E81-10204
CR-160953

AgRISTARS

EW-N1-04042
JSC-17112

MAR 1 1 1981

A Joint Program for Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing

Early Warning and Crop Condition Assessment

February 1981

METEOROLOGICAL SATELLITE DATA - A TOOL TO DESCRIBE THE HEALTH OF THE WORLD'S AGRICULTURE

T. I. Gray, Jr. and D. G. McCrary
National Oceanic and Atmospheric Administration

(E81-10204) METEOROLOGICAL SATELLITE DATA: A TOOL TO DESCRIBE THE HEALTH OF THE WORLD'S AGRICULTURE (National Oceanic and Atmospheric Administration) 12 p HC A02/MF A01 CSCL 02C G3/43
N81-31596
Unclas
00204

U.S. Department of Commerce
1050 Bay Area Blvd.
Houston, Texas 77058

Lyndon B. Johnson Space Center
Houston, Texas 77058

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No
EW-N1-04042; JSC-17712		
4. Title and Subtitle Meteorological Satellite Data - A Tool To Describe the Health of the World's Agriculture		5. Report Date February 1981
		6. Performing Organization Code
7. Author(s) T. I. Gray, Jr. and D. G. McCrary U.S. Department of Commerce		8. Performing Organization Report No
9. Performing Organization Name and Address National Oceanic and Atmospheric Administration, USDC 1050 Bay Area Blvd. Houston, Texas 77058		10. Work Unit No.
		11. Contract or Grant No.
		13. Type of Report and Period Covered Technical Memorandum
12. Sponsoring Agency Name and Address Early Warning/Crop Condition Assessment AgRISTARS 1050 Bay Area Blvd. Houston, Texas 77058		14. Sponsoring Agency Code
15. Supplementary Notes 17M Boatwright, G.O. SF3		

16. Abstract

Local Area Coverage data acquired aboard the TIROS-N satellite family by the Advanced Very High Resolution Radiometer systems have been examined to determine the agricultural information content. Albedo differences between Channel 2 and Channel 1 of the Advanced Very High Resolution Radiometer LAC (called EVI) are shown to be closely correlated to the Ashburn Vegetative Index produced from Landsat multispectral scanner data which have been shown to vary in response to "greenness", soil moisture, and crop production. The statistical correlation between the EVI and the Ashburn Vegetative Index ($\pm$ 1 day) is 0.86.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Vegetative Index Early Warning	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	12	

EW-N1-04042
JSC-17112

METEOROLOGICAL SATELLITE DATA - A TOOL TO DESCRIBE THE HEALTH OF THE WORLD'S AGRICULTURE

PRINCIPAL INVESTIGATORS

T. I. Gray and D. G. McCrary

APPROVED BY

G. O. Boatwright, Manager
Early Warning/Crop Condition Assessment Project
AgRISTARS Program

Earth Observations Division
Space and Life Sciences Directorate
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

February 1981

LEMSCO-15978

Page intentionally left blank

PREFACE

The Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing is a 6-year program of research, development, evaluation, and application of aerospace remote sensing for agricultural resources which began in fiscal year 1980. This program is a cooperative effort of the U.S. Department of Commerce, the National Aeronautics and Space Administration, the U.S. Department of Agriculture, and the U.S. Department of the Interior. Under Contract NAS 9-15800, personnel of Lockheed Engineering and Management Services Company, Inc., assisted the Early Warning/Crop Condition Assessment project in preparing this document for publication.

The expertise of many individuals was required in the course of this work. The authors acknowledge the contributions of the following persons:

- P. Ashburn, U.S. Department of Agriculture, Foreign Services Department, Crop Condition Assessment Division, who provided the Ashburn Vegetative Index data set
- L. Scott, U.S. Department of Agriculture, Economic Statistics Cooperative Service, who prepared the manuscript
- L. Lautenschlager, U.S. Department of Agriculture, Economic Statistics Cooperative Service, who provided statistical support
- F. Ravet, Earth Observations Division, National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, who provided leadership in software development
- G. Boatwright, Manager, Early Warning/Crop Condition Assessment project, U.S. Department of Agriculture, who provided encouragement and support
- M. Helfert, Oceans and Atmosphere service, National Oceanic and Atmospheric Adminstration, who provided helpful suggestions

AFFILIATION OF PRINCIPAL INVESTIGATORS

- T. I. GRAY, JR.: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Earth Satellite Service, Land Services Branch. Liason detailed to the Agriculture and Resources Inventory Surveys through Aerospace Remote Sensing program at the Lyndon B. Johnson Space Center.

- D. G. McCrary: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data and Information Service, Center for Environmental Assessment Services. Assigned to support Early Warning/Crop Condition Assessment project.

CONTENTS

PRECEDING PAGE BLANK NOT FILMED

1. BACKGROUND

In the Large Area Crop Inventory Experiment (LACIE) and the research activities that followed, the response variations within the several channels of multispectral scanner (MSS) data sets over known earth target areas were investigated. The MSS instruments were placed on board the two Earth Resources Technology Satellites (ERTS-1 and ERTS-2), which subsequently were renamed Landsat-1 and Landsat-2 by the National Aeronautics and Space Administration (NASA). These instruments have been placed on subsequent Landsats, also. The vegetative indexes, which comprise one set of research products derived from MSS data, respond to changes in "greenness" of vegetation. Although several indexes have been proposed, the auto-correlation between them is so strong that any one can be considered representative.

The LACIE project results indicated that the MSS remote sensor system is a potential tool for monitoring global agricultural conditions. To exploit this tool, the Foreign Agriculture Service (FAS) of the U.S. Department of Agriculture (USDA) formed the Crop Condition Assessment Division (CCAD), which was chartered to devise operational techniques for monitoring world food production. The CCAD has established an operational digital computer facility to ingest and process Landsat MSS data sets into agricultural analytical products. They recognized that a massive storage impact would exist if all of the daily output of the MSS was retained. Accordingly, several products have been developed for retention in a time series. This product list includes sample segments, skip-pixel-skip-line images, and vegetative indexes. The indexes file for the South American area which was used in this study was initiated in January 1980.

2. EXPERIMENTAL DESIGN

With the initiation of the Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS) project, National Oceanic and Atmospheric Administration (NOAA) personnel D. McCrary and R. Smith proposed the investigation of the polar-orbiting environmental satellite system capabilities as a complementary data source to that of the Landsat MSS. The Landsat system design provides one observation per site every 18 days per satellite, while the environmental satellite system, Television Infrared Observation Satellite (TIROS-N/NOAA), can provide a daily observation. During LACIE, cloudiness at the time of the Landsat overpass frequently precluded acquisition of suitable data for the selected target areas. Thus, the named researchers designed tasks for study which might provide data sets to complement MSS products for agricultural and resources inventories.

With the acceptance of these tasks within the Early Warning/Crop Condition Assessment project of AgRISTARS, D. McCrary requested that the Local Area Coverage (LAC) data acquired through the Advanced Very High Resolution Radiometer (AVHRR) systems be collected and archived for a series of dates for the South American principal crop areas. S. Schneider, Environmental Products Branch, National Earth Satellite Services, provided the support necessary to acquire these data sets. Meanwhile, the data sets from the MSS source were delivered to the CCAD FAS in an operational mode.

The first proposed task called for relating timely (± 3 days) MSS data products to the similiarly configured environmental data products. Although image displays of the LAC data could be produced, only subjective worthiness of such products for agricultural monitoring was possible. The two problems that existed may be described as follows.

a. The image device design needs 3 or 4 channels of data, whereas only 2 channels were available in the LAC.

b. The stability of the imaging of the LAC data varied with respect to the amount of cloud in the image area.

The best opportunity to compare the two systems appeared to be with vegetative indexes. For South America there were several LAC data sets which were nearly synoptic to the operational products of the MSS for that continent. The spectral characteristics of the AVHRR channel 1 are very similar to the combination of channels 4 and 5 of the MSS, and AVHRR channel 2 is similar to the combination of channels 6 and 7 of the MSS, as shown in the table below.

Channel	AVHRR wave length, μm	Channel	MSS wave length, μm
1	0.55 - 0.68	4 5	0.5 - 0.6 .6 - .7
2	.7 - 1.1	6 7	.7 - .8 .8 - 1.1

Thus, we formulated our Environmental Vegetative Index (EVI) to be

$$\text{EVI} = \text{Alb.(channel 2)} - \text{Alb.(channel 1)}$$

where Alb. = albedo, except that if EVI $\leq$ 0.0, the value is ignored. The Ashburn Vegetative Index (AVI) is screened in the same manner. A data point has a cloud response if EVI $\leq$ 0, and has a water response if EVI < 0.

The initial computations of the EVIs were made by using the digital counts in each of channels 1 and 2 rather than the actual calibrated albedos. However, the slopes and intercepts of the calibration curves for the two channels form nearly the same line. The major correction to the AVHRR LAC data is that of correcting the data to an apparent overhead sum: data value/cos z, where z is the solar zenith angle. Since the EVI is computed as a difference between the simultaneous responses of the two channels from the same field of view, this correction was made upon the EVI.

$$\text{EVI (corrected)} = \text{EVI}/\cos z$$

The first data set, based upon AVHRR LAC data for South America for 16 March 1980 and Landsat MSS data sets from the period 15 March 1980 through 17 March 1980, consists of EVI and AVI pairs computed for identical land target areas. These data pairs were processed by SAS* programs PLOT, CORR,

*Statistical Analysis System (SAS) programs are provided by the SAS Institution, Inc., Raleigh, North Carolina.

and GLM. Whithin this time restraint, the correlation between the pairs was 0.86. However, with a wider time window, using Landsat data acquired on 10 March 1980, the additional points added an excessive number of cloud-contaminated pixels which then decreased the correlation to 0.69. (See figures 1 and 2.)

3. CONCLUSION AND STUDY SUGGESTIONS

In this short study, the EVI is shown as being closely related to the AVI, inferring, then, that the AVHRR LAC data sets may be used to complement the MSS data (or substitute when necessary) for agricultural monitoring through time series products of vegetative indexes. Further study is necessary to qualify more fully the environmental satellite data sets as a tool for agricultural and resource inventories. Suggestions for such study are as follows.

A. Develop a method to adjust for mixed scene pixels.

B. Determine the variations within and between AVHRR LAC data associated with viewing angle, solar illumination, and atmospheric effects.

C. Determine the acceptability and adaptabililty of AVHRR LAC data sets in maintaining the indexes time series.

D. Determine the scalar variations of the indexes with respect to ground truth to calibrate the indexes for interpretation capability.

E. Establish applicable techniques which may be transferable to the proposed operational computer system.

F. Establish techniques to use EVI data for Early Warning/Crop Condition Assessment tasks.

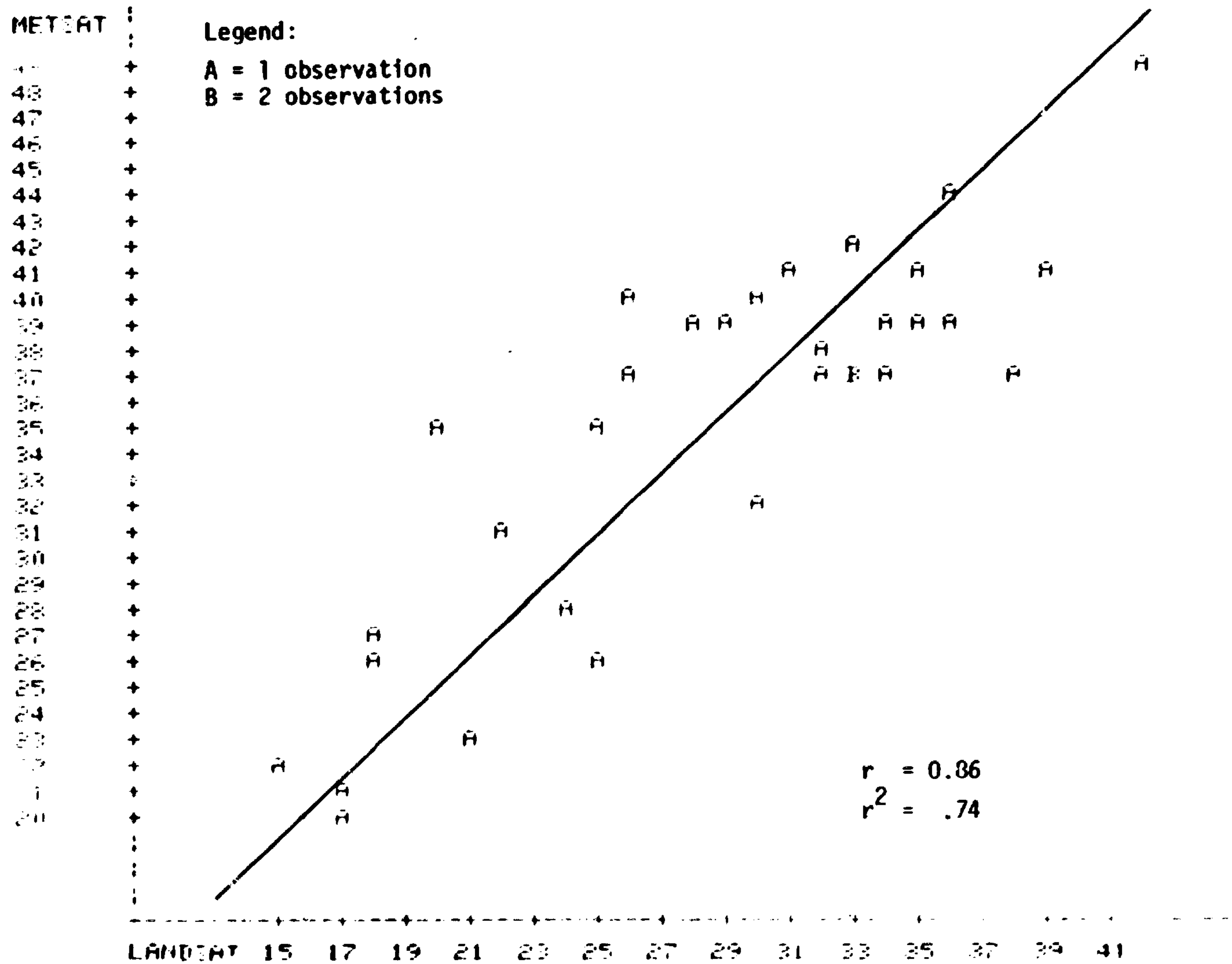

Figure 1.- Spectral response to vegetation by AVHRR and MSS sensors. METSAT data is given for 16 March 1980 and LANDSAT data is given for 15-17 March 1980.

ORIGINAL PAGE IS OF POOR QUALITY

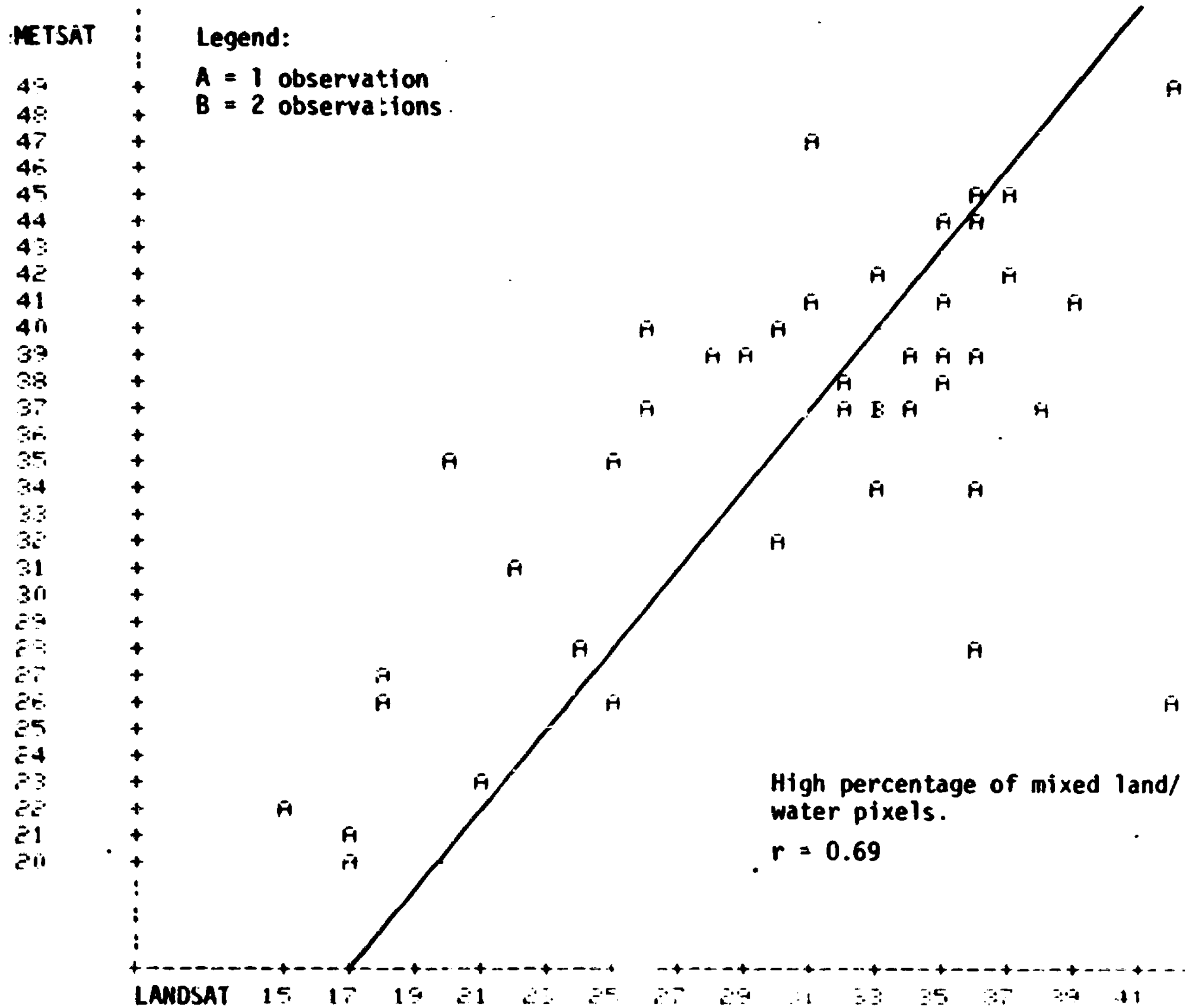

Figure 2.- Spectral response to vegetation at AVHRR and MSS sensors, with time window enlarged to include 10 March 80 MSS data points.

4. REFERENCES

Ashburn, P.: Utilization of the Vegetative Index Number in the USSR. Technical Memorandum #11, U.S. Department of Agriculture, Foreign Agricultural Service, Washington, D.C., October 1979.

Davis, L.: Utilization and Evaluation of Vegetative Indexes for Crop Condition Assessment. Technical Memorandum #10, U.S. Department of Agriculture, Foreign Agricultural Service, Washington, D.C., September 1979.

Aaronson, A.; and Davis, L.: An Evaluation of Relationships Between Vegetative Indices, Soil Moisture and Wheat Yields. Technical Memorandum #9, U.S. Department of Agriculture, Foreign Agricultural Service, Washington, D.C., September 1979.

Thompson, D.; and Wehmanen, O. A.: The Use of Landsat Digital Data to Detect and Monitor Vegetation Water Deficiencies. 11th Int. Symp. on Remote Sensing of Environment, Environmental Research Institute of Michigan (Ann Arbor), pp. 925-931, April 1977.