A Surface Layer Physics Based Technique for Blending Evaporation Duct Profiles to Mesoscale Numerical Weather Prediction Refractivity Profiles

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The complete vertical profile of near surface radio frequency (RF) refractivity at a point over the water includes an evaporation duct from the surface to the top of the atmospheric surface layer and a measured or predicted refractivity profile throughout the remaining depth of the atmospheric boundary layer. Recent progress in employing mesoscale numerical weather prediction (NWP) to capture the spatio-temporal in-homogeneity of refractivity in the littorals has generated the need to develop physics based techniques to automatically blend these two very different types of models at an appropriate height.

Evaporation duct models are, in general, atmospheric surface layer turbulence models for thermally stratified layers based on Monin-Obukhov similarity theory. They assume horizontal homogeneity of thermodynamic and wind variables and predict the vertical profiles of wind speed, pressure, temperature, moisture and modified refractivity from the surface to the top of the atmospheric surface layer. Mesoscale NWP models include prognostic equations based on Newton's second law of motion, the equation of state for an ideal gas, the first law of thermodynamics, conservation of mass, and conservation of moisture to predict vertical profiles of wind speed, pressure, temperature, moisture and modified refractivity on a horizontal grid from the surface layer to the stratosphere.

The blending point in the transition region is based on the accepted definition of surface layer depth as the height where the vertical momentum flux varies by 10% of the surface value. The evaporation duct model is initiated by the wind speed, temperature and relative humidity at the lowest NWP level as well as the sea surface temperature at the NWP model grid point. The vertical profile of momentum flux is assumed proportional to the square of the vertical gradient of the mean wind speed provided by the NWP model. The Obukhov length required to calculate the vertical profile of dimensionless wind shear and surface friction velocity are provided by the evaporation duct model.

The Naval Postgraduate School evaporation duct model and the Coupled Ocean Atmosphere Mesoscale Prediction System were employed to test the blending technique for both stable and unstable surface layers for evaporation ducts between 12 and 26m above sea level.