Field Intensity Estimation by a Combination of Ray-tracing with Radiosonde and Marine Buoy Measurements along the Brazilian Coast

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Refractivity information plays a fundamental role in the analysis of tropospheric radio waves propagation. Although horizontal variations of the refractivity have been observed, the vertical component of its gradient is more relevant and it is predominantly used in the analysis of wave propagation in the presence of ducts.

The heights of evaporation ducts formed immediately above the sea surface can be estimated by a mathematical model (Paulus, R. A., Evaporation Duct Height Calculations, San Diego: Naval Ocean System Center, 1989) that use wind speed, sea surface temperature, air temperature and humidity measured by marine buoys sensors that estimate duct heights for a refractivity gradient $\nabla N = -125\ km^{-1}$. The authors adapted (by changing wind sensor height to 4.7 m and using the measured pressure instead of 1000 hPa), implemented, and applied Paulus method to data from nine marine buoys of the Brazilian National Buoy Program PNBOIA deployed along the Brazilian coast. The statistical behavior of the duct height will be discussed. An example of the average monthly distribution of the duct height obtained by the Santa Catarina buoy (27°24.35'S, 47°15.93'W) is observed in Figure 1.

During a (25 January to 02 February 2009) Brazilian Navy naval operation, radiosondes were launched nine times from the Rio de Janeiro to the Uruguayan coasts. The total atmospheric pressure, humidity, and absolute temperature data were combined to yield vertical refractivity profiles using the Recommendation ITU-R P.453-13 model.

A ray-tracing model has been developed to consider not only a single vertical refractivity profile but also possible horizontal variations along the path. The model is able to estimate field amplitude and phase along rays and to consider multipath effects. Its results will be presented, discussed, and compared with those from well-established models (AREPS, PETOOL). Finally, the results from the application of the ray-tracing model to the above experimental data will be presented and discussed. One such example is shown in Figure 2.

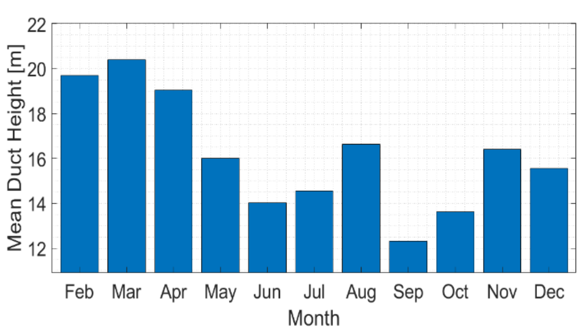

Figure 1: Average monthly distribution of the duct height obtained from the Santa Catarina buoy (27°24.35'S, 47°15.93'W) data during 2017.

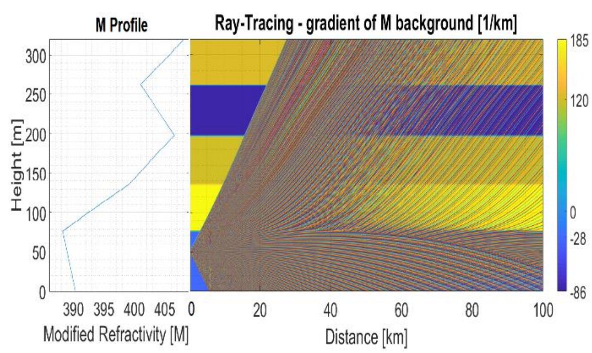

Figure 2: Ray-tracing using data from the radiosonde launched in the Rio de Janeiro coast (23°6.23'S, 43°1.4'W) on 02 February 2009.