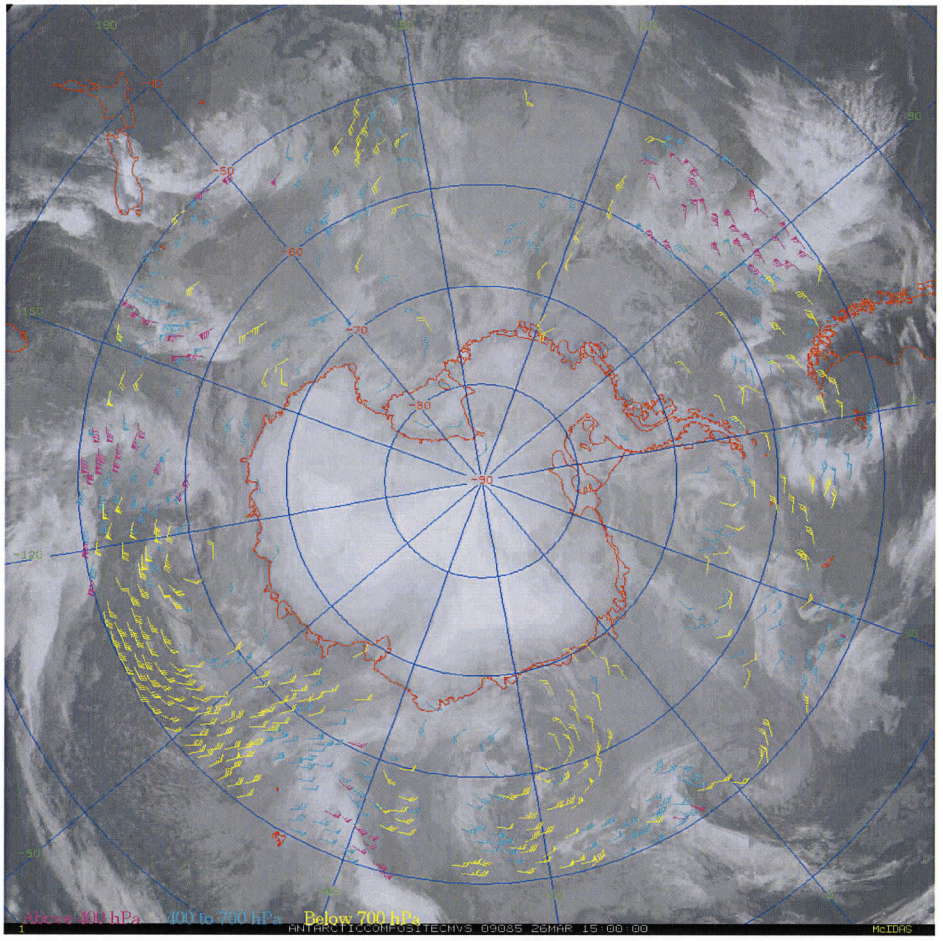
# Collaborative Research:

# Antarctic Meteorological Research Center (2006-2009)

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




Dr. Matthew A. Lazzara, Principal Investigator and Meteorologist
Dr. David B. Reusch, co-Principal Investigator
Professor Charles R. Stearns, Principal Investigator Emeritus

Space Science and Engineering Center
University of Wisconsin-Madison

Earth and Environmental Sciences Institute
The Pennsylvania State University

Submitted on May 4, 2009

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**Annual Report for Period:** 06/2008 - 05/2009
**Principal Investigator:** Lazzara, Matthew A.
**Organization:** U of Wisconsin Madison
**Submitted By:**
Lazzara, Matthew - Principal Investigator
**Title:**
Collaborative Research: Antarctic Meteorological Research Center (2006-2009)

**Submitted on:** 05/04/2009
**Award ID:** 0537827

## 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. Dr. Stearns has retired from the University of Wisconsin-Madison as of August 2008.

**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. This portion of the AMRC effort was completed by Spring 2008, as Matthew Lazzara moved into the role of Principal Investigator.

**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.

**Name:** Lazzara, Matthew
**Worked for more than 160 Hours:** Yes
**Contribution to Project:**
As of the summer of 2008, Dr. Matthew Lazzara assumed the role of Principal Investigator, in addition to his duties overseeing the day to day activities of the AMRC. Effort in the last year included development of hourly Antarctic composite generation, working with staff on atmospheric motion vector generation from the Antarctic composite, working with staff on storm tracking, working with collaborators on the composite satellite SOM, maintenance of AMRC processing and archiving systems.

**Name:** Keller, Linda
**Worked for more than 160 Hours:** No
**Contribution to Project:**
Linda Keller has worked on applying storm track methods utilizing the Antarctic composite satellite imagery.

### 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 also expanded into case study collections and satellite monitoring activities, as well as generation of Antarctic satellite composite displays over the full archive of imagery.

**Name:** Hodkiewicz, Jonathan

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Jon Hodkiewicz has assisted the project with clerical needs for the AMRC project

**Name:** Mimier, Julia

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Julia has assisted the AMRC effort with clerical assistance.

**Name:** Oswalt, Jacqueline

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Jacqueline has assisted the AMRC effort with clerical assistance.

**Name:** Rowe, Shellie

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Shellie has worked with the AMRC on its web site.

**Name:** Welhouse, Lee

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Lee has worked with the AMRC during the summer of 2008 to assist with data archiving and processing activities.

**Name:** Schroeder, Nicole

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Nicole works on the routine management of AMRC datasets, and is working to document AMRC procedures. Additionally she handles occasional data requests and works on compiling corroborating information for USAP station climatology effort.

**Name:** Rasmussen, David

**Worked for more than 160 Hours:** No

**Contribution to Project:**

DJ is undertaking the creation of long sequence Antarctic composite movies to made available for use by researchers, and in outreach activities.

**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.

**Name:** Dworak, Richard

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Rich Dworak has worked with the PI on implementing the atmospheric motion vector software and associated validation effort.

**Other Participant**

**Research Experience for Undergraduates**

## Organizational Partners

**The 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 satellite composite imagery. Dr. Reusch 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 preprocessing and post-processing Antarctic composite satellite imagery for the SOM analysis.

## Other Collaborators or Contacts

The AMRC plays an active role in the Antarctic meteorological community, in particular with United States Antarctic Program (USAP) afflilated organizations including Raytheon Polar Services Company (RPSC), SPAWAR Office of Polar Program (SOPP), and other USAP grantees such as the Microscale and Mesoscale Meteorology (MMM) division at the National Center for Atmospheric Research, Byrd Polar Research Center (BPRC) at The Ohio State 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 Oceanography, 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 Administration, World Meteorological Organization, British Antarctic Survey, etc.

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

Special effort, as a part of AMRC's case study work, in the first two years of this project was assisting in the 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 research in observational meteorology and the stewardship of meteorological data along with the ability to provide such data and expert assistance to the Antarctic community in

support of research, education, and operations.

The following activities have accented the first three years of the grant:

1. The modernization of AMRC computing equipment. This effort has occurred in phases, with the past years effort modernizing computing in Antarctic at McMurdo Station completed (Palmer Station was completed last year). 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 also require less care by on station staff, and are able to meet USAP IT and information security regulations.

2. The continuation of AMRC data collection, generation, archive and distribution efforts, including 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 between 60 to approximately 120 gigabytes per month. Antarctic-IDD offers approximately 1 gigabytes per day. On-line archives have increase by approximately 320 gigabytes.

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

4. Generating and evaluating atmospheric motion vectors (AMVs) from the AMRC's Antarctic satellite composites. This project also had the mutual benefit of the increase in the temporal resolution of the satellite composites.

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

6. Continued grassroots educational outreach efforts expanded beyond traditional K-12 students arenas to general public venues. Efforts are underway to evaluate how effect AMRC's outreach efforts are. Two methods are being employed: gather post outreach evaluations from outreach hosts in the form of a questionnaire, and in one middle school is investigating if students conceptions of Antarctic meteorology and Antarctic science have improved after the outreach effort.

7. Continued to be a principal co-host for the Antarctic Meteorological Observation, Modeling and Forecasting Workshop (AMOMFW), held in Boulder, Colorado in 2006, Rome, Italy in 2007, Madison, Wisconsin in 2008 and planned for Charleston, South Carolina in 2009.

8. The Antarctic composite satellite imagery is now being used to test methods to track cyclones in the Southern Hemisphere.

**Findings: (See PDF version submitted by PI at the end of the report)**

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

1. AMRC's computing has been modernized as of the end of the past field season.

2. The AMRC has continued its data efforts on all fronts of collection, generation,

archive and distribution, including the upgrade of the weather display in the Crary Lab at McMurdo Station. Also, the Antarctic-IDD continues to be an important community wide conduit for the sharing of Antarctic meteorological data and information.

3. SOM efforts are summarized in Dr. David Reusch's annual reports.

4. The generation of atmospheric motion vectors (AMVs) from newly available hourly Antarctic composites has been successfully accomplished. (See figure for additional description) This is a significant accomplishment, but efforts are now underway to validate/verify the AMVs. If the AMVs are indeed validated, the Antarctic composite derived AMVs will offer wind information over a portion of the earth presently not covered by geostationary or polar orbiting AMV data sets. They in turn may have application for numerical modeling and aiding directly in flight forecasting. This effort also comes with the benefit of the soon to be released availability of hourly composite imagery that was previously not available. Increased coverage by geostationary satellites, the availability of GOES-10 (for South America) and improved utilization of polar orbiting observations has come together to make hourly composites and AMVs possible.

5. In conjunction with efforts with RPSC and South Pole Meteorology Office, corrected local climate data summaries are now available from AMRC's servers. Efforts to digitize corroborating historical climatological information for McMurdo Station and other USAP stations is nearing completion, and will now allow a more complete analysis of McMurdo Station's climatology to proceed.

6. AMRC's educational outreach horizons have continued to impact to both traditional K-12 students and the public. A more formal collection of feedback is underway, with initial response to AMRC outreach events being viewed as favorable. More feedback is need to gain a better handle on the effectiveness. A focus investigation of AMRC's outreach efforts improving student's conception of Antarctic meteorology and Antarctic science shows that the effort does have an impact, but there is more to be done to more effective.

7. The AMOMFW continues to play key role in bringing together the broad Antarctic community - both research and operational interests participating.

8. Work has begun on the use of satellite imagery to track cyclones in the Southern Hemisphere. Several techniques developed for studying cyclones in the Northern Hemisphere are used as a starting point. Degradation of the satellite image by averaging over blocks of pixels is being investigated as well as infrared thresholding at one brightness level. These techniques are being refined and in some cases rejected because of unacceptable results for the Southern Hemisphere. Hierarchical threshold segmentation seems to be a better technique to isolate important cloud patterns using brightness thresholds between 150-170. Once the image is segmented, pattern recognition techniques need to be developed to match the cloud patterns for lows which can be quite extensive over the Southern oceans. Currently, the month of June, 2004 is being used to develop the templates for the cloud patterns and to test and refine thresholds and edge detection techniques to isolate and classify cyclone cloud patterns in the satellite imagery.

**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 three 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 three years:

General Public:
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* SSEC Public Tours, UW-Madison, Madison, WI (multiple tours, including University of Wisconsin Science Expeditions/Open House)
* 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
* Wisconsin State Fair, West Allis, WI
* Deerfield Cub Scouts, Deerfield, WI (2 visits)
* University of the Air, Wisconsin Public Radio, Madison, WI

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

Middle School:
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* Lodi Middle School, Lodi, WI (3 visits)
* Waunakee Intermediate School Family Science Night, Waunakee, WI

Elementary School:
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* Deerfield Elementary School, Deerfield, WI (3 visits)
* Sheboygan, WI (Elementary School)
* Pittsville, WI (Elementary School)
* Lincoln Elementary School, Madison, WI

Preschool:
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* UW Preschool Lab

McMurdo Station:
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Wednesday Night Science Lecture (2 seasons)
Sunday Night Science Lecture

## Journal Publications

Steinhoff, 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

Keller, L.M.;Baker, K.A.;Lazzara, M.A.;Gallagher, J., "A comparison of meteorological observations from South Pole Station before and after installation of a new instrument suite", Jounral of Atmospheric and Oceanic Technology, p. , vol. , (2009). Accepted, 101175.2009JTECH1220.1

## Books or Other One-time Publications

Matthew A. Lazzara, "A Diagnostic Study of Antarctic Fog", (2008). Thesis, Published Bibliography: University of Wisconsin-Madison, Department of Atmospheric and Oceanic Sciences, Madison, WI, 2008, Call Number: UW MET Publication No.08.00.L1

## Web/Internet Site

**URL(s):**

http://amrc.ssec.wisc.edu http://aws.ssec.wisc.edu ftp:// amrc.ssec.wisc.edu ftp://aws.ssec.wisc.edu

**Description:**

These web and FTP sites are the primary and secondary sites that host the AMRC database, including 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
* rsync server

* 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:

USA:
* Gonzalo Hernandez, U. Washington

France:
* Christophe Genthon

Germany:
* Wolfgang Rack

Italy:
* Cpt. Roberto Bove

Austria:
* C. Riedl

Other:
* Jorge Giammateo
* Elisabeth Schlosser

UK:
* Rebecca Jansen

Malaysia:
* N.C. Sheeba

**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 several undergraduate student team members.

**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.

## Conference Proceedings

## Special Requirements

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

## Categories for which nothing is reported:

Any Conference

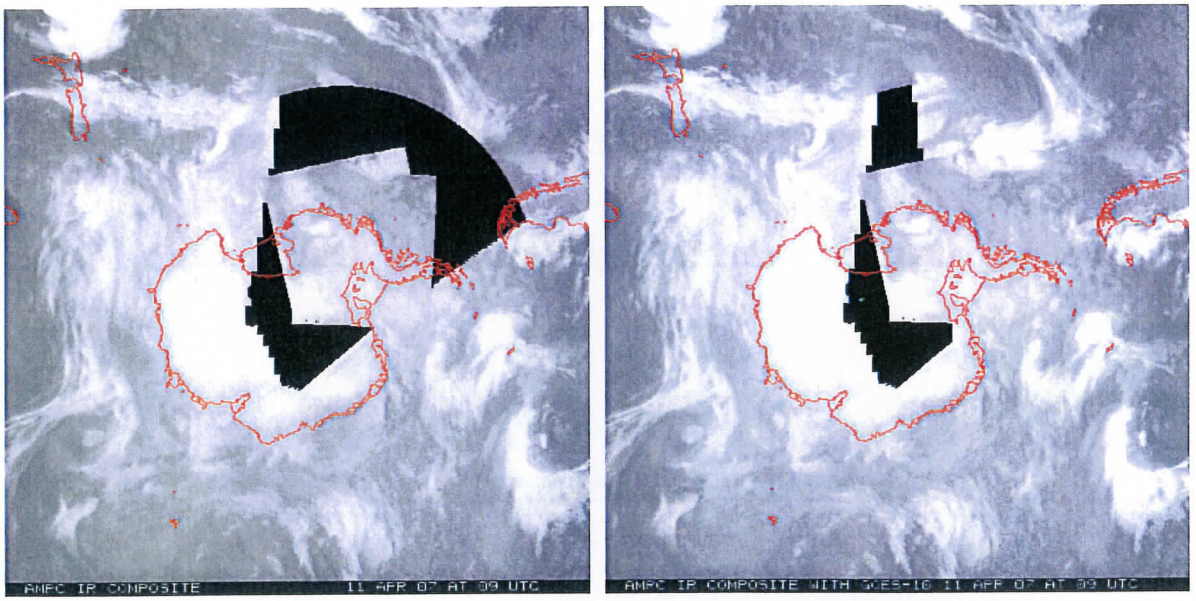



**Figure 1. A sample composite made without GOES-10 (left) and with GOES-10 (right), which demonstrates the value of the GOES-10 imagery. GOES-10 imagery, which is available on a more frequent basis, is enabling composites to be made on an hourly basis.**

**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*).**

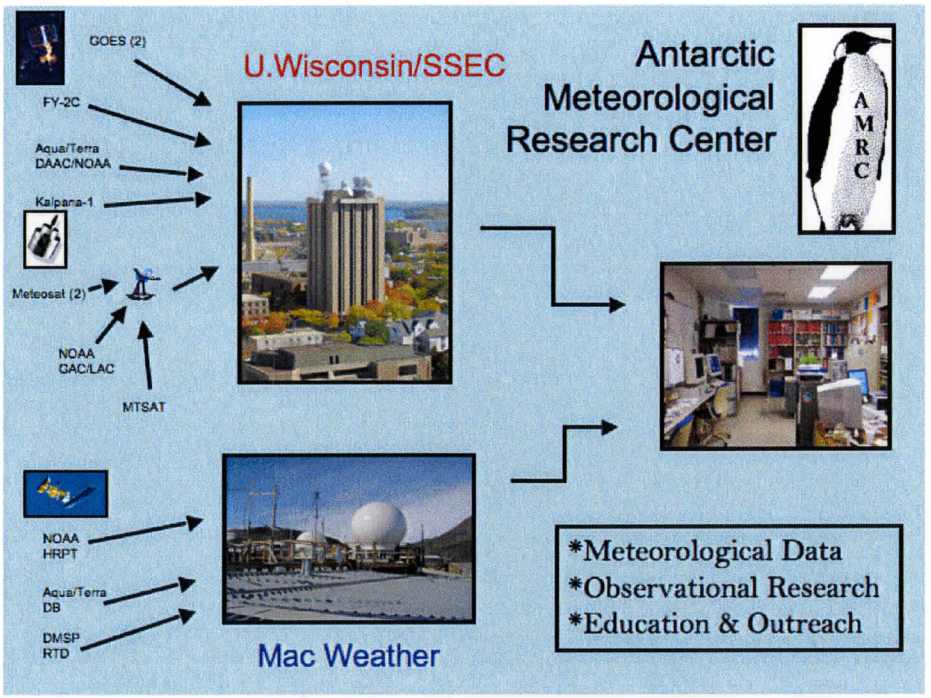



**Figure 3. A graphical depiction of the partial data flow shows the Antarctic satellite composite input data sources (missing from the figure are input from Palmer Station, Antarctica).**

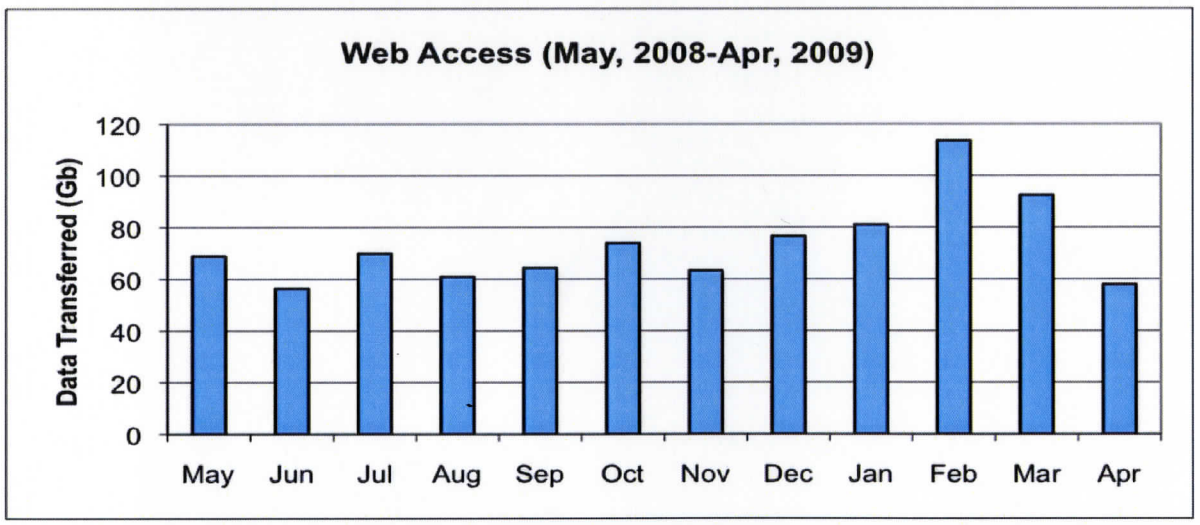



**Figure 4. The web data access amounts on a monthly basis from May 2008 through April 2009.**


**Figure 5. The 2nd annual Antarctic Meteorological Observation, Modeling, and Forecasting Workshop in Rome, Italy.**

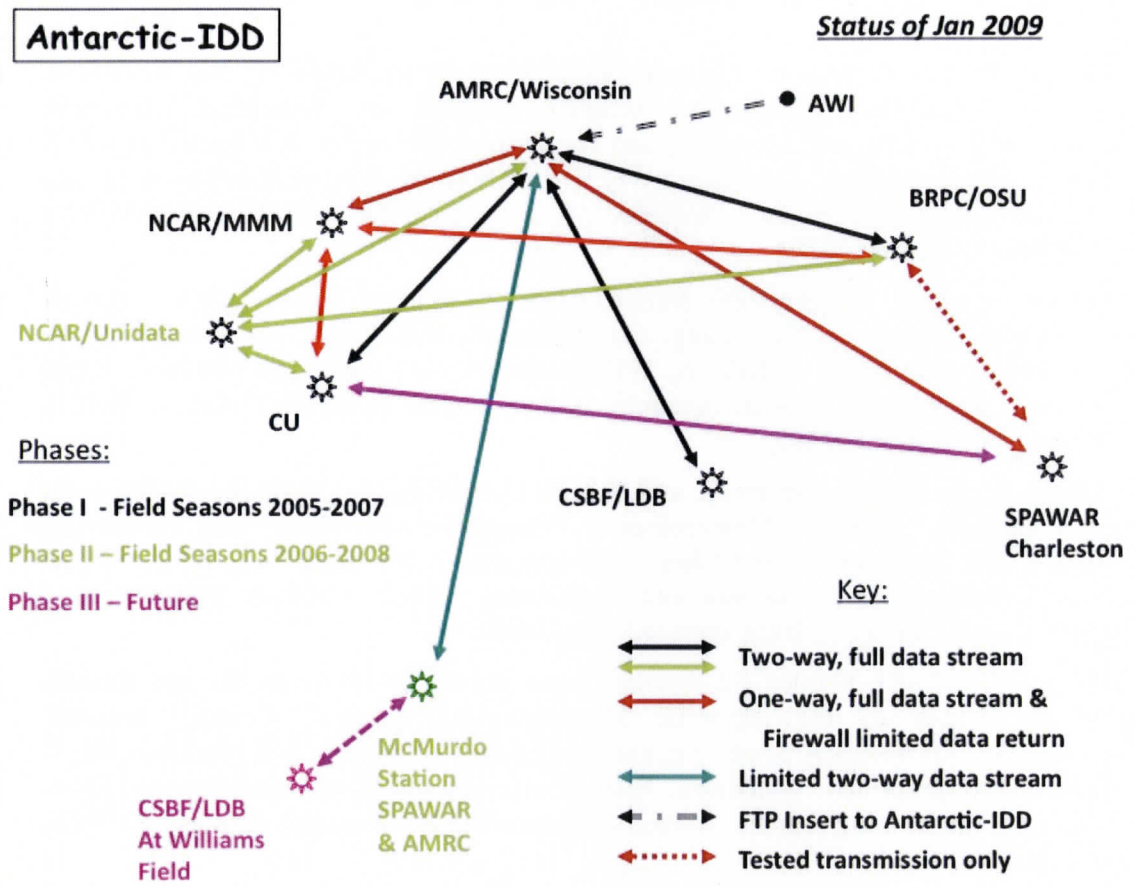



**Figure 6. The network configuration of the Antarctic-IDD updated as of January 2009.**

## Conference Proceedings


Staude, Jessica A.; Stearns, Charles R.; Lazzara, Matthew A.; Keller, Linda M., and Ackerman, Steven A. Poleward propagating weather systems in Antarctica. Antarctic Meteorological Observation, Modeling, and Forecasting Workshop, 3rd, Madison, WI, 9-12 June 2008 (preprints). [Madison, WI], [University of Wisconsin-Madison, Space Science and Engineering Center, Antarctic Meteorological Research Center (AMRC)], 2008, unpaged. Reprint #5794.

Lazzara, Matthew A. et al. The Antarctic Internet Data Distribution System 2008. Antarctic Meteorological Observation, Modeling, and Forecasting Workshop, 3rd, Madison, WI, 9-12 June 2008 (preprints). [Madison, WI], [University of Wisconsin-Madison, Space Science and Engineering Center, Antarctic Meteorological Research Center (AMRC)], 2008, unpaged. Reprint #5799.

Lazzara, Matthew A.; Ackerman, Steven A., and Hillger, Donald W. Antarctic fog depiction via satellite analysis. Antarctic Meteorological Observation, Modeling, and Forecasting Workshop, 3rd, Madison, WI, 9-12 June 2008 (preprints). [Madison, WI], [University of Wisconsin-Madison, Space Science and Engineering Center, Antarctic Meteorological Research Center (AMRC)], 2008, unpaged. Reprint #5796.

Lazzara, Matthew A.; Knuth, Shelley L.; Asuma, Jonas V.; Stearns, Charles R., and Reusch, David B. Status of the Antarctic Meteorological Research Center. Antarctic Meteorological Observation, Modeling, and Forecasting Workshop, 3rd, Madison, WI, 9-12 June 2008 (preprints). [Madison, WI], [University of Wisconsin-Madison, Space Science and Engineering Center, Antarctic Meteorological Research Center (AMRC)], 2008, unpaged. Reprint #5797.

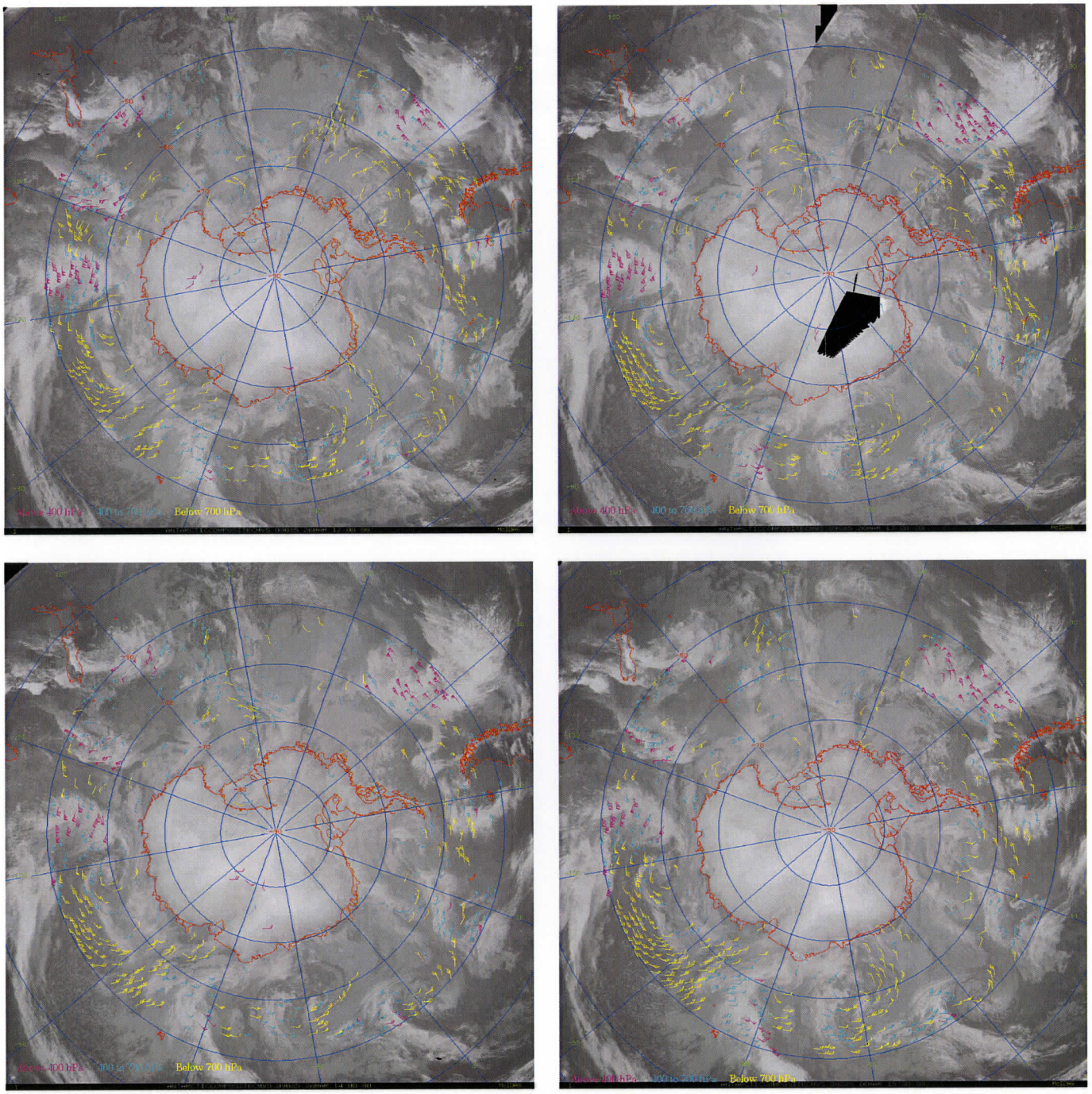
Lazzara, Matthew A. A diagnostic study of Antarctic fog. International Conference on Fog, Fog Collection and Dew, 4th, La Serena, Chile, 22-27 July 2007. Program and abstracts. Santiago, Chile, Pontificia Universidad Catolica de Chile, Instituto de Geografia, 2007, pp9-13. Reprint #5714.

Lazzara, Matthew A.; Knuth, Shelley L.; Stearns, Charles R., and Keller, Linda M. Status of the Antarctic Meteorological Research Center 2005-2006. Antarctic Meteorological Observation, Modeling, and Forecasting Workshop, National Center for Atmospheric Research (NCAR), Boulder, CO, 13-15 June 2006 (preprints). Boulder, CO, National Center for Atmospheric Research (NCAR), 2006. Reprint #5160.

Steinhoff, Daniel F.; Bromwich, David H.; Lambertson, Michelle; Knuth, Shelley L., and Lazzara, Matthew A. A dynamical investigation of the May 2004 McMurdo Antarctica severe wind event. Antarctic Meteorological Observation, Modeling, and Forecasting Workshop, National Center for Atmospheric Research (NCAR), Boulder, CO, 13-15 June 2006 (preprints). Boulder, CO, National Center for Atmospheric Research (NCAR), 2006. Reprint #5162.

Straka, William III; Key, Jeff; Lazzara, Matthew ; Santek, Dave; Gumley, Liam, and Strabala, Kathy. Satellite-derived wind, cloud, and surface products at direct broadcast sites in the

Antarctic and Arctic. Antarctic Meteorological Observation, Modeling, and Forecasting Workshop, National Center for Atmospheric Research (NCAR), Boulder, CO, 13-15 June 2006 (preprints). Boulder, CO, National Center for Atmospheric Research (NCAR), 2006. Reprint #5159.




Hourly Antarctic infrared composite imagery with atmospheric motion vectors (AMVs) plotted for the period 12 through 15 UTC on 26 March 2009. These AMVs, also known as cloud drift winds, fill a gap between geostationary satellite AMVs generated to the North and polar orbiting satellite AMVs generated to the South. This project is a collaboration between the Cooperative Institute for Meteorological Satellite Studies (CIMSS) and the Antarctic Meteorological Research Center (AMRC), both housed at the Space Science and Engineering Center, with assistance from the Data Center within SSEC. Efforts are underway to validate these winds.

**nnual Report for Period:** 06/2008 - 05/2009
**Submitted on:** 05/05/2009
**Principal Investigator:** Reusch, David B.
**Award ID:** 0538064
**rganization:** PA St U University Park
**ubmitted By:**
Reusch, David - Principal Investigator
**itle:**
ollaborative Research: Antarctic Meteorological Research Center (2006-2009)

## Project Participants

**enior Personnel**

**Name:** Reusch, David
**Worked for more than 160 Hours:** Yes
**Contribution to Project:**

**ost-doc**

**raduate Student**

**Undergraduate Student**

**Technician, Programmer**

**ther Participant**

**esearch Experience for Undergraduates**

## Organizational Partners

**niversity of Wisconsin-Madison**
his 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 nagery that is being analyzed in my part of this collaborative project.

## Other Collaborators or Contacts

## Activities and Findings

**esearch and Education Activities: (See PDF version submitted by PI at the end of the report)**

**Findings:**

**Training and Development:**

**utreach Activities:**

## Journal Publications

## Books or Other One-time Publications

## Web/Internet Site

## Other Specific Products

## Contributions

**Contributions within Discipline:**
A major goal of this project is to show that useful information on the bahavior and characteristics of clouds in south polar latitudes can be extracted from an extensive but single-channel (i.e., infrared) satellite imagery archive. The bulk of such techniques in the existing modern literature require/use measurements from multiple channels on the observing platforms and are thus not applicable to this archive. While not there yet, we are making progress and remain optimistic.

**Contributions to Other Disciplines:**

**Contributions to Human Resource Development:**

**Contributions to Resources for Research and Education:**

**Contributions Beyond Science and Engineering:**

## Conference Proceedings

## Special Requirements

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

## Categories for which nothing is reported:

Activities and Findings: Any Findings
Activities and Findings: Any Training and Development
Activities and Findings: Any Outreach Activities
Any Journal
Any Book
Any Web/Internet Site
Any Product
Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering
Any Conference

Project Activities and Findings

*Major research and education activities*

Summary:
The primary goal of this work was to use the self-organizing map (SOM) data analysis technique on the UWisconsin AMRC satellite archive (i.e., brightness temperatures derived from the satellite infrared composites) to create generalized cloud patterns that are both useful by themselves and for the classification of this imagery into groups, based on the patterns, that tell us something about south polar climate . Such classification can, for example, show us how the data change over time, perhaps due to other aspects of the climate system (e.g., ENSO). This work has been focused on a quadrant of West Antarctica bounded by longitudes 50° W and 140° W, with the southernmost corner at South Pole, and the northernmost corner at roughly 30° S (see Figure 1 for some example imagery).

An analysis like this can go in one of two major directions, each with its own data and processing requirements: simple (i.e., a binary choice of cloud/no cloud) or complex (i.e., a multilevel choice likely to include what "type" of cloud). It is only recently that we have come to realize that it appears that we have mixed our goals with our techniques. That is, we have wanted a cloud/no cloud analysis all along but have, unfortunately, been working with input data and processing steps better suited to the multilevel answer. The outcome to date has thus been overall unsatisfying results, both with respect to our current project goals and to all previous work with this tool and other datasets (e.g., Reusch et al, 2007). Because of this inadvertent disconnect, the main results so far derive more from standard "look at your data first" steps than from the more sophisticated SOM approach. We believe it is still possible to find a methodology that fits with the cloud/no cloud paradigm (see Future Steps below), so we remain hopeful that our goal will still be reached.

Activities:
The work of this project revolves around three areas: preprocessing the input, running the SOM algorithm to create generalized patterns, and postprocessing/analysis of the results to see what can be learned. Focusing first on the SOM methodology (described in greater detail in the original proposal), producing a "useful" SOM fundamentally includes an iterative process of testing a fairly small set of SOM parameters, e.g., grid size (how many patterns?), number of training iterations (are we there yet?), and learning rate (how quickly do we try to push the generalized patterns towards the answer as training progresses?). Varying the parameters over a range of values is part of "best practices" when working with SOMs and we have followed all the standard steps as used in our previous, successful work with datasets such as mean sea level pressure (Reusch et al, 2007) and sea ice (Reusch and Alley, 2007). It was the lack of improved results despite following best practices that encouraged us to question further whether there were aspects of the data itself that we needed to address.

Based on past experience with a variety of datasets, some type of preprocessing of the data was an expected step in our SOM analyses. As this project began, a key question to be answered was whether preprocessing of the input data would be necessary for the SOM-based approach to be successful in creating useful generalized cloud patterns and, in turn, reliable groups of classified

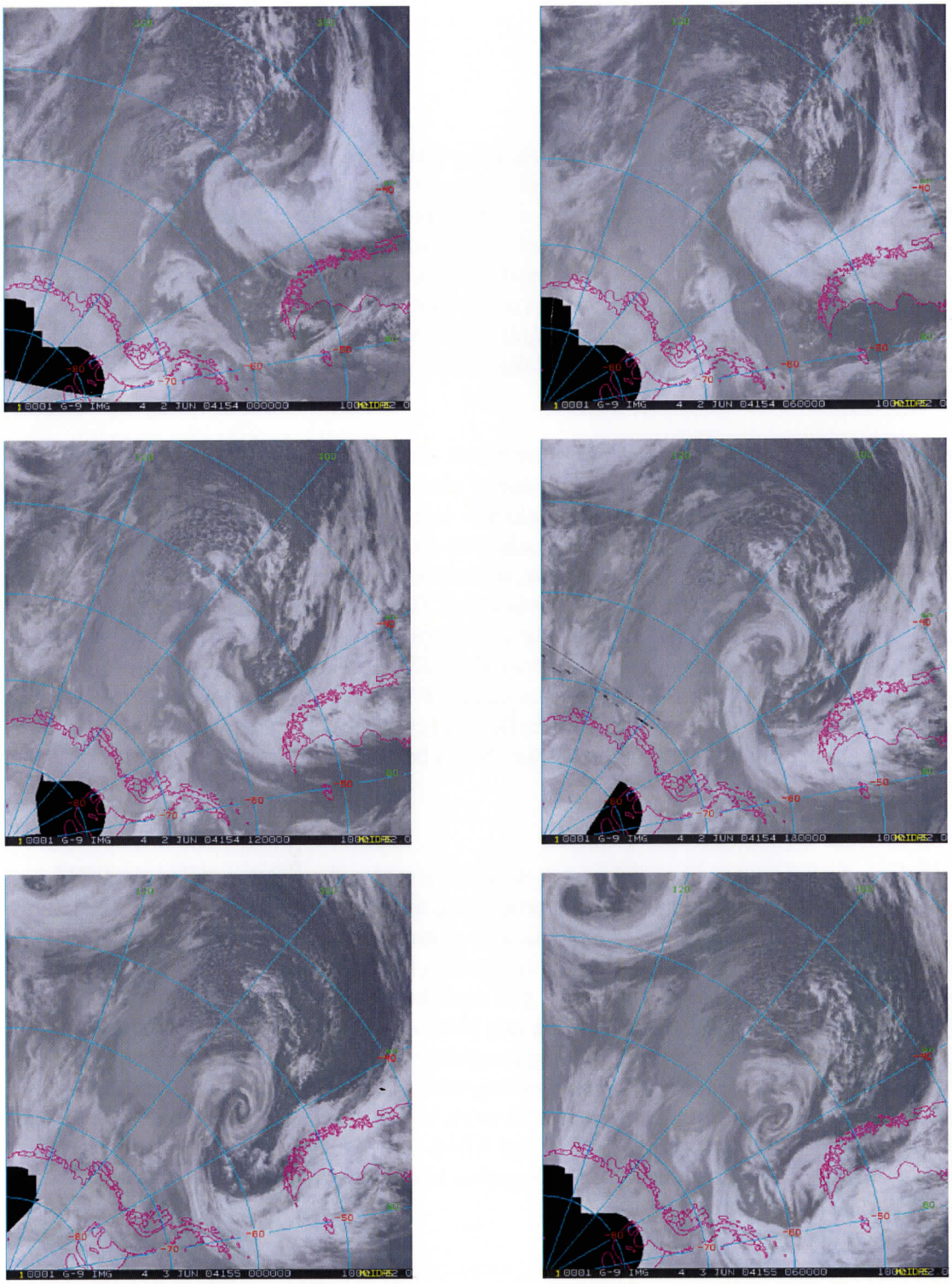


Figure 1. Examples of input satellite imagery: a June sequence from 2004/154/00Z to 2004/155/06Z. Actual data being analyzed does not include the annotation overlays.

images. Given the recent recognition of an inappropriate approach to preprocessing, we will only briefly summarize the work done under this methodology.

*Input datasets*

The size of the input dataset is a significant factor in SOM skill. More input shows more of the dataset range to the SOM. We initially focused on June 2004 at 6-hourly resolution for our pilot work (116 records). As we worked to improve SOM skill, we progressively increased dataset size: 2004/6-hrly (1367 records), 2004/3-hrly (2753 records), 2004-to-2006/3-hrly (8289 records). Frustratingly, this 70+-fold increase of input size lead to no distinct skill improvement. We now have five years of 3-hrly data available for SOM input and will be working with this in upcoming testing.

Note that input data are not immediately accessible from the AMRC data archive. Instead, a number of McIDAS-based batch processing steps must be taken to extract and format the data prior to usage by the SOM. This has been the work of my collaborator, Matthew Lazzara. I was able to meet with Dr. Lazzara once during this project year, at the 3rd Antarctic Meteorological Observation, Modeling and Forecasting Workshop (AMOMWF) held in Madison, June 9-12, 2008. We expect to meet and discuss ongoing work at the MOCA '09 Joint Assembly (IAMAS, IAPSO, IACS) in Montreal this coming July.

*Preprocessing: Basic*

Preparation of the input data for SOM processing first explored two preprocessing approaches that treated the data fairly monolithically: simple thresholding and contrast stretching/histogram binning. Thresholding was done to try to mask out non-cloud data as simply as possible. Values below a fixed brightness value were set to missing so that the SOM would only get the (brighter) data representing the clouds (Figure 2). Contrast stretching/histogram binning followed a similar goal but in a more sophisticated manner. This step was also combined with thresholding.

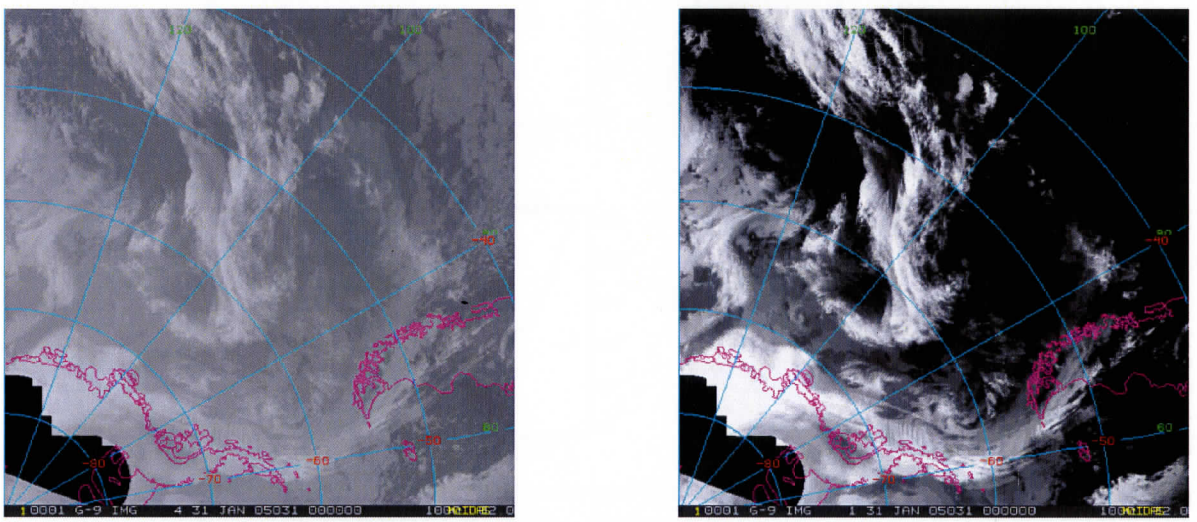


Figure 2. Examples of simple thresholding. Left: Original image from 2005/031/00Z. Right: Values below brightness of 120 have been dropped. Note also that all values south of 75 degrees are also masked during preprocessing. Actual data being analyzed does not include the annotation overlays.

*Preprocessing: Advanced*

After exploring the above approaches, we stepped back and did a proper evaluation of the data itself. This analysis revealed significant spatial (latitudinal, Figure 3) and temporal (annual cycle, Figure 4) gradients, obvious in hindsight, that we hypothesized as problematic for the SOM algorithm. In all prior work with SOMs, we were interested in how the variables being examined change over time and space, e.g., sea level pressure is expected to change spatially and with the seasons and we want the SOM to identify those patterns. As noted above, our analysis is intended to focus on cloud/no cloud, thus temporal and/or spatial changes in the value for "cloud" may actually confuse the SOM. That is, what we see as one cloud pattern, at different times, may be classified as multiple cloud patterns. For example, a cloud in January is seen differently by the SOM from a cloud in the same place in July. The result is a "smearing" in the generalized patterns and reduced SOM skill. As a first step towards resolving this (hypothesized) problem, we removed latitude band-based averages to flatten the spatial

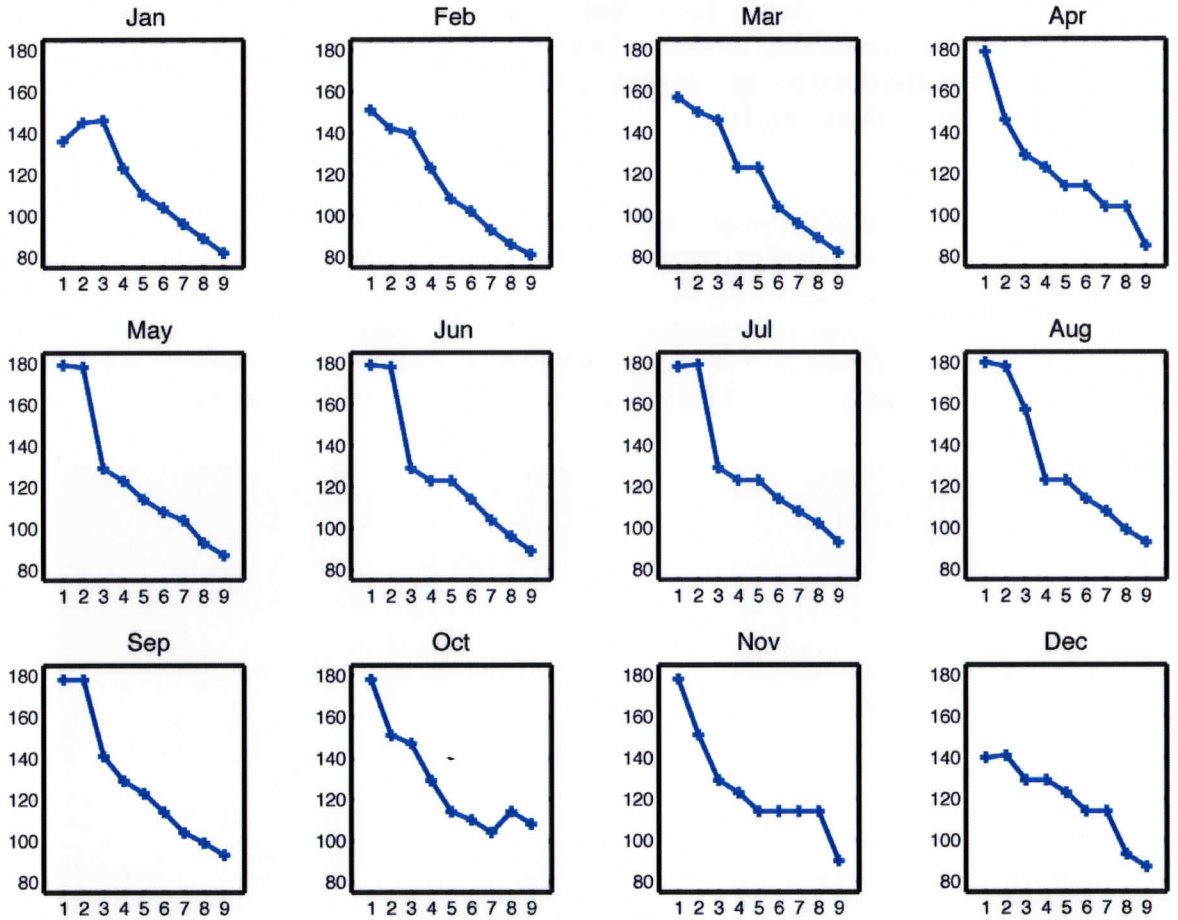



Figure 3. Monthly latitudinal gradients in maximum brightness temperatures for 2004. Data were grouped by month and latitude bin (x axis; five degree bins, starting at 75 deg S and moving north). Each point is the most frequent value from a histogram of each data subset. Brightness values (y axis) are inversely related to temperatures (180 is equivalent to approximately -35 degrees C). Note that higher latitude bins reach a peak of 180 during winter months, possibly due to sea ice.

gradients. Rather than explicitly removing the temporal gradients (i.e., annual cycle), we have focused first on monthly analyses.

As with other processing efforts, these preprocessing steps did not make a significant improvement in SOM skill. In short, preprocessing has turned out to be much more important, and more complex, than originally expected. Although we plan to switch to the cloud/no cloud, binary paradigm (see below), our previous preprocessing work is not a complete loss as some of these ideas should prove useful in converting the data to the new format.

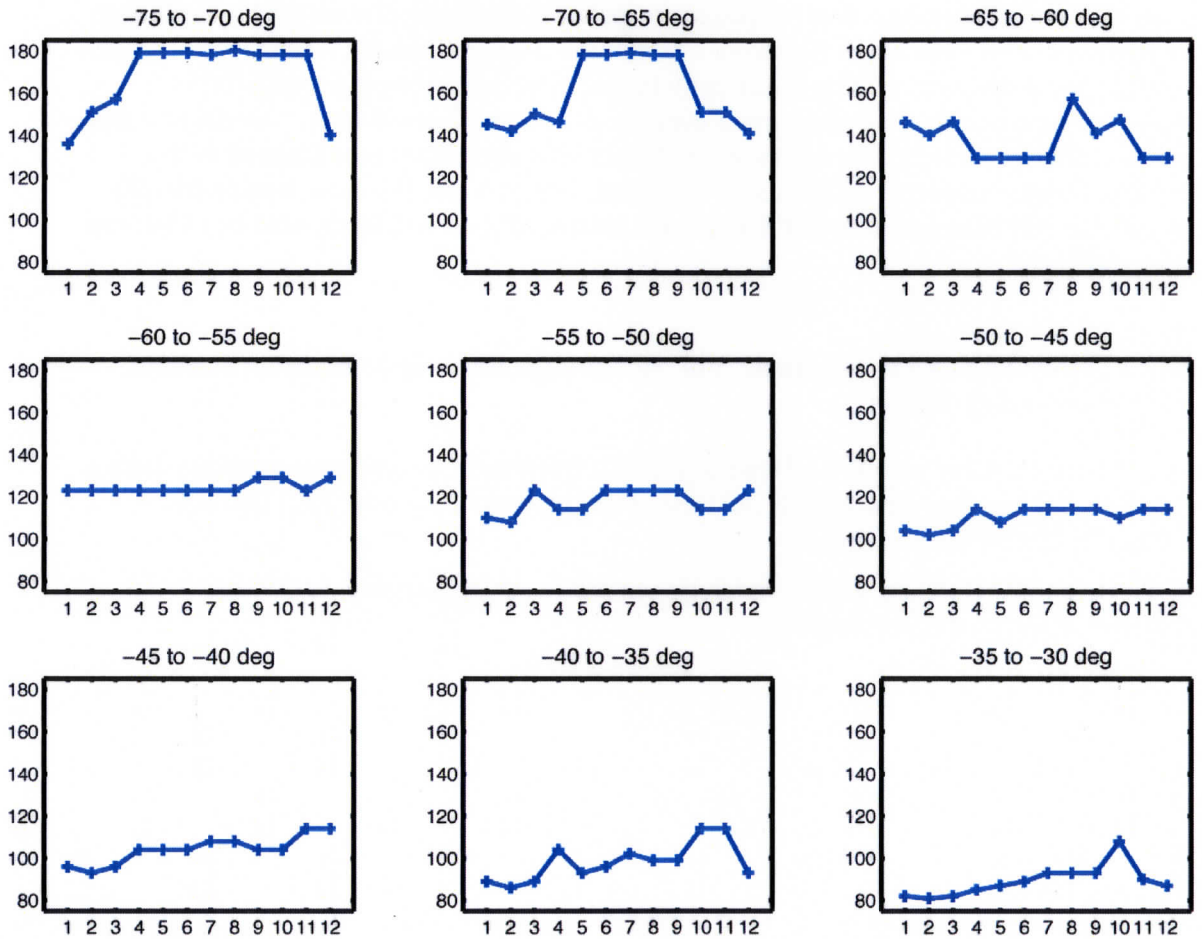



Figure 4. Annual cycles in maximum brightness temperatures for 2004, by latitude bin. Here histograms were based on data subsets by latitude bin (as in Figure 3) then month. Note again the maximum values reached for high latitude bins during winter months.

Work Products

Although results have been unsatisfying to date, a number of useful tools and intermediate results have been produced. With respect to tools, the pre- and postprocessing steps have lead to a number of new command line utilities for the various data modifications and visualization of the SOM results. This has been a mix of C code and scripting in Python, Matlab and NCL (with

associated improved skills with these languages). Similarly, the analyses of spatial/temporal gradients have required other new programming. Lastly, these gradient analyses themselves have potential value for studies of temporal change in this region.

Future Steps

Briefly, there appears to be one major area worth pursuing in further work towards our main goals: converting to the cloud/no cloud, binary world. As outlined above, the identification of cloud patterns appears to be simplified if the input data are first converted to a binary, cloud/no cloud format. This step will require new preprocessing steps as well as changes in the SOM algorithm. Currently, pattern-to-data (or pattern-to-pattern) similarity is measured in Euclidean distance terms, which is fine when the data are continuous but problematic when discrete values are involved. We anticipate needing a similarity metric more suited to binary data for the cloud/no cloud approach to work (Hamming distance is a potential candidate). Developing this new code is a relatively major step in that it will be our first significant modification of the SOM-PAK software (originally published in Kohonen, 1995). Once this new, binary-friendly similarity metric has been added to SOM-PAK, the enhanced code will likely also be of interest to a wider audience.

References

Kohonen, T., 1995: *Self-Organizing Maps*. Vol. 30, Springer Series in Information Sciences, Springer-Verlag, 362 pp.

Reusch, D. B., R. B. Alley, and B. C. Hewitson, 2007: North Atlantic climate variability from a self-organizing map perspective. *Journal of Geophysical Research*, 112, D02104, doi:10.1029/2006JD007460.

Reusch, D. B., and R. B. Alley, 2007: Antarctic sea ice: a self-organizing map-based perspective, *Annals of Glaciology*, 46.

**Annual Report for Period:** 06/2008 - 05/2009
**Principal Investigator:** Reusch, David B.
**Organization:** PA St U University Park
**Submitted By:**
Reusch, David - Principal Investigator
**Title:**
Collaborative Research: Antarctic Meteorological Research Center (2006-2009)

**Submitted on:** 05/05/2009
**Award ID:** 0538064

## Project Participants

**Senior Personnel**

**Name:** Reusch, David
**Worked for more than 160 Hours:** Yes
**Contribution to Project:**

**Post-doc**

**Graduate Student**

**Undergraduate Student**

**Technician, Programmer**

**Other Participant**

**Research Experience for Undergraduates**

## Organizational Partners

**University of Wisconsin-Madison**
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.

## Other Collaborators or Contacts

## Activities and Findings

**Research and Education Activities: (See PDF version submitted by PI at the end of the report)**

**Findings:**

**Training and Development:**

**Outreach Activities:**

## Journal Publications

## Books or Other One-time Publications

## Web/Internet Site

## Other Specific Products

## Contributions

**Contributions within Discipline:**
A major goal of this project is to show that useful information on the bahavior and characteristics of clouds in south polar latitudes can be extracted from an extensive but single-channel (i.e., infrared) satellite imagery archive. The bulk of such techniques in the existing modern literature require/use measurements from multiple channels on the observing platforms and are thus not applicable to this archive. While not there yet, we are making progress and remain optimistic.

**Contributions to Other Disciplines:**

**Contributions to Human Resource Development:**

**Contributions to Resources for Research and Education:**

**Contributions Beyond Science and Engineering:**

## Conference Proceedings

## Special Requirements

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

## Categories for which nothing is reported:

Activities and Findings: Any Findings
Activities and Findings: Any Training and Development
Activities and Findings: Any Outreach Activities
Any Journal
Any Book
Any Web/Internet Site
Any Product
Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering
Any Conference