VHF Passive Radar Interferometer Calibration using Targets of Opportunity

Melissa G. Meyer, John D. Sahr, Chucai Zhou, Dawn M. Gidner
University of Washington Electrical Engineering, Seattle, Washington

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Radar interferometry is a relatively new, powerful technique to be applied to studies of turbulence in the ionosphere. Coherent scatter radars collecting echoes on multiple antennas can, with a little extra signal processing, resolve the transverse structure of scatterers, and with the proper antenna arrangement, can locate targets in both azimuth and elevation angle. Imaging can also be done with systems of more than two antennas. We have recently demonstrated the use of interferometry with passive radar, determining uncalibrated azimuthal structure in E-region irregularities. Interferometer calibration requires care, and there are many parameters which deserve attention; we will focus on a few of them here.

An unknown phase shift is imposed on each received signal due to the transmission lines connecting the antennas and the receiver, where the data is recorded. The electrical length of these cables may be roughly determined, but a regular correction done using data from the instrument itself is desirable because of the temperature dependence of the cables and varying environmental conditions. Useful targets in this case are VHF transmitters in the area; these point targets are stationary at exactly known locations and thus their apparent "movement" in the interferometer beam can be used to calibrate the instrument. Area transmitters are also useful in determining exactly the baselines between the various antennas in the interferometer. In many cases baselines are more accurately measured by carefully observing data from the instrument itself, rather than trying to determine the exact electrical centers of the antennas and then physically measuring the distance between them.

Finally, other point targets such as aircraft, which we observe routinely, are useful in refining knowledge of the interferometer beam pattern. The width of a lobe at a certain range can be estimated by tracking commercial aircraft as they progress across it. Typically these airplanes maintain a constant velocity, and often they follow predictable courses in the sky. Thus, much can be learned by monitoring their Doppler velocity and phase progression.

Our objective is to develop a robust, effective instrument that can continuously recalibrate itself and operate reliably in the field, requiring minimal upkeep. Developing calibration techniques which utilize the data products themselves is a step in this direction. Here we will describe the abovementioned interferometer calibration techniques and demonstrate them with our VHF coherent scatter passive radar. We will also comment on the practicality of implementing these techniques and their usefulness in ionospheric radar applications.