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Turbulence dynamics in unsteady atmospheric flows[1] MOSTAFA MOMEN, ELIE BOU-ZEID, Princeton University — Unsteady pressure-gradient forcing in geophysical flows challenges the quasi-steady state assumption, and can strongly impact the mean wind and higher-order turbulence statistics. Under such conditions, it is essential to understand when turbulence is in quasi-equilibrium, and what are the implications of unsteadiness on flow characteristics. The present study focuses on the unsteady atmospheric boundary layer (ABL) where pressure gradient, Coriolis, buoyancy, and friction forces interact. We perform a suite of LES with variable pressure-gradient. The results indicate that the dynamics are mainly controlled by the relative magnitudes of three time scales: $T_{inertial}$, $T_{turbulence}$, and $T_{forcing}$. It is shown that when $T_f \approx T_t$, the turbulence is no longer in a quasi-equilibrium state due to highly complex mean-turbulence interactions; consequently, the log-law and turbulence closures are no longer valid in these conditions. However, for longer and, surprisingly, for shorter forcing times, quasi-equilibrium is maintained. Varying the pressure gradient in the presence of surface buoyancy fluxes primarily influences the buoyant destruction in the stable ABLs, while under unstable conditions it mainly influences the transport terms.

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