5A.1 THE WEATHER AND CLIMATE TOOLKIT

Steve Ansari *, Stephen Del Greco, Neal Lott
NOAA National Climatic Data Center, Asheville, North Carolina

ABSTRACT

The Weather and Climate Toolkit (WCT) is free, platform independent software distributed from NOAA's National Climatic Data Center (NCDC). The WCT allows the visualization and data export of weather and climate data, including Radar, Satellite and Model data [Appendix A].

The WCT provides tools for custom data overlays, Web Map Service (WMS) background maps, animations and basic filtering. The export of images and movies is provided in multiple formats. The WCT Data Export Wizard allows for data export in both vector polygon/point (Shapefile, Well-Known Text) and raster (GeoTIFF, ESRI Grid, Gridded NetCDF) formats. These data export features promote the interoperability of weather and climate information with various scientific communities and common software packages such as ArcGIS, Google Earth, MatLAB, etc…

Advanced data export support for Google Earth enables the 2-D and 3-D export of rendered data, isosurfaces and cross-sections. An embedded, integrated Google Earth plugin instance allows the seamless visualization of data on a native 3-D Google Earth instance linked to the standard 2-D map [Appendix B].

1. INTRODUCTION

NCDC archives many diverse datasets including, but not limited to, station observations, Radar, Numerical Model, satellite. These data are in many different complicated binary formats and represent different abstract data types such as point, time series, grid, radial and swath. While access to the raw datasets is relatively easy, integration of the data into user software and applications is often extremely difficult. Custom software must be written to decode or parse the data into formats that common software packages can read. Furthermore, these formats and software packages are different for each major scientific genre including Engineering, Atmospheric Science, Hydrology and Environmental Science. By providing conversion and data export tools, easy data access and integration is available to an increased audience.

The Weather and Climate Toolkit is the successor to the Java NEXRAD Tools, a visualization and data export tool for NEXRAD Radar data [1].

* *Corresponding author address:*
Steve Ansari, 151 Patton Avenue, Asheville, NC 28801; e-mail: Steve.Ansari@noaa.gov.

2. DATA

The WCT is based largely on the Unidata NetCDF for Java API [4]. The NetCDF for Java API supports the direct reading of native formats including GRIB, NEXRAD and HDF into Common Data Model feature types such as time series, radial, grid, etc… [Appendix A]. The WCT provides visualization and data export support based on these abstract feature types [6].

The current available release provides support for many data formats including:

- Gridded NetCDF, HDF and OPeNDAP
- GRIB version 1 and 2
- NEXRAD Level-II
- NEXRAD Level-III
- GOES AREA Files
- GINI
- GEMPAK Grids
- XMRG MPE

Users may access data on any remote HTTP or FTP server in addition to local disk. Special support is provided for NCDC HAS orders, CLASS orders and THREDDS catalogs.

Development is under way to support all feature types and therefore allow integration of any gridded, point, timeseries, swath or radial NetCDF (or readable) file into the WCT.

3. SERVICES

Remote data services are supported, providing access to data available through web services. Current data services include the NIDIS U.S. Drought Monitor [3] (Figure 1).

Development is under way for the addition of access to the NOAA Severe Weather Data Inventory, NEXRAD Mosaic archive, the National Operational Model Archive and Distribution System (NOMADS), NCDC Climate Data Online and multi-sensor precipitation totals [2, 5].

4. VISUALIZATION

Simple 2D visualization is provided for all supported datasets. The WCT includes pre-packaged data for common map layers including states, counties and cities (Figure 2, 3, 4, 5 and 6). Custom data may be added using any NAD83/WGS84 Shapefile. Background maps can be added using Web Map Services (WMS) (Figure 7). Predefined WMS background maps for USGS topographical maps, aerial photography, Landsat, land cover and shaded relief are included. The North American Datum 1983 (NAD83) lat/long grid is used as the basis for all visualizations. This allows greater

interoperability with the Web Map Services. Datasets are remapped for each view extent using a nearest neighbor resampling method if needed. Basic filtering and smoothing functionality is provided.

Users may save images to common file formats (such as JPEG, GIF, PNG). KMZ file export allows visualization in Google Earth or other virtual globe software (Figure 8). Animations are supported with output in Animated GIF and AVI formats in addition to KMZ [Appendix B].

Three-dimensional rendering of Radar data is supported using the COLLADA modeling syntax in conjunction with KMZ output in Google Earth (Figure 9) [Appendix B]. The rendered data image is draped on a COLLADA model which represents the surface of the selected beam elevation angle. Isosurface generation is also supported. A series of constant altitude slices are derived to create a lat/lon/height data cube. Isosurfaces are created from this data cube and are visualized as polygon or line KMZ output in Google Earth (Figure 10).

An internal instance of Google Earth provides an integrated viewing experience linked directly to the standard 2-D map (Figure 11). The Google Earth instance is updated following each zoom and pan of the 2-D map.

5. EXPORT

The WCT supports the export of data to several common scientific formats. Spatial and attribute filtering is provided (Figures 12, 13), allowing users to extract subsets of the original data. Currently supported export formats include [Appendix B]:

- Point & Polygon Shapefile
- Point & Polygon Well-Known Text
- Raw NetCDF (native data structure)
- Gridded NetCDF (remapped if needed)
- Arc/Info ASCII Grid
- GeoTIFF

These export formats are readable by many software packages including Geographic Information System (GIS) applications, mathematical and statistical analysis software, engineering software and meteorological analysis tools.

Command-line batch processing is supported for all data export capabilities.

6. CONCLUSION

The Weather and Climate Toolkit (WCT) provides easier access to NOAA weather and climate datasets. As free, platform independent, standalone software, the WCT reaches a large audience of diverse users. By providing visualization and export capabilities, users are able to easily integrate the data into their own applications. The WCT is built upon scalable, open source and community-driven NetCDF software which allows for flexible future development. These benefits to many user communities exemplify the overall NOAA mission.

7. REFERENCES

1. Ansari, S., and S.A. Del Greco, 2005: GIS Tools for visualization and analysis of NEXRAD Radar (WSR-88D) Archived Data at the National Climatic Data Center. *85th AMS Annual Meeting, combined preprints CD-ROM, 9-13 January 2005, San Diego CA, 21st Conference IIPS [International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology]*, American Meteorological Society, Boston, Mass., File J9.6, 9 pp. (January 2005).

2. Ansari, S., and S.A. Del Greco, M. Phillips, 2008: A geospatial database and climatology for severe weather data. *88th AMS Annual Meeting, combined preprints CD-ROM, 21-25 January 2008, New Orleans LA, 24th Conference IIPS [International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology]*, American Meteorological Society, Boston, Mass., File 5A.10, (January 2008).

3. Drought Monitor Website: http://drought.unl.edu/dm/monitor.html

4. NetCDF for Java API Website: http://www.unidata.ucar.edu/software/netcdf-java/

5. NOMADS Website: http://nomads.ncdc.noaa.gov

6. Unidata Common Data Model tutorial: http://www.unidata.ucar.edu/software/netcdf/workshops/2008/njcdm/index.html

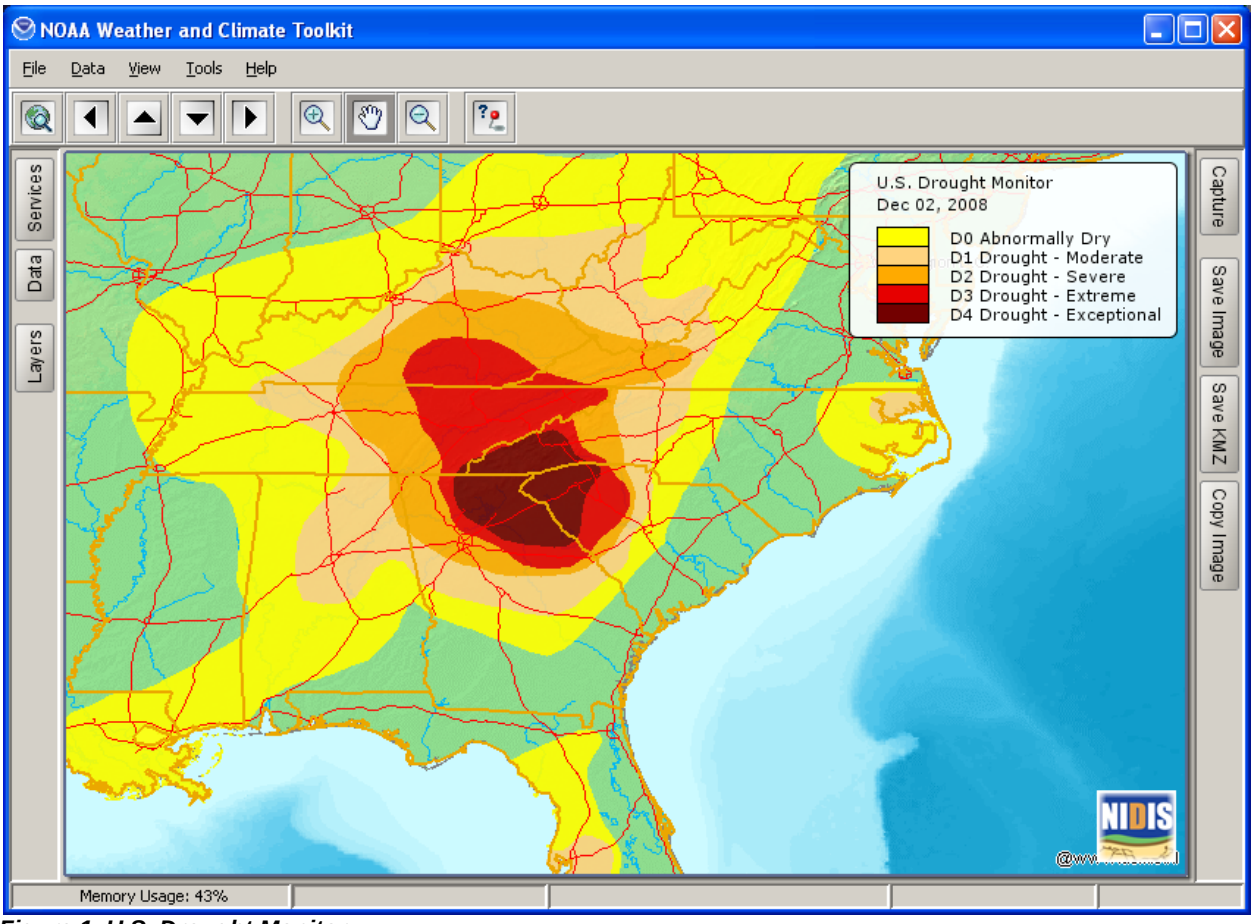

Figure 1. U.S. Drought Monitor

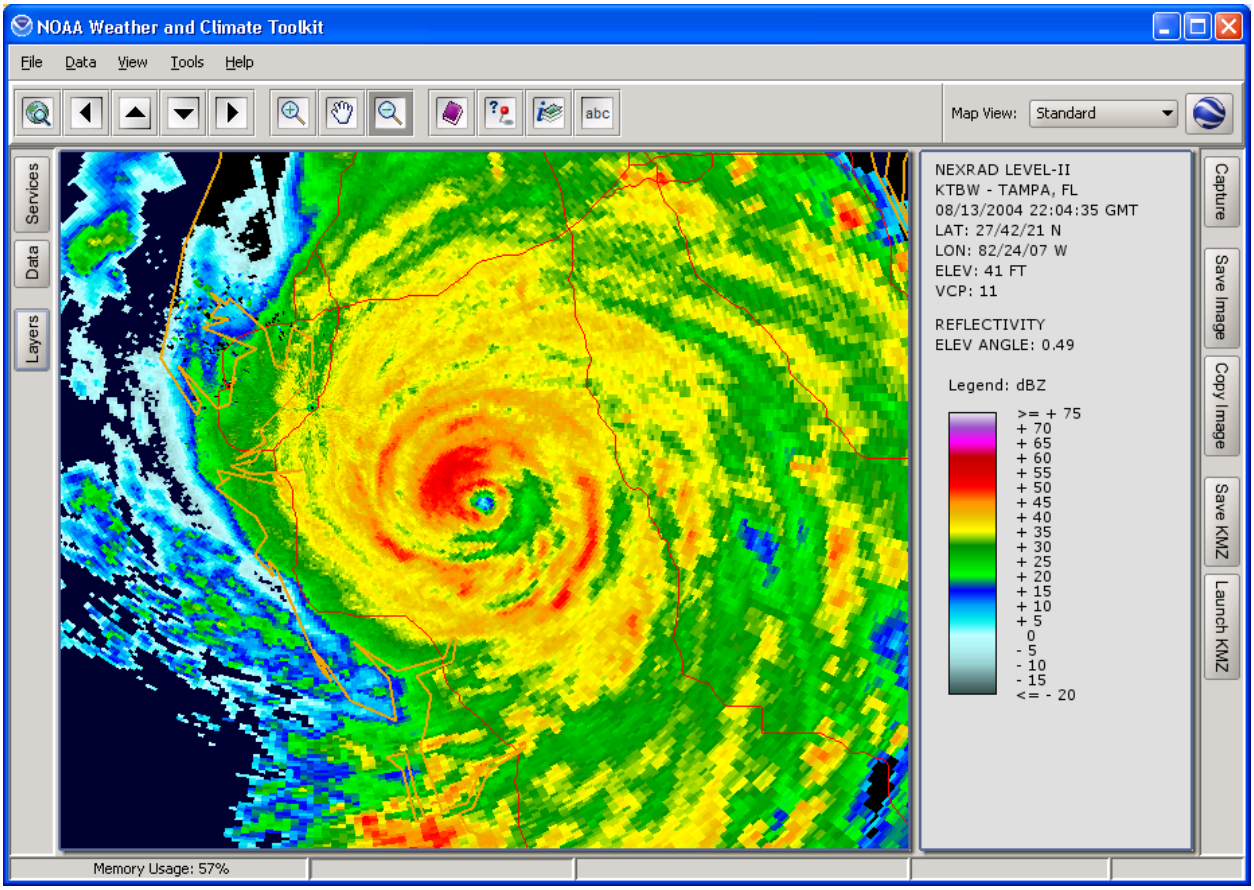

Figure 2. NEXRAD Reflectivity Data

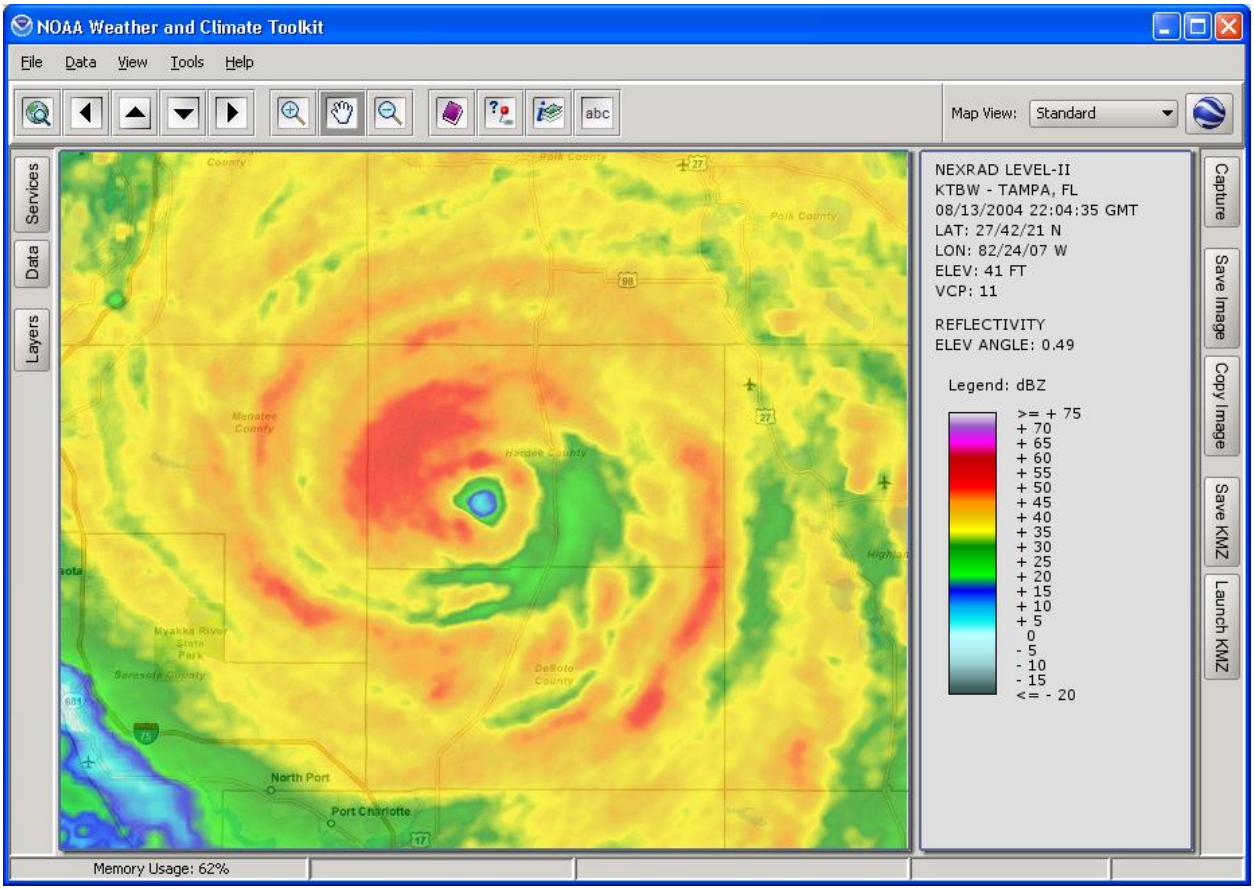

Figure 3. Smoothed NEXRAD Reflectivity Data

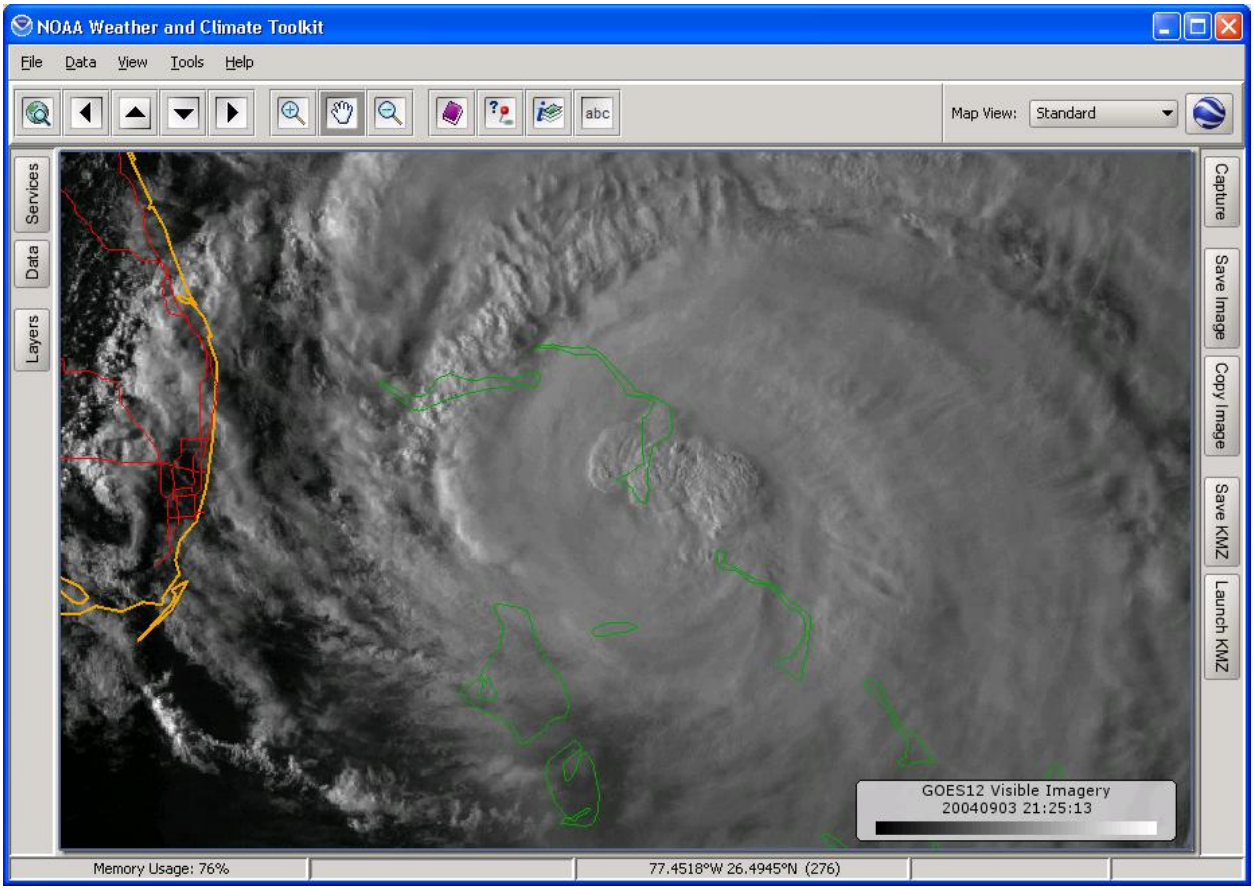

Figure 4. GOES Visible Channel

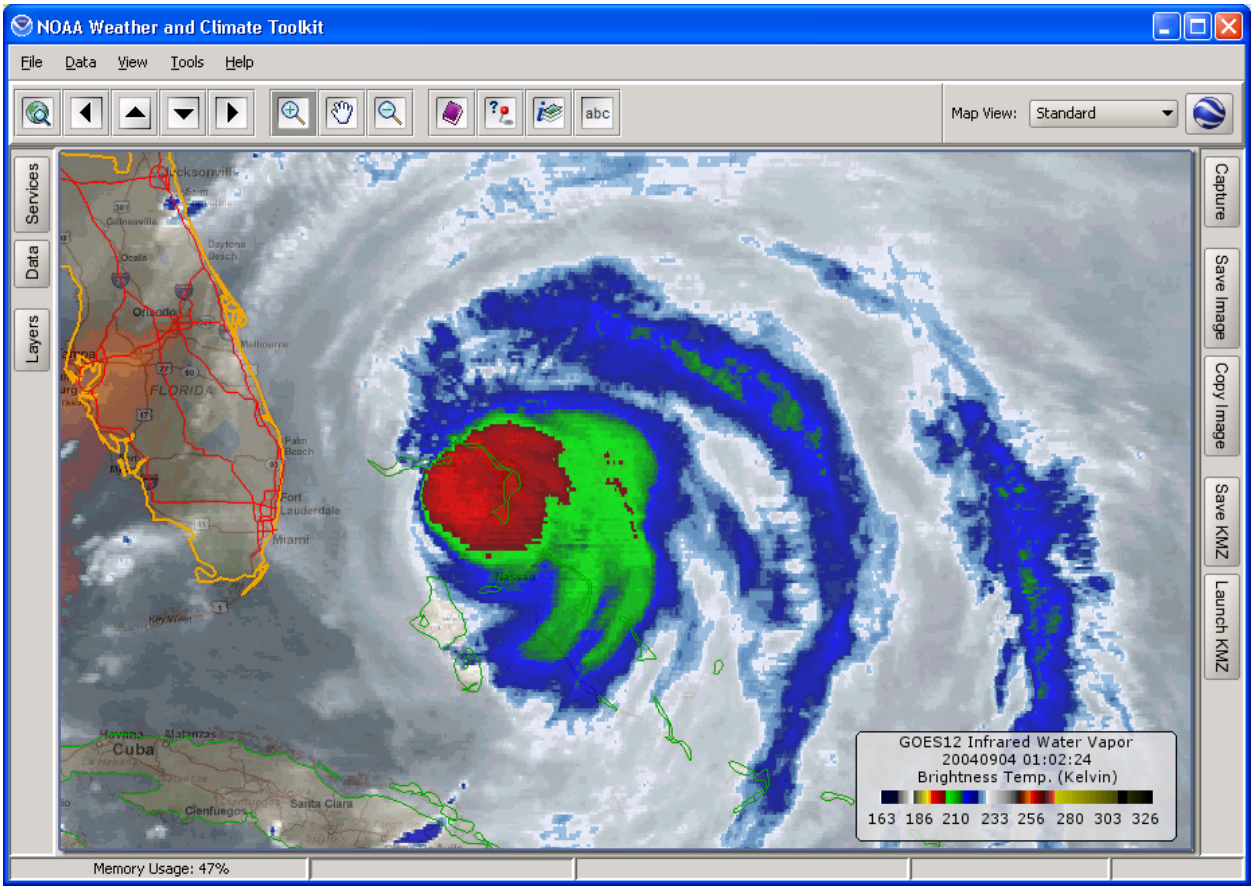

Figure 5. GOES Water Vapor

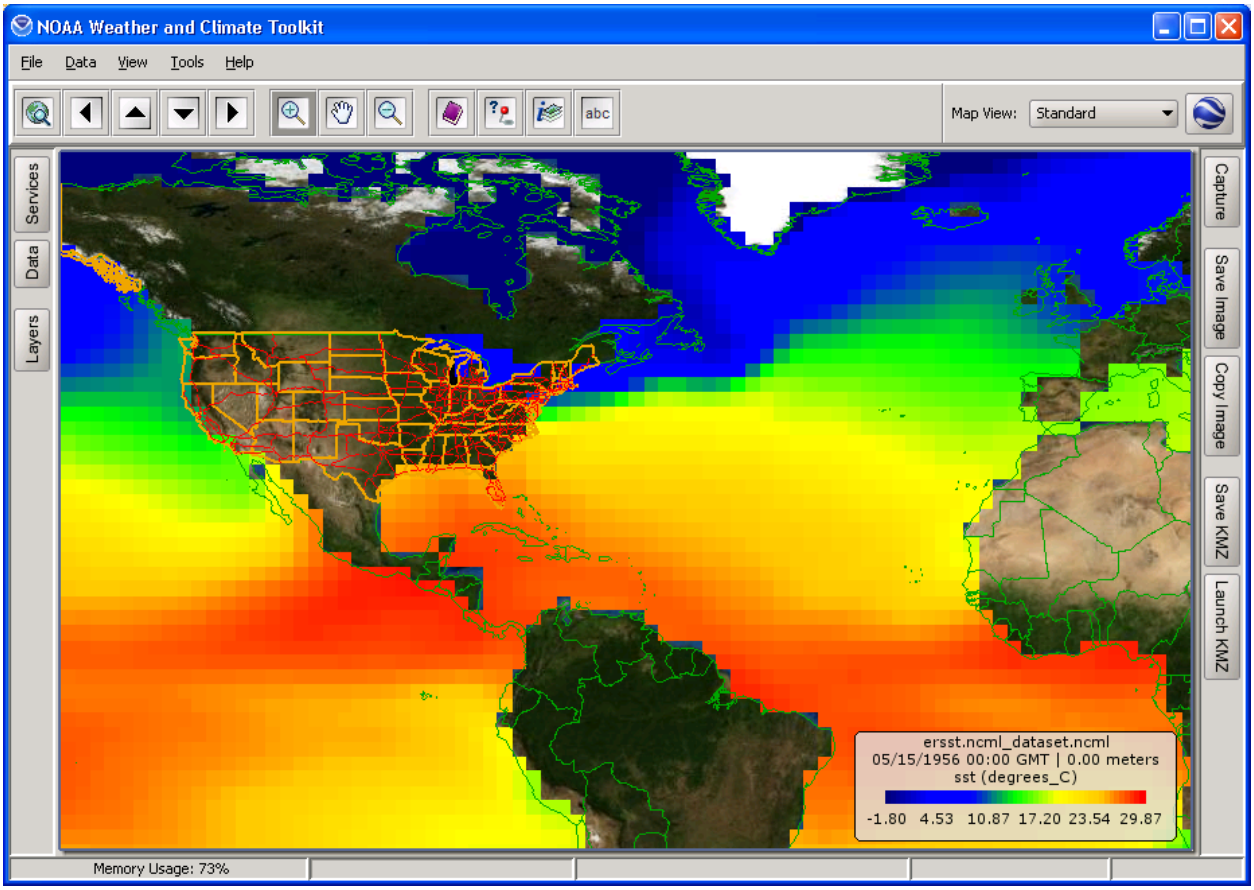

Figure 6. Sea Surface Temperature NetCDF / OPeNDAP

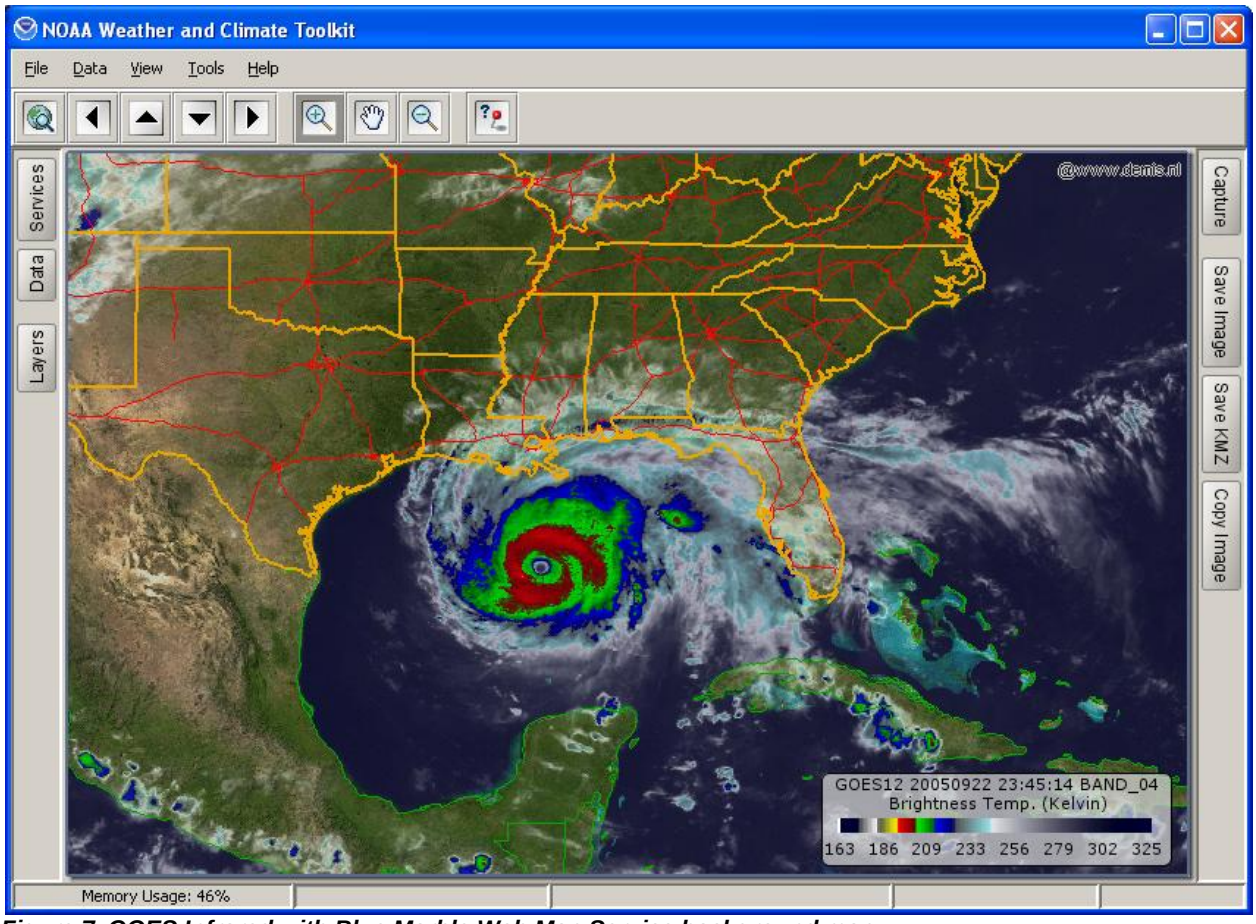

Figure 7. GOES Infrared with Blue Marble Web Map Service background map

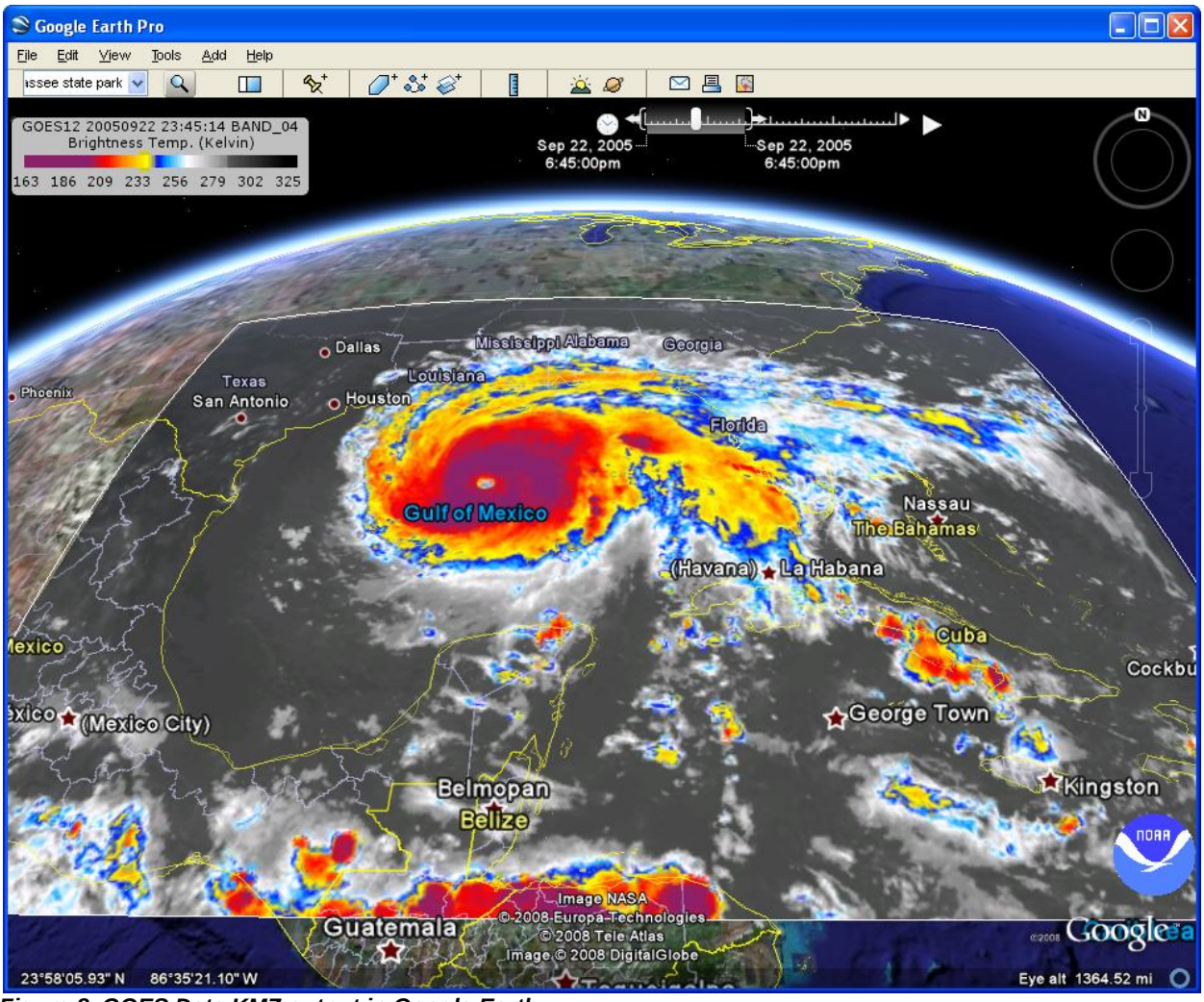

Figure 8. GOES Data KMZ output in Google Earth

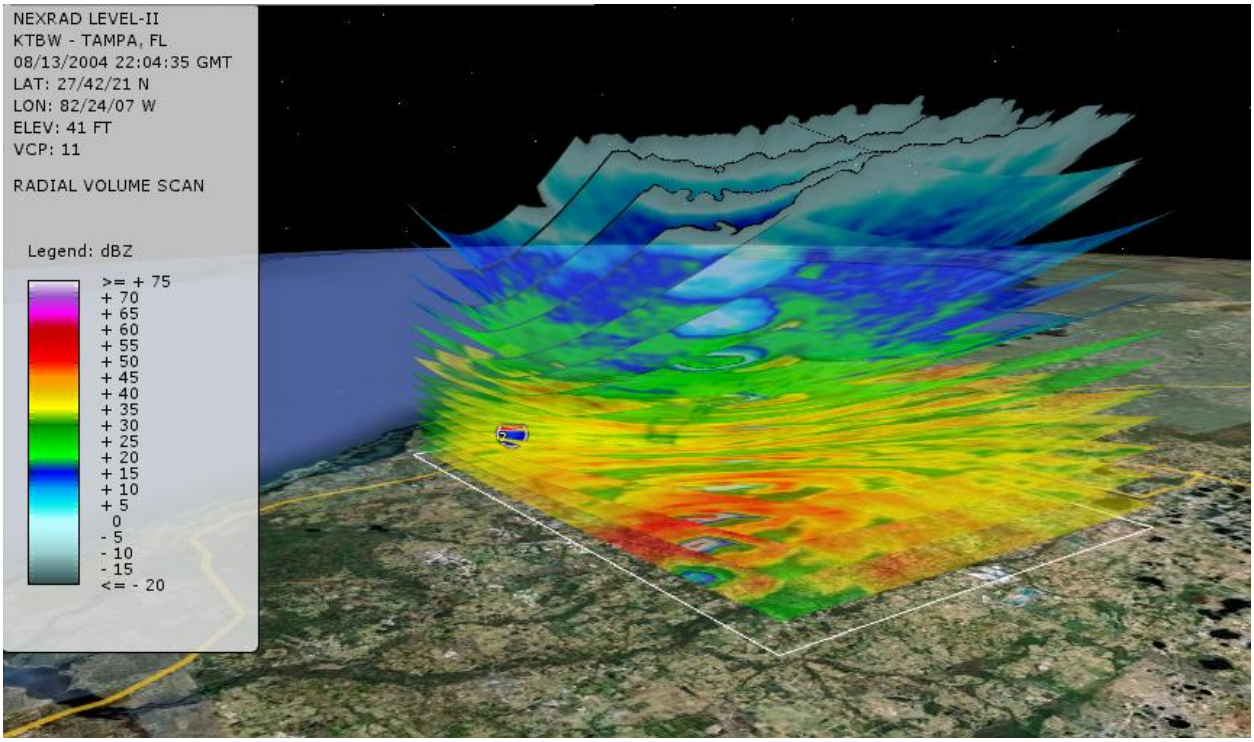

Figure 9. NEXRAD Radar data rendered in 3-D in Google Earth

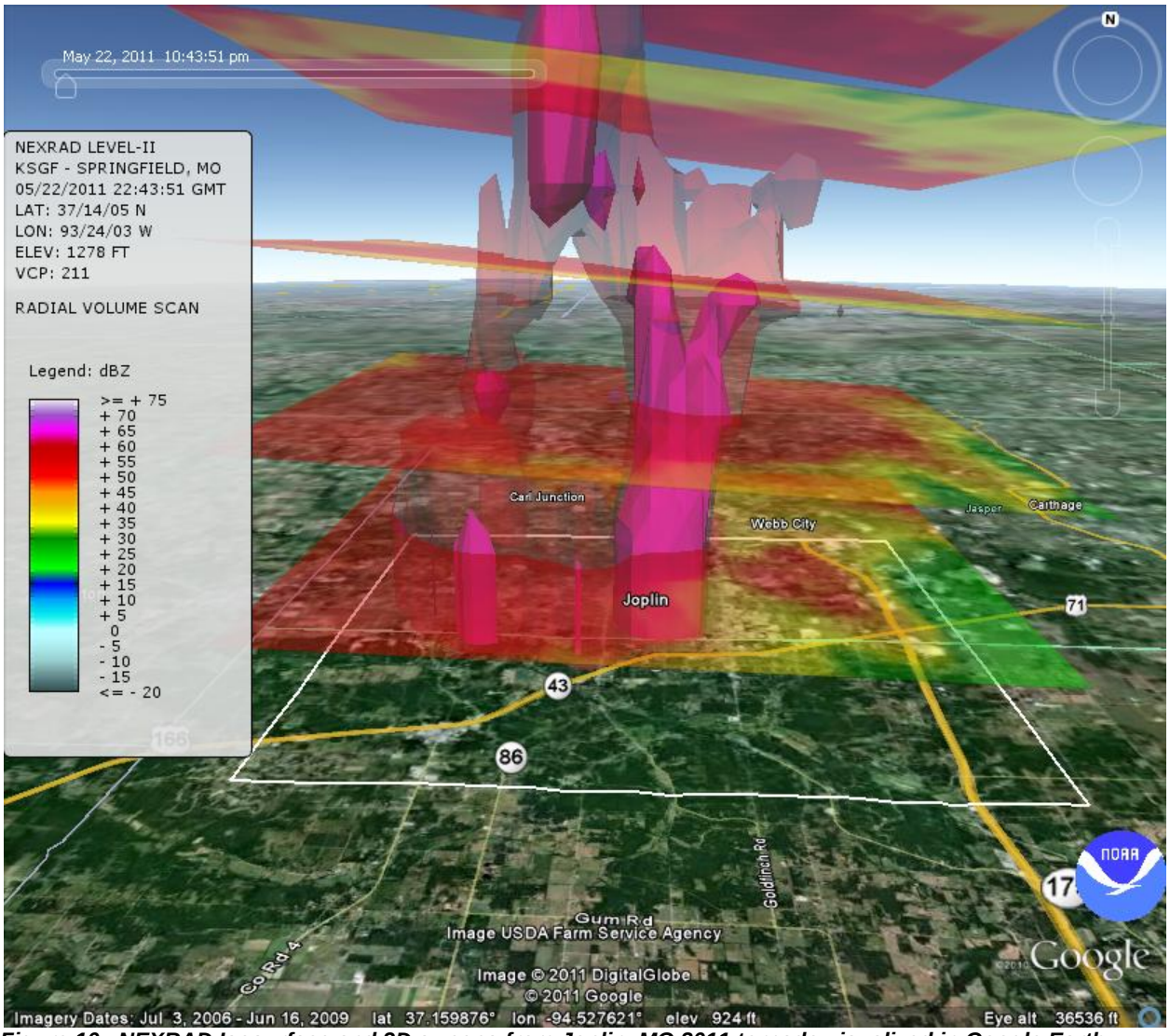

Figure 10. NEXRAD Isosurface and 3D sweeps from Joplin, MO 2011 tornado visualized in Google Earth

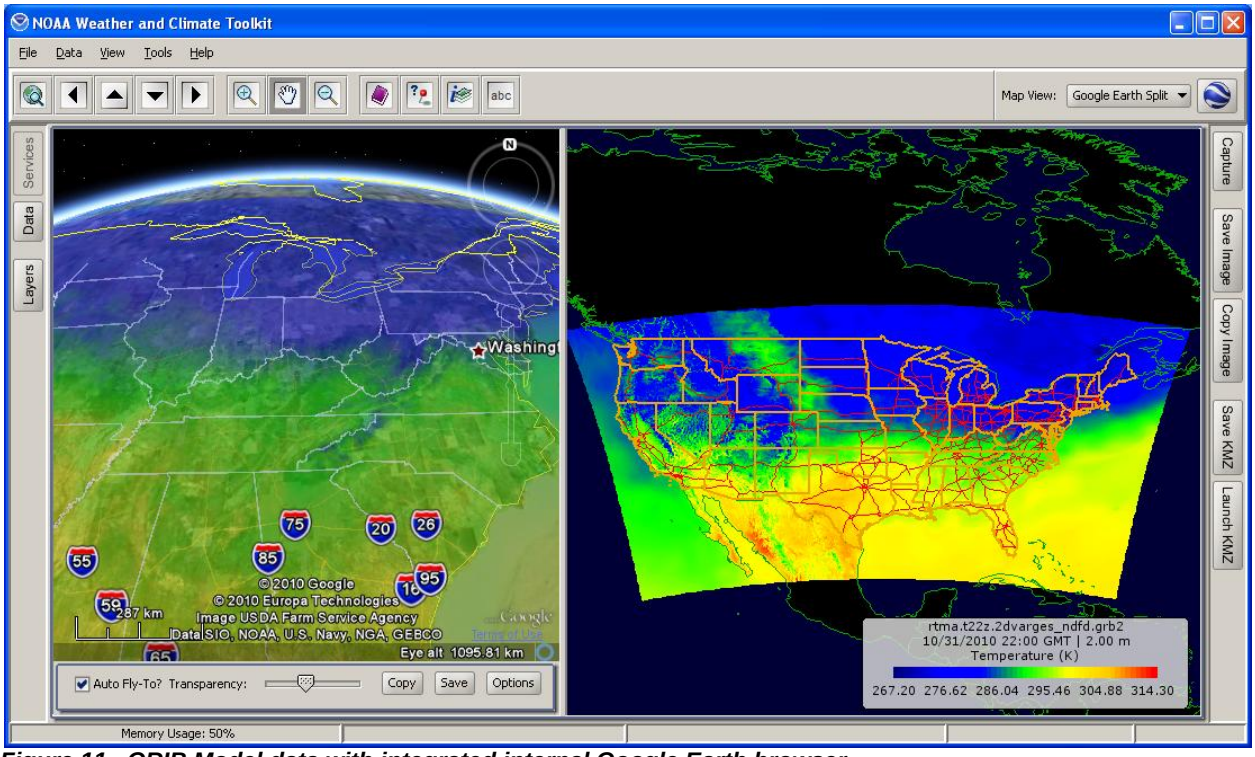

Figure 11. GRIB Model data with integrated internal Google Earth browser

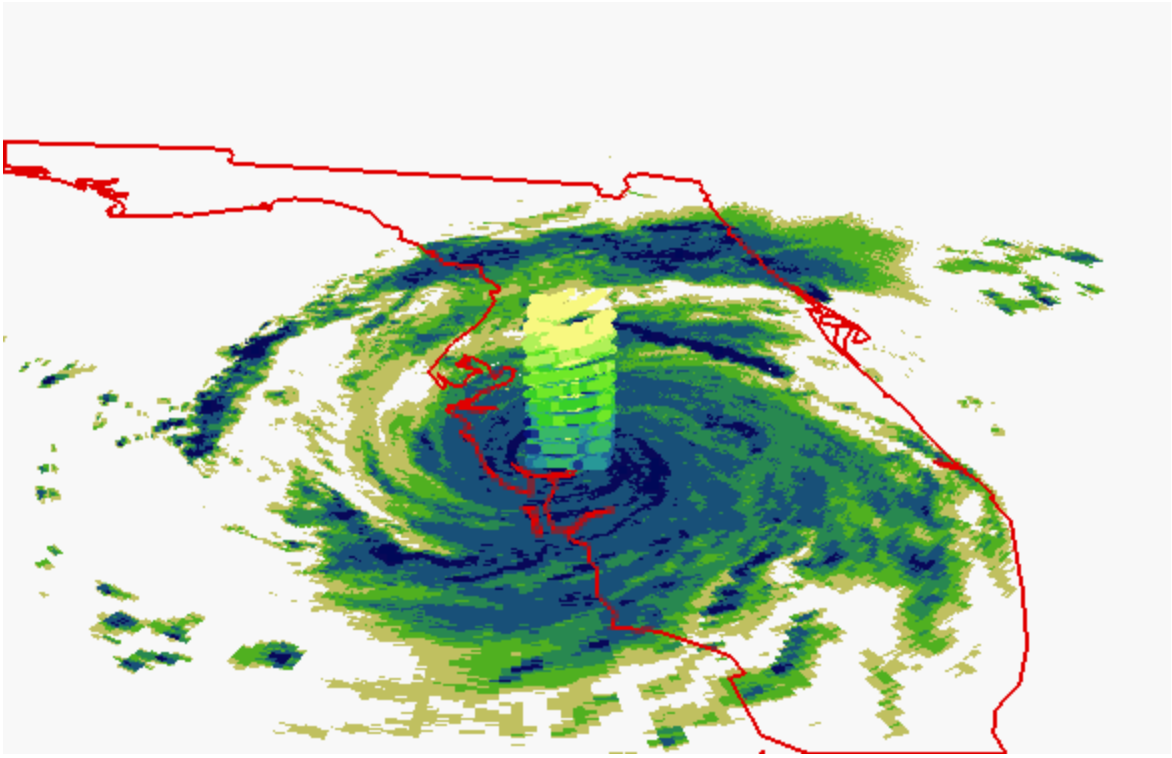

Figure 12. NEXRAD Level-II Shapefile (point and polygon) export in ArcGIS

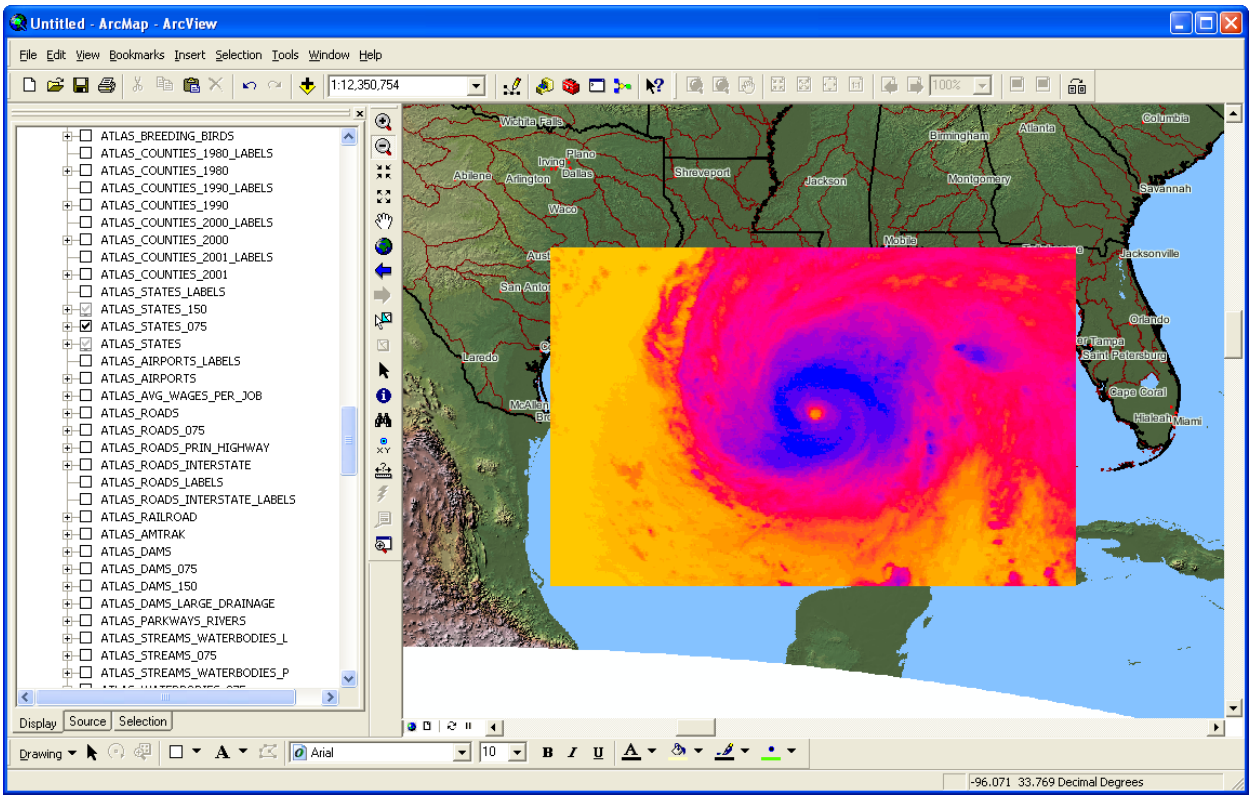

Figure 13. Spatial Subset of GOES Infrared Data in ArcGIS

APPENDIX A

1. GINI: The file format and data structure used for Satellite Data in the Advanced Weather Interactive Processing System (AWIPS). For more information: http://wxp.unisys.com/Appendices/Formats/GINI.html

2. GRIB: "The World Meteorological Organization (WMO) Commission for Basic Systems (CBS) Extraordinary Meeting Number VIII (1985) approved a general purpose, bit-oriented data exchange format, designated FM 92-VIII Ext. GRIB (GRIdded Binary). It is an efficient vehicle for transmitting large volumes of gridded data to automated centers over high-speed telecommunication lines using modern protocols. By packing information into the GRIB code, messages (or records - the terms are synonymous in this context) can be made more compact than character oriented bulletins, which will produce faster computer-to-computer transmissions. GRIB can equally well serve as a data storage format, generating the same efficiencies relative to information storage and retrieval devices." For more information: http://www.wmo.int/pages/prog/www/WDM/Guides/Guide-binary-2.html

3. HDF (Hierarchical Data Format): "At its lowest level, HDF is a physical file format for storing scientific data. At its highest level, HDF is a collection of utilities and applications for manipulating, viewing, and analyzing data in HDF files. Between these levels, HDF is a software library that provides high-level APIs and a low-level data interface." For more information: http://www.hdfgroup.org/

4. McIDAS (Man-Computer Interactive Data Access System) Area file description: "In McIDAS, satellite imagery data and supplemental information are stored on disk in data structures called areas. Each area is a binary file containing all the information necessary to display and navigate the image. Complete images are often too large to be stored completely in an area file. An area may be a geographic portion of the image or a subset produced by sampling or averaging the image data. Any point in the area can be described with image coordinates, its position in the full satellite image, or with area coordinates, its position in the area or subset of the image" For more information: http://www.ssec.wisc.edu/mcidas/doc/misc_doc/area2.html

5. NetCDF (network Common Data Form): “NetCDF (network Common Data Form) is an interface for array-oriented data access and a freely-distributed collection of software libraries for C, Fortran, C++, Java, and perl that provide implementations of the interface. The netCDF software was developed by Glenn Davis, Russ Rew, Steve Emmerson, John Caron, and Harvey Davies at the Unidata Program Center in Boulder, Colorado, and augmented by contributions from other netCDF users. The netCDF libraries define a machine-independent format for representing scientific data. Together, the interface, libraries, and format support the creation, access, and sharing of scientific data.” For more information: http://www.unidata.ucar.edu/software/netcdf/

6. Unidata Common Data Model (CDM): “Unidata’s Common Data Model (CDM) is an abstract data model for scientific datasets. It merges the netCDF, OPeNDAP, and HDF5 data models to create a common API for many types of scientific data. The NetCDF Java library is an implementation of the CDM which can read many file formats besides netCDF. We call these CDM files, a shorthand for files that can be read by the NetCDF Java library and accessed through the CDM data model.” For more information: http://www.unidata.ucar.edu/software/netcdf-java/CDM/

APPENDIX B

1. ASCII GRID: “ARC ASCIIGRID refers to a specific interchange format developed for ARC/INFO rasters in ASCII format. The format consists of a header that specifies the geographic domain and resolution, followed by the actual grid cell values. Usually the file extension is .asc, but recent versions of ESRI software also recognize the extension .grd.” For more information:
http://docs.codehaus.org/display/GEOTOOLS/ArcInfo+ASCII+Grid+format#ASCIIGrid

2. COLLADA: “COLLADA is a COLLAborative Design Activity for establishing an open standard digital asset schema for interactive 3D applications. It involves designers, developers, and interested parties from within Sony Computer Entertainment America (SCEA) as well as key third-party companies in the 3-D industry. With its 1.4.0 release, COLLADA became a standard of The Khronos Group Inc., where consortium members continue to promote COLLADA to be the centerpiece of digital-asset toolchains used by the 3-D interactive industry.” For more information: https://collada.org/mediawiki/index.php/COLLADA

3. ESRI Shapefile: “A shapefile stores nontopological geometry and attribute information for the spatial features in a data set. The geometry for a feature is stored as a shape comprising a set of vector coordinates.” For more information: http://www.esri.com

4. GeoTIFF: “GeoTIFF represents an effort by over 160 different remote sensing, GIS, cartographic, and surveying related companies and organizations to establish a TIFF based interchange format for georeferenced raster imagery.” For more information: http://trac.osgeo.org/geotiff/

5. Well-Known Text (WKT): An ASCII text representation of geometry data. Defined in the OpenGIS Consortium “Simple Features for SQL” specification. For more information:
http://dev.mysql.com/doc/mysql/en/GIS_WKT_format.html or
http://publib.boulder.ibm.com/infocenter/db2help/index.jsp?topic=/com.ibm.db2.udb.doc/opt/rsbp4120.htm