Unidata 2013:
A Transformative Community Facility
for the Atmospheric and Related Sciences

Annual Report for Award No. 0833450
for period 12/1/2012-11/30/2013

November 2013

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1 Introduction

The year 2013 was highly successful for the Unidata Program. Unidata not only continues to fulfill its core mission to provide data, tools, and support for the atmospheric science and related communities, but also continues to develop and enhance its tools and capabilities and provide leadership in cyberinfrastructure to serve an ever-broadening community of users.

During the past year, there were many notable activities and accomplishments that had a positive impact on the community across the breadth of the program, a few of which are highlighted in this report. In addition, Unidata Program Center staff prepared and submitted a new five-year core funding proposal to the National Science Foundation, which we are happy to report was approved and funded. That proposal outlines the direction of the program over the coming years, as envisioned by the Unidata staff, governing committees, and community members. Plans for the coming years are guided by the strategic visioning exercises we began in 2012, and attempt to move the program towards achievement of Unidata's mission and vision:

Unidata's Mission:

To transform the geosciences community, research, and education by providing innovative data services and tools.

Unidata's Strategic Vision:

Geoscience at the speed of thought through accelerated data discovery, access, analysis, and visualization

You can review Unidata's five-year funding proposal elsewhere on the Unidata web site.

1.1 About the format of this report

The format of this year's report is different from the format used in the past several years. The 2013 Annual Report marks the first year that the National Science Foundation required us to submit the material through the Research.gov web interface. (In previous years, we submitted a formatted document to NSF.) The information that follows is the same as that submitted to the NSF, with some slight formatting changes.

2 Accomplishments

2.1 What are the major goals of the project?

This report details activities that took place under the five-year core-funding award "Unidata 2013: A Transformative Community Facility for the Atmospheric and Related Sciences" (NSF 0833450). The proposal for that funding award grouped the Unidata program's activities into the following six thematic focus areas:

1. Broadening participation and expanding community services

2. Advancing data services

3. Developing and deploying useful tools

4. Enhancing user support services

5. Providing leadership in cyberinfrastructure

6. Promoting diversity by expanding opportunities

The following sections detail the program's activities and results during the period December 2012 – November 2013.

2.2 What was accomplished?

Major Activities

Real-time Data Distribution

Unidata's Internet Data Distribution (IDD) system allows educators and researchers to subscribe to any of the more than 30 streams of geoscience data that interest them. The IDD system comprises over 500 machines at more than 200 sites running Unidata's Local Data Manager (LDM) software to receive (and in many cases retransmit) real-time weather data. (Note that there are several organizations and projects using the LDM to move substantial amounts of data without reporting statistics to Unidata.)

The IDD system now ingests more than 315 Gigabytes of data each 24 hours, and computers operated by the Unidata Program Center push more than 13 Terabytes of data to downstream IDD participants on an average day. In addition to real-time data distribution, Unidata provides mechanisms for accessing some archived data sets and case studies. Some Unidata member sites also archive our data streams in raw, encoded form.

Software Development Activities

Ongoing enhancements to Unidata software packages provide new functionalities and capabilities for accessing, analyzing and visualizing new types of data that the UPC routinely makes available for use by the education and research community. There were significant advancements in 2013 for the Integrated Data Viewer, netCDF software libraries, Common Data Model, and THREDDS Data Server technologies; see the

"Technologies or Techniques" subsection of Section 2 below for details on software releases across Unidata's technology offerings.

Software Training Workshops

Each year, the Unidata Program Center organizes training workshops, conducted by UPC software developers, on its software and data systems. The workshop topics include Unidata's display and analysis packages, data access and management tools, and software for cataloging, browsing, and accessing remote data and metadata. The 2013 training workshops introduced a class on using the Python scientific programming language with Unidata THREDDS Data Server, which was quite popular.

The 2013 training workshops were attended by 39 participants representing a wide range of organizations, including universities, government agencies, research organizations, and the private sector.

Community Support

One of the Unidata Program Center's core activities is to provide technical support to community members using Unidata technologies for education and research. UPC software developers handle user support directly, together responding to an average of more than 300 technical support questions each month. Developers also create product documentation, training materials, and provide hands-on training workshops each year.

Participation at Scientific Meetings

Several Program center staff members attended the 93rd Annual Meeting of the American Meteorological Society in Austin, TX. The Unidata booth in the AMS exhibition hall featured demonstrations of the current versions of the National Weather Service's AWIPS II software and Unidata's Integrated Data Viewer, all of which were enthusiastically attended.

Program center staff also participated in the annual AMS Student Conference and Career Fair, which had a record 639 registered attendees. Unidata Users Committee Student Representative Stefan Cecelski was on hand to discuss Unidata with interested students at Unidata's table at the Career Fair, as were several Unidata Program Center staff members.

In addition to the AMS meeting in January 2013, UPC staff members participated in scientific meetings of the European Geophysical Union (EGU), the American Geophysical Union (AGU), the International Conference on Marine Data and Information Systems (IMDIS), and Open Geospatial Consortium (OGC) Technical Committee meetings.

Cyberinfrastructure Leadership

Unidata community members look to the UPC not only for technological solutions, but for guidance on emerging trends in cyberinfrastructure and to represent their

interests in collaborations with standards bodies and organizations that work across scientific disciplines. As standards-based solutions have become increasingly important to the conduct of international science, Unidata has assumed a central role in identifying and articulating standards, conventions, and data formats. Unidata's standards efforts have enabled ongoing collaboration with dozens of international organizations –

especially those represented in the OGC MetOceans, Earth System Science, and Hydrology Domain Working Groups.

Community Service Activities

The UPC undertakes a wide variety of activities aimed at fostering a shared vision for and community ownership of the program and encouraging community input into its operation and direction. Bringing the community and stakeholders together to share knowledge and address problems that are important to them through meetings, workshops, conferences, and other venues is a key aspect of Unidata's community service mission, as are efforts to disseminate information of interest to community members.

In addition, each year Unidata makes funding available to community members for the purchase of computer hardware designated for expanding community access to geoscience data or testing leading-edge Unidata technologies. The Unidata Community Equipment Awards encourage new members from diverse disciplinary backgrounds in the geosciences to join the Unidata community, and help existing members continue their active participation so as to enhance the community process. See "2013 Unidata Community Equipment Awards" under Significant Results below for additional details.

Specific Objectives

2013 Unidata Community Equipment Awards

The Unidata Community Equipment Awards program funds new geoscience departments to join the Unidata community and provides resources that allow existing members to continue and enhance their participation. It is regarded by the community as one of the best mechanisms for Unidata to promote diversity, as past awards tend to favor small institutions. Each year, the UPC sets aside $100K to fund the program.

Since the UPC took over the program from NSF in 2003, this grants program has provided funds for 69 projects at 52 universities. Since this program has a large, positive impact on university departments, it continues to receive very strong support from the NSF and the community.

For 2013 awards, special consideration was given to proposals that:

- Include installation of either the THREDDS Data Server or a RAMADDA server (or both) to share data relevant to furthering Unidata's mission with the community at-large

- Include installation of a prototype AWIPS II EDEX server, to share data relevant to furthering Unidata's mission with the community at-large.

We received a total of twelve responses to the 2013 RFP and funded six of them, partially or fully. (Two proposals were later combined into a single grant.) The high success rate for award proposals should encourage others who may have hesitated to apply in the past.

University	Project
Colorado State University	Expanding the use of real-time and archive

PI: Russ Schumacher	weather and climate data and Unidata tools
Stony Brook University PI: Brian Colle	An upgrade of the meteorological laboratory in support of education, research, and broader participation in the Unidata community
Texas A&M International University PI: Kenneth Tobin	Installing LDM, RAMADDA, THREDDS and IDV at TAMIU
University of Miami PI: Brian Mapes	Installing a full Unidata technology suite at the University of Miami
University of Wisconsin at Madison PIs: Wayne Feltz, Jonathan Martin	Increasing AWIPS II Capabilities at the University of Wisconsin and creating a UNIDATA community THREDDS/RAMADDA server

For highlights of the 2012 Community Equipment Awards, see the supporting file unidata_equip_award_highlights.pdf (attached). To see the wide range of previous recipient institutions and for more information on this year's awardees see:

http://www.unidata.ucar.edu/community/equipaward/

Key outcomes or Other achievements

International Standards

In February 2013, the Open Geospatial Consortium membership adopted the Climate and Forecast (CF) extension to the existing OGC Network Common Data Form (NetCDF) Core Encoding Standard version 1.0 The CF-netCDF Data Model is a flexible data model widely used in climate and weather forecast systems and in other geoscience communities. The CF conventions define metadata that provide a definitive description of what the data in each netCDF variable represents, and the spatial and temporal properties of the data. This enables users of data from different sources to decide which quantities are comparable, and facilitates building applications with powerful extraction, regridding, and display capabilities. The

CF-netCDF Data Model extension to the existing OGC Network Common Data Form (NetCDF) Core Encoding Standard version 1.0 is the latest step in a longer-term plan for establishing CF-netCDF as an OGC standard for binary encoding.

Community Collaboration

One of the strengths of the Unidata program is the close collaboration we have been able to maintain with members of the atmospheric and related sciences community. Working directly with community members allows Unidata to respond to real community needs.

 Unidata's two governing committees, composed of representatives from member universities, are perhaps our most important mechanism for community interaction. Community members serve on the committees for three-year terms, with a subset of each committee rotating off each year. In 2013, we welcomed the following new members to our governing committees:

Sen Chiao, Users Committee

Dr. Sen Chiao is an Assistant Professor in the Meteorology and Climate Science department at San Jose State University, where he is the faculty advisor for the mesoscale dynamics and modeling group. He has taught courses in Remote Sensing for Meteorology, Marine Meteorology, Numerical Weather Prediction, Mesoscale Meteorology, Planetary Boundary Layer Meteorology, as well as Dynamics and Synoptic Meteorology. His primary research interest is in numerical modeling with emphasis on tropical cyclone genesis.

Brian Mapes, Policy Committee

Dr. Brian Mapes is a Professor of Meteorology & Physical Oceanography at the Rosenstiel School of Marine and Atmospheric Science, University of Miami. He received his doctorate in Atmospheric Science from the the University of Washington, and spent time as a research scientist at NOAA's Climate Diagnostics Center before joining the University of Miami faculty in 2004. His work focuses on atmospheric convection, in the larger context of tropical weather and climate. His approach is to begin at a tangible local scale, building up to a global picture through quantitative analysis and abstraction. Dr. Mapes teaches courses on Weather and Climate, Atmospheric Dynamics, Convective and Mesoscale Meteorology, and Applied Data Analysis.

Sepideh Yalda, Policy Committee

Dr. Sepideh Yalda is a Professor of Meteorology at Millersville University. She received a doctorate in Meteorology from St. Louis University, and joined the Millersville faculty in 1997. Since 2009 she has also served as Director of the Center for Disaster Research and Education at Millersville. Dr. Yalda coordinates the Master of Science in Emergency Management program.

George Young, Policy Committee

Dr. George Young is a Professor of Meteorology at Pennsylvania State University. He received a doctorate in Atmospheric Science from Colorado State University, and has put his research efforts into a wide variety of topics including atmospheric dynamics, boundary layer turbulence, mesoscale meteorology, remote sensing, statistical meteorology, and weather risk.

Kimberly Hoogewind, Users Committee

Kimberly Hoogewind is beginning a two-year term as the Users Committee's Graduate Student Representative. She is pursuing a PhD in atmospheric science from Purdue University, studying with Dr. Mike Baldwin and Dr. Jeff Trapp. Her research interests include numerical weather prediction, data mining, and climate change and extreme weather, in particular the effects of anthropogenic climate change on future severe weather patterns.

2.3   What opportunities for training has the project provided?

As outlined in the Major Activities section above, providing software training for Unidata community members is a core activity of the Unidata Program Center. In addition to annual software training workshops hosted at the Program Center, staff

developers routinely participate in regional software training workshops sponsored by member universities. In 2013:

- UPC staff participated in a Pan American Advanced Studies Institute (PASI) an workshop on 27 May - 7 June at the Escuela Naval de Cadetes Almirante Padilla (National Naval Academy) in Cartagena, Colombia. The workshop was attended by 35 early career scientists from the U.S. and 12 countries in Latin America (Barbados, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Jamaica, Mexico, Puerto Rico and Trinidad).

- UPC staff participated in Unidata Regional Workshop sponsored by the Department of Meteorology and Climate Science at San José State University March 14-15, 2013. The workshop focused on how large datasets are accessed, organized, and interpreted under the use of free-and-open sharing of Earth System data.

Individual Unidata Program Center staff members took advantage of training and professional development activities including participation in conferences such as the UberConf software development conference in Denver, CO.

2.4 How have the results been disseminated to communities of interest?

Unidata communicates with its community in a variety of ways:

- Through interaction with our governing committees, who represent a diverse group of member universities. Through participation in scientific and technical meetings, which give staff members the opportunity to discuss technical issues directly with community members.

- Through participation in standards-crafting activities like those of the Open Geospatial Consortium.

- Through regional software workshops sponsored by member universities, along with training workshops held annually at the Program Center.

- Through Unidata's web site (http://www.unidata.ucar.edu) and News@Unidata blog (http://www.unidata.ucar.edu/blogs/news/), along with social media outlets including Facebook, Twitter, and Google+.

2.5 What do you plan to do to accomplish the goals?

The period from December 2012 through November 2013 was the final year of the five-year funding award. Unidata was granted a no-cost extension of the award, and during the extension period expects the activities described here to transition seamlessly to the activities we will undertake as a result of a new five-year funding award (Unidata 2018: Transforming Geoscience through Innovative Data Services, NSF 1344155) to begin in December 2013.

3 Products

3.1 Journals

Lazarus, S., C. J.; Baxter, M.; Hanks, A.; Whittaker, T.; Tyle, K.; Cecelski, S.; Geerts, B. & Ramamurthy, M. (2013). 2012 Unidata Users Workshop Navigating Earth System Science Data. Bulletin of the American Meteorological Society. 92 (10), .

3.2 Conference Papers and Presentations

Arms, S. C.; Oxelson Ganter, J.; Weber, J. & Ramamurthy, M. K. (2013). A Web-based Tool for Translating Unstructured Data from Dataloggers into Standard Formats. 29th Conference on Environmental Information Processing Technologies, American Meteorological Society Annual Meeting. Austin, TX.

Arms, S. C.; Weber, J. & McWhirter, J. (2013). Interactive, collaborative case studies using the IDV and RAMADDA. 22nd Symposium on Education, American Meteorological Society Annual Meeting. Austin, TX

Chastang, J.; Ho, Y. & Arms, S. C. (2013). The Integrated Data Viewer (IDV) feature updates. 29th Conference on Environmental Information Processing Technologies, American Meteorological Society Annual Meeting. Austin, TX.

Fisher, W. (2013). Information Visualization Techniques for Effective Cross-Discipline Communication (Poster). European Geophysical Union 2013 General Assembly. Vienna, Austria.

Ramamurthy, M. (2013). Data-enabled Science: Challences and Opportunities. '67th Interdepartmental Hurricane Conference. College Park, MD.

Rew, R. (2013). Experience with netCDF-4 chunking. 'UCAR SEA Software Engineering Conference. Boulder, CO

Rew, R. (2013). Making earth science data more accessible: experience with chunking and compression. 29th Conference on Environmental Information Processing Technologies, American Meteorological Society Annual Meeting. Austin, TX.

3.3 Technologies or Techniques

UPC developers are continually enhancing Unidata software packages. Ongoing enhancements to Unidata software packages provide new functionalities and capabilities for accessing, analyzing and visualizing new types of data that the UPC routinely makes available for use by the education and research community.

The following updates were released in the past year:

netCDF Libraries

4.3.0: This major release provided improved DAP support, improved parallel-netCDF support, improved Windows support in Cygwin and MSYS-based environments, integration with CMAKE, allowing for Microsoft Visual Studio-based builds, and numerous bug fixes.

NetCDF-Java library / TDS

4.3.14: The first public release incorporating a complete rewrite of GRIB1 and GRIB2 file handling, intended to correct problems that exist in version 4.2's handing of tables (especially in non-NCEP files) and time interval coordinates.

4.3.15: Incorporated new chunking strategies for writing netCDF-4 files, enhancements to GRIB-reading functionality, and a variety of bug fixes.

4.3.16: Included enhancements to GRIB feature collections, along with a variety of bug fixes and library updates.

4.3.17: Changes in this version consist of bug fixes and library updates.

4.3.18: Changes in this version consist entirely of bug fixes.

4.3.19: Changes in this version consist entirely of bug fixes.

GEMPAK

6.8: Included a major fix for GDPVSF, along with updated library support and a reorganization of the Unidata source distribution.

6.10: Introduced additional table entries and grid types, along with updated library support and bug fixes.

Integrated Data Viewer (IDV)

4.0u1: This was the first IDV release to take advantage of the netCDF-Java version 4.3 library. It included automatic redirection of data request from motherlode.ucar.edu to therdds.ucar.edu, as well as automatic renaming of GRIB variables.

4.1: A major release incorporating the new netCDF-Java 4.3.19 library. This release also included display updates,enhancements to contour labeling, and changes to the default data catalogs.

Local Data Manager (LDM)

6.11.2: Modified the handling of subscriptions by downstream LDM hosts.

6.11.4: Fixed and improves the defense against a denial-of-service attack.

6.11.5: Removed the libxml2 package from the LDM installation package to reduce the size of the LDM package and improve security.

6.11.6: Removed the PNG or ZLIB packages from the LDM installation package to reduce the size of the LDM package and improve security.

McIDAS-X

v2013.1: A cumulative set of bugfixes and enhancements in Unidata McIDAS-X including all SSEC v2013.1 modifications, some small Unidata MCGUI tweaks, and all previous updates.

AWIPS II

In April, 2013, the first UPC-release of AWIPS II (version 13.2.1) was provided for a limited number of university beta-testers. In September Unidata welcomed additional sites to join the beta-testing program.

Rosetta

Rosetta is a web-based service that provides an easy, wizard-based interface for data collectors to transform their datalogger-generated ASCII output into Climate and Forecast (CF) compliant netCDF files. Rosetta is in an alpha testing stage as part of the ACADIS project.

3.4   Websites

Title	Unidata Program Web Site
URL	http://www.unidata.ucar.edu
Description	In addition to ongoing maintenance of and inclusion of new materials on Unidata's community website (http://www.unidata.ucar.edu), the website underwent significant revision aimed at making the site useful on a wider range of devices and enhancing its visual integration with other UCAR Community Programs web sites.

3.5   Audio or Video Products

Six video tutorials dealing with the Integrated Data Viewer (IDV) were created by UPC developers and are available on YouTube (http://www.youtube.com/user/unidatanews)

4   Impacts

4.1   What is the impact on the principal discipline of the project?

Unidata's predominant impetus is service to the university atmospheric and related sciences research and education community. As shown in Table 4 of the Unidata Snapshot (attached as unidata_snapshot.pdf in Section 2), Unidata's products and services are in use by over 3000 organizations including nearly 2500 academic institutions in over 200 countries (see a map online at http://www.unidata.ucar.edu/about/usage/index.html#map). Many dozens of research labs, national and international agencies, weather services around the world, and projects large and small benefit from Unidata technologies. Unidata's scientific software libraries are routinely used by scientists and service providers in most geoscience disciplines; they are embedded in more than 20 commercial and 100 open source software packages.

4.2   Impact on Research

A survey of papers published between 2008 and 2012 in journals of the American Meteorological Society shows 110 citations of Unidata software and data services. In the same period, an additional 52 papers published in journals of the American Geophysical Union cited Unidata software and data services. A review of citations reported by the Google Scholar search engine revealed similar results. Between 2008 and 2012, Unidata software and data services were cited 1150 times in the full range of scholarly literature encompassed by the search engine.

In 2012, the UPC surveyed longstanding academic community members to find what types of research Unidata software and data services are enabling today. Among the comments were:

> *We use Unidata software/facilities quite extensively from getting global model analysis/forecast fields in real time for high-resolution coupled model development and forecasting experiments, getting satellite data for analysis, and to display our model results in IDV.*

> *Several Professors are involved with field programs that have intensive observing periods that include aircraft, etc. Unidata-provided weather and model information is integral (anywhere from minor to absolutely essential) to the field program and operational decisions. In addition, software and real-time data provided by Unidata is part of thepost-field program analysis.*

4.3   Impact on Education

Unidata software and data services are in use at nearly 750 U.S. colleges and universities and more than twice that many in other countries. Unidata reaches across geoscience disciplines to provide data and tools to researchers, educators, and students in the atmospheric sciences, hydrology, and oceanography fields, among others. From research universities to community colleges, Unidata provides timely support and service to the academic organizations that are training the next generation of geoscientists. In the process, it is estimated that more than 100,000 users are exposed to products generated using Unidata software and systems, and more than three quarters of all graduate students in the atmospheric and related sciences now use software provided by Unidata.

For example, Pennsylvania State University considers Unidata's IDD feed, along with analysis/display software packages including GEMPAK/NAWIPS and IDV, to be vital tools for research, instruction and outreach. Unidata software allows students to explore current and past weather scenarios as part of upper-level undergraduate meteorology courses, and is also used for the generation of graphics for the popular and publicly-available Penn State electronic map wall.

Unidata strives to promote diversity in the geosciences by supporting use of its technologies in a wide array of educational institutions. Unidata software and data services are used at universities in all 31 EPSCoR jurisdictions, including many institutions that have a large number of students from underrepresented communities.

4.4 What is the impact on other disciplines?

Although our core activities focus on serving scientists and educators in the atmospheric and related sciences, virtually every project Unidata undertakes has a broader impact on the geosciences community and society at large. This section touches on some of the ways Unidata enables research in the geosciences, enhances education in universities and colleges, provides support to our collaborators and users of our software, and strives to build a larger and more active community.

Unidata-developed cyberinfrastructure, in addition to being used widely in universities to advance education and research, also provides a substrate for other stakeholders in federal agencies, the private sector, and many non-governmental and international organizations. For instance, many data services in NOAA, NWS, NASA, USGS, DOE, DOD, NCAR, ECMWF, EUMETSAT, CMA, and CPTEC are built on the formats, software, and data systems that Unidata has developed. Unidata systems and technologies are integral parts of numerous large-scale projects, including SuomiNet, THORPEX, GEON, EarthScope, IPY, and others.

4.5 What is the impact on the development of human resources?

Unidata's software training activities (described in Section 1) benefit the geosciences community at large by building a base of knowledgeable users. Workshop attendees pass the skills they have gained to others at their own institutions, multiplying the effect of Unidata's training efforts.

4.6 What is the impact on information resources that form infrastructure?

The annual Unidata Community Equipment Awards program, described in more detail in Section 1, has as one of its goals the improvement of shared cyberinfrastructure resources. 2012 Community Equipment Awards resulted in the establishment of community-accessible THREDDS and RAMADDA servers, and laid important groundwork for community adoption of the NWS' emerging AWIPS II system.

In addition, Unidata's ongoing efforts to improve data storage and delivery technologies such as netCDF, the THREDDS Data Server, and the Local Data Manager contribute to a healthy and growing geoscience cyberinfrastructure.

4.7 What is the impact on technology transfer?

Unidata's netCDF software is used in two dozen commercial packages, including ArcGIS, Matlab, and IDL. It is also mentioned in 48 U. S. patents. In addition, Unidata's data systems and software packages are by several dozen companies.

4.8 What is the impact on society beyond science and technology?

Society is grappling with abrupt climate change and its effects, extreme weather and impacts, and water cycle changes. In response to these "grand challenge" problems, the geoscience community is shifting its emphasis from pure disciplinary research to a more

balanced mix that advances disciplinary knowledge while looking to apply research results to interdisciplinary questions touching both science and society. Useful data and tools provided by Unidata can allow working scientists to provide better decision support to their own communities. Giving educators better tools and data to teach students about Earth system processes can lead to a better-informed and citizenry.