Abstract

Mesoscale phenomena such as the sea/land breeze circulation and the heat island circulation induced by an urban heat island, play a major role in modifying the local weather and air quality. Over the years, numerical mesoscale models have been used by many investigators to study the sea/land breeze circulation, heat island circulation and their effects on the transport and deposition of pollutants. Although a few numerical studies investigating sea/land breeze circulation over different regions of India exists in the literature, heat island circulation induced by urban heat islands in India do not appear to have been studied numerically.

In this thesis, a three dimensional numerical mesoscale model is developed based on the primitive equations. Land surface temperature is determined by solving the energy balance equation. First order closure is used for the turbulence flux terms. An equation for the concentration of pollutant based on the conservation of pollutant mass is included in the set of model equations. The pollutants are assumed to be radiatively and chemically inactive.

A two dimensional version of this model is used to study the effects of a coastal urban heat island and its growth on the inland penetration and the intensity of sea breeze front, and on the height of the thermal internal boundary layer. The effect of the presence of the urban heat island is investigated by performing sensitivity experiments with and without an urban area on the coast. The effect of the growth of the urban heat island is studied by performing experiments with increasing widths and anthropogenic heat fluxes of the urban heat island.

The two dimensional version of the model is also used to study the effect of the growth of a landlocked urban heat island over Ramagundam, South India, on the vertical thermal structure, wind field and mixing layer height for a premonsoon day. An elevated point source emitting suspended particulate matter (SPM) is considered

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at the centre of the urban heat island. The effects of the urban heat island on the diurnal variation of the surface concentration of pollutant, the distribution of pollutant in the atmosphere and also on the deposition of the pollutant are studied.

The full three dimensional version of the model is employed for a more detailed study of the urban boundary layer and its effect on the transport and deposition of pollutants. Three types of pollutants (SPM, SO_2, NO_x) emitted from different point sources of the major industries over Ramagundam are considered in the study. The effect of the growth of the urban heat island on the diurnal variation of surface concentration is discussed. The results of the two dimensional and three dimensional model simulations are compared with one another.