In-situ measurements of electron density and electric field fluctuations over low latitudes during equatorial spread-F

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A review of in-situ measurements of electron density and electric field fluctuations over low latitudes has been presented. The paper deals only with F-region measurements conducted during equatorial spread-F epochs, mainly using rocket-borne Langmuir probe and electric field probes. At long wavelengths ($\lambda \geq 20$ km), spectra of electron density irregularities are best represented by a spectral index of $-1.5 \pm 0.4$. Some of the mechanisms, which are considered to be potential, include a two-fluid mechanism, strong shears in horizontal velocity of plasma and gravity wave organization of plasma. The spectral index of intermediate scales ($100$ m $< \lambda < 20$ km) lie in the range of $-2.4 \pm 0.2$. Regarding the mechanism of generation of intermediate scales, there is a general consensus that the generalized Rayleigh Taylor instability is the main mechanism. There are some minor problems with this mechanism, such as flattening of spectra ($n \approx -1.5$) in some regions and an insufficient growth rate, which puts a condition of minimum seed amplitude ($\approx 5\%$) for the initial perturbations. Irregularities in transitional scale ($10$ m $< \lambda < 100$ m) have much steeper spectra with spectral index ranging between $-4$ and $-5$, and are believed to be generated by low frequency electrostatic waves with finite wavelength parallel to the magnetic filed. Low frequency drift waves appear to be the most plausible mechanism at transitional scales. For short scales ($\lambda \leq 10$ m), the two most probable mechanisms are: (i) lower hybrid drift mode and (ii) a resonant wave-particle interaction.

1 Introduction

Earth’s ionosphere has served as an ideal platform for performing plasma physics experiments for more than five decades. Although ionospheric research has unraveled the mysteries of many old riddles and has discovered numerous new phenomena, there are still some problems which are not understood completely. Equatorial spread-F (ESF) is a case in point, where, even today, one does not understand why electron density and electric field fluctuations occur on some nights and not on others. The phenomena of equatorial spread-F can be understood quantitatively only if one can make simultaneous in-situ measurement of a large number of parameters, which are well known to be responsible for the generation of ESF. Some of these key parameters are electron density, horizontal and vertical electric fields, neutral winds, ion and neutral composition. The in-situ measurement of these parameters can be made by rocket and/or satellite-borne experiments. These space-borne measurements have to be complemented by a number of ground-based experiments employing radio and optical techniques.

Irregularities in electron density and electric fields are normally present in the lower part of the equatorial ionosphere, i.e. in D- and E-regions, during the daytime. On some rare occasions, F-region irregularities can be seen during the daytime also. During the night, the irregularities are present on a regular basis in the E-region. In the nighttime F-region, the scenario is quite different, because irregularities are observed on some nights and not on the others. These nighttime equatorial F-region irregularities are responsible for the spreading of the otherwise smooth traces of ionogram traces. It is due to this spreading of ionogram trace that the nighttime F-region irregularities have been associated with the name