N72-29344

SECTION 44

A COACTIVE INTERDISCIPLINARY RESEARCH PROGRAM WITH NASA

by

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ABSTRACT

The Applications area of the Texas A&M University Remote Sensing Program consists of a series of coactive projects with NASA/MSC personnel. The close working relationships developed between the Texas A&M University applications specialists has proven this to be an economic and efficient approach leading to pertinent research results. The success of this program is well illustrated by the Virus-Host Model Study and the Houston Ship Channel Water Quality Studies which were initiated during the last year. In each case, the Remote Sensing Center has served to complement and enhance the research capability within the Manned Spacecraft Center.

In addition to the Applications study area, the Texas A&M University program includes coordinated projects in Sensors and Data Analysis. Under the sensors area, an extensive experimental study of microwave radiometry for soil moisture determination established the effect of soil moisture on the measured brightness temperature for several different soil types. The Data Analysis area included a project which ERTS-A and Skylab data were simulated using aircraft multispectral scanner measurements at two altitudes. This effort resulted in development of a library of computer programs which provides an operational capability in classification analysis of multispectral data.

The level in diversity of the overall program has led to the formation of several formal laboratory groups, each headed by experienced professionals. These groups represent a wide range of disciplines selected to directly support the NASA/MSC HATS and related activity.

INTRODUCTION

The Remote Sensing Center at Texas A&M University is a consortium of four colleges: Agriculture, Engineering, Geosciences and Science.

We are an integral part of the University research program and consequently we are able to employ almost the full range of research facilities available on our campus; including equipment, laboratories, ships, aircraft, and agricultural experiment stations. More importantly, the Center is structured to enable it to effectively employ the outstanding faculty of the participating colleges, who are especially strong in application research.

The main structure of the Center which serves to coordinate all remote sensing research at TAMU, consists of eight working groups (figure 1). The sustaining University program provides the foundation for this organization and the selection of these particular groups was dictated for the most part by the objectives of our NASA Grant program. However, most of these groups have additional contract support.

The NASA Grant program consists of a balance between techniques and applications (figure 2). Although we still have a strong interest in microwave sensors, the more recent activity in development of computer software for multispectral analysis and in applications research are now being stressed under the NASA sponsorship.

PROJECTS

Under the Sensors area, we are investigating a new idea which is based upon the behavior of the depolarized electromagnetic backscatter (figure 3). The theoretical work, presented at the URSI meetings at UCLA this fall, indicates that near surface volumetric properties dominate the depolarized component. A vivid illustration is shown in this radar image of the Pisgah Crater area (figure 4) in which the volume scatter properties of the lava flow provide a sharp contrast in the depolarized image which is not evident in the like-polarized image.

In the analytical model describing these effects it can be seen (figure 5) that whereas the like-polarized term is very sensitive to the dielectric constant of the terrain, the cross-term is relative insensitive. However, in the next graph (figure 6), it is seen that the volume reflection coefficient greatly effects this depolarized component, but does not appreciatively alter the like-term. These characteristics have been verified in independent experiments, and we are presently developing a laser sensor to utilize this effect in measuring water turbidity and surface pollutants. We are also preparing to assemble a radar system to utilize the effect.

Our work on radar return from Arctic ice using NASA/MSC data from Mission 47 and 126 has led to development of a model which predicts the backscatter from a variety of ice types with a reasonable degree of reliability (figure 7). Recent work with Mission 126 data has supported earlier findings using Mission 47 data (figure 8) and confirms the ice type identification potential.

The data indicates that the dielectric constant of relatively new ice is an agreement with the waveguide measurements of CRREL, but that the effective dielectric constant of multi-year ice is much higher than predicted (figure 9). This indicates the need for reexamination of the physical sea ice model.

A project which has received special emphasis under the NASA program during the last year is the study of microwave radiometry for soil moisture determination (figure 10). Like most of our Sensor studies, an analytical model is used as a reference system for the investigation. Verification of the model required information about the source, measurements under highly controlled conditions, and finally airborne data.

Soil samples were collected at each of seven sites in Texas (figure 11) for waveguide measurements of their complex dielectric constant (figure 12). The sites were selected in support of our Skylab proposal for use of the microwave data. The dielectric constant data showed that in general sandy soils were more sensitive to moisture variations than clay soils (figure 13). In addition it was found that the absorption process in clay soils is such that the dielectric constant change with the length of time after moisture was applied (figure 14). Also wet clay soils were very sensitive to compaction, whereas, sandy soils were relative insensitive to absorption or compaction. A detailed knowledge of the characteristics of the soils is important in analysis of microwave emission from terrain because the contribution of the normal sky temperature term is low-much lower than for water measurements, for example.

The airborne measurements obtained by NASA/Goddard indicated in soil moisture dependence of approximately 1.5°K/1% soil moisture which is in excellent agreement with both the analytical model and the ground-based tower measurements (figure 15). However, the variance of the data was such that the results indicates that the present system capability for measurement of soil moisture using airborne microwave radiometers is no better than 10-15% soil moisture, that is, we believe that considerably more work is needed before radiometry can be shown to be a practical sensor for soil moisture delineation.

The Data Analysis group activities (figure 16) are devoted to developing a capability within the Center for effective use of the computer in statistical data analysis.

The products of this effort include what we call production programs (figure 17) that especially facilitate reduction of microwave

C.7

data. These programs permit the automatic reduction of a large volume of data, for example an entire line of radar scatterometry data, to a form which is compatible with our standard analysis techniques.

We have also developed the software for multispectral analysis using each of several statistical methods (figure 18).

The strong point of this activity is the excellent computer facility at TAMU which is located in the same building as the Remote Sensing Center. As you can see (figure 19), the machine has an expanded capability, but more important is the low cost and unusually good availability of the equipment. The average turnaround time on jobs is just 15 minutes, which is exceptional for a university-owned facility. The computer is supported by a large staff which is part of a $2M/yr. data processing center facility.

Within the last year the Center has acquired three new staff members whose activities are devoted to remote sensing applications. This has caused a pronounced shift in our research emphasis which we feel will increase the relavency of our products. In November we cooperated with NASA/MSC in an experiment on the Houston Ship Channel (figure 20). Airborne multispectral data were obtained using the University of Michigan aircraft. This work is part of an effort to provide our state's responsible agency with new methods of monitoring and regulating effluents. Under the new Texas laws governing pollution, the task of monitoring the state's inland water resources and coastal regions has expanded. The Texas Water Quality Board is looking to remote sensing for assistance in their programs.

Finally, I want to introduce you to one of the most exciting practical applications of remote sensing data that we have been involved in. A private land developer in Houston recently approached us for assistance in assessing the best way to utilize the natural vegetation and soils distribution on a land area scheduled for development (figure 21). The impact of urban development upon virgin lands has generally been severe and some effort was needed to minimize destruction and if possible to capitalize on the existing terrain to reduce development costs and maintain the aesthetic value of the land. This project has only just begun, but we have established several test plots on the site and have acquired aerial photography of some sections. We are hopeful that NASA will designate the area as a HATS test site and assist us with the data acquisition and analysis.

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CONCLUSION

The Texas A&M program is a rapidly expanding effort which is greatly assisted by the excellent cooperation received from the NASA/MSC personnel. We believe that this coactive effort will prove to be an important part of the overall NASA/MSC involvement in remote sensing applications research.

The following paper by Dr. Robert Toler details another of the Remote Sensing Center's project which typifies the type of coactive interdisciplinary research which we are establishing with the Manned Spacecraft Center.

RSC LABORATORIES

- ELECTRO-OPTICAL SYSTEMS

  DR. W. T. MAYO, JR.

- MICROWAVE & INFRARED SYSTEMS

  DR. J. W. ROUSE, JR.

- DATA ANALYSIS

  J. A. SCHELL

- ENVIRONMENTAL MONITORING

  DR. W. P. JAMES

RSC LABORATORIES

- SPACE OCEANOGRAPHY

  DR. G. L. HUEBNER, JR.

- VEGETATION SYSTEMS

  DR. R. H. HAAS

- PLANT PROTECTION

  DR. R. W. TOLER

- SOIL-WATER SYSTEMS

  DR. C. H. M. VAN BAVEL

NASA GRANT PROGRAM

I. SENSORS

ACTIVE MICROWAVE, PASSIVE MICROWAVE

INFRARED, LASER

II. DATA ANALYSIS

MULTISPECTRAL, MICROWAVE

III. APPLICATIONS

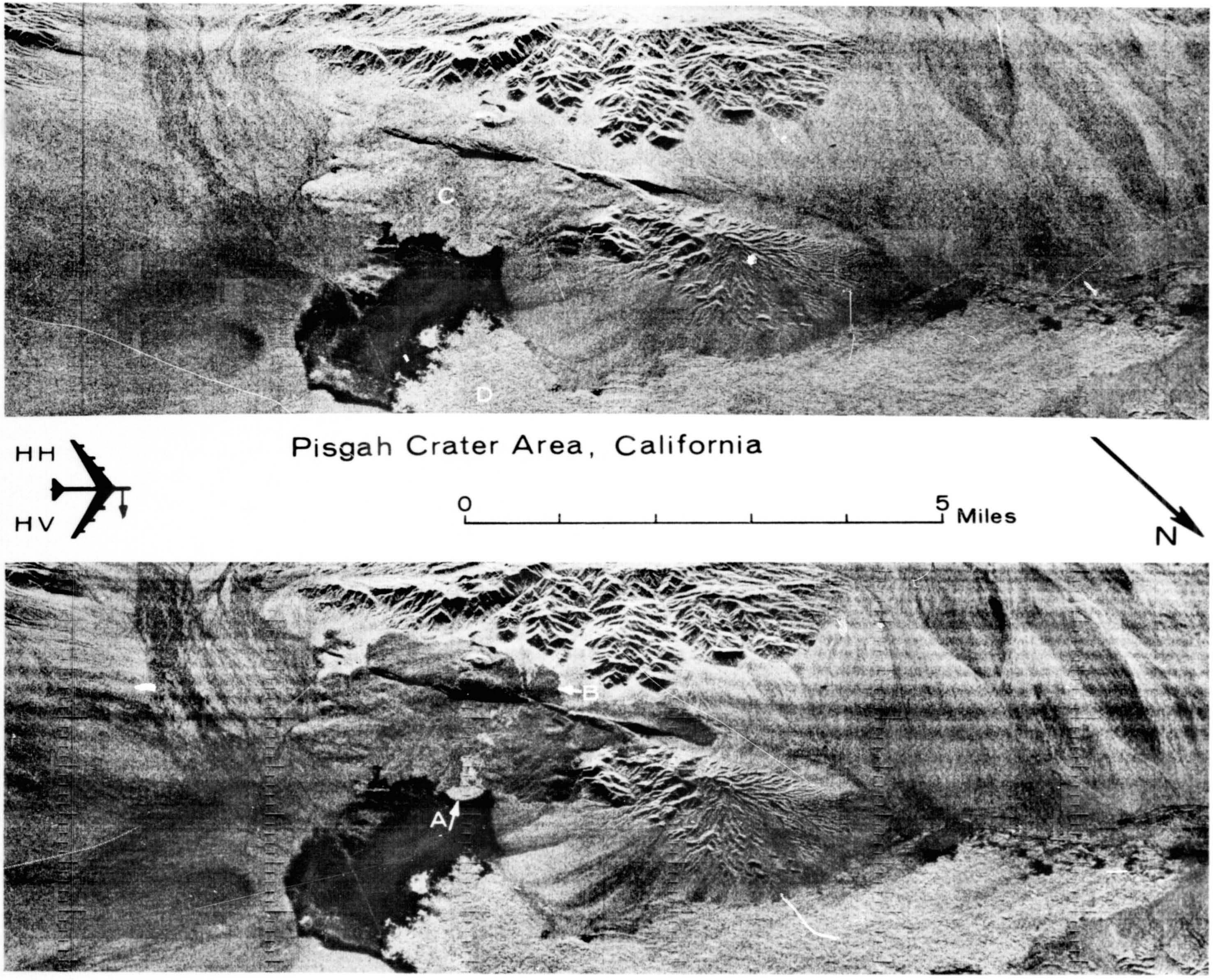
WATER QUALITY, PLANT DISEASES (VIRUS)

RANGELAND, AG STATION SURVEY

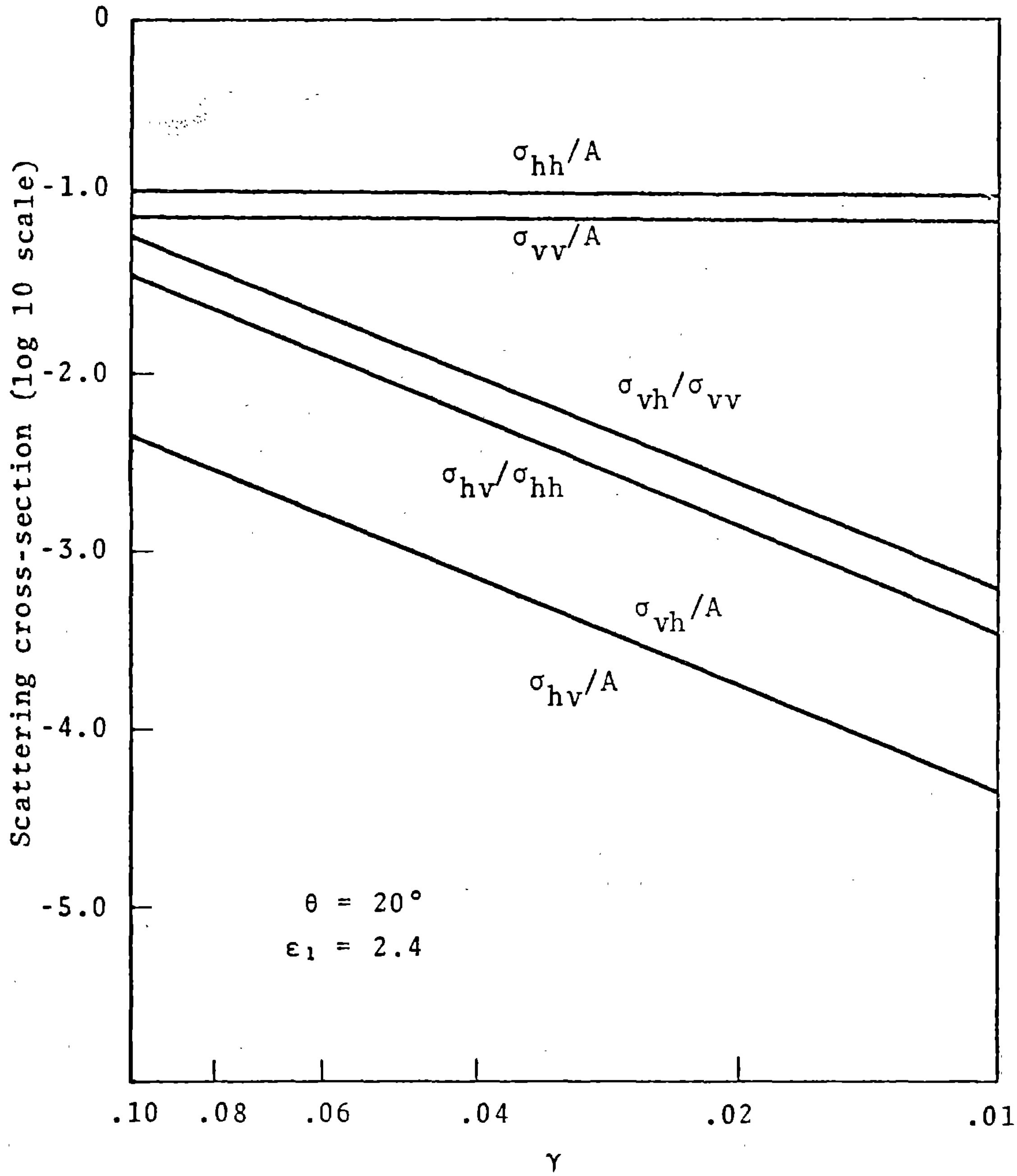
NEAR-SURFACE VOLUME SENSOR
(LASAR AND RADAR)

APPLICATIONS: WATER TURBIDITY, OIL SPILLS, TERRAIN COMPOSITION AND MOISTURE

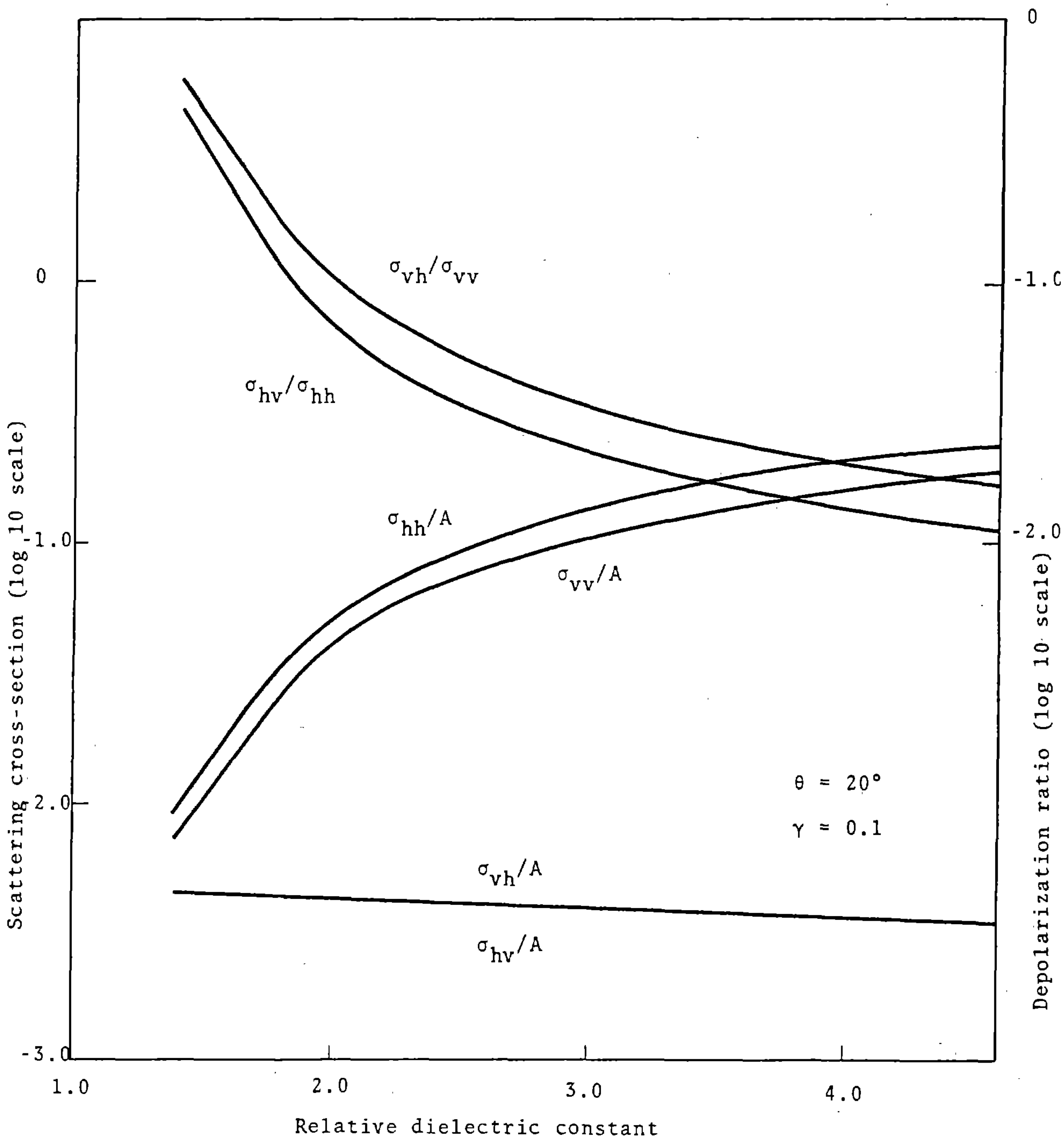
SENSOR CONCEPT IS BASED UPON DEVELOPMENT BY ROUSE (1971) WHICH DESCRIBES DEPENDENCE OF BACKSCATTER ON SUBSURFACE VOLUME SCATTER CHARACTERISTICS.



Pisgah Crater Area, California



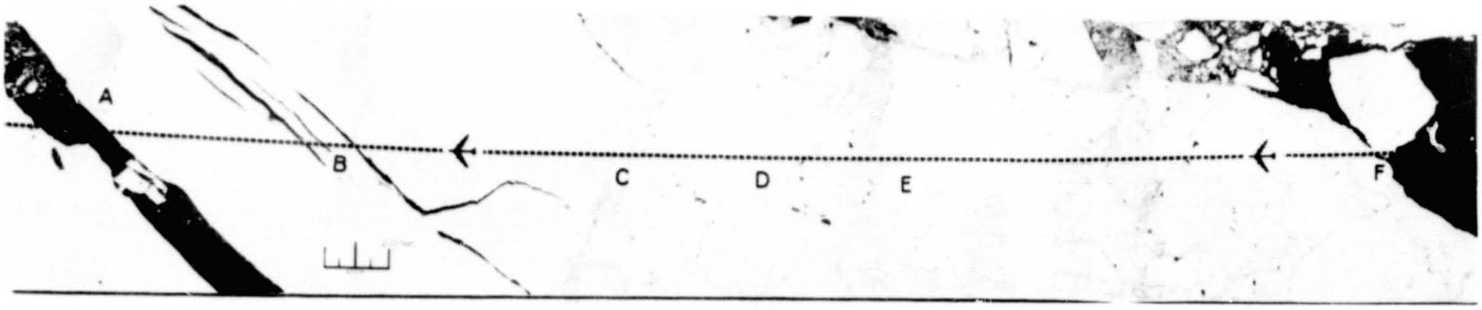
0
-1.0
-2.0
-3.0
-4.0
-5.0
Scattering cross-section (log 10 scale)
σ_{hh}/A
σ_{vv}/A
σ_{vh}/σ_{vv}
σ_{hv}/σ_{hh}
σ_{vh}/A
σ_{hv}/A
$\theta = 20°$
$\varepsilon_1 = 2.4$
.10
.08
.06
.04
.02
.01
γ


0
-1.0
-2.0
0
-1.0
2.0
-3.0
1.0
2.0
3.0
4.0
Relative dielectric constant
Scattering cross-section (log 10 scale)
Depolarization ratio (log 10 scale)
σ_{vh}/σ_{vv}
σ_{hv}/σ_{hh}
σ_{hh}/A
σ_{vv}/A
$\theta = 20°$
$\gamma = 0.1$
σ_{vh}/A
σ_{hv}/A

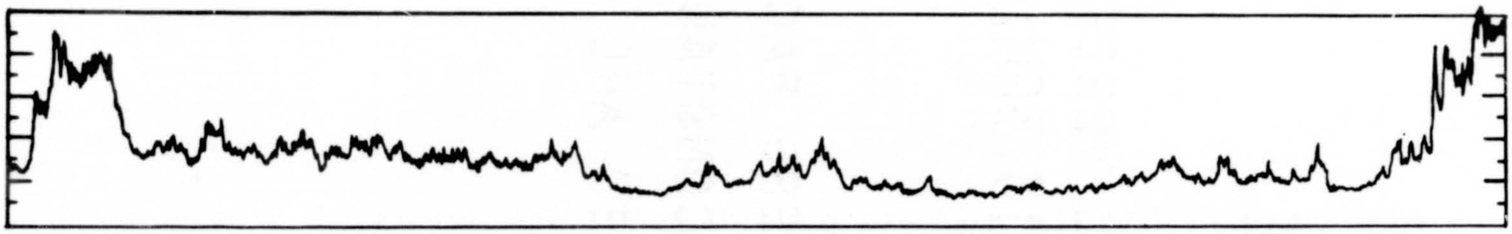
RADAR BACKSCATTER - ARCTIC ICE

DEVELOPMENT OF BACKSCATTER MODEL AND VERIFICATION OF MODEL USING MISSIONS 47 AND 126 13.3GHz RADAR DATA.

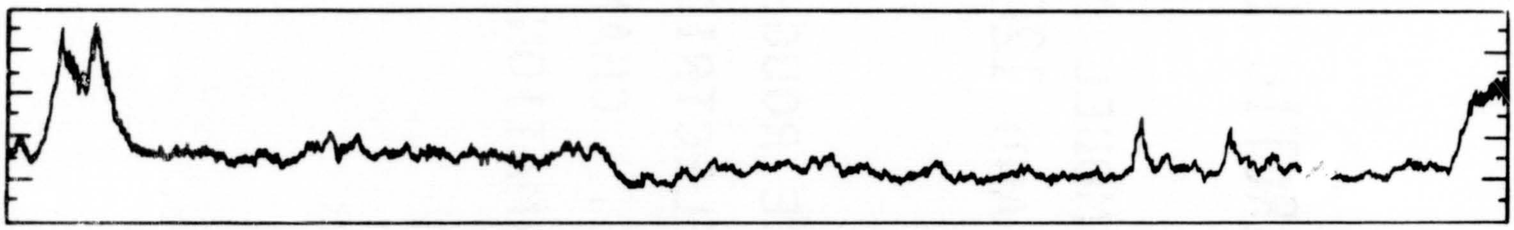
MODEL INDICATES THAT SURFACE ROUGHNESS FACTOR DECREASES AND EFFECTIVE DIELECTRIC CONSTANT INCREASES WITH AGING OF ICE. CHANGES ARE 10:1 DURING FIRST YEAR AFTER FORMATION.



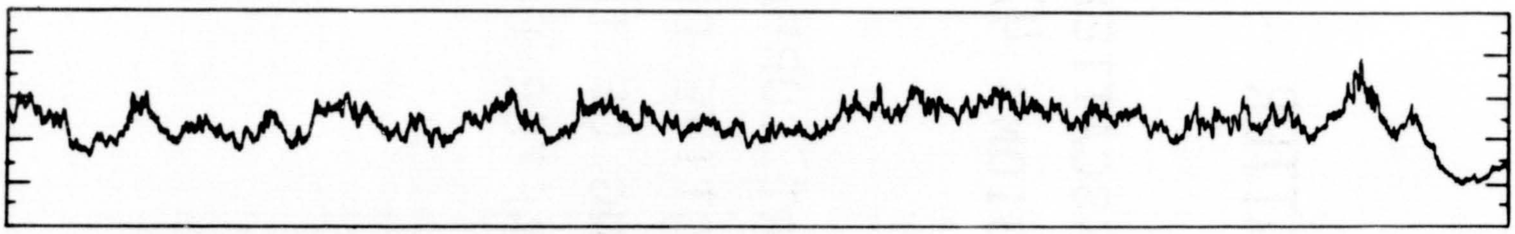
Air Photo Mosaic: Arctic Ice, Off Shore of Barrow, Alaska, 12 May 1967, line 91



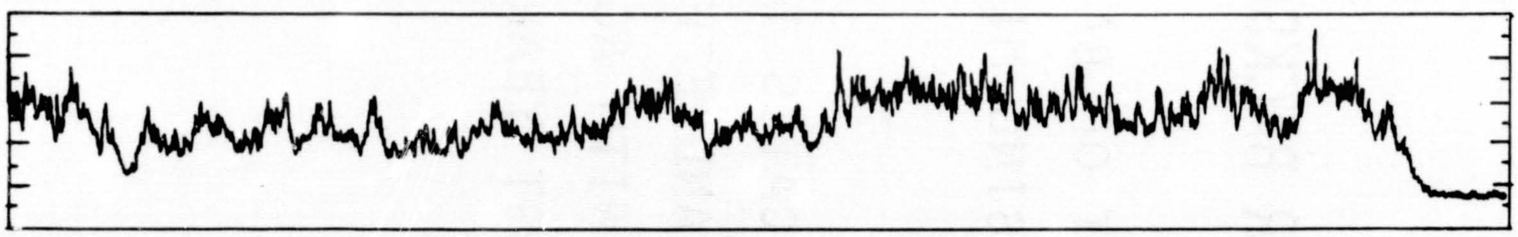
Radar Return at 2.5° Incidence Angle



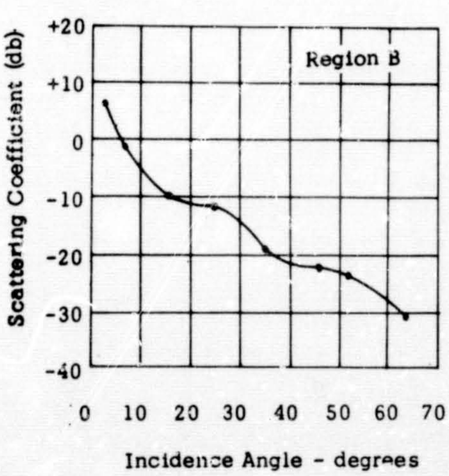
Radar Return at 6.7° Incidence Angle

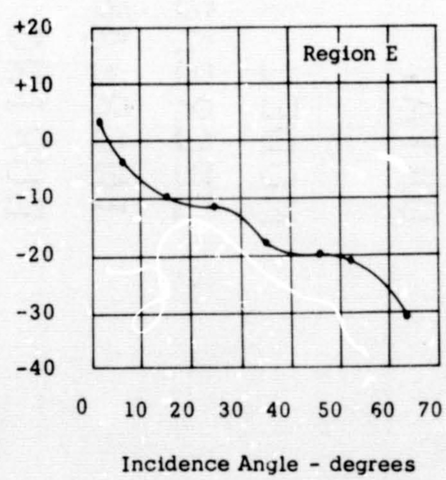


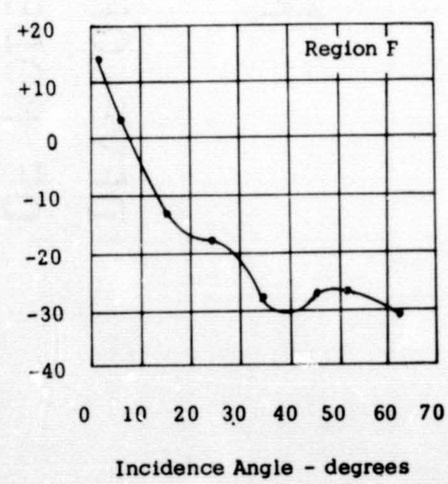
Radar Return at 25.0° Incidence Angle

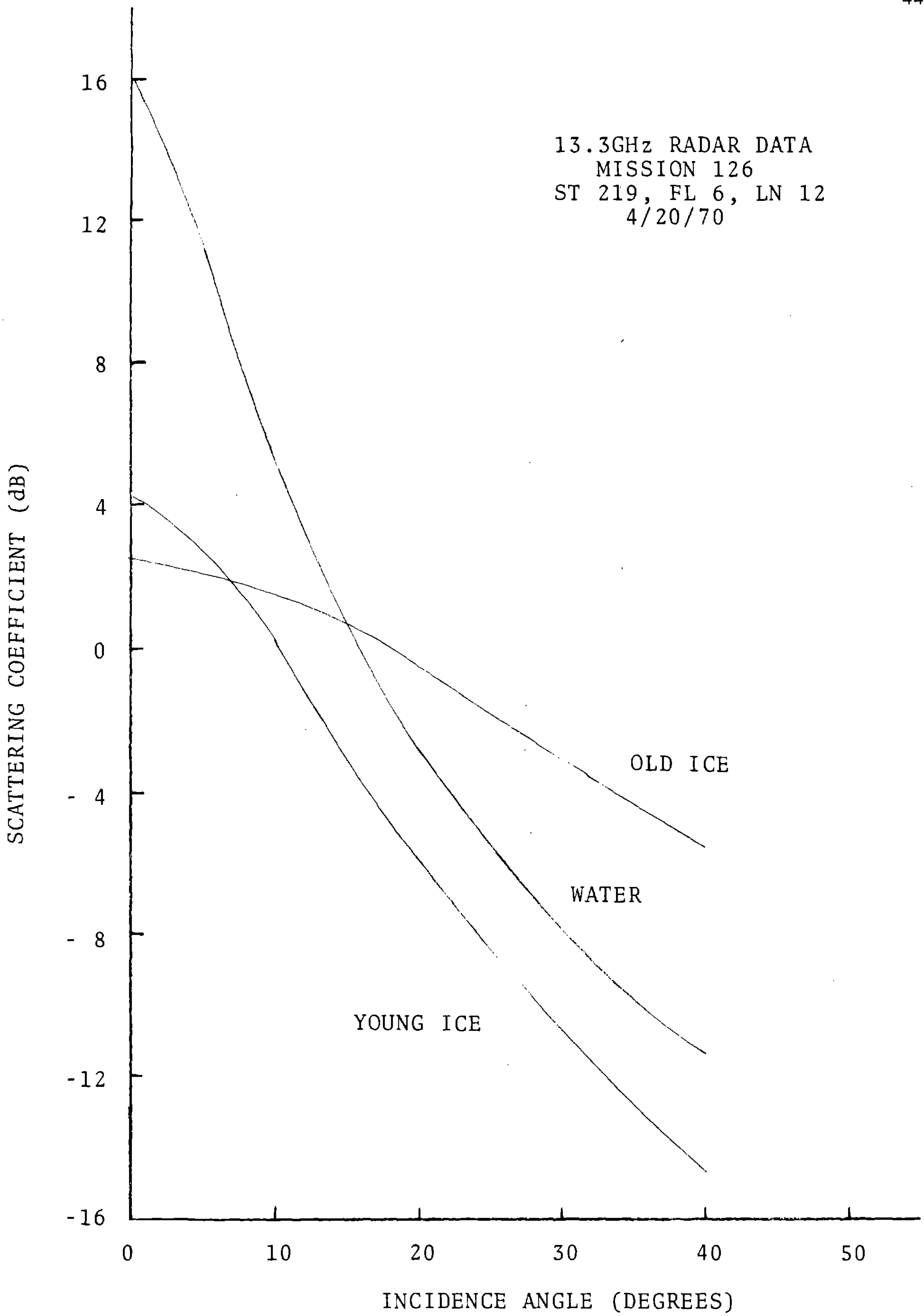


Radar Return at 52.1° Incidence Angle



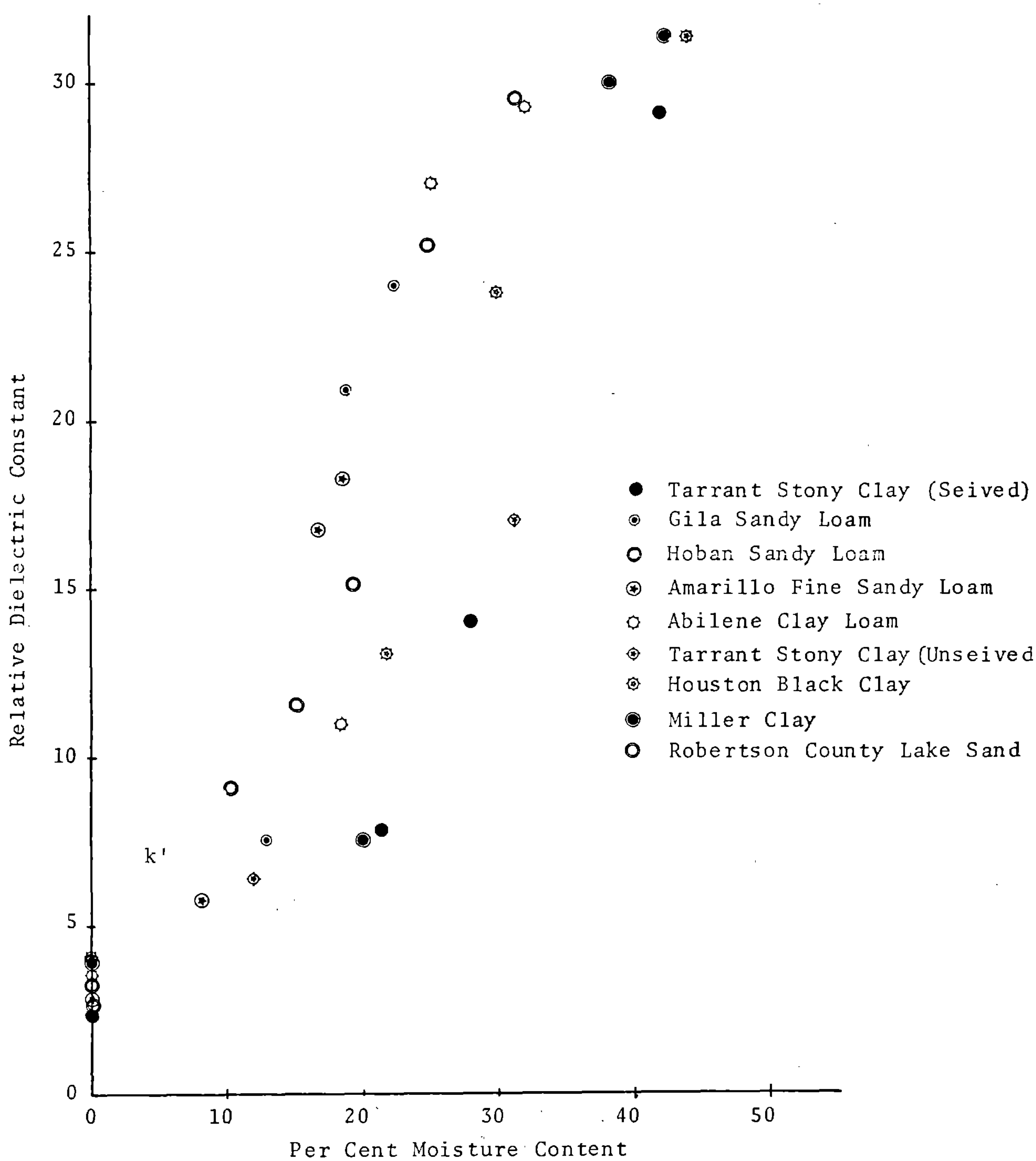




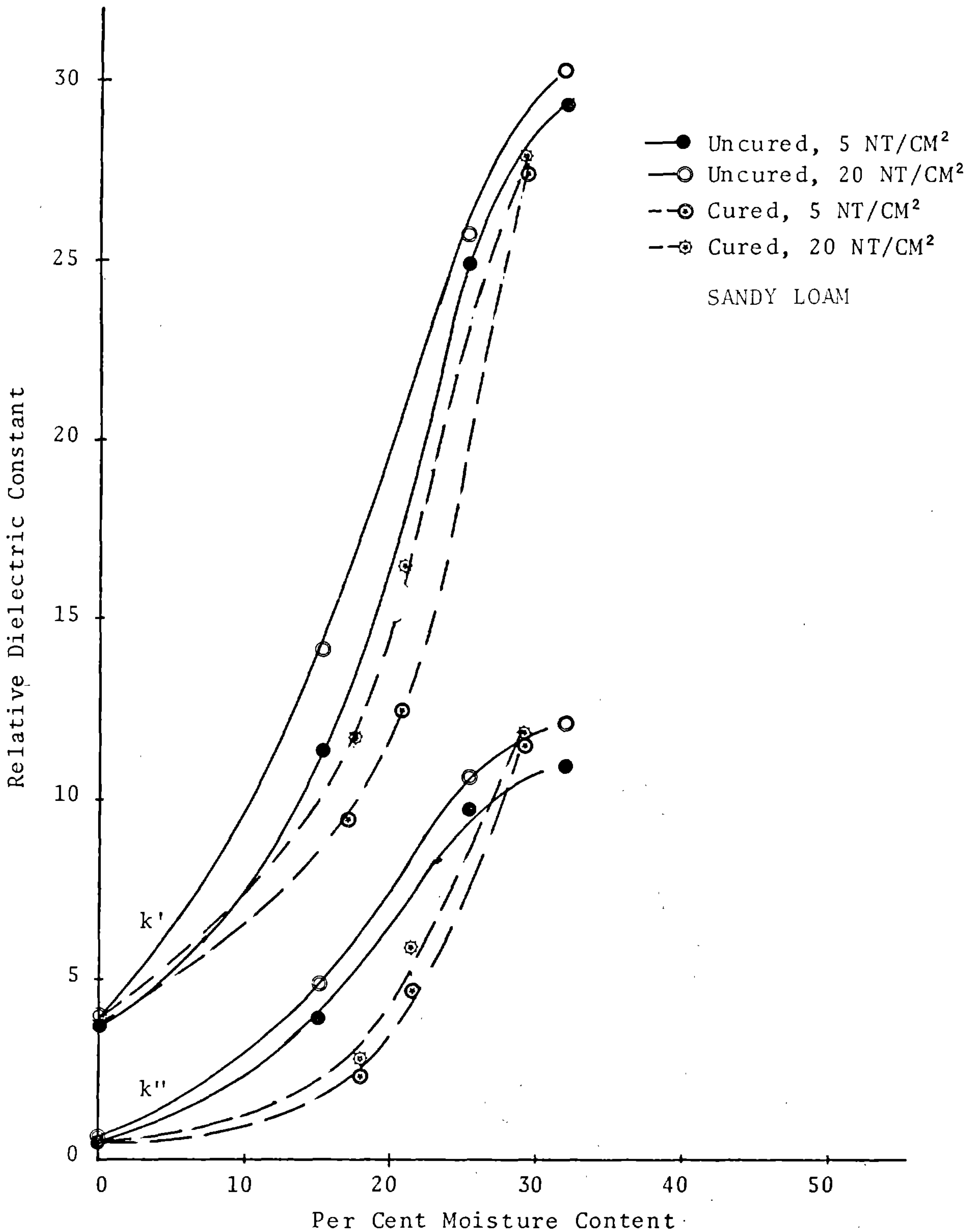

13.3GHz RADAR DATA
MISSION 126
ST 219, FL 6, LN 12
4/20/70
OLD ICE
WATER
YOUNG ICE
SCATTERING COEFFICIENT (dB)
16
12
8
4
0
- 4
- 8
-12
-16
0
10
20
30
40
50
INCIDENCE ANGLE (DEGREES)

SOIL MOISTURE DETERMINATION

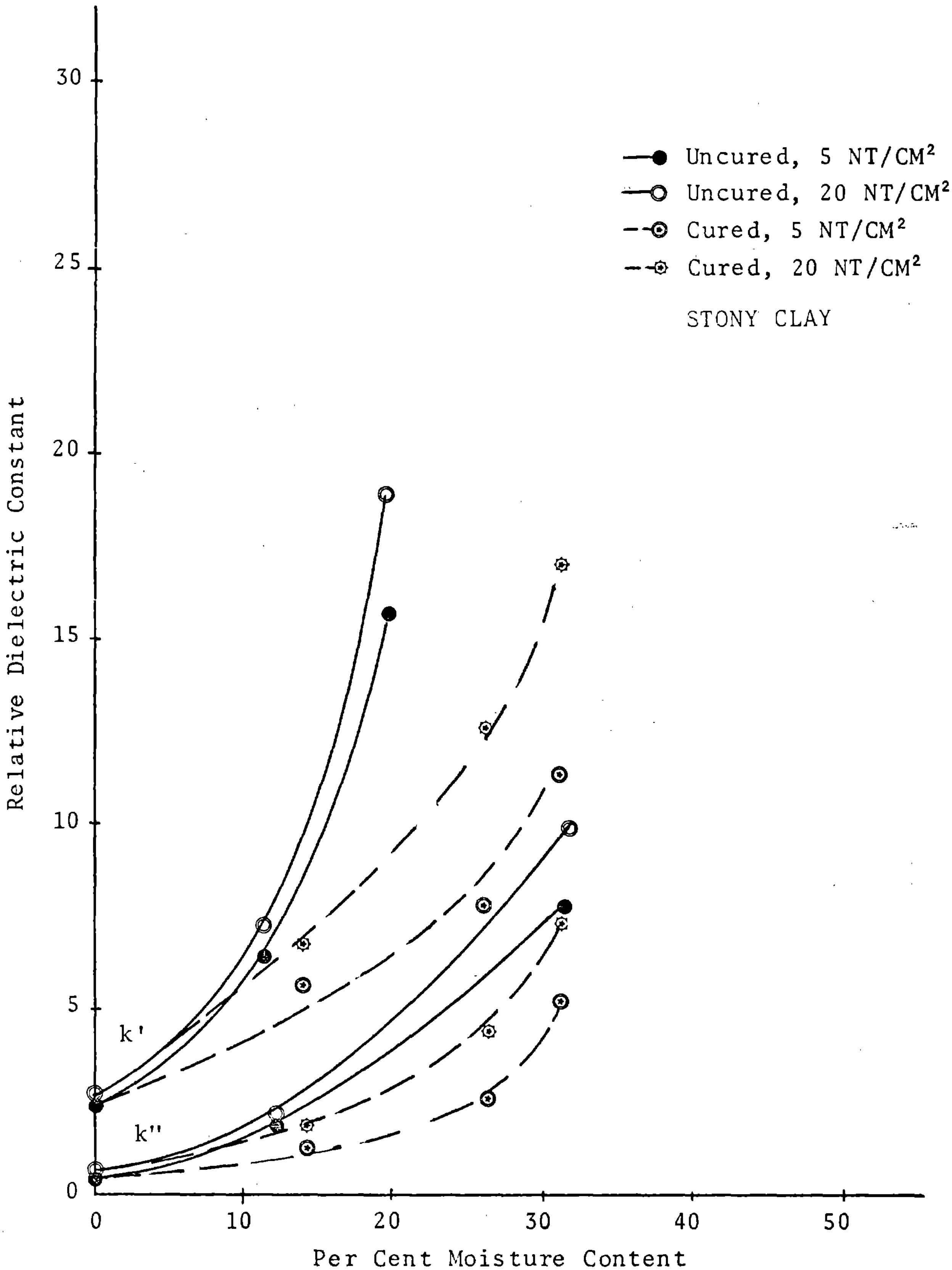
- DEVELOPMENT OF ANALYTICAL MODEL BASED UPON PEAKE MODEL
- WAVEGUIDE MEASUREMENTS OF COMPLEX DIELECTRIC CONSTANT OF TEXAS SOILS
- TOWER-MOUNTED RADIOMETER MEASUREMENTS OF SOIL SAMPLES UNDER CONTROLLED CONDITIONS
- AIRBORNE MULTI-FREQUENCY RADIOMETER MEASUREMENTS OF DOCUMENTED SITES (WESLACO)



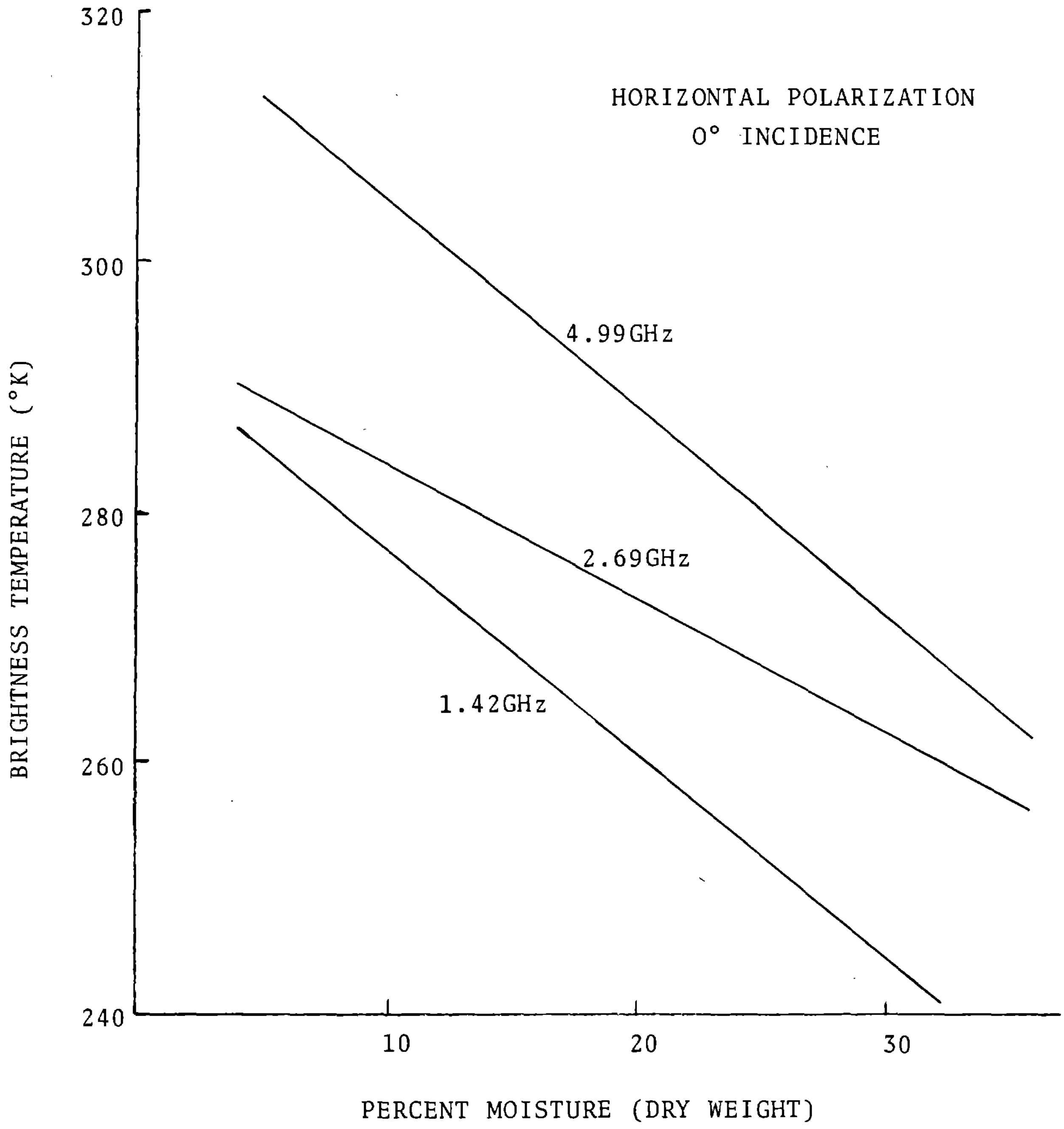
Relative Dielectric Constant
k'
Per Cent Moisture Content
0
5
10
15
20
25
30
0
10
20
30
40
50
Tarrant Stony Clay (Seived)
Gila Sandy Loam
Hoban Sandy Loam
Amarillo Fine Sandy Loam
Abilene Clay Loam
Tarrant Stony Clay (Unseived
Houston Black Clay
Miller Clay
Robertson County Lake Sand



Uncured, 5 NT/CM²
Uncured, 20 NT/CM²
Cured, 5 NT/CM²
Cured, 20 NT/CM²
SANDY LOAM
k'
k''
Relative Dielectric Constant
Per Cent Moisture Content
0
5
10
15
20
25
30
0
10
20
30
40
50



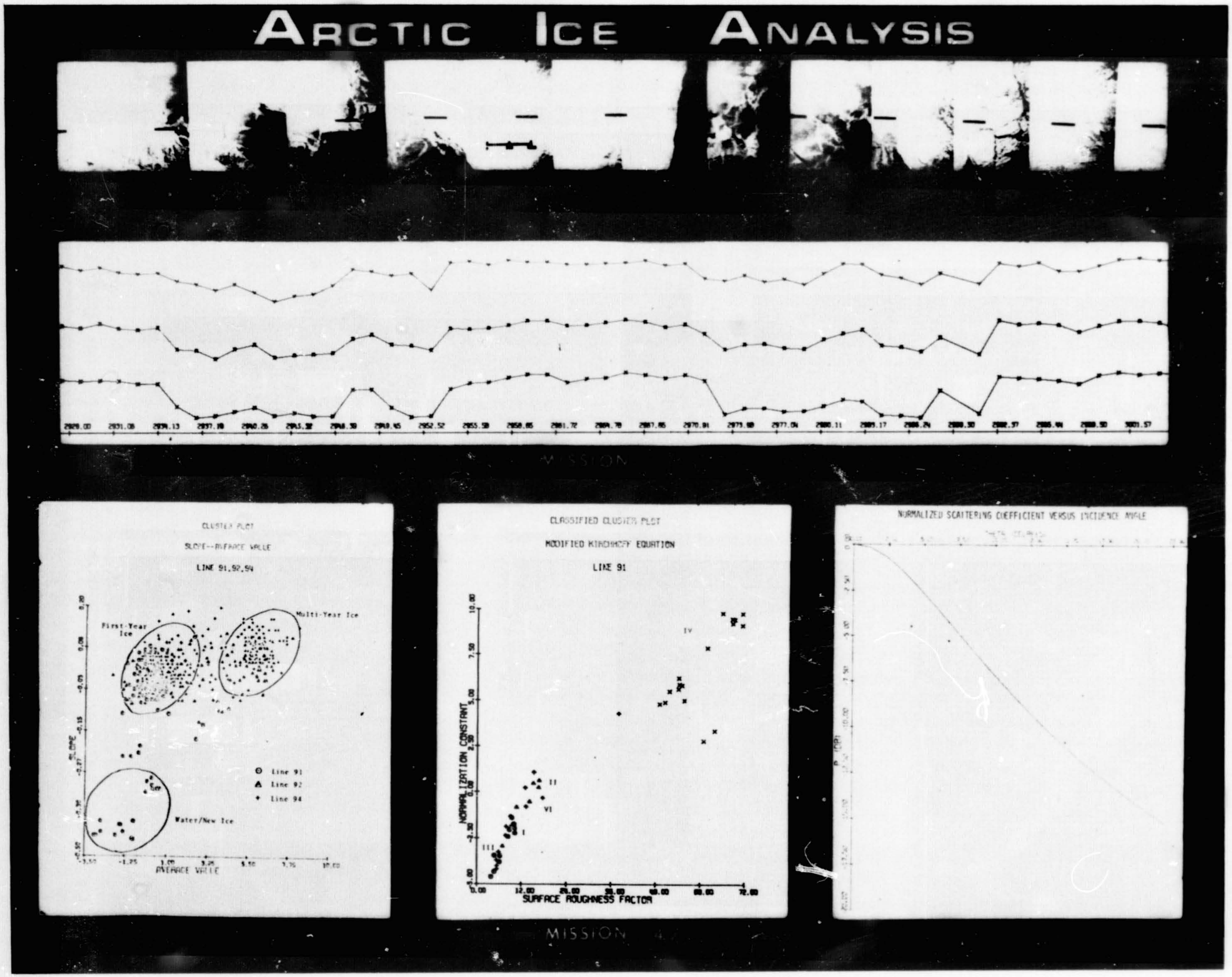
Uncured, 5 NT/CM²
Uncured, 20 NT/CM²
Cured, 5 NT/CM²
Cured, 20 NT/CM²
STONY CLAY
Relative Dielectric Constant
Per Cent Moisture Content
k'
k"
0
5
10
15
20
25
30
0
10
20
30
40
50

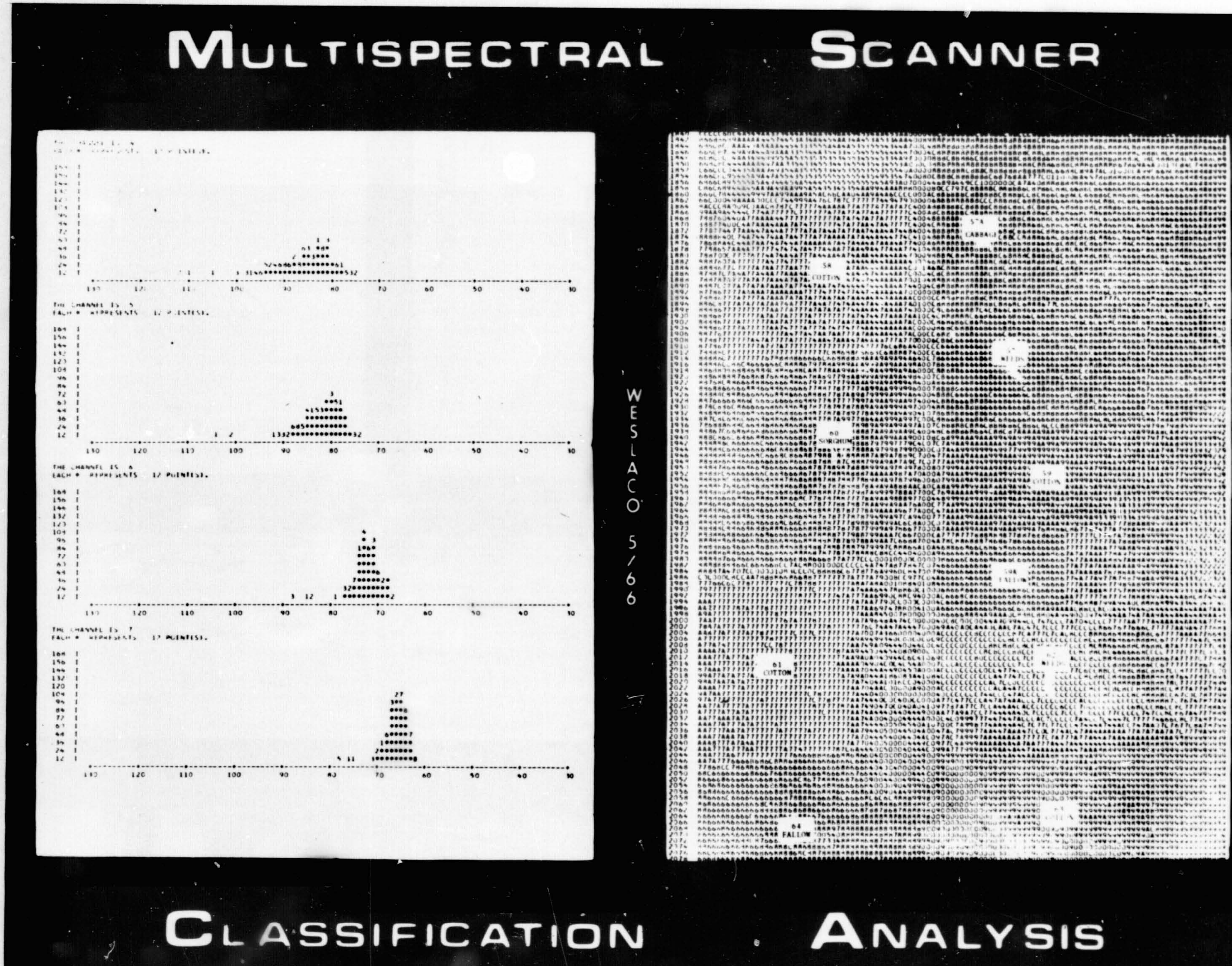


NASA/GSFC DATA
WESLACO 1971

DATA ANALYSIS LABORATORY OBJECTIVES

- PROVIDE STATE-OF-THE-ART ANALYSIS OF MULTI-SENSOR DATA
- IMPLEMENT AND DEVELOP COMPUTER SOFTWARE
- INVESTIGATE THE EFFICIENT UTILIZATION OF THE TOTAL DATA SYSTEM


ARCTIC ICE ANALYSIS
MISSION
CLUSTER PLOT
SLOPE--AVERAGE VALUE
LINE 91,92,94
First-Year Ice
Multi-Year Ice
Water/New Ice
Line 91
Line 92
Line 94
SLOPE
AVERAGE VALUE
CLASSIFIED CLUSTER PLOT
MODIFIED KIRCHHOFF EQUATION
LINE 91
NORMALIZATION CONSTANT
SURFACE ROUGHNESS FACTOR
NORMALIZED SCATTERING COEFFICIENT VERSUS INCIDENCE ANGLE
MISSION

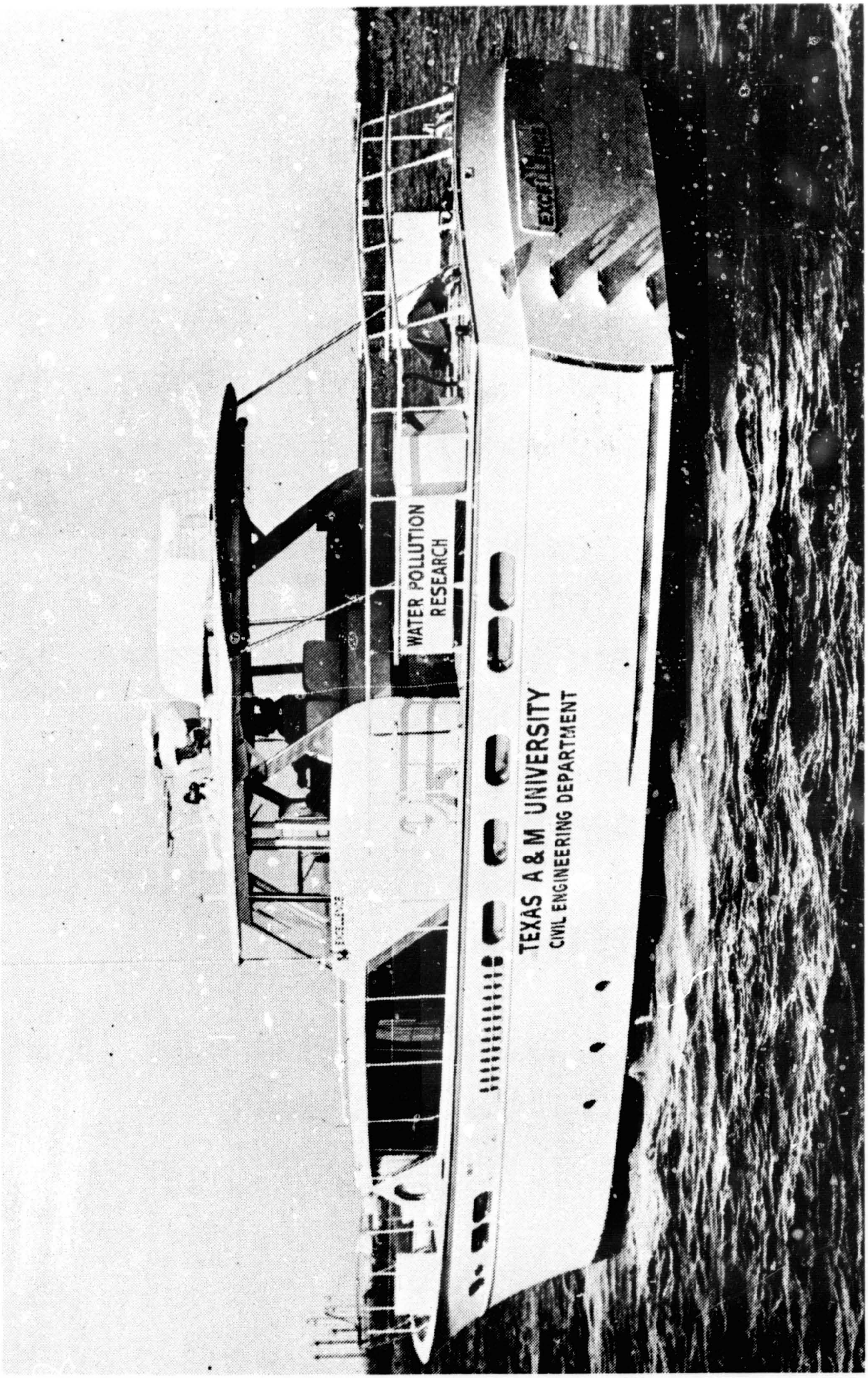

MULTISPECTRAL SCANNER
CLASSIFICATION ANALYSIS
WESLACO 5/66
THE CHANNEL IS 5
THE CHANNEL IS 6
THE CHANNEL IS 7
58 COTTON
60 SORGHUM
61 COTTON
64 FALLOW
CABBAGE
WEEDS

IBM 360/65 DIGITAL COMPUTER

- UNIVERSITY OWNED TO PROVIDE LOW COST, EFFICIENT OPERATION WITH A FULL RANGE OF COMPUTER CAPABILITY AND USER SERVICE.

- 6 MILLION BITS CORE STORAGE
- DISC STORAGE
- MAGNETIC TAPE (MULTIPLE TRACK, DENSITY)
- MULTIPLE COMPILER/UTILITIES
- CORE RESIDENT WATFIV (SOFTWARE DEVELOPMENT)
- MVT OPERATING SYSTEM (OPERATIONAL COST/TURNAROUND

- RAPID TURNAROUND (TYPICALLY 15 MINUTES)
- USER COST $375/CPU HOUR


WATER POLLUTION
RESEARCH
TEXAS A&M UNIVERSITY
CIVIL ENGINEERING DEPARTMENT

HOUSTON SHIP CHANNEL WATER QUALITY STUDY

COOPERATIVE STUDY WITH NASA/MSC, TAMU CIVIL ENGINEERING DEPARTMENT AND TEXAS WATER QUALITY BOARD.

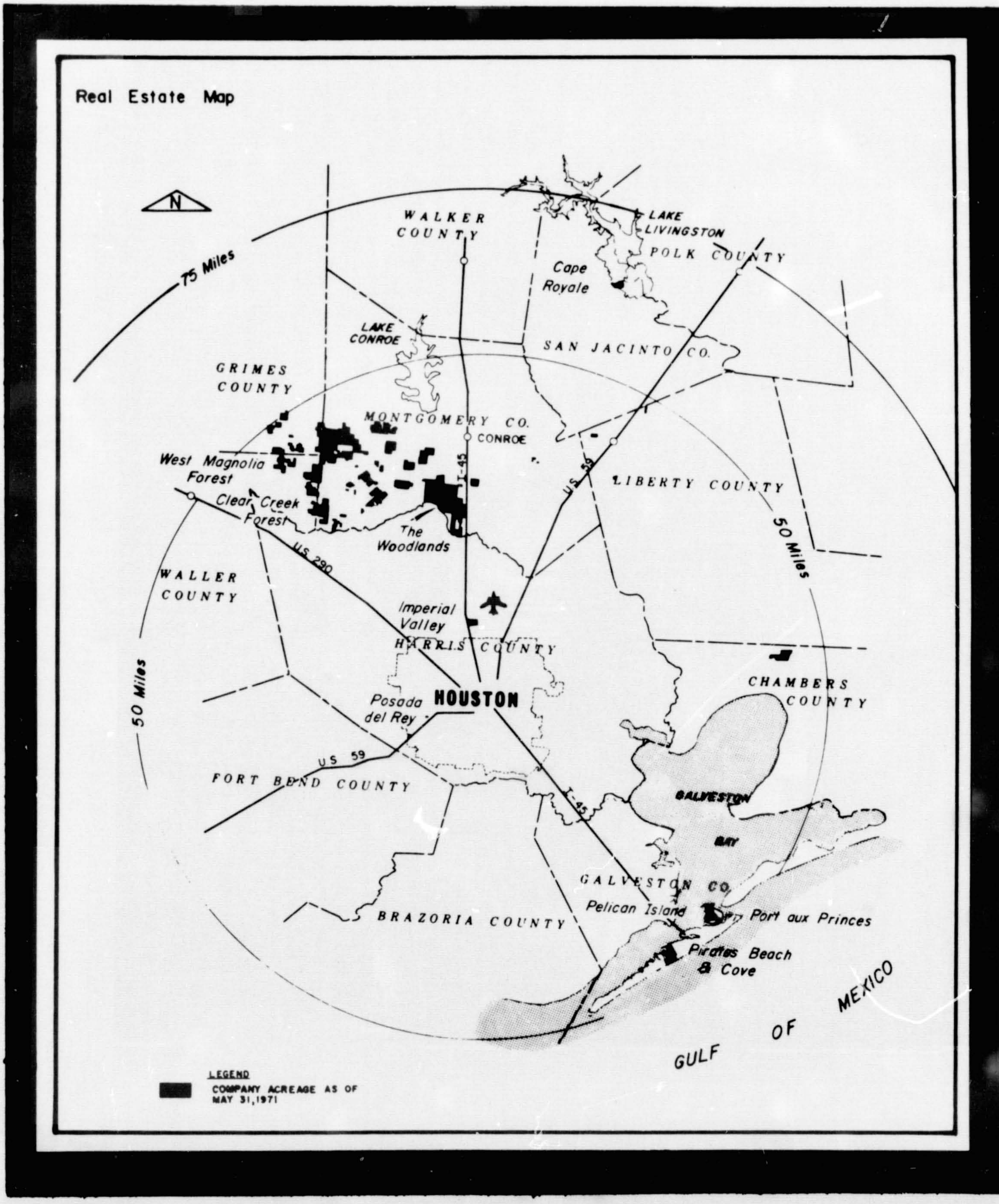
OBJECTIVE: ESTABLISH FEASIBILITY AND PROCEDURE FOR IMPLEMENTING REMOTE SENSING TECHNIQUES INTO OPERATIONAL MONITORING ACTIVITIES OF THE TEXAS WATER QUALITY BOARD.

HUD CITY PROJECT

(GEORGE MITCHELL ASSOC. DEVELOPMENT)

PLAN FOR TOTAL CITY (POP. 100,000) ON 17,500 ACRE SITE NORTH OF HOUSTON - 20 YR. DEVELOPMENT PLAN TO INCLUDE INDUSTRIAL, RESIDENTIAL, COMMERCIAL, EDUCATIONAL, AND RECREATIONAL FACILITIES.

OBJECTIVE: TO UTILIZE REMOTE SENSOR DATA TO MINIMIZE IMPACT OF MAJOR URBAN DEVELOPMENT ON THE ENVIRONMENT AND TO CAPITALIZE UPON THE CHARACTERISTICS OF THE NATURAL TERRAIN.


Real Estate Map
N
75 Miles
WALKER COUNTY
LAKE LIVINGSTON
POLK COUNTY
Cape Royale
LAKE CONROE
SAN JACINTO CO.
GRIMES COUNTY
MONTGOMERY CO.
CONROE
I-45
West Magnolia Forest
Clear Creek Forest
The Woodlands
US 59
LIBERTY COUNTY
50 Miles
US 290
WALLER COUNTY
Imperial Valley
HARRIS COUNTY
CHAMBERS COUNTY
50 Miles
HOUSTON
Posada del Rey
US 59
FORT BEND COUNTY
I-45
GALVESTON BAY
GALVESTON CO.
Pelican Island
Port aux Princes
BRAZORIA COUNTY
Pirates Beach & Cove
GULF OF MEXICO
LEGEND
COMPANY ACREAGE AS OF MAY 31, 1971