Equatorial Spread F /Plasma bubble Irregularities development conditions and possible role of sporadic E layers and meridional winds

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Abstract:

The significant impact of equatorial spread F irregularities on trans-ionospheric radio wave propagation systems has lead to growing interest in the investigation of the conditions of their development, and especially those responsible for the large degree of the widely observed variability in their occurrence and intensity on short period and day-to-day basis. The spread F/plasma bubble irregularity phenomenon results from vertical coupling process involving upward propagation of atmospheric waves (in the form of tides, gravity- and planetary waves) from the lower atmospheric regions of their origin to the dynamo region in the ionosphere where the electric fields are generated. The development of zonal (eastward) electric field enhancement in the evening hours, (that is, the prereversal electric field, PRE), by the F region dynamo is known to be the most basic requirement for the post sunset F-layer uplift as a precursor to the irregularity development. The ESF instability growth which takes place by the generalized Rayliegh-Taylor mechanism depends on diverse other factors as well, such as meridional/ transequatorial winds, flux tube integrated conductivities, and seed perturbations. The PRE development itself depends upon the strength of thermospheric zonal wind (eastward in the evening hours) and the longitudinal gradient in the integrated Pedersen conductivity. Recently it has been shown based on digital ionosonde data that there is a connection between the developments of the PRE and sporadic E layer formation at subequatorial latitudes. Larger intensity of the prereversal electric field (F region vertical drift) is found to be associated with disruption of sporadic E layer formation at a location (Fortaleza: 3.9 S, 38.45 W, dip angle: -9°) in the vicinity of the dip equator, whereas the Es layer formation is favored at a location farther away (such as Cachoeira Paulista: 22.6 S, 315 E; dip angle: - 28°). Such relationship between the PRE and the Es layer processes implies that the ESF development conditions for which the PRE development is a primarily requirement could involve sporadic E layer formation/disruption processes as an important controlling factor due to the possible effect of the Es layer to contribute/modify the flux tube integrated conductivity which controls the instability processes. This new element makes the problems of identifying the precise cause-effect relationship in an ESF variability episode an increasingly more challenging question. In this paper we have analyzed ionosonde data from equatorial and low latitude locations in Brazil to determine the ESF development under varying conditions of Es layer presence and meridional winds.