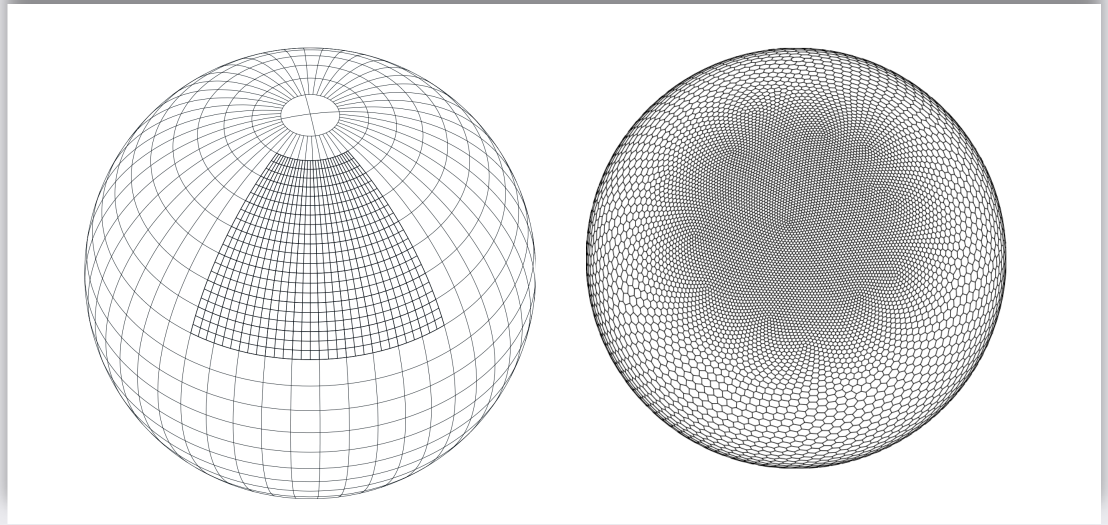
A Comparison of Mesh Refinement in the Global MPAS-A and WRF Models Using an Idealized Normal-Mode Baroclinic Wave simulation



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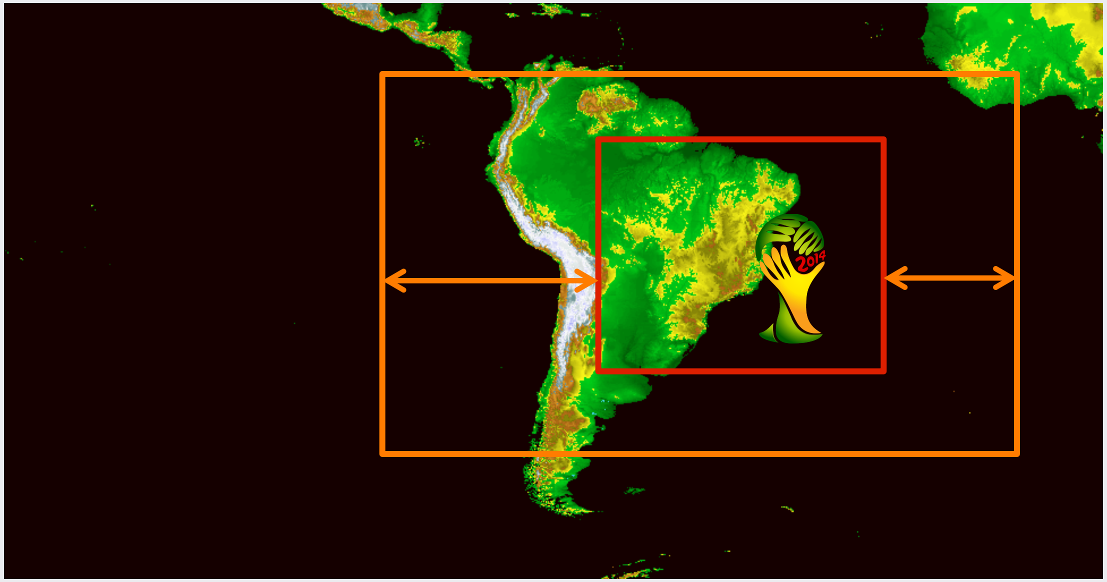
Numerical Model Errors

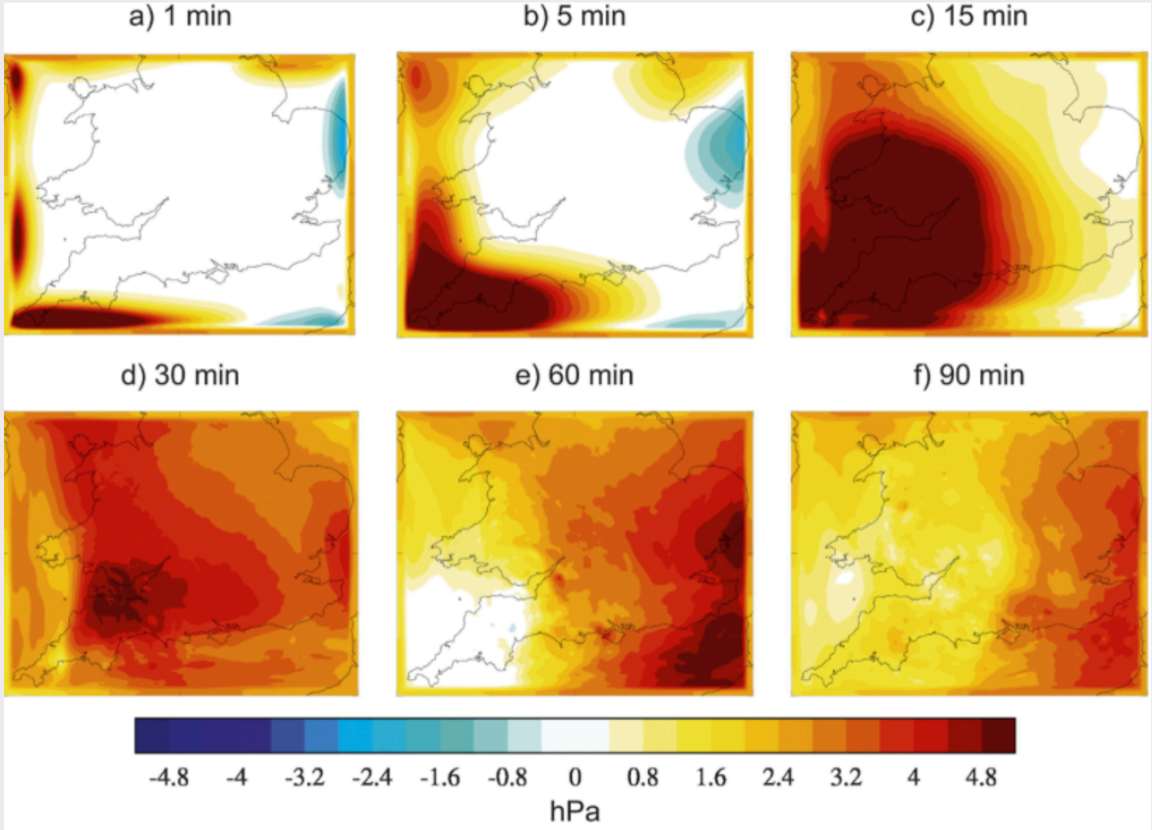
- Physics parameterization
- Initial condition
- Numerical algorithms
- Surface forcing
- Lateral Boundary Conditions (LBCs)

❑ Q. What is usual strategy for grid set up?



A1) Nested grid should be far away from boundary

Signals from LBCs

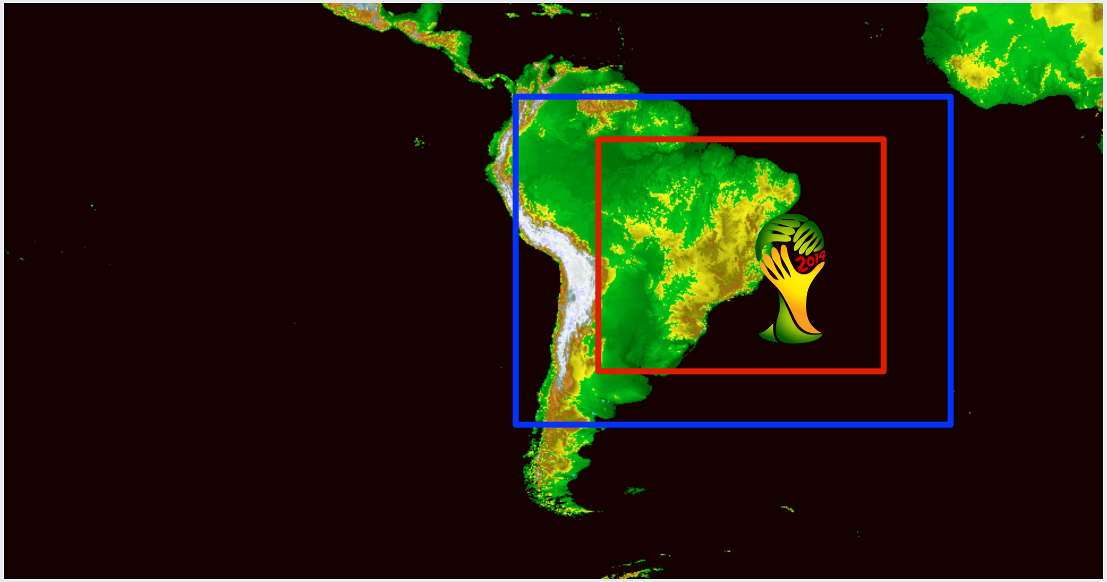


Caron (2013)

1.5km EPS
(a perturbation of surface pressure from other ensemble members)

Errors from LBCs can propagate as external gravity waves

❑ Q. What is usual strategy for grid set up?



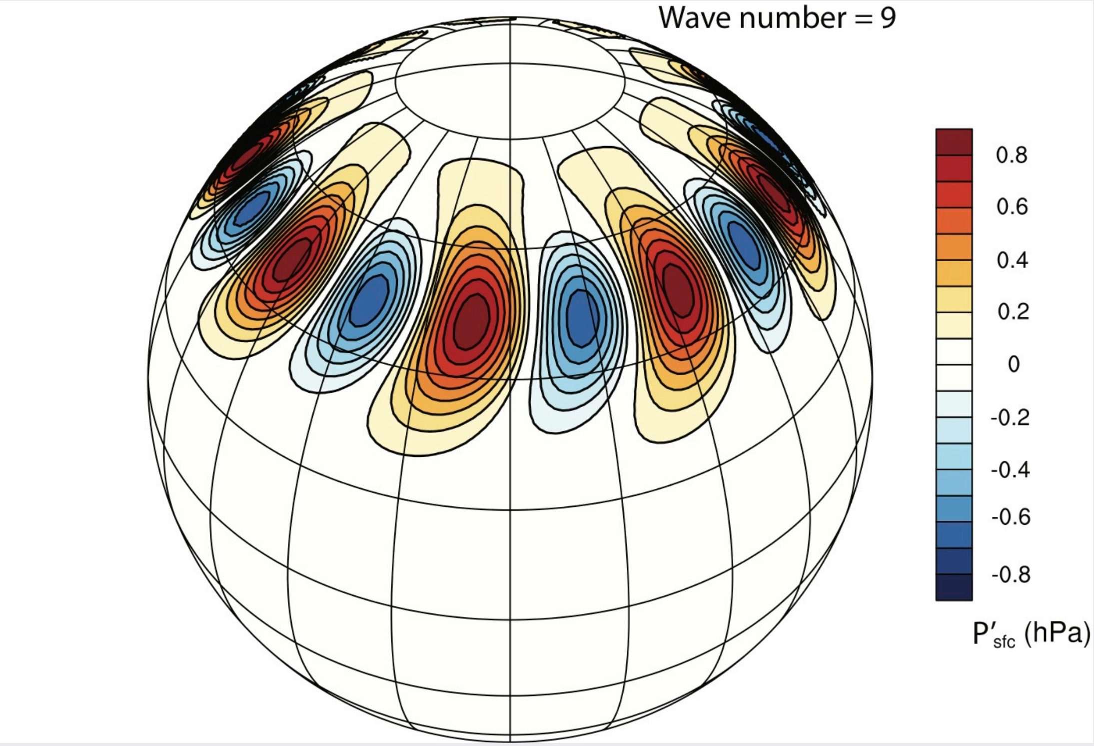
A1) Nested grid should be far away from boundary

A2) High-resolution single domain?

❑ Issues about LBCs

- How fast (much) errors from LBCs can propagate?
- Update frequency, domain size
- 2-way nesting or 1-way nesting??

Test Case



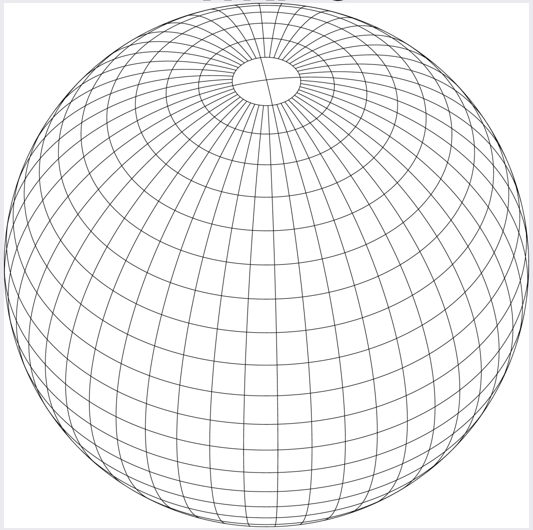
Initial condition :: Normal mode baroclinic wave (Park et al., 2013)

- **Dry simulation**
- **From a breeding method (Plougonven and Snyder, 2007)**
- **Save isobaric data (40 levels)**

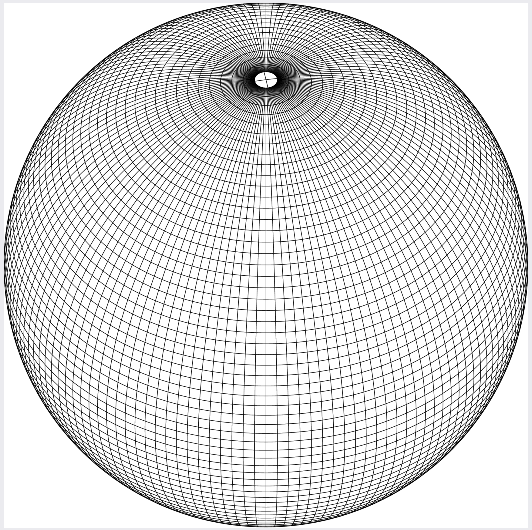
Experimental Setup

	global WRF single domain (WRF-C, WRF-H)
horizontal grids (cells)	(433×217, 1297×649)
$\triangle_{cell}$	$(0.9°, 0.3°)$
time integration	3^{rd} Runge-Kutta
$\triangle t$	(90s, 30s)
vertical levels	50
order of advection scheme (horizontal, vertical)	(3^{rd}-order, 3^{rd}-order)
3D divergence damping (β_d)	0.1
vertically implicit off-centering (β_s)	0.1
model top	10 hPa
depth of damping layer	5 km
external-mode filtering (β_e) (only for WRF)	0.01
start of polar FFT (only for WRF)	(80°, 80°)
horizontal diffusion	2d-Smagorinsky
hyper diffusion coefficient (only for MPAS-A)	none

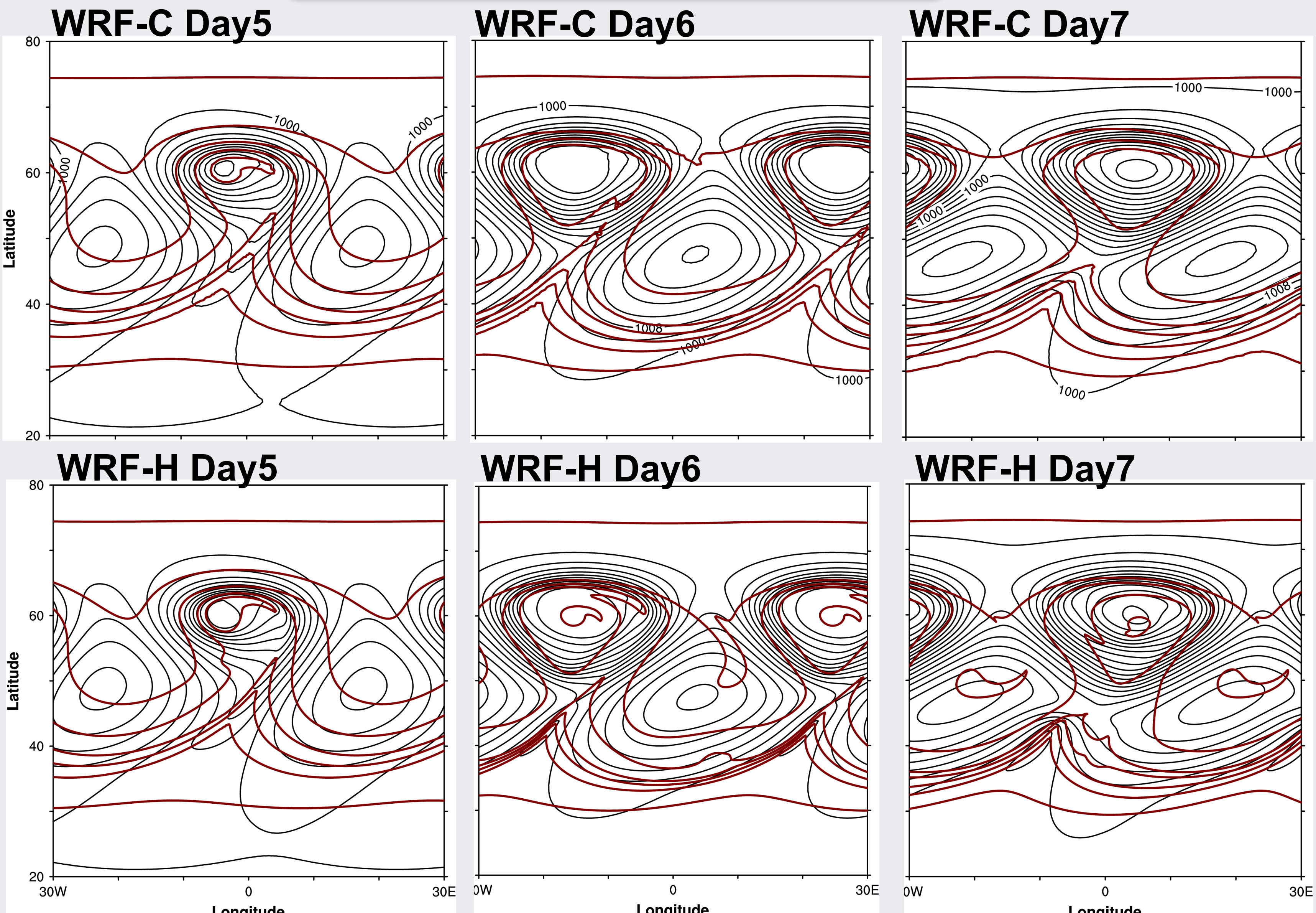
WRF-C



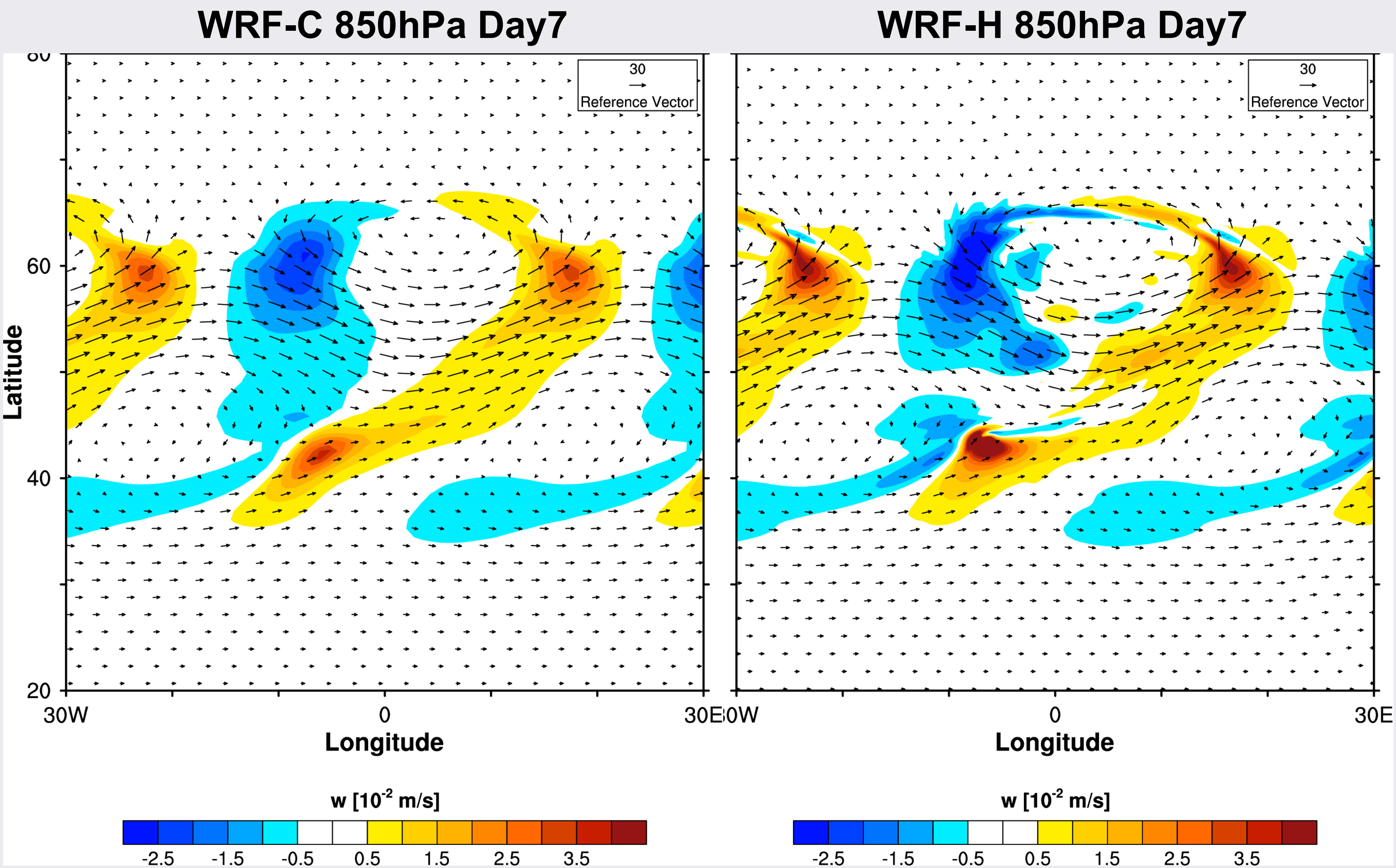
WRF-H



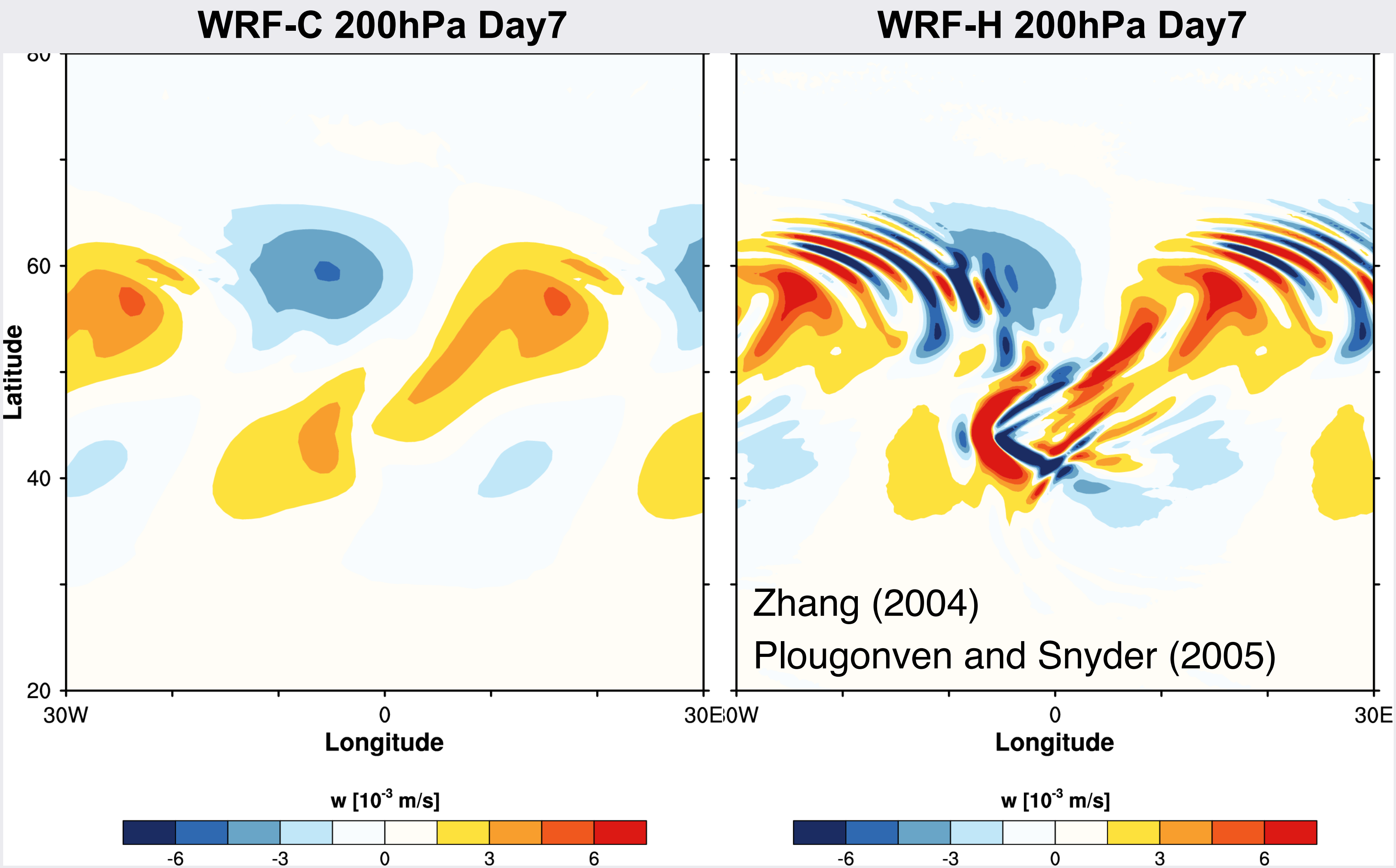
Surface Analysis



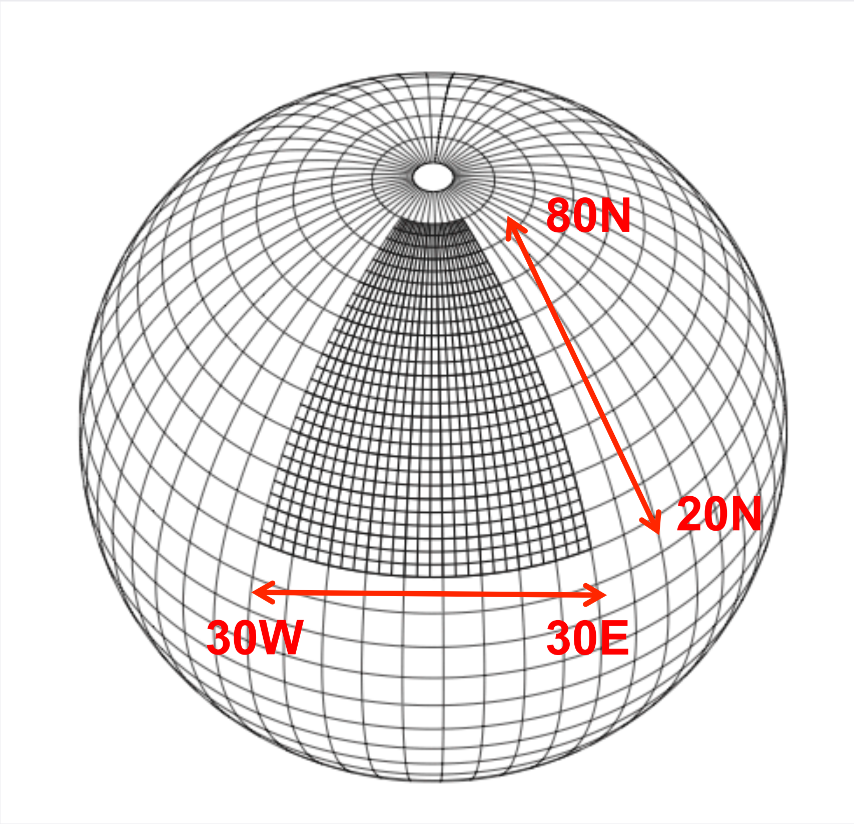
WRF – single domain



WRF – single domain



Nesting Experiment



* **For each baroclinic wave, it takes about 2.25 days to pass the nested domain**

WRF 1way-OFF	One-way (6h update)
WRF 1way-ON	One-way (90s update) → 2way but no interaction
WRF 2way	Two-way

More experiments for one-way nesting

WRF 1way-OFF.2H	(2h update)
WRF 1way-OFF.X1	(LBCs are from WRF-H)
WRF 1way-OFF.X1.2H	(LBCs are from WRF-H every 2hours)

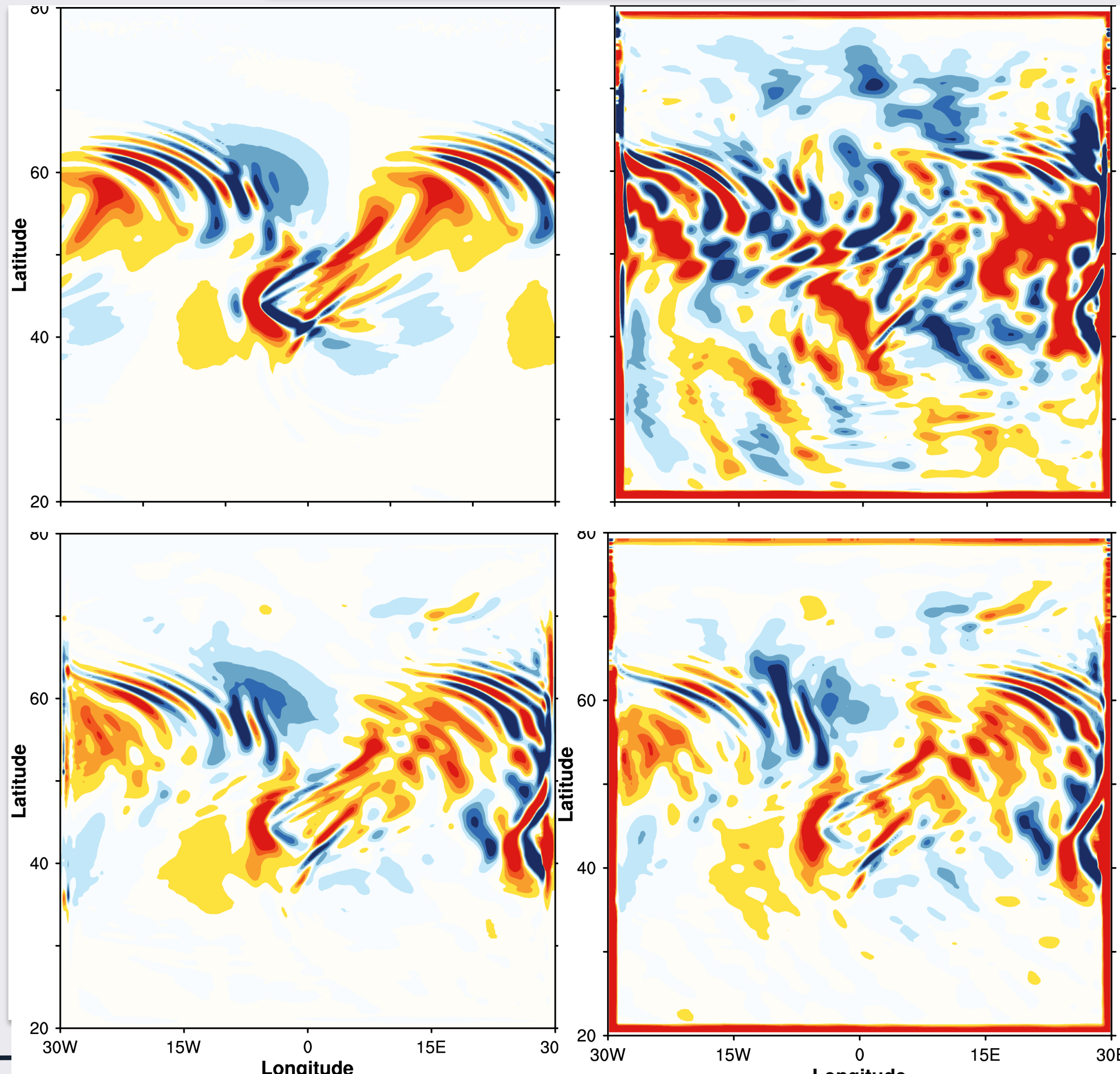
WRF nesting

WRF-H

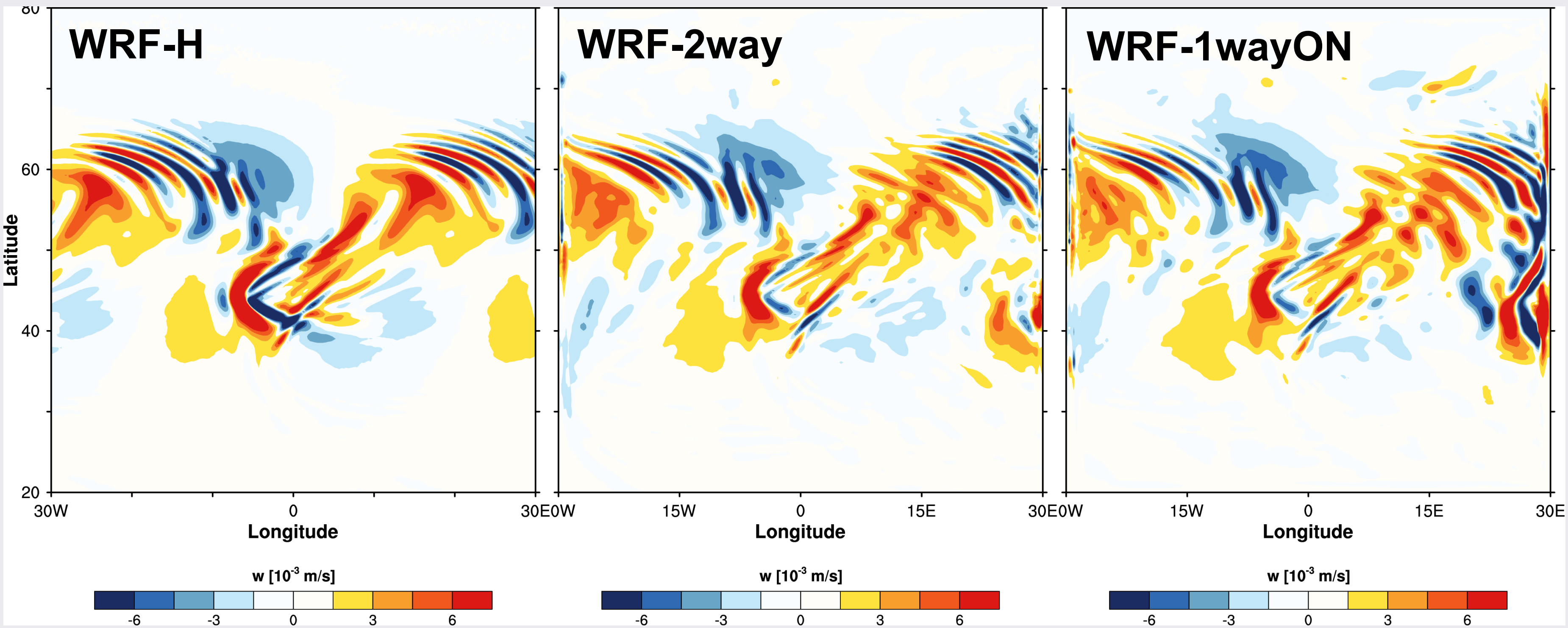
1wayOFF

1wayON

1wayOFF.2H



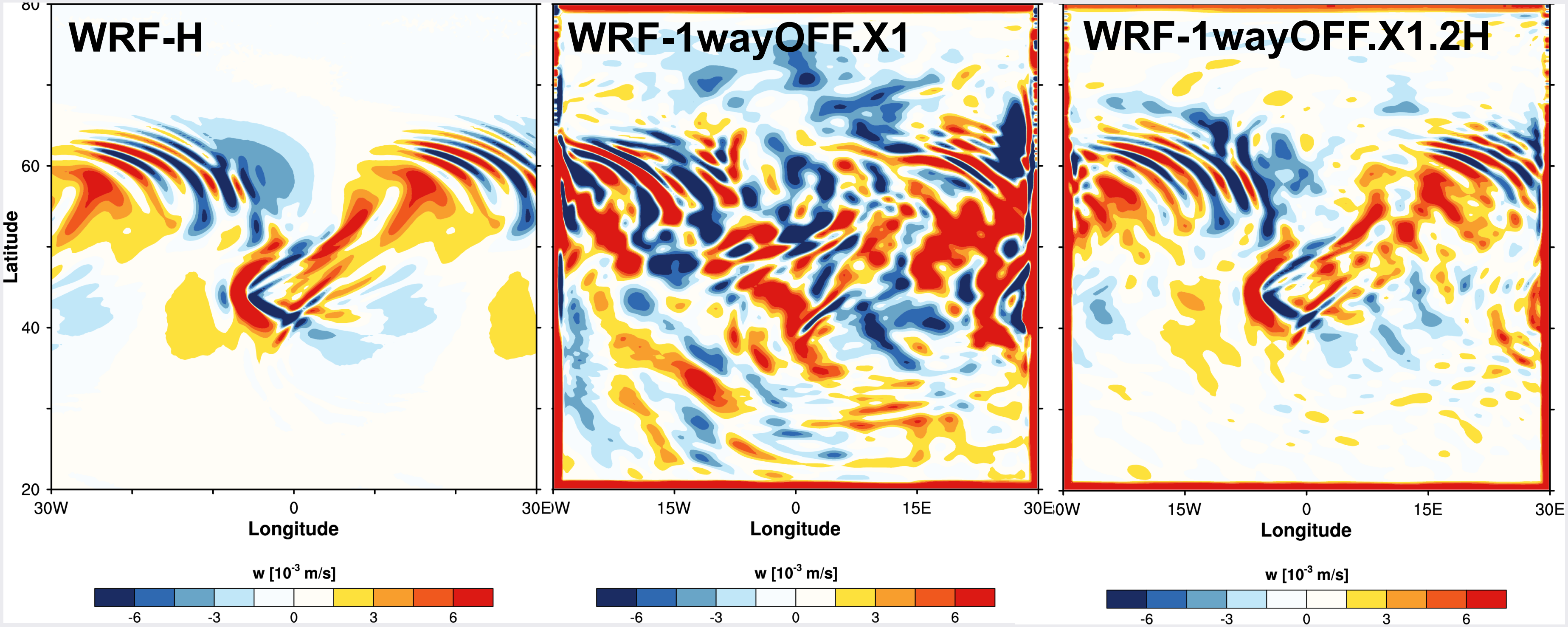
WRF – 2way nesting



- results are similar to WRF-1wayON and WRF-1wayOFF.2H (errors are mainly associated with update frequency)

update frequency estimation based on synoptic moving speed is not enough

WRF nesting for X1



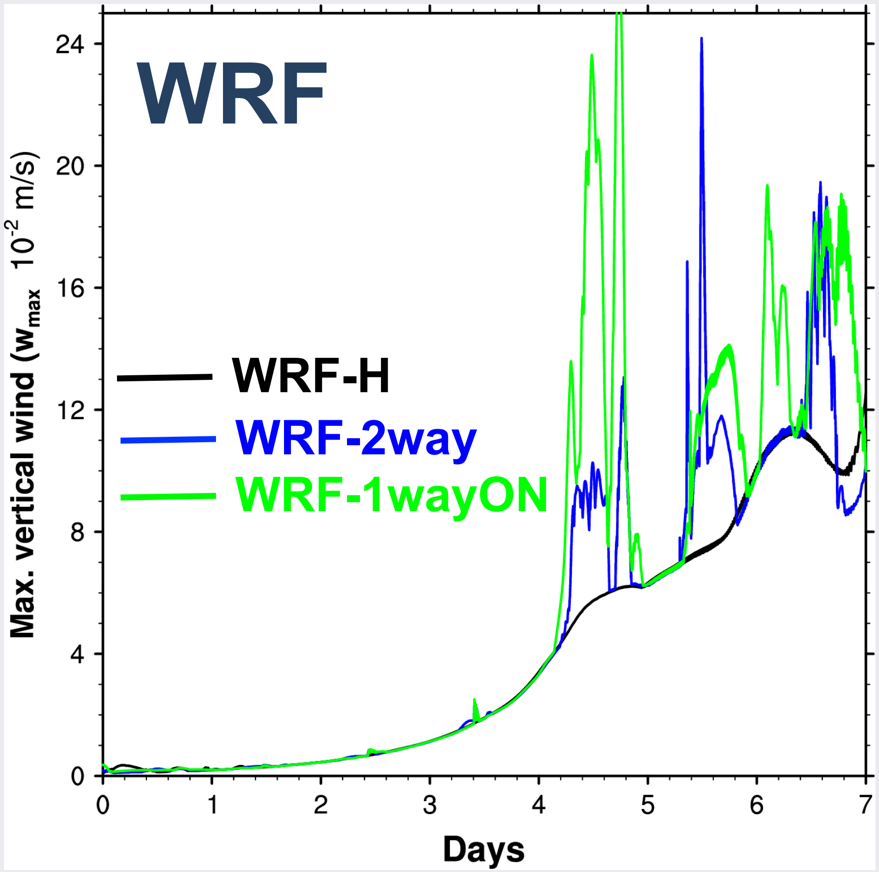
LBCs from hi-resolution data are not very helpful in reducing errors

update frequency is still important in X1 simulation

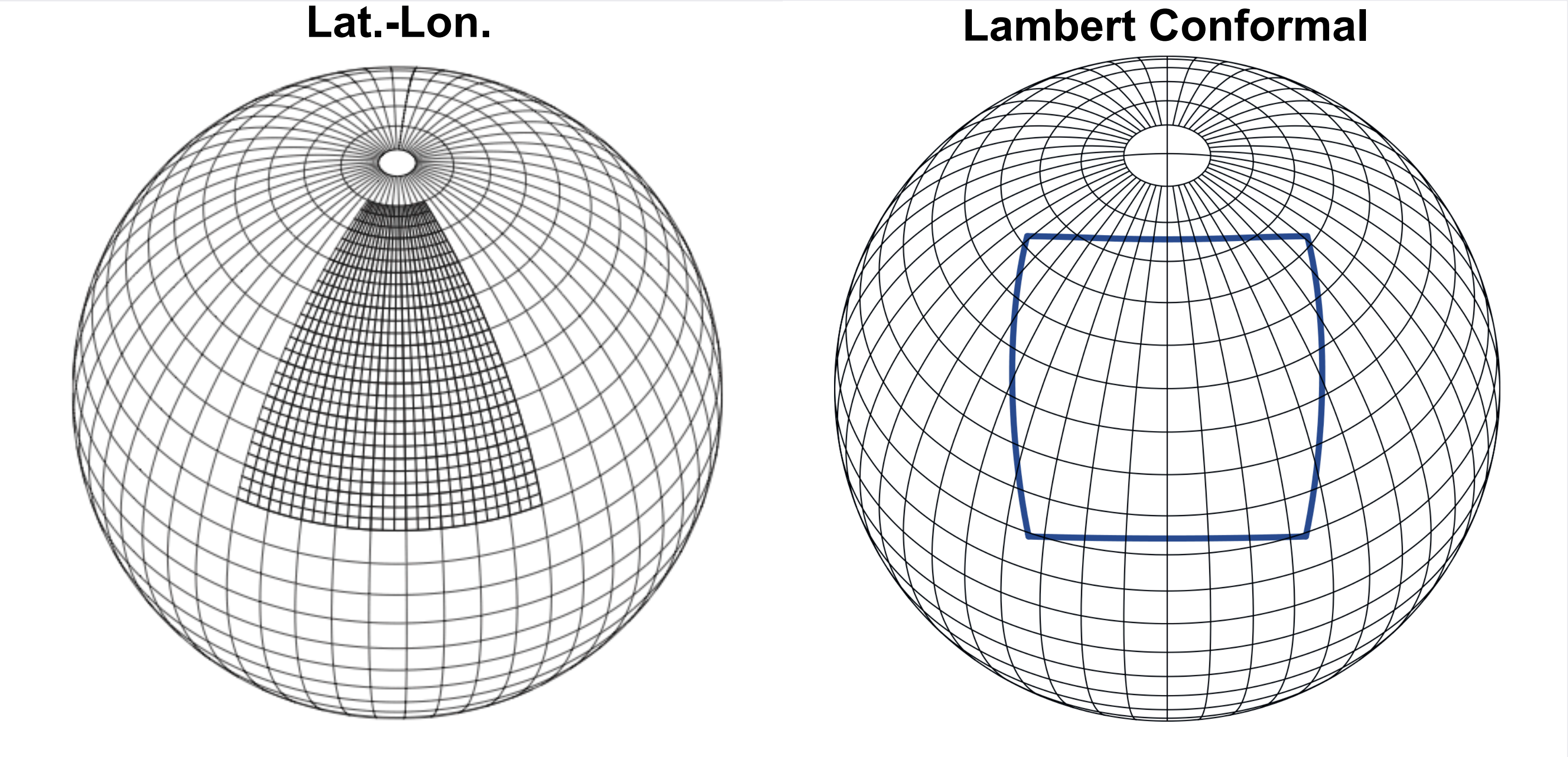
Summary from WRF-nesting

- WRF-1wayON or WRF-2way are better than WRF-1wayOFF
.. but it is not saying about good performance of their simulations

Maximum vertical velocity



WRF – LAM test

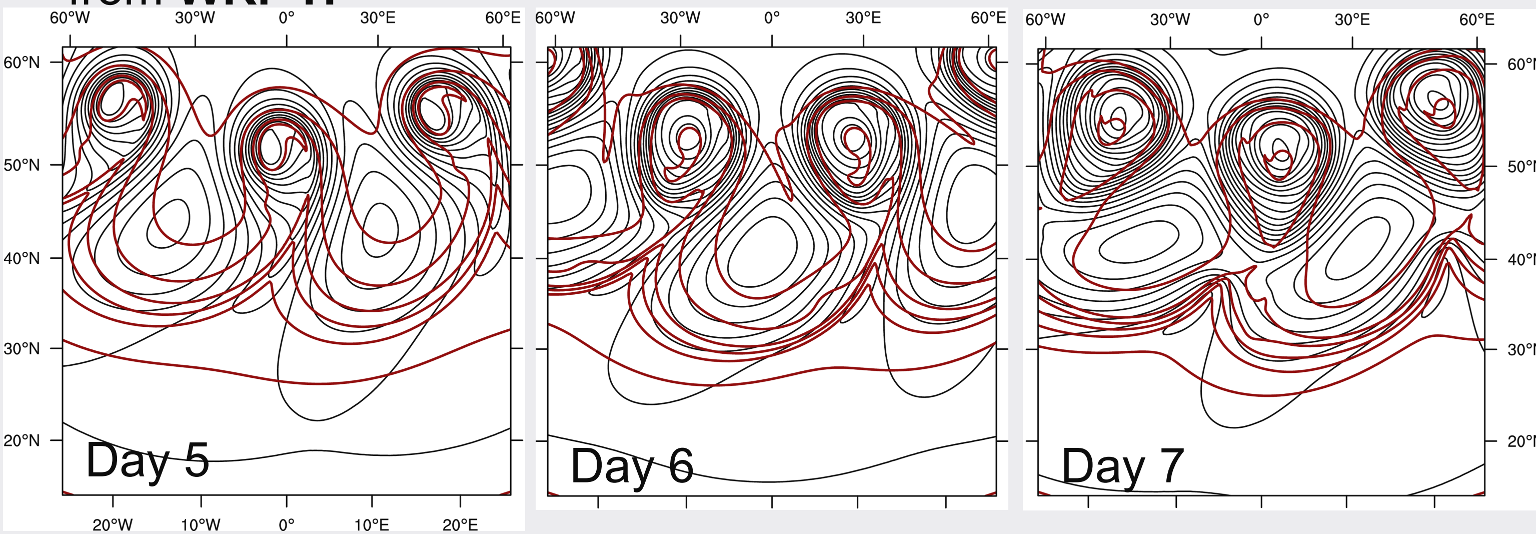


1-D interpolation is required from coarse grid to LBCs

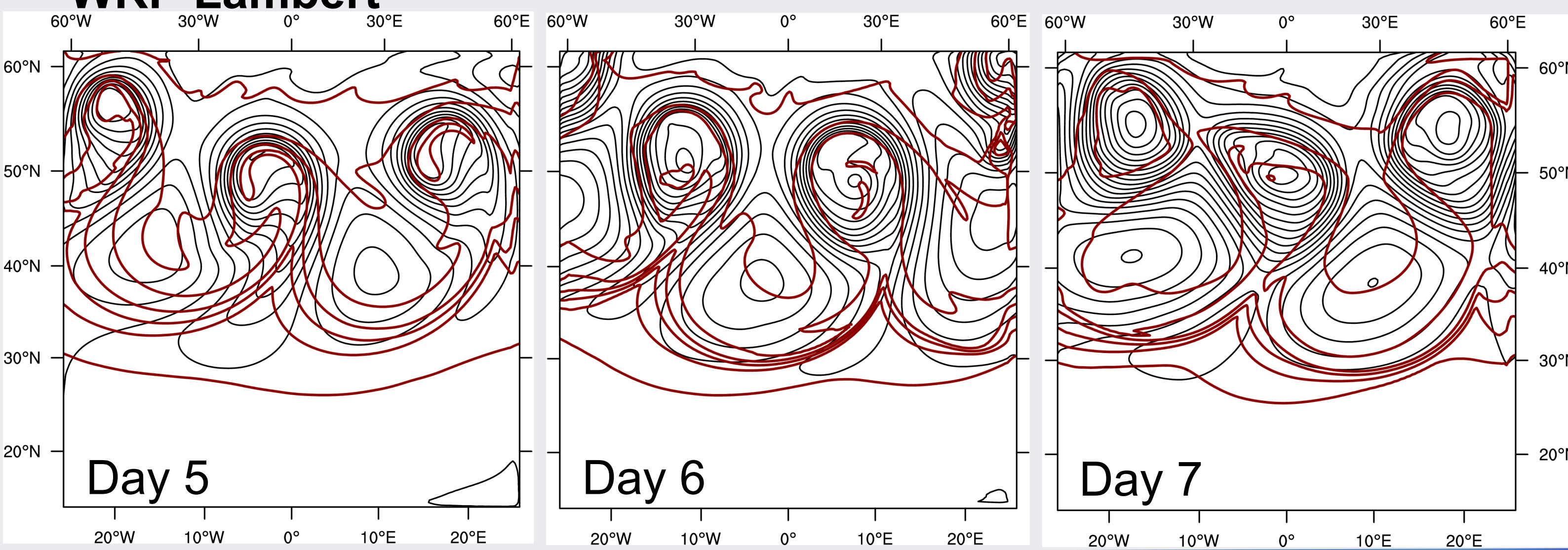
2-D interpolation is required from coarse grid to LBCs

WRF – LAM test

from **WRF-H**



WRF-Lambert



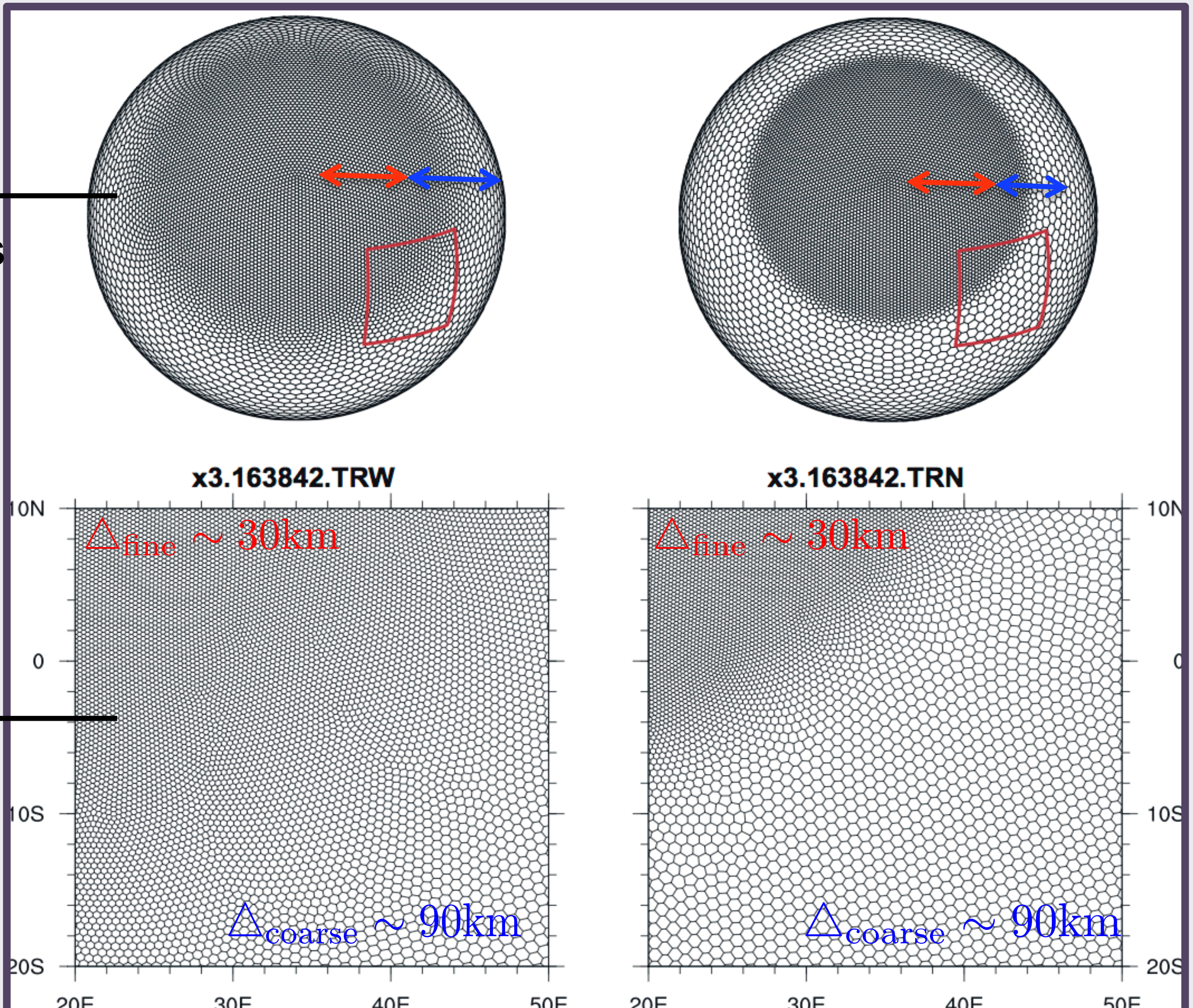
MPAS - TRW vs. TRN

High-resolution area ~ 35°

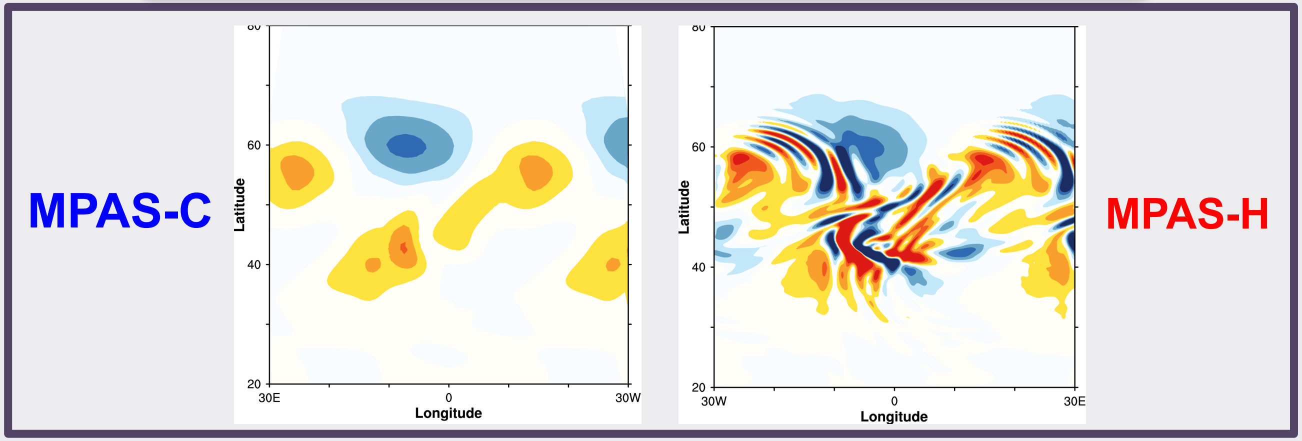
Transitional zone ~ 40° **Transitional zone ~ 20°**

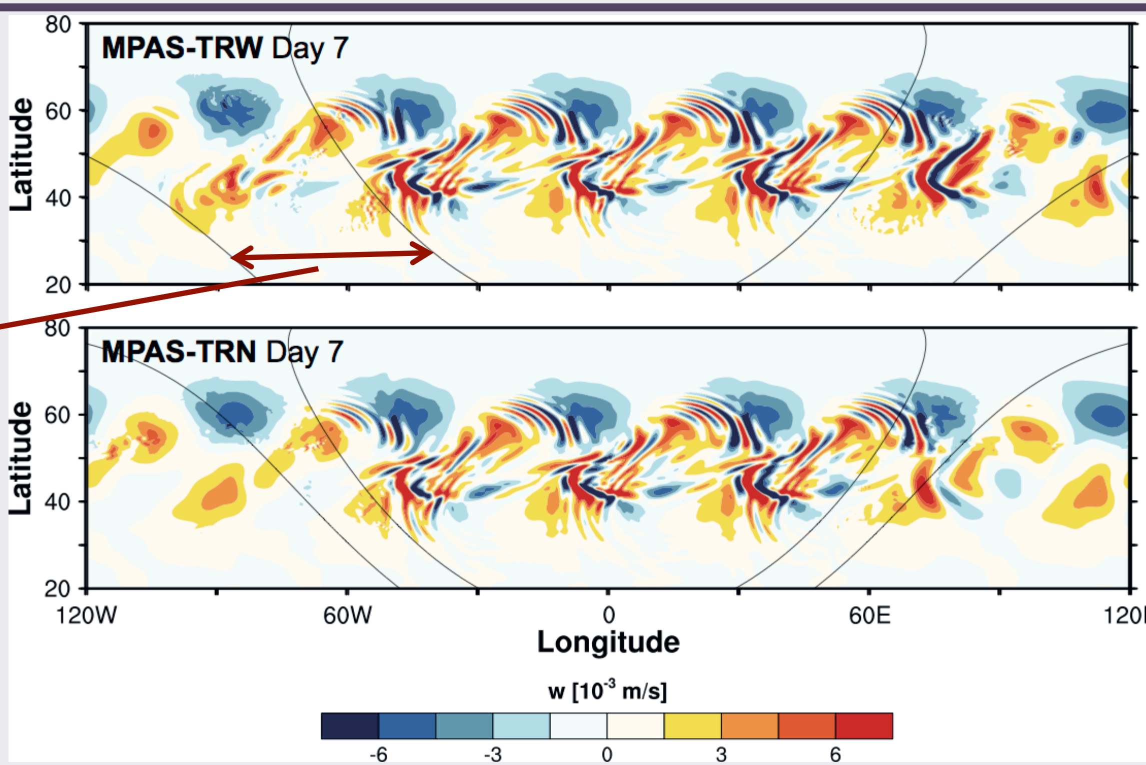
four times larger than actual meshes

actual mesh structure



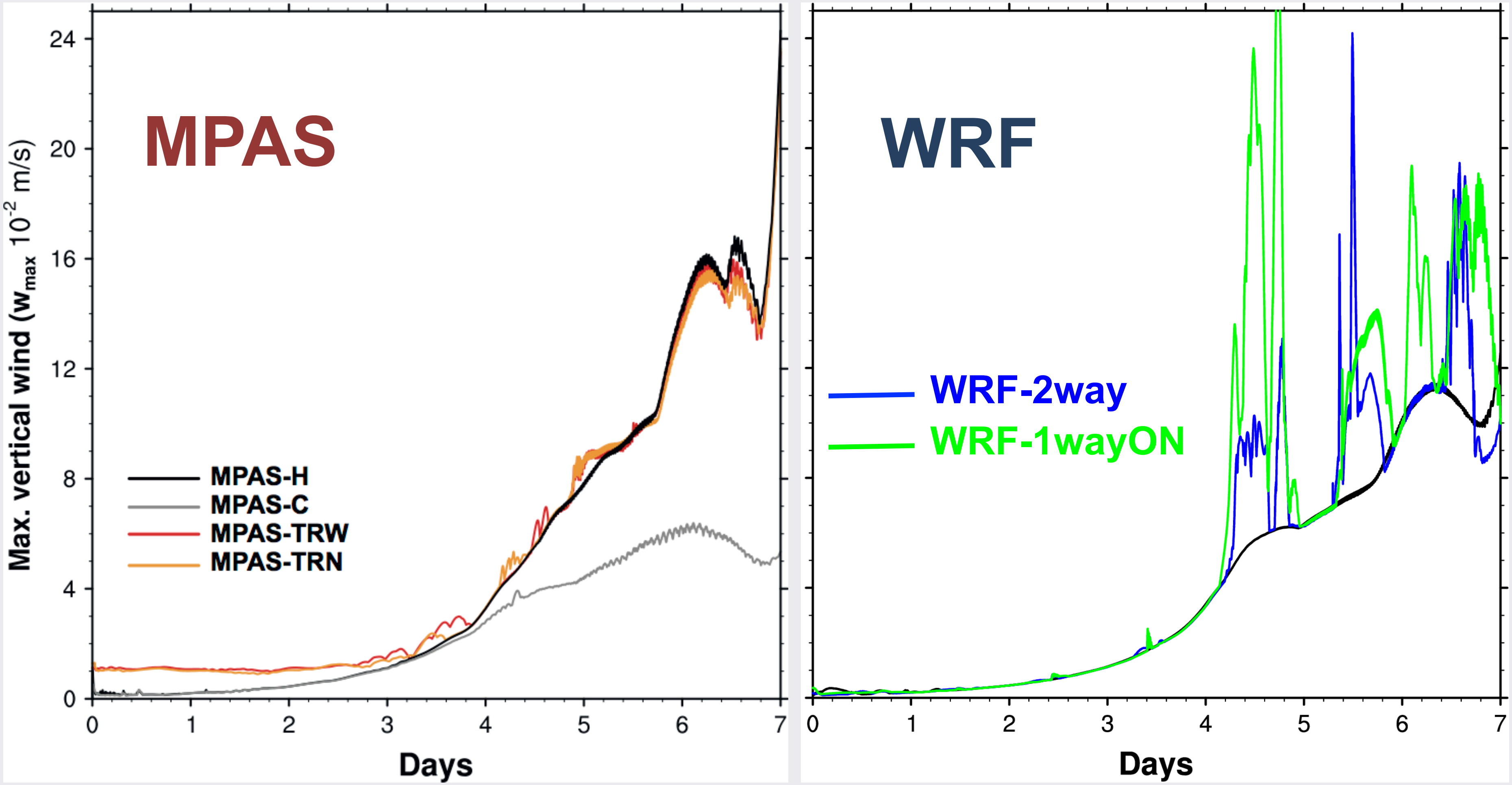
MPAS - TRW vs. TRN





transition zone

Maximum Vertical Velocity



Summary

A normal mode baroclinic wave test case is carried out between nested-WRF and MPAS-variable meshes.

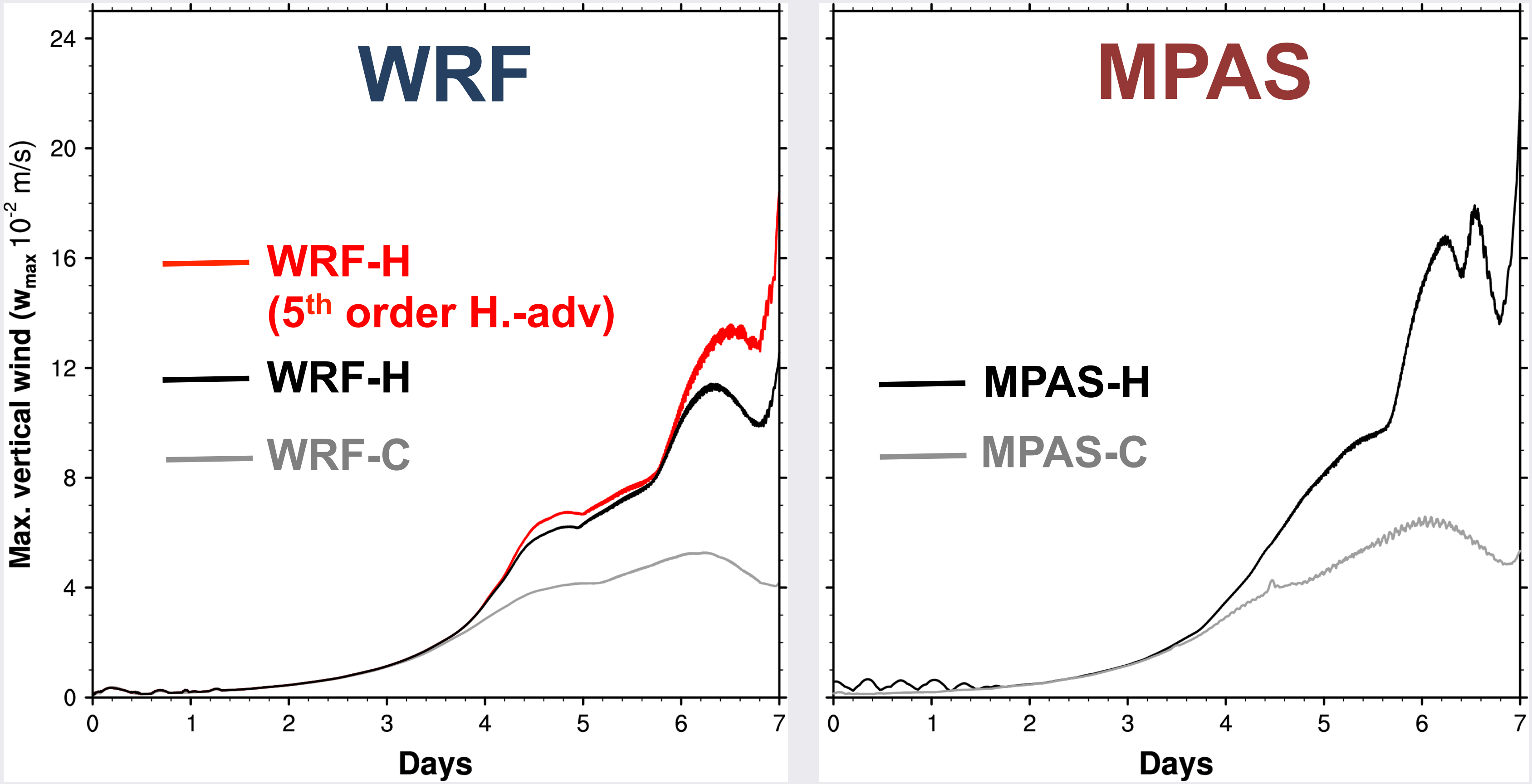
- **From WRF nested grid:**

- WRF-1wayOFF show bad performance compare to others
  :: importance of update frequency
  (Estimation of update frequency based on the phase speed of synoptic scale can give potential problem)
- Noticeable errors are obtained from surface pressure and temperature fields in Lambert Conformal projection

- **From MPAS variable meshes:**

- Baroclinic wave system and upper level gravity waves are smoothly resolved along the longitude
- There is only small amplitude of noises from transitional zone of both variable meshes

Maximum Vertical Velocity



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WRF – 2way nesting