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Understanding and Representing Stable Boundary Layer Over Cold Regions Based on Observations and A New Diagnostic Turbulence Scheme in CanAm4 Climate Models

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A new semi-empirical diagnostic turbulent kinetic energy (TKE) scheme is used in combination with observational analysis to understand and to represent stable boundary layers (SBL) over cold regions. Five year observations from Cabauw, Netherlands, demonstrate multiple regimes of turbulence, winds, and stratification under nighttime clear-sky conditions. Among observed SBL depth, approximately 10% are very shallow (<= 40m), and around 70% are 200m or deeper. This 10/70 fraction and the sharp regime transition of near-surface temperature inversions are common features in all seasons. The new TKE scheme is capable of reproducing the observed clear-sky S-shape relationship between near surface wind speed and stratification, and it reproduces a more realistic fraction of very shallow SBL than that of the operational one in the CanAM4 climate models. However, the number of weak SBL that are deeper than 200m is significantly underestimated over cold regions in both operational and new schemes. The key physical mechanism supporting the regime transition and the occurrence of deep SBLs will be summarized.