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Vortex Roll Breakup in Three-Dimensional Turbulent Boundary Layers[1] CURTIS HAMMAN, PARVIZ MOIN, Center for Turbulence Research, Stanford University — Large helical vortex rolls with axes in the general direction of the mean wind commonly appear in the unstably stratified atmospheric boundary layer. When a rapid shift in the mean wind direction occurs, the vertical transport of momentum and heat flux is sharply reduced compared to the equilibrium value. At long times, this non-equilibrium turbulent flow may develop back into a stable pattern of organized vortex rolls, now aligned with the new wind direction. This transition process is studied via direct numerical simulation of plane channel flow heated from below with impulsively started transverse pressure gradient ($Ri = -Ra/PrRe^2 = -0.25$, $Ra = 10^7$, and $Pr = 0.71$). The timescale for heat flux recovery is approximately the same for turning angles larger than 30 degrees. For higher turning angles, however, the Nusselt number will temporarily drop below one due to a significant reduction in vertical transport. Horizontal velocity and temperature spectra suggest that scale separation between large-scale, organized convective motions and turbulent eddies can prevent heat transfer reduction in transversely accelerated three-dimensional turbulent boundary layers.

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