ATTENUATION MARGIN REQUIREMENTS IN A NETWORKED RADAR SYSTEM FOR OBSERVATION OF PRECIPITATION

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In recent years, it becomes increasingly appealing to move the operating frequency of weather radar systems from non-attenuating frequencies, such as at S-band, to attenuating frequencies, such as at X-band. Through decades of research, the propagation of electromagnetic waves through precipitation has been better understood and the algorithms to correct for wave attenuation have become mature. Operating weather radar at higher frequencies is attractive because it helps to reduce antenna size, system cost, and infrastructure limitation. However, electromagnetic waves become extinct in long and intense rain paths at X band in which case there is potential for missing observations. Therefore, the excess margin for rain attenuation is one of the important metrics in radar system design and the extra attenuation margin needs to be applied to the allocation of power budget to meet the required sensitivity.

In order to produce a quantitative baseline for system design for short wavelength weather radar, research has been done to collect the statistics of total attenuation for a single radar node and a database can be created for a specific region from large amount of radar observations at non-attenuation frequencies. Larger total attenuation is more likely for longer propagation paths, especially up to 100 km radius. Therefore, not only the radiation dispersion with range but also the total attenuation increase with range needs to be considered for sufficient sensitivity. At X-band and higher, the attenuation margin can become very high at larger radar range in order to ensure reliable measurements with high probability. The NSF Engineering Research Center (ERC) for Collaborative and Adaptive Sensing of the Atmosphere (CASA) is advancing a new sensing paradigm using networked short-range radar systems to avoid problematic earth curvature blockage. Low cost X-band weather radar enables the deployment of a large number of radar nodes. The CASA ERC has developed a networked radar test bed – Integrated Project 1 (IP1) – in southwestern Oklahoma, using four X-band radar of 40 km range to cover an area of 7,000 km^2.

CASA's radar network is also a collaborative and adaptive system with distributed radar nodes densely deployed. Overlapped coverage is one of the most important aspects in designing such networked systems. The overlapped coverage further counters the attenuation margin requirements because of the diversity in the network observations. Rainfall intensity is rarely uniform over large areas; therefore the total attenuation encountered by each radar node can vary widely through different propagation paths. This diversity helps to increase the system availability and system attenuation margin can be designed lower. In this paper the attenuation margin requirements are analyzed in the network context and the metric to design a networked radar system is formed. In CASA's IP1 test bed a substantial common coverage area exists that can be observed by all the four radar nodes. In this paper the field observations in IP1 are analyzed and the distributions of total attenuation of single radar observations and that of network observations in this common coverage are presented in terms of probability of the total attenuation exceeding some a value. At high system availability, the distributions of the total attenuation viewed by the network, of the optimal (min) and the sub-optimal (2nd min) network observation, are consistently and substantially favorable than the distributions of the total attenuation viewed by individual radar. The difference between the distribution for individual radar and the distribution for the network shows the network gain of the attenuation margin.

The layout and location of the IP1 weather radar network. The coverage circles of IP1 radar are in radius of 40km. KTLX is to the northeast of the test bed and KFDR is to the southwest of the test bed.