CHAPTER XVI. C-130 INSTRUMENTS

A. INTRODUCTION

The NASA C-130 was one of the primary data collection tools used in the Washita'92 experiment. The C-130 is based out of NASA Ames Research Center in Ames, California. It is a low and medium altitude platform capable of speeds between 150 and 300 knots. For the Washita'92 experiment, the C-130 had the following operational sensors available; the NS001 multispectral scanner, the thermal infrared multispectral scanner (TIMS), and two Zeiss cameras. In addition to these instruments, the following experimental/prototype sensors were available; the electronically steered thinned array radiometer (ESTAR), a 37 GHz passive microwave radiometer, and a laser profiling system. The following sections present a brief description of each instruments and, if available, an example of the data products. Since all sensors utilized the same set of flightlines, with a few exceptions, these are described in a separate section.

B. WASHITA'92 C-130 FLIGHTLINES

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Flightline selection for the C-130 was determined primarily by the needs of the investigators utilizing the ESTAR instrument. These lines were arranged in four groups:

1. S204 - Lake Ellsworth
2. S205 - Cement Low
3. S206 - Lake Water Quality
4. S207 - Cement Block

Georeferencing of the flightlines can be accomplished using the NERDAS navigational data tape of time, latitude, longitude, and other aircraft parameters. One should note that the accuracy of this information is limited. Therefore, line coverage for S205 and S206 was also developed by using time stamped video coverage acquired during the flights. These tapes were reviewed using 1:24,000 scale maps and image data (SPOT and NS001) to determine time coverage of numerous points on each line. These points were then digitized (UTM coordinates) and recorded with the times. Due to the numerous road intersections in the region, the georeferencing accomplished using this method is considered to be quite accurate. These data flies are available in an ASCII format and the original maps used for plotting are in the possession of the Hydrology

Lab. Additional details on the flightlines are available in a series of C-130 Flight Summary Reports provided by NASA Ames that are also at the Hydrology Lab.

1. S204

Lake Ellsworth is located just southwest of the primary study site. It was flown at the beginning of each days data collection, usually around 10:00 am CST. The nominal altitude of this line was 200 m. The primary purpose of this line was the calibration of the ESTAR instrument. During the flight, thermal infrared data was also acquired with a PRT-5 thermal infrared instrument. NS001 and TIMS data were also acquired over the lake. On a few dates, ground based measurements of lake water temperatures were obtained from piers.

2. S205

The Cement Low lines, also referred to as the low level lines, were designed to provide low resolution data from instruments such as the ESTAR over ground sampling sites that would provide good calibration/verification data. Figure XVI-1 shows the location of these lines. The nominal altitude for these lines was 200 m and the ground speed was 80 m/s. In general, line was flown south to north (some exceptions), line 2 west to east, and line 3 south to north. The scan rate used by the NS001 and TIMS was not high enough to provide contiguous scan line coverage on these lines.

3. S206

These lines were designed to provide one time coverage of several lakes in the region for water quality studies. The instruments used on these lines were the NS001 and TIMS sensors. Figure XVI-2 shows the locations of these lines. The altitude was 5000 m and ground speed was 130 m/s. All lines were flown on June 13 and line 2 was also acquired on June 14.

4. S207

This group of lines, referred to as the high altitude coverage lines, were flown at a nominal altitude of 2200 m and a ground speed of 80 m/s. These lines were designed to provide overlapping coverage by the ESTAR instrument of a large study area. Figure XVI-1 shows the location of these lines. Coverage typically began at 11:00 am CST after S205 with line 5 heading from east to west. An alternating direction pattern was used with line one ending about one and a quarter hours later. Scan rates for the NS001 and TIMS were high enough to provide contiguous scan line coverage.

C. ESTAR L BAND SENSOR

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The electronically steered thinned array radiometer (ESTAR) is a synthetic aperture, passive microwave radiometer which operates at L band (21 cm, 1.4 GHz). ESTAR is a hybrid real and synthetic aperture radiometer. It employs a real aperture to obtain resolution along track and aperture synthesis to obtain resolution across track. The basic data collection parameters of the ESTAR are:

Center frequency	1.4 GHz
Polarization	Horizontal
Resolution	+/- 4 degrees (both along and across)
Swath Width	+/- 45 degrees
Bandwidth	25 MHz
Integration Time	0.25 seconds

Additional details on the ESTAR instrument can be found in Le Vine et al. (1990). Application to soil moisture mapping is described in Jackson et al. (1993).

ESTAR raw data consists of 15 correlator outputs plus records of instrument status (i.e. temperature and internal calibration) and time. These data are reduced to traces at specific look angles. For large scale mapping, angular and temporal temperature variations are filter out using accepted methods (Schmugge et al., 1992). Figure XVI-3 presents preliminary brightness temperature maps acquired by the ESTAR on the first and last flight dates. These images clearly reflect the general soil moisture conditions on each date and spatial patterns that are likely to be associated with regional soil texture variations.

D. NS001 SENSOR

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1. Bands and specifications

The NS001 multispectral scanner operates in the seven Landsat-D Thematic Mapper bands plus a band from 1.13 to 1.35 /m. The nominal bandwidths are as follows:

Band	Spectral bandwidth, /m
1	0.458 - 0.519
2	0.529 - 0.603
3	0.633 - 0.697
4	0.767 - 0.910
5	1.13 - 1.35
6	1.57 - 1.71
7	2.10 - 2.38
8	10.9 - 12.3

Sensor specifications are:

IFOV:	2.5 mrad
Ground Resolution:	7.6 meters at 3000 meters
Total Scan Angle:	100^o
Swath Width:	7.2 km at 3000 meters
Pixels/Scan Line:	699

2. Data Collected

A summary of the NS001 data acquired along the long east-west flight lines is given below. The flight lines given below are those shown in Figure XVI-1, and are those referred to in Section A as the S207 set. On each of the days listed below, NS001 data were also recorded during some of the low altitude flightlines designed specifically for coverage by other instruments. As described in the description of flightlines in Section (A) of this chapter, the scan rate used by the NS001 was not high enough to provide contiguous scan line coverage on these lines. The data on the low altidude lines may be useful for specific applications, but do not provide overall coverage of extensive areas. Data acquired along the flightlines listed below provide good overall coverage of the study area by the NS001 when weather permitted. Unfortunately, due to the prevailing conditions during most of the experiment, much of the NS001 data were acquired under partly cloudy conditions. The best weather conditions for optical data acquisition occurred on June 18. A false color composite of NS001 bands 4,3 and 2 (displayed in the red, green and blue displays, respectively) over the agricultural sites on low line 3 on that day is shown in Figure XVI-4.

Day	Time	Flightlines	Alt(m)	General weather quality
10 June	11:25-12:40	High 1-5	2100	Partly cloudy
11 June	12:00-13:10	High 1-5	2200	Partly cloudy
12 June	10:40-11:50	High 1-5	2200	Very cloudy
13 June	11:10-12:20	High 1-5	2100	Partly cloudy
	13:00-13:50	High 1-5	4570	Partly cloudy
14 June	9:30-10:30	High 1-5	2200	Partly cloudy
	10:45-11:20	High 2,4	4570	Partly cloudy
17 June	9:30-9:40	High 5	2100	Partly cloudy
18 June	9:55-12:15	High 1-5	2100	Good
	12:30-13:00	High 1,3,5	4570	Good

3. Data calibration and atmospheric correction

For some applications of NS001 data, it will be desirable to apply atmospheric corrections to the NS001 data and compare the resulting reflectances and temperatures to ground-based measurements of such. One of the purposes for the acquisition of the ground-based optical remote sensing data described in Chapter XI was to have measurements of ground-based reflectances and temperatures acquired over at least one ground field site near-simultaneously with NS001 overpasses for these comparisons. As described in Chapter XI, measurements were also made near overpass with a hand-held sun photometer, providing a limited estimate of atmospheric parameters required for deriving atmospheric corrections.

E. THERMAL INFRARED MULTISPECTRAL SCANNER - TIMS

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TIMS is a six channel NASA aircraft scanner operating in the thermal infrared (8 to 12 /m)region of the electromagnetic spectrum (Kahle and Abbot, 1985). The approximate bandwidths of the channels are (in /m):

Band	Bandwidth,
1	8.2 - 8.6
2	8.6 - 9.0
3	9.0 - 9.4
4	9.4 - 10.2
5	10.2 - 11.2
6	11.2 - 12.2

The actual response functions as measured in December 1991 are shown in Figure XVI-5. It has a 2.5 mrad IFOV, 77° FOV spread over 638 pixels. The scan rate can be varied from 7.3 to 25 scans/second in four steps. For the 2000m altitude flights the scan rate was set at 25/sec. At a typical aircraft speed of 80 m/sec this provided complete coverage at this altitude passes and about 25% coverage for the 300 m passes. Thus from an altitude of 1500 m the pixel size is 3.75 m and the cross track separation is 3.2 m at nadir. The swath width and resoulutions are given below for several altitude.

ALTITUDE AGL, km	SWATH WIDTH, km ±30° of Nadir	RESOLUTION m
2	2.3	5
4	4.6	10

For calibration, the system is equipped with cold and warm reference sources or blackbodies, approximately covering the temperature range of interest. For most of Washita-92 the temperature separation between the two references was set at 20C. All pixels are assigned a digital count value between 0 and 256 (DN). Reference source 1 is scanned at the beginning, and the second at the end of a line. The reference temperatures are known to better than 0.5 K (Palluconi and Meeks, 1985).

TIMS coverage was obtained for 80 data lines during 8 days of flights for Washita-92 between 10 June and 18 June 1992. The table of coverage given in the previous section for the NS001 applies to TIMS also. An example of the data is shown if Figure XVI-4 where samples of both the NS001 and TIMS data are shown. For the latter bands 2,4, and 6 were applied to the blue, green, and red guns of the display. The basic structure in the TIMS images is due to the temperature differences, with the vegetated fields generally being cooler, i.e. darker and the bare soils being warmer, i.e. lighter. In the bare fields there is occasionally some color due to the emissivity differences amongst the channels shown as seen in field AG001. For quartz rich soils, the lower 3 channels will have lower emissivities. These spectral emissivity differences can be used for mineral discriminations.

F. 37 GHZ DUAL-POLARIZED RADIOMETER

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The 37 GHz dual polarized radiometer was built recently to better understand the observations acquired by the scanning multichannel microwave radiometer (SMMR) on board the Nimbus-7 satellite operated from November, 1978 to August, 1987 and the special sensor microwave imager (SSM/I) on board the F-8, F-10, and F-11 satellites which have operated since July, 1987.

The radiometer measures both the horizontal and vertical polarizations simultaneously. The signal from the antenna is split by an orthogonal coupler into two identical circuits, one for each polarization. The radiometer does not use hot and cold loads, as typically used in radiometers. The signal strength is measured by the noise injection method; a noise of known strength is injected into the signal path to counter the strength of the incoming signal (null method). Radiometer specifications are as follows:

Center frequency	37 GHz
Bandwidth	900 MHz
3 dB beamwidth	6^o
Beam efficiency	92%
Polarizations	Orthogonal dual
Integration time	0.2 s
Sensitivity	1^oK

Washita '92 was the 37 Ghz radiometer's first airborne mission. It was in operation during most of the flights conducted using the ESTAR radiometer. Data quality analysis is still ongoing.

G. AIRBORNE LASER PROFILER MEASUREMENTS AT WASHITA '92

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1. Introduction

The landscape has complex patterns of vegetation and soils on a changing topography (Forman & Godron, 1986). These surface patterns influence the function of the landscape and must be understood and quantified to improve our management of natural resources. The distribution of surface patterns can be mapped from the ground or by using aerial photography or satellite imagery. However, determining the physical properties of these patterns with conventional ground-based technology is difficult, time consuming, often expensive, and usually limited to samples of small areas.

Laser technology is used routinely to measure distances along survey lines. When this technology is adapted to aerial surveys (Jepsky, 1986), rapid and accurate assessment of land surface profiles can be made. Airborne laser altimeters have been used for mapping sea ice roughness (Ketchum, 1971), topography (Krabill et al., 1984), vegetation characteristics (Schreier et al., 1985; Nelson et al., 1988; Ritchie et al., 1992; Ritchie and Weltz, 1992; Menenti and Ritchie, 1992), water depths (Penny et al., 1989), and gullies (Ritchie and Jackson, 1989). This paper provides a compilation of information on the laser altimeter measurements made during Washita'92 at the Little Washita River Watershed (June 10-18, 1992). Graphical examples of the airborne laser data are also provided.

2. Methods and Materials

A laser altimeter (profiler) mounted on the NASA C-130 is used to measure the distance from the airplane to the landscape surface as defined by any object (i.e., soil, rock, vegetation, man-made structure) reflecting the laser pulse (Ritchie & Jackson, 1989). The altitude of the airplane was around 500 ft with speeds around 150 knots (77 m per second). The instrument is a pulsed gallium-arsenide diode laser, transmitting and receiving 4000 pulses per second at a wavelength of 904 nm. Under these operating conditions, a laser measurement from the airplane to landscape surface occurs at horizonal intervals of 0.019 m along the flight path. The timing mechanism of the laser receiver allows a vertical recording precision of 0.05 m for a single measurement. Under controlled laboratory conditions, the standard deviation of the laser measurements of a stationary object is between 0.10 and 0.11 m and is constant for distances between 50 and 300 m.

Digital data from the laser receiver are recorded with a portable computer. Data from a gyroscope and an accelerometer are recorded simultaneously and are used to correct the laser data for airplane motion. A video camera, borehole-sighted with the laser, records a visual image of the flight path. A video frame is recorded 60 times per second and each frame is annotated with consecutive numbers and clock time. The video frame number is also recorded simultaneously with the digital laser data to allow precise location of the laser data on the landscape with the video data.

Landscape surface elevation is calculated for each laser measurement based on aircraft motion and known elevations along the flight path. The minimum elevations (maximum laser measurements) along a laser flight path are assumed to be ground surface elevation with measurements above these minimums being due to vegetation or man-made structures. In areas of vegetation, the minimum values (ground surface) are estimated by calculating a moving minimum elevation over a preselected number of laser measurements. Some manual editing of these minimum elevations is required in areas of dense vegetation cover.

3. Data Collected

Table XVI-1 list the laser altimeter transects measured with date, line number, and the frame numbers associated with the laser data.

Table XVI-2 lists the laser altimeter transects and give the GMT associated time so that the laser data may be associated with other data collected by the C-130.

TABLE XVI-1. List of Laser Altimeter Transect Measurement.

	WATERSHED	LASER FILE	DATE	LINE	LASER FRAME#s
1.	Little Washita	OK92-03.dat	06/10/92	L1 R2	92-6953
2.	Little Washita	OK92-13.dat	06/10/92	L2 R1	40-4779
3.	Little Washita	OK92-14.dat	06/10/92	L3 R1	30-4775
4.	Little Washita	OK92-04.dat	06/11/92	L1 R2	5616-3777
5.	Little Washita	OK92-05.dat	06/11/92	L2 R2	22093-28817
6.	Little Washita	OK92-06.dat	06/11/92	L3 R2	13399-19500
7.	Little Washita	OK92-08.dat	06/12/92	L1 R1	17361-8528
8.	Little Washita	OK92-09.dat	06/12/92	L2 R1	0-9254
9.	Little Washita	OK92-15.dat	06/12/92	L3 R1	0-8000
10.	Little Washita	OK92-22.dat	06/14/92	L1 R1	18947-7599
11.	Little Washita	OK92-23.dat	06/14/92	L2 R1	241-9748
12.	Little Washita	OK92-24.dat	06/14/92	L3 R1	118-9600
13.	Little Washita	OK92-31.dat	06/17/92	L1 R1	177-5982
14.	Little Washita	OK92-32.dat	06/17/92	L2 R1	350-7972
15.	Little Washita	OK92-33.dat	06/17/92	L3 R1	179-7390
16.	Little Washita	OK92-35.dat	06/18/92	L1 R1	127-7309
17.	Little Washita	OK92-36.dat	06/18/92	L2 R2	91-9000
18.	Little Washita	OK92-37.dat	06/18/92	L3 R2	89-9692

TABLE XVI-2: List of Laser transects with starting/ending times

LASER FILE	LASER FRAME START	GMT TIME START	LASER FRAME END	GMT TIME END
OK92-03	92	162:15:45:11:854	6953	162:15:49:00:704
OK92-13	40	162:15:57:52:817	4779	162:16:00:58:369
OK92-14	30	162:16:07:35:517	4775	162:16:10:13:842
OK92-04	5616	163:16:13:54:494	3777	163:16:16:02:822
OK92-05	22093	163:16:26:13:967	28817	163:16:29:58:325
OK92-06	13399	163:16:43:08:333	19500	163:16:46:35:207
OK92-08	17361	164:15:07:45:349	8528	164:15:12:31:702
OK92-09	0	164:15:17:15:186	9254	164:15:22:23:962
OK92-15	0	164:15:26:01:747	8000	164:15:30:28:681
OK92-22	18947	166:13:54:28:917	7599	166:13:58:48:205
OK92-23	241	166:14:04:15:016	9748	166:14:09:32:234
OK92-24	118	166:14:13:58:634	9600	166:14:19:15:018
OK92-31	177	169:14:59:02:287	5982	169:15:02:15:981
OK92-32	350	169:15:06:21:310	7972	169:15:10:35:632
OK92-33	179	169:15:14:35:222	7390	169:15:18:35:830
OK92-35	127	170:15:14:09:599	7309	170:15:18:11:942
OK92-36	91	170:15:21:49:260	9000	170:15:26:46:256
OK92-37	89	170:15:31:33:179	9692	170:15:36:53:600

1. Examples

Three examples are given of the laser altimeter data collected during Washita '92. The examples were chosen randomly and are assumed to be representative of the laser altimeter data collected.

Figure XVI-1 is laser altimeter data collected on June 18, 1992 from WASHITA '92 low level line 1 and is part of the profile collected in OK92-35 (Table XVI-1 and XVI-2). The data shown in the figure are for a 7 measurement block average of the laser measurements. The particular section shown is for a 900 m transect near meteorological site 1 (MS001). It is estimated that the meteorological station is 25 to 50 m west of the actual transect shown in Fig. XVI-1. The laser altimeter transect was made from south to north. Trees are evident along a stream channel and in a field south of the road west out of Cyril. The landscape rises north of the road and then decreases again as it move into the Little Washita River Valley. The laser transect then cross the upper end of a small lake on the Little Washita River. Since it is a infrared laser, the water gave a flat response.

Figure XVI-2 is laser altimeter data collected on June 18, 1992 from WASHITA '92 low level line 3 and is part of the profile collected in OK92-37 (Table XVI-1 and XVI-2). The data shown in the Figure XVI-2 are for a 50 m transect of the fallow agriculture site (AG002). In Fig. XVI-2a the actual laser altimeter data are shown with no corrections or analyses. In Fig. XVI-2b an 11 measurement moving average has been used to reduce the random and laser system noise (McCuen and Snyder, 1986) and to enhance a pattern that probably represents the soil surface roughness.

Figure XVI-3 is laser altimeter data collected on June 18, 1992 from WASHITA '92 low level line 3 and is part of the profile collected in OK92-37 (Table XVI-1 and XVI-2). The data shown in the Figure XIV-3 are for a 120 m transect of the corn field at the agriculture site (AG001). In Fig. XVI-3a the actual laser altimeter data are shown with no corrections or analyses. In Fig. XVI-3b an 11 measurement moving average has been used to reduce the random and laser system noise and to enhance a pattern of the corn canopy and row structure. The transect begins on the field road south of the corn field.

5. Conclusions

Laser altimeter measurements along the 3 WASHITA'92 low level flightline have provided information about the pattern of landscape micro- and macro-topography, drainage features, and ground cover. The data will be analyzed to the quantify landscape topography, vegetation canopy, and stream and gully cross section. Measurements of the topography and vegetation properties and their distribution across the landscape will be used to estimate aerodynamic roughness. Such measurements should provide valuable data for understanding the landscape of the Little Washita River Watershed.

H. AERIAL PHOTOGRAPHY.

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Aerial photography was acquired on selected dates using the Dual Zeiss cameras on the C-130. One camera (305 mm focal length) used natural color film and the other (153 mm focal length) color infrared. Coverage is described in Table XVI-3.

I. REFERENCES

Forman, R.T.T. and Godron M. 1986. Landscape Ecology. John Wiley and Sons, New York, 619 pp.

Jackson, T. J., Le Vine, D. M., Griffis, A., Goodrich, D. C., Schmugge, T. J., Swift, C. T., and O'Neill, P. E. 1993. Soil moisture and rainfall estimation over a semiarid environment with the ESTAR microwave radiometer. IEEE Trans. on Geosci. and Remote Sensing, in press.

Jepsky, J. 1986. Airborne laser profiling and mapping systems come of age. Technical Papers of the 1986 ACSM-ASPRS Annual Convention, Vol. 4, p. 229-238.

Kahle, A.B. and Abbott, E. 1986. TIMS data users workshop, June 18-19, 1985, NASA,JPL.

Ketchum, R.D., Jr. 1971. Airborne laser profiling of the Arctic pack ice. Remote Sensing Environ. 2:41-52.

Krabill, W.B., Collins, J.G., Link, L.E., Swift, R.N., and Butler, M.L. 1984. Airborne laser topographic mapping results. Photogr. Engr. and Remote Sensing 50:685-694.

Le Vine, D. M., Kao, M., Tanner, A. B., Swift, C. T., and Griffis, A. 1990. Initial results in the development of a synthetic aperture microwave radiometer. IEEE Trans. on Geosci. and Remote Sensing, vol. GE-28, pp. 614-619, 1990.

McCuen, R.H. and Snyder, W.M. 1986. Hydrologic Modeling: Statistical Methods and Applications. Prentice-Hall, Englewood, NJ, 568 pp.

Menenti, M. and Ritchie, J.C. 1992. Estimation of effective aerodynamic roughness with altimeter measurements. IGARRS'92 Proceedings Vol. II, pp. 1508-1510.

Nelson, R, Krabill, W., and Tonelli, J. 1988. Estimating forest biomass and volume using airborne laser data. Remote Sensing of Environ. 24:247-267.

Pallunconi, F. and Meeks, G. R. 1985. Thermal infrared multispectral scanner (TIMS): an investigator's guide to TIMS data, NASA, JPL.

Penny, M.F., Billard, B., and Abbot, R.H. 1989. LADS-the Australian Laser Airborne Depth Sounder. Int. J. Remote Sensing 10:1463-1479.

Ritchie, J.C., Everitt, J.H., Escobar, D.E., Jackson, T.J., and Davis, M.R. 1992. Airborne laser measurements of rangeland canopy cover. J. Range Management 45:189-193.

Ritchie, J.C. and Jackson, T.J. 1989. Airborne laser measurements of the surface topography of simulated concentrated flow gullies. Trans. Amer. Soc. Agr. Eng 32:645-648.

Ritchie, J.C. and Weltz, M.A. 1992. Using an airborne laser to measure vegetation properties. Technical Papers of the 1992 ACSM-ASPRS Annual Convention, Vol. 4, p. 395-405.

Schmugge, T. J., Jackson, T. J., Kustas, W. P., and Wang, J. R. 1992. Passive microwave remote sensing of soil moisture: results from HAPEX, FIFE and MONSOON'90. ISPRS J. of Photo. and Rem. Sens., vol. 47:127-143.

Schreier, H., Lougheed, J., Tucker, C., and Leckie, D. 1985. Automated measurement of terrain reflection and height variations using an airborne laser system. Int. J. Remote Sensing 6:101-113.

Table XVI-3. Washita '92 Aerial Photography Coverage

Date	Site	Line	Run	Altitude (m)	Cloud Coverage (%)	Film/Focal Length Code[1] and (Product Quality Code[2])
June 13	S205	1	2	2300	10	1(E), 2(F)
	S205	3	2	2300	10 - 20	1(E), 2(F)
	S207	1	1	2300	10	1(E), 2(F)
	S206	2	1	5000	50 - 70	3(F), 4(G)
	S206	1	1	5000	30 - 60	3(F), 4(G)
	S207	4	2	5000	10 - 80	3(F), 4(G)
	S207	2	2	5000	10 - 80	3(F), 4(G)
	S206	3	1	5000	10	3(F), 4(G)
June 14	S207	1	1	2300	0 - 30	3(E), 4(F)
	S207	2	2	4900	0 - 60	3(E), 4(F)
	S207	4	2	4900	30 - 50	3(E), 4(F)
	S206	2	1	4900	10 - 50	3(E), 4(F)
June 18	S205	3	2	1000	0	3(E), 4(F)
	S207	5	2	4900	0	3(E), 4(F)
	S207	3	2	4900	0	3(E), 4(F)
	S207	1	2	4900	0	3(E), 4(F)

1/ Film/Focal Length Codes: (1) Color-153 mm, (2) Color IR-305 mm, (3) Color-305 mm, and (4) Color IR-153 mm.
2/ Quality Codes: (E) Excellent, (G) Good, (F) Fair, and (P) Poor.

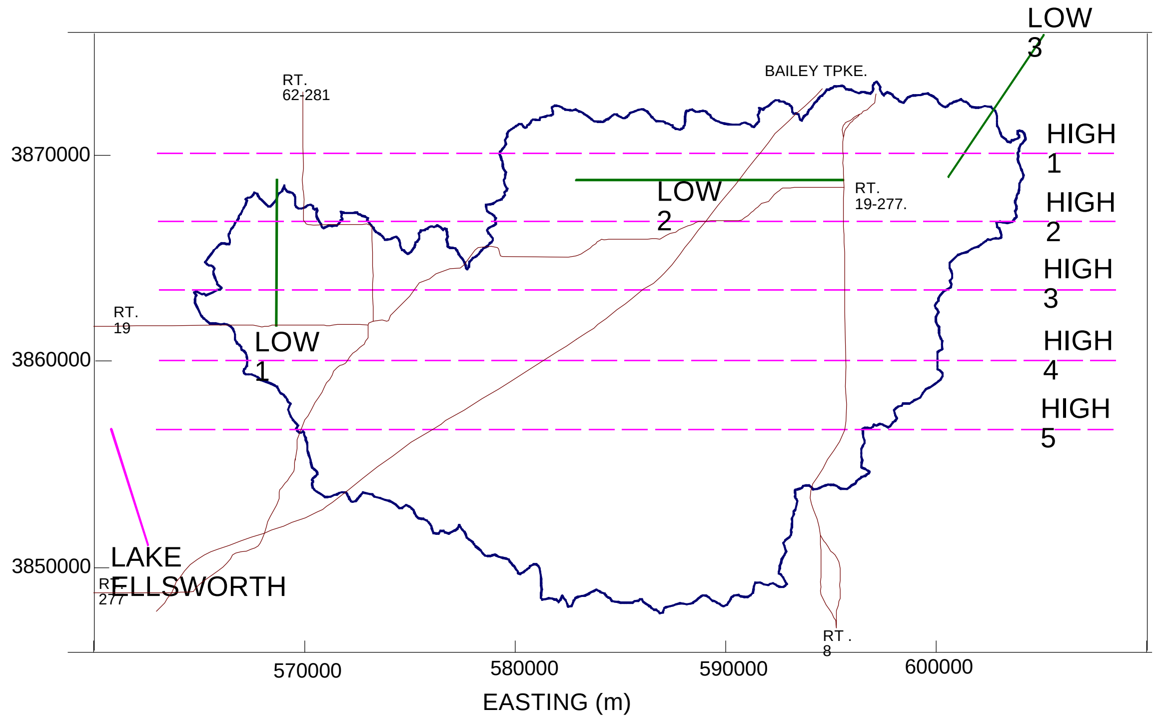


Figure XVI-1. Washita'92 C-130 Flightlines

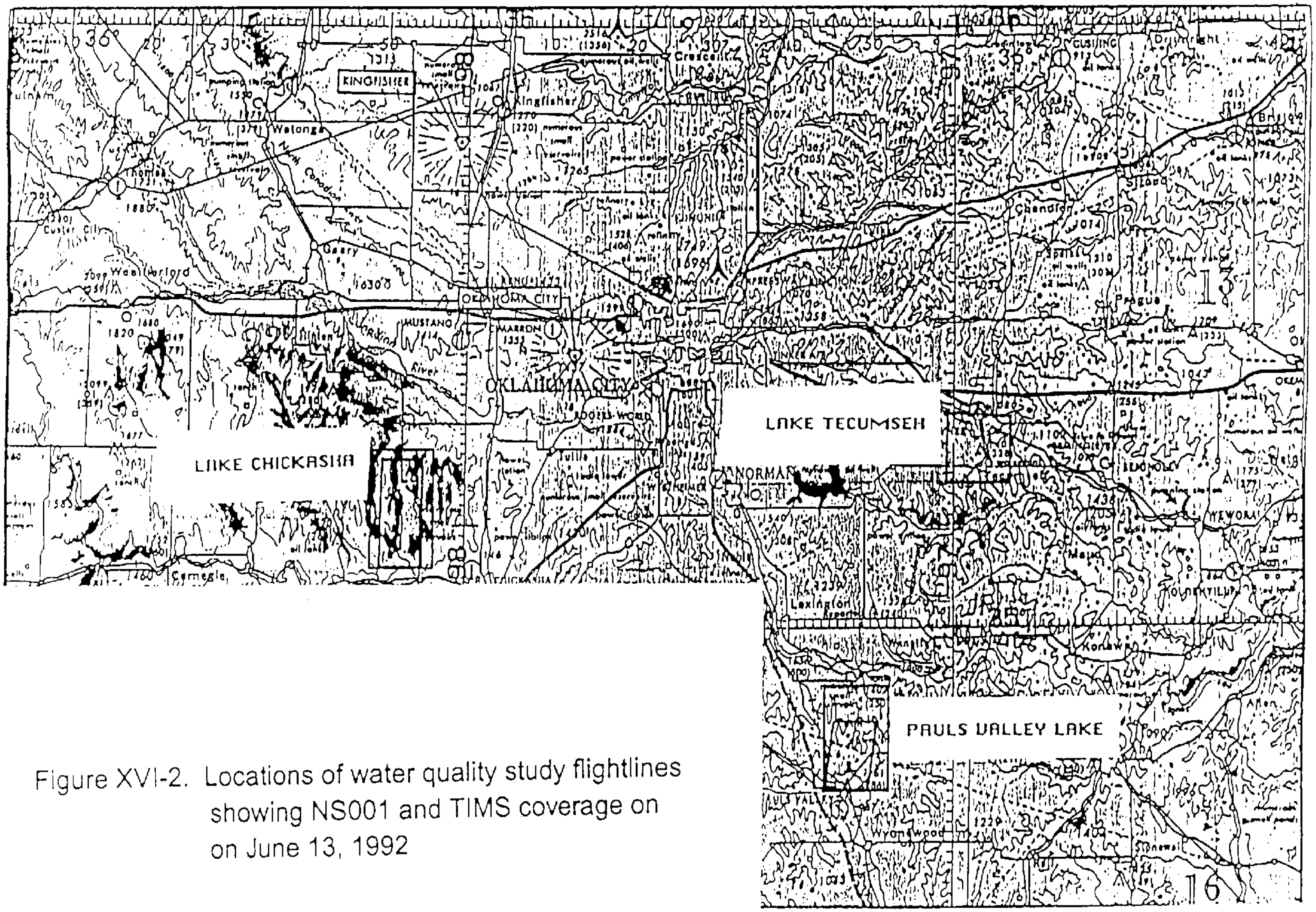
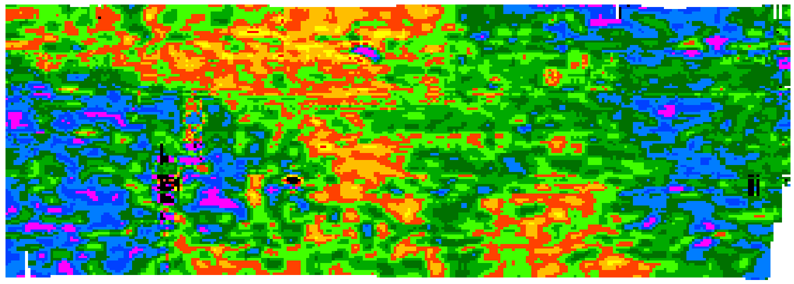
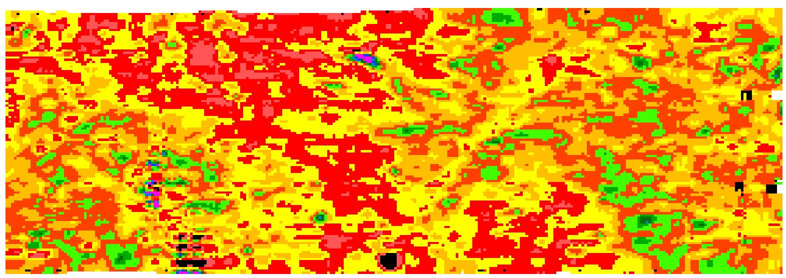


Figure XVI-2. Locations of water quality study flightlines showing NS001 and TIMS coverage on on June 13, 1992



A - June 10

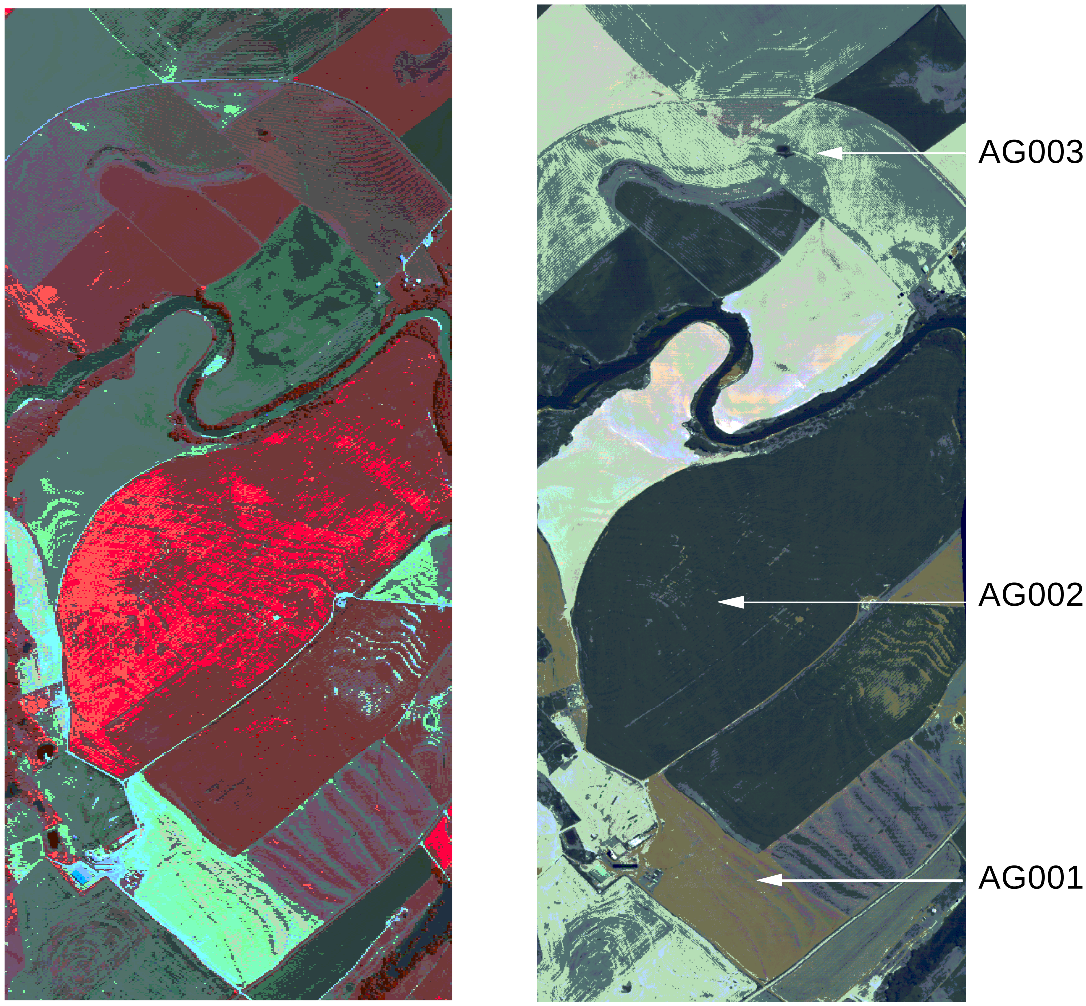


B - June 18

<180 190 200 210 220 230 240 250 260 270 280

Brightness Temperature (K)

Figure XVI-3. Brightness temperature images for the ESTAR study area of Washita '92; A) June 10, 1992 and B) June 18, 1992.



A - NS001 B - TIMS

Figure XVI-4. Aircraft NS001 and TIMS data obtained over low line 3 at 1000 m on June 18, 1992

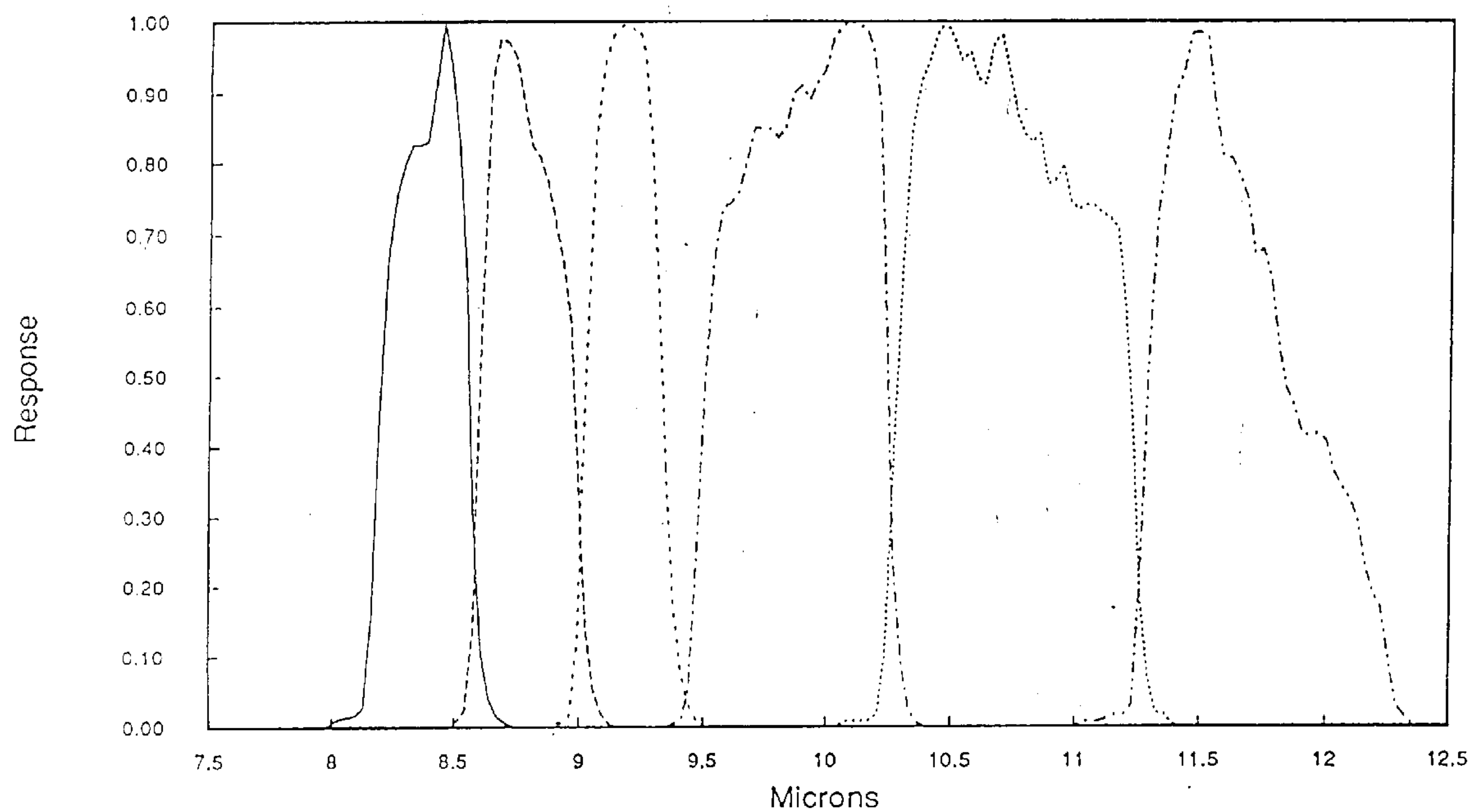


Figure XVI-5. TIMS response functions using calibration in effect on June 10, 1992.

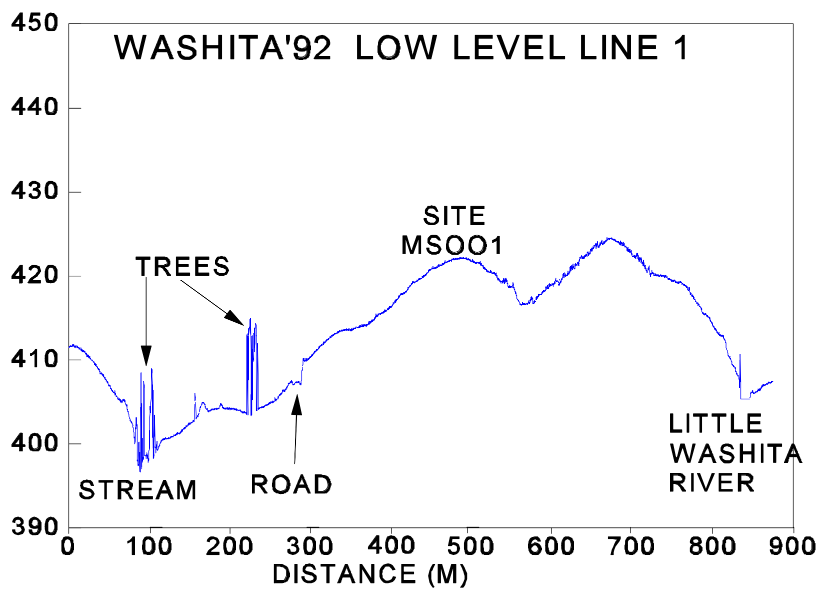


Figure XVI-6. Laser altimeter data from site MS001

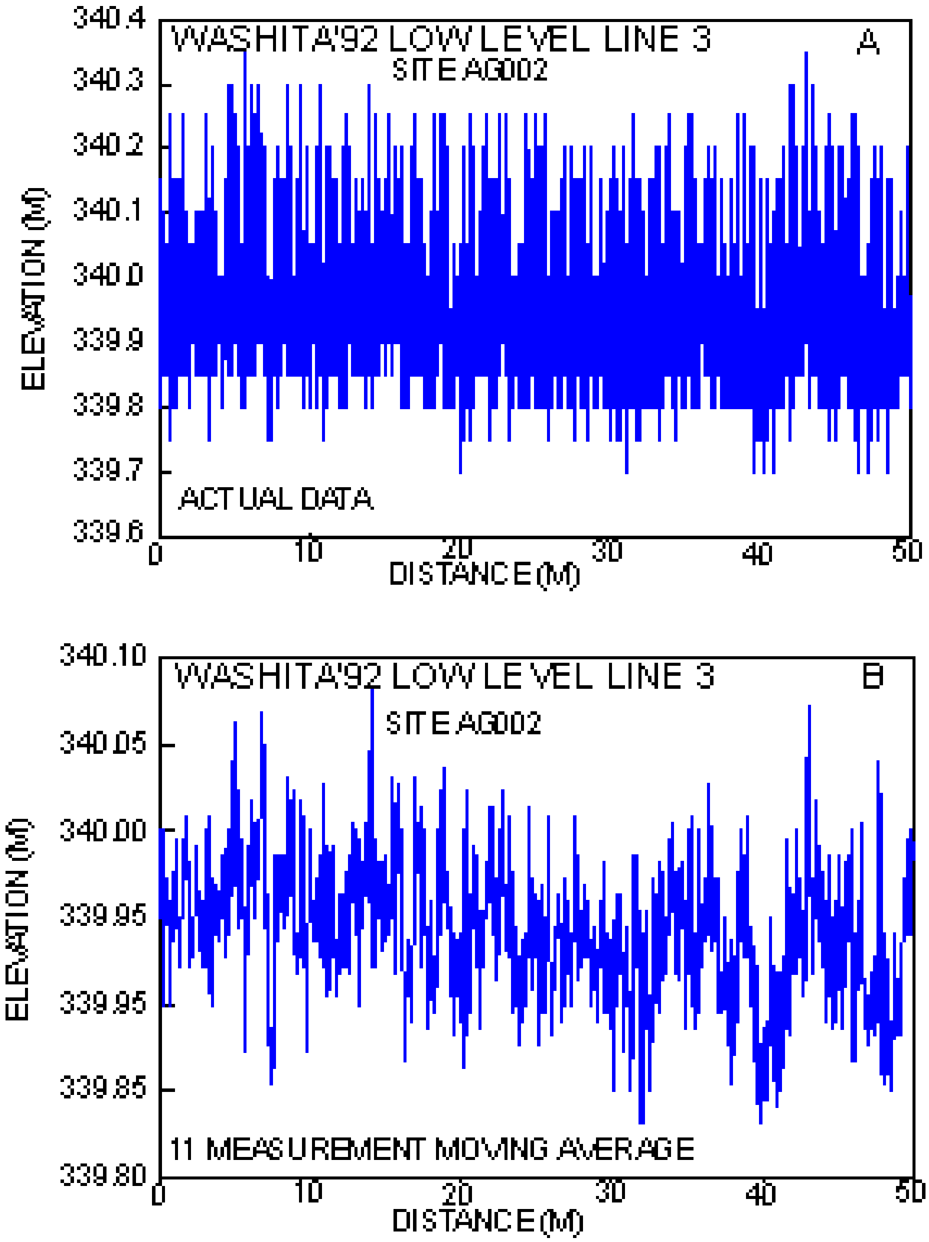


Figure XVI-7. Laser altimeter data from site AG002

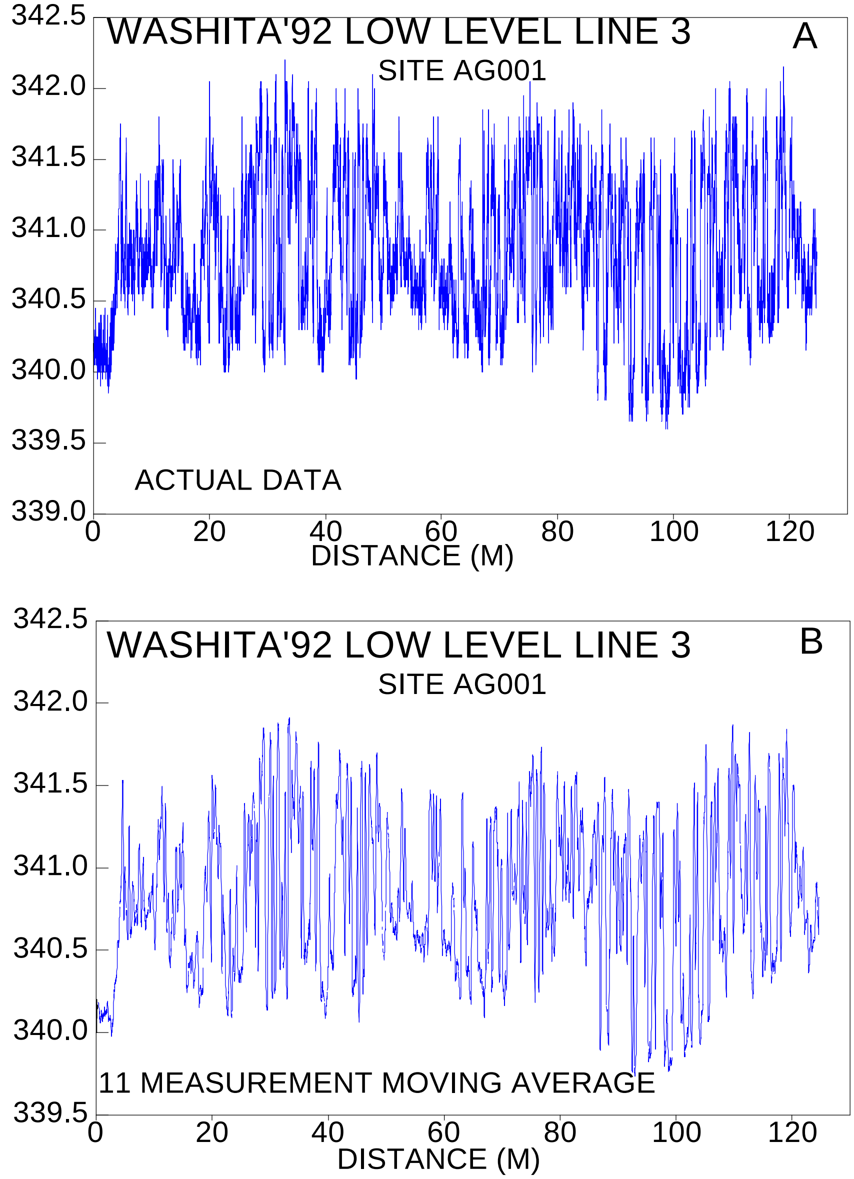


Figure XVI-8. Laser altimeter data from site AG001