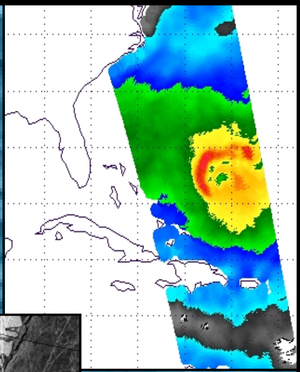
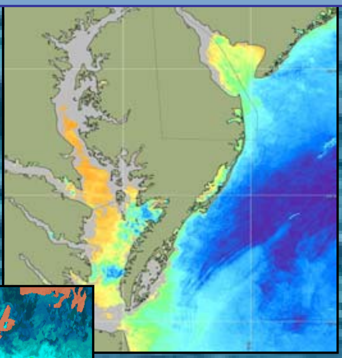
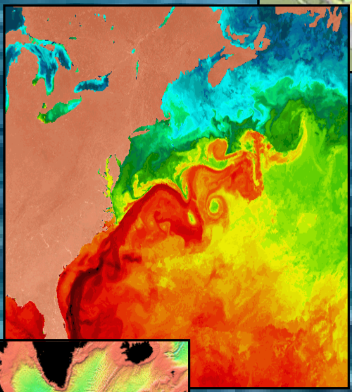
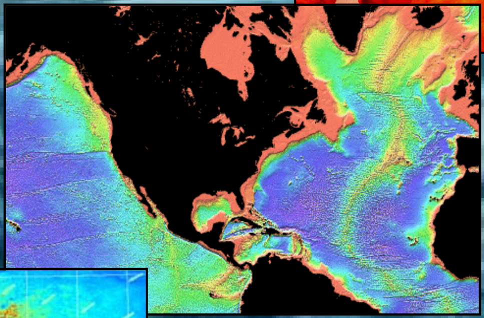
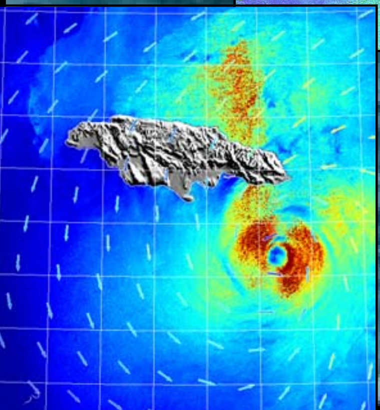


Satellite Oceanography & Climatology Division









Science & Technology Roadmap

TABLE OF CONTENTS

Executive Summary

The Satellite Oceanography and Climatology Division (SOCD) has responsibilities to fulfill mandates put forth by Congress to the National Oceanic Atmospheric Administration (NOAA). **United States Code Title 33, Chapter 17, Section 883j "Ocean Satellite Data" states** The Administrator of the National Oceanic and Atmospheric Administration … **shall take such actions, including the sponsorship of applied research, as may be necessary to assure the future availability and usefulness of ocean satellite data to the maritime community."** Within NOAA's National Environmental Satellite Data Information Service (NESDIS) Center for SaTellite Applications and Research (STAR), SOCD provides: satellite ocean remote sensing calibration and validation; the development of ocean remote sensing parameter retrievals, applications, and products; and the transition of research to operations to support Congressional mandates pursued by NOAA's five Strategic Mission Goals.

NOAA Strategic Mission Goals provide the focus for aligning NOAA activities. The Goals outline NOAA's major roles in serving society's needs for environmental data observations, data stewardship, and environmental information services. NOAA's five mission goals are:

1. Protect, restore, and manage the use of coastal and ocean resources through an **Ecosystem** approach to management
2. Understand **Climate** variability and change to enhance society's ability to plan and respond.
3. Serve society's needs for **Weather and Water** information
4. Support the Nation's **Commerce** with information for safe, efficient, **and** environmentally sound **Transportation**.
5. Provide **Critical Support for NOAA's Mission**.

SOCD provides significant direct support to each of NOAA's Mission Goals. Additionally, SOCD directly contributes to NOAA's participation in and leadership of the U.S. Integrated Ocean Observing System (IOOS) by contributing to the satellite component of the IOOS National Backbone. SOCD contributes to IOOS efforts to integrate and provide operational ocean remote sensing and *in-situ* observational data, products, and information. Globally, SOCD, through IOOS, directly contributes to the international Global Ocean Observing System (GOOS), which is the oceanic component of the Global Earth Observing System of Systems (GEOSS).

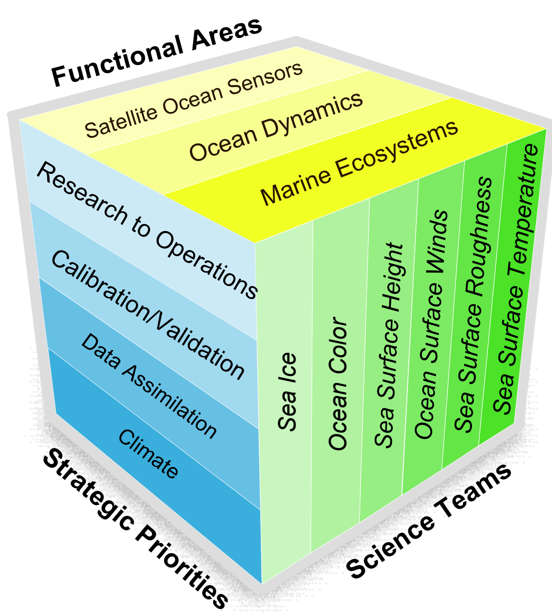
Ecosystems | Climate Variability and Change | Weather and Water | Commerce and Transportation | Critical Support

Satellite Oceanography and Climatology Division Mission

To satisfy user requirements for high-quality, state-of-the-art, end-to-end, integrated operational satellite ocean remote sensing data, applications, products, and information through calibration, validation, research, development, the development of satellite ocean remote sensing climate data records and products, and the transition of products and techniques to operations.

The Satellite Oceanography and Climatology Division (SOCD) develops and applies remotely-sensed data received from operational and research satellites, other platforms, in conjunction with *in-situ* data, to infer various oceanic and coastal phenomena and processes on a variety of temporal scales, from marine weather to climatic. To overcome challenges identified in Strategic Priorities, SOCD addresses technology barriers through linked, integrated, end-to-end scientific processes organized by three Functional Areas and six collaborative Science Teams. In pursuit of its strategic objectives, SOCD partners with other components of NOAA and NESDIS, other U.S. Government agencies, international groups, academia, and industry to develop satellites and satellite applications of derived coastal and ocean properties relating to the physical, dynamical, and biogeochemical characteristics of the coastal and open oceans. SOCD sponsors and partners with the Cooperative Institute for Oceanographic Satellite Studies (CIOSS) for research and outreach efforts focused on satellite ocean sensors and techniques, ocean-atmosphere fields and fluxes, models and data-assimilation, and ocean-atmosphere analyses. CIOSS areas of interest and effort directly align and are integrated with SOCD strategic objectives, priorities, and projects.

The SOCD Research to Operations effort is the NESDIS focus for definition, development, and support of operational satellite ocean remote sensing functions in NOAA. SOCD's NOAA CoastWatch and NOAA OceanWatch embody this effort as the main implementation pathways for NOAA's program in operational satellite ocean remote sensing. SOCD's NOAA CoastWatch and OceanWatch efforts include partnerships with regional NOAA elements to integrate satellite ocean remote sensing into NOAA mission activities. SOCD, via NOAA CoastWatch / OceanWatch, provides effective and efficient delivery systems for satellite data utilization through the transition of developmental efforts to operational activities in conjunction with relevant NOAA components and other Government and international agencies. These efforts directly contribute to NOAA's participation in the U.S. Integrated Ocean Observing System (IOOS) and the Global Ocean Observing System (GOOS).



SOCD Science & Technology Roadmap

1 INTRODUCTION

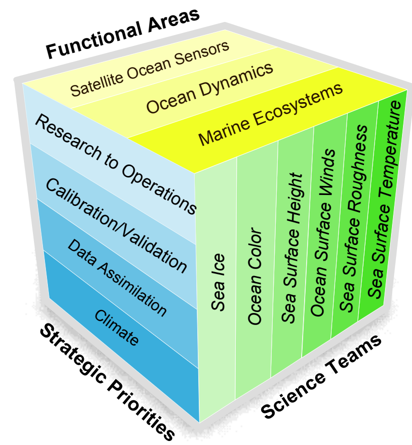


Figure 1. Cube Matrix Organization

The Satellite Oceanography and Climatology Division (SOCD) engages and participates in a wide variety of NOAA, interagency, and international programs in earth and ocean science, representing NOAA on science working teams of major satellite missions and working to ensure that operational processing of satellite data meets requirements for measuring and monitoring conditions of interest to the global community. SOCD identifies four Strategic Priorities that integrate across three Functional Areas and six Science Teams, forming an end-to-end cube matrix. The Strategic Priorities integrate the functional areas and focus the major tasks of the Science Teams. The Strategic Priorities are the 1) transition of research to operations, 2) calibration and validation, 3) data assimilation, and 4) the development of satellite ocean remote sensing for climate applications. These priorities will be updated as needed. The three functional areas are satellite ocean sensors, ocean dynamics, and marine ecosystems. Six science teams work to support these efforts: 1) sea surface temperature, 2) sea surface height (altimetry), 3) sea surface roughness (synthetic aperture radar), 4) ocean surface winds, 5) ocean color (sea surface reflectance), and 6) sea ice. It is envisioned that additional science teams will be established when new technologies permit the retrieval of new parameters, e.g. sea surface salinity. Each component is crucial to completing end-to-end satellite ocean remote sensing science research and its transition to operations. For example, the Research to Operations strategic priority focuses on completing the operational implementation of research efforts by integrating the continuum of: sensor development; observation retrievals; applications research for the parameter Science Teams, ocean dynamics, and marine ecosystems; product development for those efforts; and the transition of experimental products and processes to new operational products and processes. Each Science Team provides an end-to-end capability for a specific satellite ocean remote sensing parameter, encompassing research on retrieval algorithms, sensor calibration, data validation, applications development, product and process development, and science support for operational products, with the applications, processes, and products supporting the functional areas and strategic priorities. SOCD’s Administrative Branches align with the three Functional Areas and are titled, Satellite Ocean Sensors, Ocean Dynamics and Data Assimilation, and Marine Ecosystems and Climate.

2 DRIVERS AND TRENDS FOR SOCD RESEARCH

Key drivers for SOCD research are found at many levels and consist of legal, policy guidance, mission/user requirements, and operational responsibilities. At the highest level, Congress and the President have provided some explicit guidance within legal mandates, as well as through established plans and policies and the annual budgeting process.

2.1 Mandates

The following legal mandates provide the most direct guidance. Numerous additional mandates and interagency agreements exist to guide SOCD efforts. All facets of SOCD's efforts directly align with these mandates.

- **United States Code Title 33, Chapter 17, Section 883j, "Ocean Satellite Data":** The Administrator of the National Oceanic and Atmospheric Administration … **shall take such actions, including the sponsorship of applied research, as may be necessary to assure the future availability and usefulness of ocean satellite data to the maritime community.**

- **United State Code Title 42, Chapter 68:** Federal Emergency Management Agency's (FEMA) Federal Response Plan (FRP), April 1999 that implements the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended (Public Law 106-390) **The FRP tasks the Department of Commerce (DOC) with acquiring and disseminating weather data, forecasts, and emergency information, providing information on natural resources, predicting pollution movement, and providing information on meteorological, hydrological, ice, and oceanographic conditions.**

- **United State Code Title 15, Chapter 9 Section 313:** The Secretary of Commerce shall have charge of the **forecasting of weather, the issue of storm warnings,** … for the benefit of agriculture, commerce, and navigation, … and the collection and transmission of marine intelligence for the benefit of commerce and navigation, … the distribution of meteorological information in the interests of agriculture and commerce, **and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States, or as are essential for the proper execution of the foregoing duties**

- **United State Code Title 16, Chapter 38, Subchapter 1, Section 1801 "Fishery Conservation and Management":** The Congress finds and declares the following:
    - **The collection of reliable data is essential to the effective conservation, management, and scientific understanding of the fishery resources of the United States**.
    - **Habitat considerations should receive increased attention for the conservation and management of fishery resources of the United States.**

It is further declared to be the policy of the Congress …to assure that the national fishery conservation and management program utilizes, and is based upon, the best scientific information available; involves, and is responsive to the needs of, interested and affected States and citizens; considers efficiency; **draws upon Federal, State, and academic capabilities in carrying out research, administration, management, and enforcement ….**

Additionally, the following legislative mandates are the impetus for satellite ocean remote sensing research, applications, and products in support of NOAA outcomes, the Ecosystems and Climate Mission Goals, and the National Marine Fisheries and National Ocean Service line offices. The areas currently supported by satellite ocean remote sensing under each mandate are identified.

- **Endangered Species Act of 1973 U.S.C. 1653-1543.** Protected Species Investigations.

- **Marine Mammal Protection Act of 1973 U.S.C. 1361-1407.** Protected Species Investigations.

- **Magnuson-Stevens Fishery Conservation and Management Act 16 USC 1801-1 1882.** Protection and Restoration of Critical Habitat.

- **National Marine Sactuaries Act (PL 106-513).** Sustainable Seas Experiment.

- **National Environmental Policy Act of 1971 42 USC 4321 et seq.** Protected Species Investigations .

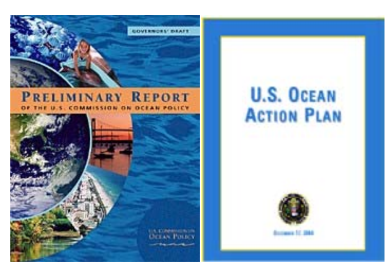
- **Marine Protection, Research and Sanctuaries Act PL 104-283.** National Centers for Coastal Ocean Science (NCCOS) / Center for Coastal Monitoring and Assessment (CCMA) efforts.

- **Harmful Algal Bloom and Hypoxia Research and Control Act of 1988. 33 U.S.C. 1121 et seq.** Monitoring and event response.

2.2 Policy

With the **Oceans Act of 2000**, Congress and the President established the U.S. Commission on Ocean Policy to establish findings and develop recommendations for a new and comprehensive national ocean policy. The Ocean Commission's final report, ***An Ocean Blueprint for the 21st Century***, provides the Commission's recommendations to Congress on what is needed to begin a new coordinated National Ocean Policy framework to improve decision making, cutting edge ocean data and science translated into high-quality information for managers, and life-long ocean related education to create well-informed citizens with a strong stewardship ethic. Recommendations relevant to SOCD address research, applications, monitoring, and operational products for the issues of: Marine Protective Areas (6-3), the NOAA Organic Act (7-1), habitat (11-3), sediment (12-5, 12-7), maritime transportation (13-6), water quality (14), a national monitoring network (15-1, 15-2, 15-3.), marine debris (18-1), fisheries vessel monitoring and bycatch (19-19, 19-23), endangered species (20-4), aquaculture (22-3), Oceans and Human Health (23-3, 23-4, 23-5), the Integrated Ocean Observing System (IOOS) (26-6, 26-7, 26-8, 26-9, 26-10), infrastructure (27-1), and international partnerships and efforts (29-7, 29-8). The Commission's findings and recommendations resulted in the President's U.S. Ocean Action Plan.

The ***U.S. Ocean Action Plan*** was developed by the Bush Administration in response to the Ocean Commission 21st Century Blueprint. Key principles outlined in the Action Plan involving SOCD input and participation includes but is not limited to:



- Develop an Ocean Research Priorities Plan and Implementation Strategy;

- Build a Global Earth Observation Network, including an Integrated Ocean Observation System, link it with Global Marine Assessment;
- Participate in the *Aquarius* mission to acquire sea surface salinity data from space;
- Create a National Water Quality Monitoring Network;
- Advance ocean stewardship;
- Support an integrated approach to oceans management;
- Extend coastal zone management;
- Improve marine managed areas;
- Conserve and restore coastal habitat;
- Promote coral reef conservation and education through implementing coral reef local action strategies, form new international partnerships to enhance management of coral reefs;
- Enhance conservation of marine mammals, sharks, and sea turtles;
- Provide data for the implementation of new legislation on oceans and humans, health, harmful algal blooms (HABs), and hypoxia; and establish a forecasting system for HABs;
- Reduce coastal water pollution;
- Advance offshore aquaculture;
- Share U.S. ocean science abroad through partnerships and capacity building;
- Promote life-long ocean education by expanding the Sea Grant Program internationally.

NOAA's FY 2006 – FY 2011 strategic plan, "**New Priorities for the 21st Century – NOAA's Strategic Plan**", identifies five cross-cutting strategies:

- Developing, Valuing, and Sustaining a World-Class Workforce
- Integrating Global Environmental Observations and Data Management
- Ensuring Sound, State-of-the-Art Research
- Promoting Environmental Literacy
- Exercising International Leadership

NOAA's strategy for integrating global environmental observations and data management most directly influences this SOCD Science and Technology Roadmap. The NOAA Strategic Plan states that Earth observations are intrinsic to NOAA's mission, affecting fundamental research and discovery, to long-range operational forecasting, to short-term warnings of immediate hazards, to day-to-day regulatory decisions. It also states that an integrated Earth observation and data management system will enhance NOAA's capabilities to meet mission goals and enable NOAA's resources to be applied more efficiently and effectively by reducing duplication, improving coverage, and providing networks to disseminate information when and where it is needed around the world. The NOAA Strategic Plan notes that through NOAA's participation and leadership in national and international global data collection and reporting efforts, such as the Global Earth Observing Systems of Systems (GEOSS) and other important observing groups and efforts, NOAA can further integrate NOAA's observing systems, data, and quality control with efforts of other nations to guarantee the best quality and coverage of Earth observing data.

2.3 Requirements

In parallel, NOAA's structure emphasizes five Mission Goals (Ecosystems, Climate, Weather and Water, Commerce and Transportation, and Mission Support) as the focal points for coordinated planning, programming, budgeting, and execution. These Mission Goals provide the framework for identifying, coordinating, and prioritizing operational and research requirements. Within the Mission Goals, specific programs identify requirements for satellite ocean remote sensing, from which SOCD derives science and technology research and development tasks and priorities. The following different levels of requirements are identified:

- **User**
  Identifying a user problem, stated with a demand for observational or analysis products, allows scientists to progress forward to improve satellite data and decision-making products to meet the needs of the user community. Feedback from the user community determines requirements that need to be satisfied; i.e., the user needs a product in order to do something. The user community includes NOAA offices, other federal agencies, DOD, NASA, state and local government, international agencies, academia, commercial industry, and the public.

- **Operational**
  It is necessary to specify operational requirements for providing satellite data and products. Developing optimum parameters (time, accuracy, reliability, latency, update frequency, coverage areas, resolution, etc.) drives research for optimal operational products and services, as well as system design. Fully operational products naturally have a higher expectancy of reliability than one-time experimental products. Balancing reliability requirements with the cost for creating continuously-consistent products creates a challenge.

- **Observational**
  Retrieving observations using satellite ocean remote sensing experiences constraints that limit the quality of the data extracted. Resolving the constraints is the observational requirement. For example, atmospheric effects must be filtered out of data in order to minimize uncertainties in the products. Research of the contributing physical factors and relationships are essential for algorithm development to address observational requirements.

- **Instrumentation**
  Parameters require specific spectral, spatial, and temporal resolutions which are inherent with the design of observation systems. User requirements, in conjunction with operational and observational requirements and constraints, are backtracked to determine the instrumentation requirements. These instrumentation requirements are then balanced with cost and design limitations to determine the design characteristics for retrieving each parameter. Requirements identified by various programs are included in the NOAA Consolidated Observations Requirements List and are stated in instrumentation requirements documentation as design thresholds and objectives.

While most efforts are requirement-driven, flexibility is retained within the program to explore innovations, with the goal of expanding relevant capabilities and capacities. User education and outreach is frequently required to realize the full potential of innovations and subsequently identify and document requirements.

2.4 Satellite Programs

The continuing sequence of operational earth observation satellites, coupled with developmental and international missions, produce numerous drivers, requirements, and opportunities for research to integrate the new instruments, even for duplicate replacement instruments. Research is required to ensure data quality and the integrity of the data time series. The figure below shows the anticipated national and international satellite launches and life expectancy for present and future satellites. Data from these satellites are utilized by the SOCD Science Teams to develop and provide products, services, and information to support informed decision making. The satellite launches drive a large portion of the satellite ocean remote sensing science requirements and priorities, particularly where there are operational continuity requirements. Necessarily, significant portions of the research and development must precede a satellite's launch in order to maximize the productivity of the satellite's limited life span.

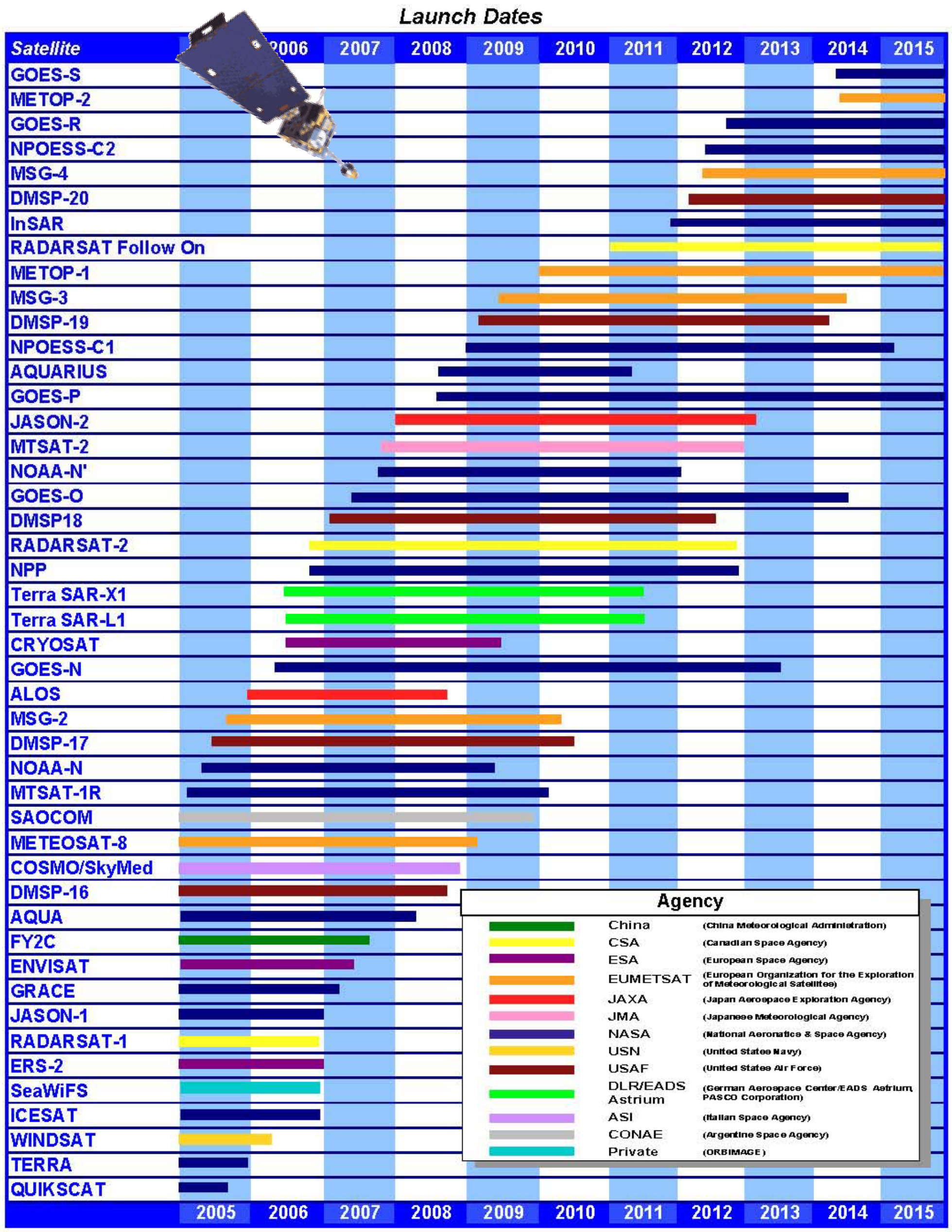


Figure 2. Satellite Launch Continuum

2.4.1 OPERATIONAL NOAA SATELLITES

With the advent of each new operational satellite mission, significant research and development is necessary to ensure proper continuity of operational data streams, continuity of data quality, and exploitation of new technology capabilities through improved parameter retrieval algorithms, operational implementation of new parameters, and the development and integration of new operational products. Each launch requires science support for initial system certifications, on-orbit calibration, and error characterization.

- **Geostationary Operational Environmental Satellite (GOES)**
  The current GOES configuration requires two GOES satellites (East and West) to be operational at all times, achieved through on-orbit spares. Continuous efforts are required to maintain the operational vicarious *in-situ* calibrations. Significant new challenges have been posed by the latest series of GOES satellites (GOES-12 and subsequent satellites) due to changes in the spectral bands available for accomplishing the sea-surface temperature (SST) retrievals, the principal ocean parameter for these missions. The GOES missions provide enhanced temporal resolution for ocean observations. The SST Science Team is using this data to develop calibrated and validated algorithms for high temporal resolution sea surface temperature and aerosol over oceans.

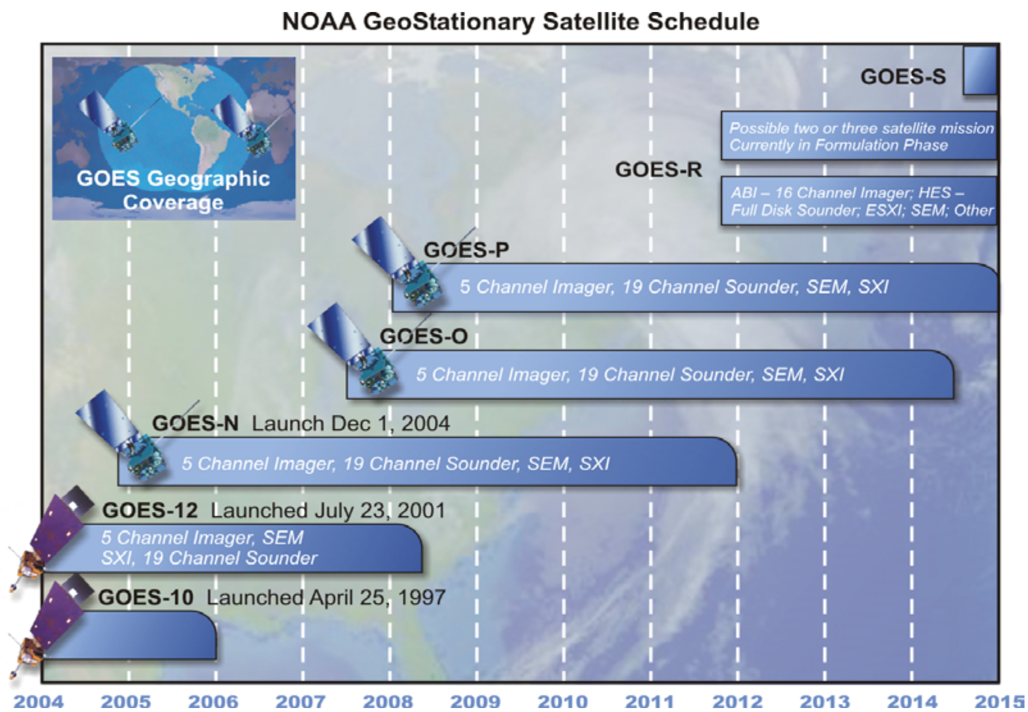


Figure 3. Geostationary Satellite (GOES) launch schedule and cover until 2015.

  - **GOES-R**
    GOES-R will be the next-generation GOES system. GOES-R preliminary design includes an Advanced Baseline Imager (ABS), the corollary to the current GOES Imager, and a Hyperspectral Environmental Suite Coastal Waters imager (HES-CW) to provide high spectral, spatial, and temporal resolution for coastal ocean color observations. The HES-CW imager will provide the first geostationary ocean color observations. This new capability will require significant research to address issues

involved with retrieving ocean color observations from a geostationary orbit, a change from all previous observations taken from polar orbits. The HES-CW imager will also require significant research to fully exploit its hyperspectral capabilities for the coastal zone, as well as take advantage of the instruments higher spatial resolution.

- **Polar-orbiting Operational Environmental Satellite (POES)**
  At least two simultaneous POES missions, offset in time, provide observations with improved spatial resolution, with respect to GOES observations, of a given location at nominally the same time each day. Additionally, the POES missions provide coverage of the Polar Regions. As with the GOES missions, continuous efforts are required to maintain the operational vicarious *in-situ* calibrations. The inter-calibration between satellite instruments is necessary to provide consistent and well-characterized data to users. The only oceanic parameter measured by the Advanced Very High resolution Radiometer (AVHRR) instruments onboard current POES missions is SST. Aerosol (particles in the atmosphere) is also derived over ocean and provides and essential input in the SST and ocean color atmospheric correction algorithms.

Figure 4. POES Satellite

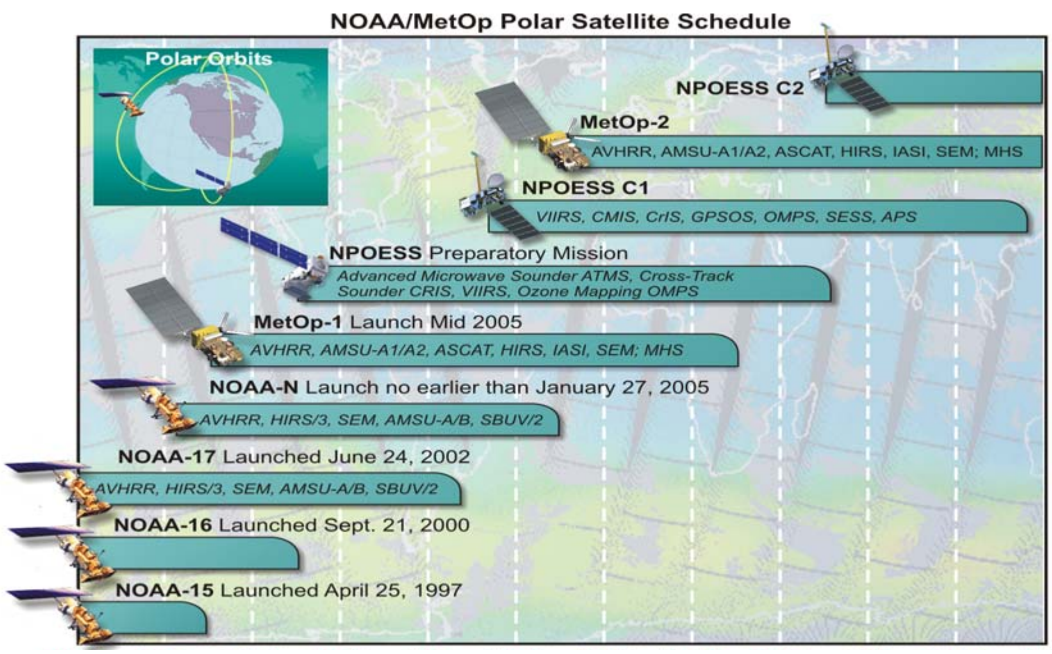


Figure 5. NOAA/ IJPS Polar Orbiting Satellite Schedule and orbits.

- **Initial Joint Polar-Orbiting Operational Satellite System (IJPS)**
  The IJPS series of missions constitute a joint European/United States polar orbiting satellite system that, from the ocean remote sensing perspective, will supplement and continue the SST/Aerosol time series from the POES AVHRR. The IJPS data will

provide enhanced resolution SST products. IJPS will also include the Advanced Scatterometer (ASCAT) which will provide, for the first time, an operational scatterometer for measuring ocean surface winds. As operational missions, continuous efforts are required to maintain the operational vicarious *in-situ* calibrations, as well as inter-calibrate with the existing POES AVHRR instruments.

- **National Polar-orbiting Operational Environmental Satellite System (NPOESS)**
  NPOESS will be the next-generation POES system. NPOESS is a joint NOAA – Department of Defense – NASA effort, coordinated through the Integrated Program Office (IPO). The mission combines civil and military programs, POES and the Defense Meteorological Satellite Program (DMSP), into a single program. NPOESS is being designed to deploy a completely new set of instrumentation, including some with currently unrefined science. The ocean remote sensing instruments include the Visible Infrared Imager / Radiometer Suite (VIIRS), for multispectral observations of ocean color and sea-surface temperature, and the Conical Scanning Microwave Imager/Sounder (CMIS), for measuring ocean surface vector winds using passive polarimetry, an in-progress and untested new technology. Passive polarimetry also provides a potential capability for operational ice detection in support of the National Ice Center (NIC) mission, augmenting visible imagery, especially in persistently cloudy regions. NPOESS planning also currently includes an altimeter on one of the missions to determine sea-surface heights for measurements of ocean dynamic features, ocean climate variability, and global mean sea-level rise.

  - **NPOESS Preparatory Project (NPP)**
    The NPOESS Preparatory Project (NPP) is a joint mission involving the National Aeronautics and Space Administration's (NASA) and the NPOESS Integrated Program Office (IPO). NPP provides risk reduction through the demonstration and validation of new instruments and parameter retrieval algorithms, as well as aspects of the NPOESS command, control, communications and ground processing capabilities prior to the launch of the first NPOESS spacecraft. Additional risk reduction is being achieved through science teams that are developing simulated data and experimental products. NPP will also serve as a continuity mission for the POES, acting as a transition to NPOESS.

- **Jason-2**
  Jason-2 will provide operational continuity of the TOPEX/Poseidon and Jason-1 exact-repeat-orbit altimetry missions for the measurement of sea-surface height in support of assessments of ocean dynamics, climate variability, and climate change. Jason-2 is a joint U.S.-European satellite program that partners NOAA, NASA, the French Centre National d'Etudes Spatiales (CNES), and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). Research support for NOAA's operational responsibilities include developing operational monitoring, quality assurance, and improving calibrations for the altimetry data.

2.4.2 NON-NOAA OPERATIONAL SATELLITES

NOAA develops partnerships with other national and international satellite agencies to share and acquire data to augment operational capabilities and capacities. This sharing creates the initial framework for an integrated Global Earth Observing System of Systems (GEOSS). International satellite data provide access to infrastructure investments, capabilities, and expertise not currently available through the U.S. domestic programs. Research support is required for proper integration of these data streams with NOAA's operational data streams and for the development of applications and products.

- **Defense Meteorological Satellite Program (DMSP)**
  The ocean remote sensing instruments on the DMSP satellites include the Optical Linescan System (OLS), for visible and infrared measurements, and the Special Sensor Microwave Imager (SSM/I), for passive microwave measurements. Ocean-related applications for these instruments include observations of sea ice extent, ice edge, sea-surface temperature, as well as ancillary observations needed for retrievals of these measurements, such as clouds.

- **ENVISAT**
  ENVISAT is a sun-synchronous European satellite that provides ocean remote sensing data useful to U.S. operational needs. Relevant instruments include: the Medium Resolution Imaging Spectrometer (MERIS) for ocean color observations; the Advanced Synthetic Aperture Radar (ASAR) for e.g. high resolution ocean surface winds, sea ice detection, oil spills; the Advanced Along Track Scanning Radiometer (AATSR) for potentially more precise SST/Aerosol, but with a limited spatial coverage; the Radar Altimeter (RA-2) for ocean topography (sea-surface height measurements) in support of ocean circulation, bathymetry, and marine geoid research.

- **MTSAT**
  MTSAT is the newest Japanese geostationary satellite, comparable to the U.S. GOES missions. Research efforts are underway to explore SST/Aerosol retrievals from MTSAT Imager (which is similar to the GOES Imager) over the western Pacific Ocean and much of the Indian Ocean and integrate these data products into global geostationary satellite ocean remote sensing products to supplement the GOES domain.

- **METEOSAT Second Generation (MSG)**
  The MSG missions are the European Space Agency's contribution to global geostationary coverage. Spectral channels of the MSG Spinning Enhanced Visible and Infra-Red Imager (SEVIRI) has an advanced set of spectral channels and superior radiometric performance compared to the heritage GOES Imager. Efforts are underway to explore SST/Aerosol over the eastern Atlantic Ocean and western Indian Ocean and integrate the MSG data products into global geostationary satellite ocean remote sensing products, and to explore the MSG/SEVIRI data for the risk reduction activities for the GOES-R/ABI sensor.

- **RADARSAT**
  RADARSAT-1 is a Canadian Space Agency (CSA) polar-orbiting satellite equipped with C-band synthetic aperture radar (SAR). This satellite's orbit has a 24-day repeat cycle. The U.S currently receives SAR data from 15.82% of the on-time of RADARSAT-1 through an MOU with CSA and NASA (NASA provided the launch for RADARSAT-1). This data supports the National Ice Center and applications demonstrations (such as the Alaska SAR Demonstration) within SOCD. These data provide a variety of operational

and developmental products, such as sea and river ice detection, wind, oil spill detection, flooding detection, and vessel detection, directly supporting safe commerce and transportation, fisheries management, and weather and water analyses. RADARSAT-2 is a follow-on mission, but is completely commercial.

With the increasing integration of Earth observing satellite systems, the use of other international operational data is being explored, e.g. Indian National Satellite (INSAT-2E), with its Very-High Resolution Radiometer (VHRR), and the Chinese FY-2 geostationary satellite program, with its Visible and Infrared Spin-Scan Radiometer (VISSR).

2.5 TRENDS

Significant internal and external trends affect the Division's science and technology roadmap by influencing research, development, and integration approaches. Principal trends are highlighted below.

- **Integrated Ocean Observing System (IOOS)**
  The U.S. Integrated Ocean Observing System will bridge the gap between operational remote sensing and *in-situ* stations in the United States. It is the United State's contribution to a Global Ocean Observing System (GOOS), which is a substantial component of the Global Earth Observing System of Systems (GEOSS). IOOS "is a coordinated national and international network of observations and data transmission, data management and communications, and data analyses and modeling that systematically and efficiently acquires and disseminates data and information on past, present and future states of the oceans and U.S. coastal waters to the head of tide."[1] The Global Ocean Observing System (GOOS) will build on, enhance and supplement existing observing programs to develop a sustained and integrated observing system that provides the data and knowledge required to: manage and restore healthy coastal ecosystems and living resources; enable safer and more cost-effective marine operations; forecast and mitigate the effects of storms; detect and predict the effects of climate change; and protect public health. The Global Earth Observation System of Systems (GEOSS) is collaborative effort between 33 nations to share and blend *in*-situ and remotely-sensed Earth observations through existing and new compatible software and hardware. The U.S. and developed nations have a unique role in developing and maintaining the system, collecting data, enhancing data distribution, and providing models to help all of the world's nations.

  The national effort to establish an Integrated Ocean Observing System has assigned a significant leadership role to NOAA. The IOOS National Backbone includes satellite ocean remote sensing, where the nature of the roles for NOAA, NASA, and the Department of Defense in support of this satellite component is still being determined. NOAA clearly has a role in supporting IOOS with operational ocean remote sensing data. NOAA's role in providing data from developmental satellite programs is less clear. SOCD's NOAA CoastWatch/OceanWatch program for providing satellite ocean remote sensing data and products has been designated as a component of the IOOS National Backbone. The technology challenge is linking significantly increasing quantities of satellite ocean remote sensing data with IOOS and the IOOS Regional Associations. An

[1] First Annual Integrated Ocean Observing System (IOOS) Development Plan, A Report of the Nation Ocean Research Council Prepared by Ocean.US, The National Office for Integrated and Sustained Ocean Observations, Ocean.US Publication No. 9.

IOOS science challenge is working with the IOOS Regional Associations to provide regional satellite ocean remote sensing data and products, with a significant focus on the coastal regime.

- **Collaborative Computing Environment**
  Internal NOAA efforts are tending toward establishing a collaborative computing environment for satellite calibration/monitoring and product development, validation, and analysis. This new environment poses a notable technology challenge with respect to coordinating the numerous high-volume data streams and storage/archive requirements needed for implementing data quality assurance and scientific stewardship of climate data records.

- **Data Fusion**
  Data fusion comprises, amongst other aspects, the blending of similar and complementary data sets to achieve "best value" data sets and the derivation of new parameters/information through combining different parameter data sets. Current illustrations of these types of efforts include: the blending of GOES and POES infrared SST data for a "best value" infrared SST data set; the blending of infrared and microwave SST data for the next-generation "best value" SST; and the combining of altimetry sea-surface height anomalies with scatterometry ocean surface winds to derive ocean surface currents.

2.6 STRATEGIC PRIORITIES

Strategic Priorities represent challenges to establishing NOAA capacities for satellite ocean remote sensing. Each Technology Area and Science Team has a fundamental role in enabling the capacities.

2.6.1 Research to Operations

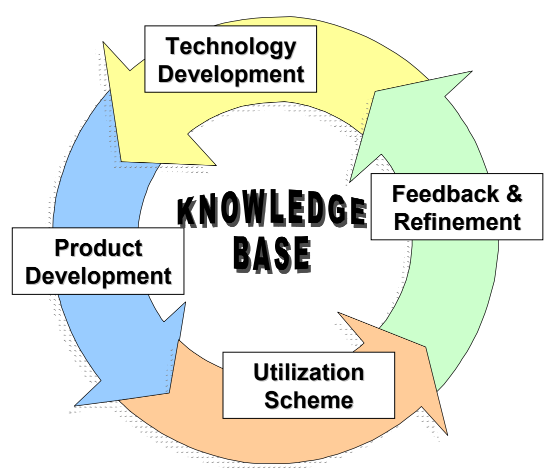


Figure 6. Transitioning products and processes from research to operations is a cyclical process.

Research to Operations encompasses a spiral process for developing and maintaining end-to-end operational science, employing a user requirement framework in conjunction with a satellite ocean remote sensing knowledge base, technology and product development, a utilization scheme, and feedback and refinement for further definition of requirements and development. The Research to Operations Priority encompasses operational, as well as developmental, data streams. The data and product streams are designed to meet user requirements and fulfill NOAA's mission and strategic objectives by developing, building, and providing the capacity for satellite ocean remote sensing data products and services, consistent with IOOS and GOOS frameworks. To this end, NOAA and NASA have embarked on a concerted effort to transition NASA research to NOAA operations, initially focusing on altimetry, scatterometry, and ocean color. Transitioning these data streams requires also transitioning associated calibration and validation capabilities and capacities. Future opportunities may also include sea-surface salinity and interferometric synthetic aperture radar following the launch and validation of the NASA's Aquarius mission and approval of InSAR. NOAA satellite ocean remote sensing activities also require transition to operations in order to fulfill mission and user requirements.

NOAA CoastWatch/OceanWatch is the vehicle for transitioning developmental satellite ocean remote sensing processes, products, and services into operational status and is the NESDIS focus for definition, development, and support of operational satellite remote sensing functions in NOAA. NOAA CoastWatch/OceanWatch partners with other NOAA elements, forming a regional node structure to implement operational satellite ocean remote sensing within NOAA. This structure parallels and will support the planned structure for the IOOS and its Regional Associations.

Future satellite applications for planned operational capabilities (NPOESS, GOES-R, JASON 2, and IJPS) are given exposure for community feedback and user capacity building in the form of new experimental products. Education and outreach, consequently, constitute a significant component of this strategic priority, with the goal to familiarize the public with satellite ocean remote sensing data, facilitate its interpretation, and expand its use. NOAA CoastWatch/OceanWatch and CIOSS provide the focus for SOCD's education and outreach efforts.

2.6.2 Fundamental Research

Office of Research and Applications pioneered a number of highly successful heritage remote sensing products from the operational POES and GOES series over ocean. We will continue to serve as the "corporate memory" for existing products, and continue fundamental cutting edge research into development of new remote sensing methodologies with the heritage platforms and sensors. We will also actively participating in shaping new remote sensing missions, sensors, and retrieval methodologies from them.

2.6.3 Quality Assurance, Calibration, and Validation

The calibration of satellite instruments and the quality control/assurance and validation of their data and products are fundamental necessities for ensuring data precision, accuracy, representativeness, and quality. The main objective of the calibration/validation strategic priority is to provide satellite ocean remote sensing observations with defined uncertainties to the operational and scientific communities, which will be achieved by developing, monitoring, and maintaining uncertainty budgets. These activities are critical for the appropriate and effective assimilation of satellite data into numerical models and the inclusion of satellite data in climate data records. In addition to the initial certification of new satellites (NPOESS, JASON-2, GOES-R), operational satellites, require ongoing evaluation of algorithms, data, and products to ensure requirements and specifications continue to be met, despite any changes of instrument operating characteristics.

2.6.4 Data Assimilation

Data assimilation provides a crucial link in transforming satellite ocean remote sensing observations into information for decision makers. Satellite data assimilation enhances the representativeness of the initial conditions and forcings used in numerical atmosphere and ocean models, thereby improving model skill and the analyses and predictions used by decision makers. The current challenge is data assimilation for separate atmosphere and ocean models. The future challenge is data assimilation for coupled ocean-atmosphere models. Data assimilation provides data fusion for observations from combinations of multiple instruments/satellites and *in-situ* observations, yielding "best value" analyses This strategic priority directly aligns with and contributes to the efforts of the Joint Center for Satellite Data Assimilation (JCSDA) to improve near-real-time and climatological forecasts. SOCD's role in data assimilation is to provide relevant data sets, along with the data uncertainties and the physics and algorithms used to obtain the retrievals.

2.6.5 Climate

The ocean component of the coupled ocean-atmosphere system responds to and influences climate variability while slowly reflecting climate change. These signatures, in turn, influence and drive the coupled ocean-atmosphere system. Because of the high heat capacity of water, while climate variability signals may be relatively large, e.g. El Niño, climate change signals in the ocean tend to be small, yet significant. Consequently, climate data records need to be precise and accurate, creating technological and scientific challenges to adequately measuring climate change over shorter time scales. Satellite ocean remote sensing provides a capability for evaluating climate-relevant parameters consistently on a global scale. Current climate-relevant satellite ocean remote sensing parameters include sea-surface height (global sea-level rise and thermal content), sea-surface temperature, sea-ice, ocean surface winds, and ocean color. It is important to establish climate data records for climate relevant parameters as soon as possible in order to have significant time-series for climate-related analyses and decisions. As science and technology evolve and improve, as well as through the acquisition of new information/data, existing climate data records need to be updated to reflect the best possible observation retrievals. Developing and maintaining accurate climate data records on a regional and global time-scale enable developing seasonal to interannual forecasts, assessing global sea level rise, and evaluating climate change, all key objectives of the NOAA Climate Mission Goal.

3 CAPABILITIES

SOCD satellite ocean remote sensing research and development capabilities address the Division's strategic priorities end-to-end and are encapsulated in end-to-end functional areas cross-matrixed by end-to-end parameter science teams.

3.1 Technology Areas

Functional Areas organize the Division's science efforts according to context, providing a fully integrated network across the Division's ocean parameter science teams and strategic priorities. The three functional areas are Satellite Ocean Sensors, Ocean Dynamics, and Marine Ecosystems.

- **Satellite Ocean Sensors**

The Satellite Ocean Sensors functional area spans the visible, infrared, and microwave spectral regions and encompasses research on developing new satellite ocean remote sensing parameters and improved algorithms for existing parameters for ultimate transition to and maintenance support for operational algorithms and data streams. This functional area focuses on defining design characteristics for new satellite instruments, exploring and defining relationships between satellite observations and geophysical parameters, and developing and validating retrieval algorithms. This task is inherently entwined with calibration and validation efforts. Science and technology areas include working with *in-situ*, as well as airborne, instrumentation in conjunction with satellite ocean remote sensing instruments.

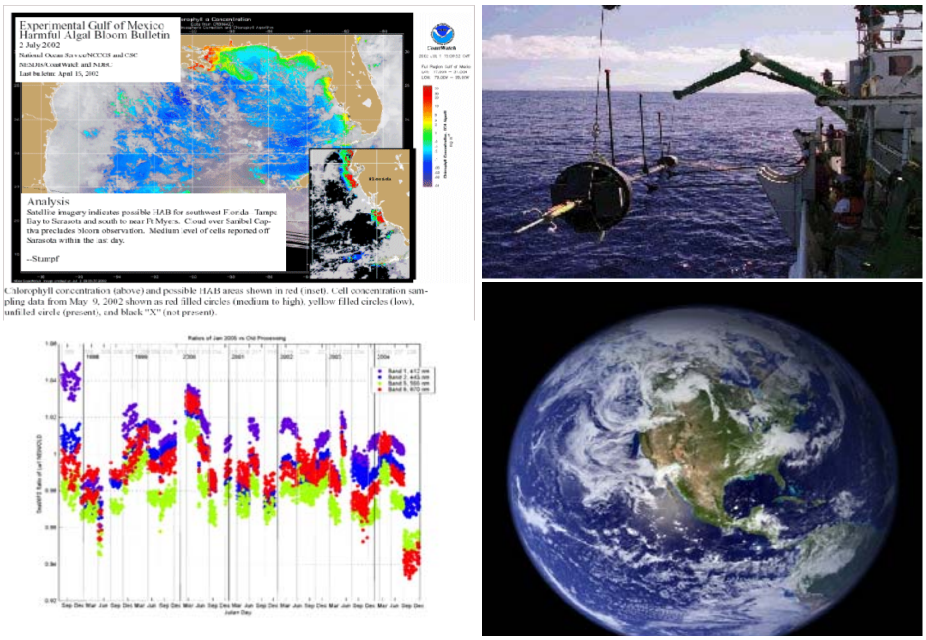


Figure 7. The Marine Optical BuoY (MOBY) (top right) provides crucial vicarious calibration of ocean color sensors and a necessary element for quality ocean color data and validation with known uncertainties, a requirement for introducing ocean color data assimilation into biogeochemical and ecosystem models.

- **Ocean Dynamics**

Ocean Dynamics focuses on the physical oceanography and marine geophysics aspects of satellite ocean remote sensing. Near-real to interannual and longer time scales are considered. Research and analysis areas include general ocean circulation and its variability, the marine gravity field, and bottom topography. Theses efforts provide: support for numerical oceanic/atmospheric prediction and global climate change models; data fusion of scatterometry wind data and altimetry sea surface height data to determine ocean surface current and their variabilities; and the identification of ocean thermodynamic processes/features and their temporal patterns through the analysis of infrared sea-surface temperature data

- **Marine Ecosystems**

Marine Ecosystems focuses on conducting research and developing operational satellite ocean remote sensing applications for oceanic, coastal, and estuarine areas to detect and address aspects of marine ecosystems important to NOAA's objectives for monitoring habitats, managing ecosystems, protecting species, maintaining human health, measuring water quality, and promoting sustainable development. Within Marine Ecosystems, Coral

Reef Watch (CRW) is a collaborative integrated program utilizing remote sensing and *in-situ* tools for near-real-time and long-term monitoring, modeling, and reporting of coral reef ecosystem physical environmental conditions. It aims to assist the management, study, and assessment of the impacts of environmental change on coral reefs. In particular, sea surface temperature data is used to determine and predict areas of coral bleaching through the measurement of accumulated heat stress. Research continues on integrating additional parameters into the assessment of coral reef health.

3.2 SCIENCE TEAMS

Science teams provide an integrated end-to-end link between the scientific research and applications and operational activities in support of the socioeconomic benefits targeted by NOAA's Strategic Goals. The science teams develop in-house, national, and international partnerships and collaborations to fulfill requirements set by the user community. NOAA capacity building is achieved through leveraging internal and external funding opportunities and efforts in conjunction partners. Notable interchange is achieved with NASA and the Department of Defense, the Navy in particular.

- **Sea Surface Temperature**

NOAA/NESDIS provides world leadership in delivering global sea surface temperatures (SST) from the infrared (IR) measurements onboard the NOAA Polar Orbiting Environmental Satellites (POES), and now also from the Geostationary Operational Environmental Satellites (GOES). Pending POES and GOES near-term satellite systems, IJPS, NPOESS, and GOES-R drive significant current operational development activities. The process begins at the research level on satellite SST retrieval algorithms, continues through the transition of retrieval algorithms to NOAA operations, concludes with operational quality assurance and validation of products, as well as product delivery to users[2]. Historically, the emphasis has been on infrared SST retrievals; however, most recently, microwave (MW) SSTs are being explored. Accompanying SST capabilities include the operational determination of calibration coefficients, intercomparison and intercalibration of different instruments, and enhanced atmospheric and aerosol corrections. The SST team provides critical support to NOAA's Ecosystems, Climate, and Weather and Water Mission Goals through direct data and products for numerous operational applications, including fisheries management, protected species, marine ecosystem monitoring and management (coral reefs in particular), numerical weather and ocean modeling and prediction, as well as understanding ocean dynamics and climate variability.

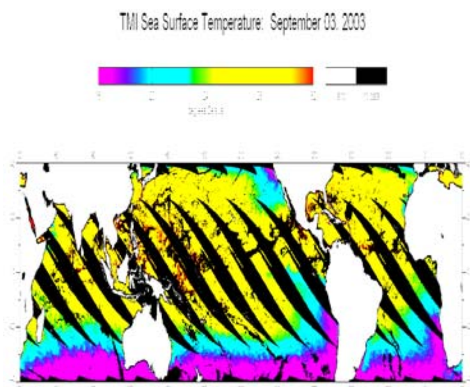


Figure 8. 30 km Sea Surface Temperature data from joint NASA/JAXA TRMM (Tropical Rainfall Measurement Mission) used to observe global weather and climate patterns.

- **Sea Surface Height**

[2] Sea Surface Temperature Science Team Research Project Plan FY 2004.

The Sea Surface Height Team deals primarily with satellite altimeter data collected over the global oceans, working with the TOPEX/Poseidon, Jason-1, and GeoSat Follow-on (GFO) data streams and preparing for the operational Jason-2 data stream. The focus of the team has been on the transition from research to operations, both in terms of data processing systems and ocean applications. Capabilities include providing the definitive data sets for the GFO mission, retracking altimeter data sets to maximize the extraction of information, and applying the altimetry data to operational applications, Team projects support four focus areas: altimeter data, ocean dynamics, marine gravity and bathymetry, and climate. Overall the Sea Surface Height team addresses NOAA strategic goals by providing high quality global altimeter data along with applications such as: forecasting El Niño events; determining the rate of global sea level rise (Climate Variability Goal); ocean current analyses (Ecosystems Goal); and mapping the deep ocean floor and improving the accuracy of bathymetric charts (Commerce and Transportation Goal)[3].

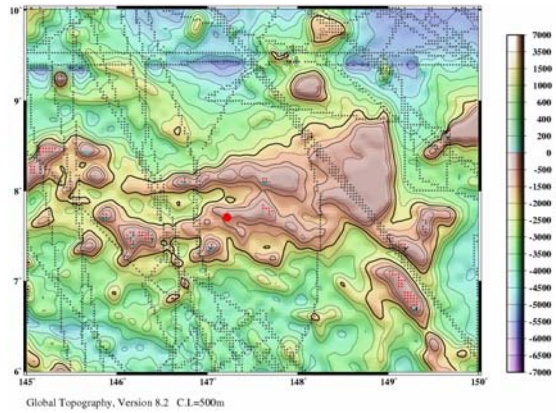


Figure 9. The crash site (marked by a red dot) of the *USN San Francisco* displayed with satellite derived bathymetry and contours. Black dots traversing the area represent charted soundings.

- **Ocean Surface Winds**

The Ocean Surface Winds Science Team (OSWST) is the focal point for satellite remote-sensing of ocean surface wind products within NOAA. Efforts and capabilities include addressing product quality and validation issues and in planning for future missions, such as the ASCAT (scatterometry) on IJPS and CMIS (passive microwave polarimetry) on NPOESS. OSWST directly supports operational users, such as the National Weather Service, through product development, validation, and implementation. Considerable effort goes toward education on the various remote sensing techniques to improve product utilization by marine forecasters. OWST activities employ SeaWinds on QuikSCAT, SeaWinds on ADEOS-II, WindSAT on Coriolis, ASCAT on IJPS, SSM/I on DMSP, AMSR on AQUA, and ADEOS-II and TMI on TRMM. OSWST is also leading an effort to quantify the impacts of ocean surface wind vector data in operational marine nowcasting and forecasting within the Ocean Prediction Center and the Tropical Prediction Center.[4] The OSWST's major contribution is to NOAA's Weather and Water Mission Goal.

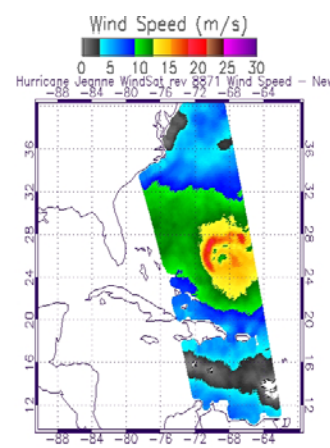
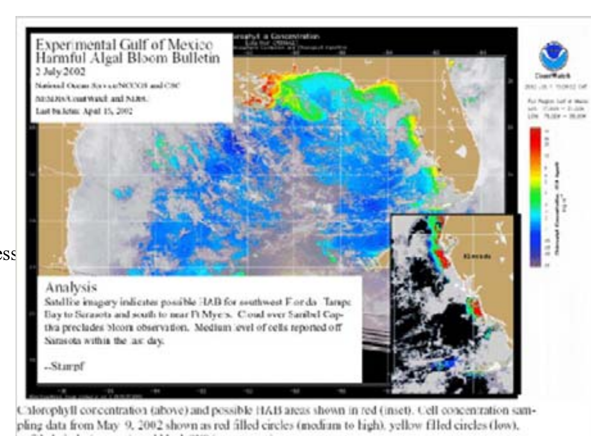


Figure 10. WindSAT image of Hurricane Jeanne. A purple thru blue scale indicates highest to lowest wind speeds.

- **Ocean Color**



Chlorophyll concentration (above) and possible HAB areas shown in red (inset). Cell concentration sampling data from May 9, 2002 shown as red filled circles (medium to high), yellow filled circles (low), unfilled circle (present), and black "X" (not present).

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3 Sea Surface Height Science Team Research Project Plan FY04

4 20th International Conference on Interactive Information and Process

The Ocean Color Science Team (OCST) provides high quality, continuous and consistent ocean color data for the user community by calibrating and validating present and future ocean color sensors by providing a foundation reference, calibrated to National Institute for Standards and Technology (NIST) absolute radiometric standards, for linking data records from different ocean color satellite instruments. This foundation reference, provided by Marine Optical Buoy (MOBY) located in clear open-ocean Hawaiian waters, is the only high-quality vicarious calibration capability in the world and it enables the team to collect quality *in-situ* data for calibrating ocean color satellite sensors. Future developments will extend validation observations into more complex coastal waters. The Marine Optical Characterization Experiment (MOCE) is a counterpart to MOBY for developing new and improved satellite ocean color remote sensing algorithms calibrated and validated by MOBY. OCST utilizes satellite ocean color data to monitor the environment by identifying climate variability trends and monitoring significant ecological events through changes in biogeochemical transformations of carbon. The overall goals of the OCST are to develop capabilities which fully use ocean color observing satellite systems to provide quantitative information relating to oceanic biological parameters, particularly; phytoplankton biomass, important biogeochemical processes, and the state and magnitude of human activity impacts in oceanic and coastal waters[5]. Developmental ocean color data is provided for operational HAB bulletins produced by NOS. The goals of the OCST support the Ecosystems and Climate Goals of NOAA's Strategic Plan.

Figure 11. Ocean color satellite data is used in producing harmful algal bloom bulletins.

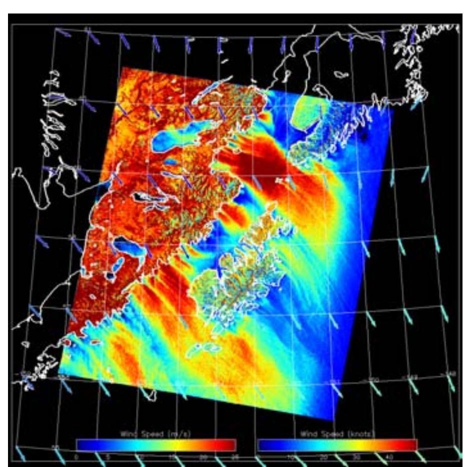
- **Sea Ice**

SOCD's Sea Ice Science Team partners with the National Ice Center's (NIC) Polar Science Team, providing the Chief Scientist for the joint NOAA – U.S. Navy – U.S. Coast Guard National Ice Center (NIC), to exploit remote sensing data and processing assets 1) to develop and validate multi-sensor sea ice products that respond to the user community's needs, 2) to expand sea ice and cryospheric research through the use of new technologies and approaches, 3) to provide science support and expertise for the production and development of analyses and forecasts of sea ice conditions for customers with global, regional and tactical scale interests, and 4) to respond to specific operational user requirements[6]. Operational data and science support is provided for visible and infrared imagery and data from POES and DMSP satellites and radar "imagery" from synthetic radar instruments (RadarSat-1, ENVISAT), as well as data from passive (SSMI/S) and active (QuikSCAT scatterometer) instruments.

Figure 12 Sea ice forecasts provide ice conditions for operational user requirements.

The Sea Ice Science Team supports the Ecosystems, Climate, Weather and Water, and Commerce and Transportation Goals.

- **Sea Surface Roughness**



[5] Ocean Color Science Team Research Project Plan.
[6] Sea Ice Science Team Research Project Plan

The Sea Surface Roughness (SSR) Science Team works through partnerships with the Canadian Space Agency (CSA), European Space Agency (ESA), the National Space Development Agency of Japan (NASDA), Japan Aerospace Exploration Agency (JAXA), and other organizations with synthetic aperture radars (SAR). There is currently no domestic SAR satellite; consequently, the U.S. relies on partners, research programs, and the data purchases to fulfill its needs. SOCD, however, provides significant leadership and development of SAR ocean products. Capabilities include efforts leading to an operational products system for automated ocean product generation from SAR data, in addition to educated use of SAR imagery within operational Federal and State agencies through the development of the SAR User's Manual and the SAR Winds Manual. Additionally, SOCD develops algorithms and products for high-resolution wind speed and direction, vessel detection, marine oil spill mapping, sea/lake/river ice location/type/concentration/motion, ocean feature detection, severe storm morphology, lower atmospheric boundary layer processes, wave spectra, significant wave height, and coastal change detection.

Figure 13. CSA and ESA SAR imagery is used to determine high speed winds.

The team supports the Weather and Water, Ecosystems, and Commerce and Transportation Mission Goal.

3.3 TRANSITIONING RESEARCH TO OPERATIONS

○ NOAA CoastWatch

SOCD's NOAA CoastWatch program transitions SOCD and NASA research to operations by developing and implementing the delivery of near-real-time developmental satellite data and products to the user community for evaluation, feedback, use, education, and outreach in support of NOAA's strategic goals. Primary users include government, military, and the commercial and public sectors.

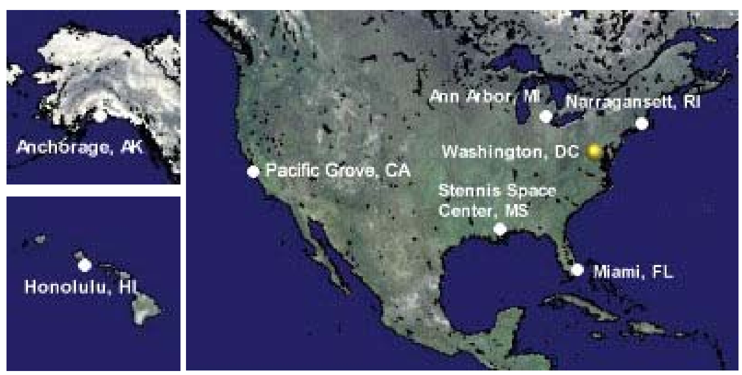


Figure 14. CoastWatch Central Command (yellow) and Regional Nodes (white).

CoastWatch is made up of a Central Operations Center and seven regional nodes, located throughout the United States on all coastlines, including the Great Lakes Region. As IOOS develops, NOAA CoastWatch will be a component of NOAA's contribution to the IOOS National Backbone for satellite ocean remote sensing. CoastWatch's regional structure will provide support to the IOOS Regional Associations.

○ OceanWatch

OceanWatch, recently initiated, extends NOAA CoastWatch to a broader context, including international participation. OceanWatch comprises a system of systems for sustained, operational satellite ocean remote sensing data, products, and

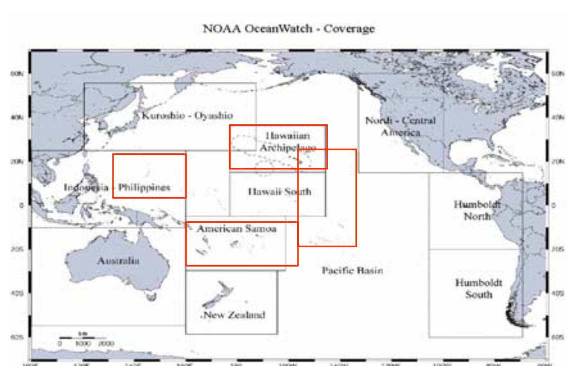


Figure 15. OceanWatch areas shown in black are an expansion added to the original CoastWatch areas shown in red.

services. Efforts focus on the development of utilities, tools, and techniques for working with, using, and applying satellite ocean data. In addition to near-real-time satellite data/product support, OceanWatch will include a climatological dimension. Initial OceanWatch components include NOAA CoastWatch, the West Coast OceanWatch node at the NOAA Pacific Fisheries Environmental Laboratory (PFEL), the Central Pacific OceanWatch node at the NOAA Pacific Islands Fisheries Science Center, and China CoastWatch (under development). The OceanWatch North Pacific Demonstration Project expands satellite data availability to the majority of the eastern coast of Asia, Indonesia and the Philippines, American Samoa, Hawaii (north and south), New Zealand and the west coast of South America. Providing operational near-real-time high resolution ocean satellite coverage to the world ocean by 2008 is the goal. The OceanWatch construct parallels, supports, and, effectively, implements an initial small piece of GOOS and GEOS.

- **WIPE**

To aid in providing processed data to users, the World-Wide Web (WWW) Image Processing Environment (WIPE) was developed. WIPE is an automated interactive web-based system built to manipulate and fuse recent and historical satellite imagery to produce high-level products at the user's request. WIPE provides server-based processing of interactive user-specified satellite data composite images/files, returning just the final product; thereby, eliminating requirements for a user to have high-volume communications links and processing capabilities for very-large satellite data sets.

4 ROADMAPS AND LINKAGES

SOCD roadmap diagrams, depicting the progression of present and future research and operations and the integration with other NOAA programs, consist of horizontal time-blocked tasks mapped by satellite launch dates, encompassed within the context of broader efforts denoted by large arrows. The progression of projects and efforts contribute to achieving identified overarching goals and objectives.

Figure 16. Strategic Priority Roadmap Example

4.1 SOCD ROADMAPS

Roadmaps for each strategic priority, technology area, and science teams are located are provided of in Appendices I, II, and III, respectively. Strategic Priority and Technology Area roadmaps span the activities of all the Science Teams within, providing end-to-end slices. Science Team roadmaps detail specific projects and efforts and time periods of accomplishment. The guiding objectives for each strategic priority, technology area, and science team are listed below.

4.1.1 Strategic Priorities

- ***Research to Operations***: To facilitate the design and implementation of operational satellite remote sensing products and services through an efficient effective delivery system to the user community.
- ***Calibration/Validation***: Provide geophysical satellite observations with defined uncertainties to the operational and science communities. The long term objective is to provide climate-quality data records.
- ***Data Assimilation***: To combine multiple satellite and *in-situ* data sets to meet NOAA requirements for satellite ocean data assimilation.
- ***Climate***: Obtain and maintain climate quality global satellite data, validated to NOAA's Consolidated Observations Requirements List (CORL) specifications.

4.1.2 Technology Areas

- ***Satellite Ocean Sensors*:**
  - Utilize visible, IR, and microwave spectral regions to develop new satellite remotely-sensed ocean parameters
  - Define and improve calibration and validation algorithms for data
  - Transition algorithms to operations
- ***Ocean Dynamics***: With respect to near-real to interannual or longer time scales with focuses on physical oceanography and marine geophysics of satellite ocean remote sensing support:
  - Numerical oceanic/atmospheric prediction and global climate change models
  - Data fusion of scatterometry wind data and altimetry sea surface height data to determine ocean surface current and variability
  - Identification of ocean thermodynamic processes/features and their temporal patterns through the analysis of infrared sea-surface temperature data

- ***Marine Ecosystems***: With respect to NOAA's objectives for monitoring habitats, managing ecosystems, protecting species, maintaining human health, measuring water quality, and promoting sustainable development:
  - Develop operational satellite ocean remote sensing applications for oceanic, coastal, and estuarine areas to detect and address aspects of marine ecosystems
  - Support the Integrated Ocean Observing System

4.1.3 Science Teams

- ***Sea Surface Temperature*:**
  - *Environmental Data Records (EDRs)*:
    - Sustain the current heritage SST/Aerosol EDRs from POES AVHRR and GOES Imager sensors
    - Develop improved methodologies for SST/Aerosol from heritage platforms and sensors
    - Actively contribute to shaping the new missions, sensors, and methodologies (IJPS, NPOESS, GOES-R)
    - Prepare for future SST/Aerosol EDRs (NPOESS, GOES-R)

    - Merge the SST EDRs and National Centers for Environmental Prediction (NCEP) data streams, to constrain the atmospheric correction and facilitate skin-to-bulk SST conversion
  - *Climate Data Records (CDRs)*: Develop high-quality global satellite SST climate data records(CDR)
    - Generate SST/Aerosol CDRs from AVHRR and GOES Imager using improved sensor characterization, cloud screening, and SST inversion techniques
    - Evaluate potential of GOES Imager to develop all-time-first SST climatology with diurnal cycle resolved
    - Evaluate POES/GOES climatologies against available ground-based climatologies and measure improvements
  - *Calibration / Validation*: Develop and implement a SST/Aerosol Quality assurance/calibration/validation system
    - *Develop web-based QA/Cal/Val system to* monitor SST/Aerosol quality from POES and GOES
    - *Use QA/Cal/Val system to* identify persistent uncertainties in SST/Aerosol EDRs and work to fix problems and reduce errors
    - Validate operational satellite SST EDRs to CORL specifications
  - *Applications*: Generate high-quality satellite-only SST products for areas lacking *in-situ* data.

- ***Sea Surface Height***:
  - *Altimeter Data Sets*: Provide altimeter CDRs to CORL specifications
    - Reduce SSH uncertainty
    - Improve timeliness and expand applications
  - *Ocean Dynamics*: Operational monitoring of dynamic topography and global sea level to CORL specifications
    - Reduce uncertainty in surface currents from altimetry
    - Apply satellite altimetry to research and operational applications with respect to ocean circulation
  - *Gravity and Bathymetry*: Global, average SSH slopes on a one-nautical mile grid, accurate to one microradian
    - Reduce uncertainty and improve resolution of global ocean gravity and bathymetry products
  - *Climate*: Operational monitoring of global sea level to CORL specifications
    - Reduce uncertainty to global sea-level rise
    - Apply satellite altimetry to research and operational applications in areas of climate variability and change

- ***Ocean Surface Winds***:
  - Operational surface wind vectors, validated to CORL specifications
    - Improve marine forecasting through satellite ocean surface wind data assimilation into numerical models

- Improve marine forecasting through forecaster use of satellite ocean surface wind products

- ***Ocean Color*:**
  - *Ocean Color Marine Optical BuoY (MOBY)*: Provide absolute radiometric standard and maintain a reference for intercomparison of ocean color satellite missions, accurate to CORL specifications; develop ocean color climate-quality data products
    - Operational vicarious calibrations of satellite ocean color sensors to reduce uncertainties in satellite ocean color measurements
  - *Ocean Color Marine Optical Characterization Experiment (MOCE)*: Operational ocean color measurements validated to CORL specifications
    - Develop and validate new and heritage ocean color algorithms for ocean bio-optical properties
  - *Ocean Color Validation*: Operational ocean color measurements validated to CORL specifications
    - Develop quantitative accuracy estimates to assess data quality
  - *Ocean Color Products and Applications*: Develop ocean color applications that address NOAA Mission Goal requirements
    - To develop capabilities to provide quantitative information relating to oceanic biological parameters, particularly; phytoplankton biomass, important biogeochemical processes, and the state and magnitude of human activities in oceanic and coastal waters.

- ***Sea Ice*:**
  - *Sea Ice Product Research and Development*: Complete sea ice CORL EDR algorithms
    - Develop operational algorithms and products that provide required measurements of sea ice and other cryospheric parameters from available active and passive microwave, infrared, and visible data
  - *Sea Ice Altimetry*: Develop sea ice freeboard estimation capability for climate research
    - Provide validated capability to estimate sea ice thickness from microwave altimeter satellites
  - *National Ice Center (NIC) Polar Research*: Reduce uncertainty in the accuracy of sea ice products and forecasts
    - Reduce sea ice detection and characterization uncertainty
    - Sustain and develop operational sea ice products, models, and forecasts to meet NIC requirements as NOAA's operational ice services activity

- ***Sea Surface Roughness*:**
  - *Securing SAR Data Access for Research and Operations*: U.S. operational SAR satellite mission as part of NPOESS

- Secure affordable, long-term, near-real-time operational access to multi-frequency multi-polarization, interferometric SAR data for product generation and image analysis

- *Synthetic Aperture Radar Product Research*: Complete CORL EDR algorithms
  - Develop operational algorithms and products providing quantitative measurements of coastal and open ocean parameters
- *SAR Applications Demonstrations and User Outreach and Education*: A well-trained operational user community and an educated public making appropriate use of SAR data and products
  - Demonstrate SAR-derived products in an operational environment to operational users
  - Cultivate and train a SAR user community
- *Operational SAR Ocean Products System Development*: Develop operational SAR ocean products software system capability
  - Develop a fully operations-ready SAR ocean products system that can be operated as a part of the NPOESS system

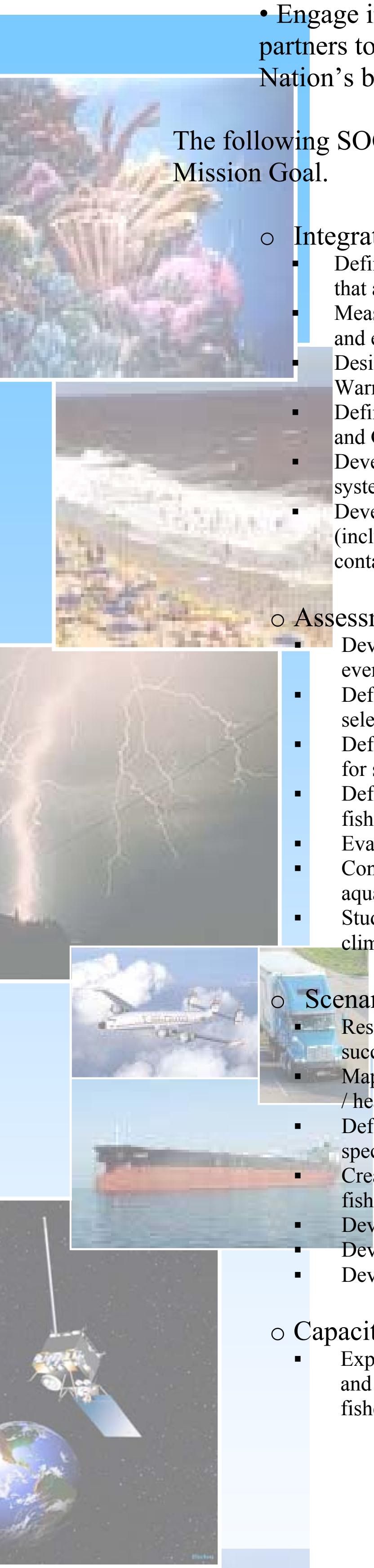
4.2 LINKS WITH MISSION GOALS AND PROGRAMS

The strategies for each NOAA Mission Goal for achieving their objectives are identified in the NOAA's FY 2006 – FY 2011 strategic plan, "**New Priorities for the 21st Century – NOAA's Strategic Plan**". The SOCD-relevant strategies are provided below. The SOCD-relevant research objectives of each NOAA Mission Goal, as listed in the NOAA's five-year (2005 – 2009) research plan (January, 2005), " **Research in NOAA: Toward Understanding and Predicting Earth's Environment**", are also listed below to demonstrate the alignment of SOCD science and technology efforts and plans with NOAA objectives. Existing and planned linkages with NOAA Mission Goal programs and activities are also described.

4.2.1 Ecosystems

The overarching objective of the Ecosystems Mission Goal is to protect, restore, and manage use of coastal and ocean resources through an ecosystem approach to management. The Ecosystem Mission Goal strategies include:

• Engage and collaborate with our partners to achieve regional objectives by delineating regional ecosystems, promoting partnerships at the ecosystem level, and implementing cooperative strategies to improve regional ecosystem health.
• Manage uses of ecosystems by applying scientifically sound observations, assessments, and research findings to ensure the sustainable use of resources and to balance competing uses of coastal and marine ecosystems.
• Improve resource management by advancing our understanding of ecosystems through better simulation and predictive models. Build and advance the capabilities of an ecological component of the NOAA global environmental observing system to monitor, assess, and predict national and regional ecosystem health, as well as to gather information consistent with established social and economic indicators.



• Develop coordinated regional and national outreach and education efforts to improve public understanding and involvement in stewardship of coastal and marine ecosystems.
• Engage in technological and scientific exchange with our domestic and international partners to protect, restore, and manage marine resources within and beyond the Nation's borders.

The following SOCD-relevant research priorities have been defined by the Ecosystem Mission Goal.

- Integrated Earth observing system and data management system
  - Define the time and space scales needed to capture the fundamental physical and biological drivers that are required for ecosystem forecasts and natural resource assessments.
  - Measure the natural scales of variability regarding physical-biological coupling, food web dynamics and ecosystem production in selected ecosystems.
  - Design and develop a comprehensive coral reef ecosystem monitoring program (Coral Reef Early Warning System).
  - Define observational needs to assess the impact of management decisions on fisheries and coastal and Great Lakes resources and habitat quality.
  - Develop and test new chemical and biological sensors for coastal and Great Lakes observing systems.
  - Develop parameters and indices of eutrophication, water quality, HABs, and contaminants (including pharmaceuticals and steroids) in coastal and marine ecosystems; provide trends in contaminant concentrations; and identify new anthropogenic contaminants.

- Assessments and forecasts of coastal and marine ecosystems
  - Develop forecasts for the ecological effects of varying weather patterns and extreme physical events.
  - Define the primary forcing factors and time and space scales that cause HABs and anoxia for selected coastal, ocean, and Great Lakes regions.
  - Define the primary forcing factors and time and space scales that affect water quality and quantity for selected coastal and Great Lakes regions.
  - Define the primary forcing factors and time and space scales that affect fish recruitment and fisheries production for selected coastal and Great Lakes regions.
  - Evaluate pelagic bycatch reduction technology and innovative TED Technology
  - Conduct environmental impact studies to establish baseline information for citing of commercial aquaculture activities.
  - Study aquatic biodiversity and how anthropogenic stresses, extreme environmental events, and climate influence population dynamics of coastal and marine ecosystems.

- Scenario development to support specific management actions and decisions
  - Research to improve our understanding of the factors affecting threatened species and the potential success of alternative remediation/management strategies.
  - Map habitat types (existing and restorable) and identify key habitat functions; evaluate the function / health of habitat.
  - Define and evaluate the value and economic/ecological costs/benefits of aquaculture for specific species in specific regions.
  - Create models coupling physical oceanography variability and biological effects on productivity, fish recruitment, and distribution.
  - Develop the next generation of multi-species fisheries and food web production models.
  - Develop environmentally sound production technologies for marine species.
  - Develop a NOAA-wide research plan for shallow coral ecosystems.

- Capacity building and effective knowledge transfer
  - Expand extension and education approaches to provide scientific information in advance of actions and regulations and to assist NOAA in fostering increased understanding and partnerships among fishers, conservation and environmental groups, coastal use community, and scientists.

- Provide cost-benefit forecasts and risk analyses of management decisions and human use of coastal and Great Lakes ecosystems.

Ecosystem Program Links

- *Habitat*: To be established.
- *Corals*: SOCD has extensive links with the Coral Reef Conservation Program, leading NESDIS's participation in this matrixed program and leading the program's Coral Reef Watch effort that monitors and assesses, amongst other factors, coral reef bleaching conditions through the use of satellite sea surface temperature data. Efforts are underway to incorporate satellite ocean surface wind, ocean color, sea-surface height, and insolation data to refine assessments. SOCD also is a major component in the developing Coral Reef Ecosystem Integrated Observing System (CREIOS), which is being planned as a component of the national IOOS.
- *Coastal and Marine Resource Management*: Specific links currently being refined. SOCD shares two billets with the NOS Coastal Services Center, supporting coastal zone management efforts.
- *Protected Species*: Specific linkages to be established. Sea surface temperature and ocean color (chlorophyll) products are provided to facilitate monitoring and avoidance of protected species, such as loggerhead and leatherback turtles, through reduced by-catch associated with swordfish and tuna fishing in the Pacific and mackerel fishing in the Atlantic. The application of satellite data to this issue is focused on efforts at the Central Pacific CoastWatch node.
- *Fisheries Management*: Specific linkages to be established. Sea-surface temperatures (SST) and sea-surface heights (SSH) provide the basis for CoastWatch's El Niño Watch that provides a current assessment of upwelling conditions along the West Coast of the U.S. The National Marine Fisheries Service has written the use of this specific operational oceanography product as guidance for designating whether El Nino conditions exist along the west coast of the US and the resulting imposition of restricted fishing areas.
- *Aquaculture*: To be established.
- *Enforcement*: Specific links to be established. SOCD provides satellite enforcement products to the U.S. Coast Guard and the Alaska Department of Fish and Game. SAR products for vessel location and ice edge are provided under the NESDIS Alaska SAR Demonstration. SAR imagery provides information on the fleet distribution and whether these observers are well distributed throughout the fleet, as well as for issues of safety. Sea-surface temperature operational products are supplied weekly to U.S. Coast Guard, First District, Fisheries Intelligence Branch, in the Atlantic in support of enforcement operations.
- *Ecosystem observation systems*: To be established.
- *Ecosystem research*: To be established.

4.2.2 Climate

The guiding focus for the Climate Mission Goal is to understand climate variability and change to enhance Society's ability to plan and respond. Specific strategies include:

• Improve the quality and quantity of climate observations, analyses, interpretation, and archiving by maintaining a consistent climate record and by improving our ability to determine why changes are taking place.
• Improve the quantification and understanding of the forces bringing about climate change by examining relevant human-induced increases in atmospheric constituents.
• Advance sub-seasonal to inter-annual climate predictions and climate change projections by improving analysis of the climate system, using ensembles of multiple, high-end climate and Earth system models.
• Develop the ability to predict the consequences of climate change on ecosystems by monitoring changes in coastal and marine ecosystems, conducting research on climate-ecosystem linkages, and incorporating climate information into physical-biological models.
• Develop and contribute to routine state-of-the-science assessments of the climate system for informed decision-making.
• Work with customers in order to deliver climate services and information products involved in health, safety, environmental, economic, and community planning that increase the effective application of this information.
• Coordinate among NOAA Line Offices the transition from investigator-driven research projects to operational facilities, capabilities, and products.
• Support educational efforts to create a more climate-literate public by developing climate educational materials, involving teachers in the research process, and generating tools to allow climate information to be used in decision-making.

The following SOCD-relevant research priorities have been established by the Climate Mission goal.

- Develop an integrated global observation and data system for routine delivery and attribution of past and current state of the climate and climate forcing
  - Produce Climate Data Records
  - Report on state of knowledge of decadal variability, the monitoring ability for this, and potential decadal predictability
  - Routine reports on detection/attribution studies linking observing capabilities with model projections
  - Implement next generation reanalysis capability
  - Deploy prototype Arctic observing system for monitoring sea ice, heat content, freshwater, and ecosystem indicators with partners
  - Routine assessments of sea level rise and required observing capabilities
  - Establish Indian Ocean climate observing system

- Document and understand changes in climate forcing and feedbacks, thereby reducing uncertainty in climate projections
  - Produce regional oceanic and terrestrial carbon uptake maps

- Improve skill of climate predictions and projections and increase range of applicability for management and policy decisions
  - Develop dynamic understanding of decadal variability and predictability studies
  - Improved summertime forecasts with analyses of field-driven monsoon data
  - Develop multi-model based operational seasonal forecast system
  - Develop probabilistic predictions for week-2 extreme events

- Understand impacts of climate variability and change on marine ecosystems to improve management of marine ecosystems

  - Ten-year trends in coastal chlorophyll and assessments of climate influence X
  - Track and improve the ability to forecast, the relationships among climate and variations in coral cover, bleaching, and anthropogenic impacts on coral reefs X
  - Detailed models of coastal inundation and ecosystem change for specific areas for use by land use managers

- Enhance NOAA's operational decision support tools to provide climate services for national socio-economic benefits
  - Develop new experimental tools (including methods, models, and educational and outreach resources) that communicate climate information and deliver techniques for incorporating that information/analysis into specific decision scenarios.
  - Implement prototype decision support tool for water management linking historical, current, next season, and decadal outlooks
  - Identify key climate-sensitive issues at regional scales
  - Develop prototype methods for the application of climate information to practical challenges associated with natural resource management and hazard mitigation

Climate Program Links

- *Climate observations and analysis*: Specific links to be established. Sea-surface temperature and sea-surface height data and, recently, ocean color data are employed to monitor ocean aspects of variability and climate change.
- *Climate predictions and projections*: Specific links to be established. Sea-surface temperature, sea-surface height, and ocean surface wind data contribute to climate modeling efforts. Ocean data assimilation efforts through the JCSDA have only just begun.
- *Climate and ecosystems*: Specific links are being established. Sea-surface temperature data are employed through the Coral Reef Watch effort and a new requirement for ocean color data to monitor phytoplankton has been stated for the monitoring of sentinel species.
- *Regional decision support*: Specific links to be established. OceanWatch efforts to establish climatological products will support this program.

4.2.3 Weather and Water

The Weather and Water Mission Goal is tasked to serve Society's needs for weather and water information. Specific strategies include:

• Improve the reliability, lead-time, and effectiveness of weather and water information and services that predict changes in environmental conditions.
• Integrate an information enterprise that incorporates all stages from research to delivery, seeks better coordination of employee skills and training, and engages customers.
• Develop and infuse research results and new technologies more efficiently to improve products and services, streamline dissemination, and communicate vital information more effectively.
• Work with private industry, universities, and national and international agencies to create and leverage partnerships that foster more effective information services.
• Build a broad-based and coordinated education and outreach program by engaging individuals in continuous learning toward a greater understanding of the impacts of weather and water on their lives.
• Employ scientific and emerging technological capabilities to advance decision support services and educate stakeholders.

The following SOCD-relevant research priorities have been identified to support this effort.

- Improve the accuracy and capabilities of NOAA's monitoring and observing systems, both *in situ* and remotely sensed

- Improve weather forecasts and warning accuracy and amount of lead time
  - Advance data assimilation techniques; satellite, radar, ocean, hydrologic, and land surface assimilation

- Improve NOAA's understanding and forecast capability in coasts, estuaries, and oceans
  - Development of a transition zone modeling system to integrate river, estuarine, and coastal models
  - Develop and evaluate advanced ocean forecasting system for currents and ocean status

Weather and Water Program Links

- *Coasts, Estuaries, and Oceans (CEO)*: SOCD's Ocean Remote Sensing program is a major component of CEO; and SOCD provides the NESDIS leadership to this matrixed program. SOCD directly contributes research, development, and the transition of research to operations to the focus of this program on near-real-time operational observations and products. CEO provides a leading role in NOAA IOOS efforts, of which, SOCD is a principal contributor to NOAA's satellite component of the IOOS National Backbone. The NOAA CoastWatch program, an identified NOAA contribution to IOOS, as a part of SOCD's Ocean Remote Sensing program, consequently, is a component of CEO.
- *Environmental Modeling*: Specific links to be established. Ongoing coordination of near-real-time operational satellite ocean data assimilation with the JCSDA needs to be expanded to support ecosystem and climatological modeling efforts. SOCD science team links with the NESDIS/STAR Cooperative Research Program Division's (CORP) research efforts at the Cooperative Institute for Climate Studies (CICS) on the use of satellite ocean remote sensing, sea-surface temperature in particular, for ecosystem modeling in the Chesapeake Bay have led to a public web site with developmental analyses of the presence of specific noxious species, sea nettles in particular. Efforts are being pursued to extend this methodology to harmful algal blooms.
- *Weather and Water Science, Technology, and Infusion Program*: SOCD's principle link with this program is through the NPOESS Data Exploitation (NDE) effort. The NDE focus provides additional products for NOAA that the NPOESS contractor is not producing with NPOESS data. SOCD's role, as a fundamental component of NDE, is in developing algorithms to support the additional products, leading ocean data calibration and validation activities, and supporting the development and distribution of products. SOCD leads NDE's NOAA-unique ocean products effort, co-leads the calibration/validation effort, and contributes to the product distribution effort. SOCD also provides NDE oversight and leadership through membership on the NDE Management Board.

4.2.4 Commerce and Transportation

The Commerce and Transportation Mission Goal supports the Nation's commerce with information for safe, efficient, and environmentally sound transportation. Specific strategies identified include:

• Expand and enhance advanced technology monitoring and observing systems, such as weather and oceanographic observations, ice forecasts and nowcasts, hydrographic surveys, and precise positioning coordinates, to provide accurate, up-to-date information.
• Develop and apply new technologies, methods, and models to increase the capabilities, efficiencies, and accuracy of transportation-related products and services.
• Develop and implement sophisticated assessment and prediction techniques, products, and services to support decisions on aviation, marine, and surface navigation efficiencies; coastal resource management; and transportation system management, operations, and planning.
• Build public understanding of the science and technology involved and the role of the environment in commerce and transportation through outreach, education, and industry collaboration.

The following SOCD-relevant research priorities have been identified.

o Reduce risks to life, health, and property within our Nation's transportation system

o Remote sensing sensor, data acquisition, and processing advances

o Issues that slow or stop movement of goods and people in the U.S. transportation system
  - Develop the standardized Next Generation Operational Forecast System
  - Develop methods to determine uncertainties for model forecasts
  - Develop methodology to attain 1-cm geoid model accuracy
  - Develop standards and protocols for weather-related electronic data exchange
  - Validate methodologies for acquisition, processing, and dissemination of weather-related data
  - Transfer research weather-observation prototypes into full operational use
  - Real-time physical oceanographic data collection
  - Hydrodynamic modeling

o Reduced risks and adverse environmental impacts from the U.S. transportation system
  - Responding to spills in a manner that minimizes the impacts to biological, economic, and cultural resources.
  - Assessing the impacts of both the spill and the response efforts on those resources.
  - Restoring the impacted resources with the highest degree of efficiency and effectiveness.

Commerce and Transportation Program Links:

- *Marine Transportation Systems*: Linkages with this program are predominately through SOCD support of the National Ice Center (NIC), whose activities are addressed by this program. SOCD provides the Chief Scientist for the NIC. Research and development activities and NIC support are explicitly captured in SOCD's Sea Ice Science Team roadmap.
- *Marine Weather*:
- *Geodesy*:
- *NOAA Emergency Response*:

4.2.5 Mission Support

The Mission Support provides critical support for NOAA's mission. This mission includes the Satellite Services sub-goal, which includes nearly all of SOCD's activities. The SOCD-relevant mission goal strategies include:

- Provide timely and effective acquisition and delivery of satellite-derived information that supports requirements from the Mission Goals.
- Provide applied research to ensure the quality, reliability, and accuracy of current and future satellite products and services to support the Mission Goals.
- Guide the development of and coordinate NOAA's homeland security-related plans, programs, and policies to enhance NOAA-wide program response, risk management, continuity of operations, and other contingency planning and program infrastructure.

MISSION SUPPORT PROGRAM LINKS

- *Geostationary Satellite Acquisition*: Firm links have been established through two paths. SOCD will have lead responsibility for leading the ocean componentsof the GOES-R acquisition Algorithm Working Group, which has responsibility of working with the various sectors of the user community to select operational algorithms for the Advanced Baseline Imager (ABI) and the Hyperspectral Environmental Suite – Coastal Waters Imager (HES-CWI). Additionally, SOCD is a member of the Coastal Observations and Applications Science Team (COAST) for the HES-CWI, which comprises user community participation in helping define instrument criteria. SOCD also provides fundamental contributions for the GOES-R Risk Reduction (GOES-R^3) effort through algorithms, calibration, products, and validation work needed to provide early use of the satellite's data to maximize the value of the satellite's finite life.

- *Polar Satellite Acquisition*:

  - *NPOESS* acquisition program links have been predominately through intergovernmental studies supporting NPOESS risk reduction and participation on the NPOESS Operational Algorithm Teams, as well as involvement with calibration/validation forums. Principal NPOESS risk reduction efforts have centered on deriving microwave passive polarimetry ocean surface wind vector retrievals in anticipation of the CMIS instrument and the transition of the NASA MODIS Ocean Quality Assurance Browse Imagery Interface (MQABI) for calibration and validation of satellite data, initially focused on ocean color data. SOCD has the potential role of federal verification of NPOESS compliance with contract data/product accuracy and quality.
  - *JASON-2* acquisition will provide operational ocean altimetry data for the first time. NOAA is the U.S. operational partner with EUMETSAT being the European operational partner and NASA and CNES being the launch partners. SOCD will provide data quality oversight for this new operational data stream. SOCD has begun the transition of altimetry quality assurance from NASA to NOAA, using JASON-1 data as the pathfinder.
  - *IJPS* is a partnership between NOAA and ESA, whereby, certain instruments from the current generation of NOAA POES satellite will be used by ESA and

the joint system will provide operational data to both ESA and NOAA. SOCD is playing a critical role in establishing the sea-surface temperature algorithm and participating in instrument calibration and product validation efforts. There will be multiple operational satellites in the IJPS series.

- *Interferometric SAR (InSAR)* initial planning links have been established for NASA's currently being designed satellite, proposed for launch in 2011. This satellite could satisfy many of NOAA's observational needs for ocean and hazard applications applicable to: tsunamis and coastal inundation, monitoring of earth deformation prior to earthquakes and volcanic eruptions, high-resolution storm and coastal wind measurements, wave spectra measurements, flood and oil spill mapping, and serve as a prototype U.S. operational SAR satellite. The NASA mission is proposed for a FY 2007 start.

- *Satellite Services*
  - *Operational GOES Support (GOES 12, 13, O, P)*: SOCD provides routine operational sea-surface temperature calibration, validation, and science support for the GOES Imager products in conjunction with the NESDIS Office of Satellite Data and Product Distribution (OSDPD). SOCD also develops new GOES SST products, including an effort to produce a blended GOES-POES "best-value" SST product.
  - *Operational POES Support (NOAA-16, 17, 18, N′, and IJPS1, 2)*: SOCD provides routine operational sea- surface temperature maintenance, calibration, validation, and science support for the POES AVHRR products in conjunction with the NESDIS Office of Satellite Data and Product Distribution (OSDPD).
  - *Developmental Satellites*: NASA's role includes exploring space science and technology and through the implementation of developmental satellites. NOAA works in conjunction with NASA to create the best possible operational observation platforms. NOAA also works with NASA to research operational application of developmental satellite data and technology. SOCD develops algorithms for retrieving environmental parameters, as well as improving methodologies. Current examples of SOCD work with NASA developmental satellites includes incorporating QuikSCAT scatterometry ocean wind vector data into the NWS operational data stream, developing the operational retrieval algorithm for WindSat passive polarimetry ocean wind vectors, developing a TRMM SST product, supporting calibration and validation of the MODIS ocean color instrument, and providing the methodology for recovering altimetry data from the impaired GFO mission. Current and pending SOCD research efforts involve the following developmental satellites.
    - *Earth Observing System (EOS) (Terra/Aqua)* currently provides sea-surface temperature and ocean color data from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument. These developmental data are currently processed and distributed in near-real time via the NOAA CoastWatch program. MODIS is the heritage instrument for the future operational NPP/NPOESS VIIRS instrument.

- *OrbImage-2*, a joint NASA-commercial effort, carries the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) ocean color instrument. Through arrangements with NASA and the Orbital Sciences Corporation SOCD's NOAA CoastWatch program processes and provides ocean color data and products for NOAA's operational use, in particular for NOAA's Harmful Algal Bloom (HAB) Bulletin. The data is also provided for other developmental ocean color applications associated with fisheries management and protected species.
- *TOPEX/Poseidon*, a joint NASA-CNES effort, is near the end of its mission life, having provided foundation altimetry data that SOCD has helped provide for NOAA's use in operational numerical modeling data assimilation, as well as stand-alone efforts (Global Sea-Level Rise (GSLR), El Niño assessments, Ocean Surface Current Analysis Real-time (OSCAR), etc.).
- *Jason-1*, again a joint NASA-CNES effort, continues the TOPEX/Poseidon exact repeat orbit, extending the length of the altimetry data record and supporting all of the activities initiated for the TOPEX/Poseidon mission.
- *GeoSat Follow-On (GFO)* is a Department of Defense mission that SOCD saved through the development of work-around processes for failed primary and backup systems. SOCD continues to compile and distribute the definitive data sets for this mission.
- *QuikSCAT* provides the SeaWinds scatterometer for the assessment of ocean surface vector winds. SOCD has been instrumental in evaluating the algorithms and data, working in conjunction with NCEP for the operational evaluation and integration of the data, and working to extend existing algorithms to better address retrievals in high wind speed conditions and in the presence of precipitation. Through SOCD leadership this data is now treated as operational data within NESDIS and the NWS. This data is also served to the public via NOAA CoastWatch.
- *InSAR* is a future NASA satellite that will revolutionize ground displacement measurements. It will aid in the development of determining climate change, and detecting natural hazards.
- *Aquarius* is a cooperative mission with The Argentine Commission on Space Activities (CONAE) to measure global sea surface salinity to resolve missing physical properties linking the hydrologic cycle and climate. Efforts will lead to producing more accurate forecasts for El Niño and ocean circulation models. SOCD will be establishing a new capability to explore a NOAA operational capacity for satellite sea-surface salinity data and products.
- *CryoSAT* is an ESA radar altimetry mission designed to determine variations in ice sheet and ice cap thinning and glacial melting in an effort to predict changes due to global warming. It will also attempt to determine freeboard estimates of floating ice. CryoSAT will assess technologies for acquiring data useful for safe navigation and as input for more accurate ocean/ice models.
- *GRACE* is NASA's Gravity Recovery And Climate Experiment in a cooperative mission with Germany to obtain accurate and high-resolution,

static and time-variable measurements of the Earth's gravity field. SOCD's SSH science team is developing a new global bathymetry product using gravity anomalies that correlate with variations in sea surface height reflecting ocean depth. Understanding the deep-water bathymetry determined from gravity models will aid in deriving a new ocean floor roughness product aimed at characterizing bottom controls on deep-ocean mixing for climate modeling purposes.

- *Advanced Land Observing Satellite (ALOS)* includes the Japanese Phased Array L-band Synthetic Aperture Radar (PALSAR) which requires research and development of L-band corollaries to the current C-band SAR algorithms and products.
- *Oceansat-1*, Indian Remote Sensing Satellite IRS-P4, is the first Indian Ocean Color polar satellite. The platform will carry an Ocean Color Monitor (OCM) and a Multi-frequency Scanning Microwave Radiometer (MSMR). OCM will collect data on chlorophyll concentration, detect and monitor phytoplankton blooms, and obtain data on atmospheric aerosols and suspended sediments in the water. MSMR will collect sea surface temperature, wind speed, cloud water content, and water vapor data. SOCD anticipates exploring the use of Oceansat-1 data for use in global products.

- *Homeland Security*: To be established.

5 CURRENT RESEARCH

Current SOCD research aligns with NOAA's Strategic and Research Plans. Individual science activities frequently address multiple mission goal research priorities. Below are significant SOCD research activities.

5.1 SCIENCE TEAM RESEARCH

Science teams provide an end-to-end path between the scientific research and applications and operational activities for specific parameters.

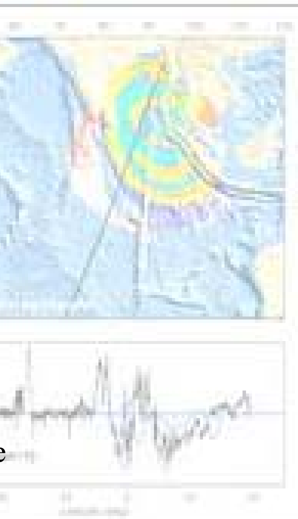
- **Sea Surface Temperature**

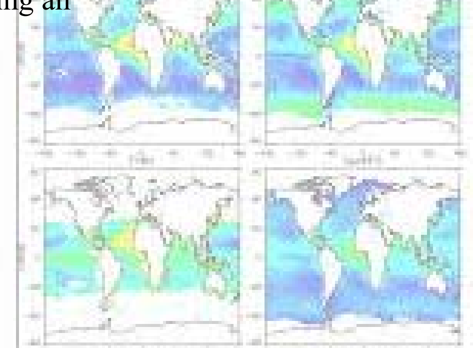
Current SST research focuses on sustaining the heritage products from POES and GOES and on development of improved retrievals. Merging SST and National Centers for Environmental Prediction (NCEP) data streams provides the potential for key SST improvements. NCEP upper air data in conjunction with radiative transfer modeling is instrumental to constrain the atmospheric correction. NCEP surface fluxes are being explored to facilitate skin-to-bulk conversion. Synergistic retrievals of aerosols and sub-pixel cloud from the same sensors are explored to do the corrections to SST for their residual effects. A probabilistic Bayesian cloud masking is being evaluated for the GOES SST. Development efforts for a comprehensive continuous diagnostic quality control / quality assurance / validation system have begun, along with improvements to the SST *in-situ* match-up database. Another effort blends geostationary and polar-orbiting SST data into a "best-value" SST product. This product is currently undergoing an evaluation prior to operational implementation. SOCD has also begun evaluation of microwave SST products. These

SOCD's efforts   will contribute to a National Ocean Partnership Program (NOPP) project to blend infrared with microwave SST data and evaluate the operational impact and to the Multi-sensor Improved Sea Surface Temperatures (MISST) for the Global Ocean Data Assimilation Experiment (GODAE) project that intends to produce an improved, high-resolution, global, near-real-time (NRT), sea surface temperature analysis through the combination of satellite observations from complementary infrared (IR) and microwave (MW) sensors and to then demonstrate the impact of these improved sea surface temperatures (SSTs) on operational ocean models, numerical weather prediction, and tropical cyclone intensity forecasting.

- **Sea Surface Height**

The SSH Team provides research in four focus areas: altimeter data, ocean dynamics, marine gravity and bathymetry, and climate. The altimeter data effort focuses on providing high-quality altimetry data sets and establishing operational data quality assessment for Jason-2, as well as overseeing the implementation of the Jason-2 data processing stream. In SOCD effort to improve the quality and utility of data from all satellite altimetry missions, past, present and future, SOCD is: presently preparing a version of the GEOSAT data set, utilizing waveform re-tracking techniques developed by SOCD in partnership with the Scripps Institute of Oceanography (SIO) to reduce the noise level of the range estimates; continuing to improve the quality of on-going missions, developing and maintaining the Radar Altimetry Database System (RADS), the most comprehensive collection of altimeter data; and recently contracted JPL to develop quality assessment software to be used by NOAA/NESDIS for monitoring the Jason-2 altimeter mission, scheduled for launch in 2008. Ocean dynamics address ocean dynamic variability, in particular with respect to ocean currents. The SSH science team is coordinating efforts to expand a data fusion methodology for computing upper ocean currents to the global oceans. The operational OSCAR program (Ocean Surface Current Analysis Real-time) provides estimates of surface currents from a combination of altimeter data (for the geostrophic component) and scatterometer data (for the Ekman component). OSCAR is currently expanding from the tropical Pacific to include the Indian and Atlantic Oceans and, eventually, to mid-latitudes. A SOCD-CIOSS partnership recently initiated a research project to determine how to best estimate the surface velocity field in the transition region between coastal and open-ocean regimes, focusing on statistical analysis and combining CODAR observations near the coast with OSCAR observations offshore (>100 km), supplemented by a model-based analysis. Based on recently emphasized operational requirements, SOCD marine gravity and bathymetry efforts will lead a NOAA, Navy, National Geospatial Agency (NGA), SIO, University of New Hampshire project to develop an improved version of the *Smith and Sandwell* global bathymetry data set. This work will take advantage of the reduced noise level of the newly SOCD re-tracked GEOSAT data set for the altimeter component and a greatly enlarged collection of acoustic soundings (provided by NGA) for the in-situ component. Work continues on developing techniques for globally mapping the 2500 m isobath, a key parameter in many Law of the Sea issues. Climate-related research addresses the rate and causes of global sea level rise (GSLR), involving data from six recent or on-going altimeter missions. To ensure that the altimeter results are accurate and stable enough to measure GSLR, SOCD is establishing a combination of quality assessment and calibration programs, including instituting an operational system for comparing altimeter and tide gauge observations.





- **Ocean Surface Winds**

A principal activity for the Ocean Surface Winds science team is the derivation and validation of the operational passive polarimetry ocean surface wind vector retrieval algorithm for WindSat in conjunction with NPOESS risk reduction for the CMIS instrument. Ocean surface wind efforts also include extensive field work aimed at improving the microwave retrieval algorithm for high winds and in the presence of precipitation, focusing on tropical cyclones and mid-latitude winter storms. For the high wind speed effort, validation of an already developed model will involve collecting and spatially and temporally collocating an extended quantity of data to fully evaluate the impact of the enhanced high wind speed model. A research focus for operational transition has been extracting higher-resolution products from scatterometer data, reducing the amount of data excluded due to land masking, improving the rain flag, and fully characterizing the impact of rain on wind retrievals.

- **Ocean Color**

SOCD ocean color research aims to provide quantitative information relating to oceanic biological parameters, particularly; phytoplankton biomass, important biogeochemical processes, and the state and magnitude of human activity impacts in oceanic and coastal waters. Specific research includes implementing a primary productivity algorithm, and developing an optical database for algorithm development and validation results. Field work plans expand the MOCE turbid water observation series of experiments in the Chesapeake Bay, collaborating with the Chesapeake Bay Program and the NOAA Chesapeake Bay Office to identify and monitor stress indicator events. In support of these activities, research and development proceeds toward the next-generation MOBY and its application in coastal waters. Efforts are beginning on transitioning a Naval Research Laboratory (NRL) capability for using ocean color for water mass classification, with the objective of operationally assessing coastal ocean dynamics and water quality.

- **Sea Ice**

Current SOCD sea ice research exploits remote sensing data and processing assets 1) to develop and validate multi-sensor sea ice products that respond to the user community's needs, 2) to expand sea ice and cryospheric research through the use of new technologies and approaches, 3) to provide science support and expertise for the production and development of analyses and forecasts of sea ice conditions. Research areas for the SI Science Team involve the application of multi-sensor observations, including visible, infrared, and microwave observations and measurements, to ice detection and monitoring in support of maritime operations and climate research. Efforts include sea ice classification, marginal ice zone research, sea ice dynamics, sea ice-atmospheric interaction, sea ice climatology, ice sheet breakup, iceberg shedding, as well as river and lake ice. Specific efforts include: the development of ALOS PALSAR L-band automated sea ice detection and classification algorithms; validation of ALOS and Envisat sea ice products; research on polarization applications of both C and L-band data; validation underflights for CryoSAT freeboard measurements, and validation of sea ice applications from SAR and other satellite data, in particular for classifying ice types and monitoring ice conditions.

- **Sea Surface Roughness**

Current synthetic aperture radar research continues the development and validation of algorithms and products for high-resolution wind speed and direction, vessel detection, marine oil spill mapping, sea/lake/river ice location/type/concentration/motion, ocean feature detection, severe storm morphology, lower atmospheric boundary layer processes, wave spectra, significant wave height, and coastal change detection. Specific tasks include extending existing C-band algorithms to the L-band for use with the Japanese ALOS instrument, with the ALOS wind algorithm having the initial priority. For C-band data, work focuses on validating Envisat SAR winds, vessel positions, and ice masks by comparing the data with buoy and other environmental data. Efforts also include completing the initial development and validation of wave products, a new polarization ratio for winds for Envisat and Radarsat-1 data, hurricane wind validation for high wind speeds, and researching the mapping of shallow coastal bathymetric features such as sand bars. Work continues toward completing a prototype SAR operational winds system for data collected via the University of Miami Center for Southeastern Tropical Advanced Remote Sensing (CSTARS) and the design and development of a prototype operational SAR validation system for winds and wave parameters, to include matches with buoy data and scatterometer wind data.

5.2 CROSS-CUTTING RESEARCH

Data fusion, the combining of different data sets to extend coverage and/or extract new information, creates cross-cutting research efforts, especially as NOAA seeks to maximize the return from remote sensing investments and pursues ecosystem management methodologies. The data fusion effort using to extract ocean surface currents by using altimetry and scatterometer data provides a prime example. Another example is the development of a GOES-POES blended "best-value" SST product and its extension to include microwave data to mitigate the effects of clouds and aerosols. Applications research addresses NOAA mission goal requirements. For oceanic feature detection, work currently focuses on the identification of ocean thermodynamic processes/features, such as fronts, eddies, and currents, and their temporal patterns through the analysis of infrared sea-surface temperature data. Research combining wind data with SST and ocean color data seeks to assess air-sea fluxes and upwelling features and climatologies. SOCD leads in applying satellite ocean remote sensing data to ecosystem management goals through its leadership of the NOAA Coral Reef Watch (CRW) component of the matrixed NOAA Coral Reef Conservation Program within the Ecosystems Mission Goal. This collaborative integrated program uses remote sensing and *in-situ* tools for near-real-time and long-term monitoring, modeling, and reporting of coral reef ecosystem physical environmental conditions. It aims to assist the management, study, and assessment of the impacts of environmental change on coral reefs. In particular, sea surface temperature data is used to determine and predict areas of coral bleaching through the measurement of accumulated heat stress. Research continues on integrating additional parameters into the assessment of coral reef health. SOCD is the global leader in providing global coral reef bleaching predictions and warnings. Another developmental integrated ecosystem management application of satellite ocean remote sensing data, GhostNet, combines satellite SST, altimetry, ocean color, and SAR data to identify ocean surface convergence regions for localizing likely areas for derelict fishing

Figure 17. GhostNet uses a combination of data to locate derelict drift nets that capture floating debris causing damage to open water and coastal water ecosystems.

nets, allowing aircraft and ship missions to sight and remove the derelict nets before they damage coral reefs and ensnare protected species.

6 PERFORMANCE TARGETS

The NOAA five-year research plan (2005-2009), "Research in NOAA", identifies the desired outcomes and performance objectives for each mission goal (listed in Appendix VI), as well as specific research milestones, establishing a framework for SOCD research and development. Performance measures can be tracked from the activity level through the Mission Goal level, linking SOCD goals and objectives to high level Mission Goal Priorities, creating the NOAA performance measurement pyramid. Performance measures are evaluated at each level to ensure quality and continuity within every level of research, development, and operations.

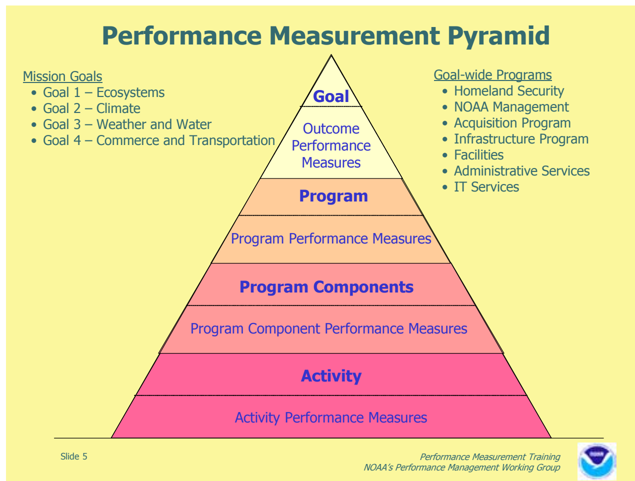


Figure 18. The Performance Measure Pyramid is used to link activities to NOAA Goals.

Division Performance Measures
SOCD performance evaluation addresses accomplishments in four areas, achievements that that Sustain/Master existing activities, is Better/Improved, is New/Creates, and/or is First/Invests. Contributing to Divisional-level performance measures, each science team has an overarching performance measure, as well as at least one performance measure for each task listed in their RPPs (listed in Appendix V).

SUSTAIN (master)
This focus describes research or development that pursues incremental advancement or diffusion of existing ideas or tools. ***The goal is*** *to generate incremental advances in knowledge and to master, extend, or share existing ideas, techniques, fields, or technical areas.* ***Progress is*** *also indicated by research to apply existing theories to new problems, prove the accuracy of a theory.*

- On an annual basis, sustain the determination, documentation, and correction of the quality of NOAA operational satellite ocean remote sensing products through regular calibration and validation activities, maintaining current assessments and adjustments to 100% of NOAA's operational satellite ocean remote sensing data streams.

- On an annual basis, sustain 90% locally-controllable availability of experimental and selected non-NOAA satellite ocean remote sensing products for community use and evaluation.

BETTER (improve)

This focus describes research or development in either scientific understanding or production that pursues incremental advancement or improvements in existing products, processes, or technologies. ***The goal is*** *to incrementally improve or* *standardize an existing model, technique, product, process, or technology for mission use. The goal of this type of research is to understand or solve an immediate problem, determine standards, or to incrementally improve the functionality of a technology or manufacturing process or lower its cost.* ***Progress is*** *judged by measurable incremental improvements in product or process cost, performance, or characteristics that can be linked to R&D.*

- On an annual basis, implement improvements in the methodology and/or quality of one to three NOAA operational and/or experimental algorithms and products.
- On an annual basis, improve the technology transfer to users of satellite ocean remote sensing, as measured by new products made available and a trend of increasing number of available products.
- On an annual basis, improve the outreach to users of satellite ocean remote sensing, as measured by a trend of increasing unique users of satellite ocean remote sensing data/products.
- On an annual basis, improve public education on satellite ocean remote sensing, as measured by unique new education modules made available.
- On an annual basis, improve public education on satellite ocean remote sensing, as measured by a trend of increasing unique users of SOCD education modules.

NEW (create)

This focus describes research or development that pursues radically or fundamentally new ideas or tools, either with or without a specific application in mind. ***The goal is*** *to come up with fundamentally or radically new ideas, techniques, theories, problem statements, or prototypes. Problems addressed are complex. In science, the goal of this research is to understand phenomena, with or without an application in mind. In technology development, the goal is to search for a concept for a new product or process. This is high-risk, long-term research.* ***Progress is*** *proof of a concept, or an increase in understanding of the problem, or additions to methods for exploring how to solve a problem, or narrowing the number of acceptable theories by proving hypotheses or identifying dead ends. The research may result in the emergence of new fields of inquiry or the emergence and adoption of new terms and techniques.*

- On an annual basis, develop one unique new (or new improvement to) operational or experimental technique, algorithm, product, or service for satellite ocean remote sensing.

FIRST (invest)

This focus describes research or development that pursues radically or fundamentally new products or process, new scientific facilities or theories. Be First implies an application of an idea. ***The goal is*** *to develop a radically new understanding, process, or product and be the first to get that product accepted for mission application. In science, the goal of this type of research is to develop a fundamentally new understanding of techniques and tools. The potential applications for the research are known.* ***Progress***

***means** agreeing on definition of the problem, developing research tools to test hypotheses, and narrowing down the number of competing theories.*

- On an annual basis, be the first to provide one new satellite ocean remote sensing algorithm, product, or service.

Overarching Science Team Performance Measures

- **Sea Surface Temperature**: Produce the best SST products from individual satellite measurements and merged satellite measurement.
- **Sea Surface Height**: To maximally utilize satellite altimetry, complementary sea level, SST, and wind speed measurements, to advance our knowledge of climate variability, ocean dynamics, gravity, and bathymetry.
- **Ocean Surface Winds**: To provide the highest quality remotely-sensed wind products over all environmental conditions in support of NOAA's operational mission
- **Ocean Color**: Develop and maintain the capability to produce climate quality Ocean Color derived products.
- **Sea Ice**: Development or transition of at least one NIC sea ice product or application that exploits the availability of unique NIC time-series in support of climatological research.
- **Sea Surface Roughness**: Research, develop, and demonstrate marine applications of SAR data leading to greater use and acceptance of these products in operational offices of NOAA and/or other Government agencies.

7 CONSTRAINTS AND ENABLERS

Infrastructure, activities, and issues can act both as enablers and as constraints to achieving science and technology objectives. Specific items to be noted include:

- **Cooperative Institute for Oceanographic Satellite Studies (CIOSS)**

SOCD initiated and provides the base support for the Cooperative Institute for Oceanographic Satellite Studies (CIOSS) at Oregon State University. This cooperative institute serves a major enabler designed to:
CIOSS is designed to

- Extend NOAA’s research involving the ocean and its interaction with the overlying atmosphere by developing and using satellite remote sensing methods that better resolve the ocean and the air-sea interface.
- Serve as a focal point for interactions between NOAA and the oceanographic research community, for research activities related to NOAA’s mission responsibilities and strategic objectives in the coastal and open ocean.
- Improve the effectiveness of graduate-level education and expand the scientific possibilities and experiences available to graduate students, including participation in joint research programs with NOAA and other government agencies.
- Provide expanded collaborative and training opportunities in satellite ocean-atmosphere remote sensing, modeling and calibration/validation activities for researchers from NOAA laboratories and facilities.

The following five themes of mutual interest to NOAA and OSU will be pursued during the initial five years. The research under these themes will address the highest priority and most relevant issues in oceanographic satellite remote sensing and modeling.

- *Satellite Sensors and Techniques*: Development of satellite oceanography techniques and applications; evaluation of existing and proposed satellite sensors, algorithms, techniques and applications.
- *Ocean-Atmosphere Fields and Fluxes*: Development, evaluation and analysis of improved fields of physical and biological parameters in the upper ocean, and of surface parameters and fluxes at the air-sea interface, using combinations of remote sensing, in situ data and modeling.
- *Ocean-Atmosphere Models and Data Assimilation*: Use of satellite-derived fields to force and evaluate numerical models of the oceanic and atmospheric circulation, including the assimilation of those fields using methods of inverse modeling. For some applications, the ocean models will include components of marine ecosystems.
- *Ocean-Atmosphere Analyses*: Dynamical and statistical analyses of data sets derived from satellites, models and in situ instruments, in order to increase our understanding of the physical, chemical, biological, geological and societal processes that affect and are affected by the ocean-atmosphere system.
- *Outreach*: We include three broad Outreach areas, each to be related to CIOSS research and its results.
  a. Formal Education of students (K-12, undergraduate and graduate students), other scientists, resource managers and the general public in aspects of oceanography, surface meteorology and the use of remotely sensed data sets and numerical models. Short courses and training workshops are included in this category, as are workshops designed to develop or evaluate present and planned sensors and techniques.
  b. Informal Education of the same groups in the same subjects, but in contexts outside of the formal educational system, short courses and workshops. This may take the form of web-based material, presentations, forums, and exhibits at public science museums ("free-choice education").
  c. Data Access includes activities that enhance the use of data sets derived from satellites and models by research scientists, students, educators, resource managers and the general public.

- **Research to Operations**

Funds are needed to transition products from research to an operational capacity. When developmental products, funded either by NOAA research base or external funds, are transitioned, it is expected that NOAA will now fund projects via operational funds. However, due to a lack of funds, there have been limitations on the transition of ocean products to operationally-funded processing; thereby creating a constraint on continuing and new research projects because current research funds are otherwise required to maintain the developmental products and support their user bases. By transitioning products from research to operations, more information is available to the user community to make informed decisions.

- **Calibration /Validation**

Calibration and validation efforts are necessary pieces of the satellite data processing scheme, providing known uncertainties in operational satellite data, enabling better assessments and predictions from satellite data. A comprehensive STAR calibration/validation enterprise is required in support of operational and developmental satellite data and products. This is a crucial issue as emphasis is placed on developing and maintaining satellite climate data records (CDRs). Such efforts would also directly support NOAA's satellite contribution to the IOOS National Backbone. A specific concern is continuity of the globally-unique Marine Optical BuoY (MOBY) ocean color vicarious calibration capability, a crucial component for obtaining calibration of satellite ocean color instruments and validation of ocean color data, especially given NOAA's imminent entrance into operational ocean color instruments, data, and products with NPP/NPOESS VIIRS and the GOES-R HES-CW. Calibration issues extend to existing SST data, and pending NOAA operational ocean surface winds and altimetry. Significant calibration/validation capabilities and capacities for calibrating/validating developmental data/products exist within NASA and these will need to transition, in some fashion, to NOAA for operational implementation.

- **Collaborative Computing Environment**

A collaborative computing environment would link heritage, present, and future satellite data types into a system where data can be assessed by the NOAA community for the calibration of instruments, the development and validation of products, and the establishment of climate quality data records. The collaborative system will enable users to contribute to and use from the same working environment to prevent duplicate research and operations, as well as simplify the information technology infrastructure and provide ready access to very large data sets. Such an collaborative environment would lead to efficiencies for both the polar and geostationary operational and acquisition efforts, specifically GOES, POES, Jason-2, NPOESS (through the NPOESS Data Exploitation (NDE) effort), and GOES-R.

- **Data Processing and Storage**

High resolution, near-real-time continuous data products are the wave of the future; ease of availability and expanding user communities increase demand. Due to the increase in data resolution and volume, there is a need for mass storage space and faster processing technology. Systems are in the process of being upgraded to meet requirements. SOCD is preparing to redesign and implement a new Information Technology (IT) infrastructure which will capitalize on data flow efficiency and eliminate redundancy. Software standards and configuration management techniques will be applied. Large computer storage systems are used to archive satellite data for future use, distribution, and climate data record reprocessing.

- **Data Assimilation**

Combining multiple satellite and in situ data sets for ocean model assimilation requires standardization of codes and much testing. Higher-resolution data and added parameters give models a more defined result in ecosystem modeling and forecasting. Data assimilation of satellite ocean remote sensing data enables greater extraction of information for use by decision makers.

- **Data Fusion**

Data Fusion provides enhanced products to expand spatial and temporal coverage. By combining data, more, better, and new kinds of information can be extracted. Enhanced focus should be given to data fusion applications research and product development.

- **Funding for Applications Research and New Product Development**

The funding structure for research and development of applications and products is splintered across numerous acquisition and operations activities. The satellite acquisition and operational satellite programs should engage STAR as the applications research and product development manager for their programs and provide budgetary authority to STAR to accomplish this role. The consolidation of applications research and product development funding authority will lead to synergies, explicitly supporting data fusion efforts as data from multiple satellites are integrated.

- **Education and Outreach**

CoastWatch/OceanWatch maintains an active effective efficient delivery system to aid in the exploitation of satellite ocean remote sensing products by the user community. The outreach website http://coastwatch.noaa.gov/cw_outreach.html, contains links to software, data, tutorials, and collaborative projects, which include the Harmful Algal Bloom Forecasting Project and El Nino Watch. The program supports education activities through interns and K-12 learning. Attending conferences and regional meetings exposes and expands the user community to new and heritage products.

Science Teams are each producing K-12+ learning modules to make the user community aware of the information that can be derived from satellite products. The Sea Surface Roughness Team is participating in the AKDEMO to teach Alaskans the uses of SAR to forecast high velocity winds and sea ice.

SOCD actively engages in hosting numerous undergraduate and graduate interns, including teacher interns, as well as post-doctoral fellows and visiting scientists. Using the CIOSS partnership, SOCD ensures that CIOSS incorporates specific education and outreach efforts in its annual funded proposal.

8 RISKS

Risks associated with this science and technology roadmap include a number of overarching issues. The ultimate measure of risk is not being ready for the operational certification of a NOAA satellite. Delay in providing operational quality-assured data and products reduce the functional period of the satellites finite lifespan, effectively incurring significant infrastructure costs. Overarching risks are noted below. Specific science team activity risks are identified in Appendix VI Science Team Risk Assessments.

- **Calibration/Validation**

Failing to calibrate and validate satellite data will increase uncertainties producing less accurate satellite retrievals, affecting the quality assurance of satellite data, and potentially leading to erroneous analyses and decisions based on that data. With the advent of new kinds of operational satellite ocean remote sensing data, NOAA must establish its own calibration and validation capacities to transition developmental data streams to NOAA operations, in particular for ocean surface winds, ocean color, and altimetry. A significant risk is getting initial and continuing operational calibration and validation activities recognized and funded within NOAA's budget process. It will also be necessary to obtain personnel with the appropriate skills and experience to accomplish these tasks. Accompanying the funding risk for skilled personnel is risk associated with inadequate calibration/validation tools. It is anticipated that some of this risk will be mitigated by the implementation of a collaborative computing environment. Independent of these factors is the risk associated with biased and or missing *in-situ* measurements for comparison, including the facilities for vicarious ocean color calibration. With respect to operational satellite ocean color instruments and data, the unfunded continuity of MOBY and the unfunded transition to an operational MOBY-II represents a nearly insurmountable risk to NPP/NPOESS VIIRS and GOES-R HES-CW, as well as the linking component for the entire existing satellite ocean color data record and its use as an ocean color climate data record.

- **Integration**

Failing to adequately integrate oceanic and atmospheric research and infrastructure activities presents a budgetary and information technology risk through duplications, interoperability disconnects, and budgetary inefficiencies. Synergy and data fusion opportunities will potentially be lost.

- **Funding**

Present funding levels do not adequately address the transition of research to operational capabilities and capacities. Tying up research funds through extended "operational" production of developmental products and data reduces research aimed at achieving NOAA's objectives; thereby precluding needed capabilities and capacities and reducing the number and types of possible operational products. This issue will become more dominant with the rapid expansion of operational satellites and kinds, quantities, and increased resolution of data.

- **Continuity**

Continuity poses a significant risk to new operational satellite ocean remote sensing data. In particular, there is no current planned operational mission to follow the Jason-2 altimetry mission, presenting the significant risk of a break in the continuous exact-repeat altimetry data set, a crucial climate data record. Overlapping continuity is crucial for adequate satellite instrument calibration and continuity of climate data records. Long-term scatterometer ocean surface wind data is also in doubt. Another significant risk is the lack of any U.S. synthetic aperture radar mission, adversely impacting the availability of data for the U.S. National Ice Center, oil spill incident response, and coastal flooding. The U.S. currently must rely on costly and incomplete foreign data, posing added risk to the public and budgetary risk to the agency.

- **Workforce**

As a very significant percentage of the SOCD approaches retirement within the next several years, coupled with routine turnover, the replacement of very specialized, skilled, experienced employees becomes a prominent risk to existing and planned research and development efforts. Additionally, turnover for all leadership positions will have occurred within the span of a little more than one year. Recent hiring efforts indicate that finding suitable replacements will be a significant task that can lead to notable interim gaps in scientific expertise and leadership. There is concern about the future availability of individuals with the necessary skills. There is no current graduate program that provides a basic standardized curriculum or broad foundation in satellite ocean remote sensing.

- **Outreach and Education**

User outreach continues to be a risk area due to the public's lack of familiarity with and use of satellite ocean remote sensing data and products. Without user education and outreach the public will not be aware of the vast amounts of knowledge, data, and information that can be applied to their benefit, how to use them, and their significant socio-economic benefits. Much effort is needed to develop user pull for satellite ocean remote sensing data, without which program justification and continuity are at risk. Education, starting early and continuing through K-12+ curricula and life-long education, and regional applications outreach efforts with and for specific user groups are fundamental to this issue.

- **Organizational Barriers**

SOCD resides at the juncture for transitioning developmental satellite data streams, applications, and products to operations. Consequently, SOCD must interact with users across the NOAA Mission Goals. The Mission Goals, in general, are not sensitive to the application of satellite ocean remote sensing to addressing their questions. SOCD expends significant effort toward getting integrated into program planning efforts; however, there are organizational barriers to getting included in the planning process, regardless of whether there is a fiscal consideration with regards to the program. Consequently, it is difficult to identify and document requirements needed to develop/justify satellite ocean remote sensing activities. The mission goal planning, programming, budgeting, and execution system (PPBES), is a challenge for research type activities and for ensuring continuity of funding for speculative efforts.

SOCD also resides at juncture for transitioning NASA ocean remote sensing efforts to NOAA operations. NOAA-NASA coordination and implementation planning are only just beginning. Differences in organizational philosophies between NOAA and NASA continue to result in friction. Funding currently provided for transition efforts is insufficient to address the magnitude of the tasks. The success of pilot transition endeavors in ocean color, ocean surface winds, and altimetry hinges on funding augmentation for NOAA to establish appropriate capabilities and capacities.

9 IMPACTS ON NOAA GOALS AND SOCIETY

Satellite-derived information provides important and effective perspectives of the environmental situation from which efficient decision-making can occur. SOCD provides satellite ocean remote sensing data, data sets, and fused data products to its customers and partners. Customers and partners span the gamut of federal, state, and local government entities, international partners, academia, industry, and public and private users.

SOCD directly enables satellite remote sensing collection of oceanographic and meteorological observations (e.g., sea-surface temperature, ocean surface winds, etc.). These data support near-real-time information needed for timely and accurate environmental forecasts in support of public safety, commerce, agriculture, navigation, etc. NOAA satellite data, products, research and services provide support for disaster relief and emergency assistance through timely, accurate, and relevant data at all hours of the day and night. Specific contributions include, for example: accurate sea-surface temperature, sea-surface height (altimetry), and ocean surface winds (scatterometry and passive polarimetry) data for routine and critical ocean and weather analysis and forecasts, such as hurricane intensity forecasts, high waves, and storm surge; synthetic aperture radar detection of 1)sea ice extent and location for maritime navigation and safety, as well as river ice breakup, 2) oil spills for pollution abatement, 3) very high resolution ocean surface winds for maritime and marine aviation safety, and 4) vessel detection for safety and fisheries regulatory enforcement; ocean color data for harmful algal bloom analyses in support of public health and public safety; sea-surface temperatures and sea-surface heights for evaluating critical climatic conditions and trends relevant to the United States, such as El Niño – Southern Oscillation (ENSO) events and subsequent impacts on weather and the imposition of fishery regulatory restrictions; the determination of ocean bathymetry from altimetry for ocean modeling in support of climate variability/change analyses, tsunami predictions, and safe navigation; altimetry sea-surface heights and scatterometry ocean surface winds for the determination of ocean surface currents in support of search and rescue, oil spill drift models, and early detection of ENSO changes, directly impacting energy and commodity futures markets; ocean color and sea-surface temperature for fisheries management, by-catch reduction, and protected species efforts; altimetry for global mean sea level rise for coastal zone management; and sea-surface temperature analyses for heat stress and bleaching alerts to coral reef managers.

These contributions and others provide the basis for a national backbone of satellite ocean remote sensing for the U.S. Integrated Ocean Observing System (IOOS), which is being implemented to specifically address and serve the national and societal needs for:

- Detecting and forecasting oceanic components of climate variability,
- Facilitating safe and efficient marine operations,
- Ensuring national security,
- Managing resources for sustainable use,
- Preserving and restoring healthy marine ecosystems,
- Mitigating natural hazards, and
- Ensuring public health.

In turn, IOOS serves as the U.S. contribution to the Global Ocean Observing System (GOOS), which has the stated objective of addressing societal needs to:

- Manage and restore healthy coastal ecosystems and living resources,
- Enable safer and more cost-effective marine operations,
- Forecast and mitigate the effects of storms,
- Detect and predict the effects of climate change, and
- Protect public health, by providing data, products, and services that directly support:
- Intergovernmental conventions;
- Government agencies, regulators, public health, certification agencies;
- Environmental management, wildlife protection, amenities, marine parks;
- Operating agencies, services, safety, navigation, ports, pilotage, search, rescue;
- Small companies; fish farming; trawler skippers, hotel owners, recreation managers;
- Large companies, offshore oil and gas, survey companies, shipping lines, fisheries, dredging, construction;
- The single user, tourist, yachtsman, surfer, fisherman, scuba diver;
- Scientific researchers in public and private institutions[18].

In turn, GOOS is the ocean component of the overarching Global Earth Observation System of Systems (GEOSS), a collaborative effort between 33 nations to blend existing and new software and hardware into a compatible state to provide satellite and *in-situ* data and information at no cost to the user. GEOSS identifies its societal outcomes and benefits as:

- Disaster reduction,
- Integrated water resource management,
- Ocean and marine resource monitoring and management,
- Weather and air quality monitoring,
- Forecasting and advisories,
- Biodiversity conservation,
- Sustainable land use and management,
- Public understanding of environmental factors affecting human health and well being,
- Better development of energy resources, and adaptation to climate variability and change[20].

10 SUMMARY

SOCD is following NOAA's lead in a 100%-requirements-driven system backed by congressional mandates and solid Mission Goals and Performance Measures. Its cross-cutting capabilities within Strategic Priorities, Technology Areas, and Science Teams enhance a sound matrix organization that can be depicted in a cube form. Roadmaps paint a progression to the future of research, development, and operations based on the satellite continuum, encompassing goals and IORD specifications. Mitigation of risks within calibration/validation, continuity, integration, and funding, will enable SOCD to move ahead benefiting society. The observing systems planned for the future will integrate data and unite world-wide scientific communities against the perils that nature unfolds.

APPENDIX IV Mission Goal Outcomes and Performance Objectives

NOAA has established agency and mission goal desired outcomes and performance objectives for assessing NOAA's achievements, progress, and the effectiveness of programs and activities. These outcomes and objectives provide context for NOAA's individual and integrated efforts and guide agency priorities.

- **Ecosystem Mission Goal: Protect, restore, and manage use of coastal and ocean resources through ecosystem approach to management**
  - **Outcomes**
    - Healthy and productive coastal and marine ecosystems that benefit society
    - A well-informed public that acts as steward of coastal and marine ecosystems
  - **Performance Objectives**
    - Increase number of fish stocks managed at sustainable levels
    - Increase number of protected species that reach stable or increasing population levels
    - Increase number of regional coastal and marine ecosystems delineated with approved indicators of ecological health and socioeconomic benefits that are monitored and understood
    - Increase portion of population that is knowledgeable of and acting as stewards for coastal and marine ecosystem issues
    - Increase number of coastal communities incorporating ecosystem and sustainable development principles into planning and management

- **Climate Mission Goal: Understand climate variability and change to enhance society's ability to plan and respond**
  - **Outcomes**
    - A predictive understanding of the global climate system on time scales of weeks to decades with quantified uncertainties sufficient for making informed and reasoned decisions
    - Climate-sensitive sectors and a climate-literate public effectively incorporating NOAA's climate products into their plans and decisions
  - **Performance Objectives**
    - Describe and understand the state of the climate system through integrated observations, analysis, and data stewardship
    - Improve climate predictive capability from weeks to decades, with an increased range of applicability for management and policy decisions
    - Reduce uncertainty in climate projections through timely information on the forcing and feedbacks contributing to changes in the Earth's climate
    - Understand and predict the consequences of climate variability and change on marine ecosystems
    - Increase number and use of climate products and services to enhance public and private sector decision making

- **Weather and Water Mission Goal: Serve society's needs for weather and water information**
  - **Outcomes**

    - Reduced loss of life, injury, and damage to the economy
    - Better, quicker, and more valuable weather and water information to support improved decisions
    - Increased customer satisfaction with quality of weather and water information and services
  - **Performance Objectives**
    - Increase lead time and accuracy for weather and water warnings and forecasts
    - Improve predictability of the onset, duration, and impact of hazardous and sever weather and water events
    - Increase application and accessibility of weather and water information as the foundation for creating and leveraging public partnerships
    - Increase development, application, and transition of advanced science and technology to operations and services
    - Increase coordination of weather and water information and services with integration of local, regional, and global observation systems
    - Quantify and reduce uncertainty associated with weather and water decision tools and assessments
    - Enhance environmental literacy and improve understanding, value, and use of weather and water information and services

- **Commerce and Transportation Mission Goal: Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation**
  - **Outcomes**
    - Safe, secure, efficient, and seamless movement of goods and people in the U.S. transportation system
    - Environmentally sound development and use of the U.S. transportation system
  - **Performance Objectives**
    - Enhance navigational safety and efficiency by improving information products and services
    - Reduce weather-related transportation crashes and delays
    - Reduce human risk, environmental, and economic consequences as a result of natural or human-induce emergencies

APPENDIX V Science Team Performance Measures

Performance measures are being established and evaluated for each of the SOCD science teams. These performance measures are preliminary versions and subject to revision.

Ocean Color

- *Overarching Performance Measure*: Develop and maintain the capability to produce climate quality Ocean Color derived products.
- *Task Performance Measures*:

1 MOBY has maintained a continuous, traceable, time series calibration record of normalized water-leaving radiance (LWN) for the past seven years. Performance will be tracked by the continuous climate-quality calibration/validation data record of spectral water-leaving radiances at the MOBY site. Additionally, performance will be measured by meeting the IPO objective to measure operational, ocean water-leaving radiance values with a threshold precision of 5% and a goal of 2% and reprocessed science quality data with a threshold of 2% and a goal of 1%.

2 MOCE cruise performance will be tracked by the number of validation match up points in the benchmark data set.

3 This performance metric assesses the implementation of the MODIS Quality Assurance Browse Imagery (MQABI) quality assurance system by the end of FY05 and resulting operational validation of the ocean color data stream products with in situ match-ups.

4 Implement all SOCD bio-optical product algorithms into NOAA operational production while meeting the IORD goals to measure operational chlorophyll concentrations with accuracy of 20% and operational inherent optical properties with an accuracy of 30%. Another performance measurement will be to produce science quality chlorophyll concentrations with an accuracy of 10% and science quality inherent optical properties with an accuracy of 20%.

5 Complete and initial transition the NRL optical water mass classification capability to NOAA by the end of FY06 and evaluate its utility for NOAA requirements.

Sea Surface Height

- *Overarching Performance Measure*: To maximally utilize satellite altimetry, complementary sea level, SST, and wind speed measurements to advance our knowledge of climate variability, ocean dynamics, gravity, and bathymetry.
- *Task Performance Measures*:

1 Altimeter Data Sets. Improve GFO GDR sea surface height accuracy from 5 cm in FY04 to 4 cm in FY06 using Topex/Poseidon and Jason-1 as the standard.

2 Ocean Dynamics. Applications: Increase percentage of ocean area covered by OSCAR analysis from ~20% (tropical Pacific) in FY04 to ~50% (all tropical oceans) by FY06, to ~80% (all mid to low latitude oceans) by FY08. Operations: Decrease turn-around time for OSCAR product from 10 days in FY04 to 1 week in FY06.

3 Marine Gravity & Bathymetry. Decrease error in marine gravity from 7 mGal in FY05 to 5 mGal in FY08. Applications: Improve global G&B resolution from 30 km in FY05 to 20 km in FY08.

4 Climate. Increase confidence in historical global sea level rise value from +/- 0.5 mm/yr in FY04 to +/- 0.3 mm/yr in FY08.

Ocean Surface Winds

- *Overarching Performance Measure*: To provide the highest quality remotely-sensed wind products over all environmental conditions in support of NOAA's operational mission
- *Task Performance Measures*:

1 Full utilization of QuikSCAT scatterometer data by the operational weather community. Implementation of an improved high wind speed model function for QuikSCAT based on aircraft experiment data. Quantification of rain impacts on scatterometer wind vector retrievals. Validation and implementation of a reduced landmask to allow use of QuikSCAT winds closer to the coast. Full readiness to support operational utilization of ASCAT data, which is currently scheduled for a December 2005 launch.

2 A full evaluation of the capabilities and limitations of ocean vector wind retrievals from WindSat. A comparison of WindSat and QuikSCAT wind vector retrievals.

3 An operational demonstration of a global ocean upwelling index product running in near-real time.

Sea Surface Roughness

- *Overarching Performance Measure*: Research, develop, and demonstrate marine applications of SAR data, leading to greater use and acceptance of these products in operational offices of NOAA and/or other Government agencies.
- *Task Performance Measures*:

1 Increase the number of synthetic aperture radar (SAR) observation platforms which have been used in applications demonstrations to meet user observation requirements from 1 to 3 by 2008.

2 Increase the number of synthetic aperture radar user observation requirements met within applications demonstrations from 1 to 3 by 2008.

3 Increase the number of new research findings and progress toward their implementation in applications demonstrations by completing at least two papers or technical reports per year on research findings in SAR applications.

4 Improve ship detection algorithm and data processing techniques to yield a 60% or greater detection performance in FY 2006.

Sea Surface Temperature

- *Overarching Performance Measure*: Produce the best SST products from individual satellite measurements and merged satellite measurement.
- *Task Performance Measures*:

1 Maximize algorithm performance for each instrument (not instrument design or specifications) and apply to all project task objectives. The indicator is satellite SST product algorithm validation results.
   a. Accuracy and precision
      Target = 0.1K instantaneous
      Metric = systematic (mean) and random (std) error relative to ground truth
      Indicator = statistics determined from ground truth match-ups
      Baseline = 0.5K rms random; <0.1K systematic
   b. Stability
      Target = 100% up time
      Metric = up time / year
      Indicator = operational log history
      Baseline = 95% up time

Sea Ice

- *Overarching Performance Measure*: Development or transition of at least one NIC sea ice product or application that exploits the availability of unique NIC time-series in support of climatological research.
- *Task Performance Measures*:

1. Sea Ice Product and Research Development: Products are evaluated using model, buoy data and observations using NOAA as well as other ships and aircraft resources of opportunity. Product evaluation and feedback by present and new users is sought. The number of new and updated experimental products, transitioned products, and new users will be followed. In addition, where appropriate skill scores will be developed to determine product performance.

2. Sea Ice Altimetry Research: For altimetry Cal/Val, decrease the amplitude of error in estimated sea-ice freeboard from approximately 1.0 m to 15 cm by 2006 along CryoSat ground tracks and the wavelength of freeboard error to 0.5 km. For altimetry climate, establish first year of sea-ice mass time series (monthly intervals) by end 2007.

3. National Ice Center Polar Research: Products are evaluated using model, buoy data and observations using NOAA as well as other ships and aircraft resources of opportunity. Product evaluation and feedback by present and new users is sought after. The number of new and updated experimental products, transitioned products, and new users will be followed. In addition, where appropriate skill scores will be developed to determine product performance.

APPENDIX VI Science Team Risk Assessments

SOCD efforts will focus on achieving the objectives of this roadmap and, as best possible, support the projected timelines. Risk is inherent in research and development activities; consequently, there are elements of uncertainty in both the science and the timelines. The anticipated risks for each science team are identified below.

Ocean Color

- Reduced operating funding levels jeopardize the existence of globally-unique high-quality vicarious calibrations, potentially leading to the loss of the only source of hyperspectral ocean color vicarious calibration in the world and subsequent disruption of calibration/validation efforts for NPP/NPOESS and GOES-R.
- Failing to provide vicarious calibration data to ocean color sensors will cause climatological data inconsistency between ocean color missions.
- Biased or missing *in-situ* measurements or comparisons represent the highest risk and may lead to inadequate product validation.
- Failure to maintain updates to ocean color products and applications may result in the increased benefits of new ocean color sensors not being realized and the wasting of associated infrastructure investments.
- Failure to implement water mass tracking will lose an opportunity to leverage Department of Defense investments and the result in NOAA’s objectives for coastal zone management being hindered

Ocean Surface Winds

- Additional skilled, experienced personnel and stable funding are required to establish a core critical mass of expertise and capability to properly support the remotely-sensed ocean surface wind vector products. Current resources are inadequate to support current requirements and to properly prepare and plan for future operational needs.
- Scatterometry Data that is presently available will not achieve its full potential within the operational weather community without full understanding of the impact of high wind speeds and rain on these measurements. If the impacts of these data at OPC and TPC are not quantified while this data is available in near-real time, NOAA will be inadequately prepared to meets its requirements and defend the continuity of this capability in the future.
- Radiometry: If WindSat is not thoroughly investigated and validated now, NOAA will be inadequately prepared for the operational NPOESS/CMIS instrument and unable to address shortfalls that passive polarimetry technique may have in meeting NOAA’s operational ocean vector wind requirements.
- Air-Sea Interactions: Without additional resources, operational products derived from global ocean vector wind fields will not be realized in a timely manner, thus reducing utilization of this data in support of NOAA's objectives and the return on NOAA infrastructure investments.

Sea Ice

- Sea Ice Product and Research Development: The major risk to sea ice research and its transition to operations is the potential failure of RADARSAT-1, which has already exceeded its design life, and the subsequent loss of access to its synthetic aperture radar data. NOAA currently relies entirely on foreign missions for synthetic aperture radar data. Access to crucial data from the planned follow-on mission, RADARSAT-2, if only available at a commercial rate, will notably increase costs.

- The largest source of error in converting sea ice freeboard to thickness is snow cover uncertainty. The application of snow thickness estimates from passive microwave satellite sensors, such as AMSR-E and from combining radar and laser, i.e. ICESat altimetry, is a key activity. The precision with which these snow thickness estimates can be made is uncertain.

- National Ice Center Polar Research: A significant risk to present operations and a compounding issue to the potentially imminent loss of Radasat-1 data are difficulties experienced by current SSM/I-based algorithms during the summer melt period and adverse data quality issues during inclement weather.

Sea Surface Height

- Altimeter Data Sets: There is no risk associated with the ongoing GFO project. Jason-2 is also a low-risk project, given that all of the software and procedures will be inherited from the ongoing Jason-1 project being run operationally by NASA and CNES and we expect to adopt most of the quality assessment routines presently being used by NASA/PODAAC and CLS.

- Ocean Dynamics: Based on the recent successful transition of the Pacific OSCAR project to NOAA/NESDIS, the risk in the follow-on OSCAR projects is associated with the extension of the OSCAR technique/methodology to mid-latitudes as the time scale of phenomology approaches or becomes less than the time scale of the observation.

- Marine Gravity and Bathymetry: There are no significant risks in the gravity and bathymetry effort.

- Climate: There are no significant risks in the GSLR project. Much of the software and procedures needed to implement an operational altimeter calibration system have already been developed at the University of South Florida. Funding has been identified to pay for the full implementation of this system.

Sea Surface Roughness

- Technical risk areas include the development of new products for which SOCD currently has no experience.
- Cost risk areas include the ability to pay for international SAR data, which, heretofore, has been only freely available for research purposes. Imagery for operational use is available only for a fee.
- Funding has not been secured for a U.S. domestic synthetic aperture mission within NASA or NOAA. Planning is in progress for InSAR mission or other possible missions to provide SAR data in the period around 2011-2015.

Sea Surface Temperature

- Risks associated with the proposed research significantly increase with algorithm/ product complexity, as well as in data volume transfer, processing, and storage.
- Failure to implement proposed research will have negative impact on operational users, possibly compromising their respective missions.
- Risks associated with NPP/NPOESS can be mitigated through cal/val efforts conducted by an independent governmental agency, within the NOAA Data Exploitation (NDE) Program.

CoastWatch/OceanWatch

- Failure to maintain the interest and involvement of key Line Offices in operational ocean satellite remote sensing may result in lost value from NOAA infrastructure investments.
- Failure to identify adequate budget to allow development of maintenance of existing and planned systems may result in lost opportunity for new and quality operational products; subsequently support for NOAA and external user requirements.

APPENDIX VII Abbreviations & Acronyms

AMSR	Advanced Microwave Scanning Radiometer
AATSR	Advanced Along Track Scanning Radiometer
ALOS	Advanced Land Observing Satellite
ASAR	Advanced Synthetic Aperture Radar
ASCAT	Advanced Wind Scatterometer
Cal/Val	Calibration & Validation
CDR	Climate Data Record
CEO	Coasts, Estuaries, and Oceans
CIOSS	Cooperative Institute for Oceanographic Satellite Studies
CMIS	Conically-scanning Microwave Imager and Sounder
CORL	Consolidated Observations Requirements List
CREIOS	Coral Reef Ecosystem Integrated Observing System
CRW	Coral Reef Watch
CSA	Canadian Space Agency
CSTARS	University of Miami Center for Southeastern Tropical Advanced Remote Sensing
CW/OW	CoastWatch/OceanWatch
DMSP	Defense Meteorological Satellite Program
DOC	Department of Commerce
DoD	Department of Defense
EDR	Environmental Data Record
EOS	Earth Observing System
ESA	European Space Agency
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FEMA	Federal Emergency Management Agency
FRP	Federal Response Plan
GEOSS	Global Environment Observation System of Sytems
GFO	GeoSAT Follow-On
GOES	Geostationary Satellite
GOES-R	Geostationary Environmental Satellite
GOES-R3	Goes-R Risk Reduction
GOOS	Global Ocean Observing System
GSLR	global sea level rise
HAB	Harmful Algal Bloom
IJPS	Initial Joint Polar-Orbiting Operational Satellite System
InSAR	Interferometric SAR
INSAT	India SAT
INSAT	Indian National Satellite
IOOS	Integrated Ocean Observing System
IORD	Integrated Operational Requirements Document
IPO	Integrated Program Office
IR	Infared
IT	Information Technology
JAXA	Japan Aerospace Exploration Agency
JCSDA	Joint Center for Satellite Data Assimilation
MECB	Marine Ecosystems and Climate Branch
MERIS	Medium Resolution Imaging Spectrometer

MOBY	Marine Optical Buoy
MOCE	Marine Optical Characterization Experiment
MSG	METEOSAT Second Generation
MSMR	Multi-frequency Scanning Microwave Radiometer
MW	Microwave
NASA	National Aeronautical and Space Agency
NASDA	National Space Development Agency of Japan
NCEP	National Centers for Environmental Prediction
NDE	NPOESS Data Exploitation
NESDIS	National Environmental Satellite Data Information Service
NGA	National Geospatial Agency
NIC	National Ice Center
NIST	National Institute for Standards and Technology
NOAA	National Oceanic Atmospheric Administration
NPOESS	NOAA Polar Orbiting Environmental Satellite
NPP	NPOESS Prepatory Plan
NRL	Naval Research Laboratory
NRT	near-real-time
NWS	National Weather Service
OCM	Ocean Color Monitor
ODDAB	Ocean Dynamics & Data Assimilation Branch
OLS	Optical Linesan System
OSCAR	Ocean Surface Current Analysis Real-time
OSDPD	Office of Satellite Data and Product Distribution
PALSAR	Japanese Phased Array L-band Synthetic Aperture Radar
PFEL	NOAA Pacific Fisheries Environmental Laboratory
POES	Polar Orbiting Environmental Satellite
PPBES	Project, Planning, Budgeting & Execution System
RADS	Radar Altimetry Database System
RPP	Research Project Plan
SAR	Synthetic Aperture Radar
SEVIRI	Spinning Enhanced Visible and Infra-Red Imager
SOCD	Satellite Oceanography and Climate Division
SOSB	Satellite Ocean Sensors Branch
SSM/I	Special Sensor Microwave Imager
SSR	Sea Surface Roughness
SST	Sea Surface Temperature
STAR	Satellite Applications and Research
TRMM	Tropical Rainfall Measurement Mission
USCG	United States Coast Guard
VISSR	Visible and Infrared Spin-Scan Radiometer
WIPE	World-Wide Web Image Processing Environment