Final Report for NASA Glenn OHIOVIEW FY01/02 Project

NASA Grant/Cooperative Agreement Number NAG3-2629

The results of the research performed by the university principal investigators are herein compiled.

OhioView's general goals were:

- To increase remote sensing education for Ohio's undergraduate and graduate students, and also enhancing curriculum in the mathematics and science for K-12 students using the capabilities of remote sensing;
- To conduct advanced research to develop novel remote sensing applications, i.e. to turn data into information for more applications;
- To maximize the use of remote sensing technology by the general public through outreach and the development of tools for more user-friendly access to remote sensing data.

TEAM MEMBERS AND RESEARCH PROJECTS - RECAP

Representing broad technical diversity, OhioView's members have been conducting research in the fields of agriculture, geology, geography, civil engineering, computer science, library science, environmental science and urban studies.

Team Member	University	Project
Loren Siebert	**Akron University**	Mapping Land Cover and Urbanization Near Volcanic Regions Using Satellite Images and Historical Topographic and Land Use Maps
Robert Vincent	**Bowling Green State University**	Application of LANDSAT 7 ETM Data to Agricultural and Environmental Problems in Northwest Ohio
Robert Frohn	**University of Cincinnati**	Development of Statewide Remote Sensing Datasets for Research and Education in Ohio, Including a Study on Farmland Loss
Richard Beck	**University of Cincinnati**	Demonstration of an Educational Web-based Prototype for a K-12 Earth Sciences Expert System
Mandy Munro-Stasiuk	**Kent State University**	Landscape Parameterization and Classification, and K-12 Outreach in Northeast Ohio
John Millard	**Miami University**	Expanding the OhioView Geospatial Digital Library: A Next Generation System, for K-12, Higher Education and the Public
Carolyn Merry	**Ohio State University**	Engineering Applications Using Landsat-7 Data
Joel Morrison	**OSU Center for Mapping**	Design of a User-Friendly Data Mining Approach for Georeferenced Images
James Lein	**Ohio University**	Mapping Natural Hazard Exposure Patterns Using Landsat 7 Data
Kevin Czajkowski	**University of Toledo**	Dissemination of Remote Sensing Technology in Northwest Ohio through K-12 and Community Outreach
Doyle Watts	**Wright State University**	Application of Remote Sensing to the Ohio Environment

OhioView 01 Final Report	University of Akron
Report Period	May 1, 2001 to September 30, 2002, extended through May 21, 2003
Grant Title	Mapping Land Cover and Urbanization Using Satellite Images and Historical Topographic and Land Use Maps
Name of Principal Investigator	Dr. Loren Siebert
Institutional Name	University of Akron
Institutional Address	Department of Geography and Planning, Akron, OH 44325-5005

Final Progress Report

Objectives:

The first objective of this research has been to develop methods of using current satellite imagery and historical topographic and land use maps to document, analyze, and visualize changes in land cover, land use, urbanization, and transportation networks. The geographic focus is Tokyo, the surrounding Kanto region, and the country of Japan.

The second objective of this research has been to develop remote sensing image and GIS data sets focused on major Japanese volcanoes for the Global Volcanism Program of the Smithsonian Institution. Such images and GIS data layers are being designed for use in the GVP's research and educational outreach.

Time Frame of Project and Project Extension into 2002-2003 Academic Year:

Achievement of the objectives of the research has been extended into a second year (under a supplemental NASA OhioView grant) for two main reasons. First, the principal investigator was awarded a one-year (2002-2003) research fellowship in Japan from the Japan Society for the Promotion of Science, to work on historical GIS of the greater Tokyo region. This has necessitated adjustments in the schedule of work performance under the NASA grant. Second, acquisition of nationwide satellite image coverage of Japan for the NASA project had to be delayed by over half a year due to technical problems on the side of the vendor (EarthSat). The complete set of satellite image data needed for the project -- 39 raw images and seven regional mosaics -- was thus not available until the end of the summer of 2002, just before the end of the initial NASA grant period.
Some work on the NASA project is being done by the PI during his year in Japan; other tasks will be performed in the US in the summer of 2003 after the PI returns from Japan. This final report is thus in reality an interim report.

(It should also be noted that, while still in Akron during the 2001-2002 academic year, the PI continued working with his colleague Dr. Richard Klosterman and their graduate research assistants on their northeast Ohio land use modeling project that began with NASA funding in prior years.)

Status of Tasks:

Substantial progress has been made in the time-consuming task of scanning, georeferencing, and reprojecting four sets of data: (1) a set of 1:200,000-scale 1980s land use maps covering the entire country of Japan, (2) a series of 1:200,000-scale historical topographic maps for the Kanto region in central Japan, (3) a series of 1:50,000-scale historical topographic maps for Tokyo and its immediate surrounding areas, and (4) a set of topographic maps of Japanese volcanic regions loaned by the Global Volcanism Program. Some additional work remains in this basic data preparation process before the entire sets of maps are ready for input into the historical GIS database for analysis and display of changes in land cover and other features.

Nationwide Landsat coverage of Japan has been obtained and preliminary evaluation of its suitability has been completed. In addition, the positions of volcanoes and corresponding satellite images and topographic and land use maps have been determined. The next step is to subset the images and maps to produce a uniform set of framed data for each volcano.

Finally, a nationwide set of 1:50,000 digital raster maps from the Geographical Survey Institute of Japan has been acquired. These need to be reprojected to match the satellite images and other maps. They will then be available for on-screen digitizing of major physical and human-created features on and near each volcano.

OhioView 01 Final Report	Bowling Green State University
Report Period	May 1, 2001 to September 30, 2002, extended through May 21, 2003
Grant Title	Application of Freshly Collected LANDSAT 7 TM Data to Remote Sensing Tasks
Name of Principal Investigator	Prof. Robert K. Vincent, Dept. of Geology
Institutional Name	Bowling Green State University
Institutional Address	Bowling Green, Ohio 43403-0218

Final Progress Report

Research Activities

During this contract we had the following research activities:

1. Implementation of the phycocyanin algorithm for a second overpass (September 27, 2000 of LANDSAT 5) was performed, using the phycocyanin model that had been developed from the July 16, 2000 LANDSAT 7 overpass data. We proved that the algorithm was robust and have started writing a paper to be submitted to a technical journal on this subject. Before that paper is completed, however, we plan in the next year's contract to apply this same algorithm to two or three frames from the summer of 2002 (we were not able to collect phycocyanin data for the summer of 2001 because it was a year of little or no toxic algal blooms). This is the first time that anyone has produced a robust phycocyanin algorithm from any satellite. Phycocyanin is a pigment in some toxic algae, including Microcystis. Toxic algae are a threat to cities that obtain their water from Lake Erie and other lakes. A copy of the submitted paper will be included in next year's final report. An oral presentation of this work was given at a meeting of the American Assoc. of Geographers, as part of an OhioView session (with other papers from OhioView scientists) on March 7, 2003 in New Orleans, LA. The reference is as follows:

Vincent, R.K., X. Qin, R. M. L. McKay, J. Miner, K. Czajkowski, T. Bridgeman, and J. Savino, Satellite Detection of Phycocyanin as a Precursor of Noxious Microcystis Blooms, American Association of Geographers Meeting, New Orleans, LA, March, 7, 2003. (Oral Presentation)

2. The turbidity model was tested only for the July 1, 2000 data set and it worked well on that date. There have been other turbidity models produced for satellite data, but this is the first such model for LANDSAT TM data. It will become part of the phycocyanin paper that is being written. Though turbidity and phycocyanin are somewhat correlated in the actual measurements of turbidity and phycocyanin content from the water samples collected on that

date, we have shown that the phycocyanin algorithm and the turbidity algorithm are not mapping the same thing.

3. Mapping of bare soil exposures resulted in an algorithm mapping bare soil from LANDSAT TM data. An oral paper was given at the Geological Society of America; the reference is as follows:

Wu, Xiaowen, and R.K. Vincent, Algorithm for Mapping Bare Soil from LANDSAT TM Data in Agricultural Terrain, Geological Society of America Annual Meeting and Exposition, Abstracts with Programs, p. 449, 2002. (Present student) (Presented as Co-Chair of the Remote Sensing Session; submitted to EEG Journal for publication)

Xiaowen Wu, the graduate student who was supported on this project, published her thesis on this subject in August, 2003, entitled:

Wu, Xiaowen, Mapping Bare Soil Cover from LANDSAT ETM+ Data, M.S. thesis, Dept. of Geology, Bowling Green State University, August, 2003.

A copy of her thesis will be supplied to NASA under separate cover. We have submitted a paper to *Engineering and Environmental Geology* based on the thesis results. This thesis came totally out of OhioView funding. The bare soil mapping will be used in future years for public health remote sensing, particularly to see if there is a connection between bare soil exposures and asthma cases in NW Ohio.

4. A paper was published on the previous years work on cropland loss to urbanization; the reference is as follows:

Vincent, R.K., C. M. Baquero-Garcia, N. S. Levine, LANDSAT TM Assessment of Cropland Loss Due to Urbanization in NW Ohio, American Soc. of Photogrammetry and Remote Sensing (ASPRS) Annual Conference, Washington, DC, April, 2002. (Former Student)

This paper was presented orally at a press conference at BGSU and to TMACOG, a transportation agency in Toledo, Ohio. It was written up in the press several places in Ohio and was the most popular paper that I have ever written or co-authored. It can be read in the ASPRS Proceedings, which can be purchased for $2/ CDROM from the American Society for Photogrammetry and Remote Sensing (ASPRS).

5. Work continued on the algorithms for mapping coliform and E. coli bacteria content in Lake Erie and its tributaries, which were developed from the July 1, 2000 and August 21, 2001 LANDSAT 7 TM frames, respectively. We are still awaiting confirmation of their robustness on later LANDSAT passes before the work is published. We have had poor luck in the research boat schedule (U. of Toledo's Lake Erie Center), weather, and equipment problems on this project. This is the first time that either coliform or E. coli (a type of coliform) has been mapped in surface waters from any satellite.

Conclusions and Research Findings

1. The phycocyanin algorithm is given as follows:

$$PC\ (\mu g/L) = 47.7 - 9.21(R31) + 29.7(R41) - 118(R43) - 6.81(R53) + 1.9(R73) - 14.7(R74)$$

Eqn. 1

where RIJ stands for the dark-object-subtracted spectral ratio of the Ith band over the Jth band of the LANDSAT TM sensor] and PC is relative phycocyanin content in micrograms per Liter. This algorithm, based solely on dark-object-subtracted ratios, is robust and proven better than any algorithm that depends on the single bands of LANDSAT TM.

2. The turbidity algorithm is given as follows:

$$\text{Turbidity (NTU)} = -17.2+27.7(R32) \qquad \text{Eqn. 2}$$

where R32 is the dark-object-subtracted spectral ratio of TM band 3 by TM band 2 and turbidity is given in Nephlometric Turbidity Units (NTU). This algorithm has not yet been proved robust, but was only used for a July 1, 2000 LANSAT 7 frame.

3. Phycocyanin and turbidity appear to be somewhat correlated in nature, and the high of one does not correspond to a high in the other, but close to it (PC highest where turbidity is moderately high).

4. A bare soil index was developed for LANDSAT TM that get higher with increasing bare soil exposures:

$$\text{Bare soil index} = 0.3^*(R34) + 0.7^*(R74) \qquad \text{Eqn. 3}$$

where R34 and R74 are the dark-object-subtracted spectral ratios of TM band 3 divided by TM band 4 and TM band 7 divided by TM band 4, respectively. This number gets larger with increased percentage bare soil cover. This algorithm does a reasonably good job of separating truly bare soil from corn stubble, which could help in mapping the area (acreage) of no-till agriculture in a given LANDSAT TM frame.

5. NW Ohio lost less than 3% of its farmland to urbanization between 1984 and 1999, based on LANDSAT TM data. This is much lower than other statistical measures that are less appropriate to quote, such as the percent of increase in urbanization, because there is much more farmland than urban regions in NW Ohio. If this 0.2% per year rate remained unchanged, it would take about 500 years for all farmland to become urbanized in NW Ohio. However, the rate is expected to increase dramatically in the future. The estimate of error in this rate was 6% (of 0.2%), using Lucas County records as "ground truth."

Accomplishments

1. The phycocyanin algorithm is the first ever for any satellite data application, and it is almost certain to be useful for mapping blooms of toxic algae in Lake Erie and other fresh water surface waters. It's marine water use has yet to be tested.

2. The turbidity algorithm is the first for LANDSAT TM data, but has been done with other satellites, such as SEAWIFS.

3. The bare soil index and method of mapping bare soil exposures is the first of its kind for any satellite. It will be useful for public health remote sensing, soil erosion estimation, and agricultural record keeping (counting no-till acreage each year).

4. The project on urbanization of farmland received the most publicity of any paper that I have ever published and had the widest public interest of any academic paper written by anyone in NW Ohio during the past year.

Lessons Learned

1. LANDSAT TM needs to have at least 4 in orbit to have enough temporal coverage (4 days) for water quality monitoring and agricultural research, and 8 would be much better (2 days). The satellites currently with better temporal coverage do not have sufficient spatial resolution to suffice for these problems; 30-m resolution is ideal for them.

2. Fast delivery of recently collected data (24-48 hours) is absolutely required for these techniques to be meaningful to society. Fortunately, OhioView gets that swift a delivery of recently collected data.

OhioView 01 Final Report	University of Cincinnati
Report Period	May 1, 2001 to September 30, 2002, extended through May 21, 2003
Grant Title	Development of Statewide Remote Sensing Datasets for Research and Education in Ohio, Including a Study on Farmland Loss
Name of Principal Investigator	Dr. Robert Frohn
Institutional Name	University of Cincinnati
Institutional Address	Department of Geography Cincinnati, Ohio 45221-0131

Final Progress Report

Most of the effort during the first quarter has focused on the development of the leaf-off Ohio state-wide mosaic. Nine leaf-off scenes have been searched and collected in the Fall and Winter months from the OhioView data server. Each scene was then clipped using an Ohio boundary ArcView shapefile in ENVI. Bands 5,4,3 and the pan-band were extracted from the dataset for each scene. Each scene was then pan-sharpened using PRePS sharpening-a method developed by Frohn (2001) to a resolution of 14.25 meters. PRePS (Pixel Replication & Pan Substitution) method sharpens Landsat-7 data to a nominal resolution of 15-meters without changing any of the original DN values.

Two mosaics have been developed from PrePs sharpening and a 9 scene dataset. The first is a virtual mosaic that cutline-fits each of the nine-pieces of the mosaic together without using any histogram matching techniques. This method does not change any DN values and thus can be used for statewide image analysis of the dataset. However, because it doesn't use any histogram matching techniques the mosaic is unattractive for presentation purposes. For this reason we have developed a second mosaic that can be used for visual presentation, visual inspection, and satellite photointerpretation purposes. This mosaic histogram matches each pan-merged scene saves the 3-band dataset to a digitally enhanced RGB file and then cutline fits each piece to create the final 9 piece statewide mosaic. The statewide leaf-off mosaic was completed at the end of this time period. The dataset is over a gigabyte. We are currently examining data compression methods for distribution of the mosaic on CD-Rom to all OhioView Universities, NASA, and OAI. It seems the simplest compression method thus far for the dataset is simply to use WINZIP. It compresses the data under 750 mb so it can fit on a CD-ROM and does not require any additional expensive software for decompression.

Effort during the last phase of the project focused on completing a leaf-on pan-sharpened state-wide mosaic. 9 scenes during the summers of 2000, 2001, and 2002 were examined for selection in the compilation of the mosaic. Each scene was then clipped using an Ohio boundary ArcView shapefile in ENVI. Bands 5,4,3 and the pan-band were extracted from the dataset for each scene. Each scene was then pan-sharpened using PRePS sharpening-a method were created, an unenhanced virtual mosaic for statewide analysis and a histogram matched mosaic for presentation, visual inspection, and/or satellite photo interpretation. Both the leaf-on and leaf off mosaics have been compressed so that they fit on 2 CD-Roms. The mosaics have been released to all OhioView Universities, NASA Glenn, and OAI.

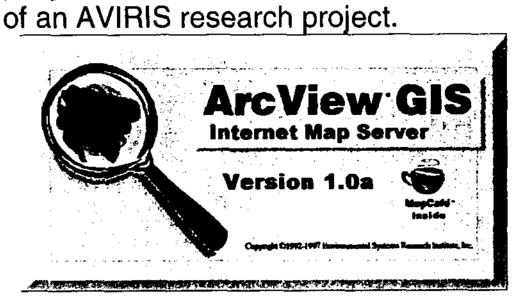
OhioView 01 Final Report	University of Cincinnati
Report Period	May 1, 2001 to September 30, 2002, extended through May 21, 2003
Grant Title	Demonstration of an educational web-based prototype for a K-12 Earth Sciences Expert System
Name of Principal Investigator	Dr. Richard A. Beck
Institutional Name	University of Cincinnati – Department of Geography
Institutional Address	401i Braunstein Hall Cincinnati, OH, 45221-0131

Final Progress Report

This project was focused on developing an Integrated Landsat-7 and GLOBE data server prototype for Ohio until January of 2002. After January 2002, the project was reoriented to work with similar data sets from Utah and NW Pakistan/Eastern Afghanistan at the request of a congressional staffer (Mike Robinson).

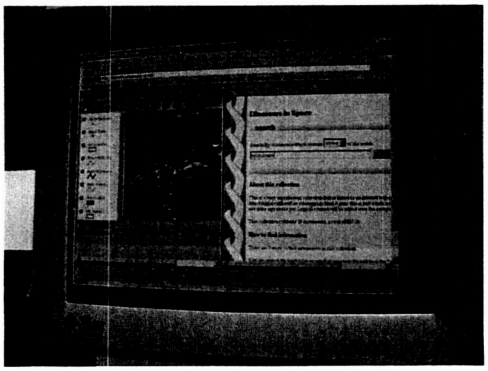
Three Internet Map Servers (IMS) were constructed using ArcView Internet Map Server, ArcIMS 3.0 and ArcIMS 3.1.

ArcView Internet Map Server Prototype
The first IMS was also integrated with a Greenstone digital library. The first server (ArcView Internet Map Server had excellent functionality and was easy to set up. It is merely an extension to ArcView 3.x. It did require some tweaking of the web server to make it operational. Unfortunately, it had abysmal reliability. Its *successful* installation required an older Windows NT operating system and on a dedicated machine with a dedicated Windows web server. This system usually worked for several minutes at a time before hanging up. Many server and hardware and operating system permutations were tried in order to improve its reliability without success. Discussions with other users were similarly discouraging. Two months were wasted on v. 1.0 which never worked. A subsequent major service pack consisting of the entire revised program v. 1.0a did work for short periods. This early test used data from Utah as part of an AVIRIS research project.



Regardless, we completed this part of the study and demonstrated **one of the first, if not the first integrations of full text digital libraries with a GIS and satellite**

imagery on the web. A digital camera image of the system as it appeared in a web browser on a Sun workstation during its short periods of successful operation is shown below.



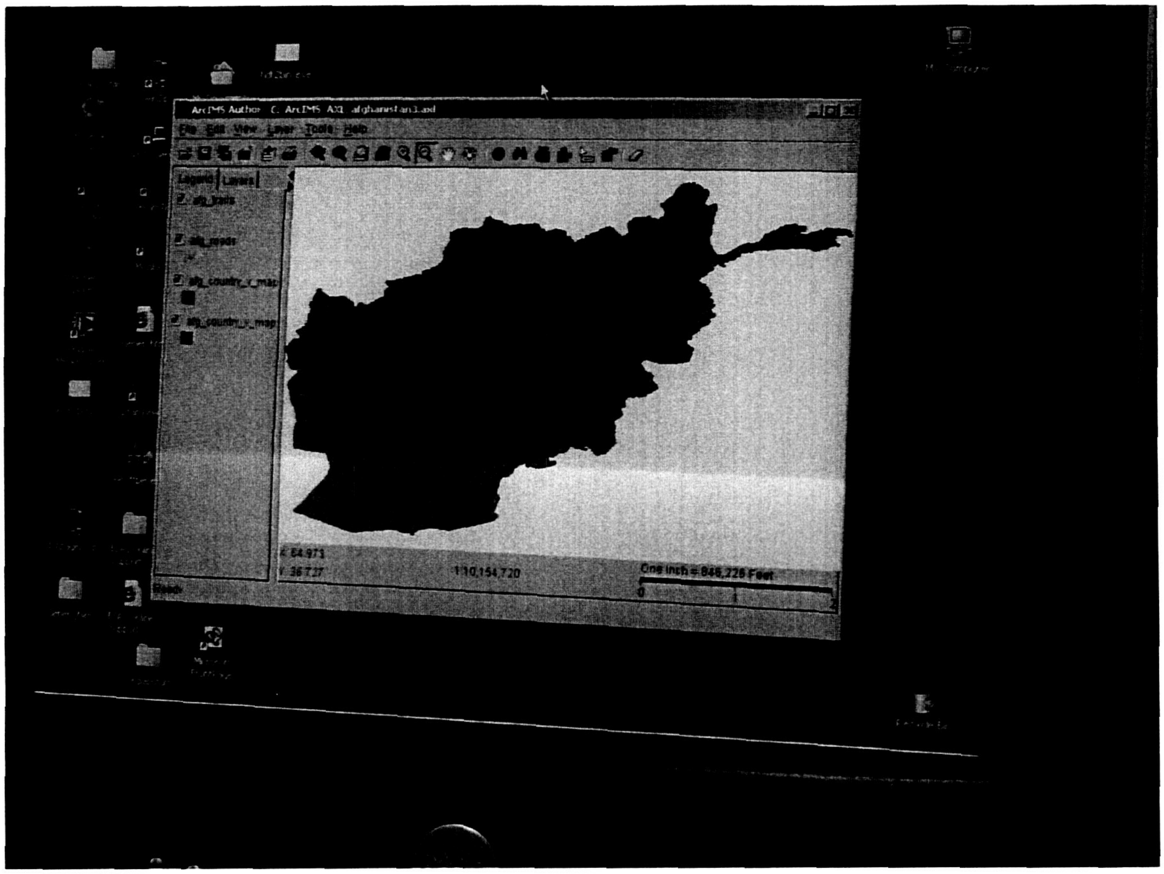
Several problems were recognized with ArcView IMS. It only worked more than a few seconds on NT although it would install on Windows 2000 and was very slow and very fragile. Moreover NT was limited to 2GB disk partitions making it difficult to work with Landsat images.

ArcIMS 3.0 Prototype

A second server built on ArcIMS 3.0 was also constructed. It also worked only on NT and with a Windows web server limited to five clients or on a UNIX machine. Given the NT limitation it was decided not to invest much in the hardware for this part of the experiment. It suffered from slow IDE drives and 256MB of RAM on a 33MHz AMD processor accordingly. As the point of the experiment was to figure out which servers be used by most teachers with little effort, the UNIX option was ignored. Although this server worked with sample data sets, its performance and promise were so limited that it was taken down. We waited for a few months for ArcView 3.1 so we could build a Windows 2000 system on better hardware.

ArcIMS 3.1 Prototype

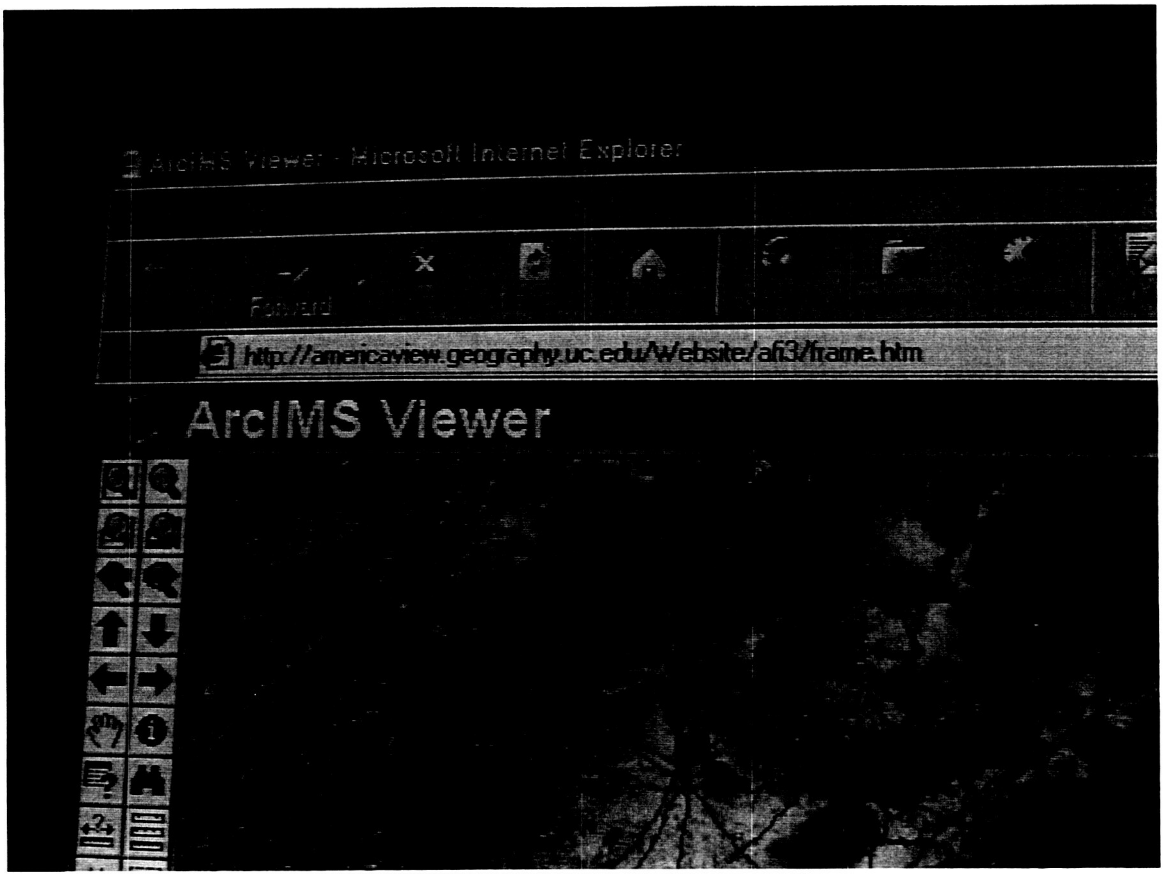
A third server built on ArcIMS 3.1 was then constructed on a Pentium 4, 1.0 GHz server with 1 GB of RAM and 80 GB of SCSI disk This server was built on Windows 2000 Professional with an Apache web server and the Jakarta/Tomcat Java Servlet Engine. The Apache server allows us to serve to an unlimited number of clients while the Tomcat servlet engine is free and very capable. Configuration of all of the components together was difficult before clarification from ESRI. Given the congressional request to OhioView to assist with 9/11 issues, it was constructed with data from Afghanistan and NW Pakistan. This server worked pretty well. A digital camera image of the server is show below.



The reliability of this server is reasonably good. Serving raster image is clearly compute and disk intensive. It was set up to serve georeferenced MrSID and JPEG imagery accordingly. However, the goal of the project is to serve Landsat-7 imagery in the context of GLOBE data. While we have successfully imported L-7 data and GLOBE point Land Cover data into this server it is slow with uncompressed imagery.

ArcIMS 4.0 Prototype
Therefore, we have purchased a dual 1.5 GHz Xeon processor dell server with 2 GB of RAM and 250 GB of SCSI disk to work with uncompressed Landsat-7 data in GeoTiff format with our Ohio GLOBE LULC data set. The server has been populated with data sets and will use ArcIMS 4.0, Apache and Tomcat. We are waiting for delivery of ArcIMS 4.0.

Conclusion
The project was only moderately successful with regard to Ohio Landsat and GLOBE point data but the third experimental (ArcIMS 3.1) server provided a very useful tool for the visualization of point and vector data of Afghanistan in the context of compressed Landsat-7 mosaics. The result was directly analogous to the original concept. A detailed view of the server with imagery, vector and point files **on the web** is shown below.



Internet Map Servers are still complex specialty Internet elements that are just getting ready for the mainstream.

OhioView 01 Final Report	Kent State University
Report Period	May 1, 2001 to September 30, 2002, extended through May 21, 2003
Grant Title	Landscape Parameterization and Classification, and K-12 Outreach in Northeast Ohio
Name of Principal Investigator	Dr. Mandy Munro-Stasiuk
Institutional Name	Kent State University, Department of Geography
Institutional Address	PO Box 5190 Kent OH 44242

Final Progress Report

PROGRAM OBJECTIVES

There were two main objectives in the program we proposed:

1. Continue our project on landscape parameterization using satellite imagery and DEMs;
2. Successfully develop a K-12 program by creating and accumulating materials, offering workshops to high-school teachers, and visiting local high-schools.

STATUS OF TASKS

1. Landscape parameterization – four major aspects of landscape parametrization were explored:
   a. River network extraction from different scales of digital elevation models;
   b. The creation of a statewide digital elevation model;
   c. Development of new algorithms for roadway planning based on satellite imagery classification and digital elevation models;
   d. Glacial terrain mapping from satellite imagery and DEMs

a. River network extraction from different scales of digital elevation models

During the summer of 2001, we purchased a portion of the USGS National Elevation dataset. Mark Bradac, an undergraduate, then graduate student, worked on this DEM dataset. For a small portion of Geauga County, in NE Ohio, he extracted river networks and watersheds in order to test the accuracy of the 30m dataset (Fig. 1). The 30m dataset was compared with a donated 3m dataset. This was combined with several weeks of field work. It was discovered that the 30m dataset was better for network extraction than the higher resolution dataset. This is an important conclusion as the 30m dataset are available to the public at no cost.

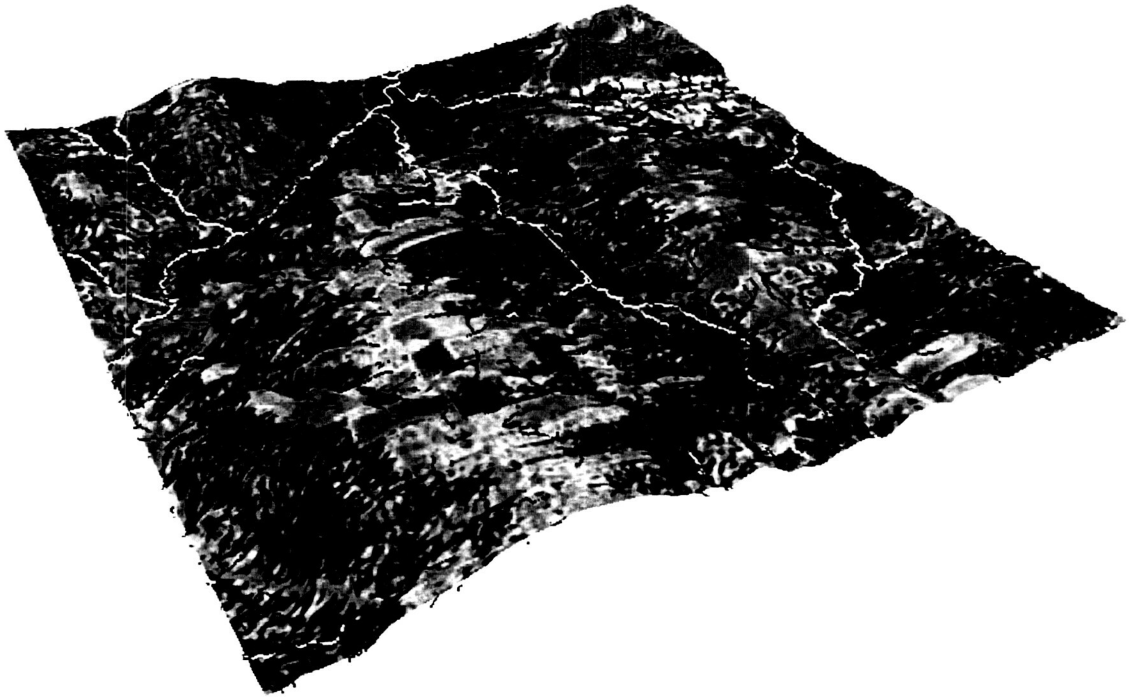


Figure 1: Derived drainage networks displayed on satellite image draped over a digital elevation model

b. Creation of a statewide Digital Elevation Model
From the National Elevation Dataset we created a statewide DEM dataset (Figure 2) that can be cropped down to sizes required for more detailed analysis.

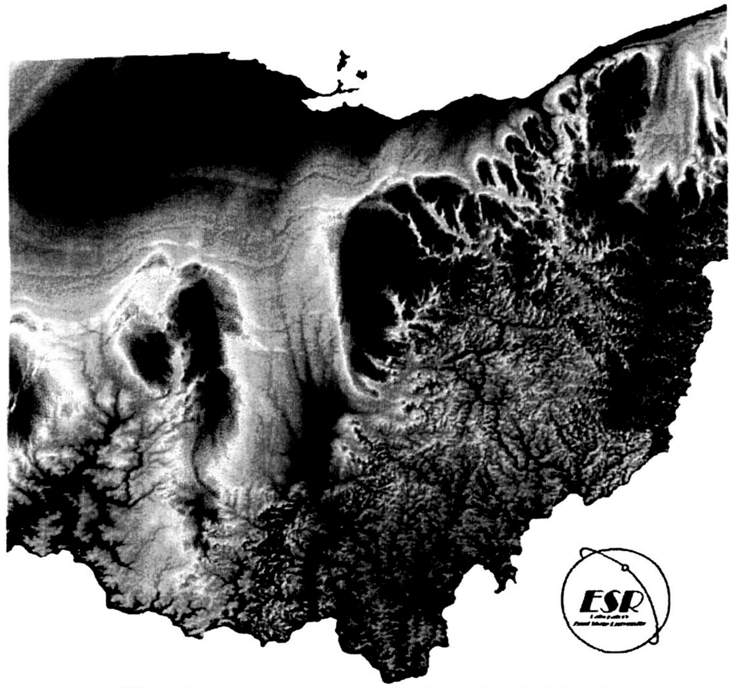


Figure 2. The Ohio DEM with major glacial features noted

c. Development of new algorithms for roadway planning based on satellite imagery classification and digital elevation models;
This work was primarily completed by Chaoqing Yu who used the NED DEM dataset, and the results of landcover classifications from satellite imagery to create new algorithms for roadway planners. The new algorithms work up to 20 times faster than existing algorithms in software packages like ArcGIS. The algorithms are based on determining the cost of building a road depending on the landcover classes and the slope derived from DEMs. For instance, water always has a high cost associated with it since a bridge is likely to have to be built. The steepest slopes also have highest costs since roads must either zig-zag, cross divides, or cross channels. The developed algorithms determine the "cheapest" route for building a road taking into

consideration the classes, slopes, and distance. For example Figure 3 shows one such scenario of a road.

Figure 3. The Knight's anisotropic path algorithm

d. Glacial terrain mapping from satellite imagery and DEMs

Several projects related to terrain mapping were completed. All subglacial channels in NE Ohio and NW Pennsylvanai were mapped using a combination of satellite imagery and DEMs (e.g. Fig. 4)

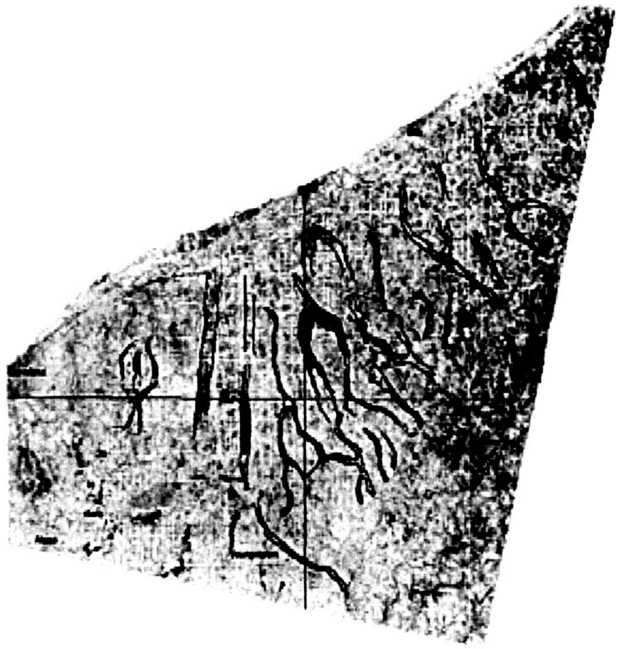


Figure 4. Map of subglacial channels in NE Ohio and NW Pennsylvania

2. **Successfully develop a K-12 program by creating and accumulating materials, offering workshops to high-school teachers, and visiting local high-schools.**

A workshop was never offered at Kent State University, however a significant volume of teaching materials were accumulated and PI Munro-Stasiuk, used this to partipate in the K-12 workshop for teachers hosted at the Ohio Aerospace Institute. She organized a GPS treasure hunt and taught teachers about Digital Elevation Models. She also participate in an Earth Day Webcast broadcast to SEMAA students. In addition we invited middle-school students to Kent State to see our Remote Sensing Labs and observe how remote sensing works. We were visited by 16 talented 11 year-old students from the Cuyahoga School District who were interested in learning about satellite imagery.

C. Publications and Presentations related to this research

Munro-Stasiuk, M. J., (In review) GPS treasure hunts: introducing K-16 students to global positioning systems and their importance in remote sensing. Journal of Geoscience Education.

Yu, C., Lee, J., and Munro-Stasiuk, M.J., (Accepted) Extensions to least-cost algorithms for roadway planning. International Journal of Geographic Information Science

Munro-Stasiuk, M. J. and Bradac, M., (2001) Preliminary mapping of glacial landforms in northeast Ohio from satellite imagery and digital elevation models. Geological Society of America, Annual Meeting, Boston, Massachusetts, Abstracts with Programs, p. A-291

Wetherholt, W. A. Munro-Stasiuk, M. J., and Lee, J., (2001) Landuse Change in Streetsboro, Portage County Ohio over a 30-year Time Span. Association of American Geographers, Annual Meeting, New York, Abstracts, p.999.

Munro-Stasiuk, M. J., and Bradac, M., (2002) Digital Elevation Models and Satellite Imagery as tools for examining glaciated landscapes: examples from Alberta, Ohio and Pennsylvania. Geological Society of North America North-Central and Southeastern meeting, Lexington, Kentucky, 2002 Abstracts with Programs, p. A-42.

Munro-Stasiuk, M. J. and Bradac, M., (2001) Preliminary mapping of glacial landforms in northeast Ohio from satellite imagery and digital elevation models. Geological Society of America, Annual Meeting, Boston, Massachusetts, Abstracts with Programs, p. A-291

OhioView 01 Final Report	Miami University
Report Period	May 1, 2001 to September 30, 2002, extended through May 21, 2003
Grant Title	Expanding the Ohioview Geospatial Digital Library
Name of Principal Investigator	John Millard
Institutional Name	Miami University Libraries
Institutional Address	King Library, Oxford OH 45056

Final Progress report

The Miami University Libraries project aimed to enhance the capabilities of the OhioView digital library by expanding the number of users that could make use of the system, increasing the diversity of datasets available to them, and improving the human-computer interface by applying user centered design and evaluation techniques.

We had the following major objectives.

Expand Web-based visualization services
Early in the project, significant work was performed on the web-based visualization server including completion of the user interface and the addition of new data. The system now includes nearly all of the Landsat 7 data owned by the consortium for areas outside Ohio and a subset of cloud free Ohio imagery. In October, we began the process of developing user requirements by conducting a user focus group that included K-12 educators and university students in Geography, Teacher education, and environmental sciences. By the close of the project, the visualization system had been completed and made available online to users.

The visualization service requires that Landsat data be minimally processed prior to use in the system. This processing consists of applying a simple 2%linear contrast stretch to the individual bands to be used. Once this step has been accomplished, each band is compressed and converted to a Multi-Resolution Seamless Image Database or MrSID file.

A Sun workstation was installed and equipped with ENVI and ERDAS Imagine. The batch processing features of both software packages were evaluated to determine which would perform the processing steps needed to prepare data for the visualization server. ERDAS was chosen overall, but further testing investigation is needed with ENVI and other packages to determine the best solution for long term, routine processing.

Develop advanced data discovery services

We proposed to enhance and improve the existing data management system employed in the OhioView digital archive to include more advanced searching tools, and additional datasets like Aster and MODIS. Our proposed search system would allow end-users to specify a geographic region of interest and retrieve information about all Ohioview datasets that cover that area. Enhancing the existing system presented several challenges

- Over reliance on a Landsat 7 metadata model. Other datasets could not easily be adapted
- Unreliable data delivery notification scheme. Email method meant notifications were often lost in transmission
- Unreliable data synchronization between metadata server and data server

The overall result of these weaknesses was that users often didn't know about new data that had been delivered. The opposite was also true; data that was reported to be available by the metadata server would generate a not found error when download was attempted. Also, non-landsat7 data in the archive was completely inaccessible. A significant amount of staff time was devoted to periodically synchronizing the metadata and data collections.

The decision was made to scrap the existing system and design a replacement that met new functional requirements. This portion of the project involved three major areas:

<u>Synchronization of data collections at the NASA Glenn Research Center.</u>
Due to system constraints, the Landsat data archive was stored on multiple disk volumes on the NASA archive server. A method was needed that would make the separate volumes appear to be one volume to correct the "Data Not Found Error". A series of maintenance scripts were developed that periodically create symbolic links from each Landsat scene, regardless of location, to a master directory. This master directory is then used to provide http access to the data archive and available for querying by the metadata synchronization system. The scripts run every hour to ensure that any change to the volumes is reflected in the master directory. This results in new data being available for download no later than 1 hour after delivery. Prior to this system, new data wasn't available until it could manually be moved from the drop location to the data archive.

Reengineering the data delivery notification system

The existing system depended on email notification of delivery to trigger a basic metadata ingest procedure. This often didn't work, as there was no check to see if the email had been successfully delivered. As a side effect of the hourly synchronization of the data archive, it became possible to write an automated script that periodically queried the data server to see if any new data had been delivered. The discovery of new data on the data server replaced email as the trigger for the metadata creation step. The data check also runs hourly.

Redesigning the metadata repository

Key to the success of the two activities above was a redesign of the core metadata structure of the system. We developed a database-based metadata management system and a two-phased metadata creation procedure. First, the database was designed to include advanced metadata elements and to support the inclusion of non-Landsat geospatial data. In particular we were interested in supporting ASTER and MODIS data. We included additional metadata elements like data processing level, cloud cover, geospatial footprint, etc. The database was constructed using Postgresql, an open-source relational database that supports storage of polygons.

In the old system, metadata was adapted from records held in the USGS FGDC clearinghouse. These records were very basic and didn't include information specific to the OhioView data purchase like processing steps, datum, etc. They also only provided a rough bounding rectangle instead of a more precise footprint. The solution was to use a more detailed metadata inventory available to Americaview members. Unfortunately, this inventory is only updated periodically, not in real-time. Hence our two phase solution.

Our two-phase metadata procedure first derives as much information as possible about the dataset from the dataset itself. This yields basic identification information like path,row.data,and platform, and processing level. This basic information is immediately ingested into the new metadata database and the dataset is made available to users searching for it. The record is marked as having incomplete metadata. Once every week, the USGS inventory database is downloaded and ingested into a separate table in the metadata database. This table is cross-referenced to the newly acquired data and the rest of the metadata is extracted and ingested. A loader was written that extracted relevant metadata directly from the HDF format of ASTER and MODIS>

The new metadata system also includes separate tables for holdings information. This allows for access to the same dataset at more than one data repository. From the metadata display, users can click a link to check availability. All of the repositories that hold a dataset are then listed along with corresponding download links.

A new search and access system was also written that takes advantage of the more precise footprint information. Users can now search by Path/Row, by entering a bounding rectangle or by selecting a geographic place name.

The net result of this new system has been a seamless presentation of the OhioView Digital Library for users. From one location, they can search for and acquire the data they need regardless of what dataset it is, where it's located and when it was acquired.

From a management perspective, manual intervention into the acquisition and ingest of data and metadata has been much reduced. The system mostly runs on it's own. Manual intervention is needed to reconfigure scripts due to major changes in data storage locations, but not for routine data acquisition.

Areas for Future Development and Research

Data Push to clients

Data users currently must periodically visit the data archive to determine if new data of their area of interest has been acquired. They must then use a web browser to download each scene individually often when the network is congested. A data push architecture would allow data users to specify a standing order of data that meets their selection criteria and schedule it to be delivered directly to their research server when network congestion was lowest.

Expanding data acquisition to routine MODIS Direct Broadcast

The USGS has recently begun providing access to adirect broadcast data from MODIS. OhioVIew reseachers and graduate students have expressed interest in collecting this data for OhioView regions of interest. An automated ingest system could be engineered that integrates routine acquisition of MODIS data into the main OhioVIew Digital Archive.

OhioView 01 Final Report	The Ohio State University
Report Period	May 1, 2001 to September 30, 2002, extended through May 21, 2003
Grant Title	Engineering Applications for Landsat-7 Data
Name of Principal Investigator	Prof. Carolyn J. Merry
Institutional Name	The Ohio State University
Institutional Address	Dept. of Civil & Environmental Engineering & Geodetic Science 470 Hitchcock Hall, 2070 Neil Avenue Columbus, Ohio 43210

Final Progress Report

Research activities. The first objective was to map land use change over a 15-year time period for six general land use categories (water, forest, crops, pasture, urban and other) for the Columbus, Ohio, ETM+ scene (path 19/row 32). Corresponding GIS data layers were placed into a database server for use as the ground truth database. GIS data layers include USGS digital line graph (DLG) data files, digital elevation model (DEM) data, field observations and agricultural reports. A unified map projection – UTM, NAD27 – based on the USGS 1:24,000 DLG data was used for all data layers to simplify image and map overlay. Tabulations by county were made for agricultural land loss. In general, agricultural land has been lost to other land uses in the central Ohio area.

The Landsat-7 image and GIS (geographic information system) database for use in research and teaching activities was continually updated and maintained. This has been an invaluable resource at OSU.

The second objective was to use Landsat-7 data in hydrologic engineering applications. Specifically, during this reporting period a graduate student's (Xin Hu) research was funded to develop and test a soil erosion model for the Coshocton River Watershed using AnnAGNPS (Annualized Agricultural Non-Point Source Pollution Model). A DEM was acquired of the area and processed through TOPAZ (TOpographic PArameteriZation) for use in identifying and mapping topographic features, surface drainage, watershed delineation, the watershed network and to calculate subcatchment parameters. A Landsat-7 image – 14 August 2001 – was used to develop a recent land use map for use in AnnAGNPS. Land cover categories included cropland, pasture and forest with a classification accuracy of 83%. Soils data from the Ohio Department of Natural Resources were also acquired for the test area. A modified curve number was also developed that accounts for the soil moisture parameter, which was lacking. NDVI (normalized difference vegetation index) maps were prepared from 14 dates of cloud-free Landsat-7 imagery. Seasonal NDVI distributions for various cover types – cropland, pasture, forest – were calculated and examined. The NDVI maps were then used to estimate the temporal changes in land cover for each watershed. This provided information on the operational status of cropland areas throughout the agricultural season. Climate data were also prepared for use in AnnAGNPS using the program GEM (climate generator). These data included daily precipitation, and maximum and minimum temperatures. Other climatic data (dewpoint temperature, sky cover and wind speed) were obtained from the U.S. Department of Commerce. The Complete_Climate program was then used to generate the climatic information required by AnnAGNPS. The AnnAGNPS model was calibrated in terms of runoff for two watersheds (pastureland – stations 192 and 110) using measured data on annual runoff from 1985 to 2001. A correlation of 0.94 was obtained for watershed station 192 using runoff data for seven years (1987-1993). A correlation of 0.60 between the measured and calculated annual runoff was obtained for watershed station 110 using runoff data for 15 years (1987-2001). A sensitivity analysis of runoff was performed using the curve number. A 1% change in curve number resulted in a 3% change in runoff. A sensitivity analysis of field capacity and saturated conductivity was also performed, but their significance was low. Additional variables that were tested included saturated conductivity, field capacity, wilting point, annual root mass, annual cover ratio, annual rainfall, and surface residue cover. The sensitivity analysis allowed us to determine the effect of each variable on the predicted annual runoff. Annualized data for the years 1985 to 2001 for precipitation, runoff, sediment and climate data records, which is used for input to the AnnAGNPS model, were developed. The runoff events for 1987-88 were studied in detail for watershed station 118 (corn-soybean rotation). The calculated runoff was close to the measured runoff from May to November, with a larger discrepancy found during the winter months. The reason was attributed to the air temperature and what the model considers as rainfall *vs.* snow. The scale issue for predicting runoff was also examined. The curve number and soil properties influenced the predicted runoff calculation. The scale of the watershed drainage area had little effect on the runoff prediction. The geometry of several weirs was measured to refine the cross section parameters. Major roads from the DLG data were included in the model. Different runoff characteristics occur for minor roads. The minor roads were mapped using a GPS unit and input to the model. More detailed elevation measurements were also obtained using a GPS unit to refine the elevation data set used in the model.

Conclusions/research findings. Landsat data has been extremely useful for hydrologic engineering studies. The data have allowed the development of a seasonal distribution of land cover for various watersheds. The research conducted for this project will be finalized into a master's thesis during Fall 2003.

Accomplishments. Participation in several webcasts and workshops were accomplished. These included:

- OhioView webcast held at NASA Glenn Research Center for Earth Day on 27 April 2002. A short workshop on measuring suspended sediment concentrations using an ALTA handheld spectroradiometer was developed for use with middle school students. This exercise was then related to Landsat-7 satellite data that is used to map suspended sediment concentration.

• OhioView teacher workshop held at NASA Glenn Research Center on 18 July 2002. The workshop focused on using the Multispec program to perform an unsupervised classification using Landsat data.

• OhioView workshop for the International Science Fair held in Cleveland, Ohio on 16 May 2003. The workshop focused on using the Multispec program to perform an unsupervised classification using Landsat data.

Master's thesis accomplished using remote sensing data acquired through the OhioView consortium include the following:

- AU01 – Sweta Bharati – *Quantification of suspended sediment in the lower Maumee River Basin using Landsat-7 imagery.* Her research focused on evaluating several model equations to predict suspended sediment concentration in the Maumee River Basin using Landsat-7 data.
- WI02 – Anand Jayakaran – *Hydrologic models in the upper catchment of the Portage River, Ohio.* His research focused on comparing four models to predict water runoff in the Portage River Basin using land cover categories derived from Landsat-7 data.
- SU02 – Jun-Pill Kim – *Flow calculations for the Scioto River Basin using the MIKE11 model.* His research focused on developing a hydrologic model of the Scioto River Basin using a dynamic model – MIKE11 – developed by the Danish Hydraulic Institute. Landsat-7 data was the source of land cover for developing the watershed characteristics.
- AU02 – Tzu-Lung Sun – *A detection algorithm for road feature extraction using EO-1 hyperspectral images.* His research focused on using EO-1 hyperspectral data in traditional feature extraction algorithms to improve road detection.

At the Ohio Geospatial Technology Conference held in Columbus, Ohio on 24-26 March 2003, two graduate students funded under this project received poster paper awards. Shiue-Shian "Jason" Lin received first place in the remote sensing group and Xin Hu received third place in the integrated geospatial methods group.

OhioView 01 Final Report	The Ohio State University
Report Period	May 1, 2001 to September 30, 2002, extended through May 21, 2003
Grant Title	Design of a user-friendly data mining approach for georeferenced images
Name of Principal Investigator	Prof. Joel Morrison, Dr. Raul Ramirez
Institutional Name	Center for Mapping – The Ohio State University
Institutional Address	1216 Kinnear Road Columbus, OH 43212

Final Progress Report

Research activities. The following major steps were addressed, as part of a long-term research agenda:

1) Research *what* needs to be shown in a multi-media map
2) Research *how* things need to be shown
3) Implement a "proof-of-concept" multi-media map
    (i) Feasibility study
    (ii) Data gathering
    (iii) Software development and system integration
    (iv) Map generation

For the last two years we have developed part of the theoretical framework. During this reporting period, we concentrated on developing a Windows-based prototype system that runs on personal computers. The current prototype system integrates raster images (Landsat, Ikonos, DOQQ's) with vector data (DLG, Census), panoramic views, and profiles (see Figure 1).

This prototype system is operational and was extended to provide multi-scale visualization capabilities during this year. Multi-scale visualization in this context is the capability to display for a particular area or region, data sources (both raster and vector), with varying resolutions. Our goal was to start by having multi-source, multi-quality, and multi-media data and information displayed at a given scale in an integrated fashion. Then, under user command the system is used to display a different resolution scale (different data sources) for the area of interest. This is done in a fashion transparent to the user. The end result is an integrated horizontal and vertical raster and vector data set, plus panoramic views and profiles (Figure 2).

Different options are available to the user. For example, the user is able to see the area of interest at different scales in a single screen, as shown in Figure 2. The user is able to view all the available information for the area of interest in a single screen at a given scale; and the user is able to see any combination of available information regardless of scale.

As part of our goals for this year, we started developing the option to visualize data quality information. This requires the developing of appropriate error models.

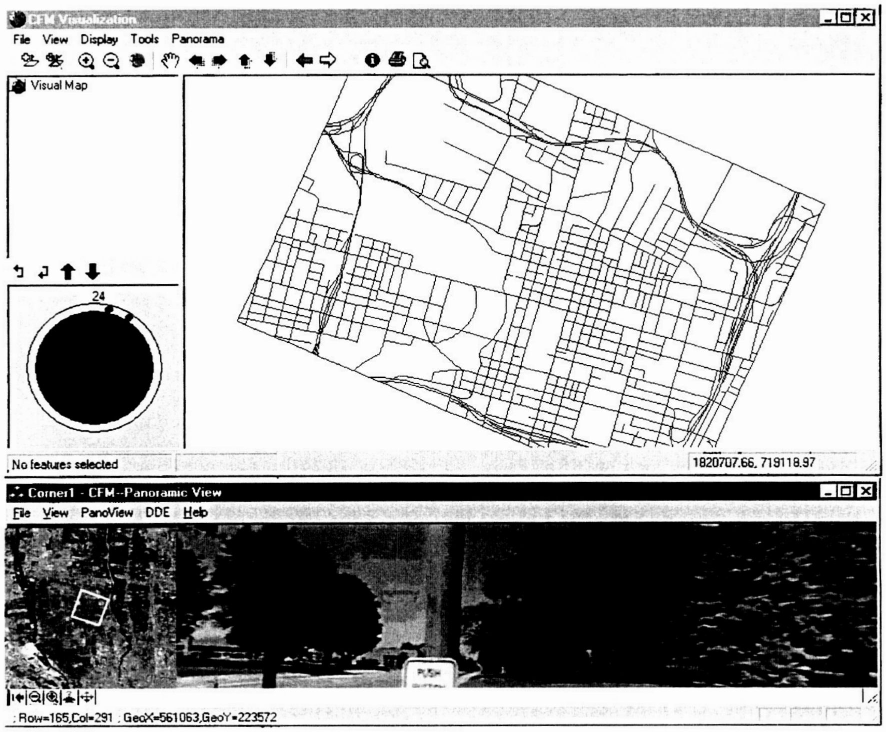
Development of these models for linear features was done as part of another ongoing project. We implemented their visualization as part of this project.

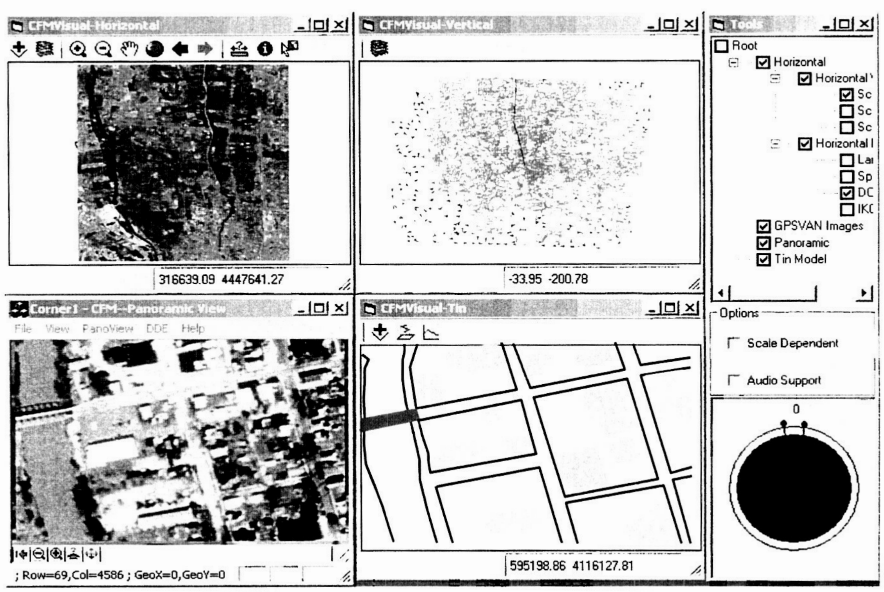
Conclusions/ research findings. To date we have used electronic technology to replicate the visualization products (paper maps) of analog technology. Today, it is highly desirable to develop cartographic visualization solutions that make better use of state-of-the-art computer technology. These visualization systems must be highly adaptive to satisfy individual user styles, be interactive, and realistic. Raster and vector data must be interleaved with imagery and enhanced by audio and animation. This is the environment where the use of Landsat-7 data will occur. The goal of this research was to continue our development of a prototype proof-of-concept geographic visualization system initiated in the prior year.

Accomplishments. The outcome of the third year of this research was an extended prototype visualization system. This system displays raster and vector data at different scales, panoramic views, and has multi-scale capabilities.

Figure 1. Prototype visualization system.

Figure 2. Multi-source, multi-scale visualization of area of interest.





OhioView 01 Final Report	Ohio University
Report Period	May 1, 2001 to September 30, 2002, extended through May 21, 2003
Grant Title	Mapping Natural Hazard Exposure Patterns Using Landsat 7 Data
Name of Principal Investigator	James K. Lein
Institutional Name	Department of Geography Oho University
Institutional Address	Department of Geography 122 Clippinger Labs Ohio University Athens, OH 45701-2979

Final Progress Report

Project Description

Natural processes are neutral in their disposition toward human populations, however, when these processes contribute to injury, death or damage to property they are defined as hazards. However, we also recognize that human activities may alter the frequency with which these events occur, increase or decrease their severity, alter the size of the area impacted, influence the rate of exposure of people or property, and influence the vulnerability of hazard exposed populations. A Critical aspect of the hazard identification problem surrounds the question of exposure and the development of tools that can assist in mapping and assess the degree to which human populations stand in harms way.

To effectively assess the levels of risk associated with exposure to a natural hazard, analysis must be conducted to provide information on the identification and description of the characteristics, geographic distribution, potential effects of hazardous events and an assessment of the vulnerability of populations and structures affected by these events. Using the problem of flood risk in southern and southeastern Ohio, this study demonstrates how Landsat 7 data can be applied to map patterns of population and infrastructure exposure to flood risk.

Program Objectives

This study is focused on three main objectives:

1) to evaluate the utility of applying Landsat data in risk exposure analysis
2) to develop a methodology for exposure characterization using remotely sensed imagery
3) to disseminate the results of this method and provide characterization data to local government agencies involved in risk assessment

Methodology

The Hocking River watershed will serve as the study site for this project. Landsat imagery will be acquired for this region and assembled into the working data set. Given the nature of this study, the plan is to incorporate night-time acquired scenes with conventional imagery to test a method of settlement estimation that can be used to produce a satellite derived risk exposure model. This model will develop from the inclusion of DEM data together with stream and flood plain layers taken from a GIS data set that has been developed for this watershed.

The project was designed to followed five-phase process as described in the original proposal. Phase one involved acquisition of the Landsat 7 imagery and the preparation of the GIS data layers. During this phase the goal was to acquire Landsat 7 Night Time thermal imagery of the study area and apply this data to develop estimates of population density. Although a night time image was acquired (LE7115211000113150), extensive cloud cover precluded its use in this study. The absence of night time thermal satellite data to produce population density estimates required modification of the original work plan. The revised methodology focused in stead on applying standard Landsat 7 data to map urban infrastructure, population density and test the use of selected band ratios that could be used to map building foot prints in order to update assessment population settlement patterns in flood zones and identify urban infrastructure under conditions of land use development and change. There were three main components to this revised study:

- Phase one involved acquisition of the Landsat 7 imagery and the preparation of the GIS data layers,
- Phase two was devoted to estimating population/settlement patterns from the L7 data.
- Phase three involved developing a flood risk exposure model.

Study Area

The mid-Ohio valley centered on Belpre-Marietta Ohio/ Parkersburg WVa. served as the site for this study.

1. Estimating Population Density

This phase of the study relied on the use of Landsat thermal data acwuired during the daylight overpass. Using this data an apparent temperature surface was generated (figure 1). Using this surface as a surrogate for land use intensity, a sample of 300 point locations were taken and thermal estimates were assembled into a file with population values acquired from the 2000 census of population for the study area. A simple regression technique was used to determine the degree of fit between surface temperature intensity and population size. The correlation coefficient for the model was $r = 0.87$ with a coefficient of determination of 0.76, suggesting that approximately 76% of the variation in population could be predicted by apparent surface temperature. The results were then pass to an interpolation function and mapping (Figure 2)

Figure 1: Apparent Surface Temperature Surface

Figure 2: Predicted Population Density: Washington County, Ohio

Next, Digital Elevation Data were acquired for the study area and processed using GIS to produce a flood zone layer (Figure 3). An "infrastructure density" surface was created by reclassifying the temperature layer (Figure 1) where temperature values exceeded 45.0. This surface was used as a surrogate for urban settlement and enabled evaluation of the degree of urban land cover that composed the study area (Figure 4).

Figure 3: Flood Zone

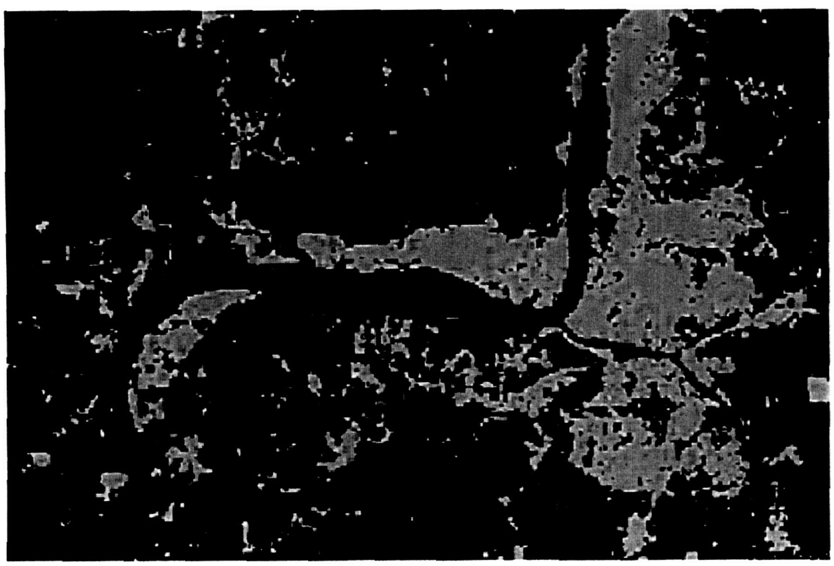


Figure 4 : Infrastructure Density

Using GIS a simple infrastructure exposure model was created by conducting a boolean overlay of the infrasturcture density and flood zone layers (Figure 5). This layer could be used to explain the degree of exiting land uses contained within a regulatory flood zone or used to describe the degree on new develop added into areas of potential risk.

Figure 5: Flood Risk Surface

2. Infrastructure Mapping

The aim of this study phase was to develop a straightforward and repeatable method to delineate building footprints within flood prone areas. The methodology, referred to here as *edge-vectorization*, serves as a means by which communities, governments, and organizations with limited economic and technological resources can supplement decision-making with cartographic products representing fine-scale building footprints for the purposes of updating infrastructure maps.

A 4-step methodology was used in conjunction with fine-resolution satellite imagery :

1: **Edge Detection** – In this study the non-linear Sobel algorithm was used to highlight the most definitive feature boundaries throughout the entire image.
2: **Edge Map Production** -involved the simplification of the edge-enhanced output as an intermediate step, which is necessary in order to prepare the raster grid for the final stage of the procedure
3: **Vectorization** - raster-to-vector data conversion served as the means by which specific boundaries associated with features of interest may be extracted from the image as a whole, while unwanted edges are eliminated
4: **Post Processing** – Clean up operations to produce the final layer

Edge-vectorization of the image was performed using the ERDAS Imagine image processing and spatial analysis software, resulting in both line and polygon ArcGIS coverages. These layers were then converted to shapefile format for post processing in ArcMap. Both the line and polygon representations consisted of detailed and easily identifiable representations of large-scale geographic features. Additional lines and polygons are present throughout the layers in the form of fine-detail residual edges that were not eliminated during production of the raster edge map. These remnants represent textural anomalies in grassy areas and streets, as well as small rooftop objects such as chimneys and ventilation ducts. The remnants can be easily clipped from the layer, along with the outlines of other unwanted features using the ArcMap feature editor.

Footprints for all buildings were successfully extracted from the original line shapefile but the representation of this data is more complex and less accurate than a results of automatic object extraction. One factor is the extremely general nature of the edge-vectorization process, which is unable to distinguish between feature outlines and insignificant edges that are also associated with those features (i.e. shadow outlines, outlines of dormer windows, and sub-portions of rooftops). Another consideration is the fragmentation of feature outlines due to spectral and spatial complexities of the original image, as well as data loss from the edge-enhanced image during edge map production. The fragmentation of boundary lines becomes more apparent and more problematic in the polygon shapefile.None of the buildings were represented as precise polygons, though portions of some buildings were completed. Another problem is associated with the fact that many feature outlines are composed of elongated polygons that create a maze of unnecessary noise both inside and outside of polygon footprints.

Initial output from the Sobel edge operator is shown in Figure 6. Although useful, this image still contains too much fine detail, both within and outside of rooftop boundaries. Further post processing was required to yield a more correct product.

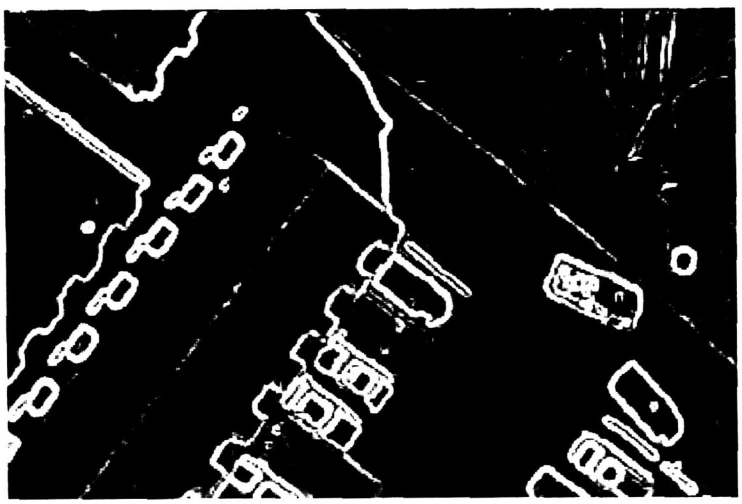


Figure 6: Results from Sobel Edge Detection Algorithm

Discussion

This study demonstrates the utility of Landsat 7 data as a fast and reliable method to acquire population and infrastructure estimates in hazard prone areas. In areas of rapid urbanization or where mapped information is incomplete or out dated, the satellite-based method can provide reason first estimates that can be used in initial hazard studies, risk assessments, and mitigation plans.

OhioView 01 Final Report	University of Toledo
Report Period	May 1, 2001 to September 30, 2002, extended through May 21, 2003
Grant Title	Dissemination of Remote Sensing Technology in Northwest Ohio through Educational and Community Outreach
Name of Principal Investigator	Kevin Czajkowski
Institutional Name	The University of Toledo
Institutional Address	2801 W. Bancroft St. Dept. of Geography and Planning University of Toledo

Final Progress Report

At the conclusion of this grant we have a better understanding of the use of webcasts in the K-12 classroom. Many classrooms are not technologically set up to view webcasts properly. Please see the section below under lessons learned. In addition, we have established working relationships with many local agencies on several projects, namely urban sprawl in Lucas County and sediment load to Lake Erie. The urban sprawl project returned very poor results while the Lake Erie Sediment project produced very promising results.

Research activities

1. Urban Sprawl in Toledo
2. Sediment yield identification in Lake Erie from Landsat imagery.
3. Teacher workshop at the University of Toledo's Lake Erie Center during the summer of 2001.
4. We followed up the workshop with two webcasts to the K-12 students and teachers, one in November 2001 and one in April 2002.

Conclusions/ research findings

Urban Sprawl in Toledo

Zhongze Wang, a graduate student in the Department of Geography and Planning at the University of Toledo used satellite images of 1984, 1990, 1994 and 1999 from the Landsat satellite to examine urban sprawl in and around the Toledo area. She utilized a hybrid unsupervised/supervised classification system and achieved an overall accuracy of 92% for the 1999 image. The accuracy of the other images was not calculated. According to the study, over 50 square miles of farmland and wooded areas in the Toledo area have been developed between 1984 and 1999.The majority of the growth has been in residential expansion causing a doubling of the total area of Toledo and its suburbs since 1984. The fastest growing areas are to the north and west of Toledo including Bedford Township, Sylvania and Springfield Township. In recent years the percent of residential and urban development in

Sylvania has surpassed the area that is undeveloped. Development accelerated from 1994 to 1999 with all areas showing large increases in developed land.

Water Quality

Bowling Green State University, the University of Toledo, Ohio State University and Ohio University have been collaborating and using satellite imagery to assess turbidity, pollution, runoff, algae and bacterial growth in Lake Erie and Ohio Rivers. A single satellite image can show a large portion of Lake Erie; remote sensing provides a synoptic picture of Lake Erie that no other source of information can match (Figure 5). The University of Toledo and Bowling Green State University have been developing techniques to derive turbidity, total suspended sediment, lake water temperature, Phycocyanin (toxic bacteria) and e coli concentration. Students and researchers have collected water samples on Lake Erie using the University of Toledo's Lake Erie Center's 24 foot research boat. Results will soon be submitted for publication. Ohio State University has been working with the USGS in Columbus to develop models to extract sediment from Landsat imagery; thereby comparing imagery to measurements taken within the Maumee River.

<u>"Observing Earth From Space" Workshop and Student Observation Program</u>

During the summer of 2001, teachers in the S.A.T.E.L.L.I.T.E.S. program attended a workshop developed by Dr. Czajkowski, Ms. Struble, and Ms. Benko. The teachers expanded their science content knowledge on topics such as the electromagnetic spectrum, solar radiation, energy budget, weather observing techniques and analysis, greenhouse gases and their effects, satellite imagery, global warming issues, and human dimensions of global change. Participants explore education pedagogical issues, such as the national standards for science and geography, constructivist theory, and the 5 E Learning Cycle (Engagement, Exploration, Explanation, Extension, Evaluation). The 5E model was emulated throughout the workshop by each trainer giving the teachers practical and first-hand observation of the concept in practice. Each teacher in the program then developed a lesson plan using the 5E model that addresses a topic covered in the workshop and shared the lesson with other teachers in the program through the programs bulletin board.

An important part of this activity is to engage students "as scientists" through an observation program in which the students take cloud and snow observations to develop a validation data set for cloud/snow distinction in satellite imagery. Teachers attending the "Observing Earth from Space" workshop were trained in observation protocols that enhance technology usage. In particular, teachers learned how to observe clouds and snow. The students performing the observations reported their observations to scientists at UT via the Internet and the observations will be used to validate satellite imagery. There is strong NASA support for this program (see http://earthobservatory.nasa.gov/Study/ForADay/).

Accomplishments

Erdas IMAGINE Distribution

The University of Toledo brokered a deal with Erdas to have consortium members purchase permanent copies of the Erdas remote sensing software for $285. UT also acted as a distributor for the software, universities reimbursed UT. Copies were purchase for university use as well as for outreach purposes. Groups that received software included:

3- University of Toledo

Kevin Czajkowski - laptop
Defiance College
Fulton County Planning Agency

2- Wright State University
Doyle Watts - laptop
Central State University
Ohio Department of Agriculture, Division of Plant Industry, Gypsy Moth Suppression Program

1 - Cleveland State University
Cuyahoga River Community Planning Organization

1 – Ohio University
2 - University of Cincinnati
5 – BGSU
1 – U. Akron - Loren Siebert

Organized special session, "Gateway to the Earth: OhioView Pilot", Association of American Geographers Conference, New York City, Feb. 28, 2001.

Presentations Given

2002 Lawrence, P. and K.P. Czajkowski, Remot sensing of Land Cover Change Analysis for Environmental Planning in Northwest Ohio, Association of American Geographer's 98th Annual Meeting in Los Angeles, CA, March 19-March 23, 2002.

2002 Benko, T., K.P. Czajkowski, J. Struble, and L. Zhao, Using Remote Sensing Technology as a Tool for Educational Outreach and Studying Global Climate Changes, Association of American Geographer's 98th Annual Meeting in Los Angeles, CA, March 19-March 23, 2002.

2002 Mather, S. V., K.P. Czajkowski, S. Stadler and S. Goware, Estimation of Surface and Air Temperature from MODIS Data; Validation Using the Oklahoma Mesonet, Association of American Geographer's 98th Annual Meeting in Los Angeles, CA, March 19-March 23, 2002.

2002 Czajkowski, K. P., Coss, J., Benko, T., Struble, J, Moebius, E., Mather, S., and Lawrence P.., Dissemination of Remote Sensing Technology from the Research Lab to the Public, Association of American Geographer's 98th Annual Meeting in Los Angeles, CA, March 19-March 23, 2002.

2002 Czajkowski, K. P., J. Struble, and T. Benko, Global Change and Remote Sensing Summer Teacher Workshop and Observation Program, American Meteorological Society, 11th Annual Education Symposium, Orlando, Florida, January, 14-18, 2002.

2002 Czajkowski K. P., Dissemination of Remote Sensing Technology in Northwest Ohio, OhioView/AmericaView Conference, NASA Glenn Research Center, January 24, 2002.

2001 Benko, T., K. P. Czajkowski, J. Struble and L. Zhao, Using Remote Sensing Technology as a Tool for Educational Outreach and for Studying Global Climate Changes, American Geophysical Union Fall Meeting, San Francisco, CA. Dec. 10-14, 2001, p. 257.

2001 Mather, S., K. P. Czajkowski, S. Stadler and S. Goward, Near Surface Environmental Variable Estimation with MODIS Data: Validation Using the Oklahoma Mesonet, American Geophysical Union Fall Meeting, San Francisco, CA. Dec. 10-14, 2001, p. 124.

2001 Czajkowski, K. P., T. Benko, J. Struble, L. Zhao, Using Remote Sensing Technology as a Tool for Educational Outreach, East Lakes Division of the Association of American Geographers (ELDAAG) conference, Cincinnati, OH, Oct. 27, 2001.

2001 Mather, S., K. P. Czajkowski, S. Stadler, and S. N. Goward, Surface Temperature Estimation with MODIS Data, Validation with the Oklahoma Mesonet, East Lakes Division of the Association of American Geographers (ELDAAG) conference, Cincinnati, OH, Oct. 27, 2001.

2001 Edwards, M., K. P. Czajkowski, K. P. and P. Lawrence, Application of Total Solids and Turbidity Readings in the Ottawa River Water shed for Non-point Source Pollution Detection, East Lakes Division of the Association of American Geographers (ELDAAG) conference, Cincinnati, OH, Oct. 27, 2001.

2001 Moebius, E. and K. P. Czajkowski, Monitoring of the Scioto Marsh Organic Soils Using Remotely Sensed Data, East Lakes Division of the Association of American Geographers (ELDAAG) conference, Cincinnati, OH, Oct. 27, 2001.

2001 Lawrence, P., S. Fuller, and K. P. Czajkowski, The Application of Remote Sensing Technology for Wetland Classification and Implications for Environmental Planning within the Maumee River Watershed, NW Ohio, East Lakes Division of the Association of American Geographers (ELDAAG) conference, Cincinnati, OH, Oct. 27, 2001.

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Presentations at National Science Teachers Association conference, "What's Happening on Earth", "From a Satellite's Point of View", St. Louis, MO, March 22-25, 2001.

Presentations at Science Education Council of Ohio conference, "What's Happening on Earth", "From a Satellite's Point of View", Cincinnati, Ohio, February 16-17, 2001.

Presentation "Climate Change and Global Warming: Current Issues and the Ongoing Debate", for Earthfest, University of Toledo, April 19, 2001.

Presentation at Education Symposium, "What's Happening on Earth", St. Johns Jesuit High School, March 28, 2001.

Presentations to Quest students, undecided and their parents, February 10, 2001 and March 24, 2001.

Presentations at Owens Community College, Ocotber 3, 2000 and April 5, 2001.

Teacher Workshop, “Global Change and Remote Sensing”, July 24-28, 2001, 30 teachers in attendance.

Presentations at SciMaTEC mini-conference, “What’s Happening on Earth”, “From a Satellite’s Point of View”, Perrysburg High School, Dec. 1, 2001.

Presentation for Mission Geography Workshop, K-6 grades, NASA Glenn Research Center, January 29, 2002.

Presentation to the Maumee River Basin partnership of Local Governments, OhioView remote sensing potentials, February 12, 2002.

Presentation: Earthfest, April 18, 2002, University of Toledo.

Presentation: Growth Strategies Day, TMACOG, April 19, 2002.

Webcast from NASA Glenn: November 27, 2001, Cloud Awareness Day from NASA Glenn Research Center in Cleveland, OH. Reached approximately 15 schools.

Webcast from NASA Glenn, April 27, 2002, EarthDay, from NASA Glenn Research Center in Cleveland, OH. Reached approximately 80 schools.

Publications

Czajkowski, K. P., T. Benko and J. Struble, Global change and remote sensing summer teacher workshop and observation program, Proceedings from the 11th Annual Education Symposium, American Meteorological Society, Jan. 13-17, 2002, p. 87-89.

Masters Degree Finished

MA – Zhongze “Wykota” Wang, Urban Sprawl in Toledo: A Case Study Using Satellite Imagery, March 21, 2001. – chair.

Lessons Learned

Webcasts

OhioView was offered the opportunity to make a Webcast from NASA Glenn Research Center in Cleveland, Ohio that was a very attractive alternative for visiting each school. The Webcast was broadcast over the Internet by NASA Glenn using their Mobile Television Unit (MTU).

Prior to the broadcast, teachers were given specific access instructions to NASA Glenn’s Internet Broadcasting webpage. Teachers or an information technology person working at each school needed to download RealPlayer 8 Basic prior to the Webcast. A studio audience of 12 students from Cleveland Heights High School helped by answering questions and doing demonstrations at NASA Glenn during the broadcast.

For almost all of the teachers and schools involved, it was the first time that they had tried logging into a Webcast. Teachers were asked to return a survey after the Webcast to help assess the utility of this new technology in their classroom. According to the 16 teachers who responded, five thought the webcast was very useful, seven said that it was somewhat useful and three teachers said that it was not valuable at all. All of the teachers said that their students were very excited about the potential for using the technology and hearing more about the project that they were working on. They were particularly excited to see their school's name flashed on the screen during the webcast. The webcast made the scientist (me) real to the students (I was not just a picture on a website). A success from the event included one school where the technology person piped the broadcast through the closed circuit television network within the school building. Every classroom was then able to watch the broadcast with only one computer connected to the Webcast. This prevented an Internet traffic problem at the school.

The main reason given by the teachers who said it was not a valuable experience sited technical difficulties. The problem most cited was poor audio quality. At least eight of the teachers said that many computers do not have speakers and for laptops with speakers, the volume cannot be turned up very high. One teacher remarked that they had 20 students huddled around one laptop trying to hear. Another problem was that the sound was asynchronous with the video, making it hard for the students to follow the program. Internet speed was another issue. Another problem that arose was that teachers and many technology people did not realize that having a large number of computers logged on at an individual school would slow the Internet at that school to a point, such that the Webcast would be garbled. Even though we warned the teachers, one IT person at a school had 30 computers in a lab logged into the Webcast. In future webcasts we will advise teachers to have only a few computers logged into the Webcast. In addition, using an LCD projector or TV will reduce the number of internet connections. One teacher after having trouble because of a large number of computers viewing the webcast, hooked the internet to a closed circuit television system within the school and showed in the webcast in every classroom in the school. Finally, many of the teachers reported a blockiness to the images that made the images difficult to view. This blockiness is inherent in the lowest resolution transmissions that result when using slow Internet lines.

Many teachers are not technologically savvy and they need help to improve their skills. We hope that by exposing them to new technologies (without scaring them) would help to improve the use of technology in the classroom. NASA Glenn, the University of Toledo's S.A.T.E.L.L.I.T.E.S. program and the OhioView Consortium plan to do more Webcasts in the future. We will use the lessons from this Webcast to improve future programs. For the next Webcast, we plan to post a video clip on the Internet prior to the Webcast so that teachers can test their computer systems. The technology is exciting and shows a lot of potential to enhance the educational experience of lot of students, but we have a steep learning curve to overcome.

OhioView 01 Final Report	Wright State University
Report Period	May 1, 2001 to September 30, 2002, extended through May 21, 2003
Grant Title	Application of Remote Sensing to the Ohio Environment
Name of Principal Investigator	Dr. Doyle R. Watts
Institutional Name	Wright State University
Institutional Address	3640 Colonel Glenn Highway Department of Geological Sciences Dayton, Ohio 45435

Final Progress Report

Summary

At the conclusion of this grant we have new methods for Gypsy Moth activity identification that can be used in the decision making process of State Agencies that participate in the Gypsy Moth Suppression Program. The unprecedented availability of satellite image data allowed us to devise algorithms that use three or more frames that cover the entire Gypsy Moth defoliation event through a single season to locate egg masses to design treatment programs for the following season. The temporal coverage provided by both Landsat 5 and Landsat 7 were required for this to be successful. During the summer of 2001 and 2002, Landsat 5 and Landsat 7 frames were analyzed to map Gypsy Moth infestations in Ohio. The work was carried out in close collaboration and consultation with the Ohio Department of Agriculture (ODA). Field verification work was conducted with the cooperation of ODA inspectors. We used the ODA aerial sketch mapping results for comparison with our results. Several algorithms were developed and tested to improve the mapping. We used dark object subtraction to adjust individual frames for change analysis. The unprecedented availability of high level processed Landsat satellite images for Ohio allowed us to utilize the changes that occur over the course of a single summer season. This is an improvement over previous efforts that compared a single frame with one collected during previous years. Three frames were analyzed for 2001 to give a predefoliation, defoliation and refoliation signature. Using three frames from the same season reduces the ambiguity. In order to apply this procedure, data from both Landsat 5 and Landsat 7 are required to provide the temporal coverage. Ratio subtraction enabled us to locate egg masses in 63% of the polygons investigated, in the Gypsy Moth infested portions of Ohio. Figure 1 shows the typical result in yellow with ODA aerial sketch mapping polygons superimposed on a Landsat false color image.

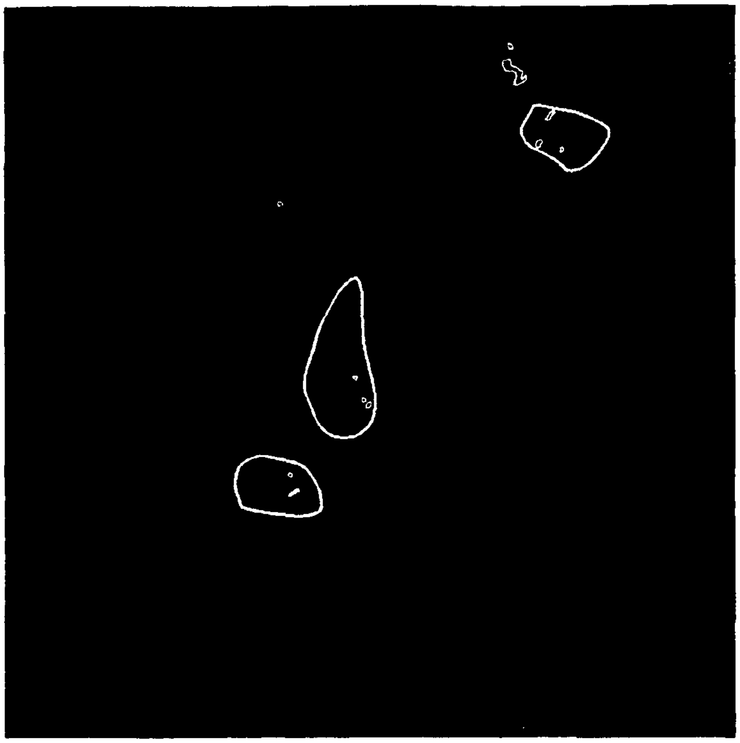

Figure 1: Areas of Gypsy Moth investation located by analysis of Landsat data in yellow compared with the areas located by aerial sketch mapping shown as white. The yellow areas are road maps to the location of egg masses. The frame is approximately 3 kilometers wide.

Change vector analysis was applied to the 2001 defoliation in the overlap area between Landsat path 18 and path 19. The overlap produces increased coverage allowing five frames to detect the complete event from defolition through refoliation in summer of 2001. Overall, 63% of the areas mapped by change vector analysis fell inside or with 500 meters of the aerial sketch mapping polygons produced by the Ohio Department of agriculture.

We were unable to reproduce published examples of the use of Landsat images and DEM's for the detection of anomalies associated with mass movement and subsidence. Clearly the signature of such events must be more complex and chaotic than the literature might suggest, at least for the areas we attempted the applications. For this reason we concentrated our efforts on Gypsy Moth detection and management.

List of Research Activities:

1. Examined subsidence risk maps provided by colleagues at Ohio Univerwsity superimposed on Landsat 7 images.
2. Searched for evidence of developing sink holes in Greene County near Yellow Springs Ohio.
3. Measured radiant temperatures over developing sink holes in Greene County.
4. Examined Landsat 7 images of sites of subsidence on I70 and I77 for precursors or signatures of subsidence.
5. Carried out band4/band3 ratio subtraction of Landsat 7 of predefoliation and defoliation images to identify Gypsy Moth activity.
6. Created and tested new algorithms using refoliation as a Gypsy Moth signature to reduce ambiguity in identification of Gypsy Moth activity.

7. Created and tested change vector analysis methods for Gypsy Moth defoliation detection.
8. Examined MODIS NDVI products for indicators of Gypsy Moth defoliation.
9. Used Ohio Department of Agriculture aerial sketch mapping results to test detection
10. Carried out field verification of Gypsy Moth activity identification in collaboration with the Ohio Department of Agriculture.

List of Conclusions:

1. Performing the subtraction of two Landsat ratio frames as done by previous workers to locate Gypsy Moth activity produced results with considerable ambiguity and confusion with brush cutting and agricultural processes
2. Using a third image that showed the inevitable refoliation following a Gypsy Moth infestation significantly reduced the ambiguity of activity location.
3. Change vector analysis in the areas of overlap of Landsat images also reduced the ambiguity of identification.
4. The areas of infestation that we mapped were smaller than the areas located by Ohio Department of Agriculture sketch mapping. But 63% of the areas that we located contained Gypsy Moth egg masses. The point of mapping Gypsy Moth activity is to locate egg masses to devise the treatment program for the following year. Unlike the aerial sketch mapping method our data produced roadmaps to Gypsy Moth egg masses.
5. Signatures of mass movement and subsidence in Landsat images are complex and chaotic in the areas in Ohio that we investigated. We could not find ways to smoothly integrate such methodology into the decision making process of the Ohio Department of Natural Resources

List of Accomplishments:

1. We introduced Landsat data to the Ohio Department of Agriculture and demonstrated how it can be integrated into the decision making process related to Gypsy Moth suppression.
2. We developed new algorithms for processing Landsat data that reduce ambiguity by using satellite images that cover the entire event from defoliation through refoliation, thereby taking advantage of the unprecedented availability of data.
3. The following works are either available or under review:
   a. Angela Hurley, 2003, Identification of Gypsy Moth Defoliation in Ohio using Landsat data. Masters thesis Wright State University.
   b. Hurley, Angela; Watts, Doyle; Burke, Brian; and Richards, Chris. Identifying gypsy moth defoliation in Ohio using Landsat data. Geological Society of America 2002 Annual Meeting Abstracts with Programs, Denver, CO. Paper No. 196-12.
   c. Hurley, A., Watts, D.R., Burke, B. Richards, C., Identification of Gypsy Moth Infestations in Ohio using Landsat Data. Submitted to Environmental & Engineering Geoscience.

Lessons learned:

The temporal coverage provided by both Landsat 5 and Landsat 7 were required to located Gypsy Moth infestation in Ohio. The unprecedented availability of high level processed Landsat satellite images for Ohio allowed us to utilize the changes that occur over the course of a single summer season. This is an improvement over previous efforts that compared a single current frame with one collected during the previous year that we also attempted. With such a long time interval between frames, it is much more likely that agricultural processes will also be detected, increasing the ambiguity of the method for Gypsy Moth identification. Confusion of Gypsy Moth activity with agricultural processes is much reduced by detecting the change during the refoliation event as well as defoliation. Using three frames from the same season reduces the ambiguity. In order to apply this procedure, data from both Landsat 5 and Landsat 7 are required to provide the temporal coverage. Ratio subtraction enabled us to locate egg masses in 60% of the polygons investigated. Wild grapevines (Vitas spp.) also gave the same signature as the greatest levels of gypsy moth activity. Change vector analysis applied to the 2001 defoliation in the overlap area between path 18 and path 19 allowing the use of five frames to detect the complete event from defolition through refoliation in summer of 2001. Overall, 63% of the areas mapped by change vector analysis fell inside or with 500 meters of the aerial sketch mapping polygons produced by the Ohio Department of agriculture. The satellite data showed the areas of highest defoliation, which in turn produced a map of the egg mass locations. This is vital for the management of the Gypsy Moth suppression program as the egg mass numbers are used to design the treatment program for the following spring. The methods we used required at least three Landsat frames to cover the event. We recognize that the regular purchase of Landsat data by the OhioLink Library organization was a key factor in the success of this program.

MODIS NDVI products did not show Gypsy Moth investations. Even an investation in Michigan covering 60000 acreas was not detected. The time averaging of data in such products likely removed the signal of Gyspy Moth investation.

We were unable to reproduce reports in the literature of signatures of subsidence and mass movement reported from Landsat images. The phenomena must be area dependent and require favorable conditions involving the interplay of subsidence, vegetation and movement of water that did not exist in the areas we looked. We were unable to recommend the use of Landsat images to detect subsidence to colleagues in the Ohio Department of Natural Resources.