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Direct Numerical Simulation of oscillatory boundary layers in the intermittently turbulent regime: coherent structures, laminarization and scaling DIMITRIOS K. FYTANIDIS, JOSE M. MIER, MARCELO H. GARCIA, PAUL FISCHER, University of Illinois at Urbana-Champaign — Experiments conducted at the Ven Te Chow Hydrosystems Laboratory (UIUC) in the transitional regime of oscillatory boundary layer flows with smooth bed, show changes in the phase shift diagram between bed shear stress and free-stream velocity maxima (Mier J.M., 2015). Nevertheless, limited by the point-wise measurements (Laser Doppler Velocimetry), it was not possible to relate this finding with the development of three-dimensional flow structures. In this work, Nek5000 is used to perform Direct Numerical Simulation (DNS) of oscillatory boundary layer flows in moderately high Re numbers. DNS results of mean flow and turbulent statistics compare well with experimental observations. Coherent structures and their effect on turbulence characteristics are examined. Vortex tubes have minimal effect on turbulent statistics and friction factor, while turbulent spots defined as sporadic, highly-energetic, lambda-shaped structures, have a significant effect. Analysis of phase shift between free-stream velocity and bed shear stress maxima agrees with the experimental observations. Theoretical analysis is performed for the prediction of laminarization during acceleration phase. A generalized logarithmic law is proposed for accelerating flows using a novel composite acceleration-shear velocity scale.

Dimitrios K. Fytanidis
University of Illinois at Urbana-Champaign

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