P1.4 Comparison of Precipitation Fields Estimated by Gage, Radar and Multiple Sensors (Gage and Radar) for SE Wisconsin and NE Illinois

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1. INTRODUCTION

Daily information on precipitation is employed year-round for purposes of water management. Real time gage data from the NWS cooperative network is often used, but because of spatial density limitations may not be adequate to estimate gradients in precipitation and thus may be inadequate to estimate precipitation over scales finer than 30-40 km. This study compares precipitation from gage, radar, and multi-sensor estimates to evaluate differences between gage and remotely sensed precipitation estimates year-round over 2 small regions for the period February 2002 – September 2004.

2. DATA AND ANALYSIS

Daily precipitation estimates are based upon daily 1) NWS quality controlled cooperative gage data (QC_coop), 2) gage data from a dense (10 km spacing) network of weighing bucket gages in Cook County IL (CCPN), 3) gridded (4 x 4 km) Stage II radar estimates (RDR), mosaicked and distributed by the National Center for Environmental Prediction (NCEP), and 4) gridded (4 x 4 km) Stage III/IV multi-sensor estimates (MPE), produced at the River Forecast Centers and mosaicked into a national product at NCEP.

2.1 Gage data

The first study area covers the northern portion of the Fox River watershed that extends from NE Illinois to SE Wisconsin (Fig 1). Real-time precipitation data are used as input into the Fox River Forecast Model which in turn is employed to assist in water level control for two dams on the Fox River. Often however, real-time data are not available at all gages at the time the model is run and the closest gage available for input may be many kilometers away from the missing gage.

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If the spatial pattern of precipitation is well represented by the MPE estimates, and the magnitude of the MPE estimates is related in a regular way to that of the gages, the remotely sensed estimates may be a great improvement over gage data for input into real-time models.

For the Fox Watershed study, QC_coop data, instead of real-time cooperative data, are compared with the gridded RDR and MPE data to avoid problems with missing real-time data. Only gages which report during the morning hours are employed.

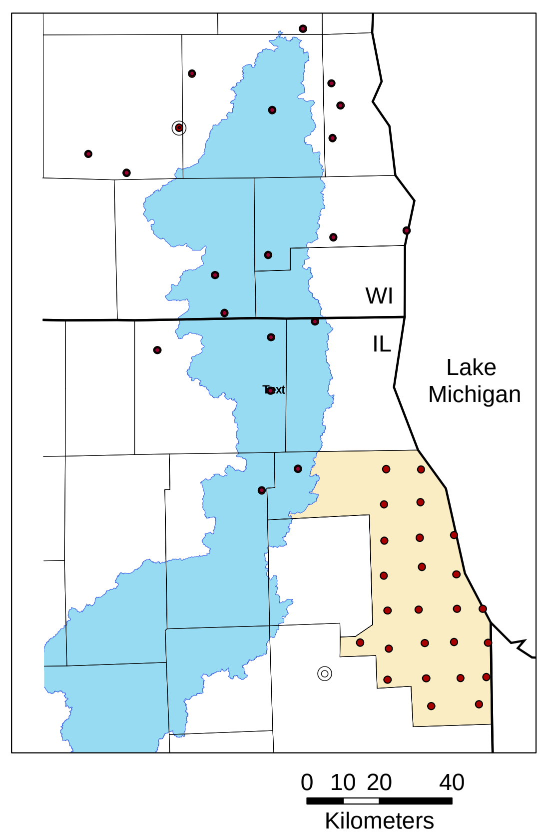

Figure 1. Fox River Watershed (blue) and Cook County Precipitation Network (yellow). QC_coop and CCPN Gages indicated by filled circles, and radars (KMMX and KLOT) by large circles.

The CCPN study area covers most of Cook County, IL, and is just to the SE of the Fox River Watershed study area (Fig. 1). These gage data are recorded on chart and data logger, and are collected and quality controlled monthly. Hourly amounts are based upon data logger readings taken at 10-min intervals, with the charts used only if digital data are missing. For this analysis, the hourly data are summed to obtain a daily total valid at 6 CST.

2.2 Gridded Precipitation Fields

Gridded radar (RDR) and multi-sensor precipitation (MPE) estimates have been obtained in near real-time from NCEP since March 1997. The MPE estimates are based upon a composite of data from the WSR-88D radars and upon hourly rain gage observations from the Hydrometeorological Automated Data System (HADS), and Automated Surface Observation Sites (ASOS). Techniques employed in processing the data are detailed in Fulton et al. (1998); and Seo (1998). County averaged monthly sums based upon the preliminary Stage II multi-sensor estimates were found to be of comparable quality to QC_coop estimates in predicting county level corn yields over the Midwest region (Westcott, et al., 2005).

During the winter of 2002, the NOAA's Office of Hydrology (OH), in conjunction with the NWS River Forecast Centers, implemented a Stage III/IV multi-sensor precipitation estimate (MPE) algorithm that includes provisions for quality-controlling gage data (NWS Ofc. Hydro. Devel., 2005), and incorporates a new method of bias-correction computation (Seo and Breidenbach, 2002). Since February 2002, the 6-hr and 24-hr Stage III/IV MPE gridded data have been downloaded daily. The 24-hr data are valid at 6 CST. The closest 4 x 4 km grid point from Stage II RDR and the Stage III/IV MPE precipitation estimates are employed for comparison with the QC_coop and CCPN precipitation amounts.

3. FOX WATERSHED

The 18 gages within the Fox Watershed were averaged together to form a "network" daily average. The closest grid point to each gage was also averaged for the RDR and the MPE data. The daily averaged RDR values in comparison to the QC_coop average values are generally centered about the 1:1 line, but with large positive and negative deviations (Fig 2a). In contrast, the differences between the MPE and QC_coop averages are smaller (Fig. 2b), and there is a tendency for the MPE values to be smaller than the QC_coop values. The MPE estimates fall more frequently within 25% of the QC_coop daily averaged values, but are most often less than the QC_coop averages. The linear correlation coefficient R between gage and gridded daily averaged pairs are 0.89 for RDR, and 0.96 for the MPE data, respectively. The linear regression slopes are 0.94 and 0.79 for the RDR and MPE, respectively.

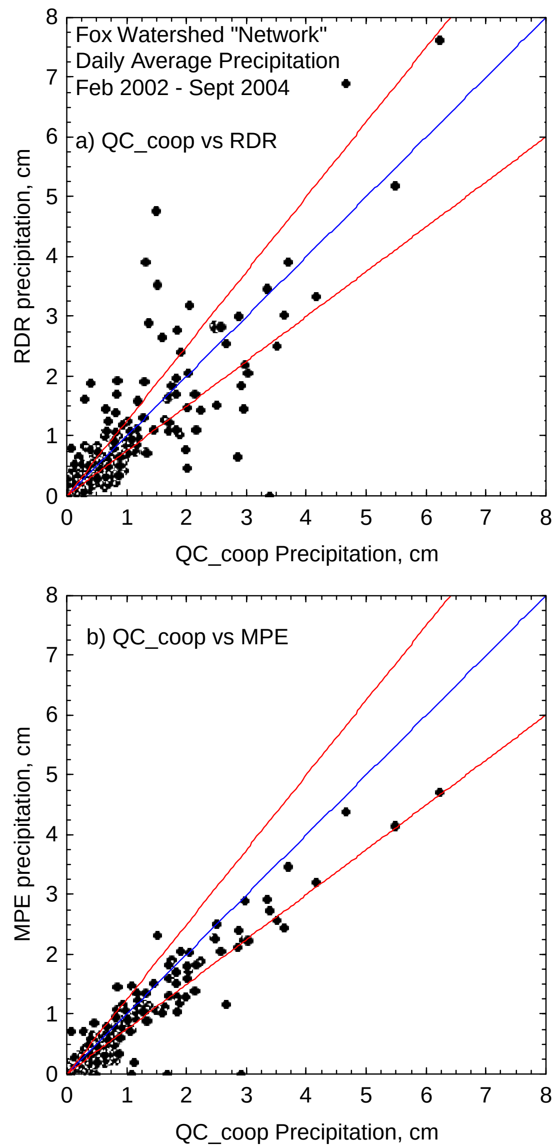

Figure 2. Daily "network" average precipitation based on QC_coop gages within the Fox Watershed and the corresponding nearest neighbor grid points for a) RDR and b) MPE estimates. The blue line indicates a 1:1 slope and the red lines indicate +/- 25 % of the QC_coop value.

4. COOK COUNTY

A similar analysis was preformed employing the CCPN gages (Fig. 3a, b). Again, there were large differences in the gage and RDR data. The differences were smaller in comparing the CCPN and MPE daily averages, but the MPE averages again were often lower than the CCPN averages. The linear correlation coefficient R between gage and gridded data were 0.87 for the RDR, 0.95 for the MPE data. The linear regression slopes were nearly the same, 0.77 for the RDR and MPE data.
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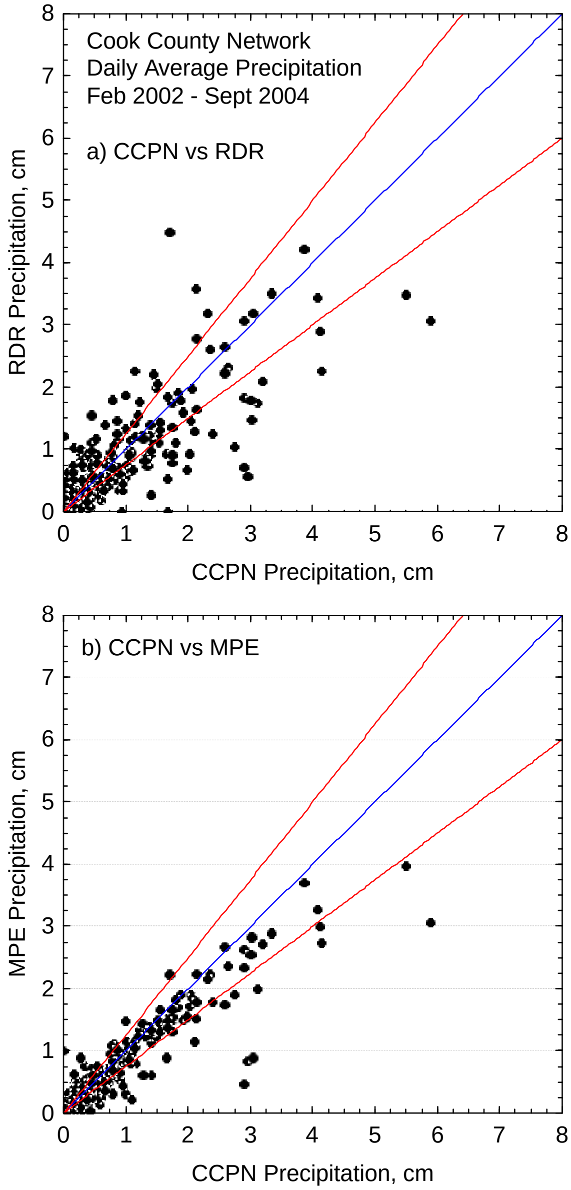

Figure 3. Daily network average precipitation based on CCPN gages and the nearest neighbor grid points for a) RDR and b) MPE estimates. The blue line indicates a 1:1 slope and the red lines indicate +/- 25% of the CCPN value.

The three outliers in Figure 3b, with the CCPN value about 3 cm and the MPE value a little less than 1 cm included, 1-31-2002, 3-26-2002, and 7-18-2003, a winter, a spring and a summer day. Irregular gridded spatial patterns on these days suggest that a glitch in one of the processing steps resulted in corrupted MPE fields.

5. DAILY VALUES AT INDIVIDUAL GAGES

Gage values of more than 2.5 cm were examined to determine how well individual gages performed on a daily basis for larger precipitation amounts. It was found that the median difference ((Gage – MPE) / Gage) *100) was about 25% for both the Fox QC_coop gages and the CCPN gages. Figure 4 shows median percent difference values for each CCPN gage. The median differences between the gage and corresponding grid point closest to the Romeoville, IL (KLOT) radar (13 km, Fig 1) and Sullivan, WI (KMKE) radar (<1 km, Fig. 1), however, were on the order of 50%, much greater than the median difference for all other gages. CCPN gage 15 is closest to KLOT. Annual precipitation maps for 2002, 2003 and 2004 and many monthly maps (not shown), indicate a minimum in precipitation, near but offset from the KLOT and KMKE radars. Gage-MPE differences did not appear dependent on distance from the radar in any other way for either the Fox QC_coop gages or for the CCPN gages.

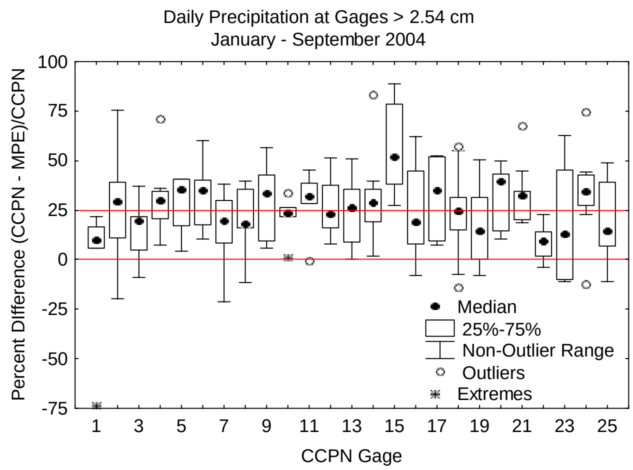

Figure 4. Median percent difference in daily precipitation between each CCPN gage and the nearest MPE grid for February 2002 to September 2004.

6. SEASONAL DIFFERENCES

For both the CCPN and Fox Networks, during the winter months of November to February, the nearest gridded RDR average daily values were typically smaller than the gage value, particularly for gage values greater than 0.5 cm. During the summer months of June to August, the nearest RDR average daily precipitation values were often larger, but could be smaller than the gage values (Fig 5a). If one assumes that winter precipitation is from low-reflectivity horizontal gradient events and that summer precipitation is from high-reflectivity horizontal gradient events, these results are similar to Klazura et al. (1999).

The MPE algorithm reduced the differences between the gage and gridded precipitation estimates (Fig. 5b). The relationship between gage and gridded MPE daily averages is similar for both wintertime and summertime days.

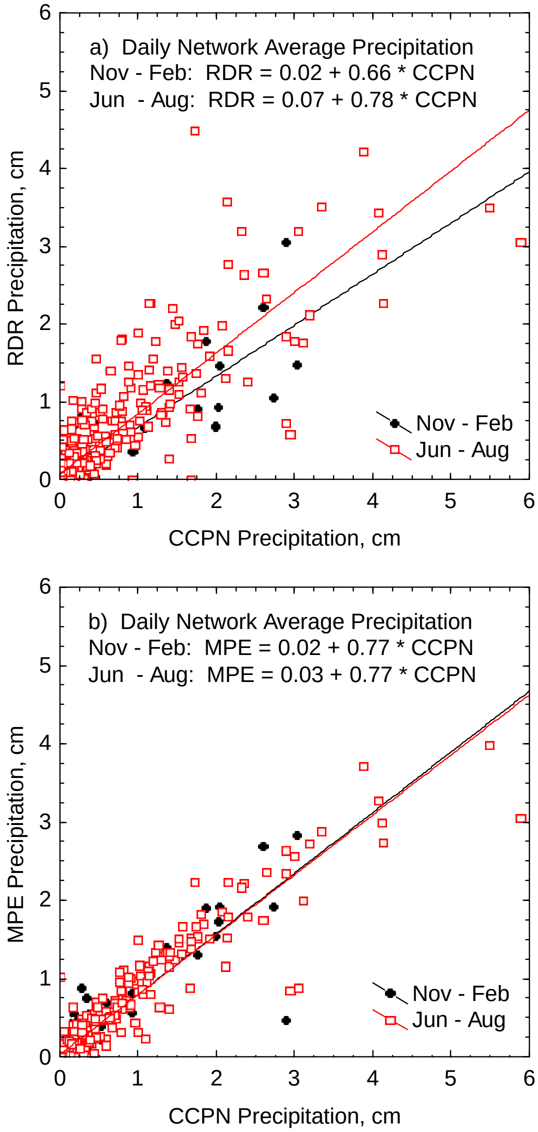

Figure 5. CCPN daily network average gage precipitation and daily average a) RDR and b) MPE precipitation by season during the period February 2002 to September 2004.

7. SUMMARY AND CONCLUSIONS

For two small regions in SE Wisconsin and NE Illinois, the MPE estimates were found to be a considerable improvement over the RDR precipitation estimates during all seasons of the year. In comparison to the QC_coop gage data and to the CCPN gage data, on average, there is a bias of about 25% throughout the year. Future work will evaluate the use of MPE estimates in the Fox River Forecast Model, taking into account the apparent bias in MPE precipitation, and comparing the simulated flow employing MPE to observed Fox River flow.

8. Acknowledgements

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9. REFERENCES

Fulton, R.A., J.P. Breidenback, D.-J. Seo, and D.A. Miller, 1998: The WSR-88D rainfall algorithm. *Wea. and Forecast*, **13**, 377-395.

Klazura, G.E., J.M. Thomale, D.S. Kelly, and P. Jendrowski, 1999: *J. Atmos. Oceanic Technol.*, **16**, 1842- 1850.

NWS Office of Hydrologic Development, 2005: *Hydroview/MPE Users Guide*, 51pp.

Seo, D.-J., 1998: Real-time estimation of rainfall fields using radar rainfall and rain gage data. *J. Hydrol.*, **208**, 25-36.

Seo, D.-J., and J.P. Breidenbach, 2002: Real-Time Correction of Spatially Nonuniform Bias in Radar Rainfall Data Using Rain Gauge Measurements. *J. Hydrometeor*:, **3**, 93–111.

Westcott, N.E. S.E. Hollinger, and K.E. Kunkel, 2005: Use of Real-time multi-sensor data to assess the relationship between normalized corn yield, monthly rainfall, and heat stress across the central united states. *J. Appl. Meteor.*, accepted.