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The surface energy budget and behavior of the stable boundary layer over the South Pole

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Routine radiation and meteorological data at South Pole Station are used to investigate historical discrepancies of up to 50 W m^{-2} in the monthly mean surface energy balance, and to investigate the behavior of turbulent heat fluxes under stable atmospheric temperature conditions. The seasonal cycles of monthly mean net radiation and turbulent heat fluxes are approximately equal, with a difference of 40 W m^{-2} between summer and winter, while the seasonal cycles of subsurface heat fluxes are only a few W m^{-2}. For an 8-month period (the winter of 2001), we have two estimates of turbulent heat fluxes, one from Monin-Obukhov (MO) similarity theory and one as the residual of the surface energy budget (i.e., subsurface heat fluxes minus net radiation, where all fluxes toward the snow surface are positive). The turbulent fluxes from MO theory agree well with the residual of the energy budget under lapse conditions. However, under stable conditions MO theory underestimates turbulent fluxes by approximately 40-60%. We also examine the relationship between turbulent heat fluxes as a residual of the energy budget, temperature inversion strength, and wind shear as a function of the bulk Richardson number (Ri_b) under stable conditions (i.e. positive Ri_b). Our Ri_b is calculated from 10-m wind speeds and 0- to 2-m temperature inversion strength. We find no critical Ri_b above which turbulent heat fluxes drop to zero. However, we do find a threshold (Ri_b = 0.05) below which 70% of the turbulent energy fluxes can be explained by only the temperature inversion strength. For $Ri_b > 0.05$, the relationship between turbulent heat fluxes and temperature inversion strength decreases, while the importance of wind shear to turbulent heat transfer grows. Above Ri_b = 0.05, a growing linear correlation also exists between atmospheric temperature inversion strength and wind shear. Thus, for extremely stable conditions, inversion strength and wind shear are not independent predictors of turbulent heat flux. The exact values of the correlation coefficients and Ri_b threshold are likely specific to the experimental conditions; however, their implications are probably valid for all stable flows. Knowledge of the time-varying surface characteristics would help to generalize these parameters.