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Radar data interpolation using a kernel-based Lagrangian nowcasting approach

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Accurate and efficient temporal interpolation of radar data is necessary for data fusion applications desiring to provide data that better represent atmospheric conditions. Interpolation is a fundamental data processing problem and several well-known interpolation techniques exist. The Dynamic Radar Tracking of Storms (DARTS) is a Lagrangian persistence-based nowcasting model that has previously shown utility in nowcasting a variety of radar data in severe weather and aviation decision support applications. DARTS also provides an inherent means to perform temporal interpolation. DARTS represents the general continuity equation modeling the motion of an observed precipitation field represented by a sequence of radar reflectivity fields as a discrete spatiotemporal linear model that is formulated in the Fourier domain and solved using linear least squares estimation. In this context, interpolation can be accurately and efficiently performed by appropriately windowing the assimilated data and evaluating an interpolating trigonometric polynomial using the Fast Fourier Transform (FFT). The utility of this interpolation methodology will be demonstrated and performance compared to linear and cubic spline interpolation methods. The use of Lagrangian persistence-based extrapolation to perform the interpolation was also investigated. Rainfall rates derived from data collected by the KFWS WSR-88D S-band radar and the X-band radar located at the University of Texas at Arlington in the Dallas-Fort Worth Testbed were used for the analyses. The results show a temporal interpolation approach that combines extrapolations of the most recent previous observation forward in time and the next later observation backward in time yielded the best performance in terms of normalized standard error. The results also show that the FFT-based approach within the context of the DARTS model yielded normalized standard error values within about 5–15% of the forward-backward extrapolation approach and ran about 2 orders of magnitude faster in terms of CPU time. Interpolation performance will also be assessed using Vaisala WRM-200 C-band and larger-scale U.S. NEXRAD and Finnish Meteorological Institute composite radar data.