A. Cover Sheet

Upgrading SFSU's Weather Graphics and Simulation Laboratory

A Unidata Equipment Grant Proposal
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B. Project Summary

In Fall 2002, with the help of an NSF-CCLI grant, the Department of Geosciences redesigned and remodeled an existing classroom to support not only traditional lecture for up to 50 students but also small-group collaboration and computer lab applications for up to 36 students. This was achieved by replacing and reorganizing furniture and by equipping the room with 18 networked 800MHz Mac G4 Titanium laptops.

The redesigned, multiuse classroom was an immediately hit with Department faculty and lecturers, and in the last five years (ten semesters) the room has hosted 95 classes enrolling 1,900 students, most of whom used the laptops at least occasionally and some almost constantly. The laptops have deteriorated with age and the intensive use, and they are now at least eight times slower than current models and have become balky and harder to maintain. In particular, they are a little too slow and unreliable to run Unidata's IDV software effectively. We began a transition in Fall 2005 away from WXP and toward the IDV in our meteorology classes, but that transition has been hampered by the state of the computers in our primary teaching classroom, and the condition of the computers is gradually worsening.

With the help of a Unidata Equipment Grant to supplement Department of Geosciences funding that exceeds the grant request, we propose to replace the eighteen Mac G4 laptops in the multiuse classroom, plus two more laptops in an adjacent computer lab, with twenty 2.16GHz Mac Book Pro laptops. These laptops would run the same diverse set of software applications that instructors currently use in a variety of courses to support their teaching, plus software beyond the practical capabilities of our existing machines, such as Unidata's IDV and the EdGCM climate model.

We would similarly upgrade a Mac G4 Xserve file server that currently serves all three of the Department's computer labs, to a Mac Xserve with two 2.0GHz dual-core Xeon processors.

C. Project Description

Institutional Background. San Francisco State University (SFSU) is one of 23 campuses of the California State University system. It is a masters-degree granting institution that enrolls over 28,000 ethnically and racially diverse full-time and part-time students.

The tenured and tenure-track faculty of the Department of Geosciences at SFSU currently comprises seven geologists, three meteorologists (John Monteverdi, Oswaldo Garcia, and Dave Dempsey), and two oceanographers. The Department offers a M.S. in Applied Geosciences, a B.S. in Geology, a B.A. in Earth Sciences, and a B.S. in Atmospheric and Oceanographic Sciences. (Effective Fall 2007, the B.S. in Atmospheric and Oceanographic Sciences[1] has been revised to conform to the 2005 American Meteorological Society’s guidelines for the bachelor’s degree in atmospheric science.)

Although these degree programs are quite active, they are not large—the graduate program graduates about five students per year, the Geology and Earth Science programs graduate half a dozen to a dozen students each year, and the Atmospheric and Oceanic

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[1] For details, see http://tornado.sfsu.edu/Geosciences/Geosciences_Docs/UndergradPrograms/MeteorologyPrograms.htm

Sciences program graduates 4-10 students every other year. On the other hand, approximately 2,700 students enroll annually in the Department's general education courses in geology, oceanography, and meteorology.

Departmental Computing Facilities: What We Have, How We Use Them, and How We Maintain Them. In Spring 1995, using a grant from the National Science Foundation's Instruments and Laboratory Improvement (NSF-ILI) program, we bought six Solaris SPARC workstations; installed them in a small, remodeled lab space; dubbed it (for grant writing purposes) the Weather Graphics and Simulation Laboratory (WGSL); and stepped tentatively into the modern era of meteorological education. We attended Unidata workshops, joined Unidata's Internet Data Distribution (IDD) system, ran the Local Data Manager (LDM) software to acquire and manage weather data in real time, and installed and began to use WXP weather graphics software (which Unidata supported at that time) in our meteorology classes. Dr. Dempsey received release time from SFSU equivalent to one 3-unit lecture course each semester to administer the WGSL and to develop curricular applications for WXP. These applications took the form of UNIX shell scripts, which eventually grew to 200+ in number with 60,000+ lines of code.

In Fall 1995 Dr. Dempsey created the California Regional Weather Server (CRWS) (http://virga.sfsu.edu), which provides to the public a variety of weather maps and images generated in near real time by the scripts developed originally for classroom use. The CRWS attracts an average of around 120,000 meaningful "hits" from about 20,000 distinct computers each week. Originally the tasks of ingesting data from the internet (using LDM software), decoding data, generating weather maps and images, and serving the resulting products to the public on the WWWeb, required half a dozen carefully orchestrated computers. Since January 2006, a single Mac G5 dual-core PowerPC has assumed all of those tasks.

In Fall 2002, a grant from the NSF's Course, Curriculum, and Laboratory Improvement (NSF-CCLI) program transformed the WGSL. We acquired the grant to create a new, integrated geosciences course that would help pre-service K-8 teachers to meet state subject-matter standards in the geosciences. The course, called "Investigating Land, Sea, and Air Interactions"[2], employs a problem-based learning (PBL) pedagogical approach, in which students work on real-world problems in small, collaborative groups. In our implementation of PBL, students rely heavily on networked computers installed in the classroom to complete small-group instructional exercises (which replace most lectures) and to research real-world problems that we pose to them. In fact, although the purpose of the grant was primarily pedagogical, most of the money went to buy nineteen Mac G4 (800 MHz) Titanium laptop computers, a Mac G4 Xserve file server, and a laser printer.

To accommodate both the networked computers and the pedagogical requirements of the course, we redesigned and remodeled an existing classroom into a multipurpose space that could support traditional lectures, small-group collaborations, and a computer lab (see Figures 1-3 below). Viewed from the front, the room is wider than it is deep, which on the average places students closer to the instructor and thereby creates a greater sense of intimacy and engagement. The room is furnished with three

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[2] See the home page for "Investigating Land, Sea, and Air Interactions" at http://funnel.sfsu.edu/courses/gm309.

long tables oriented perpendicular to the front of the room, and each table seats 12 students (for a total of 36). Students sit in upholstered, swiveling chairs on rollers, six chairs on each side of each table. In this configuration students naturally face each other, but they can swivel to face the front of the room, or roll their chairs into any configuration and swivel them into any orientation they need to consult with each other in small groups or see various parts of the room. (Additional chairs around the edges of the room expand the capacity to 50 students for some purposes.)

Residing discreetly on each table are six Mac G4 Titanium laptops (for a total of 18), each secured to the table by a flexible steel cable and connected to the internet by ethernet cables. Students slide and rotate the laptops to position and orient them as needed (for example, to share the display with nearby students). The nineteenth laptop sits on a portable cart at the front of the room, connected to an LCD projector for use by the instructor. The Mac Xserve file server is hidden in a nearby room. Although each laptop has its own IP address and name, they are otherwise clones of each other. Each is configured with a generic "student" account and is logged onto that account at all times. Each laptop NFS automounts a shared filesystem on the file server, which allows students easily to acquire files placed there by the instructor, to share files, and to access their own files from any other computer at a later time. Moreover, the computer in every Department faculty member's office also NFS automounts the shared filesystem, enabling further file sharing among faculty and students.

The room containing the original WGSL abuts the redesigned classroom and is accessible through a shared door (see Figure 1 below). Through gradual attrition and replacement of computers (funded one at a time by Departmental and miscellaneous grant funds), the original WGSL now contains eleven Windows PCs (seven laptops and four desktops) plus two Mac G4 Titanium laptops, all of which mount the shared file system on the Xserve (in the case of the Windows PCs, using Samba). The original WGSL continues to function primarily as an open-access computer lab for students taking Department of Geosciences courses, though it occasionally hosts small classes when the redesigned classroom is oversubscribed.

(The Department maintains a third computer lab on anther floor, comprising seven Apple iMac G4 and G5 desktop computers and seven Windows PC desktops. Dr. Dempsey and his intermittent student assistant help maintain those machines, which are used mostly by students in the Geology program. Although the machines in this lab also NSF automount or Samba mount the shared file system on the Xserve file server, we don't consider those machines part of the WGSL because they are not configured to access weather data or run weather graphics software such as the WXP or the IDV.)

Figure 1. Students collaborating in small groups, the primary pedagogical strategy employed in Dr. Dempsey's "Investigating Land, Sea, and Air Interactions", a class designed for pre-service K-8 teachers. Students have arranged themselves and the laptop computers to facilitate their work. The original WGSL (currently equipped with eleven Windows PCs and two Mac G4 laptops) is accessible through the (open) door visible at the back of the photo.

Figure 2. A group of students in "Investigating Land, Sea, and Air Interactions" working on their final exam, which is partly collaborative. They have arranged four computers, normally positioned in pairs on opposite sides of the table, to facilitate their collaboration. Security cables, power cords, and ethernet cables pass from the computers through holes in the table top. A power strip and ethernet hub are attached to the underside of the table, out of sight and out of harms way.

Figure 3. Dr. John Monteverdi using the redesigned classroom in lecture mode in "The Violent Atmosphere and Ocean", a general education course. Students follow John's presentation on the laptops, and are often asked to access weather maps, images, and information on the Web to respond questions that John poses, or to run animations that he's made available on the Web, etc.

Because of the unobtrusive availability of the laptop computers in a relatively attractive and comfortable teaching and learning environment, this classroom, which we refer to informally as the "MacLab" and regard as an expansion of the original, humble WGSL next door, immediately became the most popular teaching venue among the Department's faculty. In the five years (ten semesters) since we redesigned and equipped it, the classroom has hosted 95 geology, meteorology, and oceanography classes enrolling over 1,900 students, as well as several summer workshops and institutes and a number of departmental seminars. When they can, students also prefer to gather in the classroom between classes and work with the computers, even when the computers in the original WGSL next door are available.

Most of the instructors who teach in the redesigned classroom make at least some pedagogical use of the computers—mostly to ask students to access information or display animations on the WWWeb during class—which they would not do otherwise. Some instructors make the computers a primary pedagogical tool, using (for example) the WWWeb, WXP (weather graphics software), the Integrated Data Viewer (IDV), Excel, Adobe Illustrator, WorldWatcher (climate data analysis and display software), STELLA (dynamic modeling software), Jump (a statistics package), GoLive (Adobe HTML editor), Microsoft Word, Google Earth, etc. In several cases, use of the computers is the actual subject of the course (Fortran 90 programming, MATLAB, UNIX, HTML). Because more faculty members and lecturers have begun experimenting with ways to use the computers to improve their teaching, pedagogical discussions and sharing of ideas have increased noticeably, an unintended bonus of the classroom redesign.

To administer and maintain (and clean) the expanded WGSL, Dr. Dempsey has continued to receive the same release time each semester as he began receiving 12 years ago, when the WGSL was first established. Apple's Remote Desktop software makes updating software (and some other aspects of computer maintenance) possible to accomplish in bulk, which helps. Also, since the lab expansion, the Department has intermittently hired a student assistant up to ten hours per week to help with WGSL maintenance, mostly on the more repetitive tasks or on the Windows PCs (which tend otherwise to be victims of triage because they lie outside Dr. Dempsey's primary expertise, which is with UNIX, including Mac OS X).

The redesigned classroom with its laptop computers has become an essential part of the Department's teaching program. This is particularly true of the Atmospheric and Oceanic Sciences program—all eighteen of its majors courses meet in the redesigned classroom and depend on the computers in some way, as do most of the general education courses in meteorology. Together, these courses have accounted for two thirds of the students and classes that have used the classroom in its five years of existence. In fact, several of us—all meteorologists—have come to believe that they are incapable of teaching any course without access to networked computers in the classroom!

Transition to the IDV: Bumps in the Road. As described by Dr. Dempsey in the April 2006 *Unidata CommuniteE-Letter*[3], in 2005 we decided to transition away from using WXP in the classroom to Unidata's IDV instead. Motivating this decision was our perception at the time that a long-awaited convergence between the development of the IDV and our ability to use it had at last occurred.

On the technical side, Apple's implementation of Java had at last become compatible with the IDV; Unidata's programmers had gradually been (and still are) making the IDV more efficient; and we had upgraded the memory on our Mac G4 (800 MHz) laptops from 512MB to 1GB. The IDV finally appeared to be within the reach of our upgraded laptops for practical use in the classroom.

On the user side, Dr. Dempsey attended a Unidata IDV workshop in summer 2005 and learned enough about the IDV to begin learning more on his own, to submit coherent questions to Unidata's support staff and to the IDV user community, and to introduce his colleagues to the basics of the IDV. We were particularly excited by the potential for students to install and use the IDV on their computers at home, to access data and IDV "bundles" stored both locally and elsewhere on the internet, and to display (and animate and rotate) three-dimensional iso-surface plots, and a GUI, to cite several capabilities that WXP lacks.

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[3] Dempsey, D., April 2006, "Adopting IDV in the Classroom", *Unidata CommuniteE-Letter* (http://www.unidata.ucar.edu/newsletter/2006apr/06aprel.html).

In Fall 2005, for the first time, Dr. Dempsey taught students in his required, 2-unit majors' course, "Use of Computers in Meteorology", how to use the IDV instead of WXP. Dr. Dempsey was disconcerted to observe that his students seemed to get the hang of the IDV at least as fast as he did! Students completed several extensive assignments in which they learned to create plots ranging from the common color-filled contour plots of sea-level pressure with contours of 500-1000 mb thickness and surface wind vectors superimposed, to the rarer color-filled contour plot of 1000 mb temperature advection.[4]

However, Dr. Dempsey and his students soon discovered several bugs in the IDV specific to Macs and several shortcomings of our Mac G4 laptops. These bumps in the road have slowed our transition to the IDV, though Don Murray and Jeff McWhirter, Unidata's chief IDV developers, responded quickly to fix each bug, carefully recorded our suggestions for new features and GUI modifications, and even implemented some of them. We appreciated their half-day site visit to SFSU during the December 2005 AGU meeting in San Francisco, which boosted our IDV competence significantly and inspired further confidence that Unidata will be developing and supporting the IDV for the indefinite future.

In spite of Unidata's generous and dedicated help, though, we were still left with machines that ran the IDV more slowly for many purposes than we and our students would have liked—slowly enough to try our patience and detract from the IDV's potential pedagogical effectiveness. Moreover, the Mac G4 laptop graphics card proved to be incompletely compatible with the IDV, so at least one type of plot (involving vertical cross sections) produce bug-like behavior in the absence of any bug in the IDV.

In spite of these shortcomings of our computers, Dr. Monteverdi has increased his use of the IDV and has been applying it to his Weather Analysis and Forecasting I and II courses during the current academic year. He discovered and reported at least one more bug (in plotting the geolocation of sufficiently old NEXRAD Level II radar data) and motivating Dr. Dempsey to try to keep up with him. These efforts, for example, prompted members of the IDV user community (Tom Whittaker and Bill Fingerhut) and the IDV developers (Don Murray in particular) to develop and share a Jython function to create three-dimensional plots of isobaric surfaces from geopotential height fields in numerical model output and to add an item to one of the Field Selector menus to facilitate this plot, which we now use in our courses.

In August 2007, eighteen of the nineteen Mac G4 Titanium laptops in our redesigned MacLab classroom will celebrate their 5th birthday. They have been deteriorating in the face of the prolonged, intensive use described above, as well as ordinary aging. So far, one has failed outright and several others have become increasingly balky in spite of occasional recloning from a pristine clonemaster. They have become increasingly more difficult to maintain using Apple's Remote Desktop software. By some benchmark standards, they run at least eight times more slowly than currently available Apple Mac Book and Mac Book Pro laptops running Intel's dual-core CPUs—a difference that is obvious when running the IDV, for example.

It has been an exciting and pedagogically transformational five years, but it is time to upgrade the WGSL.

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[4] See http://funnel.sfsu.edu/courses/metr206/assignments/assignments.html to access the assignments. See http://funnel.sfsu.edu/students/across/IDV/DefaultIdv/bundles/T_Wind_TAdv_1000mb_05111506_RUC.xidv to access a sample xidv file.

Upgrading the WGSL: the Benefits. We propose to replace our slow, aging, 15", 800MHz, single CPU, Mac G4 Titanium laptops with new, 15", 2.16GHz, Intel Core 2 Duo CPU, Mac Book Pro laptops. In contrast to our existing Mac G4 laptops; to the smaller, less capable Mac Book laptops; and/or to Windows PC laptops, Mac Book Pro laptops offer the following advantages and opportunities:

- A Mac Book Pro will run the IDV much faster than a Mac G4—fast enough for us to use the IDV in our majors' courses and even in some general education courses on a routine basis. We are excited about the pedagogical possibilities this can offer us both in class and for (majors) students working at home, particular to help students visualize quantities in three and four dimensions, such as the jet stream (displayed as a wind speed iso-surface) and isobaric surfaces and relationships between fields in three dimensions (such as temperature and geopotential height).
- Using the IDV more routinely, at least throughout the Atmospheric and Oceanic Science program and in general education courses in meteorology, will allow both students and instructors to develop more expertise with the IDV than we can currently, and they should begin to develop more and better Jython formulas, IDV bundles, and IDV scripts for pedagogical use, some of which might be worthy of adoption by members of the Unidata community, if a formal or semi-formal mechanism for dissemination emerges, or even simply by announcement on the IDV users email list. Similarly, we will begin to acquire, test, adopt, and appreciate analogous contributions by other community members. Given his history with Unix shell script programming to facilitate use of WXP, we would not be surprised if Dr. Dempsey turns himself into a functional Jython programmer for the IDV before the next academic year is out.
- As we develop deeper expertise with the IDV, we might be able to interest our Departmental geology and oceanography colleagues in using it. Three-dimensional plots of earthquake foci and sea-surface topography (animated?) might intrigue them, for example.
- The Mac Book Pro's faster CPU will enable students to run other software faster as well, and in some cases for the first time, such as EdGCM (a workstation version of NASA's climate model adapted for classroom use)[5], which Dr. Dempsey plans to use in his "Planetary Climate Change" course in Fall 2007.
- The Mac Book Pro's graphics card (ATI Mobility Radeon X1600 with 128MB SDRAM) is more capable than the Mac G4's and the Mac Book's, which should speed rendering of the most CPU intensive IDV plots, such as three-dimensional iso-surface plots.[6] Although the card is not fully compatible with the IDV, so far we have discovered only one minor incompatibility, which we can live with. (Unfortunately, Apple shows no sign of switching to Nvidia graphics cards in its laptops, which would probably make the laptops fully IDV compatible.)
- The Mac Book Pro has a 15.4" display, as opposed to the Mac Book's 13.3" display. (Our current Mac G4s have a 15" display.) We believe that the larger display

[5] EdGCM was introduced to the Unidata community at the 2006 Unidata Summer Workshop, which Dr. Dempsey attended.

[6] Don Murray, Unidata, personal communication.

provides students with a significantly better pedagogical experience, which we want to preserve.

- The Mac Book Pro's Mac OS X operating system will continue to allow us to teach majors' students the basics of the Unix operating system. Most students already have some experience using Windows PCs, but they have little or no experience using Unix, which we feel that majors in Atmospheric and Oceanic Science should get before they graduate. (This is one reason why we choose not to switch to Windows PC laptops.) Dr. Dempsey's "Use of Computers in Meteorology and Oceanography" uses the laptops to teach the basics of Unix, which students apply to manage their own accounts in another of Dr. Dempsey's courses, "Intro to Programming with Applications to Meteorology and Oceanography", essentially a Fortran 90 programming course.
- The Mac Book Pros will be easier to maintain than our older machines because—well, because they aren't as old and balky. The fact that they run the same operating system as our current Mac G4 laptops means that administering and maintaining the new machines will present only a very slight learning curve. (Last year we replaced the nineteenth Mac G4, used by the instructor at the front of the classroom, with an older Mac Book Pro, so the learning curve is now virtually flat. This is another reason why we choose not to switch to Windows PC laptops, with which we have little expertise.)
- We have to replace our aging Mac G4s sooner or later, because some have already begin showing signs of failing and their balkiness is interfering with their pedagogical effectiveness. Replacing them with Mac Books or Mac Book Pros one by one as the Mac G4 laptops fail creates a lab with machines with two different hardware architectures. Because not all software designed to run on a Mac G4 with its PowerPC chip will run on the different architecture of a Mac Book or Mac Book Pro with its Intel chip, we would have to maintain two versions of some software, which increases the already heavy administrative burden currently borne by Dr. Dempsey and his intermittent student assistant help. We prefer to replace the Mac G4s all at once with laptops that are identical to each other in every meaningful respect.

D. Budget

Our deteriorating, heavily used, 5-year-old Mac G4 (800 MHz) laptops need to be replaced soon, both because they are showing signs of imminent decrepitude and have become harder to maintain, and because they are too slow to help us realize the pedagogical potential of Unidata's IDV and some other instructional software such as the EdGCM climate model. We prefer to replace the laptops all at once because the old machines and the new ones have different hardware architectures and hence some differences in software, which increases the maintenance burden.

We prefer to replace the Mac G4 laptops with 2.16GHz Mac Book Pro laptops because the Mac Book Pro runs all of the software that we want to use; it runs the same operating system, which saves immense amounts of our time; it has a pedagogically preferable 15" screen, vs. the much cheaper Mac Book's 13" screen; and it has an acceptable graphics card (ATI Mobility Radeon X1600 graphics processor, 128MB of

GDDR3 SDRAM) that is superior to the Mac Book's graphics card (an Intel GMA 950 graphics processor with 64MB of DDR2 SDRAM shared with main memory), which should improve the Mac Book Pro's ability to run the IDV.

The educational price of each 2.16 GHz Mac Book Pro, including local tax, is $1,952. This is about 60% higher than the cost of a Mac Book, but we feel that the larger display and superior graphics card force us to make this choice. (Incidentally, the cost is 15% lower than the cost of our original Mac G4 laptops in 2002, even without accounting for inflation.) The cost of ten of these machines totals $19,520, which is what we request from the Unidata Equipment Grant program.

The Department of Geosciences has $25,000 that it did not spend on lecturers this Spring semester, and it regards the upgrade as so important that it is willing to spend almost all of this money on the upgrade. This would cover the cost of the remaining ten Mac Book Pro laptops needed to replace the existing Mac G4 laptops (eight in the classroom lab and two in the original WGSL lab) ($19,520), plus the cost of upgrading our 4.5-year-old Mac G4 Xserver file server to an Xserve with two 2.0GHz dual-core Xeon processors and several other enhancements beyond the base model sold by Apple ($4,390). The Department's total contribution would be $23,910. In addition, the College of Science and Engineering will continue to provide release time for Dr. Dempsey to administer and manage the computer labs, and the Department of Geosciences will intermittently pay a student assistant up to 10 hrs/week to help maintain the labs.

# Items	Item Description	Unit Cost	Extension
10	Mac Book Pro laptop with: 2.16 GHz Intel Core 2 Duo processor; 1 GB RAM; 1440 x 900 pixels; 120GB hard drive1; 6x double-layer SuperDrive; and ATI Mobility Radeon X1600 graphics with 128MB SDRAM	$1,799	$17,990
		Sales tax @ 8.5%	1,530
		Total	$19,520

E. Project Milestones

We would be prepared wait until late August 2007 to try to take advantage of price decreases or hardware enhancements, if any, that Apple might introduce. We will wait no longer than that because we need to have installed and configured the laptops in time for the fall semester, when Dr. Dempsey teaches his 2-unit, required majors' course "Use of Computers in Meteorology and Oceanography", in which students will first learn to use the IDV. The new laptops will be necessary to run the IDV effectively.

Our undergraduate majors, who bear the brunt of the problems associated with our slow, aging laptops, very much look forward to an upgrade and have volunteered to help us install new laptops if we can acquire the funds to buy them.