Final Report

COMET Partner's Project

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Partners or Cooperative Project:	Partners project
Project Title:	Validating DSP precipitation product using 50 GBRA rain gauge rainfall
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Section 1: Summary of Project Objectives

South-central Texas is particularly vulnerable to flash floods. As a result, it is extremely important to have a good, quality-controlled, high spatio-temporal precipitation data as input for enhanced short-term flash flood forecasting. The WSR-88D Digital Storm-total Precipitation (DSP) product, with 2 km x 1° polar spatial resolution and 4-6 min temporal resolution, is a potential candidate for this purpose. The objective of this study is to use a high density rain gauge network (50 gauges reporting at 6-minute time intervals) on the Upper Guadalupe River Basin to validate DSP precipitation estimates. The educational aspect of this project is to train the next generation of applied scientists and operational hydrology students through collaborative research, visiting operational facilities, and attending seminars and workshops given by NWS hydrometeorologists and forecasters.

Section 2: Project Accomplishments and Findings

DSP from two radars (KEWX-Austin/San Antonio and KDFX-Laughlin AFB) during the period of 9/11/2006 to 5/3/2007 are used for the comparison with data from 50 rain gauges of the Guadalupe Blanco River Authority (GBRA) (Figure 1) at four different temporal intervals: storm total, hourly, 30-minute, and 6-minute. The storm total rainfall from the rain gauges shows high heterogeneity across the upper Guadalupe River Basin. Comparison of individual storms and the total rainfall from all storms during the study period found that distance (from the radar to gauge locations) is an important factor for radar rainfall estimation. Generally, radar rainfall estimates are better when the rain gauge to the radar is closer. Figure 2 shows that KEWX has better agreement with rain gauge totals than KDFX for the same set of rain gauges (although at different distances from each radar). KDFX dramatically underestimates rainfall (compared to the gauge totals) when the distance is larger than 200 km, moderately underestimates from 150-200 km, and overestimates from 100-150 km. Meanwhile, KEWX overestimates when the distance is from 100-170 km, slightly overestimates from 50-100 km, and moderately underestimates at less than 30 km. Storm total rainfall from rain gauges in Kendall County, at roughly the same distance from both radars (100-150 km), show KEWX and KDFX estimates are fairly close to the gauge values.

The farther distance from KDFX to most rain gauges than from KEWX to the same gauges leads to lower radar rainfall estimates for KDFX over Kendall, Comal, and Guadalupe Counties than from KEWX. Thus, the study confirms that distance is a major factor affecting radar rainfall estimation. Figure 2 also shows the elevation of each rain gauge, and the slope from the Coastal Plains in Guadalupe and eastern Comal Counties, to Texas Hill Country in Kerr County. Storms tend to become anchored, stall, or train over the Balcones Escarpment in western Comal and eastern Kendall Counties, producing flash floods. Despite the higher elevations of the Kerr County, some rain gauges recorded less total rainfall than gauges in Kendall and Comal Counties. Figure 3 shows the scatter plots of gauge and radar pairs for both radars during the study period. The KEWX (R^2=0.59) has better correlation with gauges than KDFX (R^2=0.37) does. Detail statistics for the hourly, half hourly, and 6-minutes will be included in the manuscript to be submitted for peer-reviewed publication (Wang et al. 2008a).

At the storm total scale, it is found that both radar and rain gauge have high probability of rain detection (POD, representing the probability that radar or rain gauge individually detected rainfalls, compared to the number of rainfalls that either the radar or gauge detected). The overall POD for KEWX is 8% better than the POD for KDFX (Table 1). The table also indicates radar has slightly higher POD (91% and 83%) than gauges (83% and 81%), which is a very reasonable since the radar samples a large area, while rain gauges sample the immediate area around points. However, at the hourly, 30-minute, and 6-minute intervals, rain gauges have much higher POD than radars (Tables 2-4). This is in contrast with common sense that radar should detect rainfall more often than rain gauges due to the greater sampling area. This capability of radar rainfall detection has also been identified in the new hourly radar MPE product (Wang et al. 2008b, partly supported by this Partners Project). One consideration the low PODs is that only cases with at least one rain gauge recording a storm-total rainfall of 0.25 inches were included. This does not preclude other (in some cases, most) stations having smaller storm-total rainfall during the same event, but the use of the criterion does bias the dataset away from (uniform or isolated) light precipitation events with no station reporting at least 0.25 inches. The criterion was selected since the primary concern is significant rainfall, defined here as at least one rain gauge with a storm total of 0.25 inches or greater. Further study is needed to focus on how large (amount) an event must be for the DSP produce a have a high POD.

The POD for KEWX and KDFX radars are 41% and 43% for 6-minute intervals, 55% and 49% for 30-minute intervals, and 53% and 50% for the hourly intervals, respectively. This indicates a ~10% increase from the 6-minute to the 30-minute or hourly intervals in POD, and that there is no distinct difference in POD between the radars.

Overall, we finished all the proposed tasks. Besides the analysis of KEWX and rain gauge data, we added KDFX. This took us extra time and effort, but the addition of a second radar enabled us to more thoroughly analyze the effect of radar range on rainfall estimates, and to compare the differences between the two radars and individual gauge observations. A manuscript is in preparation for submitting for peer-reviewed publication (Wang et al. 2008a).

References

Wang, X., N. Mazari, H. Xie, J. Zeitler, H. Sharif, 2008a: Validating the DSP rainfall product using 50 rain guages (*to be submitted).*

Wang, X., H. Xie, H. Sharif, and J. Zeitler, 2008b: Validating NEXRAD MPE and Stage III precipitation products for uniform rainfall on the Upper Guadalupe River Basin of the Texas Hill Country. *J. Hydrol.* **348(1-2)**: 73-86, doi: 10.1016/j.jhydrol.2007.09.057.

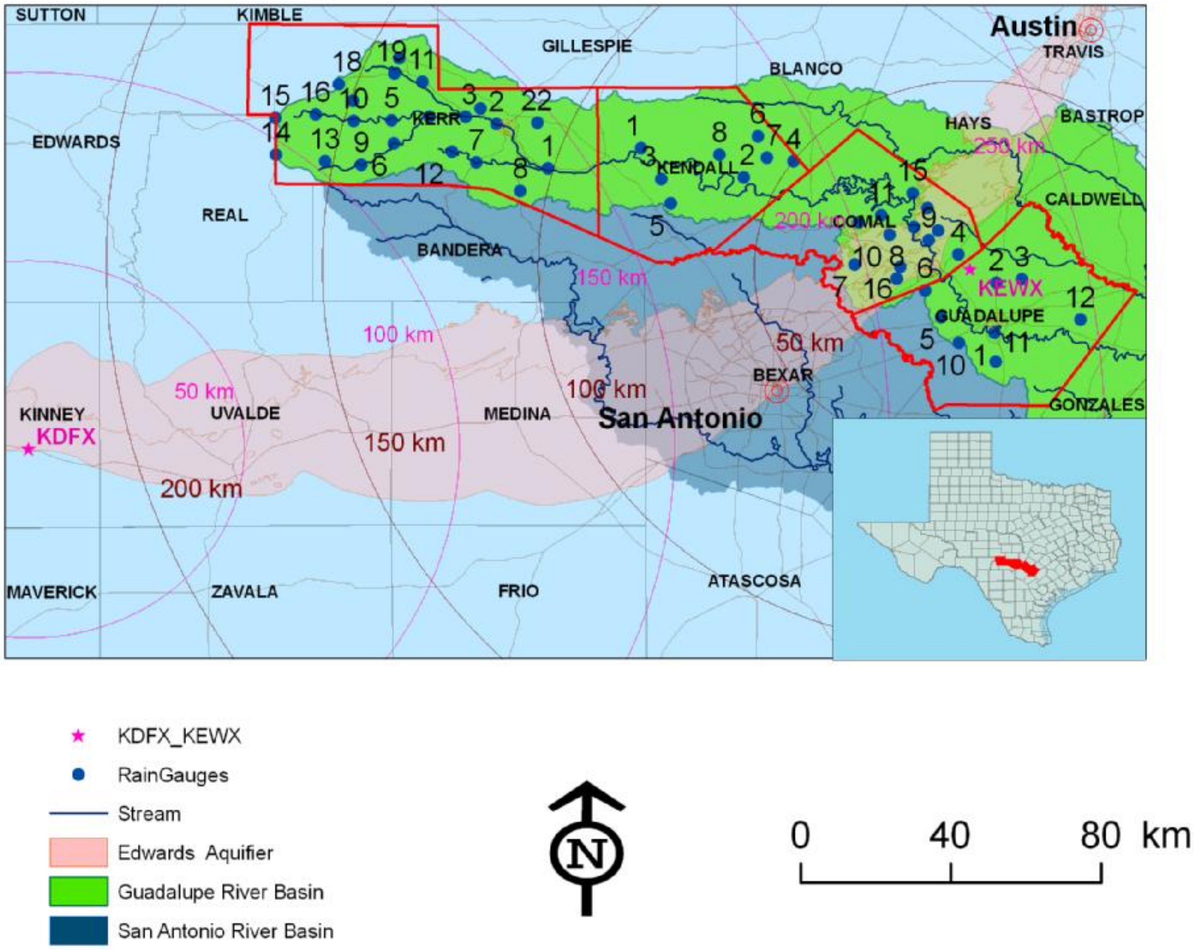

Figure 1. GBRA 50 rain gauge network (blue dots and numbers) on the Upper Guadalupe River Basin, KEWX radar range circles (50, 100, 150, 200 km in brown), and KDFX range circles (50, 100, 150, 200, and 250 km in magenta). Rain gauge locations from west to east are in Kerr, Kendall, Comal, and Guadalupe counties. Distances from KEWX to rainguages in Kerr County range from 100-170 km, to gauges in Kendall county from 50-100 km, and to gauges in Comal and Gudalupe counties less than 30 km away. Distances from KDFX to rain gauges in the Kerr County range from 100-150 km, to gauges in Kendall County from 150-200 km, and to gauges in Comal and Gudalupe counties from 200-250 km.

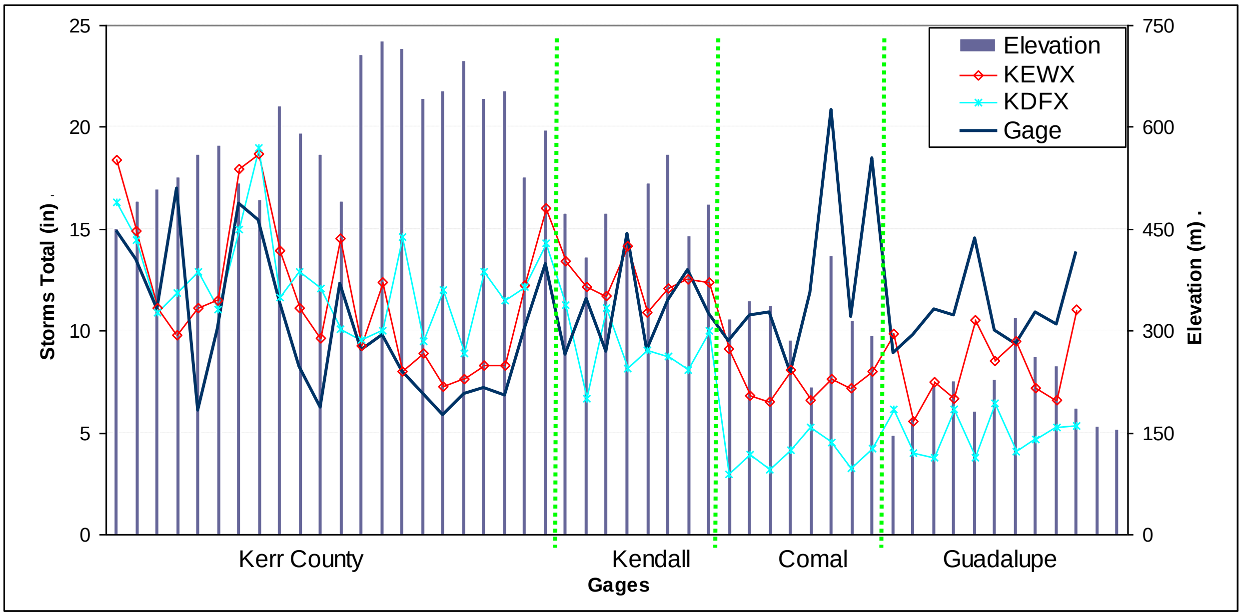

Figure 2. Total precipitation of studied storms from September 11, 2006 to May 3, 2007 for the collocated gauges and two radars, and the elevation of each rain gauge.

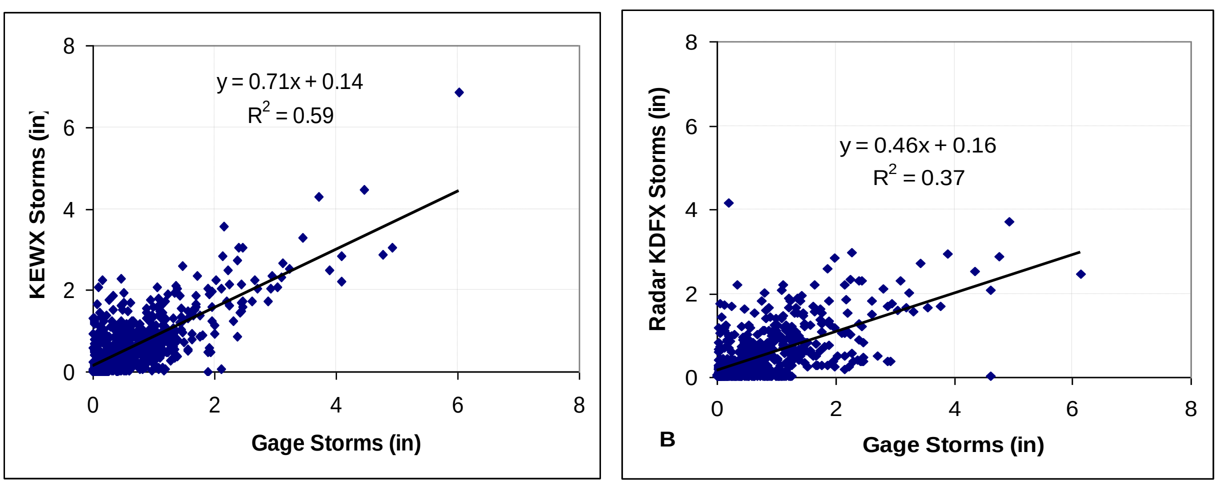

Figure 3. Scatter plots of storm total rainfall for paired rain gauges and KEWX (left) and KDFX (right) radar cells.

Table 1. Storm total rainfall comparison of two radars and gauges at four Counties

Storms Comparison	All Counties		Kerr		Kendall		Comal		Guadalupe	
	KEWX	KDFX	KEWX	KDFX	KEWX	KDFX	KEWX	KDFX	KEWX	KDFX
Gage Storm Count	851	856	392	383	158	162	152	138	149	173
Radar Storm Count	931	872	424	413	166	148	160	135	181	176
Storm Pairs	756	672	333	301	145	120	139	104	139	147
Gauge POD	83%	81%	81%	77%	88%	85%	88%	82%	78%	86%
Radar POD	91%	83%	88%	83%	93%	78%	92%	80%	95%	87%

Table 2. Hourly rainfall comparison of two radars and gauges at four Counties

Hourly Comparison	All Counties		Kerr		Kendall		Comal		Guadalupe	
	KEWX	KDFX	KEWX	KDFX	KEWX	KDFX	KEWX	KDFX	KEWX	KDFX
Gage_hourly_count	4414	4325	1475	1659	1346	1221	758	700	835	745
Radar_hourly_count	2981	2723	1275	1494	566	471	471	369	669	389
Hourly_pairs	1818	1610	698	832	408	347	313	227	399	204
Gage POD	79%	80%	72%	71%	89%	91%	83%	83%	76%	80%
Radar POD	53%	50%	62%	64%	38%	35%	51%	44%	61%	42%

Table 3. 30-minute rainfall comparison of two radars and rain gauges at four counties

30 Minutes Comparison	All Counties		Kerr		Kendall		Comal		Guadalupe	
	KEWX	KDFX	KEWX	KDFX	KEWX	KDFX	KEWX	KDFX	KEWX	KDFX
Gage_30min_count	5893	6065	2157	2610	1226	1234	1170	1081	1340	1140
Radar_30min_count	4103	3802	1776	2073	801	674	622	481	904	574
30min_pairs	2485	2141	969	1113	528	469	403	285	585	274
Gage POD	78%	79%	73%	73%	82%	86%	84%	85%	81%	79%
Radar POD	55%	49%	60%	58%	53%	47%	45%	38%	54%	40%

Table 4. 6-minute rainfall comparison of two radars and rain gauges at four counties

6-Minute Comparison	All Counties		Kerr		Kendall		Comal		Guadalupe	
	KEWX	KDFX	KEWX	KDFX	KEWX	KDFX	KEWX	KDFX	KEWX	KDFX
Gage 6min_count	21807	11307	7435	4663	5038	2528	4231	1985	5103	2131
Radar 6min_count	10904	6345	4745	3606	2387	1204	1544	752	2228	783
6min_pairs	6078	2910	2139	1507	1535	780	1002	346	1402	277
Gage POD	81%	77%	74%	69%	86%	86%	85%	83%	85%	81%
Radar POD	41%	43%	47%	53%	41%	41%	31%	31%	37%	30%

Section 3: Benefits and Lessons Learned: Operational Partner Perspective

Benefits to the NWS have been three-fold. First, we became aware of the DSP product through Dr. Xie. We changed our radar product list to produce the DSP for KEWX and KDFX, and to make the DSP the default storm-total precipitation product, which greatly increased the spatial and temporal accuracy for our rainfall estimates, and hence flash flood and river flood warnings. Second, a Meteorologist Intern (Mr. Bob Fogarty) was trained to archive, store, and process the DSP files in the Weather Event Simulator (WES). This provided a critical backup to Mr. Zeitler for archiving, storing, and developing WES scenarios for training forecasters and conducting other applied research. Third, this collaboration provided the base for future radar/rain gauge research, such as studying the benefits of dual-polarization, which will be installed on the KEWX/KDFX radars in 2010-2011, and integrated rainfall estimation, short-term forecasting, and hydrologic modeling for forecasting flash flood inundation.

Section 4: Benefits and Lessons Learned: University Partner Perspective

Through this Partner's Project, two graduate students Xianwei Wang (Ph.D. student) and Newfel Mazari (Masters student) have been partly supported. Another two hourly students helped with data processing. One manuscript has been published (Wang et al. 2008) and two presentations were given (Wang et al. 2007 and Mazazi et al. 2007). A second manuscript will be submitted for journal publication. Xie and students have visited the Austin/San Antonio NWS office three times duing the project period to discuss research and give presentations. Students toured the office and received firsthand knowledge on the operational use of radar data, including familiarization on procedures for radar rainfall monitoring and processing.

Mr. Zeitler gave a guest lecture (on November 4, 2006) entitled: *Estimating precipitation from radar* for my remote sensing class (15 graduate students). Students loved Mr. Zeitler's lecture materials, operational experiences, and broad knowledge of advantages and disadvantages of radar precipitation.

Drought was a problem throughout the first half of the study period (Fall 2006 through Spring 2007), greatly limiting the number of cases. A no-cost extension was requested and approved, allowing for the additional archival of many cases during the record seasonal rainfall and widespread flooding in Summer of 2007. We developed techniques to manipulate the archived data (MPE, Stage III and rain gauge data) during the dry period.

Section 5: Publications and Presentations

One presentation at the AMS Annual Meeting in 2007, one presentation at the AGU Fall Meeting in 2007, and one paper published in the *Journal of Hydrology*. A second paper is in preparation for journal submission. Two graduate theses were partly supported by this project.

Mazari, N., H. Xie, H., Sharif, and J. Zeitler, 2007: NEXRAD reflectivity derived rainfall estimates comparison with measurement from collocated rain gauges. AGU Fall meeting, San Francisco, CA, Amer. Geoph. Uni., H23K-07 [Available online at: http://www.agu.org/cgi-bin/SFgate/SFgate?&listenv=table&multiple=1&range=1&directget=1&application=fm07&database=/data/epubs/wais/indexes/fm07/fm07&maxhits=200&="H23K-07"]

Mazari, N., 2008: Validation of radar reflectivity and DSP product by using a network of rain gauges. *M.S. Thesis: University of Texas at San Antonio.*

Wang, X., H. Xie, and H. Sharif, 2007: The impact of local and global climate variation/change on extreme weather events in the South Central Texas. 87th Annual Meeting, San Antonio, TX, Amer. Meteor. Soc., [Available online at: http://ams.confex.com/ams/87ANNUAL/techprogram/paper_120714.htm]

Wang, X., H. Xie, H. Sharif, and J. Zeitler, 2008: Validating NEXRAD MPE and Stage III precipitation products for uniform rainfall on the Upper Guadalupe River Basin of the Texas Hill Country. *J. Hydrol.* Vol. 348(1-2): 73-86, doi: 10.1016/j.jhydrol.2007.09.057.

Wang, X., N. Mazari, H. Xie, J. Zeitler, H. Sharif, 2008: Validating the DSP rainfall product using 50 rain guages (*to be submitted).*

Wang, X., 2008: Applications of remote sensing and GIS in surface hydrology: snow cover, soil moisture, and precipitation. *PhD. Thesis: University of Texas at San Antonio.*

Section 6: Summary of University/Operational Partner Interactions and Roles

Mr. Jon Zeitler and Mr. Bob Fogarty of NWS Austin/San Antonio made a significant effort to archive the DSP data for the project. The data for two radars (KEWX and KDFX) were archived from 9/11/2006 to 5/3/2007 and delivered to UTSA for analysis. A second dataset from 5/4/2007 to 12/31/2007 was also delivered to UTSA, though this has not been used in this report, since we have not received rain gauge data from the GBRA. We will process the data when the rain gauge data are available.

Dr. Hongjie Xie advised two graduate students on data processing: retrieval from DSP, processing rain gauge values, quality control, and script development for comparison analysis.

Dr. Xie, Mr. Zeitler, and the students worked on data analysis and interpretation, and manuscript preparation. We held three meetings at the NWS Austin/San Antonio Forecast Office, one lecture was given by Mr. Zeitler to Dr. Xie's remote sensing class, and ad hoc discussions about the project occurred at other local meetings.