The physics suite upgrades of the operational HWRF model for 2014 implementation

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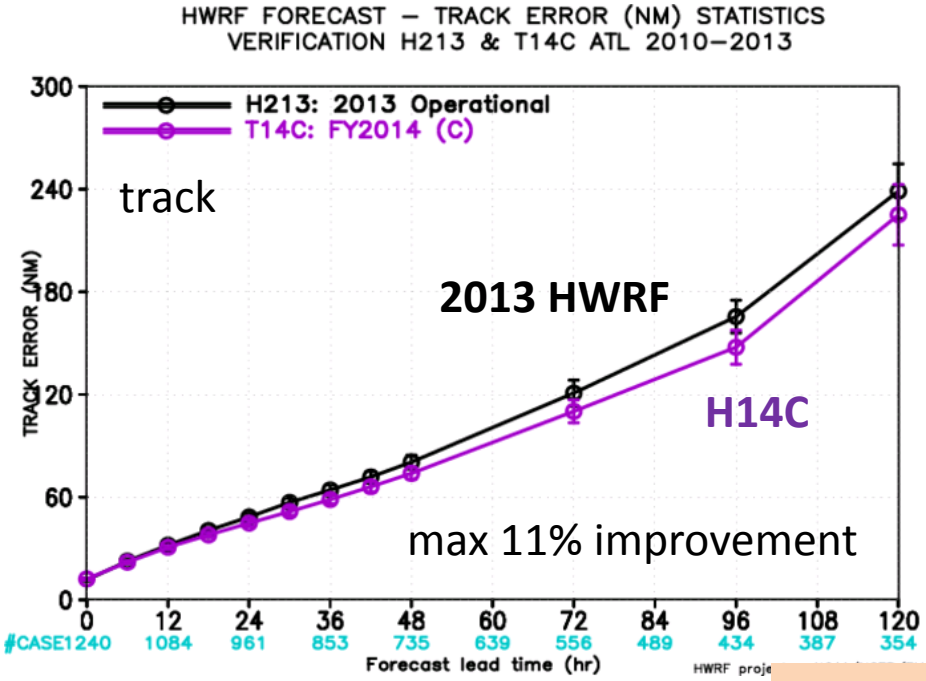
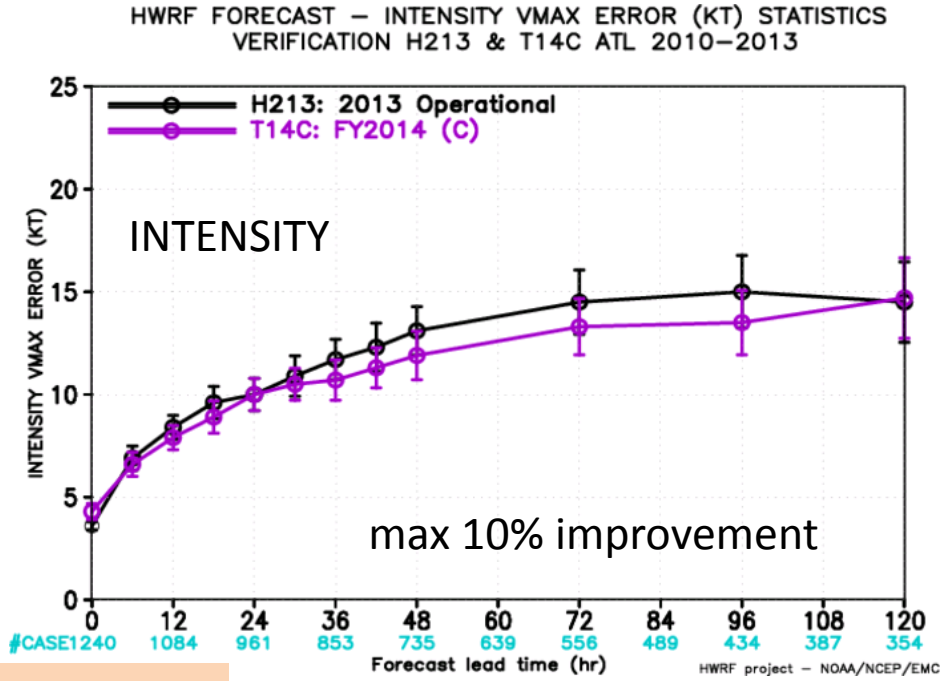
Weiguo Wang, Chanh Kieu, Eric Aligo,
Samuel Trahan, Qingfu Liu, Zhan Zhang
(EMC/NCEP/NWS/NOAA)

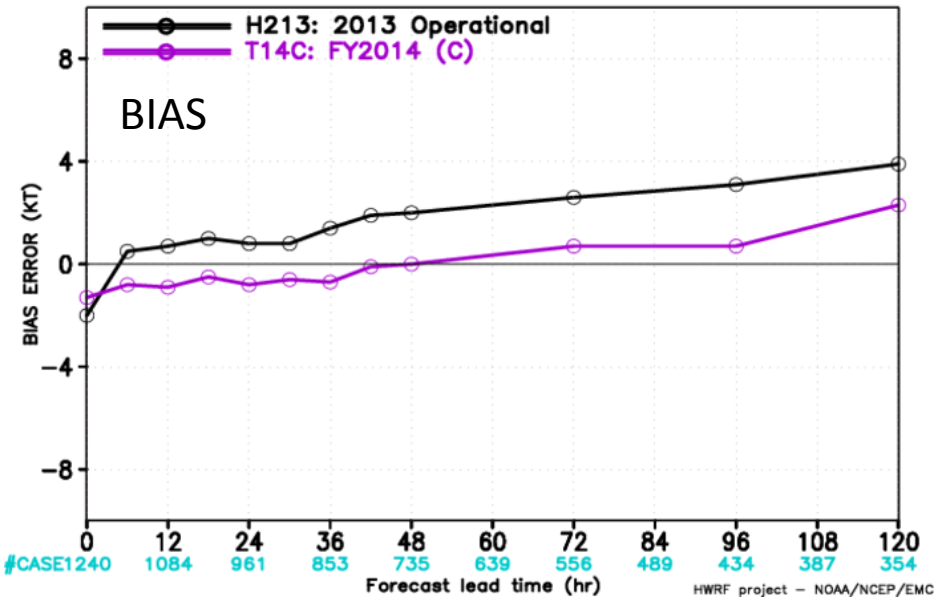
2014 HWRF pre-implementation test plan

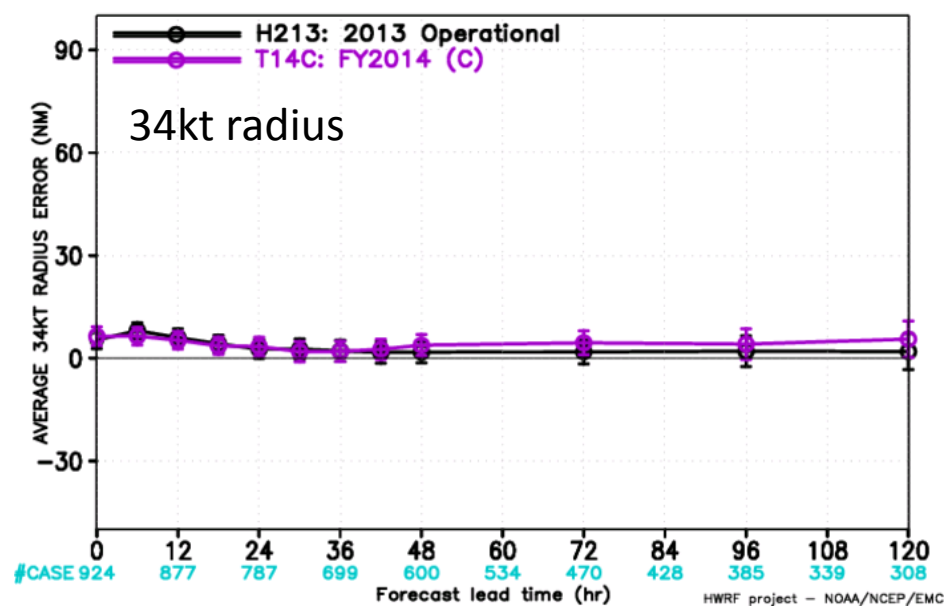
	Infrastructure upgrades	Physics upgrades					Combine
	T14C	**Nest motion (H140)**	**NOAH LSM (H141)**	**Upgraded Ferrier (H142)**	**RRTMG (H143)**	**Ocean (H144)**	**H214**
Descr.	1. Sat Da with more vertical levels 2. Extended d2/d3 3. Upgraded vortex initialization 4. GSI upgrade 5. Invest cycling	New nest motion	NOAH LSM	Separate species, Frime advection with other upgrades	Radiation	MPI-POM with new coupler	Baseline + physics *need to do test runs with new GFS in WCOSS
Person	All	Sam	Young	Weiguo	Chanh	Zhan/URI	All
Cases	Whole 2011,2012 and 2013 storms 2008, 09, 10 TDR cases	Priority cases	Priority cases	Priority cases	Priority cases	Priority cases	Whole 2011,2012 and 2013 storm
Due date	Feb. 15	Feb. 15	Feb. 15	Feb. 15	Feb. 15	Feb. 15	March 31
Platform	Jet/WCOSS	Jet	Jet	Jet	Jet	Jet	Jet/WCOSS

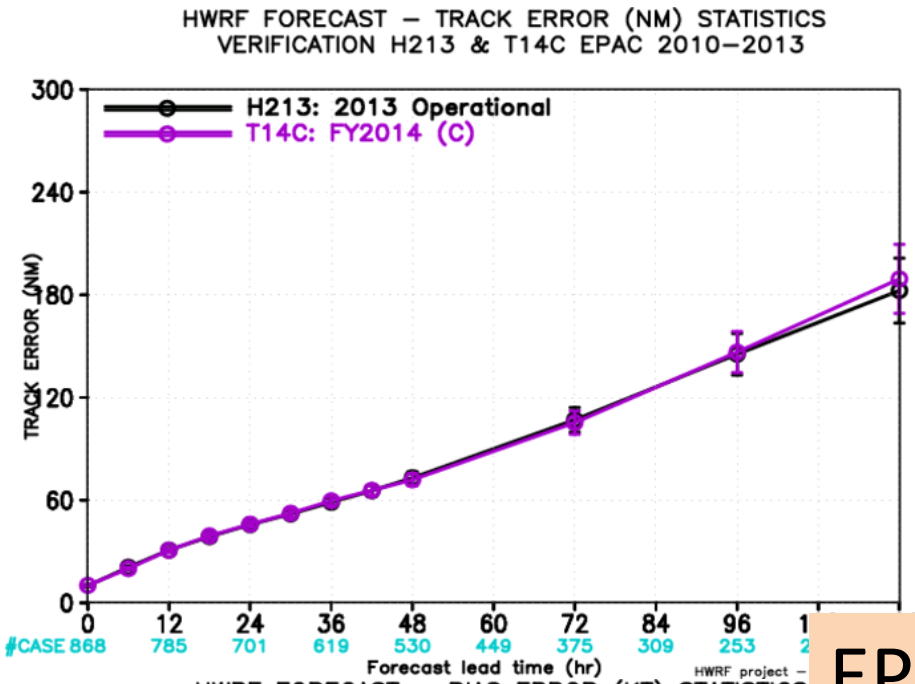

HWRF FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION H213 & T14C ATL 2010–2013
H213: 2013 Operational
T14C: FY2014 (C)
track
2013 HWRF
H14C
max 11% improvement
TRACK ERROR (NM)
Forecast lead time (hr)
#CASE1240 1084 961 853 735 639 556 489 434 387 354

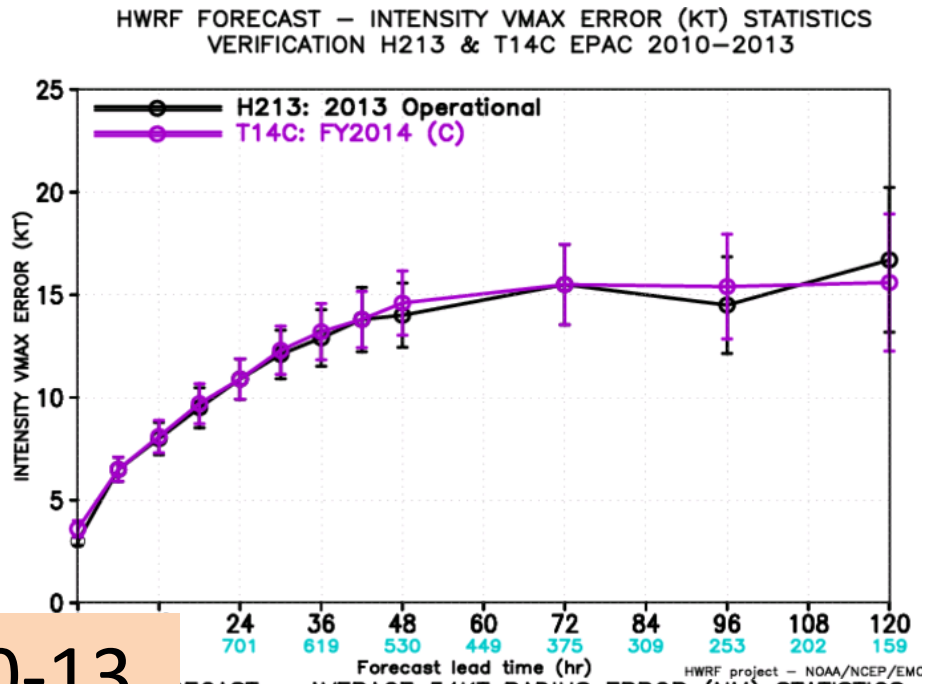

HWRF FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION H213 & T14C ATL 2010–2013
H213: 2013 Operational
T14C: FY2014 (C)
INTENSITY
max 10% improvement
INTENSITY VMAX ERROR (KT)
Forecast lead time (hr)
#CASE1240 1084 961 853 735 639 556 489 434 387 354
HWRF project – NOAA/NCEP/EMC

ATL 10-13

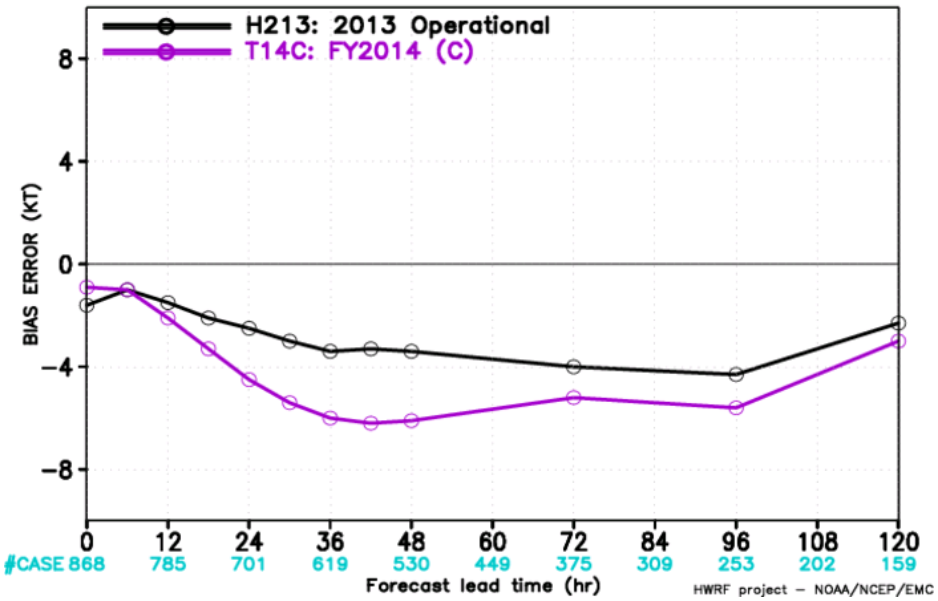

HWRF FORECAST – BIAS ERROR (KT) STATIST
VERIFICATION H213 & T14C ATL 2010–201
H213: 2013 Operational
T14C: FY2014 (C)
BIAS
BIAS ERROR (KT)
Forecast lead time (hr)
#CASE1240 1084 961 853 735 639 556 489 434 387 354
HWRF project – NOAA/NCEP/EMC

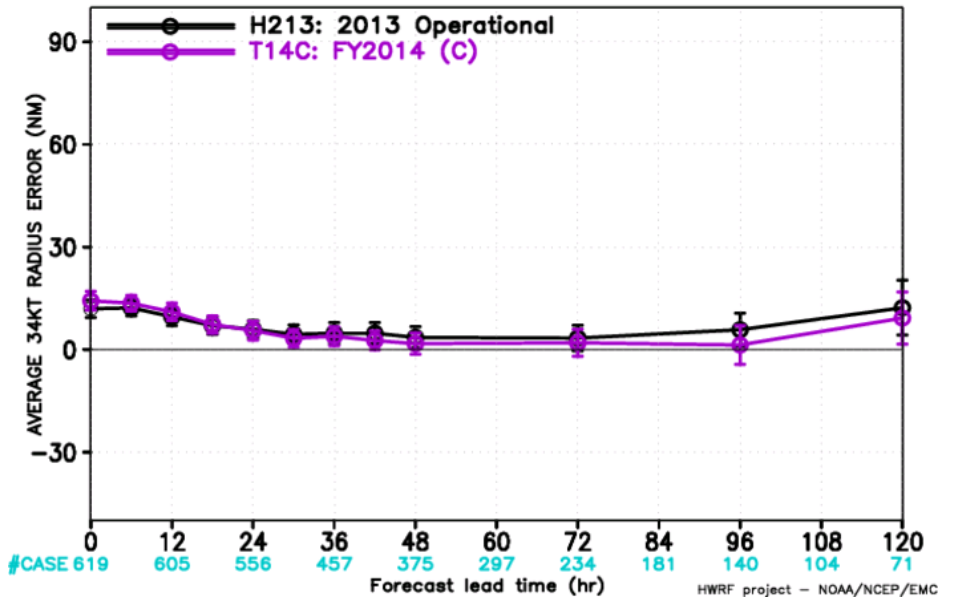

CAST – AVERAGE 34KT RADIUS ERROR (NM) STATISTICS
VERIFICATION H213 & T14C ATL 2010–2013
H213: 2013 Operational
T14C: FY2014 (C)
34kt radius
AVERAGE 34KT RADIUS ERROR (NM)
Forecast lead time (hr)
#CASE 924 877 787 699 600 534 470 428 385 339 308
HWRF project – NOAA/NCEP/EMC


HWRF FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION H213 & T14C EPAC 2010–2013
H213: 2013 Operational
T14C: FY2014 (C)
TRACK ERROR (NM)
300
240
180
120
60
0
0 12 24 36 48 60 72 84 96
#CASE 868 785 701 619 530 449 375 309 253
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC


HWRF FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION H213 & T14C EPAC 2010–2013
H213: 2013 Operational
T14C: FY2014 (C)
INTENSITY VMAX ERROR (KT)
25
20
15
10
5
0
24 36 48 60 72 84 96 108 120
701 619 530 449 375 309 253 202 159
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC

EP 10-13


HWRF FORECAST – BIAS ERROR (KT) STATISTICS
VERIFICATION H213 & T14C EPAC 2010–2013
H213: 2013 Operational
T14C: FY2014 (C)
BIAS ERROR (KT)
8
4
0
–4
–8
0 12 24 36 48 60 72 84 96 108 120
#CASE 868 785 701 619 530 449 375 309 253 202 159
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC


ECAST – AVERAGE 34KT RADIUS ERROR (NM) STATISTICS
VERIFICATION H213 & T14C EPAC 2010–2013
H213: 2013 Operational
T14C: FY2014 (C)
AVERAGE 34KT RADIUS ERROR (NM)
90
60
30
0
–30
0 12 24 36 48 60 72 84 96 108 120
#CASE 619 605 556 457 375 297 234 181 140 104 71
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC

2014 HWRF pre-implementation test plan

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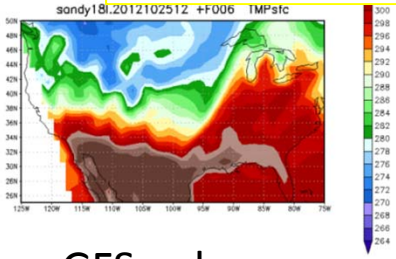
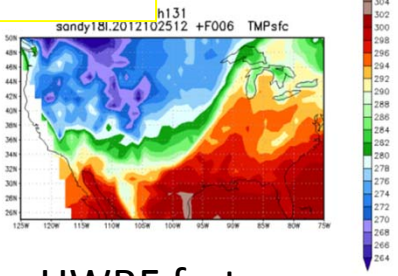
Upgraded Land Surface model
(GFDL slab to NOAH)

1. GFDL slab has shown large negative temperature bias over SW CONUS
2. NOAH LSM has more down-stream application potential (e.g. storm surge, inland flooding) on top of reducing negative temperature bias
3. Track errors of land-falling storms seem to be improved according to preliminary tests

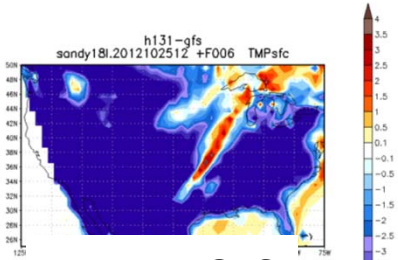
Cold bias of HWRF sfc T



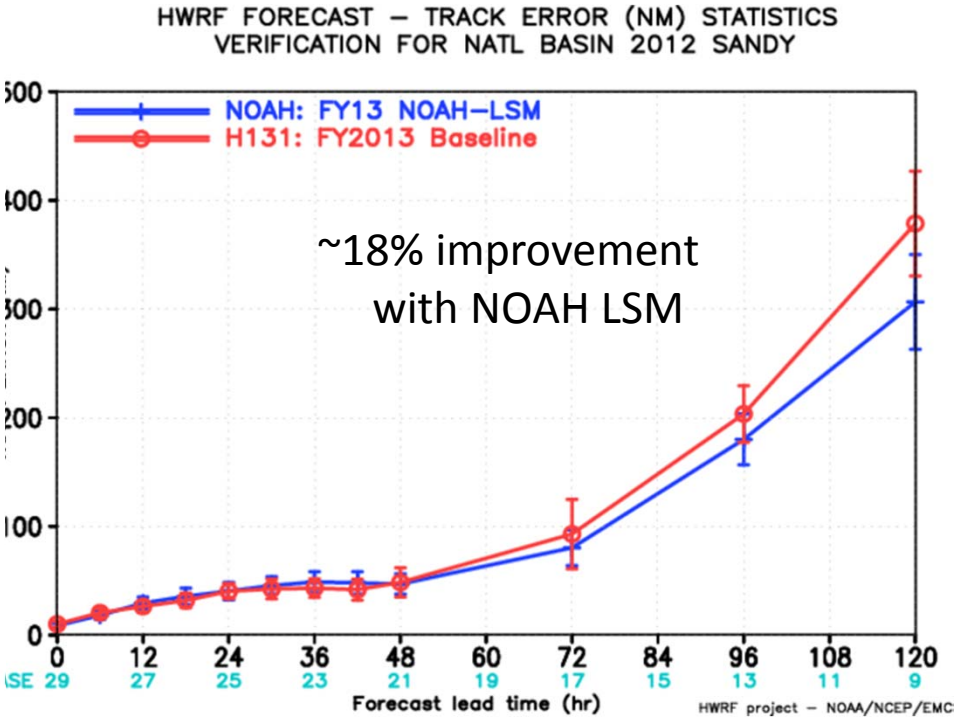
GFS anl



HWRF fcst



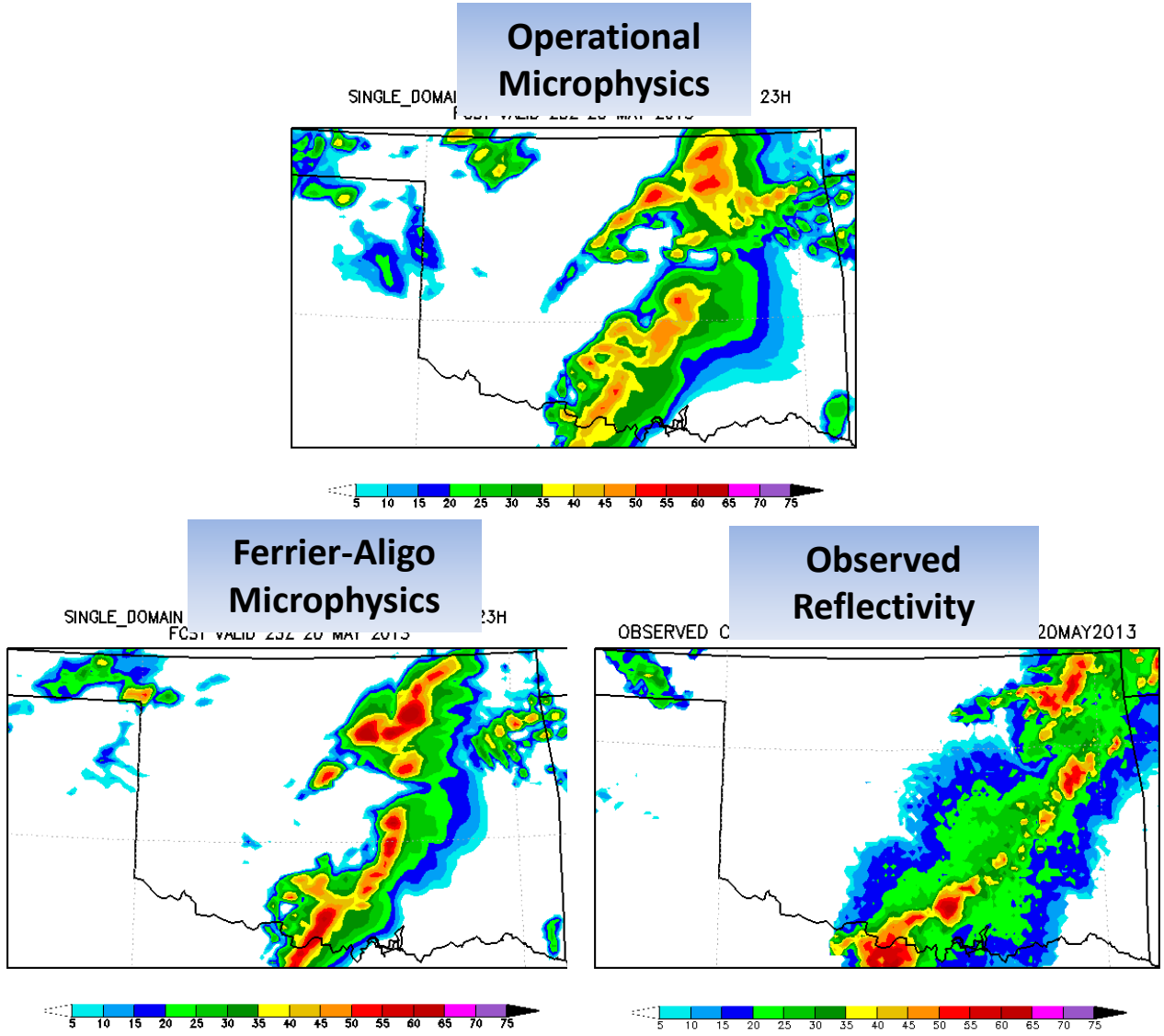
HWRF - GFS



Upgraded Ferrier-Aligo Microphysics

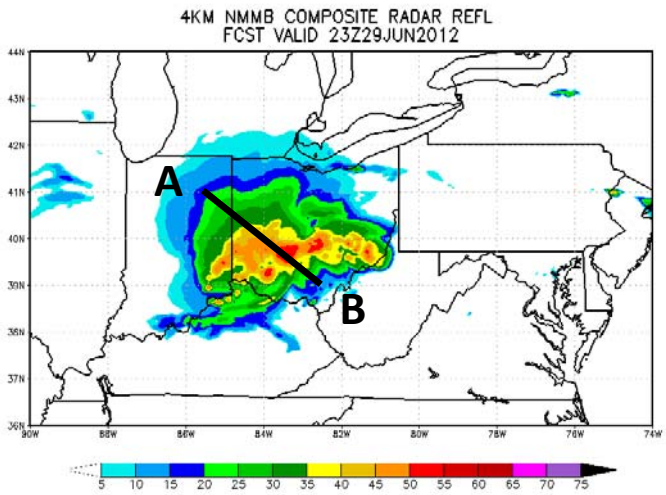
1. New ice nucleation scheme to reduce no. concentration of small ice crystals
2. Advection of mass-weighted rime factor
3. Max N_{LI} (number number concentration (#/m^3) of large ice) a function of RF and temperature
4. Slightly slower fall speeds of rimed ice

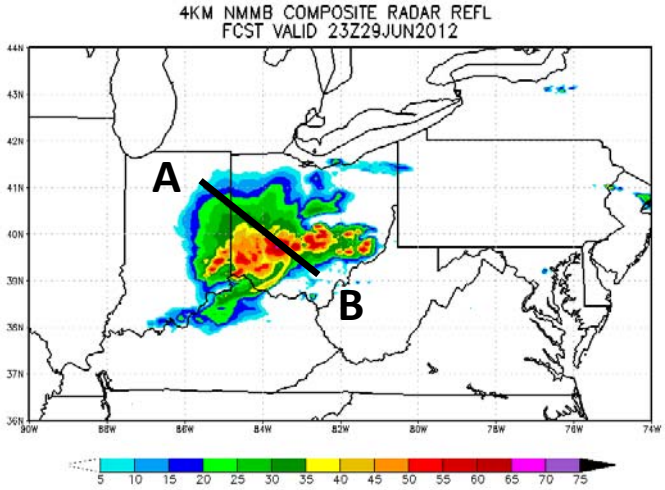
5. On top of upgraded MP, testing separate hydrometers species



Control

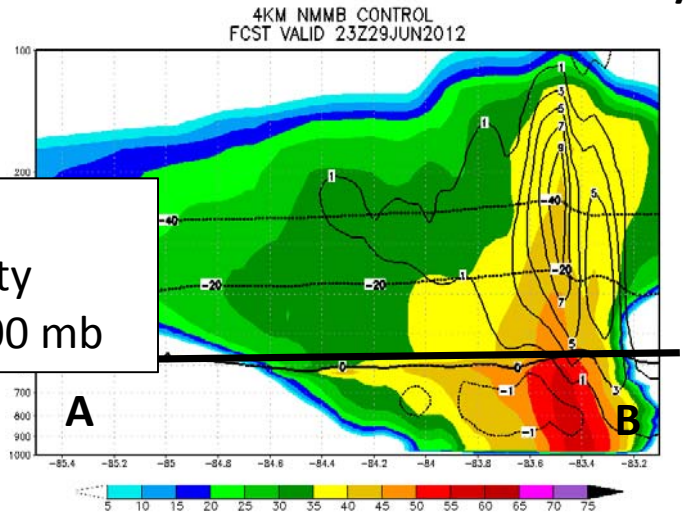
Upgraded Micro-physics

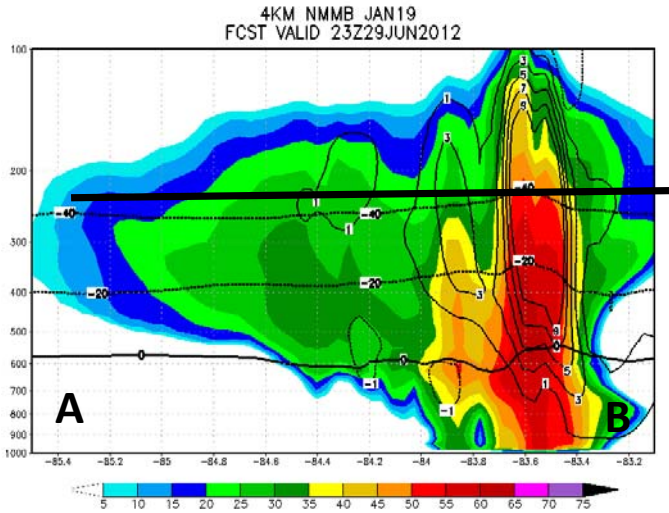




08h/23Z

50 dBZ reflectivity below 600 mb



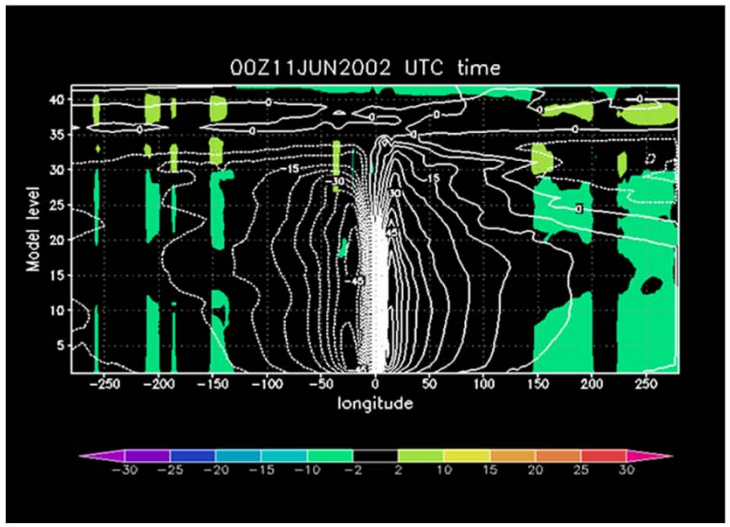


50+ dBZ reflectivity up to 250mb

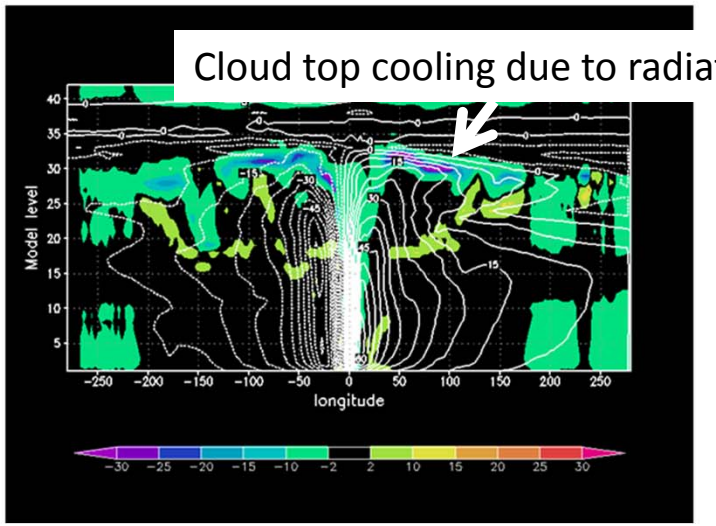
Upgraded SW/LW radiation schemes
(GFDL radiation to RRTMG)

GFDL radiation schemes have problems of proper representations of cloud-radiation interactions, especially net cloud top cooling and net cloud base warming.

HWRF radiation package



RRTMG radiation package



Priority cases for 2014 implementation tests

Landfalling storms

2010: Earl(07l), Mattew(15l)
2011: Harvey(08l), Irene(09l), Lee(13l), Nate(15l),
2012: Carlotta(03e),Paul(16e), Debby(04l), Ernesto(05l), Isaac(09l), Sandy(18l)
2013: Raymond(17e), Sonia(18e), Dorian(04l), Ingrid(10l), Karen(12l)
17 storms

Storms which perform bad

Frank(09e, 2010), Eugene(05e, 2011), Hector(08e, 2012) Dalia(04e, 2013)
4 storms

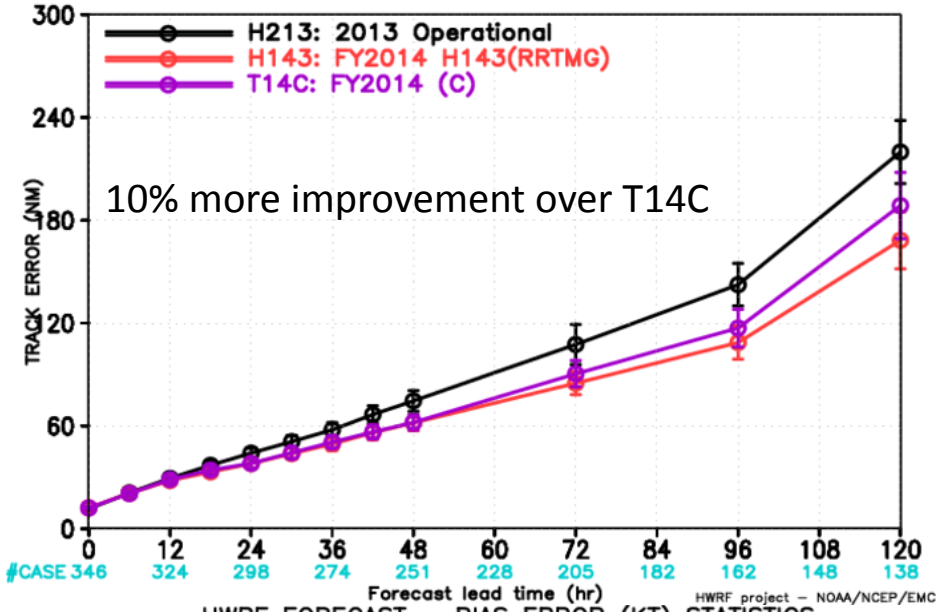
Storms which perform well

Katia(12l,2011), Leslie(12l,2012), Erik(05e, 2013), Flossie(06e, 2013)
4 storms

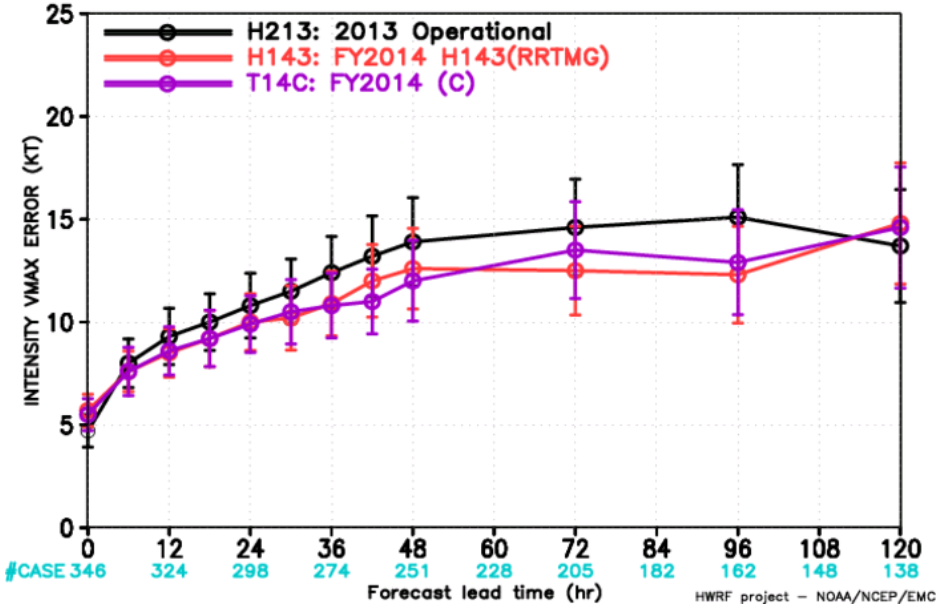
Total priority cases: 25 storms

Verification stats for RRTM-G test (H143)

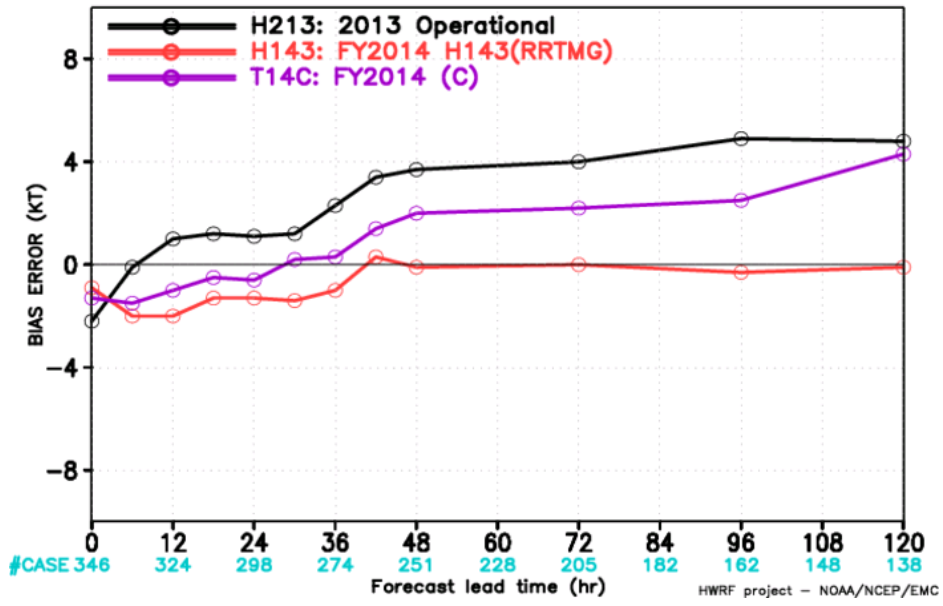
HWRF FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION H213, H143 & T14C ATL



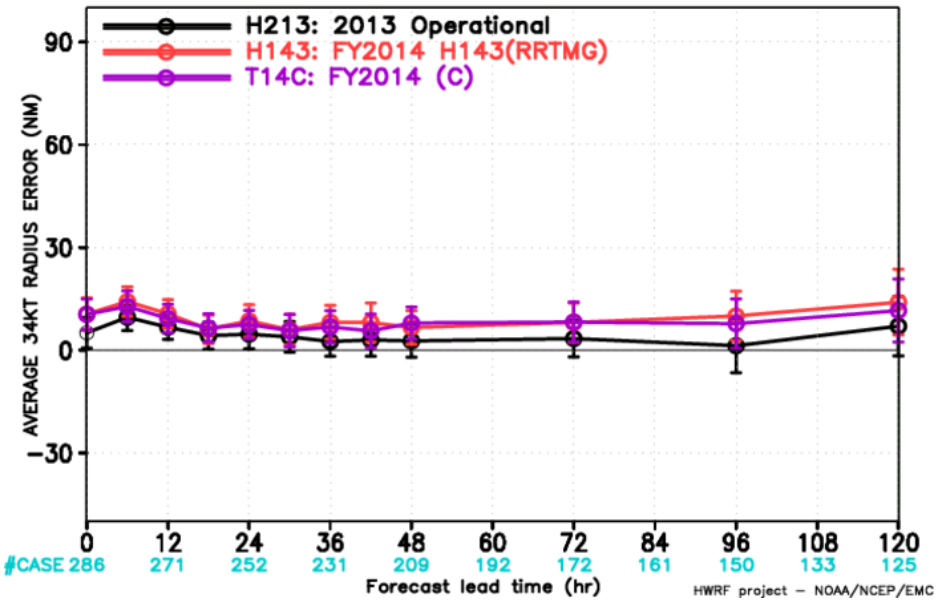
HWRF FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION H213, H143 & T14C ATL

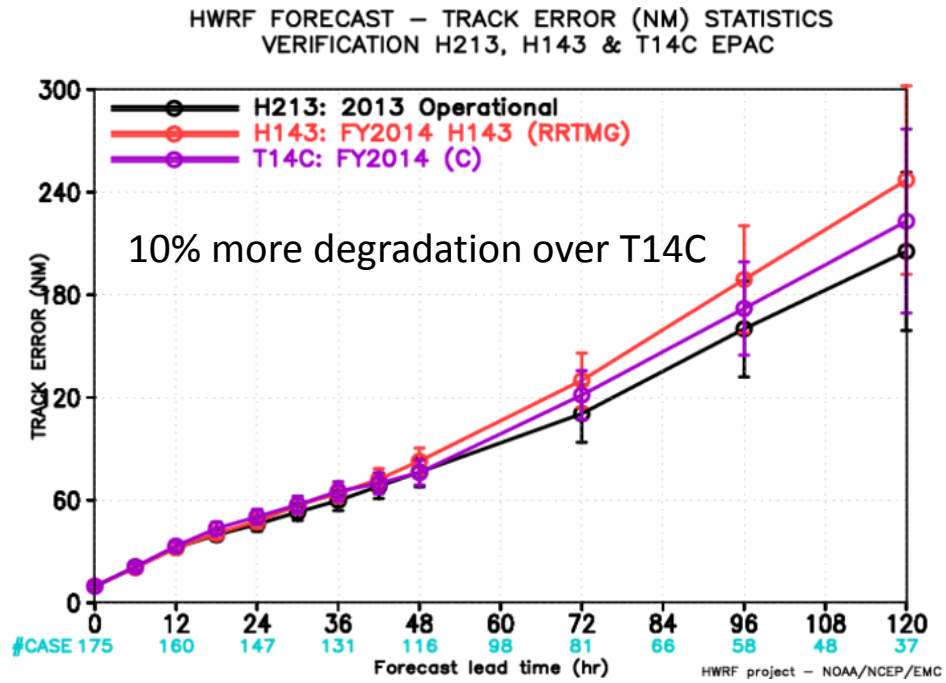


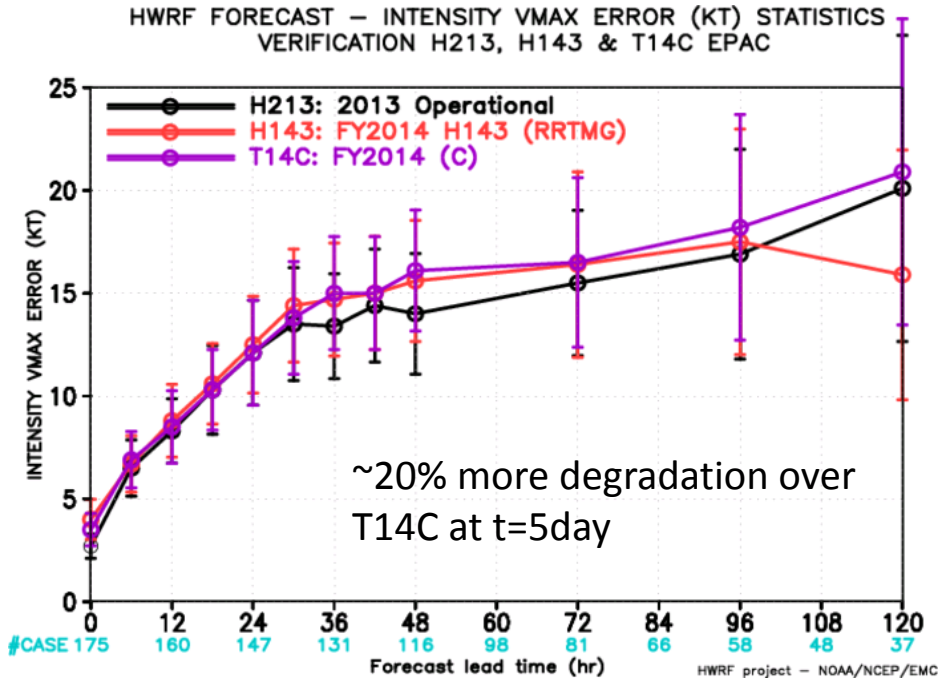
HWRF FORECAST – BIAS ERROR (KT) STATISTICS
VERIFICATION H213, H143 & T14C ATL

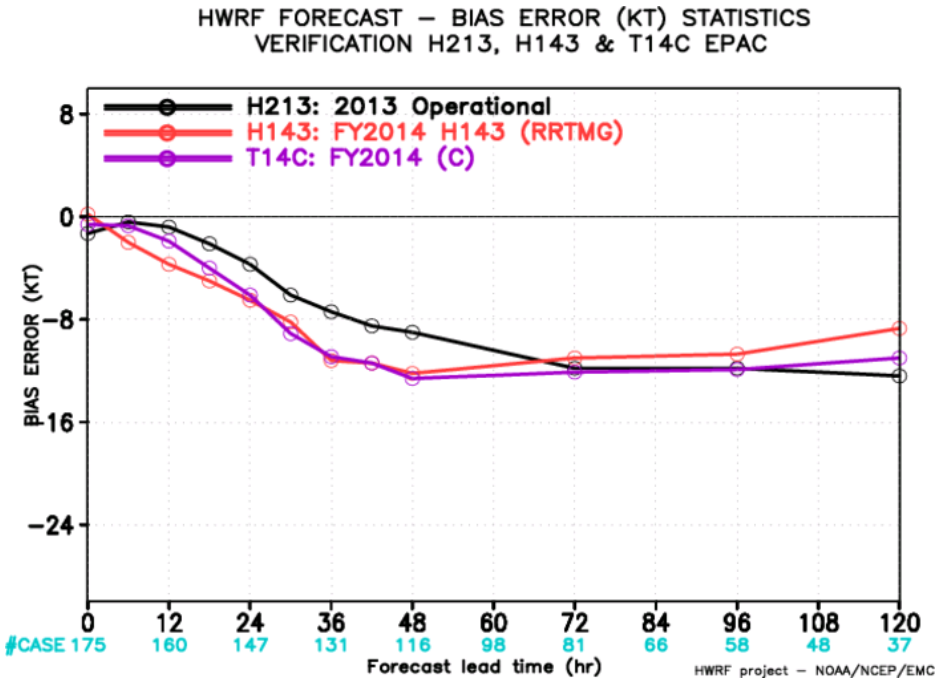


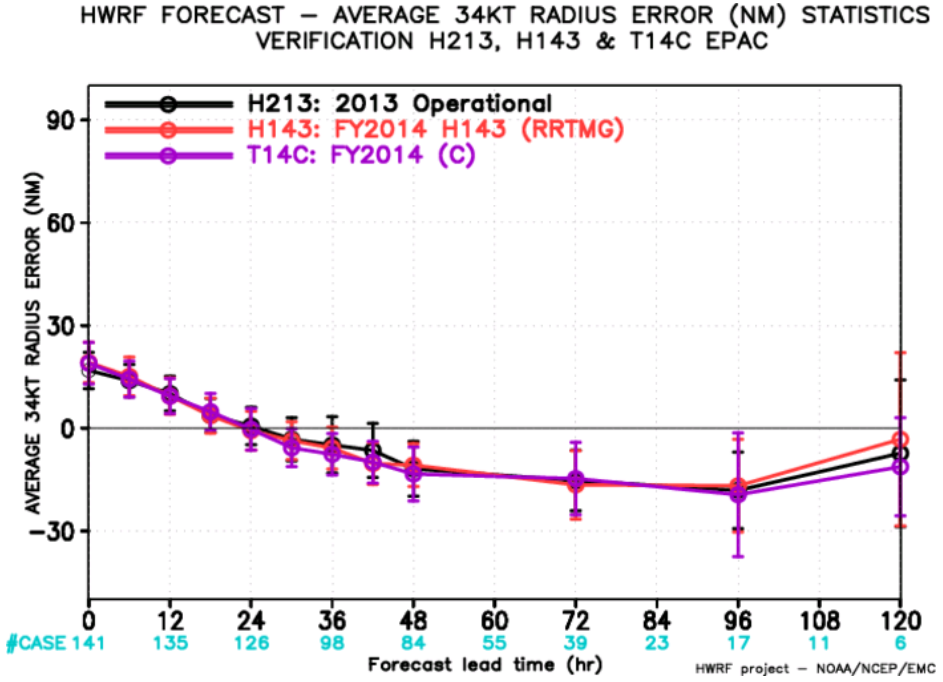
HWRF FORECAST – AVERAGE 34KT RADIUS ERROR (NM) STATISTICS
VERIFICATION H213, H143 & T14C ATL



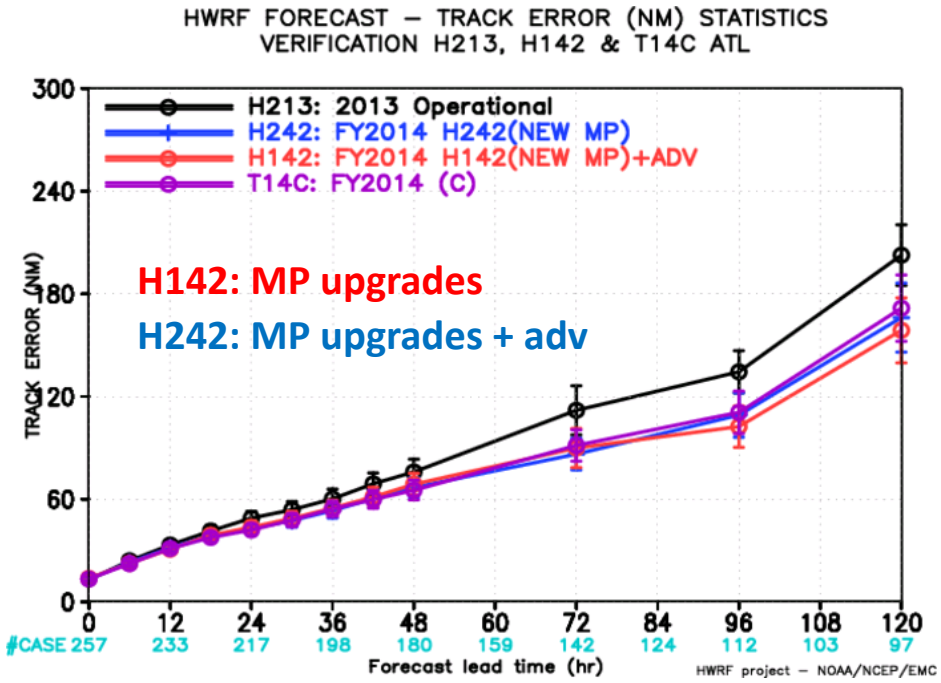

HWRF FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION H213, H143 & T14C EPAC
H213: 2013 Operational
H143: FY2014 H143 (RRTMG)
T14C: FY2014 (C)
10% more degradation over T14C
TRACK ERROR (NM)
#CASE 175 160 147 131 116 98 81 66 58 48 37
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC

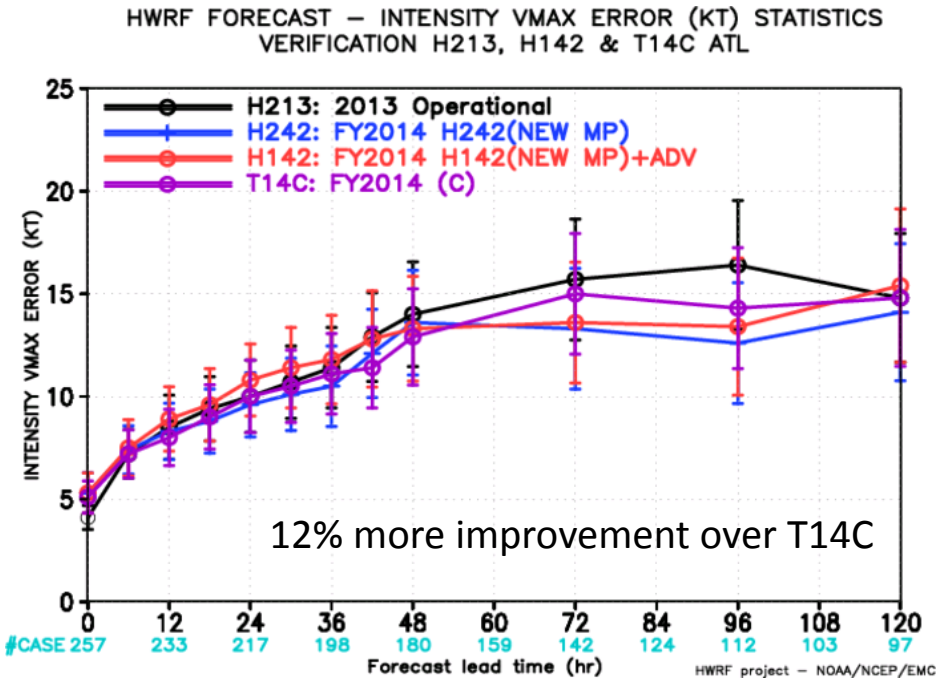

HWRF FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION H213, H143 & T14C EPAC
H213: 2013 Operational
H143: FY2014 H143 (RRTMG)
T14C: FY2014 (C)
~20% more degradation over T14C at t=5day
INTENSITY VMAX ERROR (KT)
#CASE 175 160 147 131 116 98 81 66 58 48 37
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC

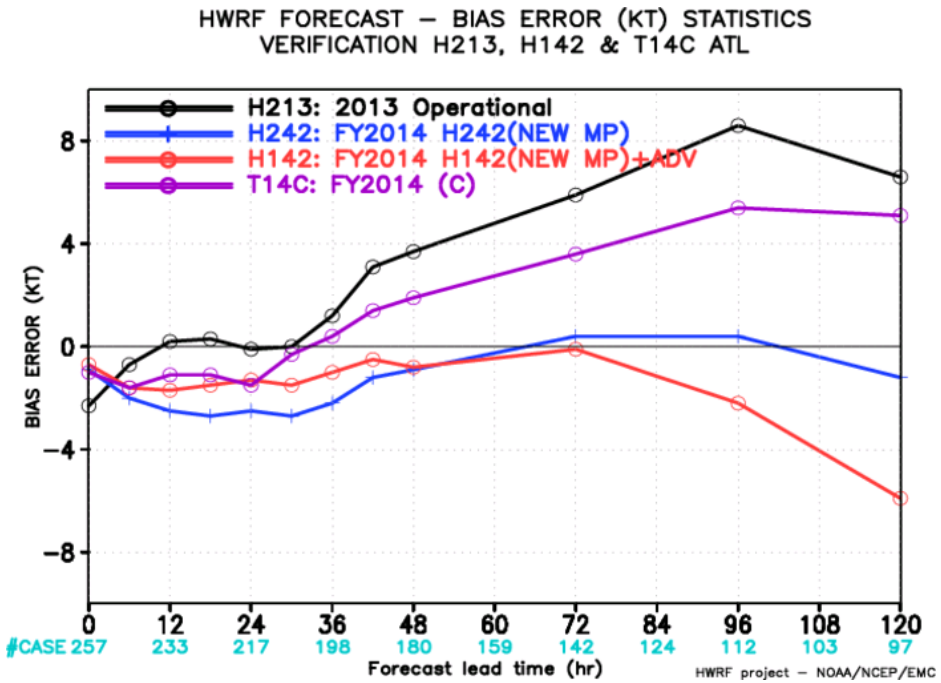

HWRF FORECAST – BIAS ERROR (KT) STATISTICS
VERIFICATION H213, H143 & T14C EPAC
H213: 2013 Operational
H143: FY2014 H143 (RRTMG)
T14C: FY2014 (C)
BIAS ERROR (KT)
#CASE 175 160 147 131 116 98 81 66 58 48 37
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC


HWRF FORECAST – AVERAGE 34KT RADIUS ERROR (NM) STATISTICS
VERIFICATION H213, H143 & T14C EPAC
H213: 2013 Operational
H143: FY2014 H143 (RRTMG)
T14C: FY2014 (C)
AVERAGE 34KT RADIUS ERROR (NM)
#CASE 141 135 126 98 84 55 39 23 17 11 6
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC

Verification stats for NEW MP test (H142)


HWRF FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION H213, H142 & T14C ATL
H213: 2013 Operational
H242: FY2014 H242(NEW MP)
H142: FY2014 H142(NEW MP)+ADV
T14C: FY2014 (C)
H142: MP upgrades
H242: MP upgrades + adv
TRACK ERROR (NM)
#CASE 257 233 217 198 180 159 142 124 112 103 97
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC


HWRF FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION H213, H142 & T14C ATL
H213: 2013 Operational
H242: FY2014 H242(NEW MP)
H142: FY2014 H142(NEW MP)+ADV
T14C: FY2014 (C)
INTENSITY VMAX ERROR (KT)
12% more improvement over T14C
#CASE 257 233 217 198 180 159 142 124 112 103 97
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC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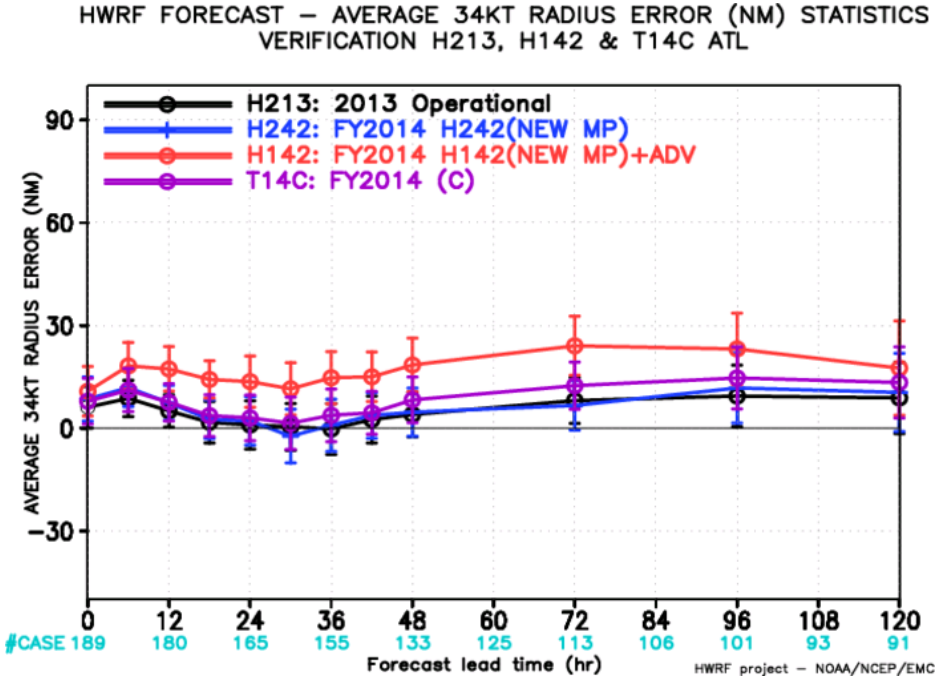
H213: 2013 Operational
H242: FY2014 H242(NEW MP)
H142: FY2014 H142(NEW MP)+ADV
T14C: FY2014 (C)
BIAS ERROR (KT)
#CASE 257 233 217 198 180 159 142 124 112 103 97
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC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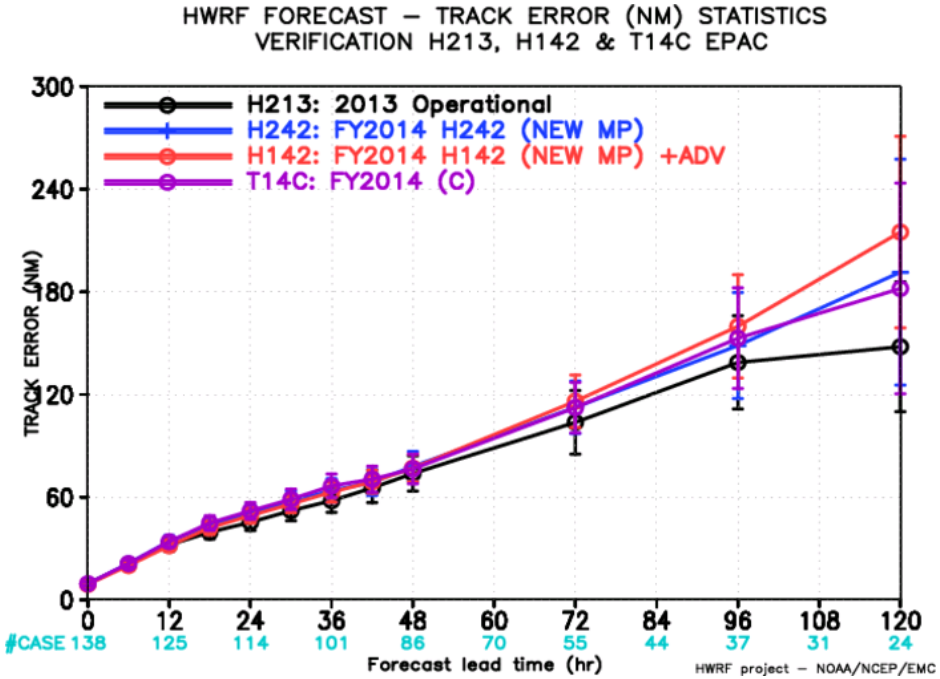
H242: FY2014 H242(NEW MP)
H142: FY2014 H142(NEW MP)+ADV
T14C: FY2014 (C)
AVERAGE 34KT RADIUS ERROR (NM)
#CASE 189 180 165 155 133 125 113 106 101 93 91
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC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T14C: FY2014 (C)
TRACK ERROR (NM)
#CASE 138 125 114 101 86 70 55 44 37 31 24
Forecast lead time (hr)
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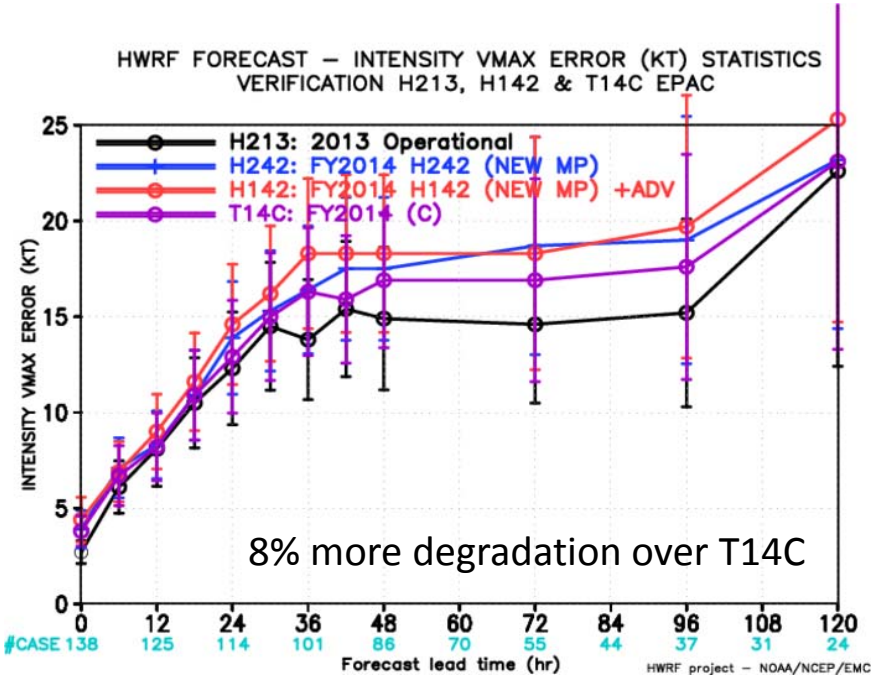
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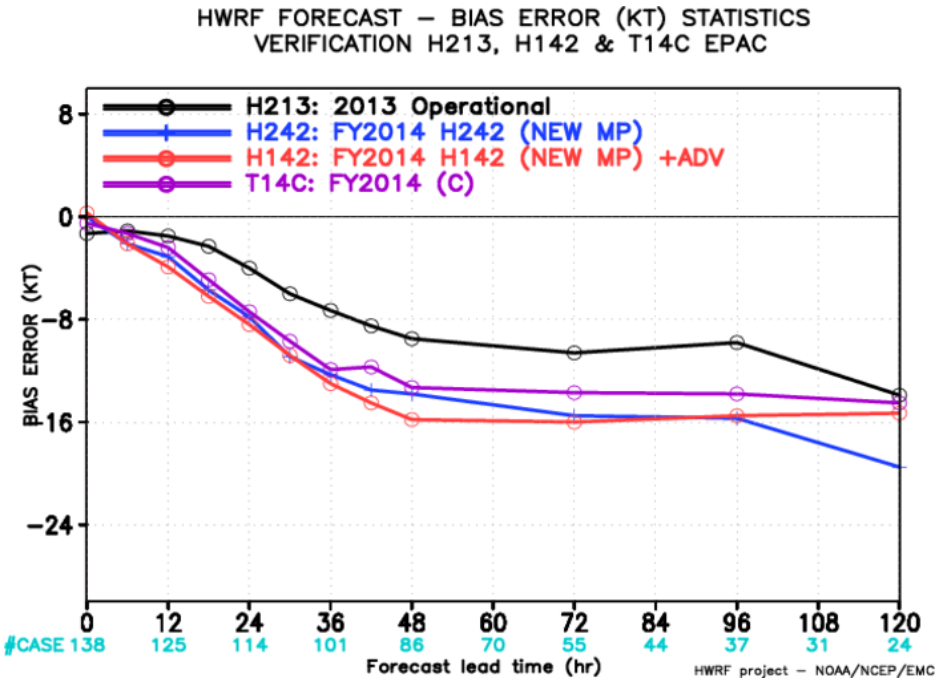
H142: FY2014 H142 (NEW MP) +ADV
T14C: FY2014 (C)
INTENSITY VMAX ERROR (KT)
8% more degradation over T14C
#CASE 138 125 114 101 86 70 55 44 37 31 24
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC


HWRF FORECAST – BIAS ERROR (KT) STATISTICS
VERIFICATION H213, H142 & T14C EPAC
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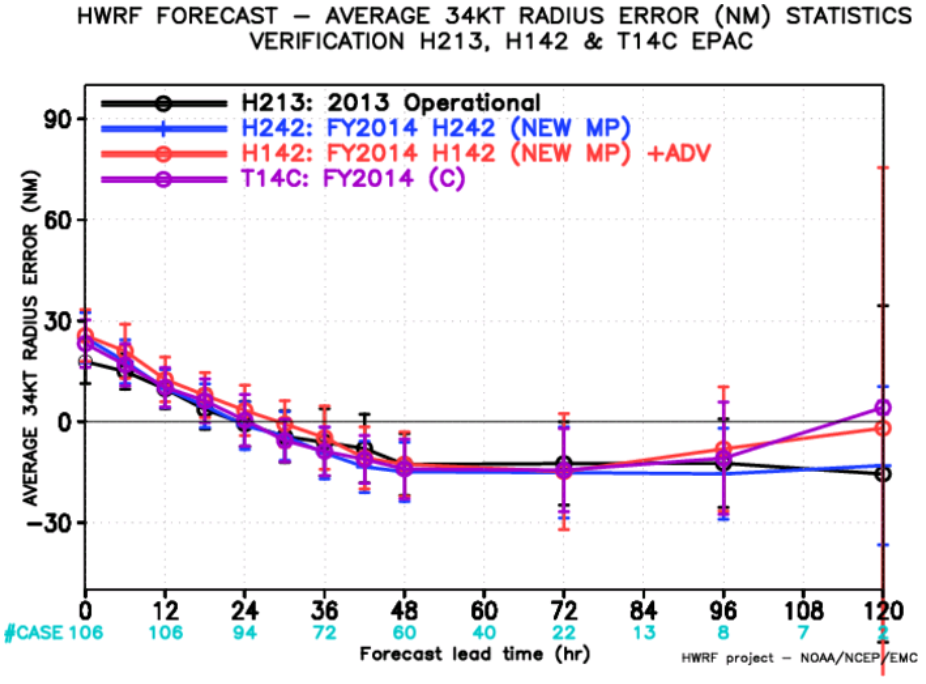
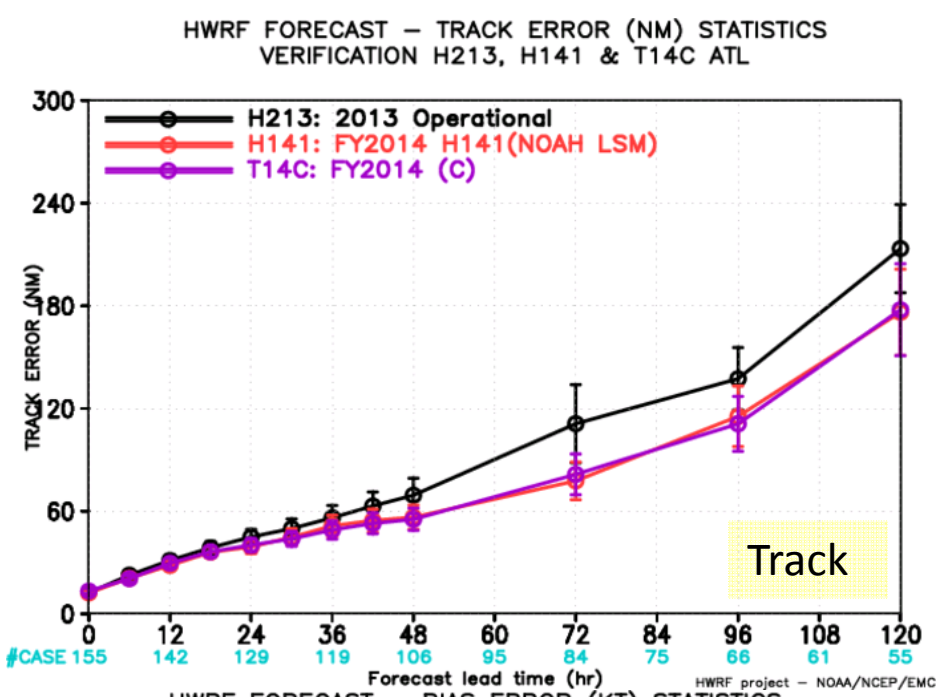
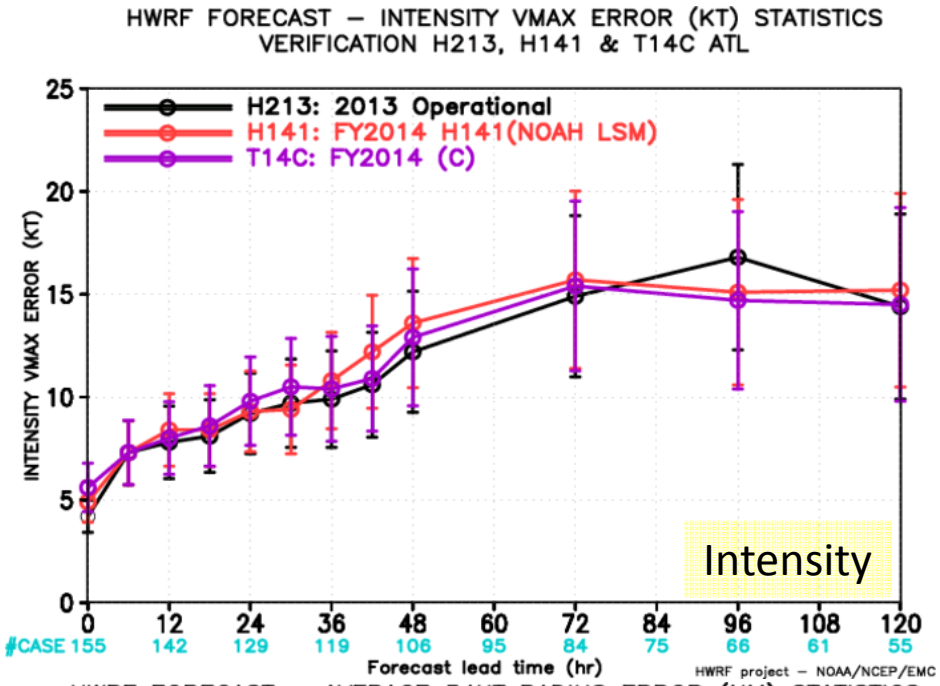
H242: FY2014 H242 (NEW MP)
H142: FY2014 H142 (NEW MP) +ADV
T14C: FY2014 (C)
BIAS ERROR (KT)
#CASE 138 125 114 101 86 70 55 44 37 31 24
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC

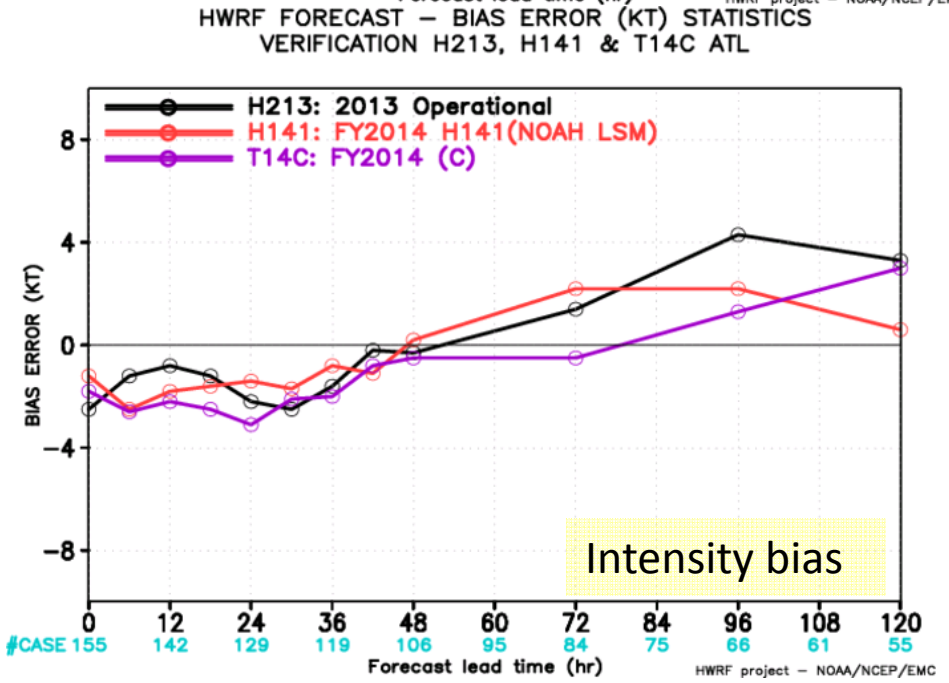

HWRF FORECAST – AVERAGE 34KT RADIUS ERROR (NM) STATISTICS
VERIFICATION H213, H142 & T14C EPAC
H213: 2013 Operational
H242: FY2014 H242 (NEW MP)
H142: FY2014 H142 (NEW MP) +ADV
T14C: FY2014 (C)
AVERAGE 34KT RADIUS ERROR (NM)
#CASE 106 106 94 72 60 40 22 13 8 7 2
Forecast lead time (hr)
HWRF project – NOAA/NCEP/EMC

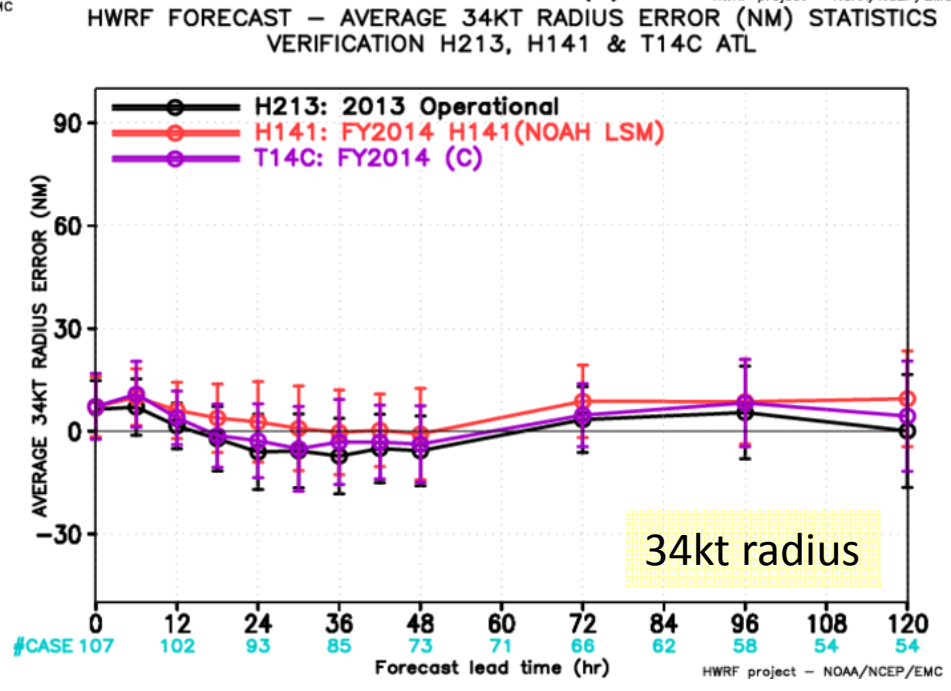
Verification stats for NOAH LSM test (H141)

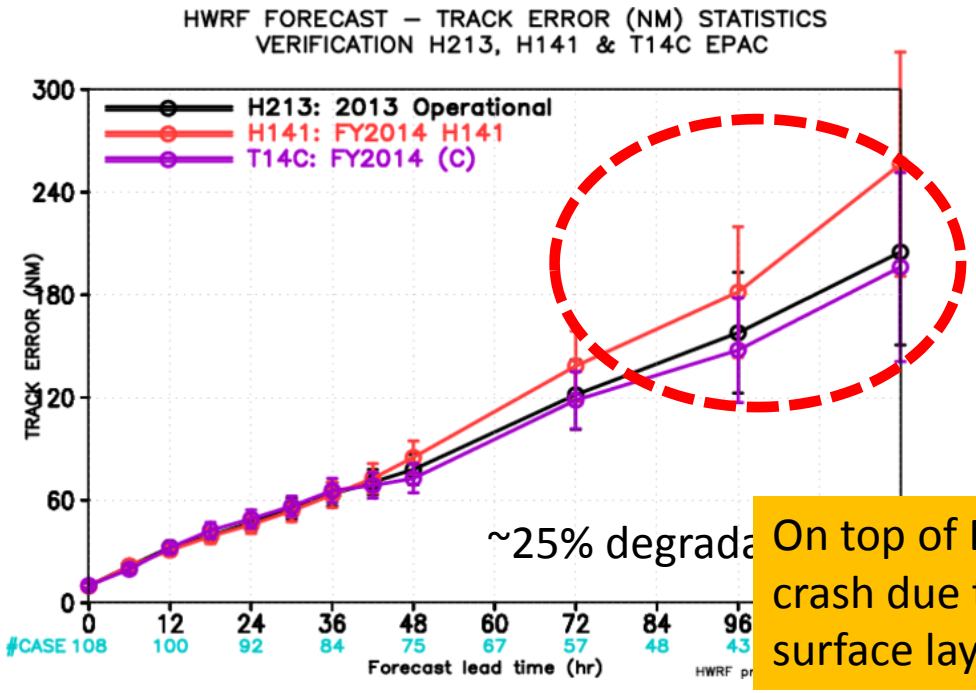
Only for priority cases

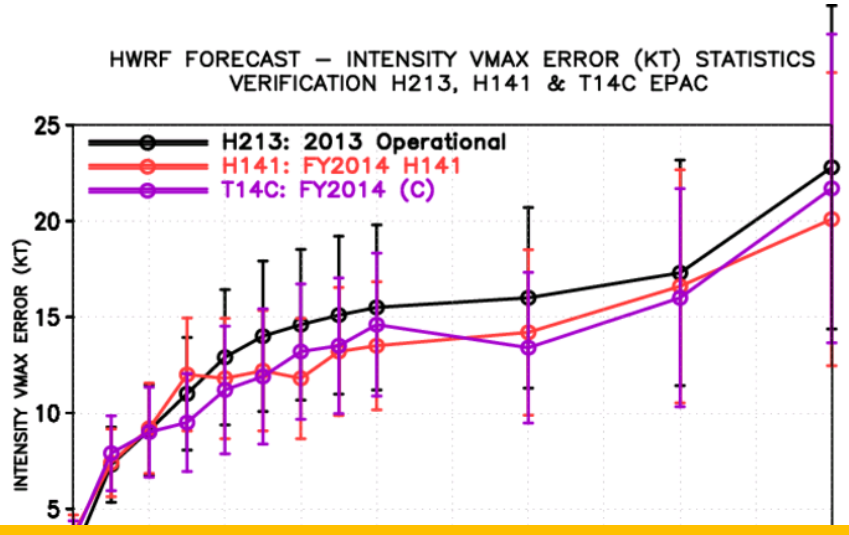

HWRF FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION H213, H141 & T14C ATL
H213: 2013 Operational
H141: FY2014 H141(NOAH LSM)
T14C: FY2014 (C)
TRACK ERROR (NM)
Forecast lead time (hr)
#CASE 155 142 129 119 106 95 84 75 66 61 55
HWRF project – NOAA/NCEP/EMC
Track


HWRF FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION H213, H141 & T14C ATL
H213: 2013 Operational
H141: FY2014 H141(NOAH LSM)
T14C: FY2014 (C)
INTENSITY VMAX ERROR (KT)
Forecast lead time (hr)
#CASE 155 142 129 119 106 95 84 75 66 61 55
HWRF project – NOAA/NCEP/EMC
Intensity


HWRF FORECAST – BIAS ERROR (KT) STATISTICS
VERIFICATION H213, H141 & T14C ATL
H213: 2013 Operational
H141: FY2014 H141(NOAH LSM)
T14C: FY2014 (C)
BIAS ERROR (KT)
Forecast lead time (hr)
#CASE 155 142 129 119 106 95 84 75 66 61 55
HWRF project – NOAA/NCEP/EMC
Intensity bias

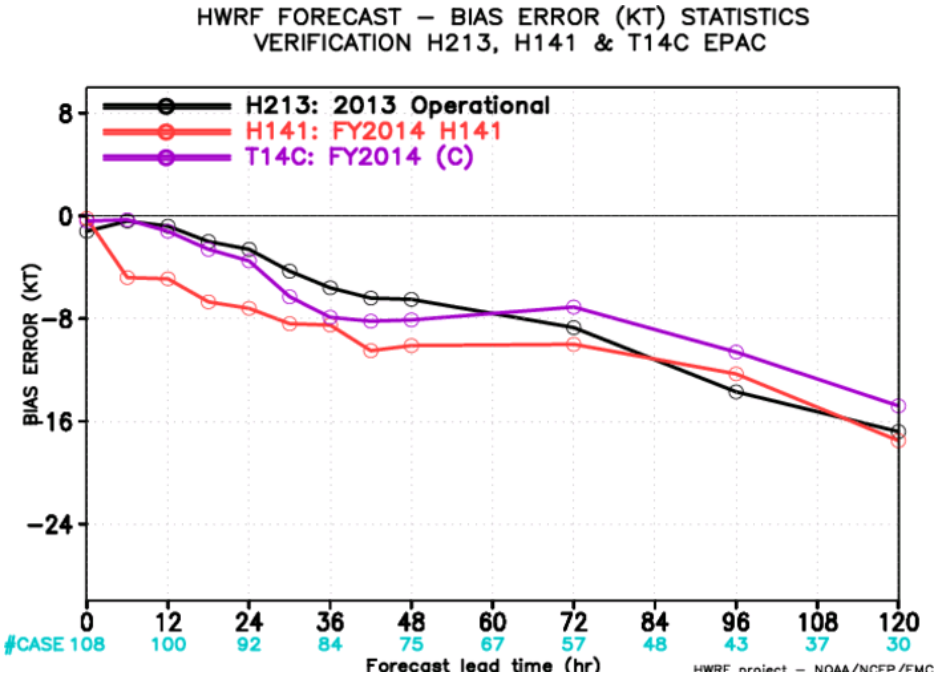

HWRF FORECAST – AVERAGE 34KT RADIUS ERROR (NM) STATISTICS
VERIFICATION H213, H141 & T14C ATL
H213: 2013 Operational
H141: FY2014 H141(NOAH LSM)
T14C: FY2014 (C)
AVERAGE 34KT RADIUS ERROR (NM)
Forecast lead time (hr)
#CASE 107 102 93 85 73 71 66 62 58 54 54
HWRF project – NOAA/NCEP/EMC
34kt radius

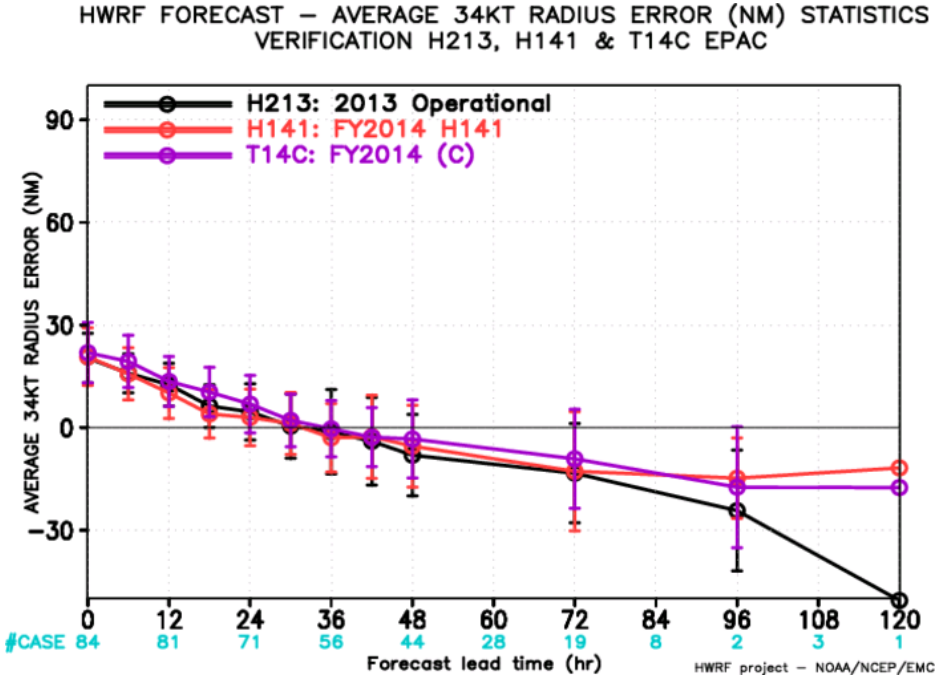




~25% degrada

On top of EP track degradation, there are several model crash due to a bug related to connection between GFDL surface layer physics and NOAH LSM





SUMMARY

Configuration		Max. Track % improvement		Max. Intensity % improvement	
		ATL	EP	ATL	EP
T14C over 2013 HWRF		+11%	+10%	~0%	~0%
H141 over T14C (NOAH LSM)		Model crashes by a bug related to the connection GFDL surface physics and NOAH land surface model. Debugging and fixing underway			
H142 (NEW MP)	H142 Separate species adv	+7%	-18%	+11%	-11%
	H242 CWM adv	+2%	-5%	+12%	-8%
H143 (RRTNG)		+10%	-11%	~0%	+20%