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7a.3 Evaluation of MPE Data for the Midwestern United States

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Introduction

In February 2002, the Stage III/IV Multi-sensor Precipitation Estimation (MPE) algorithm was implemented. In 2005, daily values of MPE for the United States became available on the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) Web site (http://www.srh.noaa.gov/rfcshare/precip_analysis_new.php). These data provide an excellent summary of 24-hour precipitation across the United States on a 4x4 km grid.

A number of studies have evaluated the accuracy of the post-Febrary 2002 MPE data (Young and Brunsell, 2008, Westcott et al., 2008, Westcott, 2009 and Habib et al., 2009). It was found in several of these studies that the MPE amounts are larger than gage amounts for lower values of precipitation, and that MPE amounts are frequently smaller than gage amounts for higher values of precipitation (Westcott et al., 2008, Westcott, 2009, Habib et al., 2009). An example from Westcott et al. (2008) is presented in Figure 1. Factors that might explain variations in MPE bias are examined here.

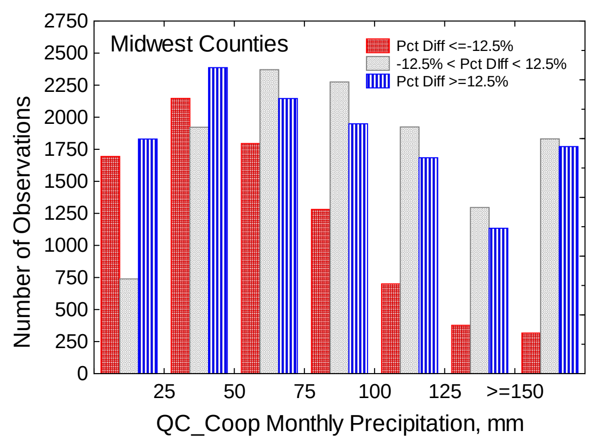
Data

Gridded Multi-sensor Precipitation Estimates

Gridded daily (0600 - 0600 CST) MPE precipitation estimates for this Midwestern study region are a composite of NWS WSR-88D 10-cm radars adjusted with Hydrometeorological Automated Data System (HADS) hourly rain gage observations. This study is based on data computed with the Stage III/IV MPE algorithm (Seo and Breidenbach, 2002) that was implemented in February 2002. These estimates are based on reflectivity values from the lowest available beam elevation at each radar pixel (Seo and Breidenbach, 2002). It is assumed that the mean bias in the radar data has been removed (Fulton et al., 1998; Seo and Breidenbach, 2002). The adjustment by HADS gages to the radar data is performed after the hourly data are mosaicked (Young and Brunsell, 2008). During 2003, the elimination of a truncation error which particularly affected estimates of stratiform precipitation further improved the State III/IV algorithm (Fulton et al., 2003).

The HADS gages used to adjust the radar grids are typically tipping bucket gages operated by various agencies, including the United States Army Corps of Engineers, the U.S. Geological Survey, the Bureau of Land Management, and NWS.

Figure 1. Monthly county-averged QC_Coop precipitation grouped by percent difference in MPE and QC_Coop estimates for the Midwestern United States for February 2002 – August 2005.



Gage Data

As is typical in most radar or MPE evaluation studies, gage data were used as the reference standard for comparison with the MPE precipitation amounts. For monthly analysis over large areas, quality-controlled NWS cooperative raingage (QC_Coop) data are ideal (Young and Brunsell, 2008; Westcott, 2009). Gages employed in the NWS cooperative network are mainly standard 8-inch (20-cm) daily non-recording gages, and generally are not used in computation of MPE. Independent dense quality-controlled rain gage networks in Illinois were used for daily comparisons by Westcott et al. (2008; weighing bucket gages), and for hourly and event comparisons Habib, et al. (2009) in Louisiana (paired tipping bucket gages). Although gage data are not without inaccuracies due to wind-dependent under catch, site exposure, and observer errors, these errors are expected to be smaller than radar errors, are generally in one direction (low), and smaller than for gage data not subjected to rigorous quality control.

Results and Discussion

Latitudinal and seasonal differences

During warm months, precipitation is dominated of course by convective activity with large precipitation amounts and large precipitation gradients. During the cold season, precipitation in the Midwest is shallower, often non-convective or stratiform in nature and associated with low pressure systems and fronts. For the Midwest (Figure 2) monthly county-averaged precipitation were examined to determine if the overall bias or relative bias per precipitation amount was affected by season or latitude by Westcott (2009). Table 1 shows that by season, the median percent differences between county-averaged monthly QC_Coop and MPE values were similar. The seasonal differences are smaller than those reported by Young and Brunsell (2008) for the Missouri Basin region. This is likely because these data are spatially averaged, whereas Young and Burnsell (2008) examined gage and grid cell pairs. Also, a portion of their region included mountainous terrain which could impact both gage and radar precipitation observations.

Westcott (2009) found for all seasons and latitude zones, except for the northern zone in the winter, that the MPE values were greater than QC_Coop values for low precipitation amounts. For all seasons and latitude zones, MPE values were lower than the QC_Coop values at higher precipitation amounts. For northern latitudes (>44ºN) in the winter, MPE values were generally lower than the QC_Coop gage values for all precipitation amounts, both large and small.

Figure 2. Northern (44-49°N), central (40-44°N), and southern (36-40°N) regions defined by latitude of county centroids. WSR-88D radars are indicated by shadowed triangles. Counties are indicated by thin black lines.

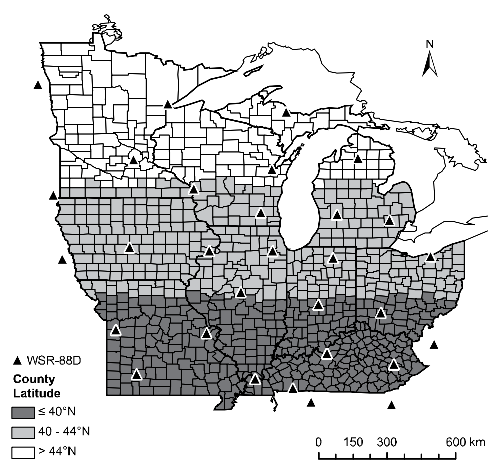


Table 1. Median Percent Difference between county-averaged monthly QC_Coop and MPE values for the midwestern United States by season and latitude for the February 2002-October 2006.

	Nov-Feb	Mar-Apr	May-Aug	Sep-Oct	Total	Sample
>44ºN	28	13	7	12	14	7837
40-44ºN	4	0	6	9	5	18377
36-40ºN	1	1	3	7	3	18100
Total	5	2	5	9	5	44314

Range from Radar

Precipitation values were further examined by range from the radar for the Midwest (Westcott, 2009). It was found for the summer months and in all latitude zones that the MPE amount was lower than the QC_Coop amount when the county centroid was within 30 km of the nearest radar. The percent difference between county-averaged monthly QC_Coop versus MPE values trended towards zero with range. Further, Westcott et al. (2008) found for daily time scales for individual grid cells, that MPE amounts were much smaller than gage amounts during all seasons of the year at ranges close (< 20 km) to the nearest radar. This is likely caused by inadequate sampling due to ground clutter filtering or because of blockage of the radar beam at ranges close to the radar (NOAA, 1991).

The MPE algorithm does not appear to sufficiently correct near-to-radar radar values perhaps because of the absence of nearby gages or perhaps because the discrepancy is so great. At more distant ranges ground clutter filtering is not so problematic, as the radar beam is above most obstructions. Also, at more distant ranges, as the radar beam width increases in areal coverage, the properties of the hydrometeors within the storm may be better sampled or better averaged for convective precipitation.

During months characterized by shallower non-convective precipitation, as the height of the radar beam increases with distance from the radar, radar-only estimated precipitation amounts can be severely affected where the radar beam is higher than the top of the precipitation layer (e.g. Smith et al., 1996; Fulton et al., 1998; Smith, 1998; Klazura et al., 1999; and Brown, et al., 2007). The center of the lowest beam sweep (typically 0.5°), will extend above about 2 km beyond about 150 km (NOAA, 2005).

It was found that in the winter months, in the central and southern regions of the Midwest that when the county center was at ranges farther than 150 km from the radar, that the MPE values became considerably lower than the QC_Coop values (Westcott, 2009).

Ideally, the MPE algorithm should correct for low radar values, if real-time gages measure precipitation for these events. The MPE algorithm, however, apparently does not correct for the radar beam overshooting the top of the precipitation layer, nor for low values close to the radar. Counties within 30 km of a radar or further than150 km from a radar make up less than 10% of this sample and thus do not explain the overall variation of MPE bias with precipitation amount, or the low MPE amounts in the northern region.

The generally poorer results for the northern region in the winter months may be related to use of the HADS tipping bucket gages in computing the MPE estimates. Tipping bucket gages are known to underestimate frozen precipitation (e.g., Groisman et al., 1999; Kitzmiller et al, 2008), prevalent at higher latitudes. While standard non-recording gages used in the cooperative network (QC_Coop) do not measure snowfall as accurately as one would like, they generally collect more frozen precipitation than tipping bucket gages. As suggested by Young and Brunsell (2008), when one considers that QC_Coop gages may under report snowfall, the discrepancy between QC_Coop and MPE amounts could be even larger.

Precipitation estimation by Gages

For small precipitation amounts, the percent difference between gage and MPE values can be quite large. This might be expected due to differences in sampling by gage and radar, or because the percent difference between two very small amounts can be quite large, or due to data processing steps, such as data interpolation of zero and non-zero gage amounts, bias adjustment, and mosaicking procedures (Habib et al, 2009).

Westcott et al. (2008), using data from a dense gage network found that neither the number of gages employed in computing gage averages nor the areal coverage per gage affected the agreement between daily gage average and daily MPE grid cell values. Further, Westcott (2009), using QC_Coop data, found that neither the county area nor the areal coverage per gage influenced the percent difference in gage and MPE monthly county-averaged values. The number of gages available to compute monthly county-averages also had no discernable impact on the correspondence between gage and MPE estimates. Similar results were found by Habib et al. (2009). For hourly data, they found larger MPE compared to gage values for smaller gage precipitation amounts and smaller MPE than gage values for larger gage precipitation amounts. This bias pattern occurred both for gage estimates computed using four gages and also using a single gage. The correlation between gages and MPE amounts increased, and the standard deviation of the MPE-gage differences decreased, however, with the use of more gages.

Habib et al. (2009) also compared precipitation totals for rain events from gages used by the Lower Mississippi River Forecast Center (LMRFC) for the real-time MPE bias adjustment with gages from their independent dense gage network. Differences between LMRFC gages and their gages were comparable to the MPE bias. This further implies that data quality problems in the HADS gages used for the MPE bias adjustment result in low MPE estimates.

Conclusions

Qualitatively, the MPE precipitation product provides a very good description of daily precipitation over the United States. At least for the central region of the United States, the MPE algorithm appears to be most appropriate during the summer months when convective precipitation occurs, except at ranges very close to the radar. The MPE algorithm represents precipitation relatively well in all seasons for latitudes where non-frozen precipitation is common. However, use of better calibrated and quality controlled gages to adjust radar values would very likely improve MPE estimates.

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