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Preview of Award 1344155 - Annual Project Report

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Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1344155
Project Title:	Unidata 2018: Transforming Geoscience through Innovative Data Services
PD/PI Name:	Mohan K Ramamurthy, Principal Investigator
Recipient Organization:	University Corporation For Atmospheric Res
Project/Grant Period:	04/01/2014 - 03/31/2019
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Submitting Official (if other than PD/PI):	Mohan K Ramamurthy Principal Investigator
Submission Date:	02/17/2016
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Mohan K Ramamurthy

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Accomplishments

* What are the major goals of the project?

This report details activities that took place under the five-year core-funding award "Unidata 2018: Transforming Geoscience through Innovative Data

Services” (NSF 1344155). The proposal for that funding award grouped the Unidata program’s activities into the following four strategic goals:

- Enabling widespread, efficient access to geoscience data
- Developing and providing open-source tools for effective use of geoscience data
- Providing cyberinfrastructure leadership in data discovery, access, and use
- Building, supporting, and advocating for the geoscience community

Note: While Unidata approaches these goals from a variety of directions, the activities and results described below reflect a special focus on adapting Unidata technologies to take advantage of new capabilities emerging from the cloud computing paradigm.

The following sections detail the program’s activities and results during the period April 2015 – March 2016.

* What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?

Major Activities:

This section summarizes Unidata’s main focus areas during the second year of the five-year grant. Additional information on the outcome of these activities can be found under “Significant Results,” below.

Data Distribution

Helping researchers and educators acquire and use real-time meteorological data was one of the Unidata program’s founding goals, and continues to be one of the core activities of the program. By participating in Unidata’s Internet Data Distribution (IDD) system, educators and researchers can subscribe to one or more of the 30 streams of current data that interest them. The IDD system comprises over 550 machines at 250+ sites running Unidata’s Local Data Manager (LDM) software to receive (and in many cases retransmit to “downstream” institutions) real-time weather data.

(Note that a number organizations use the LDM to move substantial amounts of data but do not report statistics to Unidata. Among these organizations are NOAA, NASA, USGS, USACE, the governments of Spain and South Korea, private companies, and others.)

In July 2015, Unidata coordinated with the National Centers for Environmental Prediction (NCEP) to include the Global Forecast System (GFS) model output with 0.25-degree resolution in the IDD Cooperative Opportunity for NCEP Data Using IDD Technology (CONDUIT) data stream. Addition of the 0.25-degree GFS increased the volume of GFS data by roughly a factor of four. The higher-resolution GFS data was also made available for remote access from Unidata’s THREDDS Data Server.

Cloud Technology Experiments

Finding ways to leverage the strengths of the cloud computing environment to enhance universities’ access to geoscience data and tools is one of Unidata’s highest priorities during the period of this award. During the second year of the award, UPC staff have made significant progress toward these goals, establishing successful cloud-based data distribution mechanisms (notably AWIPS II EDEX servers and THREDDS Data Servers), working with cloud service providers to enable access to historical and real-time data, and creating demonstrations of cloud-based application services (most notably for remote access to the IDV visualization software). The program continues to build relationships with cloud technology providers, and has received research access to commercial cloud computing resources from Microsoft and Amazon Web Services.

Software Development

Developing free, open-source software to help researchers and educators manage their access to and use of geoscience data is one of Unidata’s primary activities. During the second year of this award, Unidata’s development staff has mixed ongoing work toward well-defined, long-term development goals for existing technologies with newer technologies and initiatives aimed at addressing our community’s evolving technology needs. In particular, the growing popularity of the Python programming language in geoscience researchers’ and educators’ scientific workflows has prompted UPC staff to focus additional efforts on ensuring that Unidata technologies mesh well with Python-based tools and processes. The Siphon and MetPy projects are examples of Unidata efforts that are gaining traction with the expanding segment of the community that is embracing Python.

In the second year of this award UPC developers have focused their efforts on using the Docker containerization technology to deliver software to scientists in a more reliable and effective way. While these technologies are evolving quickly, Docker has become a clear community favorite. Unidata’s embrace of this popular and increasingly capable component of the modern computing environment has the potential to remove some of the barriers to adoption of Unidata technologies, especially at universities where IT resources are scarce.

Community Building

Unidata sponsors or participates in a wide variety of events and activities that bring community members together to share ideas and techniques, aids in participation, or enlarges the existing community.

Perhaps most important to the ongoing success of the Unidata program is a community-based governance structure. Unidata calls on members of its core academic community to serve on its two governing committees: the Unidata Users Committee and the Unidata Strategic Advisory Committee. Users Committee members are charged with serving as an interface between the Unidata Program Center and individuals and organizations who use Unidata data streams and services, reporting on challenges they face and shedding light on the scientific and technical environment in which they work. Members of the Strategic Advisory Committee are asked to weigh in on the larger, longer-term trends and issues they see evolving in the geosciences, guiding the program to areas where community leadership is needed and valuable. These stable avenues of communication between the UPC and the community it serves have been instrumental in helping the program meet its members evolving cyberinfrastructure needs.

While community representation via governing committees helps the Unidata program understand and serve its community, it is also valuable to bring community members themselves together. To this end, the UPC and Unidata Users Committee have traditionally organized triennial meetings of community members. The most recent Unidata Users Workshop, held in June 2015, brought together 80 community members to learn from each other, share their techniques for using a range of technologies to teach and do research, and discuss their ideas about ways Unidata can better serve the community. Unsurprisingly, the role of the Python programming language in community activities was a major topic of exploration.

In a more focused way, Unidata's Community Equipment Awards program serves to build capacity at member universities, allowing them to better serve their own students and the Unidata community at large. In the second year of the current award, three of the five Equipment Award grants are supporting universities in making the National Weather Service's AWIPS II system available to students, building students' and early career scientists' familiarity with the software being used by operational forecasters. In addition, one of the Equipment Award recipients from the first year of this award was able to extend its pilot project to use cloud resources to enable an AWIPS II system for a second year.

Additionally, UPC staff members participate actively in scientific societies and other organizations that serve our community members. Unidata participates actively in the American Meteorological Society, the American Geophysical Union, the European Geosciences Union, the ESIP Federation, the Open Geospatial Consortium, Research Data Alliance, and the NSF EarthCube initiative, among others. Staff activities in association with these groups range from highly technical work with scientific data formats and software development issues, to member assistance and support, to capacity-building for other organizations.

Finally, at the end of the second year of this award, UPC staff worked with the Unidata Users Committee to create the 2016 Unidata Community Survey. The survey was conducted online; 260 responses from the United States and 24 other countries were collected. UPC staff members are analyzing the survey results and plan to share them with Unidata's governing committees and the community at large in the spring of 2016.

Specific Objectives:

Significant Results:

This section lists some of the most significant results attained as a result of the work described in the "Major Activities" section above.

Data Distribution

The volume of observational data and model output delivered to Unidata community members and institutions in near real-time continues to grow. As of January 2016, Unidata's Internet Data Distribution (IDD) cluster nodes is handling volumes averaging roughly 26 Terabytes per day, up from roughly 16 Terabytes in early 2015.

A significant portion of this increase is attributable to the addition of NCEP Global Forecast System (GFS) model output with 0.25-degree resolution into the IDD system's CONDUIT data feed. In preparation for the addition of this model output, UPC staff worked closely with community institutions who serve as IDD relay nodes to ensure that their systems were prepared for the increase in data volume. The 0.25-degree resolution model output began flowing in late July 2015, with very few problems reported by community members as a result.

Using resources provided by a Microsoft research grant, Unidata has established an AWIPS II Environmental Data EXchange (EDEX) server on the Microsoft Azure cloud service. Access to this server is being made available to Unidata community sites, allowing them to use or test the AWIPS II CAVE client software without the need to maintain a local EDEX server. Unidata's cloud-based EDEX server is being used by more than 200 users each month, able to support multiple simultaneous connections from multiple universities at the same time, serving approximately 1 GB per day of data on average.

Unidata staff have worked in collaboration with Amazon Web Services on a portion of NOAA's Big Data Project, making a

historical archive of all NEXRAD Level II radar data collected between 1991 and the present day available to universities and the public via a variety of access mechanisms including a THREDDS Data Server and direct access to Amazon's S3 cloud-based storage.

Cloud Technologies

As part of the 2014 Community Equipment Awards program, UPC staff successfully installed an instance of the AWIPS II EDEX server in the cloud for Embry-Riddle Aeronautical University. Both the Prescott, AZ and Daytona Beach, FL campuses have access. Embry-Riddle and the UPC have also collaborated with the Phoenix, AZ and Flagstaff, AZ Weather Forecast Offices on this project, and Unidata supplied a small amount of additional funding to continue Embry-Riddle's experiment through 2015. As a result, UPC staff were able to join the PI on the Embry-Riddle project in presenting results at the 2016 American Meteorological Society annual meeting and demonstrating the use of the AWIPS II CAVE client running on a mobile device communicating wirelessly with a cloud-based EDEX server.

Unidata worked closely in collaboration with Amazon Web Services (AWS) on the NOAA Big Data Project. UPC staff were able to assist AWS in transferring NOAA's historical archive of NEXRAD Level II data to an AWS S3 data storage system, and to help AWS configure systems to continue archiving real-time NEXRAD data to the same system. Additionally, working with resources acquired through an AWS research grant, Unidata was able to effectively co-locate a publicly-accessible THREDDS Data Server with the NEXRAD data, demonstrating that geoscience data can be stored and served from related cloud-computing resources.

Using Docker containerization technology, UPC staff have demonstrated a process by which an existing client-side software application (Unidata's Integrated Data Viewer (IDV), in this case) can be configured and run from a remote, cloud-based server. This workflow makes it possible for existing client-side software packages to be easily configured on a cloud-based server and accessed interactively via an ordinary web browser. While the initial demonstration of this workflow (CloudIDV) focused on the Integrated Data Viewer, UPC developers are working to generalize the process such that other legacy software packages could be containerized and run using a similar workflow. Containerization of legacy software also has the potential to help preserve and archive specific configurations of scientific software, so that future researchers could easily recreate the software environment used in the original experiment.

Software Development

AWIPS II and GEMPAK:

Unidata's AWIPS II efforts have been focused on creating a modified version of the package tailored for the needs of the university community. In late 2015 version 14.4.1 of the AWIPS II package was made available to university users. Unidata's tailored version is currently running at approximately 20 universities.

IDV:

Unidata's Integrated Data Viewer version 5.1 was released in March 2015. Two minor update versions were provided before the release of version 5.2 in August 2015.

LDM:

Local Data Manager versions 6.12.7 through 6.12.14 were released 2015. Additionally, work on a "multicast" version of the LDM employing virtual circuit technology has been under way as part of a two-year research grant in collaboration with the University of Virginia.

NetCDF:

The netCDF-C library version 4.4.0 was made available in January 2016, and the netCDF-FORTRAN library version 4.4.3 was released shortly thereafter.

Python:

The Siphon project is a collection of Python utilities for downloading data from Unidata data technologies. It is still in an early stage of development, and is not yet considered stable, but it was used successfully during Unidata's 2015 software training workshop. UPC staff are the primary contributors to the MetPy project, which is a collection of Python tools for reading, visualizing and performing calculations with weather data. UPC staff are also contributors to the netcdf4-python project, which is a Python interface to the netCDF C library. Staff are also actively working on contributions to the popular matplotlib Python module.

Rosetta:

An instance of the Rosetta server is now hosted at the UPC for testing purposes. Rosetta now has the ability to publish converted files directly to RAMADDA and the ACADIS Gateway

TDS:

The THREDDS Data Server versions 4.6 through 4.6.3 were released in 2015, and version 4.6.3 is currently running on

Unidata's TDS server at thredds.ucar.edu. THREDDS Version 5.0 is in a testing phase; release is planned for 2016.

Community Building

The 2015 Unidata Users Workshop took place June 22-25 at UCAR's Center Green facility in Boulder, Colorado. The workshop's theme — Data-Driven Geoscience: Applications, Opportunities, Trends, and Challenges — drew participants from across the atmospheric and other geosciences communities. Attendees took part in a series of presentations and hands-on exercises that explored how trends in cloud computing and Python-based workflows affect how scientists interact with and manage ever-growing data volumes.

Attendees had the opportunity to discuss topics with the presenters in greater depth following the day's presentations. This year's workshop also reprised the popular poster session that has been a highlight of several recent workshops.

During the second year of the award, Unidata solicited atmospheric science researchers or research groups to participate in a pilot project (supported by supplemental funding from NSF) aimed at designing and implementing robust data management workflows that satisfy NSF and other federal funding agency requirements. Three community members with differing data management needs have volunteered to participate in the project:

Professor Larry Oolman of the University of Wyoming
 Professor Richard Clark of Millersville University
 Professor Gary Lackmann of North Carolina State University

Initial conversations with all three participants have taken place, and plans to address and document their varying data management needs are under development.

Key outcomes or Other achievements:

This section briefly notes some Unidata activities and achievements not listed in the "Significant Results" section, above.

As of January 2016, Unidata's IDD cluster delivers roughly 26 Tbytes/day to downstream IDD sites. UPC staff have been active participants in OGC efforts to create international standards for the use of netCDF and the CF metadata conventions. Partly as a result of these efforts, in 2015 the OGC approved the *CF-netCDF 3.0 encoding using GML Coverage Application Schema* as an Implementation Standard. Unidata continues its involvement in the the Ocean Data Interoperability Platform (ODIP) project. UPC staff are involved in EarthCube projects in collaboration with George Mason University, the University of Texas, OPeNDAP, and IRIS. In addition, Unidata is leading a collaborative effort for the funded activity *EarthCube IA: Collaborative Proposal: Advancing netCDF-CF for the Geoscience Community*. Program Center staff participated in numerous scientific conferences in the second year of the award, including:

American Meteorological Society summer and annual meetings
 American Geophysical Union annual meeting
 European Geosciences Union annual meeting
 ESIP Federation meeting
 EarthCube All Hands meeting
 National Data Service meeting
 Research Data Alliance Sixth Plenary meeting

Supplemental funding from the National Science Foundation in the second year of this award is also allowing Unidata to embark on two new community-focused projects. The first solicited atmospheric science researchers or research groups to participate in a pilot project aimed at designing and implementing robust data management workflows that satisfy National Science Foundation and other federal funding agency requirements. Unidata sought for and found three community members with varying data management needs to participate in the project. The second supplemental project is aimed at easing the transition to use of the Python programming language by creating a corpus of online training materials geared toward the geoscience community's specific needs. At the time of this report, the second supplemental project is in the planning stages.

In preparation for the launch of NOAA's Geostationary Operational Environmental Series satellite-R (GOES-R), now scheduled for late 2016, UPC staff have been creating plans to manage the very large volume of observational data expected from this satellite.

After input from the Unidata Users Committee, UPC staff have developed a Teaching Resource facility in RAMADDA. The Teaching Resource Network allows educators to store and collaborate on geoscience educational materials in a federated network environment. Currently, the Teaching Resource Network brings together material from the University at Albany, Central Michigan University, the University of Miami, NOAA ESRL, and Unidata.

* What opportunities for training and professional development has the project provided?

Users of Unidata software and data rely on the UPC for comprehensive support services. UPC software developers provide hands-on software training workshops to community members each year. In 2015, the workshops were attended by 26 participants from the university, government, and commercial spheres. UPC staff provided software training for an additional 27 participants at a regional workshop at the University of South Florida in April 2015.

Unidata's summer internship program invited student Josh Clark to spend the summer working at the Unidata Program Center in 2015. A report on the various projects Josh undertook while at the Program Center is available at:

<http://www.unidata.ucar.edu/blogs/news/entry/unidata-intern-wraps-up-summer>

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

Unidata communicates with community members in a variety of ways, both electronic and otherwise. The most important channels of communication for the Program during the proposal period have been:

Participation in scientific organizations, conferences, and meetings, including the American Meteorological Society, the American Geophysical Union, European Geosciences Union, the Open Geospatial Consortium, and the Earth Science Information Partners (ESIP) Federation. Twice-yearly meetings of Unidata's two governing committees. The governing committees are made up of representatives of Unidata's academic community, and serve as a means of two-way communication between the Program and the geoscience educators who form our core community. The 2015 Unidata Users Workshop brought 74 community members together for four days of seminars, hands-on learning, and discussion. While the majority of the workshop sessions were led by community members, UPC staff also presented work being done at the Program Center, and, there was ongoing discussion about how Unidata could assist community members in navigating the changing technology landscape.

In addition to in-person forums like these, Unidata staff publish their results and discuss ongoing research in academic journals, and through Unidata's own web site and News@Unidata blog.

* What do you plan to do during the next reporting period to accomplish the goals?

The Unidata program will continue to undertake the activities described in the "Plan of Action" section of the grant proposal for this award. For reference, this document is available on the Unidata web site (described as our "Five-Year Plan"):

http://www.unidata.ucar.edu/publications/Unidata_2018.pdf

(The five-year plan PDF is also included as a supporting file.)

An Operating Plan for the next reporting period will be submitted separately, along with a budget justification.

As a result of the supplemental funding for ADDIT and OTP projects described in Major Activities (Community Building) above, the Program Center will engage in additional activities not described in the "Plan of Action." These include:

Ongoing work with community members who have chosen to participate in the ADDIT project. Work will include refining these participants' data management processes, assisting with implementation of Unidata data management technologies where desired, and documenting the resulting process for community benefit.

Creation of Python-focused online training materials as part of the OTP project. Plans call for the creation of video training materials, written training materials, and a community-accessible repository of code examples and other training materials.

Supporting Files

	Filename	Description	Uploaded By	Uploaded On
(Download)	Unidata_2018.pdf	Unidata five-year plan of action	Mohan Ramamurthy	02/16/2016

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Products

Books

Book Chapters

Domenico, Ben (2015). NetCDF and Related Information Sources. *Mapping and Modeling Weather and Climate with GIS* Armstrong, L. and Butler, K. and Settelmaier, J. and Vance, T. and Wilhelmi, O.. ESRI Press. Redlands, CA. 227-232. Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = No

Inventions

Journals or Juried Conference Papers

Licenses

Other Conference Presentations / Papers

James, Curtis N. and Weber, J. and Wodall, G. R. and Klimowski, B. A. (2015). *A Cloud-Based Mobile Weather Server to Support Emergency Response Meteorology Training and Operations*. Proceedings, 24th Symposium on Education, 95th AMS Annual Meeting. Phoenix, AZ. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Weber, Jeff and J. McWhirter, J. and Dirks, D. (2015). *A New Approach to Sharing Curriculum and Data*. Proceedings, 24th Symposium on Education, 95th AMS Annual Meeting. Phoenix, AZ. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

James, Michael (2015). *AWIPS II for the University Community: Unidata Program Center Update*. Proceedings, 31st Conference on Environmental Information Processing Technologies, 95th AMS Annual Meeting. Phoenix, AZ. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Fisher, Ward (2015). *Accessing NetCDF4 Data in Python*. Proceedings, Fifth Symposium on Advances in Modeling and Analysis Using Python, 95th AMS Annual Meeting. Phoenix, AZ. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Fisher, Ward (2014). *Bringing Legacy Visualization Software to Modern Computing Devices via Application Streaming*. Geophysical Research Abstracts Vol. 16, EGU2014-3114, 2014 EGU General Assembly 2014. Vienna, Austria. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Downs, Robert and Lenhardt, W. Christopher and Robinson, Erin and Davis, Ethan and Weber, Nicholas (2014). *Community Recommendations for Sustainable Scientific Software*. Proceedings, 2nd Workshop on Sustainable Software for Science: Practice and Experiences (WSSSPE2). New Orleans, LA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Gallagher, James and Davis, Ethan (2014). *DAP4 Overview*. NOAA Environmental Data Management Workshop. Silver Spring, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

May, Ryan M. and Arms, S. (2015). *Exploring Client-Server Data Visualization using IPython and WebGL*. Proceedings, Fifth Symposium on Advances in Modeling and Analysis Using Python, 95th AMS Annual Meeting. Phoenix, AZ. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Weber, Jeff and McWhirter, J. and Dirks, D. (2014). *Free and Innovative Teaching Resources for STEM Educators*. Proceedings of the poster session at AGU 2014 Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Davis, Ethan and Caron, John (2014). *Issues Converting GRIB to netCDF/CF*. NOAA Environmental Data Management Workshop. Silver Spring, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Davis, Ethan (2014). *Scientific Data Formats: NetCDF*. DCERC Data Curation Workshop. Boulder, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Davis, Ethan (2014). *THREDDs, netCDF, and Other Software Tools*. PO.DAAC Technology Seminar. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Young, Joshua and Lenhardt, W. C. and Parson, M. and Benedict, K. (2014). *Taking Another Look at the Data Management Life Cycle: Deconstruction, Agile, and Community*. Proceedings of the poster session at AGU 2014 Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Weber, Jeff (2015). *Typhoon Haiyan*. Proceedings, Major Weather Events and Societal Impacts of 2014, 95th AMS Annual Meeting. Phoenix, AZ. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ramamurthy, M. and Fisher, W. and Yoksas, T. (2014). *Unidata's Vision for Transforming Geoscience by Moving Data Services and Software to the Cloud*. Proceedings of the poster session at AGU 2014 Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Davis, Ethan (2014). *Unidata: Helping the University Community Access and Use Real-time Weather Data*. Lightning talk, Open Water Data session at the America Water Resources Association Annual Conference. Tysons Corner, VA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Davis, Ethan and Young, Joshua and Ramamurthy, Mohan and Dirks, Douglas (2015). *Unidata: Helping the University Community Acquire and Use Real-time Weather Data for Education and Research*. Proceedings, ESIP Winter meeting 2015. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ho, Yuan and Chastang, J. and Yoksas, T. and Murray, D. (2015). *Using Progressive Resolution to Visualize large Satellite Image dataset*. Proceedings, 31st Conference on Environmental Information Processing Technologies, 95th AMS Annual Meeting. Phoenix, AZ. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

Other Publications

Patents

Technologies or Techniques

Thesis/Dissertations

Websites

Unidata Website

<http://www.unidata.ucar.edu/>

The Unidata website serves as a primary mechanism for Unidata Program Center staff to provide information about the program to community members and the general public. The site:

provides information about the program overall

provides descriptions of individual projects that are currently underway, along with summaries of completed projects
describes data available via the Internet Data Distribution system, and provides information on how to access that data
collects historical documents including funding proposals, annual and final project reports, and archives of governing committee records
serves as a gateway to Unidata's technical support system, and provides access to archived support information
allows community members to download software developed by the program
links to current program information and community news via the News@Unidata weblog

Unidata YouTube Channel

<https://www.youtube.com/user/unidatanews>

The Unidata YouTube channel serves as a conduit for video tutorials for Unidata software packages. While many of the video tutorials are created by Unidata Program Center staff, we also publish tutorials created by community members.

The YouTube channel also makes available video recordings of talks and presentations that are part of the Unidata Seminar Series.

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Participants/Organizations

What individuals have worked on the project?

Information about Unidata Program Center Staff has been removed from the public version of this report.

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
University of Wisconsin	Academic Institution	Madison, WI

Full details of organizations that have been involved as partners:

University of Wisconsin

Organization Type: Academic Institution

Organization Location: Madison, WI

Partner's Contribution to the Project:

Financial support

In-Kind Support

Facilities

Collaborative Research

More Detail on Partner and Contribution:

What other collaborators or contacts have been involved?

Nothing to report

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Impacts

What is the impact on the development of the principal discipline(s) of the project?

A survey of papers published in 2015 in journals of the American Meteorological Society shows 48 articles containing citations of Unidata software and data services. (Of these, 35 refer to Unidata software packages but make no mention of the Unidata program itself.) In the same period, an additional 30 papers published in journals of the American Geophysical Union cited Unidata software and data services.

What is the impact on other disciplines?

A review of citations reported by the Google Scholar search engine since the beginning of 2015 indicated that Unidata software and data services were cited 1514 times in the full range of scholarly literature encompassed by the search engine. Of these, 1241 refer to Unidata software packages but make no mention of the Unidata program itself. This correlates with anecdotal evidence of widespread use of Unidata products (especially netCDF) beyond the communities traditionally served by Unidata.

What is the impact on the development of human resources?

Because providing data and tools for use in educational settings is a core part of Unidata's mission, the bulk of the program's activities can be thought of as helping develop human resources in the geosciences. Of special note are the following metrics, collected in late 2015:

Number of U.S. universities receiving software: 256

Number of universities outside the U.S.: 597

Number of attendees of 2015 training workshops: 26

What is the impact on physical resources that form infrastructure?

Each year, the UPC sets aside \$100,000 to fund the Unidata Community Equipment Awards program. The program provides funds to encourage new geoscience departments to join the Unidata community and to allow existing members to continue and enhance their participation.

Projects funded in 2015 include:

University/PI	Project Title
Plymouth State University Brendan Hoch	Transitioning to the IDV-CAVE: Improving Classroom Technology for Meteorology
University of California, San Diego Tom DeFanti	Flash I/O Network Appliance (FIONA) connected to the 40Gb/s PRISM network at UC San Diego for worldwide access to the IDD
University of Nebraska, Lincoln Adam L. Houston	A Standalone EDEX Server and Enhanced Local IDD/LDM Infrastructure at the University of Nebraska - Lincoln
University of Wisconsin, Milwaukee A. Clark Evans	Deployment of AWIPS II at the University of Wisconsin-Milwaukee
Western Kentucky University Joshua D. Durkee	Expanding Unidata Visualization and Data Analysis for Innovative Meteorological Education at Western Kentucky University

A complete list of projects funded under the Community Equipment Awards program and the many creative applications of Unidata software and systems by the recipient universities to advance education and research is available online at <http://www.unidata.ucar.edu/community/equipaward/>.

What is the impact on institutional resources that form infrastructure?

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. Unidata undertakes a variety of activities with the goal of building a vibrant community in the geosciences and beyond. The following are a sampling of these activities:

Scientific Society Meetings

Unidata staff are active in convening sessions and making presentations at AGU, AMS, and EGU meetings as well as at other national and international conferences and workshops. UPC staff members helped create AGU's Earth and Space Science Informatics session in 2004, and the EGU ESSI Division was formally launched in 2008 with the active involvement of UPC staff. Both sessions have grown significantly.

Open Geospatial Consortium

Unidata has been an active participant in the Open Geospatial Consortium (OGC) Technical Committee, with a focus on establishing netCDF as a standard data format for use by the geospatial community. As the official UCAR representative to the Technical Committee, Unidata participates in 3-4 technical committee meetings per year to ensure that Unidata and UCAR needs are met in the emerging international standards.

In June 2015, Unidata hosted a set OGC Technical Committee meetings at UCAR facilities in Boulder, Colorado. In December 2015, the consortium approved the *OGC CF-netCDF 3.0 encoding using GML Coverage Application Schema*, an extension to the OGC CF-netCDF 3.0 encoding standard. Standards documents already adopted by the OGC are available at <http://www.opengeospatial.org/standards/netcdf>.

EarthCube Activities

Unidata's director (Mohan Ramamurthy) currently serves as the chair of the EarthCube Council of Data Facilities, and in that capacity, he serves on the EarthCube governance with membership on the Leadership Council. Between August 1, 2015 and November 30, 2015, he also served as a Co-Chair of the EarthCube Leadership Council.

Unidata participates in a variety of EarthCube activities, including collaboration on four awarded "Building Blocks" proposals. In addition, Unidata is serving as the lead organization for the funded collaborative "Integrative Activity" project *Advancing netCDF-CF for the Geoscience Community*.

What is the impact on information resources that form infrastructure?

The UPC coordinates the Internet Data Distribution system (IDD), in which hundreds of universities cooperate to disseminate earth observations via the Internet in near real time. As of early 2015, the traffic handled by servers operated by the UPC itself -- a fraction of the total IDD system -- was more than 26 Tbytes/day. While the "push" data services provided by the IDD system are the backbone of Unidata's data distribution services, the UPC also provides on-demand "pull" data services via THREDDS, ADDE, and RAMADDA data servers.

The UPC's data servers are not classified as "operational" resources, but they nonetheless have a 99.96% uptime record and are used heavily by educational sites that lack the resources to store IDD-provided data locally, or to operate their own data servers. UPC's servers are housed in a UCAR co-location computer facility for reliability, and share UCAR's Internet2/National Lambda Rail connectivity, which provides access to ample bandwidth for Unidata's needs.

The Unidata Local Data Manager (LDM) system includes network client and server programs designed for event-driven data distribution. It is the fundamental component of the IDD system. The LDM is used by hundreds of sites worldwide, and is integrated into the National Weather Service's AWIPS II package.

Unidata's Network Common Data Form (netCDF) is a set of freely-available, open-source technologies for efficiently storing scientific data. Ongoing development of netCDF has led to its wide adoption by the atmospheric sciences community, and it is especially popular among climate and ocean modelers. For example, model output datasets for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change must be submitted in netCDF format, using the associated Climate and Forecast (CF) metadata conventions. The resulting large base of netCDF users and data has led to support for the format in more than 80 open source packages and many commercial applications including ArcGIS, MATLAB, and IDL.

Unidata's THREDDS Data Server (TDS) allows for browsing and accessing collections of scientific data via electronic networks. Data published on a TDS are accessible through a variety of remote data access protocols including OPeNDAP, OGC Web Map Service (WMS) and Web Coverage Service (WCS), NetCDF Subset Service (NCSS), and HTTP. The TDS is widely used in the United States (by NOAA, USGS, NASA, and the Earth System Grid, for example) and internationally, and are part of the deep infrastructure on which next generation capabilities are being built by other organizations.

Additionally, many other tools build on the TDS (NOAA PMEL's LAS and Ferret-TDS, for example), and on Unidata's Common Data Model (CDM) on which the TDS is built.

Unidata's Integrated Data Viewer (IDV) is a 3D geoscience visualization and analysis tool that gives users the ability to view and analyze a rich set of geoscience data in an integrated fashion. The IDV brings together the ability to display and analyze satellite imagery, gridded data (such as numerical weather prediction model output), surface observations (METARs), upper air soundings, NWS NEXRAD Level II and Level III RADAR data, NOAA National Profiler Network data, and GIS data, all within a unified interface. The IDV integrates tightly with common scientific data servers (including Unidata's TDS) to provide easy access to many real-time and archive datasets. It also provides collaborative features that enable users to easily share their own data holdings and analysis products with others.

In addition, Unidata develops and supports numerous other software packages to help scientists and educators manage and use geoscience data:

AWIPS II: A weather forecasting, display, and analysis package currently being developed by the National Weather Service and the National Centers for Environmental Prediction. A modified version tailored for use by the university community was created and is supported by Unidata.

GEMPAK: The GEneral Meteorology PAcKage was developed by NCEP to display and analyze weather data. It is distributed to the university

community and supported by Unidata.

McIDAS: The Man-computer Interactive Data Access System (McIDAS) is a large, research-quality suite of applications used for decoding, analyzing, and displaying meteorological data. The older McIDAS-X system, developed by the University of Wisconsin's Space Science Engineering Center and supported by Unidata, is gradually being replaced by the IDV and by McIDAS-V (which is based on the IDV).

UDUNITS: Unidata's UDUNITS supports conversion of unit specifications between formatted and binary forms, arithmetic manipulation of units, and conversion of values between compatible scales of measurement.

Rosetta: The Rosetta project at the UPC is an effort to improve the quality and accessibility of observational data sets collected via datalogging equipment. The initial goal of Rosetta is to transform unstructured ASCII data files of the type commonly generated by datalogging equipment into the netCDF format, while minimizing disruption to existing scientific workflows.

What is the impact on technology transfer?

While Unidata's mission is to support the academic research and education community, all software packages developed by Unidata are freely available and open source.

What is the impact on society beyond science and technology?

Unidata technologies help community members reach out to their own communities, facilitating the provision of meteorological data and displays through dozens of popular web sites. For example, the College of DuPage, Iowa State University, University of Wyoming, University of Oklahoma, and University of Utah's Mesowest all make extensive use of Unidata services in their outreach. In addition, several museums (the Boston Museum of Science and San Francisco's Exploratorium among them) make use of either data or software provided by Unidata.

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Changes/Problems

Changes in approach and reason for change

Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them

Nothing to report.

Changes that have a significant impact on expenditures

Nothing to report.

Significant changes in use or care of human subjects

Nothing to report.

Significant changes in use or care of vertebrate animals

Nothing to report.

Significant changes in use or care of biohazards

Nothing to report.

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