Final Report

COMET Partner's Project

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National Weather Service Office:	Austin/San Antonio, TX
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Partners or Cooperative Project:	Partners project
Project Title:	Better understanding of NEXRAD Level II reflectivity using a network of four double-gauge platforms in a single radar cell.
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1. Summary of Project and Objectives

The purpose of this study was to improve our understanding of NEXRAD (Next Generation Radar) Level II reflectivity for the estimation of precipitation quantity and spatial distribution, by using high accuracy rain gauge measurements within a single radar cell, i.e., a network of four double-gauge platforms in one single radar cell of ~ 1 km^2. A network of four double-gauge platforms within one radar cell was installed in the Government Canyon State Park near San Antonio, Texas, in August 2007 (Figure 1). The research aspects of this project included monthly on-site visits for data collection and equipment maintenance, once every three months visits for recalibration of the rain gages, batch processing the NEXRAD Level II reflectivity data, extracting the reflectivity values for the cell where the gauges are located, batch processing the gauge measurements, generating the areal rainfall for the radar cell based on different methods, and correlation analysis between the radar data and gauge rainfall. The educational aspects of this project were 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.

2. Project Accomplishments and Findings

During the project lifetime, we collected data for 21 periods; two months (December 2007 and November 2008) had no rainfall recorded. In June and July 2008, some rain events were missed because of hardware recalibration. Table 1 shows the rainfall amount for each of 19 effective collection periods. Despite the gages being in good working condition, this project was conducted during a near-record drought. Based on 2008 data (January to December), the average total rainfall amount was 19.8 inches, well below the 30-year normal of 32.92 inches at the San Antonio International Airport KSAT (~20 miles to the northeast). The 19.8 inches is only ~60 % of the 1971-2000 30-year normal annual mean precipitation. The total rainfall for the hydrologic year 2007-2008 (Sep-Oct) was 28.16 inches, and only 16.02 inches for 2008-2009 to the end of September 2009. This suggests the 2008-2009 Hydrologic Year will be even dryer than the 2007-2008 Hydrologic Year. This demonstrates the severity of the drought that San Antonio and South Texas have been enduring.

Figure 2 shows the monthly rainfall recorded during the two years period at Government Canyon compared with both the 30-year monthly mean precipitation of San Antonio and the San Antonio International Airport. Overall, the recorded rainfall during the project cycle is below the 30-year average monthly rainfall, with the exceptions of: August 2007, with 8.84 inches of rainfall (vs. a 30-year mean of 2.57 inches); September 2007 with 4.92 inches (vs. a 30-year mean of 3.00 inches); and both March 2008 (2.63 inches) and March 2009 (3.23 inches) (vs. a 30-year mean of 1.89 inches). We note June 2008 had very little rainfall because the rain gauges were temporarily remove for recalibration. We also find from the Government Canyon data that December 2007 had no rainfall (30-year average for December is 1.96 in.), and November 2008 had no rainfall (30-year average is 2.58 inches). From the two years of data, we found a pattern change, i.e. for the 30-year average, the wettest months are May, June, and October (4.72 inches, 4.30 inches, and 3.86 inches respectively), while at Government Canyon, the wettest months are August (6.36 inches), March (2.88 inches), and May (2.75 inches). Comparing measurements, we found the Government Canyon gages (along the elevated Balcones Escarpment) had higher

rainfall than at San Antonio International Airport (~20 miles away at lower elevation), except for August 2008 and February, April, and June 2009, when the San Antonio International Airport gage recorded higher accumulations.

VBA and Python computer scripts were developed to batch process and extract reflectivity values from the 5- to 6-minute NEXRAD Level II reflectivity data for periods corresponding to rainfall detected by the rain gages. A reflectivity (Z) to rainfall rate (R) Z-R relationship of $\boldsymbol{Z = 300\ R^{1.4}}$ was applied to convert the reflectivity to rainfall (inches hr^{-1}). Correlation coefficients between the radar rainfall estimate (single cell) and gage rainfall (6-minute intervals) were calculated, along with time shifted interval amounts (1-6 minutes) to represent possible errors between radar and gages due to radar processing procedures and to allow rain detected at altitude to fall to the gages. A shift of three minutes was found to have the best correlation (r = 0.75, Figure 3).

Based on the reflectivity and corresponding gauge rainfall, we also derived a Z-R relation of $Z = 250\ R^{1.21}$ for our region, which is nearly identical to the alternate "tropical" NEXRAD Z-R relation of $Z = 250\ R^{1.2}$. Applying the new Z-R relation to Level II data, we derived new radar rainfall values and compared them with the gauge measurements (Figure 4). A similar correlation coefficient (r = 0.75) is achieved. Further data analyses are still in progress for 30-minute and hourly accumulation comparisons between radar and gages.

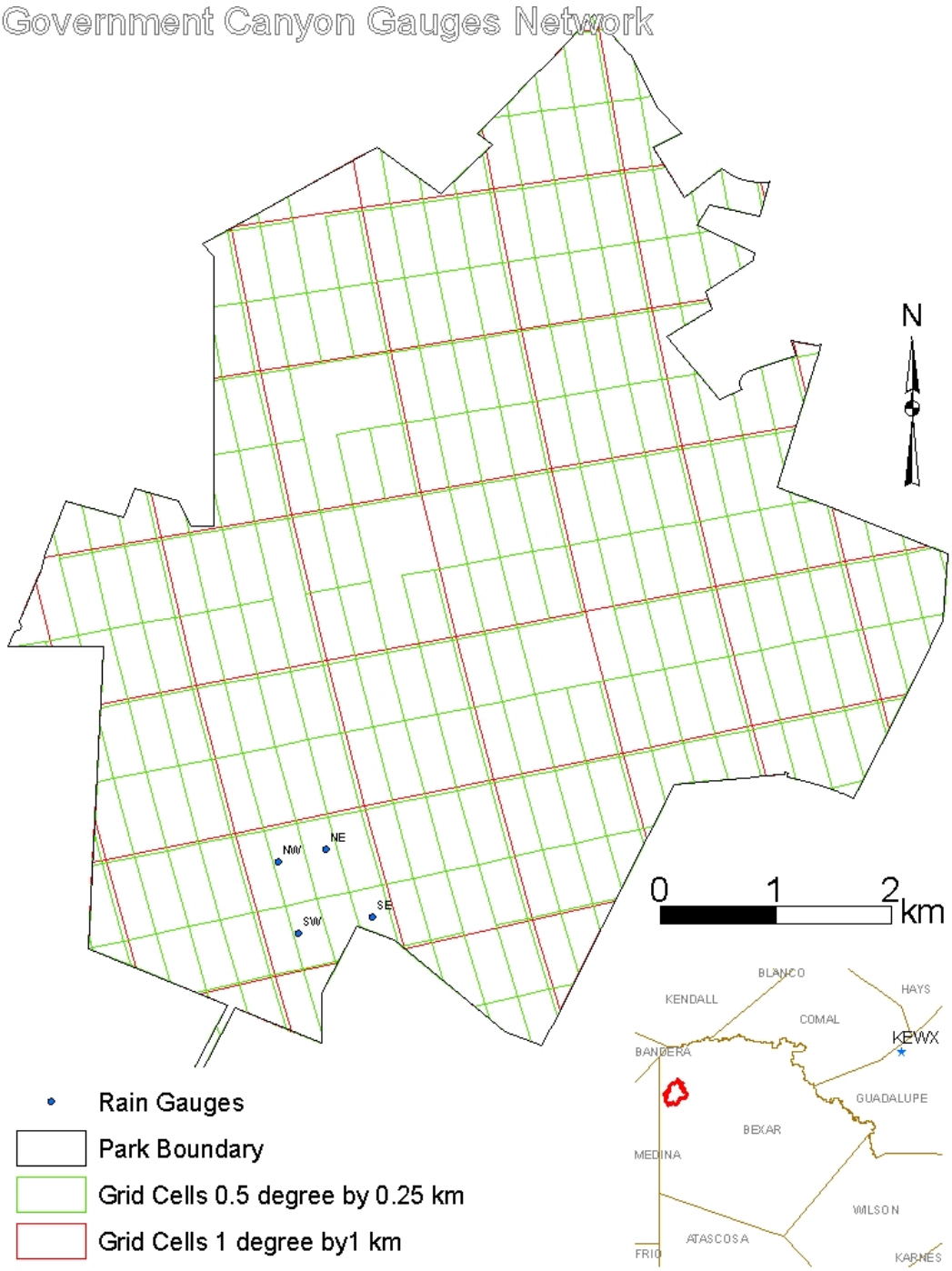

Figure 1: Location of Government Canyon State Park and the rain gage network. The red rectangles correspond to the NEXRAD grids for the Level II reflectivity product with a resolution of 1 km by 1^0. The green grids cells correspond to the "Super Resolution" grid (0.25 km by 0.5^0), which started on July 10, 2008 for the KEWX radar. The inset shows the location of the KEWX radar, Bexar County boundary, and Government Canyon (red polygon).

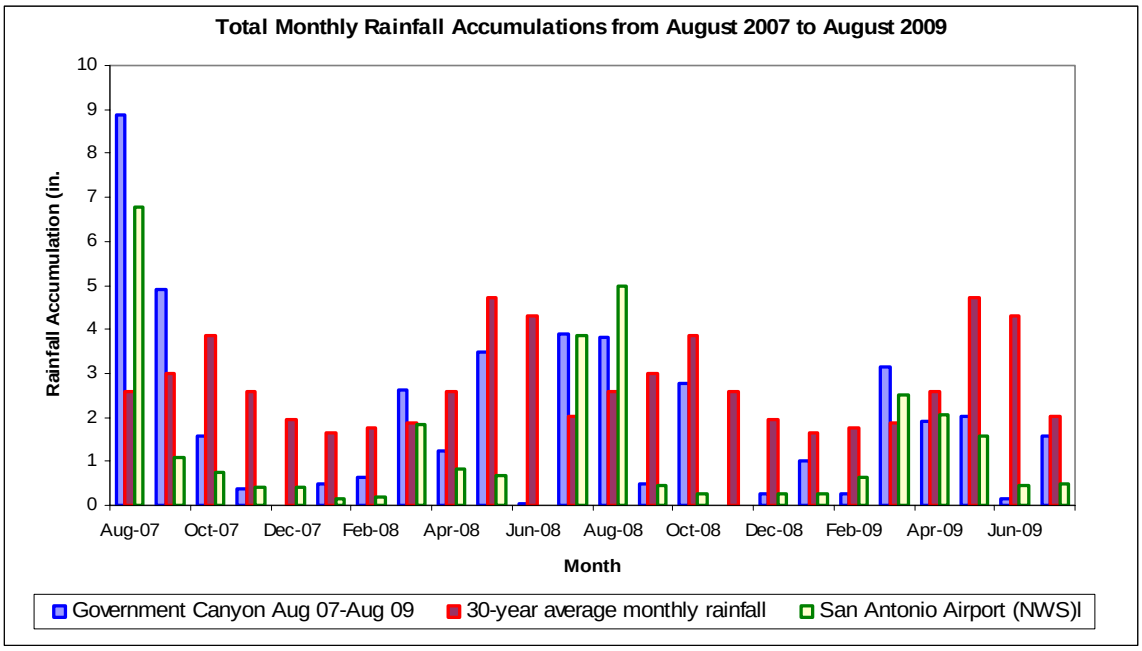

Figure 2. Monthly average rainfall collected at Government Canyon from August 2007 to August 2009, 30-year monthly average for the city of San Antonio, Texas (from http://www.rssweather.com/climate/Texas/San%20Antonio/), and the rainfall at San Antonio International Airport (from http://www.srh.noaa.gov/ewx).

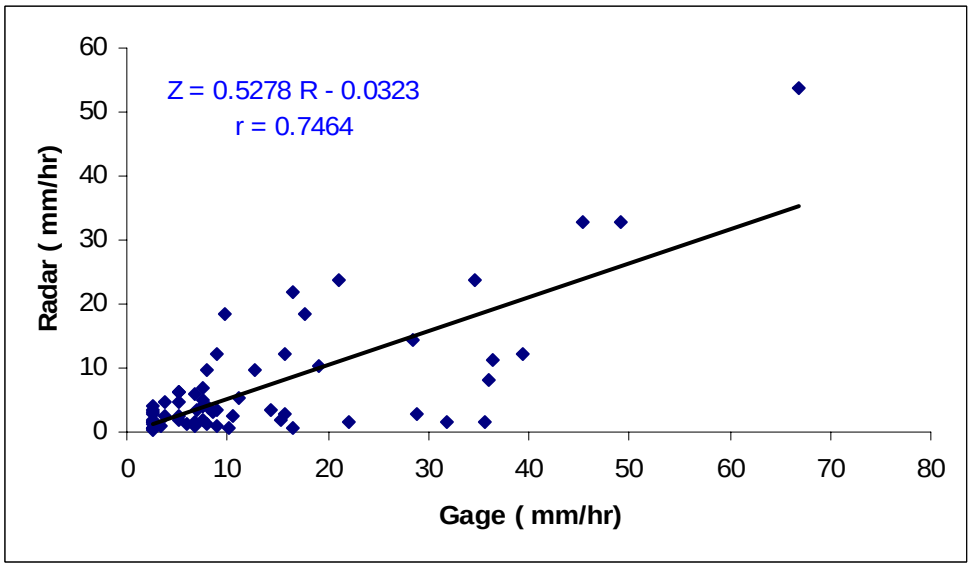

Figure 3. Correlation between 6-minute gage measurements and radar measurements (using the $Z = 300\ R^{1.4}$) with a three minute time shift.

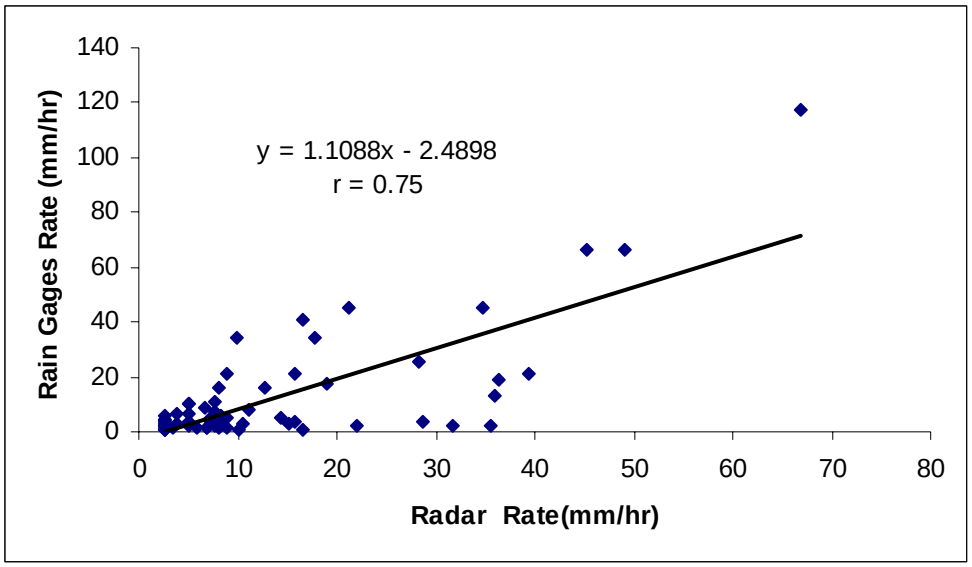

Figure 4. Correlation between 6-minute gage measurements and radar measurements (using the new derived $Z = 250\ R^{1.21}$ relation) with a three minute time-shift.

Table 1: Rainfall amount (inches) for each collection period. NE, NW, SE, SW, denote the northeast, northwest, southeast, southwest rain gauge platforms respectively. Values for each platform are the averaged rainfall of the two co-located rain gages. Blank means no data were collected due to calibration, maintenance, or other reasons.

Rainfall period	NE	SE	NW	SW	Simple mean
Aug 15-Sept 5, 07	11.5		11.3	11.0	11.3
Sep 11-Oct 11, 07	1.6	1.3		1.3	1.4
Oct 20- 23, 07	0.6	2.0	0.9	1.9	1.4
Nov 22- 25, 07	0.1		0.0	0.3	0.2
Jan 8-Feb 16, 08	0.5	0.6	0.2	0.4	0.4
Mar 3- 10, 08	1.4	1.2	1.4	1.3	1.3
Mar 18-Apr 18, 08	1.3	1.2	1.5		1.3
May 5-Jun 6, 08		2.0	1.9		2.0
Jul 7- 9, 08		3.1	3.0	2.9	3.0
Jul 23- 25, 08	2.8	2.9	3.0	2.9	2.9
Aug 5- 25, 08	3.4	3.4	3.6	3.3	3.4
Sep 13-Oct 15, 08		1.8	1.7	0.4	1.3
Dec 15, 08-Jan 6, 09	0.6	0.5	0.5	0.6	0.6
Jan 27-Feb 17, 09	0.1	0.2	0.2	0.1	0.2
Mar 11-31, 09	2.8	2.8	2.8	2.5	2.7
Apr 12-28, 09	1.5	1.6	1.5		1.5
May 16-26, 09	1.9	1.7	2.3	1.6	1.9
Jun 25-Jul 7, 09	0.4	0.3	0.2	0.1	0.3
July 18- August 12, 09	1.8	1.9	1.7	1.8	1.8

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, Forecaster 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 gage research, such as studying the benefits of dual-polarization, which will be installed on the KEWX/KDFX radars in 2012, 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, one graduate (Ph.D.) student, Mr. Newfel Mazari, was partially supported. He will present progress on this project at the 34th AMS Conference on Radar Meteorology. This project will be part of his dissertation and he is still processing and analyzing the data. Mr. Mazari co-organized UTSA's involvement in the San Antonio GIS day (November 21, 2008) and presented his precipitation study and other work in Dr. Xie's group. Undergraduate student Ms. Ann Ji, was involved in the data collection and gage maintenance during summer 2008. Through participation in the project, Ms. Ji learned how to analyze the rainfall data and study the spatial variability of the rainfall within the radar cell. She presented her results in the Earth and Environmental Science Department's annual student colloquium on January 30, 2009, and won second place in the undergraduate category for outstanding research. In summer 2009, we hosted a high school intern, Ms. Liz Perry, to learn rainfall mapping techniques. We trained Ms. Perry and another graduate student to collect and process rainfall gage data, to download NEXRAD data from NCDC using the NEXRAD Java tool, and to make simple comparisons and understand the spatial and temporal patterns of rainfall. Dr. Xie participated in the South Central Texas AMS/NWA Chapter meeting at the NWS office on November 8, 2008. In addition, we also submitted a paper from our last COMET project on related work to the *Journal of Hydrology*, and it is in revision now.

Mr. Zeitler gave a well-regarded lecture in Dr. Xie's *Remote Sensing in Hydrology* graduate course on January 19, 2009. A similar lecture the previous time the course was offered was also a great success. The students enjoyed the lecture on radar theory, operations and data processing, and especially the coming deployment of dual-polarization capability.

Section 5: Publications and Presentations

One paper was submitted for peer reviewer. One presentation was given by Ms. Ann Ji in the Department's student colloquium. One conference presentation will be given by Mr. Newfel Mazari to the AMS radar conference.

Wang, X., N. Mazari, H. Xie, J. Zeitler, H. Sharif, and W. Hammond. Validation and comparison of NEXRAD DSP and MPE products over the Upper Guadalupe River Basin, Texas. J. of Hydrology (in revision).

Ji, Ann, A preliminary study of rainfall measurements based on four double-gauge platforms at the Government Canyon State Park, Texas. Presented at the Department's student colloquium on January 30, 2009, receiving a second place award. (Advisor: Dr. Hongjie Xie).

Mazari, N., H. Xie, X. Wang, J.W. Zeitler, and H. Sharif, 2009. Validation of the NEXRAD DSP product with a high accuracy rain gauge network. 34th Conference on Radar Meteorology, Williamsburg, VA, October 5-9, 2009.

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

Mr. Jon Zeitler and Mr. Bob Fogarty of WFO 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 present and delivered to UTSA for analysis. Mr. Zeitler also advised about radar operations and data processing, and he gave two lectures to Dr. Xie's graduate courses on remote sensing in hydrology.

Dr. Hongjie Xie advised one graduate student on data collection from the rain gauge network and processing, data processing for the NEXRAD Level II reflectivity data, and data analysis. Dr. Xie also advised one undergraduate student who did a project on the gauge data analysis, and a high school intern who learned how to map rainfall.

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