Inversion Technique on Interferometric Atmospheric Radar

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Atmospheric radar, in a wide sense, including those for ionosphere, is an instrument designed primally for measuring wind velicity at altitude remotely from the ground. Standardly, two different measurement principles are known in this category. The first one is *Doppler measurement*, in which Doppler shifts are measured along the line of sight using a high directivity antenna that forms a sharp radio beam. The other is *interferometric measurement*, in which the velocity is estimated based on the temporal lags of received signals using multiple antennas. Either of them has advantages and disadvantages.

The concept of Doppler measurement is rather simple, and consequently has less systemmatic measurement biases compared to the other. In order to obtain a 3D velocity, however, simultaneous measurements are needed along multiple lines of sight, resulting in sampling at different volumes. The other interferometric measurement is typically done using small aperture antennas which has a big advantage in cost. However, a time lag measured between correlation functions of received signals includes temporal, and spatial decay factors, which is function of the shape of scattering volumes. Up to present, there was no clear way to involve those factors into interferometric measurement calculations and it did not have a sufficient accuracy.

Recently, a mathematical framework that shows how the antenna aperture, beam pattern, and the other radar system parameters reflect on the spectra and correlation functions of the received signals, the observation function in short (Nishimura et al, 2020). The framework naturally includes the concept of numerical inversion based on the observation function as shown in the work. The framework has been build based on a concept of monostatic radar (system with single antenna aperture) but it is straightforward to extend it to other radar systems including interferometer and others. The extended framework shows how we could calculate the problem of intereferometric measurement in a numerical way.

By further extendending the framework, we can propose a high directivity interferometer, which is a fusion of the basic two concepts. In this system, we are able to obtain a 3D velocity estimate at a certain point in the air using the sharp radio beam without applying a spatial average. In this study, we develop an algorithm to solve the inversion of the high directivity interferometer and evaluate its accuracy.

References

Nishimura, K., M. Kohma, K. Sato, and T. Sato, Spectral Observation Theory and Beam Debroadening Algorithm for Atmospheric Radar, IEEE Trans. Geosci. Remote Sens., 10.1109/TGRS.2020.2970200, 2020.