2B.6 RADAR VISUALIZATION AND DATA EXPORTER TOOLS TO SUPPORT INTEROPERABILITY AND THE GLOBAL EARTH OBSERVATION SYSTEM OF SYSTEMS (GEOSS), FROM THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION'S (NOAA'S) NATIONAL CLIMATIC DATA CENTER (NCDC)

Stephen Del Greco * and Steven Ansari
NOAA National Climatic Data Center, Asheville, North Carolina

1. INTRODUCTION

In February 2005, 61 countries around the World agreed on a 10 year plan to work towards building open systems for sharing geospatial data and services across different platforms worldwide. This system is known as the Global Earth Observation System of Systems (GEOSS). The objective of GEOSS focuses on easy access to environmental data and interoperability across different systems allowing participating countries to measure the "pulse" of the planet in an effort to advance society. (GEOSS website, 2005)

In support of GEOSS goals, NOAA's National Climatic Data Center (NCDC) has developed radar visualization and data exporter tools in an open system environment. The NCDC Interactive Radar Viewer and Data Exporter load Weather Surveillance Radar 1988 Doppler (WSR-88D) volume scan (S-band) data, known as Level-II, and derived products, known as Level-III, into an OPEN GIS-compliant environment. The application is launched via Java Web Start and runs on the client machine while accessing these data remotely from the NCDC archive or in near real time from other NOAA servers. The Radar Interactive Viewer provides tools for custom data overlays, animations and basic queries. The export of images and movies is provided in multiple formats that support the "blending" of radar data with other types of data.

The Data Exporter allows for data export in both vector polygon (Shapefile, Well-Known Text) and raster (GeoTIFF, ESRI Grid, VTK, NetCDF, GrADS) formats (Del Greco and Ansari, 2005).

The NCDC recently partnered with NOAA's National Severe Storms Lab to decode Sigmet C-band Doppler radar data providing the NCDC Viewer/Data Exporter the functionality to read C-Band. This also supports a bilateral agreement between the United States and Canada for data sharing and to support interoperability with the US WSR-88D and Environment Canada radar networks. In addition, the NCDC partnered with the University of Oklahoma to develop decoders to read a test bed of distributed X- band radars that are funded through the Collaborative Adaptive Sensing of the Atmosphere (CASA) project.

* *Corresponding author address:* Stephen Del Greco, NOAA National Climatic Data Center, 151 Patton Avenue, Asheville, NC 28801; e-mail: Stephen.A.Delgreco@noaa.gov.

By acquiring the capability to read various radar volume scan formats (S-band, C-band and X-band) and exporting these data into common data formats such as Shapefile for GIS, the NCDC Radar Viewer and Data Exporter is compliant with the Open Geospatial Consortium (OGC) and a common data model environment that directly supports GEOSS.

This paper describes in further detail the NCDC Radar Visualization and Data Exporter Tools, and the NCDC hopes to establish collaboration with scientists participating in GEOSS to leverage these tools for interoperable use with other global radar networks.

2. BACKGROUND

The NCDC's objective to provide reliable access to all WSR-88D (known as NEXRAD) data was achieved in part, through a modular approach. First, the NCDC required reliable access to all radar data for archiving; second, the NCDC needed to develop a process to disseminate these data and information to the general public in a reasonable manner; and third, it was necessary to build tools that the general public can use to visualize and display these data (Del Greco, 2003). The direct transfer of NEXRAD data to the NCDC archive, along with implementation of software for user data retrieval via the web, has dramatically reduced the time required to disseminate the data. With NEXRAD data acquisition and dissemination processes achieved, the next step in the NCDC's radar program called for building appropriate GIS visualization and data exporter tools.

3. NCDC NEXRAD SERVICES AND ARCHIVES

The NCDC ingests and archives NEXRAD data and products on a daily basis in near real time (~10 second latency). The archives contain data from 159 sites in the continental U.S., Alaska, Hawaii, Puerto Rico, Guam, and South Korea. The NEXRAD level II volume scan data include three moments: reflectivity, spectral width and mean radial velocity. The archives include 1.5 Petabytes (period of record 1991-present) of level II data, which increases at 252 Gigabytes/Day (~92TB per year). The Level III derived products (approximately 36 products) comprises 25 terabytes (period of record 1991-present) and increases at 4 Gigabytes/Day (~ 1.5 TB per year).

Over the next several years the implementation of dual polarization radar technology and the inclusion

of higher resolution reflectivity products are expected to increase the NCDC archives by 6.4 terabytes a day (12.8 terabyte/day with backup). NOAA long-term plans include moving towards phased array radar technology by 2020 potentially increasing data flow to 32 terabytes a day by 2020, (64 terabyte/day with back up).

These data are in high demand globally by both the public and private sectors. NEXRAD data are available at no cost via direct web access on the NCDC radar resources web page. Go to URL: http://www.ncdc.noaa.gov/oa/radar/radarresources.html for NCDC radar services information. The online inventory can be accessed at URL: http://www.ncdc.noaa.gov/nexradinv/ (See Figure 1). As much as one terabyte of data have been accessed monthly through the NCDC radar resources web page.

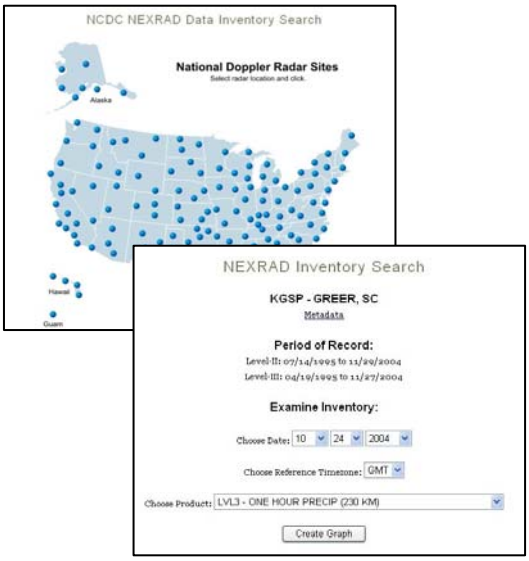

Figure 1. NEXRAD web page inventory

4. VISUALIZATION AND INTEROPERABILITY

The NCDC NEXRAD archive data are in a unique binary format. By decoding the data into OGC-defined vector features and raster grid coverage's, the data become accessible to any OGC compliant Application Programming Interface (API). Maintaining NEXRAD data in multiple common scientific formats promotes interdisciplinary use of NEXRAD data and supports fundamental GEOSS principles.

The NOAA NCDC Weather Radar Viewer and Data Exporter project consists of two programs and an open source Application Program Interface (API). All software is available free of charge from NCDC and is written entirely in the Java programming language. The Radar Data Viewer and Exporter are launched via Java Web Start. For instructions for using the Radar Data Viewer and Exporter go to the NCDC Radar Resources web page at the following URL: http://www.ncdc.noaa.gov/oa/radar/jnx/index.html and for a tutorial go to URL: http://www.ncdc.noaa.gov/oa/radar/jnx/jnxv-basics.php.

The applications include the Weather Radar Viewer, a visual browser for the data, the Weather Radar Data Exporter, and the Data Export Utility. The entire software package will run on any Java-supported platform including Windows, Macintosh and Linux. The visualization and data export software supports both the historical NEXRAD data at the NCDC and real-time NEXRAD data distributed by the National Weather Service (NWS).

Samples of several display and analysis features include:
1) Saving images and animations in multiple formats (see Figures 2, 3, and 4);
2) Simple math operations, smoothing, and filtering of the data (see Figures 5 and 6);
3) Display range rings and custom markers;
4) Custom map backgrounds using client side data and/or OGC compliant Web Map Services (WMS); and
5) Blending radar data with other data.

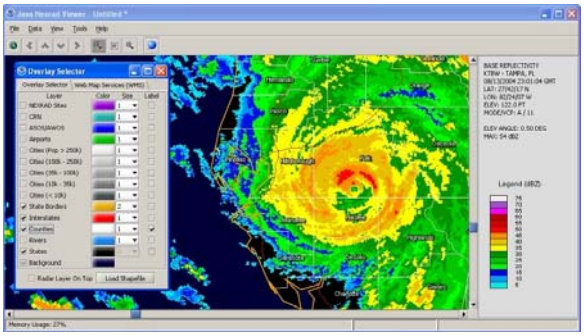

Figure 2. Screenshot of Radar Viewer with Overlay Selector

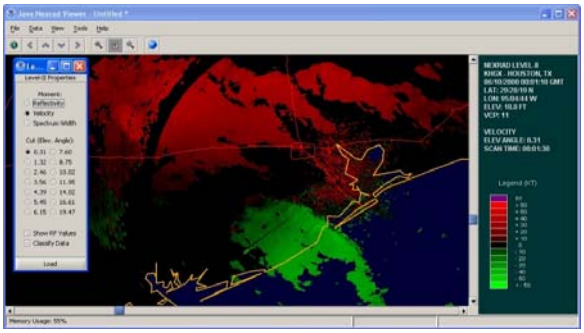

Figure 3. Screenshot of Radar Viewer with Level-II Data

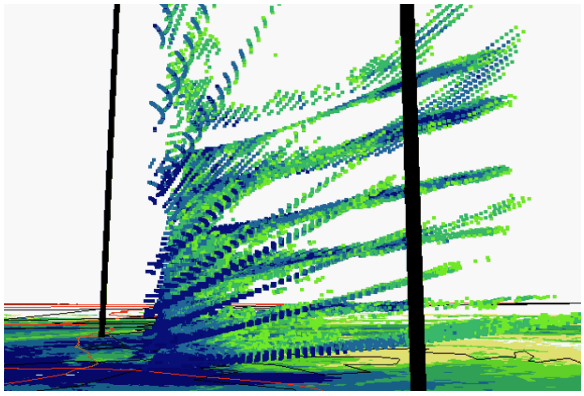

Figure 4. Hurricane Katrina 3D Radar data exported to Shapefile displayed in ArcScene, August 29, 2005

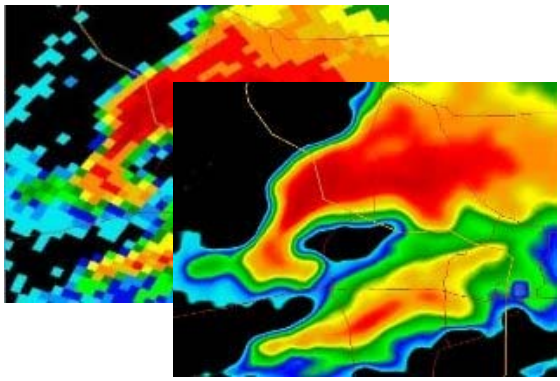

Figure 5. Radar viewer smoothing tool

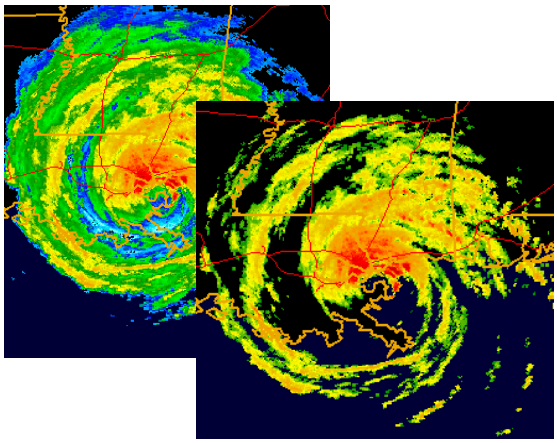

Figure 6. Radar viewer filtering tool

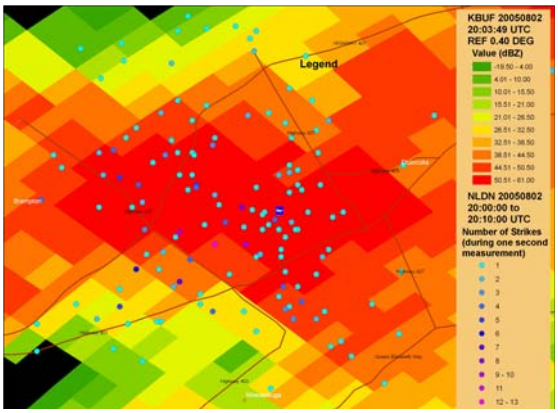

Figure 7. Radar data and lightning data exported to SHP file and displayed in ESRI GIS software for Toronto A.P. August 2, 2005 event

The Radar Data Exporter analysis features include:
1) Export data to Shapefile (see Figures 4 and 7), GML and Well Known Text (WKT) vector formats and GeoTIFF, VTK (Figure 8), NetCDF, ARC/INFO ASCII Grid, GrADS binary and simple binary raster formats. (See Appendix A);
2) User-selectable raster resolution, 3) Polygon reduction of vector data. (This significantly reduces the size of the output vector file);
4) Database support for PostGIS, ArcSDE and Oracle Spatial; and
5) Simple math operations and filtering of the data.

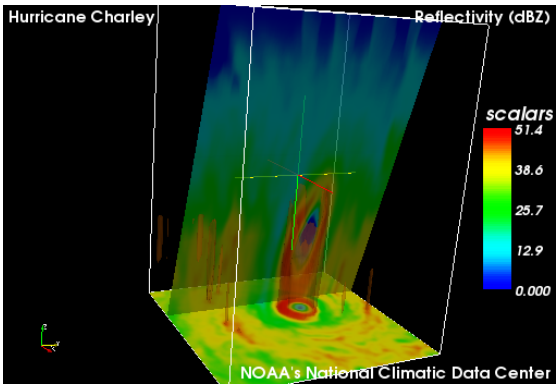

Figure 8. VTK multimedia screenshot using ParaView software displaying data exported using Radar Data Exporter tool

5. BATCH PROCESSING AND ADDITIONAL FEATURES

The radar viewer and data exporter has undergone several software revisions initiated by user feedback. For example, users were interested in a batch processing capability. Recently an XML-based batch processing feature, which allows for command-line image generation and derived product data export was introduced. See URL

http://www.ncdc.noaa.gov/oa/radar/jnx/batch.html. Additional features are scheduled to be added with the next revision. These include developing applications to build and export radar products using the latest web technology (SOA, SOAP, Web Services, etc.). Emphasis will be placed on interoperability, Open Geospatial Consortium (OGC) compliance and geophysical community-based formats such as NetCDF, that support the Common Data Model (CDM) and are portable to GEOSS.

6. REFERENCES

Del Greco, S.A., 2003: A History for WSR-88D Level II Data Services at the National Climatic Data Center, Preprints, *31ST International Conference on Radar Meteorology,* 6-12 August, Seattle, Washington, Amer. Meteor. Soc., 902-906.

Del Greco, S.A., S. Ansari, 2005: GIS Tools for visualization and analysis of NEXRAD radar (WSR-88D) archived data at the National Climatic Data Center. Preprints, *21st Int. Conf. on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology*, 9-14 January, San Diego, CA, Amer. Meteor. Soc., J9.6.

GEOSS website:
http://www.epa.gov/geoss/index.html

APPENDIX A

1. ESRI Shapefile: For information:
http://www.esri.com

2. Geography Markup Language (GML): For information: http://www.opengis.net/gml/

3. Well-Known Text (WKT): For information:
http://dev.mysql.com/doc/mysql/en/GIS_WKT_format.html

4.GeoTIFF: For information:
http://www.remotesensing.org/geotiff/geotiff.html

5. ARC/INFO ASCII Grid: For more information:
http://www.geotools.org/ArcInfo+ASCII+Grid+format

6. The Visualization ToolKit (VTK) For information:
http://public.kitware.com/VTK/what-is-vtk.php

7. NetCDF (network Common Data Form): For information:
http://my.unidata.ucar.edu/content/software/netcdf/index.html

8. GrADS (Grid Analysis and Display System) Binary: For information: http://grads.iges.org/grads/grads.html

9. Simple Binary: Floating point binary grid file with ARC/INFO header file containing grid specifications.

10. ParaView: For information:
http://www.paraview.org

11. Open Geospatial Consortium (OGC): For information: http://www.opengeospatial.org/