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High Resolution 3D Experimental Investigation of Flow Structures and Turbulence Statistics in the Viscous and Buffer Layer JIAN SHENG, EDWIN MALKIEL, JOSEPH KATZ, The Johns Hopkins University — Digital Holographic Microscopy is implemented to perform 3D velocity measurement in the near-wall region of a turbulent boundary layer in a square channel over a smooth wall at Re_τ=1,400. The measurements are performed at a resolution of $\sim 1\mu$m over a sample volume of 1.5x2x1.5mm (x^+=50, y^+=60, z^+=50), sufficient for resolving buffer layer structures and for measuring the instantaneous wall shear stress distributions from velocity gradients in the sublayer. The data provides detailed statistics on the spatial distribution of both wall shear stress components along with the characteristic flow structures, including streamwise counter-rotating vortex pairs, multiple streamwise vortices, and rare hairpins. Conditional sampling identifies characteristic length scales of 70 wall units in spanwise and 10 wall units in wall-normal direction. In the region of high stress, the conditionally averaged flow consists of a stagnation-like sweeping motion induced by a counter rotating pair of streamwise vortices. Regions with low stress are associated with ejection motion, also generated by pairs of counter-rotating vortices. Statistics on the local strain and geometric alignment between strain and vorticity shows that the high shear generating vortices are inclined at 45 $^\circ$ to streamwise direction, indicating that vortices are being stretched. Results of on-going analysis examines statistics of helicity, strain and impacts of near-wall structures.

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