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Subgrid-scale physics under stable atmospheric stratification: the SnoHATS experiment

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Stably stratified atmospheric flows are usually characterized by weak and highly anisotropic turbulence, gravity waves, instabilities, and meandering motions that are not observed in neutral or convective atmospheric flows. These features complicate both modeling and measurements in stable atmospheric boundary layers. However, recent evidence suggests that the large eddy simulation (LES) technique yields better results under stable conditions than classic numerical simulations. Nevetheless, LES results remain quite sensitive to the modeling of the unresolved, subgrid scales of turbulence. To address some of the open questions related to the modeling of these small turbulent scales under stable conditions, the Snow Horizontal Array Turbulence Study (SnoHATS) field experimental campaign– was performed over an extensive glacier in Switzerland from February to April 2006. The snow cover provided stable stratification of the flow over long periods. Two horizontal arrays of vertically separated 3D sonic anemometers were deployed to allow two [U+2011] dimensional filtering and computation of the full three-dimensional strain rate tensors.

Results presented here indicate that the subgrid scales under stable conditions remain an important sink of variance and turbulent kinetic energy from the resolved scales and carry a significant portion of the fluxes when the filter scale is larger than the distance to the wall. Surprisingly, stability was not found to be important in determining the fraction of SGS fluxes (out of the total fluxes). Stress-strain alignment was observed to be similar to the alignment under neutral and unstable conditions and to the alignment in several other canonical flows. The coefficients of the Smagorinsky model vary considerably with stability; this variation of the coefficients for both momentum and heat is shown to be better explained by stability parameters based on the Ozmidov scale, rather than the Obukhov scale. These results indicate that subgrid scale modeling is not drastically affected by atmospheric stability and hence a unified approach is possible. Nevertheless, the presentation concludes with some other challenges for stable ABL simulations that are not encountered in the neutral or unstable ABL.