A National Oceanographic Partnership Program Award

Application of an Integrated Monitoring and Modeling System to Narragansett Bay and Adjacent Waters Incorporating Internet Based Technology

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Long-term goals

Within the overall context of this initiative the Drexel/URI lead partnership proposes to develop a globally re-locatable, integrated system for real time observation, modeling, and data distribution for shelf, coastal sea, and estuarine waters. The models would be forced by input from GODAE products or similar global or shelf scale modeling systems. It is proposed to apply the system to Narragansett Bay and RI coastal waters as a demonstration of the practical use of the system to support environmental monitoring, marine pollutant transport and fate, marine transportation, and search and rescue operations and to provide a foundation to advance our understanding and predictive capabilities for the bay.

Objectives

The objectives are **i)** to develop and implement an operational three-dimensional hydrodynamic and pollutant transport model, with data assimilation, for Narragansett Bay and adjacent Rhode Island coastal waters. The application will demonstrate the ability of the models to provide hindcasts, nowcasts, and forecasts and maximize the timely and effective use of GODAE data products. The model will use GODAE data products for forcing on the open boundary and hence extend this data to coastal and estuarine waters, **ii)** to coordinate the collection, dissemination and archiving of observed sea surface elevation, water quality, meteorological, and current and water transport data from a network of monitoring stations in Narragansett Bay and adjoining waters including global ocean data products generated through the GODAE initiative and other government and state and local sources. This objective will be accomplished through the development of a platform independent, internet based, data distribution system that will allow industry, researchers, government, and the public to conveniently access all relevant data from the local monitoring system, and all model simulation results; **iii)** to assess the market for the GODAE products, output from the high resolution coastal model, and observational data products and services for Narragansett Bay and to determine the most efficient and cost effective mechanisms to distribute this data to clients and the user community, and **iv)** to transfer the technology and software for the system to private industry as a basis to develop a commercial market for a globally re-locatable, fully operational monitoring, modeling and data distribution system. The technology transfer is intended to establish a commercial basis so that data products generated by GODAE and similar initiatives can be applied and marketed on a global basis.

Approach and work plan

Dr. Piasecki at Drexel University is responsible for the development of the web-based components for the data visualization and dissemination system. In addition he has, together with Dr. Spaulding, the over-all project lead and deals with the administrative management of the project. The established restricted web-server through which the Drexel University internal research group (2 Phd students, Luis Bermudez and Saiful Islam, as well as the visiting research scientist Dr. Rainer Lehfeldt from SMILE consult in Germany) communicates, develops, and interacts with research partners abroad has proven to be extraordinarily valuable during the first two project years and promoted the collaborative effort between the partners in the Drexel research group. Building on this experience, it is planned for this year to increase the collaborative effort to further develop the data dissemination system. The system will be tested against failure, expanded as necessary, and examined again for reliability and functionality. Towards the end of the first half of this year it is planned to implement a beta version in the user

and data-provider community of Narragansett Bay to determine the utility of the system to meet the needs of user community at large. The results of this beta-test-site workshop will then be integrated into updating efforts of the system, which will be subsequently exposed to the user community a second time towards the end of the project period.

Dr. Malcolm Spaulding and Tom Opishinski, with the University of Rhode Island, Department of Ocean Engineering, Narragansett, RI are responsible for the design, development, testing, and application of the real time data collection, management and archiving system to Narragansett Bay and surrounding waters. They provide data to ASA to assist in ASA's hydrodynamic modeling investigators and to the Drexel team in support of the web based interface to the system. They are responsible for collecting data from a variety of sources, including the NOAA PORTS system, Brown University satellite thermal imagery, meteorological forecasts from NOAA/NOS, water level forecasts from NOAA/NWS, and hydrodynamic model predictions from NOAA/NCEP in support of the application to Narragansett Bay.

The Applied Science Associates, Inc. team, lead by Dr. Craig Swanson and Matt Ward, is responsible for the development and application of a hydrodynamic model to Narragansett Bay and nearby coastal waters. The model is driven by wind and water level forecasts provided by NOAA/NOS and NWS. Nowcasts and forecasts are prepared once per day and posted on the data server. They are also responsible for assessing the market, transitioning the software to the commercial sector, and creating a viable market for the integrated system. The primary focus for the current year is to make the system fully operational, rigorously test the system for Narragansett Bay and adjacent coastal waters, hold a user workshop to introduce the system to potential users, market the system nationally and internationally, and finally begin plans for initiating a pilot program for the Northeast US coastal waters under the Ocean.US integrated coastal ocean observing system plan.

Drs. John G. W. Kelley and Marina Tsidulko with NOAA's National Ocean Service (NOS) Marine Modeling and Analysis Programs in Silver Spring, MD are responsible for providing near real-time, hourly, high-resolution atmospheric analyses for use by the ASA, Inc.'s real-time, numerical estuarine forecast system. They have chosen to use NOAA's Local Analysis and Prediction System (LAPS) to create the hourly analyses and the NOAA/National Weather Service/National Centers for Environmental Prediction's non-hydrostatic, workstation version of its operational Eta mesoscale model. Plans for this year include a more extensive evaluation of the atmospheric analyses and forecasts are being evaluated at both over water and inland locations, modification of LAPS analyses scheme to improve the analyses over water, and correction of a negative bias in the Eta model's temperature and dew point temperature over land during the cold season.

Dr. John Mustard of Brown University is responsible for providing temperature images measured with the Landsat satellite. The Earth observing satellite Landsat with its ETM+ sensor crosses the study site once every 16 days at 9:30 am EST and always acquires an observation. We check the central data facility 24 hours after the scheduled overpass and assess the data quality. If the observation was cloud free and apparently of good quality, we order the data and process it using standard methods to an estimate of sea-surface temperature. The validity of the observations are assessed with in situ sensors acquired by the PORTS and NOAA buoys. Once validated, the data are presented on a web site and made available to other members of the

project as well as the public. Our plan for the upcoming year is to continue this effort until we have acquired a processed a total of 16 scenes.

Work Completed

The web-based data dissemination system (IM2), Figure 1, exists in its early beta-version stage and is ready for usage and testing by the user community. In the fact, the project team has planned to hold at user-community workshop at the University of Rhode Island in spring of this year. Early configurations of the information system had favored a so-called heavy-weight architecture that moved all computations to the client side in order to improve performance (speed of data processing). This proved to be acceptable in fast networks with sufficient bandwidth and high level client desktops, but proved to be less efficient when some older and slower desktops were used even when on the same network switch. Tests performed with remote machines, some of them using modems to connect, resulted in unacceptable wait times. As a result, the architecture has shifted from a more heavy-weight application to a more efficient light-weight solution that emphasizes the satellite nature of the Applet-technology (client or user side of the communication) and the work-intense nature of the Servlets (sever side execution of requests), which has dramatically increased the overall performance of the system.

Additional performance improvements were achieved through the rigorous application of data compression techniques, including the introduction of short-integer notation, use of binary formats, and the application of additional compression techniques like ZIP or JAR. These measures have reduced the byte volume for the various data transmission requests by 50 to 90%. These reductions proved to be the most valuable measure in improving the wait times between client action and server response. In addition, the server (LINUX box) has been configured to receive the automated data streams from University of Rhode Islands' data server for collection, separation, interpolation, storage and subsequent user query and visualization tasks. Also, the metadata descriptions of the data holdings have been completed and implemented into the web-based system. These descriptions have been derived from the Dublin Core metadata set and represent a minimum set of descriptors and elements that are necessary for querying and parsing. In contrast to ensuring an all-comprehensive and full-coverage description of the data, the objective was to reduce the range of descriptors to a bare minimum such that the effort of automatically creating the accompanying data description (or RDF) files would be minimized in size and redundant work omitted.

Finally, a substantial effort has been expended to create a user-friendly graphical user interface, GUI, that is self-explanatory, easy to operate and that delivers data products with an easy click of the mouse button. It is anticipated that the web-based information system will be used by a mostly less scientifically inclined user community with lesser demand on data sophistication and analyses tools, than the WINDOWS based COASTMAP system (developed and marketed by URI and ASA). As a result, the emphasis is on human-machine interactions and the development of a visual-based guidance approach that makes it easy for less proficient desk top users to navigate through the system and retrieve the sought information with a few simple steps. This also requires the implementation of "good" default values, i.e. preset options that are likely to match the data requests by the clients. These improvements are a direct outcome of the user survey that was conducted by Drexel University in project year one and that highlighted the need for a simple but efficient and functional user surface.

Year 2002 efforts at the University of Rhode Island (Dr. M. Spaulding) focused on the continued development and integration of the server application systems that form the foundation of the COASTMAP system. During the year ongoing evaluations of the server application systems performance and user feedback led to additional development activities to enhance COASTMAP's ability to accommodate present and future applications. For example, a number of government agencies (e.g., NOAA/NOS) are implementing secure Internet communications protocols (i.e., Secure Shell, SFTP, SHHTP) in the near future in response to national security concerns. SFTP protocol was integrated in COASTMAP's server application systems in anticipation of the changeover. An evaluation of the functionality was recently completed through a secure connection with the present project web portal hosted at Drexel University with full operation scheduled for February 2003.

Utilizing a systematic approach the Data Acquisition and Management Server (formerly "Data Server") automates processes of retrieving data from Internet-based data sources (e.g, real time, forecasted and GODAE) and subsequent processing and distribution to users and the web portal hosted by Drexel University. As the Data Acquisition and Management Server performs the primary functions for successful operation of the Integrated Monitoring and Modeling System being developed under this project, development efforts in year 2002 focused on integrating new functionality, improving scalability and performance, and expanding access to additional sources of data. The Data Acquisition and Management Server has been configured to access additional NOAA PORTS sites, SST thermal imagery from LandSAT 7 provided by Brown University, NOAA/NOS NBLAPS forecasts(NOAA/NOS), real time data from an Endeco/YSI Environmental Monitoring Buoy in Narragansett Bay and meteorological and oceanographic data sets from the Martha's Vineyard Coastal Observatory operated by the Woods Hole Oceanographic Institution. Providing support for the Endeco system proved especially useful to several firms working on a port development project at Quonset Point in Narragansett Bay. Real time data from the offshore buoy is automatically acquired by COASTMAP's Data Acquisition and Management System and distributed to the firms. Also, the Data Acquisition and Management Server was restructured in 2002 to support asynchronous, multi-tasking, operations and to improve system performance.

COASTMAP's server application systems were designed to accommodate the requirements of various size applications and future expansion through a scalable architecture. The architecture permits operation of multiple Data Acquisition and Management Servers, based on bandwidth requirements or a need to locate servers at various geographic locations. Presently multiple Data Acquisition and Management Servers may be operated (without restrictions on geographic location) with their operations managed by a System Administration Server that coordinates management operations and client-server transactions. The Data Acquisition and Management Servers transmit their operational acquisition and distribution status information to the System Administration Server in real time thus providing a centralized location to monitor system operations.

A user management module was added to the System Administration Server to manage and monitor users connecting to the system through *COASTMAP's Pro Client* software. A number of optimizations to the internal communication protocols (i.e., intercommunications between servers and between servers and clients) were implemented and resulted in significant performance improvements. In addition, a number of improvements to the data acquisition,

display, and processing modules were made during the past year. A communications module was integrated in the COASTMAP client allowing it to communicate with the server application systems to access real time and archived data sets. Development also continued on the *COASTMAP Pro Client* interface to improve existing data analysis tools and add new analysis functions. For example, the ability to overlay data sets on time series charts for visual comparisons regardless of the initial source, type or format of the data has been implemented. Finally, a new real time data status board was developed for the *COASTMAP Pro client* software based on requirement to display more than 12 data values per instrument. In the present configuration the real time status board displays data measurements for any number of sensors contained on an instrument. Many of the enhancements integrated during 2002 were derived from user feedback and from a survey conducted by Drexel University during the first year's activities. Improvements to the *COASTMAP Pro Client* software will continue based on internal testing, user feedback and future requirements.

Applied Science Associates modeling efforts this year focused on expanding the model application to Narragansett Bay with improved linkages to the atmospheric model predictions and meteorological and oceanographic data sources. These linkages included the ability to assimilate storm surge model and tidal predictions to provide an open boundary forcing condition to the Narragansett Bay model. Linkages to the atmospheric model have been conceptualized and coding is currently in progress with real time forecasting estimated for mid February 2003. These linkages allow hind-, now- and forecasting capabilities. In addition, considerable effort has been undertaken to investigate the possibility of transition opportunities. Early versions of the system have been described and presented to select audiences (federal agencies) for their potential use.

Drs. John G. W. Kelley and Marina Tsidulko with NOAA's National Ocean Service (NOS) Marine Modeling and Analysis Programs in Silver Spring, MD has implemented NOAA/Forecast System Laboratory's Local Analysis and Prediction System (LAPS) for Narragansett Bay and adjacent coastal water (Fig. 3) to provide near real-time, high-resolution (4km) hourly atmospheric analyses for use by the ASA, Inc.'s real-time, numerical estuarine forecast system. LAPS uses surface observations from traditional observing networks as well as mesonets. These networks included the Automated Surface Observing System (ASOS), FAA's Automated Weather Observing System (AWOS), NWS' Coastal-Marine Automated Networks (C-MAN), NWS' fixed buoys, voluntary observing ships, NOS' Physical Oceanographic Real-Time System (PORTS), NWS' automated cooperative climate stations, and also the private mesonet operated by Weatherflow.com. In addition, LAPS uses upper-air observations from radiosondes, boundary layer wind profilers, and ACARS weather reports. During the summer of 2002, LAPS used data from boundary layer wind profilers installed in New Hampshire and Massachusetts for NOAA's *New England Forecasting Pilot Program: High Resolution Temperature and Air Quality.* The first guess for the LAPS analysis is provided by NWS/National Centers for Environmental Prediction's (NCEP) operational Eta model (12 km resolution). In order to provide hourly, high-resolution, atmospheric forecasts for the forecast cycle of the estuarine model, NOS has also implemented a non-hydrostatic, workstation version of the NCEP's Eta weather prediction model. The workstation Eta model produces hourly forecasts out to 24 hours once per day for the same region at 4 km spatial resolution. The lateral boundary conditions for the workstation Eta model are provided by NCEP's operational Eta

model. The analyses and forecasts are available in GRIB formats and netCDF and also displayed at http://chartmaker.ncd.noaa.gov/csdl/op/aboutNBLAPS.html.

Dr. J. Mustard at Brown University acquired a total of 12 Landsat ETM+ scenes covering the period of 1/1/2001 to 12/31/2002 and processed according to standard methods to produce sea surface temperature at a 60 meter/pixel spatial resolution for the study region. Using standard methods (no atmospheric or other corrections), the accuracy was assessed using PORTS and NOAA buoy data and shown to be accurate to +/-2.7°C. We attempted to implement an atmospheric correction model using radiosonde data acquired by the National Weather Service. However, the model is not appropriate as it increased the error. Instead, we use the in situ data to correct each scene. With this approach, the accuracy was improved to +/-2.7°C. All scenes have been packaged for delivery over the web and can be accessed at the Brown University project web site given in the header. While these individual scenes are useful for model development and validation, we have significantly increased the value of these data by incorporating them into a data base that now totals over 40 scenes over the time frame 1984-2002. From this database we have created a sea surface temperature climatology with a 60 meter/pixel spatial resolution. This was accomplished by ordering the scenes by calendar day and fitting the sequence with a polynomial curve to approximate an annual cycle of sea surface temperature. The approach automatically identifies outliers or bad data points. This allows us to include scenes which may have some cloud contamination. By interpolation, a predicted sea surface temperature map of the entire study region can be generated for any date in a calendar year.

Results

The first versions of the web-based data dissemination system, IM2, showed an unsatisfactory performance when used remotely from user stations outside the developers' campus network. In addition, performance differed considerably from browser version to browser version and between software vendors. This led to a re-design of the system, which now sees the inclusion of the more powerful SWING classes of JAVA JDK 1.4. In addition, the originally envisioned architecture of the client-server communication needed to be redesigned and streamlined to provide for less wait and upload time for the crucial elements of the system. The most significant improvement of the performance was achieved by rigorously compressing the data packages that are uploaded for visualization. The inclusion of short-integer notation, binary formats that are further compressed by ZIP routines, has dramatically reduced the size of the data volume. It was found that it is crucially important to keep computational activity away from the client machine and to employ every possible strategy to have data streamed and sent in the background during the life time of a session to reduce client wait times. Finally, a set of cascading configuration files in addition to server based program modules, have automated many system functions and will aid in making it possible that this system is globally re-locatable.

The workstation Eta model surface forecasts of air temperature and wind velocity have been compared to observations for selected inland and coastal stations in the Narragansett Bay region for a 2 week period in July 2002. The limited evaluation indicated a relatively good agreement between forecasts and observations. Land-sea differences are well described although in some synoptic situations the predicted values may not match the observations. Also, in comparison with NCEP's operational 12 km Eta model, it was found that 4km resolution model better describes temperature and wind in coastal zone, whereas the models demonstrates almost the

same forecast over in land areas. In addition, qualitative evaluation of the Eta model's air temperature and dew point temperature forecasts during autumn of 2002 and first part of the winter of 2003 has shown a large negative bias over land. NOS has informed NCEP about this serious problem and is working with them to identify the source of the problem and solve it.

The creation of a validated sea surface temperature data set with 60 meter/pixel spatial resolution is a significant result. However, the development of a methodology to generate a sea surface temperature climatology has by far the most important value and impact from this effort. This was initiated and carried out by Jeremy Fisher, a graduate student working on this project. This climatology could be used in the modeling efforts to initiate the temperature fields for any date in a calendar year. It can be re-sampled to any spatial resolution or grid structure. It has great value as an environmental baseline for which to compare the actual conditions on a given day or to track changes over time.

The primary result of this year's activities at Applied Science Associates and University of Rhode Island is the continuing evolution of the COASTMAP system and early efforts to develop a commercial market for the system. In addition to the normal commercial and government markets for such a system (i.e. power and treatment plant operates, shipping and marine transportation industries, port and harbor managers, environmental regulators, commercial fishermen, spill responders, search and rescue operations, etc.) many federal and state agencies have been tasked with security (homeland and international) related responsibilities. These agencies need systems that integrate data collection and analysis capabilities, with environmental models, to provide now and fore casting capabilities. COASTMAP provides an easily re-locatable system that directly meets these needs of these agencies.

Impact and Applications

National Security

The project has led to an improvement in LAPS' surface analyses. These improvements were incorporated by LAPS development team at NOAA's Forecast System Laboratory in the latest version of LAPS. LAPS is used by the NWS nationwide and also by the U.S. Air Force. In addition, LAPS is also used by NOS to produce analyses over Chesapeake Bay including the Washington, DC metro area. These gridded analyses are sent hourly to Defense Department's Defense Threat Reduction Agency for potential use in their air dispersion trajectory models in support of Homeland Defense.

Presented below is a summary of the work in progress to market COASTMAP to potential clients. Most of these initiatives have progressed to the stage of a formal proposal, with funding decisions pending.

US Coast Guard: The US Coast Guard (USCG) Research and Development Center, located in Groton, CT, has expressed interest in implementing COASTMAP, on a prototype basis, as an environmental data collection tool for use in support of their coastal operations. This application is specifically directed at the USCG's homeland defense, search and rescue (SAR), and oil spill operations. In support of these missions the USCG requires environmental forecasts of local and regional meteorological and ocean currents to provide input to SAR and oil spill models at varying geographic scales. For example if a person were lost at sea in Vineyard Sound, offshore

Martha's Vineyard, MA, the responder could access a local National Weather Service (NWS) and ASA's regional current forecast (Figure 1) to provide input to a SAR model. However, as the search region expands the environmental data requirements change and the responder could then potentially access large-scale NWS forecasts and the NOAA Coastal Ocean Forecasting System, water level and current forecasts for the entire East Coast. Additionally data obtained from systems such as the NOAA Physical Oceanographic Real Time System (PORTS) could be analyzed for important small scale features not captured by large-scale models. The USCG R&D center also requires the data sources to be ordered in terms of data availability and quality, so the responder can act, rather than spend time during critical response period analyzing data. COASTMAP can be modified to provide this level of functionality to the responder, as the data sources available are already linked to the geographic region of interest.

ASA has significant experience in working with the United States Coast Guard, including developing their prototype Incident Command System (ICS) - based command and control system. This software allowed the US Coast Guard to manage the deployment of personnel and equipment during spills and other accidents. This system was tested in a number of Coast Guard Prep drills and was also used during the September 11 response in New York.

NUWC: The Naval Undersea Warfare Center(NUWC) located in Newport, RI has expressed interest in using COASTMAP to manage data associated with its acoustic torpedo tracking ranges. These ranges collect physical data in the form of currents, temperature and conductivity over the water column from bottom-moored stations. Acoustic data is also collected on the track of torpedoes tested within the range. The COASTMAP data server can be used to collect and disseminate this information to scientists and engineers using the COASTMAP Pro Client at remote locations. COASTMAP would also provide geographic referencing of the data collection sites and analysis and visualization of the times series data collected from the moored instruments. Simple modifications to the data visualization and analysis tools, within COASTMAP, would be necessary for the acoustic tracking data. Access to regional current and weather forecasts would also provide tools for test planning.

Scientific Research: Drexel University has submitted a proposal to the National Science Foundation (NSF) to develop a specific markup language for seismic array data that makes array data accessible to earthquake engineering applications, particularly to bridge engineering. This requires the blending of community specific data description conventions, the adaptation of general data description conventions (international metadata standards), as well as the inclusion of the Extensible Markup Language (XML). Applications of these components have been used for this project to development the IM2 system and provide an invaluable pool of information and expertise that can be applied to future projects. Another potential application is in the area of Hydroinformatics where the development of a Hydrologic Markup Language has been proposed to the Consortium of Universities for the Advancement of Hydrologic Sciences Inc., CUAHSI as one of its key initiatives in their hydrologic information sciences program.

The University of Rhode Island, Graduate School of Oceanography (GSO) located in Narragansett, RI has submitted a proposal to the National Science Foundation (NSF) to design, construct, and test a Sensor Array for Bay Research and Education (SABRE) for Narragansett Bay, RI. They are proposing to use COASTMAP as the data collection and analysis module of the SABRE system. Data would be collected from three new technologies being developed under the SABRE project including

BEAMER – a novel autonomous bottom-mounted acoustic platform with a 3-dimensional multi-sonar array designed to provide vertical profiles of velocity and turbulence intensity, surface wave field parameters, and for tracking movements of bubble clouds, zooplankton and fish.

PROFILER – an innovative moored autonomous, bottom-up vertical profiling sensor package for coherent, real-time, high-resolution measurements of the vertical structure of multiple biological, physical, chemical, and optical parameters in the water column.

GIATR & AUVs - the Gould Island Acoustic Tracking Range (GIATR) is a unique cabled network of three underwater nodes that the Navy has established on the seafloor in the East Passage of Narragansett Bay. Although the range was designed and is actively being used for acoustic tracking and communication with instrumented autonomous underwater vehicles (AUV), the underwater nodes can also be adapted to supply power and high band-width communication for other sensor packages (i.e. BEAMER and PROFILER) placed within the range.

COASTMAP would be modified to provide data visualization and analysis techniques to handle the specific needs of the SABRE data collection systems.

Commercial Sector

The objective of the IM2 web-portal is to provide a means of forecast data dissemination that satisfies the needs of a broad user community, who do not require the high level of sophistication that a system as COASTMAP could provide. As one of the outcomes of the user survey it was concluded that there is a considerable interest within the commercial fisherman, harbor-master, recreational boating, media, and education community to obtain detailed forecasts for the region. Considering the much more basic data product needs of these groups, the web-based information system is designed to cater to these needs. As a result, it is planned to make the system available to these communities, which are large in numbers, for a relatively low fee such that the system can maintain itself in the future.

Project team members have been meeting with senior representatives of Endeco/YSI Inc., a leading manufacturer of environmental monitoring instrumentation and integrated systems, discussing the potential to use COASTMAP as the software interface to their monitoring systems. We have proposed to replace Endeco/YSI's current acquisition, control and display software with COASTMAP. The transition to incorporate COASTMAP with their products is simple and straightforward since COASTMAP currently supports the Endeco/YSI data format. COASTMAP would provide all the functionality of the existing Endeco/YSI software, with the additional benefit of access to the suite of data visualization, analysis and management tools presently incorporated in COASTMAP. Additional government agencies have been contacted and have expressed interest in the system but have yet to progress to the proposal stage.

Economic Development

A potential future impact on economic development is the use of COASTMAP to evaluate large scale development projects. In Rhode Island, there is a project in progress, initiated by the RI Governor's Office, to evaluate the potential environmental impacts of establishing a proposed container port at Quonset Point in Narragansett Bay. Instrument moorings located in the existing dredged shipping channel currently collect real time environmental data and are used to

characterize the marine environment near the proposed port. A link to this system was configured within COASTMAP's Data Acquisition and Management Server operating at the University of Rhode Island. The Data Acquisition and Management Server synchronizes its operations, such that data is acquired from the Quonset Port environmental monitoring system and is distributed seconds later to participating agencies and consulting firms working on the project. Circulation and water quality models have been setup for the Quonset Port area and COASTMAP used to compare model data with in-situ measurements to improve model calibrations. After calibration, forecasts will be made of circulation and water quality under different port design options with an emphasis on impacts resulting from dredging of the channel.

Quality of Life

COASTMAP can be used to explore quality of life decisions in terms of marine resource use. The proposed container port at Quonset Point is a concern to recreational and commercial users of Narragansett Bay, as well as those living in the area. The use of COASTMAP's modeling and management tools to examine impacts associated with different port design options provides a direct means to evaluate quality of life issues. In addition, Rhode Island is exploring the possibility of developing a Bay Business Plan to coordinate planning for development and use of the bay. COASTMAP can be used to forecast marine water quality under different scenarios that can directly affect the quality of life for bay users. For instance, if a container port is built, will potential environmental impacts degrade the quality of the bay for recreational users (fishermen, sailors). The system can also serve as a decision tool to guide spill response in marine waters.

Since the IM2 information system is designed to cater to the needs of a mostly non-scientific community with very basic data needs and little use for sophisticated data analyses tools, it has the potential of providing information to the above mentioned communities that is quite unique. For example, Newport is a center for recreational boating with a large clientele involved in racing. Detailed forecasts for every point of the race track can be very helpful in determining a plotted course. Also, high accuracy and reliable 24 or 48 hour forecasts can help in determining whether a cruise should be cut short, be it recreational or commercial. In addition, the well developed tourism sector of the Bay area could benefit from reliable weather forecasts that are very detailed in nature.

In addition, if the LAPS analyses are found to be superior to present analyses used by NOS operational estuarine forecast models, then the LAPS will be made an operationally system at NOS. This could lead to improvement water level and current forecasts to support safe navigation, search and rescue, and HAZMAT response. Finally, a significant new derived data set of sea surface temperature climatology has good potential to impact a number of areas of quality of life, including new data to assess estuarine processes in Narragansett Bay and the coastal ocean and establishment of an environmental baseline for evaluation and assessment of future changes in this system

Science Education and Communication

COASTMAP is proving to be a useful tool to communicate with state and federal agencies, private contractors, and the public. For example, the ability to display and animate model results detailing impacts of various port design options for Quonset Point provides a direct means to educate concerned parties and the public. Graphic representation of data and model results

within a GIS framework, much like the presentation of weather reports, is easily comprehended. The system can also be used as a tool to connect the classroom with marine waters. Since data can be displayed real time it will be possible to view what conditions are presently occurring in the bay relative to circulation and water quality.

The web-based IM2 system, permits a large number of simultaneous users to access the data holdings of the portal server, as many instances of the portal can be regenerated on the server. Also, the required access technology is limited to a web-browser that is virtually present on all commonly desktop machines in use. In other words, the system is ideally suited to be used in class rooms for educational purposes, as well as on light weight lab-tops that can connect to a satellite phone for use in remote areas and off shore. For example, the sea surface temperature climatology product can be used in a number of education and public outreach efforts to study the effects of warm water discharge to the bay. We plan to present example products on our web site and communicate the nature of the results to local organizations such as Save the Bay.

Transitions

National Security

The improvements of LAPS' surface analysis scheme resulting from this NOPP project have been incorporated in new versions of LAPS used by the NWS,U. S. Air Force, and by NOS for generating analyses over the Chesapeake Bay including the Washington, DC metro area. These gridded analyses are sent hourly to Defense Department's Defense Threat Reduction Agency for potential use in their air dispersion trajectory models in support of Homeland Defense. NOS is working with DTRA to determine if there is a need for the gridded LAPS analyses for Southern New England including the New York City metro area.

The US Naval Oceanographic Office's (NAVOCEANO) has recently acquired a license to COASTMAP and is using the system for environmental data collection and analysis and to support its operational forecasting/modeling systems. The data collected by the system are used to develop initial conditions and environmental forcing for operational coastal models to support homeland security activities within US waters and coastal warfare activities outside of the US. Environmental data which includes water level, river stream flow, meteorological, currents and temperature, is actively being collected, managed and analyzed from seven bays and harbors (Kings Bay, GA, Mayport, FL, San Diego, CA, Norfolk, VA, San Francisco, CA, Puget Sound, WA, and Charleston, SC) within the continental United States. Data from various regions around the world, including the US East and West Coasts, the Gulf of Mexico, the Great Lakes, the Yellow Sea and the Persian Gulf, are also being actively collected and analyzed. The total numbers of sensors, worldwide, is currently 275. These data are being used in the development of local forecasting models, similar to that being developed for Narragansett Bay under this project, as well as the Navy's regional operational models. The outputs from these hydrodynamic models are to be linked through the COASTMAP system with meteorological forecasts/data for use with constituent transport models, also linked with COASTMAP, in support of operational planning and action for special warfare, coastal insertion of ground forces, response to potential terrorist activities and potential environmental accidents. At the conclusion of FY03, NAVOCEANO will have invested approximately $300,000 in software licenses and services necessary to integrate COASTMAP to help the Navy meet its homeland security responsibilities.

Commercial

The server technology, client-server communication applications, as well as the interface (portal) functionality, IM2, have been developed in close partnership with members of SMILE CONSULT, a German based software company specializing in internet based information systems, which uses part of the developments for other systems. Likewise, Drexel is using part of this prototype system for other projects that are currently under way as well as leverage for project proposals submitted to, for example, NSF's ITR program. The continued partnership and cooperation between Drexel and SMILE will generate further opportunities in using the developed technology for other projects and foster the knowledge exchange between these two partners.

Economic Development

Demonstrations of COASTMAP system have created a number of marketing and transition opportunities. Opportunities exist to further develop the operational capabilities of COASTMAP through traditional applications (e.g., bay and harbor monitoring) and newer applications involving homeland security issues. A number of these opportunities were summarized in the Impact and Applications section a.

Consideration for Excellence in Partnering Award

Ocean Sector Diversity: Three universities (URI, Drexel, Brown), two government agencies (NOAA/NOS, Navy) and one private firm (Applied Science Associates, Inc., ASA)

Partner Involvement: URI, Drexel, ASA and NOAA/NOS about equal share of funds. Navy no funding, Brown limited funding for two of the three years

Matching Contributions: State of RI funded PORTS system for Narragansett Bay ($750K). Governor's Office funded real time monitoring system for Quonset Point ($225K). Drexel University cost-shares graduate students, equipment, and faculty academic year ($214K). NOAA/NOS cost shares salaries of the responsible lead scientists ($150K).

Partner Long-Term Commitment: The project team is currently leading an initiative to develop one of the regional systems within the Ocean.US coastal ocean observing system for US waters initiative. In addition, the project team is aiming at developing data products that can be made available to a broader user community via the web-portal interface, IM2,, such that the website can sustain itself. The project team at Drexel University is anticipating hosting the web-server for a sustained period of time to provide continued services.

Success in Project Objectives: The project team is almost on schedule to complete all the project objectives established in our original proposal. The most important accomplishment is that the project has resulted in the development of one of the first truly globally re-locatable, integrated systems for real time observation, modeling, and data distribution for shelf, coastal sea, and estuarine waters. The web server and its interface (portal) use technology and components that are operating system and software (except a browser) independent, hence can be installed anywhere. This component is currently being streamlined and re-designed so it caters to the broad community market of commercial and recreational boaters as well other organizations like media and educational institutions. COASTMAP has been selected by NAVOCEAN to

support their responsibilities for operational planning and action for special warfare, coastal insertion of ground forces, response to potential terrorist activities, and potential environmental accidents for US and international waters. The revenue generated from software sales is already one fifth of the overall project budget. Initial contacts with other potential clients (USCG, NUWC, EPA, equipment manufacturers) suggest a strong market for this software product.

Publications

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French McCay, D., N. Whittier, M. Ward and C. Santos, 2002. Spill hazard evaluation for chemicals shipped in bulk using modeling. Proceedings of the 2002 IMEMS Conference, September 2-4, 2002, Trondheim, Norway.

Lehfeldt, R., Heidmann, C., Piasecki, M., (2002), "Metadata in Coastal Information Systems", 5th International Conference on Hydroscience and Engineering, September 17 - 21, 2002, Warsaw, Poland.

Lehfeldt, R., Piasecki, M., (2002), "Components of Web Portals in Coastal Engineering", 5th International Conference on Hydroinformatics, July 1 - 5, 2002, Cardiff and Bristol, Wales.

Opishinski, T.B., M. Spaulding, Application of an Integrated Monitoring and Modeling System to Narragansett Bay and Adjacent Waters Incorporating Internet Based Technology, In proceedings of 7th Annual International Conference on Estuarine and Coastal Modeling (ECM 7), St. Pete Beach, Fl, November 5-7, 2001.

Ward, M.C., M. Spaulding, A Nowcast/Forecast System of Circulation Dynamics for Narragansett Bay, In proceedings of 7th Annual International Conference on Estuarine and Coastal Modeling (ECM 7), St. Pete Beach, Fl, November 5-7, 2001.

Ward, M.C., T. Opishinski, J.C. Swanson, and D. French McCay, 2002. A globally re-locatable marine nowcast/forecast system. Proceedings, International Marine Environmental Seminar 2002.

Applied Science Associates, Inc. (ASA) is actively marketing COASTMAP. Information on COASTMAP is currently highlighted in corporate brochures and was featured in the last newsletter (www.appsci.com and appended below.

Patents and Copyrighting

The COASTMAP name has been copyrighted by Applied Science Associates, Inc (ASA).

A National Oceanographic Partnership Program Award

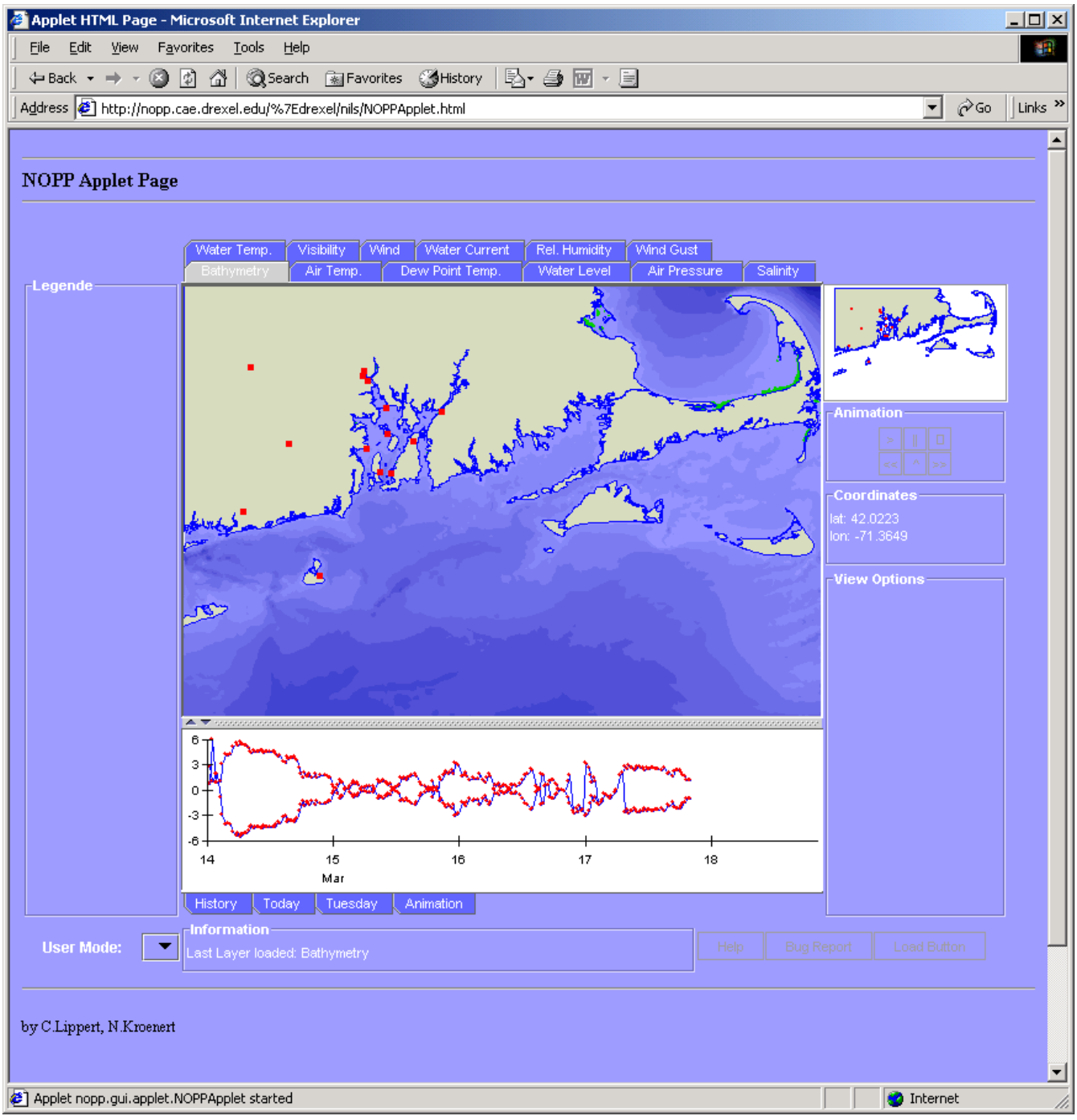

Figure 1. Drexel's Web-based Information System IM2 (Beta Version)

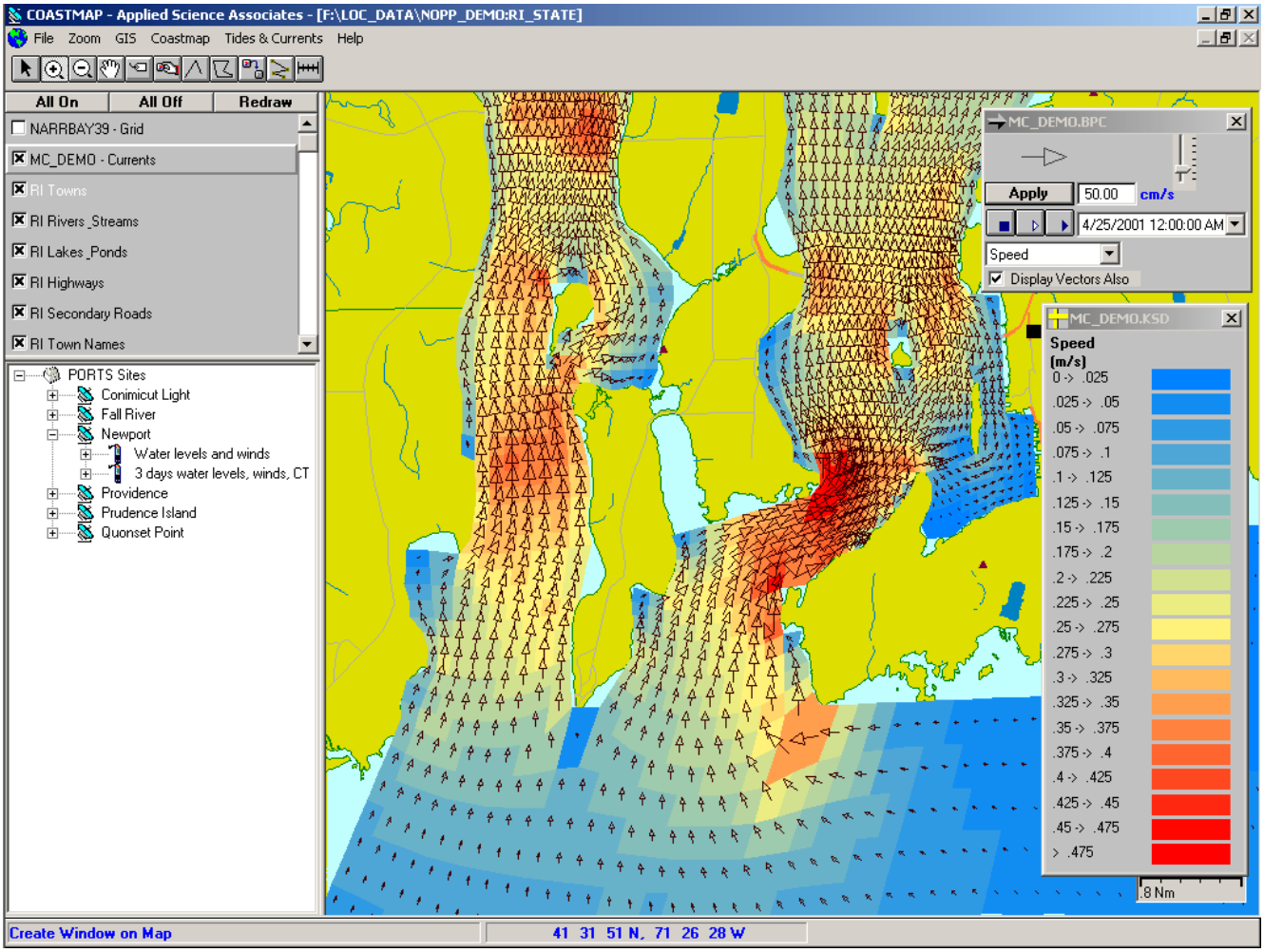

Figure 2. ASA's regional forecast model results displayed in COASTMAP

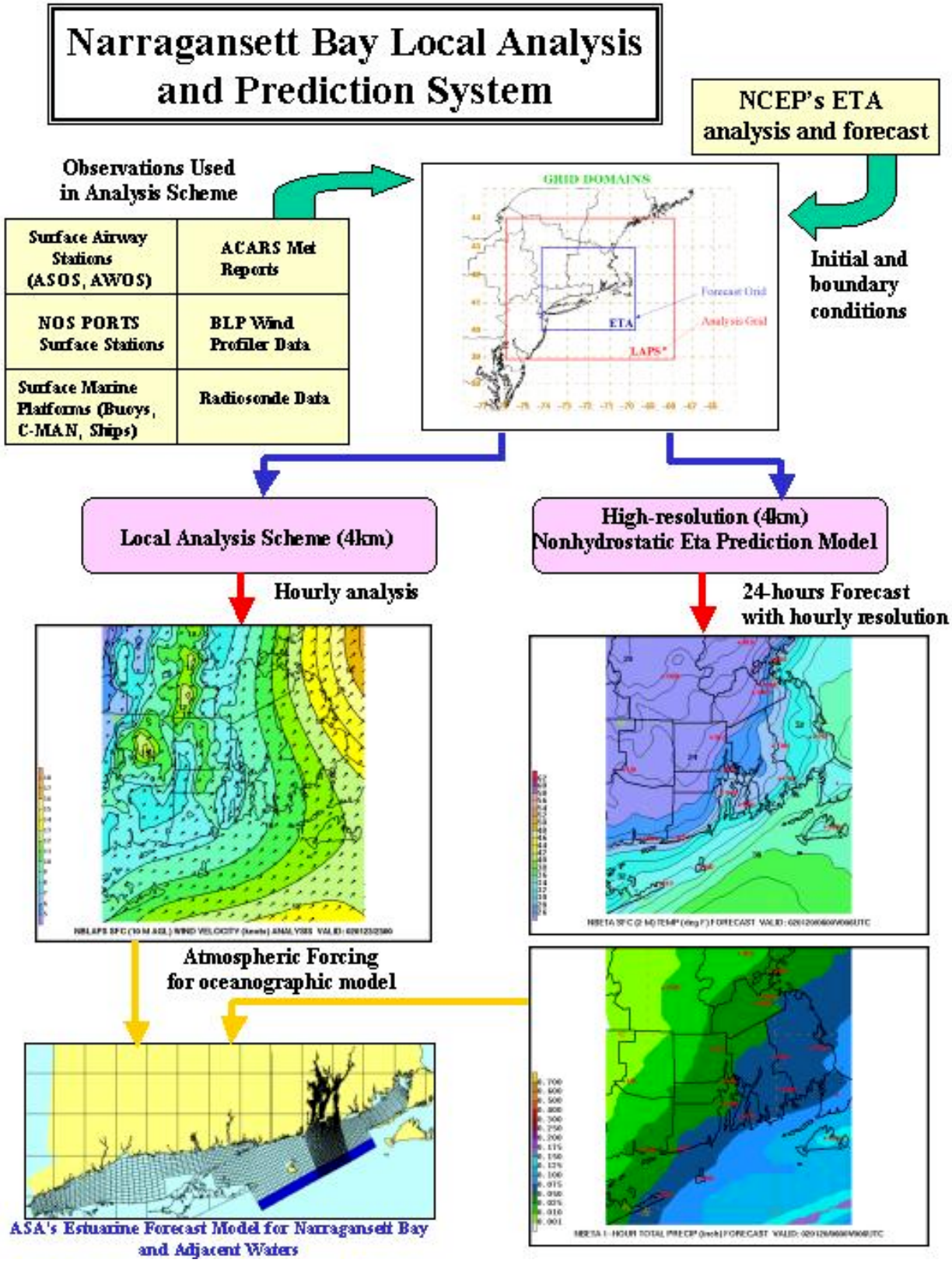

Figure 3. NOAA/NOS Narragansett Bay Local Area Analysis and Prediction System

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