J4.3 NOAA'S NOWCOAST: A GIS-WEB MAPPING PORTAL TO DISCOVER AND DISPLAY REAL-TIME COASTAL OBSERVATIONS, SATELLITE IMAGERY AND NOAA FORECASTS

Michael Allard *, Micah Wengren, John G.W. Kelley and Meredith Westington
Coast Survey Development Laboratory, NOAA National Ocean Service, Silver Spring, MD

1. INTRODUCTION

With the proliferation of computers in the classroom and more specifically, computer access to Geographic Information System (GIS) technology, teachers have an opportunity to develop interesting and relevant lesson plans that will help their students gain an appreciation for the sciences. NOAA's National Ocean Service (NOS) has developed and implemented a GIS-based Web mapping portal called *nowCOAST* (http://nowcoast.noaa.gov) to allow easy access to real-time coastal information for any region in the coastal United States. (Figure 1) The portal serves as a *one-stop shopping* solution for users to view real-time meteorological, oceanographic, hydrologic, and water quality information from numerous federally-operated networks as well as mesonets and regional ocean observing systems. *NowCOAST* also provides access to NOAA forecast products including forecast guidance from NOAA's operational numerical ocean, lake, river, and weather prediction models, National Weather Service's (NWS) forecast discussions, NWS' general weather and marine weather forecasts, and NOS' Harmful Algae Bloom forecasts. Recently, the portal has been enhanced to provide on-map display of near-real-time satellite cloud imagery, weather radar reflectivity, and surface meteorological observations.

Specifically for teachers, the *nowCOAST* web portal can be helpful by providing a single web location for them and their students to quickly locate and display real-time and forecasted environmental data in a particular watershed, estuary, Great Lake, or coastal ocean area to support class lessons and projects about weather, oceanography, hydrology, or water quality.

This paper describes the *nowCOAST* portal, its content, how to use it, and its potential in the classroom.

2. DESCRIPTION OF PORTAL

NowCOAST is a GIS-based web mapping portal to real-time coastal observations and NOAA forecast products. The portal uses Arc Internet Map Server (ArcIMS) combined with Dynamic HTML (DHTML) and Java Web Enterprise Edition (J2EE) Web programming technologies including Java Servlets and Java ServerPages for its dynamic GIS mapping capability. *NowCOAST* is built upon the Java Connector API for ArcIMS, allowing for customization of the map functionality and appearance. The Java Connector was selected over other similar ArcIMS technologies provided by ESRI, such as the ActiveX Connector and Servlet Connector, for its ability to be used on a variety of operating systems and Web servers, and the programmatic customization capability that it provided.

NowCOAST runs on a 2.6 GHz dual Intel Xeon CPU server under a Linux operating system using the Apache Web server, Jakarta-Tomcat Servlet Engine, and ArcIMS 9.0.1. Recently, *nowCOAST* was enhanced to allow on-map display of imagery and surface observations via the connection of the *nowCOAST* MapService with an Oracle 10g/Arc Spatial Database Engine (ArcSDE) database.

The *nowCOAST* portal consists of a custom map viewer and a 'Databrowser'. The map interface is based on the Java Connector and was designed to be lightweight and fast. The Databrowser interface allows the user to view and browse forward and backward through websites displaying the observations and forecasts that they locate through the map viewer. The Databrowser integrates directly with the map viewer. Additional information on the construction of *nowCOAST* can be found in Wengren et. al (2005).

3. NOWCOAST's CONTENT

Presently, *nowCOAST* contains both on-map displays of near-real-time data and imagery as well as thousands of geo-referenced links to additional observations and NOAA forecast products.

The on-map data displays surface meteorological observations from automated and manual reporting stations at airports, coastal marine platforms, fixed buoys, and ships. In addition, observations from some regional observing systems are also displayed such as the Gulf of Maine Ocean Observing System (GoMOOS). Presently, observations from NOS Physical Oceanographic Real-Time System (PORTS) and

* *Corresponding author address:* Michael Allard, NOAA/National Ocean Service, Coast Survey Development Laboratory, 1315 East-West Highway, N/CS13, Silver Spring, MD 20910-3282; email: michael.allard@noaa.gov

National Water Level Observing Network (NWLON) are not displayed; however they will be included in a future *nowCOAST* release.

The surface observations from these different networks are plotted in the international standard 'Surface-Station Model' with the air temperature (deg F) in the upper left quadrant, the dew point temperature (deg F) in the lower left quadrant, the visibility (miles) above the dew point temperature, the MSLP (mb) in the upper right quadrant, and wind direction and speed (knots) in the middle. Sea surface temperature (deg F) is located under and to the right of the dew point temperature for certain marine stations. The barb points in the direction of where the wind is coming from (i.e. meteorological convention) and the speed is indicated by different types and number of lines on the tail. The on-map display of surface observations is updated every hour.

NowCOAST also displays two main types of imagery, courtesy of NOAA/National Environmental Satellite, Data, and Information Service (NESDIS). One of these on-map layers is the Weather Radar Mosaic. *NowCOAST* displays the base reflectivity radar data. This is a display of echo intensity (reflectivity) measured in dBZ (decibels of Z, where Z represents the amount of energy reflected back to the radar). The base reflectivity mosaic is updated on *nowCOAST* every 15 minutes.

The other main type of on-map imagery displayed by *nowCOAST* is NOAA's Geostationary Operational Environmental Satellite (GOES) cloud imagery. This includes visible and infrared cloud images from both GOES-East and GOES-West. The approximate horizontal resolutions of the GOES visible and infrared images are 1 km (.62 statute mile) and 4 km (2.5 statute mile), respectively. The GOES images are updated on *nowCOAST* every hour. See Table 1 for a detailed description and examples of the on-map data and imagery.

NowCOAST also provides geo-referenced links to real-time in-situ and remotely-sensed observations of weather, ocean, river, and water quality conditions. Many of the surface meteorological observations links are shown on the hourly on-map display of observations but the links also include observations not available via the on-map display.

In addition, *nowCOAST* has geo-referenced links to NOAA forecast products including NWS public weather and marine weather text forecasts and forecast discussions, NOAA model forecast point guidance, and NOS' astronomical tidal water level predictions based on NOS harmonic constituents at six minute or hourly intervals. See Table 2 for a detailed list of observing networks and forecast products linked to by *nowCOAST*.

The on-map data and imagery can be viewed by turning on each of these map layers; one must click on the geo-referenced links to view data at that location in the Databrowser. This process and details on how to operate *nowCOAST* will be described in the next section.

4. HOW TO USE NOWCOAST

When a user opens the *nowCOAST* Web page in a browser (after making sure all popup blockers are turned off in his or her Web browser and toolbars), he/she is shown the map viewer (Figure 1) with a default view of the continental U.S. and a visible satellite image as well as an introductory message with basic instructions on use of the site superimposed upon the map. The instructions include the step-by-step process to obtain observations or forecasts, as well as tips about common usage problems that users have encountered with the site.

The *nowCOAST* map viewer consists of the map itself, the 'Jumpbar' menu above the map that provides quick step-by-step selection of data to view in the map, a set of useful Map Tools for direct manipulation of the map, and a Map Layers list to allow overlay of information from multiple GIS data layers in *nowCOAST*. Each of these components works interchangeably with the others, meaning that users have several options available to manipulate the map to view the exact data they would like.

Two different methods can be used in *nowCOAST* to obtain real-time observations and NOAA forecasts. The first method is for those unfamiliar with GIS, the second is for those with more experience with the technology. The first method is the Jumpbar, which consists of four Web-standard 'pulldown' menus (Figure 2) which allow the user to specify 1) the location (e.g. seaport, coastal state, estuary, marine sanctuary), 2) the information (i.e. specified type of observation, forecast guidance, or forecast), 3) the variable (e.g. water level, air temperature, wave height, etc.), and 4) the time (specific forecast time or time period). The Jumpbar is located above the map and is designed to visually guide the general user through this four-step process to specify the criteria they are interested in, then click on 'Go' to obtain a map with the resulting information. As described in the initial instructional message, the user is then able to click on any of the resulting observation stations or forecast points or zones to link to the website with the associated information. With six clicks of the mouse, the user can see the observation or forecast information.

The second navigation method, intended for those more familiar with GIS, consists of a combination of standard GIS mapping tools. First is a set of 'Map Tools' (Figure 3) for working directly with the map. Tools such as Zoom In/Out, Pan, Identify, Select, Zoom to Lat/Lon,

and Link to Data are provided in the toolbar. To assist users with these tools, instructional messages appear below the map when a tool is selected, and a separate help window with further instruction may also be opened. Second, *nowCOAST* offers a 'Map Layers' list, which is a catalog of the individual layers of GIS data within the portal. It is located on the right side of the viewer. The Map Layers list provides the overlay functionality central to GIS. This is useful in *nowCOAST* for a user to visually compare spatial distribution of different types of observing platforms or forecast points and zones. For instance the distribution of weather observation stations, river observation stations, and NWS text-based surface weather forecast zones for a particular region, such as the lower Potomac River watershed, can be viewed (See Figure 4).

NowCOAST provides direct hyperlink functionality to observations and forecasts at features on the map via the 'Link to Data' map tool. When the user clicks on a station or forecast zone, the Databrowser opens in a second browser window displaying the associated Web page (Figure 5). The Databrowser both allows users to view Web pages linked to using the 'Link to Data' tool as well as tabular data output from queries to the portal's underlying data on observation stations and forecasts products using the 'Select by Rectangle', 'Identify', and 'Query' tools.

The Databrowser maintains a record of user interaction with *nowCOAST* throughout the duration of the user's session. When the user links to an observation station or forecast point or zone or queries the underlying *nowCOAST* data, a record is added to the Databrowser with this information. Users are then able to browse backward and forward through this record, delete an individual record, print any dataset returned from the *nowCOAST* database, or open a new window with only the live forecast or observation Web page. These features give the user control over the information they obtain through *nowCOAST*, allowing them to retain only records of interest and compare observations taken at one location versus another, or compare an observation against a forecast, all within one browser window.

5. NOWCOAST AS AN EDUCATIONAL TOOL

"Science has to be taught differently than reading... Students learn to read by reading, and math by practicing computations…Evidence that science learning is an active process can be seen in early childhood." These are the findings from the 2004 Conference on K-12 Outreach from University Science (Haase, 2004). Data from the National Assessment Governing Board, The Nation's Report Card – Science 2000 supports these claims. It documents "increased student performance on the National Assessment of Education Progress when students worked with computers interfaced with lab equipment and computers equipped with software…." (Haase, 2004).

The nowCOAST tool is a unique way to combine science, geography, and technology in an active hands-on setting. The portal can be helpful to teachers by providing a Web site for them and their students to quickly locate lakes, oceans, and estuaries across the United States and to view the latest environmental conditions and forecasts in these areas.

Possible lessons utilizing *nowCOAST* in the classroom could involve land falling hurricanes or coastal winter storms. One of these lessons could begin by showing a satellite image overlaid with a radar image and observations at the surface (Figure 6). In this example we see Hurricane Wilma hours after its Florida landfall at approximately 0930 EDT on October 25, 2005. Students could begin by looking at the surface observations. By examining the winds they could see the counterclockwise structure in which the winds circulate around the hurricanes. They could also see how the pressure is lowest closest to the storm's center. Upon inspection of the radar and satellite images students will observe where the strongest radar echoes and most cloudiness are relative to the eye of the hurricane.

Next, the students could examine NOAA's forecast discussion for a coastal region where the hurricane will soon make landfall (Figure 7). They will learn how complex computer models are used by meteorologists in forecasting paths and strength of hurricanes and the uncertainties these models possess. Students will be exposed to the science of forecasting hurricanes, and how fronts and meteorological features hundreds of miles away affect the path and strength of these hurricanes. They will read about the expected affects of a land falling hurricane on the marine and coastal regions such as flooding and storm surge. Students can also learn about the damage these storms can cause well inland such as flooding, high winds and tornadoes.

To further illustrate these points, students will look at the observations of various river or precipitation gages affected by the hurricane. Figure 8 depicts the location of river gages across central and southern FL. One of these river gages, located in Pinellas, FL, at the time of Wilma's landfall measured approximately 2.25 inches of precipitation from the storm. This precipitation began approximately 12 hours before the hurricane came ashore in FL and will continue after the hurricane emerges over the Atlantic. Students will learn about the massive amounts of rainfall these storms can produce hurricane's effects are felt long before, during, and after landfall.

Lastly, the lesson could end by viewing storm surge observations from a NOAA Center for Operational Oceanographic Products and Services (CO-OPS) site. This will help students better understand the storm surge associated with land falling hurricanes. (Figure 9) They will learn how the timing and location of a hurricane can affect the storm surge by several feet and

how the observed water level compared with the tidal prediction at that location.

6. SUMMARY AND FUTURE PLANS

NowCOAST is designed to be a planning aid for recreational and commercial mariners, coastal managers, emergency responders, marine educators and researchers, as well as beachgoers but is also an excellent tool for the K-12 community. The NOS education/outreach office is currently working on lesson plan for *nowCOAST* in the classroom. This will allow upper level students to become familiar with this the more technical side of meteorology and oceanography before they enter college.

In the future, *nowCOAST* will display selected forecast fields from the NWS National Digital Forecast Database (NDFD), such as maximum and minimum temperatures, wind speed and direction, and wave height. Other NOAA gridded products may also be added to the portal following the NDFD. These include the National Digital Guidance Database (NGDG), output from NOS operational estuarine forecast systems, and NOAA sea surface temperature analyses.

7. ACKNOWLEDGEMENTS

The project is supported by NOS' Coast Survey Development Laboratory and is funded in part by a grant from the NOAA High Performance Computing and Communications (HPCC) Office. The initial development of *nowCOAST* was funded by a grant from NOAA/National Environmental Satellite, Data, and Informational Service's Environmental Services Data and Information Management (ESDIM) Program. We would also like to thank NESDIS for the use of its on-map imagery and observations. The portal seeks to support one of ESDIM's program objectives, which is to "improve access to NOAA environmental data and information for scientists and decision makers."

8. REFERENCES

Haase, Dr. David G. and Schulze, Dr. Sharon K., The Science House North Carolina State University. "The Conference on K-12 Outreach from University Science Departments: 2004" (2004): The Science House, North Carolina State University, 2004.18-30.

Wengren, M., J. G. W. Kelley, M. Kennedy, and M. Westington, 2005: NOS' NowCOAST: A Web Mapping Portal to Real-Time Coastal Observations and NOAA Forecasts. 12.4 *Preprints, 21st International Conference on Interactive Information Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology.*

More information available online at http://nowcoast.noaa.gov/help/techinfo.shtml?name=techinfo.

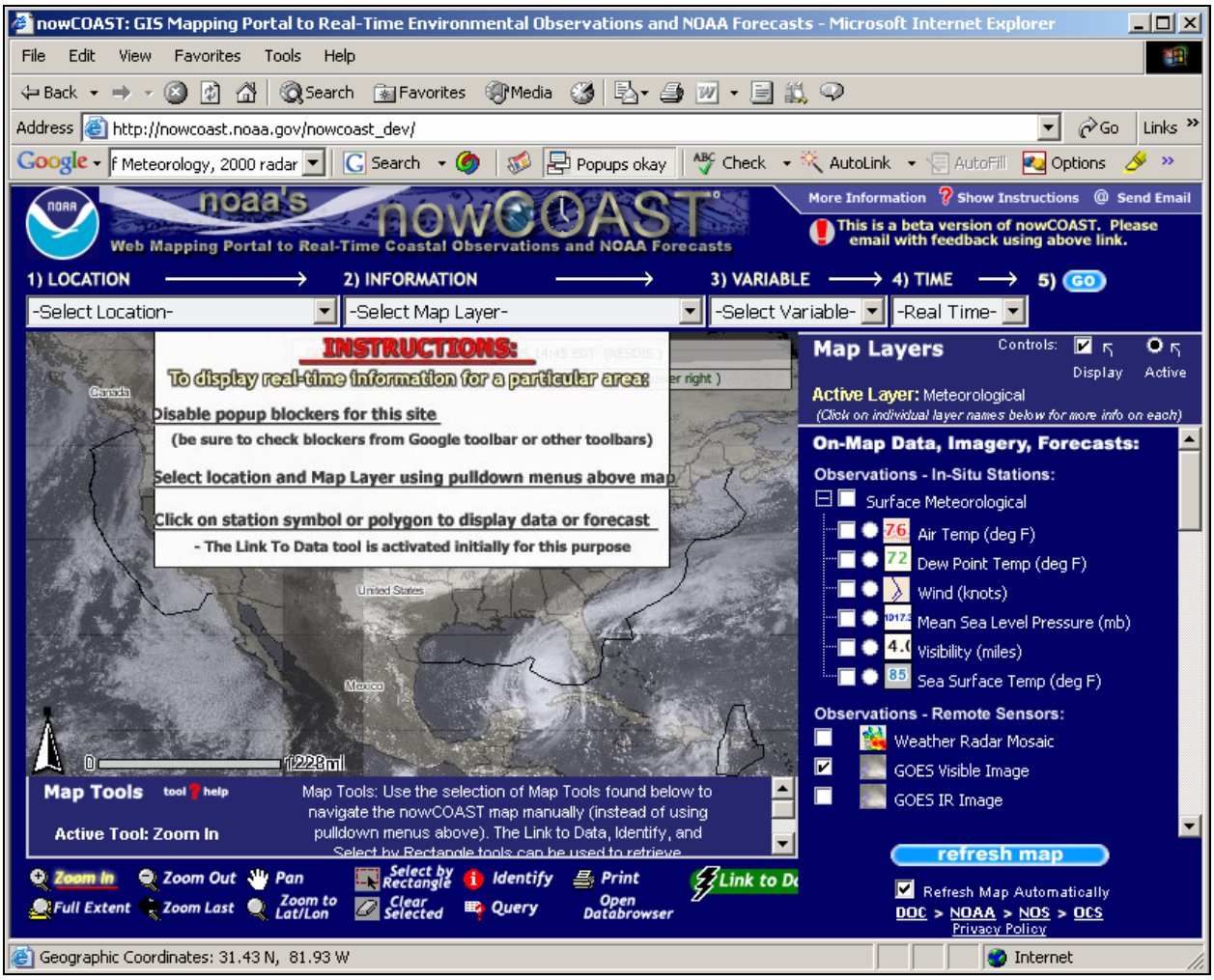


Figure 1. The nowCOAST Map Viewer in a Web browser on October 23, 2005.

Figure 2. The nowCOAST 'Jumpbar' Pulldown Menu Bar for Displaying Data on nowCOAST Map Viewer.

Figure.3.The nowCOAST Map Tools Interface Located Below nowCOAST Map for Direct Manipulation of the Map and Interaction with nowCOAST's Underlying Database.

Figure 4. An example of a nowCOAST Map Comparing Distribution of Weather and River Observation Stations overlayed on top of NWS Surface Weather Forecast Regions along with Visible Satellite and Composite Radar Images in the Lower Potomac River Watershed.

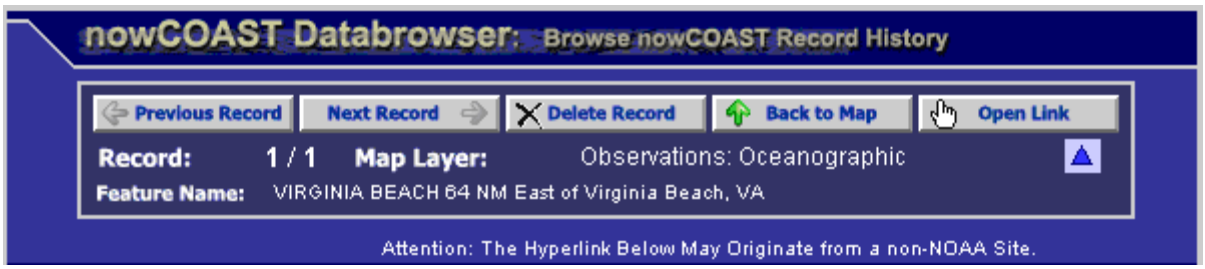


Figure 5. The nowCOAST Databrowser Interface (partial view).

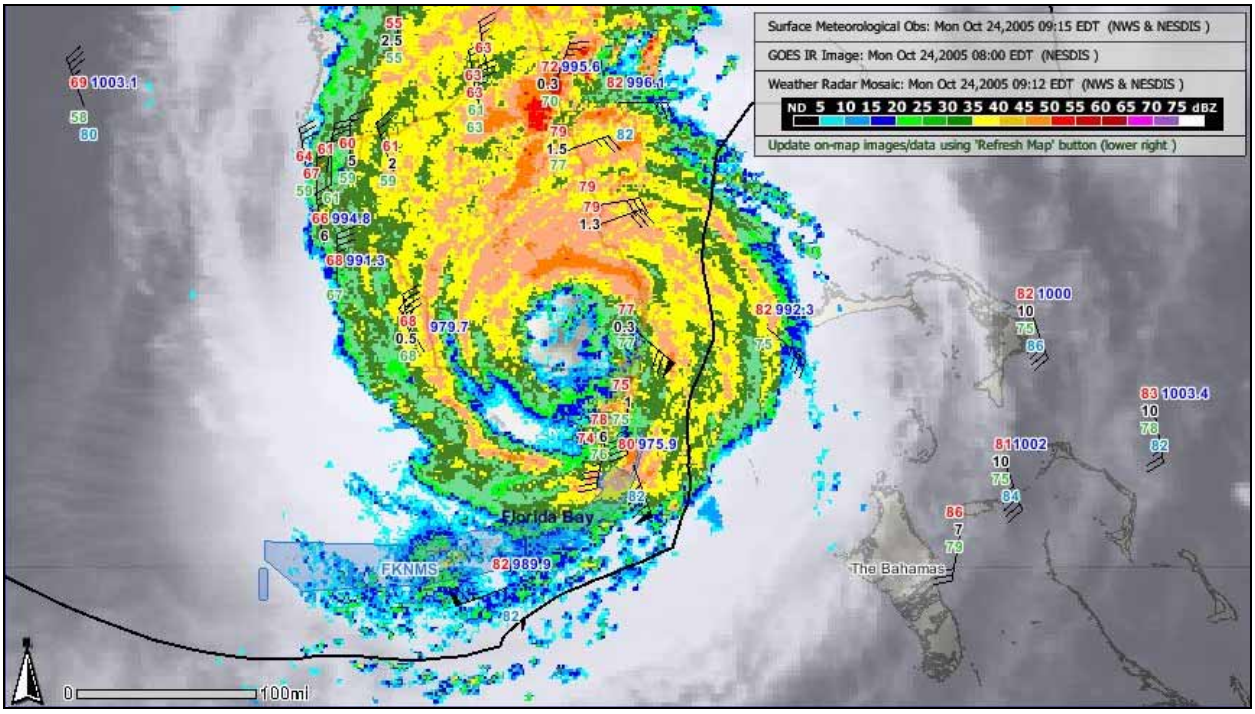


Figure 6. A nowCOAST screenshot of satellite overlaid by on-map observations, satellite and radar imagery of Hurricane Wilma on October 24, 2005 at 0930 EDT.

Figure 7. A nowCOAST screenshot the NWS Miami, FL Weather Forecast Office weather forecast discussion for the Florida Keys region depicted at the left. Discussion issued at 1040 EDT October 23, 2005.

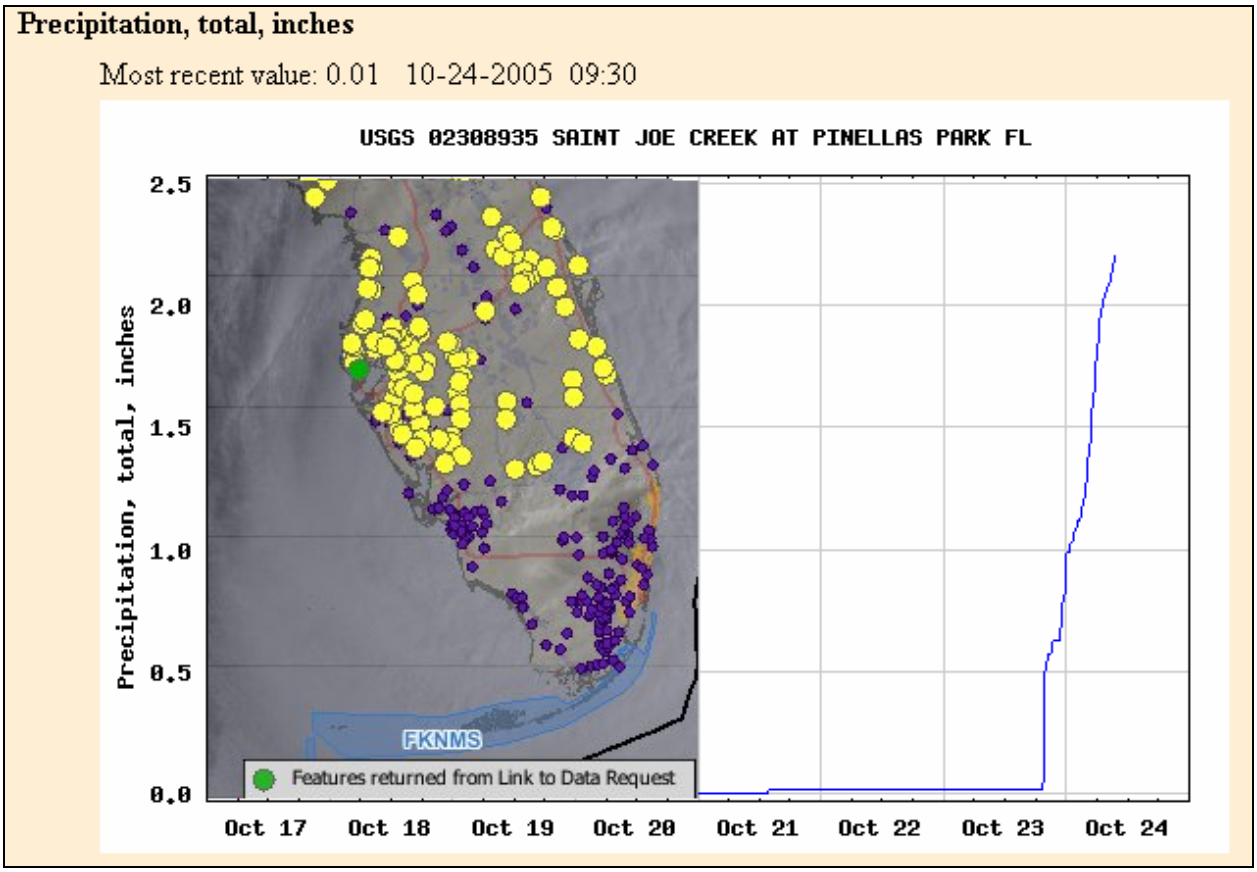


Figure 8. A screenshot of time series of precipitation at the USGS river gage station in Pinellas Park, FL obtained via nowCOAST on October 24, 2005. The Location of other river precipitation gages over central and southern Florida are represented by yellow circles. The blue line on the time series is the running precipitation total reported, in inches, at this location over the past week..

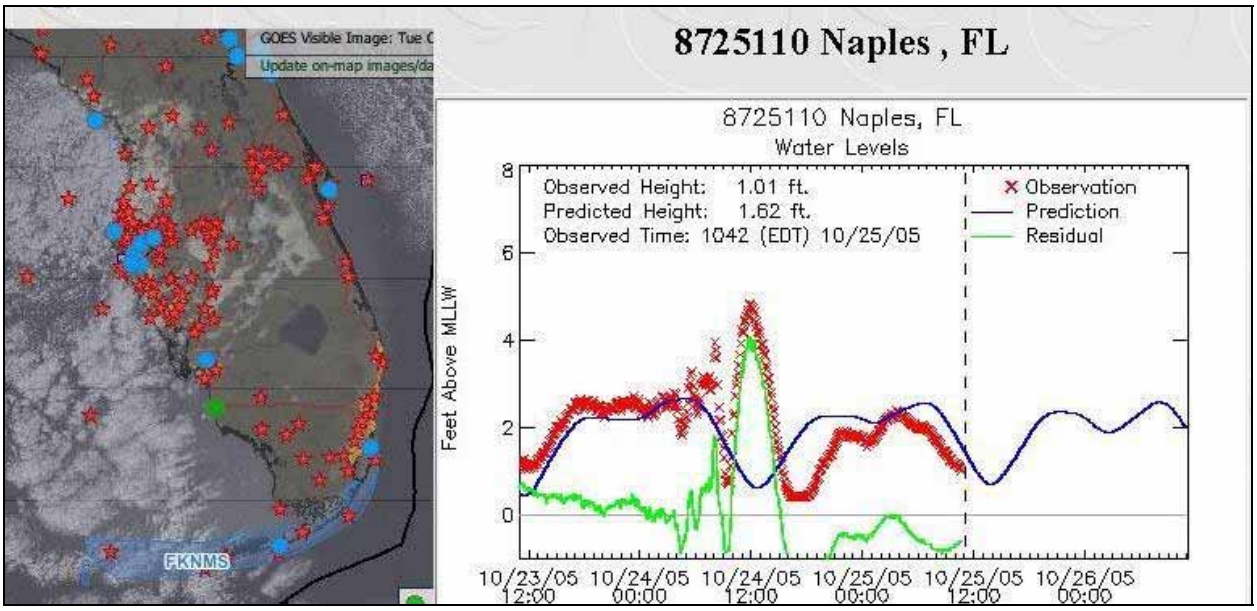


Figure 9. Time series of water observations for Naples, FL from NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) obtained via nowCOAST on October 25, 2005. The location of Naples, FL is depicted as a green dot on the map to the left. The blue dots represent all of the CO-OPS stations, whereas the red dots are all locations reporting meteorological observations.

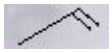
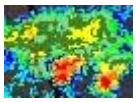
Variable or Imagery	Description	Example
Temperature (deg F)	The temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation.(AMS Glossary of Meteorology, 2000)	
Dew Point Temperature (deg F)	The dew point temperature is defined as the temperature to which a given air parcel must be cooled (at constant pressure and constant water vapor content) in order for saturation to occur. (AMS Glossary of Meteorology, 2000)	
Wind (knots)	The wind direction is the direction from which the wind is blowing (meteorological convention). For example, a NE wind direction means that the wind is coming from the NE. The wind direction is expressed in degrees from true north. The wind speed is the ratio of the distance covered by the air to the time taken to cover it. The wind speed is expressed in knots. (AMS Glossary of Meteorology, 2000)	
Mean Sea Level Pressure (mb)	The pressure exerted by the atmosphere as a consequence of gravitational attraction exerted upon the "column" of air lying directly above the point in question. As with any gas, the pressure exerted by the atmosphere is ultimately explainable in terms of bombardment by gas molecules; it is independent of the orientation of the surface on which it acts. Atmospheric pressure is one of the basic meteorological elements. It is measured by many varieties of barometer and is expressed in several unit systems. The most common unit used is the millibar (1 millibar equals 1000 dynes cm^{-2}). In regions where the earth's surface is above sea level, it is standard observational practice to reduce the observed surface pressure to the value that would exist at a point at sea level directly below if air of a temperature corresponding to that actually present at the surface were present all the way down to sea level. (AMS Glossary of Meteorology, 2000)	
Sea Surface Temperature (deg F)	The general definition of sea surface temperature (SST) is that it is the water temperature at 1 meter below the sea surface. (NOAA, 1998)	
Weather Radar Mosaic	A radar is an electronic instrument used for the detection and ranging of distant objects of such composition that they scatter or reflect radio energy, such as rain, snow or ice. NowCOAST displays the base reflectivity radar. This is a display of echo intensity (reflectivity) measured in dBZ (decibels of Z, where Z represents the energy reflected back to the radar). "Reflectivity" is the amount of transmitted power returned to the radar receiver. Base Reflectivity images are available at several different elevation angles (tilts) of the antenna and are used to detect precipitation, evaluate storm structure, locate atmospheric boundaries and determine hail potential. Base reflectivity only shows reflected energy at a single elevation scan of the radar, whereas composite reflectivity images scans many levels and displays the highest reflected energy found at various elevation angles.(AMS Glossary of Meteorology, 2000 and NOAA, 2004)	
GOES Visible and IR Imagery	GOES satellites circle the Earth in a geosynchronous orbit, which means they orbit the equatorial plane of the Earth at a speed matching the Earth's rotation. This allows the satellites to hover continuously over one position on the surface. The geosynchronous plane is about 35,800 km (22,300 miles) above the Earth which is high enough to allow the satellites a full-disc view of the Earth. GOES-East also called GOES-12 is positioned at 75 deg W longitude and the equator. GOES-West or GOES-10 is located at 135 deg W and the equator. The two satellites operate cover an area from 20 deg W to 165 deg E.	

Table 1. Descriptions of nowCOAST's on-Map Products

In-Situ Observing Networks:

Agency	Type	Number of Stations
NOS	Physical Oceanographic Real-Time System (PORTS)	64
	National Water Level Observing Network (NWLON)	232
National Data Buoy Center (**NDBC**)	Fixed Buoys	132
	Coastal Marine Automated Network (C-MAN)	59
NWS/**FAA**/Department of Defense (**DOD**)	Automated Surface Observing System (ASOS)	825
FAA	Automated Weather Observing System (AWOS)	151
NWS	Cooperative Observer Program (NERON)	102
	Integrated Flood Observing and Warning System (IFLOWS)	2029
	Remote Automated Weather Stations	1495
NOAA	Climate Reference Network (CRN)	69
	Ground-Based GPS Meteorology Demonstration Network (GSOS)	72
	UrBANet	10
	Great Lakes Network (GLERL)	8
	NOAA's Environmental Real-Time Observation Network	102
US Coast Guard	Manual Weather Observing Sites	7
EPA	Environmental Monitoring (EMPACT)	8
USGS	National Water Information System (NWIS)	9196
Non-Federal Regional Observing Networks	University of New Hampshire AIRMAP Network	3
	Carolinas Coastal Ocean Observing System (Caro-COOPS)	8
	Chesapeake Bay Observing System (CBOS)	3
	Columbia River Estuary (CORIE)	8
	Gulf of Maine Ocean Observing System (GoMOOS)	10
	Innovative Coastal-Ocean Observing Network (ICON)	2
	Long Island Shore Network (LIShore)	3
	Louisiana Universities Marine Consortium (LUMCON)	5
	Louisiana Agriclimatic Information System	25
	Martha's Vineyard Coastal Ocean Observatory	2
	Maryland Dept. of Natural Resources	14
	Maryland Dept. of Transportation	37
	New Jersey DEP	4
	North Carolina Coastal Ocean Observing System (NCCOOS)	1
	Network for Environmental Observations of the Coastal Ocean (NEOCO)	7
	Prince William Sound Network (PWSN)	7
	Scripps Institution of Oceanography	18
	South Atlantic Bight Synoptic Offshore Observational Network (SABSOON)	3
	Stevens Institute of Technology	3
	Texas Automated Buoy System (TABS)	9
	Texas Coastal Ocean Observation Network (TCOON)	48
	University of South Florida Coastal Ocean Monitoring and Prediction System (COMPS)	11
	Vermont Monitoring Cooperative's Lake Champlain Observing System	2
	Washington DOT Washington State Ferries	6
	Wave-Current-Surge Information System (WAVCIS)	7

Remote Sensing Observing Platforms:

Agency	Type	Number of Sites
NWS/**DOD**	Radiosondes	36
NOAA	Boundary Layer Profilers	46
NWS	NEXRAD Weather Radar	158
Non-Federal	HF Radar Surface Currents	11

Other Observing Platforms:

Agency	Type	Number of Cameras
Non-Federal / Various	Web Cameras	120

Predictions:

Agency	Type	Number of Locations
NOS	Astronomical Tidal	277

Forecast Model Guidance:

Agency	Type	Number of Locations
NOS	Chesapeake Bay Operational Forecast System (CBOFS)	11
	New York Operational Forecast System (NYOFS)	8
	Galveston Bay Operational Forecast System (GBOFS)	6
NWS/Meteorlogical Development Laboratory (MDL)	Model Output Statistics (MOS)	1730
NWS/MDL	Extra-Tropical Storm Surge (ETSS)	77
NWS/National Center for Environmental Prediction (**NCEP**)	WaveWatch III	41

Surface Forecasts:

Agency	Type	Number of Zones
NWS/Weather Forecast Office (WFO)	County Weather Forecasts	3470
NWS/WFO	Surf Zone Forecasts	14
NWS/WFO	Coastal/Offshore Marine Forecasts	392
NWS/**OPC**/**NHC**	High Seas Forecasts	7
NOAA/**NWS**	Harmful Algae Blooms Layer	1

Forecast Discussions:

Agency	Type	Number of Zones
NWS/Weather Forecast Office (WFO)	Coastal Marine and Reginal Weather	127
NOAA/OPC(Ocean Prediction Center)	Regional Hydrometeoroogical	13
NWS/WFO	Offshore Marine Forecasts	3

Table 2. nowCOAST's Database of Web Links to Observing Networks and Forecast Products.