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Subgrid-scale physics under strongly 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 sensing in stable atmospheric boundary layers. On the modeling side, the main problem is that the classic parameterizations of the unresolved turbulent scales, such as subgrid scale turbulence in Large Eddy Simulation (LES), are often found to be inadequate for stable conditions. To address these concerns, a field study (SnoHATS) was held at the extensive "Plaine-Morte" glacier in the Swiss Alps (3000 m) 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 dimensional filtering and computation of the full three-dimensional strain rate tensors.

Results from SnoHATS indicate that increasing stability reduces turbulent transport efficiencies. The efficiency of momentum transport is reduced faster that that of heat transport. Another important effect of stability was to increase the fraction of the total Reynolds stresses that fall in the SGS range of turbulence, effectively indicating a reduction in the integral scale of turbulence. The vertical fluxes had the highest fraction of unresolved contributions; up to 40 percent of the vertical fluxes are performed by the subgrid scales.

Despite these pronounced effects of stability, the variations of the SGS model coeffi-

cients with stability are consistent with previous results over different surfaces (HATS experiment, Kleissl et al., JAS, 2003; 2004). In addition, the orientation of the stress tensors relative to the strain tensors are remarkably similar to previously obtained results under considerably different flow conditions (Tao et al., JFM, 2002; Higgins et al., BLM, 2003).