2. Evaluation of Sterling, Virginia WSR-88D (KLWX) Rainfall Estimates Post-Calibration - Final Wrap-up

2.1 Introduction

During the period February 14-17, 2000 a team from the WSR-88D Operational Support Facility (OSF) visited the Sterling, Virginia WSR-88D radar site (KLWX) to perform newly developed and enhanced calibration procedures to improve the radar measurements of reflectivity and resulting derived products such as rainfall and VIL. This effort was motivated in part by the recent poor performance of the KLWX rainfall products relative to rain gauges for the Hurricane Floyd heavy rain event of 14-17 September 1999 where significant radar rainfall underestimation was typical (NWS 2000). This section describes the quantitative validation effort performed by the Hydrology Laboratory (HL) in cooperation with the OSF Applications Branch (Tim O'Bannon), Sterling Weather Forecast Office (SOO Steve Zubrick), and Eastern Region Scientific Services Division (Julie Gaddy) to compare radar rainfall estimates from the WSR-88D Precipitation Processing System (PPS) rainfall algorithm with corresponding rain gauge data to evaluate the integrity of the reflectivity measurements after the new calibration procedures were performed at LWX.

This chapter represents the final wrap-up of results found since June 2000 as reported in last year's MOU Final Report (Seo et al., 2000). Please see this on-line document for a thorough description of the analysis procedures, which have remained unchanged, and previous results as they will not be repeated here.

2.2 Individual Event Results

The results for each of the 27 rainfall events analyzed this year is presented in this section with figures and tables specific to each case. The event dates are listed in Table 1 along with the Z-R relationship in use on the WDSS computer at the Sterling WFO at the time of the event.

Table 1. List of the ending dates of the 27 analyzed rain events.

7/20/00	$Z=300 R^{1.4}$
8/15/00	$Z=300 R^{1.4}$
8/19/00	$Z=300 R^{1.4}$
8/23/00	$Z=200 R^{1.6}$
8/24/00	$Z=300 R^{1.4}$
8/28/00	$Z=300 R^{1.4}$
9/4/00	$Z=300 R^{1.4}$
9/5/00	$Z=300 R^{1.4}$
9/12/00	$Z=300 R^{1.4}$
9/13/00	$Z=300 R^{1.4}$
9/15/00	$Z=300 R^{1.4}$
9/20/00	$Z=200 R^{1.6}$
9/26/00	$Z=300 R^{1.4}$

11/10/00	$Z=300\ R^{1.4}$
12/14/00	$Z=130\ R^{2.0}$
1/30/01	$Z=130\ R^{2.0}$
2/6/01	$Z=130\ R^{2.0}$
2/17/01	$Z=130\ R^{2.0}$
3/5/01	$Z=130\ R^{2.0}$
3/22/01	$Z=130\ R^{2.0}$
3/30/01	$Z=130\ R^{2.0}$
4/9/01	$Z=130\ R^{2.0}$
4/10/01	$Z=130\ R^{2.0}$
4/12/01	$Z=130\ R^{2.0}$
4/16/01	$Z=130\ R^{2.0}$
6/17/01	$Z=300\ R^{1.4}$, $Z=250\ R^{1.2}$
6/23/01	$Z=300\ R^{1.4}$

Table 2 summarizes various information for each event such as the gauge-radar ratio, rain type, number of gauge-radar pairs, etc. Fig. 1a-z show the plots for each event.

Table 2. List of rainfall events along with the dominant rain type (S stratiform or C convective), mean freezing level (FZL) height, number of gauge-radar pairs, G/R ratio and correlation coefficient for the three cases of a) all pairs and b) QC'ed pairs.

Case No.	End Date	Rain Type	FZL ht (km)	No. pairs	G/R (all)	Corr (all)	No. QC pairs	G/R (QC)	Corr (QC)
1	7/20/00	C	3.5	220	1.32	0.10	57	1.29	0.48
2	8/15/00	C	3.1	139	1.52	0.50	34	1.44	0.73
3	8/19/00	C	4.2	240	1.09	0.46	80	0.80	0.91
4	8/23/00	C	4.4	212	1.17	0.39	81	0.70	0.77
5	8/24/00	C	3.8	212	1.32	0.72	60	0.84	0.86
6	8/28/00	C	3.8	142	0.84	0.71	21	0.90	0.94
7	9/4/00	C	4.3	100	0.64	0.41	46	0.70	0.57
8	9/5/00	C	3.7	100	1.29	0.58	30	0.82	0.57
9	9/12/00	C	4.4	204	2.31	0.54	81	1.43	0.82
10	9/13/00	C	4.4	216	1.91	0.62	82	0.94	0.61
11	9/15/00	C	3.3	87	1.02	0.83	25	0.63	0.78
12	9/20/00	C	4.0	102	0.91	0.55	33	0.63	0.23

13	9/26/00	C	3.5	209	2.32	0.45	52	2.01	0.39
14	11/10/00	S	2.6	142	4.28	-0.02	9	1.75	0.53
15	12/14/00	S	1.9	90	2.09	0.20	18	2.33	0.41
16	1/30/01	S	2.0	229	2.18	0.09	26	1.20	0.62
17	2/6/01	S	0.8	195	1.18	0.83	NA	NA	NA
18	2/17/01	S	2.5	213	4.12	-0.14	39	1.46	0.45
19	3/5/01	S	0.6	189	8.74	0.02	NA	NA	NA
20	3/21/01	S	1.9	115	1.57	0.66	20	1.03	0.28
21	3/30/01	S	2.6	159	3.89	0.48	12	1.59	0.28
22	4/9/01	C	3.5	207	1.39	0.77	45	0.74	0.85
23	4/10/01	S	3.4	164	0.94	0.53	60	0.66	0.60
24	4/11/01	S	3.5	227	2.04	0.41	62	1.49	0.53
25	4/16/01	S	1.4	232	5.32	0.06	11	2.35	0.45
26	6/17/01	C	4.4	225	0.92	0.64	95	0.80	0.64
27	6/23/01	C	3.9	241	0.89	0.57	72	0.61	0.54

Figure 1 (to follow over the coming pages). Storm-total radar rainfall (mm), contoured IFLOWS gauge rainfall (mm), gauge-radar scatter plot for all gauges and segregated by range, QC'ed gauge-radar scatter plot, location of IFLOWS gauges relative to LWX radar (bold dots indicate QC'ed gauges), and range dependence of gauge and radar rainfall derived from available gauge-radar pairs stratified into 23 km-wide range bands. The start and end dates and times of the event is listed at the top of the third and fourth panels.

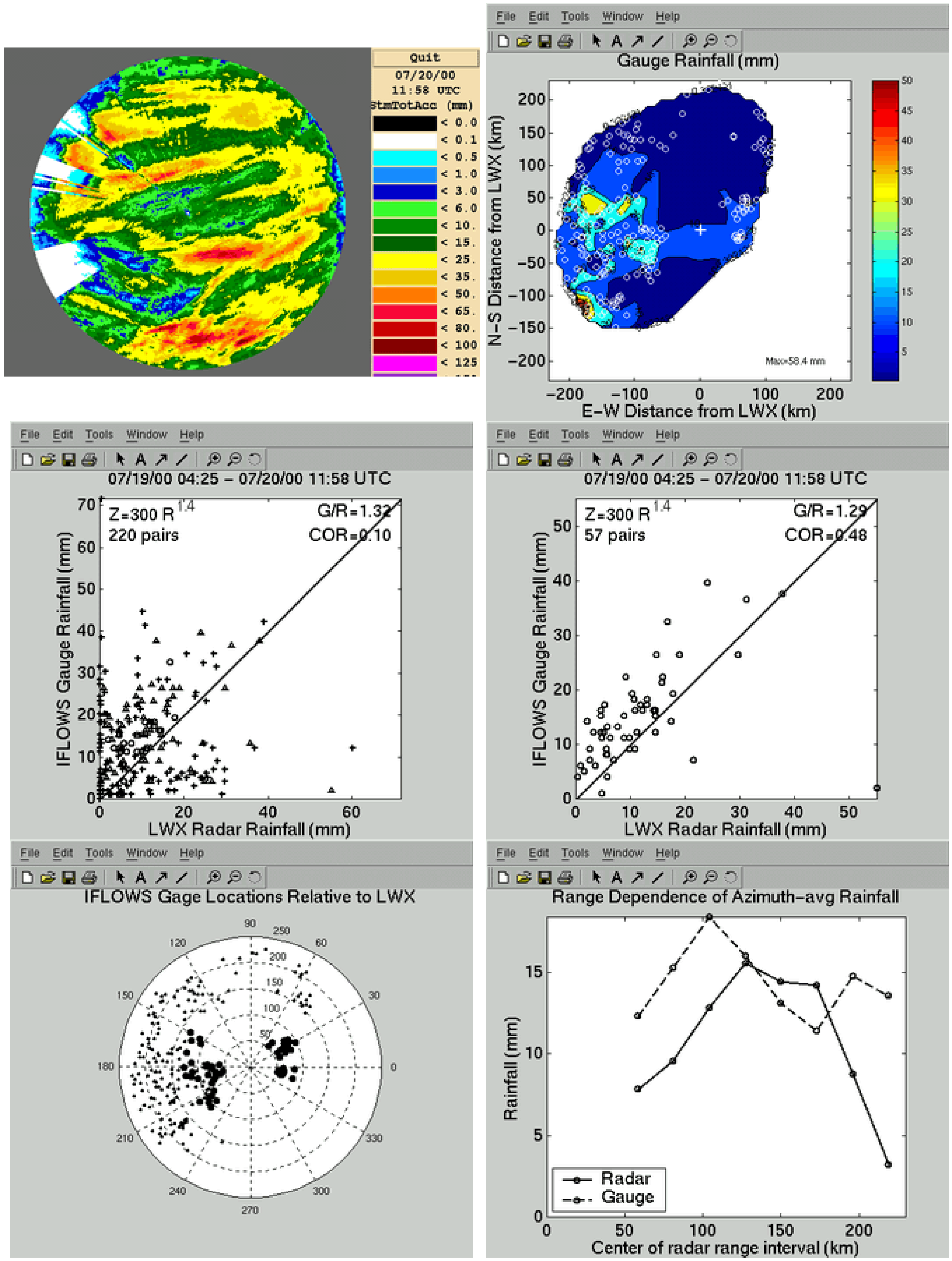

Figure 1a. July 20, 2000.

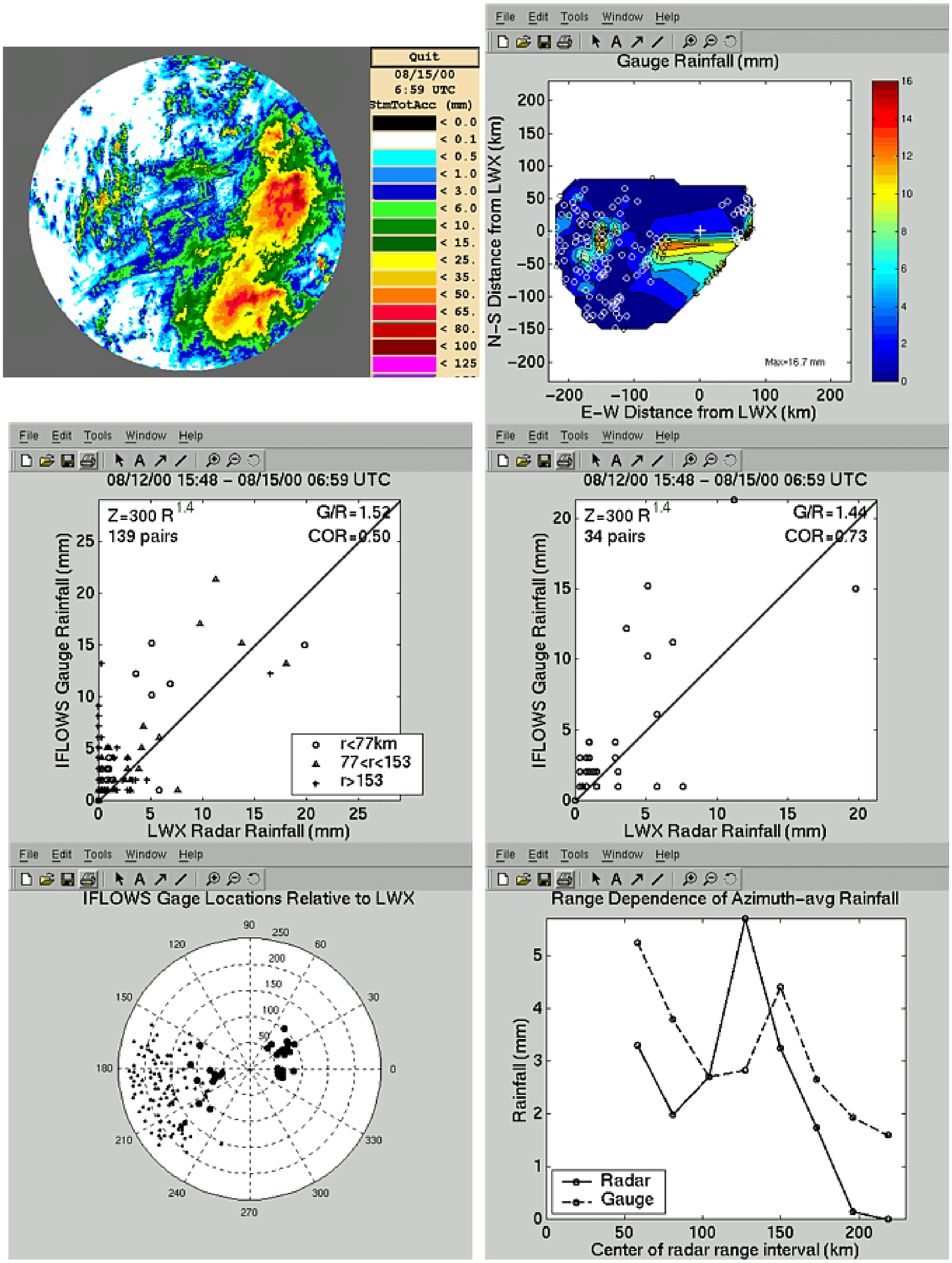

Figure 1b. August 15, 2000.

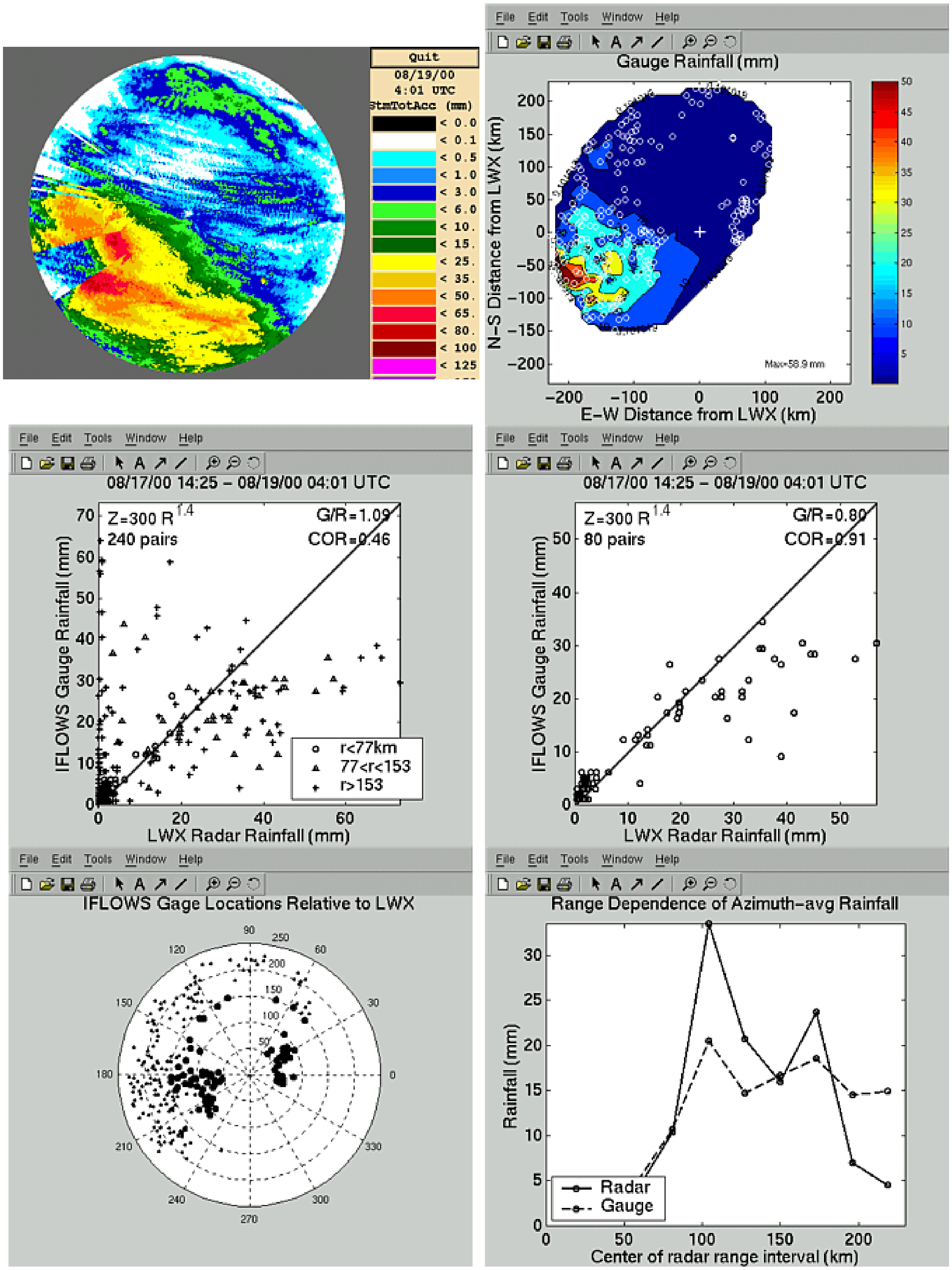

Figure 1c. August 19, 2000.

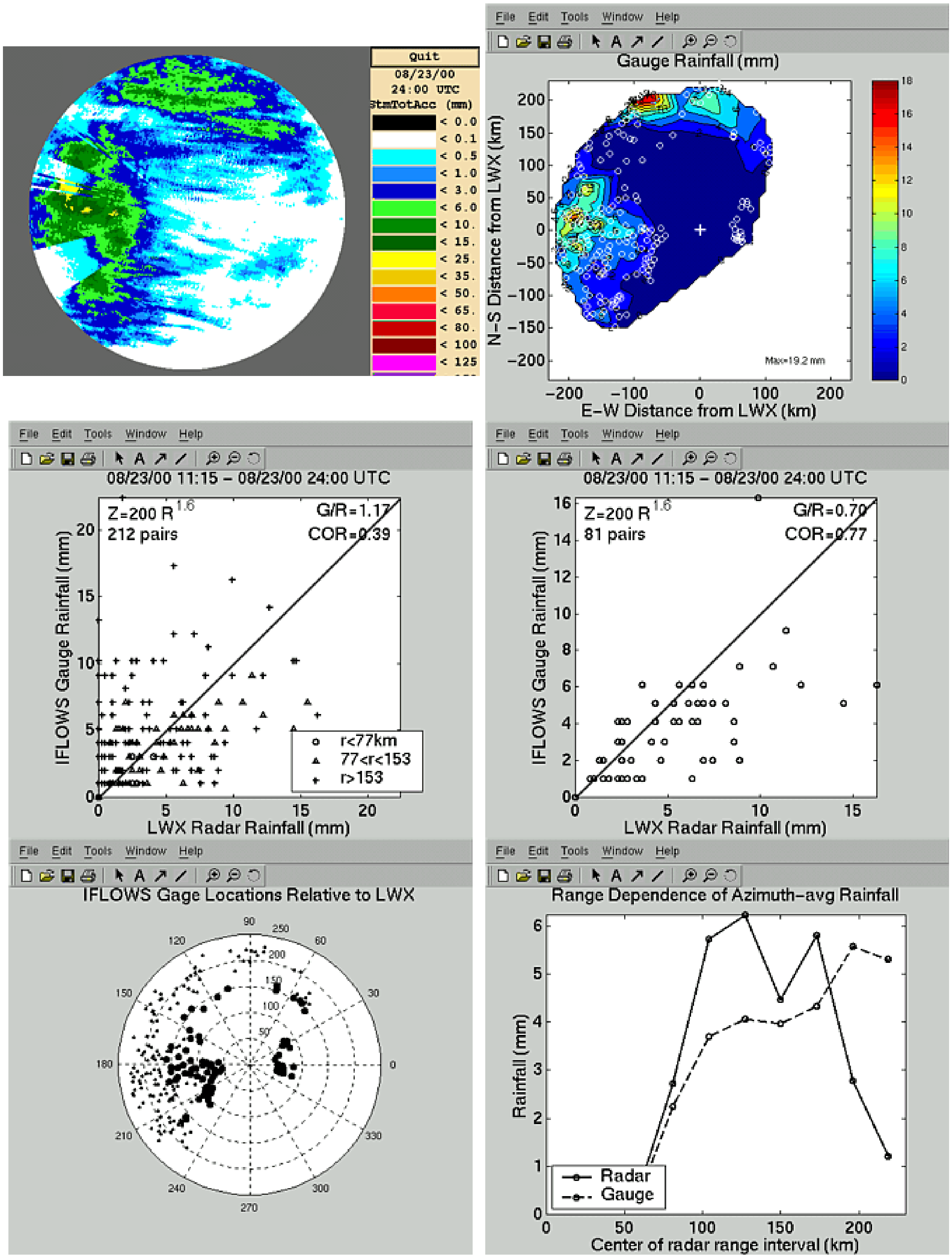

Figure 1d. August 23, 2000.

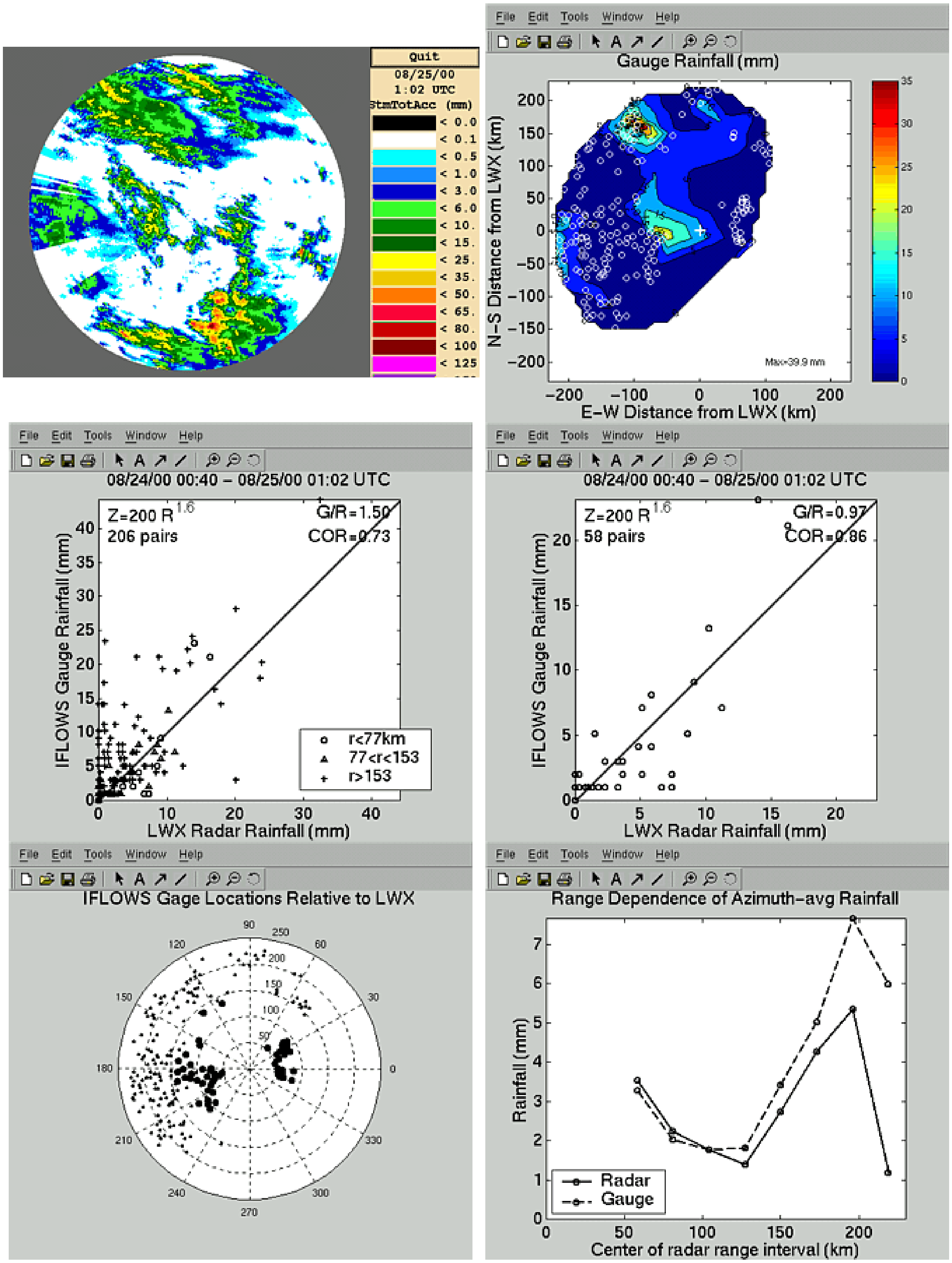

Figure 1e. August 24, 2000.

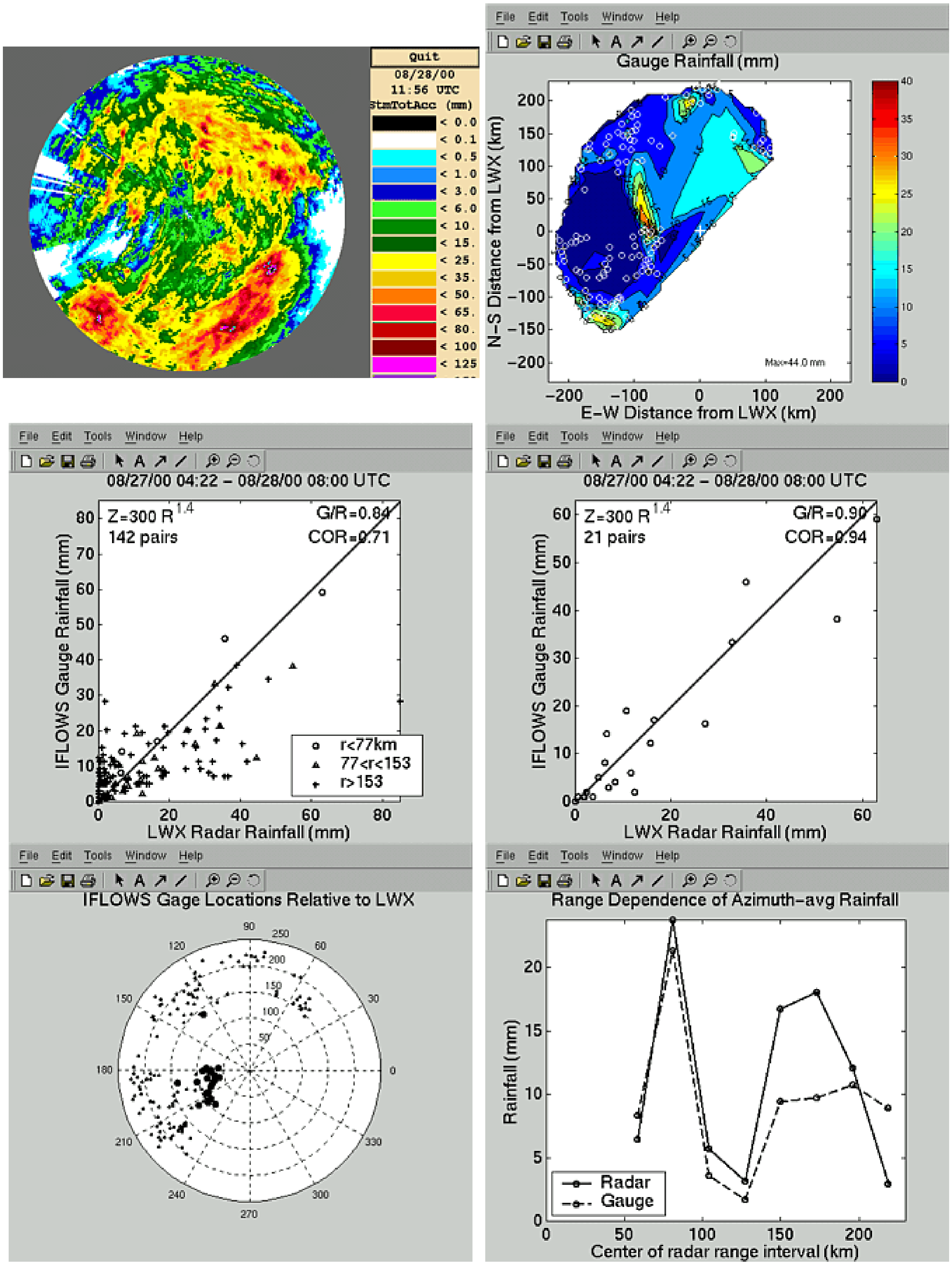

Figure 1f. August 28, 2000.

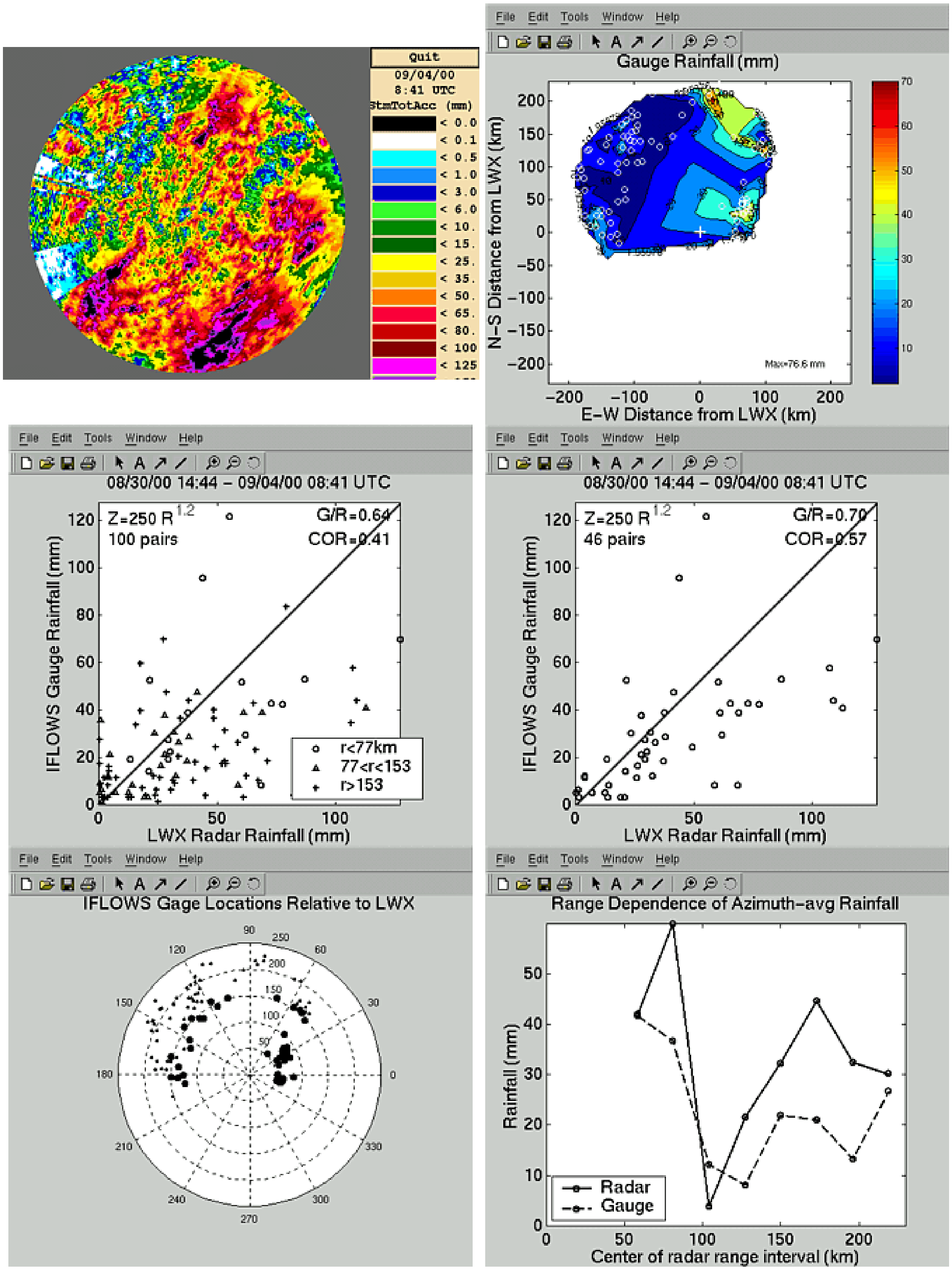

Figure 1g. September 4, 2000.

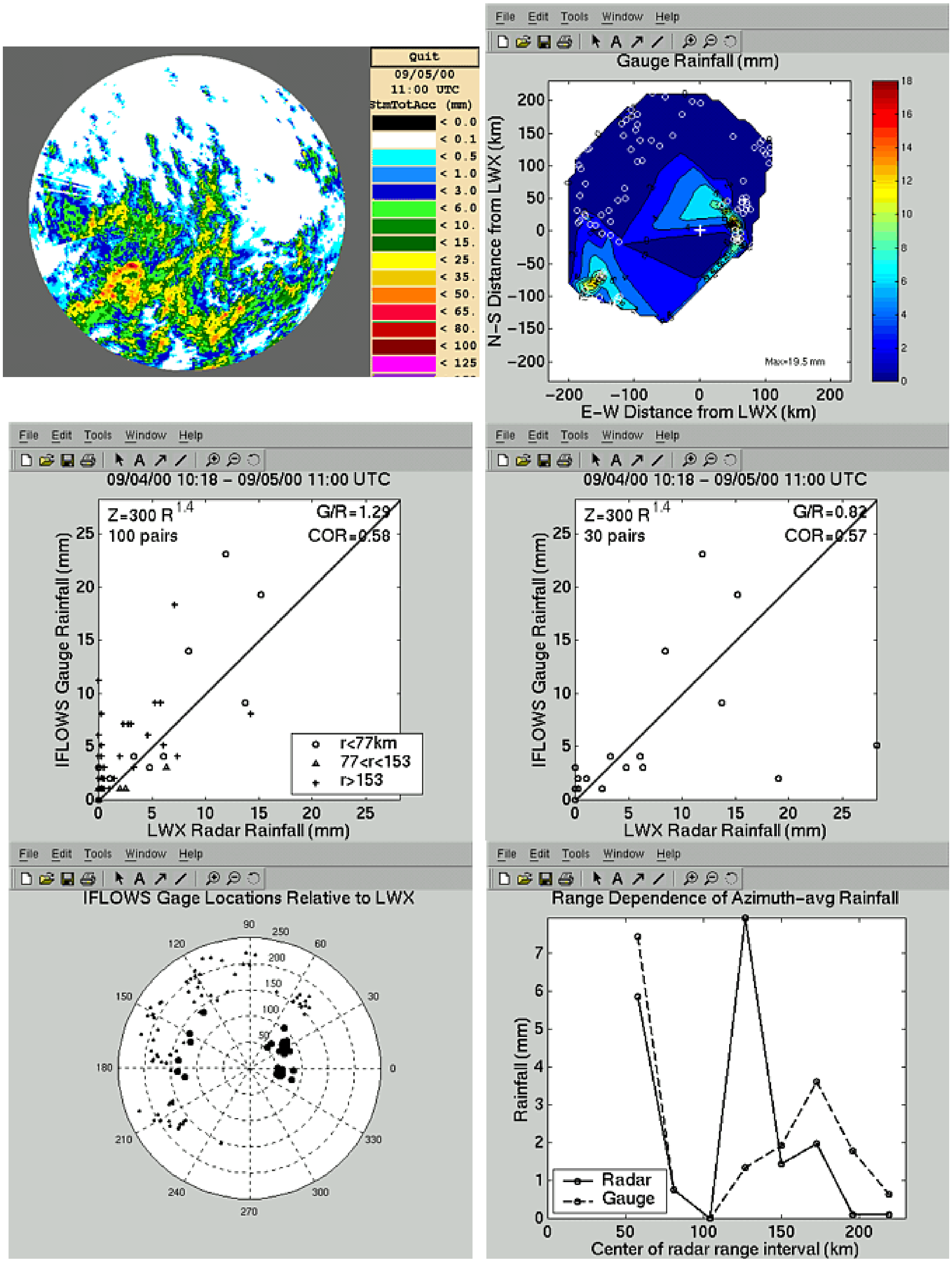

Figure 1h. September 5, 2000.

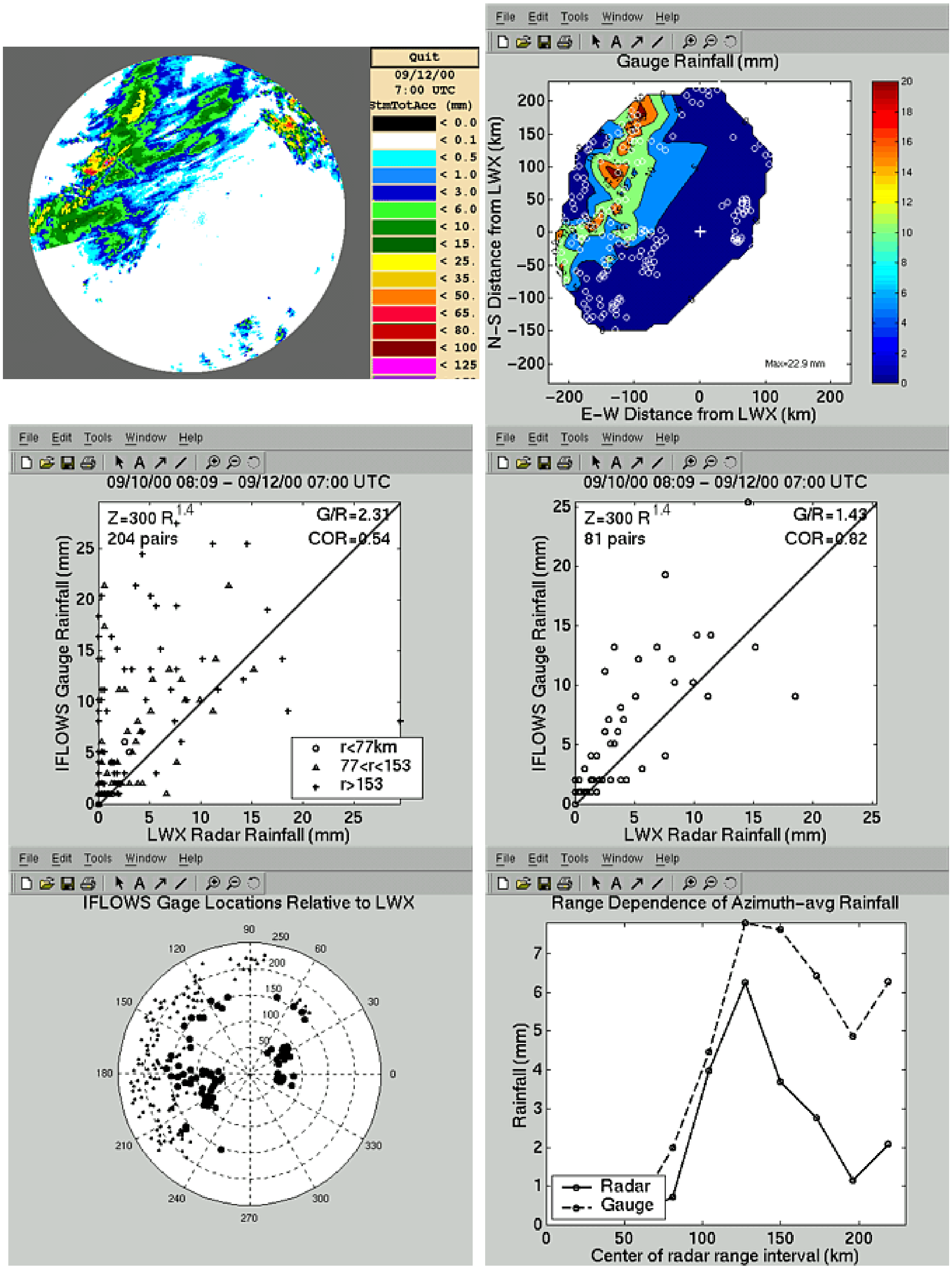

Figure 1i. September 12, 2000.

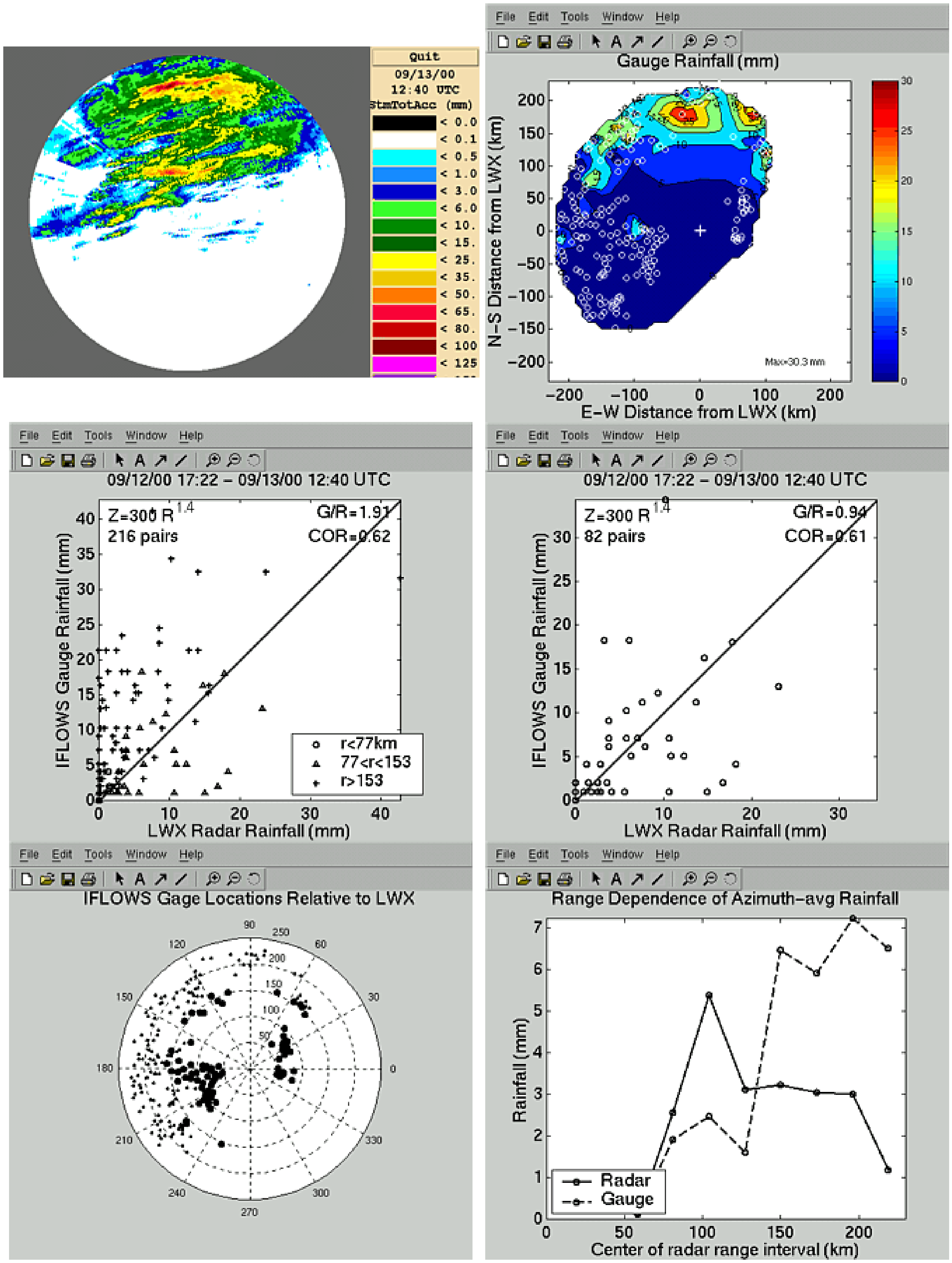

Figure 1j. September 13, 2000.

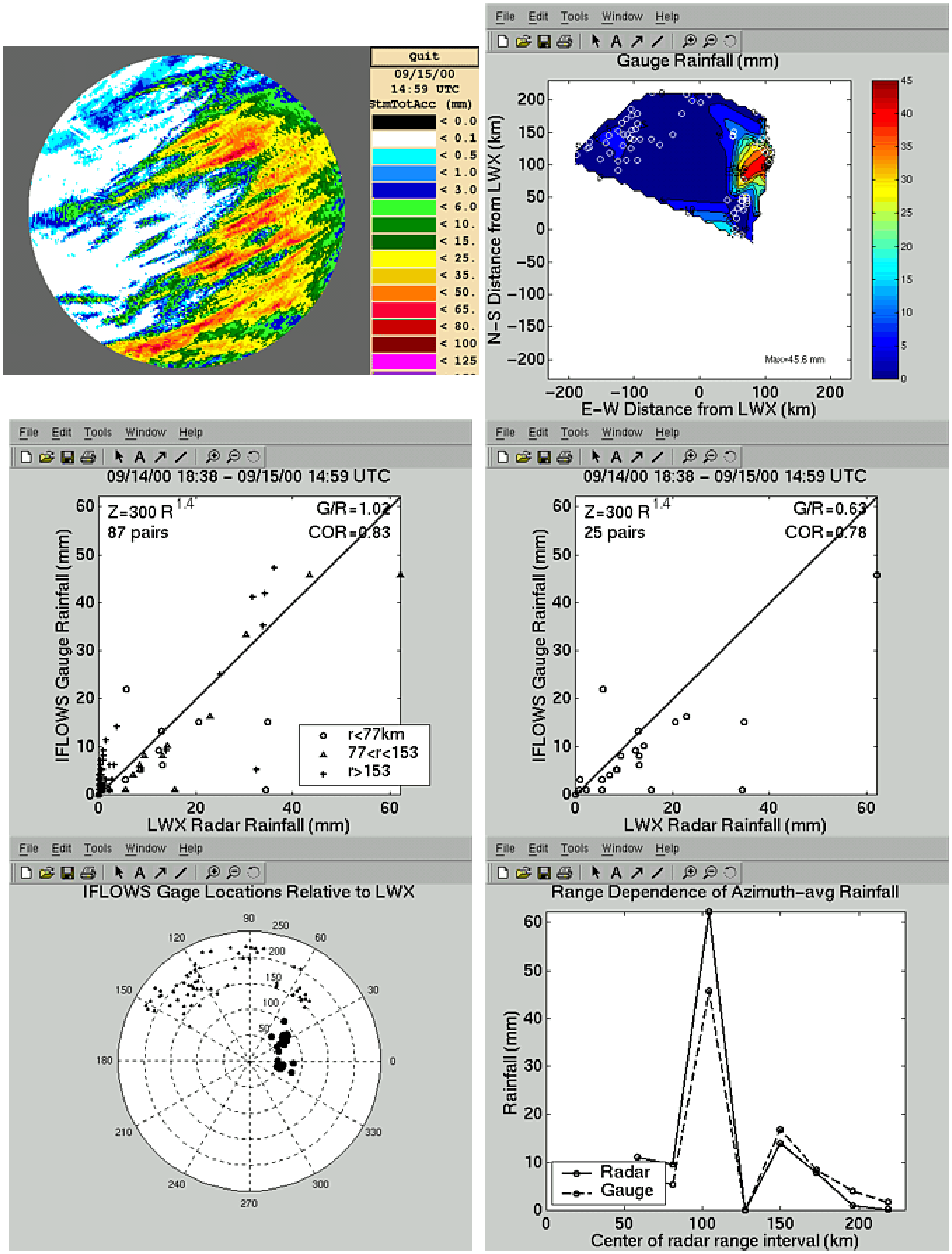

Figure 1k. September 15, 2000.

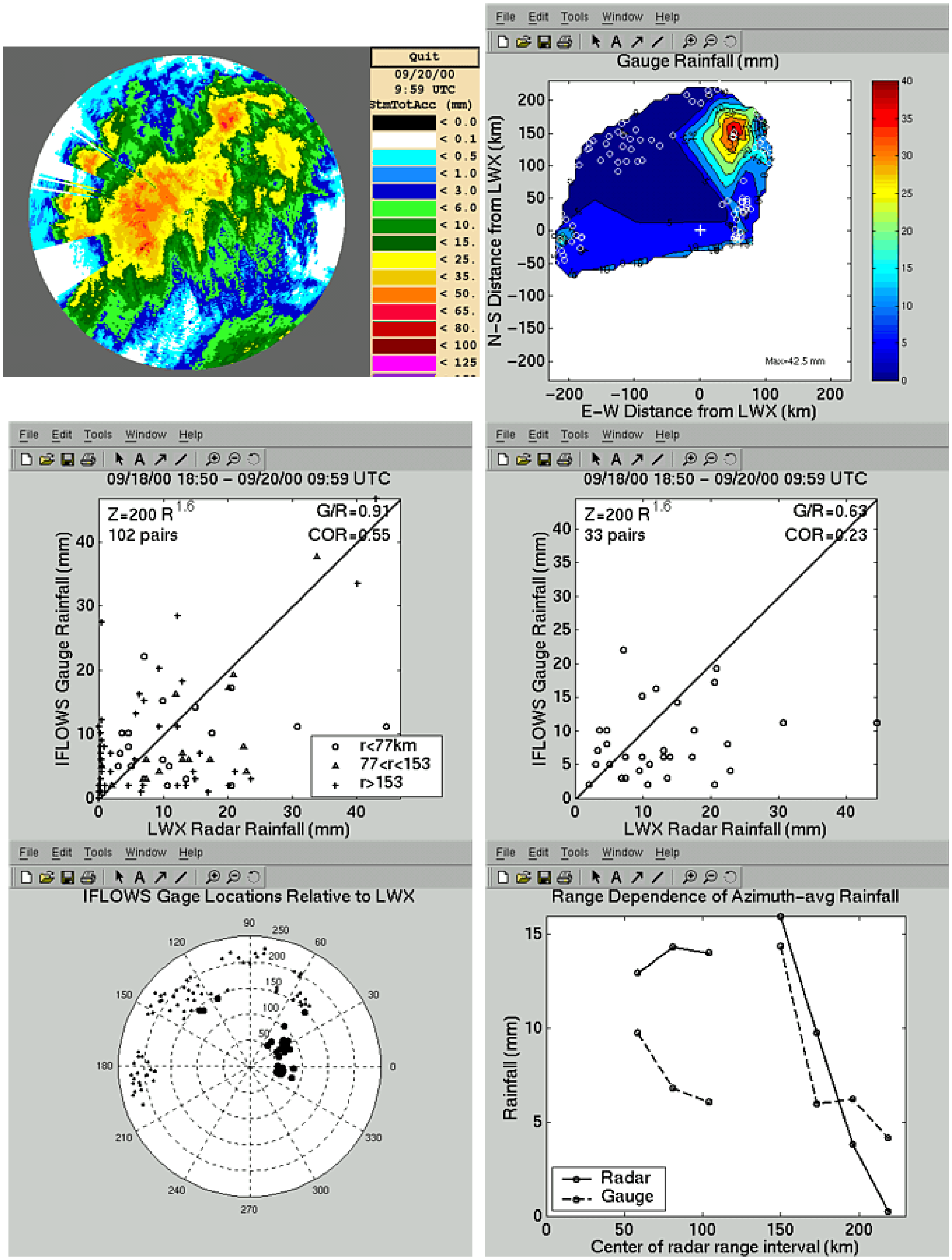

Figure 1l. September 20, 2000.

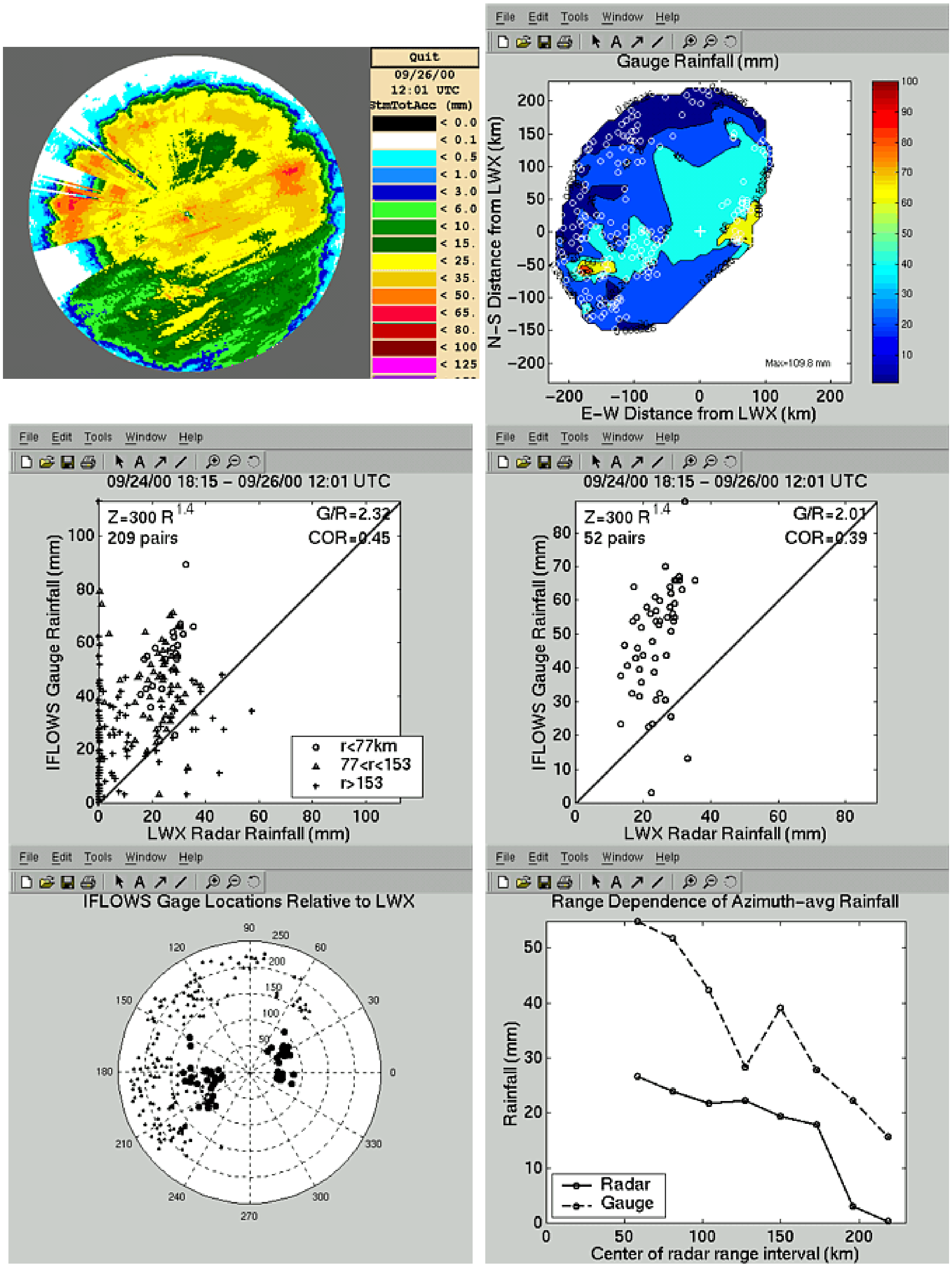

Figure 1m. September 26, 2000.

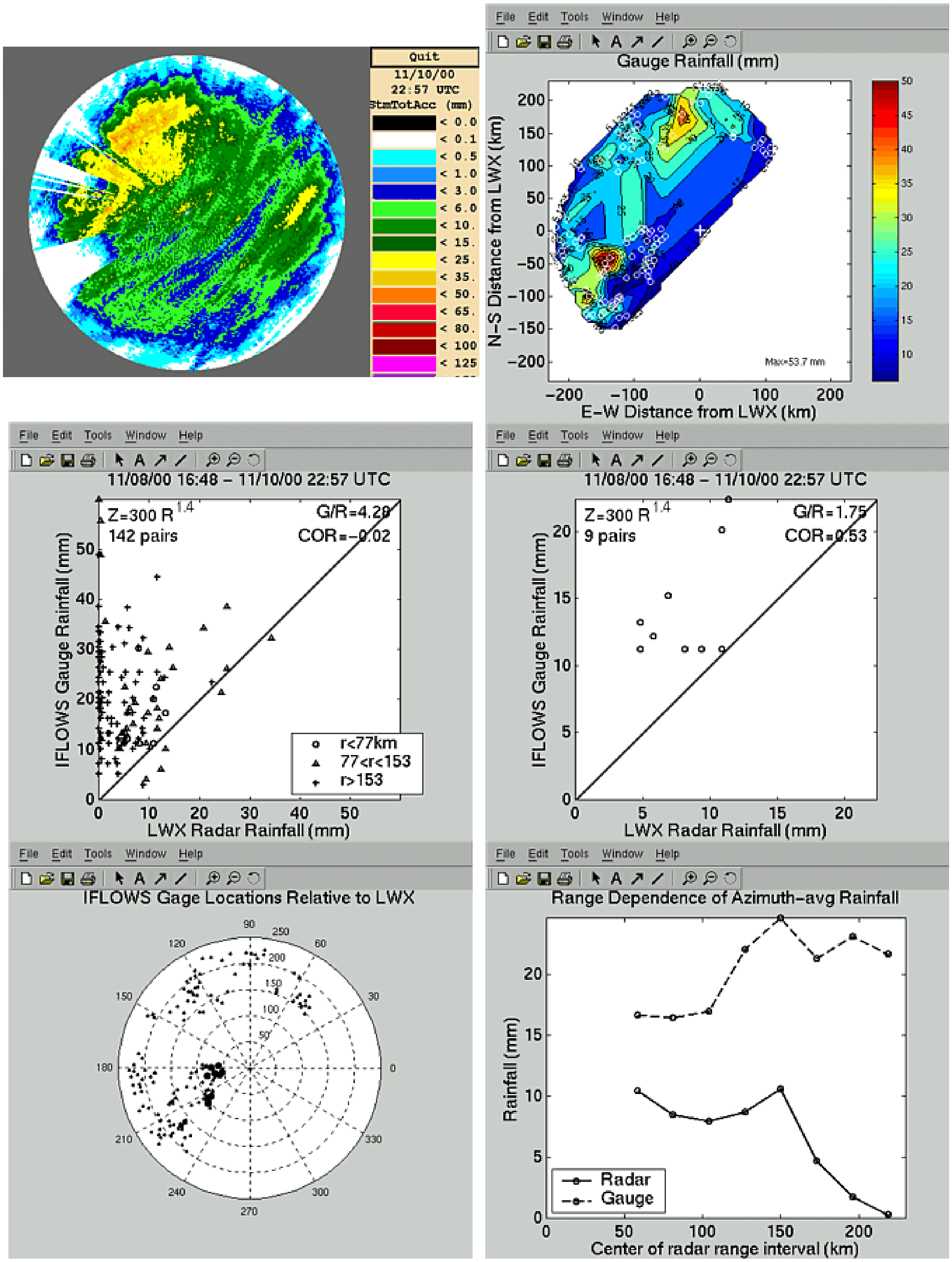

Figure 1n. November 10, 2000.

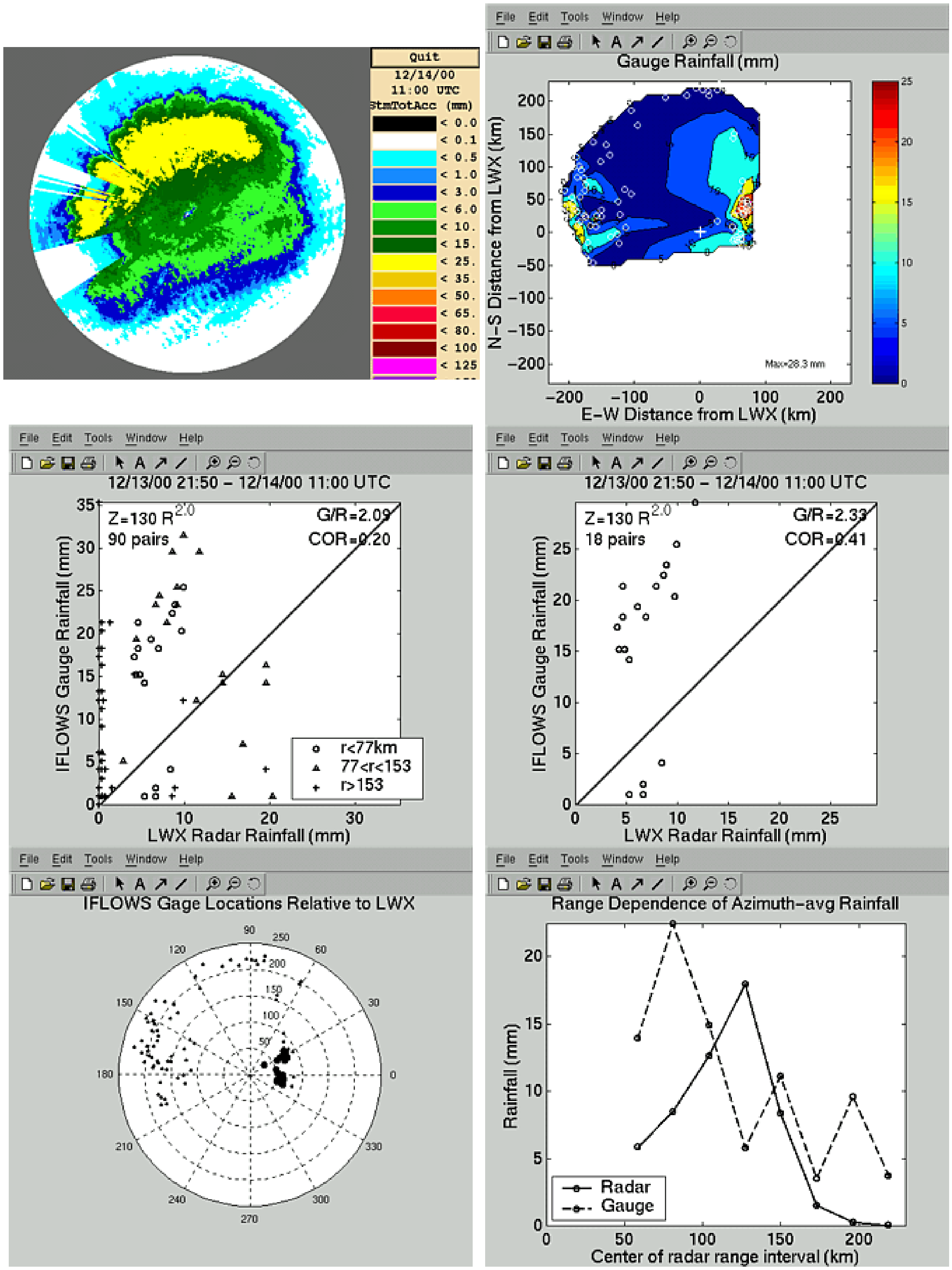

Figure 1o. December 14, 2000.

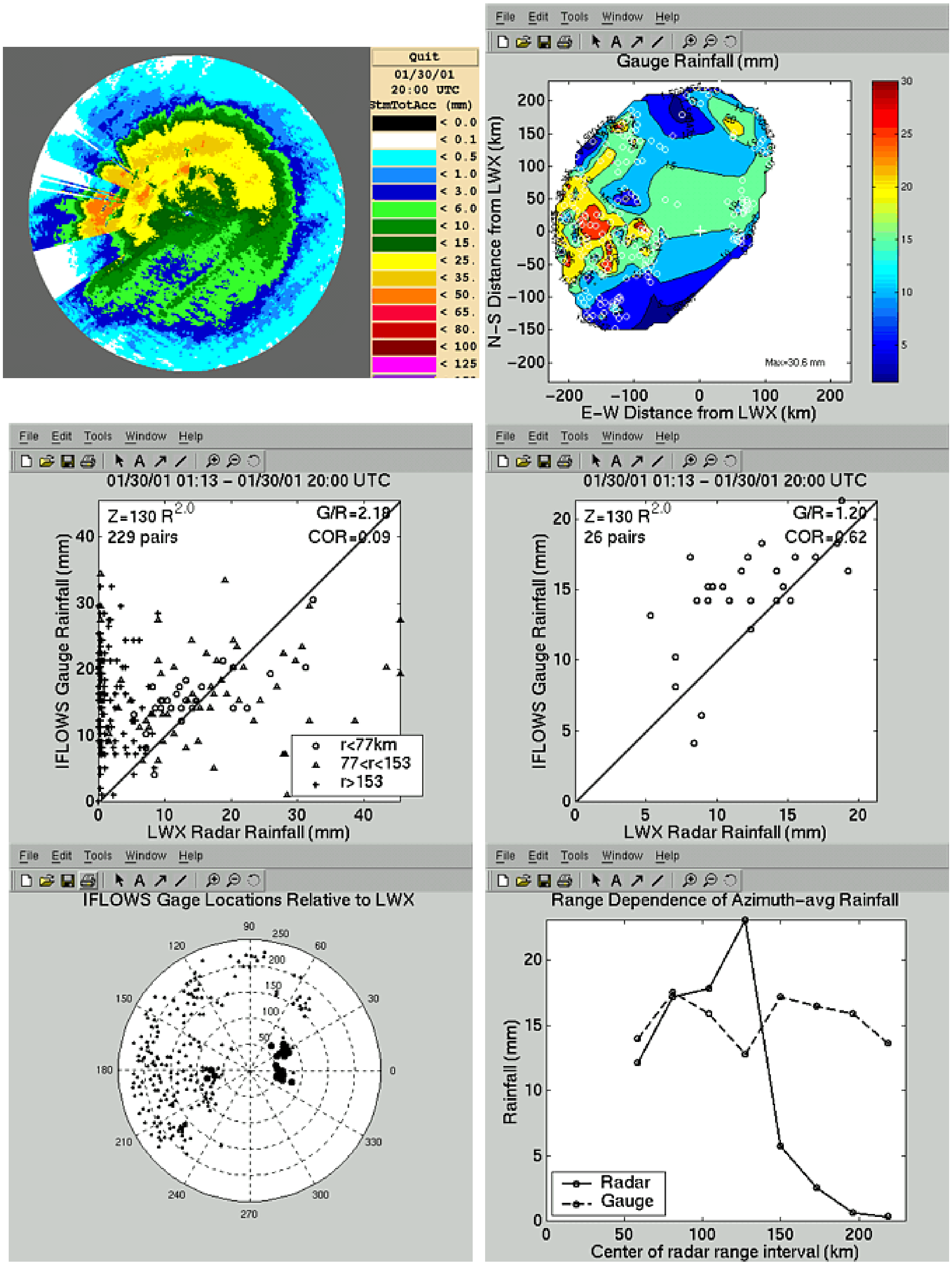

Figure 1p. January 30, 2001.

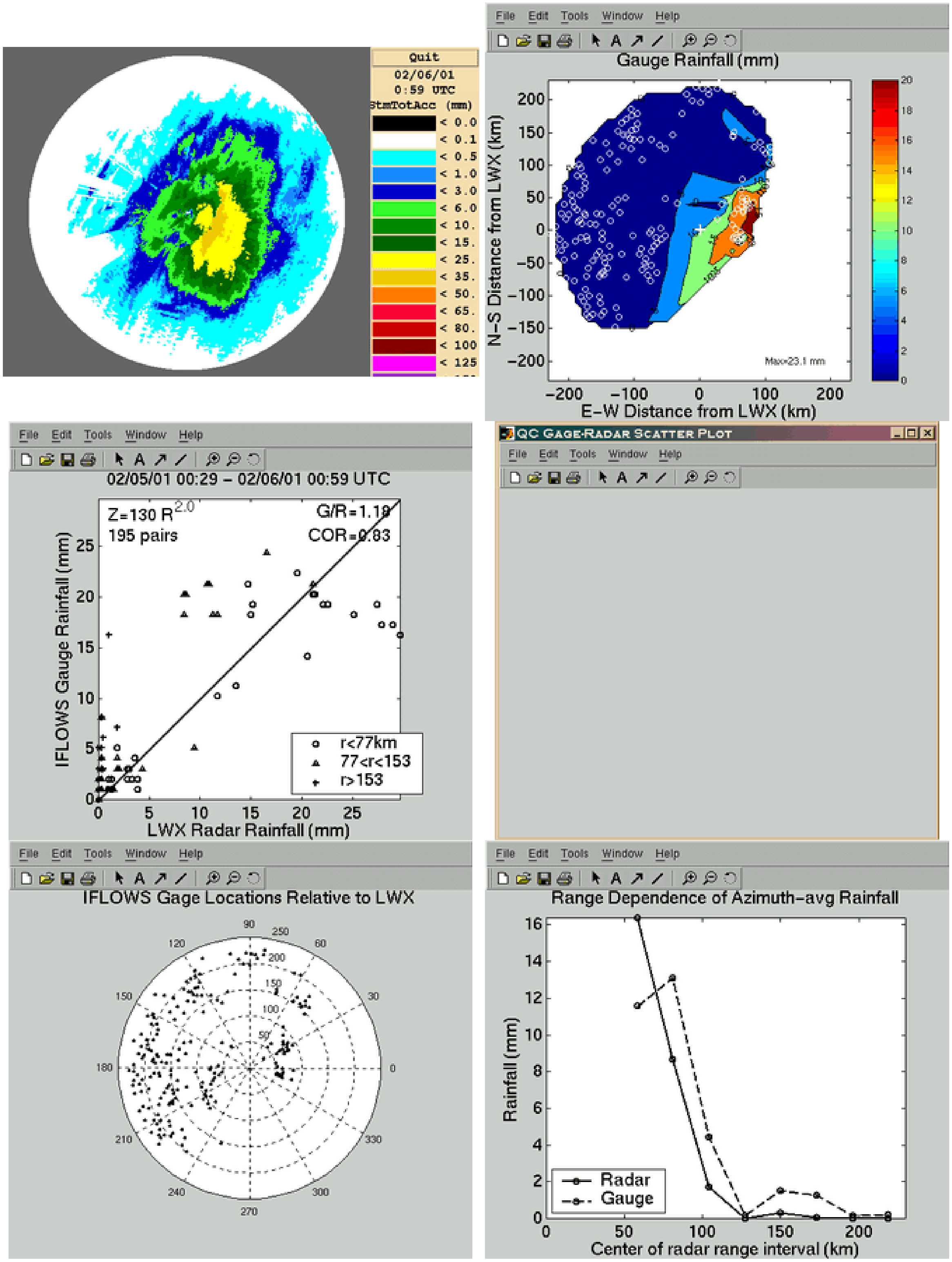

Figure 1q. February 6, 2001.

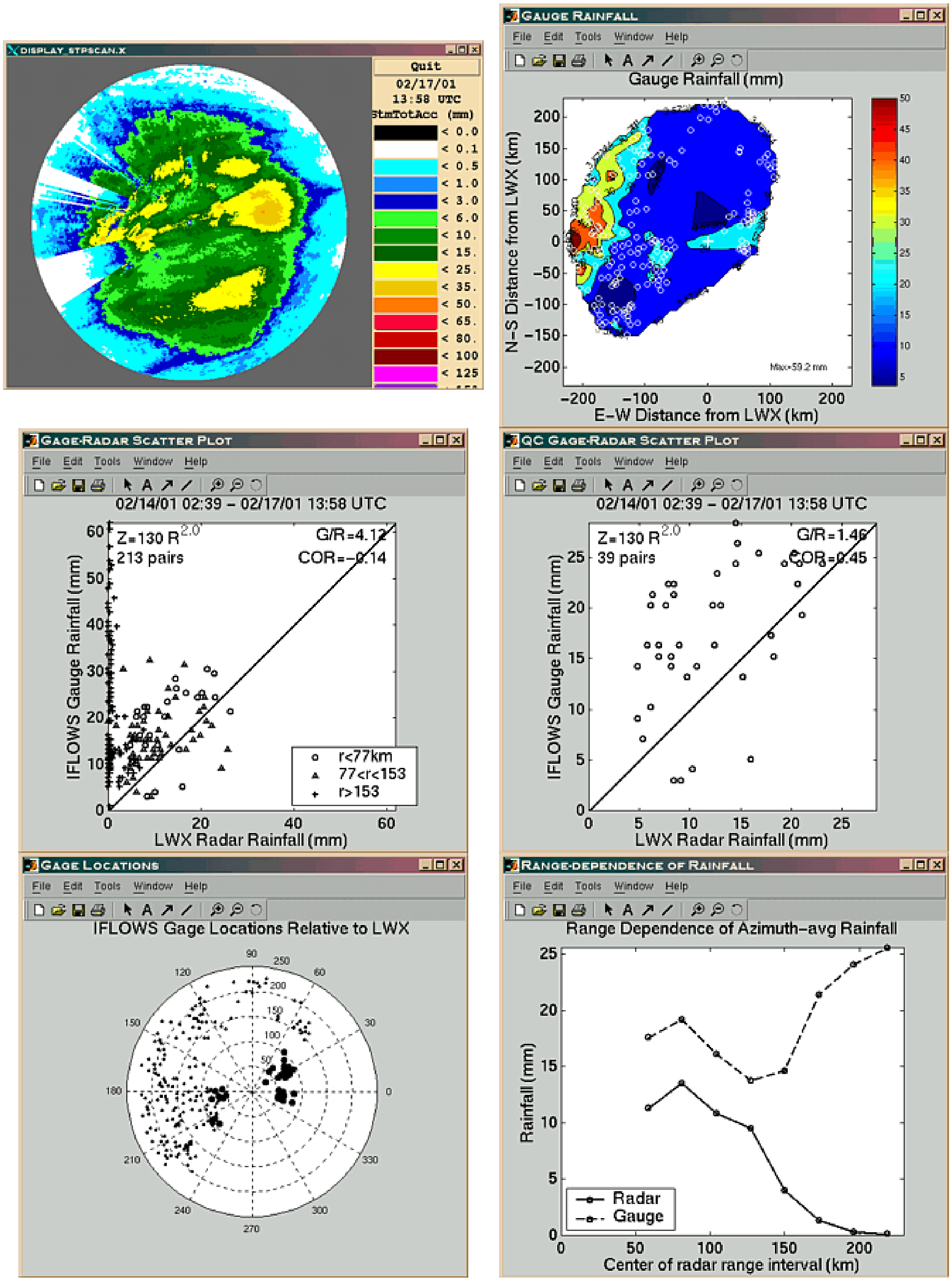

Figure 1r. February 17, 2001.

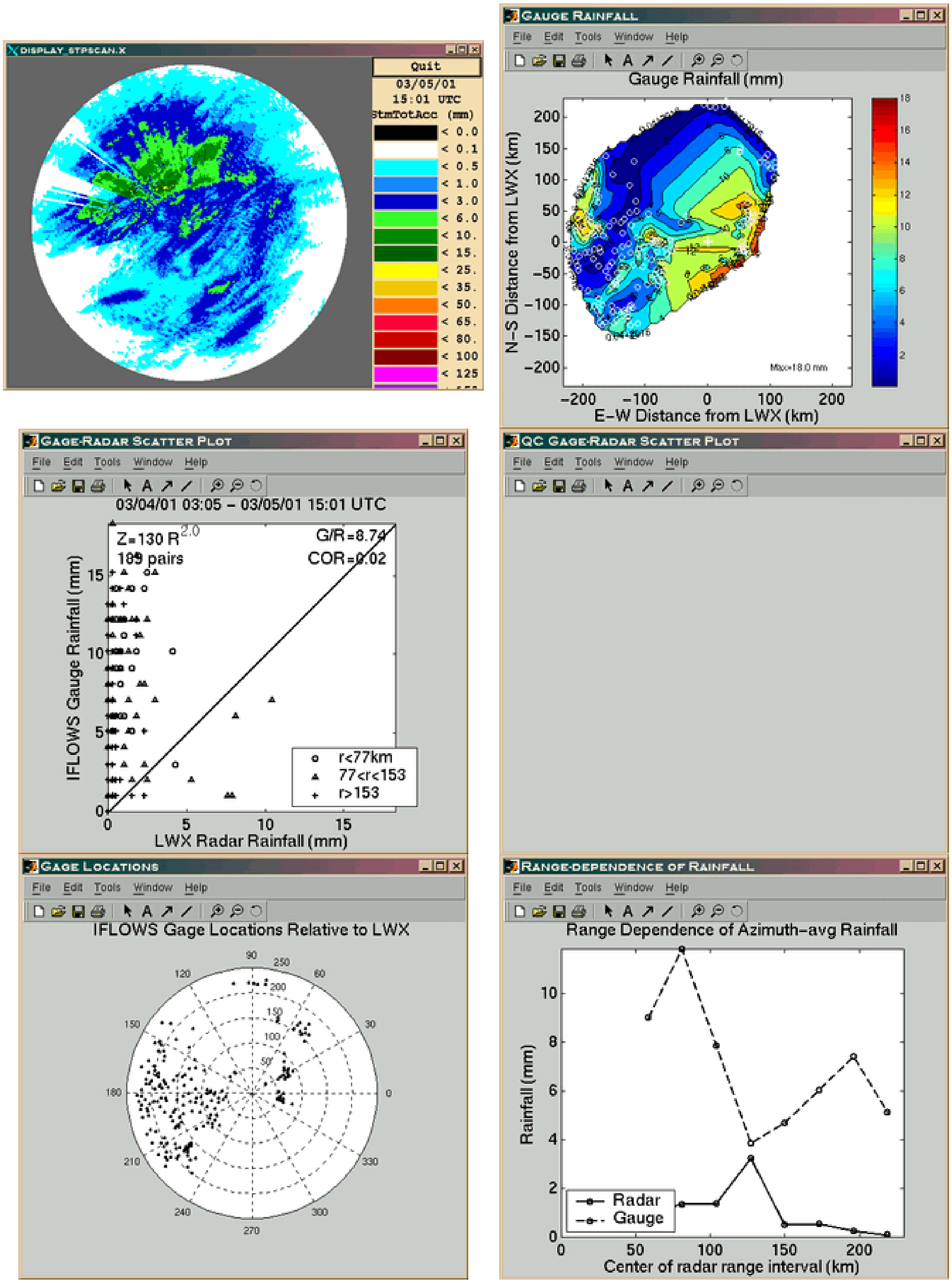

Figure 1s. March 5, 2001.

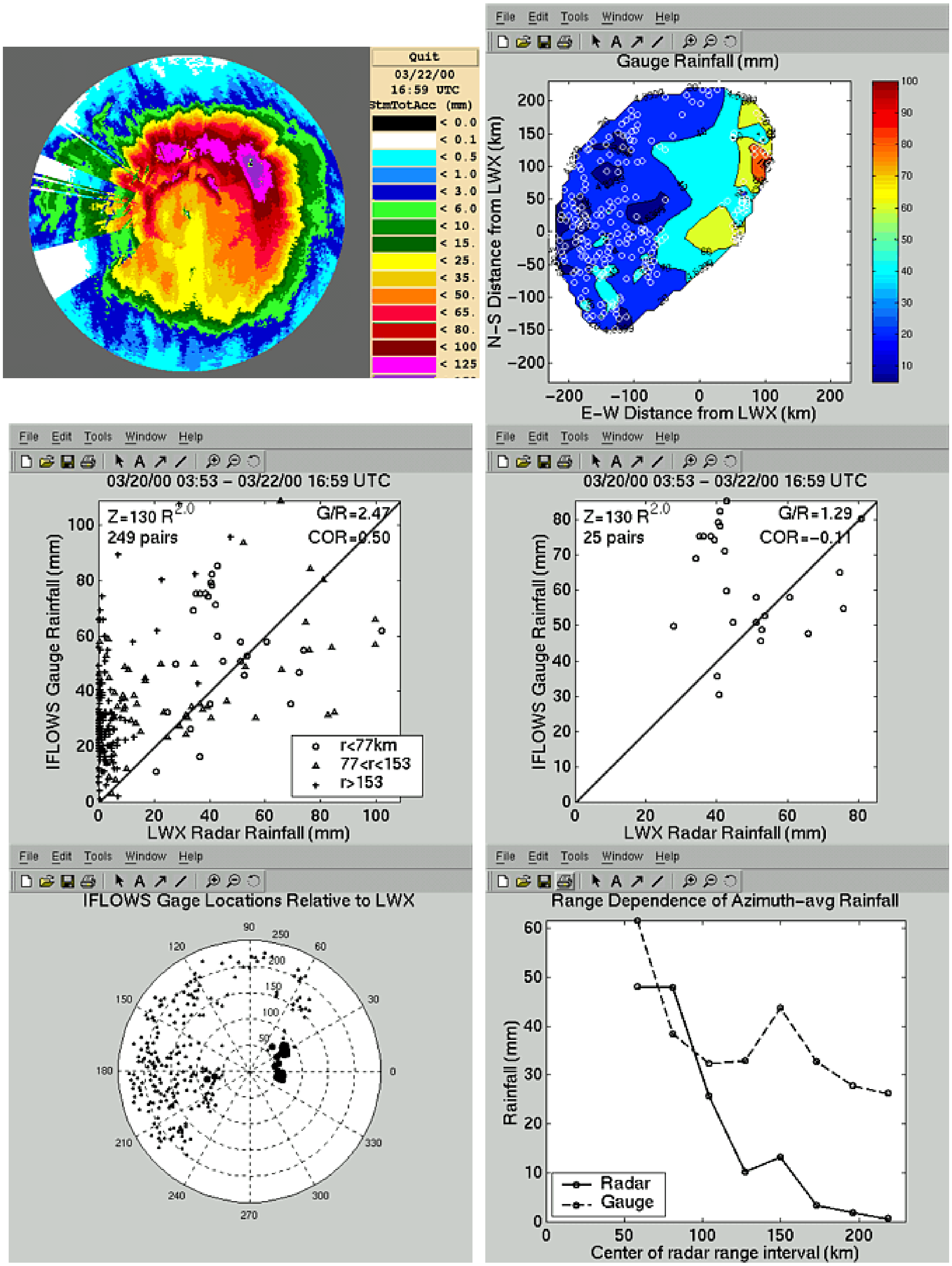

Figure 1t. March 22, 2001.

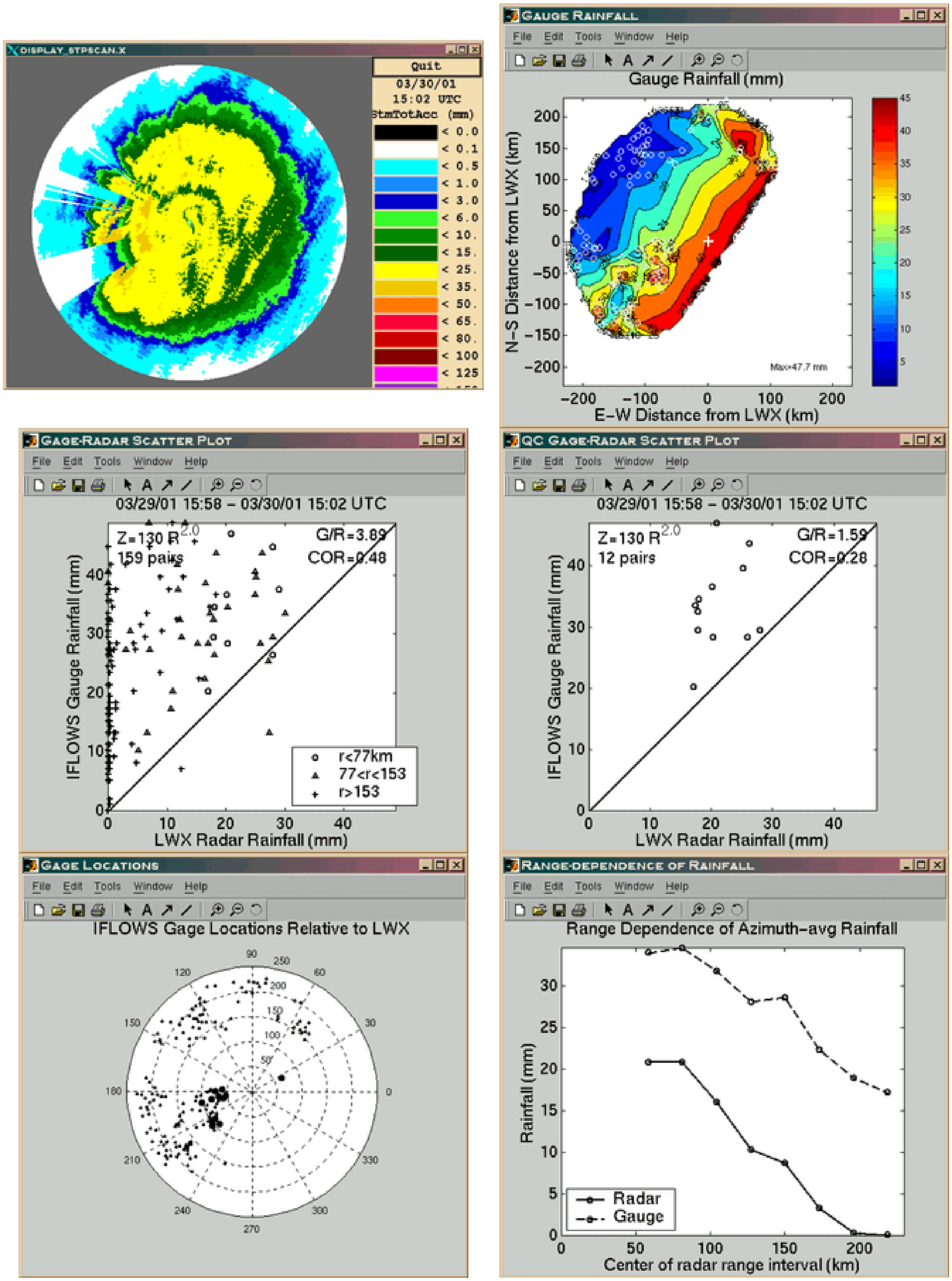

Figure 1u. March 30, 2001.

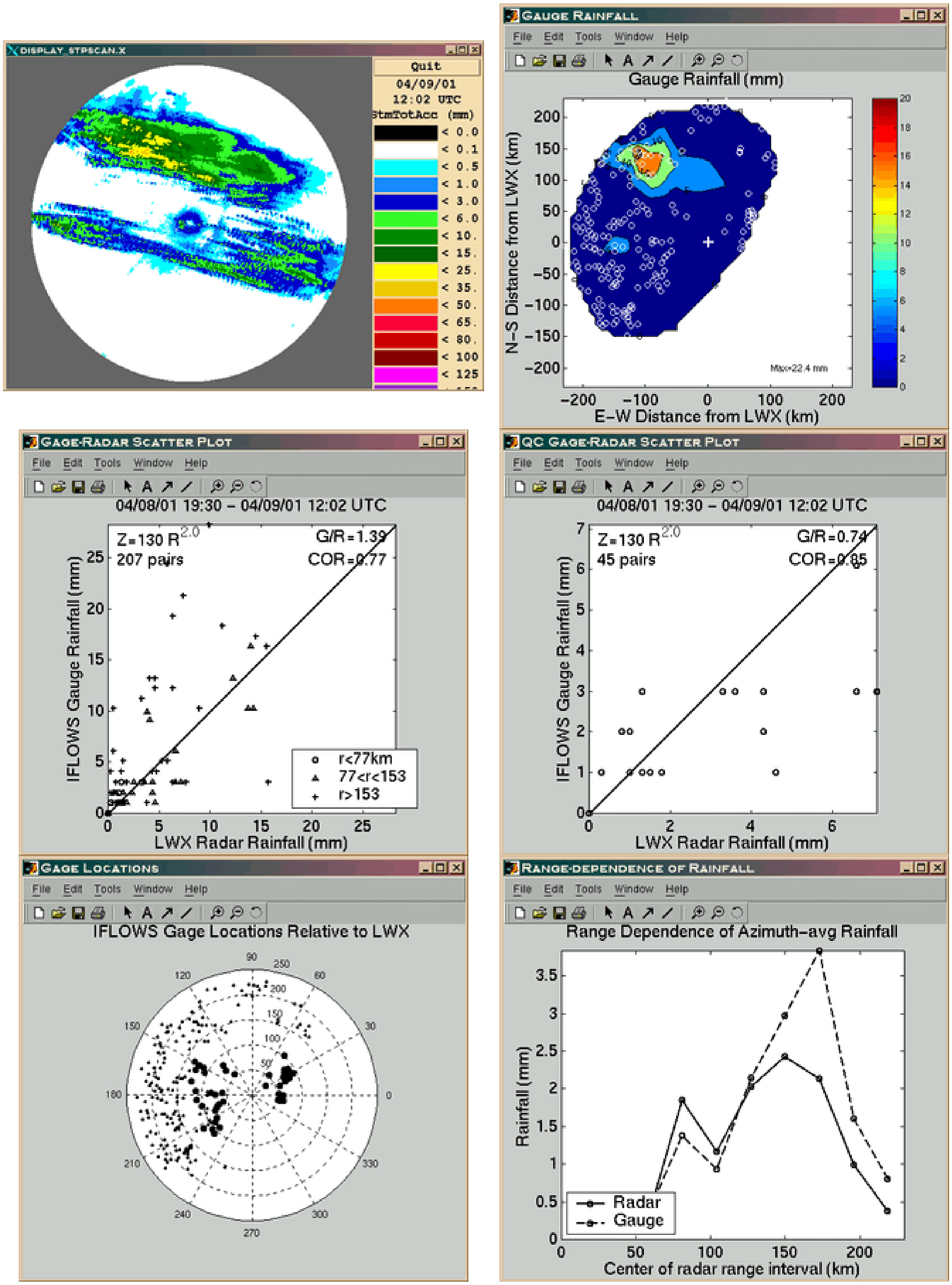

Figure 1v. April 9, 2001.

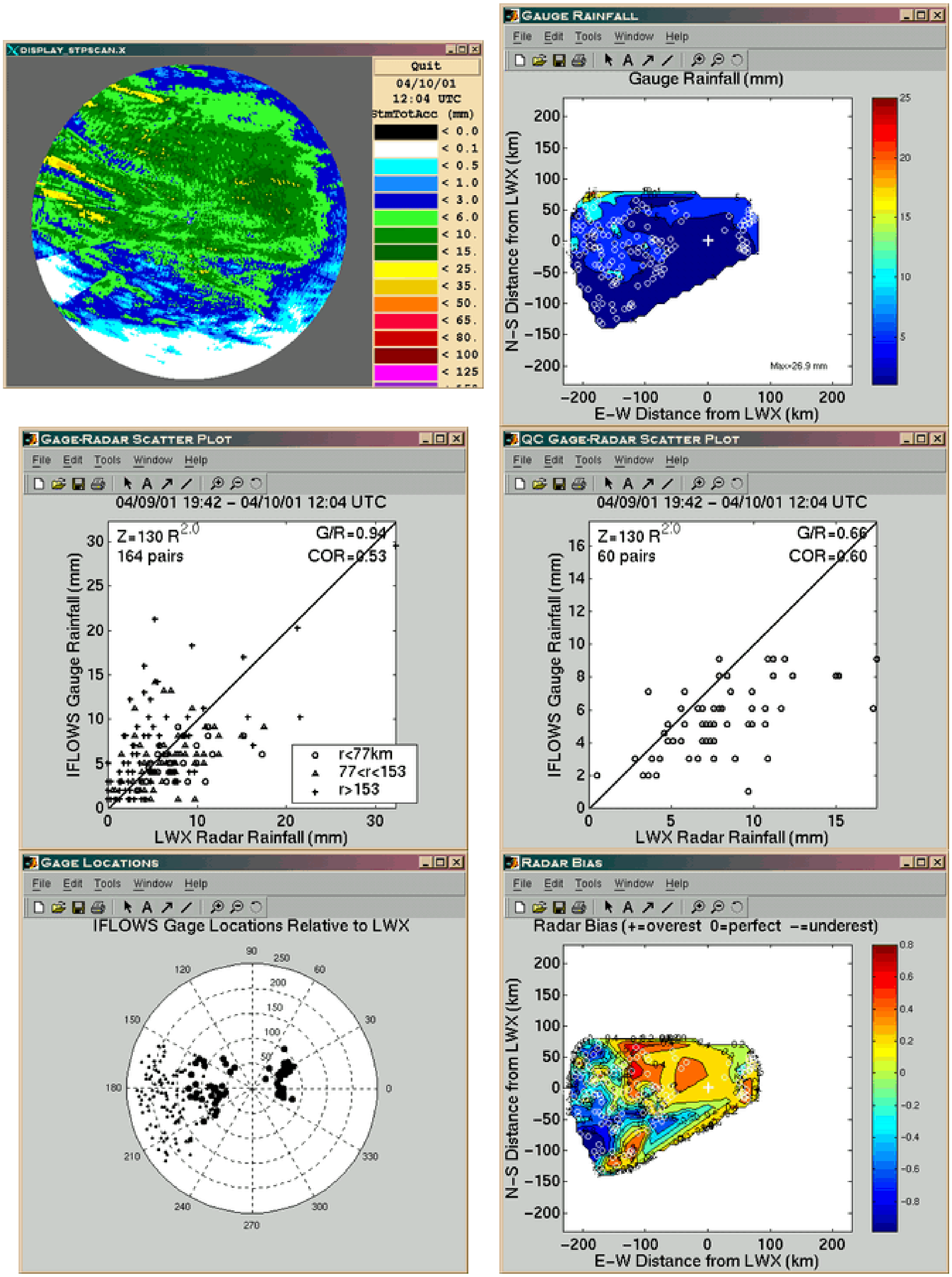

Figure 1w. April 10, 2001.

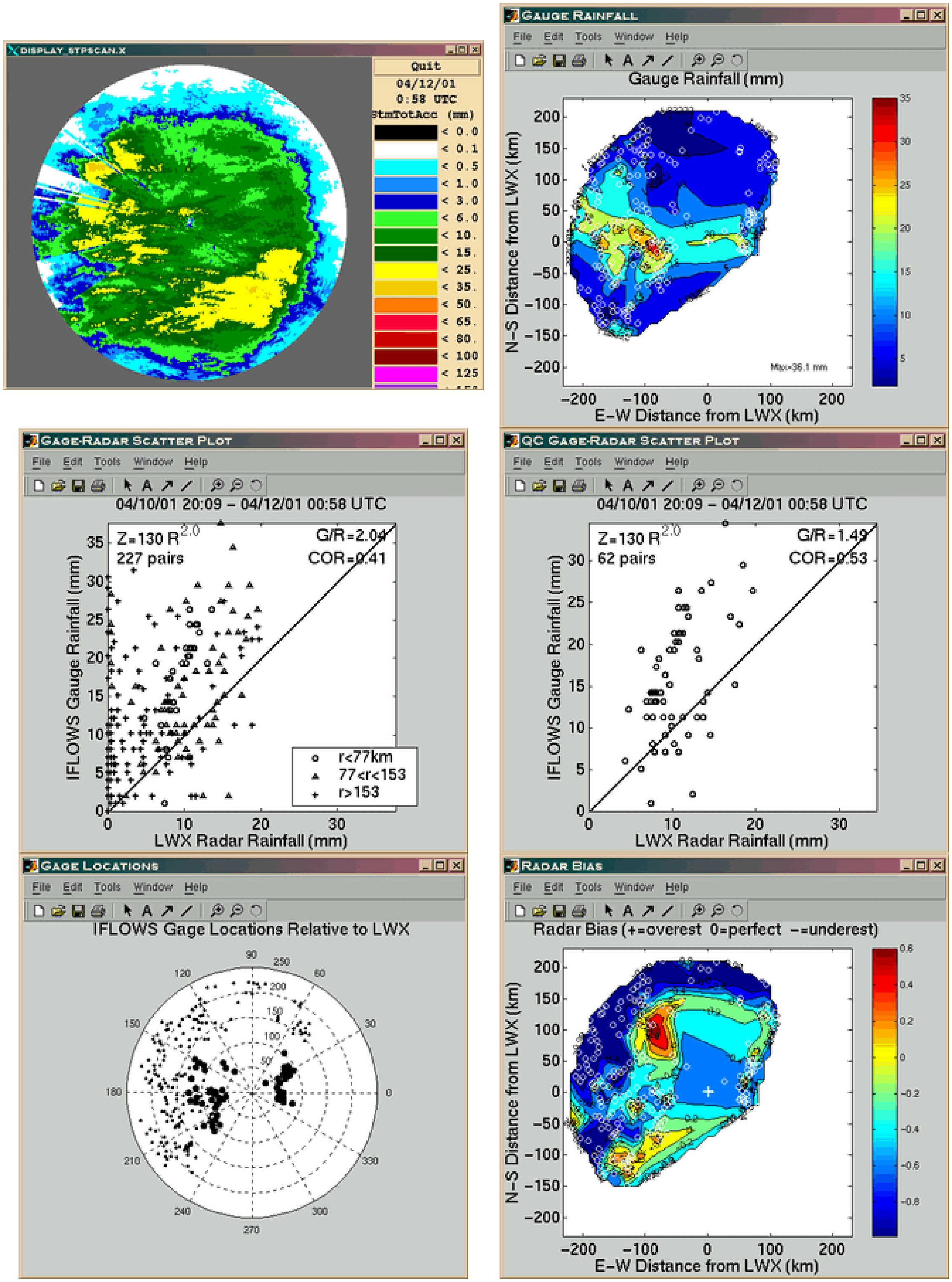

Figure 1x. April 11, 2001.

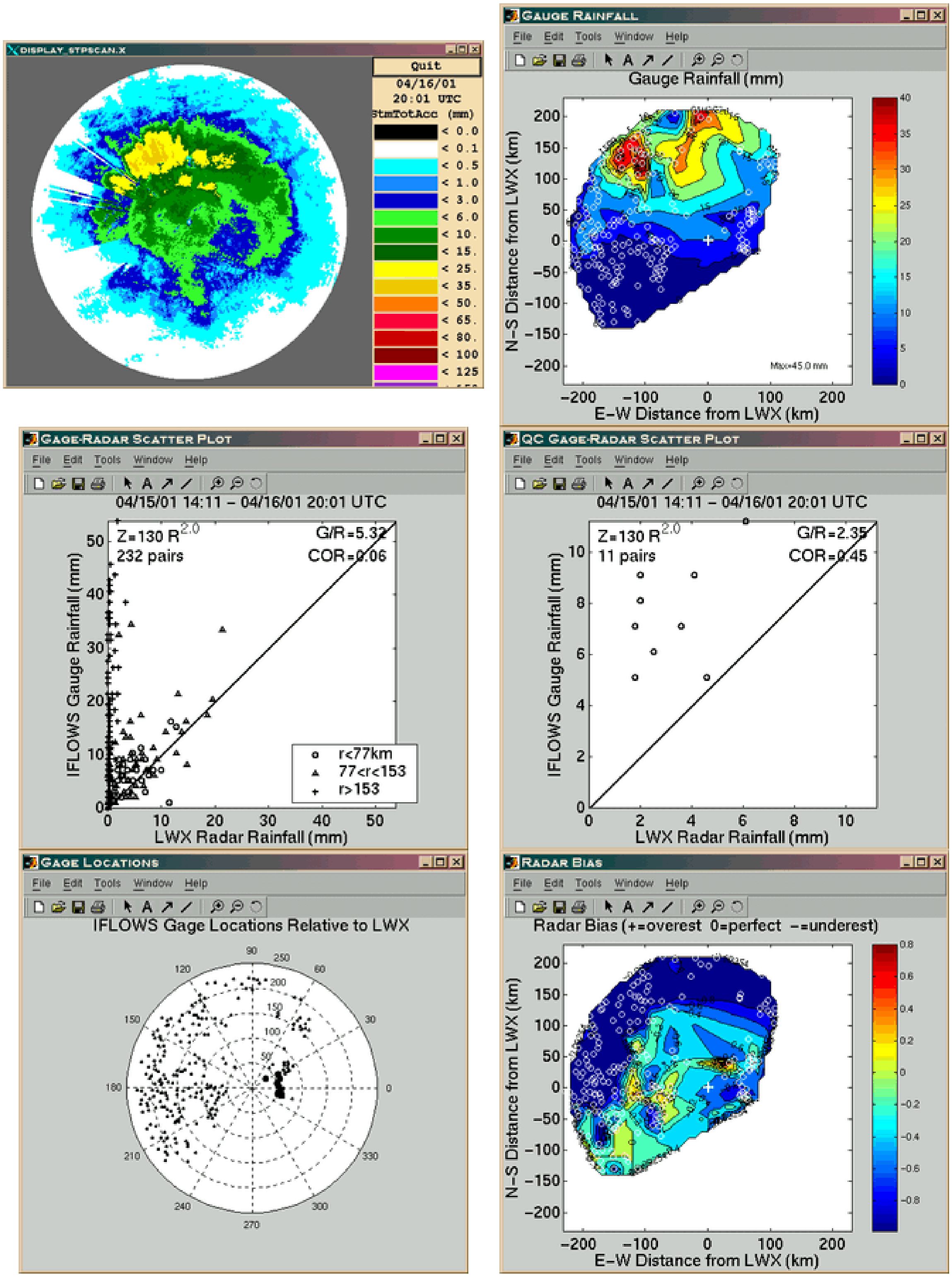

Figure 1y. April 16, 2001.

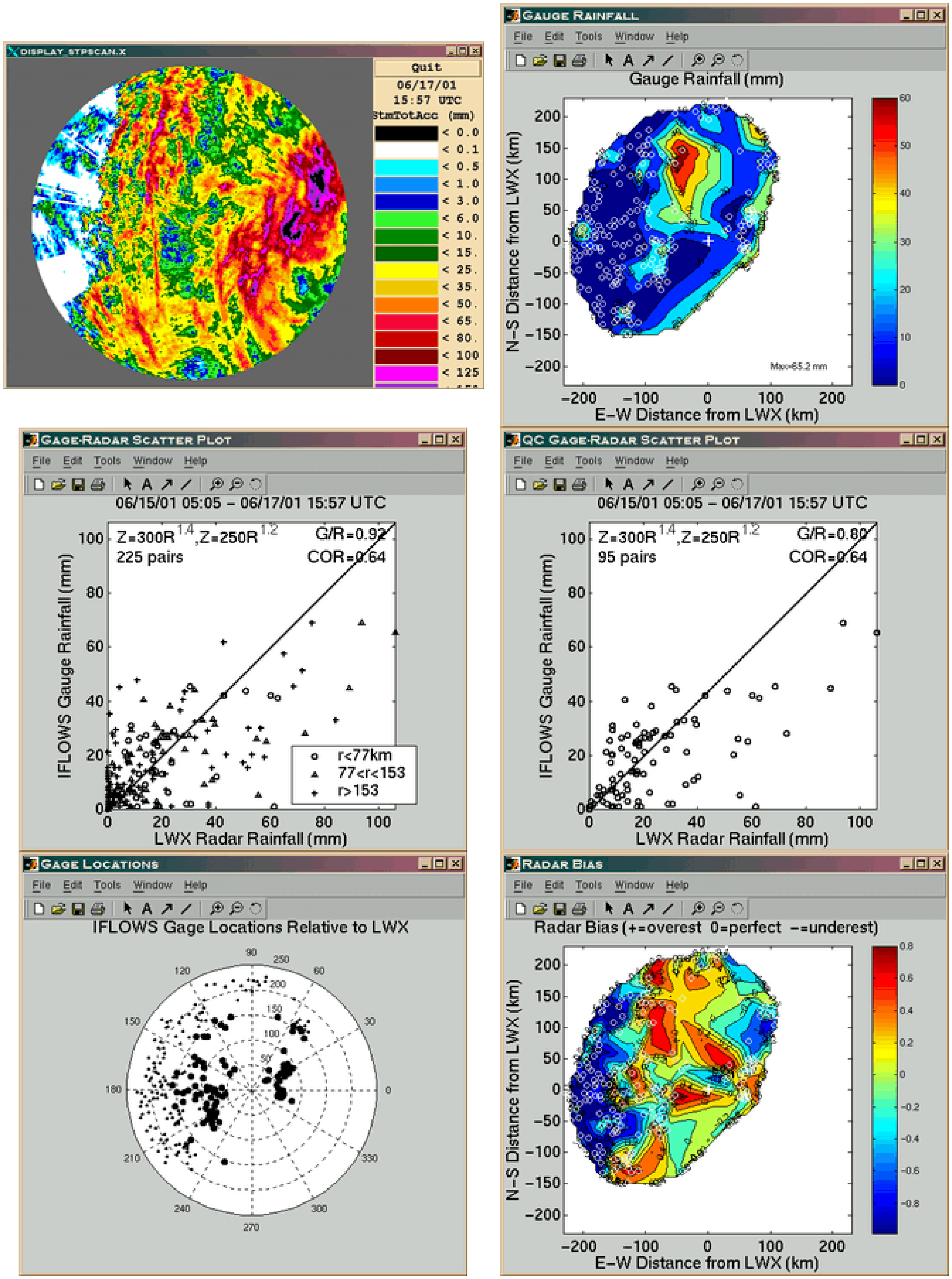

Figure 1z. June 17, 2001.

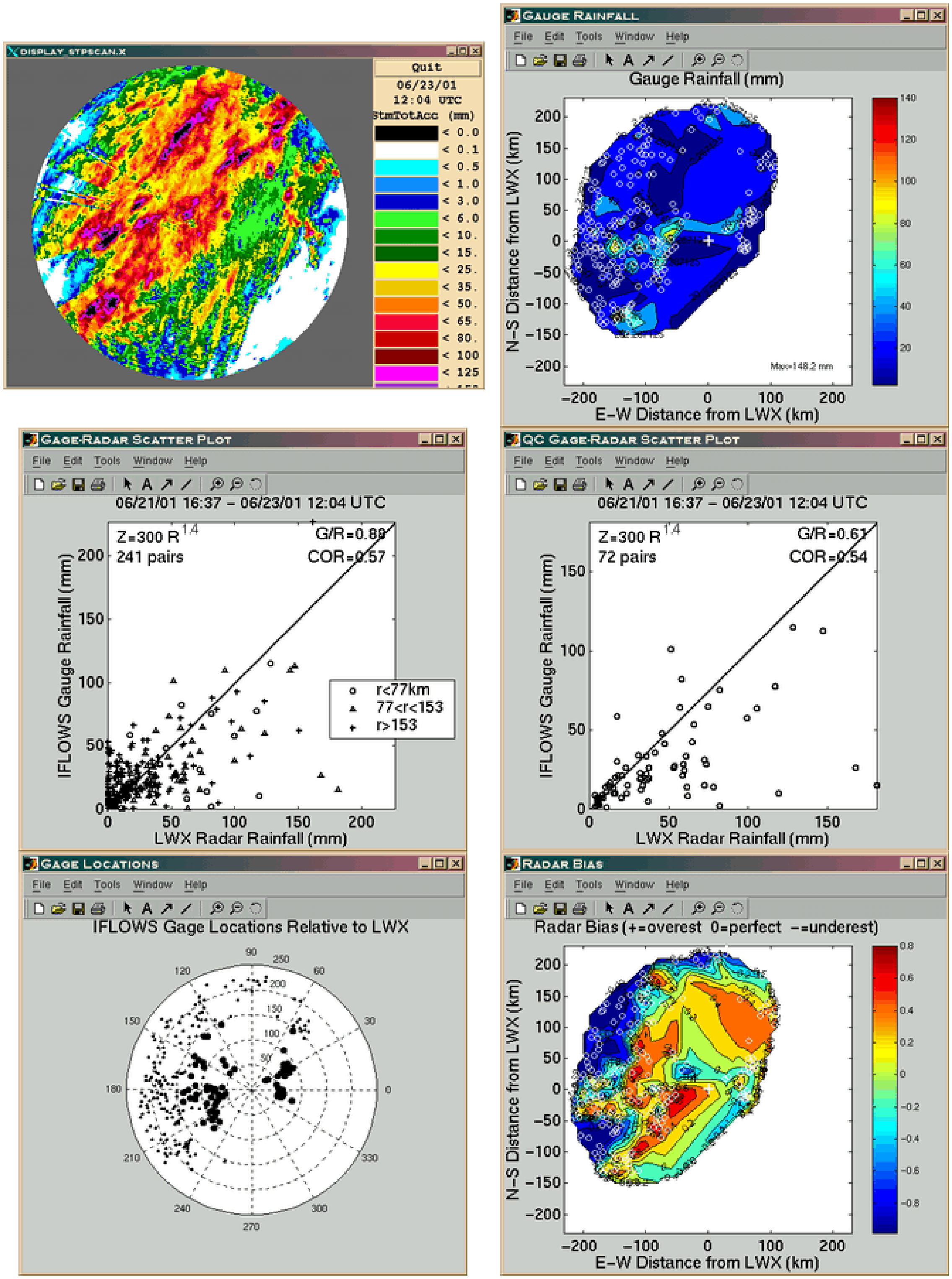

Figure 1aa. June 23, 2001.

2.3 Conclusions

The results of the analyses of 27 rainfall events from the Sterling, VA (KLWX) WSR-88D support the results from the previous year's MOU Final Report (Seo et al., 2000). The rainfall estimates appear to be improved compared with those estimates prior to the enhanced calibration by the Radar Operations Center in February 2000 when rainfall underestimation was common.

It should be understood, however, that evaluation of long-term reflectivity-based radar rainfall estimates is only one alternative way to evaluate radar calibration. There are potentially many error sources when estimating rainfall from radar reflectivity, only one of which is radar miscalibration. Improper choice of which reflectivity-rainrate relation to use is another. Additionally, errors associated with differences between point (e.g., rain gauge) and areal (e.g., radar) rainfall estimates can be large and add significant scatter in gauge-radar scatter plots, even dominant for short time scales (Ciach and Krajewski, 1999). It can often be very difficult to partition rainfall errors due to each of these effects.

References

Ciach, G. and W. Krajewski, 1999: On the estimation of radar rainfall variance, *Advances in Water Resources*, 22:6, pp. 585-595.

Seo, D.-J. and coauthors, 2000: Final Report, Interagency Memorandum of Understanding Among the NEXRAD Program, the WSR-88D Operational Support Facility, and the National Weather Service Office of Hydrology. [Available at http://www.nws.noaa.gov/oh/hrl/papers/2000mou_pdf/Mou00_PDF.html].