The accurate atmospheric parameters such as temperature and water vapor profiles are very important for numerical weather prediction. As the surface based in situ observations are very sparse and limited only over few big cities, it becomes important to explore the space based observations. Fortunately, satellite based atmospheric sounding has made advanced development in the past decade and the state-of-the-art hyperspectral sounders are providing accurate atmospheric information at high spatio-temporal resolution. The present thesis aims at improving the water vapor sounding that is very critical for tropical region and also demonstrate a few applications such as system studies, temperature-inversion and nowcasting.

The conclusion of the work carried out in this thesis is as follows:

- Chapter 1: This chapter provided an overview of the history of atmospheric sounding and its principles. Further, radiative transfer theory and methods to solve the inverse problems in sounding theory were also discussed.

- Chapter 2: In this chapter improvement of humidity profile retrieval was demonstrated by using in-house developed hybrid retrieval approach and principal component technique. A retrieval algorithm was developed which uses
principal components of the radiance spectra as predictor in regression retrieval. These principal components were derived from a diverse data set of IASI hyperspectral radiance spectra. The humidity profiles are retrieved first using traditional method by taking the logarithm of specific humidity as predictand (PCR_{LNQ}) and then by taking simple specific humidity (PCR_{Q}) as predictand. On comparing with RAOB observations and ECMWF analysis corresponding to dry atmospheric conditions, it was found that PCR_{LNQ} improves the humidity retrieval compared to PCR_{Q}. Contrary to this for wet atmospheric conditions, PCR_{Q} has shown improvement compared to that retrieved with PCR_{LNQ}. The final retrieved product is the weighted average of these two regression products, and is referred as hybrid principal component regression retrieval (PCR_{HYB}). The PCR_{HYB} has shown improvements compared to both PCR_{Q} and PCR_{LNQ}.

- chapter 3: In this chapter a system study was carried out to find the impact of additional water vapor channels (6 - 8 µm water vapor absorption band) on humidity profile retrieval. Further, these profiles were compared with humidity profiles retrieved from selected 300 channels of IASI and 60 PCs of IASI spectra (developed in chapter 2). The retrieval accuracy with 11 broad water vapor channels and 11 narrow water vapor channels (6 - 8 µm) of a multichannel sounder shows a very small improvement (~ 1%) in the humidity retrieval compared to the existing 3 water vapor channels of INSAT-3D Sounder. However, the improvement in humidity retrieval accuracy with 300 selected channels of IASI and 60 PCs of IASI spectra was 5 - 10% compared to the existing 3 as well additional 8 water vapor channels of a multichannel sounder. Therefore, it was concluded that for the improvement of water vapor sounding hyperspectral sounder is required.
Further, it has been shown that by using spectral radiances from a few selected channels, it is possible to directly retrieve LI and TPW. This study was carried out using the synthetic radiances generated from hyperspectral observations of IASI for the proposed GISAT channels. It was found out that LI and TPW could be retrieved with adequate accuracy as desired for nowcasting applications. This study is significant for GISAT in view of its capability to estimate the atmospheric stability when only few channels will be available.

- Chapter 4: In this chapter applications of hyperspectral sounding observations of various atmospheric processes such as temperature inversion and convective activities over Indian region were discussed. Hyperspectral sounding observations from both AIRS and IASI have been exploited for this study. Temperature inversion over the Gangatic plane of India during the winter season causes the very dense fog, therefore, in this study potential of hyperspectral sounding observations to capture near surface temperature inversion has been studied. Further, an attempt was made to demonstrate the capability of these hyperspectral sounders to capture the pre-convective environment over the Indian landmass region. LI, TPW and Layer Average Relative Humidity were calculated to identify the atmospheric instability 3 - 4 hour before the severe weather condition. An FCC of LI, layer average humidity from the surface to 900 hPa (RH900) and from 900 hPa to 700 hPa (RH700) was composed to reflect the pre-convective atmosphere very clearly. This procedure can be useful to predict both extremely stable and extremely unstable weather conditions.
5.1 Future Work

The large sized data product of atmospheric radianc spectra provided by the IASI instrument is very difficult to assimilate in NWP models for weather forecasting purposes. A lot of techniques such as to select a few channels of IASI having maximum information content has been developed. A selected set of IASI 300 channels provided by Collard [2007] has been used in this thesis for retrieving the atmospheric temperature and humidity profile but it has been found that the retrieval accuracy with IASI PCs developed in chapter 2 of this thesis improve the retrieval accuracy as compare to the selected set of channels. Therefore, instead of using the selected channels directly, reconstructed radiances derived from leading PCs of IASI spectra for a few IASI channels with maximum information content will be assimilated into NWP models to find the impact on weather prediction over Indian region. Weather Research and Forecasting (WRF) [Skamarock et al., 2008] model will be used for this purpose. The WRF three-dimensional variational (3D-Var) data assimilation system is capable of assimilating data from many different observational platforms including radianc measurements obtained from satellites [Liu et al., 2006]. The assimilated data include of in situ observations (radiosonde, ships, aircraft etc.) and satellite data such as surface winds, Meteosat derived atmospheric motion vectors (AMVs). In addition IASI selected channel reconstructed radiances will be used for this study.

A technique that has been developed in chapter 3 for retrieval of LI and TPW directly from sounder radiances instead of operational method that makes use of retrieval of temperature and moisture profile to compute LI and TPW will be further applied to the proxy radianc data set of a broadband sounder using IASI hyperspectral observations over Indian region. This study will provide a background work for the future GISAT satellite that will be launched by ISRO.
The potential of hyperspectral sounding observations to capture near surface temperature inversion and convective activity over Indian region has been discussed in chapter 4. This study will be extended to the diverse geographic region, including oceanic regions where temperature inversion occurs very frequently. Further, the convective activity studied in chapter 4 will be explored by using the NWP models to understand these phenomena in more depth. A nowcasting application can be developed that will use multiple satellite input as well as surface observations and NWP model analysis/forecast.