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Session 10A Paper 4

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A comparison of space and ground-based observations of electron density irregularities and implications for Spread F dynamics

Equatorial Spread F is a well-known phenomenon characterized by large-scale instabilities in the post-sunset low-latitude ionosphere and the subsequent formation of medium to small scale irregularities over large regions encompassing on the order of 10.^6 km^2 per event. The deleterious radio wave scintillation effects caused by these irregularities rank among the most severe space weather impacts on man-made technologies, such as satellite communications and global navigation satellite systems (GNSS).

The responsible mechanism for Spread F, formally identified as the gravitational Rayleigh-Taylor Instability, is commonly described as depletions or low density plasma “bubbles” that originate at the magnetic equator and expand poleward as the perturbation electric fields map along magnetic field lines. In this paradigm the meridional extent of the disturbances is wholly determined by the height of the bubbles at the equator.

Here we present an investigation of the occurrence and altitudes of bubbles as a function of solar flux from in situ observations in the context of ground based scintillation measurements. We analyze electron density data from the Communication/Navigation Outage Forecasting System (C/NOFS) satellite developed by the Air Force Research Laboratory and launched into an elliptical low earth orbit at an inclination of 13°, a perigee of 400 km and an apogee of 850 km. While the altitude variation of the spacecraft complicates the statistical comparisons of parameters for purposes that require height-normalized values, it readily supports investigations of altitude variability, specifically electron density irregularities.

The investigation presented here will identify the regions affected by low-latitude scintillation, enhance our ability to model radio occultation results and provide insight into the growth mechanism and longitudinal variability of equatorial spread F. We present the first ever extensive comparison between ground station scintillation observations and satellite observations of the ion density irregularities. This allows us to gain new insight into the flux-tube expansion mechanism of equatorial plasma bubbles.