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Sensitivity of the Nocturnal and Polar Boundary Layer to Transient Phenomena

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Atmospheric boundary layers with thermally stable stratification (SBL) are the least understood type of boundary layer due to suppressed turbulence and the presence of myriads of processes on multiple spatio-temporal scales that modulate the turbulence. Classical approaches to turbulence parameterization fail to reproduce turbulent dissipation in SBL contexts and this is a known source of errors in weather and climate models.

One of the research challenges is to develop an accurate representation of distinct regimes of the SBL and transitions between them. Defining all mechanisms which lead to these sudden regime transitions and predicting or detecting them is still a challenge. Stochastic modeling approaches are a promising framework to analyze the different types of triggers for regime transitions. Therefore, we test the sensitivity of the SBL to intermittent turbulence mixing events by extending a single-column model with physically meaningful randomizations. Noise in the boundary conditions for example represents fluctuating geostrophic wind or cloud cover. This model is used as a numerical tool to systematically investigate noise-induced regime transitions of the SBL.

The overall objective is to improve the representation of the atmospheric boundary layer in numerical weather prediction and climate models by developing stochastic parametrization concepts. It is very useful to identify abrupt regime transitions in order to anticipate air pollution hazards, fog, and frost, all of which coincide with the onset of a very stable boundary layer. In addition, current SBL parametrizations fail at representing mixing in the very stable regime and may need to switch to a parametrization where turbulence stationarity assumptions are relaxed.