LANDSAT DIGITAL DATA PROCESSING

A NEAR REAL-TIME APPLICATION

by

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ABSTRACT

An application of rapid generation of classed digital images from LANDSAT-1 was demonstrated and its feasibility evaluated by NASA in conjunction with the Environmental Protection Agency (EPA), Texas A & M University (TAMU), and the Cousteau Society. The primary purpose was to show that satellite data could be processed and transmitted to the Calypso, which was used as a research vessel, in time for use in directing it to specific locations of possible plankton upwellings, sediment, or other anomalies in the coastal water areas along the Gulf of Mexico. This was a feasibility study.

INTRODUCTION

The Calypso cruise proceeded from Key West, Florida on 8 November, 1974 to Panama City, Florida on 21 November (Figure 1). The generally east to west location of the early test sites (Figure 1, sites I-IV) provided an opportunity for sequential satellite overpasses of the test sites. The dates chosen for examination of the test sites allowed time for processing and transmitting the LANDSAT data to the ship prior to its arrival at the test site.

Of the four LANDSAT-1 images of the test areas, two were sufficiently devoid of clouds to merit further consideration: Panama City, Florida and Timbalier Bay, Louisiana (Figure 1, Test Sites III and IV). Of these two scenes, examination was particularly concentrated upon Timbalier Bay, which showed sediment-laden waters streaming from the Crowfoot Delta of the Mississippi River and dispersing in the Gulf of Mexico. In this paper, this area will be referred to as the "Mississippi Plume".

On board the Calypso for the cruise were five TAMU scientists and a representative from the Goddard Space Flight Center. NASA's first objective was to obtain ground truth data for aircraft overflights of the Coastal Zone Color Scanner (CZCS). The aircraft version of the CZCS is similar to the instrument to be flown on Nimbus-G in 1978. Both the Nimbus-G and aircraft CZCS are designed to image the sea surface in narrow spectral bands of reflectance and radiance. Secondarily, NASA desired to explore the possible applications of rapid analysis of LANDSAT data for marine coastal studies. This paper relates to the second objective. In order to proceed, NASA and EPA contracted with TAMU for the study. They, in turn, subcontracted "Calypso" as a research vessel from which to conduct oceanographic sampling.

Calypso, a converted World War II minesweeper, provided continuous sampling of sea water. Water samples collected by Calypso were analyzed for physical, chemical, and biological properties later in the TAMU laboratory.

This paper discusses the manner in which LANDSAT images were obtained, processed, and transmitted to the Calypso within three days, as well as the image interpretation and surface truth sampling programs. The feasibility of analyzing LANDSAT images in a matter of hours was demonstrated. Some usefulness of the analysis in aiding decision-making processes on a research vessel was indicated. This demonstration was made possible by a unique opportunity to use some facilities on a one-time basis for feasibility purposes only.

NEAR REAL-TIME DATA PROCESSING

The LANDSAT images used in this study were received at the GSFC tracking station. The wide-band video station tapes were processed within hours into computer compatible tapes (CCT's) by the NASA Data Processing Facility. Images on the digital CCT's were analyzed on a General Electric Image 100 interactive color TV display system. The objective of the analysis was to identify various types of water and prepare an output which could be rapidly transmitted to the Calypso.

The first cloud-free image was LANDSAT 1840-15325 (10 November, 1974). Water areas with homogeneous reflectance were identified on the color TV and used as training sites for supervised classification using all four bands (Figure 2A). In the product which was prepared for transmission, shown in Figure 2B, only one of the water classes was printed on the Gould printer-plotter. This product illustrated the boundaries between land and water, water of higher and lower reflectance, and water and clouds. The transmitted image represented about 10% of the 185 Km by 185 Km area of the original image. Individual pixels were subsampled every other line and every other column. Two types of water were identified: the highly reflective water apparently coming from the Apalachicola River into Saint George Sound and the less reflective water in the Gulf of Mexico.

The second cloud-free image was obtained on 13 November, 1974 (1843-15502). It was also processed on the Image 100 (Figure 3A). In this case the transmitted product (Figure 3B) was a full 185 Km by 185 Km LANDSAT image, subsampled every sixth column and every fifth line. Several water boundaries are visible in the monochromatic printout of the classification, with two types of water arbitrarily labeled "old silt" and "new silt". In a later processing of this image it was shown that supervised training and unsupervised level slicing of band 5 gave similar spatial distributions of water types in the Mississippi Plume area.

CLASSED IMAGE RECEPTION ON CALYPSO, AND INTERPRETATION

The monochromatic printout from the Gould Printer-Plotter was used for transmission from GSFC via slow scan facsimile over a VHF relay on the ATS-3 satellite to a synchronized facsimile recorder on board the Calypso (Figure 4). The received product showed little degradation when later compared to the original.

The classed LANDSAT image of the Panama City, Florida area was received on board the Calypso 12 November, 1974 (Figure 2B). Ground truth investigations by Calypso indicated that the highly reflective water of Saint George Sound was sediment-laden, as labeled in the image. The "air pollution plume" crossing Saint Joseph Bay was later identified as smoke from a paper mill.

The classed LANDSAT image of the Mississippi Plume area was received by Calypso on November 16, 1974 (Figure 3B). The images were on two pages and were joined together to give an overview of the Timbalier Bay and the Southwest Pass area of the Mississippi River. Later observations of the "old and new silt", made from a helicopter, suggest that the area labeled "new silt" was probably a highly concentrated area of sediments and silt and that the area labeled "old silt" was probably still part of the plume but an area of much finer siltation. From the patterns observed in Figure 3B, an initial sampling of the Mississippi Plume by Calypso was conducted on 17 November. Three stations (Figure 5, Stations V-A, V-B, V-C) were sampled, crossing the plume near the mouth of Southwest Pass. The boxed area located south of Timbalier Bay was labeled sediment, but it may have been some other material. An expanded alphanumeric printout of the boxed area was also transmitted to Calypso. Water was qualitatively broken down into various categories such as clean water, mixed water, and sediments.

The rapid analysis of the LANDSAT images enhanced the scientific program on board the Calypso. One of the major goals was to cross as many different boundary areas between as many water masses as possible. It was necessary to find these different areas in order to test the detection ability of the on-board equipment. It was shown that the more concentrated waters of the plume came directly from the Southwest Pass of the Mississippi River in a southerly direction, but turned in a more easterly direction once it came under the influence of the Gulf Stream currents. Most of these boundaries between the various plume waters were easily detected from the LANDSAT image.

INSTRUMENTATION AND PROCEDURES-CALYPSO

Oceanographic instruments and sampling procedures used on board Calypso primarily provided surface truth to aircraft overflights of the Coastal Zone Color Scanner. These instruments and sampling procedures were also instituted to study the interesting water detail shown in the classed LANDSAT image of the Mississippi Plume. Three separate studies of the plume evolved from analysis of the image. One study, on 17 November, sampled across the mouth of Southwest Pass. More detailed Calypso studies late in November and early in December sampled Stations 1 through 24 shown in Figure 5.

The following equipment, used during the entire cruise, sampled or measured the parameters of the classes of water in and around the plume: Secchi discs, bucket thermometers, precision radiation thermometer (radiometer), fluorometer, transmissometer, and scattering meter.

In addition, water samples were taken at the surface and at depths of up to 100 meters; these samples were bottled and filtered, and returned to TAMU for analysis. Zodiacs - powered rubber rafts launched from Calypso - also gathered water samples, as well as Secchi disc and bucket thermometer readings. Zodiacs sampled at one mile intervals to a distance of up to four miles at right angles to Calypso's heading.

Installed on Calypso were two satellite terminals. A direct readout meteorological satellite station received infrared and visible data from NOAA's 3 and 4. These data were used to determine weather conditions over the test areas. A VHF communications terminal provided a vital link through the ATS-3 communications satellite for coordination of experiments and for data transmission. During the data period, communications were maintained with Calypso, TAMU, and Goddard. In addition to the critical function of coordinating Calypso's position and operational readiness, LANDSAT quick-look data were transmitted via ATS-3 to Calypso for analysis and evaluation.

Since satellite overpasses preceded the water sampling by at least two days, no attempt was made to correlate the water quality parameters with LANDSAT reflectances. Sampling equipment and procedures used on this Calypso cruise should, however, provide a useful method for providing surface truth to support analysis of high resolution satellite images, if performed on a timely basis and in coordination with the satellite overpass.

CONCLUSIONS

The feasibility of near real-time monitoring of dynamic off-shore conditions from LANDSAT has been demonstrated. LANDSAT data were received at Goddard Space Flight Center. Computer Compatible Tapes produced from the original wide band video tapes were analyzed, classified on an interactive computer system, and monochromatic prints facsimiled via the ATS-3 satellite to the Calypso, located approximately 25 kilometers offshore. This process was completed in 20 hours for one site and less than three days for the other sites. Of the four LANDSAT-1 images examined, two were cloud-free. Large areas of silt and sediment were identified off the coasts of Florida and Louisiana. The monochromatic images received by Calypso are illustrative; in the future, classed images should include geographic gridding.

The rapid analysis of the LANDSAT images proved useful in helping the TAMU scientists determine the relative locations of different types of water while underway at sea, resulting in a more meaningful sampling program.

In the future, LANDSAT or some other satellite system could be used to guide research vessels to specific areas of interest. Although at present an extraordinary effort is needed on the part of NASA in order to provide this data quickly, it is hoped that future programs will include a near real-time capability for research platforms.

Cruise Track - (R/V) CALYPSO - NASA, Cruise
8th Nov. to 21st Nov., 1974

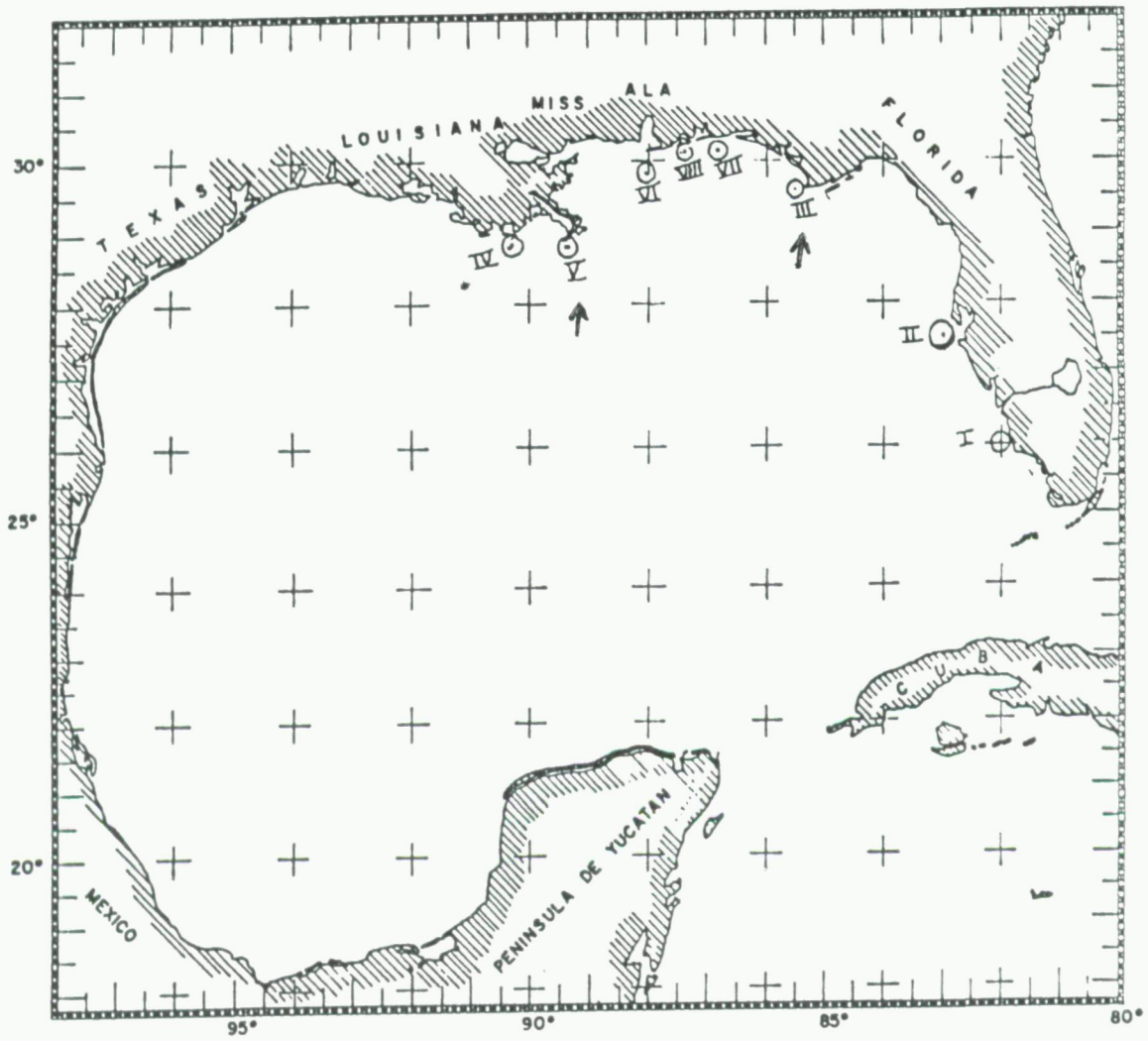

Figure 1 - Calypso Cruise Track

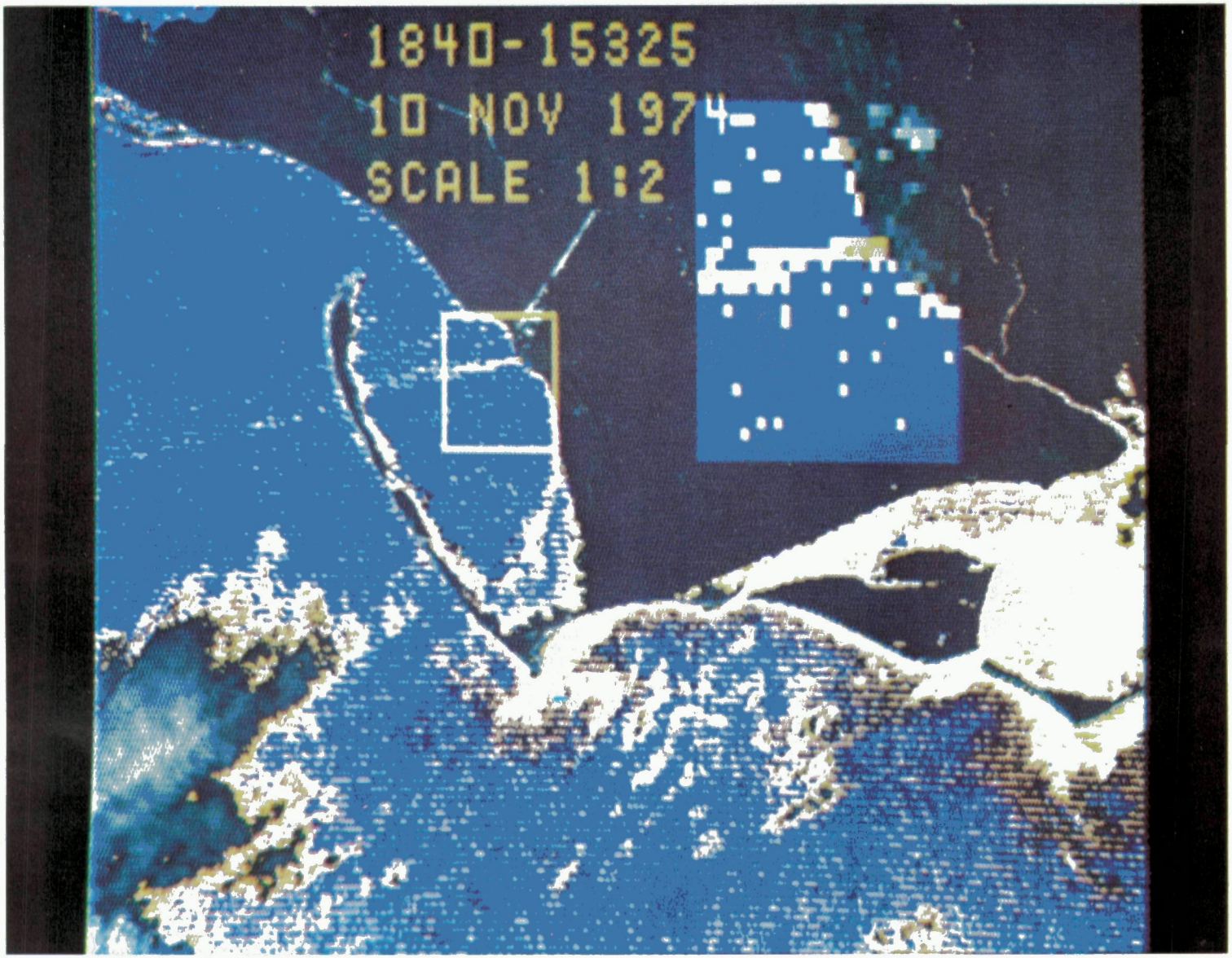

Figure 2A - Panama City Image -
Quick Look Display on an
Interactive Computer System

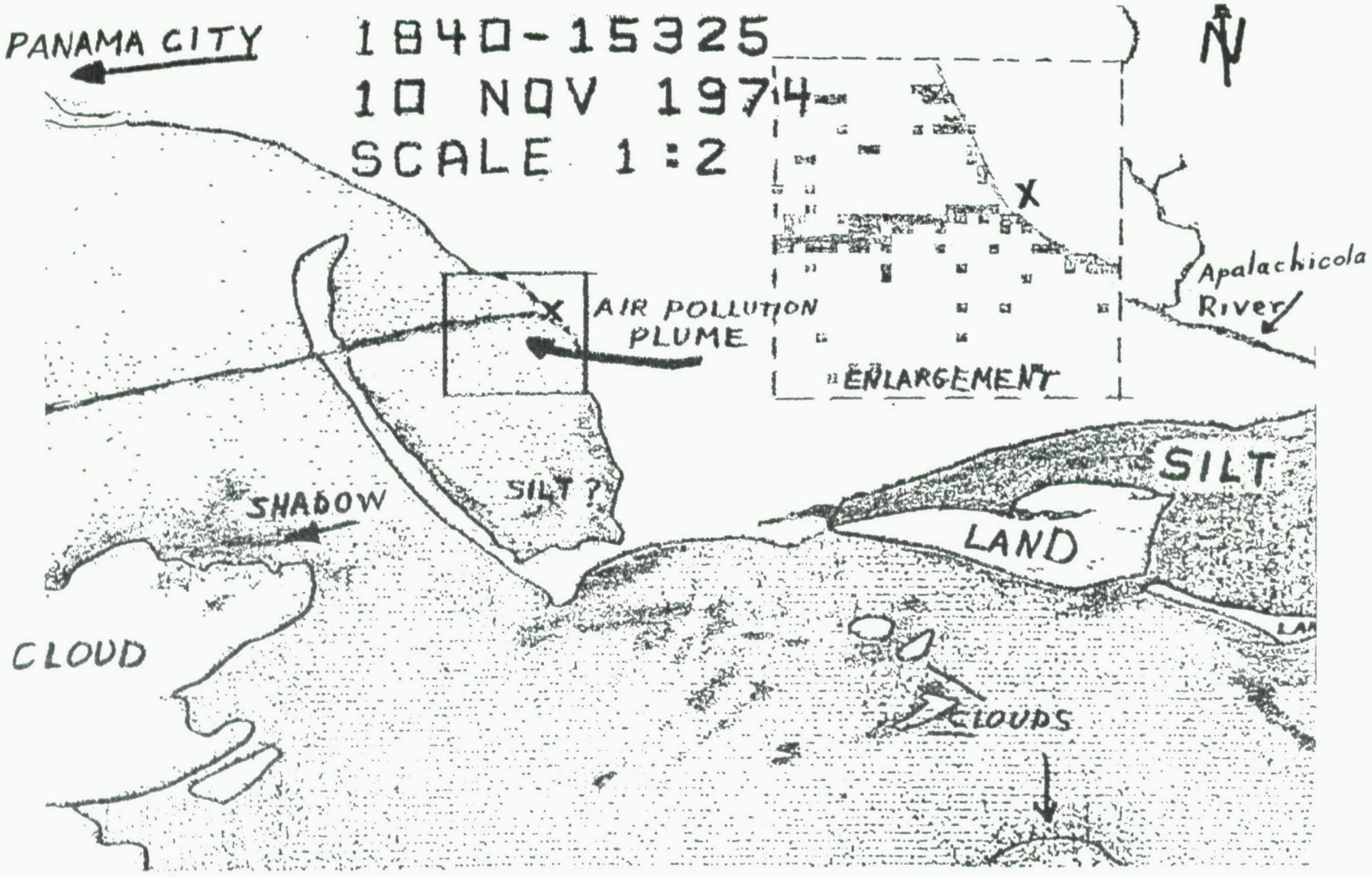

Figure 2B - Monochromatic Transmission Product - Saint Joseph Bay Part of Panama City Image with One Water Class

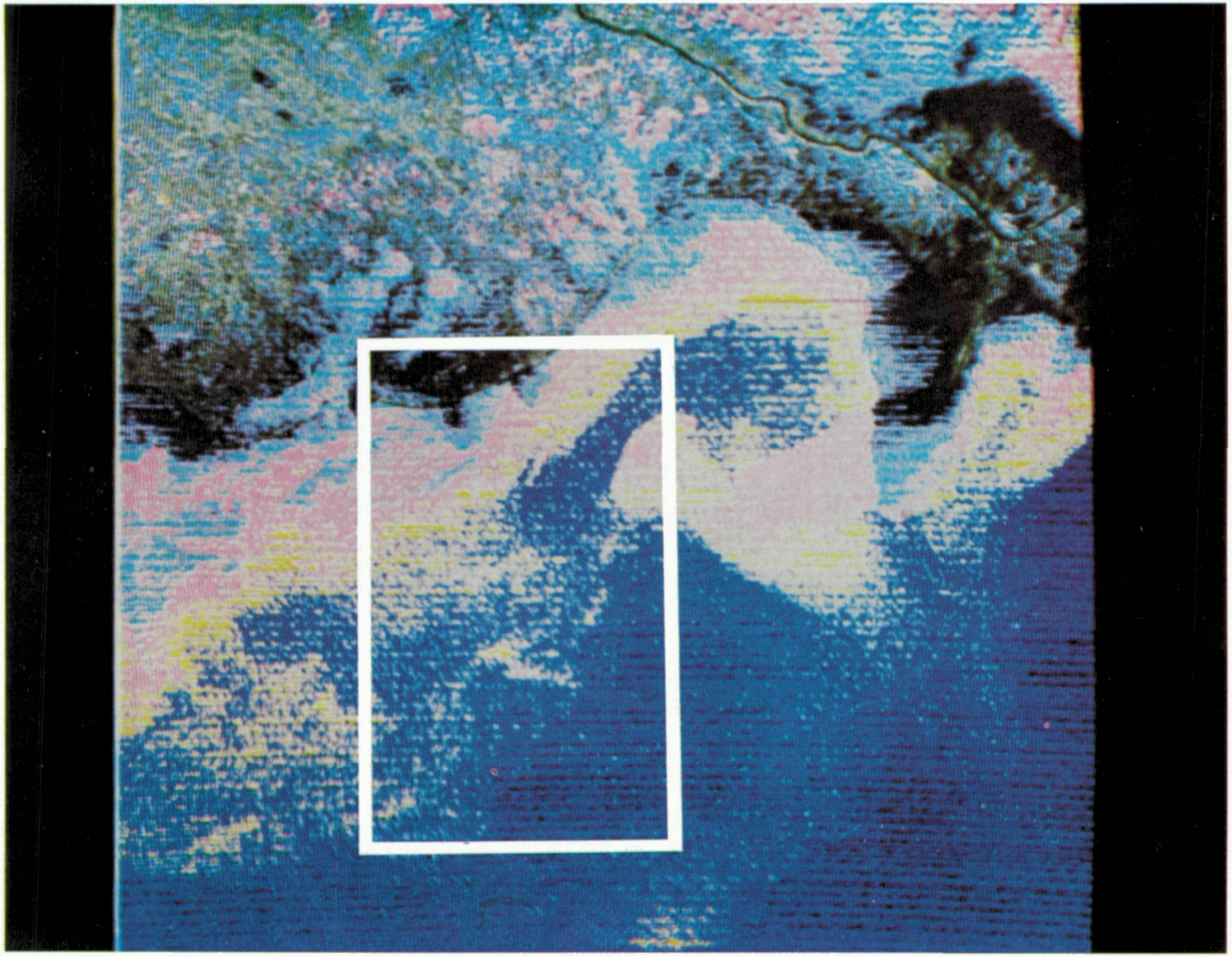

Figure 3A - Mississippi Plume Image -
Quick Look Display on an
Interactive Computer System

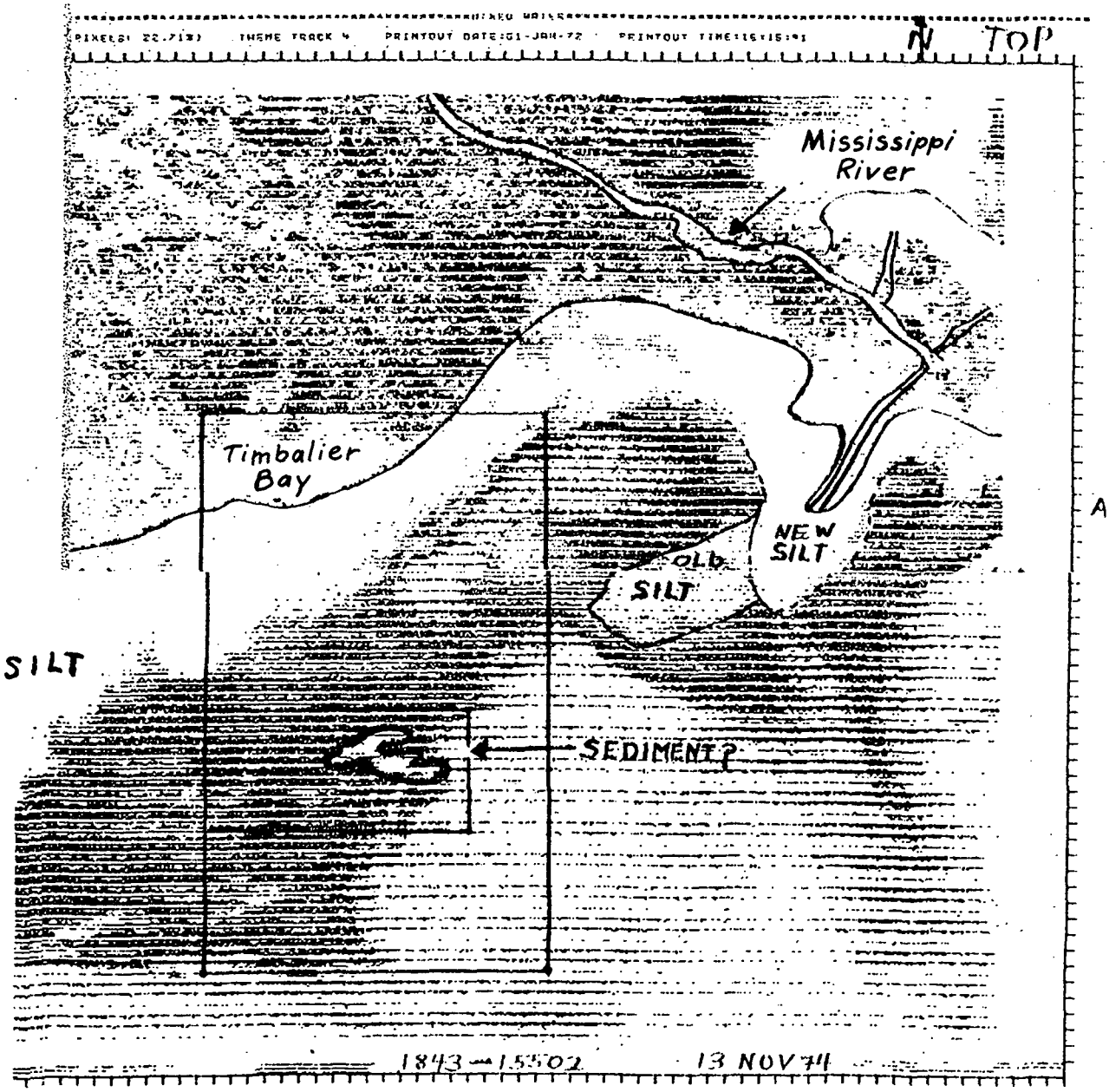

Figure 3B - Monochromatic Transmission Product - Mississippi Plume Image

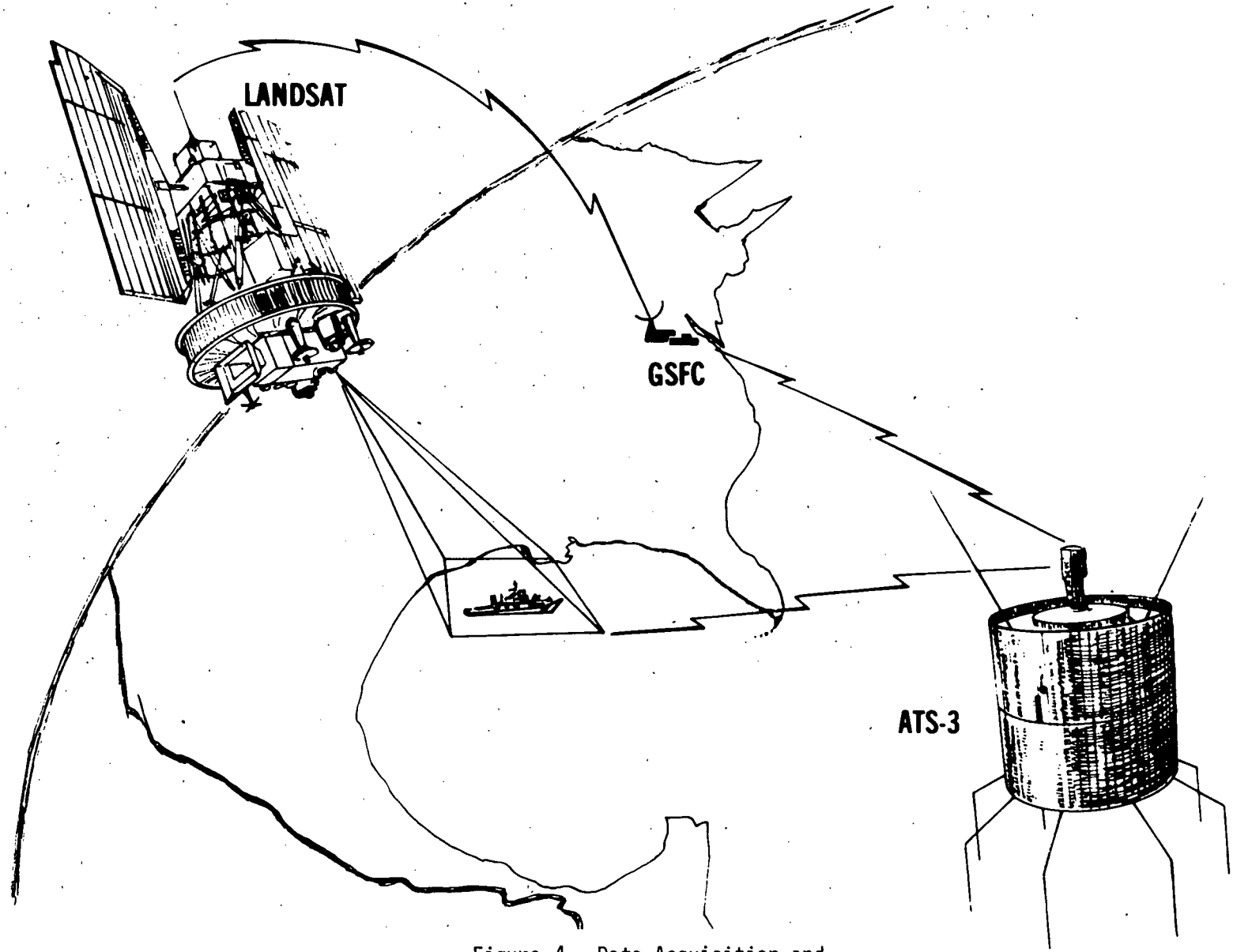

Figure 4 - Data Acquisition and Communications Network

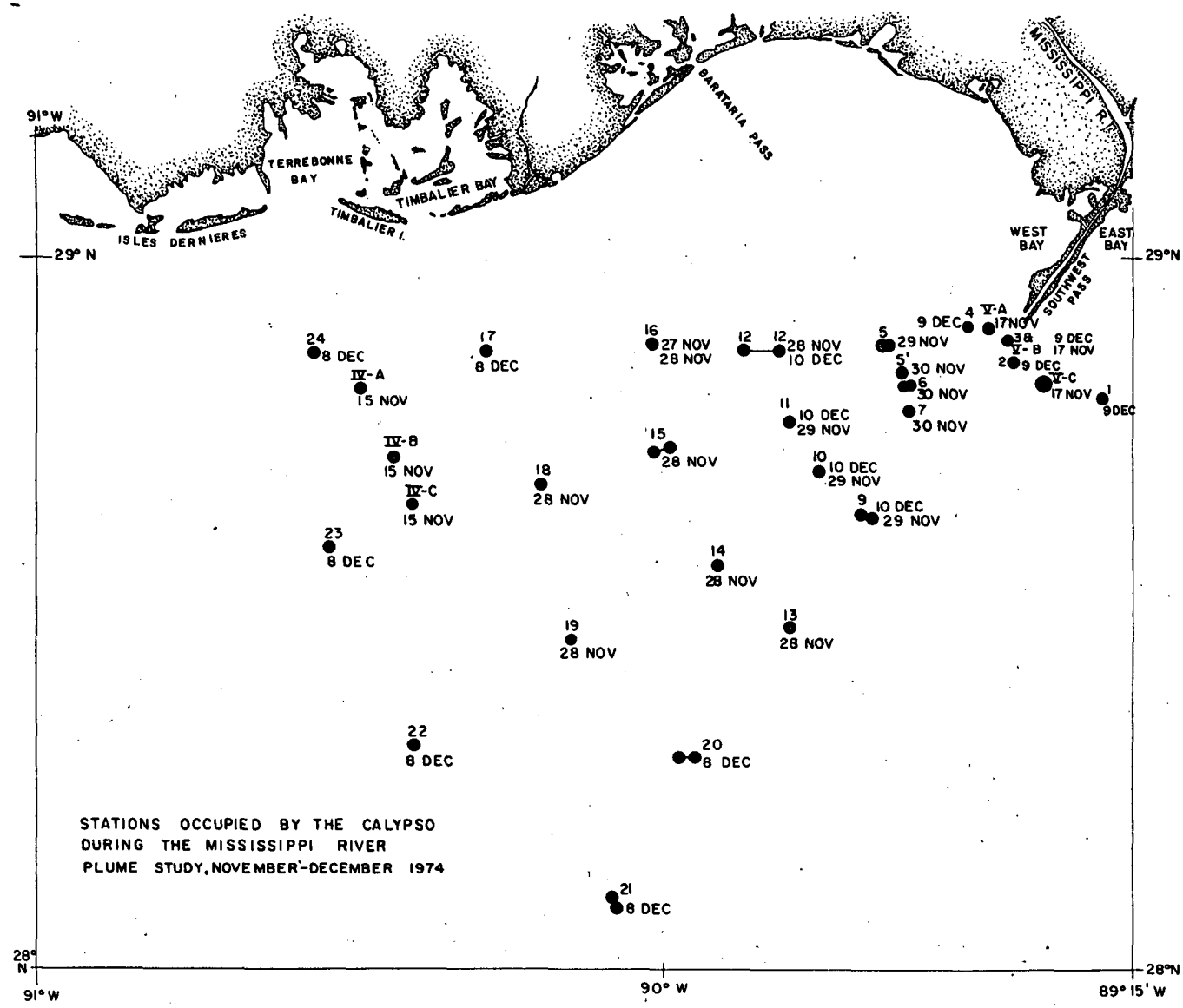

Figure 5 - Stations in Mississippi Plume