A study of PMSE based on a random rough surface scattering model

C.J. Jiang (1) , F. Li(1), C. La Hoz(2)

(1) Institute of Electronics, CAS,China (2) University of Tromso, Norway

fli@mail.ie.ac.cn

Polar mesospheric summer echoes (PMSE) are very strong radar echoes from a dust plasma layer located around 80∼90 km of altitude in the polar summer mesosphere. The radar frequency of PMSE observations is in the range of 50 MHz to 1.3 GHz. Two reasons are likely responsible for PMSE. One is the Bragg scattering from refractive index fluctuations of the atmosphere caused by turbulence. The other, according to the analysis of spectral width and aspect sensitivity of the radar echoes, is Fresnel reflection from changes in the refractive index in the vertical direction. The turbulence, which is common in thin layers in the polar mesosphere, makes the refractive index to change in a corrugated and rough form. This random rough surface can scatter the radar waves to form PMSE.

The properties of the PMSE signals are investigated using the random rough surface scattering theory. A two dimensional random rough surface model is introduced. The bi-static scattering coefficient has been calculated using the small perturbation approximation, resulting in

$$\gamma(\underset{s}{\hat{k}},\underset{i}{\hat{k}}) = \frac{4\pi k^2 \cos\theta_s}{\cos\theta_i} W(\underset{\perp}{\bar{k}} - \underset{i\perp}{\bar{k}}) \left\{ \left| f_{ee}^{(1)}(\underset{\perp}{\bar{k}},\underset{i\perp}{\bar{k}})(\underset{i}{\hat{e}}(-k_{iz}) \bullet \underset{i}{\hat{e}}) + f_{eh}^{(1)}(\underset{\perp}{\bar{k}},\underset{i\perp}{\bar{k}})(\underset{i}{\hat{h}}(-k_z) \bullet \underset{i}{\hat{e}}) \right|^2 \right\}$$ for a vertically polarized scattered wave, and for a horizontally polarized scattered wave in

$$\gamma(\underset{s}{\hat{k}},\underset{i}{\hat{k}}) = \frac{4\pi k^2 \cos\theta_s}{\cos\theta_i} W(\underset{\perp}{\bar{k}} - \underset{i\perp}{\bar{k}}) \left\{ \left| f_{he}^{(1)}(\underset{\perp}{\bar{k}},\underset{i\perp}{\bar{k}})(\underset{i}{\hat{e}}(-k_{iz}) \bullet \underset{i}{\hat{e}}) + f_{hh}^{(1)}(\underset{\perp}{\bar{k}},\underset{i\perp}{\bar{k}})(\underset{i}{\hat{h}}(-k_z) \bullet \underset{i}{\hat{e}}) \right|^2 \right\}$$ where $W(\underset{\perp}{\bar{k}} - \underset{i\perp}{\bar{k}})$ is the spectral density function of the random rough surface. It is assumed that the rough surface has a Gaussian correlation function $C(\rho) = e^{-\rho^2/l^2}$ with spectral density function $W(|\underset{\perp}{\bar{k}} - \underset{i\perp}{\bar{k}}|) = \frac{1}{4\pi}\sigma^2 l^2 e^{-(k_{dx}^2+k_{dy}^2)l^2/4}$, where l is the correlation length and σ^2 is the standard deviation of the surface height.

The calculations show the dependence of the bi-static scattering strength of PMSE on incident angle, radar frequency, altitude, polarization, and the parameters of the turbulence.