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Coherent structures and associated sub-grid scale energy transfer in a rough-wall turbulent channel flow[1] JIARONG HONG, University of Minnesota, JOSEPH KATZ, CHARLES MENEVEAU, Johns Hopkins University, MICHAEL SCHULTZ, United States Naval Academy — The turbulence structure in a rough-wall channel flow and its role in subgrid scale (SGS) energy transfer are studied utilizing PIV data obtained in an optically index-matched facility. In streamwise-wall-normal $(x - y)$ planes, the averaged flow structure conditioned on high SGS flux exhibits a large inclined shear layer containing negative vorticity, bounded by an ejection below and a sweep above. The peaks of SGS flux and kinetic energy are spatially displaced from region of high-resolved TKE. In wall-parallel $x - z$planes, the conditional flow exhibits two pairs of counter-rotating vortices that induce a contracting flow at the SGS flux peak. Instantaneous realizations in the roughness sublayer confirm the presence of these vortex pairs at the intersection of two vortex trains. In the outer layer, the SGS flux peaks within isolated vortex trains that retain the roughness signature. To explain the planar signatures, we propose a flow consisting of U-shaped quasi-streamwise vortices that develop as spanwise vorticity is stretched in regions of high streamwise velocity between roughness elements. Flow induced by legs of adjacent U-shaped structures causes powerful ejections, which lift these vortices away from the wall. As a sweep is transported downstream, its interaction with the roughness generates a series of such events, leading to the formation of inclined vortex trains.

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