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The Metrics Assessment of the Unidata Program

Final Report

December 31, 2006

Prepared by:

Nelson Consulting, LLC

Abstract:

This is the final and complete report for the metrics assessment of the Unidata program conducted from 12/12/2005 through 12/31/2006.

DOCUMENT INFORMATION

Document Developers

Sarah Nelson, Ed.D., Chief Executive Officer, Nelson Consulting, LLC
Christopher K. Nelson, Ph.D., Lead Consultant, Nelson Consulting, LLC

Document Contact

Nelson Consulting, LLC
1624 Market Street, Suite 207
Denver, CO 80202

Website: www.nelsonconsulting.us
Email: sarah.nelson@nelsonconsulting.us
Telephone: (720) 989–3502

Document Distribution

University Corporation for Atmospheric Research (UCAR)
1850 Table Mesa Drive
Boulder, CO 80305
Attention: Dr. Mohan Ramamurthy

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EXECUTIVE SUMMARY

Has the Unidata program been a successful investment? How has it been successful and why? Has it been transformational in the way you conduct your teaching and/or research? These are important questions to which the Unidata Program Center (UPC) and the National Science Foundation (NSF) were seeking answers. Based on NSF panel recommendation and in consultation with NSF officials, the Unidata Program Center hired Nelson Consulting, LLC to conduct this independent study.

Unidata is a diverse community of over 160 institutions vested in the common goal of sharing data and tools to access and visualize that data. For over 20 years, Unidata has been providing data, tools, and support to enhance Earth-system education and research. In an era of increasing data complexity, accessibility, and multidisciplinary integration, Unidata provides a rich set of services and tools. In deciding the best methodology for this study, Nelson Consulting, LLC recommended the development of a survey, the use of focus group discussions, individual interviews, and case studies. The web-based survey was used to gather information from community members who were dispersed across 44 states and 37 countries. The information gathered from the survey was used to develop the focus group protocol. Individual interviews were used to engage community members who had been members of the Unidata community for five years or longer. This group of members offered a unique perspective about the transformative nature of Unidata's work. The case studies were also used to demonstrate how the Unidata program had contributed to transformative research to enhance Earth-system education and research.

The Unidata Program Center, as the leader of a broad community:

- Explores new technologies
- Evaluates and implements technological standards and tools
- Advocates for the community
- Provides leadership in solving community problems and develops innovative solutions and new capabilities to address community needs
- Negotiates for new and important data sets for use in research and education on behalf of the community
- Facilitates data discovery and use of digital libraries
- Enables student-centered learning in the Earth system sciences by promoting use of data and tools in education
- Provides software and tools for visualization and analysis of Earth system science data
- Provides support to the growing community
- Values open standards, interoperability, and open-source approaches
- Develops innovative solutions and new capabilities to solve community needs
- Stays abreast of computing trends as they pertain to advancing research and education in the geosciences
- Performs governance activities using a community-based approach

Every stage of this study offered an opportunity for the consultants to experience all the reasons why the Unidata program has been successful and the organizational excellence reflected in the daily operations of the Unidata Program Center. The staff is extremely knowledgeable, dedicated, and interested in promoting and sharing their work. Unlike some other organizations where staff members hardly communicate with each other, it is obvious that whether a person works in software or in outreach, there is a sense of unity and equality among the personnel. Every person's contribution is viewed as important to the overall productivity of the organization. In addition to the outstanding staff and their

sense of duty, the "community process" (which includes community engagement, governance, feedback, partnership, and support) is the most important factor in Unidata's success.

In conversing with the community members, the consultants learned that the Unidata program was irreplaceable. Faculty are exposed to technological developments that affect their discipline and that they find extremely valuable for their professional development and for their students. The program is truly community-based and this is reflected in its daily operations and also at the governing level. The community members expressed how impressed they were by the ability of the staff to respond to their inquiries in a timely manner. The Unidata program has established a reliable socio-technical environment that leverages developments in data delivery to maximize creativity and learning in the geosciences. For example, the smaller undergraduate institutions appreciate the fact that without the Unidata program, it would be impossible for them to experience the current level of collaboration with other larger institutions. The ability for professors and students to access software building blocks so that they do not have to re-invent the wheel is vital for improving productivity at a small institution. The Unidata program has encouraged the community to move toward open standards and this is revolutionary from the user's and data provider's perspective.

The Unidata program has truly transformed teaching in the field of geosciences. In one institution, this transformation led to a tripling of the undergraduate majors in the meteorology program. As explained by faculty members throughout this study, without the data and software provided by Unidata, the meteorology programs would be severely limited in their ability to carry out their mission. Unidata has helped these programs expand the spectrum of meteorological data and created the ability for faculty to easily interrogate data, allowing them to spend more time teaching and on research in atmospheric science. In another instance, the National Climatic Data Center frequently uses Unidata software and formats (netCDF), and their processing and access is moving towards Unidata-developed architecture. Overall, netCDF was frequently praised as a step toward a long term perspective on standard data formats, making this one of the most important case studies in this report.

The consultants were very impressed with the indirect benefits of the Unidata program. Indirect benefits are benefits that are not directly related to Unidata's mission but they occur because the Unidata community has leveraged the direct benefits of the program. For example, the University of Kentucky has been a Unidata member for several years and this has allowed the university to build a comprehensive outreach and educational program including weather-related products for Kentucky residents within the agricultural industry. The agricultural community informed the university that the educational products they provide are a "quantum leap forward" in agriculture. In another instance, a participant from a facility that does not engage in education or research explained that many Unidata products are used in support of the Space Shuttle program. For example, the Local Data Manager is indispensable to forecast operations and plans for larger uses supporting future manned and unmanned space activities that are currently underway.

In conclusion the Unidata program is in alignment with NSF's Goals for Ideas, People, and Tools because it has (a) facilitated a more inclusive workforce and increased the community members' information technology knowledge, (b) transformed the speed at which data can be accessed, displayed, and analyzed to promote academic learning, (c) transformed organizational culture, and (d) contributed extensively to the transformational research at an institutional level by drastically reducing the amount of time and effort required to conduct research activities. In addition, the ability to visualize multiple types of data using a variety of views provides a unique learning experience for students interested in meteorology while giving students with different learning styles a way of engaging with the subject of meteorology. The Unidata workshops are highly regarded by the community with 97% of workshop participants stating they would recommend them to other people. Finally, the community-based governance works well in meeting community needs both at a personal and institutional level.

The overall perception of the Unidata Program is extremely positive based on the interviews, focus groups, survey outcomes, and case studies. The summary of recommendations outlined below are based on the outcomes of this study, statements made by community members, and statements made by Unidata personnel. The consultants are aware that it may take time to implement these recommendations; however, the effort would be a worthwhile investment. The Unidata Program can be improved by (a) the transfer of highly specialized knowledge to ensure continuity in projects, (b) hiring a QA/testing resource and/or technical writer, (c) implementing a cross-sharing of resources where developers test each other's code, (d) leveraging resources to assist in knowledge transfer of data sets, documentation, and reduction in the duplication of common process steps, (e) reviewing the current code control tools and determining if investing in new code control tools is beneficial, (f) seeking additional funding for on-site training at member universities, and (g) considering a follow up study to explore the indirect benefits of the Unidata program.

The quality of software and support offered by the Unidata Program to its community members is exceptional and community members were in strong agreement that Unidata has stayed true to its core values while accomplishing its goals. The Unidata Program is one of the most important things that UCAR has done over the years. The impact has been experienced by future scientists, educators, and students in the classroom, as well as other professionals. Unidata was repeatedly stated to be a model program by the community members. One respondent explained it as follows: “The Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI) is an organization representing more than a hundred USA universities – it is the Hydrology equivalent of UCAR. In recent years, with NSF support, CUAHSI has been working on providing hydrologists with better access to hydrology data. Most hydrologists would agree that the ultimate goal is to have an equivalent of Unidata for hydrology.”

It is fair to conclude that the Unidata Program has been successful because (a) the community is in relative agreement with the program objectives and outcomes, (b) feedback from the community is encouraged by the governing committees, (c) the workshops and training offered keep community members linked to the program, and (d) when problems arise, they are resolved in a timely manner.

SECTION I: INTRODUCTION

Overview of the Unidata Program

Unidata's mission is to provide data, tools, and community leadership for enhanced Earth-system education and research. Unidata, funded primarily by the National Science Foundation, is one of eight programs in the University Corporation for Atmospheric Research (UCAR) Office of Programs (UOP). UOP units create, conduct, and coordinate projects that strengthen education and research in the atmospheric, oceanic, and earth sciences.

Unidata is a diverse community of over 160 institutions vested in the common goal of sharing data and tools to access and visualize that data. For over 20 years Unidata has been providing data, tools, and support to enhance Earth-system education and research. In an era of increasing data complexity, accessibility, and multidisciplinary integration, Unidata provides a rich set of services and tools.

The Unidata Program Center, as the leader of a broad community:

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According to the Unidata Strategic Plan that was amended and adopted by the Unidata Policy Committee on February 26, 2002, Unidata has core values that drive all aspects of its governance and structure. The core community toward which Unidata targets its products and services is composed of post-secondary educators and researchers in Earth-system science and associated disciplines. Unidata products and services benefit scholars, at all levels, in multiple countries, in all areas of science, mathematics, engineering, and technology education. Specifically, support services and other staff-intensive activities within the Unidata Program Center are directed toward educators and researchers at post-secondary, academic institutions in the U.S.A. The final action plan dated February 1st, 2006, outlined the objectives, estimated effort, and approach for the Metrics Assessment of the Unidata Program Center as developed by Nelson Consulting, LLC in coordination with Unidata Members of the Working Group based on the role description outlined in the document "Building Unidata's Metrics and Assessment Tool DRAFT-December 14, 2005".

Background of the Evaluation Study

The evaluation study was commissioned by the Unidata Program Center, based on a NSF panel recommendation and in consultation with NSF program officials, in order to determine whether or not the Unidata program has been a successful investment. An important aspect of the study was to address the transformational impact of Unidata in the way members conduct teaching and/or research. In an effort to evaluate the Unidata program, the UPC hired Dr. Sarah Nelson of Nelson Consulting, LLC, an independent consulting firm, experienced in program evaluation to conduct an assessment of the Unidata program.

Objectives of the Evaluation Study

The primary objective of this evaluation process was to implement an outcome-based evaluation that demonstrates the impact of the Unidata program. In order to accomplish this objective the process was twofold, (I) offer a historical perspective of the program, and (II) develop a qualitative and quantitative methodology to collect data, analyze data, and then make interpretations of the outcomes of the program. The secondary objective of this evaluation process was to demonstrate how the Unidata program aligns with National Science Foundation's strategic goals of people, ideas, tools, and organizational excellence. These were the NSF goals when the study began and the new strategic goals as they align to the old goals have been explained in the section "NSF's New Definitions". The organizational excellence goal is reflected in the outcomes of this study because the impact of the Unidata Program is closely associated with the organizational excellence of the Unidata Program Center. Also, organizational excellence is addressed in "Section X: Additional Contributions to the Study".

Success Indicators of the Evaluation Study

Since one of the Unidata program's perceived strengths was its flexibility to respond to community needs, the evaluation tools used the following success indicators (Data , Tools, Community, Support, and Service) as identified in the document "Building Unidata's Metrics and Assessment Tool DRAFT-December 14, 2005" (pages 5-7).

Scope of the Evaluation Study

The evaluation activities addressed the following three outcome levels (1) Strategic outcomes, (2) Operational outcomes, and (3) Tactical outcomes. Given that organizations function at these three levels, it was important to map the evaluation outcomes to these three levels in order to provide practical conclusions for every organizational level. Each type of outcome for the Unidata evaluation is described below.

Strategic Outcomes: Alignment with NSF's goals (people, ideas, and tools) constituted strategic outcomes. Subsequently, responses that depict "strong agreement" or "agreement" translated into complete alignment or alignment with NSF strategic goals, respectively. Likewise, "strong disagreement" or "disagreement" translated into complete lack of alignment or a relative lack of alignment.

Operational Outcomes: Operational outcomes included the impact on culture in the areas of research, teaching, and collaboration, or the impact on institutional Cyberinfrastructure in the areas of data access, data distribution, as well as student, faculty, and researcher participation in field projects. Operational outcomes also addressed outreach outcomes and Unidata's core values and consistency. Responses that depict "strong agreement" or "agreement" translated into "very strong transformational effects" or "relative transformational effects" within the community, respectively. Likewise, "strong

disagreement" or "disagreement" translated into "very weak transformational effects" or "weak transformational effects".

Tactical Outcomes: Responses to demographics, data access and usage, support inquiries, and software usage constituted tactical outcomes. For example: responses regarding the state where participants reside provided feedback about the geographical diversity of the community. This outcome can be a driving force in deciding where to focus outreach efforts. Also, knowing who uses what software and how frequently they use it can assist in allocating human and financial resources to specific software projects.

NSF's New Definitions

After the evaluation study was already underway, the definitions of the NSF strategic goals were revised. This section maps the previous definitions to the current definitions as follows:

Discovery

> "Discovery" maps to the previous category of "Ideas" and the term is used to describe fostering research that will advance the frontiers of knowledge, emphasizing areas of greatest opportunity and potential benefit and establishing the nation as a global leader in fundamental and transformational science and engineering.

Learning

> "Learning" maps to the previous category of "People" and the term is used to describe cultivating a world-class, broadly inclusive science and engineering workforce, and expand the scientific literacy of all citizens.

Research

> "Research" maps to the previous category of "Tools" and the term is used to describe building the nation's research capability through critical investments in advanced instrumentation, facilities, cyberinfrastructure, and experimental tools.

Stewardship

> "Stewardship" maps to the previous category of "Organizational excellence" and the term is used to describe supporting excellence in science and engineering research and education through a capable and responsive organization.

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SECTION II: METHODOLOGY

This section describes the multiple methods used to collect and analyze data for the evaluation study. The data collection methods were a survey administration, focus groups, individual interviews, case studies, and alignment table. The following section describes these methods.

Survey

The first method of collecting data was an administration of a survey (Appendix B) to the user community. Nelson Consulting, LLC developed one survey with multiple sections using psychometric theory in order to measure the impact of the Unidata program. The survey comprised of multiple sections with each section measuring a specific component of the program (e.g., Unidata Program's core values, NSF's strategic goals, and the transformative aspects of the Unidata Program). This psychometric-theory based approach helped ensure that each section of the survey met general standards of reliability and validity required to compute outcomes of the Unidata program.

After the final action plan was completed and delivered on February 1st, 2006, this survey was reviewed by the metrics working group and shortened. The final version was approved by Dr. Mohan Ramamurthy and Linda Miller. During the December 16, 2005 meeting, the decision to use a web-based survey was approved given the fact that it allows the largest volume of data to be collected and stored in the shortest amount of time, compared to the traditional approach of mailing out the survey to participants and then manually entering the data.

- *Survey Development.* The primary method of collecting quantitative data was the development and administration of a survey. Nelson Consulting, LLC developed the survey using psychometric theory in order to measure the impact of the Unidata program. The survey measured strategic, operational, and tactical outcomes as described in the previous section.

- *Survey Participants.* The web-based survey was posted on www.surveymonkey.com and participants were asked to log in and respond anonymously. Invitations to participate in the survey effort were distributed to 3,000 email addresses from the Unidata database and a total of 432 people responded to the survey. Initial thoughts related to active community membership were that 3,000 people were active community members; however, based on the results of interviews with Unidata personnel during this evaluation, the number of active members within the Unidata community was estimated to be approximately 1,200 to 1,500, leading to a survey response rate estimated between 28.8% to 36.0%. Estimating the number of "active members" was done through counts of community members that directly asked the UPC for support; however, it is important to consider the number of community members who never ask questions to support. As a result, the estimated number of community members from 1,200 to 1,500 may be overly conservative with the number of actual community members possibly extending to many more than 1,500.

- *Survey Reliability.* The reliability of an instrument is concerned with whether it produces identical results in repeated applications. Reliability for each survey factor as well as for the overall instrument was calculated using Cronbach's alpha (or coefficient alpha). Cronbach's alpha is a measure of internal reliability or internal consistency of the scale. Since Cronbach's alpha is a correlation, it can range between -1.0 and 1.0. In most cases it is positive, although negative values arise occasionally. Typically, a Cronbach's alpha value of at least 0.70 is desired. Since this measure of reliability is positively related to the number of items included within a given scale, scales with fewer numbers of items may exhibit lower values of reliability.

Table 1: Survey Factor Reliability

Survey Factor	Factor Reliability
Alignment with NSF Goals for Ideas	0.91
Alignment with NSF Goals for People	0.88
Alignment with NSF Goals for Tools	0.90
Impact on Culture	0.90
Impact on Institutional Cyberinfrastructure	0.80
Outreach	0.70
Unidata's Core Values and Consistency	0.85
Support Inquiries	0.70
Software Usage	0.55
Overall Instrument	0.97

The overall instrument has a reliability of 0.97. This means that the results for the entire instrument are internally consistent and can produce similar results in repeated applications since the minimum recommended Cronbach's alpha value for a reliable instrument is 0.70.

Interviews

The second method of collecting data was interviews. Two groups of people were interviewed (a) faculty and researchers, and (b) software engineers/administrators at Unidata. First, faculty and researcher interviews were conducted to determine the transformational aspect of Unidata's work from early years to current years. Interview participants with a long history of participation with Unidata were identified by Dr. Mohan Ramamurthy and Linda Miller.

Second, interviews of the software engineers and managers at Unidata were conducted to examine the organization's current software engineering practices from a software process management perspective. The number of interview participants was based on the number of people who work with software services at Unidata and the number of people who consented to participate in an interview. Key software development members were identified by Dr. Ramamurthy and Ms. Miller and provided to Nelson Consulting, LLC.

The objective of the faculty and researcher interviews was to determine how the National Science Foundation's investment in Unidata has been transformational to the community. The objectives of the software interviews were (a) to provide an accurate picture of Unidata's existing software process strengths and weaknesses, (b) to provide a historical account of the activities conducted by the software organization, and (c) to encourage continual improvement in the quality of software engineering products, the processes employed, and the people who create and implement the processes.

Focus Groups

The third method of collecting data was focus groups. The focus group interviews included five groups of participants from the community who attended the July 10-14, 2006 Unidata Summer Workshop and the July 17-21, 2006 COMET workshop. Overall, the focus group participants were as follows:

- Faculty made up a total of three focus groups
- Graduate students made up one focus group
- "Others" made up one focus group. This group included members who were neither faculty nor graduate students.

Case Studies

The fourth method of collecting input was through case studies. The case studies included software that was developed at Unidata and software that was developed elsewhere but is supported by Unidata. The Metrics Working Group, led by Dr. Mohan Ramamurthy and Linda Miller, identified the case studies for inclusion in the evaluation process. The objective of the case studies was to highlight the transformational aspect of Unidata's work from the early years to the present that has impacted people, ideas, tools, and UPC excellence. The following case studies were included in this study:

- Network Common Data Form (netCDF)
- Integrated Data Viewer (IDV)
- Starcasting: Unidata's Role in Generating Custom Meteorological Forecasts in Support of Astronomical Operations at Mauna Kea
- WSR-88D Level II Radar Data Distribution Using Unidata Technologies
- International Impact Case Study

Alignment Table

The fifth method of collecting data was an effort to complete an alignment table (Appendix C). Current Governing Committee members were asked to complete the alignment table independently and anonymously based on (a) length of participation in the program, (b) experience with the program, and (c) level of involvement with the program. The evaluators then conducted a content analysis of these responses and, based on the themes that emerged, the evaluators included these themes as additional contributions to the study. The objective of the alignment table was to align Unidata program's retrospective analysis to National Science Foundation's strategic goals (people, ideas, tools, and organizational excellence).

SECTION III: SURVEY DEMOGRAPHIC RESULTS

This section identifies the results of the demographic section of the survey. Demographic areas included geographic dispersion by state and/or country, number of years experience as a member of the Unidata community, affiliation type, and profession of the survey participants.

Geographic Dispersion of Respondents

A total of 305 participants reside in the United States of America while 125 participants reside outside the United States of America. There are 2 participants who did not identify their residence.

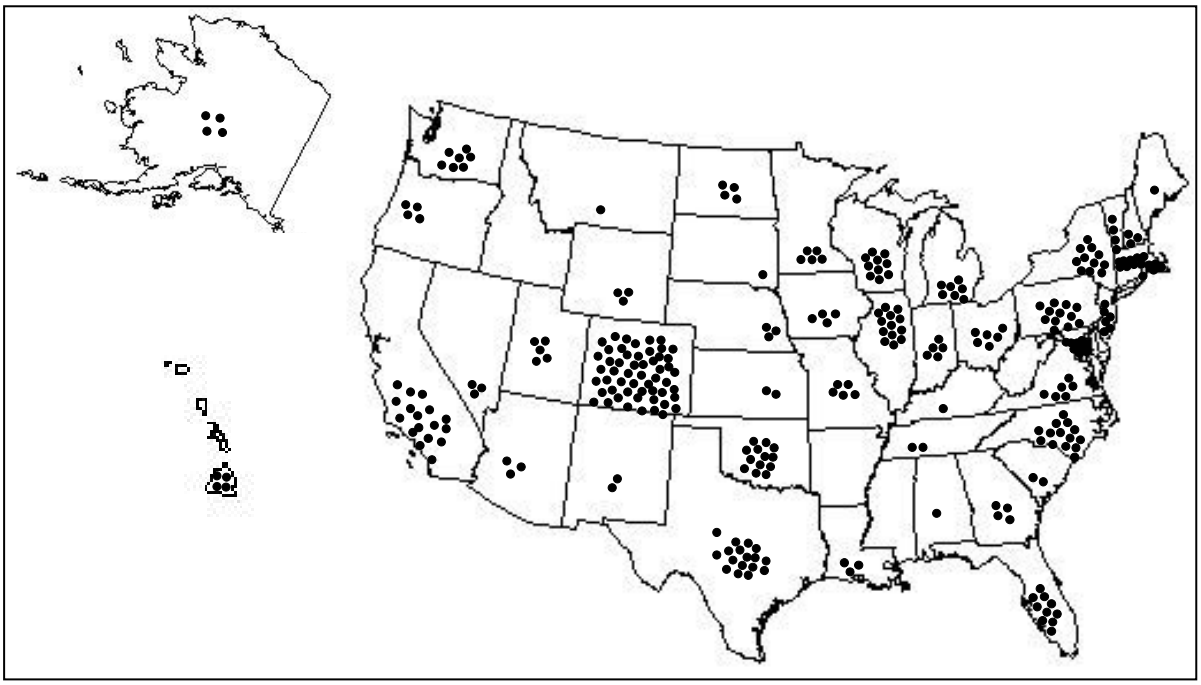


Figure 1: National Dispersion of Survey Respondents

Overall, 44 of the 50 United States (88%) had at least one respondent to the survey. The states and number of survey respondents are identified in Table 2.

Table 2: National Survey Respondents

State	Survey Responses	State	Survey Responses	State	Survey Responses
Colorado	54	Indiana	5	Kansas	2
California	17	Minnesota	5	New Mexico	2
Texas	17	Missouri	5	South Carolina	2
North Carolina	14	Utah	5	Tennessee	2
Illinois	13	Alaska	4	Alabama	1
Massachusetts	13	Georgia	4	Kentucky	1
Oklahoma	13	Hawaii	4	Maine	1
Pennsylvania	12	Iowa	4	Montana	1
New York	11	North Dakota	4	Rhode Island	1
Florida	10	Oregon	4	South Dakota	1
Wisconsin	10	Vermont	4	Arkansas	0
Maryland	9	Arizona	3	Connecticut	0
Michigan	7	Louisiana	3	Delaware	0
Washington	7	Nebraska	3	Idaho	0
New Jersey	6	Nevada	3	Mississippi	0
Ohio	6	New Hampshire	3	West Virginia	0
Virginia	6	Wyoming	3		

Figure 2: International Dispersion of Survey Respondents

There were 242 countries included in the survey and 15.3% (37) had at least one respondent to the survey. The countries and the associated number of survey respondents are identified in Table 3.

Table 3: International Survey Respondents

Country	Survey Responses	Country	Survey Responses	Country	Survey Responses
Australia	12	Argentina	3	Lithuania	1
Brazil	10	Israel	2	Panama	1
United Kingdom	10	Macau	2	Papua New Guinea	1
Canada	9	Portugal	2	Romania	1
Germany	9	Russian Federation	2	Singapore	1
Norway	8	Switzerland	2	South Korea	1
India	6	Taiwan	2	Sri Lanka	1
Italy	6	Belarus	1	Sweden	1
France	5	Bulgaria	1	Ukraine	1
Spain	5	Costa Rica	1	United Arab Emirates	1
Turkey	5	Finland	1	Vietnam	1
China	4	Hong Kong	1		
Netherlands	4	Ireland	1		

Membership of Survey Respondents

The following figure and tables (Figure 3, Tables 4 & 5) summarize the length of member participation in the Unidata program based on the year each respondent joined the Unidata community. The length of membership was calculated by using the year a member joined the Unidata Community as the base year. Overall, 414 participants provided this information.

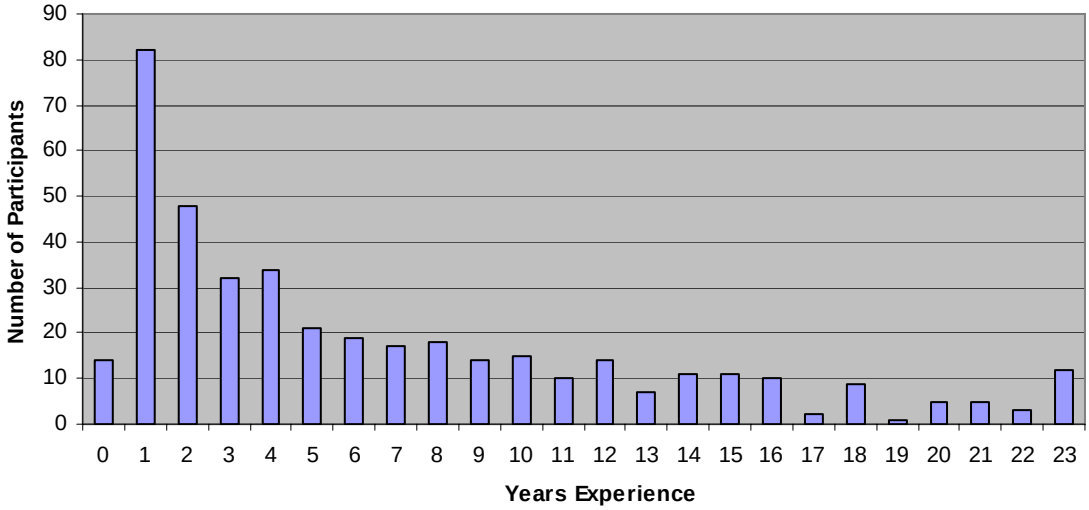


Figure 3: Years Experience

Table 4: Membership of Survey Respondents

Year Joined Unidata Community	Response Percent	Response Total	Years Experience
2006	3.4%	14	0
2005	19.8%	82	1
2004	11.6%	48	2
2003	7.7%	32	3
2002	8.2%	34	4
2001	5.1%	21	5
2000	4.6%	19	6
1999	4.1%	17	7
1998	4.3%	18	8
1997	3.4%	14	9
1996	3.6%	15	10
1995	2.4%	10	11
1994	3.4%	14	12
1993	1.7%	7	13
1992	2.7%	11	14
1991	2.7%	11	15
1990	2.4%	10	16
1989	0.5%	2	17
1988	2.2%	9	18
1987	0.2%	1	19
1986	1.2%	5	20
1985	1.2%	5	21
1984	0.7%	3	22
1983	2.9%	12	23

Note: n = 414

Table 5: Quartile Report for Membership of Survey Respondents

Parameter	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile
Length of membership	1	2	4	10	16

Note: n = 414

The average length of membership was 6.7 years while the median length of membership was 4 years as noted by the 50th percentile in Table 5. Approximately 43% of the participants had been members of Unidata for three years or less as depicted by table 4.

Affiliation of Survey Respondents

The following table identifies the affiliations of the participants for the survey.

Table 6: Affiliation Types

Affiliation Type	Response Percent	Response Total
Ph.D. Granting Institution	29.7%	127
Degree Granting Institution (BS and MS only)	11.2%	48
Government	19.6%	84
Research Laboratory	11.4%	49
UCAR	9.3%	40
Other	18.7%	80

Note: n = 428

The affiliation most represented by the participants of the survey was Ph.D. granting institutions (29.7%). The next highest representations were from government agencies (19.6%), research laboratories (11.4%), BS and MS only institutions (11.2%), followed by UCAR representation (9.3%). The "Other" affiliation category made up 18.7% of the sample and included affiliations such as high schools, foreign governments, contractors, private individuals, and meteorological institutes.

Professions of Survey Respondents

The following table identifies the professions of the survey respondents.

Table 7: Professions of Survey Respondents

Profession	Response Percent	Response Total
Faculty	14.0%	60
Graduate Student	11.9%	51
Undergraduate Student	6.1%	26
Scientist/Researcher	33.6%	144
Other	34.5%	148

Note: n = 429

The profession most represented by the participants of the survey was scientist/researcher (33.6%). The next highest represented profession was faculty (14.0%), followed by graduate students (11.9%) and finally, undergraduate students (6.1%). The "Other" profession category comprised 34.5% of the sample and included professions such as: meteorologists, contractors, emergency management, software engineers, telecommunications professionals, and weather forecasters.

SECTION IV: STRATEGIC OUTCOMES

Alignment with NSF's goals (people, ideas, and tools) constituted strategic outcomes. Responses that depict "strong agreement" or "agreement" translated into complete alignment or alignment with NSF strategic goals, respectively. Likewise, "strong disagreement" or "disagreement" translated into complete lack of alignment or a relative lack of alignment. Each part within this section includes survey outcomes, findings and interpretations, and focus group outcomes.

Alignment with NSF Goals for Ideas

Survey Outcomes

Alignment with NSF's goals (people, ideas, and tools) constitute strategic outcomes. Mean scores and standard deviations (SD) were calculated using each respondent's answers on a four-point rating scale where (1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree). Subsequently, responses that depict "strong agreement" or "agreement" translate into complete alignment or alignment with NSF strategic goals, respectively. Likewise, "strong disagreement" or "disagreement" translates into complete lack of alignment or a relative lack of alignment.

High item-total correlations indicate items that could be considered most important in discriminating between individual total scores for each set of questions related to Alignment with NSF Goals for Ideas. In other words, item-total correlations quantify the extent to which agreement with a specific item corresponds to overall agreement for the entire set of questions related to Alignment with NSF Goals for Ideas. Higher item-total correlations identify the items that could possibly be considered as most related in determining overall agreement with Alignment with NSF Goals for Ideas.

Mean scores (i.e., average scores) for each item within the section "Alignment with NSF Goals for Ideas" are plotted in Figure 4. Table 8 contains the actual question number, mean score, standard deviation, and item-total correlation for each item within this question set.

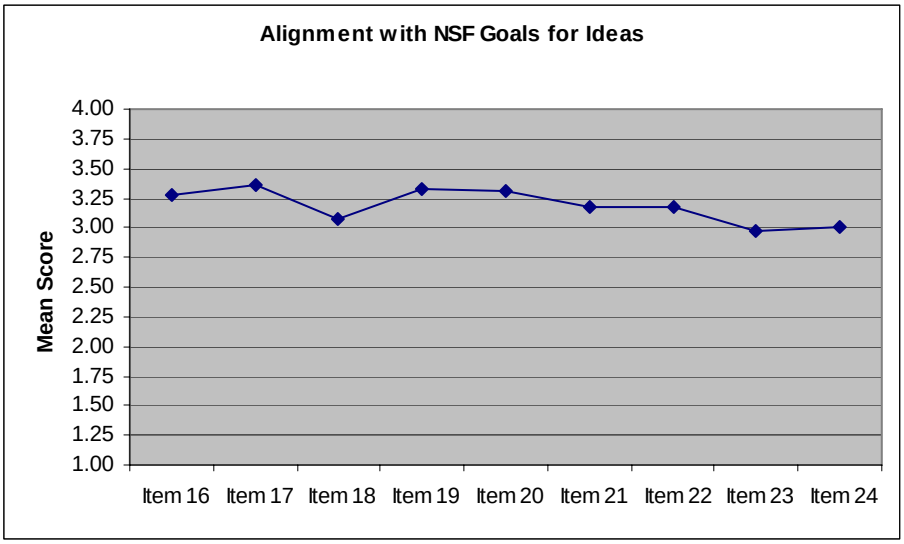


Figure 4: Results for Alignment with NSF Goals for Ideas

Table 8: Results for Alignment with NSF Goals for Ideas

Variable	Question	Mean	Standard Deviation	Item-Total Correlation
Item 16	Participating in the Unidata community has increased my intellectual capital.	3.28	0.60	0.70
Item 17	Participating in the Unidata community has increased my information technology knowledge.	3.36	0.62	0.72
Item 18	Participating in the Unidata community has contributed toward my atmospheric science knowledge.	3.08	0.70	0.65
Item 19	Participating in the Unidata community has contributed to my research capabilities.	3.32	0.64	0.66
Item 20	I have noticed technological innovations within the Unidata Community since I started participating.	3.31	0.65	0.74
Item 21	Participating in the Unidata community has helped me to engage in technological innovations.	3.17	0.67	0.73
Item 22	I have noticed that Unidata adapts to change in the community.	3.18	0.59	0.61
Item 23	Unidata has changed the way I conduct research.	2.98	0.72	0.68
Item 24	Unidata has changed the way I teach.	3.01	0.74	0.68

Findings and Interpretations

Based on the survey outcomes 92.9% of the respondents agreed or strongly agreed that Unidata has increased their information technology knowledge and this is also supported by the fact that item 17 resulted in the highest mean score of 3.36. Item 23 had a mean score of 2.98 and this can be explained by the fact that 23.7% of the participants did not find this question applicable and 17.4% of the participants disagreed or strongly disagreed with this statement.

The "technical innovations within the Unidata Community" have the highest impact related to discovery (ideas) as demonstrated by the item-total correlations that ranged from 0.61 to 0.74 with "technical innovations" computing the highest correlation of 0.74.

Focus Group Outcomes

The focus group participants were categorized into faculty and graduate students. These focus group discussions were used to further investigate the significant issues identified by the initial survey results. The following focus group discussions offer insight into some strategic issues raised in the survey outcomes.

Impact on Research Activities. Given that approximately 34% of the survey respondents identified themselves as researchers, the focus group discussions included exploring the impact that Unidata has had on research activities.

- The participants stated that although many people take Unidata products and services for granted, community members recounted the days in which obtaining data took a long time and ensuring these data were in the correct format took an even longer time. Unidata products and services have helped to drastically reduce the amount of time and effort required for community members to conduct research activities. As a result, scientists spend more time focusing on their work instead of figuring out how to access and format data.

- One perceived drawback to the advances in technology has been less social interaction among researchers and students. Research activities are now centered around computer terminals rather than paper maps, which has resulted in reducing the social interaction among researchers.

Impact on Teaching Activities. Given that 41% of the respondents were affiliated with a teaching institution, the focus group discussions explored the impact that Unidata has had on teaching.

- Everyone agrees that Unidata products and services have saved a great amount of time and effort related to the classroom experience and teaching students. The ability to access data in real-time has improved the classroom experience tremendously. Quick and timely access to data was important for everyone; however, the ability for faculty to easily integrate these data capabilities into their courses along with the "visualization" capabilities has been very important in improving the learning atmosphere within the classroom setting which helped students enjoy the courses even more. Even with the advances in technology provided by Unidata, some faculty members still have students conduct "hand analysis" activities using maps.

Quotes Worth Noting

During the focus group discussions, members shared some thoughts and part of the exploration was to get community member feedback. Here are some quotes worth noting.

- "It used to take me a long time to get my data into the correct format. Using Unidata software has helped me get these data into the proper format easier and allow me to do my analysis faster."

- "Having decoder functionality has helped greatly in my productivity. The ability to have real-time access to data is great. One negative aspect would be that moving away from paper maps reduces interaction among researchers and students which is more social."

- "Unidata has changed the way I teach – especially the importance and ease of accessing data. My teaching has evolved with Unidata products and includes not just accessing data, but the integration of data and using these data in the classroom. Unidata has state of the art thoughts about education and earth science systems and I try to integrate this into the classroom."

- "The functionality of IDV "Save as" state helps a great deal with education. This feature helps us not have to re-work multiple steps for each class."

- "Unidata products have been very useful for visualization in the classroom."

- "If Unidata would go away, it would change the way we conduct research. It's critical to what we do and we take it for granted because it is so much a part of what we do. If we lost Unidata, it would be like losing Microsoft Word as an application – it would be profound."

- "Unidata products and documentation have helped in teaching. These products have saved me time and effort compared to if I was to do this myself. We even have a graduate course in computer applications in how to use Unidata products. The Unidata tutorials have been helpful for me and then I can distribute the knowledge to students. Unidata products also help in teaching weather to non-science majors and assist with map discussions."

Alignment with NSF Goals for People

Survey Outcomes

The following figure (Figure 5) graphically displays the results for "Alignment with NSF Goals for People". Mean scores (i.e., average scores) for each item within this questionnaire section are plotted. The following Table 9 contains the actual question number, mean score, standard deviation, and item-total correlation for each item within each set of questions related to Alignment with NSF Goals for People.

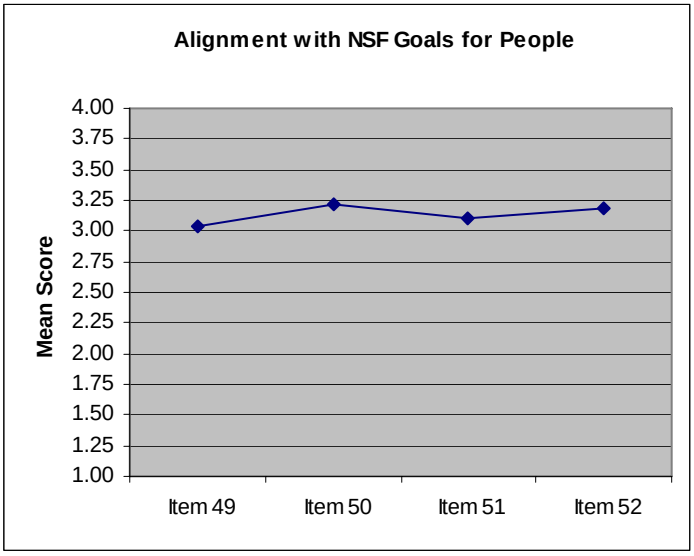


Figure 5: Results for Alignment with NSF Goals for People

Table 9: Results for Alignment with NSF Goals for People

Variable	Question	Mean	Standard Deviation	Item-Total Correlation
Item 49	Unidata has facilitated a more inclusive workforce.	3.04	0.58	0.73
Item 50	Unidata has facilitated a more knowledgeable workforce.	3.22	0.56	0.76
Item 51	Unidata has facilitated a more globally engaged workforce.	3.10	0.62	0.76
Item 52	Unidata has helped in preparing students to be highly qualified members of the scientific workforce.	3.18	0.61	0.69

Findings and Interpretations

Based on the survey outcomes 95.8% of the respondents agreed or strongly agreed that Unidata has facilitated a more knowledgeable workforce.

The item-total correlations ranged from 0.69 to 0.76, with item 50 and item 51 computing the highest correlation of 0.76. This implies that facilitating a more globally engaged workforce and facilitating a more knowledgeable workforce have the highest impact related to Alignment with NSF Goals for People.

Focus Group Outcomes

Facilitating a More Inclusive Workforce. Focus group participants agreed that Unidata has facilitated a more inclusive workforce because it enables researchers to work collaboratively and, in effect, more people are involved when using a collaborative approach. Enabling effective communication among researchers also aides in facilitating an inclusive workforce. Being able to communicate "graphically" is an important aspect of collaboration. Some institutions also reach out to elementary and high school teachers and help to educate them on how to teach earth science classes.

Facilitating a More Globally Engaged Workforce. Unidata has also facilitated a geographically diverse workforce. The workforce has included researchers across states as well as across the globe for collaborative projects.

Preparing Students. Unidata tools have given students with different learning styles a way of engaging with the subject of meteorology in a manner that they might not have been able to do before. This fact may have contributed to increasing the diversity of the students entering and staying in the field of meteorology.

Quotes Worth Noting

- "People interested in getting into meteorology have less of a barrier to becoming productive in the workforce."

- "I think one of the major benefits is that Unidata's reach is global. Most people in the community use Unidata products so it doesn't matter if you are a student or a 25 year researcher at an institute – everyone is using the same programs - that common ground is going to allow for better communication between different levels and different perspectives so people can get together on projects. It's less variable and it provides for common ground."

- "It is very easy to go from one place to another and share ideas."

Alignment with NSF Goals for Tools

Survey Outcomes

The following Figure 6 graphically displays the results for "Alignment with NSF Goals for Tools". Mean scores (i.e., average scores) for each item within this questionnaire section are plotted. The following Table 10 contains the actual question number, mean score, standard deviation, and item-total correlation for each item within each set of questions related to Alignment with NSF Goals for Tools.

This section focused on survey findings and outcomes for analysis and visualization software. Please note that detailed discussions of additional tools such as netCDF, IDV, and other tools developed or supported by Unidata are included within the "case study" section found at the end of this report.

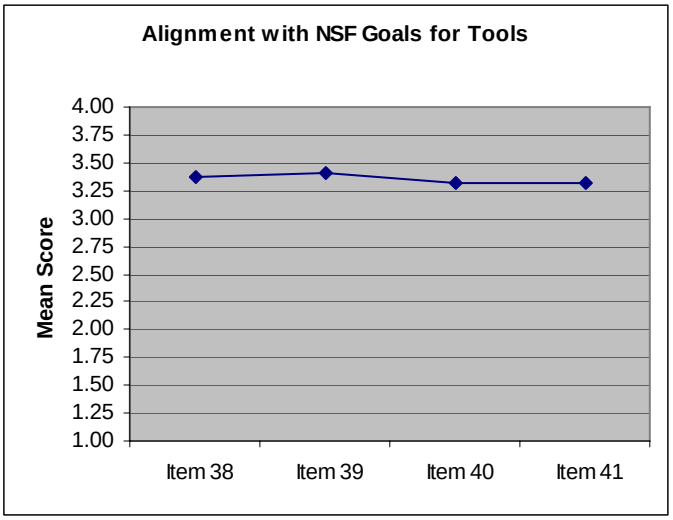


Figure 6: Results for Alignment with NSF Goals for Tools

Table 10: Results for Alignment with NSF Goals for Tools

Variable	Question	Mean	Standard Deviation	Item-Total Correlation
Item 38	Unidata has provided analysis and visualization software that enables scientific discovery.	3.37	0.54	0.78
Item 39	Unidata has provided analysis and visualization software that enables academic learning.	3.40	0.54	0.79
Item 40	Unidata has provided analysis and visualization software that enables innovation among educators.	3.31	0.55	0.81
Item 41	Unidata has provided analysis and visualization software that enables innovation among researchers.	3.32	0.55	0.76

Findings and Interpretations

Based on the survey outcomes 74.6% of the respondents agreed or strongly agreed that Unidata has provided analysis and visualization software that enables academic learning and this is further supported by the results for item 39 (m=3.40) as well as the overall results for the "Alignment with NSF Goals for Tools" that range from a mean score of 3.31 to 3.40.

The item-total correlations ranged from 0.76 to 0.81. This implies that software enabling innovations among educators have the highest impact related to Alignment with NSF's Goals for Tools.

Focus Group Outcomes

Tools Enabling Academic Learning. There was general agreement that Unidata provides analysis and visualization software that enables academic learning. The ability to visualize multiple types of data using a variety of views provides a unique learning experience for students interested in meteorology. The ability to view and analyze real-time data helps to engage the students within a classroom setting using current information. The speed at which data can be accessed, displayed, and analyzed helps to promote academic learning as well.

Tools Enabling Innovation in Teaching and Research. The tools allow for collaboration between researchers located in geographically different site locations specifically related to visualization activities. As a result, innovations among researchers are possible. The ability to analyze and visualize real-time data provides innovation for educators in the area of teaching and computer lab demonstrations with the ability to incorporate analysis and visualization activities into the classroom. The use of Unidata tools also provides an important time saving component for educators who can now incorporate analysis and visualization activities into their courses with relative ease. This time savings allows for the ability to generate innovative ideas related to educating students.

Quotes Worth Noting

- "Our students are now spoiled because they can do research projects using the data assets we get over LDM. Things that would have taken a Ph.D. student three years to complete, a student in a classroom can do in a few hours."
- "Being able to overlay multiple types of data, satellite, radar, observations, and model data, has made it easier to explain to the students that the atmosphere is three dimensional and things that you see at the surface are connected to features that you see in the mid and upper parts of the troposphere. When all we had was paper charts, it was a lot harder to see. I have put papers and publications together using this information and using these views which would not have been possible that long ago."
- "Now we can do analysis on the fly and there is a lot less effort on the instructor's part."
- "Expanding the capabilities and flexibility with which we can engage students using data was fantastic and a revolution in education and research."
- "Unidata has made analyses and data available in near real time to a much wider audience including the public and students in classes. In terms of educating the public, it's a tool with tremendous amount of leverage but also feeds back into the classroom. You can do things in large classes where students can't operate the Unidata software directly. We can also make the products available in the classroom in ways we couldn't before. Unidata has had a huge impact, not just on researchers, but also the general education in the public and general education of students."

SECTION V: OPERATIONAL OUTCOMES

Operational outcomes included the impact on culture in the areas of research, teaching, and collaboration, the impact on institutional cyberinfrastructure in the areas of data access, data distribution, as well as student, faculty, and researcher participation in field projects. Operational outcomes also addressed outreach activities and Unidata's core values and consistency. Responses that depict "strong agreement" or "agreement" translated into "very strong transformational effects" or "relative transformational effects" within the community, respectively. Likewise, "strong disagreement" or "disagreement" translated into "very weak transformational effects" or "weak transformational effects". Each part within this section includes survey outcomes, findings and interpretations, focus group outcomes, and interview outcomes where applicable.

Impact on Organizational Culture

Survey Outcomes

The following Figure 7 graphically displays the results for "Impact on Culture". Mean scores (i.e., average scores) for each item within the "Impact on Culture" questionnaire factor are plotted. The following Table 11 contains the actual question number, mean score, standard deviation, and item-total correlation for each question related to "Impact on Culture".

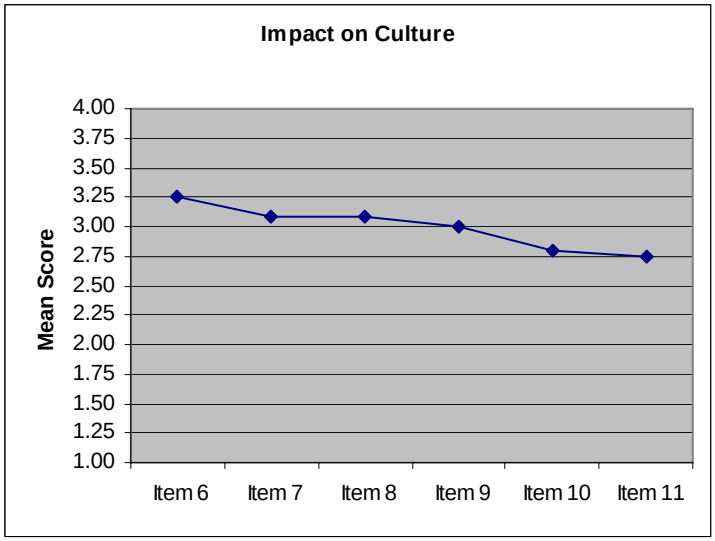


Figure 7: Results for Impact on Culture

Table 11: Results for Impact on Culture

Variable	Question	Mean	Standard Deviation	Item-Total Correlation
Item 6	The Unidata Program's technology has transformed the research culture in our atmospheric or science related department.	3.26	0.63	0.75
Item 7	The Unidata Program's technology has transformed the teaching culture in our atmospheric or science related department.	3.09	0.68	0.73
Item 8	The Unidata Program has transformed the way our atmospheric or science related department conducts collaborations.	3.09	0.70	0.70

Variable	Question	Mean	Standard Deviation	Item-Total Correlation
Item 9	The Unidata Program has transformed the way our atmospheric or science related department conducts community outreach activities.	3.00	0.69	0.72
Item 10	The Unidata Program has transformed the way faculty in our atmospheric or science related department publishes research papers.	2.79	0.71	0.72
Item 11	The Unidata Program has contributed to the increase of the overall number of participating students in our department.	2.74	0.75	0.72

Findings and Interpretations

Based on the survey outcomes, 77.5% of the respondents agreed or strongly agreed that Unidata transformed their research culture and this is further supported by the 3.26 average score of Item 6 ("The Unidata program's technology has transformed the research culture in our atmospheric or science related department."). After adjusting for the number of "not applicable" responses for Item 6, the percentage of respondents who agreed or strongly agreed that Unidata transformed their research culture was 90.9%.

Focus Group Outcomes

Transforming Publishing. Faculty members said that Unidata does play a role in research and publication since without Unidata as a data source, faculty would have to find data upon which to base publications from other sources. Faculty also pointed toward GEMPAK as the software most helpful for publications with its ability to import data and produce publication-quality figures. Faculty agreed that GEMPAK is better than most other software packages with this functionality.

Increasing the Number of Students. Community members stated that Unidata does contribute to an increased number of students within their departments. Some institutions make Unidata products available to prospective students which assists in recruiting new students into their programs and departments. Others mentioned that Unidata products benefit students who are not as proficient in science-related courses because the products assist students in seeing weather information in an entirely new and different way.

Quotes Worth Noting

- "GEMPAK is good software to produce publication-quality figures. It shines above most other software packages with this functionality."
- "We work with science education from middle school to graduate school in forty nations and all over the United States. Unidata will help our ability to impact these students."
- "Our institution benefits because we make the data available on the web and prospective students see the information and our products. Prospective students visit our facilities and weather center and are very impressed. We have a larger number of students because of Unidata and related products."
- "Our institution would not be "on the map" without Unidata. Our meteorology lab is better than some graduate schools."

- "Feedback from teachers is that many of the Unidata products have benefited students who weren't as good in science because they could see things in a whole new way."

Individual Interviews

The individual interviews were conducted in order to have a more in-depth operational perspective about the transformational nature of the Unidata program. These interviews provide a different perspective that may not have been available from the survey participants. Based on the demographics, 51% of the survey participants have been members of the Unidata Community for four years or less. People who have been members for over five years were interviewed and the outcomes are outlined in this section.

Background Information. There were two primary forces at work during the beginning stages of Unidata.

- The first was the decision by the national weather service to change the way in which they delivered data to forecast offices. This change would result in the great majority of universities being unable to access real-time weather data needed for education and research.

- The second force at work was the fact that a small number of universities were changing the way they were using data with computers. These universities were looking ahead and seeing transformative effects and were interested in researching and developing software for the use of computers. As a result, NSF was getting requests to support Research and Development efforts for classroom purposes.

- NSF thought it would be more economical to support a centralized software development effort as opposed to supporting each individual university. NSF linked this idea to the data problem and in addition, NSF had a larger vision of what Unidata could become above and beyond just the data access issue. The primary roles of Unidata were (1) data delivery, (2) provision of "supported" software, and (3) research and development for software.

Impact on Workforce, Teaching, and Collaboration. There was a tremendous transition in the way people dealt with meteorological information and its use. These events only occurred because of the technology developments such as satellites, computers, and communications technologies. The meteorology community was motivated to leverage these technologies because of the vision of some people about what the possibilities were for the future.

- The University of Wisconsin developed the "playback" capability to visualize weather data and movements. This capability impacted the public and the way that weather information was presented to the public and the public's knowledge of weather and interest in weather. As a result, there was an entire generation of people who started in the meteorology field not realizing they would end up in TV meteorology who eventually did end up in TV.

- This new area quadrupled the workforce in meteorology. Radio was the only other medium used to communicate weather information to the public and this method was limited. The only jobs in meteorology before TV were within the weather bureau or the military.

- There was also a large impact on classroom instruction.

- Meteorology also gained the interest of non-science related students and additional courses were created and offered for these interested students. Visualization of weather data revolutionized the way meteorology was taught in the classroom. This visualization technology using three dimensional pictures displayed by time evolution significantly impacted meteorology research, meteorology instruction, as well as the medical community.

- There was also a large impact on weather research as well. President Kennedy put out an invitation to the scientific community to come up with science that would be of interest to the world. The atmospheric science community proposed the ability to do weather globally using satellites and computers. This proposal was selected and this motivated the installation of satellites world-wide. Japan, Russia, and Europe had one satellite, and the United States had three satellites. These first satellites allowed everyone to see weather visually along with capabilities to do remote sensing and develop global models for prediction. This information was quickly transitioned into research groups and classroom instruction and provided the ability to analyze global structure of the atmosphere as it evolved in time.

- In summary, Unidata has a large impact on students with gaining a better understanding of career opportunities in weather. Without Unidata, the departments would not have been able to do research in the way that it happened.

- Finally, Unidata is one of the most important things that UCAR has done over the years. Impact has been great on future scientists, education in the classroom, and other professionals.

Impact on Institutional Cyberinfrastructure

Survey Outcomes

The following Figure 8 graphically displays the results for "Impact on Cyberinfrastructure". Mean scores (i.e., average scores) for each item within this questionnaire section are plotted. The following Table 12 contains the actual question number, mean score, standard deviation, and item-total correlation for each question related to "Impact on Institutional Cyberinfrastructure".

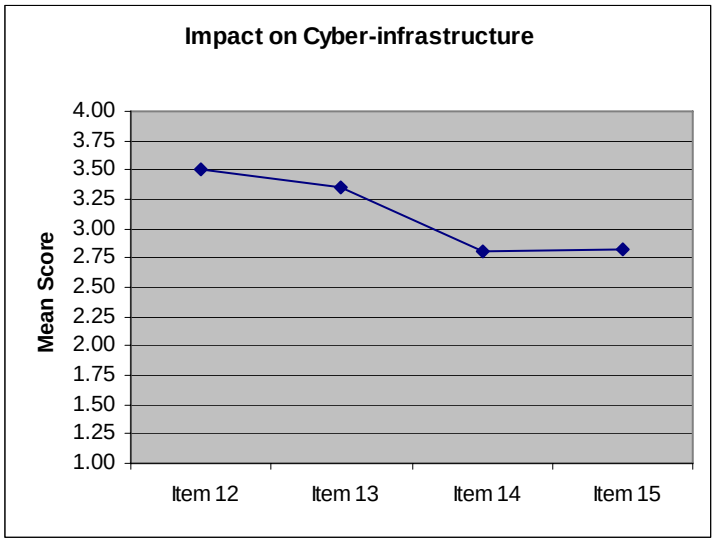


Figure 8: Results for Impact on Cyberinfrastructure

Table12: Results for Impact on Cyberinfrastructure

Variable	Question	Mean	Standard Deviation	Item-Total Correlation
Item 12	The Unidata Program has transformed the way our department accesses data.	3.50	0.59	0.55
Item 13	The Unidata Program has transformed the way our department distributes data.	3.36	0.71	0.59
Item 14	The Unidata Program has transformed the way students participate in field projects.	2.80	0.75	0.66
Item 15	The Unidata Program has transformed the way faculty members or researchers participate in field projects.	2.82	0.73	0.68

Findings and Interpretations

Based on the survey outcomes, 89.1% of the respondents agreed or strongly agreed that Unidata has transformed the way individual departments access data and this is further supported by the 3.50 average score of Item 12 ("The Unidata program has transformed the way our department accesses data").

The item-total correlations ranged from 0.55 to 0.68. This implies that transforming the way faculty or researchers participate in field projects has the highest impact related to the total score for questions related to "Impact on Institutional Cyberinfrastructure".

Focus Group Outcomes

Field Projects. Responses to the questions related to field projects during focus group sessions were mixed. Many of the faculty and graduate students have not actively participated in field projects. For those faculty and graduate students who did participate in field projects, Unidata products were found to provide necessary support for their activities. GEMPAK was identified as one of the software packages used during field projects. Also, graduate students mentioned that sometimes they are unaware of the source of the tools they frequently use within their programs and, as a result, it may be hard for them to adequately determine the impact of Unidata on their activities.

Quotes Worth Noting

- "I use GEMPAK and other programs as well for field projects. Our students get exposed to many different software packages."
- "We set up local stations and do measurements and convert data into GEMPAK. That's how we use Unidata for field projects."
- "We use Unidata software for hurricane reconnaissance missions. Students usually use the program that the professors use."
- "People that I know who have participated on field projects used Unidata (e.g., GEMPAK, data transfer, etc.). They say it's been useful, but I can't say for myself because I have not participated on any field projects."
- "Sometimes it is hard for us to gauge because we may not realize that some of the tools and data (we use) were a result of Unidata."
- "We haven't been using it (Unidata products) – at least on the projects I have been on."

Individual Interviews

Background Information. Data were initially distributed by teletype via "drops". This method of distribution changed dramatically with satellites, computers, and new telecommunications abilities. Reports prepared for early NSF sponsored workshops during the late 1960's and early 1970's showed the capability of McIDAS which was the first system to take satellite data and portray it via video methods. Soon after, the first geosynchronous and meteorological satellites were developed.

- Then, there was an announcement that data will not be sent via teletype. This announcement left the meteorological community without a way to access data. A small team of three people tried to address the problem of data distribution which included discussions about whether or not to re-institute the teletype system which ran continuously. This team also looked into sending data via satellite; however, desktop computers started to emerge at the same time. This team later formed a steering committee which endorsed the concept of Unidata and received NSF funding.
- At the time that the Unidata program began, very few scientists knew about the internet and did not use the internet. Use was limited to computer science and physics communities who had DARPA support. NSF was also forming the internet implementation ideas to make the internet available to the broader science communities and to the public. As a result, Unidata decided to focus on the internet at that time instead of building its own network.

- Universities were encouraged to participate in internet activities as the best way for acquiring and supporting software which was not originally thought of as a way for distributing data due to the thought that these data were too large to distribute this way. University departments were encouraged to participate in the emerging internet and Unidata supported universities in acquiring satellite dishes which were "receive-only" systems for broadcast data.

Data Management and Distribution. The decision was made to take an advanced approach to local data management and data distribution at the Ethernet level since national networks were not powerful enough to move large amounts of data nationally. The decision was made to put resources toward exchanging data among universities which included a development effort for local data managers to help distribute data among universities as well as within universities. In 1993, the satellite broadcast of data was no longer supported. As a result, everyone on the network was gaining data from each other.

- Then, a qualitative change occurred when universities realized they were relying on each other for data as opposed to calling the broadcaster if a data problem occurred. The 1993 transition was not only a technical transition, but also a social and cultural transition away from the single source where universities now relied on each other for data. Grants for upgrading computers and networks on campus were available so that universities would be fully responsible for receiving and relaying data to each other. There was a profound change in how universities saw each other in this environment which centered on true collaboration occurring in a communal effort to acquire and share data.

- In the early stages of the Unidata program, a few of the larger universities "tolerated" Unidata which they viewed as important for smaller universities. These few larger universities saw Unidata software as inferior to their software; however, it soon became a disadvantage for anyone to not be included where data could be exchanged. LDM were linked together in the IDD to form a national network which created an environment in which universities could acquire data in different ways.

- Over the past 20 years, the sophistication of software increased and Unidata began to launch into development projects of general software for working with earth science data. This included university representatives for design teams and included more collaborative software design projects. IDV was the result of a significant amount of internet based collaboration in development. As a result, this collaborative process has impacted the computer software development processes.

Software Project Interviews

Project Initiation and Funding. Community needs drive project initiation activities. Ideas and opportunities are also identified and defined by the development staff (e.g., how to leverage new technologies, ideas to improve products, etc.). Community needs are mainly identified through analysis of support inquiries and common themes from support inquiries.

- The needs of the community are documented and reviewed prior to project initiation.

- Project risks are discussed before a project is initiated. These risks include technology change, available resources, and schedule/timeline of implementation. Schedule and timeline issues are considered to be a lower priority during the project initiation phase.

- Funding is obtained from NSF as well as other proposals that can be used to generate additional funding for specific projects.

Project Requirements, Development and Management.

- Unidata receives approximately 150 support inquires per week for all supported packages. User support is provided through web-based documentation and tutorials, tailored and generic email, and a few phone calls. Email is strongly encouraged as the best method of communication with User Support. A new support inquiry system that was recently installed appears to be working well. This system streamlines the delivery of topic-specific inquiries to appropriate Unidata staff members, and helps insure that inquiries are handled in a timely manner.

- Developers conduct support activities and have logins to support systems. The majority of application-related requirements are identified through support inquiries and comments. Requirements for some applications are listed on the Unidata website.

- Governance committees define, rank, and prioritize requirements. Requirements are considered to be "dynamic". Training workshops are also used to generate requirements, identify changes to applications, and identify bugs to fix.

- Changes to requirements are typically communicated through internal meetings and email discussions.

Project Planning, Monitoring, and Control. Unidata does not consider itself a "production" shop. As a result, no service level agreements (SLAs) have been established for clients. Some clients/organizations have requested specific SLA's, but this is not typically accommodated.

- Projects are on various release schedules (e.g., every three months, every six months to one year which include major releases and minor releases, alpha releases, beta releases). Some releases are scheduled around the academic calendar. Notes are sent to the user community when a new release is available. User community can provide feedback through support emails.

- Project progress is monitored with periodic status reports to various governing committees. Some projects have six to nine month milestones for releases and the project team works toward incorporating the requirements into the release.

Quality Assurance (Process and Product). Extensive testing is conducted for software applications to ensure high quality products. Testing is a high priority within the organization and various test tools are used to conduct testing activities.

- Alpha testing and Beta testing are used to introduce new functionality and updates/releases to software systems to the user community.

- Ad hoc peer reviews are conducted informally as requested by developers.

Configuration Management (Change Control). Concurrent Version System (CVS) is used as the automated tool for version control and is mostly used for code control. This tool can also be used for documentation control as well.

- Some project members feel that CVS helps in effective collaboration and helps to synchronize development activities for some projects.

Organizational Processes (Focus & Definition). Software personnel keep up to date on current software process methodologies through participation in technological societies and subscriptions to technical journals (e.g., IEEE Software Journals). Some project teams implement the software development processes, standards, and guidelines of other organizations, (e.g., GEMPAK and McIDAS). Overall, there is no organizational level effort aimed at modifying software development processes.

- Developers are typically associated with specific projects and applications; however, they can be transferred among different applications. Transferring project members among different applications is not typically done. Developers help to provide application support to better identify common themes related to problems, to address the needs of the community, and to be able to address appropriate changes if necessary. Developers believe they are very responsive to the user community.

- Information is shared between application teams informally. Very good teamwork, cohesion, and collaboration exists within the development teams. Developers feel that they are committed to applications and generating high quality products. Developers are highly dedicated, highly skilled, and even have close relationships with many users.

- The identified roles of the developer include, marketing, training workshops, support, user interaction, websites, documentation, design, development, and test, build management, and release management. Most project teams are small and usually range from one to three people per team.

Organization Policies and Standards. Unidata does not mandate specific software development practices for the organization. Each development project uses various and different components of many software development methodologies. No overall Unidata software development process or policies exist. Some projects use "agile" methodology (i.e., people are more important than process, working code is more important than documentation). Some projects use "incremental" development processes.

- The Unidata staff use the CVS system for code control. Some project teams like the tool, others do not.

- Coding standards are not followed by all project team members.

- Some projects generated by proposals call for requirements documents, project plans, project commitments, and regular status reports; however, software development activities at Unidata are typically not conducted using such a formal methodology.

Training

User Training

- Many applications provide training on application functionality to the community in the form of workshops. Workshops are typically free; however, some problems have

occurred with participants canceling at the last minute and leaving unused spaces. To prevent last minute cancellations, a nominal fee of $50 per workshop is charged.

- A searchable database exists for users to find answers to application related questions.

Unidata Personnel

- Unidata is comprised of a highly skilled workforce. Many developers and members within the Unidata organization have meteorology degrees, master's degrees, computer science degrees, or Ph.D.'s.
- Some Unidata managers have found difficulty in the hiring process in searching for the personnel that are the "right fit" for the Unidata organization (e.g., fit with technical skills, fitting into the organizational culture, etc.)

Mentoring

- The SOARS program is used to mentor students.
- Informal mentoring among Unidata personnel occurs throughout the organization.

Information Alignment - Measurement and Data Analysis. Many measurements are collected by the Unidata organization. These measurements seem appropriate and are used to monitor activities of the organization. The following are examples of some key measurements collected and reported:

- The number of support responses (summarized every four months) and reported to the governance committees.
- The number of usage reports by domain (normalized usage profile reports)
- The number of downloads by release

Overall Strengths. Staff members feel that Unidata is a very successful software development organization.

- Staff members feel that quality assurance activities related to testing and user testing work well.
- Staff members feel that configuration management and code control also seem to work well.
- Project managers feel that project planning activities seem to work well.

Teamwork Strengths. Team goals are clear and the team is committed to achieving goals.

- Teams are happy with support and recognition received for efforts.
- Team structure seems to work well.
- Team collaboration seems to work well.
- Team skills and knowledge are a key strength to the organization.

Outreach

Although Unidata conducts a variety of different outreach activities which include (but are not limited to) workshops, newsletters, mentoring, scientific meetings, and webcast seminars, the evaluation of outreach activities focused on the two primary methods of (1) newsletters, and (2) workshops.

Survey Outcomes

The following Figure 9 graphically displays the results for "Outreach". Mean scores (i.e., average scores) for each item within this questionnaire section are plotted. The following Table 13 contains the actual question number, mean score, standard deviation, and item-total correlation for each question related to Outreach.

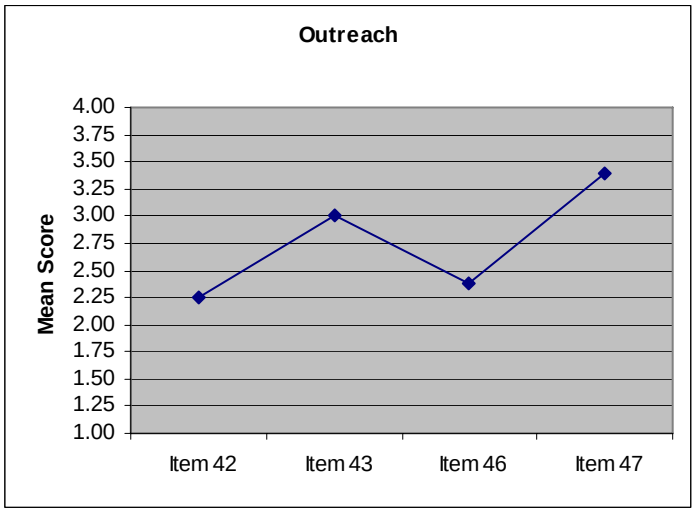


Figure 9: Results for Outreach

Table 13: Results for Outreach

Variable	Question	Mean	Standard Deviation	Item-Total Correlation
Item 42	I read the Unidata Newsletter.	2.25	0.94	0.54
Item 43	I would recommend the Unidata Newsletter to other people.	3.00	0.56	0.53
Item 46	I have attended at least one workshop over the past 5 years.	2.38	1.17	0.43
Item 47	I would recommend the workshops to other people.	3.39	0.56	0.57

Findings and Interpretations

Results for "Outreach" range from a mean score of 2.25 (Item 42: "I read the Unidata Newsletter") to 3.39 (Item 17: "I would recommend the workshops to other people"). The workshops were highly regarded by the survey participants with 97% of workshop participants* stating they would recommend them to other people.

* Note: This percentage does not include "not applicable" responses.

Overall, survey responses for the "Outreach" indicate variation in agreement with the questions. Two of four questions resulted in means scores less than 3.0 (Item 42: I read the Unidata Newsletter, and Item 46: I have attended at least one workshop over the past 5 years). For Item 42 (reading newsletter), 50.6% of the participants rarely or very rarely read the newsletter, and for Item 46 (workshop attendance), 33.4% of the participants have not attended at least one workshop within the past 5 years, while 37.0% did not find this question applicable.

The item-total correlations ranged from 0.43 to 0.57. This implies that recommending workshops to others has the highest impact related to the total score for outreach.

Focus Group Outcomes

Newsletter. Many faculty noted that the Unidata newsletter is a good source of information; however, they did not place the newsletter as a high priority given the large amount of other information they are sent from other sources. Some faculty and graduate students were unaware that a Unidata newsletter existed on the web.

Quotes Worth Noting

- "My lack of awareness of the newsletter led to not reading it."
- "I have read it, but it has not been a priority."
- "The newsletter didn't make enough of an impact that I went searching for it – but I get so many other e-newsletters from many other sources I feel a little inundated."
- "I know that the newsletter is posted. I read it once a year when it was paper. I have not read the electronic version."
- "I have read the newsletter – but not frequently. Usually I see the newsletter if I am accessing or downloading software. If I am on the web page, I will click on it and read it."
- "I am usually scanning the newsletter for opportunities related to the students or teaching or research or sometimes just being aware of new endeavors that are out there."
- "The newsletter is useful and helpful when we read it."

Unidata's Core Values and Consistency

This is section of the study provided insight into the question – to what extent has Unidata stayed true to its values while accomplishing its goals?

Survey Outcomes

The following Figure 10 graphically displays the results for "Unidata's Core Values and Consistency". Mean scores (i.e., average scores) for each item within this questionnaire section are plotted. The following Table 14 contains the actual question number, mean score, standard deviation, and item-total correlation for each question related to Unidata's Core Values and Consistency.

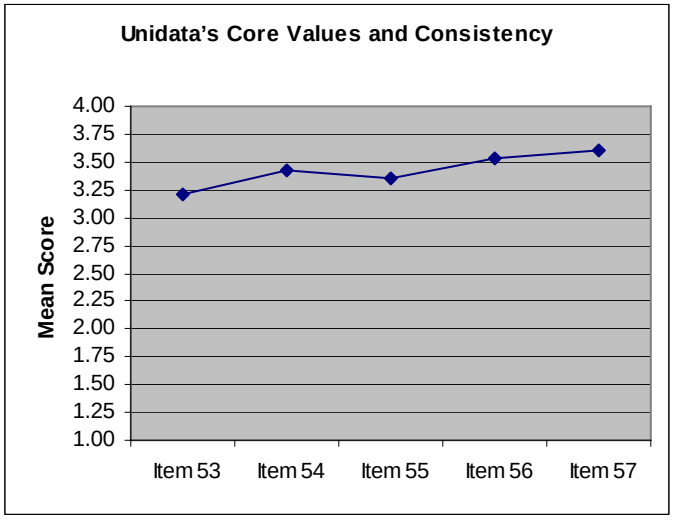


Figure 10: Results for Unidata's Core Values and Consistency

Table 14: Results for Unidata's Core Values and Consistency

Variable	Question	Mean	Standard Deviation	Item-Total Correlation
Item 53	Unidata has practiced a community-based governance.	3.21	0.56	0.55
Item 54	Unidata has provided for data access, analysis and visualization using small inexpensive computers.	3.43	0.60	0.64
Item 55	Unidata has provided state-of-the-art, well documented and supported software tools.	3.35	0.69	0.69
Item 56	Unidata has provided free and open sharing of data.	3.54	0.58	0.70
Item 57	Unidata has provided free and open sharing of software.	3.60	0.55	0.70

Findings and Interpretations

Based on the survey outcomes 97.3% of the respondents agreed or strongly agreed that Unidata has provided free and open sharing of software. Results for "Unidata's Core Values and Consistency" range from a mean score of 3.21 (Item 53: "Unidata has practiced a community-based governance") to 3.60 (Item 57: "Unidata has provided free and open sharing of software").

The item-total correlations ranged from 0.55 to 0.70. This implies that providing free and open sharing of data and software has the highest impact related to Unidata's Core Values and Consistency.

Focus Group Outcomes

Community-Based Governance. Most focus group participants were aware of the existence of the Policy Committee and the User Committee. Many community members feel the community-based governance approach works well in meeting the needs of individual community members as well as the needs of the participating institutions. Community members feel their voices are heard in the areas of software development and data access and are confident that Unidata projects are driven by these committees.

Support for Studying Scientific and Social Issues. Focus group participants were in agreement that Unidata provides support for studying scientific issues; however, some participants also agreed that social issues were supported while other participants were unsure about Unidata's support for studying social issues.

Quotes Worth Noting

- "Unidata is governed by the Policy Committee and the Users Committee."
- "Unidata grew out of community based need, and it seems to be consistent over time."
- "Unidata provides the tools necessary to answer scientific and social questions. Unidata helps the universities and scientists do great things."

SECTION VI: TACTICAL OUTCOMES

Responses to data access and usage, support inquiries, and software usage constituted tactical outcomes.

Support Inquiries

Survey Outcomes

The following Figure 11 graphically displays the results for "Support Inquiries". Mean scores (i.e., average scores) for each item within this questionnaire section are plotted. The following Table 15 contains the actual question number, mean score, standard deviation, and item-total correlation for each question related to Support Inquiries.

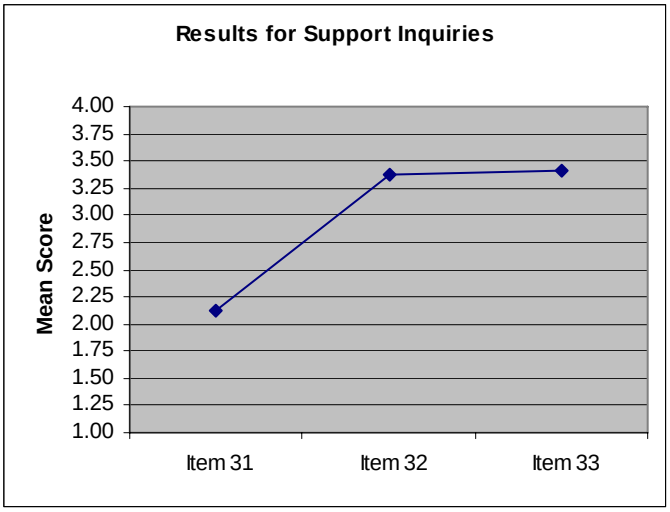


Figure 11: Results for Support Inquiries

Table 15: Results for Support Inquiries

Variable	Question	Mean	Standard Deviation	Item-Total Correlation
Item 31	I have emailed support inquiries to Unidata.	2.12	0.82	0.32
Item 32	Email responses were helpful in solving my problem.	3.37	0.70	0.66
Item 33	Email responses to my inquiries were received in a timely manner.	3.41	0.63	0.64

Findings and Interpretations

Results for "Support Inquiries" range from a mean score of 2.12 (Item 31: "I have emailed support inquiries to Unidata") to 3.41 (Item 33: "Email responses to my inquiries were received in a timely manner"). Based on the survey outcomes 67.6% of the respondents agreed that Unidata responded to support inquiries in a timely manner frequently or very frequently. After adjusting the percentage for the number of "not applicable" responses, the percentage of respondents who agreed that Unidata responded to support inquiries in a timely manner frequently or very frequently was 94.5%.

Overall, survey responses for "Support Inquiries" indicate general agreement with the questions; however, 54.2% of the participants rarely or very rarely email support inquiries to Unidata and 21.2% of the participants did not find this question applicable.

The item-total correlations ranged from 0.32 to 0.66. This implies that helpfulness has the highest impact related to Support Inquiries.

Focus Group Outcomes

Emailing Support Inquiries. Within the faculty focus groups, almost all of the faculty had emailed support inquiries to Unidata. There was general agreement that Unidata support personnel responded the same day and had a solution to their problems. Overall, there was general agreement that Unidata provided timely responses and helpful support and solutions as a result of emailed support inquiries. One focus group participant used the support inquiries email to request additional features to Unidata products. Professionalism of Unidata support was a common theme throughout the focus group discussions.

Quotes Worth Noting

- "Unidata has good professionals and I have always been impressed with how quickly they respond."

- "I have sent several support inquiries and always been very satisfied with support. Unidata does a good job dealing with a wide variety of users. I usually send inquiries related to bug fixes, where to go for a data source, or when the next release of a software product will be available."

- "Unidata really listens and is dedicated to helping us. It's always a great experience in getting support from Unidata."

- "It is important to note that Unidata support is not the norm. I do not get this type of support from other places or federal agencies that I work with. Unidata goes beyond IT support and technical support. Unidata also provides scientific support. I recommend that Unidata does not lose the excellent user support they currently provide to the community."

- "When I had an issue with LDM, I was able access a discussion group through [archived] threads to find out what my specific problem was – so community people were contributing to this thread to research the possible problem. Also, I was reaching directly back to Unidata, and they were very responsive. The issue was turned around quickly. I was able to address the community as a whole as well as Unidata."

Software Usage

Survey Outcomes

The following Figure 12 graphically displays the results for "Software Usage". Mean scores (i.e., average scores) for each item within this questionnaire section are plotted. The following Table 16 contains the actual question number, mean score, standard deviation, and item-total correlation for each question related to Software Usage.

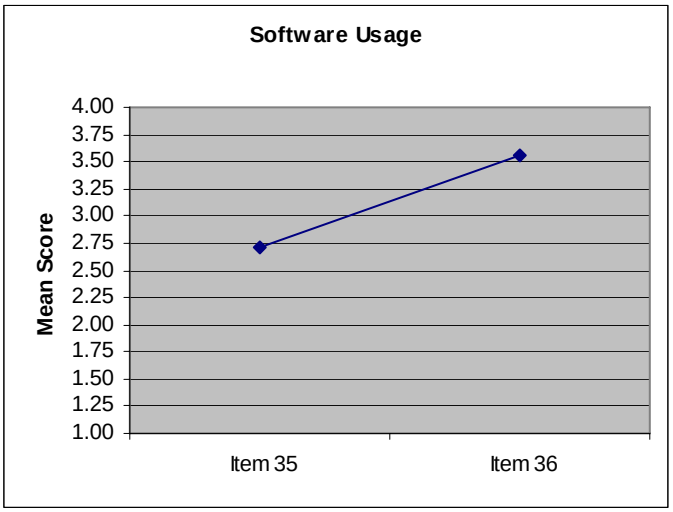


Figure 12: Results for Software Usage

Table 16: Results for Software Usage

Variable	Question	Mean	Standard Deviation	Item-Total Correlation
Item 35	I have downloaded software from Unidata.	2.71	0.76	0.39
Item 36	I would recommend the Unidata software I have used to other people.	3.55	0.59	0.39

Findings and Interpretations

Results for "Software Usage" range from a mean score of 2.71 to 3.55. Based on the survey outcomes 93.9% of the respondents agreed or strongly agreed that they would recommend Unidata software to other people and this is further supported by the average score of 3.55 for Item 36. Overall, 31.1% of the participants rarely or very rarely download software from Unidata, while 3.9% did not find this question applicable.

The item-total correlations were 0.39 for both questions. This implies that both recommending Unidata Software to other people and downloading Unidata Software have a high impact related to Software Usage. Table 17 and Table 18 outline the details of software usage.

Table 17: Software Downloads

Downloaded Software	Response Percent	Response Total
netCDF *	69.60%	236
GEMPAK	50.70%	172
IDV	47.20%	160
LDM	44.20%	150
netCDF Decoders	41.30%	140
UDUNITS	34.50%	117
McIDAS	26.50%	90
LDM-McIDAS Decoders	23.30%	79
THREDDS	11.50%	39
NOAAPORT DVB-S ingester	5.90%	20

* includes netCDF, netCDF Perl, netCDF Java

Table 18: Use of Software

Use of Software	Response Percent	Response Total
Research	70.60%	243
Collaborations	42.20%	145
Presentations	40.70%	140
Computer lab	34.90%	120
Web sites	34.90%	120
Publications	32.60%	112
Courses	32.30%	111
Field projects	30.50%	105
Thesis/Dissertation	20.60%	71
Outreach	19.20%	66
Other	15.10%	52

Findings and Interpretations

The most frequent use of software is for research purposes (70.6%) and the next highest use of software is for collaborations (42.2%) and presentations (40.70%). Other uses of the software included activities such as chromatographic computer program development, data archiving, forecasting, on-the-job training, operational decision support, real-time monitoring, NASA Space Shuttle support, and accident investigations. The most frequently downloaded software is netCDF.

Focus Group Outcomes

Downloading Software. Everyone participating in the focus group sessions had experience with downloading Unidata software. GEMPAK, McIDAS, netCDF, IDV, and LDM were specifically mentioned. Some participants mentioned that Unidata tools are the primary tools used for accessing and analyzing weather data. Everyone agreed that Unidata products are of good quality; however, one participant noted that McIDAS is difficult to install, but they have received excellent installation support when needed.

- One participant mentioned that their usage of Unidata software fluctuated based on the available functionality of the Unidata products. Their institution shifted from using GEMPAK to using GrADS as a display tool; however, their current perspective is that IDV has now improved enough such that they will plan to switch back to Unidata products (IDV). Other participants mentioned that their department's programs evolve with Unidata and they rely extensively on the products that Unidata provides to the community.

Quotes Worth Noting

- "GEMPAK is installed at my institution as the only software package for display and analysis for students as they do their work."

- "We use GEMPAK for map discussions, for student research, and for faculty research. If there is a case when I need to go back and discuss why something happened forensically, GEMPAK is usually my default. All of our data comes through the LDM."

- "The majority of the software is used for education purposes, lab work, and some research. The Unidata software provides a common base which helps the students wherever they go in weather service or any other weather-related career."

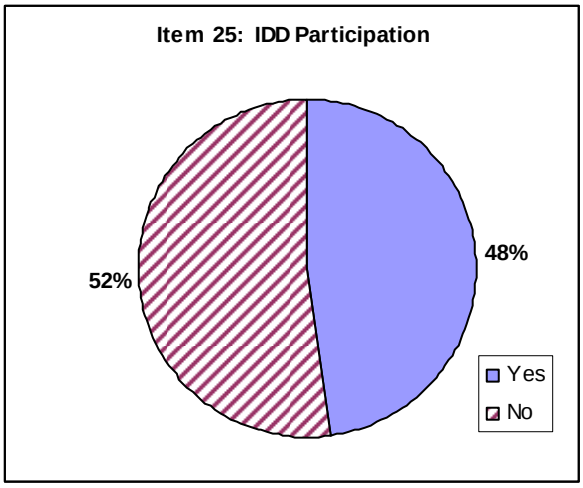
- "Our mission is research, education, and public service, and certainly the LDM software is at the core of our use in all three of those areas. We have archived several terabytes of data received through the LDM software that we use in the classroom and provide to the public through public web pages."

- "We wouldn't be able to do much of our tasks at our university without Unidata since we use many packages from Unidata. The software helps with education and outreach – LDM for data ingest from IDD and satellite dish, McIDAS to generate satellite imagery, and GEMPAK for real-time products for display in our weather center and website. IDV is starting to gain hold as people become familiar with it and start to use it and, of course, netCDF which is in the background of everything. We have been very satisfied with it all – especially for the cost savings. We could not afford this, since the competitive products are extremely expensive."

Data Access and Usage

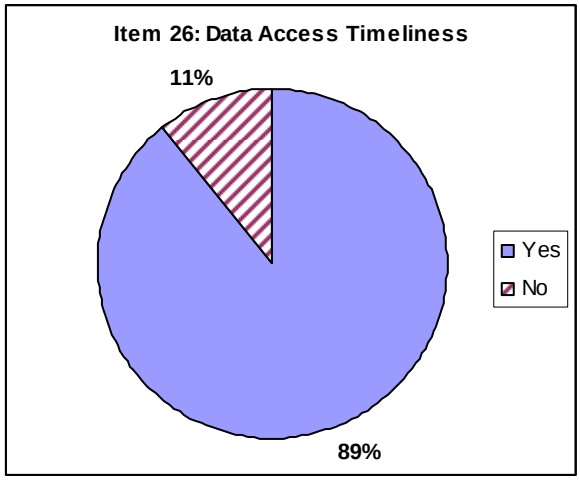
Survey Outcomes

The following figures graphically displays the results for "Data Access and Usage". Proportion of "Yes" and "No" responses for each item within this questionnaire section are identified. Information included within this section includes the actual question number, proportion of responses, and item-total correlation for each question related to Data Access and Usage.



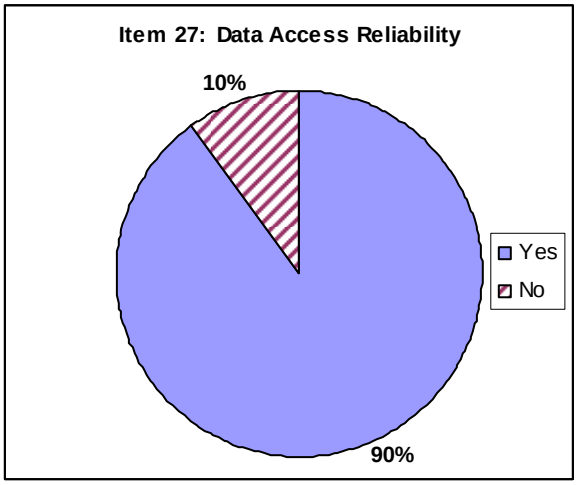
n = 359; Item-Total Correlation = 0.43

Figure 13: Internet Data Distribution Participation



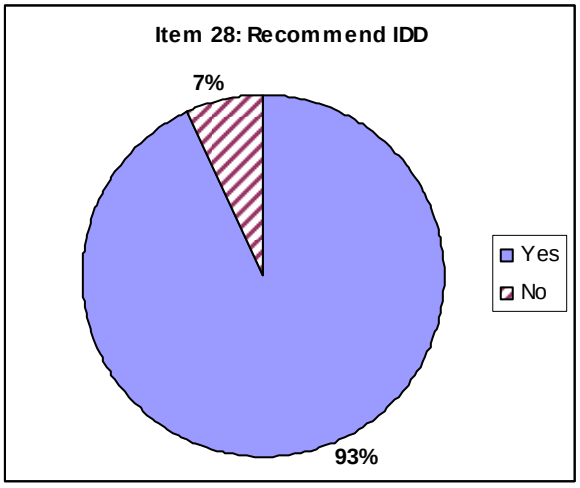
n = 239; Item-Total Correlation = 0.66

Figure 14: Data Access Timeliness



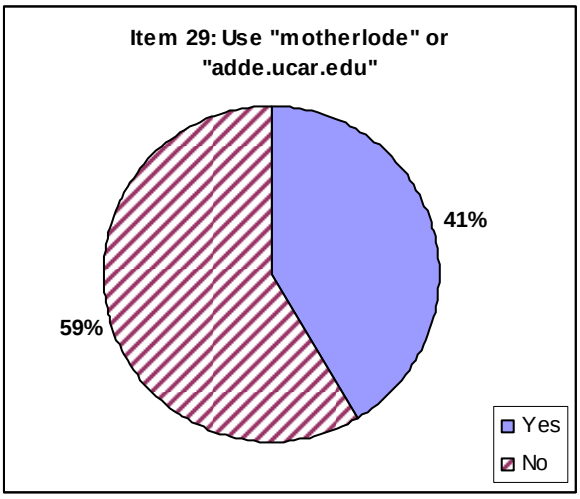
n = 238; Item-Total Correlation = 0.57

Figure 15: Data Access Reliability



n = 242; Item-Total Correlation = 0.58

Figure 16: Recommend Unidata Internet Data Distribution System.



n = 297; Item-Total Correlation = 0.30

Figure 17: Use of "motherlode" or "adde.ucar.edu"

Findings and Interpretations

Overall, survey responses for "Data Access and Usage" indicate general agreement with the questions; however, participation in IDD and Using "motherlode" or "adde.ucar.edu" to access data had less than 50% Yes responses.

The item-total correlations ranged from 0.30 to 0.66. This implies that data access timeliness is considered to have the highest impact related to Data Access and Usage.

Focus Group Outcomes

Data Access Using "motherlode" or "adde.ucar.edu". Most people participating within the focus group sessions have used these methods to access real-time data. One person continues to experience delays while using these methods to access data; however, it may be the local network connection that is causing the excessive download delays. Some community members have used motherlode for specific needs such as obtaining recently archived data, model data, or data that may have been missed during a local power failure or during downtime for computer maintenance activities. Also, interest was expressed in obtaining access to more "global" data as opposed to a focus on North America.

- A few community members had not heard of the term "motherlode". Also, comments were made related to the difficulty of browsing for specific datasets. Participants within the focus group mentioned that they are able to find datasets; however, they are not able to "look inside". As a result, there are expectations that THREDDS will make the motherlode much more accessible.

- Finally, a participant stated that these data are not of interest to climatologists and, as a result, are not used by the climatologist community. However, this participant expressed interest in possibly bringing the climatology and meteorology communities together since there are similarities that could possibly be leveraged.

Participation in IDD. Many of the focus group participants confirmed that their institution participated in the IDD. From the graduate student perspective, none of the graduate students

participating within the focus group directly use the data distribution system since the university downloads everything. The students have access to model data and surface data; however, most graduate students are unaware of the data source.

Quotes Worth Noting

- "I have used both motherlode and adde.ucar.edu. The difficulty is with our own network capability. Sometimes it takes a long time to access these data and I am not able to use in the class. If I have 17 or 18 students trying to access the motherlode for same information, then it takes too long. I think it is our network connection. Even when I access it myself, it's still slow for me – especially when trying to access data remotely. As a result, I still use LDM to down load the data locally to our servers and then it is faster for students to access these data."

- "There is a push within the funding organizations in the climatological community for climatologists to make their global, long term information more relevant for society and it needs to be tied in more with meteorological data. Actually, there is quite a big difference in variables and diagnostics that are used. We should bring the two together in the future. All of our funding is based on societal relevance and real-time seems to be more relevant to society vs. projecting climate change over decades. It's hard to marry the two, but it should be done in the future. Climatology models need to be filtered through the weather prism because they are producing weather, it's just that we deal with long term averages."

- "At our university we do use ADDE servers used for real-time access. It helps to educate students in working with data and working with a variety of data sets and using scripts to generate products on demand for users and the public."

- "The institutions that I have attended participate in the Internet Data Distribution (IDD)."

- "For the most part, everything you see in journals or from colleagues is from sources we are familiar with from Unidata – so we know we can trust it."

SECTION VII: ANALYSIS OF VARIANCE

Analysis of Mean Survey Factor Scores by Affiliation

The following table compares mean scores for each questionnaire section by affiliation group. The mean scores and sample sizes (n) for the six affiliation groups are identified by rows. Mean scores for each questionnaire section are compared in each column. Factor scores for each participant were calculated by adding the responses for each item within the questionnaire section (e.g., for the questionnaire section "Alignment with NSF Goals for Ideas", participant scores for this factor were the sum of nine questions 16 through 24 leading to a possible range of scores from 9 (if a participant rated each of the nine questions as "1") to 36 (if a participant rated each of the nine questions as "4" on the four-point rating scale).

Averages (i.e., mean scores) of each affiliation group's total scores were calculated and compared using the one-way analysis of variance technique. The one-way analysis of variance compares the means of two or more groups to determine if at least one group mean is different from the others. The F-ratio is used to determine statistical significance with 95% confidence (i.e., $p<0.05$) that at least one mean score is different. The Tukey-Kramer test was used to examine all pairs of group means. This test is conservative, which means that the two averages must be very different between groups.

Table 19: Analysis of Average Survey Scores by Affiliation

Affiliation	Alignment with NSF Goals for Ideas Mean (n)	Alignment with NSF Goals for People Mean (n)	Alignment with NSF Goals for Tools Mean (n)	Impact on Culture Mean (n)	Impact on Institutional Cyberinfrastructure Mean (n)	Outreach Mean (n)	Core Values & Consistency Mean (n)	Support Inquiries Mean (n)	Software Usage Mean (n)	Data Access and Usage Mean (n)
1. Ph.D. Granting Institution	28.97 (112)	12.64 (99)	13.51 (103)	17.76 (114)	12.61 (116)	9.58 (102)	17.36 (108)	8.87 (95)	6.38 (109)	3.20 * (111) (4)
2. Degree Granting Institution (BS/MS only)	29.95 (42)	12.95 (36)	13.77 (39)	18.18 (42)	12.92 (42)	10.80 (36)	17.54 (37)	8.60 (31)	6.33 (40)	3.63 * (42) (3,4,5,6)
3. Government	28.81 (64)	12.03 (59)	13.24 (57)	18.61 (58)	13.68 (59)	9.92 (53)	16.94 (62)	8.18 (48)	6.11 (64)	2.35 * (64) (2)
4. Research Laboratory	28.45 (41)	12.83 (36)	13.49 (36)	18.04 (43)	13.39 (40)	9.34 (35)	17.57 (40)	8.00 (35)	6.46 (41)	2.03 * (42) (1,2)
5. UCAR	27.76 (35)	12.50 (34)	12.76 (35)	18.51 (34)	12.78 (34)	10.80 (32)	16.66 (35)	8.17 (30)	6.03 (35)	2.28 * (36) (2)
6. Other	27.89 (63)	12.41 (51)	12.98 (53)	18.39 (56)	12.98 (60)	9.96 (53)	16.67 (56)	8.18 (44)	6.05 (58)	2.44 * (64) (2)

Note: * = statistically significant mean difference ($p<0.050$)

Findings and Interpretations

The results of comparing factor scores by affiliation found no mean differences between factor scores except for Data Access and Usage where Research Laboratories scored the lowest (m=2.03) and BS/MS Degree Granting Institutions scoring the highest (m=3.63), $F(5,353) = 4.93$, $p<0.05$.

These results indicate that perceptions of the various survey factors are relatively similar across institutional affiliations; however, participants within research laboratories have a lower overall perception of data access and usage compared to BS/MS degree granting institutions.

Analysis of Mean Survey Factor Scores by Profession

The following table compares mean scores for each questionnaire section by professional group. The mean scores and sample sizes (n) for the five professional groups are identified by rows. Mean scores for each questionnaire section are compared in each column. Factor scores for each participant were calculated by adding the responses for each item within the questionnaire section (e.g., for the questionnaire section "Alignment with NSF Goals for Ideas", participant scores for this factor were the sum of nine questions 16 through 24 leading to a possible range of scores from 9 (if a participant rated each of the nine questions as "1") to 36 (if a participant rated each of the nine questions as "4" on the four-point rating scale).

Averages (i.e., mean scores) of each professional group's total scores were calculated and compared using the one-way analysis of variance technique. The one-way analysis of variance compares the means of two or more groups to determine if at least one group mean is different from the others. The F-ratio is used to determine statistical significance with 95% confidence (i.e., $p<0.05$) that at least one mean score is different. The Tukey-Kramer test was used to examine all pairs of group means. This test is conservative, which means that the two averages must be very different between groups.

Table 20: Analysis of Average Survey Scores by Profession

Profession	Alignment with NSF Goals for Ideas Mean (n)	Alignment with NSF Goals for People Mean (n)	Alignment with NSF Goals for Tools Mean (n)	Impact on Culture Mean (n)	Impact on Institutional Cyberinfrastructure Mean (n)	Outreach Mean (n)	Core Values & Consistency Mean (n)	Support Inquiries Mean (n)	Software Usage Mean (n)	Data Access and Usage Mean (n)
1. Faculty	29.84 (58)	12.87 (54)	13.67 (55)	18.48 (58)	13.23 (56)	11.62 * (55) (2,3,4,5,)	17.98 (57)	9.30 * (52) (3,4)	6.41 (56)	3.78 * (58) (2,4,5)
2. Graduate Student	28.98 (41)	13.06 (37)	13.80 (39)	17.50 (43)	12.59 (44)	9.05 * (37) (1)	17.25 (39)	8.17 (30)	6.35 (40)	2.47 * (40) (1)
3. Undergraduate Student	29.02 (22)	12.30 (18)	13.37 (19)	18.31 (19)	12.24 (22)	8.51 * (15) (1)	16.00 (17)	7.21 * (12) (1)	5.95 (20)	3.33 (21)
4. Scientist / Researcher	28.44 (119)	12.23 (107)	13.12 (112)	18.25 (119)	13.24 (117)	9.64 * (107) (1)	17.06 (119)	8.20 * (99) (1)	6.18 (119)	2.49 * (120) (1)
5. Other	28.33 (119)	12.57 (101)	13.22 (100)	18.16 (109)	12.99 (114)	9.95 * (98) (1)	16.98 (108)	8.45 (91)	6.25 (114)	2.48 * (122) (1)

Findings and Interpretations

The results of comparing factor scores by profession differences between factor scores were found for Outreach, Data Access and Usage, and Support Inquiries.

For the Outreach factor, Faculty scored the highest (m=11.62) and were significantly higher than each of the remaining professional groups, $F(4,307) = 4.86$, $p<0.05$. These results indicate that Faculty have probably been the primary target of outreach activities.

For the Data Access and Usage factor, Faculty scored the highest (m=3.78) and were significantly higher than each of the remaining professional groups, $F(4,356) = 5.35$, $p<0.05$. These results indicate that Faculty perceive Unidata's Internet Distribution System (IDD) to be more reliable and timely than do the other professional groups.

For the Support Inquiries factor, Faculty scored the highest (m=9.30) and were significantly higher than Undergraduate Student and Scientist/Researcher professional groups, $F(4,279) = 3.03$, $p<0.05$. These results indicate that Faculty perceive Unidata's support to be better than do the Undergraduate Students and Scientist/Researcher.

SECTION VIII: CORRELATIONAL ANALYSIS

Relationship Between Length of Membership and Survey Factor Scores

Table 21: Factor Score Correlations with Number of Years Experience

Survey Factor	Correlation with Years Experience
Support Inquiries	0.27**
Unidata's Core Values and Consistency	0.21**
Software Usage	0.20**
Impact on Institutional Cyberinfrastructure	0.19**
Alignment with NSF Goals for Ideas	0.17**
Alignment with NSF Goals for Tools	0.12*
Impact on Culture	0.11*
Alignment with NSF Goals for People	0.11*
Outreach	0.10
Data Access and Usage	0.08

Note: ** = statistically significant relationship at p<0.01
* = statistically significant relationship at p<0.05
Used imputed total factor scores (mean imputation)

Findings and Interpretations

Based on the results of the correlation analysis between key outcome areas and years of experience, statistically significant, positive relationships were found for eight of the ten survey factors. As the number of years of experience increases for a community member, the factor scores for support inquiries, core values and consistency, software usage, impact on institutional cyberinfrastructure, alignment with NSF goals for ideas, alignment with NSF goals for tools, impact on culture, and alignment with NSF goals for people also increase with the strongest relationship identified with support inquiries (r = 0.27), Core Values and Consistency (r = 0.21), and Software Usage (r = 0.20).

SECTION IX: CASE STUDIES

This section documents the case studies included for the evaluation process. These case studies describe the software that was developed at Unidata and the software that was developed elsewhere but is supported by Unidata. The objective of these case studies is to highlight the transformational aspect of Unidata's work from the early years to the present and its impact on people, ideas, tools, and UPC excellence. The software described within this section include, netCDF, IDV, as well as the impact of other systems developed or supported by Unidata.

1. Network Common Data Form (netCDF)

The Network Common Data Form (netCDF) is software for storing and retrieving scientific data. In the mid-1980s, when Unidata developers recognized a community-wide need for a common interface between Unidata applications and real-time meteorological data, they started looking for a solution. The solution came to be known as netCDF. By making the package widely available, developers hoped to improve the existing situation in which software for scientific data access was rarely reused by others in the same discipline and almost never reused between disciplines.

From the project's outset, Unidata developers sought input and expertise from community members. A number of useful developments were taking place among its community. Along the way Unidata learned about data-access software called the Common Data Format (CDF) developed at NASA Goddard whose principles, they thought, might be used as a partial basis for the solution they were seeking.

The netCDF interface allowed users to create, access, and share scientific data in a form that is self-describing and network-transparent. "Self-describing" means that a file includes information defining the data it contains. "Network-transparent" means that a file is represented in a form that can be accessed by computers with different ways of storing integers, characters, and floating-point numbers.

Modifications in subsequent releases improved the usability of netCDF on inexpensive platforms without requiring its recompilation on other platforms. Other releases improved the package's functionality and usability.

Users have always been integral to the netCDF development effort, and that is no less true today than it was in 1996 when one user implemented and made available the first implementation of a netCDF interface for Java, another made a Python module available for netCDF, and still another user contributed a second netCDF interface for Python. A web document lists over 230 named users who have contributed related software, bug reports, fixes, valuable suggestions, and other kinds of useful support.

The sheer numbers of downloads of netCDF demonstrate its success. Specifically, in the past two years the software has been downloaded over 77,000 times to 78 countries. For reasons related to its use guidelines, this is probably only the lower bound. Seventy-five other software packages, both commercial and freely available, have been built on top of netCDF.[1]

The software might have remained static, resting on its reputation, and not implementing significant improvements, but developers took an ambitious step in 2004 when they collaborated with a

[1] Environmental Systems Research Institute (ESRI) ArcGIS, NetCDF Climate Operators, Climate Data Operators, Generic Mapping Tools, Grid Analysis and Display System, Interactive Data Language, NCAR Command Language, and MATLAB.

remote group of developers to increase the interoperability of netCDF and the Hierarchical Data Format version 5 software.

In addition to its use in every division of NCAR, netCDF is also used in a number of important efforts in climate and ocean sciences. For example, all of the output from global climate models being used to prepare the 2007 report of the Intergovernmental Panel on Climate Change is stored and accessed in netCDF form as part of the Program for Climate Model Diagnosis and Intercomparison at the Lawrence Livermore National Laboratory. Its use within the National Oceanic and Atmospheric Administration is extensive and includes using netCDF's archiving and services capabilities (Global Argo Data Repository, Climate Diagnostics Center, Pacific Marine Environment Laboratory, and the Global Systems Division of the Earth System Research Laboratory). Australia's CSIRO Division of Atmospheric Research uses netCDF's storage capabilities to store all of its GCM and ocean model results. Kyoto University (Japan), Northwestern University, and Argonne National Lab have all created and made available significant enhancements to the netCDF software.

Entraining its user community, remaining open to change and revision, thorough documentation and code that meets its requirements and standards, and is at the same time accessible to the user, have made netCDF a success. As a result, netCDF is one of the most important components of research infrastructure to come out of UCAR, with long-lasting impacts on the archives, models, applications, and middleware that depend on it.

2. Integrated Data Viewer

Unidata's Integrated Data Viewer (IDV) is a software framework for analyzing and visualizing scientific data. While it is similar to more mature Unidata-supported software visualization tools, it was meant to incorporate some important differences. To meet a community-articulated need for interactive, platform-independent applications that supported 3-dimensional displays, Unidata staff began producing prototypes of software that were Java™ based. It is worth noting that discussion in Unidata governance committees catalyzed the development that began in 1999, and the goals for the new tool included:

- Platform independence; i.e., runs on personal computers
- 3-dimensional displays
- Ability to access data remotely via multiple protocols
- Incorporation of modern interfaces and technologies
- Ability to directly incorporate user needs
- Design for long-term adaptation and maintainability

Two groups external to the Unidata Program Center have been integral to the IDV development, the MetApps Task Force and the IDV Steering Committee. The MetApps Task force guided the prototype development and the IDV Steering Committee currently provides guidance for continued IDV development. The members of these committees represent the broad spectrum of the Unidata Community from traditional meteorologists to oceanographers. In fact, it is almost impossible to imagine how the development could have occurred without input from these two groups working collaboratively with the IDV developers.

The IDV software is based on VisAD[2], a Java component library for interactive and collaborative visualization and analysis of numerical data. The original requirement for the IDV was to develop an integrated application with broad functionality similar to GEMPAK and McIDAS, but extensibility to

[2] The name VisAD is an acronym for "Visualization for Algorithm Development."

handle new data types, exploring new approaches to visualizing and interacting with the Earth system data and focusing on techniques that fuse data from multiple sources were more important goals than matching features in existing applications.

Unique capabilities provided by IDV include:

- Ability to run on inexpensive Windows and Macintosh platforms
- Remote data access through ADDE, OPeNDAP, HTTP, and OGC GIS servers as well as other kinds of data services
- Ability to connect with and access data through a THREDDS Data Server (TDS)
- Use with diverse types of geoscience data
- Visualization, animation, and interactive manipulation of three and four-dimensional variables

The IDV framework can be used and extended to create custom geoscience applications beyond the atmospheric science realm. This customization allows new applications to be tailored to specific datasets and provide customized user interfaces for different audiences and needs. One example of a customized IDV application is the GEON-IDV (http://geon.unavco.org/unavco/IDV_for_GEON.html), which is designed for geophysical data such as the datasets available in the NSF funded GEON project. Chuck Meertens, who is spearheading the use of IDV in GEON states:

> "The IDV is providing a powerful means of viewing diverse and multi-dimensional data being assembled to address complex integrative science problems such as those being investigated as part of the EarthScope project. EarthScope data, including seismic, GPS geodetic, and geologic data are being used to explore the structure and evolution of the North American continent. Using the IDV, the user can interact with seismic tomography isosurfaces, earthquake locations, GPS vectors, deformation source volumes, geologic maps, and host of other data and models. The IDV is a truly modern Cyberinfrastructure tool."

At this time IDV use is growing, not only in Unidata's traditional atmospheric sciences community, but in other geoscience areas as well. One hydrologist wrote the following in praise of the IDV:

> "I think the CUAHSI people are going to be very enamored of this. It's a kind of data vision that I think we would like to have more widely available in hydrology. I'm very encouraged by this and see this is as a very positive step in our collaboration with Unidata. And the neat thing is that this works now and it's not something that we have to wait for into the future."

Field project support is another area where the IDV has made important contributions. The IDV was used in the recent Rain In Cumulus over the Ocean (RICO) and Terrain-induced Rotor Experiment (T-REX) field projects for displaying realtime observations collected during the field campaign. The developers are continuing to collaborate with colleagues at the NCAR Earth Observing Laboratory and other institutions (e.g. University of Wyoming) to improve its utility in field projects

Given its powerful capabilities and myriad advances and adaptations, the IDV has now grown into a tool that is fundamentally altering the way educators and researchers perform analysis and visualization of geoscience data.

3. Starcasting: Unidata's Role in Generating Custom Meteorological Forecasts in Support of Astronomical Operations at Mauna Kea
by Steven Businger

I was approached in the fall of 1997 by a small group of astronomers about the possibility of establishing custom weather forecast support for the summit of Mauna Kea, one of the world's best sites for ground-based astronomy (Figure 18). To my surprise, these scientists were not so interested in how bad the near-future weather was going to be, rather they were keenly interested in exactly how "good" the weather would be for optical and infrared astronomy.

At that time innovations in telescope instrumentation had made compelling the case for seeking forecast support from the meteorological community. Thinking about nature of the challenge of providing that custom support, it was immediately clear to me that the computational and data resources[3] created and made available by the Unidata program were ideally suited to tackling this multidisciplinary problem.

The ensuing collaboration resulted in the formation of the Mauna Kea Weather Center, which resides in the Department of Meteorology at the University of Hawaii and utilizes a growing suite of computational resources distributed across two islands (Figure 19). Since January 1999, the MKWC has issued custom weather forecasts for the Mauna Kea Observatories twice daily, Monday through Friday. The MKWC web server (http://mkwc.ifa.hawaii.edu) is the primary means by which custom forecasts, satellite data, model output, and summit weather observations are made available to the astronomy community. The web server locally generates global model and satellite graphics using Unidata graphical display tools (e.g., GEMPAK, McIDAS, and IDV), from gridded model output, digital satellite, and operational National Weather Service (NWS) data that are accessed via the Internet Data Distribution (IDD) network established by Unidata. Behind-the-scenes tools, such as the Local Data Manager (LDM), which handles the incoming data streams, and netCDF (network common data form) to make the format of a wide variety of data types transparent, are integral to the smooth operations of the MKWC.

At the core of the MKWC is an operational mesoscale numerical modeling effort that provides experimental forecast guidance for astronomical image quality, or *seeing*, during prevalent fair weather. Once again, the IDD delivers the global model output that provides the boundary conditions for the mesoscale model and the form of the transferred data and the model output is the self-describing netCDF.

Forecasts of adverse weather protect the safety of Mauna Kea personnel, mitigate the hazard to telescope facilities, and allow for scheduling of maintenance when observing is impaired by cloud. The Unidata program has provided the tools and facilitated the data streams that make it possible to meet the unique forecast requirements and challenges faced by Mauna Kea astronomy community, helping to maximize the return on a significant investment.

[3] Data access via the Internet (LDM, IDD), data management (netCDF), and display and analysis tools (GEMPAK, McIDAS)

Figure 18: Photo by Richard Wainscoat of summit of Mauna Kea viewed from the northeast. In the foreground on the summit ridge, from left to right, are the UH 0.6-meter telescope (small white dome), the United Kingdom Infrared Telescope, the UH 2.2-meter telescope, the Gemini Northern 8-meter telescope (silver, open) and the Canada-France-Hawaii Telescope. On the right are the NASA Infrared Telescope Facility (silver), the twin domes of the W.M. Keck Observatory; behind and to the left of them is the Subaru Telescope. In the valley below are the Caltech Submillimeter Observatory (silver), the James Clerk Maxwell Telescope (white, open), and the assembly building for the submillimeter array. The cinder cone in the center of the photograph is Pu`u Poliahu. In the distance is the dormant volcano Hualalai (altitude 2,520 m), located near Kailua-Kona.

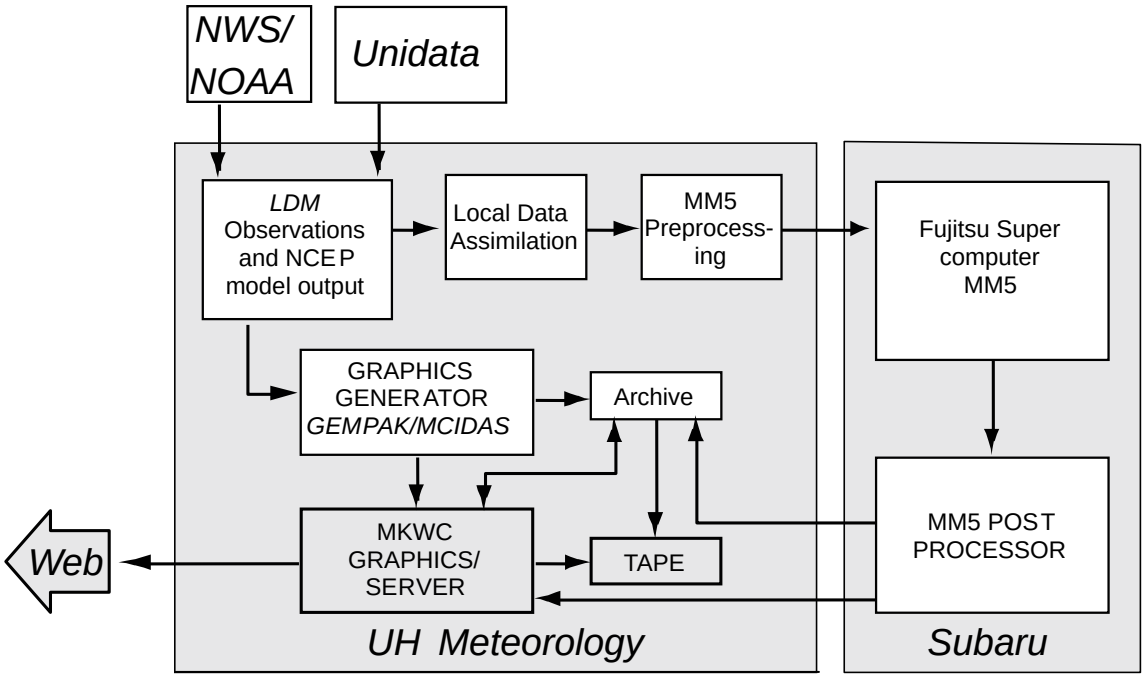


Figure 19: Schematic of the distribution of computational and data (netCDF format) resources utilized by the Mauna Kea Weather Center.

4. WSR-88D Level II Radar Data Distribution

Dating back to 1998, Unidata's involvement with the U.S. Weather Research Program served as a spring board toward the eventual use of Unidata's Local Data Manager (LDM) to serve the community's long-term needs for high-resolution Level II radar data. Thanks to the successful Internet Data Distribution (IDD) system that leveraged the LDM, a freely available software known for its adaptability and flexibility for distributing real time weather data to a growing community, it became the foundation in the Collaborative Radar Acquisition Field Test (CRAFT), a proof-of-concept project to collect and redistribute Level II data to a national network of diverse users.

Working collaboratively with stakeholders from the University of Oklahoma, University of Washington, NOAA's Radar Operations Center and research laboratories, National Weather Service (NWS), National Climatic Data Center (NCDC), and Internet2-Abilene, CRAFT successfully grew into a broad framework for distributing Level II data. According to Professor Kelvin Droegemeier, University of Oklahoma and the principal force behind CRAFT,"…the LDM served as the underpinnings of which two decades later would serve as a foundation for the Level II data and an operational system for the National Weather Service that no one could have foreseen."

Though there were several obstacles to overcome, the payoff would be great, by providing high-resolution data from the entire national network of 134 WSR 88-D radars to be used by government, universities, and private sector. The stakeholders had unique needs, such as NCDC's need to obtain the data for archival purposes, while some required the data in real-time for use in numerical weather prediction. The new system eventually replaced the data storage on 8mm tapes, improved archive reliability from 65% complete to over 95% complete, and cut the data availability time from months to seconds at a huge cost savings for NOAA. This was also an important event for researchers, who in the past had been frustrated by attempts to access the NCDC archives.

Success was achieved for the overall community, to the degree that led to the eventual technology transfer to the NWS for operational use. Subsequent to CRAFT, NWS installed the LDM at all WSR-88D sites as well as at four top level sites and uses the Internet2 backbone for distributing radar data both internally as well as to other government partners, universities, and the private sector. The Level II data distribution effort also demonstrated how a partnership centered on data sharing can be a successful model for future collaborations amongst the various sectors. In fact, this innovative solution has been successfully replicated for other data distribution and community building efforts around the globe.

5. International Impacts

Increasingly, science requires strong international scientific partnerships that advocate for sharing knowledge, information, and other assets. This is particularly true in the geosciences where the highly coupled nature of the Earth system and the need to understand global environmental processes and their regional linkages have heightened the importance of strong collaborations across national and continental boundaries.

Beginning as a collection of U.S.-based, mostly atmospheric science departments, the Unidata community has grown to international institutions. There are compelling benefits of a global cyberinfrastructure and the power of networked communities as institutions and people exchange knowledge, ideas, and resources. Recognizing those benefits, the Unidata program has developed a growing portfolio of international outreach activities conducted in close collaboration with academic, research, and operational institutions on several continents, to advance earth system science education and research. The portfolio includes provision of data, tools, support, and training as well as outreach activities that bring various stakeholders together to address important issues, with the goal of building a community with a shared vision.

MeteoForum, a pilot project initiated in 2001, was implemented to extend Unidata and COMET, a sister program in UCAR, activities into the international arena. Funded by the UCAR Office of Program, MeteoForum began with a few universities and some World Meteorological Organization (WMO) Regional Meteorological Training Centers (RMTCs) that were motivated to improve education and training in their regions through of the use of data and modern instructional methods, with the goal of acquiring access to real-time data, training materials, and other resources. The needed infrastructure was an Internet connection, appropriate computers, and suitably skilled personnel. The Unidata-developed Local Data Manager (LDM) adapted to facilitate the multi-way sharing of data through a regionally configured variation of Unidata's Internet Data Distribution (*IDD*) system. When practical, the MeteoForum participants were encouraged to contribute real time data from their region for others to use.

MeteoForum is a success story of organizations that leveraged their expertise in the creation of a data distribution system for South America, the *IDD-Brasil*. This success was built collaboratively among the UPC and several Brazilian institutions including the Universidade Federal do Rio de Janeiro, the Universidade de São Paulo, the Universidade Federal do Pará, and the Centro de Previsão de Tempo e Estudos Climáticos (CPTEC, a division of INPE). The data relay infrastructure established in Brazil, coupled with the North American *IDD*, represented the beginnings of a hemisphere-wide network that acted as a catalyst for multi-way sharing of international, national, and locally-held environmental datasets. For the first time, previously unavailable observational data and high resolution model output for Brazil were made available to both Latin American IDD-Brazil and North American IDD participants in near real-time.

The *IDD-Brasil* has had a profound and transformative impact and has helped initiate teaching innovations in multiple geoscience disciplines in Argentina, Brazil, and Chile, including the University of Costa Rica in Costa Rica, the University of Buenos Aires in Argentina, and Universities of Rio de Janeiro and São Paolo in Brazil. Integration of real-world data has provided opportunities for active, student-

centered and inquiry-based learning, infusing the excitement of discovery into geoscience courses at these institutions.

The elements of the MeteoForum project now serve as building blocks for a full-scale international data sharing effort. The data network has since been extended to the Caribbean, Antarctica, and work is underway to extend it to Africa.

SECTION X: ADDITIONAL CONTRIBUTIONS TO THE STUDY

The objective of the alignment table was to align Unidata program's retrospective analysis to National Science Foundation's strategic goals (people, ideas, tools, and organizational excellence). This section outlines the alignment table outcomes and how these outcomes map to the new NSF definitions.

NSF's Goal for People - Impact on Learning

1. The Unidata program has facilitated professional diversity by (a) including non-traditional disciplines in their extension efforts, (b) expanding the community to foreign nations, and (c) expanding the community to smaller colleges and universities in the United States.

2. The Unidata program has fostered and developed multiple software packages and has provided excellent training and expert support to the users of this software leading to a global adoption of these software tools.

3. Unidata's efforts have resulted in a more knowledgeable and diverse entry level hires into the NWS. The knowledge level of new hires has improved compared to a decade ago and more students at the universities are interested in working with the NWS on joint projects now that they have access to the same data sets which are used operationally in NOAA.

4. The Unidata program has provided capabilities that have allowed small academic programs and institutions to provide more opportunities to a broader spectrum of students and wider collaborations among institutions. For example: one respondent explained that their institution's undergraduate program had grown from 25 to 100 students and the institution had recently added a graduate program.

5. The software and tools provided by Unidata is heavily used to teach a diverse group of graduate and undergraduate students; therefore, through universities, Unidata assists in preparing a diverse workforce for the national Weather Service, the military service, and the private sector.

NSF's Goal for Ideas - Impact on Discovery

1. Through the Cooperative Opportunity for NCEP Data Using IDD Technology (CONDUIT) project, Unidata has enabled the receipt of NCEP model data in real time fostering collaboration between NCEP and external researchers to allow for further model development.

2. Real-time analysis of current weather has stimulated thesis work and scientific papers by graduate students, including investigations of lake-effect snowbands and intermountain frontal evolution.

3. Participants of the Unidata program have been able to acquire and understand retrospective digital information sources related to significant weather events through tools such as IDD, ADDE and THREDDS. This capability has been applied to numerous applications in operational meteorology, hydrology, agriculture, public safety and climate.

4. Unidata has provided valuable leadership in the standardization of data formats and visualization capabilities by providing a data distribution system (LDM) and tools to manipulate and visualize real time data (e.g., GARP, GEMPAK, NMAP, and IDV).

5. The IDV and McIDAS are used to teach the use of enhancement curves and satellite image interpretation. Also, access to model output allows students to learn the science and art of weather forecasting.

NSF's Goal for Tools - Impact on Research

1. Most institutions have revamped how they present weather analysis and forecasting courses by moving from paper maps to electronic presentations. One respondent explained that in their institution research expanded when other collaborators were able to see what the people in the institution could do with the technology provided by Unidata.

2. The Unidata streams are integral to the Mauna Kea Weather Center, which provides weather forecast support to the astronomical observatories at Mauna Kea (http://mkwc.ida.hawaiil.edu). The Unidata streams (and local archives: http://mkwc.mkwc.ifa.hawaii.edu/archive/index.cgi) are relied on by students in research projects and access to model output allows graduate students to run mesoscale models in near real time, one respondent explained.

3. The GEMPAK software is used by many students and faculty for research and instruction. The netCDF has become the most widely used file format for scientific data and allows scientists to share data and greatly facilitates collaboration between researchers.

4. On the issue of network infrastructure, one respondent explained as follows: "The Internet Data Distribution (IDD) and Local Data manager (LDM) is a showcase of Unidata's excellence. It is the backbone of a system that distributes terabytes of data, in real-time, over the internet to universities in the U.S.A., and in a number of sites in South America and Europe. Its performance and exceptional reliability is unrivaled. There is simply no other software available anywhere that can do what IDD/LDM does. It has been adopted by the National Weather Service to distribute real-time NEXRAD data from radars to the National Climatic Data Center, through the so-called CRAFT project. This has replaced an antiquated magnetic tape-based system that resulted in significant data loss and has latencies of weeks. CRAFT, IDD/LDM has significantly improved the NEXRAD holdings at NCDC. This benefits the nation as a whole. Further, the CRAFT, IDD/LDM project has made real-time NEXRAD data available to researchers at universities and to commercial companies, and IDD/LDM technology has been adopted in other countries' weather services, and is used in oceanography and hydrology. IDD/LDM has transformed data distribution from a very expensive, time-consuming, error prone process, to something almost transparent. It has also democratized access to important datasets. Individual researchers at smaller universities and K-12 schools can easily set up an LDM node and receive real-time atmospheric data".

NSF's Goal for Organizational Excellence - Impact on Stewardship

1. On the issue of stewardship and organizational excellence, Unidata distributes a large volume of atmospheric data and with very little investment in hardware and time so that individual researchers can get access to this data.

2. Unidata personnel have a reputation of supporting user's questions in a timely manner and accurately.

3. Unidata was repeatedly stated to be a model program by the community members. One respondent explained it as follows: "The Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI) is an organization representing more than a hundred USA universities – it is the Hydrology equivalent of UCAR. In recent years, with NSF support, CUAHSI has been working on providing hydrologists with better access to hydrology data. Most hydrologists would agree that the ultimate goal is to have an equivalent of Unidata for hydrology."

4. Unidata collaborates with other organizations to contribute to their success and development. This ripple effect is best explained by the fact that Unidata has reached out to CUAHSI and has had a CUAHSI representative serve as a Unidata committee member. Forming alliances with other organizations demonstrates that Unidata is not just a good steward of their resources but that the members are willing to use their resources to assist in contributing to the success of other organizations which provides a cornerstone of continuity in supporting scientist.

5. Unidata's expansion into hydrology, GIS, air quality and climate reflects an adaptive mindset and philosophy that strives to stay a step ahead of the curve as curricula change, explained one respondent.

6. Unidata, as stated by one respondent, utilizes its governance structure (including interactions with federal agencies), its connection to UCAR member representatives, and its proximity to NCAR labs and scientists, to assess and approach new opportunities and community needs. The UPC staff considers the input of the Unidata committee members, participants at workshops, and support requestors wisely to weigh those community perspectives with the core mission and values of the program.

SECTION XI: OVERALL CONCLUSIONS

Every stage of this study offered an opportunity for the consultants to experience all the reasons why the Unidata program has been successful. The staff is extremely knowledgeable, dedicated and interested in promoting and sharing their work. Unlike some other organizations where staff members hardly communicate with each other, it is obvious that whether a person works in software or in outreach, there is a sense of unity and equality among the personnel. Every person's contribution is viewed as important to the overall productivity of the organization. In addition to the outstanding staff and their sense of duty, the "community process" (which includes community engagement, governance, feedback, partnership, and support) is the most important factor in Unidata's success.

In conversing with the community members, the consultants learned that the Unidata program was irreplaceable. Faculty are exposed to technological developments that affect their disciplines and that they find extremely valuable for their professional development and for their students. The program is truly community-based and this is reflected in its daily operations and also at the governing level. The community members expressed how impressed they were by the ability of the staff to respond to their inquiries in a timely manner. The Unidata program has established a reliable socio-technical environment that leverages developments in data delivery to maximize creativity and learning in the geosciences. For example; the smaller undergraduate institutions appreciate the fact that without the Unidata program, it would be impossible for them to experience the current level of collaboration with other larger institutions. The ability for professors and students to access software building blocks so that they do not have to re-invent the wheel is vital for improving productivity at a small institution. The Unidata program has encouraged the community to move toward open standards and this is revolutionary from the user's and data provider's perspective.

The Unidata program has truly transformed teaching in the field of geosciences. In one institution, this transformation led to a tripling of the undergraduate majors in the meteorology program. As explained by faculty members throughout this study, without the data and software provided by Unidata, the meteorology programs would be severely limited in their ability to carry out their mission. Unidata has helped these programs expand the spectrum of meteorological data and created the ability for faculty to easily interrogate data, allowing them to spend more time teaching and on research in atmospheric science. In another instance, the National Climatic Data Center frequently uses Unidata software and formats (netCDF), and their processing and access is moving towards Unidata-developed architecture. Over all, netCDF was frequently praised as a step toward a long term perspective on standard data formats, making this one of the most important case studies in this report.

The consultants were very impressed with the indirect benefits of the Unidata program. Indirect benefits are benefits that are not directly related to Unidata's objectives or goals but they occur because the Unidata community has leveraged the direct benefits of the program. For example, the University of Kentucky has been a Unidata member for several years and this has allowed the university to build a comprehensive outreach and educational program including weather-related products for Kentucky residents within the agricultural industry. The agricultural community informed the university that the educational products they provide are a "quantum leap forward" in agriculture. In another instance, a participant from a facility that does not engage in education or research explained that many Unidata products are used in support of the Space Shuttle program. For example, the Local Data Manager is indispensable to current operations and plans for larger uses supporting future manned and unmanned space activities are underway.

In summary, the quality of software and the support offered by Unidata to its community members is exceptional and community members were in strong agreement that Unidata has stayed true

to its values while accomplishing its goal. In summary, the Unidata program has been successful because (a) the community is in relative agreement with the program objectives and outcomes, (b) feedback from the community is encouraged, (c) the workshops and training offered keep community members linked, and (d) when problems arise, they are resolved in a timely manner.

The Unidata Program is one of the most important things that UCAR has done over the years. The impact has been experienced by future scientists, educators and students in the classroom, as well as other professionals. Unidata was repeatedly stated to be a model program by the community members. One respondent explained it as follows: "The Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI) is an organization representing more than a hundred USA universities – it is the Hydrology equivalent of UCAR. In recent years, with NSF support, CUAHSI has been working on providing hydrologists with better access to hydrology data. Most hydrologists would agree that the ultimate goal is to have an equivalent of Unidata for hydrology."

The following sections identify the findings and conclusions at the Strategic, Operational, and Tactical levels.

Strategic Level Conclusions

Discovery - NSF Goals For Ideas

The survey outcomes demonstrate that the Unidata program is in alignment with NSF's Goals for Ideas because on a scale of 1 to 4 the average scores range from 2.98 to 3.36. Participating in the Unidata community has increased information technology knowledge within organizations and departments as demonstrated by the fact that item 17 had the highest average score of 3.36.

The "technical innovations within the Unidata Community" have the highest impact related to discovery (ideas) as demonstrated by the item-total correlations that ranged from 0.61 to 0.74 with "technical innovations" computing the highest correlation of 0.74. The community has the perception that Unidata has succeeded in the discovery goal (NSF strategic goal of "Ideas").

Based on the focus group outcomes, both faculty and students agreed that Unidata products and services have helped to drastically reduce the amount of time and effort required to conduct research activities because the data access, and format are easier to manage. This allows scientist to spend time focusing on their work and instead of figuring out how to access and format data as they did in the old days.

Learning – NSF Goals For People

The survey outcomes demonstrate that the Unidata program is in alignment with NSF's Goals for People because on a scale of 1 to 4 the average scores range from 3.04 (Item 49) to 3.22 (Item 50). Participating in the Unidata community has facilitated a more engaged workforce and also a more knowledgeable workforce.

These survey results were further corroborated by the focus group participants who agreed that Unidata has facilitated a more inclusive workforce because it enables researchers to work collaboratively and, in effect, more people are involved when using a collaborative approach.

In addition, the focus groups confirmed that enabling effective communication among researchers also aides in facilitating an inclusive workforce and in some institutions the ability to reach out to elementary and high school teachers and help to educate them on how to teach earth science classes.

The facilitation of a more globally engaged workforce is depicted in the demographics section whereby survey respondents represented 15% of the international geographic locations listed on the survey. Furthermore, the facilitation of a knowledgeable workforce is reflected in the strategic outcomes "Alignment with NSF goals for ideas whereby 92.9% of the respondents agreed or strongly agreed that Unidata had increased their information technology knowledge.

The focus group participants also agreed that Unidata tools have given students with different learning styles a way of engaging with the subject of meteorology in a manner that they might not have been able to do before and this has increased the diversity of the students entering and staying in the field of meteorology. Overall, the community has the perception that Unidata has participated in achieving the NSF strategic goal of "People".

Research – NSF Goals For Tools

The survey outcomes demonstrate that the Unidata program is in alignment with NSF's Goals for Tools because on a scale of 1 to 4 the average scores range from 3.31 (Item 40) to 3.40 (Item 39). There is agreement that Unidata has provided analysis and visualization software that enables academic learning, scientific discovery, innovation among educators, and innovation among researchers. Overall, the community has the perception that Unidata has participated in achieving the NSF strategic goal of "Tools".

The focus group participants further collaborated this alignment with NSF's Goals for Tools by confirming that (a) the speed at which data can be accessed, displayed, and analyzed helps to promote academic learning, (b) the ability to view and analyze real-time data helps to engage the students within a classroom setting using current information, and (c) ability to visualize multiple types of data using a variety of views provides a unique learning experience for students interested in meteorology.

In addition, the focus group participants explained that the tools allow for collaboration between researchers located in geographically different site locations, and provides an important time saving component for educators who can now incorporate analysis and visualization activities into their courses with relative ease. Overall, participants agreed that these time saving tools allow for the ability to generate innovative ideas related to educating students.

Operational Level Conclusions

Impact on Organizational Culture

Survey responses for the "Impact on Culture" indicate general agreement with the statement that Unidata has transformed the organization's research culture; however, based on the mean scores of slightly less than 3.0, transforming publishing, contribution to increasing the number of students, and transforming outreach reflected the lowest perceptions within organizational culture. The highest item-total correlation of 0.75 implies that transforming research culture has the greatest impact related to the overall perception of organizational culture.

These results were further corroborated by faculty at focus group discussions when they pointed toward GEMPAK as the software most helpful for publications with its ability to import data and produce

publication-quality figures. Faculty agreed that GEMPAK is better than most other software packages with this functionality.

On the issue of increasing the number of students, faculty discussed the fact that some institutions make Unidata products available to prospective students, which assists in recruiting new students into their programs and departments.

Impact on Institutional Cyberinfrastructure

Overwhelmingly, participants agreed that Unidata had transformed the way they access and distribute data. The transformational aspect of field projects was not applicable to 43.3% of the participants and it scored only 2.82. As corroborated by focus groups, that with the advancement in technology (real time data becoming available) the need for field project had declined. However, for those faculty and students who participate in field projects, Unidata projects were found to provide necessary support for their activities. GEMPAK was identified as one of the software packages used during field projects.

Software Project Interviews

Based on the software project interviews, participants confirmed that community needs drive project initiation. These needs are identified through analysis of support inquiries and common themes from support inquiries are reviewed prior to project initiation. Activities, ideas, and opportunities are identified and defined by the software development staff. The project risks (e.g., technology change, available resources, and timeline of implementation) are discussed before project initiation and the timeline is considered to have a lower priority. Funding of these projects is obtained from NSF as well as other proposals that can generate additional funding.

Approximately 1,400 active community members have been identified through support communications. The new support inquiry system streamlines the delivery of topic-specific inquiries to appropriate Unidata staff members, and helps insure that inquiries are handled in a timely manner. This was further collaborated by the survey where 95% of the respondents stated that responses were answered in a timely manner. Training workshops are used to generate requirements, identify changes to applications, and identify bugs to fix, as corroborated by faculty focus group discussions. The workshops are very popular because they bring the community members together and allow for face to face discussions about the program.

Major software, releases are scheduled every 3-12 months and sometimes around the academic calendar. Notes are sent to the community members informing them when the release is available, and the community members have the opportunity to provide feedback through support emails. Projects are monitored by governing committee members and specific milestones are incorporated into the release requirements.

For quality assurance purposes (process and product), Alpha testing and Beta testing are used to introduce functionality and updates to software systems. Peer reviews are also conducted when requested by developers at an informal level. Developers help to provide application support to better identify common themes related to problems, to address the needs of the community, and to be able to address appropriate changes if necessary. This was further corroborated by focus group discussions, where participants stated that the software team was very responsive to any software questions or issues that community members raised.

Outreach

The Unidata Newsletter, an electronic newsletter, had a score 2.25 on a scale of 1-4, and 51% of the participants rarely or very rarely read the newsletter. Based on the focus group discussions and individual interviews, the community members are aware of the newsletter but they stated that the information covered in the newsletter was easily accessible from the web site and therefore they did not find it necessary to read the newsletter because it lacked "news". A recommendation was made to make the newsletter about "news". Also, about 33% of the participants were not aware that the newsletter was posted on the web.

The workshops were highly regarded by the survey participants with 97% of workshop participants stating they would recommend them to other people. This was further corroborated by the focus group discussions where the participants stated that the workshops were extremely informative and helpful for the community because they allowed a professionally diverse group of people to meet and exchange ideas.

Also, 20% of the participants stated that they had downloaded software for the purposes of outreach. Based on the ANOVA outcomes, faculty have probably been the primary target of outreach activities because they scored significantly higher than other professional groups (Table 20).

Unidata's Core Values and Consistency

Every question regarding Unidata's consistency in keeping with its core values scored 3.21 or higher in a scale of 1-4, and 97% of the community members believe that Unidata has remained true to its values and consistent with its values throughout the years. The focus groups corroborated this statement further by explaining that the community-based governance works well in meeting community needs both at a personal and institutional level.

Unidata's consistency is further corroborated by the correlation analysis. As the number of years of experience increases for a community member, the factor scores for support inquiries, core values and consistency, software usage, impact on institutional cyberinfrastructure, alignment with NSF goals for ideas, alignment with NSF goals for tools, impact on culture, and alignment with NSF goals for people also increase with the strongest relationship identified with support inquiries ($r = 0.27$), Core Values and Consistency ($r = 0.21$), and Software Usage ($r = 0.20$).

As expressed throughout this study, Unidata has contributed extensively to the transformational research at an institutional level. The case studies explain the innovative measures that have made this transformational research possible.

Tactical Level Conclusions

Demographics

While Arkansas, Delaware, Idaho, Mississippi, and West Virginia were found not to have any survey participants, this outcome is not surprising because these states were not found to have any existing atmospheric science university programs. However, Western Connecticut State University has an atmospheric-related university program within the Department of Physics, Astronomy, and Meteorology and the lack of representation in Connecticut was unexpected. Please note that these outcomes reflect only the dispersion of the survey participants and not the dispersion of the community served by the Unidata program. For example, according to Unidata personnel, Mississippi has a large number of community

members but because they did not participate in the survey, their presence was not reflected in this dispersion.

The average length of Unidata membership was 6.7 years while the median length of membership was four years. Approximately 43% of the participants had been members of Unidata for three years or less. Based on the affiliation type outcomes, one may conclude that 40% of the survey participants are involved with some form of research-based, degree-granting institutions.

Approximately 48% of the survey participants are either scientists/researchers or faculty members. This aligns with the Unidata Strategic plan because support services and other staff-intensive activities within the Unidata Program Center are directed toward educators and researchers at post-secondary, as well as academic institutions in the U.S.A.

Support Inquiries

As discussed during the software interviews, Unidata personnel respond to community inquiries in a timely manner and they involve the community in project development by using the community member's feedback to assess priorities for project development. This was further corroborated by the survey respondents who overwhelmingly agreed (94.5%) that Unidata had responded to support inquiries in a timely manner frequently or very frequently. The new support inquiry system that streamlines the delivery of topic-specific inquiries to appropriate Unidata staff members is working well.

Based on the item-total correlation for the issues affecting Support Inquiries, helpfulness has the highest impact and members believe that email responses from the Unidata Personnel were helpful in solving their problem.

The issue of timely responses and helpfulness was further corroborated by focus group discussions whereby all faculty members had indeed emailed support inquiries to Unidata and they all (100%) confirmed that Unidata Personnel responded the same day and had a solution to their problem. This demonstrates a very high level of effectiveness in terms making an impact with the community.

The focus group participants also underscored the fact that the Unidata staff was very professional in responding to their support inquiries. One participant stated "I do not get this type of support from other places or federal agencies that I work with. Unidata goes beyond IT support and technical support. Unidata also provides scientific support. I recommend that Unidata does not lose the excellent user support they currently provide to the community."

Based on the ANOVA outcomes, faculty perceive Unidata's support to be better than do the undergraduate students and scientist/researcher professionals (Table 20).

Software Usage

Whether participants had downloaded Unidata software once or several times, 93% of participants concluded they would recommend Unidata software to other people. This high regard for Unidata's software was a continuous theme throughout this study. The top four most downloaded software was netCDF, GEMPAK, IDV, and LDM.

When asked about the use of software, the top three reasons were research (71%), collaborations (42%) and presentations (41%). There was concern expressed about the difficulty of installing McIDAS

but the people also explained that they had received all the necessary support needed when they contacted Unidata about their difficulty.

Data Access and Usage

Data access reliability and timeliness was impressive with 90% of the people agreeing that data could be accessed and used reliably and in a timely manner. The Unidata Internet Data Distribution system was also highly perceived by 93% of the people who stated that they would recommend it to others. Overall, data timeliness had the highest impact related to data access and usage.

Data access using “motherlode” or “adde.ucar.edu” scored low with only 59% of the participants stating that they had used it. Based on the focus group discussions, all the participants had accessed data using the “motherlode” but expressed difficulty with browsing for specific datasets, they explained that while they were able to find datasets, they were unable to “look inside” and they expressed the expectation that THREDDS would make “motherlode” more accessible. This focus discussion might explain why 41% of the participants do not use the “motherlode”.

Based on the ANOVA outcomes, faculty perceive Unidata’s Internet Distribution System (IDD) to be more reliable and timely than do the other professional groups (table 20).

SECTION XII: RECOMMENDATIONS

The overall perception of the Unidata program is extremely positive based on the interviews, focus groups, survey outcomes, and case studies. The recommendations outlined below are based on (a) the outcomes of this study (b) statements made by community members, and (c) statements made by Unidata personnel. It is important to note that some of the recommendations outlined within this section may require significant time to implement as well as possibly require additional resources to ensure successful implementation.

1. Transfer highly specialized knowledge to ensure continuity in projects. Given the longevity and continuity of projects and the highly specialized knowledge required to work on the various Unidata software projects, transferring this highly specialized knowledge is critical because few people have the actual knowledge base for each project/application. Succession planning to ensure longevity of projects and "back up personnel" need to be included in the strategic plan.

2. Consider filtering climate model output through the weather prism. Although there is a big difference between the variables and diagnostics used in the climate and weather community, climate models can be filtered through the weather prism because they are producing weather. Since there is a preference within funding organizations in the climate community to make their global, long term information more relevant for society, connecting it to meteorology data would make real-time more relevant to society than projecting climate change over decades. Unidata can explore this possibility in the future.

3. Consider seeking additional funding for on-site training at member universities because it may be more effective than web casts of in-house training that are a one-way dialogue.

4. Consider cohesiveness to standard software engineering practices and hire a QA/testing resource and/or technical writer in an effort to improve productivity and document quality when projects overlap with each other.

5. Consider implementing a cross-sharing of resources where developers test each other's code. Although this approach may impact productivity in the short-run, it may increase quality and knowledge transfer across the organization in the long-run.

6. Review the current code control tools and determine if investing in new code control tools is beneficial. This will help resolve the different perspectives on this issue.

7. Where appropriate, develop peer reviews at a functionality level. While informal peer reviews/code reviews are occurring within the organization, develop a formal organizational policy for the conduct of peer reviews to include code walkthroughs, test results reviews, and requirements reviews in order to continually improve (a) the quality of products and (b) knowledge transfer of various applications across the organization. For example, pilot test the peer review process with a single project starting with code reviews and determine what works well and what does not work well within the current organizational culture at Unidata. If the peer review pilot test is successful, extend the peer review process to other applications and other types of peer reviews (e.g., requirements reviews, project plan reviews, test plan reviews, etc.).

8. Continue to actively solicit the user community for input related to requirements. Collect the requirements into a list and allow the community (or a subset of the community) to prioritize the list of requirements for future releases.

9. Improve organizational process focus and definition activities by determining if an organization-wide process improvement effort should be implemented. Responsibility of the overall process improvement effort should be assigned to a few key subject matter experts within the organization. Areas to discuss would include (but are not limited to) requirements solicitation and prioritization processes, project planning and project tracking processes, peer review processes, configuration management processes, and formalized approaches to software development and testing.

10. Improve engineering practices for teams by determining a development, test, and implementation approach that works best for each individual project and team. Document the approach and communicate to each team.

11. Consider using the web based newsletter for "news" that is not typically covered on the main website. The outcomes demonstrate that outreach efforts are targeted toward faculty and 51% of the participants rarely or very rarely read the newsletter. Faculty shared that they do not read the web based newsletter because the information can be found on the main website and so the newsletter is perceived as a repetition of the material covered on the website.

12. Consider a follow up study to explore the indirect benefits of the Unidata program. While this study focused on the direct benefits of the Unidata program, it is apparent that there are multiple indirect benefits of the program. For example; how is Unidata impacting the next generation of scientists? Based on the focus group discussions and interviews, participants explained that they use Unidata products for outreach targeted to K-12 educators in an effort to show them how to engage young minds in science. Also, approximately 20% of the participants download software for outreach purposes. Conducting a follow up study on these issues would demonstrate how NSF's investment in the Unidata program is affecting discovery and learning in the next generation of scientists.

APPENDIX A: GLOSSARY

AAAS	American Association for the Advancement of Science http://www.aaas.org/
ACARS	Aircraft Communications Addressing and Reporting System
ADDE	Abstract Distributed Data Environment, a McIDAS remote data access system
ADaM	Algorithm Development and Mining System under development at UAH http://datamining.itsc.uah.edu/environment.html
ADAS	ARPS Data Analysis System http://www.caps.ou.edu/ADAS.html
AGU	American Geophysical Union http://www.agu.org/
AMDAR	Aircraft Meteorological Data Relay
AMPS	Antarctic Mesoscale Prediction System
AMS	American Meteorological Society http://www.ametsoc.org/AMS/
AOI	Automated Operator Interface
API	Application Program Interface
APRDC	Asia Pacific Data Research Center http://apdrc.soest.hawaii.edu/
Archydro	GIS for water resources
ARM	Atmospheric Radiation Measurement Program DOE's global change research program http://www.arm.gov/
ARPS	Advanced Regional Prediction System
ATM	Division of Atmospheric Sciences, NSF
AVN	Aviation Model at NCEP
AWIPS	Advanced Weather Interactive Processing System, an NWS program initiated in the 1990s; also known as the "modernization program"
B	Byte
BEA	A company, BEA Systems http://www.bea.com/framework.jsp?CNT=homepage_main.jsp&FP=/content
BMRC	Bureau of Meteorology Research Centre, Australia
BPEL4WS	Business Process Execution Language for Web Services http://www-106.ibm.com/developerworks/webservices/library/ws-bpel/
BRAN	Boulder Research and Administrative Network
BUFR	**B**inary **U**niversal **F**orm for the **R**epresentation of meteorological data
CAPS	Center for the Analysis and Prediction of Storms, University of Oklahoma
CASA	Collaborative Adaptive Sensing of the Atmosphere http://www.casa.umass.edu/
CDC	Climate Diagnostics Center http://www.cdc.noaa.gov/
CDM	Common Data Model http://www.unidata.ucar.edu/software/netcdf/CDM/
CEOP	Coordinated Enhanced Observing Period http://www.gewex.org/ceop.htm
CF	NetCDF Climate and Forecast (CF) Metadata Convention http://www.cgd.ucar.edu/cms/eaton/cf-metadata/
CI	Cyberinfrastructure, the digital computation, communication, information facilities, and services needed for the functioning of science and engineering research communities
CIESIN	Consortium for International Earth Science Information Network http://www.ciesin.org/
CIMSS	Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin-Madison
CLASS	Comprehensive Large Array-data Stewardship System http://www.nodc.noaa.gov/sog/noaaclass/

CNR	Italian National Research Council http://www.cnr.it/sitocnr/Englishversion/Englishversion.html
COAMPS	U.S. Navy's regional weather model http://www.nrlmry.navy.mil/coamps-web/web/home
COLA	Center for Ocean-Land-Atmosphere Studies http://grads.iges.org/cola.html
COMET	Cooperative Program for Operational Meteorology Education and Training
CONDUIT	Cooperative Opportunity for NCEP Data Using IDD Technology, a project that makes high resolution model data sets available to the U.S. Weather Research Program (USWRP) and to universities using Unidata's IDD technology
CRAFT	Collaborative Radar Acquisition Field Test, a joint effort of the Center for Analysis and Prediction of Storms (CAPS) at the University of Oklahoma, the Oklahoma Higher Education State Regents, the University of Washington, and Unidata to access and distribute NEXRAD Level II data in near real time
CSMF	Climate System Modeling Federation
CUAHSI	Consortium of Universities for the Advancement of Hydrological Science, Inc. http://www.cuahsi.org/
CVS	Concurrent Version System Version control system
DAML-S	DAML Services, DAML-based Web Service Ontology http://www.daml.org/services/
DAML	DARPA Agent Markup Language http://www.daml.org/
DAP	Data Access Protocol
DARPA	Defense Advanced Research Projects Agency http://www.darpa.mil/
data feed	To the Unidata LDM, a sequence of data products, all of the same feed type, injected into the IDD from a single data source
data product	To the Unidata LDM, a unit of data with an associated feed type, product ID, injection time, origin, and sequence number
data source	To the Unidata LDM, a remote provider of data products
data stream	To the Unidata LDM, a sequence of bulletins all of the same feed type broadcast from a single data source. Once the bulletins are converted into data products, the result is called a data feed
DDS	DLESE Data Services
decoder	To the Unidata LDM, a program that converts transmitted data products into a different form more suitable for use by applications. Decoders often combine multiple products into a single decoded file
DIDAKT	Data Integrated Documents and Knowledge Tools
DIF	Directory Interchange Format http://gcmd.gsfc.nasa.gov/User/difguide/difman.html
DIFAX	Digital facsimile map, a data stream of digitized maps formerly provided by the NWS
DIMES	DIstributed MEtadata System from George Mason University http://xml.coverpages.org/YangIIPS19-DIMES.pdf
DL	Digital Library
DLESE	Digital Library for Earth System Education http://www.dlese.org/
DMAC	Data Management Analysis Center
DORADE	DOppler RAdar Data Exchange Format http://www.atd.ucar.edu/rsf/UserGuides/ELDORA/DataAnalysis/DataAnalysis.html#DORADE
DODS	Distributed Oceanographic Data System, former name for the discipline-specific National Virtual Oceanographic Data System and the discipline-independent access protocols now known as OPeNDAP. http://www.opendap.org
DQC	Dataset Query Capabilities - THREDDS XML Document type that describes the possible ways that an end-user can choose dataset subsets
DUE	Division of Undergraduate Education, NSF Division
DVB-S	Digital Video Broadcasting over Satellite
ECMWF	European Center for Medium range Weather Forecasting http://www.ecmwf.int/
EDR	Environmental Data Record
ENSO	El Nino Southern Oscillation

ERE	Environmental Research and Education
ESG	Earth System Grid http://www.earthsystemgrid.org/
ESIG	Environmental and Societal Impacts Group, NCAR program
ESIP	Earth System Information PartnersFederation http://www.esipfed.org/
ESML	Earth Science Markup Language http://esml.itsc.uah.edu/
ESRI	Environmental Systems Research Institute http://www.esri.com/
ESRL	Earth System Research Laboratory (formerly FSL) http://www.esrl.noaa.gov/
ESS	Earth System Science
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites http://www.eumetsat.int/Home/index.htm
FES	Fluid Earth Systems
FFRDC	Federally Funded Research and Development Center
FGDC	Federal Geographic Data Committee http://www.fgdc.gov/
FNMOC	Fleet Numerical Meteorology and Oceanography Center https://www.fnmoc.navy.mil/
FOS	Family of Services, a collection of data streams from NWS
FFRDC	Federally Funded Research and Development Center
FSL	Forecast Systems Laboratory NOAA.renamed Earth System Research Laboratory (ESRL)
GALEON	Gateway or Geo-interface for Air Land Earth Ocean netCDF
GCMD	Global Change Master Directory http://gcmd.gsfc.nasa.gov/Aboutus/sitemap.html
GDS	GrADS/DODS Server http://grads.iges.org/grads/gds/
GEM	Global Environmental Multiscale Model
GEMPAK	General Meteorological Package. http://www.unidata.ucar.edu/software/gempak/
GEON	The GEOsciences Network http://www.geongrid.org/
GEOSS	Global Earth Observation System of Systems http://www.epa.gov/geoss/
GIS	Geographic Information Systems, standards are set for these systems by OpenGIS and ISO
GMAO	Global Modeling and Assimilation Office (NASA)
GML	Geography Markup Language http://opengis.net/gml/
GNOME	GNU Network Object Model Environment http://www.gnome.org/
GOES	Geostationary Operational Environmental Satellite, NOAA weather satellite
GPS	Global Positioning System, a system that uses satellites for navigation
GRIB	Gridded Binary
GRID	Computational Grids http://www.globus.org/
GrADS	Grid Analysis and Display System http://grads.iges.org/grads/
GSD	Global Systems Division http://www.fsl.noaa.gov/gsd/
HDF5	Hierarchical Data Format version 5 - data format for scientific data http://hdf.ncsa.uiuc.edu/HDF5/
HPCC	High Performance Computing & Communications
HPSS	High Performance Storage System

http	Hypertext Transfer Protocol, the protocol used to transfer hypertext documents
IAI	Inter-American Institute for Global Change Research http://www.iai.int/
IDD	Internet Data Distribution System, a Unidata near-real time data dissemination system in use at over 150 institutions http://www.unidata.ucar.edu/software/idd/
IDL	Interactive Data Language http://www.rsinc.com/idl/index.asp
IDV	Integrated Data Viewer, the IDV is a platform independent framework developed by Unidata for 3-D visualization and analysis of geoscience data. http://www.unidata.ucar.edu/software/idv/
IHOP	International H2O Project
IMAA	Institute of Advanced Methodologies for Environmental Analysis http://www.imaa.cnr.it/
INGRID	Name for an online data system at LDEO. It's not an acronym http://ingrid.ldeo.columbia.edu/
IOOS	Integrated Ocean Observing System http://www.ocean.us/
IPCC	Intergovernmental Panel on Climate Change http://www.ipcc.ch/
IPRC	International Pacific Research Center http://iprc.soest.hawaii.edu/
IPY	International Polar Year http://www.ipy.org/
IRI	International Research Institute for Climate Prediction at LDEO http://iri.columbia.edu/
IRIS	Incorporated Research Institutions for Seismology http://www.iris.edu/
ISO TC211	International Standards Organization TC211, a spatial data standard http://www.isotc211.org/
ISO	International Standards Organization http://www.iso.ch/iso/en/ISOOnline.openerpage
ITR	International Technology Research (for national priorities)
Java	An object-oriented, platform-independent language from Sun, now widely used to create applets and applications for the Internet
JODI	Journal of Digital Information http://jodi.tamu.edu/
JPL	Jet Propulsion Laboratory http://www.jpl.nasa.gov/
KDI	Knowledge and Distributed Intelligence
LAS	Live Access Server http://ferret.pmel.noaa.gov/Ferret/LAS/ferret_LAS.html
latency	In the context of the Unidata LDM, the delay in delivery of a data product since it was first injected from a data source site
LDEO	Lamont-Doherty Earth Observatory http://www.ldeo.columbia.edu/
LDM	Local Data Manager http://www.unidata.ucar.edu/software/ldm/
LEAD	Linked Environments for Atmospheric Discovery http://www.itsc.uah.edu/lead/project_summary.html
MADIS	Meteorological Assimilation Data Ingest System
McIDAS	Man-computer Interactive Data Access System http://www.unidata.ucar.edu/software/mcidas/
MetApps	Meteorological Applications Task Force
Metadata	Data about (behind) the data (the attributes associated with the data)
MeteoForum	Pilot project for advanced international meteorological training centers
MM5	mesoscale model, version 5, Pennsylvania State University/NCAR mesoscale (regional) limited-area model

MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration http://www.nasa.gov/
NCAR	National Center for Atmospheric Research http://www.ucar.edu/ncar/
ncBrowse	netCDF File Browser http://www.epic.noaa.gov/java/ncBrowse/
NCDC	National Climatic Data Center http://www.ncdc.noaa.gov/oa/ncdc.html
NCEP	National Centers for Environmental Prediction http://wwwt.ncep.noaa.gov/
NcML	The netCDF Markup Language http://www.unidata.ucar.edu/software/netcdf/ncml/
NDAP	National Digital Archives Project
netCDF	Network Common Data Form http://www.unidata.ucar.edu/software/netcdf/
NEXRAD	Next Generation Weather Radar http://www.ncdc.noaa.gov/oa/radar/radarresources.html
Nexrad Level II	Base or broadband data
NGDC	National Geophysical Data Center http://www.ngdc.noaa.gov/
NIDS	NEXRAD Information and Data System
NLR	National Lambda Rail http://www.nlr.net/
NMM	Nonhydrostatic Mesoscale Model
NMAP	An integrated display and product generation GUI environment
NNTP	Network News Transfer Protocol
NOAA	National Oceanic and Atmospheric Administration, U.S. Department of Commerce, replaced ESSA http://www.noaa.gov/
NOAAport	NOAA's broadcast data dissemination system http://205.156.54.206/noaaport/html/noaaport.shtml
NOGAPS	U.S. Navy Operational Global Atmospheric Prediction System
NOMADS	The NOAA Operational Model Arvhive and Distribution System http://data1.gfdl.noaa.gov/
NSDL	National Science Digital Library http://nsdl.org/render.userLayoutRootNode.uP
NSF	National Science Foundation http://www.nsf.gov/
NVODS	National Virtual Ocean Data System (formerly part of DODS)
NWS	National Weather Service, NOAA
OAI	Open Archives Initiative http://www.openarchives.org/
ODC	Open Data Consortium Project to Standardize Data Distribution http://www.geoall.net/docs/ODC_Descriptive_Article.pdf
OFCM	Office of the Federal Coordinator for Meteorology
OGC	Open GIS Consortium http://www.opengis.org/
OGSA	Open Grid Services Architecture http://www.globus.org/ogsa/
OMB	Office of Management and Budget
OPeNDAP	Open source Project for a Network Data Access Protocol (formerly DODS) http://www.opendap.org/
PACI	Partnership for Advanced Computational Infrastructure
PIRE	Partnerships for International Research and Education http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=12819

PMEL	Pacific Marine Environment Laboratory, NOAA http://www.pmel.noaa.gov/
Python	Programming language created by Guido van Rossum in 1990. http://www.python.org/
QC	quality control
RAMS	Regional Atmospheric Modeling System
RICO	Rain in Cumulus Over the Ocean
RSM	Regional Spectral Model
SAO	Surface Airways Observations
SCD	Scientific Computing Division, NCAR Division
SCOOP	SURA Coastal Ocean Observing and Prediction
SHEF	Standard Hydrologic Exchange Format http://weather.gov/oh/hrl/shef/indexshef.htm
SINOTS	Interoperability System for supporting the Italian Scientific Community working in Earth Observations from Space
SIS	Scientific Information System (sometimes used in contrast to GIS)
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol http://www.w3.org/TR/SOAP/
SSEC	Space Science and Engineering Center http://www.ssec.wisc.edu/
STEM	Science, Technology, Engineering, and Mathematics
SURA	Southeastern Universities Research Association http://www1.sura.org/0000/0000_Home.html
SWEET	Semantic Web for Earth and Environmental Terminology http://sweet.jpl.nasa.gov/ontology/
TACC	Texas Advanced Computing Center http://www.tacc.utexas.edu/
TAMDAR	Tropospheric Airborne Meteorological Data Reporting
TDS	Thredds Data Server http://motherlode.ucar.edu:8080/thredds/docs/
THORPEX	THe Observing system Research and Predictability EXperiment http://www.wmo.int/thorpex/about.html
THREDDS	Thematic Real-time Environmental Distributed Data Services http://www.unidata.ucar.edu/projects/THREDDS/
TIGGE	THORPEX Interactive Grand Global Ensemble
TIMSS	Trends in International Mathematics and Science Study http://nces.ed.gov/timss/
TMRP	Team Multidisciplinary Research Project
UAH	University of Alabama-Huntsville http://www.uah.edu/
UCAR	University Corporation for Atmospheric Research, a nonprofit corporation comprising a consortium of universities involved with atmospheric research, governing body for NCAR, incorporated in 1960 in Delaware then later moved corporate headquarters to Colorado
UCSB	University of California Santa Barbara http://www.ucsb.edu/
UDDI	Universal Description, Discovery and Integration of Web Services http://www.uddi.org/
UDUNITS	The Unidata units library supports conversion of unit specifications between formatted and binary forms, arithmetic manipulation of unit specifications, and conversion of values between compatible scales of measurement. http://www.unidata.ucar.edu/software/udunits/
UPC	Unidata Program Center http://www.unidata.ucar.edu/
UPS	Uninterruptible Power Supply

USGC	U.S. Global Change http://www.usgcrp.gov/
USGS	U.S. Geological Survey http://www.usgs.gov/
VGEE	Virtual Geophysical Exploration Environment http://dpc.ucar.edu/vgee/
VisAD	Visualization for Algorithm Development. VisAD is a Java component library for interactive and collaborative visualization and analysis of numerical data.
W3C	World Wide Web Consortium http://www.w3.org/
WCS	Web Coverage Service http://www.opengis.org/pressrm/pressrelease/20021218_WCS_RFC_PR.htm
WFS	Web Feature Service http://www.opengis.org/techno/specs/02-058.pdf
WMO	World Meteorological Organization, Geneva, Switzerland
WMS	Web Mapping Service http://www.opengis.org/techno/specs/00-028.pdf
Workstation ETA	A version of NCEP's mesoscale model designed to run on workstations
WRF	Weather Research and Forecasting Model
WSCI	Web Service Choreography Interface http://www.w3.org/TR/wsci/
WSDL	Web Services Description Language http://www.w3.org/TR/wsdl
WSR-88D	Weather Surveillance Radar 1988, Doppler, NWS, used in NEXRAD
WxWISE	Weather Wise http://itg1.meteor.wisc.edu/wxwise/
XML	Extensible Markup Language http://www.w3.org/XML/

APPENDIX B: SURVEY QUESTIONS AND RESPONSES

1. Demographics

1. If residing in the USA, please identify your state.	Response Percent	Response Total
Alabama	0.30%	1
Alaska	1.30%	4
Arizona	1%	3
Arkansas	0%	0
California	5.60%	17
Colorado	17.70%	54
Connecticut	0%	0
Delaware	0%	0
Florida	3.30%	10
Georgia	1.30%	4
Hawaii	1.30%	4
Idaho	0%	0
Illinois	4.30%	13
Indiana	1.60%	5
Iowa	1.30%	4
Kansas	0.70%	2
Kentucky	0.30%	1
Louisiana	1%	3
Maine	0.30%	1
Maryland	3%	9
Massachusetts	4.30%	13
Michigan	2.30%	7
Minnesota	1.60%	5
Mississippi	0%	0
Missouri	1.60%	5
Montana	0.30%	1
Nebraska	1%	3
Nevada	1%	3
New Hampshire	1%	3
New Jersey	2%	6
New Mexico	0.70%	2
New York	3.60%	11
North Carolina	4.60%	14
North Dakota	1.30%	4
Ohio	2%	6
Oklahoma	4.30%	13
Oregon	1.30%	4
Pennsylvania	3.90%	12
Rhode Island	0.30%	1
South Carolina	0.70%	2
South Dakota	0.30%	1
Tennessee	0.70%	2
Texas	5.60%	17
Utah	1.60%	5
Vermont	1.30%	4
Virginia	2%	6
Washington	2.30%	7
West Virginia	0%	0
Wisconsin	3.30%	10
Wyoming	1%	3

2. If residing outside the USA, please identify your country.	Response Percent	Response Total
Afghanistan, Islamic State of	0%	0
Albania	0%	0
Algeria	0%	0
American Samoa	0%	0
Andorra, Principality of	0%	0
Angola	0%	0
Anguilla	0%	0
Antarctica	0%	0
Antigua and Barbuda	0%	0
Argentina	2.30%	3
Armenia	0%	0
Aruba	0%	0
Australia	9%	12
Austria	0%	0
Azerbaidjan	0%	0
Bahamas	0%	0
Bahrain	0%	0
Bangladesh	0%	0
Barbados	0%	0
Belarus	0.80%	1
Belgium	0%	0
Belize	0%	0
Benin	0%	0
Bermuda	0%	0
Bhutan	0%	0
Bolivia	0%	0
Bosnia-Herzegovina	0%	0
Botswana	0%	0
Bouvet Island	0%	0
Brazil	7.50%	10
British Indian Ocean Territory	0%	0
Brunei Darussalam	0%	0
Bulgaria	0.80%	1
Burkina Faso	0%	0
Burundi	0%	0
Cambodia, Kingdom of	0%	0
Cameroon	0%	0
Canada	6.80%	9
Cape Verde	0%	0
Cayman Islands	0%	0
Central African Republic	0%	0
Chad	0%	0
Chile	0%	0
China	3%	4
Christmas Island	0%	0
Cocos (Keeling) Islands	0%	0
Colombia	0%	0
Comoros	0%	0
Congo	0%	0
Congo, The Democratic Republic of the	0%	0
Cook Islands	0%	0
Costa Rica	0.80%	1
Croatia	0%	0

Cuba	0%	0
Cyprus	0%	0
Czech Republic	0%	0
Denmark	0%	0
Djibouti	0%	0
Dominica	0%	0
Dominican Republic	0%	0
East Timor	0%	0
Ecuador	0%	0
Egypt	0%	0
El Salvador	0%	0
Elbonia	0%	0
Equatorial Guinea	0%	0
Eritrea	0%	0
Estonia	0%	0
Ethiopia	0%	0
Falkland Islands	0%	0
Faroe Islands	0%	0
Fiji	0%	0
Finland	0.80%	1
Former Czechoslovakia	0%	0
Former USSR	0%	0
France	3.80%	5
France (European Territory)	0%	0
French Guyana	0%	0
French Southern Territories	0%	0
Gabon	0%	0
Gambia	0%	0
Georgia	0%	0
Germany	6.80%	9
Ghana	0%	0
Gibraltar	0%	0
Great Britain	0%	0
Greece	0%	0
Greenland	0%	0
Grenada	0%	0
Guadeloupe (French)	0%	0
Guam (USA)	0%	0
Guatemala	0%	0
Guinea	0%	0
Guinea Bissau	0%	0
Guyana	0%	0
Haiti	0%	0
Heard and McDonald Islands	0%	0
Holy See (Vatican City State)	0%	0
Honduras	0%	0
Hong Kong	0.80%	1
Hungary	0%	0
Iceland	0%	0
India	4.50%	6
Indonesia	0%	0
Iran	0%	0
Iraq	0%	0
Ireland	0.80%	1
Israel	1.50%	2
Italy	4.50%	6
Jamaica	0%	0

Japan	0%	0
Jordan	0%	0
Kazakhstan	0%	0
Kenya	0%	0
Kiribati	0%	0
Kuwait	0%	0
Kyrgyz Republic (Kyrgyzstan)	0%	0
Laos	0%	0
Latvia	0%	0
Lebanon	0%	0
Lesotho	0%	0
Liberia	0%	0
Libya	0%	0
Liechtenstein	0%	0
Lithuania	0.80%	1
Luxembourg	0%	0
Macau	1.50%	2
Macedonia	0%	0
Madagascar	0%	0
Malawi	0%	0
Malaysia	0%	0
Maldives	0%	0
Mali	0%	0
Malta	0%	0
Marshall Islands	0%	0
Martinique (French)	0%	0
Mauritania	0%	0
Mauritius	0%	0
Mayotte	0%	0
Mexico	0%	0
Micronesia	0%	0
Moldavia	0%	0
Monaco	0%	0
Mongolia	0%	0
Montserrat	0%	0
Morocco	0%	0
Mozambique	0%	0
Myanmar	0%	0
Namibia	0%	0
Nauru	0%	0
Nepal	0%	0
Netherlands	3%	4
Netherlands Antilles	0%	0
New Caledonia (French)	0%	0
New Zealand	0%	0
Nicaragua	0%	0
Niger	0%	0
Nigeria	0%	0
Niue	0%	0
Norfolk Island	0%	0
North Korea	0%	0
Northern Mariana Islands	0%	0
Norway	6%	8
Oman	0%	0
Pakistan	0%	0
Palau	0%	0
Panama	0.80%	1

Papua New Guinea	0.80%	1
Paraguay	0%	0
Peru	0%	0
Philippines	0%	0
Pitcairn Island	0%	0
Poland	0%	0
Polynesia (French)	0%	0
Portugal	1.50%	2
Puerto Rico	0%	0
Qatar	0%	0
Reunion (French)	0%	0
Romania	0.80%	1
Russian Federation	1.50%	2
Rwanda	0%	0
S. Georgia & S. Sandwich Isls.	0%	0
Saint Helena	0%	0
Saint Kitts & Nevis Anguilla	0%	0
Saint Lucia	0%	0
Saint Pierre and Miquelon	0%	0
Saint Tome (Sao Tome) and Principe	0%	0
Saint Vincent & Grenadines	0%	0
Samoa	0%	0
San Marino	0%	0
Saudi Arabia	0%	0
Senegal	0%	0
Seychelles	0%	0
Sierra Leone	0%	0
Singapore	0.80%	1
Slovak Republic	0%	0
Slovenia	0%	0
Solomon Islands	0%	0
Somalia	0%	0
South Africa	0%	0
South Korea	0.80%	1
Spain	3.80%	5
Sri Lanka	0.80%	1
Sudan	0%	0
Suriname	0%	0
Svalbard and Jan Mayen Islands	0%	0
Swaziland	0%	0
Sweden	0.80%	1
Switzerland	1.50%	2
Syria	0%	0
Tadjikistan	0%	0
Taiwan	1.50%	2
Tanzania	0%	0
Thailand	0%	0
Togo	0%	0
Tokelau	0%	0
Tonga	0%	0
Trinidad and Tobago	0%	0
Tunisia	0%	0
Turkey	3.80%	5
Turkmenistan	0%	0
Turks and Caicos Islands	0%	0
Tuvalu	0%	0

USA Minor Outlying Islands	0%	0
Uganda	0%	0
Ukraine	0.80%	1
United Arab Emirates	0.80%	1
United Kingdom	7.50%	10
United States of America	6%	8
Uruguay	0%	0
Uzbekistan	0%	0
Vanuatu	0%	0
Venezuela	0%	0
Vietnam	0.80%	1
Virgin Islands (British)	0%	0
Virgin Islands (USA)	0%	0
Wallis and Futuna Islands	0%	0
Western Sahara	0%	0
Yemen	0%	0
Yugoslavia	0%	0
Zaire	0%	0
Zambia	0%	0
Zimbabwe	0%	0

3. I have been a member of the Unidata community since:	**Response Percent**	**Response Total**
2006	3.40%	14
2005	19.80%	82
2004	11.60%	48
2003	7.70%	32
2002	8.20%	34
2001	5.10%	21
2000	4.60%	19
1999	4.10%	17
1998	4.30%	18
1997	3.40%	14
1996	3.60%	15
1995	2.40%	10
1994	3.40%	14
1993	1.70%	7
1992	2.70%	11
1991	2.70%	11
1990	2.40%	10
1989	0.50%	2
1988	2.20%	9
1987	0.20%	1
1986	1.20%	5
1985	1.20%	5
1984	0.70%	3
1983	2.90%	12

4. Please identify your affiliation type. (check all that apply)	Response Percent	Response Total
Commercial Firm	10.70%	46
Community College	2.10%	9
Ph.D. Granting Institution	30.60%	131
Degree Granting Institution (BS and MS only)	13.80%	59
Government	26.20%	112
Military	0.70%	3
Research Laboratory	16.60%	71
University Corporation for Atmospheric Research (UCAR)	9.30%	40
Other (please specify)	11.20%	48

5. Please identify your profession. (check all that apply)	Response Percent	Response Total
Administrative Professional	2.80%	12
Consultant	7.70%	33
Faculty	14%	60
Graduate Student	12.10%	52
Instructor	5.40%	23
IT Professional	24.20%	104
K-12 Student	0.20%	1
Postdoc	2.60%	11
Project Manager	8.60%	37
Scientist/Researcher	40.80%	175
Senior Management	4%	17
Undergraduate Student	6.50%	28
Other (please specify)	11.40%	49

2. Impact on Culture

6. The Unidata Program's technology has transformed the research culture in our atmospheric or science related department.	Response Percent	Response Total
Strongly Agree	30.10%	116
Agree	47.40%	183
Disagree	7.30%	28
Strongly Disagree	0.50%	2
Not Applicable	14.80%	57

7. The Unidata Program's technology has transformed the teaching culture in our atmospheric or science related department.	Response Percent	Response Total
Strongly Agree	15.90%	61
Agree	33.90%	130
Disagree	8.90%	34
Strongly Disagree	0.80%	3
Not Applicable	40.60%	156

8. The Unidata Program has transformed the way our atmospheric or science related department conducts collaborations.	Response Percent	Response Total
Strongly Agree	21%	81
Agree	43.90%	169
Disagree	10.40%	40
Strongly Disagree	1.80%	7
Not Applicable	22.90%	88

9. The Unidata Program has transformed the way our atmospheric or science related department conducts community outreach activities.	Response Percent	Response Total
Strongly Agree	13.60%	52
Agree	36.90%	141
Disagree	10.70%	41
Strongly Disagree	1.30%	5
Not Applicable	37.40%	143

10. The Unidata Program has transformed the way faculty in our atmospheric or science related department publishes research papers.	Response Percent	Response Total
Strongly Agree	8.60%	33
Agree	**35.50%**	**136**
Disagree	18.30%	70
Strongly Disagree	2.10%	8
Not Applicable	35.50%	136

11. The Unidata Program has contributed to the increase of the overall number of participating students in our department.	Response Percent	Response Total
Strongly Agree	7.80%	30
Agree	21.70%	83
Disagree	18.30%	70
Strongly Disagree	1%	4
Not Applicable	51.20%	196

3. Impact on Institutional Cyberinfrastructure

12. The Unidata Program has transformed the way our department accesses data.	Response Percent	Response Total
Strongly Agree	50.90%	192
Agree	38.20%	144
Disagree	3.20%	12
Strongly Disagree	0.50%	2
Not Applicable	7.20%	27

13. The Unidata Program has transformed the way our department distributes data.	Response Percent	Response Total
Strongly Agree	42.20%	159
Agree	35.50%	134
Disagree	8%	30
Strongly Disagree	1.30%	5
Not Applicable	13%	49

14. The Unidata Program has transformed the way students participate in field projects.	Response Percent	Response Total
Strongly Agree	7.50%	28
Agree	24.90%	93
Disagree	13.40%	50
Strongly Disagree	1.90%	7
Not Applicable	52.30%	195

15. The Unidata Program has transformed the way faculty members or researchers participate in field projects.

	Response Percent	Response Total
Strongly Agree	8.60%	32
Agree	32%	119
Disagree	13.70%	51
Strongly Disagree	2.40%	9
Not Applicable	43.30%	161

4. Alignment with NSF Goals for Ideas

16. Participating in the Unidata community has increased my intellectual capital.

	Response Percent	Response Total
Strongly Agree	32.80%	119
Agree	57%	207
Disagree	4.40%	16
Strongly Disagree	1.10%	4
Not Applicable	4.70%	17

17. Participating in the Unidata community has increased my information technology knowledge.

	Response Percent	Response Total
Strongly Agree	41.40%	151
Agree	51.50%	188
Disagree	4.10%	15
Strongly Disagree	1.10%	4
Not Applicable	1.90%	7

18. Participating in the Unidata community has contributed toward my atmospheric science knowledge.

	Response Percent	Response Total
Strongly Agree	23.90%	87
Agree	47.30%	172
Disagree	14.60%	53
Strongly Disagree	1.10%	4
Not Applicable	13.20%	48

19. Participating in the Unidata community has contributed to my research capabilities.

	Response Percent	Response Total
Strongly Agree	34.30%	124
Agree	45%	163
Disagree	5%	18
Strongly Disagree	1.10%	4
Not Applicable	14.60%	53

20. I have noticed technological innovations within the Unidata Community since I started participating.

	Response Percent	Response Total
Strongly Agree	37.80%	137
Agree	48.10%	174
Disagree	7.50%	27
Strongly Disagree	0.80%	3
Not Applicable	5.80%	21

21. Participating in the Unidata community has helped me to engage in technological innovations.	Response Percent	Response Total
Strongly Agree	28%	101
Agree	51.20%	185
Disagree	9.70%	35
Strongly Disagree	1.40%	5
Not Applicable	9.70%	35

22. I have noticed that Unidata adapts to change in the community.	Response Percent	Response Total
Strongly Agree	23.70%	85
Agree	56.50%	203
Disagree	6.10%	22
Strongly Disagree	0.80%	3
Not Applicable	12.80%	46

23. Unidata has changed the way I conduct research.	Response Percent	Response Total
Strongly Agree	17.40%	63
Agree	41.60%	151
Disagree	15.70%	57
Strongly Disagree	1.70%	6
Not Applicable	23.70%	86

24. Unidata has changed the way I teach.	Response Percent	Response Total
Strongly Agree	9.90%	36
Agree	20.40%	74
Disagree	8%	29
Strongly Disagree	0.80%	3
Not Applicable	60.80%	220

5. Data Access and Usage

25. I have participated in Unidata's Internet Data Distribution (IDD).	Response Percent	Response Total
Yes	47.90%	172
No	52.10%	187

26. Was data access from Unidata's Internet Data Distribution timely?	Response Percent	Response Total
Yes	89.10%	213
No	10.90%	26

27. Was data access from Unidata's Internet Data Distribution reliable?	Response Percent	Response Total
Yes	89.90%	214
No	10.10%	24

28. I would recommend to other people data access through the Unidata Internet Data Distribution system.	Response Percent	Response Total
Yes	93%	225
No	7%	17

29. I have used "motherlode" or "adde.ucar.edu" to access data.		Response Percent	Response Total
	Yes	41.40%	123
	No	58.60%	174

30. I use these data for: (check all that apply)		Response Percent	Response Total
	Collaborations	37.90%	96
	Computer lab	36%	91
	Courses	39.90%	101
	Field projects	27.70%	70
	Outreach	22.10%	56
	Presentations	44.70%	113
	Publications	28.90%	73
	Research	68.80%	174
	Thesis/Dissertation	20.60%	52
	Web sites	39.10%	99
	Other (please specify)	11.10%	28

6. Support Inquiries

31. I have emailed support inquiries to Unidata.		Response Percent	Response Total
	Very frequently	3.60%	13
	Frequently	20.90%	75
	Rarely	35.50%	127
	Very rarely	18.70%	67
	Not Applicable	21.20%	76

32. Email responses were helpful in solving my problem.		Response Percent	Response Total
	Very frequently	33.80%	120
	Frequently	31.30%	111
	Rarely	4.20%	15
	Very rarely	1.70%	6
	Not Applicable	29%	103

33. Email responses to my inquiries were received in a timely manner.		Response Percent	Response Total
	Very frequently	33.80%	120
	Frequently	33.80%	120
	Rarely	3.10%	11
	Very rarely	0.80%	3
	Not Applicable	28.50%	101

7. Software Usage

34. I have downloaded the following software: (check all that apply)		Response Percent	Response Total
	GEMPAK	50.70%	172
	IDV	47.20%	160
	LDM	44.20%	150
	LDM-McIDAS Decoders	23.30%	79
	McIDAS	26.50%	90
	netCDF (netCDF, netCDF Perl, netCDF Java)	69.60%	236
	netCDF Decoders	41.30%	140
	NOAAPORT DVB-S ingester	5.90%	20
	THREDDS	11.50%	39
	UDUNITS	34.50%	117

35. I have downloaded software from Unidata.		Response Percent	Response Total
	Very frequently	10.10%	36
	Frequently	54.90%	196
	Rarely	23.80%	85
	Very rarely	7.30%	26
	Not Applicable	3.90%	14

36. I would recommend the Unidata software I have used to other people.		Response Percent	Response Total
	Strongly Agree	56.90%	203
	Agree	37%	132
	Disagree	2.20%	8
	Strongly Disagree	0.80%	3
	Not Applicable	3.10%	11

37. I use the software for: (check all that apply)		Response Percent	Response Total
	Collaborations	42.20%	145
	Computer lab	34.90%	120
	Courses	32.30%	111
	Field projects	30.50%	105
	Outreach	19.20%	66
	Presentations	40.70%	140
	Publications	32.60%	112
	Research	70.60%	243
	Thesis/Dissertation	20.60%	71
	Web sites	34.90%	120
	Other (please specify)	15.10%	52

8. Alignment with NSF Goals for Tools

38. Unidata has provided analysis and visualization software that enables scientific discovery.		Response Percent	Response Total
	Strongly Agree	36.10%	127
	Agree	52.80%	186
	Disagree	2%	7
	Strongly Disagree	0.30%	1
	Not Applicable	8.80%	31

39. Unidata has provided analysis and visualization software that enables academic learning.	Response Percent	Response Total
Strongly Agree	32%	112
Agree	42.60%	149
Disagree	0.90%	3
Strongly Disagree	0.30%	1
Not Applicable	24.30%	85

40. Unidata has provided analysis and visualization software that enables innovation among educators.	Response Percent	Response Total
Strongly Agree	24.50%	85
Agree	43.50%	151
Disagree	2%	7
Strongly Disagree	0.30%	1
Not Applicable	29.70%	103

41. Unidata has provided analysis and visualization software that enables innovation among researchers.	Response Percent	Response Total
Strongly Agree	30.80%	107
Agree	53.90%	187
Disagree	1.20%	4
Strongly Disagree	0.90%	3
Not Applicable	13.30%	46

9. Outreach

42. I read the Unidata Newsletter.	Response Percent	Response Total
Very frequently	8.30%	29
Frequently	24.40%	85
Rarely	30.20%	105
Very rarely	20.40%	71
Not Applicable	16.70%	58

43. I would recommend the Unidata Newsletter to other people.	Response Percent	Response Total
Strongly Agree	8.80%	30
Agree	41.30%	141
Disagree	8.50%	29
Strongly Disagree	0.30%	1
Not Applicable	41.10%	140

44. I use the Newsletter information for: (check all that apply)	Response Percent	Response Total
Collaborations	14.10%	25
Computer lab	11.30%	20
Courses	9.60%	17
Field projects	8.50%	15
Outreach	6.80%	12
Presentations	9%	16
Publications	8.50%	15
Updates on Unidata activities	74%	131
Web sites	6.80%	12
Other (please specify)	9.60%	17

45. I have attended the following workshops. (check all that apply)		Response Percent	Response Total
	Unidata Regional Workshops	18%	20
	Triennial Users (Summer) Workshops	29.70%	33
	Training Workshops	84.70%	94

46. I have attended at least one workshop over the past 5 years.		Response Percent	Response Total
	Strongly Agree	14.90%	50
	Agree	14.60%	49
	Disagree	12.80%	43
	Strongly Disagree	20.60%	69
	Not Applicable	37%	124

47. I would recommend the workshops to other people.		Response Percent	Response Total
	Strongly Agree	19.30%	63
	Agree	24.20%	79
	Disagree	1.50%	5
	Strongly Disagree	0%	0
	Not Applicable	55%	180

48. I use the workshop information for: (check all that apply)		Response Percent	Response Total
	Collaborations	27.50%	36
	Computer lab	40.50%	53
	Courses	39.70%	52
	Field projects	17.60%	23
	Outreach	19.80%	26
	Presentations	32.10%	42
	Publications	18.30%	24
	Research	51.90%	68
	Thesis/Dissertation	9.20%	12
	Web sites	27.50%	36
	Other (please specify)	17.60%	23

10. Alignment with NSF Goals for People

49. Unidata has facilitated a more inclusive workforce.		Response Percent	Response Total
	Strongly Agree	16.80%	50
	Agree	72.70%	216
	Disagree	8.40%	25
	Strongly Disagree	2%	6

50. Unidata has facilitated a more knowledgeable workforce.		Response Percent	Response Total
	Strongly Agree	27.40%	84
	Agree	68.40%	210
	Disagree	2.90%	9
	Strongly Disagree	1.30%	4

51. Unidata has facilitated a more globally engaged workforce.		Response Percent	Response Total
	Strongly Agree	22.80%	70
	Agree	67.10%	206
	Disagree	7.80%	24
	Strongly Disagree	2.30%	7

52. Unidata has helped in preparing students to be highly qualified members of the scientific workforce.		Response Percent	Response Total
	Strongly Agree	27.20%	80
	Agree	66%	194
	Disagree	4.80%	14
	Strongly Disagree	2%	6

11. Unidata's Core Values and Consistency

53. Unidata has practiced a community-based governance.		Response Percent	Response Total
	Strongly Agree	27.30%	81
	Agree	67%	199
	Disagree	4.70%	14
	Strongly Disagree	1%	3

54. Unidata has provided for data access, analysis and visualization using small inexpensive computers.		Response Percent	Response Total
	Strongly Agree	48%	157
	Agree	46.80%	153
	Disagree	4.90%	16
	Strongly Disagree	0.30%	1

55. Unidata has provided state-of-the-art, well documented and supported software tools.		Response Percent	Response Total
	Strongly Agree	44.80%	151
	Agree	47.80%	161
	Disagree	5%	17
	Strongly Disagree	2.40%	8

56. Unidata has provided free and open sharing of data.		Response Percent	Response Total
	Strongly Agree	58%	195
	Agree	39.30%	132
	Disagree	1.80%	6
	Strongly Disagree	0.90%	3

57. Unidata has provided free and open sharing of software.		Response Percent	Response Total
	Strongly Agree	63.30%	214
	Agree	34%	115
	Disagree	2.40%	8
	Strongly Disagree	0.30%	1

APPENDIX C: ALIGNMENT TABLE

Instructions for completing the Alignment Table

1. Participants are encouraged to respond based on (a) length of participation in the program, (b) experience with the program, and (c) level of involvement with the program. For example, a participant whose main focus is support services to the community may not have much to contribute towards contributions to cyber-infrastructure.

2. Issues to think about when responding to the questions include but are not limited to:

    - Discuss the diversity found in the community (disciplinary, institutional, geographic) – PEOPLE
    - Discuss support services to society/community – IDEAS
    - Discuss contributions to cyber-infrastructure – TOOLS
    - Discuss innovative responses to community needs – UPC EXCELLENCE

Alignment Table

NATIONAL SCIENCE FOUNDATION GOALS	FROM 1983 - 2006
	PLEASE TYPE YOUR RESPONSES IN THIS COLUMN. USE ADDITIONAL PAPER IF NECESSARY
PEOPLE • How has the Unidata Program facilitated a more (a) inclusive, (b) knowledgeable, and (c) globally engaged workforce that reflects the nation's diverse population? PLEASE USE SPECIFIC EXAMPLES.	
IDEAS • How has Unidata Program facilitated building intellectual capital and fundamental knowledge in the field of engineering or science? PLEASE USE SPECIFIC EXAMPLES.	
TOOLS • How has the Unidata Program facilitated investing in multi-user facilities, distributed networks, digital libraries and computational infrastructure that add unique value to research and are widely shared among researchers across the nation? PLEASE USE SPECIFIC EXAMPLES.	
UPC EXCELLENCE • How has the Unidata program adapted to change in the community while fulfilling its core values? PLEASE USE SPECIFIC EXAMPLES.	

Additional Questions

1. How has Unidata best served you?

2. What suggestions for improvement would you like to give to Unidata?

