NCDC the "One Stop Shop" for all WSR-88D Level II Data Services

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1. Abstract

The National Climatic Data Center (NCDC) currently receives Weather Surveillance Radar – 1988 Doppler (WSR-88D) level II (base) data from 120 National Weather Service (NWS), 12 Federal Aviation Administration (FAA) and 26 Department of Defense (DOD) sites on 8mm tape or online [3]. The NCDC robotic mass storage system warehouses approximately 900 terabytes of Level II data and grows annually at a rate of 60 terabytes a year (120 terabytes with offsite backup). Over the next several years enhanced radar technologies, such as dual polarization, will be implemented and growth of the radar digital archive may increase by a factor of 26. The NCDC is partnering with the Radar Operations Center, the National Severe Storms Lab, the University of Oklahoma and Unidata on the Collaborative Radar Acquisition Field Test (CRAFT) project [6]. CRAFT started as a grass roots effort to transmit level II data electronically, from 6 WSR-88D sites directly to the NCDC robotic mass storage system. To date, 59 of the 158 WSR-88D sites are transmitting level II data in real time to NCDC (Figure 1). NCDC has truly become a "One Stop Shop" for WSR-88D radar users. Direct digital access to level II radar inventories, data, and visualization software are available, at no cost to the user, via the NCDC radar resources web page. http://lwf.ncdc.noaa.gov/oa/radar/radarresources.html) Large data volume requests that, in the past, took weeks to months to disseminate are accessible in minutes to hours. Plans for future user services include a web interfaced browsing tool to visualize inventoried radar data and building radar climatologies based on specific weather phenomena.

2. Introduction

The WSR-88D network was first conceived as a real time surveillance system with no provision to archive or transmit level II data to users in real time. Level II data includes radial velocity, spectrum width, and reflectivity [5]. All 158 Doppler weather radar stations have been retrofitted with a robotic tape cartridge recording system [1]. Prior to August 2000, all incoming level II data were archived on 8mm tape (77 thousand tapes); these data have recently been migrated to the NCDC Mass Storage System.

Access to level II data from sites sending 8mm tapes to NCDC are not readily available to the user community until several weeks after an event. The capture rate, using 8mm tape, to record level II data at the radar site for the entire NEXRAD network is 65% at best. This is due to the fact that the tape recording systems are not meant to be used continuously, as they are currently being used in the field. Sites (Figure 1) that electronically transmit level II data to NCDC have capture rates at over 95% and data are available in near real time. Also, there are hardware specific cost benefits for both NCDC and the NWS. For example, the NWS over a one year period spent $768K on level II 8mm recording system repairs. To date, the stability of electronic transmission has led to suspending recording on 8mm tapes at 59 radar sites.

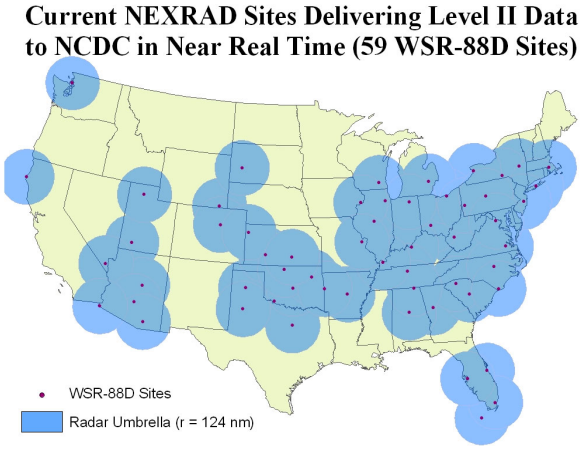


Figure 1. WSR-88D Sites electronically transmitting in near real time as of November 2002

3. Improvements to Operations

Until recently, the acquisition, archive, and dissemination of level II data required several interactive steps (Figure 2). Providing level II data for users from the 8mm tape library was both expensive

and time consuming. Retrieval time for one radar site for one day from 8mm tape took four hours. The typical level II data user requires data from multiple radar sites over a period of days. Therefore it took NCDC several days or weeks to fill these orders [4]. However, with all radar data now residing on the NCDC mass storage system (Figure 3), access to and dissemination of level II radar data have been substantially improved. For example, retrieval time for 20 gigabytes of level II data from the NCDC mass storage system takes approximately 30 minutes; however, if copied from tape it requires 58 customer tapes and 9 work stations each running 26 hours for a total of 234 hours. Other benefits for using the NCDC mass storage system to archive level II data include: 1) Level II base data reside on the standard NCDC archive media, 2) provides 12:1 compression ratio and tar capabilities, 3) reduces costs of tape drives and maintenance by eliminating tape sorting and merging, 4) provides more efficient and less expensive access to the data, and 5) enhance quality control process by automating several interactive steps [4].

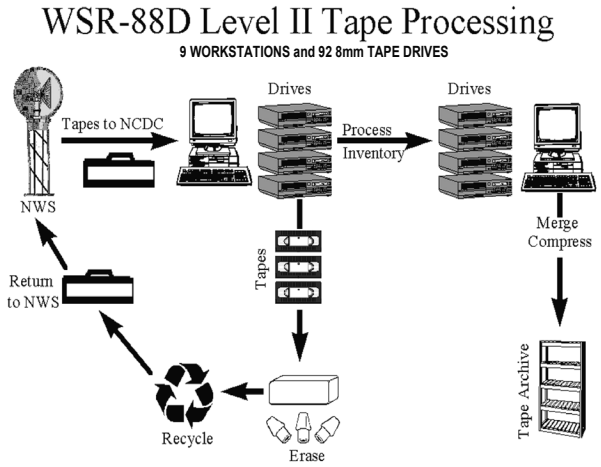


Figure 2. Recent interactive WSR-88D level II 8mm tape processing required nine workstations and 92 8mm tape drives

4. Web Based Services

The NCDC has developed a web interface to provide direct access to WSR-88D level II digital data products via the radar resources web page. Users are able to directly access NEXRAD data, at no cost, via

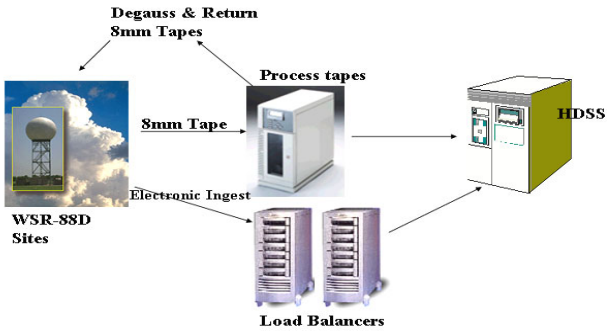


Figure 3. Current WSR-88D level II processing for electronic ingest or tape

FTP without contacting a NCDC customer service representative. To browse NEXRAD data inventories the user goes to http://has.ncdc.noaa.gov, selects the level II option, and follows the instructions for dataset retrieval (Figure 4). When data processing is complete, NCDC forwards retrieval instructions to the data requester's e-mail address. On average, retrieving one day's worth of data for one station using the internet takes approximately one hour. However, data retrieval across larger "backbone" networks such as the Next Generation Internet (NGI) for one day's worth of radar data for one station takes minutes. To date level II data accessed from the NCDC Mass Storage System, in terms of volume, exceeds all other NCDC data sets (Figure 5).

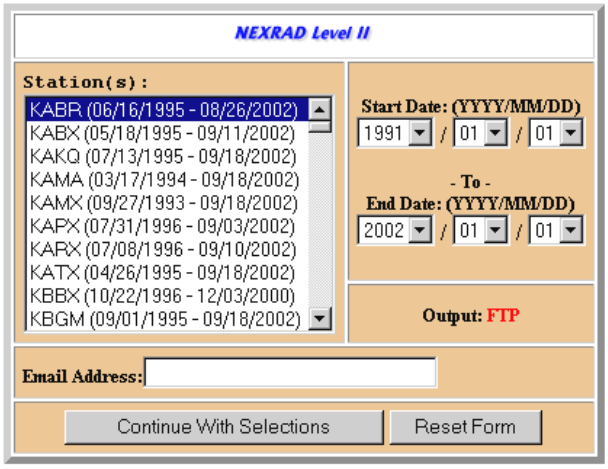


Figure 4. Web interface to radar data inventories

HAS Statistics (for selected criteria above):			
DATASET	TOTAL REQUESTS	TOTAL FILES TRANSFERRED	TOTAL BYTES TRANSFERRED
NEXRAD LEVEL II	257	9,099	445,426,961,920
9956	385	457,523	286,401,849,530
ATOB	19	6,661	119,898,000,000
ISH	29	44,300	44,920,711,764
SRRS TEXT	272	940	41,861,729,427
ISCCP/B1	24	5,753	28,111,392,744
SRRS GRAPHICS	34	76	15,687,353,973
NEXRAD LEVEL III	30	476	9,933,861,859
GHRR	75	115	6,838,604,280
3280	33	1,151	1,753,289,230
6301	50	369	1,646,076,474
LHRR	7	16	779,693,600

Figure 5. Data transfer stats from the NCDC mass storage system for Aug 01, 2002 – Sept 23, 2002. Total bytes transferred for level II, 445,426,961,920

The NCDC collaborated with the National Severe Storms Laboratory to modify the Interactive Radar Analysis Software (IRAS) visualization software [7]. IRAS is a platform independent software application and is available for download at URL: http://lwf.ncdc.noaa.gov/oa/radar/iras.html. The IRAS development is part of the activity surrounding the CRAFT project to deliver high-resolution WSR-88D Level II radar data via the Internet in real time (Figure 6). The software application allows users to read and display real time and archived Level II radar data on platforms supporting Java (version 1.3 and higher).

Java-IRAS functions include:

- Plan Position Indicator, displays elevation cuts
- Constant Altitude PPI, displays heights
- Range Height Indicator displays azimuths
- Auto-update of selected or all elevation cuts when new data are available
- Basic looping of PPI or CAPPI displays
- High resolution map overlays
- Standard WSR-88D color tables
- Zoom and re-center capability for PPI and CAPPI displays

NCDC is currently integrating IRAS to be used as a web-based browser. Users will be able to peruse the inventories and visualize the three types of radar moments (reflectivity, spectrum width, velocity) prior to ordering data.

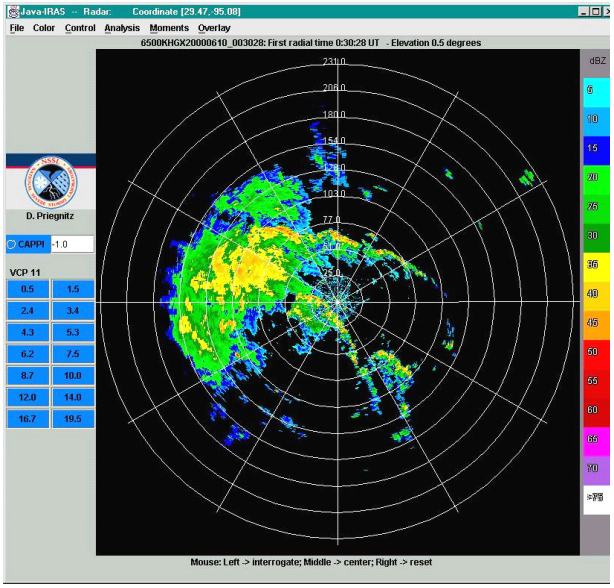


Figure 6. IRAS depicts flooding event June, 2000

5. Potential Growth NCDC Radar Archives

The recent deployment of the WSR-88D Open Radar Product Generator (ORPG) and on-going deployment of the Open Radar Data Acquisition (ORDA) module provides WSR-88D computational capabilities for developing higher resolution data, new products, and new data streams [2]. There are also plans to implement new technologies, such as dual-polarization Doppler radar into the national WSD-88D network in approximately five years. These additional data streams will improve estimates of rain and snow rates, hail detection, and rain/snow transition in winter storms.

An increasing number of users will request level II data in near real time as well as retrospectively for research and development, verification, training, and other uses. The NWS is developing plans for collecting and distributing Level II data to NCDC and other users in near real time. NCDC data ingest and archive requirements will be significantly impacted over the next several years. Today's annual receipt of 60 terabytes may, in approximately seven years, increase to as much as 1,600 terabytes per year or 3,200 terabytes with backup (Figure 7). Chart A illustrates the NWS new data requirements and estimated data flow rates [2].

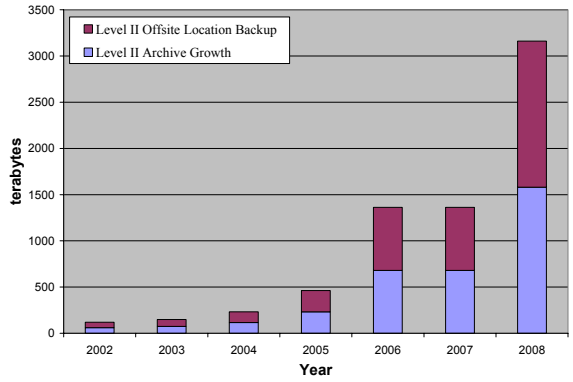
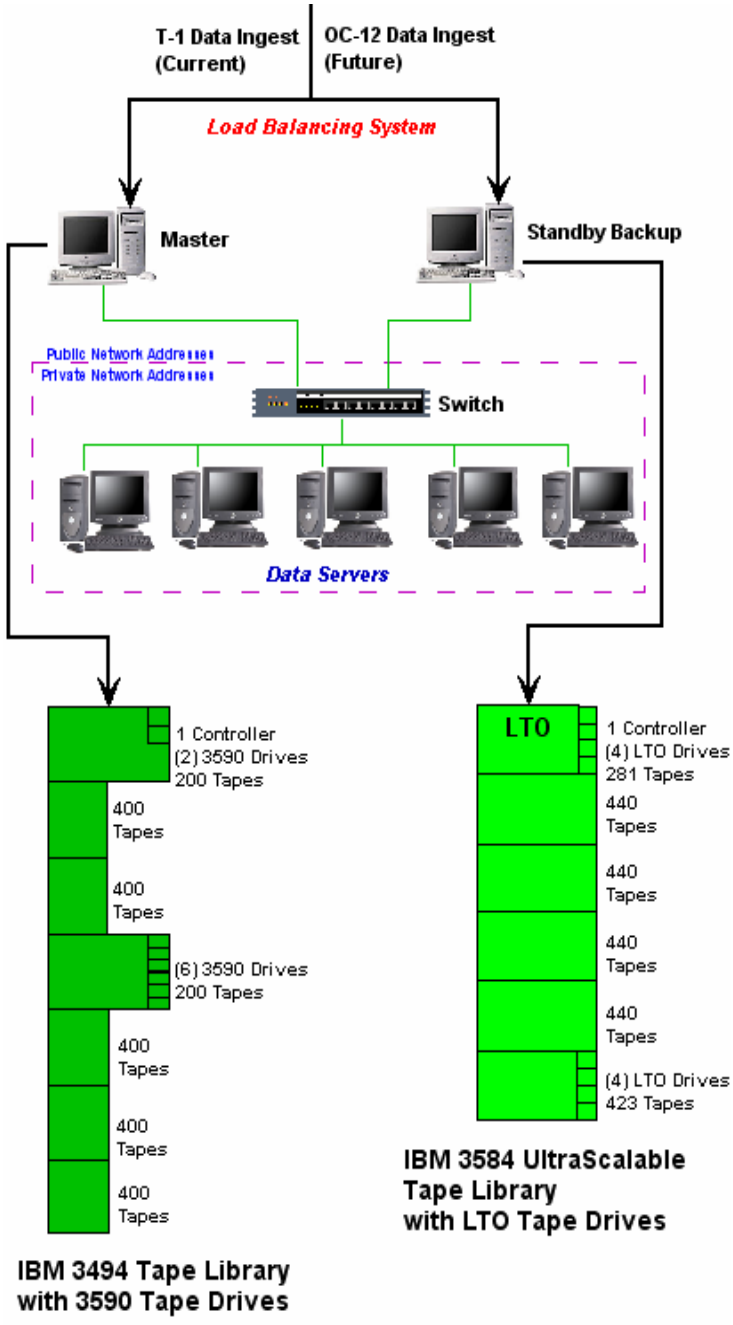


Figure 7. Potential NCDC WSR-88D Level II archive growth including offsite data backup

Chart A [2]

New Data Requirement	Data Flow Increase Multiple Factor	Target Implementation Date (Q/YY)	Data Flow Cumulative Multiple Factor
4.1 Minute Volume Coverage Pattern	1.24	4/03	1.24
250 m, vice 1 km, Reflectivity Data	1.56	4/04	1.93
0.5 °, vice 1.0 ° Azimuthal Sampling	2.00	1/05	3.86
Doppler Data To End Of 2nd Trip	1.49	4/05	5.76
Two Different Clutter Filters & SNR Thresholds	1.97	1/05	11.35
Dual Polarization, 4 New Moments	2.32	1/08	26.35

NCDC ingest and archive processing for the sites transmitting data electronically involves using Unidata Local Data Manager [8] software to move the data from the sites via the internet to NCDC where it is stored directly into the mass storage system. The existing architecture includes five load balancers and the IBM 3490 tape library with five cabinets and eight tape drives. Each cabinet holds 400 tapes at 80 gigabytes per tape with an average compression ratio of 12:1 resulting in 960GB of data per tape.



Projected Tape Storage Capacities (GB)

CY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3590 tape	40	40	80	80	200	200	200	400	400	800	800
LTO tape	100	100	200	200	400	400	800	800	800	1600	1600

Figure 8 Data ingest and storage architecture, courtesy Mark Smith, NCDC IT Branch

Therefore the current mass storage system has an archiving capacity of 1920 terabytes (384 terabytes per cabinet). The tape library is scalable and new tape cabinets can be added as capacity fills; however, the current architecture will not be able to keep up with the potential radar data growth at a magnitude of twenty six fold. Future plans call for upgrading the communications line from a T-1 (1.54 megabits per second) to a OC-12 (622 megabits per second) and the current tape library to an ultra scaleable system that has much higher tape storage capacities. Figure 8 shows the current electronic ingest to archive process (left), future architecture (right) and projected tape storage capacities.

6. Data Mining Services

"Data mining" refers to an emerging technology that is a response to the information age in which we live. Availability of low cost computers and data storage has enabled the routine processing of large databases, where previously the computation required was either too expensive or time consuming. There is great potential for mining WSR-88D level II data. Each WSR-88D tilt sequence produces millions of data points consisting of three variables distributed over a large volume. Mining tools will be used to browse the NCDC, level II radar data archives in an effort to reveal, analyze, and extract unique unknown continuous parameters in the data that may lead to the identification of specific weather events or phenomena. This type of information can lead to improved understanding of hazardous weather events and possibly improve forecast prediction. NCDC is partnering with the National Severe Storms Lab, University of Oklahoma and University of Alabama, Huntsville to develop and implement data mining tools.

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