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Parameterization Sensitivity and Instability Characteristics of the Maximum Sustainable Heat Flux Framework for Predicting Turbulent Collapse

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The collapse of turbulence in the stable boundary layer is investigated using a one dimensional model of Couette flow. We demonstrate that the maximum sustainable heat flux (MSHF) framework for predicting turbulent collapse is qualitatively robust to the choice of turbulence parameterization and extend these earlier stability analyses by numerically determining the unstable modes along the unstable branch. All of the parametrizations exhibit a MSHF beyond which turbulence collapses, yet important quantitative differences in equilibrium structure between the models were found. Whereas the equilibrium structure for Businger-Dyer-type stability functions are independent of the momentum roughness length z_0, all of the other relations show a strong dependence on z_0 with regard to their shapes and the value of the MSHF. As for the stability properties of the equilibrium curves, these all depend on z_0 and only a single unstable eigenmode was found along the unstable branches. Transitions between stable and unstable regimes occur at extrema of the equilbrium curves in parameter space. Remarkably, some of the parameterizations even exhibit multiple extrema separating, disjointed regions of stability and instability. In practice, the MSHF framework is robust qualitatively, but the quantitative differences that arise as a result of varying the turbulent closure scheme must be accounted for when using the MSHF framework to predict the collapse of turbulence in the SBL especially in the case of small z_0.