HWRF Nesting

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HWRF Tutorial, 26-29 April 2011, Boulder, CO

Acknowledgement

- **John Michalakes (MMM, NCAR)**
- **Robert Tuleya (GFDL/EMC) and Morris Bender (GFDL)**
- **Dusan Jovic, Zavisa Janjic, Thomas Black (EMC)**
- **Vijay Talapragada and Samual Trahan(HWRF team at EMC)**
- **Kao-San Yeh (CIMAS, University of Miami)**
- **Thiago Quirino (AOML/HRD)**
- **Frank Marks (AOML/HRD) and Robert Atlas (AOML)**
- **HFIP & DTC**

HWRF Grid Configuration

- Horizontal: Rotated Latitude-Longitude E-Grid
- Vertical: σ-p hybrid
- Nesting
  - Coincident grid points at start and end points
  - Fixed nest ratio: 1:3
  - Moving one grid each time

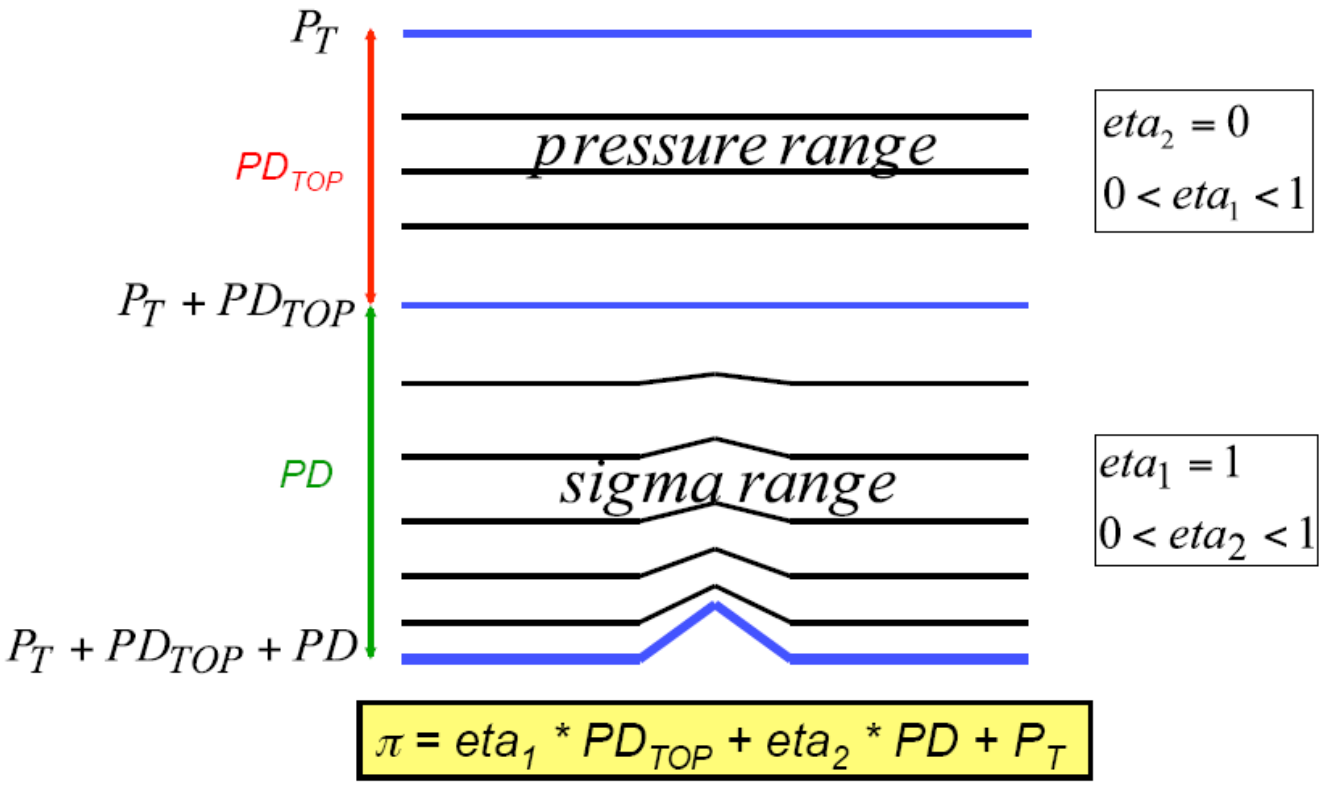
Rotated latitude-longitude domain

Regular Latitude-Longitude map background

Rotated Latitude-Longitude map background

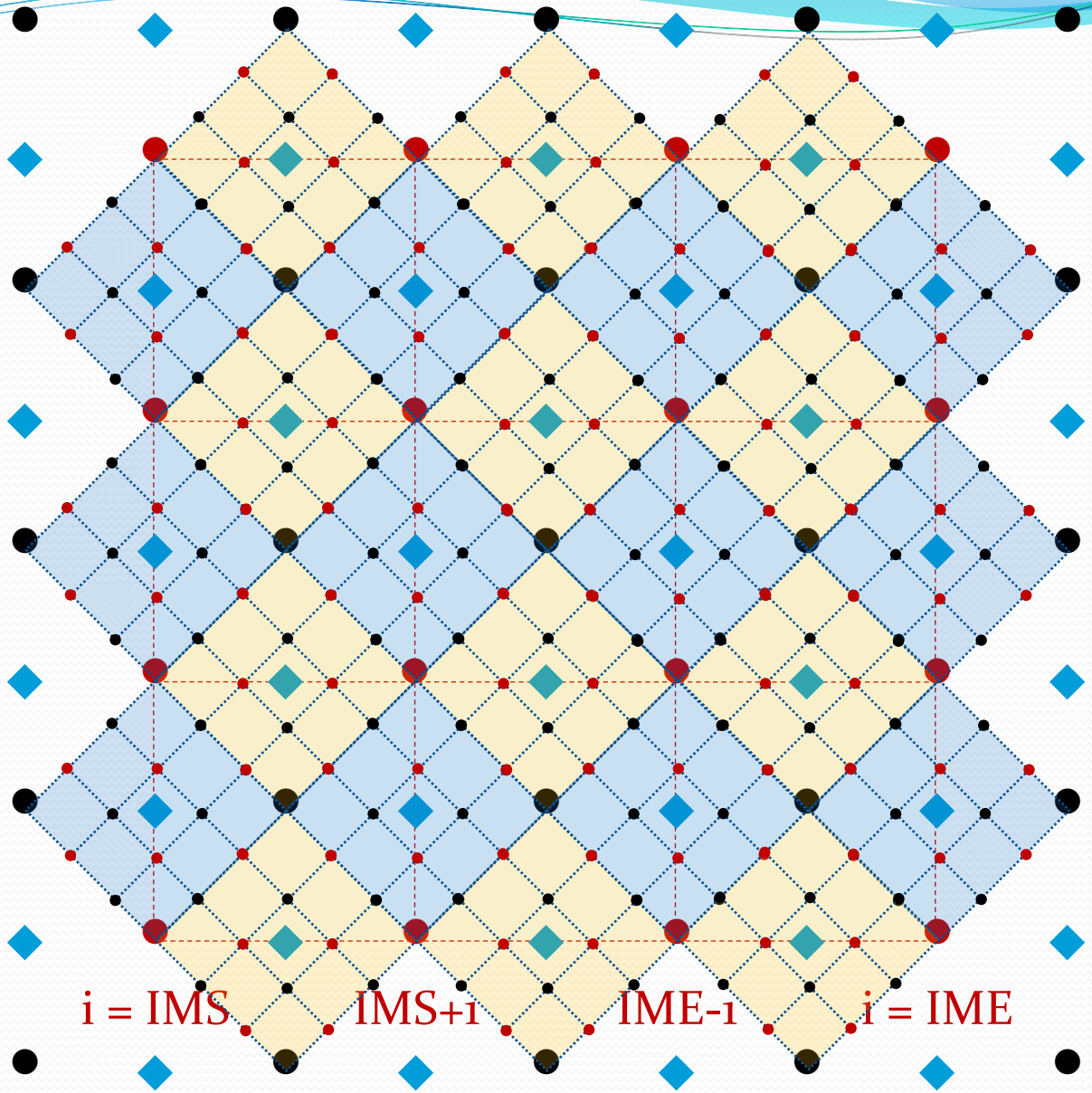
Credit: Zavisa Janjic WRF-NMM Tutorial

Sigma-Pressure Hybrid Coordinate



Credit: Zavisa Janjic WRF-NMM Tutorial

E-GRID Refinement: Mass Grid Points

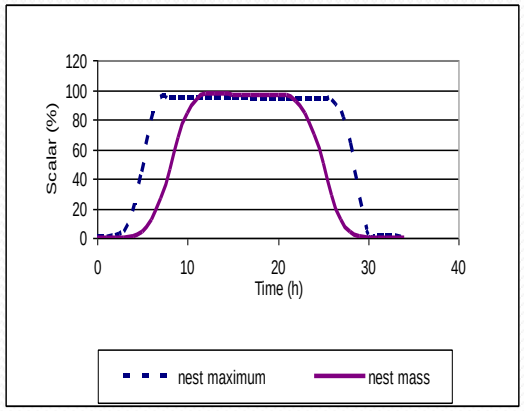


Nesting approach

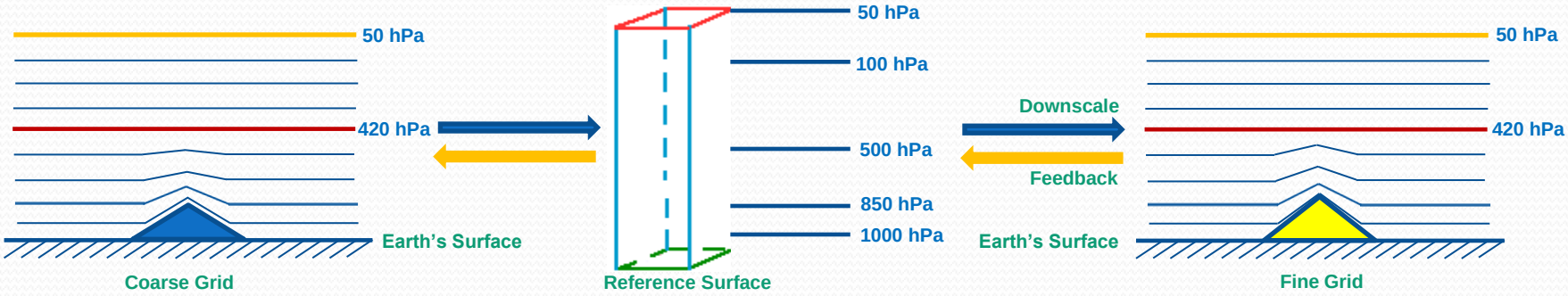
- E-grid indexing
- Nearest Neighbor is along the diagonal
- Interpolations consistent with model dynamics along the diagonal
- Boundary conditions uses square grid volume
- Vertical Mass Adjustment

Salient features: Initial Conditions

- **Bi-linear Interpolation along the horizontal**
- **Nearest neighbor for land state variables except terrain**
- **Simplified land-surface treatment that avoids the need for additional inputs such as the soil temperatures, soil moisture or SSTs over isolated land or water bodies inconsistent with the parent domain**
- **The algorithm sacrifices mass and energy conservation for the sake of smooth solutions across the interface (Zhang et al. 1986; MWR)**
- **For short-term numerical forecasts in which the use of appropriate model physics and the patterns to be forecast may be important than exact mass and energy conservation, as long as the mass (or energy) discrepancy at the interface is small.**



Vertical Mass Adjustment



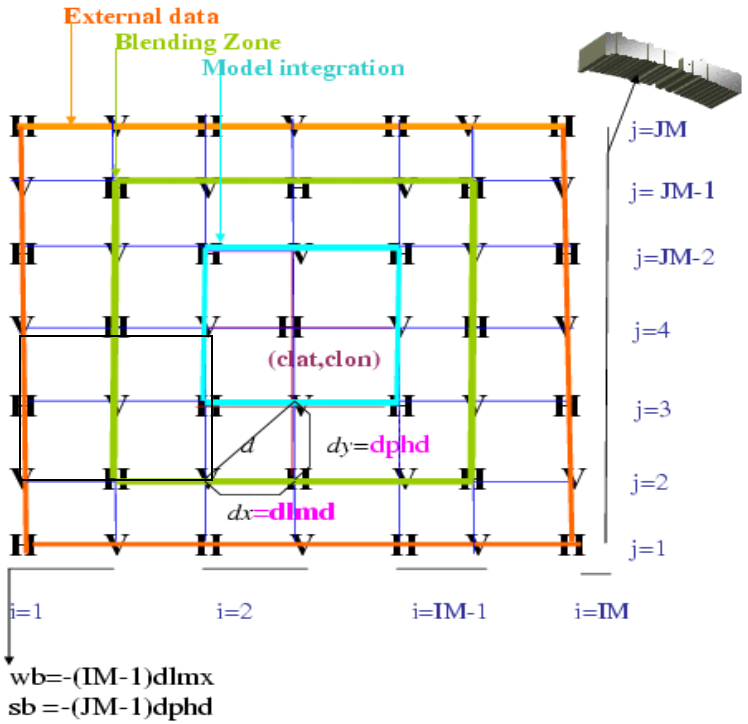
- Pressure NOT directly interpolated from parent hybrid to nested hybrid (sigmas don't match!.)

- The height, temperature and moisture fields from the parent domain are vertically interpolated onto pre-defined standard pressure surfaces.

- The above meteorological fields from the mother domain are further interpolated horizontally onto nested grids on the same pressure surface.

- Finally, by using the high-resolution topography over the nested domain, pseudo hydrostatic mass balancing is carried out to prescribe the initial values in the nested domain.

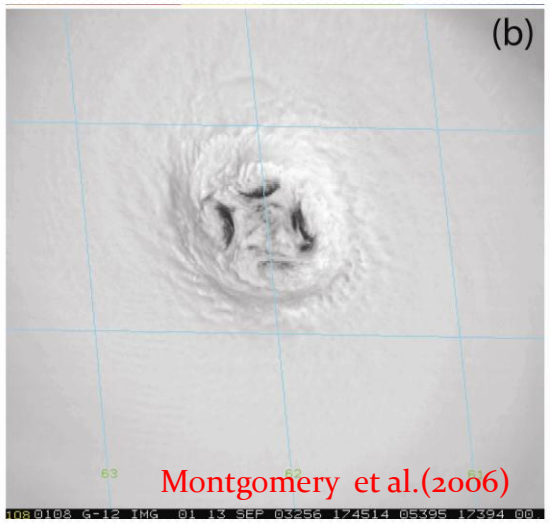
HWRF NESTED BOUNDARY CONDITIONS

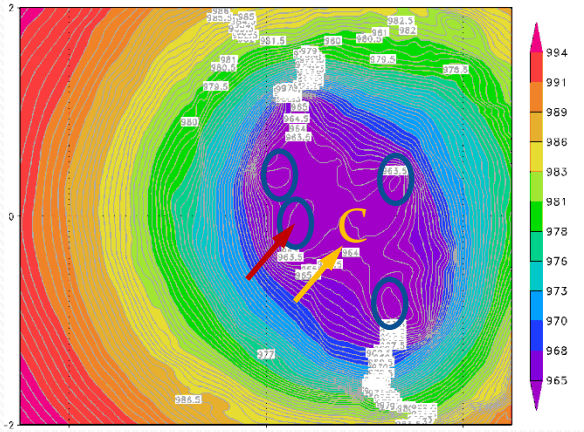


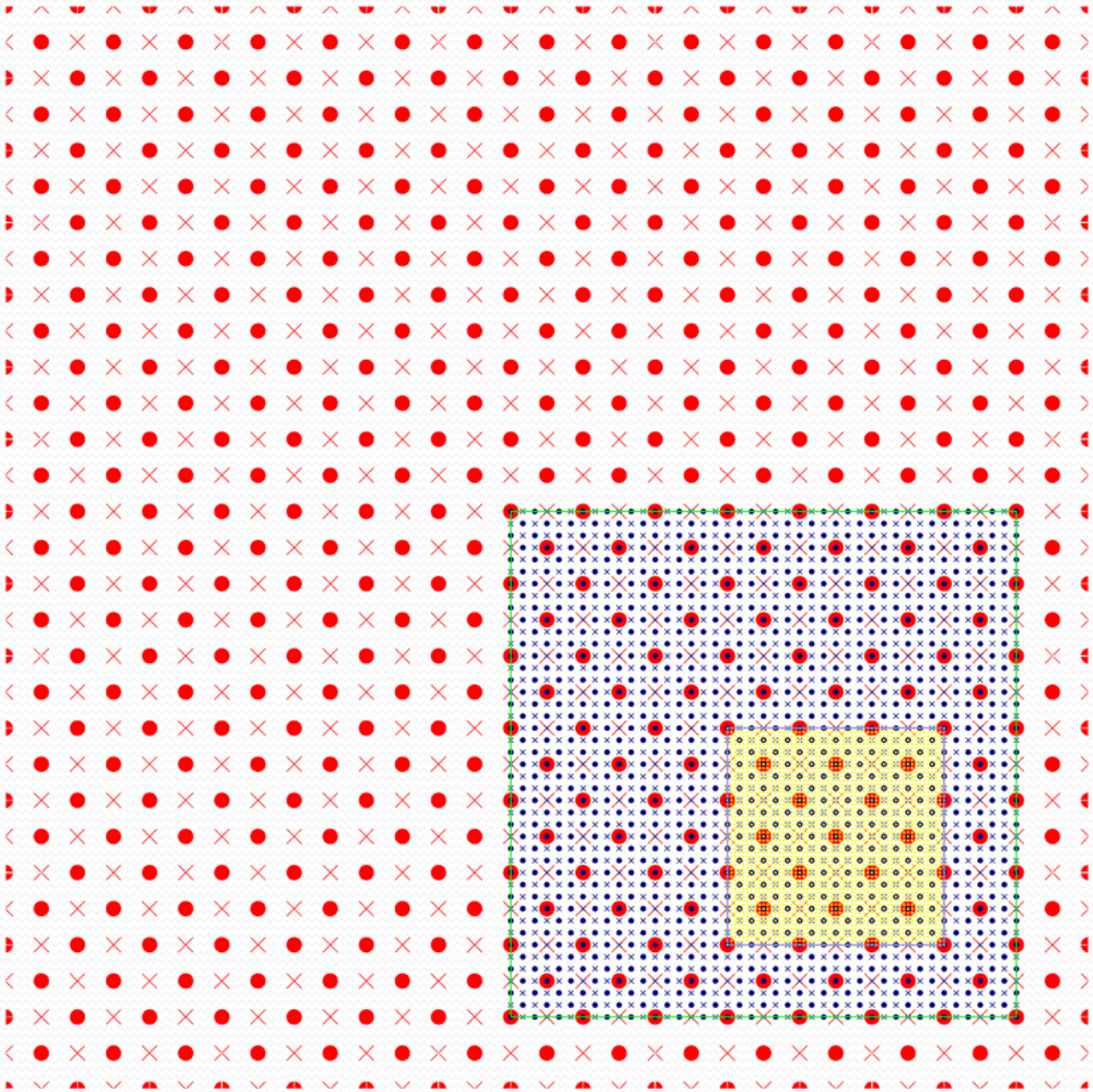
- External Data: Prescribed from the parent after mass adjustment of hydrostatic variables/ direct interpolation of other variables
- Blending Zone: Simple 4 point averaging
- Dynamic Interface: Model integration starts from 3rd row/column

Key Issues

- Moving nest algorithm
  - Mathematical requirements
    - Stable and unique storm center
  - Computational requirements
    - Effective and efficient
  - Solution
    - Centroid MSLP
    - Range limit to start moving (resolution dependent)







Nest movement

HWRF namelist.input: nest specific!

```
&domains
 max_dom                = 2,
 grid_id                = 1,          2,
 parent_id              = 0,          1,

&time_control
 start_year             = 2008,     2008,
 start_month            =   09,       09,
 start_day              =   09,       09,
 start_hour             =   00,       00,
 start_minute           =   00,       00,
 start_second           =   00,       00,
 end_year               = 2008,     2008,
 end_month              =   09,       09,
 end_day                =   09,       09,
 end_hour               =   06,       06,
 end_minute             =   00,       00,
 end_second             =   00,       00,
```

./frame/LOGICAL FUNCTION nests_to_open

```
CALL nl_get_max_dom ( 1, max_dom )

DO nestid = 2, max_dom

 IF ( .NOT. active_domain( nestid ) ) THEN
   CALL nl_get_parent_id ( nestid, parent_id )
    IF ( parent_id .EQ. parent%id ) THEN
      CALL nl_get_start_year (nestid,s_yr)
      CALL nl_get_end_year (nestid,e_yr)
      CALL nl_get_start_month (nestid,s_mm)
      CALL nl_get_end_month (nestid,e_mm)
      CALL nl_get_start_day (nestid,s_dd)
      CALL nl_get_end_day (nestid,e_dd)
      CALL nl_get_start_hour (nestid,s_h)
      CALL nl_get_end_hour (nestid,e_h)
      CALL nl_get_start_minute (nestid,s_m)
      CALL nl_get_end_minute (nestid,e_m)
      CALL nl_get_start_second (nestid,s_s)
      CALL nl_get_end_second (nestid,e_s)

…….
ENDDO
```

Domain configuration for the nest

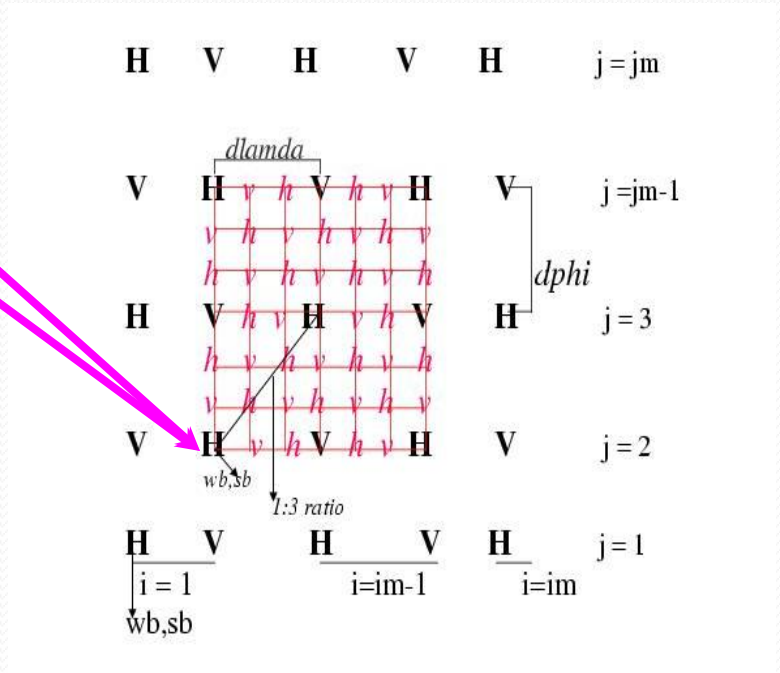
```
&domains
 time_step                  = 54,
 time_step_fract_num   = 0,
 time_step_fract_den    = 1,
 max_dom                    = 2,
 s_we                       = 1,      1,
 e_we                       = 216,   60,
 s_sn                       = 1,      1,
 e_sn                       = 432,  100,
 s_vert                     = 1,      1,
 e_vert                     = 43,    43,
 parent_grid_ratio          = 1,      3,
 parent_time_step_ratio=  1,      3,
 dx                         = .18,  0.06,
 dy                         = .18,  0.06,
```

Dummy for the nested domain

```
./frame/MODULE module_integrate

RECURSIVE SUBROUTINE integrate

DO WHILE ( nests_to_open( grid , nestid , kid ) )

  a_nest_was_opened = .true.

  CALL med_pre_nest_initial  ( grid , nestid ,          &
                               config_flags )

  CALL alloc_and_configure_domain                       &
       ( domain_id = nestid ,  grid = new_nest ,        &
         & parent = grid , & kid = kid )

  CALL Setup_Timekeeping (new_nest)

  CALL med_nest_initial( grid , new_nest ,
config_flags )

 END DO
```

HWRF: ISTART, JSTART AND GRID MOTION

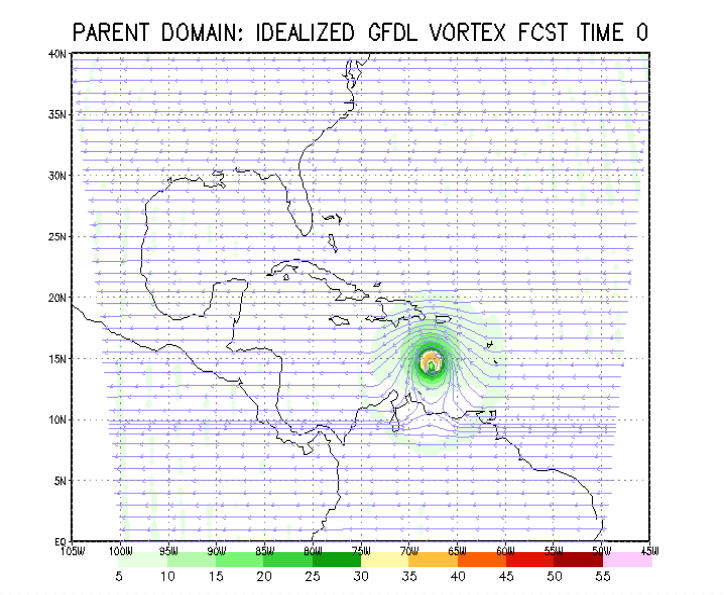
```
&domains
 grid_id                 = 1,     2,
 i_parent_start          = 0,     ISTART1,
 j_parent_start          = 0,     JSTART1,
 num_moves               = -99,
```



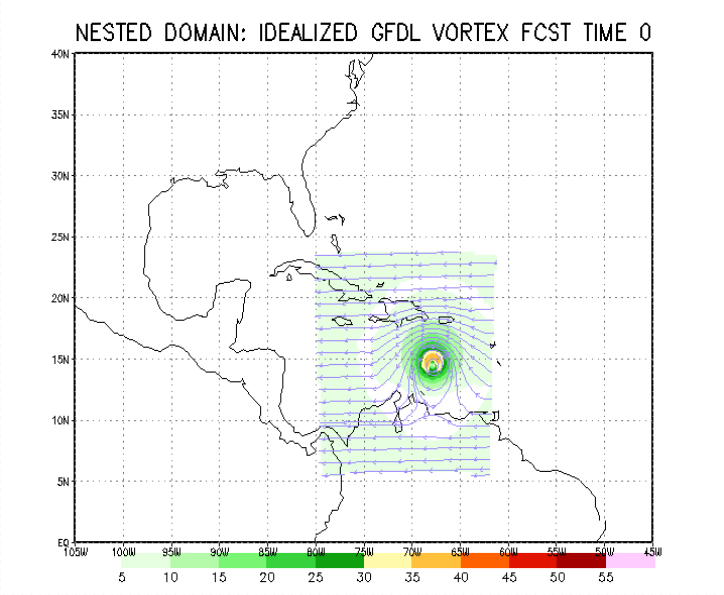
Option for automatic grid motion, specifically for Hurricanes; For locating the initial grid based on storm center, we are providing an utility ../hwrf-utilities/vortex_init/hwrf_set_ijstart/swcorner_dynamic.F. However this code has to be re-compiled independent of the WRF model.

Basic Testing of the Nest Dynamics

Parent domain of the size of about 60° x 60° at 36 km resolution

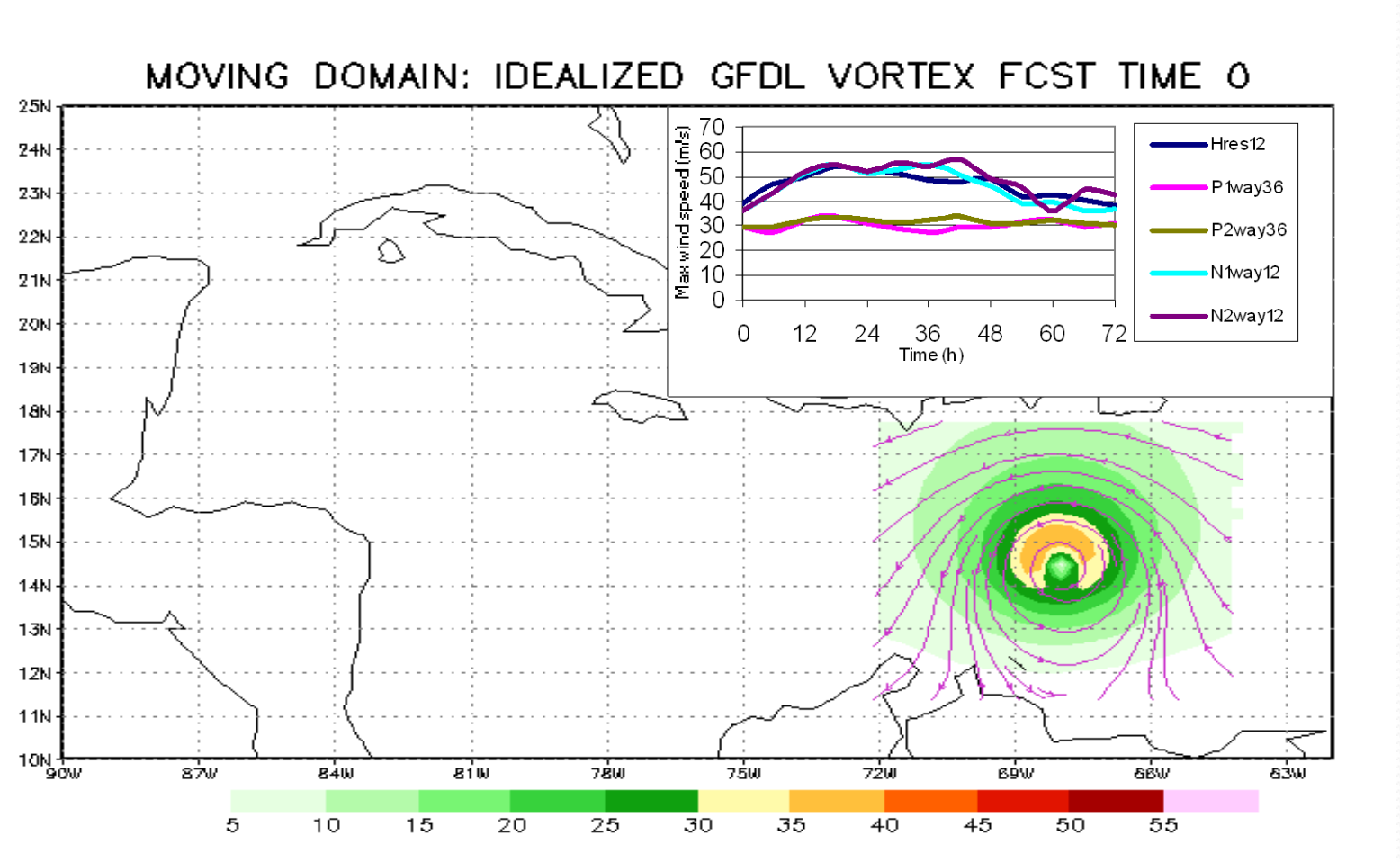


Nested domain of the size of about 20° x 20° at 12 km resolution



The initial condition for this idealized case did not include topography and land, however, as in the case of static, one-way nest the code is general enough to take care of topography.

Moving domain of size of about $7^0 x 7^0$ at about 12 km resolution



Despite the small size of the nested domain, as long as the vortex is located in the center of the nest, we see the effect of lateral boundary diffusion to be limited and we are indeed able to hold on to the intensities!