Science and Technology Roadmap

Cooperative Research Program (CoRP)

National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service
Center for Satellite Applications and Research

Table of Contents

EXECUTIVE SUMMARY

The setting of the Cooperative Research Program (CoRP) within NOAA and the NESDIS Center for Satellite Applications and Research (STAR) is briefly summarized. CoRP is one of three divisions within STAR and includes academic partners located at a number of university sites across the country. Current CoRP research capabilities are described along with a science roadmap for the next decade. This science discussion is in the context of the seven basic categories of CoRP research which include 1) Instrument Science, Calibration and Validation; 2) Satellite Retrieval of Geophysical Variables; 3) Algorithm and Product Development for Weather Analysis and Forecasting; 4) Land Surface Product Development; 5) Ecological Product Development; 6) Climate Studies; 7) Satellite Training and Outreach. The primary drivers for CoRP research over the next decade are user needs for improved satellite products and the several orders of magnitude increase the volume of data that will become available due to new satellite systems that will come on line. Through its close collaboration with academic partners, CoRP is well situated to perform the research needed to optimize the utility of these new data sources. The guiding principles for the next decade are to make use of simulated and synthetic data sources for advance preparation, include a concentration on the hyperspectral observations that will become available, and to take a multi-sensor approach to product development. The decades of experience within CoRP in sensor science and calibration and validation will be a valuable resource, and the strong training program in CoRP should be continued and expanded to ensure user readiness. In addition, the close association with universities will help to develop the future work force in remote sensing and satellite meteorology and oceanography. A set of five performance measures for CoRP is proposed, and the relationship between CoRP research and NOAA's goals is summarized.

1. INTRODUCTION

1.1 Setting within NOAA

The National Environmental Satellite, Data, and Information Service (NESDIS) is one of five Line Offices within the National Oceanic and Atmospheric Administration (NOAA) and provides timely access to global and environmental data and information services from satellites and other sources. To accomplish this, NESDIS acquires and manages operational environmental satellites, provides data and information services, and conducts related research. Research on the use of satellite data for monitoring meteorological, climatological, terrestrial, and oceanographic environmental characteristics is conducted under the auspices of the Center for Satellite Applications and Research (STAR), the science arm of NESDIS. STAR's responsibilities include determining future systems, developing new applications of satellite data, and developing algorithms and prototype software systems for transition into the production of operational satellite products. STAR's research is grouped into three divisions, each division named for their focus and responsibility: Satellite Meteorology and Climatology Division (SMCD), Satellite Oceanography and Climate Division (SOCD), and Cooperative Research Program (CoRP). The purpose of this document is to provide a science and technology roadmap for the CoRP Division.

1.2 CoRP Mission and Structure

CoRP is the focal point within STAR for facilitating and broadening the scientific research resources available to support NOAA's strategic goals (see section 8 for a discussion of NOAA's goals). More specifically, CoRP guides the direction of satellite-related research efforts. CoRP is a unique organization consisting of federal researchers and academic research partners at the Cooperative Institutes. It is through these academic partnerships that CoRP leads the development of a skilled future workforce for NOAA and fosters interactions within local communities and internationally. For more than two decades, the Cooperative Institutes have proven to be among the most productive of NOAA's investments.

CoRP stretches across the nation and includes three branches, four Cooperative Institutes, and one minority-serving institution Cooperative Center (i.e., a consortium of eight colleges and universities) (Figure 1.1). To foster strong interactions and facilitate the transition of research results, each CoRP branch is collocated with a Cooperative Institute. This collocation provides access to the academic community and longer-range exploratory research projects in atmospheric and oceanic sciences and remote sensing.

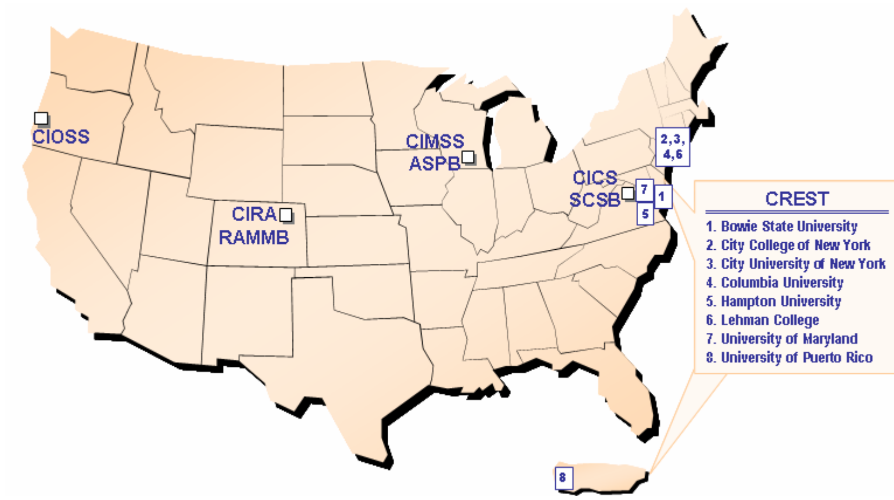


Figure 1.1 Locations of CoRP members.

1.3 CoRP's Federal Branches

There are three federal branches within CoRP: the Regional and Mesocale Meteorology Branch (RAMMB), collocated with the Cooperative Institute for Research in the Atmosphere (CIRA) in Fort Collins, Colorado; the Advanced Satellite Products Branch (ASPB), collocated with the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin in Madison, Wisconsin; and the Satellite Climate Studies Branch (SCSB), collocated with the Cooperative Institute for Climate Studies at the University of Maryland in College Park, Maryland.

RAMMB conducts research on the use of satellite data to improve analysis, forecasts, and warnings for regional and mesoscale meteorological events. Many RAMMB research projects focus on tropical cyclone and severe thunderstorm genesis, development, intensification, and prediction. Other projects study mesoscale forecast and nowcast products based on multi-spectral satellite data integrated with other observations, such as Doppler radar and aircraft reconnaissance data, and numerical prediction models. RAMMB is also actively involved in satellite training. Unique aspects of RAMMB include their close ties with operational forecast centers such as the National Centers for Environmental Prediction (NCEP) Tropical Prediction Center in Miami FL and NCEP Storm Prediction Center in Norman, OK. A number of forecast products and applications developed in the research environment have been transferred to operational centers. The focus on tropical cyclones and severe weather takes advantage of the very strong research programs in these areas at the co-located Department of Atmospheric Science at Colorado State University. Another unique aspect of RAMMB is the focus on GOES imagery and image interpretation.

ASPB conducts research in new satellite systems and develops advanced products from environmental satellite data for weather forecasting and monitoring of the earth-atmosphere system. ASPB research activities include validating and improving the calibration of measured radiances from current satellite sensors, planning and specifying future advanced satellite systems and instruments, and developing algorithms that estimate cloud properties, vertical profiles of temperature and moisture, atmospheric motion, and fire characteristics. ASPB also investigates the use of satellite products in numerical weather prediction systems and implements these new techniques and products into NESDIS operational systems, including real-time product demonstrations. National and international collaborations with scientists at major modeling and satellite development centers maximize the benefit of satellite observations in the global observing system. Unique aspects of ASPB research include applications and retrieval methods for sounder data from both geostationary and polar orbiting satellites, wind estimation techniques from satellites, polar meteorology, and future satellite planning. The co-located CIMSS and the University of Wisconsin Atmospheric and Oceanic Science Departments have a long history of cutting edge research in these areas.

SCSB conducts research on the use of earth observing satellites to study regional and global climate variability. SCSB ensures the accuracy, validation, and quality control of products; implements regional ecosystems models for forecasting applications and climate research; and develops advanced algorithms for retrieving atmosphere, land, and ocean climate parameters from multispectral satellite sensors. In addition, staff members participate in various national and international climate programs for climate monitoring and assessment, particularly global precipitation. Unique aspects of SCSB include the focus on global and climate research, ecosystems methods, and precipitation and hydrological studies. Similar to the other Branches, the SCSB specialty areas are well-matched with the expertise at the co-located cooperative institute (CICS) and the Department of Atmospheric and Oceanic Science at the University of Maryland.

1.4 CoRP's Academic Partners

CoRP currently has five academic partners that bring complementary expertise and significantly broaden the research capabilities available to NOAA, NESDIS, and STAR. The partners include the three cooperative institutes collocated with the CoRP federal branches (CIRA, CIMSS and CICS), and the Cooperative Institute for Oceanographic Satellite Studies (CIOSS) located at Oregon State University in Corvallis, Oregon, which does not currently possess a collocated federal branch. All of these institutes are administered by NESDIS except CIRA, which is a joint institute administered by the NOAA Office of Oceanic and Atmospheric Research (OAR). CoRP academic partners also include the Cooperative Remote Sensing Science and Technology Center (CREST) which is a consortium of several Minority-Serving Institutions. Although CREST is technically not a Cooperative Institute, the use of the term Cooperative Institutes will include CREST for the purposes of this document. All of the Cooperative Institutes include MOUs/MOAs which define their research themes. The research themes are included in the following brief summaries of the CoRP academic partners.

CIRA was established in 1980 by an MOU between Colorado State University (CSU) in Ft. Collins, Colorado and NOAA. The CIRA mission is to increase the effectiveness of atmospheric research of mutual interest to NOAA, CSU, the state of Colorado, and the nation.

Cooperative Institute for Research in the Atmosphere
Global and Regional Climate Studies
Cloud Physics
Local and Mesoscale Area Weather Forecasting and Evaluation
Applications of Satellite Observations
Air Quality and Visibility
Societal and Economic Impacts
Numerical Modeling
Education, Training, and Outreach

CIRA's research in severe weather and tropical cyclone forecasting includes use of rapid scan satellite data, derivation of satellite-based mesoscale convective climatologies, applications of mesoscale satellite sounding, numerical modeling, and development of statistically based forecast methods that utilize multiple regression and discriminant analysis, as well as more advanced techniques, such as expert systems and neural networks. CIRA also analyzes GOES observations—including fog, rapid scan applications, and hurricanes—and conducts research in satellite data assimilation for numerical weather forecasting models, including Third-World forecast support.

The research described above is primarily related to CIRA's relationship with NESDIS. CIRA research also includes a large scope of problems such as data assimilation, air quality and cloud physics associated with its interaction with NOAA/OAR.

Cooperative Institute for Meteorological Satellite Studies
Weather Nowcasting and Forecasting
Clouds and Radiation
Global Hydrological Cycle
Environmental Trends and Climate

CIMSS, established in 1980 at the University of Wisconsin-Madison, serves as an international center for research on the interpretation and uses of operational and experimental satellite observations and remote sensing data acquired from aircraft and the ground.

CIMSS plays a major role in instrument design and testing—and related software development—for improved space-based measurements of the earth's atmosphere. CIMSS is very active in national and international field programs, testing new instrumentation and data processing systems and assessing the geophysical utility of measurements. CIMSS uses real-time data from polar and geostationary satellites, as well as ground-based measurements for validation and calibration of satellite data. CIMSS is also developing algorithms for temperature and humidity sounding, fire, aerosol, cloud, and wind products.

CICS was established in 1983 at the University of Maryland, College Park and conducts research in satellite climatology, climate diagnostics, environmental prediction, and risk reduction for future satellite sensors.

Cooperative Institute for Climate Studies
Global Energy and Water Cycle
Climate Diagnostics and Prediction
Ecological Modeling and Forecasting
Atmospheric Chemistry

CICS research covers a broad range of topics within remote sensing research and development, data assimilation, and analysis of remote sensing, in situ and model-generated data. Recent research efforts at CICS have focused on examination of long-term data sets for climate trends, oceanic remote sensing applications, regional ecosystem modeling and forecasting, land-surface classification, radiation budget, and algorithm development.

Cooperative Institute for Oceanographic Satellite Studies
Satellite Sensors and Techniques
Ocean-Atmosphere Fields and Fluxes
Ocean-Atmosphere Models and Data Assimilation
Ocean-Atmosphere Analyses
Outreach, Education, and Training

CIOSS, located at Oregon State University, is the newest Cooperative Institute, formed in 2003, and was competitively selected. At the present time, CIOSS does not have a collocated CoRP Branch. Its primary purpose is to conduct research involving satellite remote-sensing and modeling of the ocean and its air-sea interface.

CIOSS seeks to develop, evaluate, improve, and use methods of ocean remote sensing and ocean-atmosphere modeling in order to increase our understanding of the ocean and atmosphere. CIOSS has identified research areas where it intends to make its major contributions, including interpreting model fields from the nested coastal model, using satellite data to estimate surface heat fluxes caused by visible and infrared radiation, and assimilating satellite altimeter and surface radar data into nested coastal circulation models. CIOSS is also actively involved in risk reduction activities for future satellites, with an emphasis on ocean applications.

CREST was competitively selected and established in 2001 by the Educational Partnership Program of OAR as one of five centers focused on the development of under-represented students to acquire NOAA-related skills and serve as the scientific workforce of the future. Because CREST research focuses on remote sensing, NESDIS STAR serves as the technical monitor of the CREST program. CREST does not have a collocated STAR Branch, but it works jointly with STAR staff on a wide variety of projects.

CREST is a consortium of several Minority-Serving Institutions: City College of the City University of New York (CUNY), which is the consortium lead; Bronx Community College; Bowie State University; Columbia University; Hampton University; Lehman College; University of Maryland (Baltimore); and the University of Puerto Rico (Mayaguez).

Cooperative Remote Sensing Science and Technology Center
Atmospheric Remote Sensing and Air Quality Monitoring
Estuarine, Coastal and Marine Remote Sensing and Water Quality Monitoring
Remote Sensing Applications for Environmental Assessment and Forecasting

1.5 CoRP Research Categories

Sections 1.3-1.4 provided a general introduction to the research activities of the federal branches of CoRP and their academic partners. CoRP research can be classified into seven basic categories, as shown in Table 1.1. These categories will be used as an organizational structure for the remainder of this document. The CoRP research areas in Table 1.1 map directly onto NOAA's four primary mission goals and mission support function (see Section 8).

Table 1.1. The Seven Basic Categories of CoRP Research

1. Instrument Science, Calibration and Validation
2. Satellite Retrieval of Geophysical Variables
3. Algorithm and Product Development for Weather Analysis and Forecasting
4. Land Surface Product Development
5. Ecological Product Development
6. Climate Studies
7. Satellite Training and Outreach

2. TRENDS AND DRIVERS FOR RESEARCH

As described in section 1, CoRP works with academic partners to perform applied research in satellite meteorology and oceanography and with federal and state agencies to transition analysis and forecast algorithms to operations. In this section the governmental regulations and user requirements that drive the activities of CoRP are briefly summarized. Developments and trends in technology that will influence the direction of CoRP research in the next several years are also described.

2.1 Governmental Mandates and User Requirements

At the highest level, guidelines issued as a result of Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Public Law 106-554) provide a legal basis for NOAA research. This law provides the general umbrella under which NESDIS-STAR and CoRP performs their research mission (see www.noaanews.noaa.gov/stories/iq.htm).

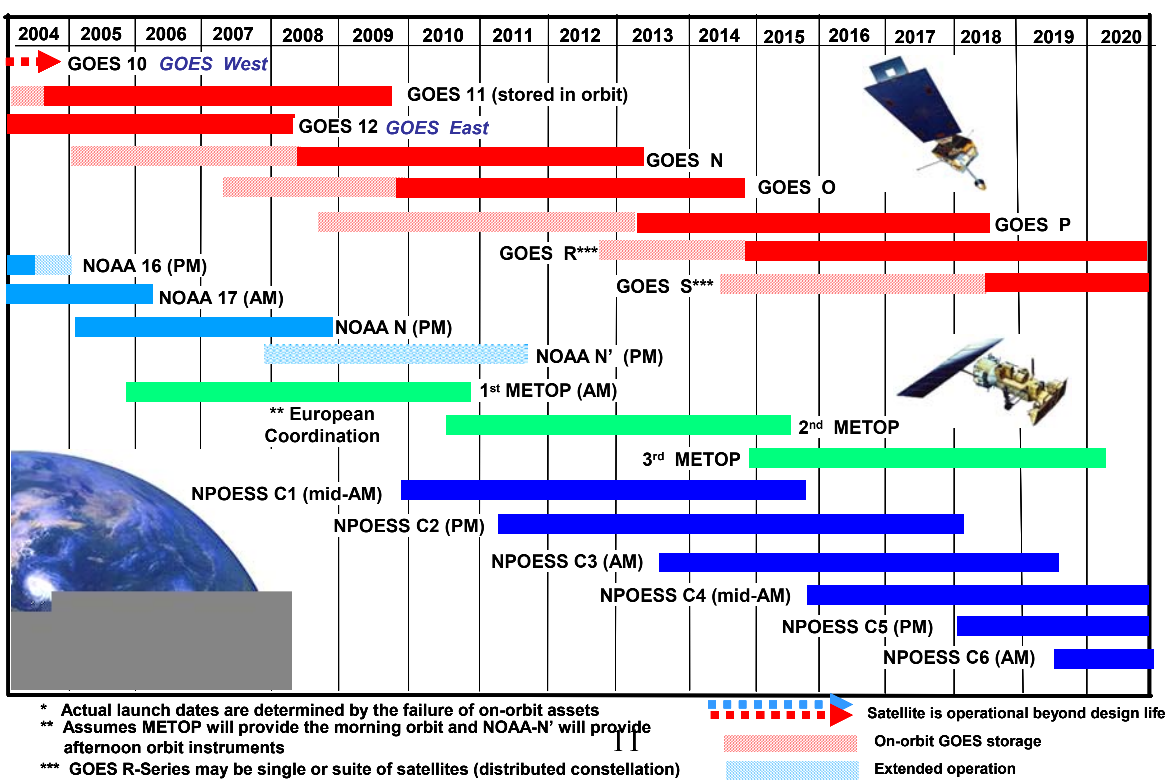
There are many other governmental regulations for the specific areas of research listed in Table 1.1. For example, the retrieval and weather product development activities listed in Table 1.1 contribute to activities covered by the Weather Service Organic Act and the Inland Flood Forecasting and Warning System Act. The CoRP climate research is in support of the Administration's Climate Change Initiative (CCRI), which was implemented in response to a 2001 National Research Council Report (NRC, 2001). There are numerous Congressional Acts, Executive Orders, and NOAA-Specific polices, that provide a mandates for CoRPs efforts to develop ecological products (for example, the Harmful Algal Bloom and Hypoxia Research and Control Act). For more details of the governmental mandates and laws that form the basis for CoRP research see NOAA (2005).

The legal mandates are in response to user requirements. The satellite science and calibration/validation activities in Table 1.1 are in direct support of the NESDIS-STAR primary mission described in section 1.1. This work is also in support of the NESDIS commitment to the Global Earth Observing System of Systems (GEOSS) program. The weather-related activities in Table 1.1 provide support to the National Weather Service (NWS). This work helps to provide new input to operational numerical models such as the NCEP Global Forecasting System (GFS), and also products utilized directly by NWS forecasters. For example, RAMMB and ASPB in collaboration with CIRA and CIMSS have developed a new product to estimate tropical cyclone intensity from microwave satellite data, which is being transferred to operations of the NCEP Tropical Prediction Center. The weather research also includes precipitation estimation and forecast techniques, which help the NWS fulfill its mission to protect life and property. The land surface work in Table 1.1 includes wildfire detection products which support the needs of a number of National and International Agencies. Wildfires contribute to the generation of fine aerosols (less than 2.5 μm in diameter) which pose a serious health hazard. Climate changes have wide ranging consequences for the nation and the world. The work in this area is in response to numerous requirements from users, including policy makers, resource mangers, and agriculture and transportation officials. The full utilization of satellite services requires an understanding of available data and products. The satellite training activities are in support of users in all of the other areas listed in Table 1.1. The long-range support for satellite development requires continued availability of a skilled workforce. The training and outreach activities in Table 1.1 include the development of this future workforce. The CoRP academic partners play a fundamental role in the success of this activity.

2.2 Science and Technology Drivers

Ever-improving technology and exponentially increasing computer power are driving every science field, and the geosciences are no exception. Computers and technology directly affect essentially every aspect of modern-day weather- and climate-related activities, from numerical modeling to severe-weather forecasting to air quality monitoring. Remote sensing trends and capabilities are fundamental to such research and operational activities. There are several trends that are driving CoRP's activities in support of NOAA's goals, including: (1) the launch of new satellites, (2) the emergence of hyperspectral remote sensing, and (3) data assimilation and blending products.

Several new operational satellites, including four new satellite configurations, are slated for launching within the next 15 years as illustrated in Figure 2.1. These satellites—which include METOP, GOES NOPQ, GOES R, and NPOESS—will have greatly increased real-time sensor data and data rates and will be sampling in new channels and wavelengths. In support of these launches, CoRP-sponsored projects at the Cooperative Institutes will help to develop new sensors and products, innovative approaches for handling increased data rates, techniques for calibration and validation, enhanced observations from new sensor channels, improved data and product displays, and integrated environmental and ecological models.



* Actual launch dates are determined by the failure of on-orbit assets
** Assumes METOP will provide the morning orbit and NOAA-N' will provide afternoon orbit instruments
*** GOES R-Series may be single or suite of satellites (distributed constellation)

Figure 2.1 Schedule for Launches of NOAA Satellites through 2020.

As spatial resolution of satellite imagery increases, so does the need for higher spectral resolution. As such, the emergence of hyperspectral remote sensing data (i.e., retrieval of data at hundreds or thousands of wavelengths) provides unparalleled spectral resolution. This allows for better discrimination of atmospheric, oceanic, and terrestrial parameters, which in turn increases NOAA's ability to more accurately observe and model Earth processes. One example of CoRP's contribution to this is its work on the slated GOES R Hyperspectral Environmental Suite (HES). With the HES Sounder, NOAA is evolving their GOES sounding capability to produce three dimensional depictions of atmospheric temperature and moisture with better vertical resolution, horizontal resolution, temporal resolution, and greater spatial coverage. The HES–Coastal Waters extends NOAA's observations to shorter wavelengths for retrieval of additional ocean and land surface properties. Product from this new data source is a main driver of CoRP research in the next decade. This will include new retrieval methods and weather, land surface, and ecological product development as well as climate applications.

With the ever-increasing types and amounts of geophysical data, CoRP researchers are utilizing data assimilation to improve model precision and accuracy and product blending to glean unique information that individual products alone cannot provide. For example, satellite-derived wind measurements are especially valuable in polar regions where few in situ observations exist. CoRP researchers are deriving estimates of high-latitude wind information from MODIS and assimilating these data into numerical models, increasing the accuracy of numerical model forecasts. Another example is the analysis of tropical cyclones. Several instruments provide sub-sets of information on the tropical cyclone wind field. Feature track winds from GOES measure the outer wind circulation, IR techniques can estimate the maximum winds, and scatterometter and passive microwave measures can provide wind estimates away from the high precipitating region of the inner core. This information will need to be combined in an optimal way to provide a more complete estimation of the tropical cyclone wind field.

The launch of new satellites with new instrumentation, the availability of hyperspectral observations and the need for multi-sensor products are major drivers for the satellite training activities of CoRP. These training activities will need to begin well in advance of the launch of the satellites to prepare users for this new information. This will be a challenge given the rapid advances that are expected from these new data sources and products, and the large increase in the amount of data that will become available.

3. RESEARCH CAPABILITIES

As summarized in Section 1, CoRP has research capabilities in a wide variety of areas in satellite meteorology and oceanography. Table 1.1 listed the basic categories of this expertise at the CoRP federal branches. To guide current research and assist with future planning, Science Project Summaries (SPSs) have been developed for CoRP research projects. These SPSs will be available on the CoRP web site in the near future. The other divisions of STAR also have project plans to guide their research.

Appendix A lists the SPS titles by CoRP research topic at the federal branches and Appendix B shows diagrams summarizing the main goals and long range plans for these projects. A brief overview of the CoRP research capabilities associated with the SPSs is provided in this section.

A basic function of CoRP is to work with the other divisions of STAR and NESDIS to assist with calibration, validation and science testing as new satellites come on line. This work continues during the lifetimes of the NOAA satellites to ensure the reliability of the data, since calibrations can drift, instruments can fail or data can become noisy. The ASPB and RAMMB and their academic partners at CIMSS and CIRA are the focal points for this work.

Environmental satellites provide radiance measurements in a variety of channels in the visible, infrared and microwave portions of the electromagnetic spectrum. Numerical weather prediction models typically directly assimilate these radiances using sophisticated data assimilation methods. For some applications it is necessary to retrieval geophysical variables from these radiance values. ASPB and SCSB have considerable experience with retrieval techniques including temperature, moisture and precipitation. SCSB and CIOSS are involved in retrieval techniques for ocean applications. Using feature tracking techniques, atmospheric winds can also be retrieved from satellite radiance measurements. ASPB and CIMSS have a long history of work in this area from geostationary satellites, and are also involved in new approaches to estimate winds from polar orbiting satellites in high latitudes. This work is closely coordinated with other divisions of NESDIS to improve operational retrieval products, and a number of researches at CREST are participating in this effort.

CoRP has a very active research program in the development of satellite-based products for weather analysis and forecasting. Products are being developed for tropical cyclone and severe weather forecasting, fog and volcanic ash detection, precipitation estimation and forecasting, and cloud property determination. These products are tested in the research environment and are often transitioned to operational agencies within NESDIS and the NWS. All of CoRP contributes to these activities.

SCSB and ASPB and their partners are involved in work to better estimate land surface properties and hazards including detection of wildfires. Accurate representations of land properties are required in many satellite retrieval and product algorithms, and can influence the weather and climate through the variability in surface energy exchanges.

The wildfire detection research includes the development of operational products that are used by the National and International fire response communities.

A relatively new research area of CoRP is in ecological modeling. This work is currently focused on the detection and prediction of marine organisms using satellite data in combination with other techniques, such as hydrodynamic modeling and in-situ measurements. SCSB is the leader of this work in cooperation with CICS, CIOSS and the other divisions of STAR.

Satellite observations are fundamental to the study of inter-annual variability and climate changes. A challenging aspect of the use of satellite data for this research is that the available sensors have undergone large variations since the beginning of the satellite era in the 1960s. In addition, sensor characteristics vary with time and the equatorial crossing times of polar orbiting satellites drift during the satellite lifetimes. SCSB and ASPB and their academic partners have extensive research capabilities in this area and are involved in a number of studies that normalize satellite estimates to provide stable long-term records of geophysical variables. RAMMB and CIRA are also involved in research to use GOES climatologies to study interannual variability in cloud cover in North and South America.

In order for users to maximize the utility of satellite observations, they must be properly trained. There is a considerable ongoing effort in this area, which is focused at RAMMB and CIMSS in collaboration with CIRA and CIMSS. Distance learning courses are being developed and delivered to a wide variety of operational users, an International Virtual Laboratory has been established in cooperation with the World Meteorological Organization (WMO) to enhance utilization in other countries, and scientists and staff from all of CoRP routinely participate in training and workshops at the National and International Levels. In addition, the academic partnerships in CoRP help to train the future work force in satellite meteorology and oceanography.

4. CURRENT RESEARCH

The CoRP research capabilities were described in the past three sections. In most of these sections the research was described in a fairly general way. In this section short summaries of several research projects at the CoRP federal branches are provided to give a more specific idea of the type of capabilities in this branch of NESDIS-STAR.

4.1 ASPB Projects

4.1.1 A New Global Cloud Climatology

Clouds have long been recognized as the dominant modulators in determining the radiation budget in the atmosphere and at the surface. Accordingly, much of the inconsistency in predictions of climate change with various climate models is due to uncertainties and differences in cloud responses to anthropogenic forcing. While global satellite-derived cloud climatologies exist, the long-term time series of the key cloud products show significant disparities. For example, the image below shows the time-series of total cloud amount from several cloud climatologies. Given the discrepancies and weaknesses with the existing cloud climatologies, ASPB has begun the development of a new cloud climatology using an improved version of the Advanced Very High Resolution Radiometer (AVHRR) Pathfinder Atmosphere Extended (PATMOS-x). The goal is to develop a new global cloud climatology that is well characterized and that can be used with confidence by climate researchers for decadal climate variability studies.

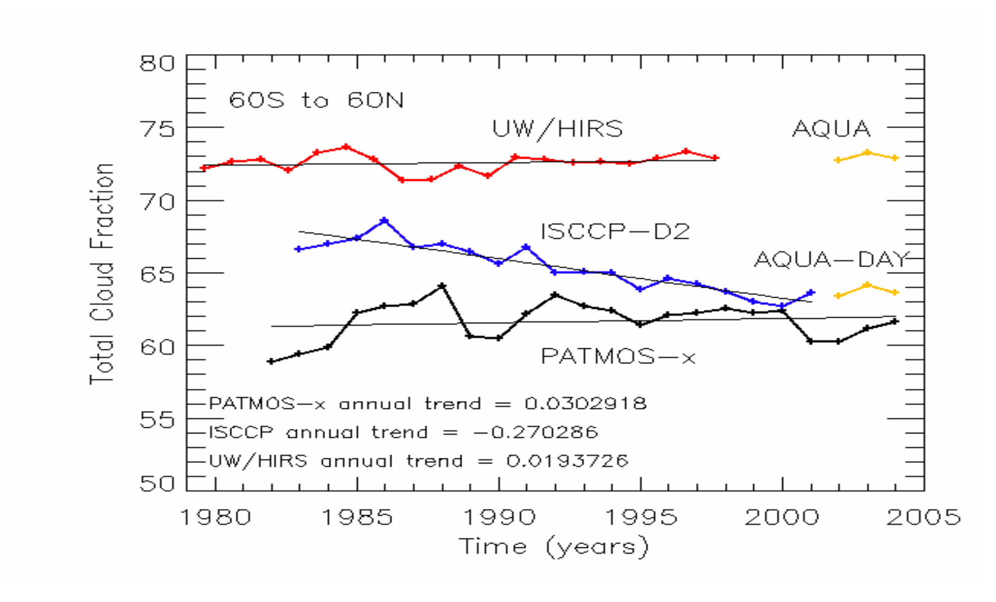


Figure 4.1 Comparison of the July total cloud amount time series (daily averaged and from 60°S to 60°N) from several cloud climatologies. AQUA refers to the MODIS instrument on EOS/AQUA, ISCCP refers to the International Satellite Cloud Climatology Project, UW/HIRS refers to the University of Wisconsin HIRS climatology, and PATMOS-x is the AVHRR Pathfinder Atmospheres Extended.

4.1.2 GOES-R High-spectral Resolution Sounder Simulations

In preparation for the future Geostationary Operational Environmental Satellite (GOES)-R instruments, ASPB and CIMSS perform research on the next generation advanced imager and high-spectral resolution infrared sounder, the Hyperspectral Environmental Suite (HES). HES simulation codes were developed to better understand which spectral regions are required to optimally generate temperature and moisture profiles. These simulations codes are also being used by the EUropean organization for the exploitation for METeorological SATellites (EUMETSAT) to assist in trade studies for Meteosat Third Generation (MTG). Other HES-related studies deal with the synergistic use of high spatial resolution imager data and the high spectral resolution sounder data. The work is part of SPS 1.2 in Appendix A and B.

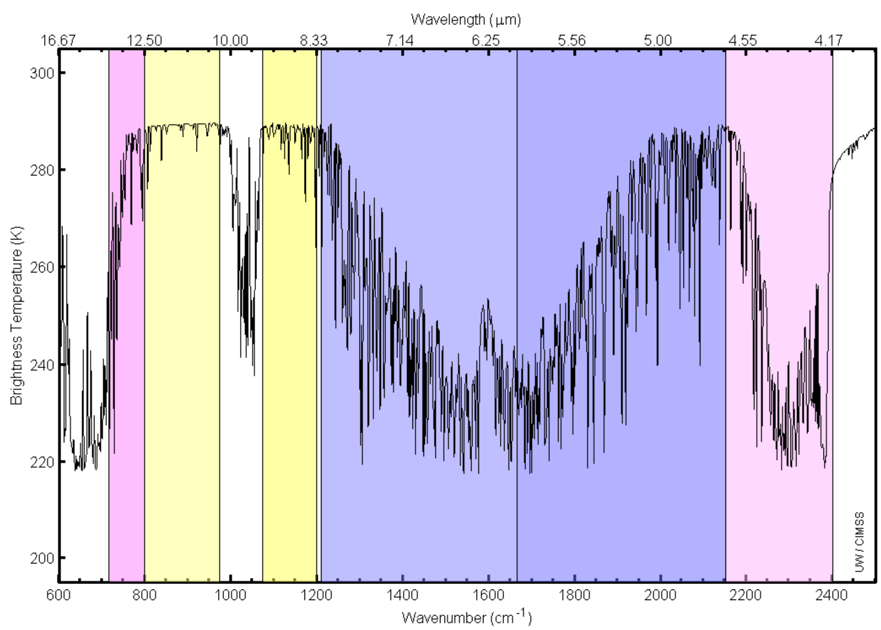


Figure 4.2. The black line above is a calculated spectrum from the standard U.S. atmosphere. The spectral trade-off study consisted of comparing retrieval results for different spectral regions (shaded). These consist of regions sensitive to CO_2 (800 to 718 cm^{-1} or 2400 to 2150 cm^{-1}), the window region (990 cm-1 to 800 cm^{-1} or 1200 to 1075 cm^{-1}), and mid-level moisture regions (2150 to 1666 cm^{-1} 1666 to 1210 cm^{-1}).

4.2 RAMMB Projects

4.2.1 Improvements in Tropical Cyclone Intensity Forecasting

The skill of operational tropical cyclone intensity forecasts is much less than that for track. Because of the complexity of the intensity forecast problem, empirically-based forecast models have generally outperformed the more general numerical hurricane models. The primary empirical model utilized by the NCEP Tropical Prediction Center in

Miami is the Statistical Hurricane Intensity Prediction Scheme (SHIPS). This model is continually being improved through better utilization of satellite observations. One important factor in the intensification of tropical cyclones is the total heat available from the ocean. In a project partially supported by the NOAA Joint Hurricane Testbed, a new version of SHIPS was developed that includes the ocean heat content (OHC) estimated from satellite altimetry data. Because of the sub-surface ocean structure, the OHC can have much more spatial variability than the sea surface temperature. Figure 4.3 shows an example of an OHC analyses used for the intensity predictions of Hurricane Ivan. Note the large values of OHC (red) just south of Louisiana. This is a warm eddy feature that helped Ivan to maintain its intensity until just for its landfall. A similar feature affected Katrina during the 2005 season, and was a contributing factor to the major disaster caused by that storm. This work is part of SPS 3.4 in Appendix A and B.

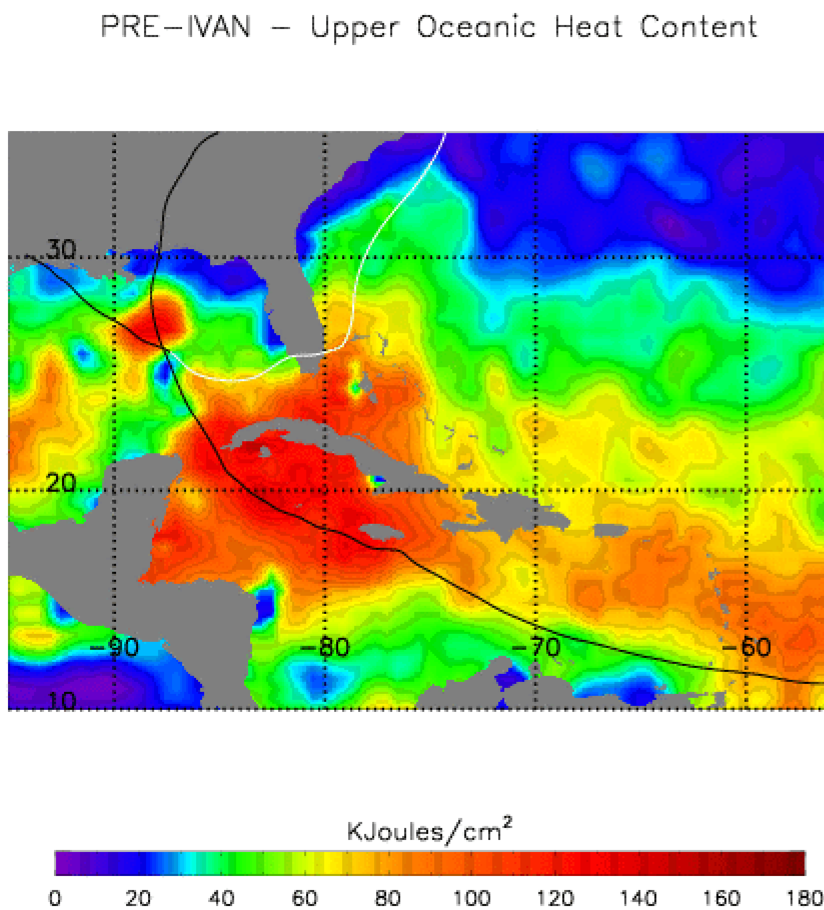


Figure 4.3. The ocean heat content estimated from satellite imagery used in the SHIPS intensity forecasts for Hurricane Ivan (2004). The track of Ivan is indicated by the black and white lines (Ivan looped back south through the Bahamas and back into the Gulf of Mexico after its first Gulf Coast landfall).

4.2.1 The Virtual Institute for Satellite Integration Training (VISIT)

Due to budget constraints of NWS and other agencies, the ability to fund travel for employee training has been very restrictive over the past few years. To continue to provide satellite training to NWS and other forecasters the VISIT program was established. This program was a collaborative effort between RAMMB, ASPB and their academic partners (CIRA and CIMSS). This program applies distance learning methods via to provide satellite training via the Internet. The VISITView software developed by CIMSS was fundamental to this effort, and allows for simultaneous access and manipulation of the training material across several remote locations. The sessions are led by a subject matter expert and typically last from 1 to 2 hours. The material is highly tailored to operational applications, and the material is usually presented in the AWIPS (Advanced Weather Interactive Processing System) format that is available in real-time to NWS forecasters. Some recent VISIT sessions include "Utilizing GOES Imagery with AWIPS Format to Forecast Winter Weather" and "Prediction Super-Cell Motion in Operations". A certificate of completion is issued to each participant that completes the course. Figure 4.4 shows the number of VISIT certificates issued since 1999. More than 14,000 forecaster-hours of training have been provided by the VISIT program. This work contributes to SPS 7.1 in Appendix A and B.

IST/VISIT Cumulative Training Certificates Issued

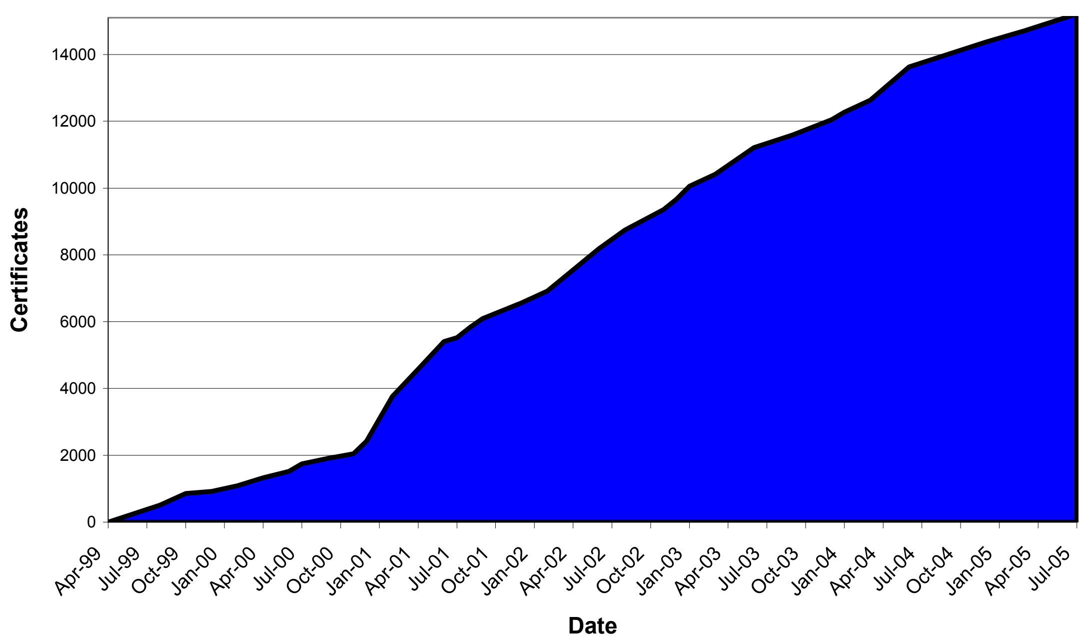


Figure 4.4. The number of Integrated Sensor Training/VISIT certificates issued since 1999.

4.3 SCSB Projects

4.3.1 Nowcasting Sea Nettles and Harmful Algal Blooms in the Chesapeake Bay

Various noxious marine biota, such as jellyfish and noxious algal blooms, periodically afflict the waters of the Chesapeake Bay and the coastal U.S. The recent outbreak of the ichthyotoxic dinoflagellate *Pfiesteria piscicida* and the periodic invasion of sea nettles (*Chrysaora quinquecirrha*) in the summer are examples of these events. The adverse impact of these biotic events may be mitigated if their presence could be monitored and predicted.

Multiple interacting physical, chemical, and biotic factors lead to the development and persistence of biotic events. Information on many of these factors is accessible in near-real time from geographic databases, numerical circulation models, and operational satellites. The capability to assess pertinent environmental factors in near-real time offers the potential to operationally predict the presence of noxious biotic events if the specific environmental conditions associated with their occurrence are known.

We are currently developing methods to generate nowcasts illustrating the probable distribution patterns of sea nettles (*Chrysaora quinquecirrha*), a stinging jellyfish, and the ichthyotoxic dinoflagellate *Karlodinium micrum* in Chesapeake Bay (Fig. 4.5). This is accomplished by constructing robust statistical habitat models of the target organisms and applying their habitat models to relevant input parameters derived or acquired in a timely manner. For example, sea nettle nowcasts are produced by applying their empirically derived habitat model to surface salinity estimated from a numerical hydrographic model of Chesapeake Bay and sea-surface temperature derived from the hydrographic model or NOAA satellite imagery.

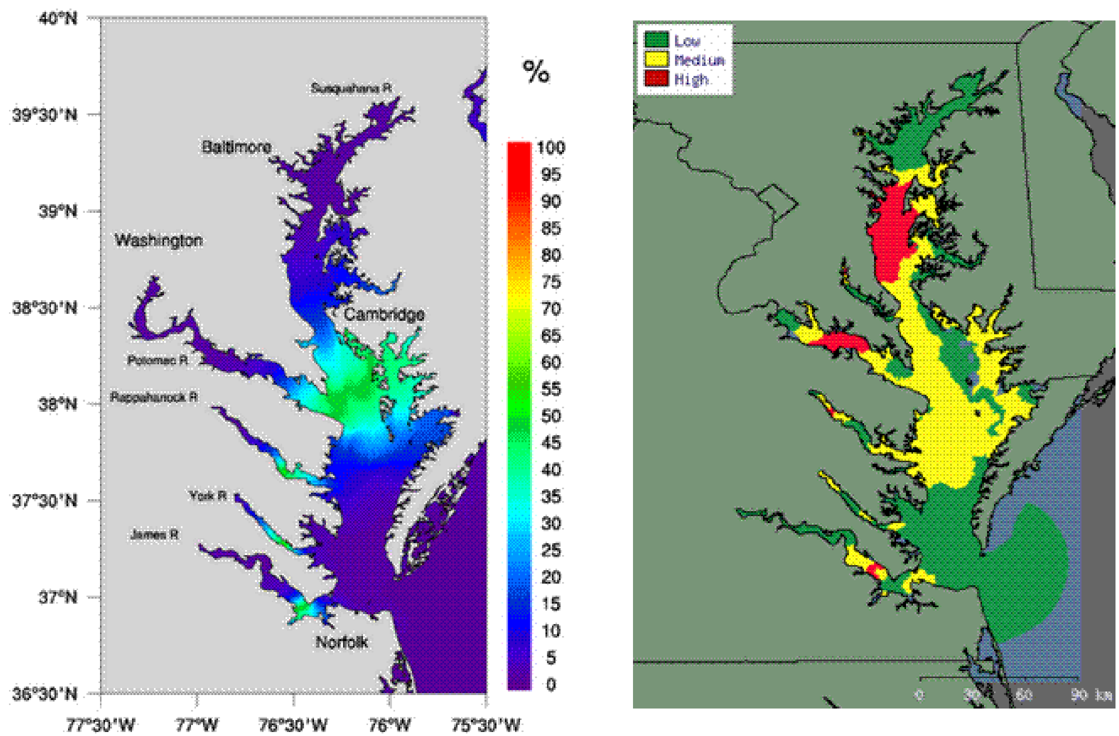


Figure 4.5. Chance of encountering sea nettles, C. quinquecirrha, on August 15, 2004 (left) and the relative abundance of the harmful algal bloom K. micrum on May 27, 2004 (right).

This project represents collaboration between scientists at NOAA ,Yale University, Shannon Point Marine Center and the University of Maryland Center for Environmental Science, and is part of SPS 5.2 in Appendix A and B.

4.3.2 The Global Precipitation Climatology Project

The Global Precipitation Climatology Project (GPCP) is an element of the Global Energy and Water Cyclone Experiment (GEWEX, see www.gewex.org) of the World Climate Research program (WCRP). It was established by the WCRP in 1986 with the initial goal of providing monthly mean precipitation data on a 2.5°× 2.5° latitude-longitude grid. Monthly mean precipitation estimates are being produced beginning in 1979 and planned to go through 2010. The GPCP has accomplished this by merging infrared and microwave satellite estimates of precipitation with rain gauge data from more than 6,000 stations. Infrared precipitation estimates are obtained from GOES (United States), GMS (Japan) and Meteosat (European Community) geostationary satellites and NOAA operational polar orbiting satellites. Microwave estimates are obtained from the U.S. Defense Meteorological Satellite Program (DMSP) satellites using the Special Sensor Microwave Imager (SSM/I). These data sets are used to validate general circulation and climate models, study the global hydrological cycle and diagnose the variability of the global climate system. Data sets have been expanded so that in addition to the monthly mean product available, the GPCP now has a 2.5°×2.5° degree pentad data set starting in 1979 and a 1°×1° daily data set starting in 1997. The work is part of SPS 6.1 in the Appendices.

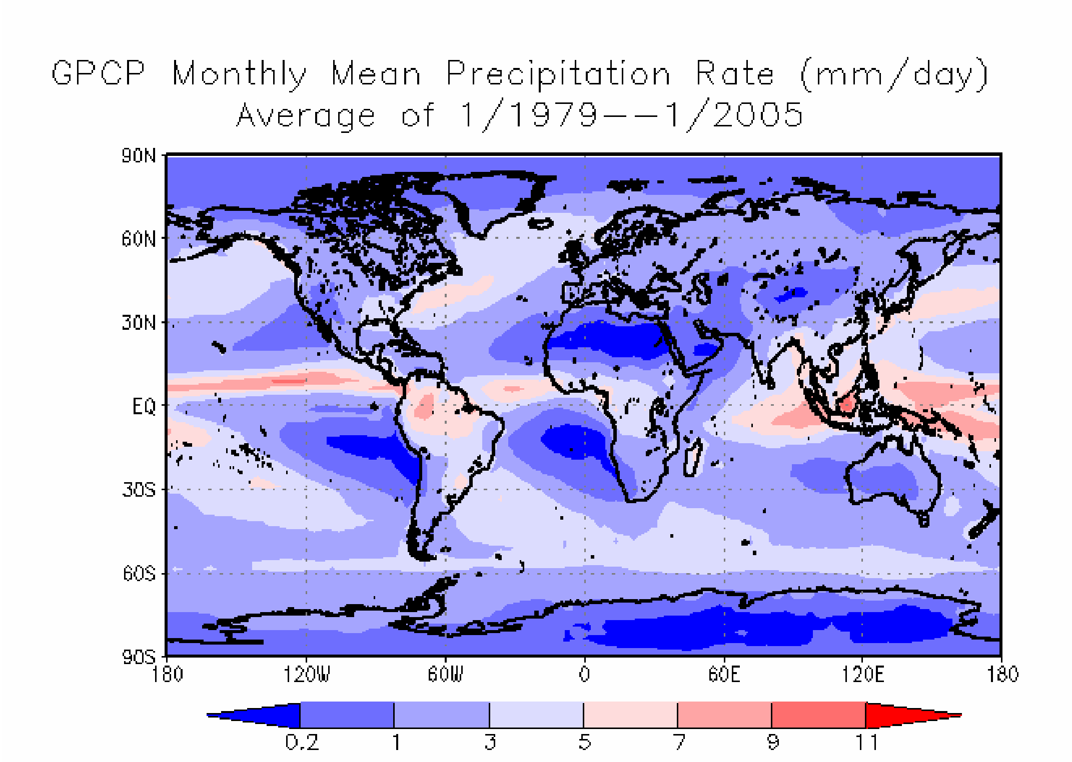


Figure 4.6. An example of the January monthly mean precipitation rate from the GPCP.

5. SCIENCE AND TECHNOLOGY ROADMAP

Sections 3 and 4 described the research capabilities of CoRP and provided a few specific examples of current projects. The future directions of the research effort for CoRP are being driven by the factors summarized in section 2. From the user perspective, the U.S. economy is very sensitive to weather and climate. Thus, there is an underlying need for continued improvements of products. The new satellite sensors scheduled to come on line in the next decade summarized in Figure 2.1 (including hyperspectral observations) and continued increases in computing power and data storage capabilities provide opportunities to meet the need for new and improved satellite-based products. This Section provides a roadmap for how CoRP research will contribute to this effort to maximize the utility of satellite data to meet user needs. Details of how the individual CoRP projects plan to meet their objectives are provided in the diagrams in Appendix B. The discussion below provides a description of the science directions of CoRP from the broader perspective of the main research areas summarized in Table 1.1.

CoRP and its academic partners have decades of experience in calibration and validation, and science studies needed to check out new satellite systems. The need for this activity will accelerate as we approach the NPOESS and GOES-R era. It is essential that CoRP maintain a critical mass of expertise in this area and continue its collaboration with other groups within and outside of NESDIS. It is expected that the CoRP contribution to these activities will increase because the suite of sensors planned for GOES-R and NPOESS include operational hyperspectral instrumentation that is not currently available on operational NOAA satellites.

The advanced satellite sensors will provide new opportunities for improving the retrievals of geophysical parameters. The increase in computer power will allow the use of more powerful retrieval methods, and the academic partners of CoRP will provide access to wide range of expertise in this area. Two basic principles should guide this retrieval work in the next decade to capitalize on the satellite advancements. First, the hyperspectral data should be emphasized to extract the information related to the retrieval of temperature, moisture and precipitation. This data also has great potential to improve satellite wind estimates by allowing features to be tracked in physical space, in addition to radiance space, and should help to reduce the errors due to the high assignment. The second principal is to take a multi-sensor approach to the retrieval problem, which would include the NOAA satellites as well as the multitude of other information that is part of the GEOSS program.

The two principles described above for retrieval research apply equally well to the future development of satellite products for weather analysis and forecasting. The inclusion of hyperspectral data and taking a multi-sensor approach should be emphasized. It will be a challenge for CoRP (and all of STAR) to work with operational agencies to maintain their current satellite products while introducing advanced versions at the same time. Another emphasis in CoRP with regard to new product development will be the utilization of synthetic and simulated data as part of risk reduction activities. Sophisticated numerical models in combination with advanced radiative transfer code can be used to generate synthetic radiances that are similar to what will be available from future satellites. In addition, current satellites can provide subsets of data that will be available from future systems. For example, MODIS and AIRS can be used for preliminary product development for the next generation imager and sounder that will become available with GOES-R. CoRP should focus on these synthetic and simulated data to develop and test new products well in advance of the launch of NOAA's next generation operational satellite systems.

The availability of hyperspectral observations and imager data with finer temporal, spatial and spectral resolution is especially well suited for the improvement of land surface and coastal ocean products. The emphasis in the former area should be on the characteristics of surface properties such as emissivity, and coordination with product development activities that require this information. The new data sources also hold great promise for improvements in wild fire detection. In the coastal ocean, the focus will be on product development and assimilation of these data into coastal ocean model.

The development of ecological products in CoRP is a relatively new endeavor, and the emphasis has been on the detection and prediction of marine organisms. With the continued increase in population along the coastal U.S. and the related environmental interactions, the need for these types of products will likely increase. CoRP should expand this research effort and work towards improving the coordination with the potential users of these products. The HES Coastal Waters capability planned for GOES-R holds great promise for improvements in this area. Although this work is fairly new within CoRP, an effort should be made to increase the coordination and collaboration with other parts of NESDIS-STAR with expertise in this area, especially CIOSS and SOCD.

The new satellite sensors provide an opportunity and a challenge for the CoRP climate studies. The new data provides new information but with different spatial, temporal, spectral and radiometric properties than the long term satellite climate records. The emphasis of CoRP research is to continue to work with academic partners and other agencies inside and outside of NESDIS to best utilize new data sources for climate monitoring, and normalizing and calibrating the data to ensure continuity in the long term time series. Improvements in computer technology should also be exploited in this area. The continued advances in storage technology will make it possible to have on-line versions of long term datasets that were previously only available on storage media such as tapes with much slower access speeds.

As described above, the new satellite observations have the potential to contribute to improvements in retrievals, and in weather, ocean, land-surface and climate products. Some of these will be relatively "stand-alone" products such as the Automated Biomass Burning Algorithm (ABBA) under development by ASPB. The new satellite data also have great potential for improvements in numerical forecast models of the atmosphere and ocean. Many of the CoRP satellite products directly utilize numerical model analyses and forecasts, such as the tropical cyclone formation product developed by RAMMB. Thus, any model improvements will lead to better products that use the model information. The primary improvement mechanism for numerical models is through the inclusion of the satellite data in sophisticated data assimilation system. CoRP will contribute to this effort through collaboration with academic partners on exploratory studies of new data assimilation methods and through the Joint Center for Satellite Data Assimilation (JCSDA) for transitioning new methods to operational forecast systems. Data assimilation techniques also have the potential to help quantify the information content of new observations (include satellite data) in the context of all the other available data sources. CoRP researchers should perform these information content studies to help guide the efforts at operational modeling centers.

The orders of magnitude increase in the volume of satellite observations that will be available in the coming data will present a new challenge for the users of this information. CoRP will play a major role in training activities to assist users with this evolution. Four primary focus areas need to be continued and enhanced to make sure that users will be ready. First, the very successful VISIT program will need to educate the NWS and other operational forecasters on the new satellite data types. Similar to the product development efforts described above, synthetic and simulated datasets can be used to educate forecasters before GOES-R and NPOESS come on line. Second, a new satellite-specific training course will be required. Preliminary work on a new Satellite Hydrology and Meteorology (SHyMet) training program is being developed by RAMMB and ASPB in collaboration with CIRA and CIMSS. The initial version of the course will utilize distance learning methods, but may include an on-site component in the future. This SHyMet course will need to be expanded in the coming decade to include training on the future satellite systems. Third, the international coordination through the WMO Regional Meteorological Training Centers will need to be continued. As illustrated by the emphasis on the GEOSS program, earth observing requires a global effort. Fourth, the training of the future workforce in remote sensing and satellite meteorology is essential for the long-term success of NESDIS mission. The relationship between NESDIS-STAR and its cooperative institutes and CREST will make a major contribution to filling this need, so the continuation of these relationships is a critical function of CoRP.

6. PERFORMANCE TARGETS

The ultimate measure of CoRP's success is its contribution to meeting NOAA's goals (see Section 8), but other measures are necessary to gauge its performance in other ways and on shorter timescales. The 14 Research Project Plans within CoRP each contain a number of fairly specific performance targets and milestones. From a broader perspective, CoRP has identified the following five metrics by which it plans to evaluate its work in developing and disseminating useful satellite products.

6.1 Number of Products Transitioned From Research to Operations

According to a 2000 report by the National Research Council that was funded jointly by NOAA and NASA (NRC, 2000), the transition of research products to operations is a necessary component of the research process, yet this important step often is not fully realized. It is part of CoRP's fundamental mission to augment NOAA's satellite data analysis efforts by developing new, successful products from current and planned satellites that can be transitioned to the operational environment. As discussed in the previous Sections, CoRP often develops products to help a NOAA agency (e.g., the National Hurricane Center, the Storm Prediction Center) fulfill its mandate to better serve and protect the public. Because the successful transition of new research products to operations directly relates to a tangible enhancement for NOAA, this is a key objective for CoRP and, consequently, is a closely monitored measure of performance.

6.2 Number of Operational Products Maintained or Improved

Although the initial transition of a research product to operations is important, subsequent efforts to maintain or improve that product are equally, if not more, essential. By allotting adequate time and attention to such maintenance efforts, CoRP ensures that its products are up-to-date and, in doing so, prevents the months to years of its scientists' research efforts from becoming obsolete. For example, CIRA scientists recently updated a set of algorithms that estimate tropical cyclone intensity and wind structure. The algorithms—which were originally developed using data from 1999–2001 and tested operationally by the NHC during the 2002 and 2003 tropical seasons—were updated with a much larger, more representative set of data from 1999–2004. The improved algorithms will provide more accurate estimates for operational use by the NHC during future tropical seasons.

6.3 Number of Research Publications

In keeping with NOAA's commitment to disseminating research results, CoRP has defined another of its performance measures as the number of peer-reviewed research publications published annually. This metric serves as an indicator of the relevance of CoRP's research beyond NOAA to the broader atmospheric science community, and it reflects CoRP's dedication to sharing information and ideas to promote greater understanding which, in turn, leads to better science.

6.4 Number of Web-page Hits

In addition to the number of research publications published by its scientists, CoRP also considers the number of web-page hits as an indicator of its dissemination efforts. The CoRP web-pages for which activity is being monitored include all of the Cooperative Institute sites (see http://rammb.cira.colostate.edu/corp) and the CoRP branch sites.

6.5 Number of Training Hours

A final means of assessing CoRP's performance again pertains to dissemination but specifically that which is targeted to operational users via training. Common means of training include the UCAR and NWS jointly established Cooperative Program for Operational Meteorology, Education and Training (COMET) and the VISIT program established jointly by the Cooperative Institutes, NESDIS, and the NWS. The general goal of these training opportunities is to maximize the benefit of new technologies and promote a better understanding of the atmosphere by accelerating the transfer of research to operations via distance education. Without adequate education and training of end users—especially given the number of new data sources planned for the next decade—much of the utility of this new (and current) data will be squandered. CoRP's focus on training is to prevent this from being the case.

7. CONSTRAINTS AND ENABLERS

CoRP's research is a diverse set of projects that is ambitious for meeting NOAA's goals. These projects rely on cutting-edge science and technology and continued evolution of computer power and sensor development. Although current and anticipated scientific and technological capabilities will suffice for CoRP to conduct its research, certain constraints and potential problems should be acknowledged.

- *Data processing and storage* – The exponentially increasing volumes of data as well as increasing model complexity pose a tremendous data processing and storage challenge. This is especially true in terms of data compression and quick retrieval.
- *Power consumption* – As computing power increases, so does the need for electrical power and heat sinks.
- *Calibration and validation* – As noted by a NOAA-commissioned NRC report (NRC, 2004), satellite data must be calibrated and validated throughout the sensor's lifetime, especially if quality climate data records are to be generated from the data. However, financial, logistical, and personnel constraints make consistent calibration-validation efforts extremely challenging.
- *Redundancy* – In many cases, few back-up options exist in the event of power failures, delayed satellite launches, or satellite/sensor failures. Not only can this compromise research goals, but it can create gaps in operational and climate data records.
- *Empirical data for statistical and numerical model development* – Both statistical and numerical models require large development datasets in order to ensure that they are robust. Depending on what the predictive variables are, a sufficient dataset could take years to develop.

Because nearly all of CoRP is located remotely from NESDIS-STAR, it will be a challenge to deal with the technological constraints listed above. The solution will be a combination of centrally located resources that can be accessed remotely, such as mass storage devices and computing clusters, and local computing capabilities at the remote sites. For operational transition activities, computing environments that mirror those of operations will greatly facilitate these efforts. NESDIS-STAR should coordinate with other agencies to make these resources available to CoRP. This arrangement would be a primary enabler for CoRP to achieve its mission.

8. IMPACT ON SOCIETY AND NOAA GOALS

In the fall 2004, NOAA released its strategic plan for the next five years, which outlines its goals, strategies, and priorities for the 21st century (NOAA, 2004). The Strategic Plan focuses on the most critical needs of the nation and the global community, particularly in the areas of environment, public safety, and the economy. NOAA has identified four mission goals—which are broadly categorized as Ecosystems, Climate, Weather and Water, and Commerce and Transportation—and one mission support goal.

NOAA Strategic Plan Mission Goals
Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management
Understand climate variability and change to enhance society's ability to plan and respond
Serve society's needs for weather and water information
Support the nation's commerce with information for safe, efficient, and environmentally sound transportation
Provide critical support for NOAA's mission

Per its mission, much of CoRP's work is to most effectively utilize available and anticipated satellite data in ways that meet NOAA's goals and priorities, which consequently work to serve society by meeting the Nation's economic, social, and environmental needs. Some of CoRP's research projects target a single NOAA goal—mostly commonly, Weather and Water—but many serve to fulfill two or more of the NOAA goals—the most common combination being Weather and Water and Climate. Although CoRP's contributions to NOAA's goals—including the specific performance objectives of each—and society have been discussed implicitly throughout this roadmap, they are outlined more explicitly below.

8.1 Ecosystems

Goal: Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management	
Objectives	**Role of CoRP S&T in Meeting Challenge**
Increase number of regional coastal and marine ecosystems delineated with approved indicators of ecological health and socioeconomic benefits that are monitored and understood	• Develop and implement capabilities for using observing satellite systems to detect, monitor, and predict the habitat of transition zone species (e.g. swordfish, loggerhead sea turtles) and health of marine ecosystems

Increase number of invasive species populations eradicated, contained, or mitigated	• Develop and implement remote identification, monitoring, and prediction systems to detect and predict the distribution of biogeochemically important and noxious or harmful marine organisms in coastal waters

8.2 Climate Variability and Change

Goal: Understand climate variability and change to enhance society's ability to plan and respond	
Objectives	**Role of CoRP S&T in Meeting Challenge**
Describe and understand the state of the climate system through integrated observations, analysis, and data stewardship	• Develop retrieval algorithms and processing systems for hydrological cycle products to better understand the role of water in the climate system and the role of climate change on water resources • Develop instrumentation for geostationary satellites and derive, calibrate, and validate resulting products from the data
Improve climate predictive capability from weeks to decades, with an increased range of applicability for management and policy decisions	• Develop instrumentation for geostationary satellites and derive, calibrate, and validate resulting products from the data
Reduce uncertainty in climate projections through timely information on the forcing and feedbacks contributing to changes in the Earth's climate	• Develop retrieval algorithms and processing systems for hydrological cycle products to better understand the radiative response to cloud and precipitation systems
Understand and predict the consequences of climate variability and change on marine ecosystems	• Develop and implement capabilities for using observing satellite systems to observe and increase understanding of the oceanic processes that influence climate, and monitor seasonal to interannual variability of those processes
Increase number and use of climate products and services to enhance public and private sector decision making	• Develop retrieval algorithms and processing systems for hydrological cycle products and develop global monthly precipitation analyses to better understand the role of

	climate change on water resources • Develop, implement, and maintain a global real-time fire detection, and characterization monitoring system from geostationary satellite data

8.3 Weather and Water

Goal: Serve society's needs for weather and water information	
Objectives	**Role of CoRP S&T in Meeting Challenge**
Increase lead time and accuracy for weather and water warnings and forecasts	• Develop algorithms using satellite data to estimate tropical cyclone current intensity, location, and size and to predict initial tropical cyclone formation and intensity changes • Develop algorithms using satellite data to improve severe weather and mesoscale analysis and forecasting • Use satellite-derived high-latitude wind information in NWP models to improve their forecast accuracy • Use satellite-derived surface, radiative flux, and atmospheric products in NWP models to improve their forecast accuracy • Develop instrumentation for geostationary satellites and derive, calibrate, and validate resulting products from the data
Improve predictability of the onset, duration, and impact of hazardous and severe weather and water events	• Develop algorithms using satellite data to estimate tropical cyclone current intensity, location, and size and to predict initial tropical cyclone formation and intensity changes • Develop algorithms using satellite data to improve severe weather and mesoscale analysis and forecasting • Use satellite-derived high-latitude wind information in NWP models to improve their forecast accuracy • Use satellite-derived surface, radiative flux, and atmospheric products in NWP models

	to improve their forecast accuracy • Develop, implement, and maintain a global real-time fire detection, and characterization monitoring system from geostationary satellite data • Develop instrumentation for geostationary satellites and derive, calibrate, and validate resulting products from the data
Increase application and accessibility of weather and water information as the foundation for creating and leveraging public (i.e., federal, state, local, tribal), private and academic partnerships	• CoRP's projects and some of its data are available on the Cooperative Institutes web pages for use by other public, private, and academic users
Increase development, application, and transition of advanced science and technology to operations and services	• Develop algorithms using satellite data for tropical cyclone analysis and forecasting for operational use by the NHC and JTWC • Develop algorithms using satellite data for severe weather and mesoscale analysis and forecasting for use by the NWS and SPC • Derive high-latitude wind information from satellites for use by the NWP community • Derive surface, radiative flux, and atmospheric products from satellites for use by the NWP community • Develop instrumentation for geostationary satellites and derive, calibrate, and validate resulting products from the data
Increase coordination of weather and water information and services with integration of local, regional, and global observation systems	• Participate in data assimilation and information content studies in coordination with the JCSDA and academic partners
Reduce uncertainty associated with weather and water decision tools and assessments	• All CoRP projects that emphasize developing algorithms for use by operational agencies serve to reduce uncertainty • All CoRP projects that utilize satellite data with increased temporal, spatial, and spectral resolution serve to reduce uncertainty

Enhance environmental literacy and improve understanding, value, and use of weather and water information and services	• Develop national and international satellite training programs to improve understanding and utilization of satellite data

8.4 Transportation

Goal: Support the nation's commerce with information for safe, efficient, and environmentally sound transportation	
Objectives	**Role of CoRP S&T in Meeting Challenge**
Reduce weather-related transportation crashes and delays	• Develop, implement, and maintain a global real-time fire detection, and characterization monitoring system from geostationary satellite data

9. SUMMARY

This document provided a summary of the organization structure and current research capabilities of CoRP and a science roadmap for the future. If the technological challenges of providing computer infrastructure and data to the geographically distributed organization like CoRP, and the administrative challenges of maintaining and increasing support as needed can be overcome, the next decade has great potential for the improvement of satellite data and products due to the many new satellites and sensors that are planned. CoRP is well situated to contribute to these improvements due to its past research experience and close association with academic partners and users of satellite data and products. The guiding principles for the next decade are to make use of simulated and synthetic data sources for advance preparation, include a concentration on the hyperspectral observations that will become available, and to take a multi-sensor approach to product development. The decades of experience within CoRP in sensor science and calibration and validation will be a valuable resource, and the strong training program in CoRP should be continued and expanded to ensure user readiness. In addition, the close association with universities will help to develop the future work force in remote sensing and satellite meteorology and oceanography.

REFERENCES

NOAA (National Oceanic and Atmospheric Administration), 2004. New Priorities for the 21st Century—NOAA's Strategic Plan, Updated for FY2005–FY2010. Available online at *http://www.spo.noaa.gov/pdfs/NOAA%20Strategic%20Plan.pdf*.

NOAA, 2005: Research in NOAA. Toward Understanding and Prediction Earth's Environment. A Five-Year Paln: Fiscal Years 2005-2009. Available at

NOS (National Ocean Service), 2003. A Strategic Plan for NOAA's National Ocean Service, FY 2003–2008 and Beyond. Available online at *http://www.oceanservice.noaa.gov/about/pdfs/03_stratplan.pdf*.

NRC (National Research Council), 2000. From Research to Operations in Weather Satellites and Numerical Weather Prediction: Crossing the Valley of Death. Washington, DC: National Academy Press.

NRC, 2001. Climate Change Science: An Analysis of Some Key Questions. Washington, DC: National Academy Press.

NRC, 2004. Climate Data Records from Environmental Satellites. Washington, DC: National Academy Press.

NWS (National Weather Service), 2005. National Weather Service Strategic Plan for 2005–2010. Available online at *http://www.weather.gov/sp/NWS_strategic_plan_01-03-05.pdf*.

APPENDIX A
The 14 CoRP Science Project Summary Titles Listed by Research Topic and Branch

A.1 Instrument Science, Calibration and Validation

A.1.1 ASPB Current GOES Science and Data Validation

A.1.2 ASPB GOES-R Advanced Baseline Imager (ABI)/Hyperspectral Environmental Suite Science, Data Compression and Risk Reduction

A.2 Satellite Retrieval of Geophysical Variables

A.2.1 ASPB MODIS Polar Winds

A.2.2 SCSB Advanced Precipitation Algorithms

A.3 Algorithm and Product Development for Weather Analysis and Forecasting

A.3.1 ASPB Clouds from Polar Orbiting Imagers (VIIRS, CLAVR, PATMOS)
(Note: This SPS also contains a Climate Studies Component)

A.3.2 RAMMB Mesoscale and Severe Weather Research and Applications Development

A.3.3 RAMMB Tropical Cyclone Satellite Research and Application Development

A.3.4 SCSB Consolidated Microwave Hydrological Products

A.4 Land Surface Product Development

A.4.1 ASPB GOES Surface and Insolation Project (GSIP)

A.4.2 ASPB Geostationary Satellite Wildfire Automated Biomass Burning Algorithm (WF_ABBA) Product Development and Applications

A.5 Ecological Product Development

A.5.1 SCSB Interannual Variability of Oceanic Phytoplankton Biomass and Productivity

A.5.2 SCSB Predicting Marine Organisms

A.6 Climate Studies

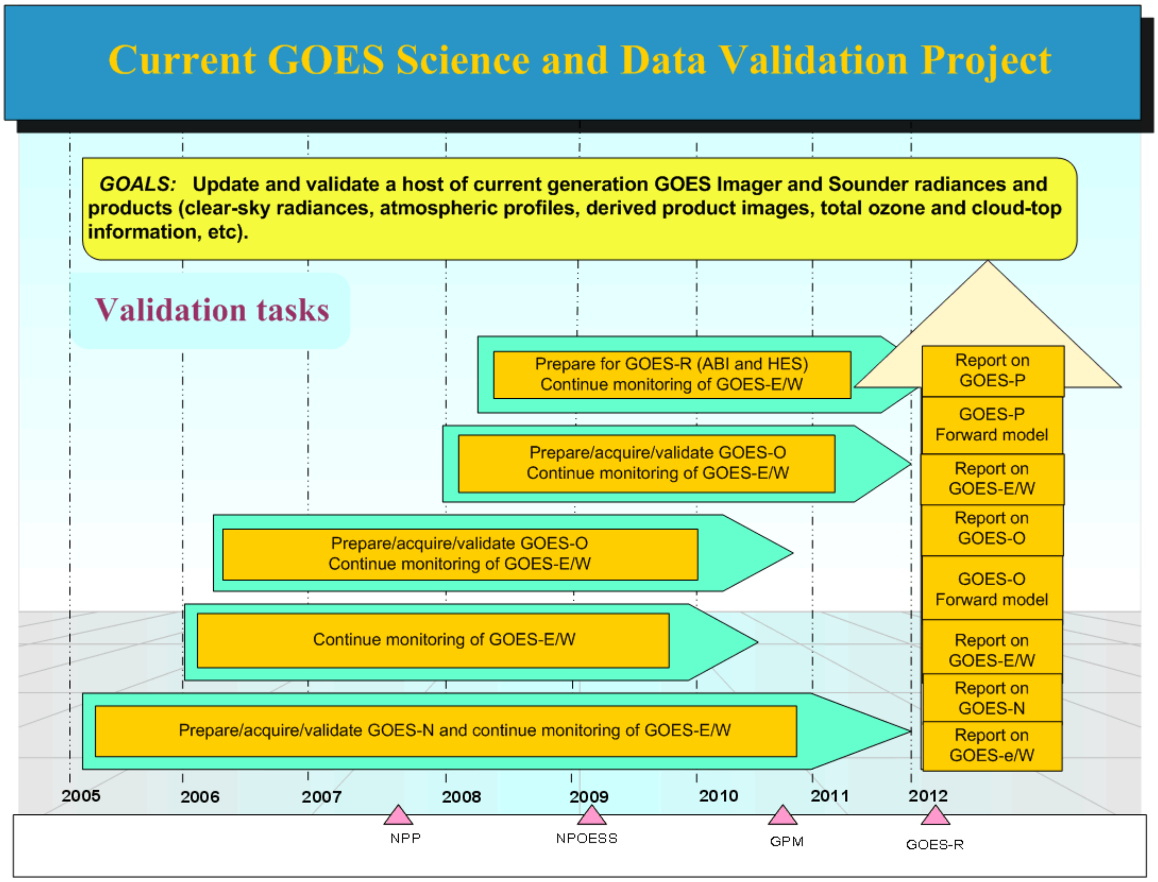
A.6.1 SCSB Global Precipitation Climatology Project

A.7 **Satellite Training and Outreach**

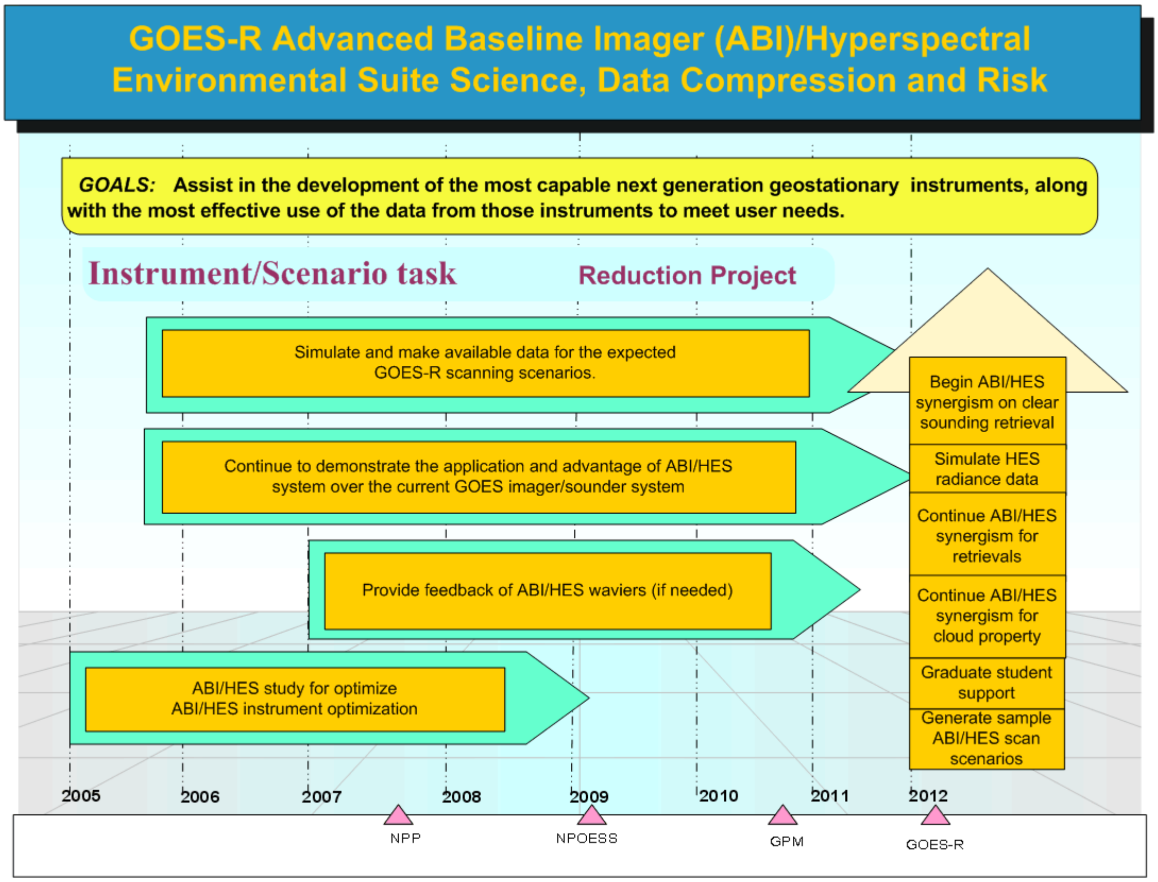
A.7.1 RAMMB Satellite Training and Outreach Project

Appendix B
CoRP Science Project Summary Outlines by Research Topic and Branch

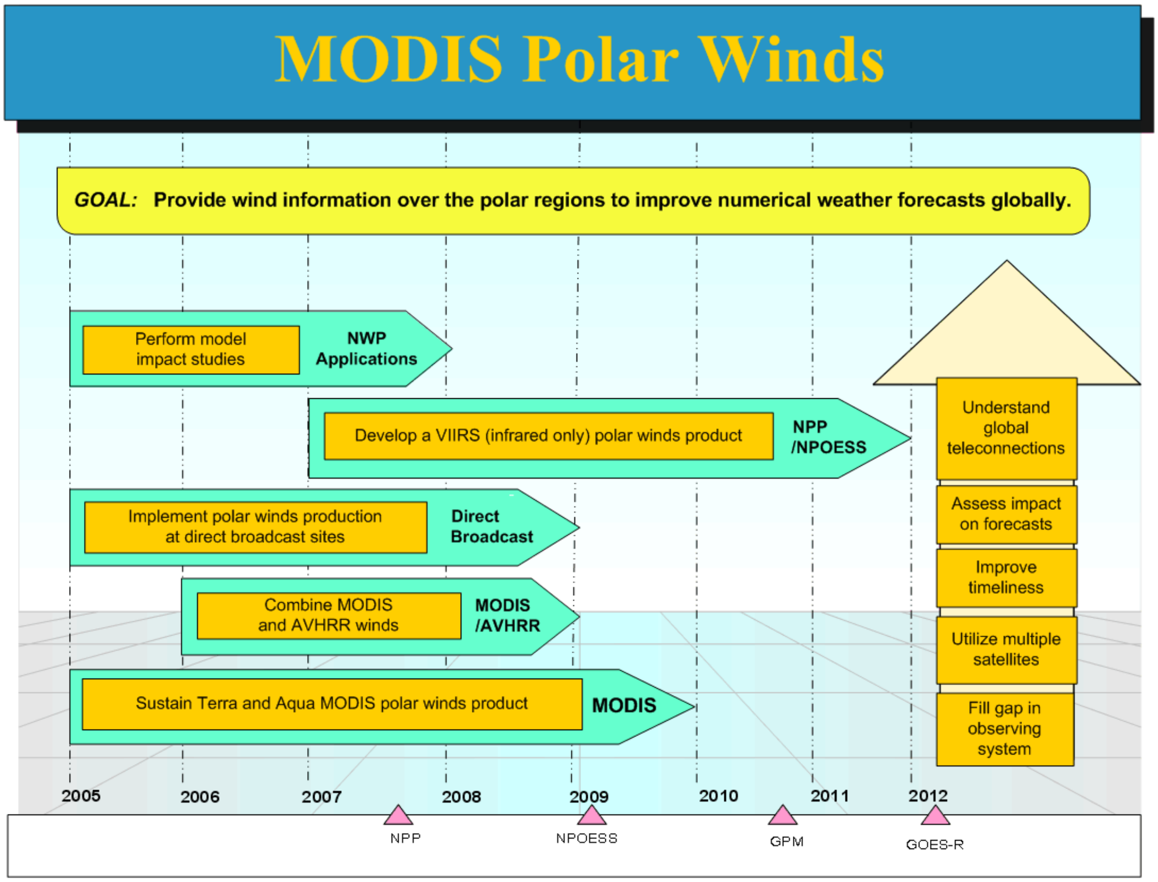
B.1.1 ASPB Instrument Science, Calibration and Validation Topic



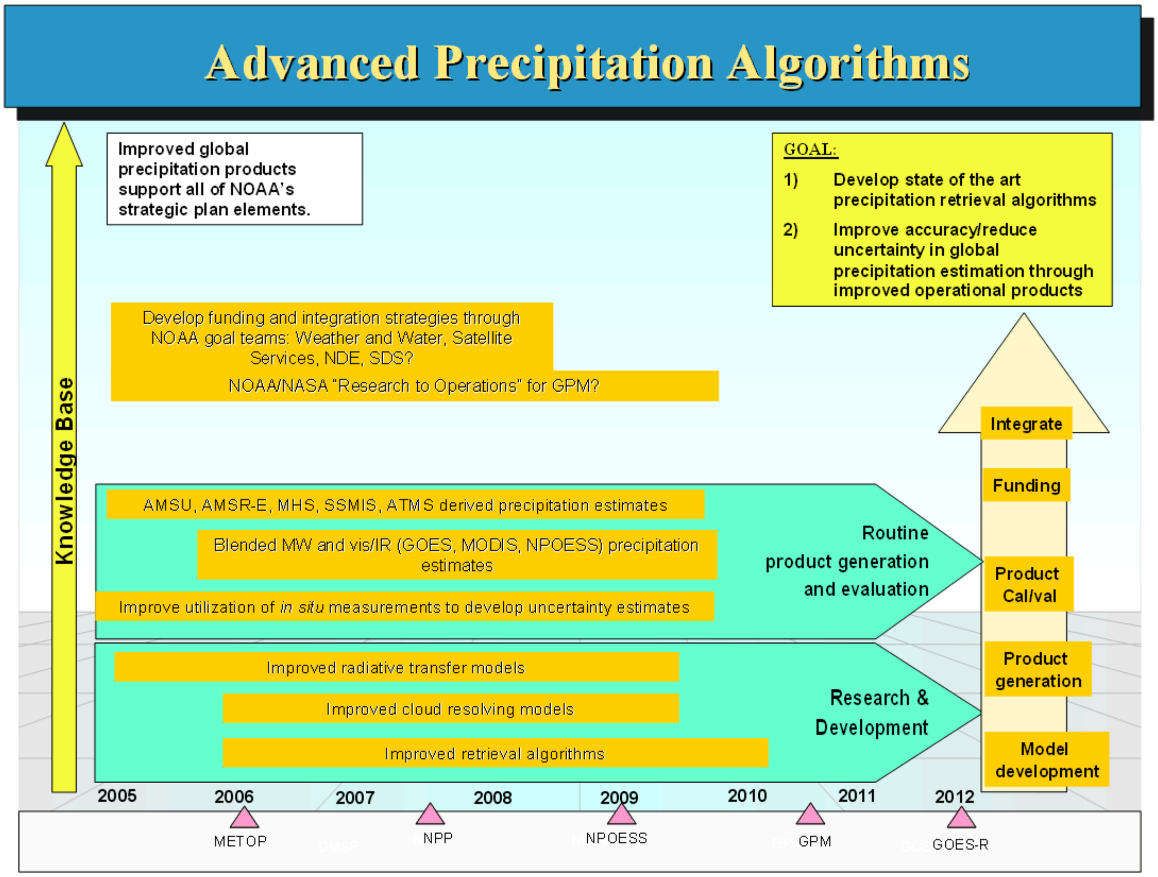
B.1.2 ASPB Science, Calibration and Validation Topic



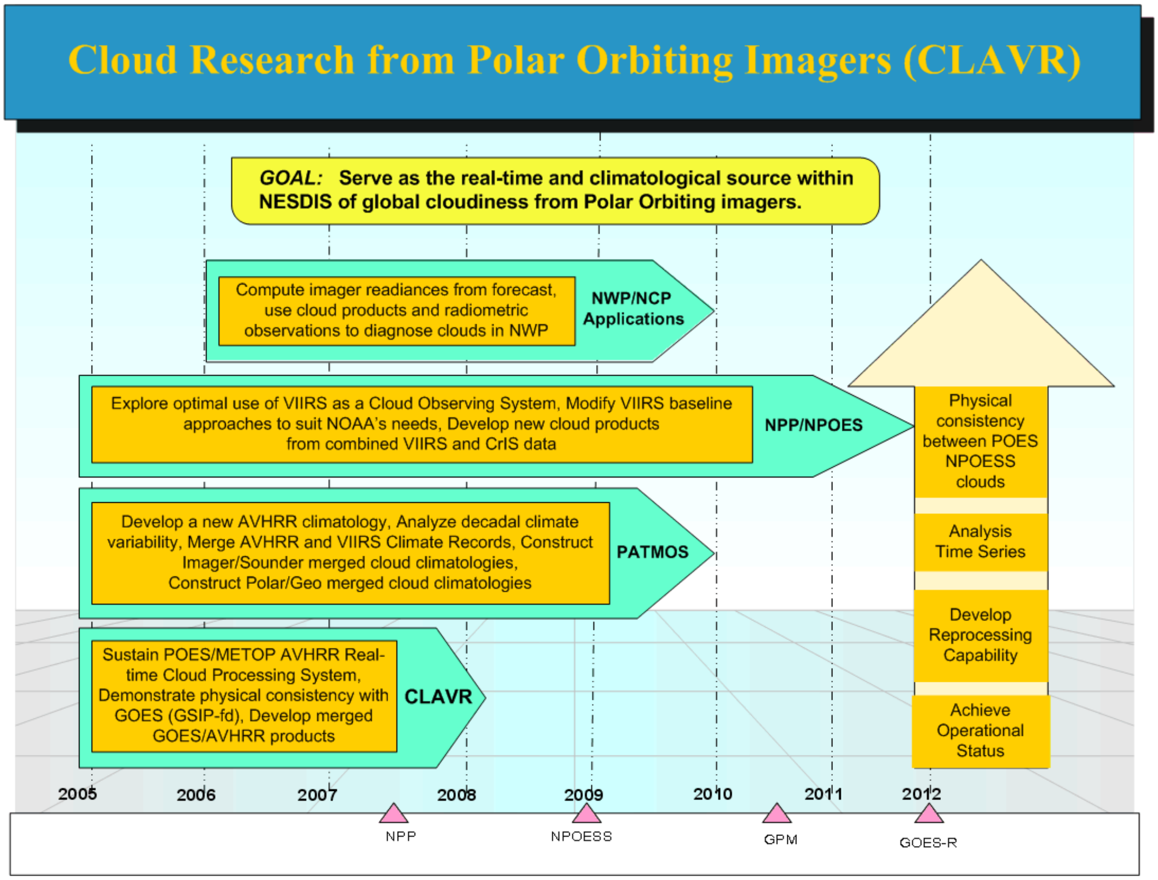
B.2.1 ASPB Satellite Retrieval of Geophysical Variables Topic



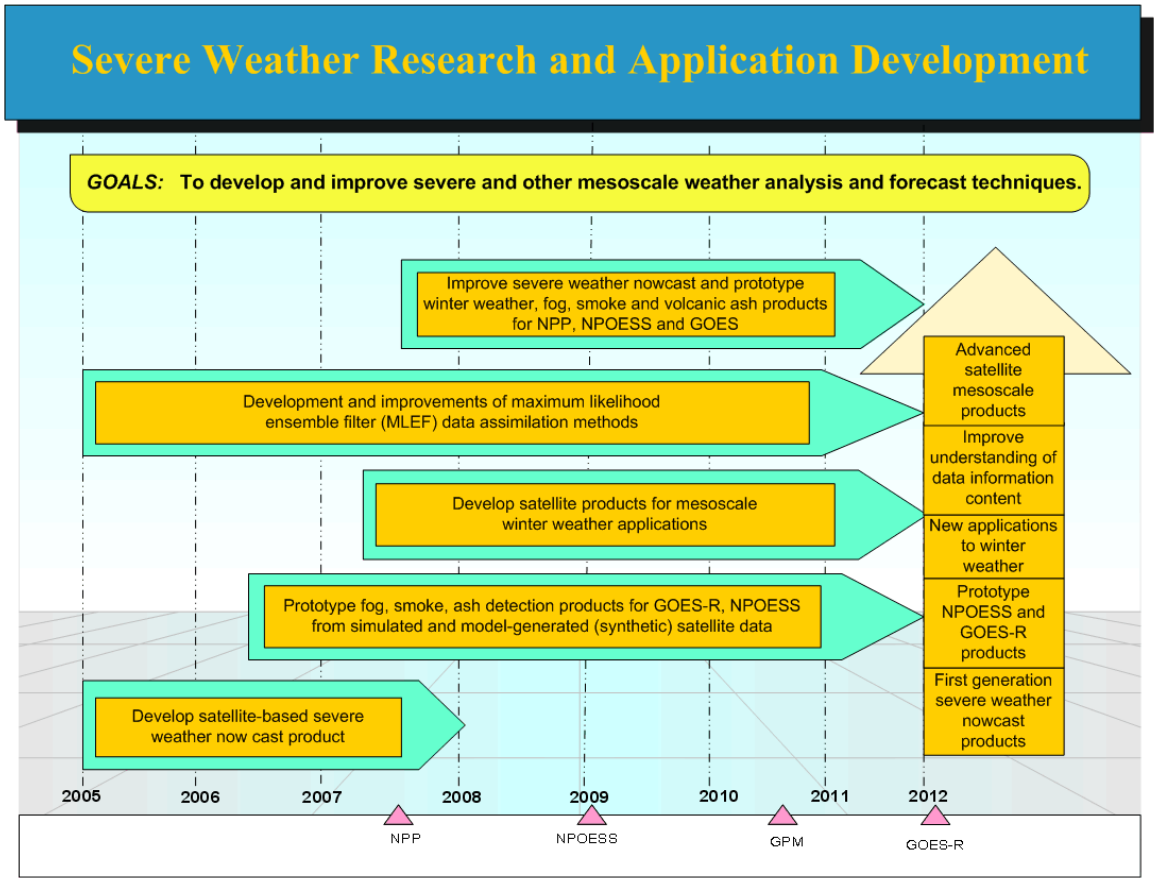
B.2.2 SCSB Satellite Retrieval of Geophysical Variables Topic



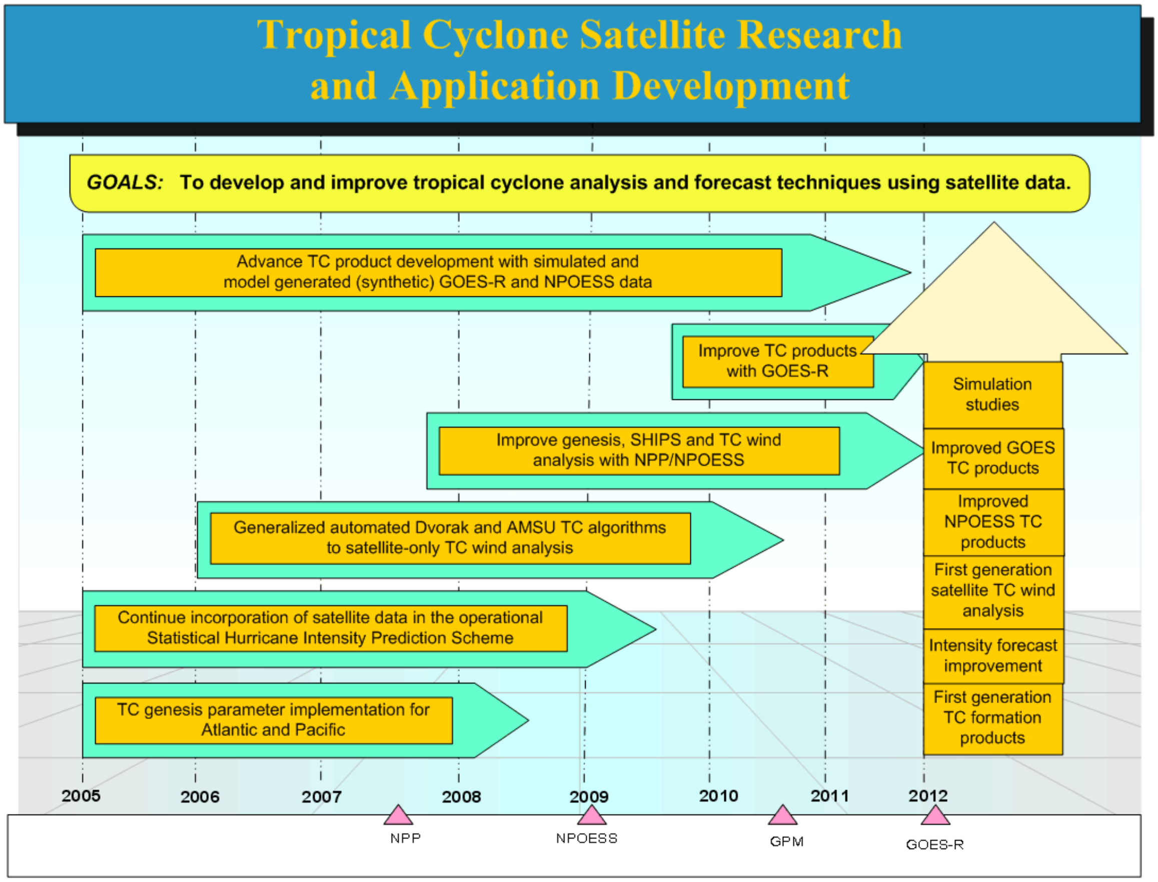
B.3.1 ASPB Algorithm and Product Development for Weather Analysis and Forecasting Topic



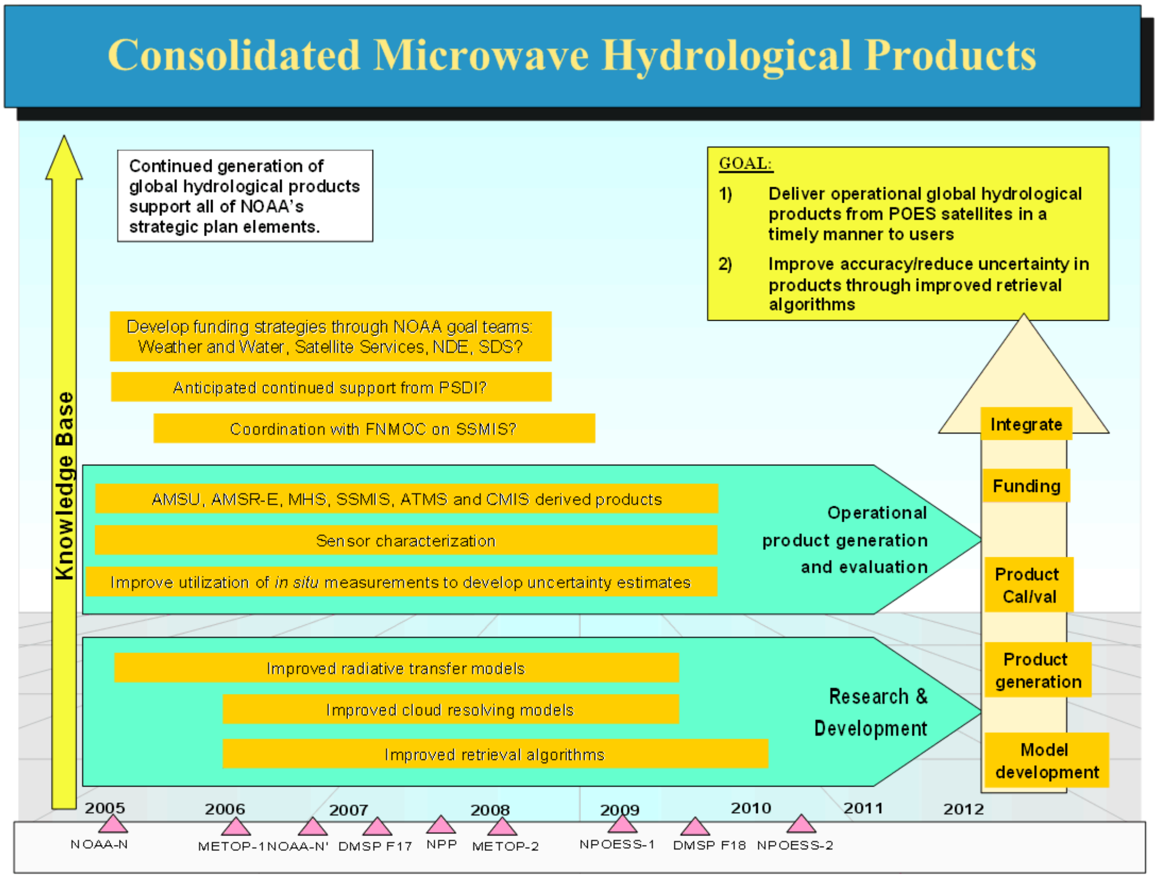
B.3.2 RAMMB Algorithm and Product Development for Weather Analysis and Forecasting Topic



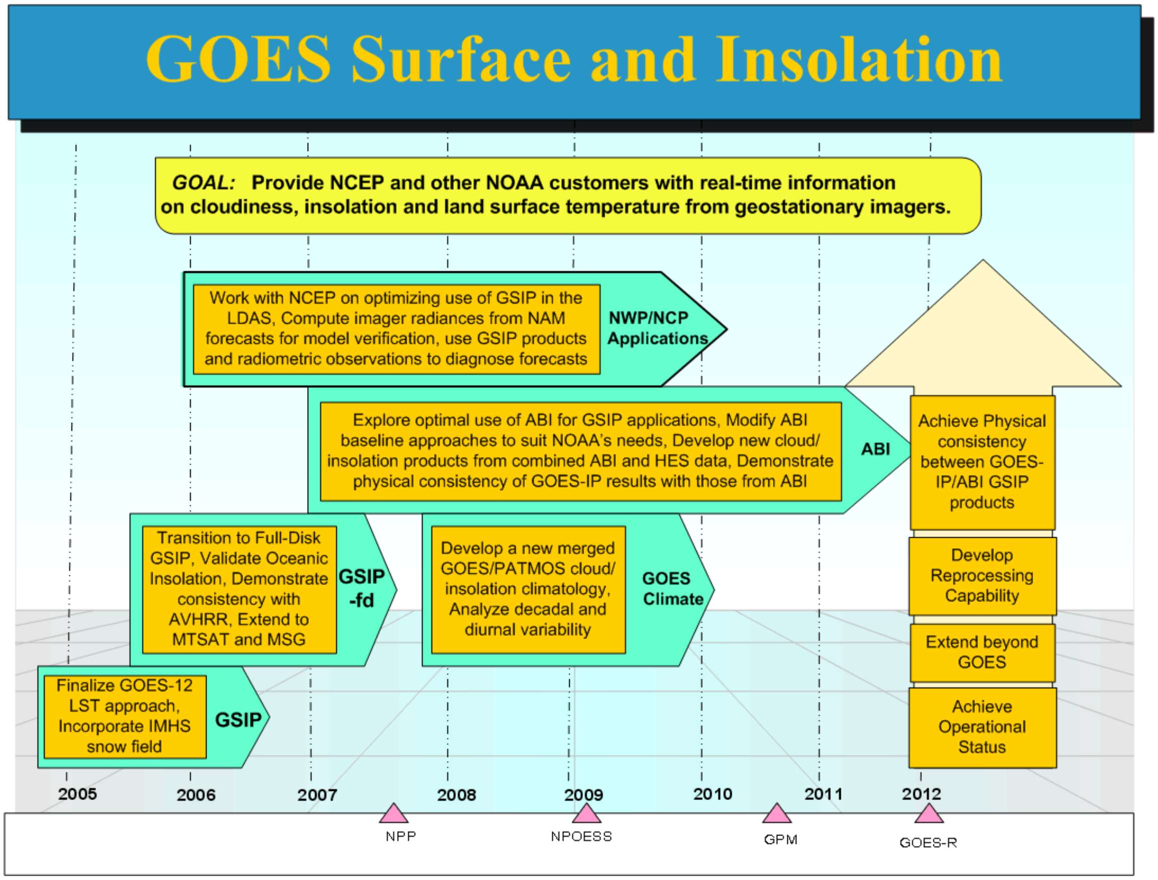
B.3.3 RAMMB Algorithm and Product Development for Weather Analysis and Forecasting Topic



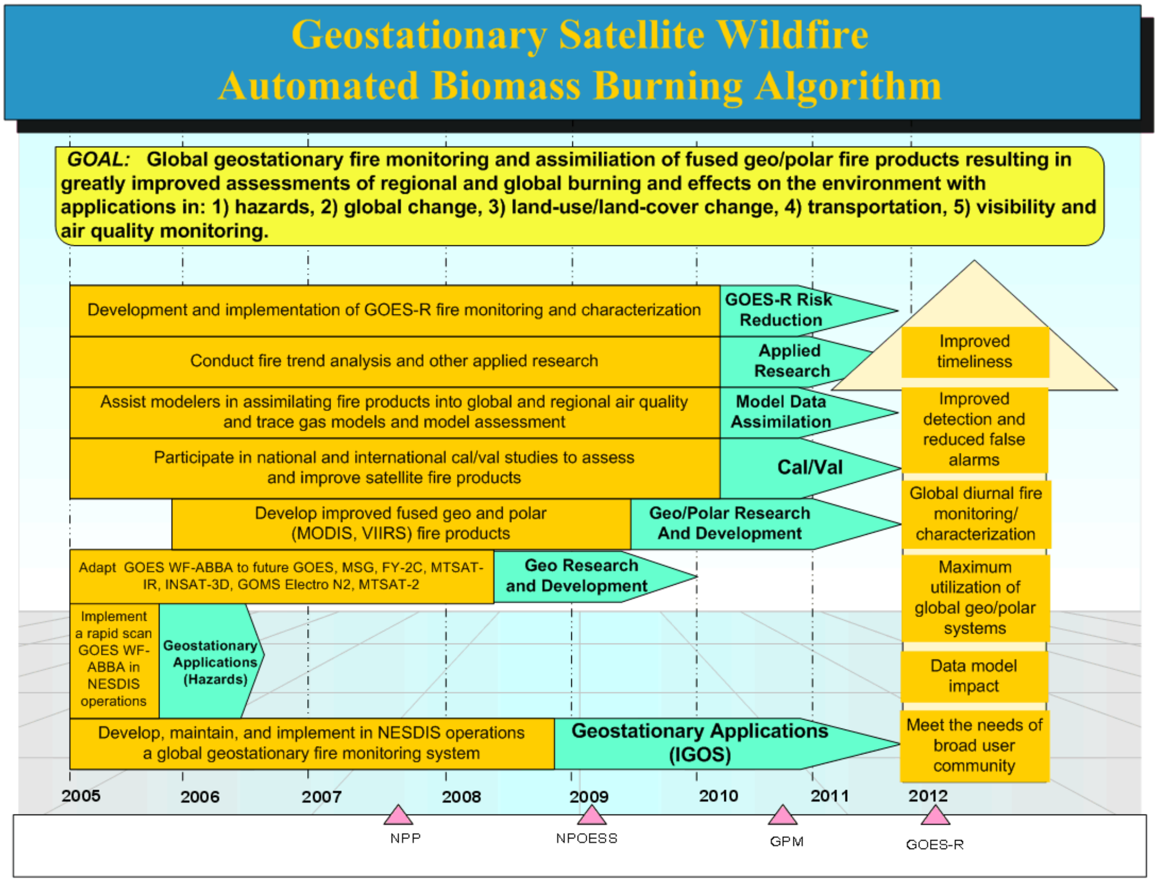
B.3.4 SCSB Algorithm and Product Development for Weather Analysis and Forecasting Topic



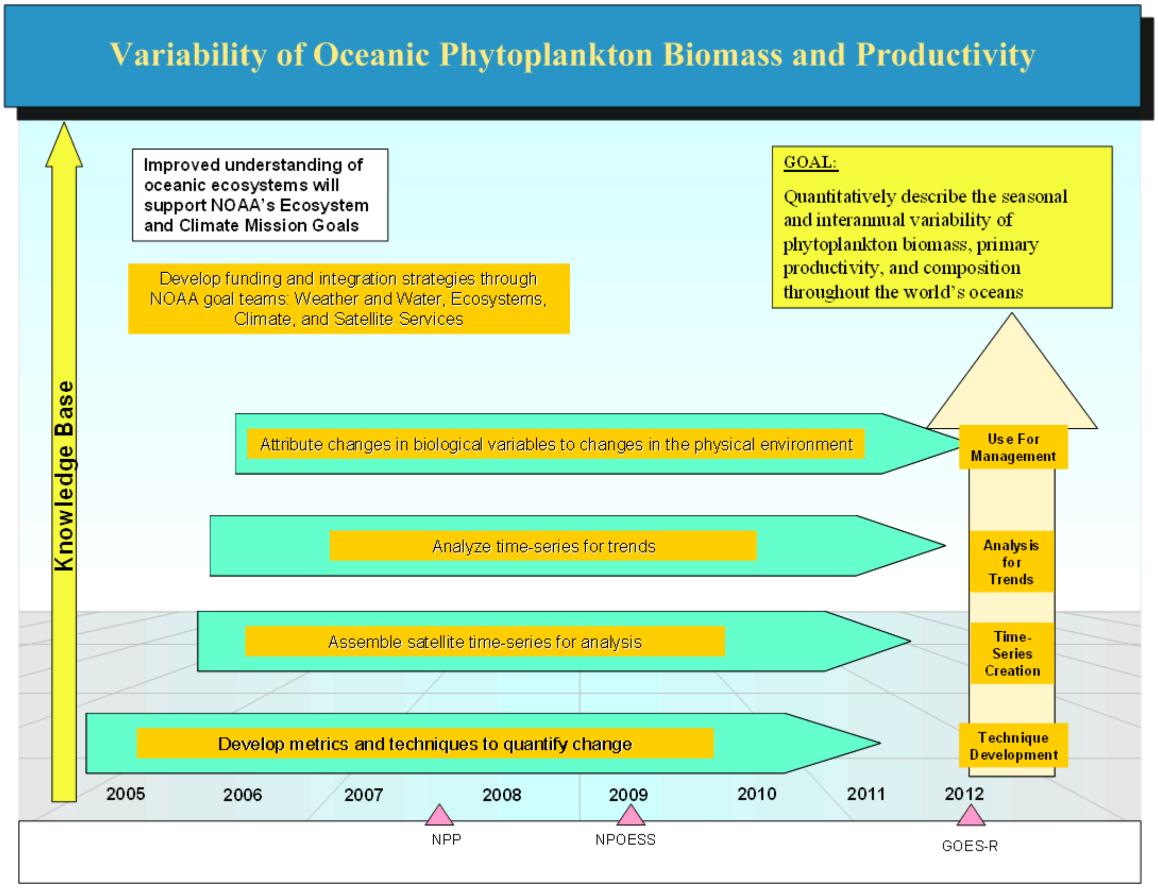
B.4.1 ASPB Land Surface Product Development



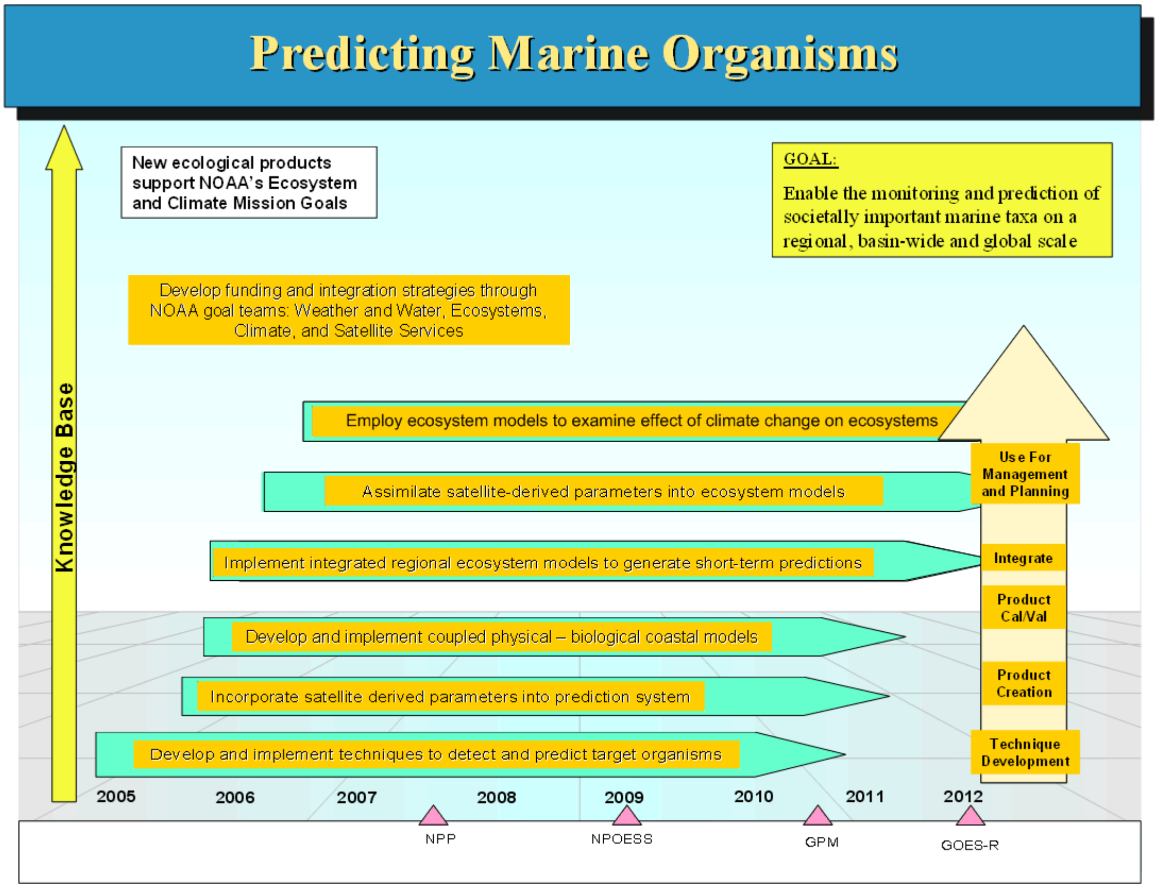
B.4.2 ASPB Land Surface Product Development



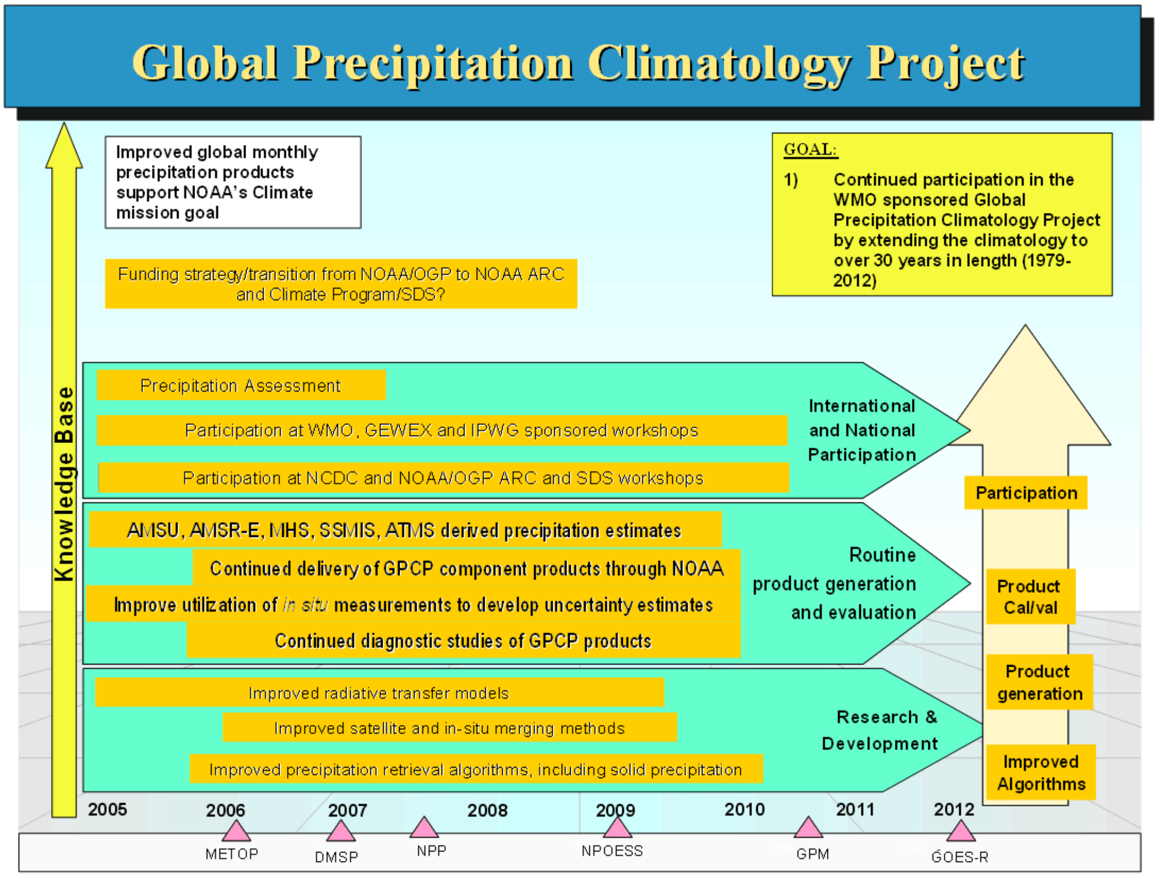
B.5.1 SCSB Ecological Product Development Topic



B.5.2 SCSB Ecological Product Development Topic



B.6.1 SCSB Climate Studies Topic



B.7.1 RAMMB Satellite Training and Outreach Topic