DEVELOPMENT OF THE BASIN-SCALE HWRF SYSTEM

PRESENTER: XUEJIN ZHANG (AOML/HRD)

DEVELOPMENT TEAMS:
AOML/HRD, NCEP/EMC, DTC, GFDL, URI, AND NPS

ACKNOWLEDGEMENT:
S. GOPALAKRISHNAN AND F. MARKS (AOML/HRD)
V. TALLAPRAGADA (NCEP/EMC)
Y. KUO (DTC)
JET MANAGEMENT (NOAA)
HFIP SUPPORT

TEAM MEMBERS

- AOML/HRD

  G. Alaka, R. Black, H. Chen, J. Delgado, S. Diaz, S. Goldenberg, K. Sellwood, R. St. Fleur, T. Quirino, J. Zhang, X. Zhang, and HRD colleagues

- NCEP/EMC

  B. Ferrier, Q. Liu, J. Michalakes, D. Sheinin, M. Tong, S. Trahan, W. Wang, Z. Zhang, and EMC/Hurricane team

- DTC

  L. Bernardet, L. Carson, J. Frimel, C. Holt, and HWRF task team

- GFDL

  T. Marchok and M. Bender

- URI

  B. Thomas and I. Ginis

- NPS

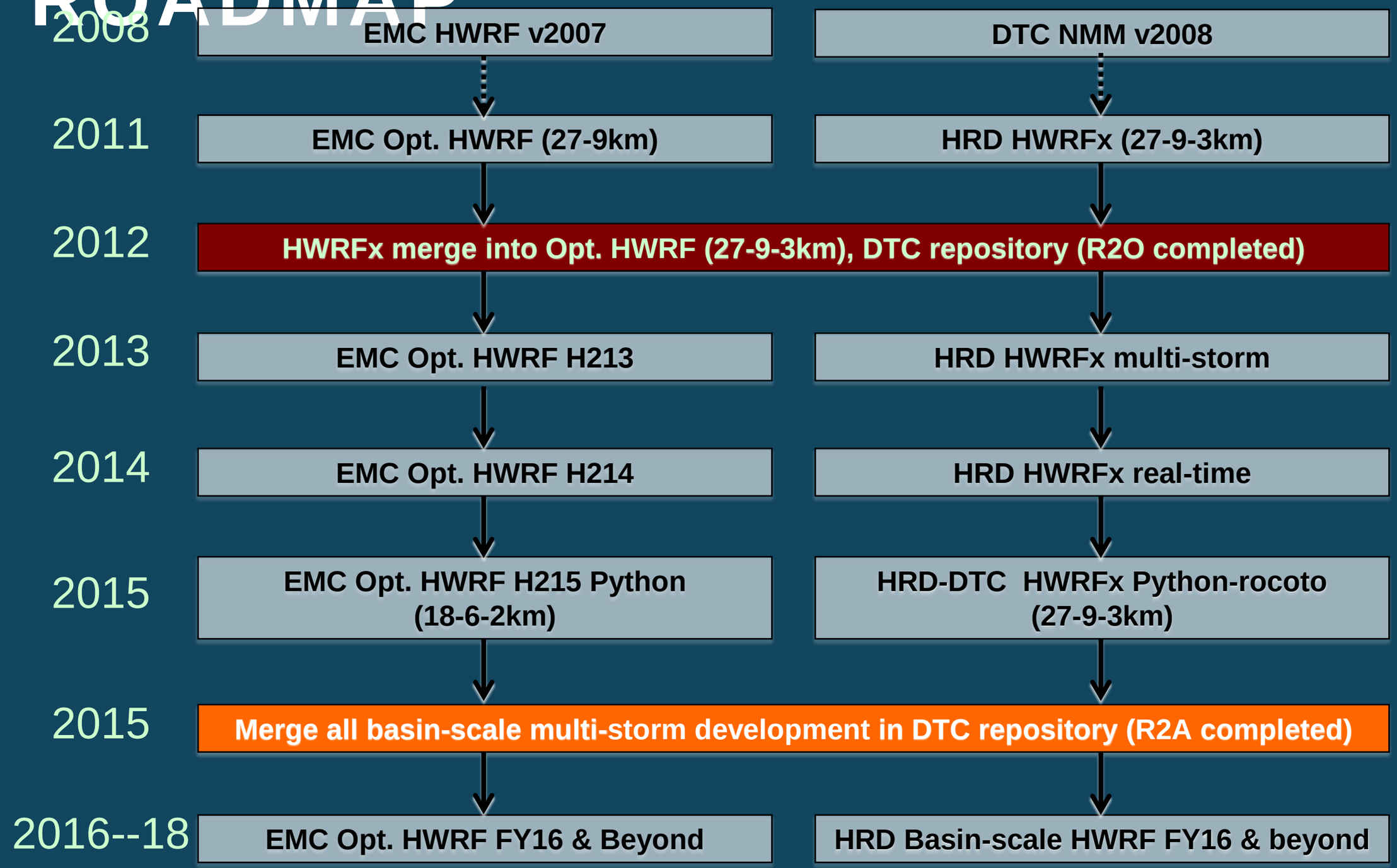
  M. Boothe, M. Montgomery, and B. Rutherford

ADVANCING THE HWRF SYSTEM FY16 & BEYOND

	2016*	2017*	2018*	2019*
Resolution/ Infrastructure	WRF-NMM core V3.7.1a with retention of non-hydrostatic status during the nest movement	Community R2O efforts (HFIP-HIWPP): Basin-scale HWRF NEMS/NMM-B	Upgrades to infrastructure - NEMS/ESMF/NMM-B, other oceanic basins, HWRF Ensembles, Global to local scale modeling for hurricanes	
Physics	Microphysics, PBL scheme upgrade	Advanced microphysics including impacts of dust and aerosols, Coupling to Sea Spray, Scale-aware, event-aware physics for high-resolution		
DA/ Vortex Initialization	Improve inner core DA (TDR, dropsonde, aircraft recon, clear sky satellite radiances), invest cycling	Hybrid-EnKF DA, advanced vortex relocation procedure, improved GSI/Hybrid techniques, DA for moving nests, HWRF Ensembles in DA, cloudy radiance assimilation Two-Way regional Hybrid DA		
Ocean	Atmos/Ocean/Wave coupling	Improved ocean data assimilation, physics and resolution, unified coupled system for ATL & EPAC		
	HWRF-HYCOM for all oceanic basins (driven by Global RTOFS)			
Waves		Multi-grid surf zone physics, effects of sea spray		
Diagnostics and Product Development	HWRF Ensemble based products, Coupling to Hydrological/ Surge/ Inundation models, advanced model diagnostics based on observations, improved product development			

Credit: EMC/HWRF group

DEVELOPMENT AND THE R2O/R2A TRANSITION ROADMAP



DEVELOPMENT AND THE R2O/R2A TRANSITION HIGHLIGHTS

- 2012: Multiple storm multiple nest code developed (AOML, EMC)
- **2012: Multiple nest code R2O transition completed (EMC, AOML, DTC)**
- 2013: Basin-scale multiple storm real-time implementation scripts developed (AOML, EMC)
- 2013-14: Basin-scale HWRF system tested and preliminary evaluated (AOML, EMC, DTC)
- 2014-15: Basin-scale Python scripts implementation (O2R) (DTC, EMC, AOML)
- 2015: Multiple storm parallel integration developed (EMC, DTC, AOML)
- 2015: Full multiple storm basin-scale HWRF with 2015 opt. HWRF Python scripting and physics tested (AOML, DTC, EMC)

READY FOR R2O TRANSITION

- Developed parallel integration (EMC, DTC, AOML)
- Implemented Python scripts and Rocoto workflow management for the real-time basin-scale HWRF system (DTC, EMC, AOML)
- Tested the real-time basin-scale HWRF forecasts (AOML, DTC, EMC)
- Tested the retrospective basin-scale HWRF forecasts (AOML, DTC, EMC)
- Prove the value of the basin-scale HWRF (AOML, EMC, DTC)
- Developed genesis capability with the basin-scale HWRF (DTC, EMC, GFDL, AOML)
- Developed genesis products (NPS, AOML, GFDL, EMC, DTC)

Color code: Completed; Ongoing

MILESTONES

- Configure 2015 operational HWRF model (18-6-2km), including NOAH LSM coupling, for basin-scale multi-nested, multi-storm hurricane modeling system (27-9-3km) (AOML, EMC, DTC)
- Implement ocean coupling and ocean initialization for multiple storms in multiple oceans in basin-scale HWRF (AOML, EMC, URI)
- Include ensemble-based data assimilation (2015 HWRF configuration) in basin-scale HWRF (EMC and DTC will work on integrating multi-nest DA and blending techniques to work for the basin-scale system) (AOML, DTC, EMC)
- Run retrospective cases with updated 2015 basin-scale HWRF, evaluate results versus operational HWRF (AOML, DTC, EMC)
- Run basin-scale HWRF with multiple, moving nests real-time in the 2015 demonstration project (AOML, DTC, EMC)
- Test and evaluate land surface (NOAH LSM) coupling for basin-scale HWRF, including evaluating QPF for land-falling storms (AOML, EMC)

Color code: Completed; Ongoing; Need resources

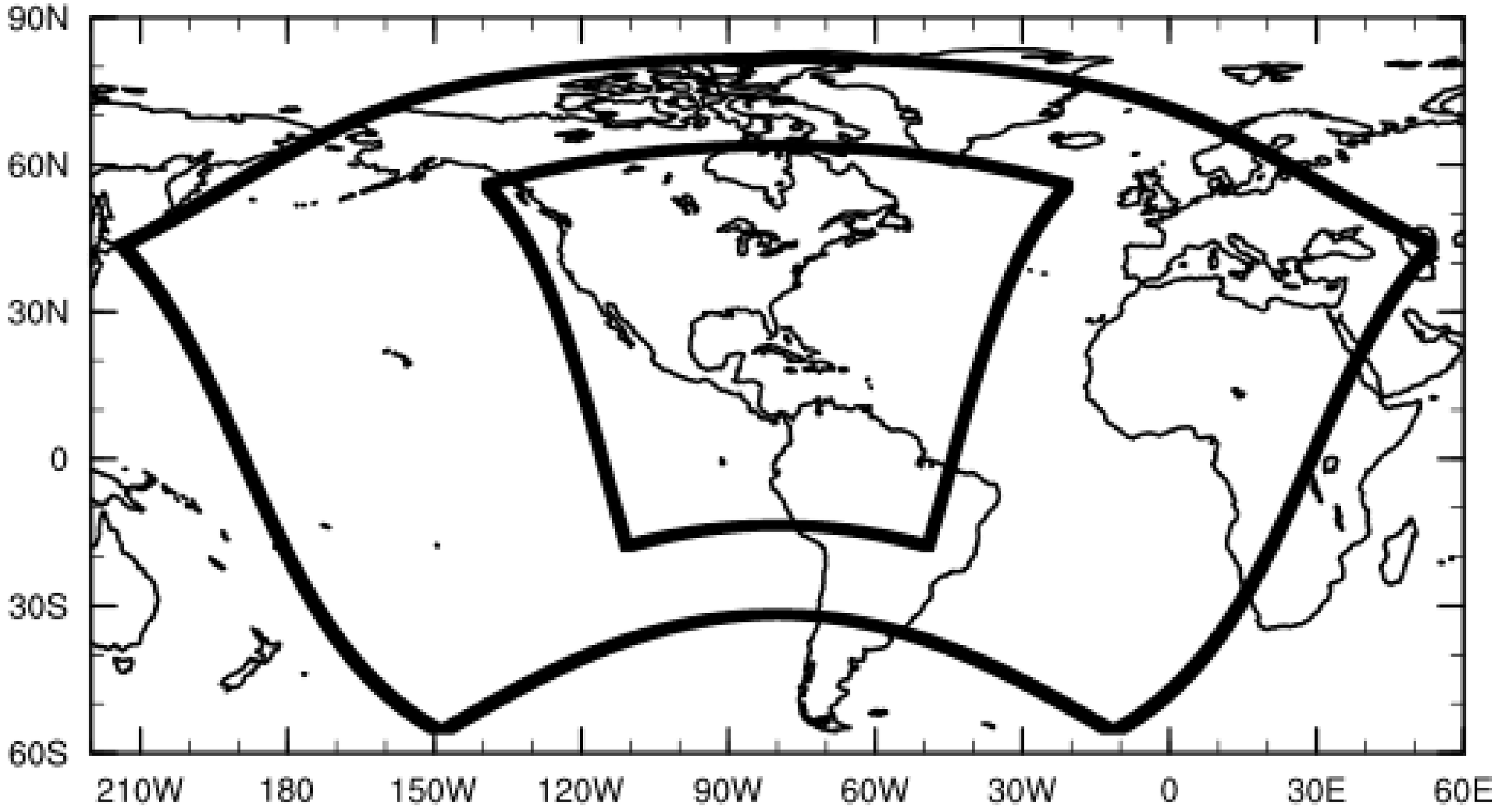
BASIN-SCALE HWRF VS. OPERATIONAL HWRF

	2013 Opt. HWRF (H213)	2013 Basin-scale HWRF (H3HW)	2014 Opt. HWRF (H214)	2015 Opt. HWRF (H215)	2015 Basin-scale HWRF (H5HW)
Domain	27 KM: 77.6˚ X 77.6˚ 9 KM: 10.5˚ X 10.14˚ 3 KM: 7.18˚ X 6.46˚	27 KM: 213.6˚ X 113.6˚ 9 KM: 10.5˚ X 10.14˚ 3 KM: 7.18˚ X 6.46˚	27 KM: 77.6˚ X 77.6˚ 9 KM: 12.66˚ X 12.18˚ 3 KM: 7.9˚ X 7.06˚	18 KM: 77.6˚ X 77.6˚ 6 KM: 12.74˚ X 12.29˚ 2 KM: 7.94˚ X 7.07˚	27 KM: 213.6˚ X 113.6˚ 9 KM: 12.66˚ X 12.18˚ 3 KM: 7.9˚ X 7.06˚
Vertical Levels	42 levels	61 levels	61 levels	61 levels	61 levels
Model Top	50hPa	2hPa	2hPa	2hPa	2hPa
Vortex Initialization	at 3 KM	at 3 KM	at 3 KM	at 2 KM	at 3 KM
Data Assimilation	GSI	No GSI	Hybrid	Hybrid + Ensemble (TDR)	Hybrid
Cycling	Yes (9-3 km vortex)	Yes (9-3 km vortex)	Yes (9-3 km vortex)	Yes (9-3 km vortex)	Yes (9-3 km vortex)
Ocean Coupling	Yes	No	Yes	Yes	No
Multiple Storm	No	Yes	No	No	Yes
Physics schemes					
Microphysics	Modified Ferrier	**Modified Ferrier**	**Modified Ferrier**	**Modified Ferrier-Aligo**	**Modified Ferrier-Aligo**
Radiation	GFDL	**GFDL**	**GFDL**	**RRTMG**	**RRTMG**
Surface	GFDL	**GFDL**	**GFDL**	**GFDL(V215)**	**GFDL(V215)**
PBL Scheme	Modified GFS	**Modified GFS**	**Modified GFS**	**Modified GFS (V215)**	**Modified GFS (V215)**
Convection	SAS, No CP (3 KM)	**SAS, No CP (3 KM)**	**SAS, No CP (3 KM)**	**SAS, No CP (2 KM)**	**SAS, No CP (3 KM)**
Land Surface	GFDL Slab	**GFDL Slab**	**GFDL Slab**	**NOAH**	**NOAH**

BASIN-SCALE HWRF (H3HW) VS. OPERATIONAL HWRF (H214) VERIFICATION

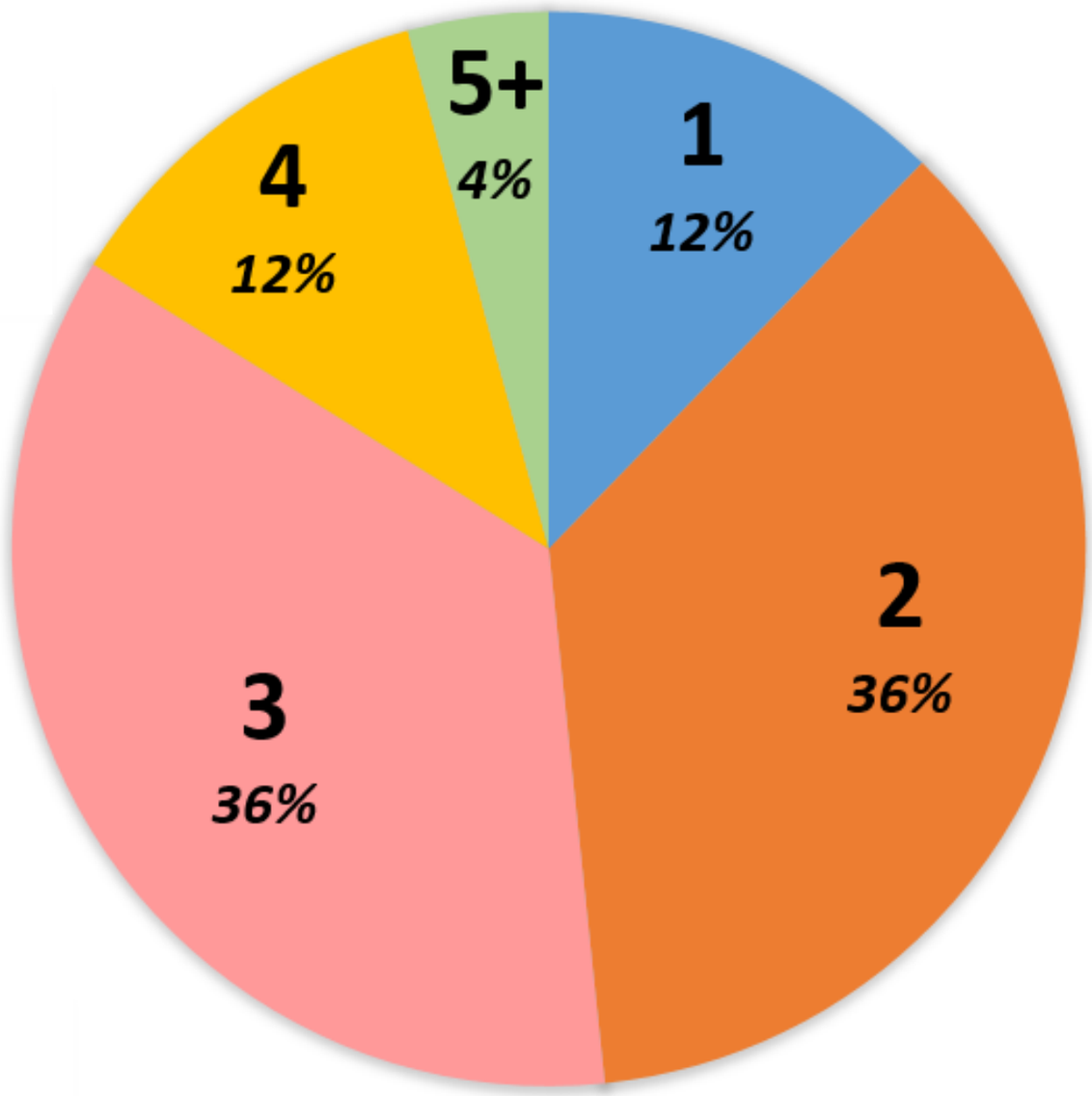
- Commonalities
  - GFS v2012 retrospective forecasts for 2011-2014
  - Model top and vertical levels
  - Physics
- Differences
  - Basin-scale HWRF ran up to 4 named or invest storms
  - Basin-scale HWRF no DA in the innermost domain
  - Basin-scale HWRF no ocean coupling (GFS SST were used and static during the 126-hour forecast)

BASIN-SCALE HWRF VS. OPERATIONAL HWRF



DISTRIBUTION OF NUMBER OF ATL AND EP TCS AND INVEST STORMS (2011-14)

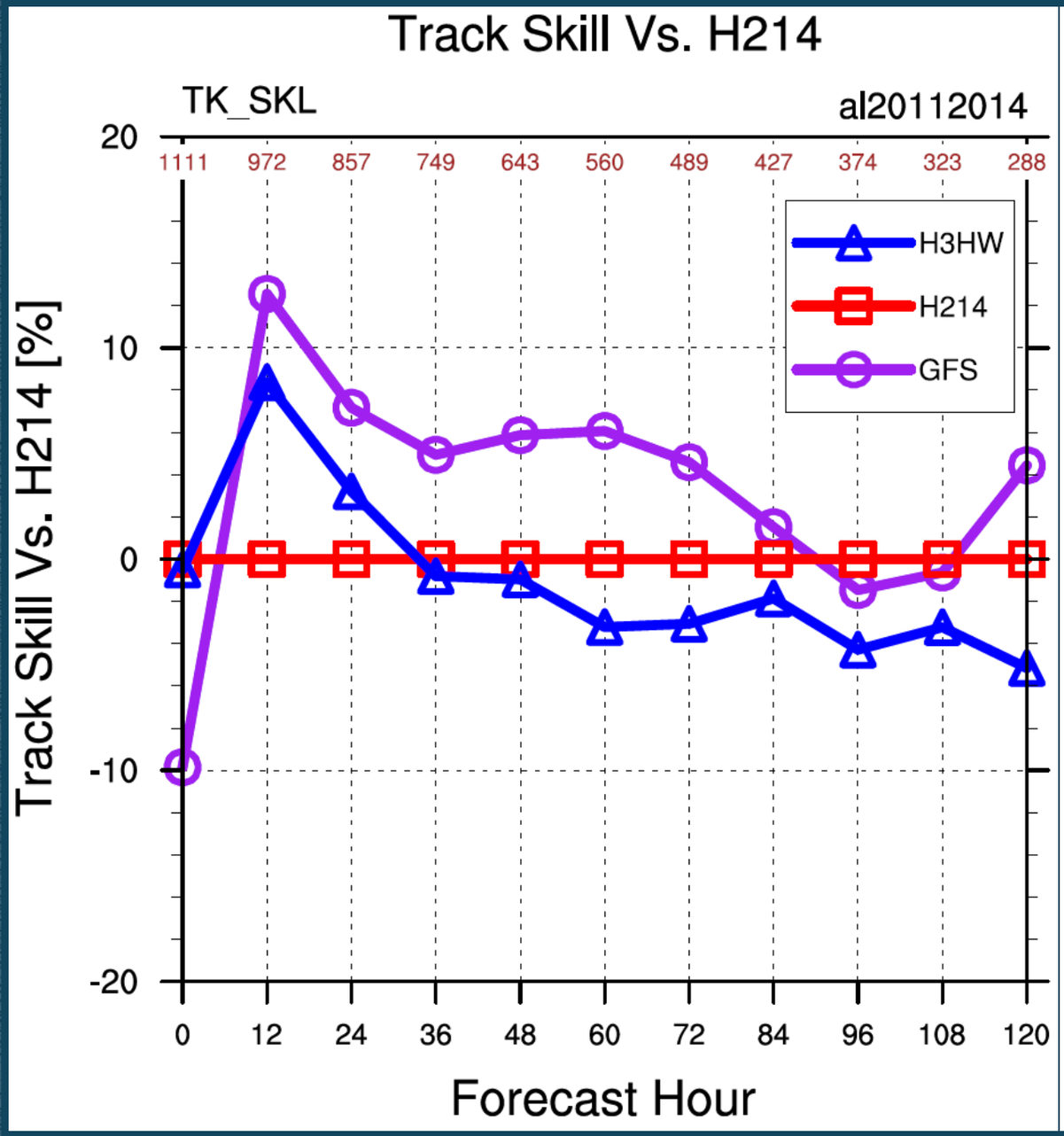
>1: 88%
>2: 52%



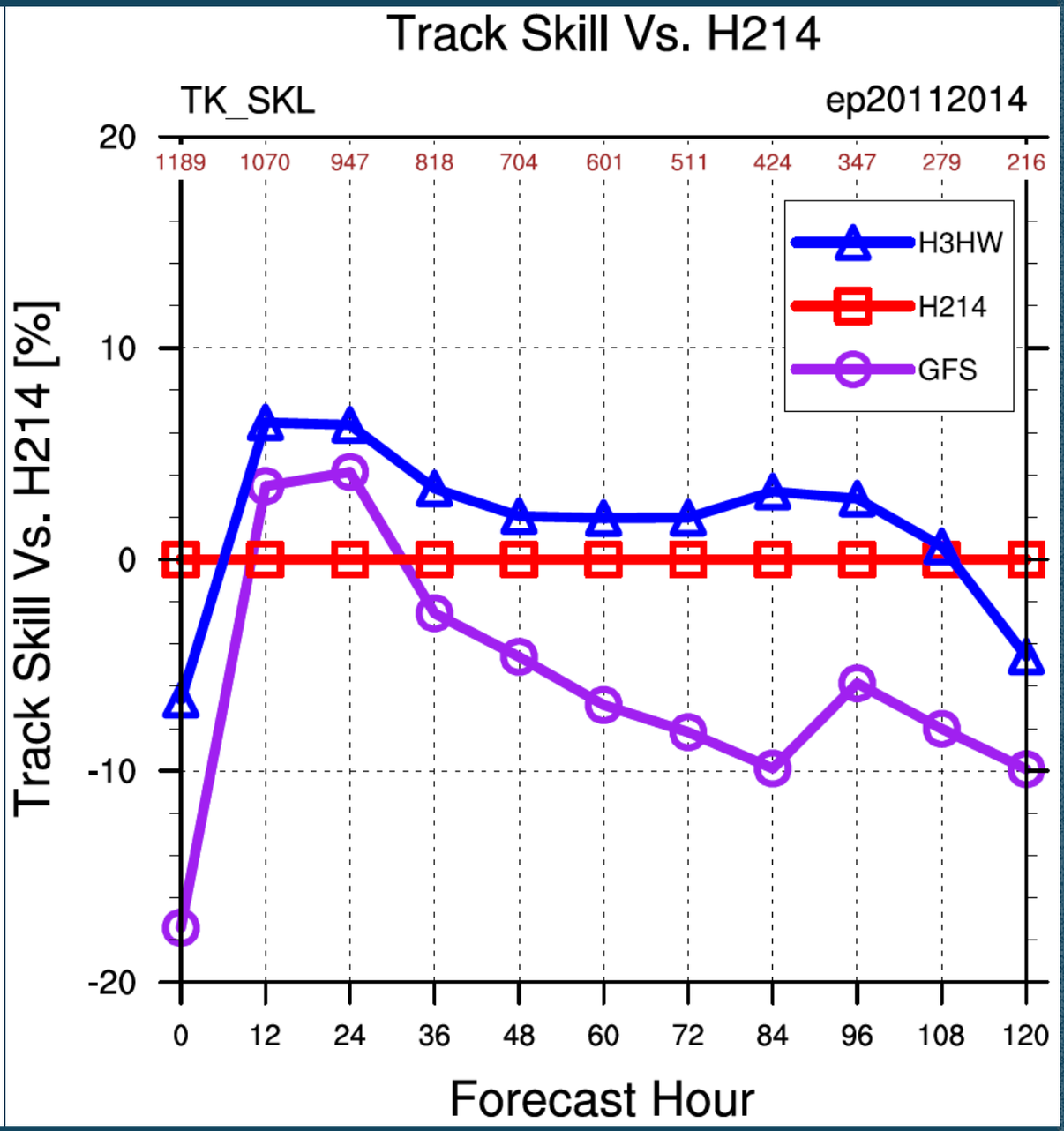
1111 verifiable forecast cycles for ATL basin

PROVING THE VALUE OF THE BASIN-SCALE HWRF

STRATIFIED VERIFICATION (2011-14)



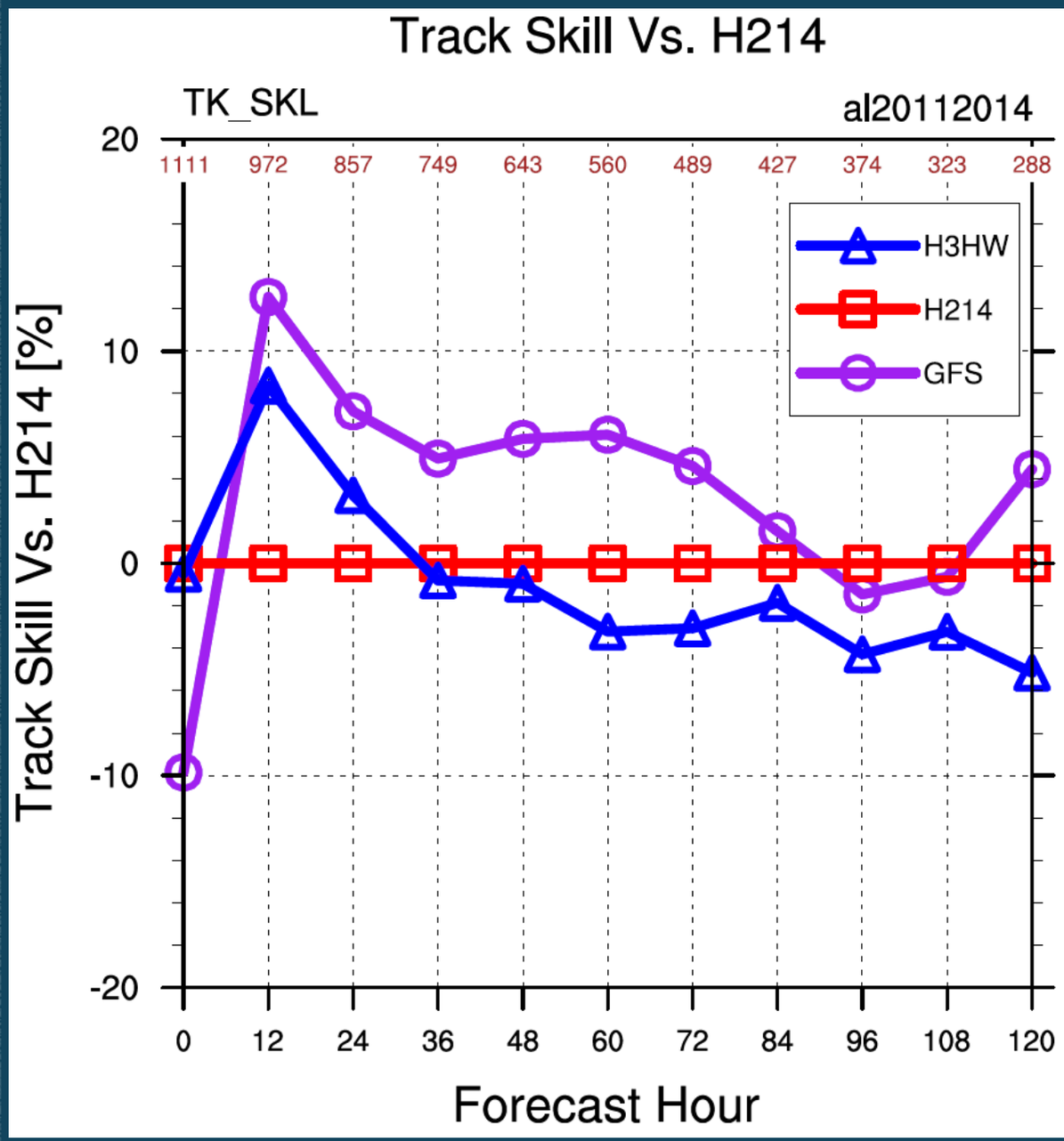
Full sample ATL



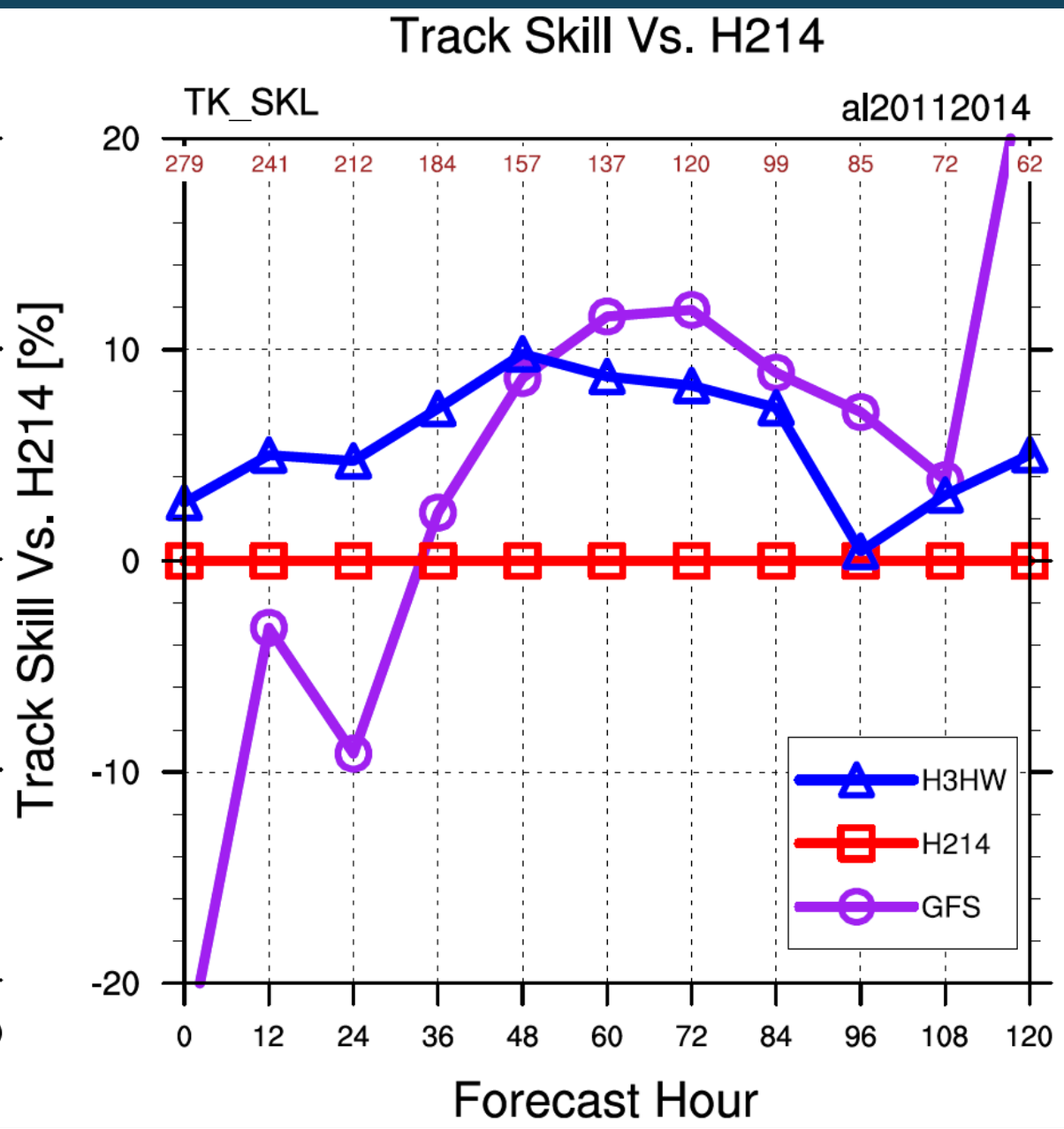
Full sample EP

PROVING THE VALUE OF THE BASIN-SCALE HWRF

STRATIFIED VERIFICATION (2011-14)



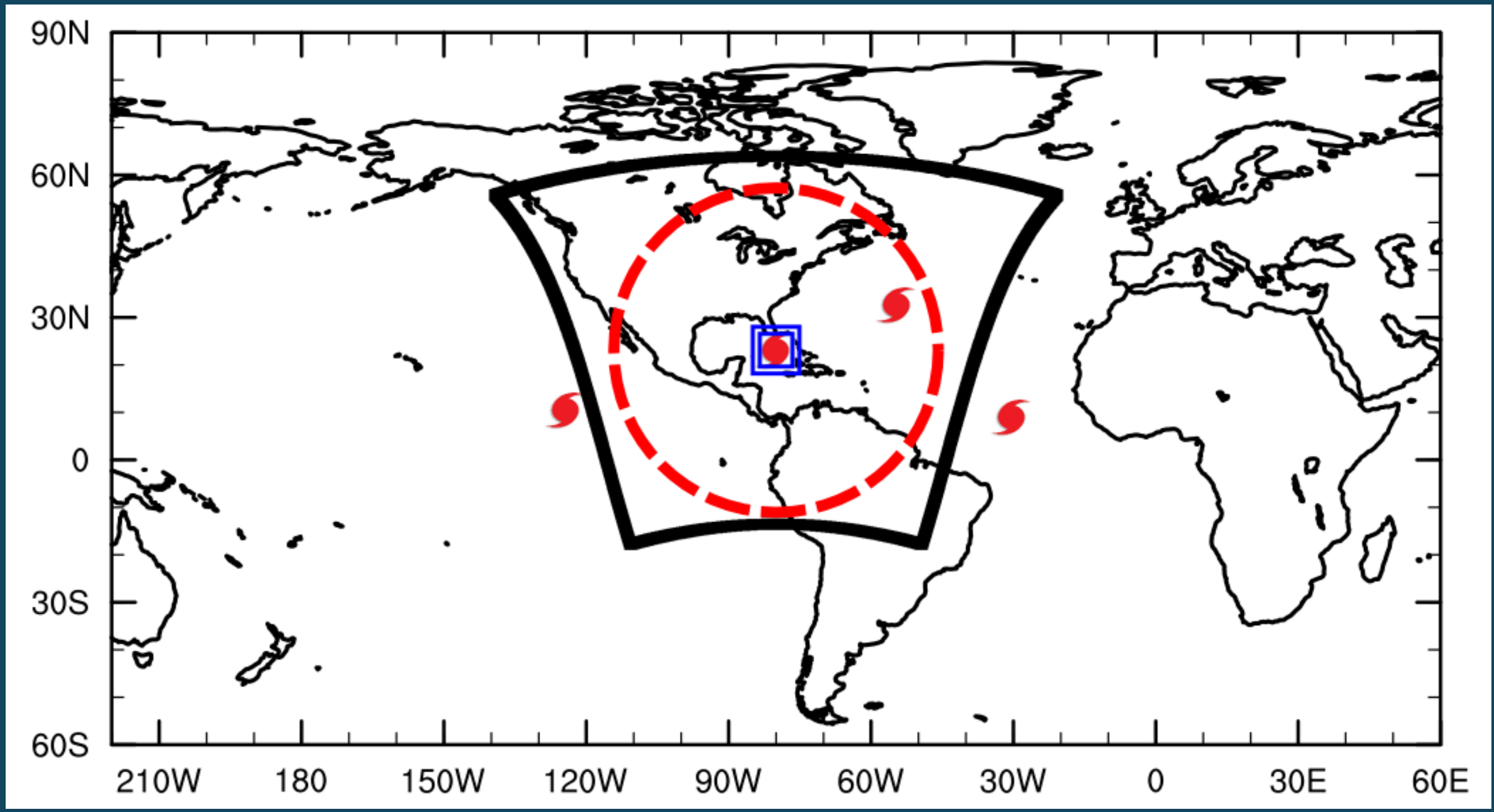
Full sample ATL



1 ATL storm with ≥1 EP storm

PROVING THE VALUE OF THE BASIN-SCALE HWRF

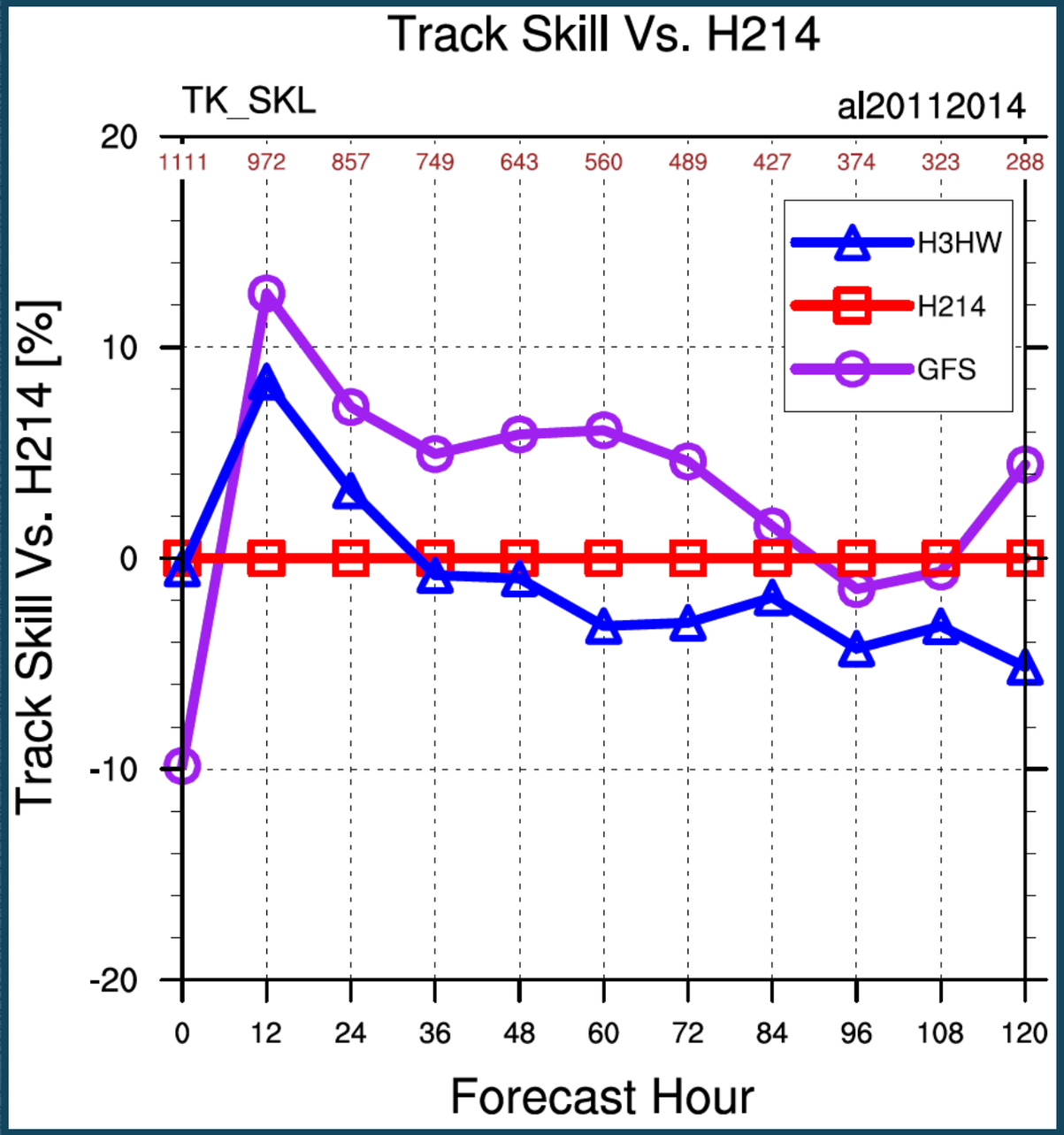
STRATIFIED VERIFICATION



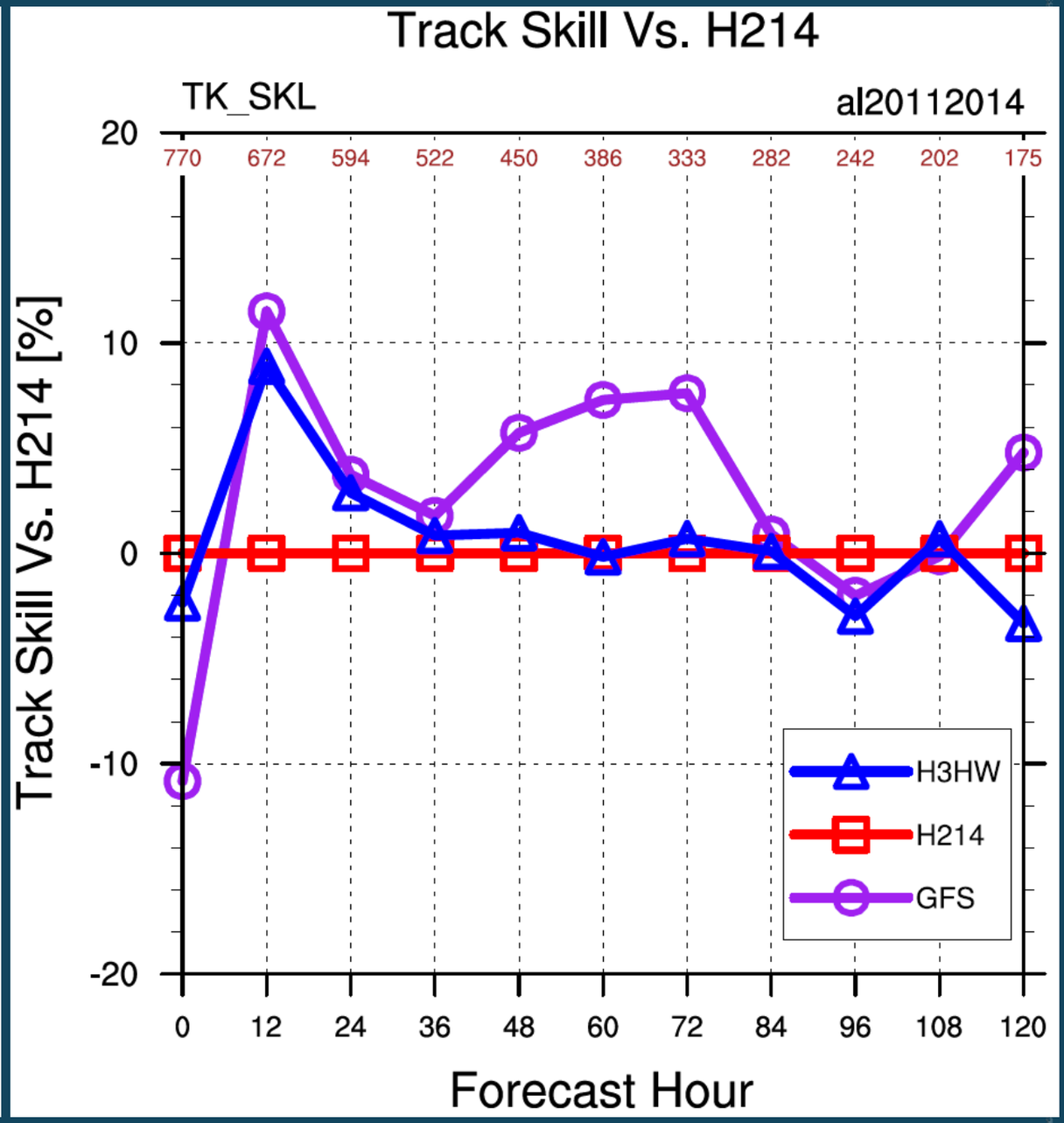
3500km verification radius

PROVING THE VALUE OF THE BASIN-SCALE HWRF

STRATIFIED VERIFICATION (2011-14)



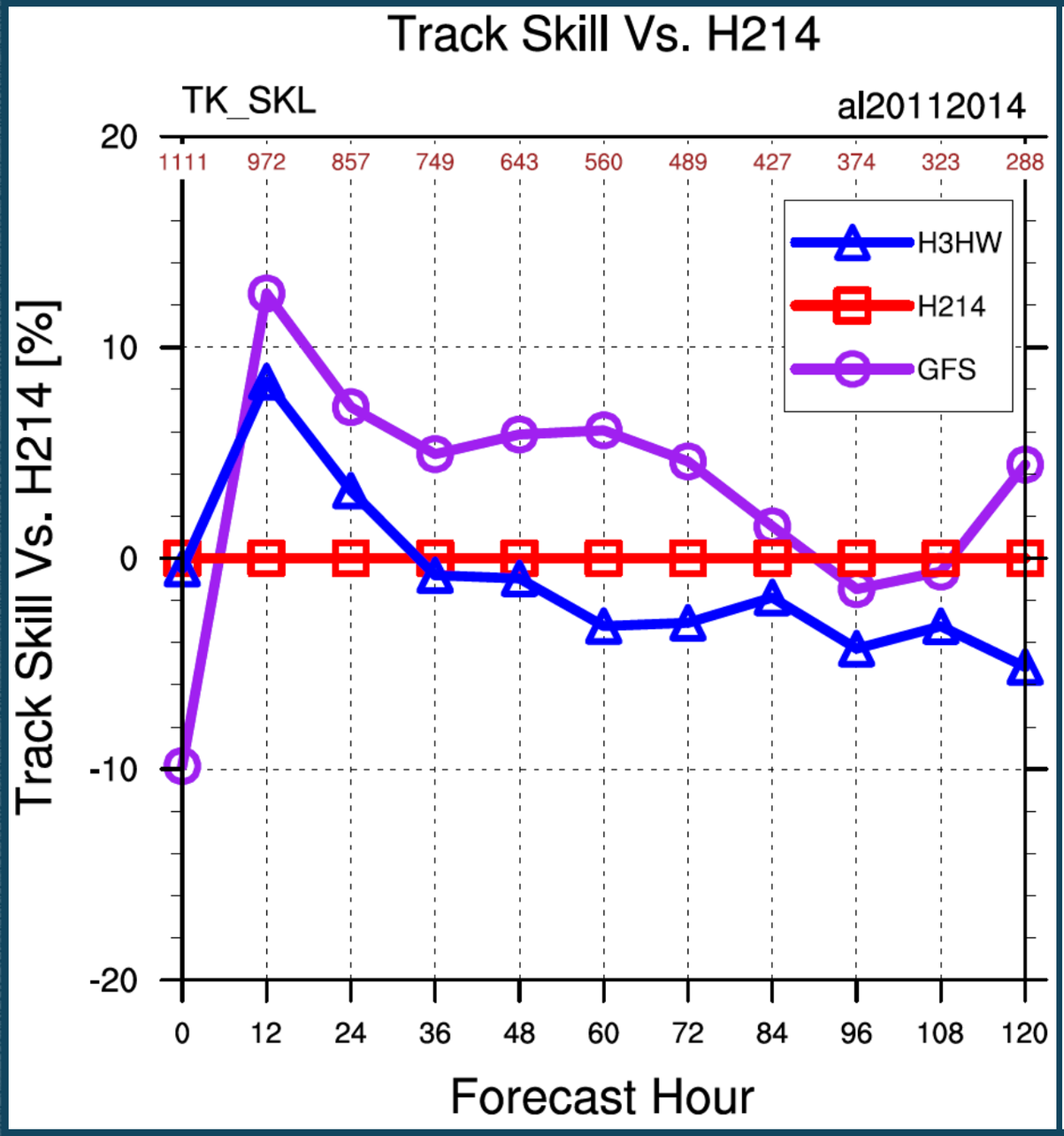
Full sample ATL



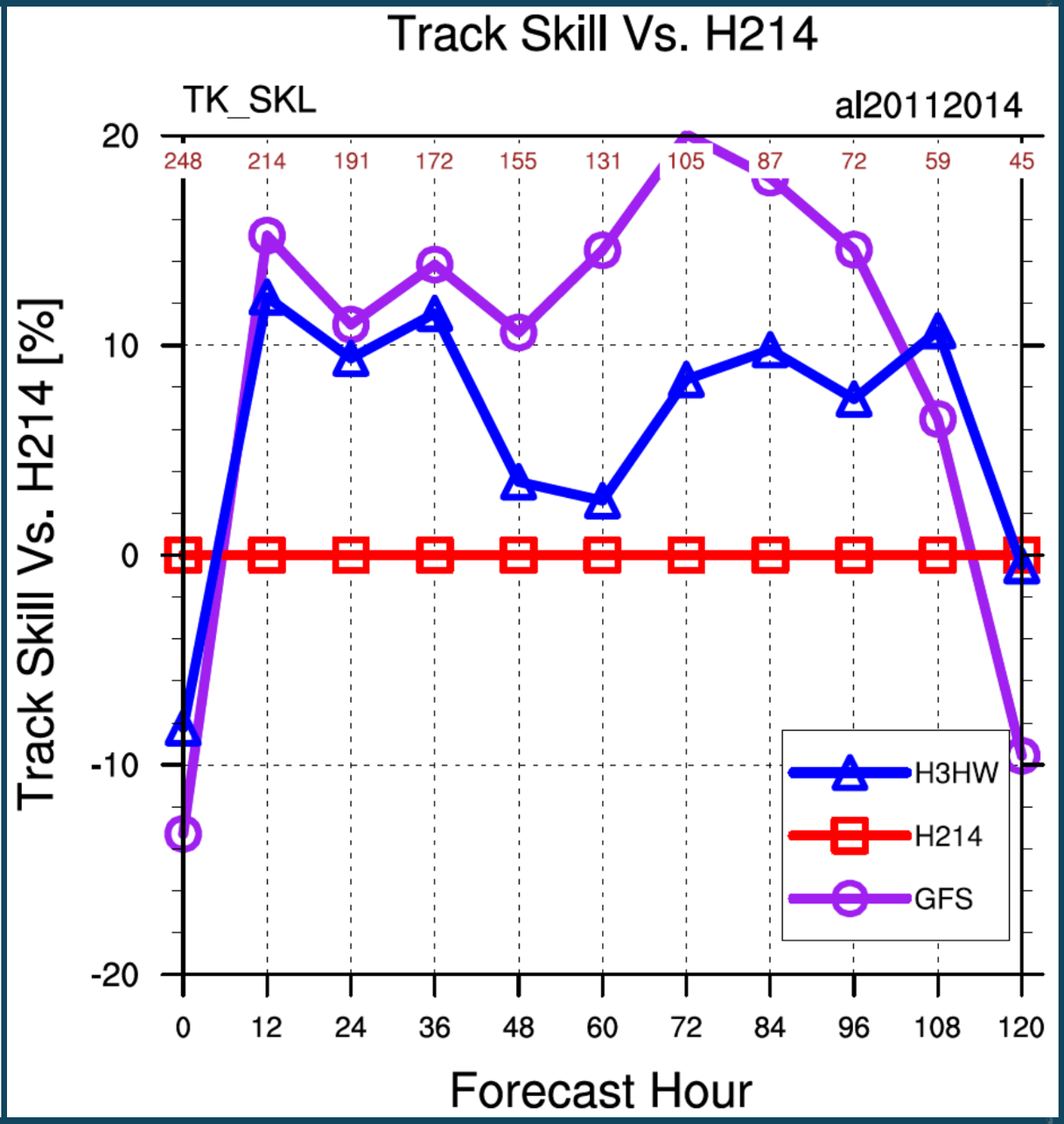
≥1 storm(s) outside 3500km radius

PROVING THE VALUE OF THE BASIN-SCALE HWRF

STRATIFIED VERIFICATION (2111-14)



Full sample ATL



≥2 storm(s) outside 3500km radius

BASIN-SCALE HWRF SYSTEM:
DEVELOPMENT PRIORITIES

- Multi-basin ocean coupling (MPIPOM/HYCOM)
- Ensemble capability
- Multiple storm-scale DA infrastructure/implementation (TDR hybrid)
- Outermost domain DA infrastructure/implementation (satellite hybrid and experimental satellite data)
- Genesis capability
- 1km resolution infrastructure/implementation (I/O, scalability)

BASIN-SCALE HWRF SYSTEM:
EVALUATION PRIORITIES

- Retrospective forecasts (2013-15) with basin-scale HWRF v2016
- Stratified verification
- Assess the value of basin-scale HWRF
  - Genesis capability and products
  - Multi-storm effects
- Assess effect of the vortex and basin domain satellite DA
- Explore the value of 1km upgrade

EXTRA SLIDE

FUTURE OUTLOOK 5-25 YEARS:

	5-10 years	2020+
Resolution/ Infrastructure	Basin-Scale HWRF with multiple moveable nests (at cloud resolving resolutions) and high-resolution HWRF ensembles Higher (1km) resolution Downstream applications (including landfall related storm surge, waves, flooding and inundation)	Global to Local Scale Modeling to capture multi-scale interactions High-Resolution Ensembles for events of interest
Physics	Observations based physics Incorporate effects of sea-spray, aerosols, waves, boundary layer rolls – explicit representation of inner core processes	Ensemble based physics approach
DA/ Vortex Initialization	Hybrid/EnKF with 4-D VAR Vortex initialization within the DA, focus on assimilation of all-weather radiances and aircraft data	Part of the data assimilation for global system
Ocean/Wave/Land	Fully coupled ocean-wave-land-atmosphere system	
Products & Downstream applications	MEETING THE NEXT-GENERATION NEEDS OF HURRICANE SPECIALISTS AT NHC AND JTWC	