NOWCASTING FOR RAINFALL ACCUMULATION PREDICTION

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ABSTRACT

Short-term prediction (nowcasting) of high-impact weather events can lead to significant improvement in warnings and advisories resulting in substantial savings of life and property. While nowcasting of precipitation has traditionally been done using radar reflectivity (Z_h) data, research over the last decade indicates that using the specific differential phase (K_{dp}), defined as one-half the range derivative of the two-way differential phase (φ_{dp}), has several advantages over using Z_h for estimating rainfall accumulation. Since φ_{dp} is a dual-polarized radar product and not a power measurement, rainfall estimates derived from K_{dp} are not susceptible to radar calibration error, attenuation, or beam blockage and are less affected by anomalous propagation. Rainfall rate estimates derived from K_{dp} are also less sensitive to variations in drop size distributions and to the presence of dry, tumbling hail than those derived from Z_h. The specific differential phase can also be used to correct for attenuation losses and to verify radar hardware calibration [1].

Additionally, X-band ($\lambda \sim 3$ cm) polarimetry offers important practical advantages over longer wavelength radar polarimetry at shorter ranges. One advantage is a significantly stronger differential phase shift on propagation, which is proportional to the radar frequency (for Rayleigh scattering). This allows the use of K_{dp} -based rainfall estimators for lighter rainfall rates when measured with X-band radars versus measurements made by longer wavelength radars. X-band radars are also smaller, less expensive, require less energy for the same sensitivity, and are more easily transported compared to their longer-wavelength counterparts. These traits make X-band radars a convenient tool for quantitative precipitation estimation (QPE) where high-resolution rainfall measurements are needed in a limited area such as a relatively small watershed or for specialized studies like those in urban hydrology [2].

Studies have shown the Lagrangian persistence nowcasting paradigm, which assumes constant precipitation pattern motion over the forecast lead time period, to be an effective means of storm prediction over short leads times [3]. The Lagrangian persistence paradigm consists of estimating a motion vector field based on a sequence of past observations (estimation) and recursively combining this motion vector field with the most recent observation and subsequent predictions to generate future predictions (advection). Previous studies have shown using the Dynamic and Adaptive Radar Tracking of Storms (DARTS) method to estimate storm motion with a *SINC*-kernel-based advection algorithm produced efficient and accurate nowcasts of Z_H during operational use in the Collaborative and Adaptive Sensing of the Atmosphere (CASA) X-band radar network during the 2009 Integrative Project #1 (IP1) experiment [4]. DARTS also provides a convenient means to perform scale decomposition by integrating Fourier low-pass filtering in the prediction model [5].

Precipitation patterns include features over a variety of scales where generally smaller-scale features have shorter lifetimes than larger-scale features. Thus, each scale has a maximum lead time up to which variation at that scale can be predicted and attempting to predict scales beyond this maximum lead time can degrade nowcasting performance. Germann and Zawadzki [3] presented a framework in which the predictability of precipitation patterns can be analyzed. This analysis had a threefold application, namely, to determine the scale-dependence of predictability, to set a standard against which the skill for quantitative precipitation forecasting by numerical modeling can be evaluated, and to extend nowcasting by optimal extrapolation of radar precipitation patterns. While this study considered the use of continental-scale Z_h fields, the methodology can be generalized to study the scale characteristics and predictability of other meteorological field variables measured on smaller scales.

This paper presents a preliminary performance evaluation of the DARTS based nowcasting method applied to K_{dp} fields derived from CASA X-band radar data. Scale-dependence and predictability of K_{dp} fields relative to Z_h fields are also investigated. The results will show the extent to which K_{dp} fields can be predicted according to their scale-dependent properties and the utility of such predictions in estimating rainfall accumulation.

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