A Wireless Real-Time Coastal Observation Network

A new integrated coastal observation system is providing preliminary data from the North American Great Lakes. This system can be implemented in other coastal regions. To date, it has been successfully deployed on Lakes Michigan, Huron, and Erie to make seabed to sea-surface measurements of chemical, biological, and physical parameters, which are transmitted wirelessly through buoys and permanent stations. Called the Real-Time Coastal Observation Network (ReCON), the new system leverages existing networking technology to provide universal access to a wide variety of instrumentation through the use of an underwater Ethernet port server [Mohr, 2002]. A team of NOAA engineers and scientists has completed the development and testing of this integrated coastal observation network.

Utility of the Network

An Ethernet-based coastal observation network design enables the creation of system components, such as sensor drivers, data transfer software, system control functions, database management, web display and archival functions, using standard web-design tools. The underwater, universal hub easily allows the attachment of sensors at any time during the deployment period. Portable buoys and permanent stations transferring data into network nodes distributed across broad coastal regions can be integrated at a central location using the Internet. This implementation of a coastal network providing real-time chemical, biological, and physical observations has already benefited ecosystem researchers, resource managers, forecasters, educational institutions, and public users. Further, regional observations downloaded at time intervals required to describe particular ecosystem features and events can be presented to managers and operational forecasters through ad hoc web displays or to students and researchers through searchable database management systems.

Using this approach, an observation network can be deployed in any coastal region with Internet availability. Buoys need only be placed within antenna range of the shore station. Deployment range, dependent on the height of the shore antenna, can be as much as 32 kilometers allowing buoy placement anywhere within an approximate 1600 square-kilometer area. Additional buoys or fixed stations can be used to extend range through the use of the relay capability inherent in wireless network devices. The observation network supplies enough throughput capacity to simultaneously support continuous measurements from both standard oceanographic and meteoroilogical instrumentation (such as wind and temperature measurements, current velocity profiles, and chemical sensors) and more advanced surface and underwater applications such as streaming imagery.

By leveraging existing internet technology for real-time data collection, the ReCON observation infrastructure can be significantly upgraded to provide forecasters, researchers, coastal resource managers, and the public with the data necessary to make informed decisions in response to ecosystem change [Ocean 05, 2002].

The transition of this research and development effort to an operational coastal implementation has the potential to improve forecasts and forecast verification, increase marine safety, and reduce public health risks while responding to established national goals [Ocean 05, 2000].

Network Specifications

The important aspects of the ReCON coastal internet-based network are the ability to wirelessly connect buoys to shore at distances up to 32 kilometers or to other buoys in an array, and to connect vessel-based data collection systems through offshore buoys or directly to the shore. The ReCON universal hub provides a standard instrumentation interface for the deployment of multi-sensor data collection platforms. Data archiving, data management, and system control are implemented through the Internet.

Portable buoys [Frey et al., 2000] and permanent stations are connected to shore through wireless internet radios capable of providing up to 1.5 megabytes per second of system bandwidth. Connections to underwater instrumentation are implemented through a marine-grade Ethernet network cable. This connection allows buoy computer access to data or imagery from multiple devices plugged into an underwater network hub using standard marine connectors. Data and imagery are first transferred to and stored on the buoy computer, then transferred at a scheduled time (typically hourly) to the shore computer over the wireless internet connection.

System Implementations in the Great Lakes

Permanent and buoy-based ReCON systems have been deployed at coastal locations around the Great Lakes, beginning in 2003. A network computer located at the Great Lakes Environmental Research Laboratory (GLERL) in Ann Arbor, Mich., accesses the data from shore computers through the Internet. The buoy computer monitors the solar-battery power system, allowing variable power cycling to conserve energy during periods of limited solar exposure. Underwater sensors can be re-programmed from the central computer in Ann Arbor in anticipation of rapidly changing ecosystem events. During such episodic events, specific system components can be placed in continuous operation to enable high resolution temporal sampling.

A ReCON system deployed on western Lake Erie on a U.S. Coast Guard navigation structure, in collaboration with the University of Toledo’s Lake Erie Center (located in Oregon, Ohio), supported preliminary investigations into conditions contributing to episodic hypoxia events and subsequent effects on benthic organisms. Figure 1 shows data collected from this station during 2005. Water depth at the station was 8 meters. Sensors at the station included a bottom-mounted acoustic Doppler current profiler, a YSI 6000E multiprobe, and a bottom-mounted acoustic Doppler current profiler, a YSI 6000E multiprobe.

Fig. 1. (a) Wind speed in meters per second (blue) and current speed 1 meter above the bottom in centimeters per second (black). (b) Wind direction (blue) and current direction at 1 meter above bottom (black). The wind direction follows the meteorological convention, so the wind is from the direction indicated. The current direction follows the oceanographic convention so the flow is toward the direction shown. (c) Water temperature 1 meter above the bottom (black) and dissolved oxygen concentration in milligrams per liter 1 meter above the bottom.
The campaign will focus on a region of the atmosphere called the tropical tropopause layer (TTL), the transition region between the troposphere and stratosphere. The TTL is the boundary between two regions of the atmosphere: the troposphere, where weather occurs, and the stratosphere, which is largely free of weather. The TTL is a critical layer because it can significantly influence weather and climate. The campaign is designed to collect data to better understand the TTL and its role in the Earth’s climate system.

The team is using a variety of instruments and techniques to collect data in the TTL. They will use airborne platforms, such as NASA’s King Air Plane and the NASA Armstrong Flight Research Center’s C-130, to collect data from the surface to high altitudes. They will also use ground-based instruments and satellite data to collect information about the TTL.

The campaign is expected to last for several months, during which time the team will collect data on the TTL’s properties, such as temperature, pressure, and composition. The data collected will be used to improve our understanding of the TTL and its role in the Earth’s climate system. The campaign is an important step in achieving this goal, and it is expected to provide valuable insights into the TTL and its impact on the Earth’s climate.