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National Digital Forecast Database

Gridded Weather Forecast Information Now Available in a GIS Format

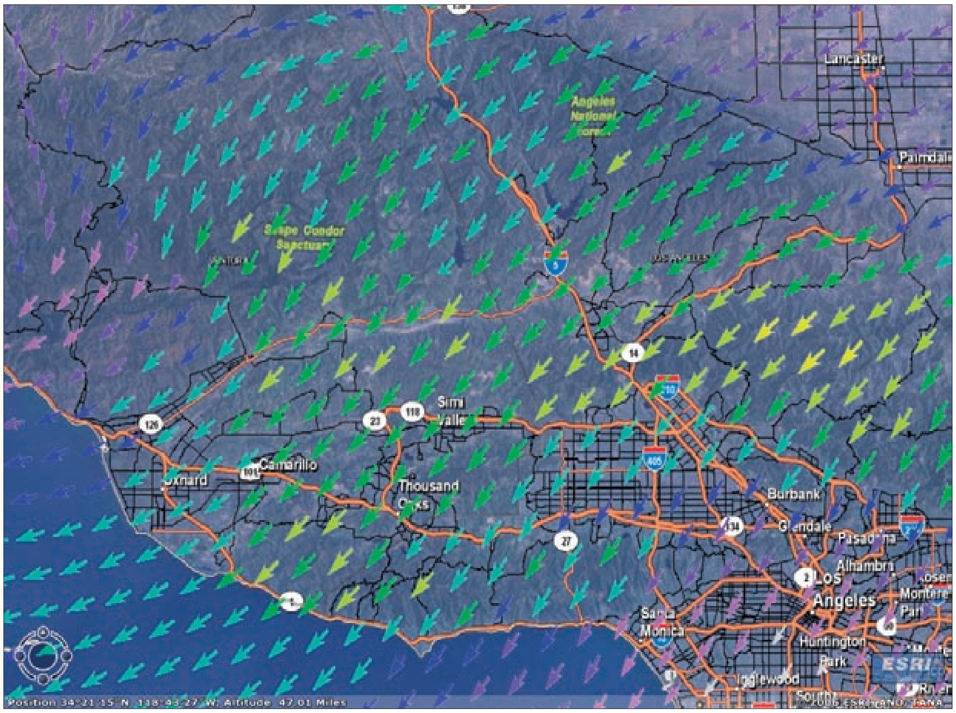
By Jayme L. Laber, Senior Hydrologist, NOAA/National Weather Service

The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) Los Angeles/Oxnard, California, weather forecast office (WFO) is providing gridded weather forecast information to customers in a geographic information system (GIS)-friendly format. Weather forecast information is available as GIS shapefiles and can be brought into a desktop GIS by adding an ArcIMS image service in ArcGIS or ArcGIS Explorer. This service is part of an effort to meet the growing customer and partner demand for weather forecast products in a GIS-compatible format.

The Los Angeles/Oxnard WFO creates the gridded forecasts at varying time scales for San Luis Obispo, Santa Barbara, Ventura, and Los Angeles area counties and adjacent Southern California coastal waters. The forecasts are created locally within the WFO as 2.5-kilometer grid cells covering the forecast area using the Graphical Forecast Editor (GFE). Periodically throughout a day, the grid cells are transmitted to the National Digital Forecast Database (NDFD).

The NDFD provides access to NWS weather forecasts in digital form from a central location. NDFD contains a seamless mosaic of digital forecasts from NWS forecast offices, working in collaboration with NOAA's National Centers for Environmental Prediction. The 2.5-kilometer gridded data is downscaled to a 5-kilometer grid before being made available from the national server.

The database provides faster access to accurate, easier-to-understand information in new formats that are used to create a wide range of text, graphic, gridded, and image products.



National Digital Forecast Database wind speed and wind direction forecasts are displayed using ESRI's ArcGIS Explorer. A color-coded and sized arrow symbology scheme can be applied to wind forecasts.

In This Issue

Shapefile Service

Weather forecasts for maximum and minimum temperature, relative humidity, wind speed, wind direction, and quantitative precipitation forecast (QPF) are made available as GIS shapefiles and can be accessed at www.wrh.noaa.gov/lox/gis/shape.php. All the forecasts are available as polygon shapefiles except for wind speed and wind direction, which are available as point shapefiles. A color-coded and sized arrow symbology scheme can be applied to wind forecasts. A layer file that can be applied for the symbology and instructions for applying the arrows are also available on the Web page.

The shapefile service for weather forecast information covers all of coastal Southern California from San Luis Obispo County south to the San Diego County border with Mexico. This includes

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RIDGE Radar from the National Weather Service

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The National Weather Service (NWS) makes its weather, water, and climate information widely available using commonly accepted standards and technologies. In 2003, the National Oceanic and Atmospheric Administration (NOAA) NWS began development of an experimental ArcIMS site to provide emergency managers with a means to access real-time weather data both prior to and after the landfall of a tropical storm or hurricane. This project was migrated to the National Weather Service Southern Region Web farm based in Fort Worth, Texas, and served tropical storm/hurricane information as GIS-ready data in the 2007 season. These services were initially designed as an experiment to test scalability and the feasibility of these types of services. Hurricane model track information, warning polygons, and satellite and radar imagery will also be viewable and available through this GIS server.

Current Status of GIS

An NWS radar team was formed in 2000 and tasked with making WSR-88D information available on the Web. Since their inception in 2000, the NWS radar Web pages have become very popular, accounting for up to 50 percent of all NWS Web traffic during hurricanes reaching landfall and 20 to 40 percent of Web traffic during "normal" weather. During a severe weather outbreak in early April 2006, the NWS radar integrated display with geospatial elements (RIDGE) Web pages garnered 70 percent of the total NWS Web traffic. In fact, during the week of August 24–29, 2005 (i.e., during Hurricane Katrina), the NOAA NWS Web counters registered 3.4 billion hits.

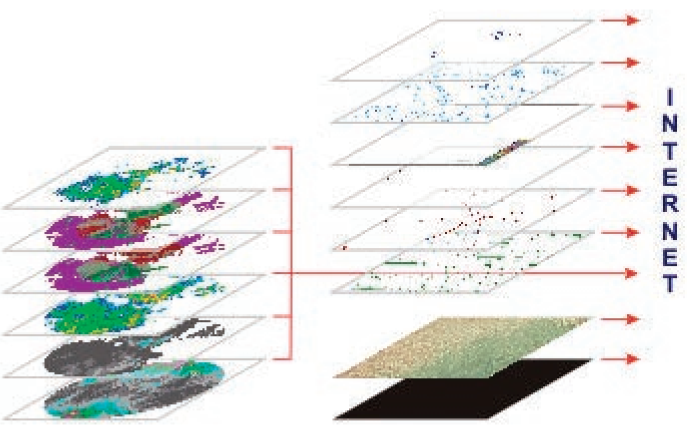
Preliminary numbers for the month of August 2005 showed more than 200 million individual users. These numbers are astounding when one considers bandwidth use, since the average NWS radar Web page is approximately 110 KB. Another comparison to increasing Web use can be made using recent and older hurricanes as examples on the Southern Region (SR) Web farm. Hurricane Lili made landfall along the Louisiana coastline on October 2, 2002. Web counters on the SR Web farm that day registered 19.1 million hits, 1.3 million users, and 141 GB of data transferred. Hurricane Katrina made landfall in eastern Louisiana on August 29, 2005. Web counters at SR registered 87.2 million hits, 5.7 million users, and 673 GB of data transferred. Similar numbers were reported during Hurricane Rita three weeks later.

Although the NWS radar Web pages have become popular and successful, the sites have had their share of problems. The software that generated the imagery through early 2006 was dated and very difficult to modify. Several factors can be linked to that problem. First, the development team was dissolved after the initial Web page deployment in 2000, and several of the original programmers retired and/or no longer work for NWS. Road and highway background information was difficult to update given the old software and data format. Lastly, the architecture of the dataflow and image production led to several single points of failure, which, given the popularity of the NWS radar page, is unacceptable. The above, along with no operational funding or support, led to a stagnant product, and the NWS radar information and display were not updated in six years. In 2003, the Office of Chief Information Officer (OCIO) provided SR seed funding to explore technologies and better architecture and replace the existing displays.

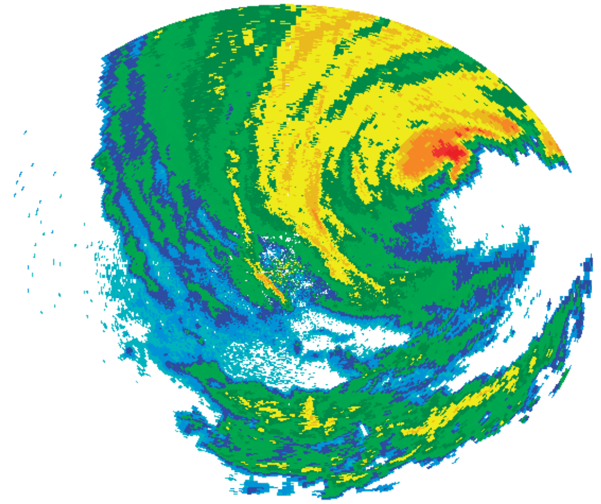
SR, in a partnership with North Central Texas Council of Governments (NCTCOG) and software originally developed at NCTCOG, developed RIDGE. The first tests online began in February 2004.

Architecture

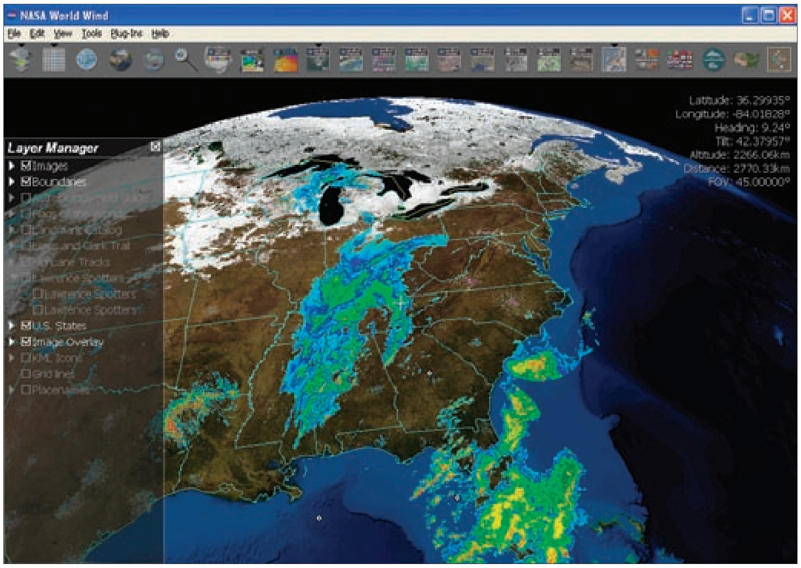
RIDGE was developed to address several flaws in the existing NWS radar Web page and dataflow design. RIDGE eliminates the points of failure through redundancy and displacement. Initially, RIDGE was operated in Fort Worth, Texas (SR headquarters) and was expanded to Kansas City, Missouri (Central Region headquarters), and Silver Spring, Maryland (NWS headquarters), several months before the March 2006 imple-



RIDGE uses layers of transparent GIFs and the Web browser to display radar information with any number of geographic reference layers.

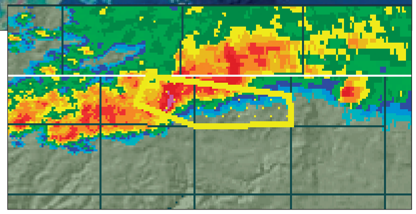


The single layer (image) containing radar information and the associated world file allow easy import into GIS software.



RIDGE radar imagery loaded into GIS software utilizes georeferenced information.

RIDGE radar and hurricane information loaded into ArcGIS shows Tropical Storm Humberto in 2007.



Warning polygon on RIDGE issued by the NWS, indicating area of highest threat due to adverse weather.

mentation. Data is collected through the Satellite Broadcast Network (SBN), also called the NOAA Port. By adding to the number of data collection points and duplicating image generation locations, the possibilities of a radar Web site being down occur only when the radar itself is down.

The current RIDGE was built using object-oriented programming code using the Microsoft .NET architecture. The design uses robust hardware and software documentation while being under full configuration management. Phase 2 of RIDGE was designed using object-oriented Java for multiplatform capabilities, keeping the software from being tied to specific operating systems. The Java version will allow utilization of OpenGL for fast rendering of the data and can output any format supported under the Java platform extension API, Java Advanced Imaging (JAI), including, but not limited to, shapefiles, PNG, JPEG, GIF, and SVG.

Web Structure

RIDGE on the Web was built using several concepts:

- Most Web browsers use caching.
- GIS is a growing and expanding field.
- Background/Reference information changes.
- Display the latest warning polygons in conjunction with radar information.

Cache

RIDGE uses layers (transparent GIFs) to present the information on the Web. Each layer contains specific reference information that is easily updated or removed without affecting the other layers or, more importantly, the radar image generation software. Using Web scripts that are browser independent, each layer's visibility can be changed at the user's request.

The layering technique also allows browsers to cache the layers of geographic information (images), the scripts, and the Web page. On a user's second visit to a specific radar, only the small (< 20 KB) changed information (radar image, legend, and warning overlay) is downloaded. This technique also allows NWS to display other radar products (images) without directing the user to another product-specific Web page. For example, a user initially views base reflectivity and wants to then load a storm's total precipitation. Instead of being directed to another Web page designed to host the graphic of the storm's total precipitation, the user retains the current Web page and layers of geographic information and replaces the base reflectivity and legend with storm total precipitation and corresponding legend.

GIS is a science that reaches across all domains, both socioeconomic and technological. With that in mind, RIDGE attempts to bring a rapidly changing dataset to the predominantly static GIS world while minimizing bandwidth. RIDGE accomplishes that by separating the radar output image from the remainder of the image and associating the graphic with a real-world coordinate file—that is, georeferencing the image using a world file (a text file used to display raster images in real-world coordinates). Georeferencing an image establishes the relationship between page coordinates on a planar map and real-world coordinates. Each RIDGE radar image has an associated world file that contains the information necessary to plot the image using commercial and open source GIS software.

Georeferencing an image not only helps GIS users but also enables the RIDGE Web page to contain additional enhancements. One of these enhancements is range-bearing information. Using JavaScript, which tracks mouse movement and GIS information from each image, distance and latitude-longitude information can be displayed on the Web site based on user requests. This feature allows users to determine distances between the location of a storm and a point, as well as latitude-longitude information, by clicking the mouse.

KML Support

While the RIDGE radar display allows the use of interactive toggles with the image on the Web, RIDGE images can be best utilized with GIS software.

The NWS RIDGE developers have taken the next step in providing the RIDGE radar in compressed Keyhole Markup Language (KML) files (KMZ files) compatible with several GIS software applications. KML is an XML-based language accepted by several commercial GIS software applications, and because of the RIDGE project, NWS is evaluating KML as an official format for data dissemination.

Each of the layers containing geographic references is created using shapefiles that are developed and maintained by the responsible agency. For example, road information is maintained and made available by the Department of Transportation, and river data is maintained by the United States Geological Survey. NWS accesses these datasets and generates the background layers independently of the software that generates the radar images. Having the background information in its native form from the authoring agency allows NWS to maintain the latest changes on the Web page.

Warning Polygons

The RIDGE Web pages are the first to display NWS warning polygons for tornados, severe

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National Digital Forecast Database

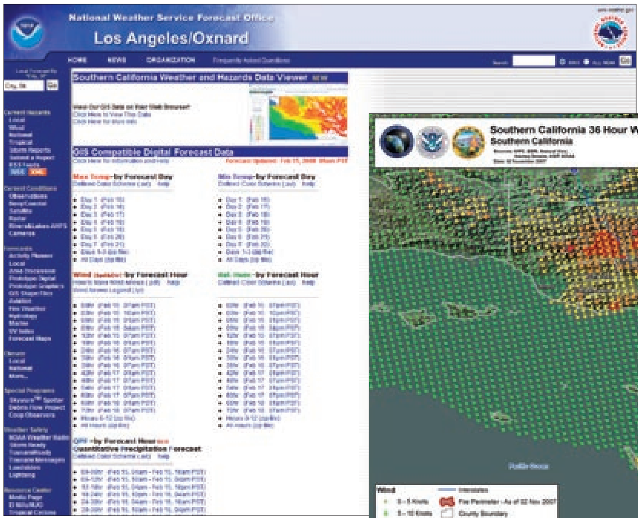
forecast areas covered by the Los Angeles/Oxnard and San Diego weather forecast offices.

Digital weather forecast information from the NDFD is available in a gridded binary (GRIB2) format. A software tool, DeGrib, reads, views, and converts GRIB2 formatted data; it can be downloaded from www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/download.php. The DeGrib program is run by command line scripts that access the NDFD data and convert forecast information into GIS-compatible shapefiles. Therefore, to use the shapefiles within their own GIS systems, users only need to download the zipped shapefiles from the Web page.

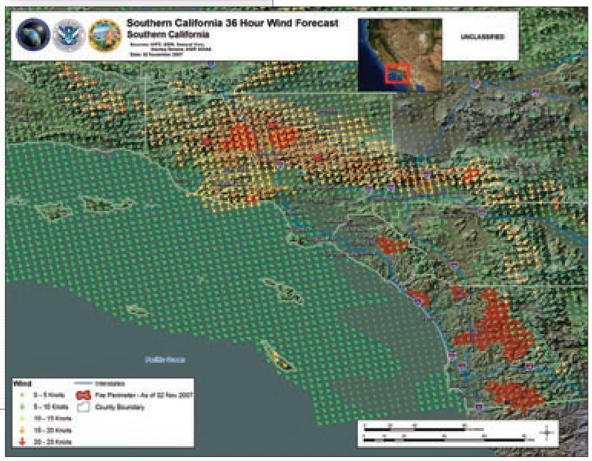
Image Service

The NOAA Coastal Services Center, in partnership with the Los Angeles/Oxnard and San Diego WFOs, developed an image service using the ESRI ArcIMS application to make NDFD weather forecast information available at http://maps.csc.noaa.gov/CSP_SoCal/. The shapefile service, described above, allows GIS software users to access digital weather forecast information and fuse it with their own data layers to generate personalized displays. Currently, the image service affords customers who are not users or owners of GIS software the ability to access the digital weather forecast information and generate an image display using a computer and an Internet connection.

Maximum and minimum temperature, wind speed, wind direction, relative humidity, wave height, and QPF are available from the image service.



This shows an example of GIS shapefile access to National Digital Forecast Database forecasts from the NOAA/NWS Los Angeles/Oxnard weather forecast office Web site.



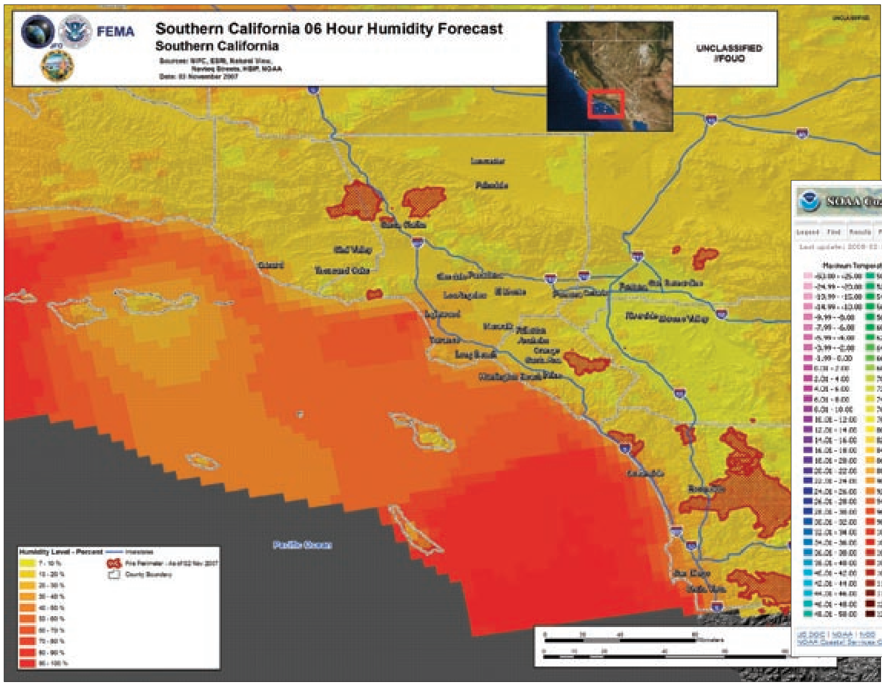
Sample display of wind speed and wind direction forecast for Southern California. A color-coded and sized arrow symbology scheme can be applied to wind forecasts.

Adding the Data as a Service to a Desktop GIS Application

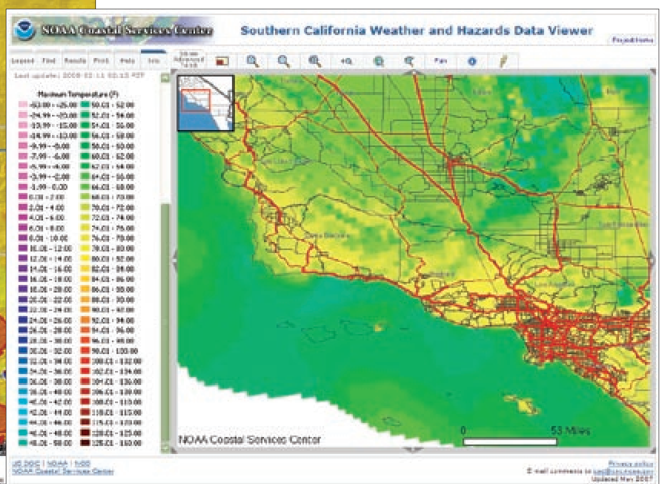
Weather forecast data can be brought into a desktop GIS application by adding an ArcIMS image service in ArcGIS or ArcGIS Explorer and pointing it to the Web site nowcoast.noaa.gov. The service name at this address is ndfd. One advantage or benefit of adding the forecast data as a service is the availability of weather forecast data for the entire continental United States (rather than just Southern California). Additionally, as with the shapefile service, this data can be used within a GIS system in tandem with custom geospatial datasets.

A wide spectrum of Southern California agencies and users are giving the NDFD forecast weather shapefile and image services, made available by the Los Angeles/Oxnard WFO, an emphatic thumbs-up. These digital weather forecast services will continue to evolve and expand with new technology and customer needs.

For more information, contact Jayme L. Laber, senior hydrologist, NOAA/National Weather Service, Los Angeles/Oxnard weather forecast office, by phone at 805-988-6621 or by e-mail at Jayme.Laber@noaa.gov.



A sample relative humidity forecast is displayed for Southern California.



NOAA Coastal Services Center Southern California Weather and Hazards Data Viewer displays maximum temperature forecast data.

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RIDGE Radar from the National Weather Service

thunderstorms, and flash floods, as well as special marine datasets, in conjunction with radar data. In addition to county-based warnings, the NWS forecast offices issue polygon warnings that typically cover a smaller area and focus on the area with the greatest threat of adverse weather. This information is contained within the text of the county warnings in the form of latitude-longitude points. These points, when plotted, are the corner points of a complete polygon representing the high-threat area. Since RIDGE is GIS based, the polygons can be easily brought into RIDGE as a layer. Initially, the warning polygon layer was generated in conjunction with the radar image for time matching during loops. However, due to the rapid evolution of severe weather, the RIDGE developers increased that process to one-minute warning polygon updates with time matching on the loops for all frames except the final frame. Future enhancements of RIDGE will allow the user to click on warnings, causing the warning text to pop up.

RIDGE-Lite

Some users block JavaScript from use in browsers, and not all PDA clients can utilize JavaScript/Java capabilities. As a result of some customer feedback on this issue, the team developed a RIDGE-Lite Web site. This site features no scripting or layers and is designed for slower Internet connections by removing some less-bandwidth-friendly geographic references and scripts. This is done by combining the RIDGE image layers into a single graphic. RIDGE-Lite gives users an option to continue viewing radar (at the expense of all the enhancements) and makes use of animated GIFs for looping.

National Mosaics

The initial version of the NWS National Radar Mosaic featured a 10 km composite generated from the Radar Coded Message (RCM). The RIDGE team was able to institute a 2 km mosaic along with sector mosaics including Hawaii and Alaska composites. All the RIDGE mosaics and sectors are georeferenced as well for integration into GIS software. Future enhancements to the mosaics will include clutter filtering and faster update cycles through the Warning Decision Support System-Integrated Information (WDSSII) application evaluation program.

Phased Changes

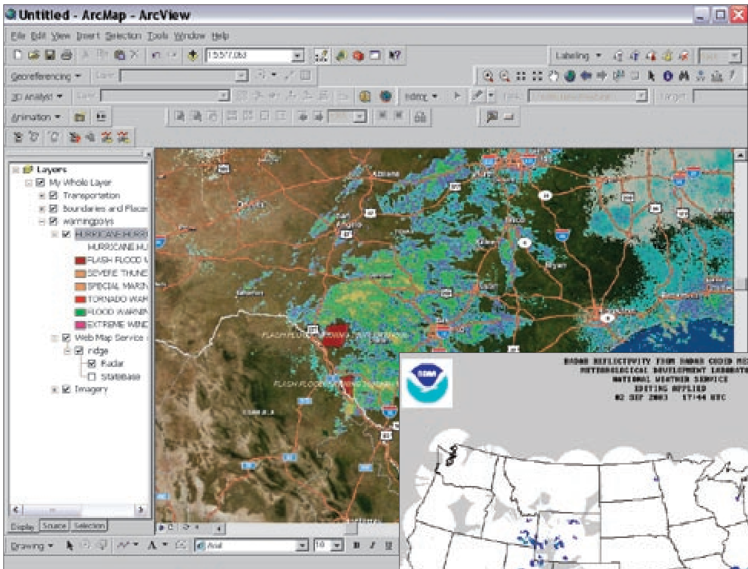
RIDGE went into operational production on March 1, 2006. The implementation had its share of issues—mainly user issues with browser compatibilities and links. Most of those problems abated within a few months. Even after the implementation of Phase 1, the RIDGE team was developing version 2 (the Java version).

Unlike the original NWS radar Web team, the RIDGE team remained intact after implementation. This, combined with yearly funding and support, will help maintain and grow the NWS radar Web pages. Additional resources will allow NWS to put additional radar products online. The existing RIDGE page features Base Reflectivity 0.5, Base Velocity 0.5, Storm Relative Motion, Composite Reflectivity, Storm Total Precipitation, One-Hour Precipitation, and Long Range Reflectivity. Echo Tops, Layer Reflectivity, VAD winds, and VIL are among some of the products slated for future enhancements.

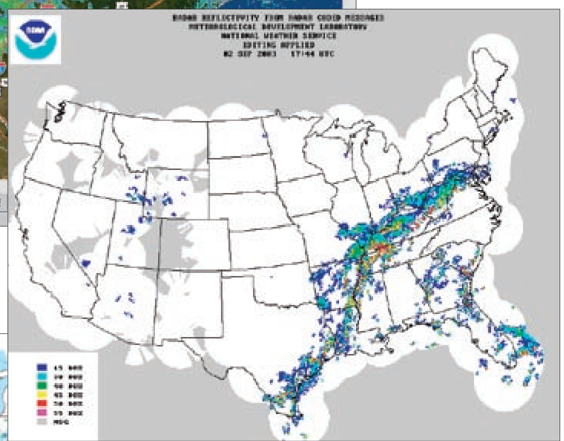
The new NWS radar pages utilize a browser cache in an attempt to reduce bandwidth. This is accomplished by consolidating Web pages and separating the images into layers. Each image layer is a transparent GIF that, when stacked in the same location, appears to be one image. This layering also allows the user to turn layers on or off, allowing NWS to add more geographic references.

NWS warning polygons are displayed for the first time in conjunction with radar data using RIDGE, which transforms the traditional text warning describing radar to a real-time visual warning. RIDGE also allows GIS users to add radar information to GIS applications by making a world file available with each image. The ability to add radar and warning information to GIS applications without having to acquire and decode radar data makes it much easier for decision makers to access real-time radar and warning information. Through browser-enabled scripting, RIDGE brings simple technology to the user without compromising bandwidth. Range-bearing and latitude-longitude calculations can be done because of this scripting and because the images are GIS based. The RIDGE images are also offered through KML for GIS applications that support KML. RIDGE will be continually improved and updated.

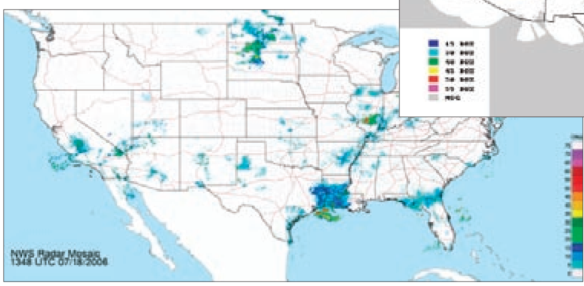
Information on RIDGE radar and how to incorporate it into a GIS display is available at http://radar.weather.gov. More weather-related GIS data is also available at www.weather.gov/gis.



A display of warned areas and the latest RIDGE radar image.



The original NWS Mosaic derived from the 10 km RCM message.



The new 2 km NWS Mosaic as a georeferenced GIF file.

Taking NEXRAD Weather Radar to the Next Level in GIS

By Scott T. Shipley, Department of Geography and GeoInformation Science, George Mason University

The National Weather Service (NWS) currently serves near real-time radar information in GIS-ready formats through its radar integrated display with geospatial elements (RIDGE) service at http://radar.weather.gov. The current RIDGE service provides two-dimensional products as each radar scans through 360 degrees azimuth at its lowest beam elevation angle, which is nominally about one-half degree above the horizon. These products are generally seen draped on the surface as ground overlays, mapping radar reflectivity or radial velocity as a function of position (latitude-longitude) and animated in time. This is a fabulous and useful service, which is now being taken along on portable handheld devices. The message is clear to the casual user: any radar echo over your location means it should be raining, or snowing, or whatever it's supposed to be doing outside at the moment. But sometimes there are no radar echoes over a user's location, yet they're getting soaked.

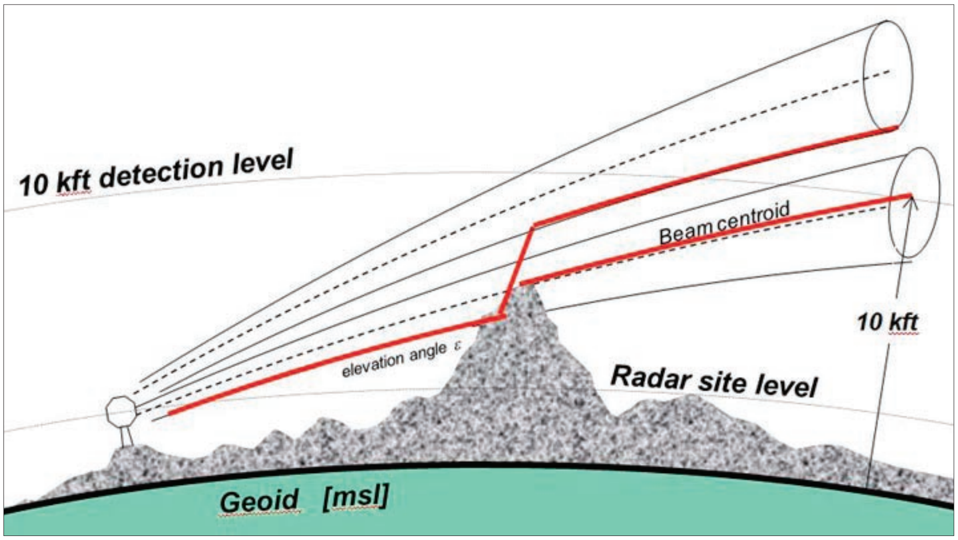


Figure 1. Radar propagation paths show occultation of the lowest elevation beam by terrain. When more than 50 percent of a beam is removed by occultation, that beam is considered blocked, and radar signals are obtained from the next-highest elevation scan.

So what's going on? The answer can be found in the third dimension.

Radar beams propagate horizontally through the atmosphere along Great Circles, but do not usually follow a straight path or ray in the vertical dimension. As shown in figure 1 for standard atmospheric conditions, radio beams are normally refracted downward toward the earth. Any departure from this standard path is known as anomalous propagation (AP). If the radar beam encounters an obstacle, such as terrain or buildings, power is removed from the radio beam and a radio shadow appears behind the obstacle. This effect is known as *occultation*.

Beam occultation by terrain raises the lowest detection altitude behind an obstacle, defining the lower limit, or floor, of the active radar volume. The degree of occultation is symbolized by the percentage of beam removed in tenths of vertical beam width.

Applying the 50 percent blockage rule to a radar collection provides an indication of the vertical extent for radar coverage in a region. This is shown in figure 2 for the five NEXRAD systems covering the Front Range of the Colorado Rockies. A regional floor is found by combining all radar grids with the *minimum* analysis condition and the application of SetNull, so that only detectable areas of the atmosphere are combined.

The challenge is to show where terrain is blocking the NWS weather radar network and to what

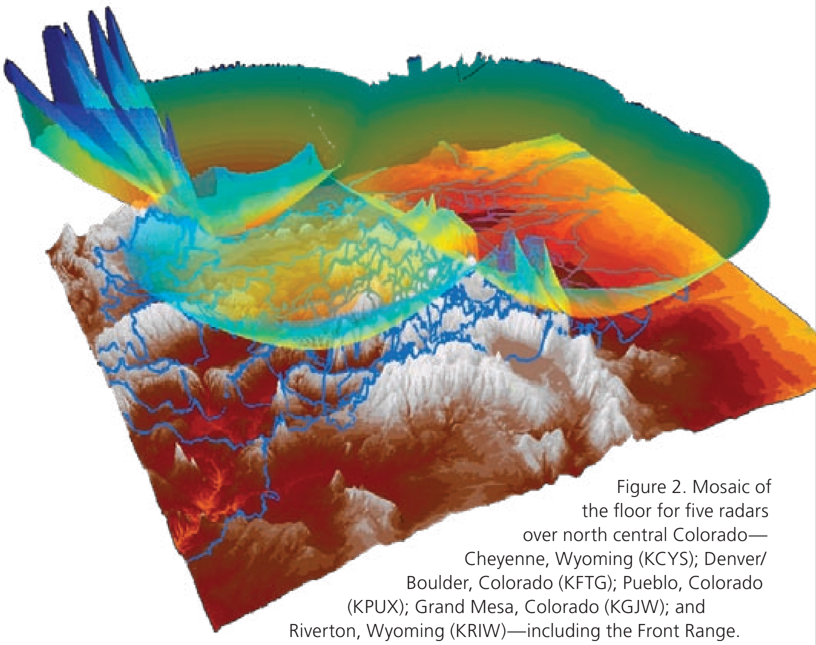
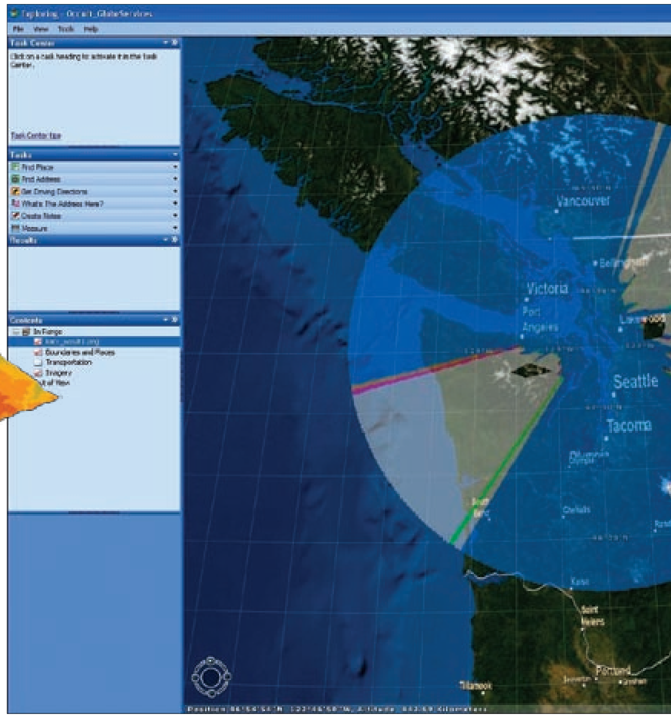


Figure 2. Mosaic of the floor for five radars over north central Colorado—Cheyenne, Wyoming (KCYS); Denver/Boulder, Colorado (KFTG); Pueblo, Colorado (KPUX); Grand Mesa, Colorado (KGJW); and Riverton, Wyoming (KRIW)—including the Front Range.



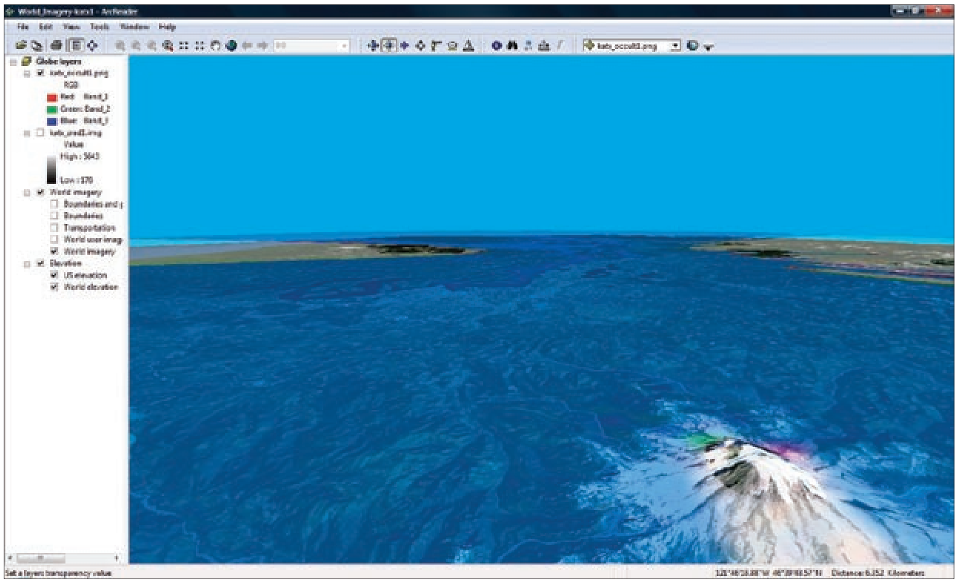


Figure 4. Close-up image of the KATX occultation pattern using ArcReader. The top of Mt. Rainier, at bottom right, provides a convenient ruler to verify vertical placement of the radar beam centroid.

degree. GIS provides a straightforward solution by comparing the vertical beam centroid (midpoint of the beam) as a floating surface to a digital terrain model at an appropriate spatial resolution. The resulting pattern for the Seattle, Washington, NEXRAD (KATX) is shown as a floating surface with ArcGIS Explorer in figures 3 and 4. The occultation patterns for all 155 NEXRAD systems are published as a globe service in ArcGIS Server 9.3 and are available for inspection, courtesy of WxAnalyst, Ltd., at http://wxanalyst.com/radar.

The NEXRAD occultation patterns are also available in KML format, using collaborative design activity (COLLADA) to model the 3D surface.

The RIDGE radar data is now accessible in 3D using the same floating surfaces for each beam elevation angle. This is shown in figures 5a and 5b for the Sacramento, California, NEXRAD (KDAX) using RIDGE reflectivity from the storm of January 4, 2008.

Acknowledgment—The author acknowledges the intellectual contribution of Steve Ansari of the National Climatic Data Center, which led to implementation of the 3D beam centroid surfaces in KML/COLLADA.

For more information, contact Scott Shipley by e-mail at sshipley@gmu.edu.

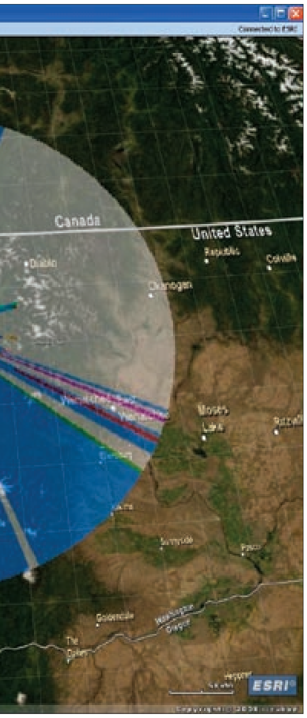
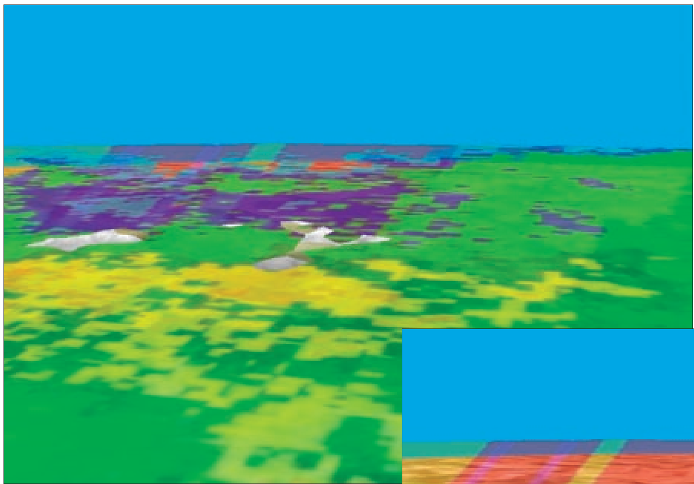
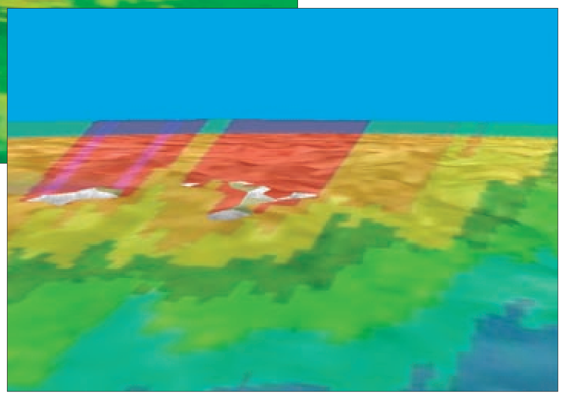


Figure 3. Occultation pattern for the lowest elevation scan of the Seattle, Washington, NEXRAD (station KATX) in ArcGIS Explorer. Note the total blockage of this elevation scan by terrain to the east and west and by Mt. Rainier to the south-southeast. The occultation pattern is a 3D service draped on beam centroid elevation. Areas where the terrain layer is higher than the beam centroid can be seen penetrating the coverage.





Figures 5a (above) and 5b (right). KDAX (Sacramento, California), looking west over the Sierra Nevada Mountains. The image on the left shows a lowest elevation scan without radar reflectivity. The image on the right depicts a lowest elevation scan with radar reflectivity, showing the rain shadow behind the mountains due to occultation.

Something Old, Something New, Something Blue—A Marriage of Weather and GIS

By Jack Settelmaier, National Weather Service, Southern Region HQ, Fort Worth, Texas

The core mission of the National Weather Service (NWS) is to protect against life and property losses and promote commerce. To support this mission, more than 122 forecast offices located around the United States constantly monitor the weather, release forecast information, and issue life- and property-saving weather warnings as conditions warrant. Increasingly, these warnings and forecasts are issued in formats that can easily be ingested into partners' and users' computer systems to aid in their decision-making efforts.

Delivering NWS products and services in more modernized formats has made nearly all NWS information directly ingestible by GIS, such as ESRI's ArcGIS, for further processing and interrogation.

In a previous issue of *Atmospheric Front,* Ken Waters detailed how NWS made use of ESRI's ArcGIS technology to help move NWS to operational status with its storm-based warnings paradigm shift. This article will briefly detail three more ways NWS is marrying NWS data with GIS tools such as ArcGIS.

Something Old

Something old refers to taking old NWS verification statistics that have been readily available for many years, but were previously not paired with GIS for geographic display and analysis. For nearly its entire existence, NWS has kept statistics to monitor its forecast performance. For most of that time, these old statistics were used internally to self-monitor forecast performance. NWS has always endeavored to ensure that its forecast performance remains at a high level as it incorporates new technology into operations. More recently, some of these previously internal statistics were used to satisfy the Government Performance Result Act (GPRA) of 1993 requirements to ensure that the agency is meeting its performance goals and should continue to be funded.

As an example of the kinds of performance statistics NWS maintains, figure 1 shows a graph of average forecast error for minimum temperature (based on forecasts from the National Digital Forecast Database [NDFD]) for April 2008 for each of seven forecast days. That is, on average around the country for forecasts in April 2008, NWS forecasts for a minimum temperature seven days prior to it being measured averaged within 5.25 degrees Fahrenheit of what was actually observed. Conversely, for April 2008, forecasts of the following day's minimum temperature tended to be within 2.75 degrees of what was observed. These performance numbers not only tend to be smaller for warmer months of the year (4.25 and 2.50, respectively, for August 2008) given the smaller diurnal ranges but also are heavily influenced by the conditions experienced during the month in question. In addition, the conditions experienced that month are a function of the weather pattern that was predominant.

To glean this more detailed understanding of forecast performance and to identify under what conditions forecast improvement can most likely be realized in the future, GIS can be used. Simply displaying these old performance statistics geographically in a GIS obtains a quick geospatial understanding of NWS forecast performance. As an example, figure 1 displays the Day Seven 12UTC Temperature performance statistics (based on gridded forecast information as a proxy for minimum temperature forecasts) applicable to each of the county warning forecast areas (CWFAs) of the NWS local forecast offices.

Displaying even old performance statistics in GIS, one is immediately drawn to the higher forecast errors located in the central part of the country. An atmospheric scientist can take that initial information and conduct further analysis to understand that such large errors located in the center of the country are at least somewhat attributable to the large climatic variability that this geographic area experiences many months out of the year, especially during a spring month, when winter and summer air masses are readily moving north and south and colliding over an area often referred to as Tornado Alley. As one might expect, forecasting the weather seven days in advance with such

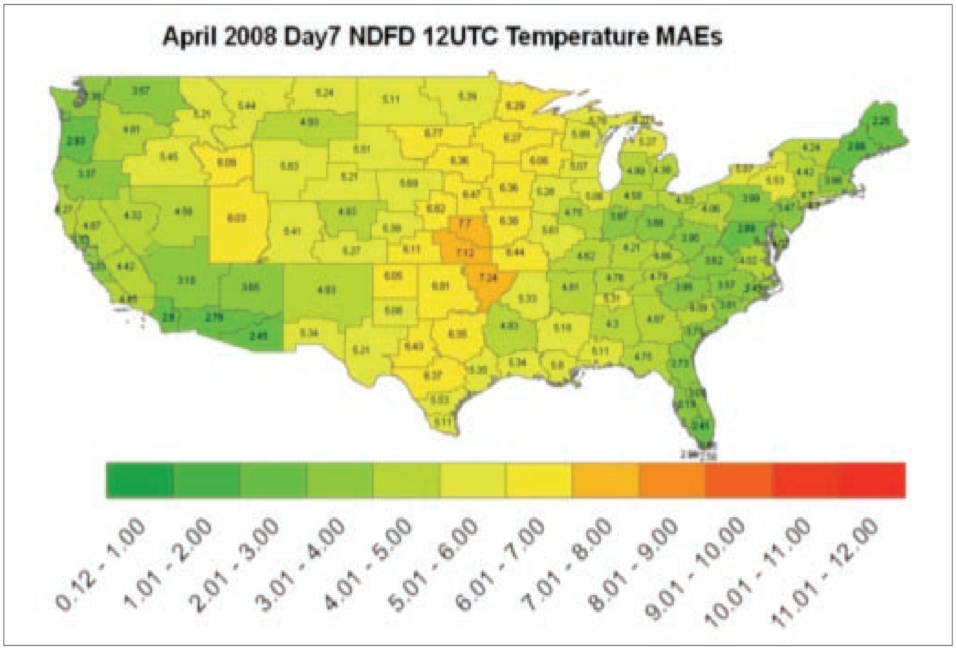


Figure 1. Day Seven 12UTC Temperature performance statistics (based on gridded forecast information as a proxy for minimum temperature forecasts) applicable to each of the county warning forecast areas of the NWS local forecast offices.

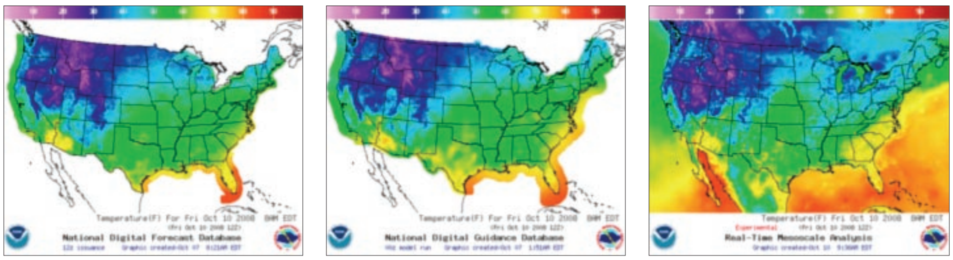


Figure 2. GMOS (a) and NDFD (b) morning temperature forecasts compared with the RTMA observed conditions (c).

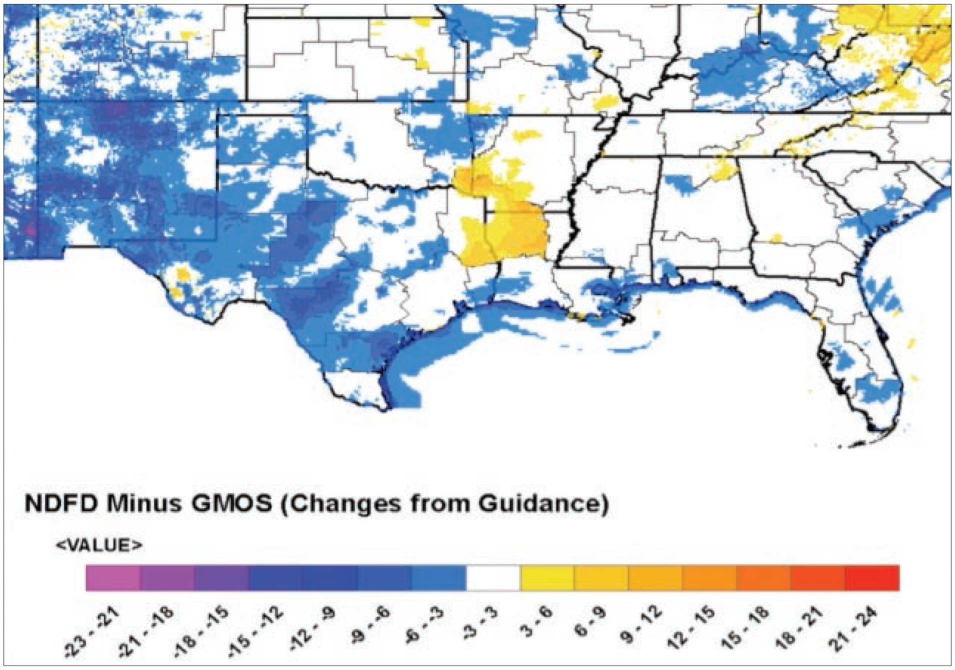


Figure 3. Color-highlighted areas showing where NDFD forecasts were either warmer or cooler than what was initially forecast in the GMOS first-guess forecasts. Areas with no color are where the NDFD and GMOS forecasts were within 3 degrees Fahrenheit of each other.

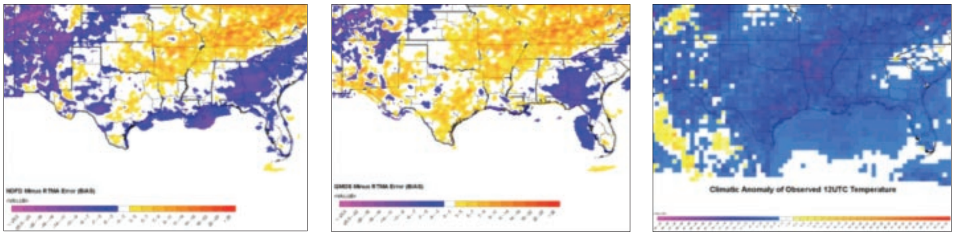


Figure 4. GMOS (left) and NDFD (middle) morning temperature forecast errors, compared with observed climatic anomaly for the morning temperature that day (right). Note that the errors tend to be greatest near the leading edge of an observed cold anomaly (just behind a cold front).

varying conditions is not easy; hence, the larger errors observed.

GIS has added to the overall understanding of the performance characteristics of NWS forecasts. Examples of additional analysis will be covered in the next section of this article.

Something New

Something new refers to current NWS efforts to gather more detailed—with respect to time and space—performance statistics that can be explored using GIS to increase overall understanding of NWS weather forecasting performance. It is possible to explore weather forecast performance characteristics by looking at performance on a temporal scale of days (rather than months as shown above), and on a spatial scale of 5 km NDFD forecast grid boxes (rather than CWFAs as shown above).

This new approach takes forecast and observation data from as high as five kilometers to calculate performance statistics. Specifically, the gridded NDFD and a gridded automated statistical forecast system called Gridded Model Output Statistics (GMOS) are being compared utilizing high-resolution analyses of observed conditions available from Real-Time Mesoscale Analysis (RTMA).

This explores an automated forecast system that was developed by NWS to provide a first-guess forecast from which local NWS forecasters can then make changes as they see fit. By comparing these two forecast schemes alongside the conditions that were observed, NWS hopes to home in on the atmospheric conditions that are most conducive to forecasters being able to make incremental changes to the automated forecasts, and thus improve the forecast.

As an example, data is collected from each forecast scheme for each forecast day leading up to an observed event. This data is collected from NWS servers in its native gridded binary (GRIB) format, converted to shapefiles, and processed using tools from ESRI's ArcGIS toolboxes, all in an automated fashion using scheduled tasks acting on Python scripts. The resulting data is then displayed in graphics and inserted into ArcMap documents that can be perused or served as a service via ArcGIS Server. An example of the imagery is shown in figure 2.

Despite the color scales being identical for each image—even when looking at larger images than are inserted here—it is quite difficult to see areas where forecasters have made alterations to the forecasts. Given that these are Day Three forecasts, it is easier to see, for example, that both forecast schemes had predicted cooler temperatures (green) over the Southeast than were observed (yellow). ArcGIS Desktop 9.3 is used to further analyze and process the data that feeds these images to make determinations of where significant edits to the first-guess forecasts have been made. Insignificant edits (defined as +/- 3 degree F changes for Days 1–3 and +/- 5 degrees F for Days 4–7) are delineated as white in an image, as shown in figure 3.

After the insignificant edits are whited out, what remains are portions of the forecast that were modified by local office forecasters to either warm (yellow to red colors) or cool (blue to purple) the forecast database from what was initially presented as a first guess. After seeing where significant edits were made, additional images can be reviewed, resulting from further ArcGIS automated processing, that show each forecast scheme's error as well as how climatologically anomalous the observed conditions were, as shown in figure 4.

The NDFD had a larger cold-bias error in the Southeast than did the GMOS, with arguably very similar performance characteristics elsewhere.

Something Blue

Something blue makes reference to our blue planet as viewed inside ESRI's ArcGIS Explorer or ArcGlobe. In 2008, the headquarters of the Southern Region of NWS, located in Fort Worth, Texas, became a partner in a NASA-funded project to evaluate the use of TouchTable technology as a collaborative tool. A TouchTable is a large display monitor, akin to a computer or television screen, that can be utilized either in a vertical or horizontal position. What puts the "touch" in TouchTable is the ability for users to manipulate or control the computer software by touching the screen. Sensors located around the monitor respond, and software takes those touch cues and relates them to the underlying software on the machine.

The NWS TouchTable was configured by

continued on page 10

continued from page 9

Something Old, Something New, Something Blue—A Marriage of Weather and GIS

StormCenter Communications and is built on ESRI software. Users configure what they want to display and manipulate on the TouchTable by authoring a document in ArcGlobe. All participants in a collaboration session view the same data layers. Any annotations, zooming/panning, or turning off/on layer manipulations are instantly viewable on the screens of all the participants. In this way, along with an audio connection via telephone, briefings can take place on any number of topics.

NWS will use the TouchTable to review datasets that can communicate the impacts weather may have on mitigation, response, and recovery operations prior to, during, or after events such as hurricanes or catastrophic flooding. Figure 5 shows a TouchTable screen shot used to convey the severity of the fullness of the reservoir upstream from Presidio, Texas. By using the Swipe tool between layers showing the mean reservoir conditions and LANDSAT imagery showing the conditions during this event, it was possible to convey just how full the reservoir was in comparison with normal conditions.

NWS meteorologists continue to explore ways to marry weather data and GIS. Explaining and understanding the environment and the impact weather has on our lives is mission critical to the NWS. You can keep an eye on datasets NWS is making available in GIS-ready formats at http://weather.gov/gis.

For more information, contact Jack Settelmaier at jack.settelmaier@noaa.gov. Settelmaier is the digital techniques meteorologist at the National Weather Service's Southern Region Headquarters Science and Technology Services Division in Fort Worth, Texas.

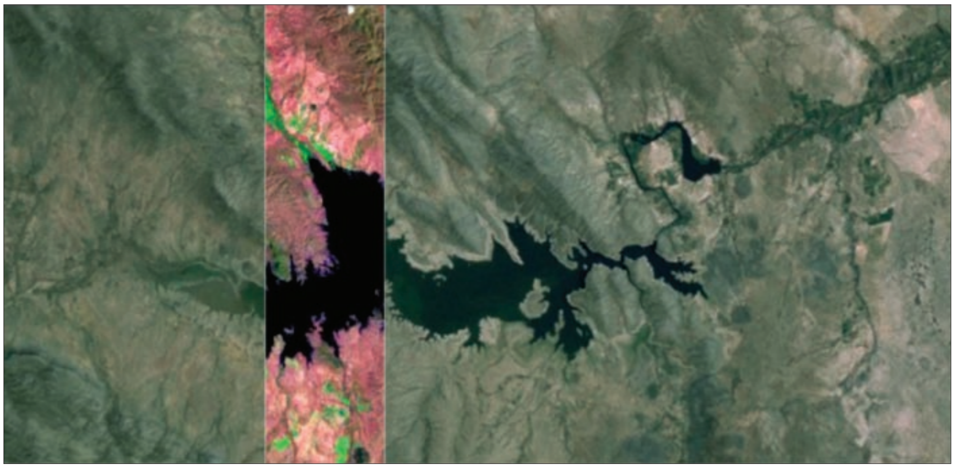


Figure 5. Pre- and postevent comparison showing a sliver of a LANDSAT image depicting the extent of flooding (black areas). The LANDSAT imagery figure is pink, with the deep black showing inundated nearshore areas that are normally dry.

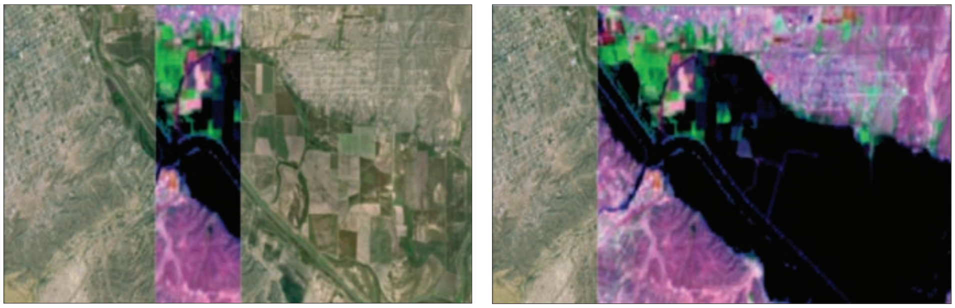


Figure 6. Images depict farmland inundation near Presidio, Texas. The image on the left shows agricultural areas that are submerged; in the image on the right, faint white lines indicate levees that were overtopped and broken in many places.

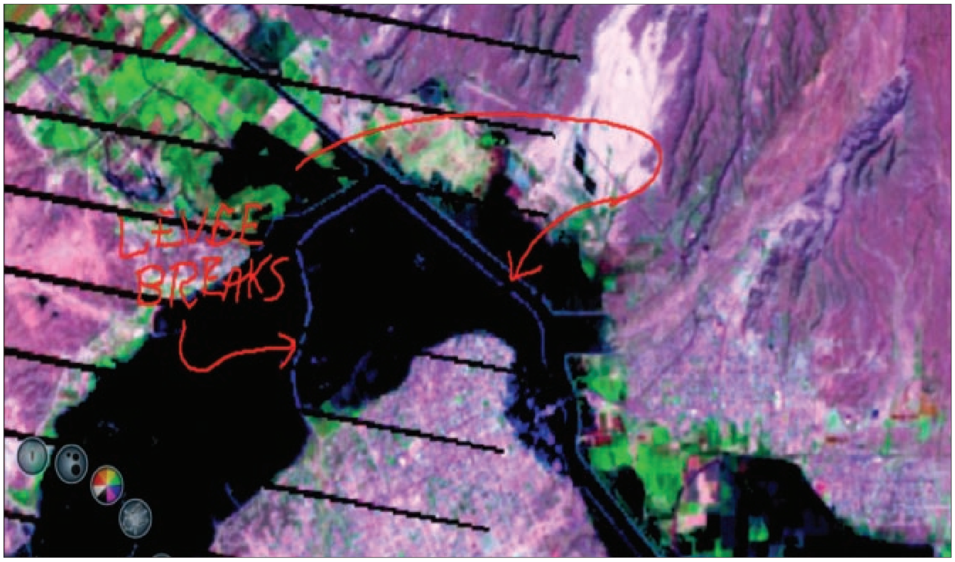


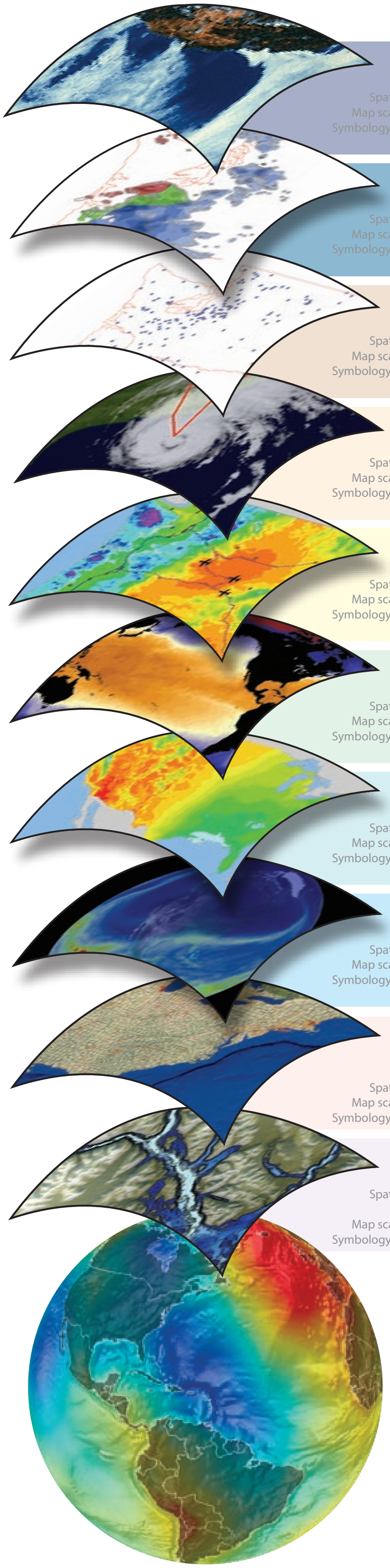
Figure 7. A closer view of the area shown in figure 6, demonstrating the annotation capability of the TouchTable.

Report from the Atmospheric Data Model Working Group

October 2008

Work continues at a fast pace on *The Collected Works of Team Atmosphere*. Team Atmosphere is an international group of volunteers from education, government/military, and industry who are pooling their talents to create a unified and open atmospheric data model (ADM) for GIS applications in the atmospheric and oceanographic sciences. Construction of the ADM is a cross-disciplinary activity, merging data concepts and structures from meteorology and hydrology, oceanography, space environment, remote sensing, biology, chemistry, and others. ADM meetings are eclectic, ranging from discussions of "fishsticks" (the endangered Pollock fishery) to four-dimensional models of data from satellite and airborne remote sensors. The ADM is simultaneously challenged by the rapid evolution of GIS technologies, most recently by innovations in virtual globes such as ArcGIS Explorer and Google Earth. Team Atmosphere's vision goes beyond the current capabilities provided by GIS engines and virtual globes, and some ADM recommendations to ESRI are impacting new capabilities in ArcGIS and ArcGIS Explorer.

The ADM response is primarily a workbook that demonstrates representative applications in Team Atmosphere's areas of specialization. These applications are currently organized into four topics addressing observations, forecasts and verification, integrated inputs, and Web services. This compendium also provides the reports of the ADM working groups on symbology, spatial referencing, time and animation, and tools (tips and tricks). Of course, the collected works would not be complete without the ADM itself, which is a work in progress. *The Collected Works of Team Atmosphere* swiki is maintained online courtesy of the National Center of Atmospheric Research in Boulder, Colorado, under the stewardship of Olga Wilhelmi. Access to the ADM swiki is currently limited to Team Atmosphere, which is open to contributing members and new volunteers. For more information, visit the Atmospheric Special Interest Group at www.gis.ucar.edu/sig/index.html.



Layer stack	**Weather Satellite Measurements**
Map use	Raw satellite images, derived products
Representation	Raster series, grids
Spatial relationships	Overlay
Map scale and accuracy	1:10,000/ 100m
Symbology and annotation	Black and white, or graduated color ramp

Layer stack	**Weather Radar Measurements**
Map use	Radar raw data, derived products
Representation	Raster series, grids
Spatial relationships	Overlay
Map scale and accuracy	1:10,000/100m
Symbology and annotation	Black and white, or graduated color ramp

Layer stack	**Weather Point Measurements**
Map use	Fixed observational stations, gages, upper-air data
Representation	Vector series
Spatial relationships	Can be related to center point of grid cell
Map scale and accuracy	1:10,000/100m
Symbology and annotation	Point marker symbol

Layer stack	**Weather Events**
Map use	Droughts, floods, hurricanes, storms
Representation	Vector polygons
Spatial relationships	Boundary shape overlays often with transparency
Map scale and accuracy	1:15,000,000/1Km
Symbology and annotation	Polygon with varying 3D base heights

Layer stack	**Atmospheric Mobile Measurements**
Map use	Mobile platforms, aircrafts
Representation	Vector points, lines
Spatial relationships	Can be related to center point of grid cell
Map scale and accuracy	1:15,000,000/1Km
Symbology and annotation	Point marker symbol

Layer stack	**Atmospheric Boundaries**
Map use	Weather fronts, temperature boundaries
Representation	Vector polygons, lines
Spatial relationships	Multiple time series polygons can be merged and animated
Map scale and accuracy	1:15,000,000/1Km
Symbology and annotation	High/Low pressure front lines and cones of intensity,can be animated

Layer stack	**Climate Point Measurements**
Map use	Observed climate variability and change
Representation	MultiPoints, with multiple z, m, and t values, or interpolated raster series
Spatial relationships	Point marker symbols can be used to create interpolated raster surfaces
Map scale and accuracy	Full Extents/1Km
Symbology and annotation	Interpolation grids can be animated

Layer stack	**Numerical Models**
Map use	Weather forecasting models climate prediction models
Representation	Raster series, grids
Spatial relationships	Attribute values can be used to create interpolated raster surfaces
Map scale and accuracy	Full Extents/1km
Symbology and annotation	Raster grids can be animated

Layer stack	**Human Elements**
Map use	Population density, land use, greenhouse emissions, watches/warnings, Administrative boundaries,
Representation	Vector
Spatial relationships	Polygons can overlap an area
Map scale and accuracy	1:15,000,000/1km
Symbology and annotation	Polygon with varying unique value color scheme

Layer stack	**Earth Surface Characteristics**
Map use	Topography, Albedo, Snow cover, land cover
Representation	Raster, vector polygons, TINS
Spatial relationships	Raster has cell center value, Vectors have Coutour values, TINs facets have surface value
Map scale and accuracy	Full Extents/1km
Symbology and annotation	Graduated color ramp

The Thematic Layers

Proposed data layers for the atmospheric data model

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