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Evaluating and Improving Parameterizations of the Variance of Temperature Fluctuations Over Heterogeneous Landscapes for Surface Boundary Conditions in Atmospheric Models

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The implementation of higher-order turbulence closure schemes in Earth system models (e.g., the Cloud Layers Unified by Binormals; CLUBB) aims to improve the modeling of convection and radiative transfer in numerical weather prediction and climate models. However, the added value of these schemes is constrained by the specification of boundary conditions on higher-order statistics. At the land surface, many of the higher order turbulence statistics that are required as boundary conditions are parameterized using formulations more appropriate for stationary and planar-homogeneous flow in the absence of subsidence. A case in point is the variance of the potential temperature fluctuations. Because of the additive nature of variances arising from non-uniformity in surface heating, current parameterizations are not readily generalizable. The current scheme used in CLUBB, as well as other models, relies on limited studies over uniform terrain, with the variance entirely determined by local sensible heat flux, friction velocity, and the Obukhov stability parameter without regard to local site characteristics. This presentation aims to address this weakness by leveraging the National Ecological Observation Network (NEON) network of eddy covariance towers to validate the current parameterization scheme for potential temperature variance, as well as propose improvements for more heterogeneous terrain.

The turbulence fluctuations of temperature at 39 NEON sites are processed and quality controlled, removing points occurring at night, while precipitation is falling, and with sub-zero temperatures. Results overall indicate the current scheme performs well, especially over flat homogeneous terrain where local flux relationships dominate. When there is sufficiently heterogeneous, rough terrain or non-closure of the local energy balance, however, existing schemes fail to accurately estimate the variances in temperature. In these cases, the parameterization needs to be modified, and initial results suggest simple adjustments can yield improvements and reduce error close to that of the uniform sites with local energy balance closure. The successful improvement of the temperature variance parameterization scheme implies high potential for similar, new, empirically derived parameterizations for the surface boundaries for other higher order turbulent statistics (e.g. temperature skewness) in atmospheric turbulence models.