THE ROLE OF MULTISPECTRAL SCANNERS AS DATA SOURCES
FOR EPA HYDROLOGIC MODELS
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by
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Models are used by scientists with the Environmental Protection Agency (EPA) as aids to understanding the complexities of natural phenomena, their interactions, and the impact of man's activities. As environmental controls become more expensive and the penalties of judgment errors become more severe, models as analytical tools must be increasingly efficient and accurate. Construction, execution, and improvement of any model requires large amounts of accurate data. Unfortunately, current modeling capabilities exceed most available data bases. For this reason, scientists are studying the potential of remote sensors to provide environmental data over large areas of the world. Environmental models, such as those used by EPA, are usually based on physical, chemical, and biological parameters. Although many parameters may be used as input, model response is largely determined by a small subset of key parameters which must be complete and quite accurate. Remote sensing must contribute to these key parameters efficiently and cost-effectively if it is to play an important role in environmental modeling.

Most modeling efforts in the EPA are carried out at the three Environmental Monitoring Systems Laboratories (EMSL) or at one of a number of smaller research laboratories across the country. All remote sensing is handled by either the Environmental Photographic Interpretation Center (EPIC) at Warrenton, Virginia, or at its parent laboratory, the EMSL at Las Vegas, Nevada. EPIC's main emphasis is photo acquisition and interpretation while multispectral scanner and satellite data interpretation as well as MSS research is at Las Vegas. EMSL-LV owns a Daedalus 1260 11-channel multispectral scanner. Thus most projects involving the acquisition of remotely sensed data for modeling have involved EMSL-LV. A few of these projects were for providing input data for a specific model, but most have resulted in the demonstration of the feasibility of obtaining parameters which could be used in modeling. Examples of such projects are as follows:

- A study by D. D. Frank and S. M. Lieu of Hydrocomp, Inc. (contracted by EPA) specifically compared data derived from Landsat with conventionally derived data as input into the model, Hydrological Simulation Program - FORTRAN (HSPF). HSPF was designed to simulate hydrologic and water quality processes in natural and man-made water systems. One set of water quality parameters was calculated from Landsat data using transformation functions that relate land use classes to pollutant loading rates and potency factors (number of pounds of pollutant per ton of sediment). Another set of parameters was derived using conventional field methods. Simulations were then run, and outputs from the two sets of data were compared. Output included hydrologic response such as overland flow, interflow, and baseflow, and water quality criteria: annual loading of sediment, biological oxygen demand, ammonia, and orthophosphates. The Landsat-derived data performed at least as well as the conventionally-derived data and had many advantages, not the least of which was an estimated cost savings of 30 to 50 percent.

- EMSL-LV derived and mapped water quality parameters at Flathead Lake, Montana, using the Daedalus 1260. Comparative water quality data were collected concurrently with the flight times. Best subset multiple linear regression analysis showed strong correspondences between the MSS values and the conventionally-derived values. Quantitative, digital maps of surface temperature, total phosphorus, nitrate nitrogen, total suspended solids, and transparency were then produced for the entire lake by parallelepiped classification of regression transformed MSS data. These maps will be used to characterize the distribution of turbidity plumes within Flathead Lake and to predict the effect of increasing urbanization in the Flathead River basin on the lake's trophic state.

- EMSL-LV is currently working together with EPA researchers in Corvallis, Oregon, to evaluate the effects of acid rain in the Adirondacks. MSS data are being studied as a possible source of parameters needed to model the buffering capability of lakes. Among water quality parameters and relationships being evaluated are runoff, pH, transparency, total suspended solids, and phytoplankton. Overflights using the Daedalus 1260 have been made and preliminary results appear promising. A report is expected to be released next spring.

- An extensive four-phase study using Landsat data was done on Lake Champlain, Vermont. Phase I addressed classification of Landsat MSS data for classification of water quality parameters including chlorophyll a. Phase II extended the classification of those parameters to other lakes in the state. Phase III used the Daedalus MSS to produce digital images describing classification of aquatic vegetation in lower Lake Champlain and adjacent land cover types. Phase IV, being undertaken by the University of Vermont, is examining the rest of the water quality in the rest of the state's lakes using a multidate approach.

- A combination of Landsat MSS data and contact-sensed data along with multivariate statistical techniques were used to successfully classify the trophic status of 145 lakes in Illinois. Five trophic indicators (chlorophyll a, inverse of Secchi depth, total phosphorus, conductivity, and total organic nitrogen) were transforemd into two multivariate indices. These indices, as dependent variables, and the four Landsat bands, as independent variables, were utilized in regression models to cluster the lakes into trophic rankings.

- Appalachicola Bay is one of Florida's greatest shellfishing areas. Problems with shellfish contamination and toxicity from non-point source runoff keep reoccurring during the past several years. Water quality sampling using a standard grid pattern was very labor intensive and required extensive interpretation. Dr. Jack Hill, now with Louisiana State University, when studying the runoff and flow patterns within the Bay using Landsat data, concluded that the sampling sites could be more efficiently located. When sampling sites were relocated according to flow patterns, suspected contaminants and the effects of runoff from clearcutting were more precisely located. This type of approach, keyed into water quality models, and limited ground-truth sampling could prove very useful for environmental assessments of complex estuaries.

These projects are just some examples of how MSS data have or could meet hydrologic modeling input needs. Remote sensing is also being studied as a promising tool in related areas such as the detection of leachate from landfills, algae blooms, septic tank failures, wetlands clearing and drainage, identification of acids from bases stored in barrels using thermal sensors, and identification of organic carbons and chlorophyll a using a laser fluoresensor.

To advance the use of remote sensing, EPA should encourage the use of current technology for water quality studies by establishing or accepting standards that relate water quality parameters to remotely sensed data. Since this has not been done, the states have been reluctant to use remote sensing because they were uncertain EPA would accept the data as valid. Under the present Administration, however, the states are encouraged to develop and implement their own unique programs including water quality standards. If remote monitoring can meet the state's criteria, then that state can now decide for itself whether or not remote sensing is a sensible, economical approach.

Application of remote sensing would be helped by a greater awareness of its capabilities on the part of EPA and the state pollution control programs. They need to be educated as to its potential as a tool for water quality planning, and as a tool is how it should be presented -- not as a panacea. Remote sensing can best be used as an extension of field sampling by using regression models -- not as a replacement for field sampling.

Several remote sensing research projects could potentially serve as "sparkplugs" for stimulating greater remote sensing application in EPA, but the Agency has very limited resources for additional projects at this time. The only program receiving increased funds is hazardous waste.

Research projects that would be useful are:

- Establishing a unified data base by taking already established techniques and conducting corresponding studies in different physiographic regions of the country. A lack of standardization in present studies prevents EPA from knowing what MSS channels and what hydrologic parameters can be expected to be useful in different regions. Techniques for dealing with regional variations need to be developed.

- Identification of optimum scanners for identification of hydrologic parameters over various parts of the country. This information should be taken in consideration in planning for future satellites.

- Scanner missions could be included aboard the space shuttle. Vast amounts of hydrologic data using different sensors could be collected and then studied to determine the optimum.

- Data for time series models could be provided by continuous monitoring from satellites in synchronous orbit. Perhaps the system could be programmed to flag water quality anomalies.

- Multidate studies would greatly benefit if atmospheric calibration was improved. Atmospheric calibration is perhaps one of the greatest problems encountered in doing any type of multidate study.

- Refinement of land cover classification would enhance the use of satellite-derived information. For example, pesticide pollution is an area of major concern. Since pesticides are often very organism specific, refinement of agricultural classification (crop type, for example) has significant potential in modeling risk analyses for evaluating pesticides in a given area.

- Another possible study would be to consider the effects of accuracy gains in the estimation of basic watershed characteristics. Just how sensitive are water quality parameters to changes in watershed characteristics? For example, how does a change in land use in the basin affect the dissolved oxygen?

- How accurate must hydrologic parameters be? If the sensitivities of hydrologic parameters were known, remote sensing could be more accurately evaluated as a tool.

Multispectral scanners have provided parametric data that either have been or can be used in environmental models, but their full potential is far from being recognized. The future of MSS as a tool lies in researchers' ability to instill an awareness of its capabilities to those people who work in the realms of practical application. To do so, MSS data must be readily available, cost-effective, and have an established accuracy level.