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

David H. Bromwich[1], Matthew A. Lazzara[2,3], Arthur M. Cayette[4], Jordan G. Powers[5], Kirstin Werner[6], John J. Cassano[7], Steven R. Colwell[8], Scott Carpentier[9], and Xun Zou[1]

[1] Byrd Polar and Climate Research Center, The Ohio State University, Columbus, OH, USA
[2] Antarctic Meteorological Research Center, Space Science and Engineering Center, University of Wisconsin-Madison, Madison, WI, USA
[3] Department of Physical Sciences, Madison Area Technical College, Madison, WI, USA
[4] Naval Information Warfare Center, Charleston, SC, USA
[5] National Center for Atmospheric Research, Boulder, CO, USA
[6] Year of Polar Prediction (YOPP) International Coordination Office, Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany
[7] National Snow and Ice Data Center, Cooperative Institute for Research in Environmental Sciences and Department of Atmospheric and Oceanic Sciences, University of Colorado, Boulder, CO, USA
[8] British Antarctic Survey, Cambridge, United Kingdom
[9] Bureau of Meteorology, Hobart, Tasmania, Australia

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[1] 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 workshop 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 updated the research achievements from the YOPP summer Special Observing Period (SOP) in the Southern Hemisphere (November 16, 2018 to February 15, 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[2].

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 for the past two decades. Matthew Lazzara provided an update

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[1] http://polarmet.osu.edu/WAMC_2021/
[2] http://polarmet.osu.edu/WAMC_2021/BPCRC_tech_report_2021-001.pdf

42 on the new Antarctic Meteorological Research and Data Center (AMRDC), as the follow-on

43 effort. This is a joint undertaking between UW-Madison and Madison Area Technical College

44 and funded by the National Science Foundation's (NSF) Office of Polar Programs. The project

45 establishes a formal data repository for US Antarctic meteorological datasets. The repository

46 offers a sustained location for Antarctic meteorological datasets from a variety of sources, that

47 follow FAIR (findable, accessible, interoperable, and reusable) principles, and allow the issuance

48 of digital object identifiers (DOIs) - all meeting NSF requirements for investigators seeking a

49 final location to deposit datasets from their projects. The AMRDC will also hold unique datasets

50 from USAP main stations, field camps, airfields, etc. Creations of Antarctic satellite imagery

51 composites (Fig. 2), maintaining the Antarctic Internet Data Distribution (Antarctic-IDD; Fig. 3)

52 and providing expert analysis work (e.g., climatology reports, case studies, white papers, etc.) are

53 also a part of the new effort.

54

55 *2.2 Automatic Weather Station network.*

56   The largest meteorological network across the Antarctic continent is composed of

57 Automatic Weather Station networks (AWSs). Presentations by Lee Welhouse, Dave

58 Mikolajczyk and Mairi Simms discussed the United States (University of Wisconsin-Madison)

59 and United Kingdom (UK) AWS networks across the Antarctic. Updates on past field season

60 work (despite the pandemic) were presented along with plans for the upcoming 2021-2022 field

61 season. The UW-Madison AWS group did not have a field season in 2020-2021 for the first time

62 in 40 years. During the 2021-2022 field season, activities will include AWS repairs at some

63 critical AWS sites in West Antarctica, and those in the Ross Ice Shelf/McMurdo Station area.

64 Other work underway include testing new communication systems and improving the observing

65 strategy based on World Meteorological Organization recommendations. Simms presented the

66 work accomplished on the UK AWS networks during the 2020-2021 field season. The British

67 Antarctic Survey (BAS) maintains a network of 8 AWS in Antarctica and also services four for

68 other countries. During the previous summer season all but two (Limbert and Baldrik) were

69 visited and the Koni Steffen AWS was removed. Next season it is hoped that some of the BAS

70 AWS will be changed over to a pole mounted system rather than a mast system to reduce

71 servicing time.

72

73 *2.3 Operational Meteorology*

74   Naval Information Warfare Center, Atlantic, Polar Programs (NPP) provides operational

75 meteorological forecasting and weather observing services for the United States Antarctic

76 Program. Meteorological service by NPP has been in place since 1997 supporting aviation, ship,

77 and station services. This is a continuation of the support provided by the United States Navy

78 since the construction of McMurdo Station. Support and management over the decades have

79 been adaptive to provide the National Science Foundation the greatest ability to take advantage

80 of the science support and improve the accuracy and knowledge through cooperative learning

81 and data sharing initiatives.

82   Presentations by Arthur Cayette, John Meyer, Michael Johnson and Jeffrey Fournier

83 discussed the meteorological services provided by NPP. It was noted that NPP provides over

84 2500 forecasts and briefing services annually. The scope of these responsibilities includes, but is

85 not limited to:

86 ● Antarctic continental weather forecasting and McMurdo Station weather observing

87   support services for all USAP customers;

88   ● Ship, traverse, station, camp and personnel weather support for any USAP location south

89   of 60 ºS latitude;

90   ● Archival and dissemination of weather data;

91   ● Provision of USAP interface for data sharing with regional and world meteorological

92   organizations;

93   ● Implementation and maintenance of training and qualification/certification program;

94   ● Maintaining an active quality assurance program that ensures proficiency of assigned

95   personnel, accomplishment of program objectives, and safety of operations .

96

97   **3. High-Latitude Environmental Prediction**

98   Sessions on high-latitude numerical weather prediction (NWP) and model development

99   are perennial components of the WAMC. The 2021 WAMC featured talks on various

100   applications of atmospheric models over Antarctica, for both real-time forecasting and research.

101   Two presentations by Jordan Powers and Kevin Manning addressed the Antarctic Mesoscale

102   Prediction System (AMPS) efforts. AMPS is a real-time NWP system maintained by the U.S.

103   National Center for Atmospheric Research to support the needs of the weather forecasters for the

104   U.S. Antarctic Program (USAP).

105   The annual update talk focused on upcoming changes to the AMPS archive. The High

106   Performance Storage System at NCAR, which has housed the archive, is being decommissioned,

107   and this has forced a shift to a disk-based storage system. Given the new hardware's capacity

108   constraints, the revised AMPS archive will focus on holding GRIB format model output (mostly

109   WRF) for the long term, while still making full model output in native netCDF format available

110   for a period of up to six months. A second AMPS talk covered the system's development plans

111   for the next few years. In addition to this shift to a new AMPS archive infrastructure, the system

112   will see increasing emphasis on the Model for Prediction Across Scales (MPAS), currently run in

113   AMPS. MPAS will be applied at higher resolution to match the WRF grid (e.g., 8-km

114   continental), and it will be tested with a new regional domain capability. Model physics for both

115   WRF and MPAS will continue to be a focus in AMPS, particularly the areas of microphysics and

116   the planetary boundary layer. In system computing efforts, AMPS will be moving to a new

117   community supercomputer at NCAR from 2022 on, and the system will continue to use cloud

118   computing for support when the mainframe is under service.

119   Also, results from the Atmospheric Radiation Measurement (ARM) West Antarctic

120   Radiation Experiment (AWARE) project were presented during the meeting. Funded by the

121   Department of Energy (DOE) and the National Science Foundation (NSF), this project collected

122   and analyzed observations of atmospheric energy components, air masses, and cloud

123   microphysics over Ross Island and West Antarctica, with the goal of better understanding the

124   causes and mechanisms of the changing climate (Lubin *et al.*, 2020). The ongoing AWARE

125   project provides support for a wide variety of research. In David Kingsmill's presentation, the

126   forecast ability of AMPS for strong wind and precipitation events was evaluated based on

127   AWARE observations. Keith Hines presented much improved Polar WRF simulations of frigid

128   mixed-phase clouds observed at McMurdo during AWARE project. Mckenzie Dice showed an

129   analysis of the relationship of atmospheric state and boundary layer variability at McMurdo

130   based on the AWARE dataset[3]. During the austral summer in 2018-2019, data were collected

131   from the Siple Dome Field Camp for 28 days. Dan Lubin, the lead PI of AWARE project,

132   introduced the new West Antarctic dataset at the meeting.

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[3] https://www.arm.gov/research/campaigns/amf2015aware

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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 mid-latitude regions. ARs can be associated with extra-tropical cyclones and contribute to the 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 workshop included several presentations on this topic.

During the workshop, the methodology of ARs 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 from 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.

154

4.2 Extreme precipitation events

156   Associated with ARs, extreme precipitation events over Antarctica were fully

157 investigated and discussed during the WAMC meeting. Etienne Vignon provided an overview of

158 rainfall occurrence over Antarctica and a projection based on multiple latest-generation climate

159 models, which suggested more frequent and intense precipitation events in the future (Vignon *et*

160 *al.,* 2021). As mentioned in Diogo Luís's presentation, precipitation is a major factor for surface

161 melting, sea ice loss, and the change of ocean surface salinity. The input of the freshwater has a

162 significant impact on the global hydrological cycle and ocean circulation. Thus, the predictability

163 of extreme precipitation events is critical for the Southern Ocean/Antarctica. As mentioned in

164 Svitlana Krakovska's presentation, extra observations of the vertical structure of weather

165 systems, such as cold fronts and jet streams, can help decrease the uncertainties in weather

166 forecasts. Thus, vertical radiosonde data will be used to adjust model forecasts, especially for

167 microphysical properties of clouds and precipitation.

168

169 *4.3 Antarctic Cyclones and Strong Wind Events*

170   Extra-tropical cyclones are highly associated with the extreme snowfall and strong wind

171 events over Antarctica (Turner *et al.*, 2019). Participants in the WAMC workshop delivered

172 presentations on this topic from multiple angles, including interaction between cyclones and a

173 stratospheric air intrusion and the atmospheric blocking trends over the Antarctic Peninsula

174 region. In Adrian McDonald's presentation, the strong relationship between extra-tropical

175 cyclones and extreme snowfall were discussed. Julio Marín presented his ongoing research on

176 the seasonality of atmospheric blocking over the AP region, as well as its impact on moisture

177 transport and temperature. The goal of this section was to build a better understanding of the

178 formation, impacts, and predictability of the cyclones.

179

4.4 Other Topics

181   The WAMC workshop also covered other research topics, such as the teleconnection

182   between tropical Atlantic and Antarctic climate, foehn warming over the AP and West Antarctic

183   region, high salinity shelf water formation in polynyas, the impact of Antarctic clouds, and the

184   climate application of an expanded ice core dataset. The broad range of different topics

185   motivates research and provides all participants a broad perspective in which to practice their

186   research.

187

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

189   As the meeting host, David Bromwich emphasized the two main goals of the YOPP-SH

190   meeting: 1) give the project investigators and representatives of national agencies that are active

191   in Antarctica the opportunity to provide updates on their research resulting from the YOPP

192   summer SOP in the Southern Hemisphere (Nov. 16, 2018 to Feb. 15, 2019); 2) highlight

193   advanced planning for the upcoming winter SOP in 2022 (mid-April to mid-July) with its

194   focused activities during a number of Targeted Observing Periods (TOPs).

195   Kirstin Werner from the International Coordination Office for Polar Prediction (ICO)

196   noted that the Polar Prediction Project (PPP) has moved into its Consolidation Phase (2019-

197   2022) with a conclusion of the project scheduled for the end of 2022, while the YOPP in the

198   Southern Hemisphere (YOPP-SH) community continues to be active until 2024. The final phase

199   of the PPP decade includes the planning and organization of the YOPP Final Summit (1-4 May

200   2022, Montreal, Canada), the YOPP Final Polar Prediction School, a Fellowship program

201   (aligned with YOPP Final Summit), and the evaluation of the project's success. The YOPP Final

202 Summit School[4] is planned to take place from 29 April to 1 May 2022 in Rimouski near

203 Montreal, and will provide around 30 early career scientists the opportunity to develop skills in

204 Arctic and Antarctic weather and sea-ice forecasting and at the same time establish connections

205 and develop a network in the polar research community. Besides educational outreach, YOPP-

206 SH also supports research on social sciences. Victoria Heinrich delivered a presentation to better

207 understand the relationship between various weather information and decision making over

208 Antarctica, which will help mitigate operational risks and improve human safety.

209   During the 6th YOPP-SH meeting, the scientific achievements and future plans of each

210 nation involved in Antarctic efforts to enhance forecasting skill in the high southern latitudes

211 were presented, as well as potential collaborations among different nations. For example,

212 research on Antarctic sea ice (e.g., Sea Ice Prediction Network South project), data denial

213 experiments for the YOPP-SH summer SOP (e.g., Antarctic Mesoscale Prediction System

214 experiment), and studies on ARs (e.g., extreme events over the Antarctic Peninsula) were all

215 presented during the meeting. These talks covered multiple aspects of Antarctic research initiated

216 by the YOPP-SH project and likely feed into the realization of the Antarctic winter SOP in 2022.

217 In addition, there were two discussion sessions about the winter SOP forecasting teams for i) the

218 Ross Sea and East Antarctica region, and ii) the Antarctic Peninsula and the Weddell Sea region,

219 which were led by David Bromwich and Irina Gorodetskaya, respectively. Most of the presented

220 projects contributing to the Antarctic winter SOP 2022 are already funded for the upcoming

221 activities, and scientists from different countries expressed their motivation to improve the

222 weather and sea-ice forecasts and build a better understanding of polar meteorology over

223 Antarctica during the austral winter.

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[4] https://yoppfinalsummit.com/yopp-school

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225   **6. Summary and Future Plans**

226   The WAMC and YOPP-SH meetings provide an annual opportunity for the Antarctic

227   weather and climate communities to discuss their research findings and plan next steps, including

228   for the YOPP Winter SOP. Despite the inability to meet in person due to the ongoing COVID

229   pandemic these meetings were well attended (over 140 participants) and had active discussions.

230   All of the presentations and extended abstracts from the workshops are available online[5]. Cloud

231   and precipitation conditions are very active topics for Antarctic research. Current NWP models

232   fail to capture these features accurately due to limited observations and process understanding.

233   Also, atmospheric rivers play a dominant role in extreme precipitation events resulting in surface

234   melting in summer and enhanced snowfall in winter. In addition, observational networks, data

235   archives and model improvements were emphasized during the meeting, which are critical for

236   real-time forecasts and weather and climate research.

237   For the future, the observation activities for YOPP-SH Winter SOP will be conducted via

238   international collaboration (Fig. 4). The two target regions are the Antarctic Peninsula region and

239   the Ross Sea/East Antarctica region, and the scientific foci are major cyclones impacting coastal

240   Antarctica and associated atmospheric rivers. The impact of extra radiosonde observations on

241   weather forecasts will be identified and quantified, and better prediction of extreme weather will

242   be delivered for the benefit of scientific and operational activities in Antarctica. In addition, the

243   AMRDC will provide a formal data repository for operational meteorology and climate research.

244   It is hoped that the 2022 WAMC and the YOPP-SH meetings will be held, at least

245   partially, in-person. Planning for these meetings is currently on-going.

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[5] http://polarmet.osu.edu/WAMC_2021/

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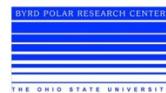
294
295   Figure 1. Opening of the 16th WAMC Meeting. (Picture on the left is from Antarctica Guide[6])

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[6] https://www.antarcticaguide.com/antarctica-wildlife-2/antarctica-penguins

ANTARCTIC COMPOSITE INFRARED IMAGE 4 AUG 21 AT 22 UTC AMRC (SSEC UW-MADISON)
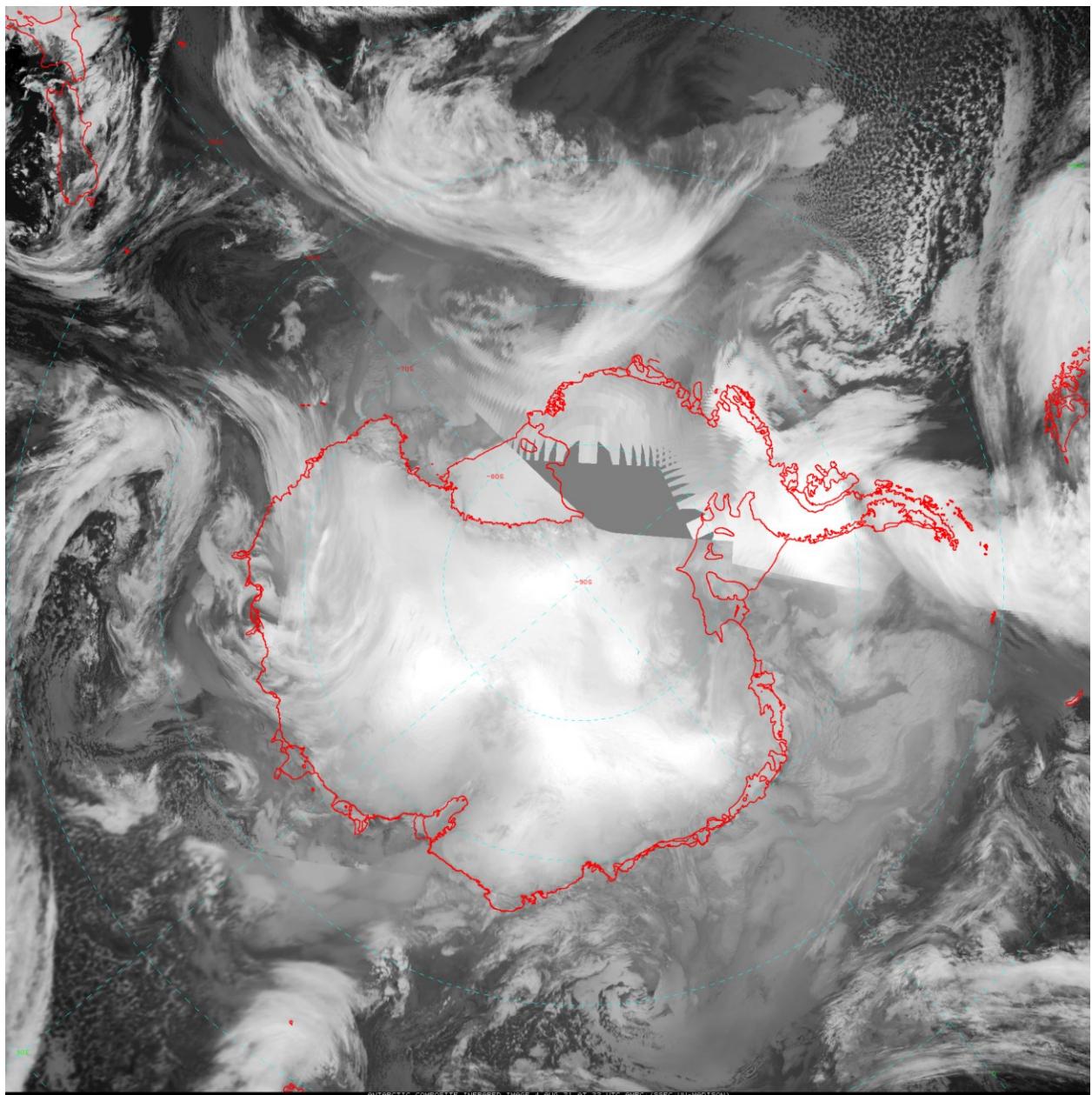
Figure 2. A sample infrared Antarctic composite from 22 UTC on August 4, 2021 made
operationally at UW-Madison as a part of the AMRDC project.
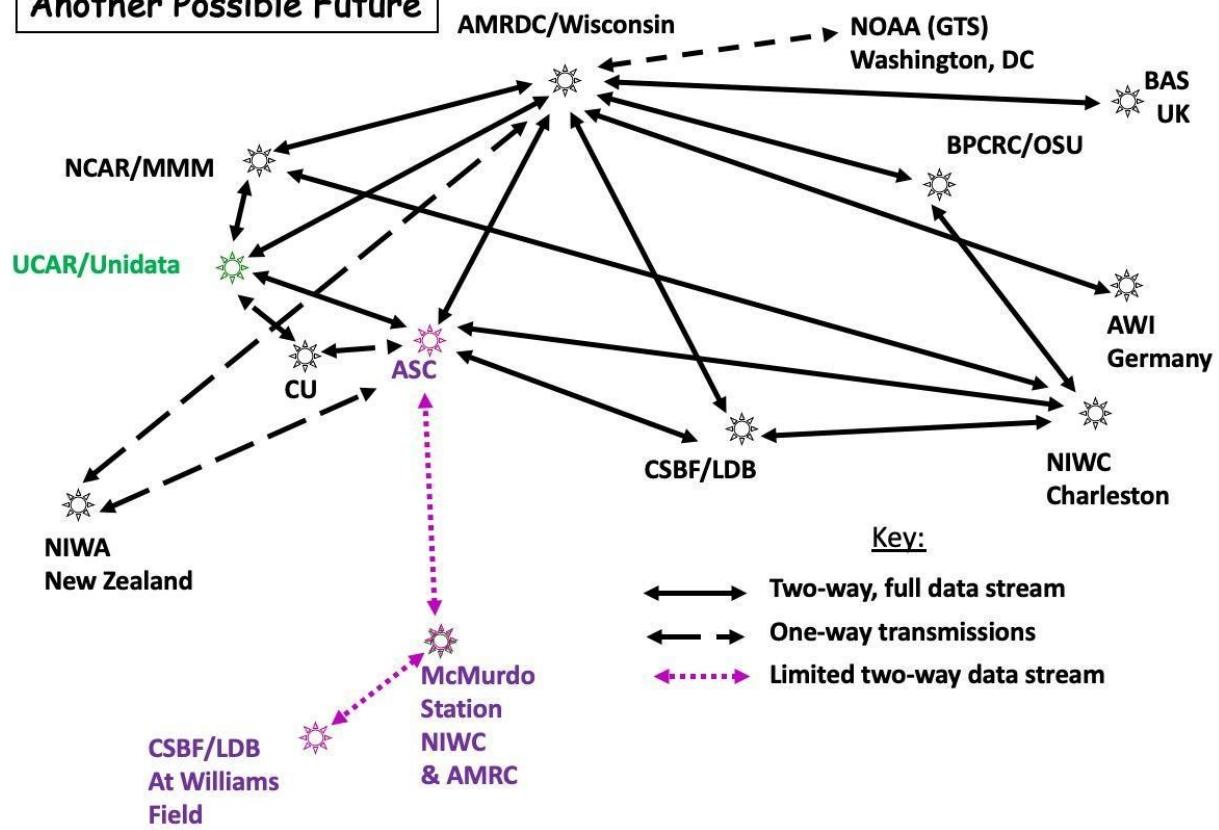
Figure 3. The Antarctic-Internet Data Distribution real-time data relay for Antarctic meteorological data, is a key element of the AMRDC project, in service to the Antarctic meteorological community. It connects operational, education, and research segments with a distribution/sharing of real-time model and observational data. Here a possible future for the network is outlined.

YOPP-SH Radiosonde Sites (Winter TOPs)

Extra Per Day (Regular Per Day)   Red Dots

(Labels visible on map: Neumayer 1(1), Syowa 1/2(2), KGI 2(0), Maram 1(0), Mawson 1(1), Kerg 1(1), Punta Arenas 1(1), Verna 1(1), Rothera 1(1), Davis 1(2), DC 1(1), Casey 1(2), McM 1(1), TNB 1(0), DDU 2(1), Macq 1(2), Inver 2(2))
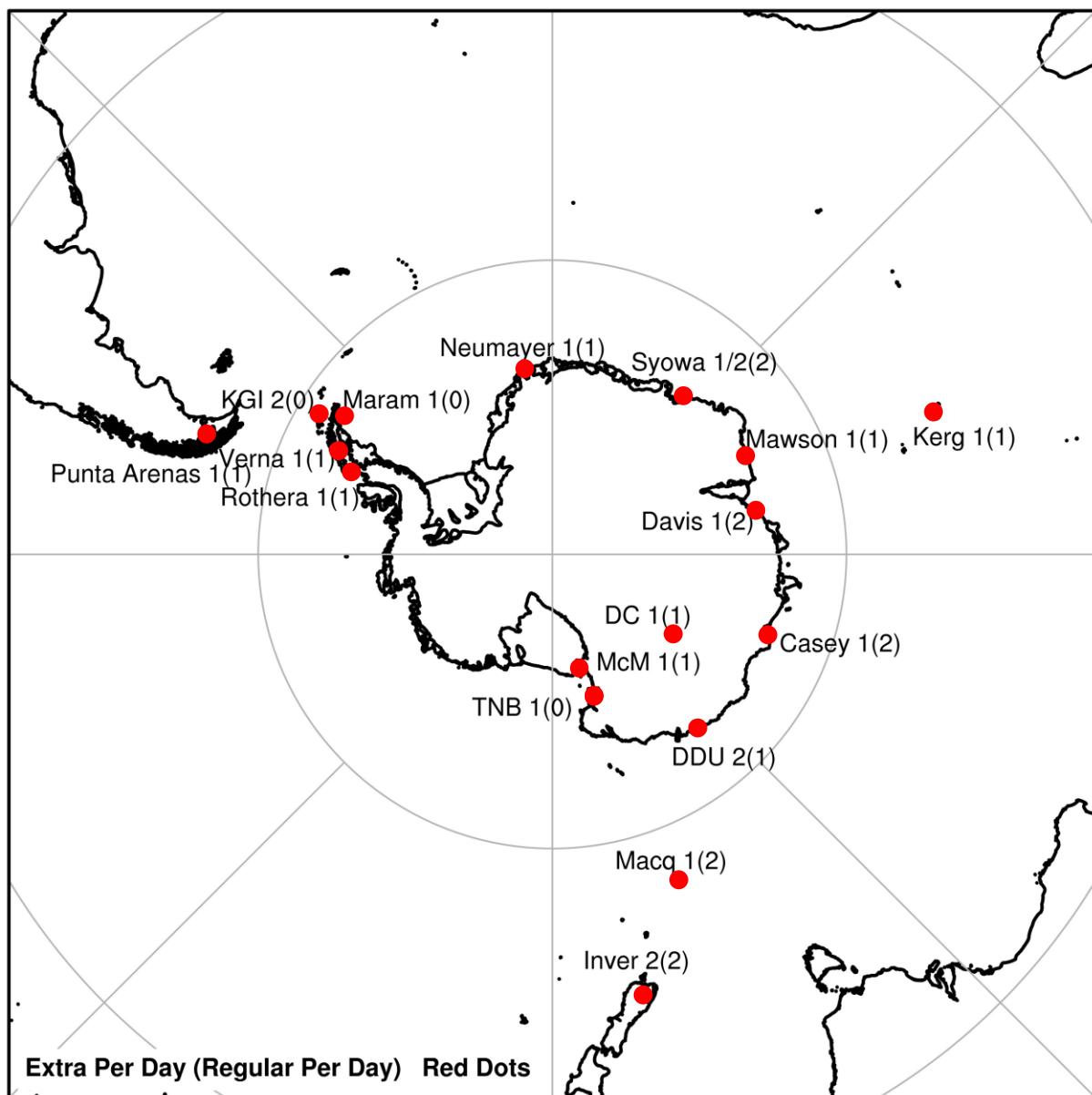
306
307   Figure 4. Planned radiosonde launches during YOPP-SH Winter TOPs as of August 19, 2021.