Abstract

A major concern of this thesis is the singular temperature distribution, called the Lifted Temperature Minimum (LTM), which is characterised by air layers lying within a meter from the ground being cooler than ground by a few degrees. This thesis investigates the temporal evolution of the LTM for different surface properties, using a mathematical model due to Vasudevanurthy, Srinivasan and Narasimha (referred to as VSN below). The response of the LTM to a short perturbation in the form of a 30 s gust is also studied. Finally, the same model is used to investigate some aspects of the evolution of nocturnal temperature inversions in the absence of and with substantial eddy diffusion, mainly to explore its validity or otherwise in describing the inversion.

It is found that for low values of the ground cooling rate and at times sufficiently far from the initial instant the location of the minimum rises in proportion to the square root of elapsed time. This behaviour is found to be similar to the growth of the thermal boundary layer over a flat plate in the thermal Rayleigh problem and hence the air layer topped by the temperature minimum is shown to be essentially a thermal conduction layer. The results confirm the theory underlying the VSN model, which suggests that the LTM is formed by the smearing by molecular conduction of the radiative slip in temperature (under an inversion) between the ground and the air layer just above it. The behaviour in time of the temperature difference across the Ramdas layer suggests the presence of two disparate time constants in the problem. It is also found that the height and the intensity of the LTM obtained using the present study for relevant values of the ground emissivity and cooling rate are consistent with observations.

Secondly, after the 30 s gust is withdrawn, it is shown that the LTM begins to regenerate by a quick radiative adjustment but recovers completely from the perturbation by a slow diffusive relaxation. The time scales involved in these two processes are found to be related to similar time constants that are inherent in the theory underlying the VSN model.

Finally, the simulation results show that in the absence of eddy diffusion, that is when radiation alone is present, the inversion height as well as the temperature difference across it
(although only at very long times after the initial instant) grow in proportion to the square root of the elapsed time. It is seen during such conditions that the inversion height as well as the temperature differentials across the inversion can change substantially as a result of a change in ground cooling rate and ground emissivity. This dependence of the inversion properties on ground emissivity and cooling rate are not reported so far in the literature. When substantial eddy diffusion is present, the inversion height as well as the temperature differential across it are substantially reduced. The simulations results are found to be in qualitative agreement with observations.