

6.4 USING GIS FOR ENVIRONMENTAL DATA IN IOWA

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1. INTRODUCTION

The Iowa Environmental Mesonet (IEM) (Todey et al, 2002) is a project at Iowa State University with the goal of gathering, comparing, disseminating and archiving environmental data from the state of Iowa. Geographic Information Systems (GIS) has provided the IEM an invaluable mechanism for data visualization and distribution. This paper highlights some of ways the IEM is using GIS to distribute environmental data in Iowa. *Author's note: An appendix of Internet URLs is provided for software referenced in this text.*

2. TECHNICAL COMPONENTS

Data arriving at the IEM servers come in a variety of formats. None of these formats would be classified as a true GIS datasource. Via a handful of conversion scripts, the various data types are eventually stored in a PostgreSQL relational database. We choose PostgreSQL as our database engine because of its open-source license and enterprise functionality. PostgreSQL also has an extension called PostGIS, which spatially enables PostgreSQL data tables. With this extension, the PostgreSQL database can act as a backend spatial datasource for GIS. PostGIS supports most of the OpenGIS "Simple Features Specification for SQL."

With the IEM data stored in a spatial database, many database enabled GIS applications are able to efficiently query out data they need. The IEM uses a GIS web-mapping application called MapServer to produce web graphics and display query results.

MapServer is an OpenSource environment for building spatially enabled web applications. Utilizing other OpenSource technologies, MapServer is a fast, cross platform GIS.

The IEM also uses an extension to PHP called PHP MapScript to accomplish GIS tasks. PHP is a popular scripting language used primarily for web development. The PHP MapScript extension provides the MapServer API in the PHP environment. The functionality of PHP and flexibility of MapServer create a terrific environment for building and maintaining GIS applications.

3. MAPSERVER APPLICATIONS

To date, the IEM has produced over twenty web-based GIS applications using MapServer. It is our intention to build more applications and refine ones previously built. For the sake of brevity, we will highlight four of these applications.

3.1 Iowa Tornado Database

A climatology of tornado reports in Iowa was generated based on a dataset provided by the Storm Prediction Center in Norman, Oklahoma. This dataset was massaged and mined into a spatial database for further manipulation and display. MapServer easily combines this datasource with other GIS layers to produce a zoomable, queryable web application.

Using the configurability of MapServer, tornados with different classifications are visually differentiated by color (Figure 1). The MapServer interface also allows the user to query the generated image for metadata about the points (tornadic events) plotted in the image.

Tornado reports were the first step in our effort to convert other hazard climatologies into a GIS

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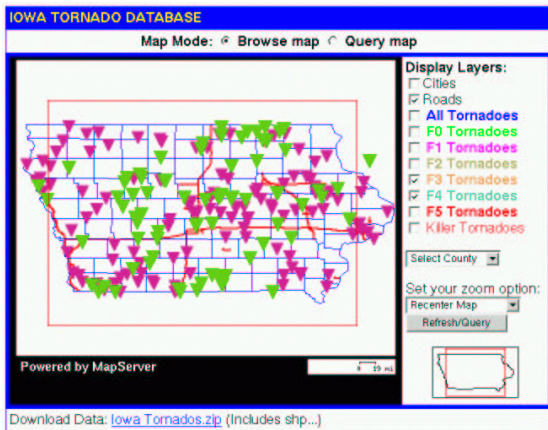


Figure 1: A view of the MapServer interface to the Iowa Tornado Database. F3 and F4 Fujita scale tornadoes are selected and plotted in different colors on the image.

database. Having the reports in a GIS container will open the door to many interesting comparisons. For example, a spatial correlation between tornado sightings and major roadways can be accomplished using Simple Query Language (SQL) instead of writing a program. Having the dataset in a spatial database will make the data more usable.

3.2 Where's it raining?

The IEM collects environmental data from local school networks operated by KCCI-TV (Des Moines, IA) and KELO-TV (Sioux Falls, SD). These networks report live, up to the minute precipitation numbers to the IEM server. A process monitors this datafeed and generates 15 minute accumulations in real-time.

With the help of a meteorological software package called GEMPAK, a process converts recent NEXRAD imagery into GeoTIFFs. GeoTIFFs are TIFF format images with a spatial reference attached to them. Due to the lack of a tool to formally do this conversion, scripts and rough fitting are used to spatially align the image to a projection.

MapServer, via a web interface, combines the NEXRAD imagery with the 15 minute accumulations to produce a qualitative comparison (Figure 2) of the base reflectivity product (#19) and gauge accumu-

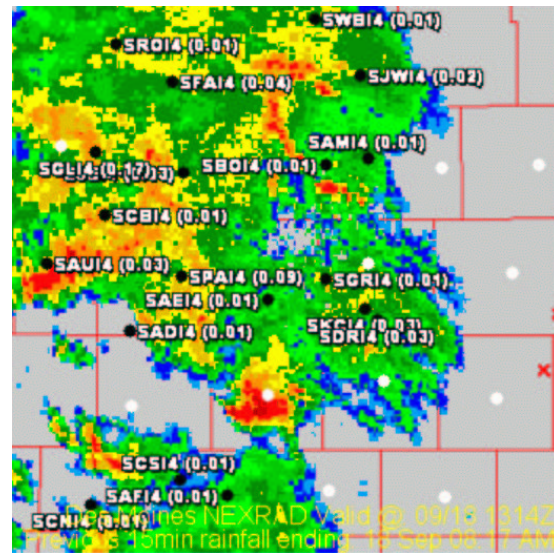


Figure 2: A view of the PHP MapScript output from the *Where's it raining?* application. NEXRAD base-reflectivity is shown overlaid with live 15 minute accumulations (in white).

lations. This application has been useful in cases of virga and most any rainfall event. Another valuable use of this application is to visually identify locations that should be receiving rainfall, but are not reporting it. An example use of this application was a case where a station was reporting precip well after the storm had past. It's accumulation on the plot was noticeable since there was a lack of a reflectivity return near the site. After consulting with the site administrators, it was determined that the tipping bucket was partially plugged, causing the delayed precipitation measurement.

3.3 NWS COOP Climatology

The NWS COOP database provides the official climatological record for the United States. COOP data is not typically available in GIS-ready formats. There is usually a step involved or a process to run in order to convert from a climate format to a GIS format. For many users, the conversion step discourages use of the data. Since the IEM acts as a data bridge between those with data and those needing data. Providing the NWS COOP dataset in GIS format is an

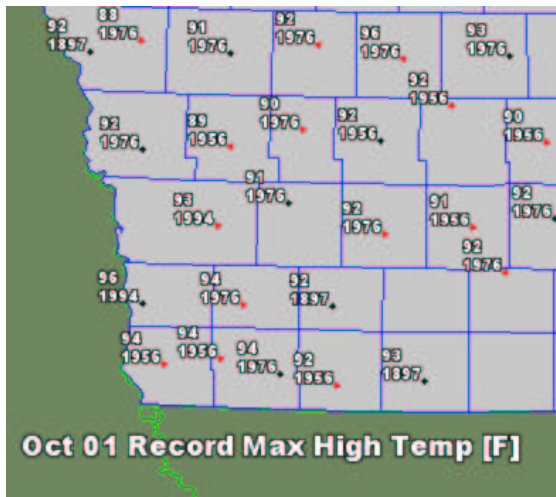


Figure 3: An example plot of record high temperatures over SW Iowa for the day of 1 October. The dominance of 1976 would seem to indicate how wide spread the warmth that day was.

example of our mission.

With the help of the spatial database, the COOP data is easily queryable by MapServer and available for other applications that connect to the database. Spatially plotting climatological extremes can provide an interesting look at historical weather. For example, plotting a day's record high temperature and the year of the record shows the spatial distribution of temperatures (Figure 3) and the spatial extent of the record by comparing the years. For example, some days will break records in a few locations, while others will be wide-spread events. Visual inspection and GIS manipulation are two processes that can help identify suspect data points in the archive.

3.4 Data Map Generation

Visualization is a powerful tool for most types of story telling. In meteorology, the theorem holds that a picture is worth a thousand words. For example, NEXRAD base reflectivity is typically represented with images and not tables. Many web users of the IEM are interested in quick and clean data displays of a variable (i.e., temperature) across the state.

(Figure 4).

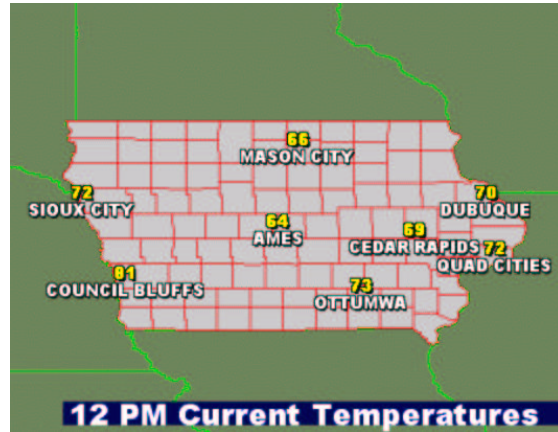


Figure 4: Output from a PHP MapScript application that dynamically plots a parameter from stations of the user's choice.

PHP MapScript is able to produce dynamic GIS plots based on user selections and program customization. Since the application is GIS based, it makes it very easy to incorporate other GIS layers such as road databases and river basins. For example, we have combined a NEXRAD reflectivity layer with a GIS layer containing NWS Weather Forecast Office (WFO) County Warning Area (CWA) shapes with current county and polygon warnings highlighted. (Figure 5) This plot can be looped over time to produce an interesting look at cell propagation within a warning box.

4. NEXRAD IMAGERY

The IEM was first exposed to GIS after receiving many requests for real-time NEXRAD information for use in GIS. While NEXRAD imagery is now freely available on the Internet, it is typically one step away from being GIS ready. Users were most interested in viewing NEXRAD reflectivity products and precipitation estimations. After some investigation, we found it relatively easy to geo-reference reflectivity images and statically provide the data to users.

Some users are not able to handle imagery, and prefer the ESRI shapefile format. NEX2SHP (Ship-

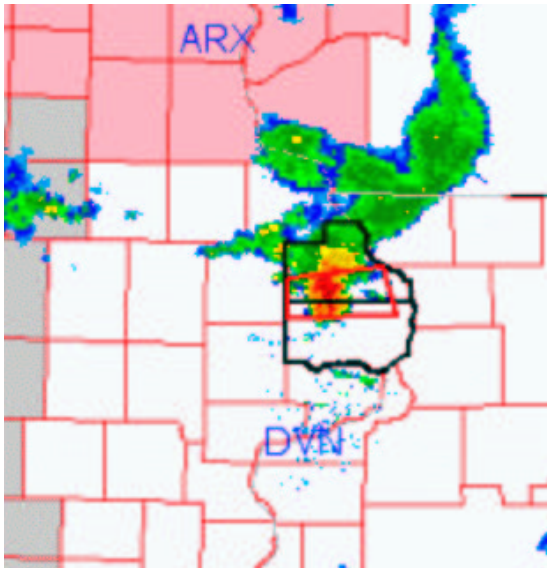


Figure 5: An example plot showing the polygon and county based active warnings for a time the NEXRAD imagery from Davenport, IA (DVN) was valid. This product can be looped on the website.

ley, 2002), an open-source encoder written by Scott Shipley, is currently being used to convert real-time imagery into shapefile format. We are currently only processing NEXRAD sites with Iowa coverage. Future versions of NEX2SHP will also include beam elevation information and the polygons of the NEXRAD range bins, instead of simple point shapes.

The real challenge has been how to stream this information to users in real-time, avoiding static downloads. The GIS applications also need to be configured to refresh their data-source to incorporate the most recent imagery. It also seems difficult to include timestamp information within the products. We are looking for ways to meet these challenges in the near future.

5. CONCLUSIONS

Using the spatial extension, PostGIS, to the PostgreSQL database, the IEM has been able to efficiently store environmental data observed the state of Iowa. With the help of MapServer, we have been

able to generate dynamic GIS plots of datasets for fast and clean viewing by our users. Using PHP MapScript, an extension for PHP, we have been able to generate customizable plotting applications and data visualization engines for the website.

The IEM has just broken the surface with regards to the use of GIS with environmental data in the Iowa. We would be the first ones to admit that we are not using GIS to its full capability. As we continue to build partnerships and collaborations, new ideas to utilize GIS will be formulated and it will be exciting to see where our efforts take us.

6. REFERENCES

- Shipley, S., 2002: NEXRAD to shapefile conversion and GIS beam propagation analysis in 3D. **19th Symposium on Interactive Information Processing Systems**, Annual Meeting of the American Meteorological Society, 9-13 February, Long Beach, CA.
- Todey, D.P., D.E. Herzmann, and G.S. Takle, 2002: The Iowa Environmental Mesonet - combining networks into a single network. **6th Symposium on Integrated Observing Systems**, Annual Meeting of the American Meteorological Society, 14-17 January, Orlando, FL.

A APPENDIX

List of URLs for referenced software.

	URL
ESRI	http://www.esri.com/
IEM	http://mesonet.agron.iastate.edu/
IEM GIS Effort	http://mesonet.agron.iastate.edu/GIS/
GEMPAK	http://www.unidata.ucar.edu/packages/gempak/
GeoTIFF	http://www.remotesensing.org/geotiff/geotiff.html
MapServer	http://mapserver.gis.umn.edu/
OpenGIS	http://www.opengis.org/
OpenSource	http://www.opensource.org/
PHP	http://www.php.net
PHP MapScript	http://www2.dmsolutions.ca/webtools/php_mapscript/
PostgreSQL	http://www.postgresql.org/
PostGIS	http://postgis.refrations.net/