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SEMI-ANNUAL STATUS REPORT

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Title of Investigation

The Application of Remote Sensing Technology
to the Solution of Problems in the
Management of Resources in Indiana

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Submitted to:

The Office of University Affairs
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I. Introduction

This Semi-Annual Status Report covers the period from June 1 to November 30, 1974 and contains a review of the research and applications, completed or in progress, as funded by the Office of University Affairs, NASA, and conducted by Purdue University, Laboratory for Applications of Remote Sensing.

This reporting period marks the beginning of the second year of funding for a proposal entitled "The Application of Remote Sensing Technology to the Solution of Problems in the Management of Resources in Indiana." As indicated in this title, the purpose of this work is to introduce remote sensing into the user community within the state of Indiana. The user community being those local, regional and state agencies involved in the decision, monitoring and/or managing processes of the state's resources.

In order to carry out this work, it is not only necessary to initiate projects with these agencies, but also it is necessary to meet with and provide information to as many people and groups as well as agencies as possible. During the past six months, 12 meetings were held with nine different groups. Approximately 105 people heard and participated in these meetings.

The nine groups that were contacted and received information about this program were as follows:

- State Forestry Planning Committee
- State Board of Health
- Indiana Department of Natural Resources, Division of Reclamation
- USDA - Soil Conservation Service
- Hoosier Heartland Association of Conservation, District Supervisors
- Kankakee - Iroquois Regional Planning Commission
- Executive Directors of the 18 regional planning areas in Indiana
- Indiana Geological Survey

In addition to these meetings a paper reporting the work done for the Indiana Heartland Coordinating Commission was presented at the 66th Annual Meeting of the American Society of Agronomy. It was presented to the Land Use and Management Section at which approximately 200 people were in attendance.

Listed below are the projects that are in progress or completed and are reported in this document:

Land Use Inventories
1. Land Use Inventory of the Indiana Heartland
2. Kankakee-Iroquois Planning Commission
   Jasper County Land Use Study
3. Strip Mining and Reclamation in Southwestern Indiana

Water Resources
1. A siting package for Electrical Power Facilities
2. Thermal Mapping of Water

Technique Development
1. Direct Change Detection
2. Data Base Development
3. A Method for Locating Gravel Deposits

This report is organized in such a way that each one of the eight projects is reported on separately. The background, status and conclusions are given for each project. Publications to be written are listed at the end of each project, if such is the case. There have been no published reports during this reporting period.

The NASA Technical Officer for this project is:

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II. Project Reports

A. Land Use Inventories--Three projects are reported here. The first one is a continuing report on activities with the 8 county planning agency working in the area around Indianapolis. The second one is a project to demonstrate the usefulness of ERTS data for land use inventories in one county of the four county Kankakee-Iroquois planning region. The third project is a continuation of the previous work done with the Indiana Department of Natural Resources, Division of Reclamation in the strip mines of southwestern Indiana.

1. Land Use Inventory of the Indiana Heartland

Background

The Indiana Heartland Coordinating Commission (IHCC) is a regional planning body that provides direction for planning activities of regional significance. Regional growth and development, human resources, and environmental quality are the primary concerns of this group. In this urban-rural area many conflicts of land use are present and most of them have regional significance.

The IHCC has requested a land use inventory of each county which the staff can use to identify basic land use patterns. The IHCC staff plans to utilize this data as follows:

1. To determine population growth patterns; to plan for orderly growth.
2. To assess the urban-rural land use conflict; to develop appropriate guidelines to alleviate the conflict.
3. To study spatial organization of the region; to make planning decision for regional facilities (i.e. highways, airports, etc.).
4. To identify environmentally significant areas such as prime agricultural land, stream corridors, forest preserves, and ecologically sensitive areas; to plan for an ecologically sound environment for the health and welfare of the region.

Upon the request of the IHCC staff, LARS accepted the opportunity to prepare a land use inventory using ERTS-1 data and computer-aided analysis techniques.

Status of Project

All but two of the county land use inventories have been completed. The remaining counties will be completed shortly.

The format for this inventory is a computer printout map that is the same size and scale as a 7 1/2' USGS topographic map. The two can be overlaid for comparison and updating. Each county will also have tabular information of percentages and hectarage of the four major land uses and eight subclasses.

Feedback from the IHCC staff has been most useful in formulating our objectives and increasing our inventory accuracy. The feedback has been in the form of memos of field surveys and policy statements of the commission. Numerous telephone conversations and personal visits have helped maintain useful communications.

LARS has also recently acquired aerial photography of the entire Heartland region. This photography is 70mm color and color infrared. Upon seeing its quality and usefulness as a complement to the ERTS-1 data, the IHCC decided to purchase a copy of both films for their own use.

Conclusions

This project is moving toward its completion in the near future. This inventory technique will have application to many agencies in the state. The planning staff needs to be well trained in the use of this data for decision-making. The ultimate goal of this project is to create a product that many agencies will want to purchase for their own needs in resource management. A LARS Information Note will be published during the next semi-annual reporting period.

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3. Strip Mining and Reclamation in Southwestern Indiana

Background

Coal is still the primary source of fuel for generating electrical energy in Indiana and the United States. Much of the coal in Indiana is located near the surface, and strip mining has been used extensively to extract this coal in southwestern Indiana.

ERTS data over southwestern Indiana have been analyzed to assess the capability of computer implemented classifications in monitoring the extent of strip mining and reclamation activities. Conclusions drawn from this study suggested that applications of computer aided analysis techniques to ERTS data may provide valuable information for and assistance to the Division of Reclamation in their work. This effort resulted in several meetings with officials of the Division of Reclamation. One of the meetings was a field trip to Jasonville where current mining and reclamation activities were observed.

It was then decided to present the Division of Reclamation with some quantitative results obtained at LARS. This would provide them with an opportunity to field check some of the results and hence, gauge the extent to which LARS technology could assist them in their work.

Project Status

Two test sites over southwestern Indiana were selected. A 3 date (Aug. 72 - Jan., May 73) temporal/spectral analysis was conducted over Test Site 1. The classification results were displayed in form quadrangles similar to the USGS topographic quadrangle maps. One of these quadrangles covering the same area as Lynnvillequadrangle map put out by USGS was given to the Division of Reclamation for evaluation.

Next a small area from Test Site II, covering the USGS Jasonville quadrangle map, was analyzed. This analysis too was of temporal data (2 dates - June & Sept. 73) but using an experimental classification technique. The results showed a small improvement over the conventional LARSYS classifier. No definite conclusions can be drawn about the new classifier as its still in the experimental stage and will probably undergo further development before it is implemented into LARSYS.

A meeting with Mr. McNabb, Director, and other officials from the Division of Reclamation has been scheduled for January 22. Some positive feedback about the results is expected then.

Conclusions

1. Utilizing existing LARSYS programs and ERTS-1 MSS data the extent of strip mining operations can be mapped.
2. Based on the findings of this report it appears feasible to use ERTS-1 data to monitor periodically the extent and location of current strip mining and reclamation operations.
3. If the mining companies will provide their projected plans for stripping, it will be possible to determine what land use classes are being eliminated by the mining process.

At present the results of the two classifications are being field-checked by the Division of Reclamation. The next phase of the project will be planned after the January 22 meeting.

B. Water Resources--Two projects are reported here and are primarily concerned with the discharge of thermal effluent into streams and rivers in Indiana.

1. A Siting Package for Electrical Power Facilities

Background

With an ever increasing per capita demand for energy in general, and electrical energy in particular; and with an ever increasing population; it is becoming more evident that questions concerned with how land should be used are more and more on the public's mind. The purpose behind our research into the siting of electrical generation and transmission facilities is to help those involved with such questions have the best possible means, at their fingertips, for answering such questions. The collection of the necessary data and calculational tools for bringing about such a means is being assembled into a reference tool called a "Siting Package."

It is a known fact that a 1000 MWe coal plant running with an 80% load factor emits 21,000 tons per day of carbon dioxide and 330,000 tons per year of collected fly ash as well as dumps 1570 thermal megawatts of heat. A nuclear plant on the other hand produced radionuclides and special materials such as plutonium and dumps 2120 thermal megawatts of heat.

The Siting Package consists of a number of calculational tools, each designed to:

1) permit more meaningful facility and land use decisions
2) reduce the time necessary for making these decisions

Our work here at LARS deals with one of the areas of concern listed above, i.e. the nature and distribution of discharge heat from the facility. Specifically we are developing the capability to analyze and model the behavior of thermal discharges in rivers. Later work will add the capability to perform the same type of analysis for ponds, lakes, and other 'stagnant' bodies of water.

Status of Project

Developing our thermal discharge package has essentially been a three part process.

The first step was to develop and assemble the necessary computer software for separating water from other cover types in scanner data and producing a temperature map of these water areas alone.

The second step was implementing on the LARS system a time dependent, 3-D thermal discharge model.

The third and final step, and the one on which current efforts are being concentrated, is the integrating of the scanner data with the model to achieve our objectives, i.e. the ability to predict thermal discharge behavior.

The second part of our thermal discharge package involves the implementation of a thermal discharge simulation model. The model which we are using was developed by Richard Hills (MSME 1974) under Dr. Ray Viskanta here at Purdue. The model is very comprehensive, taking into account such factors as air temperature, barometric pressure, humidity, wind speed, solar radiation effects, ambient water temperature, river flow rates, stratification effects, and others. The output of the model is a 3-D temperature field as a function of time. Since the model treats the physical situation with much detail, we have high hopes in its ability to help us accurately model real life situations, especially once we learn how to compensate for some of the idealized assumptions which are sometimes violated, e.g. fluid flowing in a rectangular channel, and the water is relatively clear.

The third phase of our project is the integration of the scanner data, ground observation data and our model to produce accurate 3-D temperature maps. In our experiments we use the scanner and 3-D ground truth data to help us adjust certain model parameters to provide the most accurate modelling possible. Ideally, we would like to incorporate the scanner data directly into the model as a surface boundary condition. This is beyond the scope of the present work, however, it is planned as future research.

Ultimately our goal is terms of a Siting Package then is to 1) demonstrate that we can use remote sensing in conjunction with our model to accurately map 3-D temperature distributions in rivers with thermal discharges and 2) establish the validity of the model alone to predict 3-D temperature distributions for both existing and proposed discharges.

Let's look then at exactly what our experiment consists of. Our first step was to choose an appropriate site or sites to study. Based on several factors including the river discharge geometry and the willingness of the utilities concerned to provide assistance, we chose to study two plants, both on the Ohio River. The first, near New Albany Indiana, is the Gallagher Power Station, owned and operated by Public Service Co. of Indiana. We also had an added bonus in this location since there are two other power plants downstream, both owned by Louisville Gas & Electric Co. LG&E has also been of assistance in supplying us with data necessary for our study.

The second plant was the Clifty Creek Power Station near Madison, Indiana. Unfortunately on the day of our flight the atmospheric conditions were less than ideal at the Madison location and some of the data is of questionable value to us. For this reason, most of the remainder of the discussion will be aimed at the New Albany location.

Once the sites had been chosen, we determined all the necessary information to request an ERIM scanner mission. Approval for the mission was received in July of this year and a preliminary expedition was planned to look over the flight line, checkout equipment, and devise a system of ground observation gathering. It was necessary to establish a coordinate system on the river to allow accurate distance measurement for correlation with the model. Consequently a student in surveying was included in our party to help devise an appropriate system.

The flights were scheduled for and carried out on July 31. All of the necessary data for that time period (July 30-Aug 1) was or has been collected and we are currently in the process of analyzing our results.

Conclusion

Upon completion of this work, we should be able to supply state agencies, utilities, local citizen groups and others with a means of making meaningful decisions regarding power plant siting. These decisions can be made on economic as well as environmental terms and should help shorten the costly delays which plague the power companies today and the customer's electric bill tomorrow.

Future work, which includes expanding the modelling capability to lakes and ponds, mathematical incorporation

of scanner data into the model solution, and improving the calculational speed of the modelling should provide a comprehensive package for thermal discharge modelling and analysis and should aid in the optimum choice of cooling methods as well as plant selection and siting.

2. Thermal Mapping of Water

Introduction

In order to establish an adequate criterion for water quality norms, rapid and accurate means of evaluating and monitoring certain water quality parameters are needed. Currently, computer-aided processing of remotely sensed thermal infrared data offers a satisfactory method for accurate determination of surface water temperature.

This project was primarily concerned with the application of these techniques to meet certain needs of the Indiana State Board of Health, Division of Water Pollution Control, which is responsible for determining and monitoring the water quality of streams and rivers throughout the state of Indiana.

The specific objectives of this investigation were:

1. To determine the accuracy and reliability of water temperature measurements using remotely sensed data.
2. To determine the optimum wavelength band and flight altitude.
3. To study the physical characteristics of thermal effluents from power generating plants.
4. To study the effects of thermal discharges on the ecosystems of a river environment.
5. To establish an optimum set of procedures to gather, process and analyze thermal scanner data for operational temperature mapping of water bodies.
6. To provide state Agencies (such as the Indiana Board of Health) with factual, accurate and comprehensive information on the thermal regime of streams affected by power plant discharges.

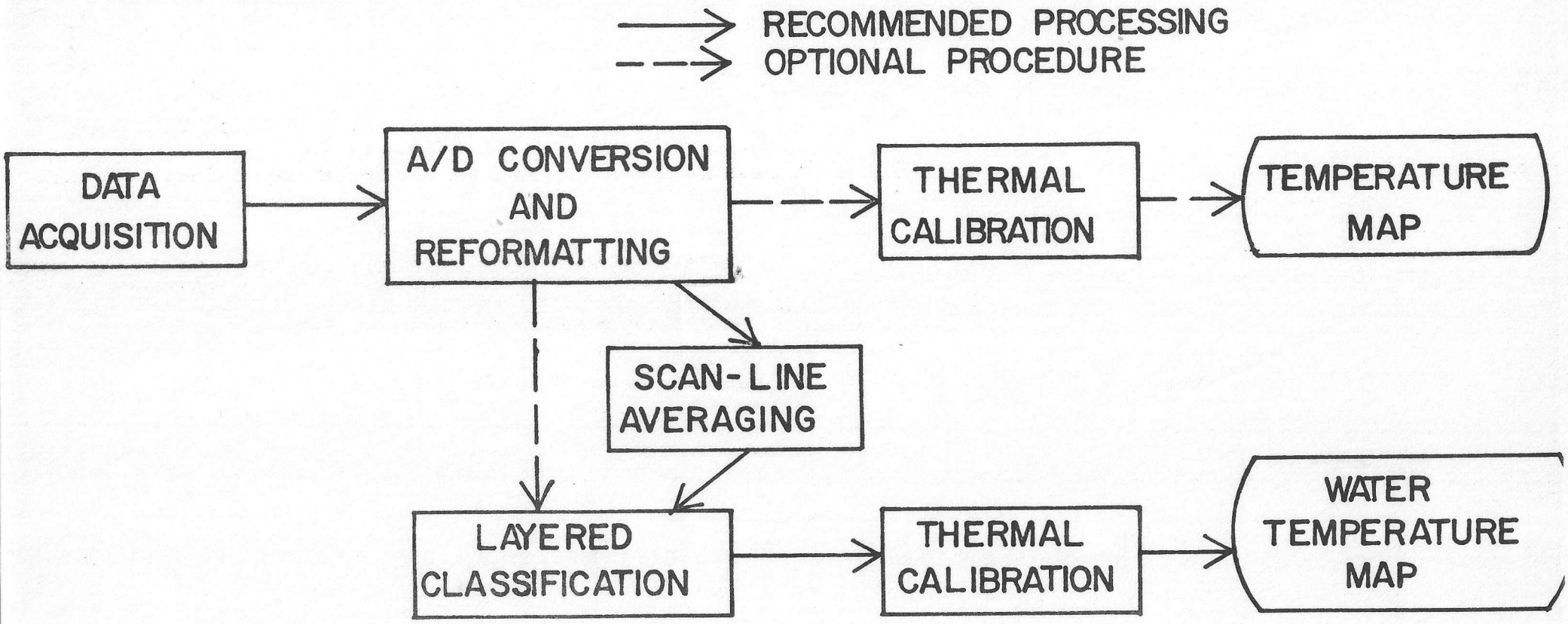
Status of Project

Figure 1 shows the procedural sequence of analysis for the effective application of remote sensing and computer-aided data processing techniques to thermal mapping of surface water for use on an operational basis.

Conclusions

This calibration techniques allow absolute temperatures to be determined directly from the scanner data, as no

Figure I. THERMAL MAPPING OF WATER BODIES FROM AIRCRAFT ALTITUDES



surface observations are necessary. In this way, water-temperature maps were produced with accuracies of $\pm$ 0.2°C from infrared scanner data collected at an altitude of 5000 feet (1500 meters). The influence of the atmosphere (flight altitude) was determined, and the results showed that radiant temperatures as measured through the 4.5-5.5 μm band are influenced to a greater extent than those measured through either the 9.3-11.7 or 8.0-13.5 μm bands. The "scan-line averaging" produced a pictorial amelioration of the thermal maps without affecting the accuracy of the radiant temperature measurements.

The utilization of the "Layered Classifier" proved to be of considerable help in the thermal mapping of water for those times of the year when radiant temperatures were the same as the temperature of the adjacent soils and vegetation.

Finally, the computer generated thermal maps produced in this manner were utilized by the Indiana State Board of Health, Division of Water Pollution Control to determine the coefficient of heat transfer from thermal effluents in the vicinity of Indianapolis.