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Workshop Proceedings

APPLICATION OF DRIFTING BUOY TECHNOLOGIES FOR COASTAL WATERSHED AND ECOSYSTEM MODELING

Ann Arbor, Michigan

June 5-7, 2005

Funded by NOAA's Coastal Services Center through the Alliance for Coastal Technologies (ACT)

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An ACT 2005 Workshop Report

A Workshop of Developers, Deliverers, and Users of Technologies for Monitoring Coastal Environments:

Application of Drifting Buoy Technologies for Coastal Watershed and Ecosystem Modeling

Ann Arbor, Michigan

June 5-7, 2005

Sponsored by the Alliance for Coastal Technologies (ACT) and NOAA's Center for Coastal Ocean Research in the National Ocean Service.

Hosted by ACT Partner organization the University of Michigan.

ACT is committed to develop an active partnership of technology developers, deliverers, and users within regional, state, and federal environmental management communities to establish a testbed for demonstrating, evaluating, and verifying innovative technologies in monitoring sensors, platforms, and software for use in coastal habitats.

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ACT WORKSHOP: APPLICATIONS OF DRIFTING BUOY TECHNOLOGIES FOR COASTAL WATERSHED AND ECOSYSTEM MODELING

EXECUTIVE SUMMARY

The Alliance for Coastal Technologies (ACT) Partner University of Michigan convened a workshop on the Applications of Drifting Buoy Technologies for Coastal Watershed and Ecosystem Modeling in Ann Arbor, Michigan on June 5 to 7, 2005.

The objectives of the workshop were to: (1) educate potential users (managers and scientists) about the current capabilities and uses of drifting buoy technologies; (2) provide an opportunity for users (managers and scientists) to experience first hand the deployment and retrieval of various drifting buoys, as well as experience the capabilities of the buoys' technologies; (3) engage manufacturers with scientists and managers in discussions on drifting buoys' capabilities and their requirements to promote further applications of these systems; (4) promote a dialogue about realistic advantages and limitations of current drifting buoy technologies; and (5) develop a set of key recommendations for advancing both the capabilities and uses of drifting buoy technologies for coastal watershed and ecosystem modeling.

To achieve these goals, representatives from research, academia, industry, and resource management were invited to participate in this workshop. Attendees obtained “hands on” experience as they participated in the deployment and retrieval of various drifting buoy systems on Big Portage Lake, a 644 acre lake northwest of Ann Arbor. Working groups then convened for discussions on current commercial usages and environmental monitoring approaches including; user requirements for drifting buoys, current status of drifting buoy systems and enabling technologies, and the challenges and strategies for bringing new drifting buoys "on-line".

The following general recommendations were made to:

1). organize a testing program of drifting buoys for marketing their capabilities to resource managers and users.

2). develop a fact sheet to highlight the utility of drifting buoys.

3). facilitate technology transfer for advancements in drifter buoys that may be occurring through military funding and development in order to enhance their technical capability for environmental applications.

In addition to the general recommendations, the following recommendations were directed to ACT because of the programs command of both organizational and technological resources:

1). Facilitation of communication forums (on-line or other) to disseminate ideas and results was recommended.

2). Development of funding mechanisms for mini grants (or others) between industry and users of environmental applications which could utilize specific medical/biotech cross-over technologies along with support from the National Institute of Health (NIH) was encouraged.

ALLIANCE FOR COASTAL TECHNOLOGIES

There is widespread agreement that an Integrated Ocean Observing System (IOOS) is required to meet a wide range of the Nation's marine product and information service needs. There also is consensus that the successful implementation of the IOOS will require parallel efforts in instrument development and validation and improvements to technology so that promising new technology will be available to make the transition from research/development to operational status when needed. Thus, the Alliance for Coastal Technologies (ACT) was established as a NOAA-funded partnership of research institutions, state and regional resource managers, and private sector companies interested in developing and applying sensor and sensor platform technologies for monitoring and studying coastal systems. ACT has been designed to serve as:

- An unbiased, third-party testbed for evaluating new and developing coastal sensor and sensor platform technologies,
- A comprehensive data and information clearinghouse on coastal technologies, and
- A forum for capacity building through a series of annual workshops and seminars on specific technologies or topics.

ACT, Headquartered at the UMCES Chesapeake Biological Laboratory, has eight Partner Institutions around the country that provide a variety of habitats and a range of technical expertise for testing sensor sensor/platforms for use in coastal observing systems.

The Stakeholder Council provides input into ACT priorities from private sector companies and resource managers involved in sensor technology development and use.

The regional Alliance Member Chapters organized by each ACT partner assures input from the broader coastal observing community stakeholders.

The ACT workshops are designed to aid resource managers, coastal scientists, and private sector companies by identifying and discussing the current status, standardization, potential advancements, and obstacles in the development and use of new sensors and sensor platforms for monitoring, studying, and predicting the state of coastal waters. The workshop goals are to both help build consensus on the steps needed to develop and adopt useful tools while also facilitating the critical communications between the various groups of technology developers, manufacturers, and users.

ACT Workshop Reports are summaries of the discussions that take place between participants during the workshops. The reports also emphasize advantages and limitations of current technologies while making recommendations for both ACT and the broader community on the steps needed for technology advancement in the particular topic area. Workshop organizers draft the individual reports with input from workshop participants.

ACT is committed to exploring the application of new technologies for monitoring coastal ecosystem and studying environmental stressors that are increasingly prevalent worldwide. For more information, please visit http://www.act-us.info/.

GOALS FOR THE DRIFTING BUOY WORKSHOP

The ACT Workshop on Applications of Drifting Buoy Technologies for Coastal Watershed and Ecosystem Modeling sought to summarize the state of drifting buoy technologies and to make strategic recommendations for the future development and application of drifting buoys for commercial use and coastal environmental research and monitoring.

The workshop addressed the following goals:

- To educate potential users (resource managers and scientists) in the current capabilities of drifting buoy systems,
- To provide an opportunity for users (resource managers and scientists) to observe first hand the deployment, drift, and recovery of various drifting buoys,
- To engage manufactures with scientists and managers in discussions on system capabilities and requirements needed to promote further application of their drifting buoys systems,
- To promote a dialogue about realistic advantages and limitations of current drifting buoy capabilities, and
- To develop a set of key recommendations for advancing both the capabilities and uses of drifting buoy systems.

ORGANIZATION OF THE DRIFTING BUOY WORKSHOP

The Application of Drifting Buoy Technologies for Coastal and Estuarine Modeling was held on June 5-7, 2005 at the University of Michigan at Ann Arbor, Michigan. The workshop was sponsored by University of Maryland ACT Partner comprised of The University of Michigan's Cooperative Institute of Limnology and Ecosystems Research (CILER) and the Marine Hydrodynamics Laboratories. The workshop organization committee was: Dr. Tom Johengen, Dr. Guy Meadows, Mr. Hans Van Sumeren and Ms. Heidi Purcell.

Participants arrived in Ann Arbor the afternoon of Sunday June 5, and gathered that evening for a reception and dinner. Participants were welcomed to the workshop by Dr. Guy Meadows and they viewed a presentation introducing them to the ACT program by Dr. Tom Johengen. The key note speaker, Mr. Alex Steele of the Los Angeles County Sanitation District, delivered a presentation highlighting the drifting buoy program they have implemented for ocean monitoring sewage outfalls. Monday morning, participants gathered at Portage Lake Yacht Club to hear brief introductions on each drifting buoy system to be demonstrated by participating manufacturers. Following the presentations, participants loaded onto pontoon boats for buoy deployment. Participants were given the opportunity to observe the deployment of each buoy, as well as the buoys' behavior in the water and their retrieval.

Once ashore, participants attended manufacturer presentations as well as welcome and workshop organization presentations by Dr. Guy Meadows and workshop facilitator Dr. Nancy French. Participants then divided into groups of individual sectors; academia/research, industry, and resource managers, to address the discussion questions.

Discussions focused on the following four charge questions:

1. What are the problems with current environmental monitoring approaches?
2. What are the requirements for drifting buoy systems?
3. What is the current status of drifting buoy systems and enabling technologies?
4. What are the challenges and strategies for bringing new drifting buoy systems "on-line"?

The groups reported out on their deliberations during the following plenary session. The final day participants divided into cross-sector groups to discuss the output from Monday's plenary session and refine their recommendations. Cross-sector facilitators then presented their recommendations in a final plenary session. All recommendations were then voted upon by all participants to refine them to the listed 5 recommendations.

OVERVIEW OF DRIFTING BUOYS

Lagrangian drifting buoys can be used for tracking fish larvae, ice bergs, pollutants and oil slicks. They can be used in search and rescue, as well as for gathering data such as current velocities, current direction, and ocean temperatures to better enable scientists to model the ocean environment and associated climate.

In addition to Lagrangian buoys, floating buoys are used in cases when it is not required to follow a moving parcel of water. These buoys do not necessarily follow the current, but are deployed and allowed to move with the wind while collecting data.

Although drifting buoys have been used to study the ocean environment dating back to the Challenger Expedition in 1872, their usefulness was limited by the inability to accurately track the buoys for great distances. In the 1970's the implementation of the ARGOS satellite system helped solve this problem. The ARGOS instrument, located aboard the NOAA Polar-orbiting Operational Environmental Satellites (POES), can receive data transmitted by the buoys and relay that data to ground stations around the world. This system has made it possible to easily track the movements of a great number of buoys scattered over a large area. This technological development paved the way for two of the more ambitious ocean circulation programs that are gathering a large collection of data on the world's oceans. As these programs developed so did the drifting buoys themselves, making available a variety of drifting buoys, many of which were represented at this workshop.

Global Drifting Program

Since 1988 over 2,500 Lagrangian drifters have been deployed as part of the Surface Velocity Program (SVP) of the World Ocean Circulation Experiment (WOCE) and the Tropical Ocean and Global Atmosphere Program (TOGA), and then of Global Drifter Program. On September 18, 2005, the Global Drifter Program will reach its goal of 1,250 buoys in sustained service. This program, a component of the Global Ocean Observing System, provides mixed layer velocity and sea surface temperature observations in all major ocean basins. In 1991 the buoys deployed for this program were standardized to the surface velocity profile (SVP) drifter. The SVP consists of a spherical hulled surface buoy containing the ARGOS antennae, electronics, and sensors, a sub-surface sphere at about 3 meters to reduce the wave motion effects on the drogue, and a holey-sock drogue centered at a depth of 15 meters. The data from these buoys are distributed in real time onto the Global Telecommunications System (GTS) and to the Drifting Buoy Data Assembly Center.

Argo

The Argo array, as part of the Integrated Global Observation Strategy, has deployed 1,960 floats since 2000, with a goal of 3,000 floats deployed in 3 degree spacing reporting 100,000 temperature and salinity profiles per year by 2006. Argos are autonomous profiling floats that collect temperature and salinity data from the upper 2,000 meters of ice free ocean. Once deployed, the floats submerge to approximately 2,000 meters. Every 10 days they slowly rise to the surface testing the sea temperature and salinity as they rise. Once on the surface, the float transfers its data to an orbiting satellite then submerges to repeat this cycle. Data is transferred via GTS and made public within 24 hours of collection. The floats are designed for approximately 150 of these cycles.

Although the Global Drifting Program and the Argo Array may be two of the largest projects, they are certainly not the only ones currently using drifting buoys. Numerous projects using a variety of drifting buoy technologies are on-going at this time, many of which occur in the coastal and estuarine environment. The open ocean design of the drifting buoys used in the above mentioned programs must be adjusted for the higher traffic, shallower waters, as well as the smaller spatial and temporal scales occurring in the coastal estuarine environment.

The ARGOS positioning system is accurate from150 to 1000 meters, a resolution that is sufficient for the large scale ocean currents, but cannot accurately portray the finer motions within the coastal zone. A higher resolution tracking method must be refined in order to obtain the data needed to accurately model the coastal environment. The installation of GPS (Global Positioning System) in the buoys using a cellular communications system to transmit data in the near-real-time is currently being investigated by Ohlmann et al. This method demonstrates an accuracy of 10 meters, a fine enough resolution for modeling the coastal and estuarine environment.

WORKSHOP RECOMMENDATIONS

Three general recommendations came from the workshop deliberations:

- The organization of a testing plan of drifting buoys for marketing their capabilities to managers and users. The implementation of a testing program for drifting buoys would serve several purposes; it would make available to users unbiased information on the quality and performance of the various drifting buoys, educate the resource managers and scientists in the current drifting buoy technologies and their possible uses, as well as expand the current market of users by making product information more accessible.

- The development of a fact sheet to highlight the utility of drifting buoys. The development of an information sheet containing the current available sensors, drogues, buoy hulls, as well as data collection and transfer options that could be posted, possibly on the ACT website, for reference by all interested users and manufacturers could alert these parties to the questions and problems that drifting buoys can best address.

- The facilitation of technology transfer for advancements in drifter buoys that may be occurring through military funding and development in order to enhance their technical capability for environmental applications. The research and technological advances funded through military agencies such as DARPA can be valuable to both drifting buoy users and manufacturers, but is not always available for public use. The pursuit of a similar level of research for environmental applications would greatly enhance the technological capabilities of current drifting buoy systems.

Two recommendations were directed to ACT to consider in developing its program:

- The facilitation of forums to disseminate ideas and results. Creating an on-line forum for daily/weekly discussions will greatly aid in the dissemination of information among interested parties. This on-line forum could be augmented by an annual conference that would allow for product demonstrations, presentations on current research, commercial drifting buoy projects, as well as the result of the testing program mentioned in the above general recommendation.

- The facilitation of funding mechanisms for mini-grants, partnerships between industry and users for research and development. The majority of the drifting buoy manufacturers are small businesses, with current development funding originating with science research funding. This creates a "short fuse" response, with manufacturers concentrating their development on immediate research needs. It is critical to the advancement of drifting buoy technologies to create a "longer fuse" atmosphere, in which manufactures can focus on development based on perceived future needs.

APPENDIX A. DEMONSTRATED DRIFTING BUOYS

Demonstrated Drifting Buoys

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Product Description
The Microstar Coastal Lagrangian Drifter is a low-cost, current following drifter designed to meet the characteristics of coastal environments, tracking the mean current at a fixed depth (1m to 5m) beneath the water surface. It may be used as an expendable drifter, but can also be recovered and redeployed. Telemetry options are Mobitex terrestrial data packet network, Argos satellite system, Global Star satellite system or Inmarsat D+. Onboard sensors include GPS, Sea Surface Temperature, Battery Voltage, Submergence and an optional salinity sensor. Transmitted data is received by a host computer continuously connected to the Web and available in near-real time on a password protected web site. Data retrieval is available by pager or laptop in areas without internet access. The drogue is a tristar configuration constructed of nylon that may be collapsed like an umbrella for large array deployment from a small platform. The standard drogue is modular and may be replaced if it is damaged or lost. Its depth is centered at 1 m below the surface with a drag area ratio of greater than 40. Other custom depths are available. Battery life ranges from 1 week to more than 1 year depending on the telemetry system, sensor load and battery type. The Microstar has been independently calibrated with both current meters and HF radar to verify its water following capabilities.

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Product Description
Automated Lagrangian Water-Quality Assessment System (ALWAS) is an inexpensive, free-floating, water quality measuring and water shed evaluation system. It is capable of making a wide range of measurements rapidly and simply and storing the results for later retrieval. The system includes the buoy, water quality and parameter sensors, a microprocessor and recording device, GIS interface software, and a decision support system (DSS) that generates water quality maps based on the measurements. The buoy, as presently configured, measures temperature, depth, conductivity, pH, dissolved oxygen, turbidity, chlorophyll-A, nitrates, barometric pressure as well as GPS data such as geographic location, speed, number of satellites used, date and time. Optional sensors available are salinity, total dissolved solids (TDS), oxidation reduction potential (ORP), chlorides, fluorides, copper, zinc, and ammonias. The buoy can record up to thirty hours of data with all parameters being measured at 10-second intervals.

3. Brightwaters Instrument Corporation
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Product Description
The Brightwaters model 104 Autonomous GPS Drifter is a Lagrangian drifting buoy similar in design to the Coastal Ocean Dynamics Experiment (CODE) drifter developed at the Scripps Institute of Oceanography. This drogue design provides excellent coupling with the surface layer and exhibits little wave rectification. The positioning series is stored internally as well as telemetered via short-range packet radio and/or the ARGOS satellite network. Two sizes of this drifter are available. The standard size has a six-inch diameter case, a long battery life and can be fitted with more options. The smaller buoy has a three-inch diameter case, this "mini" can be easily hand deployed and retrieved by one person. Standard sensors available are temperature and salinity, but these buoys feature robust expansion capability, for custom configurations and sensor payloads.

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Product Description

CSBuoy-NS is a wireless, floating, self-contained package that allows resource managers to monitor critical water quality parameters. The buoy requires a minimal amount of setup and can be easily deployed. The buoy does not include sensors, allowing customization to fit the user's needs. The on-board data logger must be programmed to measure the user's sensors. The polyethylene buoy houses a data logger, a wireless transceiver, ¼ wave whip antenna, rechargeable battery and solar panel. The data collected by the data logger can be retrieved via radio or directly with a computer or handheld PDA. The unit is powered by 12VDC battery and charged with a 5 watt solar panel. This power configuration allows the CSBuoy to collect data continuously over many months or years without interruption. The buoy weighs approximately 35 lbs., 47 inches in height, and 30 inches in float diameter. The CSBouy-NS is made for the quiet water marine environment (ponds and small lakes) it is not suitable for wave or tidal activity.

5. Metocean Data Systems Limited
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Product Description

The Davis Drifter was developed as a Coastal Ocean Dynamics Experiment (CODE) drifter in the 1980s by Dr. Russ Davis of Scripps Institute of Oceanography. The drogue is designed to carry the buoy in currents within one meter of the water surface. The data acquisition and processing electronics can be interfaced with a wide array of sensors, dependent on the users needs. The sensors can be mounted directly to the hull or suspended below it. A Rockwell International GPS engine can also be incorporated to provide position accuracies that are necessary for coastal studies. The aluminum hull is 4 inches in diameter and weighs 27 pounds. Position is telemetered via ARGOS satellite network. Operating life is 50, 100, 150 days with a 30-minute update rate. Standard sensors are Sea Surface Temperature, Battery Voltage and GPS receiver.

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