# AMPS Update – June 2017

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*Boulder, CO*

12th Workshop on Antarctic Meteorology and Climate
Boulder, CO: 26-28 June 2017



# Outline

- Review – what is AMPS
- Highlights of what's new this past season
- Future

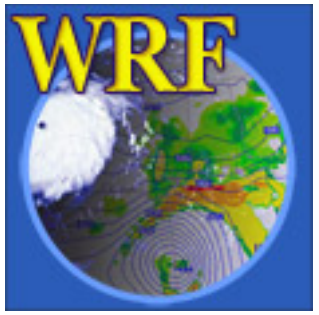
# The Antarctic Mesoscale Prediction System (AMPS)



- Real-time, experimental NWP system serving the needs of forecasters for the U.S. Antarctic Program
- Funded by NSF Office of Polar Programs
- Based on NCAR's Weather Research and Forecasting (WRF) model
  - Using adaptations from OSU/BPCRC Polar WRF
- Twice-daily forecasts since September 2000
- Real-time NWP graphics, text, and GRIB openly available through AMPS web page

# THE WEATHER RESEARCH & FORECASTING MODEL

- Community model
  - Large and active community worldwide
  - Week-long summer and winter tutorials
  - Annual WRF Users' Workshop

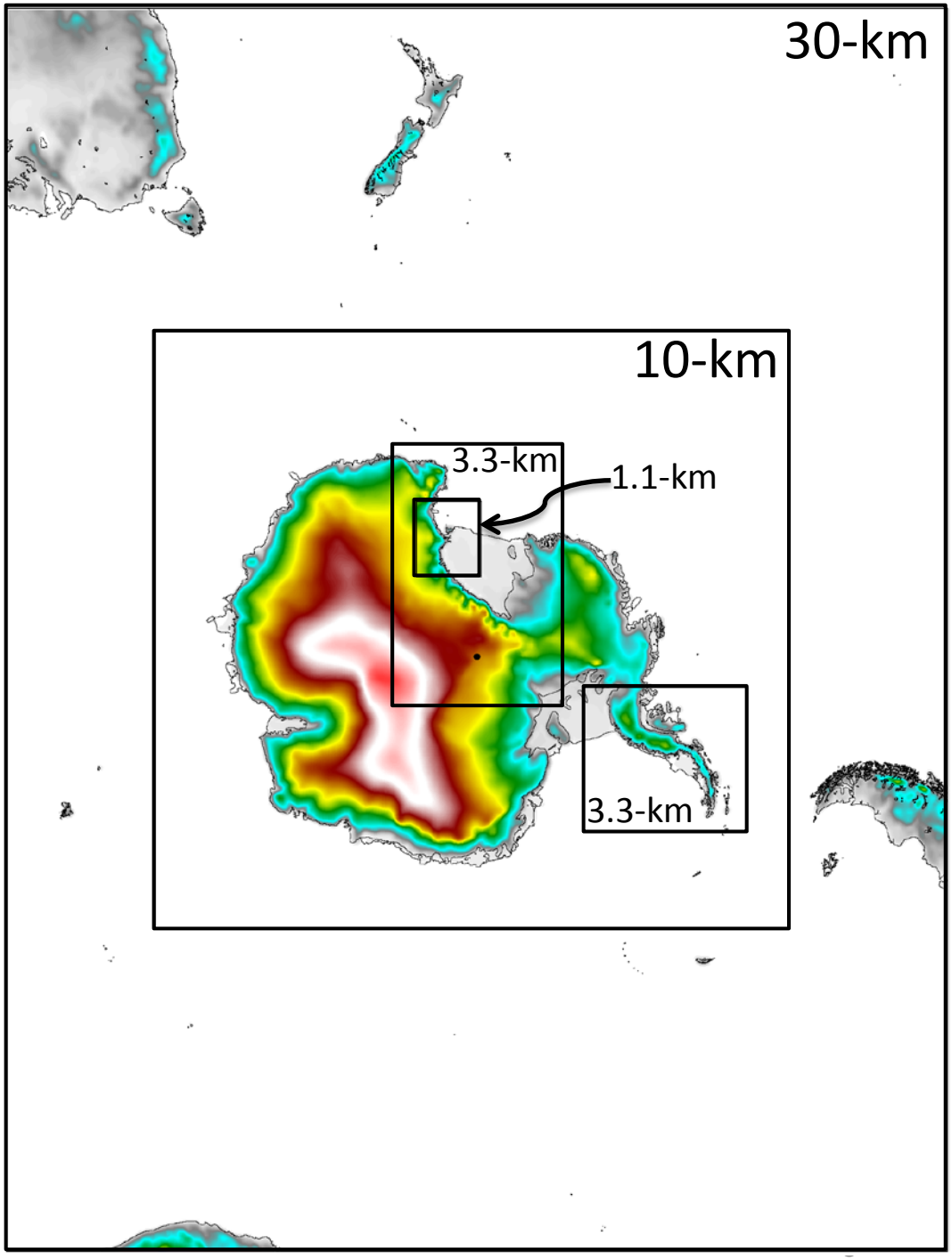



- Regional focus
  - Short-term, high-resolution (1 -10 km grid spacing) simulations
  - Real-time forecasting (e.g., AMPS)
  - Longer-term, regional climate simulations

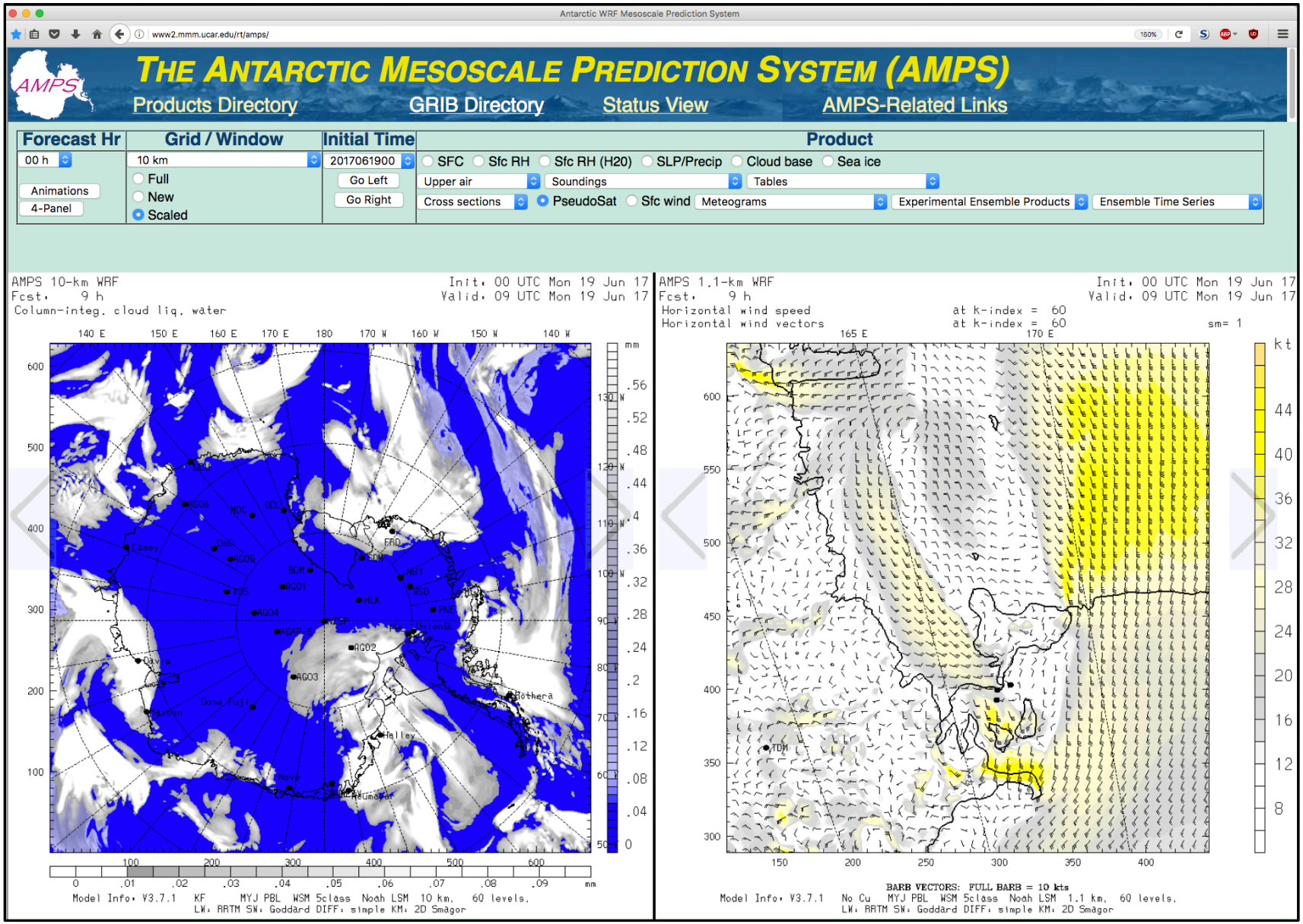
- Arctic/Antarctic adaptations
  - Taking advantage of OSU/BPCRC Polar WRF effort
  - Feeding back to WRF community as appropriate

# AMPS Grid Configuration

- AMPS runs WRF with five two-way interactive nests
  - 30- and 10-km grids over all of Antarctica and environs
    - 3-hourly output to forecast hour 120
  - 3.3- and 1.1-km grids over areas of particular interest to USAP
    - Hourly output to forecast hour 39
- Two forecasts per day
  - 00Z and 12Z forecast cycles
- Grids initialized from NCEP GFS, with additional WRF Data Assimilation step
  - Hybrid Ensemble/3D-Variational Data Assimilation
  - 30-km lateral boundary conditions from GFS
- Ensemble on 30- and 10-km grids
  - Small ensemble: O(20 members)



# http://www2.mmm.ucar.edu/rt/amps



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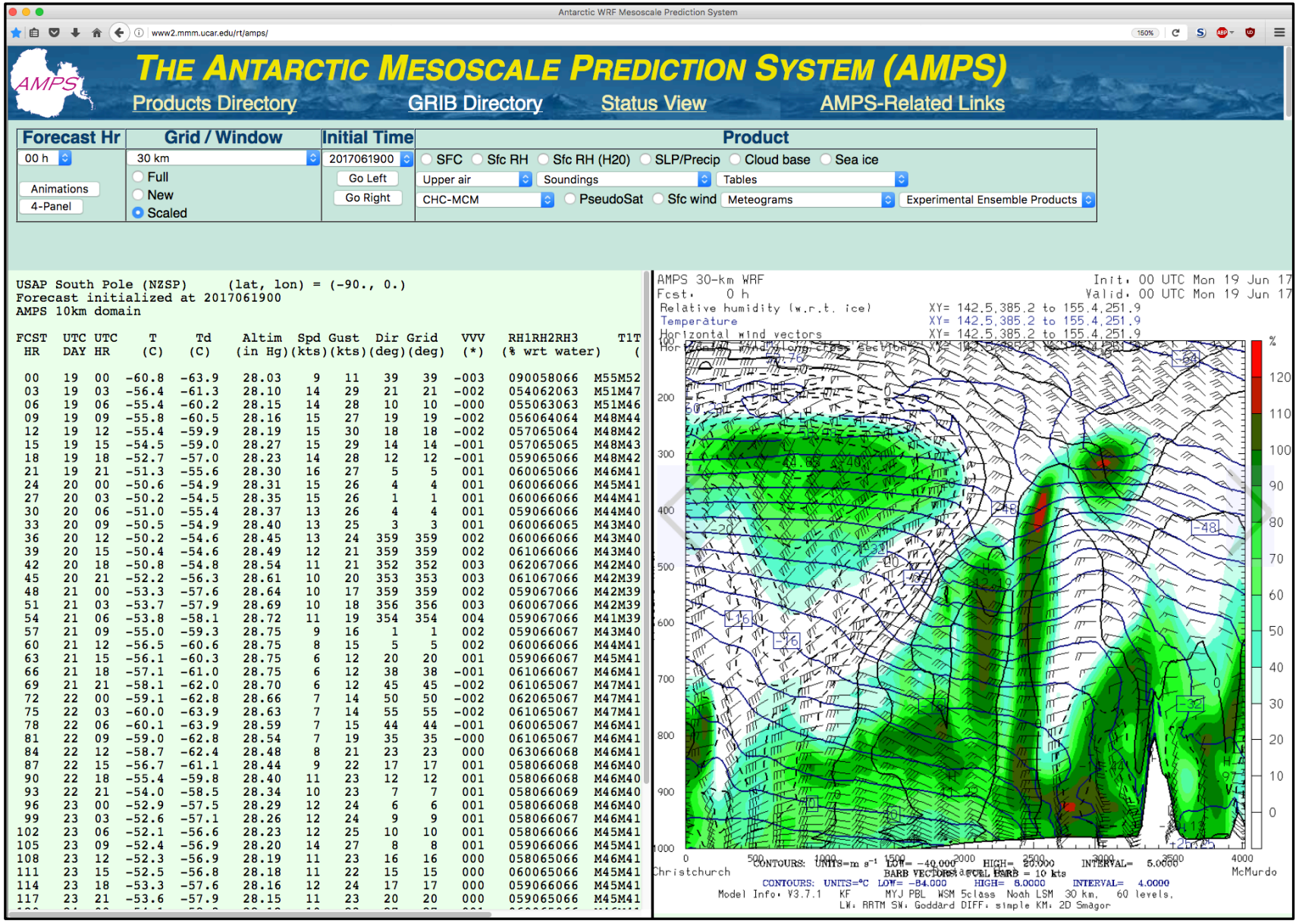

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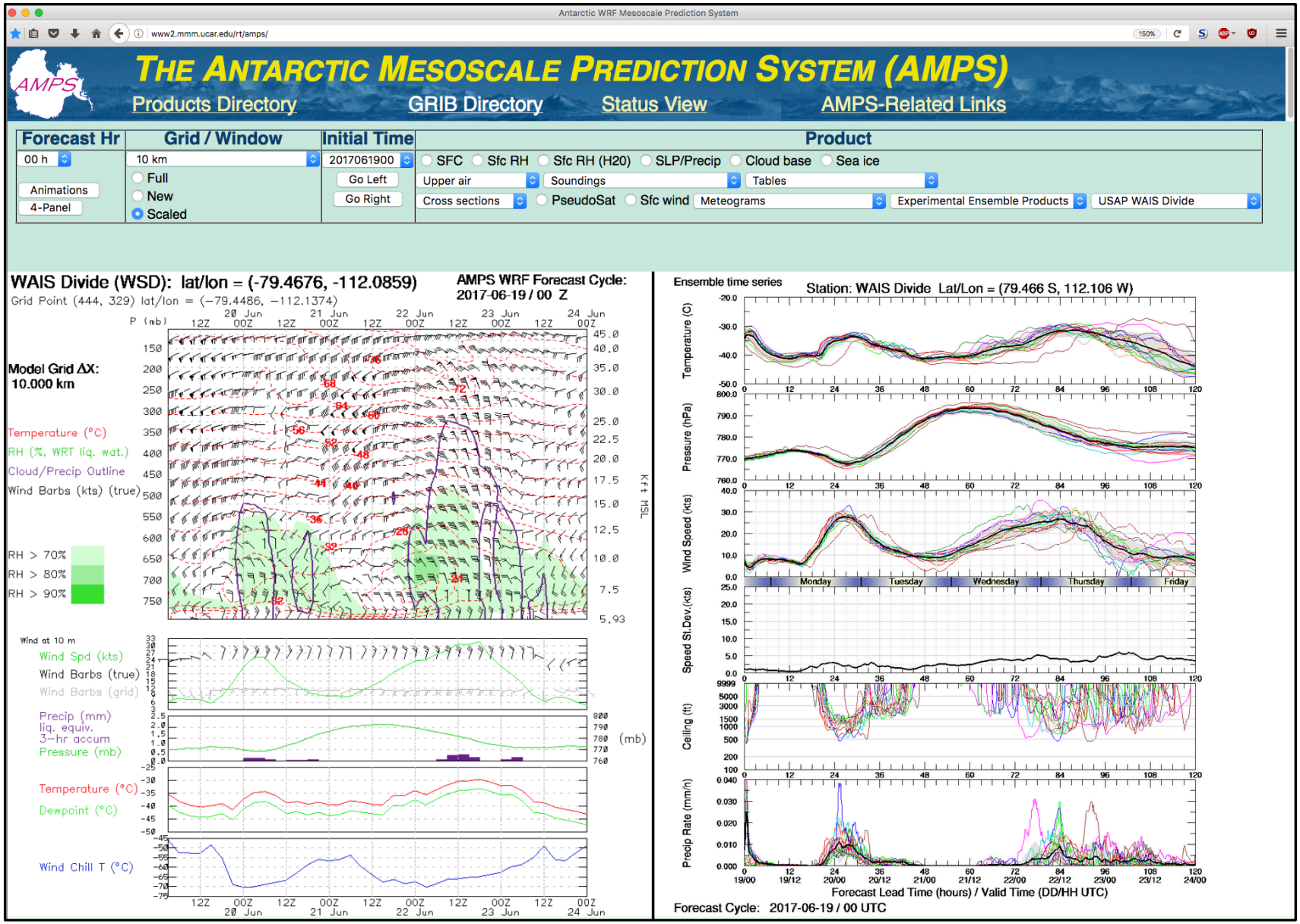


# New this year!

# Observations from BAS

- Thanks to Steve Colwell (BAS)
- Steve noticed BAS sites missing from our GTS source (Unidata)
  - May need to get Unidata to extract surface BUFR obs?
- Steve created an FTP site for AMPS to pull real-time data from his catalogue of surface reports
- Testing this additional data in AMPS data assimilation resulted in a consistent reduction of forecast surface pressure bias
- Implemented September 2016
- Surface observations now drawn from three sources:
  - GTS (through Unidata)
  - AMRC (thanks to AMRC and AWS crews!)
  - BAS

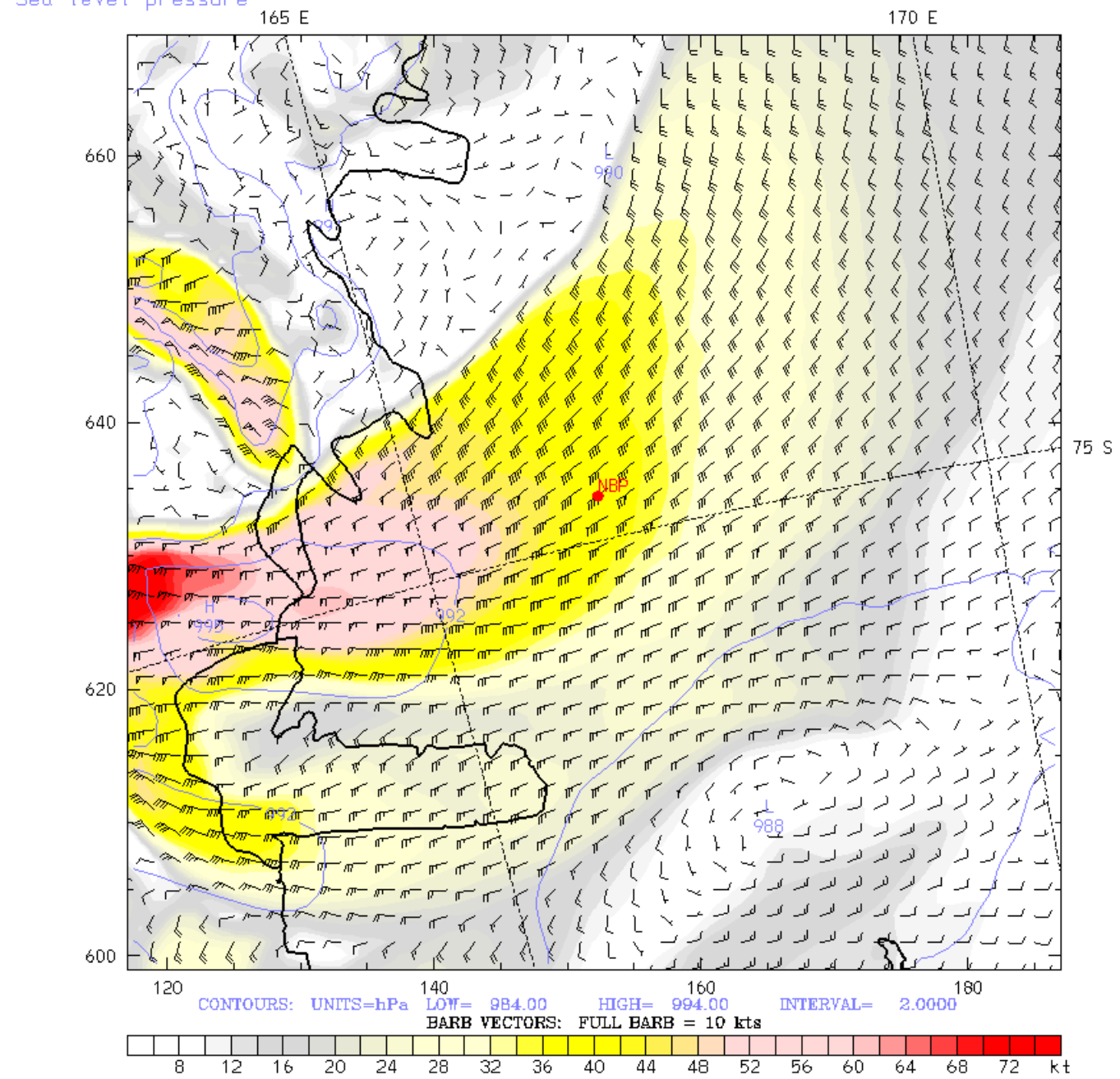
# Field campaign support

- AMPS has traditionally supported various Antarctic field campaigns
  - Customized NWP products
    - As time and resources allow
    - As consistent with AMPS goals and mission


ACE
- Antarctic Circumnavigation Expedition
- Three-month circumnavigation of Antarctica
  - Wide variety of ecological, biological, climatological, meteorological, etc. investigations
- Ship-following AMPS graphics window


PIPERS
- Polynyas, Ice Production, and seasonal Evolution in the Ross Sea
- Two-month expedition of the Nathaniel B. Palmer to the wintertime Ross Sea
- Ship-following AMPS graphics window

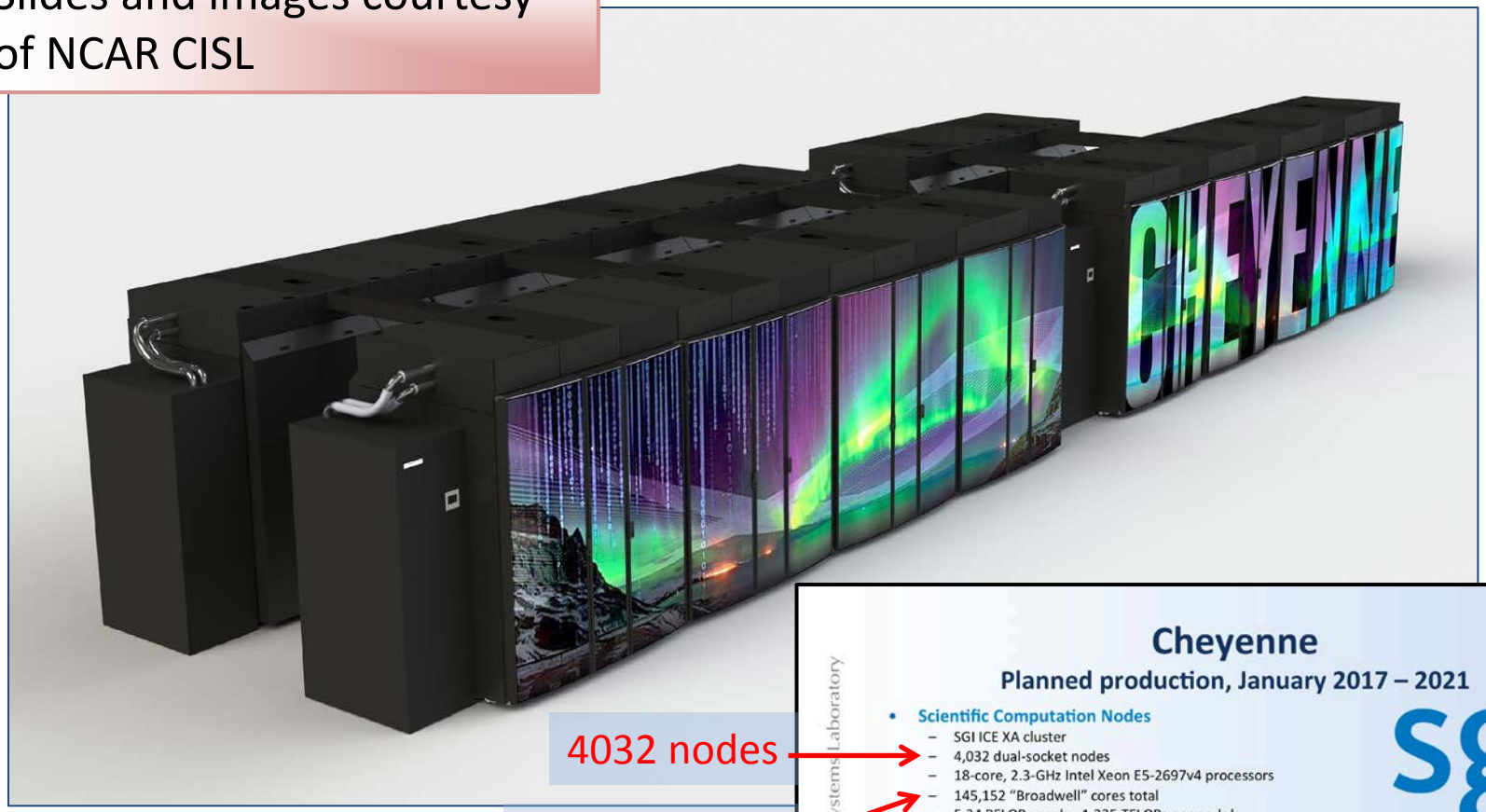
  - ROSETTA-ICE
    - Lamont-Doherty Earth Observatory study of Ross Ice Shelf
    - AMPS “truly valuable” in decision making to deploy autonomous ocean floats


AMPS -- Nathaniel B. Palmer Zoom
Init: 00 UTC Mon 01 May 17
Fcst: 12 h
Valid: 12 UTC Mon 01 May 17
Horizontal wind speed
at k-index = 60
Sea-level pressure
165 E
170 E
660
640
620
600
75 S
NBP
L
980
H
992
L
988
120
140
160
180
CONTOURS: UNITS=hPa LOW= 984.00 HIGH= 994.00 INTERVAL= 2.0000
BARB VECTORS: FULL BARB = 10 kts
8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 kt

# New computing platform

- Fifth generation of AMPS computing platforms
  - Box (90/30/[10]-km) (Sep 2000)
  - Pegasus (60/20/6.7/3.3-km) (Apr 2005) [dedicated]
  - Bluefire (45/15/5/1.7-km) (Oct 2008) [shared]
  - Erebus (30/10/3.3/1.1) (Jan 2013) [dedicated]
  - **CHEYENNE** (Jun 2017) [shared]

Slides and images courtesy of NCAR CISL




4032 nodes

145,152 cores

## Cheyenne

### Planned production, January 2017 – 2021

- **Scientific Computation Nodes**
  - SGI ICE XA cluster
  - 4,032 dual-socket nodes
  - 18-core, 2.3-GHz Intel Xeon E5-2697v4 processors
  - 145,152 "Broadwell" cores total
  - 5.34 PFLOPs peak – 1.325 TFLOPs per node!
  - 313 TB total memory (3,164 64-GB and 864 128-GB nodes)
  - **>2.45 Yellowstone equivalents**
- **High-Performance Interconnect**
  - Mellanox EDR InfiniBand
  - 9-D enhanced hypercube topology
  - 100-Gbps link bandwidth — 0.5 µs latency
  - 36 TB/s bisection bandwidth
  - 224 36-port switches, no director switches
- **Login Nodes**
  - 6 nodes with 2.3-GHz Intel Xeon E5-2697v4 processors
  - 36 cores & 256 GB memory per node
- **Service Nodes (scheduler, license servers)**
  - 4 nodes; Intel Broadwell processors
  - 36 cores & 64 GB memory per node

CISL Computational & Information Systems Laboratory

NCAR

sgi

intel

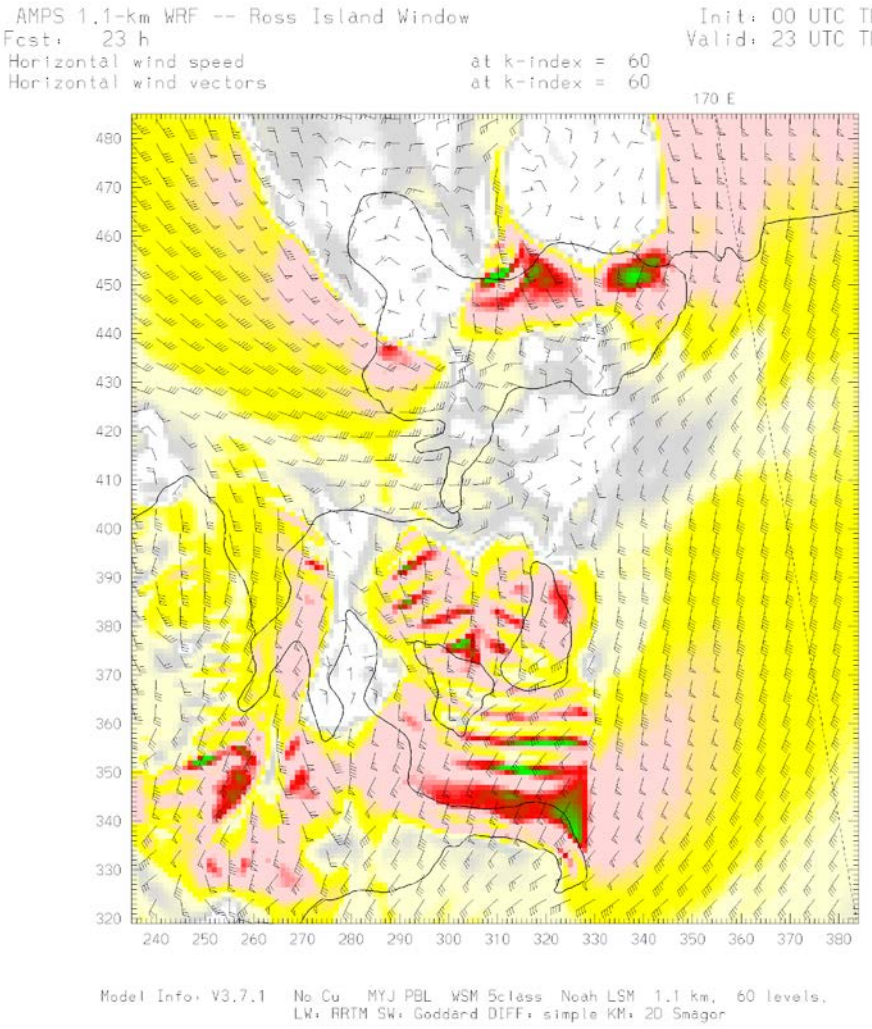
Mellanox TECHNOLOGIES

3

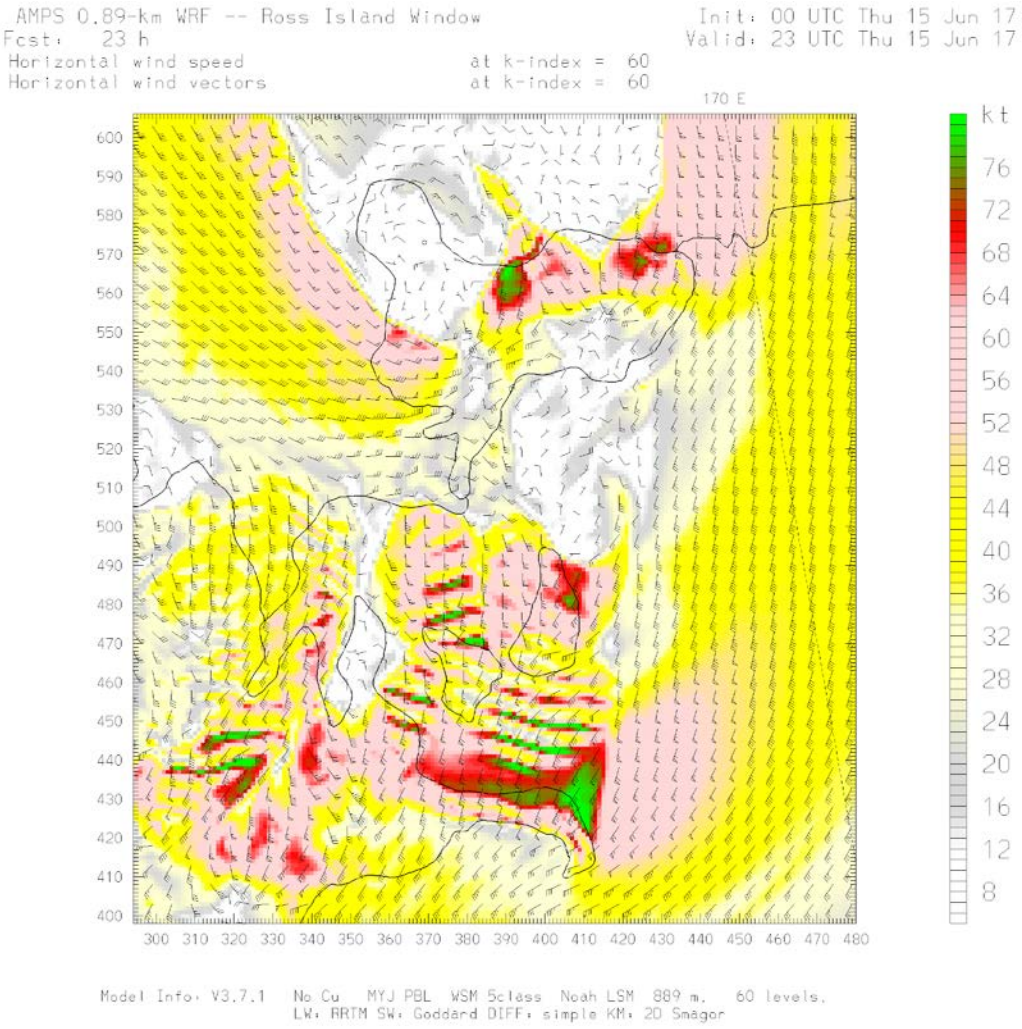
- AMPS has dedicated high-priority queue on Cheyenne
- Approximately 2.5× computing power available to AMPS


- Higher resolution WRF runs
  - Testing 24/8/2.67/0.89 km grids
- Expanded ensemble
  - Test WRF physics options
  - Better hybrid Ensemble/3DVar data assimilation
- Better MPAS
  - Higher resolution – 10km mesh over continent
  - Updated release (4.0 → 5.1 → 5.2)

1.1-km grid

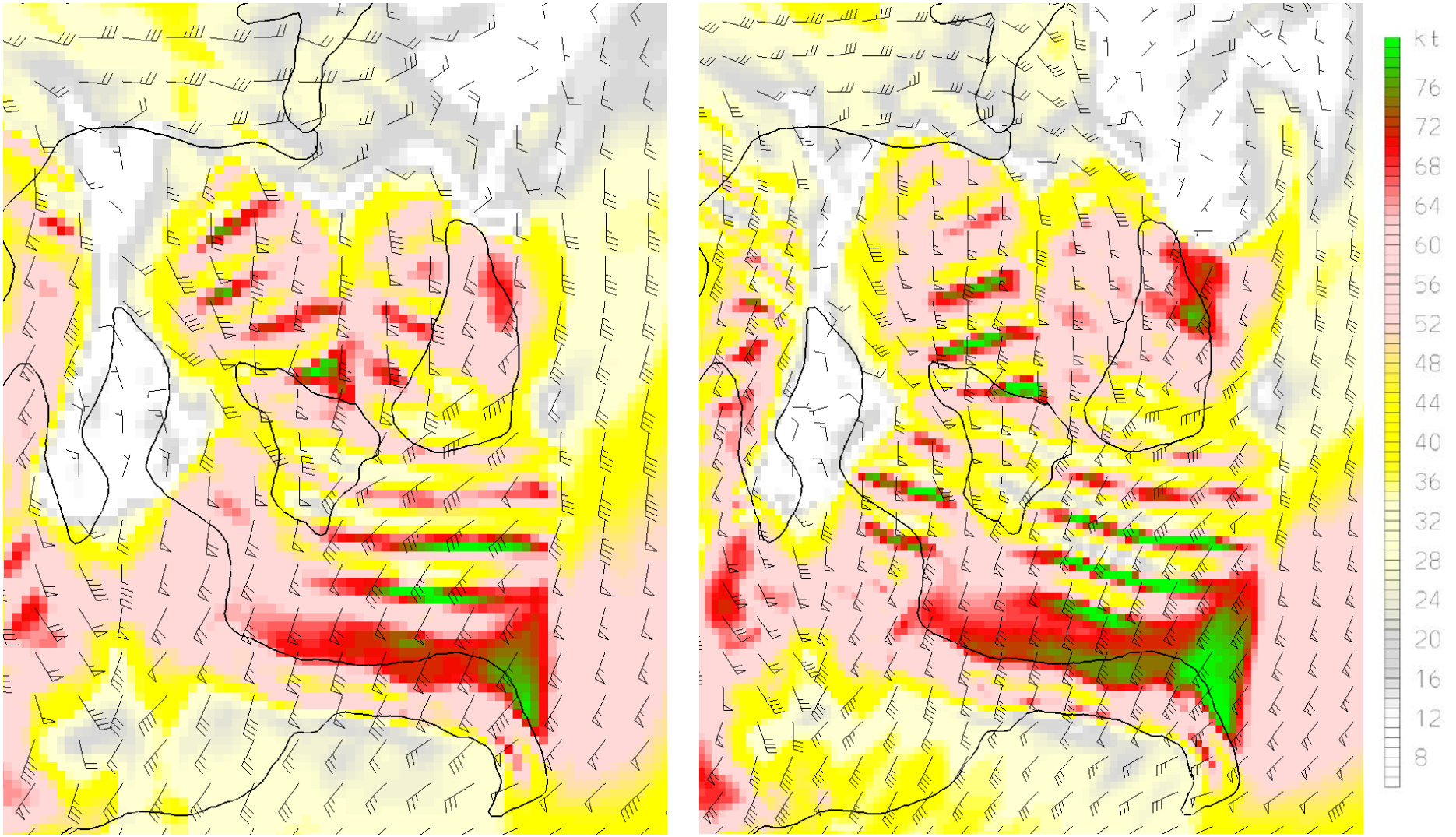



0.89-km grid



1.1-km grid

0.89-km grid



# Coming Attractions!

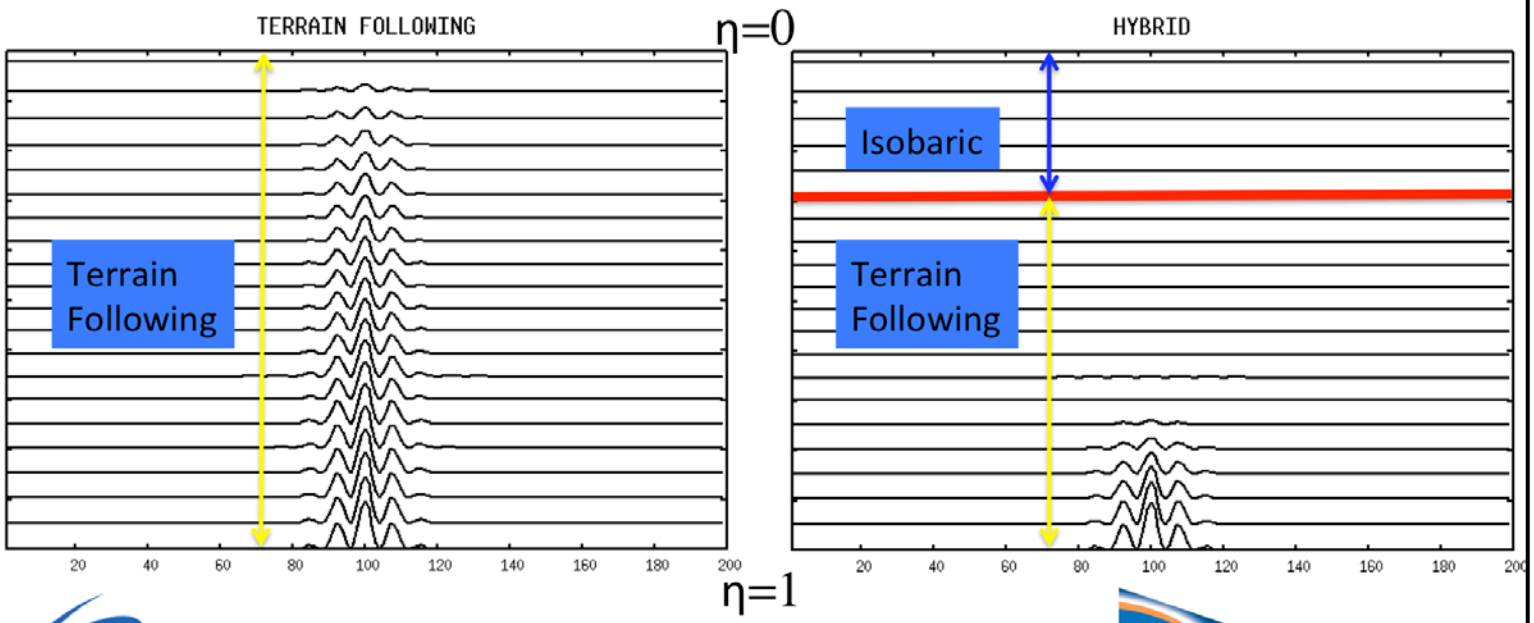
# WRF Version 3.9x

- Code update (currently AMPS uses WRFv3.7.1)
  - Accumulated bug fixes and improvements
- New physics options
  - Predicted Particle Property ($P^3$) microphysics might be interesting
- New ensemble options
  - Stochastically perturbed parameterization tendencies
    - Adds random perturbation patterns with spatial and temporal coherence to the physics tendencies
    - Promotes ensemble "dispersion", i.e., variation among members
- New "hybrid" vertical coordinate

Slides courtesy of Dave Gill

# A Hybrid Terrain-Following Vertical Coordinate in WRF

Dave Gill  Joe Klemp  Jimy Dudhia




DTC Developmental Testbed Center

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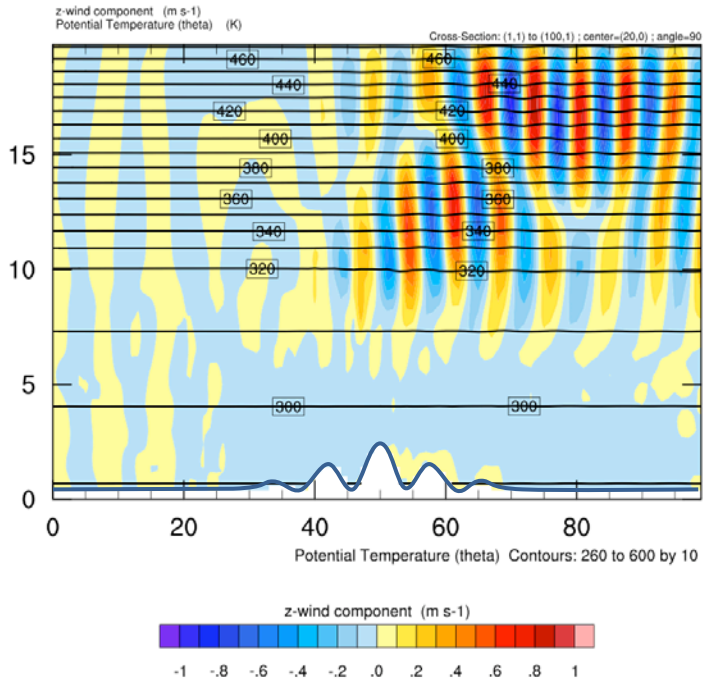
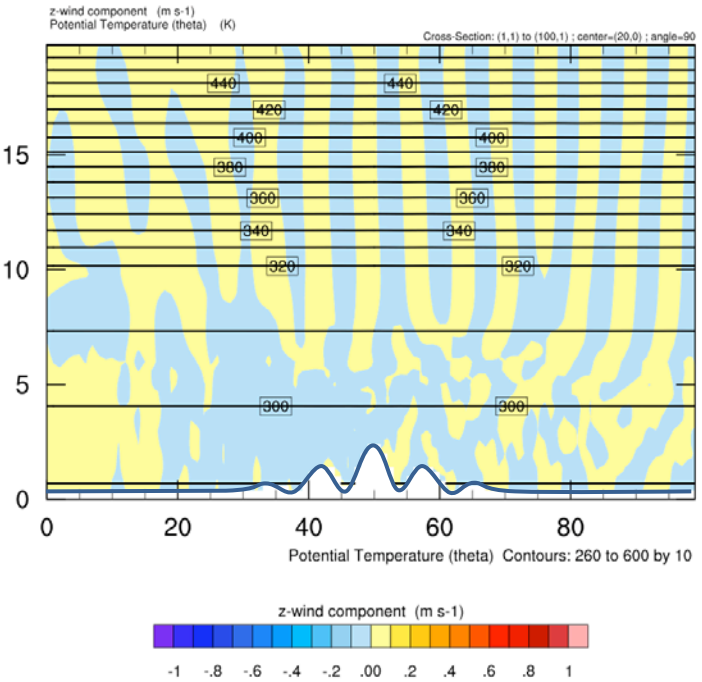
Slides courtesy of Dave Gill

# Schar 2000 m, 20 km Z, 500 m dz, 1 km dx, $W_{5h}$ (m/s)

## Terrain Following

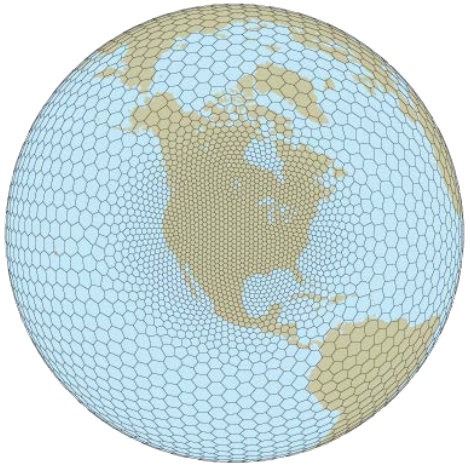



## Hybrid Coordinate



# Model for Prediction Across Scales

- MPAS not viewed as replacing WRF
  - In WRF community, or in AMPS
  - AMPS will likely be running WRF for the foreseeable future
    - MPAS runs with the high resolution in AMPS would be prohibitively expensive
- Why MPAS?
  - Global-to-regional mesh refinement greatly reduces lateral boundary and nest boundary interface problems
  - Regional MPAS available soon
  - Development shifting from WRF to MPAS
    - WRF will take advantage of MPAS development
      - E.g., hybrid vertical coordinate
      - "scale-aware" or "scale-insensitive" physics
    - WRF maintained for the long term
  - Model development (particularly physics) at NCAR to stress interoperability among models
    - Global perspective (including polar regions) necessary
  - Possible future WRF one-way nests driven from MPAS



# Thank You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LABORATORY