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Preview of Award 1901712 - Annual Project Report

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Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
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Submission Date:	04/12/2024
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: Next-generation Data Services and Workflows to Advance Geoscience Research and Education” (NSF 1901712). The proposal for that funding award grouped the NSF Unidata program’s activities into the following focus areas identified in the NSF Unidata Strategic Plan:

Managing Geoscience Data

Providing Useful Tools

Supporting People

Note: While NSF 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 NSF 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 2023 – March 2024. This report is being filed due to NSF Unidata’s receipt of a No Cost Extension for grant 1901712.

* 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 NSF Unidata’s main activities during the fifth 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 NSF Unidata program’s founding goals, and continues to be one of the core activities of the program. By participating in NSF 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 170 sites are running NSF 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 NSF Unidata. Among these organizations are NOAA, NASA, USGS, USACE, the national weather services of Spain and South Korea, private companies, universities, and others.)

NSF 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, 135 are publicly accessible and providing data to other community members.

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

NSF 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 NSF Unidata’s highest priorities during the period of this award. During the fifth year of the award, UPC staff have made significant progress toward these goals, most notably through the expansion of the NSF Unidata Science Gateway on NSF’s Jetstream Cloud, including implementation of Jetstream 2 features.

One of the most exciting tools in the NSF Unidata Science Gateway is a JupyterHub server, which allows students and educators to access NSF Unidata-provided Jupyter notebooks illustrating atmospheric science concepts. The NSF 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 1800 students

Three separate workshops at the Annual Student Conference for the American Meteorological Society 2024 annual meeting, supporting 137 student participants.

As part of the Science Gateway, NSF Unidata also operates cloud-based data distribution mechanisms (notably AWIPS EDEX servers and THREDDS Data Servers). Additionally, NSF 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 NSF Unidata's primary activities. During the fifth year of this award, NSF 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

NSF 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 fifth 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, NSF Unidata staff participate 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 NSF Unidata. This group was awarded an NSF CISE Community Research Infrastructure grant (with NSF Unidata as an unfunded collaborator), described in the Specific Objectives section of this report.

This year, UPC 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; NSF Unidata staff have fewer opportunities to interact with community members at the combined conference booth.

We maintain an online presence via the News@NSF 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 NSF Unidata program, in large part, to our community-based governance structure. NSF Unidata calls on members of its core academic community to serve on its two governing committees: the NSF Unidata Users Committee and the NSF Unidata Strategic Advisory Committee. Users Committee members are charged with serving as an interface between the NSF Unidata Program Center and individuals and organizations who use NSF 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. NSF 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.

Outreach to Underserved Communities

One area of special focus during the period of this grant has been NSF Unidata's program of outreach to historically

Specific
Objectives:

underserved communities. In order to build better relationships with communities that have not previously been heavily involved with NSF Unidata, in the fifth year of the award NSF Unidata staff have continued participation in the SACNAS National Diversity in STEM Conference and the AISES National Conference.

Since 2021, NSF 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, NSF 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. NSF 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. As part of the ongoing collaboration, in February 2024 the Southwestern Indian Polytechnic Institute (SIPI) in Albuquerque, New Mexico hosted a workshop titled Exploring Data Sovereignty and the Sovereign Data Network. More than 40 individuals from Tribal Colleges and Universities (TCUs), R1 universities, and other agencies and groups associated with IDS and Earth System Science (ESS) attended, including UCP staff members and several other participants affiliated with NSF Unidata.

NSF Unidata's participation in the Sovereign Network project has opened doorways in other areas as well. The project team (including NSF 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 the fall of 2023, NSF Unidata Staff led a regional workshop at the University of Maryland, Baltimore County (UMBC) titled *MetPy for Quantitative Analysis of Meteorological Data*. The workshop was organized in collaboration with NOAA's Educational Partnership Program with Minority Serving Institutions (NCAS-M) at Howard University. Over the course of two days, 21 participants from UMBC, Howard/NCAS-M, Morgan State University, and Johns Hopkins University explored MetPy, the TDS, and Siphon as tools for analysis of ESS data.

Additionally, with the goal of encouraging participation by underserved individuals and institutions, NSF Unidata's Diversity, Equity, and Inclusion committee has suggested and helped to implement structural changes to several NSF 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 and October 2023 Pulse Survey, with similar goals.

Strategic Planning

Every five years, NSF 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 NSF 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 NSF 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 NSF 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 created a five-year core funding proposal titled “Unidata Reimagined: New Approaches to Community Data Services” that was submitted in October 2023. The proposal outlines

NSF Unidata's proposed activities on behalf of the community in the coming years.

NSF Unidata Users Workshops

NSF 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 NSF Unidata staff to discuss and share best practices for helping students engage in data-enabled science.

After delays due to COVID-19 restrictions on gathering, the NSF Unidata Users Workshop was held in Boulder, Colorado June 5-8, 2023, hosting 91 participants from 42 universities, agencies, and private sector organizations. The NSF Unidata Users Committee hosted the workshop, with the theme *Storytelling with Earth System Science Data: Challenges and Opportunities for Effective, Ethical, and Reproducible Science*, to advance our collective ability to tell effective and ethical stories using Earth System Science Data. The challenge of storytelling with our data was infused throughout the event; workshop attendees ranging from graduate students to senior scientists explored ways to communicate the meaning of scientific ideas in effective and ethical ways, using a variety of different kinds of data, and taking advantage of new tools like Artificial Intelligence and Machine Learning (AI/ML).

Over the four-day workshop, presenters and attendees engaged in conversation and learned about new tools and techniques to analyze data across disciplines. Traditional training has been centered in disciplinary practices; increasingly we need to combine datasets and approaches from multiple disciplines to get at the intersections inherent in Earth Systems Science. Sessions focusing on AI/ML helped participants learn how to use these emerging tools to draw connections and identify patterns within complex data. Other portions explored ethical use of data, including the ideas highlighted by CARE (Collective benefit, Authority to control, Responsibility, and Ethics) and FAIR (Findable, Accessible, Interoperable, and Reusable) data practices. Together, these ideas help us work toward Open and reproducible scientific workflows that lead to the highest quality of research.

Hands-on learning experiences were also an important part of the workshop. Several of the workshop days included afternoon breakout sessions suitable for more in-depth exploration of data and concepts. Numerous sessions allowed attendees to open up their laptops and try out the tools and techniques we had been discussing with their own data. Jupyter notebooks, pre-configured hosted remotely on NSF Unidata's Science Gateway JupyterHub server, made this process easy for everyone, even if they had not previously worked with the technology.

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 NSF Unidata community members and institutions in near real-time continues to grow. As of March 2023, NSF 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. At that time, the volume of data served via remote access methods (TDS, ADDE, and standard web servers) averaged approximately 2.3 Terabytes per day.

NOTE: As a result of a variety of factors including changes in UPC data server configurations, UPC staff changes, and an accidental loss of data-flow statistics by a third-party service provider, as of March 2024 we are not confident in our ability to accurately report data delivery metrics in the same format as in previous annual reports. We hope to have a reliable reconstruction of data flows for the 2023-2024 cycle ready for inclusion in the Final Report for NSF 1901712, to be delivered in early 2025.

NSF 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. NSF Unidata receives data from SSEC's GOES-16/17/18 fanout servers, and SSEC feeds from NSF Unidata's GOES Rebroadcast (GRB) ingest system. This sharing of the feed streams has allowed SSEC and NSF Unidata to minimize the effects of solar and terrestrial interference on our satellite data reception.

Cloud Technologies and the NSF Unidata Science Gateway

Cloud-computing related activities during the fifth year of this award have focused on making NSF Unidata Science Gateway resources more broadly useful and widely available. In addition to the activities described in "Major Activities," above, Program Center staff are continuing the process of revamping the NSF 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, NSF Unidata Program Center staff have worked closely with NTU and SIPI to develop capacity for environmental modeling for Tribal Nations. Science gateway development staff were able to provide the Tribal Nations with the capability to run the WRF model on geographic areas including Tribal lands, using 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 NSF 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 1.5 release in May of 2023, its version 1.5.1 release in July 2023, a version 1.6 release in December 2023, and a version 1.6.1 in January 2024. These releases are notable for the ongoing community code contributions and general project participation, including contributions from 2023 and earlier NSF Unidata summer interns.

NSF 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, 500 repositories and 57 open source packages depend on the MetPy project.

AWIPS:

During the summer of 2023, the NSF Unidata AWIPS development team released several beta versions of version 20.* of the NSF Unidata AWIPS package, which moved the software from Python version 2 to version 3. NSF Unidata AWIPS version 20.3.2-1 was officially released in December 2023, with a beta release of version 20.3.2-2 in February 2024.

NSF 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.

IDV:

The most recent version of NSF Unidata's Integrated Data Viewer, version 6.2 update 2, was released in December 2023. Version 6.2 of the IDV, released in August 2023, is a major release of the software that features a new Level II Radar grid display, point cloud and point grids displays, and the ability to use non-geolocated point data. Version 6.2 also updated the list of available ADDE servers and the WMS feature.

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 version 6.15 was released in December 2023.

NetCDF:

The netCDF-C library version 4.9.2 was released in March of 2023. The netCDF-Fortran library version 4.6.1 was released in May of 2023.

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. A beta-test version of TDS 5.5 became available in March 2024.

Due to budgetary constraints, the TDS development team lost one of its three members in December 2023. Work on the previously announced "microservices" architecture changes are currently under review in light of the reduced team resources.

Key outcomes
or Other
achievements:

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

DeSouza Award

Each year, the NSF Unidata Users Committee presents the Russell L. DeSouza award to a community member whose energy, expertise, and active involvement enable the NSF Unidata Program to better serve geoscience. Honorees personify NSF Unidata’s ideal of a community that shares data, software, and ideas through computing and networking technologies. The 2023 award was given jointly to Andrea Zonca of the San Diego Supercomputing Center and Jeremy Fischer of Indiana University for their work on the NSF Jetstream project and in particular for the assistance they have given NSF Unidata in the creation of its Science Gateway, which relies heavily on Jetstream infrastructure.

Artificial Intelligence/Machine Learning (AI/ML)

In the fifth year of the award NSF Unidata’s AI/ML program has begun a process of engagement with the NSF Unidata scientific community to help us better understand their needs, and facilitate AI/ML-centric conversations between the NSF 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. Our AI/ML engineer is part of the UPC staff team that secured an NSF “CyberTraining” grant to facilitate creation of resources to help university students gain familiarity with AI/ML tools as they related to the Earth Systems Sciences; work on this project is ongoing in collaboration with partners at Metro State University of Denver.

Projects Begun under the EarthCube Program

While the NSF EarthCube program has wound down, UPC staff are involved in the following ongoing projects begun under that program:

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

In the fifth year of the award, UPC 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 NSF Unidata software packages in the context of the atmospheric sciences. During the fifth year of this award we have been able to hold a mix of in-person and virtual software training workshops. Workshops we were able to conduct included:

A UCAR Professional Development workshop for the benefit of 30 UCAR summer interns.

A “MetPy for Quantitative Analysis of Meteorological Data” workshop for 21 participants.

A “Python Readiness Series: Train-the-Trainer” workshop for 10 participants.

Two Python workshops at Colorado State University, for a total of 39 participants.

An AI/ML-focused workshop for 36 participants.

An AMS Short Course titled “MetPy: Creating Meteorological Python Workflows from Scratch” at the AMS Annual Meeting in January, 2024. The day-long Short Course had 27 attendees.

A workshop at the American Meteorological Society Student Conference, held in association with the AMS Annual Meeting in January, 2024. The workshop had roughly 38 attendees consisting of undergraduate, masters, and doctoral students.

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 NSF Unidata developer’s blog every Monday, most often with an accompanying short video tutorial. The series now has more than 310 installments on a wide range of MetPy related topics, and has been viewed more than 65,000 times in the past year. The “AWIPS Tips” series began publishing in mid-2021 to provide short explanations of AWIPS features and techniques; the 71 installments of the series include 11 video tutorials that have been viewed more than 5100 times in the past year.

NSF Unidata’s asynchronous learning management system (LMS) site -- NSF Unidata eLearning (<https://elearning.unidata.ucar.edu/>) uses the Moodle learning management software, and is designed to provide asynchronous learning experiences for NSF Unidata software packages. The eLearning site currently features courses on AWIPS CAVE, the Python-AWIPS data access framework, and “microlearning” courses on multidimensional data and using the THREDDS Data Server with Siphon.

Committee Membership Changes

Each fall, a portion of the membership of each of NSF Unidata’s advisory committees “turns over,” with members who have served a three-year term rotating off and new members joining the mix. In 2023, the committees changed as follows:

Charles Graves from Saint Louis University finished his term on the Strategic Advisory Committee.

Kevin Goebbert from Valparaiso University left the Users Committee to join the Strategic Advisory Committee.

Sean Freeman from the University of Alabama in Huntsville joined the Users Committee.

Giuseppe Torri from the Water Resources Research Center at the University of Hawai’i at Mānoa joined the Strategic Advisory Committee.

Jon Thielen from Colorado State University finished his term as Graduate Student Representative.

Roger Riggan from the University of North Carolina at Charlotte joined the Users Committee as Graduate Student Representative.

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

In addition to NSF Unidata’s software training efforts (described elsewhere in this report), the Program Center has been offering student summer internship opportunities since 2013. In the fifth year of this award NSF Unidata was happy to host three participants in our 2023 summer internship program at the NSF Unidata Program Center.

Jhamieka Greenwood from Florida State University came to NSF Unidata hoping to expand her knowledge of graphic visualization of atmospheric data. She incorporated her work into interactive Jupyter notebooks to assist fellow learners. She attended the NSF Unidata Users Workshop and Project Pythia Hackathon virtually; helping her to gain experience working with atmospheric science data and learning to use PyVista and RAPIDS for graphical data visualization.

Jessica Souza from Texas Tech University came to NSF Unidata to work with the Unidata’s THREDDS Data Server development team to implement preprocessing steps such as filtering and scaling on the raw datasets available from THREDDS Data Servers. Her work provided users with an option to download dataset containing preprocessed variables for more straight forward applications in AI/ML.

Erin Rhoades from Metropolitan State University of Denver came to NSF Unidata hoping to combine her passions for coding and data visualization. During her internship, she solidified her fundamental knowledge of Python and GitHub, working to develop several Cookbooks for Project Pythia.

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

NSF 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 NSF Unidata's two governing committees. The governing committees are made up of representatives of NSF 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 2023 returned to a hybrid format, with some committee members participating in person and others joining remotely. A joint meeting of both governing committees was held in hybrid format in November.

NSF Unidata staff members conducted virtual and in-person training sessions and workshops over the course of the year.

In addition to in-person forums like these, NSF Unidata staff publish their results and discuss ongoing research in academic journals, and through NSF 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/X, LinkedIn, and Facebook.

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

During the No Cost Extension period of this award, the NSF Unidata program will begin shifting towards the priorities outlined in our most recent grant proposal, "Unidata Reimagined: New Approaches to Community Data Services." Many of the activities described in the new proposal build on the work funded by the current core program funding grant; these activities will be the target for any funds remaining from the current grant.

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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](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](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 Tsonos, 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](https://doi.org/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

Chastang, Julien and Expinoza, Ana (2024). *Advancing Atmospheric Science Education: Customized PyAOS JupyterHubs via the Unidata Science Gateway*. Proceedings, 104th AMS Annual Meeting. Baltimore, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Greenwood, Jhamieka and Martin, Thomas (2023). *An Overview of Interactive Data Visualizations with PyVista and RAPIDS*. 2023 AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Souza, Jessica C. S., and Leeman, John and Camron, Michael A. and May, Ryan M. (2024). *Assessing MetPy Mondays Impact on the Community to Address User Needs*. Proceedings, 104th AMS Annual Meeting. Baltimore, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Tyle, Kevin R. and Camron, Michael A. and Clyne, John and Ford, Robert and Eroglu, Orhan and Grover, Maxwell A. and Kent, Julia and May, Ryan M. and Munroe, James and Rose, Brian E. J. (2024). *Cooking up a Storm with Project Pythia*. Proceedings, 104th AMS Annual Meeting. Baltimore, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Fisher, Ward and Heimbigner, Dennis and Johnson, Hailey A. (2023). *Current State of netCDF Zarr Integration*. 2023 AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Johnson, Hailey A. and Souza, Jessica C. S. and Drwenski, Tara and Lerman, Megan and Martin, Thomas (2023). *Extensible NcML for the NetCDF-Java Library and the THREDDS Data Server*. 2023 AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Dye, Dennis G., Romine, Peter, Weber, Jeff (2023). *Facilitating Data Sovereignty and Data Governance for Environmental Monitoring on Tribal Lands*. 2023 AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Souza, Jessica C. S. and Drwenski, Tara M. and Johnson, Hailey A. and Lerman, Megan N. and Martin, Thomas (2024). *Implementing dataset preprocessing on the THREDDS Data Server*. Proceedings, 104th AMS Annual Meeting. Baltimore, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Jones, Katherine D. and Jennings, Lydia L. L. and Carroll, Stephanie and Martinez, Andrew and Balch, Jennifer and Duerr, Ruth, and Johnson, Noor, and Spellman, Katie and Weber, Jeff and Maldonado, Julie and Taitingfong, Riley and Alegado, Rosie and David-Chavez, Dominique M. and Dye, Dennis G. and Ketchum, Terry Scott and Thomas, William J. and Tofighi-Niaki, Adrien (2023). *Indigenizing your research: Recommendations from the Earth Data Relations Working Group to Implement Indigenous Data Governance across Earth Sciences*. 2023 AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Corbin, Nicole (2024). *Microlearning Strategies for Data Readiness in the Classroom*. Proceedings, 104th AMS Annual Meeting. Baltimore, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ho, Yuan (2023). *Pre and Post process of the Machine Learning dataset with UNIDATA's IDV*. 2023 AGU Fall Meeting. San Francisco, CA. Status =

PUBLISHED; Acknowledgement of Federal Support = Yes

Camron, Michael A. and Clyne, John and Eroglu, Orhan and Ford, Robert and Grover, Maxwell A. and Kent, Julia and May, Ryan M. and Munroe, James and Rose, Brian E. J. and Tyle, Kevin R. (2024). *Project Pythia: Three Years of Community Building Through Open Source Technology and Education*. Proceedings, 104th AMS Annual Meeting. Baltimore, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Weber, Jeff, Dye, Dennis G., Romine, Peter (2023). *The Sovereign Network: A Platform for Interoperable, Convergent Science*. 2023 AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ho, Yuan (2024). *Three-Dimensional Gridded Visualization and Analysis of Individual NEXRAD Level 2 Volume Radar Data*. Proceedings, 104th AMS Annual Meeting. Baltimore, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Meyer, Tiffany C. and Carter, Shay (2024). *Unidata AWIPS Update*. Proceedings, 104th AMS Annual Meeting. Baltimore, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Davis, Ethan and Fisher, Ward and Heimbigner, Dennis and Johnson, Hailey A. and May, Ryan and Oxelson Ganter, Jennifer and Dirks, Douglas G. (2023). *Updating the NetCDF User's Guide and Specifications*. 2023 AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

May, Ryan M. and Camron, Drew and Goebbert, Kevin H. (2024). *What's New and What's Coming in MetPy*. Proceedings, 104th AMS Annual Meeting. Baltimore, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

Other Publications

Patent Applications

Technologies or Techniques

Thesis/Dissertations

Websites or Other Internet Sites

NSF Unidata Website

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

The NSF Unidata website serves as a primary mechanism for NSF 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 NSF 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.

NSF Unidata YouTube Channel<https://www.youtube.com/user/unidatanews>

The NSF Unidata YouTube channel serves as a conduit for video tutorials for NSF Unidata software packages. While many of the video tutorials are created by NSF 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 NSF Unidata Seminar Series.

NSF Unidata eLearning<https://elearning.unidata.ucar.edu/>

NSF 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.

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Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Ramamurthy, Mohan	PD/PI	5
Camron, Michael	Other Professional	5
Carter, Shaylina	Other Professional	10
Chastang, Julien	Other Professional	10
Cooper, Stonie	Other Professional	11
Corbin, Nicole	Other Professional	7
Davis, Ethan	Other Professional	10
Dirks, Doug	Other Professional	9
Drwenski, Tara	Other Professional	11
Emmerson, Steve	Other Professional	6
Espinoza, Roberto	Other Professional	11
Fisher, Ward	Other Professional	11
Heimbigner, Dennis	Other Professional	7
Ho, Yuan	Other Professional	11
Johnson, Hailey	Other Professional	11
Lerman, Megan	Other Professional	7
Martin, Thomas	Other Professional	9
May, Ryan	Other Professional	5
Meyer, Tiffany	Other Professional	11
Neidigh, Joshua	Other Professional	3

Oxelson, Jennifer	Other Professional	10
Perna, Matthew	Other Professional	11
Purvis, Inken	Other Professional	9
Ruscetta, Sheri	Other Professional	3
Schmidt, Mike	Other Professional	9
Vance, Tanya	Other Professional	8
Weber, Jeff	Other Professional	11
Yoksas, Tom	Other Professional	2
Zuranski, Michael	Other Professional	11
Dos Santos Souza, Jessica	Undergraduate Student	3
Greenwood, Jhamieka	Undergraduate Student	2
Rhoades, Erin	Undergraduate Student	3

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: 5

Contribution to the Project: Program Director - Administration and Management

Funding Support: No other funding support

Change in active other support: Yes [cpos-804839.pdf](#)

International Collaboration: No

International Travel: Yes, Germany - 0 years, 0 months, 6 days; Austria - 0 years, 0 months, 7 days; Austria - 0 years, 0 months, 5 days

Michael Camron

Email: dcamron@ucar.edu

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 5

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: 10

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: 11

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: 7

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: No

Doug Dirks

Email: ddirks@ucar.edu

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 9

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: 11

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: 6

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: 7

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

Hailey Johnson

Email: hajohns@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

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: 5

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: 11

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: 3

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

Funding Support: Unidata Indirect - UOPIND

International Collaboration: No

International Travel: No

Jennifer Oxelson

Email: oxelson@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

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: 9

Contribution to the Project: Administrative Support

Funding Support: Unidata Indirect - UOPIND

International Collaboration: No

International Travel: No

Sheri Ruscetta

Email: ruscetta@ucar.edu

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 3

Contribution to the Project: Administrative Support

Funding Support: Unidata Indirect - UOPIND

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: 8

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: 2

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: 11

Contribution to the Project: Software Engineer - program development

Funding Support: No other funding source

International Collaboration: No**International Travel:** No**Jessica Dos Santos Souza****Email:** jsouza@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**Jhamieka Greenwood****Email:** jgreenwood@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**Erin Rhoades****Email:** erhoades@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

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: The University of Wisconsin provides real-time and archive data to the Unidata Program Center.

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

Nothing to report

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Impacts

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

A survey of papers published in 2023 in journals of the American Meteorological Society shows 107 articles containing citations of NSF Unidata software and data services. In the same period, an additional 191 papers published in journals of the American Geophysical Union cited NSF Unidata software and data services.

What is the impact on other disciplines?

A review of citations reported by the Google Scholar search engine in 2023 indicated that NSF Unidata software and data services were cited 45611 times in the full range of scholarly literature encompassed by the search engine. Of these, 4078 refer to NSF Unidata software packages but make no mention of the NSF Unidata program itself. This correlates with anecdotal evidence of widespread use of NSF Unidata products (especially netCDF) beyond the communities traditionally served by NSF Unidata.

What is the impact on the development of human resources?

NSF 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 NSF 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 for the 2023-2024 cycle:

Number of U.S. universities receiving software: 228

Number of universities outside the U.S.: 574

Approximate number of attendees of 2023-2024 training workshops in-person and virtual: 582

What is the impact on physical resources that form infrastructure?

Community Equipment Awards

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

Projects funded in 2023 include:

University/PI	Project Title
Coastal Carolina University Paul T. Gayes	Establishing Weather & Climate Instructional and Research Students Services at Coastal Carolina University Via the Creation of the UCAR Facility for Oceanic & Atmospheric Modeling & Visualization (FOAM-V)
Embry-Riddle Aeronautical University – Daytona Beach Christopher G. Herbster	Hardware Enhancements to Support Physics Informed Machine Learning (PIML) to Improve Airport Weather Forecasts
Howard University Nakul Karle	Enhancing Computing Accessibility in the Atmospheric Science Program at Howard University
University of Missouri Patrick S. Market	Maintaining access to LDM and EDEX data streams to cybersupport CAVE and legacy NAWIPS software at the University of Missouri

A complete list of projects funded under the Community Equipment Awards program and the many creative applications of NSF 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?

NSF 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, NSF Unidata has assumed a central role in identifying and articulating standards, conventions, and data formats. NSF 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. NSF 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:

NSF Unidata Science Gateway

The NSF Unidata Science Gateway on NSF's Jetstream Cloud collects NSF 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 NSF Unidata Science Gateway is a JupyterHub server, which allows students and educators to access NSF Unidata-provided Jupyter notebooks illustrating atmospheric science concepts. During the 2023-2024 academic year NSF 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. With the advent of the Jetstream2 program, the NSF Unidata Science Gateway is able to offer community members the ability to take advantage of GPU resources alongside CPU resources, facilitating the use of AI/ML tools and techniques. All told, courses serving over 1800 students at 32 universities have now taken advantage of this NSF Unidata resource. In addition, the Science Gateway provided resources for three workshops associated with the AMS Annual Meeting in January 2024, serving 137 meeting participants.

NSF 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 2023, Science Gateway resources helped support 15 SOARS protégés in their summer session.

The growing acceptance and use of the NSF Unidata Science Gateway has led the program to allocate additional resources to the project from our core funding. In the fifth year of this award, Program Center staff continued the ongoing "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 2024.

Of special interest has been the operation of a community-accessible cloud-based AWIPS Environmental Data EXchange (EDEX) server. NSF 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. NSF Unidata’s cloud-based EDEX server provides roughly 35 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.

In the 2023-2024 resource allocation cycle, NSF Unidata has been awarded 8 million Service Units (SUs) from the NSF ACCESS program to maintain continuous community availability for essential servers like EDEX, JupyterHub, THREDDS, RAMADDA, and LDM/IDD nodes via the NSF Unidata Science Gateway. This grant allows community members to take advantage of a variety of CPU and GPU virtual machines (VMs) with various configurations. This is the UPC’s largest allocation since 2015, and a significant increase from the 2022-2023 cycle’s resource grant of roughly 5 million SUs.

Scientific Society Meetings

NSF 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 2024, NSF Unidata staff and community members convened sessions and made presentations as part of the 40th Conference on Environmental Information Processing Technologies (EIPT), the 14th Symposium on Advances in Modeling and Analysis Using the Programming Languages of Open Science, and others.

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, NSF Unidata staff have also begun participating in SACNAS, AIHEC, and AISES conferences and meetings.

Open Geospatial Consortium

NSF Unidata has a long history of involvement with the Open Geospatial Consortium working towards implementation and adoption of data standards. A NSF 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.

NSF 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 NSF 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 NSF 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.

Projects Begun under the EarthCube Program

NSF Unidata participates in a variety of activities begun under the NSF EarthCube program, including collaboration on several awarded “Building Blocks” proposals. Currently, NSF 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. (See note under “Significant Results: Data Distribution” regarding presentation of statistics as of early 2024.)

While the “push” data services provided by the IDD system are the backbone of NSF 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 2023 the UPC provided roughly 2.4 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 NSF Unidata’s needs.

The NSF 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.

NSF 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.

NSF 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 NSF Unidata’s Common Data Model (CDM) on which the TDS is built.

NSF 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 MetPy-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 sixty contributors who are not UPC staff members.

NSF 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 NSF 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.

NSF 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, NSF 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 NSF 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.

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

What is the impact on society beyond science and technology?

NSF 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 NSF 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 NSF Unidata.

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

Nothing to report.

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Changes/Problems

Changes in approach and reason for change

Nothing to report.

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

Nothing to report.

Changes that have a significant impact on expenditures

Nothing to report.

Significant changes in use or care of human subjects

Nothing to report.

Significant changes in use or care of vertebrate animals

Nothing to report.

Significant changes in use or care of biohazards

Nothing to report.

Change in primary performance site location

Nothing to report.

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