THE ANTARCTIC MESOSCALE PREDICTION SYSTEM – JUNE 2019 UPDATE

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1. INTRODUCTION

The Antarctic Mesoscale Prediction System (AMPS) provides real-time numerical weather prediction (NWP) guidance to weather forecasters for the United States Antarctic Program (USAP), and informally to the larger international Antarctic community. Sponsored and funded by the National Science Foundation (NSF) Office of Polar Programs (OPP), and operated out of the National Center for Atmospheric Research (NCAR), AMPS has been an ongoing effort since the year 2000. AMPS is based primarily around the Weather Research and Forecasting model (WRF) developed principally at NCAR's Mesoscale and Microscale Meteorology (MMM) Laboratory. In its use of WRF, AMPS makes use of adaptations developed under the Polar WRF effort at the Ohio State University (OSU) / Byrd Polar and Climate Research Center (BPCRC). In addition to WRF, AMPS has been testing, for Antarctic applications, the atmospheric core of the Model for Prediction Across Scales (MPAS-Atmosphere, herein simply MPAS), also developed principally at NCAR/MMM. AMPS distributes its real-time NWP products primarily through the AMPS web site (http://www2.mmm.ucar.edu/rt/amps; Fig.1). The

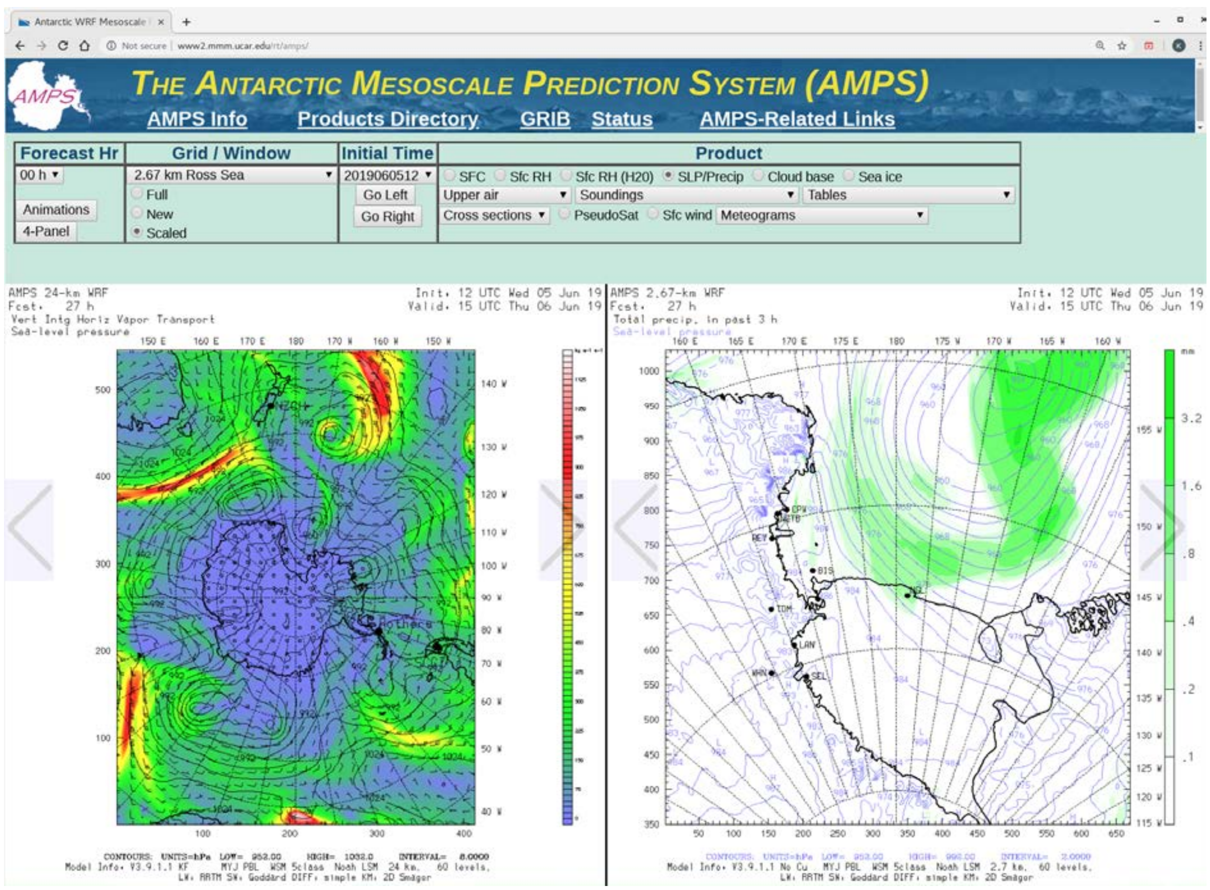

Fig. 1. AMPS web page with sample charts, on the 24-km large-scale “Antarctica and Southern Oceans” grid (L) and the 2.67-km “Ross Sea” window (R).

products available at the AMPS web site largely reflect input from and collaboration with USAP forecasters based at the Naval Information Warfare Center Atlantic (NIWC Atlantic) in Charleston, South Carolina, and at McMurdo Station, Antarctica. Additional input and feedback from the broader international community of Antarctic forecasters and researchers is considered as resources and priorities allow, and, as a result, AMPS provides customized sets of products for several regions of the Antarctic continent.

AMPS also maintains a long-term archive of its model output. The AMPS archive has been used by students and researchers for projects such as case studies and short-term regional climate studies. Information regarding the AMPS archive may be found at www2.mmm.ucar.edu/rt/amps/information/archive_info.html.

(a)

(b)

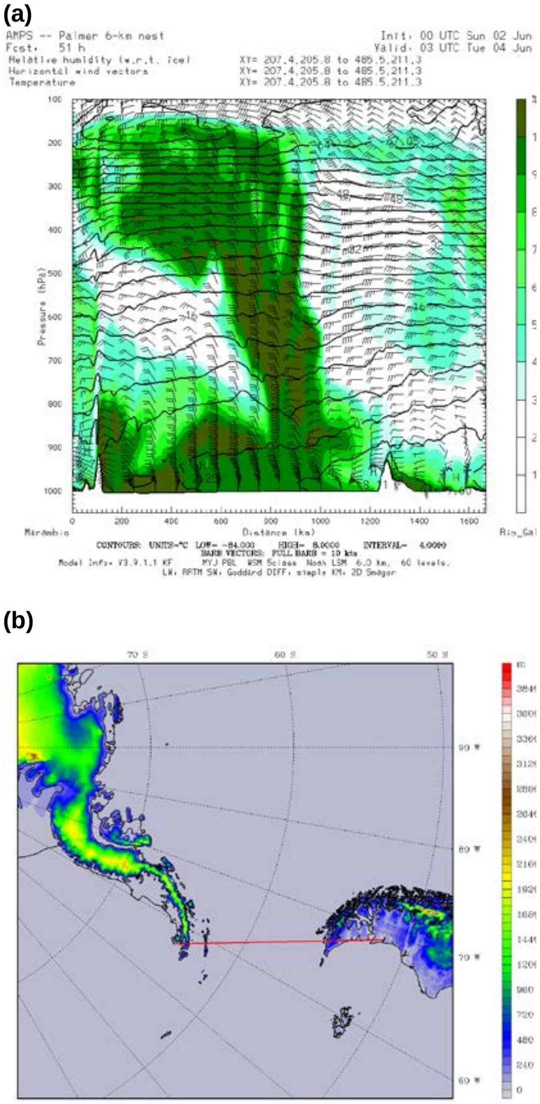

Fig. 2. (a) AMPS cross section from Marambio (L) to Río Gallegos (Right), from the AMPS 6-km Palmer window. (b) Location of the Marambio – Río Gallegos cross section (red line) in the AMPS 6-km Palmer window.

2. RECENT AMPS DEVELOPMENTS

a. New products in AMPS

One of the strengths of AMPS is the ability to rapidly respond to forecaster requests for new products and product changes. Handling new requests from forecasters has become a routine occurrence, with new sites for meteograms the most common type of request, from forecasters for many Antarctic programs. New this year for AMPS has been interaction with forecasters for Argentinian Antarctic efforts, with AMPS now providing time/height meteograms over several Argentinian research bases on or near the Antarctic Peninsula. Additionally, a vertical cross-section from Río Gallegos to Marambio base supports Argentinian forecasting for flights (Fig. 2).

With USAP forecasters now providing forecasts for Australian Airbus 319 flights for USAP support, AMPS has added an upper-air chart for the 39,000-foot flight level (FL390), comparable to the 35,000-foot level (FL350) charts used for the C-17 flights. This chart provides wind and temperature information, with indications of regions of strong wind shear, in the AMPS Christchurch/McMurdo window (Fig. 3).

Sometimes, product requests are for less direct and immediate logistical needs, and more for experimental evaluation. At the previous (2018) Workshop on Antarctic Meteorology and Climate, a research meteorologist for USAP expressed an interest in

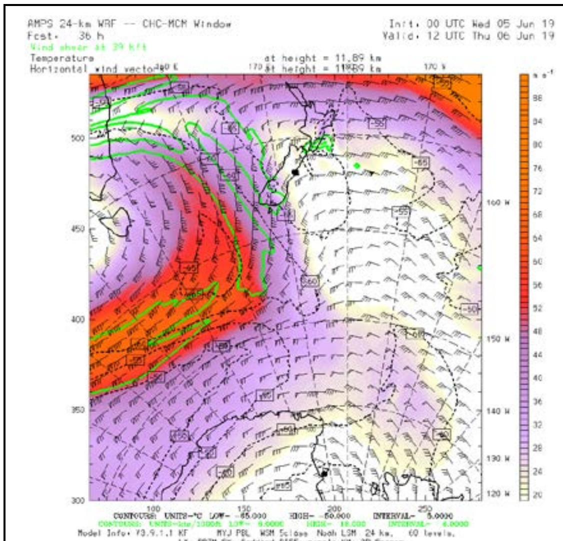

Fig. 3. Sample FL390 (Flight Level 39,000 ft) chart in the AMPS Christchurch – McMurdo window.

seeing if potential vorticity (PV) charts from AMPS might provide useful information for forecasters. AMPS now provides several PV charts on the larger-scale AMPS grids (24-km and 8-km grid spacing; Fig. 4).

b. Field project support
Often, AMPS has been called upon to provide forecast charts in short-term support of various field programs. This year, researchers with the NOAA Antarctic Marine Living Resources Program were interested in receiving AMPS forecast information on site at their camp at Cape Shirreff on Livingston Island. AMPS provided meteograms (Fig. 5) and textual time-series at their site via e-mail. Delivery was restricted to this minimal set of information by limited communications to the remote site.

c. NCEP GFS changes
Sometimes, changes are thrust upon AMPS from external events. Recently, the National Centers for Environmental Prediction (NCEP) updated their Global Forecast System (GFS), the output of which is used by AMPS for creating initial and boundary conditions for AMPS forecasts. Included in the GFS update were changes to the model data distributed by NCEP (and ingested by AMPS), which necessitated changes to the WRF Preprocessing System (WPS) software. The appropriate changes to WPS have been in place since WPS version 4.0, but have not been ported to earlier versions. AMPS was running WPS version 3.9.0.1, and therefore an update was required. The WRF model in AMPS remains at version 3.9.1.1.

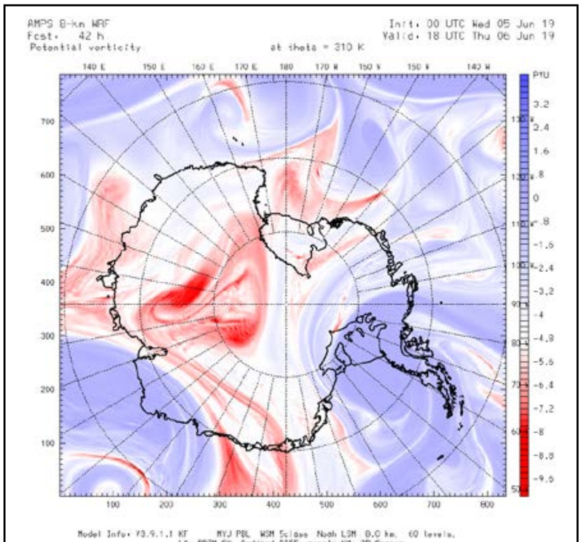

Fig. 4. AMPS potential Vorticity chart for isentropic level 310 K, on the AMPS 8-km Antarctic Continent window.

d. Additional radiosonde reports
In the process of collecting real-time observations distributed in coordination with the Year of Polar Prediction -- Southern Hemisphere (YOPP-SH) program, it was discovered that certain radiosonde reports routinely distributed from the continent were not included in the AMPS observations stream. Specifically, radiosonde reports from Concordia (89625) and Terra Nova Bay (89662) were not included. The AMPS observations processing now supplements the observation stream with these reports, when available.

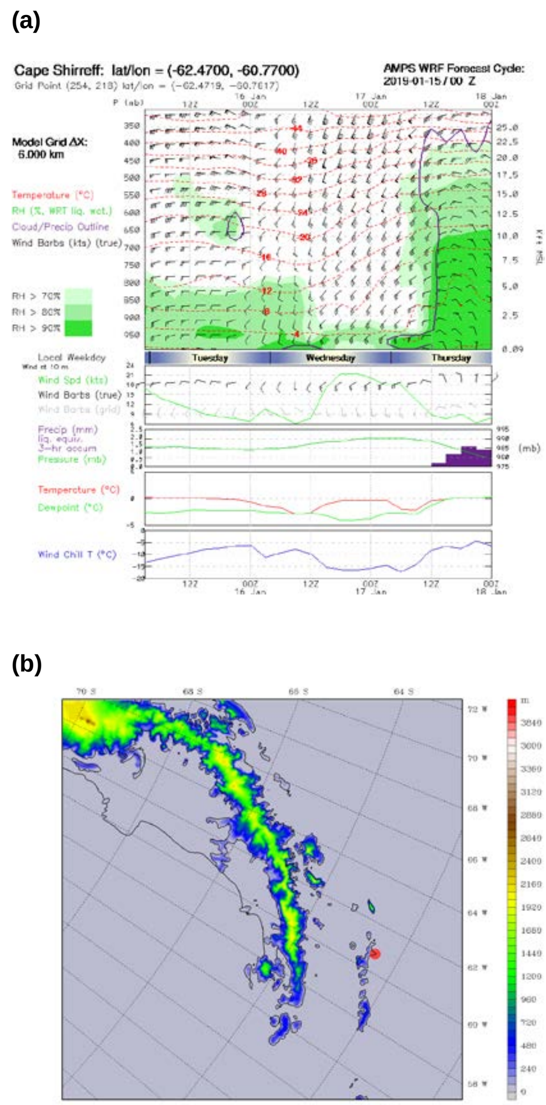

Fig. 5. (a) Example of AMPS time/height meteograms at Cape Shirreff, from the AMPS 6-km Palmer window. (b) Location of Cape Shirreff (red dot) on Livingston Island, off the Antarctic Peninsula.

3. AMPS COMPUTING STATUS

For computing needs, AMPS relies primarily on a computer called "Cheyenne". Cheyenne is located at the NCAR/Wyoming Supercomputing Center (NWSC), an NSF-funded facility operated by NCAR's Computational and Information Systems Laboratory (CISL). The AMPS computing allocation on Cheyenne reflects an NSF/OPP funding contribution to the supercomputer. AMPS is recognized within CISL as a high-priority project, with requirements specific to its real-time nature and its support of USAP activities.

a. Improved reliability for AMPS computing

The Cheyenne computer has been a challenge to work with. Its first two years of service have been characterized by random job failures and unscheduled machine downtime. (Not all downtime should be attributed to a balky computer: the electrical infrastructure providing power to NWSC was damaged in storms and required repeated downtime for extensive repairs.) Now in its third year of service, Cheyenne's reliability has improved significantly, with both random job failures and unscheduled downtime reduced considerably. These failures still occur on occasion, though, and AMPS production requires continuous oversight.

CISL recognizes AMPS' need for reliable computing, and allows AMPS to use a small cousin of Cheyenne, called "Laramie", as a machine for fallback computing for AMPS. When Cheyenne is down or acting tetchy, AMPS production on Laramie is often an option. Though Laramie doesn't have the computing capacity for the full AMPS production, it can accommodate the principal AMPS forecasts and suites of products forecasters are accustomed to finding. Laramie provides a suitable fallback capability which AMPS makes use of as needed.

The Cheyenne and Laramie supercomputers are the computing workhorses of AMPS, but there are several other computers involved in the variety of tasks in support of AMPS. These tasks include data collection and reformatting, forecast status monitoring, graphics format translation, and data distribution via email, Antarctic-IDD, and the AMPS web page. As the computing ecosystem becomes more complex and interdependent, the need for constant oversight and maintenance of programs, scripts, and operating system utilities expands.

b. AMPS experience with "The Cloud"

There are times when the Cheyenne and Laramie computers are both out of service, and continued AMPS production requires a second level of fallback computing. For these situations, CISL has arranged for AMPS to use computing capacity provided by cloud computing providers. NWSC has had outages of several days' duration, and AMPS was able to continue production (at a slightly scaled-back level) during these periods. AMPS occasionally has need for these services still.

CISL is exploring the capabilities of several cloud computing services, and finds AMPS a useful "use case" for the sort of capabilities that NWSC users might require from cloud computing. The cloud providers, for their part, see weather modeling and NWP applications as a potential business opportunity, and are interested in learning what real-time NWP projects need and expect from their services. Therefore, AMPS and the WRF/MPAS support team at NCAR have had opportunities to work with several cloud providers.

The AMPS experience with cloud computing is a mix of success and frustration. There are certainly challenges to using cloud computing. Separate platforms requires maintaining multiple AMPS installations. Porting and compiling of programs is not straightforward, and since each cloud platform is a different environment, each installation is a new experience with its own unique difficulties. There are also differing perspectives regarding expectations, workflow, system requirements, and capabilities between cloud provider and customer, requiring some rethinking and compromise on both sides. The cost of compute cycles for on-demand cloud computing can be significantly higher than allocations on an on-site supercomputer, but may be justifiable for occasional, fallback use to maintain continuity of service.

4. UPCOMING AMPS ACTIVITIES

2020 will mark 20 years of AMPS providing NWP support for Antarctic forecasting. In the coming years, we hope to be able to continue supporting NSF USAP activities and science, and, as resources and commitments allow, to continue providing NWP data and products to the international Antarctic community. Several specific tasks or activities are likely as priorities for development and research within the AMPS project in the shorter term.

a. Model updates

In order to keep up-to-date with the WRF and MPAS modeling advances, the newest versions of WRF and MPAS will be tested for use in AMPS. In this effort, we hope to continue the long-term collaboration between AMPS and the OSU/BPCRC Polar WRF effort in adapting these models to the unique challenges of Antarctic weather prediction.

b. Regional MPAS

We will continue to apply MPAS to Antarctic weather prediction, evaluating its potential as a partial or full replacement of WRF in AMPS. The new development of regional MPAS implementation (as opposed to the original limitation of a full global mesh) makes some of the higher-resolution requirements for AMPS more computationally feasible in MPAS. One possible configuration would be to use a regional MPAS mesh for the large-scale/continental-scale forecast, and from that mesh drive higher-resolution WRF or MPAS meshes (in a one-way nest configuration) for high-resolution guidance over areas such as McMurdo Station and the Antarctic Peninsula.

c. YOPP-SH study and AMPS data assimilation strategies

A separate study (see Powers et al. (2019) in this volume) evaluating the impact of additional observations taken during the YOPP-SH Special Observing Period will also test the effectiveness of data assimilation (DA) strategies as used in AMPS. If this study suggests clear advantages of alternate methods from what is currently used in AMPS, we may use these results to adapt the AMPS real-time DA process as appropriate. This may lead to heavier reliance on a larger ensemble, or to smaller adjustments to current techniques.

d. Tests of cloud microphysics schemes

Growing evidence suggests that using more advanced microphysics parameterization schemes could improve the forecast of clouds and precipitation in AMPS. The challenge is that these more sophisticated schemes are also more computationally demanding. With additional computing resources expected with a projected 2021 replacement of the current NWSC supercomputer, improved microphysics becomes computationally feasible for AMPS.