UNIDATA COMMUNITY EQUIPMENT AWARD PROPOSAL

# Enhancing the Use of IDV and GEMPAK in Undergraduate Research and Education at Central Michigan University

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**Requested Amount:** **$14,668.40**

# Enhancing the Use of IDV and GEMPAK in Undergraduate Research and Education at Central Michigan University

Martin Baxter, Department of Geography, Central Michigan University

## 1 Project summary

The Geography Department at Central Michigan University began offering a Bachelor of Science in Meteorology in the fall of 2006. The department is currently applying for membership in the UCAR Academic Affiliate Program in order to more formally participate in, and contribute to, the UCAR community's scientific and educational activities. As the only B.S. degree in meteorology available in the state of Michigan, university administrators at all levels are in strong support of the meteorology program. The department now has four Ph.D. meteorologists, one tenured, two tenure-track, and one temporary. The department also employs a dedicated full-time system administrator. The meteorology curriculum at CMU is detailed in Appendix A.

The department's server is currently ingesting several Unidata products using Dell hardware, and these data are available to all faculty and students. The real-time data server and storage were acquired with a previous Unidata equipment grant. The meteorology teaching lab contains ten Linux PCs currently using NFS and ADDE to access the ingested data. Software running on these machines includes GEMPAK, McIDAS, and IDV. The dean of the College of Science and Technology has agreed to upgrade these ten machines during the summer of 2007 using college funds. The meteorology teaching lab currently contains workstations separate from classroom tables. In contrast to this configuration, the new workstations will be placed on classroom tables, allowing faculty to more effectively integrate Unidata software into our lectures. This hardware upgrade will provide the current meteorology teaching lab with an even greater teaching focus.

This proposal is for an additional five workstations and data storage. Currently students can only access Unidata software and data from within the meteorology teaching lab, which is regularly occupied with classroom activities. Students working on course assignments and research must plan their work around the extensively used meteorology teaching lab. As the number of incoming meteorology majors continues to grow every year, the lack of sufficient hardware resources will be an increasing problem. The addition of five machines will provide for a new meteorology case-study and research lab, to be housed in a room adjacent to the meteorology teaching lab.

With new hardware in both the teaching and case-study/research meteorology labs, the department will be able to more effectively utilize the full capabilities of the IDV. Currently, case studies within courses such as Synoptic Meteorology and Mesoscale Meteorology are conducted using either GARP or web-based resources. If the proposal is

funded, the faculty will transition existing case studies within GARP to the IDV. These case studies will then be shared with the Unidata community.

# 2 Project description

## 2.1 Equipment requested

The five workstations requested in this proposal have the following configuration:

- Dell PCs with Windows Vista Business
- Fedora Core 6 will be installed
- Intel Core 2 Duo Processor, 2.4 GHz
- 4 GB DDR2 SDRAM
- 20" Widescreen Flat Panel Monitor
- 256 MB NVIDIA graphics card
- 250 GB SATA hard drive
- 3 year limited warranty and on-site service

Due to the complexity of the three-dimensional visualizations performed using software such as the IDV or Vis-5D, a fast processor, a significant amount of memory, and an NVIDIA graphics card are included. The choice of NVIDIA is made exclusively for the best Linux compatibility. In addition, two of the following disk storage units are requested:

- LaCie Gigabit Ethernet RAID disk storage, 2 TB

## 2.2 How the equipment will help meet the overall goals of the project

The requested hardware will allow students to more effectively use the IDV and GEMPAK in both their coursework and in undergraduate research projects. During the spring of 2007, the current meteorology teaching lab is occupied for 19 hours per week with coursework. In many cases, the teaching lab may only be unoccupied for a one hour break between classes, an insufficient amount of time to complete work. This greatly reduces the amount of time students have to use Unidata software to complete coursework and research. With continued growth in the number of meteorology students expected in future years, multiple sections of core courses may need to be taught, further compounding the problem. The table below details the number of degrees awarded in meteorology over the past five years.

| 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|
| 5 | 4 | 7 | 6 | 9 |

The number of students graduating is expected to increase in the next 3-5 years since 22 new majors have been signed thus far in the 2006-2007 school year. More information on the meteorology program and curriculum can be found in Appendix A.

Courses which will benefit from this hardware upgrade include but are not limited to: Synoptic Meteorology, Mesoscale Meteorology, Meteorological Radar and Satellites, Numerical Weather Prediction, and Dynamic Meteorology. In the spring of 2008, I will begin teaching a special topics course entitled "Computer Applications in Meteorology". This course will provide instruction on using Unidata software, so that students entering the aforementioned courses and conducting research projects will be able to "jump in" to using the applications productively. It is anticipated that this course will typically be taken by second semester freshmen as it becomes an established part of the program. A strong focus of the course will be on the IDV, as the faculty intend for the IDV to be the primary tool used in laboratory exercises, lecture demonstrations, and analysis of real-time data.

As the program grows, the number of students collaborating with faculty on research projects will continue to increase. Students will require additional disk space and workstations dedicated to research that will allow the students to conduct research. The faculty thinks it is important for the students to have their own storage and workstations separate from faculty resources, as this will enhance the *independent* nature of the student research. The storage requested would also allow for space separate from real-time storage for case-studies and other student research projects.

There are many programs at Central Michigan University designed to support undergraduate research: the Honors Program, the Student Research and Creative Endeavors Exhibition, and the Posters at the Capitol event in Lansing are some examples. Evidence of undergraduate research at CMU since the year 2000 is documented in Appendix B. The meteorological faculty has begun to support undergraduate students via externally funded projects, as evidenced by my recently approved Partners grant through the COMET Program. The new workstations would allow for faculty and students to work together to investigate how the IDV can best be used in a research environment – with an increasing focus on the creation of three-dimensional visualizations. The faculty also intends to migrate to the IDV for research projects due to its versatility in reading and displaying many different formats of data. For instance, the IDV's ability to accept GIS data along with meteorological data might prove useful, as our department features a B.S. and M.S. degrees in GIS. Many meteorology majors are GIS minors, and the IDV would allow them to combine their skill sets. There currently exists no other software package in the department that would allow them to do this.

## 2.3 How the equipment will impact the Unidata community

I have considerable expertise in the creation and presentation of case studies that allow students to use real data to investigate relevant physical processes. These case studies illustrate material first presented in lecture format, asking students questions that lead them into their own insights on the relationships between the physical processes and sensible weather. The IDV would allow us to migrate away from case studies that feature paper instructions by using the IDV's capability to interface with HTML code. I have created case studies not only for students at Saint Louis University and Central Michigan University, but also for use by U.S. and Canadian meteorologists in COMET residence

courses. To date, these case studies are presented via GARP and the National Weather Service's Weather Event Simulator. With the new hardware, myself and other meteorology faculty can work together to create case studies and bundles for the Unidata community. At present, few case studies and bundles exist within the community that are designed to exploit the IDV's unique capabilities.

The faculty will also provide feedback to the developers of IDV throughout our experience in developing case studies and bundles, helping to enhance future releases of the IDV in ways that will assist users with needs similar to us. The IDV remains in a state of continuous development, and may not be suited to replace other Unidata software packages; therefore some laboratory tasks might still be best accomplished using GEMPAK, GARP, and other programs in the N-AWIPS suite. This is why the title of the proposal does not focus solely on the IDV. If this proposal is funded, Unidata will receive valuable feedback from an undergraduate-only institution relating to the IDV. We can provide usability surveys to our students, gathering feedback not only on positives and negatives relative to how students use the IDV, but also feedback as to how to best teach students how to use the IDV. The latter would be accomplished through the aforementioned "Computer Applications in Meteorology" course.

## 2.4 Relationship of proposed hardware to departmental hardware

The addition of the new hardware would allow us to house both meteorology teaching and case-study/research laboratories in adjacent rooms. If this proposal is accepted, the additional workstations will increase the amount of machines available for general meteorology student use by 50%. Beginning summer 2007, the teaching lab will feature ten 2.4 GHz processor PCs, each with 2 GB of memory, with funding for these new workstations provided by the College of Science and Technology. All of these machines are dual boot (Windows XP and Fedora Core 5). Ingest and storage of real-time data is accomplished using a Dell PowerEdge with a 3.2 GHz processor and 528 GB of storage. Our department maintains two additional labs featuring Pentium 4 machines running Windows 2000, used mostly for running GIS software, a major component of the geography program. The meteorology program and its computational resources are largely separate from the resources of other programs in the department.

The meteorology program also houses two clusters. One system has 14 Xeon processors on 7 motherboards, with each motherboard containing 2 GB of memory. The other system has 20 Opteron processors on 10 motherboards, with each motherboard containing 4 GB of memory. It is anticipated that students will have increasing access to these clusters for running numerical simulations as part of coursework and undergraduate research. The hardware requested will allow for increased storage of model data, and faster processing power to convert model output to GEMPAK format or NetCDF format for use with the IDV.

## 2.5 Feasibility of attaining our goals

Our full-time dedicated system administrator, Mel Taylor, will set up all hardware and install all Unidata programs, overseen by the PI. I am familiar with the IDV through the online tutorial and have used the IDV to examine isentropic surfaces as a supplement to lecture material in Synoptic Meteorology. Dr. Orf has used the IDV to create labs on understanding and interpreting water vapor imagery and analyzing level II radar data for the Meteorological Radar and Satellites course. Drs. Orf and Mower have attended Unidata workshops in prior years, receiving training on a variety of Unidata applications. The meteorology faculty has used Unidata software extensively in the past. With GARP no longer supported, the faculty recognizes the need to transition to the IDV, and is ready and willing to learn this new tool and contribute our efforts to the Unidata community.

Dr. Orf has considerable experience in three-dimensional visualization through his research and the use of numerical models in the classroom through his participation in a recent Unidata workshop. This experience makes him particularly suited for most effectively increasing our use of the IDV in undergraduate education and research. Through discussions amongst the faculty, the following case study topics that might best utilize the IDV's capabilities emerged:

- the Eady index and explosive cyclogenesis
- potential vorticity thinking
- isentropic analysis
- three-dimensional reflectivity structure of convective phenomena

# 3 Budget

This proposal is for hardware only. Our system administrator will install and configure the hardware. All quotes come from Dell and LaCie. The Dell quote includes an educational discount. Cost sharing is not a part of this proposal; however, the College of Science and Technology is supporting the infrastructure of the meteorology program through upgrading the ten PCs in the meteorology teaching lab. In addition, the department will provide funding for the provision of network connections for all five workstations.

| | |
|---|---|
| 5 workstations with previously specified configuration | $2290.68 x 5 = $11453.40 |
| 2 TB of disk storage | $1369.99 x 2 = $2739.98 |
| Shipping | $475 |
| **Total cost** | **$14,668.40** |

# 4 Project milestones

Hardware will be purchased immediately following the receipt of funding. The department has allocated existing space to the program and acquired desks for the requested workstations. Disk storage will be housed in existing space in the server room.

The installation of the hardware and Unidata software will occur shortly after the hardware is delivered. Beginning in the fall of 2007, students will be instructed that the IDV is the best tool available for examining real-time data. In courses that make use of the IDV, students will be provided with a brief introduction to the IDV. The Computer Applications in Meteorology course will be taught in the spring of 2008, and will provide students with more formal and extended training on the use of the IDV. In Synoptic Meteorology I and II, transition of existing case studies from GARP format to the IDV format will take place over the 2007-2008 school year. Any new case studies will be developed using the IDV.

# APPENDIX A

## The Meteorology Program and Curriculum at Central Michigan University

The program meets both National Weather Service and American Meteorological Society guidelines, preparing students for graduate school or careers in the National Weather Service, private industry, or public broadcasting.

*Required Courses (30 hours):*

MET 240 – Meteorology (3)
MET 310 – Atmospheric Radiation and Thermodynamics (3)
MET 312 – Meteorological Radar and Satellites (3)
MET 320 – Cloud Physics (3)
MET 330 – Dynamic Meteorology I (3)
MET 335 – Dynamic Meteorology II (3)
MET 340 – Synoptic Meteorology I (3)
MET 345 – Synoptic Meteorology II (3)
MET 450 – Mesoscale Meteorology (3)
MET 480 – Numerical Weather Prediction (3)

*Additional Requirements I (31 hours):*

MTH 132 – Calculus I (4)
MTH 133 – Calculus II (4)
MTH 223 – Linear Algebra and Matrix Theory (3)
MTH 233 – Calculus III (4)
MTH 334 – Differential Equations (3)
PHY 145 – University Physics I (4)
PHY 146 – University Physics II (4)
PHY 175 – University Physics Laboratory I (1)
PHY 176 – University Physics Laboratory II (1)
STA 382 – Elementary Statistical Analysis (3)

*Additional Requirements II (2-3 hours):*

Select one of the following:
CPS 150 – FORTRAN Programming (2)
CPS 180 – Principles of Computer Programming (3)

*Additional Requirements III (5-8 hours):*

Select one of the following options:
<u>Option A</u>
CHM 120 – Survey of Chemistry (4)
CHM 127 – Introductory Chemistry Laboratory
<u>Option B</u>
CHM 131 – Introduction to Chemistry I (4)
CHM 132 – Introduction to Chemistry II (4)

*Total: 68-72 semester hours*

# APPENDIX B

## Examples of Student Research Projects Since 2000 Resulting in Professional Presentations:

- Blough, C., 2000: Using GIS to Assess the Influence of Topography on Lake Effect Snow in Northern Michigan. *CR Tech Attachment 2000-02.*

- Shadbolt, R., 2001: Teleconnections During the El Nino. *Posters at the Capitol, Lansing, MI.*

- Gilbert, C., 2002: The Effects of Initial Conditions in the Source Region on Lake Effect Snowfall in NW Lower Michigan. *Posters at the Capitol, Lansing, MI.*

- Widajewski, S., 2003: Positive Cloud-to-Ground Lightning in Severe Thunderstorms During the July 2, 1997 Tornado Outbreak. *Midwest Extreme and Hazardous Weather Regional Conference, Champaign, IL.*

- Griesinger, M., 2004: The Effect of Lake Michigan on Passing Summertime Convection. *Posters at the Capitol, Lansing, MI.*

- Parker, A., 2005: A Closer Look at the Influence of El Nino on Central Michigan Climate. *14th Annual US/Canada Great Lakes Operational Meteorology Workshop, Grand Rapids, MI.*

- Benny, M., 2006: The Effects of Varying Microphysical Parameterizations on the Formation of Hail in Simulated Supercell Thunderstorms. *Posters at the Capitol, Lansing, MI.*

- Green, J., 2006: Estimation of Lake Effect Snowfall Using Radar Reflectivity Data. *Posters at the Capitol, Lansing, MI.*

- Strey, S., 2007: The Effect of Tropical Cylones on Michigan's Climate. *Great Lakes Meteorology Conference, Valparaiso, IN.*