

INTERPRETATION OF HF SOUNDING OBSERVATIONS IN
THE EARLY STAGES OF THE FORMATION OF EQUATO-
RIAL BUBBLES

Sales, G.¹, Huang, X.¹, Reinisch, B. W.¹
, Dozois, C.¹, Abdu, M.²

¹Center for Atmospheric Research, 600 Suffolk St., Lowell MA
01854 USA

²Instituto Nacional de Pesquisas Espaciais (INPE), feAve dos As-
tronautas 1758 C.P. 515, 12202-970 Sao Jose dos Campos, SP
Brazil

During the recent COPEX campaign in South America (Oct. 2002 through Dec. 2002), data taken at the equatorial station near Cachimbo, Brazil often showed, in the early evening, the presence of satellite traces on the vertical ionograms always preceding the appearance of strong equatorial bubbles. These radio soundings, made continuously over the duration of the campaign with a time resolution of five minutes, were previously analyzed to show that these additional ionogram traces appeared, on the average, seven minutes after the vertical velocity in the F-layer reached its peak value and 15 minutes before local spread F began. It is important to note that all of the events occur before the solar terminator, at F-region altitudes, passes over the sounder. F-layer sunset is approximately 60 minutes after ground sunset. The time of occurrence and structure of these satellite traces are interpreted as the initial deformations of the lower region of the F-layer some of which ultimately grow to become eastward drifting equatorial bubbles.

Using a relatively simple model of quasi-periodic perturbations of a realistic F-layer model in conjunction with a new numerical 3-D ray tracing code developed here by one of the authors (Huang), it has been possible to connect these disturbances to the appearance of the extra traces on the vertical ionograms. It is shown here that after sufficient development of the instability, the condition for ray orthogonality with the deformed layer is satisfied over a range of sounding frequencies. These simulations were carried out over the time period for the development of the bubbles from their initial appearance until the instability grows through the peak of the F-layer. These ray tracing results also indicate the trapping of HF waves within the bubble structure, often at frequencies above foF₂, resulting in the characteristic extended traces seen on ionograms as equatorial bubbles drift inward from distances of several hundred kilometers from the sounder.

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1. (a) Gary Sales
UMLCAR
600 Suffolk St.
Lowell, MA
01854 USA
Gary_Sales@uml.edu
(b) 9789344918
(c) 9784597915
2. G - Ionospheric Radio and
Propagation
3. (a)
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