DEVELOPMENT OF MULTIPLE MOVING NESTS IN THE BASIN-SCALE HWRF SYSTEM: DESIGN AND CHALLENGES

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NCEP/EMC TEAM

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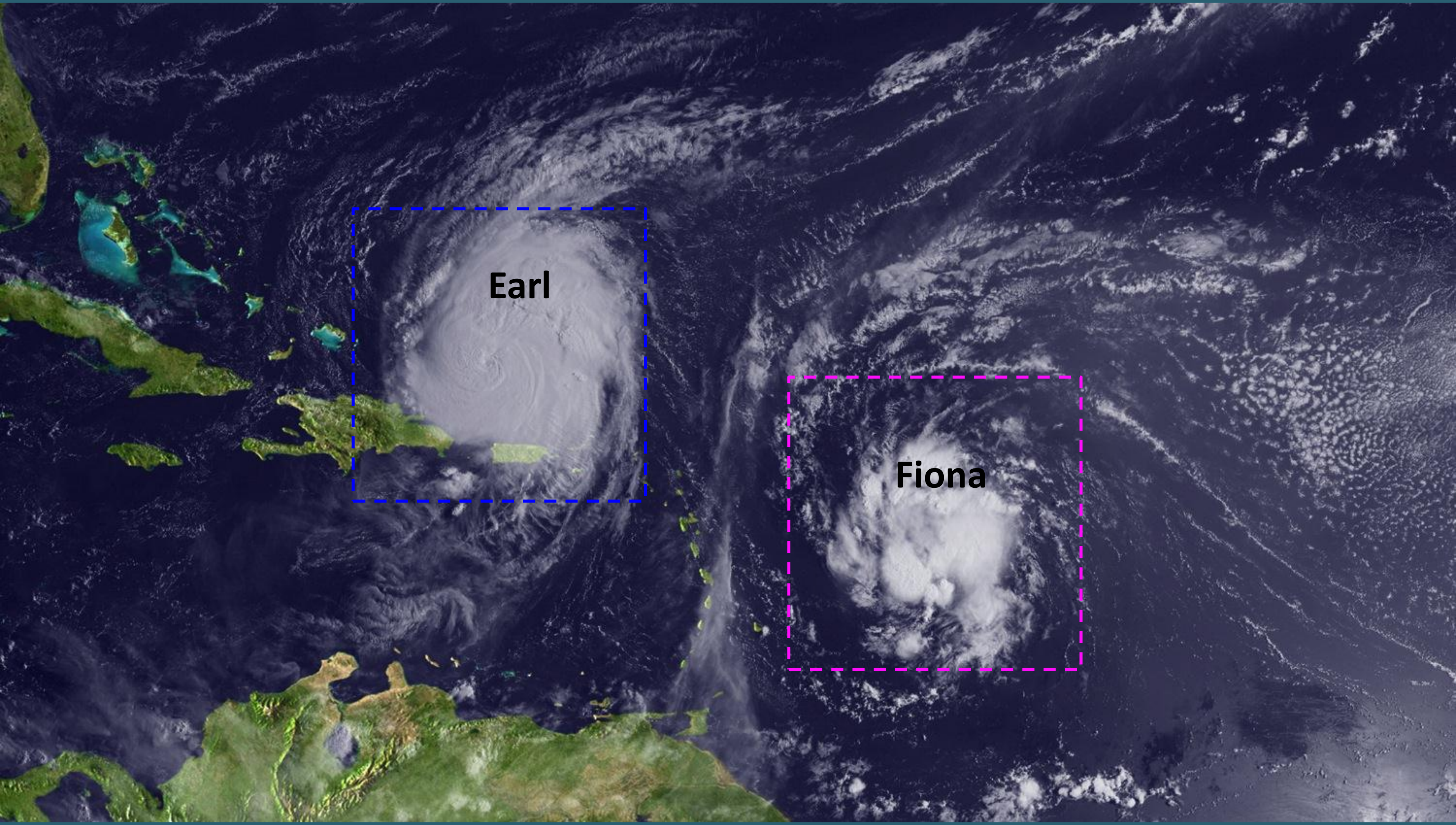
Outline

- Why the basin-scale modeling system for hurricane forecast?
- Design philosophy
- Challenges and Priorities

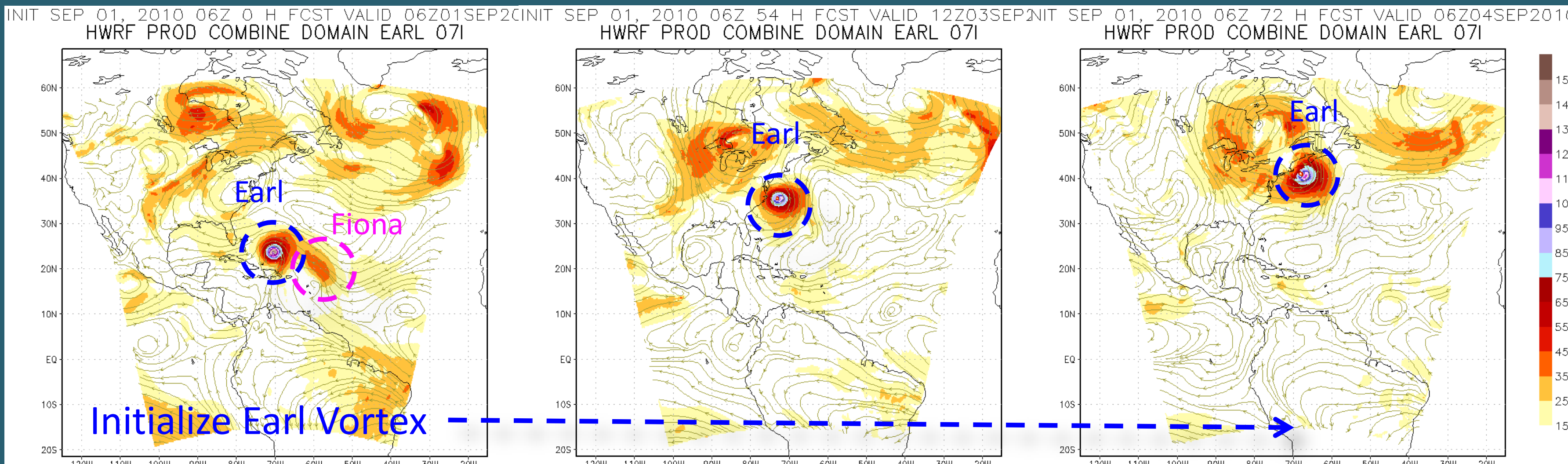
Why?

- Why do we need a basin-scale model system for hurricane forecast?
  - Scientifically
    - Multiple scale interactions
    - Upstream systems and mid-latitude systems
    - Land and topography impact
  - Statistically
  - Forecast needs

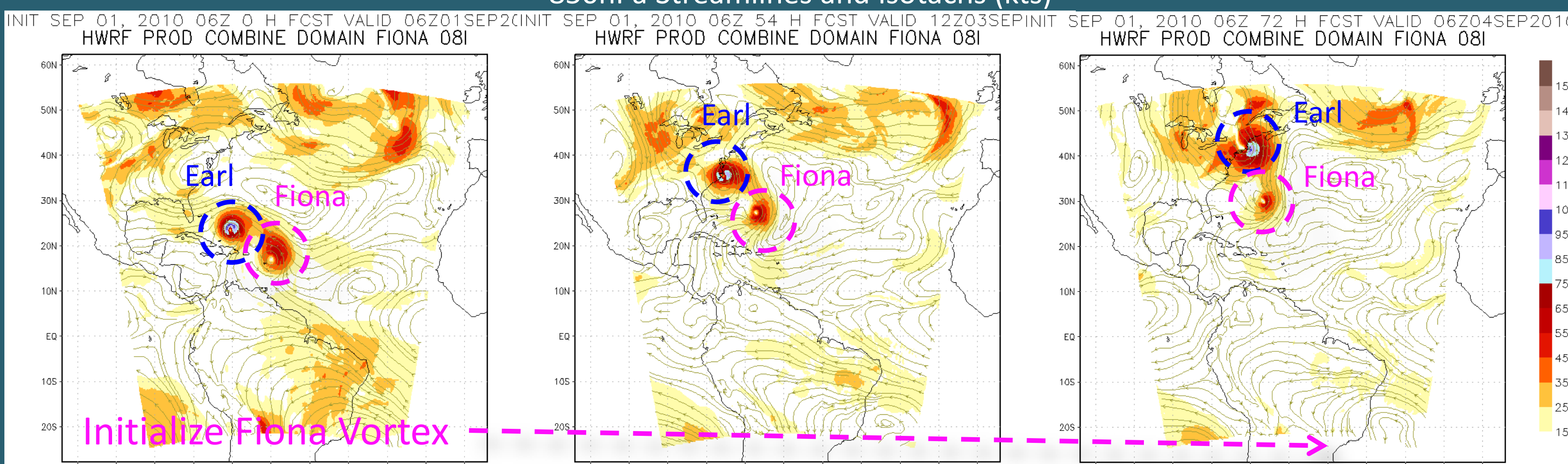
Example



Model Forecast Issue

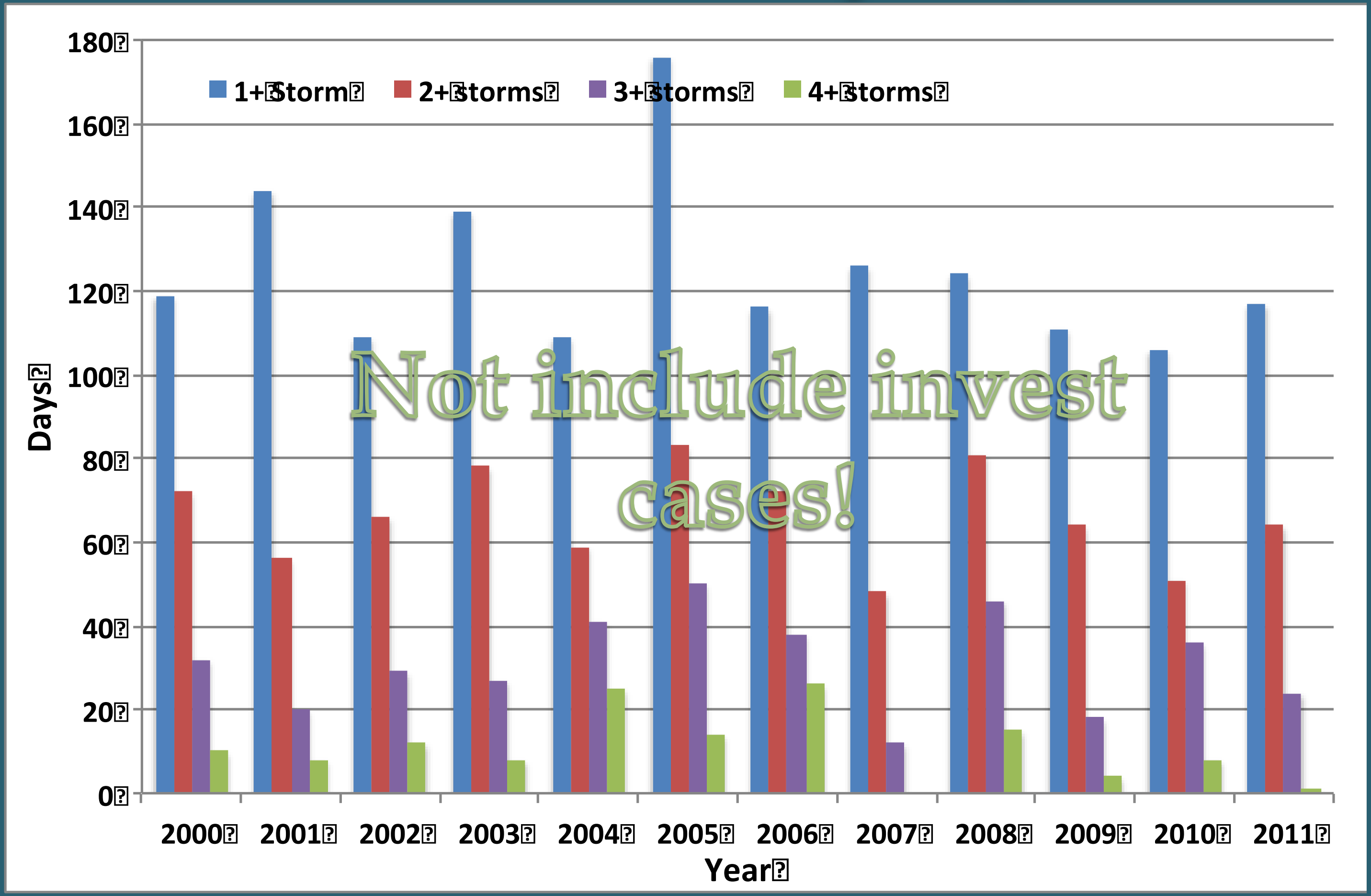


850hPa Streamlines and Isotachs (kts)



http://www.emc.ncep.noaa.gov/gc_wmb/vxt

Annual Storm Days (ATL+EP)



	1+ storm days	2+ storm days	3+ storm days	4+ storm days	Total storm days
ATL	87.4(57.6%)	31.3(35.8%)	9.6(11.1%)	1.4(1.6%)	151.8
EP	77.8(48.0%)	25.5(32.8%)	5.4(6.2%)	0.3(0.4%)	161.9
ATL+EP	124.7(65.1%)	66.2(53.1%)	31.1(35.6%)	10.9(8.8%)	191.6

Forecast Needs

- **JHT Main Activities**
  - Identify new techniques, models, observing systems, etc. with potential for improving forecast guidance, via an announcement of opportunity and a proposal, review, and funding process.
  - Establish and maintain an infrastructure to facilitate the modification and transfer of research applications into the operational computing, communication, and display environment.
  - Etc.
- **HFIP Goals**
  - **The goals** of the HFIP are to improve the accuracy and reliability of hurricane forecasts; to extend lead time for hurricane forecasts with increased certainty; and to increase confidence in hurricane forecasts. These efforts will require major investments in enhanced observational strategies, improved data assimilation, numerical model systems, and expanded forecast applications based on the high resolution and ensemble-based numerical prediction systems.

Credit to:
JHT website: http://www.nhc.noaa.gov/jht/index.php
HFIP website: www.hfip.org

Current HWRF Forecast System

- Automatic parallelization
- Storm following moving nests
- Two-way interactions
- Transparent parallelization to scientific programming
- Physics configured in hurricane regime
- All forecast products and diagnostic tools ready for hurricane forecast applications
- Limitations:
  - One storm per forecast
  - Cycling
  - Independent DA application
  - Extended forecast (7-day forecast)
  - Storm based system not tropical forecast system (e.g. easterly waves, genesis problem)
  - Ensemble

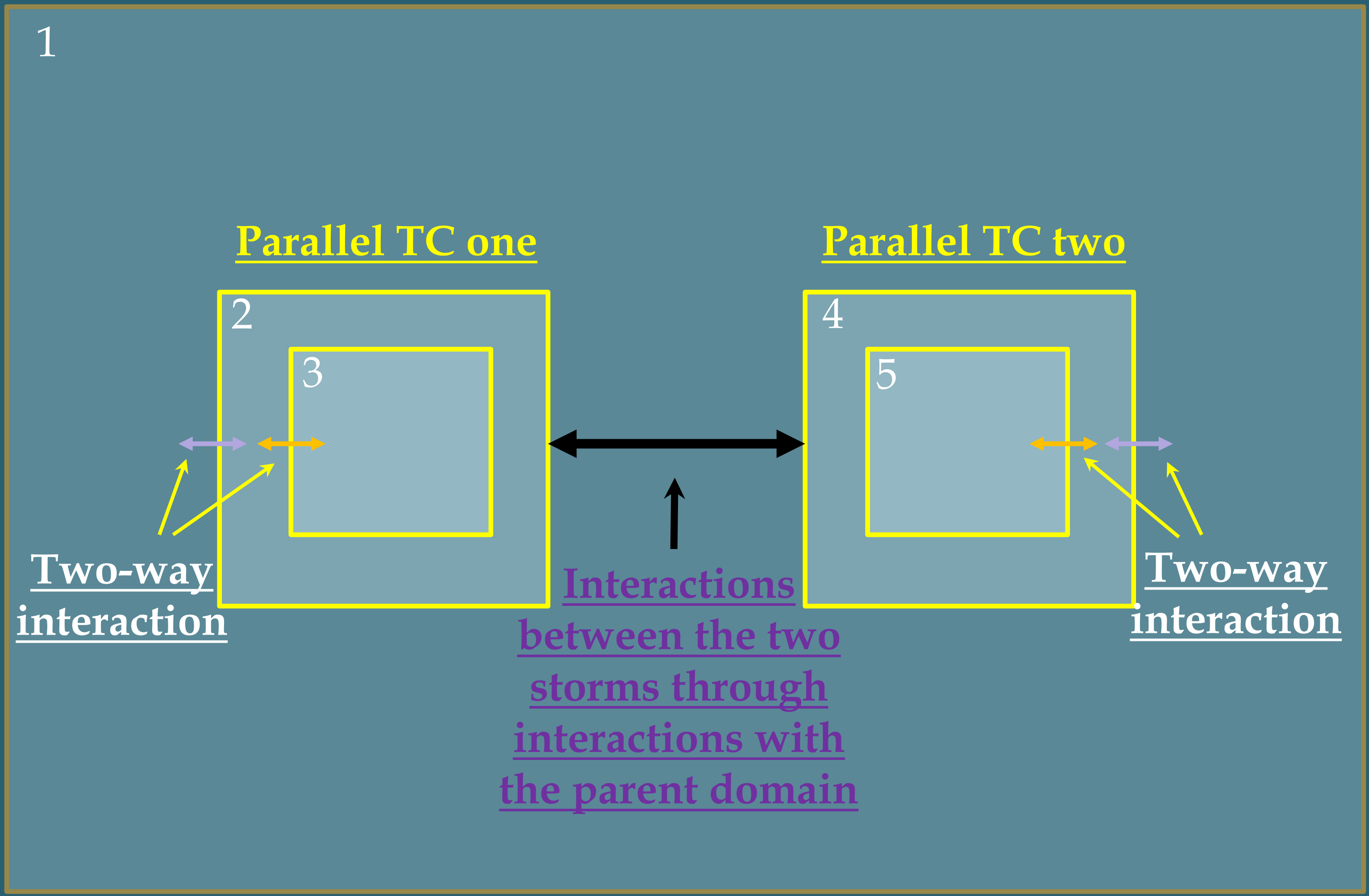
Current Model Configurations

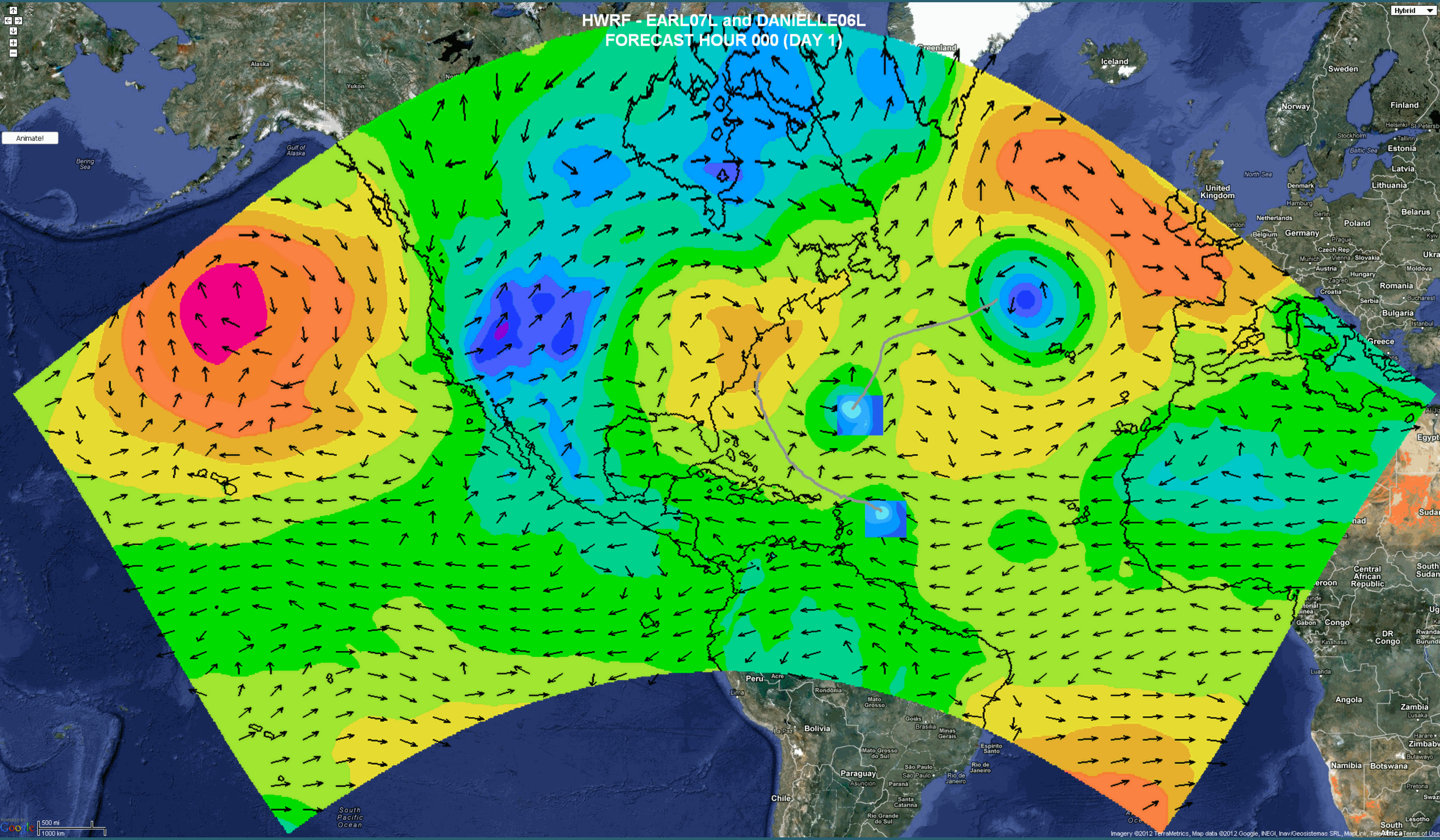
	2011 Oper. HWRF	Stream 1.5 HWRF	2012 HWRF Operational
Domain	27 KM: 77.76˚X 77.76˚ 9 KM: 7.2˚ X 6.0˚	27 KM: 77.76˚ X 77.76˚ 9 KM: 10.56˚ X 10.2˚ 3 KM: 7.6˚ X 6.4˚	**27 KM: 77.76˚ X 77.76˚ 9 KM: 10.56˚ X 10.2˚ 3 KM: 6.12˚ X 5.42˚**
Vortex Initialization	27-9 KM: Yes, with GSI	27-9 KM: Yes, GSI 3 KM: No, Downscaled	**Modified Vortex Initialization at 3 KM, with 30x30º analysis domain and GSI**
Cycling	Yes(Vortex only)	Yes (9 km vortex only)	**Yes (3 km vortex only)**
Ocean Coupling	27-9 KM: Yes	27-9 KM: Yes 3 KM: No, Downscaled	**27-9 KM: Yes 3 KM: No, Downscaled**
Physics schemes			
Microphysics	Ferrier	Ferrier	**Modified Ferrier (High-Res)**
Radiation	GFDL	GFDL	**GFDL**
Surface	GFDL (2011)	GFDL (High_res)	**GFDL (High_res)**
PBL Scheme	GFS	2011 GFS (High-res)	**2012 GFS (High_res)**
Convection	New SAS	New SAS (27-9 KM) no CP (3 KM)	**SAS (High-Res), No CP (3 KM), Shallow Convection**
Land Surface	GFDL Slab	GFDL Slab	**GFDL Slab**
GWD	Yes(27km); No(9km)	Yes(27km); No(9-3km)	**Yes(27km); No(9-3km)**

Basin-scale Model Configurations

	2012 HWRF Operational	Basin-scale Model (Stream 2)
Domain	27 KM: 77.76˚ X 77.76˚ 9 KM: 10.56˚ X 10.2˚ 3 KM: 6.12˚ X 5.42˚	27 KM: 178.20˚ X 77.58˚ 9 KM: 10.56˚ X 10.2˚ 3 KM: 6.12˚ X 5.42˚
Vortex Initialization	Modified Vortex Initialization at 3 KM, with 30x30° analysis domain and GSI	27KM: GFS 9-3 KM: No, Downscaled
Cycling	Yes (3 km vortex only)	No
Ocean Coupling	27-9 KM: Yes 3 KM: No, Downscaled	27-9-3 KM: No
Physics schemes		
Microphysics	Modified Ferrier (High-Res)	Modified Ferrier (High-Res)
Radiation	GFDL	GFDL
Surface	GFDL (High_res)	GFDL (High_res)
PBL Scheme	2012 GFS (High_res)	2012 GFS (High_res)
Convection	SAS (High-Res), No CP (3 KM), Shallow Convection	SAS (High-Res), No CP (3 KM), Shallow Convection
Land Surface	GFDL Slab	GFDL Slab
GWD	Yes(27km); No(9-3km)	No(27km); No(9-3km)

The basin-scale HWRF system





Initial time: 201082900

Basin-scale HWRF Configuration Test

	Number of Nest Domains	Wall Clock Time	PEs
27 km	No	50 mins	196
27-9-3 km	2 (1 storm)	137 mins	196
27-9-3 km	4 (2 storms)	256 mins	196
27-9-3 km	4 (2 storms)	288 mins	160

No optimization and off-the-shelf runs

Challenges and Priorities

- Code transfer and merge (this month)
- How to initialize vortex?
  - Current operational HWRF vortex initialization (ongoing)
  - GSI (ongoing)
  - Hybrid DA (ongoing)
  - Other option such as HEDAS (ongoing)
- Coupler (need upgrade)
- New nest moving algorithm (need upgrade)
- Code efficiency
  - Configuration changes (need configuration tests)
  - Code optimization (debug the computational cost)
  - WRF framework changes (proposed effort)

Ideal solution

- Increasing efficiency by increasing processors
- Increasing number of nests does not increase forecast wall-clock
- Optimize the processor allocation for improving model efficiency (shorten the forecast wall-clock and optimize computing usage)

WRF Framework Solution

Based on WRF model parallelization philosophy and current available supercomputer structure, we propose the following solution:

- Parallelize nest domain integration
- Enhance user's controllability of assigning number of CPUs for each domain
- Keep feedback flexibility in-between nests (user controllable)
- Minimize the WRF infrastructure change
- Transparent to scientific programming
- Backwards compatibility