Chapter 6  Conclusions

The all sky observations conducted from Kavalur during the months of February-April, in the year 2002 reveals the occurrence of plasma depletions in several nights. The observations were remarkable in that there were several nights with intense depletions. Moreover, depletions appeared in all the three wavelengths in some of the nights. There were total 33 nights of observations possible, with 10 days of observations in February (6-16), and 12 days in March (4-17), and 11 days in April (5-15). The 630.0 nm images showed depletions in 27 nights, which is about 80% of the total observations. Similarly depletions were seen in the 777.4 nm in about 25 (~75%) nights. Also, about 19 (~57%) nights there were depletions in the 557.7 images. It is rather unusual that depletions were observed in 630.0 nm in 11 consecutive nights of March (4-14), and April (5-15). About 70% (19/27) of the nights with depletions in 630.0 nm also had depletions in 557.7 nm images. There is no significant geomagnetic activity during the observation period.

The east-west extensions (or width) of the observed depletions were in the range of 50-350 km. For the case of 557.7 and 630.0 nm images, the east-west extent is very similar. However, the depletions seem to be a bit wider in the 777.4 nm. In the pre-midnight the width of the depletions were mostly in the range 100-300 km. In the post-midnight period, in some of the cases, depletions of narrower width (less than 100 km) were also observed. However, in some of the nights during the observations there were cases when depletions seemed to develop overhead in the post-midnight period. Such developing depletions could have smaller widths. Width of the depletions appears to decrease with time, with a rate of about 3.1-3.6 km/minute. However, for the depletion in the post-midnight period, the rate of decrease is about 2.3-2.5 km/minute. The density gradient associated with the depletions that are seen in the post-midnight period could be different from that in the earlier hours, and hence their rate of decay also could be different.

The observations were used to estimate the drift velocity of the depletions in three different wavelengths. The median values who about 100-120 m/s in the evening period, which gradually decreases with time in the night, and becomes about 50 m/s in the post-midnight period. The 777.4 velocities are slightly less than that of the 630.0
nm values in the evening period. However, in the post-midnight period, the 777.4 nm velocities are a bit larger. The 630.0 and 777.4 nm velocities are estimated for different altitudes, and the observed difference in their values could thus indicate altitude difference in the zonal plasma drift. In the mid-night and early post-midnight period, the 557.7 nm velocities are slightly less than that in the 630.0 nm, probably because of the much less number of depletions in 557.7 nm images in this period compared to that in the 630.0 nm. In the later part of the night, both the velocities are very similar. There is an increasing trend in the 557.7 and 630.0 nm velocities in the post-midnight period, which could be influenced by newly developing depletions imaged in that period.

Several new features of plasma depletions are observed in this study such as the new type of ‘joined’ pair of depletions where the northern (and later the southern) ends join together, producing an inverted ‘V’ shape bifurcation, which later merge together, sequences of depletions developing in the field of view of the all sky imager in the post-midnight period, depletions in 630.0 nm images entering the field of view (FOV) as dark patches from the north end in the post-midnight period, and the frequent observations of plasma depletions in 557.7 nm images.

The joining and merging of depletions and the post-midnight development provide information about the ionospheric conditions and that could result in such features. The joined depletions appear developing in the FOV, and it is possible that the eastern and western depletions of the pair could drift with different velocities if they are at different levels of development. The fact that the pole ward ends of the depletions join before their center regions merge indicates higher eastward velocities at higher altitudes above equator. Similar influence of shear in the zonal plasma drift is evident in the spitting and joining of depletions observed from Mt. Abu, indicating the complex turbulent nature of the irregularities. The westward tilt and bifurcation of depletion are more frequent when imaged from low latitude stations such as Mt. Abu, or Mt. Lulin, while at the locations such as Kavalur, which is more close to the equator, depletions tend to appear as dark bands with minimum structures. This indicates that bifurcation occurs as the bubble rise over certain altitude, and it is unlikely that it is produced when irregularity is generated.

Sequences of depletions that develop within the FOV are imaged in these observations, and when these depletions appear the $h'F$ values are about 250 km. Since
the instability growth requires higher F-layer altitudes, it is possible that small scale irregularities are generated several minutes earlier when the h’F was higher, and by the time they grow to a sufficient level to be captured by the imager the F-layer moves down to lower altitudes.

The field aligned mapping of irregularities together with the altitude dependence of the 630.0 nm emission is proposed to be responsible for the depletions to appear as dark patches at the northern ends of the FOV. The dark patches in 630.0 nm images in the post-midnight hours, which enter the FOV from northern latitudes and grow towards equator, are in fact the signatures of the field aligned plasma depletions that are seen in the off equatorial latitudes where the depleted flux tubes meet the emission layer owing to the lower F-layer height than that at the magnetic equator. Near the equatorial region, the irregularity layer is above the airglow band, and depletions are limited to northern end of the FOV.

Detailed analysis is carried out to understand the important physical parameters that influence the emissions of the 557.7 nm in various local times and solar activities, and result in the appearance of depletions in the ground based images. The results indicate that due to the enhancement of the thermospheric component of the 557.7 nm emission and/or the less efficient masking effect, the occurrence of depletions becomes pronounced in the post-midnight period of the solar maximum. By contrast, the significant mask results in the 557.7 nm depletions of the thermosphere being unlikely observed during years of the solar minimum.