Preview of Award 1901712 - Annual Project Report

< Back

Cover | Accomplishments | Products | Participants/Organizations | Impacts | Changes/Problems

Cover

Federal Agency and Organization Element to Which Report is Submitted:	**4900**
Federal Award or Other Identifying Number Assigned by Agency:	**1901712**
Project Title:	**Unidata: Next-generation Data Services and Workflows to Advance Geoscience Research and Education**
PD/PI Name:	**Mohan K Ramamurthy, Principal Investigator**
Recipient Organization:	**University Corporation For Atmospheric Res**
Project/Grant Period:	**05/01/2019 - 04/30/2024**
Reporting Period:	**05/01/2022 - 04/30/2023**
Submitting Official (if other than PD\PI):	**Mohan K Ramamurthy Principal Investigator**
Submission Date:	**03/22/2023**
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	**Mohan K Ramamurthy**

Back to the top

Accomplishments

* What are the major goals of the project?

This report details activities that took place under the five-year core-funding award “Unidata: Next-generation Data Services and Workflows to Advance Geoscience Research and Education” (NSF 1901712). The proposal for that funding award grouped the Unidata program’s activities into the following focus areas identified in the Unidata Strategic Plan:

Managing Geoscience Data

Providing Useful Tools

Supporting People

Note: While Unidata has identified a number of different initiatives that fall under these broad categories of service, the activities and results described below share a continuing 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 2022 – March 2023.

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

Major Activities:

This section summarizes Unidata’s main activities during the fourth 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 35 streams of current data that interest them. Voluntary reporting from IDD system sites indicates that more than 530 machines at roughly 190 sites are 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 national weather services of Spain and South Korea, private companies, universities, and others.)

Unidata also facilitates data distribution by developing and supporting remote data access server technologies. While we do not require licensing or registration of the THREDDS Data Server (TDS), we have received information from thousands of unique IP addresses running the server. Of these, 159 are publicly accessible and providing data to other community members.

Finally, many community members connect to remote access servers managed directly by the Unidata Program Center (UPC). Unidata’s TDS, McIDAS ADDE, and AWIPS EDEX servers together provide more than two terabytes of data to remote users every day.

Unidata Science Gateway

Continuing to find ways to leverage the strengths of the cloud computing environment to enhance universities’ access to Earth Systems Science data and tools is one of Unidata’s highest priorities during the period of this award. During the fourth year of the award, UPC staff have made significant progress toward these goals, most notably through the expansion of the Unidata Science Gateway on NSF’s Jetstream Cloud, including implementation of Jetstream 2 features in the second half of the year.

One of the most exciting tools in the Unidata Science Gateway is a JupyterHub server, which allows students and educators to access Unidata-provided Jupyter notebooks illustrating atmospheric science concepts.The Unidata JupyterHub servers have proven to be the most popular feature of the Science Gateway; since the Gateway’s inception, they have been deployed for workshops and courses including:

Ongoing semester-long data science classes at Southern Arkansas University.

Courses and workshops associated with 22 different universities and organizations, accommodating more than 1200 students

Three separate workshops at the Annual Student Conference for the American Meteorological Society 2023

annual meeting, supporting 65 student participants.

As part of the Science Gateway, Unidata also operates cloud-based data distribution mechanisms (notably AWIPS EDEX servers and THREDDS Data Servers). Additionally, Unidata continues to work with cloud service providers to enable access to historical and real-time data.

More details on the Science Gateway are found in the other categories of this section.

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 fourth year of this award, Unidata's software 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.

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. In addition, in the fourth year of this award, the Program has enhanced its focus on outreach and provision of services to underserved communities within the atmospheric and related sciences.

In order to build better relationships with underserved communities, Unidata staff have begun participating in the Society for Advancement of Chicanos/Hispanics & Native Americans in Science (SACNAS) National Diversity in STEM Conference and the American Indian Science and Engineering Society (AISES) National Conference. Participation in the AISES conference has already borne fruit in the form of a collaborative effort between the Southwestern Indian Polytechnic Institute, Navajo Technical University, and Unidata. This group was awarded an NSF CISE Community Research Infrastructure grant (with Unidata as an unfunded collaborator), described in the Specific Objectives section of this report.

This year, Unidata's more traditional venues for community interaction and outreach have begun to return to something like normal as COVID-19 travel restrictions ease. Staff have been able to engage with community members at the AMS and American Geophysical Union (AGU) annual meetings, spending time talking about Program activities at UCAR's booth in both conferences' exhibition halls. The number of conversations we were able to have at these conferences has been affected by UCAR's decision to have a single exhibit booth for all UCAR programs; Unidata staff have fewer opportunities to interact with community members at the combined conference booth.

We maintain an online presence via the News@Unidata weblog and a variety of social media channels. All of these forms of interaction allow us to hear directly from community members about their data access and cyberinfrastructure issues and concerns.

We attribute the ongoing success of the Unidata program, in large part, to our 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.

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, the American Indian Higher Education Consortium (AIHEC), and the Research Data Alliance (RDA), 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:

Outreach to Underserved Communities

One area of special focus during the period of this grant has been Unidata's program of outreach to underserved communities. In order to build better relationships with communities that have not previously been heavily involved with

Unidata, in the fourth year of the award Unidata staff have continued participation in the SACNAS National Diversity in STEM Conference and the AISES National Conference.

Since 2021, Unidata has been collaborating with the Southwestern Indian Polytechnic Institute (SIPI) and Navajo Technical University (NTU) on NSF grant 2131301, “A Sovereign Network System for Environmental Monitoring, Data and Information Exchange, and Collaboration among Tribal Colleges and Universities.” As a part of that project, Unidata staff led an IDV+RAMADDA workshop for SIPI and NTU faculty and students in March 2022, and have been participating in the construction of meteorological instrument towers associated with the project at both institutions. Unidata's Science Gateway team has also taken part in this collaboration, working to enable forecasts over the Navajo Nation using the high-resolution WRF model running in the NSF Jetstream2 cloud.

Unidata's participation in the Sovereign Network project has opened doorways in other areas as well. The project team (including Unidata staff) is participating in an NSF-funded working group on data sovereignty (Earth Data Relations). The NSF project was also awarded an NCAR Collaborative Opportunities for Research Engagement award; funds from that grant will be used to put on an AIHEC partners workshop alongside a data workshop for the sovereign network. In 2023, Nebraska Indian Community College joined the sovereign network, and other Tribal Colleges and Universities have expressed interest in participating.

Additionally, with the goal of encouraging participation by underserved individuals and institutions, Unidata’s Diversity, Equity, and Inclusion committee has suggested and helped to implement structural changes to several Unidata programs, including modifications to how equipment awards, internships, workshops, and committee placements are announced and selected. The DEI committee and other interested staff members are working with the program Director to develop plans to address the results of UCAR’s 2021 Culture Survey, with similar goals.

Strategic Planning

Every five years, Unidata staff work closely with members of our governing committees to review the program's progress toward its stated goals and to chart a course for the coming years. This strategic planning process gives the Unidata community a chance to evaluate and adjust the program’s activities in light of ongoing changes in the technological and educational landscape.

In crafting the new strategic plan, we began by convening discussions with Unidata’s Strategic Advisory Committee to determine the broad outlines of the process and gather community input. A series of meetings and activities involving UPC staff and members of both the Strategic Advisory Committee and the Users Committee brought consensus on four high-level strategic goals for the program:

Providing Data and Tools
We want to ensure that researchers, educators, and students have fair and equitable access to Earth Systems Science data and software tools.

Reducing Barriers to Participation
We want to grow the Unidata community by providing access to high quality research and learning resources for data-centric Earth Systems Science.

Fostering Community Action
We want to act as a community hub to support readiness and adoption of new techniques and approaches to solve Earth Systems Science problems.

Innovating on Technology
We want to continue to guide the Earth Systems Science community toward innovative technical solutions

With these high-level community-focused goals in mind, we are continuing the planning process to define the specific strategies that will guide the Program’s concrete actions in the coming years.

Unidata Users Workshops

Unidata Users Workshops gather participants from across the community to discuss topics such as useful tools to access data and strategies for teaching computational concepts. The workshops bring together geoscience educators, pedagogical experts, and Unidata staff to discuss and share best practices for helping students engage in data-enabled science.

Traditionally, workshops are held every three years. Due to COVD-19 related uncertainty about prospects for workshop attendance, along with the strong preference for an in-person workshop, the Unidata Users Committee made the decision to delay the next Users Workshop until such time as physical gatherings were allowed. The next Unidata Users Workshop will be held in Boulder, Colorado June 5-8, 2023, with the theme: *Storytelling with Earth System Science Data:*

Challenges and Opportunities for Effective, Ethical, and Reproducible Science.

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 March 2023, Unidata’s Internet Data Distribution (IDD) clusters deliver roughly 90 Terabytes per day to downstream systems, up from roughly 70 Terabytes per day in 2022. The volume of data served via remote access methods (TDS, ADDE, and standard web servers) now averages approximately 2.3 Terabytes per day.

Because relaying data from the National Weather Service’s NOAAPort system is an important component of Unidata’s data services, UPC staff have created new technologies to improve the quality of this data stream. The project, nicknamed “blender,” merges NOAAPort broadcasts from geographically dispersed sites into a single stream that can be distributed via the IDD.

Unidata’s collaboration with the University of Wisconsin’s Space Science and Engineering Center (SSEC) continues to be productive and beneficial for the atmospheric science community. Unidata receives data from SSEC’s GOES-16/17/18 fanout servers, and SSEC feeds from Unidata’s GOES Rebroadcast (GRB) ingest system. This sharing of the feed streams has allowed SSEC and Unidata to minimize the effects of solar and terrestrial interference on our satellite data reception.

Cloud Technologies and the Unidata Science Gateway

Cloud-computing related activities during the fourth year of this award have focused on making Unidata Science Gateway resources more broadly useful and widely available. In addition to the activities described in “Major Activities,” above, Program Center staff have begun the process of revamping the Unidata Science Gateway website, with the goal of creating a community-directed virtual hub to enable learning and support research for current and future Earth Systems Science students, educators, and researchers.

As part of the Tribal College and University Sovereign Network project mentioned above, Unidata Program Center staff have been working closely with NTU and SIPI to develop capacity for environmental modeling for Tribal Nations. Science gateway development staff have made progress on providing the Tribal Nations with the capability to run the WRF model on the NSF Jetstream2 cloud through the use of a containerized version of WRF developed by the Developmental Testbed Center at NCAR RAL.

Additional discussion of Unidata’s Science Gateway work can be found in “Impact on institutional resources that form infrastructure,” below.

Software Development

MetPy:

The MetPy project, which is a collection of Python tools for reading, visualizing, and performing calculations with weather data, made its version 1.3 release in April of 2022, its version 1.4 release in January 2023, and a version 1.4.1 release in March 2023. These releases are notable for the ongoing community code contributions and general project participation, including contributions from 2022 and earlier Unidata summer interns.

Unidata’s MetPy developers continue to engage with the Pangeo project, a grass-roots effort to develop a community stack of tools serving the atmospheric, oceanic, land, and climate science. This engagement is enhanced by work on the Pangeo EarthCube award.

According to GitHub, 290 repositories and 32 open source packages depend on the MetPy project.

AWIPS:

During the summer of 2022, the Unidata AWIPS development team released version 18.2.1-6 of the Unidata AWIPS package. They then began actively developing a new Unidata AWIPS release of NWS’s version 20; which required significant changes to underlying technologies, including moving from Java version 1.8 to 1.11, and from Python version 2 to 3. A beta-test version of Unidata AWIPS 20.3.2-0.1 was made available to the community in February 2023.

Unidata’s efforts to make AWIPS available to the university community rely heavily on NSF Jetstream resources, which allow the Program Center to operate remotely-accessible AWIPS Environmental Data EXchange (EDEX) servers that are freely available to our university partners. With the transition to Jetstream2, the development team has begun

experimenting with a special, large virtual machine in Jetstream2 as a potentially more efficient technology for Unidata's community-accessible EDEX servers.

IDV:

The most recent version of Unidata's Integrated Data Viewer, version 6.1 update 2, was released in September 2022. Version 6.1 of the IDV, initially released earlier in 2022, is a major release of the software that features time series display of the PROBSEVERE Statistical models output that provide probabilistic guidance to forecasters on the likelihood of severe weather occurrence for convection in the near term; testing of Advanced Dvorak Technique (ADT) for longwave-infrared, temperature measurements; and updates to WRF grid diagnostic formulas to directly create the derived parameters such as: Equivalent potential temperature, relative humidity, Saturated Equivalent potential temperature, dewpoint, and others.

In collaboration with UCAR Center for Science Education and Computational Information Systems Laboratory, the project developed an extended IDV package for a Real-Time Weather Museum Touchscreen. This new real-time weather museum touchscreen display will undergo further usability testing to eventually join other weather and climate exhibits at NCAR's Mesa Lab in Boulder, CO, and at the NCAR-Wyoming Supercomputing Center Visitor Center in Cheyenne, WY.

LDM:

Local Data Manager versions 6.13.17, 6.14.1 through 6.14.5 were released in the past year. In addition, to mitigate issues with lost data frames from NWS NOAAPort broadcasts, the LDM team has developed a new technology to merge multiple broadcasts from geographically dispersed sites into a single, more nearly complete data stream. The data stream from this technology, currently nicknamed "blender," can then be processed into data-products that the LDM distributes. The blender technology is currently undergoing acceptance testing at the Unidata Program Center.

NetCDF:

The netCDF-C library version 4.9.0 was released in June of 2022, improving many NCZarr features, which provide netCDF compatibility with widely used key-value pair cloud storage systems (such as Amazon's S3, for example). Versions 4.9.1, and 4.9.2, which featured a number of smaller enhancements, were released in February and March of 2023, respectively.

TDS:

The THREDDS Data Server (TDS) version 5.4 was released in July 2022, and support for TDS versions 4.6.x (and earlier) was officially ended as of August 31, 2022. The TDS development team has been actively supporting organizations in upgrading their TDS instances from 4.6.x to the current release version.

Thanks to supplemental NSF funding during the third year of this award, Unidata was able to hire a software engineer to assist with TDS development and maintenance. During the fourth year of the award, the team was also able to replace a TDS developer who had left the UPC in 2020, bringing the team to three full-time engineers. This in turn has allowed the team to both make progress on software development milestones and better support the TDS user community.

Looking further ahead, the TDS team is developing a proof-of-concept version of the TDS based on the "microservices" architecture, with the goal of making the TDS more flexible, stable, and faster and easier to update. While transitioning the TDS from its current "monolithic" architecture to a microservices architecture will require significant effort and take time, the team expects the project to pay benefits by removing some of the existing barriers to community involvement in future TDS development. A microservices-based TDS will make it far easier for community members to contribute to the maintenance (and extension!) of this important community resource.

Key outcomes or Other achievements:

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

New Data Streams

In the fourth year of this award, the UPC began partnering with UCAR's COSMIC program to make radio occultation data provided by Spire Global available to the Unidata community via the IDD system. The new data products include atmospheric profile without moisture information, atmospheric occultation profile with moisture information included, WMO BUFR profiles, and absolute total electron content.

DeSouza Award

Each year, the Unidata Users Committee presents the Russell L. DeSouza award to a community member whose

energy, expertise, and active involvement enable the Unidata Program to better serve geoscience. Honorees personify Unidata's ideal of a community that shares data, software, and ideas through computing and networking technologies. The 2022 award was given to Ryan Abernathey of Columbia University. Dr. Abernathey's ongoing advocacy and efforts promoting the open availability of data and software in the geoscience community were seen by the Users Committee as tremendously influential and important.

Artificial Intelligence/Machine Learning (AI/ML)

In the fourth year of the award the UPC was able to hire an engineer to focus on artificial intelligence/machine learning learning topics with the end goal of reducing the "time to machine learning." The engineer hired in 2022 replaced another engineer who chose to leave Unidata and go to the private sector less than one year after joining the team.

Unidata's AI/ML program has begun a process of engagement with the Unidata scientific community to help us better understand their needs, and facilitate AI/ML-centric conversations between the Unidata community and internal software development teams. An initial focus has been to provide "scaffolding" for Earth Systems Science educators and students, so they better understand where machine learning techniques can be applied to their investigations.

EarthCube Projects

UPC staff are involved in the following ongoing EarthCube projects:

Pangeo: An Open Source Big Data Climate Science Platform (collaboration with NCAR/CISL, and Columbia University-Lamont-Doherty Earth Observatory)

Project Pythia: A Community Learning Resource for Geoscientists (collaboration with NCAR/CISL, NCAR/CGD, and the University at Albany, SUNY)

Scientific Conferences

Participation by Program Center staff at scientific conferences in the fourth year of the award began to return to pre-COVID-19 levels. Staff members were able to participate in-person and virtually in a range of conferences, including:

American Indian Science and Engineering Society National Conference

American Meteorological Society summer and annual meetings

American Geophysical Union annual meeting

European Geosciences Union annual meeting

ESIP Federation summer and winter meetings

Research Data Alliance Plenary meetings

Society for Advancement of Chicanos/Hispanics & Native Americans in Science National Diversity in STEM Conference

Open Geospatial Consortium Technical Committee meetings

Software Training

UPC staff conducts workshops focused on building skills with Unidata software packages in the context of the atmospheric sciences. During the fourth year of this award as COVID-19 travel restrictions began to ease, we have been able to hold a mix of in-person and virtual software training workshops. Workshops we were able to conduct included:

An AMS-sponsored virtual course entitled "MetPy for Quantitative Analysis of Meteorological Data" for 45 participants in March, 2022.

A workshop titled "Python for Atmospheric Science: Exploratory Data Analysis workshop" held at Colorado State University in October, 2022, serving 15 participants.

A workshop at the American Meteorological Society Student Conference, held in association with the AMS Annual Meeting in January, 2023. The workshop had roughly 56 attendees consisting of undergraduate, masters, and doctoral students.

An AMS Short Course titled "MetPy for your Data: Analyzing Meteorological Observations in Python" at the AMS Annual Meeting in January, 2023. The day-long Short Course had 38 attendees.

A workshop at the Southwestern Indian Polytechnic Institute (SIPI) in the spring of 2022 covering LDM

configuration, IDV visualizations, RAMADDA install and set-up. Faculty and students from both SIPI and the Navajo Technical University (NTU) participated.

A virtual IDV training workshop in March 2022 for five students at the Universitat de Barcelona in Spain using GFS datasets from Unidata's TDS server and the IDV's grid coverage feature to do analysis across data boundaries.

A virtual training workshop in May 2022 for researchers in Italy who are using the IDV to visualize 3D oceanographic observations in the Mediterranean sea for climate research.

A virtual IDV training workshop in September 2022 for 15 students in a radar class at Millersville University.

An an introduction of IDV and RAMADDA in October 2022 for Bahir Dar University in Ethiopia.

A virtual IDV training workshop in October 2022 for 20 students in a weather briefing class at Florida Tech University.

Two virtual LDM training workshops for National Weather Service personnel, serving 70 total participants.

UPC staff also produce two distinct series of asynchronous learning materials published on the web. The "MetPy Mondays" series, centered on the use of MetPy but including other general Python programming topics, has continued uninterrupted since 2018. MetPy Mondays brings a short discussion of a MetPy related topic to the Unidata developer's blog every Monday, most often with an accompanying short video tutorial. The series now has more than 275 installments on a wide range of MetPy related topics, and has been viewed more than 67,000 times in the past year. The "AWIPS Tips" series began publishing in mid-2021 to provide short explanations of AWIPS features and techniques; the 22 installments of the series include 11 video tutorials that have been viewed more than 6200 times in the past year.

Unidata's asynchronous learning management system (LMS) site — Unidata eLearning (https://elearning.unidata.ucar.edu/) uses the Moodle learning management software, and is designed to provide asynchronous learning experiences for Unidata software packages. The eLearning site currently features courses on AWIPS CAVE and the Python-AWIPS data access framework.

Committee Membership Changes

Each fall, a portion of the membership of each of Unidata's advisory committees "turns over," with members who have served a three-year term rotating off and new members joining the mix. In 2022, the committees changed as follows:

Charles Pavloski from the University of Pennsylvania finished his term on the Strategic Advisory Committee.

Ryan Abernathey from Columbia University joined the Strategic Advisory Committee.

John Allen from Central Michigan University and Kimberley Wood from Mississippi State University left the Users Committee to join the Strategic Advisory Committee.

Redina Finch from Western Illinois University, Aaron Kennedy from the University of North Dakota, Todd Murphy from the University of Louisiana at Monroe, Craig Ramsayer from Virginia Tech, and Keah Schuenemann from Metro State University of Denver all joined the Users Committee.

Program Center Staffing

As a result of new development initiatives, new non-core funding, and normal staff turnover, the Unidata Program Center has added five new members to the technical staff in the fourth year of this award. Newly hired personnel are filling vacancies on our Community Services and Artificial Intelligence/Machine Learning teams, adding capacity on the THREDDS Data Server project and the IDD system effort, and filling a newly-created Data Engineer position.

The Program Center continues to work to foster diversity in our technical staff. As of spring 2023, our technical team includes seven women, six of whom have joined the program since August 2019.

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

In addition to Unidata's software training efforts (described elsewhere in this report), the Program Center has been offering student summer internship opportunities since 2013. As COVID-19 restrictions on in-person engagement have lifted, in the fourth year of this award Unidata was able to resume hosting participants in our summer internship program at the Unidata Program Center. We were happy to have three students join us in Boulder during the summer of 2022:

Hassanpreet Dhaliwal from Texas Tech University came to Unidata hoping to explore the data visualization and retrieval of meteorological parameters using Java and python-based applications. Working with Unidata's IDV and python development teams, she implemented new ways to visualize the planetary boundary layer (PBL) values from trajectory sounding data. In the process, she gained still in writing reusable and sustainable code for scientific exploration.

Rhoen Fiutak from the Colorado School of Mines came to Unidata to work with the AWIPS development team and with our educational designer on a range of projects that would help students and others access educational tools that allowed them to realize their role in bringing meaning to numbers. Her summer's work saw her not only contribute to AWIPS educational resources, but gain wider experience in designing learning tools for users, from interviewing professors or working with subject matter experts to delivering a finished resource.

Nathaniel Martinez from the University of Chicago came to Unidata hoping to combine two interests — atmospheric and computer science — into one project. He accomplished this by working on expanding Metpy's radar functionality, documentation, and examples, in the process expanding his technical skill set with Python and general software development processes.

* Have the results been disseminated to communities of interest? If so, please provide details.

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, the Earth Science Information Partners Federation, the Society for Advancement of Chicanos/Hispanics & Native Americans in Science, the American Indian Science and Engineering Society, and the American Indian Higher Education Consortium.
>
> Meetings of Unidata’s two governing committees. The governing committees are made up of representatives of Unidata's academic community, and serve a three-year term to enhance two-way communication between the Program and the geoscience educators who form our core community. Committee meetings in 2022 returned to a hybrid format, with some committee members participating in person and others joining remotely. In order to work with UCAR restrictions on in-person gathering, the spring 2022 meetings were delayed until early summer. A joint meeting of both governing committees was held in hybrid format in November.
>
> Unidata staff members conducted virtual training sessions and workshops over the course of the year, with varying levels of formality.

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. Both the UPC and individual staff members also communicate with the community via social media channels including Twitter, LinkedIn, and Facebook.

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

During the fifth year of this award, the Unidata program will continue to undertake the activities described in the “Plan of Action” section of the grant proposal. For reference, this document is available on the Unidata web site:

http://www.unidata.ucar.edu/publications/Unidata_2024.pdf

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

Back to the top

Products

Books

Book Chapters

Inventions

Journals or Juried Conference Papers

View all journal publications currently available in the NSF Public Access Repository for this award.

The results in the NSF Public Access Repository will include a comprehensive listing of all journal publications recorded to date that are associated with this award.

Tan, Yuanlong and Veeraraghavan, Malathi and Lee, Hwajung and Emmerson, Steven and Davidson, Jack W.. (2022). High-performance reliable network-multicast over a trial deployment. *Cluster Computing*. 25 (4) p. 2931-2952. Status = Added in NSF-PAR
doi: https://doi.org/10.1007/s10586-021-03519-6

Federal Government's License = Acknowledged. (Completed by Ramamurthy, null on 03/21/2022) Full text Citation details

Meyer, Tiffany and Krocak, Makenzie J. and Smith, Travis M. and Stumpf, Greg and Gerard, Alan. (2021). The Experimental Warning Program of NOAA's Hazardous Weather Testbed. *Bulletin of the American Meteorological Society*. 102 (12) . Status = Added in NSF-PAR
doi: https://doi.org/10.1175/BAMS-D-21-0017.1

Federal Government's License = Acknowledged. (Completed by Ramamurthy, null on 03/21/2022) Full text Citation details

Arms, Sean and Chastang, Julien and Grover, Maxwell and Thielen, Jon and Wilson, Matthew and Dirks, Douglas. (2020). Introducing Students to Scientific Python for Atmospheric Science. *Bulletin of the American Meteorological Society*. 101 (9) E1492 to E1496. Status = Added in NSF-PAR
doi: https://doi.org/10.1175/BAMS-D-20-0069.1

Federal Government's License = Acknowledged. (Completed by Ramamurthy, null on 03/22/2021) Full text Citation details

Snowden, Derrick and Tsontos, Vardis M. and Handegard, Nils Olav and Zarate, Marcos and O' Brien, Kevin and Casey, Kenneth S. and Smith, Neville and Sagen, Helge and Bailey, Kathleen and Lewis, Mirtha N. and Arms, Sean C.. (2019). Data Interoperability Between Elements of the Global Ocean Observing System. *Frontiers in Marine Science*. 6 . Status = Added in NSF-PAR doi: 10.3389/fmars.2019.00442

Federal Government's License = Acknowledged. (Completed by Ramamurthy, Mohan on 03/31/2020) Full text Citation details

Licenses

Other Conference Presentations / Papers

Dye, Dennis G., Romine, Peter, Weber, Jeff (2022). *A Network System for Environmental Monitoring, Data Sovereignty and Data Governance on Tribal Lands*. 2022 AGU Fall Meeting. Chicago, IL. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Weber, Jeff, Dye, Dennis, Romine, Peter (2023). *A Network System for Environmental Monitoring, Data Sovereignty and Data Governance on Tribal Lands*. 39th Conference on Environmental Information Processing Technologies, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Grover, Maxwell, Collis, Scott M., Sherman, Zachary, Ilhi, Monica, Kumar, Jitendra, Theisen, Adam, Jackson, Robert C., Rose, Brian E. J., Tyle, Kevin R., Kent, Julia, Camron, Drew (2023). *ARMing the Open Science Community with Radar Cookbooks: from the Colorado Rockies to the Gulf Coast and Beyond*. 13th Symposium on Advances in Modeling and Analysis Using Python, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Yu, Wei, Xue, George, Ho, Yuan, Zhao, Xiaochen, Wang, Yixuan, Bao, Daoyang (2023). *Advances In Urban Flash Flood Model Forecasting System*. 37th Conference on Hydrology, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Fisher, Ward (2022). *Bridging Legacy Scientific Software and Cloud-Native Data with Open-Source Application Streaming*. 2022 AGU Fall Meeting. Chicago, IL. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Espinoza, B. and Chastang, J. and Weber, J. and Dye, D. and Romine, P. (2022). *Democratizing Access to Atmospheric Modeling with WRF employing NSF Cloud Computing Resources*. Gateways 2022. San Diego, California, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Dhaliwal, H. K., Camron, Drew, Carter, Shay, Ho, Yuan (2023). *Determining Planetary Boundary Layer Depth via Integrated Data Viewer (IDV) from Atmospheric Sounding Profile Data*. 22nd Annual Student Conference, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Fiutak, Rhoen, Carter, Shay, Corbin, Nicole, Meyer, Tiffany C. (2023). *Developing Educational Resources for Unidata Advanced Weather Interactive Processing System (AWIPS) Data Visualization Frameworks*. 22nd Annual Student Conference, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Calhoun, Kristin M., Campbell, Patrick Adrian, Sandmael, Thea, Satrio, Clarice N., Hyland, Patrick T., Steeves, Rebecca B., Meyer, Tiffany C., Obermeier, Holly, Hogg, David, DeWinter, Taylor, LaDue, Daphne S., Karstens, Chris, Smith, Travis M., Klockow-McClain, Kim, Stumpf, Gregory J., Berry, Kodi L. (2023). *Development and Evolution of Probabilistic Hazard Information for Severe Hazards*. Special Symposium on Forecasting a Continuum of Environmental Threats (FACETs), 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Zonca, A. and Chastang, J. (2022). *Distributed computing on the cloud for Science Gateways with Dask*. Mini Gateways 2022. Online. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Brewster, Keith A., Ware, Randolph H., Wang, Junhong, Shrestha, Bhupal, Bosart, Lance F., Freedman, Jeff, Brotzge, Jerald A., Crain, David J., Huang, Allen, Ising, Jan, Berchoff, Don, Weber, Jeff, Conway, Bill, Dill, Kimberly, Lalumiere, Andre, Kostreva, Benjamin, Mahaffey, Matt, Matt, Ryan, Neece, Gregory, Patton, David, Waggoner, Nick, Wilfong, Tim (2023). *High-Accuracy, High-Temporal Resolution Observation plus Model (OpM) Profiling and Forecasting*. 23rd Symposium on Meteorological Observation and Instrumentation, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Zender, Charles S., Hartnett, Edward, Heimbigner, Dennis, Fisher, Ward (2022). *How and Why to Increase Dataset Compression Ratios Relative to CMIP6*. 2022 AGU Fall Meeting. Chicago, IL. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Gagne, David John, Becker, Charlie, Bharathi, Prahalath, Cains, Marianna Goodall, Chapman, William Eric, Gantos, Gabrielle, Kim, Eliot, Martin, Thomas, Molina, Maria J., Schreck, John, Wilde, Keely, Willson, Justin, Wirz, Christopher D., Zheng, Zhonghua (2023). *Machine Learning Opportunities and Challenges from the NCAR Analytics and Integrative Machine Learning Group*. 22nd Conference on Artificial Intelligence for Environmental Science, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

May, Ryan M., Camron, Drew A., Goebbert, Kevin H., Theilen, Jonathan (2023). *MetPy in 2022: Continuing to Build an Open Source Project and its Community*. 13th Symposium on Advances in Modeling and Analysis Using Python, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Camron, Drew A., Banihirwe, Anderson, Cardinale, Christopher, Clyne, John, Corbin, Nicole, Eroglu, Orhan, Grover, Maxwell, Kent, Julia, Kootz, Alea, Long, Matthew, May, Ryan M., Morley, James, Paul, Kevin, Rose, Brian E. J., Sizemore, Michaela, Tyle, Kevin R., Zacharias, Anissa (2023). *Project Pythia: A Community Update on Open and Sustainable Geoscientific Python Education*. 13th Symposium on Advances in Modeling and Analysis Using Python, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Kent, Julia, Camron, Drew, Clyne, John, Ford, Robert G., Grover, Maxwell, May, Ryan, Paul, Kevin, Rose, Brian E. J., Tyle, Kevin (2022). *Project Pythia: A Pangeo Community Tool for Open-Source Education*. 2022 AGU Fall Meeting. Chicago, IL. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Tyle, Kevin, Camron, Drew, Clyne, John, Ford, Robert, Grover, Maxwell, Kent, Julia, May, Ryan, Paul, Kevin, Rose, Brian E. J. (2022). *Project Pythia: Transforming Software Engineering Education for GeoScience*. 2022 AGU Fall Meeting. Chicago, IL. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ware, Randolph H., Kennedy, Aaron D., Weber, Jeff, Couillard, Maxim, Pryor, Ken, Demoz, Belay, Stone, Richard, Shrestha, Bhupal, Wang, Junhong, Brotzge, Jerald A., Ising, Jan, Crain, David J., Huang, Allen, Czarnetzki, Alan C., Berchoff, Don, Conway, Bill, Dill, Kimberly, Lalumiere, Andre, Mahaffey, Matt, Matt, Ryan, Neece, Gregory, Patton, David, Waggoner, Nick, Wilfong, Tim (2023). *Radar and Radiometer Observations of the 2020 NY State Derecho*. 23rd Symposium on Meteorological Observation and Instrumentation, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Drwenski, Tara M., Johnson, Hailey A., Lerman, Megan N. (2023). *Reimagining the THREDDS Data Server with a Modern, Microservice-based Architecture*. 39th Conference on Environmental Information Processing Technologies, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Collis, Scott M., Theisen, Adam, Grover, Maxwell, Schuster, Douglas, Sherman, Zachary, Tang, Jingyin, Kent, Julia, May, Ryan, Abernathey, Ryan, Hoffman, Forrest M., Tyle, Kevin, Mullendore, Gretchen L., Jackson, Robert Clyde, Rothenberg, Daniel A., Irving, Damien Brent, Camron, Drew (2022). *Successes And Vision For Open Earth Sciences (Invited)*. 2022 AGU Fall Meeting. Chicago, IL. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Goebbert, Kevin H., May, Ryan M., Camron, Drew (2023). *Teaching Atmospheric Science Using Open Source Tools and Data*. 39th Conference on Environmental Information Processing Technologies, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Martin, Thomas (2022). *Teaching Remote Data Science in a University Setting: Lessons Learned and Future Directions*. 2022 AGU Fall Meeting. Chicago, IL. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ramamurthy, M. and Chastang, J. (2022). *The use of the Unidata Science Gateway as a cyberinfrastructure resource to facilitate education and research during COVID-19*. EGU General Assembly 2022. Vienna, Austria. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Meyer, Tiffany C., Carter, Shay, Corbin, Nicole (2023). *Unidata AWIPS Hosted in the Cloud*. 39th Conference on Environmental Information Processing Technologies, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Chastang, J. and Corbin, N. and Davis, E. and Espinoza, B. and Vance, T. (2022). *Unidata Science Gateway Reimagined: Unifying Access to Educational and Research Resources*. Gateways 2022. San Diego, California, USA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Chastang, Julien, Espinoza, Ana, Ramamurthy, Mohan K. (2023). *Unidata Science Gateway: Past, Present, and Future Plans*. 39th Conference on Environmental Information Processing Technologies, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ramamurthy, Mohan K. (2023). *Unidata: Transforming Earth System Sciences through Innovative Data Services*. 39th Conference on Environmental Information Processing Technologies, 103rd AMS Annual Meeting. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

Other Publications

Patent Applications

Technologies or Techniques

Thesis/Dissertations

Websites or Other Internet Sites

Unidata Website
https://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.

Unidata eLearning
https://elearning.unidata.ucar.edu/

Unidata’s eLearning site serves as a repository of Unidata-created online learning materials. The site is freely available, although site registration is required. Current content supports learners new to the Common AWIPS Visualization Environment (CAVE) and the Python-AWIPS data access framework; additional modules are in the planning stages, as are mechanisms by which university educators can repurpose Unidata-created content in their own courses.

Back to the top

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Ramamurthy, Mohan	PD/PI	7
Camron, Michael	Other Professional	6
Carter, Shaylina	Other Professional	10
Chastang, Julien	Other Professional	11
Cooper, Stonie	Other Professional	6
Corbin, Nicole	Other Professional	10
Davis, Ethan	Other Professional	10
Dirks, Doug	Other Professional	10
Drwenski, Tara	Other Professional	10
Emmerson, Steve	Other Professional	11
Espinoza, Roberto	Other Professional	11
Fisher, Ward	Other Professional	11
Heimbigner, Dennis	Other Professional	11

Ho, Yuan	Other Professional	11
ILES, Mustapha	Other Professional	1
Johnson, Hailey	Other Professional	10
Lerman, Megan	Other Professional	7
Martin, Thomas	Other Professional	9
May, Ryan	Other Professional	7
Meyer, Tiffany	Other Professional	10
Neidigh, Joshua	Other Professional	2
Oxelson, Jennifer	Other Professional	11
Perna, Matthew	Other Professional	11
Purvis, Inken	Other Professional	8
Ruscetta, Sheri	Other Professional	5
Schmidt, Mike	Other Professional	9
Vance, Tanya	Other Professional	9
Weber, Jeff	Other Professional	11
Yoksas, Tom	Other Professional	11
Zuranski, Michael	Other Professional	7
Dhaliwal, Hassanpreet	Undergraduate Student	3
Fiutak, Rhoen	Undergraduate Student	2
Martinez, Nathaniel	Undergraduate Student	2

Full details of individuals who have worked on the project:

Mohan K Ramamurthy
Email: mohan@ucar.edu
Most Senior Project Role: PD/PI
Nearest Person Month Worked: 7

Contribution to the Project: Program Director - Administration and Management

Funding Support: No other funding support

Change in active other support: Yes C&P Ramamurthy_Annual Project Report_3-2023.pdf

International Collaboration: No
International Travel: Yes, Sweden - 0 years, 0 months, 5 days; Austria - 0 years, 0 months, 8 days

Michael Camron
Email: dcamron@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 6

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding support

International Collaboration: No

International Travel: No

Shaylina Carter
Email: srcarter@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 10

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Julien Chastang
Email: chastang@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 11

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Stonie Cooper
Email: cooper@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 6

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding support

International Collaboration: No
International Travel: No

Nicole Corbin
Email: ncorbin@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 10

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Ethan Davis
Email: edavis@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 10

Contribution to the Project: Software Engineer & Technical Manager - program development & project management

Funding Support: No other funding source

International Collaboration: Yes, Germany, Spain, Sweden, United Kingdom
International Travel: Yes, Spain - 0 years, 0 months, 16 days

Doug Dirks
Email: ddirks@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 10

Contribution to the Project: Program Editor/Writer - community service outreach

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Tara Drwenski
Email: tdrwenski@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 10

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Steve Emmerson
Email: emmerson@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 11

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Roberto Espinoza
Email: respinoza@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 11

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Ward Fisher
Email: wfisher@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 11

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Dennis Heimbigner

Email: dmh@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 11

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Yuan Ho
Email: yuanho@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 11

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Mustapha ILES
Email: mustapha@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Hailey Johnson
Email: hajohns@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 10

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Megan Lerman
Email: lerman@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 7

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Thomas Martin
Email: tmartin@ucar.edu
Most Senior Project Role: Other Professional

Nearest Person Month Worked: 9

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Ryan May
Email: rmay@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 7

Contribution to the Project: Unidata Deputy Director - program development & project management

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Tiffany Meyer
Email: tiffanym@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 10

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Joshua Neidigh
Email: jwneidigh@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 2

Contribution to the Project: Senior Program Administrator - program administration and management

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Jennifer Oxelson
Email: oxelson@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 11

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Matthew Perna
Email: mperna@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 11

Contribution to the Project: Systems Administration

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Inken Purvis
Email: ipurvis@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 8

Contribution to the Project: Administrative Support

Funding Support: No other funding support

International Collaboration: No
International Travel: No

Sheri Ruscetta
Email: ruscetta@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 5

Contribution to the Project: Administrative Support

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Mike Schmidt
Email: mschmidt@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 9

Contribution to the Project: Systems Administration

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Tanya Vance
Email: tavance@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 9

Contribution to the Project: Community Services Manager - community outreach & management

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Jeff Weber
Email: jweber@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 11

Contribution to the Project: Project Manger - project management

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Tom Yoksas
Email: yoksas@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 11

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: Yes, Costa Rica
International Travel: No

Michael Zuranski
Email: mzuranski@ucar.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 7

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Hassanpreet Dhaliwal
Email: hdhaliwal@ucar.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Student Intern - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Rhoen Fiutak
Email: rfiutak@ucar.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Student Intern - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

Nathaniel Martinez
Email: nmartinez@ucar.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Student Intern - program development

Funding Support: No other funding source

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
Leeman Geophysical LLC	Other Organizations (foreign or domestic)	Siloam Springs, AR
University of Wisconsin	Academic Institution	Madison, WI

Full details of organizations that have been involved as partners:

Leeman Geophysical LLC

Organization Type: Other Organizations (foreign or domestic)
Organization Location: Siloam Springs, AR

Partner's Contribution to the Project:
Other: Production of MetPy Monday videos

More Detail on Partner and Contribution: John Leeman with Leeman Geophysical LLC was the originator of MetPy Mondays while he was at Unidata and has taught many of the Python workshops with us. He is continuing the MetPy Monday videos and keeping up their regular releases and growing success to continue growing our Python portfolio.

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:

Were other collaborators or contacts involved? If so, please provide details.

Nothing to report

Back to the top

Impacts

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

A survey of papers published in 2021 in journals of the American Meteorological Society shows 96 articles containing citations of Unidata software and data services. In the same period, an additional 230 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 in 2022 indicated that Unidata software and data services were cited 3591 times in the full range of scholarly literature encompassed by the search engine. Of these, 3108 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?

Unidata's efforts to provide software training contribute directly to levels of computational and data science literacy among geoscience students and educators.

What was the impact on teaching and educational experiences?

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 improve teaching and educational experiences in the geosciences. Of special note are the following metrics, collected in late 2022:

Number of U.S. universities receiving software: 230

Number of universities outside the U.S.: 594

Approximate number of attendees of 2022-2023 training workshops in-person and virtual: 266

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 2022 include:

University/PI	Project Title
University of Louisiana at Monroe Todd Murphy	Deploying a JupyterHub Server to Support Education and Research at ULM

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:

Unidata Science Gateway

The Unidata Science Gateway on NSF's Jetstream Cloud collects Unidata-related technologies and demonstrates a workflow involving combining cloud-based resources to create end-to-end scientific workflows. One of the most exciting tools in the Unidata Science Gateway is a JupyterHub server, which allows students and educators to access Unidata-provided Jupyter notebooks illustrating atmospheric science concepts. During the 2022-2023 academic year Unidata continued its program of offering to set up JupyterHub systems to support atmospheric and related science courses, providing pre-configured computing environments to ten universities. All told, courses serving over 1100 students at 26 universities have now taken advantage of this Unidata resource. In addition, the Science Gateway provided resources for three workshops associated with the AMS Annual Meeting in January 2023, serving 141 meeting participants.

Unidata Science Gateway resources have been used in UCAR's Significant Opportunities in Atmospheric Research and Science (SOARS) for several

years now. In the summer of 2022, Science Gateway resources helped support 22 SOARS protégés in their summer session.

The growing acceptance and use of the Unidata Science Gateway has led the program to allocate additional resources to the project from our core funding. In the fourth year of this award, Program Center staff began a “Science Gateway Reimagined” effort, with the goal of enhancing the Science Gateway to better serve as “a community-directed virtual hub to enable learning and support research for current and future earth systems students, educators, and scientists.” These efforts are underway and continuing in the spring of 2023.

Of special interest has been the operation of a community-accessible cloud-based AWIPS Environmental Data EXchange (EDEX) server. Unidata’s distribution of the CAVE client points to this EDEX server by default, allowing university users to get up and running quickly without the need to configure a local data server. Unidata’s cloud-based EDEX server provides roughly 34 Gigabytes per day to remote access users. A separate cloud-based EDEX server is used for development and testing, and is available as a failover replacement for the primary hosted EDEX in the event of technical difficulties.

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. At the AMS Annual Meeting in January 2023, Unidata staff and community members convened a session as part of the 9th Conference on Environmental Information Processing Technologies (EIPT). That session, titled “Community Driven: Unidata Projects Enhancing Geoscience Teaching and Research,” sought to update community members on Unidata's work with the Science Gateway, AWIPS, the THREDDS Data Server, Data Sovereignty and Data Governance on Tribal Lands, and using Open Source Tools to teach Atmospheric Science. About a hundred people attended one or more of the session’s talks.

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. During the course of this award, Unidata staff have also begun participating in SACNAS, AIHEC, and AISES conferences and meetings.

Open Geospatial Consortium

Unidata has a long history of involvement with the Open Geospatial Consortium working towards implementation and adoption of data standards. A Unidata staff member is currently co-chair of the OGC netCDF Standards Working Group (SWG); this group continues to make progress on a draft OGC standard document “OGC Encoding Linked Data Graphs in NetCDF Files” that provides a mapping for netCDF metadata into linked data graphs in RDF and other formats.

Unidata staff members also attend meetings of the OGC MetOcean Domain Working Group (DWG) which includes representatives from a number of national meteorology services. A recent focus of this group has been development of an OGC web API for Environmental Data Retrieval (OGC API - EDR) which supports common environmental data request patterns. OGC API - EDR has been accepted as an OGC standard, continues to be under development, and is currently being used as a data access mechanism in the WMO Information System 2.0 (WMO WIS 2.0). A related effort to establish CoverageJSON as an OGC Community Standard is ongoing.

National Water Center

The National Water Model (NWM) is a hydrologic model that simulates observed and forecast streamflow over the entire continental United States. Based in large part on the community-developed Weather Research and Forecasting Model Hydrologic modeling extension package (WRF-Hydro), the NWM integrates terrestrial hydrology and atmospheric conditions to provide streamflow predictions for approximately 2.7 million river reaches. Several Unidata technologies are in use in connection with the NWM and at the National Water Center (NWC) in Tuscaloosa, Alabama:

- Output from the NWM is delivered in netCDF format, making it easy to analyze and visualize the model output using a variety of standard software tools, from coding-focused workflows in Python or R to full-featured applications such as the IDV and ESRI’s ArcGIS.
- NWM output is made available via NOAA’s National Operational Model Archive and Distribution System (NOMADS) project, which incorporates the TDS and lists Unidata as a “Core Collaborator.”
- LDM software is used for data transfer at the NWC, both to acquire data for NWM initialization and to transfer the model output to NOMADS.

EarthCube Activities

Unidata’s director (Dr. Mohan Ramamurthy) represents Unidata on the EarthCube Council of Data Facilities.

Unidata participates in a variety of EarthCube activities, including collaboration on several awarded “Building Blocks” proposals. Currently, Unidata is teaming with Columbia University, NCAR, and Continuum Analytics on *Pangeo: An Open Source Big Data Climate Science Platform*, and with NCAR and the University at Albany, SUNY on *Project Pythia: A Community Learning Resource for Geoscientists*.

What is the impact on information resources that form infrastructure?

The UPC created and continues to coordinate the Internet Data Distribution system (IDD), in which hundreds of universities, government agencies, and

others cooperate to disseminate earth observations via the Internet in near real time. As of early 2023, the traffic handled by servers operated by the UPC itself -- a fraction of the total IDD system -- was more than 90 Tbytes/day, for roughly 33 petabytes over the course of a year.

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. With the inclusion of image data from the GOES-16/17/18 satellites, in 2022 the UPC provided roughly 2.3 Tbytes of data per day to the community via remote access mechanisms.

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 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 Sixth 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 MetPy project is aimed at bringing GEMPAK-like meteorology functionality to the Python environment. The package has seen strong adoption within the atmospheric sciences research and education community, with hundreds of students and faculty attending MeyPy-focused workshops in the past year. In addition, the number of community contributors to the open source project has also grown significantly, with more than forty contributors who are not UPC staff members.

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.

Unidata works closely with the National Weather Service and the National Centers for Environmental Prediction to create a version of the AWIPS software tailored for use by the university community.

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

Siphon: The Siphon project is a collection of Python utilities for downloading data from Unidata data technologies. Siphon's current functionality focuses on access to data hosted on a THREDDS Data Server. Siphon development has slowed as Program Center staff have been allocated to other projects, but the package continues to gain functionality slowly, for example when requirements are revealed in the course of MetPy development.

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. Over time, the community using the visualization functions of McIDAS-X has adopted different technologies (many of the functions have been incorporated into the IDV, for example). This, coupled with the small number of software developers available to contribute to development and maintenance efforts, has led Unidata to explore ways to transition away from providing resources for the software’s continued development. Discussions with SSEC about ways to continue supporting existing users are under way. Another portion of the McIDAS-X software involves data distribution. Abstract Data Distribution Environment (ADDE) servers are in wide use in the Unidata community; traffic on Unidata-maintained ADDE servers constitutes roughly one third of all remote access data traffic. Unidata is committed to maintaining access to this server technology as a data distribution mechanism, even if we no longer support McIDAS-X as an end-user visualization tool.

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.

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.

What percentage of the award's budget was spent in a foreign country?

Nothing to report.

Back to the top

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

In recent years, Unidata has had increasing difficulty recruiting and retaining software engineers at the salary levels mandated by UCAR’s human resources policies. Relatively low (compared with non-UCAR opportunities) software developer salary levels have led to both increased turnover and difficulty attracting qualified candidates for open positions in several of Unidata’s project areas. Hiring software engineers in the Boulder area, which has become a hub for many information technology companies including Google, Apple, and Microsoft, has become increasingly problematic.

This trend has been somewhat mitigated by greater institutional openness within UCAR to hiring full-time remote staff. Unidata has availed itself of the opportunity to incorporate off-premises staff, and now has six members of the technical team who are full-time remote employees.

Thanks in part to supplemental funding from the National Science Foundation over the past two years, Unidata has in the fourth year of this award been able to fill open positions in our data services, THREDDS development, and AI/ML initiatives. While we are happy to have staff members available to make progress on all of these important projects, we are cognizant of the ongoing cost of retaining the employees we have worked so hard to attract, train, and integrate into the Program Center’s operations.

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.

Change in primary performance site location

Nothing to report.

Back to the top

< Back