atmospheric front

ESRI • Summer 2005 Atmospheric GIS

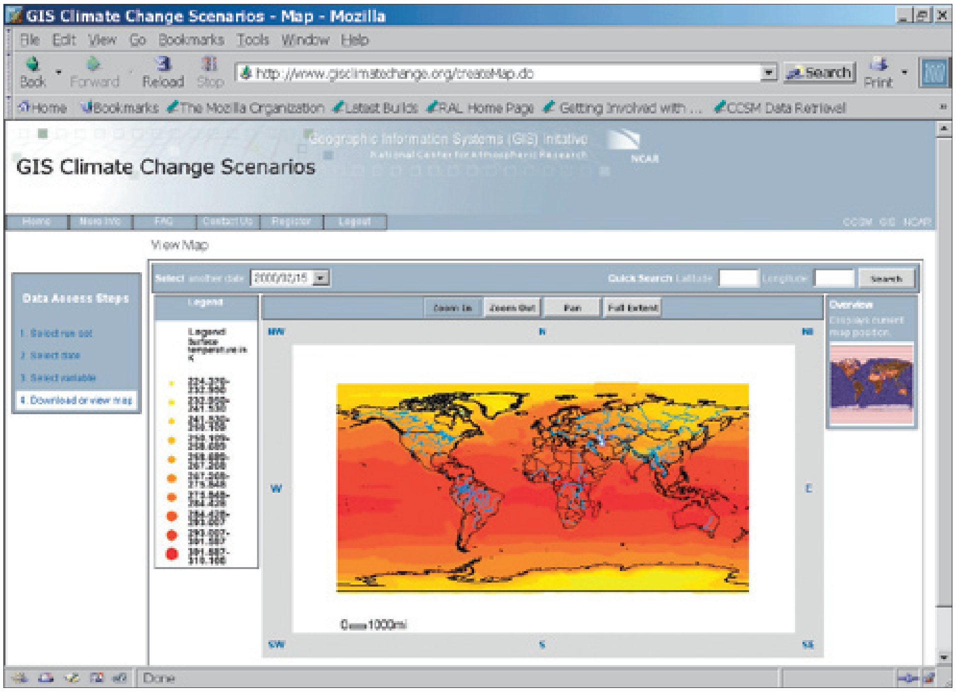
GIS Climate Change Web Site

By Olga Wilhelmi and Jennifer Boehnert

Global climate models have been developed over the past decade to better understand and prepare for climate variability and change. Findings from climate modeling have been widely used in climate change science and policy. However, the datasets or outputs from these models have primarily remained in the domain of atmospheric science. The use of GIS for monitoring and analysis of land surface processes and socioeconomic trends has significantly expanded over the past decade as well. In spite of the significance of climate change impacts on human infrastructure and the correlation between land surface and climate, there has been a lack of analysis of climate change and its impacts in a GIS environment.

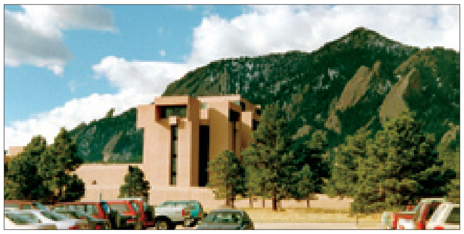
Until now, this lack of integration has chiefly been a factor of disparate data formats. The development of converters has been one mechanism to help bridge this gap between atmospheric data and GIS data. To convert data from one format to another, one must first understand the input data and its variables and formats. This can lead to duplication of data, extremely large GIS output datasets, and confusion about input variable values. The Geographic Information System (GIS) Initiative at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, has been working for the past year to easily distribute climate modeling data from the Community Climate System Model (CCSM) to the GIS community through the GIS Climate Change Scenario Web site.

CCSM is a coupled climate model that simulates the earth's system and allows for research of the earth's past, present, and future climate states. These CCSM datasets are being produced at NCAR for the Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC). IPCC was jointly established by the World Meteorological Organization (WMO) and the United Nations Environment Programme in 1988 to assess the available information on climate change and its impacts, then to provide advice for adaptation and mitigation to climate change in the form of assessments, reports, and technical papers, which are widely used by policy makers and scientists.



This GIS data portal provides access to free global datasets of climate change scenarios that are being generated by the Community Climate System Model (CCSM). The datasets can be downloaded in common GIS formats (i.e., shapefiles) and used for further visualization, analysis, and mapping of global climate change.

In This Issue



The GIS Climate Change Scenario Web site provides an easy-to-use interface to the CCSM datasets. The Web site accesses the CCSM dataset (which is natively stored in a netCDF format), extracts the user's requested time and variable selection, and converts the data to an ESRI point shapefile. The user has the option to view the data displayed in an ArcIMS interactive map or to download the data as an ESRI shapefile to be used in ArcGIS. CCSM model runs are also being distributed by the IPCC Data Distribution Center and Earth System Grid in their native data format, netCDF. The GIS Climate Change Scenario Web site is a complimentary data portal that is targeting the GIS community; users that are familiar with GIS tools have not had access to climate-related datasets in the past. This Web site is unique in its on-the-fly retrieval, extraction, and conversion of the netCDF CCSM datasets to a GIS format. Visit the Web site at www.gisclimatechange.org.

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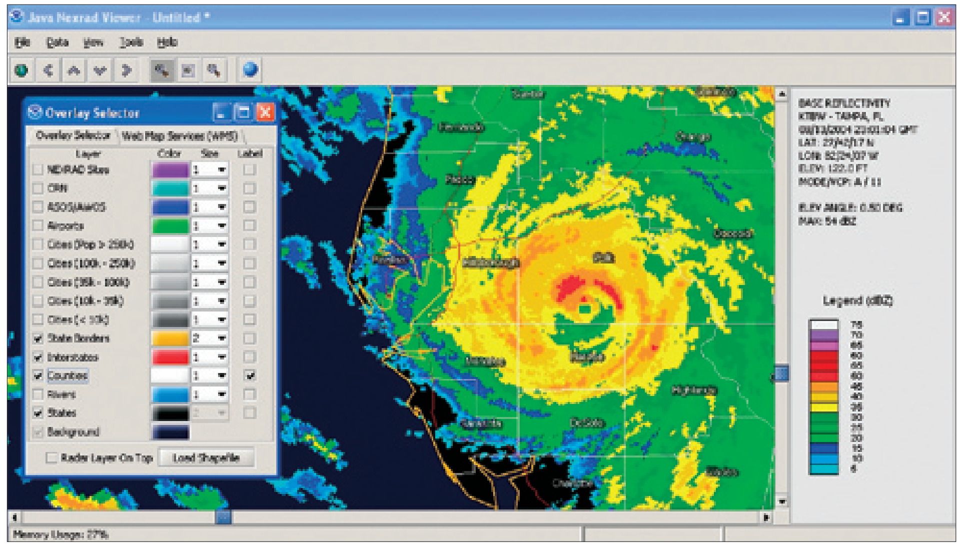
Software Links NEXRAD Weather Radar Data to GIS

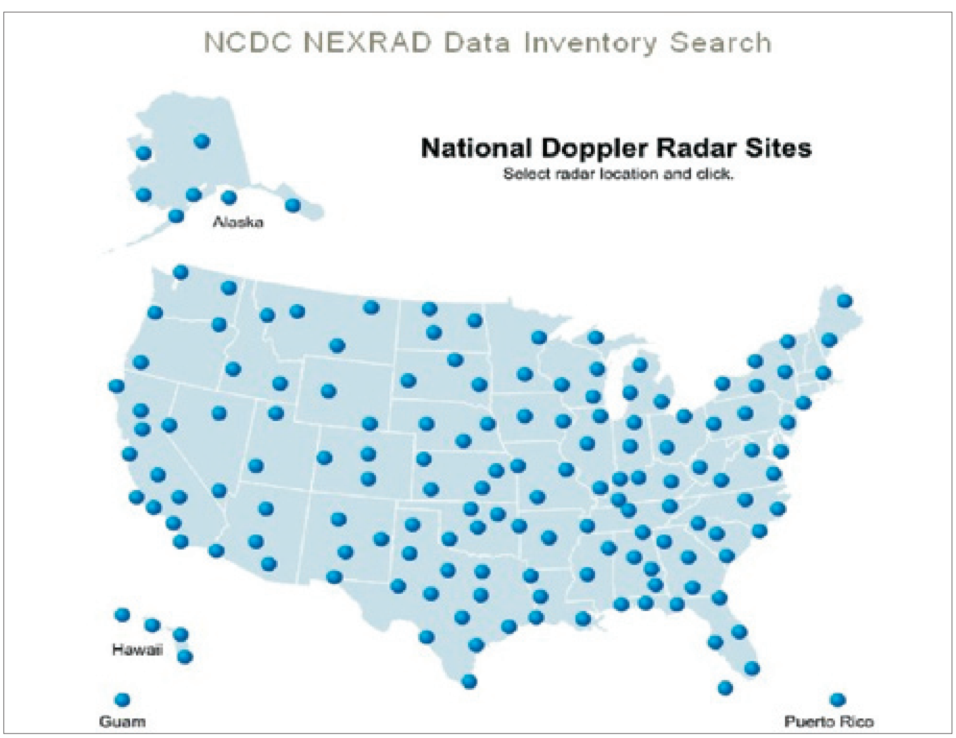
By Steve Ansari

The National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) currently archives more than 1,000 terabytes of Weather Surveillance Doppler Radar (WSR-88D), commonly referred to as Next Generation Radar (NEXRAD), data from 1991 to the present. The current growth rate is 480 gigabytes per day with a potential increase to 6.5 terabytes per day as new radar technologies are introduced. Within this data lies a treasure trove of information for many disciplines including hydrology, atmospheric science, engineering, biology, and environmental science. Unfortunately, the complexity of the data format has made it virtually impossible for many potential users to use this data. NCDC is addressing this issue by developing NEXRAD tools, which feature visualization and export capabilities. Exporting the data to common GIS vector and raster formats allows for the easy integration of NEXRAD data into ESRI's ArcGIS.



Screen shot of the Java NEXRAD Viewer displaying Hurricane Charley.

NEXRAD data is produced from a national network of 161 WSR-88D radars, each with a range of 230 km. The radars have a rotating antenna, which scans at multiple vertical (elevation) angles into the atmosphere. A single series of scans or "sweeps" at multiple elevation angles is defined as a volume scan. NEXRAD data consists of the raw base data, commonly referred to as Level II, and derived products, referred to as Level III. Level II data contains the three base moments: reflectivity, velocity, and spectrum width. Reflectivity is the amount of energy reflected back to the radar site from aerial particles such as raindrops. Reflectivity describes an instantaneous intensity of rainfall and does not directly yield a precipitation amount. Velocity is measured by using the Doppler effect (difference in emitted frequency of moving objects) to estimate the movement of the raindrops. The individual velocity and reflectivity measurements are averaged for each bin or polar grid cell (r, ø). A bin represents a range and horizontal (azimuth) angle from the radar site. Spectrum width is the standard deviation of the many velocity measurements for each bin. A larger spectrum width can indicate turbulence. NEXRAD Level III data is derived from the Level II data. These products include precipitation estimates, cloud top heights, vertical wind profiles, storm tracking predictions, and hail/tornado detection. NEXRAD data can be ordered free of charge from the NCDC NEXRAD inventory system (www.ncdc.noaa.gov/nexradinv/index.jsp) or the NCDC Mass Storage Archive (http://has.ncdc.noaa.gov).



NEXRAD data may be ordered free of charge from the NCDC NEXRAD inventory (www.ncdc.noaa.gov/nexradinv/index.jsp).

Java NEXRAD software consists of two applications and an open source application program interface (API). The applications include the Java NEXRAD Viewer, a visual browser for the data, and the Java NEXRAD Data Exporter, the data export utility. The Java NEXRAD Viewer allows for custom map backgrounds using ESRI shapefiles and Open Geospatial Consortium-compliant Web Map Services. Images and animations may be saved in multiple formats. Simple math operations and filtering of the data are supported. The Java NEXRAD Data Exporter currently allows for the export of NEXRAD data to common GIS formats such as Well-Known Text, ESRI shapefile, ArcInfo ASCII GRID, and ArcInfo binary GRID. The environmental scientific data formats GrADS binary and netCDF are also supported. Database support for ArcSDE, Oracle Spatial, and PostGIS, along with additional formats such as GeoTIFF and HDF, are planned for the future. The applications support an XML-based batch processing feature, which allows for command-line image generation and data export. The open source Java NEXRAD API allows developers to integrate NEXRAD processing into custom applications. The entire software package is written in Java and will run on any Java-supported platform including Windows, Macintosh, and Linux. Java NEXRAD software supports both the historical NEXRAD data at NCDC and real-time NEXRAD data distributed by the National Weather Service (NWS). This allows developers and analysts to perform real-time GIS analysis on all NEXRAD data.

Hurricane Charley was used to create an example case study of precipitation totals throughout Florida. The Java NEXRAD Data Exporter was used to export the Level III Storm Total Precipitation product, a radar-derived estimate, to a polygon shapefile. This shapefile was loaded into ArcMap, and areas of four inches of rainfall or greater were selected. These areas of heavy precipitation were then compared to Census 2000 data. Age and racial distributions were created, and the median age was mapped. Using this NEXRAD precipitation product, an estimated two million people may have been affected by precipitation of at least four inches during Hurricane Charley. Importing NEXRAD data into a GIS connects the NEXRAD data to the people and infrastructure affected. The use of NEXRAD data in a GIS may benefit areas such as disaster response, flood prediction, and habitat analysis. Exporting Level II data to points with a height attribute allows for 3D analysis. The eye wall of Hurricane Charley was isolated in ArcMap and rendered in ArcScene, creating a unique 3D view of the hurricane. The Java NEXRAD Data Exporter also aided GIS research conducted by Dr. Scott Shipley of Raytheon, examining terrain-based blockage of NEXRAD. For further reading, see Ansari and Del Greco (2005) GIS tools for visualization and analysis of WSR-88D archived data at the National Climatic Data Center, 21st International Conference on Interactive Information Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology; extended abstract and narrated slides can be found online at http://ams.confex.com/ams/Annual2005/techprogram/paper_84729.htm.

Java NEXRAD software creates a bridge between NEXRAD data and GIS. By incorporating NEXRAD into GIS systems, new relationships between weather data and other data sources may be found. Examples of common GIS data sources include business, agricultural, medical, biological, and demographic data. The Java NEXRAD software is available free of charge from NCDC (www.ncdc.noaa.gov/oa/radar/jnx/index.html).

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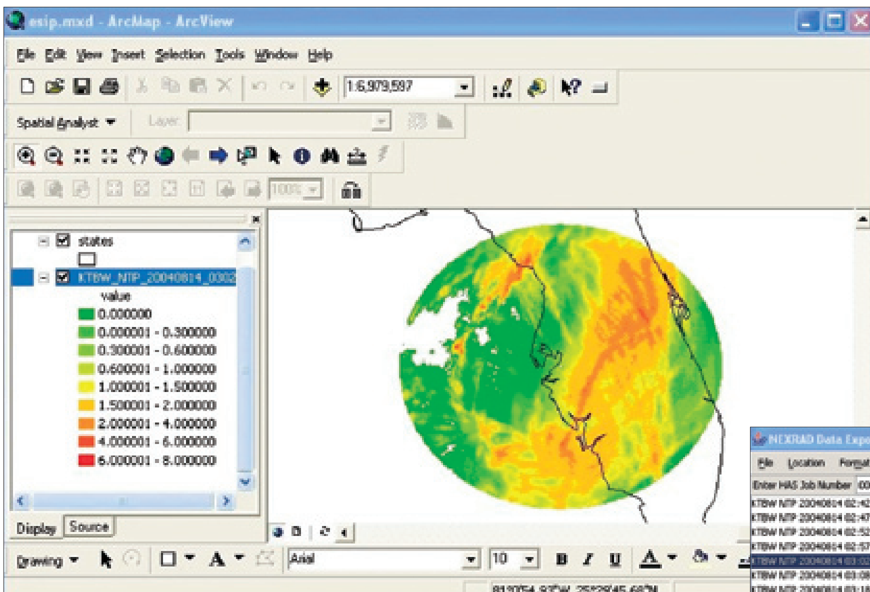
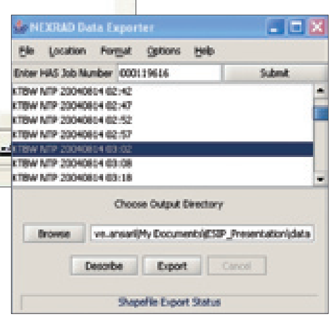
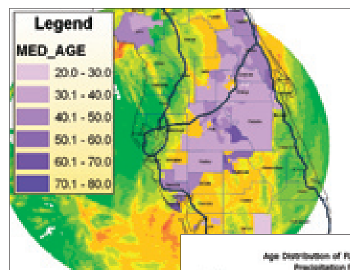
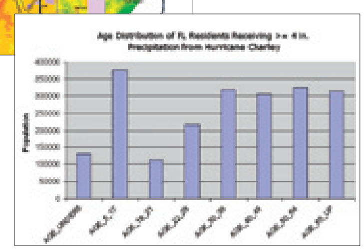


After converting the NEXRAD data to shapefile, the data is loaded into ArcGIS.

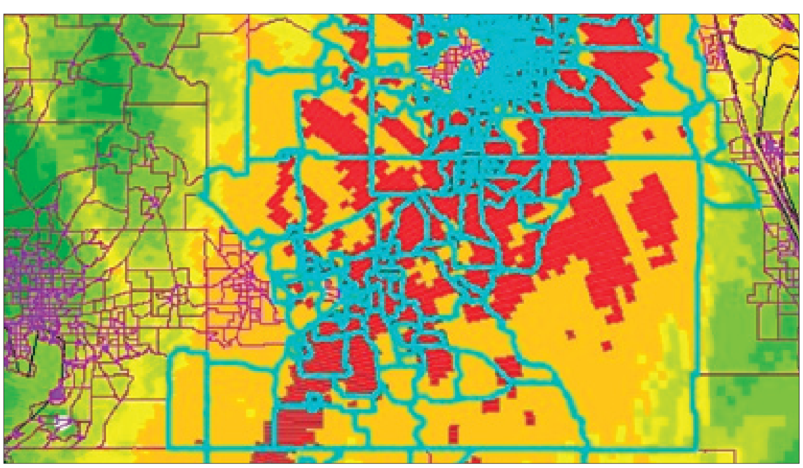


The Java NEXRAD Data Exporter utility exports to multiple formats including shapefile.

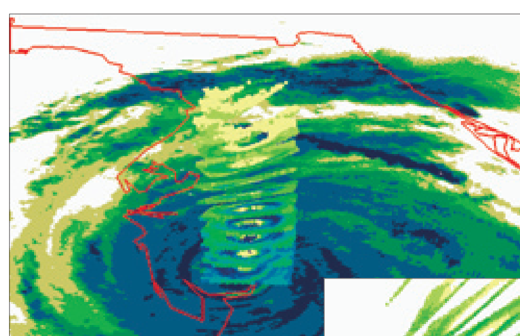


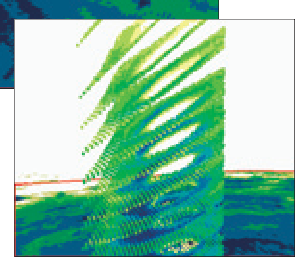


Median age of the census blocks containing areas of at least four inches of precipitation.



Areas of at least four inches of precipitation (red) are compared to Census 2000 blocks (intersecting blocks are colored light blue).





Shown is a subset of a NEXRAD Level II reflectivity volume scan exported to point shapefile and displayed in ArcScene. The eye wall of Hurricane Charley is clearly visible at multiple elevations. (The elevation has been exaggerated.)

Using ArcGIS Engine and Java 3D for True 3D Visualization and Analysis of Atmospheric and Marine Data

By Nazila Merati and Tiffany Vance

GIS includes a variety of analytical functions for spatial data. Unfortunately, they do not currently support the level of three- and four-dimensional analytical functions needed to support a "scientific GIS." Examples of these types of functions might be the calculation of the volume of the intersection between two volumes, such as the overlap between a school of fish and its prey or the length of a vector path through a volume, such as the path of a marine mammal through a water mass. Oceanographic tools need to include calculations, such as the depth of the mixed layer or thermocline, or display a temperature-depth plot on an arbitrary plane slicing through a water volume.

As a prototype of a scientific GIS, NOAA has developed a project called OceanGIS. This project integrates spatial functionality from ArcGIS and open-source GIS software with analytical tools developed in Java and visualization tools found in Java 3D and the Visualization ToolKit (VTK) (http://public.kitware.com/VTK/). While the first version uses open-source shapefile readers and Java to perform analyses, subsequent versions will take advantage of the power of ArcGIS Engine to expose GIS functionality to the tools developed. The building blocks of OceanGIS are shown in figure 1.

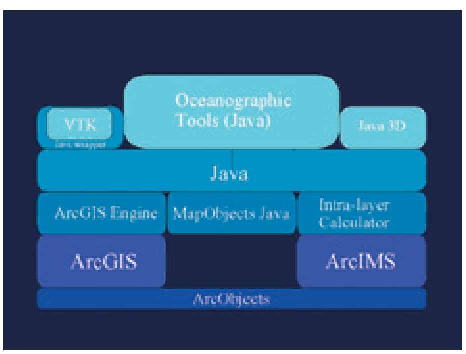


Figure 1 System diagram for the OceanGIS prototype.

NOAA is using a combination of Java/Java 3D and the recently introduced ArcGIS Engine product to create a prototype of a scientific GIS. NOAA combined the spatial tools exposed through the ArcGIS Engine—Java API with the analytical capabilities of algorithms written in Java with the complex visualization capabilities of Java 3D. Modules from each of these technologies are combined to create innovative tools, allowing users to import georeferenced data, make spatial selections, perform spatial and scientific analyses, and output the results as visualizations for further examination. Use of the ArcIMS—Java Connector allows these modules to be implemented in ArcIMS sites for Web-based analysis.

ArcGIS Engine is an ESRI developer product for creating and deploying ArcGIS solutions. It is a simple, API-neutral, cross-platform development environment for ArcObjects—the C++ component technology framework used to build ArcGIS. ArcGIS Engine software's object library makes full GIS functionality available through fine- and coarse-grained components that can be used in Java and other environments. Using ArcGIS Engine, one can build solutions and deploy them to users without requiring the ArcGIS Desktop applications (ArcMap, ArcCatalog) to be present on the same machine. It supports all the standard development environments, including Java, C++, and .NET, and all the major operating systems. In addition, users can embed some of the functionality available in the ArcGIS extensions. This product is a developer kit as well as deployment package for ArcObjects technology. ArcGIS Engine integrates GIS functionality into an application with the data being available for calculations in non-GIS components. ArcIMS has a limited set of spatial capabilities, but it is capable of interfacing with the Java 3D API via the Java Connector. This will allow the ArcIMS community to utilize tools built with this project using ArcGIS Engine.

Java allows users to make a variety of scientific calculations on the data and to provide the results back to both the GIS component and a Java 3D (http://java.sun.com/products/java media/3D/)-based visualization component. The ArcIMS—Java Connector could be used to produce a map coordinates base that would allow data retrieval from a DODS server (www.opendap.org) and subsequent plotting with tools designed for interaction with gridded fields. The Java 3D API is an application programming interface used for writing stand-alone, three-dimensional

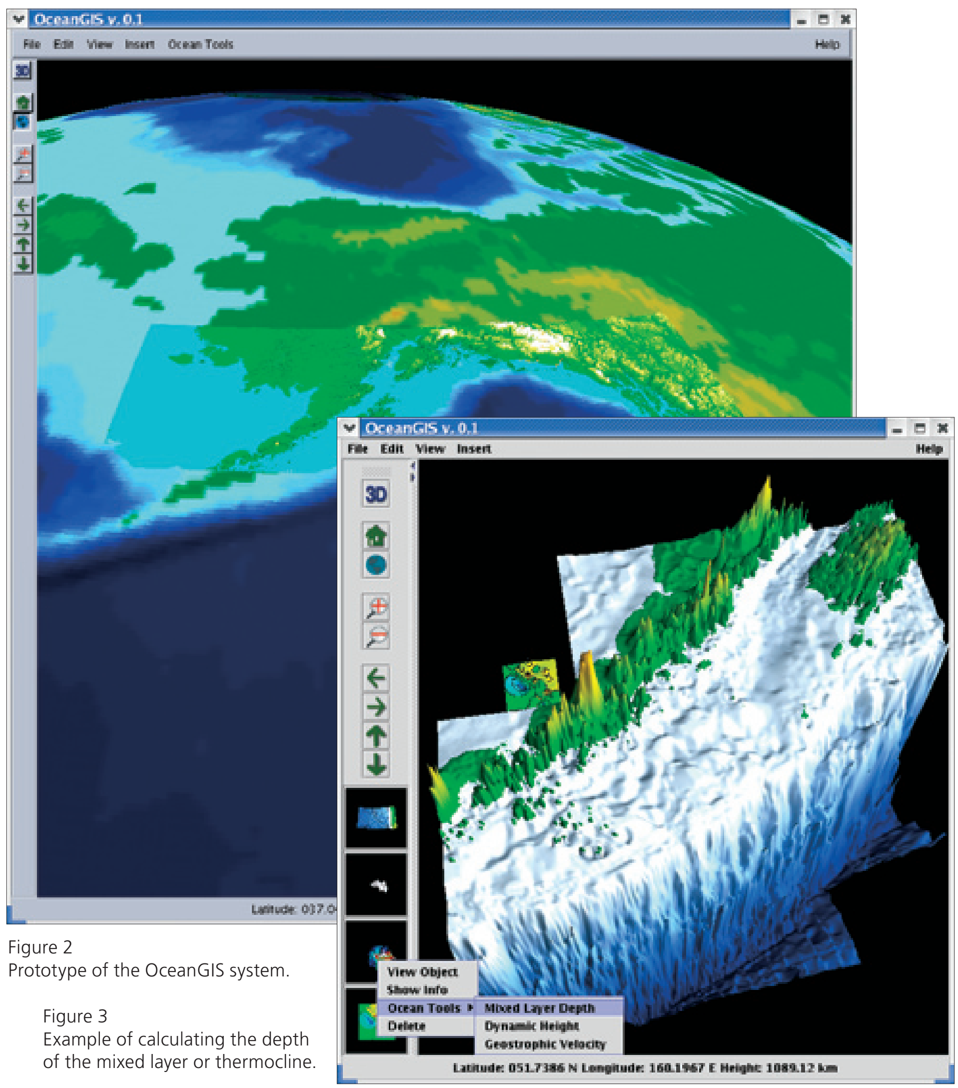


Figure 2
Prototype of the OceanGIS system.

Figure 3
Example of calculating the depth of the mixed layer or thermocline.

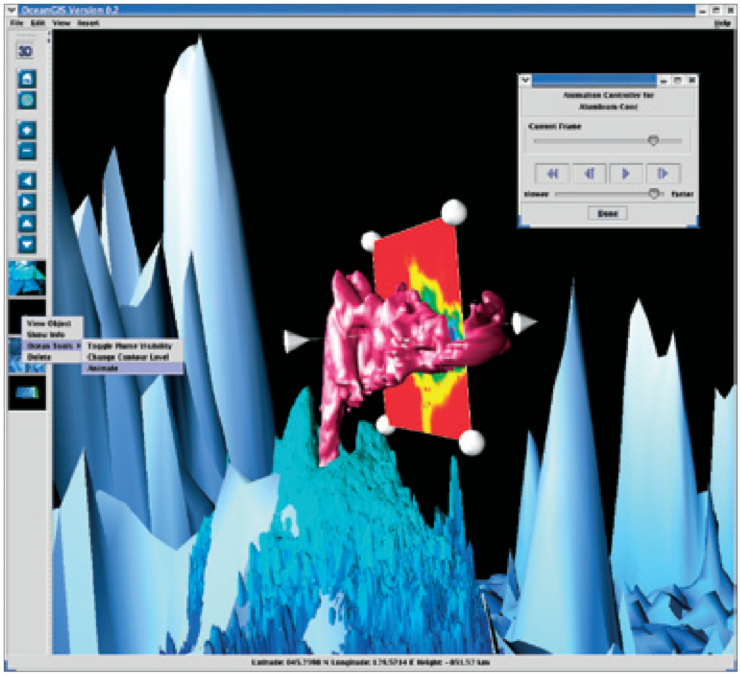


Figure 4
Integrating VTK with OceanGIS for volume rendering.

graphics applications or Web-based 3D applets. It gives developers high-level constructs for creating and manipulating 3D geometry and tools for constructing the structures used in rendering that geometry. With Java 3D API constructs, application developers can describe large virtual worlds, which in turn, are efficiently rendered by the Java 3D API. The Java 3D API extension is designed as a high-level, platform-independent 3D graphics programming API and is amenable to cost of PC game cards and software renderers through midrange workstations all the way up to high-performance, specialized, 3D image generators. Support for runtime loaders was included to allow Java 3D to handle a wide variety of file formats such as interchange formats, VRML 1.0, and VRML 2.0. Java 3D will allow users to go beyond standard data visualization, allowing for true 3D analysis and interrogation of data.

NOAA also explored the use of a second 3D API, VTK (www.kitware.com). Like Java 3D, VTK is a cross-platform, 3D application programming interface built on, and independent of, the native rendering library (OpenGL). It exposes Java bindings (as well as TCL and Python). It is written in C++; uses the object-oriented modeling approach of Rumbaugh, et al.; and includes similar scene graph, lighting models, and graphic primitives as Java 3D. What VTK does that Java 3D doesn't (yet) do is Boolean operations on 3D volumes (intersection, union); volume rendering; filtering, including convolution, FFT, Gaussian, Sobel, permutation, and high- and low-pass Butterworth filters; and divergence and gradient calculation. The VTK data model allows for fast topology traversal, making these filters very fast, and allows for rapid mesh decimation. VTK also offers powerful 3D probe widgets that allow easy interaction with the data, and it has methods to utilize parallel architecture through the Message Passing Interface. These aspects of VTK make it a desirable development tool.

As an OceanGIS prototype, NOAA created a simple application that allows users to switch from 2D to 3D projections, read simple shapefiles, rotate/pan/zoom in a new window, hyperlink to objects, and conduct 3D "picking" (figure 2). NOAA has also implemented a utility that calculates, using Java, the depth to the mixed layer (thermocline) (figure 3). Future developments include using VTK/Java 3D to perform volume calculations, rendering, and analysis (figure 4). NOAA is also planning to use ArcGIS Engine to allow traditional GIS analysis, add an interface to allow Internet map servers to use 3D tools, and integrate development with new efforts to use NOAA Grid services to allow integration into a larger cyberinfrastructure.

Citations **Rumbaugh, J., M. Blaha, W. Premerlani, F. Eddy,** and **W. Lorenson,** *Object-Oriented Modelling and Design,* Englewood Cliffs: Prentice-Hall, 1991.

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National Weather Service Produces Warning Shapefiles

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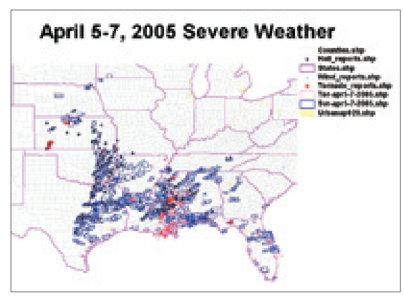
The NWS has been well known for issuing vital warnings for hazards such as tornadoes, large hail, and high winds. Historically, these warnings were issued for an entire county at a time. Over the past few years, the agency has begun to recognize the importance of focusing warnings on the location of the actual hazard without regard to geopolitical boundaries.

As part of this effort, one office in NWS has been maintaining a real-time database of short-term warnings such as tornado, severe thunderstorm, flash flood, and special marine warnings. Using this database, geospatial files or shapefiles are also created and distributed.

Current shapefiles of NWS warnings can be found at www.prh.noaa.gov/regsci/gis/shapefiles/.

In addition, an ESRI ArcIMS site exists with a map service with recent warning polygons and severe weather reports, which can be found at www.prh.noaa.gov/regsci/gis/warn.html.



Example of plotted NWS warnings with tornado and hail reports.

Team Atmospheric User Group Committee

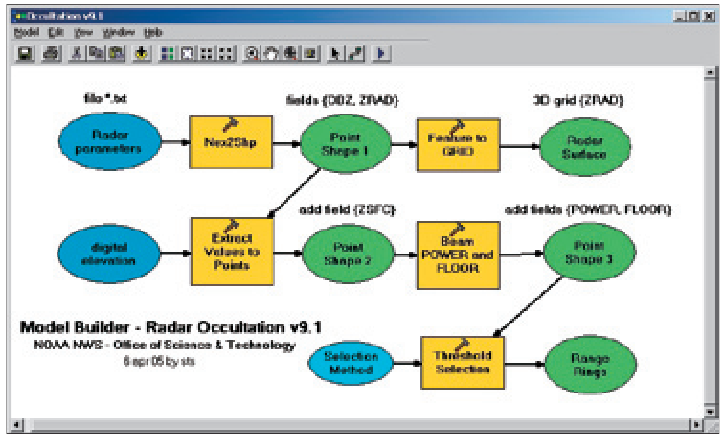
An Operational GIS Application for Radar Occultation

ArcGIS Is Applied in 3D to Estimate Beam Power Losses Due to Terrain and Man-Made Obstacles

By Scott T. Shipley and Ira A. Graffman

NOAA's NWS has been adapting GIS to analyze the blockage of radar beams by terrain and man-made objects for several years, culminating this year in an operational application based on ArcGIS 9.x. NOAA's NWS Office of Science and Technology has adapted a NEXRAD-to-shapefile conversion utility to predict theoretical radar propagation in a standard atmosphere and combines this result with digital elevation to determine where the radar beam is with respect to the earth's surface. Observations of radar beam power loss related to man-made obstacles, such as towers and tall buildings, are well correlated to the FAA Obstructions to Aviation database. The GIS application replicates observed occultation patterns (absence of radar reflectivity) for existing radars and is useful in conducting "what-if" scenarios for the placement of new or relocation of existing radar systems. This article provides a brief overview of the method and discusses current thinking on what might be next on the horizon.

A NEXRAD base product conversion utility was created in Visual Basic by Shipley in 1999 and made available for public use (essentially the GNU license) through the George Mason University at http://geog.gmu.edu/projects/wxproject/. The initial NEX2SHP.exe version 2.0 converts base reflectivity (NEXRAD Level III Product Number 19) into a point shapefile consisting of radar reflectivity (0 ≤ DBZ ≤ 15) at 1 km range intervals from 1 to 230 km for approximately 360 ± 5 radials and adds a theoretically calculated height field ZRAD [m msl]. The number of radials is variable from scan to scan, since each radial is integrated by the radar during azimuthal scanning, resulting in a nominal azimuthal beam width of 1 ± 0.1 degrees. NWS currently uses NEX2SHP version 7k, which has been enhanced to simulate test patterns for other radars including the FAA Terminal Doppler Weather Radar. Version 7k has not yet been released to GNU license, pending a final review of the code for errors and readability. The version 2.0 source is available upon request from the author (sshipley@gmu.edu).



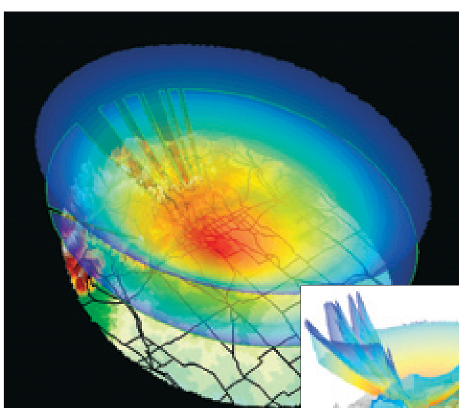
ModelBuilder logic for range ring generation from a radar parameter (.txt) file.

When the input data file is a text file with extension *.txt, the NEX2SHP utility attempts to interpret the contents as named parameters. If an optional parameter is omitted, default values for optional parameters are assumed to describe a NEXRAD system. The contents of the text file are interpreted as follows (table).

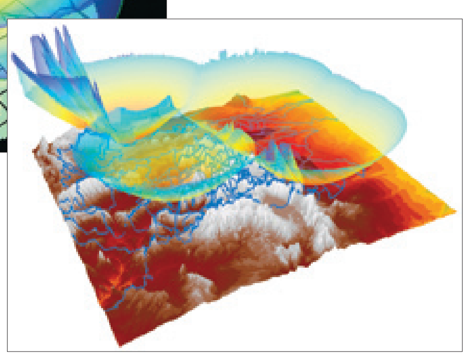
The sequence of processing steps lends itself to representation in ModelBuilder, as shown in the accompanying figure. After the input parameters are finalized in a text file, the NEX2SHP utility creates a point shapefile (Point Shape 1), which is used to create a GRID surface (Radar Surface) useful for 3D displays in ArcScene. The NEX2SHP product is combined with a digital elevation model to append elevation of the surface as the field ZSFC [m msl] (Point Shape 2). Each radar cell is then processed record by record to determine both a beam power reduction factor (0% ≤ POWER ≤ 100%) and the FLOOR [m msl] or minimum height for detection of precipitation (Point Shape 3). A final threshold method selects one point along each radial where the beam reaches a detectability threshold (programmable), and these points are converted into range rings (polyline and polygon).

The results of this procedure are shown in a second figure for the NEXRAD located at Boulder, Colorado (station KFTG). This figure shows two radar surfaces for the lowest two Plan Position Indicator (PPI) azimuthal scans, namely at 0.5 degrees and 1.5 degrees beam elevation. Range rings (polylines) are draped on each corresponding radar surface to show the detection threshold. The mountain peaks responsible for occultation of the KFTG radar beam along the Front Range are easily identified. For enhanced visual effect, the range rings (polygons) are then used with the setnull method on each radar surface to create a 3D surface for regions visible to the radar. Transparency enhances the finished effect.

The radar surface grid by-product is also useful for draping NEXRAD reflectivity coverages obtained from other sources such as shapefiles



Lowest two PPI scans for NWS radar at Boulder, Colorado (KFTG), showing occultation by the Front Range of the Colorado Rockies at the lowest radar beam elevation angle of 0.5 degrees.



Detection floor for hydrometeors, mosaic from five radars over north-central Colorado.

Table: Input parameters for NEX2SHP version 7k

lat 39.00*	radar latitude [decimal degrees]
lon -100.0*	radar longitude [decimal degrees]
zmsl 1507*	local ground level at radar base [m MSL]
elevangle 0.5*	elevation angle [decimal degrees]
towerheight 30*	height of antenna above ground [m AGL]
numradials 360	number of azimuthal samples per scan
numrangebins 230	number of range bins per azimuth
rangebinlength 1.0	length of each range bin [km]
verticalbeamwidth 1.0	vertical beam angular width [decimal degrees]

*indicates required parameter

produced by NEX2SHP from NEXRAD Level III Product Number 19 files. Another great source of GIS-ready radar data is provided by the NCDC—see Steve Ansari's article in this same issue. In fact, NCDC NEXRAD archives were used to overlay Level II reflectivity on the theoretical range rings, providing an empirical verification of the analysis approach (there were no radar echoes in the occultation areas). Some disagreements with the Level II data and several features require further investigation, but all the methods are in general agreement (original SRI site surveys, ROC algorithm, NCDC Level II data—aka "truth," and GIS occultation method).

Once the individual occultation coverage grids have been determined for several adjacent radars, the mosaic method can then be used to assemble a radar coverage grid for an entire region. The third figure shows the mosaic of five radars over north-central Colorado including the Front Range (Cheyenne, Wyoming [KCYS]; Denver/Boulder, Colorado [KFTG]; Pueblo, Colorado [KPUX]); Grand Mesa, Colorado (KGJW); and Riverton, Wyoming (KRIW). A regional floor is found by combining all radar grids for the parameter FLOOR with the MINIMUM analysis condition, and after application of the set null method, only detectable areas of the atmosphere are combined. The key conclusion is that full radar capabilities are realized in the immediate vicinity of each radar, but they may be limited to higher altitudes in remote areas due to both distance from a radar as well as occultation by terrain. In some regions between KGJW and KRIW, the radar floor appears to be as much as 4,000 m above ground level. This analysis approach clearly identifies localities that may be at risk for flash floods without warning by radar due to the characteristics of radar coverage in those areas. In such areas, alternate means for flash flood detection must be (and are usually) employed.

A comparison to current standards for radar occultation patterns includes products generated by the NEXRAD ROC and original NEXRAD siting studies developed by the Stanford Research Institute, showing general agreement. Factors leading to variations among these approaches include

1. Range-height beam propagation assumptions, significant at longer ranges. Effective earth radius coefficients for radar beam propagation vary among the approaches, typically 4/3 or 6/5.
2. Atmospheric ducting for nonstandard atmospheres. The 4/3 and 6/5 effective earth radius coefficients assume ICAO standard atmosphere without temperature inversions in the lower troposphere.
3. Radar sample volume definition, primarily vertical beam power distribution. The current application assumes that beam power is distributed uniformly with height across the verticalbeamwidth (an input parameter).
4. Horizontal beam spread and DEM resolution. The current application assumes that all radar energy is located at the centroid of the radar sample volume, and surface elevation is determined at the location of each centroid. Higher-resolution DEMs are needed at close ranges where the sample volumes are smaller and in areas where the radar beam grazes the surface.

For further reading, see Shipley, Graffman, and Saffle (2005), Weather Radar Terrain Occultation Modeling Using GIS, 21st International Conference on IIPS for Meteorology, Oceanography, and Hydrology; extended abstract and narrated slides are available online at http://ams.confex.com/ams/Annual2005/techprogram/paper_87245.htm.

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Silver Spring, Maryland

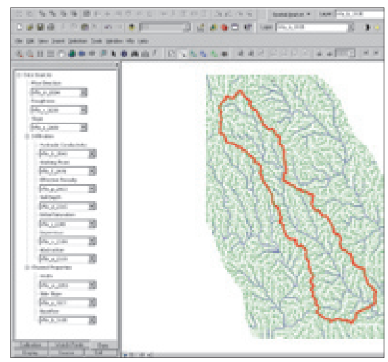
Partner News

Vieux & Associates, Inc.

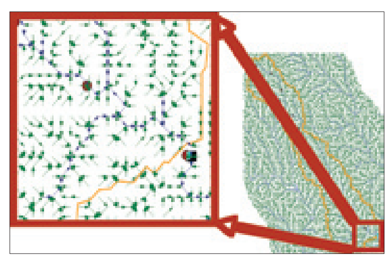
Vieux & Associates, Inc., turns rainfall rates into runoff rates. Clients needing quantitative rainfall monitoring and advanced hydrologic modeling are served with our rainfall monitoring and advanced hydrologic modeling technologies, referred to as WaterIT.

Better rainfall input for models improves model results and reduces calibration time. Using high precision and accurate rainfall for engineering design achieves an efficient solution for clients needing to know how much it is raining between rain gauges.

Vieux & Associates, Inc., has been an ESRI business partner since 1999 and an ESRI product user since 1992. Vflo for ArcGIS is a desktop hydrologic analysis and prediction package that is integrated with ArcGIS 9.x. Using terrestrial properties derived from soils, land cover, topography, and channel hydraulics, and with rainfall rates over that area, flow rates at any location can be analyzed and predicted. Vflo is a fully distributed, physics-based hydrologic model capable of utilizing geographic information and multisensor precipitation input to simulate rainfall and snowmelt runoff from major river basins to small catchments.



ArcGIS interface for Vflo model.



Zoom to flow direction display.

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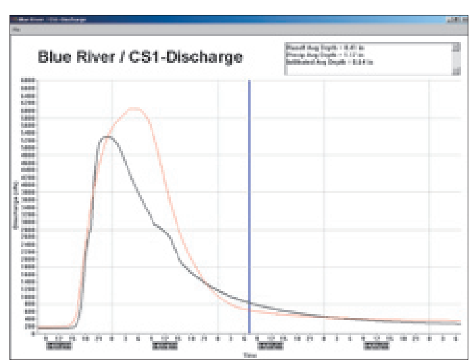

ArcGIS interface for Vflo and modeled hydrographs generated by ArcGIS for Vflo.

Atmospheric Front is a publication of the Water Resources Group of ESRI.

For more information about ESRI GIS solutions for Water Resources applications or for a reseller near you, call
1-800-447-9778
(1-800-GIS-XPRT)

International Calls
1-909-793-2853, ext. 1-1235

Visit ESRI's Web site at
www.esri.com

Send inquiries to
Lori Armstrong, Water Resources Industry Solutions Manager
larmstrong@esri.com

"Many members of the academic community in the atmospheric sciences are beginning to work more closely with colleagues in other disciplines (hydrology, for example) who have traditionally used GIS tools in their research and education. Unidata is pleased that the ESRI Atmospheric Sciences data model group is working to bridge the gap between traditional atmospheric sciences datasets and GIS tools. We are especially enthusiastic about the prospect of using standards-based interfaces and protocols to facilitate data sharing between the atmospheric science and GIS communities."

Ben Domenico
Program Manager, Unidata/UCAR
Boulder, Colorado

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