

Ensemble Forecasting of Tropical Cyclone Track in GEFS

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Presented by Xiqiong Zhou

EMC/NCEP/NWS/NOAA

Hurricane Ensemble Workshop

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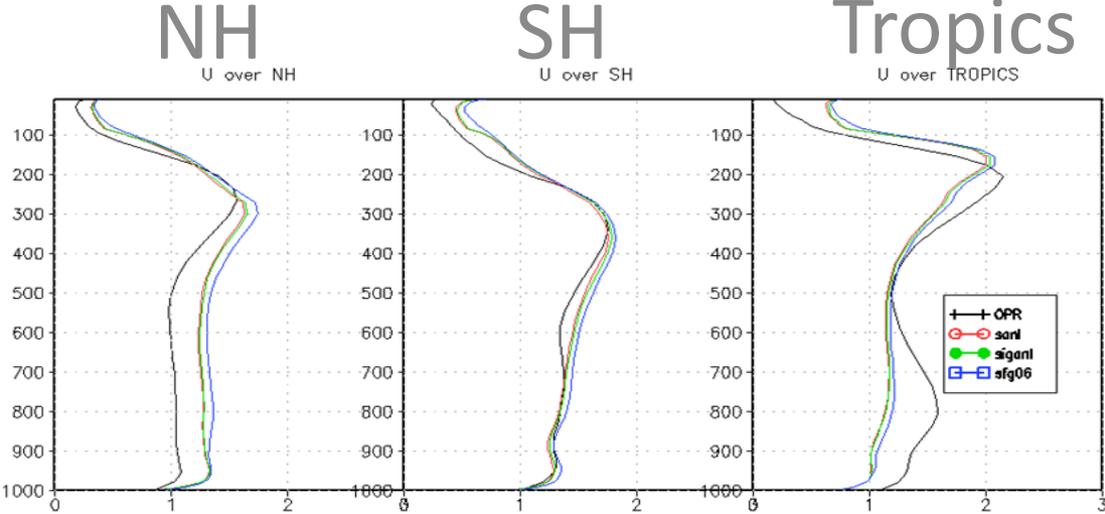
Outline

- GEFS upgrade
 - configuration
 - overall performance
 - TC track forecast
- Sensitivity study for degraded cases
 - cross test
- Conclusions

GEFS Upgrade

	V10.0.0 (OPR)	11.0.0 (PARA)
GFS Model	Euler, 2012	Semi-Lagrangian, 2015
Resolution 0-192 h	T254 (52km) L42 (hybrid)	T _L 574 (34km) L64 (hybrid)
Resolution 192-384 h	T190 (70km) L42 (hybrid)	T _L 382 (52km) L64 (hybrid)
Initialization Scheme	ETR	EnKF
Computational Cost	84 nodes (+ post process)	300 nodes 1 st segment 250 nodes 2 nd segment
Execution time	55 min	35 min 1 st segment 30 min 2 nd segment
Output resolution	1° x 1°	0.5° x 0.5° for 0-8 days 1° x 1° the rest
Output frequency	6h	3h the first 8 days; 6h the rest

Initial Perturbations from ETR and EnKF



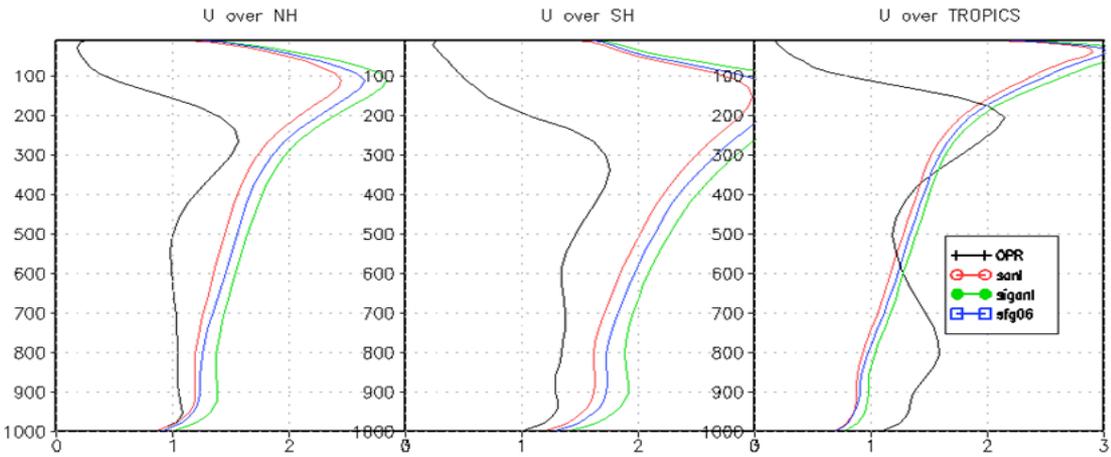
- Zonal wind

EnKF2.0.1
2015
implementation

EnKF Major upgrades:

- T254L42 to T574L64
- Use SPPT suite

2012
implementation



TC Initial Perturbations in GEFS (Liu et al. 2000, 2006)

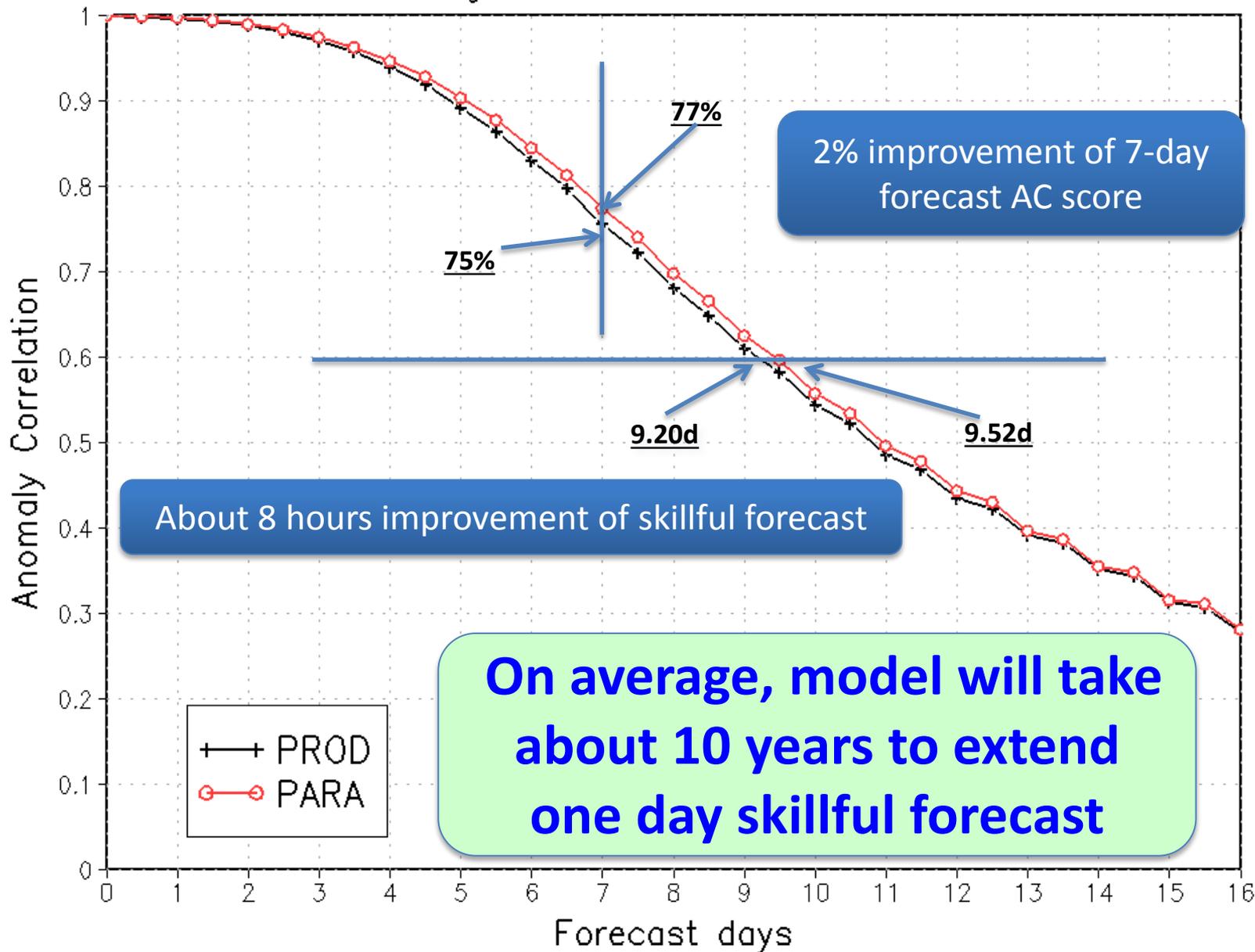
- 6 hour forecast ensemble (ETR-> EnKF)
- TC is separated from Environment flow
- TC component is centered to the observed location
- TC perturbations are added to analysis

$$P = C \cdot (X - Xc) \cdot \|Xc\| / \|X - Xc\|$$

C=0.05, Xc is the control, $\|X\|$ is the square root of the sum of X over the whole hurricane area

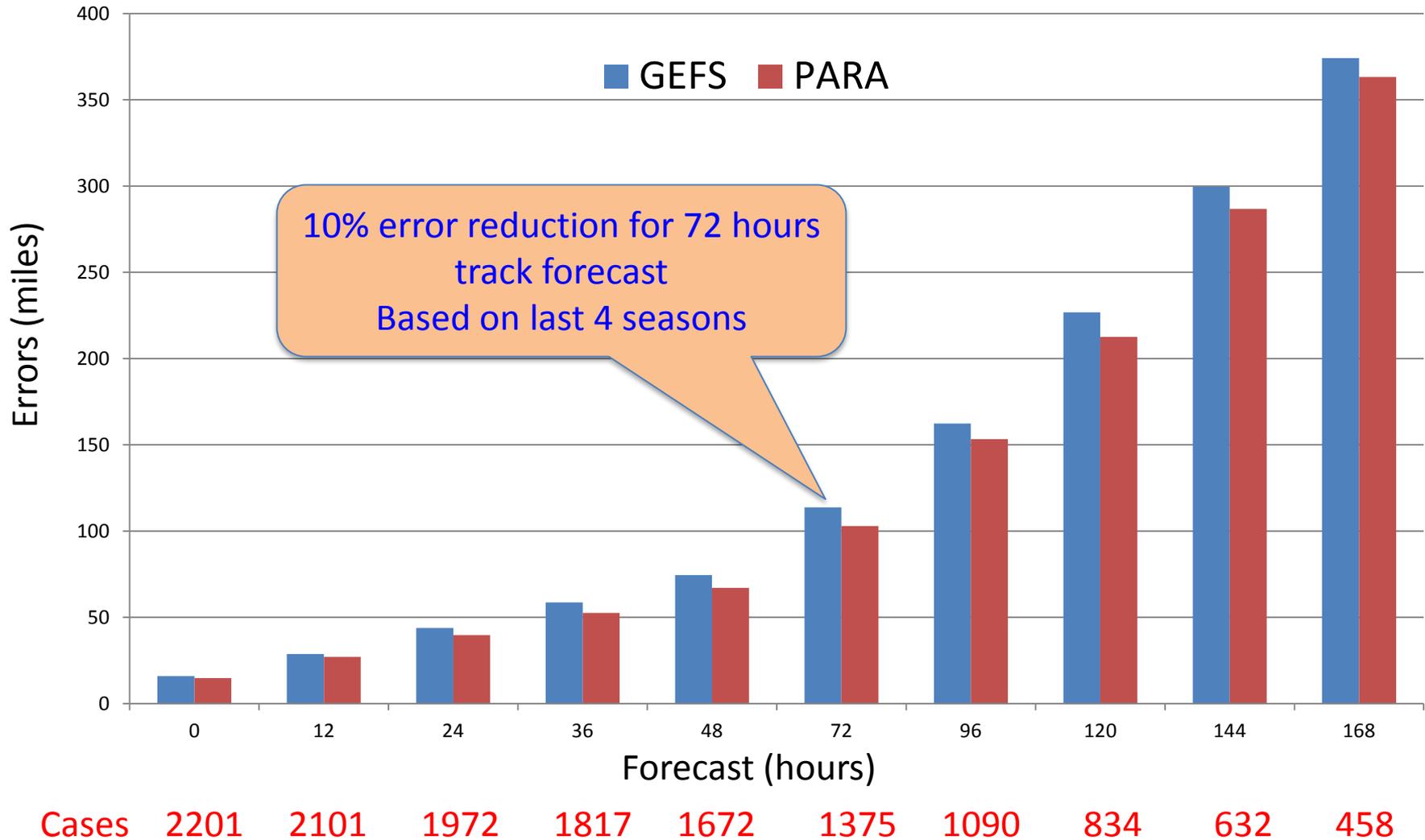
685 cases

Northern Hemisphere 500hPa Height Ensemble Mean Anomaly Correlation Average For 20130516 – 20150331

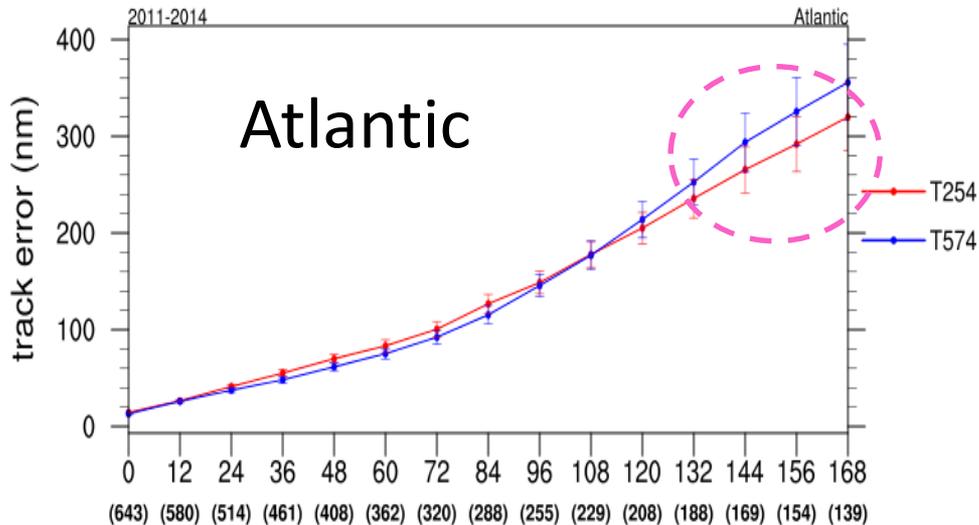


TS track errors for 2011-2014 seasons

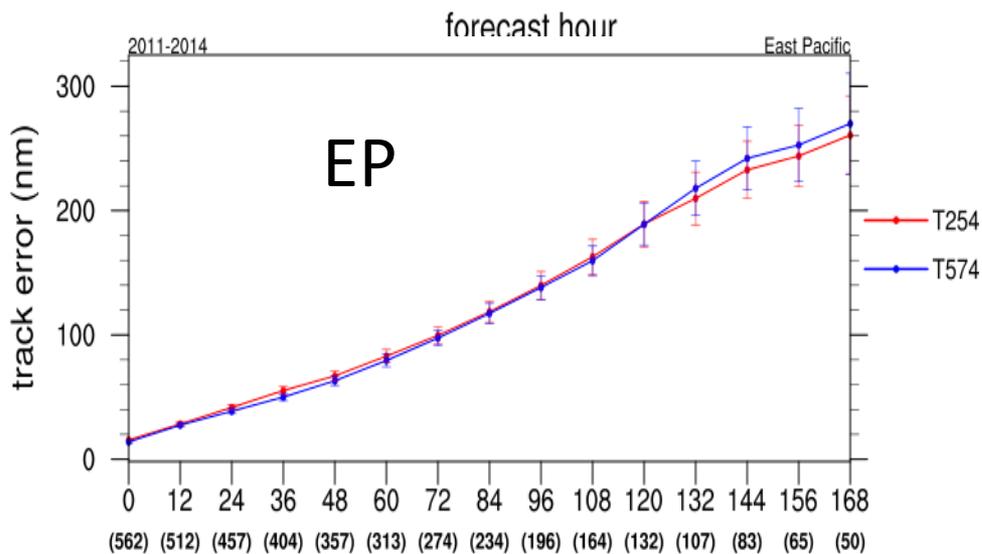
Statistics for all basins



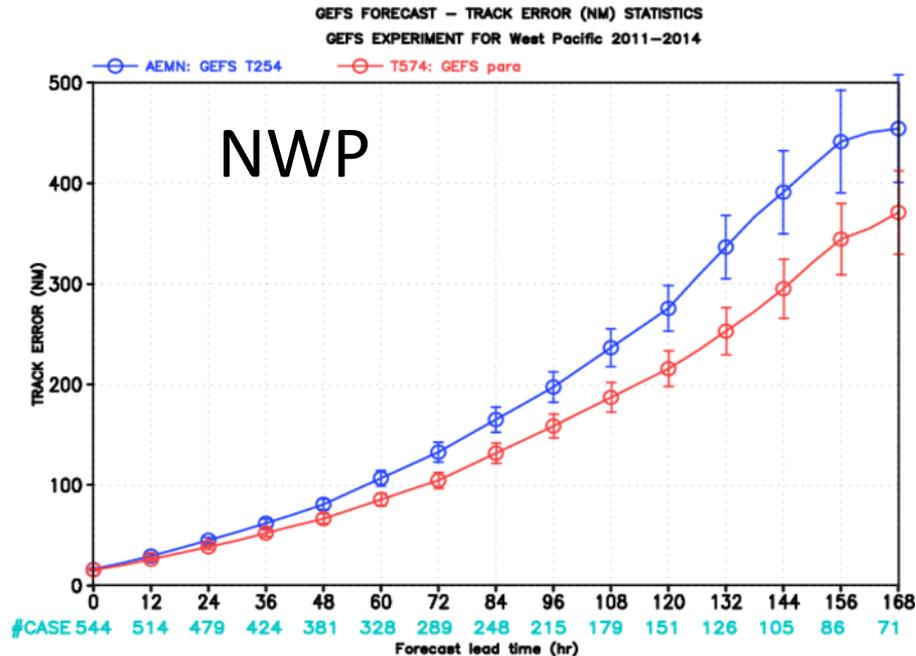
TS track errors for 2011-2014 seasons



[Courtesy of Andrew Penny \(NHC\)](#)



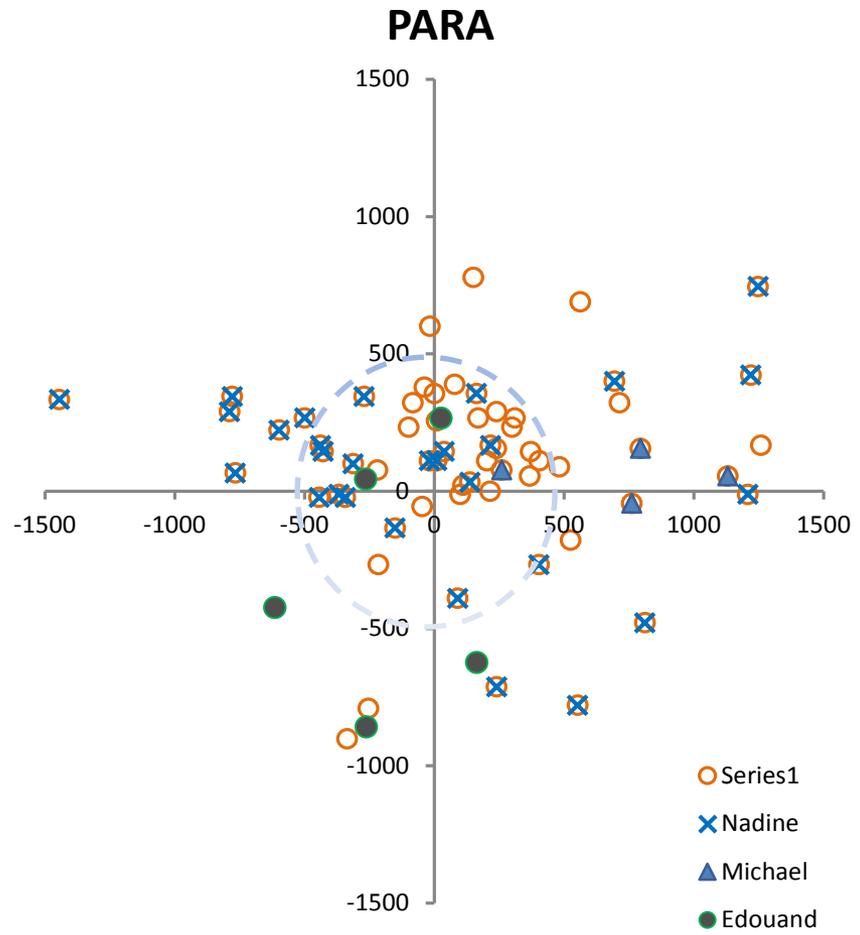
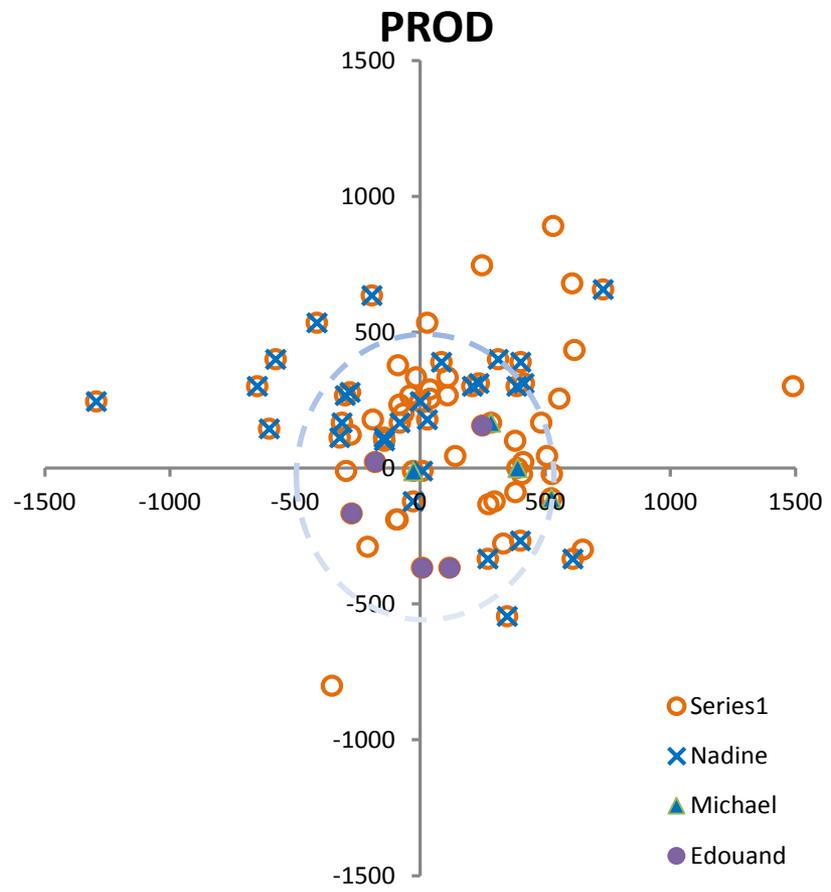
forecast hour
(# of cases)



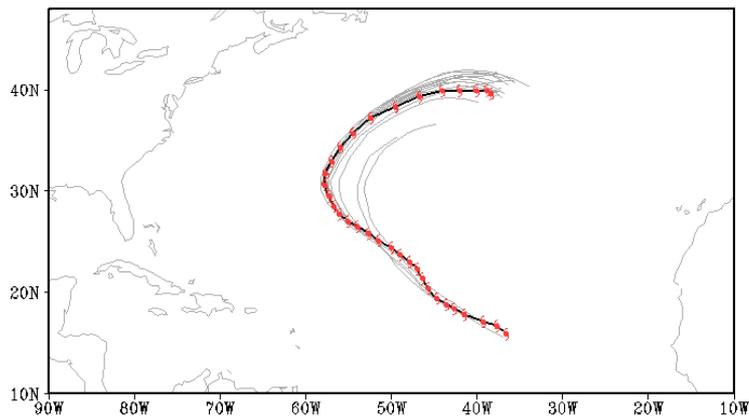
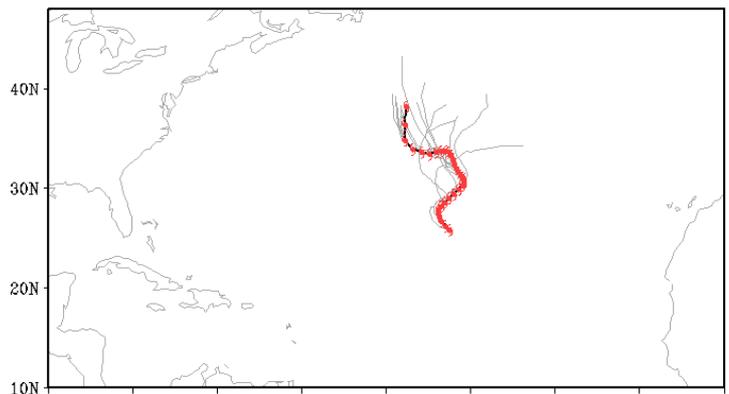
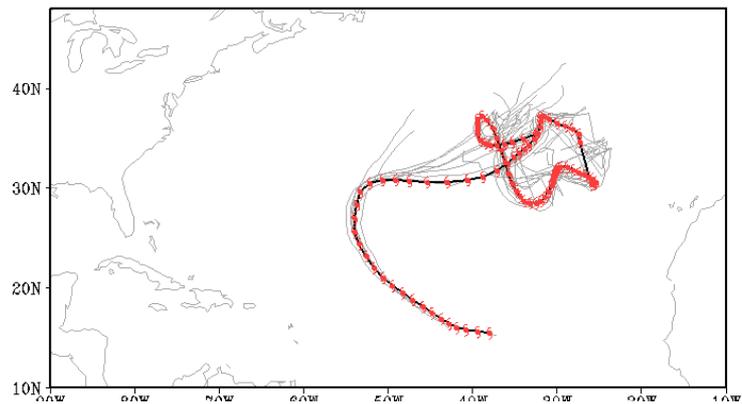
The deviation of TC location from the OBS over Atlantic

(2012-2014) 6 day FCST

Hurricane Nadine (2012) accounts for 30 in 77 total cases

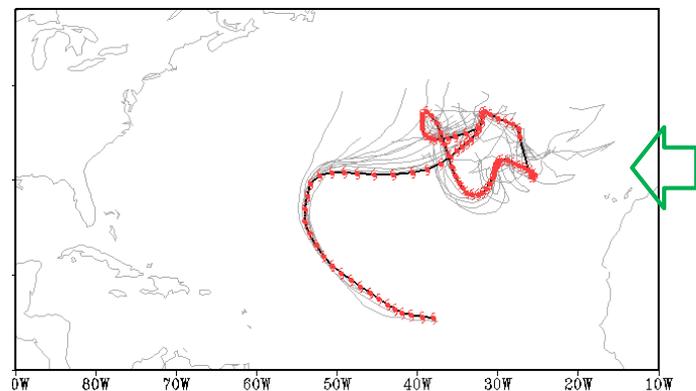


PROD

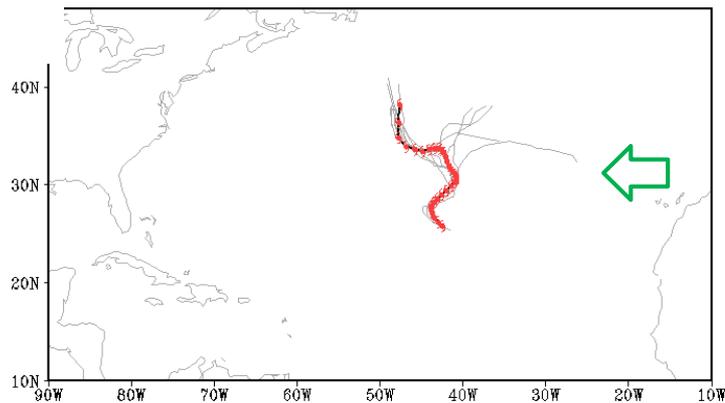


2012 Nadine (PARA)

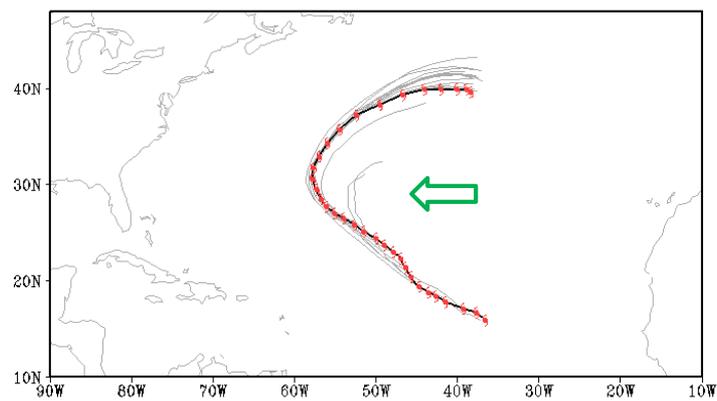
PARA



Nadine (2012)



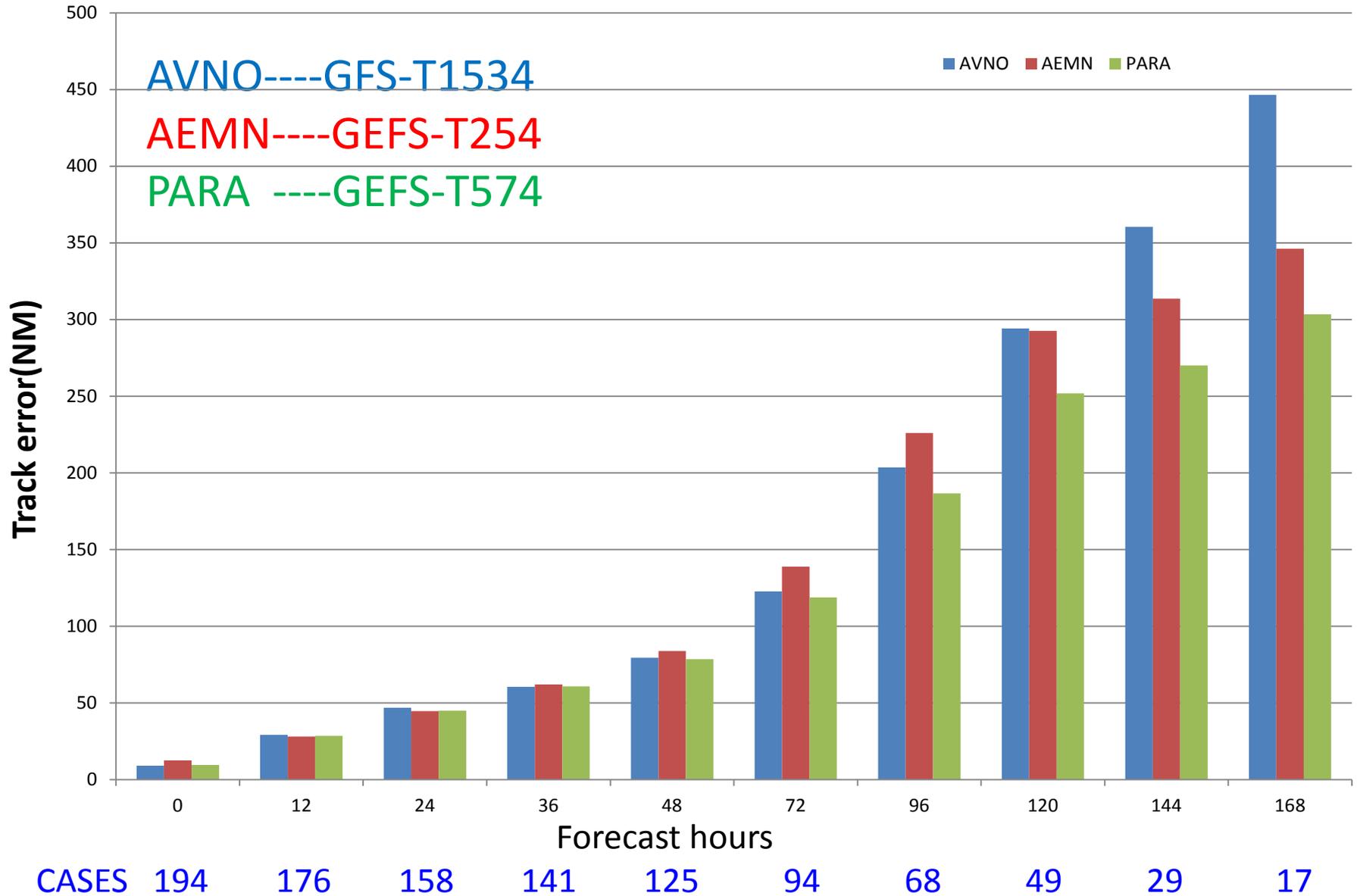
Michael (2012)



Edouard (2014)

Atlantic 2015

AL03-12, 07/08-11/09 GEF5-T574 in parallel @NCO

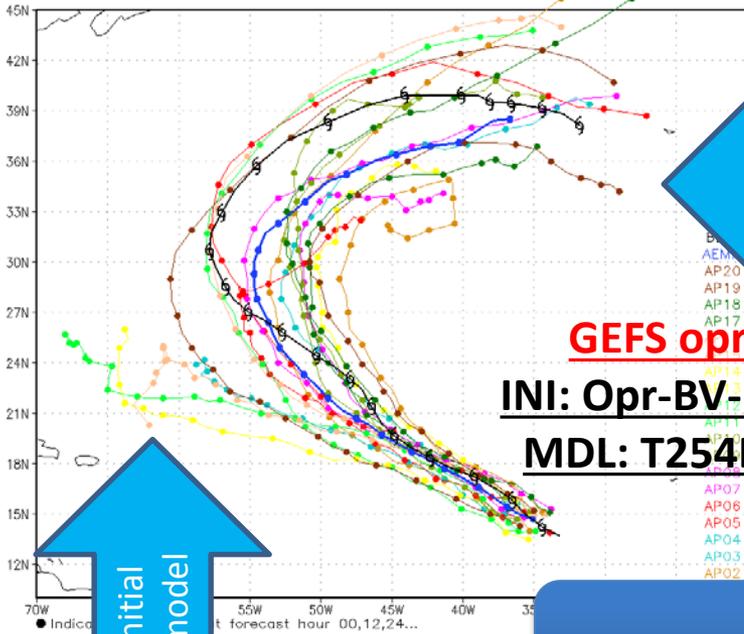


Cross testing (initial .vs model)

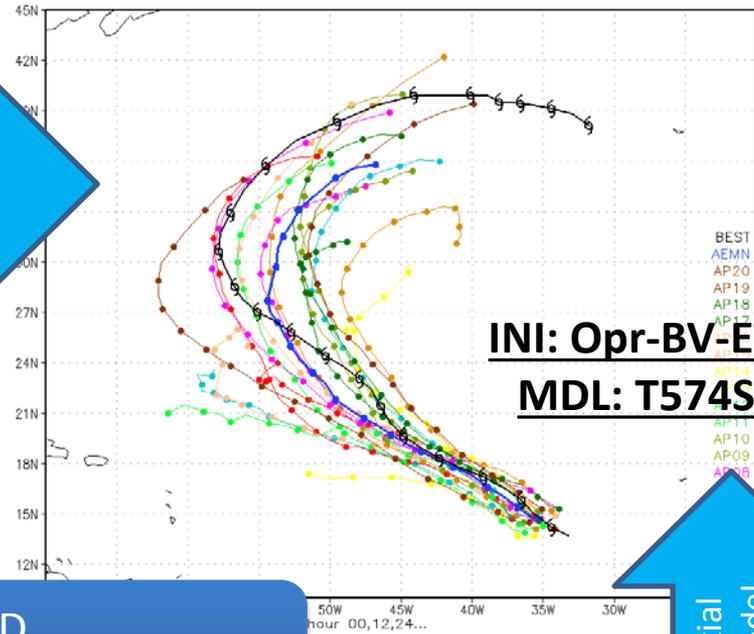
	PROD	PARA
Models	T254L42 (EU)	T574L64 (SL)
Analysis	PROD	PARA
(Initial Pert.)	(BV-ETR)	(EnKF)

- Test one: Prod (BV-ETR) and T254L42 (EU) - Opr
- Test two: Prod (BV-ETR) and T574L64 (SL)
- Test three: Para (EnKF) and T254L64 (EU)
- Test four: Para (EnKF) and T574L64 (SL) - Para

NCEP Ensemble Forecast TC Track Verification 2014091100



NCEP Ensemble Forecast TC Track Verification 2014091100

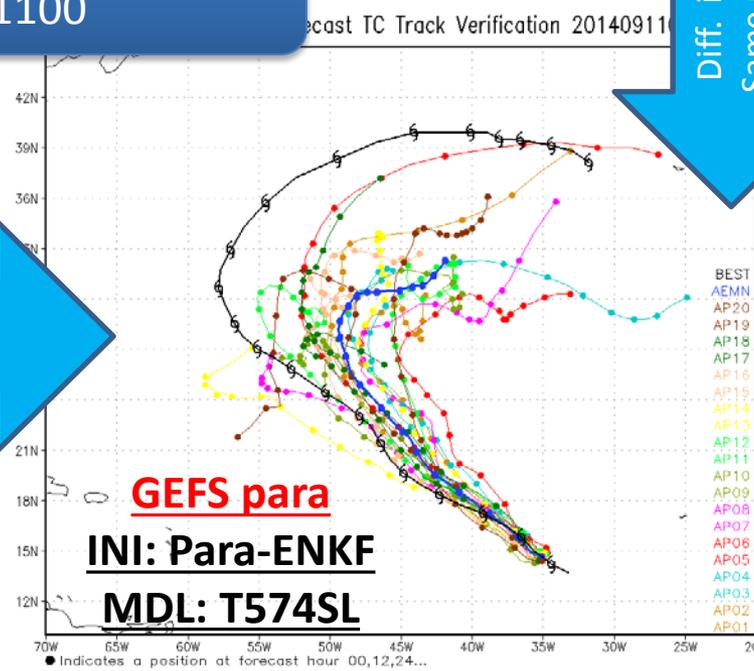
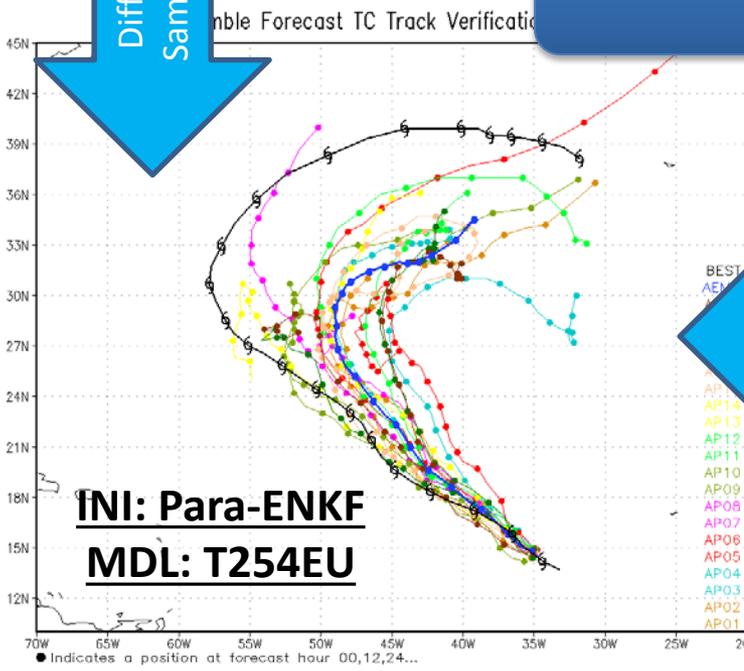


Same initial Diff. model

Diff. initial Same model

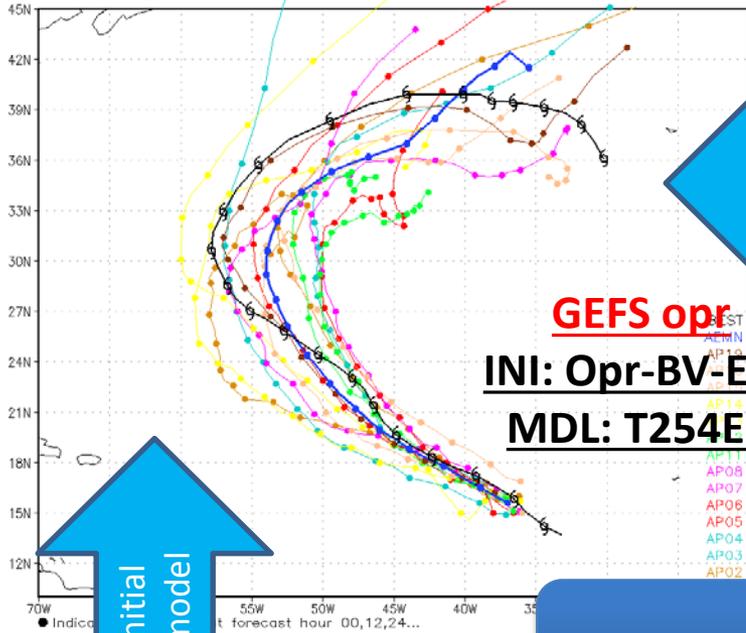
EDOUARD
Ini: 2014091100

Diff. initial Same model



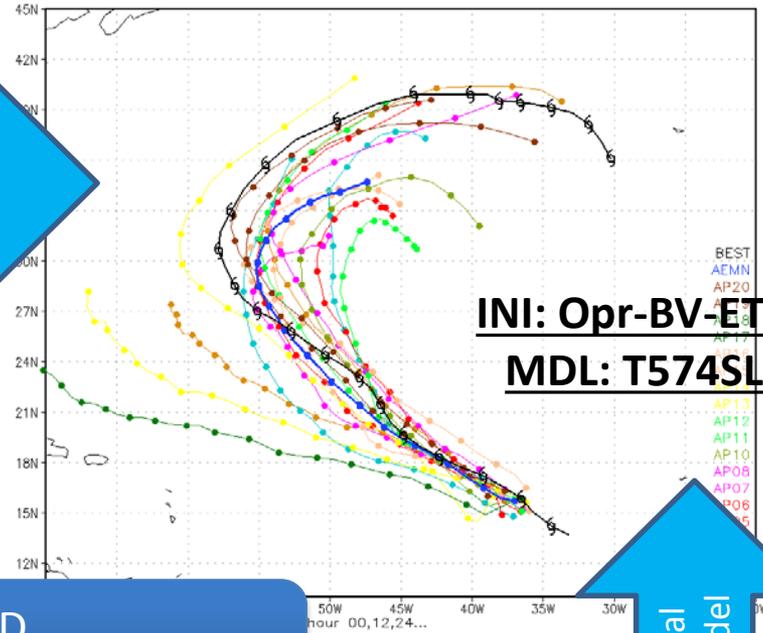
Same initial Diff. model

NCEP Ensemble Forecast TC Track Verification 2014091112



GEFS opr
INI: Opr-BV-ETR
MDL: T254EU

NCEP Ensemble Forecast TC Track Verification 2014091112



INI: Opr-BV-ETR
MDL: T574SL

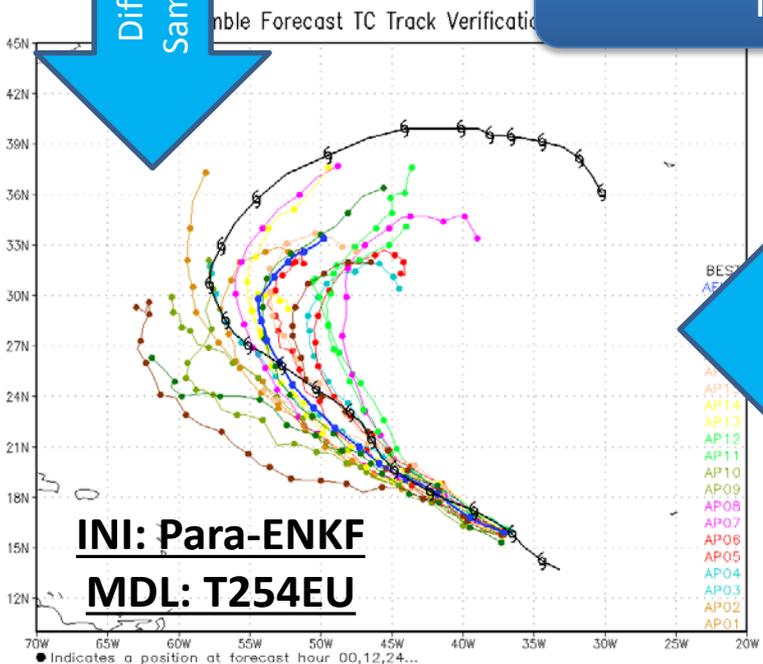
EDOUARD
Ini: 2014091112

Diff. initial
 Same model

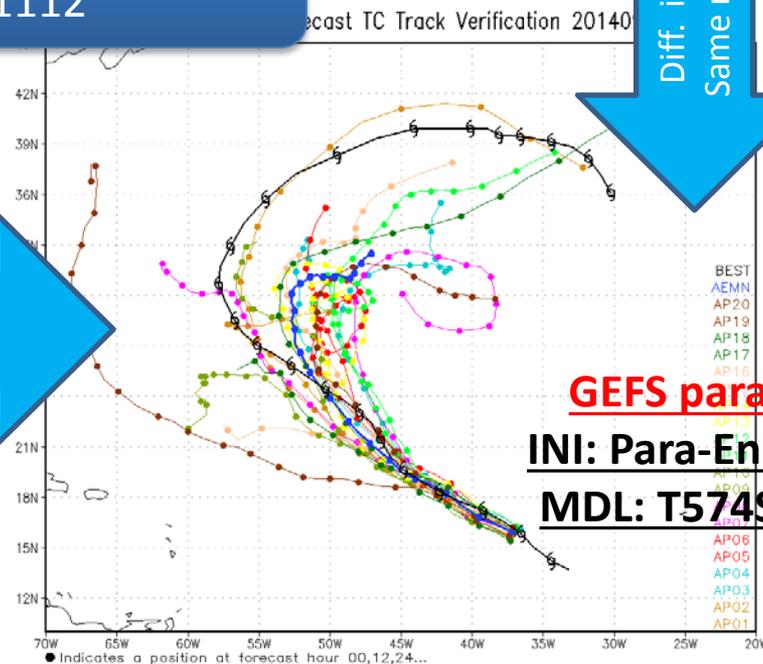
Same initial.
 Diff model

Diff. initial
 Same model

Same initial
 Diff. model



INI: Para-ENKF
MDL: T254EU

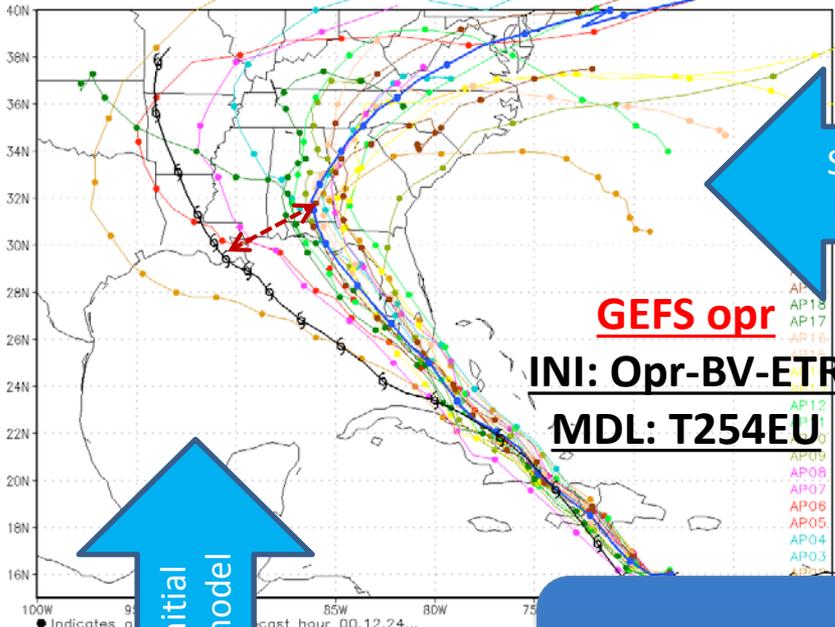


GEFS para
INI: Para-EnKF
MDL: T574SL

● Indicates a position at forecast hour 00,12,24...

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NCEP Ensemble Forecast TC Track Verification 2012082400

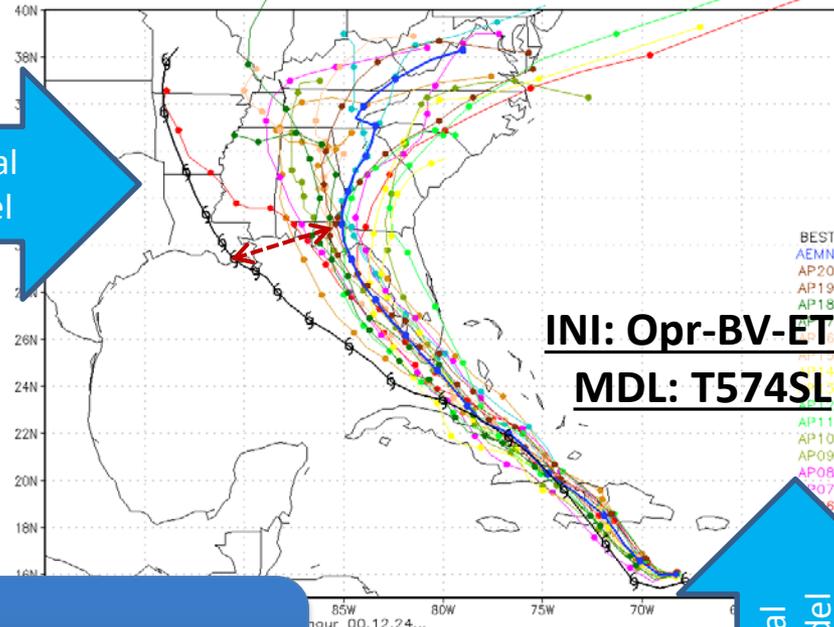


GEFS opr

INI: Opr-BV-ETR

MDL: T254EU

NCEP Ensemble Forecast TC Track Verification 2012082400



INI: Opr-BV-ETR

MDL: T574SL

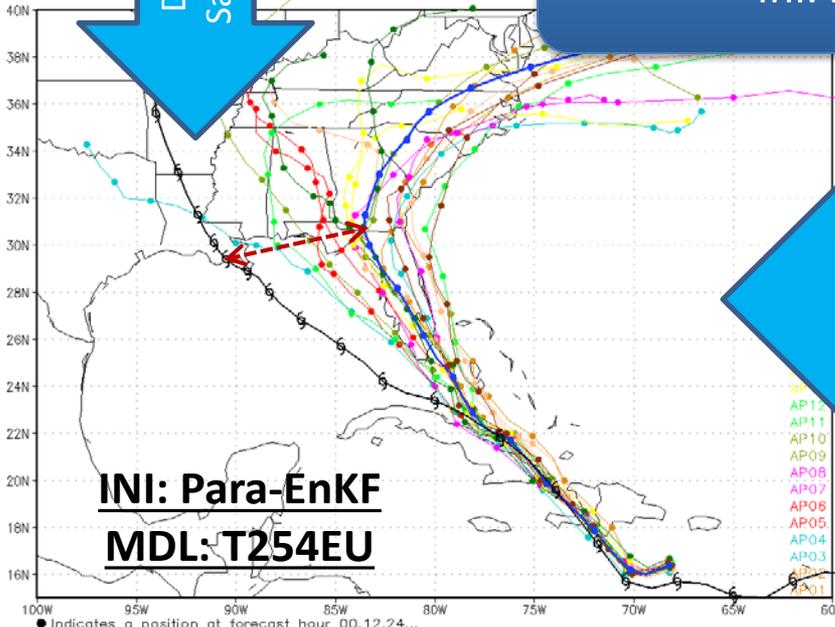
Same initial
Diff. model

Diff. initial
Same model

Diff. initial
Same model

ISAAC
Ini: 2012082400

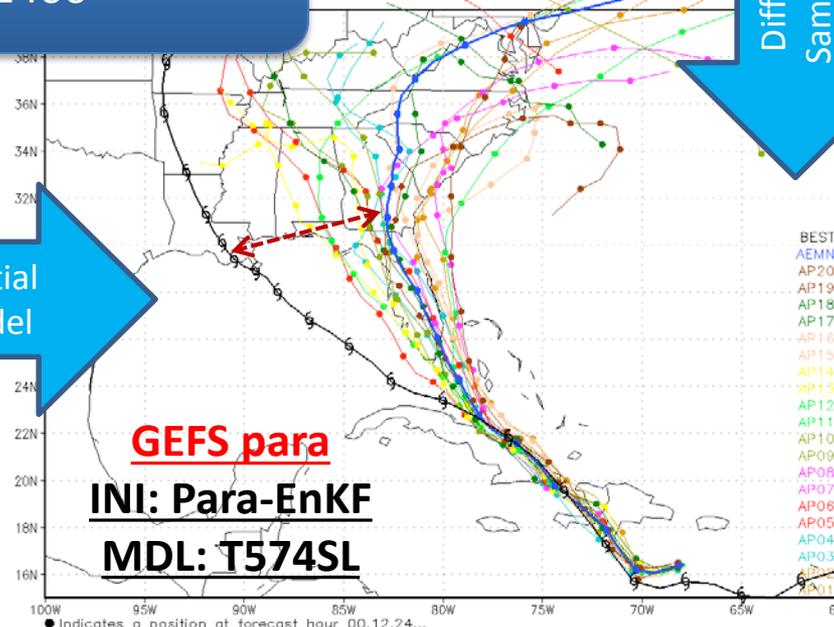
NCEP Ensemble Forecast TC Track Verification 2012082400



INI: Para-EnKF

MDL: T254EU

NCEP Ensemble Forecast TC Track Verification 2012082400



GEFS para

INI: Para-EnKF

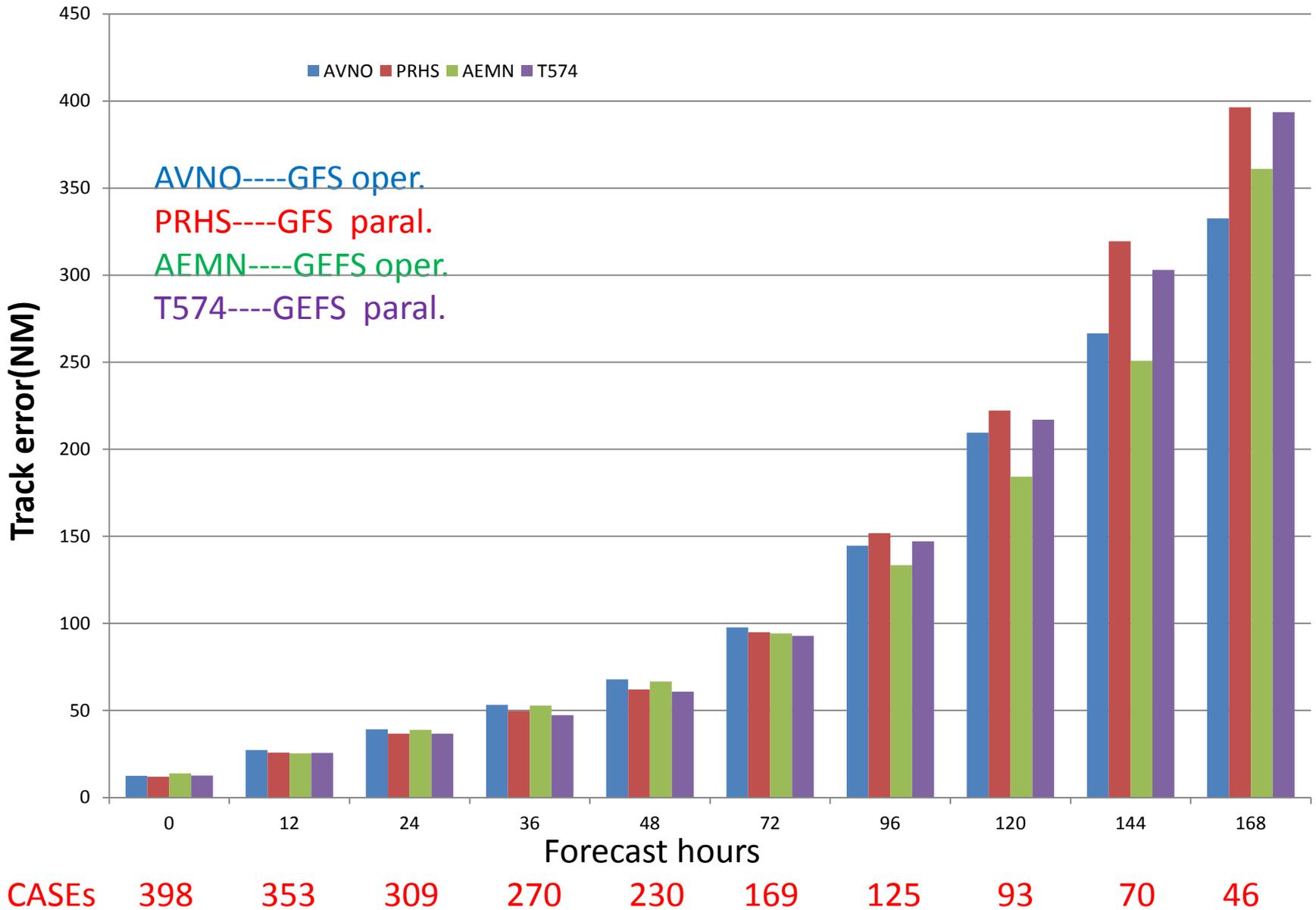
MDL: T574SL

Same initial
Diff. model

Summaries and Discussions

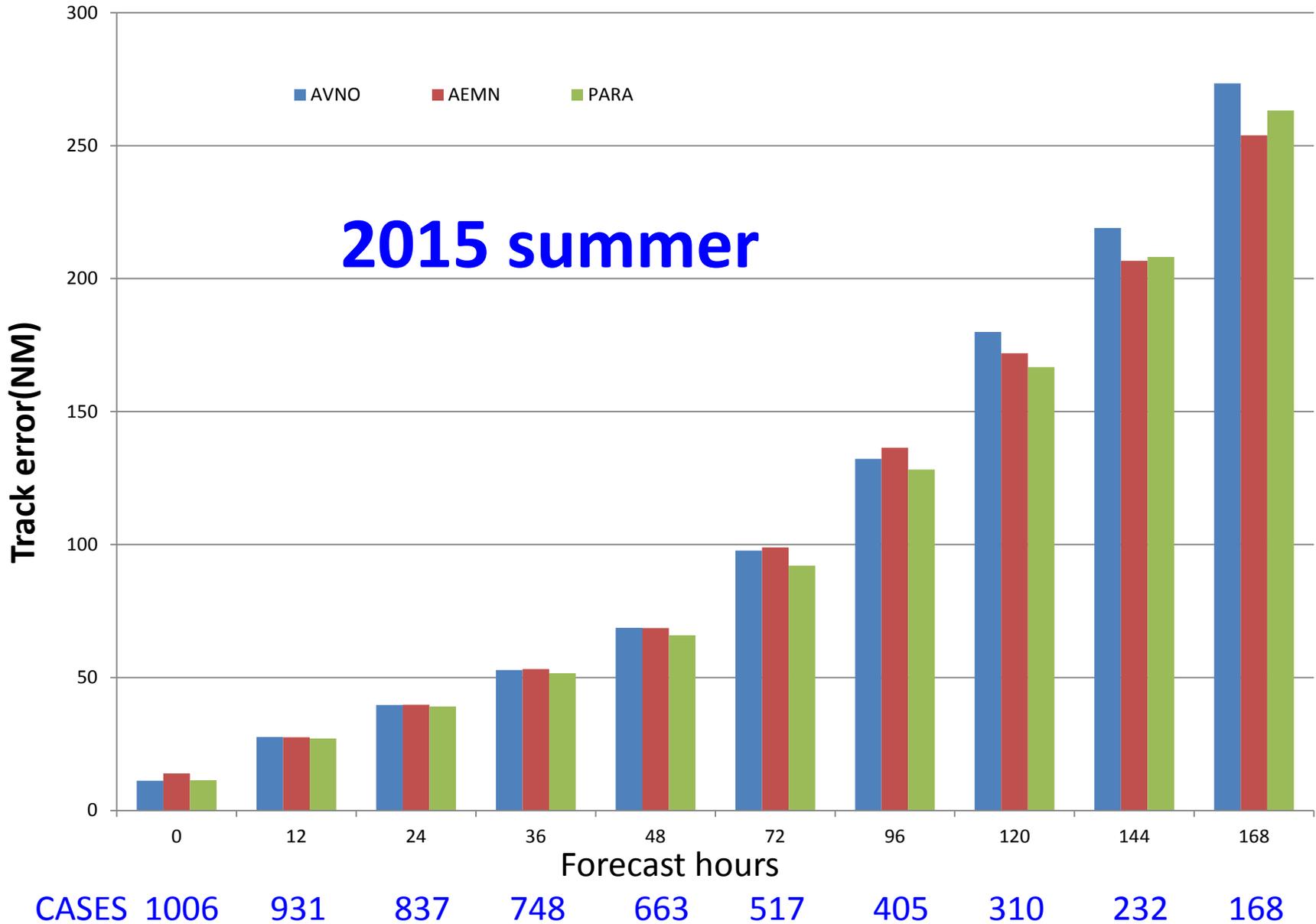
- New GEFS improves large-scale weather pattern forecasts
- New GEFS overall improves TC track forecast (2011-2014). Significant improvement is seen in WNP. Slight better forecasts in EP and Atlantic up to day 4, but a slight degradation in 6-7 day track forecast
- The model and analysis cross testing of the production and parallel shows that the degradation of 6-7 day track forecast in Atlantic is likely related to the initial conditions. Further study is needed in the future
- Positive in the 2015 Atlantic hurricane season
- **On-going study:**
 - 1) Higher resolution
 - 2) Larger ensemble size?
 - 3) Tuning TC perturbations
 - 4) To find why 6-7 day track forecasting degraded

00/12Z, 2012-2014 Atlantic TC track verifications (7-days)

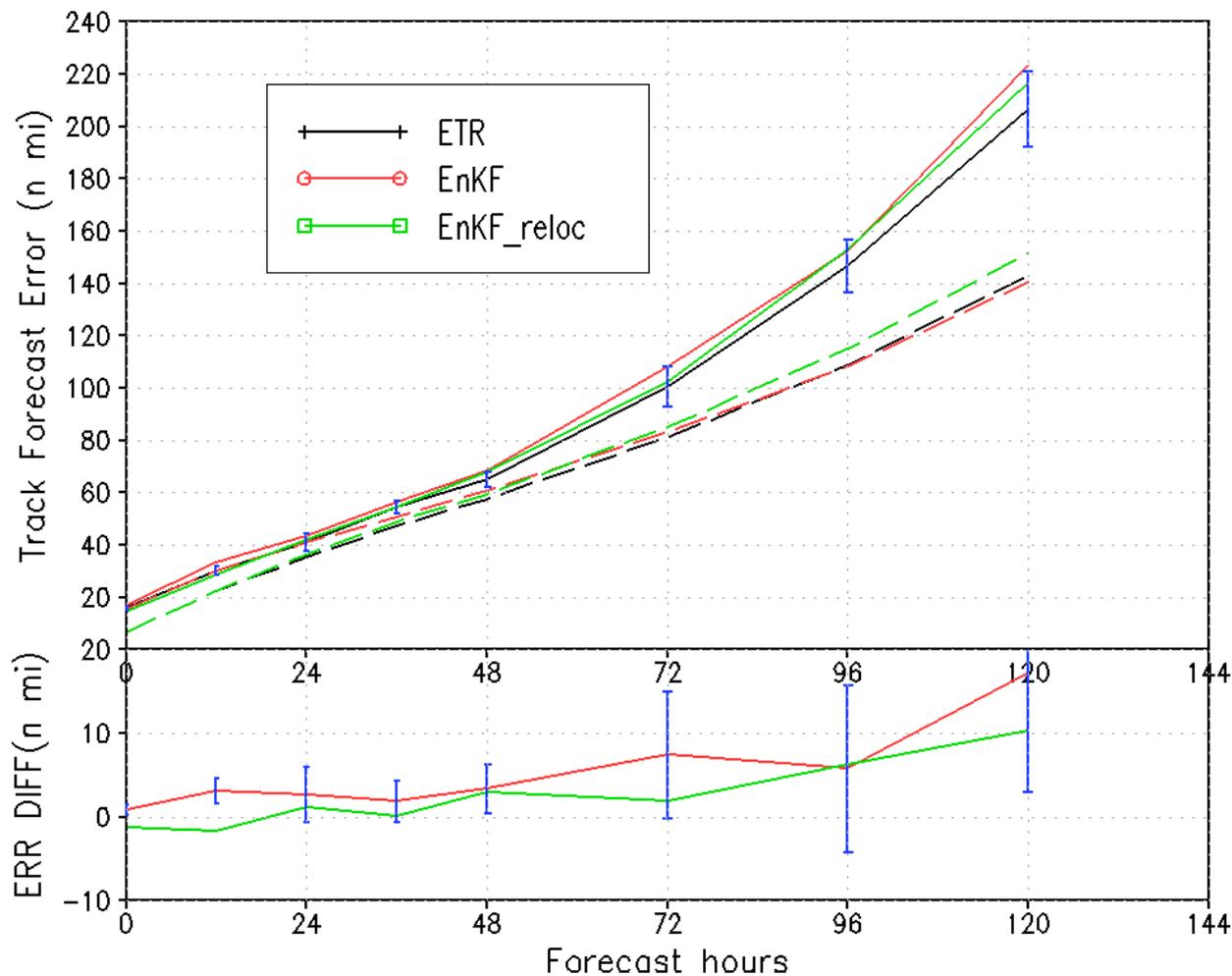


AL03-11, CP01-08, EP04-17, WP09-23, 07/08-10/06, 2015

2015 summer



Previous work – ETR vs EnKF w/o relocation



- 2011 hurricane season
- Euler T254L42
- GFS10.0.0
- Blue bar: Bootstrap test
- EnKF 2012 version

GRADS: CDLA/IGES

Case No. 232 218 187 171 150 119 89 66

Why TC relocated

- Without relocation

From Yochiro Ota



- With relocation

