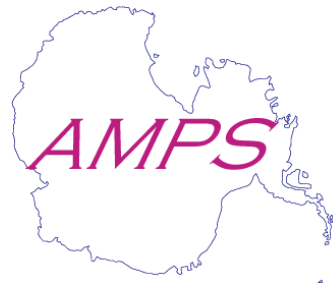


AMPS: LOOKING AHEAD

Jordan G. Powers

Mesoscale and Microscale Meteorology Laboratory
National Center for Atmospheric Research
Boulder, Colorado, USA

Workshop on Antarctic Meteorology and Climate
June 21–23, 2021



AMPS— Overview

- **AMPS: Antarctic Mesoscale Prediction System**

- Priorities

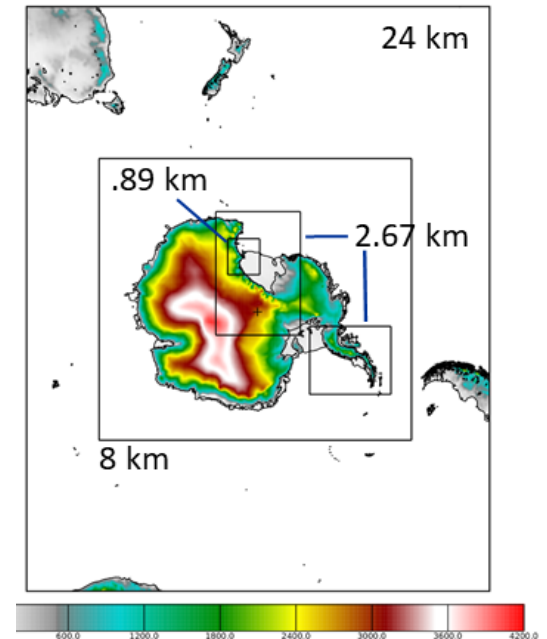
- ◆ USAP and NSF Office of Polar Programs
- ◆ Naval Information Warfare Center (NIWC) & DIGITALiBIZ

- Development Areas (to 2023)

- ◆ Modeling
- ◆ Computing
- ◆ AMPS Archive
- ◆ Community Assistance

Note: New community supercomputer at NCAR in 2022 (“Derecho”) needed for support a number of planned activities

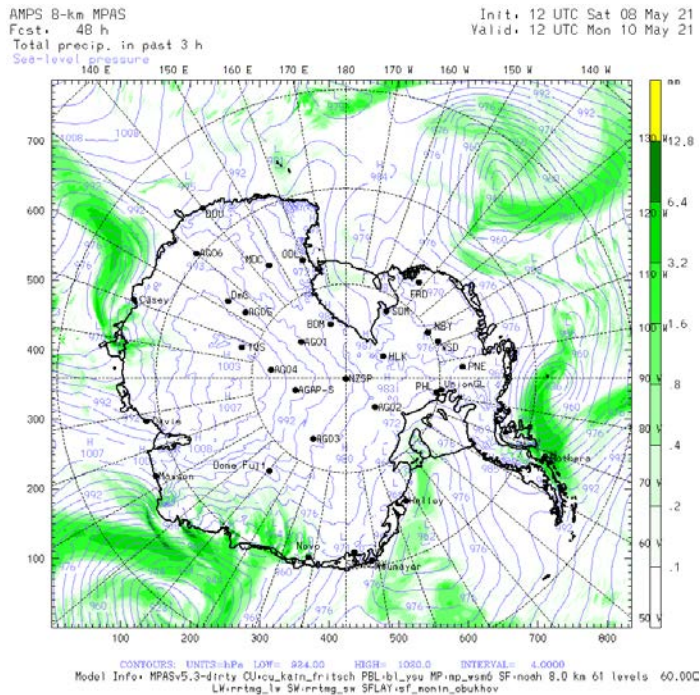
AMPS WRF Domains



Modeling— MPAS Developments

- **MPAS (Model for Prediction Across Scales): Refined Continental Mesh**
 - Current MPAS configuration: 60 km–10 km global domain
 - **10-km refinement covering Antarctica**
 - **Plan: 8-km refined mesh over Antarctica (60/8-km global domain) for consistency with WRF for comparisons and evaluations**

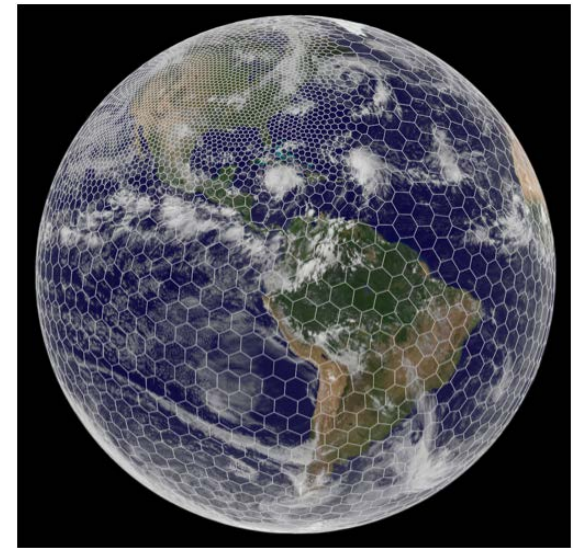
Caveat: Requires New NCAR HPC



MPAS Global Mesh



**MPAS 48-hr Forecast
SLP and 3-hrly precip
Valid: 12 UTC 8 May 2021**

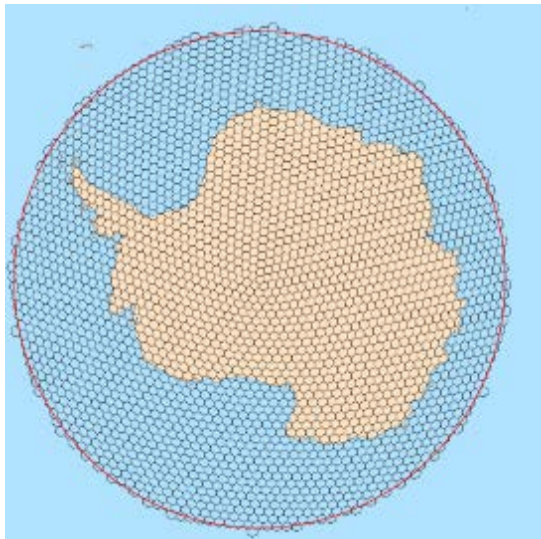


Modeling— MPAS Developments

- **MPAS: Regional Antarctic Domain**

- MPAS: Running a global domain for forecasting regionally imposes extra computational cost
- New MPAS *regional capability* allows a limited-area domain: Focused forecasting

**Regional MPAS:
Uniform
Antarctic
mesh**



**Regional PAS:
Mesh with local
refinement**



Modeling— MPAS Developments

- **Plans**

- 1) Test regional MPAS over Antarctica

- ◆ Boundary Conditions: GFS/UFS
 - ◆ Evaluate performance of limited-area v. global MPAS over Antarctica

- 2) AMPS Ensemble: Include regional MPAS members

- ◆ Multi-model ensembles more dispersive than single-model
 - ◆ Increase AMPS ensemble diversity

Modeling— MPAS Developments

- **MPAS: Polar LSM (Land Sfc Model) Modifications**

- Noah LSM used in WRF & MPAS is no longer under development
- NoahMP (Noah Multi-Physics) scheme has superseded Noah LSM
- Plans
 - ◆ Implement polar mods into NoahMP
 - ◆ Apply polar NoahMP in MPAS forecasts

- **MPAS: Data Assimilation**

- Current MPAS forecasts initialized without DA
- JEDI DA system (Joint Effort for Data Assimilation Integration) developed by JCSDA (Joint Center for Satellite Data Assimilation) is model-independent and can do DA for MPAS
- Plans: Test and implement JEDI for DA to initialize AMPS MPAS



Modeling— WRF Developments

- **WRF Microphysics (MP) Focus**

- Want to better represent Southern Ocean cloudiness and liquid water clouds over Antarctica in forecasts
- Current WRF in AMPS: WSM5 (WRF single-moment 5-class) scheme
- WRF more-sophisticated options: 2-moment schemes
 - ◆ Mixing ratios of hydrometeors
 - ◆ Number concentrations of hydrometeors
 - Ex: P3, Morrison, Thompson-Eidhammer schemes
 - ◆ Downside: Schemes can cost up to 40% more run time
- **Plans: Test 2-moment MP more fully and implement based on results**
 - **Requires new NCAR HPC (2022)**

Modeling— WRF Developments

- **Data Assimilation (DA) Advancement: WRF**

- Current: Hybrid 3DEnVar DA Approach

- ◆ 3DVAR using background error (BE) information obtained in part from forecast ensemble

- ◆ Relies on AMPS ensemble of ~15 members

- Tested: Ensemble Kalman Filter (EnKF) DA

- Approach using DART in YOPP-SH radiosonde impact study

- New: Multi-Resolution Incremental 4DVAR (MRI-4DVAR)

- (i) Less costly than traditional 4DVAR

- (ii) Good results for Arctic simulations in Ohio State Univ. study

- **Plans** (dependent on new HPC)

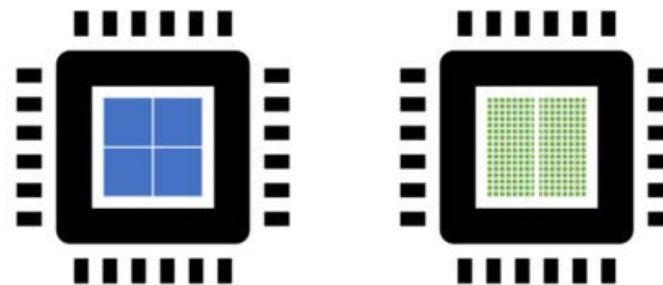
- 1) Increase AMPS ensemble size: Enhancement for DA and for fcsts

- 2) Test MRI-4DVAR & EnKF and implement per results

Computing— GPU Developments

- **WRF Code: GPU Testing**

- GPU= Graphics Processing Unit
(cf. CPU: Central Processing Unit)
- GPUs: Part of new NCAR HPC
- GPUs: More potential compute power/node
- Caveat: Modification of WRF/MPAS codes needed for GPU operation
- TempoQuest, Inc. (TQI): GPU-ized version of WRF (AceCast)



CPU	GPU
Central Processing Unit	Graphics Processing Unit
4-8 Cores	100s or 1000s of Cores
Low Latency	High Throughput
Good for Serial Processing	Good for Parallel Processing
Quickly Process Tasks That Require Interactivity	Breaks Jobs Into Separate Tasks To Process Simultaneously
Traditional Programming Are Written For CPU Sequential Execution	Requires Additional Software To Convert CPU Functions to GPU Functions for Parallel Execution

- **Plans**

- Continue testing of TQI WRF in AMPS (sSpeedups up to 30% to date)
- Evaluate potential for AMPS WRF to run operationally on GPUs

Computing— AMPS in the Cloud

- AMPS in the Cloud

- Usage: Primary and secondary NCAR HPCs available for AMPS down for maintenance or problems

- Cloud Service Providers Used for AMPS

- ◆ 2018–2020: Penguin Computing

- ◆ 2020–2021: Rescale, Inc.



- Note: Only core WRF forecast and products generated w/cloud ops

- *No MPAS*

- *No ensemble forecast*

- *No Palmer and New Zealand 6-km forecast domains*

- *No special forecast domains (Ex: 1-way nests)*

- **Plans** (dependent on new HPC)

- AMPS backup operation: Rescale w/possible expansion

- Possible: Addition of NZ, Palmer, or other 1-way nests

AMPS Archive

- **Background**

- Archive: Holdings of AMPS MM5 and WRF forecast output for research and studies
- Location: NCAR High Performance Storage System (HPSS) tape-based facility (retired)
- New NCAR data storage system: “Campaign Storage” (CS)
 - ◆ Disk-based file system
 - ◆ Access: Faster than HPSS
 - ◆ Capacity: Less than HPSS

- **Plans: Archive Migration to Campaign Storage**

- 1) Previous archive model output in GRIB format migrated to CS

- **Plans: Archive Migration (cont'd)**

- 2) Long-term storage: WRF GRIB output w/selected levels and fields

- 3) Short-term storage: WRF native output w/6-month retention

- 4) Access: NCAR Climate Data Gateway (CDG)

- AMPS CS holdings to be published on the CDG

- <https://www.earthsystemgrid.org>**

- Link/access to archive contents available by Sept. '21



Community Assistance— Field Campaign Support

- **YOPP-SH 2022 Campaign**

- Winter Targeted Observing Periods (TOPs) for weather events in two regions:
Ross Sea and Antarctic Peninsula/Weddell Sea

- Plans: Support of YOPP-SH forecasting teams

- Tailored plots/windows for focus areas



- **Experiments with Southern High-Latitude Operations**

- AMPS: NWP guidance to field experiments for support for planning and operations

- Plans: Fcst graphics/windows provided in product suite on request

Summary: AMPS Looking Ahead

- **Modeling**

- Polar physics advancement: WRF and MPAS
- MPAS: Improved continental mesh & regional testing
- Data assimilation: Add to MPAS and new WRF approaches

- **Computing**

- New CSP and cloud suite development
- GPU exploration

- **Community Support**

- Revamped AMPS archive
- Field campaign NWP: YOPP-SH & other experiments
- Requests from Antarctic community



The NSF Office of Polar Programs makes this all possible!