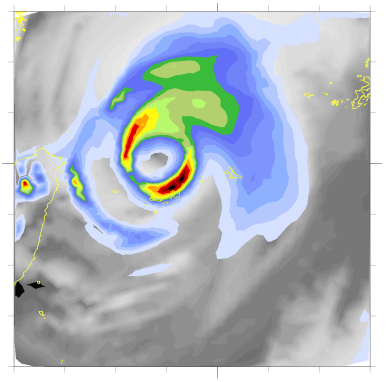
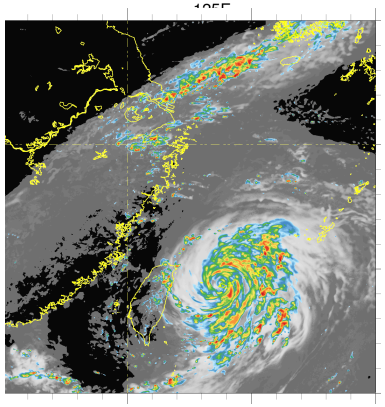
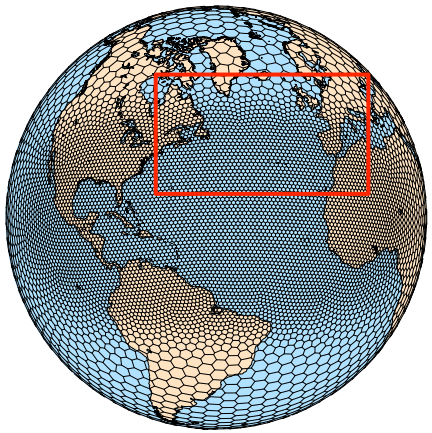
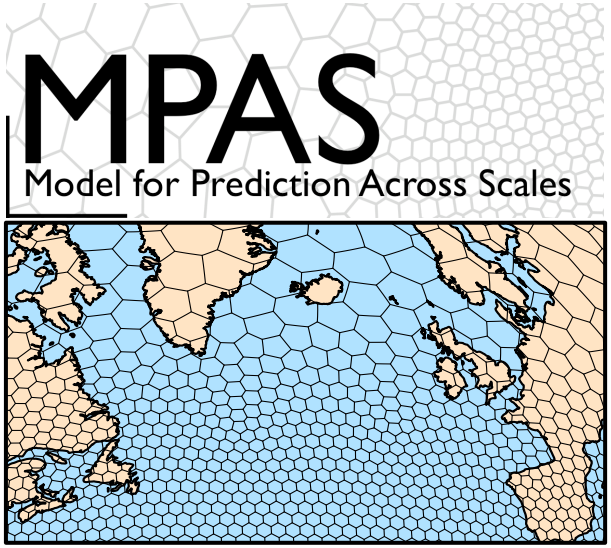
Current Status of CAM-MPAS :: Typhoon Forecasts Using Variable Resolution (CAM & WRF physics)

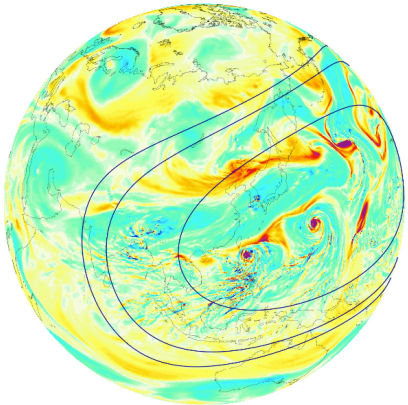






Sang-Hun Park, Bill Skamarock and Peter Lauritzen
National Center for Atmospheric Research



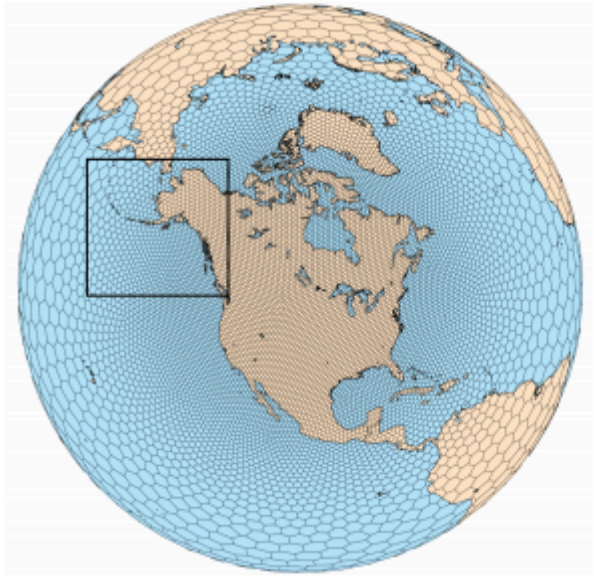


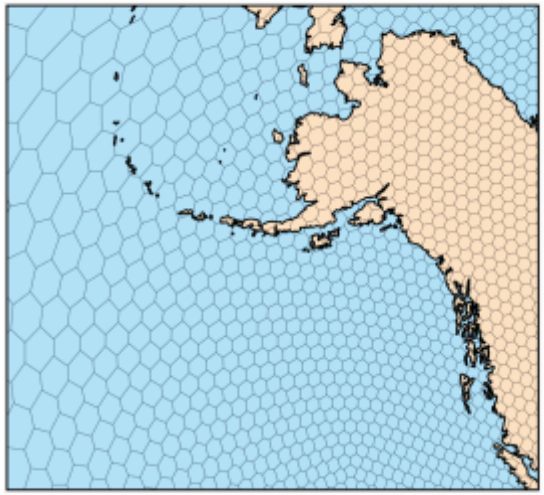
Contents

- Introduction of MPAS
- Long-time Simulations
  - APE Results
  - AMIP Run
- Scalability Tests
- TC Forecasting (WRF physics vs. CAM physics)
- - Track and Rain
- - Intensity
- - Future Plan
- Conclusion

MPAS
Model for Prediction Across Scales

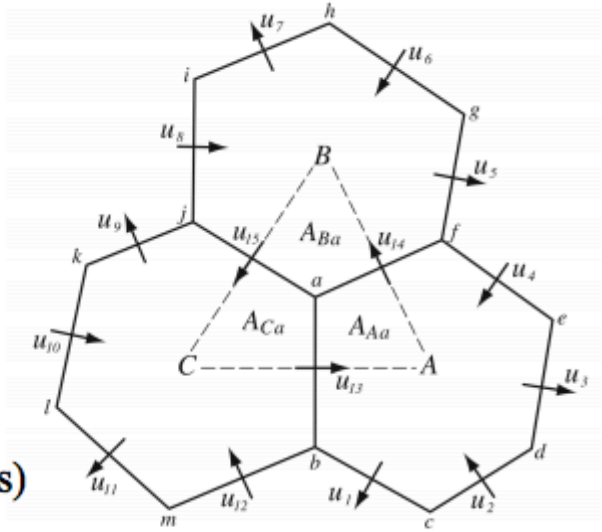
MPAS-Atmosphere





Applications

- NWP, Regional Climate and Climate



Equations

- Fully compressible nonhydrostatic equations (*explicit* simulation of clouds)

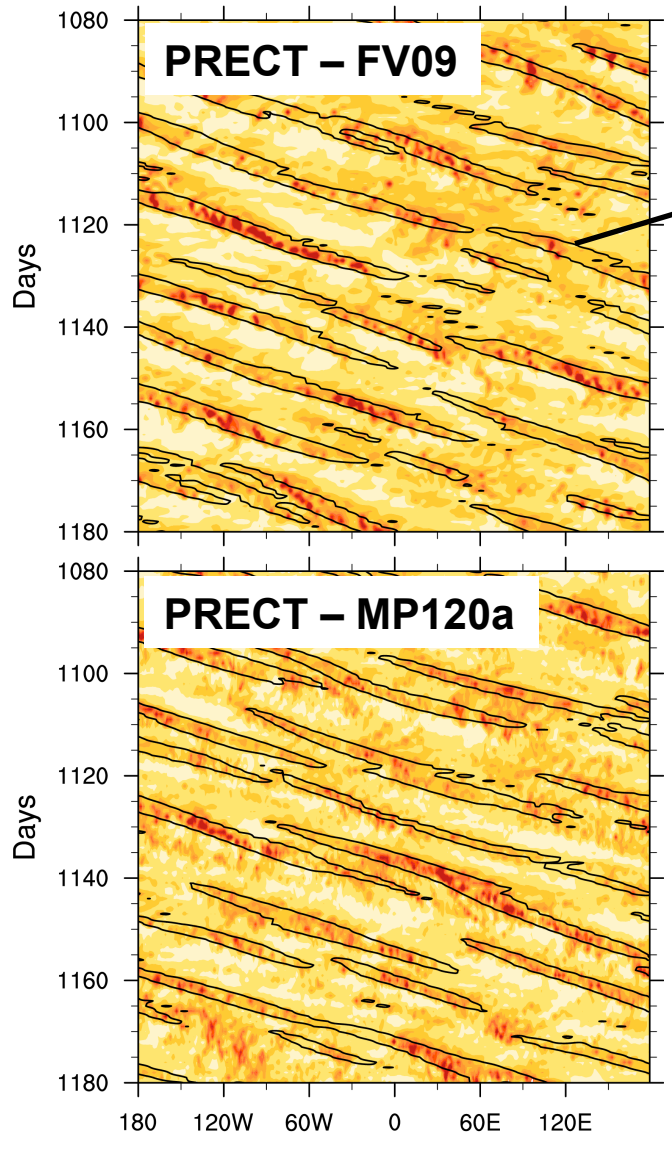
Solver Technology

- Most of the techniques for integrating the nonhydrostatic equations come from WRF.
- C-grid centroidal Voronoi mesh.
- ARW physics (Nested Regional Climate model configuration).

MPAS is designed to complement ARW,

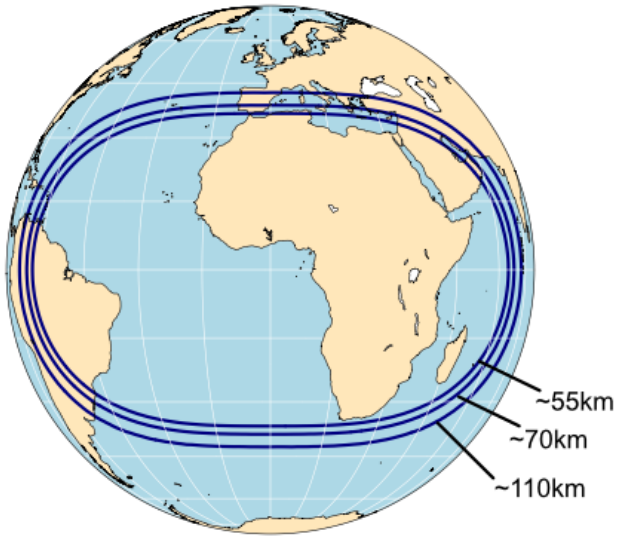
Slide from : *https://mpas-dev.github.io*

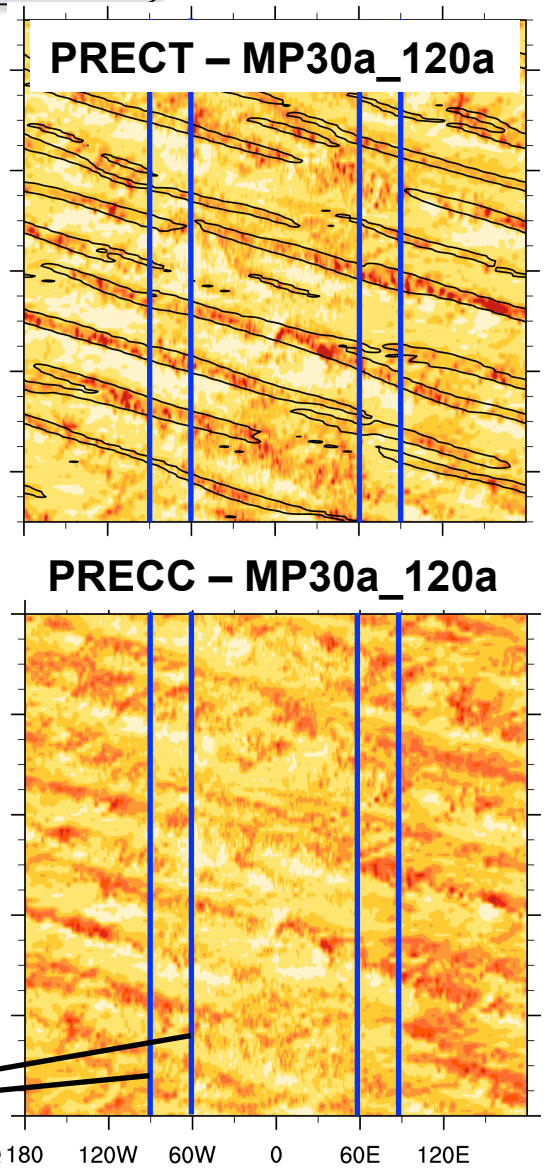
Aqua-Planet Experiments



- Hovmöller Diagram with CAM5
- Filtered Kelvin wave

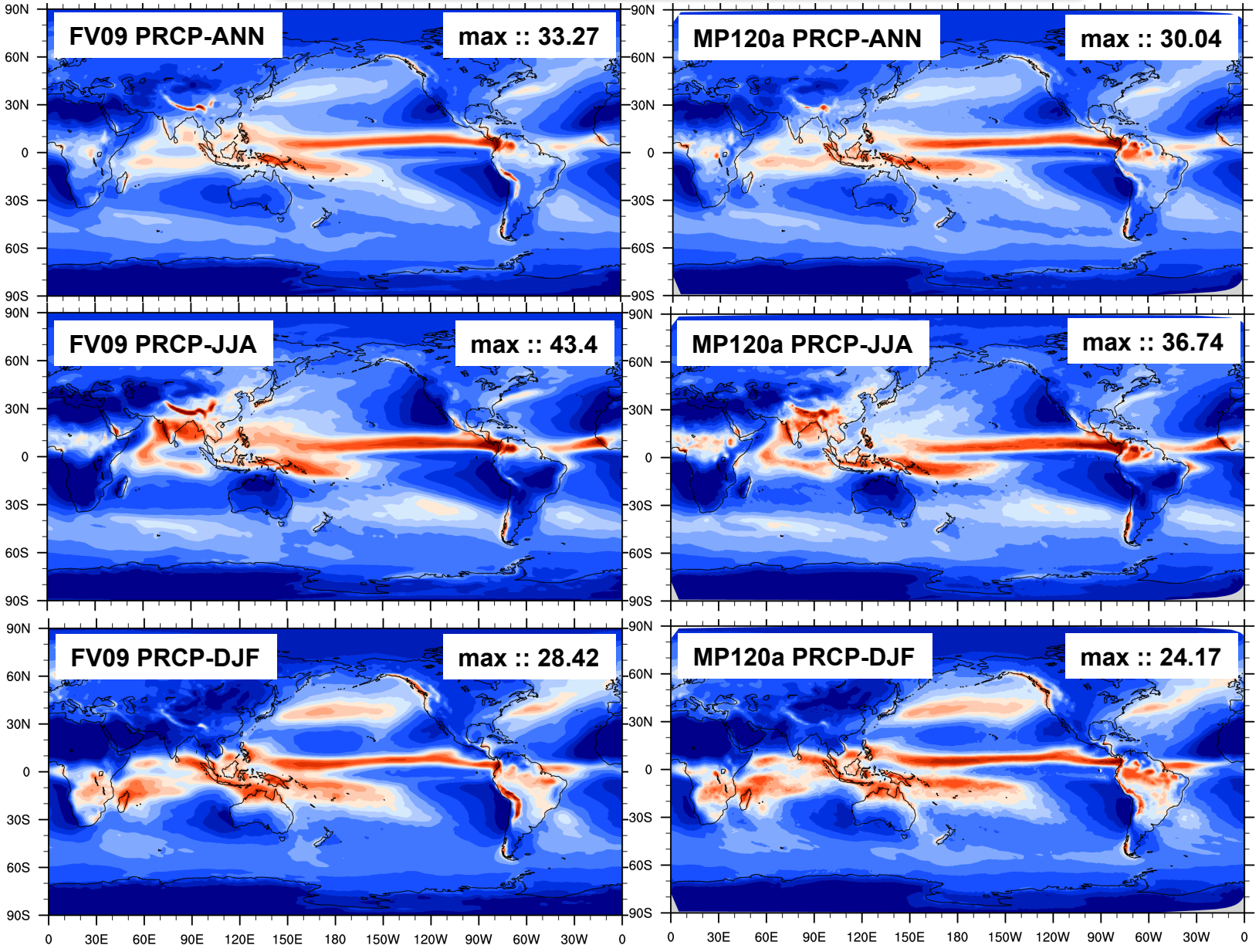
- Variable Mesh (30km ~ 120km)





mesh size transitional zone

AMIP Experiments



Preliminary Results for Scalability

- AMIP simulation for 5 days (FC5) in NCAR Yellowstone
- Only compare dynamical component run time in "*ccsm_timing_stats*"

name	processes	threads	count	walltotal	wallmax (proc	thrd)	wallmin (proc	thrd)
DRIVER_INIT	512	512	5.120000e+02	1.050339e+05	205.190 (8	0)	205.092 (1	0)
driver_init_comps	512	512	5.120000e+02	9.521684e+04	186.179 (511	0)	185.782 (81	0)
phys_grid_init	512	512	5.120000e+02	1.236437e+03	2.447 (195	0)	2.398 (511	0)
driver_init_maps	512	512	5.120000e+02	2.474627e+03	4.948 (0	0)	4.768 (233	0)
driver_init_atminit	512	512	2.488320e+05	7.255616e+02	2.176 (511	0)	0.724 (0	0)
stepon_run1	512	512	2.467840e+05	9.018880e+05	1766.290 (506	0)	1751.312 (511	0)
diag_dynvar_ic	512	512	2.467840e+05	1.738689e+00	0.017 (0	0)	0.001 (477	0)
comp_adv_tends1	512	512	2.467840e+05	2.019300e+03	5.095 (245	0)	1.173 (511	0)
dyn_run	512	512	2.467840e+05	8.743788e+05	1714.972 (285	0)	1695.603 (510	0)
dyn_run_alloc	512	512	2.467840e+05	2.628937e+02	0.898 (255	0)	0.286 (511	0)
xy_to_yz	512	512	4.935680e+05	4.056413e+04	88.339 (2	0)	72.570 (395	0)

- AMIP 1-deg.

CORE / DYN_CORE	256	512	1024
FV	47.277	27.158	26.571
SE	126.501	65.481	37.931
MPAS	110.976	58.962	32.814

Preliminary Results for Scalability

- AMIP simulation for 5 days (FC5) in NCAR Yellowstone
- Only compare dynamical component run time in "*ccsm_timing_stats*"
- **AMIP 1-deg.**

CORE / DYN_CORE	256	512	1024
FV	47.277	27.158	26.571
SE	126.501	65.481	37.931
MPAS	110.976	58.962	32.814

- **AMIP .25-deg (~30km).**

CORE / DYN_CORE	512	1024	2048	4096
FV	1714.972	931.008	495.291	320.023
SE	3988.152	2145.339	1124.766	607.570
MPAS	3021.370	1593.654	849.589	445.231

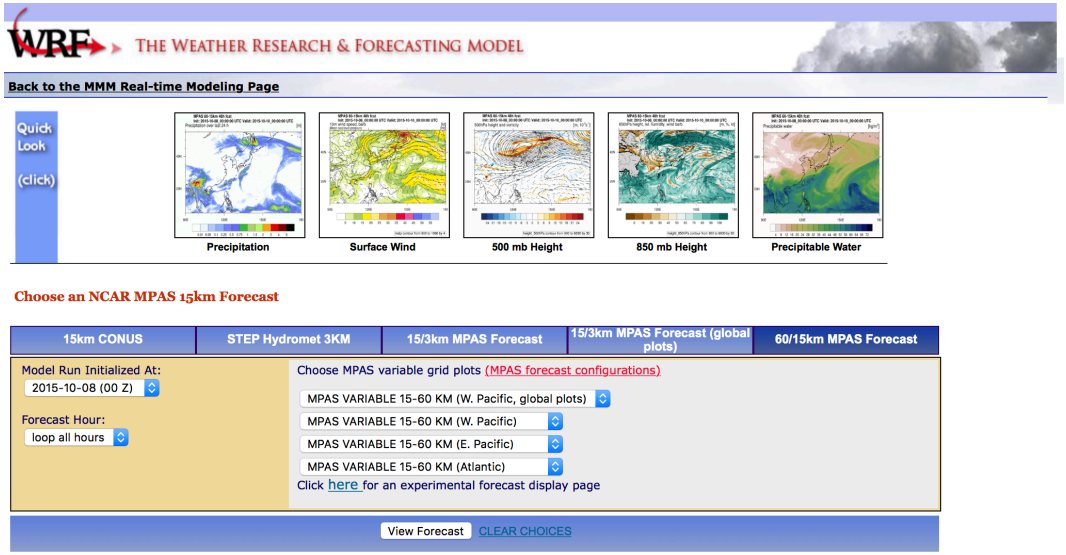
CAM for Weather Forecasting (short and medium)

- High-resolution climate tests are being tested
- These may be helpful to simulate organized convection and meso-scale structure within long-time run
- Variable resolution for weather forecasting can be good test bed to study role of physics on high-resolution
- MPAS dynamical core supports global simulation regardless of horizontal resolution such as < 10km. (fully non-hydrostatic)

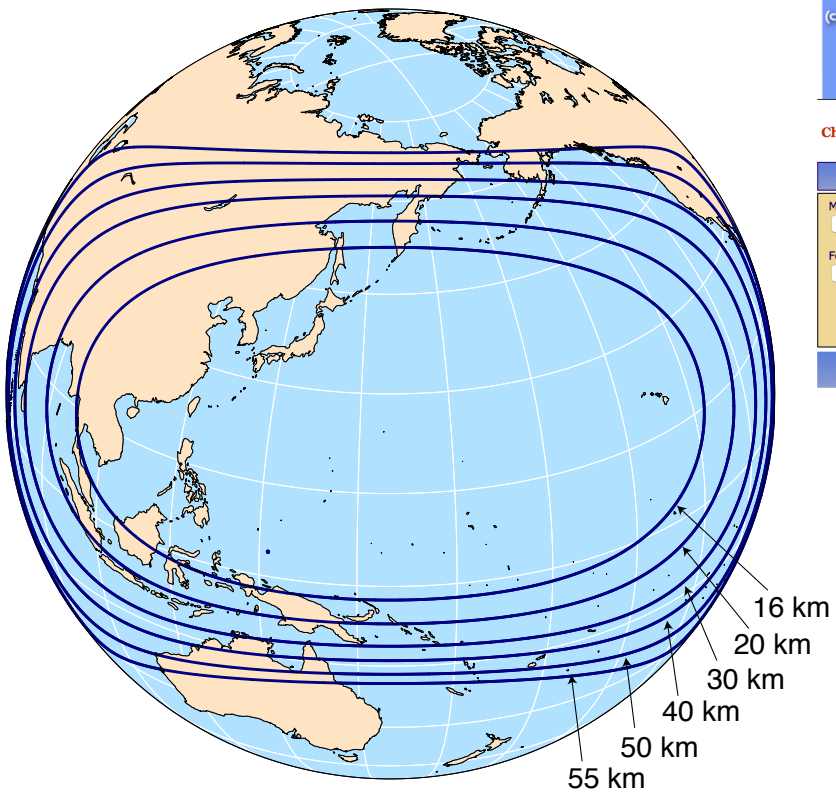
→ *Let's do NWP test using CAM + MPAS!*

TC Forecast Using WRF Physics

http://wrf-model.org/plots/realtime_mpas.php



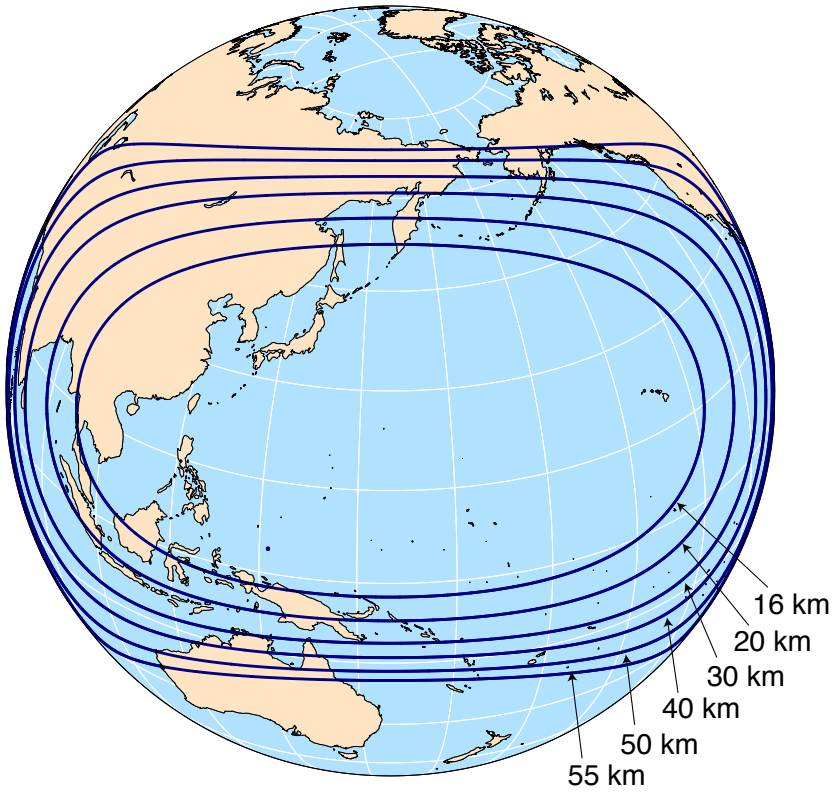
MPAS-TC Mesh Contour



- Every 10 day forecasting during TC season
- Using variable resolution (15~60km)
- Three different target region
  - Western Pacific
  - Eastern Pacific
  - Atlantic

Forecast Configuration

MPAS-TC Mesh Contour

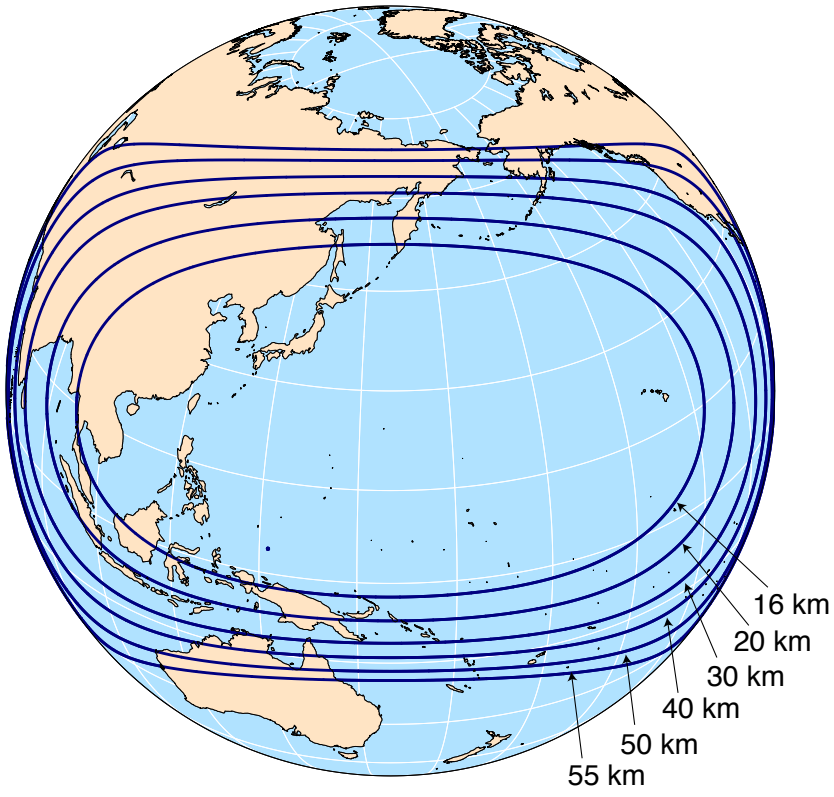


	WRF-MPAS	CAM-MPAS
Initial Data	GFS 15km F00 analysis	
SST	GFS 15km Skin temperature	NOAA OISST 1x1 deg. (weekly)
Run Time	10 Days	5 Days
Model Top	30 km (55 levels)	~45 km (30 levels)
Mesh Size	535554 Cells* (fine 15km ~ coarse 60km)	
DT for dynamical core	60s (RK3) (setting for fine resolution)	
DT for physics	Different depend on schemes	1800s

* uniform 30km :: 655362 Cells
uniform 15km :: 2621442 Cells

Forecast Configuration

MPAS-TC Mesh Contour



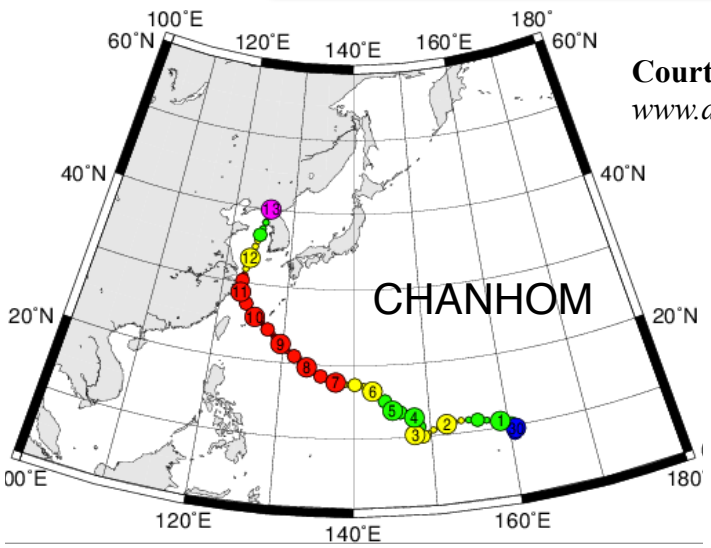
Physics (WRF-MPAS)

- Surface Layer : Monin-Obukov
- PBL : YSU
- Land Surface Model : NOAH 4-layers
- Gravity Wave Drag : None
- Convection : new Tiedtke
- Microphysics : WSM6
- Radiation : RRTMG
- DT for PBL, CP, MP (=dt_dyn, 60s)

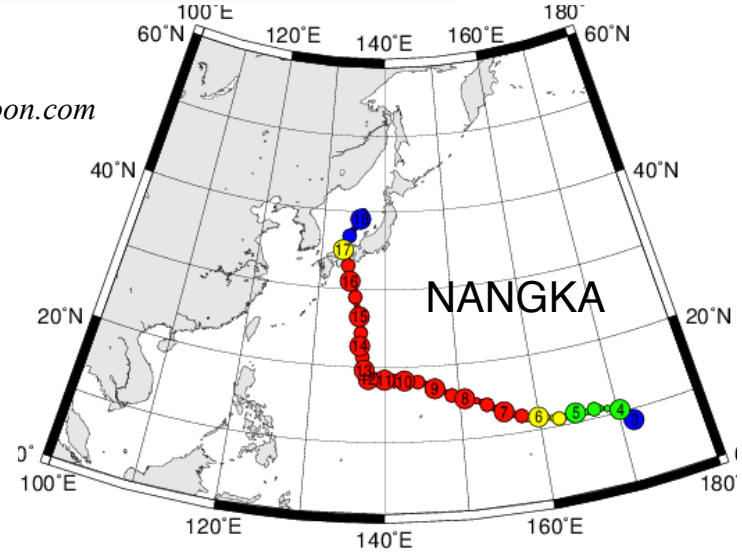
Physics (CAM-MPAS)

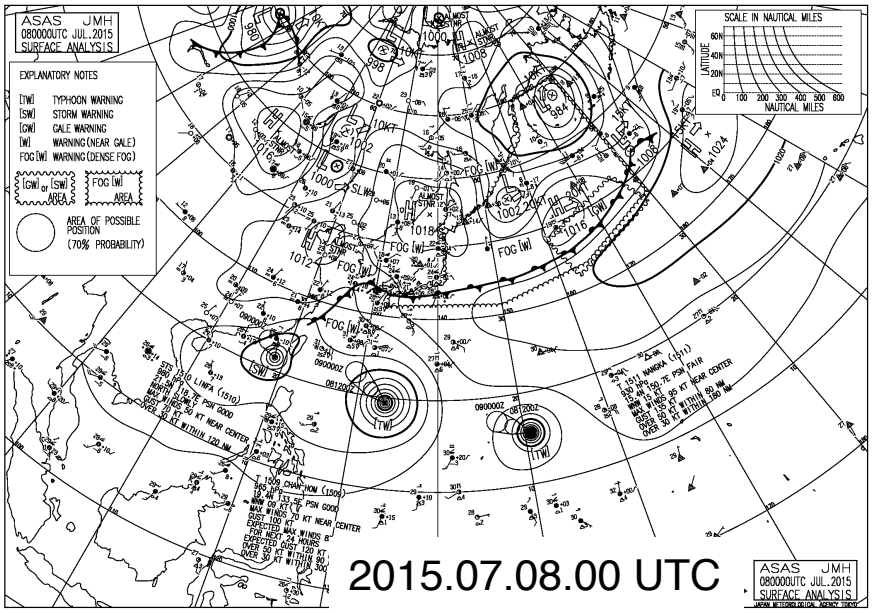
- CAM 5.3
- CLM 4.0 (1month spin-up)
- DT physics = 1800s

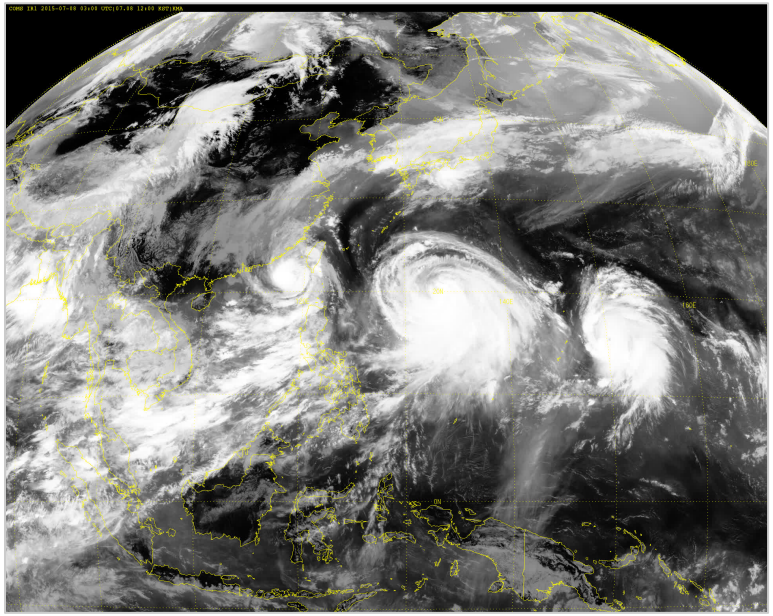
CHANHOM / NANGKA



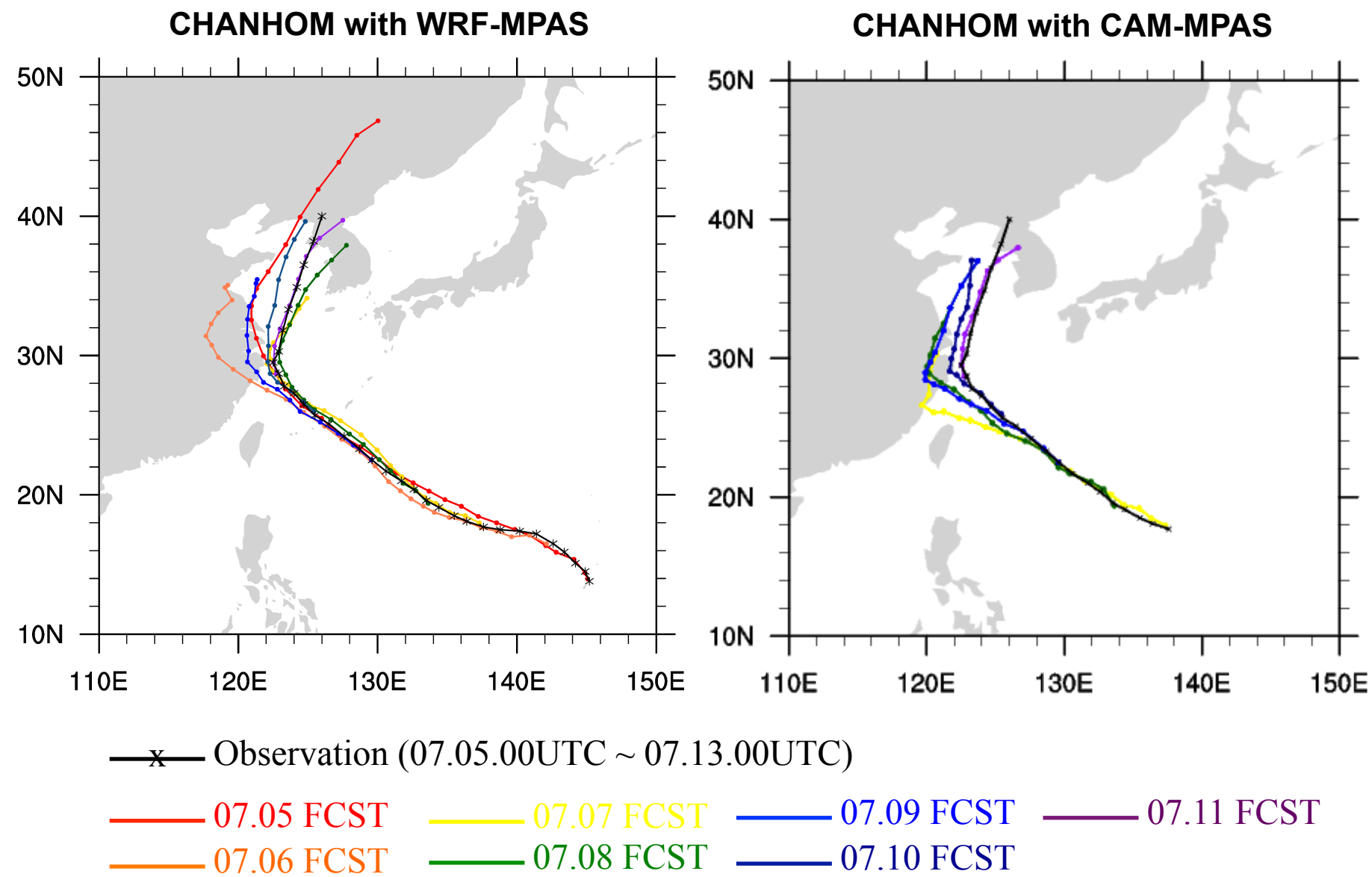
Courtesy :
www.digitaltyphoon.com







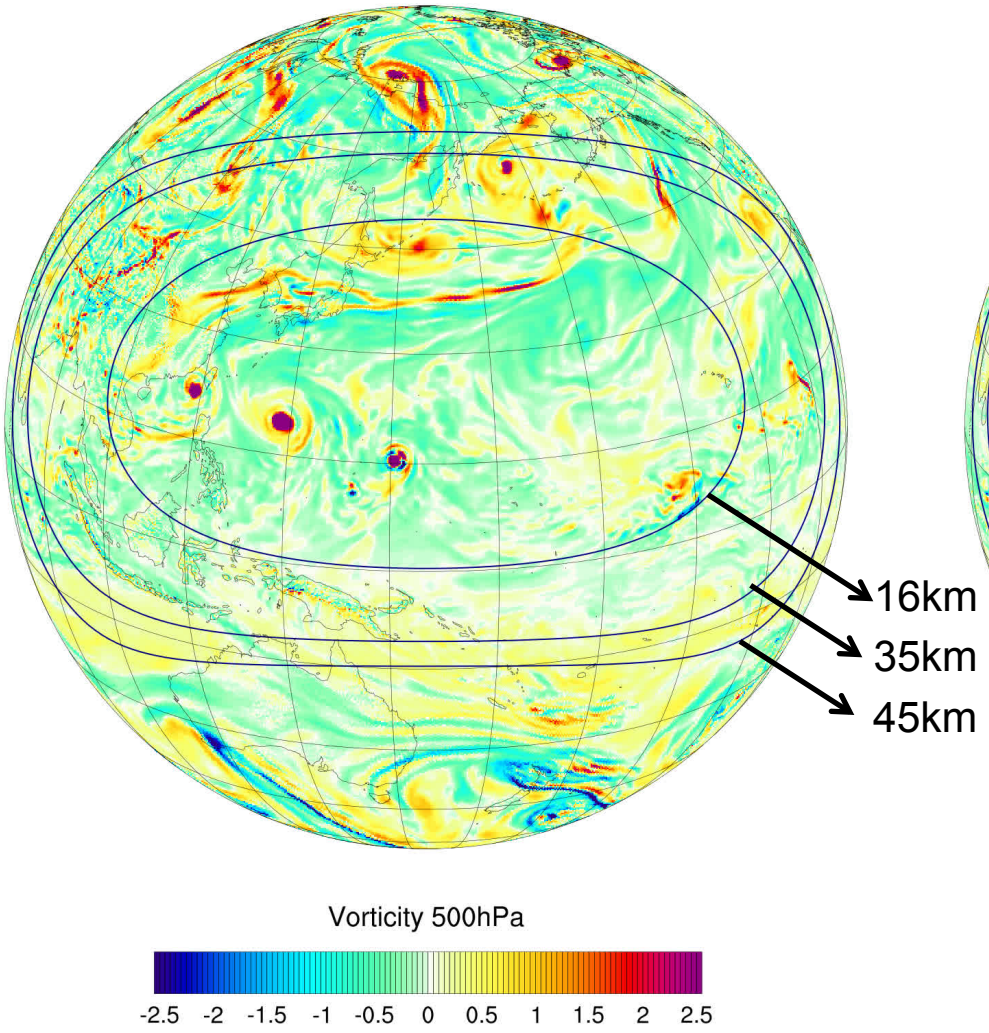
15~60km Forecast - CHANHOM

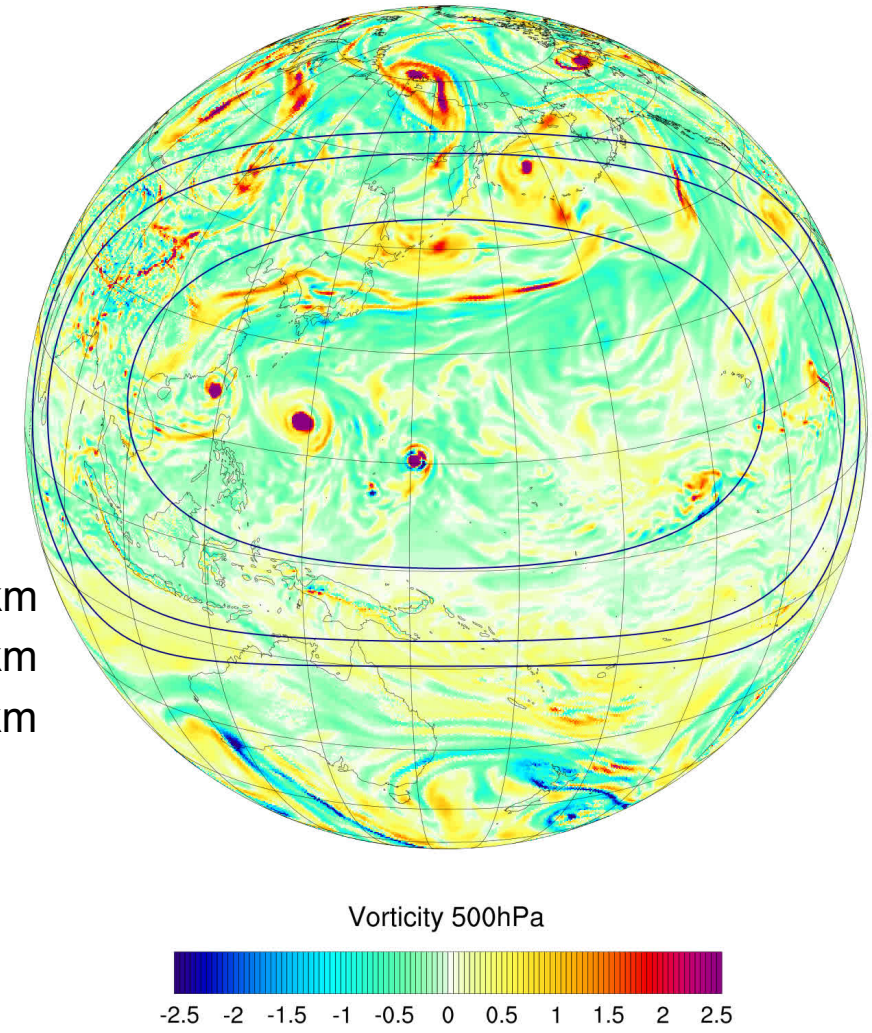


15~60km Forecast – CHANHOM / NANGKA

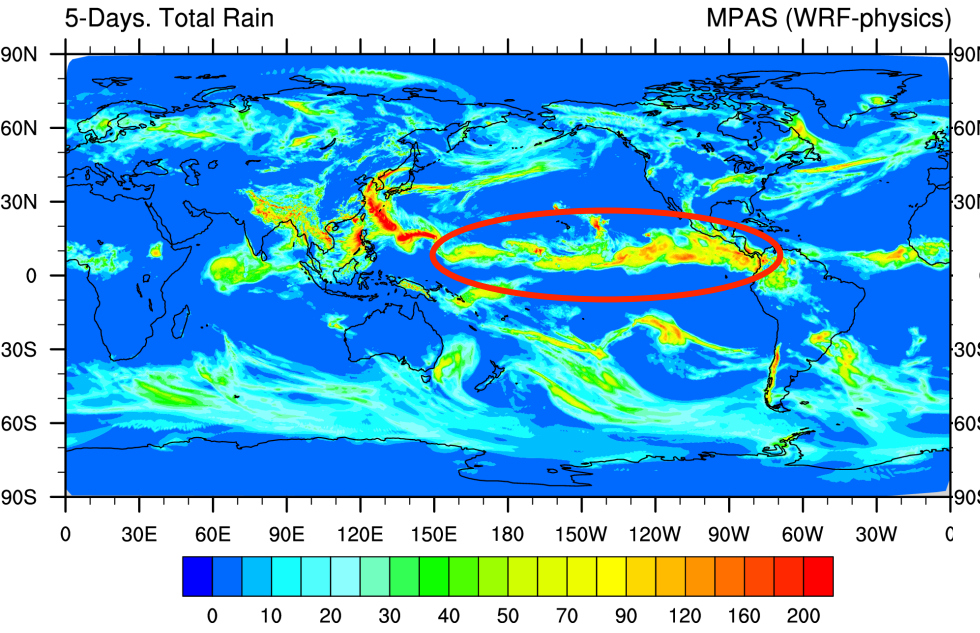
MPAS (WRF physics) 2015-07-08_00

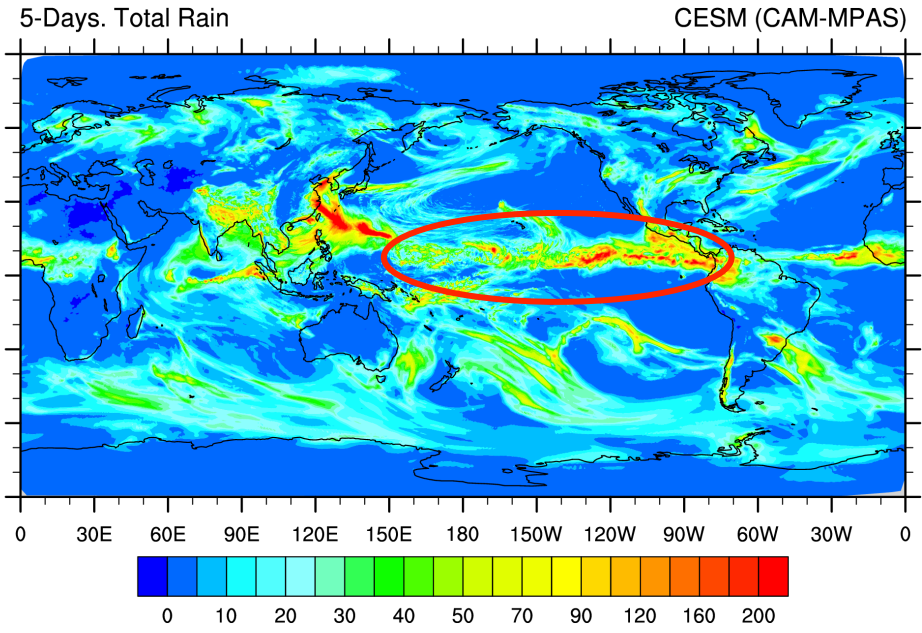
CESM (CAM-MPAS) 2015-07-08_00



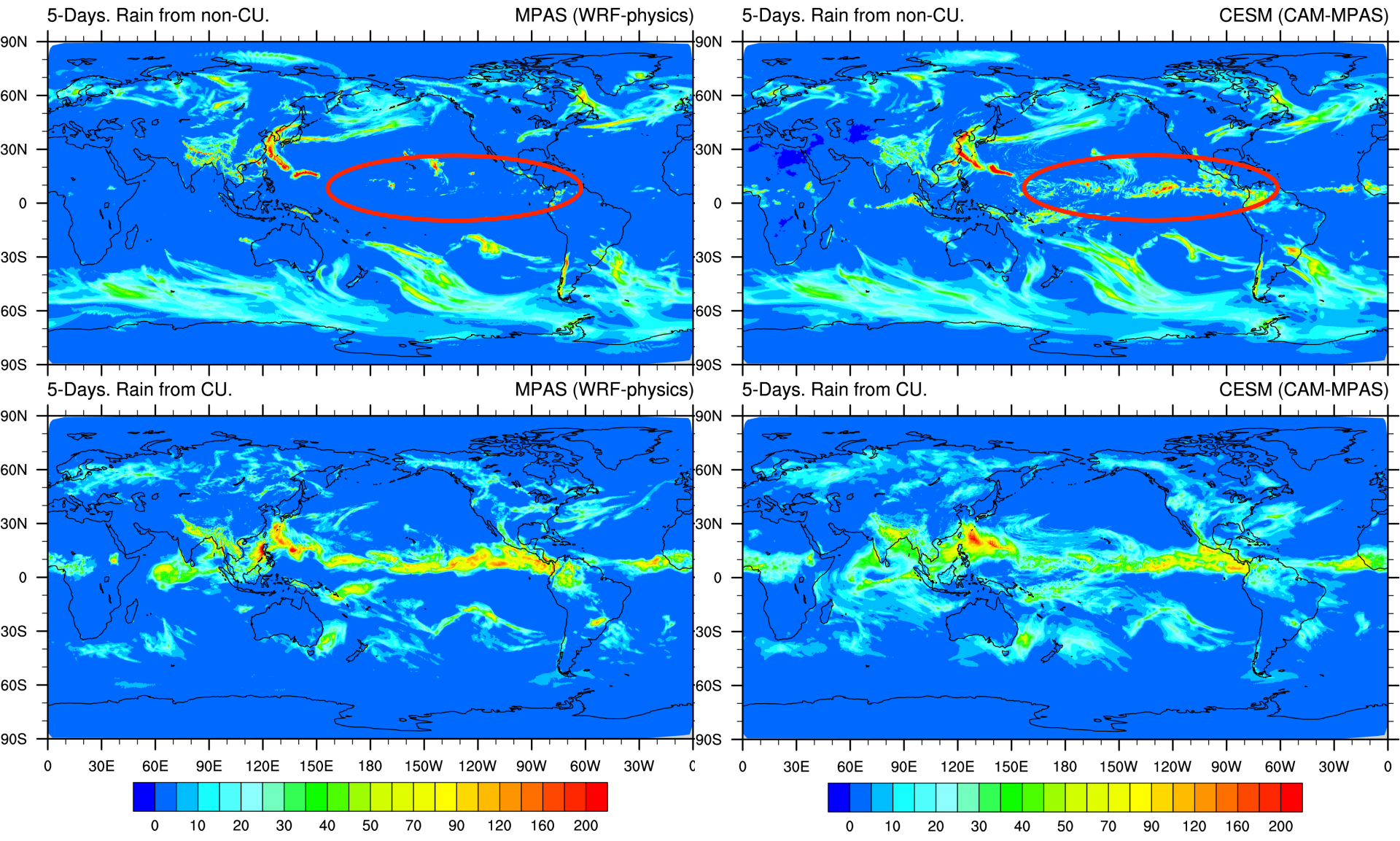


15~60km Forecast – CHANHOM/GONI



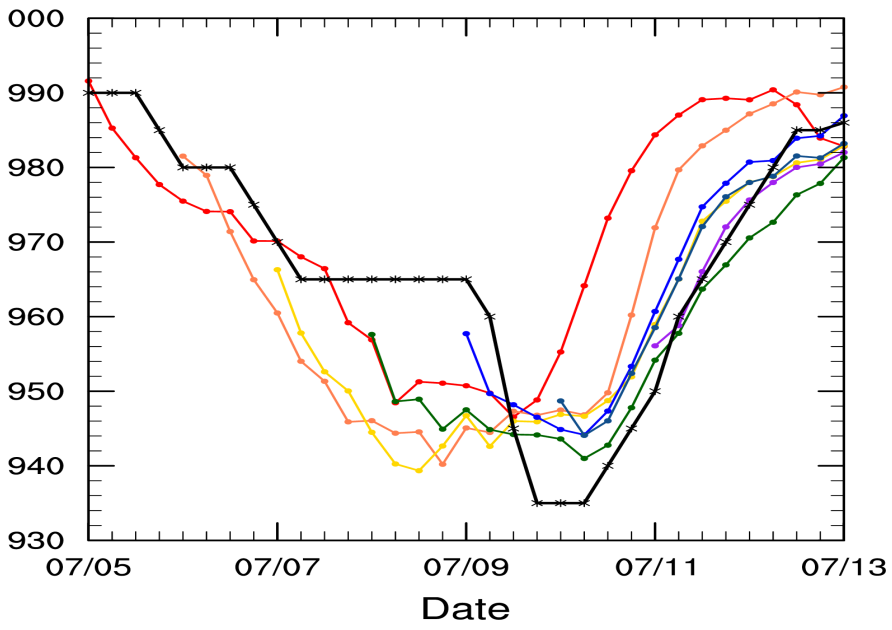


15~60km Forecast – CHANHOM/GONI

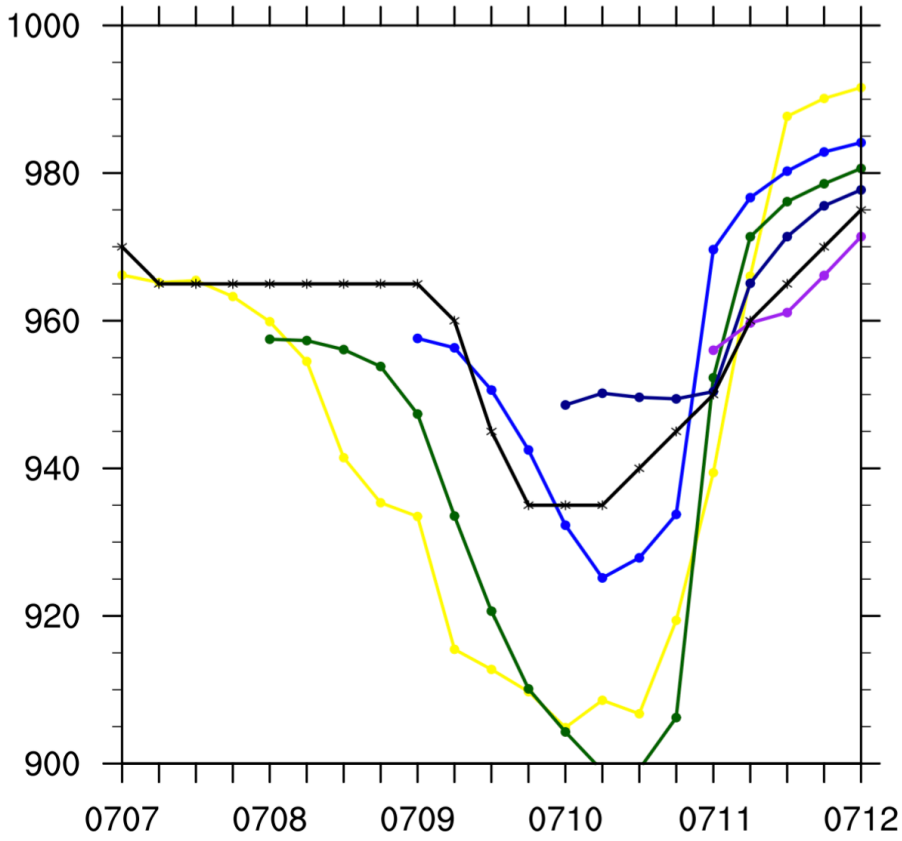


15~60km Forecast - CHANHOM

CHANHOM with WRF-MPAS



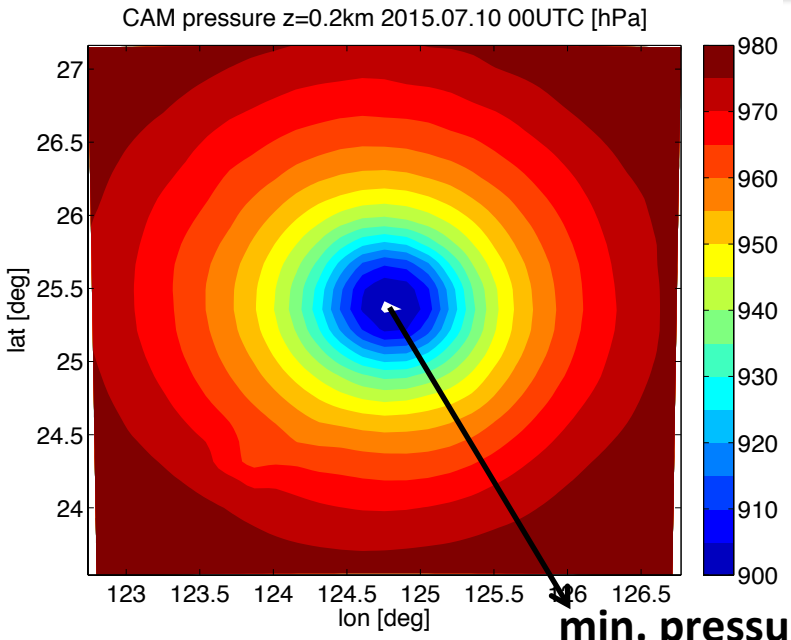
CHANHOM with CAM-MPAS

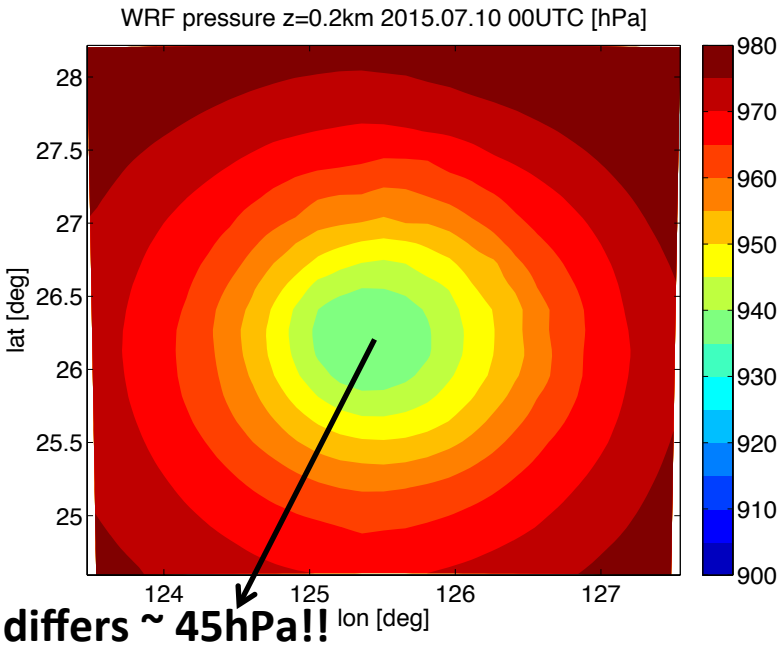


Observation (07.05.00UTC ~ 07.13.00UTC)

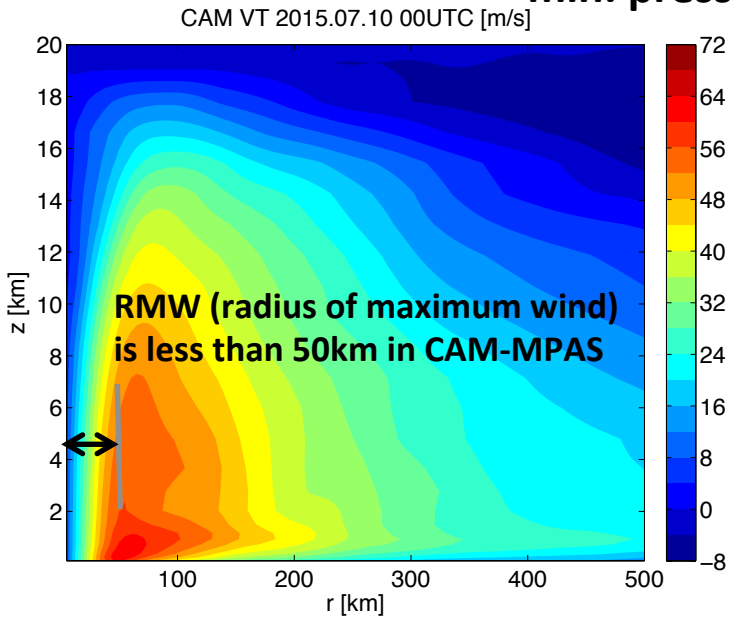
07.05 FCST
07.06 FCST
07.07 FCST
07.08 FCST
07.09 FCST
07.10 FCST
07.11 FCST

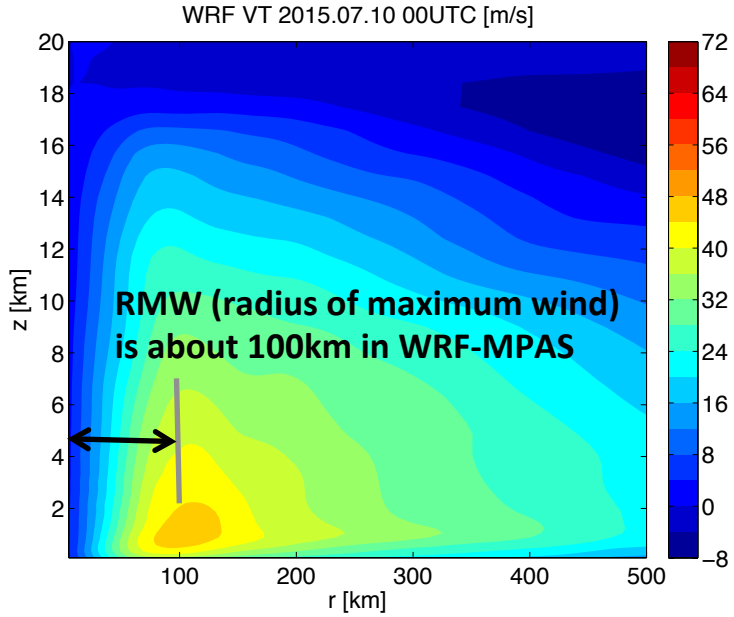
15~60km Forecast - CHANHOM



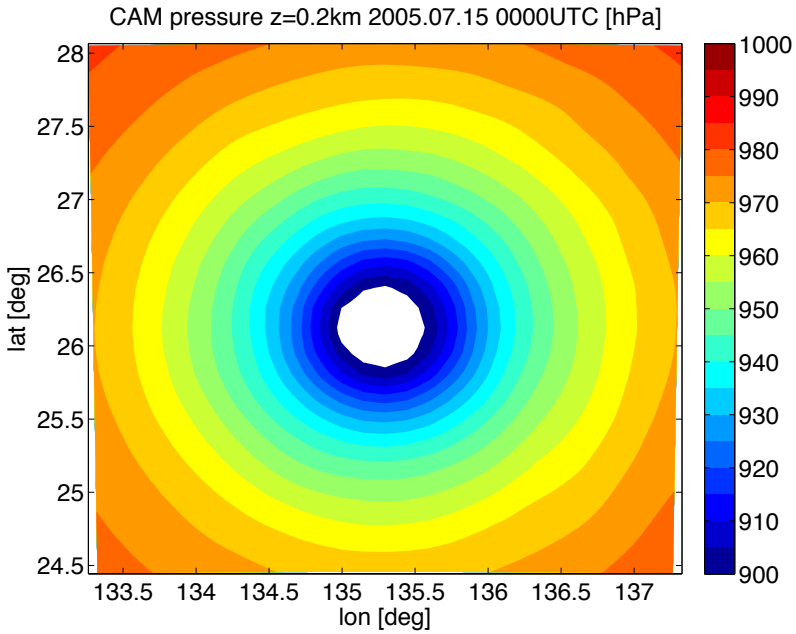


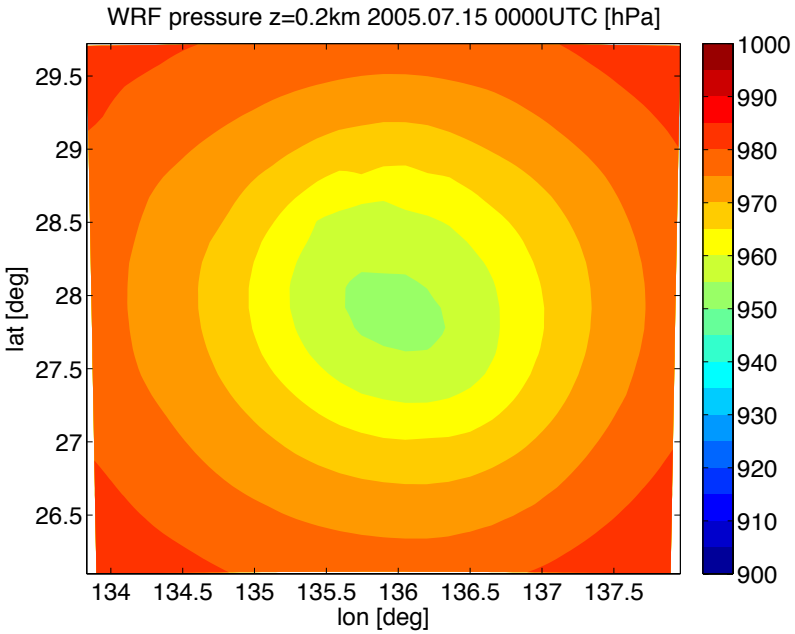
min. pressure differs ~ 45hPa!!

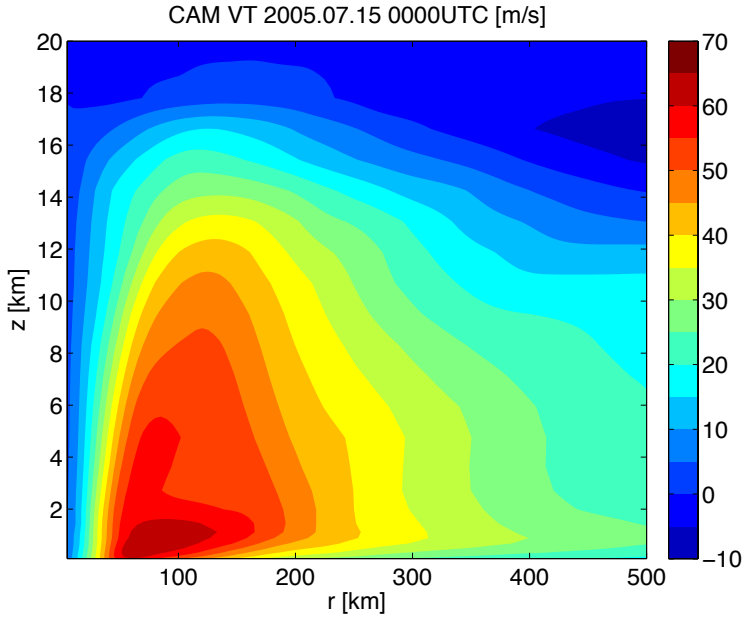


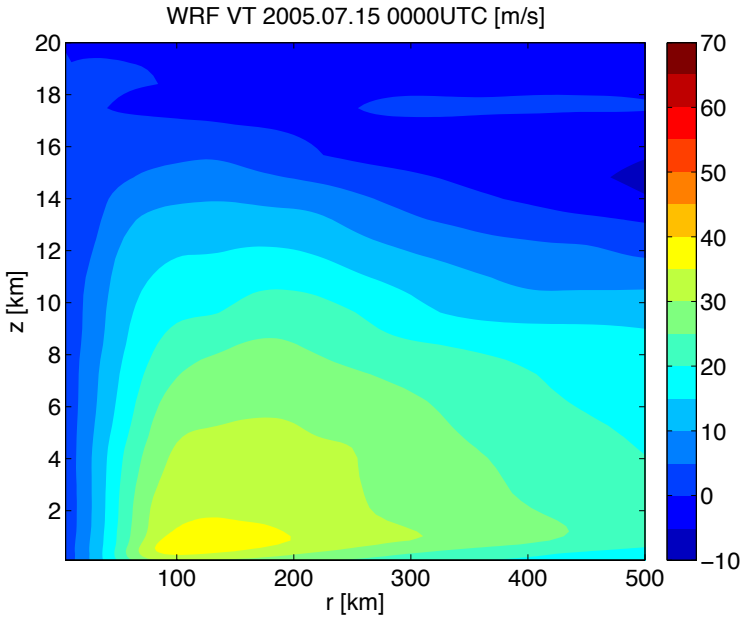


15~60km Forecast - NANGKA





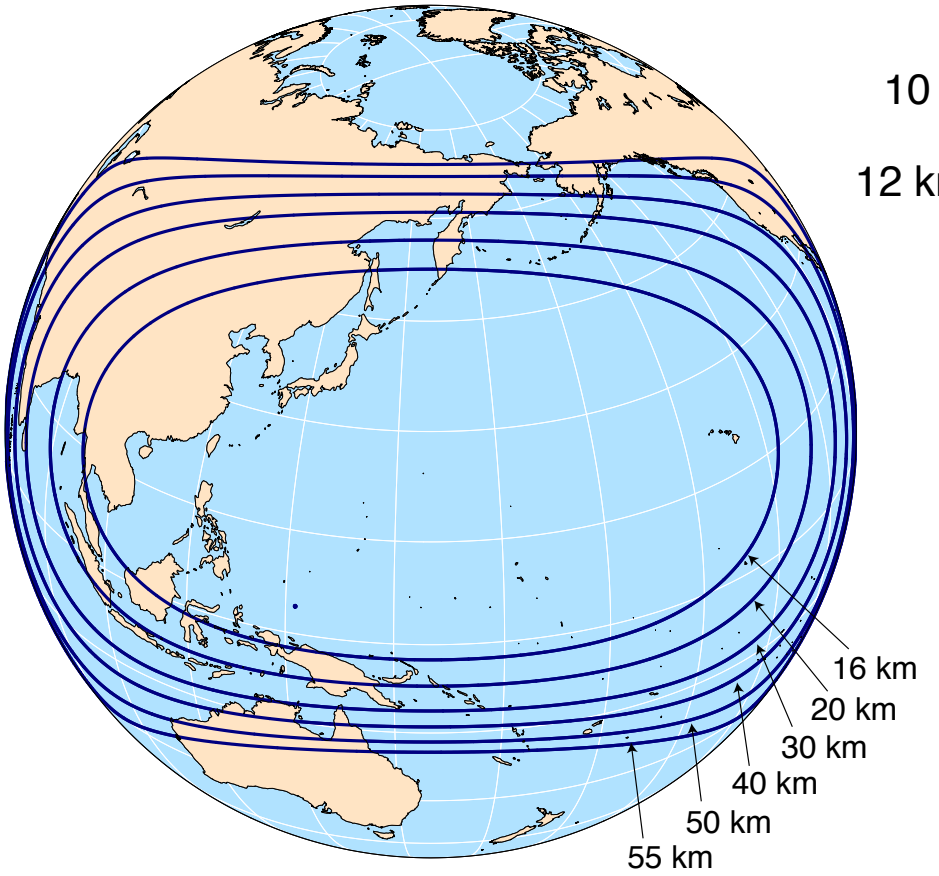




High-Resolution Global Test : WRF-MPAS

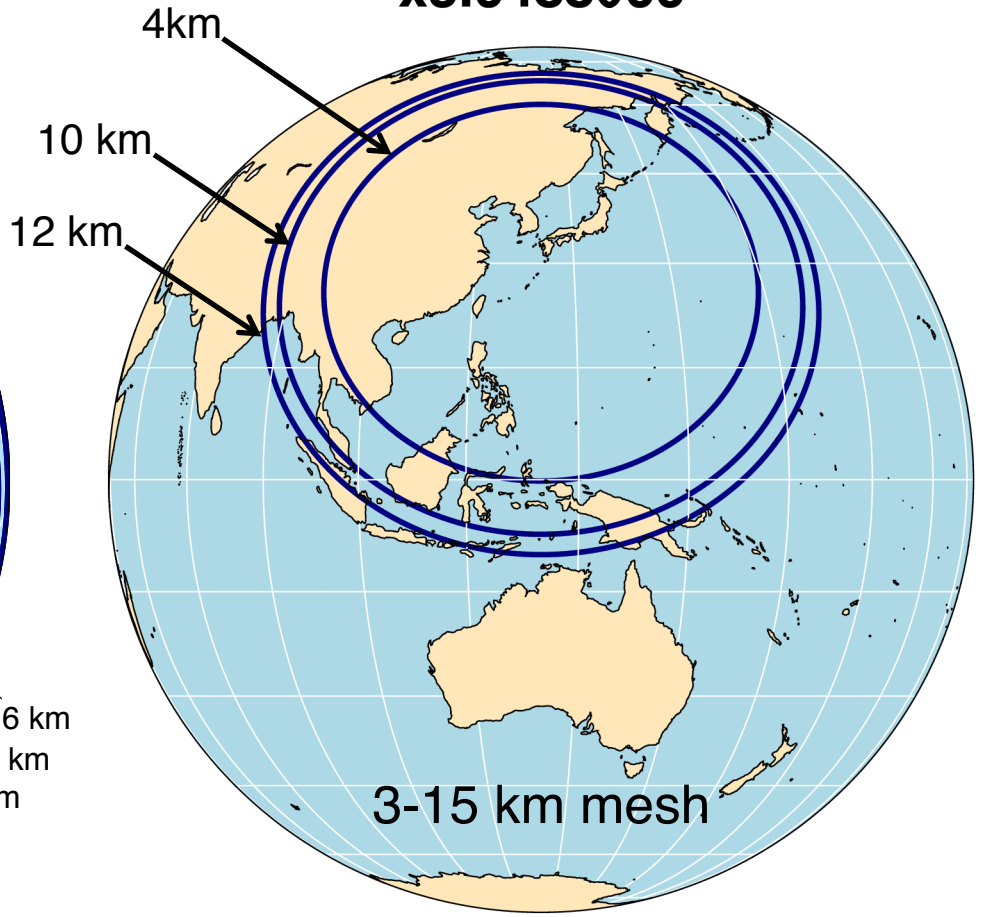
MPAS-TC Mesh Contour

x4.535554



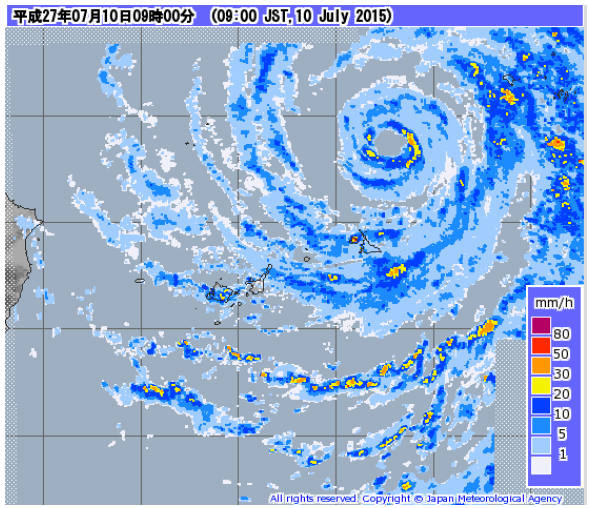
15-60 km mesh

x5.6488066

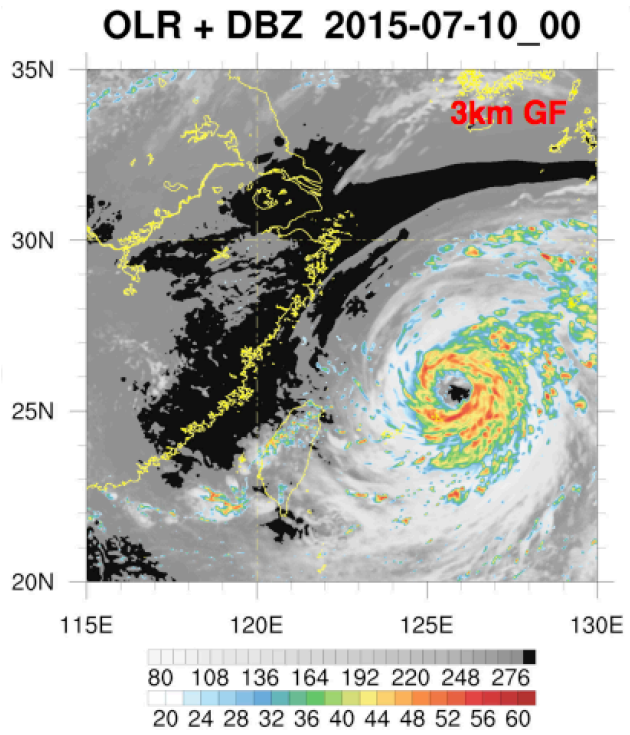


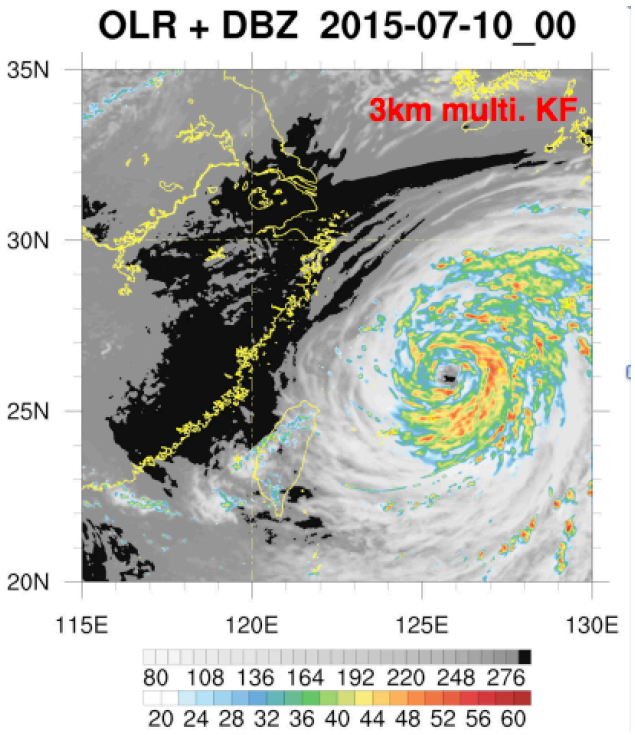
- Smaller area in target region
- Narrow transitional zone
- Instead of Tiedtke, GF and msKF CPS

High-Resolution Global Test – CPS sensitivity

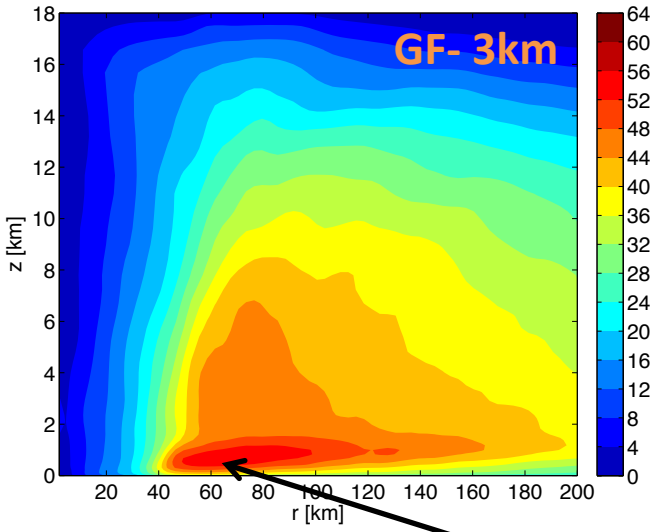


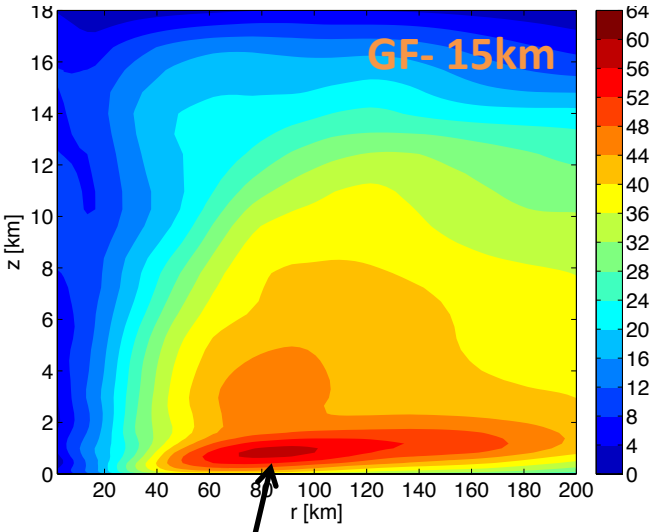
Miyakojima Radar

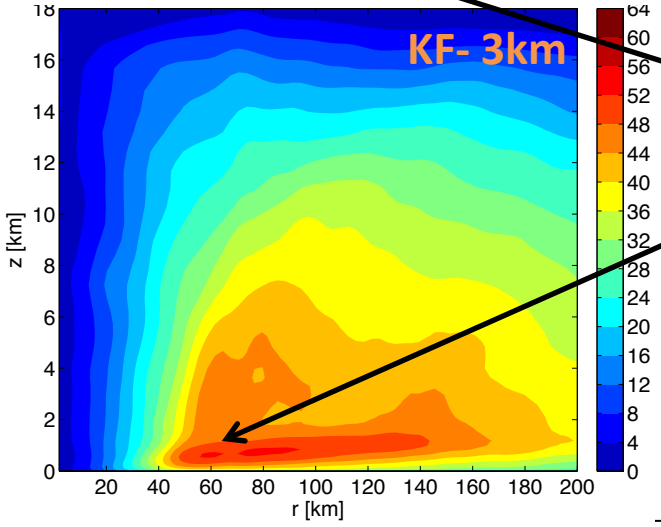




High-Resolution Global Test – CPS sensitivity

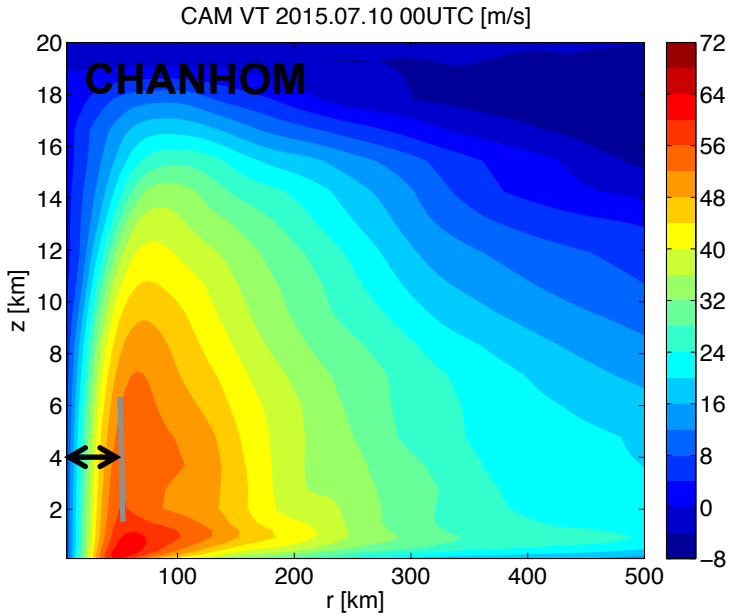


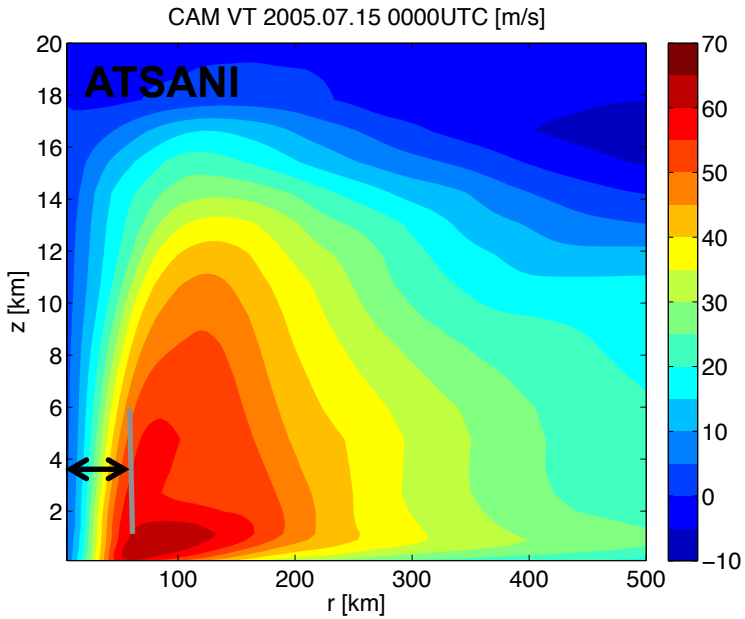




RMW (radius of maximum wind) in 3km is a little bit smaller than 15km.
~ 60km

15~60km Forecast – CAM-MPAS





- Too strong TC from CAM-MPAS
- Possible options to reduce intensity
  - Changing DT for physics
  - Relaxation time scale from ZM
  - Any suggestions for scale-aware parameter from CAM5.3?
  - next version of CAM (5.5 or 6.0?)

→ See *Colin Zarzycki* Talk in this afternoon

Conclusion & Future Work

- CAM-MPAS is working stably
  (APE, AMIP and NWP)
- But, we still need to careful comparison with other dycores
  e.g.) AMIP simulation (coarse & fine resolution)
- We will have couple of MPAS version to speed up

DYN_CORE \ CORE	512	1024	2048	4096
FV	1714.972	931.008	495.291	320.023
SE	3988.152	2145.339	1124.766	607.570
MPAS	3021.370	1593.654	849.589	445.231
MPAS new	?	?	?	?

- We will have more TC tests to investigate strong TC simulation
  (tune scale-aware parameters or using CAM 5.5 or next)
- Also try global convection permitting simulation
  for TC tests (e.g. 3~15km)