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Dynamics of up-gradient eddy fluxes of potential vorticity near the tropopause and synoptic-planetary scale interactions

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The role of eddy fluxes in the general circulation is often approached by treating eddies as (macro)turbulence. In this approach, the eddies act to diffuse certain quasi-conservative quantities, such as potential vorticity (PV), along isentropic surfaces in the free atmosphere. The eddy fluxes are determined primarily by the eddy diffusivities and are necessarily down-gradient of the basic state PV field. Here we call attention to a pronounced and significant region of up-gradient (i.e. notionally 'anti-diffusive') eddy PV fluxes near the subtropical tropopause in both hemispheres. They exist in a region of strong and positive background PV gradient and thus enhance the angular momentum of the mean flow.

Analyses of the enstrophy budget suggest that the up-gradient PV fluxes are maintained by poleward enstrophy fluxes. Finite-amplitude effects thus represent leading order contributions to the enstrophy budget, whereas dissipation is only of secondary importance locally. The up-gradient PV fluxes are found to be predominantly due to planetary scale waves, which are generated through scale interactions during synoptic scale Rossby wave breaking along the tropopause wave guide. The nature of this upscale cascade and its fundamental role in wave-mean flow interaction phenomena in geophysical fluid dynamics will be discussed.