EMS Annual Meeting Abstracts
Vol. 11, EMS2014-174, 2014
14th EMS / 10th ECAC

Importance of Aerosols in Predicting the onset of Radiation Fog

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Under calm and clear-sky conditions, radiation is the principal mode of heat transfer in the nocturnal atmospheric boundary layer, and it governs the vertical temperature distribution near the ground. In a set of experiments, we show that the presence of aerosols and their number density determines the intensity of the near surface radiative-cooling and the final value of the minimum temperature observed [1]. Aerosols, through radiation in the window-band, provides an alternate path for the surface air layer to lose heat to the cold upper atmosphere. This process creates a few-decimeter thick, cooler air layer between warmer ground and upper air layers. Resulting temperature profile, thus has an anomalous structure in which, minimum temperature occurs few decimeter above the ground. Observed minimum temperature in the cooler layer is 3-6 ^{o}C lower than the ground temperature. Thickness of the cold layer is determined by the length scale associated with the non-linear vertical distribution of aerosols and the diffusion process. We also present filed experiments, to show that the fog formation is closely related to this anomalous temperature profile. We find that [2], the initiation of the radiation-fog occurs when the minimum temperature, few decimeters above the ground, falls below the local dew-point temperature. Thus accounting for the aerosols and their radiative process is important in modeling micro-meteorological processes in the nocturnal boundary layer. It changes the very nature of the sensible heat-flux boundary condition by modifying the vertical temperature profile. In addition, for correct modeling of the radiation fog formation, it is important to include effects of aerosols and their vertical distribution. In the presentation, we will show results from the field and laboratory experiments to support our conclusions.

[1] Mukund, V., Singh, D. K., Ponnulakshmi, V. K., Subramanian, G., & Sreenivas, K. R. (2014, January). Field and laboratory experiments on aerosol-induced cooling in the nocturnal boundary layer. Quarterly Journal of the Royal Meteorological Society, Vol. 140: 151–169.

[2] Singh, D. K., Ponnulakshami, V. K., Mukund, V., Subramanian, G., & Sreenivas, K. R. (2013, May). Radiation forcing by the atmospheric aerosols in the nocturnal boundary layer. In RADIATION PROCESSES IN THE ATMOSPHERE AND OCEAN (IRS2012): Proceedings of the International Radiation Symposium (IRC/IAMAS) (Vol. 1531, No. 1, pp. 596-599). AIP Publishing.