Inversion of Advective Volumetric Scatter with Atmospheric Radar and Cross-Radial Velocity Measurement

Koji Nishimura[1,2,3], Taishi Hashimoto[1,2,3], Toru Sato[4] and Masaki Tsutsumi[1,2,3]

[1]Polar Environment Data Science Center, Joint Support-Center for Data Science Research, Research Organization of Information and Systems
[2]National Institute of Polar Research
[3]The Graduate University for Advanced Studies (SOKENDAI)
[4] Kyoto University

Atmospheric radar, including mesosphere stratosphere and troposphere (MST) radar, incoherent scatter (IS) radar, and small wind profiler radar, is mostly to observe volumetric scatters from the neutral and ionized atmosphere. Since these targets have very small radar cross sections and consequently radar observations need integrations of signals (or power spectra) for a significant duration to obtain a sufficient signal-to-noise ratio, the targets move in and out of the field of view while collecting a data segment of minimal duration for analyses. Hence, the radar observation system should natually be described as a spatial and temporal equation, and its analytical solution has long been awaited. Recently, Nishimura et al. (2019) has established the spectral solution of this problem. We refer to the methodology based on this solution as Inversion of Advective Volumetric Scatter (InvAVS). The solution is able not only to describe the spectrum of the target atmosphere, but also to describe the relationship between the spectrum and multiple receivers applied for inteferometry. This means that we are able to measure the cross-radial velocity of the atmosphere without using multiple Doppler components based on multiple beam measurement. The concept of the cross-radial velocity measurement itself has a long history and it has been refered to as Spaced Antenna (SA) measurement. SA is a methodology for radar to measure horizontal wind velocity components using horizontally deployed antenna arrays. This technique has a strong advantage that it is able to measure wind velocity with quite small relative apertures and transmitter power. This cost effective technique therefore has a constant support by operational users as well as the multiple beam techniques such as Doppler Beam Swing (DBS). As is well known by the community, however, SA has an issue of persistent measurement biases, with which an obtained wind velocity is roughly by 10 percent underestimated compared to the one of in-situ measurement. In the present study, we extend InvAVS to cross-correlation of the observed signals in a rigourous form, and apply it to cross-radial velocity measurement.