HWRF Dynamics

Differences between HWRF and WRF-NMM

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HWRF model was developed based upon WRF-NMM dynamic core..

some changes were made in dynamics and physics for hurricanes.

WRF-NMM dynamics (brief)

1. Full compressible equations which split into hydrostatic and nonhydrostatic contributions ($\varepsilon = 1/g\,(dw/dt)$)
2. Horizontal advection: 2nd order Adams-Bashforth
3. Vertical advection: Crank-Nicolson scheme
4. Horizontal grid: Arakawa E-grid
5. Vertical coordinate: sigma-pressure hybrid
6. Horizontal diffusion: 2nd order, nonlinear Smagorinsky-type horizontal diffusion

Prognostic Variables:

► Mass variables:

PD – hydrostatic pressure depth (time and space varying component) (Pa)

- PINT – nonhydrostatic pressure (Pa)
- T – sensible temperature (K)
- Q – specific humidity (kg/kg)
- CWM – total cloud water condensate (kg/kg) for Ferrier Microphysics (others-all hydrometeo species)
- Q2 – 2 * turbulent kinetic energy (m^2/sec^2)– not used in the current HWRF configuration

► Wind variables:

- U, V – wind components (m/s)

Arakawa E grid

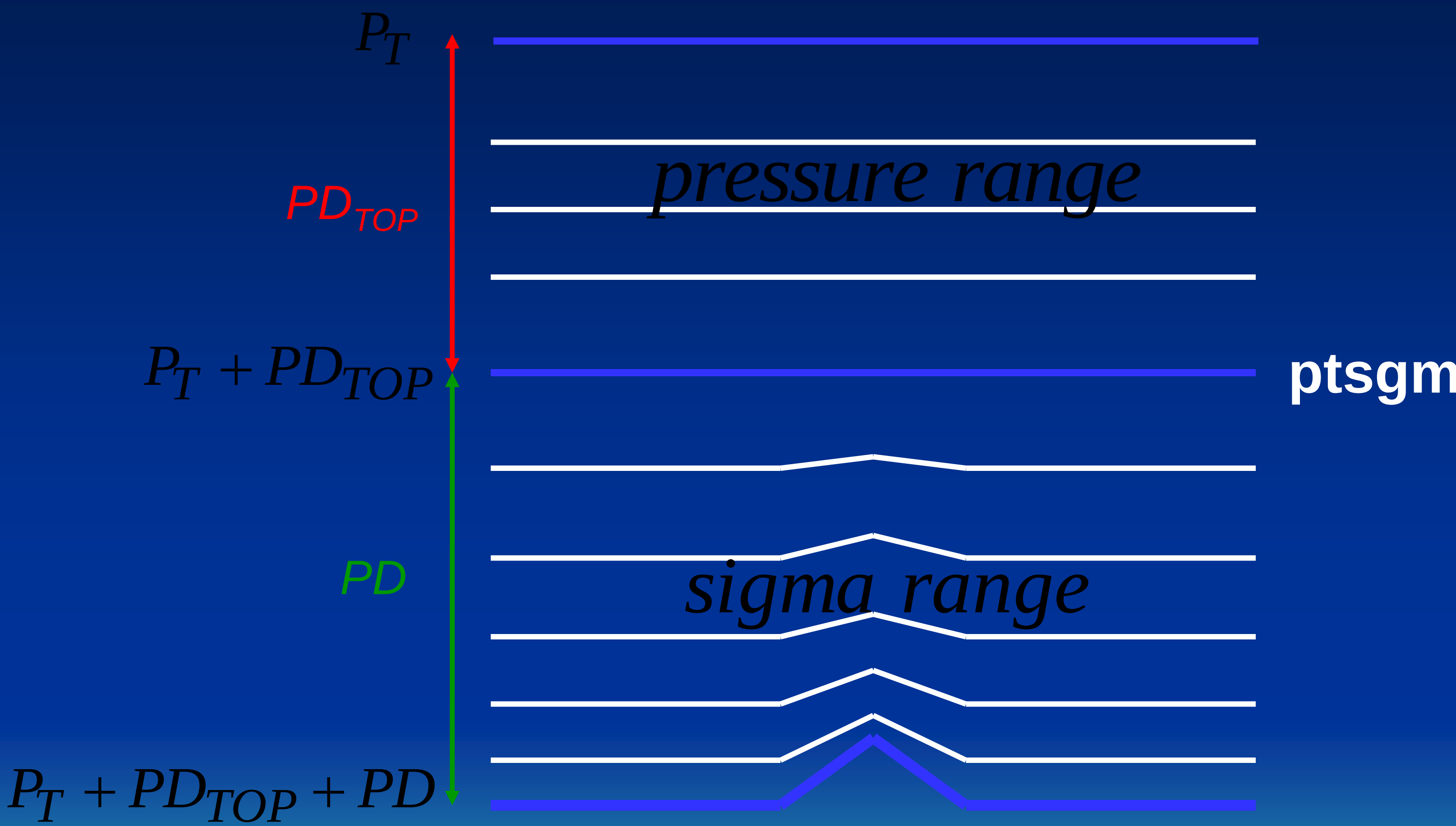
J=5	H	v	H	v	H	v	H	(v)
J=4	v	H	v	H	v	H	v	(H)
J=3	H	v	H	v	H	v	H	(v)
J=2	v	H	v	H	v	H	v	(H)
J=1	H	v	H	v	H	v	H	(v)
	I=1		I=2		I=3		I=4	

H=mass point, v=wind point

red=(1,1) ; blue=(1,2)

Provided by Matt Pyle

Sigma-Pressure Hybrid Coordinate



$$p = eta_1 * PD_{TOP} + eta_2 * PD + P_T$$

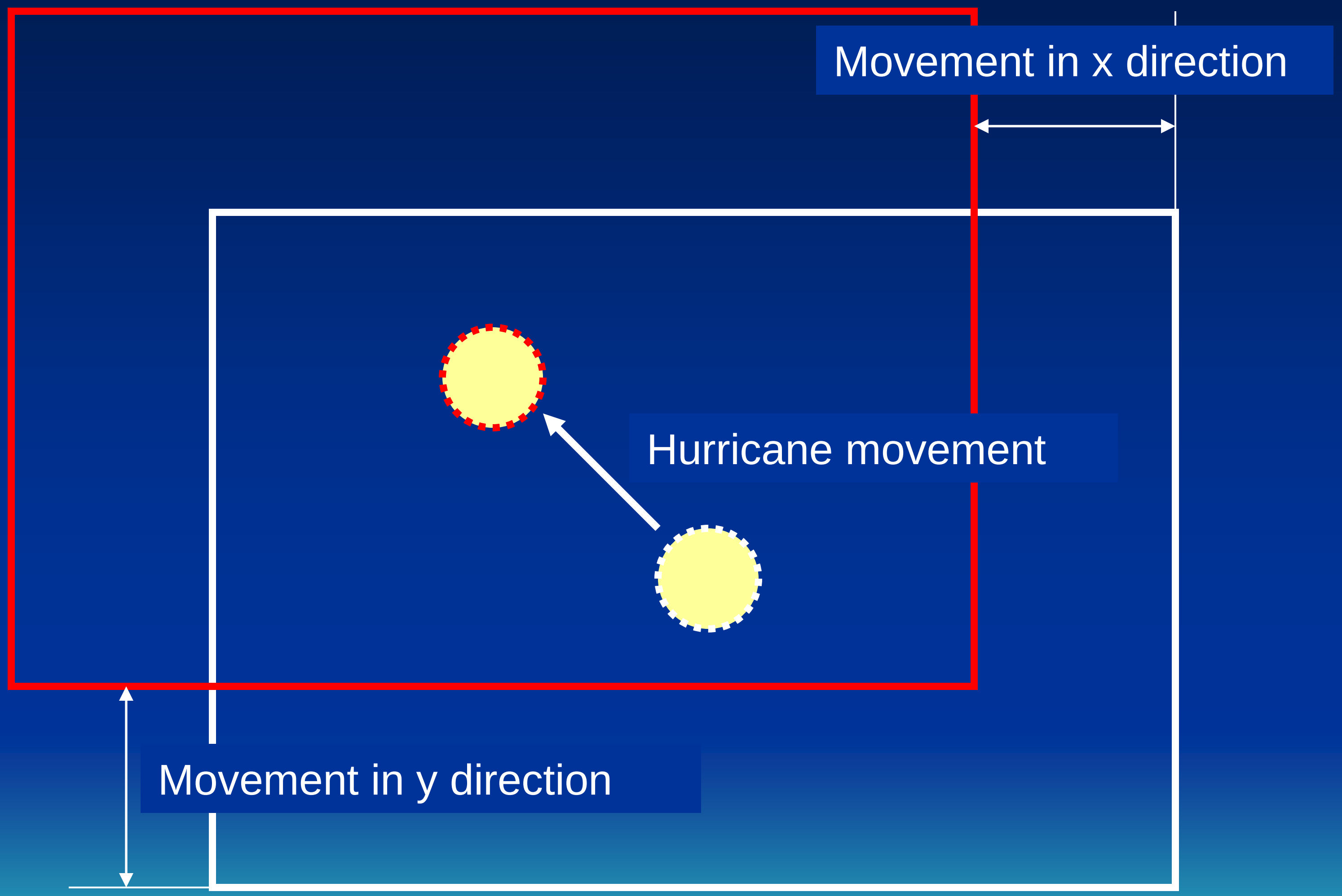
Provided by Matt Pyle

What are the differences in HWRF and WRF-NMM dynamics?

1. Vortex following moving nest
2. Horizontal diffusion related to turbulent kinetic energy
3. Ocean coupler related changes
4. Momentum tendency added by SAS convection scheme

Vortex following moving nest

1. Find the center of a hurricane vortex
2. Determine the movement of a vortex in terms of I and J grid point
3. Shift model prognostic variables to a moved nest domain
4. Assign the static data (terrain, lat, lon) at the moved domain
5. Interpolating the prognostic variables from parent to nest grid point over the leading edge.

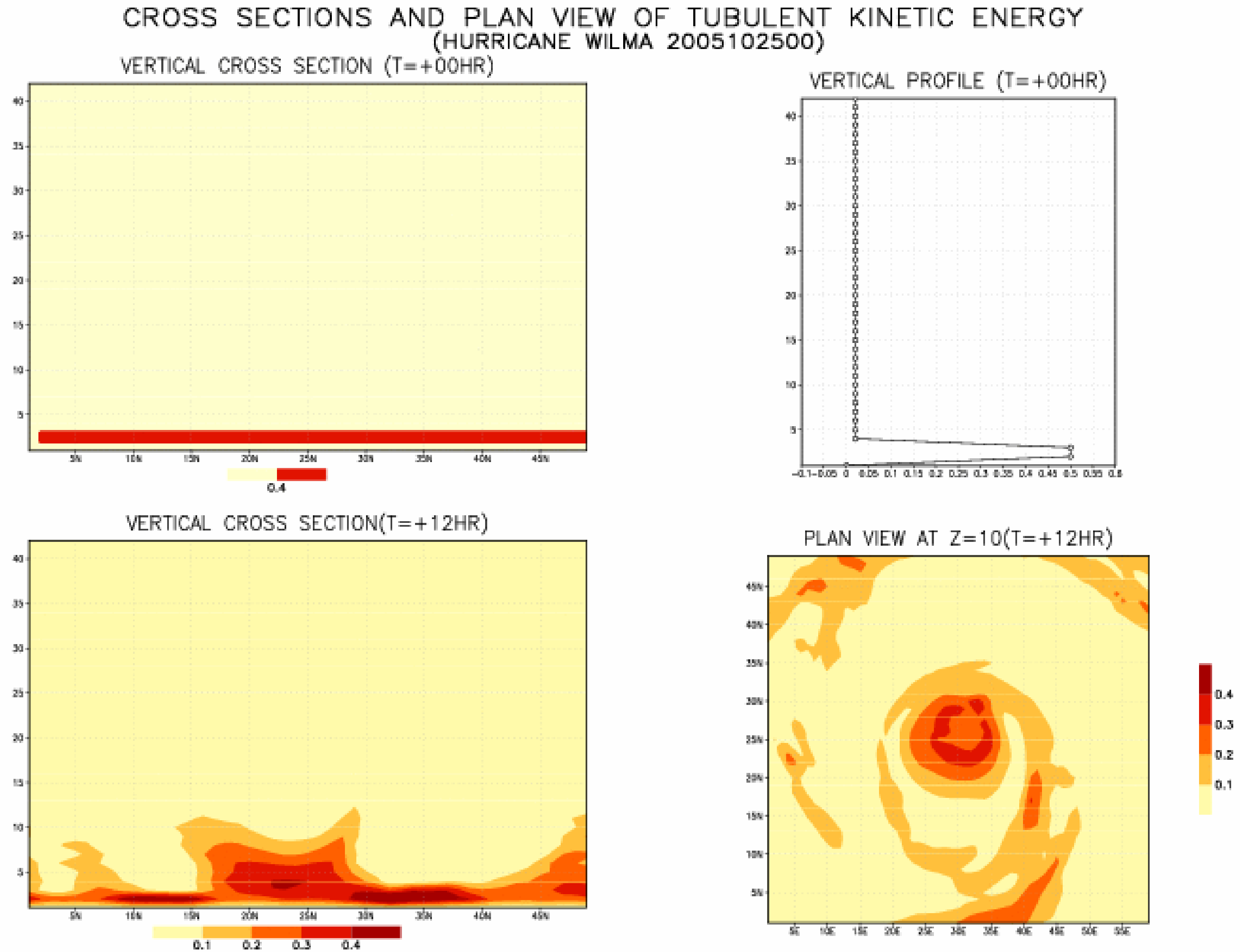

Movement in x direction
Hurricane movement
Movement in y direction

Horizontal Diffusion of HWRF

$$F_D = h\_diff * [2(\frac{\partial u}{\partial x} - \frac{\partial v}{\partial y})^2 + 2(\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y})^2 + 2Cq^2 / 2]^{1/2}$$

deformation **TKE**

TKE is not a prognostic variable in the HWRF (GFS PBL is non-local non-TKE based scheme different from MYJ), so the horizontal diffusion effect from TKE should be zero.



increases the magnitude of horizontal diffusion artificially

Also, HWRF has a namelist variable to control the magnitude of horizontal diffusion.

namelist

&physics

h_diff = 1.0   1.0

Registry

rconfig   real h_diff   namelist,physics   max_domain   1.0   irjh

Changes related to Ocean coupler

► Ocean model needs input data from the atm model.
- Sensible and latent heat fluxes (twbs, qwbs)
- in/out short/long wave radiation(rlwin,rswin,radot,rswout)
- x/y component of surface stress (taux, tauy)
- 3D pressure and precipitation (pint, prec)

In solve_nmm.F

"call ATM_DO_FLUXES"

►Ocean model returns SST value to atm model

In solve_nmm.F

"call ATM_GETSST"

Momentum mixing

- The SAS scheme has a vertical momentum transfer mechanism in addition to moist and heat transfer
- The momentum mixing process has been evolving from explicit assignment of portion of momentum transfer to implicit more dynamically consistent approach.
- This momentum mixing is done in module_cu_sas.F using namelist variable momix