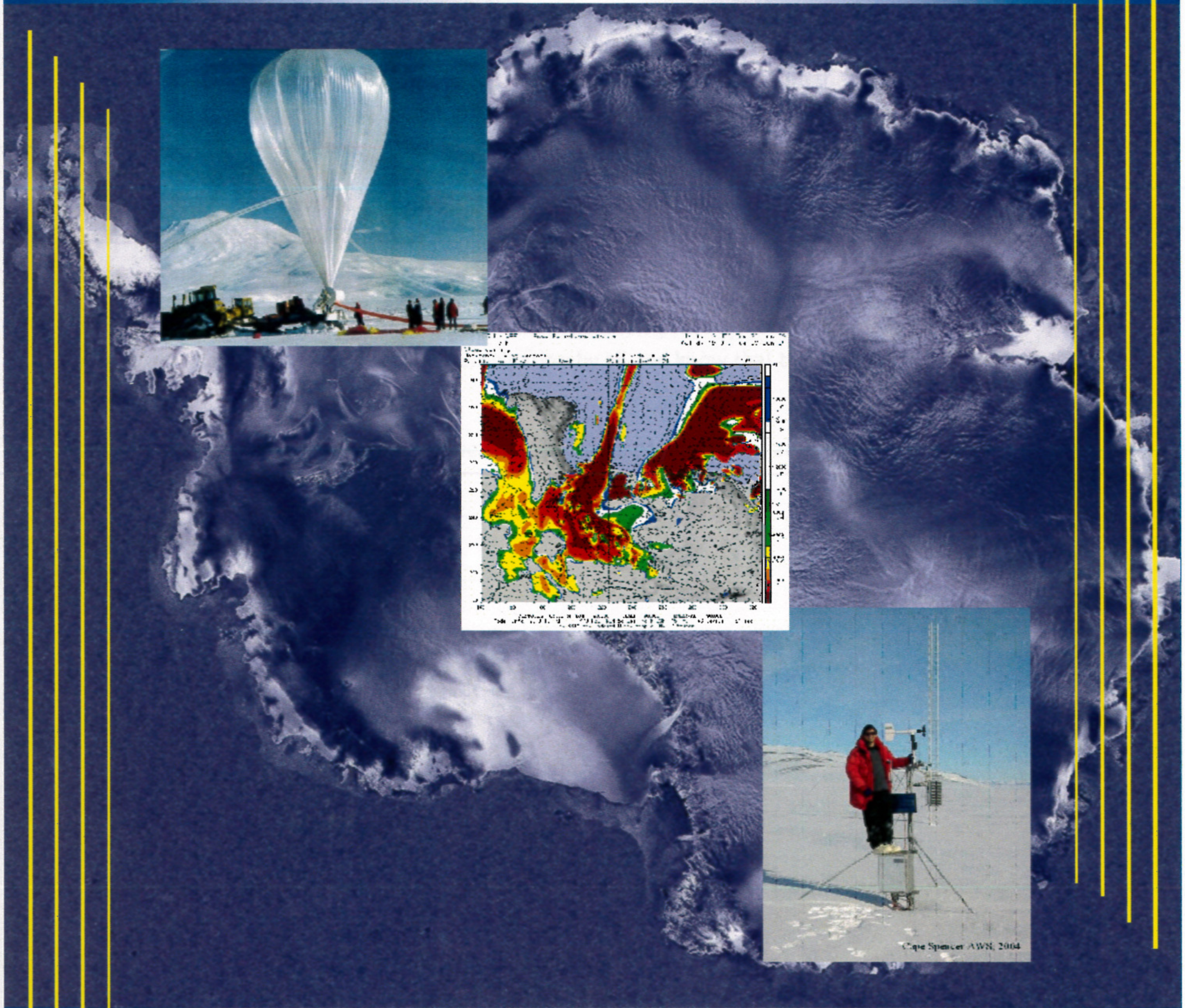
4th Antarctic Meteorological Observation, Modeling, and Forecasting Workshop



SPAWAR Systems Center, Atlantic
Charleston, South Carolina, USA
14-16 July 2009

Preface

The 4th Antarctic Meteorological Observation, Modeling, and Forecasting (AMOMF) Workshop gathers together Antarctic groups with research, operational, and logistical interests in Antarctic meteorology and forecasting. The activities and developments of the Antarctic Meteorological Research Center (AMRC), Antarctic Automatic Weather Station (AWS), and Antarctic Mesoscale Prediction System (AMPS) efforts are addressed and feedback is collected. Beyond this, the workshop serves as a forum for advancements and ideas in Antarctic meteorological observing systems, numerical weather prediction (NWP), and weather forecasting. It is a venue for discussions on the international efforts in Antarctic meteorology and logistical support. Previous workshops have demonstrated that the exploration and discussion of shared goals benefits all in these communities.

This year Space and Naval Warfare (SPAWAR) Systems Center Atlantic in Charleston, South Carolina, is hosting the workshop. We thank SPAWAR and Scientific Research Corporation (SRC) for their support of the meeting.

We thank all of those who submitted papers and will make presentations and who will attend the meetings. We look forward to active participation by all and know that the sessions will be informative and fruitful.

On a personal note, it is a pleasure to welcome professional associates and personal friends to Charleston.

Workshop Organizers
14 July 2009

The 4th Antarctic Meteorological Observation, Modeling, and Forecasting Workshop

Charleston, South Carolina
14–16 July 2009

<u>Monday, 13 July, 2009</u>

1730-1930 Icebreaker, Wando Room, Embassy Suites

<u>Tuesday, 14 July, 2009</u>

Session: Welcome

0900 Welcoming Comments
Michael Peebles, Program Manager, SPAWAR Office of Polar Programs

0915 Workshop Overview

Session: Antarctic Observational Efforts (1)
Chairperson: Ken Edele

0930–0950 Antarctic Automatic Weather Station Program:
2008–2009 Field Season Overview
Matthew A. Lazzara, University of Wisconsin– Madison

0950-1010 Antarctic Automatic Weather Station Program: Future Plans and Discussion
Matthew A. Lazzara, University of Wisconsin– Madison

1010-1030 History of Seaspace Antarctic Support
Hae-Yong Shin, Seaspace Corporation

1030-1100 Break

Session: Antarctic Observational Efforts (2)
Chairperson: John J. Cassano

1100-1120 Antarctic Peninsula Automatic Weather Station Servicing by BAS
for Summer 2008/09
Steven R. Colwell, Tamsin Gray, British Antarctic Survey

1120-1140	South Pole Meteorological Modernization: A Comparison Before and After Installation of a New Instrumentation Suite ✓ Matthew A. Lazzara, University of Wisconsin– Madison
1140-1200	Real-time and Archived Antarctic Meteorological Data Via a Synergy of Interactive Processing Tools ✓ Matthew A. Lazzara, University of Wisconsin– Madison
1200-1330	Lunch
1330-1350	Status Report on the USAP Terascan Systems Andy Archer, Raytheon Polar Services Corporation ✓
1350-1410	VIRTUALPOLE Stefano Dolci, CNR, Italy

Session: Applications of Antarctic Observations
Chairperson: Steven R. Colwell

1410-1430	Plans for UAV Observations of Air-Sea Interactions in the Terra Nova Bay Polynya ✓ John J. Cassano, University of Colorado
1430-1500	Break
1500-1520	Antarctic Atmospheric Motion Vectors: Applications of Antarctic Composite Satellite Imagery ✓ Matthew A. Lazzara, University of Wisconsin– Madison
1520-1540 Poster	Surface Melt Magnitude Retrieval over Ross Ice Shelf, Antarctica Using Coupled MODIS Optical and Thermal Satellite Measurements Christopher Karmosky, Pennsylvania State University
1540-1600	Real-Time Data Processing at BAS and SCAR ✓ Steven R. Colwell, Tamsin Gray, British Antarctic Survey
1600-1630	Discussion: Observations
1630	Adjourn for Day

Wednesday, 15 July, 2009

Session: Antarctic NWP and Modeling (1)
Chairperson: David H. Bromwich

0900–0920	Weather Forecasting at Dronning Maud Land — A Problem of NWP–Model Mix Hans-Joachim Moeller, Deutscher Wetterdienst (DWD)
0920–0940	The Development of a Numerical Weather Prediction Climatology and its Application to Antarctic Weather Forecasting Neil D. Adams, Australian Bureau of Meteorology
0940–1000	AMPS Real-time Forecasts — 2009 Update Kevin W. Manning, National Center for Atmospheric Research
1000–1020	Testing of WRF V3.1 and AIRS Satellite Data in AMPS Jordan G. Powers, National Center for Atmospheric Research
1020–1050	Break
1050–1110	The Impact of Grid Nudging on Forecasts with Polar WRF David H. Bromwich, Aaron Wilson, and F. Otieno, The Ohio State University

Session: Antarctic NWP and Modeling (2)
Chairperson: Jordan G. Powers

1110–1130	Identification of Preferred Physics Options for Polar WRF Simulations in the Arctic John J. Cassano, University of Colorado
1130–1150	The Forecast Performance of Polar WRF in the Antarctic David H. Bromwich and F. Otieno, The Ohio State University
1150–1210	Foehn Winds in the McMurdo Dry Valleys of Antarctica Daniel Steinhoff, The Ohio State University
1210–1330	Lunch
1330–1350	The AMPS Forecast Archive: A Support for Field Programs in Antarctica Julien Nicolas, The Ohio State University
1350–1420	Discussion: NWP and Modeling

Session: Antarctic Forecasting
Chairperson: Chester Clogston

1420–1440	Challenges to Remote Forecasting for Deep-Field Camps Rolf D. Hennig, SPAWAR Office of Polar Programs
1440–1500	Break
1500–1520	SOPP Weather Forecasting Operations Bill Brown, SPAWAR Office of Polar Programs
1520–1540	Antarctic Operational Forecast Availability Ken Edele, SPAWAR Office of Polar Programs
1540	Adjourn for Day
1730	Workshop Dinner, Poogan's Porch, 72 Queen Street, Charleston

Thursday, 16 July, 2009

0900–1200	General Discussions 1) AWS Planning and Issues 2) AMPS Feedback and Support 3) Forecasting Needs and Issues
1200	Adjourn

ANTARCTIC AUTOMATIC WEATHER STATION PROGRAM: 2008-2009 FIELD SEASON OVERVIEW

Matthew A. Lazzara*[,1], George A. Weidner[2], Jonathan E. Thom[1], Shelley L. Knuth[1, 3],
John J. Cassano[3], and Melissa A. Richards[3]

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

1. ABSTRACT

During the 2008-2009 field season over 27 Automatic Weather Station (AWS) sites were visited for servicing, including the installation of 2 new sites: Sabrina AWS (Figure 1) Margaret AWS (Figure 2). This presentation will review the AWS field season activities, repairs, servicing, and installations. The presently known and verified network of all national and international AWS plotted on the map in Figure 3.

2. ACKNOWLEDGEMENTS

The authors wish to thank the Office of Polar Programs at the National Science Foundation ANT-06368783. Thanks goes to Raytheon Polar Services, PHI Helicopters, Ken Borek Air, IPEV, and Mawson's Huts Foundation.

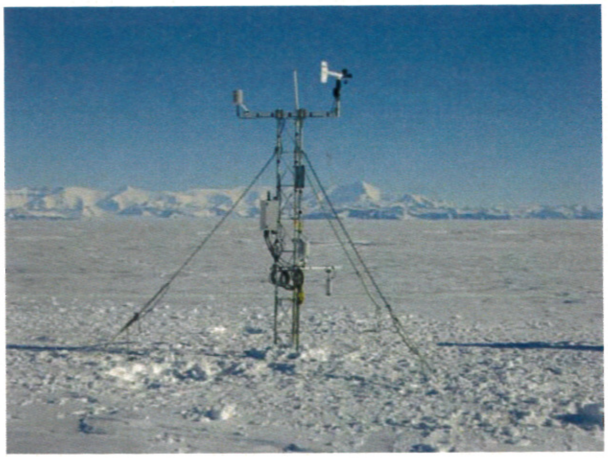

Figure 1. Sabrina AWS installed in January of 2009.

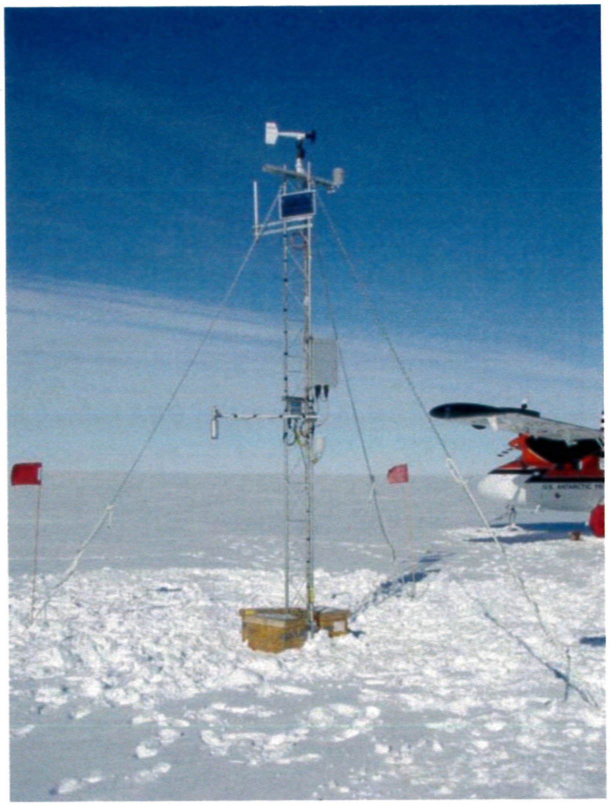

Figure 2. Margaret AWS installed in November of 2008.

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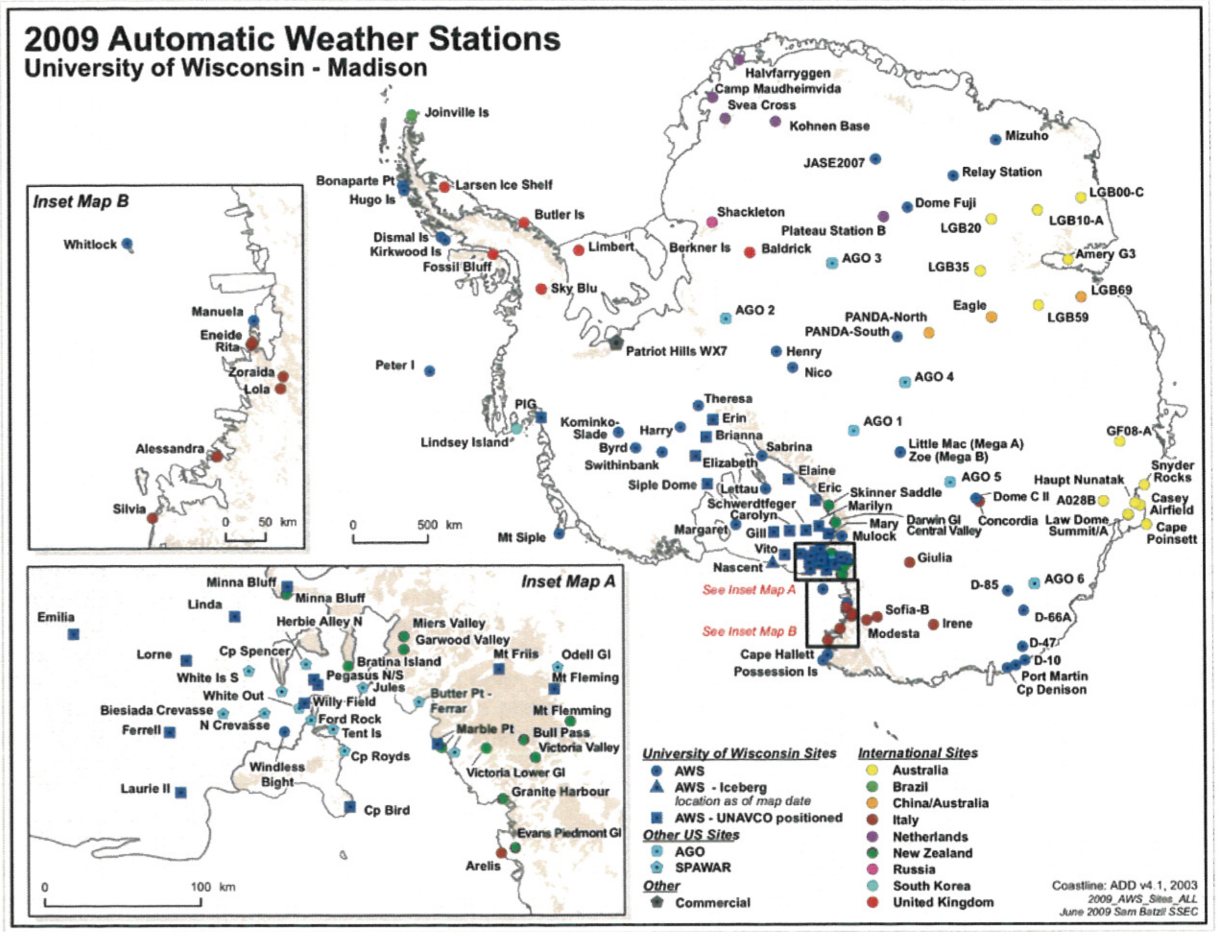

Figure 3. The 2009 Automatic Weather Station map of all verified AWS installed in Antarctica (as of June, 2009).

ANTARCTIC AUTOMATIC WEATHER STATION PROGRAM: FUTURE PLANS AND DISCUSSION

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1. ABSTRACT

The future of the United States Antarctic Program (USAP) Automatic Weather Station (AWS) network has important implications toward the research goals of the network as well as impacts operational and third party users of the observations from the network. This presentation outlines the general plans for the 2009-2010 field season and lays out our proposal for the short to mid-term future of the network. An open forum will follow this presentation to discuss these plans as well as answer questions, and review comments and suggestions for future AWS operations.

2. AWS 2009-2010 FIELD SEASON PLANS

Plans for the 2009-2010 field season fall under two categories: activities by (1)the University of Wisconsin field team and (2) its collaborators. Table 1 outlines the draft plan for the 2009-2010 season by the Wisconsin field team. Efforts are sub-divided into 4 areas: (1) installation of a Tall Tower AWS 100 miles south of McMurdo Station, (2)servicing of AWS sites within helicopter range of McMurdo Station, (3)servicing of AWS sites from fixed wing platform based out of McMurdo Station, (4)servicing of AWS sites in West Antarctica, and one AWS test installation at South Pole.

Collaborations on a national and international basis will permit a multi-regional effort this upcoming season with AWS servicing expected to take place in several areas, as outlined in Table 2. In addition, a recent request for three new AWS installations in support of research and operations in West Antarctica are also scheduled. This will yield some of the first weather observations in this part of Antarctica on a year round basis. These installations would not be possible without collaborative transportation resources

3. FUTURE FIELD SEASONS

Projecting into the future, the AWS network will need to reflect current economic realities, funding limitations, and changes in policy. Overall, the AWS network should meet its primary role to support current and pending proposed NSF funded Antarctic research activities. Table 3 outlines a proposed draft plan. With the shift of Argos communication costs to grantees (and hence incurring additional overhead costs) combined with the current economic situation, funding priorities will be impacted for the AWS network. The number of AWS units deployed will be reduced a small percentage. A number of AWS sites will stay in operation, however, they will formally have new caretakers (and no longer be a part of the Wisconsin network) or will have data collected via a less expensive means (such as via UHF radio modems).

The Wisconsin AWS program continues to actively seek collaborative opportunities that can be accommodated within the framework of the USAP that enhance the AWS program while benefiting the broader community. The primary objective remains to optimize the research capabilites of the largest surface meteorological observing network in Antarctica and effectively augment the other international AWS networks on the continent for the benefit of research and operations. We encourage and look forward to engaging in an active dialog with all interested parties on this important topic.

4. ACKNOWLEDGEMENTS

The authors wish to thanks the Office of Polar Programs at the National Science Foundation ANT-06368783.

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Table 1. AWS Activities planned this season (2009-2010) by U. Wisconsin field team[1]

AWS Site	Latitude	Longitude	Elevation	Status	Field Season Activity	Comments
Tall Tower	78.82° S	173.33°E	Unknown	Not installed – new AWS site	First installation	Site to be renamed, Put-in by traverse and twin otter
Elaine	83.097°S	174.29°E	62 m	Installed Off air	Servicing	Twin Otter
Carolyn	79.939°S	175.884°E	52 m	Installed Off air	Servicing	Twin Otter
Lettau	82.481°S	174.57°E	39 m	Installed	Servicing	Twin Otter
Gill	79.922°S	178.586°W	54 m	Installed	Servicing	Twin Otter
Byrd	80.007°S	119.404°W	1530 m	Installed	Servicing	Twin Otter or LC130 to camp
Siple Dome	81.656°S	148.773°W	668 m	Installed	Servicing	Twin Otter or LC130 to camp
Kominko-Slade (WAIS Divide)	79.466°S	112.106°W	1801 m	Installed	Servicing	Twin Otter or LC130 to camp
Elizabeth	82.607°S	137.078°W	519 m	Installed	Servicing	Twin Otter
Harry	83.003°S	121.393°W	945 m	Installed	Servicing	Twin Otter
Erin	84.904°S	128.828°W	990 m	Installed	Servicing	Twin Otter
South Pole	-90°S		Unknown	Not installed	Install of test AWS (non-transmitting)	LC130 day trip. One year test - only
Cape Bird	77.21°S	166.439°E	38 m	Installed	Servicing	Helicopter
Ferrell	77.846°S	170.819°E	45 m	Installed	Servicing	Helicopter
Laurie II	77.517°S	170.801°E	37 m	Installed	Servicing	Helicopter
Linda	78.426°S	168.418°E	43 m	Installed	Servicing	Helicopter
Marble Point	77.439°S	163.754°E	108 m	Installed	Servicing	Helicopter
Minna Bluff	78.554°S	166.69°E	895 m	Installed	Servicing	Helicopter

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[1] This list is subject to modification based on any AWS failures that may occur before the start of the field season. Some sites may not be visited due to limited logistics or weather. This list is not in priority order.

Table 2. AWS Activities planned this season (2009-2010) by U. Wisconsin collaborators [2]

AWS Site	Latitude	Longitude	Elevation	Status	Collaborator	Comments
Pegasus North	77.952oS	166.5oE	10 m	Installed – needs servicing	John Cassano	USAP - O-400-M
PIG Helo Camp (Site C)	75.6°S	99.917°W	Unknown	Not installed – new AWS site	David Holland field team (includes UNAVCO)	USAP - WAP
Thurston Island	72.53°S	97.56°W	Unknown	Not installed – new AWS site	David Holland field team (includes UNAVCO)	USAP - WAP - POLENET
Bear Peninsula	74.546°S	111.88°W	Unknown	Not installed – new AWS site	David Holland field team (includes UNAVCO)	USAP - WAP - POLENET
E-66	68.912°S	134.655°E	2485 m	Installed – needs repair	Christophe Genthon	France - IPEV
Port Martin	66.82°S	141.39°E	39 m	Installed – needs repair	Christophe Genthon	France - IPEV
Dome Fuji	77.31oS	39.7°E	3810 m	Installed – needs repair	Takao Kameda	Japan - JARE
Relay Station	74.017°S	43.062°E	3353 m	Installed – needs repair	Takao Kameda	Japan - JARE
Cape Denison	67.009°S	142.664°E	31 m	Installed – needs servicing	Rob Easther	Mawson's Huts Foundation
Panda South	82.325°S	75.989°E	4027 m	Installed – needs repair	Bian Ligen, Cunde Xiao	China - CHINARE

[2] This list is not in priority order and is subject modification.

Table 3. AWS Activities proposed in future years (pending funding and is subject change).

AWS Site	Latitude	Longitude	Elevation	Plan	Comments
I-157 Fuel cache	78.0°S	96.03°W	Unknown	New AWS install	Proposal pending with NSF. Install proposed 2010-2011
I-189 Fuel Cache	77.17°S	123.4°W	Unknown	New AWS install	Proposal pending with NSF. Install proposed 2010-2011
Swithinbank	81.201°S	126.177°W	959 m	AWS removal	Proposal pending with NSF. Removal proposed 2010-2011 or 2011-2012
Brianna	83.889°S	134.154°W	525m	AWS removal	Proposal pending with NSF. Removal proposed 2010-2011 or 2011-2012
Theresa or Harry	Theresa: 84.599°S Harry: 83.003°S	Theresa: 115.811°W Harry: 121.393°W	Theresa: 1463 m Harry: 945 m	AWS removal	Proposal pending with NSF. Removal proposed 2010-2011 or 2011-2012 – exact site to be removed to be determined.
Larsen Ice Shelf, Bulter Island, Sky Blu, Limbert, Baldrick	Various	Various	Various	AWS communications hand over to British Antarctic Survey	United Kingdom takes over AWS completely in 2010-2011 or 2011-2012 field seasons.
Minna Bluff, Linda, Lorne, Ferrell, Laurie II, Windless Bight, Willie Field, Pegasus North	Various	Various	Various	AWS communications switch from Argos DCS to UHF/VHF modem	Proposal pending with NSF. Switch to take place over 2 field seasons 2010-2011 and 2011-2012. Exact sites pending communications tests.
Mt. Friis, Mt. Fleming	77.533°S 77.747°S	160.271°E 161.516°E	1950 m 1580 m	Removal of Argos DCS communications	AWS returned to original PIs or removed.
Megadunes AWS (Little Mac, Zoe, etc.)	~80.7°S	~124.45°E	~2884 m	Removal of older AWS, and leave one working AWS	Proposal Pending with NSF for 2010-2011 field season

AWS Site	Latitude	Longitude	Elevation	Plan	Comments
Mt. Siple, Possession Island, Kirkwood Island	Various	Various	Various	AWS sites with no logistics plans to visit for repair	As sites fail, they will not be replaced or repaired
Dismal Island	68.087°S	68.825°W	10 m	AWS may be adopted by BAS	Future unknown, under discussion
Ross Ice Shelf site 1, Ross Ice Shelf site 2	Near Sabrina AWS - TBD	Near Sabrina AWS - TBD	Near Sabrina AWS - TBD	New AWS install – temporary for 2 years	Proposal pending with NSF. Installation in 2010-2011 and removal in 2012-2013
Henry	89.011°S	1.025°W	2755 m	AWS Removal	Proposal pending with NSF. Removal proposed 2010-2011 or 2011-2012. Recommend AWS site to be taken over by McMurdo Weather
Nico	89.00°S	89669°E	2935 m	AWS Removal	Proposal pending with NSF. Removal proposed 2010-2011 or 2011-2012. Recommend AWS site to be taken over by McMurdo Weather
Whitlock	76.144°S	168.392°E	206 m	AWS repair	Proposal pending with NSF. Repair pending availability of over-water helicopters.
Peter I Island	68.769°S	90.67°W	90 m	AWS replacement	AWS installed, but not working. Proposal pending with NSF. AWS replacement proposed 2010-2011, and depends on availability of helicopters on the Oden.

HISTORY OF SEASPACE ANTARCTIC SUPPORT

Hae-Yong Shin

SeaSpace Corporation
Poway, California, USA

SeaSpace has been active in the Antarctic scientific activities by supplying a number of remote sensing ground stations from direct broadcast satellites. The primary telemetries down-linked are MODIS from Terra and Aqua satellites, HRPT from NOAA satellites, RTD from DMSP satellites, and GVAR from GOES satellites. The down-linked data is processed by TeraScan software to produce level 1 and level 2 products. These data products are used for the study of atmospheric and oceanographic applications over Antarctic continent and surrounding water bodies, and to support navigation operations through air and sea. Through over 20 years of Antarctic experiences SeaSpace has accumulated vast knowledge of building very reliable equipment that can survive harsh environment and providing valuable data during mission critical times. SeaSpace will continue to support Antarctic efforts by developing and implementing new products and by supporting sensors that will be flown in the future missions.

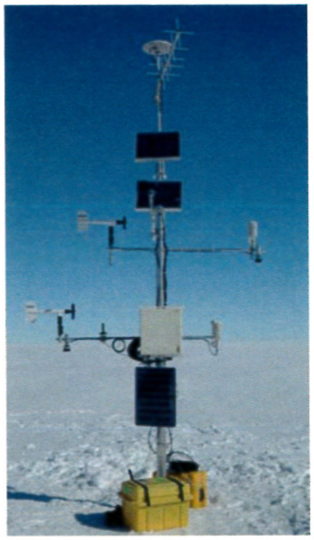
Antarctic Peninsula Automatic Weather Station Servicing by BAS for Summer 2008/09

Steve Colwell and Tamsin Gray
British Antarctic Survey

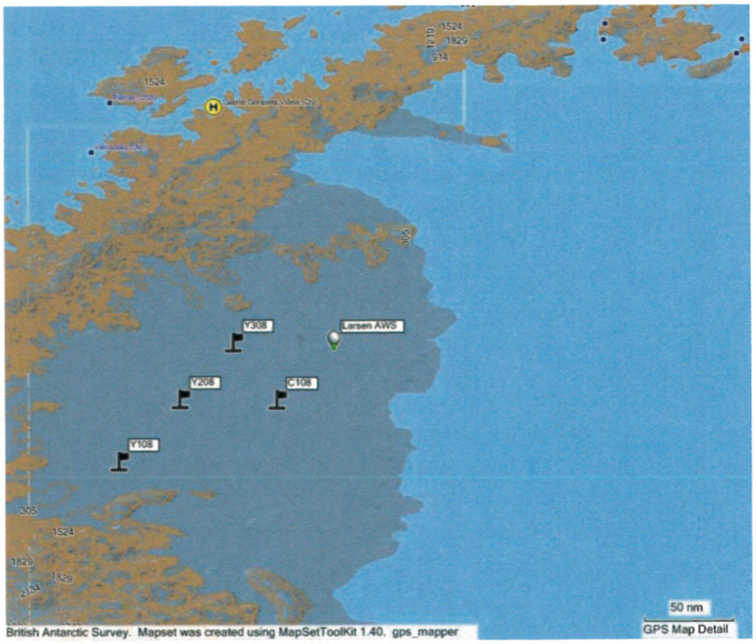
The British Antarctic Survey service 5 AWS on the Antarctic Peninsula. The AWS are Fossil Bluff, Sky Blu, Limbert, Butler Island and Larsen Ice Shelf, all are currently operating well. All of these AWS have now had Iridium modems installed and this then allows the data to be downloaded once a week and then allows completed CLIMAT messages to be calculated and the 10 minute values are also being uploaded onto the university of Wisconsin ftp site on a monthly basis.

A Kipp and Zonen CNR1 radiation sensor was installed on the Larsen AWS this season and that gives incoming and outgoing long-wave and short-wave radiation, this sensor seems to be operating well.

In addition, six new AWS were installed out of. Five of these are spread across the Larsen C ice shelf in a collaborative project between NSF (led by Konrad Steffen), IMAU (led by Michiel van den Broeke) and BAS (led by John King), in the locations marked below. One of the IMAU AWS is co-located with the BAS Larsen AWS.



NSF AWS with GPS, net radiation sensor and two sets of wind, temperature and humidity sensors spaced one metre apart. Three identical stations were installed on Larsen C this season.



All of these stations are also equipped with GPS and are transmitting data via the ARGOs or GOES satellite networks. An AWS was installed on the Fleming Glacier, just north of Alexander Island on the mainland, by the University of Valdivia, Chile, although this is not transmitting data at present.

Baldrik AWS was visited to replace the suspect pressure sensor, add an extra battery box and to download the data and this AWS is now operating well.

An AWS was also installed at Thiel Mountains by a collaborative effort between Ronald Ross and ALE (Antarctic Logistics & Expeditions) and the data from this AWS is being downloaded every hour via Iridium and it is then processed at BAS and inserted onto the GTS with WMO number 89087.

READER is in the process of being updated to the end of February 2009 to make the data complete for IPY.

The International Antarctic Forecasting Handbook has been turned into web pages and can be accessed at
http://www.antarctica.ac.uk/met/momu/International_Antarctic_Weather_Forecasting_Handbook/index.htm

Steve Colwell has been selected as the new chair of the SCAR Expert Group on Operational Meteorology in the Antarctic and one plan is to pull together all of the records of temperature, pressure wind speed and wind direction from surface stations, AWS and upper air stations and make the individual observations, in a standard format, available via a Google Earth style interface

Archive
Web
pages ✓

SOUTH POLE METEOROLOGICAL MODERNIZATION: A COMPARISON BEFORE AND AFTER INSTALLATION OF A NEW INSTRUMENTATION SUITE

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1. ABSTRACT

The Amundsen-Scott South Pole surface meteorological instrument suite was upgraded in 2004 as a part of the South Pole Station Modernization (SPSM) program. To ensure that the new and old instruments were recording similar information, the old and new suites of instruments ran simultaneously for a year. Statistical analysis of the time series of temperature, pressure and wind reports was used to determine if there were any significant differences in the observations. The results of the analysis found a pressure bias was introduced in the new suite as well as a systematic sign change between summer and winter. Significant differences were found in the winter months for temperature and wind speed, while no differences are found for wind direction distribution.

There were are also noticeable differences in wind speed between the Clean Air platform near the Clean Air facility and the platform at the approach end of the skiway. Wind speeds are lower at the skiway when the wind is from the northeast quadrant and lower at the Clean Air tower when the wind is from the southwest quadrant, reflecting the effect of increased roughness due to the station structures on the airflow across the station. Clean Air also often reports lower speeds than the skiway in flow from the southeast, most likely due to interference from a building in that sector.

2. ACKNOWLEDGEMENTS

The authors would like to thank Michael Carmody and Raytheon Polar Services Corporation as well as the Meteorological Technicians at Amundsen-Scott South Pole Station for providing the data and information on the instrument suites. We would like to thank George Weidner of the Antarctic Automatic Weather Station Program at the University of Wisconsin-Madison for discussions about the instrument characteristics. The National Science Foundation Grant ANT-0537827 provided support for this research.

3. REFERENCE

Keller, L.M., K.A. Hill, M.A. Lazzara and J. Gallagher, 2009: A comparison of meteorological observations from South Pole Station before and after installation of a new instrument suite. *J.Tech.*, accepted.

Table 1. Instruments and specifications for South Pole observations for both the old and new sensors.

Sensor	Location	Sensor	Operating Range	Accuracy
Temp.	CAT	RM Young	Down to -80C	+/- 0.2C
	DOME	Omega Platinum RTD	N/A	+/- 0.2C
Pressure	CAT	Druck	Down to -40C	+/- 0.75 hPa
	DOME	Navy Digital	N/A	+/- 0.30 hPa
Winds	CAT, SKI	RM Young	-70C to +55C	+/- 0.67 mph
	DOME	RM Young	-70C to +55C	+/- 0.67 mph

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Figure 1. An aerial photograph taken on January 29, 2005 showing the location of the observation towers at South Pole Station. The red arrow points to the location of the SKI set of instruments (which are off the left side of the photo beyond the radome). The red circle shows the location of the CAT instruments and the yellow circle indicates the location of the DOME instruments. The picture is looking to the north-northwest. (Photo courtesy of Bill Henriksen, NSF.)

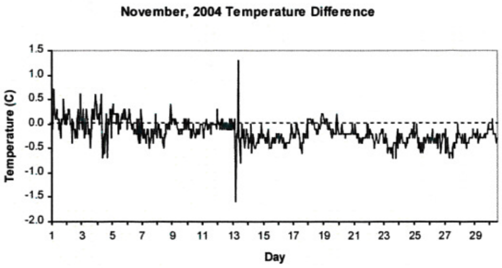

Figure 3. Difference in temperature for the DOME observations minus the CAT observations for November, 2004.

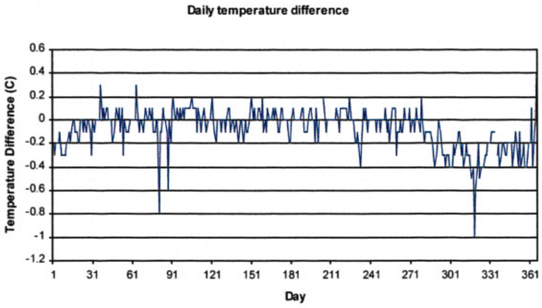

Figure 4. Mean daily temperature differences for February, 2004 through January, 2005.

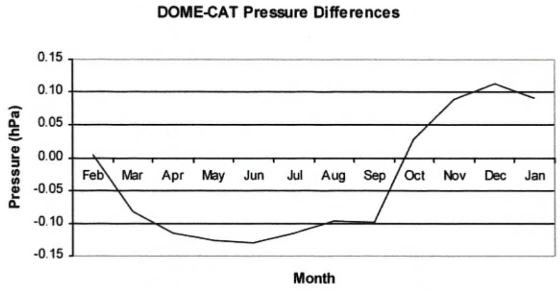

Figure 6. Difference in mean monthly pressure for the DOME observations minus CAT observations during the study period.

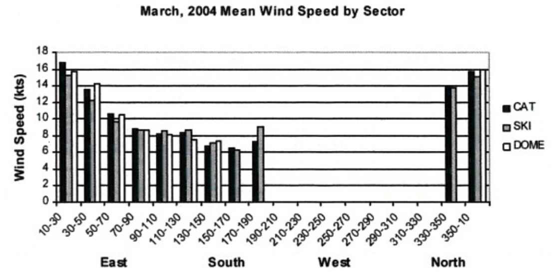

Figure 7. Wind speed in knots by 20 degree sectors for March, 2004 for each of the studied sites (CAT, SKI, and DOME).

REAL-TIME AND ARCHIVED ANTARCTIC METEOROLOGICAL DATA VIA A SYNERGY OF INTERACTIVE PROCESSING TOOLS

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http://motherlode.ucar.edu/repository/entry/show/RAMADDA/Projects/Antarctic+IDD

1. ABSTRACT

Over the last four years real-time numerical weather prediction, satellite and observational data have been distributed across the Antarctic Internet Data Distribution (Antarctic-IDD) system, a data-sharing network based on Unidata's Local Data Manager (LDM) software (Lazzara et al., 2006). The distribution of data through the Antarctic-IDD has proven to be a successful way to easily distribute the real-time data.

Recently, collaboration among United States Antarctic Program (USAP) and Unidata Program Center personnel has resulted in the establishment of a UCAR-based facility that provides programmatic and human-interactive access to the rich datasets available in the Antarctic-IDD. This effort employs the Unidata-developed Repository for Archiving, Managing and Accessing Diverse DAta (RAMADDA), Thematic Real-time Environmental Distributed Data Services (THREDDS) Data Server (TDS) and Man computer Interactive Data Access System (McIDAS) Abstract Data Distribution Environment (ADDE) server technologies. Transparent, programmatic access to the data served by RAMADDA, THREDDS and ADDE is freely available through a variety of data analysis and visualization applications including the Unidata Integrated Data Viewer (IDV) and University of Wisconsin (UW) Space Science and Engineering Center's (SSEC) next generation McIDAS, McIDAS-V.

Users can now access, analyze, and visualize real-time Antarctic numerical model, satellite and observational data from their local machine without any additional resources than having IDV or McIDAS-V installed and an Internet network connection. Future plans include establishment of real-time and archive RAMADDA/TDS server capability at the SSEC that will be jointly managed by the AMRC and SSEC Data Center and will provide free and open access to Antarctic meteorological datasets and information.

2. ACKNOWLEDGEMENTS

The authors wish to thanks the Office of Polar Programs at the National Science Foundation ANT-0537827.

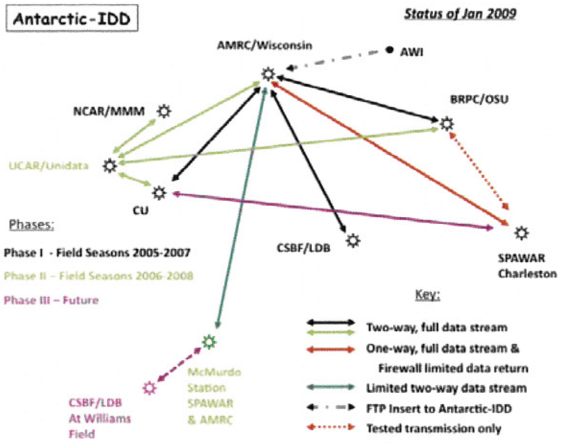

Figure 1. Status of the Antarctic-IDD as of January 2009

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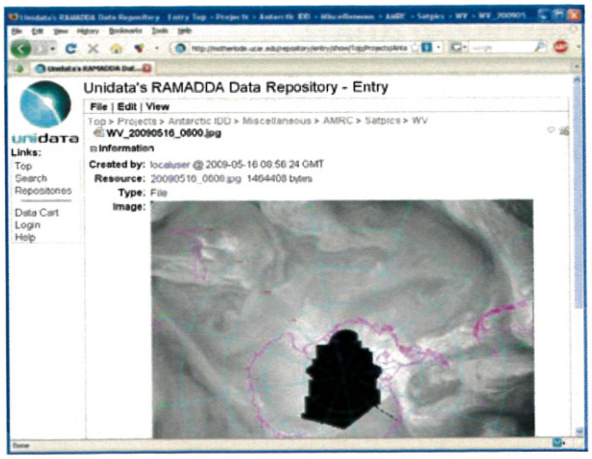
Unidata's RAMADDA Data Repository - Entry

Top > Projects > Antarctic IDD > Miscellaneous > AMRC > Satpics > WV

WV_20090516_0600.jpg

Information

Created by: localuser @ 2009-05-16 08:58:24 GMT

Resource: 20090516_0600.jpg 1464408 bytes

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Figure 2. A sample AMRC Antarctic composite water vapor image seen via the RAMADDA Data Respository.

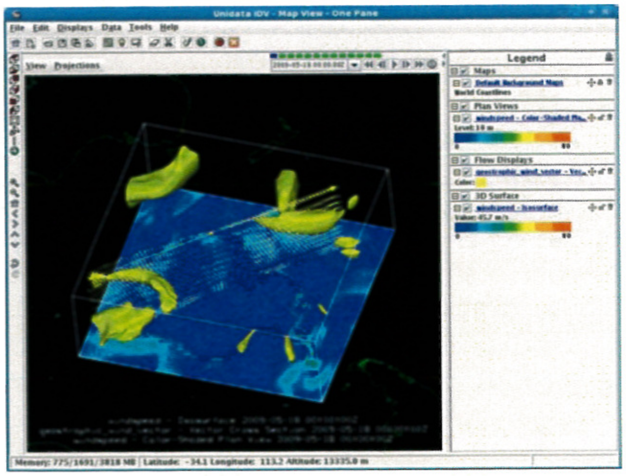

Figure 3. A display of AMPS numerical model output rendered in IDV with data severed from the Unidata RAMADDA server.

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STATUS REPORT ON THE USAP TERASCAN SYSTEMS

Andrew Archer
Raytheon Polar Services Company

This presentation will cover the state of the USAP TeraScan systems at all sites.

VIRTUALPOLE

Stefano Dolci

P.N.R.A. S.C.r.l
Rome, Italy

VirtualPole is an application that allows virtual exploration of Antarctica through the main installations built and operated by man in order to support logistic activities and scientific research. The innovative way of handling satellite images introduced by Google EarthTM enables visualizing and knowing every corner of the planet with the greatest of ease, and yet exploration of Antarctica still remains a demanding task because of poor information Google provides about this continent, the few points of geographical reference compared with the extent of territory and the unfamiliarity with it. Using a simplified Web interface, VirtualPole helps user to interrelate data with geographical location and returns results of queries using the most suitable tools and graphic solutions among those Google EarthTM platform makes available. Current version of the product, in advanced prototyping phase, allows testing adopted solutions through the use of placemarks, balloons, tematic layers and 3D models applied to real data of various typology.

PLANS FOR UAV OBSERVATIONS OF AIR-SEA INTERACTIONS IN THE TERRA NOVA BAY POLYNYA

John J. Cassano, Shelley Knuth, and Melissa Richards

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University of Colorado
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The first NSF funded unmanned aerial vehicle (UAV) use in Antarctica will take place during September 2009. The project will use Aerosonde UAVs to observe air-sea interactions at the Terra Nova Bay polynya. The presentation will provide an overview of the project goals, discuss the logistics and weather forecasting concerns for the UAV operations, and provide a brief overview of the late-winter climatology in the Terra Nova Bay region.

ANTARCTIC ATMOSPHERIC MOTION VECTORS: APPLICATION OF ANTARCTIC COMPOSITE SATELLITE IMAGERY

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1. ABSTRACT

Wind information has been estimated with geostationary satellite data for many years (Velden et al., 2005) and more recently using polar-orbiting satellites (Key et al., 2003). However, from the point of view of the Antarctic, there is a latitudinal gap in coverage between these two wind sets as depicted in Figure 1. This has inspired an investigation using Antarctic composite imagery – a combination of geostationary and polar orbiting observations (Lazzara et al., 2003) – for the generation of atmospheric motion vectors (AMV),.

One requirement for this investigation is to increase the temporal resolution of the infrared Antarctic composites from three-hourly to hourly, thereby providing wind information on the same temporal scale as with geostationary satellites. This will also be a benefit for other research and operational users of the composite. These hourly composites, although already accessible on some AMRC/Wisconsin servers, will be made more broadly available to the community in the upcoming months. The improved methodology resulting in the successful creation of hourly infrared composites over the Antarctic and adjacent Southern Ocean will be applied to other composites made over the Antarctic and Arctic (Lazzara and Knuth, 2009), as increases in their temporal resolution are planned in the near future.

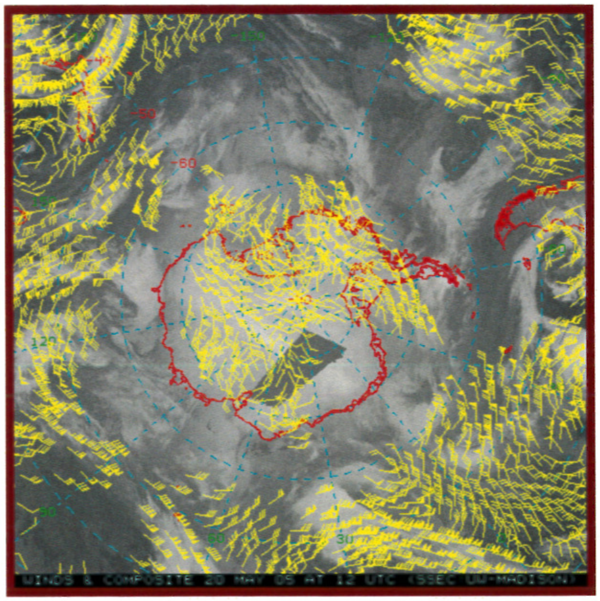

Figure 1. A sample Antarctic composite with geostationary and polar orbiting satellite derived atmospheric motion vectors plotted, which reveal the "ring" of missing observations about the continent.

AMVs are being derived routinely from the composite observations (Figure 2) to build a dataset large enough to assess the quality of the winds. While the composites have the strength of observations from both geostationary and polar-orbiting platforms, it is not yet clear how accurate the wind information is, given the very limited radiosonde and aircraft data in the Southern Hemisphere that can be used for validation Initial but limited comparisons with radiosonde and aircraft wind observations indicate a vector root mean squared error of 9 ms^{-1}. However, tests to optimize the

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quality of the AMVs are currently being worked on.. While verification and validation activities are currently ongoing, it is expected that this activity will continue through the upcoming 2009-2010 field season. This brings rise to the critical importance of aircraft reports (AIREPs) from US Antarctic Program aircraft (e.g. 109th New York Air National Guard LC-130s, Royal New Zealand Air Force C-103, US Air Force C-17) and other aircraft that fly missions between the middle latitudes and the Antarctic. Their observations of winds enroute has the potential to provide a significant set of validating observations needed to determine if the composite AMVs will be on the order of accuracy as its cousin polar-orbiting and geostationary wind sets.

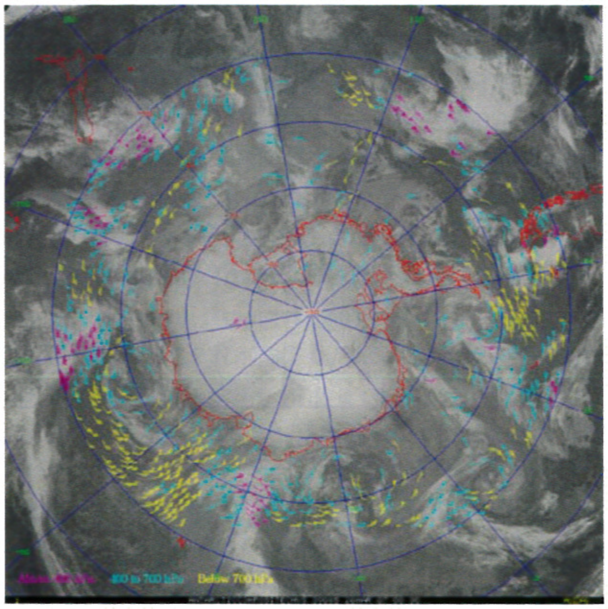

Figure 2. A sample hourly Antarctic composite imagery with corresponding atmospheric motion vectors from 7 UTC on 26 March 2009.

2. ACKNOWLEDGEMENTS

The authors wish to thanks the Office of Polar Programs at the National Science Foundation ANT-0537827. Thanks go to Jerry Robaidek at the SSEC Data Center for his assistance with the temporal improvements in the composites used in the project.

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SURFACE MELT MAGNITUDE RETRIEVAL OVER ROSS ICE SHELF, ANTARCTICA USING COUPLED MODIS OPTICAL AND THERMAL SATELLITE MEASUREMENTS

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Ice shelf stability is of crucial importance in the Antarctic because shelves serve as buttresses to glacial ice advancing from the Antarctic Ice Sheet. Surface melt has been increasing over recent years, especially over the Antarctic Peninsula, contributing to disintegration of shelves such as Larsen. Unfortunately, we are not realistically able to quantify surface snowmelt from ground-based methods because there is sparse coverage in automatic weather stations. Satellite based assessments of melt from passive microwave systems are limited in that they only provide an indication of melt occurrence and have coarse resolution. Though this is useful in tracking the duration of melt, melt amount of magnitude is still unknown. Coupled optical/thermal surface measurements from MODIS were calibrated by estimates of liquid water fraction (LWF) in the upper 1cm of the firn derived from a one-dimensional thermal snowmelt model (SNTHERM). SNTHERM was forced by hourly meteorological data from automatic weather station data at reference sites spanning a range of melt conditions across the Ross Ice Shelf during a relatively intense melt season. Melt intensities or LWF were derived for satellite composite periods covering the Antarctic summer months at a 4km resolution over the entire Ross Ice Shelf, ranging from 0-0.5% LWF in early December to areas along the coast with as much as 1% LWF during the time of peak surface melt. Spatial and temporal variations in the amount of surface melt are seen to be related to both katabatic wind strength and wind shifts due to the progression of cyclones along the circumpolar vortex. A future application of surface melt mapping using this empirical retrieval model is to determine melt magnitude over other Antarctic Ice Shelves, such as Larsen, where surface melt has been well documented in contributing to the disintegration of the ice shelf.

WEATHER FORECASTING AT DRONNING MAUD LAND - A PROBLEM OF NWP-MODEL MIX

Hans-Joachim Moeller

Alfred Wegener Institute (AWI) / Deutscher Wetterdienst (DWD)

Each NWP-Model is not good enough by half to meet the forecaster requirements. So it must improve such as post processing, statistic methods or comparing with other models. Because of missing first and second one the last one is carried out for weather forecasting at Droning Maud Land. The forecaster uses a NWP-Model-Mix whereas the weight functions are functions of scale, forecast time, consistency, systematic error, model tendency, model product etc. Because of short time of operating experience and also missing verification data the functions and its value must sized by the forecaster themselves. To define the real values of the functions for each model run twice a day is a labor and time intensive job. It can be done at Dronning Maud Land only by the meteorologist, with accurate education in synoptic and numeric meteorology and long experience in polar weather forecasting, but is just as much instinctive.

The Development of a Numerical Weather Prediction Climatology and it's Application to Antarctic Weather Forecasting.

Dr. Neil Adams*

June 23, 2009

1 Introduction

Researchers at the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC) are involved in the development of a sea-ice analysis and forecasting system that ultimately will provide the Australian Antarctic community with an operational sea-ice analysis and forecasting tool to assist navigation at sea, and local Antarctic sea-ice research. The core of the forecasting system is version four of the Los Alamos National Laboratory's Community Ice (CICEv4) model (Hunke et al. 2008). The system is primarily designed to run in a coupled mode with global climate and ocean models. However, it can be run in a stand-alone mode, and the ACE CRC development team have implemented the CICEv4 code as a regional sea-ice model covering only the southern hemisphere, using the same polar-stereographic grid as employed by the Australian Bureau of Meteorology's polar-stereographic Limited Area Prediction System - polarLAPS (Adams in press). The rationale behind employing the same grid as the polarLAPS model is the ease with which atmospheric forcing data can be ingested by the sea-ice model. The data assimilation system under development for the sea-ice model is based on the Bluelink Ocean Data Assimilation (BODAS) system (Oke et al. 2007), with the initial version expected to assimilate only sea-ice concentration data. BODAS is an optimal interpolation system requiring error covariance matrices for each of the state variables, and these matrices need to be generated from a suitably long climate run of the sea-ice forecast system. To provide the atmospheric forcing data for the climate run polarLAPS was run from 1 January 1998 to 31 December 2008, nested within NCEP-DOE Reanalysis-2 data (Kanamitsu et al. 2002). Although these model runs were primarily performed to provide forcing data for the sea-ice forecasting system they also have the potential to provide a wealth of data to Antarctic weather forecasters. With 11 years of model data it is possible to carefully look at model statistics in the form of model biases and errors and to also provide forecasters with a unque data-set over those parts of Antarctica for which there are no long term surface or upper air observational records. The follow paper introduces some of the analysis undertaken to describe the polarLAPS model climatology, and potential benefits to Antarctic weather forecasting.

2 The modelling system

PolarLAPS is a polar-stereographic implementation of the ALAPS model (Adams 2004) and designed to overcome some of the more serious short-comings of ALAPS resulting from converging meridians towards the southern boundary and the proximity of the domain boundaries to the main forecast areas of interest. In it's current form polarLAPS runs as a down-scaling system and in forecast mode is nested within output from the National Centers for Environmental Prediction Global Forecast System (NCEP-GFS) (www.emc.ncep.noaa.gov/modelinfo/index.html).

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For the climate runs the NCEP-DOE Reanalysis-2 data (Kanamitsu et al. 2002) was used to provide initial and boundary conditions for the forecast runs, and over the 11 year period the model was re-initialised every 24 hours at 0000 UTC, with model output from +12 hours out to +36 hours saved from each run. The 11 year climatology was then constructed from hourly surface forecasts and three hourly upper-level forecasts from between the +12 hour time-step and +35 hour time-step. The initial 12 hours of model output was discarded in order to give the model adequate spin-up time. Figure 1 shows the domain employed by the polarLAPS system in the climate run mode.

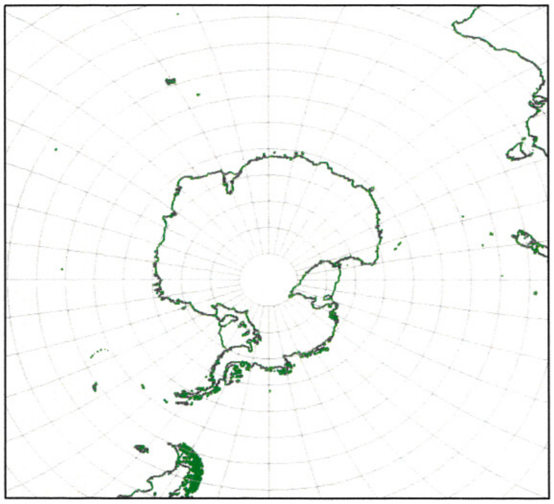

Figure 1: PolarLAPS domain used in climate system

The modelling method employed was designed for speed of processing as a strict time-line of achieving results was in place, with the 11 years of data taking seven months on an NEC SX6 super-computer. There were some issues with the modelling system employed. A bug in the set-up code resulted in monthly mean one degree sea surface temperature data being used rather than weekly data. The 12 hour spin-up for the model runs was most definitely too short given the interpolation of 250 km resolution reanalysis data directly to the 27.5 km resolution polarLAPS domain. Recent studied of the polarLAPS model skill (Adams in press) showed that polarLAPS nested within the 100 km resolution NCEP-GFS output took around 16 hours of spin up before the model skill improved sufficiently to out-perform the same model code but nested within the 75 km resolution Australian global Model (GASP) output. The 16 hour spin up was considered a direct result of the shock to the model system from the interpolation process. Given the much coarser resolution of the reanalysis data it would be expected that the spin-up would be some what longer than 16 hours. Ideally, such a down-scaling process would be more functional if the system was re-started every 6 hours with model output from between +24 hours and +29 hours from each model run used to construct the climatology. However, the aim of the system was not to provide accurate regional climate data, but 11 years worth of polarLAPS data from which to force a sea-ice modelling system to generate error covariance matrices.

3 Performance of the polarLAPS climatology

The initial testing of the model performance involved a comparison of model biases, root mean square errors (RMSE) and bias corrected RMSE for screen temperature, surface pressure and near surface wind speed at Casey, Mawson and Vostok. Biases and RMSE (not shown), were in general improved in polarLAPS over the reanalysis data used to initialise polarLAPS. Although, the wind statistics at Mawson were slightly degraded in bias and RMSE over the reanalysis output. However, the bias corrected RMS errors from polarLAPS were better for all locations and variables (Table 1). The down-scaled polarLAPS bias corrected RMS errors were only marginally worse than the statistics from the real-time forecast runs of the model, nested within the NCEP-GFS data, where the temperature bias corrected RMSE was 2.4 K, pressure 3.1 hPa and wind speed 5.1 ms^{-1}.

General features of the Antarctic atmosphere were

bC-RMSE	Temp (K)	SLP (hPa)	Wind (m/s)
	L - N	**L** - N	**L** - N
Casey	**3.0** 4.7	**4.7** 34.7	**5.9** 7.4
Mawson	**2.9** 3.7	**3.9** 34.3	**5.7** 6.6
Vostok	**3.1** 5.4	-	**2.8** 4.4

Table 1: Model bias correct RMSE for temperature, pressure and wind speed at Casey, Davis and Vostok. (L - polarLAPS, N- Reanalysis-2).

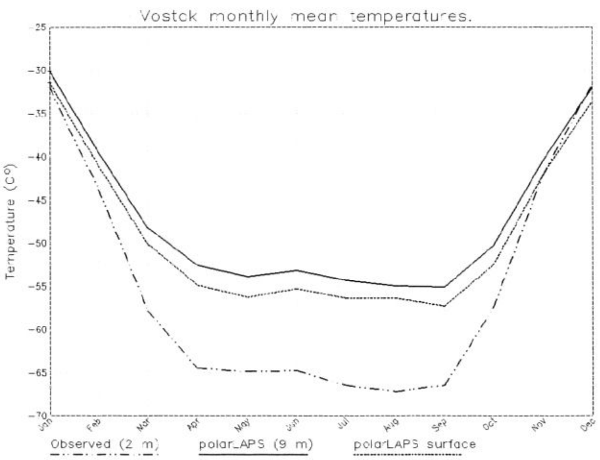

Figure 2: Mean monthly Vostok temperatures for the period 1998 - 2008. Solid line is the polarLAPS 9 m data, dashed line the Vostok observations, and the dotted line the polarLAPS surface temperature.

well captured in the down-scaling process. Figure 2 shows the aggregate monthly mean temperatures from Vostok between 1998 and 2008 from polarLAPS, with the near surface (~9 m) temperature plotted as a solid line, and the modelled surface temperature as a dotted line. The observed (2 m) temperatures are shown as dashed line. The polarLAPS climatology has under-estimated the winter-time temperatures by some 10 to 12 °C, which is a significant departure from observed. The model grid point is at an elevation of 3470 m with the actual station height at 3488 m so height differences are unlikely to significantly contribute to the error. The model surface temperatures are also too warm, suggesting that the initialisation of the model surface temperature field was in error and forcing near surface air temperatures to be too warm. Where the polarLAPS climatology did perform well was in modelling the core-less winter and the slight warming around June associated with the build up of the strong winter-time surface outflow.

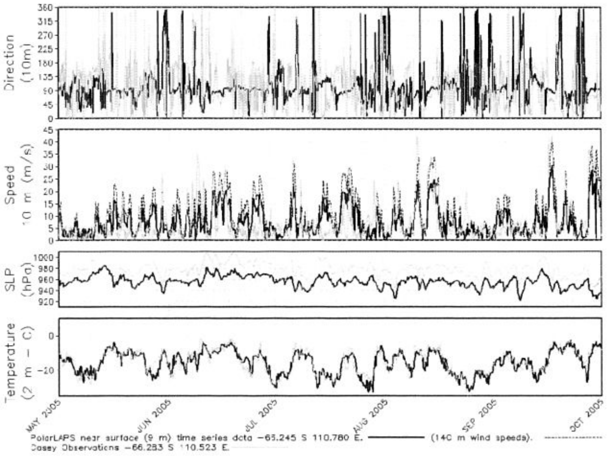

Figure 3: Time series plot of polarLAPS data and Casey observational data for the period 1 May to 1 October 2005. Solid black lines are polarLAPS 9 m data, thin grey line Casey observational data and thin dashed line the polarLAPS 140 m wind speed.

Closer examination of the time series data also highlighted the relatively good performance of the down-scaling process. Figure 3 shows a time-series plot of three hourly data from the grid point closest to Casey Station (66° 17' S, 110° 31.4' E). Model data from the 0.9988 sigma level (~9 m) are shown in black, and Casey observations in grey. Wind speed data from the polarLAPS 0.9820 sigma level (~140 m) are shown as a dotted line. Temperatures match very well, and the profile of pressure also matches very well, but with an obvious bias resulting from the model grid point being at an elevation of 234 m and the station barometer at a height of 42.3 m. Close inspection of the wind speed time series shows the polarLAPS climate runs picked the majority of strong wind or storm events, although under-estimated their strength. The polarLAPS winds from 140 m better captured the storm events although slightly overestimated wind speeds between events. The wind direction record is somewhat difficult to interpret, although the model has bias towards east to northeasterly flow and appears not to capture the southerly events that are evident in the observational record. The anomalies in the modelled winds are best compared through the use of wind speed and direction frequency analyses. Figure 4a shows the frequency analysis from the polarLAPS 9 m winds, with Figure 4b the analysis from the observational data. Figure 4c is the polarLAPS 140 m frequency analysis. The bi-modal nature of the Casey 10 m wind is quite apparent in Figure 4b with a predominance of light (~5 ms^{-1}) northeasterly and south to southeasterly flow. The polarLAPS prevailing 9 m flow is a light east to northeasterly. Storm events at Casey have a prevailing direction around 85° true, where as the polarLAPS storms at both 9 m and 140 m are from around 95° true. The reasoning behind the biases needs further investigation but it would appear that the specified friction within the polarLAPS dynamics has been set too high, resulting in a retardation of the modelled surface flow and an increase in the down-slope direction of the wind.

4 Summary and Conclusions

Eleven years of polarLAPS runs have been performed to provide atmospheric forcing data for a sea-ice forecasting system under development. However, these data provide a unique resource for weather forecasters operating in the Antarctic in as much as a model climatology is now available for data sparse locations across the Antarctic continent and Southern Ocean. The climatology is not perfect, with a very rudimentary down-scaling process employed, but careful analysis of the model output can be used to highlight model deficiencies that in turn can benefit the interpretation of the climatology. At present the climatology is quite short but this prototype system suggests that down-scaling is a worthwhile process and a modern NWP system coupled to a modern global

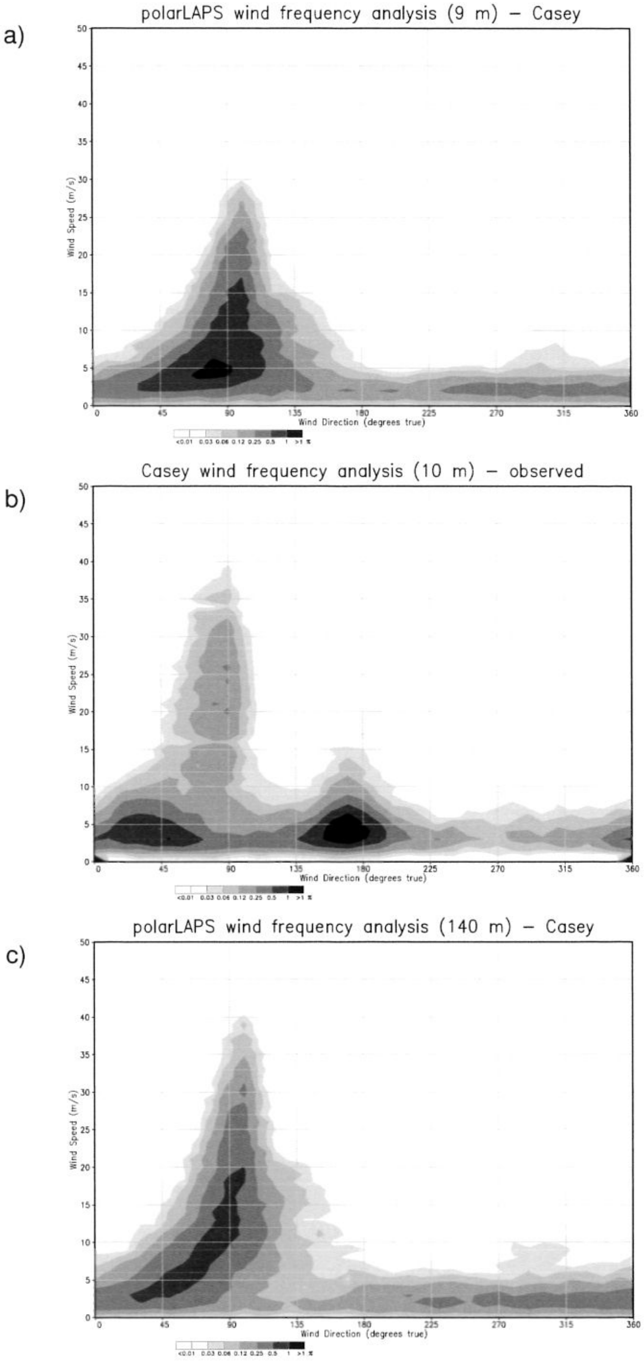

Figure 4: Wind speed and direction frequency analyses for a) polarLAPS 9 m data, b) Casey surface (10 m) observations and c) polarLAPS 140 m data.

reanalysis dataset may offer much in providing a high resolution long term Antarctic climate dataset.

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AMPS Real-time Forecasts – 2009 Update

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1) INTRODUCTION

The Antarctic Mesoscale Prediction System (AMPS) is an experimental real-time forecasting system offering high-resolution numerical weather prediction (NWP) products for Antarctic forecasters. The mission for AMPS is specifically to support United States Antarctic Program (USAP) flight logistics in and around McMurdo Station, but the coverage of AMPS products is continental in scope. Since October of 2000, AMPS has made its real-time NWP products freely available to the Antarctic community, through the AMPS web page (*http://www.mmm.ucar.edu/rt/amps*).

AMPS is a collaboration among investigators at the National Center for Atmospheric Research (NCAR), the Ohio State University (OSU), and the University of Colorado (CU), supported by funding and resources from the National Science Foundation (NSF). In addition to these formal collaborations, over its multiple cycles of NSF funding, AMPS has fostered informal collaborations and interactions with many other researchers, research groups, and forecasters worldwide.

2) THE END OF THE MM5 ERA

AMPS began in 2000, using the Pennsylvania State University/NCAR Mesoscale Model, version 5 (MM5). In more recent years, AMPS has added a second model, the Weather Research and Forecasting model (WRF), to its production runs. AMPS has been running WRF in parallel with MM5, with the goal of evaluating WRF, improving WRF for the Antarctic environment, and eventually replacing MM5 with WRF. Researchers at the OSU Byrd Polar Research Center (BPRC; work by Keith Hines, David Bromwich, and others) have built upon their experiences from adapting MM5 to the polar environment, applying that expertise to WRF. Testing these polar improvements to WRF within AMPS has has been ongoing. After several cycles of improvements and evaluations, WRF was determined to be a viable replacement for MM5 in AMPS. Following the 2008 workshop in Madison, WI, we turned off the MM5 AMPS forecasts for good. WRF is now the sole model running in AMPS.

3) NEW COMPUTING PLATFORM

Thanks to continued generous support from the NSF, AMPS received a significant increase in its computing capacity in the autumn of 2008. Three nodes of NCAR's primary supercomputer, *bluefire*, have been dedicated for AMPS usage. Three nodes of a similar architecture were purchased and configured as a stand-alone machine to serve as a test platform for development work at NCAR's Computational and Information Systems Laboratory (CISL), the division that operates NCAR's supercomputers. This stand-alone machine also serves as a backup platform for AMPS when the primary platform is down.

Bluefire is an IBM Power 575 supercomputer. The machine as a whole has 128 nodes with 32-processors on each node, for a total of 4096 IBM Power6 processors running at 4.7 GHz.

In October 2008, AMPS began running on three nodes (96 processors) of bluefire. This amounts to an estimated 2- to 3-fold increase in computing power over the old Linux cluster. This increased capacity has gone primarily toward increasing the horizontal resolution and vertical extent of the AMPS model grids, as discussed below.

4) UPGRADE TO WRF VERSION 3.0.1.1

In October 2008, we upgraded the WRF model used in AMPS from WRFv2.2 to WRFv3.0.1.1. This version of

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WRF offers several features over earlier versions of WRF, such as adaptive timesteps, more advanced diffusion options, better treatment of the model lid. Keith Hines of OSU/BPRC has adapted his polar modifications from WRFv2.2 to this newer version.

5) CHANGES TO MODEL CONFIGURATION:

Along with the update to the WRF version, several changes to the model configuration have been implemented.

Increased resolution; raised model top

The increased processing power made available by the new computing platform has allowed us to significantly enhance our model configuration. We have increased the resolution of all grids, moving from a 60/20/6.7/2.2-km setup to a 45/15/5/1.7-km setup. We have raised the model top from 50 to 10 hPa, and increased the number of vertical levels from 31 to 44. We have enhanced the vertical resolution of the model, especially below about 1 km.

Vertical damping

The extended model top necessitated applying a damping term to the vertical velocity near the model top. Weak damping is applied over the top 7 km of the grid. Without this damping, reflections of vertically propagating energy eventually contaminate the model integration leading to numerical instability and model crashes.

Diffusion

With the higher resolution grids, and the shallower model levels near the surface, instances of small-scale numerical noise near the surface became common. These did not appear to adversely affect the model results, but did look unphysical. Applying the new 6th-order diffusion option in WRF removed this noise.

Adaptive time step

Even on the new machine, the higher-resolution configuration proved to be too expensive to run within a target wallclock time of 4 to 5 hours. To reduce the cost, we have activated the new adaptive timestep option in WRF. This option increases the model time step (faster model integration) when the numerical stability of the integration allows it, and reduces the model time step (slower model integration) to keep solutions stable when the situation demands it. With this option, we are able to complete the model run within about 5 hours.

6) ADDITIONAL PRODUCTS

A few new sets of products have been implemented this year in support of certain field programs. In support of forecasting for the Antarctica Gamburtsev Province (AGAP) project, we have implemented a zoomed-in plotting window of our 15-km grid over the region of interest on the East Antarctic plateau.

Two new plotting windows have also been implemented in support of an upcoming project using uninhabited aerial vehicles (UAVs) to study interactions amongh the atmosphere, the ocean, and sea ice. These windows from the 15-km grid and from the 5-km Western Ross Sea grid offer zoomed-in views which should be useful in in planning and executing the UAV missions.

A new capability that we've implemented on an experimental basis is our "Meteogram-On-Demand" feature. This feature allows users to submit a form specifying the location at which a meteogram chart is desired. Within approximately 5 to 7 minutes, the requested meteogram appears in a specific directory of the AMPS web site.

7) PLANS

A new version of WRF, version 3.1, was released in the spring of 2009. We are currently evaluating this version of WRF for use in AMPS.

One attractive enhancement of WRFv3.1 is the inclusion of some polar modifications: specifically, a fractional sea-ice treatment, and adaptations to the land-surface model to better represent thermal properties of glacial ice. These polar modifications are based on an amalgamation of approaches developed by modelers at BPRC, NCAR, and the National Centers for Environmental Prediction (NCEP).

8) ACKNOWLEDGEMENTS

The authors wish to acknowledge the support and encouragement of the National Science Foundation. Enthusiastic support and valuable feedback and suggestions from forecasters at SPAWAR and around the world have contributed greatly to the success of AMPS.

TESTING OF WRF V3.1 AND AIRS SATELLITE DATA IN AMPS

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1. INTRODUCTION

With the distribution of WRF (Weather Research and Forecasting model; Skamarock et al. 2008). Version 3.1 in April 2009, for the first time the user community has an officially-released set of polar modifications to improve performance over the high latitudes. This new version provides a supported tool for research and real-time applications over the polar regions. The first part of the work presented here examines the impact of the released "Polar WRF" on the simulation of a severe Antarctic weather event, the 15 May 2004 McMurdo windstorm (Powers 2007).

Satellite datasets are important in the Southern Hemisphere to cover the expanses that lack in-situ observations. As is known to the meteorological community, measurements over the Antarctic continent are sparse, particularly above the surface. The Atmospheric Infrared Sounder (AIRS) is an instrument aboard NASA's polar-orbiting Aqua satellite and can provide vertical profiles of temperature and moisture. In light of its coverage of the high southern latitudes, it thus has the potential to provide data useful for Antarctic NWP, such as in AMPS (the Antarctic Mesoscale Prediction System) (Powers et al. 2003). In the second part of this work, a preliminary investigation probes the effects of assimilating AIRS data on AMPS forecasts of the 2004 McMurdo windstorm case.

In these investigations AMPS provides the environment for the polar WRF and AIRS tests. AMPS generates NWP guidance over Antarctica in support of the flight operations and scientific activities of the United States Antarctic Program (USAP) and various nations. See http://www.mmm.ucar.edu/rt/amps.

2. WRF V3.1 POLAR MODIFICATIONS

Polar modifications have been tested and used in the WRF code for a while (see, e.g., Powers and Manning (2008)), but it is only with WRF V3.1 that a package has been in an official release and supported. The polar modifications in V3.1 address sea ice and the Noah land surface model (LSM). These are summarized as follows.

- Sea ice: Capability to handle fractional coverage in grid cells

- Noah LSM modifications

– Use of the latent heat of sublimation for calculations of latent heat fluxes over ice/snow surfaces

– Adjustment of snow density, heat capacity, thermal diffusivity, and albedo (increase to .80) over ice points

– Use of snow thermal diffusivity if snow coverage > 97%

– Sea/land ice points soil moisture= 1.0

– Albedo and emissivity of sea ice set to 0.80 and 0.98

– Thermal conductivity on sea/land ice set to snow thermal conductivity

– Call to soil moisture flux subroutine skipped for sea/land ice points

– Limit on depth of snow layer in soil heat flux calculation

– No limit on snow cover fraction over sea/land ice

3. AIRS Data

The Atmospheric Infrared Sounder (AIRS) (*see* Chahine et al. (2006), LeMarshall et al. (2006)) is an instrument on NASA's Aqua satellite. It scans across the ground-projected track of the satellite with an 800-km swath and measures upwelling infrared energy, the infrared brightness from the surface and the atmosphere. AIRS has over 2300 spectral channels and the information in these can be used to develop a profile of temperature and water vapor at heights though the column. AIRS's resolution at nadir is 13.5 km, and its temperature and humidity accuracies in the troposphere are 1K and 15%, respectively. The data used for the assimilation experiments performed here are retrievals of temperature and water vapor. The data are thinned to 45 km for these runs.

3. CASE BACKGROUND AND MODEL CONFIGURATION

a. May 2004 Severe Wind Event at McMurdo Station, Antarctica

The 15 May 2004 McMurdo windstorm pounded America's main base (Fig. 3) with damaging winds of over 44 ms^{-1} and gusts exceeding 52 ms^{-1} (Powers 2007). Figure 1 presents time series of wind speeds at McMurdo-area automatic weather stations (AWSs) during the episode, which spanned 1800 UTC–0000 UTC 15–16 May 2004. The event was forced by a deep synoptic low that traversed from Marie Byrd Land, across the Ross Ice Shelf, to east of Ross Island, as shown in Fig. 2. The intense flows through the McMurdo region reflected the low's position east of the island, the strong pressure gradient around/between the low and a synoptic high over East Antarctica, and enhancement from barrier wind effects of the Transantarctic Mountains.

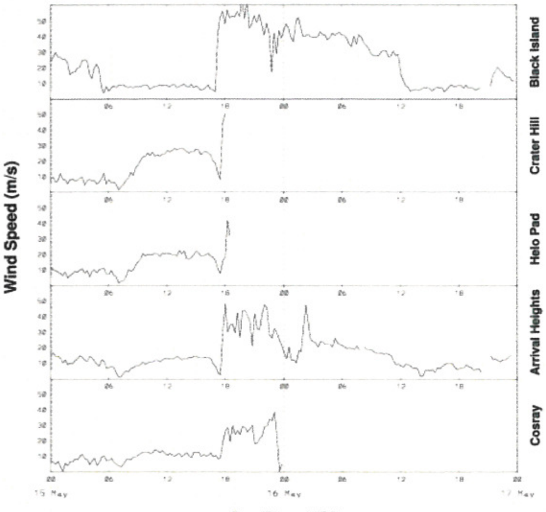


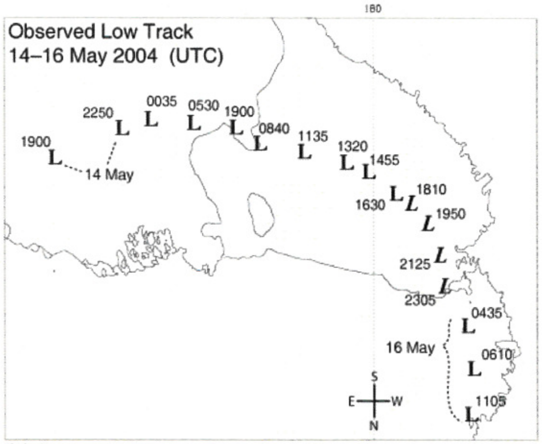
Fig. 1: Observed wind speeds (ms^{-1}) at various AWS sites in the McMurdo area 0000 15 May –0000 17 May 2004.

b. Model Configuration

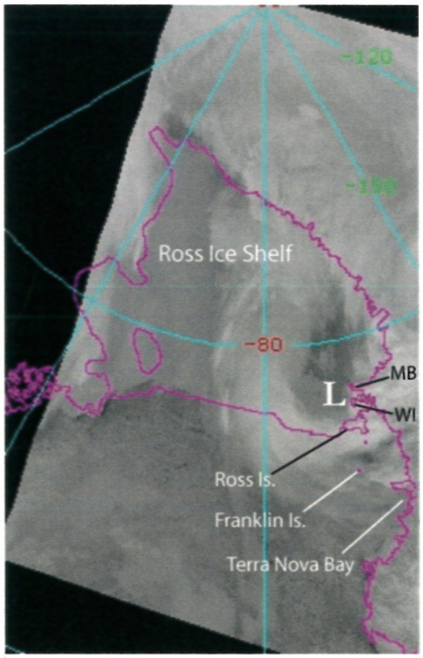
4 domains: 60 km / 20 km / 6.67 km / 2.23 km (Fig. 3)
Vertical resolution: 31 levels
Model top: 50 mb
IC/BC: GFS analysis/GFS forecast BCs
Sea ice IC: National Snow and Ice Data Center (NSIDC) analysis
Forecast length: 36 hrs (0000 15 May–1200 16 May 2004)
Assimilation domains: 60-km and 20-km grids

Experiments

REG— WRF w/o polar modifications
POL_V31— WRF w/V3.1 polar modifications
POL_AIRS_O— Polar WRF, AIRS data assimilated
POL_AIRS— Polar WRF, AIRS + conventional data assimilated
POL_CTRL— Polar WRF, no data assimilation



2(a)



2(b)

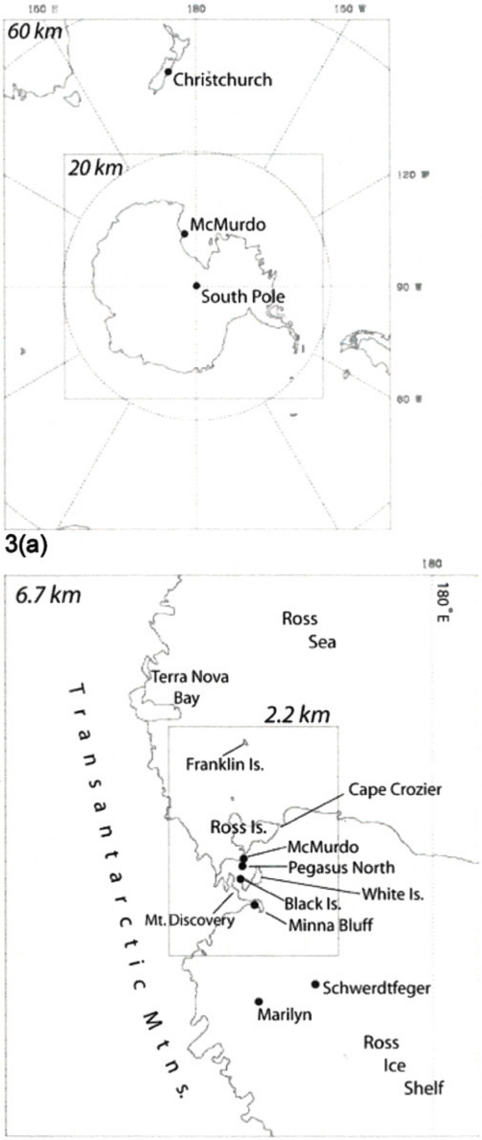
Fig. 2: Event low pressure system and satellite imagery. (a) Observed surface low track positions (UTC). (b) IR imagery for 2125 UTC 15 May 2004.

4. RESULTS

a. Polar WRF V3.1

While both of the ARW experiments simulate the transit of the low, differences in the track and evolution on the mesoscale near Ross Island significantly affect the wind event forecast. Figure 4 presents the surface wind and SLP forecasts for 1900 UTC (hr 19) and 2300 UTC 15 May (hr 23). At 1900 UTC the ARW without the polar modifications does not produce the strong flow around Ross Island (Fig. 4(a)), while the new polar V3.1 does (Fig. 4(b)), as observed. Later during the observed event, at 2300

UTC, POL_V31 Fig. 4(d)) yields much stronger winds at McMurdo proper than REG (Fig. 4(c)).

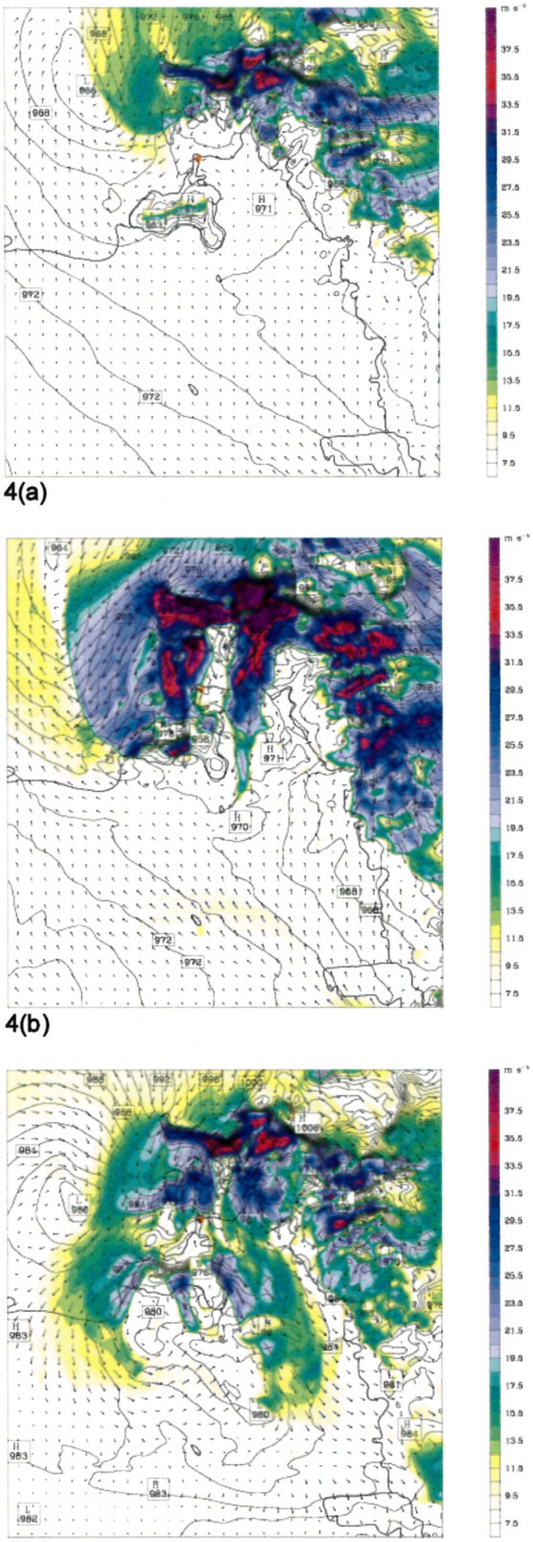


3(a)

3(b)

Fig. 3: ARW domains. (a) 60-km and 20-km grids. (b) 6.67-km and 2.2-km grids. Dots mark observation/AWS sites.

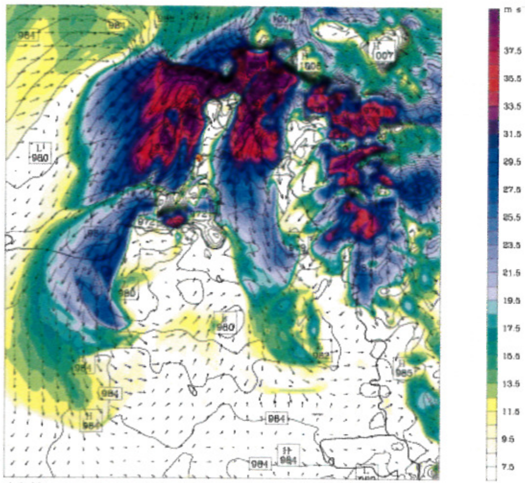
Figure 5 presents the observed and ARW wind speed traces for Black Island, Arrival Heights, and Pegasus North AWS sites (Fig. 3(b)). For all of the sites, the polar V3.1 more faithfully captures the event's magnitude than the non-polar version; it also shows improvements in the pre- and post-event periods. For example, at Black Is., REG (Fig. 5(a)) does not display close to the observed magnitude or duration of the event. With POL_V31, however, the timing of the onset of the event is reproduced, as well as the timings of the pre-event periods of moderate winds (0000–0600 UTC) and weak winds (0600–1800 UTC) (Fig. 5(b)).



4(a)

4(b)

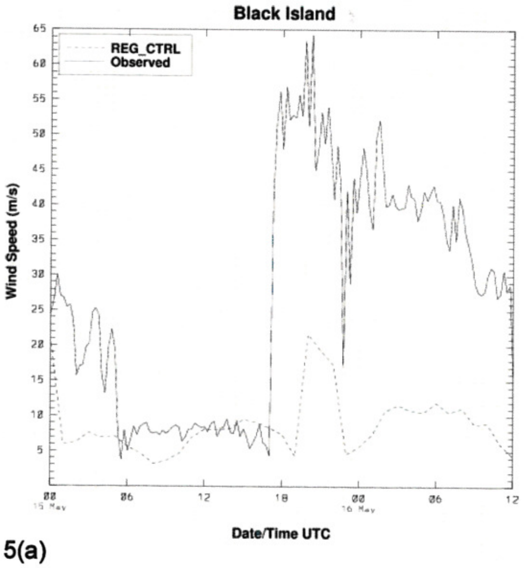
4(c)



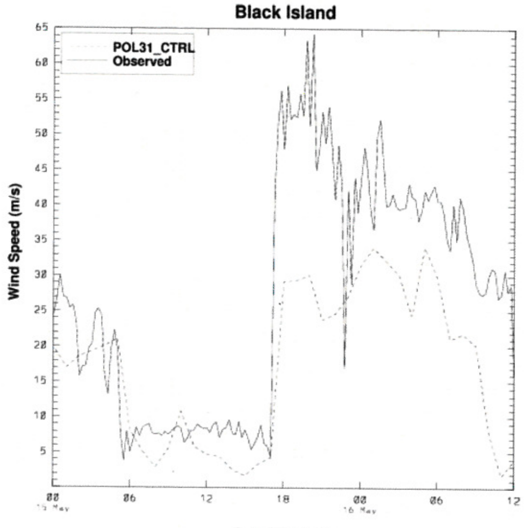
4(d)

Fig. 4: Surface winds and SLP from the REG and POL_V31 experiments for forecast hrs 19 (1900 UTC) and 23 (2300 UTC). SLP interval= 1 hPa. Vector magnitude= 17 ms^{-1}/vector interval. Wind speed scale at right; medium blue approximately 25 ms^{-1}. Orange dot marks McMurdo. (a) Hr 19 REG. (b) Hr 19 POL_V31. (c) Hr 23 REG. (d) Hr 23 POL_V31.

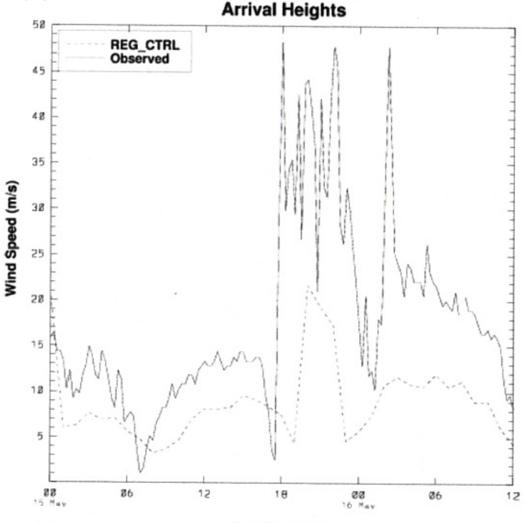
At Arrival Heights both ARW configurations significantly underforecast the event, which seems to be due to an excessive model topographic shadow. That is, in the model the features of Minna Bluff, Black Is., and White Is. shield a broad downstream area from the highest surface flows, and this effect reaches northward to McMurdo/Hut Point Peninsula. Thus, REG (Fig. 5(c)) shows a wind speed bump, but the duration is not long and the magnitude is not large. The polar V3.1 simulation does better, however: although its timing is late, POL_V31 does produce significant winds (up to 33 ms^{-1}) and a longer episode (Fig. 5(d)).



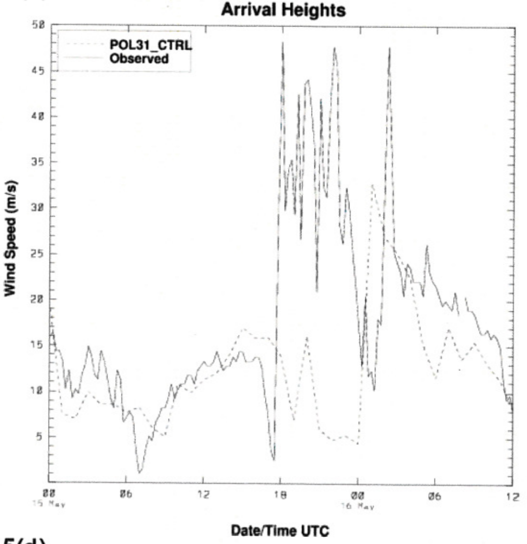
5(a)



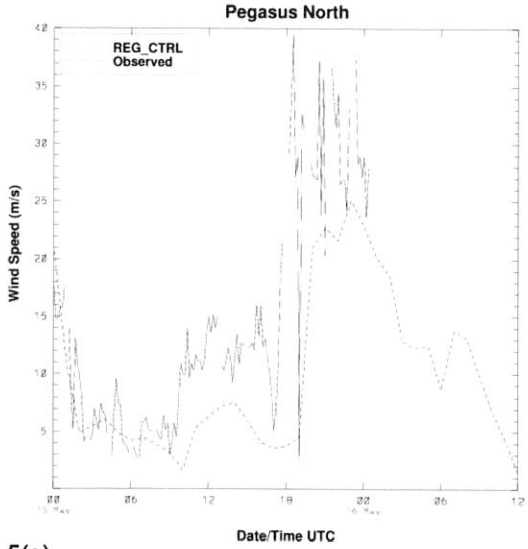
5(b)



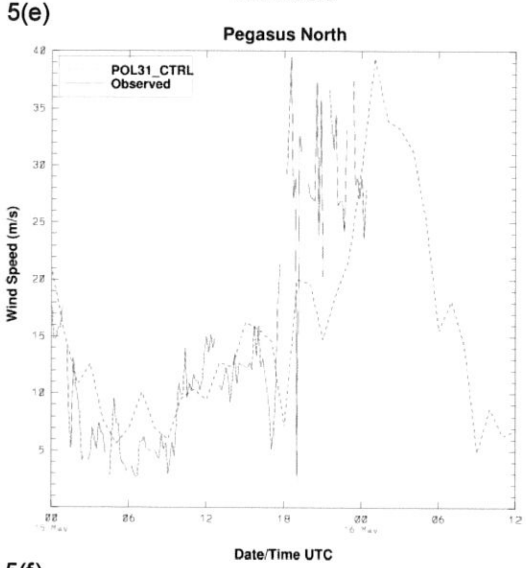
5(c)



5(d)



5(e)



5(f)

Fig. 5: Observed (solid) and ARW (dashed) wind speeds (ms^{-1}) for 0000 UTC 15 May–1200 UTC 16 May 2004 for McMurdo-area sites. (a) Black Is. REG. (b) Black Is. POL_V31. (c) Arrival Heights REG. (d) Arrival Heights POL_V31. (e) Pegasus North REG. (f) Pegasus North POL_V31.

At Pegasus, REG (Fig. 5(e)) yields an event, but it is tardy and its maximum winds are weak compared to observation. POL_V31 (Fig. 5(f)), on the other hand, succeeds in forecasting the observed maximum of near 39 ms^{-1} and better times the event's onset.

Table 1 presents the wind speed biases, MAEs (mean absolute errors), and RMSEs calculated at Arrival Heights, Pegasus North, Black Island, Minna Bluff, Marilyn, and Schwerdtfeger AWSs (Fig. 3(b)). For the period surrounding the event (hrs 12–30), POL_V31 displays lesser negative (underforecast) biases *and* lower MAEs and RMSEs than REG. The average wind speed bias and MAE are reduced by approximately 5.9 ms^{-1} and 3.7 ms^{-1}, respectively, in POL_V31 compared to REG. These are 57% and 33% reductions in these two errors. These error improvements for bias and MAE in POL_V31 are statistically significant at the 95% confidence level. The forecast wind speed RMSE is reduced by 3.6 ms^{-1} (27%), but this figure is not statistically significant at the 95% level.

Considering the whole 36-hr forecast period (Tab. 2), the results are similar. POL_V31's bias and MAE are about 4 ms^{-1} (50%) and 2 ms^{-1} (23%) less, respectively, than REG's, and these are statistically significant. POL_V31's RMSE is 1.8 ms^{-1} (17%) lower, but this is not statistically significant.

b. AIRS Tests

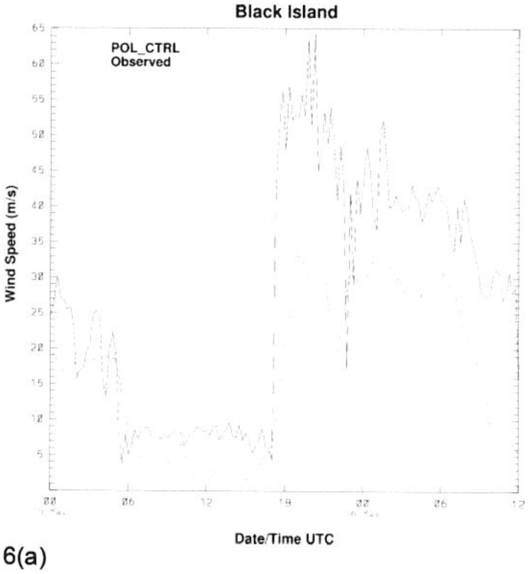
Two additional experiments have been performed, addressing the assimilation of AIRS data. The first, POL_AIRS_O, involves the assimilation of the retrieved AIRS temperature and moisture information only. The assimilation is performed with the WRF-Var 3-dimensional variational (3DVAR) data assimilation (DA) capability. This is the DA system used in AMPS. The second experiment, POL_AIRS, assimilates the AIRS data plus most of the other conventional and satellite data used in AMPS (surface synoptic and METAR reports, AWS data, soundings, aircraft reports, satellite geostationary and MODIS cloud-track winds). Both the POL_AIRS_O and POL_AIRS experiments use the AMPS operational version of polar WRF (containing a few more polar modifications for the Noah LSM than in the released WRF V3.1) and are compared with an experiment called POL_CTRL, in which no data assimilation is performed. In all of the runs, GFS (Global Forecasting System) analyses and forecasts for 0000 UTC 15 May 2004 are used for the first-guess field and boundary conditions, respectively.

Figure 6 presents the results of the three experiments for the Black Island AWS site. The no data assimilation (POL_CTRL) run (Fig. 6(a)) produces an event of lower amplitude than that observed, with peak winds hitting 33 ms^{-1}(instead of about 60 ms^{-1}). With the assimilation of AIRS data only (POL_AIRS_O), the event looks similar, but the intensity is less in the observed period (1800 UTC 15 May–0000 UTC 16 May). Assimilating the full suite of observations in addition to AIRS (POL_AIRS, Fig. 6(c)) improves the overall wind strength, although the start of event is a little delayed. Overall, the wind speed time series differences are not striking, and this is seen at the other McMurdo-area sites (not shown).

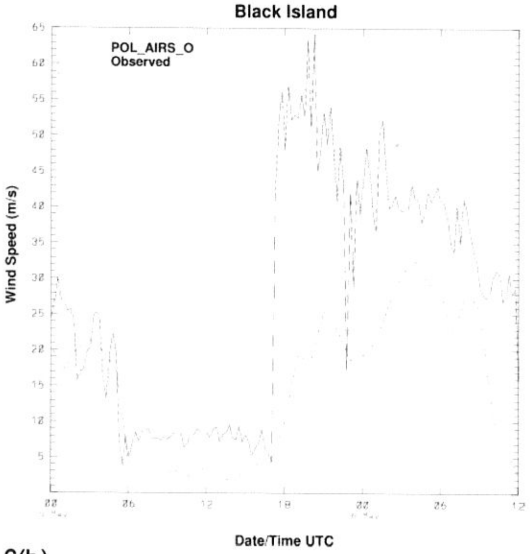
Tables 3 and 4 presents the error statistics for the tests for the period surrounding the event (hrs 12–30). For most parameters in both experiments (POL_AIRS_O and POL_AIRS), the results are statistically indistinguishable (at the 95% level) from the no data assimilation control forecast.

For the POL_AIRS_O run (Tab. 3), the single area in which it differs from POL_CTRL is in bias averaged over the verifying sites. The POL_AIRS_O mean wind speed bias is -6.2 ms^{-1}, compared to that for POL_CTRL of -3.9 ms^{-1}. The difference translates to POL_AIRS_O underforecasting the event more than POL_CTRL, by 2.4 ms^{-1}. The differences in forecast wind speed MAE and RMSE between these two experiments, however, are not statistically significantly different.

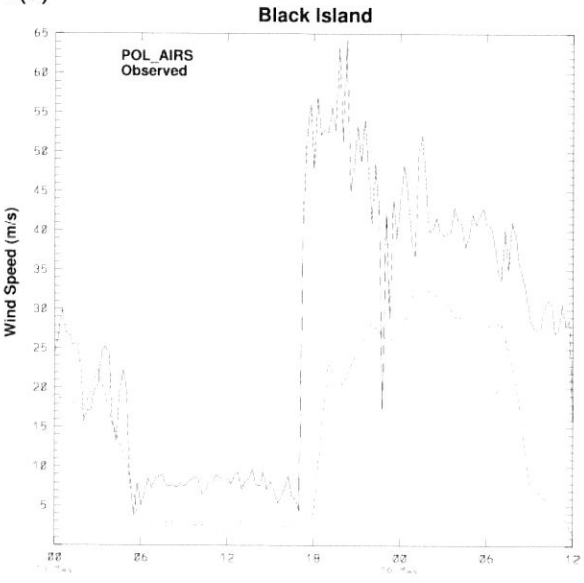
Comparing POL_AIRS with POL_CTRL (Tab. 4), the bias, MAE, and RMSE are all slightly greater in the AIRS run (bias: -2.0 ms^{-1}; MAE: 1.3 ms^{-1}; RMSE: 0.8 ms^{-1}). However, these differences are *not* statistically significant. Comparing the averaged errors between POL_AIRS and POL_AIRS_O (Tabs. 3,4), the differences in the averaged wind speed bias, MAE, and RMSE are all less than .8 ms^{-1} and no difference is found to be statistically significant.



6(a)



6(b)



6(c)

Fig. 6: Observed (solid) and ARW (dashed) wind speeds (ms^{-1}) for 0000 UTC 15 May–1200 UTC 16 May 2004 for Black Island site. (a) POL_CTRL. (b) POL_AIRS_O. (c) POL_AIRS.

5. CONCLUSIONS

The work reported here explores some new capabilities and datasets for AMPS that may be applied for either real-time forecasting or research involving high-latitude NWP with WRF in general. For the first time, in the V3.1 release, WRF officially offers polar modifications to capture better the conditions and processes over the high latitudes and extensive ice sheets. In a case of a high-impact, severe wind event in Antarctica, this release package is found to yield statistically significant improvements in forecasts of the critical parameter of wind speed. Both the magnitude and timing of the event are improved by the polar capability in V3.1. The biases and MAEs in the forecast wind speeds are both practically and statistically significantly reduced in the polar WRF release. It is anticipated that in the future additional polar modifications will be added to the WRF repository.

A preliminary examination of the impacts of AIRS data on ARW forecasts of the event has also been undertaken. At this time, the assimilation of AIRS data alone is not found to have statistically significant effects on wind speed forecast average MAEs or RMSEs, although significance is seen in an increase in the wind speed bias. In the assimilation of conventional observations with AIRS, the forecast wind speed errors for the event period can not be concluded to be statistically different from those of a forecast without DA. It is recognized, however, that these are single case tests and that more robust statistics may be obtained through evaluating longer periods. An analysis of the impact of AIRS data on AMPS forecasts for a longer (three-week) period is in progress.

ACKNOWLEDGEMENTS

The author would like to thank Lorraine Manlay of Météo-France and the University of Toulouse and Dr. Thomas Auligné of NCAR for their provision of the AIRS data used in this study.

Tab. 1: Forecast surface wind speed errors (ms^{-1}) for McMurdo-area AWS sites (Fig. 3(b)) for hrs 12–30. REG and POL_V31 analyzed and compared. Averages based on hourly output. Average errors for all six sites and error differences shown at bottom. Values that are statistically significant marked in red boldface with asterisk.

Forecast Wind Speed Errors (ms^{-1}): Hours 12–30
1200 UTC 15 May–0600 UTC 16 May 2004

	Arrival Heights			*Minna Bluff*		
Expt	Bias	MAE	RMSE	Bias	MAE	RMSE
REG	-14.59	14.66	18.21	-10.14	13.28	14.33
POL_V31	-10.23	14.00	19.46	-2.92	7.28	8.77

	Pegasus North			*Black Island*		
Expt	Bias	MAE	RMSE	Bias	MAE	RMSE
REG	-5.12	6.03	7.04	-22.11	23.03	27.78
POL_V31	.026	6.38	8.58	-11.23	11.23	13.69

	Marilyn			*Schwerdtfeger*		
Expt	Bias	MAE	RMSE	Bias	MAE	RMSE
REG	-6.64	6.88	7.80	-3.87	3.87	4.69
POL_V31	-1.07	3.39	4.42	-1.51	2.88	3.40

	Average Errors			*Error Differences (POL_V31–REG)*		
Expt	Bias	MAE	RMSE	Δ|Bias|	ΔMAE	ΔRMSE
REG	-10.41	11.29	13.31			
POL_V31	**-4.49***	**7.53***	9.72	**5.92***	**-3.73***	-3.59

* = Statistically significant difference at 95% level

Tab. 2: Forecast surface wind speed errors (ms^{-1}) for McMurdo-area AWS sites (Fig. 3(b)) for hrs 0–36. REG and POL_V31 analyzed and compared. Averages based on hourly output. Average errors for all six sites and error differences shown at bottom. Values that are statistically significant marked in red boldface with asterisk.

Forecast Wind Speed Errors (ms^{-1}): Hours 0–36
0000 UTC 15 May–1200 UTC 16 May 2004

	Arrival Heights			*Minna Bluff*		
Expt	Bias	MAE	RMSE	Bias	MAE	RMSE
REG	-9.23	9.64	12.90	-8.50	9.96	11.61
POL_V31	-6.18	8.42	13.33	-4.31	7.25	9.07

	Pegasus North			*Black Island*		

Expt	Bias	MAE	RMSE	Bias	MAE	RMSE
REG	-3.68	4.56	5.77	-15.30	15.70	20.33
POL_V31	0.92	4.59	6.62	-8.82	9.43	11.86

	Marilyn			*Schwerdtfeger*		
Expt	Bias	MAE	RMSE	Bias	MAE	RMSE
REG	-6.46	6.87	8.22	-3.85	4.70	5.82
POL_V31	-3.19	5.19	7.02	-1.80	4.70	5.74

	Average Errors			*Error Differences (POL_V31–REG)*		
Expt	Bias	MAE	RMSE	Δ|Bias|	ΔMAE	ΔRMSE
REG	-7.84	8.57	10.78			
POL_V31	**-3.89***	**6.60***	8.94	**3.95***	**-1.97***	-1.83

* = Statistically significant at 95% level

Tab. 3: Forecast surface wind speed errors (ms^{-1}) for McMurdo-area AWS sites (Fig. 3(b)) for hrs 12–30. POL_AIRS_O and POL_CTRL analyzed and compared. Averages based on hourly output. Average errors for all six sites and error differences shown at bottom. Values that are statistically significant marked in red boldface with asterisk.

Forecast Wind Speed Errors (ms^{-1}): Hours 12–30
1200 UTC 15 May–0600 UTC 16 May 2004
P_A_O = POL_AIRS_O

	Arrival Heights			*Minna Bluff*		
Expt	Bias	MAE	RMSE	Bias	MAE	RMSE
P_A_O	-10.71	12.61	18.26	-5.76	11.28	12.60
POL_CTRL	-9.15	13.58	20.52	-2.90	6.34	8.19

Pegasus North				*Black Island*		
Expt	Bias	MAE	RMSE	Bias	MAE	RMSE
P_A_O	-0.17	6.10	7.95	-15.43	15.43	19.04
POL_CTRL	1.91	6.28	9.42	-11.71	11.91	14.08

Marilyn				*Schwerdtfeger*		
Expt	Bias	MAE	RMSE	Bias	MAE	RMSE
P_A_O	-2.45	4.13	5.13	-2.94	3.84	5.51
POL_CTRL	-0.95	3.23	3.94	-0.58	2.29	2.97

	Average Errors			*Error Differences (POL_AIRS_O – POL_CTRL)*		
Expt	Bias	MAE	RMSE	Δ|Bias|	ΔMAE	ΔRMSE
P_A_O	-6.24	8.90	11.42		+1.63	+1.56
POL_CTRL	**-3.90***	7.27	9.85	**2.34***		

* = Statistically significant difference at 95% level

Tab. 4: Forecast surface wind speed errors (ms^{-1}) for McMurdo-area AWS sites (Fig. 3(b)) for hrs 12–30. POL_AIRS and POL_CTRL analyzed and compared. Averages based on hourly output. Average errors for all six sites and error differences shown at bottom. Values that are statistically significant marked in red boldface with asterisk.

Forecast Wind Speed Errors (ms^{-1}): Hours 12–30
1200 UTC 15 May–0600 UTC 16 May 2004

	Arrival Heights			*Minna Bluff*		
Expt	Bias	MAE	RMSE	Bias	MAE	RMSE
POL_AIRS	-8.68	11.29	16.05	-4.98	10.06	10.92
POL_CTRL	-9.15	13.58	20.52	-2.90	6.34	8.19

	Pegasus North			*Black Island*		

Expt	Bias	MAE	RMSE	Bias	MAE	RMSE
POL_AIRS	-3.34	7.78	8.96	-13.79	13.79	17.78
POL_CTRL	1.91	6.28	9.42	-11.71	11.91	14.08

	Marilyn			*Schwerdtfeger*		
Expt	Bias	MAE	RMSE	Bias	MAE	RMSE
POL_AIRS	-3.13	4.30	5.15	-1.35	4.16	4.86
POL_CTRL	-0.95	3.23	3.94	-0.58	2.29	2.97

	Average Errors			*Error Differences (POL_AIRS – POL_CTRL)*		
Expt	Bias	MAE	RMSE	Δ|Bias|	ΔMAE	ΔRMSE
POL_AIRS	-5.88	8.56	10.63		+1.29	+0.77
POL_CTRL	-3.89	7.27	9.85	1.98		

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IDENTIFICATION OF PREFERRED PHYSICS OPTIONS FOR POLAR WRF SIMULATIONS IN THE ARCTIC

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The Weather Research and Forecasting (WRF) model is gaining increasing use for applications in the polar regions. A key to the performance of WRF in the polar regions is the evaluation and identification of an ideal suite of WRF physics parameterizations to best represent the polar atmosphere. A comprehensive suite of WRF simulations over the Arctic Ocean have been completed. These simulations were designed to evaluate a wide range of possible WRF physics options for use in the polar regions. The WRF simulations were compared to observations from the SHEBA ice camp and from Barrow, AK of near surface atmospheric state, radiative fluxes, and cloud liquid and ice water path. The conclusions from the study indicate a preferred suite of longwave radiation, shortwave radiation, microphysics, and boundary layer schemes which provide the best results for polar applications of WRF.

FOEHN WINDS IN THE MCMURDO DRY VALLEYS OF ANTARCTICA

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1. INTRODUCTION

A foehn wind is a warm, dry, downslope wind resulting from synoptic-scale, cross-barrier flow over a mountain range. Foehn winds are a climatological feature common to many of the world's mid-latitude mountainous regions, where they can be responsible for wind gusts exceeding 50 m s^{-1} and adiabatic warming at foehn onset of +28°C. Intensive monitoring experiments in mid-latitude regions such as the Alpine Experiment (ALPEX) in the eastern Alps (Seibert 1990) and the Mesoscale Alpine Programme (MAP) in the Rhine Valley (Bougeault et al. 2001) have detailed the complex atmospheric processes that occur during foehn by use of high density observational networks, aircraft, satellite imagery and mesoscale numerical modelling. However, foehn winds in high latitudes and polar regions have not been studied extensively. Analysis of meteorological records from the McMurdo Dry Valleys (MDVs), a unique ice-free area of the Antarctic, has identified that foehn winds (termed *polar foehn*) are responsible for unprecedented temperature changes of >40°C. The resulting warm, dry and gusty winds are suspected to have significant effects on landscape forming processes in the MDVs including glacial melt (Doran et al. 2008), rock weathering (Selby et al. 1973), niveo-aeolian processes (Ayling and McGowan 2006; Speirs et al. 2008) and biological productivity (Fountain et al. 1999; Foreman et al. 2004). It is also interesting to speculate the role that warm foehn winds in the MDVs have regarding the lack of extensive ice-cover in this region.

Despite the significance of the polar foehn, no detailed scientific investigation of foehn has been conducted in the MDVs. Periods of strong dry westerly winds that cause large increases in air temperature in the MDVs have generally been attributed to adiabatic compression causing warming of the air mass, but there is disagreement regarding the exact mechanism for their origin with some studies referring to them as katabatic while others have invoked a foehn mechanism (Thompson et al. 1971; Thompson 1972; Keys 1980; Clow et al. 1988; McKendry and Lewthwaite 1990; 1992; Doran et al. 2002; Nylen et al. 2004). Katabatic winds are believed responsible for the strong winds at confluence zones in the large glacier valleys south and north of the MDVs, but the valleys themselves do not lie in a confluence zone of katabatic winds (Parish and Bromwich 1987; Clow et al. 1988; Parish and Bromwich 2007). Various studies including that by McKendry and Lewthwaite (1990; 1992), Doran et al. (2002) and Nylen et al. (2004) have identified a poor understanding, need for detailed measurement, and the considerable scope for research on the local wind regime in the MDVs. McKendry and Lewthwaite (1992, p596) concluded that "further work is required to clarify the interactions between synoptic-scale flow and the rather unusual topographic setting, and to explain the exact mechanism by which upper level flow is deflected into the [Wright] valley". Since this statement 15 years ago, these knowledge gaps and research requirements remain. A more complete understanding of synoptic scale circulation, local meteorological conditions and environmental interactions in the MDVs could potentially benefit the independent and cooperative research projects undertaken in the region which, since discovery by Robert Falcon Scott's expedition in 1903, has become the most intensely studied region in the Antarctic. Understanding of turbulent lower and upper atmospheric airflow is also crucial for the safe operation of helicopter and light aircraft regularly traversing this region. Furthermore, investigation into synoptic scale processes and resulting meteorological influences has significance in terms of understanding regional and local effects of global climate variability and change.

This paper presents initial findings resulting from the ongoing collaborative research between The University of Queensland and The Ohio State University combining observational and model data to broaden the

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understanding of the complex meteorology in the MDVs. This paper presents output from the Antarctic Mesoscale Prediction System (AMPS) applied to a strong winter foehn wind event in 2007. Onset of foehn winds occurred on 21 May 2007 and lasted 5 days with wind gusts to 38.9 m s^{-1} and induced warming at the valley floor by +48.5°C. This paper presents the meteorological conditions and synoptic forcing mechanisms associated with this event followed by a synoptic climatology of the polar foehn through 2006 and 2007.

2. PHYSICAL SETTING

The MDVs are situated in the Transantarctic Mountains, bounded by the McMurdo Sound/Ross Sea to the east and the East Antarctic Ice Sheet to the west (Figure 1). The MDVs consist of three large northeast-southwest trending ice-free valleys (the Victoria, Wright and Taylor Valleys), which collectively cover an area of approximately 4800 km^2, the largest ice-free area in Antarctica. Large mountain ranges rising over 2000 m ASL separate the valleys, which have a polar desert climate due to their location in a precipitation shadow of the Transantarctic Mountains (Monaghan et al. 2005). Annual precipitation is < 50 mm water equivalent with precipitation decreasing away from the coast (Fountain et al. *in press*). Mean annual air temperature from seven valley floor automatic weather stations (AWS) range between -14.8°C to -30°C depending on site location and period of measurement (Doran et al. 2002). The wind regime of the MDVs is strongly dominated by either up- or down-valley topographically channelled airflow. During summer, thermally generated easterly valley winds dominate. This circulation develops due to differential surface heating between the low-albedo, valley floors and the high-albedo glacier surfaces to the east, analogous to sea/lake breeze circulations elsewhere (McKendry and Lewthwaite 1990). In winter, wind direction is typically more variable. Topographically modified southwesterly wind events, believed to be foehn are frequently experienced throughout the year in the MDVs (Thompson 1972; Keys 1980; Clow et al. 1988; McKendry and Lewthwaite 1990; 1992; Ayling and McGowan 2006). Doran et al. (2002) notes the highest frequency of these strong westerly winds in the MDVs occur in the winter months.

3. METHODS

Meteorological data presented in this paper were obtained from automatic weather stations (AWS) operated by the McMurdo Dry Valleys Long Term Ecological Research (LTER) program (Doran et al. 1995). Table 1 outlines the location and station ID for the AWS used here. The configuration of these stations is detailed at http://www.mcmlter.org/queries/met/met_home.jsp and in Doran et al. (2002). Measurements were collected at 3 m above the surface except for Canada Glacier (TCa), where air temperature and relative humidity measurements are from 2 m above the surface. No data was available from Lake Brownworth during the foehn event presented here. A selection criterion was developed to identify foehn wind events in the MDVs AWS records. Foehn onset was detected by an increase of wind speed above 5 m s^{-1} from a southwesterly direction, a warming of at least +1°C per hour and a decrease of relative humidity by at least 5 % per hour. Due to the transient nature of some foehn events, an additional criterion of a 'foehn day' was developed to identify strong events. A foehn day at an AWS station is defined as a day that has detected foehn onset and experiences 6 or more continuous hours of foehn conditions with wind speed >5 m s^{-1} from a consistent southwesterly direction. Preliminary validation suggests that the criterion is able to successfully identify foehn events with at least 95 % accuracy.

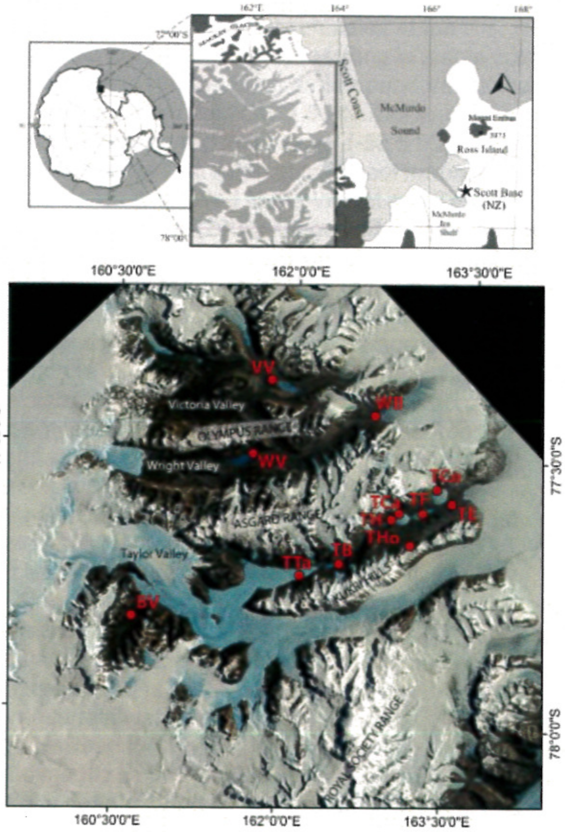

Figure 1. McMurdo Dry Valleys AWS network. Landsat ETM+ image captured 21 Nov 2001.

Numerical model products presented here are obtained from the Antarctic Mesoscale Prediction System (AMPS), a high-resolution numerical forecasting model operated by the Polar Meteorology Group, Byrd Polar Research Center and the National Center for Atmospheric Research (NCAR). AMPS employs a polar modified version of the fifth generation Pennsylvania

Table 1: MDV AWS information

ID	Location	Station	Latitude, longitude	Elevation (m asl)
VV	Victoria Valley	Lake Vida	-77.3778, 161.8006	351
WV	Wright Valley	Lake Vanda	-77.5168, 161.6678	296
WB		Lake Brownworth	-77.4335, 162.7036	279
TE	Taylor Valley	Explorers Cove	-77.5887, 163.4175	26
TF		Lake Fryxell	-77.6109, 163.1696	19
TH		Lake Hoare	-77.6254, 162.9004	78
TB		Lake Bonney	-77.7144, 162.4641	64
TTa		Taylor Glacier	-77.7402, 162.1284	334
THo		Howard Glacier	-77.6715, 163.0791	472
TCa		Canada Glacier	-77.6127, 162.9634	264
TCo		Commonwealth Glacier	-77.5637, 163.2801	290
BV	Beacon Valley	Beacon Valley	-77.8280, 160.6568	1176

State University/NCAR Mesoscale Model (Polar MM5; Bromwich et al. 2001; Cassano et al. 2001). A review of AMPS model components is provided by Powers et al. (2003) and evaluations of the model system are given by Guo et al. (2003) and Bromwich et al. (2005). Monaghan et al. (2005) reviewed the climate of the McMurdo region (including the MDVs) in the 3.3 km grid domain and shows AMPS successfully captured important temporal and spatial aspects of the region's climate. Additionally, Steinhoff et al. (2008) demonstrated that the 3.3 km domain is valuable on an event basis in the analysis of a downslope windstorm near McMurdo.

Comparisons of AMPS time series and AWS data in this project shows that the newly implemented 2.2 km domain performs reasonably well in the MDVs, effectively able to identify the onset and cessation of strong foehn wind events. At present, the model is unable to capture dynamic temperature and humidity changes on the valley floors, however, on the valley side walls away from cold air pooling on the valley floor, model performance is markedly improved. This issue is believed to be related to the smoothed model topography and the planetary boundary layer scheme used by the model. In this paper, AMPS products for the 2.2 km domain are used to determine the regional flow characteristics in which the influence of these effects is markedly reduced. Subsets of the 20 km domain are also utilized to examine synoptic circulation characteristics during foehn events.

4. RESULTS AND DISCUSSION

4.1 Foehn characteristics

Using the foehn identification criteria we identified a strong foehn event in the MDVs AWS records with onset on 21 May 2007, lasting 5 days. Prior to foehn onset, weak pressure gradients were evident over the western Ross Sea region (Figure 2) associated with a large anticyclone centred over Victoria Land. Surface air flow over the study region at this time was dominated by katabatic winds draining from the Antarctic interior. These diverge behind the MDVs with winds draining out of the large glacial valleys south (Byrd, Mulock and Skelton Glaciers) and north (David and Reeves Glaciers) of the MDVs. Meteorological conditions on the floors of the MDVs were cold and calm while at the higher elevation glacier stations, cold and moist downslope flow approached 8 m s^{-1}. These winds are localized cold air drainage winds from the surrounding mountain ranges and glaciers with flow at TTa, TCa, TCo and Tho directed towards the valley center. Cold air draining to the valley floor accumulates at the topographic low points (lakes) resulting in stable cold air pools with near-surface (3 m) air temperatures below -40 °C and relatively humidity > 80 %. Coldest air temperatures were recorded at VV (-53.5 °C), which reflects the relative strength of cold pool formation in the Victoria Valley compared to the Wright and Taylor Valleys. Doran et al. (2002) suggested that the greater cold pool strength near Lake Vida is related to the valley's bowl-shaped topography. The exposed yet closed topography would result in more intense radiative cooling and formation of a stronger temperature inversion (e.g. Clements et al. 2003).The stably stratified inversion in the valley floors may decouple from winds above and explain why drainage winds recorded at the glacial stations are not observed at the valley floor stations in the days leading to foehn onset. AMPS cross-sections during this time (not shown) suggest stable stratification of the atmosphere above the MDVs to at least 8 km ASL.

Between 19 May 2007 and 22 May 2007, a cyclonic depression off the coast of Adelie Land (Fig. 2) tracked eastward and strengthened with a minimum central pressure of 950 hPa. The cyclonic system slowed and remained relatively stationary off the coast of Marie Byrd Land between the Ross and Amundsen Seas (Fig. 3). This synoptic setting produced a strong zonally-oriented pressure gradient across the western Ross Sea and Transantarctic Mountains region. Between 09:30 and 10:00 UTC on 20 May 2007, a gradual warming commenced at all MDV AWSs. This warming characterizes the 'pre-foehn conditions' of foehn events in the MDVs as noted in other case studies by McGowan and Speirs (2008) and is believed to be associated with the gradual erosion of the stably stratified cold air pool in the valley floors from above by the foehn. Warming of approximately 10°C was observed over the 24 hours prior to onset of strong foehn winds (Fig. 4).

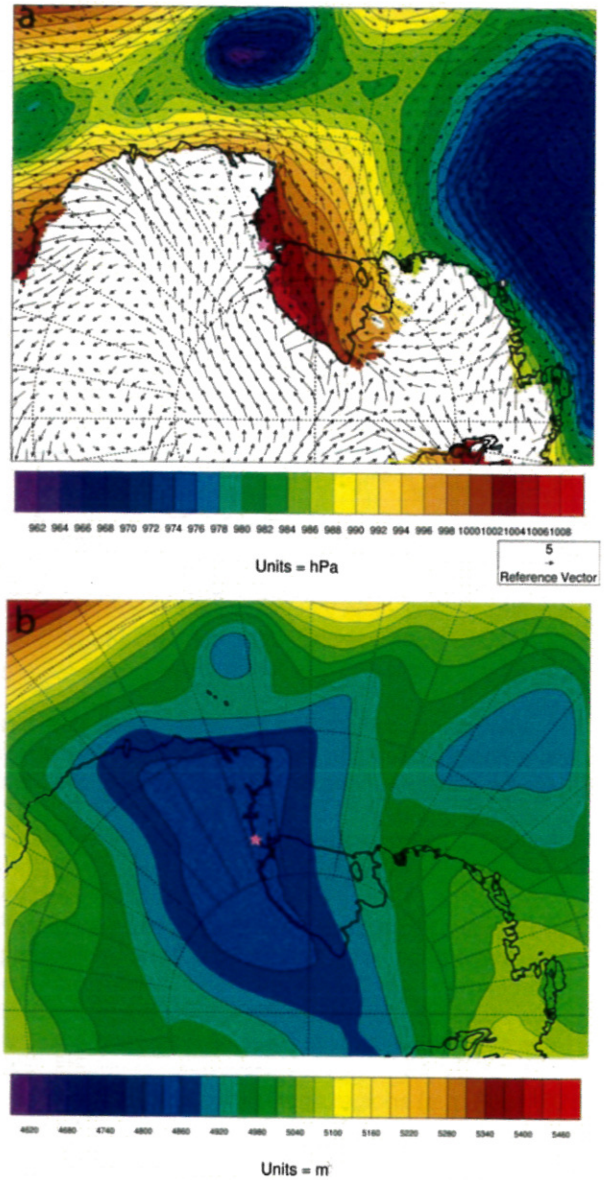

Figure 2. AMPS a) MSLP and wind vectors from σ=0.9983 and b) 500 hPa geopotential height analyses prior to foehn event (19 May 2007 00:00 UTC). Note MSLP data above 500 m is masked due to inaccuracies in calculating MSLP over the cold and high elevation Antarctic continent. Magenta star represents MDV location.

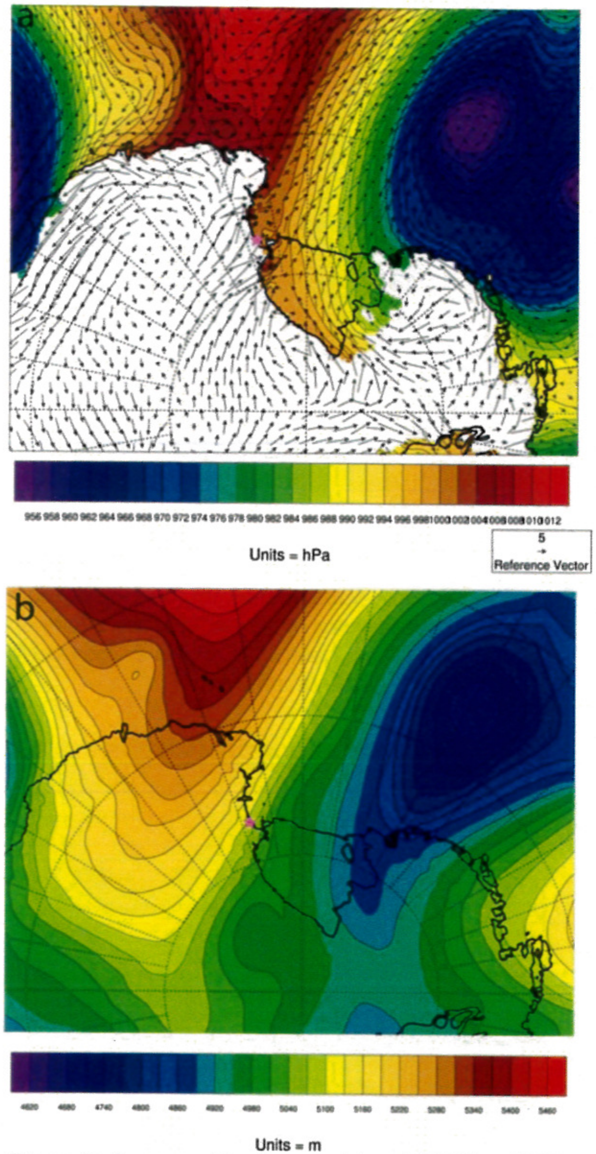

Figure 3. Same as Fig. 2 except for at (23 May 2007 12:00 UTC).

Grounding of the foehn winds shows significant spatial complexity through the Victoria, Wright and Taylor Valleys (Table 2). Foehn conditions were initially observed in the western Taylor Valley, a characteristic also noted by Nylen et al. (2004). Onset of strong foehn winds first occurred at TTa (21 May 2007 03:15 UTC) and TB (09:45 UTC) followed by WV in the adjacent Wright Valley. It was characterized by an immediate increase in wind speed >10 m s^{-1} from a consistent southwest direction, increase in temperature and decrease in relative humidity. It was almost 24 hours after initial foehn onset in the western Taylor Valley when strong winds were recorded at the eastern stations (TH, TF, TE, TCa, TCo, THo). Lake Vida was the last station to identify foehn onset later on 22 May 2007 at 17:00 UTC (Table 2). During this event strong southerly foehn winds are observed in the Beacon Valley in the southwest MDV region (see Fig. 1). The Beacon Valley is sheltered by mountain ranges in all directions except to the northeast where it opens to the upper Taylor Glacier. Given these topographic constraints it is unlikely katabatic drainage from the East Antarctic Ice Sheet could enter the Beacon Valley.

Cross sections and trajectory analyses from the AMPS 2.2 km grid domain (Figs. 5 and 6) confirm that

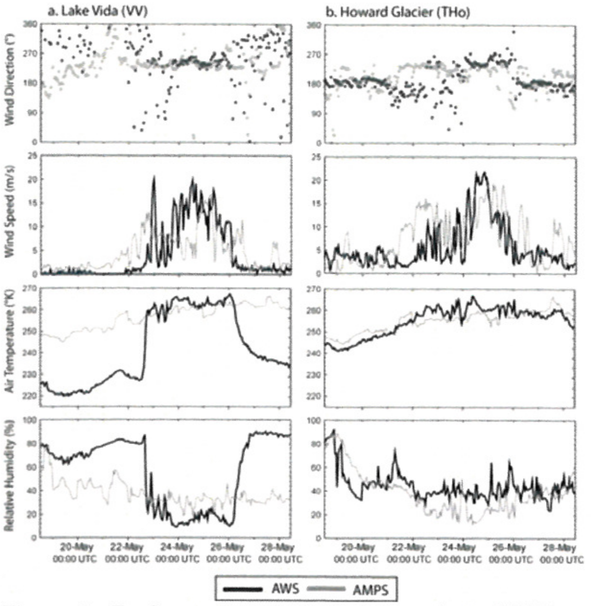

Figure 4. Foehn meteorological observations (AWS and AMPS) at Lake Vida (VV, Victoria Valley) and Howard Glacier (THo, Taylor Valley).

southerly flow is deflected from higher atmospheric levels to the surface as initially proposed by McKendry and Lewthwaite (1990). Backward trajectories presented in Fig. 5 illustrate that flow is south-westerly (parallel to the 500 hPa height contours) before arrival to the valley surface. Upstream flow over the ice sheet shows relatively stable vertical stratification (Fig. 6).

Flow appears to diverge to either side of Taylor Dome (peak elevation of 2450 m) and is forced to cross the mountain ranges separating the valleys. A prominent large-amplitude mountain wave pattern develops with vertical propagation to levels at least 8 km above sea level. Mountain wave activity is commonly associated with foehn winds in mid-latitude regions (e.g. Beer 1976; Durran 1990; Seibert 1990; Zängl 2003) but have not been linked to foehn winds in the MDVs until now. Dramatic temperature changes on the valley floor at foehn onset can be explained by the displacement of cold stable air by potentially warmer air from upper levels, in addition to adiabatic warming as air is brought to the surface from above ridge level. Regions of lower wind speeds appear above the valley centers associated with the mountain wave crests while wind speed maximums occur at the wave trough near the north-facing valley walls. Figure 5 also shows deflection of flow along the valley axis, particularly in the Wright Valley. This is a combination of forced channelling owing to the westerly component of the upstream flow but also pressure-driven channelling (see Whiteman and Doran 1993) associated with the strong horizontal pressure gradient across the MDVs. During the strongest winds later on 24 May 2007, wind direction at TTa turned almost southerly demonstrating air flow overcame topographic controls as it descended the slopes of the Kukri Hills (See Fig. 1).

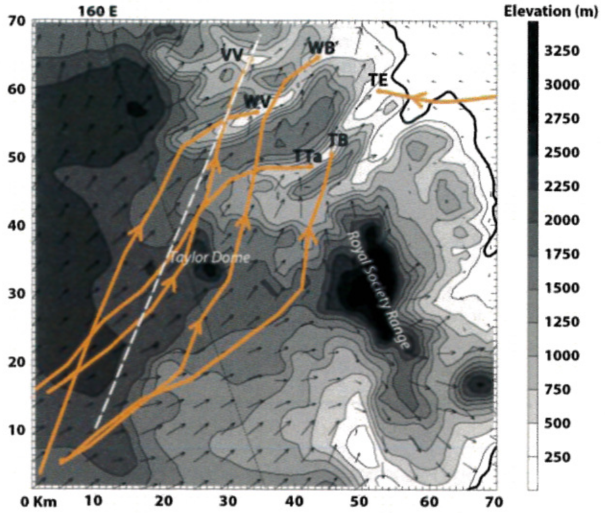

Figure 5. AMPS backward trajectories for air parcels arriving at MDV AWS station sites (~12.9 m above the modelled surface) for 24 May 2007 12:00 UTC. Dashed line shows the location of the cross-section in Figure 6. Wind vectors are for the lowest model level (~12.9 m above the surface).

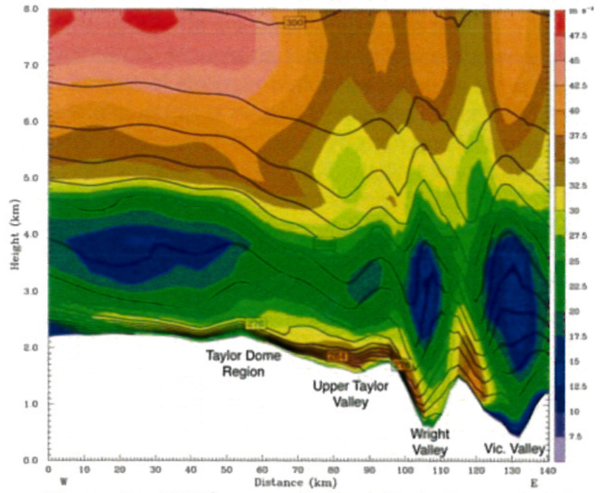

Figure 6. AMPS cross-section of wind speed and potential temperature (solid lines) for 24 May 2007 12:00 UTC. Location of cross-section shown in Figure 5.

Foehn cessation was first observed in the eastern Taylor Valley on 24 May 21:30 UTC with strengthening of cool and moist easterly winds with initial gusts up to 26.2 m s^{-1}. Wind speed later decreased to below 10 m s^{-1} on 25 May 09:00 UTC. Onset of strong easterlies caused foehn cessation at TE, TF, TH, TCa and TCo in the Taylor Valley, however, at THo on the southern valley wall (Kukri Hills) foehn conditions prevailed until 26 May 02:00 UTC when it was replaced by the onset of light southerly drainage winds. Foehn conditions ceased at all remaining western stations (TB, TTa, WV, VV, BV) by 26 May 07:45 UTC with return to pre-foehn conditions dominated by light cold drainage winds.

Table 2: Foehn characteristics at MDVs AWS

AWS	Onset (UTC)	Succession (UTC)	Min. Pre-foehn air temp (°C)	Max. foehn air temp (°C)	Min. foehn relative humidity (%)	Mean foehn wind direction	Max. foehn gust speed (m s^{-1})
TTa	05/21/2007 03:15	05/26/2007 13:45	-34.2	-5.1	10.1	224.8	33.3
TB	05/21/2007 09:45	05/26/2007 06:30	-41.4	-3.5	6,9	247.9	31.9
TH	05/22/2007 03:00	05/25/2007 23:15*	-36.1	-3.9	12.8	237.5	29.6
TF	05/22/2007 05:00	05/25/2007 02:45*	-44.1	-7.3	13.8	234.3	34.5
TE	05/22/2007 07:00	05/24/2007 21:30*	-40.8	-8.1	17.0	238.2	29.9
TCa	05/22/2007 03:00	05/25/2007 08:00*	-31.6	-5.4	12.5	234.8	35.7
TCo	05/22/2007 04:45	05/24/2007 23:00*	-32.0	-7.5	13.2	245.8	38.9
THo	05/22/2007 05:00	05/26/2007 02:00	-30.9	-6.1	10.9	215.6	34.8
WV	05/21/2007 23:15	05/26/2007 07:45	-46.5	-4.6	12.1	251.6	32.3
VV	05/22/2007 17:00	05/26/2007 07:15	-53.5	-5.0	7.9	232.8	27.9
BV	05/22/2007 16:15	05/26/2007 03:45	-36.2	-10.0	7.0	195.2	32.7

* Non-continuous foehn conditions between onset and cessation.

Foehn cessation at these stations was marked by an immediate drop in wind speed, a gradual decrease in air temperature and increase in relative humidity. The wave pattern evident in Fig. 6 significantly dampened with a return to near stable stratification due to weakening of the synoptic cyclone off Marie Byrd Land and associated pressure gradients. Post-foehn air temperatures remained elevated (compared to pre-foehn) for several days following the event, a feature also noted by Nylen et al. (2004).

4.2 Synoptic climatology

Foehn events such as the 21-26 May 2007 are a common occurrence in the MDVs. In the two calendar years of 2006 and 2007, foehn days occurred 28% of all days at THo, 27% at WV and 10% of days at VV. Data suggests higher frequency occurs at TB in the western Taylor Valley region, however incomplete AWS data prevents analysis. Highest frequency of events occurred in winter (MJJ, 41%) followed by spring (ASO, 33%), summer (NDJ, 13%) and autumn (FMA, 13%). Composite MSLP and wind vectors for 2006 and 2007 were constructed based on 172 foehn days recorded at 3 or more stations compared to 172 non-foehn days when no stations recorded foehn conditions. There were 398 total non-foehn days through 2006 and 2007, 172 selected to match the sample number of foehn days. Non-foehn days were purposely excluded if they occurred on either side of a foehn event to reduce the chance of pre-foehn and post-foehn conditions being included in the non-foehn analyses. Annual, summer (NDJ), and winter (MJJ) mean MSLP and surface wind vectors presented in Figs. 7-9, respectively, clearly identify the presence of a strong cyclonic system off the coast of Marie Byrd Land during foehn days in contrast to weak pressure gradients during non-foehn days. Interestingly, the cyclonic system is stronger in summer (Fig. 8a) than in winter (Fig. 9a). This could be related to the strong easterly 'sea breeze' circulation that develops in the MDVs during summer. The easterly circulation is extremely well-developed in terms of its strength, depth and persistence compared to thermal winds of lower latitudes (McKendry and Lewthwaite 1990) and may prevent grounding of foehn winds for extended periods (> 6 hours) to the valley floors unless overcome by particularly strong synoptic forcing.

The cyclonic system and associated pressure gradients present on MDV foehn days have widespread effects across East Antarctica. Composites of winter mean wind speed (Fig. 10) highlight stronger airflow across the Ross Ice Shelf and Ross Sea Coast during foehn days. Seefeldt et al. (2007) noted that strong katabatic winds across the Ross Ice Shelf occur when pressure gradients are perpendicular to the Transantarctic Mountains similar to those shown in Fig. 7a. A tongue of stronger airflow can also be seen east of Ross Island which is related to the climatological "Ross Ice Shelf air stream" or "RAS" (Parish and Bromwich 1998; Parish et al. 2006). Additionally, these composites indicate this synoptic situation is responsible for stronger airflow across north Victoria Land and Adelie Land.

This investigation demonstrates how cyclonic systems near the coast of Marie Byrd Land (between the Ross and Amundsen Seas) result in winds over the MDVs that lead to foehn. The Ross and Amundsen Seas are climatologically-favored regions for the persistence of cyclonic systems (Voskresenskii and Chukanin 1987; Simmonds and Keay 2000) and account for the high frequency of foehn events in the MDVs. The position and intensity of low pressure systems in this region displays one of the most prominent ENSO signals in the Antarctic (Carrasco and Bromwich 1993; Cullather et al. 1996; Gallée 1996; Kwok and Comiso 2002). During neutral and La Niña phases of ENSO, a region of low pressure occupies a position near the eastern Ross Ice Shelf. Conversely, during El Niño the low occupies a location further east towards the Antarctic Peninsula (Bromwich et al. 1993; Cullather et al. 1996; Carleton 2003; Bromwich et al. 2004).

Accordingly, we suggest that the significant interannual climate variability and ENSO signal that exists in the MDVs (Welch et al. 2003; Bertler et al. 2006; Doran et al. 2008) may be caused by the regions foehn wind regime (and warming) during La Niña phases and a less prominent foehn regime (cooling)

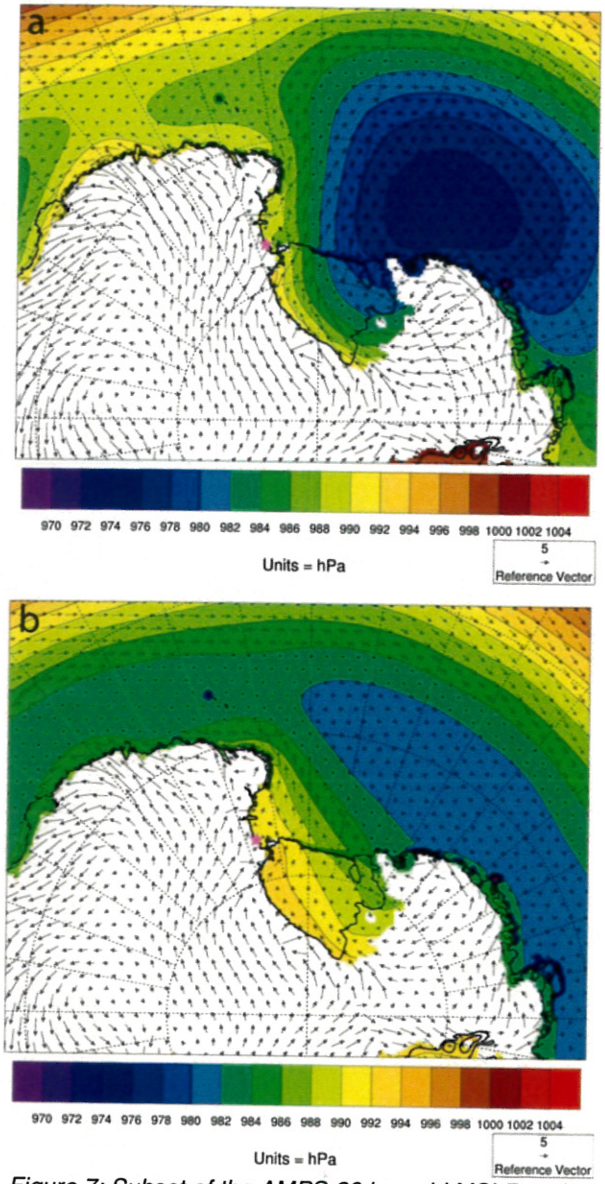

Figure 7: Subset of the AMPS 20 km grid MSLP and surface wind vector composites for 2006 and 2007 a) foehn days and b) non-foehn days.

during El Niño phases. It is postulated that the frequency and intensity of foehn events in the MDVs may provide an indicator for assessing changes in large-scale circulation patterns such as those associated with ENSO in this part of the Antarctic.

5. CONCLUSION

The MDVs frequently experience episodes of warm, dry and gusty foehn winds which are a dramatic climatological feature of this snow and ice free environment. This paper presents initial findings resulting from the ongoing collaborative work combining observational and model data to further the understanding of complex atmospheric and climate

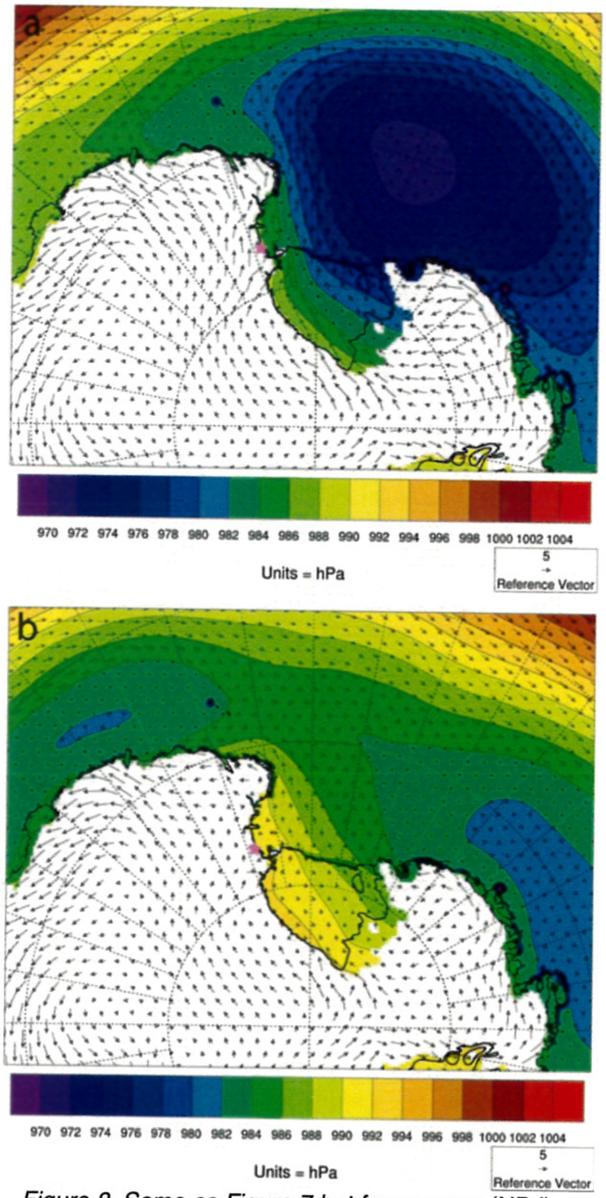

Figure 8. Same as Figure 7 but for summer (NDJ).

dynamics in the MDVs, particularly during foehn events. A winter foehn event examined here presents the spatial and temporal complexity associated with foehn onset and cessation in the MDVs. Model products from the AMPS 2.2 km domain indicate topographic interaction of synoptically forced airflow with the Transantarctic Mountains causes mountain wave activity which may contribute to foehn wind genesis in the MDVs. Importantly, this paper clarifies that a foehn mechanism is responsible for such strong wind events in the MDVs and the influence of katabatic surges from the polar plateau triggering events is minimal. A climatological analysis of all 2006 and 2007 foehn events was performed and illustrates a strong cyclonic low pressure system off the coast of Marie Byrd Land and resulting strong pressure-gradients over the

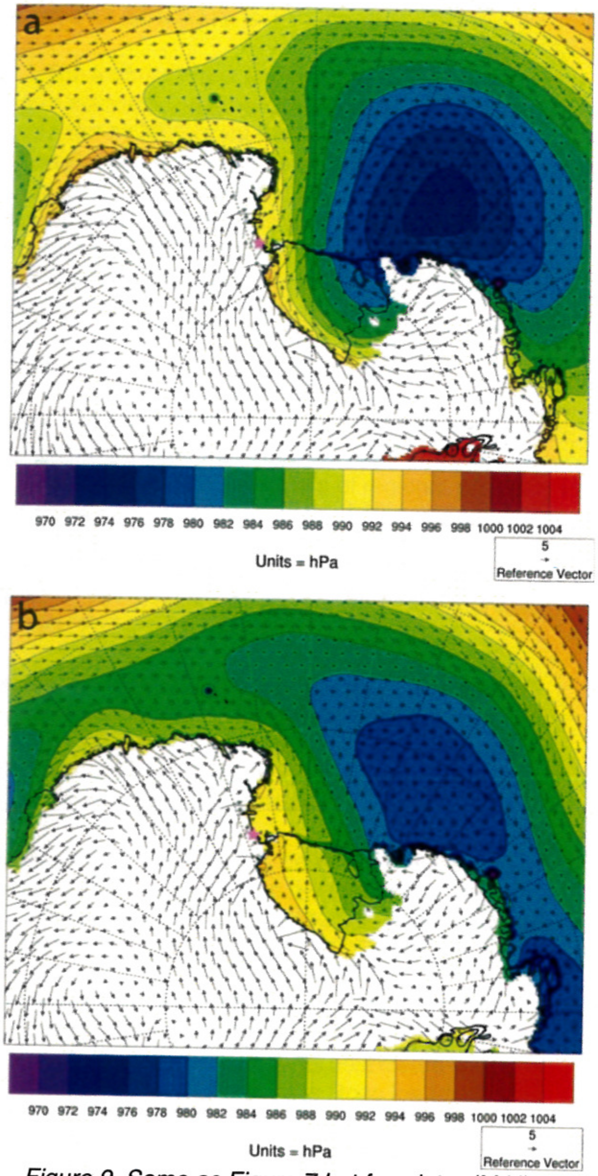

Figure 9. Same as Figure 7 but for winter (MJJ).

mountain ranges of the MDVs are responsible for foehn in the MDVs during all seasons. Accordingly, it is postulated that the frequency and intensity of foehn events may vary with ENSO and other linked teleconnections such as the Southern Annular Mode (Fogt and Bromwich 2006), which influence the position and frequency of these cyclonic systems in the Ross Sea region.

Further research is in progress detailing the synoptic climatology during foehn events and modelling of the complex atmospheric structure during the foehn event presented here. Future 1.1 km domain model runs with AMPS moving from MM5 to the Weather Research and Forecasting model (WRF; Skamarock et al. 2005) should improve model representations due to the higher order numerics in WRF. Important model validation by field research is planned in 2009 and 2011.

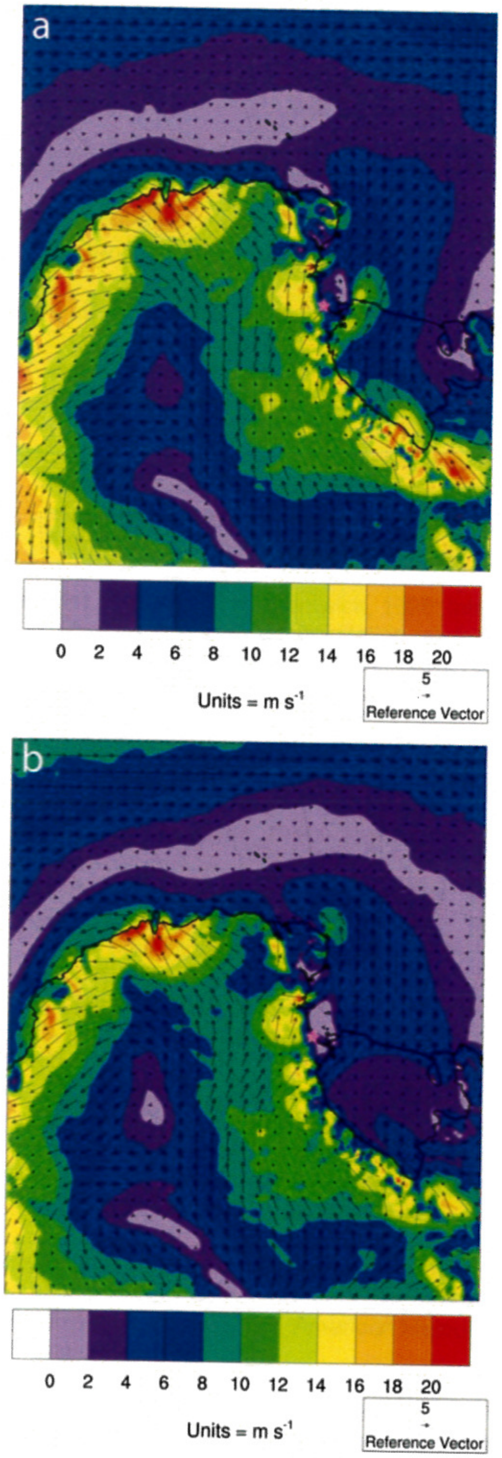

Figure 10. Subset of the AMPS 30km grid showing average winter (MJJ) wind speed for 2006 and 2007 a) foehn days and b) non-foehn days.

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THE AMPS FORECAST ARCHIVE: A SUPPORT FOR FIELD PROGRAMS IN ANTARCTICA

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The twice-daily weather forecasts from the Antarctic Mesoscale Prediction System (AMPS) run since 2001 have so far been archived on the NCAR Mass Storage System. In order to give the Antarctic research community more immediate access to this valuable, yet voluminous, data source, a subset of the AMPS archive has been made available by the Polar Meteorology Group of the Byrd Polar Research Center (BPRC) on its website for several years. An update of this database is currently underway that will eventually provide continuous 6-hourly and monthly time series in portable netCDF format for the different AMPS domains and for common surface, upper-level (700, 500 and 300 mb) and column-integrated variables. Time series from this updated database were recently used to provide some insight into typical summer weather conditions in Antarctica for preparation of upcoming field projects. These include drilling operations carried out by the Ice Core Paleoclimatology Group of the BPRC in the Antarctic Peninsula and a recovery mission led by the US Navy in Thurston Island, coastal West Antarctica, both missions being planned for the austral summer 2009-2010. In both cases, we restricted our study to the archived forecasts run with Polar MM5 between 2005 and 2008. The model configuration was indeed upgraded in late 2005 to attain a resolution of 20 km over the entire Antarctic continent and 6.6 km over the Antarctic Peninsula. We took advantage of the model configuration remaining unchanged until June 2008 to investigate the three summer seasons 2005-06, 2006-07 and 2007-08, and compute short climatologies over the projected sites of operation. We specifically examined meteorological variables most susceptible to affect field operations. These short surveys provide further examples of possible applications of AMPS, beyond real-time weather forecasting and scientific studies of Antarctic climate.

Challenges in Remote Forecasting for Deep-field Camps

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1. INTRODUCTION

Space and Naval Warfare Systems Center (SPAWAR) Atlantic, Office of Polar Programs (SOPP) stood up its Remote Operations Facility (ROF) in Charleston, South Carolina during the months prior to the 2005/2006 austral summer operating season. Part of its mission was to take over the forecasting and briefing services formerly provided by SOPP forecasters at the USAP Deep Freeze Weather Office in Christchurch, New Zealand, and also some of the forecasting services from the McMurdo Weather Office, i.e. issuing the Terminal Aerodrome Forecasts (TAFs) for the deep-field camps where Hercules LC-130 aircraft from the 139th Expeditionary Airlift Squadron were scheduled to fly, and those camps designated as operating hubs for the Twin Otter DHC-6 or Basler BT-67 aircraft of Kenn Borek Air Ltd. (KBA) and providing in-flight weather updates to the KBA aircraft.

Remote forecasting in data-sparse polar regions inherently has its challenges, especially in view of the demanding performance metrics that evaluate forecast accuracy and mission effectiveness that rival other organizations blessed with a network of rich observations and advanced METSAT imaging. One of the forecast performance benchmarks set by SOPP is to maintain at least an 80-percent monthly TAF accuracy rate (90-percent for McMurdo) with respect to ceiling/visibility categories of 1000 ft/3 miles, 500 ft /2 miles, and 300 ft/1 mile at the 4, 8, 12, and 16-hour forecast intervals; also, weather forecasts will not inaccurately compel aircraft commanders to delay, cancel, or abort a total of 40 missions for the operating season.

2. AVAILABLE REAL-TIME DATA

The ROF has access to camp observations and University of Wisconsin Antarctic Automatic Weather Stations (UWAAWS). The camp observations are accessed via a locally developed application that displays the observation in textual form. Additionally, the observations are ingested into Marta Yosemite™ Viewer that plots the observations, along with UWAAWS observations, on regional or continental map overlays.

Selected METSAT imagery is provided by the TeraScan® ground-stations at McMurdo and Palmer Stations. The HRPT receiver captures X-band data from Terra and Aqua EOS satellites, L-/S-band AVHRR data from NOAA TIROS-N satellites, and S-band data from DMSP satellites. Unfortunately, the TeraScan system processers create single-channel products only.

Our NWP system of choice is AMPS, followed by the Joint Air Force/Army Weather Information Network (JAAWIN).

3. CHALLENGES

a. Providing aviation forecasts for deep-field camps or unmanned sites where no weather observations are available

Many sites to which the Twin Otter DHC-6 or Basler BT-67 aircraft fly are unmanned and extremely remote, as these aircraft set up a fuel cache in many locations and often refuel there during the course of the operating season. KBA aircraft are also the first to "put in" at sites where new camps are set up. Sites that are manned oftentimes consist of small field parties with personnel typically not trained to take weather observations.

Forecasts for these types of missions are based on single-station analyses (if there is an AWS in the region), METSAT imagery, and NWP forecasts. ROF forecasters maintain surveillance over the region for which the route-of-flight is overflying and provide in-flight weather updates as the situation dictates.

b. Forecasting visibility in blowing snow

Several studies have investigated the correlation between wind speed and blowing snow events, and also discuss the dynamics involved in these processes. Wind speed thresholds for overcoming the dependent variables of snowpack resistance, and for initiating snow transport and blowing snow have been offered in these studies. SOPP forecasts for restricted visibility in blowing snow, using these wind speed thresholds as guidance, do not verify well for those sites in Marie Byrd Land. A somewhat higher degree of success occurs for sites in East Antarctica.

c. Forecasting for low and very low ceilings

Low ceilings, e.g. < 1000 feet, and very low ceilings, e.g. < 300 feet are frequently reported with fog conditions and precipitation. South Pole and Siple Dome are permanent sites where ceilings can rapidly fluctuate between low and very low ceilings, sometimes several times an hour and for periods of up to 6 to 12 hours. The upper-air sounding from

South Pole is the only site in the continental interior that forecasters can analyze and from which to ascertain the vertical extent of the boundary layer and saturated layers. Guidance from METSAT imagery is used, but again, single-channel images limit interpretation and analysis. The AMPS cloud ceiling forecasts are also used as guidance, with better success in Marie Byrd Land than over East Antarctica.

d. Interpreting single-channel detection METSAT imagery for analyzing fog and low clouds

The current real-time METSAT files from the TeraScan® ground stations at McMurdo and Palmer Stations are processed exclusively with single-channel detection for creating all its products. Forecasters use the TeraScan® TeraVision interface to display these products, and use either manual contrast stretch enhancements or automatic RGB enhancements. Single-channel infrared detection of fog and low clouds is difficult because of the relatively similar radiative properties between it and the surface in its ambient environment, and also because of the relatively broad range of values that define the channel's spectrum. Single-channel visible channel detection of these features is easier than using infrared channels because the differences in albedo are greater than the radiative difference; however, low sun angle images resolve fog and low clouds as dark featureless layers.

Advanced METSAT imagery, as discussed by Lazzara (2006), will allow forecasters to exploit multi-channel and differential multi-channel color combination imagery to mask fog, low clouds, water clouds, and ice clouds in its environment; thereby improving detection and analysis, and subsequent forecasts

e. Forecasting high wind speed events for McMurdo

Forecasting for McMurdo Station and its airfields is not a task currently performed by the ROF; however, the SOPP strategic plan envisions the ROF providing all forecasting services from Charleston within the next few years. One of the forecast tools used for guidance in forecasting high wind speed events at McMurdo is a locally-developed application referred to as WindAlert, an Excel Visual Basic Application that uses empirical guidelines developed by Holmes et al. 2000 that uses UWAAWS data to forecast high wind speed events at Pegasus Ice Runway. The UWAAWS units used for the empirical guidelines are Minna Bluff, Pegasus North, Marilyn, Schwerdtfeger, and Elaine. A stipulation of these empirical guidelines is the changes in temperature, wind direction, and the Δ-pressure between two AWS units occur within the last 18 h.

The application is loaded on the forecaster's computer workstation and automatically downloads the AWS observations from the SSEC server in McMurdo. The forecaster must periodically clear the data from the application because there is no script to do so. Another shortcoming of this application is that the application does not know the current time, so it cannot truncate its database to the most recent 18 hours in keeping with the "18-hour" stipulation. Having stated these shortcomings however, the application does provide good guidance when used in conjunction with AMPS.

Motivation for raising this subject is twofold:

1) With the network of UWAAWS expanding in the northwest Ross Ice Shelf, and the ice shelf drift of the "older" AWS units used in the study, is it feasible to reinvestigate this study if provided a grant by NSF?

2) Is it possible to create a better application than the WindAlert Excel VBA, and if so, might this be something for the BPRC Polar Meteorology Group to take on if provided a grant by NSF?

4. SUMMARY

Some of the challenges of remote forecasting can be mitigated by the ongoing commitment of the Antarctic meteorological community; i.e. the continual improvement of AMPS, and the outstanding research studies that are published in various journals. A commensurate level of commitment in upgrading the meteorological satellite ground stations in McMurdo and Palmer Stations to provide advanced imagery as discussed in this abstract and Lazzara (2006), and improving the SOPP WindAlert application as discussed here, will also improve forecast performance.

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