SIMULATING NEUTRALLY AND STABLY STRATIFIED TURBULENT EKMAN FLOWS WITH A STOCHASTIC TURBULENCE MODEL

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We investigate turbulent Ekman flows as canonical problem related to the atmospheric boundary layer. The configuration is given by a rotating wall (fixed in the rotating frame of reference), a geostrophically balanced bulk flow \( G \) above this wall, and a buoyant scalar to account for stratification effects. Dirichlet boundary conditions are used for all variables similar to [1]. The coupling of the wall and the fluid is accomplished by a thin layer of size \( \delta = \sqrt{\nu/\Omega} \) (laminar Ekman layer thickness), where \( \nu \) is the kinematic viscosity and \( \Omega \) the background rotation rate. The length scale \( \delta \) imposes strong resolution requirements and considerably limits the numerically accessible Reynolds numbers. In the case of strong stratification, further complications arise due to intermittency [1], which cannot be modeled with standard gradient-diffusion closures (e.g. [2, 7]).

We address these challenges by the lower-order, stochastic, so-called one-dimensional turbulence (ODT) model [3]. ODT aims to resolve all scales of a turbulent flow but reduces the dimensionality. The computational domain is a 1-D line, which is here oriented vertically, and reaches from the wall up into the unperturbed bulk flow [4]. Along this line, diffusive transport and the Coriolis effect are resolved directly, whereas the effects of turbulent advection and pressure fluctuations are modeled by stochastic mapping events. These events are selected with highest probability where shear and buoyancy yield net extractable energy. Here we use an adaptive ODT implementation [6].

In the talk, we consider first the case of neutral stratification in order to validate the model. After that, we discuss in more detail the effects of stratification. For both cases, various statistical quantities will be shown and compared to available reference data. Preliminary ODT results for neutrally and stably stratified Ekman flows are shown in figure 1.

**Figure 1.** Left—neutral stratification: Hodographs of the mean velocity \((U, V)\) and the corresponding values of the wall-shear stress angle \(\gamma_T\) for various \(Re = G\delta/\nu\). The unphysical ‘kink’ around \(U/G \approx 0.8\) is currently further investigated but \(\gamma_T(Re)\) is fairly well captured by ODT. Right—stable stratification: Instantaneous vertical profiles of the buoyancy \(b\), the streamwise \(u\) and the spanwise \(v\) velocity component for the laminar initial state (\(t = 0\)) and a snapshot after 1.5 inertial periods. These ODT results are in qualitative agreement with available reference data (not shown). Here, we have used the ODT model parameters of turbulent channel flow [5].

**References**


