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Analytical damped-oscillator models for unsteady atmospheric boundary layers[1] MOSTAFA MOMEN, ELIE BOU-ZEID, Princeton University — Geophysical flows are dynamical systems that are evolving nonlinearly with time. Non-stationary shear and buoyancy forces are the main sources that drive the unsteadiness of such flows. However, due to their inherent complexity, most previous studies focused on steady-state conditions. In these boundary layers, the pressure gradient, buoyancy, Coriolis, and friction forces interact. The mean PDEs governing the unsteady version of the problem, which emerges when these forces are not in equilibrium, are solvable only for a limited set of forcing variability modes, and the resulting solutions are intricate and difficult to interpret. Here we derive a simpler physical model that reduces the governing RANS equations into a first-order ODE with non-constant coefficients. The origin of the non-stationarity of turbulence can be buoyant stabilization/destabilization and/or unsteady pressure gradient. The reduced model is straightforward and solvable for arbitrary turbulent viscosity variability, and it captures LES results for linearly variable buoyancy and pressure gradient pretty well. The suggested model is thus general and will be useful for elucidating some features of the diurnal cycle, for short-term wind forecast, and in meteorological applications.

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