Applied Coherent Technology, Corp.

Harmful Algal Bloom Use Case

Leveraging the ACT Architecture For Coastal Zone Management

(ACT-REACT™ Workstation and WIPE™ Server)

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Plain Language Description

Short Definition

Scientists at NOAA's Center for Coastal Monitoring and Assessment (CCMA) and National Ocean Service (NOS) are interested in analyzing relevant and available data, then issuing a Harmful Algal Bloom (HAB) Bulletin for public consumption.

Purpose

An original HAB system was developed to help automate the analysis and bulletin creation process. Most of the analysis steps were carried out by forecasters viewing data products from multiple different web pages. The original system provided links to the data products such as chlorophyll anomaly products from SeaWiFS or MODIS, and wind data and forecasts from the National Data Buoy Center (NDBC) and NOAA NWS. Additional observational data – for example cell counts were provided by state agencies via additional links.

The existing methodology involved accessing the data from several sources, visualizing and analyzing them with various software applications and using yet another application to create and distribute the bulletin.

The problem we address is simplifying the data discovery, data fusion and analysis process and using technology to automate bulletin creation to the extent possible. In this use case, we show how the user is freed from the burden of concern with data location, format, and accessing that data without having to resort to multiple search engines/applications.

The goal for the effort included reducing the time necessary to produce a bulletin, simplifying the analysis and bulletin creation process and making it easier to incorporate new data into the analysis process. Other goals included improving the ability for the system to enable HAB and other event analysis in other areas of interest (e.g., different parts of the Gulf of Mexico, the East Coast of Florida and other bodies of water).

Scenario of Expected Use

HAB bulletin creation is a subset of the broader area of interest of Rapid Environmental Assessment (REA). We recognize that pulling together (locating, ingesting, fusing) environmental data is never an end unto itself. Rather, we want to complete those tasks as quickly, transparently and effortlessly as possible to allow the end user to concentrate on the decision at hand. In the case of the HAB, the decision is whether the environmental evidence points to harmful bloom conditions. Efficiencies are gained when 1) the analyst spends less time getting the data input together, 2) the analysis involves one simple tool for visualization, analysis and bulletin creation (reduced number of steps), 3) based on 1 and 2, gains valuable time to more thoroughly analyze the data and thus create a higher quality output and 4) directly benefit the public by issuance of more timely Nowcasts /Forecasts.

HAB Scenarios

HAB bulletins are issued for the following scenarios:

Case 1: New Bloom
Case 2: Update an existing bloom and discolored water.
Case 3: ReSuspension
Case 4: Trichodesmium spp. blooms
Case 5: Unique non-brevis blooms
Case 6: Unusual events.

The Input

The methods used for bloom detection require routine remote sensing, especially satellite ocean color imagery, and *in situ* data. The data sources used in this effort include ocean color imagery from the SeaWiFS/OrbView2 and or Moderate Resolution Imaging Spectroradiometer (MODIS) satellites that have been processed using coastal-specific algorithms, wind data from coastal and offshore buoys, field observations of bloom location and intensity provided by state agencies, and forecasts from the National Weather Service. Data may be available locally (own machine acting as server), remotely (any accessible data server, assuming permissions)

The following table addresses data and data sources:

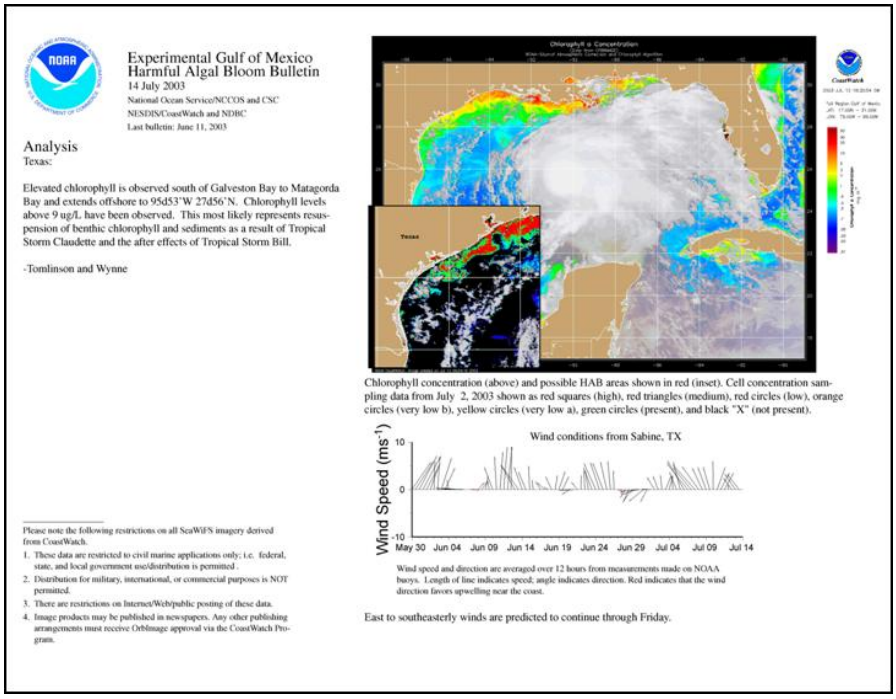
Data and Use	***Source***
Real-time daily chlorophyll, 60-day mean chlorophyll and chlorophyll anomaly products are provided via electronic mail for use in developing the HAB bulletins for the Gulf of Mexico. Yellow features in the chlorophyll anomaly images are used to highlight regions in which chlorophyll has increased by 1 µg l-1. Several criteria are necessary for an anomaly to be considered a potential *Karenia brevis* bloom. An anomaly of 1 µg l-1 corresponds to 105 cells l-1 of *K. brevis*, the level at which respiratory irritation and marine mammal deaths occur.	Chlorophyll and anomaly imagery is provided by NOAA CoastWatch from both the SeaWiFS and MODIS sensors.
In order to forecast the transport of these events (or to hindcast the source of the *K. brevis* bloom), winds from the Coastal Meteorological Automated Network (CMAN) are acquired. In addition forecast model winds are considered.	National Data Buoy Center (NDBC) and National Weather Services (NWS) North American Mesoscale (NAM) model.
K. brevis observations	Local agencies
Marine Weather Forecasts	National Weather Service (NWS)
Other data including: Reports of discolored water, fish kills, respiratory distress, or dolphin or manatee strandings, etc.	Local agencies, public, etc.

Summary of Process Steps

1. Accessing Processed Imagery – Ocean color imagery for the Gulf of Mexico is obtained automatically by CoastWatch, and an e-mail is sent that a new image is available.
2. Creating the Bulletin – Software has been designed to produce the pdf file containing the relevant data and analysis.
    a. Selecting Imagery
    b. Analyzing Winds
    c. Anomaly inset selection and condition report
    d. Bloom impact analysis
    e. Excluding anomaly polygons
    f. Generating, reviewing and sending the bulletin– Current subscribers are maintained in mailing lists that are region-specific to allow customization of analysis.

The Output

The following figure is a sample bulletin.



Metrics for Determining Effectiveness of New Approach

1. As compared to present methods:
    a. The user accesses and analyzes all required data and creates the bulletin through their local application. No other application is required to create the final product.
    b. The single user interface offers a broad range of capabilities to fuse data in time and space.
    c. Much of the bulletin data included is automatically generated and positioned in the bulletin.
    d. Time spent in the end to end process is significantly reduced.
    e. Resulting bulletin has the same or better quality than when produced with traditional methods.

Definition of Success

All required time coincident and geo-spatially applicable data is located and made available to the analyst.

The analyst fully analyzes the data and makes a determination of the existence (or non-existence) of harmful algal blooms in the area of interest.

The analyst is presented with a template which he/she completes with applicable text.

The bulletin is published.

All of these success criteria are completed within the single application.

Formal Use Case Description

Use Case Identification

Use Case Designation
Harmful Algal Bloom Bulletin Generation
Use Case Name
Harmful Algal Bloom Bulletin Creation and Publishing

Revision Information

Prepared by:
Hank Pomeranz
For Applied Coherent Technology Corporation
November 20, 2007
Version 1.0.a Initial
Modified by:
Patrick McBride
December 20, 2008-12-22
Version 1.0 Final

Successful Outcomes

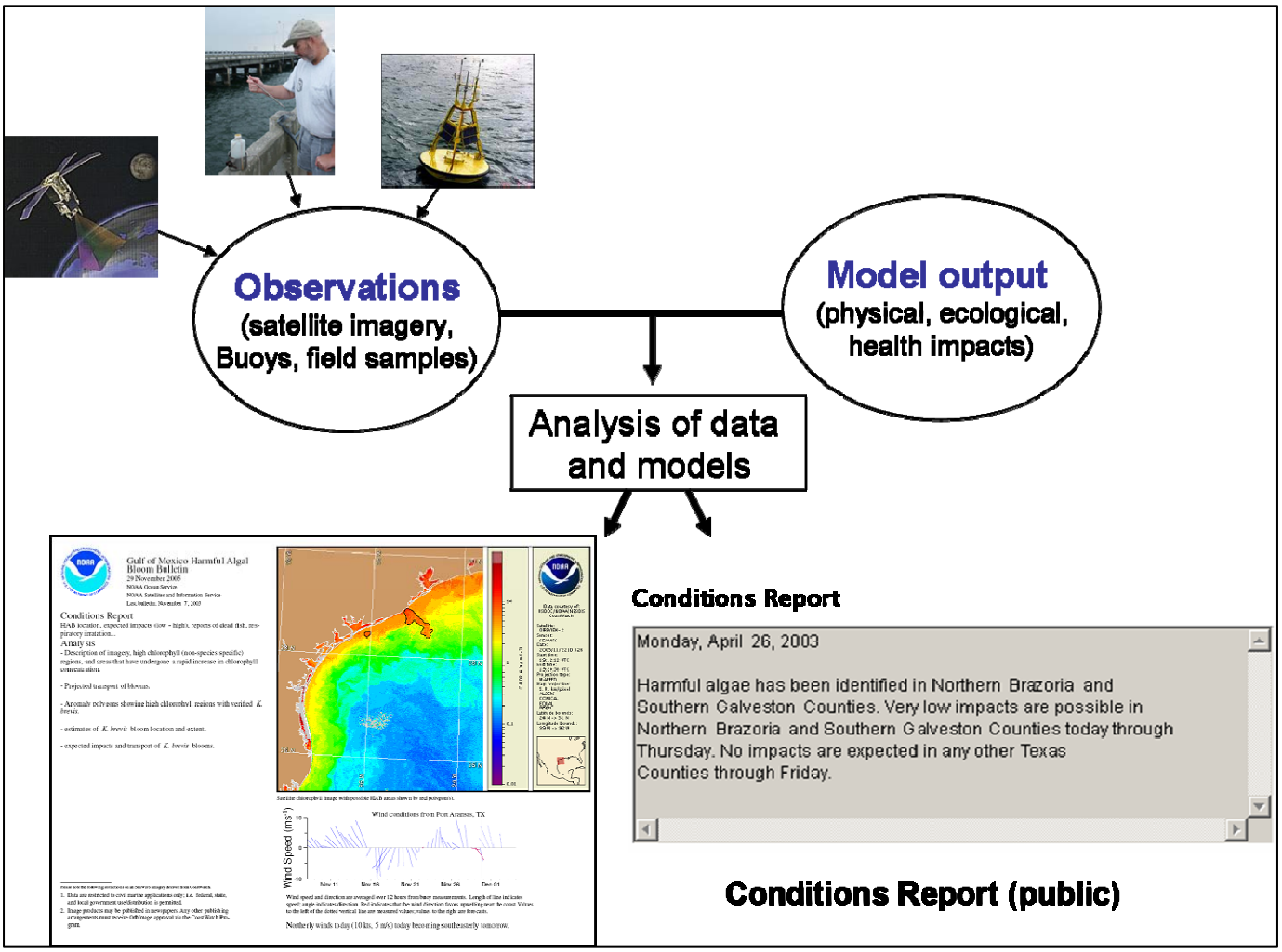
User generates a complete HAB bulletin based on all available data for the geographical area of interest.

Failure Outcomes

Application fails to access data either by non-availability or error condition - results in the inability to create bulletin or bulletin of lower quality.

General Diagrams

Schematic of Use case



Use Case Elaboration

Actors

Primary Actors

HAB Analyst, aka: Ecoforecaster

NOAA Scientists: In addition to their science role, the team provides HAB Analysts functions for select areas.

Other Actors

Data Generator

The data sources used include ocean color imagery from the SeaWiFS/OrbView2 and or Moderate Resolution Imaging Spectroradiometer (MODIS) satellites that have been processed using coastal-specific algorithms, wind data from coastal and offshore buoys, field observations of bloom location and intensity provided by state agencies, and forecasts from the National Weather Service.

Bulletin Peer Reviewer

Coastal Zone Managers: Fisheries Managers, Health Departments

Industry and Public

Preconditions

All potential data and sources of that data are identified and permissions are established to access the data.

Network access is available for remotely stored data or all data is contained on the local data server.

Client application locally available.

Postconditions

HAB bulletin in required formats for dissemination such as PDF, HTML.

Normal Flow (Process Model)

1) Based on schedule, User logs into application with appropriate login and password.

2) User selects region and time of interest and chooses to access geospatial and time coincident data meeting both criteria.

3) The application brings the data to the local workbench or processes the data on the remote platform, depending on bandwidth constraints.

4) Data is presented in Layers (similar to a standard GIS application) that can be turned on and off, individually or simultaneously controlled, probed and analyzed with a resulting image rendered for further use.

4) Once determined to be the correct image for publication, the user "saves" the image for use in the bulletin.

5) When ready, the user selects to build the report. At that time, the report template is automatically populated with the appropriate "saved" images and data plots.

6) The analyst then fills in the text portion of the bulletin – thereby completing bulletin creation.

7) Finally, the bulletin is saved in the appropriate format for web based publishing or other dissemination.

Alternative Flows

Even in the case of no new harmful algal bloom a bulletin is produced to update prior bulletins or denote that there is not HAB activity in the region of analysis.

Special Functional Requirements

Extension Points

Diagrams

Use Case Diagram

State Diagram

Other Diagrams

Non-Functional Requirements

Performance

Enable ecoforecasters to gain rapid access to needed data.

Reliability

Enable ecoforecasters to access current data products. In the event that new data is not available or accessible, enable the eco forecaster to access the most recent or earlier versions of the data.

Scalability

Usability

Enable ecoforecasters to view and analyze the various data sets as layers in a single, overlaid map-projected view.

Security

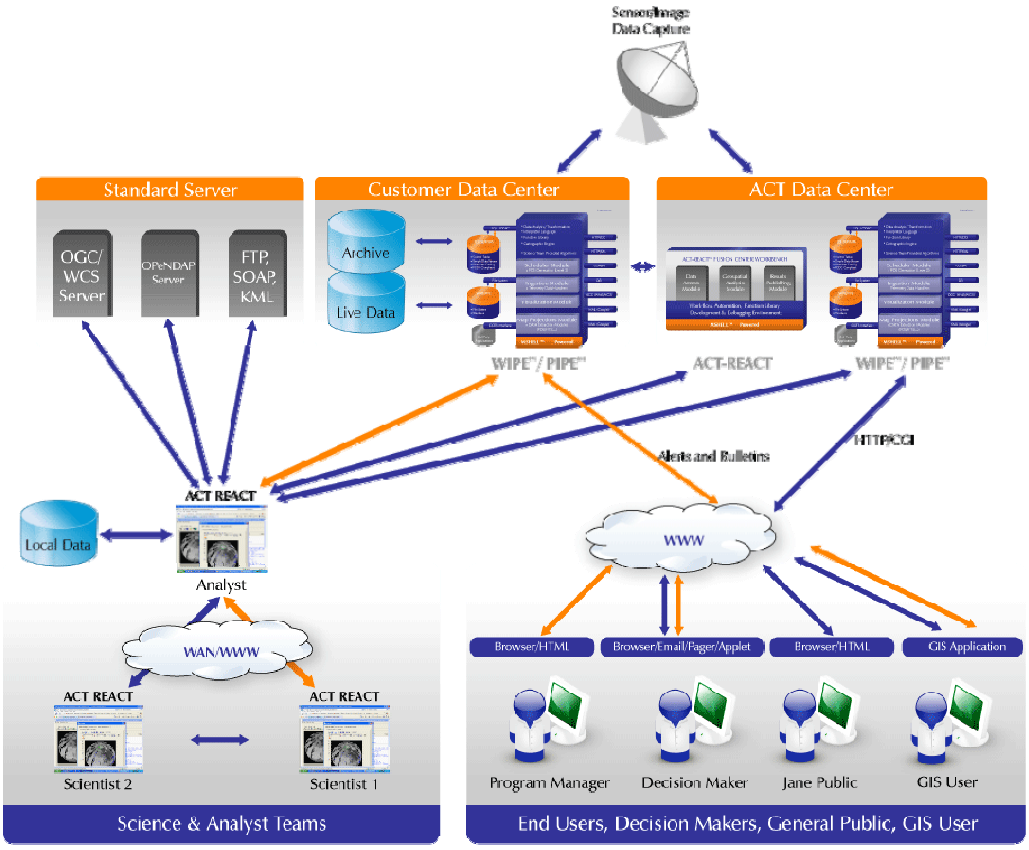
Other Non-functional Requirements

Selected Technology

Overall Technical Approach

Architecture

The use case implementation with the ACT architecture is a specific case of the generic architecture -- leveraging ACT software including ACT-REACT workstation and ACT WIPE server as shown below.



Definition

Rapid Environmental Assessment Composition Tools – REACT™

An analytic and fusion center workbench for geospatial analysis and decision support.

Technology A - Rapid Environmental Assessment Composition Tools (ACT-REACT™)

Description

Key components include:

- **Network Centric Geospatial Data Access** -- easy access to multiple local and remote data sets, servers and formats is combined with powerful data transformation features and the ability for users to perform coincidental data analysis. Access to numerous data formats through the open source Geospatial Data Abstraction Library (GDAL) is included.
- **Geospatial Analytic Environment –** a powerful multi-layer analysis and fine grain cartographic viewer capability is supported by the comprehensive MSHELL™ scripting language and its robust function library.
- **Results Publishing –** users can work with a large array of output format options and alert and report capabilities.
- **Work Flow –** Users can easily create and save simple or complex work flows that enable multi-layered data analysis and visualization, virtual product generation, conditional alerting and publishing. The work-flow engine provides access to a robust function library and numerous data sources (e.g., FTP, WWW, OGC servers, OPeNDAP, WIPE™/PIPE™).
- **Integration –** Collaboration and reuse is enhanced by enabling users to easily publish data and results to WIPE™/PIPE™ and other servers. Work flows created and tested in ACT-REACT™ can also be run on WIPE™/PIPE™ servers or shared with other ACT-REACT™ nodes.

MSHELL™ **is the core processing engine powering ACT-REACT™.**

Benefits

Provides a single tool and User-Interface for the entire HAB creation process. Automates the process where possible to save time and effort. Removes the burden on the analyst to search multiple data sources or invoke additional applications to view and analyze the data.

Limitations

Requires an up-to date workstation with a reasonable graphics card running Windows, MAC OS, or Linux.

Technology B - World Wide Information Processing Engine (WIPE™)

Description

WIPE™ is a mature network-centric geospatial data processing, management and analysis server for Earth observing sensors. WIPE integrates earth and space based sensor data with ancillary data such as global and regional meteorological and oceanographic numerical models. WIPE™ automatically pre-processes, geo-references and prepares the data for research and operations consumption. WIPE™ also fully manages the collection, warehousing, archival and dissemination of geospatial data and leverages MSHELL™ to automate analysis tasks, generate research products and send alerts. WIPE integrates seamlessly with ACT-REACT™ enabling researchers to effortlessly fuse data from multiple sources, reuse prior analytical products and discover new insights.

Key components include:

- **GEO Spatial Data Management** – a high volume server for automating the processing and assimilation of sensor and geospatial data including: data ingestion, geo referencing, distribution, fusion, mission specific custom transformations, mosaic generation, storage management, distribution, and archival.
- **Anywhere Access to GEO Spatial data** – provides researchers, operations teams, decision makers and end users browser/html and API-based access to volumes of data and visualization capabilities. In addition to web-based access WIPE integrates with GIS applications, Google Earth and a multitude of other software tools.
- **Image Visualization Engine** – the engine serves images, image mosaics, 2d/3d plots and video clips to a browser.
- **Analysis Automation** – a built-in script processing engine and scheduler enables WIPE™ to automatically analyze static and dynamic geospatial datasets and generate near-real-time results.
- **Reporting, Publishing and Alerting** – enabling the automatic generation of multi-format reports and alerts (e.g., email)
- **Repository** – in addition to managing and storing raw sensor data, WIPE™ is a network-based repository for analysis data, research products, reports and alerts.
- **Interoperability** – support for metadata standards such as FGDC, numerous data access methods (e.g., HTTP, XML, OGC/WCS, KML, FTP, JAVA, etc), over 150 data streams, over 60 raster data formats through the open source Geospatial Data Abstraction Library (GDAL), and the ability to build custom data format readers.
- **MSHELL™** – WIPE™ is powered by the ACT image processing engine and architecture. WIPE™ can be installed on a single machine or individual server components can be distributed over multiple servers for high-availability and high performance scenarios.

Benefits

Enables simplified, network based access to multiple different types of sensor and other geospatial datasets. Automates the ingestion and processing of various data streams and provides alerts and notifications for reliable management and access for geospatial datasets.

Enables ACT-REACT users to very access data across the networks, share new data products and bulletins, collaborate on analytical tasks, and simplify peer-review processes.

Limitations

While WIPE is able to automatically ingest hundreds of different sensor data streams and to talk to multiple different servers (e.g., OGC, FTP, HTTP, etc.), access to new data streams requires development of a Data Ingestion Module (DIM).

References

1) REACT™ is a product of Applied Coherent Technology, Inc of Herndon, VA. See description at: http://www.actgate.com/home/act-react.htm

2) WIPE™ is a product of Applied Coherent Technology, Inc of Herndon, VA. See description at: http://www.actgate.com/home/wipe.htm

3) Harmful Algal Bloom Bulletin Manual - Instructions for generating information on Karenia brevis blooms in the Gulf of Mexico with an emphasis on Texas

4) MODIS - http://oceancolor.gsfc.nasa.gov/

5) SeaWiFS - http://oceancolor.gsfc.nasa.gov/SeaWiFS/

6) National Data Bouy Center - http://www.ndbc.noaa.gov/

7) National Weather Services (NWS) - http://www.nws.noaa.gov/

8) North American Mesoscale (NAM) model - http://www.emc.ncep.noaa.gov/