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The near-wall structure of the vorticity field in atmospheric flows

CURTIS HAMMAN, PARVIZ MOIN, Center for Turbulence Research, Stanford University — Prompted by suggestions that long-lived, coherent structures are regions of high helicity ($\vec{\omega}\cdot\vec{u}$) and low dissipation, Rogers & Moin (1987, PoF) examined the helicity field in turbulent channel flow, and did not find evidence to support this helicity conjecture. They concluded, however, that buoyancy forces may preferentially and chronically concentrate cork-screw eddies in wall turbulence. We examine this hypothesis by studying numerical simulation databases of thermal convection with a mean flow in large-aspect ratio channels. Roll cells generated by buoyancy forces in the bulk are contrasted with near-wall, hairpin-like vortices sustained by mean shear. At moderate bulk Richardson numbers, near-wall helicity fluctuations increase showing strong peaks in relative helicity density pdfs but less so in regions of low dissipation. Transverse strain imposed by erupting and impinging thermal plumes embedded in the streamwise-aligned, large-scale circulation is found to tilt these hairpin packets in a herringbone pattern reducing the local turbulence production but increasing the local turbulent dissipation as in 3D turbulent boundary layers. Recent simulations and implications for understanding large-eddy structures in PBLs using LES are discussed.

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