CHAPTER XIX. SIR-C/X-SAR

E.T. Engman
Code 974
NASA/GSFC
Greenbelt, MD 20771

A. INTRODUCTION

The Shuttle Imaging Radar-C and X-Band Synthetic Aperture Radar (SIR-C/X-SAR) (Figure XIX-l) is a cooperative space shuttle experiment between the National Aeronautics and Space Administration (NASA), the German Space Agency (DARA), and the Italian Space Agency (ASI). The experiment is the next evolutionary step in NASA's Spaceborne Imaging Radar (SIR) program that began with the Seasat Synthetic Aperture Radar (SAR) in l978, and continued with SIR-A in l98l and SIR-B in l984. It also represents a continuation of Germany's imaging radar program which started with the Microwave Remote Sensing Experiment (MRSE) flown aboard the Shuttle on the first SPACELAB mission in l983. The SIR-C/X-SAR Mission benefits from synergism with the Magellan Mission to Venus, other international spaceborne radar programs, and prototype aircraft sensors such as the JPL Airborne SAR (AIRSAR) and the German Aerospace Establishment (DLR) E-SAR.

The SIR-C/X-SAR mission extends the capability of an aircraft campaign by providing regional-scale data on a rapid temporal scale. The mission design also enables areas to be imaged at multiple aspect and incidence angles, important parameters for studying many land and ocean processes. The extensive surface measurement campaigns will provide critical data to be used in development of algorithms needed to produce key geophysical products for assessing global change issues. By having multiple flights, insights on seasonal variations for the key science issues will also be provided. Such validation and algorithm development studies are critical for developing future mission concepts.

B. RADAR SYSTEM DESCRIPTION

SIR-C provides increased capability over Seasat, SIR-A and SIR-B by acquiring digital images simultaneously at two microwave wavelengths (λ): L-band ($\lambda \cong 24$ cm) and C-band ($\lambda \cong 6$ cm). These vertically and horizontally polarized transmitted waves will be received on two separate channels, so that SIR-C will provide images of the magnitude of radar backscatter for four polarization combinations: HH (<u>H</u>orizontally transmitted <u>H</u>orizontally received), VV, HV, and VH; and also data on the relative phase difference between the HH, VV, VH and HV returns. This allows derivation of the complete scattering matrix of a scene on a pixel by pixel basis. From this scattering matrix, every polarization configuration (Linear, circular or elliptical) can be generated during ground processing (e.g. Zebker et al., l987). The radar polarimetric data will yield more detailed information about the surface geometric structure, vegetation cover, and subsurface discontinuities than image brightness alone (e.g. Elachi et al., l990). X-SAR will also operate at X-band ($\lambda \cong 3$cm) with VV polarization, resulting in a three-frequency capability for the total SIR-C/X-SAR system. The system characteristics are listed in Table XIX-1. Because radar backscatter is most strongly influenced by objects comparable in size to the radar wavelength, this multifrequency capability will provide information about the Earth's surface over a wide range of scales not discernible with previous single-frequency experiments.

C. SUPERSITE CONCEPT

The SIR-C/X-SAR Science Team has selected nineteen Supersites for intensive coverage during the mission. In addition, fifteen backup Supersites have been selected for added redundancy should operating parameters change during the mission. Interdisciplinary studies will occur at each Supersite, and in general, more than one PI will concentrate his activities at the Supersite. Table XIX-2 lists the Supersites and Backup Supersites.

Nominally, 50 hours of SIR-C/X-SAR data will be recorded onboard the shuttle during each flight. A limited amount of these data will be transmitted to ground receivers for near-real-time digital processing during the mission. Supersites will drive radar parameters and look directions during the mission and will receive priority for survey and standard product processing following the mission.

Calibration ground equipment will be deployed at the calibration Supersites in southern Germany, The Netherlands, and Australia, and at other science driven Supersites, including Chickasha, Oklahoma. Pertinent data, including the geographic locations of calibration devices at the Supersites, will be archived for use with SIR-C/X-SAR data by future investigators.

D. DATA COLLECTION

Two missions were conducted in l995, the first from April ll to l7 and the second from October 2 to 6. The second mission replaced a last second aborted mission in August. Figure XIX-2 illustrates the Shuttle data takes over Oklahoma on both the ascending and descending orbits. Table XIX-3 and XIX-4 list the shuttle data takes during these two missions. Figure XX-3 illustrates the SIR-C/X-SAR data from two days over the Chickasha Supersite (to be provided in color) and Figure XIX-4 illustrates a soil moisture product from a simple algorithm (also in color).

E. REFERENCES

Dubois, P.C., J. J. van Zyl, and E. T. Engman, 1995, Measuring soil moisture with imaging radar, IEEE Trans Geosic. Remote Sens., 33(4), 915-926.

Elachi, C., Y. Kuga, K.C. McDonald, K. Sarabandi, T.B. A. Senior, F. T. Ulaby, M. W. Whitt, Radar polarimetry for geoscience applications, F. T. Ulaby and C. Elachi editors, Artech House, Inc., 364 pp.

Zebker, H. A., J.J. van Zyl and D. N. Held, 1987, Imaging radar polarimetry from wave synthesis, Jour. Geophys. Research, 92, 683-701.

Table XIX-1. SIR-C/X-SAR System Characteristics.

Parameter	L-band	C-band	X-band
Orbital Altitude		225 km	
Wavelength	0.235 m	0.058 m	0.031 m
Resolution		20 x 30 m on the surface	
Swath Width	15 to 90 km	15 to 90 km	15 to 40 km
Look Angle Range		17 to 63 degrees from nadir	
Bandwidth		10 to 20 MHz	
Transmit Pulse Length	33.8, 16.9 and 8.5μs	33.8, 17 and 8.5μs	40μs
Pulse Repetition Rate		1395 to 1736 pulses per second	
Data Rate	90 Mb/s	90 Mb/s	45 Mb/s
Data Format	8, 4 b/word and (8,4) BFPQ	8,4 b/word and (8, 4) BFPQ	4,6 b/word
Total Science Data		50 hours/channel/ mission	
Total Instrument Mass		11000 kg	
DC Power		3000 to 9000 W	

Table XIX-2. SIR-C/X-SAR Supersites.

DISCIPLINE	SUPERSITES	BACKUP SUPERSITES
Calibration	Flevoland, The Netherlands Kerang, Australia Oberpfaffenhofen, German Western Pacific (rain experiment)	Matera, Italy Sarobetsu, Japan Palm Valley, Australia Eastern Pacific
Ecology	Manaus, Brazil Raco, Michigan Duke Forest, North Carolina	Amazon Survey, Brazil Prince Albert, Saskatchewan, Canada Howland, Maine Altona, Manitoba
Electromagnetic Theory	Safsaf, Sudan	
Geology	Galapagos Islands Sahara Death Valley, California Andes Mountains, Chile	Hawaii Saudi Arabia Hotien East, China
Hydrology	Chickasha, Oklahoma Otztal, Australia Bebedouro, Brazil Montespertoli, Italy	Mahantango, Pennsylvania Mammoth Mountain, California
Oceanography	East-North Atlantic Gulf Stream Southern Ocean	Equatorial Pacific North Sea

Table XIX-3. April mission dat takes for Shuttle for the Chickasha, Oklahoma super site.

Date	Orbit	DT	CPA/Time	Flight dir	Look dir	Look Angle	Inc Angle	Mode *
4/11	34	34	2/1:03:31	A	S	25.46	26.52	16X
4/12	50	50.1	3/0:44:37	A	S	37.75	39.32	16X
4/12	55	55.4	3/8:30:49	D	S	56.79	60.05	11X
4/13	66	66.1	4/0:25:24	A	S	46.25	48.44	16X
4/13	71	71.3	4/8:11:31	D	S	52.35	55.09	11X
4/14	82	82.1	5/0:05:54	A	S	52.16	54.81	11X
4/14	87	87.51	5/7:51:55	D	S	47.06	49.32	11X
4/15	98	98.11	5/23:46:05	A	S	56.34	59.48	11X
4/15	103	103.3	6/7:31:59	D	S	40.86	42.69	16X
4/16	119	119.2	7/7:11:44	D	S	33.84	35.27	16X
4/17	135	135.3	8/6:51:09	D	S	26.38	27.47	16X

MODE 16X: LHH, LVH, LVV, LHV, CHH, CVH, CHV, CVV, XVV
MODE 11X: LHH, LHV, CHH, CHV, XVV

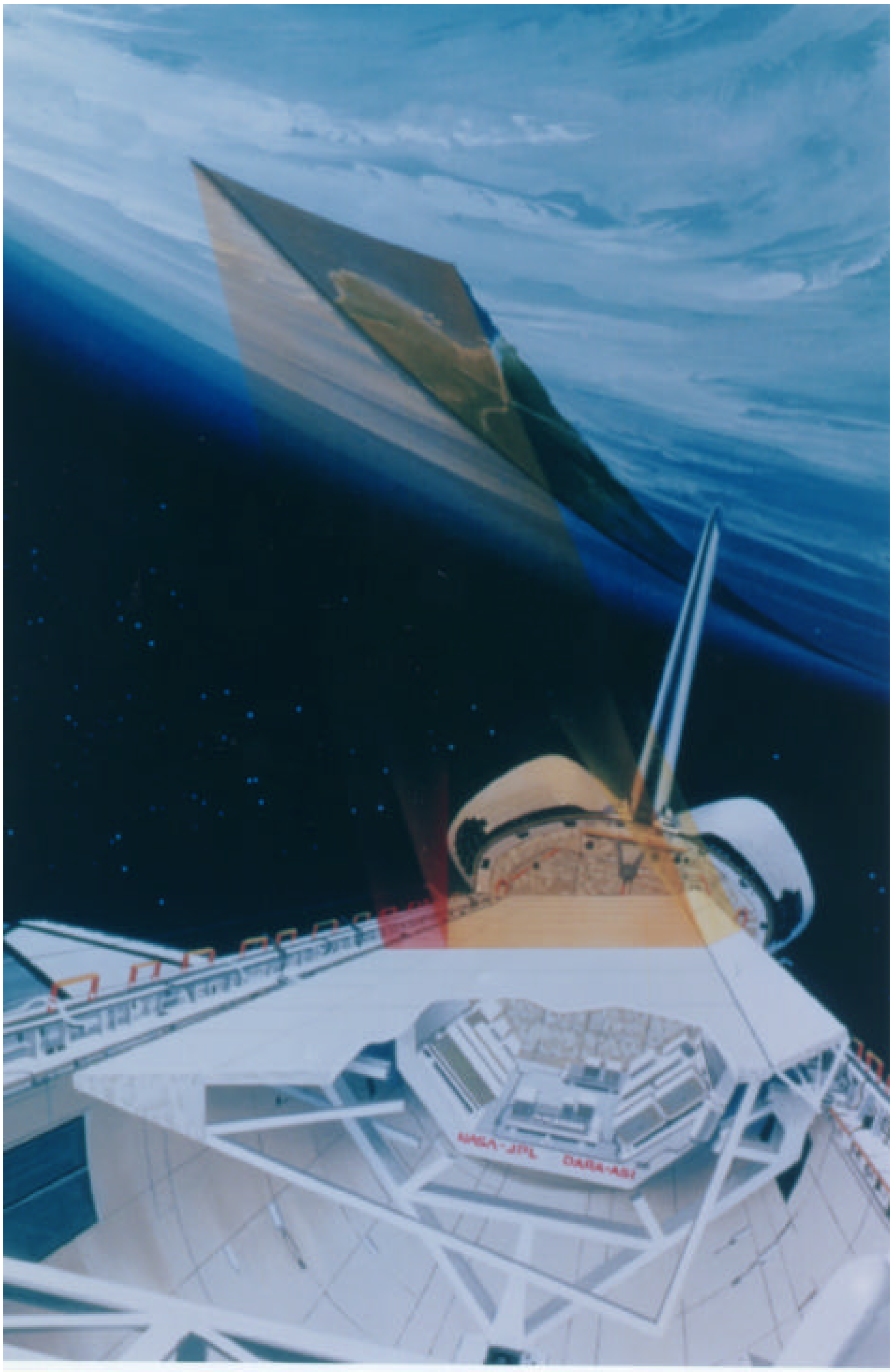

Figure XIX-1. Artist’s rendition of the deployed antenna in the Shuttle Payload Bay imaging the Earth’s surface.

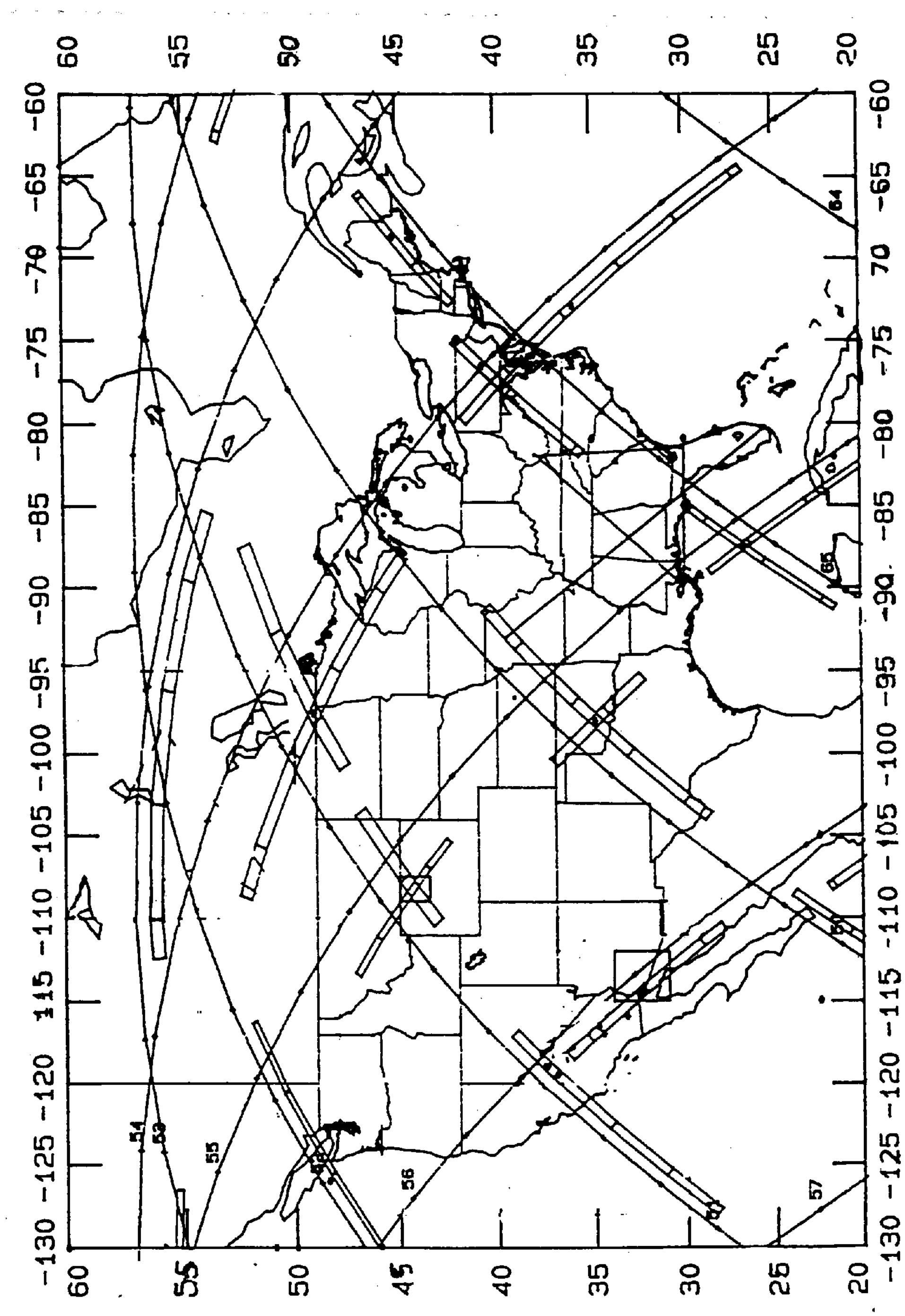

Figure XIX-2. Map illustrating shuttle tracks (solid lines) and areas where data were taken (rectangles). Note ascending (lower left to upper right) and descending (upper left to lower right) data takes cross over Chickasha.

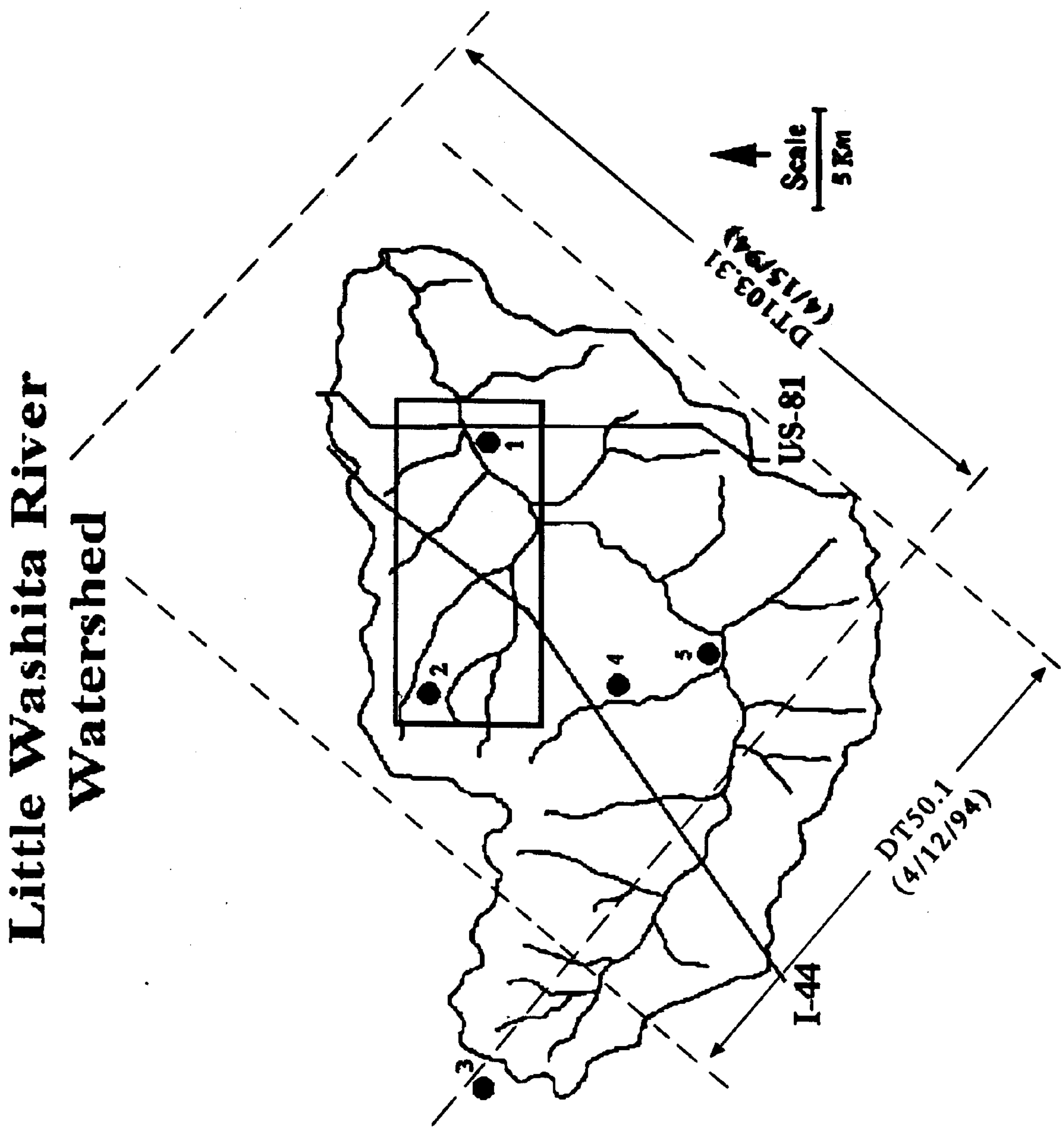

Figure XIX.3. A schematic map of the Litle Washita Watershed illustrating the radar coverage for two passes, DT50.1 and DT103.31 shown in Figure XIX-4. The numbered points refer to areas where intensive ground data were obtained. The rectangular box is the region illustrated in Figure XIX-5.

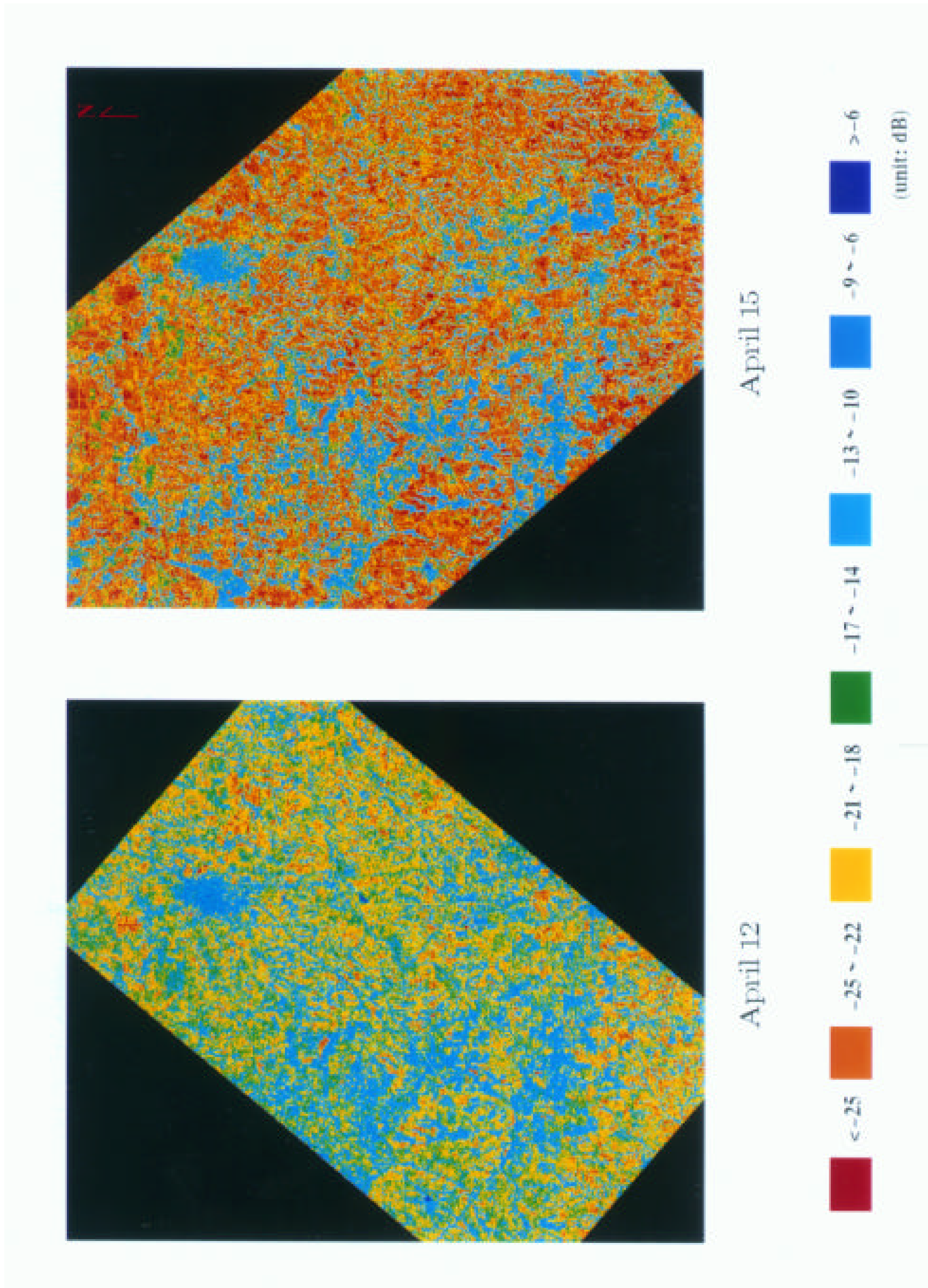

Figure XIX-4. SIR-C/X-SAR radar backscatter in decibels (dB) for two passes, DT50.1 and DT103.31. The region of the Little Washita covered is shown in Figure XIX-3.

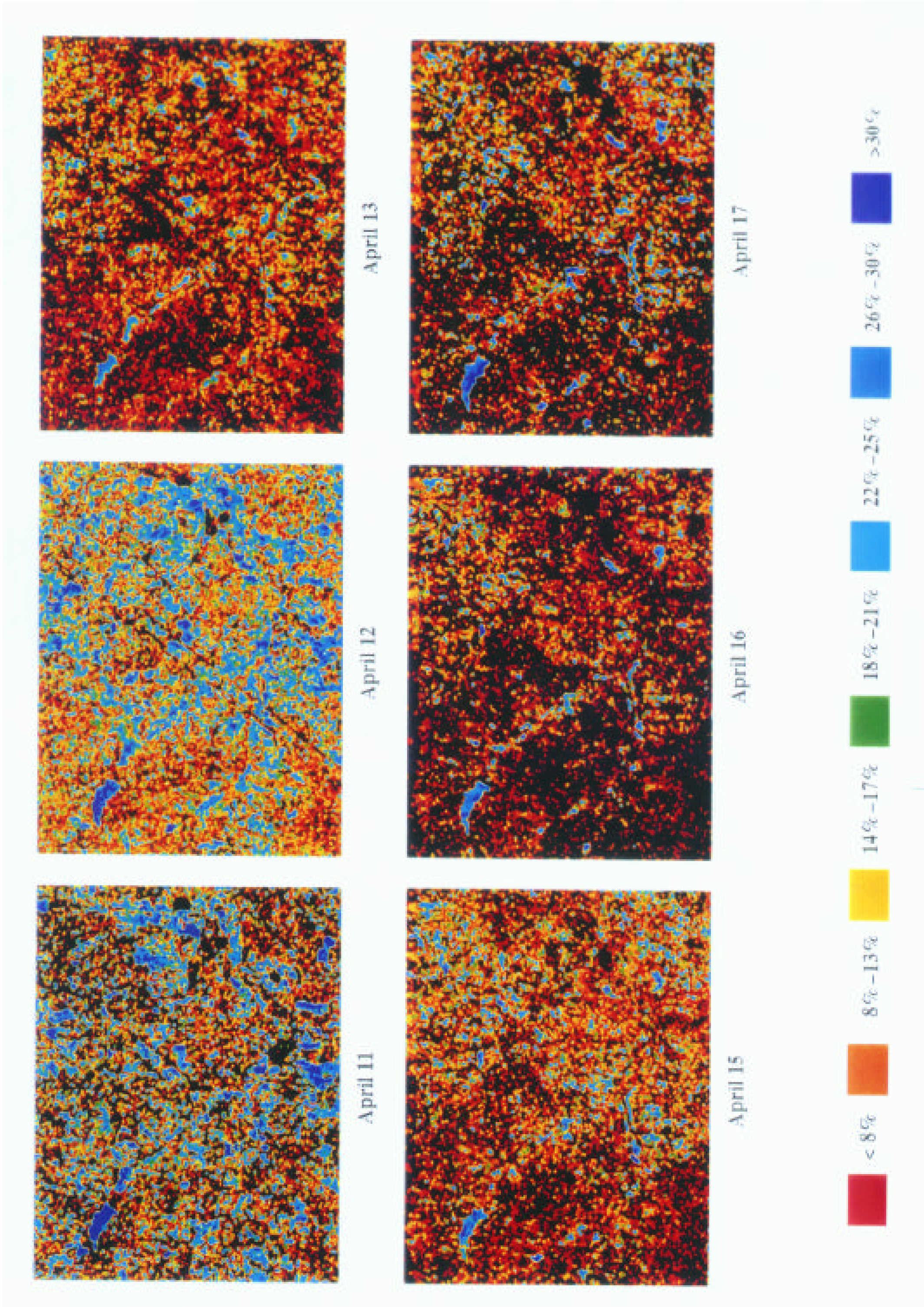

Figure XIX-5. Time series of changes in volumetric soil moisture derived from the Dubois et al (1995) algorithm for the area inside the rectangular box in Figure XIX-3.