

Annual Report: October 2006-September 2007

Award Number: ITR (ASE+ECS) 0427341

Title: ITR Collaborative Research

UCAR Principal Investigator: Mohan K. Ramamurthy; Unidata

Working in close partnership with our collaborators at the University of Iowa, we continue to make steady progress in realizing the original goals envisioned in the NEXRAD ITR proposal. In this progress report, we summarize Unidata's activities pertaining to the NEXRAD ITR project during the past year in the following areas: 1) Continued provision of NEXRAD Level II radar data to universities participating in the project; 2) Local generation of Level II metadata and creation of a new data feed, NEXRAD4 or HYDRO feed, for distribution of radar Level II metadata and along with Level II data in the Unidata Internet Data Distribution system; 3) Deployment of NEXRAD-ITR *MapServer* at Unidata; 4) New methods for accessing and visualizing NEXRAD Level II and Level III data. Although all of these activities are related to the NEXRAD-ITR project and are of benefit to the hydrology community, some of them leverage other core activities in the Unidata Program, funded by other awards.

1. Expansion and Continued Provision of NEXRAD Level II Radar Data

Unidata continues to supply the University of Iowa with a top-level feed for Level II radar data using the LDM/IDD. Originally, the data feed included only 10 radars of interest, but during the last year that number was expanded to include all 158 WSR-88D sites. As a result, the Level II data volume increased to ~300 MB/hour or 7.2 GB/day. To facilitate the Level II data feed as well as the new HYDRO feed, Unidata installed a new dedicated system to this project, using funds from this NSF award. Despite the increased volume of the data, the University of Iowa IDD connection continues to be robust and reliable. To insure reliable and timely ingest of the Level II radar data at the University of Iowa, their site was moved higher up on the IDD topology last year, and they began feeding from the University of Wisconsin (a top-level relay node). With the new topology, the LDM/IDD has performed well in delivering the data in a timely manner despite the significant increase in the volume of the radar data. Since Unidata also hosts a top level feed for Level II radar data, the Unidata Program Center began to implement the University of Iowa developed algorithms for metadata generation to accompany the installation and operational use of the University of Minnesota *MapServer* (described below).

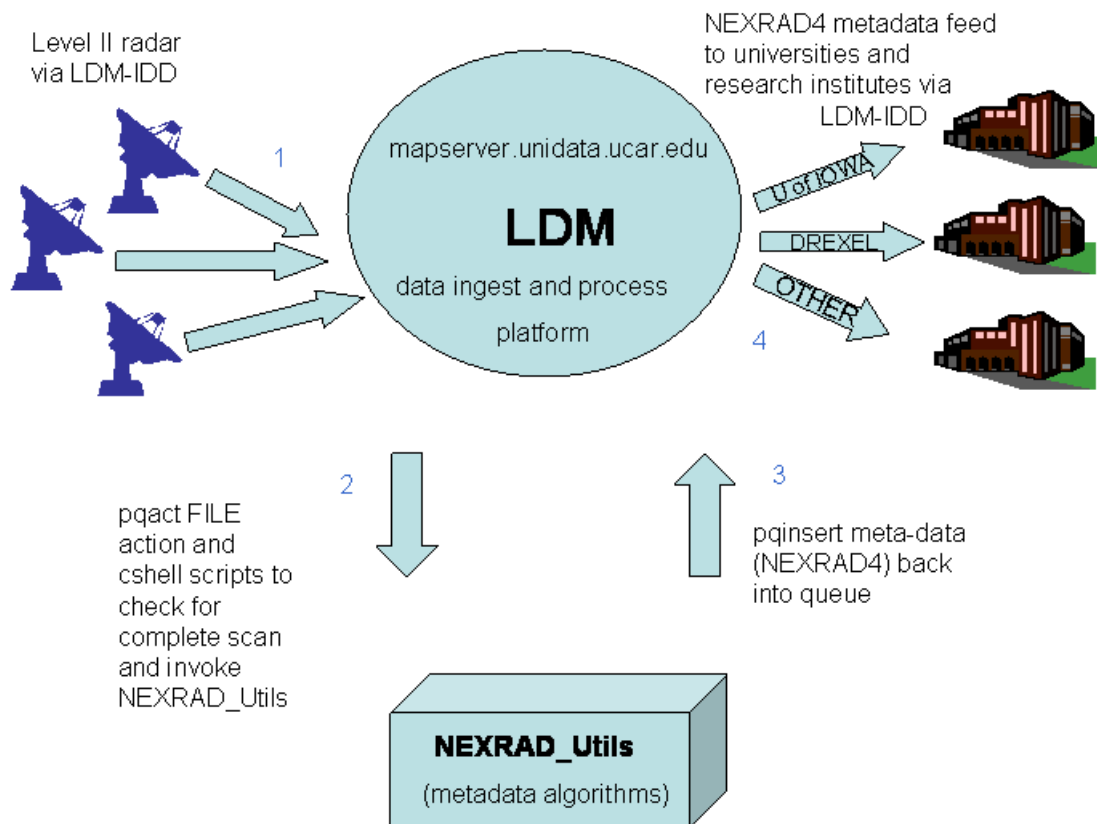
2. NEXRAD4 (HYDRO) Feed and Generation of Level II Metadata

During the past year, Unidata created a new type of data feed for the hydrology community. Unlike traditional data feeds that distribute only the data in real-time, the new feed called NEXRAD4 or HYDRO augments *value-metadata* along with the original data. As a result, the NEXRAD4/HYDRO feed is a significant step to facilitate data mining and knowledge extraction from the vast volumes of radar data.

Researchers at the University of Iowa are continuing to develop additional metadata descriptions as well as new algorithms for metadata generation. As those algorithms become ready for operational deployment, Jeff Weber, an associate scientist supported by this award, has been implementing those algorithms and augmenting the Level II radar data feeds through a new LDM/IDD HYDRO feed. Unidata and University of Iowa PIs mutually agreed last year that Unidata will begin generating the value-added metadata locally and then distribute the metadata and Level II files in the new NEXRAD4/HYDRO feed.

Presently, the metadata generated from all 158 sites in the Level II radar feed are being distributed (with the Level II radar data) via an experimental (EXP) channel of the IDD data stream. Earlier this year, Drexel University became one of the first hydrology community site outside of this project to receive data from the HYDRO feed. It should be noted that we are currently working to create a more permanent HYDRO feed of the data stream for the benefit of a larger hydrologic community.

The following schematic shows the data flow in the generation metadata and the distribution of associated data and metadata in the HYDRO feed.



3. NEXRAD-ITR MapServer at Unidata

Past experience with the hydrologic community indicated they generally use PC-based operating systems, and these are most often Windows machines. The hydrologic community is also strongly tied with GIS applications. With this in mind, it was deemed that a map server would enhance the ease of access and usability for the hydrologic community.

During the past year, we developed, tested, and deployed a dedicated map server at the Unidata Program Center, enabling the availability of the *MapServer* to Unidata's large user community. The installation of the University of Minnesota *MapServer* at Unidata has gone well and continues to be tested internally before making it publicly available. To that end, the UPC staff are currently investigating performance and scalability issues for deployment to a larger community, along with the selection of products and data overlays for integration into the *MapServer*. We anticipate providing a range of useful products from this project to the Unidata and hydrology communities.

4. New Methods for Accessing and Visualizing NEXRAD Level II and III Data

In addition to distributing the rich metadata to the community via the IDD, Jeff is exploring ways to integrate the resulting metadata into THREDDS catalogs and provide data access via the THREDDS Data Servers. The THREDDS Data Server (TDS), implemented in 100% Java, is a web server that provides metadata and data access for scientific datasets, building on existing technologies and protocols:

- THREDDS Dataset Inventory Catalogs are used to provide virtual directories of available data and their associated metadata. These catalogs can be generated dynamically or statically.
- The NetCDF-Java library reads NetCDF, OPeNDAP, and HDF5 datasets, as well as other binary formats such as GRIB and NEXRAD into a Common Data Model (CDM), essentially an (extended) netCDF view of the data. Datasets that can be read through the NetCDF-Java library are called CDM datasets.
- TDS can use the NetCDF Markup Language (NcML) to modify and create virtual aggregations of CDM datasets.
- An integrated server provides OPeNDAP access to any CDM dataset. OPeNDAP is a widely used, subsetting data access method extending the HTTP protocol.
- An integrated server provides bulk file access through the HTTP protocol.
- An integrated server provides data access through the OpenGIS Consortium (OGC) Web Coverage Service (WCS) protocol for any "gridded" dataset whose coordinate system information is complete.
- An integrated NetCDF Subset Service allows subsetting of THREDDS datasets, using earth coordinates (such as latitude/longitude bounding boxes and date ranges) and returns NetCDF binary files, XML or CSV ASCII.

To enable remote access to NEXRAD Level II data, enhancements were made to the NetCDF-Java library to read NEXRAD data into a "Common Data Model". As a result,

the Common Data Model now provides uniform access, using HTTP and OPeNDAP, to NetCDF, HDF5, GRIB 1 and 2, and NEXRAD datasets. The WCS extension to the TDS is also of significance to the hydrology community, because of their need to overlay rainfall and other information on top of specific watersheds and basins. The Common Data Model has made it possible to access model grids via the WCS web services approach. As a result, hydrologists in CUAHSI (David Maidment, personal communication) are now able to access precipitation forecasts from the North American Mesoscale model (which now uses the WRF-NMM model) over specific hydrologic basins and watersheds, as well as incorporating the data into GIS clients. It should be added that the TDS development work is carried out using funds other funding sources and are being leveraged in this project.

Unidata is also currently investigating distributing in real-time and providing remote access to datasets from the National Mosaic and Quantitative Precipitation Estimation (NMQ) project, a joint initiative between the National Severe Storms Laboratory, Federal Aviation Administration, National Weather Service/Office of Hydrologic Development, the Office of Climate, Water and Weather Services and the University of Oklahoma Cooperative Institute in Mesoscale Meteorological Studies.

The NMQ serves as a testbed for research, development, evaluation and science to operations infusion of high resolution 3D Mosaic of multiple radars and radar networks for model assimilation and aviation applications, Quantitative Precipitation Information (QPI) including Multiple Sensor Quantitative Precipitation Estimation (MSQPE) and Very Short Term Quantitative Precipitation Forecasts (VSTQPF) for the monitoring and warnings of floods and flash floods and in support of comprehensive hydrology and ecosystem modeling. The NMQ system ingests data from a number of sensors and products from various sources, including WSR-88D radars, rain gauges, satellite IR images, Rapid Update Cycle model output, National Weather Service Hydro Estimator hourly precipitation and NWS Stage IV precipitation data. Using these data, 3D mosaics of reflectivity, precipitation and several other products are created at 31 vertical levels and at a horizontal resolution of 1 km x 1 km.

While this is a leveraged activity, we believe these datasets will be of considerable value to the hydrology community.

On the analysis and visualization end, advances were made to Unidata's Integrated Data Viewer (IDV) to use the netCDF Java library to read in NEXRAD Level II and Level III. Using the netCDF Java library, both Level II and Level III datasets can now be read from local disk as well as from remote THREDDS servers and visualized by the IDV. With these advancements, archived data from the National Climatic Data Center can now be downloaded and visualized using the IDV. In addition, the GEMPAK analysis and display application can also visualize Level II radar data.

Unidata has also continued to collaborate with NCDC on their OPeNDAP and THREDDS implementations to provide access to the metadata archives at NCDC as well as the Level II radar data.

5. Publications

AGU Fall Meeting

IN13E-08

TI: Towards Better Utilization of NEXRAD Data in Hydrology - an Update

AU: * Kruger, A, et.al.

EM: anton-kruger@uiowa.edu

AF: The University of Iowa, IIHR-Hydroscience and Engineering 100 SHL, Iowa City, IA 52242 United

States

Unidata CommunitE-letter

Using NEXRAD Data in the Hydrologic Community, Witold Krajewski and Anton Kruger, Unidata CommunitE-letter, Volume 4, number 4,

August 2007

<http://www.unidata.ucar.edu/newsletter/2007aug/index.html>

6. Project Personnel

1. Dr. Mohan Ramamurthy (PI, cost-shared for up to 1 month and not supported by this award)
2. Jeff Weber, Associate Scientist (budgeted for support by this award for up to 3 months/year)
3. Jennifer Oxelson, Web Developer (budgeted for support by this award for 10% of her time)
4. Mike Schmidt (System Administrator, who charges only a small fraction of his time on this project)