Convection Permitting Global Prediction: Evaluation for Operational Application in NOAA.

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NOAA NGGPS Presentation
The Project

• Evaluate the impacts of global convection allowing resolution for weather and subseasonal prediction in NOAA
• Evaluate various model configurations for potential use by NOAA to move to convection permitting resolution for global models.
• Started with MPAS and hopefully will move to FV-3
Important Note

• Attempted to use the public release of FV-3
• Not ready for prime time
  • Computer dependencies
  • Inadequate pre and post processors
• No support
• Minimal documentation
• Thus, decided to do all simulations with MPAS.
• Hopefully, FV-3 will be ready for outside users in the future.
• The model: MPAS v5.1 (global)
• Physics: ‘convection_permitting’ suite
• Four cases (all integrated 28 days):
  • November 22, 2011 (DYNAMO)
  • February 8, 2013
  • December 2, 2003
  • December 8, 2013
Convection-permitting suite

• Scale-aware convection parameterization of Grell and Freitas (2014)
• Cloud microphysics scheme developed by Thompson and Eidhammer (2014).
• Gravity wave drag over orography: GWDO (WRF 3.6.1).
• Long- and short-wave radiation: RRTMG (WRF 3.9.1), except for climatological aerosols.
• PBL and surface layer: MYNN (WRF 3.9.1).
• Land surface model: NOAH (WRF 3.9.1).
• Configurations:
  • 15-km resolution, nTiedke cumulus scheme
  • 3-km resolution, no cumulus scheme
  • 15-km resolution, no cumulus scheme
  • 15-to-3-km tropical channel, Grell-Freitas
• NCEP FNL analyses used for ICs and BCs
• SSTs fixed at initial value
Computer resources per 3-km run

- Supercomputer: Cheyenne (5.34 petaflops)
- Run on 1024 nodes → 36,864 cores
- Core hours: 2.7 million
- Wall clock: 74 hours
- Output: ~80TB
Section 2
Tropical verification
Precipitation (mm/h) Hovmöllers (15S-15N) reveal:

- Weaker, more widespread rain in models with parameterized convection
- Improved eastward MJO propagation in 3km model for three cases
- Problematic westward propagation in 15km simulations
One Case

- CFS and 15km MPAS produce too much (little) light (heavy) precipitation
- 3km MPAS closely matches TRMM estimates
- Same result for all four cases!
Improvement in diurnal timing over both land and water
- Amplitude over land is still overestimated
- Same result for all four cases

solid = ocean
dashed = land
Precipitation statistics:
Diurnal cycle

1. Introduction
2. 3km vs 15km
3. 15km no-Cu
4. Channel
5. Discussion

Case-1

Case-2

Case-3

Case-4

rain rate [mm h⁻¹]
local hour
Is there a cheaper way to run a global CPM?

What about the 15-km simulations \textit{without} Cu parameterization?

- Too much heavy precipitation
- Way too dry
- Too little light precipitation
- Improved diurnal timing

*Identical results for all four cases*
Is there a cheaper way to run a global CPM?

What about the 15-km simulations \textit{without} Cu parameterization?

- Too much heavy precipitation
- Too little light precipitation
Is there a cheaper way to run a global CPM?

What about the 15-km simulations *without* Cu parameterization?

**No MJO**
Is there a cheaper way to run a global CPM?

What about the 15-km simulations \textit{without} Cu parameterization?

too dry
Is there a cheaper way to run a global CPM?

What about the 15-km simulations *without* Cu parameterization?

*Improved diurnal timing*
Is there a cheaper way to run a global CPM?

What if we use 3-km resolution in the tropics only?
Is there a cheaper way to run a global CPM?

What if we use 3-km resolution in the *tropics only*?

**Same benefits to tropical precipitation statistics**

MJO propagation is not as well-captured as in the 3-km global run
Is there a cheaper way to run a global CPM?

What if we use 3-km resolution in the *tropics only*?

There seems to be some advantage to having global convection-permitting
Section 3
Structure of organized tropical convection
Consider the "Kelvin" wave in Case-1:
Structure of organized convection

Latent heating and vertical motion:

- Stronger LH release and vertical motions in 3-km run
- Stronger downward motion behind the updraft:

![Graph showing Q1 [J kg⁻¹ s⁻¹] and w [m/s] -- 5S to 5N, comparing ERAS, MPAS_15km, and MPAS_3km results.](image)
Cloud water and rain water

- More widespread cloud ice in 3-km simulation
- More intense precipitation
Precip. statistics:
Rain frequency (%)
Section 4
Extratropical verification
Subseasonal extratropical skill: PNA

CASE-1

weekly 500-hPa height anomalies [m]
Extratropical skill: weekly Z500 scores

ALL CASES

• The bulk of the improvement is in week-3
• Similar results over the entire Northern Hemisphere
• 15-km no-Cu run performs worse than other MPAS configurations
Channel MJO and subseasonal PNA skill

- MJO propagation not well-captured in the channel run
- But good Z500 prediction in the PNA region for week-2 and week-3
Comparison to GOES satellite imagery over south America

- https://atmos.washington.edu/~njweber2/figures_cheyenne/papers/mpas_overview/sat_comparison/SouthAmerica_w_obs/aloooper/
Surface verification: CONUS

reporting NWS/FAA stations for all MPAS cases | n = 634 sites
CONUS error reduction: MPAS_3km – MPAS_15km
Section 5
Discussion
• The global convection-permitting MPAS improves upon the 15-km configuration in several regards:
  • Tropical precipitation statistics
  • MJO propagation
  • Vertical structure of organized tropical convection
  • Weekly extratropical circulation forecast skill

• Omitting the convection scheme at coarse (15-km) resolution and running a channel grid configuration both have their benefits, but were unable to replicate the MJO skill of the global 3-km configuration
Conclusions

• Convection-permitting resolution has substantial benefits
• Now evaluating improvements in the midlatitudes of both hemispheres.
• Looking forward to using a viable version of FV-3
• Bottom Line: Global convection-permitting resolution is going to be the future of global NWP.
• The computational resources are not unreasonable...NOAA could do this once a week...but really could use additional computer resources to make this a reality.
The End of the Beginning

“NOW THIS IS NOT THE END. IT IS NOT EVEN THE BEGINNING OF THE END. BUT IT IS, PERHAPS, THE END OF THE BEGINNING.”

Winston Churchill

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