EMS Annual Meeting Abstracts
Vol. 18, EMS2021-362, 2021
https://doi.org/10.5194/ems2021-362
EMS Annual Meeting 2021

Numerical Analysis of a Hybrid Stochastic Turbulence Model for Stable Stratification

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We present results on the modeling of intermittent turbulence in the nocturnal boundary layer using a data-driven approach. In high stratification and weak wind conditions, the bulk shear can be too weak to sustain continuous turbulence and the sporadic submesoscale motions trigger the turbulence production.
The main idea is to extend a TKE-based, 1.5 order turbulence closure model by introducing a stochastic differential equation (SDE) for the nondimensional correction of the mixing length. Such a nonstationary SDE model is built upon the traditional surface-layer scaling functions, which model the effect of the static stability on the surface-layer profiles using scaling with the Richardson (Ri) number . The nonstationary parameters of the SDE equation are determined from data with a model-based clustering approach. Furthermore, it is found that parameters scale with the local gradient Ri number, resulting in a closed-form nonstationary stability correction depending only on this local gradient Ri number. Beneficial is the interpretation of the noise term of the SDE. This term is interpreted as an effect of the submesoscale motions on turbulent mixing. Furthermore, the SDE model provides a conceptual view on intermittent turbulence, whereby in the noise-free limit, the steady-state solution converges to the traditional functional scaling. Per construction, the SDE is readily incorporated in a turbulence closure by modifying the definition of the stability correction. Details will be provided.
We will present a numerical analysis of such a hybrid model for quasi-steady-state solutions with different model settings. Furthermore, we investigate the regime transitions between weakly and strongly stable flows under intermittent mixing based on the temperature inversion characteristics.