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Radiative flux divergence in the surface boundary layer from observational and model perspectives

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Radiative flux divergence (RFD) is one of several physical processes governing the heating and cooling in the near surface atmosphere. Although its importance has been stressed in past studies, the precise role of RFD in the evolution of the temperature structure of the nocturnal boundary layer is still under debate. While some studies emphasize the importance of RFD in the onset of nocturnal cooling, other studies indicate that RFD actually leads to warming near the ground under inversion conditions.

Observations of RFD became possible when net radiometers with sufficient sensitivity were developed in the early 50s. Since then, however, only a handful of experiments have investigated RFD. Most observations have been limited to a single atmospheric layer or cover only a short period of time and offer no information on the vertical variation of RFD. On the other hand, theoretical deductions and model approaches of varying complexity have been used to evaluate RFD in the atmospheric boundary layer. These models varied in their vertical and spectral resolution, with layers thicknesses ranging between 10s of meters and millimeters. Model studies provide valuable information on the spectral composition of RFD, and allow parametric studies to quantify the effects on RFD of temperature inversion strength, inversion shape, surface emissivity, humidity gradients, etc. Traditional radiative transfer models, however, are limited to homogeneous and flat surfaces.

This contribution has three aims. Firstly, an overview will be given of previous observational and modeling studies of RFD, highlighting similarities and contradictions in the findings. Secondly, results will be presented from recent observational and modeling studies. Observations from Greenland and Arizona resolve the vertical structure of RFD and its temporal evolution under two very different climatic conditions. The new model results are from traditional and three-dimensional radiative transfer models that, for the first time, quantify the heating and cooling due to RFD within topographic basins and valleys. Thirdly, these new observational and model results will be used to integrate previous findings into a comprehensive picture of RFD. Differences among previous results will be used to highlight the various problems of observational and modeling approaches such as measurement uncertainties and vertical model resolution.