CHAPTER 5

CONCLUSION

5.1 SUMMARY AND CONCLUSION

This thesis analysed the spatio-temporal variation in PM2.5, AOD 550 nm and meteorological parameters, and the PM2.5-meteorology, PM2.5-AOD 550 nm relations; investigated PBLH variation, and its interaction with PM2.5 surface concentration at diurnal and seasonal scale; and estimated PM10 surface concentration using GWR model by integrative assimilation of surface PM10, AOD 550 nm, and meteorological variables over BV at the valley-site scale. Besides, it explored multiple data sources, assessed the performance (efficacy and uncertainty) of the satellite and reanalysis data (with reference to ground-based data for the studied parameters), and assessed the GWR model performance and validation over the complex terrain of BV.

PM2.5 surface concentration, AOD 550 nm and the meteorological variables RH, AT, WS and Ps showed pronounced east-west asymmetry in the spatial distribution in all seasons over BV during the study period. In comparison to the central and western parts of BV, the easternmost part was noted with a lower concentration of PM2.5 surface concentration. Seasonal and spatial variation in PM2.5 surface concentration and AOD 550 nm is driven by changes in meteorological variables and the terrain heterogeneity. Small inter-annual variability (difference between the minimum-maximum value) of meteorological parameters, AOD 550 nm and PM2.5 surface concentration was observed over BV. PM2.5-AOD 550 nm relation varied widely in magnitude (weak to very strong positive), which could be due to the spatial and temporal inhomogeneity of aerosol’s extinction efficiency. The observed PM2.5-Meteorology relation reveals a sizeable contribution of non-hygroscopic organic precursor and carbonaceous aerosols to the total PM2.5 surface concentration over the valley. The hotspots of PM2.5 surface concentration coincided with high AOD 550 nm loading across the seasons (except pre-monsoon).

The diurnal variability of PM2.5 surface concentration was in synergy with the diurnal variation of PBLH over the entire valley. During the day-time, deeper PBLH (up to 2100 m in pre-monsoon) due to convective turbulent mixing developed over the valley contributed to low PM2.5 surface concentration. While at night-time, nocturnal radiative cooling of the surface caused shallow PBLH confining aerosol vertical mixing thus increasing surface concentration of PM2.5. The diurnal evolution of PBLH reveals that turbulent mixing within PBL plays a dominant role in the entrainment of PM2.5 surface concentration. The spatial pattern of PM2.5 surface concentration and AOD 550 nm displayed clear synergy with PBLH in all seasons. PBLH-PM2.5 relationship showed variation spatially and seasonally. The easternmost parts of the valley had consistently represented a strong positive PBLH-PM2.5 relationship while the central and western parts represented weak to moderate. Though the PBLH-PM2.5 relationship was positive in all the seasons, the strength of the relationship varied considerably (weak to strong).

PM10 surface concentration estimated by the GWR model was slightly underestimated as compared to the observed PM10 $\mu g/m^3$ surface concentration across the 10 sampling stations. The overall R^2 of model fitting suggests that while estimating PM10 surface concentration GWR model can explain 62% of the total variability of data for BV. The regression coefficient (β) values computed by the GWR model indicate the heterogeneity in the relationship (nature and strength) between the PM10 (dependent) and AOD 550 nm AT and PBLH (independent variables). The strongest positive relation in PM10-AOD 550 nm was found to be in the western part of BV. Higher PM10 surface concentration and AOD 550 nm were observed in the western and central parts. Expectedly, Guwahati had the highest PM10 concentration along with a high AOD 550 nm.

The performances of MODIS AOD 550 retrievals, MERRA-2 PM2.5 estimates, ERA5 ECMWF meteorological variables, MERRA-2 PBLH, and ERA5 ECMWF BLH were assessed with reference to corresponding ground-based observations from AERONET, MAPAN, IMD, GPS radiosonde respectively. MERRA-2 PM2.5 estimate moderately represented the PM2.5 surface concentration for the Tezpur station. Except for WS, all the other ERA5 ECMWF meteorological variables AT, RH, and Ps well represented the ground-based meteorological observations for the corresponding stations- Dibrugarh, Guwahati, Lakhimpur. MODIS AOD 550 nm retrievals performed well for the Dibrugarh station when compared with AERONET AOD 500 nm. Eight fundamental atmospheric fields from GPS radiosonde, ERA5 ECMWF BLH and MERRA-2 PBLH were used for PBLH. Vertical gradient profiles of the 8 fundamental atmospheric fields were generated and examined to identify the best indicator of PBLH. The result showed that the vertical gradient profile of WS was the best indicator of PBLH for early morning hours over the station. ERA5 ECMWF BLH and MERRA-2 PBLH were validated with reference to radiosonde PBLH estimates. MERRA-2 PBLH outperformed ERA5 ECMWF BLH when compared with radiosonde PBLH estimates for the Dibrugarh station. GWR model performance and efficacy in estimating PM10 surface concentration were also assessed with reference to the 10 sampling stations over BV. The GWR model performed well for the estimation of PM10 surface concentration with R^2 and RMSE values of 0.62 and 22.74 $\mu g/m^3$ respectively.

5.2 FUTURE SCOPE

1. GWR model can be further developed using multiple explanatory variables (e.g. climatic variables, Land Use Land Cover, demographic data, road map) for more precise forecasting of PM2.5 and PM10 at higher temporal and spatial resolution over a large geographic area. GWR model captures well the spatial variation in relationships among the dependent-independent variables, it can be applied to quantify the nature and strength of each explanatory variable on the dependent variable.

2. Causality analysis of PM2.5-Meteorology for deeper insight into aerosol-meteorology feedback mechanism and quantification/potential of the casual factors in regulating PM2.5 surface concentration.

3. Plume behaviour in different boundary layer conditions influences the aerosol surface concentration at vertical, horizontal and temporal scale. It would to interesting to see if MERRA-2 PBLH and MERRA-2 PM2.5 estimates data can be effectively used to investigate the plume behaviour and fumigation effect on surface and boundary layer *aerosol*.