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Hydrometeorological and statistical analyses of heavy rainfall in Midwestern USA

S. Thorndahl (1), J.A. Smith (2), and W.F. Krajewski (3)

(1) Aalborg University, Department of Civil Engineering, Aalborg, Denmark (st@civil.aau.dk), (2) Princeton University, Department of Civil and Environmental Engineering, Princeton, NJ, USA (jsmith@princeton.edu), (3) The University of Iowa, IIHR - Hydroscience and Engineering, Iowa City, IA, USA (witold-krajewski@uiowa.edu)

During the last two decades the mid-western states of the United States of America has been largely afflicted by heavy flood producing rainfall. Several of these storms seem to have similar hydrometeorological properties in terms of pattern, track, evolution, life cycle, clustering, etc. which raise the question if it is possible to derive general characteristics of the space-time structures of these heavy storms. This is important in order to understand hydrometeorological features, e.g. how storms evolve and with what frequency we can expect extreme storms to occur.

In the literature, most studies of extreme rainfall are based on point measurements (rain gauges). However, with high resolution and quality radar observation periods exceeding more than two decades, it is possible to do long-term spatio-temporal statistical analyses of extremes. This makes it possible to link return periods to distributed rainfall estimates and to study precipitation structures which cause floods. However, doing these statistical frequency analyses of rainfall based on radar observations introduces some different challenges, converting radar reflectivity observations to "true" rainfall, which are not problematic doing traditional analyses on rain gauge data. It is for example difficult to distinguish reflectivity from high intensity rain from reflectivity from other hydrometeors such as hail, especially using single polarization radars which are used in this study. Furthermore, reflectivity from bright band (melting layer) should be discarded and anomalous propagation should be corrected in order to produce valid statistics of extreme radar rainfall. Other challenges include combining observations from several radars to one mosaic, bias correction against rain gauges, range correction, ZR-relationships, etc.

The present study analyzes radar rainfall observations from 1996 to 2011 based the American NEXRAD network of radars over an area covering parts of Iowa, Wisconsin, Illinois, and Lake Michigan. The radar observations are processed using Hydro-NEXRAD algorithms in order to produce rainfall estimates with a spatial resolution of 1 km and a temporal resolution of 15 min. The rainfall estimates are bias-corrected on a daily basis using a network of rain gauges.

Besides a thorough evaluation of the different challenges in investigating heavy rain as described above the study includes suggestions for frequency analysis methods as well as studies of hydrometeorological features of single events.