Characterizing Evaporative Duct Properties and Their Impact on Electromagnetic Propagation

Robin Corey Cherrett*, Qing Wang
The Naval Postgraduate School, Monterey, CA

Evaporative duct (ED) results in abnormal electromagnetic wave propagation in the atmosphere. Because of the difficulty in directly measuring the evaporative duct properties, surface layer models have been used to derive ED properties using input of temperature, humidity, wind, and sea surface temperature from a single level. Yet it is always desirable to relate the ED properties, such as evaporative duct height (EDH) and strength (EDS), to variable space directly describing surface layer thermodynamic and wind conditions. Most commonly used quantities as independent variables include air-sea temperature difference (ASTD) for thermal stability, relative humidity (RH) for water vapor amount, and wind speed. In previous studies, these variables are allowed to vary within their reasonable ranges. The EDH and EDS are hence examined as a joint function of ASTD and RH at a given wind speed. Two issues exist in this approach. One is the adequacy of the ASTD, RH, and wind speed used to describe the EDH and EDS dependence. Some of the currently used variables, e.g., RH, may not be the most appropriate quantity to relate to ED properties. The use of ASTD is also questionable since it does not directly relate to the dynamic stability of the surface layer turbulence. Another issue is whether the choices of surface layer conditions are realistic representations of the atmosphere. Some of the extreme values of the model diagnosed ED properties may be a result of unphysical combination of the input quantities to the ED models.

In this study, we intend to describe ED properties using physically sound parameter space in hope to obtain clearly defined relationships. The ED will be calculated using the COARE surface flux algorithm modified to produce mean wind and scalar profiles in the surface layer. The EDH and EDS are then diagnosed based on the derived modified index of refraction (M) profiles. To avoid using unrealistic surface layer conditions generated from given ranges of the parameters involved, we used observations from multiple buoys around the U.S coast to include a wide range of surface conditions. Measurements from eight buoys yielded more than 45,000 surface layer M-profiles. These M-profiles were used as input to AREPS to generate a database of propagation loss for certain target heights and propagation distances and relate these quantities to the distribution of EDH and EDS in an effort to understand how propagation losses are associated with the ED properties. Our results suggest bulk Richardson number, specific humidity depression, and wind speed are the most appropriate surface layer variables to describe the variability of EDH and EDS and that propagation loss are most sensitive to EDH and to a lesser extent to EDS.