2013 HWRF Nesting

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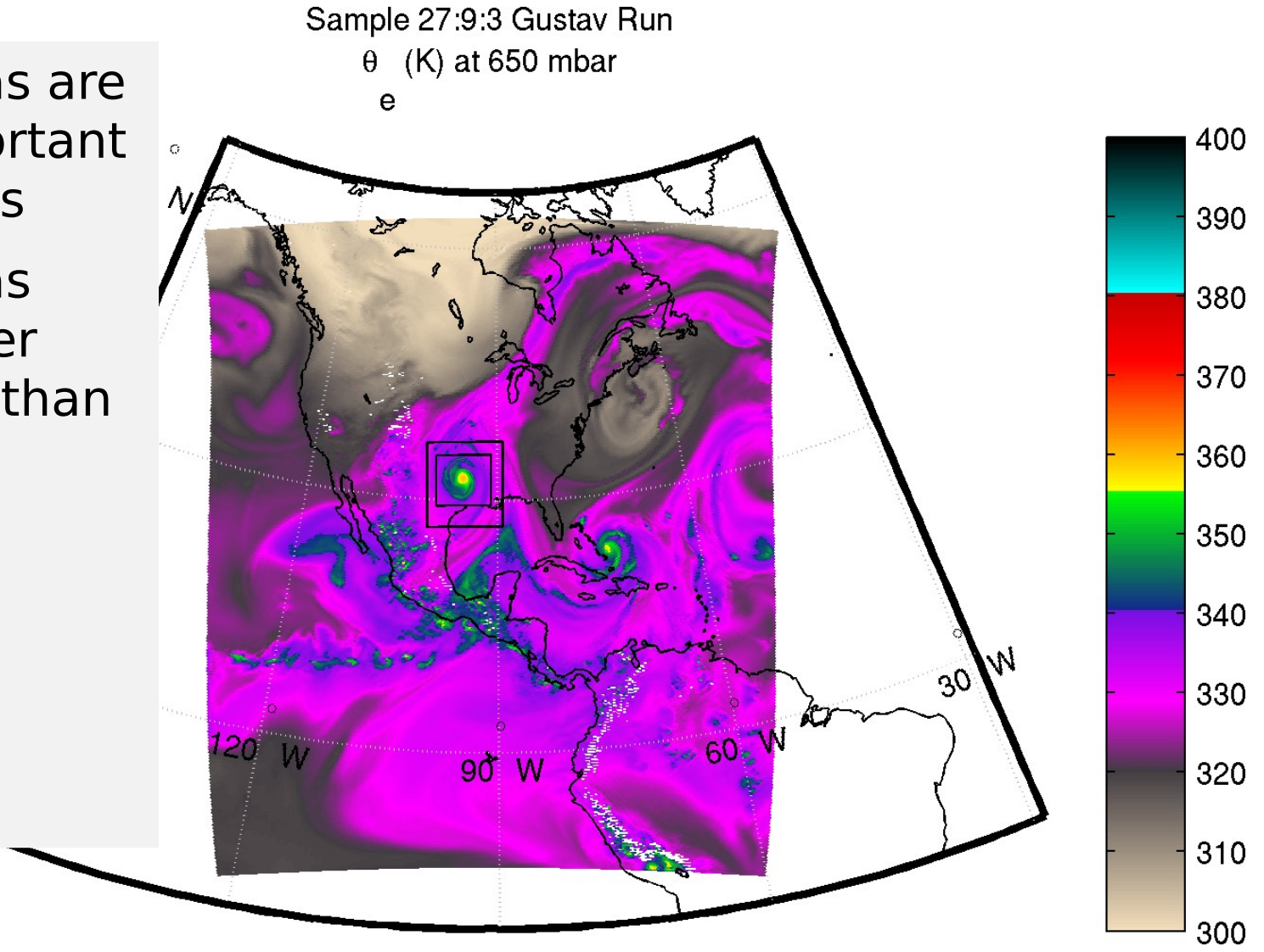
  - Tropical Cyclones need High Resolution
- Vortex-Tracking Nests
- Different Terrain Heights in Different Domains: Mass Adjustment
- Upscale/Downscale Interpolation
- Questions

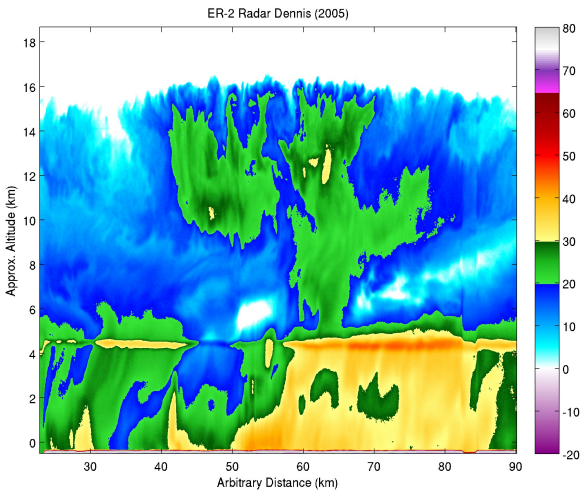
Telescoping Nesting: What and Why?

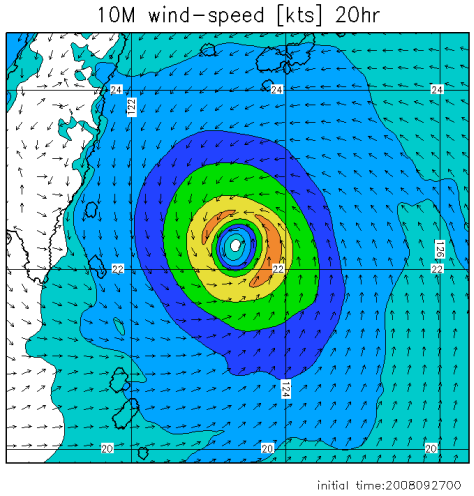
- Some areas are more important than others
- Some areas need higher resolution than others

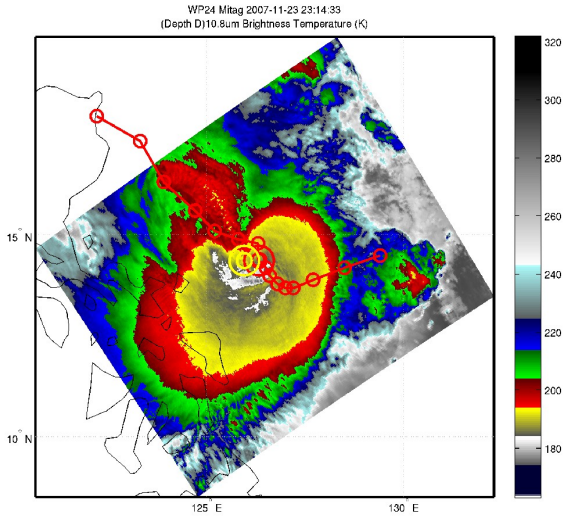


Telescopic Nesting: What and Why?
Small-Scale Features

- Important to tropical cyclone intesity and structure

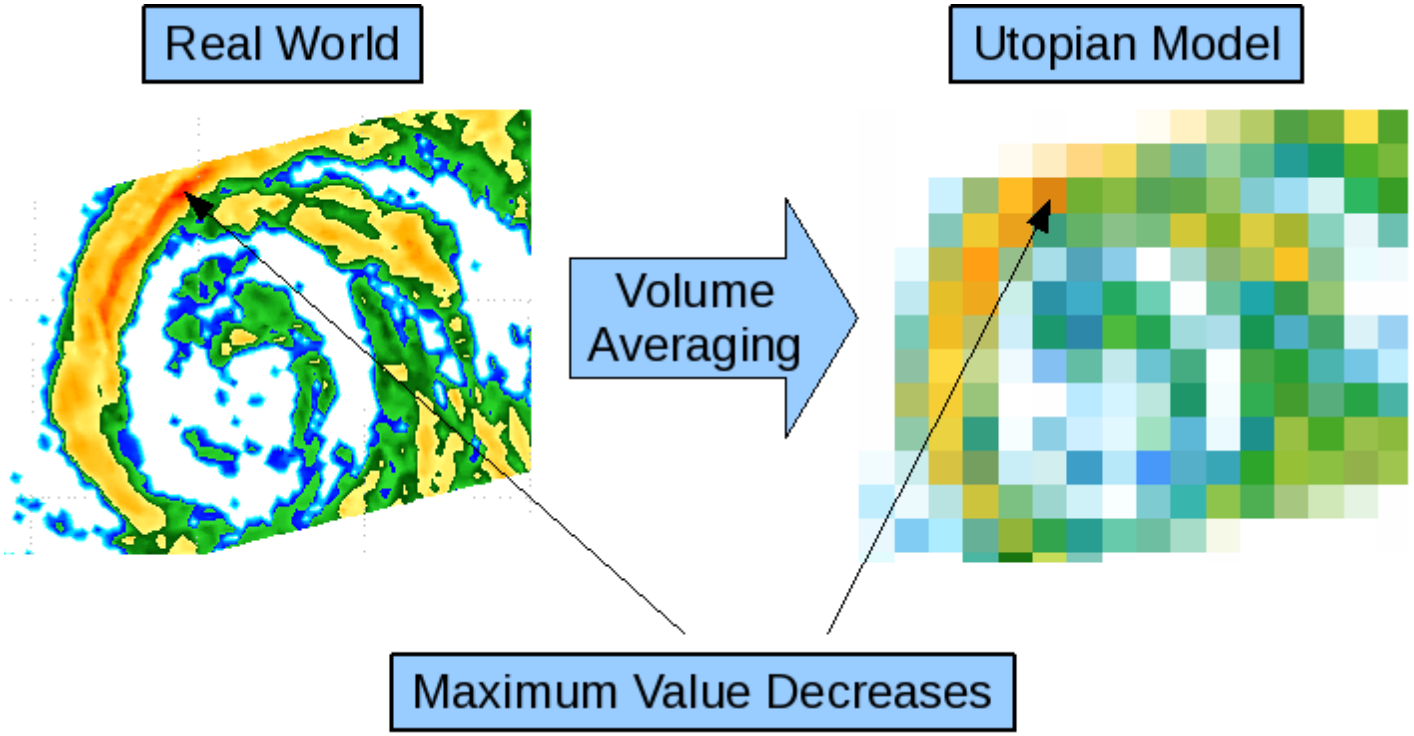




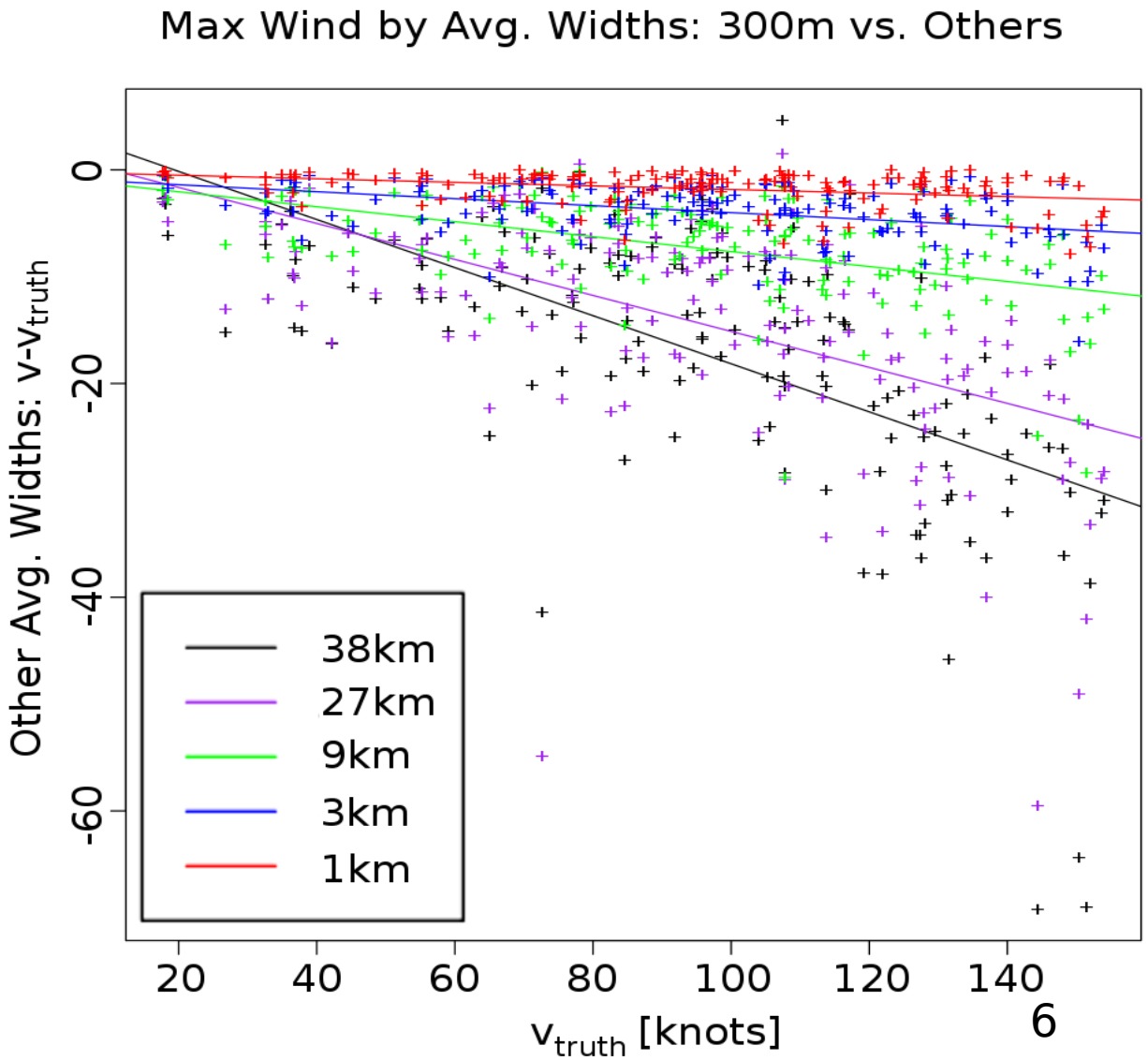


Tropical Cyclone Nesting: What and Why?

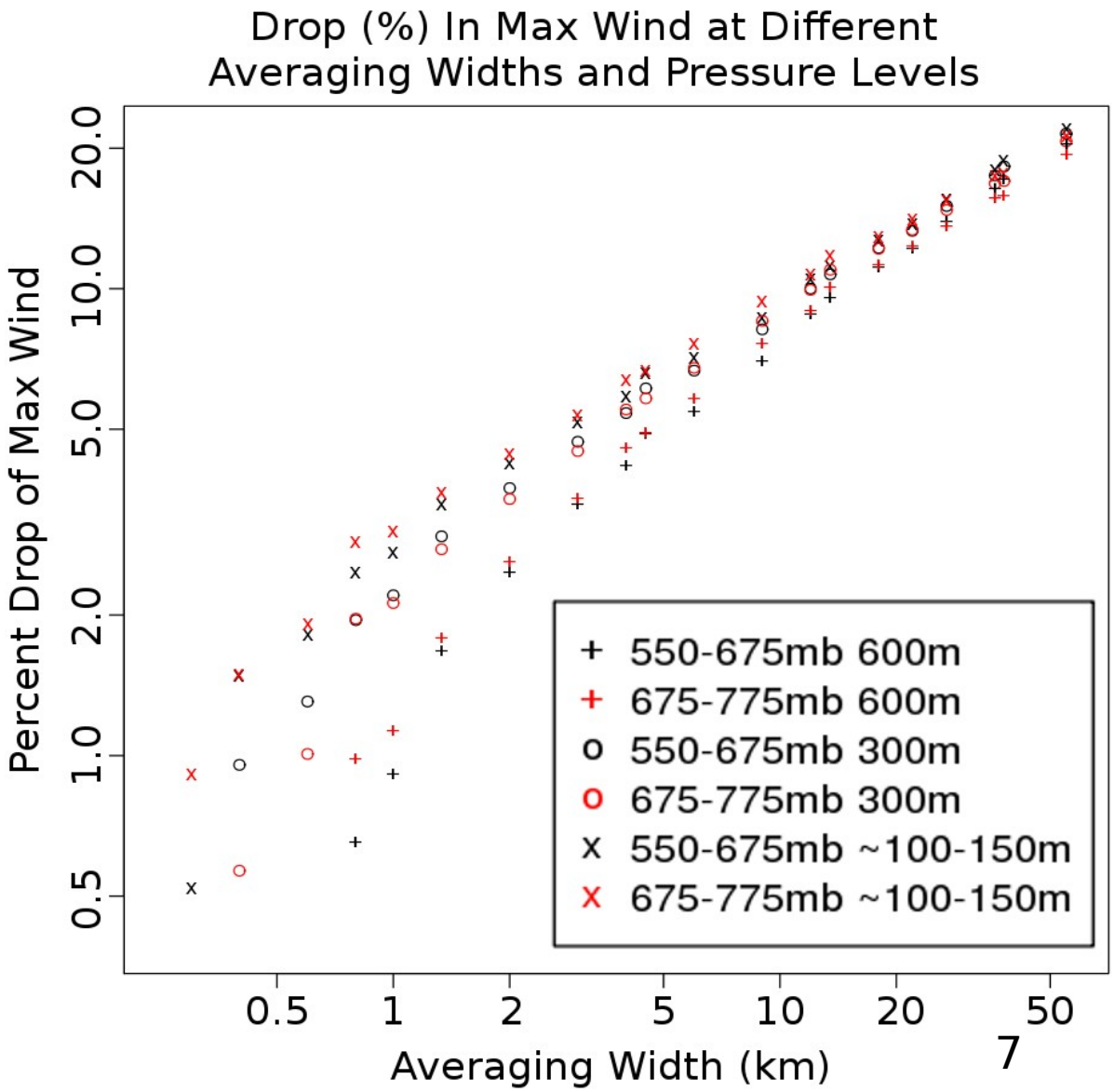
Resolution-Dependent Intensity Bias



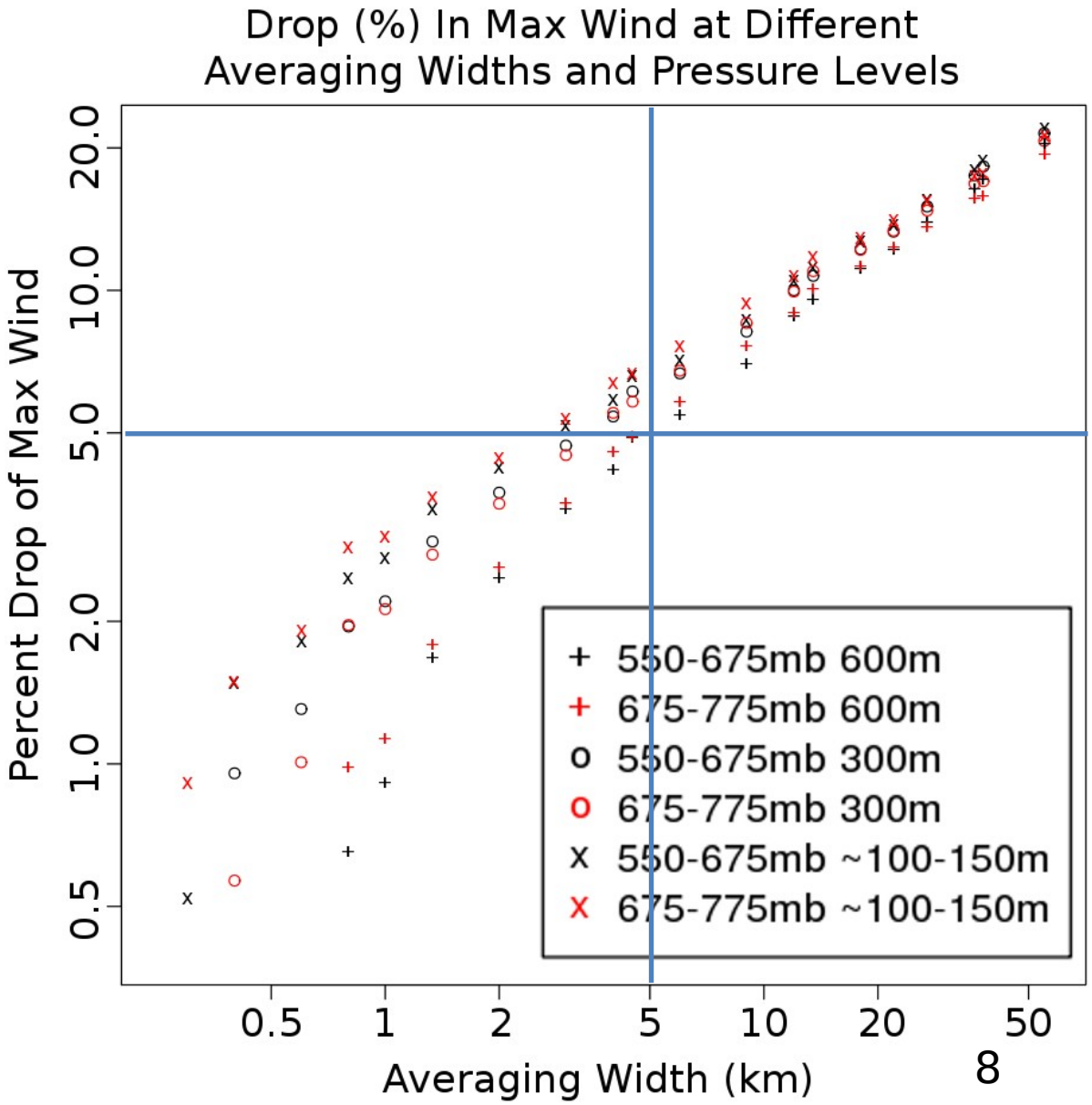
Resolution-Dependent Intensity Bias



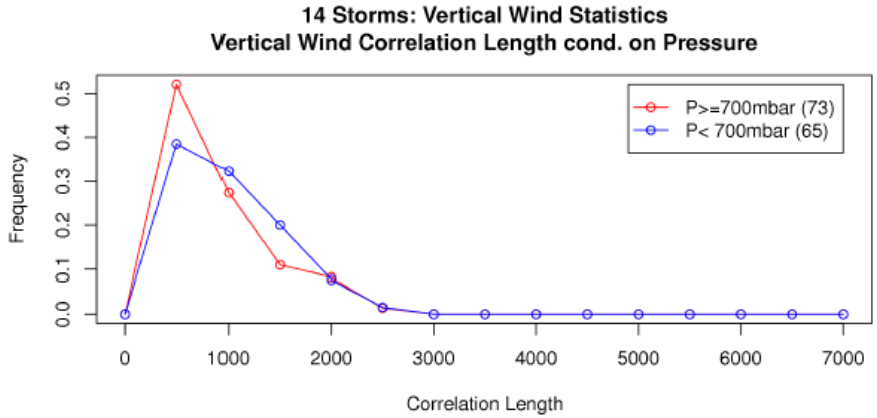
Tropical Cyclone Nesting: What and Why?
Resolution-Dependent Intensity Bias

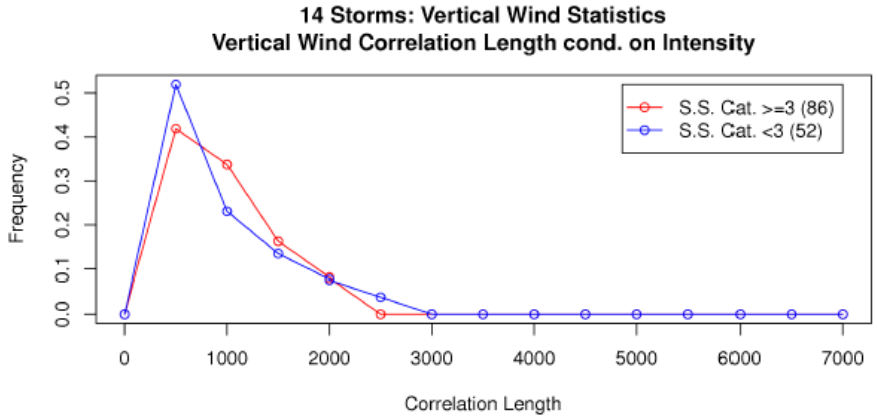


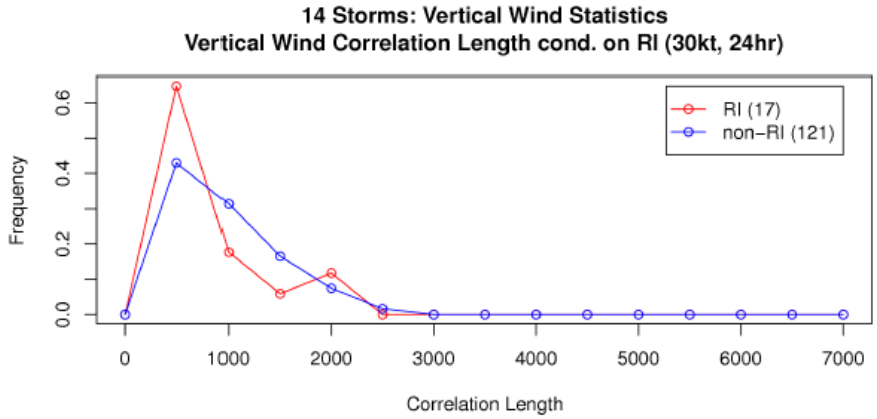
Resolution-Dependent Intensity Bias

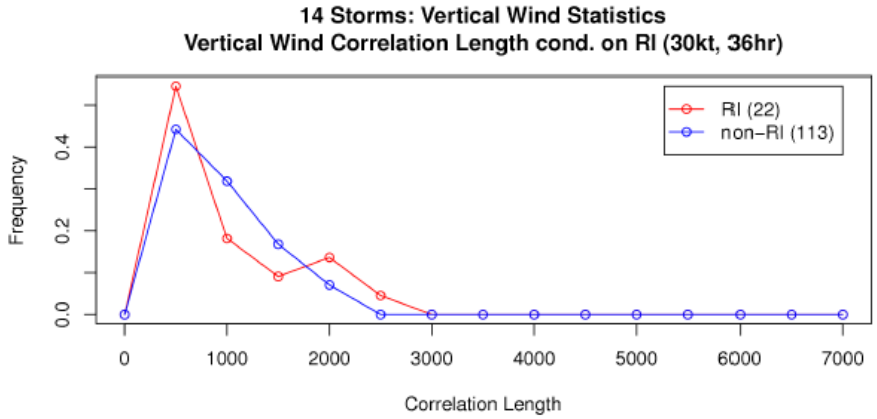


Tropical Cyclone Nesting: What and Why?
Convection Scales



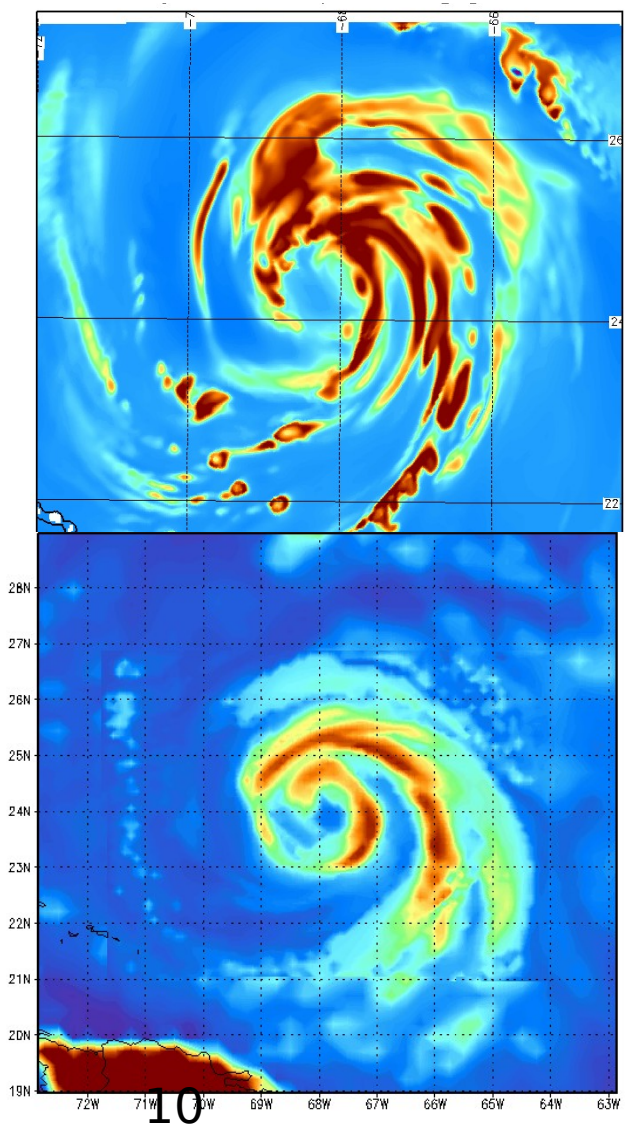






Need High Resolution
For Structure and Intensity

- Tropical cyclones need higher resolution:
  - <5km to represent wind maximum
  - <5km for mesovortices, vorticity waves
  - <3km for resolved convection
  - <1km for vorticity sheets
  - Need <4km for satellite products
- Cannot do 3km everywhere. Too expensive!

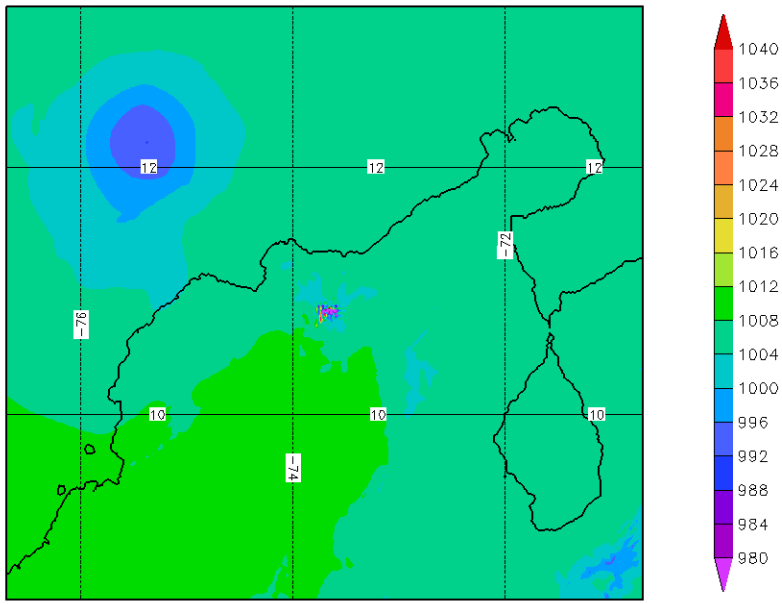


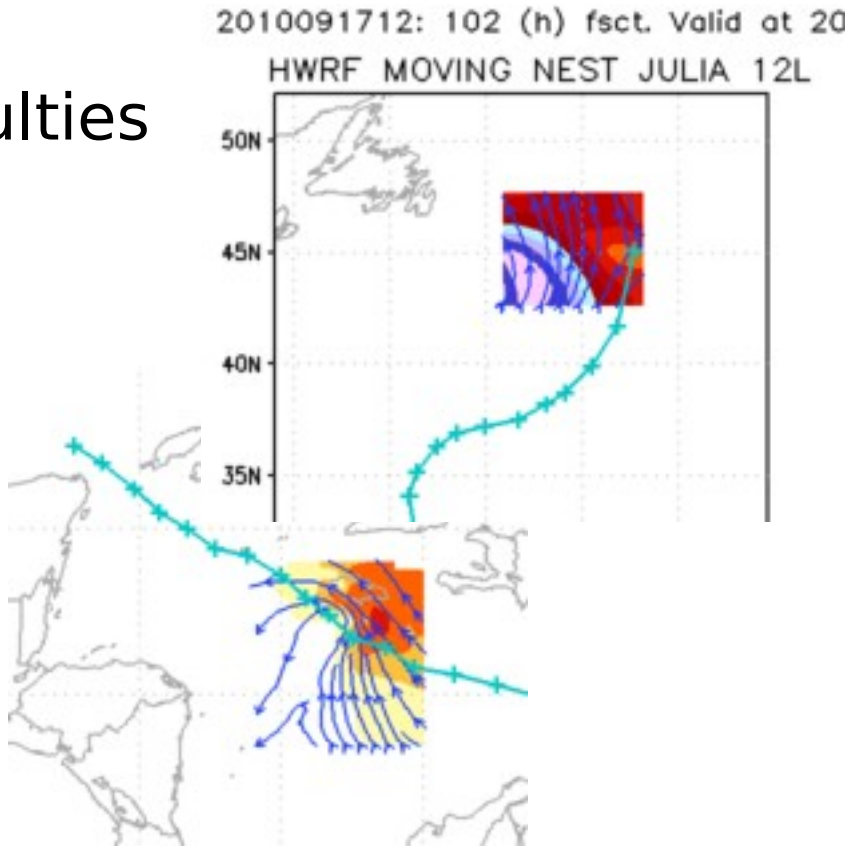
Vortex Tracking Nests
Older Methods

- 9km, 3km domains track the storm
- Where is the storm?
  - MSLP minimum?
  - Dynamic pressure minimum?
  - Maximum surface vorticity vector magnitude?
  - Mass centroid location?
  - ?????

Vortex Tracking Nests
Older Methods

- Interactions with other Tropical Cyclones
- Interactions with Synoptic-Scale Systems
- MSLP Numerical Difficulties

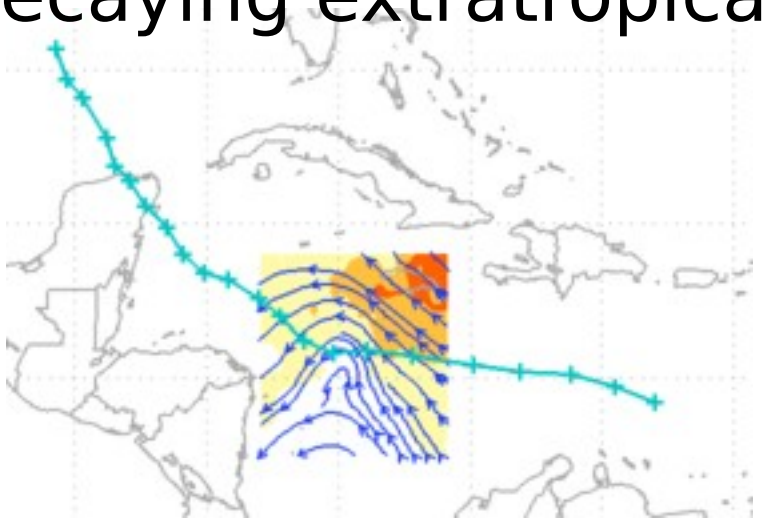




Nest Motion Solution

Nine Field Tracker

- MSLP or vorticity alone is not enough
- New method is nearly 100% successful
  - Only problems are when nest movement interval is too small for storm speed.
  - Rare: decaying extratropical systems



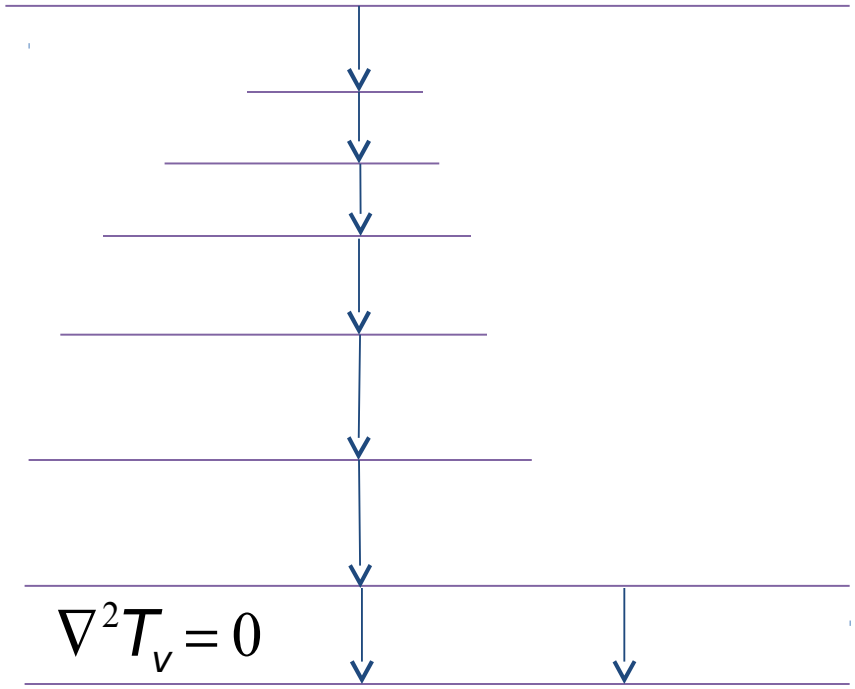
Vortex Tracking Nests
New Method

- Track Nine Smoothed Fields:
  - Vorticity – 10m, 850 mbar, 700 mbar
  - Wind minimum – 10m, 850 mbar, 700 mbar
  - Height – 850mbar, 700 mbar
  - Membrane MSLP
  - Advanced Mean Sea Level Pressure technique by Hui-Ya Chuang at EMC
- Discard fields that are far from the average
- Final average is new location

Vortex Tracking Nests

Membrane MSLP

$$dP = -\rho g dz$$

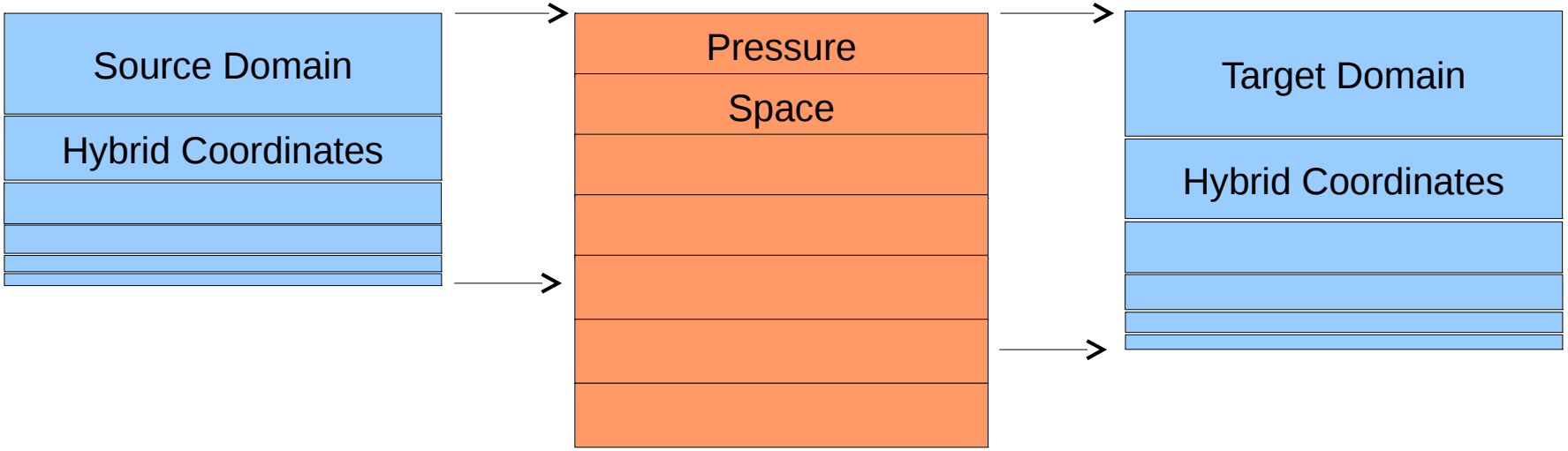


- Re-express atmosphere as ocean world on pressure levels
- Extrapolate virtual temperature on pressure surfaces
- Smooth atmosphere
- Integrate to get P(z=0)

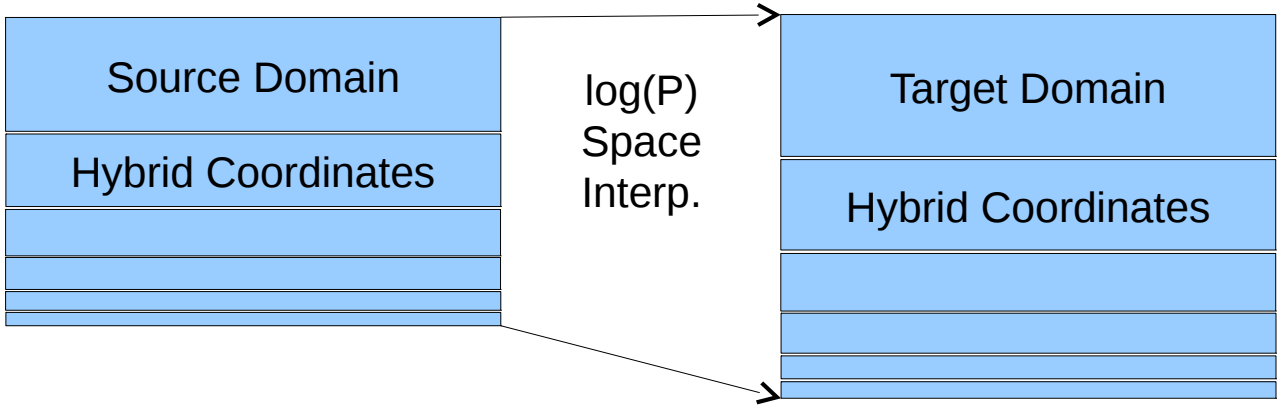
Different Terrain Heights

Inter-Domain Mass Adjustment

2012 HWRF: two step spline



2013 HWRF: single step linear

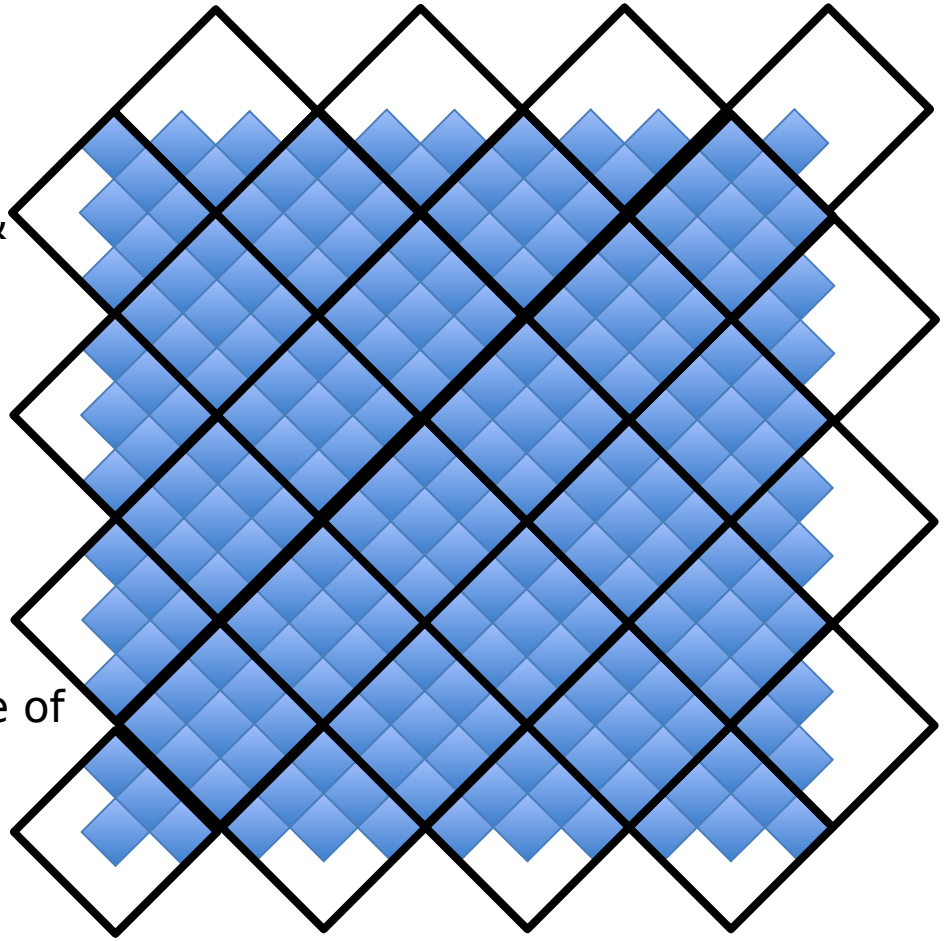


Different Terrain Heights
Inter-Domain Mass Adjustment

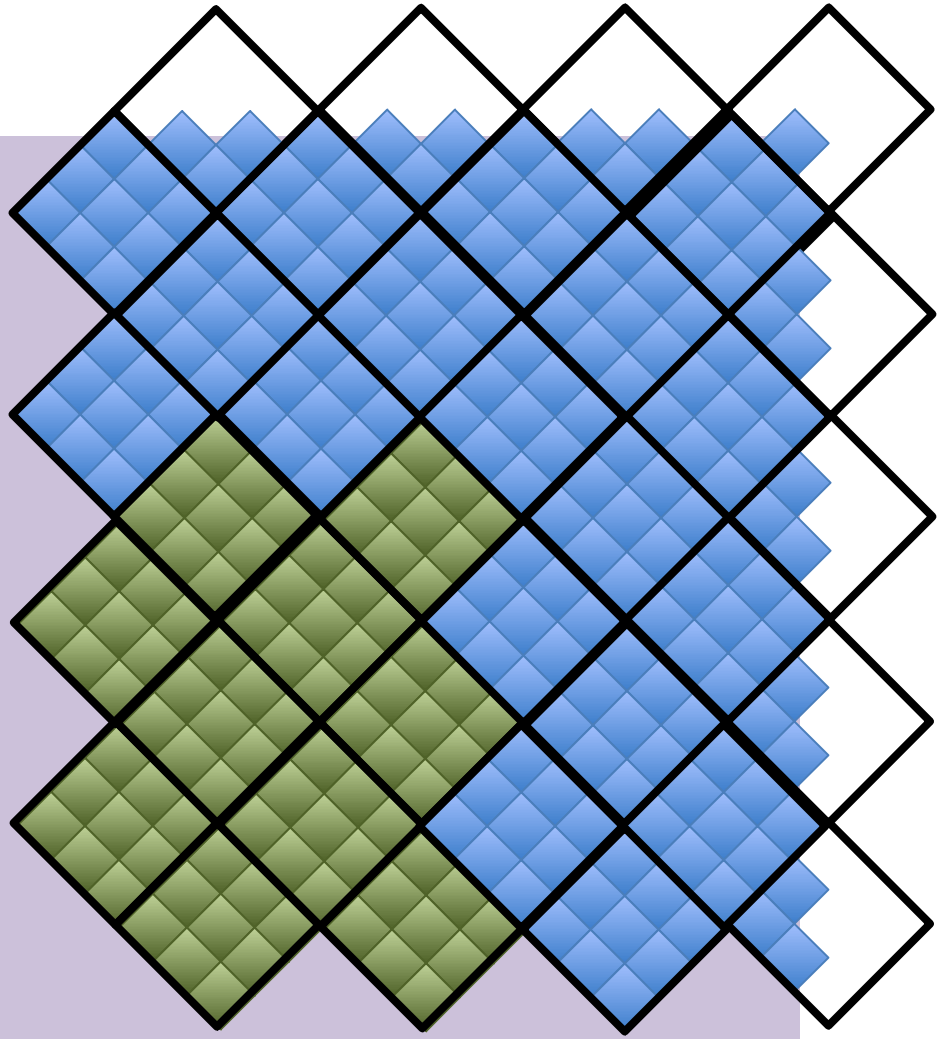
- New method advantages:
  - allows non-bulk microphysics
  - Tested with Thompson and WSM6 schemes
  - Faster
- Improved upscale interpolation

Domain Discontinuities
Diamond Gridpoints, Rectangular Grid

- Nine child points in each parent
- Cannot exactly match up edges (mass & energy conservation impossible)
- Domain init: downscale parent
  - Four point averaging or nearest neighbor
- Boundary forcing:
  - Edges only: downscale parent
  - Points adjacent to edges are average of edge and inner point



Domain Discontinuities
Upscale Feedback



- 2013 HWRF
  - 50% feedback to inner (green) points
  - Nine point averaging or nearest neighbor (depends on field)

Registry/Registry.HWRF
Interpolation Routines share/interp_fcn.F

- Three cases: upscale(Up/u), downscale(Down/d), boundary forcing(Bdy/f)
- Four methods: nearest neighbor (Near), binary copy (Copy), mass adjustment (Mass), velocity (Vel)
- Put them together:

```
state real  u ijkb   dyn_nmm 1 v i01rh02u=(UpVel)d=(DownVel)f=(BdyVel)

state real  v ijkb   dyn_nmm 1 v i01rh02u=(UpVel)d=(DownVel)f=(BdyVel)

State real f_ice ikj dyn_nmm 1 – rhd=(DownMassIKJ:@EExtrap,0.0)u=(UpMassIKJ:@EExtrap,0.0)

state real qv ijkfbt moist   1 m rhu=(UpMass:@ECopy,0.0),
d=(DownMass:@ECopy,0.0)f=(BdyMass:@ECopy,0.0)

@ECopy,0.0 = extrapolation method (below ground): copy lowest model level

@EConst,5.5 = extrapolate using constant 5.5 below ground

@EExtrap,5.5 = linearly extrapolate to constant at 1030 mbars
```