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## 1. ABSTRACT

The Emergency Management Hurricane Tracker (EMHURR) is an experimental NWS application that uses spatial database technology to fuse disparate NWS datasets into a common GIS ready format. EMHURR was developed to assist emergency management personnel with planning and decision-making tasks required during the onset of a hurricane or tropical storm. In the following paper the architecture and interface will be explored along with routines used to automate the retrieval, processing and display of weather data in near real time.

## 2. BACKGROUND

A Water Resources Internet Mapping Team was chartered by the Science and Technology (S&T) Committee of the NWS Corporate Board to recommend a coherent and cost-effective water resources Internet mapping strategy. The team was formed in September 2001 and remained in place until April 2002, at which time the team recommended follow-up studies of Internet mapping (Graffman, 2003). In August 2002, a follow-up team was commissioned by the committee to study the technology from a meteorological and hydrological perspective. In April 2003, in the final report to the committee, the team concluded it appeared feasible to display data in this manner, but there was much to be learned about the technology. Therefore, the team proposed to develop a prototype website to further investigate the feasibility of using IMS technology with hydrologic and meteorological data.

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employee participation in scientific discourse.  
The views expressed are those of the author(s)."

The S&T committee accepted the report and agreed to fund the building of a prototype. The website was given the designation EMHURR. The initial prototype limited its area of study to the southeastern United States. After the 2004 hurricane season, a report was made to the S&T that the team successfully showed the utility of the prototype but a number of factors caused the programs that created the GIS data to have problems. It was recommended the system be converted from "flat file" GIS data (shapefiles) to a database centric system; however, no funding was available for conversion.

## 3. SCOPE OF THE PROJECT

The original prototype (Graffman, 2003), was developed to assist emergency management (EM) personnel with planning and decision-making tasks required during the onset of a hurricane or tropical storm. The primary objectives of this application were to provide EMs with a single geographically driven web portal for accessing, visualizing and downloading weather data sets during a tropical cyclone event.

After the 2004 meeting with the S&T, it was decided that Version II would be developed on a time available basis. The geographic area of Version II was expanded to cover the Atlantic and Caribbean, the Eastern Pacific and Central Pacific, and the Western Pacific. The team implemented an ArcSDE™ enabled SQLServer™ database for storage and rapid retrieval of EMHURR data layers and added customized zoom/identify functions to the user interface.

## 4.0 ARCHITECTURE

The architecture of EMHURR used two Windows™ 2000 personal computers. One functioned as the processing (crunch) server and the other as the ArcIMS™ server. The processing server was used to decode, create, convert, update and geo-process data sets. Data were pushed or pulled to/from the processing server from various NOAA line offices at predefined intervals. Intervals

were set to ensure that datasets were updated in a near real time fashion. The data was then decoded, processed and written out to the database residing on the ArcIMS™ server.

For Version I, legacy ArcView 3.x Avenue code was used to decode the hurricane forecast information on the ArcIMS™ server. The hurricane track layers were the only layers that changed status, thus requiring edits to the map configuration (axl) file and the subsequent refreshing of the map service. To refresh the map service, the map configuration file was written out whenever there was a change of status (addition or deletion) of a storm. The map configuration file was transferred to the ArcIMS™ server along with a “sentry” file, indicating the configuration file had been modified. The ArcIMS™ server continuously checked for the sentry file, and when detected, ran a batch file to refresh the EMHURR site. Both processors used Soft Tree’s 24x7 scheduler software to run the processing programs at the appropriate time.

## **5.0 DATA**

A unique challenge to the development of EMHURR was acquiring and processing datasets served by the application. Since the majority of EMHURR datasets are dynamic, EMHURR required an automated system for retrieving, decoding and processing source datasets into an ArcIMS compatible format in near real time. Below is a description of the datasets used by EMHURR Version II, and a brief summary of data creation, conversion and geo-processing functions applied to each dataset.

### **5.1 Storm Track**

The storm track consisted of a point layer representing storm forecast locations, a line layer representing the storm track, and a polygon layer representing the cone of uncertainty (max forecast error observed in the previous 10 years). The point forecast layer displayed forecast points at 12 hour intervals to a forecast lead time of 120 hours or 5 days. The source of this layer was a forecast advisory produced by the NWS Tropical Prediction Center’s National Hurricane Center (NHC). The data were pushed to the processing server via the NWS Telecommunication Gateway. For Version II, the Legacy ArcView/Avenue scripts were rewritten in Visual Basic and ArcObjects™ to create a Windows™ executable file. This executable ingested the advisory text and created the storm track “feature classes” to the ArcSDE™ database. The executable also created a new map configuration file as needed and a Javascript text file containing storm name info. These files were then “pushed” to the ArcIMS™ server.

### **5.2 Watches, Warnings, Statements**

Watches and Warnings Advisories (WWA) are alerts issued by the NWS when there is a likelihood of a severe weather event. The WWA layer consisted of county polygons rendered by advisory type. The source of this layer was an XML CAP file downloaded from the NWS Office of the Chief Information Officer (Bunge, 2004). This XML file was downloaded every 10 minutes to the crunch server and parsed. County geometry and WWA information were written to a WWA feature class by copying geometry data from a template feature class containing county data for the entire country. If the county already existed in the WWA feature class, the additional WWA data was written to extra fields in the feature class. The attributes saved in the WWA feature class included up to 10 event types, event times and the URLs of the actual WWA.

### **5.3 Satellite data**

Near real-time infrared imagery from the GOES East and GOES West Satellites were included in EMHURR to provide insight into the intensity and structure of storms. This imagery was supplied from the GOES satellites by NOAA’s National Environmental Satellite (NESDIS) Services Division. The imagery was downloaded every 15 minutes, alternating between GOES East and GOES West data supplied in a geo-tiff format to the ArcIMS Server. The data was then copied to the SDE database as a raster.

### **5.4 Flood Outlook**

The Flood Outlook data layer delineates polygonal areas where flooding is likely to occur. The Hydrometeorological Prediction Center provided the flood outlook data once per day in a text format. This text file was converted to a polygon shapefile using a Visual Basic/ArcObjects program and rendered according to flood likelihood.

## **6.0 USER INTERFACE**

EMHURR is based on an ArcIMS HTML template developed by staff members at the NOAA National Ocean Service’s Coastal Services Center (CSC). Their help supplying the template and follow-up support was instrumental to the success of the EMHURR prototype. The CSC template is a heavily customized version of the ArcIMS Designer produced HTML template. Major viewer customizations were made to the table of contents, legend display and the toolbar. In the following section these customizations will be described and illustrated with screenshots.

### 6.1 Table of Contents and Legend

The table of contents (TOC) was moved to the left side of the viewer and modified into a directory tree structure (Figure 1).

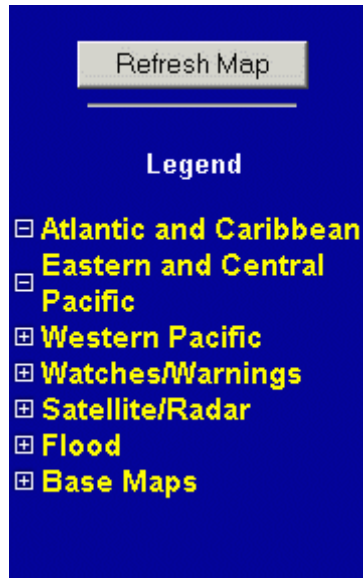


Figure 1 - Table of Contents

Layers were grouped into categories that could be expanded to reveal data layers or extracted to hide data layers. Custom legends were created for each layer and embedded within the tree directly below the layer. This structure provided a flexible method of viewing data layers by category and allowed the site to contain many data layers without appearing cluttered. These customizations were made with HTML and Javascript. The custom legend graphics were created with Macromedia Fireworks software and saved in a gif or jpg format. In Figure 2, the Atlantic and Caribbean category/area is expanded to reveal the Storm Path and Cone of Uncertainty check boxes used to turn on/off the layers and the name of the storm.

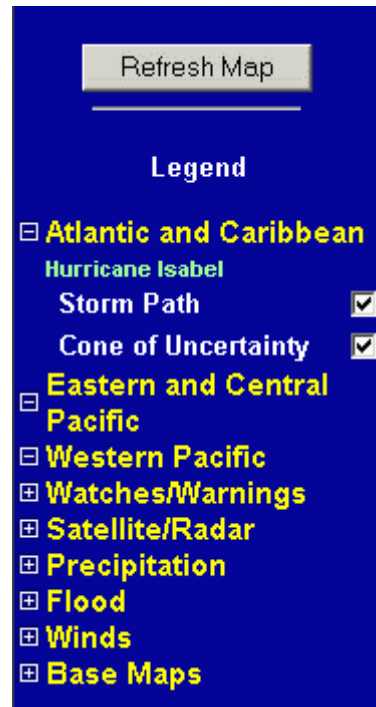


Figure 2 - Expanded storm area

Version II allowed the user to left click the yellow area/category name in the TOC to zoom to a predefined extent for the selected region. Version II also allowed the user to click the storm name for additional storm information. Example output from this function can be seen below in Figure 3.

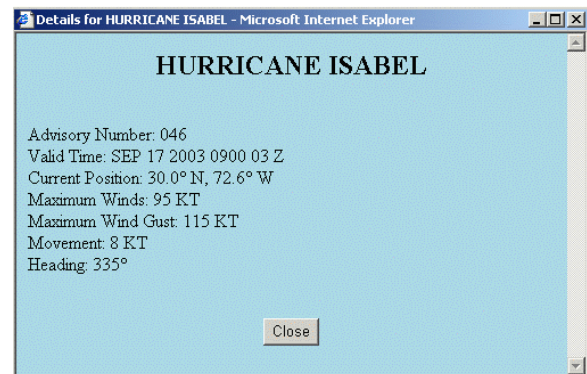


Figure 3 – Details about storm window

Figure 4 shows a TOC with the watches/warnings layer's legend.



Figure 4 - Watches Warnings Layer

makes the layer "active." Using the "Identify" tool on the toolbar and clicking on a feature in the "active" layer brings up a table with more information about the feature.



Figure 5 - WWA Layer "Active"

## 6.0 TOOLBAR

The toolbar (Figure 3) was positioned at the top of the map frame in a horizontal orientation. Standard ArcIMS tools such as panning and zooming were retained in the toolbar. New tools for obtaining user help and submitting feedback were added to the toolbar. When clicked, the feedback button will open an NWS web page containing a form for entering user feedback. The Help button opens another page containing detailed help information. When clicked, the Quick Help button displays user instructions in the text frame positioned directly below the map display.

Figure 5 shows the TOC with the Watch/Warning level turned on and the layer name highlighted. This

Figure 6 shows the results of an Identify action prior to the landfall of Hurricane Isabel. In the text frame directly below the map display is a table containing WWA information for Sussex County, VA. This table was returned when the user clicked on the county with the Identify tool. The Identify tool was customized to return a pre-defined set of feature attributes in a newly formatted HTML table. The table contains the county and state, type of event (flood watch), and the time of the event. Notice that the text values in the event field were converted to hyperlinks. When clicked these hyperlinks will take the user directly to an NWS Watches and Warnings web page where the actual watch or warning will be displayed.



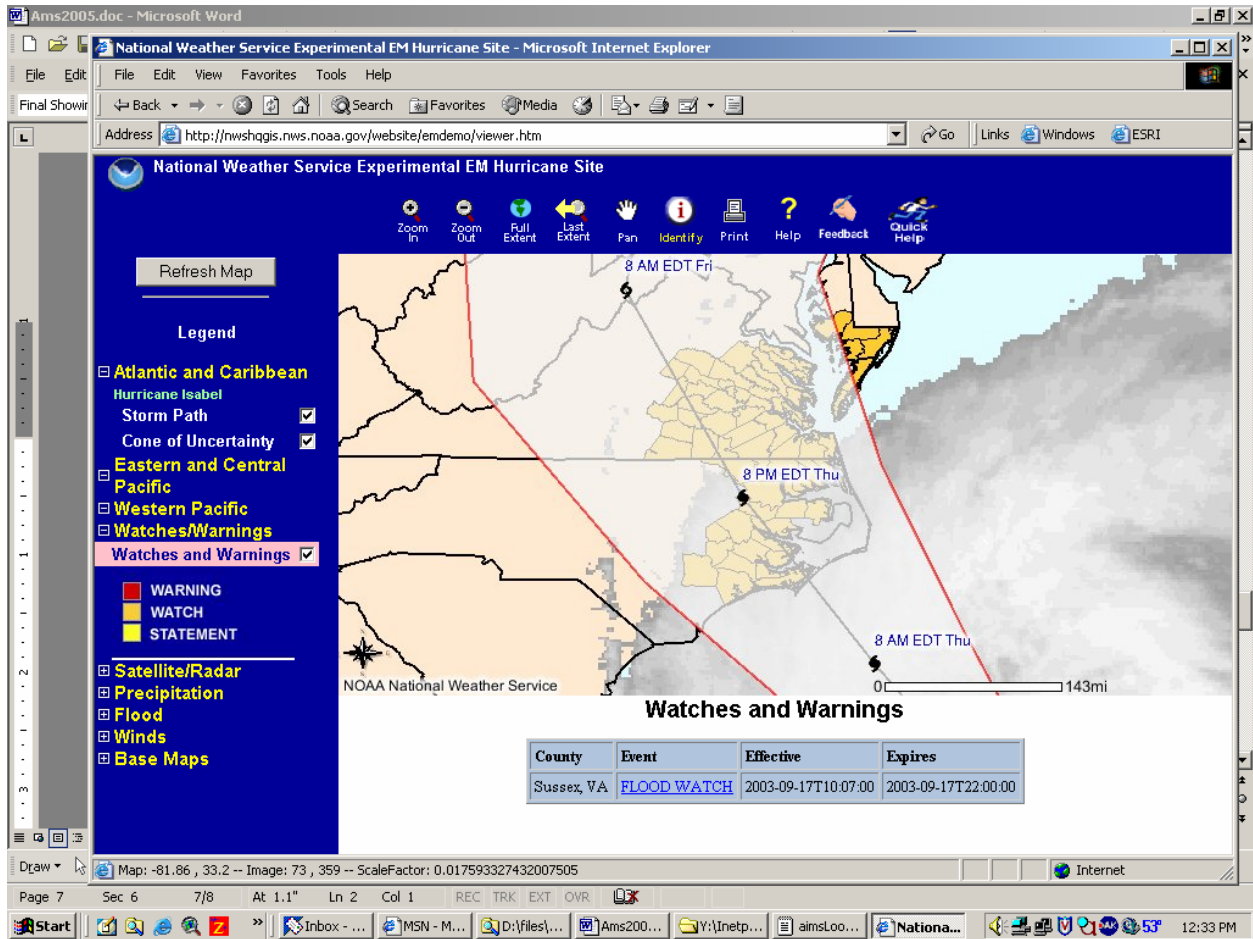


Figure 6 - Results using Information tool

## 7.0 HOW DID WE DO?

The first real test for EMHURR Version I came in mid-September 2004 during the approach and land fall of Hurricane Isabel. During this time, the limits of the processing software and the website were exposed. Of concern were limitations in the application's ability to adequately handle the increased volume of user requests. Another potentially important point of failure was the network connection between the crunch server and the ArcIMS server. The servers communicated with each other by sending files back and forth via mapped drives. This technique did not work reliably during Version I processing.

To increase the reliability in Version II, the software used to decode the NHC advisories was ported to Visual Basic with Arc Objects and run on the processing machine. This new code also allowed staff to abandon shapefiles in favor of using ArcSDE™ with Microsoft SQLServer and reduced the number of

files to be copied either between machines or on the server machine by 15 files per storm. The files that needed to be copied to the ArcIMS server (map configuration files and storm name files) were copied using simple FTP processes to move the files rather than using mapped drives.

These changes to EMHURR II eliminated communication problems between the two machines. There were, of course, minor decoding bugs one expects to see when parsing text data and something unexpected appears. The only major problem, later resolved, was the mode in which the scheduler software was run. Once this was fixed the processing software ran for days without problems.

## 8.0 CONCLUSION

EMHURR was developed to provide an example of how an enterprise GIS architecture can be successfully used to integrate and disseminate weather data in a common web based environment. In EMHURR Version II, the most significant enhancement was the use of ArcSDE, which enabled the source data to be stored in a SQL Server RDMS. This enhancement improved both speed and reliability compared to EMHURR Version I and acts as a model for using a spatially enabled database to store and distribute weather data.

## 9.0 ACKNOWLEDGEMENTS

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