SUMMARY

In this chapter we give the summary of the work presented in this thesis and also the direction of future research work.

Theoretical studies:

Theoretical investigations on the role of three dimensional winds of gravity wave origin, at the equator, have brought out several new features. These are

(i) The value of wave length \( \lambda \) (of the gravity wave winds), along the geomagnetic field line is very important to the development of the wind induced electric fields. For the wave parameters assumed in the calculations, it is found that above 90 km the polarization fields are substantially shorted even at the equator.

(ii) Hither to, it has not been possible to explain satisfactorily, the generation mechanism of the small scale (type Ss) irregularities measured using the rocket borne probes. These irregularities are believed to be due to the two stream plasma instability mechanism which requires a threshold value of the drift velocity of electrons relative to ions. But the in-situ studies show that the threshold criterion was not met, yet the irregularities were observed.

It is found that the east west electric currents driven due to the gravity wave winds are a significant fraction of the
main electrojet current even at the peak of the electrojet. Since the gravity wave driven currents are sinusoidal in nature, they may satisfy the threshold criterion for the excitation of the two stream plasma instability in localised regions.

(iii) The gravity wave winds can give rise to the ionization layers. Contrary to the earlier belief, the ion convergence rate in the lower E region, at the equator, is found to be larger than in the mid latitudes. However, the convergence rates are not large enough to produce the ionization layers during the daytime. Nighttime stratification of ionization can be explained satisfactorily using the gravity wave winds.

(iv) If the curvature of the geomagnetic field lines is taken into account, $k_y$ varies rapidly with the dip angle, undergoing a change of sign. If the gravity waves are present everywhere on a given field line, the electric fields are generated mainly around the region where $k_x = 0$. In the regions away from it, the fields due to the local winds (with finite $k_x$) are shorted within a wave length. Thus the region around the point where $k_x = 0$ is the source region and the rest of the region of the ionosphere connected by the geomagnetic field line acts as a load to this source region.

(v) The electric fields in the source region are generated most efficiently, if the source region overlaps the region of maximum Pedersen conductivity, $\mathcal{J}_P$. Thus in the daytime
when $\sigma_0$ is maximum in the E region, the source of the electric field would be situated there. It is equivalent to saying that the effective dynamo is situated in the E region during the daytime. Similarly, in the nighttime, whenever $\sigma_0$ is maximum in the F region, the effective dynamo is situated in the F region.

(vi) The source region electric fields can be transmitted to the other regions of the ionosphere via the geomagnetic field lines. Attenuation of electric fields during transmission is dependent on the vertical wavelength $\lambda_z$, of the gravity waves. The attenuation increases with the decreasing $\lambda_z$.

(vii) The gravity wave induced electric fields (GWEF) can give rise to the spread F irregularities. It is found that the gravity waves in the E region during the evening and nighttime are more suitable for the generation of spread F irregularities. Further, it is found that the growth of the irregularities due to the GWEF is linear in the initial stages and hence they grow faster than those due to the plasma instability processes. Thus they could act as a seed to the plasma instabilities which may grow faster in the latter stages.

For the lack of sufficient observations on the gravity wave winds, only model calculations could be made in this thesis. Hence there is a need to include the observed wind profiles in these calculations to have a better understanding
of various physical processes operative in the ionosphere. To measure the gravity wave winds, high sensitivity incoherent backscatter and meteor trail radars are needed to be established.

To test the theories proposed in this thesis, correlative studies on the large scale electron density irregularities on a given field line, connecting E and F regions are very essential. Also, simultaneous measurements of the electric fields and the winds are very essential.

Experimental studies:

The experimental studies on the measurements of electric fields and on the performance of various techniques for the measurement of electron density have been very encouraging. The highlights of these studies are the following:

(i) The $\mathbf{V} \times \mathbf{B}$ effect arising in the electric field measurements can not be eliminated by shielding the connecting wires, from the sensors to the input of the measuring device, by the $\mu$-metal tubes. The $\mu$-metal in the logic proposed is, however not resolved.

(ii) A new arrangement of the sensors for the measurements of vertical electric field has been developed and flown successfully. The observations indicate, very clearly, that fluctuations in the vertical field are of the order of a few millivolt per meter in the electrojet region.
Comparative studies to measure the electron density, using the mutual admittance probes and the Langmuir probes show that the MAP can be used to measure the absolute electron density in the ionosphere. Hence the calibration factor, to convert the Langmuir probe current into the electron density can be calculated.

There is a need to measure the electric fields and electron density, simultaneously, in the equatorial E and F regions. Such studies will throw light on the generation mechanisms of the electron density irregularities. Power spectrum calculations of the fluctuations in the electric fields and the electron density irregularities will further our understanding of such processes.

Regions of depleted electron density (bubbles) have been proposed to explain the spread F irregularities. The electric fields inside the bubble are believed to be larger than the background fields. Measurements of the electric fields and their direction will be helpful in confirming whether the Rayleigh-Taylor plasma instability mechanism is the cause of the equatorial spread F.

We have proposed a multiprobe experiment, to be flown on a 150 km class Indian Satellite, to study the spread F phenomena. These studies are aimed at measuring the electron density irregularities (both large scale and small scale);
small and large scale electric fields both in the horizontal and vertical directions; the 6300 Å air glow emissions to determine the location and orientation of the bubbles and to find roughly the location of the F region peak by determining whether the satellite is above or below it; and to measure the Mg$^+$ ion concentration to study the dynamics of the E and F regions and also to study the ionization layer formation during the daytime.