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# Structure of weather prediction errors in stably-stratified atmospheric conditions

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Stably-stratified atmospheric conditions still challenge numerical weather forecast, especially in high latitudes where they are frequently observed all year around. In stably-stratified atmosphere, surface is colder than air above. Such conditions suppress vertical turbulent mixing and may lead to surface layer decoupling in numerical models. Enhanced mixing could prevent decoupling but being implemented without sufficient care results in damped response of the surface layer meteorological variables on fluctuations of the weather conditions. In this study, we investigate weather prediction errors related to such a damped response. We run a group of operational prediction models (HIRLAM-HARMONIE, SL-AV) with a set of different turbulence parametrizations that includes HARATU, TOUCANS, and pTKE schemes. The results are compared with real weather observations and idealized GABLS setups proposed for a high latitude domain. We found that the systematic warm temperature bias in the models is caused by too slow response of the modelled temperature on the implied cooling. The largest (and quickly growing) errors are found over the first few hours of cooling, whereas in longer perspective the errors diminish as the model equilibrates with more stationary weather conditions. We develop a theory that may explain the observed structure of weather prediction errors. The explanation is based on the well-known coupling between the turbulent mixing intensity and the thickness of the mixed layer embedded into the parametrization of the mixing length scale. The required enhanced mixing could be provided by the energy-flux balance scheme by Zilitinkevich et al., but it does not reduce the warm bias as it makes the mixed deeper and less responsive. We propose more accurate limitations on the mixed layer thickness to improve the temporal structure of the surface layer temperature response in the weather prediction models.