

## 2013 UPDATE ON ACCESS TO REAL-TIME AND ARCHIVE NOAA WEATHER RADAR DATA

Tim Crum, Donald J. Horvat, and Christina A. Horvat  
WSR-88D Radar Operations Center, Norman, OK

Michael Istok  
NOAA's NWS Office of Science & Technology  
Silver Spring, MD

Stephen DelGreco and Steve Ansari  
NOAA's NESDIS National Climatic Data Center  
Asheville, NC

### 1. INTRODUCTION

NOAA's National Weather Service (NWS) electronically collects Weather Surveillance Radar-1988, Doppler (WSR-88D) Level 2 data. As of January 2013, the WSR-88D sites on the NWS Level 2 Data Collection and Distribution Network include all 122 NWS WSR-88Ds, plus 13 DOD and 5 FAA WSR-88Ds (140 radars total). Additionally, these data are archived.

The NWS's National Centers for Environmental Prediction (NCEP) has a requirement for real-time Level II data for assimilation into numerical forecast models, currently the Rapid Refresh (RAP) model. The concept of real-time network transmission of Level 2 data was proven in a collaborative effort (Collaborative Radar Acquisition Field Test project - CRAFT). (Kelleher et al. 2007) The use and importance of Level 2 data has grown, plus methods for data transport, low latency, and storage have evolved. (Horvat et al. 2011; Kelleher et al. 2007)

The NWS has a requirement to archive WSR-88D Level II data for post-event analysis, algorithm development, algorithm tuning, data quality studies, etc. These data along with WSR-88D Level 3 and TDWR-SPG (Terminal Doppler Weather Radar - Supplemental Product Generator) products are openly available to all users from NOAA's National Climatic Data Center (NCDC).

This paper provides updates on:

- The continued evolution of the real-time NWS Level 2 Data Collection and Distribution Network
- Potential additions to the WSR-88D Level 2 Network.
- Information on NCDC's continued work to provide enhanced WSR-88D Level 2 and Level 3 data delivery and analysis tools and plans for adding more radar data and tools for users.

### 2. REDESIGNED LEVEL 2 DATA COLLECTION NETWORK UPDATE

In 2010, the WSR-88D Radar Operations Center (ROC) completed implementing the major portion of a redesigned Level 2 network (Horvat et al. 2011). While the initial national network implementation in 2004 greatly boosted Level 2 data delivery reliability and shortened latencies, it was not able to meet the weather community's growing demand for a data delivery reliability at nearly 100% and with "small" latencies.

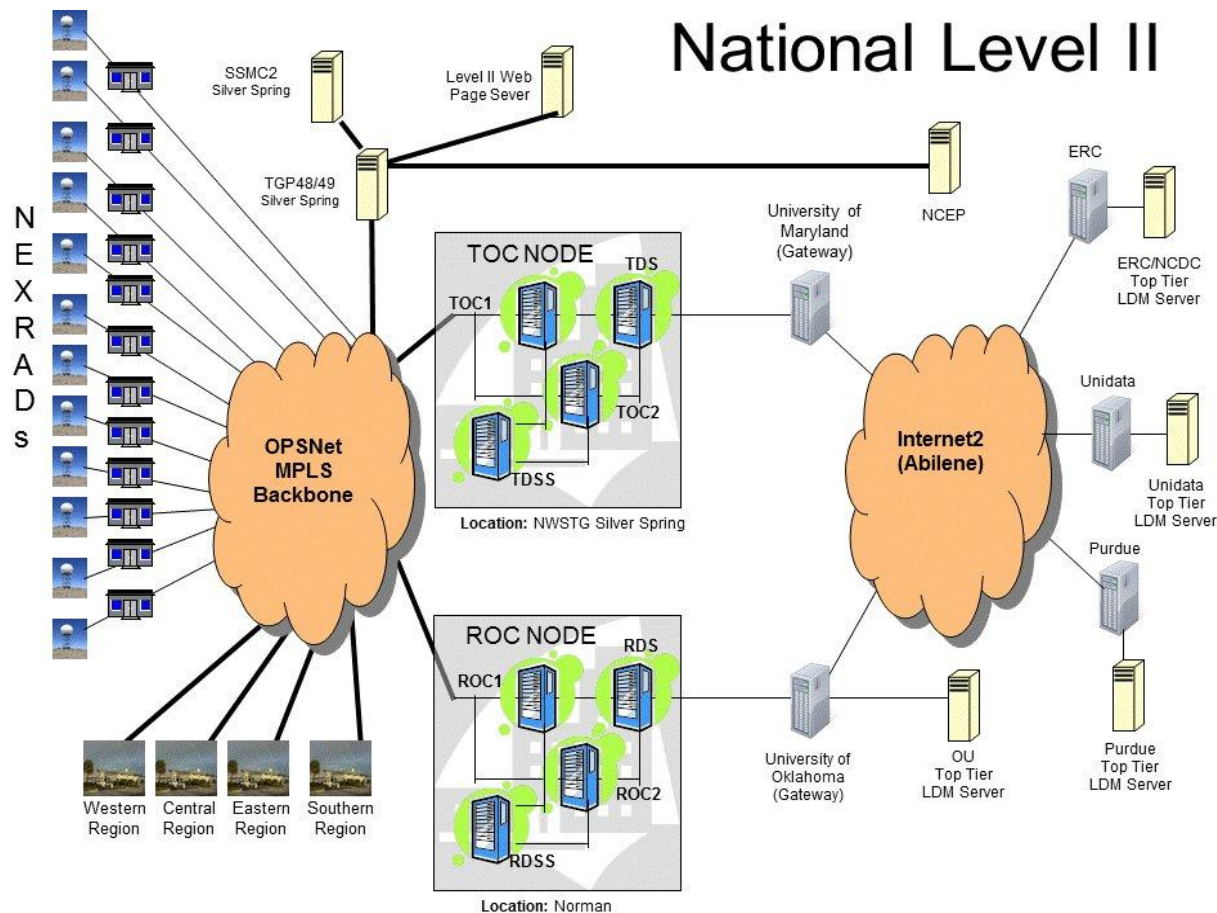
During the network redesign and hardware refresh, the ROC removed the original NWS regional headquarters server implementation. The new design placed a new high-availability, geographically-diverse cluster at the NWS's Telecommunications Gateway (NWSTG) located in Silver Spring, MD; and one at the ROC in Norman, OK. Both clusters have a "hot" back-up server, are on line 24/7, and have an auto-failover mode to further increase the reliable network-wide delivery of Level 2 data. Additionally, the NWS's Telecommunications Operations Center (TOC) provides 24/7 monitoring of the Level 2 data streams.

A second Internet2 access gateway has been implemented at the University of Oklahoma to join the Internet2 gateway at the University of Maryland MAX gigabit Point of Presence (gigaPoP). This ensures duplicate Level 2 data feeds onto Internet2 from two geographically diverse locations. The configuration (Fig. 1) supplies real-time Level 2 data to four Internet2 Top Tier sites for further distribution to a variety of users, in addition to NCEP:

- Education and Research Consortium of the Western Carolinas, Inc. (ERCWC)/Education and Research Network (ERN)/ERC Broadband (ERCB).
- Purdue University
- University of Oklahoma (OU)/ Integrated Robust Assured Data Services (IRADS)
- Unidata
- NWSTG to NCEP

---

\* Corresponding author address: Dr. Tim Crum, WSR-88D Radar Operations Center, 1200 Westheimer Drive, Norman, Oklahoma 73069; e-mail: TimD.Crum@noaa.gov.



**Fig. 1. Schematic of the refreshed NWS Level II Data Collection and Distribution Network as of January 2013.** WSR-88D Level II data flows from radar sites, left side of figure, via the OPSnet “cloud” to two national clusters/aggregation points: primary at the NWS Telecommunications Gateway (NWSTG) and backup at the WSR-88D Radar Operations Center (ROC). The NWS sends Level II data to NWS National Centers for Environmental Prediction, two separate Internet2 gigabit Point of Presence (gigaPops) for further distribution to the four Internet2 Top Tiers, and on to a wide variety of Level II users.

### 3. LEVEL 2 DATA CHANGES

Level 2 data users need to be aware of, and plan for future changes to the Level 2 data stream content, increased data rates, and required bandwidth. These improvements are scheduled to continue through 2014. Sources of the added bandwidth and estimated data rate changes follow.

#### 3.1 Level 2 Data Stream Changes

As WSR-88Ds are modified for dual polarization (ending in June 2013), three dual polarization variables are added to the legacy/single polarization three base moments in the Level 2 data stream (Crum et al. 2013). This added capability/data approximately doubles the amount of Level 2 data transmitted from the network’s radars.

In early 2014, a new, dynamic scanning method called the Supplemental Adaptive Intra-Volume Low-Level Scan

(SAILS) will be introduced in Build 14. SAILS inserts one supplemental “Split Cut” scan, normally 0.5°, into existing severe weather volume coverage patterns (VCPs) 12 and 212. This additional Split Cut scan is inserted into the “middle” of the volume scan to evenly space the time intervals between low-level data updates. SAILS, like the recently-reintroduced Automated Volume Scan Evaluation and Termination (AVSET) function, is operator-controlled and will not operate continuously. The ROC estimates the combination of SAILS and AVSET (when the operators select their use) will increase a radar’s Level2 data flow 25%, beyond that added by the dual polarization modification. More information on SAILS and AVSET is available at:

<http://www.roc.noaa.gov/WSR88D/NewRadarTechnology/NewTechDefault.aspx>

### 3.2 Additional Level 2 Sites on the Network

The NWS plans to add the eight remaining Air Force WSR-88Ds in the “lower 48” states to the Level 2 Data Collection and Distribution Network by mid-2013. Adding the seven FAA WSR-88Ds in Alaska and the Air Force WSR-88D in Guam are dependent on future communications bandwidth needs and availability of funding.

### 4. LEVEL 3 DATA CHANGES

As with Level 2 data, users of Level 3 products need to be aware of and plan for future changes in Level 3 data streams for the same reasons listed above for Level 2. The addition of dual polarization at a network site adds 15 products to the NWS’s Radar Product Central Collection Dissemination Service (RPCCDS).

We are often asked how the Level 2 and Level 3 data are sent from the radar to users. We have prepared Fig. 2 and Fig. 3 to help readers understand the data paths’ architecture.

### 5. NATIONAL CLIMATIC DATA CENTER (NCDC)

The NCDC has done an outstanding job supporting the NWS’s WSR-88D Level 2 and Level 3 data archive requirements since 1993. The NCDC has also served growing user data demands as seen in the next two sections.

#### 5.1 Archived WSR-88D Level 2 and Level 3 Data

We described the increased WSR-88D data rates in Sections 3 and 4 above; and these data also go to NCDC. If the NWS collects it, the NCDC archives it and makes it available to requestors.

The amount of Level 2 and Level 3 data archived per year is shown in (Fig. 3). The amount of Level 3 data archived increased six-fold from 2008 to 2012. This is due to the addition of legacy products and dual polarization WSR-88D products to the NWS Central Data Collection data stream and the addition of TDWR-SPG products from 45 sites.

Additionally, the amount of archived Level 2 and Level 3 data ordered/accessed more than doubled between 2011 and 2012 (Fig. 4). We attribute the large annual increases in data ordering, since 2008, to the user community’s increased applications for these data and ease of manipulating the data. In 2012, the email domains of archive Level 2 requestors were: 27% .gov; 29% .edu; 1% .mil; and 43% “other.” The median Level 2 user-request retrieval latency was ~6 min. in 2011.

#### 5.2 Display Tools for WSR-88D Archived Data Users

The NCDC continues to expand the capability of the Weather and Climate Toolkit (WCT) to support user exploration of WSR-88D archive data and other weather and climate data types, including satellite and model data. The WCT is platform-independent software available from the NCDC at no charge. The WCT allows the visualization and export of data. By leveraging the NetCDF for Java library and Common Data Model, the WCT is scalable and capable of supporting many new datasets. Gridded NetCDF files

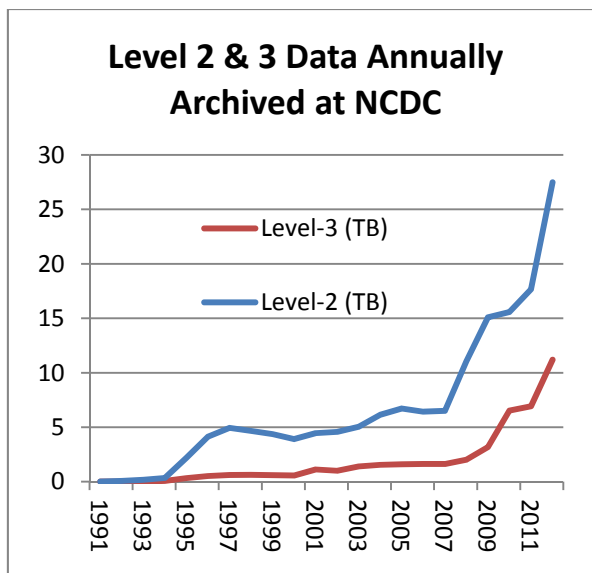


Fig. 3. Annual amounts of Level 2 and Level 3 data archived at NCDC since collection began in 1993.

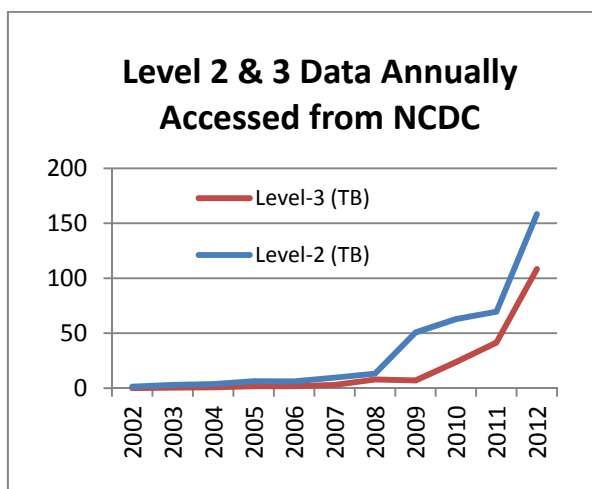


Fig. 4. Annual amounts of Level 2 and Level 3 data users requested and NCDC provided the last 11 years.

(using Climate-Forecast (CF) conventions) are supported, along with many other formats. The WCT provides tools for custom data overlays, Web Map Service (WMS) background maps, animations and basic filtering. Fig. 5 and Fig. 6 are example images of how the WCT can depict radar data and increase user understanding and use of the data.

The NCDC has plans for further enhanced WCT capabilities. An example is in Fig. 6. A short listing of possible additions includes:

- Improved Point and Time Series (station data) support,
- Comparison between station data and grid/radial data,
- Enhance Time Morphing features,
- Batch / Command-line KMZ export; and,

- Enhanced integration with the Climate Services portal (<http://www.climate.gov>)

## 5.2 NCDC Weather Radar Goals

The NCDC vision for radar data services is to stay on the leading-edge of user friendly visualization and data conversion tools. In addition, the NCDC is exploring how to manage radar data sets that are even larger than the WSR-88D Level 2 while reaching out to other countries to provide a similar service for their radar data sets.

## 6. ACKNOWLEDGEMENTS

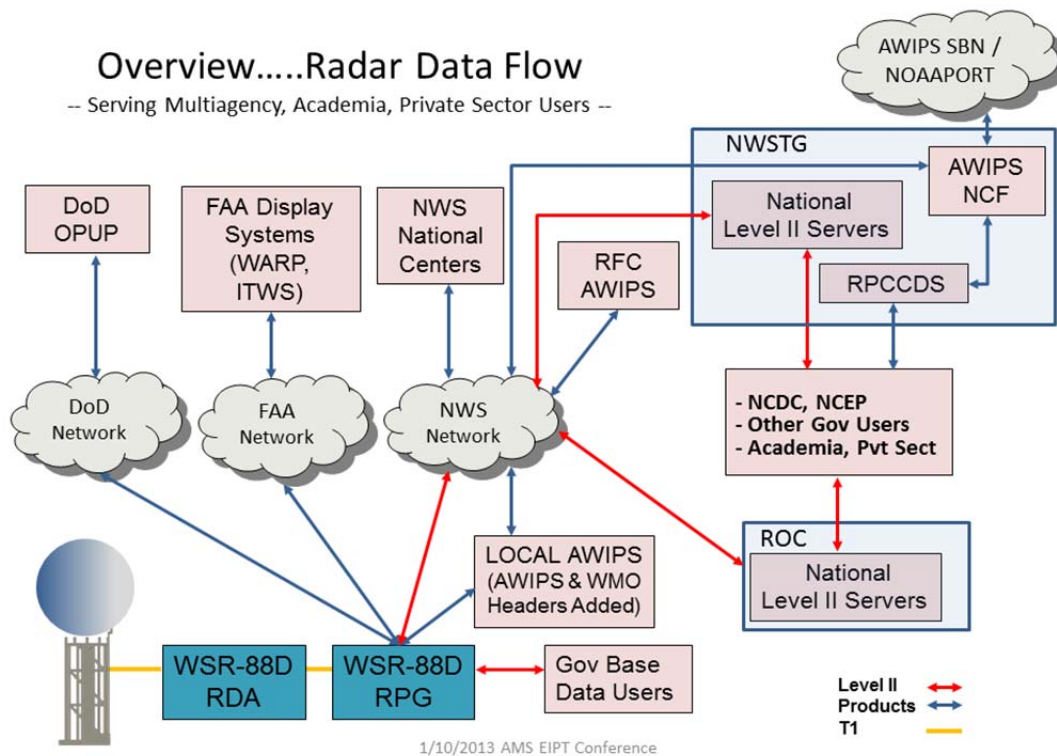
The NWS TOC provides real-time operational support and monitoring of the Level II network.

Real-time Level 2 data distribution to external users is provided by the Level 2 Top Tiers at the University of Oklahoma/Integrated Robust Assured Data Services (IRADS), Purdue University, and The Education and Research Consortium of the Western Carolinas, Inc. (ERCWC)/Education and Research Network (ERN)/ERC Broadband (ERCB). The points of contact for the above-listed three Top Tiers are available at: [http://www.roc.noaa.gov/WSR88D/PublicDocs/Level\\_II/Top\\_Tier\\_PointsOfContact0112.pdf](http://www.roc.noaa.gov/WSR88D/PublicDocs/Level_II/Top_Tier_PointsOfContact0112.pdf). Unidata serves as a Top Tier for their member universities.

It is of interest to note that what started as a collaborative effort with the Project CRAFT (Collaborative Radar Acquisition Field Test) in the late 1990s continues to thrive and progress as a collaborative effort.

## 7. REFERENCES

- Ansari, S. et al, 2012: The Weather and Climate Toolkit: 2012. *28<sup>th</sup> Conf. on Interactive Information and Processing Systems*, New Orleans, LA, Amer. Meteor. Soc., Paper 5A.1
- Crum, T. et al, 2013: WSR-88D Radar Projects: 2013 Update. *29<sup>th</sup> Conf. on Environmental Information Processing Technologies*, Austin, TX, Amer. Meteor. Soc., Paper 8.1.
- Crum, T. et al, 2010: NWS WSR-88D and TDWR-SPG data collection and distribution network status and plans. *26th Conf. on Interactive Information and Processing Systems*, Atlanta, GA, Amer. Meteor. Soc., Paper 4.6.
- Horvat, D. et al, 2011: The Refreshed WSR-88D Level II Data Collection and Distribution Network. *27th Conf. on Interactive Information and Processing Systems*, Seattle, WA, Amer. Meteor. Soc., Paper 3A.1.
- Kelleher, K. E., and Coauthors, 2007: Project CRAFT: A real-time delivery system for NEXRAD Level II data via the Internet. *Bull. Amer. Meteor. Soc.*, **88**, 1045-1057.



**Fig. 2.** Depiction of the flow of WSR-88D Level 2 and Level 3 data from a WSR-88D to NWS distribution centers for further transmission to users.



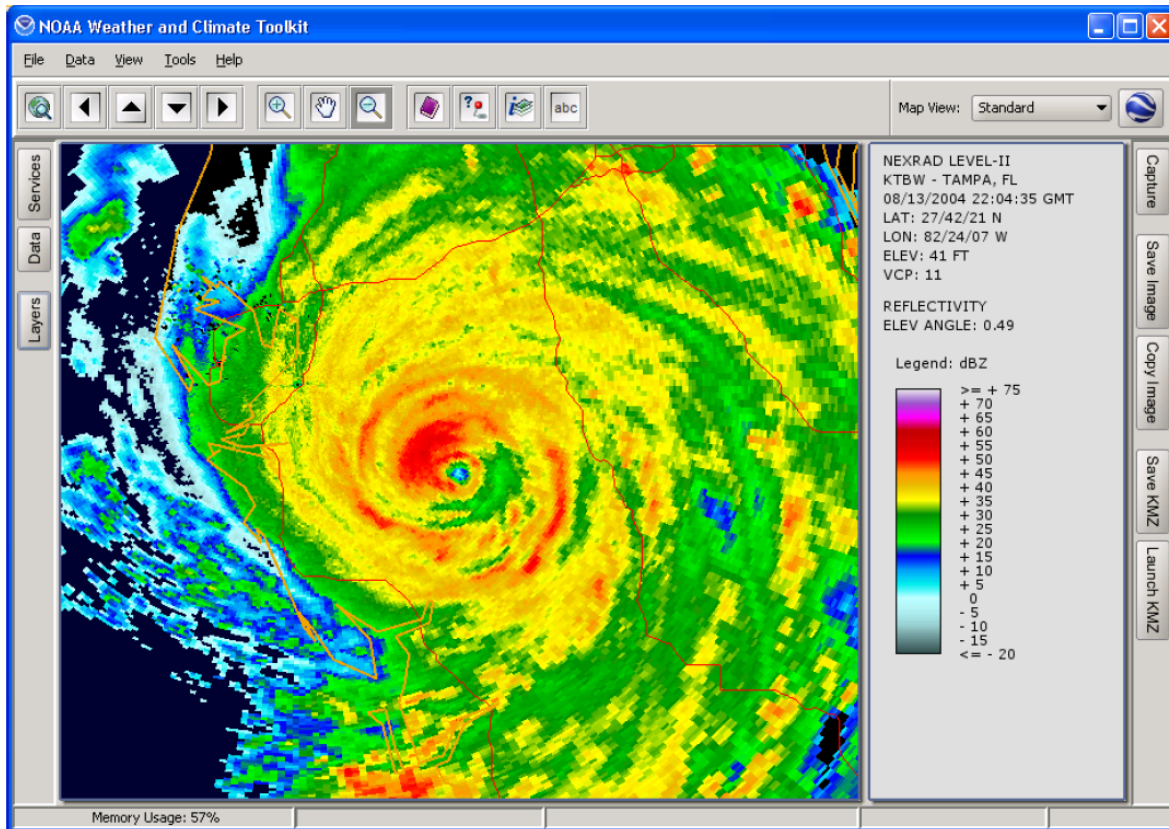


Fig. 5. Sample image of WSR-88D Level 2 Reflectivity for Hurricane Charley (2004), created by the Weather and Climate Toolkit (WCT) available for free download from NCDC.

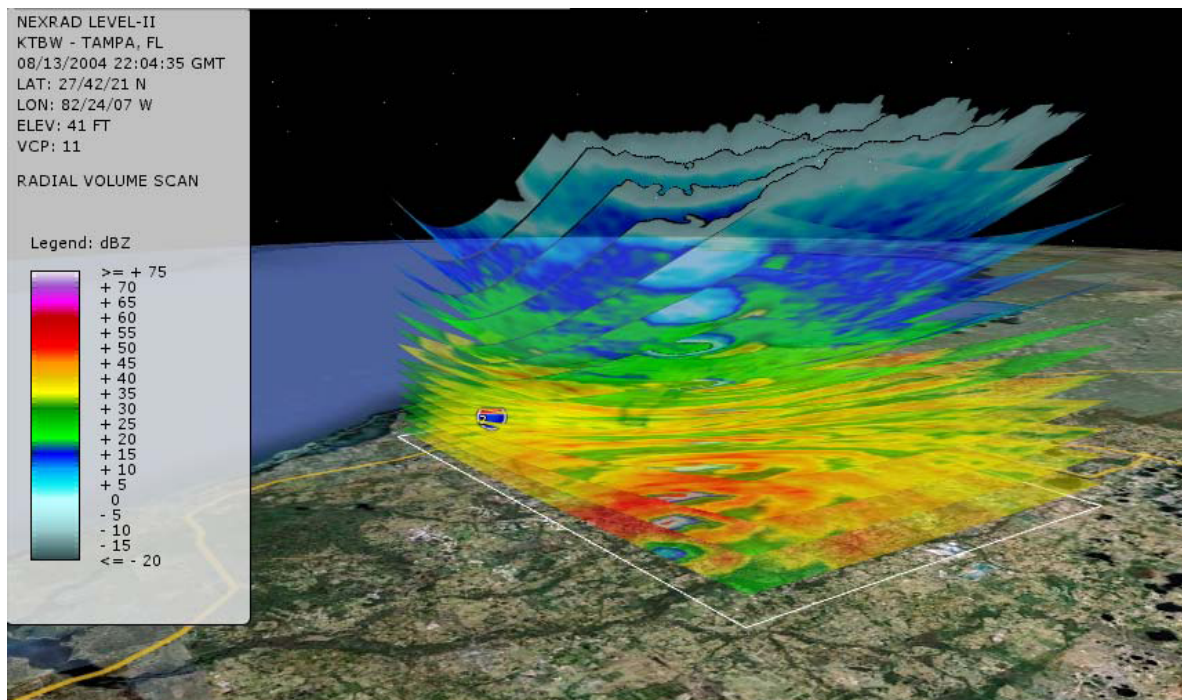


Fig. 6. Example WSR-88D reflectivity data from all scans angles from the KTBW (Tampa, FL) WSR-88D, exported from the WTC as a 3D-enabled KMZ file and visualized on Google Earth.

New Feature

# Visualization

- Math tool (max, min, avg, abs max, sum)  
(Under 'More...' link on 'Data Selector' or 'Grid Properties')

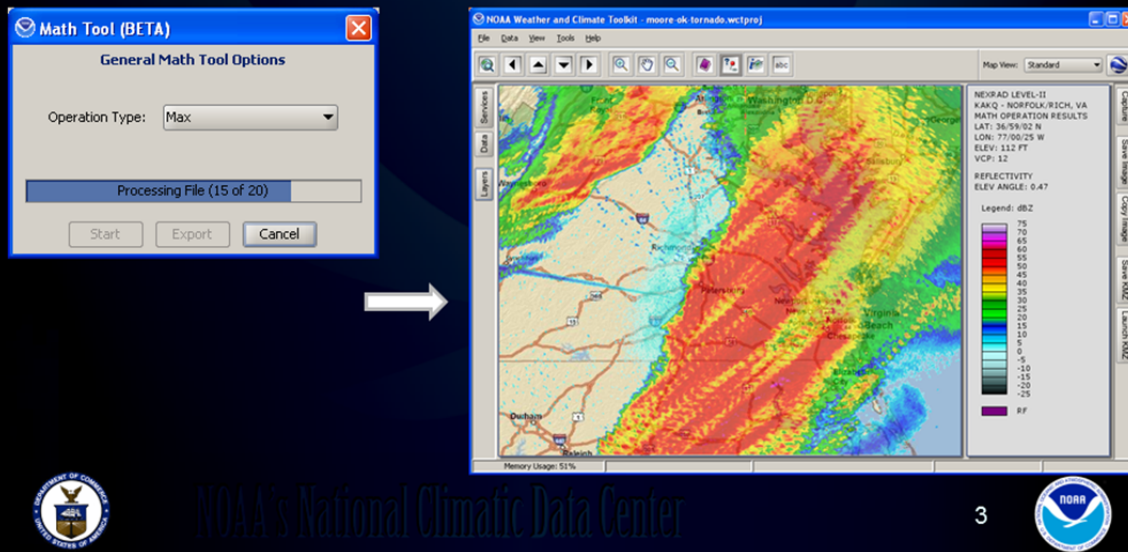


Fig.7. Screen capture of a new WCT tool that manipulates the WSR-88D Level 2 data and can perform simple analysis functions on a series of files.

## 8. RELATED WEB SITES/USEFUL RESOURCES

- Federal Meteorological Handbook No.11 (FMH-11): <http://www.ofcm.gov/homepage/text/pubs.htm>
- WSR-88D Dual Polarization training materials: <http://www.wdtb.noaa.gov/>
- ERC Real-Time Level II Data Monitoring Site: <http://www.ercbroadband.org/index.php/level-ii-data-status>
- NWS Real-Time Level II Data Monitoring Site: <http://weather.noaa.gov/monitor/radar2/>
- NWS Real-Time Level 3 Product Site Status: <http://weather.noaa.gov/monitor/radar3/>
- NWS Radar Product Central Collection Dissemination Service: <http://www.nws.noaa.gov/tg/rpccds.html>
- NCDC Radar Archive Data: <http://www.ncdc.noaa.gov/oa/radar/radarresources.html>
- WSR-88D Common Operations and Development Environment: <http://www.weather.gov/code88d/>
- WSR-88D Radar Operations Center
  - Home Page: <http://www.roc.noaa.gov/WSR88D/>
  - Interface Control Documents: <http://www.roc.noaa.gov/WSR88D/Program/ICDs.aspx>
  - Level II/Base Data Information: [http://www.roc.noaa.gov/WSR88D/Level\\_II/Level2Info.aspx](http://www.roc.noaa.gov/WSR88D/Level_II/Level2Info.aspx)
  - Level III/Product Information: [http://www.roc.noaa.gov/WSR88D/Level\\_III/Level3Info.aspx](http://www.roc.noaa.gov/WSR88D/Level_III/Level3Info.aspx)
- NOAA Earth System Research Laboratory: <http://www.esrl.noaa.gov/research/themes/regional/>