Rough Ocean Surface Effects on Genetic Algorithm Inversions for Estimating Evaporation Duct Refractivity Profiles

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Radar system performance is impacted by short-term weather patterns through changes in the atmospheric index of refraction. In order to predict a system's "instantaneous" performance on any given day, detailed knowledge of the spatial distribution of atmospheric refraction is needed. This information is difficult to obtain on a routine basis from measurements, and numerical weather models are often too coarse in resolution to be used without coupling to higher resolution boundary layer models, which is challenging. For these reasons, use of inversion techniques has been increasing to address this need. Inversion methods use propagation models in combination with radar measurements to inversely determine information about the distribution of atmospheric refractivity.

In this study, we use synthetic radar data in combination with the Variable Terrain Radio Parabolic Equation (VTRPE) radar propagation model (Ryan, 1991) to solve refractivity inversion problems, focusing on evaporation ducts. This PE code accurately incorporates effects of atmospheric refraction on the propagation. Genetic algorithms are the optimization scheme used to solve the inverse problem. The refractivity profile is parameterized by three variables based on a log-linear representation of an evaporation duct – the duct height, duct "curvature", and the refractivity slope in the mixed layer above the evaporation duct. These parameters have been shown to be important for accurate characterization of the shape of evaporation duct refractivity profiles and for propagation prediction (Saeger et al., 2015). These parameters are inversely determined using VTRPE, genetic algorithms, and synthetic radar data.

Unlike most of the prior "refractivity from clutter" studies (e.g., see review by Karimian et al., 2011), this study examines inversions based on point-to-point propagation rather than the return from the sea surface. This approach removes complexities associated with uncertainties in surface reflection coefficients. In addition, the use of synthetic data permits quantitative evaluation of the accuracy of the inverse solutions. We compare the accuracy of inversions performed with and without a nominal sea state included. The results include discussion of inverse solution accuracy when the inverse approach uses the exact same phase-resolved wave field as the (synthetic) measured propagation data as well as approaches using a statistically equivalent sea surface. Presented results will also include statistical evaluation of the accuracy of recovered refractivity profiles, including a breakdown of the accuracies associated with each of the three parameters mentioned previously.