

UTILIZING GOOGLE EARTH AS A GIS PLATFORM FOR WEATHER APPLICATIONS

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1. Introduction

Google Earth (formerly known as Keyhole; <http://earth.google.com>) is a free-for-personal-use application that streams high-resolution static satellite imagery (Figure 1) and map overlays over a broadband internet connection to a 3D display on a user's desktop. Google Earth provides the user the ability to overlay images, icons, and polygons via Extensible Markup Language (XML) tags. These user-generated products may be shared over the internet and requested by Google Earth at specified intervals, which provides the ability to stream continuously updating real-time imagery. Because Google Earth is an application that runs on inexpensive hardware, it provides an easy way to view weather products that are disseminated over the internet.



Figure 1: An example of high-resolution satellite data in Google Earth showing downtown St. Louis.

The National Severe Storms Laboratory (NSSL) has begun utilizing geoTIFF (TIFF with geospatial information tags; Ritter and Ruth 2000) images as a way to share experimental severe weather products with other researchers and operational meteorologists for evaluation and feedback. A variety of multi-sensor severe weather

products are generated by NSSL and shared to Google Earth and other Geographic Information Systems (GIS) users via the internet at <http://wdssii.nssl.noaa.gov>. These products include spatially gridded fields of Vertically Integrated Liquid, Maximum Expected Hail Size, tracks of circulations derived from Doppler velocity data, composite reflectivity, and 30-to-60 minute forecast reflectivity fields, among others. These products, which have a spatial resolution of approximately 1 km by 1 km, are generated every one to five minutes within the Warning Decision Support System – Integrated Information (WDSS-II) on the scale of the continental United States (Lakshmanan et al 2006). The WDSS-II system provides the images in GeoTIFF format which may be imported into most GIS software, including Google Earth.

This manuscript shows examples of products generated within the WDSS-II framework that are available for viewing in the Google Earth application, and demonstrates the process by which researchers can share their work with other Google Earth and other GIS users via the internet.

2. NSSL Weather products

The National Severe Storms Laboratory and the Storm Prediction Center cooperatively run an experimental WDSS-II system that generates high-resolution three-dimensional radar reflectivity data and other severe weather guidance products for the continental United States (Lakshmanan et al 2006). These products have been made available on an experimental basis in several forms, such as:

1. generic netCDF (Rew et al 1997) files, displayable by the WDSS-II graphical user interface and other display systems,

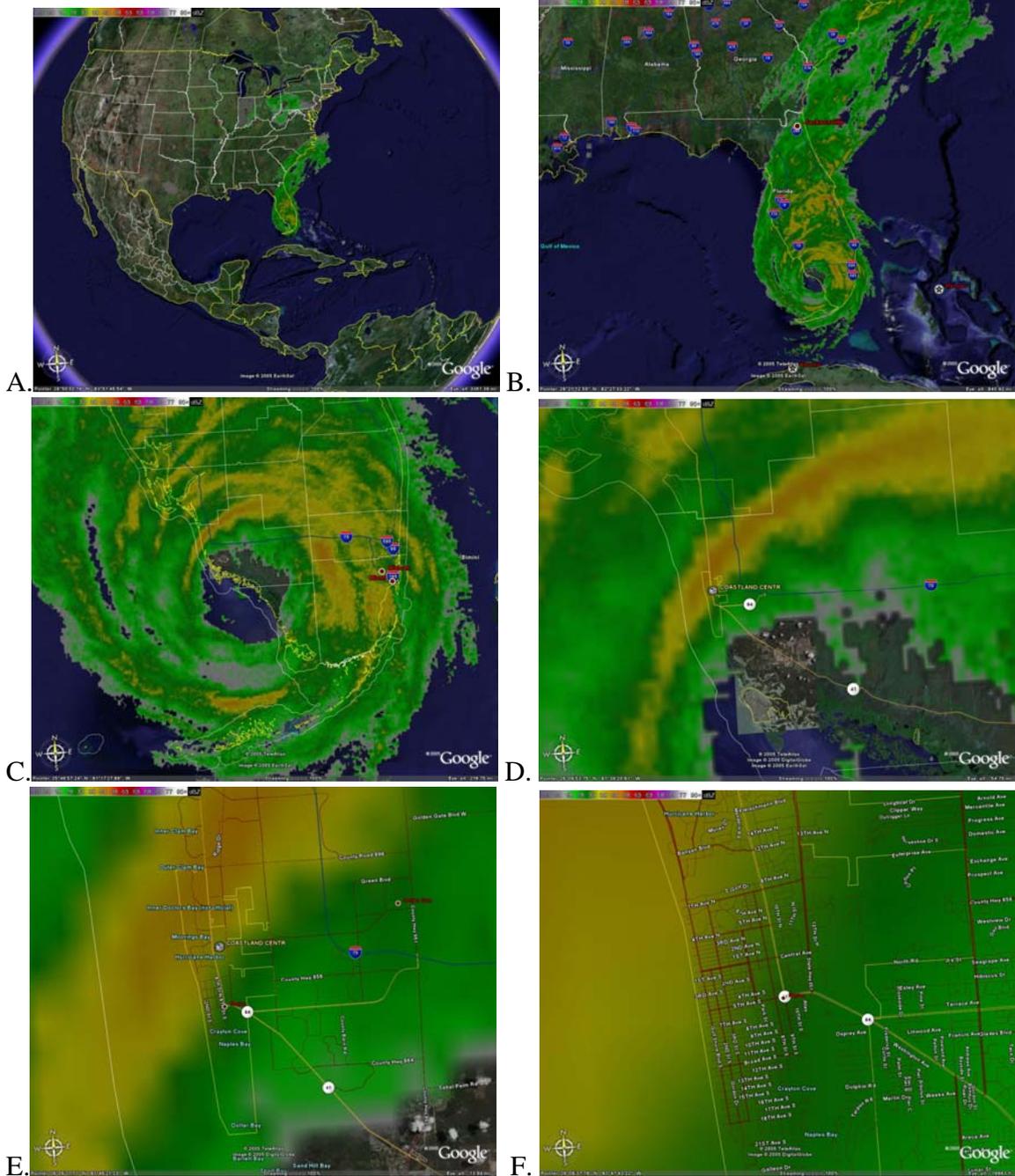


Figure 2: A national reflectivity composite product shown at decreasing scales.

2. AWIPS-format netCDF files, used by National Weather Service,
3. static PNG images on the World Wide Web,
4. GeoTIFF format that may be read by GIS programs.

The WDSS-II system includes tools to convert data from generic netCDF to other data and image formats, including GeoTIFF. While converting from data formats to image formats typically results in a loss of data resolution, image formats are usually viewable by anyone with a computer. The free version of Google Earth does not read

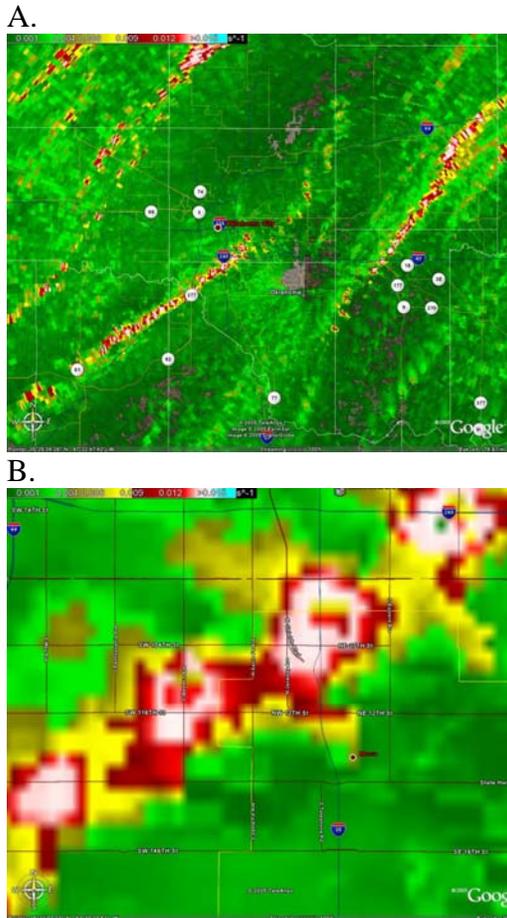


Figure 3: Radar-detected low-level circulation paths of the May 3, 1999 thunderstorms that produced damaging tornadoes in central Oklahoma (A) with a higher resolution image of Moore, OK (B). Bright reds and yellows indicate more intense circulation.

the geospatial reference tags from GeoTIFF natively, and requires a reference file in XML format to describe the spatial extent of the image. GeoTIFF files generated by WDSS-II use a geographic map projection, where each pixel represents the same width and height in degrees longitude and latitude.

Figure 2 shows a continental United States (CONUS) scale image of radar reflectivity data (A) in Google Earth, with progressively smaller scales (B, C, D, and E) zooming in on Hurricane Wilma, while the last image (F) shows the Naples, FL area with detailed road network information. In this case, the resolution of the street overlay information is greater than that of the 1-km resolution

radar products, but users can get a sense of where the heaviest precipitation is occurring or what locations might be specifically affected by the winds in the hurricane's eye wall. The blurriness of the radar images in the close-up views is caused by Google Earth's OpenGL rendering technique.

Figure 3 shows an example of the "Rotation Tracks" product generated by the WDSS-II system (Smith and Elmore 2004). By combining this product with high-resolution GIS information, users may determine where a storm's low-altitude circulation was most intense and which streets may have suffered damage. This information is extremely valuable to emergency management officials in a disaster response situation. It is also very useful for those who conduct post-storm damage assessment surveys as they can determine exactly what areas may have been affected by tornadic winds. Older techniques for sending out assessment teams frequently required hours of examining radar data and manually plotting circulation locations on a map before the assessment teams were able to get out into the field and begin their work.

There are numerous other products available that benefit from the integration of GIS information and weather data. NSSL presently generates products that estimate hail fall location and size, precipitation amount, show weather satellite imagery, and forecast storm location fields, among others.

3. Generating and sharing weather products for Google Earth

A powerful aspect of Google Earth is that it allows users to create and share all sorts of dynamically-updating data over the internet. This is accomplished using Keyhole Markup Language (KML; <http://code.google.com>), an XML dialect used to describe the data so that it may be interpreted and plotted in Google Earth. Data fields are dynamically updated through use of a "network link", which is part of the KML format specification. KML allows users to overlay many basic data types that are useful for weather data, such as images, point data, lines, and polygons.

A:

```

<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://earth.google.com/kml/2.0">
  <Folder>
    <name>WDSS-II Real-time Weather Imagery</name>
    <GroundOverlay>
      <Icon><href>http://wdssii.nssl.noaa.gov/geotiff/CONUS/MergedReflectivityQComposite_20051103-184446.tif</href></Icon>
      <visibility>1</visibility>
      <name>MergedReflectivityQComposite at 20051103-184446</name>
      <color>ffffff</color>
      <LatLonBox>
        <north>51.000</north>
        <south>21.000</south>
        <east>-67.000</east>
        <west>-127.000</west>
      </LatLonBox>
    </GroundOverlay>
    <Placemark><name>copyright</name>
      <visibility>1</visibility>
      <description> Created by WDSS-II http://www.wdssii.org/ (c) Univ of Oklahom
a, National Severe Storms Laboratory </description>
    </Placemark>
  </Folder>
</kml>

```

B:

```

<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://earth.google.com/kml/2.0">
  <Folder>
    <name>NSSL / U. of Oklahoma CONUS radar</name>
    <open>1</open>
    <description>These data are experimental...</description>
    <ScreenOverlay>
      <name>Reflectivity Colorbar</name>
      <Icon>
        <href> http://wdssii.nssl.noaa.gov/geotiff/colormaps/MergedReflectivityQComposite.jpg </Icon>
        <overlayXY x="0.5" y="0.5" xunits="fraction" yunits="fraction"/>
        <screenXY x="0.15" y="0.99" xunits="fraction" yunits="fraction"/>
        <rotationXY x="0.5" y="0.5" xunits="fraction" yunits="fraction"/>
        <size x="-1" y="-1" xunits="pixels" yunits="pixels"/>
      </ScreenOverlay>
      <NetworkLink>
        <name>Continental US Radar</name>
        <Url>
          <href>http://wdssii.nssl.noaa.gov/geotiff/CONUS/MergedReflectivityQComposite.kml</href>
          <refreshMode>onInterval</refreshMode>
          <refreshInterval>120</refreshInterval>
        </Url>
      </NetworkLink>
    </Folder>
  </kml>

```

Figure 4: An example of (A) a KML containing a link to an image as well as the geographic information about the boundaries of the image, and (B) a KML file containing a link to a static image overlay and a network link to (A) that update once every 120 seconds.

One example of an image overlay is the WDSSII CONUS reflectivity product. To make this product dynamically update requires two steps. First, the web address and location of the image in geographic projection is described using a "GroundOverlay" tag (Figure 4, A) as part of a KML file. Another file contains an "ScreenOverlay" tag describing the location of an image that describes the data values for each color as well as a "NetworkLink" tag that points to the location of the first file. The first file updates once every 120 seconds with new data, while the second file tells the Google Earth application to fetch the first file at the given time interval.

Another basic data type that is viewable in Google Earth is simple point data. Figure 5 shows an example KML file containing a single data point. This file contains a "Placemark" tag with coordinates and text that will be plotted inside Google Earth. Polygons, lines, and user-created icons are also part of the KML specification and may be useful for the display of weather data.

```

<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://earth.google.com/kml/2.0">
  <Placemark>
    <name>Wind gust to 60 kts</name>
    <Point>
      <coordinates>-99.12,38.87,0</coordinates>
    </Point>
  </Placemark>
</kml>

```

Figure 5: A KML file describing a single point.



Figure 6: NWS warning polygons (Severe Thunderstorm Warnings in orange) overlaid on radar reflectivity data in Google Earth. Clicking on a push-pin attached to a polygon will pop up the text of the warning.

The overlays in Figure 6 were created with a mixture of “LineString” and “Placemark” KML tags.

about the WDSS-II system is available at <http://www.wdssii.org>. Google Earth may be downloaded at <http://earth.google.com>.

4. Summary

Google Earth provides an easy-to-use GIS platform that is widely available, runs on inexpensive hardware platforms, and allows easy real-time sharing of data, thus making it a useful tool for the integration of weather data with GIS information. The NSSL is making several multi-radar and multi-sensor products available as GeoTIFF files with associated KML files that may be viewed in Google Earth and other GIS applications. By making these experimental products available online, it allows potential users to submit feedback about the products and provides the fruits of research the general public in a timelier manner than has been possible in the past. Several of these products are potentially very useful in emergency response situations, where their integration with GIS information is especially helpful.

Products are available online at <http://wdssii.nssl.noaa.gov>, while information

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References

- Lakshmanan, V., T. M. Smith, K. Cooper, J. J. Levit, G. J. Stumpf, and D. R. Bright, 2006: *High-resolution radar data and products over the Continental United States*. Preprints, 22nd Conf. on IIPS, Atlanta, Amer. Meteor. Soc.
- Rew, R. K., G. P. Davis, S. Emmerson, and H. Davies, *NetCDF User's Guide for*

C, An Interface for Data Access,
Version 3, April 1997.
<http://www.unidata.ucar.edu/software/netcdf/docs/netcdf/>

Ritter, N., and M. Ruth, 2000: GeoTIFF
Format Specification.
<http://www.remotesensing.org/geotiff/spec/geotiffhome.html>

T. M. Smith and K. L. Elmore, 2004: *The use of radial velocity derivatives to diagnose rotation and divergence.* Preprints, 11th Conf. on Aviation, Range, and Aerospace, Hyannis, MA, Amer. Meteor. Soc., P5.6 - CD preprints.