Abstract Submitted
for the DFD16 Meeting of
The American Physical Society

Five layers in a turbulent pipe flow.[1] JINYOUNG LEE[2], JUNSUN AHN, HYUNG JIN SUNG, KAIST — The scaling laws governing the five layers of the mean velocity distribution of a turbulent pipe flow were characterized using the available DNS data (Re_τ = 544, 934, 3008). Excluding the very near-wall and core regions, the buffer, meso- and log layers were identified by examining the streamwise mean momentum equation and the net force spectra. The (outer) log layer was located in the overlap region where the viscous force was negligible. Another (inner) log layer was observed in the buffer layer, in which the viscous force was directly counterbalanced by the turbulent inertia. A meso-layer between the buffer and outer log layers was found to feature viscous effects. The acceleration force of the large-scale motions (LSMs) penetrated the outer log layer at higher Reynolds numbers, as observed in the net force spectra. The acceleration force of the LSMs became strong and was counterbalanced by the deceleration force of the small-scale motions (SSMs), indicating that the inner and outer length scales contributed equally to the meso-layer. The outer log layer was established by forming an extended connection link between the meso- and outer layers.

[1]This work was supported by the Creative Research Initiatives (No. 2016-004749) program of the National Research Foundation of Korea (MSIP) and partially supported by KISTI under the Strategic Supercomputing Support Program.
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Date submitted: 01 Aug 2016 Electronic form version 1.4