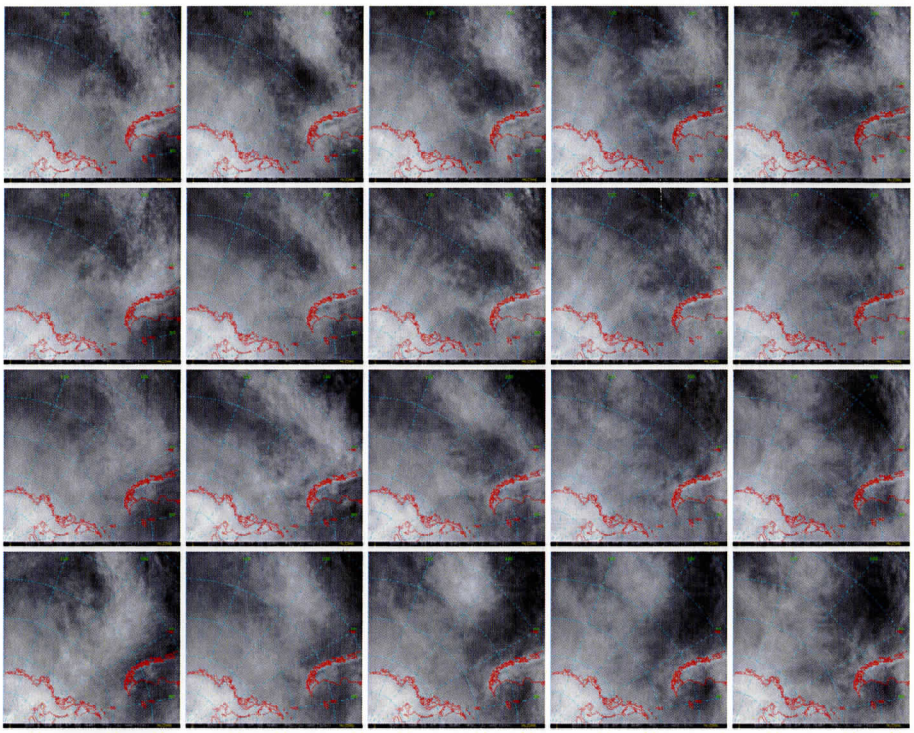
AMRC 2nd Annual Project Report: NSF-OPP Grant #0537827, June 1, 2006 to May 31,2008

Collaborative Research:

Antarctic Meteorological Research Center (2006-2009)

A Report to the Office of Polar Programs, National Science Foundation



Professor Charles R. Stearns, Principal Investigator
Dr. David B. Reusch, co-Principal Investigator
Dr. Matthew A. Lazzara, co-Principal Investigator and Meteorologist
Shelley L. Knuth, Meteorologist
Jonas V. Asuma, Student Meteorologist

Space Science and Engineering Center
University of Wisconsin-Madison

Earth and Environmental Sciences Institute
The Pennsylvania State University

Submitted on May 21, 2008

Annual Report for Period: 06/2007 - 05/2008
Submitted on: 05/21/2008
Principal Investigator: Stearns, Charles R.
Award ID: 0537827
Organization: U of Wisconsin Madison
Title:
Collaborative Research: Antarctic Meteorological Research Center (2006-2009)

Project Participants

Senior Personnel

Name: Stearns, Charles
Worked for more than 160 Hours: No
Contribution to Project:
Dr. Charles R. Stearns oversees the Antarctic Meteorological Research Center (AMRC) as Principal Investigator.

Name: Lazzara, Matthew
Worked for more than 160 Hours: Yes
Contribution to Project:
Matthew Lazzara works on the day to day activities of the AMRC including program management, data management, data requests, consulting, product generation oversight and data flow. His role includes project lead, educational outreach and coordination with other associated communities including the WMO, NCDC, etc. In addition, he is coordinating the modernization of AMRC's computing systems.

Name: Knuth, Shelley
Worked for more than 160 Hours: Yes
Contribution to Project:
Shelley Knuth works on day to day activities of the AMRC, including data management, data requests, educational outreach activities and questions. In addition, she oversees the AMRC web and FTP sites, case study collection and is expanding into product generation and data flow management.

Post-doc

Graduate Student

Undergraduate Student

Name: Asuma, Jonas
Worked for more than 160 Hours: Yes
Contribution to Project:
Jonas Asuma's role has included the digitization of meteorological metadata records, assistance with web and ftp site management, data archival, and he is expanding into case study collections and satellite monitoring activities.

Name: Hodkiewicz, Jonathan
Worked for more than 160 Hours: No
Contribution to Project:
Jon Hodkiewicz assists the project with clerical needs for the AMRC project

Technician, Programmer

Name: Bellon, Willard
Worked for more than 160 Hours: No

Contribution to Project:
Bill Bellon assisted with web site design and maintenance for the AMRC project

Name: Nolin, Scott

Worked for more than 160 Hours: No

Contribution to Project:
Scott Nolin has assisted with the acquisition, setup, and maintenance of AMRC computing, especially meeting the NSF guidelines for USAP IT for AMRC's computing in Antarctica.

)ther Participant

{esearch Experience for Undergraduates

Organizational Partners

'he Pennsylvania State University
This grant is a collaborative research project with Dr. David Reusch at The Pennsylvania State University, with our collaboration focusing on climatological applications of AMRC's signature atellite composite imagery. He has visited AMRC project team members and installed the processing software on AMRC's new computing resources to construct self-organized maps (SOMs) from the satellite composite imagery. We are actively working with Dr. Reusch in reprocessing and post-processing Antarctic composite satellite imagery for the SOM nalysis.

Other Collaborators or Contacts

The AMRC plays an active role in the Antarctic meteorological community, in particular vith United States Antarctic Program (USAP) afflilated organizations including Raytheon 'olar Services Company (RPSC), SPAWAR Office of Polar Program (SOPP), and other USAP grantees such as the Microscale and Mesoscale Meteorology (MMM) division at the lational Center for Atmospheric Research, Byrd Polar Research Center (BPRC) at The Ohio tate University (OSU), and University of Colorado-Boulder. The AMRC project continues to complement the Arctic and Antarctic Research Center project at the Scripps Institute of)ceanography, University of California-San Diego.

The AMRC continues to keep in close touch with other important organizations for the USAP including the National Climatic Data Center, National Oceanic and Atmospheric dministration, World Meteorological Organization, British Antarctic Survey, etc.

The AMRC collaborates with Dr. Jeff Key of NOAA/NESDIS/CIMSS on the real-time eneration of AMVs (Polar winds) from MODIS observations received at McMurdo Station or input to real-time numerical modeling efforts, including the Antarctic Mesoscale Prediction System (AMPS).

pecial effort, as a part of AMRC's case study work, in the last two years was assisting in tne study of the May 2004 severe wind event with Daniel Steinhoff at BRPC/OSU.

Activities and Findings

Research and Education Activities:
The mission of the Antarctic Meteorological Research Center (AMRC) is to perform esearch in observational meteorology and the stewardship of meteorological data along

/ith the ability to provide such data and expert assistance to the Antarctic community in support of research, education, and operations.

'he following activities have accented the first two years of the grant:

1. The modernization of AMRC computing equipment. This effort has occurred in phases, /ith the past years effort modernizing computing in Antarctic at McMurdo and Palmer Stations. These efforts have benefited the USAP by offering data and weather displays to those on-station and reducing bandwidth use to sites off station. These newer systems lso require less care by on station staff, and meet USAP IT regulations.

2. The continuation of AMRC data collection, generation, archive and distribution efforts, ıcluding specialized data requests for Antarctic meteorological data, such as satellite imagery for research and education as well as for field programs. Efforts in the area of the Antarctic-IDD continue as well. Data distribution via the web and FTP services run etween 60 to approximately 120 gigabytes per month. Antarctic-IDD offers ₄pproximately 1 gigabytes per day. On-line archives have increase by approximately 256 gigabytes, excluding AMRC's NOAA polar orbiting backup archive.

. Engaged in collaboration with Dr. David Reusch at Penn State University, including preprocessing and post-processing satellite composites for SOM research.

. Initiated efforts to process atmospheric motion vectors (AMVs) from the satellite composites. The processing environment as well as an increase in the temporal resolution of the satellite composites are underway to support this effort.

. Efforts are underway in gathering together complete climatology information for South Pole and McMurdo Station including historical climate summary information, metadata ıformation, etc. South Pole efforts are closely worked on with South Pole Meteorology)ffice. McMurdo efforts are closely worked on with SPAWAR Office of Polar Programs.

6. Continued grassroots educational outreach efforts expanded beyond traditional K-12 udents arenas to general public venues.

7. Continued to be a principal co-host for the Antarctic Meteorological Observation, lodeling and Forecasting Workshop, held in Boulder, Colorado in 2006 and Rome, Italy in)07.

indings:

We began work on the activities listed above. The status of this work is as follows:

Approximately 80 to 90% of AMRC's computing has been modernized with plans for ınal equipment to be acquired and installed in the upcoming field season.

The AMRC has continued its data efforts on all fronts of collection, generation, ...chive and distribution, including the upgrade and final installation of weather display in the Crary Lab at McMurdo Station. Also, the Antarctic-IDD continues to be an important)mmunity wide conduit for the sharing of Antarctic meteorological data and information.

3. AMRC hosted a visit by AMRC's collaborator, Dr. David Reusch, established a framework for the climatological analysis of the satellite composites, assisted with computing resources needed for the project, etc.

4. The AMVs work on the Antarctic composites has been started, but it is too early to report any findings at this time.

5. In conjunction with efforts with RPSC and South Pole Meteorology Office, progress has been made with South Pole's historical meteorological observations. A byproduct of recent PhD dissertation efforts, McMurdo Station's historical meteorological observations and climatology have started to be re-evaluated. Some of these data sets are not well cared for and require significant effort to quality control and make use of them.

6. AMRC's educational outreach horizons have expanded into the general public with events at public libraries, cub scout pack meetings, etc.

Training and Development:

Project participants have seen training and development milestones reached in the following areas:

* One member's completion of a Bachelor's Degree
One member's completion of a Master's Degree
* One member's completion of a PhD Degree
* First hand experience in computing, meteorological data and interactive processing for the project's undergraduate student as well as the opportunity to deploy to McMurdo Station Antarctica.
Computing, polar and satellite meteorology, public speaking & educational outreach opportunities for all project members

Outreach Activities:

One of the three pillars of the AMRC project is a grass roots educational outreach effort. The following lists AMRC's outreach efforts in the last two years:

General Public:

SSEC Public Tours, UW-Madison, Madison, WI (multiple tours)
* E-mails answering questions, offering information or providing data to students and the general public including special reports to classrooms and the general public during field deployments.
* Mount Horeb Public Library, Mount Horeb, WI
* Wednesday Night at the Lab, UW-Madison, Madison, WI
Mount Horeb Cub Scouts, Mount Horeb, WI
West Madison Cub Scouts, Madison, WI
* MidWest Severe Storm Tracking and Response Center, Inc., Monona, WI

University/College:
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* Madison Area Technical College, Madison, WI (multi-visits)

Middle School:
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* Lodi Middle School, Lodi, WI (2 visits)
Waunakee Intermediate School Family Science Night, Waunakee, WI

Elementary School:
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* Deerfield Elementary School, Deerfield, WI (2 visits)
Sheboygan, WI (Elementary School)
Pittsville, WI (Elementary School)

McMurdo Station:

Wednesday Night Science Lecture

Additional events are planned including additional elementary school visits, weather club lectures, and working closely on a special geography project with an elementary school.

Journal Publications

teinhoff, D.F., D.H. Bromwich, M. Lambertson, S.L. Knuth, and M.A. Lazzara, "A Dynamical Investigation of the May 2004 McMurdo Antarctica Severe Wind Event using", Monthly Weather Review, American Meteorological Society, p. 7, vol. 136, (2008). Published, 10.1175/2007mwr1999.1

Books or Other One-time Publications

Matthew A. Lazzara, "A Diagnostic Study of Antarctic Fog", (2008). Thesis, Published
Bibliography: TBA

Web/Internet Site

URL(s):

tp://amrc.ssec.wisc.edu http://ice.ssec.wisc.edu ftp://
nrc.ssec.wisc.edu ftp://ice.ssec.wisc.edu

Description:

hese web and FTP sites are the primary and secondary sites that host the AMRC database, cluding real-time meteorological data, historical data, and metadata. These sites are

shared by AMRC's sister project, the Antarctic Automatic Weather Station Program. These sites are undergoing expansion as additional data is posted on these sites from the AMRC off-line archive as well as additional metadata and site specific resources are added.

Other Specific Products

Product Type:

Data or databases

Product Description:

The AMRC has collected and archived a variety of generated satellite composite datasets, automatic weather station observations, polar orbiting satellite observations, numerical model analyses and forecasts, surface and upper air observations, GTS text data sets and USAP station data.

Sharing Information:

This data collection is increasingly available via the following means:

* Web site
* FTP site
  McIDAS ADDE server
  Antarctic-IDD/LDM system and Unidata's IDD/LDM system
* Metadata via the data interchange format (DIF) with the Antarctic Master Directory at the National Snow and Ice Data Center and NASA Global Master Directory
  Via "word of mouth" and as advertised via talks, presentations at professional meetings and lectures.

Contributions

Contributions within Discipline:

The AMRC contributes to the field of meteorology with its unique products and archive of freely available datasets. In the last year the following have been provided datasets from the AMRC:

US:
* Dan Steinhoff, BPRC/OSU
* Mark Seefeldt, CU
  Gary Huffard, NWS-AK
* Doug MacAyeal, UC
* Santiago Gasso, NASA
  Larry Saranthus, Devon Gas
  Valerie Loeb, Moss Landing Marine Lab
* Annalisa Schilla, CU
  Gonzalo Hernandez, U. Washington
  Mike Willis, BRPC/OSU
* Mark Twickler, NICL/UNH
* Laurie Padman, ERSC

Australia:
  Steve Pendlebury
  Meraz Mostafa
* Clare Oatley
* Gabrielle Kelly

China
* Yan Hao

Germany:
* Wolfgang Rack

Italy:
* Cpt. Roberto Bove

Austria:
* C. Riedl

UK:
* Gareth Marshall
* Alex Pezza

Malaysia:
* N.C. Sheeba

Other:
* Serg Zarin

Contributions to Other Disciplines:

Historically, the AMRC has been a contributor to other disciplines, such as glaciology, oceanography, artists and writers, etc. This project continues this, as opportunities and interest arises.

Contributions to Human Resource Development:

The AMRC's visibility, especially via the internet and other means, attracts many questions and requests. Our offering of expertise and answers to students and the general public raise awareness of the Antarctic and the important role it plays in the Earth system.

Within the project team, human resource development can be exemplified via the graduation of one team member with a PhD, and the on-going development of computing and meteorology skills for an undergraduate student team member.

Contributions to Resources for Research and Education:

The Antarctic Meteorological Research Center is a central polar meteorology center within the University of Wisconsin-Madison, Space Science and Engineering Center. This project complements other projects within SSEC, offering an Antarctic point of view on a variety of activities taking place within the center, such as interactive processing, satellite meteorology, etc.

Contributions Beyond Science and Engineering:

The datasets the AMRC has invested time and effort into collecting are becoming increasingly critical for research projects exploring a wide range of topics from glaciology to climate in the Antarctic, and logistical decision making within the USAP. This effort continues into this project. More will be reported in future reports.

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

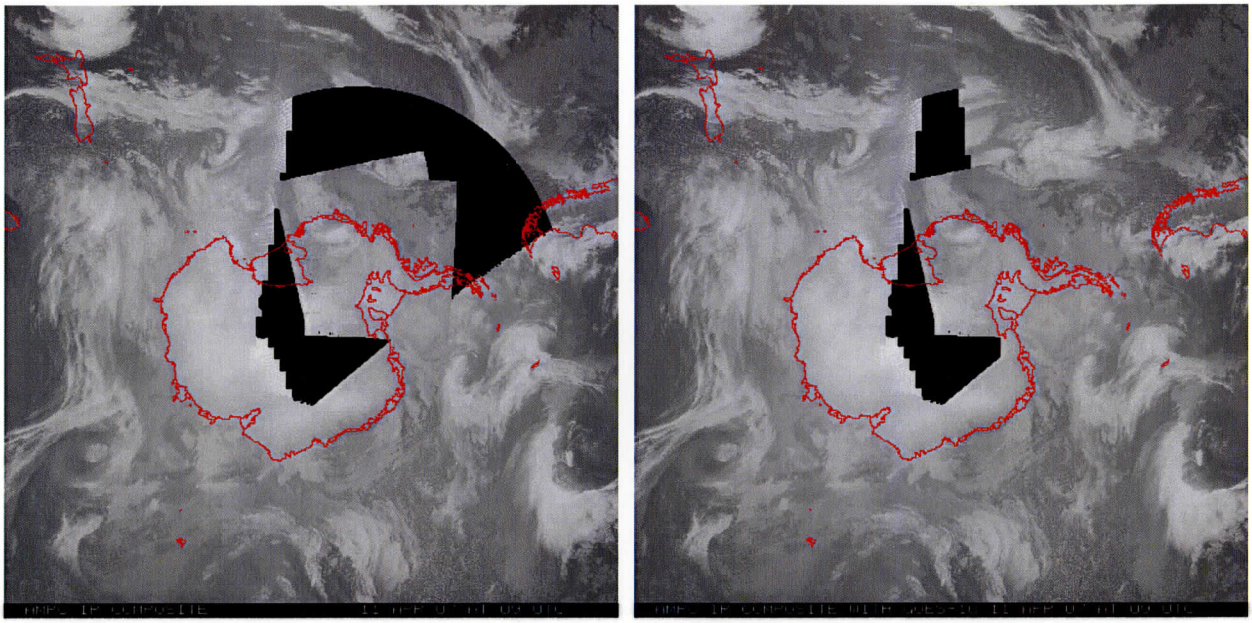

Figure 1. A sample composite made without GOES-10 (left) and with GOES-10 (right), which demonstrates the value of the GOES-10 imagery. In the near future, GOES-10 imagery, which is available on a more frequent basis, will be used to make composites on an hourly basis.

Figure 2. Educational outreaches to public groups, such as this Mt. Horeb Public Library book club are a focus of the AMRC grassroots educational outreach program (*Photo Courtesy of the Mt. Horeb Public Library*).

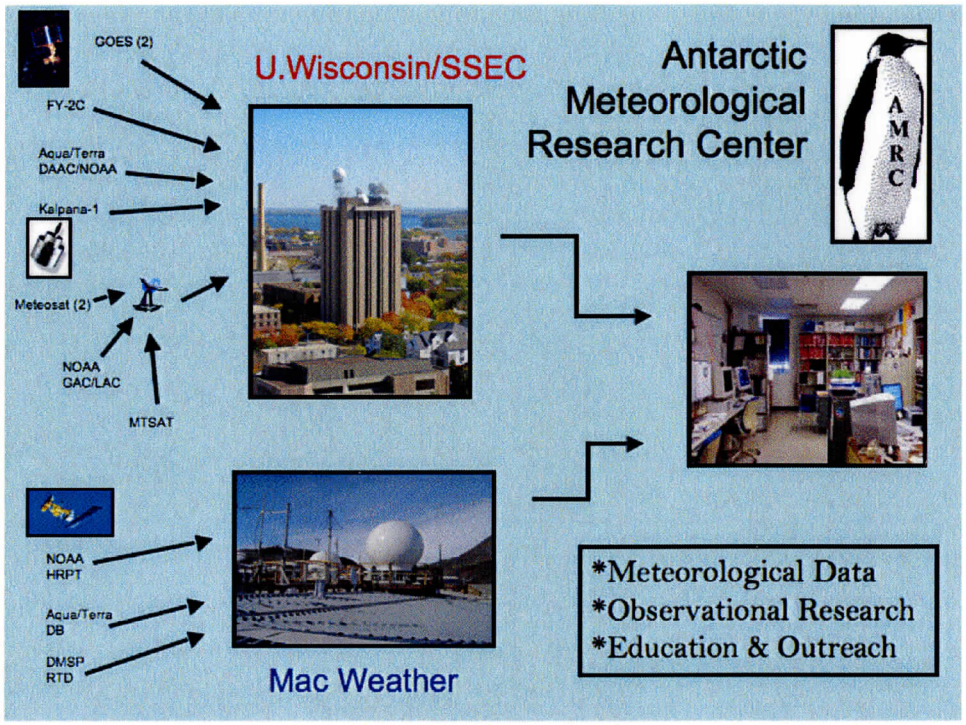

Figure 3. A graphical depiction of the partial data flow shows the Antarctic satellite composite input data sources (missing from the figure are input from Palmer Station, Antarctica).

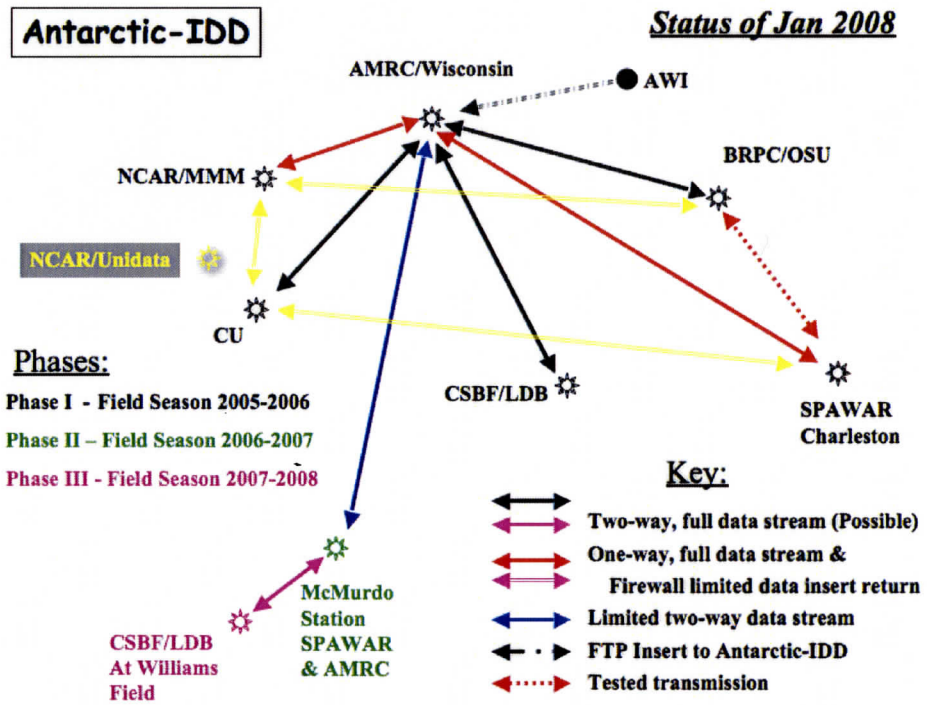

Figure 4. A schematic of the Antarctic-IDD as of January 2008 showing the path of data sharing and exchange among members of the USAP and beyond.

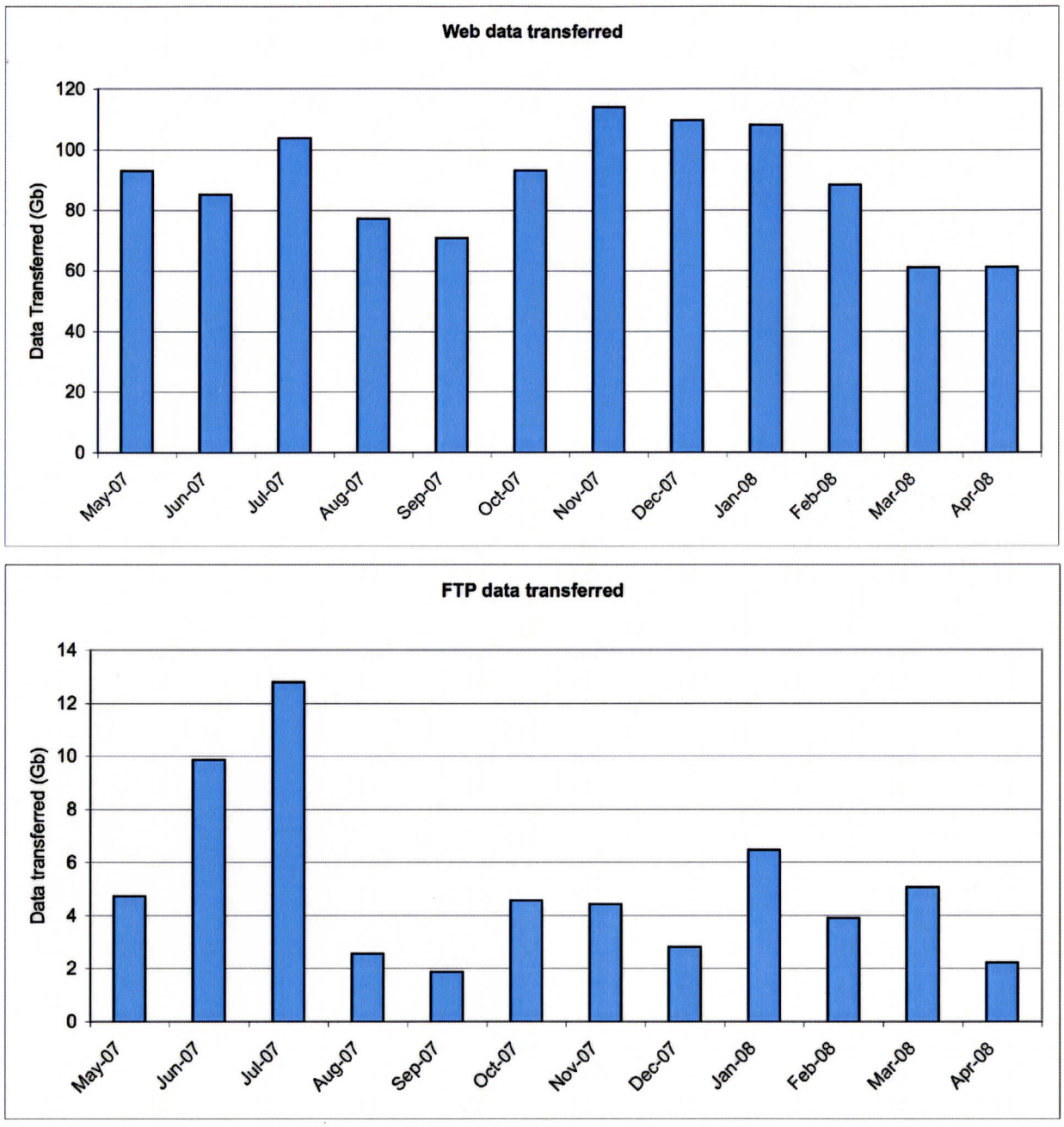

Figure 5. The web and FTP data transfer amounts on a monthly basis from May 2007 through April 2008. FTP data transfers are highly variable, depending on requested data volumes by end users.

Figure 6. The 2nd annual Antarctic Meteorological Observation, Modeling, and Forecasting Workshop in Rome, Italy.

ANNUAL REPORT FOR AWARD # 0538064

PA St U University Park
Collaborative Research: Antarctic Meteorological Research Center (2006-2009)

Participant Individuals:

Partner Organizations:
University of Wisconsin-Madison: In-kind Support; Collaborative Research

This grant is a collaborative research project with members of the Antarctic Meteorological Research Center (AMRC) in the Space Science and Engineering Center (SSEC). The AMRC is providing data, computing and analysis support with respect to the AMRC's satellite composite imagery that is being analyzed in my part of this collaborative project.

Activities and findings:

Research and Education Activities:

The pilot of the Self-Organizing Map-based analysis continues and has established that the SOM-based approach is fundamentally viable. To progress to full-scale studies will require refinements (ongoing) to the (pre)processing steps to improve the information content of the data being analyzed (see below). To keep processing manageable, the pilot focuses on 6-hourly satellite data for June 2004 but has switched to a domain covering the Amundsen-Bellingshausen Sea region at full-resolution (a 512x512 piece of the full 2048x2048 image; see Figure 1 of attached PDF).

Main results from the pilot so far:
1) Established the overall methods/steps required. This is a blend of my standard SOM tools and McIDAS-based image processing tools available from the AMRC.
2) Validated the analysis software's ability to work with these large datasets. The 512x512 data size uncovered an invalid assumption by the original developers as to just how large the data might be. An easy fix to make once the error was found but the finding of it was time-consuming.
3) Provided a much better sense for the computing and time requirements for processing of these substantial datasets (much more time than has been needed on any of my prior work). There is no longer any question that the multicore Xeon-based systems of the AMRC are essential to this project (although we aren't currently able to take advantage of parallel processing on the multiple cores, a possible future project).

With respect to validation, the SOM patterns have clear structure with, in many cases, unique and interpretable cloud patterns (see Figure 2 of attached PDF). These results are not yet as satisfyingly clear cut as seen in work with other datasets but we believe we understand why and just need to test/refine our theory.

The theory is simply that a greater level of data preprocessing is needed so that the SOM algorithm is better able to distinguish what we're really most interested in: the significant cloud patterns. Without preprocessing, the SOM gives background cloudiness equal weight with the more interesting patterns. As a result, the signal-to-noise in the final generalized SOM patterns is less than satisfactory. The AMRC has significant experience with processing satellite imagery to highlight various aspects, so the potential for a sophisticated preprocessing step is definitely there. However, I will also be investigating simpler approaches to better results. It is important to note that the necessity for preprocessing was not known in advance so this is a very useful and informative result.

As part of assessing the utility of image preprocessing, I am also investigating whether there may be alternative techniques with skill comparable to (or better than) the SOMs-based approach, perhaps as a replacement but more likely as a complement. An example of this is the affinity propagation algorithms of Frey and Dueck, 2007. There are also variations on the basic SOM approach that merit study.

Following up an April 2007 visit to Madison, I was also able to meet with collaborator Matt Lazzara multiple times last June/July at the IUGG General Assembly in Perugia, Italy (and to a lesser degree at the 2nd Antarctic Meteorological Observation, Modeling and Forecasting Workshop in Rome, held before IUGG). These meetings were very useful for understanding the detailed work steps required from both parties and planning out how to accomplish them.

I anticipate presenting the overall project results from the pilot at the 3rd Antarctic Meteorological Observation, Modeling and Forecasting Workshop to be held in Madison June 9-12, 2008.

As mentioned in the 2007 report, an unexpected opportunity to teach 'Global Climates' in Spring 2007 in the Penn State Geography department provided a very useful chance for sharing my knowledge and expertise in climate analysis with undergraduates in our Geography and Meteorology departments. These activities benefit from the same skills needed to be successful on this project. Obviously, the flow of work/results on this project has been affected by these ongoing teaching duties (I also taught a similar course in Fall 2007 and am currently teaching last Spring's course again now; see Outreach Activities) but this is offset by the unexpected Broader Impacts benefits.

It is unlikely that this teaching will continue in the coming academic year (it was a sabbatical fill-in position) but the possibility cannot yet be ruled out.

Frey and Dueck, Clustering by Passing Messages Between Data Points, Science, 315, 972-976, 2007.

Outreach Activities:

Expertise applicable to the work of this project has been used in the course of teaching two Penn State undergraduate Geography department courses related to global climate: a general education course (enrollment ~80) during fall semester, 2007, and a writing-intensive geography-majors course (enrollment 24) during spring semester, 2008.

Journal Publications:

Book(s) of other one-time publications(s):

Other Specific Products:

Special Requirements for Annual Project Report:

Categories for which nothing is reported:
Participants: Other Collaborators
Participants: Other Collaborators
Findings
Research Training
Products: Journal Publications
Products: Book or other one-time publication
Products: Other Specific Product
Products: Internet Dissemination
Contributions Within Discipline
Contributions to Other Disciplines
Contributions to Education and Human Resources
Contributions to Resources for Science and Technology
Contributions Beyond Science and Engineering
Special Reporting Requirements
Animal, Human Subjects, Biohazards

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