AMPS Update – July 2025

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1. INTRODUCTION

The Antarctic Mesoscale Prediction System (AMPS) is a high-resolution, real-time numerical weather prediction (NWP) system focused on the Antarctic. AMPS is funded by the U. S. National Science Foundation (NSF) and run at the NSF National Center for Atmospheric Research (NSF NCAR) in support of weather forecasters for the U. S. Antarctic Program (USAP).

AMPS operates two NWP models, the Weather Research and Forecasting model (WRF), and the Model for Prediction Across Scales (MPAS). Both models include adaptations for Antarctic conditions; modifications to WRF have been largely driven by the Polar-WRF effort from the Byrd Polar and Climate Research Center (BPCRC) of the Ohio State University. MPAS is a newer model, and appropriate polar modifications are still under development.

Both models are run twice daily on hardware at the NSF NCAR-Wyoming Supercomputing Center (NWSC) operated by NSF NCAR's Computational and Information Systems Laboratory (CISL). High-priority super- computing allocations for AMPS are provided by additional funding from the NSF Office of Polar Programs. AMPS runs in a reduced capacity on cloud services when NWSC resources are unavailable due to scheduled maintenance or unplanned outages.

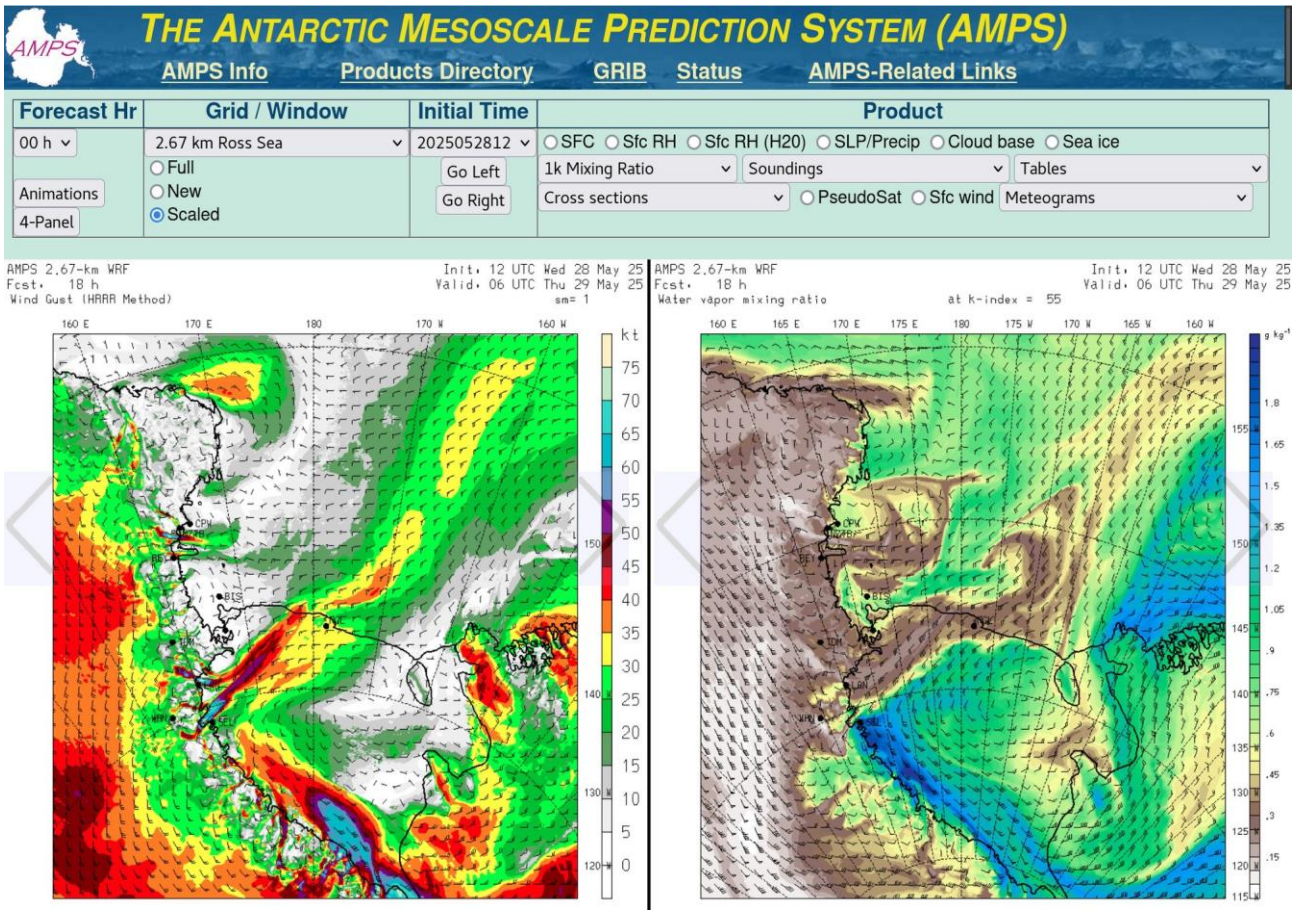

Fig.1. AMPS web page (https://www2.mmm.ucar.edu/rt/amps), showing the selection panel and sample plot selections of near-surface wind gust (left) and 1-km mixing ratio (right) from the WRF 2.67-km Ross Sea/Ross Ice Shelf window.

The models are run with high-resolution meshes, covering the Antarctic continent at 8-km mesh spacing or finer, with higher resolution regions over areas of greatest USAP activity: in the Ross Island region, the Antarctic Peninsula, and the South Pole.

Graphics and tabular products derived from the WRF and MPAS output are posted openly on the AMPS web page (https://www2.mmm.ucar.edu/rt/amps, Fig.1). Also available at that web page are GRIB files derived from the most recent WRF forecasts. These GRIB files, subsets of the full native model output, are also maintained in a long- term archive of AMPS forecast data.

2. NEW HOME FOR THE AMPS ARCHIVE

The AMPS Archive has a new home, supported by NSF NCAR's Research Data Archive (RDA). The RDA is a repository of meteorological, atmospheric composition, and oceanographic observations, as well as operational and reanalysis model datasets, made available to the community. The RDA is integrated with NSF NCAR computing services to support atmospheric and geosciences research. The new web address for the AMPS Archive is https://rda.ucar.edu/datasets/d473002 (Fig. 2), and this replaces the older Earth Systems Grid (ESG) portal access. The RDA site now houses the long-term archive of AMPS GRIB files and AMPS graphical and tabular products. A related page, at https://rda.ucar.edu/datasets/d473003, hosts a shorter-term archive: 6 months of the most recent WRF full model output in native NetCDF format.

The new archive sites are open to all; no user registration is required. Users will likely find the new sites easier to access than the old ESG portal, easier to navigate, and easier to download data from. The archives will be updated monthly with recent model output from AMPS. Interim access to the more recent data – after it has aged off of the real-time AMPS web site but before the archives

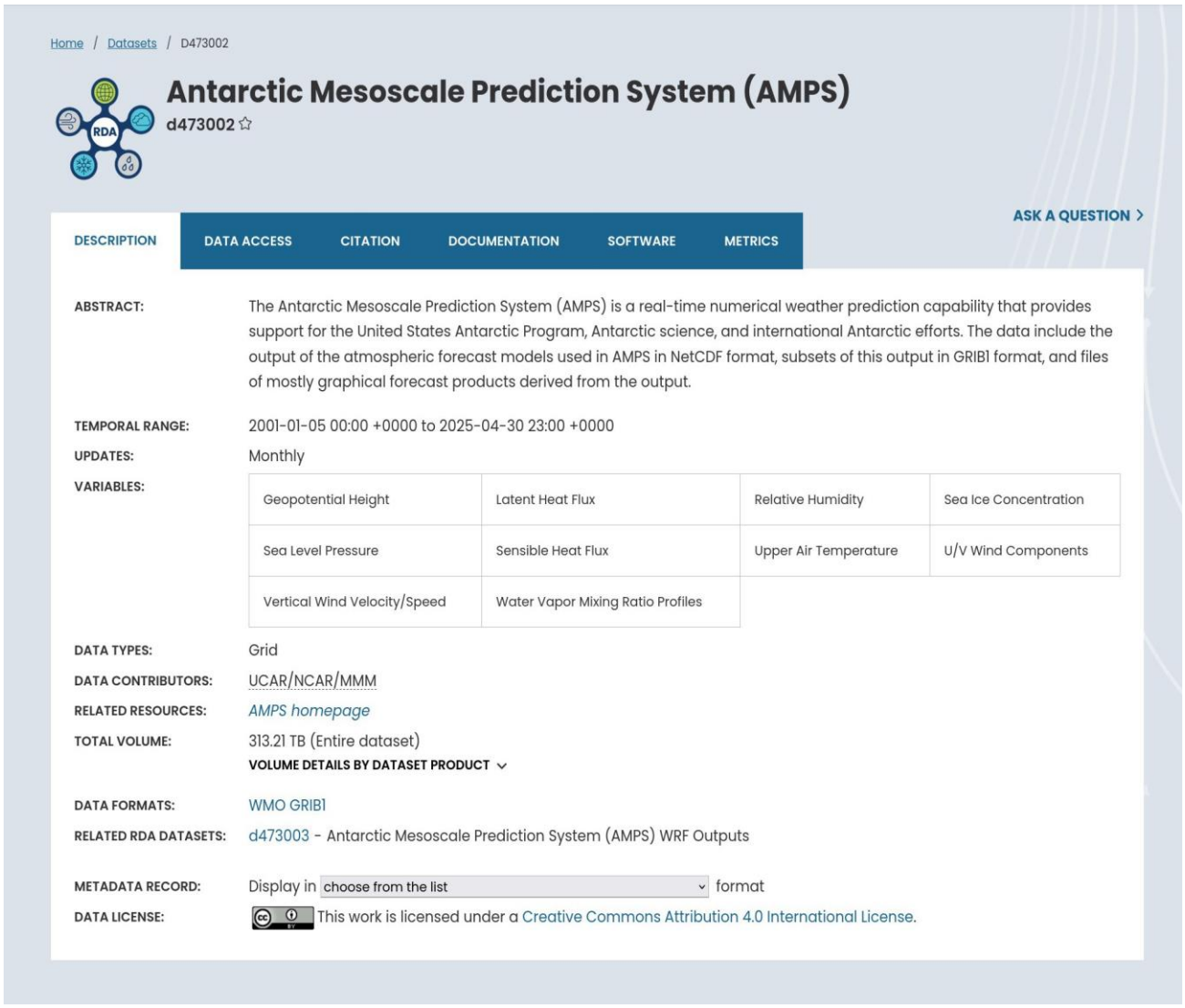

Fig.2. Web site for the AMPS Archive, hosted by NCAR NSF Research Data Archive. https://rda.ucar.edu/datasets/d473002.

are updated – may be available through the Globus service, with details on this still to be worked out.

3. NEW AMPS GRAPHICAL PRODUCTS

The AMPS website includes a few new products, evolving out of discussions with forecasters. At the request of USAP forecasters, charts depicting turbulence indices have been added to the suite of AMPS graphics. Two indices have been included so far: the Ellrod TI1 index and the Brown index. Both of these indices are used in various operational turbulence diagnostics tools of operational centers, but it is unclear how they perform for that purpose over the high southern latitudes and based on the output of WRF from AMPS. The Ellrod TI1 index is based on horizontal deformation and vertical wind shear, while the Brown index considers vorticity and deformation. Sample images of these turbulence indices are shown in Fig. 3.

The USAP forecasters have long speculated with the AMPS team about whether trajectories tracing the recent history of an air mass over a site of interest might offer useful information to forecasters. This question can now be put to the real-time test, with the addition of back trajectory plots to the AMPS product suite. Trajectories are initiated near the surface in the immediate vicinity of Phoenix Airfield and Williams Field, at each hour of the forecast, and run backward in time for up to 24 hours. Traces of those trajectories are plotted from three different points-of-view (from the south, from the east, and from above), to present a 3-D representation of the trajectory histories (e.g. Fig.4).

4. MPAS DEVELOPMENTS AND PLANS

WRF has been used in AMPS since 2005, finally replacing the earlier MM5 model in 2008. MPAS, a newer model, has been in testing in AMPS for several years, and the current goal is for MPAS to replace WRF in AMPS within one to two years. Significant effort will be required to meet this schedule.

WRF is a robust, mature model, possibly the most widely- used atmospheric NWP model in history. So why is this shift to MPAS afoot? And why has this become a priority now? In large part, this reflects the natural progression of software projects. Development priorities at NSF NCAR and in the atmospheric modeling community are shifting towards MPAS; development on WRF has slowed considerably in recent years, and WRF will be frozen in the future as was MM5. MPAS, as a newer model, is designed for contemporary supercomputers, whereas WRF was designed for the computers of 25 years ago. MPAS is also becoming positioned to take advantage of the computational capacity offered by Graphical Processing Units (GPUs). MPAS also takes advantage of two decades of advances in software design, NWP methods and the science of atmospheric modeling. In order for AMPS to remain at the forefront of the science, a shift to MPAS is called for.

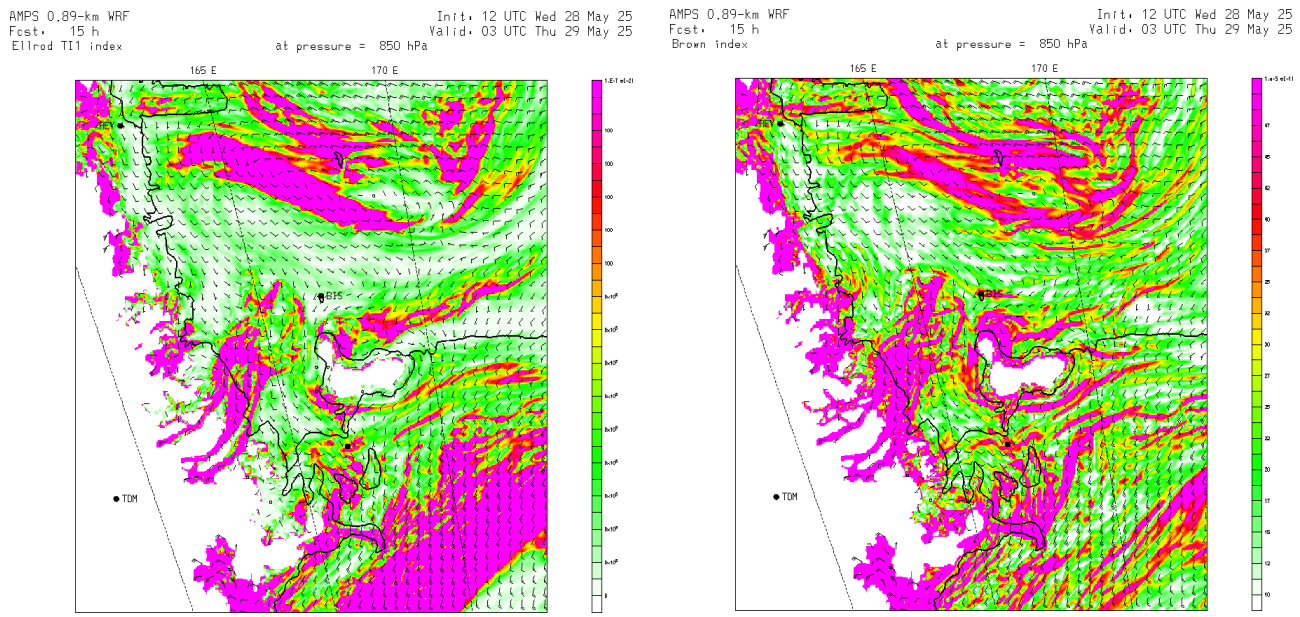

Fig.3. Turbulence indices included in AMPS products. Ellrod TI1 index (left) and Brown index (right) are shown for the same forecast hour on the WRF 0.89-km grid.

To justify the operational switch to MPAS as the sole NWP model running in AMPS, MPAS must be able to offer at least a similar set of capabilities as WRF provides for supporting USAP forecasters. MPAS should also have comparable or better forecast skill to WRF in AMPS forecasts. Regarding this, however, though its larger-scale evolution of weather systems is sililar to WRF's, MPAS does currently show some problems in the Antarctic that must be addressed (e.g., Fig. 5).

For forecast system capabilities, steady progress has been made toward meeting or improving on the grid resolution that WRF offers. In particular, implementation is underway for a high-resolution mesh (1-km mesh cell size or smaller) around Ross Island, similar in the resolution to the 0.89-km WRF Ross Island grid (Fig. 6). This is now possible for MPAS via a small-scale regional mesh, forced

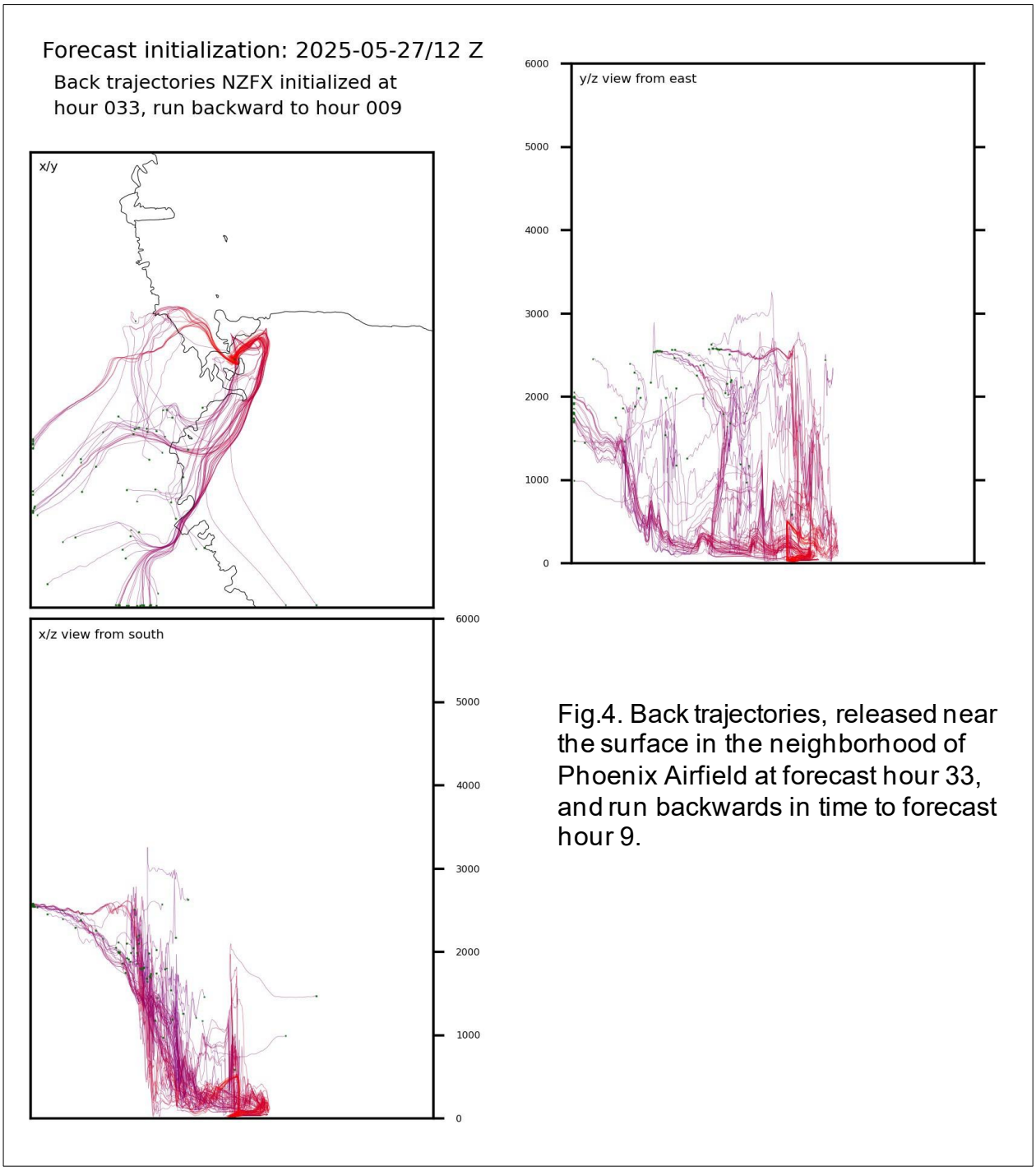

Fig.4. Back trajectories, released near the surface in the neighborhood of Phoenix Airfield at forecast hour 33, and run backwards in time to forecast hour 9.

by boundary conditions derived from the larger-scale MPAS model results.

A feature of AMPS much appreciated by forecasters is the AMPS Ensemble, currently running 22 WRF members with perturbed initial conditions. AMPS currently does not run an MPAS ensemble. This is mostly a question of computing capacity, however: there is no other significant impediment to running an MPAS ensemble. In the short term, a small ensemble (~5 members) of regional MPAS members, on a resolution similar to the 24/8-km WRF ensemble, is likely. This could be computationally feasible if the number of WRF ensemble members is reduced accordingly.

An MPAS ensemble, even a small one, makes experimentation with data assimilation for MPAS more achievable. Any data assimilation in AMPS with MPAS will leverage the development of the MPAS-JEDI toolkit, a collaborative effort of the MPAS data assimilation community and the Joint Effort for Data assimilation Integration (JEDI) project led by the Joint Center for Satellite Data Assimilation (JCSDA).

One aspect of the transition from WRF to MPAS that has been under-appreciated is the status of MPAS graphics. Currently, the graphics capabilities directly available for MPAS output do not compare with the graphics software that has been developed for WRF over the past 25 years. AMPS uses the RIP4 plotting package for most of its graphics. RIP4 was developed for MM5 and WRF, and AMPS converts MPAS output to WRF format in order to use the same RIP4 software for MPAS. This solution is workable but not optimal, relying on interpolation from the MPAS mesh to a WRF grid, and using up substantial time and disk space for the conversion. Additionally, the graphics libraries that RIP4 depends on are approaching end-of-life. RIP4 itself is aging software, is incompatible with modern graphics libraries, and may not be maintainable for the long term. Additional effort,

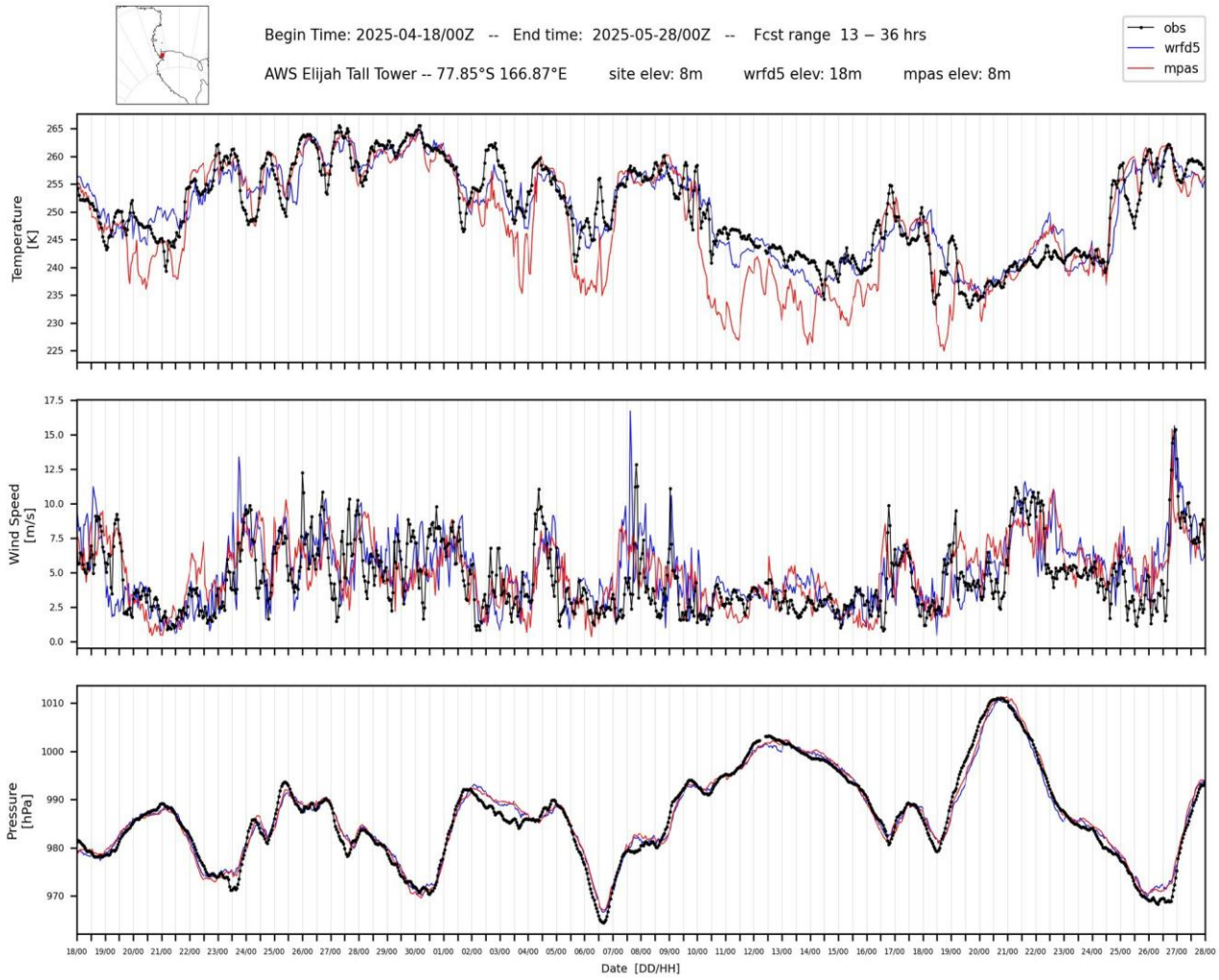

Fig.5. Comparison of WRF (blue) and MPAS (red) near-surface temperature (top), wind speed (middle), and pressure (bottom) as compared to near-surface observations (black) from Elijah Tall Tower, for the period of 18 Apr to 28 May 2025. Thanks to the Antarctic Meteorological Research and Data Center and the Automatic Weather Station Program of the University Wisconsin-Madison for collecting and making available their Antarctic observational datasets.

therefore, will have to be put into developing MPAS graphics for AMPS. In this, AMPS can take advantage of, and contribute to, the larger community effort to develop MPAS graphics.

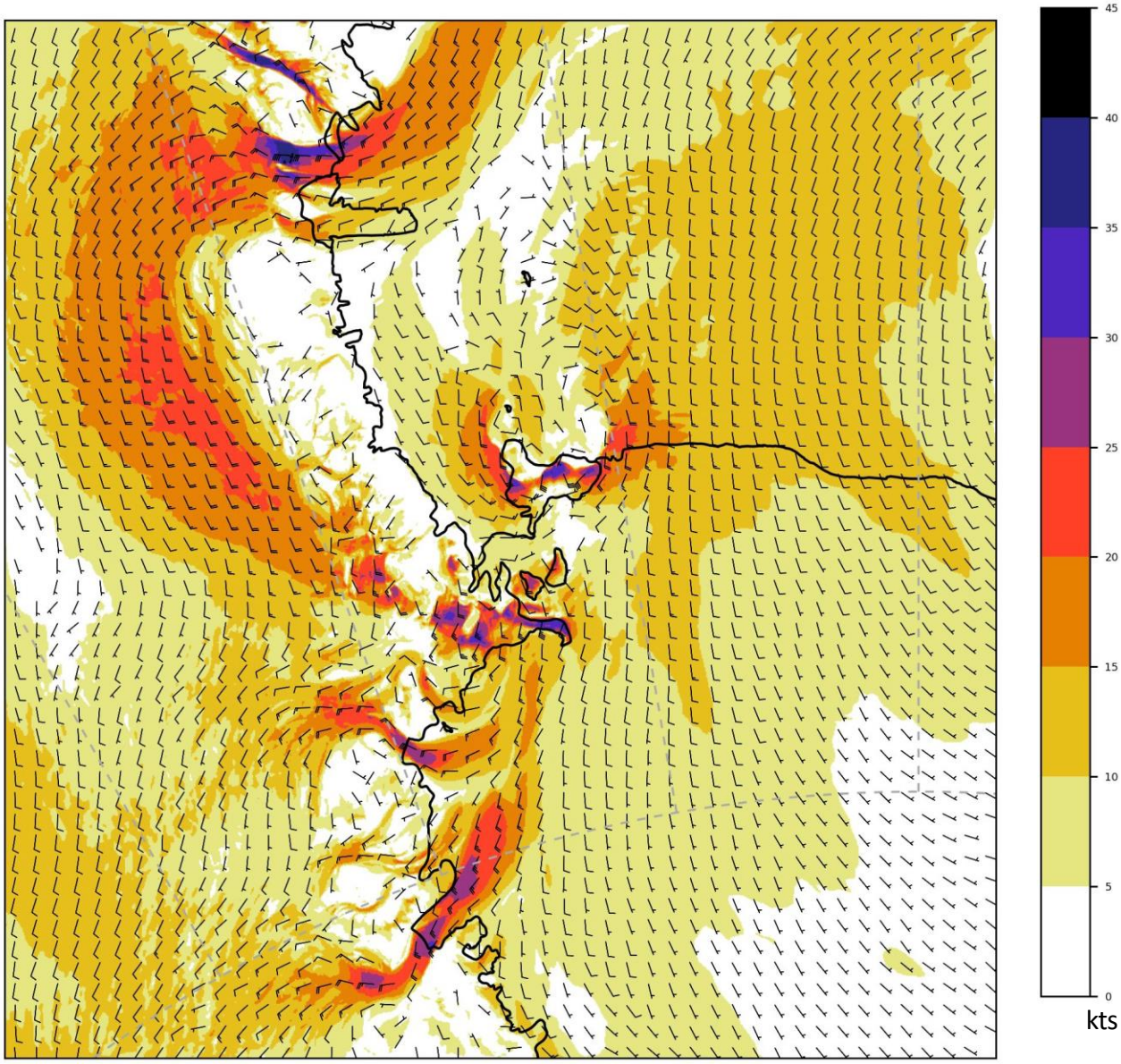

Fig. 6. Sample plot of wind speed (kts) and wind barbs (full barb = 10 kts) on the MPAS 1-km mesh, on the 6th model level from the surface (approximately 150 m AGL), for the 30 hour forecast initialized at 12Z 16 May 2025 and valid for 18Z 17 May.