CHAPTER VII

SUMMARY AND CONCLUSIONS

For a variety of economic and practical geographic reasons, industrial development has been taking place in regions of complex topography. Industrial emissions are, at times, being released at low heights with respect to the surrounding terrain which may lead to very high pollution levels and adverse affects. Another air pollution concern is the possibility of persistence of severe atmospheric stagnation conditions in lower, sheltered regions of complex terrain under certain large scale meteorological conditions.

Air quality simulation models provide a means of relating the influence of industrial growth and urbanization to future pollution scenario. In order to develop diffusion models an understanding of the flow regimes in complex topographic regions is imperative. The principal objectives of the present work have been:

i) to describe and discuss the flow behavior in complex terrain, with a special emphasis on mountain valley environments using field experimental data,

ii) to develop an air quality model based on Gaussian puff algorithm to simulate airborne effluents in valley environments, and

iii) to adapt a model for air quality simulation in an industrial complex situated in hilly terrain in India.
Observed meteorological data and tracer concentrations data from ASCOT (Atmospheric Studies in COMplex Terrain) field studies conducted in Brush Creek Valley, U.S.A. is used to discuss and describe the valley meteorology and transport and diffusion processes in valley drainage flows. Results of the data analysis are presented in chapter 4. Observed tracer concentration patterns are presented for the first arc cross-section and along the valley-axis.

Review of earlier works in complex terrain, and transport and diffusion mechanisms are given in chapter 2 of this thesis. Chapter 3 provides a review of modeling methodologies with an emphasis to air quality simulation in complex terrain.

A diffusion model has been developed from Gaussian puff algorithm to simulate atmospheric tracers in a deep valley. Provisions are included in the model to treat restricted lateral dispersion in the valley due to presence of sidewalls. Two-dimensional wind field generated from tethersonde wind data is utilized in the model to transport the puffs in the modeling region. On-site turbulence measurements are used in the model simulations to characterize diffusion coefficients. Perfluorocarbon tracer were released during the ASCOT experiments in Brush Creek valley. Model simulations are made for two tracer release experiments which are then compared with the observed tracer concentrations at 51 receptor locations. Model description and results are presented in chapter 5.
An attempt has been made to adapt an operational air quality model based on Gaussian puff equation to Singrauli thermal power plants area to simulate SO$_2$ concentrations. Model predictions are compared with the observed SO$_2$ concentrations at three air quality monitoring stations in the area. The modeling approach and results are discussed in chapter 6 of this thesis.

CONCLUSIONS

ASCOT field study data has been very useful in understanding the valley meteorology and the effects of complex terrain on diffusion and transport of airborne effluents.

Strong surface inversions are observed in the valley environments. Increasing potential temperatures are observed throughout the depth of the valley indicating that the entire valley atmosphere is stable during nocturnal periods.

A low-level wind maximum located few tens of meters AGL has been typical of this valley during night periods. The drainage layer is identified as the height where the wind speed decreases to a minimum, and simultaneously, the wind direction changes by more than 50% of the difference between the down-valley direction and ridgetop wind direction. The wind direction within this drainage layer is essentially down-valley.

Hanins and Sawford (1979 a) model gave a reasonable estimate of the drainage layer depth. The estimated drainage layer depths are about 70-75% of the observed temperature inversion heights.
Ridgetop wind speed has played a definitive role in restricting the nocturnal drainage layer. Shallow drainage flows are characterized by strong ridgetop winds and vice versa.

The observed average $\sigma_g$ and $\sigma_u$ in the Brush Creek drainage are about $5^\circ$ and $20^\circ$ to $25^\circ$ respectively; these values are much more larger than those generally observed over flat terrain during stable conditions.

Following points can be arrived at from the observed tracer concentrations at the first arc and along the valley-axis. Peak concentrations occurred generally on the lower parts of east sidewall; The influence of tributary flows is evident in the form of unusual tracer levels at higher elevations; Warming of the west sidewall and subsequent ventilation of the tracer plume by upslope flows after local sunrise is clearly seen during all experiments; The tracer plume is generally confined within the drainage layer; Location of the low-level wind maxima played a major role in tracer distribution; Despite the presence of a strong nocturnal jet, high concentrations are recorded very close to the release site, providing evidence for strong subsidence in the valley.

A puff trajectory model that can accommodate variable meteorological and emission conditions has been modified for valley situations. Modifications are incorporated for
restricted dispersion due to valley sidewalls, and subsidence in the valley. This model, named VALPUFF, has been applied to simulate the surface concentration data from two tracer experiments, one elevated release and one surface release. On-site turbulence measurements are used for estimating diffusion coefficients. The model simulations are evaluated by comparing the predicted hourly concentrations with observations at 51 surface samplers. Paired statistical measures, such as Fractional Bias (FB) and Normalized Mean Square Error (NMSE), are computed to evaluate the model performance.

About 52% of the predictions are within a factor of 5 of the observations for ground release simulations, while 84% are within a factor of 5 for elevated release. The model thus appears to perform better for the elevated release. The fine scale terrain and flow features, which cannot be represented in the model, are expected to become important in the ground release simulation.

The observed concentrations are tracked well despite the model's simplistic approach in accounting for subsidence. The hydraulic approach used here avoids the difficult task of including the details of vertical windshear in the drainage layer, while implicitly accounting for it. Thus, VALPUFF can be used as practical tool for modeling dispersion of elevated plumes in a deep valley. It can also provide reasonable estimates of the surface concentrations from ground-level releases in a simple valley, such as Brush Creek, for industrial
A puff trajectory model, TRIAD has been adapted for air quality simulation in Singrauli, a complex terrain in North India. Hourly winds from three surface meteorological stations in the study area have been used in the model for wind field interpolation for transporting the puffs in the modeling region. SO$_2$ concentrations are simulated for a post-monsoon (October) day and for a day in winter (February). Separate simulations are made for daytime periods and nighttime periods. Predicted hourly SO$_2$ concentrations are compared with the observed concentrations at three monitoring sites in the modeling region.

Statistical analyses indicate that the model predictions are within reasonable limits for daytime simulations. About 85% of the model values are within a factor of 5 of the observed values for winter day-time simulations, whereas, it is about 70% for post-monsoon day-time. However the model performed very poorly for nighttime simulations on both the seasons. This might partly be attributed to inappropriate diffusion estimates.

**RECOMMENDATIONS:**

Because of the inherent nature, complex topographic sites play an important role in economic development of several countries including India. When it comes to development and industrialization one should not ignore the negative aspects of these phenomena. Most of the European and American countries have been busily finding ways to understand complex flows and to mitigate air pollution issues in irregular topographic regions.
Such an effort is lacking in our country where substantial industrial activity is taking place in hilly regions. We have been forced to adapt methods which may or may not fit well to our tropical conditions. Secondly, we may not be able to validate some of the well established (in extra-tropics) phenomena due to non-availability of a good data base from any hilly region in India. It is high time, therefore, that we conduct extensive field studies to evolve or to establish flow structures in complex terrain in tropical India. This would help us improve our modeling capability to a greater degree.