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## **Award 1344155 - Annual Project Report**

### **Cover**

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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
Reporting Period:	04/01/2014 - 03/31/2015
Submitting Official (if other than PD\PI):	Mohan K Ramamurthy Principal Investigator
Submission Date:	02/10/2015
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:

1. Enabling widespread, efficient access to geoscience data
2. Developing and providing open-source tools for effective use of geoscience data

3. Providing cyberinfrastructure leadership in data discovery, access, and use
4. 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 2014 – March 2015.

**\* 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 first year of the five-year award. 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 weather data that interest them. The IDD system comprises over 600 machines at 230+ 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 of 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.)

The NOAAPort data feed, delivered by NOAA's Satellite Broadcast Network (SBN), is a major component of the IDD's data offerings. In late 2014, NOAA made changes to the system to increase its available bandwidth and facilitate its offering of a wider range of weather products to the community. While the new system became operational in the fall of 2014, UPC staff have spent considerable effort since that time working with community sites that receive the satellite broadcast to tune equipment for reliable reception of the enhanced data feed.

**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 first year of the award, UPC staff have worked to better understand available cloud technology offerings in the contexts of generating geoscience data products from existing data streams, operating data servers in cloud environments, and making end-user data analysis and visualization applications available via cloud-based application servers. The program has begun to develop relationships with a number of cloud technology providers, and has received access to cloud resources in Microsoft's commercial Azure cloud environment via research grants.

UPC staff have begun to tackle the technical challenges involved in moving portions of Unidata's data distribution and use technologies to cloud environments, and are also working to refine ideas about which elements of the generalized geoscience data workflow can benefit most from the use of cloud-based resources.

**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. While a large portion of Unidata's software development work during the first year of this award represents incremental progress towards well-defined, long-term development goals for existing technologies, a number of newer technologies and initiatives are shaping future goals. Of particular note is the growing influence of the Python programming language on geoscientists' software use in general and Unidata's activities in particular. As more geoscientists embrace Python as a cornerstone of their own scientific software workflows, UPC staff are working to make sure that Unidata technologies are easy to integrate into those workflows. Another notable addition to Unidata's technology mix is a class of software aimed at making remote computing resources (that is, cloud resources) easier to develop, deploy, configure, and administer. While technologies like Vagrant, Docker, CDash, and Jenkins will probably not become familiar to the majority of scientists and educators who use Unidata software and services, they will be important to those tasked with building, administering, and maintaining the computing environment they use. Integrating these new technologies, and being able to educate the Unidata community on how to use them effectively in their own computing environments, is an important goal for the program.

### **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, providing input on their data and software needs, 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. Planning for a Unidata Users Workshop in the summer of 2015 is well underway, and has been a significant activity during the first year of the current award.

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. The Equipment Awards are used by grantees to purchase computer hardware or cloud services that allow them to provide Unidata data streams or software at their own institutions and in some cases to other community members or the public. In the first year of the current award, five of the seven 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.

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, 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.

Specific Objectives:

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

Significant Results:

### **Data Distribution**

As a result of the changes to the NOAAPort feed in 2014, the UPC has been able to include model output from NCEP’s High Resolution Rapid Refresh (HRRR) model in the IDD.

UPC staff are working with community members to determine interest in and ability to receive GFS 0.25-degree model output in the CONDUIT data feed.

As a part of the program for university beta testers of the AWIPS II package, the UPC has set up an Environmental Data EXchange (EDEX) server on the Microsoft Azure cloud service. Access to this server is available only by participants in the beta testing program.

### **Cloud Technologies**

Unidata operates mid-sized instances in both the Amazon EC2 and Microsoft Azure west clouds for the purpose of generating image products for the IDD FNXRAD (NEXRAD Level III national composites) and UNIWISC (GOES-East/West image sectors) data streams. The EC2 instance is currently the primary source of the FNXRAD and UNIWISC data streams to IDD participants.

UPC staff are currently testing an instance of the THREDDS Data Server (TDS) running in the Microsoft Azure west cloud. The Azure cloud instance is currently serving data to AWIPS II CAVE clients at 44 organizations, including 13 universities.

UPC staff are using a mid-sized instance in the Microsoft Azure cloud to investigate running the IDV as a remotely-accessible application. RAMADDA has been installed and can generate non-interactive IDV displays.

Docker is a new cloud-centric technology that borrows the notion of containers from the shipping industry to facilitate installation and deployment of server side applications. UPC staff are exploring the possibility of creating Docker containers for easy distribution and installation of RAMADDA in a cloud environment.

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.

### **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 2014, the

existing beta-testing program was expanded to allow additional university participants, and the system is currently running at 22 universities.

IDV:

Unidata's Integrate Data Viewer version 5.0 was released in May 2014. Update version 5.0u1 and 5.0u2 were released in August and November 2014, respectively.

LDM:

Local Data Manager version 6.12.6 was released in September, 2014. Additionally, work on a "multicast" version of the LDM employing virtual circuit technology is under way as part of the second year of a two-year research grant in collaboration with the University of Virginia.

NetCDF:

The netCDF-C library version 4.3.2 was made available in April 2014, following two release candidates. Version 4.3.3 of the netCDF-C library is currently on its third release candidate; we expect to be able to release a final version in the spring of 2015. The netCDF-FORTRAN library version 4.4.0 was released in July 2014.

Python:

Prototyped an implementation of THREDDS' CDMRemote protocol to provide OPeNDAP-like access to data via Python APIs. Staff are exploring a version of the IPython notebook on a data server to demonstrate benefits of data-proximate, cloud-based analysis in Python. Staff are also actively working on a contribution to the popular matplotlib Python module to facilitate its use for making station plots (the biggest missing piece preventing use of matplotlib for day-to-day meteorological analysis).

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 version 4.5 is available as a development release, and is currently running on Unidata's TDS server at thredds.ucar.edu. Version 4.5.4 of the Common Data Model/NetCDF-Java is also available. The THREDDS team is also investigating the use of Docker technology to deploy instances of the TDS in cloud environments.

### **Community Building**

Program Center staff participated in numerous scientific conferences in the first 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

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.

Key outcomes or Other achievements: This section briefly notes some Unidata activities and achievements not listed in the “Significant Results” section, above.

- As of February 2015, Unidata’s IDD cluster delivers roughly 16 Tbytes/day to downstream IDD sites.
- Program Center staff are developing significant knowledge and expertise in cloud-based technologies. After the initial experiments undertaken in the first year of this award, our understanding of the technical and economic barriers to widespread use of cloud technologies for geoscience data delivery is greatly enhanced.
- UPC staff have been active participants in OGC efforts to create international standards for the use of netCDF and the CF metadata conventions.
- 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, and IRIS

**\* 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 2014, the workshops were attended by 48 participants from the university, government, and commercial spheres. UPC staff provided software training for an additional 21 participants at a regional workshop at the University of Miami.

Unidata’s summer internship program invited two students to spend the summer working at the Unidata Program Center in 2014. A report on the two students -- Florita Rodriguez from Texas A&M Univeristy in College Station, TX, and Shawn Cheeks from Marshall University in Huntington, WV -- and their projects is available at: [http://www.unidata.ucar.edu/blogs/news/entry/unidata\\_interns\\_wrap\\_up\\_summer](http://www.unidata.ucar.edu/blogs/news/entry/unidata_interns_wrap_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, 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.

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](http://www.unidata.ucar.edu/publications/Unidata_2018.pdf)

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## Products

### Books

### Book Chapters

### 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

Diaz, Arturo and Tobin, K. (2015). *Unidata Activities at Texas A & M International University*. Proceedings, 31st

Conference on Environmental Information Processing Technologies, 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 University Community Access and Use Real-time Weather Data*. UCAR Ignite. Boulder, CO. 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?

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Name

Most Senior Project Role

Nearest Person Month Worked

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

**International Collaboration:** No

**International Travel:** No

**Florita Rodriguez**

**Email:** florita@ucar.edu

**Most Senior Project Role:** Undergraduate Student

**Nearest Person Month Worked:** 3

**Contribution to the Project:** Student Intern - program development

**Funding Support:** NSF Grant S1344155

**International Collaboration:** No

**International Travel:** No

### 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?

NO

## Impacts

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

A survey of papers published in 2014 in journals of the American Meteorological Society shows 68 citations of Unidata software and data services. (Of these, 29 refer to Unidata software packages but make no mention of the Unidata program itself.) In the same period, an additional 22 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 2014 indicated that Unidata software and data services were cited 1405 times in the full range of scholarly literature encompassed by the search engine. Of these, 1117 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 2014:

- Number of U.S. universities receiving data or software: 322
- Number of universities outside the U.S.: 837
- Number of attendees of 2014 training workshops: 48

### **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 2014 include:

<b>University/PI</b>	<b>Project Title</b>
Embry-Riddle Aeronautical University Curtis N. James	Linux Server in the Cloud
Metropolitan State University of Denver Sam Ng	Enriching Meteorological Education in Undergraduate Courses Using Real-Time, High Resolution Datasets at Metropolitan State University of Denver
Pennsylvania State University Charles F. Pavloski	AWIPS II Prototype Testing Equipment for a Standalone Experimental EDEX/LDM/CAVE System for Penn State and Unidata
San Jose State University Sen Chaio	Acquisition of AWIPS II EDEX Server and CAVE Client in a Synoptic Weather and Analysis Classroom
University of Iowa Ibrahim Demir	Improving Visualization and Access to Radar Data using Unidata Tools for Flood Prediction and Management
University of Missouri Patrick S. Market	Increasing Access to AWIPS-II in the Unidata Community and at the University of Missouri

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; participation in the AGU ESSI program has grown to 571 abstracts for the 2014 Fall Meeting. The EGU ESSI Division was formally launched in 2008 with the active involvement of UPC staff; it has grown significantly, receiving 271 papers at the 2014 EGU Geosciences Meeting.

## **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 2014, Unidata negotiated for UCAR a renewed five year Memo of Understanding with the OGC, which provides voting membership for UCAR on the OGC Technical Committee. Unidata also agreed to host a set OGC Technical Committee meetings in June 2015. Also in 2014, the CF-netCDF Standards Working Group (SWG) was replaced by the NetCDF SWG, reflecting the fact that the OGC is considering additional netCDF conventions (e.g., netCDF-uncertainty) that are not yet CF conventions. Standards documents already adopted by the OGC are available at <http://www.opengeospatial.org/standards/netcdf>

## **GRIB/CF-netCDF Interoperability Efforts**

For several years, Unidata has been involved in efforts to “bridge the gap” between two of the most widely used data formats in the atmospheric sciences community: Gridded Binary (GRIB) and netCDF with the associated CF metadata conventions. In 2014, this activity included active participation in a workshop titled “Closing the GRIB/NetCDF gap,” hosted by the European Centre for Medium Range Weather Forecasts (ECMWF). Unidata's THREDDS team has already developed some of the technology necessary to enable conversion between the two formats, but additional collaboration between the numerous stakeholders will be required to make the two formats truly interoperable.

## **EarthCube Activities**

Unidata continues to participate in a variety of EarthCube activities, including collaboration on four awarded “Building Blocks” proposals. In addition, Unidata's director (Mohan Ramamurthy) has been selected as the chair of the Council of Data Facilities, and in that capacity, he serves on the EarthCube governance with membership on the Leadership Council.

## **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 16 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. It is being modified and supported for use by the university community 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.

## 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.