

## **N O T I C E**

THIS DOCUMENT HAS BEEN REPRODUCED FROM  
MICROFICHE. ALTHOUGH IT IS RECOGNIZED THAT  
CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED  
IN THE INTEREST OF MAKING AVAILABLE AS MUCH  
INFORMATION AS POSSIBLE

Columbia University in the City of New York | New York, N. Y. 10027

DEPARTMENT OF GEOGRAPHY

International Affairs Building  
420 West 118th Street

"Made available under NASA sponsorship  
in the interest of early and wide dis-  
semination of Earth Resources Survey  
Program information and without liability  
for any use made thereof"

E80-10161  
CR-163178

APPLICATION OF DIGITAL ANALYSIS OF  
MSS DATA TO AGRO-ENVIRONMENTAL STUDIES

Final Technical Report  
NASA Grant NSG-5080  
March 1, 1980

(E80-10161) APPLICATION OF DIGITAL ANALYSIS  
OF MSS DATA TO AGRO-ENVIRONMENTAL STUDIES  
Final Report (Columbia Univ.) 14 p  
HC A02/MF A01

N80-25737

CSCI 02C

G3/43

Unclass  
00161

Principal Investigators

Robert A. Lewis  
Samuel N. Goward

## CONTENTS

- I. Introduction
- II. Completed Research
- III. Ongoing Research
  - A. Simulation Studies
  - B. Interpretive Techniques
  - C. Vegetative Land Cover Analysis
- IV. Conclusions

APPENDIX: Papers and Reports

## I. Introduction

This final technical report marks a change in the funding arrangement between the Department of Geography, Columbia University and the Earth Resources Program, NASA Goddard Institute for Space Studies from a NASA Grant (NSG 5080) to a NASA Cooperative Agreement (NCC 5-20). The change has been instituted to reflect the increased interaction between Columbia and GISS investigators and does not alter the substantive nature of research activities conducted by the Columbia investigators. Much of the research begun under NASA Grant NSG 5080 will be continued under NASA Cooperative Agreement NCC 5-20 and thus much of the work reported here represents intermediate developments on continuing research activities.

Since September 1975 the Department of Geography, Columbia University has conducted research in collaboration with the NASA Goddard Institute for Space Studies (GISS), Earth Resources Program. The research is concerned with development and application of remote sensing techniques to monitor earth resources. Studies have addressed a broad range of topics including simulation of advanced sensor systems, development of computer-aided interpretation techniques, and analysis of remote sensor data to study agricultural activities, natural vegetation, and human impact on the environment.

The primary purpose of the research is to aid in development of a global earth resources monitoring system which would rely on satellite data collection systems as major data sources. The

studies conducted have supported definition of future sensor systems, advancement of automated analysis techniques, and evaluation of the utility of existing data to earth resources studies.

Primary data sources for these studies have been 24 channel aircraft multispectral scanner data, Landsat data, helicopter acquired FSS spectroradiometric data as well as other remote sensor data made available through the offices of GISS. Data analysis has been carried out on the GISS IBM 360/95 computer and ancillary systems with software developed and implemented at GISS.

The faculty of the Department of Geography, Columbia University has worked closely with GISS personnel as well as supervised the student research assistants who have undertaken individual projects within the framework of this grant. In addition to the principal investigators, the staff at any one time has included five funded graduate students and several graduate researchers funded from other sources. Participating Columbia University faculty members from the Department of Geography have included Professors Kempton Webb, Leonard Zabler, Jerry Coiner, and Colin High.

## II. Completed Research

A large part of available resources under NSG 5080 have been committed to the support of GISS spectral data analysis and allied advanced satellite sensor system simulations. An extensive series of investigations were conducted to determine appropriate parameters for the Thematic Mapper Instrument. Thematic Mapper data were simulated using 24-channel multispectral scanner data flown over selected LACIE test sites. These studies are reported in: Ungar and Egbert, 1976; Ungar and Kiang, 1976; and Ungar et al., 1976. The role of Columbia investigators in this research is described in the semi-annual reports for this grant prepared for the period from Sept. 1975 through Sept. 1977. Another major effort in this category was the production of an atlas of high resolution spectral data from the GISS spectrometer for agricultural crops and other agricultural ground surfaces from Imperial Valley, California (Ungar et al., 1977).

Several studies have been conducted within the broad framework of research to evaluate the Landsat systems' capabilities to monitor the agricultural and environmental conditions of the earth's land areas. These geographically diverse studies have addressed issues in resource assessment, resource utilization and the environmental impact of human use of natural resources (for example, see Cary, 1979; Neary, 1978; Richman, 1979). These studies not only have contributed to advancement of Landsat data applications but also have supported GISS simulation studies and interpretive techniques development by providing case

studies to test concepts and methods. Much of this work has constituted thesis research for advanced degrees in the Department of Geography. Furthermore, some of these studies have been supported by outside funding sources, which has resulted in significant contributions to the project at no additional cost to NASA.

### III. Ongoing Research

#### A. Simulation Studies

Research in this area has concentrated on analysis of LACIE Field Spectrometer System (FSS) data for the purpose of studying temporal variations of agricultural crop spectral signatures and their significance for current and proposed multispectral sensors. Preliminary findings have been reported in Ungar et al., 1979.

Previous work has centered on FSS data collected for Finney County, Kansas during the 1974-75 growing season. Further data, covering Finney County, Kansas during the 1975-76 and 1976-77 growing seasons and Williams County, North Dakota during the 1975 - 1977 growing seasons have been acquired from the Laboratory for Applications of Remote Sensing at Purdue University. Analysis procedures, as previously reported in the July 1, 1979 semi-annual report for this grant, have been carried out on the new observations. The reduced temporal resolution of the data from the 1976 and 1977 growing seasons has seriously impacted the value of the results. However, given the data limitations, the

findings of the previous work has been reinforced. Ratios of spectral bands in selected portions on the visible, near-infrared and middle infrared track crop biophase effectively.

When the ratio vectors of individual agricultural fields are superimposed by crop type a time offset between field vectors is present. It is postulated that the offset is the result of differing planting dates between fields. In an effort to demonstrate that temporal band ratio vectors consistently track crop development, two normalization techniques have been attempted: normalizing to planting date and normalizing to accumulated degree days since planting. These two procedures provide successive incremental improvements in coregistration of the temporal vectors. A third procedure which will include accumulated solar insolation since planting is currently being developed in a continued effort to improve vector coregistration.

#### B. Interpretive Techniques

A signature optimization (automated training and signature extraction) procedure is being developed at GISS to reduce analyst time spent on refining sensor data classification. Experience has shown that a significant portion of human analysis time is spent on refining signature parameters to fit classification results to a priori knowledge of training areas in the study region. Where this a priori knowledge is of adequate detail to produce digital ground truth maps of the training area, the iterative procedure of signature optimi-

zation may be automated. Previous GISS automated signature optimization experiments with 24-channel aircraft MSS data have been encouraging (Ungar et al., 1978). As a result, LACIE Landsat segment data and associated digital ground truth have been acquired from LACIE scientists at JSC. This data base is being used to expand the signature optimization experiments and to test alternate mathematical optimization solutions. If successful, this research could lead to development of fully automated analysis procedures in specific applications areas.

Current activities are concentrated on intensive analysis of LACIE Landsat segment data from Kansas and Minnesota. Rigorous evaluation of analyst procedures used for signature extraction has led to the conclusion that effective computer-assisted analysis of multispectral image data is constrained not only at the classifier training stage but also during signature extraction. Significant analyst time is spent analyzing data structure within and between classes of interest. The strategies used by various analysts at GISS are being investigated to determine the most effective and efficient means to conduct signature extraction. One way to improve these procedures is to relate signature extraction and classification procedures. Certain (unknown) signature attributes should be indicative of classifier parameters that describe the "best" envelope around the class signature. The Earth Resources programming staff is currently developing software that may assist in this regard. Since signature extraction and classifier training problems are in certain respects highly related, resolution of the signature extraction procedures will significantly contribute to development of signature optimization procedures.

### C. Vegetative Land Cover Analysis

A doctoral candidate in the Department of Geography, Chris Brest, has begun a study of urban-rural albedo differences through analysis of Landsat data under the direction of Dr. Goward. The Earth Resources group has acquired 25 cloud-free Landsat scenes of the Hartford, Connecticut area collected between 1972 and 1978. These scenes cover all months of the year and thus provide an unusually complete data set with which to analyze the seasonal dynamics of urban-rural albedo contrasts.

Chris spent several weeks in Hartford during July and August collecting spectroradiometric measurements of pavements and rooftops in the urban-suburban setting. These measurements should permit effective calibration of the Landsat data to assess the urban-rural percent reflectance differential. This study will help to resolve a key question with regard to the formation of urban climate: are urban albedos lower than rural albedos in a humid temperate setting? If the calibration procedure proves effective, the calibrated data base may also serve to support atmospheric and spectral research that the GISS Earth Resources scientists are conducting.

### IV Conclusions

Research and activities conducted under NASA Grant NSG 5080 have been mutually beneficial to NASA scientists at GISS and the students and staff of the Department of Geography, Columbia

University. NASA/GISS Earth Resources activities have received significant research support in a highly cost-effective manner through utilization of Columbia University graduate students and staff. In return, Columbia University staff and students have been provided access to facilities and activities not typically available in the academic community. The success of this arrangement is indicated by the continuation of these activities under NASA Cooperative Agreement NCC 5-20.

## APPENDIX

Papers and Presentations on Research  
conducted wholly or in part under NSG 5080

September 1975 - December 1979

Cary, Tina K. "Agricultural Systems in East Africa Viewed from Landsat." Proceedings of the Symposium on Machine Processing of Remotely Sensed Data, Purdue University, Laboratory for Applications of Remote Sensing, West Lafayette, Indiana, June 1979, pp. 432.

Cary, Tina K. "Landsat Analysis of Human Ecosystems in Kenya: Project Overview, and Field Experience." Paper presented at Laboratory for Applications of Remote Sensing, Purdue University, January 19, 1979.

Cary, Tina K. "Detection of Swidden Agriculture in Kenya by Computer-Aided Analysis of Landsat Data." M.A. Thesis, Department of Geography, Columbia University, May 1978

Colner, Jerry C. "Role of Geographic Information System in Development Planning." Proceedings of 2nd Annual Innovations in Land Use Management Symposium, Bismark, North Dakota, June 1977.

Colner, Jerry C. and High, Colin J. "Monitoring Tropical Land Cover Dynamics from Remotely Sensed Data." XXIII International Geographical Congress. Proceedings of General Physical Geography, Vol. 5, Moscow, 1976, pp. 71-73.

Colner, Jerry C. and Levine, Arthur L. "Applications of Remote Sensing to Urban Problems." Urban Systems, Vol. 4, Nos. 3 & 4, 1979, pp. 285-219.

Colner, Jerry C. and Ungar, Stephen G. "Ground Truth Management System to Support Multispectral Scanner (MSS) Digital Analysis." Proceedings of ASP-ASCM Joint Annual Meeting, Washington, D.C., Feb. 27 - March 5, 1977.

Conant, Francis and Cary, Tina K. "A First Interpretation of East African Swiddening via Computer-Assisted Analysis of 3 Landsat Tapes." Proceedings of Symposium on Machine Processing of Remotely Sensed Data, Purdue University, Laboratory for Applications of Remote Sensing, Lafayette, Indiana, June 1977, pp. 36-43.

Conant, Francis and Cary, Tina K. "Computer-Aided Analysis of Landsat Data on Shifting Cultivation in East Africa: Preliminary Results and Further Considerations." Proceedings of the 11th International Symposium on Remote Sensing of Environment, April 1977, pp. 1243-1244.

- Lytle, Steve. "Measuring the Impact of Environmental Parameters on Computer Classification of Agriculture." M.A. Thesis, Department of Geography, Columbia University, May 1978.
- Matthews, Elaine. "Changing Patterns of Global Cereal-Crop Yields: 1958-1975." M.A. Thesis, Department of Geography, Columbia University, May 1978.
- Nearby, Patricia. "Agricultural Systems Change in Southern New Jersey." M.A. Thesis, Department of Geography, Columbia University, May 1978.
- Nearby, Patricia and Colner, Jerry C. "Detecting Transition in Agricultural Systems." Paper presented at the 1979 ASP-ACSM Convention, Washington, D.C., March 1979.
- Nearby, Patricia and Colner, Jerry C. "Monitoring Agricultural Systems." Poster Session at the 12th International Symposium on Remote Sensing of Environment, Manila, Philippines, April 1978.
- Prentice, Katharine C., and Colner, Jerry C. "Agriculturally Induced Vegetation Change (1958 - 1975)." forthcoming Human Ecology, 1988.
- Richman, Howard. "LANDSAT as a Hydrologic Land Use Classification Tool for the Saw Mill River Watershed." M.A. Thesis, Department of Geography, Columbia University, May 1979.
- Textor, Suzanne and Colner, Jerry C. "Digital Analysis of Human Impact on Tropical Vegetation." Proceedings of Symposium on Machine Processing of Remotely Sensed Data, Purdue University, Laboratory for Applications of Remote Sensing, West Lafayette, Indiana, June 1976, p. 38-7.
- Ungar, Stephen G. and Egbert, Dwight. "Thematic Mapper Studies: Data Quality Analysis." NASA Goddard Institute for Space Studies, New York, April 1976.
- Ungar, Stephen G. and Kiang, Richard. "Thematic Mapper Studies: Band Correlation Analysis." NASA Goddard Institute for Space Studies, New York, April 1976.
- Ungar, Stephen G., Colner, Jerry C., et al. "Thematic Mapper Classification Studies." NASA Goddard Institute for Space Studies, New York, April 1976 (revised 1978).

ORIGINAL PAGE IS  
OF POOR QUALITY

Ungar, Stephen G., Collins, William, Colner, Jerry C., et al.  
"Atlas of Selected Crop Spectra -- Imperial Valley, California."  
NASA/GSFC TM 79743, July 1977.

Ungar, S.G., Goward, S., Bradley, D., Chaikin, G. "Catalog of  
Band Ratio Variations, 1974/1976 Growing Season, LACIE Intensive  
Test Site, Finney County, Kansas." NASA Goddard Institute for  
Space Studies, New York, August 1979.

Ungar, Stephen G., Wasilewsky, J., and Zeitz, P. "Toward Fully  
Automated Agricultural Inventory from Satellites." in  
COSPAR: The Contribution of Space Observations to Global  
Food Information Systems, Godby, E.A. and Otterman, J.  
(eds.) 1978, pp. 59-62.

Wilson, Helene and High, Colin J. "Digital Processing of Landsat  
Data for the Survey of Rural Land Use in the West African  
Savanna." Paper presented at the Annual Meeting of the  
Association of American Geographers, New York, April 1976.