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Turbulent wall flows over spanwise-heterogeneous surfaces: non-periodic deviation from Reynolds-averaged flow patterns. WILLIAM ANDERSON, UT Dallas — Turbulent flows respond to bounding walls with a predominant spanwise heterogeneity – that is, a heterogeneity parallel to the prevailing transport direction – with formation of Reynolds-averaged turbulent secondary flows. These secondary rolls constitute manifestation of Prandtl's secondary flow of the second kind: driven and sustained by spatial heterogeneities in the Reynolds (turbulent) stresses. Results from large-eddy simulations and complementary experimental measurements of flow over spanwise-heterogeneous surfaces are shown: the resultant secondary cell location is clearly correlated with the surface characteristics, which ultimately dictates the Reynolds-averaged flow patterns. However, results also show the potential for instantaneous sign reversals in the rotational sense of the secondary cells. This is accomplished with probability density functions and conditional sampling. In order to further this, a base flow representing the streamwise rolls is introduced. Upon substitution of the base flow into the streamwise momentum and streamwise vorticity transport equations, and via use of a vortex forcing model, we assess phase-space evolution (orbit) of the resulting system of ordinary differential equations. The system resembles the Lorenz system, but the forcing conditions differ intrinsically. Nevertheless, the system reveals that chaotic, non-periodic trajectories are possible for sufficient inertial conditions.

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