Pre-Proposal

"Defining the Value and Potential Use of Remote Sensor Satellite Data on LTER Sites in the U.S."

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Pre-proposal on Defining the Value and Potential Use of Remote Sensor Satellite Data on LTER Sites in the U.S.

Background

Since the launch of Landsat-1 in 1972, data obtained with multispectral scanners from satellite altitudes has been used and abused, praised and denounced, analyzed and ignored by many individuals and organizations throughout the world. Much of the differences of opinion concerning the merit, or lack thereof, of such data has often been the result of misunderstandings concerning the characteristics of the data and/or effective data handling and analysis procedures. For example, many people have become very excited about the high spatial resolution (i.e., 10 and 20 m) of the data obtained by the SPOT multilinear array sensors, but have not given adequate consideration to the fact that the SPOT sensors cannot obtain data in the very important middle infrared (i.e., 1.3-3 1m) portion of the electromagnetic spectrum. Data in these wavelengths can only be obtained by the Thematic Mapper scanner on Landsats 4 & 5. Or consider the idea that the $1,600 cost of a full frame of SPOT data appears to be much less than the $3,300 cost of a full frame of T.M. data. However, when one remembers that the swath of the SPOT scanners is only 60 kilometers versus the 185 km of the TM scanner, it is apparent that, on a per unit area basis, TM data is relatively inexpensive as compared to SPOT data. In fact, the digital TM data costs about $0.25/square mile versus $1.15/sq. mi. for the SPOT data. (See Table 1.) Unfortunately, one cannot obtain either type of data for only the specific area of interest, and the cost of a quarter frame of TM data is approximately half the cost of a full frame (i.e., the cost is doubled, on a unit area basis, for only a quarter frame as compared to a full frame).

There are many ways in which one can use satellite multispectral scanner data. In general, scientists and others throughout the world have found that, as compared to hard copy images of the Landsat or SPOT data, various types of digital processing and analyses provide a capability and flexibility to obtain an output product that is of optimum utility. The output maps can be produced at whatever scale is desired and with enhancement of the particular features of interest, either through various transformation and enhancement procedures or through a classification of the various cover types present based upon their spectral characteristics. The Phoenix Map (Appendix A) shows an excellent example of the spatial resolution of Landsat MSS and TM data and SPOT 10m and 20m data at various scales and with various combinations of data input. It provides a bit of insight as to the level of detail that can be achieved through appropriate digital processing of data obtained from altitudes of kilometers.

One the major advantages for digital processing of satellite data lies in the potential for combining such data into a G.I.S. (Geographic Information System) data base. Such GIS data bases might include satellite-derived maps of land cover/land use, along with soils, elevation, slope and aspect, land ownership, transportation networks, locations of weather stations, or a variety of other spatially defined information, along with the attribute files that describe and characterize these feature. Such GIS data bases provide a very powerful tool for a variety of analysis and modelling activities.

Objectives

The proposed objective of this work would be to develop a cooperative, interdisciplinary program to provide appropriate support to the scientists at all LTER sites throughout the country, to allow them to assess the value and potential use of satellite multispectral scanner data as an integral part of the research activities at their LTER site.

Such an effort would probably be rather flexible and open-ended, depending on the interests of the scientists at the particular LTER site. Our activities at CSU would probably entail both service and research components. The service component could include obtaining appropriate sets of Landsat and SPOT data, pre-processing the data, and in conjunction with the LTER scientists, analyzing the data in whatever manner seems appropriate and desirable. Perhaps we could even work with the site scientists in developing GIS data bases, if that were desired. The research component would involve working with the various LTER site scientists to answer and questions as: What is the most appropriate type of satellite data to use to obtain a particular type of output product, based on the spectral, spatial, and radiometric characteristics of the data? What is the optimal time of year to obtain such satellite data, given the phenological characteristics of that particular area? What is the potential value of satellite multispectral scanner (and perhaps radar) data to assess and monitor change in the characteristics of earth surface features over time? Many other questions could be posed, and in many cases, experience may provide some insight as to the probable answer, but there may be a large element of uncertainty unless we actually test the hypothesis being examined.

Justification

Effective research often calls for interdisciplinary efforts involving scientists with widely varied backgrounds and experience. The current situation involving the potential value of satellite remote sensor data as part of the LTER research activities seems to call for such an interdisciplinary approach. I believe that my background and experience at both Purdue University and Colorado State University have provided me with some degree of sensitivity concerning the requirements for and ingredients of effective interdisciplinary efforts.

As a co-founder of LARS (Laboratory for Applications of Remote Sensing) at Purdue, and Leader of the Ecosystems Research Program for many years, I had many excellent opportunities to work with a reasonably large group of scientists and engineers on a variety of research projects. The Landsat, Skylab, Shuttle Imaging Radar-B (and associated Landsat TM data analysis) projects for which I have been Principal Investigator, as well as various other research activities, have enabled me to develop a basic understanding of some of the interrelationships between the spectral, spatial, and temporal aspects involved in working with digital optical and microwave data obtained from satellite altitudes.

During my 24 years at Purdue, my time was totally devoted to research and teaching remote sensing of natural resources. As the attached biographical sketch tends to indicate, much of my work has focused on the refinement and evaluation of computer-aided analysis techniques as applied to satellite multispectral scanner data. I am a firm believer in the importance of understanding the spectral characteristics of the data with which one is involved. (I keep telling my graduate students to "think spectrally"!)

If desired by the LTER scientists, I would be willing to develop an appropriate proposal to allow us to pursue a cooperative interdisciplinary effort to evaluate the value of and potential use for remote sensor data on the LTER sites. I would be available for up to 20-25% time during the academic year and 50-75% time during the summer to devote to such an effort, and would imagine that one or perhaps two graduate students would also need to be involved, depending on the amount of data analysis that would be needed.

It would be an honor and an exciting opportunity to pursue such an effort involving remote sensing (and GIS?) with the LTER team!

Table 1 -- Comparison of Satellite Sensor Systems*

Satellite	Landsats-1,2,3	Landsats-4 & 5	SPOT-1	
Date(s) Launched	July 23, 1972 July 21, 1975 March 5, 1978	July 16, 1982 March 1, 1984	February 21, 1986	
Altitude	920 Km (570 m)	705 Km (438 mi)	832 Km (517 mi)	
Cycle for Complete Coverage of the Earth	18 days	16 days	26 days[1]	
Equatorial Crossing Time	8:50; 9:08; 9:31 a.m.	9:45 a.m.	10:30 a.m.	
Currently Functional?	No	Yes	Yes	
Sensor	MSS[2] (Multi-Spectral Scanner)	TM[3] (Thematic Mapper)	Multispectral HRV (High Resolution Visible)	Panchromatic HRV
Ground Resolution	80 m	30 m	20 m	10 m
Swath Width	185 Km	185 Km	60 Km	60 Km
Wavelength Region and Bands				
Visible	0.5-0.6 μm 0.6-0.7 μm	0.45-0.52 μm 0.52-0.60 μm 0.63-0.69 μm	0.50-0.59 μm 0.61-0.68 μm	0.50-0.73 μm
Near IR (Reflective)	0.7-0.8 μm 0.8-1.1 μm	0.76-0.90 μm	0.79-0.89 μm	
Middle IR (Reflective)		1.55-1.75 μm 2.08-2.35 μm		
Thermal IR (Emissive)		10.4-12.5 μm[4]		
1988 Cost of Data				
Total Cost Per Frame[5]	$ 660	$ 3300	$ 1600	$ 1600
Cost/Sq Mile	$ 0.05	$ 0.25	$ 1.15	$ 1.15

[1]The SPOT satellite can be pointed to obtain data from adjacent ground tracks, thereby providing a potential for obtaining data from a a particular location several times per week.

[2]Landsats-1&2 also carried 3-band RBV (return beam vidicon) systems, but the data quality was not good so relatively little data was acquired. Landsat-3 carried a pair of panchromatic RBV cameras having 40 m ground resolution that acquired good quality B & W imagery for many regions of the world. Landsat-3 also had a thermal infrared channel as part of the MSS system, but this channel failed soon after the launch.

[3]Landsats-4&5 also carried a 4-band MSS system similar to that on Landsats 1-3.

[4]Ground resolution for the Thermal IR wavelength is 120 m.

[5]Digital data tapes, 1600 bpi, geometrically and radiometrically corrected, but not having cartographic control.

*From: Hoffer, R.M. 1988. "Remote Sensing From Space--Two Decades of Change." Invited Paper. Resource Technology '88, An International Symposium on Advanced Technology in Natural Resource Management. American Society for Photogrammetry and Remote Sensing, Falls Church, VA, pp. 4-17.

BIOGRAPHIC SUMMARY

Name: Roger Milton Hoffer
Born: December 5, 1937; Rogers City, Michigan

Current Address: Department of Forest and Wood Sciences
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Education:

B.S. in Forestry (with high honors), 1959; Michigan State University
M.S. in Watershed Management, 1960; Colorado State University
Ph.D. in Watershed Management, 1962; Colorado State University

Experience:

1988-present: Professor of Forestry and Remote Sensing, and Director, Remote Sensing and Geographic Information Systems Program, College of Forestry and Natural Resources, Colorado State University. Position involves teaching undergraduate and graduate course in Remote Sensing of Natural Resources, conducting remote sensing research, and coordinating teaching, research and training programs involving remote sensing and G.I.S. technologies for characterizing and managing natural resource ecosystems. Special interests include the interpretation and analysis of satellite multispectral scanner data, synthetic aperture radar data, and color infrared photography.

1983-1988: Professor of Forestry, Department of Forestry and Natural Resources, and Senior Scientist, LARS, Purdue University, West Lafayette, Indiana 47907. Primary activities included teaching courses in Photo Interpretation and in Remote Sensing of Natural Resources, and directing remote sensing research involving forest resources.

1975-1983: Professor of Forestry, Department of Forestry and Natural Resources, and also Leader, Ecosystems Research Programs, LARS, Purdue University. Work involved teaching three courses in Remote Sensing of Natural Resources, and directing remote sensing research of forest resources. Emphasis was placed upon development and testing of various computer-aided analysis techniques using multispectral scanner data to reliably differentiate, identify, and map various vegetation, soil, and water resource features.

1968-1975: Associate Professor, Department of Forestry and Conservation, and also Leader, Ecosystems Research Programs, LARS, Purdue University. Full time research and teaching in remote sensing of natural resources. Research work emphasized the spectral characteristics of the various earth surface features.

1964-1968: Purdue University, full time research in remote sensing of natural resources. Co-founder and Program Leader of the Laboratory for Applications of Remote Sensing (LARS), recognized nationally and worldwide as a leader in computer-aided analysis of multispectral scanner data.

1962-1964: U.S. Army (Infantry). Stationed in Georgia, Korea, and California. Promoted to 1st Lt. in March, 1963. Served as Platoon Leader, company Executive Officer, Battalion Adjutant, and Company Commander. Received EIB.

1962: Watershed Specialist, U.S. Forest Service. Worked on five national forests in South Dakota and Wyoming, advising on erosion control practices in various problem watershed areas.

1959-1962: N.D.E.A. Fellow, Colorado State University. Research involved study of the relationships between solar radiation and lodgepole pine stand density. Study directed at forest management practices designed to optimize the regime of snow-pack runoff from watersheds of the lodgepole pine zones of the Rocky Mountains.

<u>Professional Activities</u>:

Author or co-author of over 170 scientific publications and papers concerning remote sensing of natural resources, including invited papers at International Congresses in Austria, Brazil, Canada, Colombia, Costa Rica, France, Germany, Hungary, Japan, Norway and the U.S. Other papers and lectures on remote sensing have been given in various countries throughout the world, including Afghanistan, Bolivia, Brazil, Canada, England, France, Italy, Japan, the Netherlands, Panama, Peru and Thailand. Have taught numerous remote sensing short courses in the U.S., as well as in Thailand, Bolivia, and Brazil.

Principal Investigator on Landsat, SKYLAB, Shuttle Imaging Radar (SIR-B), and several other major contracts involving remote sensing of earth resources. Served on a number of NASA panels involving design characteristics of future satellite systems and on review panels evaluating NASA's earth resources applications programs. Currently on NASA's Shuttle Imaging Radar Science Teams.

At present, I am the President of the American Society for Photogrammetry and Remote Sensing (approximately 8,000 members) and have previously served as National President-Elect and Vice-President, as Associate Editor of <u>Photogrammetric Engineering and Remote Sensing</u> (the monthly journal of ASPRS), as National Director of the Remote Sensing and Interpretation Division of ASPRS, and as Vice-President and President of the Western Great Lakes Region. Have also served on the National Board of Directors (twice), Chairman of the National Long Range Planning Committee, Chairman of a National Committee on Divisional Structure, as well as Chairman of the Education Committee and the Agriculture Committee of the Remote Sensing Applications Division. Within the Society of American Foresters, I have served as Chair-Elect, and Chairman of the Remote Sensing and Photogrammetry Working Group (approximately 720 members).

Served as a consultant to the U.S. Agency for International Development in Brazil from October to December 1971, and to the U.S. Geological Survey in Thailand and Afghanistan during January and February and June 1973. Have also served as Consultant to the U.S. Army Corps of Engineers, 1973;Institute for S.E. Asian Studies, 1974; United Nations, 1975; and the U.S. Agency for International Development (AID) in Bolivia during April and May 1976, and again in August 1977; the Food and Agriculture Organization (FAO) in Brazil in November-December, 1980; American Institute of Biological Sciences, 1982-1983; Marine Biological Laboratory, Woods Hole, Mass., 1981-1983; the Office of Technology Assessment, U.S. Congress, 1983; and Computer-Assisted Development, Inc., 1988.

Qualified and endorsed as a Certified Photogrammetrist (No. 343) by the American Society for Photogrammetry and Remote Sensing. Listed in American Men and Women in Science and in Who's Who in Frontier Science and Technology.

Honors and Awards:

Elected as National Vice President and President-Elect of the American Society for Photogrammetry and Remote Sensing (1987 and 1988, respectively).

Received The Best Poster Paper Award among the 60 poster papers presented at the XVI International Congress of the International Society for Photogrammetry and Remote Sensing, Session P-01 Kyoto, Japan, July 1-10, 1988.

Received the Certificate of Merit as well as a Certificate of Appreciation from the Society of American Foresters (1986 and 1988) because of activities as Chair-Elect and Chairman of the Remote Sensing and Photogrammetry Working Group, which was the "most active working group" in SAF in 1985-1986 and again in 1987-1988.

Selected as one of six finalists for a position as an Astronaut Payload Specialist on a Shuttle Imaging Radar mission (originally scheduled for July 1987 but cancelled following the Challenger tragedy).

Received the Group Achievement Award from NASA in 1979 as part of the Supporting Research Team on the Large Area Crop Inventories Experiment (LACIE), described as "the world's first major proof of concept experiment of satellite aided crop production monitoring."

Selected as Best Teacher in the Department of Forestry and Natural Resources by the Purdue Student Association, Spring 1979.

Recipient of the 1978 Alan Gordon Memorial Award, given each year by the American Society for Photogrammetry and Remote Sensing to an individual who contributes to significant achievements in remote sensing and photographic interpretation. The selection committee stated that, in their opinion, Dr. Hoffer's "overall positive impact on the development of computer-aided data analysis techniques has not been surpassed by anyone in the field."

Received the American Society for Photogrammetry and Remote Sensing (ASPRS) Presidential Citation for Meritorious Service in 1977, 1978, 1979, 1987, and 1989.

Received an ASPRS Ford-Bartlett Award in 1978, 1979, and 1981.

Joint recipient with the other members of the LARS staff, of the 1976 Pecora Award, presented annually by NASA and USGS to recognize organizations and individuals who have made outstanding and significant contributions to the development and application of remote sensing technology.

Recipient of the District Award of Merit, Sagamore Council, Boy Scouts of America (1980).

Professional and Honorary Societies:

Society of American Foresters (SAF), American Society for Photogrammetry and Remote Sensing (ASPRS), Indiana Academy of Science, Sigma Xi (Scientific), Xi Sigma Pi (Forestry), Alpha Zeta (Agricultural), Phi Kappa Phi (Scholastic) and several others. (Also a member of the National Eagle Scout Association.)

Current Outside Support

Hoffer, R. M., Principal Investigator. "Microwave and Optical Remote Sensing of Forest Vegetation, Phase II." Department of Forest and Wood Sciences, College of Forestry and Natural Resources, Colorado State University, Fort Collins, Colorado. June 1, 1988 - September 30, 1989. $83,600. Contract No. 95833 sponsored by NASA, through the Jet Propulsion Lab and California Institute of Technology, Pasadena, California.

Selected Articles and Publications (last 10 years):

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Hoffer, R. M. and S. M. Davis. 1980. "Principles of Photointerpretation." Educational Minicourse consisting of 40 slides, tapes, and study guide. Part of a coyrighted minicourse series entitled Fundamentals of Remote Sensing. Office of Continuing Education, Purdue University. 17 pp.

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