Effect of Random Medium on Wave Propagation in Evaporation Ducts above a Rough Sea Surface

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Evaporation ducts are frequently observed at lower latitudes, often appear over water bodies, featuring rapid decrease of humidity with height. The world-wide mean of the evaporation duct height is about 10 m, sometimes reaches 30 m or even 40 m. The evaporation ducts are strongly affected by the features of water surface. For example, a rough sea surface tends to destroy the trapping property of the duct structure and change the path-loss pattern. The scattering effect of the rough sea surface can be simulated by introducing an effective reflection coefficient into the boundary condition.

Consider a two-dimensional wave propagation environment, the turbulent effect on the refractive index fluctuation can be derived from the three-dimensional Kolmogorov power spectrum using the Wiener-Khinchin theorem, including the anisotropic effect of the outer scale. The average M-profile, the varying outer scale of turbulence, and the structure constant of the refractive index are categorized under different atmospheric conditions.

In this work, the split-step Fourier (SSF) propagation algorithm is used to study wave propagation in evaporation ducts above a rough sea surface, with random fluctuation of refractive index in the ducts. The PJ model of modified refractivity in an evaporation duct under neutral condition is extended to the unstable and stable atmospheric conditions; and significant differences of path-loss distribution between unstable and stable conditions are observed.

The scattering effect of rough sea surface is simulated by introducing a correction factor of surface roughness into the boundary condition. Less obvious ducting effect is observed in unstable condition since stronger interference between the sea surface and the propagating wave tends to disolve the duct.

Although stronger ducting effect appears under neutral and stable conditions than the unstable condition; the turbulence effect becomes more obvious with larger structure constant in the former case, and the propagating signal is relatively affected to a larger extent. Note that the surface layer only exists in the lowest 10 % of the boundary layer, and thinner boundary layer is expected when the atmospheric stability is increased.