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• **News & Views** •

The 19th Workshop on Antarctic Meteorology and Climate and 8th Year of Polar Prediction in the Southern Hemisphere Meeting

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ABSTRACT

The 19th Workshop on Antarctic Meteorology and Climate (WAMC) and the 8th Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) meeting were held in June 2024 at the Byrd Polar and Climate Research Center, The Ohio State University, Columbus, Ohio. These hybrid events convened 79 participants from 15 nations to foster international collaboration on Antarctic meteorology, climate research, and forecasting. The WAMC featured presentations on automatic weather stations, numerical weather prediction, Antarctic sea ice dynamics, and extreme weather events. The YOPP-SH meeting emphasized the positive impacts of enhanced observations during the 2022 Winter Special Observing Period (SOP) on forecast accuracy and addressed the transition toward the Polar Coupled Analysis and Prediction for Services (PCAPS) initiative. The outcomes reflect significant advancements in polar meteorological research and underscore the importance of sustained collaborative efforts, including improved observational networks and advanced modeling systems, to address the unique challenges of Antarctic meteorology. Future workshops will continue to support and expand upon these critical themes.

Key words: meteorology, Antarctica, modeling, automatic weather station, polar climate

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1. Overview

The 19th Workshop on Antarctic Meteorology and Climate (WAMC) was hosted by the Polar Meteorology Group on 10–12 June 2024, at the Byrd Polar and Research Center, The Ohio State University, Columbus, Ohio. The workshop was conducted in a hybrid format, allowing participation both virtually and in-person. The primary objective of the WAMC is to unite those with research and operational/logistical interests in Antarctic meteorology, forecasting, and related disciplines. It featured presentation sessions and discussions on current results and ideas in Antarctic meteorology and climate, numerical weather prediction, and weather forecasting, from contributors around the world. Subsequently, the 8th Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) Meeting occurred on 13–14 June 2024, at the same location. For the eighth YOPP-SH meeting, project investigators provided status reports on research resulting from the YOPP winter Special Observing

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Period (SOP) in the Southern Hemisphere: 15 April to 31 August 2022. The presentations and discussions emphasized the intensive observation periods during the SOP known as Targeted Observing Periods (TOPs). Again, in-person and online participation options were available. Together, both meetings had a total of 79 attendees, across 15 nations (Fig. 1).

2. WAMC: Automatic weather station networks and operational aspects

Over the course of three days, the 19th WAMC meeting featured 28 presentations focusing on Antarctic meteorology, forecasting, and related disciplines. The first workshop session included presentations and a discussion about the Automatic Weather Station (AWS) network and operational aspects in Antarctica. The first presenter was David MIKOLAJCZYK from the University of Wisconsin (UW-Madison), who described the 2023–24 field season for the UW-Madison AWS program. Their initial plan was to do servicing based out of McMurdo and the West Antarctic Ice Sheet (WAIS), but their WAIS work was cancelled due to logistical issues. The field team consisted of two people that visited 18 out of 20 planned AWSs. Five more sites in the UW-Madison AWS network were visited with help from other groups—namely, the Naval Information Warfare Center (NIWC), Geophysical Habitat of Subglacial Thwaites (GHOST)/Thwaites Interdisciplinary Margin Evolution (TIME), Polar Earth Observing Network (POLENET), the Japan Antarctic Research Expedition (JARE), and the French Polar Institute Paul-Émile Victor (IPEV). Overall, it was a successful season, but there were some issues.

Next, Lee WELHOUSE from UW-Madison, detailed the plans for the 2024–25 field season for the UW-Madison AWS program. The main goals are to work in the WAIS as well as at McMurdo-based AWSs. The West Antarctic AWSs have not been visited in at least six years and need to be serviced as two stations are buried. The field teams will include two groups to complete a new Tall Tower installation on the McMurdo Ice Shelf and regular season visits. The National Institute of Polar Research (Japan) plans to visit two AWSs they collaborate on, but no work is scheduled with other collaborating groups this coming field season. Past challenges in getting to the WAIS are a concern again for this next field season, but the team hopes to get out there.

Jo COLE from the British Antarctic Survey (BAS) outlined the field season review of the BAS Antarctic Peninsula AWS Network from 2023–24. The field team consisted of two groups: one assigned to Rothera and the other to Halley. The Halley airplane runway was under construction, so it was necessary to use a temporary alternate location for servicing the AWS. Out of Rothera, the team serviced three AWSs: Butler Island, Fossil Bluff, and Sky Blu. Both Butler Island and Sky

Fig. 1. In-person and virtual attendees pose for a picture on the second day of the 19th WAMC.

Blu AWS had an Iridium transmission issue that unfortunately could not be fixed at either site. However, raising all three stations went well. From Halley, they serviced two AWSs: HiRise 18 and HiRise 14. Fossil Bluff, Butler Island, Sky Blu, and Limbert are planned to be visited next field season (2024–25).

Sabina KUCIEBA from BAS presented the meteorological measurements and annual checks at Halley Research Station. Halley IV is verified every two months due to its location on the Brunt Ice Shelf. Other measurements include a Dobson spectrophometer, auto Dobson (not working due to a leak in the dome hatch from melted snow), Système d'Analyse par Observation Zénithale (SAOZ), radiosonde launches, Surface Synoptic Observations/Meteorological Aerodrome Report (METAR), CNR4 net radiometer, and a SPN1 sunshine pyranometer. Besides that, they serviced three AWSs that are now running properly with snow and air samples collected at CASlab. Sabina also mentioned that there were a few instances of convective clouds in the 2023–24 field season and precipitation such as snow pellets and freezing drizzle, the latter being very rare at Halley.

An update on the digitization of the early Antarctic Peninsula meteorological records and recent Antarctic activities of the World Meteorological Organization (WMO) was given by Steve COLWELL from BAS. The goal is to digitize paper-based historical surface data from UK stations on the Antarctic Peninsula. So far, the longer records have been digitized, but the stations with shorter operation periods from the mid 1940s onward have not. In total, there are 6000 pages of data to be scanned, but the data are not always complete, so standard optical character recognition cannot be used. All available data are on the UK READER website. A WMO Antarctic Advisory Group (AAG) was created to facilitate exchange of information between the operational and scientific communities. The WMO Regional Climate Centers (RCC) give better climate services and products to the scientific community. An Antarctic RCC is being established.

The NIWC Polar Program (NPP) Antarctic Weather Forecasting Handbook needs to be updated, and Joey SNARSKI from NPP covered the reasoning why and mentioned some examples of what could help. Documenting the current forecasting techniques and knowledge is needed to update the handbook and create a more uniform training experience, along with improving the understanding of current weather patterns by adding the most up to date knowledge available. Using over 21 000 METARs from October–February 2014–24, Joey found the prominent wind directions and the weather associated with the sectors he created. The climatological wind regime features a northeastern wind (335°–105°) 62% of the time. Furthermore, most fog observations occur during this wind regime (75%).

Michael JOHNSON from the Naval Information Warfare Center Atlantic (NIWC LANT) Polar Programs Integrated Product Team (IPT), presented the NPP programmatic changes and future goals. Space and Naval Warfare Office of Polar Programs meteorology personnel worked either in McMurdo or Christchurch (New Zealand) until 2006 when a remote operations facility was established at Charleston, South Carolina Naval Weapons Station. By 2020, the personnel were regularly producing all non-McMurdo forecast products. However, after the austral winter of 2020, there were limited personnel and logistical support, so the Remote Operations Facility (ROF) took on most of the weather functions that were traditionally handed by McMurdo. In the 2023–24 season, there was one forecaster and six observers at McMurdo and 11 forecasters at Charleston. From the lessons learned, the next field season will have two forecasters in McMurdo, an improved survey process, and more defined jobs for meteorologists and meteorological technicians versus forecasters and observers. NIWC Atlantic Polar Programs is on track to acquire a weather radar system for McMurdo that will be X-band, dual polarization, and portable with a planned installation in 2027. The TeraScan will be replaced, probably in 2028.

After the first section of presentations, a discussion was held by Lee WELHOUSE to address AWS needs and questions. The first discussion topic raised was whether reducing the number of stations by the Antarctic Meteorological Research and Data Center (AMRDC) would improve station servicing. This would not be possible, because AMRDC can go for several years without visiting stations while still receiving quality data. The issue recently has been limited logistical support after the COVID-19 pandemic to get out to stations that are past due. A related question that was considered was the optimization of AWS locations, but they are generally placed in locations that are helpful for forecasters and research. There is a demand to have a station near Siple Coast, but during the field season, this area is difficult to travel to, making it logistically difficult to install and service an AWS there. It would be ideal to have an AWS between Dome C and Dome A, and at the S+200 cache. The current two communication systems used for the AWS in the AMRDC network are Argos (around 40 AWS) and Iridium (around 12 AWS). Unfortunately, Argos 1 was discontinued, and the group is looking into newer versions. They are not actively switching to Iridium because additional batteries are required to run Iridium transmissions, especially in colder regions. The data from the AMRDC AWSs are provided freely via their repository, and metadata will be put in WMO's Observing Systems Capability Analysis and Review Tool (OSCAR) in the future. The AMRDC website also portrays real-time data from the AWSs, but only for temperature, pressure, relative humidity, wind speed, and wind direction. Some of the forecasters relayed that real-time acoustic depth gauge data are desired.

Ethan KOUDELKA from UW-Madison provided a detailed overview of the data archival operations that happen year-round, and the changes that take place during each field season. Ethan detailed how the AMRDC utilizes the Local Data Manager (LDM) to receive data from across the world for inclusion in its repository. Through the Antarctic-Internet Data Distribution system (IDD) there is an improved availability and exchange of Antarctic Meteorological data, such as satellite composite imagery, automatic weather station observations, Antarctic Mesoscale Prediction System (AMPS) data, and more. After-

wards, Ethan reviewed some of the data the AMRDC receives and archives, which can be hourly, daily, or monthly. Most of the data transfer is automated, but a portion is received via email.

Originally prepared by Matthew LAZZARA from UW-Madison, David MIKOLAJCZYK stepped in to report on the project status on the AMRDC. The new AMRDC website has been launched, and the AMRDC data repository now has over 5000 datasets. Current datasets include AWS observations, satellite composites, McMurdo radiosonde data, and more. The repository also hosts 106 external datasets. The satellite composite imagery is now being made on two different new systems. Different data visualizers have been created to help visualize AWS observations, meteorograms, AMPS model runs, satellite imagery, and more. Undergraduate and graduate students play a large role in the AMRDC group and work on numerous exciting projects. Meteorological data services are provided via Unidata's Thematic Real-time Environmental Distributed Data Services (THREDDS), Man computer Interactive Data Access System Abstract Data Distribution Environment (McIDAS-ADDE), and Antarctic-IDD LDM. For storage and backup, the repository is copied onto a tape two to three times per year, but the cloud is also being considered for the repository.

3. WAMC: Antarctic meteorology and forecasting research

3.1. *Forecasting, modeling, and numerical weather prediction*

Kevin MANNING from the National Center for Atmospheric Research (NCAR) presented The Antarctic Mesoscale Prediction System (AMPS) updates. The National Science Foundation (NSF) funded, experimental and real-time numerical weather prediction (NWP) system supports the United States Antarctic Program (USAP). AMPS now uses the Derecho supercomputer, which has approximately 2.5 times the computing power compared to the previous machine. As such, a two-moment microphysics parameterization has been added, a new land model is being used, and an expanded AMPS ensemble can be made. Also, a high-resolution Model for Prediction Across Scales (MPAS) mesh can be used. A recent resource NCAR has made available in real-time comprises GRIB index files to minimize the volume of downloads. A short-term plan for those working on AMPS is to develop a real-time surface and upper air statistics page.

Following Kevin, Jordan POWERS from NCAR explored other plans for AMPS. First, the group wants to investigate the MPAS regional domains for ensembles and testing various limited area domains. A plan was presented to test and implement the Joint Effort for Data Assimilation Integration (JEDI) in MPAS for AMPS. There is a desire to implement polar land surface model modifications as well. Updating and evaluating the physics used in AMPS is ongoing with the new microphysics. There will be graphics processing unit (GPU) testing to evaluate the potential for MPAS forecasts via GPUs. Moving AMPS to the cloud to generate core Weather Research and Forecasting (WRF) model forecasts will be utilized as new cloud hardware is available. A request from the 109th airlift wing was to create McMurdo area aviation weather information for a weather condition study. The modelers plan to do South Pole Overland Traverse (SPOT) analysis for the NSF and review the atmospheric conditions in abnormal snow surfaces that affected the 2023–2024 SPOT. Archiving the forecast output from WRF and making it available to the community is planned as well. Long-term plans include assisting with the Hercules Dome deep ice core project, and more modeling developments with MPAS and testing GPUs as well as cloud computing.

Günther HEINEMANN from the University of Trier described several potential climate indicators that could be applied to monitor the past and future state of the Antarctic climate system. He applied the same approach with their regional climate model, Consortium for Small-Scale Modeling (COSMO) model in Climate Mode (COSMO-CLM), abbreviated as CCLM (non-hydrostatic). From 2050–2100, almost no cooling was seen in any regions across summer, winter, or annually. Winter showed extreme warming in the Weddell Sea with more than 8°C of warming. Melt days were seen to increase with time in all regions, particularly within the Antarctic Peninsula and Ross Ice Shelf.

Eric BAZILE from Meteo-France, presented on the Meteo-France NWP system and the near real time Application of Research to Operations at Mesoscale (AROME) forecast at 1.5 km over Dumont d'Urville and Dome C. The NWP systems in France are based on the global numerical weather prediction model Action de Recherche Petite Echelle Grande Echelle (ARPEGE). For ARPEGE, they are now moving to hybrid four-dimensional variational schemes (4D-VAR) for data assimilation. AROME (France) is moving to three-dimensional ensemble variational (3DEnVar) data assimilation. For physics, they are implementing the European Centre for Medium-range Weather Forecasts (ECMWF)'s Radiation scheme (ecRad) with the Monte Carlo Independent Column Approximation (McICA) solver for cloud computations. This has resulted in improvements in the South Pole ARPEGE E-Suite evaluation. In summary, some progress has been made in ARPEGE in the Antarctic since July 2022 and the AROME-Southern Hemisphere (SH) model at 1.5 km resolution improved the temperature prediction.

Another subject addressed was the currently available Antarctic turbulence forecasting products: AMPS, the Fleet Numerical Meteorology and Oceanography Center Navy Global Environmental Model (FNMOC-NAVGEM), The United States Air Force Weather Web Services (AFW-WEBS), and Observational Global Information Meteorological (OGIMET). But a standard model product for turbulence forecasting at lower and upper levels would improve the efficiency and precision of turbulence forecasts and enhance the situational awareness of regional turbulence potential. Kaitlyn PAYNE from the

NIWC Polar Program (NPP) talked about the Graphical Turbulence Guidance-Global (GTG-G), which is one example of a desired product. To derive turbulence indices, Pilot Reports (PIREPS) and observations are used to weigh diagnostics and make calculations, both of which are not readily available in Antarctica. Work is currently ongoing to integrate turbulence indices into AMPS. Additionally, PIREPS will continue to be promoted until an AMPS product that combines upper- and lower-level turbulence forecasts can be made available.

Saurav Dey SHUVO from The Ohio State University (OSU) presented findings from a study simulating the February 2020 North Dakota blizzard using a blowing snow algorithm coupled with the Polar Weather Research and Forecasting Model (Polar WRF). The model used 100 vertical levels for the blowing snow algorithm in five simulations with durations ranging from 48 to 120 hours from 0000 UTC 15 February. His simulation results indicated good qualitative agreement with the GOES-16 satellite images, with the simulation having greater accuracy closer to initialization time. However, Saurav mentioned some challenges, including artifacts from the land surface model and issues with urban parameterization. Further simulations would be conducted to upgrade the model and apply the blowing snow algorithm to the Antarctic region.

Xun (Jerry) ZOU from the Center for Western Weather and Water Extremes (CW3E) discussed the combined effects of atmospheric rivers (ARs) and foehn warming over the Antarctic Peninsula. Using Polar WRF, 40 strong AR events during austral summer were examined, identifying four distinct AR patterns. She noted that each pattern has a different effect on the Larsen Ice Shelf, with the northern Larsen C Ice Shelf being the most vulnerable to foehn-induced surface warming due to the topography of the Antarctic Peninsula. Ongoing research will investigate the upwind latent heat release and its effect on warming mechanisms to understand the impact of ARs on the ice melt in the region through the continued use of high-resolution model simulations.

Currently there are biases in Antarctic sea ice representation using a coupled atmosphere–ocean–sea ice model based on the Scripps-KAUST Regional Integrated Prediction System (SKRIPS) framework. Ivana Cerovecki from the University of California in San Diego discussed two primary sources of bias within the model: inaccurate cloud representation and parameterized ocean heat exchanges. Cloud representation biases in the fifth generation ECMWF atmospheric reanalysis (ERA5) model resulted in downward longwave radiation (DLW) biases. When DLW in simulations was increased, the sea ice growth predictions aligned closer to observed data, reducing the overestimation of sea ice extent. Additional sensitivity tests on the ocean heat exchange highlighted how this parameterization significantly affects sea ice formation.

Phil REID from the Australian Bureau of Meteorology continued discussing the challenges of representing Antarctic sea ice dynamics in NWP global models. His group's research investigated recent shifts in Antarctic sea ice extent, focusing on the significant reduction observed since 2015. The atmosphere, while a primary driver of variability in sea ice extent, was not the only driver for the recent changes observed, and ocean warming must also be considered when explaining the change in the Antarctic sea ice regime. Exploring these changes in global coupled models indicates a periodicity in forecasting errors regarding sea ice extent that could be associated with a periodic interaction between sea ice and Antarctic cyclones represented within the model. The findings emphasize the need for better observational data and improved model parameterization to create more accurate forecasts for Antarctic sea ice.

Pranab DEB from the Indian Institute of Technology Kharagpur talked about enhanced surface melting across West Antarctic ice shelves and the link to central Pacific sea surface temperatures and the South Pacific Convergence Zone (SPCZ). Two metrics measuring the frequency and intensity of daily maximum temperatures exceeding a melt threshold of 273.15 K were used to create a melt potential index (MPI). An overall negative trend in MPI frequency and intensity was found to be present over the coastal West Antarctic and ice shelves during the summer season (DJF) 1979–2018. However, the trend shifted in the late 1990s from decreasing to increasing with enhanced melting in West Antarctica from 1999–2018. The Interdecadal Pacific Oscillation and its coupling with the SPCZ led to increased precipitation and surface melting in the WAIS after the late 1990s.

3.2. *Observation applications and research*

Naoyuki KURITA from Nagoya University analyzed a 30-year temperature record (1993–2022) from Relay Station, located in the Dronning Maud Land region, and identified a warming trend of 0.48 °C ± 0.41°C $(10\ \mathrm{yr})^{-1}$. The study associated this warming trend with a meridional dipole pressure pattern with high pressure located over the interior of East Antarctica and low pressure located over the southern Indian Ocean. The variability of the Mascarene high-pressure center located over the southern Indian Ocean influenced this dipole pattern. The presentation concluded with a discussion on how the recent warming of the Indian Ocean pushed the Mascarene high further east, leading to increased warm-air intrusions as far as the Dome Fuji region of East Antarctica.

David BROMWICH from OSU presented a study that evaluated the accuracy of ERA5 data in representing Antarctic temperature trends from 1940 to 2022. The study compared ERA5 output with an observation-based reconstruction of 2-m air temperature (RECON), which has a monthly resolution between 1958 and 2022, as this was the period of reliable observational availability. When comparing ERA5 temperature trends to RECON, it was noted that ERA5 has greatly reduced skill in capturing temperature changes before 1979, when satellite data coverage was limited. ERA5 did represent temperature

trends post-1979 more accurately. Bromwich argued against using ERA5 for long-term temperature trend analysis (1940–2022) due to warming artifacts, which would skew any analysis conducted using said data.

The Antarctic sea ice extent was below average in three years: 2017, 2022, and 2023. Ryan FOGT from Ohio University presented an analysis of Antarctic sea ice extremes within the context of the 20th century. He explained that a historical dataset of sea ice extent could be reconstructed based upon midlatitude temperature and pressure data as far back as the early 20th century. This extended period allows for greater context in the variability of sea ice over time, with the results still highlighting the extreme minimum extent observed in more recent years. The reconstructions note how 2023 could be considered an extreme event and may indicate the shift toward ocean-driven dynamics over atmospheric influence on the Antarctic sea ice extent, though uncertainties within the reconstruction must be considered.

Continuing this discussion, David REUSCH from the University of Washington presented on the variability in Antarctic sea ice, highlighting how the 2023 sea ice extent was more than three standard deviations below the long-term average. Several datasets were analyzed using self-organizing maps to explore the nonlinear aspects of sea ice variability and compare these results to early Antarctic exploration, particularly the Belgica voyage in 1898. While the research is still in its preliminary stages, early results indicate more significant variability in sea ice extent in West Antarctica during the summer, with winter ranges being reasonably uniform. In the future, David will revisit past data to explore how things changed in early expeditions in the Antarctic regions to better understand recent sea ice variability.

Brian RAKOCZY from OSU presented an analysis of the temporal and spatial variability of the Antarctic katabatic wind regime as represented by the ERA5 reanalysis data. ERA5 near-surface wind speed and direction were evaluated by comparing them to in situ observations. His analysis highlighted an underestimation of high wind speeds along coastal regions and errors in wind direction over regions with complex topography. Examining wind speed anomaly trends, they noted that ERA5's resolution may result in a smoothing of the data, causing repeated inconsistencies with observed trends. Brian will conduct further examination of these trends along with an analysis of the Southern Annular Mode and the El Niño–Southern Oscillation to determine the accuracy of ERA5 output for long-term katabatic wind speed studies.

David MIKOLAJCZYK from the AMRDC and Mariana FONTOLAN LITELL from OSU co-presented an examination of the extreme cold weather during the austral winter of 2023. This extreme cold event impacted Antarctic operations, including the winter fly-in period at McMurdo Station. The researchers observed that temperatures dropped below −50°C, breaking multiple records across the continent. They used ERA5 data and identified four different cold phases between mid-July and the end of August. This examination indicated robust negative anomalies in the 500-hPa geopotential height fields over the impacted regions. These anomalies were associated with minimal cloud cover and weak winds, resulting in strong near-surface temperature inversions. Further examination is planned to improve the understanding of extreme cold events and their prediction.

4. The 8th YOPP-SH meeting

4.1. *Session I*

Over the course of two days, the 8th YOPP-SH meeting featured 10 presentations focusing on the winter YOPP-SH. This SOP spanned from 15 April to 31 August 2022. David BROMWICH from OSU started with an overview of YOPP-SH, providing current project updates, including a recent publication (Bromwich et al., 2024) of collective efforts of several individuals in the project (Fig. 2). The YOPP-SH team is evaluating the additional sounding data from the TOPs to determine their impact in forecast accuracy, aiming to enhance numerical weather prediction for winter conditions. The forecasts improved significantly, especially south of 60°S latitude, and the observations of clouds and precipitation are refining the microphysical parametrizations for mixed-phased clouds. Overall, the winter SOP campaign was a huge success.

Eric BAZILE from Meteo-France presented the current progress of Meteo-France's contribution to the winter YOPP-SH. Meteo-France contributed to the winter YOPP-SH with additional sounding profiles at two stations, Kerguelen and Dumont d'Urville, and by providing 10-day forecasts with the ARPEGE and AROME models. Eric summarized the results of observing system experiments (OSEs) performed by removing all the sounding data between 60°S and 90°S, during the four months of the winter YOPP-SH. The OSE with ARPEGE showed an insignificant impact of the extra Antarctic sounding data after 24 hours for temperature but a positive impact for geopotential height. Generally, more analysis is required, especially in the statistics of the assimilation cycle.

Then, Keith HINES from OSU presented a study of clouds and precipitation at Davis Station for an AR case in early June 2022, which happened during TOP2. He performed Polar WRF simulations of this event by assimilating radiosonde observations from Davis and Zhongshan stations. They were compared to simulations of the AR event with the Met Office Unified Model (UM) Regional Nesting Suite. Polar WRF showed more liquid, and UM more ice. In addition, Polar WRF showed more downwelling longwave radiation. Keith concluded that the data assimilation of the YOPP-SH radiosondes into the Polar WRF simulations had a significant positive impact on cloud prediction.

Mariana FONTOLAN LITELL from OSU talked about the positive forecast impact of the TOPs extra radiosondes on

Fig. 2. YOPP-SH winter TOPs conducted. Photographs clockwise from the top right show radiosonde releases from McMurdo, Neumayer, Kerguelen and Syowa stations, with the Aurora Australis in the background of Syowa (Bromwich et al., 2024). © American Meteorological Society. Used with permission.

Polar WRF experimental runs. NCAR has been performing Polar WRF simulations assimilating the extra observations from the TOPs. These experiments are performed with and without the extra radiosondes and validated against ERA5. For TOP3 and TOP7, the experiments with the extra radiosondes presented better forecast skill, and their impact was more prominent south of 60°S. Mariana also mentioned a case study in which the extra experiment produced a more precise simulation of a cyclone near Dumont d'Urville station.

4.2. *Session II*

Nahidul SAMRAT from NIWC Polar Programs had a recorded presentation showcasing experiments conducted using the Met Office global NWP system to quantify the impacts of the extra TOP soundings. To evaluate the impact of the extra winter SOP radiosondes, they performed a full data denial experiment, consisting of a control experiment with all observations and a denial experiment where certain kinds of observations were removed to demonstrate their impact on the forecast. Another method mentioned was the forecast sensitivity to observation impact (FSOI). Overall, observation removal systems can cause a decrease in the average forecast skill in the polar regions. Nahidul's conclusions led to recommendations to maintain the current observing network in the polar regions.

Zhangcheng PEI from the Australian Antarctic Program Partnership presented results for mixed-phased cloud simulations in Antarctica. Their double-moment cloud microphysics scheme can account for the impact of aerosol changes in the microphysics. This work uses Davis observations from the 2019 summer campaign to assess the capability of the high-resolution UM. The model had two configurations: RAL3 (double moment) and RA2M (single moment). RAL3 performs worse than RA2M in simulating meteorological conditions. Overall, UMs could generally simulate the timing and vertical structure of mixed clouds during the study period; however, there were disparities in the ability to replicate the cloud phase among different cloud microphysics configurations.

Naohiko HIRASAWA from the National Institute of Polar Research, Tokyo, Japan, explained that Syowa station participated in the winter SOP with extra observations. It also included precipitation observations, including X-band radar and AWSs on the ice sheet. The research team is currently working on analysis and interpretation of data from ultrasonic snow depth sensors; it has stepwise surface rises (contribution to accumulation) and pulse-like variations (fluctuations in snow surface height). This study investigated the accumulation and pulse-like variations with reference to the timing of precipitation events at Syowa. Naohiko emphasized one accumulation event, and atmospheric inflows from the ocean were observed in relation to the synoptic-scale systems. So far, the causes that separate stepwise rises from pulse-like variations have not been identified.

4.3. *Session III*

On the second day of YOPP-SH, Irina GORODETSKAYA from the Interdisciplinary Centre of Marine and Environmental Research of the University of Porto (CIIMAR) delivered the opening presentation. Irina's work aims to show how warming has affected winter precipitation over the peninsula using microwave rain radars, ERA5 reanalysis, and high-resolution Polar WRF simulations. The transition of snow to rainfall becoming more frequent in the region is the focus of study. Some vertical profile representations in the ERA5 data and Polar WRF simulations were compared using the merged observations

and the model data format approach developed under the YOPP Model Intercomparison and Improvement Project at designated supersites (YOPPsiteMIIP), including King Sejong station. A strong AR on 10 May 2022 caused anomalous rainfall and intense snowfall. Low and mid-level liquid-containing clouds strongly enhanced downwelling longwave surface radiation during the event.

Penny ROWE from Northwest Research Associates presented a study that aimed to characterize seasonal clouds and precipitation at Escudero station. Penny described the main concerns with melting events on the peninsula. Her study focused on cloud characterization over King George Island, based on micropulse lidar, radio soundings, universal cloud water sensors, broadband radiation measurements, and surface meteorology, satellite data, and outputs from Polar WRF model outputs. Results show that there is little seasonal variation, with clouds occurring 96% of the time. Polar WRF produced downward shortwave and longwave radiative fluxes that agreed more closely with observations than ERA5.

Keith HINES from OSU presented a study of Polar WRF simulations of an AR event that impacted the Antarctic Peninsula on 16 May 2022, during TOP1. These simulations were compared with enhanced observations from Rothera, Vernadsky, and Escudero. The simulation used the two-moment Morrison microphysics scheme. The observed and simulated precipitation was primarily rain at Escudero with higher temperatures, while the more southerly stations of Vernadsky and Rothera experienced colder temperatures and mostly snowfall. In this AR case, the simulated longwave cloud forcing matched the observed values, and Polar WRF provided an accurate simulation of clouds and hydrology. The next step of this analysis is to study the contribution of secondary ice production in the clouds for this event. This presentation marked the conclusion of the YOPP-SH meeting.

4.4. *Evolution of YOPP-SH into PCAPS and participation opportunities*

David BROMWICH led this discussion, mentioning that the Polar Coupled Analysis and Prediction for Services (PCAPS, https://www.wwrp-pcaps.net/) is the follow-on to the Polar Prediction Project-Year of Polar Prediction (YOPP), and that its Southern Hemisphere component YOPP-SH is scheduled for completion at the end of 2024. PCAPS is an initiative of the World Weather Research Programme (WWRP) of the WMO and is dedicated to enhancing environmental forecasting in the Arctic and Antarctic regions for human and environmental wellbeing. It will run from 2024 to 2028 with the possibility of an extension for four more years. At the time of the meeting, the PCAPS project plan was still under development, so the draft was the source for the present information.

PCAPS is a global collaboration, and many of the individuals involved are part of the social sciences community aiming to communicate and evaluate the impact of the forecasts. In more detail, PCAPS aims to enhance the observing system and improve the usage of satellite data for forecast initialization and validation of forecast models. A key part of this is to improve coupled model analysis and prediction. It is likely that Task Teams will be formed for each PCAPS activity area—namely, services, sustainability, prediction, partnerships, and inclusivity. A potential challenge discussed was funding, which will require proposals to national science agencies. There are practical considerations that need to be addressed for the successful competition of PCAPS.

The Australian Bureau of Meteorology, Environment and Climate Change Canada (ECCC), Meteo-France, and ECMWF have expressed interest in participating, and PCAPS could be linked to activities of the Scientific Committee for Antarctic Research (SCAR). It is hoped that WWRP could incentivize additional operational centers to participate. Another topic discussed was the possibility of having an international cooperative observational resource. In the near future, a MOSAiC-type platform (https://mosaic-expedition.org/) might be available through the developing Antarctica INSYNC project (https://www.antarctica-insync.org/). Overall, PCAPS is a project that will require enthusiastic community efforts, and besides the anticipated challenges, there is considerable interest in it, and it was well accepted by the YOPP-SH community. The next steps are to complete the content and details envisaged for PCAPS, followed by encouraging people and organizations to participate or initiate their involvement in the Southern Hemisphere aspects of PCAPS.

5. Workshop outcomes

The 19th WAMC showcased significant advancements in Antarctic meteorology and forecasting. Organized by the Polar Meteorology Group, the workshop drew attendees from 15 nations and was followed by the 8th YOPP-SH meeting. This hybrid event promoted international collaboration, featuring diverse topics such as AWSs, NWP, sea ice dynamics, and the winter YOPP-SH campaign. The two events featured some new research in diverse fields that enriched participants' knowledge and awareness.

The workshops underscored the importance of collaborative research, such as enhanced observation networks, and advanced modeling systems to address the unique challenges of Antarctic meteorology. The transition to PCAPS heralds a new era of integrated analysis, promising significant strides in polar environmental forecasting and operational efficiency. These developments underscore the scientific community's strong commitment to understanding and mitigating the impacts of climate change in one of the planet's most vulnerable regions. Overall, these two events encapsulated the breadth and depth of discussions and many other activities relevant to Antarctic meteorology and climate, showcasing the community's

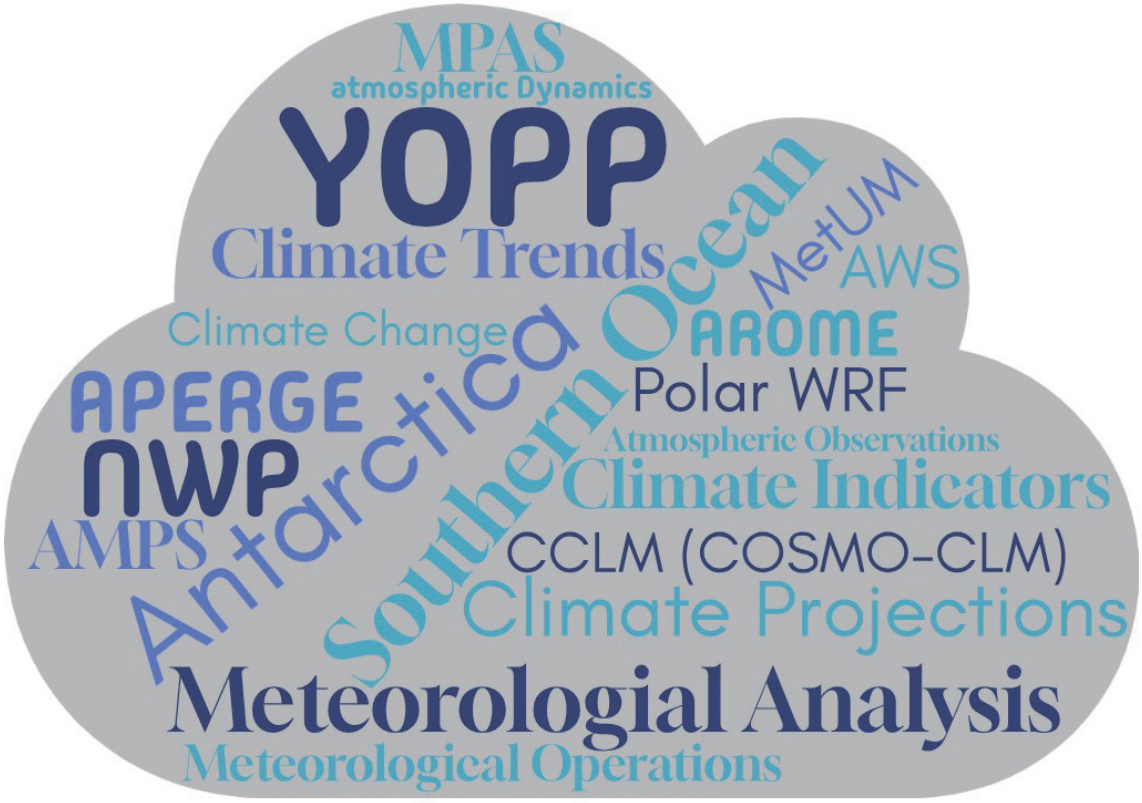

Fig. 3. Word cloud showcasing a summary of the key topics discussed during the 19th WAMC and 8th YOPP-SH meetings. The size of each word reflects the main emphasis of themes across both meetings.

dedication to innovation and collaboration for a common cause. Figure 3 illustrates the main themes discussed at both meetings. The 20th WAMC will be hosted by the Korea Polar Research Institute (KOPRI), in Incheon, Republic of Korea, on 16–18 July 2025.

6. Workshop materials

All presentations, abstracts, extended abstracts, programs, and recordings from the WAMC and YOPP-SH workshops can be accessed at https://polarmet.osu.edu/WAMC_2024/.

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