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Comparison of GCIP and stage III radar-rainfall estimates over the Mississippi River Basin for 1997

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Summary The worth of archival, long-term, high spatial and temporal resolution radar-rainfall estimates for hydrologic modeling has not yet been established. In particular, uncertainties remain regarding accuracy at the event time-scale, which is a modeling requirement for mass conservation. To explore this issue, an archival radar-rainfall precipitation dataset produced from the National Reflectivity Composite for the GEWEX Continental-Scale International Project (GCIP) and US National Weather Service, Weather Surveillance Radar 1988-D (WSR-88D) Stage III (SIII) data were compared with data from 982 National Climatic Data Center (NCDC) rain gages throughout the Mississippi River Basin. These two datasets are derived from the same radar-reflectivity observations but they are different. The GCIP dataset was developed from low resolution (5 dBZ bins) national radar mosaic imagery using a systematic procedure that employed one climatologically-derived reflectivity-rainfall relationship, while the SIII radar-rainfall estimates are produced using a processing algorithm developed by the US National Weather Service that employs near-real time adjustment and varied parameterizations in different River Forecast Centers around the Mississippi River Basin. Statistical analyses were performed to compare both radar-rainfall datasets with rain gage data on an event time-scale for the entire year of 1997. The investigation shows that the GCIP dataset, given a change in the equation used to calculate rainfall from reflectivity, has a lower root mean square difference for the majority of gages in four of the five river forecast centers that cover the Mississippi River Basin compared to SIII in 1997.

Introduction

The Weather Surveillance Radar-1988 Doppler (WSR-88D) System was developed through the Next Generation Weather

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Radar (NEXRAD) program in the late 1980s by the Departments of Commerce, Defense, and Transportation (Crum and Alberty, 1993). The program resulted in a network consisting of 158 WSR-88D radars, where approximately 90% (142) of the WSR-88D radars provide coverage for the contiguous United States (http://www.roc.noaa.gov). The WSR-88D radar network is a source of a variety of meteorological data for the US including reflectivity, mean radial velocity, and Doppler velocity spectrum width (Heiss et al., 1990; Crum and Alberty, 1993). The reflectivity (Z) data can be processed into rainfall rates (R), using the power law: $Z = aR^b$, where a and b are dependent on the drop size distribution (DSD) (Battan, 1973).

Even though radar-rainfall products provide high resolution ($4 \times 4\ \mathrm{km}^2$) data across the continental US, the radar-rainfall estimates have various errors. Radar-rainfall errors can be grouped into two categories: errors in measuring reflectivity and errors in relating reflectivity to surface precipitation. Sources of reflectivity measurement error include hardware calibration problems (Smith et al., 1996; Ulbrich and Lee, 1999), range effects (Kitchen and Jackson, 1993; Smith et al., 1996), anomalous propagation (Doviak and Zrnic, 1993), and beam blockage (Young et al., 1999). Relating radar-reflectivity to surface precipitation is ''highly complex'' (Austin, 1987) because it is dependent on physical factors which vary between storms (Stout and Mueller, 1968; Wilson and Brandes, 1979; Smith and Krajewski, 1993). One such physical factor, DSD, varies throughout a single storm (Uijlenhoet et al., 2003). Analysis of these many factors on the radar-rainfall estimation process is not the purpose of this study. Here, we compare algorithms used to produce archival products.

Multiple archived radar-rainfall datasets exist for large portions of the continental US that provide high spatial ($4 \times 4\ \mathrm{km}^2$) and temporal (hourly) coverage. These radar-rainfall products provide better spatial coverage than gage networks. Before using radar products in hydrologic studies, the radar-rainfall products must be examined to evaluate their errors. Once areas and storms with high quality radar coverage are identified, radar-rainfall products can be used with a greater degree of certainty in hydrologic analysis and modeling. This paper compares two radar-rainfall datasets, among widely available data sources, to determine which provides the best radar-rainfall estimate for use in hydrologic modeling requiring a high spatial and temporal resolution over the Mississippi River basin.

The Mississippi River basin, shown in Fig. 1, is the third largest in the world. It drains an area of 2,909,650 km^2, which is 41% of the area of the United States and a small portion of southern Canada. The annual average precipitation over the basin is 835 mm y^{-1} with approximately 650 mm y^{-1} of evapotranspiration and 187 mm y^{-1} of runoff (Milly and Dunne, 2001). Fig. 1 shows the spatial distribution of gage-estimated precipitation over the basin during the year analyzed in this study, 1997, together with the location

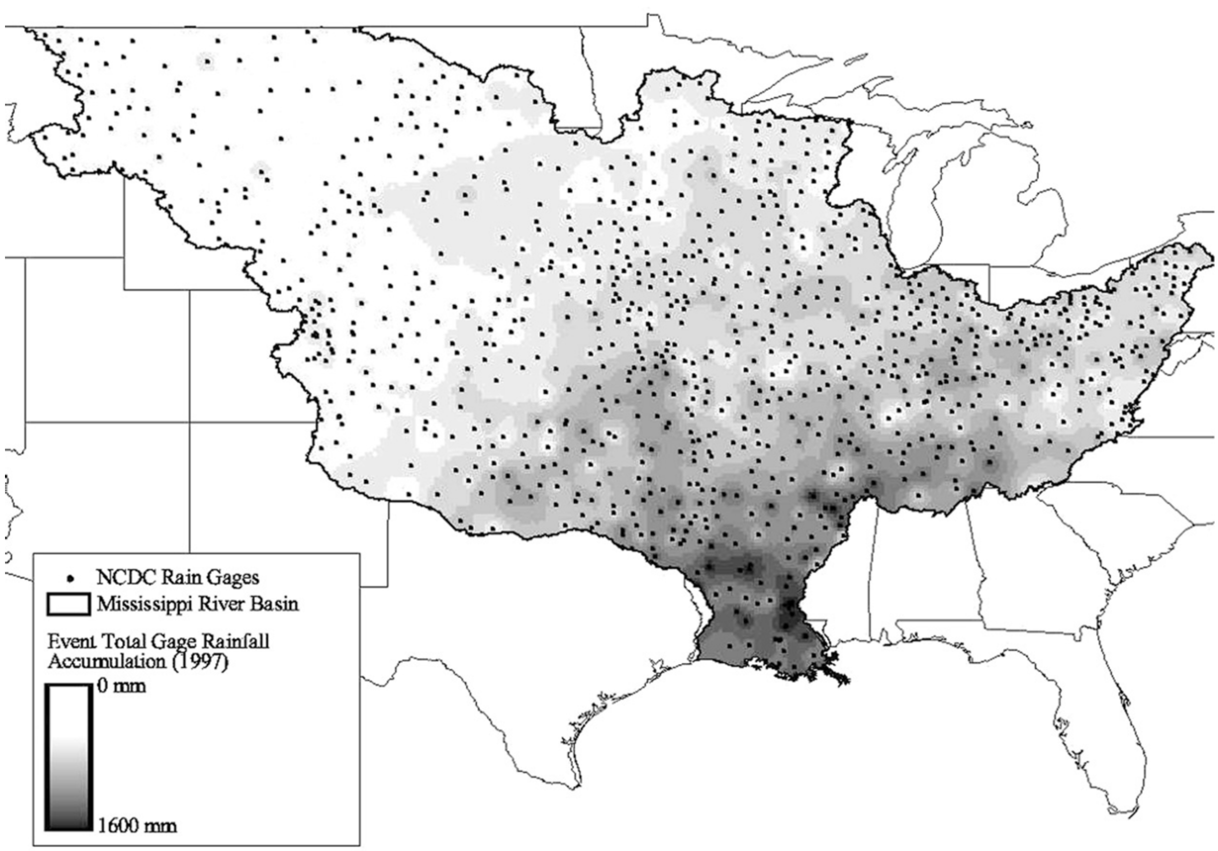

Figure 1 Mississippi River Basin with overlay of 982 rain gages used in this study and gage-estimated and interpolated precipitation for 1997.