CHAPTER XII: TRUCK MOUNTED RADAR SYSTEM

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A. INTRODUCTION

The Hydrological Sciences Branch (Code 974) at NASA Goddard Space Flight Center currently operates a quad-polarized multifrequency truck-mounted radar system in conjunction with George Washington University. This system was deployed to Chickasha, OK in support of the Washita '92 experiment- Ten days of truck radar data at 1.6 GHz and supporting measurements were acquired over a number of agricultural and grassland sites to complement the eight days of simultaneous aircraft microwave measurements (AIRSAR, ESTAR). These radar data will be used in the following analyses:

1. to investigate and document the capabilities of microwave sensors for soil moisture estimation and for modeling microwave backscatter through vegetation canopies;

2. to examine synergistic effects between active and passive microwave sensors for soil moisture estimation; and

3. to compare microwave data at different scales from different platforms (GSFC truck radar, aircraft AIRSAR and ESTAR, and satellite JERS-1).

While final absolute calibration of the truck radar data remains to be completed, preliminary results indicate that the relative sensitivity of the truck radar data to soil moisture variations equals or surpasses that observed in previous experiments with the AIRSAR.

B. RADAR SYSTEM DESCRIPTION

A 1990 Navstar hydraulic boom truck serves as a mobile staging platform for GSFC's multifrequency radar system (Fig. XII-1). This vehicle permits stable deployment of sensor packages up to ~500 lbs. in weight to a maximum height of 65 feet above the ground with hydraulically driven motion in three planes. The system includes an inclinometer with direct digital readout for boom platform angle, a helium neon laser for pointing accuracy during external calibration runs, and a portable

electrical generator for instrument power at remote sites.

GSFC's truck radar has recently been reconfigured around an HP8719A network analyzer belonging to GWU. Only the radar at an L band center frequency of 1.6 Ghz (18.75 cm) was operational in the new system during June, 1992 at Chickasha (4.75 Ghz will be ready in 1993, 10 GHz in 1994). The L band antennas consist of two four-foot parabolic dishes with a 12° beam width and dual-polarized feeds which permit quad-polarized data to be collected (HH, VV, HV, VH). During the Chickasha experiment the network analyzer was stationed on the ground and connected to the antennas on the boom by a 30-m RG214 cable. The resulting cable loss of about 24 dB at 1.6 GHz necessitated the use of an amplifier with a gain of about 27 dB to increase the signal to noise ratio.

An HP3488A switching control unit was mounted on the boom to control polarization switching. A pair of HP 3720A HP IB extenders, one on the ground connected to the network analyzer and then linked via RG59 cable to the other extender on the boom connected to the switching unit, were used to convert HP-IB data to serial format. The radar system was controlled through an IBM-386-based Toshiba notebook computer using "Labwindows" software and Quick Basic programming.

During actual data collection the network analyzer was set in S_{21} mode and an IF-bandwidth of 300 or 1000 hertz was selected depending upon the signal to noise ration (lower bandwidth for higher noise). The sweep time for the pulse was also adjusted whenever a change in bandwidth was introduced. Typically, a sweep time of 0.45 ms was used for an IF-bandwidth of 1000 hertz. Internal system calibration was carried out using semi-rigid coax cable and manufacturer's recommended procedures, while absolute (external) calibration was achieved using an aluminum trihedral corner reflector with a side length of 90 cm. Corner reflector and noise floor measurements were made each time the radar truck moved to a new test site. In order to get spatial averaging of the test fields, the radar boom was swept in azimuth for 120°. Approximately 100 data points were collected at each polarization during each 120° azimuthal sweep; these sweeps were repeated for each desired incidence angle (measured from nadir). Normal operating procedure involved data collection at angles of 30°, 40°, and 50°; however, at a few test sites (AG031 and MS004) an extended angular range of 20° to 60° or 70° was utilized for vegetation modeling purposes. An example of truck radar data from a corn field in Chickasha is shown in Figure XII-2.

C. FIELD SITE DESCRIPTIONS

The truck radar acquired data at three agricultural sites (AG001, AG002, AG003) and three pasture sites (MS001, MS002, MS004). The agricultural fields are located in a bend of the Washita River just outside the northeast boundary of the Little Washita River Watershed, and are located on Line 3 of the low altitude ESTAR flightlines (and on AIRSAR flightline Chickasha 2C300-3 among others). They are bounded by Maple

Road to the north and east, Cottonwood Road to the south, and the McNeff dairy to the west. Site AG001 is a large corn field (formerly a center pivot field) characterized by isolated areas of poor drainage, standing water, and tall grass and weeds surrounded by healthy corn plants up to 7' high in east-west rows. An east-west road cuts the field into northern (AG011) and southern (AG001) portions, within which separate soil moisture transacts were sampled for comparison with aircraft data. The truck radar staged exclusively in the northern part of the corn field primarily at two measurements sites, Site AG041 on the west opposite the feedlot and Site AG031 along the bisector road.

Field AG002 is a roughly L-shaped bare field, located just to the south of the corn field, whose surface resulted from the farmer plowing the field after the winter wheat cover was cut for silage prior to the start of the Washita 1992 experiment. The field is divided into a western halt (AG002) with a bare surface of small clods and an eastern half (AG012) with a bare surface covered by growing crabgrass. It is characterized by fairly linear north-south trending areas of poor drainage which continue into the southern part of the corn field; these linear depressions remained moist throughout most of the experiment. The truck radar staged at two sites, one on the west side of AG002 along the dairy road and the other to the east in AG012 along Cottonwood Road.

Field AG003 is situated in the bend of Maple Road north of the Washita River, and during June, 1992 it had a homogeneous cover of flowering alfalfa approximately 18" high. A small pie-shaped section of the field along the road consisted of winter wheat stubble (AG013) which was also sampled as part of the field's general soil moisture transect. Starting on June 16, 1992 the alfalfa in AG003 was cut in a pattern from west to east; by June 18 (the last experiment day), the field was completely cut and the rows of cut alfalfa were being consolidated prior to baling. The truck radar staged at one measurement site on the east side along Maple Road, south of the section of winter wheat stubble.

The three pasture sites visited by the truck radar represent a range in the density of surface cover. MS001 is sparse pasture (mainly weeds) with bare soil visible, while MS002 is a taller, thicker pasture with some weeds and thatch. In contrast, the cover at MS004 consists of very tall, lodged "love grass" with a heavy thatch layer. The truck radar consistently staged at one location in each of these three fields; however, on June 12 an additional set of measurements were obtained at K. Humes' site in MS002.

Additional descriptive information about the test fields can be found in Chapter IV.

The following are additional notes on field conditions obtained as part of the radar truck experiment that were not included in the original data report.

AG001 (Corn)
Height: 2.1 m
Plant Density: 4.5 plants/m^2
Wet Biomass: 5.25 kg/m^2
Dry Biomass: 1.195 kg/m^2
Vegetation Water Content: 4.05 kg/m^2
Surface Roughness RMS Height: 1.27 cm (photo grid, avg of 5 profiles)
Notation used for radar data:

CORN PL - the midpoint of the radar's 120° azimuth sweep was parallel to the corn rows,
CORN PP - the midpoint of the radar's 120° azimuth sweep was perpendicular to the corn rows.

AG002 (West side of bare field)
Surface Roughness RMS Height: 1.98 cm (N-S) and 2.62 (E-W)

AG003 (Alfalfa)
Height: 38-45 cm
Stem Density: 380.3 stems/m^2
Wet Biomass: 1.305 kg/m^2
Dry Biomass: 0.298 kg/m^2
Vegetation Water Content: 1.007 kg/m^2

MS004 (Love Grass)
Stem Density: 847 stems/m^2
Wet Biomass: 1.11 kg/m^2 (includes thatch)
Dry Biomass: 0.80 kg/m^2
Vegetation Water Content: 0.31 kg/m^2

D. DATA COLLECTION SCHEDULE

The daily data collection schedule for the truck radar is shown in Table XII-1 for June 9-June 18, 1992. All radar measurement series were conducted at a frequency 1.6 GHz and polarizations of HH, VV, HV, VH for each angle indicated. To clarify measurement sites, a few notes are necessary: (1) Site AG051 on June 10 is on the west side of AG011 north of site AG041; (2) on June 11 site AG041 was measured from the bisector road around the corner; and (3) site MS012 on June 12 is K. Humes' transect site in MS002. In regard to soil moisture measurement, three sampling schemes were utilized:

1. transect -- the standard sampling done for comparison with aircraft data; usually consisted of 9 samples per transect with each sample approximately 100 paces apart;

2. limited--used on non-flight days; 6 samples taken approximately 25 paces apart in a pattern encompassing the truck radar data area; and

3. grab--used on first visit to pasture sites; 5 soil cores taken around truck radar data area and combined into a single sample; can be compared to transect data taken earlier.

Table XII-1 Truck radar data collection schedule.

Date	Location	Radar Data	Soil Moisture Sampling	Other
6-09-92	AG041	30°, 40°, 50°	Limited	
6-10-92	AG041	30°, 40°, 50°	Transect	
	AG051[1]	30°, 40°, 50°	Transact	
	AG002	30°, 40°, 50°	Transect	
	AG012	30°, 40°, 50°	Transect	
	AG003	30°, 40°, 50°	Transect	
6-11-92	AG041[2]	30°, 40°, 50°	Transect	
	AG002	30°, 40°, 50°	Transect	
	AG012	30°, 40°, 50°	Transect	
	AG003	30°, 40°, 50°	Transect	
6-12-92	MS001	30°, 40°, 50°	Transect & Grab	
	MS002	30°, 40°, 50°	Transect	
	MS012[3]	30°, 40°, 50°	Grab	
	AG003	--		Plant architecture, density & biomass; canopy height, leaf density & clump characteristics
6-13-92	AG041	30°, 40°, 50°	Transect	
	AG031	20° to 70° by 5°	Transect	
	AG002	30°, 40°, 50°	Transect	
	AG012	30°, 40°, 50°	Transact	
	AG003	30°, 40°, 50°	Transect	
	AG031	--		Plant & canopy density, biomass & architecture; surface roughness photographically against grid

Table XII-1 (cont.) Truck radar data collection schedule.

Date	Location	Radar Data	Soil Moisture Sampling	Other
	AG002	--		Surface roughness photographically against grid
6-14-92	MS001	30°, 40°, 50°	Transect	
	MS002	30°, 40°, 50°	Transect	
	MS004	20° to 60° by 5°	Transect	Plant & canopy density, biomass & architecture
6-15-92	AG041	30°, 40°, 50°	Limited	
	AG031	20° to 70° by 5°	Limited	
	AG002	30°, 40°, 50°	Limited	
	AG012	30°, 40°, 50°	Limited	
	AG003	20° to 60° by 10°	Limited	
6-1 6-92	AG041	30°, 40°, 50°	Transect	
	AG031	20° to 70° by 5°	Transect	
	AG002	30°, 40°, 50°	Transect	
	AG012	30°, 40°, 50°	Transect	
	AG003	30°, 40°, 50°	Transect	
6-17-92	MS001	30°, 40°, 50°	Transect	
	MS002	30°, 40°, 50°	Transect	
	MS004	20° to 55° by 5°	Transect	
6-18-92	AG041	30°, 40°, 50°	Transect	
	AG031	20° to 70° by 5°	Transect	
	AG002	30°, 40°, 50°	Transect	
	AG012	30°, 40°, 50°	Transect	
	AG003	30°, 40°, 50°	Transect	

Figure XII-1. GSSFC truck-based radar at corn site AG031. Note the corner reflector used as a calibration target in foreground.

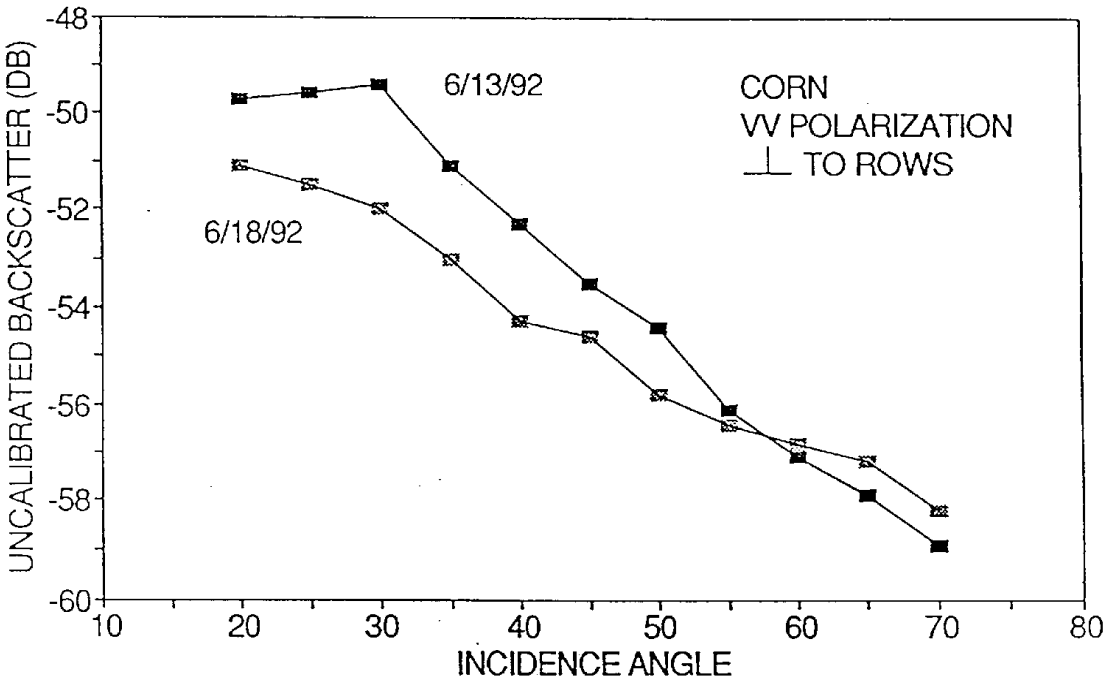

Figure XII-2. Truck radar data at 1.6 GHz vertical polarization as a function of incidence angle for two days at corn site AG031. Perpendicular to rows.