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Large eddy simulation of boundary layers with embedded spanwise vortices IFTEKHAR NAQAVI, UGO PIOMELLI, Queen's University — We performed large eddy simulations of a zero-pressure-gradient boundary layer interacting with strong, spanwise-oriented vortices. A periodic array of spanwise vortices is generated at the edge of the boundary layer; as they advect downstream, they introduce strong perturbations that extend to the near-wall region, and alter significantly the turbulence dynamics. Localized separation regions are observed below the vortices. Phase averaged data show that the vortices have lost their coherence 10δ downstream of the point where they are generated however the boundary layer does not recover its equilibrium state even after 60δ. While the vortices remain coherent the phase-averaged velocity profiles show a strong wake, and the logarithmic law is shifted first upwards, and then downwards as the vortex passes. After the coherence is lost all the phases show almost identical behaviour, but the recovery towards an equilibrium boundary layer profile is slow. The fluctuations due to the vortices can be decomposed into a periodic and a random component. The periodic fluctuations supply up to 50% of the total Reynolds stresses in the coherent region, but their contribution is reduced significantly when the vortices decay, and the Reynolds stress due to the random fluctuations is dominant. Flow visualizations show strong uplift and stretching of the near-wall vortices.

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