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A data-driven stochastic parametrisation of intermittent turbulence in the stably stratified atmospheric boundary layer

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We present results on the modelling of intermittent turbulence in the nocturnal boundary layer using a data-driven approach. In conditions of high stratification and weak wind, the bulk shear can be too weak to sustain continuous turbulence, and the sporadic submeso motions play an important role for the turbulence production. We show a way to stochastically parametrise the effect of the unresolved submeso scales and include it into a 1.5-order turbulence closure scheme. This is achieved by introducing a stochastic equation, which describes the evolution of the non-dimensional flux-gradient stability correction for momentum (ϕ_m). The unperturbed equilibrium solution of the equation follows the functional form of the universal similarity function. The stochastic perturbations reflect the instantaneous excursions from its equilibrium state, and the distribution of values covers the scatter found in observations at high stability.

The non-stationary parameters of this equations are estimated from a time-series data of the FLOSS2 experiment using a model-based clustering approach. The clustering analysis of the parameters shows a scaling relationship with the local gradient Ri number, leading to a suggested closed-form model for the stochastic flux-gradient stability correction. The spatial correlation in height of the perturbations is included in the model as well. The resulting equation captures the transition of the stability correction across and beyond the critical Ri up to a value of 10. The out-of-sample prediction shows a valid transient dynamics into and within the regime of strongly-stable stratification.