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Cooling and heating due to longwave radiative flux divergence in the atmospheric surface layer at the Summit Greenland Environmental Observatory

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The radiative flux divergence, together with the divergence of the sensible heat flux, plays an important role for the thermodynamics of the stable boundary layer. Nevertheless, measurements of the radiative divergence are extremely rare. For this reason, observations of the incoming and outgoing longwave radiation fluxes in the layer between 0.5 and 50 m above ground were carried out by the Swiss Federal Institute of Technology (ETH) from June 2001 to July 2002 at the Greenland Summit Environmental Observatory (72°35'N, 38°30'W, 3203 m.a.s.l.). For the summer of 2002, continuous measurements are available at four levels between 0.5 m and 50 m, with more detailed observations of the vertical profiles during selected periods. During an average summer night, the net longwave flux divergence in the layer between 2 m and 10 m corresponds to a cooling of the order of -15 Kd-1. During daytime, a heating of up to 30 Kd-1 is observed for the same layer. Below 10 m, the divergence of the incoming and outgoing fluxes are usually of opposite sign. Measurements clearly indicate a dominating effect of the divergence of the outgoing flux for most situations. The absolute values of heating or cooling caused by the divergence of the incoming and outgoing longwave flux are largest close to the surface and decrease with height. During clear nights, the effect of net divergence changes from cooling in the 2-10 m layer to heating in the layer below. Under these conditions, a reduction of the temperature gradient in the layer between 0.5 and 2 m is often observed. The diurnal variation of the heating or cooling caused by the divergence of the longwave fluxes is presented for several layers and for different meteorological conditions, as clear and overcast skies, and calm and windy situations. The longwave radiative heating or cooling rates often reach magnitudes comparable to the observed temperature tendency.