

2015 HWRF
Dynamics and Nesting
January 2016

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Overview

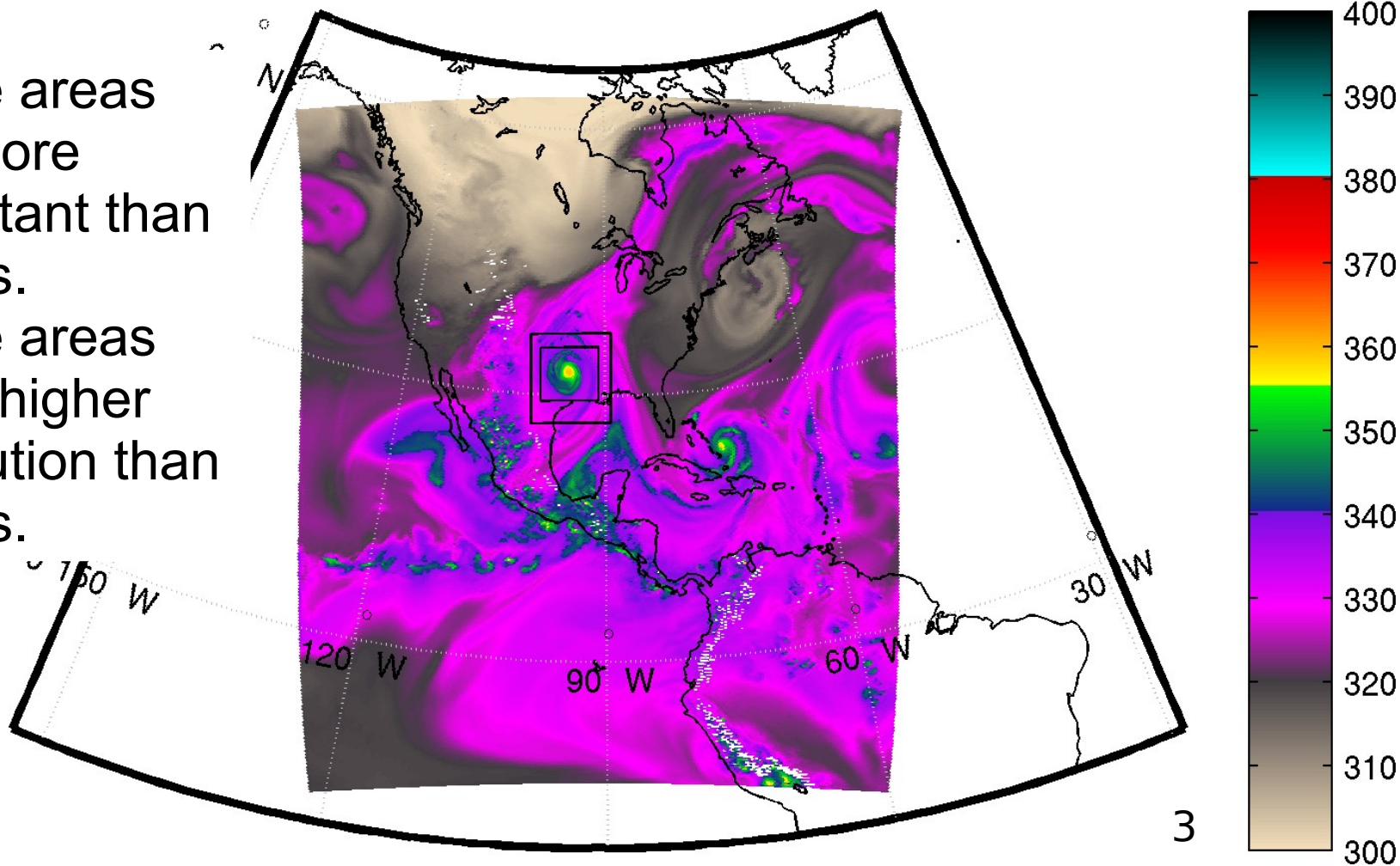
- Coordinates
- Nesting
 - Boundary conditions
 - Upscale feedback
 - Vertical interpolation/extrapolation
- Vortex Tracking Nests
- Diagnostic Products

Nesting: Why?

Sample 27:9:3 Gustav Run

θ (K) at 650 mbar

e

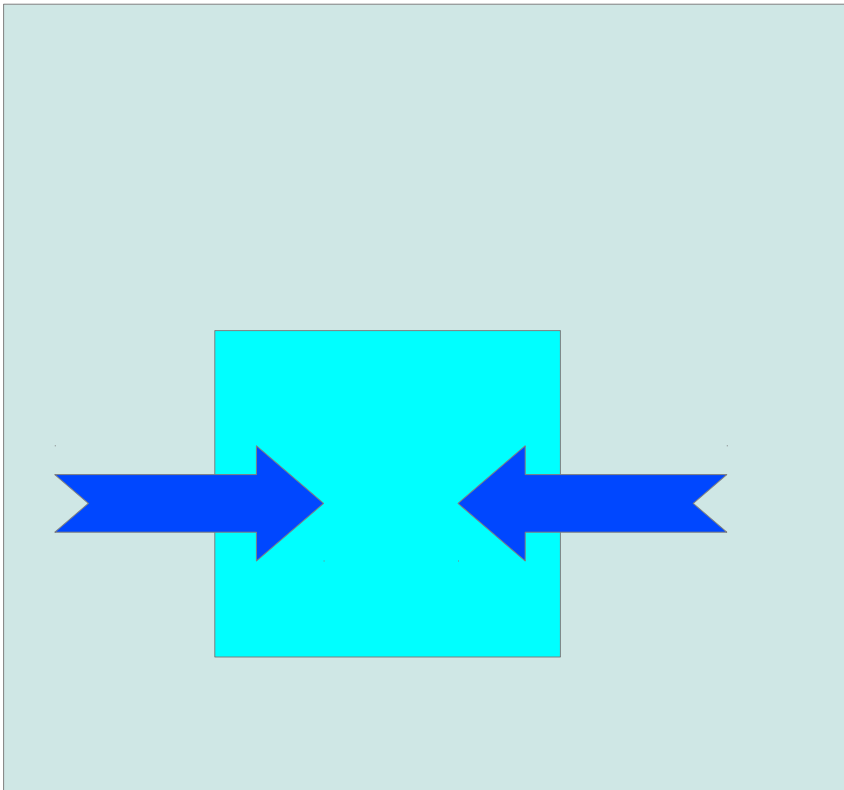


- Some areas are more important than others.
- Some areas need higher resolution than others.

Nesting: When?

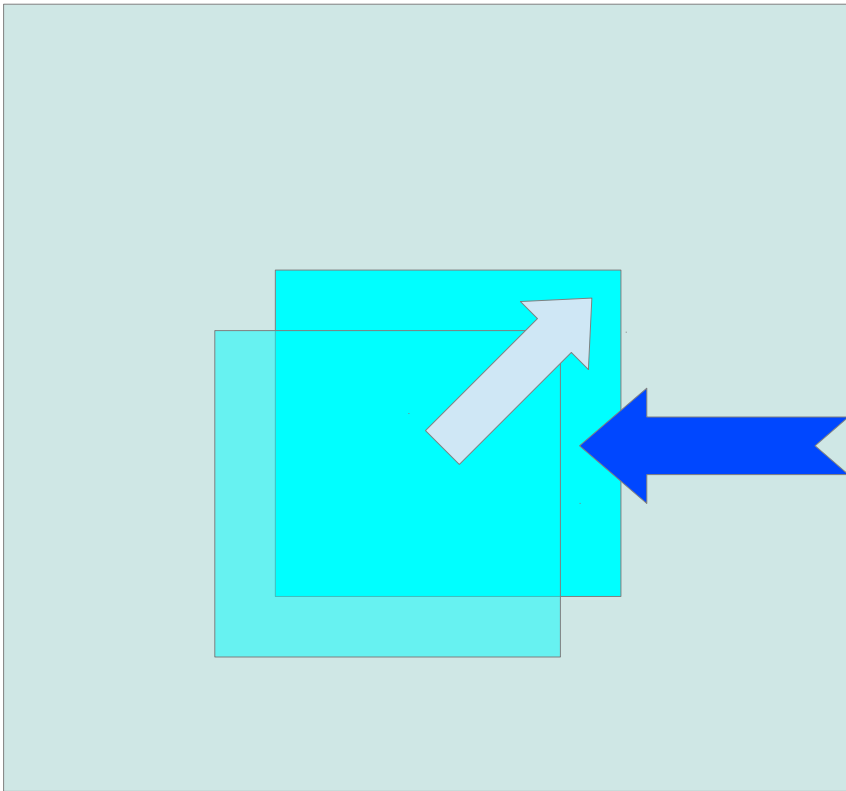
Nest Initialization

- Nest initialization
 - Fill nest with data from parent.



Nesting: When?

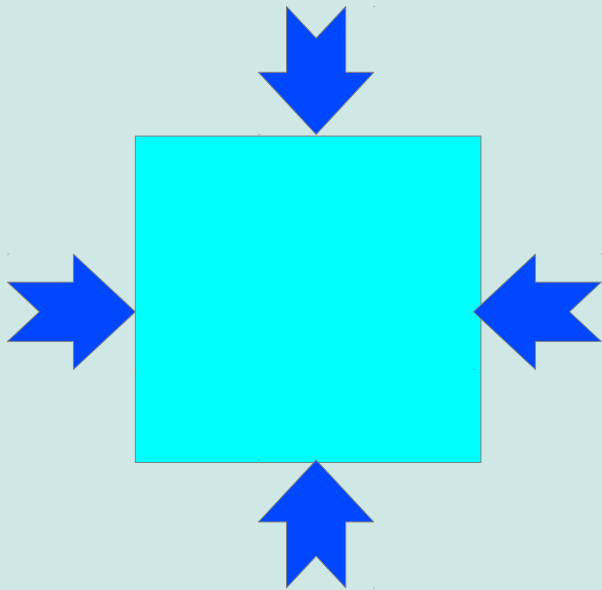
Nest Move



- Nest initialization
 - Fill nest with data from parent.
- Nest move
 - Fill leading edge with data from parent.

Nesting: When?

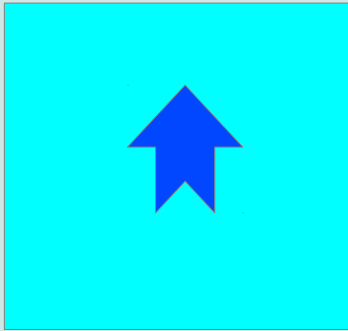
Nest Move



- Nest initialization
 - Fill nest with data from parent.
- Nest move
 - Fill leading edge with data from parent.
- Boundary forcing
 - Nest boundary updated from parent data.

Nesting: When?

Nest Move



- Upscale feedback.
 - Nest data copied to parent every parent timestep.

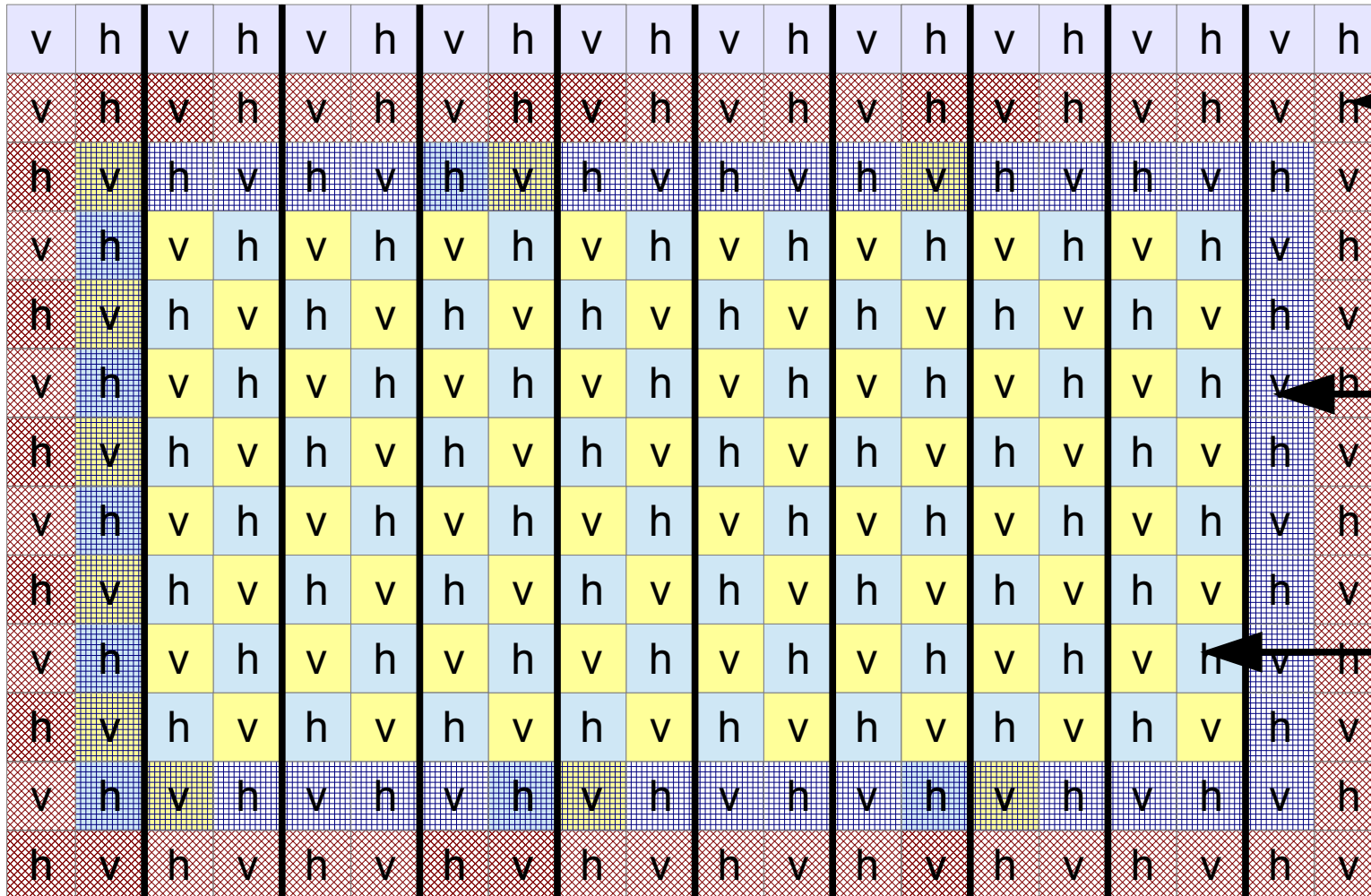
Horizontal Grid

Semistaggered Arakawa E Grid

v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h
v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h
h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v
v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h
h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v
v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h
h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v
v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h
h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v
v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h
h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v

Boundary Conditions

Semistaggered Arakawa E Grid



Prognostic variables

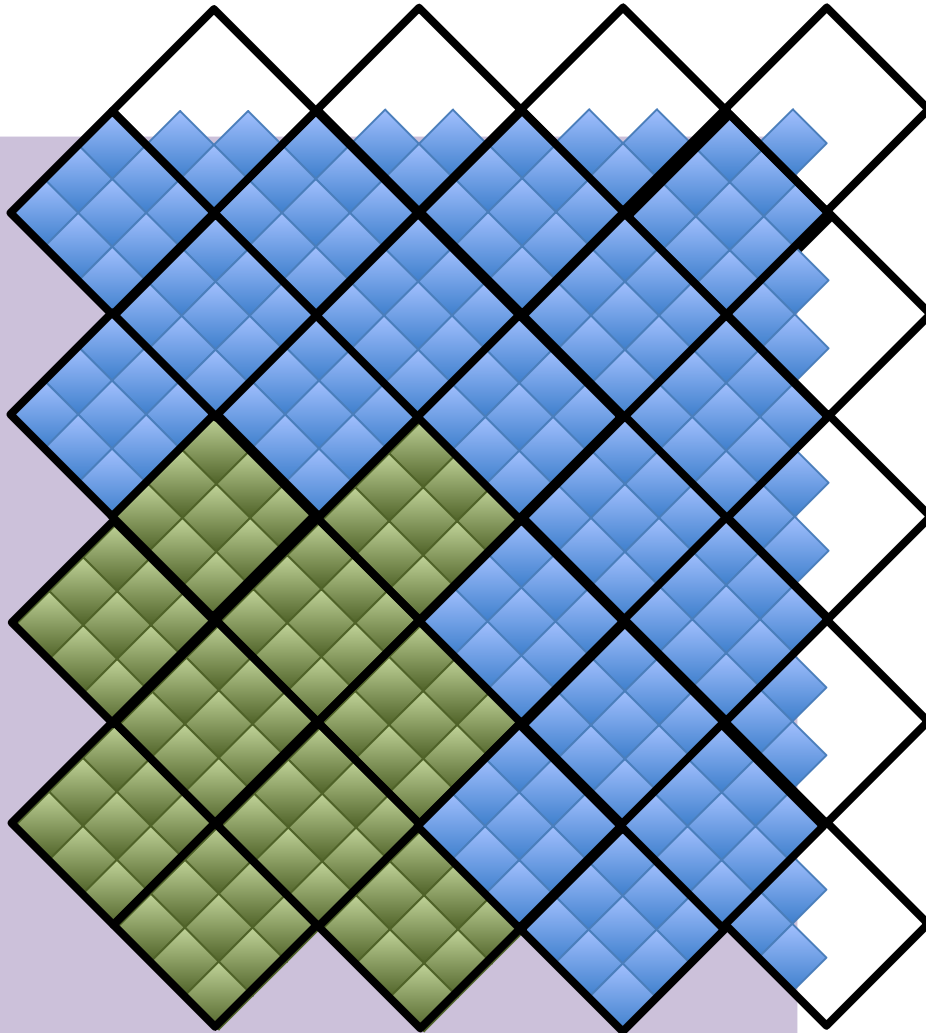
- Mass variables

- π_D : Hydrostatic Pressure depth (Psfc-ptsgm)
 - Pa
- T: Temperature - K
- Q: Specific Humidity - kg/Kg
- CWM: Total cloud water mixing ratio (Qc+Qr+Qi)
 - Kg/Kg
- Q2: 2 * turbulent kinetic energy - m²/sec²
(not in HWRF)

- Wind variables

- U,V : zonal and meridional wind components
 - m/sec

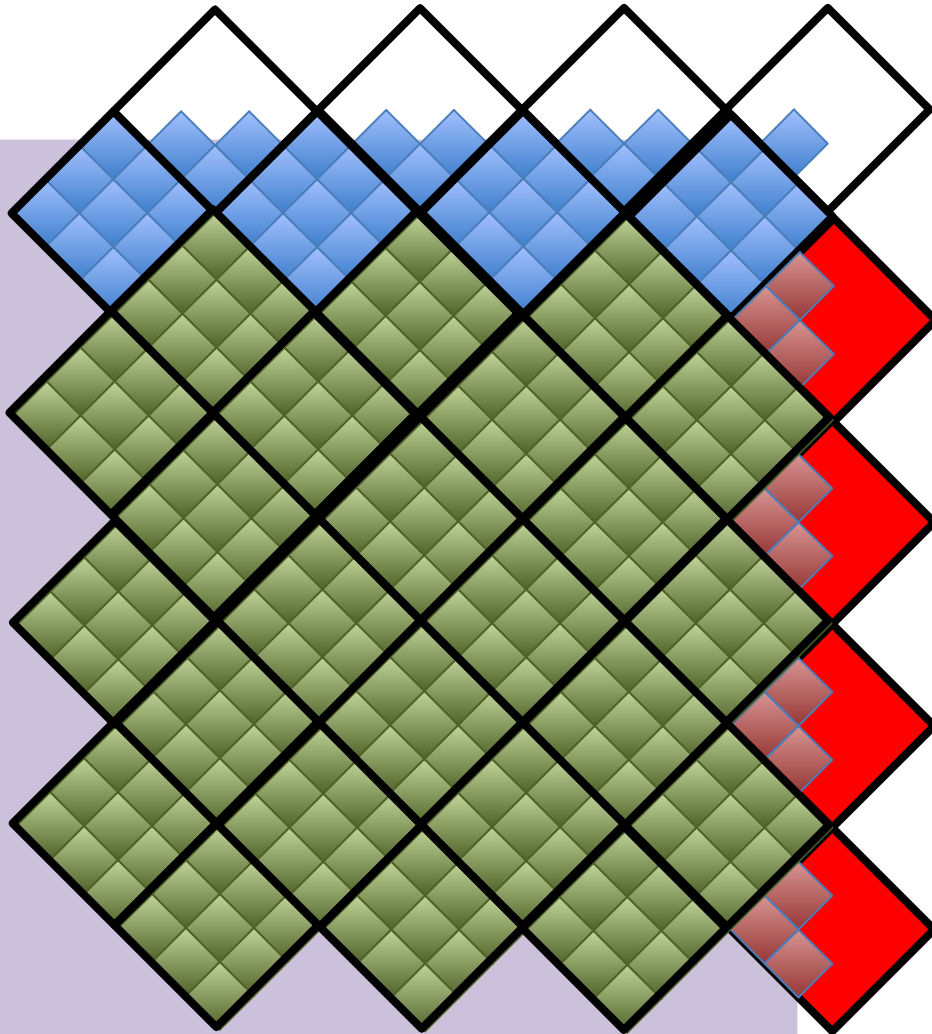
Upscale Feedback



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

Domain Discontinuities

Old (2012) Buggy Upscale Feedback

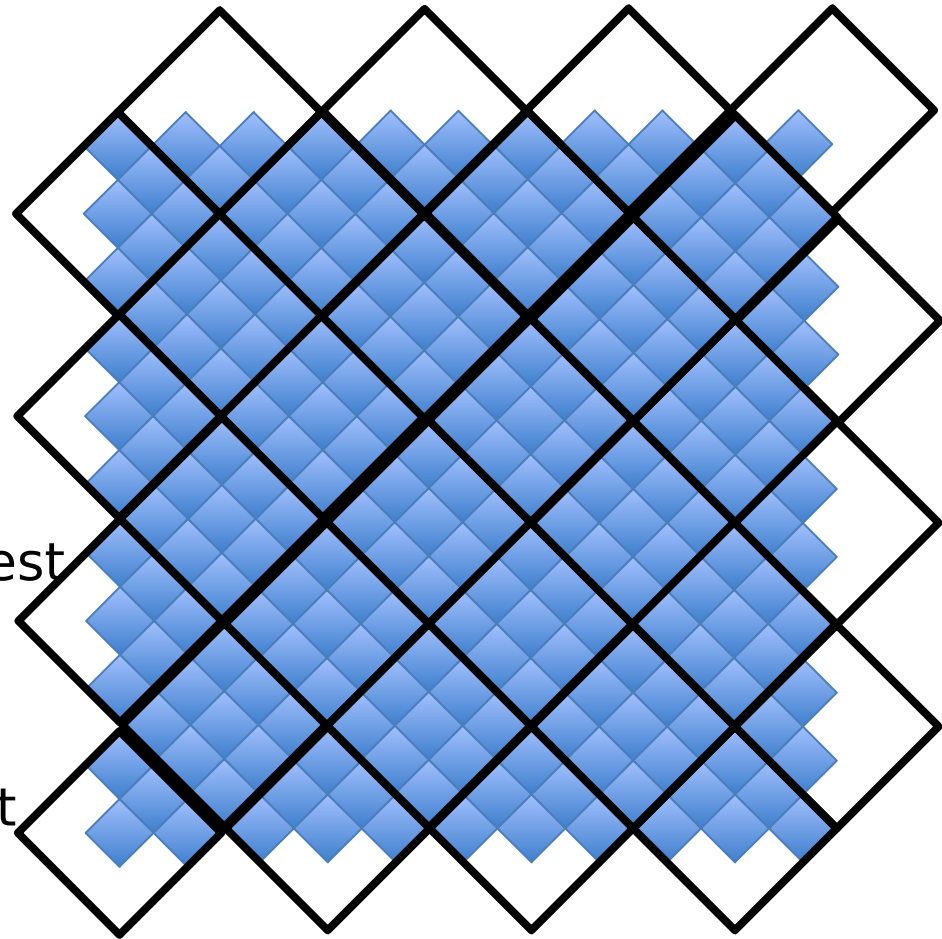


- 2012 HWRF
- East boundary bug:
 - Feedback into parent gridpoints that only partially contain nest gridpoints
 - Bug only for velocities.
 - Caused numerical stability issues

Domain Discontinuities

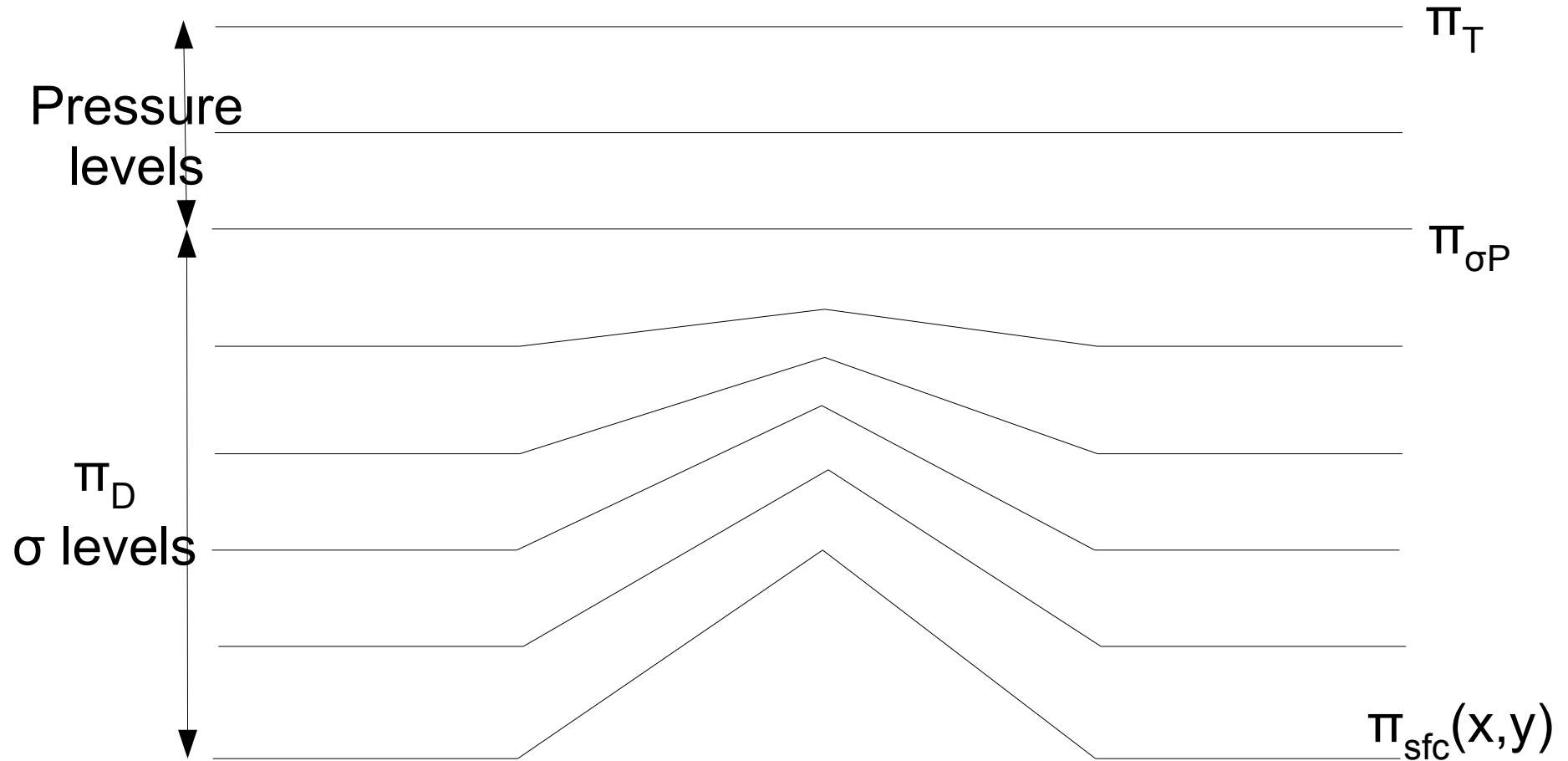
Diamond Gridpoints, Rectangular Grid

- 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



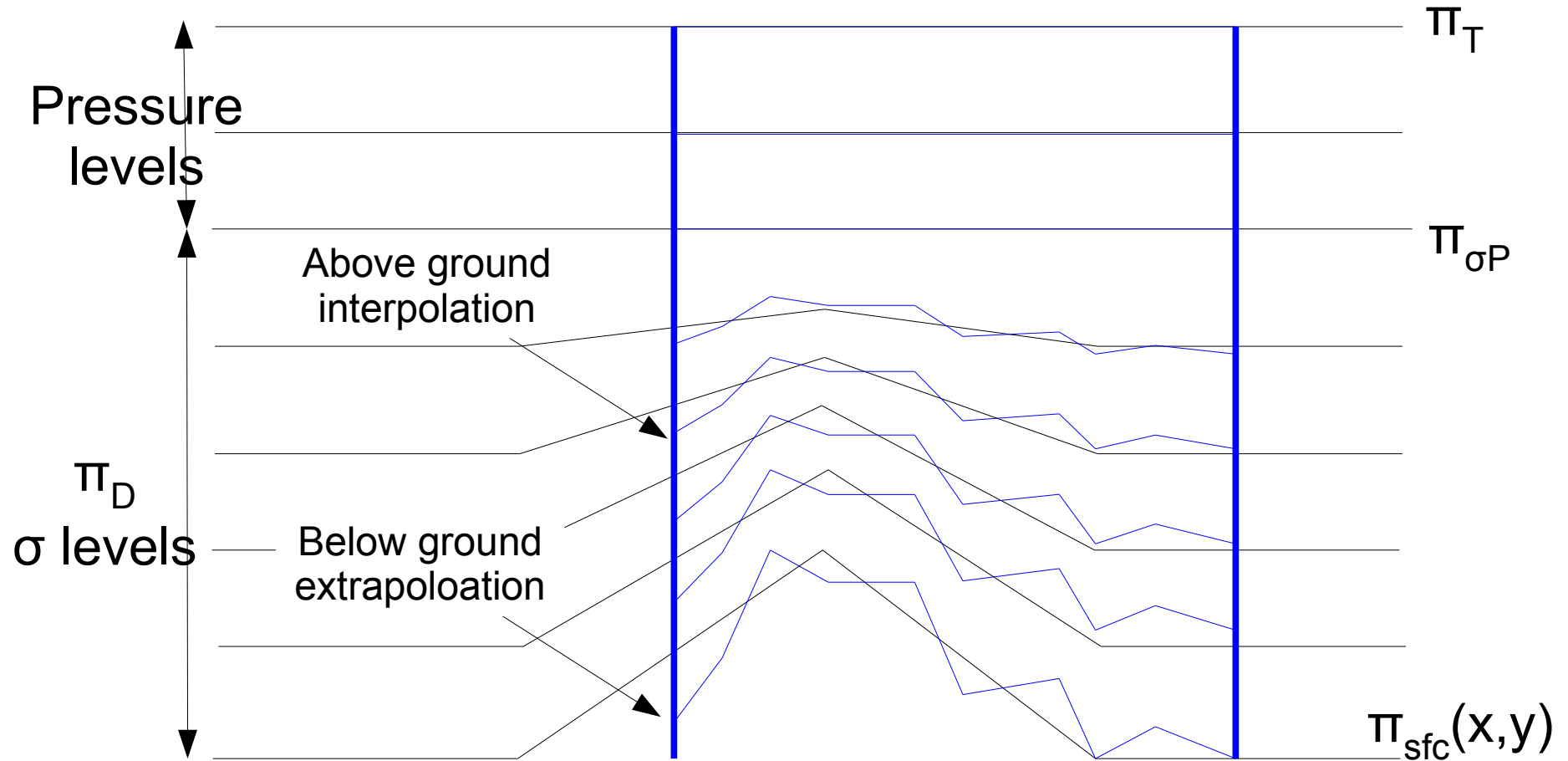
Vertical Structure

Hybrid Sigma/Pressure



Vertical Structure

Hybrid Sigma/Pressure



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  i j k b    dyn_nmm 1 v i01rh02u=(UpVel) d=(DownVel) f=(BdyVel)
```

```
state real  v  i j k b    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  i j k f b t 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
```

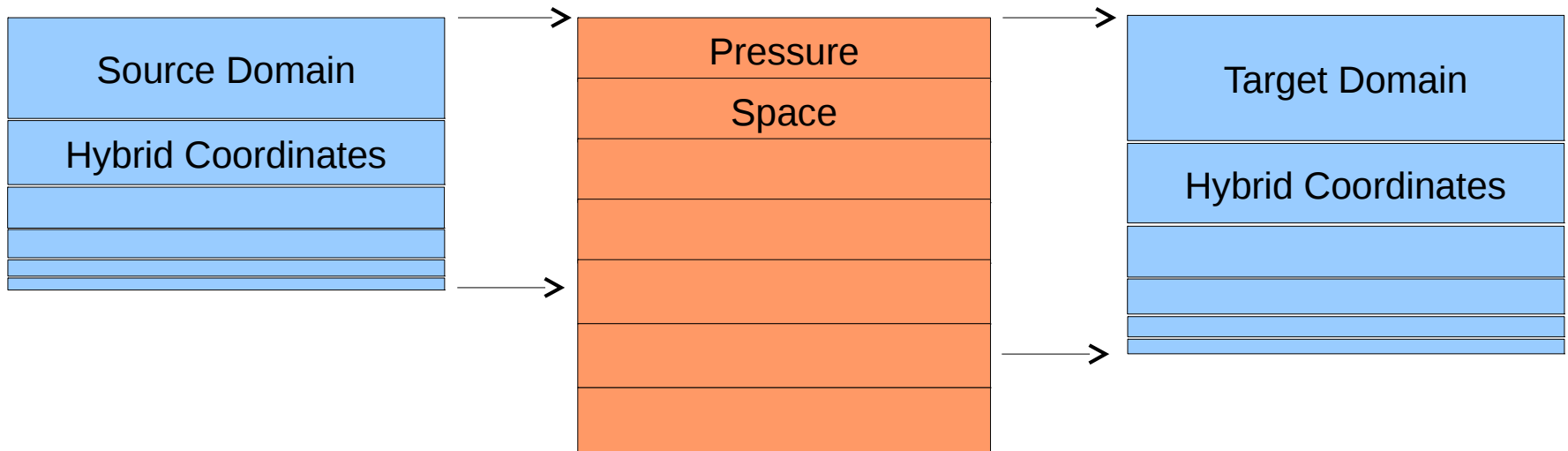
```
@EConst,5.5 = extrapolate using constant 5.5 below ground
```

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

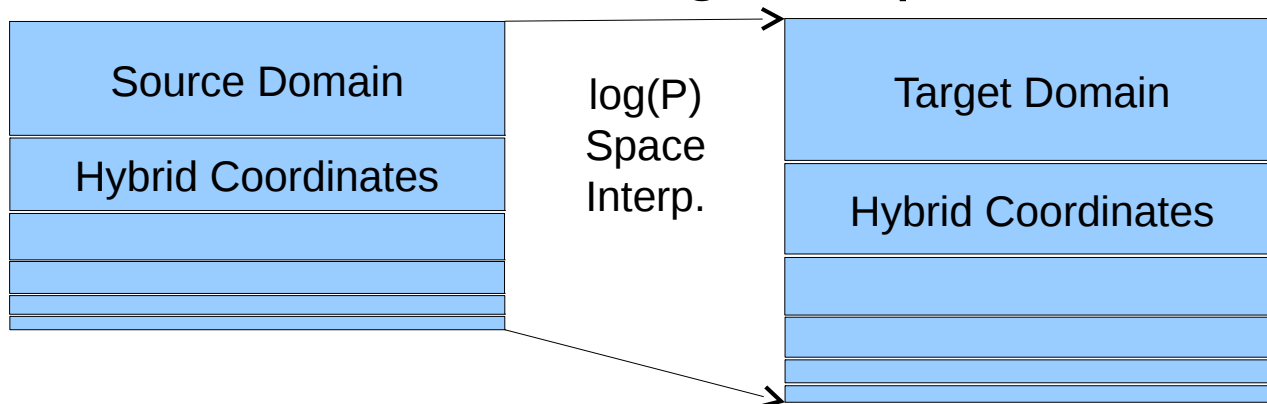

Different Terrain Heights

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

Microphysics

MOIST/SCALAR/F*/CWM

- Mass densities kg/kg: QC, QV, ...
- Number densities: QNI, QNR, ...
- Total condensate: CWM
- Two types of schemes:
 - Non-advected: CWM prognostic
 - Advected: CWM diagnostic

Vortex Tracking Nests

Overview

- Older methods:
 - MSLP or PDYN
 - Mass Centroid
- Current method:
 - d03: Parallelized version of post-processing GFDL vortex tracker.
 - d02: Follow d03.

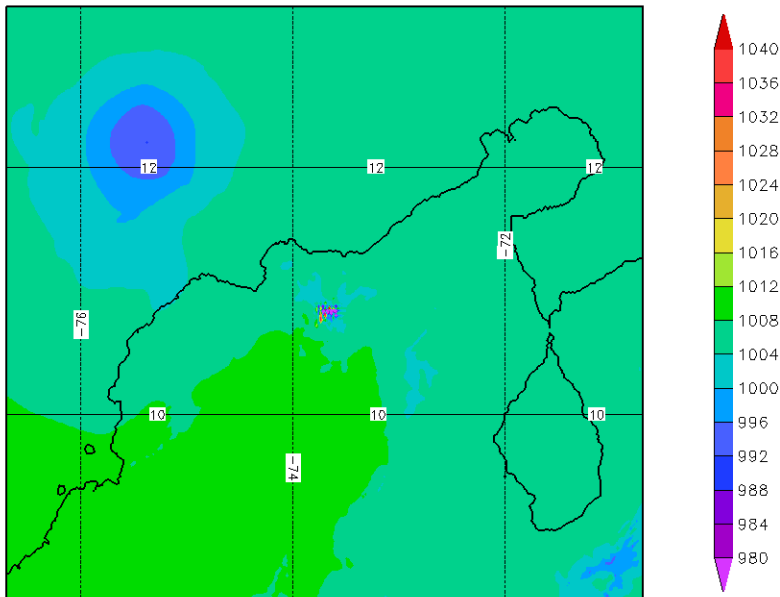
Vortex Tracking Nests

Older Methods

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

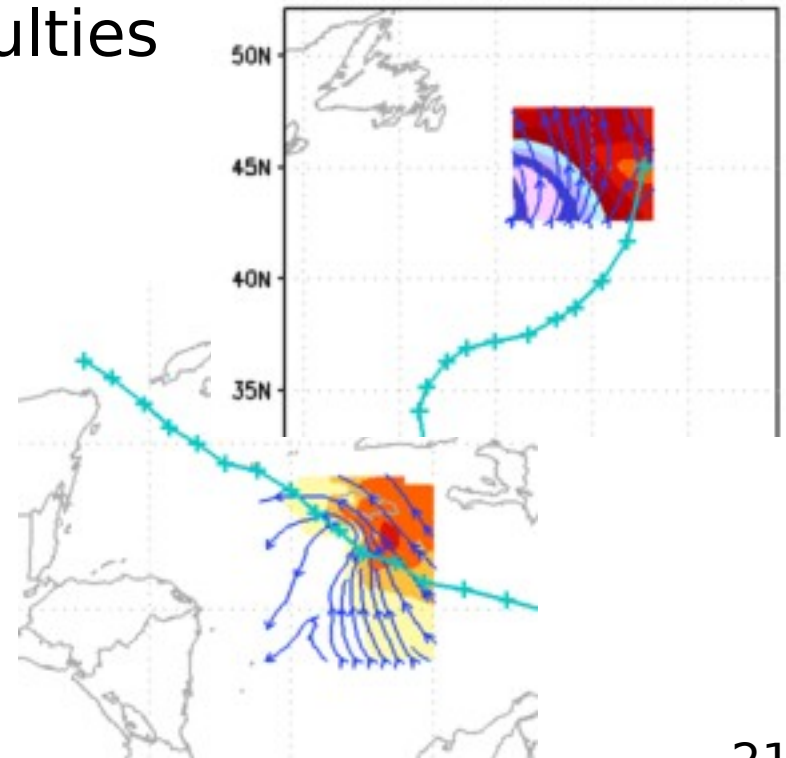
Experimental Product

Mean Sea Level Pressure [mb] for 53hr



Initial date: 2011102412

2010091712: 102 (h) fscf. Valid at 20
HWRP MOVING NEST JULIA 12L



Vortex Tracking Nests

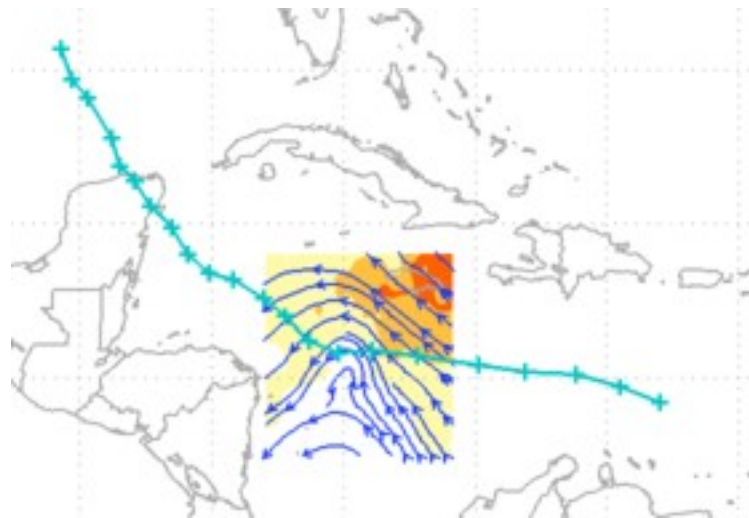
Older Methods

- 6km, 2km domains track the storm
- Where is the storm?
 - MSLP minimum?
 - Dynamic pressure minimum?
 - Maximum surface vorticity vector magnitude?
 - Mass centroid location?
 - ??????

Nest Motion Solution

Nine Field Tracker

- MSLP or vorticity alone is not enough
- New method is nearly 100% successful
 - Note: 2014 upgrade fixed problems with fast storms & most small storms
 - Rare problems with extremely small, extremely strong storms.



Vortex Tracking Nests

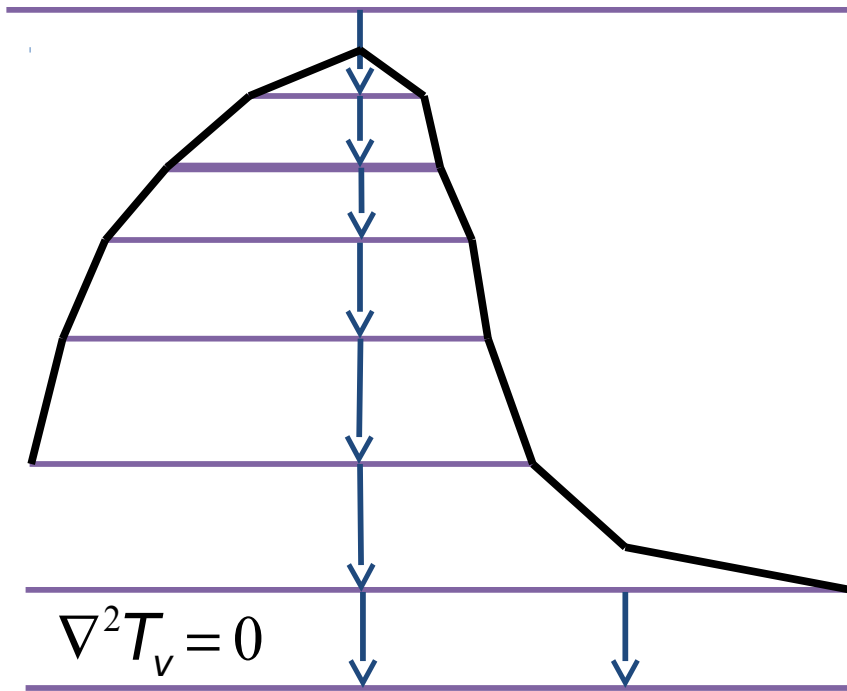
New Method

- 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
- 2014 upgrades improved smoothing.

Vortex Tracking Nests

Membrane MSLP

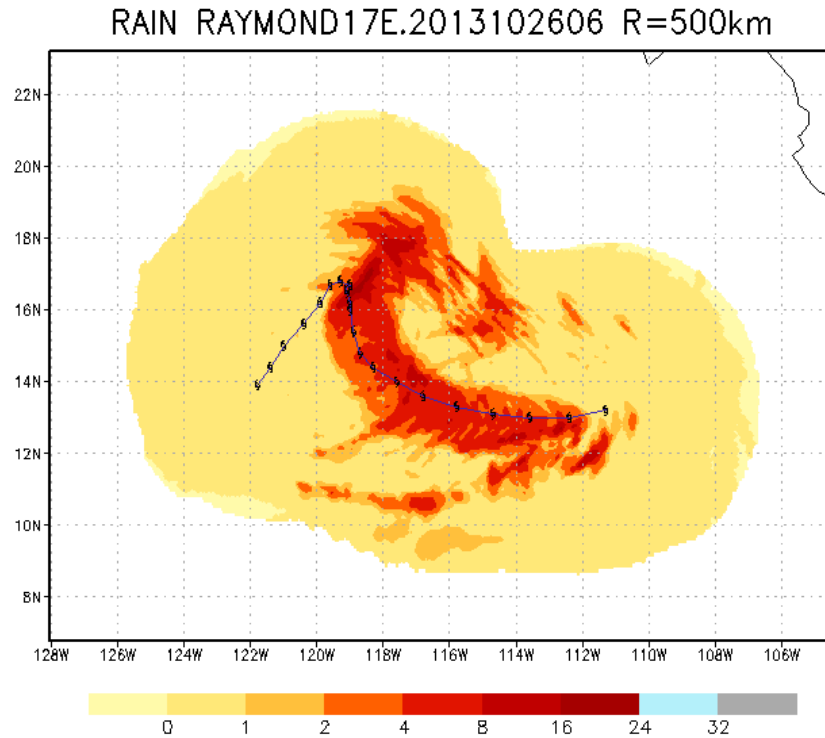
$$dP = -\rho g dz$$



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

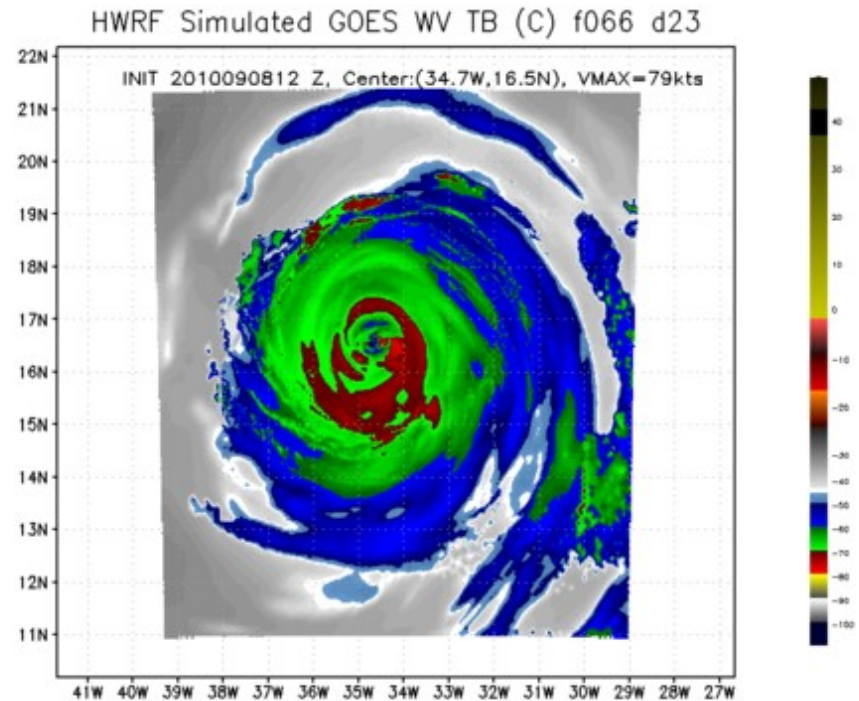
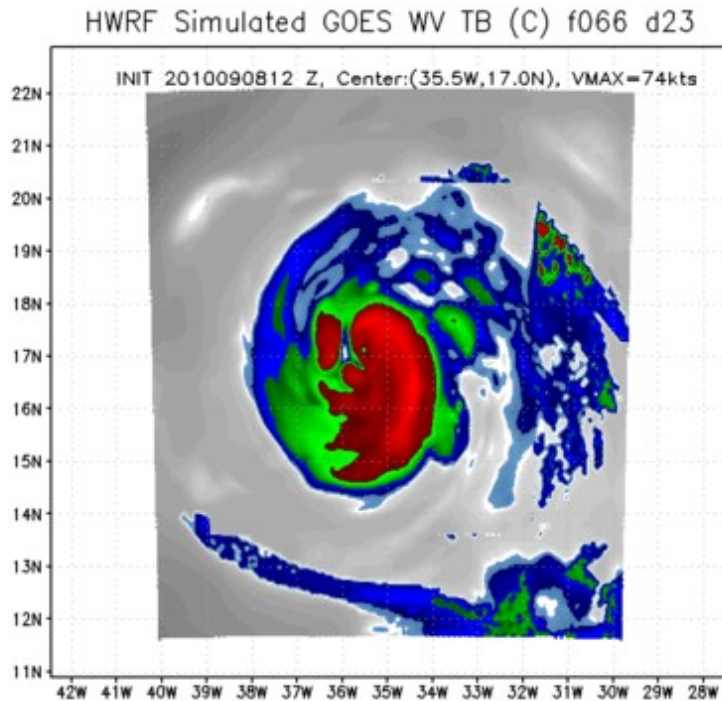
Diagnostic Products

Rain and Wind Swath



Diagnostic Products

Synthetic Satellite



- Convection scheme in 27km, 9km domain, but not 3km.
- Post includes convective rain when calculating synth. sat.
- Result: discontinuities in satellite products.
- Fix: don't use convection rain in satellite products.

Diagnostic Products

Synthetic Satellite

- Other Products:
 - High-frequency Tropical Cyclone Forecast (HTCF)
 - Per-timestep track, MSLP min., wind max.
 - Track
 - dbZ

