atmospheric front

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Atmospheric GIS

In This Issue

Weather Verification Using Geographic Information Systems

Ken Waters, National Weather Service, Honolulu, Hawaii

Introduction

The National Weather Service (NWS) issues approximately 30,000 short-term warnings for weather hazards in the United States each year. These include tornado, severe thunderstorm, flash flood, and special marine warnings. Historically, these warnings have been issued by county, where the entire county is under a warning. As of late, however, NWS has begun to emphasize the importance of "polygon warnings." These warnings are now issued for a polygon that outlines the major weather threat. This can dramatically reduce the area of coverage of the warning and thus reduce the tendencies for false alarms. Therefore, this is seen as a major service improvement for the agency.

A major part of NWS's warning program is measuring the quality of service. In the past, this meant matching warning events such as a tornado touchdown to the individual warnings. In other words, NWS determines whether there was a warning out for a particular county during the time a tornado touched down and how much lead time was provided between the warning issuance time and the event time. NWS also tracks the false alarm ratio, measuring what percentage of warnings issued did not have an associated event measured during the time of the warning and in the county warned.

However, with polygon warnings, the verification situation changes dramatically. Previously, a database could be used to keep track of which counties were warned under each warning, then perform a one-for-one match between events and warnings. By employing polygon warnings, there is a major need for performing geospatial analysis that can't be done with database software outside of a geographic information system (GIS). Some groundbreaking work has been done in this arena using ESRI's ArcGIS. A shapefile of all the polygon warnings for 2005 has been constructed. In addition, a point shapefile of all the events has been constructed from the event

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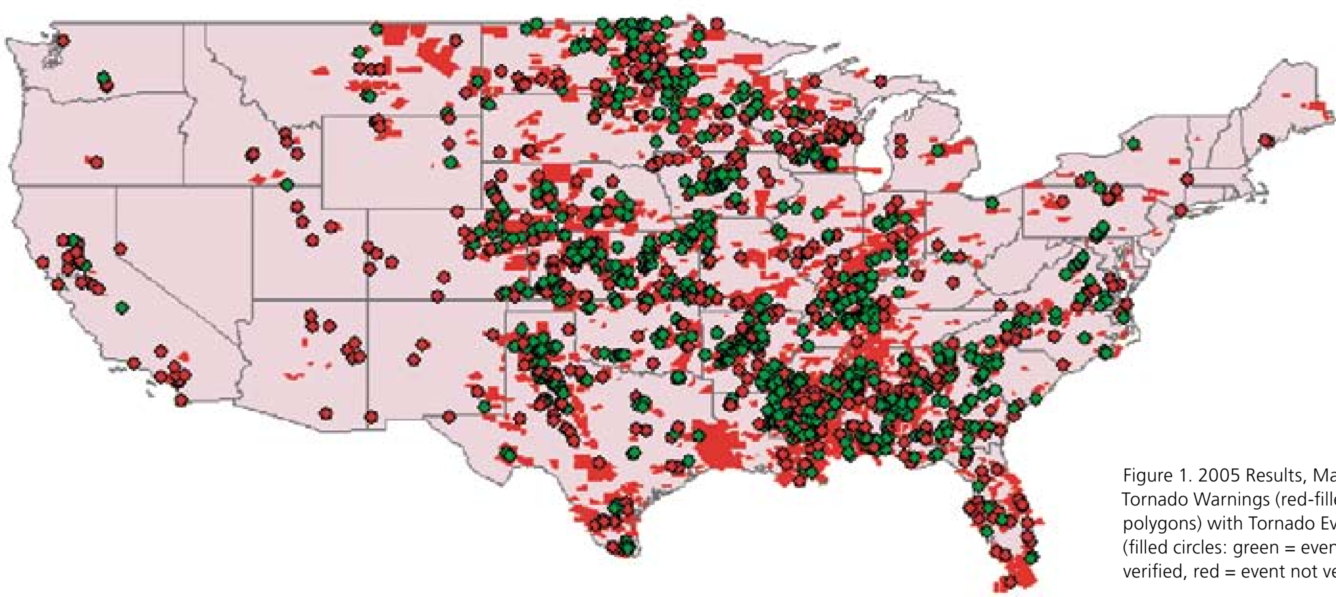

Figure 1. 2005 Results, Matching Tornado Warnings (red-filled polygons) with Tornado Events (filled circles: green = event verified, red = event not verified)

GIS-Alien Datasets

Stephanie Granger
Jet Propulsion Laboratory, California Institute of Technology

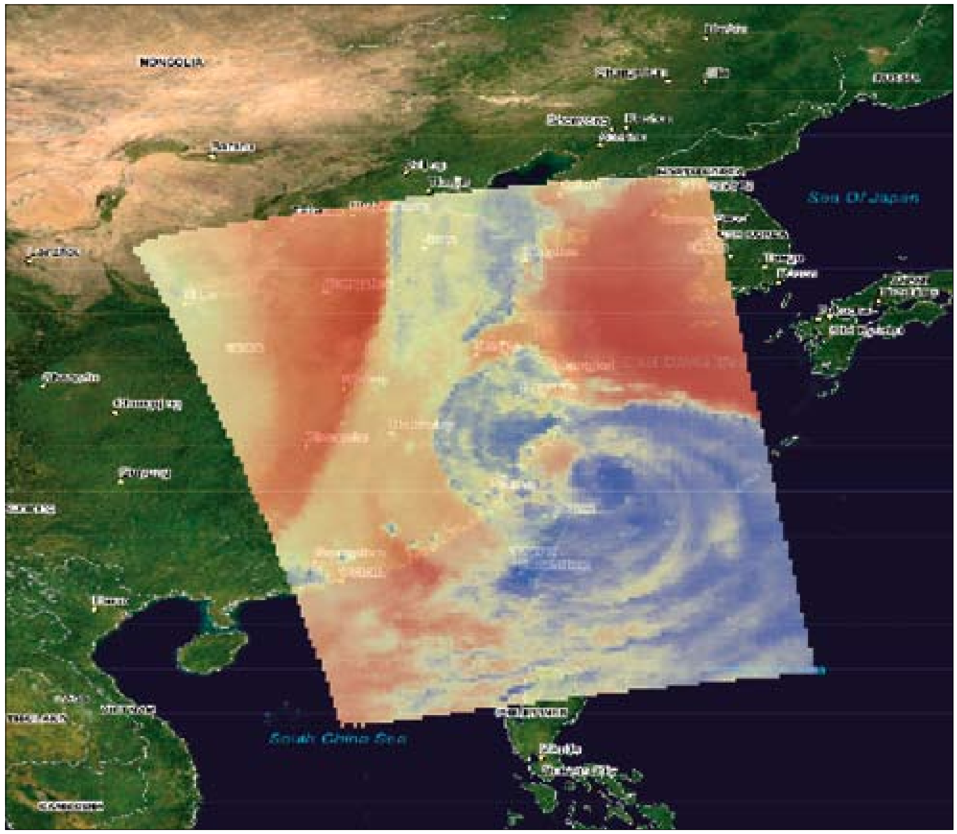

Figure 2. AIRS Radiance Measurements of Typhoon Matsu: August 2005

The Atmospheric Data Modeling Group has identified some datasets used by the atmospheric community that can be considered GIS alien. We define *GIS-alien* datasets as data that does not fit easily into traditional GIS raster, point, or vector data classes. Examples of such products are satellite measurements from non-imaging instruments. These datasets are large in terms of data volume and data structure, often contain multiple parameters, have sampling characteristics unique to a particular instrument, and can have two or three spatial dimensions.

The sampling characteristics of the non-imaging satellite instruments are what make them difficult to represent as a traditional GIS data type. To illustrate the difficulty, the scanning geometry of the National Aeronautics and Space Administration (NASA) Atmospheric Infrared Sounder (AIRS) suite of instruments (figure 1) is examined. The AIRS suite consists of the Atmospheric Infrared Sounder and two microwave components, the Advanced Microwave Sounding Unit (AMSU) and the Humidity Sounder of Brazil (HSB). The measurements from the suite of instruments are used together to provide geophysical parameters in 2D and 3D space. The AMSU spatial resolution is coarse relative to the other two instruments, so final geophysical products are provided at the AMSU spatial resolution.

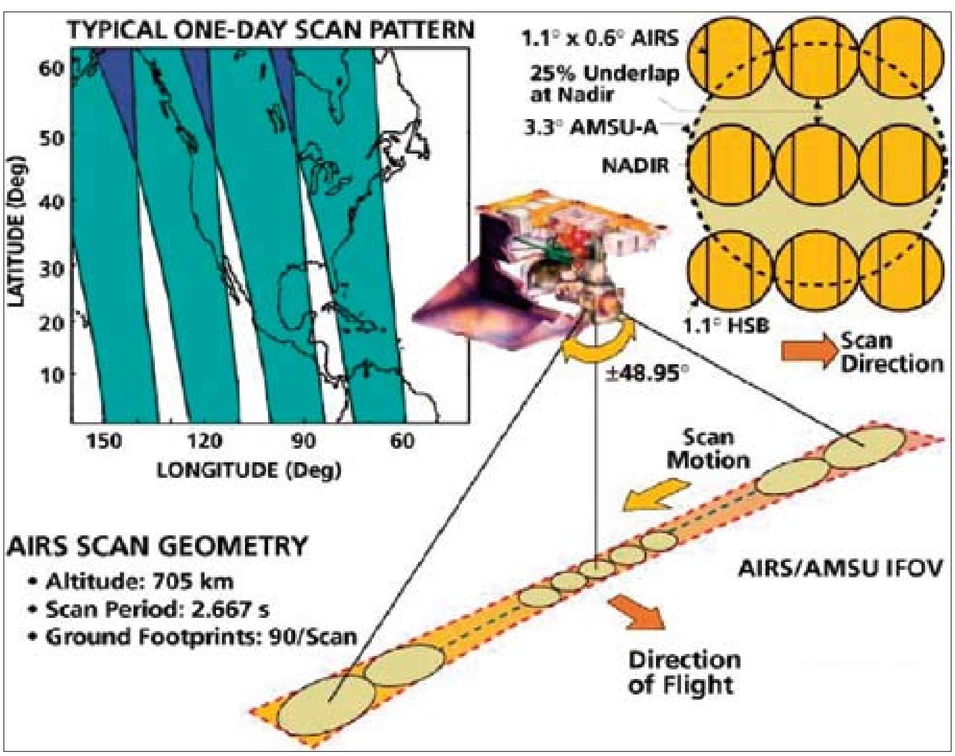

Figure 1. AIRS/AMSU Scanning Geometry

The AIRS suite of instruments is in a polar orbit onboard the Aqua platform as part of NASA's Earth Observing System (EOS). The Aqua platform is in a sun-synchronous, polar orbit with a 1:30 p.m. equator crossing time. AIRS is a continuous scanning instrument taking 90 measurements (footprints) along its scan; AMSU takes 30 measurements. As the instrument scans, the platform moves north and south in an ascending or descending orbit relative to the north pole; in addition, the earth is rotating (west to east) beneath the satellite. The orbital direction of the satellite platform and the earth's rotational motion coupled with the curvature of the earth result in a characteristic ragged "swath" (figure 2) of data where a single scan resembles a bow tie (figure 1). A swath contains footprints that are not necessarily contiguous; there may be gaps between footprints, or they may overlap. Due to the sampling geometry, the resulting datasets are generally sparse relative to the sampling area and may have characteristics of vector, point, and raster data types (Raskin 2005 and Granger et al. 2005). Researchers at the Jet Propulsion Laboratory (JPL) and University of

Redlands (Raskin, Kumler, Granger, and Kemp 2005) are working to develop a hybrid data type to represent satellite swath data. This hybrid data type will be available to the atmospheric community and the Atmospheric Data Model.

Another issue arises when making comparisons between instruments; the scanning footprint will have a shape that is unique for a particular instrument (figure 3).

Using this illustration, the sampling characteristics of three EOS instruments, AIRS (the small gray pattern), AMSU (the large circles), and the Microwave Limb Sounder (MLS) (the gray streak identified by the black *X*s) can be compared. Note the gaps between footprints and the pronounced differences in footprint shape. It may be useful for the Atmospheric Data Model to include a specification defining the characteristics of the viewing geometry for nonimaging satellite instruments.

The research described in this publication was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

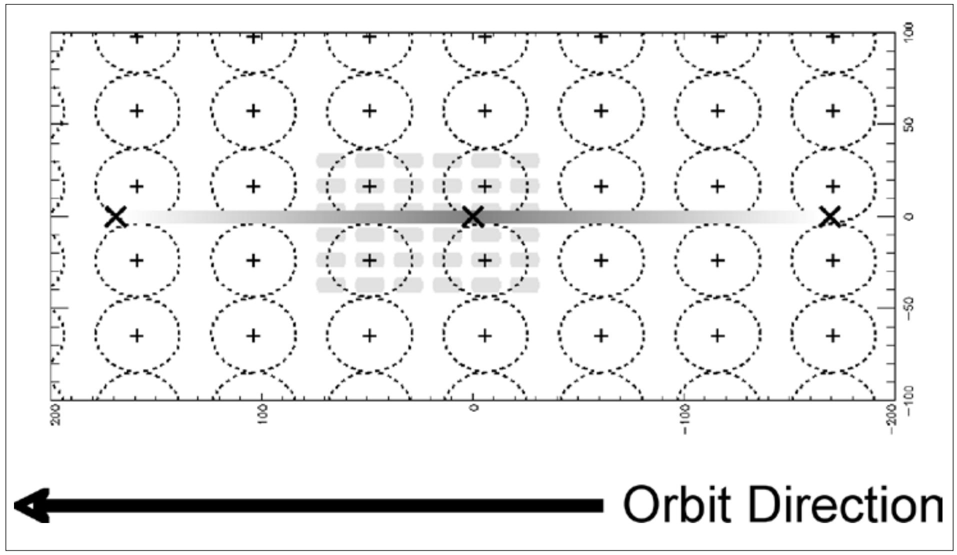

Figure 3. Comparison of Footprint Sampling Characteristics (Courtesy Eric Fetzer, JPL)

References

Granger, Stephanie, E. Dobinson, R. Raskin, and A. Bingham, 2005. "GIS Solutions for Analysis and Visualization of Atmospheric and Oceanographic Datasets." Proposal to NASA Advancing Collaborative Connections in Earth Science (ACCESS).

Raskin, Rob, 2005. Jet Propulsion Laboratory, personal correspondence.

Raskin, Rob, M. Kumler, S. Granger, and K. Kemp, 2006. "Enabling Multi-Parameter, Multi-Sensor, Multidimensional Earth Science Data Analysis Through Geographic Information Systems (GIS)." JPL Director's Research and Development Fund Proposal (Pending).

The Atmospheric User Group provides a unique venue for bringing GIS users of atmospheric data together. It's the only such venue that I know of that pulls from government, academia, the military, and the commercial sector to allow discussion of data formats. The interaction is valuable to me and helps me keep in touch with what others are doing in this arena.

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Event List

2007 Federal User Conference
January 9–12
Washington, D.C.

2007 American Meteorological Society (AMS)
January 14–18, 2007
San Antonio, Texas

2007 ESRI Developer Summit
March 20–22
Palm Springs, California

2007 ESRI International User Conference
June 18–22
San Diego, California

An Atmospheric Data Model

Cataloging Data by Usability in GIS

The Atmospheric Data Modeling Group

The Atmospheric Data Model (ADM) is a voluntary effort seeking a unified description of atmospheric data objects. The goal is seamless integration of atmospheric data, bringing atmospheric observations and products into GIS applications. This can be as simple as *point and click,* which defines the fully described class of data called *GIS ready.* Much atmospheric information is provided in formats that require processing to transform them into GIS-ready objects. This *GIS-friendly* data can be fully described with existing GIS data objects (point, arc, polygon, or raster). There is a third class of data that is neither GIS ready nor easily described by existing data objects. These objects may be partially described where they intersect existing GIS object structures, but GIS must expand its object classes and operators for this data to be fully described. Such atmospheric data objects are dubbed *GIS alien,* at least for the moment.

GIS Ready—Several repositories of atmospheric GIS-ready data are listed in table 1. These are generally noncommercial sources provided by government or university communities and are known to be fully free and open. Use should include references to the source, as each reference may help when continued funding is sought. This data is fully described by existing GIS data structures, plus metadata associated by record in the form of a one-to-one table of attributes and/or metadata and supplemental information associated by data object (e.g., by file). The format of existing GIS data objects is described in table 2. *GIS ready* implies that the data is fully usable by GIS. Viewers that only download images of data layers (see table 3) are not GIS ready, since additional effort is needed to load these files into GIS and the imaged data is not available for analysis. Transformations needed to recover data from viewer images may also degrade the information content.

GIS Friendly—Most atmospheric datasets must be processed into the formats listed in table 2 before they can be used in a GIS. A partial listing of common GIS-friendly datasets is given in table 3. The friendly-to-ready transformation can be as simple as attaching a World file for image registration. An example of image registration is shown in figure 1, where a 500 hPa Northern Hemispheric chart (*.tif) is loaded into ArcGlobe or ArcReader through the addition of a World file (*.tfw) and projection description (contained in *.aux, in this case for the Northern Hemispheric Polar Stereographic

GIS-Ready Data	Source	Online Location
Conventional Weather Data		
National Weather Service weather data available in GIS formats, as follows:	NOAA/NWS	www.weather.gov/gis/
- Watch Warning Advisory (WWA)	- PRH	www.nws.noaa.gov/regsci/gis/
- WSR-88D NEXRAD Radar Imagery	- RIDGE	http://radar.weather.gov/GIS.html
- Flash Flood Guidance (FFG)	- SRH	www.srh.noaa.gov/rfcshare/ffg.php
- Precipitation Analysis	- SRH	www.srh.noaa.gov/rfcshare/precip_analysis.php
NWS/AWIPS Map Backgrounds	NOAA/NWS	www.nws.noaa.gov/geodata/
NESDIS Real-Time GeoTiff (images only)	NOAA/NESDIS	www.gis.ssd.nesdis.noaa.gov/
SST, Height, Winds, and Currents	NASA/JPL	http://poet.jpl.nasa.gov
National Virtual Ocean Data System (NVODS)	NOAA/PMEL	http://ferret.pmel.noaa.gov/NVODS/servlets/dataset
Iowa Environmental Mesonet	Iowa State University	http://mesonet.agron.iastate.edu/GIS/
Climate Data		
NationalAtlas.gov	NOAA	http://nationalatlas.gov/maplayers.html
- Tornadoes (1950–2004)	NOAA	http://nationalatlas.gov/mld/tornadx.html
- Tropical Cyclones (1851–2004)	NOAA	http://nationalatlas.gov/mld/huralll.html
Tropical Cyclone Tracks (1958–present)	NOAA/Coastal Services Center	http://hurricane.csc.noaa.gov/hurricanes/download.html
Community Climate System Model	NCAR/GIS	www.gisclimatechange.org
NCAR Geospatial Map Index	NCAR/GIS	www.gis.ucar.edu/maps_data_dataset.html
Climate (precipitation, snow depth, Tmax, Tmin)	NOAA/CPC	ftp://ftp.cpc.ncep.noaa.gov/fews/gfs/37_km/00z/gis
Daily and Hourly Precipitation	NOAA/CPC	ftp://ftp.cpc.ncep.noaa.gov/fews/CMORPH/GIS
Weather Hazards (international)	NOAA/CPC	ftp://ftp.cpc.ncep.noaa.gov/fews/weather_hazards

Table 1. Free and open GIS-ready data sources. Users can add open GIS-ready data to this list.

GIS Data Object	Spatial Structure	Examples
Points (shapefile, comma-delimited text)	2D—f(x,y), {z,t} as attributes 3D—f(x,y,z), {t} as attribute	Observations and locations, model centroids, remote sensor retrievals at centroids, lightning strikes, tropical cyclone and tornado locations
Arcs (polyline shapefile)	2D—f(x,y), {z,t} as attributes 3D—f(x,y,z), {t} as attribute	Atmospheric fronts, air parcel trajectories, isopleths (aka analysis), balloon/aircraft/ship/buoy tracks, satellite ground track, tropical cyclone and tornado tracks
Polygons (shapefile)	2D/3D—f(x,y), {z,t} as attributes	Radar, air mass or tracer boundaries, zone/areal forecast, satellite footprints along a surface
Rasters (grids and images)	2D/3D—f(i,j), {x,y} by projection, {z} by value or external layer, attributes not supported	Model grid analyses and forecasts, satellite images

Table 2. Existing GIS Data Structures (Shapefile structure is defined at www.esri.com/library/whitepapers/pdfs/shapefile.pdf.)

Projection). The friendly-to-ready transformation may also be more complex, for example, when converting compressed GRIB model product layers into a set of floating-point arrays (with Header and World files). NetCDF model product layers must be converted in this fashion for ArcGIS 9.1, but netCDF will be a native format and therefore a GIS-ready dataset in ArcGIS 9.2. Several tools for data conversion are listed in table 4.

Sometimes the conversion process is so intensive that the data is not so friendly but still accessible. Consider the airborne lidar vertical cross section or sounding of the urban boundary layer over Cincinnati, Ohio, shown in figure 2. The original data is a conventional raster dataset but observed in the dimensions x (along ground track) and z (vertical above ground level, or AGL). Each raster cell is converted to a point {x,y,z}, where {x,y} is recalculated from aircraft navigation then displayed using ArcScene over conventional geographic information. Since this vertical cross section is a set of points, customary raster operations are not available.

GIS Alien—There are a number of atmospheric data objects that cannot be fully characterized by the geometries listed in table 2. Conventional hydrometeorological plots such as the time series or meteogram, shown in figure 3, can be represented in GIS using the x-axis as time and the y-axis as any scalar parameter. Certain GIS operations in the x,y spatial domain also make sense when x is replaced with t and y = f(t), but functions for period extraction and cross-correlation in these dimensions are not currently available. The data of figure 3 is associated with a point {x,y,z}. The covariation of this information in space and time with similar data at adjacent locations is an important factor in weather analysis and forecasting.

There are few GIS data objects that describe three-dimensional volumes and surfaces. Existing approaches to 3D include polygons in two dimensions that are extruded in the vertical and truncated by an upper and lower surface.

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GIS-Friendly Data	Source	Online Location
National Digital Forecast Database (NDFD)	NOAA/NWS	www.weather.gov/ndfd/
Current Radar Data (Level III)	NOAA/NWS	www.nws.noaa.gov/tg/rpccds.html
Radar Data Archive (Levels II and III)	NOAA/NCDC	www.ncdc.noaa.gov/oa/radar/radardata.html
GRIB Model Products—NDFD and NCEP	NWS/MDL NOAA/NCEP	www.weather.gov/mdl/degrib/links.php www.weather.gov/tg/modifiles.html
NetCDF Model Products	NCAR et al.	http://dss.ucar.edu/catalogs/
Meteorological Charts	NOAA/NWS	http://weather.noaa.gov/fax/graph.shtml
HYSPLIT Trajectories (PC version supports direct shapefile production)	NOAA/ARL	www.arl.noaa.gov/ready/hysp_info.html
Web Viewers (images for download)		
Forecast Model Products	NOAA/NCEP	www.nco.ncep.noaa.gov/pmb/nwprod/analysis/
NOAA's CoastWatch	NOAA/NESDIS	http://coastwatch.noaa.gov/
- SST (Sea Surface Temperature)	- ORAD	http://coastwatch.noaa.gov/cw_dataprod_sst.html
- Ocean Color	- ORAD	http://coastwatch.noaa.gov/cw_dataprod_color.html
- Ocean Surface Winds	- ORAD	http://coastwatch.noaa.gov/cw_dataprod_winds.html
- NESDIS Real-Time GeoTiff	NOAA/NESDIS	www.gis.ssd.nesdis.noaa.gov/
- Fire Products	- OSDPD/SSD	www.firedetect.noaa.gov/viewer.htm
- Snow and Ice Analysis	- OSDPD/SSD	www.gis.ssd.nesdis.noaa.gov/website/SSDSnow/viewer.htm
- GOES Aerosol and Smoke Product (GASP)	- OSDPD/SSD	www.gis.ssd.nesdis.noaa.gov/website/GASP/viewer.htm

Table 3. Sources of GIS-Friendly Data

An Atmospheric Data Model

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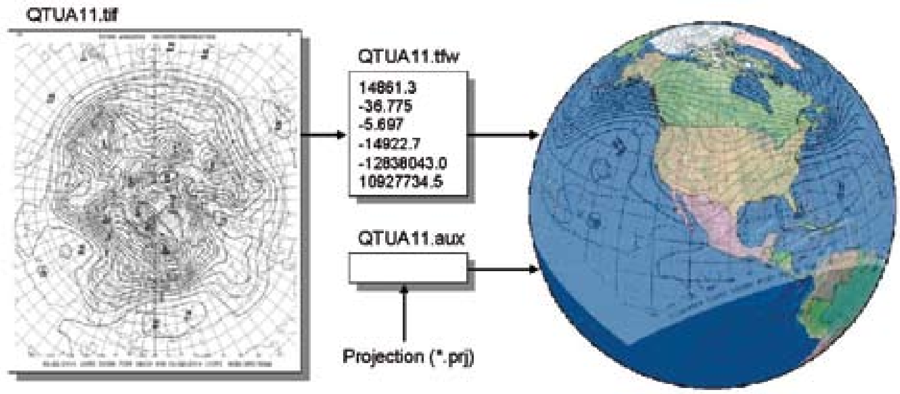
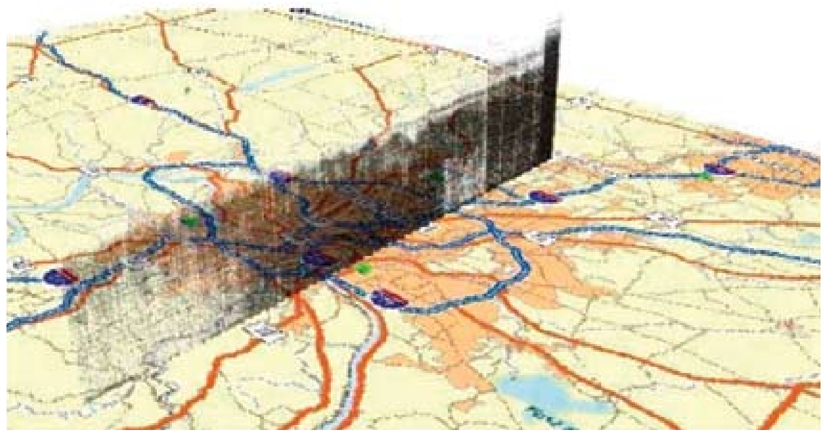
Higher-dimensional objects, including the 4D and 5D structures supported by VisAD (www.ssec.wisc.edu/~billh/visad.html), would be useful if available as well as VisAD's methods for working with hyperspectral dimensions such as wavelength or frequency. Such higher-dimensional objects and their corresponding operations would be useful for the analysis of satellite profiler (hyperspectral) data. In the previous companion article, Stephanie Granger (Jet Propulsion Lab [JPL]) explores such GIS-alien structures for the Aerometric Information Retrieval System (AIRS) instrument currently flying in a polar orbit on the Earth Observing System (EOS)/Aqua.

GIS operations are generally limited to the structures identified in table 2. GIS techniques are currently synonymous with mapping and cartography. However, the concept of GIS and its practice has a much broader potential when the paradigm is expanded into an n-dimensional topology.

This list is maintained at http://geog.gmu.edu/projects/wxproject/gisdata.htm. Send contributions to sshipley@gmu.edu.

Members of the ADM Working Group in 2006 are Scott Shipley (chair), GMU & ERT, Inc. (sshipley@gmu.edu); Stephanie Granger, NASA/JPL (steph@airs1.jpl.nasa.gov); Nazila Merati, NOAA/PMEL/JISAO (Nazila.Merati@noaa.gov); Tiffany Vance, NOAA/NMFS (Tiffany.C.Vance@noaa.gov); and Bonnie Reed, General Dynamics (Bonnie.Reed@noaa.gov).





Top: Figure 1. Conventional 500 hPa forecast as TIFF image, displayed in ArcGlobe/ArcReader after geolocation. Each standard chart (*.tif) becomes GIS ready by adding a World file (*.tfw) and giving the chart projection.

Bottom: Figure 2. Airborne lidar cross section of aerosols on the boundary layer over Cincinnati, Ohio, captured on the morning of July 18, 1980, by NASA. Vertical cross sections are common in atmospheric analysis but are not easily supported in current GIS. This is an example of not-so-friendly GIS data, since processing is prohibitive due to a multistep process for a very large number of points.

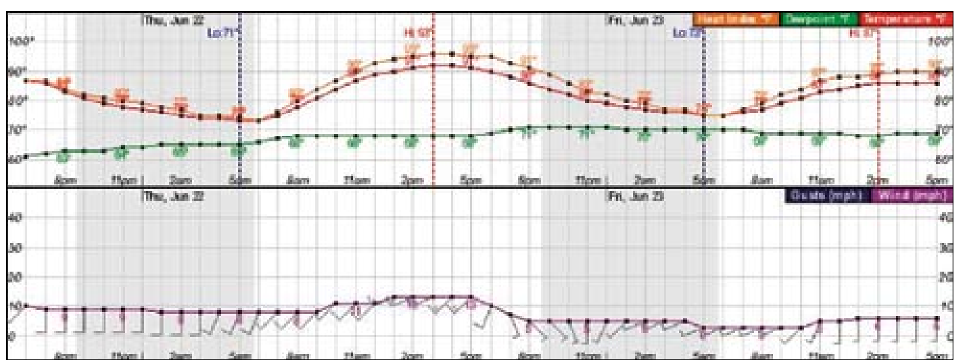


Figure 3. Time Series Weather Forecast (meteogram) for Washington, D.C., Starting June 21, 2006 (www.nws.noaa.gov/) (Select location, then follow the link to Hourly Weather Graph.)

GIS-Friendly Tools	Source	Online Location
NCDC Java NEXRAD	NCDC	www.ncdc.noaa.gov/oa/radar/jnx/index.html
NEXRAD to Shapefile	GMU	http://geog.gmu.edu/projects/wxproject/nex2shp/nexrad.htm
NetCDF Converters (direct read in ArcGIS 9.2)	UNIDATA ESRI	www.unidata.ucar.edu/software/netcdf/ http://arcscripts.esri.com/details.asp?dbid=13894
GRIB Converters	CPC MDL	www.cpc.ncep.noaa.gov/products/wesley/grb2grid.html www.nws.noaa.gov/ndfd/gis/ndfd_GIS_tutorial.html
HDF-EOS to GeoTiff	EOS	http://newsroom.gsfc.nasa.gov/sdptoolkit/HEG/HEGHome.html

Table 4. GIS Data Conversion Tools

Weather Verification Using Geographic Information Systems

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reports. ArcGIS has excellent geoprocessing tools to work with; however, the nature of this specific task requires a substantial amount of custom programming. Examples include parsing out strings in some of the table attributes and applying special tests (temporal, for example) to determine if a proper match has been made between warnings and events. For these reasons, a choice was made to use Visual Basic for Applications (VBA) for the required tasks.

Figure 2. Close-in look over central Mississippi showing tornado warning polygons with overlays of events, both verified (green) and not verified (red).

Results

Initial results have been very promising. ArcGIS has been used to compute the probability of detection (POD) or, in other words, whether there was a warning in place for the area that had a tornado touchdown. In addition, the lead time (LT) for each event that did indeed have a warning was computed. The resultant tables have been exported for statistical use in Microsoft Excel. Figure 1 shows the 48-state view of polygon warnings and events. Figure 2 is a closeup look at the state of Mississippi, which seemed to be the most tornado-active region in the United States in 2005.

What was discovered was that the POD using polygons rather than counties was lower due to the fact that the warning was much smaller in area, raising the risk that a warning might miss an event. The legacy county-based method, however, might count that event as verified since the county is usually much larger than the polygon warning.

Future work will look at other events, such as hail reports, and match them to other NWS warnings such as the severe thunderstorm warnings as shown below in figure 3.

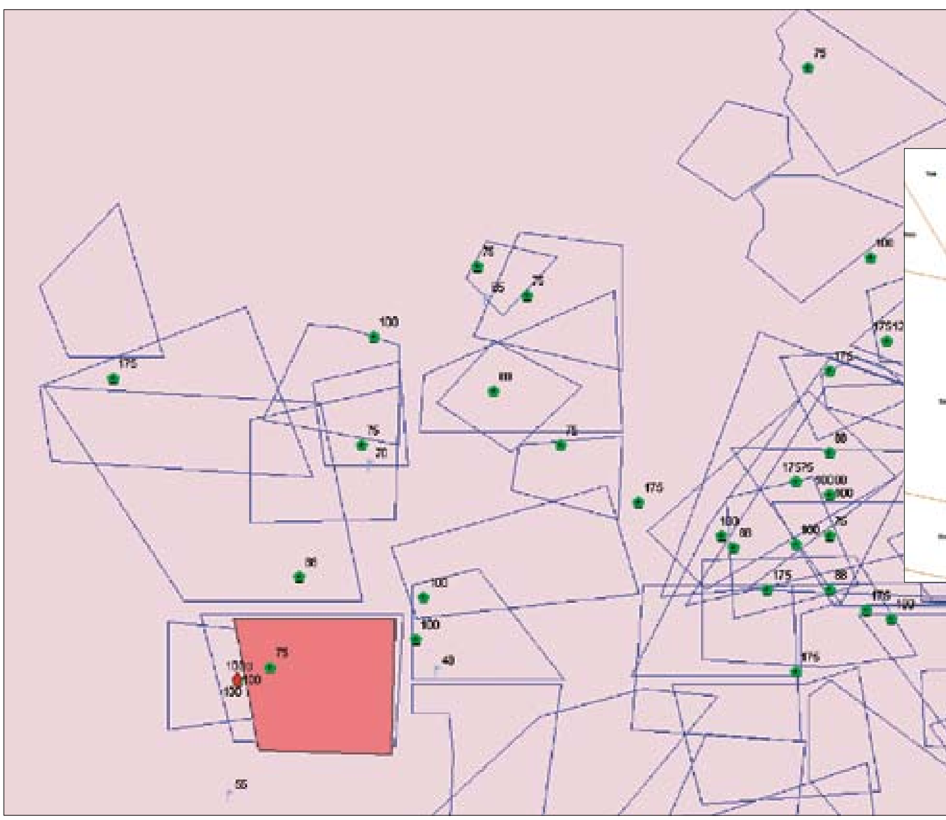

Figure 3. Hail reports (in green) overlaid with severe thunderstorm warnings in New Mexico (blue unfilled polygons). The label for the hail reports is in hundredths of an inch (e.g., 75 signifies 0.75 or ¾" hailstones). The red-filled polygon is for a tornado warning with the red diamond-shaped marker showing a tornado touchdown.

County Area Ratio

To better illustrate the service improvement that polygon warnings provide, it became necessary to design a new measure. This measure is a comparison of the area of each polygon warning to the sum of the counties that the warning was issued for. ArcGIS was used to compute the areas of the polygons, and customized VBA code was used to parse out the counties from each warning. This data is composed of a string list of all the counties in one field of the data attribute table. VBA was required to break the string into individual Universal Geographic Codes (UGC), which are unique to each county in the country. Then the code matches a county table of area in square mileage and computes the ratio of the two areas for each warning. This new measure, County Area Ratio (CAR), is used by the agency to demonstrate service improvement with polygon warnings.

Conclusion

There remains much promise with the use of ArcGIS and VBA to revolutionize the way the National Weather Service verifies its warnings. This is only the start of many more applications of the GIS that the agency can take advantage of.

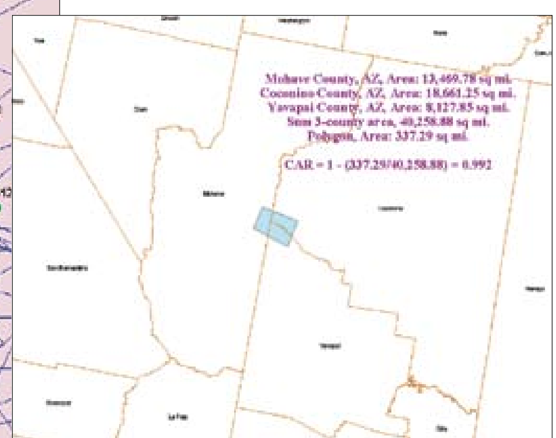

Figure 4. Example of the CAR measure using an actual severe thunderstorm warning issued in Arizona that overlapped three counties. Using the legacy county-based method, this warning was huge, more than 40,000 square miles, covering much of the state of Arizona. However, using polygons, the warning was much smaller, less than 400 square miles. Thus, this results in a dramatically reduced area of the state that is under this warning.

GIS Applications in Weather and Geophysical Services in Hong Kong

By Chiu Ying Lam, Director, and Lap Shun Lee, Scientific Officer, Hong Kong Observatory

Weather information is meaningless until it is related to specific geographic locations. As the official authority in Hong Kong to forecast weather and issue warnings on weather-related hazards, the Hong Kong Observatory (HKO) has a long tradition of GIS use, that is, processing meteorological and other geophysical data in a spatial frame and presenting it on geographical displays for both internal analysis and external service delivery.

The history of using GIS in HKO, in the more restrictive sense of a computer-based operation, can be traced back to the 1980s. The first computer-based weather radar was implemented in 1983 to replace the old analog system. It displayed signal returns in different colors according to rain intensity, allowed the selection of radar scans at different altitudes, and forecast the movement of rain areas based on extrapolation. These GIS features enabled weather forecasters to follow the movement and development of rain areas in an efficient manner. In 1988, HKO installed the first computer-based system to receive high-resolution satellite pictures. This provided a unique global view of cloud cover distribution.

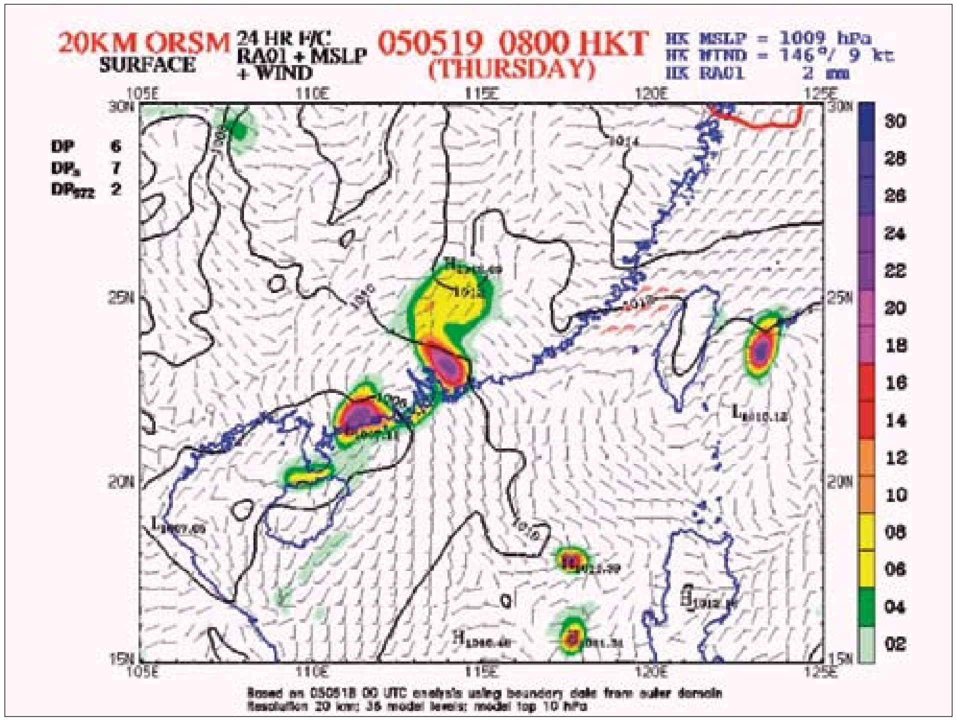

Figure 1. Predicted Weather Based on Numerical Computation

With the aid of GIS, forecasters could determine more quickly and accurately the position and movement of weather systems such as tropical cyclones. This is very much taken for granted now, but at that time, it excited forecasters who were accustomed to analyzing analog radar signals relative to coastlines printed on plastic overlays and measuring distance on a facsimile cloud image by ruler.

As technology advanced further, the observatory began to formulate weather forecasts based not only on observational data but also on numerical weather prediction products. Nowadays, the application of high-speed computers, which solve a complex set of mathematical equations to simulate physical conditions in the atmosphere, results in a huge amount of numerical products consisting of spatial and temporal variations of assorted weather elements. GIS assists in displaying the information neatly so that forecasters can assimilate it conveniently and effectively. Figure 1 shows how information on wind, rain, and atmospheric pressure, forecast for the next 24 hours, is typically displayed with the aid of GIS.

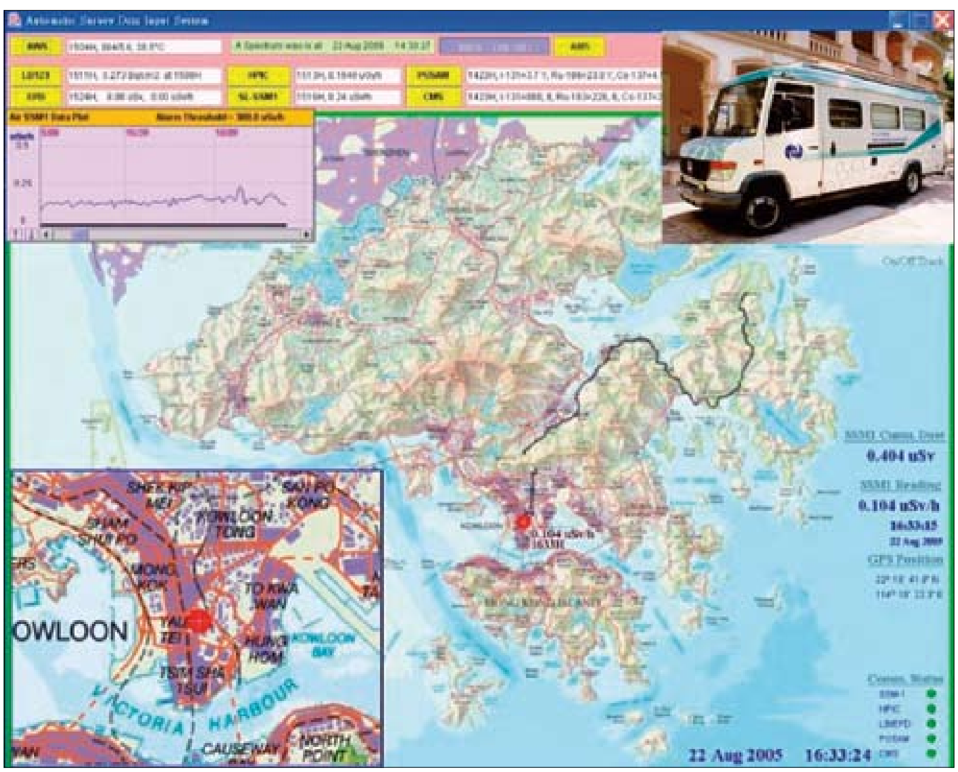

Figure 2. Radiological Data Measured en Route

Besides applications on weather forecasting, GIS is also widely used by the observatory in other areas such as radiological measurements. During the course of a radiological survey, a custom-fitted van with radiological measuring equipment on board transmits data back to the observatory headquarters in real time. A sophisticated GIS tool designed by the observatory instantly displays the track of the van and the radiological measurement made en route, as shown in the example in figure 2. This served as a quick and convenient tool to assess the radiological situation. Another GIS application, built on ArcIMS, is used by HKO to monitor the radiation levels in Hong Kong, which are measured by a network of radiation monitoring stations every minute. ArcIMS provides a platform for integrating the real-time radiation data with other meteorological and geographical information. It also provides the system developer with a library of GIS modules to enhance the graphical interface to meet the increasing demand from end users.

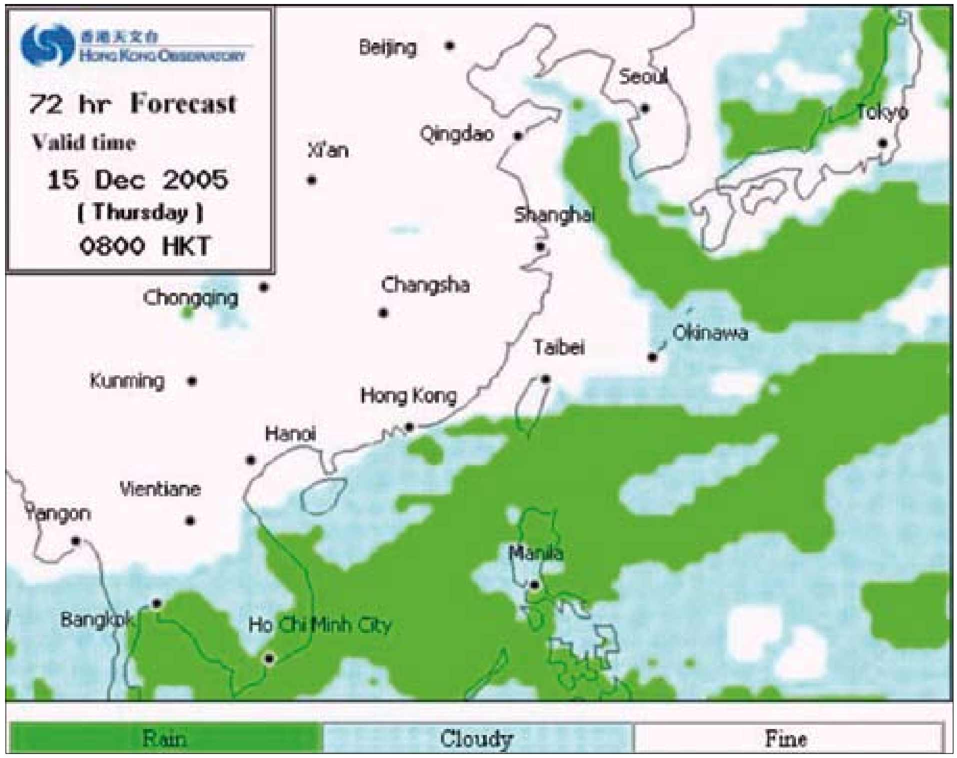

Figure 3. Forecast Weather Chart for the Public

The above examples illustrate how GIS serves as an operational tool to integrate, analyze, and display weather and geophysical information. However, the power of GIS is more than this. The emergence of the Internet was a breakthrough that has enabled HKO to widely expand its range of GIS-type products from analysis within the department to the delivery of services to external users. The observatory operates a network of automatic weather stations covering the entire territory. Through a Web browser, one can easily obtain real-time weather information within any area of interest. Besides observational data, weather forecast charts generated by high-speed computers, which were only used by weather forecasters in the past, are now also made available on the Internet, empowering citizens to make intelligent weather-related and location-specific decisions for themselves (figure 3). The use of GIS and the Internet together has also enabled an influence much beyond Hong Kong, reaching out practically to the rest of the world. Recognizing the leading expertise of HKO in Internet service, the World Meteorological Organization (WMO) has entrusted the observatory to design, develop, and host two WMO Web sites on worldwide official weather forecasts and warnings, viz, the World Weather Information Service (www.worldweather.org) and the Severe Weather Information Centre (severe.worldweather.org). These two Web sites have been well received since their formal operation in 2005 (figure 4).

The Hong Kong Observatory has more dreams for the future. Once numerical weather prediction becomes even more reliable, location-specific weather forecasts with fine time resolution, say one hour, may be provided to the public. Together with the use of other geophysical data, such as the distribution of slopes vulnerable to landslide, the observatory may, in a timely manner, forecast the potential for landslides due to heavy rain. One of the dream products is shown in figure 5. In the future, it is expected that more and more weather services will make use of the combined GIS and mobile technology. For example, imagine someone in the street without an umbrella, caught in the rain, but in a hurry to get to an

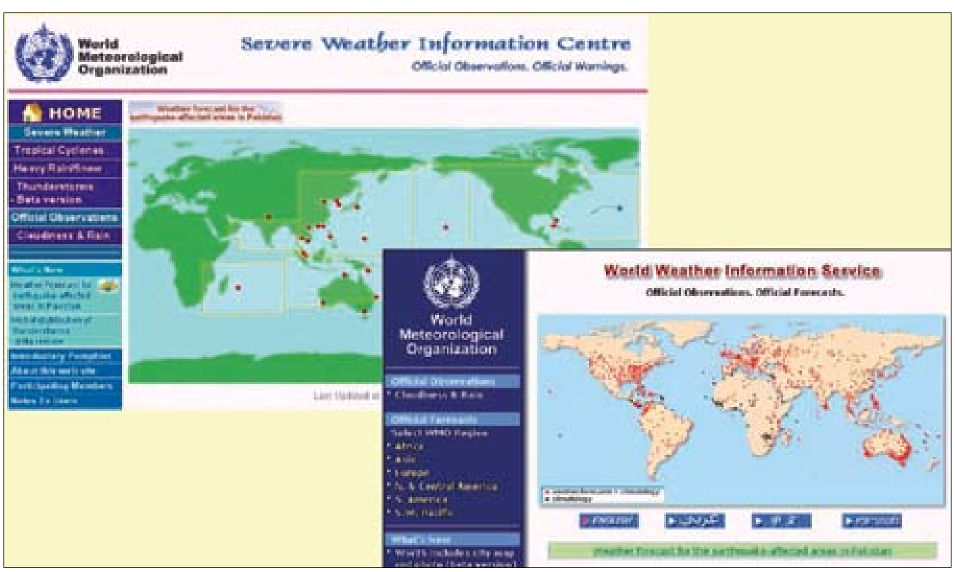

Figure 4. Web Sites Operated on Behalf of the World Meteorological Organization

continued on page 10

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important meeting. If this person could use a mobile phone or a personal digital assistant (PDA) to obtain information about when the rain will stop, a decision could be made to either stay under the shelter for a period of time or to run to the meeting in spite of getting wet. Figure 6 shows what he/she might see on his/her phone.

There are even more possibilities of using GIS to enhance public weather services. With the rapid advancement of GIS and weather forecasting techniques, there is no doubt that in the future we would be much better prepared for the weather and enjoy a safer life.

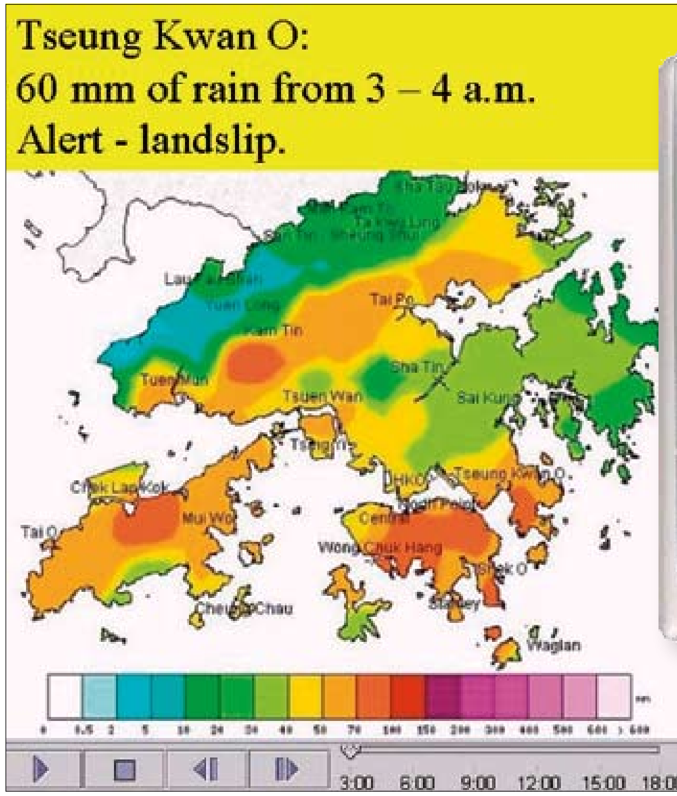

Figure 5. Time- and Location-Specific Weather Forecasts and Alerts

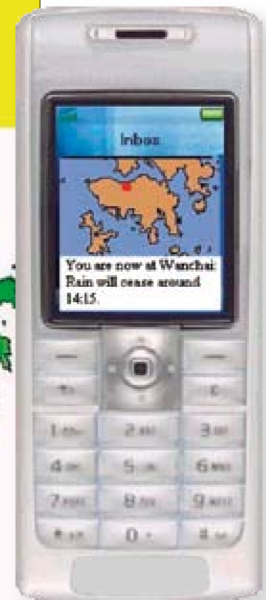

Figure 6. Combined GIS and Mobile Technology to Provide In Situ Weather Service

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Team Atmospheric would like to congratulate NOAA's National Geodetic Survey (NGS) and the Jet Propulsion Lab (JPL) for the Special Achievement in GIS awards they received at the 2006 ESRI International User Conference.

WeatherBug Professional

WeatherBug Professional delivers nationwide weather information summarizing all National Weather Service (NWS) data elements and lightning detection as well as weather station site information from more than 8,000 locations into one easy-to-integrate Web service. This service is currently available as an ArcIMS feed that can power Web pages as well as ArcGIS applications. WeatherBug's 8,000-site weather network updates content every two seconds as compared to every hour by the National Weather Service sites and can be accessed as a monthly or annual subscription.

In addition to Web services, WeatherBug offers a product called the Smart Notification Weather Service. This service was built using ArcSDE and ArcIMS for the geoprocessing components. It precisely matches live, neighborhood-level severe weather threats with a user's location; issues two-way alert messages to that user's phone, pager, or voice mailbox; and responds back to the issuer. These alerts include lightning threats and strikes, wind gusts, heat index, wind chill, rain rate, and all National Weather Service alerts and warnings. All alerts are verified and checked by WeatherBug's 24/7 Meteorology Control Center before being issued to subscribers. Smart Notification can work with all GPS-enabled cell phones and in-vehicle GPS tracking devices or can operate in static mode, where it can alert based on proximity to fixed assets.

WeatherBug has been an ESRI business partner since 2006 and an ESRI product user since 2004.

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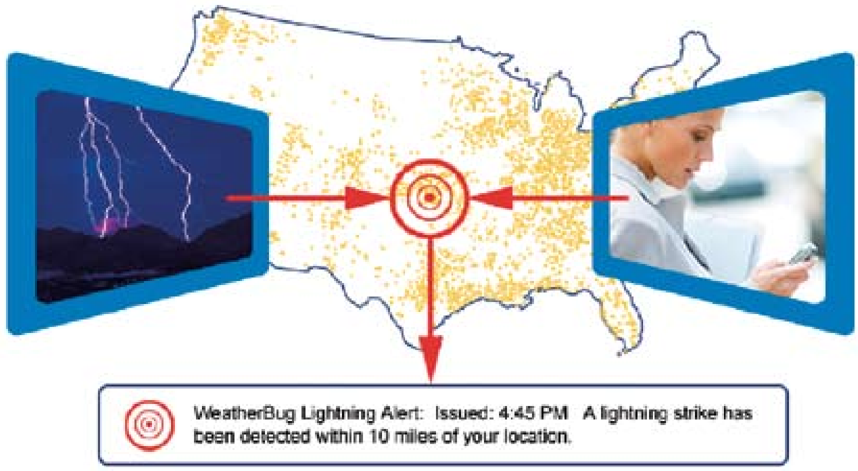

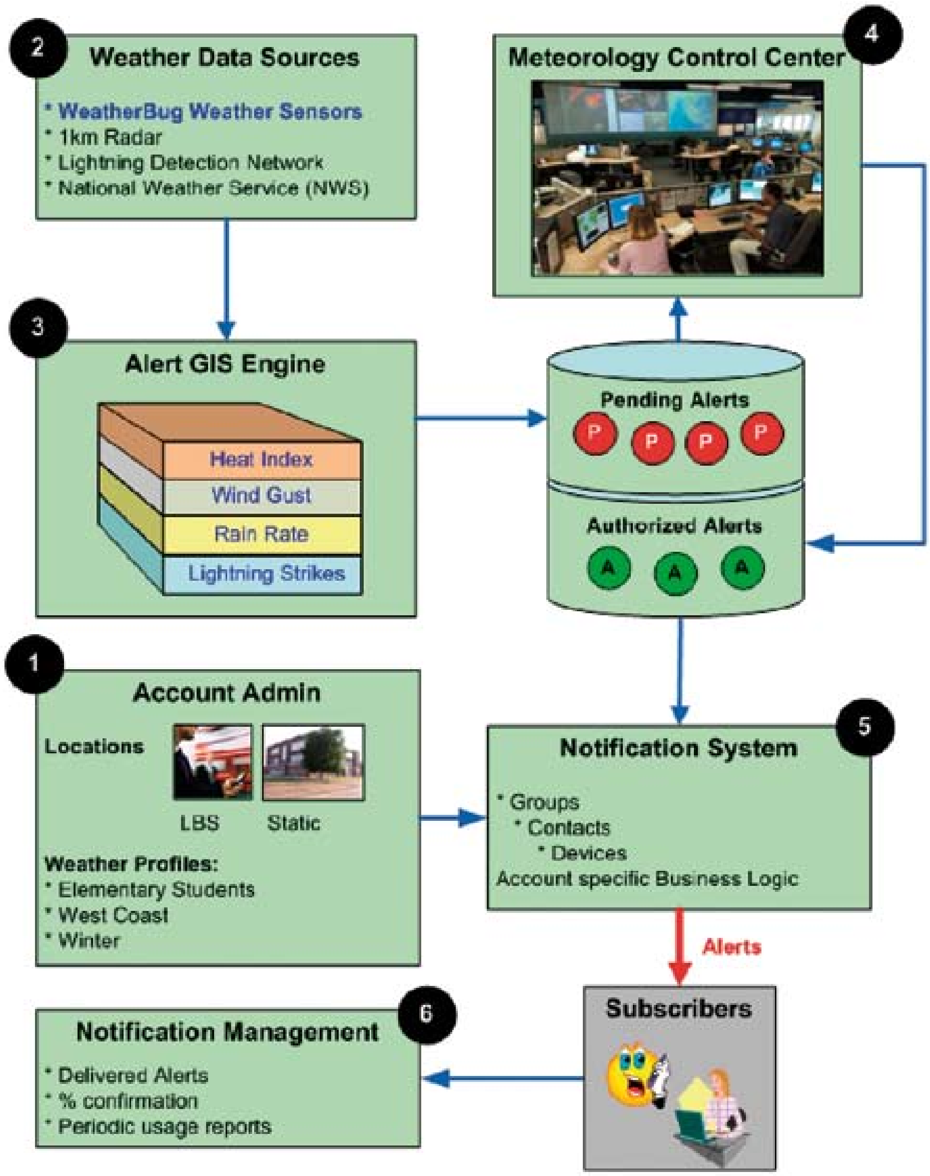

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