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DIGITAL ANALYSIS OF POTOMAC RIVER BASIN ERTS IMAGERY: SEDIMENTATION LEVELS AT THE POTOMAC-ANACOSTIA CONFLUENCE AND STRIP MINING IN ALLEGHENY COUNTY, MARYLAND

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ABSTRACT

Two simple algorithms for classification of sedimentation levels in water and for delineation of active strip mines are in use as part of the development of a more general resource management information system. ERTS MSS CCT's are processed so that each pixel in each channel is geographically referenced and can be accessed individually during whole frame, multi-channel analysis or partial frame analysis.

The sedimentation analysis clearly separates classes representing the turbid Anacostia water, the less disturbed Potomac (really), and mud flats resulting from effluent of a major sewage treatment plant. Mud flats of organic or mineral origin are easily distinguished. Several classes of sedimentation are easily constructed.

Strip mines are classified as bright arcuate objects with unique reflectance and geometrical properties. In our imagery of Allegheny County, Maryland, the mines occur in rural areas where open fields are on the dissected Allegheny plateau, forests are more generally in stream channels below. The mines are cut into the horizontal contour of the valley slopes and are easily distinguished from their surroundings. Some field observations have been made, but we are not sure all mines were classified as such.

Introduction

The Earth Resources Technology Satellite offers a unique opportunity for synoptic observation of hydrological, geological and vegetational resources as they interreact within a region, such as the Potomac River Basin. This river basin, more than many others, is characterized by variation: variation in physiography which occurs as the river flows

from the Allegheny Plateau through the Ridge and Valley Province, the Blue Ridge Mountains, the Piedmont Plateau, and finally through the Coastal Plain into Chesapeake Bay; variation in underlying geological structure, soil type and depth, and with consequent variation in land-use, and vegetational cover; variation in climate, as illustrated by the variation in rainfall, in which the Allegheny Plateau receives more than 70 inches of rainfall annually, while the adjacent Ridge and Valley Province receives less than 40; in which the Coastal Plain is subject to heavy tropical storms as well as unpredictable thunder showers, delivering inches of rainfall in an hour. The great variation in intensity of rain across the basin coupled with the variation in soil structure and bedrock geology means that optimum development of the Basin's resources must be based on maximum understanding of the interactions of geological, vegetation, hydrological and climatic interactions occurring within the Basin if extensive damage to the environment in terms of water pollution, loss of top-soil, and sediment deposit build-up in the river channel are to be prevented. Thus, development of a data-bank based on the data from repetitive satellite coverage is imperative.

As part of the development of a data-resource bank for determining such interactions we have employed both analog multi-band imagery and digital data obtained from ERTS-A. We have developed computer analytic techniques to quantitatively evaluate changes occurring in the river in such factors as the sedimentation and organic pollution levels.

The procedure used here is one that does not require a large or dedicated computer or more than one tape drive. While the procedure is quite simple, the results appear to correlate quite well with the qualitative observations which can be made by analysis of the imagery in photographic form.

Results

The analytical technique which we have used is basically a three-step approach. The first step is to perform geographical referencing for the entire data set. This is done using a pattern-recognition technique with band 7 of the ERTS bulk-data on Computer Compatible tapes. The low reflectance of water in band seven is used to locate water features of known geographical co-ordinates. The difference between the apparent location derived from the header record on the CCT and the actual location is applied as a correction in deriving a referenced data set. The error for an individual pixel is less than 250 meters. Geographically referenced data sets have been created for several dates for the Potomac River at the Anacostia confluence and for strip mine regions in the Allegheny Plateau.

Preliminary results of the analysis of the region at the Anacostia Potomac confluence illustrate the second step of our analytical technique, multi-channel density-slicing employed in analysis of change detection. Since change detection is the significant result to be obtained from repetitive coverage by ERTS, changes in extent or presence of various classes or reflectance levels were sought rather than an absolute correlation with ground-truth quantitative sediment or organic pollution levels. A computer printer-plot map of the region for two dates in which each 50 X 80 m pixel is displayed as a printed value was generated from the geographically referenced data set at a scale of 1:20,000. The printed values correspond to nine levels of reflectance, five corresponding to a general increase in reflectance in a color composite relative to Chesapeake Bay, and three to a decrease. Values for normal reflectance level of sea, bay or unpolluted river water are in the range shown as N (normal). The algorithm used to generate these levels was derived simply by combining reflectance levels from the data tape by multiplication and assigning the product to previously determined density levels and using the density slicing techniques described.

Most of the sedimentation in the Potomac Estuary on 23 September (Fig. 1) was found either in the Anacostia River channel or down stream below the Occoquan Creek. Low values in the region below Roosevelt Island are associated with local sewage outfalls. In fact, we seem to be able to find most of the major sewage effluent sources using this analysis. Very high values of sedimentation are found in the Anacostia. These are associated with two major sources of sediment: a sand and gravel operation and run-off from open surfaces associated with construction of roads and buildings.

On 11 October, we, and of course everyone, found a very different pattern. Run-off from a heavy rainfall had carried sediment into the Potomac from West Virginia eastward. Figure 2 shows that a much different distribution of sediment is found, being heavy in the Washington area and including the region around Roosevelt Island. While levels near the previously mentioned outfall are modified by effluent, so much mineral sediment has been carried in that the outfall is obscured. The highest values are again found in the mudflats of the Blue Plains sewage plant near Wilson bridge. The mud-flat is organic, not mineral and therefore the reflectance values are very low in all channels.

A similar algorithm (addition of all four channels with subsequent density-slicing) has been developed for detection of strip-mines in the Allegheny Plateau. Normalization for this region is performed by determining the maximum, minimum and range of values over the area under investigation for each date, then using these ranges in determining the range corresponding to the composite reflectance of the strip mines.

In summary, the digital techniques developed for identification of sedimentation levels are adaptable to large or small computer installations. The results show that we can classify sedimentation levels and that it should be possible to correlate levels found in analysis with particulate levels measured in the field. In addition, organic effluents which do not contain chlorophyll were also observable, making possible the identification and monitoring of sewage and other organic inputs into riverine waters.

'1062-1519000' '23SEP72' ' SUN EL44 AZ143
 33 'DEG' 53 'MIN 15 IN ROY' 1020
 70 'DEG' 58 'MIN 15 IN COLUMN NUMBER' 405
 'HSS BAND FOR DATA IS' 4 X 5 X 6

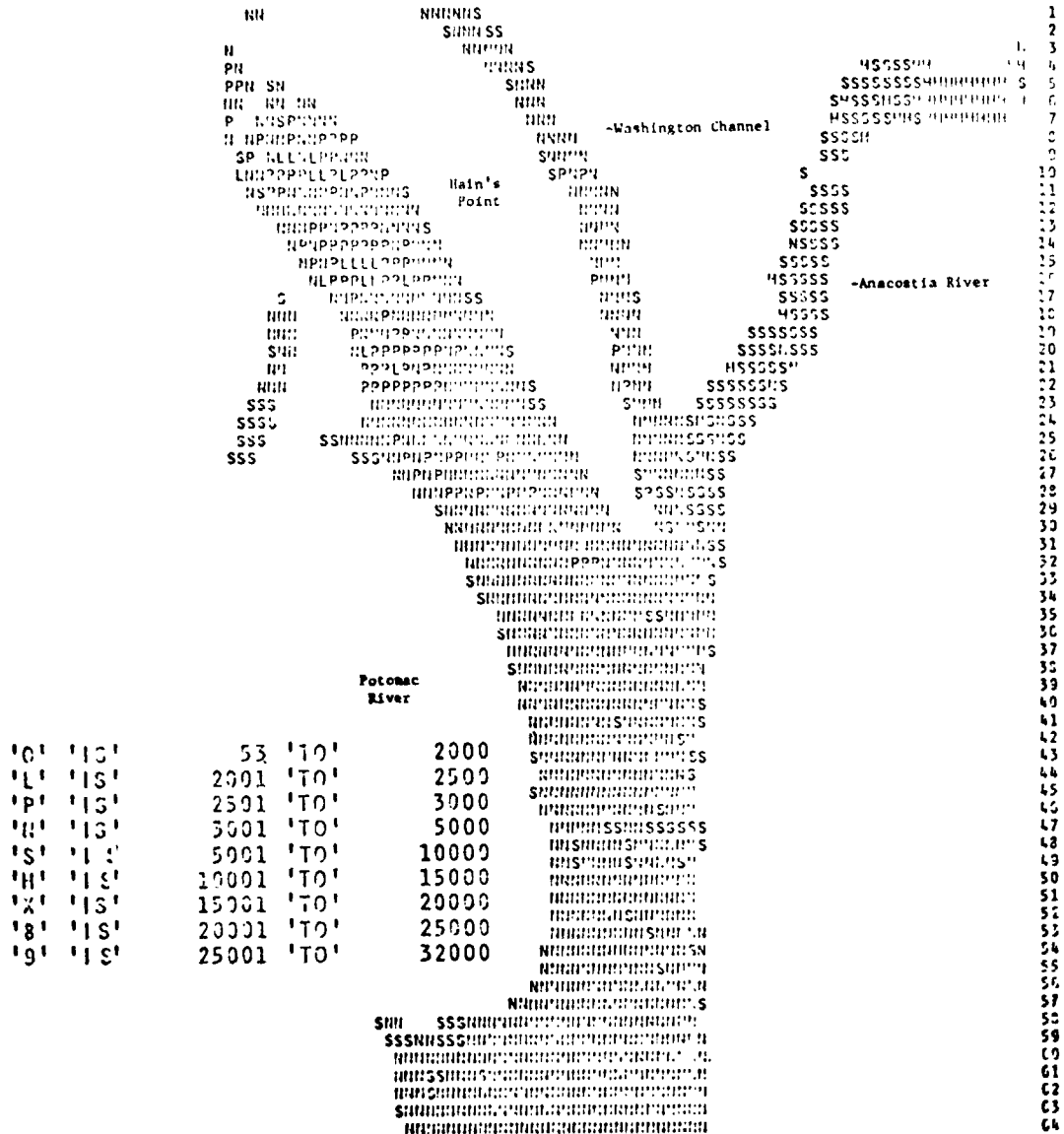


Figure 1 Digital Display of Sedimentation 23 Sep 72

'1030-1519201' '110 T72' ' SUN EL35 A2140 '
 30 'DEG' 53 'MIN IS IN RO.' 11/0
 70 'DEG' 58 'MIN IS IN COLUMN NUMBER' 435
 'MGS RWD FOR DATA IS' 4 X 5 X 0



Figure 2 Digital Display of Sedimentation 10 Oct 72