Office of Research and Applications

Leadership in Environmental Remote Sensing Research: A Strategic Vision

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service

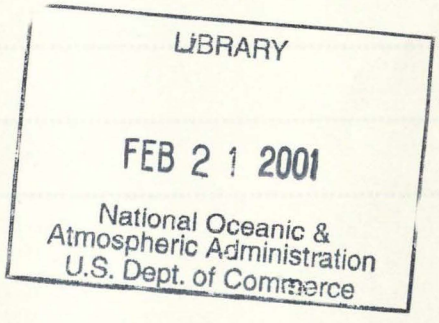
Office of Research and Applications
SIGNIFICANT RESEARCH ACHIEVEMENTS

- 1961 - ...nch of TIROS I (Visible, TV ...ges)
- 1961 - ...ephanalysis (Analysis of Cloud Type and Distribution)
- 1962 - First Measurement of the Earth's Radiation Budget (ERB) from TIROS
- 1965 - First Calibration Device for Vidicon Cameras Developed
- 1966 - First Analysis of Northern Hemisphere Snow and Ice Coverage
- 1966 - First Cloud Motion Winds from Movie Loops of Geostationary (ATS) Satellite Data
- 1968 - Development of the First Prototype Sounder Instrument (SIRS) to Fly On-board a Satellite (Nimbus)
- 1968 - Operational Processing of Satellite Cloud Climatologies
- 1969 - Tropical Storm Intensity Classification
- 1969 - First Vertical Profiling of Atmospheric Temperature and Moisture from Satellite Sounders
- 1970 - First Demonstration of Sea Surface Temperature (SST) Measurement from Satellites
- 1971 - First Ocean Color Experiment Conducted with ERTS-1
- 1972 - Special Satellite Units Established at National Meteorological Centers
- 1972 - Automated Picture Pair Winds Become Operational
- 1972 - Implementation of First Operational Satellite Sounding System
- 1972 - Urban Heat Islands Detected in Satellite Data
- 1972 - Global Ocean SST Observations (GOSSTCOMP) Operational
- 1974 - First Comprehensive Guide to Satellite Imagery Interpretation
- 1974 - First Geostationary Meteorological Satellite Launched (SMS-1)
- 1974 - Operational Production of Earth Radiation Budget Product
- 1974 - Differential Heating/Thunderstorm Forecast Technique Developed
- 1974 - Fog Dissipation Technique Developed
- 1974 - First "Nowcasting" Experiment
- 1975 - First Geostationary Operational Environmental Satellite (GOES)
- 1975 - Enhancement Curves for Infrared Imagery Developed
- 1975 - First Rapid Scan Imaging from GOES
- 1975 - Satellite Precipitation Estimates
- 1975 - GOES Data Monitors Freezing Temperatures in Florida Citrus Areas
- 1976 - Thunderstorm Arc Cloud/Gust Fronts Identified in Satellite Data
- 1978 - Global Satellite Winds Produced for the First GARP Global Experiment
- 1978 - Implementation of the TIROS Operational Vertical Sounder (TOVS) Sounding System
- 1978 - First Ozone Measurement from TOVS
- 1979 - Methodology Developed for GOES Solar Radiation (Insolation) Estimates
- 1979 - Analysis Techniques for Phytoplankton Concentrations from the Coastal Zone Color Scanner (Nimbus 7) Developed

Cover: The sphere that appears on the cover of this report is composed of images that illustrate various research projects and activities of ORA. Front Cover, left to right, top to bottom: GOES Visible Image, Eastern Sector; Antarctic Ozone Distribution; Global Sea Surface Temperatures (SSTs); Coastal SSTs; Oceanographic Research Vessel; Instrumented Research Aircraft; Snow-covered Palmer Pennisula; and the Mt. Pinatubo Eruption. Above: Launch of a NOAA Satellite.

Office of Research and Applications

LEADERSHIP IN ENVIRONMENTAL REMOTE SENSING RESEARCH: A STRATEGIC VISION



March 1993

National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service

PREFACE

In June 1992, the Director of the NESDIS Office of Research and Applications (ORA) convened the staff of ORA for a strategic planning work session at Andrews Air Force Base, Maryland. The purpose of the session was to establish a consensus from which ORA could create and develop new remote sensing technologies, products, and management approaches to provide essential remote sensing services to the Nation for environmental monitoring and prediction. ORA recognizes that it must keep pace with the steady increase of new satellite systems and Earth applications of space technology through the next decade. To meet its mission ORA will stress basic and applied research, the development of innovative remote sensing products, the education of its scientists, and the exchange of knowledge and technology. ORA will aggressively confront the challenges of the Earth's environment such as ozone depletion, climate change, and the health and productivity of the land and ocean.

ORA aims to provide leadership in remote sensing services to the Nation to assure public safety, improve the Earth's environment, and manage our oceans and fisheries. This strategic plan outlines the initial steps to enable ORA to continue its leadership and long history of success in remote sensing research and development and ensures a continuum of high quality advanced products to support the monitoring and management of the Earth's environment from space. ORA will work rapidly to create a detailed plan to implement activities to accomplish its goals.

Strategic Planning Committee

Rao Achutuni, Michael Chalfant, Robert Dennis, Frances Holt, Herbert Jacobowitz, Donald Miller, Karl Pechmann, John W. Sherman III, Robert Stockman, Carmella Watkins, and James Zaitzeff with contributions from all the members of the NESDIS Office of Research and Applications. Publication Production by Paige Bridges and Lori Paschal.

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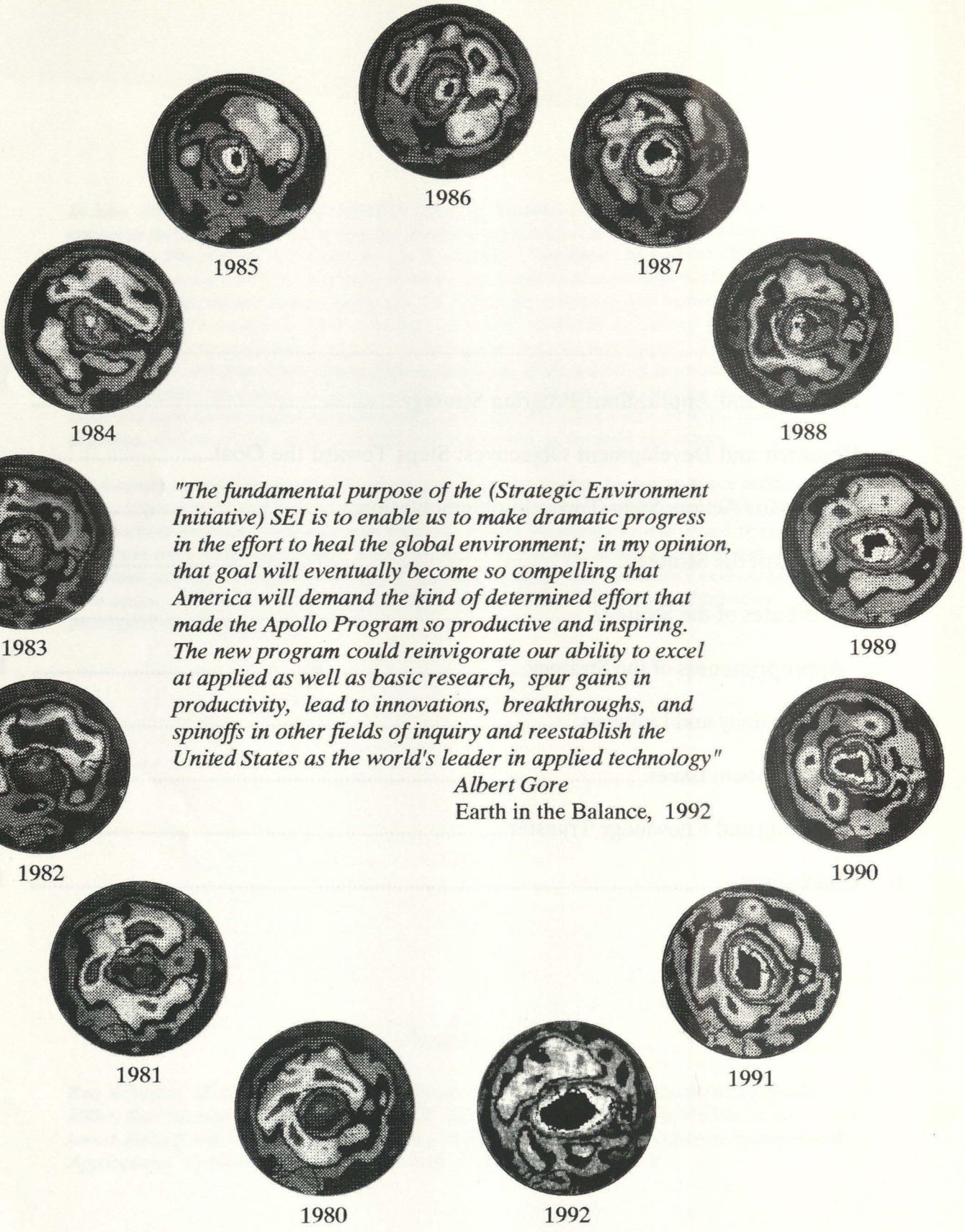


"The fundamental purpose of the (Strategic Environment Initiative) SEI is to enable us to make dramatic progress in the effort to heal the global environment; in my opinion, that goal will eventually become so compelling that America will demand the kind of determined effort that made the Apollo Program so productive and inspiring. The new program could reinvigorate our ability to excel at applied as well as basic research, spur gains in productivity, lead to innovations, breakthroughs, and spinoffs in other fields of inquiry and reestablish the United States as the world's leader in applied technology"

Albert Gore
Earth in the Balance, 1992

Thirteen years of data from NOAA's polar-orbiting TIROS Operational Vertical Sounder (TOVS) show the decrease in protective stratospheric ozone over Antarctica. The central black spot represents the lowest total ozone values.

LEADERSHIP IN ENVIRONMENTAL REMOTE SENSING RESEARCH: A STRATEGIC VISION

1. ORA TODAY

The launch of the Tiros-1 satellite in 1960 established for all the world, a new era in environmental monitoring. This satellite, primitive by today's standards, provided televised images of the ocean, ice cover, and weather systems from a totally new perspective. It was now possible to monitor the Earth in an interrelated manner at different scales of space and time. Since 1960, the United States has spent billions of dollars on space technology to acquire remotely sensed data for operational and research use. As a result, the large array of operational sensors and spacecraft in flight today have now made that vision a reality.

The Office of Research and Applications (ORA) supports the mission of the National Oceanic and Atmospheric Administration (NOAA) and the National Environmental Satellite, Data, and Information Service (NESDIS) to provide operational observations from environmental satellites to describe and predict our dynamic Earth system.

ORA began as a small group of scientists who examined the early images from space, developed algorithms for computing environmentally meaningful parameters from satellite-observed radiances, and designed improved sensors. Today, over one hundred scientists and support personnel conduct research to develop algorithms for the application of satellite data to environmental monitoring and prediction. Research results and applications developed over the last thirty years are the operational sensors and products of today.

ORA also participates in the development of future spacecraft sensors and conducts a vigorous program of calibration and validation of satellite data to ensure high quality products. To assure that research results are available to operational forecasters and environmental scientists and managers, ORA conducts a robust program to transfer research results to the operational and user community through training workshops at domestic and international sites, publication in scientific journals, and presentations at scientific meetings.

Since the inauguration of satellite remote sensing of the Earth, NOAA's investment in applications research and development has been a very small percentage (less than 1%) of the total cost of the programs. This investment has resulted in the development of products such as sea surface temperature observations, atmospheric soundings of temperature and moisture, animated geostationary imagery, cloud drift winds, and precipitation estimates that operational users rely on every day. These products have continually evolved over two decades of production. The path from conception and design of new sensors to spacecraft flight typically takes a decade. However, ORA is able to utilize these sensors to provide new or improved products in a much shorter time span, usually 1 to 5 years. To ensure that NESDIS produces the highest quality products possible during the development process, ORA continuously updates product and processing

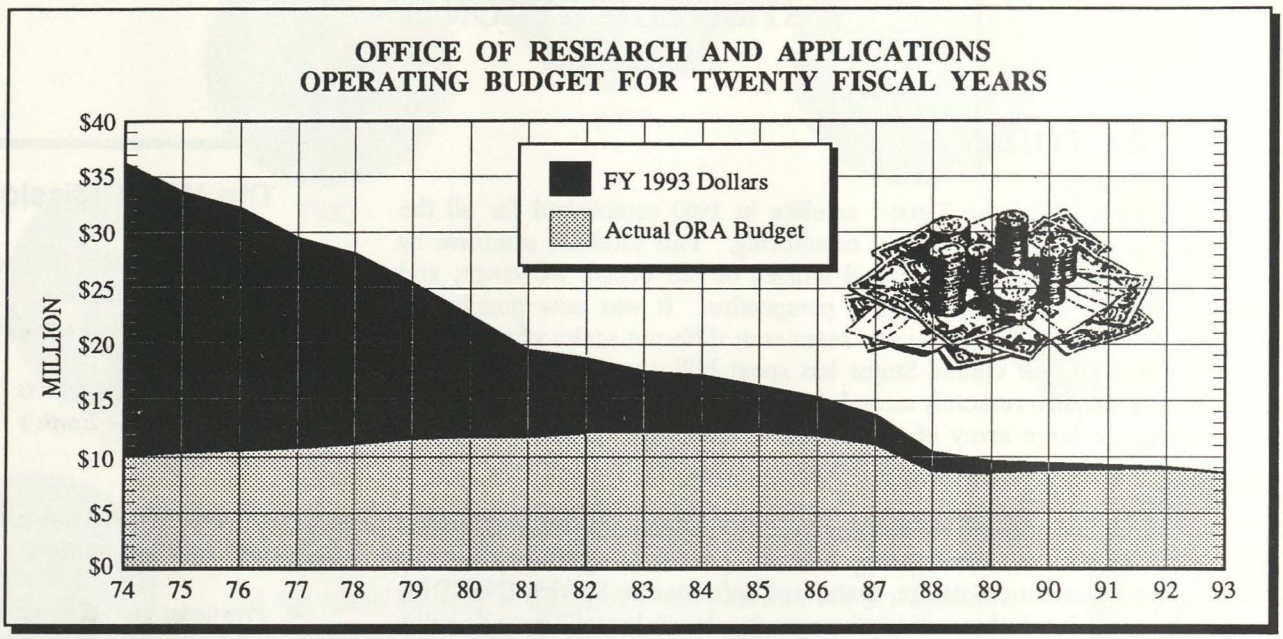
The NOAA Mission

NOAA, the Nation's oceanic and atmospheric agency, through science and service:

- *Describes and predicts changes in the Earth's environment*
- *Manages the Nation's ocean and coastal resources*
- *Promotes global stewardship of the world's oceans and atmosphere.*

To fulfill this mission, NOAA

- *Conducts oceanic and atmospheric research to improve environmental products and services*
- *Develops and maintains environmental data bases and disseminates environmental information products*
- *Manages the marine environment*
- *Protects habitat and endangered species*
- *Operates environmental satellites, ships, aircraft, and buoys.*



Operating budget for the Office of Research and Applications for 1974-1993. The gray area represents actual dollars and the dark area represents the purchasing power of this budget based on 1993 dollars.

"Perhaps the greatest impulse to trying to foresee and plan the future comes from the combination of having new tools with which to do it and the growing realization that every technological and social innovation has repercussions which spread like a wave through the complex interlocked sections of society" ---Ward Madden

algorithms. ORA also modifies sensor algorithms to compensate for changes due to spacecraft aging or replacement or to correct for natural climatic variation, such as that caused by aerosols from the eruption of Mt. Pinatubo.

NESDIS operates the largest civilian space-based remote sensing program in the world. Japan, Europe, Russia, India, and China all have successfully launched environmental satellites, each with unique sensors and observing missions. ORA has a long tradition of collaboration on research projects with foreign agencies and scientists. This collaborative effort provides a framework for the continued sharing of resources and knowledge among NESDIS' international partners. The exchange of information through on-site study visits provides a cost-effective mechanism that aids NESDIS in processing and applying these data for environmental monitoring.

2. RESEARCH AND APPLICATIONS PROGRAM STRATEGY

ORA's mission is to conduct a balanced program of research and applications development to serve the community of satellite data users. Although the user community within NOAA may set the priorities for ORA's scientific work, users outside of NOAA may influence a significant portion of our development effort. In developing this strategic plan, we address the overall goal of a balanced research and applications development program from five essential elements:

- a clear understanding of the mission of ORA within NESDIS and NOAA programs
- cognizance of the technical scope of development efforts and the user base for ORA products for the allocation of ORA research and development (R&D) resources
- ready access to scientific data
- adequate high level computing resources that will allow ORA to fulfill its R&D mission
- attention to special problems within the existing ORA environment and incorporation of remedies into the strategic plan.

The overall goal of ORA is to address the problems unique to the remote sensing of the environment from satellites. ORA's R&D plans for gathering satellite and supporting data for the development of algorithms must also consider the requirements of other NOAA Line Offices (LOs).

Our Strategic Vision is to lead research and develop advanced applications for environmental satellite technology.

The fundamental concept behind ORA is enablement. Our function, historically and for the foreseeable future, is to conduct the research needed to develop products used by operational practitioners, scientists, and environmental and political managers. These products help users to effectively interpret data from the U.S. Polar-orbiting Operational Environmental Satellites (POES) and the Geostationary Operational Environmental Satellites (GOES).

ORA has developed a long succession of products that have returned substantial benefits to the Nation. Products of ORA's science have made pre-eminent contributions to environmental monitoring. These include rapid scan imaging for improved forecasts and warnings of flash floods, severe local storms, tropical storms, and hurricanes. Cloud drift winds and satellite temperature soundings contribute to improved numerical weather prediction. In addition, ORA scientists have also developed products to monitor global ozone, aerosols, precipitation, vegetation condition, drought, and sea surface temperature from NOAA's satellites; these serve a diverse user community ranging from the fisherman to the climatologist.

To continue this program, ORA plans a rigorous effort to build upon its success in the development of new and innovative applications of remote sensing for the Nation. ORA's diverse R&D programs include the following:

- designing and developing instrumentation and calibration procedures for satellites

The NESDIS Mission

The National Environmental Satellite, Data, and Information Service

- *Administers an integrated program for the development and use of all operational civilian satellite-based environmental remote sensing systems*
- *Designs, develops, and operates a series of civilian satellite systems for observing the land, ocean, atmosphere, and the sun*
- *Processes and distributes satellite products and services to domestic and foreign users on a routine basis*
- *Administers the national and international acquisition, processing, dissemination, and exchange of environmental data*
- *Archives and analyzes environmental data from satellites and other sources for use by government, commerce, industry, the scientific and engineering communities, and the general public*
- *Manages the climatological, oceanographic, geophysical, and environmental data for the Nation.*

- developing algorithms to convert measured radiances into useful parameters for numerical weather prediction and climate monitoring
- designing applications for the weather forecaster, the agricultural practitioner, and the marine scientist
- distributing information to managers responsible for the coastal resources or those concerned with public safety
- transferring research results into operations through publications and training.

"We place very great weight on the intrinsic value of basic science, out of which has flowed extraordinary and often unanticipated benefits to society, including enormous enrichment of the human spirit" --- John Gibbons, Science Advisor to President Clinton

To date, ORA has directed most of its efforts toward climate and weather forecasting studies. Marine research has been limited and focused primarily toward image analysis and ocean color measurement for coastal applications or evaluation of climate scale events, such as those associated with El Niño-Southern Oscillation and sea surface temperature trends. ORA needs, as does any healthy organization, to establish a plan for future resource acquisition and funding for directed research. We must balance our satellite research and development to maximize the continuing national investment in the POES and GOES programs and to take advantage of environmental data from other domestic and foreign satellite programs.

ORA also needs to expand the breadth of its research and applications development to include new and improved products for the scientific community and informational products for broadcasters, natural resource organizations at the state and local government level, environmental organizations, and the general public.

3. RESEARCH AND DEVELOPMENT OBJECTIVES: STEPS TOWARD THE GOAL

Space-based remote sensing provides a unique perspective for observing, as a whole, the interrelated solar, atmospheric, oceanographic, and land processes of the Earth. The importance of observing the Earth's system is clearly indicated by the plans set forth by a number of the world's industrialized countries to invest billions of dollars in satellite systems to better monitor our environment. These platforms will carry new sensors that will provide revolutionary measurements of our ocean, land, and atmosphere and extend our understanding of the complex processes at work in the environment.

Opportunities for research and new products abound and are only limited by our own curiosity. However, the potential volume of data to be handled by ORA scientists from future systems dwarfs what is available today. ORA's precedent in capitalizing on the lastest advances in satellite technology speaks confidently about ORA's ability to lead the Nation's effort in exploiting environmental remote sensing in the future. However, without a strategic vision of research objectives, these data will be under-utilized, and advances in NOAA's environmental monitoring and prediction programs will be limited. Full return on the very expensive investments in satellite observing

technologies will require a mere fraction of these investments to be used for applications research, development, and demonstration.

The overall criteria for selecting ORA objectives are those that

- serve the operational and scientific communities by providing meteorological, oceanographic, and terrestrial products
- meet the R&D challenges presented in the next five years by new satellite systems and sensors
- transfer research advances and techniques to NESDIS operations when needed
- consider and involve other government agencies, academia, and the private sector to optimize the scientific benefits of the study of environmental satellite data.

ORA has identified seven objectives to improve the remote sensing research program of NOAA and NESDIS in relation to the historical record and future satellites. Each of these objectives affects critical scientific and societal issues and impacts strongly on issues of national security and policy. These objectives are the initial steps that will posture ORA to meet its primary goals of the Strategic Vision.

Objective 1. Increase the Recognition of ORA Capabilities

ORA has a rich heritage of leadership in environmental remote sensing. Success is reflected in the multitude of operational products available today. However, ORA's expertise, activities, and invaluable contributions are not clearly understood or utilized by other elements of NOAA. Numerous publications or publicity events that feature satellite imagery or products developed by ORA fail to credit ORA for the satellite enhancements or derived algorithms that were used. ORA must make every effort to remedy this situation. Clearly, with global remote sensing as its forte, ORA can take leadership in building bridges and contributing to all NOAA programs.

Strategic Goal: Increase ORA visibility, participation, and recognition within NOAA and the scientific community.

Objective 2. Acquire Critical Technology to Insure ORA is a Technically Relevant Research Facility

NOAA has some of the most powerful computers in the world, necessary for the analysis of problems in fluid dynamics for weather and oceanic forecasting. ORA, in developing algorithms for use by NOAA's

The ORA Mission

NESDIS Office of Research and Applications

- *conducts an integrated program of research and technology development in the uses of satellite data to support operational requirements of NOAA*
- *coordinates NESDIS Earth science and satellite experiments*
- *assesses the requirements of the remote sensing community and incorporates these in the activities and goals of the research and applications programs*
- *provides expert services to other NESDIS offices regarding sensor development, instrument problems, or systems hardware components*
- *represents NESDIS in coordinating remote sensing research activities with appropriate NOAA elements or other U.S. Government or international agencies*
- *interacts with the academic community through NOAA/university cooperative institutes to provide a mechanism for research collaboration in scientific areas of mutual interest.*

National Weather Service (NWS) and NESDIS operations, must develo software for products that are compatible with these computers and, in ma cases, must treat the same family of equations, or similar expressions, in i research and applications tasks. We must connect with NWS and NESDI operations both conceptually and physically in order to achieve the corre degree of support. ORA must address the following:

- Automated Data Processing (ADP) requirements for compatible computational power
- management of the appropriate computer environment for research and development efforts
- interconnectivity between ORA scientists and other LOs, Federal agencies, and academia
- establishment of technical relevancy essential to maintaining a premier remote sensing research facility.

"We simply cannot be competitive unless we in the federal government play a significant role in the development of enabling technologies." ... Dr. D. Allan Bromley, Science Advisor to President Bush

ORA's fundamental service is the support of satellite data use. Hardware and software for imaging and processing are critical to the attainment of ORA goals. Hardware and software technology changes rapidly, and ORA scientists must have state-of-the-art capabilities available to them to fully utilize the information and make detailed analyses of the content of the satellite data. Speed, resolution, visualization, and flexibility of display are critical to this work. Scientists also must have access to large data sets and the computational capabilities to test new algorithms efficiently. High speed workstations with advanced graphics and processing packages are important tools for modeling and impact studies of the environment.

ORA scientists require routine access to the NOAA and NESDI mainframes to retrieve the data for their area of study or to participate i validation studies and impact tests with other NOAA components. I addition, ORA administrators must interconnect with NESDIS and NOA management. Interconnectivity, particularly within the NOAA family, wou facilitate communication among managers, scientists, and administrati personnel. Compatibility within ORA would result in more efficient use satellite and other observational data sets, software, and peripherals.

Steps toward interconnectivity have been made with the installati of several communications systems. However, data transfer is slow an laborious. Further, processing of R&D programs takes a secondary plac behind operational data processing requirements. Advanced workstations and a dedicated computer facility would allow ORA to more effectively carry out test and evaluation functions necessary for product improvement and development in preparation for operational implementation.

Consolidating all ORA offices into one location would enhance communication and accelerate scientific efforts. ORA presently has employees in four locations: two in the Washington area, one in Fort Collins, CO, and one in Madison, WI. Bringing ORA scientists together periodically to exchange expertise, discuss ideas, and address concerns of our primary NOAA clients would be mutually beneficial and would expedite development activities.

Strategic Goal: Establish an ADP Unit within ORA responsible for planning, maintaining, and upgrading computer systems and training ORA employees in systems usage.

Objective 3. Expand ORA Efforts in Oceanic Remote Sensing

The ocean and atmosphere are closely linked in determining the Earth's weather and climate. The oceans play a crucial role in our lives on Earth. Our ability to better understand and predict ocean processes depends on global measurements of ocean parameters that are now becoming available through new satellite sensor technology.

Single and multichannel satellite sensors to measure ocean color, surface winds over the ocean, wave height, sea ice, sea surface temperature, circulation, and topography provide important environmental information that affects national and social goals and the establishment of environmental policy. This information serves as a basis for decisions affecting public safety, climate change, environmental management, and defense. We have become dependent on knowledge of sea surface temperature fields for weather prediction models, for long-term diagnostics of environmental events, and for the evaluation of the health of our coastal and estuarine waters.

ORA anticipates receiving high-resolution, high-volume marine satellite data from the next generation of Earth observing satellite systems such as the European Space Agency's ERS, the U.S./Japan ADEOS/NSCAT, the U.S./France TOPEX/Poseidon, Canada's Radarsat, and the U.S. SeaWiFS. The multichannel measurements from these sensors are critical for advancing our understanding of the role of the oceans in climate and global change, marine winds, coastal pollution, primary productivity, fisheries recruitment, and ocean circulation. The data volume from these systems will more than double, resulting in an even greater increase in computational and data management complexity.

ORA is in a unique position to focus the development of remote sensing technology to address the environmental and monitoring issues for NOAA. ORA has a long history of innovative oceanic remote sensing research and technology development covering the basic subdisciplines of oceanography. Creation of an Oceans Laboratory within ORA would provide a stronger oceans program. It would also enable NESDIS to capitalize its resources to develop an enhanced oceanographic products suite incorporating data from the constellation of new satellite systems focused on the collection of marine observations.

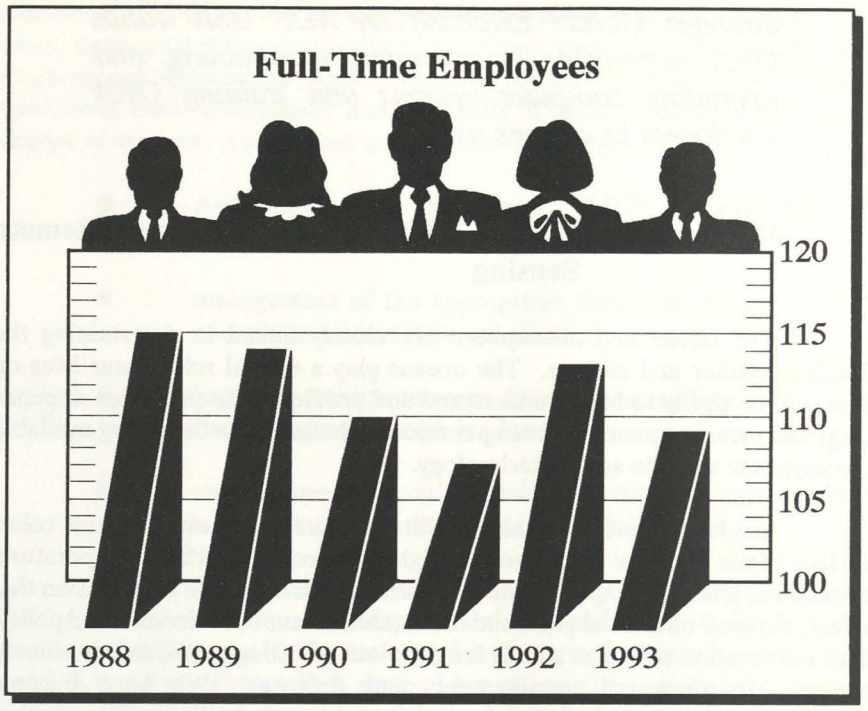
Strategic Goal: Build a vital program in oceanic research designed to fulfill needs for critical measurements to better understand and predict ocean processes.

ORA Oceanic Research Programs

- *Satellite Data Calibration and Validation*
- *Bio-optical Instrument Development*
- *Application Demonstrations*
- *Algorithm Development*
- *Advanced Airborne Instrument Development*
- *Microwave Technique Development*
- *Upwelling Dynamics*
- *Improved Atmospheric Corrections*
- *Coastal Marine Product Development for Environmental Management*
- *Coastal Numerical Hydrodynamic Predictive Models*
- *Analysis, Forecasting, and Climate Applications*
- *Sea Surface Temperature*
- *Ocean Color and Productivity*
- *Winds, Waves and Circulation*
- *Sea Ice*

ORA Climate Research Programs

- *Earth Radiation Budget Monitoring*
- *Cloud Climatology*
- *Vegetation Index*
- *Atmospheric Aerosol Distribution*
- *Global Precipitation Estimates*
- *Ozone Monitoring*
- *Surface Radiation Budget*
- *Drought Monitoring*
- *Global Deforestation and Fire Detection*
- *Urban Heat Islands*
- *Sea Surface Temperature Trends*
- *Snow and Ice Distribution*
- *Pathfinder Data Sets*
- *Long-term In-Orbit Sensor Calibration*
- *Atmospheric Deep Layer Temperature Determinations*



Staffing levels of the Office of Research and Applications from 1988-1993.

Objective 4. Foster a Management Style to Encourage Risk-Taking and Creativity

Innovation and creativity are vital elements in any R&D organization. Encouragement of risk-taking remains at the heart of successful research programs. Innovation involves new perceptions by groups of individuals; creativity is an idea or object proffered as new by an individual. In this technology-based organization, the trend is innovation. The need for understanding and managing innovation should be widespread.

NOAA has offered a mandate for each component to attract "the best and the brightest." In the next two years, 29% of ORA will be eligible for retirement. In the next five years, 39% of the existing workforce will be eligible to retire. In order to maintain the vitality and health of the organization, ORA must consider mechanisms for replacing those employees with a diverse and vigorous workforce so that viable research will continue.

ORA must increase its understanding of systematic innovation. Methods and values of teamwork, cooperative approaches to research and applications development, and recognition of accomplishment must be stressed. Innovation and creativity in an organization enhance positive communications with other agencies, strengthening the relationships for scientific cooperation and generating more technical contributions to the scientific community. As the capacity for change in an organization increases, opportunities arise. An open communicative attitude increases information

available to employees, simultaneously increasing the productivity gained from that information. The same approach to inter-LO, interagency, and international projects will result in more effective interfaces with other NOAA offices and with sources outside the organization.

Strategic Goal: Adopt a management style that facilitates the creative process to maximize ORA's capabilities to meet its goals.

Objective 5. Improve Availability of Satellite Data Attuned to Users' Needs

National requirements for environmental data clearly indicate that ORA needs to direct critical attention towards improving the availability of satellite data. An end-to-end satellite system must be developed if NOAA is to meet its objective of becoming the Earth system agency.

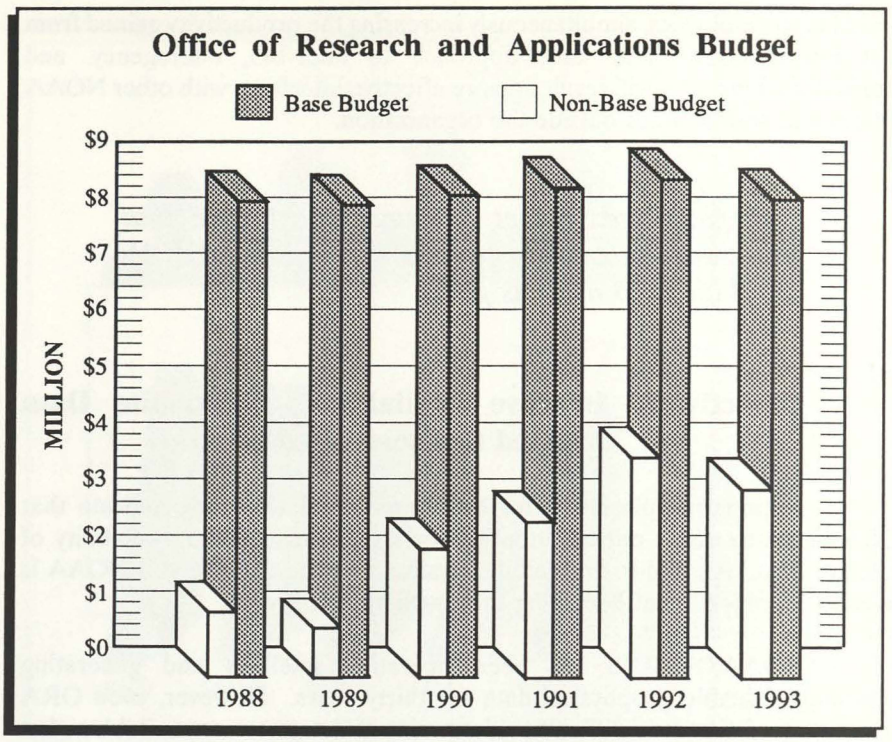
NOAA/NESDIS has been operating satellites and generating extremely valuable geophysical data for thirty years. However, even ORA scientists find that it is difficult to determine if data sets are available, what format they are in, and how to access these data. In addition, many scientists have additional difficulties in using the data for their particular studies. The National Academy of Sciences stated "that in an increasingly computerized environment there has not been sufficient attention paid to making software tools available and usable to the scientist or engineer in the context of his/her working environment." NOAA must provide potential users more information so that users can aptly apply the information from satellite data to solve their problems.

NOAA's archives of satellite data contain raw remote sensing observations such as radiances as well as derived products. The derived products consist of geophysical parameters that are computed from the raw observations by means of processing algorithms. One may divide the user community into two parts: the remote sensing specialist and the scientist, who is less sophisticated in the processing and use of this data. The non-remote sensing specialist will benefit most from satellite data.

Today, much attention is focused on trying to understand our environment. Questions are being asked about the effects of global warming, pollution, depletion of ozone, and other related problems. Satellite data can help scientists understand these phenomena and recommend courses of action for decision makers. If we provide easier access to these data and enhance available documentation, ORA, as well as the potential user community at large, can employ these observations to strengthen the Nation's response to preserving our environment.

Strategic Goal: Improve ORA access to and utilization of environmental satellite data through mutual cooperation with NESDIS Data Centers.

"An important step in the right direction would be to take a new approach to the collection of information about what precisely is happening to the global environment....the information should be collected as quickly as possible, and second, it should --wherever feasible-- be collected in a manner that facilitates public education and fosters a greater understanding of what the new information means within the larger context of rapid global change" --- Albert Gore, Earth in the Balance, 1992



Office of Research and Applications budget for 1988-1993. Funds from the NESDIS base operating budget are shaded; unshaded bars are reimbursable funds from other programs such as Climate and Global Change.

Objective 6. Achieve Stability in the Funding of the ORA Research Program

In an era of budgetary constraint, ORA, like other agencies and offices, has competed for reimbursable money to supplement declining base funds. Acceptance of reimbursable money is a commitment to perform tasks for the funding agency or program. Program resources often support popular issues and can be transitory.

Base money supports the "critical mass" of satellite research and applications development. When a renavigation is necessary, the science is usually funded from base. When non-linear sea surface temperatures were needed to correct for aerosol haze from volcanoes, base money funded the research to correct the algorithms.

The program initiatives of NOAA, however, are critical to the implementation of the ORA Strategic Plan. The implementation process will have available resources related to programs such as the NWS Modernization, Climate and Global Change, and the Coastal Ocean Program. The ORA response to these proposed programs, including development of algorithms, applications, and validation of products, provide essential support for NOAA to complete its mission. R&D related to satellite data for each of these programs is important and commercially valuable. Yet, the reimbursable program work remains a distraction from the primary mandate of ORA.

Strategic Goal: Establish a desirable ratio between base money and program support as a guide to improve the stability of ORA research activities.

Objective 7. Enhance Public Education in Remote Sensing Technology for Earth Science

Science education in U.S. public schools lags behind that of other developed Nations. ORA can contribute to improving teacher literacy and interest through the availability of materials and data for the study of remote sensing in the science curriculum. Current efforts, however, do not meet the goal of increasing public understanding of remote sensing. Seeing the Earth as a "whole" can be a very powerful teaching tool; NOAA's satellite observations provide this view and could be used to invigorate the science curriculum.

NOAA is responsible for expanding the general public's knowledge of the environment and, in particular, their understanding of NOAA's role as the Nation's environmental steward. NOAA's LOs assist the Nation's educational communities by working with public schools and the university community to develop curricula and demonstration materials. However, primary and secondary education specialists have little training in the specialized area of remote sensing technology.

ORA provides specific training modules for NOAA LOs and other Federal agencies. Modules are available in tropical meteorology, application of satellite imagery to forecast improvement, and coastal oceanography. However, there is limited support at this time to bring these learning modules to public schools and undergraduate programs.

The problem has a wider scope. Satellite imagery appears nightly on the television. Covers of books have color-enhanced images of the Gulf Stream. Billions of people have seen a satellite view of Earth. Viewers of satellite data products, however, frequently perceive those products as colorful show-and-tell, with little understanding of remote sensing, its complexity, strengths, and limitations. The Nation needs a more appropriate program for the general public and students at the undergraduate level. ORA can provide the seeds for developing an expanded focus for remote sensing in public education.

Currently, ORA manages cooperative research institutes at the University of Wisconsin and Colorado State University that provide excellent support to graduate education in meteorological remote sensing. The academic participants provide ORA with outstanding research capability, while these students receive the experience of practical applications for their scientific studies. ORA scientists located at these institutes have the university resources available to them for research and have a source of highly trained scientific staff. These research institutes illustrate the potential value of ORA cooperation with educational institutions.

"Each executive department and agency...that: ... has a scientific mission; employs significant numbers of scientists, mathematicians, and engineers;...shall, assist in the mathematics and science education of our Nation's students, teachers, parents, and the public by establishing programs at their agencies to provide for training elementary and secondary school teachers to improve their knowledge of mathematics and science. Such programs... shall involve partnerships with universities, State and local elementary and secondary school authorities, corporations and community based organizations."
Presidential Executive Order, November 16, 1992

ORA Atmospheric Research Programs

- *Automated Surface Observing System (ASOS) Supplemental Satellite Products*
- *Heavy Precipitation Estimation*
- *Improved Cloud Drift Winds*
- *Automated Satellite Wind Computation*
- *Clear Air Turbulence Analysis and Forecasts*
- *Low Cloud/Fog Analysis and Dissipation Techniques*
- *Aircraft Icing*
- *Improved Atmospheric Moisture Profiles*
- *Expert System Techniques*
- *Tropical Storm Development Estimates*
- *Microwave Applications*
- *Extratropical Cyclone Pressure Estimates*
- *Improved Severe Local Storm Forecasting Techniques*
- *Atmospheric Temperature Sounding Enhancements*

Strategic Goal: Establish a Working Group for Public Education in Environmental Remote Sensing (PEERS) to direct ORA activity in support of NOAA's educational outreach in the public schools and undergraduate colleges.

4. AGENDA FOR ACTION: STEPS TOWARD IMPLEMENTATION

The ORA Strategic Planning Committee recommends particular actions for ORA to consider in developing its implementation plan in order to achieve each objective.

Increase the Recognition of ORA Capabilities

Many opportunities abound to increase the organizational recognition of ORA. We can undertake several simple activities to improve the dissemination of information about ORA activities such as an increase in informational briefings for all NOAA LOs, a redesign of publications, particularly the quarterly report, and an internal review of mailing lists. Special publications of a topical or technical nature by ORA staff should also be pursued. Scientists should be encouraged to contact colleagues in other NOAA offices to begin a dialogue on ways to explore the use of satellite data in various program areas to augment the observational data sets in use and to arrange for collaborative projects and data exchange. Improving and expanding informational briefings on ORA programs at all levels throughout the organization would increase the knowledge level of all employees and could result in higher program efficiencies.

Acquire Critical Technology to Insure ORA is a Technically Relevant Research Facility

ORA should continue to pursue its efforts to develop a state-of-the-art research facility. Cooperative activities with operational staffs should be pursued to assist ORA in assessing the technology requirements for satellite data streams, communications, and user requirements. ORA must implement a program to plan, acquire, and manage the computer technologies to ensure interconnectivity, interoperability, and functional readiness to support the development of advanced satellite data processing algorithms and new products.

Expand ORA Efforts in Oceanic Remote Sensing

NESDIS should establish an Oceans Laboratory within ORA to focus its research and applications development in remote sensing oceanography for NOAA, to extend NOAA's oceanographic remote sensor engineering, and to improve oceanographic remotely sensed data management. This effort can be initiated with existing resources. ORA has expertise in oceanic remote sensing research but lacks a broad depth to address all research issues of the marine sciences. The Oceans Laboratory would provide NESDIS with an administrative focus to establish research priorities that support NOAA goals

for oceanic and coastal remote sensing R&D. With enhanced resources the position of NESDIS as a leader in oceanic and coastal remote sensing would be clearly established.

Foster a Management Style to Encourage Risk-Taking and Creativity

To maintain its leadership role in environmental research, ORA must have a high quality workforce and must provide a working environment conducive to creativity, risk taking, and opportunity. It must continue to display a culture that fully utilizes and equitably recognizes the abilities and contributions of all employees. Emphasis on teamwork or non-hierarchal approaches to problem solving or projects should be promoted to heighten the exchange of expertise. When appropriate, jobs should be restructured to provide developmental opportunities.

The job is not finished by just hiring the "best and brightest." A concerted effort must be made to provide new and current employees opportunities to grow and continue to make a lasting contribution to the organization.

Improve Availability of Satellite Data Attuned to Users' Needs

ORA scientists, as well as scientists outside of NOAA, make intensive use of satellite data and frequently need ground truth data for calibration or validation. ORA scientists are knowledgeable in the use of satellite data for environmental analyses and should work with the NESDIS Data Centers to improve documentation, access, and utilization of NESDIS data sets. Several areas of data servicing have been identified. Enhanced documentation or users' guides could effectively minimize the difficulties that scientists and decision makers often encounter. This cooperative effort would benefit NOAA's position as the responsible organization for the management and provision of environmental observations.

"Earth observation data are needed for policy decisions and for a better understanding of the impact of man's activities on such phenomena as global change"... Jean Marie Lutton, European Space Agency

Achieve Stability in the Funding of the ORA Research Program

ORA receives funds from NOAA programs such as CoastWatch, Data Management, and Climate and Global Change. These funds enable ORA to conduct more research than would be possible under base funding and in many cases allows for upgrading of equipment and software when base funding is insufficient to support rapid changes in technology. Movement of our processing from the mainframe to workstations or personal computers has been possible using money from the major programs. However, ORA cannot expect that these program funds will continue to augment the basic needs of the organization. NESDIS management must have a better understanding of the role of R&D in assuring its high quality product suite and the role of research in the development of new or enhanced products that will ensure the vitality of NESDIS' and NOAA's environmental monitoring and prediction programs in the future. In addition, ORA management must annually review

its priorities in light of resources and convey this information to all employees to ensure that we will meet organizational goals.

Enhance Public Education in Remote Sensing Technology

ORA should focus immediately on the development of educational applications and avenues to transfer its remote sensing knowledge and its software and products. Policy makers in government and industry have stressed repeatedly the need for the most advanced education of the American workforce if this country is to remain competitive in a global economy. Scientists within ORA have unique opportunities to make significant contributions to the understanding of satellite technology and use of satellite data within our public school system where this education must start. Many research tools, satellite data, satellite-derived products, imaging software, and training modules are adaptable to the science curricula in public schools.

5. BENEFITS OF THE STRATEGY

ORA plays an important role in the mission of NOAA and NESDIS to provide operational observations from environmental satellites to describe and predict our dynamic Earth system. ORA has a long and successful heritage in developing algorithms for, and applications of, satellite data for environmental monitoring and prediction. ORA also participates in the development of future spacecraft sensors and conducts a vigorous program of calibration and validation of satellite data to ensure high quality products. Today's products are the result of more than two decades of efforts by ORA.

"Ensuring the protection of the environment in which we live is now accepted as a matter of paramount importance, requiring attention at the highest political level on an international scale"
--- Jean Marie Luton, European Space Agency

The concern about our environment is international in scope. Satellite remote sensing provides the ultimate platform to monitor the Earth's environment. The launching of spacecraft is only the beginning. It is only after the sensor signals are transformed into an image or geophysical product that the data become valuable. NOAA, as the Nation's lead agency for operational environmental monitoring, prediction, and stewardship, relies on NESDIS for observations, products, and information on which to base its programs and decisions. NESDIS, in turn, relies on ORA for the development of the science needed to support NOAA's mission. This strategic plan outlines ORA's approach to continue the utilization of the Nation's investment in space to support NOAA's mission and benefit the population at large.

Attributes of the Strategy

The strategic plan addresses the near-term effort to ensure that ORA remains a relevant R&D center. It addresses concerns about emerging satellite technology, cooperation among domestic and international scientific organizations, and our ability to maximize the benefits of new observations and results. The plan also addresses management issues to ensure a healthy organization through the development of fresh approaches to program oversight, vigor, and replenishment.

Appropriateness of the Strategy

External changes in the federal sector and budget limitations have sent many organizations "back to the drawing board" to examine program priorities. ORA has taken the same approach by enlisting its employees in the development of this strategy. Further, major changes in the amount of data available from both U.S. and foreign spacecraft require that ORA plan for the acquisition of these data and the development of products from these new data platforms. This is particularly critical in the area of ocean products, where data from five new spacecraft will soon be available. Development of satellite products to support NOAA's ocean and fisheries activities will be paramount, and ORA must be prepared to effectively carry out this charge.

Connectivity and Linkages

NESDIS is the largest civilian operator of space-based remote sensing systems in the world. ORA scientists have a long tradition of collaboration in research projects with scientists from NASA; the Departments of Interior, Agriculture, and Defense; and academia. NESDIS has also undertaken cooperative studies and projects with a large number of foreign organizations. Further, ORA works closely with many NOAA offices including the National Weather Service, the National Ocean Service, National Marine Fisheries Service, Oceanic and Atmospheric Research, the Office of Coastal Ocean Programs, and the Climate Program Office. This strategic plan supports continued development of interdisciplinary projects and provides a framework for synergy among all the world's scientists concerned with the state of the environment.

Management Issues

There are no alternative strategies to satellite technology. We may, however, address alternatives to developing science for new satellites or alternatives to using NOAA-owned-and-operated satellites. ORA must take the lead in conceptualizing the future of environmental remote sensing. We may attack the problem through the following candidate subjects, among many:

- developing fresh approaches to old sensor techniques
- continuing technology assessments in conjunction with NASA and other space research programs
- using the NASA Earth Probe program for special operational sensors to meet specific needs.

ORA must seriously examine its management and organizational structure to determine its flexibility, appropriateness, and future responsiveness. The present structure of the oceanographic R&D, for example, is split between laboratories with limited coordination and research planning. ORA must solve this problem administratively in order to accomplish its assigned goals in marine remote sensing.

Satellite Acronyms

ADEOS - *Advanced Earth Observing System*

ATS - *Applications Technology Satellite*

ERS - *European Remote sensing Satellite*

GOES - *Geostationary Operational Environmental Satellite*

ITOS - *Improved TIROS Operational System*

Nimbus - *NASA Research and Development Satellite*

NSCAT - *NASA Scatterometer*

POES - *Polar-orbiting Operational Environmental Satellite*

Radarsat - *Radar Satellite*

SeaWifs - *Sea-viewing Wide-Field of View Sensor*

SMS - *Synchronous Meteorological Satellite*

TIROS - *Television and Infrared Operational Satellite*

TOPEX/ Poseidon - *Oceanic Topography Experiment (Poseiden experiment within France)*

A number of policy-related issues have been raised in the previous sections. Management must address these issues, make policy decisions, and convey these decisions to ORA employees to assist them in carrying out their daily work management.

Several key issues are listed below:

- the role of Federal agencies, viz. ORA, in Earth observations
- research and applications policy that includes Cooperative Institutes, long-term program support policy, limitations to ORA's domain in R&D, and the relationship of ORA research data sets to the Data Centers' holdings
- algorithm and product development policy for atmospheric, oceanic, and terrestrial applications
- ORA's long-term plans for R&D in relation to non-NOAA satellite instruments
- memoranda of agreement/understanding that need to be developed and negotiated with other Earth Observing System organizations.

Training and Knowledge Transfer

ORA has a Training and Information Services Branch heavily committed to training NOAA and other agencies in the use of remote sensed technology. This Branch could form a core for the ambitious goals of ORA to increase both public awareness of and public education in remote sensing.

6. CONCLUSION

For nearly 30 years the scientists in ORA have made significant contributions to the U.S. environmental remote sensing program. Today's products and sensors are the results of the research of ORA scientists. NOAA and NESDIS must continue their investment in R&D to ensure a continuum of high quality, advanced products to support the monitoring and management of the Earth's environment from space. Looking to the next century, plans by the United States alone to invest in improved satellite remote sensing of the Earth will dwarf the sums spent since 1960. This plan outlines ORA's fundamental objectives to ensure ORA's continued leadership and viability as the remote sensing research center for the Nation.

Inside Cover: Hurricane Andrew. Back Cover: remote sening spacecraft ring the left half of the sphere. Images in the sphere from left to right, top to bottom: Vegetative Index; GOES Visible Image, Western Sector; Hurricane Iniki; Volcanic Aerosol Distribution; Interactive Workstation Display; Buoy Deployment; Forest Fire Smoke Plumes; and Hurricane Bob.

ORA SIGNIFICANT RESEARCH ACHIEVEMENTS (Cont')

1980 - Combined Visible-Infrared Image Product Operational

1980 - First Geostationary Satellite Soundings from the VISSR Atmospheric Sounder (VAS) on GOES 4

1980 - Cooperative Institutes Established at The University of Wisconsin and Colorado State University

1981 - Tracking of Water Vapor Features Shown to be Useful for Mid-Level Flow (Winds)

1981 - Multi-Channel SST (MCSST) Algorithm Implemented

1982 - NOAA Operational VAS Assessment (NOVA) Conducted

1982 - First Experimental Vegetation Index Product

1982 - Production of Special Deep Layer and Thermal Gradient Wind Sets from GOES for National Hurricane Center

1983 - Satellite Capability to Monitor Aerosols Demonstrated

1983 - Experimental Solar Radiation (Insolation) Product Implemented

1985 - Correction of SSTs for Volcanic Aerosols Developed

1985 - Surface Cyclone Pressure Estimates

1985 - Satellite Clear Air Turbulence Signatures Identified

1985 - Local (14km) SSTs Produced

1985 - First Solar Backscatter Ultraviolet (SBUV) Instrument for Ozone Measurement Launched

1986 - First Interactive Computer System, the VAS Data Utilization Center (VDUC), Installed

1986 - Interactive (WINDCO) Winds Processing from GOES Initiated

1987 - Experimental Product to Monitor Aerosols

1987 - Implementation of Defense Meteorological Satellite Program (DMSP) Sounding System

1988 - Implementation of the Physical Retrieval Algorithm for TOVS

1988 - Implementation of Angular Reflection Models in ERB Product

1988 - Operational Production of Vegetation Index Product

1990 - Operational Product to Monitor Aerosols

1990 - High Latitude (Polar) Winds from NOAA Polar Orbiting Satellite Data

1990 - Operational Implementation of Method to De-stripe GOES Visible Images

1990 - Cross-product and Non-linear Algorithm Improvements to SSTs

1991 - Experimental Production of Microwave Precipitation, Snow Cover, Winds, Ice, and Water Vapor Products

1991 - Precipitation Estimates Utilized for the Hydrometeorological Monitoring and Management of the Nile River

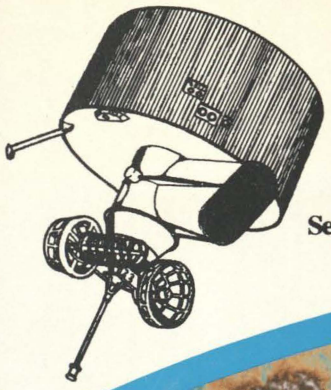
1991 - Carbon Dioxide Heights from GOES Sounder Improve High-Level Winds

1992 - Operational Automated Wind (AUTOWINDCO) Product Operational

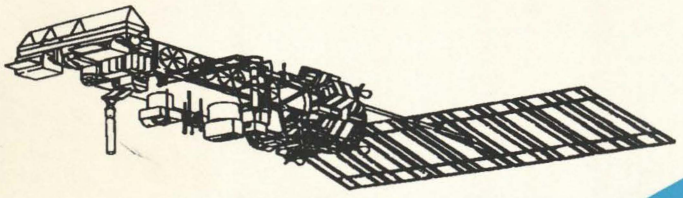
1992 - Cooperative Oceanic Remote Sensing Project Established at U.S. Naval Academy

1992 - First Prototype Marine Optical Buoy System for Calibration and Validation of Satellite Sensors Deployed

1993 - Satellite Product to Supplement Automated Surface Observing System (ASOS) Operational

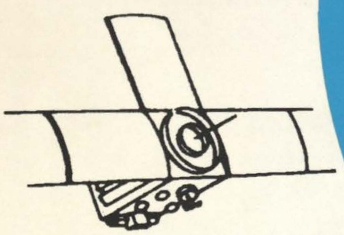


GOES 4
September 1980

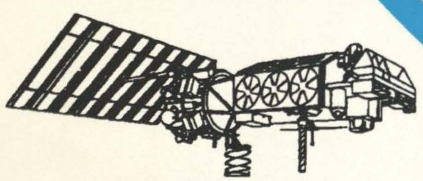


TIROS N (ATN)
September 1978

SMS-1 / GOES
May 1974



ITOS 1
January 1970



TIROS N
February 1966

Nimbus 1
August 1964

TIROS 1
April 1960