

North American Topography

EROS DATA CENTER

ANNUAL REPORT

FISCAL YEAR 1991

**U.S. GEOLOGICAL SURVEY
NATIONAL MAPPING DIVISION**

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FOREWORD

Events of this past year have produced significant changes in our world. We have witnessed conflict in the Middle East followed by the torching of the Kuwait oil fields and the devastation to the surrounding environment. We saw the eruption of Mt Pinetubo in the Philippines and its extensive impact upon the land and the people of that country. The cessation of the Cold War has opened avenues for economic and technological opportunities with Eastern Europe and the Soviet Union, as well as for new initiatives to address environmental issues of global proportions associated with that part of the world. Growing concern regarding the depletion of the polar ozone layer, deforestation of the major forests of the world, contamination of lakes and rivers due to acid rain, and other events present new opportunities and challenges for Earth scientists attempting to respond to the increased need for information about the environment. The EROS Data Center, as a data management and research field center of the U.S. Geological Survey's National Mapping Division, is proud to have contributed its resources in responding to the technical and information needs surrounding these and other important environmental issues.

From its inception in 1971, the EROS Data Center has maintained a commitment to provide remotely sensed land-surface data and technical assistance of the highest quality to national and international organizations involved in land management and environmental assessment activities. In keeping with this commitment, the Data Center responded to requests from the Department of Defense and U.S. Government intelligence agencies by supplying digitally processed and enhanced satellite images in support Operation Desert Shield/Storm. Similarly, satellite images were provided for areas in South America as part of the Nation's counter-narcotics program and the War on Drugs. The EROS Data Center provided technical support to the United States Agency for International Development (USAID) to help develop the Famine and Early Warning System (FEWS) for participating countries in the Sahel region of Africa. The Center also provided near real-time satellite data of areas in the conterminous U.S. and in Alaska to several Federal land management and regulatory agencies.

New research initiatives conducted by the EROS Data Center in support of the U.S. Global Change Research Program will significantly impact the future role of the Center and its ability to meet the growing data and information needs of the scientific community. These initiatives include (1) active participation in the National Mapping Division's land characterization research effort, a program designed to improve our understanding of the spatial distribution of terrestrial conditions and processes; (2) development of an operational prototype of the Global Land Information System that allows interactive inquiry, browse, and ordering capability to components of the National Satellite Land Remote Sensing Data Archive and to other selected global Earth science data sets; (3) development of a time series Advanced Very High Resolution Radiometer (AVHRR) data set of North America, completed this year as a joint effort with the Canada Centre for Remote Sensing to demonstrate international cooperation in the development of consistent satellite-acquired data sets for global change research; and (4) research in support of the joint National Aeronautics and Space Administration's Earth Observing System Data and Information System (EosDIS), to prepare for receiving data from the first in a series of polar orbiting satellites to be launched in the late 1990's.

To support these and several other major activities, the Center's team of skilled scientists, technicians, and clerical personnel worked diligently to maintain the EROS Data Center's high level of excellence in the areas of data management, product generation, computer systems development, and spatial data research as reflected in this report.

We are pleased to provide this annual report for Fiscal Year 1991 which summarizes the activities and accomplishments of the EROS Data Center.

Donald T. Lauer
Acting Chief, EROS Data Center

On the Cover: This 10-km rendition of North American topography was produced at the U.S. Geological Survey's EROS Data Center with a Calcomp 5800 electrostatic plotter. The terrain shading and color-coded elevation increments were generated from ETOPO5, the National Oceanic and Atmospheric Administration's raster global elevation data set with a five-minute resolution. The rivers, lakes and international boundaries were generated using the Central Intelligence Agency's World Data Bank II vector data set. The data is shown in a Lambert Azimuthal Equal Area projection.

I. OVERVIEW

The Earth Resources Observation Systems (EROS) Data Center, located in Sioux Falls, SD, is a data management, systems development, and research field center of the U.S. Geological Survey's National Mapping Division. The Center was established in the early 1970's to receive, process, and distribute data from National Aeronautics and Space Administration (NASA) experimental Landsat satellites. The Center holds the world's largest collection of space and aircraft acquired imagery of the Earth. These holdings include over 2 million images acquired from satellites and over 8 million aerial photographs. The Center is also a major focal point for information concerning the holdings of foreign Landsat ground reception stations and data acquired by other countries' Earth observing satellites.

The central U.S. location provides the Center with a unique capability to receive real-time electronic signals from Earth orbiting satellites used for developing data sets of most of the North American continent.

The EROS Data Center carries out a broad range of activities in the management of global Earth observations data, including the development and operation of advanced systems for receiving, processing, distributing, and applying land related Earth science, mapping, and other geographic data and information. These data support scientific studies, resource management, and environmental monitoring activities world-wide. The Center is a major supplier of analytical and other support services to Federal agencies involved in the application of these data to research programs.

To support the Data Center's mission, the facility houses one of the largest computer complexes in the Department of the Interior. In addition to computers to support scientific processing and analysis of data, over 100 locations in Federal, State, and commercial offices are linked to the Center for data inquiries. More than 60,000 inquiries and orders are received annually, resulting in the distribution of over 250,000 products to scientists and resource managers around the world.

The Center works closely with NASA, the National Oceanic and Atmospheric Administration (NOAA), Department of the Interior organizations, and other Federal agencies to develop advanced systems and techniques for applying Earth observations and other geographic information to Earth science problems.

The Center receives, processes, and carries out research on image data from the Advanced Very High Resolution Radiometers on polar orbiting meteorological satellites and from the U.S. Landsat satellites. The Center uses these data and data from French, Japanese, Soviet, other foreign satellite systems to produce high quality image maps for a wide variety of scientific uses.

The Center uses these data and other Earth-science information to support a broad range of studies designed to improve our understanding of the mechanisms and processes leading to global environmental change. To support this research, the Center combines a multidisciplinary scientific staff in geology, hydrology, cartography, geography, agronomy, soils science, forestry, meteorology and climatology with engineering expertise in systems development, telecommunications, and the computer sciences.

Center activities include operation of the National Satellite Land Remote Sensing Data Archive, a legislatively mandated responsibility to maintain a high quality data base of space acquired images of the earth suitable for use in future study of global change and related scientific programs, and the Federal Land Remote Sensing Research Program. This Program allows Federal agencies, universities, and other organizations to assign scientists and researchers to the Center on a full-time basis with complete access to analytical equipment, data, and research facilities of the Center.

Facilities at EROS include advanced data and information analysis laboratories, production data processing systems and digitizing capabilities, business and scientific systems, software development, geographic information systems development and implementation, and on-line computerized access to data directory, catalog, and inventory information about the Center holdings and the land data holdings of other facilities.

As a major participant in the U.S. Global Change Research Program, EROS provides data to scientists from around the world to improve understanding and ability to predict future change. The Center is also a key participant in NASA's "Mission to Planet Earth" and plans to process and archive land related data from the NASA Earth Observing System polar platforms and sensors aboard the NASA Space Station in the mid-1990's.

The EROS Data Center operates field offices in Alaska and in North Africa to support resource and environmental studies in those regions.

II. RESEARCH AND DEVELOPMENT

Global Land Data Management and Research

Landsat Data Conversion and Archive Maintenance

Preservation of Landsat data as a national resource remains a high priority, requiring conversion of Landsat Thematic Mapper (TM) and Multispectral Scanner (MSS) data to a stable storage medium. The primary system to begin this conversion was purchased in FY 1991 at a base cost of \$1,500,000. TM conversion will begin early in FY 1993. As currently scheduled, conversion of the post-1978 MSS data will begin late FY 1992, when the TM Archive Conversion System (TMACS) becomes operational. Figure 1 shows the TMACS configuration as planned.

The TMACS does not provide for conversion of all of the archive, nor does it provide the required TM/MSS product generation capability. Approximately 300,000 scenes of pre-1979 MSS data are stored on a wide-band video tape media that is rapidly deteriorating, rendering the data potentially irretrievable within a few years. Funding has not been provided to purchase the equipment to convert these data, which represent the only continuous moderate-resolution global time-series coverage of the Earth's land and shallow seas for 1972-78. These data are widely regarded as an invaluable baseline of information for global change research scientists.

Global Land Information System (GLIS)

The Global Land Information System (GLIS) is one of the USGS contributions to the U.S. Global Change Research Program. The EROS Data Center released a prototype of GLIS for operational use in June 1991. This interactive system is designed to assist scientists seeking information about and access to land data products for use in Earth science and global change research studies.

The system refers to a variety of regional, continental, and global land data sets, provides query features to assist in determining potential utility and availability of data sets, and supports on-line requests for related data products. Both textual and graphical user interfaces are provided. These are accessible by either wide-area network or dial-up communications linkage through a personal computer-based user interface which includes interactive user specifications for geographic search parameters, geographic coverage plots, and on-line digital image browse capabilities. Examples of on-screen user query features are shown in Figures 2a & 2b.

The Advanced Very High Resolution Radiometer (AVHRR) and Landsat components of the National Satellite Land Remote Sensing Data Archive that are in the public domain are the major satellite data currently referenced in GLIS. Two new satellite-based data sets, the Sahel/North Africa composited AVHRR Greenness data and the Zobler Global Soils data were added during the fourth quarter of FY 1991. Nine others, including the remainder of the U.S. held Landsat MSS and TM data (for which distribution is restricted) and metadata for Landsat data in other international archives, will be added early in FY 1992. Plans are being developed to provide Earth Science Information Center (ESIC)-state offices and other Interior bureaus with access to GLIS. GLIS will be fully operational by September 1992.

Global Data Set Development, Processing, and Distribution

Normalized Difference Vegetation Index (NDVI)

As part of the U.S. Global Change Research Program, EDC is developing a variety of satellite and earth science data sets of continental and global areas for use by global change researchers. Much of this effort is placed on producing time-series data sets from 1-km resolution AVHRR data that include NDVI for the conterminous United States (1990-1991), Eastern Europe/Soviet Union (1987-1991), and Alaska (1990). These data sets are now operational. The NDVI of conterminous United States (Figure 3) was the basis for developing more detailed vegetation/land cover descriptions used in preparing the preliminary map of 1990 vegetation greenness index (Figure 4). A logical extension of this application was further developed in a prototype 1-km resolution AVHRR time-series data set of North America that was completed this year (Figure 5). This was a collaborative effort with the Canada Centre for Remote Sensing to demonstrate international functionality in the development of consistent satellite-acquired data sets for global change research.

Digital Elevation Data Set Development

A 500-meter resolution North American digital elevation data set is being assembled using existing grid and contour data sets provided by the Canadian Geophysical Centre, the Canadian Communications Research Centre, Canada Energy, Mines, and Resources, and the U.S. Defense Mapping Agency. This data set will replace and significantly enhance the 10-km resolution North American digital elevation data set shown on the cover of this report.

The Mexican portion of the North American digital elevation data set being assembled at EDC was combined with Conterminous United States data to facilitate a hydrologic analysis of the Rio Grande Basin. The ten-million cell data set was processed with automated hydrologic feature extraction software to produce stream networks and major basins that compared favorably with mapped stream networks, demonstrating that automated analysis of digital elevation data at the 15-arc second cell size can be expected to produce valid hydrologic parameters for large-area models.

An experiment was conducted to interpolate raster elevation data from the vector hydrography and hypsography in the new Defense Mapping Agency Digital Chart of the World (DCW) product using the ANUDEM algorithm. The DCW, scheduled for release in 1992, will contain global vector information at a 1:1,000,000 scale. The DCW grid compares sufficiently favorably to ETOPO5 and level-1 Digital Terrain Elevation Data to warrant pursuing the DCW option as a useful source of large-area topographic information.

The Digital Elevation Product Catalog with global topographic data sets including detailed descriptions was updated. This catalog and a summary of the Global Survey Database were presented at the CEOS ad hoc workshop on auxiliary data sets held at the National Geophysical Data Center in Boulder, Colorado.

Other Significant Activities

EDC participated in an International Geosphere/Biosphere Program (IGBP) data and Information Systems "Workshop for Global Scale Terrestrial Biospheric Data" held in Toulouse, France from June 17-19, 1991; attended an international meeting organized by the Sahel Sahara Observatory - a French program, regarding development of AVHRR data processing standards; digitized the United Nations Food and Agriculture World Soil Resources map at 1:25,000,000-scale for soil interpretation for global change modeling and impact assessment; and developed a method for integrating spatial data of dissimilar type, scale, resolution, and information content for large area forested regions, with concentration on deforestation in the Amazon Basin.

Land Characterization Research

Distribution of Terrestrial Conditions and Processes

The Land Characterization research program is being conducted to develop multiple-scale digital descriptions of land characteristics in order to improve understanding of the spatial distribution of terrestrial conditions and processes, and to link this understanding to process modeling. Several pilot research projects are linking geographic data to quantitative analyses of land processes and land-atmosphere interactions. These include analyses of the release of methane from Arctic tundra and the exchange of water and energy between the land and the atmosphere. This is an expanding effort in collaboration with the U.S. Department of Agriculture being conducted at a new Terrestrial Ecosystem Regional Research and Analysis Laboratory (TERRA Lab) in Fort Collins, Colorado.

Land Characteristics Data Base

A prototype land characteristics data base was developed for the Conterminous United States. A 1990 multi-temporal AVHRR data set and ancillary spatial data (elevation, climate, soils, ecological regions) were classified to produce a land characteristics data base composed of seasonally distinct land cover regions (see figure 5), and associated detailed vegetation and site attributes. The U. S. Forest Service is evaluating the use of the land surface characterization data base for the creation of a national small-scale forest cover-type map.

Global Energy and Water Experiment (GEWEX)

A global change research project was initiated with the Water Resources Division (WRD) to link the new North American elevation data and other large-area surface data sets being developed at EDC with the parameterization requirements of the Global Energy and Water Experiment project. GEWEX is a program initiated by the World Climate Research Program to observe, understand, and model the hydrological cycle and energy fluxes in the atmosphere, at land surfaces and in the upper oceans. The GEWEX Continental-Scale International Project site will be the Mississippi River Basin.

Other Significant Activities

Completed the land cover classification of Chesapeake Bay watershed using AVHRR data. The Environmental Protection Agency is evaluating this data set for its Environmental Monitoring and Assessment Program (EMAP) applications. The University of Nebraska, Center for Advanced Land Management Information Technology, has established a visiting scientist position at EDC to assist in land characterization research.

Earth Observing System Data and Information System Support

The EROS Data Center is the Distributed Active Archive Center (DAAC) for Land Processes data to be acquired and distributed in support of the Earth Observing System (EOS) Program. This responsibility requires storage and management of data acquired by four of the major land remote sensing instruments of the EOS Program. Project management activities are consolidated in the EOS Data Systems Project Office, and are generally devoted to long-range EOS planning and coordination and project management of near-term system and data set prototyping projects.

EOS Planning and Coordination

USGS/NMD On-site Liaison at GSFC

A major element of EOS is the EOS Data and Information System (EOSDIS), to be developed under a systems integration contract. One USGS staff position was established at the NASA Goddard Space Flight Center in Greenbelt, MD. in mid-1991 to represent USGS interests and provide on-site support to specification and procurement of that contract.

EOS Investigators Working Group Meeting

EDC staff participated in a meeting of the EOS Investigators Working Group held in Seattle, Washington in August, 1991. The purpose of the meeting was to identify and discuss alternatives for a revised EOS system configuration and payload definition that provides flexibility for adjusting to budget fluctuations. NASA is expecting overall EOS funding to be reduced from \$17 billion to \$11-12 billion, requiring at least a reconfiguration of the space segment. Reconfiguring to a series of smaller platforms allows other elements of flexibility, such as use of smaller launch vehicles, and some adjustments may be required to EOSDIS as well. The remainder of the meeting was devoted to discussion of which sensors should be included on the initial scaled-down platforms. A final recommendation will be developed at a meeting of the EOS Payload Panel in October 1991. Strong interest was expressed in two initial platforms, one morning and one afternoon. The morning platform would emphasize land observation, and candidate sensors would be ASTER, MISR, MODIS-N, MOPITT, and SAGE. The afternoon platform would emphasize atmosphere and ocean observation, and candidate sensors would be AIRS, AMSU, MHS, CERES, HIRDLS, MIMR, and MODIS-N. A final recommendation will be developed at a meeting of the EOS Payload Panel in October 1991, however, final selection and configuration will not be announced by NASA until mid-December.

TM/MSS Archive Conversion System Functional Capabilities

Landsat Archive on Non-Computer-Compatible Tapes



1982-1992 TM Data

- 19,500 28-track High-Density Tapes
- 41,000 Gigabytes of Thematic Mapper Data
- 2,500 sq. ft. Archive at Landover, MD



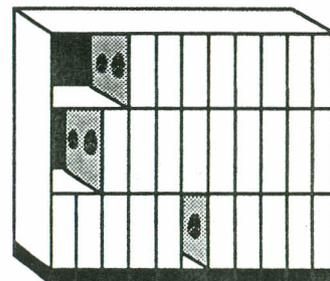
1979-1992 MSS Data

- 8,200 14-track High-Density Tapes
- 10,500 Gigabytes of Multispectral Scanner Data
- 1,000 sq. ft. Archive at EDC

Data Transcription



- 1,200 Transverse-Scan Digital Cassette Tapes
- 51,500 Gigabytes of Landsat Data
- 200 sq. ft. Archive at EDC
- Fully Supported, Production Recorder

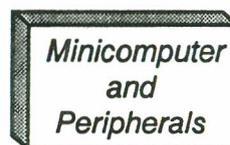


EDC Manual Archive

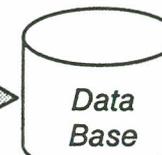
Data Management



Cloud-Cover Scoring
and Quality Assessment



Minicomputer
and
Peripherals



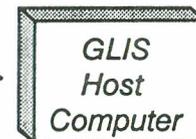
Data
Base

Scene Characteristics
and Archive Inventory



Optical Disk

Subsampled Browse Scenes
TM and MSS: 450 Gigabytes



GLIS
Host
Computer



Scientist 32-bit
Workstation

Network
Interconnection

Figure 1 - Thematic Mapper Archive Conversion System (TMACS)

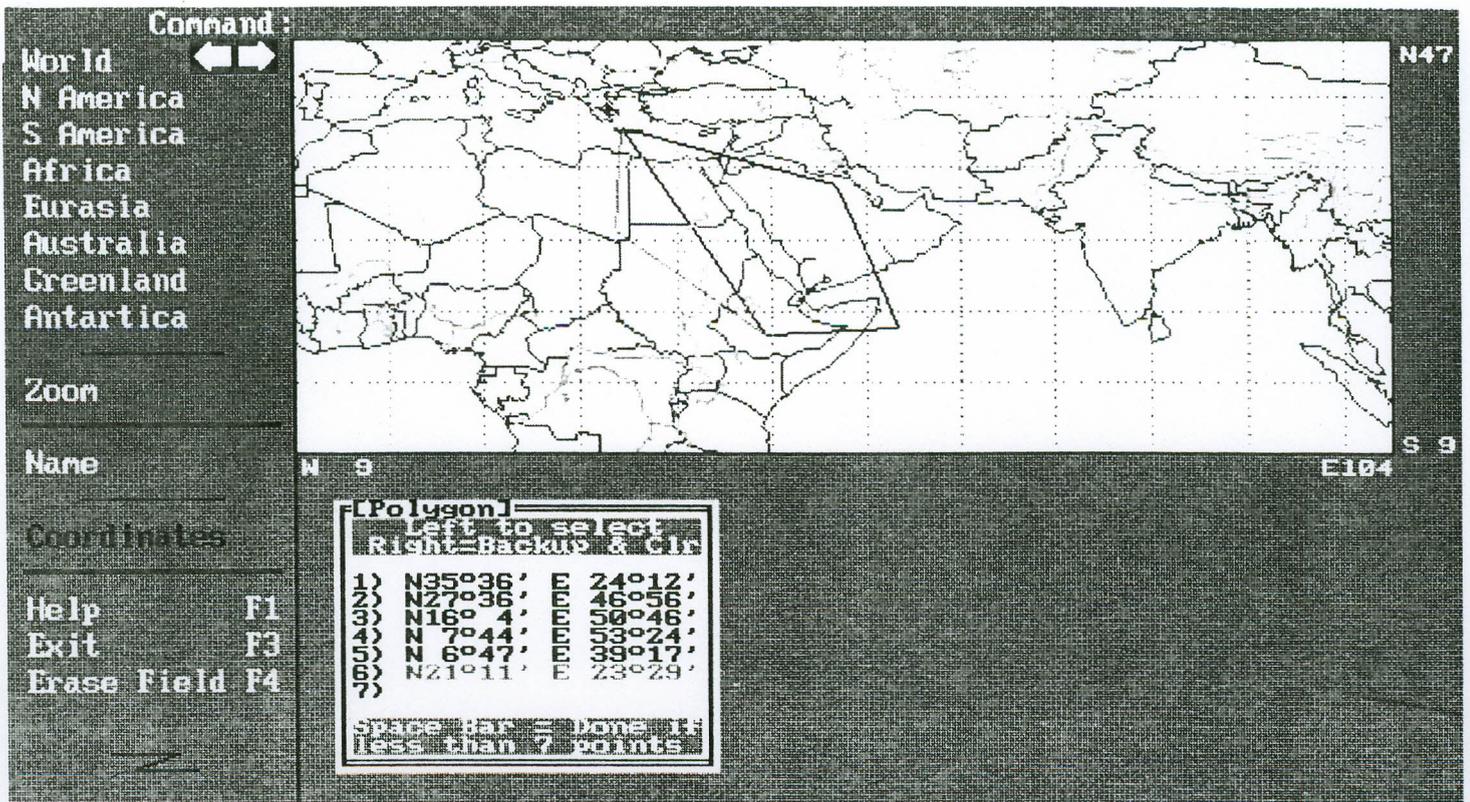


Figure 2a - GLIS Geographical Area Selection Screen

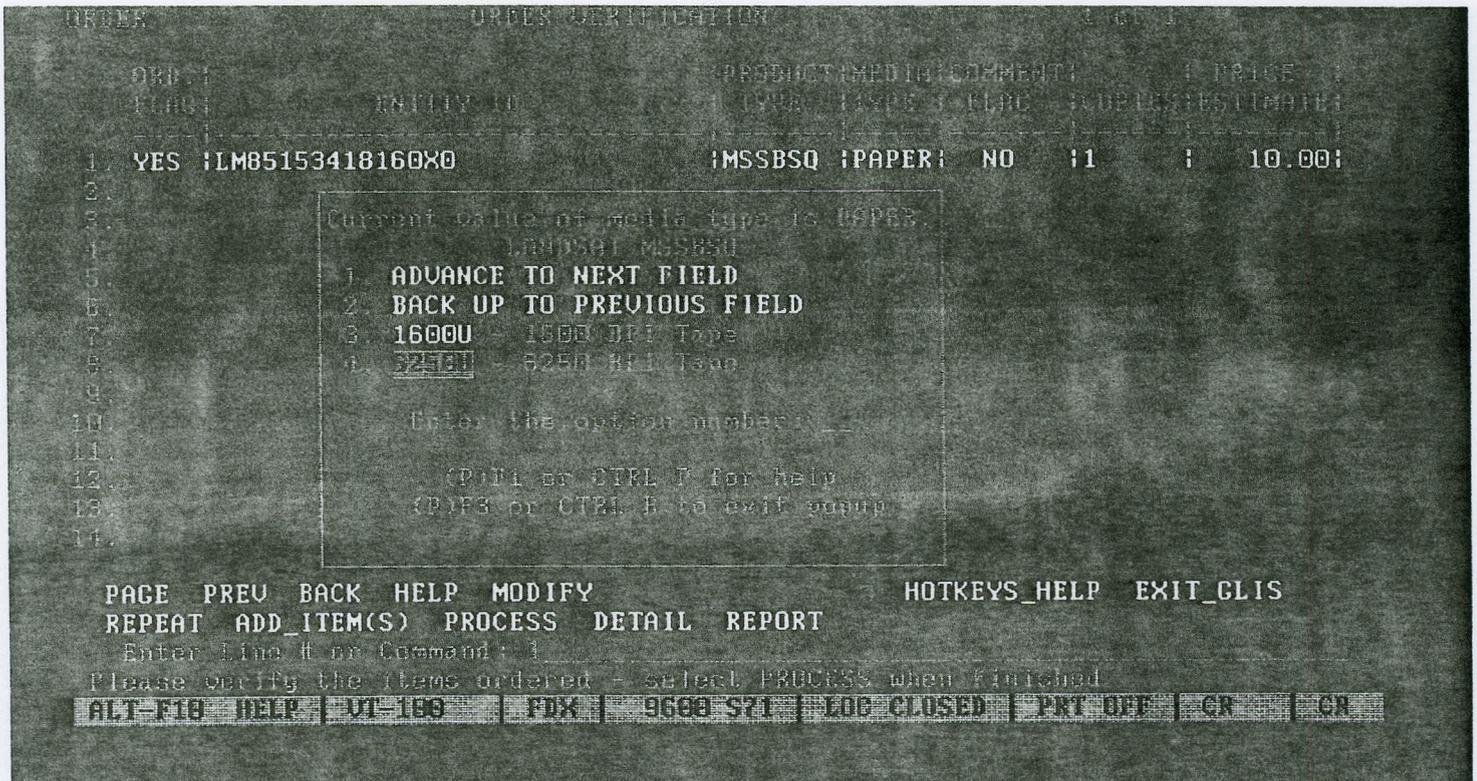
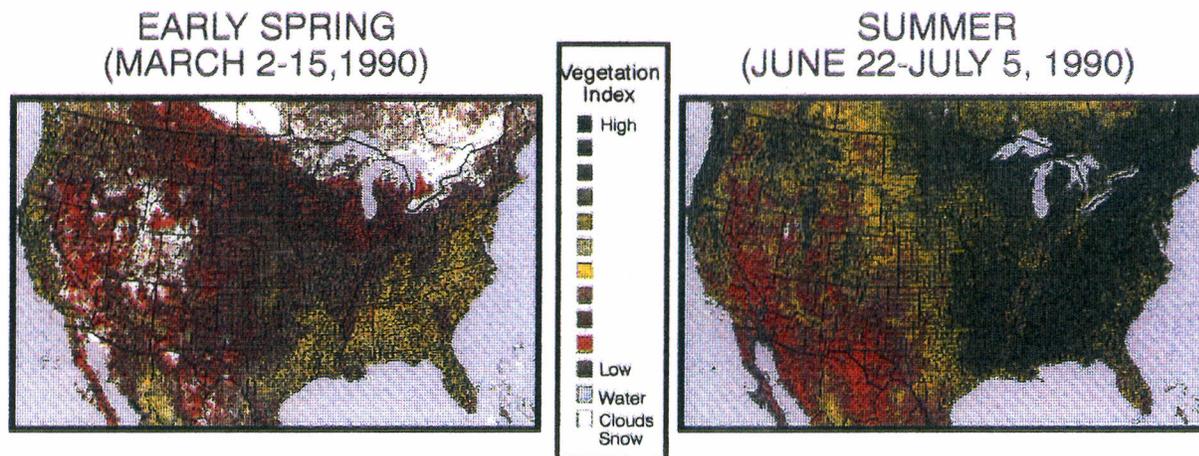


Figure 2b - GLIS Product Ordering Screen

GLOBAL LAND DATA SET DEVELOPMENT

MONITORING VEGETATION CONDITION WITH AVHRR DATA OF THE CONTERMINOUS UNITED STATES



BIWEEKLY NORMALIZED DIFFERENCE VEGETATION INDEX IMAGES

- USES:
- MONITORING DEVELOPMENT OF CROPS AND NATURAL VEGETATION DURING A GROWING SEASON
 - DETECTING IMPACTS/EFFECTS OF DROUGHT, EXCESS RAINFALL, AND OTHER CLIMATIC VARIATIONS ON VEGETATION

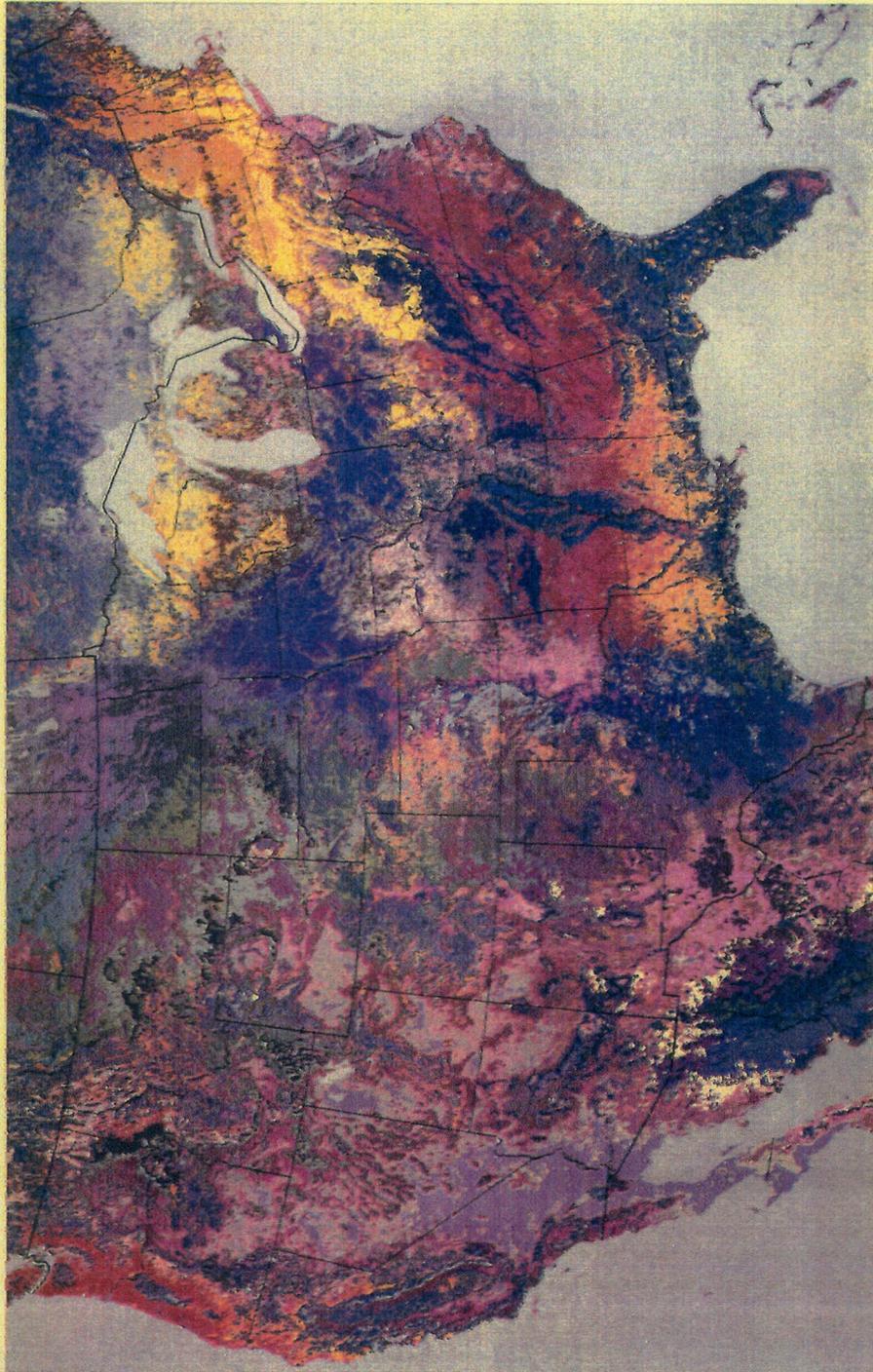
USERS: • EPA • USFS • NWS • BLM • NPS • STATES

NMD-151-91

Figure 3 - Global Land Data Set Development

PRELIMINARY MAP OF 1990 VEGETATION GREENNESS CLASSES

CLASS #



THESE SPECTRAL CLASSES REPRESENTING CLUSTERED THE SERS VEGETATION CONDITION DATA, WERE DERIVED FROM THE VEGETATION CONDITION DATA, WHICH WERE NORMALIZED TO THE VEGETATION CONDITION DATA, WITH NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI) VALUES TRANSFORMED FROM 0.03-1.00 INTO BINARY, EIGHT CONSECUTIVE REPORTING PERIODS WITH EACH REPRESENTING ONE MONTH. THE DATA WERE REPORTED WITH AN INTERVAL, WERE USED BY THE ANALYSIS.

AREA SCALES
 1000,000 HECTARES 1000,000 ACRES
 10000 50 KM 15625 50 MI
 1 HECTARE = 2.47 ACRES

1:5,000,000
 100 0 200
 200 KILOMETERS
 100 0 200
 200 MILES

STATE/PROVINCIAL BOUNDARY
 INTERNATIONAL BOUNDARY

U.S. STATE BOUNDARIES DERIVED FROM USGS 1:2,000,000 D/C
 INTERNATIONAL AND STATE/PROVINCIAL BOUNDARIES FROM WORLD DATA BANK II
 LAMBERT EQUAL-AREA PROJECTION
 COORD. 10°W, 48°N

GRID DATA CENTER
 BETWEEN WASHINGTON
 AND WASHINGTON STATE
 BOULDER, CO

Figure 4 - Preliminary Map of 1990 Vegetation Greenness Index



Figure 5 - North American Vegetation Greenness Index (August 11-20, 1990)

Systems Engineering Support

Each of the EOS archive centers is participating in a series of engineering design activities to develop long term operating concepts for the EOSDIS. Issues of DAAC-to-DAAC data exchanges, standard data formats, software development standards, and distributed data bases are being scrutinized. A medium-speed private communications network has been implemented to support information systems interaction and data set exchanges between the archive centers, while communications support for science user access will be supplied by the traditional public Internet network facilities. A significant amount of time was devoted to developing and reviewing requirements and operational concepts for long-term EOSDIS implementation to more effectively guide the near-term prototyping activity.

Facility Expansion Requirements Definition

A facility requirements document was completed and funding was received to contract for the design of a major expansion of the present EDC facility to support EOSDIS Distributed Active Archive Center responsibilities. The facility design contract will be awarded early in FY 1992.

EOS Instrument Science Team Participation

EDC continued to participate in science team meetings for the Moderate Resolution Imaging Spectrometer (MODIS), the Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER), and the High Resolution Imaging Spectrometer (HIRIS). EDC staff participates in defining instrument characteristics and systems specification, providing representation on issues that potentially impact the Center's responsibilities, and informing the Team of Center activities and plans. Through this interaction, EDC assesses requirements for precursor data to conduct algorithm development for land products that would be processed at EDC following the launch of the first EOS platform in 1998. EDC also hosted a MODIS meeting to discuss land cover product requirements, and at that meeting assisted in formulation of a proposal to acquire a global 1-km AVHRR data set to support EOS and IGBP requirements for global land products.

Landsat Pathfinder

The first meeting of a science working group (SWG) to define a Landsat Pathfinder was held in August 1991, in Arlington, Virginia. To prepare for early-EOS research and development, several existing data sets must be preserved and/or re-processed. To ensure that appropriate data sets were identified and data preservation activities initiated, NASA defined a series of "pathfinder" projects. One such project was suggested and approved to address identification and processing of selected Landsat data to support specific global science objectives. Participants represented NASA's Ames Research Center (ARC) the Landsat Pathfinder Scientist, USGS, EPA, The Nature Conservancy, Woods Hole Research Center, MD and several universities.

The goal of the Landsat Pathfinder is to establish long-term medium and high resolution data sets that are specifically reviewed and selected for their regional and global importance. This Landsat Pathfinder Collection will be optimized for global change research. The objectives are to make critical archived Landsat and other data available; acquire current observations to compliment historical data; establish a mechanism that provides easy, integrated, and complete access to these past, present, and future data sets; and establish and maintain intercalibration of sensors.

The SWG is responsible for identifying the science issues to be addressed by the Pathfinder, and the requirements for products (time sequence and spatial extent), calibration and validation, and standards. The next meeting of the Landsat Pathfinder SWG will be at EDC during the week of October 27, 1991, to define potential Landsat Pathfinder data sets and products.

EOS Data and Information System (EOSDIS) Prototyping

Development tasks were initiated in 1991 to begin early prototyping of capabilities required for implementation of EOSDIS. The major system development activity emphasized prototyping a distributed information management system to link the various archive centers into a "one-stop shop" for information about earth science data. In addition, other tasks were initiated to collect and process several types of global data to be used as precursor data sets for early research and development of algorithms and science scenarios, and to prepare for eventual data acquisition from EOS platforms in the late 1990's. These efforts to prototype system functionality and improved data sets is targeted to provide improved access to re-processed data by mid-1994, and are referred to collectively as the Version 0 Project.

Land Processes DAAC Science Advisory Panel

Each archive center is required to establish a science advisory panel to provide science guidance during the development of the operational archive center. A charter and operating guidelines were prepared for the Land Processes panel, and have been submitted for review and approval as a federal advisory panel. An organizational meeting of potential panel members was held at EDC in June for them to become familiar with EDC and EOSDIS programs and plans. The Panel will be called upon to provide advice and guidance on a wide range of programs and activities. The next meeting of the Panel will be held in December 1991, pending final approval of the Panel's Charter by the Department of the Interior (DOI).

Global Land 1-KM AVHRR Data Set

Significant interest developed this year within the scientific community for the development of a 1-km AVHRR data set of global land coverage, to support environmental monitoring and Earth-system science investigations. A project to acquire, archive and manage a consistent set of these data of all land masses and coastal areas worldwide was identified, designed and approved as a FY 1992 initiative, and received endorsement from NASA Headquarters and various scientific organizations as critical to the preparatory studies for EOS. As a result, NASA has designated EDC as the primary contact for the coordination and collection of the data set as part of EDC's role as the EOS Land Processes Distributed Active Archive Center.

Numerous meetings with NASA, National Oceanic and Atmospheric Administration (NOAA), and the European Space Agency resulted in concurrence on a strategy that assigns NOAA responsibility for recorded LAC AVHRR data; European Space Agency (ESA) responsibility for coordinating data collection efforts with 10-12 designated High Resolution Picture Transmission (HRPT) stations; Australia, CSIRO responsibility for coordinating data collection efforts with 3-4 designated HRPT stations, and EDC

responsibility for coordinating data collection efforts with the international HRPT stations required to achieve global land coverage. Significant international cooperation will be required to ensure the acquisition and compilation of the data set which is scheduled begin by March 1992.

Global Topographic Data Sets

Access to topographic data (particularly in digital form) is a requirement raised at every EOS-related scientific meeting. These data are critical to processes for correcting and/or presenting global data (particularly satellite-acquired remote sensing data), and to scientific investigations that are carried out in support of global data analyses. The Land Processes DAAC has responsibility for developing a plan to assess the availability of Digital Elevation Model (DEM) data and document the tasks required to acquire, process, archive and/or otherwise provide access to topographic data of the world.

The major elements of that plan will discuss existing digital topographic data archives and how they can be accessed, alternatives for generating digital topographic data sets from existing map-based reference materials, generation of topographic data sets from remote sensing data sources, and generation of improved derivative products from baseline data sets.

Airborne Instrument Data Sets

Many remote sensing data sets pertinent to land science research have been collected, primarily as a result of NASA funding, over the last decade. These data are currently archived at various NASA locations, each requiring separate funding from NASA to sustain the archive and provide for distribution of associated products. NASA has issued a policy statement that these data will be assimilated by the EOSDIS, and that selected data archives should be considered for transfer to the Land Process DAAC.

A plan was developed in FY 1991 to cooperate with JPL and the ARC to design and implement systems required to establish archives of Thermal Infrared Multi-spectral Scanner (TIMS) and Advanced Visible and Infrared Imaging Radiometer (AVIRIS) data at the DAAC at EDC. A draft USGS/JPL MOU has been developed and is being reviewed by JPL, and a similar document, already in place between the USGS and ARC, will require some modification. The key FY 1992 development represented by the plan is to purchase a workstation, transcribe the TIMS archives at JPL and ARC to new media, and set up a working archive at the DAAC to assume responsibility in 1993 for product generation and distribution. Transfer of the AVIRIS data archive will be addressed as a FY 1993 requirement.

Remote Sensing Research and Spatial Data Analysis Technical Development

Soil Interpretations for Global Change Modeling and Impact Assessment (60GC0891)

Development continued for a map of Major Soil Regions of the World, in cooperation with soil scientists in the Soil Conservation Service (SCS). Corrections to the draft map were entered into the data base, and revised maps were plotted and sent to SCS for review. The global map will be printed by USGS at a scale of 1:30,000,000, in early FY 1992.

Integration of Simulation Modeling and Remote Sensing for Monitoring Primary Production in Natural Ecosystems (60GC0991)

The Agricultural Research Service at Fort Collins, Colorado is developing a generalized model for tracking biomass production in diverse ecosystems, including dry land agriculture, irrigated agriculture, grass/shrublands, and grasslands. Collaborative research was initiated with Colorado State University to characterize the test site area. Studies are underway at EDC to implement the use of Landsat MSS "greenness" and "brightness" for local characterization of AVHRR data. An open-file report is being prepared to document the 1989 and 1990 data collected at the Central Plains Experimental Range and the satellite data set archived for the Colorado test site area.

Large Area Estimation of Evapotranspiration with Satellite Data for Global Change Investigations (60GC1091)

A paper was presented at the Fourth Tennessee Water Resources Symposium showing the results of the NDVI evapotranspiration (ET) comparison with the Thornthwaite Water Budget model estimation. The Bureau of Reclamation has provided thematic mapper data for the irrigation districts on the Lower Colorado River to be evaluated. Data base development continues for the Carson River and Willamette Valley studies.

Identification of Global and Continental Map Projections (60DC0191)

Implementation of map projections and the development of software tools to graphically represent errors incurred when reprojecting raster data sets were completed. Data sets and accompanying graphics are being prepared to show distortion introduced to raster images of global data during reprojection.

Automated Extraction of Hydrographic and Woodland Features in Alaska from SPOT Digital Data (60DH0291)

Georeferenced merged SPOT digital imagery and Digital Line Graph (DLG) data were transmitted to Rocky Mountain Mapping Center (RMMC) to demonstrate that the data collected can be presented with sufficient detail and positional accuracy to meet the standards for 1:63,360-scale quadrangle mapping in Alaska. Classification of the woodland is still being refined. Attempts to overlay water and woodland features presented several problems which must be resolved before the coverage layers can be successfully integrated into a data set.

Small-Scale Mapping from Global Data Sets (60SD1291)

Procedures to produce press-ready plates for small-scale maps derived from global data sets were developed as part of the Modernization-Product Generation program. A greenness image and a set of state and national boundaries from ARC/INFO were integrated using the Scitex workstation. A revised version of the greenness image and ARC/INFO data will be sent to Reston for processing. A set of film separates will be made, and a color proof will be generated to check for registration problems.

Network Communication Experiments (60DC1691)

The Network Image Transfer Experiment (NITE), the efforts of previous communication network research, provided the basis for collecting and analyzing data involved in the current study. A report on the present NITE will be finished first quarter FY 1992 and released to users for their comments. Installation of T1 circuits, fiber glass, and in-house realignment of networks and equipment is nearing completion.

Terrain-Dependent Insolation Model (60GC0192)

Initial research, algorithm development, and refinement is underway and is expected to be completed by mid-February 1992. The primary focus during the next 2 months will be on the development and testing of an Atmospheric Transmission Module that will provide quantitative measures of both direct and diffuse components of downwelling solar radiation. These measures, in conjunction with output from the Terrain Illumination Module, will be used to compute instantaneous and cumulative insolation values for each facet (condition of slope and aspect) of a DEM-based terrain map.

Currently, interim products are being prepared for presentation and review at the Third Workshop for Global Change Research in NMD to be held in November 1991;

Hyperspectral Data Visualization (60DH0391)

A demonstration of the project was made to Dallas Peck, Director, USGS, and Allen Watkins, Chief, NMD. A technique called "brushing," which allows multiple data windows to interact, was implemented using AVIRIS data and will be extended to a three-dimensional model.

Development of Radar Data Processing Capabilities (60DH0691)

Algorithms are under development for the geometric and terrain correction of Synthetic Aperture Radar (SAR) imagery. Software was written to be easily reconfigured for various geometric models and interpolation methods. Presently, the software includes the satellite and sensor model for the SEASAT SAR system. It is expected that the model can be easily extended for the Earth Remote Sensing Satellite-1 (ERS-1) SAR and the ALMAZ SAR.

A paper entitled, "Evaluation of Terrain Models for the Geocoding and Terrain Correction of Synthetic Aperture Radar Images" will be presented at the Committee on Earth Observations Satellites SAR Calibration Workshop at German Aerospace Research Establishment, Oberpfaffenhofen, Germany in October 1991.

Agency for International Development Technical Assistance*AGRHYMET Program Support for West Africa*

The Agricultural-Hydrological-Meteorological (AGRHYMET) Program was established to assist nine west African countries to modernize data collection, analysis, and reporting of agricultural, meteorological and hydrologic conditions. The program is implemented with assistance from a number of donors in the nine countries of Burkina, Cape Verde, Chad, Gambia, Guinea Bissau, Mali, Mauritania, Niger, and Senegal. Each country has a National AGRHYMET Center (NAC) and the region is served by the AGRHYMET Regional Center (ARC) in Niamey, Niger. The Agency for International Development (AID) sponsors the USGS to provide technical assistance and training.

The USGS has fully transferred a system to process AVHRR data which are directly received at the ARC. These data are processed into NDVI maps and digital files. The data are combined with weather data to provide a synoptic crop condition assessment for each country at the respective NAC's and for the region at the ARC.

Technical assistance was provided to conduct a full requirement needs assessment (RNA) for management and analysis of geographic data. This RNA considered all aspects including data acquisition, management, and analysis. The RNA provides the basis for design of Geographic Information Systems (GIS) capabilities providing a distributed network linking the regional and national capacities.

The USGS plans to continue support for the next 2 years in order to fully implement the distributed GIS. An RNA is under progress to support the telecommunication of data for timely access of data necessary to support crop condition assessments.

Famine and Early Warning Data Management and GIS

Severe droughts ravaged sub-Saharan Africa during the recent times of 1971-1973 and 1984. Untold crop and livestock losses created massive human suffering and loss of life. The Famine and Early Warning System (FEWS) was established under the sponsorship of AID to provide timely information so that decision makers can implement famine prevention measures for seven famine-prone countries in the Sahel and Horn of Africa. The food security of the region is dependent on the complex interaction of many socio-economic and physical factors.

Comprehensive and accurate monitoring data are not generally available. Therefore, the EDC has assisted FEWS through AID sponsorship in defining and structuring a GIS which takes optimal advantage of existing data, including remote sensing, so that a convergence of indicator approach can be applied to analyze the multisectoral data and communicate the results to decision makers. The purpose is to identify vulnerable populations and monitor their at-risk conditions.

Data management procedures have been developed by EDC including archiving standards and analysis routines. Training has been provided to the AID contractor in the field. A multilevel systems approach is being implemented where EDC serves as a central technical assistance, technical support facility, and an interim data archive. Data are screened in the field, appropriately documented, entered into the system, and statistically and spatially analyzed. The data serve as monitoring of current conditions

as well as establishing a baseline from which to measure deviations from the normal. The system is structured to not only analyze data, but to effectively display and communicate the results in map form to the decision makers of the host countries and international donor agencies. An example of these map data are shown in Figure 6.

The initial data archiving and processing system included an array of off-the-shelf processing software packages which were available, but required considerable training for the system operator. The USGS is developing public domain desk-top data managers that require minimal training before using, and service data management and analysis that can be used in the African countries. These data managers include rainfall (RAINMAN), population (POPMAN), NDVI time-series data (NDVIMAN), and agricultural statistics (AGSTATSMAN) data types.

IGADD Program Support for East Africa

The Intergovernmental Authority on Drought and Development (IGADD) services the east Africa region for early warning and food security. The program, headquartered in Djibouti, has member countries including Djibouti, Ethiopia, Kenya, Somalia, Sudan, and Uganda. The Regional Center for Services in Surveying, Mapping, and Remote Sensing (RCSSMRS) in Nairobi, Kenya, has been designated for technical support to the early warning mission of IGADD. The purpose of the USGS agreement with the AID is to provide technical assistance and support to the RCSSMRS in the use of time-series remote sensing from AVHRR NDVI. The use of the data is to provide a tool for assessing crop and rangeland condition as related to early warning. Training courses have been developed by USGS with supporting data files for conducting the remote sensing early warning analysis using geographic information system tools on national and regional geographic basis. The courses will be offered, together with RCSSMRS staff and will be transferred to that facility for continued offerings.

Alaska Field Office (AFO) Activities

Baseline Studies for Monitoring Global Climate Change in the Arctic Environment - (Research Project #60GC0791)

Activities in this research project for FY 1991 included: (1) the establishment of a cooperative program for the development of an Ecoregion Mapping program for Alaska in support of a circumpolar ecoregion mapping for arctic and sub-arctic regions in conjunction with the Environmental Protection Agency (EPA) and Environment Canada; (2) the initiation of a cooperative Forest Health and Monitoring Program with the U.S. Forest Service (USFS) for boreal forests, currently a proposed element of EPA's Environmental Monitoring and Assessment Program (EMAP) program; and (3) the establishment of monitoring sites for habitat and wildlife species conditions and dynamics in the Arctic National Wildlife Refuge in cooperation with the U.S. Fish and Wildlife Service and the continued cooperation with the University of Alaska, Fairbanks on the Bonanza Creek LTER monitoring site.

Ecoregion Mapping Program

Numerous statewide spatial data bases have been developed in support of ecoregion delineation and characterization. Published maps on data elements such as soils, permafrost, physiographic provinces, stream basins, various climatic variables, hydrography, coastline, geology have been automated and integrated with DEM and NDVI information derived from biweekly composites of AVHRR data. These statewide data bases serve a broad global change community interested in parameterization of conditions in the arctic and boreal regions of Alaska and will directly support boreal forest monitoring programs.

Soviet Union/AFO Scientific Exchange

In support of a cooperative and ongoing USFWS research with the Soviet Academy of Science, the Chief of the AFO accompanied two USFWS research biologists on a scientific exchange visit to Moscow, USSR during the month of August. The Soviet Academy's Institute of Evolutionary Ecology and Animal Morphology was the host for the 10-day series of meetings, seminars, and briefings. Informative half-day meetings were also held with the Soviet Ministry of Forestry and the Center of Nature (Priroda) which is the primary center for the processing, distribution and development of applications for remotely sensed data acquired by the Soviet satellite "Resource-F". Computer tapes containing digital radar, passive microwave, and visible panchromatic data acquired over Alaska in August by the Soviet "Resource 0" satellite were obtained during the visit. The data is being geo-referenced and will be further processed and evaluated for potential applications to USFWS/AFO global change studies.

International Permafrost Association

The AFO is supporting the International Permafrost Association (IPA) in developing a circumpolar permafrost map to be presented at the Sixth International Conference on Permafrost, July 5-9, 1993, in Beijing, China. The AFO is working with Oscar Ferrians, USGS Branch of Alaskan Geology, in revising the 1962 permafrost map of Alaska for the forthcoming circumpolar permafrost map. In addition, the AFO hosted Soviet, Canadian, and American researchers on the circumpolar permafrost mapping effort for discussions on the circumpolar mapping effort.

Department of Defense and Intelligence Technical Assistance

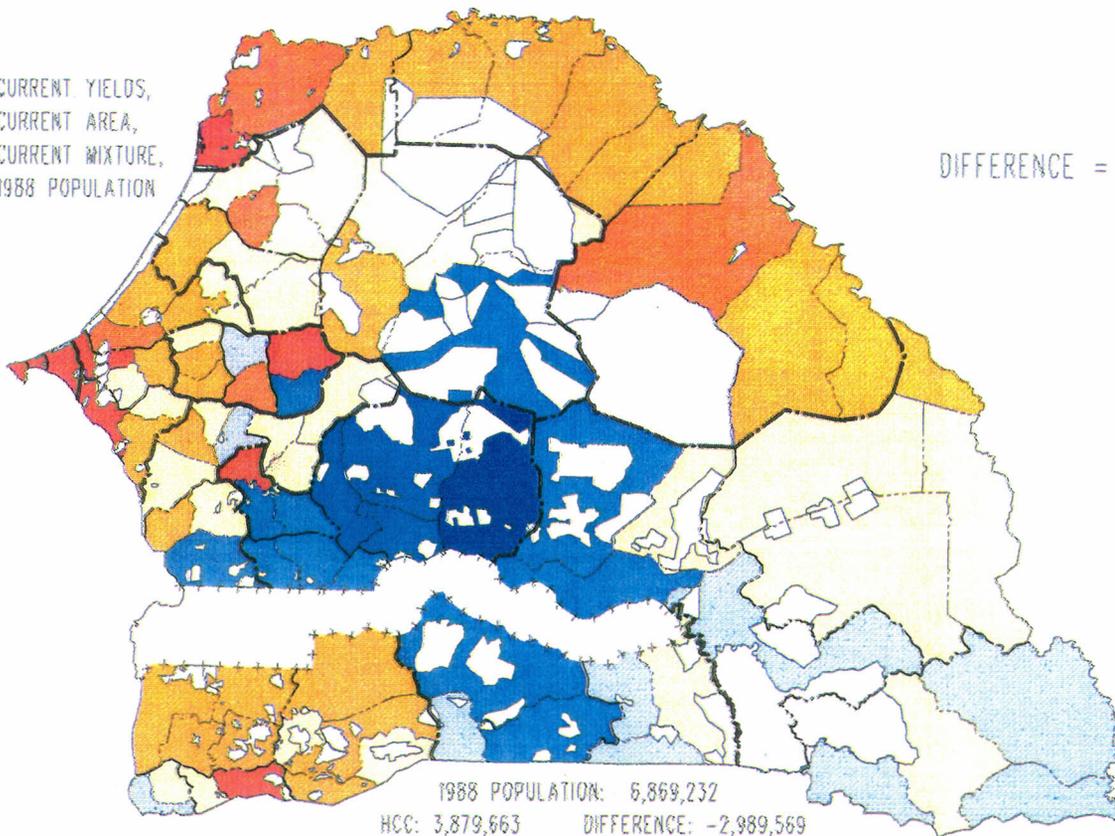
South America Image Mapping

Over the past two years, EDC has been collaborating with DMA in producing a series of 1:100,000-scale image maps for selected areas in Peru and Columbia. Image processing included geometric registration, mosaicking, and enhancing Landsat TM data. At-scale lithographic separates are provided to DMA. During FY 1990, a total of 70 1:100,000-scale image maps were completed. Thirty-three additional image maps were being completed in FY 1991, and are currently in lithographic preparation. The extent of coverage for these image maps and additionally processed data is shown in Figure 7, South American Image Mapping.

HUMAN CARRYING CAPACITY FROM RAINFED CEREAL GRAIN PRODUCTION RELATED TO POPULATION

CURRENT YIELDS,
CURRENT AREA,
CURRENT MIXTURE,
1988 POPULATION

DIFFERENCE = HCC - POP



IMPROVED YIELDS,
CURRENT AREA,
CURRENT MIXTURE,
2010 POPULATION

DIFFERENCE
(in 000'S)

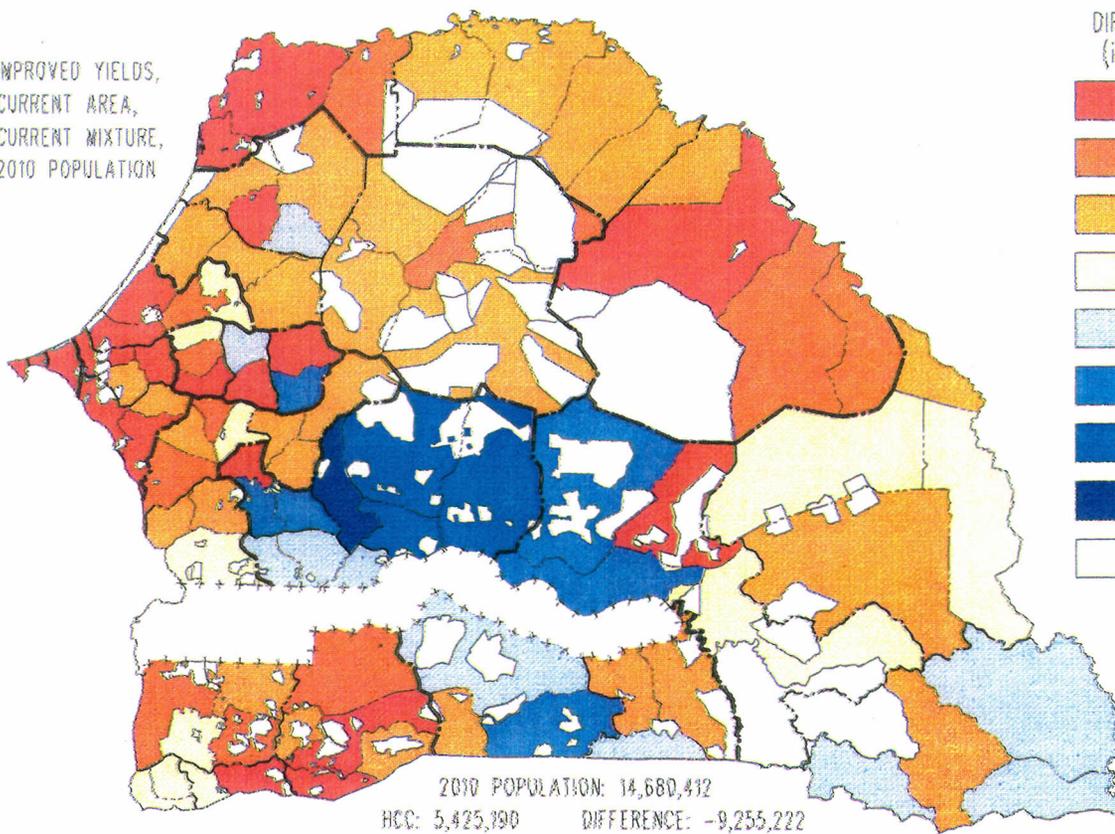
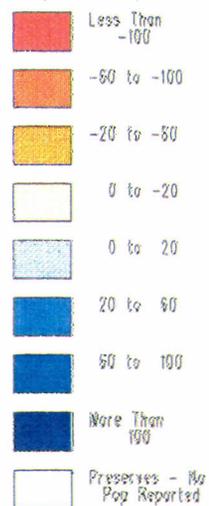


Figure 6 - Example of FEWS Data

South America Image Mapping

(Status as of October 1991)

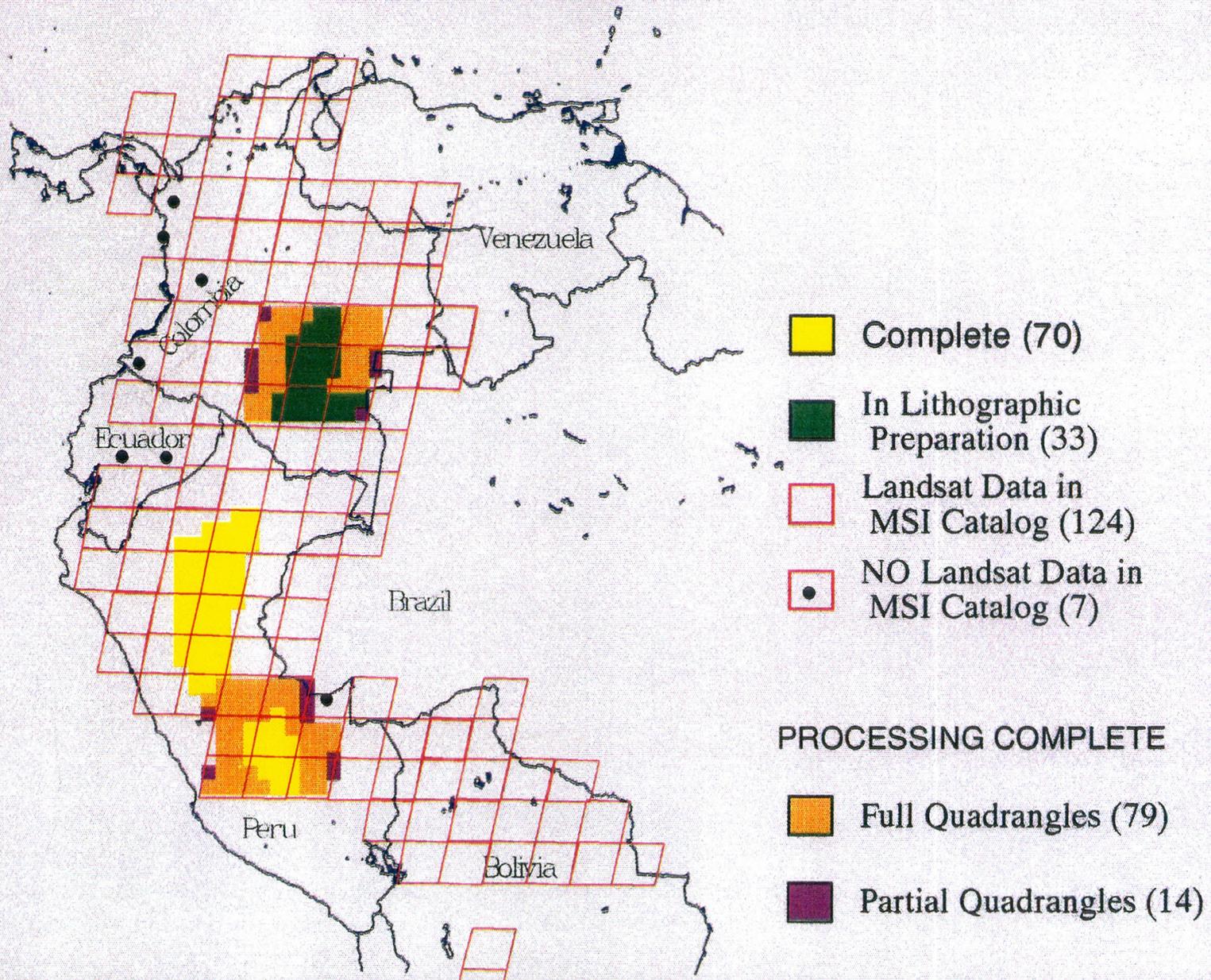


Figure 7 - South America Image Mapping

Desert Shield/Storm Assistance

EROS Data Center supported Department of Defense (DoD) and U.S. Government intelligence agencies by supplying digital data and satellite images for Operation Desert Shield/Storm activities beginning in early August, 1990. Figure 8 shows the index for the area of coverage for enhanced satellite products.

Meteorological Satellite image data--AVHRR was acquired by the U.S. Geological Survey from the Domestic Communications Satellite System (DOMSAT) on a continuous basis throughout the period. From these data a photo-image mosaic of the Middle East was prepared for DoD agencies (Figure 9). Specially processed (enhanced) Landsat TM satellite images were produced at scales ranging from 1:50,000 to 1:250,000, for change detection, map updates, and terrain analysis. The largest project was an eight-scene TM mosaic covering Kuwait and portions of Saudi Arabia and Iraq. Four 1:250,000-scale quadrangles with vector collars and UTM grids were produced as final products from this data set, including a subscene of Kuwait City (Figure 10).

Landsat TM satellite image data were acquired in the final phases of Operation Desert Storm to evaluate the extent of the Kuwait oil field fires and the oil slick in the Persian Gulf. Figure 11 shows the extent of the Kuwait oil field fires. These data were used to aid military operations and to assist in environmental monitoring. The U.S. Geological Survey EROS Data Center maintains a digital data archive and catalog system of all civil satellite data purchased and products produced for the Army and certain other DoD agencies.

Cooperation with Sarnoff Research Center

Two major areas of cooperation with the National Information Display Laboratory (NIDL) at the Sarnoff Research Center are underway: (1) *Data Compression*. NIDL has investigated data compression techniques for the transfer and display of browse images for the GLIS. (2) *Landsat Change Detection*. EDC has been investigating an appropriate test site for this study. Presently Yellowstone Park and Prudhoe Bay are candidates. EDC will provide Landsat temporal data for NIDL to register and perform change detection with their spatial, motion detection algorithms.

Through collaborative efforts with NIDL, the EDC is actively involved in developing strategies to support a Dual Use Technology Transfer program initiative that transfers Department of Defense technology to civilian applications. These efforts focus primarily on the processing and archiving of hyperspectral data from "HYDICE" and development of software tools for analyzing and visualizing hyperspectral data.

Additional effort will be devoted to Feature Recognition Databases (Infobases), and Electronic Display Calibration. Feature Recognition Databases (Infobases) enables access and "smart" browsing of large volumes of image and other data for large-scale time-critical applications. USGS involvement will expedite the development of this technology and evaluate it's application for information management systems.

Electronic Display Calibration tools will allow users to evaluate degradation of displays and evaluation of image processing techniques on visual perception either of hard copy products or soft copy displays.

Defense Advanced Research Projects Agency (DARPA) Gigabit Network Project

EDC is participating in the development of a proposal for a three-year Multi-dimensional Applications and Gigabit Internetwork Consortium (MAGIC) project. The proposal, funded for \$500,000 over three years, will be made to the Federal High Performance Computing and Communications Program to establish a very high-speed, wide-area networking environment to facilitate the testing and evaluation of applications. The joint proposal from EDC, Minnesota Supercomputer Center, U.S. Sprint, Lawrence Berkeley Laboratory, SRI International, and the University of Kansas includes processing digitized aerial photography for real-time terrain visualization.

Photogrammetric Modelling of SPOT Stereo Images

Completed the development of restitution capabilities for SPOT imagery and the implementation of these capabilities on a digital photogrammetric workstation. A final report was received in April 1991. A completed software package was received in June and is currently installed at EDC. DMA encourages the further development of a digital/softcopy photogrammetric research facility with the capability to evaluate the potential of new sensor systems and softcopy workstations, to develop appropriate software, and to provide an independent source of technical expertise and advise on digital photogrammetric issues.

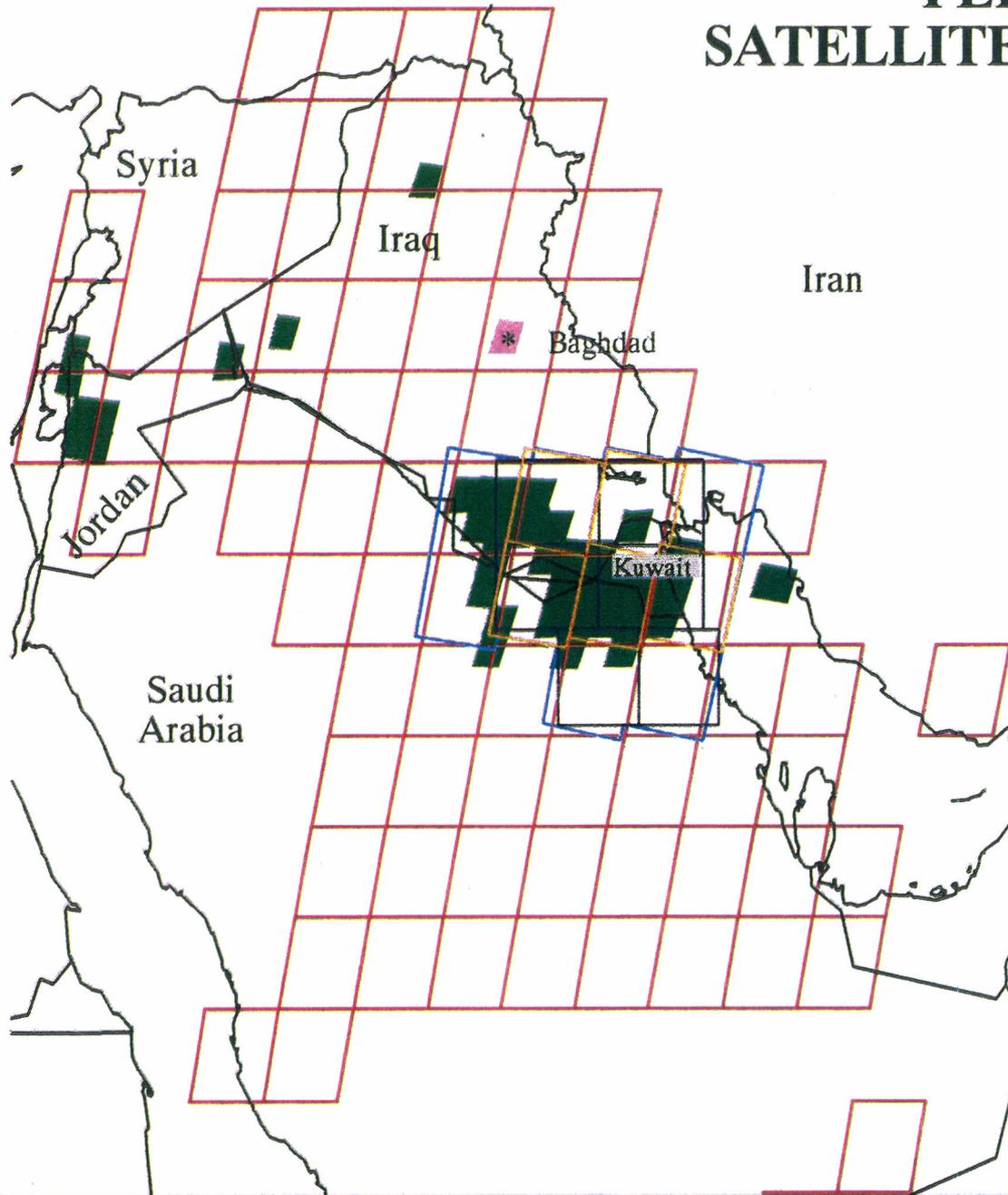
United Nations Environment Programme/Global Resource Information Database (UNEP/GRID) North America Node

The United Nations Environment Programme (UNEP), together with the National Aeronautics Space Administration (NASA) and the U.S. Geological Survey, signed agreements earlier this year to establish and operate a Global Resource Information Database (GRID) facility at the EROS Data Center in Sioux Falls, South Dakota. This was done in collaboration with NASA, the University of California (Santa Barbara), and the University of New Hampshire. The Sioux Falls GRID facility joins a network of regional facilities (Nairobi, Kenya; Bangkok, Thailand; Geneva, Switzerland; Arendal, Norway; and Tsukuba, Japan) responsible for expediting the collection, compilation, and international distribution of global data sets to support global environmental assessments. The facility will support and enhance North American contributions to global climate change research, the International Geosphere/ Biosphere Program, and other major environmental assessment programs.

GRID activities included a final set of AVHRR data products of the Kuwait/Persian Gulf area spanning the entire war period sent to UNEP offices in Geneva, Switzerland and Nairobi, Kenya. UNEP also provided a copy of the digital data to the government of Japan to assist them in developing funding alternatives to aid in the reconstruction of Kuwait.

The first year's operation has proven beneficial for all parties to the agreement. Because of the mutual benefits, an agreement to extend these joint activities for the next 2 years has been prepared and is pending approval.

PERSIAN GULF SATELLITE IMAGE PRODUCTS



-  Landsat 10-Scene TM Mosaic (1)
-  1:250,000 Scale Image Maps (6)
-  Change-Pairs (12)
-  Spot-TM Merge (1)
-  International Boundaries from WDBII

Satellite Data in MSI Catalog (As of August 24, 1991)

-  Landsat Data (214)
-  Spot Data (56)

Figure 8 - Desert Storm Image Mapping

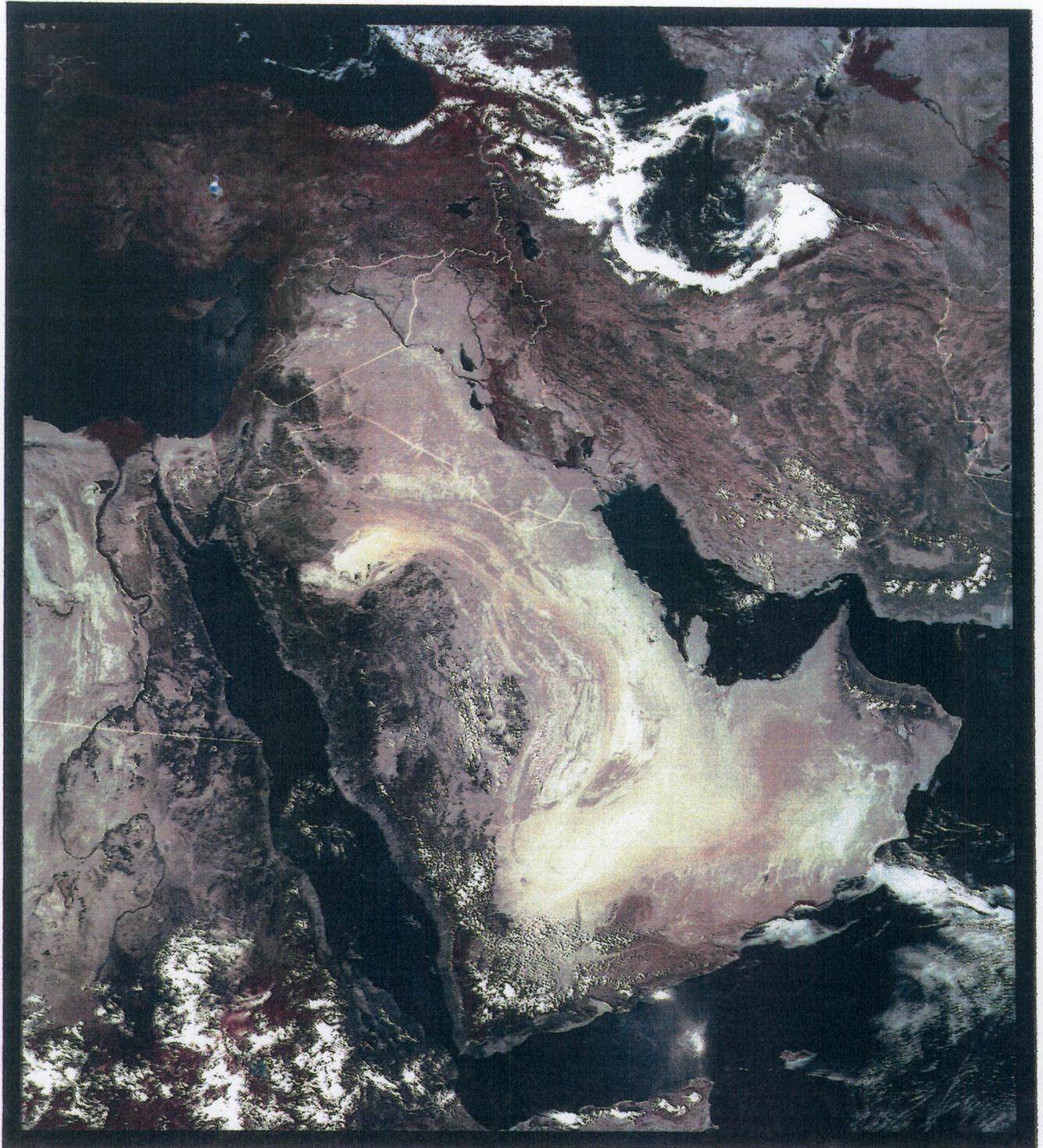


Figure 9 - AVHRR Four-scene Mosaic of the Middle East (September 1990)



Figure 10 - Kuwait City (Landsat Thematic Mapper Subscene, October 15, 1990)



Figure 11 - Kuwait Oil Field Fires (Thematic Mapper, February 15, 1991)

III. DATA PRODUCTION AND DISTRIBUTION ACTIVITIES

National Mapping Program Support

Map Production Support

Six Interim Land Cover Mapping quadrangles were completed in FY 1991 (Flaxman Island, Barter Island, and Demarcation Point, Blying Sound, Middleton Island, and Cordova) and were submitted for inclusion to the NDCDB.

Three image maps for DMA (Forts Irwin, Sill, and Rucker) and four image maps for Department of the Army (Forts Leonard Wood, Bragg, Mackall, and Benning) were completed and shipped to Eastern Mapping Center for printing. Three "Fort" maps remain in work to be completed in January 1992.

All scenes for the Central Arctic Management Area MSS mosaic have been registered and mosaicking is taking place.

Seventy-four MSS scenes and maps for control have been received from the Office of International Geology for a Pakistan mosaic project. Initial inspection of the maps indicates there is not sufficient control over the entire country, and so product accuracy will be limited. Control selection for this mosaic will start in October, 1991.

An 18-scene MSS mosaic of Burkina Faso for the International Program Section was started. Following the mosaicking, twenty-six 1:200,000-scale quadrangles will be extracted.

National Aerial Photography Program (NAPP)

NAPP imagery, to be used as a source for digital orthophoto in quadrangle production, was the subject of a meeting held at EDC in August 1991. Issues focused on the current workflow, terminology, and problems that exist in the Digital Orthophoto Production System. Participants included Eastern Mapping Center (EMC), Western Mapping Center (WMC), Division Headquarters, the SCS, and EDC. A strategy was developed to identify and resolve image quality problems. As part of that strategy, WMC identified test areas, and test images for scanning are currently being prepared. This study is being coordinated with the NAPP Program Office in Reston and the Western Mapping Center.

A new Calcomp plotter to prepare NAPP flight line plots is online and producing plots of acceptable quality.

Other NAPP activities included the development of a computerized locator system that significantly reduces the time required to process a customer search for NHAP/NAPP products, and an updated NAPP data base user manual that include several software modifications requested by the Office of Production Contract Management to facilitate inspection and reporting of black-and-white photographs acquired by the program.

Digital Data Production and Development

The FY 1991 POD goal of 94 reformatted quads of 1:100,000-scale DLG's was exceeded by 16 quads. The nine remaining projects consisting of 72 quads is scheduled for completion in the third quarter, FY 1992.

DLG-E and Standards Data Base development projects were identified. Hardware requirements, staffing levels, implementation goals, and associated costs were finalized for the five-year effort. Initial hardware and software development tool requirements were purchased to allow project planning, system design and staff training to proceed. Other associated activities included initial staffing with some existing staff members, hiring new and backfill staff personnel, and planning space, furniture, communications, and other logistics requirements. Since the project is a coordinated effort among Mid-Continent Mapping Center, Rocky Mountain Mapping Center, Reston, and EDC, project staff members continue to have heavy travel demands.

Distributed Ordering, Researching, Reporting, and Accounting System (DORRAN) Support Activities

Plans for UNIFY data base implementation of ALTOS DORRAN capabilities on Data General equipment at EDC, the Mapping Centers, and Reston Headquarters were finalized. Year-end close-out order and account processing was completed. Planning was begun on the new Landsat data base, the application of X-Windows system techniques to DORRAN, system changes to allow full edit of AVHRR product orders on DORRAN, modification of the GLIS ordering function, and updating the data base manual.

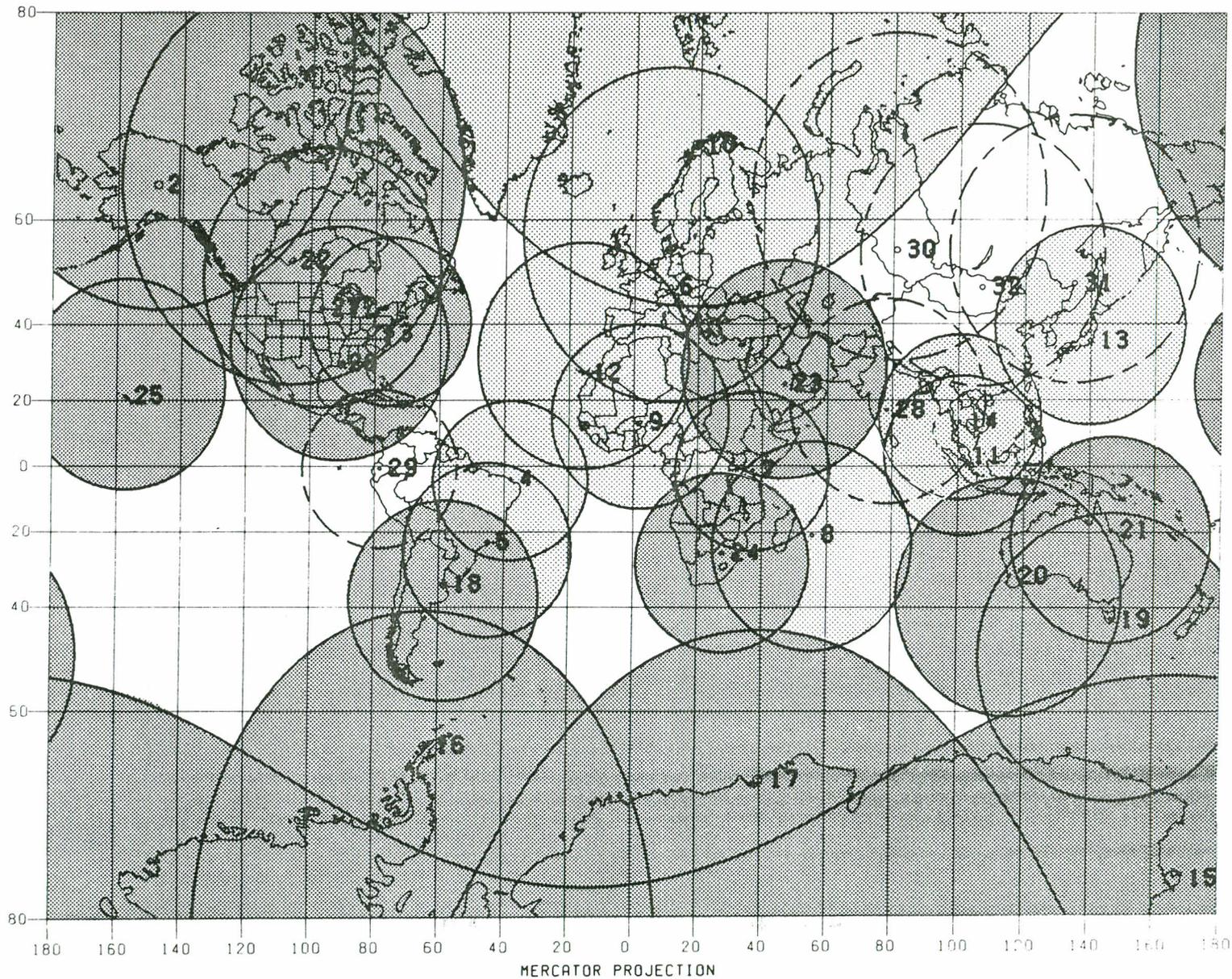
In addition, a Management Control Review (MCR) of the DORRAN was conducted in response to DORRAN's classification as a sensitive system as defined by OMB Circular A-130, Appendix III, which requires that sensitive information systems be re-certified every three years. The results of the MCR were forwarded to the Acting Chief, Office of Geographic and Cartographic Research.

Satellite Data Operations

AVHRR Data Acquisition, Processing and Archiving

Since May 1987, EDC has been receiving and archiving AVHRR data for the conterminous United States and portions of Canada and Mexico via transmissions from NOAA "TIROS" series satellites. In June 1990, EDC augmented its capabilities to receive, process, and archive AVHRR tape-recorded data which provides for worldwide data coverage. EDC currently acquires 35 to 45 scenes per day of recorded and direct-receive data, and the archive now totals over 24,000 AVHRR scenes. These data are processed for Department of the Interior land science applications and other Federal agency research projects. In addition, EDC has been meeting with the European Space Agency and others to discuss strategies for acquiring a global 1-km AVHRR data set via HRPT receiving stations worldwide, with EDC, in support of the EOS Program, serving as the central archive for the assembly of global AVHRR products. Figure 12 shows the array of HRPT receiving stations from which 1-km AVHRR data will be acquired.

GLOBAL LAND 1KM AVHRR DATA SET PROPOSED HRPT GROUND STATION NETWORK



■ U.S Geological Survey (USGS)

□ European Space Agency (ESA)

Black Dashed Lines - Ground Stations Under Consideration

Figure 12 - Global Land 1km AVHRR Data Set Acquisitions

Other accomplishments included the completion of 19 biweekly vegetation condition maps of the conterminous U.S. for the 1990 growing season and 18 of 21 planned biweekly periods for 1991, with composites and various ancillary data sets made available through the Earth Science Information Center (ESIC) network on a five CD-ROM set that is compatible with PC-DOS, Apple Macintosh, and UNIX operating system workstations. A base image prepared from AVHRR data was completed for Alaska and Mexico for use in future greenness map production requiring multi-date image-to-image registration. Processing of AVHRR greenness products of Central Asia continues along with test and research products covering the North American and African continents.

Landsat Data Acquisition, Processing and Archiving

Landsats 4 and 5 continue to operate nominally although both have far exceeded their design lifetimes. Landsat 6 scheduled for a mid-1992 launch. The National Space Council has convened a Landsat Working Group to determine how to implement the President's decision to continue a Landsat-type capability after Landsat 6. At present, there appear to be two alternatives - building a "clone" of Landsat 6 to maintain continuity and minimize the possibility of a data gap between Landsat 6 and the follow-on, and building a system with improved technology and capability, such as solid-state sensor arrays, stereoscopic imaging, and higher spatial resolution (at least 10 meters), which may result in a larger data gap.

Funding of \$17.2M requested in the FY 1992 Department of Commerce budget for Landsat 4/5 operations was reduced to \$7.5M. NOAA will attempt to recover the remaining approximately \$10M needed for operational costs for the full year through contributions from DoD, USDA, and NASA. The Land Remote Sensing Data Archiving Authorization Act of 1991 (S.230), introduced by Senator Pressler, passed the Senate and is awaiting House approval. The same language contained in S.230 is also in the 1992 NOAA House Authorization bill. EOSAT has started construction of its Norman, Oklahoma Data Receiving Facility and has installed the Landsat 6 image processing system in Lanham, Maryland.

Inventory of two-year and older Landsat MSS data was freed of exclusive marketing right restrictions by EOSAT in November 1990. The Government may now distribute these data, along with EOSAT, at cost of reproduction and distribution rather than wait until 1994, as was previously agreed.

A prototype Worldwide Landsat Catalog CD-ROM was developed and eight review copies sent to ESIC offices. These disks were developed as a potential upgrade to the current Landsat MicroCatalog distributed by the Data Center.

Several plots were produced to display the coverage of Landsat MSS data acquired between 1972 and 1978 that is stored on wide-band video tapes (WBVT). The 43,000 scenes which were transferred from WBVT to CCT's during the mid-1980's were also plotted.

IV. OTHER ACTIVITIES

South Dakota Space Grant Consortium

A State Advisory Board meeting of the NASA funded Space Grant Consortium was held in June 1991 at EDC. The focus of the Consortium is to improve the applications of space-related technology within the state; members of the Consortium are EDC, South Dakota State University and the South Dakota School of Mines. The selection of 20 scholarships, two fellowships, and three summer university faculty employees funded through the Consortium was announced. Plans were developed for the second years effort and general guidance was given by the Advisory Board.

As part of the South Dakota Space Grant Consortium, EDC hosted three professors from state universities for the summer to promote the use of space research within the state. These professors focused on geologic GIS applications, satellite noise attenuation, and radar geometry.

International Space Year (ISY) Training Course

EDC conducted an International Training Course on Remote Sensing Applications for Environmental Assessment and Monitoring during September/October, 1991. The 4-week course was organized by the United Nations as part of International Space Year (ISY) activities, and was jointly sponsored by NASA, NOAA, and the USGS. The course was attended by 25 students that were selected from over 200 applicants.

While the course was based on EDC's 28 previous international training courses (Black Hills field trip, image processing exercises, etc.), it broke new ground in the extensive use of PC's for training, and in performing smaller scale analysis using regional and global data bases. The students were recruited by the United Nations Development Program (UNDP) offices, and represented a diverse group of well-qualified and highly motivated individuals from around the world.

China Protocol

Arrangements are currently in progress for the first trip of the China Protocol tentatively scheduled from October 27 through November 9, 1991. Dr. Paul Seevers and Ms. Brenda Jones (EDC) have been designated as the visiting scientists. Discussions to be held during the visit are to finalize the report on the previous 5-year Protocol; to evaluate standards for data processing, data flows, and new data analysis techniques; and to explore methods of data processing and exchange of Landsat Metsat data for change detection and spatial data integration.

Mt. Pinatubo Eruption

Several pre-eruption satellite images at various scales have been prepared using selected SPOT and TM data. Acquisition of suitable post-eruption satellite image data is being pursued, but is hampered by persistent cloud cover. Enhanced satellite

images will be produced using post-eruption data as soon as these data become available. At such time, a DEM data set will be produced from SPOT stereo data.

Maps and Minds

EDC and the Siouxland Heritage Museum sponsored the "Maps and Minds" exhibit in Sioux Falls. The exhibit was the largest ever presented at the museum. During the six week showing, over 5,000 visitors toured the exhibit, including 1,000 children.

Professional Publications

EDC personnel contributed over 50 manuscripts for publication in professional and scientific journals, conference proceedings, newsletters and miscellaneous government reports and circulars during fiscal year 1991.

Technical Reference Unit Activities

To enhance its usefulness to EDC staff, the Technical Reference Unit (TRU) has automated many of the procedures used to retrieve and disseminate research materials. The Online Computer Library Center (OCLC) network is used to locate and retrieve materials throughout the United States. This same OCLC database is used to catalog the TRU's research collection. A four-year cataloging effort has produced a computerized listing of the TRU research collection holdings that will be placed into the South Dakota Library Network (SDLN) for automated access by EROS Data Center staff and SDLN members. With the addition of the remote sensing collection, the TRU becomes the first government entity to independently add its special collections to SDLN. The network, that is expanding to include data retrieval from North Dakota and Minnesota, promotes resource sharing and information exchange.

V. STATISTICAL DATA

Introduction

The following tables and graphs summarize the EDC's data services activities for fiscal year 1991. Included is information on sales and distribution of products and services, revenue, customer profiles, and the current holdings of the EDC archives and databases.

Information on both USGS data distributed by EDC and those Landsat products and services that are produced or processed by EDC under its agreement with NOAA and the Earth Observation Satellite Company (EOSAT) is also included.

Overview

In fiscal year 1991, EDC provided over 4.6 million dollars worth of USGS products and services (including sales from MSS data older than 2 years) and processed over 9.3 million dollars in EOSAT transactions for a total in excess of 14 million dollars. More than 15,000 user inquiries were received during the year, and over 14,000 individual orders were filled.

**FY 1991
Products and Services**

	USGS		EOSAT	
	#	\$	#	\$
Photographic Products	168,963	2,961,405	1,160	51,360
Digital Products/Processing	14,088	1,496,787	4,394	2,905,392
Reference Aids	N/A	22,098	N/A	23,187
Service Charges	N/A	N/A	3,482	126,050
Miscellaneous	1,427	184,119	2,541	6,245,103*
TOTAL	184,478	4,664,409	11,577	9,351,092

*Primarily products produced at EOSAT but billed by EDC.

Tables and Graphs

- Section I. USGS Products and Services
- Section II. EOSAT Products and Services
- Section III. EDC Archives and Databases

Section I: USGS Products and Services

This section summarizes EDC activities dealing with the sale and distribution of USGS products; i.e., exclusive of those EOSAT products produced by EDC under its agreement with NOAA and EOSAT.

In fiscal year 1991, EDC provided over 4.6 million dollars worth of USGS products and services. Of this total, 1.9 million dollars were direct repay sales and 1.6 million dollars were products and services provided through full repay EDC projects for a total of over 3.5 million dollars in reimbursables. The remaining 1.1 million dollars were for products and services distributed to users within the USGS, including EDC, other National Mapping Division centers, and other divisions of the USGS. Included in the 4.6 million dollars were sales from EOSAT MSS data greater than 2 years old totaling over \$174,000.

Tables and Graphs

- o Annual Sales Report
- o Product Profile - USGS Photographic Data
- o Customer Profile - USGS Photographic Data
- o Landsat Data Purchased for Federal Agencies by USGS via Brokerage Agreement with EOSAT

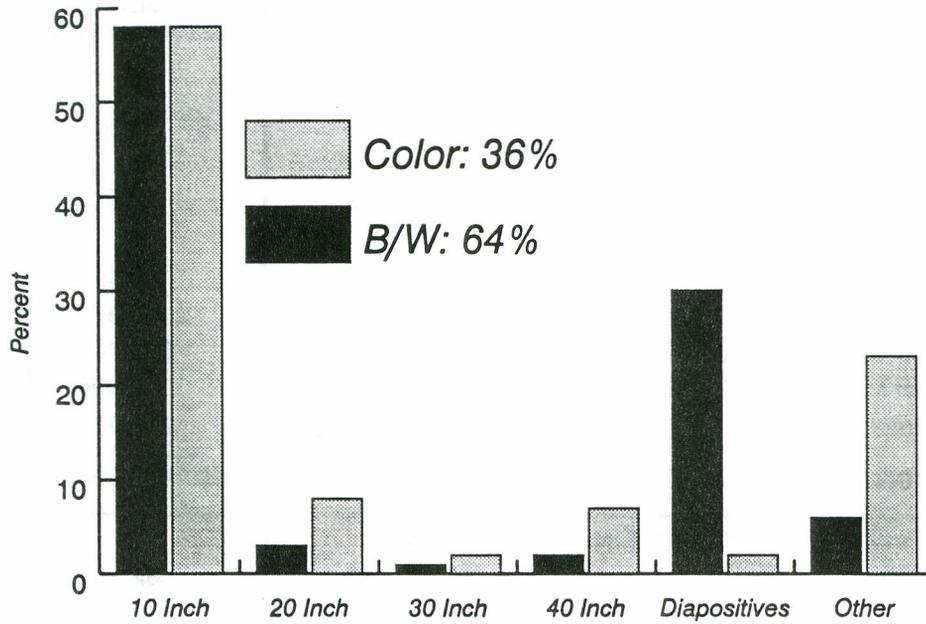
EDC Annual Sales Report

Fiscal Year 1991

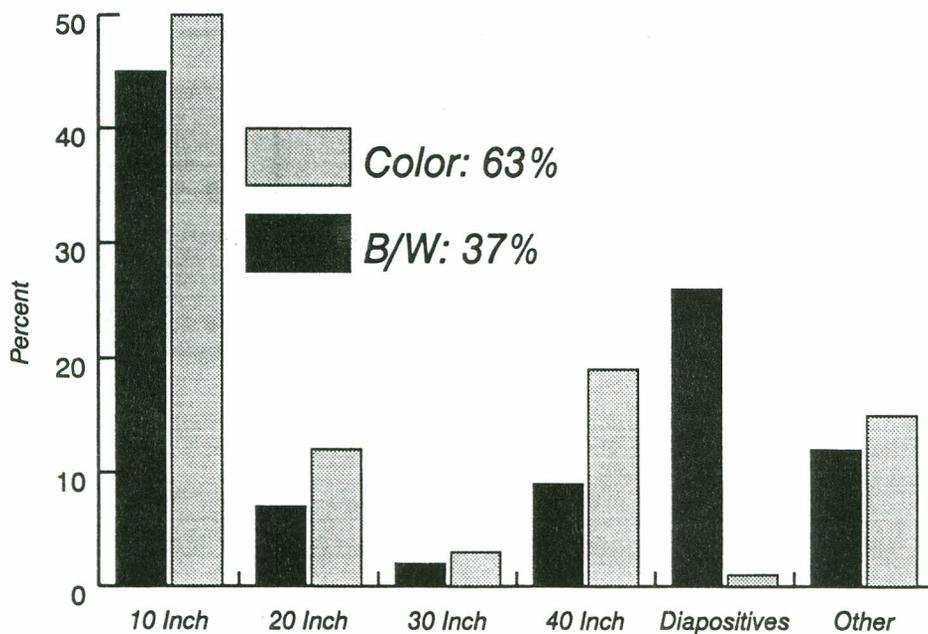
	DIRECT REPAY CUSTOMERS	EDC REPAY PROJECTS	USGS CUSTOMERS
PHOTOGRAPHIC DATA			
AERIAL			
NAPP	\$1,114,170	\$ 10,154	\$ 301,460
SLAR	15,503	0	15,617
Other	389,168	748	40,918
SATELLITE			
AVHRR	7,425	30,165	0
Other	19,927	3,379	1,031
Digital Film Recorder Products	9,440	289,700	114,880
USGS Landsat MSS Data > 2 yrs.	34,095	5,496	19,375
Other Photographic Data	56,807	289,858	192,089
TOTAL PHOTOGRAPHIC DATA	\$1,646,535	\$ 629,500	\$ 685,370
DIGITAL DATA PRODUCTS/PROCESSING			
Data Processing	22,606	562,992	179,828
SLAR	1,120	960	4,320
AVHRR	83,388	152,174	168,982
NDCDB	94,240	40	3,359
USGS Landsat MSS Data > 2 yrs.	46,200	37,520	31,800
NURE Data	11,680	0	0
Other Digital Data Products	8,900	62,811	23,867
TOTAL DIGITAL DATA/PROCESSING	\$ 268,134	\$ 816,497	\$ 412,156
MISCELLANEOUS			
Reference Aids	9,337	400	12,361
Other Products and Services	9,487	171,400	3,232
TOTAL MISCELLANEOUS	\$ 18,824	\$ 171,800	\$ 15,593
GRAND TOTAL	\$1,933,493	\$1,617,797	\$1,113,119
Satellite Data Brokerage Fees	\$ 128,420	\$ 27,225	\$ 2,381

Product Profile: USGS Photographic Data Fiscal Year 1991

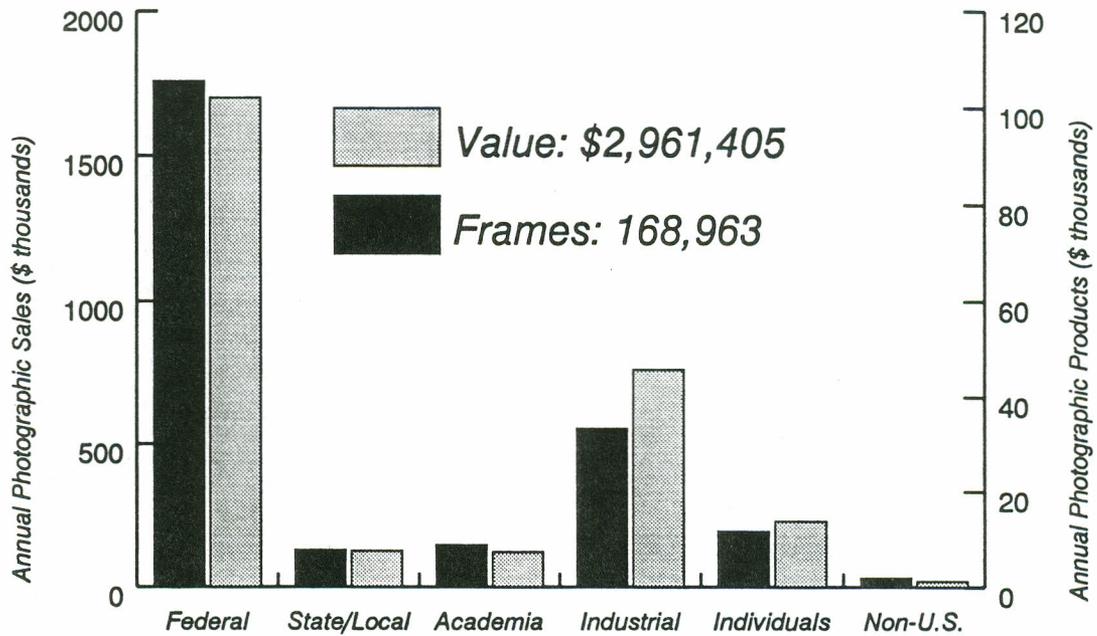
Total Frames: 168,963



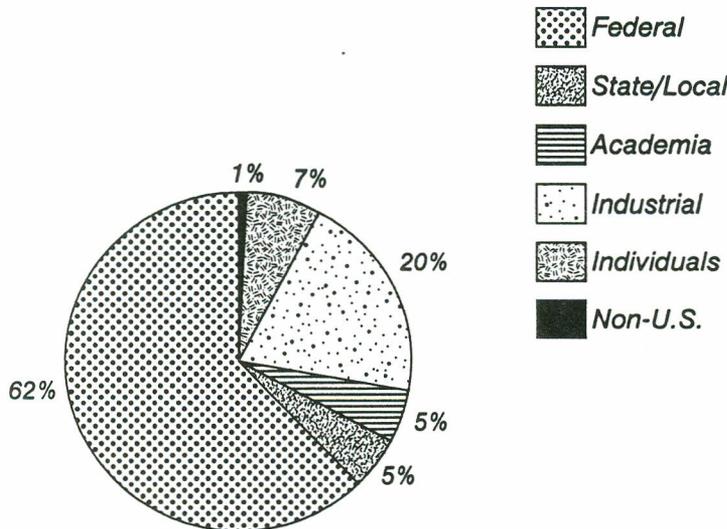
Total Data Value: \$2,961,405



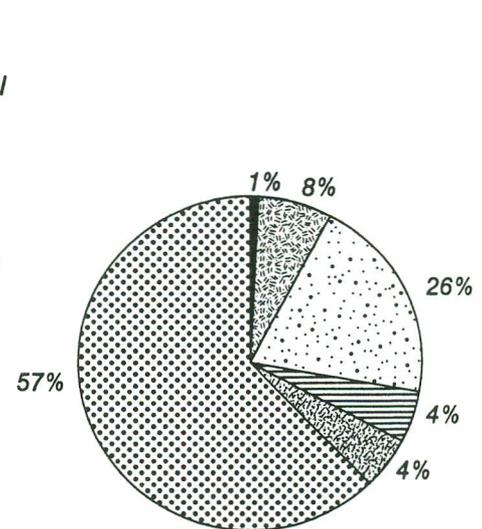
Customer Profile: USGS Photographic Data Fiscal Year 1991



Frames



Dollars



Landsat Data Purchased By USGS Via Brokerage Agreement With EOSAT Fiscal Year 1991

BROKER	ITEMS	DOLLARS
Ag/FAS/Domestic	3,810	1,331,850
Ag/FAS/Foreign	2,245	820,010
Ag/Forest Service	9	13,409
Ag/Soil Conserv. Serv.	18	52,811
CIA	410	160,919
Commerce/NOAA/NESDIS	17	93,640
Defense	218	468,867
Interior/BIA	7	26,255
Interior/BLM	2	6,410
Interior/BR	17	46,056
Interior/NPS	3	8,915
Interior/Survey	17	36,181
Interior/Survey/GD	78	71,655
Interior/Survey/WRD	13	41,431
NASA/Ames	8	22,681
NASA/GSFC	0	-345
NASA/GSFC - Science Office	15	58,715
NASA/Langley	0	750
TOTAL	6,887	\$3,260,210

Section II: EOSAT Products and Services

This section summarizes EDC activities in support of the USGS agreement with NOAA and EOSAT for the production and distribution of Landsat products and services.

Landsat sales reported in this section refer only to data distributed by EDC, or distributed by EOSAT but billed through EDC. Some Landsat products that are both produced and billed directly by EOSAT do not appear in the following tables and graphs.

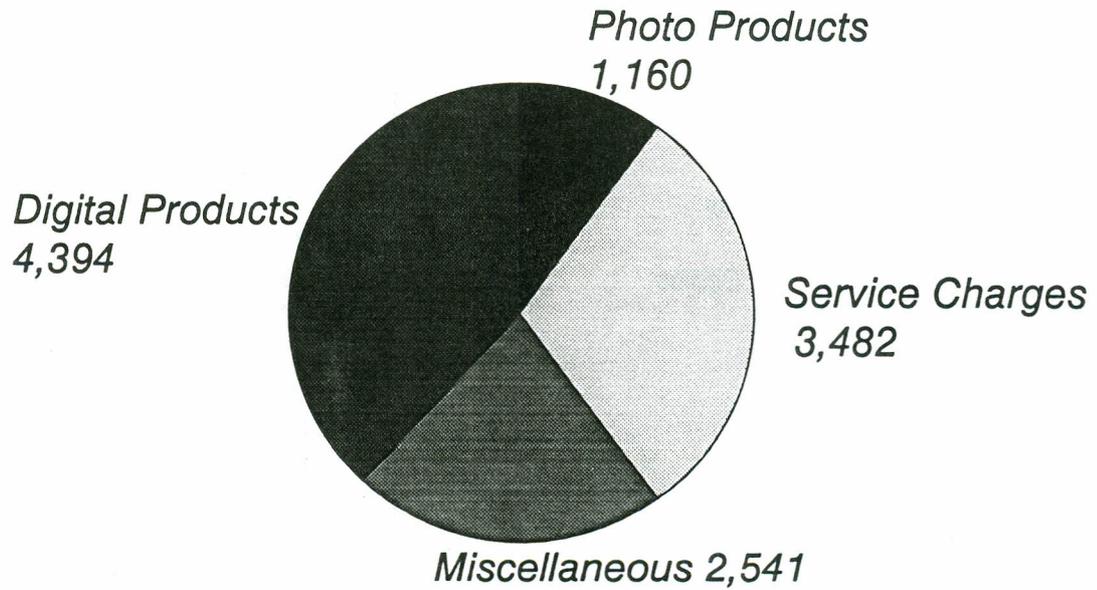
In fiscal year 1991, total revenue from Landsat products and services processed through EDC was over 9.3 million dollars. Of that amount, nearly 3 million dollars was for digital products and \$51,000 was for photographic products. A miscellaneous category, which consisted primarily of data produced and distributed by EOSAT but billed through EDC, accounted for over 6.1 million dollars. The remaining \$259,000 was for accession aids, postage charges, and service charges.

Tables and Graphs

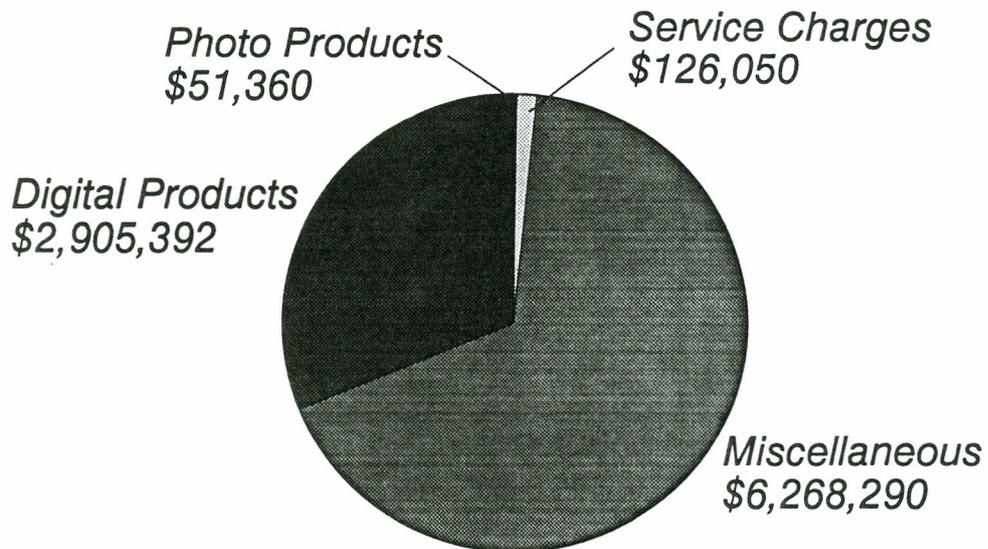
- o EOSAT Products, Services and Revenue
- o EOSAT Product Summary
- o Customer Profile - EOSAT Data

EOSAT Products, Services, and Revenue Fiscal Year 1991

Total Products/Services: 11,577



Total Revenue: \$9,351,092



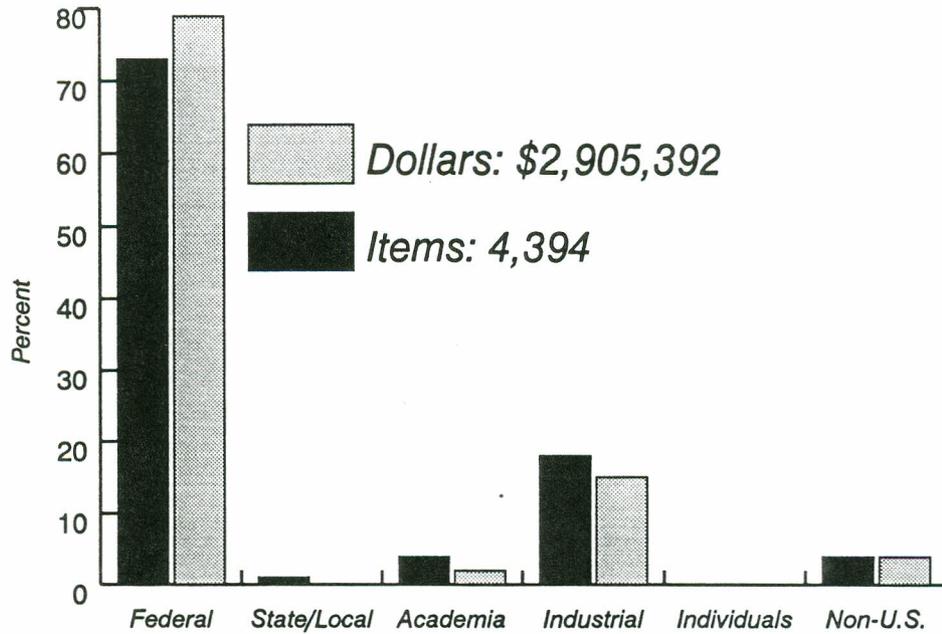
EOSAT Product Summary

Fiscal Year 1991

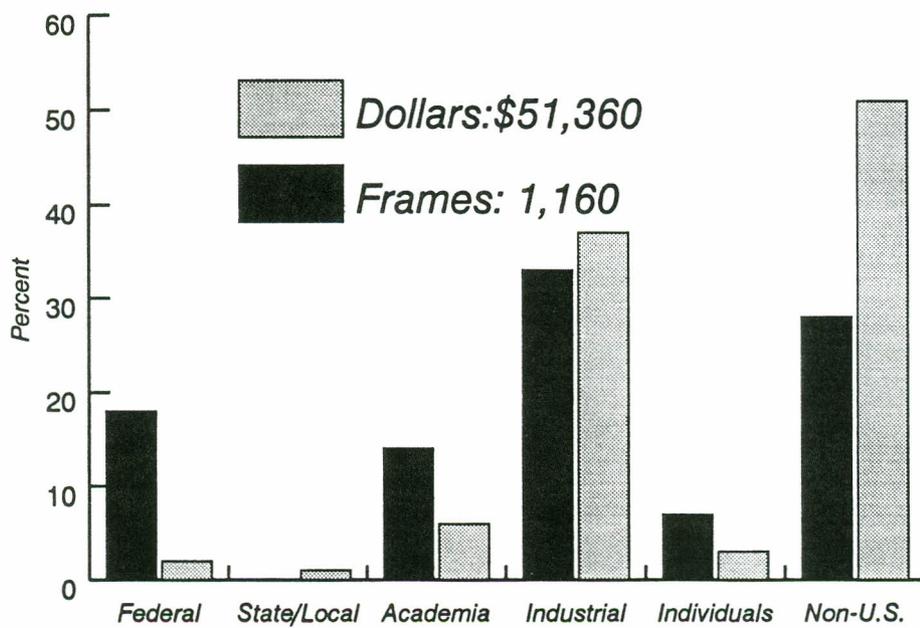
PRODUCTS/SERVICES/CHARGES	ITEMS	DOLLARS
PHOTOGRAPHIC PRODUCTS	1,160	\$ 51,360
MSS/RBV	1,114	26,070
TM	46	25,290
DIGITAL PRODUCTS	4,394	2,905,392
MSS/RBV Scenes	3,768	2,405,270
Additional MSS Copies	16	1,440
TM TIPS Quads	466	441,512
Additional TM TIPS Copies	20	1,800
TM Floppy Disks	124	55,370
MISCELLANEOUS	2,541	6,135,613
REFERENCE AIDS	N/A	23,187
POSTAGE CHARGES	N/A	39,292
SALES TAX	N/A	70,198
SUBTOTAL	8,095	9,225,042
SERVICE CHARGES	3,482	126,050
TOTAL REVENUE	11,577	\$9,351,092

Customer Profile: EOSAT Data Fiscal Year 1991

Digital Products



Photographic Products



Section III: EDC Archives and Data Bases

This section provides the status of data archives, both digital and photographic, that are maintained by EDC to preserve and reference remotely sensed, cartographic, or earth science data held by EDC. In addition, several data bases are maintained by EDC to reference or catalog data held elsewhere that is of interest to EDC customers.

As of the end of fiscal year 1991, EDC archived over 6.9 million frames of USGS photographic data and over 30,000 tapes containing USGS digital data. In addition, EDC archived over 2.8 million frames of photographic Landsat data and 110,000 tapes of digital Landsat data. The International Landsat Data Base maintained by EDC for NOAA/EOSAT referenced approximately 2.2 million scenes of Landsat data held by foreign ground stations.

Tables

- o USGS Photographic Data Archived at EDC
- o USGS Digital Data Archived at EDC
- o Landsat Data Archived at EDC
- o Landsat Data Referenced in EDC Data Base
- o Summary of Data Archived at EDC

Data Archive Report As Of September 12, 1991

USGS PHOTOGRAPHIC DATA ARCHIVED AT EDC

AERIAL PHOTOGRAPHY		
SOURCE	ROLLS	FRAMES
US Geological Survey	17,246	2,568,782
NAPP	6,598	1,021,001
Bur. of Land Management	625	124,992
Bur. of Reclamation	301	60,181
National Park Service	80	13,411
Bur. of Indian Affairs	49	9,913
TOTAL DEPT. OF INTERIOR	24,899	3,798,280
Army Map Service	1,680	213,873
US Air Force	3,377	330,211
US Navy	6,321	431,170
Corps of Engineers	82	22,924
TOTAL DEPT. OF DEFENSE	11,460	998,178
Ames Research Center	3,934	510,768
Johnson Space Center	7,622	1,009,763
Other	1,413	125,427
TOTAL NASA	12,969	1,645,958
OTHER SOURCE AGENCIES	1,995	341,171
TOTAL AERIAL PHOTOGRAPHY	51,323	6,783,587

SATELLITE PHOTOGRAPHY		
SOURCE	ROLLS	FRAMES
SKYLAB	634	44,845
APOLLO/GEMINI/APOLLO-SOJUZ	127	18,372
SHUTTLE (LFC 8 ROLLS)	864	80,685
TOTAL SATELLITE PHOTOGRAPHY	1,625	143,902

Data Archive Report As Of September 12, 1991

USGS Digital Data Archived at EDC

SOURCE	MAGNETIC TAPES
AERIAL IMAGE DATA	
NASA Data	
TMS 8-Channel Data	653
TMS 12-Channel Data	501
TIMS 6-Channel Data	202
M2S 11-Channel Data	77
AOCI 10-Channel Data	16
National Park Service	93
Side-Looking Airborne Radar (SLAR)	<u>1,368</u>
TOTAL	2,910
SATELLITE IMAGE DATA	
AVHRR	
EDC-HRPT Data	9,192
LAC Data Received via DOMSAT	10,351
LAC Data Received From Other Sources	3,108
Federally-Owned Landsat Data (FOLD)	3,246
SPOT Data	278
Department of Defense MSI Data	<u>587</u>
TOTAL	26,762
NDCDB DATA	
Digital Elevation Model (DEM)	76
1:2 Million Digital Line Graph (DLG)	<u>4</u>
TOTAL	80
EARTH SCIENCE DATA	
National Uranium Resource Evaluation(NURE)	958
Geophysical Research Program	<u>14</u>
TOTAL	972
TOTAL DIGITAL HOLDINGS	30,724

Data Archive Report As Of September 12, 1991

Landsat Data Archived at EDC

PHOTOGRAPHIC DATA	ROLLS	FRAMES
MSS 70 MM Film, Landsat 1,2,3	7,708	1,342,187
MSS 9" B&W Film	9,447	1,280,024
TM 9" B&W Film	2,968	177,118
MSS Color Composites	N/A	18,136
TM Color Composites	N/A	<u>1,866</u>
TOTAL	20,123	2,819,331
DIGITAL DATA	1/2" Mag.Tapes	HDT's
MSS	43,546	31,970
TM	<u>34,758</u>	
TOTAL	78,304	

Landsat Data Referenced In EDC Landsat Data Base

LOCATION	SCENES
DATA HELD IN U.S. BY EOSAT AND/OR EDC	
MSS/RBV	773,868
TM	<u>175,418</u>
TOTAL	949,286
DATA HELD BY FOREIGN GROUND STATIONS	
Argentina	10,790
Australia	210,671
Brazil	85,889
Canada	529,507
Earthnet (Europe)	587,248
Italy	492,720
Japan	177,860
Pakistan	7,839
South Africa	65,857
Spain	<u>26,903</u>
TOTAL	2,195,284

Data Archive Report As Of September 12, 1991

Summary of Data Archived at EDC

PHOTOGRAPHIC DATA	FRAMES
AERIAL	6,783,587
SATELLITE	143,902
LANDSAT	<u>2,819,331</u>
TOTAL	9,746,820

DIGITAL DATA	MAGNETIC TAPES	HDT's
AERIAL IMAGE DATA	2,910	—
SATELLITE	26,762	—
NDCDB	80	—
EARTH SCIENCE DATA	972	—
LANDSAT	<u>78,304</u>	<u>31,970</u>
TOTAL	109,028	31,970

EROS Data Center
U.S. Geological Survey
National Mapping Division
Sioux Falls, SD 57198
(605) 594-6511
FTS 753-7511