Volume Scatter Simulation for 3D Wind Vector Estimation using Radar Inversion

*Ryosuke Tamura[1], Koji Nishimura[1], Hiroyuki Hashiguchi[1]

1. Research Institute for Sustainable Humanosphere

To estimate accurate 3-dimensional wind velocity and its dispersion by an atmospheric radar, Nishimura et al. [1] proposed Spectral Observation Theory (SOT). In this theory, we only postulate that the temporal function of each turbulence scattering obeys ergodic hypothesis. Then, the correlation function (CF) of the received signal is equal to the multiplication of scattering CF, two-way beam pattern CF and window CF; these CFs are determined by wind velocity, its dispersion, and observation time window, respectively. This implies that we can estimate those parameters by implicit inversion based on SOT, which we refer to as radar inversion technique (RI).

This new analysis technique is characterized in that using multi-received channels radar we are able to estimate the parameters from a single radar beam. By default, however, SOT does not consider aspect sensitivity [2] which is caused by specular reflection from theatmospheric stratified structure. As received signal is in many cases affected by aspect sensitivities and we do not know the true parameters, it is difficult to evaluate the validity of RI. For that reason, we conduct a 3-dimensional volume scatter simulation which assumes that a large number of moving point scatterers that model the atmospheric turbulence. The velocity of the points are random following the normal distribution having a given mean wind velocity and variance.

By this simulation, we can get idealized radar echoes from the atmospheric turbulence, which does and does not affected by the aspect sensitivity. Using the results of the simulations, we evaluate the accuracy of our proposed techniques.

[1] K. Nishimura, M. Kohma, K. Sato and T. Sato, ” Spectral Observation Theory and Beam Debroadening Algorithm for Atmospheric Radar, ” in IEEE Transactions on Geoscience and Remote Sensing, doi: 10.1109/TGRS.2020.2970200.
[2] Briggs, B. H. "Radar measurements of aspect sensitivity of atmospheric scatterers using spaced-antenna correlation techniques." Journal of atmospheric and terrestrial physics 54.2 (1992): 153-165.

Keywords: atmospheric remote sensing , atmospheric radar