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Identification and parameterisation of regime dynamics in the stably stratified nocturnal boundary layer

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The stably stratified nocturnal boundary layer (SBL) can be classified into two distinct regimes: one with moderate to strong winds, weak stratification and mechanically sustained turbulence (wSBL) and the other with moderate to weak wind conditions, strong stratification and collapsed turbulence (vSBL). With the help of a hidden Markov model (HMM) analysis and its estimation of a the most likely regime occupation sequence using the input information of the three dimensional state variable space of stratification, mean wind speeds, and wind shear the SBL can be classified in these two regimes in both the Reynolds-averaged as well as turbulence state variables. The HMM analysis allows study of the climatological behaviour of the SBL regime dynamics and quantification of the importance of accounting for the SBL variability caused by the different regimes and transitions between them (which are not accounted for in state-of-the-art forecast models). Evidence is provided that no clear deterministic relationship between external drivers and the regime occupation and regime transitions exist underlining the importance to parameterise the effects of SBL regimes explicitly stochastic. In particular, the vSBL to wSBL transition, the recovery of turbulence, is considered to occur due to intermittent turbulent events which are not resolved in state-of-the-art forecast models. An approach extending the existing boundary layer parameterisation schemes with a stochastic term allowing for a representation of those intermittent turbulent events and therefore SBL regime transitions and dynamics is discussed. The parameterisation presented relies on the climatological regime event durations and regime transition probabilities obtained from the HMM analysis of the observational data across different tower sites. Results from a simplified single-column model using such a parameterisation are presented.