# 5A.10 A GEOSPATIAL DATABASE AND CLIMATOLOGY OF SEVERE WEATHER DATA

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

Mark Phillips
University of North Carolina Asheville, Asheville, North Carolina

## ABSTRACT

The Severe Weather Data Inventory (SWDI) at NOAA's National Climatic Data Center (NCDC) provides user access to archives of several datasets critical to the detection and evaluation of severe weather. These datasets include

- NEXRAD Level-III point features describing general storm structure, hail, mesocyclone and tornado signatures
- National Weather Service Storm Events Database
- National Weather Service Local Storm Reports collected from storm spotters
- National Weather Service Warnings
- Lightning strikes from Vaisala's National Lightning Detection Network (NLDN)

SWDI archives all of these datasets in a spatial database that allows for convenient searching and subsetting. These data are accessible via the NCDC web site, Web Feature Services (WFS) or automated web services. The results of interactive web page queries may be saved in a variety of formats, including plain text, XML, Google Earth's KMZ and Shapefile [Appendix A].

NCDC's Storm Risk Assessment Project (SRAP) uses data from the SWDI database to derive gridded climatology products that show the spatial distributions of the frequency of various events. SRAP also relates SWDI events to other spatial data such as roads, population, watersheds, and other geographic, sociological, or economic data to derive products that are useful in municipal planning, emergency management, the insurance industry, and other areas where there is a need to quantify and qualify how severe weather patterns affect people and property.

## 1. INTRODUCTION

Severe weather impacts the lives of millions of people each year. The protection, planning, and response to these challenges are central to NOAA's mission. Part of this mission includes disaster planning, mitigation, and recovery which is often atop public perception and occupies many of NOAA's resources.

Tools to aid in this mission are important for many reasons. Better preparedness and improved recovery can help save lives, reduce costs, and provide comfort.

The development of NEXRAD Radar systems have dramatically improved severe weather detection and have saved countless lives. Algorithms developed at the NOAA use NEXRAD data to detect and track tornados, hail and mesocyclones in real-time. While these data are invaluable for real-time operations, historical analysis is also beneficial. Comparison with other independent data sources such as human observations and lightning sensors provides a long-term source of quality assurance. The observational data tend to show biased information because reports are often located in populated places or along major roads. The remotely sensed data allow for a more homogenously spaced distribution of weather information.

## 2. DATA

Five initial data sources for the SWDI are the NEXRAD Level-III products, the National Weather Service (NWS) Storm Events Database, the NWS Local Storm Reports, the NWS Warning areas and the National Lightning Detection Network (NLDN) [3, 4, 5].

The NEXRAD Level-III data are products generated with NOAA algorithms from NEXRAD Level-II (base) volume scan data. Several of the Level-III products identify and describe severe weather. These products consist of mesocyclone, hail, tornado and storm structure point features which are decoded and geo-located using the Java NEXRAD Tools software package [1] (Figure 1). The temporal resolution of the NEXRAD derived datasets is dependant on the scan mode of the Radar site and varies between 4 and 10 minutes. The entire NCDC archive of NEXRAD data will eventually be reprocessed to populate the SWDI. This includes general coverage of the continental United States since 1995 with the earliest data from 1991.

The Local Storm Reports are preliminary reports from trained sources such as storm spotters, law enforcement, emergency response, etc. These reports are later verified by the NWS and added to the Storm Events Database.

The Storm Events Database consists of verified qualitative observations of events such as hail, tornados, lightning, flooding, high wind and more. The data either have a geographic coordinate specified or are organized by county or city. The Storm Events data are event summaries and contain data from 1950 to the present [4] (Figure 2).

The NWS Warnings include the current polygon and legacy county-based warnings for severe thunderstorms, tornados and flash flooding.

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

The NLDN data are generated from Vaisala's national network of lightning sensors. The sensors use time-of-arrival and magnetic direction finding to identify and geo-locate each lightning event [3] (Figure 3). The temporal resolution of NLDN data is one second.

Future datasets include polygon areas of interest derived from gridded datasets such as NEXRAD and/or Multi-Sensor precipitation estimates, hail estimates, and hurricane and tropical storm tracks.

## 3. GEOSPATIAL DATABASE

A geospatial database is used to manage the data in the SWDI. The database spatially links the diverse datasets together in a way that is not possible using conventional databases or data storage methods [6]. Having the severe weather data in a central geospatial database links the data to other NCDC datasets that are spatially registered in the database. The severe weather data can then be spatially joined to other datasets and vice versa. For example, the county, climate division, closest fixed observing sites, cities, schools and roads can easily be calculated for any spatially registered tornado signature. The simple, modular design allows datasets to remain unique and independent while sharing only a spatial relationship (Figure 4). A geographic location is all that is needed to add new datasets to the SWDI. This offers a high level of flexibility in dealing with many different types of data from various sources.

## 4. ACCESS

Several access methods are provided to accommodate various types of users. Web pages provide interactive search options while Representational State Transfer (REST) web services provide automated access to the data via several established protocols (Figures 5, 6). Users are able to search on several criteria including location, city, county, state, climate division, hydrologic unit, time period and product. Data may be downloaded in common formats such as plain text (CSV), XML, KMZ, GeoRSS and Shapefile [Appendix A].

REST web services use intuitive URLs to represent unique resources. Standards such as common formats (CSV, XML, KMZ, GeoRSS, Shapefile), MIME types and HTTP response codes are used to enhance interoperability [2].

The REST services use a folder syntax to represent the virtual data structure. The purpose of this syntax to is to separate the parent-child relationships from the searching or filtering operations. For example, the URL: 'http://www.ncdc.noaa.gov/swdiws/csv/nx3tvs/20070501:20070601', represents a query of one month of NEXRAD Tornado Vortex Signature (TVS) data in text CSV format. Query parameters are used for filtering. Example query parameters include:

- '?stat=count'
- '?radius=5.0&center=-90.0,46.0'
- '?state=LA'
- '?huc=10042357'

For more examples, refer to Appendix B.

Additionally, Open Geospatial Consortium (OGC) defined Web Feature Services (WFS) provide numerous options for the direct integration of the SWDI into GIS applications such as ESRI ArcGIS [6].

## 5. STORM RISK ASSESSMENT PROJECT

The Storm Risk Assessment Project builds upon the access and query capabilities in the SWDI to produce climatology products. The climatology products are merged with socio-economic datasets to quantify and assess risks of severe weather to lives and property. The assessments are invaluable to a diverse set of users such as emergency management, municipal planning, the insurance industry and many others.

## 6. CONCLUSION

The SWDI provides efficient and user-friendly access to an extensive archive of severe weather data. The SWDI will aid in the quality control of severe weather products, facilitate new research and assist disaster response and mitigation. The relational geospatial database provides a modular, flexible solution for data storage and management. This allows SWDI datasets such as NEXRAD, NLDN, Weather Warnings and observational Storm Events to remain independent while sharing a common spatial relationship. Multiple data access methods are provided to satisfy different types of users. Interactive web pages provide extensive search options while web services offer an efficient method of automated data access. By incorporating web services, users may seamlessly integrate the SWDI into custom applications. The Storm Risk Assessment Project (SRAP) produces climatology products and incorporates socio-economic data for risk quantification. The SWDI and SRAP present valuable severe weather data in a simple, flexible and integrated manner that benefits many user communities and exemplifies 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. "Building Web Services the REST Way", Website: http://www.xfront.com/REST-Web-Services.html

3. Cummins, K. L., M. J. Murphy, E. A. Bardo, W. L. Hiscox, R. B. Pyle, and A. E. Pifer, 1998. A Combined TOA/MDF Technology Upgrade of the U. S. National

Lightning Detection Network, J. Geophys. Res., 103, 9035-9044. Idone, V. P.,

4. Storm Events Website: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms

5. NOAA Storm Prediction Center Storm Reports: http://www.spc.noaa.gov/climo/

6. WFS Reference Website: http://en.wikipedia.org/wiki/Web_Feature_Server

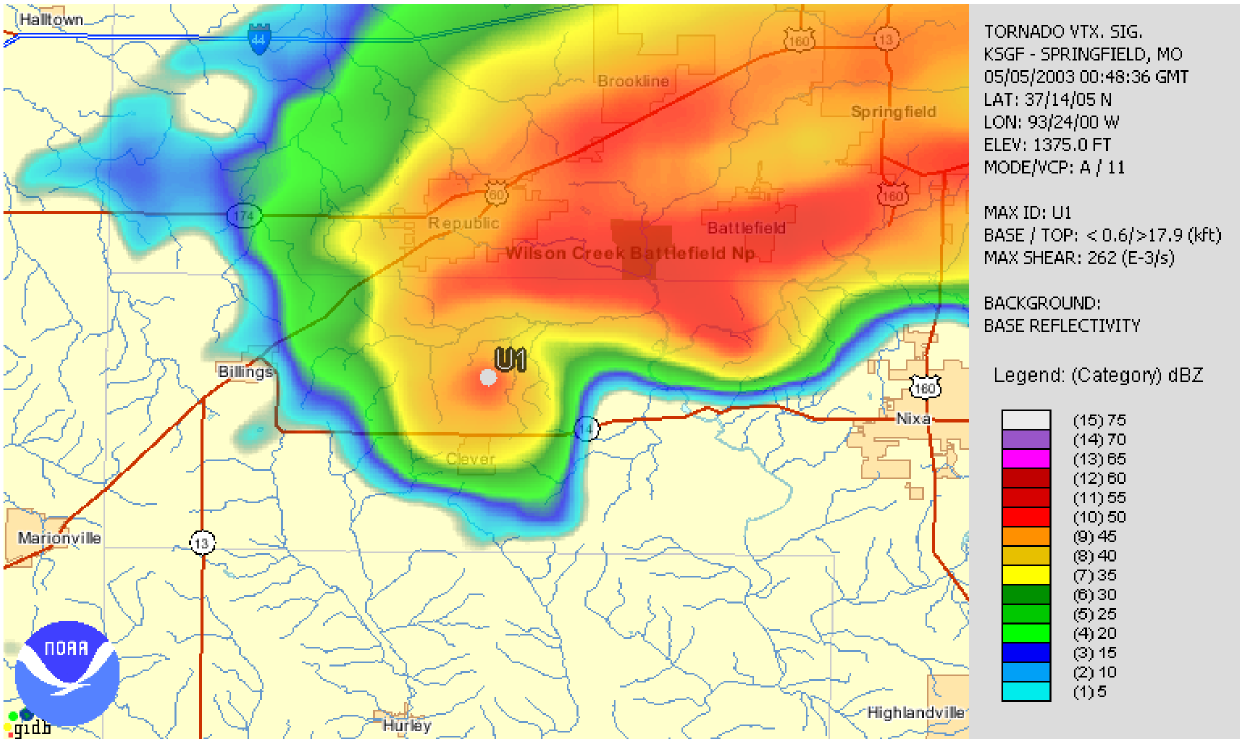



**Figure 1.** NEXRAD Level-III Tornado Vortex Signature and Reflectivity Data

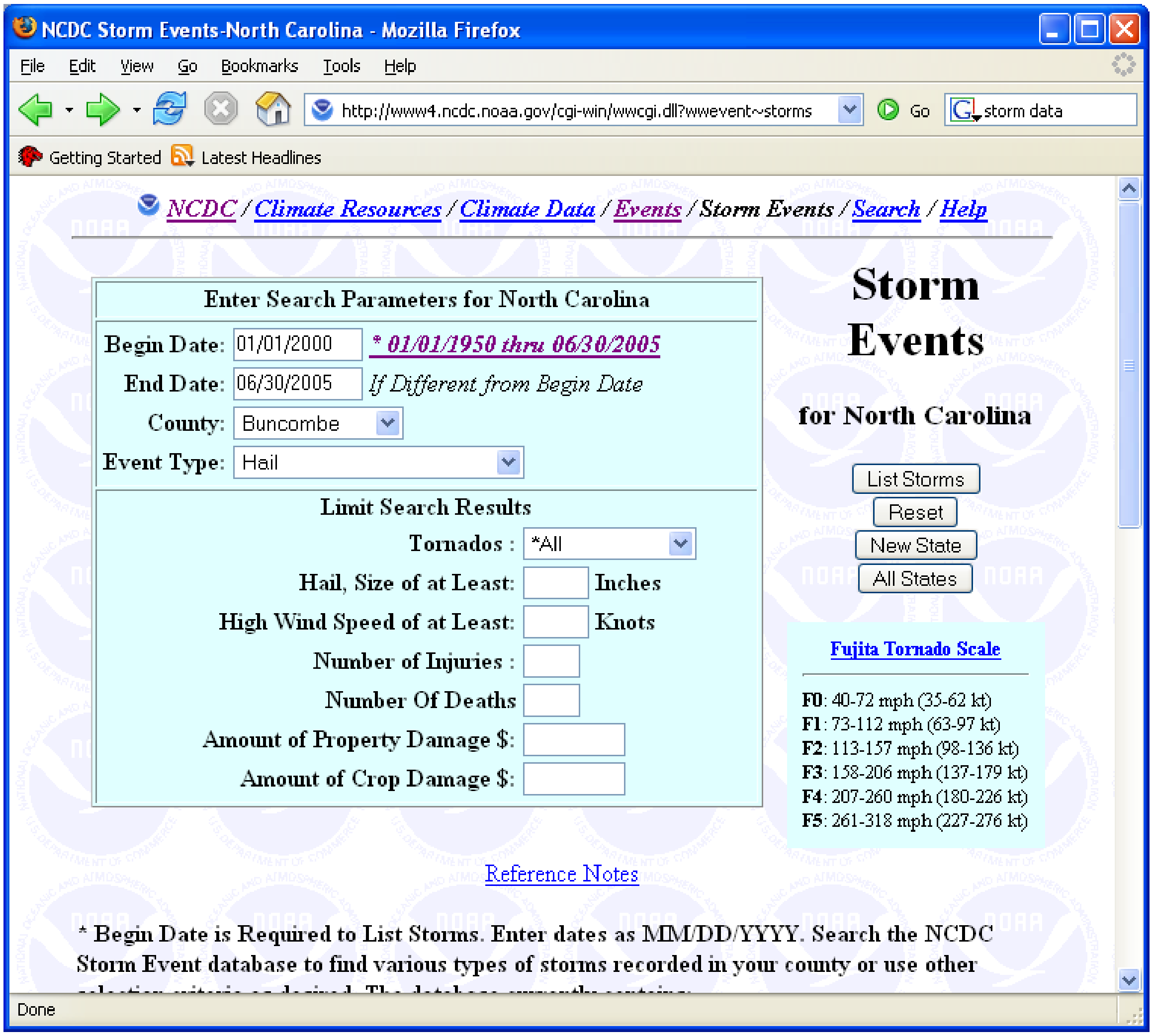



**Figure 2.** Storm Events Database

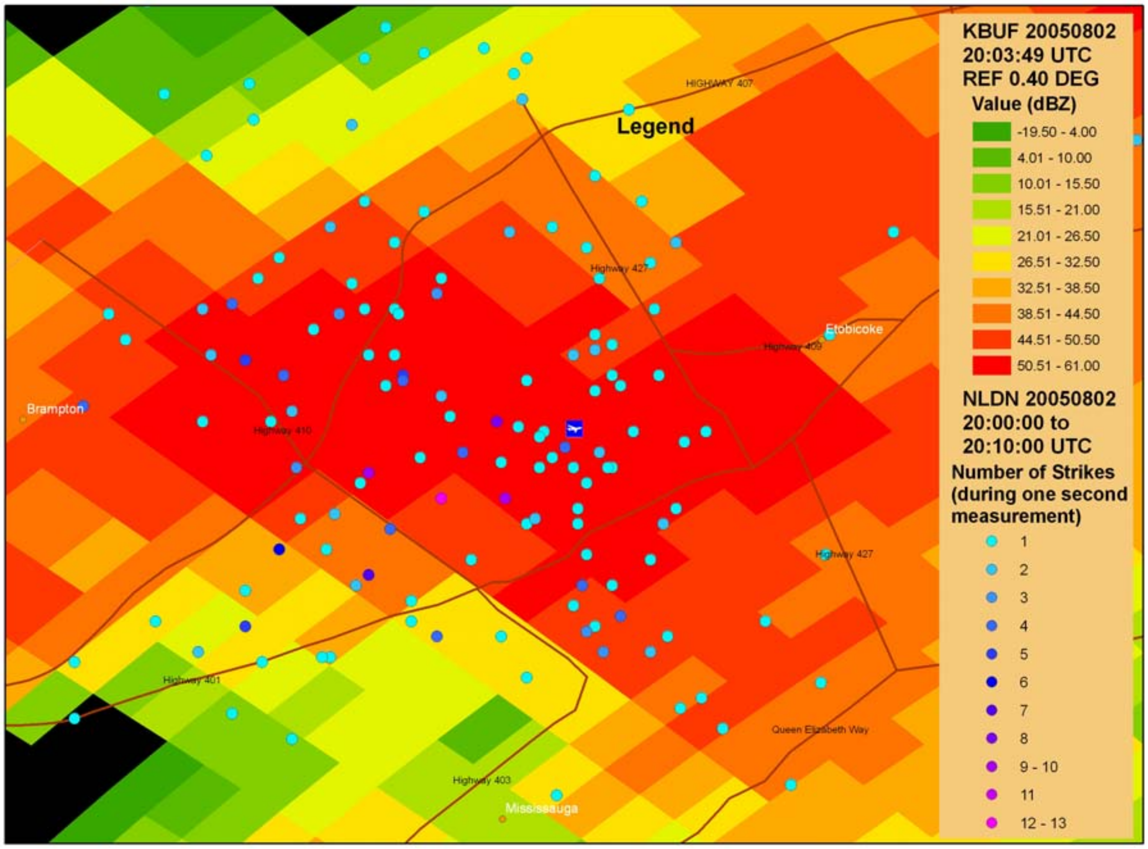



**Figure 3.** NLDN and NEXRAD Reflectivity Data

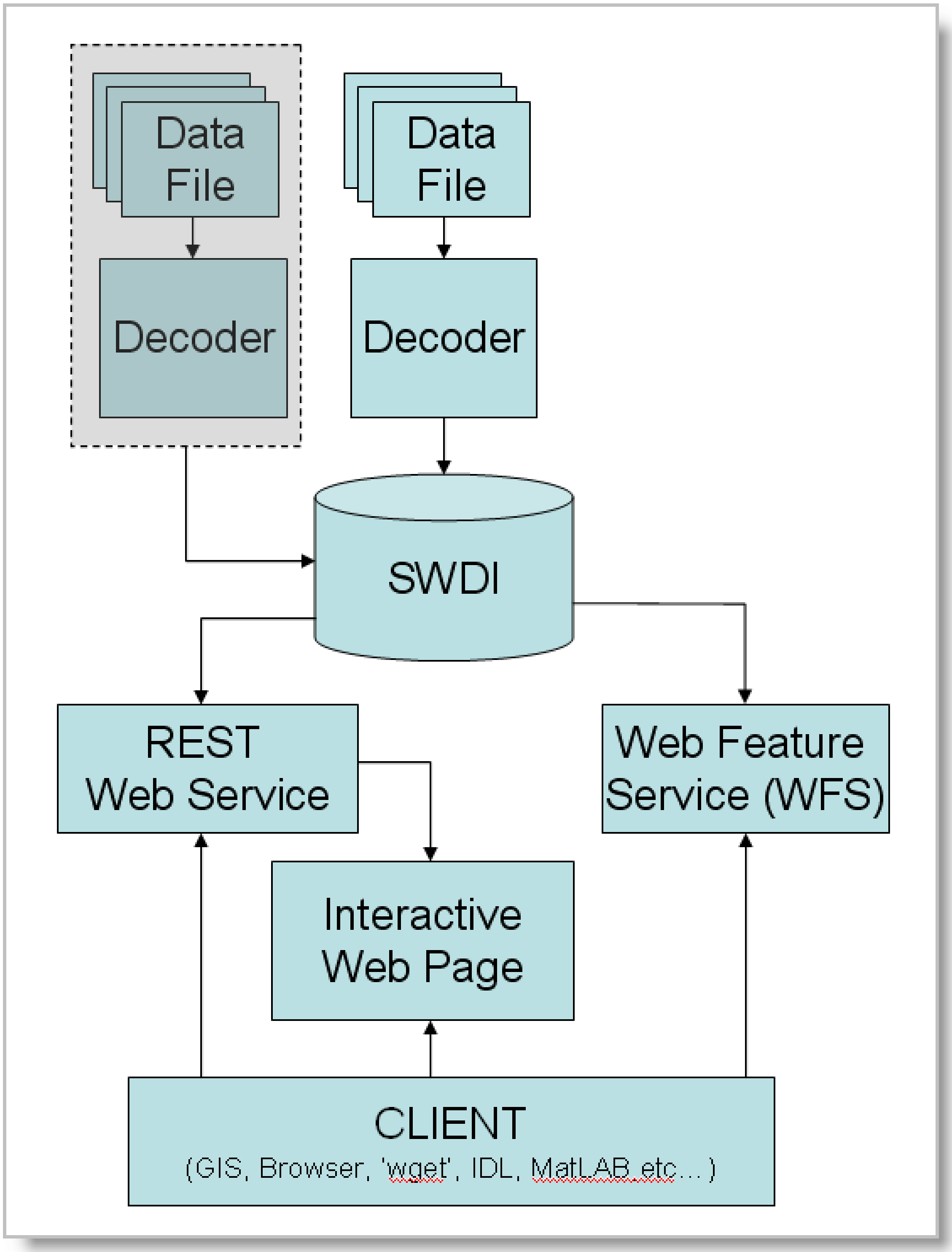



**Figure 4.** Severe Weather Data Inventory Flowchart

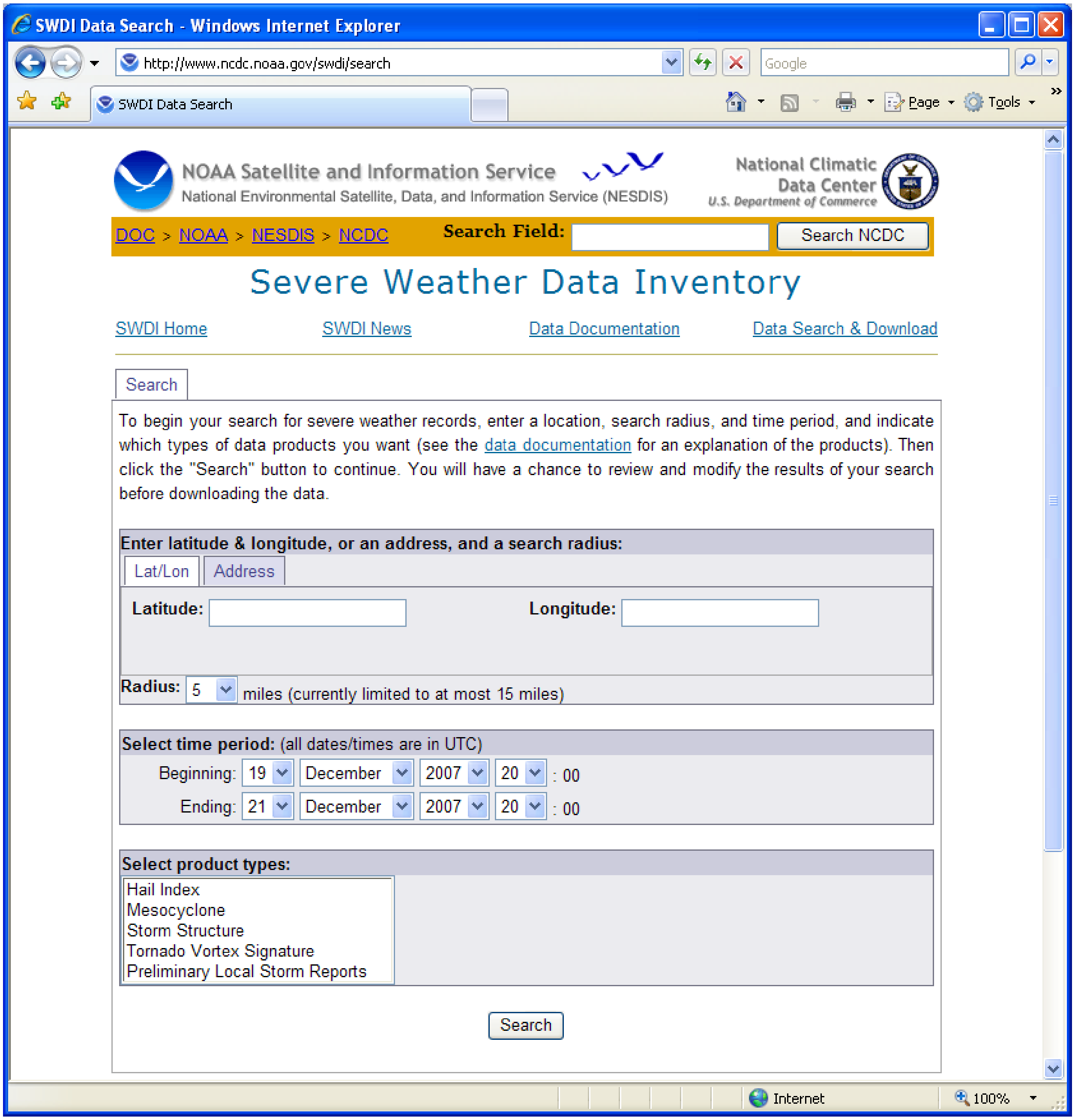
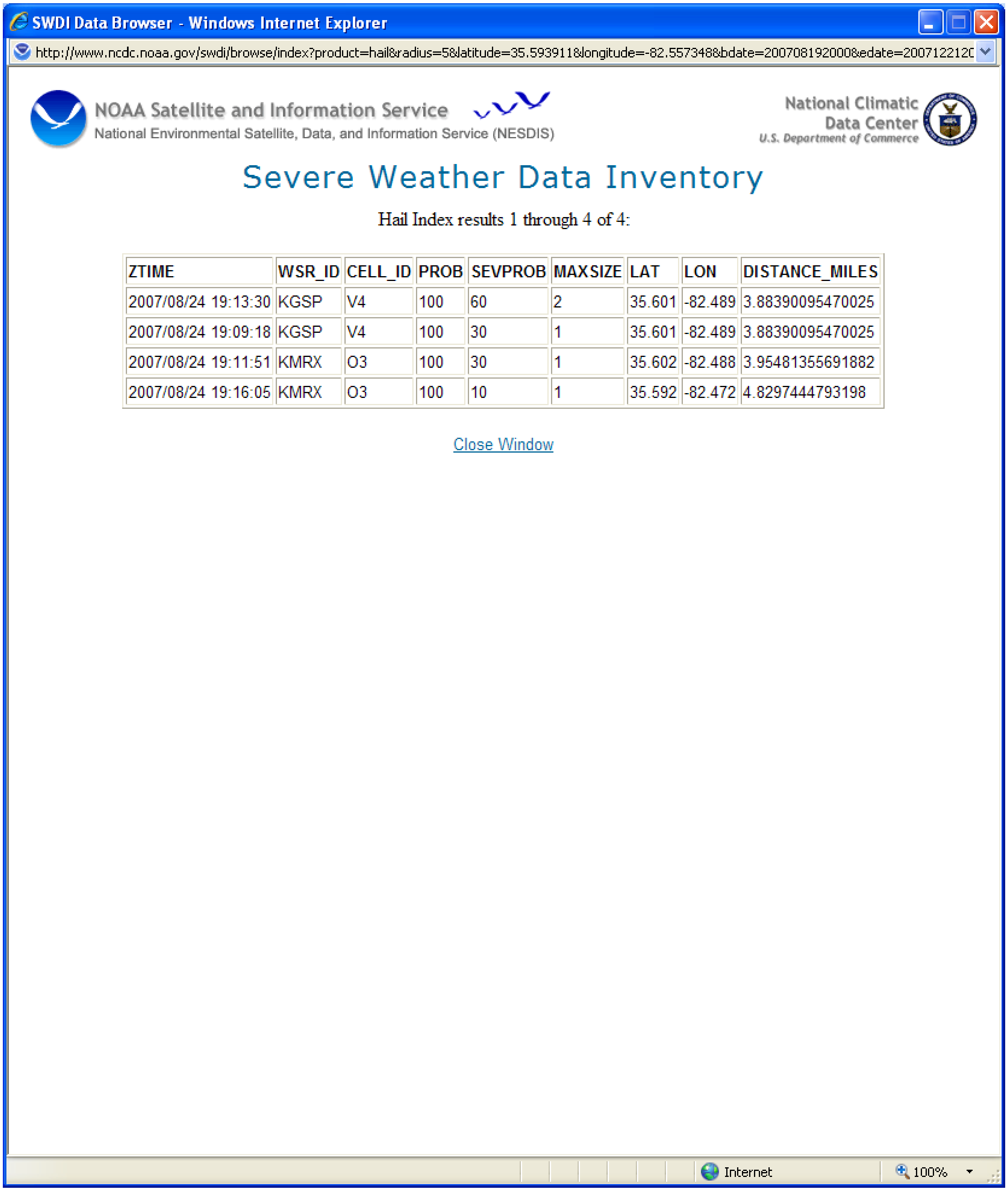



**Figure 5.** Severe Weather Data Inventory Interactive Web Page Access


SWDI Data Browser - Windows Internet Explorer

http://www.ncdc.noaa.gov/swdi/browse/index?product=hail&radius=5&latitude=35.593911&longitude=-82.557348&bdate=200708192000&edate=200712212C

NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)

National Climatic Data Center
U.S. Department of Commerce

# Severe Weather Data Inventory

Hail Index results 1 through 4 of 4:

| ZTIME | WSR_ID | CELL_ID | PROB | SEVPROB | MAXSIZE | LAT | LON | DISTANCE_MILES |
|---|---|---|---|---|---|---|---|---|
| 2007/08/24 19:13:30 | KGSP | V4 | 100 | 60 | 2 | 35.601 | -82.489 | 3.88390095470025 |
| 2007/08/24 19:09:18 | KGSP | V4 | 100 | 30 | 1 | 35.601 | -82.489 | 3.88390095470025 |
| 2007/08/24 19:11:51 | KMRX | O3 | 100 | 30 | 1 | 35.602 | -82.488 | 3.95481355691882 |
| 2007/08/24 19:16:05 | KMRX | O3 | 100 | 10 | 1 | 35.592 | -82.472 | 4.8297444793198 |

Close Window

Internet 100%

**Figure 6.** Severe Weather Data Inventory Interactive Web Page Search Results

**APPENDIX A**

1. ESRI Shapefile [1]: “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

2. Geography Markup Language (GML): “Geography Markup Language is an XML grammar written in XML Schema for the modeling, transport, and storage of geographic information.” For more information: http://www.opengis.net/gml/

2. GeoRSS: “GeoRSS is an emerging standard for encoding location as part of an RSS feed. (RSS is an XML format used to describe feeds ("channels") of content, such as news articles, MP3 play lists, and blog entries. These RSS feeds are rendered by programs such as aggregators and web browsers.)”
http://en.wikipedia.org/wiki/GeoRSS
http://www.georss.org/

3. KML: “Keyhole Markup Language (KML) is an XML-based language schema for expressing geographic annotation and visualization on existing or future web-based online maps (2d) and earth browsers (3d).”
http://en.wikipedia.org/wiki/Keyhole_Markup_Language
http://code.google.com/apis/kml/documentation/

4. Shapefile: “The ESRI Shapefile or simply a shapefile is a popular geospatial vector data format for geographic information systems software. It is developed and regulated by ESRI as a (mostly) open specification for data interoperability among ESRI and other software products.”
http://en.wikipedia.org/wiki/Shapefile
http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf

**APPENDIX B**

SWDI REST Web Service URL Examples:

1) Query for one month of NEXRAD TVS data in a zipped Shapefile:

   http://www.ncdc.noaa.gov/swdiws/shp/nx3tvs/20070301:20070401

2) Query for the first 25 records of NEXRAD TVS data in CSV format from March 2007:

   http://www.ncdc.noaa.gov/swdiws/csv/nx3tvs/20070301:20070401/25

3) Query for the second set of 25 records from Query #2:

   http://www.ncdc.noaa.gov/swdiws/csv/nx3tvs/20070301:20070401/25/26

4) Calculate only the number of results:

   http://www.ncdc.noaa.gov/swdiws/csv/nx3tvs/20070301:20070401?stat=count

5) Filter the results to 10 miles of the location -96.0, 35.0:

   http://www.ncdc.noaa.gov/swdiws/csv/nx3tvs/20070301:20070401?center=-96.0,35.0&radius=10.0

6) Filter the results to the state of Kansas:

   http://www.ncdc.noaa.gov/swdiws/csv/nx3tvs/20070301:20070401?state=KS