ADVANCES IN ATMOSPHERIC SCIENCES, 2021

• **Meeting Summary** •

The 16th Workshop on Antarctic Meteorology and Climate and 6th Year of Polar Prediction in the Southern Hemisphere Meeting

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1. Overview

In June 2021, the 16th Workshop on Antarctic Meteorology and Climate (WAMC) and the 6th Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) Meeting (http://polarmet.osu.edu/WAMC_2021/) were held online and hosted by the Polar Meteorology Group at Byrd Polar and Climate Research Center, The Ohio State University, Columbus, Ohio (Fig. 1). The WAMC is organized annually by the WAMC Planning Committee and aims to integrate research and operational/logistical interests in Antarctic meteorology, numerical weather prediction, and weather forecasting, as well as related aspects. The 16th WAMC was followed by the 6th YOPP-SH Meeting, which provided updates on the research achievements from the YOPP summer Special Observing Period (SOP) in the Southern Hemisphere (16 November 2018 to 15 February 2019; Bromwich et al., 2020). Also, the plans for the upcoming winter SOP in 2022 were highlighted. The meetings had approximately 140 attendees from over 15 countries, which are listed in the meeting report (http://polarmet.osu.edu/WAMC_2021/BPCRC_tech_report_2021-001.pdf).

2. Operational meteorology, observations, and data management.

The WAMC opened with a series of presentations related to operational meteorology, observations, and data management. The key results presented in this session are summarized below.

2.1. *Antarctic Meteorological Research and Data Center*

The Antarctic Meteorological Research Center (AMRC) has been a fixture at the University of Wisconsin-Madison (UW-Madison) for the past two decades. Matthew LAZZARA provided an update on the new Antarctic Meteorological

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Fig. 1. Opening of the 16th WAMC meeting (picture on the left is from Antarctica Guide, https://www.antarcticaguide.com/antarctica-wildlife-2/antarctica-penguins).

Research and Data Center (AMRDC), as the follow-on effort. This is a joint undertaking between UW-Madison and Madison Area Technical College and is funded by the National Science Foundation's (NSF) Office of Polar Programs. The project establishes a formal data repository for US Antarctic meteorological datasets. The repository offers a sustained location for Antarctic meteorological datasets from a variety of sources that follow FAIR (findable, accessible, interoperable, and reusable) principles and allows the issuance of digital object identifiers (DOIs), meeting NSF requirements for investigators seeking a final location to deposit datasets from their projects. The AMRDC will also hold unique datasets from United States Antarctic Program (USAP) main stations, field camps, airfields, etc. Creations of Antarctic satellite imagery composites (Fig. 2), maintaining the Antarctic Internet Data Distribution (Antarctic-IDD; Fig. 3), and providing expert analysis work (e.g., climatology reports, case studies, white papers, etc.) are also a part of the new effort.

2.2. *Automatic Weather Station network.*

The largest meteorological network across the Antarctic continent is composed of Automatic Weather Station networks (AWSs). Presentations by Lee WELHOUSE, Dave MIKOLAJCZYK, and Mairi SIMMS discussed the United States (UW-Madison) and United Kingdom (UK) AWS networks across the Antarctic. Updates on past field-season work (despite the pandemic) were presented along with plans for the upcoming 2021/22 field season. The UW-Madison AWS group did not have a field season in 2020/21 for the first time in 40 years. During the 2021/22 field season, activities will include AWS repairs at some critical AWS sites in West Antarctica and at sites in the Ross Ice Shelf/McMurdo Station area. Other work underway includes testing new communication systems and improving the observing strategy based on World Meteorological Organization recommendations. Simms presented the work accomplished on the UK AWS networks during the 2020/21 field season. The British Antarctic Survey (BAS) maintains a network of eight AWS sites in Antarctica and services four sites for other countries. During the previous summer season, all but two (Limbert and Baldrick) were visited, and the Koni Steffen AWS site was removed. A goal for next season is for some of the BAS AWS sites to be changed over to a pole mounted system rather than a mast system to reduce servicing time.

2.3. *Operational meteorology*

Naval Information Warfare Center, Atlantic, Polar Programs (NPP) provides operational meteorological forecasting and weather observing services for the USAP. Meteorological services by NPP have been in place since 1997, supporting aviation, ship, and station services. This is a continuation of the support provided by the United States Navy since the construction of McMurdo Station. The support and management provided by NPP over the decades has been adaptive in order to provide the National Science Foundation (NSF) with the greatest ability to take advantage of scientific opportunities and improve data accuracy and knowledge through cooperative learning and data sharing initiatives.

Presentations by Arthur CAYETTE, John MEYER, Michael JOHNSON, and Jeffrey FOURNIER discussed the meteorological services provided by NPP. It was noted that NPP provides over 2500 forecasts and briefing services annually. The scope of these responsibilities includes, but is not limited to:

- Antarctic continental weather forecasting and McMurdo Station weather observing support services for all USAP cus-

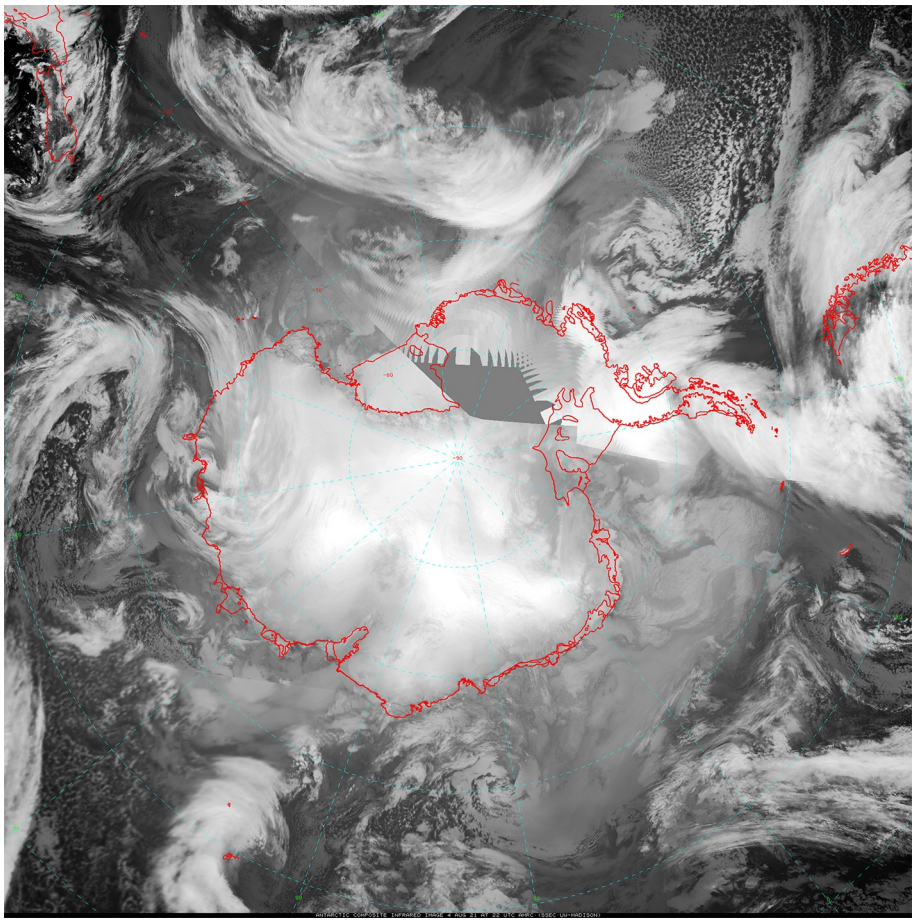

Fig. 2. A sample infrared Antarctic composite from 2200 UTC 4 August 2021, made operationally at UW-Madison as a part of the AMRDC project.

tomers;

- Ship, traverse, station, camp, and personnel weather support for any USAP location south of 60ºS latitude;
- Archival and dissemination of weather data;
- Provision of USAP interface for data sharing with regional and world meteorological organizations;
- Implementation and maintenance of training and qualification/certification program;
- Maintaining an active quality assurance program that ensures proficiency of assigned personnel, accomplishment of program objectives, and safety of operations.

3. High-latitude environmental prediction

Sessions on high-latitude numerical weather prediction (NWP) and model development are perennial components of the WAMC. The 2021 WAMC featured talks on various applications of atmospheric models over Antarctica, for both real-time forecasting and research. Two presentations by Jordan POWERS and Kevin MANNING addressed the Antarctic Mesoscale Prediction System (AMPS) efforts. AMPS is a real-time NWP system maintained by the National Center for Atmospheric Research (NCAR) that supports the needs of the weather forecasters with the USAP.

The AMPS annual update presentation focused on upcoming changes to the AMPS archive. The High-Performance Storage System at NCAR, which has housed the archive, is being decommissioned, and this has forced a shift to a disk-based storage system. Given the new hardware's capacity constraints, the revised AMPS archive will focus on holding GRIB format model output (mostly WRF) for the long term, while still making full model output in native netCDF format available for a period of up to six months. A second AMPS talk covered the system development plans for the next few years. In addition to this shift to a new AMPS archive infrastructure, the system will see increasing emphasis on the Model for Prediction Across Scales (MPAS), currently run in AMPS. MPAS will be applied at a higher resolution to match the WRF grid (e.g., 8-km continental), and it will be tested with a new regional domain capability. Model physics for both WRF and MPAS will continue to be a focus in AMPS, particularly microphysics and planetary boundary layer physics. Regarding system computing efforts, AMPS will be moving to a new community supercomputer at NCAR starting in 2022, and the system will con-

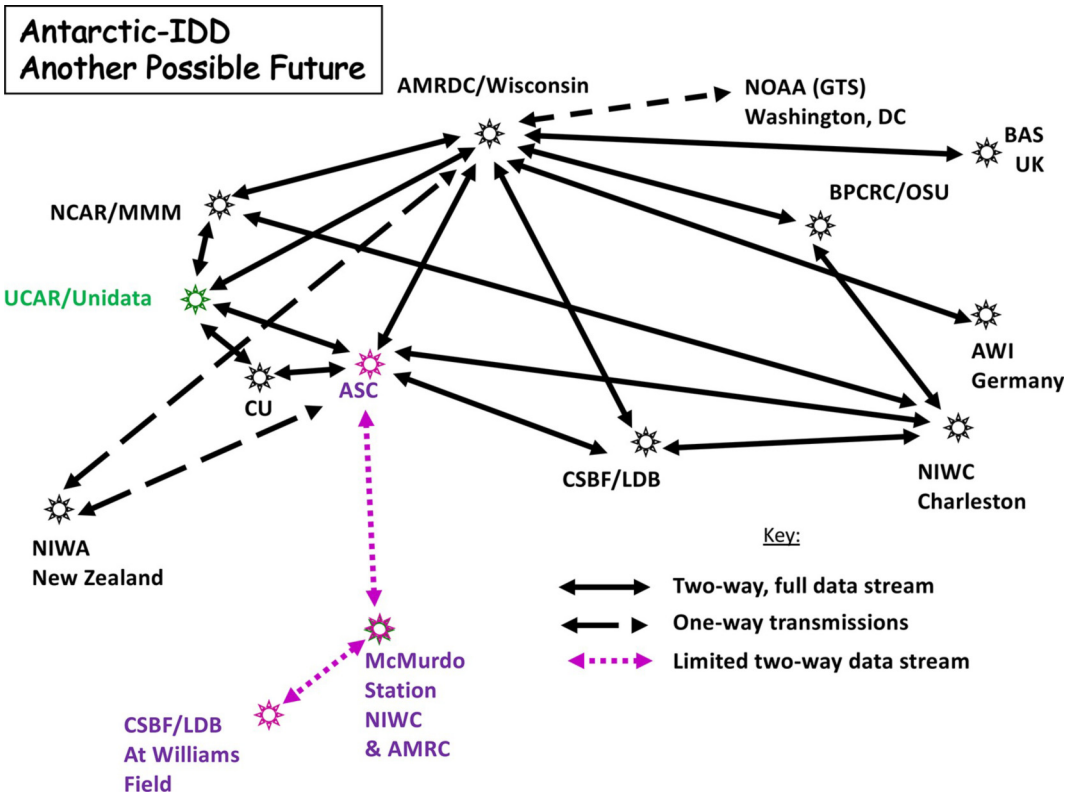

Fig. 3. The Antarctic-Internet Data Distribution real-time data relay for Antarctic meteorological data, a key element of the AMRDC project, serves the Antarctic meteorological community. It connects operational, education, and research segments with a distribution/sharing of real-time model and observational data. Here, a possible future plan for the network is outlined.

tinue to use cloud computing for support when the mainframe is under service.

Also, results from the Atmospheric Radiation Measurement (ARM) West Antarctic Radiation Experiment (AWARE) project were presented during the WAMC meeting. Funded by the Department of Energy (DOE) and the NSF, this project collected and analyzed observations of atmospheric energy components, air masses, and cloud microphysics over Ross Island and West Antarctica, with the goal of better understanding the causes and mechanisms of the changing climate (Lubin et al., 2020). The ongoing AWARE project provides support for a wide variety of research. In David KINGSMILL's presentation, the forecast ability of AMPS for strong wind and precipitation events was evaluated based on AWARE observations. Keith HINES presented on much improved Polar WRF simulations of frigid mixed-phase clouds observed at McMurdo during the AWARE project. Mckenzie DICE showed an analysis of the relationship of atmospheric state and boundary layer variability at McMurdo based on the AWARE dataset (https://www.arm.gov/research/campaigns/amf2015aware). During the austral summer in 2018/19, data were collected from the Siple Dome Field Camp for 28 days. Dan LUBIN, the lead principal investigator of the AWARE project, introduced the new West Antarctic dataset at the WAMC meeting.

4. Research on Antarctic weather and climate

The WAMC workshop provides a chance for the Antarctic community to present their scientific findings and exchange research ideas on polar meteorology, weather forecasting, and climate studies. During the virtual workshop this year, many more participants than usual joined this session, which covered a wide variety of topics.

4.1. *Atmospheric rivers*

Atmospheric rivers (ARs) are narrow corridors of warm moist air, usually forming in subtropical and midlatitude regions. ARs can be associated with extratropical cyclones and contribute to surface melting and extreme precipitation (e.g., Gorodetskaya et al., 2020). Impacted by the local topography, ARs can amplify the foehn effect over the Antarctic Peninsula and West Antarctica, and thus accelerate the break-up of ice shelves via surface warming (e.g., Bozkurt et al., 2018; Zou et al., 2021). As a major source of atmospheric water content, ARs are also responsible for cloud formation and affect the surface energy balance (e.g., Nicolas et al., 2017). Thus, the 16th WAMC included several presentations on this topic.

During the workshop, a methodology of AR detection over Antarctica was first introduced from a climate perspective by Jonathan WILLE (Wille et al., 2019). Then, the impacts of ARs on snowfall/precipitation, surface melting, surface mass balance, and the stability of ice shelves were analyzed for both climate and weather scales based on observations, reanalysis data, and model simulations. Finally, Christine SHIELDS discussed the observation and predictability of ARs over Antarctica, which will benefit climate projection in the future.

4.2. *Extreme precipitation events*

Associated with ARs, extreme precipitation events over Antarctica were fully investigated and discussed during the WAMC meeting. Etienne VIGNON provided an overview of rainfall occurrence over Antarctica and a projection based on multiple latest-generation climate models, which suggested more frequent and intense precipitation events in the future (Vignon et al., 2021). As mentioned in Diogo LUÍS's presentation, precipitation is a major factor for surface melting, sea ice loss, and the change of ocean surface salinity. The input of the freshwater has a significant impact on the global hydrological cycle and ocean circulation. Thus, the predictability of extreme precipitation events is critical for the Southern Ocean/Antarctica. As mentioned in Svitlana KRAKOVSKA's presentation, extra observations of the vertical structure of weather systems, such as cold fronts and jet streams, can help decrease the uncertainties in weather forecasts. Thus, vertical radiosonde data will be used to adjust model forecasts, especially for microphysical properties of clouds and precipitation.

4.3. *Antarctic cyclones and strong wind events*

Extratropical cyclones are highly associated with the extreme snowfall and strong wind events over Antarctica (Turner et al., 2019). Participants in the WAMC delivered presentations on this topic from multiple angles, including interaction between cyclones and a stratospheric air intrusion and the atmospheric blocking trends over the Antarctic Peninsula region. In Adrian MCDONALD's presentation, the strong relationship between extratropical cyclones and extreme snowfall was discussed. Julio MARÍN presented his ongoing research on the seasonality of atmospheric blocking over the Antarctic Peninsula region, as well as its impact on moisture transport and temperature. The goal of this section was to build a better understanding of the formation, impacts, and predictability of the cyclones.

4.4. *Other topics*

The WAMC also covered other research topics, such as the teleconnection between tropical Atlantic and Antarctic climate, foehn warming over the Antarctic Peninsula and West Antarctic region, high salinity shelf water formation in polynyas, the impact of Antarctic clouds, and the climate application of an expanded ice core dataset. The broad range of different topics motivates research and provides all participants a broad perspective in which to practice their research.

5. Plans for the YOPP-SH winter Special Observing Period (SOP)

As the meeting host, David BROMWICH emphasized the two main goals of the YOPP-SH meeting: (1) give the project investigators and representatives of national agencies that are active in Antarctica the opportunity to provide updates on their research resulting from the YOPP summer SOP in the Southern Hemisphere (16 November 2018 to 15 February 2019); (2) highlight advanced planning for the upcoming winter SOP in 2022 (mid-April to mid-July), with its focused activities during a number of Targeted Observing Periods (TOPs).

Kirstin WERNER from the International Coordination Office for Polar Prediction (ICO) noted that the Polar Prediction Project (PPP) has moved into its Consolidation Phase (2019–2022) with a conclusion of the project scheduled for the end of 2022, while the YOPP-SH community continues to be active until 2024. The final phase of the PPP decade includes the planning and organization of the YOPP Final Summit (1–4 May 2022, Montreal, Canada), the YOPP Final Polar Prediction School, a Fellowship program (aligned with YOPP Final Summit), and the evaluation of the project's success. The YOPP Final Summit School (https://yoppfinalsummit.com/yopp-school) is planned to take place from 29 April to 1 May 2022 in Rimouski (near Montreal) and will provide around 30 early-career scientists the opportunity to develop skills in Arctic and Antarctic weather and sea-ice forecasting and at the same time establish connections and develop a network in the polar research community. Besides educational outreach, YOPP-SH also supports research on social sciences. Victoria Heinrich delivered a presentation on better understanding the relationship between various weather information and decision making over Antarctica, which will help mitigate operational risks and improve human safety.

During the 6th YOPP-SH meeting, the scientific achievements and future plans of each nation involved in Antarctic efforts to enhance forecasting skill in the high southern latitudes were presented, as well as potential collaborations among different nations. For example, research on Antarctic sea ice (e.g., Sea Ice Prediction Network South project), data denial experiments for the YOPP-SH summer SOP (e.g., Antarctic Mesoscale Prediction System experiment), and studies on ARs (e.g., extreme events over the Antarctic Peninsula) were all presented during the meeting. These talks covered multiple aspects of Antarctic research initiated by the YOPP-SH project and likely feed into the realization of the Antarctic winter SOP in 2022. In addition, there were two discussion sessions about the winter SOP forecasting teams for (1) the Ross Sea

and East Antarctica region, and (2) the Antarctic Peninsula and the Weddell Sea region, which were led by David BROMWICH and Irina GORODETSKAYA, respectively. Most of the presented projects contributing to the Antarctic winter SOP 2022 are already funded for the upcoming activities, and scientists from different countries expressed their motivation to improve the weather and sea-ice forecasts and build a better understanding of polar meteorology over Antarctica during the austral winter.

6. Summary and future plans

The WAMC and YOPP-SH meetings provide an annual opportunity for the Antarctic weather and climate communities to discuss their research findings and plan next steps, including for the YOPP winter SOP. Despite the inability to meet in person due to the ongoing COVID pandemic, these meetings were well attended (over 140 participants) and had active discussions. All the presentations and extended abstracts from the workshops are available online (http://polarmet.osu.edu/WAMC_2021/). Cloud and precipitation conditions are very active topics for Antarctic research. Current NWP models fail to capture these features accurately due to limited observations and process understanding. Also, atmospheric rivers play a dominant role in extreme precipitation events, resulting in surface melting in summer and enhanced snowfall in winter. In addition, observational networks, data archives and model improvements were emphasized during the meeting, which are critical for real-time forecasts and weather and climate research.

For the future, the observation activities for YOPP-SH winter SOP will be conducted via international collaboration (Fig. 4). The two target regions are the Antarctic Peninsula region and the Ross Sea/East Antarctica region, and the sci-

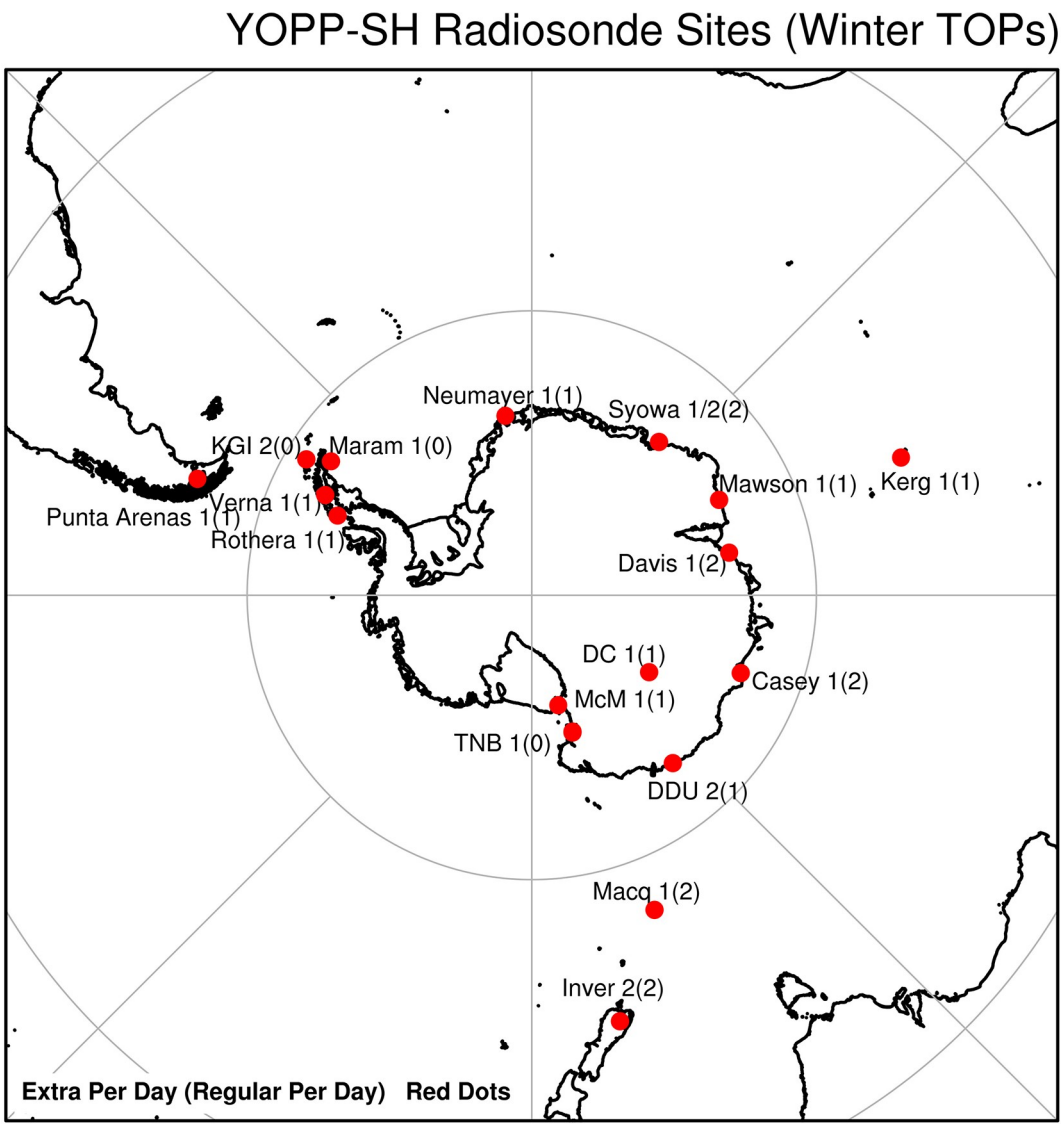

Fig. 4. Planned radiosonde launches during YOPP-SH winter TOPs as of 19 August 2021.

entific foci are major cyclones impacting coastal Antarctica and associated atmospheric rivers. The impact of extra radiosonde observations on weather forecasts will be identified and quantified, and better prediction of extreme weather will be delivered for the benefit of scientific and operational activities in Antarctica. In addition, the AMRDC will provide a formal data repository for operational meteorology and climate research.

For 2022, the hope is for the WAMC and the YOPP-SH meetings to be held, at least partially, in-person. Planning for these meetings is currently on-going.

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