the eastward flux of eddy / wave energy. The result is that the total westward flux of eddy / wave energy by an array of Rossby-wave types may sometimes cancel out the eastward flux of eddy / wave energy owing to advection by mean currents in the extension regions.