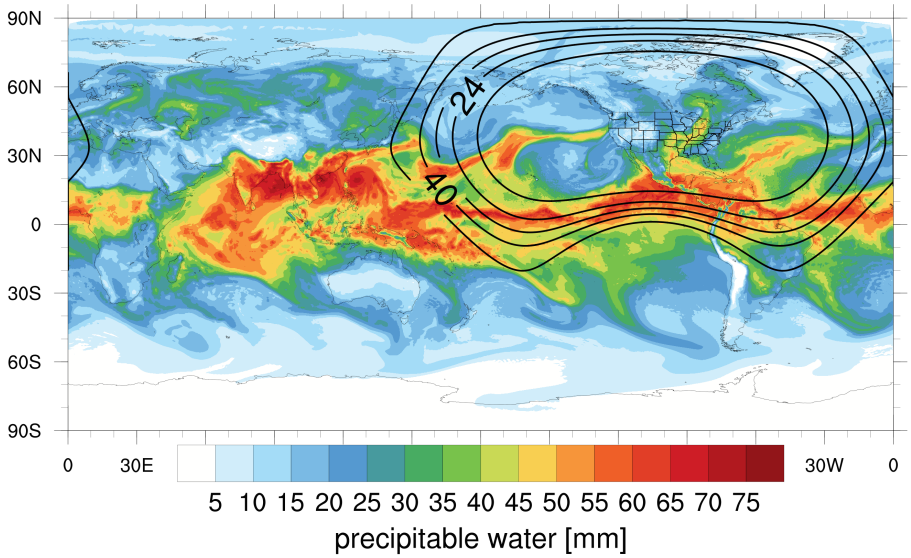
The MPAS global ensemble analyses in mesoscale applications

Soyoung Ha and Chris Snyder

National Center for Atmospheric Research



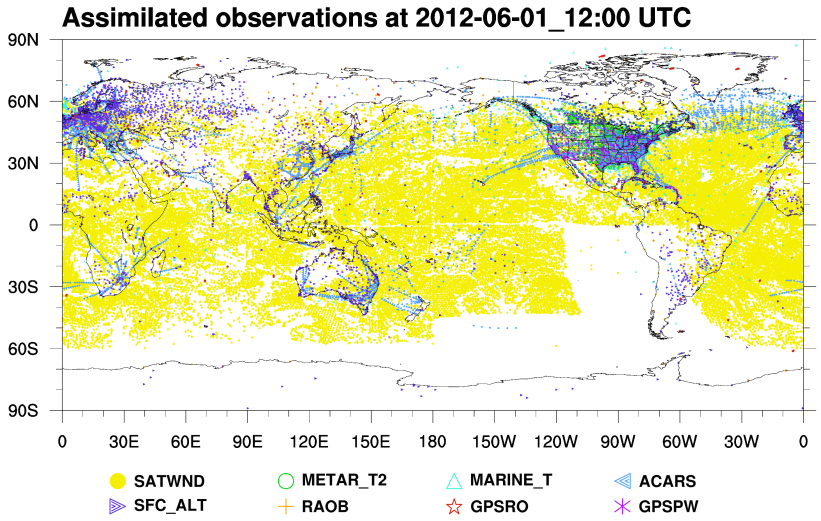
Contributions from MPAS model and DA development team
(Bill Skamarock, Michael Duda, Laura Fowler, Hui-Chan Lin, Craig Schwartz, Zhiquan Liu, and Tom Augliné)
and the DART/IMAGe team (Glen Romine, Nancy Collins, and Jeff Anderson)

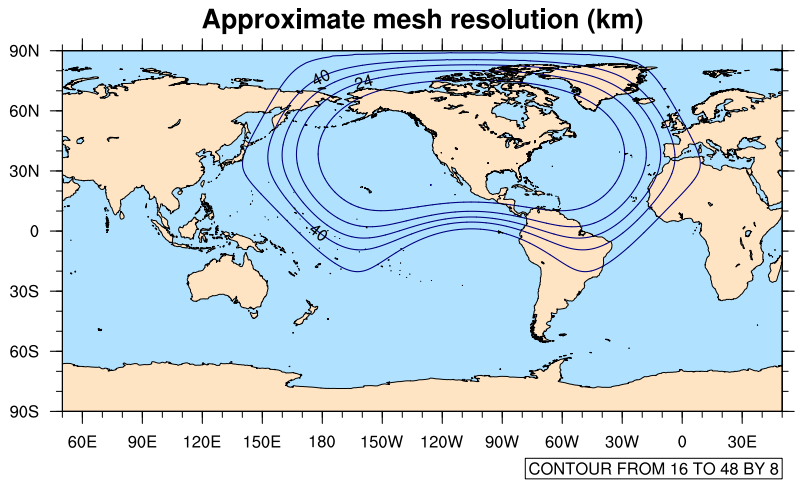
MPAS global ensemble analyses

- Forecast model: Model for Prediction Across Scales (MPAS)
  - Unstructured grid meshes on C-staggering, a terrain-following height coordinate
  - Fully compressible nonhydrostatic global model
  - Current release 4.0: http://mpas-dev.github.io/
  - 'mesoscale_reference' physics suite: Noah LSM, YSU PBL, WSM6 Microphysics, Tiedtke cumulus, RRTMG SW/LW schemes
- Analysis system: Data Assimilation Research Testbed (DART)
  - Ensemble Kalman Filter analysis
  - Current "Lanai" release includes an interface to both MPAS-atmosphere and MPAS-ocean core http://www.image.ucar.edu/DAReS/DART/Lanai_release.html
  - Forward operators based on native grids and vert. coordinate in MPAS
- Ensemble analysis/forecast cycling has been well tested in various cases

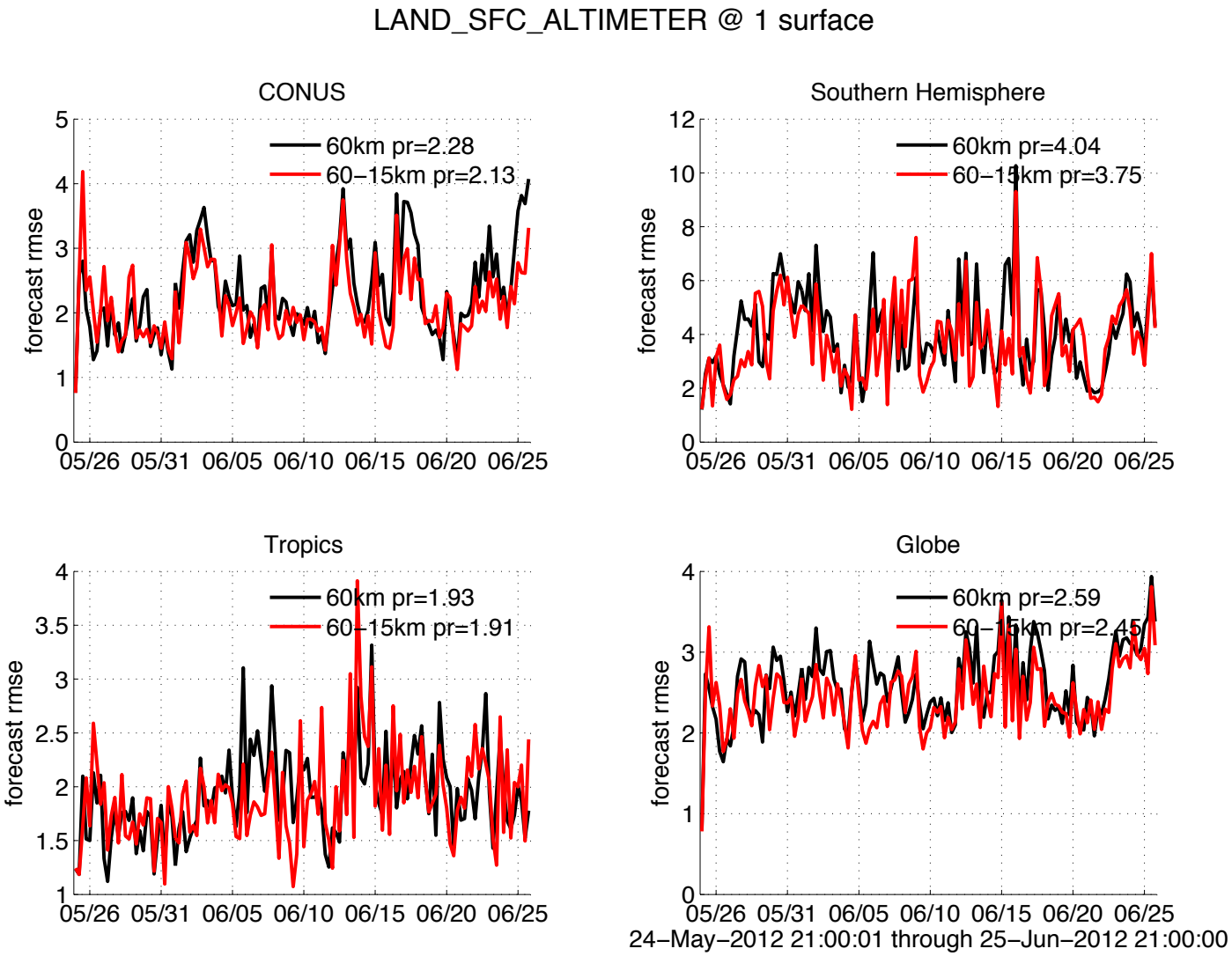
Mesoscale analyses in MPAS

- Grid: 60-15 km variable mesh, 55 vertical levels up to 30 km
- Cycling experiments
  - 6-hr cycling for May 25 – June 25, 2012
  - 96-member ensemble analyses/forecasts on the same variable mesh
  - Assimilating radiosonde, aircraft, satwnd, GPS RO, marine and METAR obs
  - 5-day forecasts from the EnKF mean analyses, twice daily, every other day
- Compared to 60-km quasi-uniform mesh w/ the same configuration

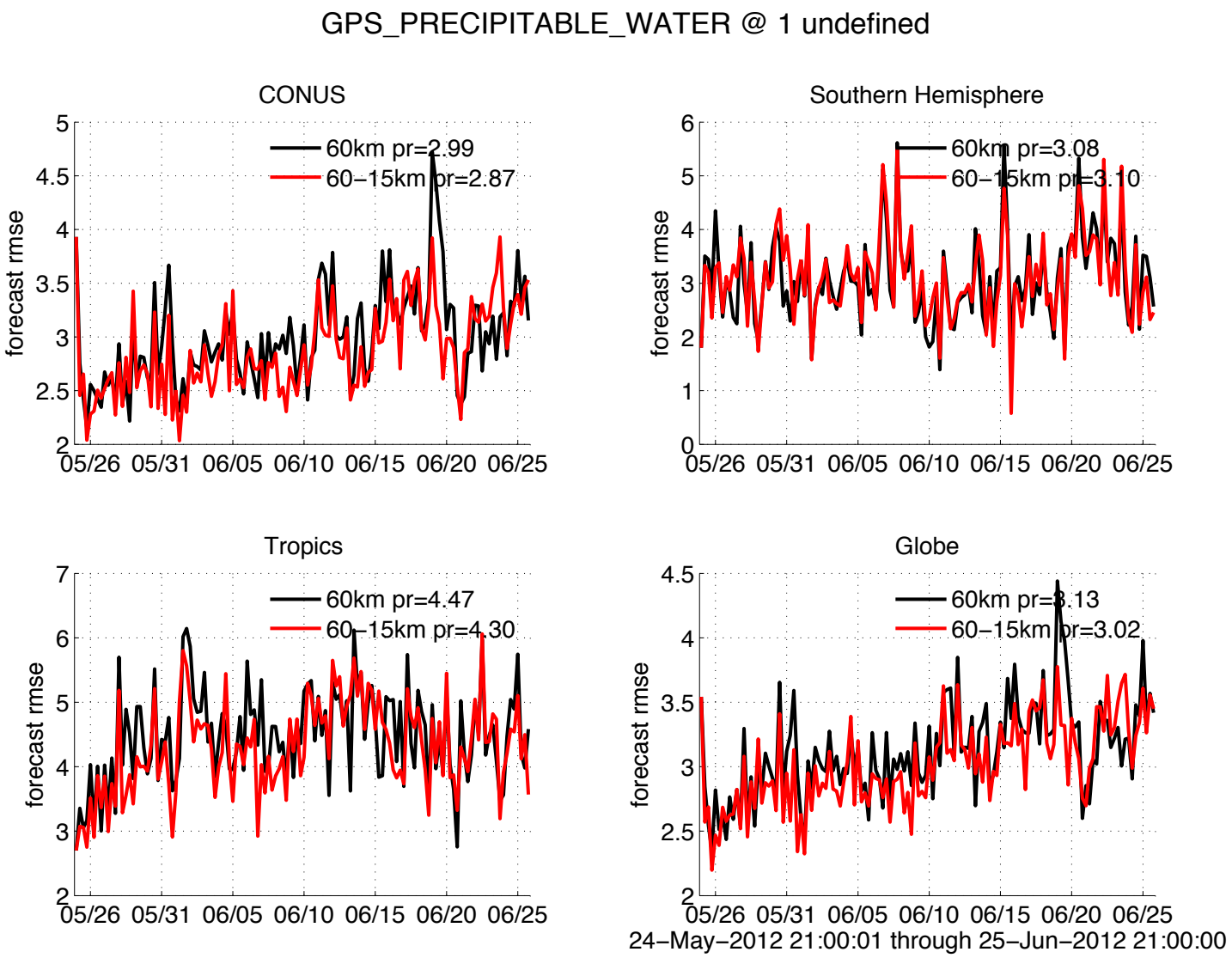




6-hr forecast verification against surface altimeter obs

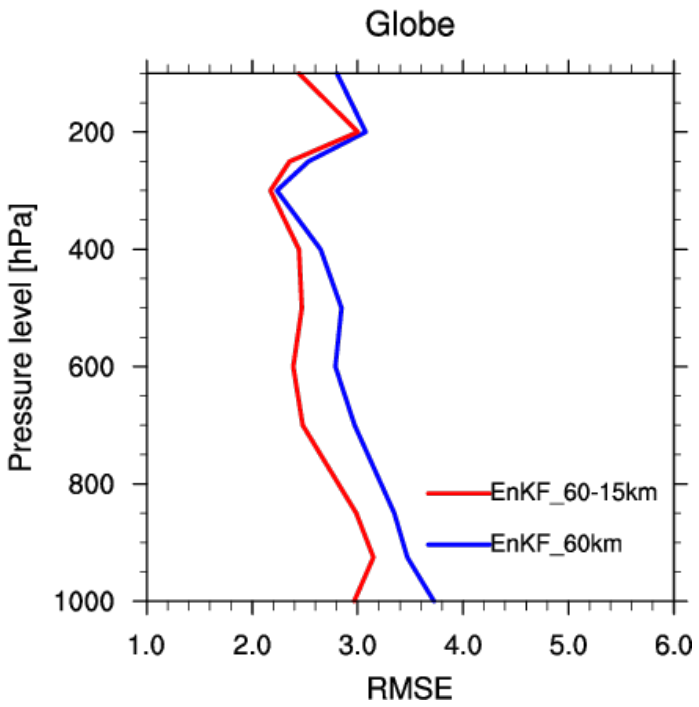


6-hr forecast verification against GPS PW observations

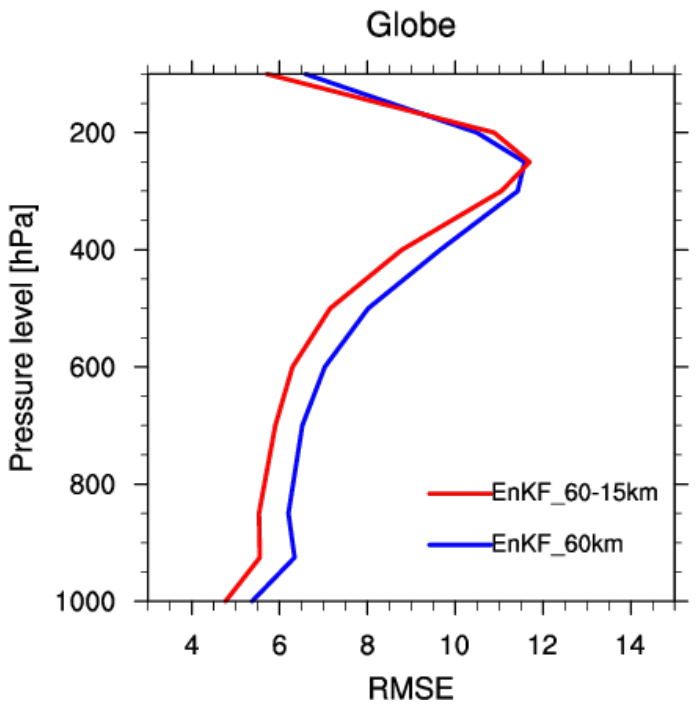


5-day forecast verification against FNL analyses

Temperature



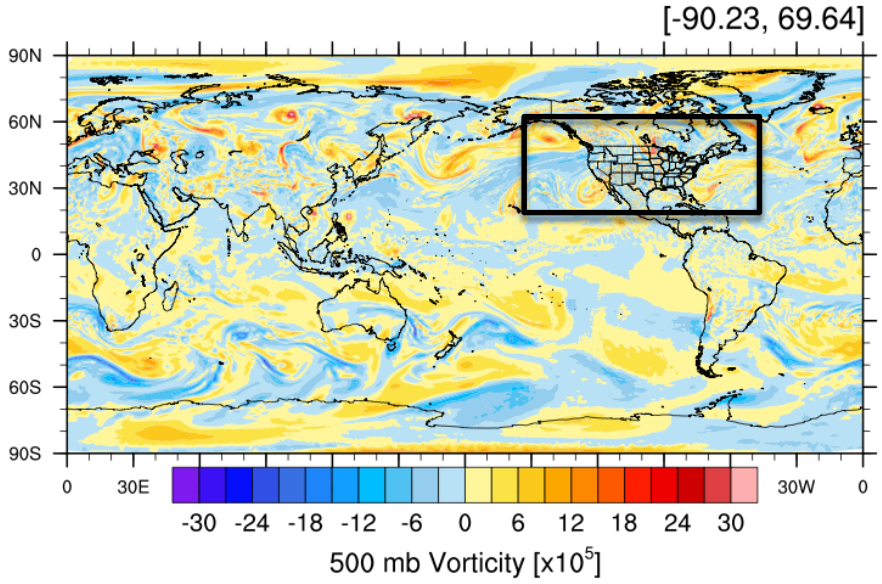
Zonal wind



The variable mesh increased the forecast skills over the whole globe.

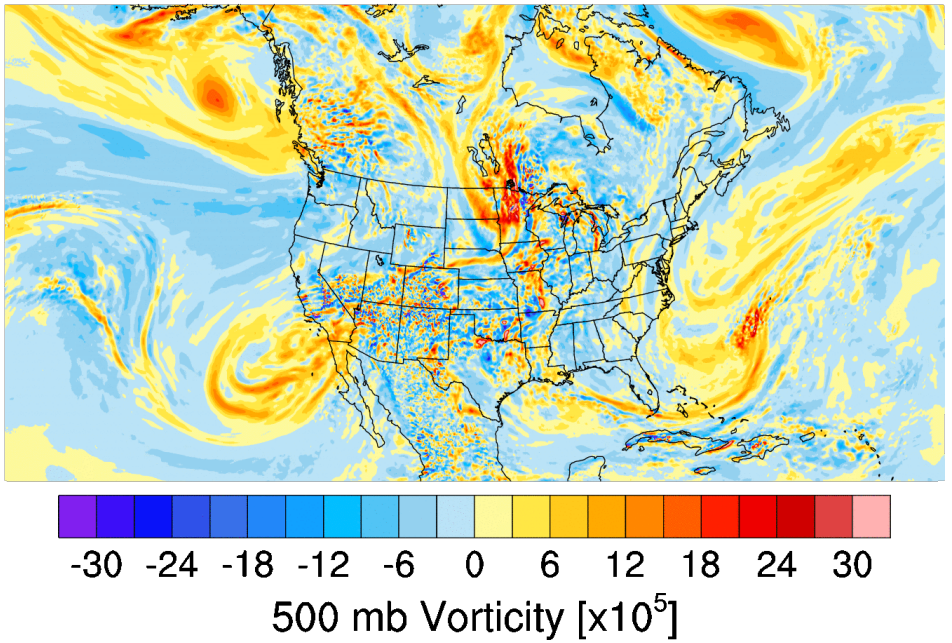
5-day forecast in 60-15km mesh: 500 hPa Vorticity

EnKF mean analysis at
2012-06-17_00 UTC



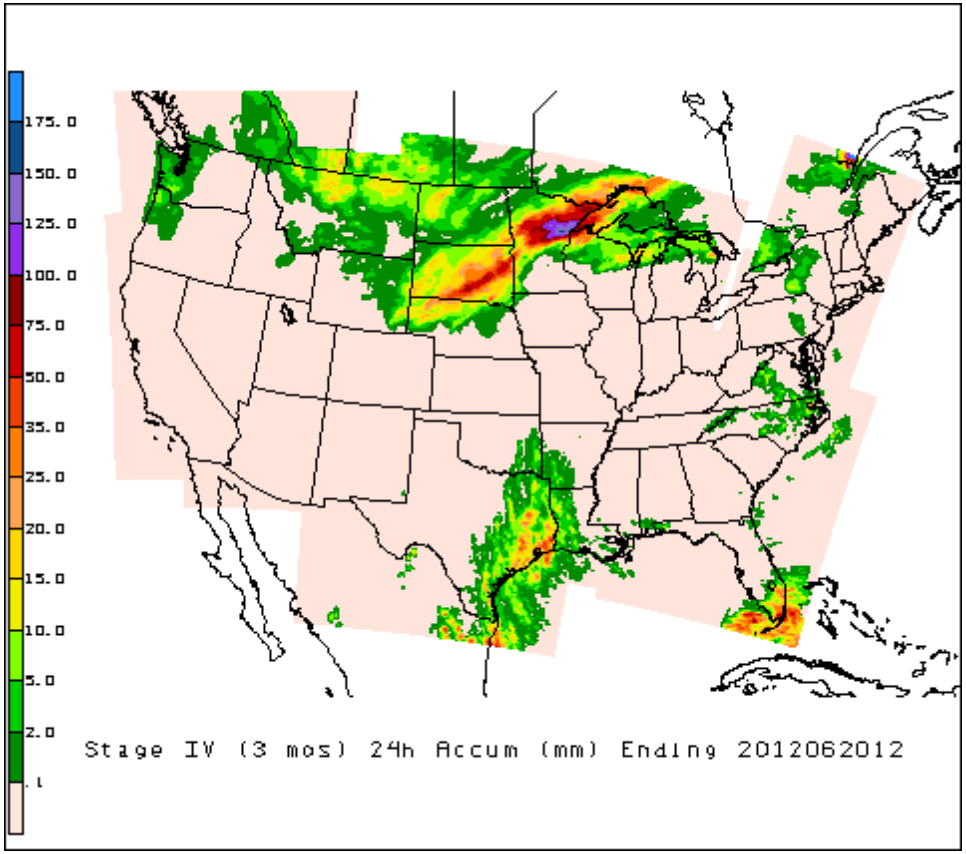
x4.535554: 0 h forecast from 2012061700

[-90.23, 69.64]

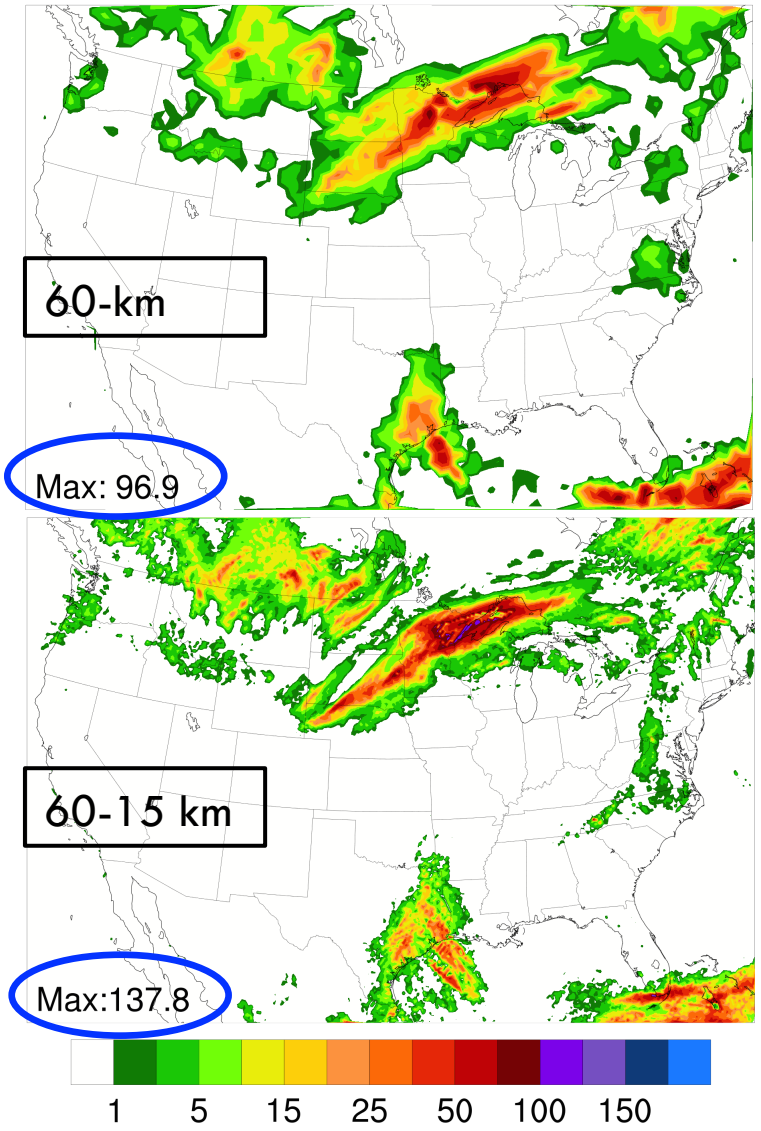


24-h accum. rainfall [mm]

NCEP Stage IV
ending at 2012-06-20_12Z

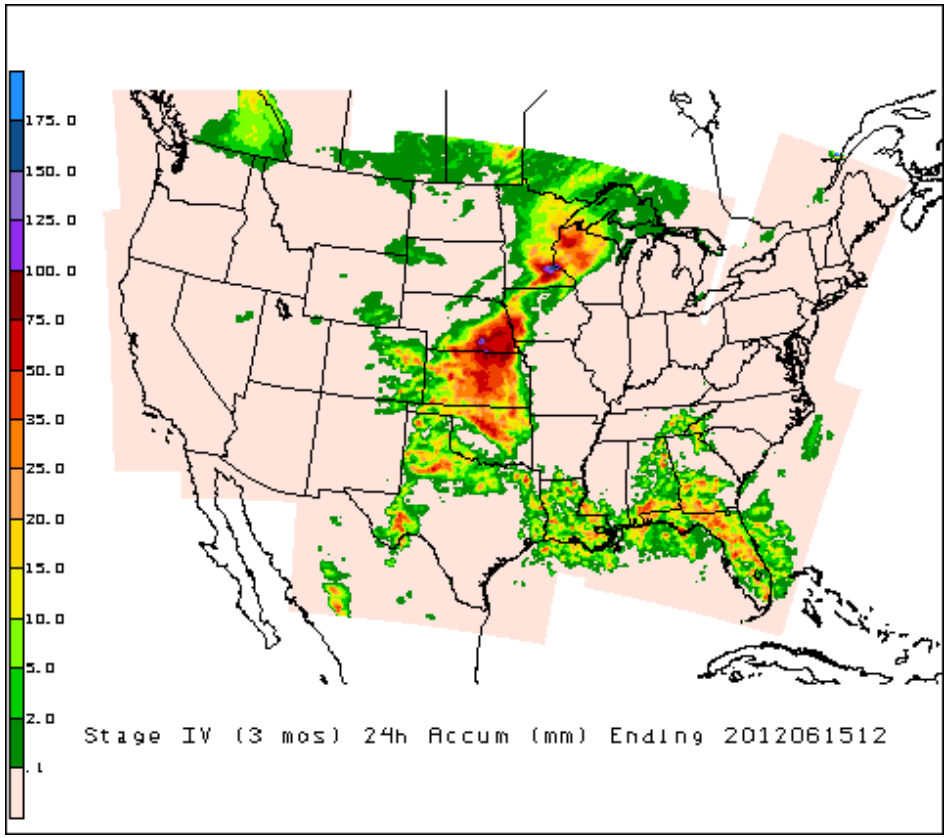


24-hr MPAS forecast from the EnKF mean analysis at 2012061912

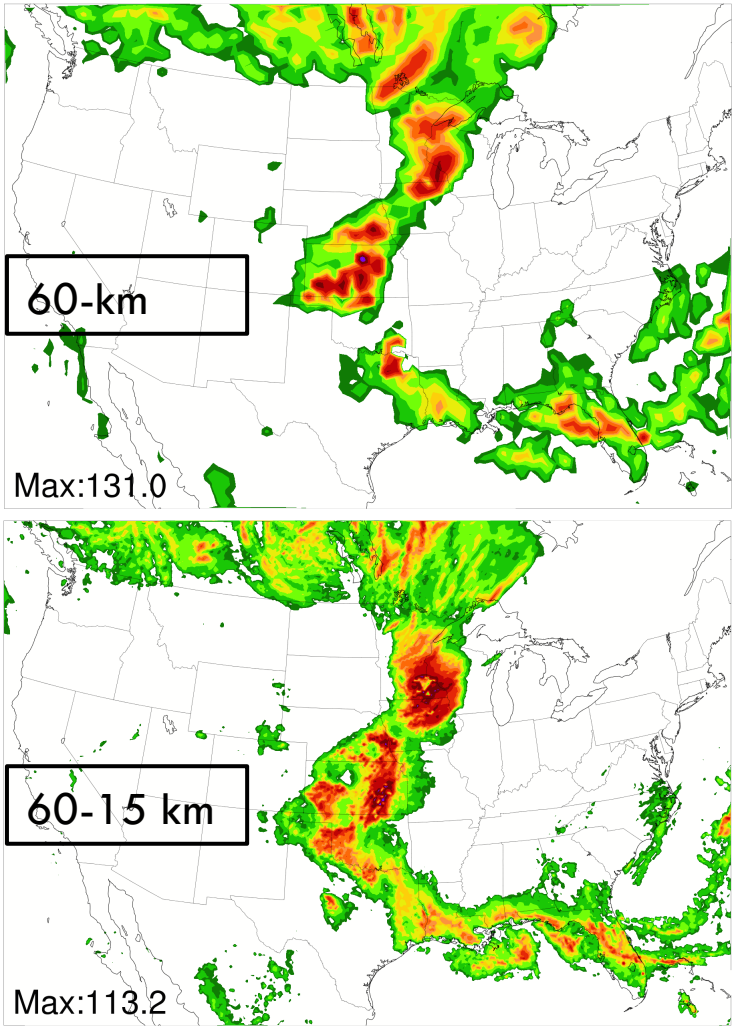


24-h accum. rainfall [mm]

NCEP Stage IV
ending at 2012-06-15_12Z



48-hr MPAS forecast from the EnKF mean analysis at 2012061312



Comparison to WRF/DART

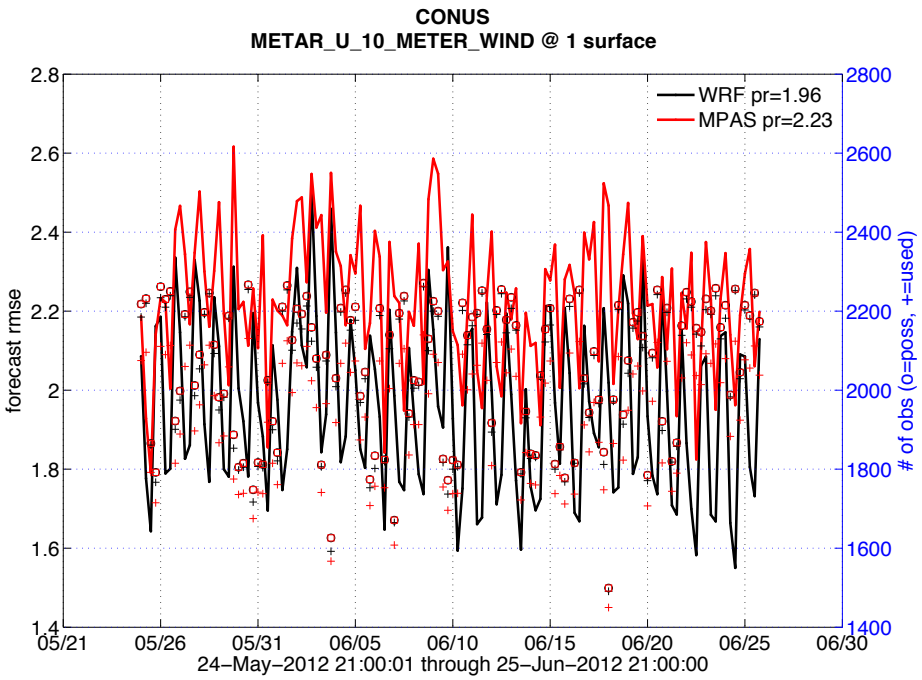
- G. Romine's WRF/DART cycling
  - Two-month period from May – June, 2012, 6 hr cycling
  - 15-km grid resolution over the CONUS domain, nested down to 3-km mesh over Central US, w/ 40 vertical levels up to 50 hPa

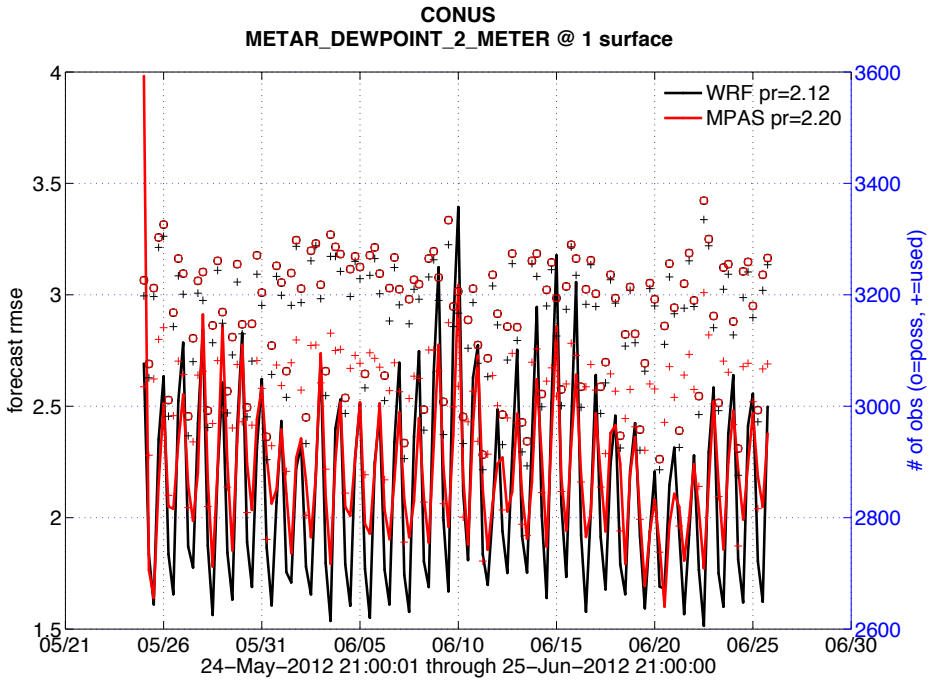
  => Very similar spatial resolution as in the refined mesh area in MPAS/DART
  - Physics suite: MYJ PBL, Morrison double-moment microphysics, Noah LSM, Tiedtke cumulus, RRTMG SW/LW radiation schemes
  - Assimilation: Same observation types as the ones used in MPAS/DART
  - Ensemble Kalman filter design: 50-member ensemble, double the vertical localization (8-km half-width) of MPAS/DART, adaptive prior inflation vary more quickly with time than in MPAS/DART cycling

  => Filter configuration is certainly different for the analysis.
  - Wrf_obs_preprocessing for the regional model vs. mpas_obs_preprocessing for the global model

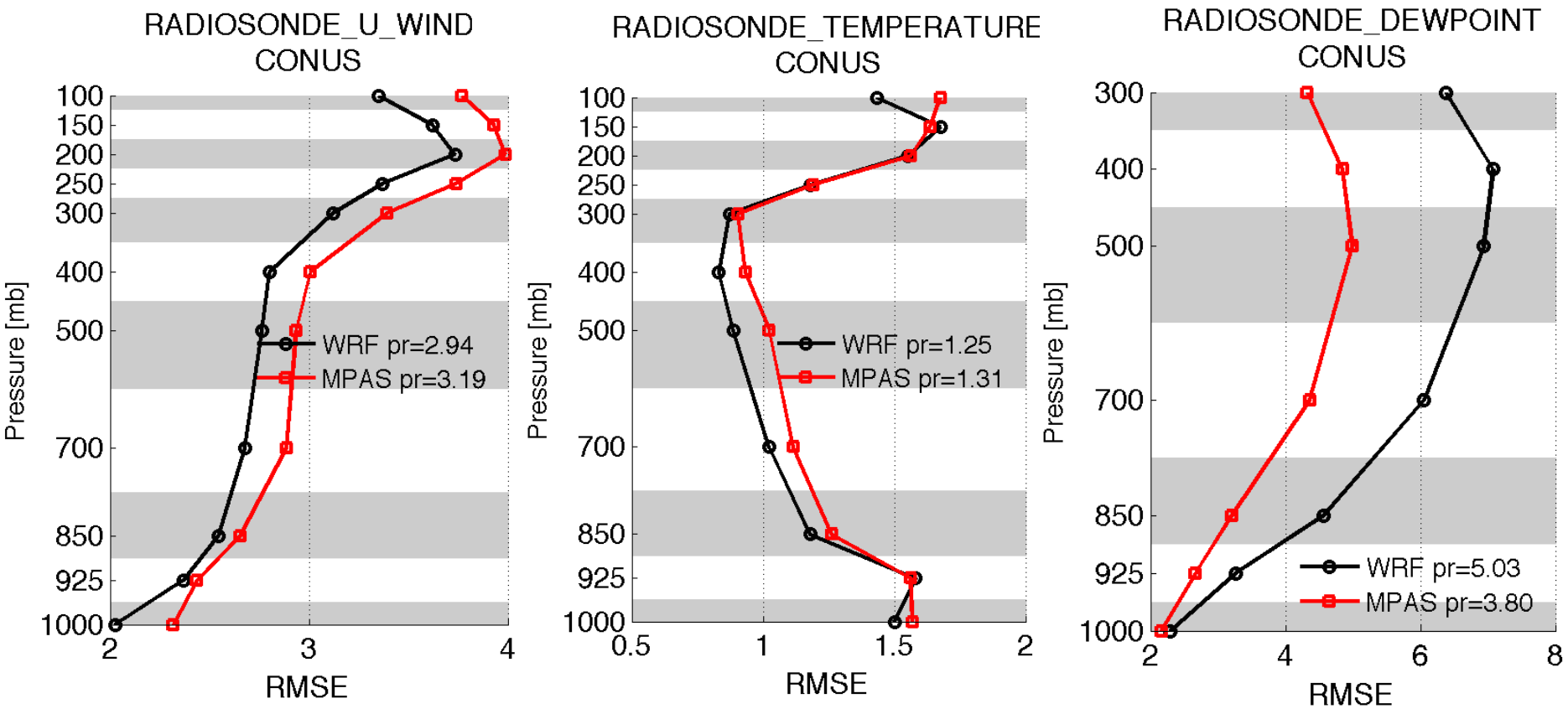
Preliminary results: WRF/DART vs. MPAS/DART (1/2)

6-h forecast verification against METAR surface observations





Preliminary results: WRF/DART vs. MPAS/DART (2/2)



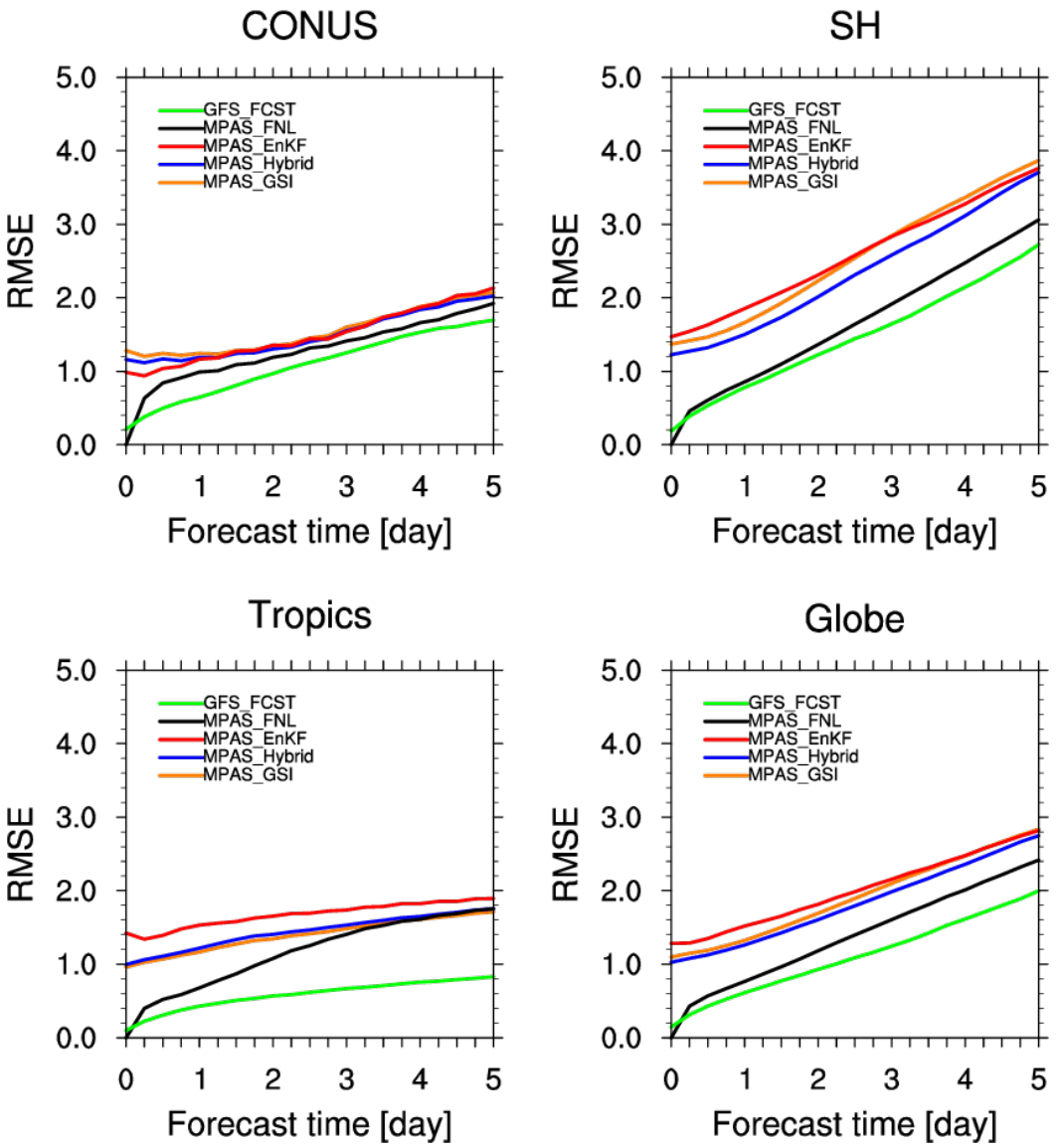
- 6-h forecast in horizontal wind and temperature is better in WRF/DART => Due to the lack of gravity wave drag (GWDO) on the variable mesh; ongoing work
- moisture forecast looks better in MPAS/DART <= the large rejection rate due to the smaller ensemble spread. Need further process for common observations.

Various analysis techniques for MPAS

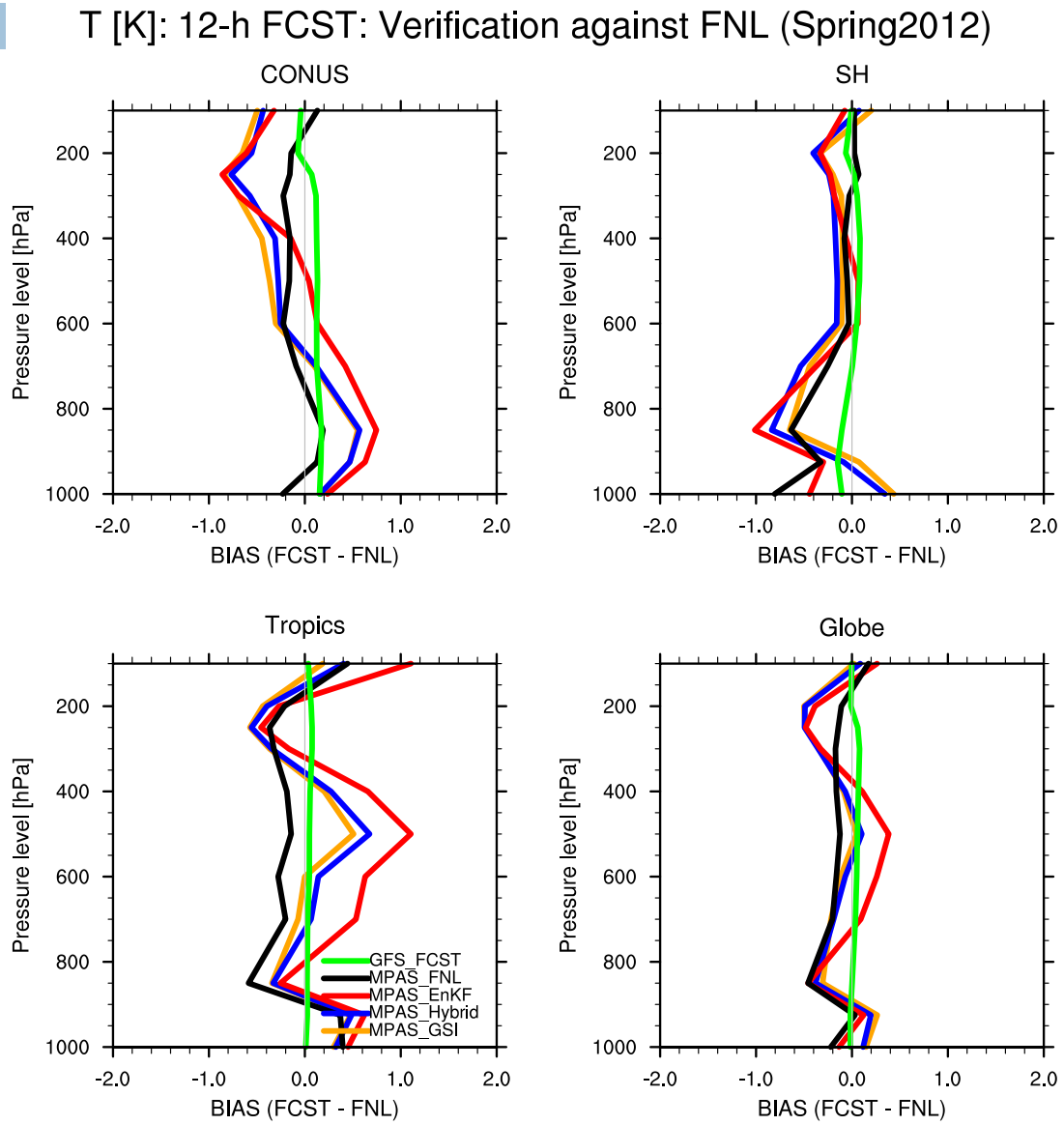
- MPAS/GSI converter (C. Schwartz and H.-C. Lin)
  - Variable transform (MPAS prognostic fields to GSI analysis variables)
  - Grid transform (from the unstructured mesh in the height coordinate to lat/lon grids in the hybrid sigma-pressure coordinate)
- Analysis increments are added to MPAS prior states
- Tested at x1.40962 mesh over the same one-month period of spring 2012

Preliminary results: various analysis techniques

500hPa T [K]: Verification against FNL analyses (Spring 2012)



Preliminary results: various analysis techniques



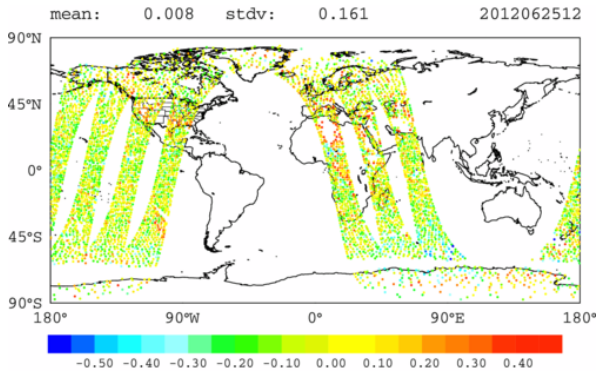
Future plans

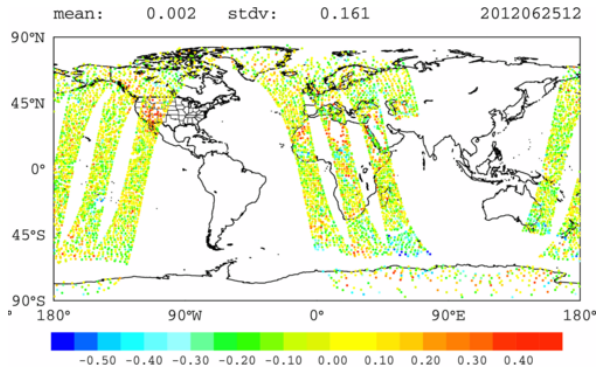
- Dealing with model error
  - Higher model top: from 30-km to 1-mb (~42-km)
  - Gravity wave drag over orography (GWDO) in variable meshes
  - Check physical tendencies
  - Stochastic Kinetic Energy Backscatter (SKEB) – J. Berner
- Further improvements on various analysis systems – Ha, Schwartz and Lin
  - Optimal localization and inflation in the ensemble DA system
  - Testing recent updates in GSI converter + satellite radiance DA in MPAS/GSI
  - An implementation of the Ensemble-Variational Integrated Localized (EVIL) for MPAS

Advertisement

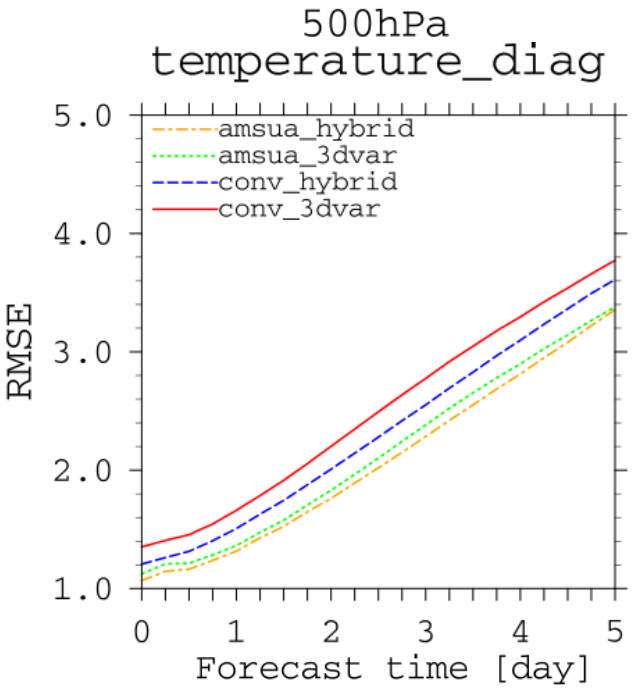
- Posters: Data Assimilation Development and Testing

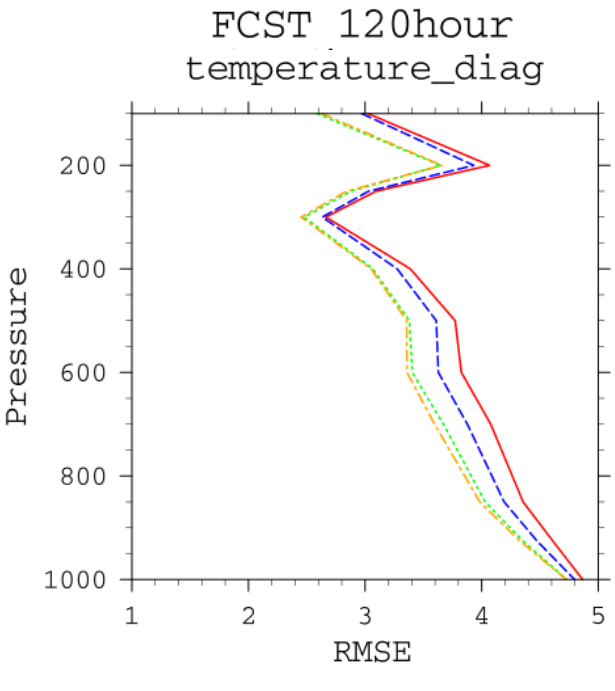
P10: "Three-dimensional variational and hybrid data assimilation for the MPAS-A system." Hui-Chan Lin and Craig Schwartz.





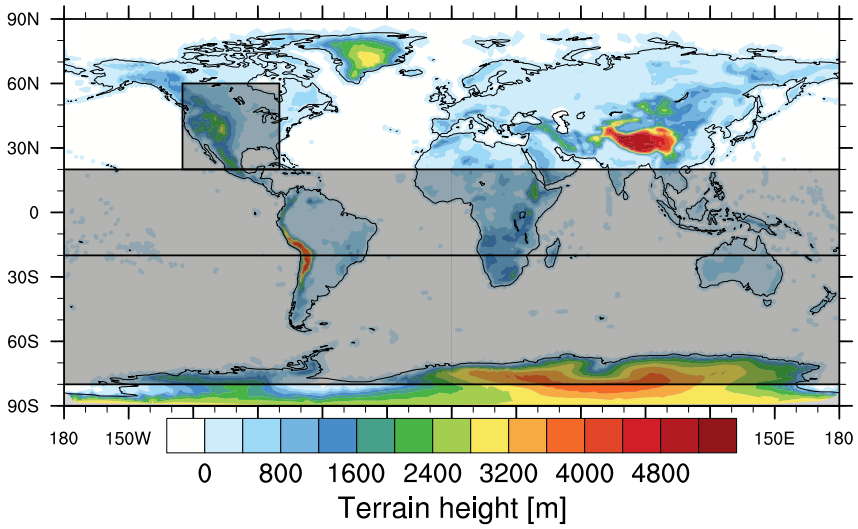
Verification against FNL analyses:
Southern Hemisphere





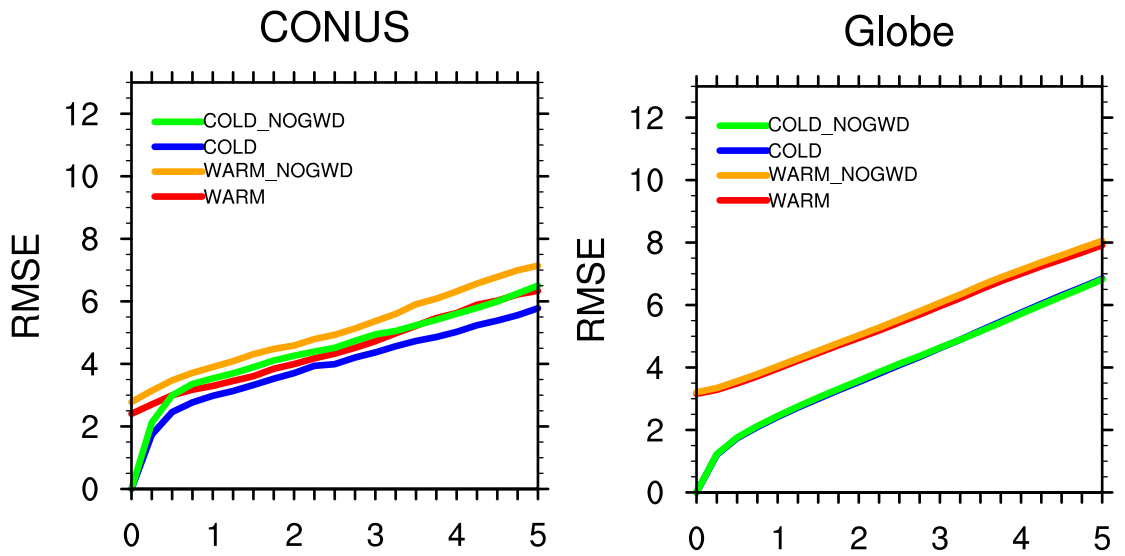
GWDO tests

- Grid: X1.40962 (120-km quasi-uniform mesh)
- Period
  - Cycling from May 25 – June 25, 2012, every 6 hrly
  - 5-day forecast verification from June 1 – 25, 2012 twice daily, every other day (26 samples)
- Comparison between 4 different forecasts
  - COLD <- GFS analysis
  - COLD_NOGWD
  - WARM <- EnKF analysis
  - WARM_NOGWD

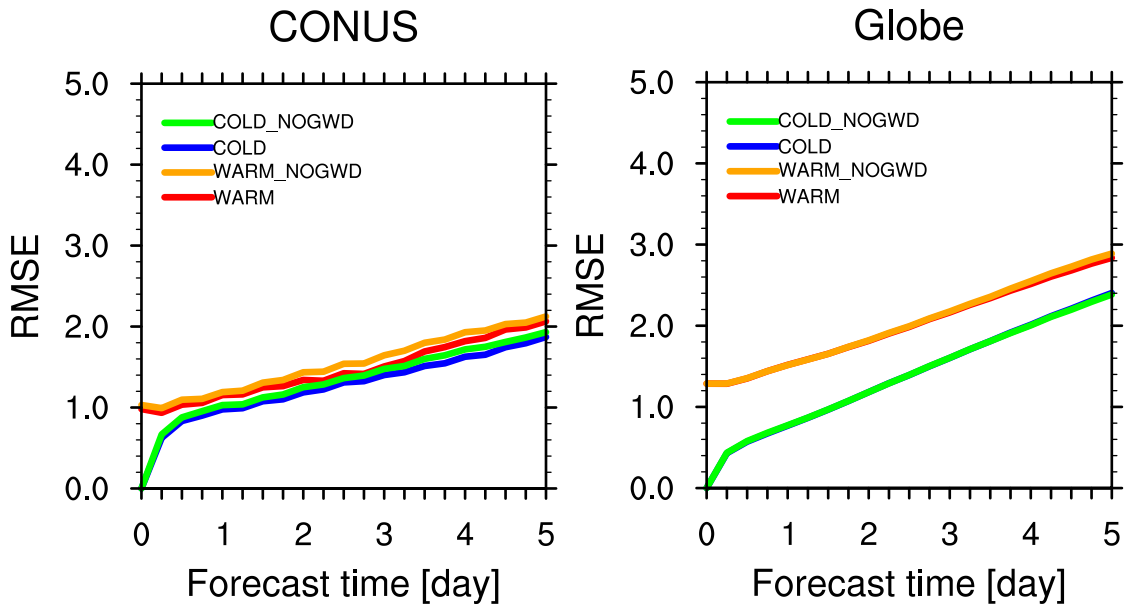


Verification against FNL analysis (Spring 2012)

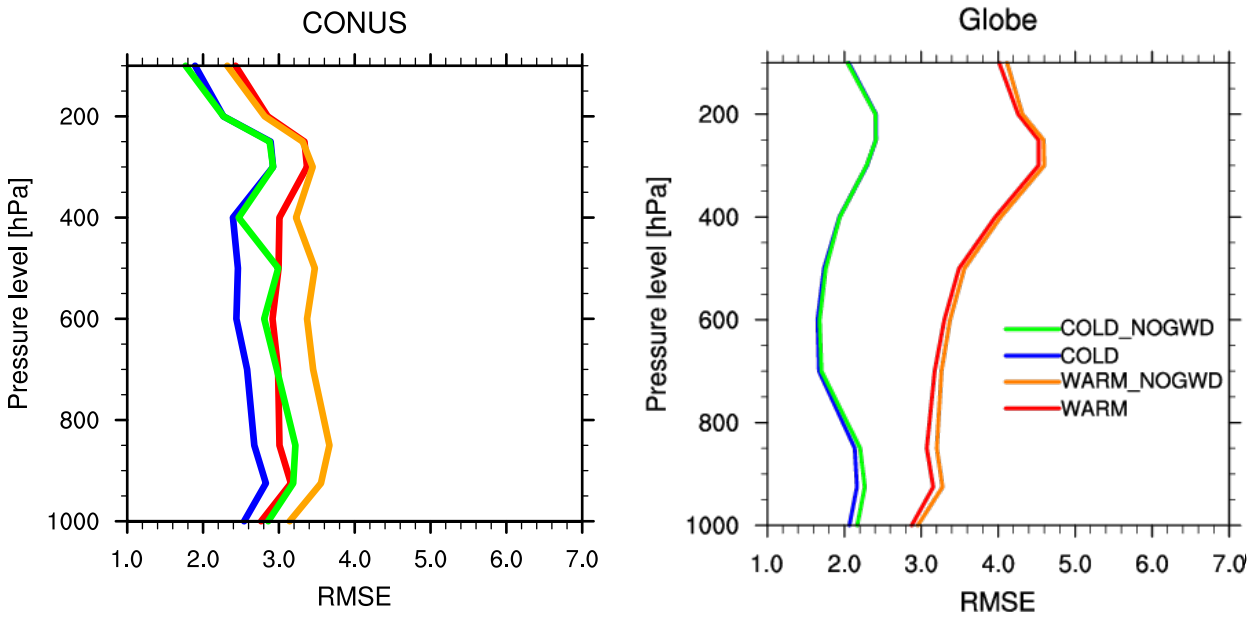
500 mb u-wind



500 mb temperature



U-Wind [m/s]: 12-hr FCST



U-Wind [m/s]: 5-day FCST