Storms and the formation of high salinity shelf water (HSSW) in Antarctic polynyas

Uotila, Petteri

Ohio Academy of Science
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BPCRC Technical Report 2021-001

The 16th Workshop on Antarctic Meteorology and Climate (WAMC)
June 21-23, 2021

The 6th Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) Meeting
June 24-25, 2021

(Virtual)

Polar Meteorology Group
Byrd Polar and Climate Research Center
The Ohio State University
Columbus, OH

Compiled in 2021 by the

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Copies of this report are available from The Ohio State University, Byrd Polar and Climate Research Center, Polar Meteorology Group's meeting web page. Visit http://polarmet.osu.edu/WAMC_2021 to download this report.

The WAMC Committee

David Bromwich, The Ohio State University (2021 Organizer)
Scott Carpentier, Australian Bureau of Meteorology
John Cassano, University of Colorado-Boulder
Arthur Cayette, NIWC Systems Center
Steve Colwell, British Antarctic Survey
Matthew Lazzara, Madison Area Technical College and University of Wisconsin-Madison
Jordan Powers, National Center for Atmospheric Research

The YOPP-SH Committee

David Bromwich, The Ohio State University
Kirstin Werner, Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research

Preface

The 16th Workshop on Antarctic Meteorology and Climate (WAMC) (June 21-23):

This workshop is organized (typically annually) by members of the WAMC Planning Committee from across the globe. The WAMC brings together those with research and operational/logistical interests in Antarctic meteorology and forecasting and related disciplines. As in the past, the annual activities and status of the Automatic Weather Station (AWS), Antarctic Mesoscale Prediction System (AMPS), and Antarctic Meteorological Research and Data Center (AMRDC) efforts will be addressed, and feedback and results from their user communities will be solicited. More broadly, this workshop also is a forum for current results and ideas in Antarctic meteorology, numerical weather prediction, and weather forecasting, from contributors around the world. There will be discussions on the relationships among international efforts and Antarctic forecasting, logistical support, and science.

The 6th Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) Meeting (June 24-25):

For the sixth YOPP-SH meeting, project investigators and representatives of national agencies active in Antarctica will provide updates on research resulting from the YOPP summer Special Observing Period (SOP) in the Southern Hemisphere, November 16, 2018 to February 15, 2019. Advanced planning for the upcoming winter SOP in 2022 and its focused activities during the Targeted Observing Periods will be highlighted.

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https://www.swoop-antarctica.com/emperor-penguin-colony

16th Workshop on Antarctic Meteorology and Climate (WAMC, Virtual)

Hosted by Polar Meteorology Group and Byrd Polar and Climate Research Center, The Ohio State University

SCOPE

Research, operational aspects and logistical interests in Antarctic meteorology and forecasting and related disciplines will be discussed.

More broadly, this workshop also is a forum for current results and ideas in Antarctic meteorology, observations, automatic weather stations, numerical weather prediction, and weather forecasting, from contributors around the world.

COMMITTEE

- David Bromwich, Ohio State University (2021 Organizer)
- Scott Carpentier, Australian Bureau of Meteorology
- Arthur Cayette, NIWC Systems Center
- Steve Colwell, British Antarctic Survey
- John Cassano, University of Colorado-Boulder
- Matthew Lazzara, Madison Area Technical College & University of Wisconsin-Madison
- Jordan Powers, National Center for Atmospheric Research

WAMC Meeting Agenda

[A]: abstract is available, [E]: extended abstract is available

Day 1: Monday June 21, Session 1
11:00-13:30 EDT / 15:00-17:30 UTC

Chair: David Bromwich

AWS update

11:00 – 11:10	**Welcome and Introduction** David Bromwich Byrd Polar and Climate Research Center
11:10 - 11:25	**Automatic Weather Station Observation Strategies and Hardware Updates**[A] Lee Welhouse Antarctic Meteorological Research and Data Center University of Wisconsin-Madison, USA
11:25 - 11:40	**University of Wisconsin-Madison 2021-2022 AWS Field Season Plans**[A][E] David Mikolajczyk Antarctic Meteorological Research Center/SSEC/UW-Madison, USA
11:40 - 11:55	**Antarctic Peninsula Automatic Weather Station Network 2020-21 - Field Season Review**[A] Mairi Simms British Antarctic Survey, UK

Operational Meteorology

11:55 – 12:10	**Operational Meteorology during COVID-19**[E] Michael Johnson NPP / DIGITALiBiz,
12:10 – 12:25	**Incorporating Automation into NPP Meteorology's Observational Reporting at McMurdo Station**[A] John Meyer NPP, USA
12:25 – 12:30	**Break**
12:30 – 12:45	**2020-21 USAP Operational Meteorology Field Season**[A][E] Arthur Cayette Naval Information Warfare Center (NIWC), Atlantic - Polar Programs (PPP)
12:45 – 13:00	**Portable Doppler Radar Evaluation Results at Phoenix Field, Antarctica**[A][E] Joseph Snarski NIWC Polar Programs, USA

13:00 – 13:15 **Review of X-Band Scanning Radar Observations from Phoenix Airfield**[A]
Mark Seefeldt
University of Colorado - Boulder, USA

13:15 – 13:30 **Strategies for using satellite imagery to detect shallow fog in Antarctica - A review of an advection fog event at Phoenix airfield**[A][E]
Jeffrey Fournier
NIWC Polar Program/iBiz, USA

End of the Session 1

Day 1: Monday June 21, Session 2
17:00-19:30 EDT / 21:00-23:30 UTC

Chair: John Cassano

Antarctic Meteorology

17:00 – 17:15 **A Far Infrared Radiative closure experiment for Antarctic Clouds**[A]
Gianluca Di Natale
Istituto Nazionale di Ottica – CNR, Italy

17:15 – 17:30 **Using a neural network to retrieve cloud height from remote sensing measurements in polar regions**[A]
Penny Rowe
NorthWest Research Associates, USA

17:30 – 17:45 **Assessing Physical Relationships Between Forcing Mechanisms and Boundary Layer Variability at McMurdo Station, Antarctica**[A]
Mckenzie Dice
University of Colorado Boulder

17:45 – 18:00 **Correction for radiative heating errors in naturally ventilated air temperature measurements made from AWS on the Antarctic Plateau**[A]
Naoyuki Kurita
Nagoya University, Japan

18:15 – 18:20 **Break**

18:20 – 18:35 **The Antarctic Meteorological Research and Data Center: A Phoenix Rising from the Ashes**[E]
Matthew Lazzara
Madison Area Technical College and University of Wisconsin-Madison, USA

18:35 – 18:50 **The AMRDC Repository: Focus on FAIR Antarctic Meteorological Data**[A]
Matthew Noojin
Madison College, USA

18:50 – 19:05 **The Antarctic-Internet Data Distribution System: The Global Antarctic Telecommunications System**[E]
Matthew Lazzara
Madison Area Technical College and University of Wisconsin-Madison, USA

19:05 – 19:30 **Ice Breaker**

End of the Session 2
End of the Day 1

Day 2: Tuesday June 22, Session 1
11:00-13:35 EDT / 15:00-17:35 UTC

Chair: Art Cayette

Precipitation, Strong Winds and PBL, Part I

11:00 – 11:15 **Summer surface mesoscale temperature processes on the East Antarctic Plateau during the YOPP-SH SOP**[A]
Sergi Gonzalez
AEMET, Spain

11:15 – 11:30 **Dominant role of vertical air flows in the unprecedented warming on the Antarctic Peninsula in February 2020**[A]
Min Xu
School of Atmospheric Sciences, Sun Yat-sen University, China

11:30 – 11:45 **Atmospheric drivers of extreme precipitation events over coastal West Antarctica**[A]
Sai Prabala Swetha Chittella
CORAL, Indian Institute of Technology KHARAGPUR, Indian

11:45 – 12:00 **Precipitation over the Southern Ocean: ERA5 and WRF/AMPS evaluation during two snowfall events around Mertz Glacier**[A]
Diogo Luís
Department of Physics, University of Aveiro, Portugal

12:00 – 12:15 **Preliminary results of precipitation phase transition study with PolarWRF and MRR-Pro data over Vernadsky station**[A]
Svitlana Krakovska
Ukrainian Hydrometeorological Institute, National Antarctic Scientific Centre, Ukraine

12:15 – 12:20 **Break**

12:20 – 12:35 **Sensitivity analysis of the radar snowfall rate estimates to the microphysics of ice particles in Antarctica coast**[A]
Claudio Duran-Alarcon
Department of Physics & CESAM, University of Aveiro, Portugal

High-Latitude Environmental Prediction, Part I

12:35 – 12:50 **AMPS Update - June 2021**[E]
Kevin Manning
National Center for Atmospheric Research

12:50 – 13:05 **AMPS: Looking Ahead**[E]
Jordan Powers
National Center for Atmospheric Research

13:05 – 13:20 **Mesoscale Evaluation of AMPS using AWARE Radar Observations of a Wind and Precipitation Event over the Ross Island Region of Antarctica**[A]
David Kingsmill
CIRES and NSIDC, University of Colorado, Boulder

13:20 – 13:35 **Simulating Frigid Supercooled Clouds for McMurdo, Antarctica with Polar WRF**[A]
Keith Hines
Polar Meteorology Group, Byrd Polar and Climate Research Center, The Ohio State University, USA

End of the Session 1

Day 2: Tuesday June 22, Session 2
17:00-19:20 EDT / 21:00-23:20 UTC

Chair: Jordan Powers

High-Latitude Environmental Prediction, Part II

17:00 – 17:15 **AEMET-γSREPS: The Spanish Convection-permitting LAM-EPS on Antarctica**[A]
Alfons Callado-Pallarès
AEMET (Spanish Meteorological Agency), Spain

17:15 – 17:30 **The Siple Dome Challenge: Can Your Model Match a New West Antarctic Dataset?**[A]
Dan Lubin
Scripps Institution of Oceanography, USA

Precipitation, strong winds and PBL Part II

17:30 – 17:45 **Identifying Snowfall Clouds at Syowa Station, Antarctica via a Convolutional Neural Network**[A]
Kazue Suzuki
Department of Science and Engineering, Hosei University, Japan

17:45 – 18:00 **Connecting Antarctic Snowfall and Extra-tropical cyclones**
Adrian McDonald
University of Canterbury, New Zealand

18:00 – 18:15 **Extreme atmospheric blocking trends and seasonality on both sides of the Antarctic Peninsula**[A]
Julio Marin
Universidad de Valparaiso, Chile

18:15 – 18:20 **Break**

18:20 – 18:35 **Polar low CAT event during HALO flight: a case study**[A]
Paola Rodriguez Imazio
CONICET-SMN Argentina

18:35 – 18:50 **A numerical simulation of strong wind event in January 2013 at the King Sejong Station, Antarctica**[A][E]
Seong-Joong Kim
Korea Polar Research Institute, Republic of Korea

18:50 – 19:05 **Living and working in Antarctica and the sub-Antarctic: Weather information use and decision-making**[A]
Victoria Heinrich
University of Tasmania, Australia

19:05 – 19:20 **Major Surface Melting Events over Ross Ice Shelf, Antarctica**[A]
Xun Zou
Polar Meteorology Group, Byrd Polar and Climate Research Center, The Ohio State University, USA

End of the Session 2
End of the Day 2

Day 3: Wednesday June 23, Session 1
11:00-13:20 EDT / 15:00-17:20 UTC

Chair: Kevin Manning

Climate Studies

11:00 – 11:15 **Antarctic Atmospheric River Climatology and Impacts**[A]
Jonathan Wille
Université Grenoble Alpes, France

11:15 – 11:30 **Antarctic Atmospheric Rivers: Flavors and Modes of Variability**[A]
Christine Shields
National Center for Atmospheric Research, USA

11:30 – 11:45 **Temperature and precipitation projections for the Antarctic Peninsula over the next two decades: contrasting global and regional climate model simulations**[A]
Deniz Bozkurt
Departamento de Meteorología, Universidad de Valparaíso, Valparaíso, Chile

11:45 – 12:00 **Present and Future of Rainfall in Antarctica**[A]
Étienne Vignon
Laboratoire de Météorologie Dynamique/CNRS, France

12:00 – 12:15 **Trends in Atmospheric Humidity and Temperature above Dome C, Antarctica Evaluated from Observations and Reanalyses**[A]
Philippe Ricaud
CNRM, France

12:15 – 12:20 **Break**

12:20 – 12:35 **Tropical-Antarctic Teleconnections and their Impacts on the Antarctic Climate Changes**[A]
Xichen Li
Institute of Atmospheric Physics, Chinese Academy of Sciences

12:35 – 12:50 **A model-based climatology of low-level jets in the Antarctic**[A]
Günther Heinemann
Environmental Meteorology, University of Trier, Germany

12:50 – 13:05 **Augmenting West Antarctic Weather and Climate Observations with an Expanded and Updated Ice Core Array**[A]
Peter Neff
University of Minnesota

13:05 – 13:20 **How the mesoscale variability casts doubt on the representativeness of observations near the Antarctic Peninsula**[A][E]
Denys Pishniak
NASC, Ukraine

End of the Session 1

Day 3: Wednesday June 23, Session 2
17:00-19:45 EDT / 21:00-23:45 UTC

Chair: Matthew Lazzara

17:15 – 17:30 **Temporal variations in Antarctic ice sheet surface accumulation observed with snow depth sensors in automatic weather stations**[A]
Naohiko Hirasawa
National Institute of Polar Research, Japan

Poster Session

17:30 – 17:32 **Ross Island Area Severe Weather Conditions**[A]
Logan Frey
Madison Area Technical College, USA

17:32 – 17:34 **Storms and the formation of high salinity shelf water (HSSW) in Antarctic polynyas**[A][E]
Petteri Uotila
University of Helsinki, Finland

17:34 – 17:36 **From the Mountains to the Penguins in the Deep Blue Sea: Importance of Atmospheric Forcing Resolution to the Simulation of the Ocean for a Biological Hotspot off the Antarctic Peninsula**[A]
Mike Dinniman
Old Dominion University, USA

17:36 – 17:38 **Antarctic Meteorological Research and Data Center: Antarctic Meteorological Data Flow**[A]
Taylor Norton
AMRC, SSEC, UW-Madison, USA

17:38 – 17:40 **The Hunt for Tabular Icebergs using Weather Satellites**[A]
Ethan Koudelka
Antarctic Meteorological Research and Data Center, USA

17:40 – 17:42 **Estimating surface meltwater input to the ocean over the last 40 years from King George Island ice cap, Antarctica**[A]
Christian Torres
Universidade Federal do Rio Grande, Brazil

17:42 – 17:44 **Antarctic Peninsula warm winters influenced by Tasman Sea temperatures**[A]
Kazutoshi Sato
Kitami Institute of Technology

17:44 – 18:15 **Breakout rooms**

LDM Training Session

Host: Matthew Lazzara

18:15 – 19:15 **Antarctic-Internet Data Distribution/Local Data Manager Basic Training & Discussion Session**

Conclusions and Discussions

Host: David Bromwich

19:15 – 19:45 **Open Discussion**

End of the Session 2
End of the WAMC meeting

Automatic Weather Station Observation Strategies and Hardware Updates

Lee Welhouse[1,3], David Mikolajczyk[1,2], Matthew Lazzara[1,3], Taylor Norton[1,2], George Weidner[1,2], Linda Keller[1,2], Andy Kurth[4], Forbes Filip[4], Josh Thorsland[4], and John Cassano[5]

[1]Antarctic Meteorological Research Center, Space Science and Engineering Center, University of Wisconsin-Madison
[2]Dept. of Atmospheric and Oceanic Sciences, University of Wisconsin-Madison
[3]Dept. of Physical Sciences, School of Arts and Sciences, Madison Area Technical College
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[5]Cooperative Institute for Research in Environmental Sciences, University of Colorado-Boulder

The Automatic Weather Station (AWS) project has reached 40 years of service in Antarctica and currently consists of a number of different styles of weather stations and transmission types. The history of the AWS2B to Campbell Scientific AWS, to the current development of the Polar Climate and Weather Station (PCWS) will be discussed. Over the years ARGOS has been our primary means of data transmission, with more recent use of Iridium in some regions. With the primary ARGOS transmitter in use being discontinued new modems are being explored along with pros and cons to each particular system. Iridium modems, new ARGOS 3 transmitters, as well as Swarm transmitters are being tested. Other upcoming changes in hardware are discussed. Along with this need for hardware changes, the observation strategy for past and future stations is explored. Partially in response to the improved bandwidth offered by newer satellite communication technology we are able to determine the best observation strategies for the entire network. The current goal is to transition the network to a more WMO standard observation strategy for the PCWS and the Campbell Scientific AWS where viable.

University of Wisconsin-Madison 2021-2022 AWS Field Season Plans

David E. Mikolajczyk[1,2], Lee J. Welhouse[1,3], Matthew A. Lazzara[1,3], Taylor P. Norton[1,2], George Weidner[1,2], Linda Keller[1,2], Andy Kurth[4], Forbes Filip[4], Josh Thorsland[4], and John Cassano[5]

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[5]Cooperative Institute for Research in Environmental Sciences, University of Colorado-Boulder, Boulder, CO

The 2021-2022 Antarctic field season for the University of Wisconsin-Madison (UW) Automatic Weather Station (AWS) will include much needed servicing of the AWS network and work on UW computer servers in McMurdo. Due to the COVID-19 pandemic, UW was unable to deploy a field team to Antarctica for the previous 2020-2021 field season. This upcoming field season, two field team members will focus on high- priority site visits in the Ross Island and Ross Ice Shelf region, as well as in West Antarctica. Some notable site visits include Alexander Tall Tower! on the Ross Ice Shelf and Austin and Kathie in West Antarctica. In McMurdo, the field team will install a new computer server and update existing computer hardware.

UNIVERSITY OF WISCONSIN-MADISON 2021-2022 AWS FIELD SEASON PLANS

David E. Mikolajczyk*[1,2], Lee J. Welhouse[1,3], Matthew A. Lazzara[1,3], Taylor P. Norton[1,2], George Weidner[1,2], Linda Keller[1,2], and John Cassano[4]

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https://amrc.ssec.wisc.edu

1. OVERVIEW

The University of Wisconsin-Madison (UW-Madison) has managed an Automatic Weather Station (AWS) network (Fig. 1), currently consisting of 58 AWS, in the Antarctic since 1980 (Lazzara et al. 2012). While the AWS network is autonomous, it still requires regular servicing. UW-Madison has deployed a field team to Antarctica for every austral summer field season since 1980 until last year's 2020-2021 field season, due to the COVID-19 pandemic.

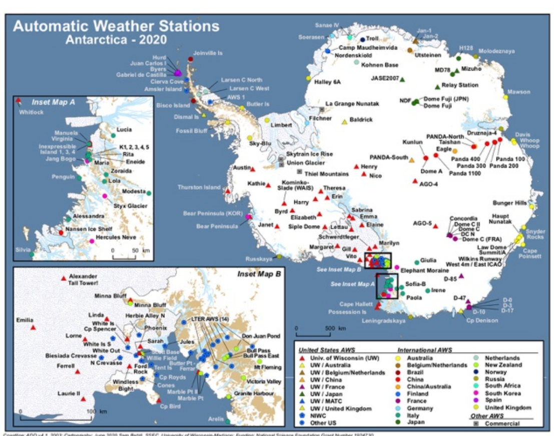

Figure 1. All known Antarctic AWS, as of 2020.

This upcoming 2021-2022 field season will consist of much-needed servicing in the Ross Island, Ross Ice Shelf, and West Antarctica regions. Due to the pandemic, deploying personnel from UW-Madison will be limited to two personnel from UW-Madison, David Mikolajczyk and Lee Welhouse. Additionally, the team will install a new computer server in McMurdo.

2. ROSS ISLAND AND ROSS ICE SHELF AWS

From McMurdo, there are several high priority site visits planned. The instrumentation and power system at Alexander Tall Tower! will be raised. Marilyn, Elaine, and Schwerdtfeger will be serviced, and collocated Polar Climate and Weather Station (PCWS) systems will be installed. Minna Bluff is not currently transmitting and will be fixed.

Other site visits require wind monitor replacement (Laurie II), raises (Margaret, Vito, Emilia, Ferrell, Lettau, Siple Dome), and regular checkups (Marble Point, Marble Point II, Cape Bird).

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3. WEST ANTARCTICA AWS

Perhaps the most critical AWS to visit this field season are Austin and Kathie, which receive high snow accumulation and are at risk of getting buried. Two AWS on the coast, Bear Peninsula and Thurston Island, are planned to be visited to fix power and wind monitor issues. The power system at Kominko-Slade will be updated.

4. COMPUTER SERVER IN MCMURDO

The team will install a new computer in McMurdo, which is part of the Antarctic Meteorological Research and Data Center (AMRDC) project (for more information, see Matthew Lazzara's presentation about the AMRDC in this program). This server will be an upgrade from existing hardware and will provide a robust mechanism for data flow received in McMurdo and distributed to UW-Madison and beyond, including by utilizing the Antarctic-Internet Data Distribution system.

5. ACKNOWLEDGEMENTS

This material is based upon work supported by the National Science Foundation, Directorate for Geosciences, Office of Polar Programs, under Grants 1543305, 1848710, and 1924730.

6. REFERENCES

Lazzara, M., G. Weidner, L. Keller, J. Thom, and J. Cassano, 2012: Antarctic Automatic Weather Station Program: 30 Years of Polar Observation. *Bull. Amer. Meteor. Soc.*, **93**, 1519-1537.

Antarctic Peninsula Automatic Weather Station Network 2020-21 - Field Season Review

Mairi Simms, Steve Colwell

British Antarctic Survey

The British Antarctic Survey (BAS) is responsible for a network of automatic weather stations (AWS) located on the Antarctic Peninsula and in the Halley region. BAS also service two further AWS on the Larsen C ice shelf in collaboration with the University of Utrecht. All BAS AWS sites measure wind speed, wind direction, temperature, pressure and relative humidity. Data are logged to a Campbell CR1000 data logger and ten minute averaged data are saved to a data card. Ten minute averaged data are transmitted via SBD Iridium every three hours and relayed as SYNOPS on the GTS. Once a week the complete data set is sent via Iridium. The AWS are powered by two 100Ah 12V lead acid batteries, charged by solar panel. Assuming normal service, these stations need only be visited to raise the instruments, logger box and batteries above snow accumulation and to retrieve and replace data cards. Visits usually take place every one or two years depending on weather conditions and aircraft operational commitments.

OPERATIONAL METEOROLOGY DURING COVID-19

Michael D. Johnson

Naval Information Warfare Center (NIWC), Atlantic - Office of Polar Programs (NPP), North Charleston, SC

DIGITALiBiz, Inc. (iBiz), North Charleston, SC

1. OVERVIEW

The NPP meteorology team supporting the United States Antarctic Program (USAP) had to rapidly adapt to changing constraints and challenges due to the Coronavirus Pandemic. New Zealand (NZ) immigration limitations severely restricted the number of personnel that could deploy to McMurdo Station, which impacted the overall number of missions supported as well as limiting the operational maintenance support available. Required isolation and quarantine periods constrained the number of personnel that could report to work and entailed the creation several contingency plans for maximum schedule flexibility. Uncertainty in mission support demands allowed for the testing of new position qualifications, as well as the implementation of new technologies to increase remote support capabilities.

2. BACKGROUND

NPP meteorology provides operational meteorological support to USAP operations. This support consists of broad spectrum of aviation, maritime, and surface weather products and services tailored to the need of various USAP participants in accordance with World Meteorological Organization and other standards. These products and services are traditionally produced either from McMurdo Station or from a remote operations facility (known as the ROF) located on Joint Base Charleston (JBC) in South Carolina. While staffing numbers have fluctuated over the past 10 years, operating seasons 2017-18 and 2018-19 saw a staff of 6 personnel primarily based in Charleston (all forecaster qualified) and 12 total personnel primarily based in McMurdo (4 forecasters and 8 observers). The 2019-20 season included an extra forecaster for radar evaluation purposes. Winter operations nominally consist of 2 personnel stationed at McMurdo Station (1 forecaster and 1 observer).

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Forecast production is normally divided between McMurdo Station and the ROF, depending on the type of product being produced and the method of dissemination. This division relies on the coordination between NPP personnel at each location, and each location can take primary responsibility for product generation depending on the situation. For example, a fire emergency at McMurdo station in January of 2020 necessitated a complete evacuation of the McMurdo offices, with the forecast team at the ROF taking over for all products and meteorological watch requirements. Observations (synoptic, aviation, and upper-air) would normally only be conducted from McMurdo Station (manually). A team lead would also be appointed for each location to provide on-site administrative support and represent the Chief Meteorologist at any required meetings.

3. AUSTRAL WINTER 2020

The plan for support during Austral Winter 2020 was rapidly rewritten as the pandemic "blossomed" throughout the world. Soon after the end of the 2019-20 season, the NPP team in Charleston went to maximum telework flexibility. The scheduled personnel rotation at McMurdo Station for March was canceled, and only one member of the team could remain deployed (forecaster). This necessitated an immediate change from manual to automatically observed synoptic observations and a suspension of the METAR encoded observations for McMurdo Station (89664/NZCM). The ROF in North Charleston was also activated for 120 hours per week to enable a continual watch over meteorological conditions impacting McMurdo Station. After a hasty training period, the single forecaster remaining at McMurdo Station remained responsible for daily upper air soundings (with assistance from the electronics technicians during flight operations) and any required airfield observations during flight operations. The ROF would increase to continuous staffing for flight operations periods and provide all forecasting support. The ROF also took responsibility for transmitting any automatically observed synoptic observations along with updating the McMurdo intranet weather information webpage.

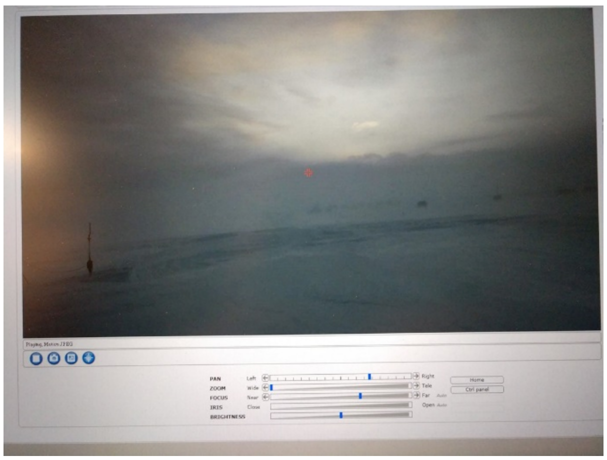

Figure 1. Webcam image from NZFX during Condition 2.

Another operational adaptation made was to limit the number of people utilizing government facilities due to occupancy restrictions and potential facility closures. As the ROF is primarily located on JBC, the decision was made to allow the ROF to relocate to an alternate site (local contractor's office facility) in accordance with the NPP Continuity of Operations Plan (COOP) and utilize laptop computers. This reduced potential exposure to personnel as fewer people have access to the alternate site. Select NPP personnel were granted full VPN access to USAP networks on approved contractor computer systems. Additionally, new remote access software to computer systems located on JBC or at the Antarctic Support Contractor's office in Centennial, Colorado was tested and utilized on both government and contractor furnished computers.

4. AUSTRAL SUMMER 2020-2021

The plan for support to the 2020-21 season was provide a defense in depth to allow for COVID-19 impacts to the staff, while continuing to test remote capabilities. The other key task for the 2020-21 season was the trial for an assistant forecaster position, who would be tasked with initial product preparation and monitoring meteorological conditions. The staff at McMurdo was reduced to 5 total personnel (1 forecaster, 1 assistant forecaster, 3 observers), which minimized the number of personnel that had to deploy through NZ. The forecaster took the role of team lead throughout the season and coordinated much of the flight support scheduling and provided on-call support for any emergencies in McMurdo.

Figure 2. 2020-21 McMurdo Team.

The staff in Charleston was increased to 12 total personnel (9 forecasters and 3 assistant forecasters). This assignment allowed for at least 2 qualified forecasters to be on-duty continuously, which created maximum flexibility when personnel had to enter isolation or quarantine for suspected or confirmed COVID-19 cases. The assistant forecaster positions were directed to initiate draft forecast products for further development by the forecaster on duty, monitor webcams and automated weather stations, and provide basic briefing support either in-person (McMurdo) or over the phone. Additionally, assistant forecasters would transmit automatically observed synoptic observations when no personnel were working in McMurdo Station. The Chief Meteorologist was also able to cover shifts when personnel were unable to report due to suspected or confirmed COVID-19 cases.

5. AUSTRAL WINTER 2021

Currently McMurdo Station is operating with 2 personnel on station (1 forecaster and 1 observer), with the ROF in standby mode for any potential emergency or scheduled flight operation periods (currently just one scheduled for early August). Winter operations are projected to continue until the first flight of main body participants scheduled in October. The winter forecaster is tracking daily the times of the effective satellite "blackout" period after the increase in data availability instituted in the past Austral Summer.

6. AUSTRAL SUMMER 2021-22

For the upcoming season, the NPP MET team will be reduced in staffing, as the Forecast Assistant position test has concluded. Forecast Assistant tasks will be incorporated into some of the observer duty lists, with the goal for increased personnel capability in future seasons. Six total personnel will deploy to McMurdo (2 forecasters and 4 observers) starting this July due to NZ requirements, and six personnel (all forecasters) will operate from the ROF. The duties will likely be divided between each location again, but with more forecasting duties expected to be completed from McMurdo. Increased automation is expected to be employed for the observing staff at McMurdo this season, as AWA software is currently being trialed for implementation by 01 October. This will enable the observing staff to provide support to both airfields if required due to anticipated deployment of LC-130s to McMurdo by December. Dedicated forecast assistants will not be employed this season; however, some forecast preparation tasks may be assigned to observers as required. The senior ranking forecaster at McMurdo will also serve as team lead.

7. SUMMARY

Given the uncertainty surrounding the COVID-19 pandemic and its impacts to the 2020-21 USAP campaign, NPP undertook the opportunities to test out some new concepts and tools to maintain and enhance its operational support. The increased availability of remote forecasting tools allowed for increased capability of displaced forecasting staff and permitted continued operations even with federal facility restrictions. Increasing the available remote workforce enabled maximum staffing flexibility when personnel had to isolate or quarantine due to suspected or confirmed COVID-19 exposure. Increased automation allowed for a baseline standard of service to be maintained. Finally, cross training traditional observers into forecast assistants set a foundation for continued development of a career progression pyramid, while strengthening the quality of NPP meteorology products.

Incorporating Automation into Observational Reporting at McMurdo Station

John Meyer

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NPP Meteorology currently utilizes two computer programs to encode and transmit manual meteorological observations. One is tailored exclusively for METAR observations, and the other for SYNOP reports. These programs have suited our needs for many years. However, both programs require human input, and the topic of automation has periodically been discussed. Mainly, how to balance keeping human observers involved with the process, while having automated systems to fill any potential gaps. The effects of COVID-19 have emphasized the usefulness of automation. The McMurdo weather office has had to operate with reduced staffing since April of 2020, thereby limiting routine manual observations. A rearrangement of personnel was improvised to continue meeting operational requirements for the 2020-2021 season, but automated observation software would have allowed for more continuous coverage. Another piece of software, Mesotech's Airport Weather Advisor (AWA), is part of the Automated Weather Observing Systems (AWOS) currently in use at McMurdo Station, Phoenix Field, and Williams Field. Up until now, the AWA has only been used to display raw sensor data from the AWOS. However, it also has some of the automation capabilities that we are seeking. This paper explores the versatility, limitations, and overall viability of using the AWA software as NPP Meteorology's main method of encoding and transmitting both manual and automated METAR and SYNOP observations in the future.

2020-21 USAP Operational Meteorology Field Season Q/A Performances

Arthur M. Cayette

Naval Information Warfare Center (NIWC), Atlantic – Polar Programs (NPP)

The 2020-21 field season operations was encumbered by the COVID-19 outbreak. Special care and consideration was afforded to avoid the exposure on continent. The precautions lead to the planning and execution of a reduced operational plan to a caretaker status. Due to the drastically reduced flight schedule, primary operational meteorology measures cannot be compared to previous collectives of performance achievements.
The ISO/WMO recommended goals for a true Quality Assurance program is not to merely monitor and judge the statistical performance of any activity over time, but to learn from the model and identify the strengths and weaknesses to improve what you can when you can. This broader view has allowed the past year to reflect on the operational meteorology performance in efficiency rather than hardline goal numbers and identify areas where automation and robotic processes (RPA) of known and suspected calculations can be enacted to improve quantitative forecasting efforts.

2020-21 USAP Operational Meteorology Field Season

Q/A Performances

A. M. Cayette
Naval Information Warfare Center (NIWC), Atlantic – Polar Programs (NPP)

1. INTRODUCTION

The 2020-21 field season operations was encumbered by the COVID-19 outbreak. Special care and consideration was afforded to avoid the exposure on continent. The precautions lead to the planning and execution of a reduced operational plan to a caretaker status. While the operational meteorology performance numbers were among the highest recorded, due to the drastically reduced operational schedule the sampling of operational meteorology measures cannot be compared to previous collectives of performance achievements.

The ISO/WMO recommended goals for a true Quality Assurance program is not to merely monitor and judge the statistical performance of any activity over time, but to learn from your model and identify the strengths and weaknesses to improve what you can, when you can.

This broader view has allowed the past year to reflect on the operational meteorology performance in efficiency rather than hardline goal numbers and identify areas where automation and robotic processes (RPA) of known and suspected calculations can be enacted to improve quantitative forecasting efforts.

2. BACKGROUND

With the inability to use comparable statistics, NPP's Quality Assurance focused on the review of the programs efficiency of forecast decision-making, production of customer products and training. Some initiatives were planned to take advantage of the slowdown in operations for United States Antarctic program (USAP) 2020-21 summer season.

A function of the normal McMurdo staff was held back to the remote operational facility (ROF) in Charleston and given the assignment

to extend the observational function beyond the standard METAR and Synoptic codes and apply the meaning of the word "observations" to all collected data forms. With limited responsibilities, the test in applying new observations could be afforded without affecting daily needs.

A goal to aid in a greater collective knowledge about the surrounding region would enhance the simple weather observation at a single location. This design would allow the build of more advanced warnings for changes in the weather patterns beyond the simple spot location surface based METAR code.

3. ENHANCED OBSERVATION PROCESSES

All processes were manual assembly and/or computation with the intention to invest in the automation if deemed a viable asset. Summary of items included:

- Produce, plot, and monitor "Fog Target Temperatures" for selected locations
- Identify and plot forecasted 1,000' divergent wind patterns in the McMurdo area
- Monitor Webcam still animation loops, log and report noted changes
- Perform analysis of all operational area upper air soundings highlighting potential cloud layers, icing, turbulence, and any unusual features/ changes
- Copy and Save all subsequent weather reports to applicable flight briefing packets after briefing through the conclusion of the flight

- Run QC program for selected METAR observations. Collect and report errors.
- Collect and transmit all camp/field observations
- Notify forecaster of significant changes to selected METAR reports
- Notify Forecasters and catalog significant divergence between surface weather reports and AMPS output parameters
- Notify Forecasts and catalog significant divergence between Upper Air weather reports and AMPS output parameters
- Observance of selected phenomena on Satellite
    - fog patterns
    - snow squalls
    - onset of katabatic winds
- **Add OTHER tasks when identified**

The manual tasks fell short in productive gains but did assist in what could be automated in the near term and over the course of time. Each item continues to have high merit in contributing to advances in forecasting techniques, development of alert metrics, and general understanding of the complex weather relationships.

4. INITIATED PROJECTS UNDERWAY

Currently there are two actions underway each are fundamental and will contribute to a foundation for additional projects in data automation.

- Automation of the McMurdo Building 165 Automated Weather Observation System. This equipment is currently used for 3 to 6 hourly synoptic / intermediate observations. Adding automation to this process will allow the production of METAR observations distributed through GTS that will increase the reporting to global modeling to hourly and allow the continuation of 3-hourly synoptic reports through the winter months. Each of these feature if done manually are too intensive for the staffing allocated.

- Quality Check of AWS observations vs. AMPS output. AMRDC has been funded to provide periodic checks of multiple sensor suites coupled to comparative values to the model output. These checks can provide a multitude of automated advances in areas as initiating of AMPS products to a more quantitative understanding of bias behaviors.

- "Data Assembler" Automate the copy and save of product data from their origins into the finished products. Observations, TAFs, Flight winds etc. This project will complete flight packet information from a flights beginning to its final destination.

- Automating the send process direct from the Field Camps into the database is an ongoing project.

5. NEAR FUTURE AUTOMATION DESIRES

- "Fog Alert" – A collection of short and medium range elements aiding as a probabilistic forecasting tool. '
- "Webcam Alert" using pattern recognition to identify when changes to the background image occurs
- Automate a Quality Control Check to include the comparison based on the AMRDC / AMPS QC data and will embrace the extended future features of:
    - Notify forecaster of significant changes to selected weather reports
    - Notify Forecasters and catalog significant divergence between surface weather reports and AMPS output parameters
    - Notify Forecasts and catalog significant divergence between Upper Air weather reports and AMPS output parameters

6. SUMMARY

We embrace ideas and cooperatives that have come from collaborative meetings and science research. Many of these processes will produce initial quantitative measures to gain numerical values, help to improved forecasting proficiency, and aid in future operational and science climate studies.

Portable Doppler Radar Evaluation Results at Phoenix Field, Antarctica

Joey Snarski

DIGITALiBiz Inc, Charleston, SC, USA

Abstract:

A portable Doppler radar (PDR) manufactured by EWR Radar Systems and facilitated through the United States Air Force was installed at Phoenix Airfield, McMurdo Antarctica on October 25th, 2019. The PDR experienced technical issues on the November 25th, 2019 which inhibited the PDR from detecting any targets as well as software issues which allowed for only 30 days of evaluation. During the evaluation period, 9 days showed meteorological returns with evidence of snow in clouds, precipitating snow, and potentially blowing snow. Horizontal Doppler velocities were available for analysis as well as a variety of secondary products such as velocity azimuth displays (VADs), precipitation accumulation, spectrum width, and more. With corrective action to the technical issues, a Doppler radar will provide significant value to USAP forecasting efforts.

Portable Doppler Radar Evaluation Plan at Phoenix Field, Antarctica

Joey Snarski
DIGITALiBiz Inc, Charleston, SC, USA

Overview:

A portable Doppler radar (PDR) was deployed to McMurdo Station, Antarctica during the 2019-2020 austral summer operating season for the United States Antarctic Program (USAP). The goal was to test the radar's ability to detect the small, dry snow particles observed in the region, identify any mechanical or engineering issues which could negatively affect the equipment, and determine how the variety of radar products might improve weather forecasting efforts and thus aviation operational success for the program.

Results:

The PDR remained operational for only 30 days before experiencing mechanical and software issues which ended the evaluation. During that time however, the PDR was able to detect snow in cloud, precipitation snow, and some evidence suggesting blowing snow. Targets were identified up to 50 miles from the radar in two of three evaluation sectors. The third sector had a shortened detection range of about 15 miles, likely due to complex terrain which the PDR was unable to properly filter out. Doppler velocities were in a reasonable range when compared with surface observations. In some instances, the Doppler directions provided a unique perspective not available in any other data source (i.e. satellite imagery). The velocity azimuth displays produced by the PDR were especially close when compared with rawinsonde data from McMurdo Station. These estimated vertical wind profiles can provide great benefit by filling in the gaps between 12-hourly rawinsonde launches. The PDR did not experience any significant mechanical issues due to winds or rime icing although winds were relatively light during the evaluation period. The radar did experience interference with radar onboard nearby aircraft which needs to be deconflicted.

Conclusions:

Even in the short duration that the PDR remained operational it was proven that the radar accomplished its two primary goals. It was able to detect fine, dry snow particles and produce products that would improve weather forecasting in the region. Additional benefits of the PDR include enhanced case study and scientific understanding of the local meteorology. These advantages ultimately lead to improved safety and success of USAP operations.

Review of X-Band Scanning Radar Observations from Phoenix Airfield

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An X-band scanning radar (EWR Radar Systems E700XD) was installed at Phoenix Airfield during the 2019-2020 main body field season in support of operational forecasting efforts by Naval Information Warfare Center (NIWC) Polar Programs (NPPS) at McMurdo Station. The observations collected by the E700XD was archived for additional analyses and case study evaluation. Unfortunately, due to issues with the E700XD, and a spin-up period in determining data collection and archiving, a fairly limited X-band scanning radar dataset was collected. This presentation will highlight the data that was collected, specific cases of precipitation events captured by the E700XD, and comparisons to the Antarctic Mesoscale Prediction System (AMPS). Additionally, lessons learned from the 2019-20 main body season deployment will be reviewed for potential data access and sharing between the research and operational communities in any future X-band scanning radar deployments.

STRATEGIES FOR USING SATELLITE IMAGERY TO DETECT SHALLOW FOG IN ANTARCTICA – A REVIEW OF AN ADVECTION FOG EVENT AT PHOENIX AIRFIELD

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[2]DIGITALiBiz Inc., North Charleston, SC
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On the morning of 2 FEB 2021, unexpected fog was reported at Phoenix Airfield, Antarctica. An LC-130 was scheduled to depart Christchurch at 0900 and arrive at Phoenix Airfield at 1700 NZDT. The earliest reports of fog were distant NE-E (true direction) of the airfield and came as the plane was about to depart. However, distant is ambiguous and there are no landmarks to measure the distance of fog from the airfield. Forecasters deliver a point of safe return forecast midway through such flights, so that the flight crew can decide to proceed or turn back.

Output from the 0 UTC 1 FEB AMPS run offered mixed signals for fog potential. It correctly depicted a moist surface layer with northeast (true) winds of 5-10 kt across the northwest Ross Ice Shelf. However, it showed a considerable dry layer just off the surface. Infrared imagery did not reveal the presence of fog during this event, which is typical due to the small temperature difference between fog and the surrounding surface skin temperature. Visible imagery did show the fog, but only after manually manipulating the standard gray scale. This manipulation was necessary due the oblique early morning sun angle resulting in the fog top brightness being nearly identical to the surrounding snow and ice. The shallow fog became much more obvious in the Day/Snow Fog product, a multispectral composite that enhances the appearance of fog against a background of snow and ice during the daytime.

STRATEGIES FOR USING SATELLITE IMAGERY TO DETECT SHALLOW FOG IN ANTARCTICA –

A REVIEW OF AN ADVECTION FOG EVENT AT PHOENIX AIRFIELD

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1. INTRODUCTION

Naval Information Warfare Center (NIWC) Polar Programs (NPP) forecasters generate Point of Safe Return (PSR) forecasts for the long flights from New Zealand to Antarctica. An LC-130 departed Christchurch at 20 UTC, 1 February 2021. Its estimated time of arrival was 04 UTC, 2 February, at Phoenix Airfield. The PSR forecast was delivered at 23 UTC. The flight crew then had 1 hour to make their final decision to proceed to Antarctica or to turn back to New Zealand.

Unexpected fog was reported at and near Phoenix Airfield from mid-afternoon through late evening on 1 February, or the morning of 2 February, local time. This shallow fog was difficult to detect using standard Infrared (IR) and visible channel imagery. Alternative strategies for using satellite imagery to detect fog are reviewed here. Note that this review does not distinguish between mist (BR) and fog (FG).

2. FOG CLIMATOLOGY OF ROSS ISLAND REGION

Lazzara (2008) noted a sharp decrease in the number of fog days late in the austral summer. The peak was 83 in January and only 22 in February, based on 10 years of surface observations from nearby Williams Field. This study also found that the primary airmass source regions associated with fog were the southern Ross Ice Shelf, the East Antarctic Plateau, or a combination of the two.

3. SYNOPTIC OVERVIEW

Skies cleared rapidly early on the evening of 1 February (LT), as a minor short wave trough exited the northern Ross Ice Shelf into the Ross Sea. At 1900 LT the surface temperature ranged from -3^{o} C at Phoenix Airfield to -7^{o} C across the northwest Ross Ice Shelf. By midnight LT, temperatures had fallen to about -11^{o} C.

The airmass source region for this event was computed using a single backward trajectory generated by the National Oceanic and Atmospheric Administration (NOAA) Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model. An air parcel at 10 meters AGL was initialized at Phoenix Airfield at 21 UTC, 1 February. The model-generated vertical velocity from the 00 UTC, 2 February Global Forecast System (GFS) solution was used by the HYSPLIT model to trace the airmass backward for 48 hours.

The airmass originated approximately 2800 meters above MSL near the Amundsen Coast, over the extreme southern Ross Ice Shelf (figure 1). It then translated northwestward to Byrd Glacier near the end of day one. Here the airmass descended approximately 1150 meters in 3 hours. That is an average descent of 10.6 cm/s, which is an order of magnitude greater than synoptic scale vertical motion.

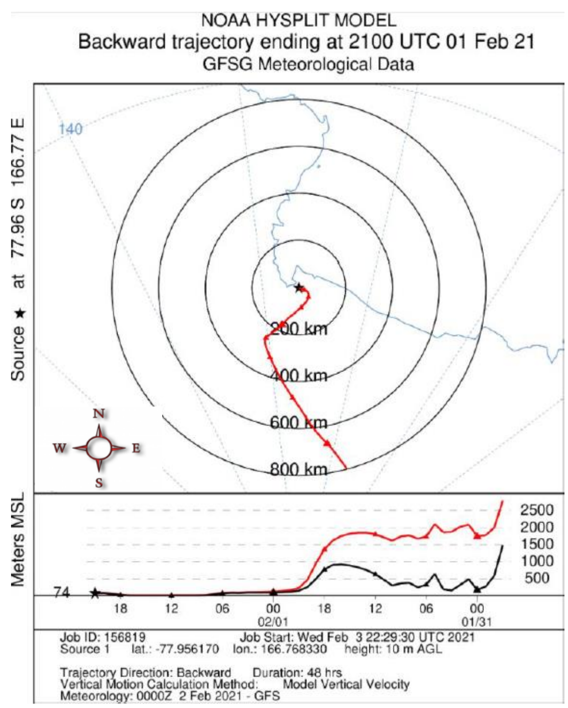


Figure 1. Backward trajectory of parcel (top) with map centered at Phoenix Airfield. Vertical time-height plot (bottom).

The parcel temperature only warmed 3º C. Calculations for dry adiabatic descent yield a warming of 10º C. It is possible that offsetting, diabatic cooling came from mixing with cold, katabatic flow from the East Antarctic Plateau off Byrd Glacier.

NPP forecasters rely heavily on output from the Antarctic Mesoscale Prediction System (AMPS). In particular, the 0.89 km horizontal resolution window was designed to better capture the rugged terrain and its significant impacts on local weather. Only the 00 UTC, 1 February AMPS run, at 0.89 km resolution, was available in its entirety for support of this flight.

The AMPS solution (Figure 2) verifying at 22 UTC, 1 February showed a large area of surface relative humidity values between 80% and 90% across the northwest Ross Ice Shelf, including Windless Bight. The forecast surface wind was generally northeast (true direction) 5-10 knots. This is the time when the lowest visibility (1000 meters) was reported at Phoenix Airfield.

The AMPS solution was similar to the observations from this time (Figure 3). This combination of relative humidity and wind (speed and direction) is consistent with the climatological conditions associated with advection fog. However, these conditions are often forecast and do not result in fog.

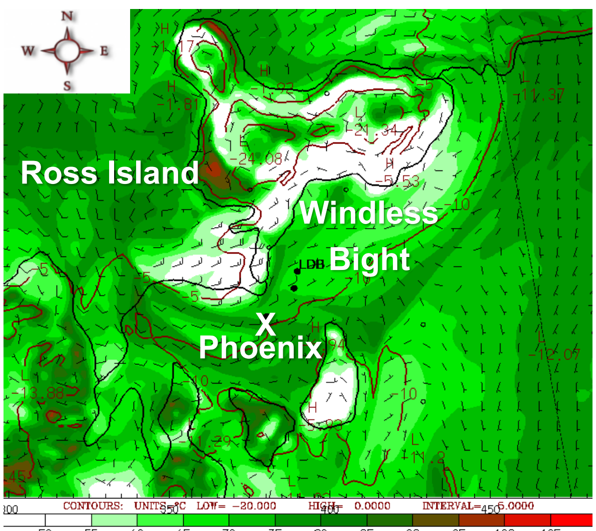


Figure 2. 00 UTC 1 Feb 0.89 km resolution AMPS run valid 22 UTC, 1 Feb. Surface relative humidity (with respect to water) is the image, with color scale at the bottom. Surface temperature (º C) contours are solid black lines. Surface wind vectors (knots and true direction) are black wind barbs.

The AMPS forecast Skew-T Log-P diagrams (Figure 4) were atypical of fog. They showed a shallow surface inversion, which is a common feature of the Planetary Boundary Layer (PBL) over the Ross Ice Shelf. During the morning hours, the forecast surface relative humidity was 75 to 80% at the airfield. Immediately above the surface level, through 3,000 ft AGL, the humidity ranged from 35 to 40%. This environment suggested the potential for dry air entrainment into the near-surface layer. Assuming this vertical profile represented a perfect forecast, a forecaster would assume that fog was unlikely, or that it would be very shallow.

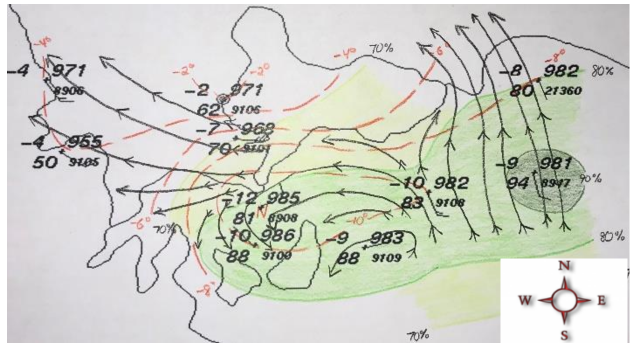


Figure 3. Subjective analysis of automated surface observations from 22 UTC, 1 Feb. Relative humidity above 70% is highlighted in shades of green, ranging from light green (70%) to dark green (90%+). Temperature (º C) contours are dashed red lines. Streamlines are long black arrows.

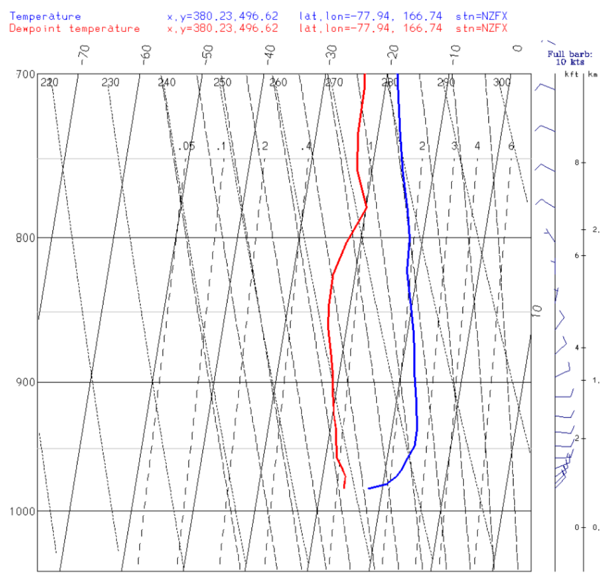


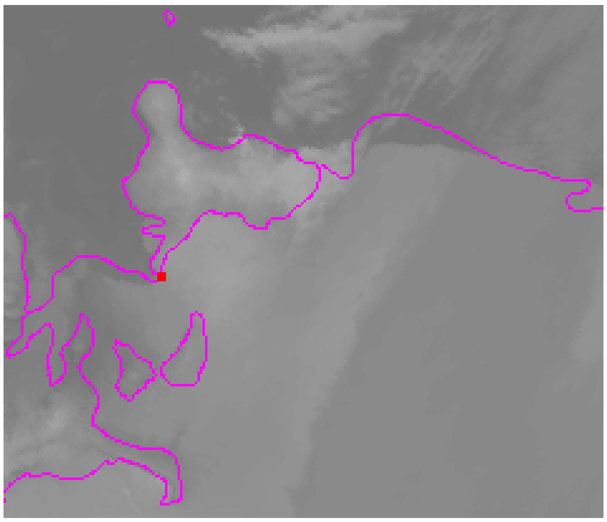
Figure 4. 00 UTC 1 Feb 0.89 km resolution AMPS run valid 19 UTC, 1 Feb. Standard skew-T Log-P diagram from surface through 700 mb. Wind vectors (knots and true direction) are depicted as standard barbs on right. Fog was observed upstream of Phoenix Airfield at this time.

Despite persistent, light northeast winds in the PBL, the model output never showed a deepening of the near-surface moist layer, or an increase in the surface relative humidity above 80%. These factors imply the lack of advection fog at Phoenix Airfield.

4. ANALYSES OF SATELLITE IMAGERY AND SURFACE OBSERVATIONS

IR channel imagery from the polar orbiting satellite passes did not reveal the presence of fog during this event. This is typical of IR imagery due to the small temperature difference between fog and the surrounding surface skin temperature. However, the 11 UTC, 1 February IR image (Figure 5a) did show an area of cooler surface skin temperatures across the Windless Bight region. This cool region matches well with the observed 4^{o} C to 7^{o} C cooling that occurred at the surface that evening, after skies had cleared and the surface winds were light.

a.



b.

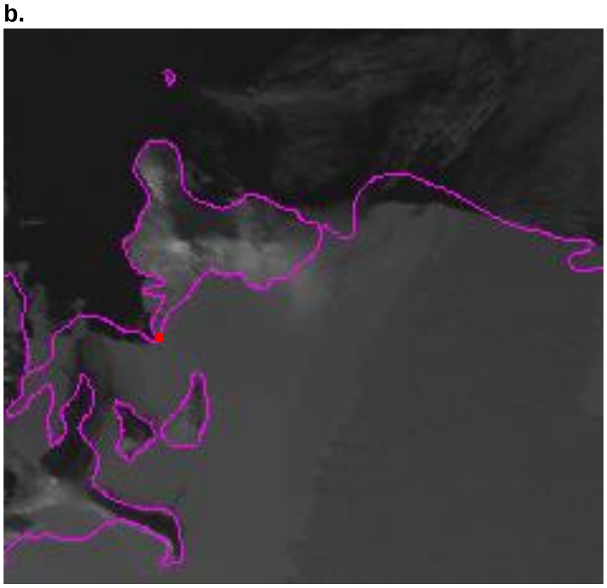


Figure 5a (top). 11 UTC 1 Feb IR channel image with standard gray scale. Note slightly brighter gray across Windless Bight. Figure 5b (bottom). 11 UTC visible channel image showing clear skies over Windless Bight. Both images from the Aqua satellite.

Visible channel imagery is often preferred to IR for detecting fog. However, even this imagery can struggle to show fog in polar regions, especially during the times of low sun angle. At such times, the oblique sun angle often results in fog top brightness that is nearly identical to the surrounding snow and ice.

When viewing visible channel imagery, it is common practice to use one gray scale across multiple images. This scale is usually chosen to help normalize pixel brightness associated with changing sun angle. This results in a more seamless loop of images, which helps maintain a sense of continuity when examining changes in cloud features. A subtle disadvantage to this approach is the potential masking of fog during the times of low sun angle.

Another way of using satellites to detect fog involves the use of multispectral red, green, blue (RGB) composites that enhance the appearance of fog against a background of snow during the daytime. One such product, the Day/Snow Fog product, is available on the website maintained by the Research in the Atmosphere and NOAA's Regional and Mesoscale Meteorology Branch (RAMMB) Satellite Loop Interactive Data Explorer in Real-time (SLIDER). However, there is typically a 3 to 6-hour delay between the image valid time and when it is available on the RAMMB-SLIDER website.

Lazzara (2008) used a similar method along with an additional analysis to enhance fog via creating Fog Principal Component Imagery (PCI) RGB composites. Aqua and Terra Moderate-Resolution Imaging Spectroradiometer (MODIS) imagery is routinely processed on McIDAS-X. However, NPP forecasters currently do not have access to this imagery for operational use at this time.

The primary platform used by NPP forecasters to analyze satellite imagery is TeraScan ®. When NPP forecasters issued their regularly scheduled Terminal Aerodrome Forecast (TAF) for Phoenix Airfield at 15 UTC, 1 February, the latest available visible channel image was from the Aqua pass at 1055 UTC (Figure 6). It did not show fog in the vicinity of Ross Island.

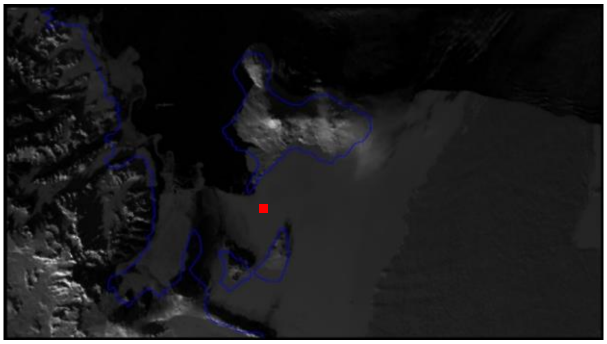


Figure 6. 1055 UTC 1 Feb Aqua MODIS visible channel with NPP default gray scale.

The 15 UTC TAF is the forecast most frequently used in deciding to proceed with, delay, or cancel the day's intercontinental flight. Most flights are scheduled to depart New Zealand at 20 UTC. Fog was not forecast at Phoenix Airfield in this TAF.

The first indication of fog came from the 1655 UTC surface observation from Phoenix Airfield. The experienced NPP weather observer reported fog to the distant northeast and east (true direction), upstream of the airfield. Unfortunately, the definition of "distant" is ambiguous.

From 1755 UTC through 1955 UTC, the observer at Phoenix Airfield continued to report fog to the distant east. The predicted and observed east to northeast flow suggested the possibility of this upstream fog being advected into the airfield. However, with insufficient upstream landmarks, the observer was unable to discern any movement of the fog.

The first evidence of fog in satellite imagery (Figure 7) came from the 1217 UTC Visible Infrared Imaging Radiometer Suite (VIIRS) visible channel image from the Suomi National Polar-orbiting Partnership pass (S-NPP). Fog was not evident using NPP's standard gray scale in TeraScan. However, fog became apparent across the Windless Bight after the manual manipulation of this scale.

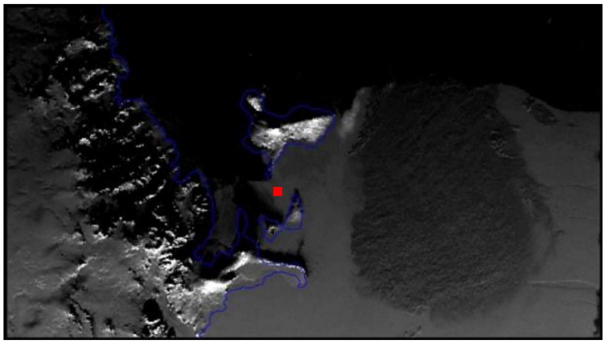


Figure 7. 1217 UTC 1 Feb S-NPP VIIRS visible channel with manually manipulated gray scale.

The next evidence of fog came via the NOAA-20 satellite passes. In particular, the Day/Snow Fog product from the RAMMB-SLIDER website revealed the location and shallow character of this fog more distinctly than the visible channel imagery. In both the 1343 UTC and 1525 UTC images (Figure 8), fog was evident across the Windless Bight. However, no expansion of fog toward Phoenix airfield was evident.

NOAA-20 imagery was not being processed by TeraScan in early February. Therefore, the 1343 UTC NOAA-20 image was not available prior to the flight crew weather briefing at 1730 UTC.

Fog was finally reported at Phoenix Airfield at 2037 UTC. The prevailing visibility was 4800 meters, but only 1000 meters in the eastern sector. The visibility quickly became unrestricted at 2104 UTC. However, the observer continued to note the proximity of fog in the 2104 UTC observation.

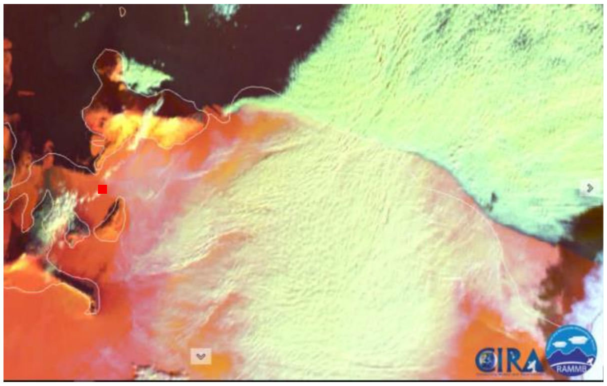
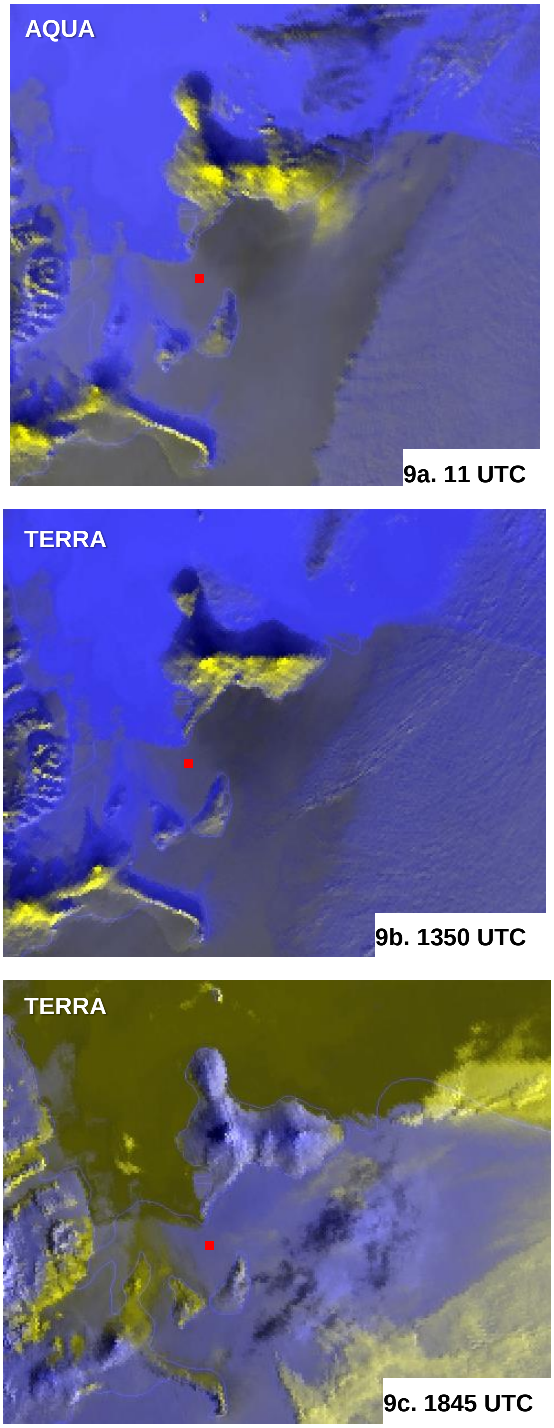


Figure 8. 1525 UTC 1 Feb NOAA-20 VIIRS Day/Snow Fog.

Fog briefly returned to the airfield at 2155 UTC, when the visibility reached its lowest value of 1000 meters. At 2236 UTC, the visibility became unrestricted for the remainder of the day. However, the observer continued to report fog to the distant northeast as late as 2255 UTC.

During the times of lowest visibility, the Ross Island region was in its daily satellite "blackout". This period occurs from mid-morning through mid-afternoon local time, as the orbits of all the polar orbiting satellites leave this zone uncovered.

The Fog PCI RGB imagery from the Terra and Aqua MODIS passes could be made available much sooner than the Day/Snow Fog imagery. The sequence of images in Figure 9 shows that the fog developed around local midnight and persisted with little change through the morning hours. Had this imagery been available to forecasters in real time, they would not have been caught off guard by the first manual surface observations of the day.



Figures 9a-9c. Fog PCI imagery from Aqua and Terra MODIS.

5. CONCLUSIONS

Satellite imagery is the most helpful fog detection tool in regions of sparse surface observations. However, fog can still be difficult to detect, especially during times of low sun angle in regions of persistent snow and ice. The use of multispectral composites, as well as manually adjusting the standard gray scale for viewing loops of visible channel images, can help forecasters detect fog under these challenging circumstances.

6. ACKNOWLEDGEMENTS

The authors wish to thank Linda Keller for processing NPP archived automated weather observations for the observation plots used in the subjective surface analyses. The authors wish to thank Rebecca Burtney for her work as the weather observer at Phoenix Airfield during the event. The authors also wish to thank Arthur Cayette for initially noting the appearance of fog in the Day/Snow Fog images from the S-NPP and NOAA-20 satellite passes.

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A Far Infrared Radiative closure experiment for Antarctic Clouds

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Most uncertainties in the characterization of the longwave emission of cirrus clouds come from the lack of spectrally resolved measurements in the far-infrared (FIR) spectral region from 100 to 667 cm−1 (100–15 μm). The Antarctic Plateau represents one of best place where these measurements can be performed because the high-altitude and the very dry conditions allow to sound efficiently the infrared spectrum down to the FIR region. The purpose of this research is the spectral characterization of ice and mixed-phase clouds in order to evaluate the radiative models in the FIR regime, where the clouds effect is very strong, and systematic spectral measurements are scarcely available. This can be accomplish by means of the synergy of different instruments installed at Dome-C, such as a Fourier transform spectroradiometer (REFIR-PAD), operating in the spectral broad band between 100-1600 cm-1 (6-100 mu) since 2012, the backscattering/depolarization lidar at 532/1064 nm, a micro rain radar (MRR) at 24 GHz , an ice-camera and halo-camera. The retrieval of the optical and micro-physical properties (effective diameters of the ice crystals and optical depth) of ice and mixed-phase precipitating clouds is performed by using a suitable code with the REFIR-PAD and lidar measurements, and they can be used to estimate the cloud reflectivity at the radar frequency for comparison with the MRR and ice camera data.

Using a neural network to retrieve cloud height from remote sensing measurements in polar regions

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Cloud height, which determines cloud temperature, strongly influences cloud radiative forcing. At the same time, there is a need for additional observations of cloud height in polar regions. Polar cloud heights have been retrieved from infrared radiance measurements using two methods: CO_2 slicing and the minimum local emissivity variance (MLEV) method. Retrieving cloud height from downwelling radiances is challenging, and the two methods can produce results that are wildly incorrect or differ substantially from each other. However, the two methods are complimentary in that they use overlapping but distinct frequency regions and have differing sensitivities to errors (notably, instrument noise and errors in atmospheric temperature and water vapor). This suggests combining the two approaches, but prior work has shown this to be challenging. One possible solution is a neural network, which first learns how to predict cloud height through a training set with known answers, or labels, and then is applied to unlabelled data. Here preliminary work is presented exploring the potential of a neural network to predict polar cloud height from downwelling infrared radiance measurements. As a basic proof of concept, a feed-forward neural network was trained and tested with simulated data with no imposed noise or bias for two different inputs: 1) computed cloud emissivities for a set of potential cloud heights, averaged over small frequency regions, and 2) the local emissivity variance (LEV) at the same set of potential cloud heights (the LEV is also used by the MLEV method). The training and testing sets consisted of 490 and 123 simulated radiance spectra (respectively) corresponding to 20 unique atmospheric profiles and mixed-phase clouds with properties randomly selected from uniform distributions for optical depth (0 to ~5), ice fraction (0 to 1), and cloud base (0 to 8 km). Clouds were correctly predicted to be low or high by the neural network with accuracies of 90% (using the LEV as inputs) and 99% (using emissivities as inputs). The latter outperforms the accuracies for MLEV (98%) and CO_2 slicing (95%). Work is needed to modify the neural network to retrieve quantitative cloud heights, as well as to etermine the accuracy when noise and bias exist, which results in considerably lower accuracies for MLEV and CO_2 slicing. Future work also includes testing on real data, exploring methods for dimensionality reduction, and exploring combining the MLEV and CO_2 slicing methods.

Assessing Physical Relationships Between Atmospheric State and Fluxes and Boundary Layer Variability at McMurdo Station, Antarctica

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Observations at McMurdo Station Antarctica from 23 November 2015 through 5 January 2017 were used to characterize the physical relationships between boundary layer variability and atmospheric state and fluxes present annually and seasonally. These measurements were taken during the ARM (Atmospheric Radiation Measurement) West Antarctic Radiation Experiment (AWARE), which was conducted with the aims of explaining the dynamical mechanisms of climate change in West Antarctica, one of the most rapidly warming places on Earth.

The basis of this analysis was the use of self-organizing maps (SOM), a neural network algorithm, to identify the range of potential temperature profiles present in the twice-daily radiosonde data during the AWARE campaign. The SOM technique condenses the 787 AWARE potential temperature profiles in the lowest 500 m of the atmosphere to 20 patterns that span the range of potential temperature profiles, or stability regimes, present in the 13-month dataset. The SOM identified patterns ranging from strongly stable regimes to weakly stable regimes, throughout the depth of the lowest 500 m. It was found that in the winter (MJJA), moderate to strongly stable regimes occur about as frequently (39.7%) as weakly stable regimes (38.9% of the season), and weakly stable regimes dominate in the summer (DJ, 68.8% of the time). The SOM also identified patterns that were characterized by weak stability near the surface and enhanced stability aloft, as well as patterns characterized by enhanced stability near the surface and weak stability aloft. Other observations, such as wind speed and surface radiative fluxes, that correspond to the time each SOM pattern was recorded can be analyzed to understand the relationship present between the different stability regimes and these other variables. It was found that weak winds correspond to strongly stable patterns, and stronger winds correspond to weakly stable patterns. Additionally, wind speed profiles were analyzed, and low-level jets (LLJs) were identified in several of the stability regimes in several seasons, including every season where there is weak stability in the lower half of the profile and enhanced stability aloft. Radiative fluxes were also examined seasonally and across stability regimes. Although the net radiation decreases from the weak stability to strong stability regimes in the winter, as expected, the net radiation is still negative when stability is weak, indicating that the stronger wind speeds seen in this regime in the winter is likely causing this regime to occur. Finally, bulk Richardson number profiles were assessed, and related to features seen in the potential temperature gradient and wind shear profiles to examine turbulence generation processes in the boundary layer.

Correction for radiative heating errors in naturally ventilated air temperaturemeasurements made from AWS on the Antarctic Plateau

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Solar radiative heating errors (warm biases) of surface temperature measurement with naturally ventilated air temperature sensors are examined at the Dome Fuji site in east Antarctic Plateau. The difference between naturally ventilated and fan-aspirated air temperature sensors occasionally reaches more than 10°C in low-speed wind during austral summer. As expected, the warm bias increase with increasing shortwave radiationand diminish with increasing wind speed. In addition, a significant dependence is found with respect to solar angle; monotonously decreasing of the bias from austral summer towinter. Multiple linear regression between the observed bias and wind speed and downward shortwave radiation at the surface showed a robust correlation (R=0.93). Thus,at Dome Fuji site, a correction for warm biases of temperature observations made in naturally ventilation shield is possible using the multiple regression analysis. This approach also works for the AWS at the Relay station 370 km south from the Dome Fujisite.

THE ANTARCTIC METEOROLOGICAL RESEARCH AND DATA CENTER: A PHOENIX RISING FROM THE ASHES

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https://amrdcdata.ssec.wisc.edu/

1. ABSTRACT

Easy access to Antarctic meteorological datasets is of the utmost importance to encourage data exchange, extend scientific research, and engagement in earth system study. The Antarctic Meteorological Research and Data Center (AMRDC) aims to bring Antarctic meteorological datasets, with an emphasis on observational data sets, to the broader community. Housed within the center is a new repository that will host currently available datasets (e. g. Wisconsin Automatic Weather Station data, Antarctic satellite composites, field camp observations, etc.) as well as campaign meteorological datasets deposited by other Antarctic investigators. As a discipline-specific data center, the AMRDC aims to be an active host of real-time and archived data. Data servers and services will be a part of this effort including formal support for the Antarctic-Internet Data Distribution system. The AMRDC will engage students throughout the project not only in its data efforts, but also via case study work, climatological reporting (complimenting existing efforts), and development of white papers on associated topics. This effort will be advised by a peer advisory board. The AMRDC will be a fully recognized Antarctic meteorological data center, for and by the community. It has the potential to be a participant in the WMO's Antarctic Regional Climate Center network. This presentation will give an overview of the AMRDC repository and web portal project efforts; outline plans for contributions to the repository; discuss meteorological data creation, servers and services; denote the role of students and an advisory board and profile plans for the future.

2. REPOSITORY AND WEB PORTAL

The primary focus of this effort is the establishment of a data repository. The AMRDC has selected the Comprehensive Knowledge Archive Network (CKAN), an open-source platform for the storage and distribution of archived data. CKAN is used in a variety of environments such as enterprise and government including https://www.data.gov/ in the USA. The initial demonstrational release of the AMRDC repository can be found here: https://amrdcdata.ssec.wisc.edu/ (See Figure 1). All of the data holdings currently/historically held by the Antarctic Meteorological Research Center (AMRC) will be placed in this new

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repository. The repository is structured around construction of descriptive and comprehensive metadata, assigning Digital Object Identifiers (DOIs) for the data, supporting interoperability standards and FAIR data principles: Findable, Accessible, Interoperable and Reusable.

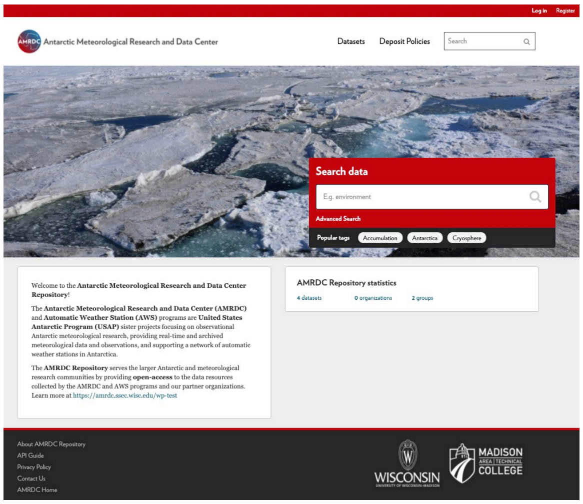

Figure 1. The initial draft of the AMRDC data repository, http://amrdcdata.ssec.wisc.edu/ using the open source CKAN to manage the data portal.

A companion effort is the recasting of the website that the AMRC has used to provide Antarctic real-time meteorological data and information to the community. The new site, under construction, will mirror the new emphasis on data. When released, the website will be found here: https://amrdc.ssec.wisc.edu/

3. CAMPAIGN & INVESTIGATOR DATA

As a community resource, the AMRDC in the near future will accept datasets from the meteorological community as soon as the repository is fully operational. Hence, meteorological campaign or signal investigator datasets will be eligible to be placed into the repository at the AMRDC. This will fulfill publisher requirements for depositing final datasets that support publications into disciplinary repositories as well as fulfill open data requirements of funding agencies. (e. g. NSF, etc.). Further, deposited data will also have proper metadata and controlled vocabulary assignments along a Digital Object Identifier (DOI), all of which are essential for data publishing and data citation.

4. METEOROLOGICAL DATA CREATION, DATA SERVERS AND DATA SERVICES

This project will continue to generate products the AMRC has been known for (e. g. tracking icebergs via weather satellite imagery). The Antarctic satellite composite imagery which is uniquely generated by this project will continue in an operational and official capacity. In the coming year, this product will be extended to have the composite rotated to have 0° longitude at the top of the image, which matches how many in the Antarctic community view the Antarctic and Southern Ocean (see Figure 2).

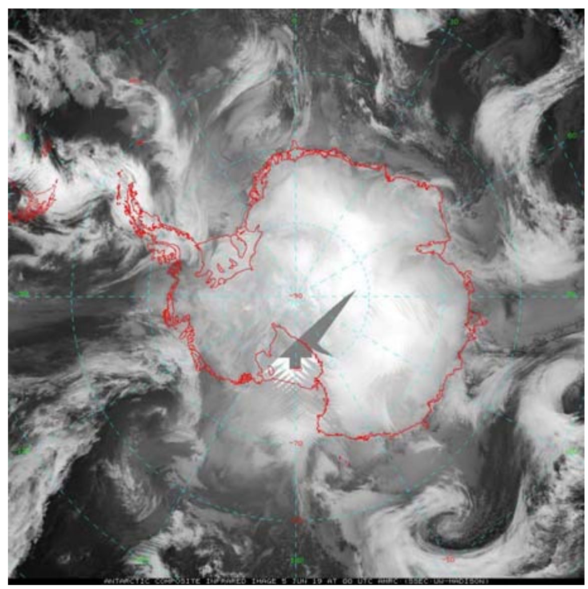

Figure 2. A test sample Antarctic infrared composite image, rotated from the historical view with "standard grid-North" or Greenwich up at the top of the image.

The AMRDC project will provide data servers and data services to the meteorological community. The Antarctic-IDD effort is discussed separately in Lazzara et al. 2021. Additionally, McIDAS ADDE service will continue with real-time data availability in the short term. The long running archive, which is still available on the older AMRC system, will require additional effort to continue to make it available via ADDE without having to hold two copies of the core official archived data.

5. ADVISORY BOARD AND STUDENTS

Elements that are essential to this project's success include: the AMRDC Advisory Board (AAB) and student engagement. We are fortunate to have a diverse group of peers providing guidance and expert advice (See Table 1). The AAB is meeting roughly quarterly in their guiding role. In addition, this project is engaging undergraduate and graduate students at all levels including on the AAB.

Table 1. Members of the AMRDC Advisory Board.

AMRDC Member	Institution
Mike Carmody	ASC
Art Cayette	NIWC
Carol Costanza	NCAR
Bob Dattore	NCAR
Mckenzie Dice	U. Colorado
Jonathan Pundsack	U. Minnesota
Jerry (Xun) Zou	OSU/BPCRC
Matthew Lazzara, ad hoc	Madison College

6. FUTURE

The AMRDC is a long-term effort, to benefit the Antarctic meteorological community. Your participation, your input, and your data are welcome and encouraged. While not every problem or concern is being tackled, the challenges facing Antarctic meteorology cannot be addressed without you. The AMRDC is rising from what has been demonstrated for many years under the AMRC.

7. ACKNOWLEDGEMENTS

This material is based upon work supported by the National Science Foundation, Directorate for Geosciences, Office of Polar Programs, under Grants 1951603 and 1924730. Thanks for the advice and efforts by the AMRDC Advisory Board, the Madison College Grants Office, and Space Science & Engineering Center support staff, without whom this project would not be possible.

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The AMRDC Repository: Focus on FAIR Antarctic Meteorological Data

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The Antarctic Meteorological Research and Data Center (AMRDC) Repository was established as the long-term archive and access point for Antarctic meteorological datasets deposited by the AMRDC and its partner organizations. Meteorological data presents unique challenges in storage, sharing, and description. To meet the needs of its extensive archival holdings, the research team explored a number of software platforms and metadata standards. The recently launched AMRDC Repository was ultimately built on open-source data platforms that encourage extensibility and interoperability. The AMRDC Repository's information architecture seamlessly accommodates a diverse array of meteorological data formats, while also offering opportunities for collecting usage analytics as well as encouraging metadata harvesting and/or sharing with other discipline-specific repositories and databases. The research team's future goals for the repository extend beyond data transfer and storage into implementing open-data standards which will allow users of meteorological data processing software to efficiently access the AMRDC Repository's data holdings. This presentation will summarize the AMRDC Repository's progress from concept to fully-fledged data repository, while outlining the research team's commitment to FAIR repository standards (Findability, Accessibility, Interoperability, and Reusability) as well as future plans for development and institutional partnerships.

THE ANTARCTIC-INTERNET DATA DISTRIBUTION SYSTEM: THE GLOBAL ANTARCTIC TELECOMMUNICATIONS SYSTEM

Matthew A. Lazzara[*1,2], Taylor P. Norton[2,4], David E. Mikolajczyk[2,4], Lee J. Welhouse[1,2], Jerrold O. Robiadek[2], Jean M. Philips[2], Matthew G. Noojin[1], Jeff F. Havens[3], and Owen H. Graham[3]

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1. ABSTRACT

The Antarctic-Internet Data Distribution (Antarctic-IDD) was developed in 2004 as a means of data sharing between the operational and research communities in the United States Antarctic Program (USAP). Since this time, the Antarctic-IDD network has ebbed and flowed over the years. Today it is the only effective method for exchange of operational meteorological data between the McMurdo Weather Office and the Antarctic Meteorological Research and Data Center (AMRDC) along with other key participants including the National Center for Atmospheric Research, the Columbia Scientific Balloon Facility, etc. This presentation will review the history and current state of the Antarctic-IDD such as the product naming and evolution of the network. Further, future plans will be outlined as the AMRDC funded effort includes a future of fostering the Antarctic-IDD. This system has the potential to connect those of us in the Antarctic community across the globe to exchange real-time Antarctic meteorological datasets for the benefit of forecasting, operations, research and education.

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2. HISTORY

The Antarctic-IDD came into being out of a discussion held at the Automatic Weather Station, Antarctic Meteorological Research Center, Antarctic Mesoscale Prediction System (AWS/AMRC/AMPS) joint meeting in Charleston, SC in 2004, the forerunner of this meeting, the Workshop on Antarctic Meteorology and Climate (WAMC). At the meeting, a group discussion was held on "Antarctic Meteorological Community Synergies and Interactions" and was introduced by Al Sutherland from the National Science Foundation (NSF). The idea of the Antarctic-IDD has been already discussed between the National Science Foundation (NSF) and NSF's Unidata Project along with the AMRC. The initial network was started in 2005 after some training for those of us participating in the Antarctic community (Lazzara et al., 2006). The network evolved to be not only a research and development (R&D) effort, but a real demonstration project (Seefeldt et al., 2009). While some usage since this time was operational in nature (primarily used by the USAP weather forecasting group), the network remained in an R&D demonstrational model in the intervening years since this time. Today, the network hosts large volumes of Antarctic observation and numerical weather prediction datasets on the order of 7 to 10 Gb per day (See Table 1).

Table 1. Sample products, the formats they are available in and the source of those products currently available in real-time on the Antarctic-IDD real-time distribution.

Dataset (format)	Source
AMPS **(grib, png, etc.)**	NCAR/MMM
Wisconsin AWS **(txt, MD, GIF)**	UW-Madison
NIWC AWS **(METAR/txt, MAX)**	NIWC
Satellite Composites **(area, netCDF, GIF)**	UW-Madison
USAP Field Camp **(txt)**	NIWC (ASC)
McMurdo Radiosonde **(txt)**	NIWC

3. PRODUCT NAMING

The product naming convention selected by the initial participants of the Antarctic-IDD followed the following methodology:

ANT.Center.Data.day.time.etc.etc.suffix

Where:

- ANT = All products start with ANT
- Center = The originating center (e.g. NCAR, AMRC, etc.)
- Data = The data type (e.g. model output, satellite, observation)
- Day, Time, Model level, Forecast Hour, Spectral Band, etc.
- Suffix = File Format

As an example, the following product:

ANT.AMRC.AWS.Linda.20210606.txt

Means:

- ANT = Antarctic-IDD
- AMRC = Originating center
- AWS = Data type
- Linda = from Linda AWS
- 20210606 = Data is from June 6, 2021
- txt = This product is in ASCII text format

The current operating products are not 100% compliant with this naming methodology, but it is the goal for the network to achieve.

4. NETWORK EVOLUTION

The network, over its 16-year existence, has under gone expansion and contraction (See Figure 1). The best network design that avoids single point failures has only been partially achieved during this research demonstration. One of the main tasks of the AMRDC is to elevate the Antarctic-IDD to an operational status (See Figure 2). With interest and needs from others to join along with requests to have the community rejoin the network, a more robust network may be achievable in the near future.

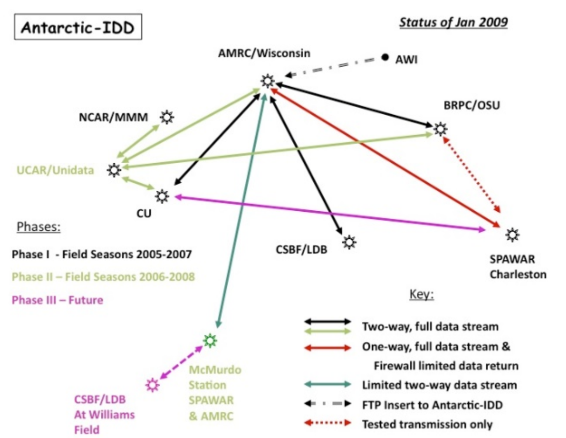

Figure 1. This is status of the Antarctic-IDD network as of January 2009.

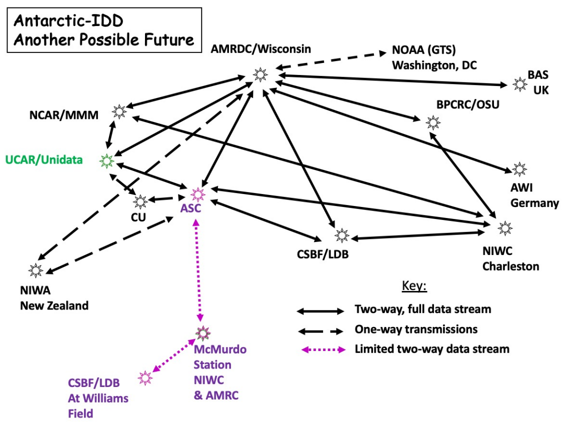

Figure 2. A possible future Antarctic-IDD network configuration that is more robust and includes a growing participation.

5. FUTURE

The future of the Antarctic-IDD network is in the hands of this community. Efforts are underway to have some datasets delivered in real-time from the AMRDC to the Global Telecommunications System (GTS), via the Telecommunications Gateway at the National Oceanic and Atmospheric Administration (NOAA). The Antarctic-IDD will be essential for the success of the AMRDC, as it is the only means of data relay between NIWC and AMRDC, ensuring the archive of that data source (Lazzara et al., 2021). An area of improvement is needed to make the active network more robust. If ASC and NSF participate in the Antarctic-IDD, it provides a critical relay node within the network in the mid-latitudes and a clean handling of traffic to and from Antarctica for the USAP. The addition of other participants is yet another future growth for the network, be they returning participants or new from across the globe. It is clear that better exchange of meteorological data benefits everyone, the providers, the researchers, the educators, and the forecasters. Ultimately any improvements in forecasting that are realized via timely data delivery make the safety of all of us working in Antarctica better.

6. ACKNOWLEDGEMENTS

This material is based upon work supported by the National Science Foundation, Directorate for Geosciences, Office of Polar Programs, under Grants 1951603 and 1924730. Thanks for the advice and efforts by the AMRDC Advisory Board, the Madison College Grants Office, and Space Science & Engineering Center support staff, without whom this project would not be possible.

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Summer surface mesoscale temperature processes on the East Antarctic Plateau during the YOPP-SH SOP

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The East Antarctic Plateau is a massive ice sheet with a homogenous orography and very gentle slopes. The atmospheric processes in the region have been studied previously based on vertical analyses of the boundary layer or long-term climatology using the few weather stations available in the region. However, there is a lack of studies examining the horizontal mesoscale meteorological processes of the Eastern Plateau on a daily scale. We present a characterization of the mesoscale surface air temperature gradients of the Eastern Antarctic Plateau near Dome F in the 2018-19 summer. We combined reanalysis outputs and in-situ weather observations, taking advantage of a mobile automatic weather station (M-AWS) that allowed us to record meteorological observations at different locations. We compared daily variations of the summertime nocturnal surface air temperature recorded during the expedition with ERA5 reanalysis. We report (1) cold pools and (2) variable nigh-time meso-α gradients (200-500 km) from day to day depending on the synoptic conditions, not consistently reproduced by ERA5. We also report (3) surface meso-β anticyclonic eddies with warm cores and horizontal gradients of more than 5 ˚C $100km^{-1}$ simulated by ERA5 reanalysis. Mesoscale analysis complements climatological evaluations and helps to interpret the daily performance of surface air temperature values provided by reanalysis on the Antarctic Plateau.

Dominant role of vertical air flows in the unprecedented warming on the Antarctic Peninsula in February 2020

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[2]MNR Key Laboratory for Polar Science, Polar Research Institute of China, Shanghai, China
[3]Finnish Meteorological Institute, Helsinki, Finland
[4]Department of Meteorology, University of Valparaíso, Valparaíso, and Center for Climate and Resilience Research (CR)2, Santiago, Chile

Near-surface air temperature at the Argentinian research base Esperanza on the northern tip of the Antarctic Peninsula reached 18.3 °C on 6 February 2020, which is the highest temperature ever recorded on the entire Antarctic continent. Here we use weather observations since 1973 together with the ERA5 reanalysis to investigate the circulation that shaped the 2020 event, and its context over the past decades. We find that, during the 2020 event, a high-pressure ridge over the 40°-100°W sector and a blocking high on the Drake Passage led to an anticyclonic circulation that brought warm and moist air from the Pacific Ocean to the Antarctic Peninsula. Vertical air flows in a foehn warming event dominated by sensible heat and radiation made the largest contribution to the abrupt warming. A further analysis with 196 extreme warm events in austral summer between 1973 and 2020 suggests that the mechanisms behind the 2020 event form one of the two most common clusters of the events, exhibiting that most of the extreme warm events at Esperanza station are linked to air masses originating over the Pacific Ocean.

Atmospheric drivers of extreme precipitation events over coastal West Antarctica

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We investigate the atmospheric drivers of extreme precipitation events (EPEs) over coastal West Antarctica (WA) using daily precipitation data from the RACMO2 model for the period 1979-2016. EPEs contribute ~41% of the total precipitation at selected stations over coastal WA (Evans Knoll (EK) and Bear Peninsula (BP)). For both stations, EPEs are more frequent during winter followed by autumn, spring, and summer. Empirical orthogonal function (EOF) analysis was performed on geopotential height at 850 hPa to identify the dominant spatial and temporal patterns (i.e., principal components (PCs)) of atmospheric circulation over the southern hemisphere. EOF-1 mode represents the Southern Annular Mode (SAM) pattern. EOF-2 mode captures the longitudinal movement of Amundsen Sea Low (ASL) while EOF-3 resembles the El Nino Southern Oscillation (ENSO) signal over coastal WA. EOF-4 depicts the intrusion of atmospheric rivers. Composite of geopotential height and wind anomalies at 850 hpa during EPE days over EK, dominated independently by the 4 major PC modes reveal that all these patterns are associated with intense moisture convergence over coastal WA resulting in extreme precipitation. Overall, 93.5% of EPEs over EK are connected to these 4 dominant PC modes, out of which PC1, PC2, PC3, and PC4 contribute 9.88%, 40.28%, 26.23%, and 23.61%, respectively. Thus westward movement of ASL is the primary driver of EPEs over coastal WA, followed by ENSO forcing and atmospheric rivers.

Precipitation over the Southern Ocean: ERA5 and WRF/AMPS evaluation during two snowfall events around Mertz Glacier

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Uncertainty in Southern Ocean/Antarctica precipitation estimates is high due to the lack of measurements to evaluate model and reanalysis products performance. Unique precipitation measurements were carried out during the Swiss Polar Institute's Antarctic Circumnavigation Expedition (ACE) (December 2016 - March 2017). High temporal resolution measurements of precipitation were performed by a Snow Particle Counter (SPC) and by a micro rain radar (MRR) aboard the RV Akademik Tryoshnikov. Radiosondes were launched periodically to observe the vertical structure of the atmosphere. Additionally, MRR and radiosonde measurements from Dumont D'Urville station (DDU) were available when the expedition was in the Mertz Glacier region. In this study, two distinct snowfall events that occurred during the ACE campaign were chosen to evaluate ECMWF's ERA5 reanalysis product and AMPS (Antarctic Mesoscale Prediction System using Polar-WRF model). The first event on 2 February 2017 was associated with an extratropical cyclone east of Adélie Land and a moderate along-shore moisture transport. The second event on 8-10 February 2017 was associated with a cyclone west of Mertz blocked by a high-pressure ridge, directing a strong moisture transport towards Adélie Land with intense precipitation affecting the coastal region. The precipitation amount and phase, as well as vertical profiles, are analysed using observations, and compared to the model and reanalysis data.

Preliminary results of precipitation phase transition study with PolarWRF and MRR-Pro data over Vernadsky station

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Precipitation phase transition is crucial in West Antarctica where recent warming due to climate change cause more rains in the last decades. Such physical process is a difficult subject for study worldwide but particularly in Antarctica where there is a comparatively low number of measurements. The goal of this study is to test a complex approach of applying different data sources including from numerical model to precipitation phase transition cases in the region of Vernadsky station during the austral summer. We use ERA5 reanalysis and PolarWRF simulation to compare and verify their outputs with precipitation measurements at Vernadsky station. Data of ERA5 hourly reanalysis with resolution 0.25° x 0.25° were taken to access synoptic scale precipitation and pressure distribution over the region and as input data for PolarWRF simulation over the domain 100*130 points with resolution 9 km centered on Vernadsky station (65°S, 64°W). For verification of PolarWRF simulated data was taken Micro Rain Radar Pro (MRR-Pro) measurements of vertical profiles of cloud and precipitation characteristics.

Evaluation of simulated with PolarWRF results showed consistency with MRR-Pro reflectivity data generally. Verification become challenging due to many of indirect effects on measured data

Sensitivity analysis of the radar snowfall rate estimates to the microphysics of ice particles in Antarctica coast.

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Precipitation observations are crucial to improve the understanding of the hydrological system and to evaluate the current climate models. During the last years, ground-based radars have become a robust tool for monitoring precipitation in the Antarctic region, by using relationships between the radar reflectivity factor (Ze) and the solid precipitation rate (S). Currently, there are a few Ze-S relationships in Antarctica, parameterized using in-situ observations, such as atthe Dumont d'Urville station (DDU) on the coast of Adélie Land and at the Princess Elisabeth station (PE) in the escarpment region of Dronning Maud Land and averaged over a range of local snowfalls with different properties. In order to analyze the sensitivity of the radar snowfall rate estimates to the microphysics of ice particles, we used the measurements of precipitation performed at the DDU station, including a vertically-pointing micro rain radar, snowfall rate and snowfall microphysical properties derived from a disdrometer and a multi-angle snowflake camera (MASC), among other meteorological data. The analysis of the variability of the Ze-S relationship parameters will be presented as well as the dependency on ice particle characteristics. Variability of radar reflectivity and snowfall microphysical properties derived from the Antarctic Circumnavigation Expedition (ACE, austral summer 2016-17) MRR observations near the Adélie Land coast will also be presented and compared with DDU measurements.

AMPS Update – June 2021

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1. INTRODUCTION

The Antarctic Mesoscale Prediction System (AMPS) is a real-time, experimental, numerical weather prediction (NWP) system for Antarctica. Funded by the National Science Foundation Office of Polar Programs, and tailored for the needs of forecasters for the United States Antarctic Program. Real-time AMPS graphics, text, and GRIB products are freely available on the AMPS web page, https://www2.mmm.ucar.edu/rt/amps.

2. AMPS ARCHIVE

The Antarctic Mesoscale Prediction System (AMPS) is a real-time, experimental, numerical weather prediction (NWP) system for Antarctica. Funded by the National Science Foundation Office of Polar Programs, and tailored for the needs of forecasters for the United States Antarctic Program. Real-time AMPS graphics, text, and GRIB products are freely available on the AMPS web page, https://www2.mmm.ucar.edu/rt/amps

Perhaps the most significant point of update for the community is the revision of the long-term archive of AMPS forecast output. For twenty years, the full model output files of the twice-daily AMPS forecasts have been archived to NCAR's tape storage system. This useful archive has been used for a variety of research, including short-term Antarctic climate studies of seasons or years, individual case studies, Antarctic NWP research, and forecast statistics of specific locations within the AMPS model domains.

However, increasing costs of data storage and exponential growth of data volume across all NCAR's data holdings, NCAR has chosen to reduce its data archiving capacity going forward. So with NCAR's decision to decommission the tape archive system, and move all users to lower-capacity disk storage, the strategy for archiving AMPS forecasts has had to change significantly, in order to reduce the data volume of the AMPS archive.

All existing forecast output in the AMPS archive has been converted to GRIB format. Selected model output variables and model diagnostic fields are archived, at selected pressure levels and a subset of model levels (Table 1). This subsetting, combined with the lossy compression enabled in GRIB, reduces the current AMPS archive data volume from nearly one petabyte to about 150 terabytes.

Going forward, only these GRIB subsets of model output files will be archived for the long term. A short-term, rolling archive of the most recent three to six months forecast (as disk space allows) of full model output files will be maintained.

Access to the AMPS archive will be through the Climate Data Gateway (https://...). This portal should be familiar to current users of the AMPS archive. An update to the AMPS holdings at the Climate Data Gateway should be in place soon, with the catalog and links pointing to the new archive of data on disk, rather than to the files on tape. Access to the new archive should be significantly faster than to the tape archive, since disk access is much faster than tape access, and file sizes are significantly reduced. This should enable easier use of the AMPS archive, particularly for applications that may need access to months or years of AMPS output. Users internal to NCAR's computing environment may have direct access to the AMPS files on disk, and should contact the AMPS team for details.

While the loss of the full model output is unfortunate, the increasing long-term costs of data storage and the increasing data volume of AMPS files (as well as NCAR's decision to reduce its archive capacity) have made this transition necessary. It is expected that the easier and faster access to AMPS data will in the long run make the AMPS archive more useful to a wider base of users.

Table 1: Fields and levels available in the new AMPS GRIB files

- Surface:
  - Latitude
  - Longitude
  - Sea-ice
  - Land/sea mask
  - Geopotential height
  - Precipitation accumulation (1 hour or 3 hour)
  - Pressure
  - Latent heat flux
  - Sensible heat flux
  - Downward shortwave radiation
  - Downward longwave radiation
  - Temperature
  - Inversion Strength
  - Inversion Height
  - Cloud Fraction
  - PBL Height
  - Albedo
  - U*
- Sea-level
  - Sea-level pressure
- Top of Atmosphere
  - Outgoing longwave radiation
- Integrated atmosphere column
  - Precipitable water
  - Integrated cloud liquid water
  - Integrated cloud ice
  - Integrated rain water
  - Integrated snow
- Layers below ground (cm)
  - 0-10
    - Temperature
  - 10-40
    - Temperature
  - 40-100
    - Temperature
  - 100-200
    - Temperature
- Above ground (m)
  - 2
    - Temperature
    - Mixing Ratio
    - Cloud water mixing ratio
    - Rain water mixing ratio
    - Ice mixing ratio
    - Snow mixing ratio
    - RH
  - 10
    - U
    - V
- Above MSL (m)
  - 150
    - U
    - V

```
 300
    U
    V
Isobaric levels (hPa)
   1000
    975
    950
    925
    900
    875
    850
    800
    700
    600
    500
    400
    300
    250
    200
    150
    100
    70
    50
    30
    20
      At all the above isobaric levels:
         U
         V
         W
         Temperature
         Mixing Ratio
         Cloud water
         Rain water
         Cloud ice
         Snow
         Geopotential Height
         RH
Model levels (index number above ground)
    1
    2
    3
    4
    5
    6
    7
       At all the above model levels:
          Geopotential Height
          Pressure
          Temperature
          Mixing Ratio
          U
          V
```

AMPS: LOOKING AHEAD

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1. INTRODUCTION

The Antarctic Mesoscale Prediction System (AMPS) is a real-time numerical weather prediction (NWP) capability covering Antarctica and the high southern latitudes (Powers et al. 2012). While its primary mission is to provide guidance for the weather forecasters of the U.S. Antarctic Program, it also assists a wide range of international programs. In addition, AMPS supports researchers, students, and field campaigns. AMPS's main forecast model has been the Weather Research and Forecasting (WRF) Model (Skamarock et al. 2019; Powers et al. 2017) that has polar physics enhancements (Bromwich et al. 2013). AMPS also, however, runs the global Model for Prediction Across Scales (MPAS) (Skamarock et al. 2012). AMPS is funded by the U.S. National Science Foundation Office of Polar Programs.

The AMPS effort is looking forward to a new phase that would take it to 2023. In 2022 NCAR will get a new high performance computer (HPC) that AMPS will run on, and a number of the planned advancements must await the extra capacity it will provide. For this period, there are a number of areas for advancement: (i) modeling, (ii) computing, (iii) archiving, and (iv) community assistance. This report summarizes these activities.

2. DEVELOPMENT AREAS

a. Modeling

AMPS is an infrastructure for generating NWP guidance for USAP weather forecasters and other users. AMPS itself is not a model, but a system in which different models are run and that generates and distributes forecast products from them. The models run in AMPS are WRF and MPAS. Looking ahead, the areas of modeling development in AMPS will be: WRF code and physics upgrades, MPAS grid and physics enhancements, the AMPS ensemble, and WRF and MPAS data assimilation.

1) WRF

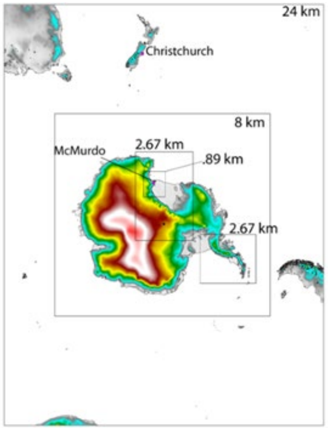
AMPS runs WRF in a multiply-nested configuration, and Fig. 1 shows its current domain array. This has two outer forecast domains of 24- and 8-km horizontal grid spacing (Fig. 1(a)), with the 8-km nest covering the Antarctic continent. Finer 2.67-km grids cover the Ross Sea/Ice Shelf sector and the Antarctic Peninsula (Fig. 1(b)). An innermost nest over the Ross Island region has 0.89-km spacing (Fig. 1(b)).

The main WRF code upgrades will be in the model version and the physics. New major versions of WRF are released annually, and AMPS keeps as current as practical, with periodic updates to the latest version. This requires verification of forecasts from both the current and new codes to ensure comparable or improved performance. The current WRF version in AMPS is V3.9.1.1, but recent testing has cleared the way for the implementation of V4.2.2. Another refresh will occur in the new term.

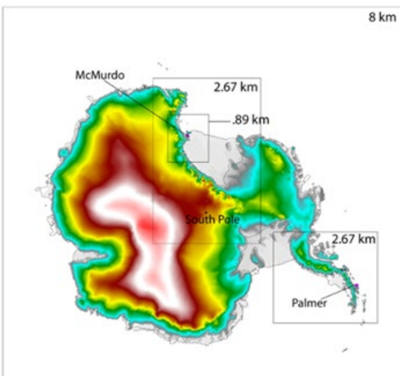
In terms of model physics, one area that will be addressed is the land surface model (LSM). The current LSM, Noah, is no longer underdevelopment by its overseeing group. Its successor is the Noah-MP (Noah Multi-Physics) package (Niu et al. 2011). The Noah-MP LSM offers multiple options for key land-atmosphere interaction processes. Thus, in the new phase Noah-MP would be tested over Antarctica, and eventually the polar mods built into Noah ported to it.

Another area of physics improvement for WRF in AMPS is that of moist processes. Over the high southern latitudes WRF has shown noted errors in cloud prediction such as a low bias in areal coverage and an underprediction of cloud liquid water in Antarctica. Microphysics can be key here, and thus the choice of scheme will be addressed. While WRF currently runs the WSM5 (WRF Single-Moment 5-Class) scheme, two-moment schemes available may prove more accurate in this application, and some have been tested in AMPS to an extent thus far. The downside of the more sophisticated packages is their computational cost, which increase wallclock run times for the forecast production, with some to 40%. Thus, any implementation of a new microphysics scheme will need to await the availability of the new NCAR HPC.

Data assimilation will be another target area for WRF. The DA system used in AMPS is WRFDA (WRF Data Assimilation System) (Barker et al. 2012), and in AMPS it employs a hybrid 3-dimensional ensemble/variational approach (3DEnVar) (Wang et al. 2008). For WRF initialization, the first-guess fields come from analyses from the Global Forecasting System (GFS), the National Centers for Environmental Prediction's global atmospheric model (NOAA 2003). The hybrid 3DEnVar approach blends static background error (BE) covariances calculated from previous WRF forecasts with flow-dependent covariances derived from the forecasts of an ensemble, here the WRF ensemble for AMPS. The hybrid system thus incorporates a measure of flow-dependent information into the assimilation process.



(a)



(b)

Fig. 1: AMPS WRF forecast grids. (a) 24-km and 8-domains over the Southern Ocean and continent. (b) 8-km Antarctic continental grid, 2.67-km Ross Ice Shelf/Sea and Antarctic Peninsula grids, and 0.89-km Ross Is. region grid.

New DA approaches for WRF will also be explored. As part of a YOPP-SH study NCAR and The Ohio State University have been examining the impact on AMPS forecasts of the extra radiosondes from the program's Special Observing Periods. For this we have tested Ensemble Kalman Filter DA (Houtekamer and Zhang 2016) using the DART (Data Assimilation Research Testbed) capability (Anderson et al. 2009). We will continue to test this for possible future application. Another target for testing will be Multi-Resolution Incremental 4DVAR (MRI-4DVAR; Liu et al. 2020). Now available in WRFDA, this time-dependent data assimilation method can be run at a different resolution than the target forecast, thus decreasing computational cost compared to traditional 4DVAR. Moreover, it has proven encouraging in Arctic WRF simulations by collaborator Ohio State.

AMPS runs an ensemble of WRF with about 15 forecasts on the 24- and 8-km grids. The ensemble members are initialized from NCEP's Global Ensemble Forecasting System (GEFS; Zhou et al. 2017). The ensemble is used for two purposes: (i) probabilistic guidance and (ii) generating background error covariance input to the hybrid data assimilation (DA) method used for the main AMPS deterministic runs. Our plans include increasing the size of the ensemble for greater spread in the forecasts and for better error information for the DA system. This will require the added capacity of the new NCAR HPC, however.

2) MPAS

AMPS runs MPAS with a global mesh of 60-km spacing that refines to 10-km spacing over the approximate area of the WRF 8-km domain (Fig. 2). This has provided the necessary enhancement over the target region, although the 10-km grid obviously does not match the WRF resolution. Thus, the plan is for the MPAS configuration to upgraded to a 60/8-km mesh. This will improve the MPAS surface representation of Antarctica and will make the MPAS and WRF forecasts consistent over the continent. The latter will enable comparable statistical verifications of the models. This change will require the expanded capacity of the new HPC.

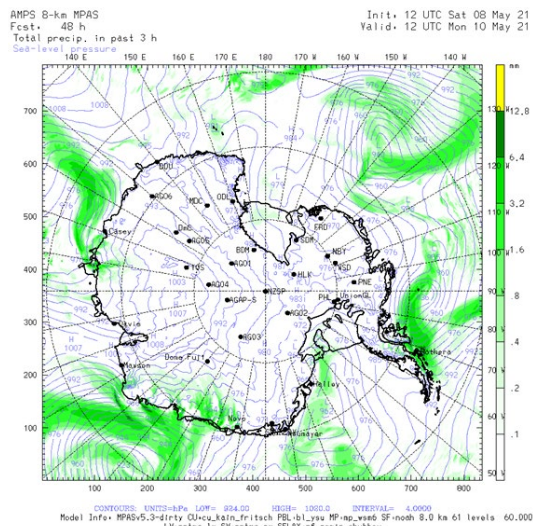
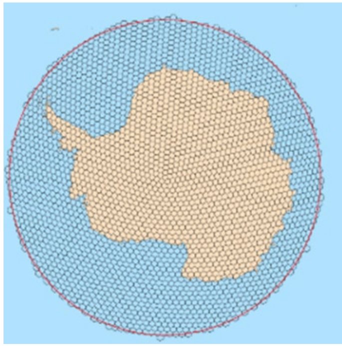


Fig. 2: AMPS MPAS forecast. Plotting window captures approximate 10-km regional refinement and matches the area of the WRF 8-km domain. 48-hr forecast of 3-hrly precip (shaded, mm, scale to right) and SLP (contour interval=4 mb), valid 1200 UTC 8 May 2021.

MPAS has recently developed a regional capability that allows it to be run as a limited area model. Thus, it can be deployed like WRF with a bounded domain covering a target region with the resolution desired. The MPAS regional capability avoids the baggage of global computation that can be unnecessary in certain applications. The defined domain can have a uniform mesh or one that refines toward the interior. The latter allows for a coarser boundary that can match the resolution of the gridded data used for the boundary conditions (BCs), while offering better resolution inward. This can provide a smooth transition from the prescribed BCs to the evolving forecast in the domain interior. Figure 3 shows both a uniform-resolution regional mesh and a variable-resolution one. Looking ahead, the regional MPAS setup configuration will be tested over Antarctica and its performance will be compared to both the WRF and global MPAS configurations in AMPS.



(a)

(b)

Fig. 3: Examples of MPAS regional domains. (a) Uniform mesh over Antarctica. (b) Mesh with local refinement in interior over North America.

In pursuing the limited-area MPAS capability, we also plan to include regional MPAS members in the AMPS ensemble. This will make for a more diverse forecast array, and multi-model ensembles can provide more dispersiveness than single-model ensemble (e.g., the current WRF-only ensemble in AMPS).

The next-phase plans for AMPS include "polarizing" some of the physics available to MPAS. Specifically, the Noah land surface model, currently available to MPAS, will be addressed, with polar mods used in its WRF implementation ported. As it is for WRF, the Noah-MP LSM is also a candidate for implementation into MPAS. And, once the polar mods are ported to NoahMP for WRF, the revised package could be used in MPAS.

Lastly, MPAS in AMPS is currently run without data assimilation. However, the JEDI DA system (Joint Effort for Data Assimilation Integration), developed by JCSDA (Joint Center for Satellite Data Assimilation), has become available for MPAS. JEDI is a model-independent DA system and a number of models, both atmospheric and oceanic, can now use it; these include FV3 (NOAA), LFRic (UK Met Office), NEPTUNE (U.S. Navy), WaveWatch III (NOAA), MOM6 (NOAA), and WRF. To give MPAS in AMPS a DA ability, and allow it to incorporate both regular and special observations (such as those from YOPP-SH), JEDI will be tested.

b. Computing

On the computing front, there will be a big boost for AMPS with the new NCAR HPC. This will allow a lot of the described work— an expanded ensemble, more sophisticated physics, increased resolution, and advancements in DA.

One aspect of the new HPC is its offering of substantial GPU resources. GPUs— Graphics Processing Units— represent a different compute architecture than the traditional CPUs (Central Processing Units) that NWP models have always run on. GPU architectures provide many more processing cores/unit (e.g., 5000) than a CPU, with the cores being cheaper to produce. An HPC with more cores/platform offers more compute power/unit— if one's code can take advantage of it. The caveat has been that modification of WRF/MPAS codes is needed for their effective GPU operation. Fortunately, there are now versions of both models that have been ported to GPUs.

For AMPS, WRF testing on GPUs has begun, and moving forward the plan is to evaluate the modified code's operational GPU potential. This will leverage code support from the private firm of TempoQuest, Inc. (TQI), which markets a GPU-ized version of WRF. Preliminary, small-scale (i.e., limited number of compute cores applied) testing has been positive, with speedups of a test AMPS setup of up to 30% compared to a CPU run. This work will continue, as well as comparable testing for AMPS of a GPU-ized MPAS code, already developed under an NCAR collaboration with IBM.

Cloud computing is another developing area for AMPS. The system has turned to cloud compute resources intermittently over the past few years when the NCAR HPCs available for AMPS are down for problems or maintenance. Until recently the cloud service provider (CSP) for AMPS had been Penguin Computing. AMPS, however, has been testing the environment and capabilities of Rescale, Inc. through its relationship with the Computational and Information Systems Laboratory of NCAR, which supplies the community HPCs. The built Rescale environment can now support AMPS when the primary computers are down. We note, however, that in any cloud operation AMPS has not yet been run with its full complement of models, domains, and product offerings, as the cloud porting of all facets of AMPS has been impractical and cloud compute capacity is not the same as on the home AMPS system. For example, when run on the cloud AMPS does not run MPAS, the ensemble, the Palmer and New Zealand forecast domains, and any temporary forecast domains for field campaigns or special USAP activities. Moving forward the cloud developments for AMPS will be operation on Rescale and covering more system forecast components.

c. AMPS Archive

The AMPS Archive is the collection of forecast output and products from the system. The holdings are of the MM5 and WRF runs and go back to 2001. As the material has been the full model output in native format, as well as a subset of this in GRIB format, this represents a large volume that has been housed on NCAR's High Performance Storage System (HPSS), a huge tape storage facility.

As of October 2021 NCAR will decommission the HPSS for community use. In preparation, AMPS has migrated the GRIB archive holdings to a disk facility at NCAR known as campaign storage (CS). CS is a resource for storing datasets of NCAR and universities. While CS does not have the capacity of the HPSS, it will provide for faster access to archived files.

The plan for AMPS is the continued migration of forecast output and products to CS. This will entail subsetting of selected model levels and fields to GRIB format for the long-term storage, as the full model output can no longer be kept indefinitely. However, AMPS will continue to retain on CS for six months the latest full WRF model output. This can be useful for acquisition for case studies or forecast reviews.

Access to the CS holdings will be via the NCAR Climate Data Gateway (CDG) portal. The CDG, formerly called the Earth System Grid (ESG), is an NCAR dataset hosting facility for geosciences community, and the AMPS archive has been available through it and the ESG for a number of years. While prospective users must register for access to the CDG, there is no cost. The new archive access will be via a page under the main CDG link (https://www.earthsystemgrid.org), and this will be established later in 2021.

d. Community Assistance

AMPS will continue to support the international Antarctic community as resources and priorities allow. One specific plan is to support the YOPP-SH 2022 winter observing campaign. This is to consist of Targeted Observing Periods (TOPs) to take atmospheric measurements, mostly radiosondes, for weather events of interest affecting two regions— the greater Ross Sea/Ice Shelf and the Antarctic Peninsula/Weddell Sea. The event types currently include strong cyclones and atmospheric rivers. There will be two YOPP-SH forecasting teams analyzing conditions favorable for the target events, and their forecasts will guide whether a TOP is ordered or not. AMPS will be providing requested products from its models to help the teams in their forecasts.

Apart from the known YOPP-SH campaign, AMPS will continue to assist other experiments with southern high-latitude operations. It stands ready to provide tailored NWP guidance for planning and operations, with new products either added to the web output suite or e-mailed directly to participants.

3. SUMMARY

The AMPS effort looks forward to continuing to support the USAP and to assist the Antarctic community. The next few years envision work in improving the models used, both WRF and MPAS, advancing computational dimensions of the system, and serving Antarctic science and logistics. The planned activities include the following.

– Polar physics advancement: WRF and MPAS
– MPAS: Improved continental mesh & regional testing
– Data assimilation: New WRF approaches and an MPAS capability
– Forecast ensemble enhancement
– Development of cloud operations
– GPU applications
– Revamped AMPS archive
– YOPP-SH support

A number of activities are dependent on the anticipated new HPC at NCAR, whose acquisition is in progress. While these plans may be affected by other NSF or USAP directives, more valuable opportunities, or exigencies, the AMPS effort is hopeful to address most of these advancements.

ACKNOWLEDGEMENTS

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Mesoscale evaluation of AMPS using AWARE radar observations of a wind and precipitation event over the Ross Island region of Antarctica

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The Antarctic Mesoscale Prediction System (AMPS) became operational in 2001 and has been the primary source of data for many of the studies that have examined wind and precipitation characteristics over the Ross Ice Shelf of Antarctica. AMPS also serves as a critical forecast tool for operations of the U. S. Antarctic Program. Evaluation of AMPS forecasts has been limited due to scarce meteorological observations, especially on the mesoscale. The present study addresses this gap with remote sensing observations collected during the Atmospheric Radiation Measurement (ARM) West Antarctic Radiation Experiment (AWARE) sponsored by the U.S. Department of Energy and National Science Foundation. AWARE occurred from 23 November 2015 to 5 January 2017 and made use of the second ARM mobile facility (i.e., AMF2). The primary AMF2 observing platform employed in this study is the X-band Scanning ARM Cloud Radar (XSACR), which was deployed on the southern tip of Ross Island near McMurdo Station. XSACR reflectivity and radial velocity observations over the Ross Island region are compared with AMPS output for a wind and precipitation event that spanned 16-20 January 2016. Notably, simulated radial velocity from AMPS compares favorably with observed radial velocities from XSACR. However, simulated AMPS reflectivity shows some significant differences from observed XSACR reflectivity.

Simulating Frigid Supercooled Clouds for McMurdo, Antarctica with Polar WRF

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Supercooled liquid is common in clouds near coastal Antarctica and occasionally occurs at temperatures near -30°C. Similar clouds are observed in the Arctic. The common microphysics in climate and mesoscale models, however, will glaciated out clouds at frigid temperatures. Thus, models can underrepresent liquid in such clouds. Moreover, mixed-phase clouds in the both the Arctic and Antarctic often have a liquid layer near cloud top. We seek to simulate the frigid mixed-phase clouds observed during two 2016 cases periods at McMurdo during the Atmospheric Radiation Measurement (ARM) West Antarctic Radiation Experiment (AWARE). Simulations were conducted with the polar-optimized version of the Weather Research and Forecasting model (Polar WRF). We used the state-of-the-art two-moment Morrison-Milbrandt P3 microphysics scheme, that is an update to the widely-used Morrison microphysics scheme. Nudging of the simulations to observed rawinsonde profiles at McMurdo, Antarctica and local automatic weather station observations resulted in increased realism. Humidity amounts were increased, and the condensates were also increased and closer to observed amounts. Observations over the Southern Ocean and Antarctica often show pristine conditions with extremely low ice nucleating particle (INP) concentrations. When the ice physics in the Polar WRF simulations was adjusted for small INP concentrations the cloud liquid increased and more realistic liquid water paths were achieved. Correspondingly, cloud ice was decreased. Simulated liquid cloud layers near cloud top were produced for both the March and November cases. As cloud liquid increased, the clouds became optically thicker, and the longwave and shortwave simulations improved. Accurate representation of INP amounts appears to be critical for simulation of Antarctic clouds.

AEMET-γSREPS: The Spanish Convection-permitting LAM-EPS on Antarctica

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Since 26th April of 2016 the Spanish Meteorological Agency (AEMET) is operating a mesoscale Ensemble Prediction System called AEMET-*γ*SREPS. Currently *γ*SREPS is daily integrated up to 60 hours over Iberian Peninsula and Canary Islands twice per day at 00 and 12 UTC. Interestingly it is run as well at 00 UTC around the Livingston Island, that is, around Antartic Peninsula including South Shetland Islands, during the Spanish Antarctic Campaign from 15th December to 31st March since 2018/2019. The main *γ*SREPS goal is to improve operational forecasts with a measure of their predictability or a measure of the forecast uncertainty: on one hand of the severe weather events, and the other hand, the local surface variables with local impact as visibility in Antarctic Scientific Stations. For this reason mesoscale horizontal and vertical resolutions of the system are essential to take into consideration the effect for example of the islands' orography and coastline characteristics, and to resolve explicitly some physical processes which may become very important in forecasting the location and intensity of the events, as for instance, strong winds.

*γ*SREPS is a 20-members multi-NWP model and multi-boundaries LAM-EPS system which comes up crossing four regional non-hydrostatic convection-permitting NWP models at 2.5 Km: HARMONIE-AROME (ACCORD-HIRLAM), ALARO (ACCORD-ALADIN), WRF-ARW (NCAR-NOAA) and NMMB (NCEP-NOAA); with five global NWP models' boundary conditions: ECMWF-IFS, NCEP-GFS, MétéoFrance-ARPÈGE, JMA-GSM (Japanese) and CMC-GEM (Canadian). Currently *γ*SREPS Antarctic version is 12-members not using the ARPÈGE and JMA-GSM boundary conditions. Multi-model and multi-boundaries approaches have been selected to take into account the NWP model and boundary conditions uncertainties respectively due to hold a better skill-spread relationship than other EPS techniches.

Around Antarctic Peninsula, *γ*SREPS performance is shown through case studies and an objective verification with standard probabilistic verification scores comparing it with ECMWF EPS. The planned foreseeable AEMET-*γ*SREPS system developments and improvements over Antarctic Peninsula domain are: extend forecast from 48 to 72 hours, increase from 12 to 20 members including boundary conditions from Météo-France and maybe from JMA, delivering specific EPS-grames products on Antarctic stations and an automatic monthly verification compared to ECMWF EPS.

The Siple Dome Challenge: Can Your Model Match a New West Antarctic Data Set?

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Following the successful ARM West Antarctic Radiation Experiment (AWARE) campaign (2015-16), a large-scale experiment that comes along about once in a generation, we endeavored to make the atmospheric measurements most relevant to the surface energy balance more transportable, so that a core dataset relevant to model improvement can be gathered at many Antarctic locations. These measurements consist of (1) upward- and downward-viewing pyranometers and pyrgeometers for the shortwave and longwave net radiative fluxes, (2) a sonic anemometer system for turbulent fluxes, (3) a shortwave spectroradiometer for retrieving cloud microphysical properties, and (4) an all-sky camera recording cloud fraction. We deployed this instrument suite at Siple Dome Field Camp in West Antarctica during austral summer 2019-20, where it successfully obtained 28 days of data that can provide a stringent test for the meteorology and cloud microphysics simulated by regional and global models. During this season the instruments sampled conditions ranging from (1) a storm system imparting energy to the surface, to (2) subtle cloud microphysical changes as moisture and precipitation advect "up the dome" and the cloud properties change from mixed-phase to mainly liquid water throughout the day. This tractable yet detailed dataset should be useful for experiments with a variety of models to diagnose sources of discrepancy and test improvements.

Identifying the Snowfall Cloud at Syowa Station, Antarctica via a Convolutional Neural Network

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This study evaluated the impact of atmospheric river clouds on snowfall amounts based on limited observation data to estimate the surface mass balance (SMB) of Antarctica. To accomplish this, we attempted to identify the snowfall cloud at Syowa Station, Antarctica. We constructed a new convolutional neural network (CNN) architecture with multinomial and binary classifications and added National Oceanic and Atmospheric Administration (NOAA)/Advanced Very High Resolution Radiometer (AVHRR) images over five years. The CNN was based on VGG16, and concatenate layers were added as the inception module. We replaced all the convolution layers with global average pooling to reduce the number of parameters. Based on the positive CNN sample re- sult, the multinomial classification emphasized the entire cloud structure, while the binary classification focused on cloud continuity. The results indicated accuracies of 71.00% and 65.37% for binary and multinomial classifications, respectively.

Extreme atmospheric blocking trends and seasonality on both sides of the Antarctic Peninsula

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We analyze the seasonal evolution and trends of extreme atmospheric blocking from 1979-2018 using a simple, geopotential height-based method over two domains, one located to the west (150-90 ºW, 50-70ºS) and the other over and to the east (90-30ºW, 50-70ºS) of the Antarctic Peninsula. Spatial patterns of geopotential heights on days with extreme blocking feature well-defined ridge axes over and west of much of South America. Days with the most extreme blocking showed upper-tropospheric ridge and cut-off low features regularly associated with extreme weather patterns.
Extreme blocking days were more frequent in the first half of the period (1979-1998) than the second (1999-2018) in all seasons in the west domain. On the other hand, extreme blocking days seem to be more common over the east domain in 1999-2018 than 1979-1998 for austral winter, spring, and autumn. We found strong correlations and similar temporal trends between extreme blocking days and multi-day blocking events (2+ or 4+ consecutive days of extreme blocking). West of the Antarctic Peninsula, extreme blocking days occur most frequently when the Antarctic Oscillation is negative, whereas over and to the east of the Peninsula, they are more frequent when it is positive. We propose that this simple index can be used to indicate atmospheric blocking affecting the Antarctic Peninsula, similar to how the Greenland Blocking Index has been used to diagnose blocking, its trends, and its impacts over the Arctic.

Clear air turbulence event during HALO aircraft flight: a case study

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A synoptic review of a Clear-Air Turbulence (CAT) event occurred during HALO aircraft flight on 12 November 2019 was performed using ERA5 reanalysis (ECMWF), and GFS (NCEP) and PWRF forecast models. Results were compared with *in situ* measurements obtained from a radiosonde launched from Marambio base in Antarctica at 17:45 UTC, and measurements from the Basic HALO Measurement and Sensor System (BAHAMAS). Synoptic analysis reveal a strong and well-defined polar low located at West of the Antarctic Peninsula over the Bellingshausen Sea in the morning of 12 November. At the north of the polar low, a small and deep perturbation at 300hPa level moved quickly towards the north-west of the Antarctic peninsula at 18 UTC, favoring a cold air advection at low levels over Bellingshausen Sea and a stratospheric air intrusion between 450hPa and 300 hPa levels near 62ºS-60ºW . These conditions favoured a strong upper level frontogenesis, associated with a tropopause folding in that region. Additionally, a strong jet streak greater than 100knots at 300hPa was observed at 60ºS , with horizontal and vertical wind shear. Strong temperature gradients and high Thermal Front Parameter (TFP) were observed in the NWP model at 200-350hPa . Ellrod Turbulent Index1 and Brown Index indicate moderate to severe turbulence conditions between 300hPa and 250hPa . Radiosondes data from Marambio station show a sharp temperature inversion with an amplitude of 4K between 250hPa and 200hPa (nearly from 9800m to 11000m), for times close to the critical occurrence of the synoptic pattern. Vertical pattern of the Richardson number shows values between 0.6 and 10 above the identified tropopause folding, indicating buoyancy driven turbulence. These conditions are reproduced in BAHAMAS measurements, where large peak to peak fluctuations can be observed in all meteorological parameters around 18 UTC. Horizontal and vertical energy spectra show a well defined energy cascade towards small scales, with Kolmogorov scaling. Structure and autocorrelation functions for the wind speed were also calculated, supporting the evidence of turbulent atmospheric conditions, with signatures of anisotropy generated by stratification. Scales involved are found to be between the buoyancy length scale L_B~1500m and the Ozmidov scale L_O~110m . Turbulent parameters TKE and EDR indicate a localized event of moderate to severe turbulence around 62ºS-58ºW, with the aircraft flying nearly 4000m above the tropopause folding.

A numerical simulation of a strong wind event in January 2013 at King Sejong Station, Antarctica

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A strong wind event (SWE), so-called "severe gale" with a 10-min average wind speed of above 22 m/s occurred on 7 January 2013 at the King Sejong (KSJ) station on the tip of the Antarctic Peninsula (AP). We examine the cause of the SWE and assess the short-term predictability of such event using the state-of-the-art Polar Weather Research and Forecasting (Polar WRF) model. The simulation results initialized at 0000 UTC on 6 January 2013, the day prior to the occurrence of the SWE, produce the most accurate representation of the SWE in terms of strength (~ 94 % of the peak wind speed). Both model results and observational records reveal that the SWE is mainly caused by the approach of a deep depression with the center pressure of 950 hPa. On top of this synoptic configuration, a particular shape of topography of the AP plays a non-negligible role for further intensification of the wind at the KSJ station. As the cyclone approaches to the AP, the sea-level pressure becomes deeper and is deformed around the AP due to the topography, and driving southeasterly winds traversing the AP. The continuous flow overriding the AP generates downslope windstorm at the lee side of the AP. The windstorm effect driven by the deformation of sea level pressure by the topography of the AP is not properly represented in the coarser resolution (27 km) model domain than higher (3 and 9km) resolutions. We conclude that the SWE at the KSJ station on 7 January, 2013, is caused by the combined effect of synoptic-scale low pressure system with local topography of the AP. (Ref.: QJRMS, 145:1267-1280, 2019)

A NUMERICAL SIMULATION OF A STRONG WIND EVENT FOR JANUARY 2013 AT KING SEJONG STATION, ANTARCTICA

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1. OVERVIEW

The Antarctic Peninsula is highly influenced by deep cyclonic systems of the Bellingshausen Sea that pass through the Drake Passage because it is located at the latitude of the circumpolar trough (Turner *et al.,* 2009). Therefore, severe weather events, such as strong winds and blizzards, often occur around the AP. Turner et al. (2009) examined the characteristics of strong wind events over the AP using in-situ meteorological observation at the Bellingshausen and Faraday stations and concluded that the strong wind events over the AP are strongly influenced by synoptic-scale depressions in its vicinity. Notwithstanding Turner et al. (2009) work, there is still a lack of comprehensive understanding on severe weather events over the AP. In this study, we examine a strong wind event that occurred on 7 January 2013 at King Sejong station (hereinafter called KSJ station) located in the AP, using the Polar WRF model (Hines and Bromwich, 2008) and surface meteorological observations.

2. DATA AND METHOD

Surface observations from the Automatic Meteorological Observation System (AMOS) operating in the KSJ station for 27 years from 1989 to 2015 are used to analyze the strong wind event and validate the model results. Hourly mean data derived from 10 min average observations of 10 m wind speed and direction, 2m air temperature and sea level pressure are used in this study.

The Polar WRF (Hines and Bromwich, 2008) model (version 3.7), which is a modified version of the Advanced Research WRF (ARW; WRF-ARW) (Powers *et al.*, 2017) that better represents key regional physical processes over the polar region, is used for the simulation of the strong wind event at the KSJ station. For the numerical simulation of the strong wind event, we apply three model domains with a horizontal resolution of 27, 9 and 3 km around Kin g George Island, where the KSJ station is located. The Polar WRF models are initialized at different times (at 0000 UTC every day from 1 to 6 January) and integrated for the selected period from 0000 UTC 6 January to 0000 UTC 9 January 2013 to examine the sensitivity to the initialization time of the model.

3. RESULTS

The strong wind event occurred at the KSJ station on 7 January 2013 lasted for almost 12 hours and is recorded as a blizzard in the weather report. The hourly mean wind speed is around 10 m/s on 6 January and then start to rapidly increase at 0000 UTC on 7 January until it reaches its maximum of about 21 m/s at 0800 UTC on January 7. This strong wind continue until around 1800 UTC on 7 January, during which time it shows a maximum instantaneous wind speed exceeding 41 m/s. The wind speed gradually decrease and remain at around 5 m/s after 0600 UTC on 8 January.

Figure 1 shows the hourly time series of surface variables resulted from Polar WRF simulations (3 km) initialized at different times at 0000 UTC from 1 to 6 January and considering spin-up time of 24 hours. The black dots represent hourly mean observations at the KSJ station. Among them, the simulated wind speed from “jan6”, the model that is initialized 24 hours before the occurrence of the strong wind event, is most consistent with observations. Simulated wind speeds generally agree well with the observations, especially during the generation and maintenance phase of the strong wind on 7 January. The wind speed which is approximately 8.6 m/s at 0000 UTC on 7 January rapidly increase and reach its maximum value of ~ 21 m/s at 0800 UTC and remain at this level until 18 UTC in observations. The simulated wind speed from “jan6” captures variation of this strong wind well, in terms of strength (overestimate by 14 % of the wind speed at 0000UTC and underestimate by 4% of the wind speed at 0800 UTC) and abrupt transition of the wind speed. Among the remaining experimental results, “jan5” which is initialized on 5 January, two days before the occurrence of strong wind event, simulates wind speed that is relatively consistent with observations. However, the peak wind speed is slightly underestimated by 14 % compared to the observation. Simulations initialized before 0000 UTC on 4 January underestimate the peak wind speed by around 30% and poorly represent the timing of the wind speed shift. Simulation result from “s24h” show similar wind speed to those from “jan6” on 6 and 7 January. Note that the simulated wind speed on 7 January from “s24h” are the same as those from “jan6”, but they start to diverge from “jan6” and observations at 0000 UTC on 8 January. The sea level pressure minimum, with the value of ~962 hPa at 1600 UTC on 7 January, is well represented by “jan6” with the value of ~963 hPa. Other experiments show a minimum pressure that is slightly lower than observations, by about 2–3 hPa (“jan2" show the lowest value of ~ 958 hPa).

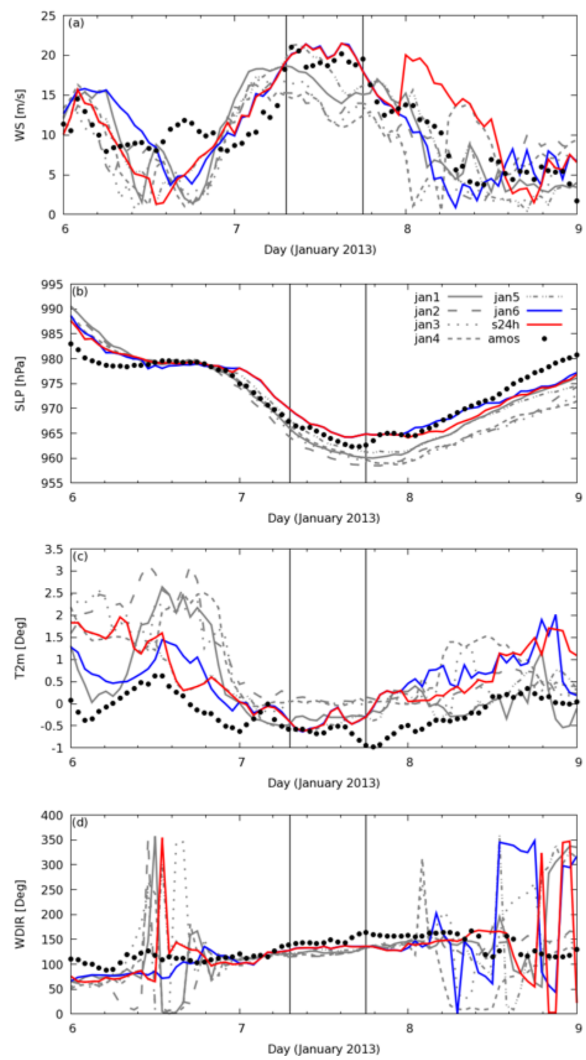

Figure 1. Hourly time-series of (a) 10 m wind speed (m/s); (b) sea level pressure (hPa); (c) 2 m air temperature and (d) wind direction (degree) from AMOS and polar WRF simulations (3 km) with different initialization time (jan1 – jan2) and consideration spin-up time of 24 h (s24h). The solid vertical lines indicate the strong wind period from 0700 UTC to 1800 UTC on 7 January.

4. CONCLUSION

The 3 and 9 km model simulations of strong wind events show a good agreement with the observation, whereas the 27 km model shows remarkably poor simulation performance for the wind speed and sea level pressure. We conclude that the strong wind event at the KSJ station on 7 January is caused by combined effect of both synoptic-scale low pressure system and local topography of AP near the KSJ station.

5. ACKNOWLEDGEMENTS

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Living and Working in Antarctica and the Sub-Antarctic: Weather Information Use and Decision-Making

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People in Antarctica and the sub-Antarctic use weather information daily. Their work, travel and research schedules are dictated by the weather. Adverse conditions can risk lives, stop work, and thwart research projects. Understanding people's weather information use and needs is important to improving services, human safety, and performance. Through survey and interviews, our YOPP endorsed, mixed-methods research project explores how, when, and why people use weather information in the Antarctic and sub-Antarctic. Participants had deployed with National Antarctic Programs, tourism operators, and private organisations in a range of roles. Results indicated top information sources were websites, station intranets, forecasts, current weather displays, and meteorological professionals. The usefulness of weather variables did not change across location, roles, or work environments for the most highly rated items like wind, short-term forecasts, and meteorologist's advice, but did vary across lower rated items like sea state and tides. Weather information use and decisions were subjective, activity and context specific, to reduce risks and plan and schedule tasks. Accessibility to information and services varied between locations and organisations, with some participants unable to access forecasts. Results demonstrate that weather information use and related decision-making are an important part of participants ability to work and function in the Antarctic and sub-Antarctic.

Major Surface Melting over the Ross Ice Shelf, Antarctica

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Over the past three decades, West Antarctica (WA), especially the Ross Ice Shelf (RIS), has experienced more frequent surface melting during austral summer, which can cause potentialice loss in the future. This research investigates 4 extensive melt events over the RIS (1982/83, 1991/92, 2005 and 2016 cases) based on Polar WRF (PWRF) simulations driven by ERA5 reanalysis data and Moderate Resolution Imaging Spectroradiometer (MODIS) observed albedo. Compared to Antarctic Mesoscale Prediction System (AMPS), PWRF outputs significantly reduce the cold bias near the surface by ~2 ºC. In this research, three major regional rivers, direct warm advection, recurring foehn effect, and cloud introduced radiative impacts are identified and quantified based on PWRF outputs, ERA5 reanalysis data, and Clouds and the Earth's Radiant Energy System (CERES) satellite data.

First, the direct warm air advection usually affects the coastal area and rarely results in strong melting. However, the moisture brought over the continent can benefit cloud formation, especially low-level liquid clouds, and thus impact the surface energy balance via increasing downward longwave radiation. Second, for 3 of 4 melt cases, more than 50% of the melting period experiences foehn warming that contribute 2 – 4 ºC increase in surface temperature. And the foehn effect can be amplified by strong moist imports from the ocean to coastal Marie Byrd Land (MBL). Additionally, the decreasing surface albedo caused by the surface melting reduces the upward shortwave radiation and promotes the expansion of the melting over the middle RIS and western MBL. For future research, the prediction of the stability of West Antarctic Ice Shelves should not only consider the large-scale climatic modes but also regional drivers. And the detailed physical mechanisms have a significant influence on the accuracy of the prediction.

Antarctic Atmospheric River Climatology and Impacts

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The mass balance of Antarctica is sensitive to intrusions of extremely warm, moist airmasses from the mid-latitudes in the form of atmospheric rivers (ARs). These storms provide a sub-tropical link to the Antarctic continent and are very consequential to the mass balance of the ice sheet. Using an AR detection algorithm designed for Antarctica and regional climate simulations from MAR, we created a climatology of AR occurrence and their associated impacts on surface melt, ice shelf stability, and snowfall.

Despite their rarity of occurrence over Antarctica (maximum frequency of 1-3 days per year over a given coastal point), ARs have a relatively large impact on the surface melt processes in West Antarctica and snowfall patterns of East Antarctica. ARs have previously been shown to trigger surface melting along Marie Byrd Land and the Ross Ice Shelf. Recent analysis shows their potential to destabilize the ice shelves along the Antarctic Peninsula. During the summer season along the Larsen ice shelves, ARs contribute to 60-80% of the most intense melt, runoff, and high temperature extremes. Through a combination of melt pond formation and subsequent hydrofracturing initiated by leeward foehn winds and radiative fluxes, and sea ice disintegration that allows swells to stress the ice shelf margins, ARs can destabilize the leeward ice shelves. Intense AR landfalls coincided with the collapse of the Larsen A in January 1995 and the Larsen B in the summer of 2002.

In East Antarctica, ARs are responsible for 20-30% of snowfall and a majority of the heaviest precipitation events with ramifications for past climate reconstruction using ice cores. Despite ARs having a modest impact on total precipitation, annual snowfall trends across East Antarctic were primarily driven by trends in AR frequency while ARs controlled the inter-annual variability of precipitation across most of the Antarctic ice sheet from 1980-2018.

Our results suggest that atmospheric rivers play a significant role in the Antarctic mass balance. Thus any future changes in atmospheric blocking or tropical-polar teleconnections, which control AR behavior around Antarctica, may have significant impacts on future surface mass balance projections and subsequent sea level changes.

Antarctic Atmospheric Rivers: Flavors and Modes of Variability

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Atmospheric rivers (ARs) are long, narrow, filamentary structures that act as synoptic-scale vehicles of poleward moisture transport. For Antarctica, extreme precipitation occurs almost exclusively during landfalling ARs and can contribute to either melting, or snow accumulation events. In this presentation, we examine different regional flavors of atmospheric rivers that make landfall along the Antarctic coastlines and the different modes of variability associated with them. The Southern Annual Mode (SAM), the Pacific South American mode (PSA), and the Pacific Decadal Oscillation (PDO) are analyzed explicitly for atmospheric river events and subsequent precipitation. Preliminary results suggest that different modes of variability are important for different hotspot locations around the continent. Sensitivity to ARDT (Atmospheric River Detection Tool) will also be shown. Methodologies designed to detect and track ARs specifically for Antarctica more consistently identify ARs extending deeper inland compared to global algorithms where storms typically are found in the Southern Ocean and only brush the Antarctic coastlines.

Temperature and precipitation projections for the Antarctic Peninsula over the next two decades: contrasting global and regional climate model simulations

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We assessed the near future (2020–2044) temperature and precipitation changes over the Antarctic Peninsula under the RCP8.5 scenario. We used historical and projected simulations from 19 global climate models (GCMs) participating in CMIP5. We compare and contrast GCMs projections with two groups of regional climate model simulations (RCMs): (1) high resolution (15-km) simulations performed with Polar- WRF model forced with bias-corrected boundary conditions obtained from NCAR-CESM1 over the Antarctic Peninsula, (2) medium resolution (50- km) simulations of KNMI-RACMO21P forced with EC-EARTH obtained from the CORDEX-Antarctica. Following opposite circulation pattern changes, both boundary conditions exhibit different warming rates, indicating a possible continuation of natural decadal variability. Overall, RCM projections follow the same climate change signal depicted in the boundary conditions with increases in annual mean temperatures (0.5ºC to 1.5ºC) and precipitation (5% to 10%). Nonetheless, RCM projections show less warming and a smaller increase in melt days and rain days in the Larsen Ice Shelf compared to their respective driving fields. We conclude that it seems still difficult to get consistent projections from GCMs for the Antarctic Peninsula as depicted in both RCM boundary conditions. We argue that added value of RCMs depends on the processes shaped by finer local details and different physics schemes of the RCMs, particularly over the Larsen Ice Shelf.

Present and Future of Rainfall in Antarctica

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Given the cold temperatures prevailing in Antarctica, most precipitation over the ice sheet falls as snow. However, little is known about liquid precipitation, namely drizzle and rain, although it can have serious ecological and climatic impacts. By combining several decades of meteorological reports at 10 Antarctic stations with atmospheric reanalyses, this study provides the first climatological characterization of rainfall occurrence in Antarctica. Stations on the East Antarctic coast have reported between 0 and 22 days per year with liquid precipitation that mostly occurs in summer and that generally coincides with a warm intrusion associated with a blocking anticyclone. On the other hand, there is between 50 and 93 rainy days per year on average over the north-western edge of the Antarctic Peninsula. In the latter region, the annual number of rainy days significantly decreased during the summer cooling period at the beginning of the 21st century and the trend reached -35.1 days per decade over the 1998-2015 period at Faraday-Vernadsky station. Projections from seven state-of-the-art climate models reveals that the overall future warming of Antarctica will be accompanied by more frequent and more intense rainfall events. In the high-emissions SSP5.85 scenario, the difference in liquid precipitation between the 2081-2100 and 2015-2034 periods equals +7.6 mm y^{-1} on average over the whole Antarctic continent. Liquid precipitation explains on average 15 % of the total precipitation increment at the continental scale and almost 57 % when considering the Antarctic Peninsula. A deeper analysis of the projection also suggests that continental areas that can experience temperatures greater than 0°C together with significant liquid precipitation amount will increase by a factor of about 3 by the end of the century, expanding particularly over the Ronne, Filchner and Ross Ice Shelves. Those regions will therefore be exposed to a higher risk of surface snow melting by the preconditioning of surface snow.

Trends in Atmospheric Humidity and Temperature above Dome C, Antarctica Evaluated from Observations and Reanalyses

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The time evolution of humidity and temperature above Dome C (Antarctica) has been investigated by considering observations performed at Dome C from radiosondes since 2005 and from the microwave radiometer HAMSTRAD since 2012. These data have been coupled with reanalyses selected since the end of the 20th century (from 1980 to 2017/2018) from ERA-Interim, MERRA2 and JRA-55, and the southern annular mode (SAM) index over the same period. The observations at Dome C reveal a significant moistening (0.08 ± 0.06 g m^{-3} dec^{-1}) associated with a significant warming (1.08 ± 0.55 K dec^{-1}) in summer, and a significant drying (-0.04 and -0.05 ± 0.03 g m^{-3} dec^{-1}) associated with a significant cooling (-2.4 ± 1.2 and -5.1 ± 2.0 K dec^{-1}) in autumn and winter, respectively whilst, in spring, no significant trends are evaluated. Considering the reanalyses, our study showed that 1) the summer moistening/warming and the autumn and winter drying/cooling observed in the beginning of the 21st century agreed with the reanalyses and 2) periods of moistening/warming alternated with periods of drying/cooling whatever the season considered. The decadal trends in Integrated Water Vapour (IWV) and 2-m temperature were obviously anticorrelated to the decadal trends in SAM index for all the seasons but spring. Our study suggests that the decadal trends observed at Dome C since the beginning of the 21st century in humidity and temperature are well within the variability of the atmosphere analysed since the end of the 20th century.

Tropical-Antarctic Teleconnections and their Impacts on the Antarctic Climate Changes

Xichen Li, Wenju Cai, Gerald A. Meehl, Dake Chen, Xiaojun Yuan, Marilyn Raphael, David M. Holland, Qinghua Ding, Ryan L. Fogt, Bradley R. Markle, Guojian Wang, David H. Bromwich, John Turner, Shang-Ping Xie, Eric J. Steig, Sarah T. Gille, Cunde Xiao, Bingyi Wu, Matthew A. Lazzara, Xianyao Chen, Sharon Stammerjohn, Paul R. Holland, Marika M. Holland, Xiao Cheng, Stephen F. Price, Zhaomin Wang, Cecilia M. Bitz, Jiuxin Shi, Edwin P. Gerber, Xi Liang, Hugues Goosse, Changhyun Yoo, Minghu Ding, Lei Geng, Meijiao Xin, Chuanjin Li, Tingfeng Dou, Chengyan Liu , Weijun Sun, Xinyue Wang, Chentao Song

Substantial zonally-asymmetric changes have been observed in the Antarctic over the satellite era. These include accelerated glacier melting, rapid thinning of ice shelves in West Antarctica and the Antarctic Peninsula but little net change in East Antarctica, and, until 2015, increased sea ice surrounding most of Antarctica but decreased sea ice in the Amundsen and Bellingshausen Seas. These zonal asymmetries are also accompanied by temperature and circulation anomalies in the Southern Hemisphere atmosphere and ocean. Many features, such as mixed temperature trends over the continent and the slight overall increase in sea ice before 2015, are not captured by the zonally-averaged picture frequently considered in simple models of the response to increasing greenhouse gas concentrations. An important part of the observed patterns involves anomalous atmospheric convective heating in the tropics, which drives a tropical-polar connection via a quasi-stationary Rossby wave train that propagates poleward and eastward into the polar regions. Ongoing efforts that seek to understand the key ocean-atmosphere processes linking the tropical oceans to the Antarctic have suggested that teleconnections associated with a negative phase of the Interdecadal Pacific Oscillation and a positive phase of Atlantic Multidecadal Oscillation, have worked in tandem to cause a large fraction of the observed changes in recent decades. These advances have implications for assessing whether and how the driving forces of the observed trends may continue to operate into the future. However, due to limited observations and the constraints imposed by inherent biases in models, uncertainties remain in our ability to assess and understand the importance of these teleconnections versus changes due to projected increases in greenhouse gases and future ozone recovery. Sustained efforts in ocean and climate observations, climate model improvements, and a more comprehensive pan-Antarctic approach are needed to enable further progress.

A model-based climatology of low-level jets in the Antarctic

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Low-level jets (LLJs) are climatological features in polar regions. It is well-known that katabatic winds over the slopes of the Antarctic ice sheet are associated with strong LLJs. Barrier winds occurring e.g. along the Antarctic Peninsula may also show LLJ structures. A few observational studies show that LLJs occur over sea ice regions. We present a model-based analysis of LLJs in the Antarctic for the period 2002-2016. The sensitivity of the LLJ detection on the selection of the wind speed maximum is investigated. The common criterion of an anomaly of at least 2m/s is extended to a relative criterion of wind speed decrease above and below the LLJ. While the katabatic LLJs are relatively insensitive to the choice of the relative criterion, the frequency of LLJs over the sea ice is highly sensitive. The LLJs are evaluated with respect to the frequency distributions of height, speed, directional shear and stability for different regions.

Augmenting West Antarctic Weather and Climate Observations with an Expanded and Updated Ice Core Array

Peter Neff

University of Minnesota

Antarctic weather and climate observations are inherently limited in time and space, presenting challenges for fully understanding observed variability and ongoing trends. In West Antarctica, where ice mass loss due to ice-ocean-atmosphere interactions is focused, a spatial array of decades to centuries-long ice core records augments observations from Byrd Station (1957 - present) and automated weather stations. However, this ice core array is limited to inland regions above 1000 m elevation and is now out of date, having largely been collected in the late 1990s. This inland ice core network can easily be updated by returning to sites and recovering no more than 15 m of ice. The network can be expanded to low-elevation coastal regions near changing ice shelves by recovering 150 m long ice cores from ice rises, ideal areas of grounded ice punctuating the Pacific coastline of West Antarctica. Preliminary constraints on coastal snow accumulation over recent decades can be gained from analysis of high-frequency radar collected by NASA Operation IceBridge and a new shallow ice core from Mt. Siple, and also inform selection of future coastal ice core sites which can provide records of temperature, wind, sea ice, and other environmental factors.

How the mesoscale variability casts doubt on the representativeness of observations near the Antarctic Peninsula

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For the most Marine Antarctic area and the Antarctic continent itself surface condition is highly uniform. Therefore, meteorological measurements there have no problems with the representativeness. However, some coastal regions and especially the Antarctic Peninsula demonstrate a huge mesoscale variability of weather conditions, which is equivalent to the process of synoptic scale. For estimation of weather condition variability, the mesoscale polygon of 10 weather stations was setup around Ukrainian Antarctic Akademik Vernadsky Station in April 2019. 3 weather stations from the US Palmer region were also taken into analysis. Although the polygon collected data for only 20 days, it was enough for a preliminary assessment of the possible weather conditions variability, caused mainly by the mountains aerodynamics. For better understanding of physical processes, the results of polygon measurements were completed by the high resolution Polar WRF model.

As it was expected, the wind condition typically varies from 0 to storm speed, temperature changes up to 5°C within the polygon area (~20 km) and a time moment. These aerodynamic perturbations can often reach Akademik Vernadsky Station, situated 8 km far from the Peninsula mountains, and make the measurements not representative (e.g. for global atmospheric models). The similar effect should cover other research stations situated in the Antarctic Peninsula region.

HOW THE MESOSCALE VARIABILITY CASTS DOUBT ON THE REPRESENTATIVENESS OF OBSERVATIONS NEAR THE ANTARCTIC PENINSULA

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1. OVERVIEW

For most of the Marine Antarctic area and the Antarctic continent itself surface condition is highly uniform, therefore meteorological measurements there have no problems with the representativeness. However, some coastal regions and especially the Antarctic Peninsula (AP) demonstrate a huge mesoscale variability of weather conditions, which is equivalent to a process of synoptic scale. This is known from publications that have studied this issue using high-resolution atmospheric simulations in the region. (Zhang, Zhang, 2018, Kirchgaessner et al., 2019, Pishniak, Beznoshchenko, 2020). At the same time most research stations (and consequently weather data) are placed in the coastal regions due to historical and logistical circumstances.

2. METHODS

In order to estimate weather condition variability, the mesoscale polygon of simple weather stations was set up near Ukrainian Antarctic Akademik Vernadsky Station in April 2019. It included 10 loggers with temperature, humidity and wind sensors, placed on small islands and capes of the west coast of AP, over the ocean area around Vernadsky Station. Beside that, data from 3 weather stations of US Palmer region was used for covering the north side.

Unfortunately, the insufficient reliability of the equipment for the Antarctic harsh environment did not allow the planned long-term measurements to be carried out. The polygon collected data for only 20 days, but it was enough for a preliminary assessment of the possible weather conditions variability, caused mainly by the mountains aerodynamics. For better understanding of physical processes, the results of polygon measurements were completed by the high resolution Polar WRF model (Hines et al., 2011).

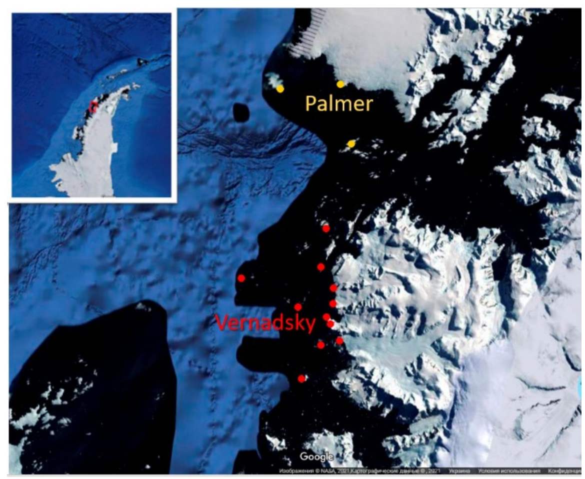

Figure 1. Location of polygon weather stations

3. RESULTS

As it was expected from live experience, the wind conditions typically vary from 0 to storm speed within the polygon area (~20 km) in a certain time. Often wind direction shows a formation of local vortex behind the Kyiv Peninsula. Although the base weather station at Vernadsky is situated 8 km far from the Peninsula mountains, it obviously feels their influence as a complex air dynamic effect. Vernadsky weather station suffers from wind shadow when the general wind has north-east direction and vice-verse it appears under mainstream line when the direction is from the north. The wind direction for Vernadsky Station is strongly modifying in general.

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The temperature variation through the polygon reached 5°C. As the experiment took place at the end of April, the influence of additional solar insolation should be negligible in this time (underlying surface is mainly water and snow). The bigger temperature drops occur near the AP coast. They were caused not only by cold winds from glacier valleys, but also by warm foehn-type winds, reaching down the ground from the upper levels.

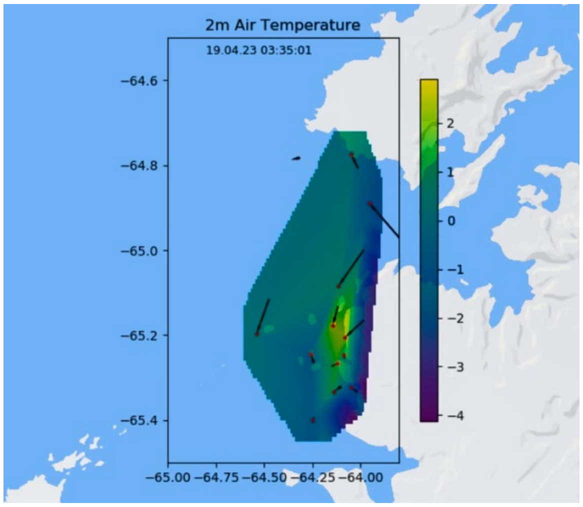

Fig. 2 – Weather map at 03:35 UTC 23 April 2019 demonstrate temperature and wind fields. Warm core and local vortex appears near Kiev Peninsula west coast.

The temperature variations are not so often and strong effect on Vernadsky weather station as wind perturbations, but up to ten times per year observers can clearly define local foehn phenomenon. According to the model simulation foehn-type phenomenon in the region also appears without precipitation formation, but because of forced mixing of stable stratifying atmosphere.

The mesoscale polygon has no pressure sensors, but it has weather stations from Palmer region, which is at a distance of about 50 km. The quick comparison shows very small pressure differences between the locations (less than 1 hPa in case of mesoscale perturbations), so we do not pay attention to this parameter.

4. CONCLUSION AND DISCUSSION

Obviously, the studied observation period is not enough for the reliable statistics on how often and within what limits the deviations caused by the relief and mesoscale disturbances of the atmosphere should be expected. At the same time, available observations at the mesoscale polygon around Akademik Vernadsky Station show the temperature deviations, that can "unreasonably" reach several degrees. The wind parameters can be significantly distorted under certain synoptic conditions. Similar effects should be expected also at the other weather monitoring locations on the Antarctic Peninsula.

High-resolution regional mesoscale models can clarify the conditions and mechanisms for the formation of such forced atmospheric perturbations. However, the models do not always reproduce well the general situation in the atmosphere. Probably the most significant source of model error comes from the initial global analysis. The comparison of model to extended in-situ observation at the polygon makes it possible to establish situations when model simulations are more trustful and when are less. From the other side, this experiment demonstrates the necessity of high-resolution model data assimilation algorithms, to reduce a risk of introducing incorrect, destructive information into the rough (global) models.

6. ACKNOWLEDGEMENTS

The mesoscale weather polygon was installed thanks to technical support of Roman Bratchyk and all Akademik Vernadsky Station crews 23 and 24 Ukrainian Antarctic Expeditions, who put a lot of effort to obtain its data.

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Temporal variations in Antarctic ice sheet surface accumulation observed with snow depth sensors in automatic weather stations

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Automatic Weather Stations (AWSs) with ultrasonic snow depth sensors were newly installed at four sites. The installation was started in January 2016 and completed in October 2019. The sites are H128 in the coastal region, MD78 in the continental slope region with the katabatic wind, NRP in the inland high region on the upside of the continental slope, and NDF on the summit of the ice sheet. The purpose of this AWS system is to clarify the temporal variations of accumulations affected by synoptic-scale disturbances and diurnal variations while reflecting the regional characteristics over a wide area of the Antarctic ice sheet. This paper investigates the temporal variations of surface height observed at these four sites. The results are as follows: 1) The temporal changes of surface height include stepwise fluctuations and pulse-like fluctuations, and the rise in surface height is mainly caused by stepwise rises, rather than pulse-like fluctuations. 2) A comparison between H128 and NRP showed four cases in which surface height fluctuations appeared simultaneously over a wide area. The NOAA infrared image reveals that the cloud area associated with a synoptic-scale disturbance formed over the ice sheet. 3) The surface height is less likely to rise largely between different sites on the same day. 4) At the three sites other than NRP, a slow decline in surface height was observed during the warm season.

Ross Island Area Severe Weather Conditions

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Antarctica is home to some of the harshest weather on planet earth. Temperatures regularly drop well below zero with snow and windstorms reducing visibilities to near zero. Every year, numerous locations across Antarctica experience severe weather. The Ross Island region of Antarctica, home to the United States Antarctic Program (USAP) McMurdo Station, is no exception. In the USAP, there are three levels or conditions of severe weather: Condition 1, Condition 2 and Condition 3. Condition 1 is characterized by winds above 55 knots, wind chill lower than -100 degrees Fahrenheit, and/or visibility of less than 100 feet. Condition 2 is characterized by winds between 48 and 55 knots, wind chill between -74 and -100 degrees Fahrenheit, and/or Visibility between 100 feet and a quarter mile. Condition 3 is anything less severe than Condition 2. This project analyzes the severe weather conditions declared on and near Ross Island. The next goal for this project is to search for satellite imagery to contribute to case studies of these events. Combined with the frequency and trends of severe weather occurrences, this study aims to characterize the worst weather occurring in this region. The project results will help forecasters and logistics planners who support scientists' travel to Antarctica. This is the first analysis of these severe weather conditions as declared in this region of Antarctica, and the first attempt at bringing all available information together into one place.

Storms and the formation of the high salinity shelf water in the Barrier polynya, East Antarctica

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Despite its impacts on the deep-water formation and transport of heat underneath the ice shelves, the high salinity shelf water (HSSW) production rates in coastal Antarctic polynyas are not well known. Due to the important role of intensive air-sea interaction, one might expect the HSSW production to increase significantly during storms compared to normal weather conditions. For this study, few storm cases were selected and a high-resolution ocean model was forced by these storms. Then, changes in the modelled upper ocean characteristics due to these storm events, with potential effects on the HSSW formation rates, are analyzed. Preliminary results of this on-going work will be presented on a poster.

STORMS AND THE FORMATION OF HIGH SALINITY SHELF WATER IN THE BARRIER POLYNYA, EAST ANTARCTICA

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https://www2.helsinki.fi/en/researchgroups/geophysics-of-the-hydrosphere

1. INTRODUCTION

In the Antarctic coastal polynyas intense sea-ice production occurs under strong and persistent cold winds. As a result, salt is rejected from the growing sea ice to the upper ocean and high salinity shelf water (HSSW) is formed. Importantly, HSSW is an important precursor of the Antarctic Bottom Water (AABW), the largest water mass in the World Ocean (Meredith et al. 2019).
Despite its oceanographic and climatic importance, HSSW production rates in the coastal Antarctic polynyas are not well known. Due to the important role of intensive air-sea interaction, one might expect that the HSSW production rates significantly change during storms. For this study, two storm cases were selected and a high resolution ocean model was forced by salt and heat fluxes, and winds at the ocean surface. Then, the changes in the upper ocean hydrographic characteristics before and after these storm events were analysed for one coastal polynya, the Barrier polynya (Figure 1).

2. OCEAN MODEL

We used the pan-Antarctic version of the Regional Ocean Modelling System (ROMS v3.6), or so-called the whole Antarctic ocean model (WAOM v1.0), with a 4-km horizontal resolution. Notably, the WAOM v1.0 is the first pan-Antarctic ocean model that covers the entire Antarctic shelf and resolves both mesoscale eddies and tides (Richter et al. 2020). These processes are important for oceanic transports and mixing in coastal regions rich in topographic details.

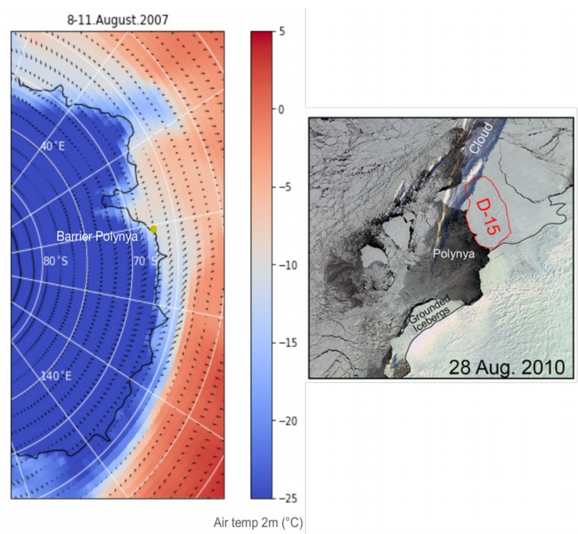

Figure 1. In the left panel, the location of the Barrier polynya (green dot), ERA-Interim mean 2-m air temperature (colour surface) and 10-m wind vectors during the 8–11 August 2007 storm. In the right panel, a satellite image of the Barrier polynya is shown with icescape features highlighted (from Nihashi and Ohsima, 2015, © American Meteorological Society. Used with permission).

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In the WAOM configuration, ROMS is driven by prescribed salt and heat fluxes at the air-sea or ice-sea surfaces (Tamura et al. 2011). Instead of coupling ROMS with a sea-ice model, this setup is considered advantageous because current numerical dynamic-thermodynamic sea-ice models struggle to realistically reproduce coastal polynyas occurring on the leeside of land-fast ice regions and icebergs. The momentum flux is determined by a bulk formula and ERA-Interim atmospheric reanalysis winds (Dee et al. 2011). The WAOM configuration here is similar to the one by Richter et al. (2020), except the ROMS lateral boundary was extended north to include the oceanic jets and fronts in the Ross Sea sector. This change was found to decrease model temperature and salinity biases. Moreover, the surface boundary heat flux was reduced to one fourth of its original value, and the brine injection was left unmodified unlike Richter et al. (2020). These adjustments resulted in a faster model spinup and a more realistic looking hydrography.

3. RESULTS AND DISCUSSION

The Barrier polynya was selected to this study because Tamura et al. (2016) found higher correlations between sea-ice production rates, off-shore winds and air temperature for this particular polynya than for many others. The Barrier polynya is surrounded by land, an ice shelf, icebergs and land-fast ice, with off-shore wind directions ranging from east to south (Figure 1).

After exploring synoptic charts for the 2007 winter, two storm events (1–5 and 8–11 August) were selected for closer inspection based on their contrasting impacts on the upper ocean density. Time series of basic meteorological variables covering the storm events are shown in Figure 2.

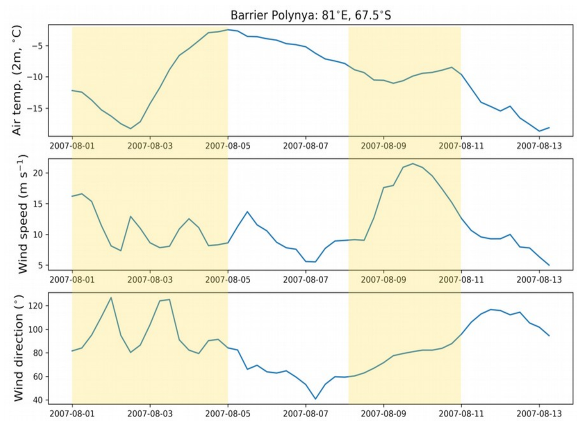

Figure 2. ERA-Interim 2-m air temperature (top panel), wind speed (middle panel) and wind direction (lower panel) at the Barrier polynya during the first half of August 2007. Periods of two storm events are highlighted with yellow shading.

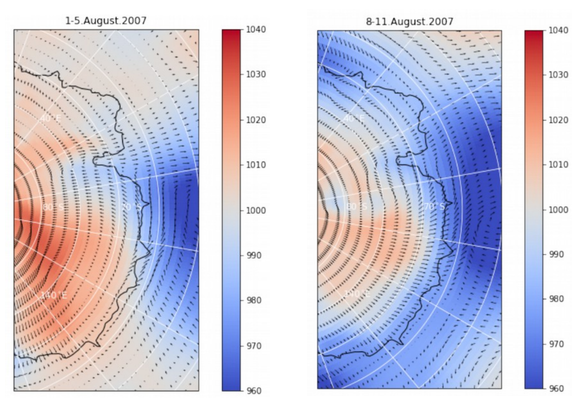

Figure 3. ERA-Interim average sea level pressure (hPa) and wind vectors during the storm events of 1–5 August (left panel) and 8–11 August 2007 (right panel).

Storm event in 1–5 August 2007

This event was characterised with a low pressure system north of the polynya, and weakening and directionally variable winds in the Barrier polynya region (Figure 3 left panel and Figure 2, middle and lower panels). This caused a significant advection of marine air shown as a warming from about -20°C to -2°C over the polynya (Figure 2, top panel).

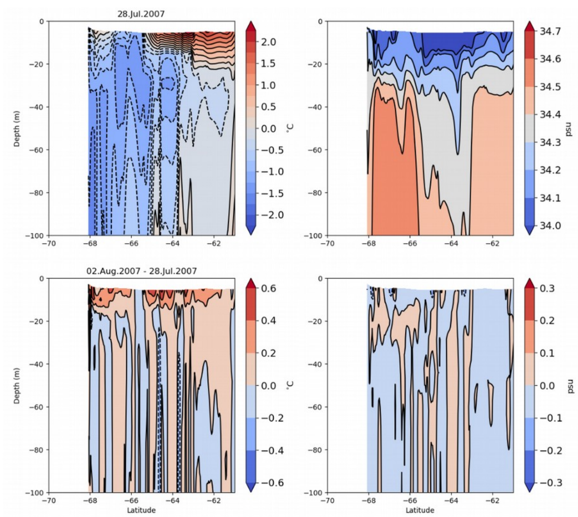

Figure 4. WAOM 4-km simulated upper ocean temperature (left) and salinity (right) transects across the Barrier polynya region on 28 July 2007 (top row), and their differences between 2 August 28 July (bottom row).

Changes in top 100 m ocean temperature indicate warming in top 10 metres (Figure 4 lower left panel), likely due to warming air. No clear changes in the upper ocean salinity, and therefore in sea-ice production are seen (Figure 4 lower right panel). However, the average surface salinity flux remains relatively high during the event (not shown), indicating significant sea-ice production, at least at the beginning of the event. Due to the ocean surface warming and consequently increasing upper ocean stability, one might expect decreasing HSSW production rates during the event.

Storm event in 8–11 August 2007

The second event was dominated by a deeper and bigger low pressure system than the first event (Figure 3 right panel and Figure 2, middle and lower panels). In the polynya region, the storm caused strengthening of off-shore winds, a cold air outbreak and relatively cold air temperatures of around -10°C over the polynya (Figure1, left panel and Figure 2, top panel).

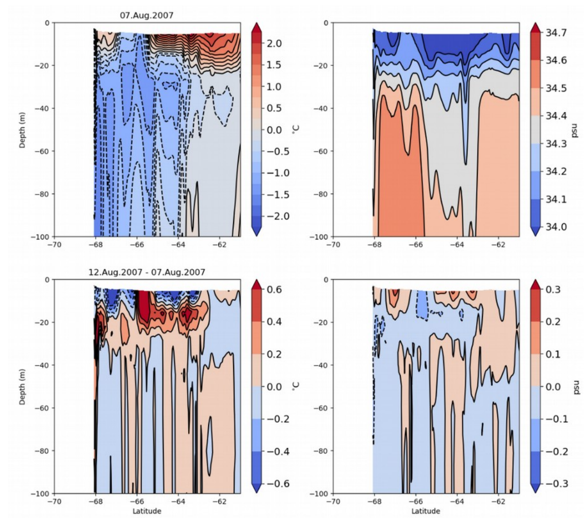

Figure 5. As Figure 4, but for 7 August (top row), and differences between 12 and 7 August 2007 (bottom row).

In terms of hydrographic changes, significant cooling is visible in top 10 metres, while the warming just below 10 metres indicates upper ocean overturning (Figure 5 lower left panel). Increases in the upper ocean salinity are related to increasing sea-ice production (Figure 5 lower right panel), triggered by off-shore winds. This further enhances the upper ocean convection and can also be expected to increase the HSSW production. The average sea-ice production rate is at a relatively low level (not shown), compared to the first storm event.

4. CONCLUSION

This small exercise highlights the sensitivity of the upper coastal ocean response to atmospheric forcing. Rather similar looking synoptic conditions result in almost opposite evolutions of upper ocean vertical stratification and mixing. Reasons for this originate from local details in land- and icescape features in the vicinity of the Barrier polynya. Moreover, different weather histories before the two events and therefore varying initial states at the beginning of the two events are likely to play important roles.

5. FUTURE PLANS

Next, more storm cases will be identified and analysed for several polynyas along the East Antarctic coast. This will provide results toward climatological importance on the favourable conditions for HSSW formation. Moreover, pan-Antarctic WAOM simulations have been carried out using 10-km, 4-km and 2-km ROMS horizontal resolution, which material will be analysed to determine impacts of resolved topographical features, tides and ocean eddies. A major objective of the project is to determine AABW production rates with respect of resolved coastal processes.

5. ACKNOWLEDGEMENTS

This work is supported by the Academy of Finland, under the grant 322432, The impact of Antarctic Ice Sheet – Southern Ocean interactions on marine ice sheet stability and ocean circulation (COLD). We acknowledge our project collaborators Ben-Galton Fenzi (University of Tasmania) and Ole Richter (Alfred Wegener Institute) for their support with the WAOM model. We are grateful to Zhaoru Zhang and Xiaoqiao Wang (Shanghai Jiao Tong University) for providing ideas and inspiration to this study. In Figure 1, channel 31 and 32 images from the NASA Moderate Resolution Imaging Spectroradiometer (MODIS) on Aqua provided by NASA's Level 1 and Atmosphere Archive and Distribution System website (LAADS web; http://ladsweb.nascom.nasa.gov/) were used, and the bathymetry was obtained from the General Bathymetric Chart of the Oceans (GEBCO) One Minute Grid. We thank these data providers.

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From the Mountains to the Penguins in the Deep Blue Sea: Importance of Atmospheric Forcing Resolution to the Simulation of the Ocean for a Biological Hotspot off the Antarctic Peninsula

Michael Dinniman[1], Katherine Hudson[2], John Klinck[1], Josh Kohut[3], Carlos Moffat[2], Matthew Oliver[2], Mollie Passacantando[3], Hank Statscewich[4], Jacquelyn Veatch[3], and Xin Wang[2]

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[2]College of Earth, Ocean, and Environment, University of Delaware, Lewes, DE, USA
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Many biological hotspots, which are critical to the marine ecosystem structure and function along the Western Antarctic Peninsula (WAP), are located near submarine canyons. A project (SWARM) is currently underway to study how the circulation dynamics associated with the Palmer Deep canyon near Anvers Island contribute to a persistent hotspot above the canyon, as shown by known penguin foraging locations. An extensive observing campaign was carried out during summer 2019/2020 to observe the ocean physical and biological characteristics of the area. As part of this, an existing high resolution (1.5 km) ocean circulation model was modified to run simulations covering the field season.

In order to force the model, two atmospheric products were selected that covered the spatial extent of the model domain: the ERA5 reanalysis (~ 30 km horizontal resolution) and archived forecasts from the Antarctic Mesoscale Prediction System (AMPS: Grid “2” at 8 km horizontal resolution). Wind observations were available from two AWS stations situated on islands ~21 km apart that bracket the northern end of the canyon. Because of the orography of Anvers Island to the northeast (which is the direction the prevailing winds come from), there is often a significant difference in the winds at the two AWS stations.

When compared to the AWS stations over summer 2019/2020, both wind products represent the daily averaged variability quite well. However, the ERA5 winds, as would be expected because of the resolution differences, were significantly weaker over the canyon than the AMPS winds. The AMPS winds also were able to represent some of the temporal variability in the difference in wind speed between the two AWS stations.

Ocean model simulations in this area often suffer from having too shallow surface mixed layers during the summer. Properly representing the mixed layer depth can be critical to simulating ocean primary productivity in the area, which will be important to the ecosystem. Here, simulations were run with both wind products, as well as changing the temporal frequency of the ERA5 winds used to force the ocean, and modifying the vertical mixing parameterization. Changing the wind frequency or the vertical mixing parameterization had little effect on the mean simulated summer mixed layer depth over Palmer Deep (mean increase of ~ 1 m). However, switching the winds from ERA5 to AMPS deepened the summer mixed layer by ~ 11 m. We plan to use this ocean model to explore several biological hot spots along the WAP, and as many of these are located in near-coastal environments, the higher resolution AMPS winds should be quite helpful.

Antarctic Meteorological Research and Data Center: Antarctic Meteorological Data Flow

T. Norton and M. Lazzara

UW-Madison

There are a variety of ways and locations that the Antarctic Meteorological Research and Data Center (AMRDC) receives data. This poster diagrams the data flows from different sources, via different transmissions, and for different data types. The primary means of data transferred is via the Antarctic-Internet Data Distribution or Antarctic-IDD (using Unidata Project's Local Data Management (LDM) software), E-mail distribution, abstract data distribution environment (ADDE) service, and secure file transfer protocol (SFTP) service. Some datasets, such as our Antarctic composite imagery, have multiple data avenues and is one of the datasets created at the AMRDC. Discussions will focus on additions, improvements and forgotten data. Feedback from workshop participants is encouraged.

The Hunt for Tabular Icebergs using Weather Satellites

Ethan Koudelka

Antarctic Meteorological Research and Data Center

The Antarctic Meteorological Data and Research Center has engaged in an ad hoc outreach effort to the community tracking tabular icebergs via weather satellite over the Antarctic and adjacent Southern Ocean. This poster details some of the importance of iceberg tracking, as well as current events surrounding tabular icebergs specifically the media's incorrect characterizations of the world's largest tabular icebergs.

Estimating surface meltwater input to the ocean over the last 40 years from King George Island ice cap, Antarctica

Christian Torres[1]; Wolfgang Gurgiser[2]; Jorge Arigony-Neto[1]

[1]Institute of Oceanography, Universidade Federal do Rio Grande, Brazil
[2]Department of Atmospheric and Cryospheric Sciences, University of Innsbruck, Austria

South Shetland Islands, located in Antarctica, have experienced warming (1970-1998; +0.27 °C/dec.) and cooling (1999-2015; -0.69 °C/dec.) trends during the last decades. However, it is not well-known if these temperature changes are sufficient to accelerate and decelerate mass loss and runoff from glaciers in this region. In this context, we will analyze surface mass balance and runoff on the King George Island ice cap, over the last 40 years. For this, we will (1) estimate energy/mass balance and runoff using a COupled Snowpack and Ice surface energy and mass balance model in PYthon (COSIPY), and (2) evaluate atmospheric and oceanic influences on the temporal variability and trends of the surface energy/mass balance and runoff of those glaciers. We evaluated ERA5 reanalysis data, which will be used to force COSIPY, for 5 years (2011-2015) with one automatic weather station (AWS) in-situ data. We find that ERA5 daily solar radiation ($r = 0.938$; RMSE = 40 W/m^2), atmospheric longwave radiation ($r = 0.726$; RMSE = 14 W/m^2), air temperature ($r = 0.931$; RMSE = 1.45 °C), relative humidity ($r = 0.593$; RMSE = 7 %), air pressure ($r = 0.826$; RMSE = 6 hPa) and wind speed ($r = 0.65$; RMSE = 3.8 m/s) are in good agreement with AWS over the whole period. However, annual total precipitation in some years is overestimated strongly (percentage precipitation difference (PPD) = +91% in 2011 and PPD = +75% in 2015) by ERA5. Therefore, we will have to improve ERA5 total precipitation data with downscaling methods before running COSIPY.

Antarctic Peninsula warm winters influenced by Tasman Sea temperatures

Kazutoshi Sato[1,2], Jun Inoue[3,4,2], Ian Simmonds[5] and Irina Rudeva [6,5]

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[6]Australian Bureau of Meteorology, Melbourne, Australia

The Antarctic Peninsula of West Antarctica was one of the most rapidly warming regions on the Earth. The increases in air temperature over Antarctica are related to enhanced warm advection associatedwith changes in the atmospheric circulations over the Southern Ocean. (e.g., the Amundsen Sea Low [ASL] or the Southern Annular Mode [SAM]). The El Niño-Southern Oscillation (ENSO) modulates the position and strength of the ASL. Previous studies examined relationships between atmospheric circulation over the Southern Ocean and tropical oceanic variability, often called 'tropical-polar teleconnections'. However, no previous study has reported the impact of change in sea surface temperature (SST) into the Southern Hemisphere mid-latitudes on Antarctic climate variability. Various studies reported warming sea temperature in the Tasman Sea in recent years. A warming Tasman Sea has strengthened the westerlies between high and mid-latitudes, and thus has influenced cyclone tracks over the Southern Ocean. Therefore, these atmospheric circulation changes related to anomalous SST warmingover the Tasman Sea would contribute to recent anomalous warm AP winters. In this study, we reveal that increases in winter SST in the Tasman Sea modify Southern Ocean storm tracks. This, in turn, induces warming over the Antarctic Peninsula and sea ice retreats over the Bellingshausen Sea and DrakePassage via planetary waves triggered in the Tasman Sea. We show that atmospheric response to SST warming over the Tasman Sea deepen the ASL, leading to warm advection over the Antarctic Peninsula, even in the absence of anomalous tropical SST forcing.

WAMC, List of attendees

NO.	Last name	First name	Country
1	Alexander	Simon	Australia
2	Andersson	Tom	UK
3	Andreasen	Julia	USA
4	Arndt	Stefanie	Germany
5	Bai	Lesheng	USA
6	Baldini	Luca	Italy
7	Boeira Dias	Fabio	Finland
8	Bozkurt	Deniz	Chile
9	Bracci	Alessandro	Italy
10	Bracegirdle	Tom	UK
11	Bromwich	David	USA
12	Callado-Pallarès	Alfons	Spain
13	Carmody	Michael	USA
14	Cassano	John	USA
15	Cayette	Arthur	USA
16	Chen	Thomas	USA
17	Chenoli	Sheeba	Malaysia
18	Chittella	Sai Prabala Swetha	India
19	Choi	Yonghan	South Korea
20	Christophe	Genthon	France
21	Colwell	Steve	UK
22	Cordero	Raul	Chile
23	Dare	Richard	Australia
24	Dattore	Bob	USA
25	Di Natale	Gianluca	Italy
26	Dice	Mckenzie	USA
27	Dinniman	Mike	USA
28	Dolci	Stefano	Italy
29	Duran-Alarcon	Claudio	Portugal
30	Ekrami	Negar	Portugal
31	Fournier	Jeffrey	USA
32	Frey	Logan	USA
33	González	Sergi	Spain
34	Gorodetskaya	Irina	Portugal
35	Gossart	Alexandra	New Zealand
36	Grazioli	Jacopo	Switzerland
37	Grumbine	Robert	USA
38	Gulli	Paul	USA
39	Heil	Petra	Australia
40	Heinemann	Günther	Germany
41	Heinrich	Victoria	Australia
42	Hines	Keith	USA
43	Hirasawa	Naohiko	Japan
44	Hofsteenge	Marte	New Zealand
45	Hollister	Michelle	Australia

46	Hwang	Hyewon	South Korea
47	Jackson	Mike	USA
48	Johnson	Cassidy	USA
49	Johnson	Michael	USA
50	Keller	Linda	USA
51	Kim	Seong-Joong	South Korea
52	Kingsmill	David	USA
53	Kirchgaessner	Amelie	UK
54	Koçak	Ebru	N/A
55	Koppanyi	Harry	USA
56	Koudelka	Ethan	USA
57	Krakovska	Svitlana	Ukraine
58	Kristiansen	Jørn	Norway
59	Kurita	Naoyuki	Japan
60	Kuye	Akin	UK
61	Lazzara	Matthew	USA
62	Li	Xichen	China
63	Liggett	Daniela	New Zealand
64	Lipuma	Lauren	USA
65	Liu	Zhengyu	USA
66	Lubin	Dan	USA
67	Luís	Diogo	Portugal
68	Lynds	Jamie	New Zealand
69	Manning	Kevin	USA
70	Mansilla	Gonzalo	Chile
71	Marin	Julio	Chile
72	Marincovich	Giselle Lujan	USA
73	Mayes	Peter	USA
74	McDonald	Adrian	New Zealand
75	Meyer	John	USA
76	Michael	Bob	USA
77	Mikolajczyk	David	USA
78	Milne	Peter	USA
79	Min	Xu	China
80	Moffat-Griffin	Tracy	UK
81	Motoyama	Hideaki	Japan
82	Mottram	Ruth	Denmark
83	Mounier-Vehier	Alice	Portugal
84	Mullenax	Robert	USA
85	Nasar-u-Minallah	Muhammad	Pakistan
86	Neff	Peter	USA
87	Nicholson	Ruanui	New Zealand
88	Nie	Yafei	Finland
89	Noojin	Matthew	USA
90	Norton	Taylor	USA
91	Onsi	Bella	USA
92	Park	Sang-Jong	South Korea
93	Peterson	Ashley	USA

94	Petteri	Uotila	Finland
95	Pilson	Gaby	USA
96	Pishniak	Denys	Ukraine
97	Pletzer	Tamara	New Zealand
98	Pope	Allen	USA
99	Porhemmat	Rasool	New Zealand
100	Powers	Jordan	USA
101	Querel	Richard	New Zealand
102	Radenz	Martin	Germany
103	Ramugondo	Ntanganedzeni	South Africa
104	Reid	Phil	Australia
105	Reusch	David	USA
106	Ricaud	Philippe	France
107	Richter	Maren Elisabeth	New Zealand
108	Rivaben	Nicolás	Argentina
109	Rodriguez Imazio	Paola	Argentina
110	Roff	Greg	Australia
111	Rowe	Penny	USA
112	Rushing	Matt	USA
113	Sato	Kazutoshi	Japan
114	Scardilli	Alvaro	Argentina
115	Schlosser	Elisabeth	Austria
116	Schroeder	Ean	USA
117	Seefeldt	Mark	USA
118	Seo	Wonseok	South Korea
119	Shields	Christine	USA
120	Simms	Mairi	UK
121	Smith	Inga	New Zealand
122	Smith	Patrick	USA
123	Snarski	Joseph	USA
124	Snyder	Hannah	USA
125	Spago	Sofia	Argentina
126	Sutherland	Dave	USA
127	Suzuki	Kazue	Japan
128	Torres	Christian	Brazil
129	Towseef	Syed	India
130	Uotila	Petteri	Finland
131	Vichi	Marcello	South Africa
132	Vignon	Étienne	France
133	Vitale	Vito	Italy
134	Wang	Sheng-Hung	USA
135	Welhouse	Lee	USA
136	Wille	Jonathan	France
137	Yu	Yining	China
138	Zou	Xun	USA
139	Zwoliński	Zbigniew	Poland

Credit: Meteo-France

SIXTH YOPP-SH MEETING (VIRTUAL)

June 24 -25, 2021

Hosted by Polar Meteorology Group and Byrd Polar and Climate Research Center, The Ohio State University

SCOPE

- Review the scientific results from the Summer Special Observing Period in the 2018 – 2019 austral summer
- Discuss plans for the winter Target Observing Periods in 2022

COMMITTEE

David H. Bromwich
Kirstin Werner

YOPP-SH Meeting Agenda
[A]: abstract is available, [E]: extended abstract is available

Day 1: Thursday June 24, Session 1
11:00-14:10 EDT / 15:00 – 18:10 UTC

Chair: David Bromwich

Summer YOPP-SH SOP

11:00 – 11:10	**Welcome and Introduction** David Bromwich Byrd Polar and Climate Research Center
11:10 – 11:25	**Update from the YOPP International Coordination Office for Polar Prediction**[A] Kirstin Werner Alfred Wegener Institute Helmholtz Center for Polar and Marine Research, Bremerhaven, Germany
11:25 – 11:40	**Four seasons of forecasting summer Antarctic sea ice: lessons learned from the SIPN South project**[A] François Massonnet Université catholique de Louvain (UCLouvain)
11: 40 – 11:55	**Seasonality of sea ice and snow properties from autonomous ice-tethered platforms in the Weddell Sea, Antarctica**[A] Stefanie Arndt Alfred Wegener Institute Helmholtz Center for Polar and Marine Research, Bremerhaven, Germany
11:55 – 12:10	**OSE during YOPP-SH with ARPEGE-SH 4DVAR** Eric Bazile Météo-France/CNRS, France
12:10 – 12:25	**Data denial experiments for the YOPP-SH summer SOP using AMPS-Polar WRF**[A] David Bromwich Byrd Polar and Climate Research Center, The Ohio State University, USA
12:25 – 12:30	**Break**
12:30 – 12:45	**Targeted measurements and numerical modelling of atmospheric rivers at the Antarctic Peninsula during the summer YOPP-SH special observing period: impacts on clouds and precipitation**[A] Irina Gorodetskaya University of Aveiro, Portugal

12:45 – 13:00 **Analysis of the 16 Feb 2016 windstorm on South Shetland Islands and assessment of the short-range predictability of the event**[A]
Sergi González
AEMET, Spain

13:00 – 13:15 **Supercooled Liquid Water Cloud remotely observed and analyzed above Dome C, Antarctica and future in situ observations**[A]
Ricaud Philippe
CNRM, France

13:15 – 13:30 **Evaluation of the Present Antarctic Weather Station Network in Monitoring the Intra-seasonal to Decadal Climate Variability**[A]
Xichen Li
Institute of Atmospheric Physics, Chinese Academy of Sciences, China

Winter SOP

13:30 – 13:40 **South African plans for the winter SOP in 2022**[A]
Tamaryn Morris
South African Weather Service

End of the Session 1

Day 1: Thursday June 24, Session 2
17:00-19:00 EDT / 21:00-23:00 UTC

Chair: Jordan Powers

17:00 – 17:15 **What we have learned so far: Stakeholder interactions and needs**[A]
Daniela Liggett
University of Canterbury, New Zealand

Topic: Winter SOP (continued)

17:15 – 17:25 **Australian plans for the winter SOP in 2022**[A]
Phillip Reid
Australian Bureau of Meteorology

17:25 – 17:35 **Japanese plan of observation and research for the TOPs of YOPP-SH in 2022**[A]
Naohiko Hirasawa
National Institute of Polar Research, Japan

17:35 – 17:45 **New Zealand plans for the winter SOP in 2022**
Adrian McDonald
Director Gateway Antarctica/ Professor School of Physical and Chemical Sciences
University of Canterbury, New Zealand

17:45 – 17:55 **Korean Contribution to YOPP-SH Winter TOP**[A]
Sang-Jong Park
Korea Polar Research Institute

17:55 – 18:10 **YOPP-SH US Plans - Coordination**
Jordan Powers, Matthew Lazzara, Art Cayette, David Bromwich
National Center for Atmospheric Research
Madison Area Technical College and University of Wisconsin-Madison
Naval Information Warfare Center (NIWC)
Byrd Polar and Climate Research Center, The Ohio State University

18:20 – 18:30 **Weather Decisions: Social Science Project for YOPP-SH Winter TOP-1**[A]
Victoria Heinrich
University of Tasmania, Australia

18:20 – 18:30 **Break**

Discussion of Forecasting Team for Greater Ross Sea and East Antarctica

Host: David Bromwich

18:30 – 19:00 **Open Discussion**

End of the Session 2
End of the Day 1

Day 2: Friday June 25, Session 1
11:00-13:35 EDT / 15:00-17:35 UTC

Chair: Kirstin Werner

Winter SOP (continued)

11:00 – 11:10 **Introduction**
David Bromwich
Byrd Polar and Climate Research Center

11:10 – 11:20 **Atmospheric rivers and their impacts on clouds, precipitation and melt: the Portuguese contribution to YOPP targeted observing periods during austral winter 2022 with radiosonde profiling and precipitation radar**[A][E]
Irina Gorodetskaya
University of Aveiro, Portugal

11:20 – 11:30 **The Chilean contribution to YOPP Targeted Observing Periods (TOPS) during Austral winter 2022**[E]
Raul Cordero
Universidad de Santiago, Chile

11:30 – 11:40 **British Antarctic Survey Activities during the SH winter SOP**[A]
Tom Lachlan-Cope
British Antarctic Survey, UK

11:40 – 11:55 **Italian contribution to YOPP-SH winter 2022 special observing period**[A]
Vito Vitale
CNRM, Italy

11:55 – 12:05 **French Contributions to Winter-SOP**
Eric Bazile
Meteo France, France

12:05 – 12:10 **Break**

Discussion of Forecast Sensitivity to Observations Experiments for Winter TOPs

Host: David Bromwich and Eric Bazile

12:10 – 12:40 **Open Discussion**

12:40 – 12:50 **Planned activity for YOPP-SH winter SOP on the Ukrainian Antarctic Station Akademik Vernadsky**[A]
Svitlana Krakovska
NASC, Ukraine

Poster Session

12:50 – 12:55 **Study of the variability of temperature and ozone in the lower-middle stratosphere of the Antarctic Peninsula in disturbed Dst periods**[A]
Adriana Maria Gulisano
IAA/DNA, IAFE (UBA-CONICET), DF FCEyN UBA, Argentina

Discussion of Forecasting Team for the Greater Antarctic Peninsula

Host: Irina Gorodetskaya

12:55 – 13:05 **Forecasting team and measurement planning of targeted observing periods at the Greater Antarctic Peninsula region during the winter YOPP-SH 2022**[A]
Irina Gorodetskaya
University of Aveiro, Portugal

13:05 – 13:35 **Open Discussion on the Greater Antarctic Peninsula**

End of the TOPP-SH Meeting

End of the Conference

Update from the YOPP International Coordination Office for Polar Prediction (ICO)

Kirstin Werner

WMO WWRP PPP International Coordination Office
Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research

The Polar Prediction Project (PPP) initiated by the World Meteorological Organization's (WMO) World Weather Research Programme (WWRP) has moved into its Consolidation Phase (2019–2022). While the YOPP in the Southern Hemisphere community continues to be active until 2024, there are several activities currently ongoing in view of finalizing the ten-year project by end of December 2022. These include the organization of the YOPP Final Summit (1–4 May 2022, Montreal, Canada), the planning of the YOPP Final Summit School and Fellowship programme (aligned to YOPP Final Summit), and the evaluation of the project's success.

Four seasons of forecasting summer Antarctic sea ice: lessons learned from the SIPN South project

François Massonnet[1], Jan Lieser[2], Phil Reid[3], John Fyfe[4], Cecilia Bitz[5], Will Hobbs[6]

[1]Georges Lemaître Centre for Earth and Climate Research, Earth and Life Institute, Université catholique de Louvain, Louvain-la-Neuve, Belgium
[2]Antarctic Climate & Ecosystems CRC, Hobart, Australia
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[5]Department of Atmospheric Sciences, University of Washington, Seattle WA, U.S.A.
[6]University of Tasmania, Hobart, Australia

The SIPN South project (https://fmassonn.github.io/sipnsouth.github.io/) is an international, coordinated initiative endorsed by the Year Of Polar Prediction (YOPP), that aims at identifying the skill of current seasonal predictions of sea ice around Antarctica. Here, we review and analyze four sets of retrospective forecasts of summer sea ice conducted by 20 groups since 2017. We evaluate the ability of the forecasts to reproduce observed sea ice area at the circumpolar and regional levels, as well as in predicting the timing of sea ice retreat. We find that a substantial spread exists already at day one in the forecasts. We also find that the forecasts based on statistical modeling perform generally better than forecasts based on dynamical modeling. We also present plans for a coordinated forecast in autumn 2022 aligned with the next Southern Ocean Targeted Observing Period.

Seasonality of sea ice and snow properties from autonomous ice-tethered platforms in the Weddell Sea, Antarctica

Stefanie Arndt[1], Leonard Rossmann[1], Louisa von Hülsen[1], Mario Hoppmann[1], Marcel Nicolaus[1]

[1] Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, 27570 Bremerhaven, Germany

Studying seasonally varying snow and sea ice properties in the ice-covered oceans is a key element for investigations of processes between atmosphere, sea ice, and ocean. A dominant characteristic of Antarctic sea ice is the year-round snow cover, which substantially impacts the sea ice energy and mass budgets, e.g., by preventing surface melt in summer, and by amplifying sea ice growth through extensive snow ice formation. However, substantial observational gaps in the seasonal cycle of the Antarctic pack ice and its snow cover lead to a limited understanding of important processes in the ice-covered Southern Ocean.
Here, we introduce a unique observational dataset comprised of a number of critical parameters relevant to sea ice and its snow cover, recorded by a suite of snow and ice mass balance buoys (IMBs) deployed in the Weddell Sea between 2013 and 2021.
Using snow buoy data, we infer a year-round, mainly event-driven snow accumulation of up to 90cm on the Weddell Sea pack ice, which only melts during the summer months after drifting into the marginal ice zone. Vertical temperature profiles from co-deployed IMBs are used to validate these findings, and to calculate energy budgets across the atmosphere-ocean boundary. From these calculations, we get highest monthly sea-ice growth rates of about 10cm in May, while sea ice melt is most dominant in the marginal ice zone with a monthly rate of about 50cm in December.

Data denial experiments for the YOPP-SH summer SOP using AMPS-Polar WRF

David H. Bromwich[1,2], Jordan G. Powers[3], Kevin W. Manning[3], and Xun Zou[1]

[1]Polar Meteorology Group, Byrd Polar and Climate Research Center, The Ohio State University, Columbus, Ohio, USA
[2]Atmospheric Sciences Program, Department of Geography, The Ohio State University, Columbus, Ohio, USA
[3]Mesoscale and Microscale Meteorology Laboratory, National Center for Atmospheric Research, Boulder, Colorado, USA

Cycling assimilation and forecast experiments using the Antarctic Mesoscale Prediction System (AMPS) framework and employing the Polar WRF model are presented for the YOPP-SH summer special observing period. Cycling assimilation with Hybrid Ensemble 3DVAR on the Southern Ocean (24 km) and Antarctic (8 km) AMPS grids starts from the GFS analysis and then is cycled at 6-hour intervals for three days using all observations including satellite radiances (called SOP) and using the same observations but excluding (denying) the additional soundings collected during the SOP (called NoSOP). The subsequent 72-hour forecasts for 3 study periods (November 15-December 7, 2018; January 1-17, 2019; February 1-17, 2019) starting at 00UTC each day are compared with surface weather observations, radiosonde measurements, and the ERA5 global reanalysis to assess the forecast impact of the additional radiosonde releases.

The SOP forecasts show better near-surface temperature and wind speed forecasts over Antarctica than NoSOP primarily over West Antarctica. Similarly, the radiosonde profiles confirm the better temperature and wind speed forecasts throughout the troposphere but with variable results for relative humidity. A broader evaluation against ERA5 reveals the improved forecast skill for SOP versus NoSOP persists out to 72 hours for temperature, wind speed and relative humidity but is primarily confined to the Antarctic vicinity, consistent with the additional radiosonde spatial coverage. Enhanced relative humidity forecast skill is greater at lower latitudes later in the forecast than for the other two variables.

Targeted measurements and numerical modelling of atmospheric rivers at the Antarctic Peninsula during the summer YOPP-SH special observing period: impacts on clouds and precipitation

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Atmospheric rivers (ARs) are elongated narrow corridors of intense moisture transport forming in subtropical and mid-latitude regions and associated with extra-tropical cyclones. Poleward-directed ARs reaching Antarctica can cause both extreme precipitation and major melt events. We use observations available during the Year of Polar Prediction (YOPP) special observing period in austral summer 2018-2019 to explore the double role of ARs, as carriers of both heat and moisture, in their impacts on cloud radiative forcing and precipitation (rain and snow) at the Antarctic Peninsula (AP). Measurements from several stations are combined using YOPP and regular observations: at Escudero and King Sejong stations located on King George Island and Vernadsky station in the western AP. The selected ARs passed first over the southern South America, and we use observations conducted at Punta Arenas to track their evolutions. We present case studies characterizing the temporal evolution of the ARs, focusing on thermodynamic and dynamic conditions accompanying the transition between snowfall and rain, using radiosonde measurements and ground-based remotely sensed measurements of water vapor, clouds and precipitation. We demonstrate the added value of assimilating more frequent radiosonde observations in improving weather forecasts during ARs, using the Polar-WRF model. In addition, we evaluate representation of precipitation phase transition in Polar-WRF simulations and ERA5 reanalysis.

Analysis of the 16 Feb 2016 windstorm on South Shetland Islands and assessment of the short-range predictability of the event

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Despite the improvement of the atmospheric models, weather forecasting in the Antarctic Peninsula is still a scientific and technologic challenge. Therefore, it is important to assess the ability to forecast highimpact events. This communication presents the analysis of a large cyclone that caused a great impact on the Spanish station Juan Carlos I. We also assess the short-range predictability of this event. On 14-16 Feb 2016, a cyclone deepened from the southeastern Pacific to the Antarctic Peninsula, crossing over the South Shetland Islands. The presence of a jet stream produced a strong warm advection, which contributed to an explosive development of the cyclone. The cyclone produced a strong windstorm in the vicinity of the South Shetland Islands. At the Juan Carlos I station, located on Livingston Island west of the Tangra Mountains (maximum elevation 1700 m), the wind was reinforced downslope of the mountain, producing a maximum speed of 138 km/h that caused severe damage to the station. We have conducted a prospecting analysis of the short-range predictability of this event using a subset of the convection-permitting ensemble prediction system AEMET-γSREPS with four different regional mesoscale models. As main result related to the predictability it has been found that the four models grouped into two different cyclone paths with 6 different consequences on Juan Carlos I station. This implies a low short-range predictability in a high-impact event.

Supercooled Liquid Water Cloud remotely observed and analyzed above Dome C, Antarctica and future in situ observations

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A comprehensive analysis of the water budget over the Dome C (Concordia, Antarctica) station has been performed during the summer 2018-2019 as part of the YOPP international campaign. Thin (~100-m deep) supercooled liquid water (SLW) clouds have been detected and analyzed using remotely sensed observations, at the station (LIDAR, microwave radiometer HAMSTRAD, net surface radiation from BSRN, radiosondes) and on satellite (CALIOP LIDAR) combined with a specific configuration of the NWP model ARPEGE-SH. Two case studies are presented. On 24 December 2018, the atmospheric planetary boundary layer (PBL) evolved following a typical diurnal variation, with the SLW clouds observed at the top of the PBL. The second case study takes place on 20 December 2018, when a warm and wet episode impacted the PBL with no clear diurnal cycle of the PBL top. The amount of liquid water measured by HAMSTRAD was ~20 times greater in this perturbed PBL than in the typical PBL. In both cases, ARPEGE-SH was not able to accurately reproduce these SLW clouds. The discrepancy between the observed and calculated net surface radiation was reaching +50 W m^{-2}. The model was then run with a new liquid water partition function and was able to generate SLW clouds on 24 December 2018. In the near future, in situ observations of SLW clouds will be performed by means of SLW probes attached to meteorological radiosondes (summer 2021-2022) and aboard a light remotely-piloted aircraft system (summer 2022-2023).

Evaluation of the Present Antarctic Weather Station Network in Monitoring the Intra-seasonal to Decadal Climate Variability

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In recent decades, hundreds of weather stations and automatic weather stations were set up over the Antarctic, which provides great potential in improving the quality of the measurement of climate variabilities on intra-seasonal to decadal time scales, and may largely improve the weather prediction skill around Antarctica. However, it is seen that the present Antarctic atmospheric reanalysis and observational datasets still suffer from large uncertainty, partially due to the limited usage of the weather station observations in producing these reanalysis datasets. On the other hand, the sites selection of the present weather stations network highly depends on the logistic issues, as a result, the observation in may stations are not persistent. It is thus very necessary to evaluate the present Antarctic observational network. In this study, an Ensemble Kalman Filter-based method are used to evaluate the present weather station and automatic station network in monitoring the intra-seasonal to decadal variabilities around Antarctica. In particular, we focus on the ability of the present network in observing the surface temperature and sea level pressure around Antarctica on different time scales. Results show that a sub-set of present networks with about 100 stations will be good in constraining the uncertainties in the observational dataset, while several new stations over Central Eastern Antarctica and the coastal region of the West Antarctic will help to further improve the quality of the observations.

South Africa's plans for YOPP 2022

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The South African Weather Service (SAWS) maintains upper-air stations on two sub-Antarctic bases; Marion and Gough Island, the latter of which is leased from the United Kingdom. In addition, SAWS undertakes upper air ascents from its state-of-the-art ice-breaker, the S.A. Agulhas II. Provisional plans for the Year of Polar Prediction (YOPP) work for South Africa will focus primarily on upper air ascents from the vessel, given the location further north of the sub-Antarctic bases to be of relevance. The vessel does take-over voyages to Antarctica from December to January each year, and when possible, research cruises to the sea-ice edge during winter months, given the current global pandemic. In addition, the vessel managers are provisional in discussions for a charter cruise to the Weddell Sea, whereby if allowed, additional upper-air ascents could be undertaken to provide critical information from this region.

What we have learned so far: Stakeholder interactions and needs

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This presentation will summarise the Polar Prediction Project's Societal and Economic Research and Applications Task Team's (PPP-SERA) lessons learnt from engagement with stakeholders who utilise polar weather, water, ice and climate (WWIC) information in support of their operations. Fisheries, tourism and government stakeholders as well as indigenous community members in the Arctic shared their perspectives with WWIC information and environmental forecasts in a series of PPP-SERA Open Sessions and a range of research projects involving PPP-SERA members over the last five years. The wealth of qualitative data obtained that way hints at the value of experience in WWIC-related decision-making and identifies that 'one size' does not fit all as forecasting is concerned. A rigid dichotomy between users and producers of WWIC information no longer exists. Continued technological advancement has resulted in a diverse landscape of environmental forecasting products requiring different skills to derive meaningful and task-suited information, which in turn affects the perceived and actual risks associated with operational decision-making.

Australia's contribution to YOPP-SH TOPs

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Abstract

Relevant Australian Antarctic organisations are very pleased to be able to contribute to the YOPP-SH TOPs in 2022. Both the Australian Bureau of Meteorology (BoM) and the Australian Antarctic Division (AAD) have provided letters of support for this initiative, and while all contributions are subject to operational constraints the following provides a brief outline of the motivation and intended involvement.

Australia's involvement in the YOPP-SH TOPs is motivated by the project's national and international collaborative efforts that:

- Aid in objectively understanding the value of high-latitude observations,
- Promote model improvements over the high-southern latitudes,
- Help understand large-scale precipitation regimes,
- Promote the understanding of the value and use of forecast and observation systems,
- Develop a greater understanding of user and stakeholder needs, and
- Collaborate with the international scientific community.

Intended involvement in this project is multi-faceted. The BoM intends to provide extra radiosonde launches across Casey, Davis, Mawson and Macquarie Island, along with numerical weather prediction analysis and verification. BoM's Antarctic forecast team are keen to contribute to the identification of TOPs, assist in case studies and model analysis, along with the examination of operational impacts of events on future aviation services. The AAD is intending to install at Davis a suite of instruments relevant to this project, with data from these instruments being made availablefor model verification and event analysis. Finally, Victoria Heinrich is involved in the PPP-SERA task team, examining the decision-making processes involved in the TOPs functioning.

Japanese plan of observation and research for the TOPs of YOPP-SH in 2022

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We are preparing for observation and research toward the TOPs of YOPP-SH in 2022. At present, we don't have a complete plan for international collaboration yet, but here I would like to talk about planned observations and expected researches. At Syowa Station, we regularly carry out radiosonde observations twice a day, and it is expected that we can add about 40 to 60 observations to this. In particular, we will respond to TOPs requests. Syowa Station has started operating the X-band (9.4 GHz) precipitation radar from this year. The goal of this observation is to describe the precipitation system during strong winds such as Blizzard, and to evaluate the precipitation throughout the year. Using the data during the TOPs, the archived data of AMPS, and the numerical model by WRF etc. that we will carry out, we will study about impact on the forecast of the increase in radiosonde observations and the impact on the description of the precipitation system at Syowa Station. This part still needs to be concrete in the future. We have recently installed four new AWSs on the ice sheet. The snow surface level is observed using an ultrasonic snow depth sensor. We will investigate the impact on the snow surface level during this TOPs as well.

Korean Contribution to YOPP-SH Winter TOP

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Abstract

Korea Polar Research Institute, South Korea (KOPRI) is running two Antarctic stations: the King Sejong Station (KSJ) on King George Island near the Antarctic Peninsula and the Jang Bogo Station(JBG) in Terra Nova Bay, Victoria Land.
At the King Sejong Station, radiosonde launches are planned during winter TOP in 2022. Total 70 to 90 launches will be available to meet requirements during the winter TOP. And for the winter TOP, 18UTC (3pm at the KSJ) seems most feasible, because overwintering member shall take the role while doing his own works. But we are open to discussion about the launch time if necessary. As an extra parameter, a visibility sensor is planned to be installed in February 2022.

Besides, about 100-radiosonde observation is planned at the Jang Bogo Station, Terra Nova Bay (74°37'S, 164°14'E) in 2022. They are grouped into three; the first group for stratospheric ozone (mid-August to November), the second for YOPP-SH TOP (Midwinter), and the last for super-cooled liquid water in the atmosphere. The last one is planned to be performed in coordination with Dome-C (year-round) and Mario Zucchelli Stations (summer) observations, which is under discussion with Italian CNR-ISP.

ACKNOWLEDGEMENTS
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Weather Decisions Social Science Project for YOPP-SH Winter TOP-1

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As part of the PPP Societal and Economic Research and Applications (SERA) task team I (Vicki Heinrich) am interested in working with the forecasters and researchers during the SH winter TOP on a social science project that runs in tandem with the TOP. This is a unique opportunity to examine weather decision-making, information use, and outcomes across an international research program and multiple stakeholders. We aim to examine the forecast and research teams' go/ no go decisions to release additional radiosondes, or not, for each TOP weather event. The methods proposed are based on Cognitive Task Analysis from Naturalistic Decision Making (NDM) theory which seeks to understand how people make decisions in applied or 'real world' situations, like a forecasting office, instead of 'artificial' laboratory settings (Klein 2008). This project is in development and your participation, suggestions and feedback are welcome - what would you like to know from this research?

Ethics approval: Sought through the UTAS Human Research Ethics Committee.

Record keeping during the TOP: At each event/ decision time, record sources of information, steps taken, forecast advice, consensus on decisions, and individual confidence in the final decision (0-100%). This will be guided by the forecast teams' strategy and protocols.

Time commitment: Additional record keeping and questionnaire responses would be expected to take 10 - 15 minutes per decision/ weather event. If used, workshops, interviews, or focus groups may take 1-2 hours.

Outcomes: Empirical evidence to assess the quality of the decisions during the TOP, data collection outcomes, and success of the TOP project. To quantify achievements and outcomes this may include a summary of the decisions made, information sources, and procedures used, comparisons of goals before and after the TOP, verification, confidence, and retrospectively examining if decisions were good or poor in terms of the TOP goals and forecasted versus actual weather event.

This project will lead to greater understanding of Antarctic weather forecasting, information use, and decision-making, and more broadly contribute to research on decisions made under uncertainty and forecaster cognition.

Atmospheric rivers and their impacts on clouds, precipitation and melt: the Portuguese contribution to YOPP targeted observing periods during austral winter 2022

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Antarctic ice sheet melt is one of the main contributors to sea level rise. The western and northern regions of the Antarctic Peninsula have been a hotspot of the Antarctic climate change with both strong increase in surface mass balance (driven by precipitation) and significant near-surface air warming trends and records. Among important controlling factors of both precipitation and surface melt are warm/moist air intrusions, particularly those associated with atmospheric rivers, which bring extra heat and moisture from subtropical latitudes. They are typically linked with liquid-containing clouds, which during austral winter cause strong warming of the surface, and also can cause intense snowfall as well as rainfall. We will conduct measurements at the Chilean station Escudero located on King George Island, including frequent radiosonde profiling together with cloud liquid water content sensors during warm air intrusions associated with long range moisture transport (atmospheric rivers) and local moisture convergence. Precipitation sampling will be done for for stable isotope analysis. These will be combined with precipitation radar measurements by means of the vertically pointing 24GHz micro-rain radar. The measurements will conducted as part of the Portuguese Polar Program projects in collaboration will Chilean and French projects and will start in January 2022 and continue through the winter YOPP-SH special observing period from April to mid-July 2022.

ATMOSPHERIC RIVERS AND THEIR IMPACTS ON CLOUDS, PRECIPITATION AND MELT: THE PORTUGUESE CONTRIBUTION TO YOPP TARGETED OBSERVING PERIODS DURING AUSTRAL WINTER 2022

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1. ABSTRACT

Antarctic ice sheet melt is one of the main contributors to sea level rise. The western and northern regions of the Antarctic Peninsula have been a hotspot of Antarctic climate change with strong precipitation-driven increases in surface mass balance, significant near-surface warming trends, and record temperatures. Among important controlling factors of both precipitation and surface melt are warm/moist air intrusions, particularly those associated with atmospheric rivers, which bring extra heat and moisture from subtropical latitudes. They are typically linked with liquid-containing clouds, which during austral winter cause strong warming of the surface, and also can cause intense snowfall as well as rainfall.

Measurements will be conducted by our team at the Chilean station Escudero, located on King George Island, including frequent radiosonde profiling together with cloud liquid water content sensor measurements during warm air intrusions associated with long range moisture transport (atmospheric rivers) and local moisture convergence. Precipitation sampling will be done for stable isotope analysis. These will be combined with precipitation radar measurements by means of a vertically pointing 24 GHz micro-rain radar. The measurements will be conducted as part of the Portuguese Polar Program projects in collaboration with Chilean and French projects and will start in January 2022 and continue through the winter YOPP-SH special observing period from April to mid-July 2022.

2. FIELD CAMPAIGN

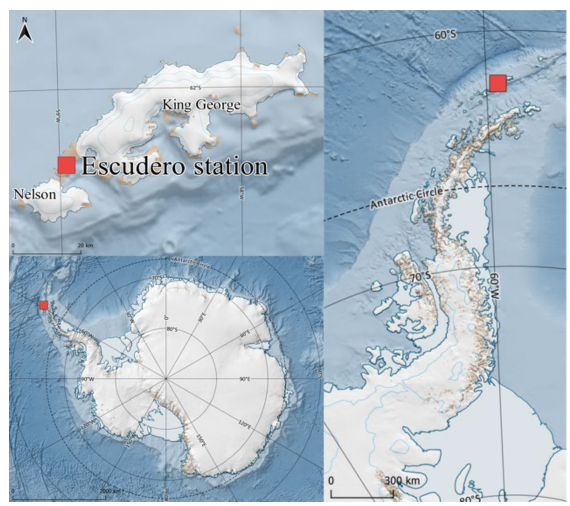

Figure 1. The red square indicates the location of Escudero station on King George Island, just north of the Antarctic Peninsula.

The field campaign will take place at the Chilean Antarctic base Escudero (62°S; 59°W), located on King George Island, north of the Antarctic Peninsula (AP; see Figure 1), starting in January 2022 with preparing for the YOPP-SH targeted observing periods

(TOPs) in Antarctica. The measurements will be made out during Austral winter 2022 (April-July 2022).

2.1 Measurements

Radiosondes: Radiosonde launches at high temporal resolution (every 1-3 hours) will be done to characterize warm air intrusions associated with extra-tropical cyclones, with a special focus on those associated with atmospheric rivers (ARs) and those with primarily local moisture sources. A number of radiosondes will be equipped with cloud supercooled liquid water content (SLWC) sensors (www.anasphere.com/ slwc.html; see Figure 2). These extra radiosondes will be launched during TOPs in addition to regular radiosondes launched from Escudero and King Sejong stations at 00 UTC and 12 UTC, respectively, by Chilean and Korean Antarctic Programs. Extra radiosonde measurements will be submitted along with regular radiosondes to the WMO Global Telecommunication System (GTS).

Figure 2: Launch of a radiosonde together with SLWC sensor during the Antarctic Circumnavigation Expedition. © Irina Gorodetskaya.

Micro rain radar (MRR): Profiles of precipitation will be characterized using a vertically-pointing K-band (24 GHz) MRR (Figure 3). This instrument is a robust low-energy consumption device, which requires minimum maintenance during field operations, ideal for Antarctic missions (Gorodetskaya et al 2015; Grazioli et al 2017; Durán-Alarcón et al., 2019) and will be installed at Escudero station providing continuous measurements of precipitation vertical profiles with a vertical resolution of 100 m and 1-minute temporal resolution from 300 m to 3 km above ground level.

Figure 3. Micro rain radar (MRR) that will be deployed at Escudero station. Photo shows the same MRR model installed at Dumont d'Urville Antarctic station (France) during an APRES3 campaign in February 2017. ©Claudio Durán-Alarcón.

MRR measurements are used to monitor solid and liquid precipitation using radar reflectivity, vertical velocity and spectral width of precipitating hydrometeors, among other Doppler spectral moments. The drop-size distribution of liquid particles is obtained using an idealized relationship between size and fall velocity and is used to estimate rainfall rates, liquid water content, and the path-integrated attenuation (Peters et al., 2005). For snow, empirical relationships between reflectivity and snowfall rate are often used due to the large uncertainty of velocity-size relationships depending on the solid particle type (Maahn and Kollias, 2012). MRR profiles have also been a useful tool for monitoring melting layer height (Brast and Markmann, 2019) and recently Garcia-Benadi et al., (2020) have proposed an algorithm for the discrimination of the precipitation phase.

Precipitation sampling: Snowfall and rainfall samples will be collected for further laboratory analysis of their stable isotope composition, which will be used to constrain the moisture source and pathways information. These observations will be analyzed together with back trajectories using the methodologies as described by Terpstra et al (2021) and Thurnherr et al. (2021).

2.2 Atmospheric river forecast

The Antarctic Mesoscale Prediction System (AMPS, http://www2.mmm.ucar.edu/rt/amps/), based on the Polar Weather Research and Forecasting (Polar-WRF) model, will be used for forecasting AR events and planning additional radiosonde measurements. Events of interest will also be identified using the global forecasting system (GFS) produced by the National Centers for Environmental Prediction (NCEP) and the Integrated Forecasting System (IFS) produced by the the European Centre for Medium-Range Weather Forecasts (ECMWF). These will allow identification of AR and non-AR events, in order to decide the timing of the TOPs and the frequent radiosonde launches, to ensure conditions are captured before, during and after the AR passage. The events will be also tracked using the IWV maps from microwave satellite products.

Forecast-measurement protocols will be established prior to the field campaign and tested during the summer period, which will be used during the YOPP-SH winter TOPs.

3. EXPECTED RESULTS

The observations conducted by our team at Escudero station will contribute advanced measurements of cloud and precipitation properties, as well as analysis of changes that occur during ARs, particularly those that lead to warming during winter (such as increases in the cloud LWC or cloud base height temperature). This work is crucial to improving our understanding of the impact of clouds and ARs on the Antarctic climate system.

Radiosonde observations will provide unique information on the distribution of the LWC in the troposphere, associated with ARs and other warm-air intrusion events. Characterization of clouds together with precipitation radar measurements and weather observations will provide detailed information for analyzing the impact of mixed-phase clouds on precipitation and surface radiative balance.

The radiosonde data will also be used for evaluating the ability of reanalysis products (e.g. ERA5 and MERRA-2) to reproduce strong moisture inversions and low-level jets, typically associated with ARs, as well as the Integrated Water Vapor (IWV) and integrated vapor transport (IVT).

Precipitation measurements with the MRR will be used to analyze changes in precipitation intensity and phase transition (identifying melting layer height in the vertical profile and characterizing snowfall to rainfall transition at the ground) and to derive snowfall and rainfall intensity at the ground. This will be the first MRR installation at the South Shetland Islands.

Stable isotope analysis of precipitation samples will provide insights into the role of long-range moisture sources on cloud microphysics and precipitation.

Further, the Polar-WRF model will be evaluated using radiosonde and precipitation measurements with particular focus on the cloud-precipitation microphysical scheme. Predictability of intense precipitation events will be assessed. This evaluation is expected to lead to suggestions for cloud-precipitation scheme modifications based on the measurements that will be communicated to the Polar-WRF development group at Ohio State University (http://polarmet.osu.edu/PWRF/) .

4. ACKNOWLEDGMENT

Field activities will be supported by two Portuguese Polar Program projects: “Antarctic Peninsula precipitation and surface Mass balance: what is the role of Atmospheric Rivers?” (APMAR) and “Towards a better Understanding of the Link between cloud microphysics and precipitation during warm air Intrusions north of the Antarctic Peninsula” (TULIP) with additional instrument support of the French ARCA-ANR project (PI Vincent Favier), IGE/APRES3 project (PI Christophe Genthon), projects by USACH team (PI Raul Cordero), and instruments installed via the YOPP-SH endorsed project CAALC (PI Penny Rowe). We thank INACH and PROPOLAR for the field logistics support.

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ATMOSPHERIC PROFILING, GROUND-BASED MEASUREMENTS AND FORECASTING MODELING: THE CHILEAN CONTRIBUTION TO YOPP TARGETED OBSERVING PERIODS (TOPS) DURING AUSTRAL WINTER 2022

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1. OVERVIEW

The YOPP-SH Special Observing Period (SOP) during 2018/19 showed that an increased frequency of observations in Antarctica and the Southern Ocean improve predictive skills on forecasts of major cyclones around Antarctica. A second SOP during the late fall and early winter in 2022 will allow us to test the flow-dependent impact of additional observations on the characterization of intense Southern Ocean cyclones and associated atmospheric rivers.

Given our strong interest in conducting Antarctic fieldwork outside austral summer, we will contribute to YOPP-SH SOP-2022 by launching radiosondes for atmospheric profiling and conducting atmospheric radiation measurements on King George Island (at the northern tip of the Antarctic Peninsula). In addition, the Polar Weather Research and Forecasting model (PWRF) over the Antarctic Peninsula region will be run by the Chilean Weather Service (Dirección Meteorológica de Chile, DMC).

The Chilean contribution to YOPP-SH SOP-2022 during Austral Winter 2022 will be provided in the frame of the project "Atmospheric Radiation Measurements on King George Island (Southern Ocean / Antarctic Peninsula)" funded by the Chilean Antarctic Institute (INACH) and Chilean Science Foundation (ANID).

Figure 1. Radiosoundings launching and ground-based measurements will be carried out at our facilities at the Chilean Escudero Station King George Island (62°S).

2. FIELD EXPERIMENTS AND MODELING FOR YOPP

Our field experiments will begin in late 2021 or early 2022 and will extend until the end of the YOPP-SH SOP-2022 in the late fall and early winter in 2022. They will include the following measurements:

1) Balloon-borne radiosoundings will measure atmospheric pressure, temperature, humidity and winds up to 20 km a.s.l. We are committed to launching up 100 radiosondes. Launchings will be coordinated with the Korean station on King George Island, King Sejong, with a focus on the SOP. Radiosonde measurements will be submitted to the WMO Global Telecommunication System (GTS);

2) Measurements of the downwelling and upwelling shortwave and longwave radiation, and other surface fluxes by using both broadband and spectral instruments (including a double monochromator-based shortwave spectroradiometer);

3) Atmospheric mapping profiles by a Micro-Pulse Lidar (MiniMPL) affiliated with NASA´s MPLNET Network. These measurements will allow detecting tropospheric clouds and aerosols, assessing the type of clouds (altitude, geometric thickness and phase);

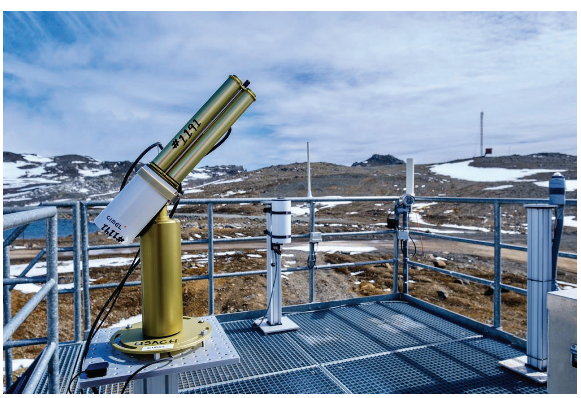

Figure 2. Sun Photometer and additional radiometric instrumentation at our facilities at Escudero Station on King George Island.

4) Measurements of the aerosol optical depth (AOD) by using a multi-channel CIMEL sun photometer affiliated to NASA's AERONET Network.

Regarding the modeling efforts during the SOP-2022:

5) the DMC will run the PWRF model over the Antarctic Peninsula region with the outer domain at 25-km horizontal resolution. The nested inner simulations will be run at 5- and 1-km resolution, focusing on King George Island. Forecast simulations at 00, 24, 48, 72, and 96 hours will be validated against surface observations and in-situ balloon-borne radiosonde measurements.

3. CURRENT ACTIVITIES ON KING GEORGE ISLAND

We are currently conducting a 4-year climate-related field campaign (the first of its kind in the northern Antarctic Peninsula) that includes observations committed to the YOPP-SH SOP-2022.

We expect that our activities on King George Island will allow us to assess the site-specific, weather-driven variability of shortwave and longwave radiation in the area (which in turn will facilitate the characterization of the atmospheric and surface energy budget), and to assess low and midlevel cloud properties, paying particular attention to the critical role of supercooled liquid clouds (which have been shown to be related to climate model biases). We also expect that our efforts on King George Island will enable us to characterize the atmospheric state, surface radiation budget, and cloud properties in the region.

The ground-based measurements conducted so far are being used to test satellite products (see for example Sepulveda et al., 2021). In particular, ground-based data will be used to test cloud properties derived from the NASA A-Train satellite sensors MODIS (onboard Aqua satellite), CALIOP (onboard CALIPSO satellite) and AIRS (onboard Aqua satellite) as well as new sensors (e.g. JAXA SGLI onboard GCOM-C). We will also make comparisons to radiation data from the Earth's Radiant Energy System (CERES) Energy Balanced and Filled (EBAF) data products.

Prior field experiments on King George Island included launching dozens of balloon-borne radiosondes as part of our contribution to the prior YOPP Special Observing Period (December 2018 - March 2019). These measurements were also used (in close collaboration with the team led by Irina Gorodetskaya), for characterizing atmospheric river events occurring over King George Island during the SOP (Bromwich et al., 2020).

Figure 3. Radiosonde launching on King George Island (62^{o}S) during the prior YOPP's Special Observing Period" (December 2018 - March 2019).

4. EXPECTATIONS

Our measurements during the SOP-2022 and subsequent analysis will support explorations of Antarctic atmospheric forecasting ability at the beginning of the austral cold season when the southern sea ice cover is rapidly expanding.

In addition, our measurements will provide valuable observations allowing monitoring and characterization of atmospheric river events that make landfall on the Antarctic Peninsula, and of major Southern Ocean cyclones that frequently impact the Antarctic regions in a profound way.

We expect to make progress towards a better understanding of the interplay between the atmosphere, clouds and the surface radiation budget over the Antarctic Peninsula and the Southern Ocean.

5. ACKNOWLEDGEMENTS

The Chilean contribution to YOPP-SH SOP-2022 during Austral Winter 2022 will be provided in the frame of the project “Atmospheric Radiation Measurements on King George Island (Southern Ocean / Antarctic Peninsula)” funded by the Chilean Antarctic Institute (INACH) and Chilean Science Foundation (ANID).

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British Antarctic Survey Activities during the SH winter SOP

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British Antarctic Survey, UK

During the 2021/22 Antarctic season the British Antarctic Survey will deploy new instruments to observe aerosol and cloud at Rothera Station on the Antarctic Peninsula. The new observations made at this site will include the physical and chemical properties of aerosols (including whether they will act as cloud nuclei) and LiDAR measurements of clouds. These measurements will largely be continuous, but it is planned that extra filters will be collected during atmospheric river events. As well as these additional measurements the existing series of surface-based observations and radio sondes will continue with extra radio sondes being flown when requested. As well as the aerosol observations made at Rothera some limited aerosol measurements will be taken at Bird Island during the 2022 winter.

Italian Contribution to the YOPP-SH winter SOP

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The plan disccused at Italian level will be presented. Considering that a better representation of cloudiness conditions and precipitation events (in particular ARs) are key targets of the science plan for YOPP-SH Special Observing Period (SOP) in winter 2022, Italian contribution will focus on improve knowledge on the atmospheric water budget over Antarctica, its seasonal behaviour and vertical distribution, its accurate representation in models. For this purpose, we will connect extra activities during the winter SOP period to a coordinated plan extending from summer 2021 to summer 2022. Our attention will concentrate, in particular, on the role of SLW clouds, also with respect effects on radiation budget, and precipitation events. Extra soundings with standard as well as LWC sondes and connection/upgrade of ongoing and planned ground-based observations related to these topics at the two sites of Dome C and Terra Nova Bay (TNB) will provide new and more integrated datasets, with a focus on SLW clouds.. The possibility to collect observations at a coastal site and an interior site 1000 km away from each other, should allow to evaluate the accuracy of current models at the synoptic scale. At the same time, the plan to improve winter observations and better connect them with already planned summer activities should provide us a unique opportunity to better understand the water budget behaviour along the whole year.

Planned activity for YOPP-SH winter SOP on the Ukrainian Antarctic Station Akademik Vernadsky

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Ukrainian Antarctic station Akademik Vernadsky (UASAV) is situated at the western side of the Antarctic Peninsula and has a good location for study, e.g. orographic enhancement of precipitation, catabatic winds from the continent, sea-ice forming and movement with ocean currents, atmospheric aerosols in pristine environment, etc. In the last few years, meteorological measurements at UASAV were extended and new equipment was installed, e.g. automatic weather station Vaisala PWD-22, radar precipitation sensor Luft WS-100, Micro Rain Radar Pro (MRR-Pro). We plan to start regular radiosounding in early 2022 once per day and will contribute to the YOPP-SH winter Special Observing Period (SOP) by more frequent launching radiosondes. We consider possibility to launch ozone layer sondes once per month when regular Dobson spectrophotometer measurements are stopped due to low sun in winter. We will coordinate our measurements with the international community and freely exchange all data with consortium participants. Our special interest is precipitation phase transition in and under clouds particularly during extreme weather events such as atmospheric rivers. Numerical simulation with Polar WRF and other models suitable for cloud and precipitation formation study are planned to implement as well.

Forecasting team and measurement planning of targeted observing periods at the Greater Antarctic Peninsula region during the winter YOPP-SH 2022

Irina Gorodetskaya and AP forecasting team

The Antarctic Peninsula (AP) region is a hotspot of climate change showing air temperature warming greater than the global average and a significant increase in precipitation. However, there is a significant discrepancy between observations and models in capturing these trends. Operational forecasts also show a rather low predictability skill for the AP and entire Antarctica. Winter YOPP-SH is an international initiative that aims to consolidate efforts of many countries at conducting enhanced observations during several Targeted Observing Periods (TOPs) targeting key atmospheric and oceanic phenomena, including extreme events, in a regional approach. Winter YOPP-SH initiative is challenging and unique as it encompasses a range of scientific interests, while relying on limited resources and personnel during winter. Thus, it requires developing a specific strategy and forecast-measurement protocols, which we propose to establish and test during a dry run in July 2021 to be used during the YOPP-SH winter TOPs in 2022. During the workshop, organization of a dry run for the AP (and in connection with other regions) will be discussed and planned with all interested parties, with a purpose of identifying existing forecasting capabilities aiming at the various phenomena of interest, combining information about measurements (including long-term monitoring and extra radiosondes and other enhanced measurements during TOPs from stations and ships), and ways of communication between the forecast and measurement teams and with other regions.

Study of the variability of temperature and ozone in the lower middle stratosphere at Marambio Station in disturbed Dst periods

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Abstract:

Motivation: Geomagnetic storms are caused by solar and interplanetary events that generatedisturbances in various regions of the terrestrial space environment; these events can last hours or days.

Magnetospheric substorms are episodes of transport and dissipation of energy in the ionosphere and the magnetosphere, in time lapses of the order of 10 minutes to 3 hours, andare much more frequent than geomagnetic storms.

Objective: The aim of this work is to study the variability of temperature and ozone profilesin the lower-middle stratosphere of the Antarctic region during severe Space Weather events. Vertical profiles of these atmospheric parameters are analyzed at the Marambio station, among solar cycles 23 (1998-2008) and 24 (2009-2018).

The data are obtained by ozone-radio soundings, and are provided by the National Meteorological Service of Argentina and the Meteorological Institute of Finland.

YOPP-SH, List of attendees

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1	Alexander	Simon	Australia
2	Almeida da Silva Ferreira	Larissa	Brazil
3	Andersson	Tom	UK
4	Arndt	Stefanie	Germany
5	Bai	Lesheng	USA
6	Baldini	Luca	Italy
7	Bazile	Eric	France
8	Bozkurt	Deniz	Chile
9	Bracci	Alessandro	Italy
10	Bracegirdle	Tom	UK
11	Bromwich	David	USA
12	Carpentier	Scott	Australia
13	Cayette	Arthur	USA
14	Chen	Thomas	USA
15	Chenoli	Sheeba	Malaysia
16	Choi	Yonghan	South Korea
17	Colwell	Steve	UK
18	Cordero	Raul	Chile
19	Dare	Richard	Australia
20	Dattore	Bob	USA
21	Di Natale	Gianluca	Italy
22	Dick	Kirsty	Scotland
23	Ekrami	Negar	Portugal
24	Essary	Falon	USA
25	Favier	Vincent	France
26	González	Sergi	Spain
27	Gorodetskaya	Irina	Portugal
28	Gossart	Alexandra	New Zealand
29	Grazioli	Jacopo	Switzerland
30	Grumbine	Robert	USA
31	Gulisano	Adriana Maria	Argentina
32	Gulli	Paul	USA
33	Guyot	Adrien	Australia
34	Hafner	Jakob	Germany
35	Heil	Petra	Australia
36	Heinemann	Günther	Germany
37	Heinrich	Victoria	Australia
38	Hines	Keith	USA
39	Hirasawa	Naohiko	Japan
40	Hollister	Michelle	Australia
41	Hwang	Hyewon	South Korea
42	Inoue	Jun	Japan
43	Johnson	Cassidy	USA
44	Johnson	Michael	USA
45	Keller	Linda	USA

46	Kim	Seong-Joong	South Korea
47	Kirchgaessner	Amelie	UK
48	Koppanyi	Harry	USA
49	Koudelka	Ethan	USA
50	Krakovska	Svitlana	Ukraine
51	Kristiansen	Jørn	Norway
52	Kuye	Akin	UK
53	Lachlan-Cope	Tom	UK
54	Lazzara	Matthew	USA
55	Li	Xichen	China
56	Liggett	Daniela	New Zealand
57	Liu	Zhengyu	USA
58	Luís	Diogo	Portugal
59	Lynds	Jamie	New Zealand
60	Manning	Kevin	USA
61	Mansilla	Gonzalo	Chile
62	Marin	Julio	Chile
63	Marincovich	Giselle Lujan	USA
64	Massonnet	François	Belgium
65	McDonald	Adrian	New Zealand
66	McFarquhar	Greg	USA
67	Meyer	John	USA
68	Michael	Bob	USA
69	Mikolajczyk	David	USA
70	Milne	Peter	USA
71	Moffat-Griffin	Tracy	UK
72	Morris	Tamaryn	South African
73	Motoyama	Hideaki	Japan
74	Mounier-Vehier	Alice	Portugal
75	Mullenax	Robert	USA
76	Nasar-u-Minallah	Muhammad	Pakistan
77	Nicholson	Ruanui	New Zealand
78	Nie	Yafei	Finland
79	Norton	Taylor	USA
80	Onsi	Bella	USA
81	Park	Sang-Jong	South Korea
82	Philippe	Ricaud	France
83	Pilson	Gaby	USA
84	Pishniak	Denys	Ukraine
85	Pletzer	Tamara	New Zealand
86	Pope	Allen	USA
87	Powers	Jordan	USA
88	Radenz	Martin	Germany
89	Ramugondo	Ntanganedzeni	South Africa
90	Reid	Phil	Australia
91	Reusch	David	USA
92	Richter	Maren Elisabeth	New Zealand
93	Rodriguez Imazio	Paola	Argentina

94	Roff	Greg	Australia
95	Rowe	Penny	USA
96	Scardilli	Alvaro	Argentina
97	Seo	Wonseok	South Korea
98	Smith	Patrick	USA
99	Snyder	Hannah	USA
100	Spago	Sofia	Argentina
101	Sutherland	Dave	USA
102	Swart	Sebastiaan	Sweden
103	Torres	Christian	Brazil
104	Uotila	Petteri	Finland
105	Vichi	Marcello	South Africa
106	Vitale	Vito	Italy
107	Wang	Sheng-Hung	USA
108	Welhouse	Lee	USA
109	Werner	Kirstin	Germany
110	Wille	Jonathan	France
111	Zou	Xun	USA