Title

Spaced-Antenna Wind Estimation Using an X-Band Phased-Array Weather Radar

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Abstract

Over the past few decades, several single radar methods have been developed to probe the kinematic structure of storms. All these methods trade angular-resolution to retrieve the wind-field. To date, the spaced-antenna method has been employed for profiling the ionosphere and the precipitation free lower atmosphere. This work focuses on applying the spaced-antenna method on an X-band active phased-array radar for high resolution horizontal wind-field retrieval from precipitation echoes.

The ability to segment the array face into multiple displaced apertures allows for flexible spaced-antenna implementations. The methodology employed herein comprises of Monte-Carlo simulations to optimize the spaced-antenna system design and analysis of real data collected with the designed phased-array system. The contribution that underpins this dissertation is the demonstration of qualitative agreement between spaced-antenna and Doppler beam swinging retrievals based on real data.

First, simulations of backscattered electric fields at the antenna array elements are validated using theoretical expressions. Based on the simulations, the degrees of freedom in the spaced-antenna system design are optimized for retrieval of mean baseline wind. We show that the designed X-band spaced-antenna system has lower retrieval uncertainty than the existing S-band spaced-antenna implementation on the NWRT. This is because of the flexibility to synthesize small overlapping apertures and the ability to obtain statistically independent samples at a faster rate at X-band. We then demonstrate a technique to make relative phase-center displacement measurements based on simulations and real data from the phased-array spaced-antenna system. This simple method uses statistics of precipitation echoes and apriori beamwidth measurements to make field repeatable phase-center displacement measurements.

Finally, we test the hypothesis that wind-field curvature effects are common to both the spaced-antenna and Doppler beam swinging methods. Based on a close-range winter storm data set, we

find that the spaced-antenna and fine-resolution Doppler beam swinging retrievals are in qualitative agreement. The correlation between the spaced-antenna and fine-resolution Doppler beam swinging retrievals was 0.57. The lowered correlation coefficient was, in part, due to the high standard deviation of the DBS retrievals. At high wind-speeds, the spaced-antenna retrievals significantly departed from variational retrievals of mean baseline wind.

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