Pulse Compression Waveform Design Considerations for Extreme Weather Observations

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High-resolution radar observations of extreme weather phenomena, specifically on storm- and tornado-scales, are often confined to mobile platforms, which are capable of strategic positioning in order to obtain low-level measurements. Due to size, weight, reliability, and cost concerns, low-powered solid-state transmitters are being increasingly used on mobile radar systems. In order to increase the sensitivity of these radars, pulse compression waveforms are used for increased data quality. However, multiple issues regarding the use of long pulse waveforms for distributed targets and extreme weather observations are yet to be fully addressed in the literature. This paper discusses some of these issues, as well as ongoing research at the University of Oklahoma Advanced Radar Research Center regarding power efficiency, amplitude distortion, Doppler tolerance distortions, polarimetric moment estimates in low-SNR areas, and fill-pulse blind range mitigation. Additionally, emphasis is placed on other potential benefits regarding the use of pulse compression for observations of severe local storms and tornadoes, most notably the potential for significant increases to native range resolution and the resulting impact on meteorological studies such as dual-Doppler analyses. In order to demonstrate these recent advances and their applications to the severe weather observation and research communities, the application of these techniques is discussed for three distinctively different mobile radar platforms at the University of Oklahoma: The 100-W solid-state, polarimetric, transportable PX-1000, the 3.5-kW TWT distributed fan-beam mobile Atmospheric Imaging Radar, and the 20-kW TWT polarimetric, mobile, rapid-scanning RaXpol, all of which operate at X-band. Examples of recently-observed significant extreme weather cases, including multiple violent tornado cases, are presented in a comparison-based format in order to show the drastic positive impact advanced long pulse waveforms can have on mobile observing systems, as well as other low-cost, low-power radar platforms.