CaRICOOS Conceptual Design

Program: IOOS

RA: Caribbean Regional Association (CaRA, ARCa in Spanish)

RCOOS: Caribbean Regional Integrated Coastal Ocean Observing System

Priorities

CaRA Stakeholders have identified sea state and marine weather (winds, waves, currents and storm surge/coastal inundation) as the highest priority needs for ocean observing and forecasting in the region. Enhanced observations/forecasts are expected to minimize loss of life and/or property while providing adequate support to marine recreational/tourist activities. The latter constitutes an important segment of our region economy. Variables pertinent to long-term climate change such as sea surface temperature or sea level are of interest to a narrower range of issue-focused stakeholder sectors.

CaRA stakeholders have expressed great uncertainty in regard to coastal development and other uses of our coastal regions in the light of climate change trends and the foreseen changes in tropical storm intensities and sea level change. Stakeholders in need of the flood maps and associated products to be derived from these forecast tools are: emergency managers and the Commonwealth's Emergency Management Agency, planners, social scientists, the National Weather Service/NOAA, population living near the coast, developers, the Commonwealth's Tourism Company, the Commonwealth's Office of the Insurance Commissioner, the Commonwealth's Port Authority, the Commonwealth's Electric Power Authority (all power plants all located by the coastline), and all businesses located at, and depending on, ocean-related activities.

In-water observation assets here proposed will allow unprecedented implementation of operational coastal ocean observation in the CaRA region and demonstration of the RCOOS concept. Our work will support NWS San Juan in its mission; support economic development trough providing for safe marine recreational activities, essential to the tourism industry of the CaRA region; support environmental management of essential fish habitat conservation and restoration, fisheries and live resource management; provide for safer maritime operations including commercial and recreational sectors and port operations; support commercial fisheries efforts; support emergency management for search and rescue, coastal inundation and pollutant dispersion; support state and federal planning agencies in coastal zone decision making and facilitate marine environmental research.

CaRICOOS Conceptual design

We propose to assemble fundamental elements including infrastructure, expertise, logistic and technical resources into an operational regional observing system delivering data to government and private stakeholders as well as tailored data products to pertinent societal sectors. These elements have been identified in diverse programs, institutions and agencies. In order to optimize investment in observational infrastructure while assuring sustained operations without overextending regional capabilities we propose to a) deploy field assets at optimal sites identified through gap analysis and research derived and climatologic data analysis, an utilize numerical model to provide context for “in situ” observations and region wide nowcasting b) utilize proven technology and expertise which will be transferred to the region and c) build upon existing infrastructure and expertise available in/for the region.

CaRA has identified the four core areas of winds, waves, currents, and coastal inundation in which operational numerical modeling efforts are to be focused. These modeling components correspond to a similar thrust in the proposed coastal observational component of this proposal. Experts in each modeling component have been consulted and recruited to guarantee the timely generation of operational products that meet our stakeholder needs.

Observing System

The observing system CaRA proposes to implement intends to integrate and optimize a core suite of coastal observations into a region-specific framework of products and services driven by needs expressed by of our stakeholders. There is currently no single coherent, integrated effort directed to the coastal and near-coastal environments in the CaRA region. Observing systems independently focused on weather, cyclones, earthquakes, and tsunamis are currently in place within our region, however, the region is devoid of observing platforms instrumented to observe the coastal ocean. We seek to bring CaRA into the IOOS national effort through the implementation of new observational and modeling assets for the region. Our uniqueness within the national context and the expressed goals and objectives of IOOS provide ample justification for the existence of CaRICOOS.

Elements for the Observing system will include:

Coastal Buoys Systems

CaRA Stakeholders have identified sea state (winds, waves and currents) as the highest priority needs for ocean observing. While CaRA will rely heavily on ocean modeling to meet these needs, in situ assets for real time data and model validation will be essential. Initially CarICOOS plans call for 3 buoys. Hardware cost: $1,000,000. Operating cost $ 250,000/year.

The geographic configuration of the archipelago domain requires instrumentation to be deployed at spatial scales adequate to resolve this complexity.

Long term plans call for 5 fully instrumented coastal buoys. Additional Hardware cost: $1,000,000. Operating cost $ 250,000/year.

HF Radar

Full HF radar coverage for coastal waters of PR and the USVI is a priority for SAR, spill trajectory evaluation and environmental modelling. Initially, we propose a long range system which will require 15 antenna emplacements. Hardware Cost $ 1,700,000. Operation Cost: $200,000/year In the longer-term, we will plan for short-range systems filling in the more sensitive areas such as the Vieques Sound and Mona Passage. Hardware costs $500,000. Operating cost: $100,000/year.

Inshore water quality buoys

In support of public health initiatives for beach water quality, CarICOOS will include and array of inshore buoys equipped for water quality monitoring, measuring parameters known to correlate to pathogenic contaminants including salinity, turbidity and dissolved oxygen. Currently the PR Environmental Quality Board monitors 24 beaches in Puerto Rico, Vieques and Culebra and the VI Department of Planning and Natural Resources monitors

45 beaches in St. Thomas, St. Croix and St. John. Hardware cost: $ 3,500,000 Operation cost: $ 200,000/year.

Hurricane intensification forecast capability

Uncertainty in the oceans upper heat content is a primary unknown in forecasting intensity and tracks of large storms. A multi-RA initiative addresses this knowledge gap through the STORM glider initiative. Expressed stakeholder concerns regarding wind and inundation damage and storm track trajectories will be addressed through a long-term program to better understand tropical storm system dynamics.

Table 1. CaRICOOS activities and products.

Product Area	**Activity**	**Specific Products**
Coastal Meteorological data	Observing network operation	Near realtime wind speed and direction data display and warning products Web based Radio Mobile cel Kiosk displays
	operational WRF model output	Input to NWS for Graphical Forecast System
	operational RAMS model output	
	Hardened met station operation	

Sea State (winds, waves & currents)	Instrumented buoy network	Near realtime ocean wind speed and direction products Wave height period and direction data display and warning products Web based Radio Mobile cel Kiosk displays
	Surface current mapping	Outreach through Alliance for Minority Participation targeting school teachers
	HYCOM-ROMS circulation model output	Outreach through NOAA CREST program
	ADCIRC coastal inundation models output	Specific inundation products for emergency managers and infrastructure planners
	SWAN waves output	
Water Quality	Coastal buoy observing network	Buoy output to PR-EQB and VI-DPNR
	Surface current mapping	

Tropical Cyclone hazards	Storm Glider initiative	Ocean heat content and water column structure in support of heat flux research

Data Management

Locally generated, operational, regional model outputs as well as regional “in situ” observations will be made available to our stakeholders, and to the general public, through the implementation of IOOS-DMAC standards. We will establish an OPeNDAP server as our primary model data repository and web distribution vehicle. Tools for the distribution of unstructured grids will be implemented by the ADCIRC modeling group.

DMAC compliance by the coastal observing buoys will be initially handled by PhOG/OST. Similarly, atmospheric data DMAC will be initially handled by WeatherFlow. We propose to recruit DMAC-cognizant IT personnel from UPRM’s engineering programs. Selected candidates will be trained in DMAC standards and procedures by the buoy and modeling teams and by several RAs which have offered to help us develop DMAC expertise.

Modeling - Data Analysis – Product Development

The CaRICOOS’ modeling and data analysis component will generate coastal wind, wave and circulation forecasts while providing an integrative regional context to observational data from core coastal observing assets. The modeling program will also generate improved storm surge driven coastal inundation maps and surface tidal elevation products.

Wind products are currently being generated from our local implementation of the WRF (Weather Research and Forecasting). The model has been tested and calibrated, and sustained operational output (exp) has been achieved, in a 4 km grid; we are pursuing a final resolution of 2 km. Boundary and initial conditions are captured from standard NWS output. On a longer term basis CaRICOOS will develop operational ensembles from WRF and RAMS.

Wave products will be derived from the SWAN (Simulating Waves Nearshore) model as implemented by Dr. Juan Carlos Ortiz in his PhD dissertation in 2003. Dr. Ortiz used three nested computational grids: 1) a coarse grid covering the North Atlantic from 20°W to 80°W and 10°N to 70°N, the grid spacing is 1.25° by 1.0° to match NOAA's WAVEWATCH III configuration; 2) an intermediate regional grid from 64°W to 67.5°W and 17.5°N to 19.5°N, covering the region at a resolution of approximately 1.8 km; and 3) a fine mesh of 35-50 m resolution for selected nearshore areas. In contrast to most wave model implementations currently in use, the SWAN model covers the entire North Atlantic domain and is not nested in NOAA's operational WAVEWATCH III coarse North Atlantic grid. Dr. Ortiz will optimize coverage of the intermediate and fine grids to generate operational wave products at desired locations.

Prof. Aurelio Mercado, one of our PIs and a world renowned expert on coastal hazards from storm surges and tsunamis will direct the Coastal Inundation modeling component. Prof. Mercado will generate storm surge flood maps for Puerto Rico and USVI based on the ADCIRC (Advanced Circulation) model, and in collaboration with Dr. David Hill and Dr. Brian Blanton. This endeavor is of primary societal concern in our region due to the importance of accurate coastal flood estimates in the regulatory process for coastal development.

Regional general circulation will be modeled using the UCLA ROMS version, which performs local refinement via nested grids (Adaptive Grid Refinement in Fortran) and has the ability to manage an arbitrary number of embedding levels as well as to do solution adaptive grid-refinement.

ADCIRC will also be used to generate short-term forecasts of water surface elevations and tidal currents using, will perform data assimilation, and implement a web-based interface for the dissemination of results. The primary objective of this component of the proposed work is to implement near-real-time simulations of the tidal elevations and currents in the Caribbean domain.

Most of the modern day ocean GCMs, such as HyCOM, ROMS, NLOM, and NCOM have been implemented for the North Atlantic Ocean, including the CaRA EEZ, however, the grids fur such a large model domain are necessarily coarse in resolution and do not represent well the coastal boundary layer. Basin-wide HyCOM will be used to obtain initial and boundary conditions for the higher resolution ROMS nested grids and for the creation of full-resolution products focused on our region. In the past we have used numerical output from NLOM in larval dispersion and mesoscale eddy research, however, information exchange with the various modeling groups, at operational time scales, cannot be guaranteed. We will provide our stakeholders with the best available model output and products for our region.

Rough Estimate of Cost

Our cost estimate for the initial implementation of CaRICOOS over a 5 year period is in the order of $4,000,000. The long-term maintenance of observing system assets and of operational modeling efforts, and the progressive augmentation of existing assets is estimated at $1,000,000 per year; thus resulting in a 10-year budget of $9,000,000.