

## GIS AS A BRIEFING AND PLANNING TOOL IN THE NWS

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### 1 INTRODUCTION

<sup>1</sup>This paper will describe how the National Weather Service (NWS) uses a Geographic Information System (GIS) for planning and briefing by internal and external users. Two applications of GIS will be explored. The first, river conditions, is a presentation of river gauge locations across the continental U.S. showing each gauge's deviation from flood stage. The second application is a presentation of tropical depression/ tropical storms/ hurricanes/typhoon forecasts and past track. This paper will describe the use of GIS in the data ingest and processing of raw data, the actual data presentation and the use of the application for briefings and planning. These projects use the Environmental Systems Research Institute's (ESRI) ArcView GIS 3.2 software and ArcIMS internet mapping software.

### 2 HURRICANE FORECASTS

#### 2.1 Overview

The GIS system monitors hurricanes and tropical storms from birth through death in the Atlantic and Caribbean basin, the Eastern Pacific Ocean from the West Coast of the U.S. to 140 W, the Central Pacific Ocean from 140 W to 180 W and the western Pacific Ocean. The Atlantic-Caribbean and Eastern Pacific data are obtained from the National Hurricane Center in Miami, FL. Data for the Central Pacific comes from the Central Pacific Hurricane Center (NHC). Western Pacific data is drawn from the Joint Typhoon Warning Center.

#### 2.2 Input

The project started originally as an ArcView tool to automatically ingest a hurricane forecast and then create graphics that could be manually edited for use in a briefing on Atlantic and Caribbean tropical storms. For simplicity and quicker development, the forecast discussion issued by NHC was selected to create the graphic. The tool advantage of the simple table of forecast data contained in this image. At this time, all images draw from the forecast discussion except the Western Pacific, which uses the Tropical Storm Warning text file. This file is decoded by a Visual Basic script. The output is then put into a file in the same format as the forecast advisory.

#### 2.3 Output

ArcView 3.2 is run via a command line whenever it determines new data are available. A project containing Avenue (ArcView's coding language) scripts is used to create shapefiles for the output. The shapefiles created are:

**Forecast Points:** This is a point shapefile containing the current and forecast positions from the table. The first record of the shapefile details the current information about the storm. All fields are filled in this first record, which includes the storm type (hurricane, tropical storm, or tropical depression), its name, the latitude/longitude of the point's current position, maximum wind speed, and additional comments. The remaining records contain information about the forecast positions of the storm; the latitude and longitude of the forecast point, the forecast time of the point, and any comments found.

**Forecast Track:** This shapefile is a line connecting each forecast point with no additional attributes.

**Forecast Cone:** This polygon shapefile shows the area of uncertainty of the forecast. This cone is

created only if there are forecast data present. The cone is a statistical area of uncertainty assuming the further out in time the forecast goes, the less accurate it will be. Circles are drawn around each forecast point for the statistically predefined radii of uncertainty (defined as 53, 97, 137, 174, and 255 nm). These circles are combined to create the cone of uncertainty.

**Past Points:** This is another point shapefile that shows the actual track of the storm. This shapefile is populated by adding the initial point of successive forecast advisories. The attributes in the past point shapefile are the same as the forecast positions.

**Past Track:** This line shapefile connects the points of the past track.

## 2.4 Processing

The latest input data are first examined by ArcView. The system determines whether the storm is **new**, **old**, **expired**, **reborn**, or **updated**. A new storm requires a new set of output shapefiles so that a new map configuration file can be created that contains the new storm. An old storm requires no processing. An expired storm requires that a new map configuration

file be produced that does not contain the storm. A reborn storm requires that the old shapefiles for the storm be used, that the map configuration file have information about the storm added to it. An updated storm requires the shapefiles for the storm be updated with the latest data. Once all of the data files have been checked and shapefiles created or updated, the map configuration files and JPEGs are produced. The respective map services are then refreshed for those cases when a new map configuration file was produced.

## 2.5 Presentation

Two forms of data presentation are created. The first, directly from ArcView, is a static JPEG image of each active storm, Figure 1. A link to the JPEG is made from the Office of Climate Water and Weather Services (OS) tropical page. The JPEG is created after zooming to the forecast cone and zooming out 125%.

The second form of data is the ArcIMS presentation, Figure 2. The presentation is a simple page, derived from the ArcIMS 3.x default http template. The page contains the standard NWS Corporate banner, a simplified toolbar, and a customized layer list.



Figure 1: Static JPEG Image of a Storm

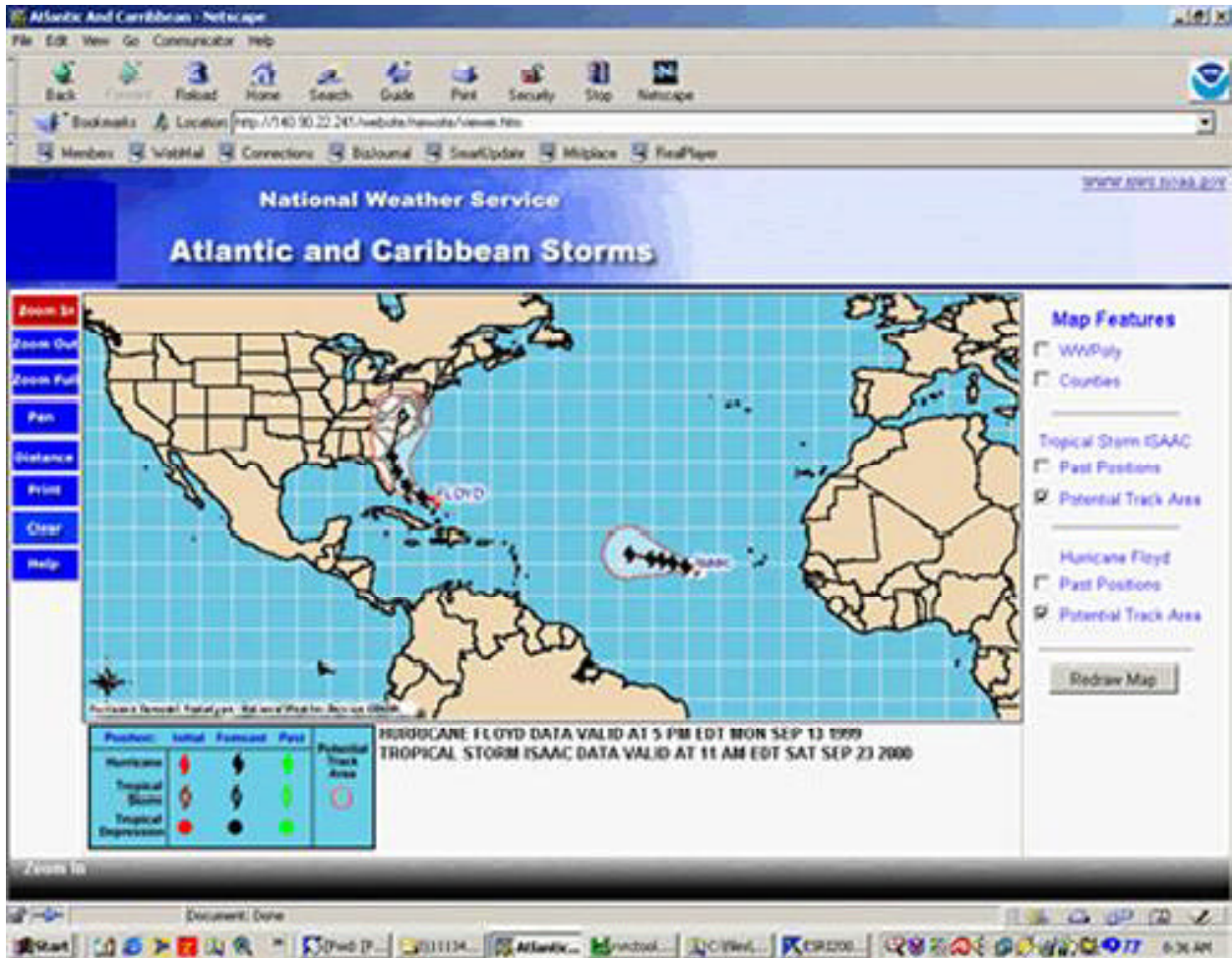


Figure 2: Initial ArcIMS Hurricane Forecast Map



Figure 3: The Map

When the page is first accessed, it displays a full view of the storm area. All storms in the area are displayed. The storm name, without the type, is displayed at the initial position of the storm.

## 2.5.1 Toolbar

The toolbar, Figure 4, consists of custom-made buttons. For functions acting as tools as opposed to

buttons (e.g., **zoom in** vs. **print**), the buttons are red when active. The functions behind the buttons are the standard **out of the box** ArcIMS options, **zoom in**, **zoom out**, **pan**, **distance** (measure), **clear** (remove measure lines), and **zoom full** (zoom to full extent). There is also a print tool. The print page was modified to allow printing on standard 8 ½" x 11" paper with an option to add a custom title and to use the legend on the display.

**Table of Contents (TOC):** Map layers that do not contain actual storm data appear at the top of the TOC, Figure 5. The user cannot control the background map and



Figure 4: Toolbar

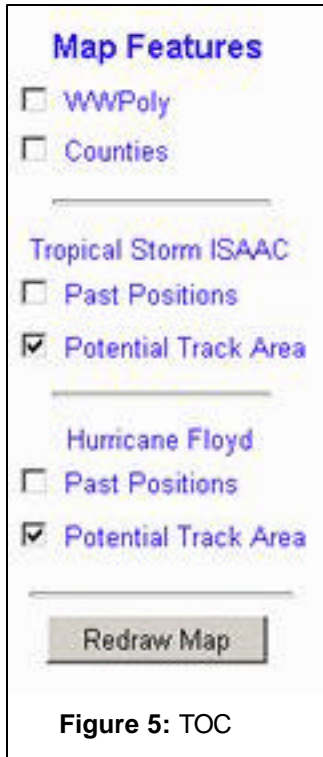


Figure 5: TOC

latitude/longitude lines. At the highest level, the user can only turn on county boundaries. As the user zooms in, additional layers are available. The major cities are defaulted to **on** and the county and state country names are defaulted **off**. The WWPoly is experimental; it is yet used in the online version.

If present, storm layers appear next, each separated by a horizontal line. The name of the storm (e.g., Tropical Storm Isaac, Hurricane Floyd) is displayed first, followed by the

option to toggle on or off the forecast cone and past positions layers. The user cannot access the forecast points and track. The “refresh map” button was renamed “redraw map.”

**The Text Box:** Below the map is the ArcIMS text box containing a legend, Figure 6. Beside the legend is text for each storm giving the storm’s name and the date and time of the advisory containing the data used to create the image. When there are no storms, text is updated hourly describing the last time the system searched for new data.

Position:	Initial	Forecast	Past	Potential Track Area
Hurricane				
Tropical Storm				
Tropical Depression				

HURRICANE FLOYD DATA VALID AT 5 PM EDT MON SEPT 14 1999 TROPICAL STORM ISAAC DATA VALID AT 11 AM EDT SAT SEP 23 2000

Figure 6: Text Box. (Text would appear to right.)

### 3 River Conditions

#### 3.1 Overview

The river conditions project was designed to provide a national overview of river conditions (deviations from flood stage at river gauge locations). The project allows users access to the actual gauge data. The project also acts as a portal to other NWS data. The user can bring up, where available, a hydrograph for the gauge and can access the Hydrologic Statements issued by the local Weather Forecast Office (WFO).

#### 3.2 Input Data

The U.S. Geological Survey manages most of the river gauges used in this presentation. Real-time stream flow data are collected as frequently as every 15 minutes and processed by the Hydrometeorological Automated Data System (HADS) and from the Advanced Weather Information Processing System (AWIPS) Integrated Hydrologic Forecast System (IHFS), Figure 7.

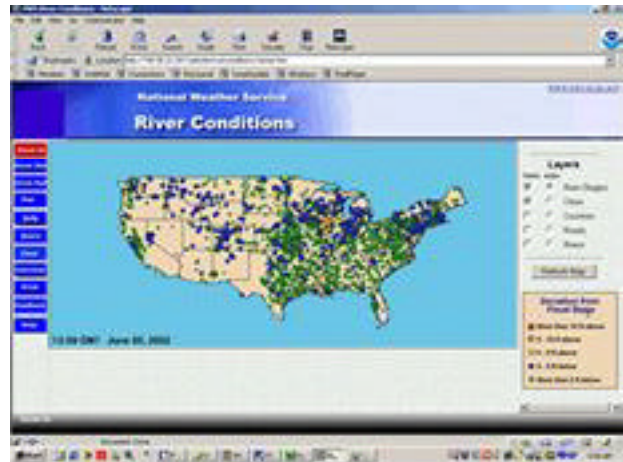


Figure 7: River Conditions ArcIMS Presentation

#### 3.3 Processing

Data from the two sources, delivered to the Hydrologic Information Center (HIC) processor in delimited ASCII format, contain an identifier, date/time information, and an observed river stage value. The two data streams are read by ArcView, combined into a single virtual table, and sorted by site identifier. The most recent observation is extracted for each location and is checked to be sure that it is not older than 24 hours.

The table is then compared to a table with locations having known problems; matching records are flagged as missing. The data then joins a static “locations” table containing the remainder of the data attributes. A “delta,” or deviation from flood stage, is calculated by subtracting the observed stage from the flood stage. A check is made for data that are out of range. Finally, the date and time of the each observation are copied from the input data and the tables are “unjoined.”

### 3.4 Output Data

Data are written to a shapefile and to a dBase file on the HIC server. The shapefile is used to update a view with symbols based on the delta values. The layout containing the view is exported to a JPEG file, which is then sent to the (HIC Web server via FTP: [http://www.nws.noaa.gov/oh/hic/.](http://www.nws.noaa.gov/oh/hic/)) Other text files used on the HIC page also are copied to the server. The local dBase file is copied to the ArcIMS server. The dBase file contains the same attributes as the shapefile used by ArcIMS. The dBase file is joined to the shapefile by the “id” field. The date, time, observed, and delta fields are computed using the version of ArcView running on the server.

### 3.5 Presentation

#### 3.5.1 The Static Map

A sample of the static map image created from ArcView is shown below. The current version can be found at the HIC Home Page. The dots represent river gauges and are color-coded and sized according to their deviation from flood stage, as described in the legend.

#### 3.5.2 The ArcIMS Map

The ArcIMS map shown in Figure 9 was created at the same time as the static map image, Figure 8, and shows the same data. The same symbology are used to denote the river gauge locations as was used in the static image

#### 3.5.3 The Toolbar

Like the hurricane presentation, the toolbar, Figure 10, consists of custom-made blue buttons. Buttons that act as tools are blue when inactive and red when active. The toolbar offers the standard ArcIMS, **zoom in**, **zoom out**, **pan**, and **zoom full** options as well as the ArcIMS **identify** tool (called INFO) and a **query**



Figure 8: River Conditions Static Image



Figure 9: River Conditions IMS Map

tool. Similar output is produced from both buttons and, with the exception of the **id** and **shape** fields, all fields are listed. The **clear** button removes the results of a query or info transaction. There is also a **print** tool. Again, the print page was modified to a standard 8½” x 11” and allows the user to add a custom title. In the future, there will be a **download** button to obtain the data used in the presentation. The **feedback** and **help** buttons open a new window, send feedback to the developers, and provides a help page. When the river conditions shapefile is queried, however, two of the fields provide links to additional information.

The HYDRO\_URL field links, when available, to a hydrograph (defined as a graph showing the water level or stage, discharge, or other property of a river volume with respect to time). Clicking the cell opens a new window to the hydrograph pertaining to the particular point. The majority of the hydrographs linked from the NWS Central Region (ND, SD, WY, CO, NE, KS, MN, IA, MO, WI, MI, IL, IN, and KY) are from the Advanced Hydrologic Prediction Services (AHPS). Hydrographs may also come from the individual WFOs or the US Geological Survey. Many NWS hydrographs include forecast conditions as well as observations. Similarly, the WFO\_URL provides a link to hydrologic products



**Figure 10:**  
Toolbar

(statements, forecasts, and flood warnings) issued by WFOs.

### 3.5.4 The TOC

The table of contents, Figure 11, is a slightly modified standard ArcIMS HTML contents containing layers for river stages, which include the actual river gauge location and deviation from flood stage, as well as additional layers for selected cities, county boundaries, roads, and rivers. A legend has been added to the bottom of the TOC.

## 4 Using the GIS In Planning/Briefing

The River Conditions Web page, when first accessed, offers a quick national overview of river levels. The color-coding is designed to highlight

areas where flooding is occurring. It allows users to quickly zoom into an area of interest to get a more detailed picture conditions in an area. In addition, users can add cities, counties, roads and the rivers to enhance the image. The presentation also demonstrates the potential of integrating other data layers into the display (satellite and radar for example), for a more detailed view. For briefing and planning purposes, this ability, first with zooming or querying and then with the hyperlinks, allows drilling down into other data types and acts as a portal into NWS data— without requiring knowledge of the NWS organizational structure. The ability to add data also shows the potential to provide users access to other National Oceanic and Atmospheric Administration (NOAA) data types—integration of different data sources can be transparent to the user. The Website can act as a single point of service for such users as Federal Emergency Management Agency ( FEMA), the Army Corps of Engineers or even individuals who may want to access river stages for recreational purposes.



**Figure 11:** TOC

Similar to the River Conditions page, the hurricane/ typhoon pages start out with a view extent over the entire area of interest. Thus, the user gets an immediate briefing of all the active storms at first glance. The minimal set of tools in the toolbar creates an easy to understand interface. The pan and zoom tools allow the user to quickly focus on the storm of interest and the additional data layers allow a more complete understanding of the possible impacts of the storm. The ability to print the maps or do screen captures, and the static jpegs allow for presentation graphics to be quickly created.

## 5 Future

Improvements to the river conditions presentation may include the following:

- Upgrade the roads layer to display roads in addition to interstate highways
- Add additional rivers to the river data set so all river gauge points are on their associated rivers
- Add other improvements as identified from a user survey

Improvements to the hurricane tracker may include:

- Decode substitution of the forecast advisory with another product (such as the marine advisory).
- Addition of information about storm movement from the alternate data source

## 6 Conclusion

GIS has been used to create and maintain map data for internal and external use in the NWS since 1995 using ArcView 3.2. The map data includes Public Forecast Zones, counties, Fire Weather Zones. Internally the map data are put on a server behind the AWIPS firewall. The AWIPS Map Database Catalog (AMDC) is the method of supplying external users with updated map data. ArcIMS shows promise as a tool to deliver existing products internally and externally in an easy-to-use fashion.

## 7 Acknowledgments

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