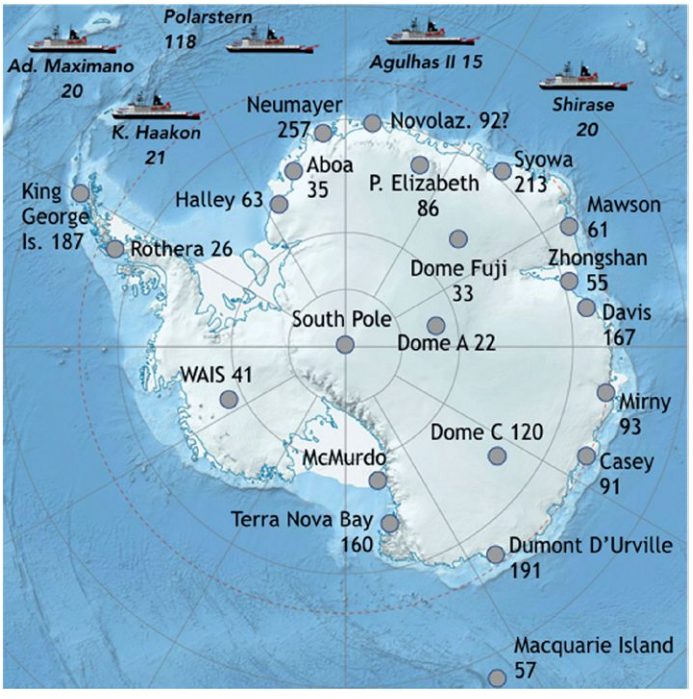
Year of Polar Prediction

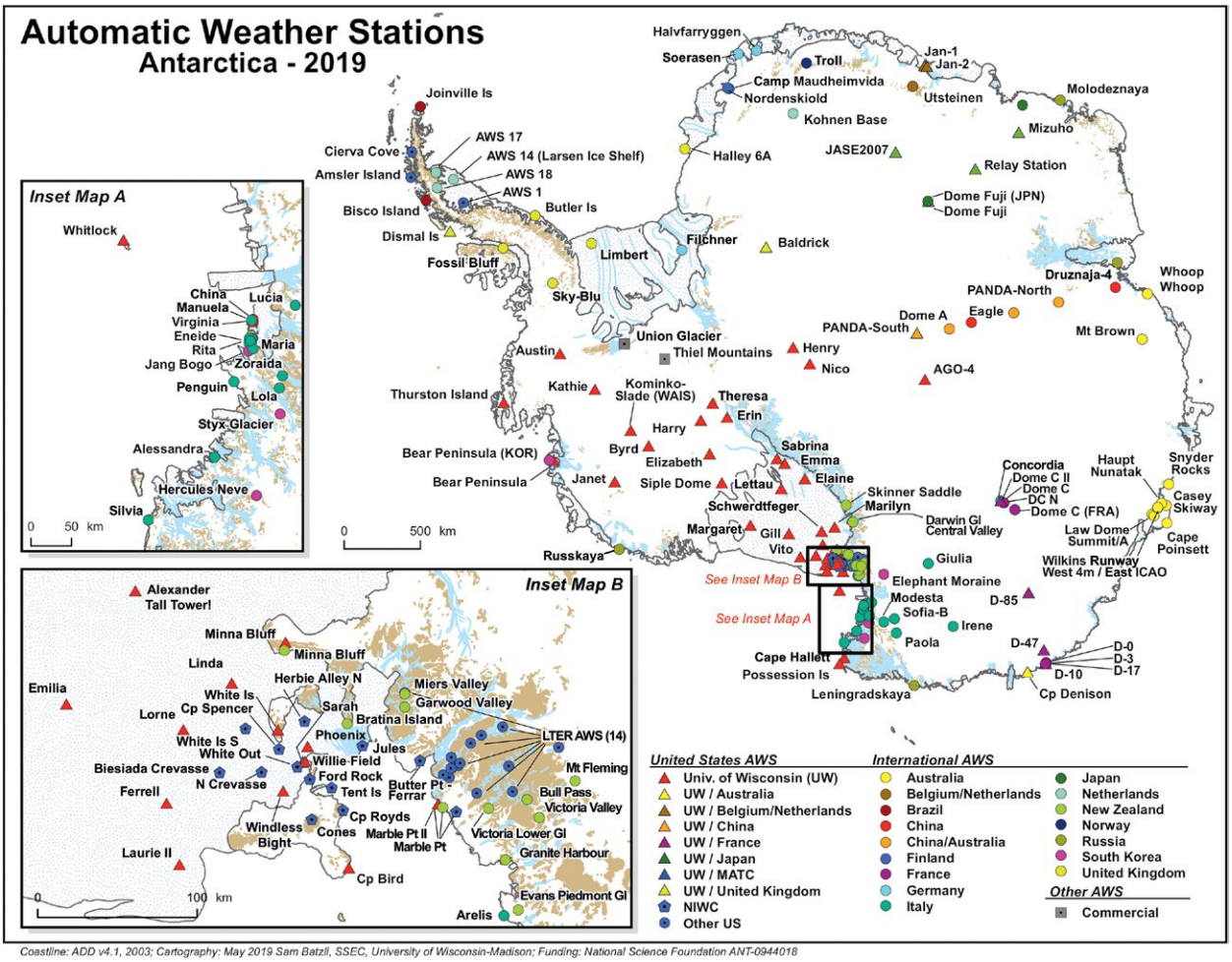
A Focus on Antarctica

Adapted from "The Year of Polar Prediction in the Southern Hemisphere (YOPP-SH)," by **David H. Bromwich** (The Ohio State University), **Kirstin Werner, Barbara Casati, Jordan G. Powers, Irina V. Gorodetskaya, Francois Massonnet, Vito Vitale, Victoria J. Heinrich, Daniela Liggett, Stefanie Arndt, Boris Barja, Eric Bazile, Scott Carpentier, Jorge F. Carrasco, Taejin Choi, Yonghan Choi, Steven R. Colwell, Raul R. Cordero, Massimo Gervasi, Thomas Haiden, Naohiko Hirasawa, Jun Inoue, Thomas Jung, Heike Kalesse, Seong-Joong Kim, Matthew A. Lazzara, Kevin W. Manning, Kimberley Norris, Sang-Jong Park, Phillip Reid, Ignatius Rigor, Penny M. Rowe, Holger Schmithüsen, Patric Seifert, Qizhen Sun, Taneil Uttal, Mario Zannoni,** and **Xun Zou**. Published online in *BAMS*, October 2020. For the full, citable article, see DOI:10.1175/BAMS-D-19-0255.1.



Counts of additional radiosonde launches during the YOPP-SH SOP. Routine launches were also made at most of these locations. For example, McMurdo and the South Pole each had two routine soundings per day. Neumayer station and Terra Nova Bay increased coverage up to four times per day. In all, during the SOP an average of 24 additional radiosondes were launched each day, roughly doubling the number of routine soundings.

From 16 November 2018 to 15 February 2019, the Year of Polar Prediction (YOPP) in the Southern Hemisphere (SH) held a special observing period (SOP). YOPP is a flagship activity of the Polar Prediction Project (PPP), a 10-year (2013–22) WMO/WWRP initiative. Seventeen nations contributed to greatly enhanced observations during the SOP—primarily from radiosondes and drifting buoys.



Coastline: ADD v4.1, 2003; Cartography: May 2019 Sam Batzli, SSEC, University of Wisconsin-Madison; Funding: National Science Foundation ANT-0944018

Sea ice and snow are key variables in the global climate (e.g., through ice–albedo feedback and freshwater budgets during melt and formation): they strongly impact global circulation far beyond the polar regions. To obtain information about the seasonal and interannual variability and evolution of ice floes in YOPP-SH SOP, various autonomous ice-tethered platforms were deployed: ice mass balance buoys (IMBs) deriving sea ice growth; snow-depth buoys measuring snow accumulation over the year; and surface velocity profilers (SVPs) monitoring local oceanic and sea ice drift. Drifting buoys were typically equipped with sensors measuring sea level pressure and air and/or internal temperature.

An additional 2,224 radiosondes were launched during the SOP from 24 land-based stations and 5 ships. The resulting unique dataset is a foundation for observing system experiments. Most atmospheric soundings were transmitted for real-time use by global forecasting centers such as NCEP. Also, all SVP and snow buoys reported their position together with measurements of surface temperature and atmospheric pressure for operational forecasting centers. The additional YOPP data appear to improve numerical weather prediction (NWP) of polar weather and sea ice.

Météo-France created a specific NWP model configuration for YOPP-SH SOP called ARPEGE-SH, based on its global model ARPEGE but with its high-resolution area (~7.5 km) over Antarctica instead of over France. In addition to an increase in the horizontal resolution of ARPEGE-SH,

Antarctic Automatic Weather Stations (AWS) known to be operating in 2019.

The British Antarctic Survey's open-access archive of SOP soundings is at https://yopp.met.no/node/34.

AMPS forecasts are freely available at www2.mmm.ucar.edu/rt/amps.

All buoys that were deployed and have been active in Antarctica can be viewed at http://iabp.apl.washington.edu/IPAB_Table.html, provided by the International Programme for Antarctic Buoys (IPAB).

the improved forecasts with the model may have also benefitted from assimilation of the 680 radiosonde temperature observations in the boundary layer during YOPP-SH SOP.

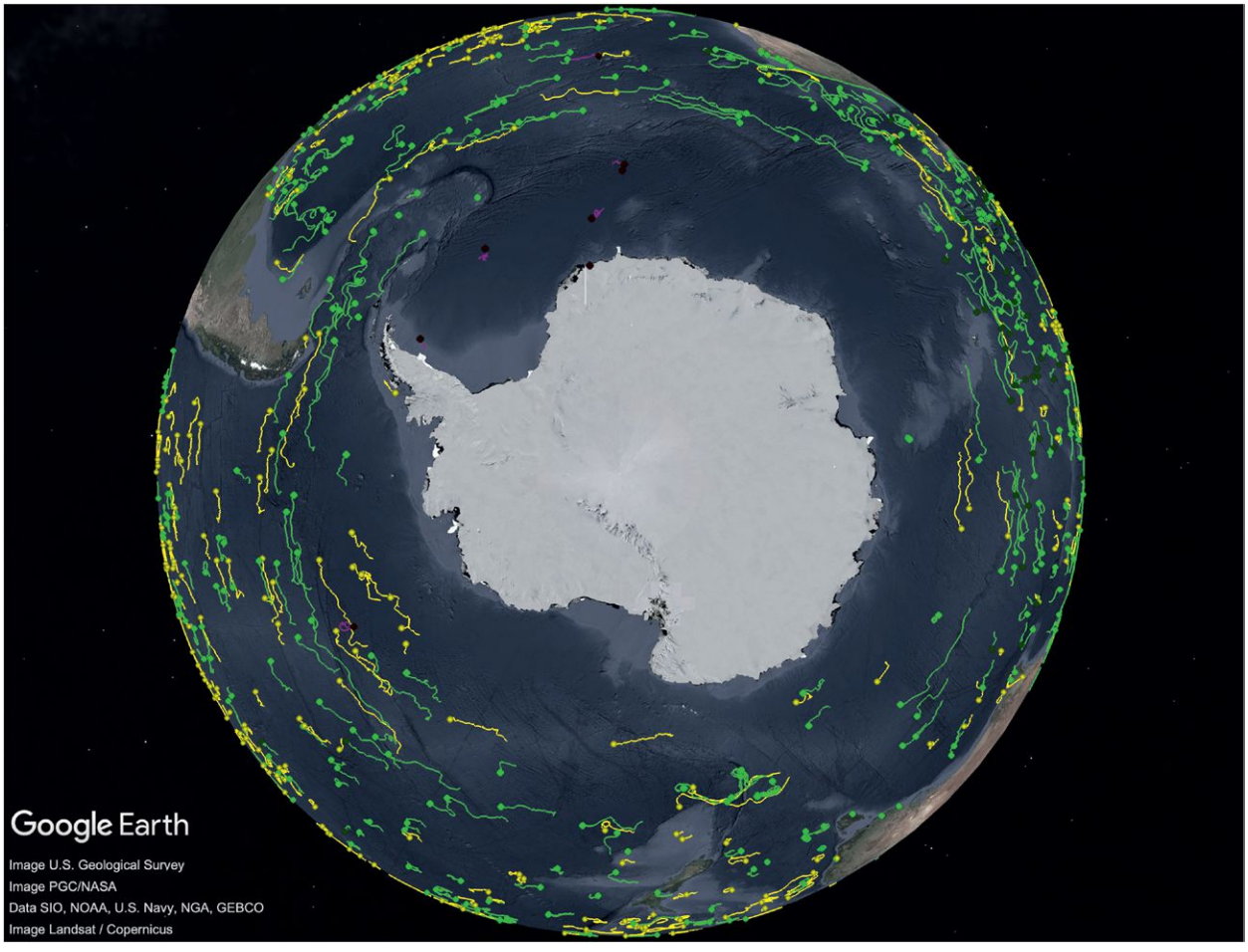
In a targeted study, the Antarctic Mesoscale Prediction System (AMPS), a real-time NWP system run by NCAR based on the Weather Research and Forecasting (WRF) model, is being applied (with 24-km grid spacing over the Southern Ocean) to understand the forecast impact of the additional YOPP-SH SOP radiosonde data. Preliminary results focus on forecasts for the strongest cyclone in the Amundsen Sea in the test period (28 December 2018 to 20 January 2019). With the additional SOP soundings, 48-h forecasts of the target cyclone clearly improved in terms of surface pressure and wind bias. Similarly, in two SH cases investigated prior to YOPP-SH SOP, ensemble predictions of cyclone development and trajectory were only successful when additional radiosonde observations were assimilated.

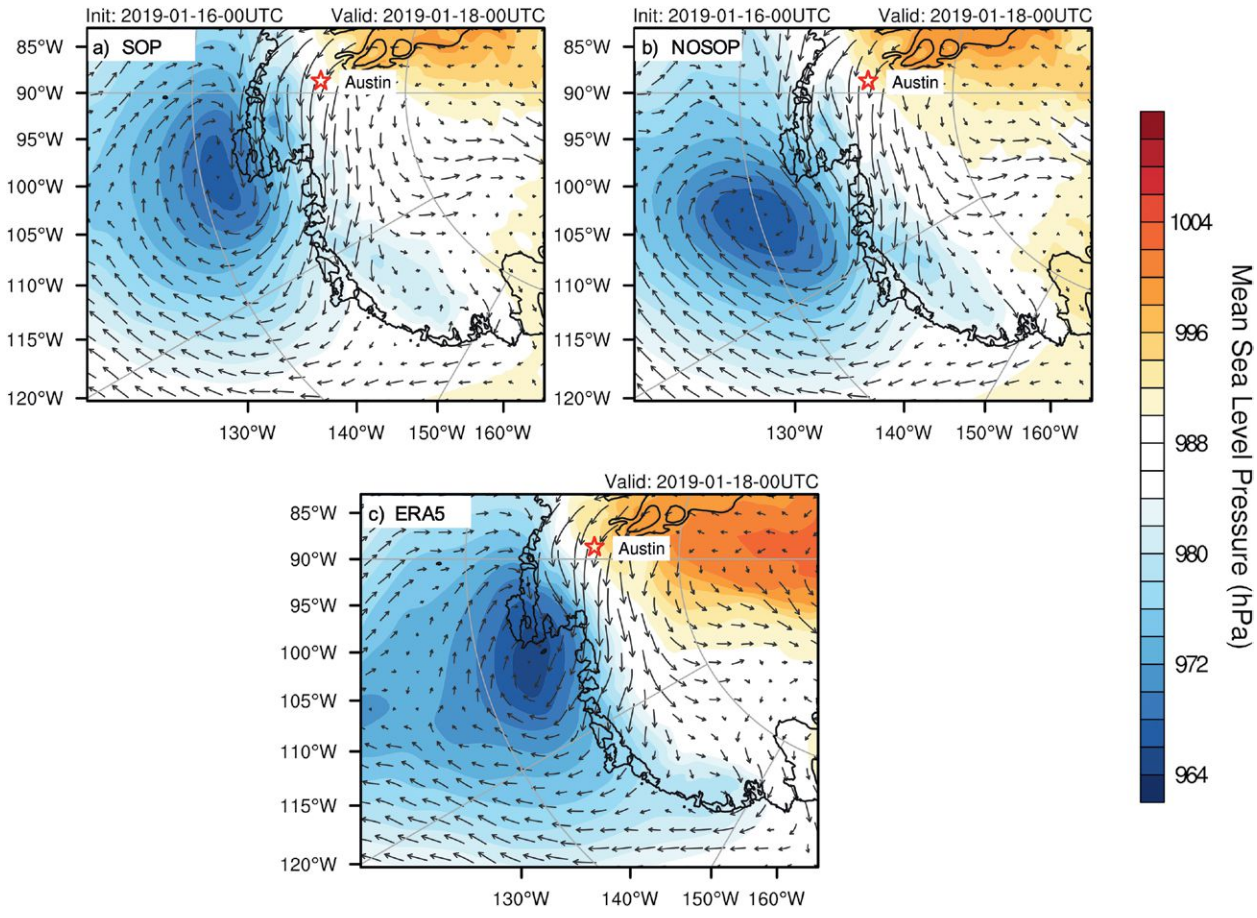
Although satellite data improve upper-tropospheric fields, YOPP results in the Northern Hemisphere (NH) show that a

The European Centre for Medium-Range Weather Forecasts (ECMWF) provides an archive of their twice-daily global coupled atmosphere–ocean–sea ice–land model forecasts for the entire YOPP period starting in May 2017—see the YOPP Data Portal (https://yopp.met.no/) for details.

A control configuration has WRF forecasts assimilating the set of routine (i.e., pre-SOP) observations available to AMPS ("no-SOP" runs), while the test configuration adds the extra SOP soundings to that observation set ("SOP" runs) in the assimilation step.

Overview of drifting buoys active at the start of the YOPP-SH SOP. Yellow buoys only report surface temperature to the WMO Global Telecommunications System, while green buoys also report surface pressure. Purple buoys close to Antarctica were supplied by the Alfred Wegener Institute. Tracks show hourly locations during November 2018 with dots denoting end-of-month positions. The very limited coverage south of about 60°S is primarily due to sea ice.





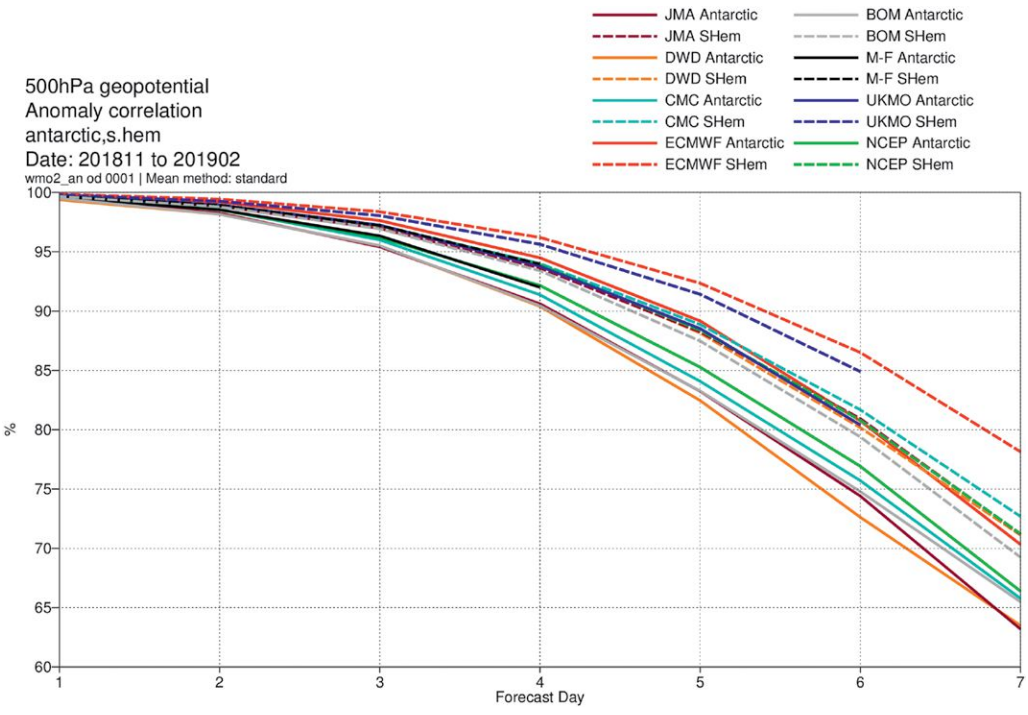
Compared to the forecast without SOP additional soundings and to the ERA5 global reanalysis, the 48-h SOP forecast utilizing the additional soundings more accurately captures this sea level low center along the West Antarctic coast, including its orientation along with the surface wind field (vectors).

skillful forecast of circulation in the mid- and lower troposphere depends on radiosondes. The impact of extra radiosondes on weather predictions in the Antarctic and SH midlatitudes will be further investigated by focusing on the contrast between Antarctic and Arctic observing networks.

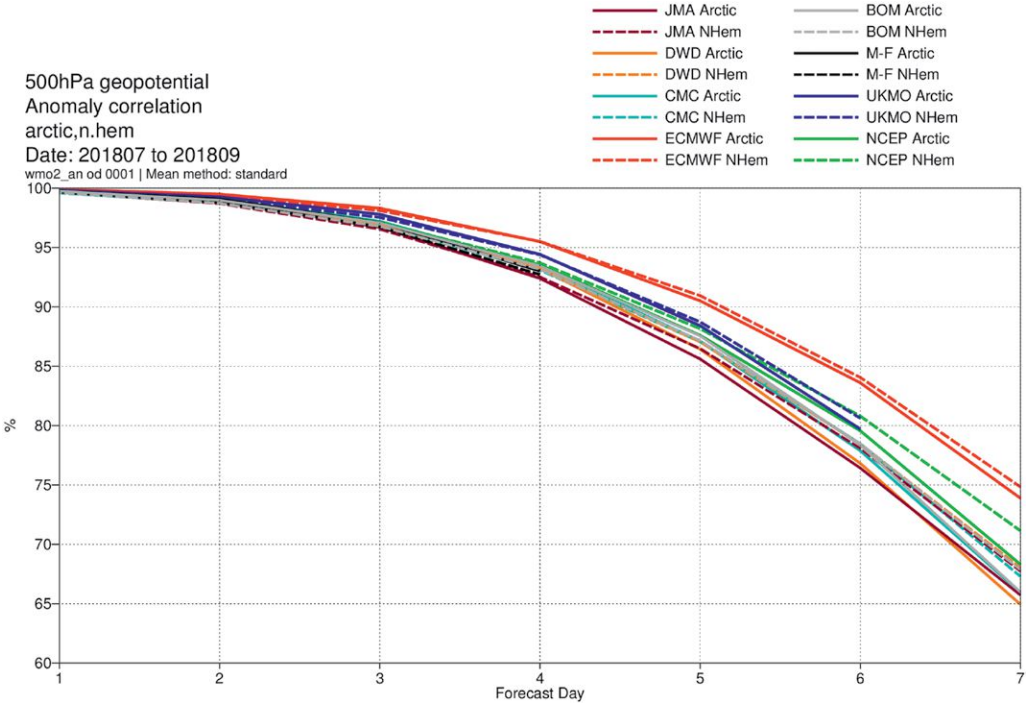
In addition to NWP-based studies, a YOPP site Model Intercomparison Project (YOPPsiteMIP) is coordinating process-based model evaluation using observations from selected Arctic and Antarctic supersites. This evolving project encourages contributions by other modeling centers and welcomes evaluation studies.

YOPP-SH SOP global model evaluations confirmed that extratropical SH forecast skill lags behind NH skill and the contrast is greatest between the polar regions. Improving the ability to forecast meaningful weather and sea ice conditions and understanding their uncertainties are vital for such harsh and isolated locations. PPP will conclude by focusing on translating YOPP scientific insights into more reliable weather and sea ice forecast services for human activities in the polar regions. A workshop planned for June 2021 in Columbus, Ohio, aims to create dialogue between forecasters, researchers, and other forecast users regarding how best to present Antarctic forecasts. Later in 2021, similar PPP workshops will focus on transitioning Arctic science to service provisions.

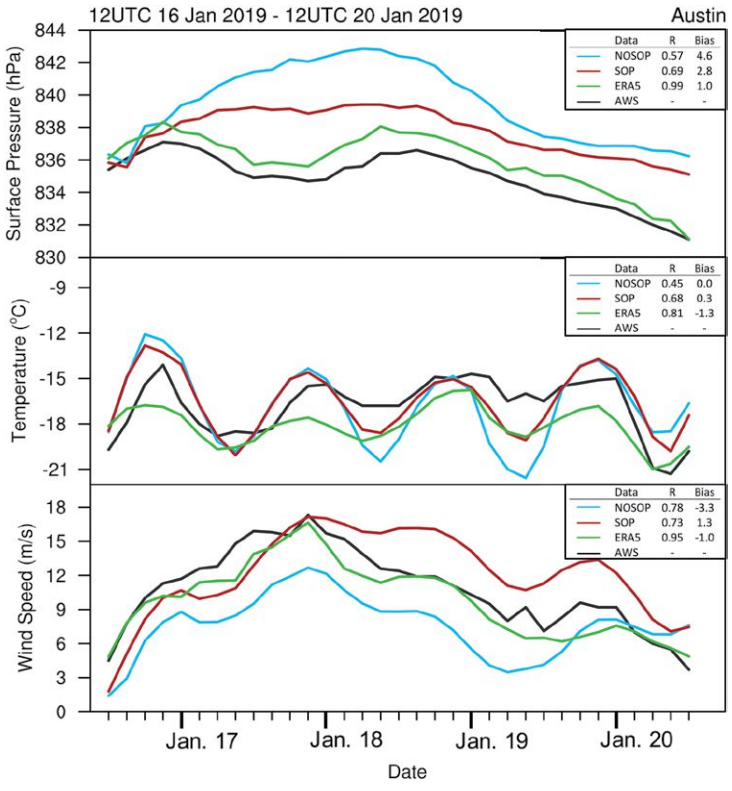
The routine observations used in AMPS are surface data (e.g., AWS, SYNOP, METAR); upper-air soundings; aircraft observations; ship and buoy observations; geostationary and polar-orbiting satellite AMVs (atmospheric motion vectors); GPS radio occultations; and AMSU (Advanced Microwave Sounding Unit) radiances.



Southern summer: After day 4, the 500-hPa forecast is 12–18-h poorer over Antarctica than over the extratropics (poleward of 20°S)—this is seen by comparing the dashed lines with the solid lines for each color (model). The contrast between polar and midlatitudes is larger for the SH, presumably because observational coverage and understanding of atmospheric processes is more limited, implying the potential for YOPP-SH SOP to improve forecasts significantly.

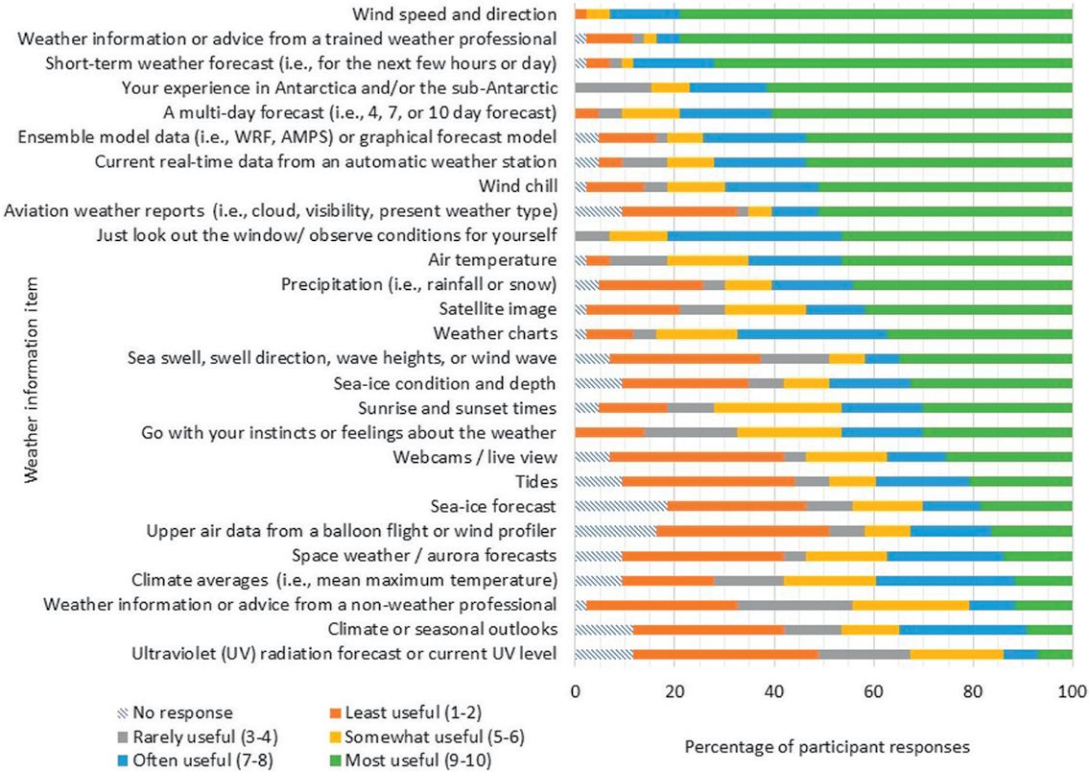


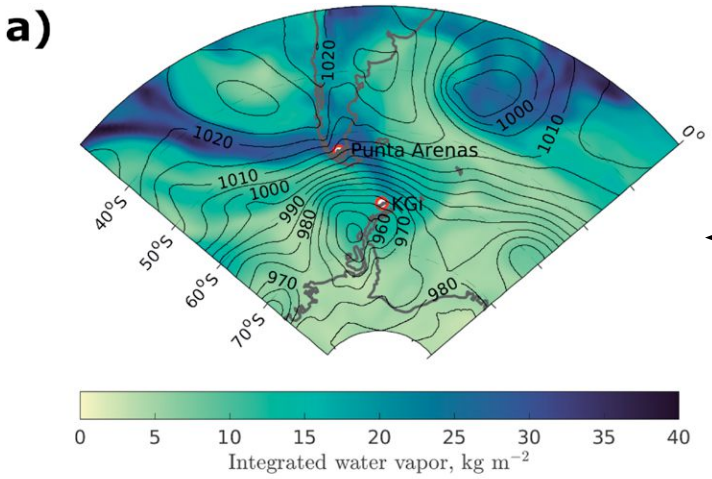
Northern summer: Forecast performance for the Arctic is superior compared to Antarctica and is only 0–6 h behind that for the extratropical North (latitudes poleward of 20°N).



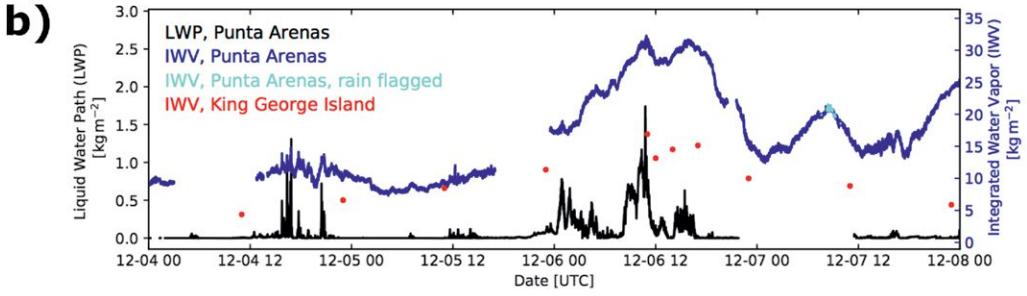
The Austin AWS observations in West Antarctica compared to the no-SOP and SOP versions of forecasts (initialized at 0000 UTC 16 Jan 2019) and to the ERA5 reanalysis. Bias is the average bias error in each parameter (hPa, °C, m s^{-1}) for the period. The positive impact of the SOP soundings is consistent with other recent findings reporting forecast improvements from additional radiosonde data.

Usefulness of weather information during deployment to the Antarctic and/or sub-Antarctic. Percent of responses to the question, "On a scale from 1 (not at all useful) to 10 (most useful), please assess how useful you find each of the following items when you are in the Antarctic and/or sub-Antarctic." PPP fills a gap in evidence-based research to support best practice decision-making for improved health, safety, and performance in Antarctica. Research by Victoria Heinrich of the University of Tasmania applies psychological theory to examine how, when, and why people use weather and climate information, and how comprehension, relevance, and use of this information might be improved in context with the demands, pressures, constraints, and needs of the users.

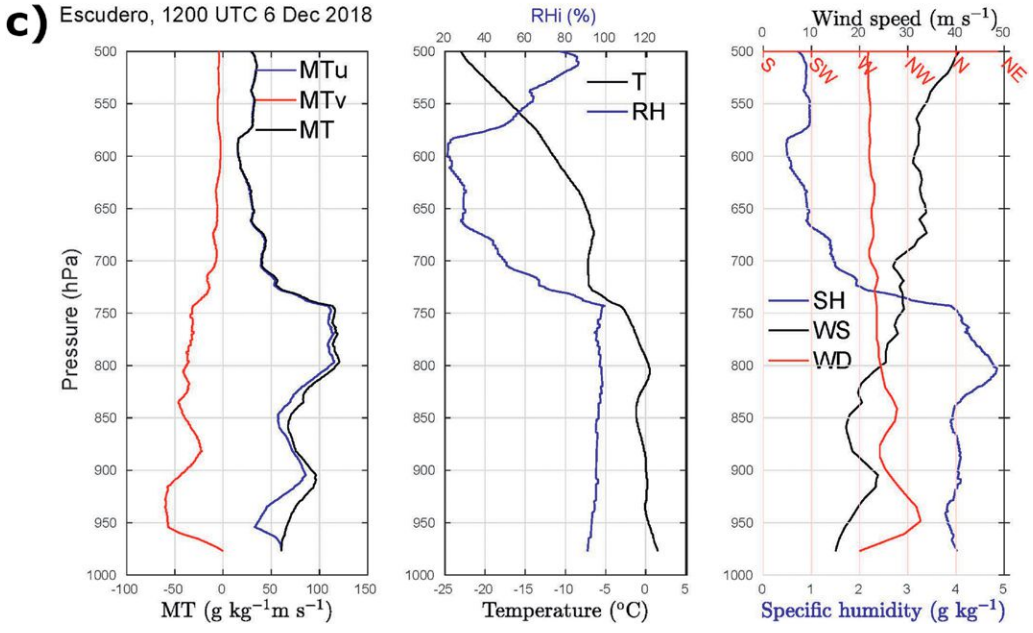




An atmospheric river (AR) affects both Punta Arenas and King George Island (KGI) at 1800 UTC 6 Dec 2018, as shown in integrated water vapor (IWV) and mean sea level pressure. ARs impact Antarctic surface mass balance—they can bring extreme precipitation, especially in summer when temperatures can hover around freezing and precipitation frequently transitions between snow and rain.



IWV and cloud liquid water path (LWP) at Punta Arenas and IWV at KGI during 4–7 Dec 2018.



Radiosonde vertical profiles at KGI during the peak of the AR: (left) moisture transport [meridional (MTv), zonal (MTu), and total (MT)]; (center) temperature (T) and RH with respect to ice (RHi); and (right) specific humidity (SH), wind speed (WS), and wind direction (WD). Extremes in lower-tropospheric humidity, temperature, wind speed, and moisture transport are associated with ARs, which are not always well represented by reanalyses. Models struggle to correctly forecast weather during ARs. In the YOPP-SH SOP even WRF model runs made with radio soundings from King Sejong underestimated the precipitation peak.

During the SOP, 350 intermediate and high school students from the Milan, Italy region participated in a wide-ranging educational project, CAPIRE-YOPP, with Antarctic data.

A drawing by a student was attached to a balloon launched in an extra sounding from Dome Concordia.

METADATA

Editor's note: These answers were distilled from contributions by lead author David Bromwich and several coauthors.

BAMS: What would you like readers to learn from this article?

David Bromwich (The Ohio State University): *Improving weather forecasts and numerical weather prediction modeling is important, time consuming, and complicated work that requires coordination and cooperation across multiple countries, organizations, and researchers. However, forecasts and models are only as good as the value and benefit they bring to users in their daily activities and tasks. If the information is of no value or benefit to the users, then they will not use it, and considerable time, effort, and resources are wasted. It is therefore important to understand how, when, and why users access weather information and to ask users what products and services are most useful to them.*

BAMS: How did you become interested in the topic of this article?

DB: *My research group has substantial interest in numerical modeling of atmospheric processes in the Antarctic and Arctic. We were key participants in establishing the Antarctic Mesoscale Prediction System (AMPS) as a practical application of our research. We continue to contribute to its advancement, and YOPP-SH is an ideal way to further this goal.*

BAMS: What surprised you the most about the work you document in this article?

DB: *The great interest and enthusiasm of the international Antarctic community in improving weather predictions for the Southern Ocean and Antarctica was a delightful surprise along with ensuring that user needs and wishes are fully taken into consideration. All contributions required substantial individual initiative to raise the resources required.*

BAMS: What was the biggest challenge you encountered while doing this work?

DB: *Coordination of all the different groups associated with many countries was a major undertaking. The International Coordination Office for YOPP at the Alfred Wegner Institute in Germany was a primary reason for the success achieved.*