Verification of TC Tracks and Intensity Forecasts

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Ensemble team leader of EMC/NCEP/NWS/NOAA
Present For 6th NAEFS workshop
May 3rd 2012, Monterey California

Acknowledgements

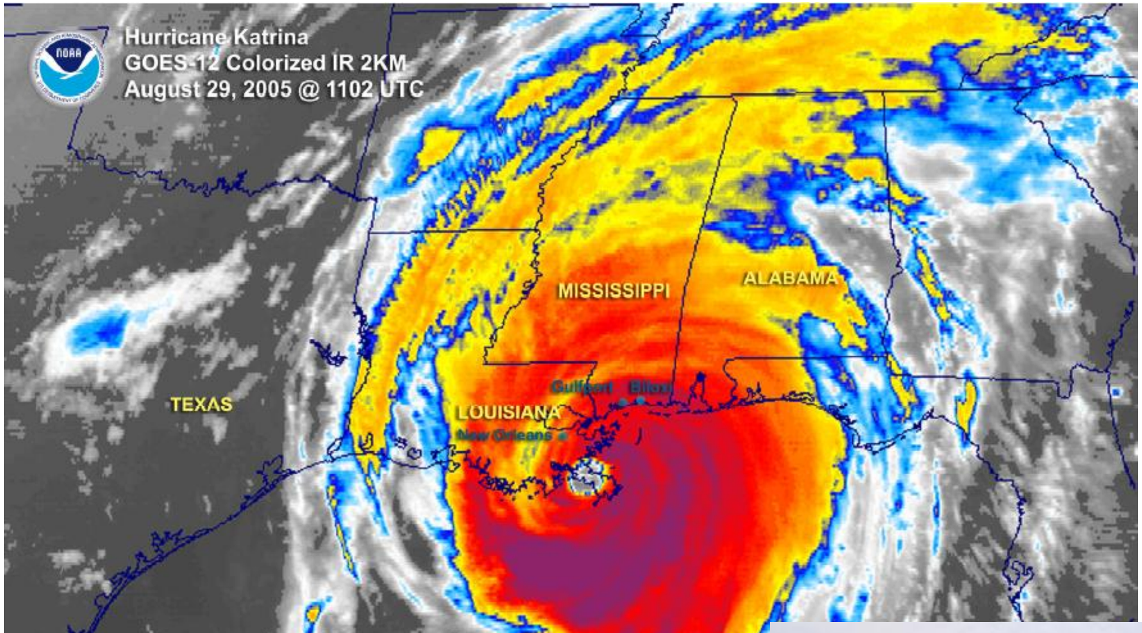
- JWGFVR – WGNE Joint working group for verification and research
- EMC – Environmental Modeling Center of NCEP
- NHC – National Hurricane Center of NCEP
- ESRL – Earth System Research Laboratory
- GFDL – Geophysical Fluid Dynamical Laboratory
- HFIP – Hurricane Forecast Improvement Project
- DTC – NCAR Development Test Center

Contents

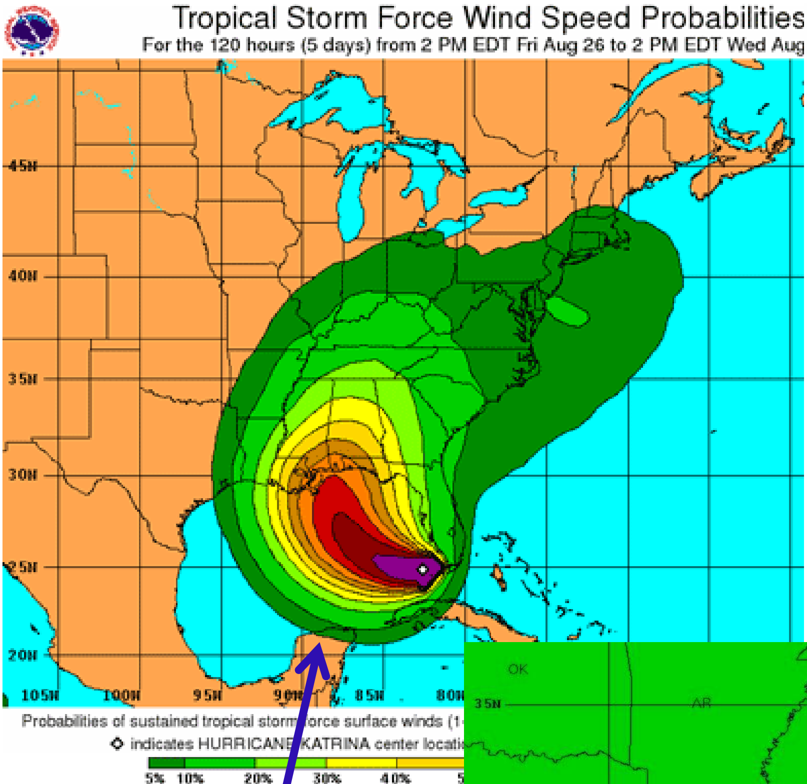
- Quick review of historic events
- Review of TC forecast products
- Available Observation and analyses
- Verification practice for Probabilistic (and/or ensemble) forecasts
  - Tracks
  - Intensity
- NCEP ensemble TC performance
  - GFS, GEFS, HWRF, GFDL, NAM, SREF and etc…
- Multi-model TC performance
  - TIGGE
  - NAEFS – NCEP + CMC (possible FNMOC: future NUOPC)
  - Ensemble post process
- Seasonal TC prediction (outlook)
  - NCEP
  - ECMWF

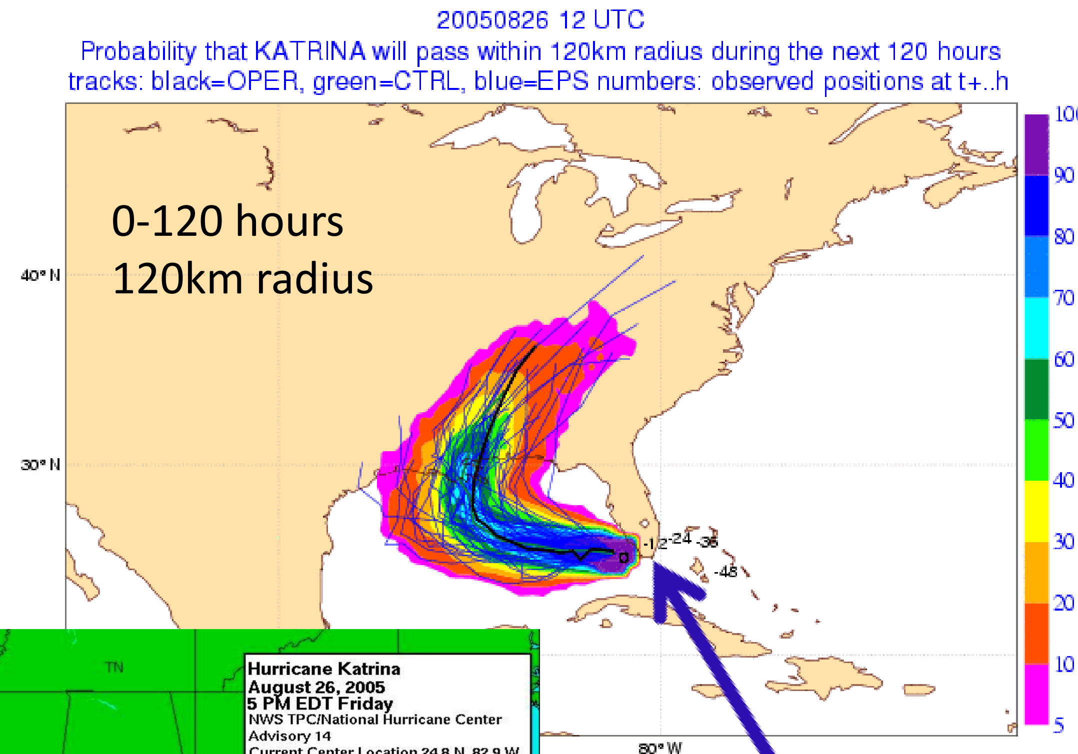
Quick Review of Historic Events

Example of Hurricane Katrina



Example of Hurricane Katrina





Early prediction:
Friday – August 26
NHC's prediction

ECMWF ensemble
forecast: Strike
probability from
Friday – August 26

Review of TC Forecast Products

Tropical Storm Uncertainty Fcst

Example of NHC TC Forecast Products

- **Text Products**
  - Tropical Weather Outlook
  - Special Tropical Weather Outlook
  - Tropical Weather Discussion
  - Public Advisory
  - Intermediate Advisory
  - Forecast Advisory
  - Forecast Discussion
  - Surface Wind Speed Probabilities
  - ICAO (Aviation) Advisory
  - Update
  - Position Estimate
  - Valid Time Event Code
  - Monthly Weather Summary
  - Tropical Cyclone Reports
- **Graphical Tropical Weather Outlook**
  - Track Forecast Cone
  - Surface Wind Field
  - Surface Wind Speed Probabilities
  - Cumulative Wind History
  - Maximum 1-min Wind Speed Probability
  - Storm Surge Probabilities
- **Graphical Products (Experimental)**
  - GIS Products
  - Podcasts (Audio)
  - Media Video cast Briefings
  - NHC Web Widgets

Available Observations

Available Observations

- Reconnaissance
  - H*Wind? Wind radii?
- Surface networks
  - Automatic weather stations, rain gauge networks, tide gauges, moored buoys, ship reports, etc.
- Radar
  - Automated radar eye fix – Yip and Wong (2004)
  - Single-Doppler method for eye fix – Lee and Marks (2000)
- Satellite
  - Visible and infrared (IR) satellite imagery
- Best tracks
  - A subjective estimate of the storm's center location and intensity at each 6 h and is identified by analysts at NHC and other centers using all observations available at the time of the analysis

Verifications

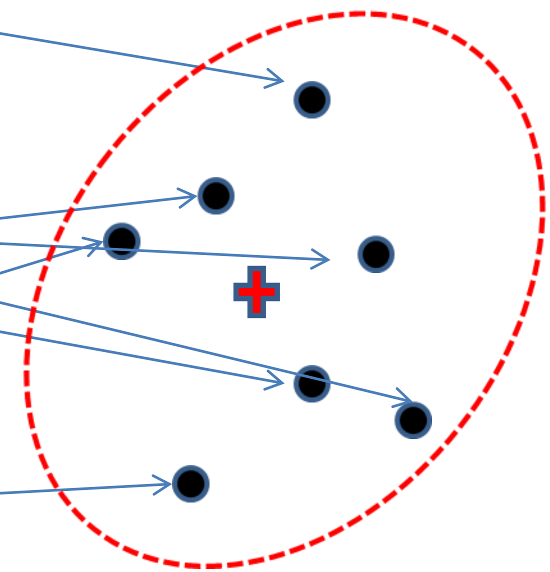
(deterministic forecast)

TC Verification – Deterministic Forecasts

- Track and storm center verification
  - Best on “best track” and “forecast track”
- Intensity
  - based on max wind
  - based on central pressure
  - other related parameters such as radial extent of storm/hurricane force winds
  - intensity trends
  - intensity error distribution
- Storm structure
  - Wind radii - the distance from the center of the cyclone to the maximum extent of winds exceeding 34, 50, and 64 kts
  - four quadrants surrounding the cyclone (NE, SE, SW, NW)
- Weather hazards resulting from land falling TCs
  - Precipitation
  - Wind speed
  - Storm surge

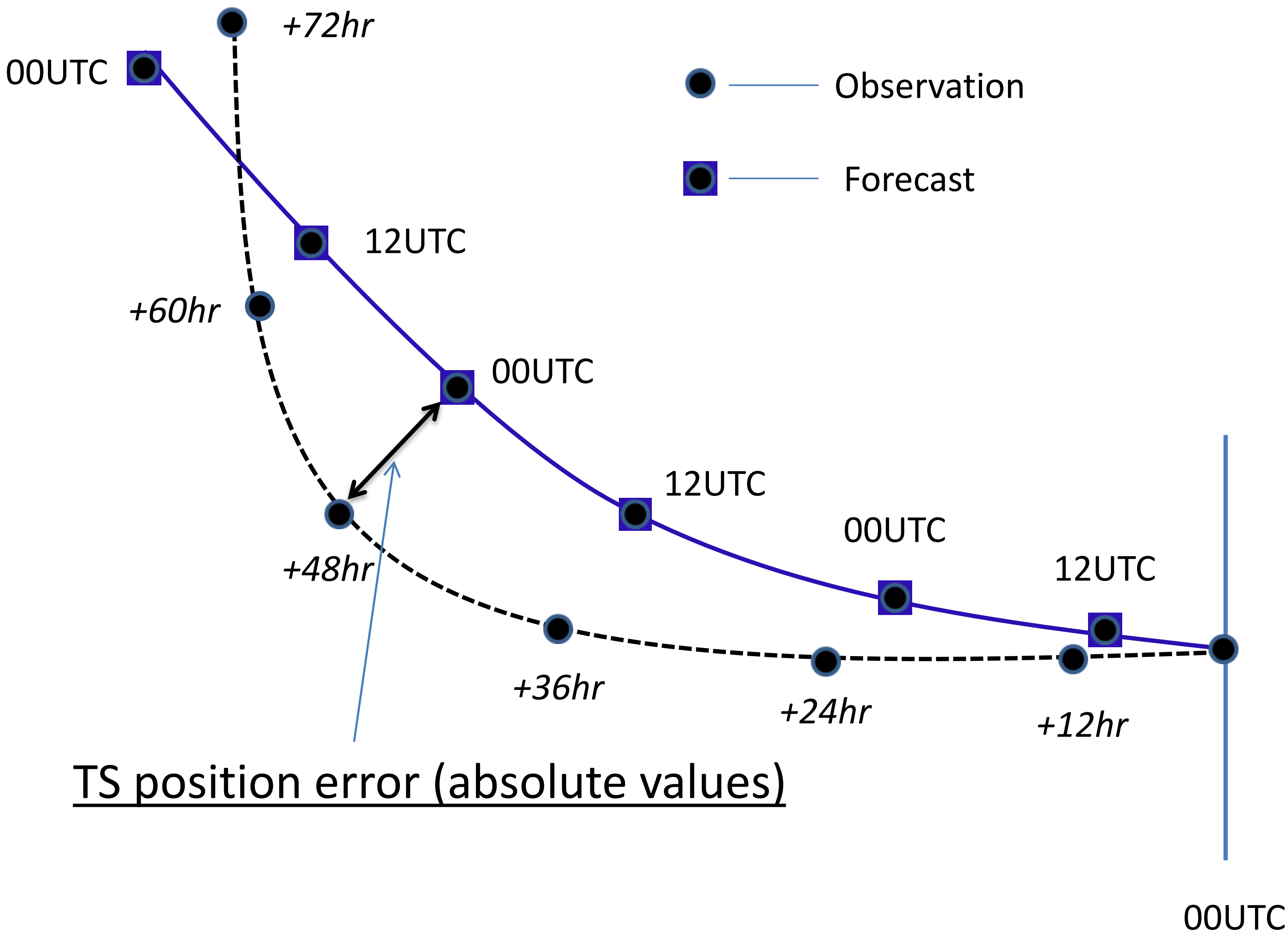
How to Get Forecast Position?

- Surface pressure
- Winds
  - 10m, 850, 700 and 500hPa
- Geopotential height
  - 850 and 700hPa



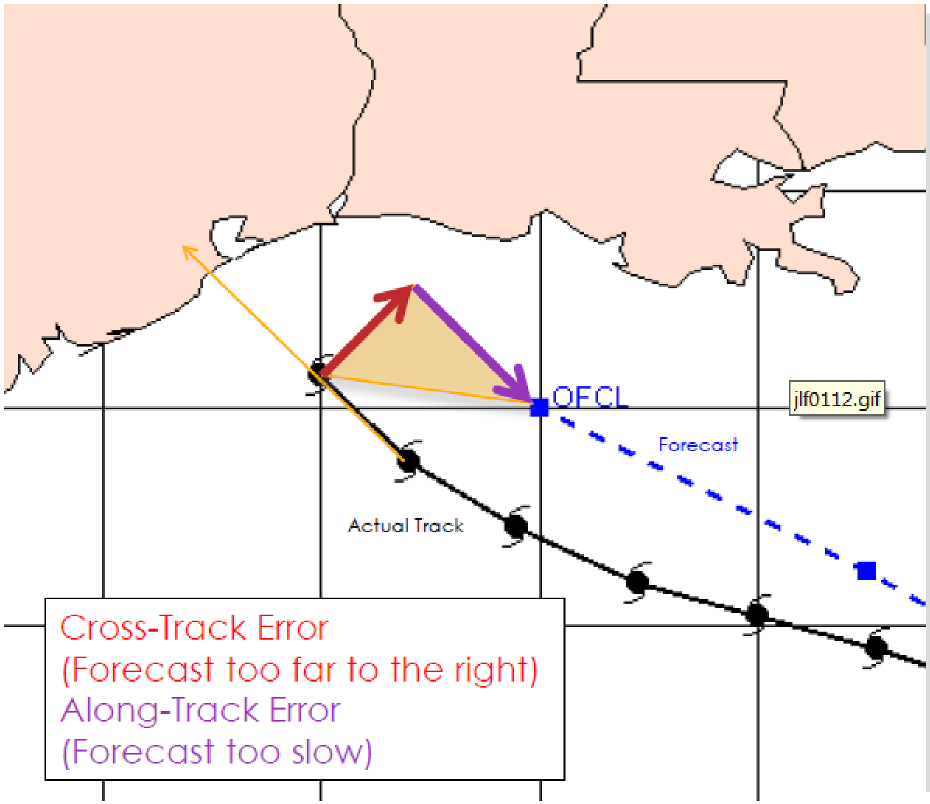
Could be many different ways to get forecast position

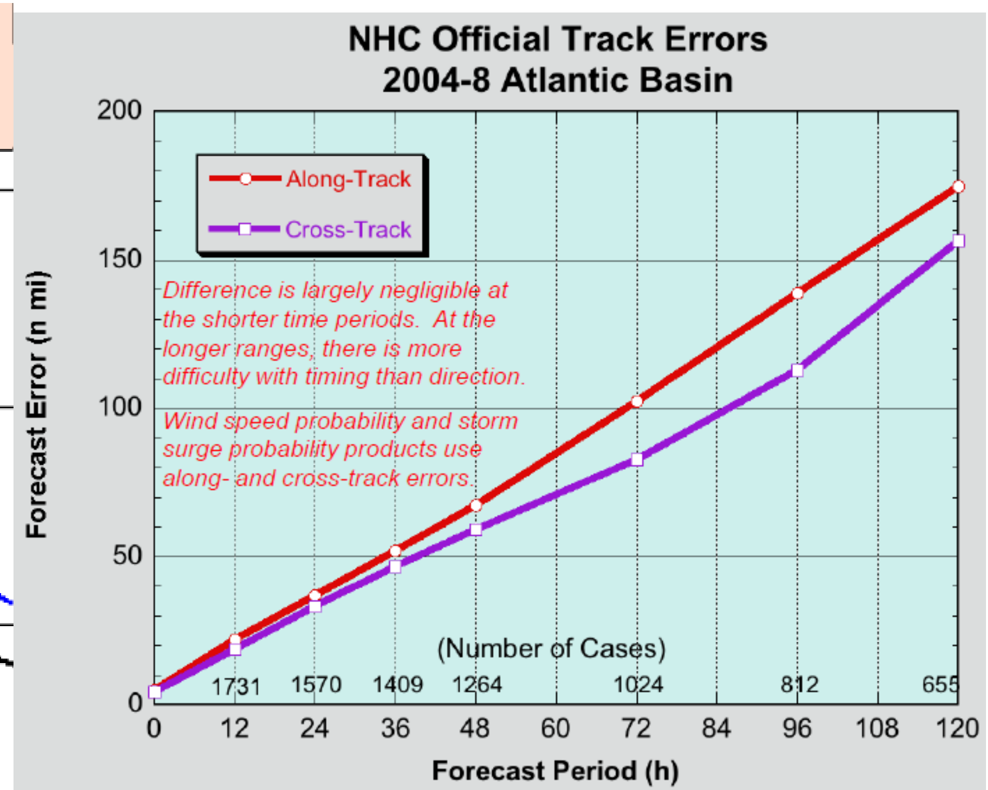
Schematic Diagram for TS Position Error (general verification)



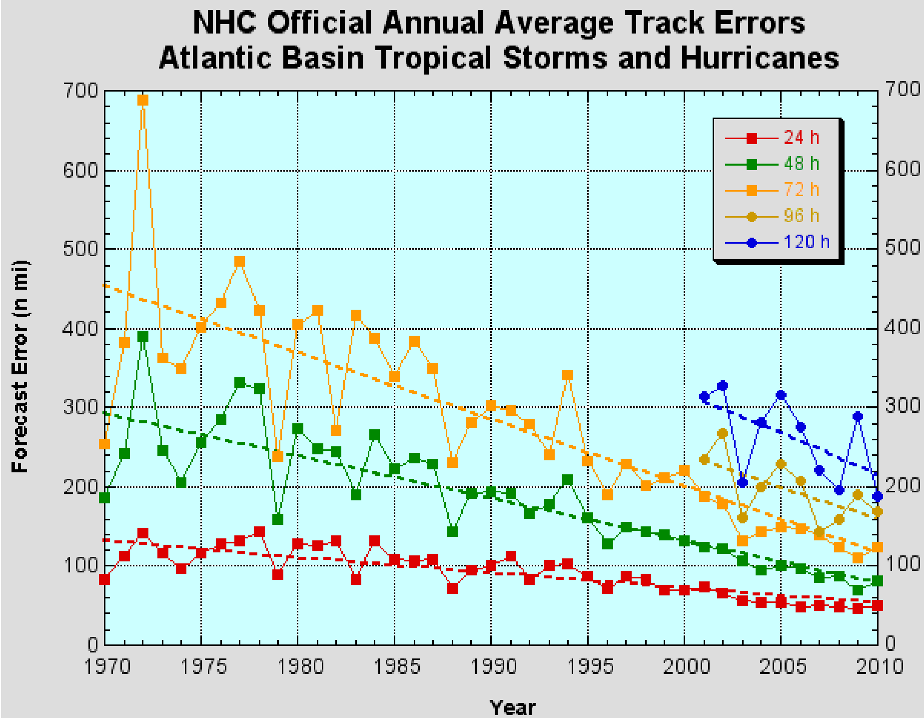
Verification for deterministic TC forecasts

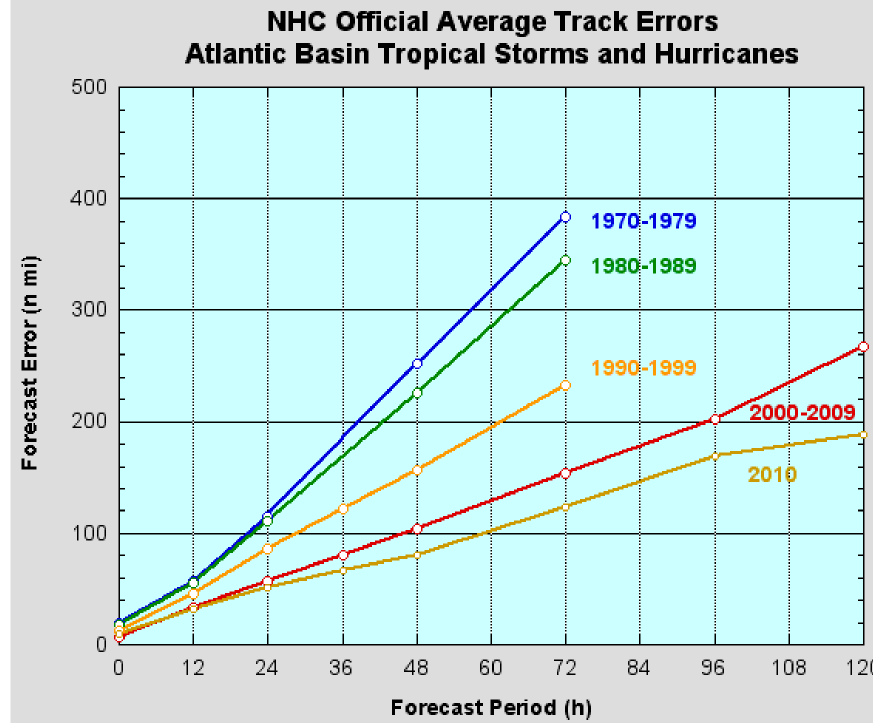
- Example – along-track and cross-track errors

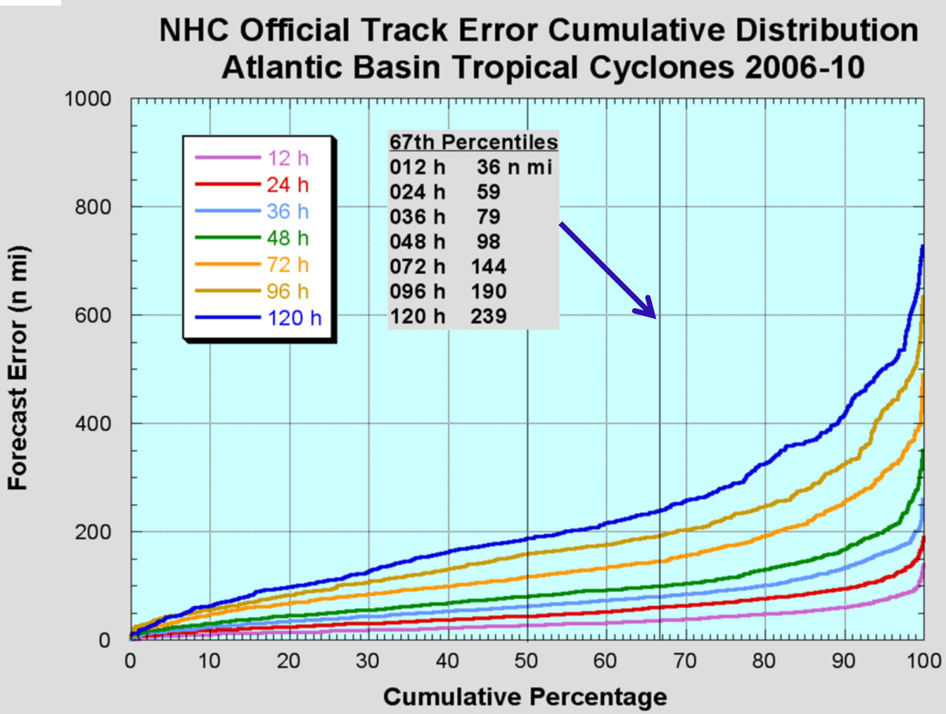


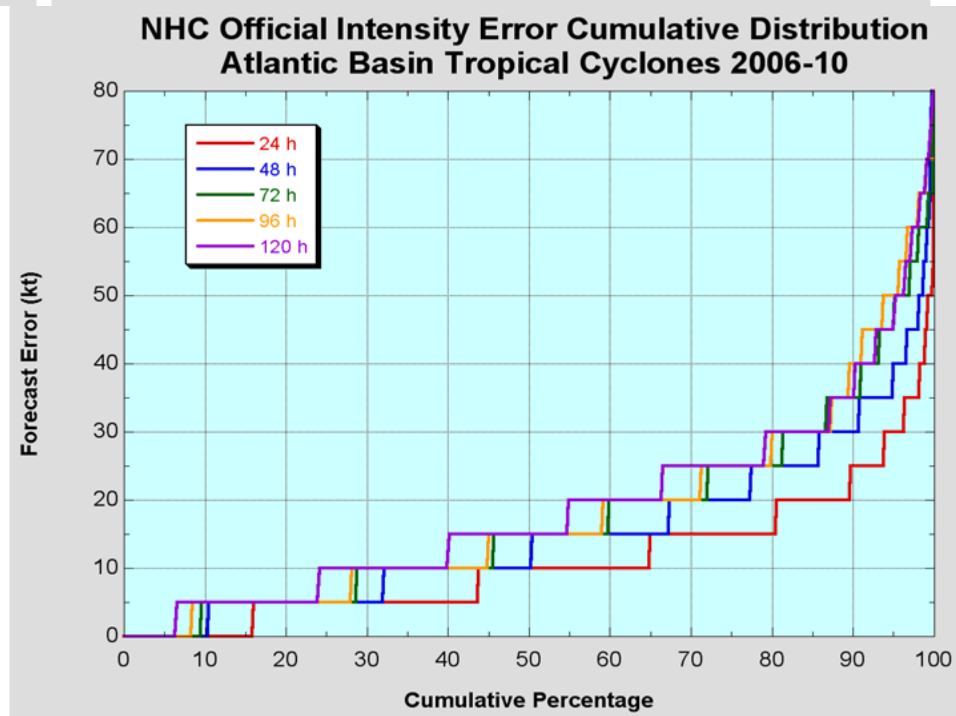


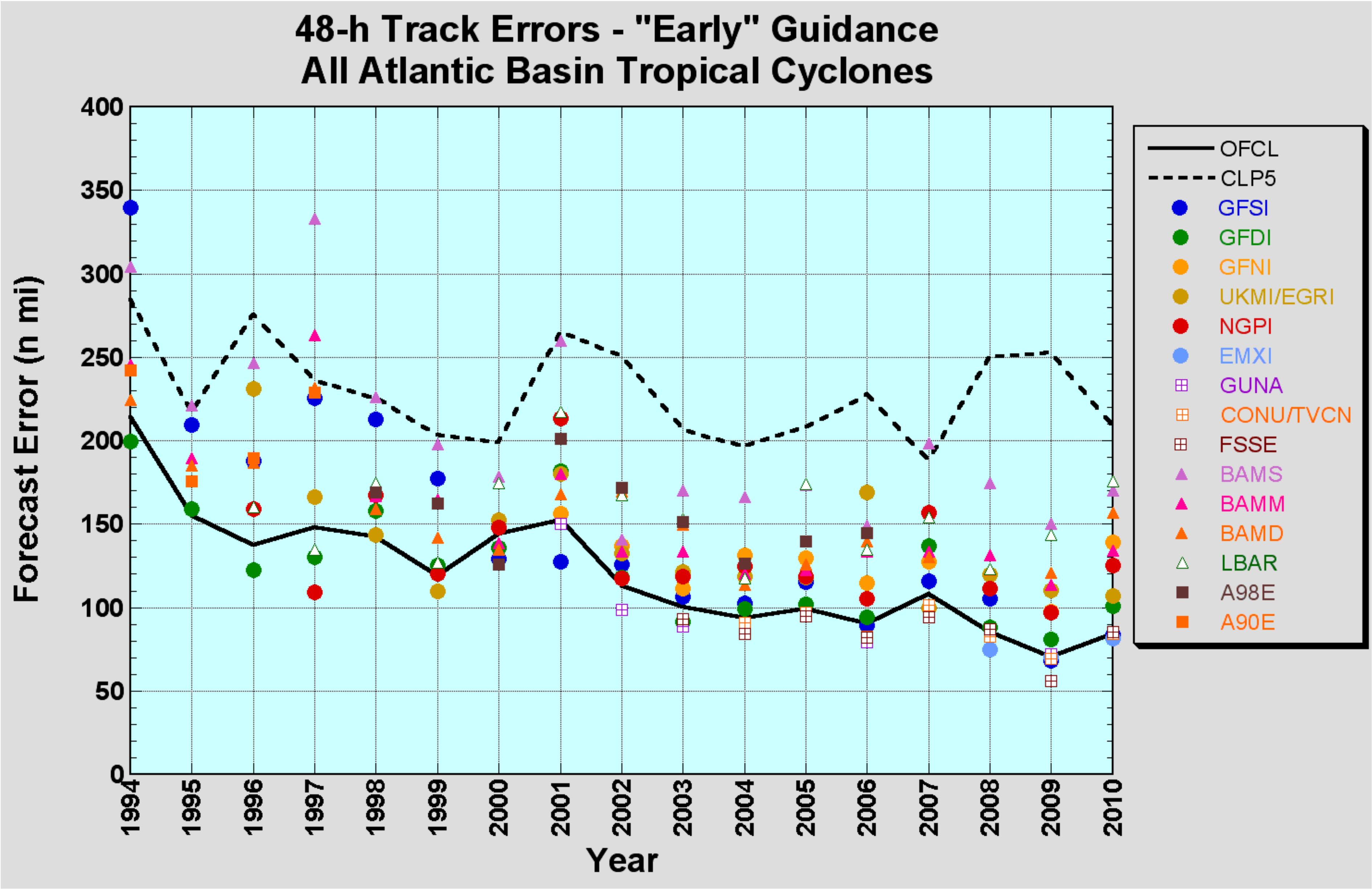
Courtesy James Franklin, NHC


NHC Official Annual Average Track Errors
Atlantic Basin Tropical Storms and Hurricanes
24 h
48 h
72 h
96 h
120 h
Forecast Error (n mi)
Year

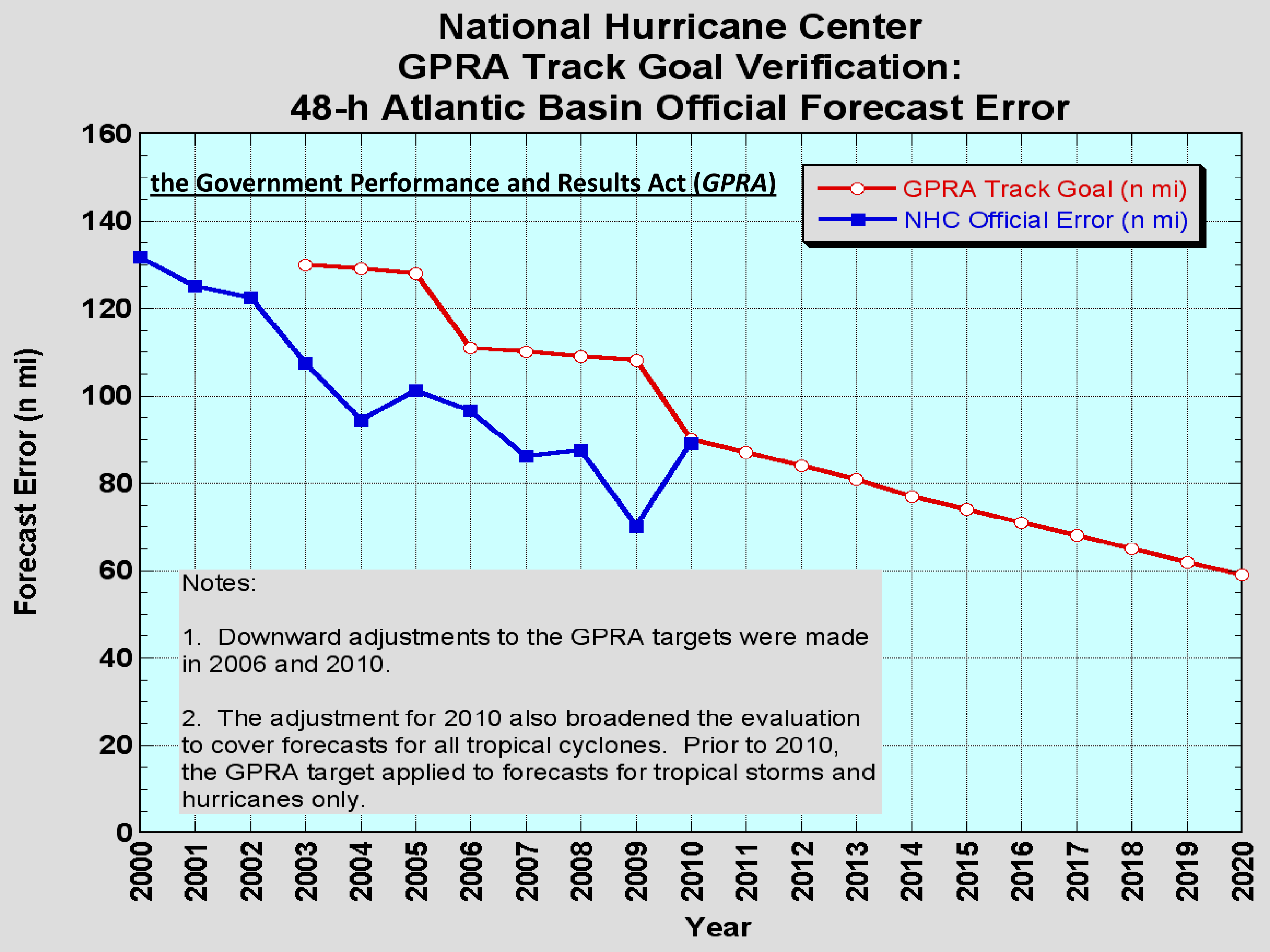

NHC Official Average Track Errors
Atlantic Basin Tropical Storms and Hurricanes
1970-1979
1980-1989
1990-1999
2000-2009
2010
Forecast Error (n mi)
Forecast Period (h)


NHC Official Track Error Cumulative Distribution
Atlantic Basin Tropical Cyclones 2006-10
12 h
24 h
36 h
48 h
72 h
96 h
120 h
67th Percentiles
012 h 36 n mi
024 h 59
036 h 79
048 h 98
072 h 144
096 h 190
120 h 239
Forecast Error (n mi)
Cumulative Percentage

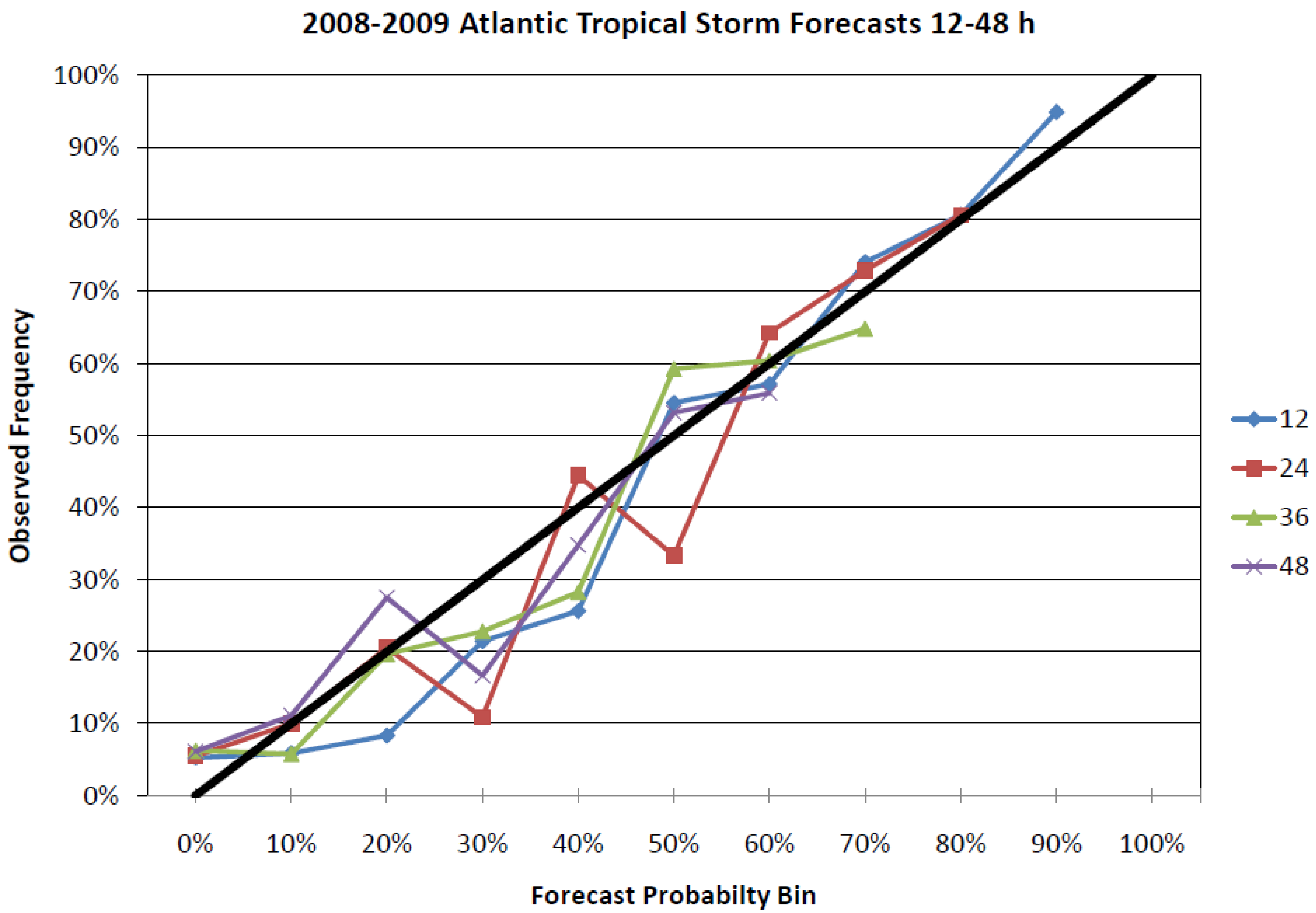

NHC Official Intensity Error Cumulative Distribution
Atlantic Basin Tropical Cyclones 2006-10
24 h
48 h
72 h
96 h
120 h
Forecast Error (kt)
Cumulative Percentage



FSSE – FSU supper ensemble


National Hurricane Center
GPRA Track Goal Verification:
48-h Atlantic Basin Official Forecast Error
the Government Performance and Results Act (GPRA)
GPRA Track Goal (n mi)
NHC Official Error (n mi)
Forecast Error (n mi)
Year
160
140
120
100
80
60
40
20
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Notes:
1. Downward adjustments to the GPRA targets were made in 2006 and 2010.
2. The adjustment for 2010 also broadened the evaluation to cover forecasts for all tropical cyclones. Prior to 2010, the GPRA target applied to forecasts for tropical storms and hurricanes only.

Intensity Reliability Verification



Number of Forecasts									
95	34	36	28	39	11	36	54	62	138
73	40	39	46	36	33	70	96	93	0
48	52	56	57	46	54	96	111	111	0
49	36	40	60	92	94	127	0	0	0

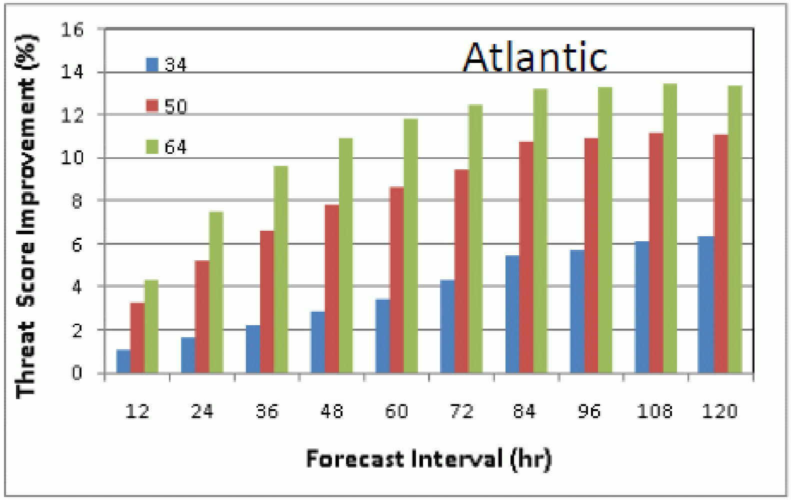
Courtesy of M. Brennan

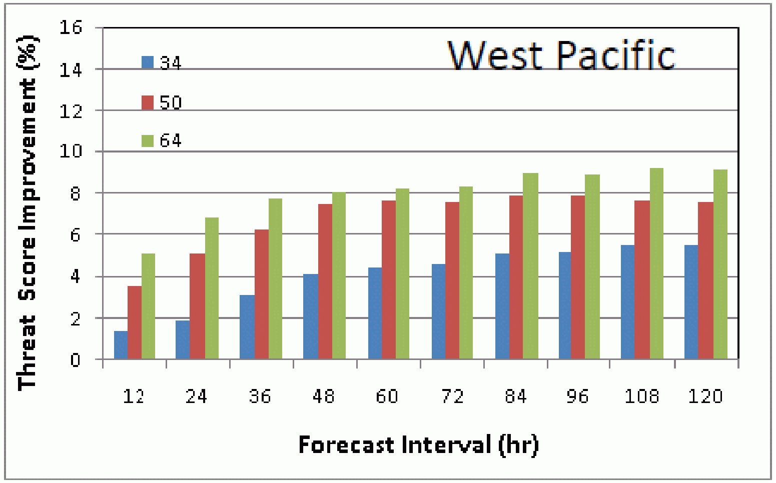
Intensity Probability (?) Verification

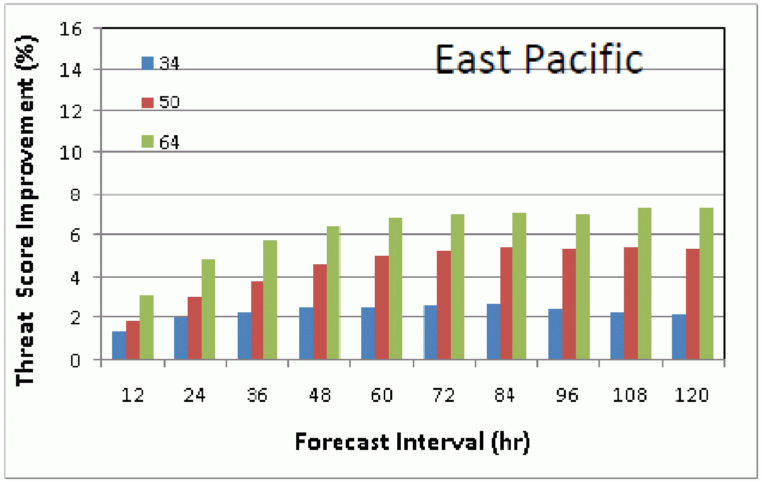
- Performed for 2008-2009 in the Atlantic and east Pacific
- Forecast probabilities were grouped into 10% bins
- Sample sizes are still quite small for high probability

Threat Score Improvements with GPCE version

GPCE -
Goerss Predicted Consensus Error





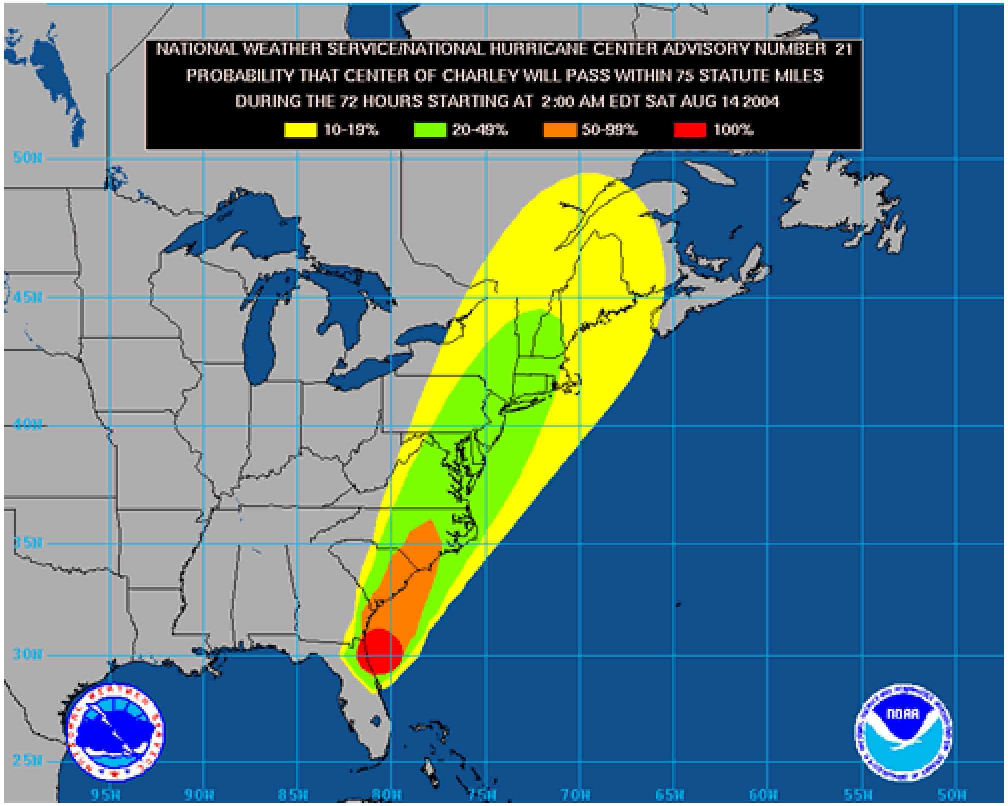


Courtesy of M. Brennan

Probabilistic Products and Verification

(Ensemble based - Experimental)

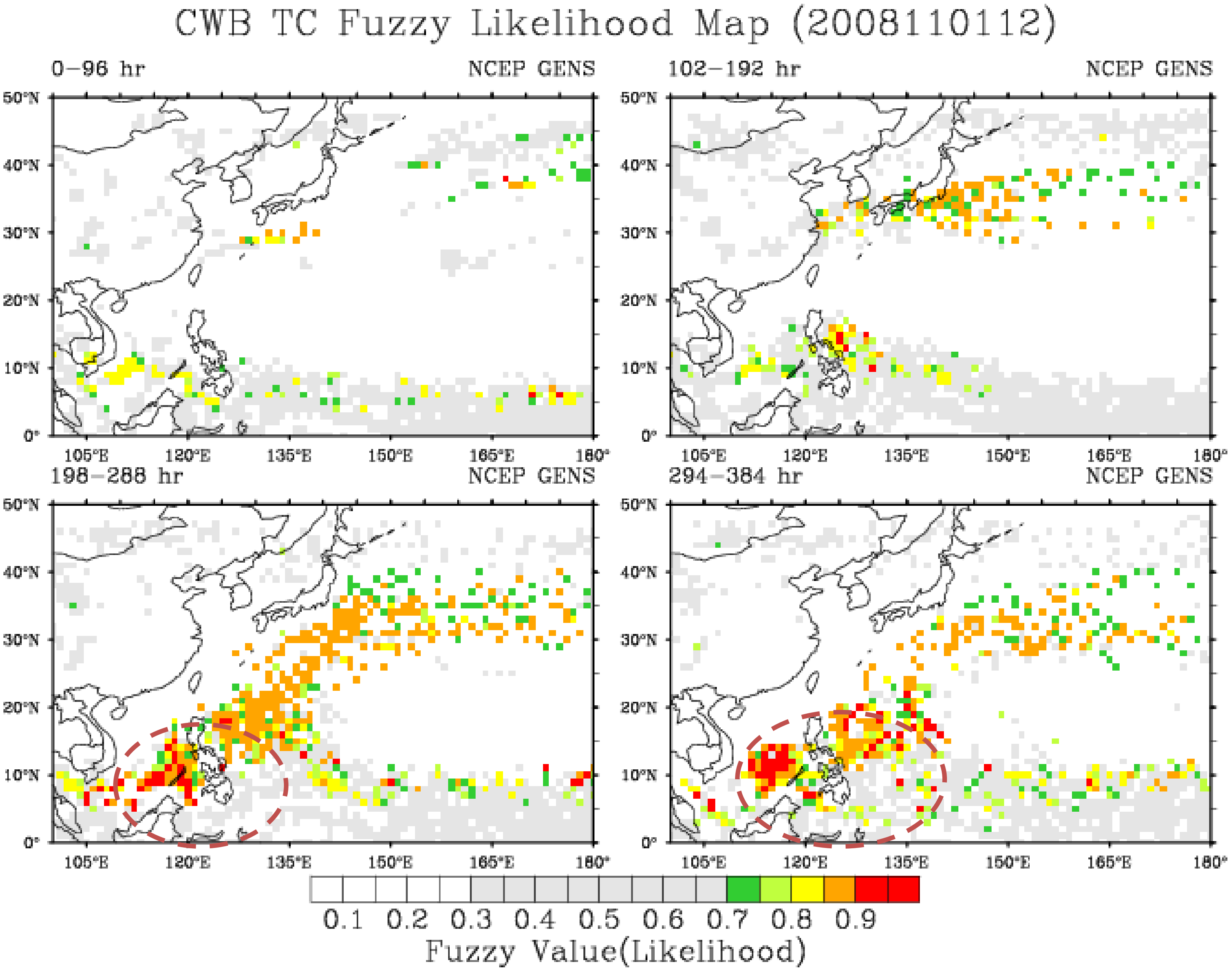
Strike Probability (NHC)



NHC started to calculate strike probability forecast products since 2004. It has been phased out since they introduced wind speed probability.

NHC's method of calculation is based on single deterministic and uncertainties (cone) from historic analysis and forecast

The map above is a hurricane strike probability map for Hurricane Charley from August, 2004. It maps the probability, in percent, that the center of the storm will pass within 75 statute miles of a location during a 72 hour time interval. Contour levels shown are 10% (yellow), 20% (green), 50% (orange) and 100% (red).



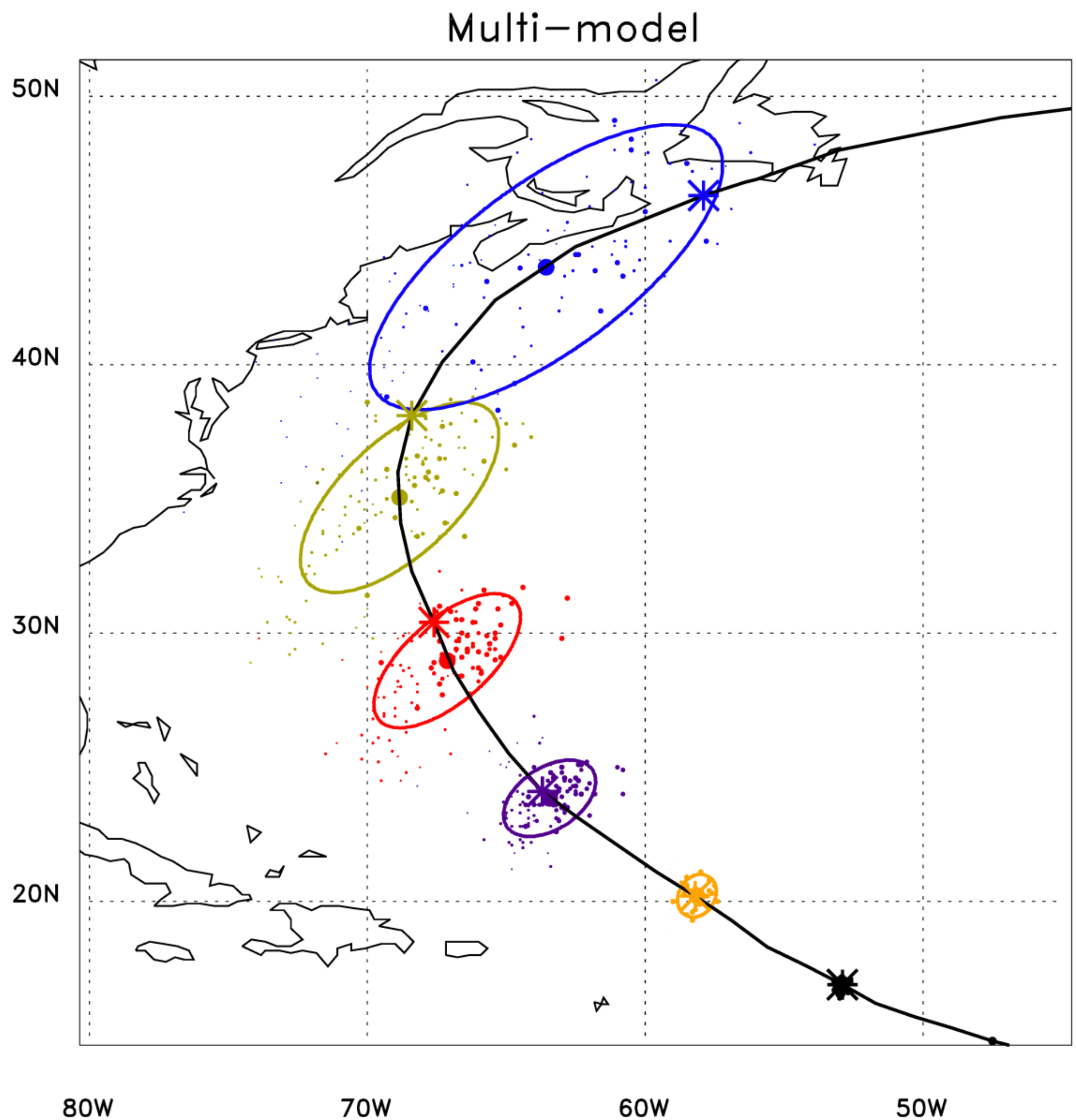
[Courtesy of Hsiao-Chung Tsai and Kuo-Chen Lu (Tsai and Lu, 2008)]

An experimental multi-model product

Dot area is proportional to the weighting applied to that member

•= ens. mean position* = observed position

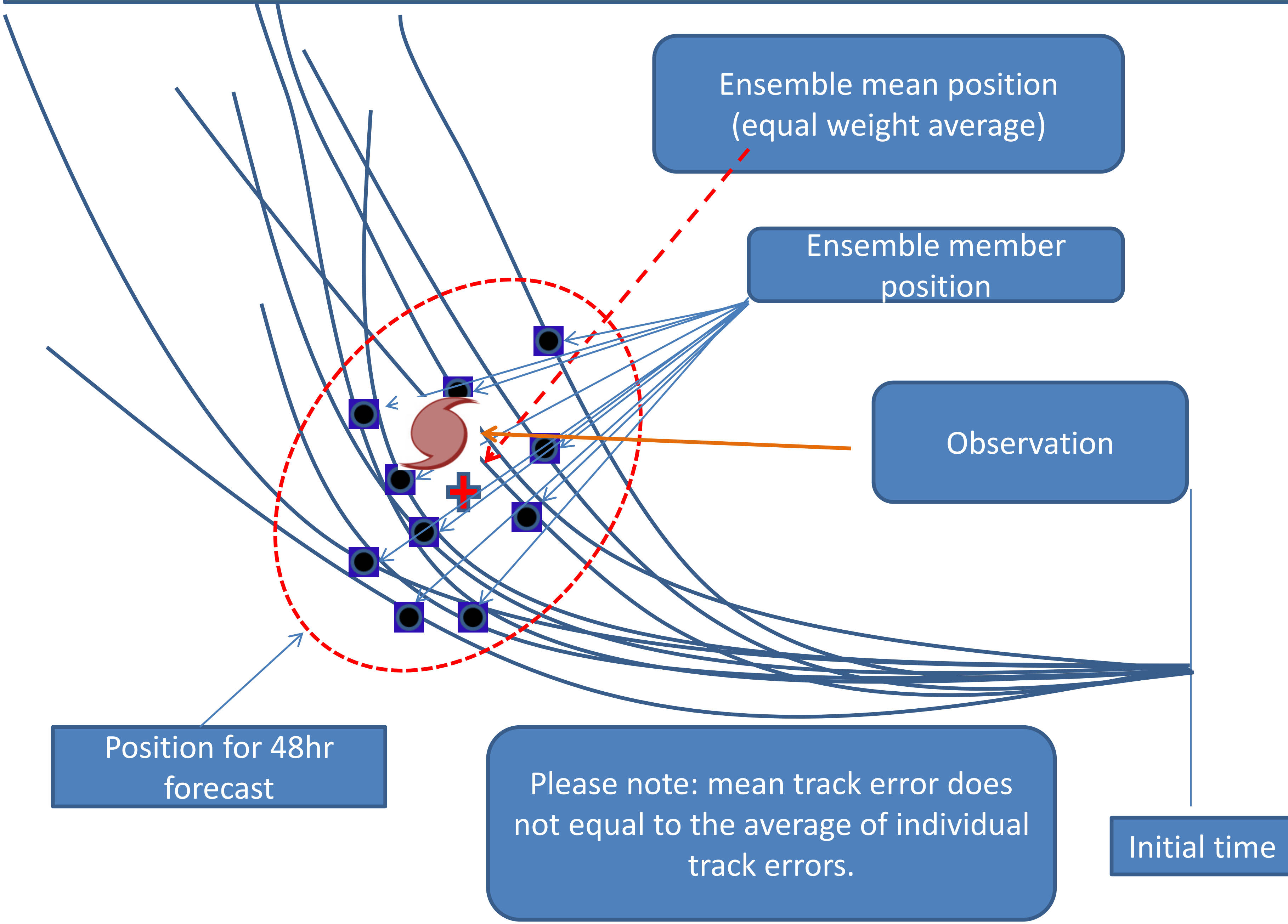
[Courtesy of Tom Hamill]



TC Verification – Ensemble based Probabilistic Forecasts

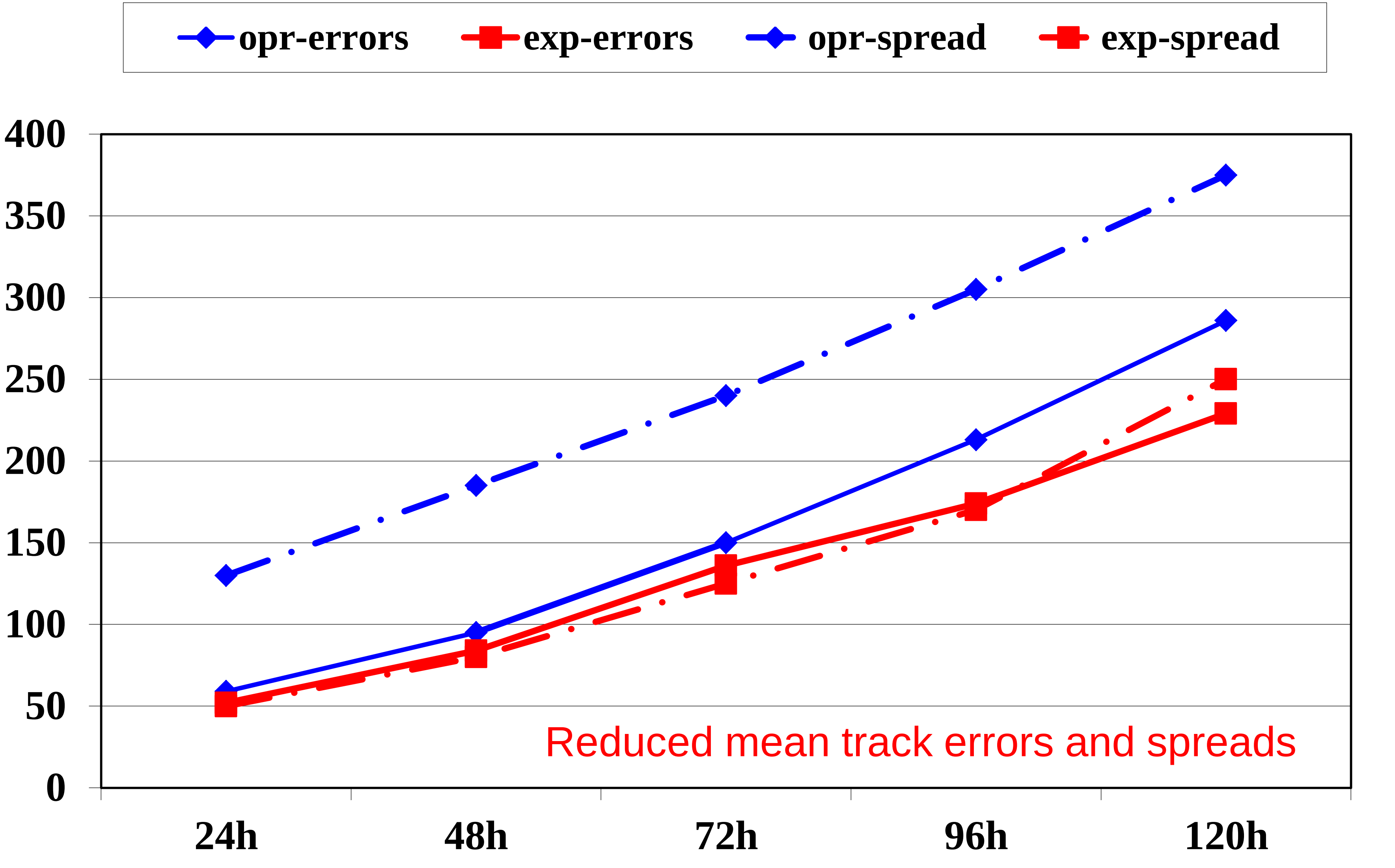
- Track and storm center verification
  - Ensemble mean (and RMS) errors
  - Ensemble spread
  - Direct position error
  - Spread error relationship
- Intensity
  - Ensemble mean errors
- Weather hazards resulting from land falling TCs
  - Precipitation
  - Wind speed
  - Storm surge

Schematic Diagram for Ensemble TC Track Forecast



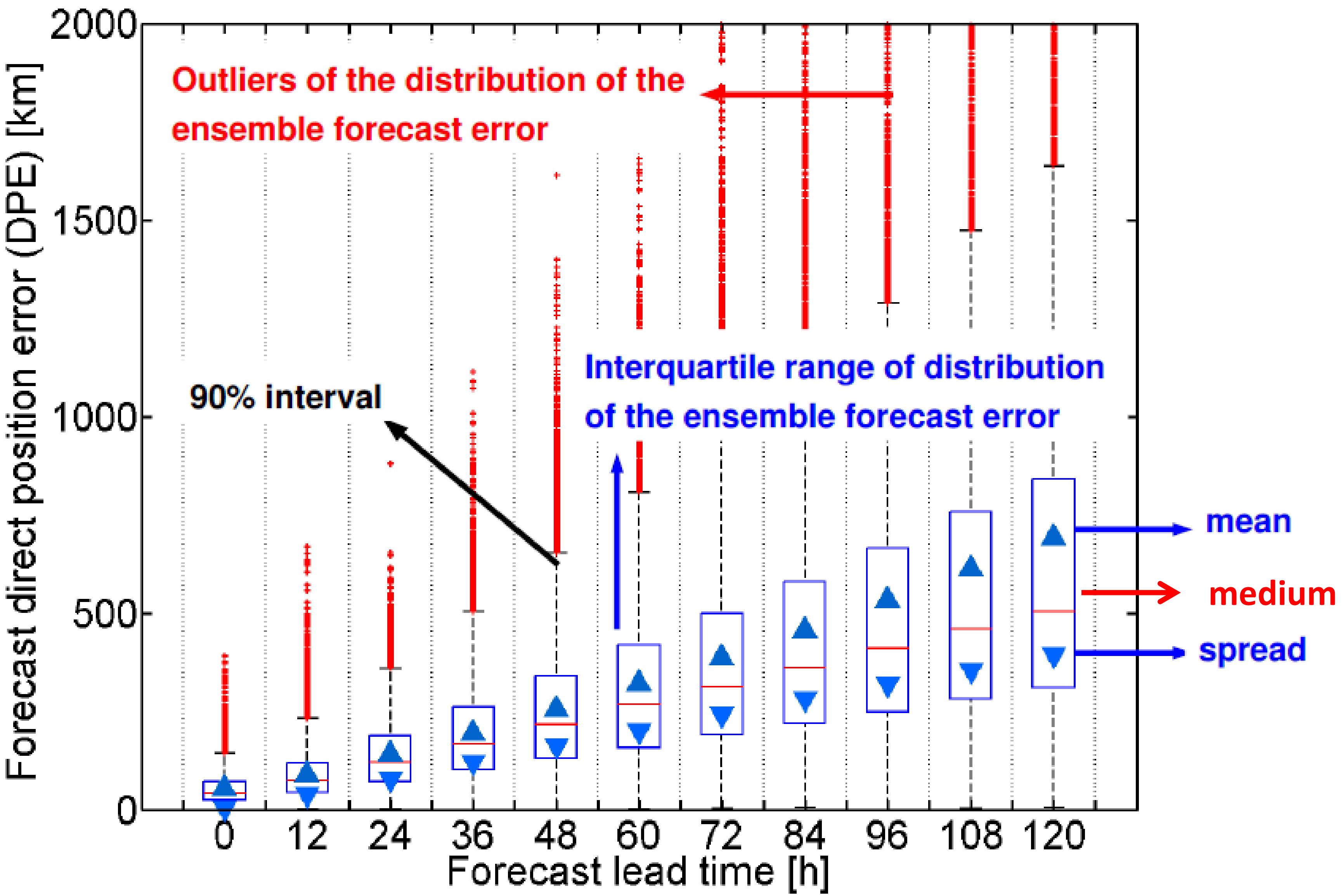
Track Errors and Spreads

2004 Atlantic Basin (8/23-10/1)



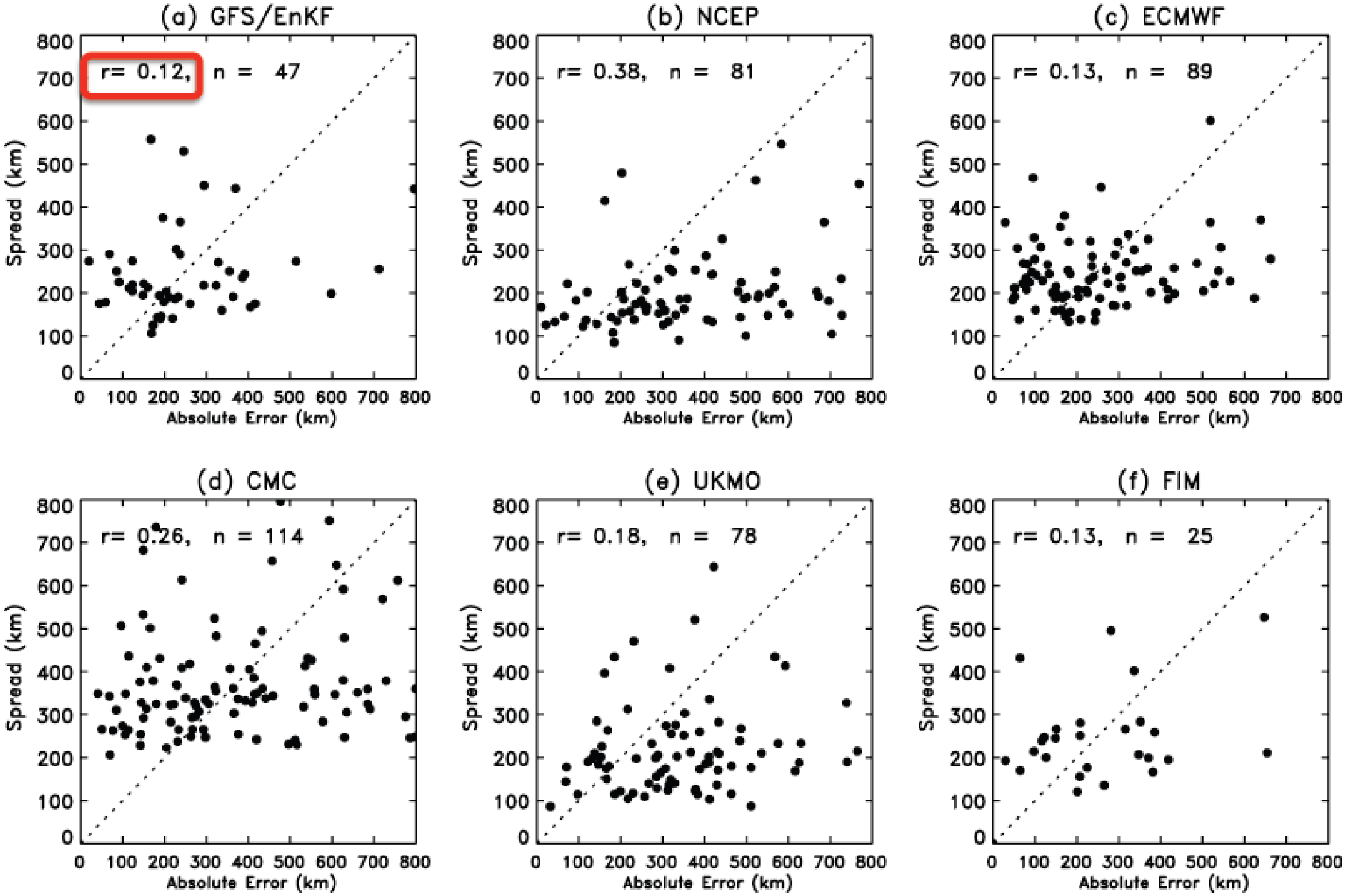
Courtesy of T. Marchok

Direct position error



Courtesy of Aemisegger and et. al

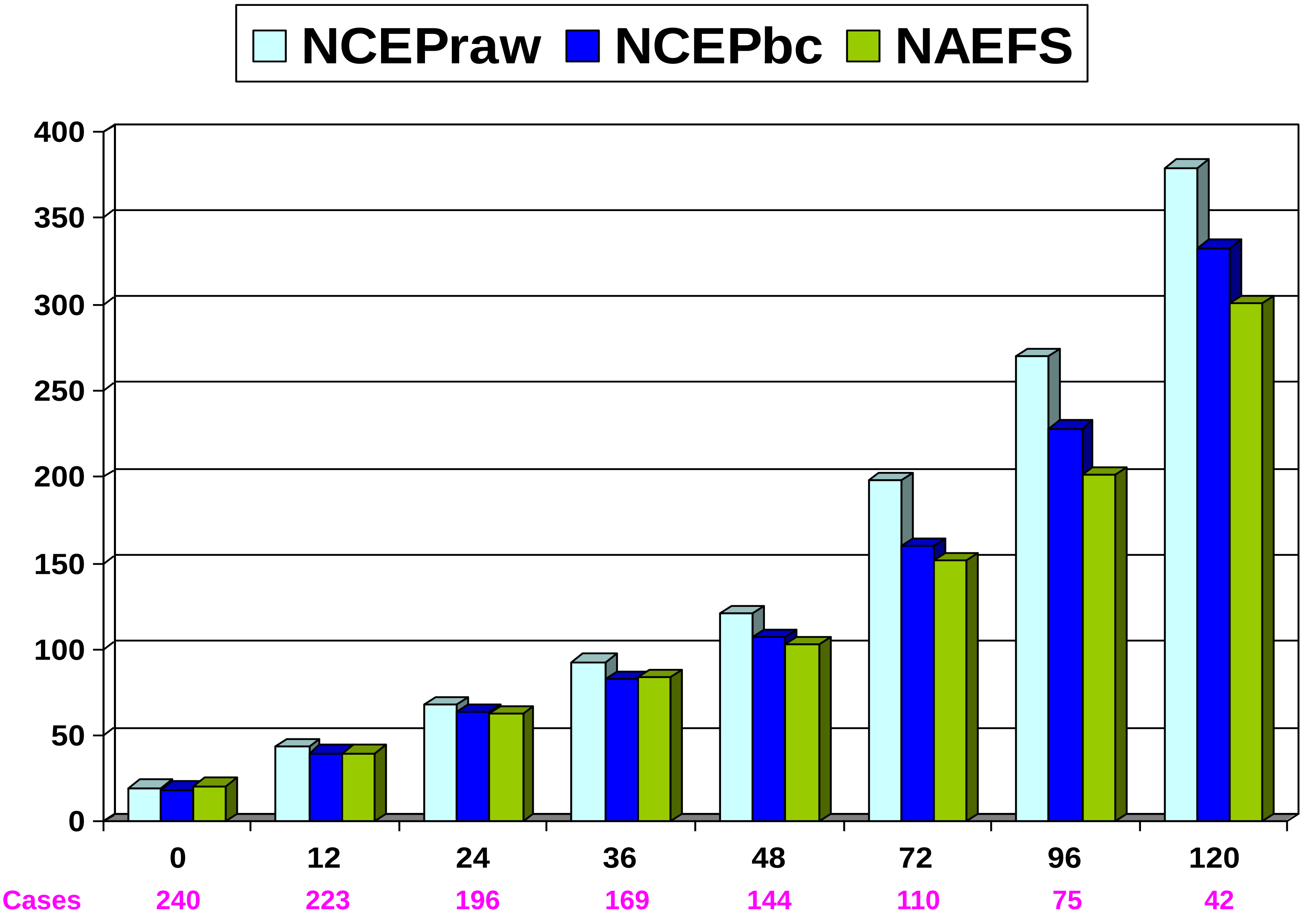
Spread-error relations? (Day-3)



Courtesy of T. Hamill

NAEFS
(Multi-model ensembles)

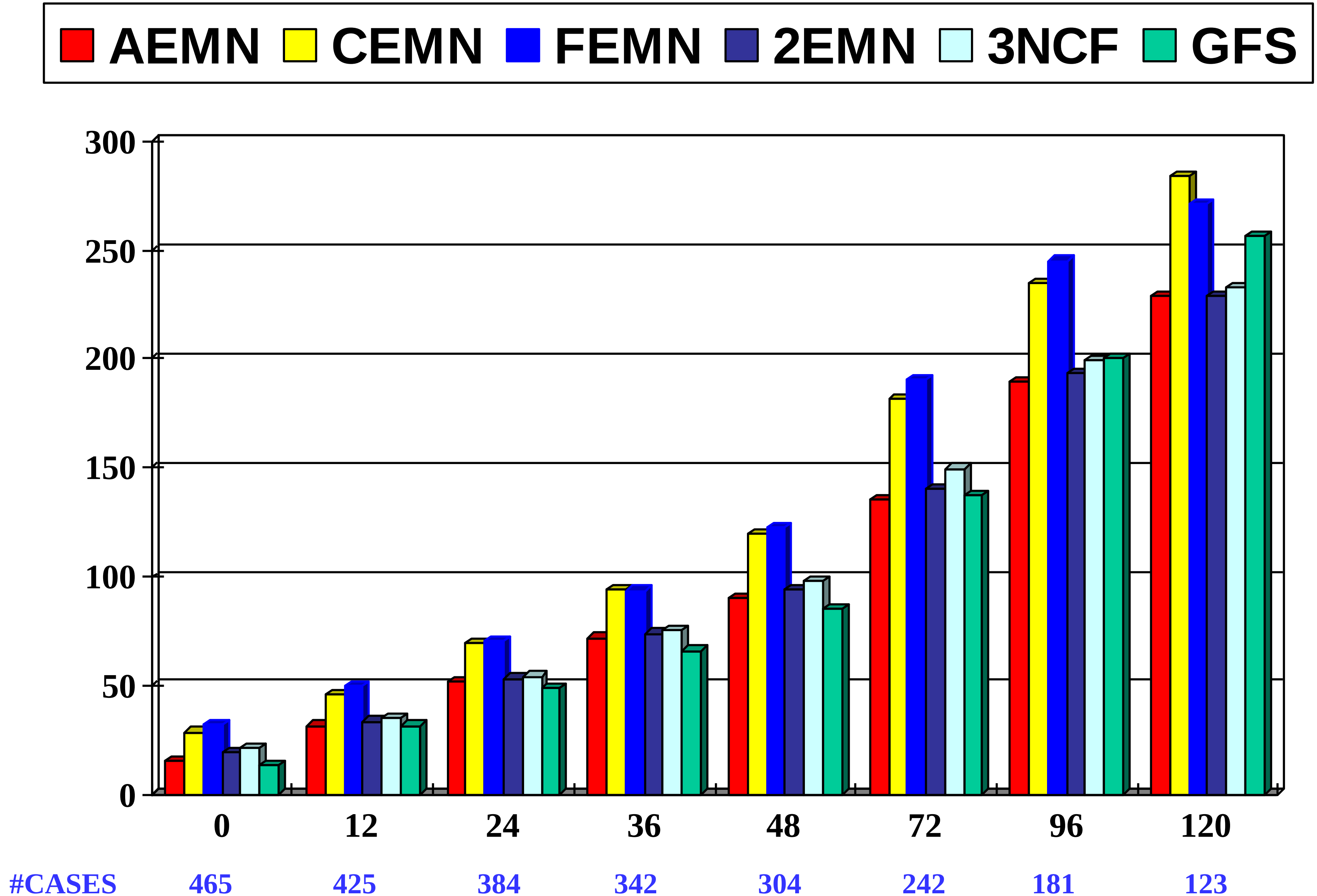
Track forecast error for 2009 season (AL+EP+WP)



NAEFS is combined NCEP (NCEPbc) and CMC's (CMCbc) bias corrected ensemble and bias corrected GFS

Courtesy of Jiayi Peng

Atlantic, East and West Pacific, AL01~17, EP01~09,WP03~22 (05/01~09/30/2011)



Courtesy of Jiayi peng

Concerns and Discussions

- From Barbara Brown (NCAR/ETC)

Tropical Cyclone Forecast Evaluation

- Most tropical cyclone verification (at least operationally) focuses on only 2 variables: track location and intensity.
  - Since a great deal of the damage associated with tropical storms is related to other factors, this seems overly limiting
  - Some additional important variables:
    - Storm structure and size
    - Precipitation
    - Storm surge
    - Landfall time, position, and intensity
    - Consistency
    - Uncertainty
    - Info to help forecasters (e.g., steering flow)
    - Other?
- Tailoring verification to help forecasters with their high-pressure job and multiple sources of guidance information

Tropical Cyclone Forecast Evaluation

- Measurements of TC wind and precipitation are very limited and create a limitation on our ability to evaluate and understand performance of TC forecasts
  - *Observation uncertainty is likely large but not taken into account – how should it be treated?*
- Measurements of storm intensity are somewhat questionable and perhaps unstable
  - *Does estimating the maximum wind speed make sense when these measurements are unreliable?*
  - *Would a more robust statistical measure (e.g., 90th percentile of wind speed) be more reasonable?*
- When storms make landfall and weaken there often is a public (or media) perception of a "false alarm“
  - *Can we do anything to counteract this perception?*

Tropical Cyclone Forecast Evaluation

- ***False alarms*** (i.e., forecast storms living longer than the actual storm) and ***misses*** (un-forecasted storms) are ignored by operational and research TC verification systems.
  - Genesis forecast evaluation is also needed
- Many TC forecasts now include uncertainty information, or are based on ensembles
  - Current methods for evaluating this uncertainty are inadequate and are often not applied.
  - How can this uncertainty information be applied? Can we set up any rules for this based on the evaluation?
    - E.g., How can info about *performance* of uncertainty be made useful for forecasters?

Thanks!!!

NHC TC Track Forecast

- Best practice

(1) TC track prediction formula for Atlantic and East Pacific

$$OFCL = (1-\alpha-\beta)*OFCI + \alpha*TVCN + \beta*(EMX....)$$

α ----weighting for consensus β ----weighting for non-consensus aid

OFCL------Official NHC forecast

OFCI------Previous cycle OFCL, adjusted (Interpolated)

TVCN------Average of at least 2 of GFSI, EGRI, NGPI, EMXI, HWFI, GFNI, GHMI (Consensus)

(2) TC track prediction formula for West Pacific

$$JTWC = (1-\alpha-\beta)*JTWI + \alpha*CONW + \beta*(ECM....)$$

α ----weighting for consensus β ----weighting for non-consensus aid

JTWC----JTWC official forecast

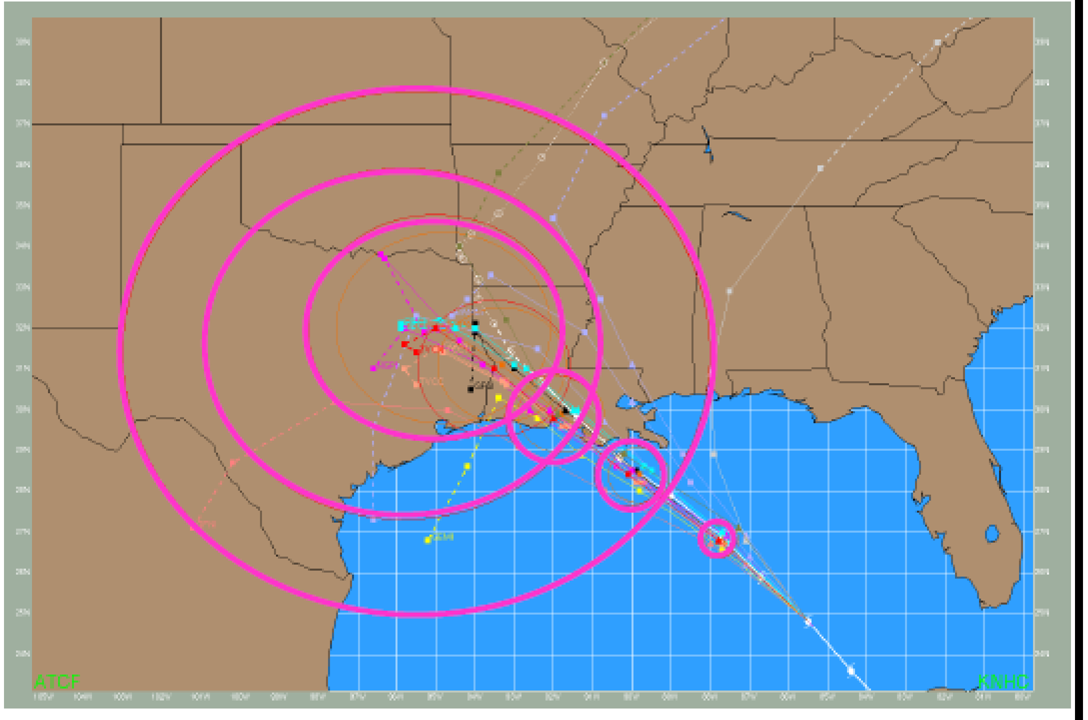
JTWI----Previous cycle JTWC, interpolated

CONW----Consensus with AVNI, EGRI, ECMI, NGPI, JGSI, GFNI, JTYI, TCLI, WBAI

Goerss Predicted Consensus Error (GPCE)

Goerss (2007), *Mon. Wea. Rev.*

- Estimates track error based on the spread of the members of the TVCN track consensus
  - Currently composed of: GFS, ECMWF, UKMET, NOGAPS, HWRF, GFDL, GFDN
- Designed so that verifying TC position will be inside the GPCE circle about 70% of the time



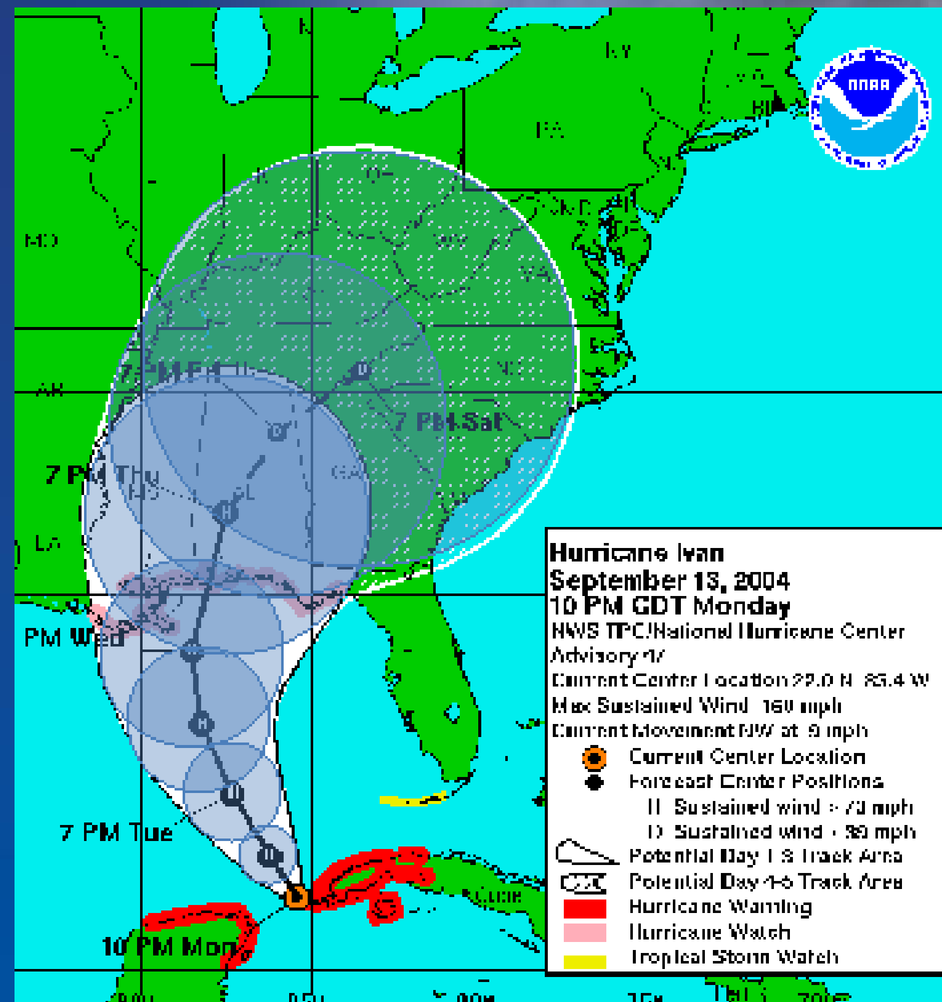
- Objective measure of confidence of the consensus track forecast
- Available to forecasters in real-time when making the forecast

Courtesy of M. Brennan

NHC Forecast Cone

- Represents the probable track of the *center* of the tropical cyclone.
- Formed by connecting circles centered on each forecast point (at 12, 24, 36 h, etc.)
- Size of the circles determined so that, say, the actual storm position at 48 h will be within the 48-h circle 67% of the time.

Forecast Period (h)	2009 Circle Radius (n mi) ('04 – '08 errors)	2010 Circle Radius (n mi) ('05 – '09 errors)
12	36	36
24	62	62
36	89	85
48	111	108
72	167	161
96	230	220
120	302	285



SHIPS Rapid Intensification Index

Kaplan et al. (2010), *Wea. Forecasting*

- Statistical guidance for rapid intensification
- Current version operational in 2008
- Provides probability of 25, 30, and 35 kt intensity increase in the next 24 hours
- Based on eight predictors:
  - Tropical Cyclone
    - Previous 12-h intensity change
    - Difference between current intensity and MPI
  - Atmospheric
    - 200-hPa divergence
    - 850-200 hPa vertical wind shear
    - 850-700 hPa relative humidity
  - Oceanic
    - Upper-ocean heat content
  - Satellite
    - Standard deviation of IR brightness temperature (convective symmetry)
    - Coverage of tops with brightness temperatures < -30°C
- Available to forecasters in real-time with other SHIPS output

Courtesy of M. Brennan

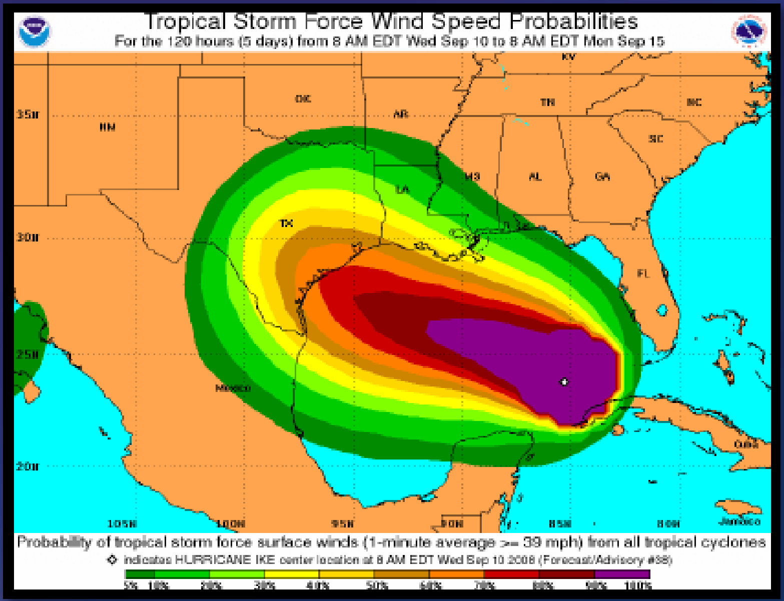
Wind Speed and Intensity Probability Products

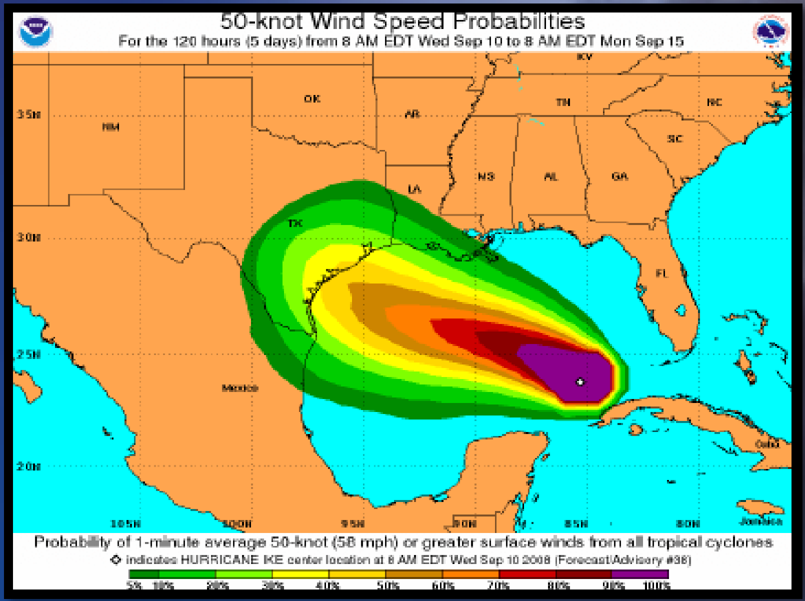
DeMaria et al. (2009), *Wea. Forecasting*

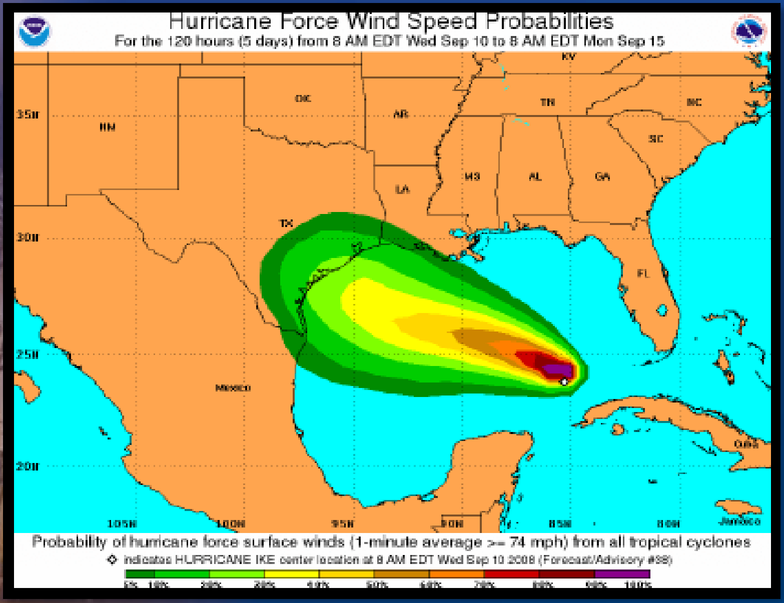
- Depict location-specific probabilities of 34-kt, 50 kt, and 64-kt winds
- Created using 1,000 Monte Carlo realizations created by random sampling of NHC track and intensity forecast errors from the previous 5 years
  - Centered on official NHC forecast
  - Errors are serially correlated
- Uses climatology and persistence model for wind radii
- Accounts for inland decay
- Available to NHC forecasters after forecast is made but prior to release of advisory
- Steered EMs and other users toward these products in lieu of the cone graphic since they provide information on *impacts*

Courtesy of M. Brennan

Surface Wind Speed Probabilities







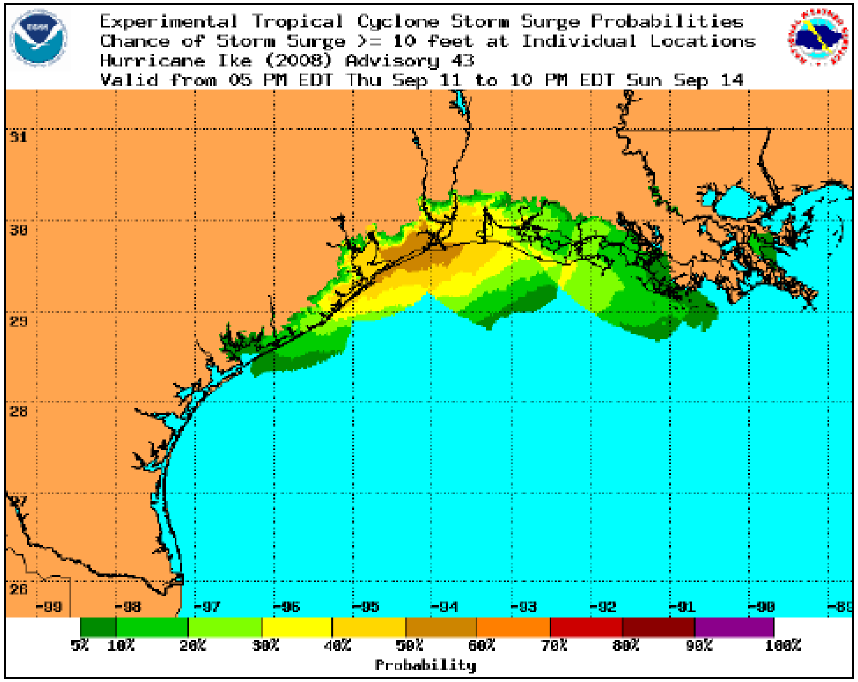
Maximum 1-minute Wind Speed Probability

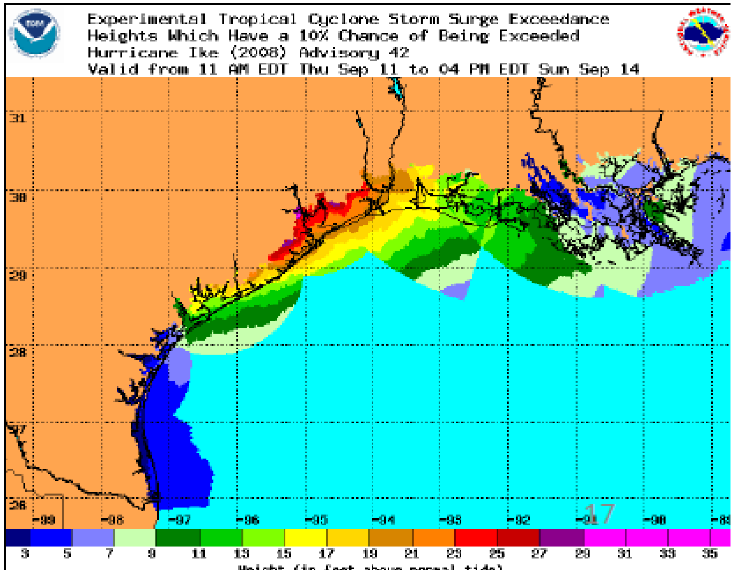
Intensity (Maximum Wind Speed) Probability Table
Hurricane Ike Advisory Number 38
10:00 AM CDT Sep 10 2008

	Forecast Time						
Wind Range (mph)	12 hour for 7 PM Wed	24 hour for 7 AM Thu	36 hour for 7 PM Thu	48 hour for 7 AM Fri	72 hour for 7 AM Sat	96 hour for 7 AM Sun	120 hour for 7 AM Mon
Dissipated	<1%	<1%	<1%	<1%	1%	55%	73%
Tropical Depression (<39)	<1%	<1%	<1%	<1%	4%	20%	16%
Tropical Storm (39-73)	1%	2%	2%	3%	26%	12%	6%
Hurricane (all categories)	99%	98%	98%	97%	69%	13%	6%
-- Category 1 (74-95)	23%	19%	11%	12%	25%	2%	<1%
-- Category 2 (96-110)	59%	43%	24%	20%	16%	2%	1%
-- Category 3 (111-130)	16%	32%	46%	38%	18%	5%	3%
-- Category 4 (131-155)	1%	4%	15%	23%	8%	3%	2%
-- Category 5 (>155)	1%	1%	2%	4%	2%	1%	<1%
Forecast Maximum Wind	105 mph	110 mph	120 mph	125 mph	120 mph	40 mph	30 mph

Probabilistic Storm Surge

- Run when hurricane watch or warning in effect for the U.S.
- Output:
  - Probabilities of storm surge exceeding thresholds from 2-25 ft
  - Exceedence height for various probability threshold (e.g., the surge height that has a 10% chance of being exceeded)
- Available within about 30 minutes of advisory release time
- Difficult to verify, but preliminary comparisons with deterministic SLOSH runs underway





Courtesy of M. Brennan

NOAA Hurricanes Seasonal Forecast

- NOAA Seasonal Forecast Methodology
  - Assess states of the ocean and atmosphere.
  - Use model forecasts for El Niño/Atlantic SSTs and incorporate any analog techniques and dynamical model forecasts of TCs.
  - Predict range of overall activity and probabilities of above-, near-, and below average seasons.
  - Qualitative/Quantitative process.
  - No forecast of hurricane landfalls, just the total seasonal activity for the entire basin
- Seasonal Hurricane Outlooks
  - NOAA does not issue a landfall forecast, because there is very little useful skill.
  - Overall skill is quite small in May, but significantly better than climatology in August.
  - 1 August update issued because ~90% of the remaining seasonal activity is after that date.

NOAA 2010 Atlantic Hurricane Season Outlooks

Activity Type	2010 Outlooks: August Update	2010 Outlooks: May 27	Normals
Chance Above Normal	90%	85%	33%
Chance Near Normal	10%	10%	33%
Chance Below Normal	0%	5%	33%

There is a high likelihood (90% chance) that the 2010 season will be above normal. This update reiterates the pre-season outlook issued in May.

Named Storms	14-20	14-23	11
Hurricanes	8-12	8-14	6
Major Hurricanes	4-6	3-7	2
ACE (% Median)	170-260	155-270	100

The outlooks indicate a 70% probability for each range. All ranges remain above-normal. The ACE range indicates a continued high likelihood of a very active season (ACE $\geq$ 175%).

The types of observations that have been used over the years to monitor tropical cyclones (Chu et al. 2002).

1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
=Ship logs and land observations →											
=Transmitted ship and land observations →											
			=Radiosonde network →								
				=Military aircraft reconnaissance===							
					=Research aircraft reconnaissance →						
					=Radar network →						
						=Meteorological satellites →					
							=Satellite cloud-tracked & water-vapor-tracked wind →				
									=SSM/I & QuikSCAT wind, MODIS →		
							=Omega and GPS dropsondes →				
							=Data buoys →				
								=SST analysis →			
							=Dvorak technique →				
				=DOD TC documentation published (ATR, ATCR) →							
							=McIDAS and other interactive systems (AFOS, ATCF, AWIPS and MIDAS, etc.) →				
1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010

NOAA 2011 Atlantic Hurricane Season Outlooks

2011 Outlooks

Activity Type	August Update	May 19 Outlook	Normals
Chance Above Normal	85%	65%	33%
Chance Near Normal	15%	25%	33%
Chance Below Normal	0%	10%	33%

Compared to the pre-season outlook issued in May, there is a higher likelihood (85% chance) that the 2011 season will be above normal.

Named Storms	14-19	12-18	11
Hurricanes	7-11	6-10	6
Major Hurricanes	3-5	3-6	2
ACE (% Median)	135-215	105-200	100

The outlooks indicate a 70% probability for each range.

The updated outlook indicates:

1. **Above-normal numbers of named storms, hurricanes, and major hurricanes,**
2. **The potential for more named storms, hurricanes, and total seasonal activity (i.e. ACE index) than indicated in May.**

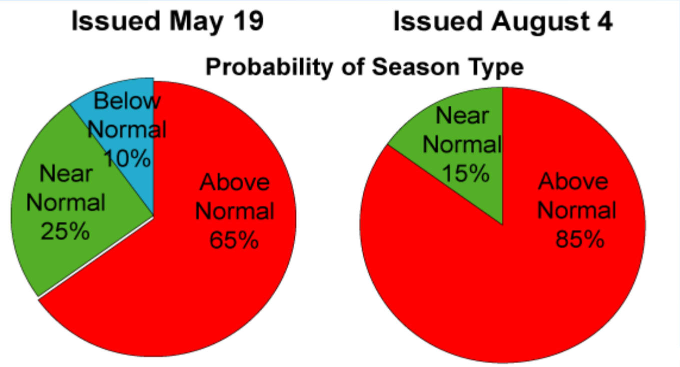
Experimental Verification Methods

- Verification of deterministic and categorical forecasts of extremes
- Spatial verification techniques that apply to TCs
- Ensemble verification methods applicable to TCs
  - Probability ellipses and cones derived from ensembles
  - Two-dimensional rank histograms
  - Probabilistic forecasts of extreme events (high risk, low probability events)
- Genesis forecasts

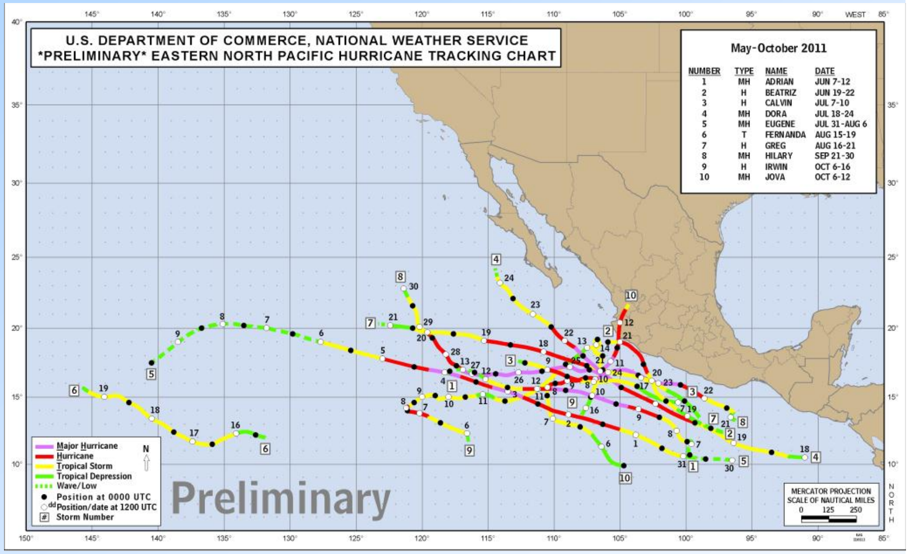
Tropical Storm Forecasts

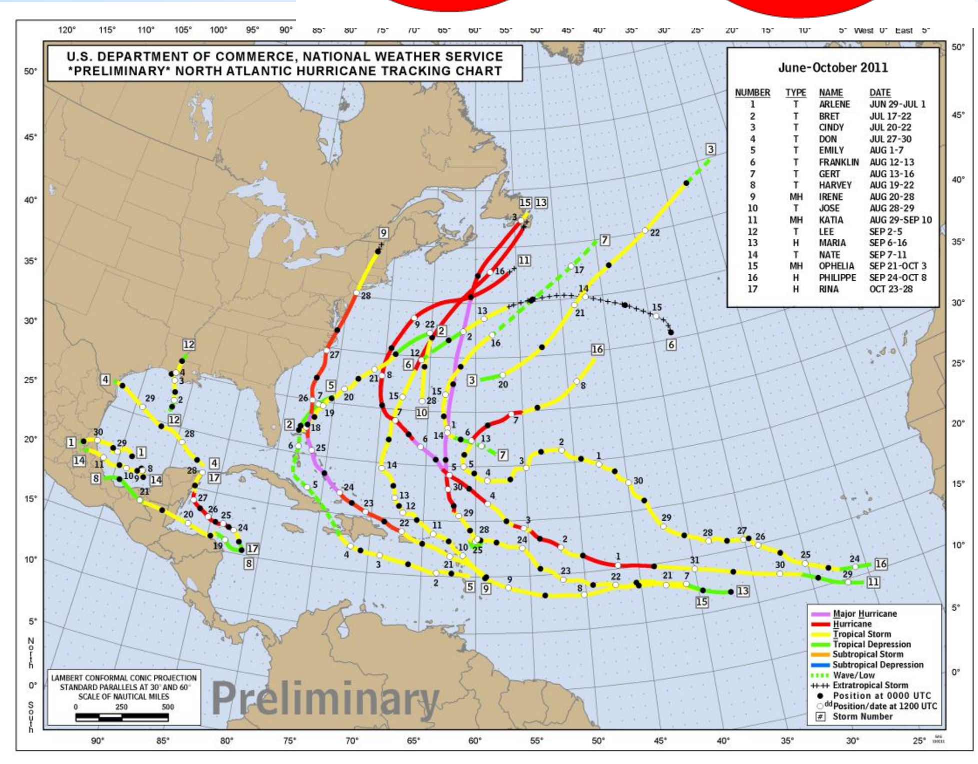
Official CPC product made in collaboration with NHC/NWS and HRD/NOAA

<u>ATLANTIC</u>
14-19 Named Storms / 19
7-10 Hurricanes / 7
3-5 Major Hurricanes / 3
An ACE range of 135%-215% of the 1981-2010 median. / 133

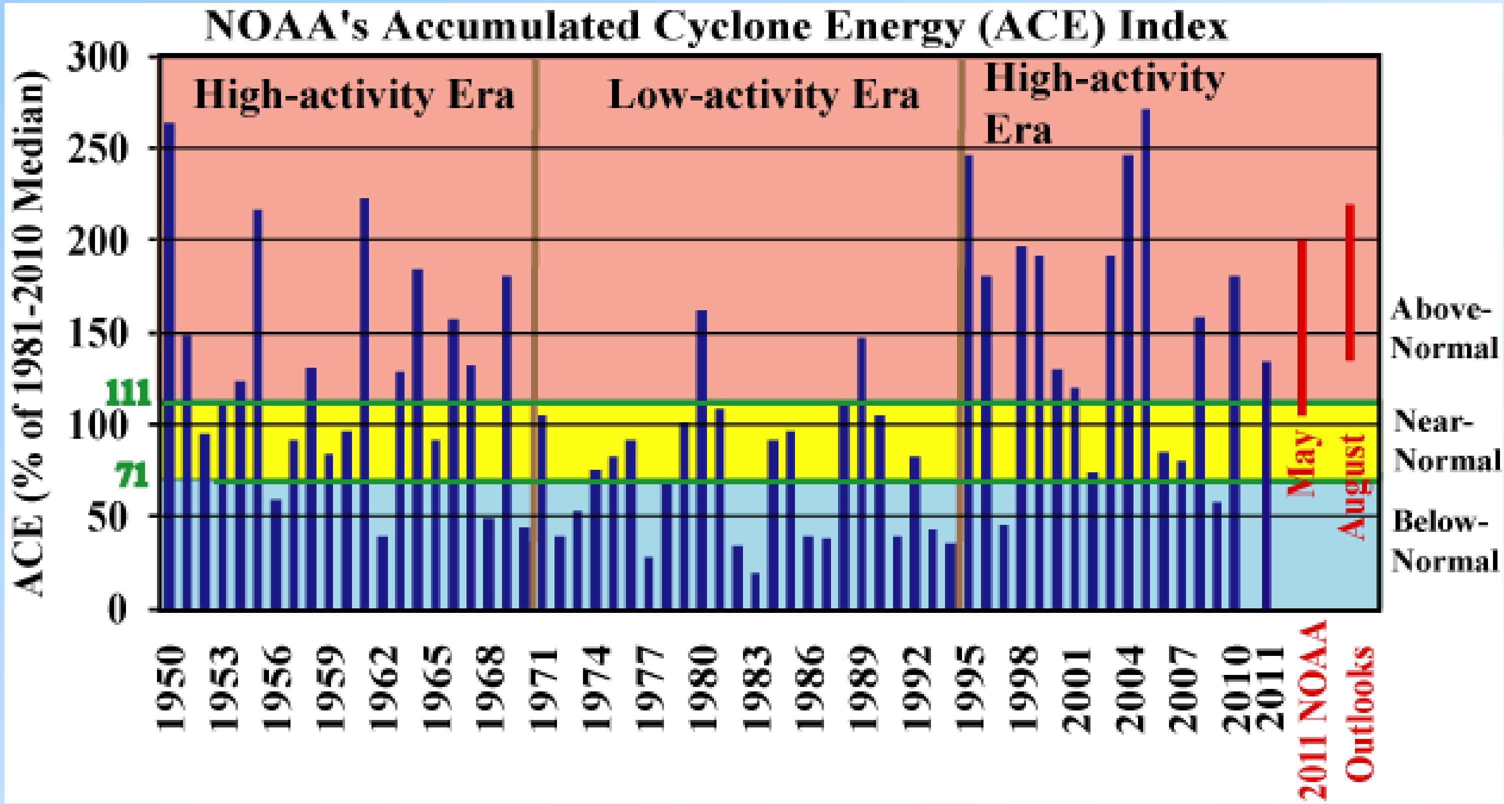


<u>EAST PACIFIC</u>
9-15 named storms / 11
5-8 hurricanes / 10
1-3 major hurricanes, / 5
An ACE range 45%-105% of the median. / 113



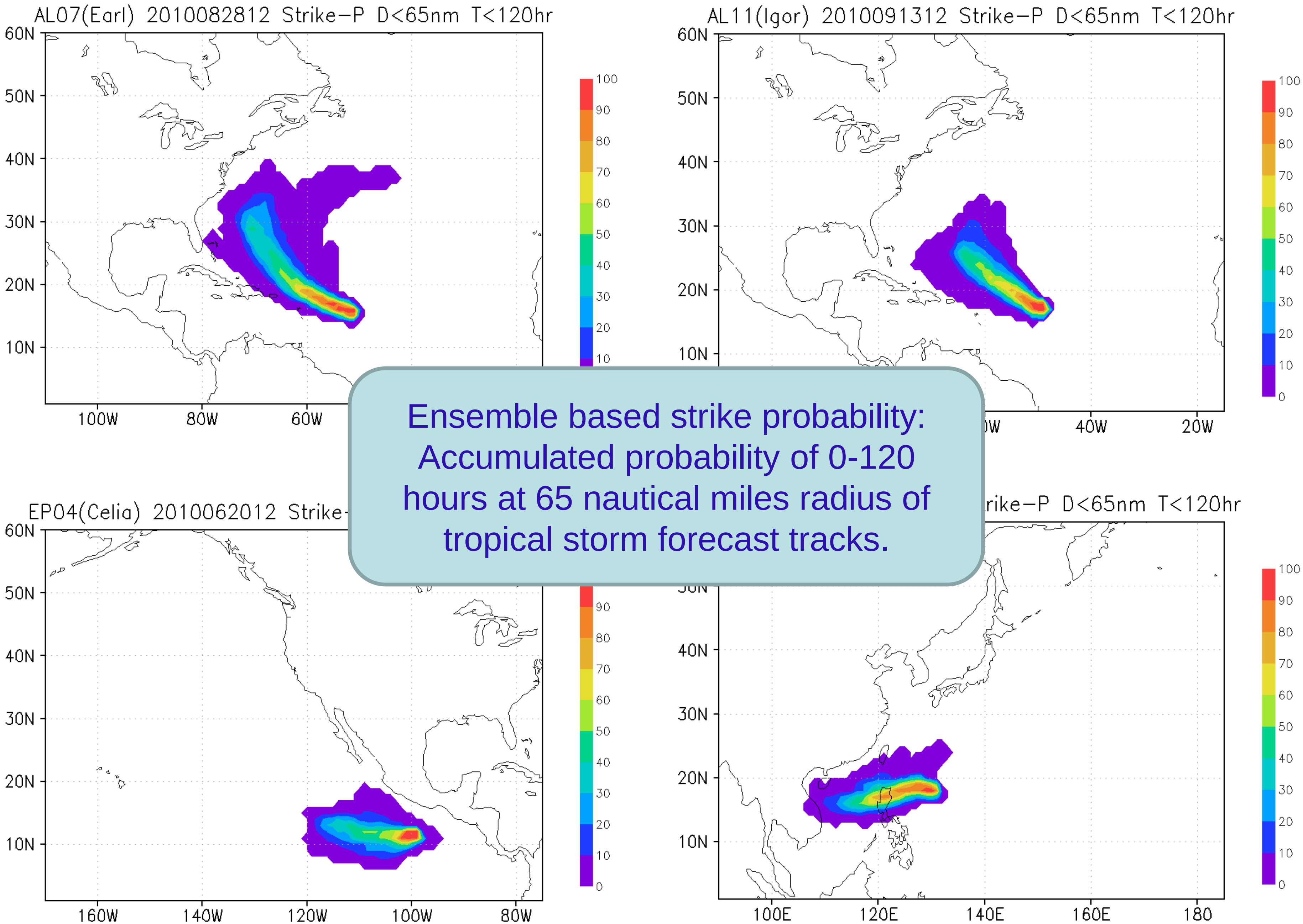


2011 ACE Outlook In A Historical Perspective



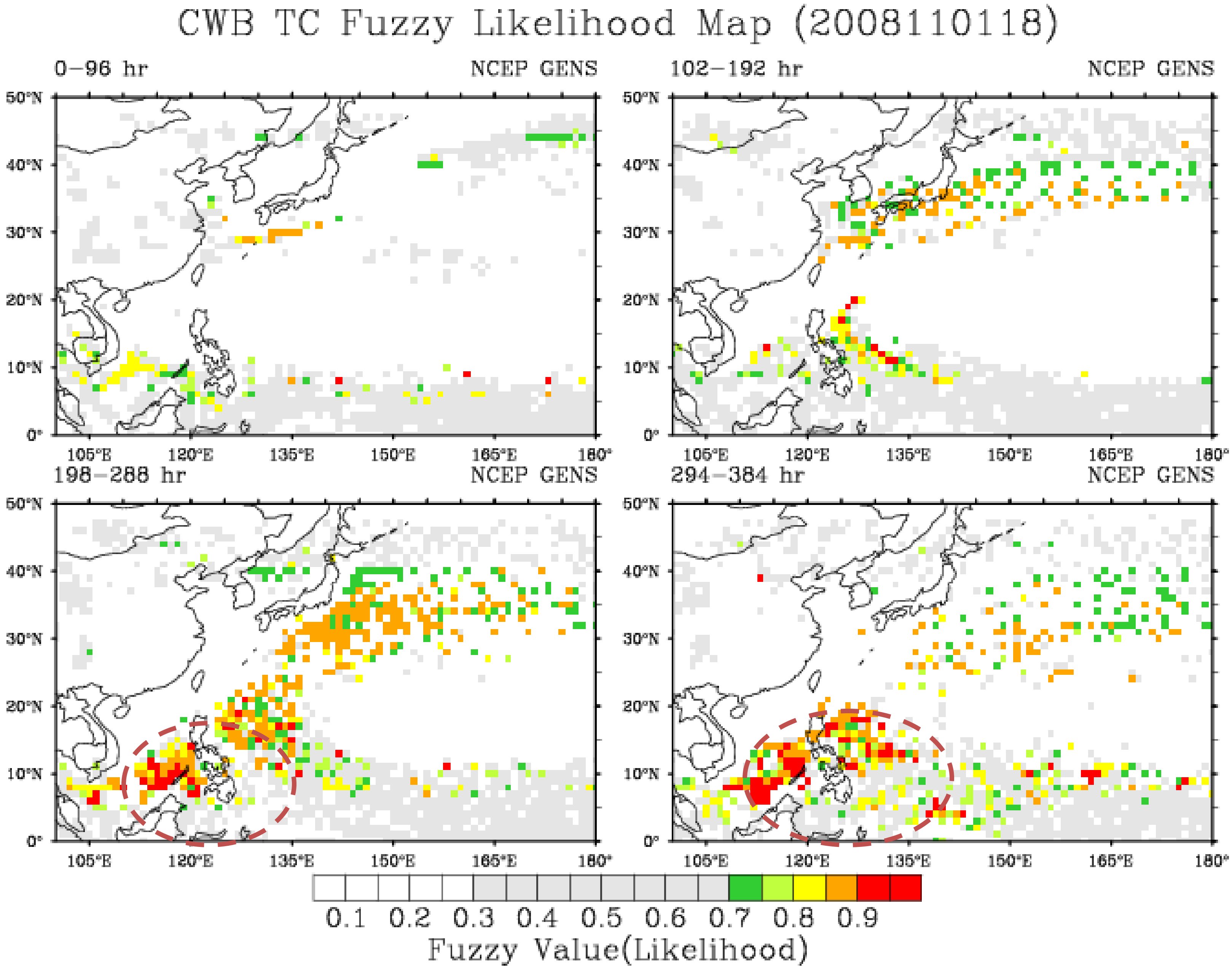
ACE=$\sum_{NS} \sum_{T} V_{max}^2$ for all named storms while at least TS strength (4x daily).

•2011 is an above-normal season, reflecting continuation of high activity era.



Ensemble based strike probability: Accumulated probability of 0-120 hours at 65 nautical miles radius of tropical storm forecast tracks.

Courtesy of Jiayi Peng



Courtesy of Hsiao-Chung Tsai and Kuo-Chen Lu (Tsai and Lu, 2008)

Ensemble based probabilistic ellipses

Initialized 00 UTC
5 August 2009.

* indicates observed best-track position.

Bi-variate normal distribution fit to ensemble member positions; contour encloses 90% of fitted probability.

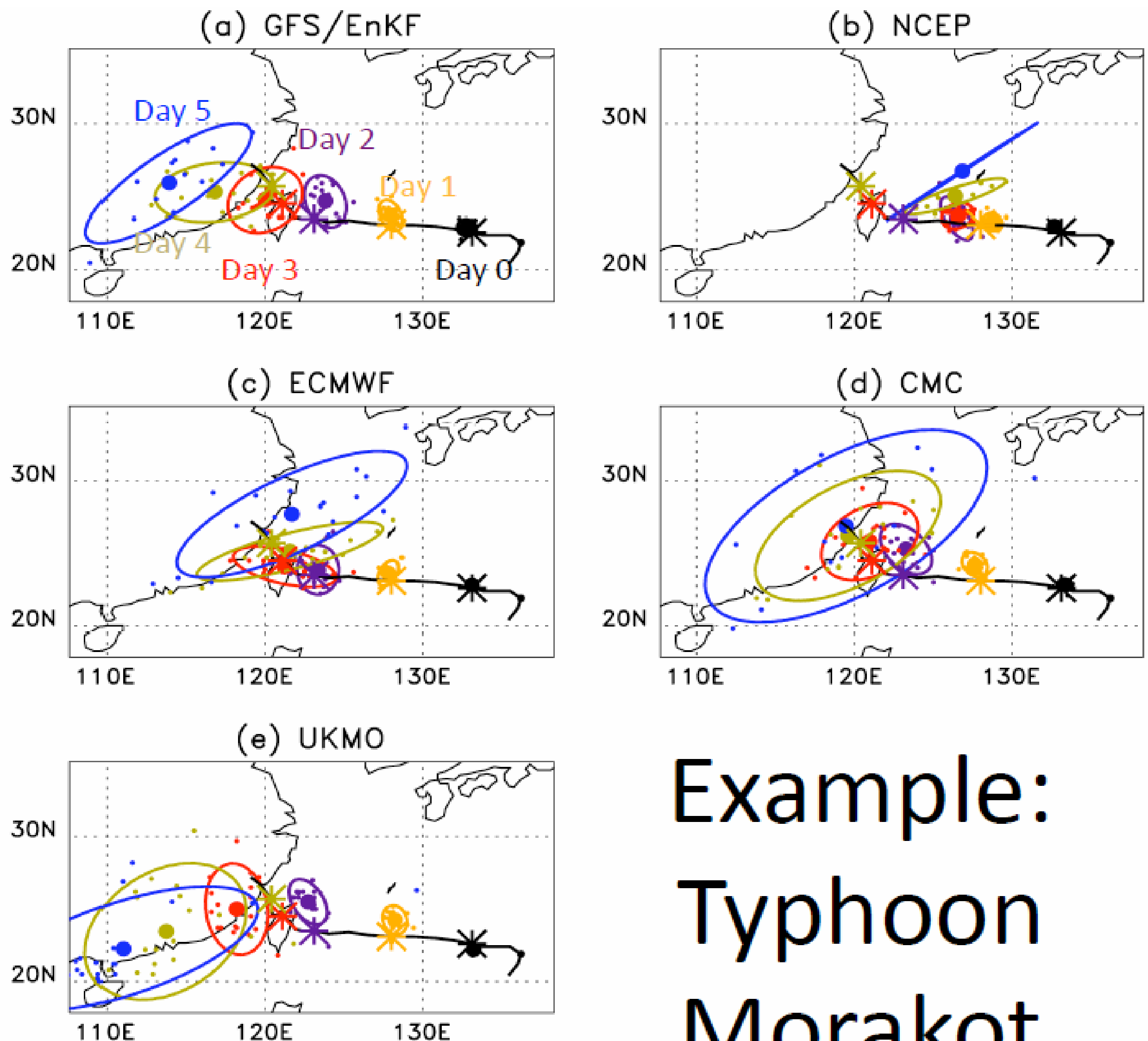
GEFS/EnKF a bit north and too fast.

NCEP has northward & westward bias, few members track.

ECMWF tracks decent up to Taiwan landfall

CMC has very large spread, esp. after landfall.

UKMO too north, too fast.



Example: Typhoon Morakot

[Courtesy of Tom Hamill]()

Example: Hurricane Bill

Initialized 00 UTC 19 August 2009.

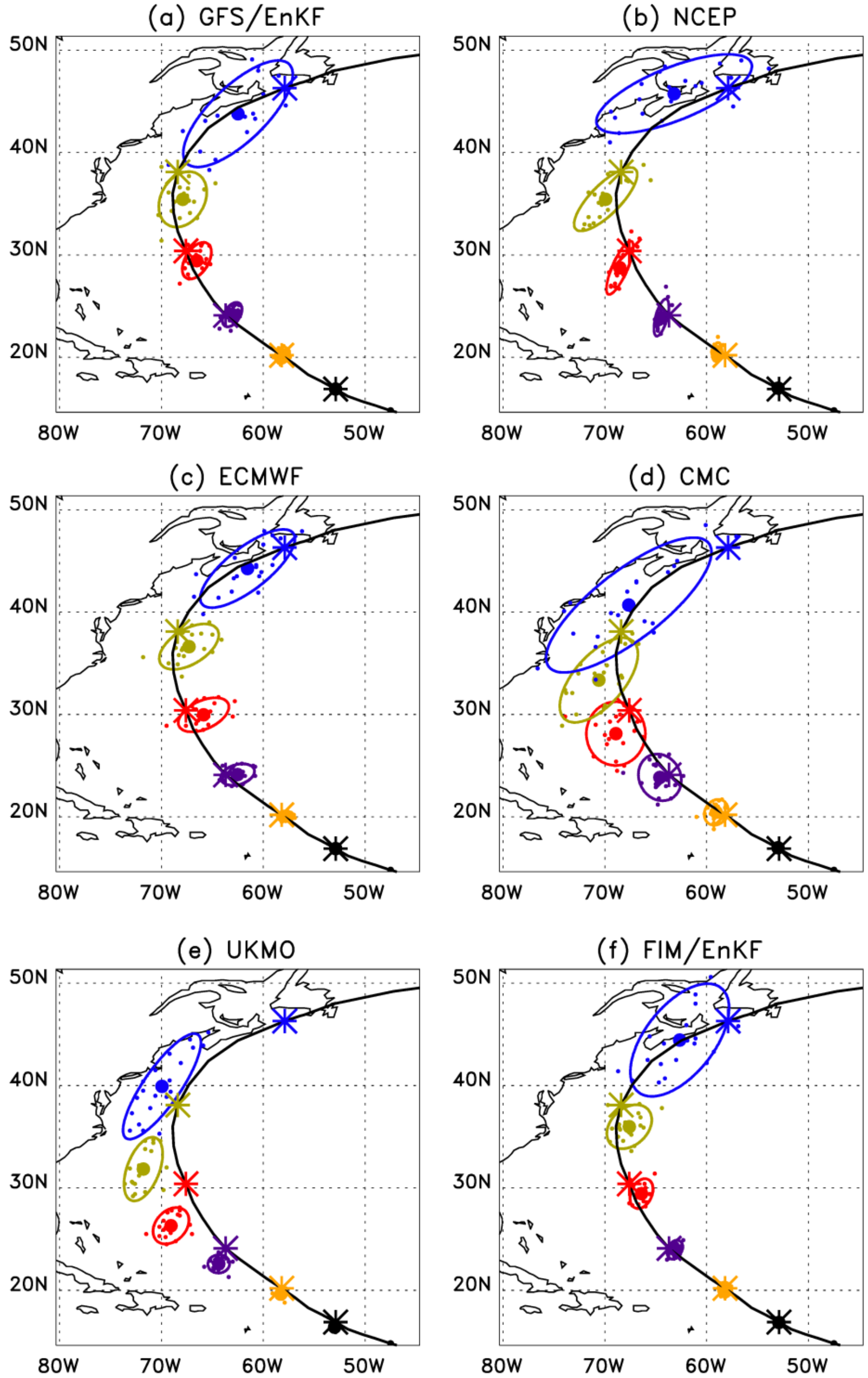
Contours provide fit of bivariate normal to ensemble data. Encloses 90% of the probability.

All models slow, to varying extents.

GEFS/EnKF, ECMWF, NCEP, FIM tracks decent.

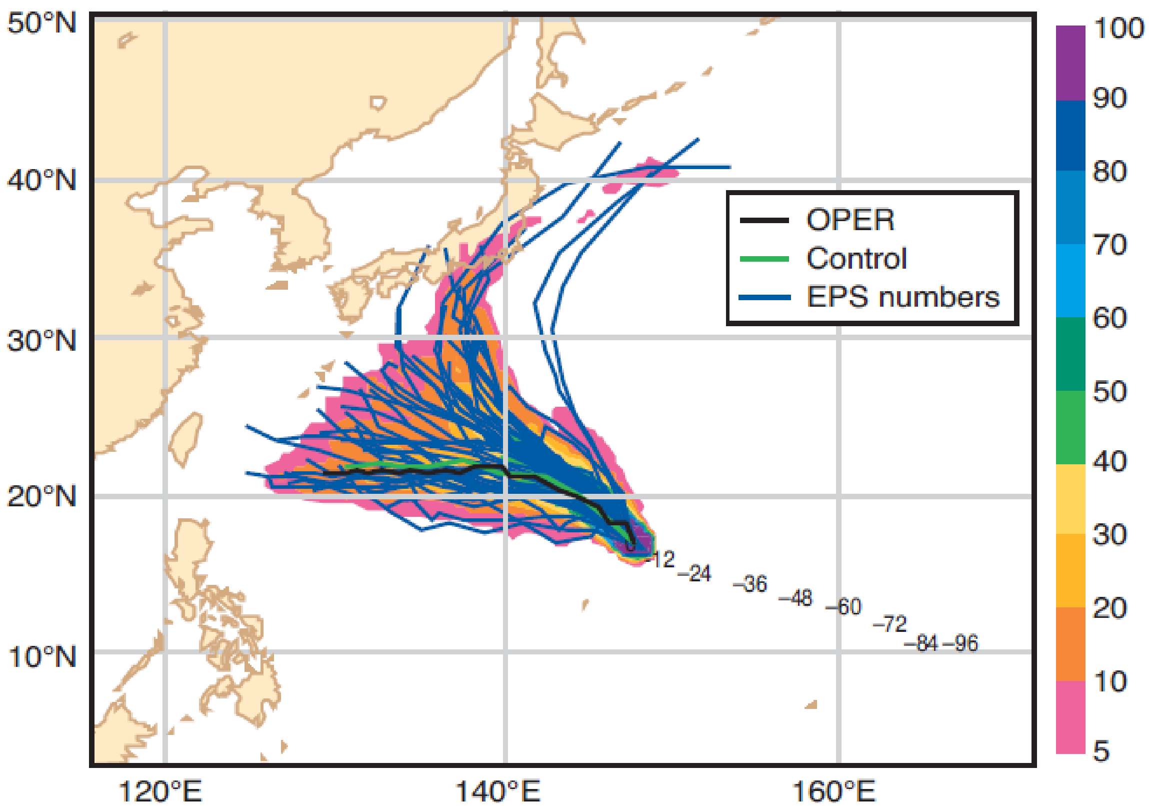
UKMO, CMC have westward bias.

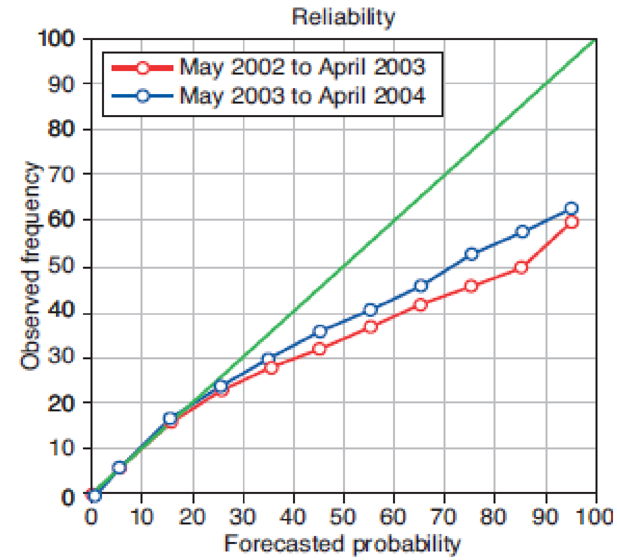
Courtesy of Tom Hamill

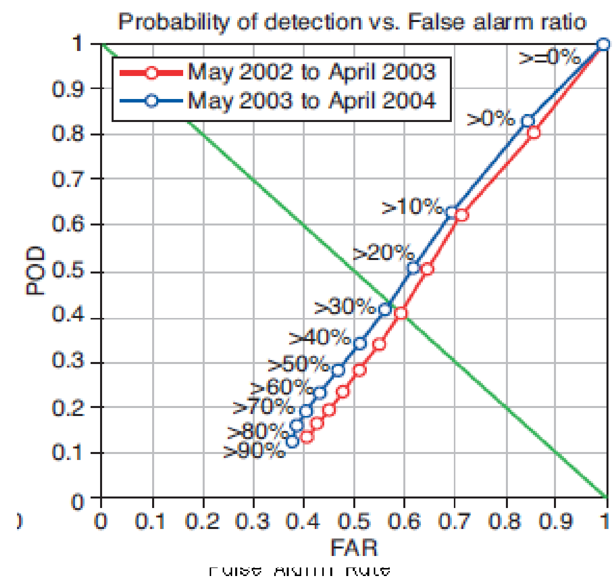


Verification methods for ensemble TC forecasts

Strike probabilities

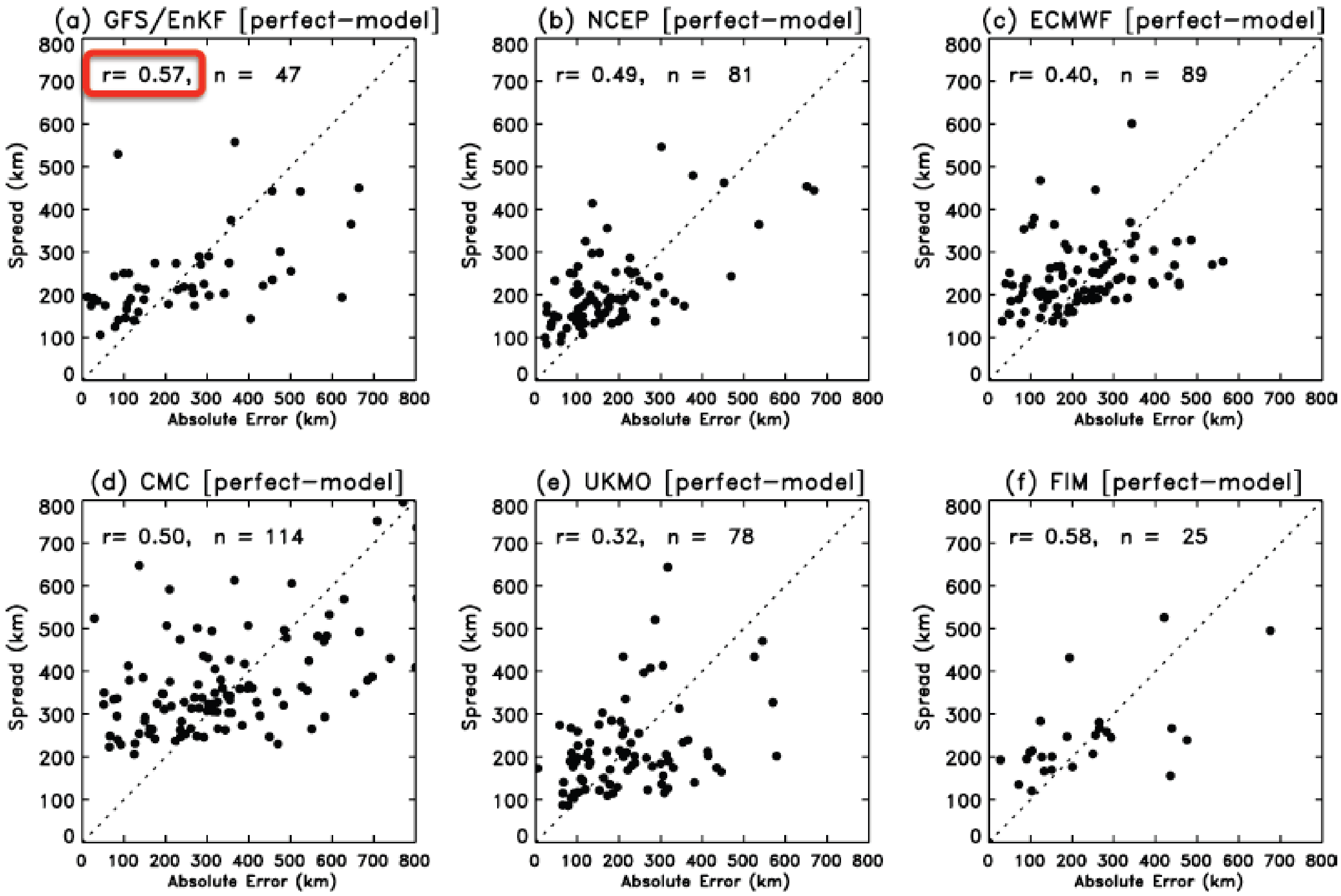






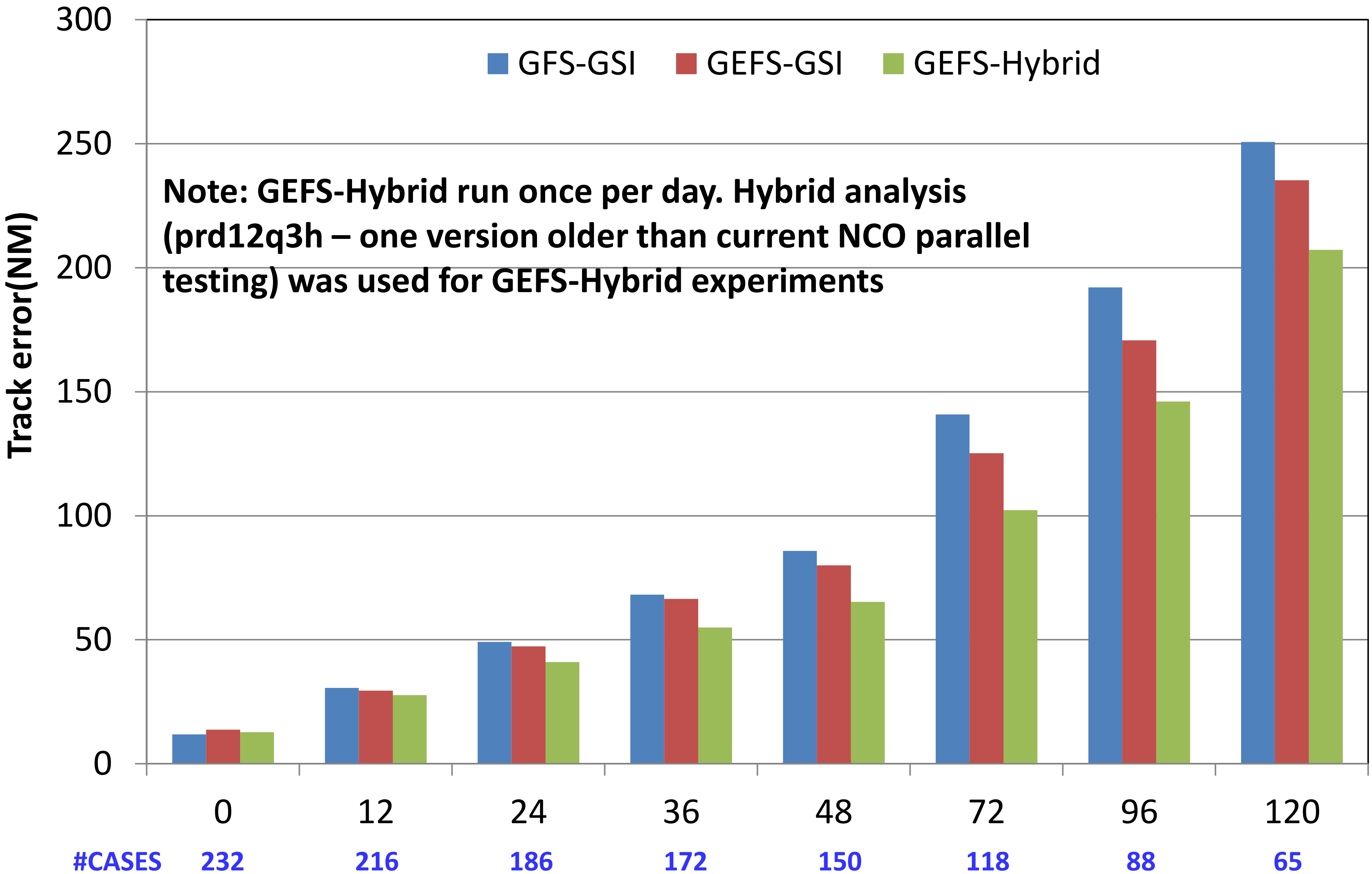
ECMWF 2005

Spread-error relations, perfect-model assumption



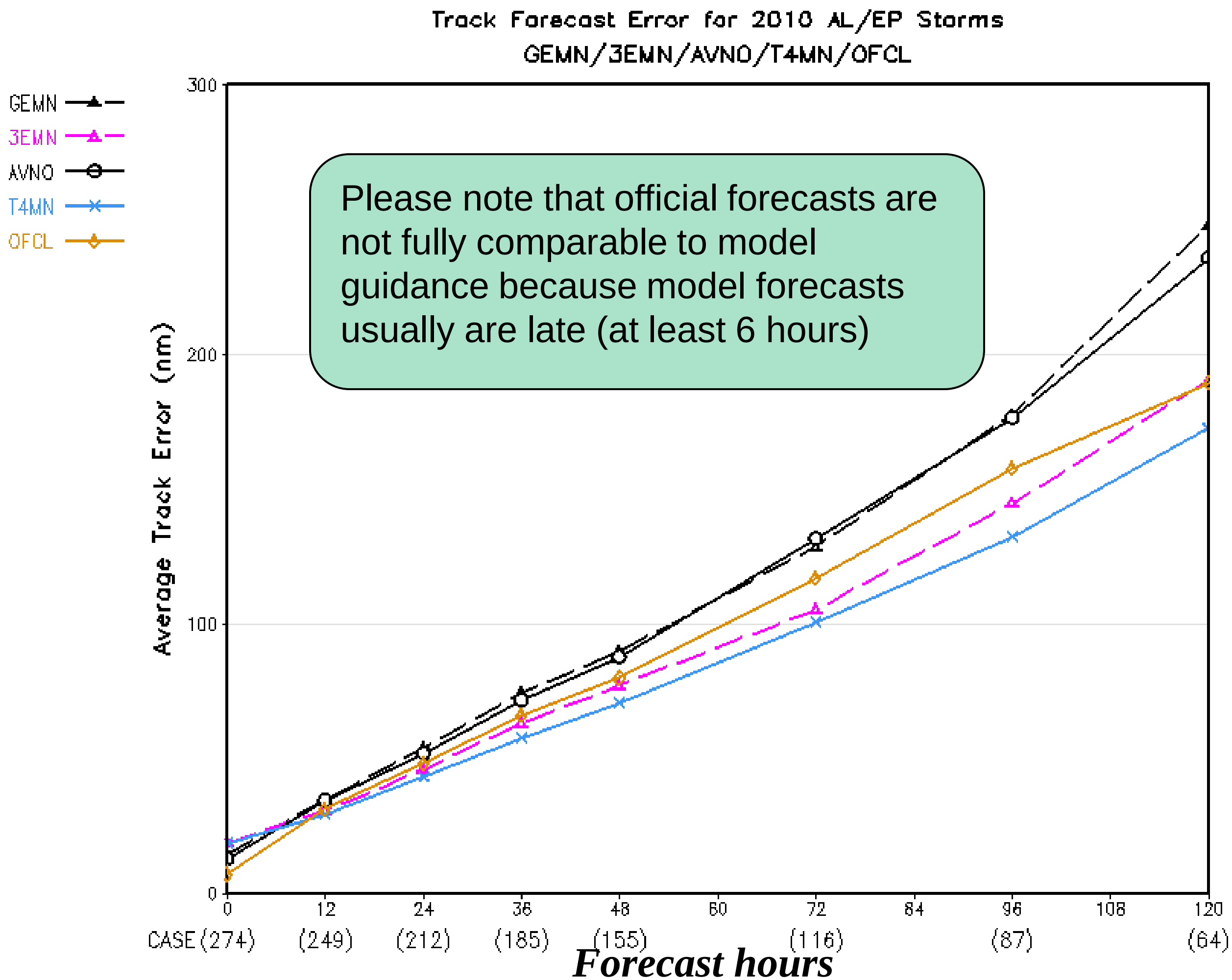
Courtesy of T. Hamill

AL01-18,EP03-12, WP08-23 (07/01-10/25/2011)



Courtesy of Jiayi Peng and Xiaqoing Zhou

Multi-model ens. 33 TCs in Atlantic and East Pacific in 2010



1Nautical Mile=1.852km

Verification:
3EMN and T4MN are much better than OFCL.

GEMN — NCEP (GEFS) 20-member mean

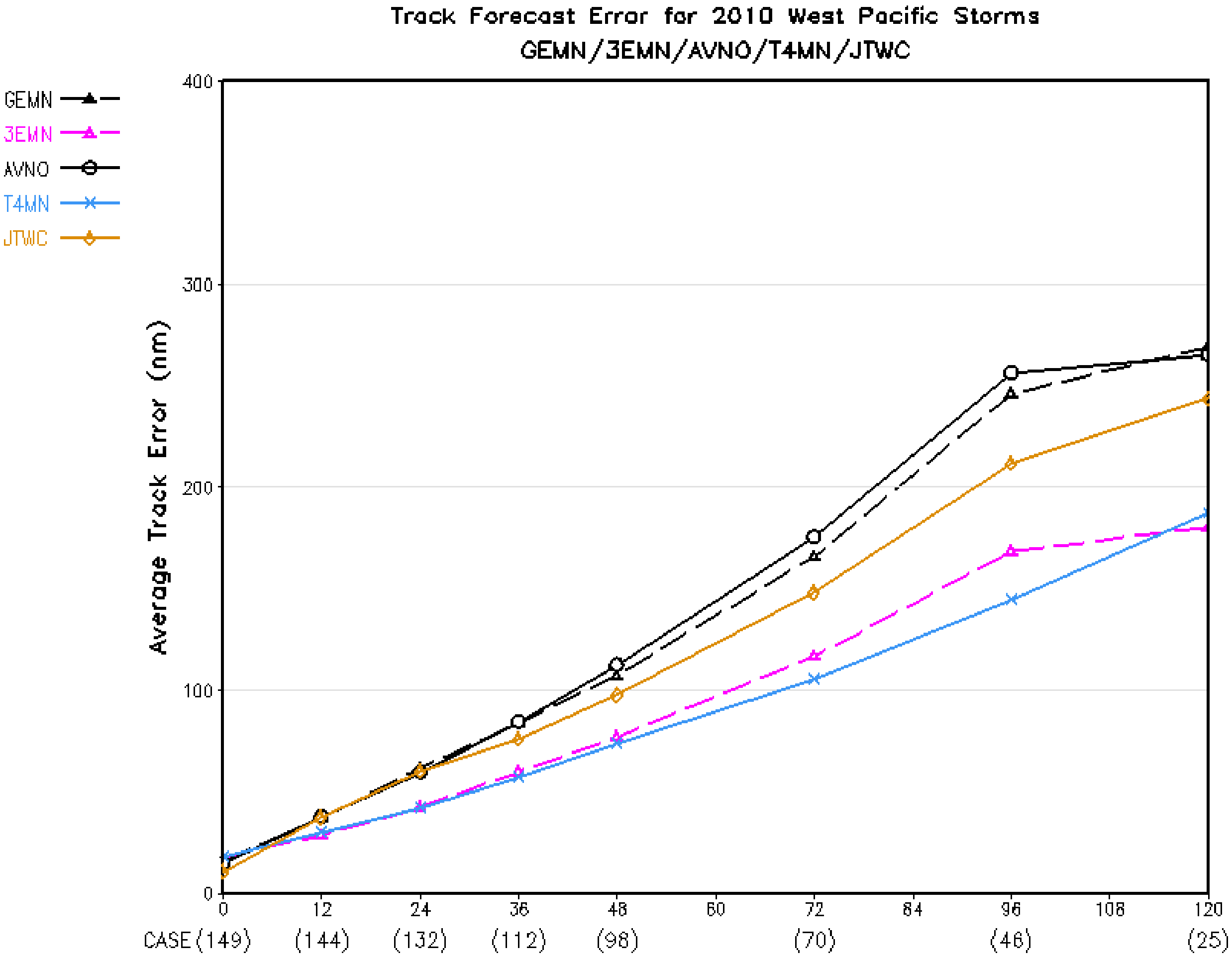
3EMN — NCEP+CMC+ECMWF 90-member mean

AVNO — NCEP (GFS) deterministic run (T574L64)

T4MN — 3EMN+(NCEP+CMC+ECMWF, three deterministic runs)

OFCL — OFCL official forecast

Courtesy of Jiayi Peng



Forecast hours

19 TCs in West Pacific

Verification:
3EMN and T4MN are much better than JTWC.

GEMN — NCEP (GEFS) 20-member mean

3EMN — NCEP+CMC+ECMWF 90-member mean

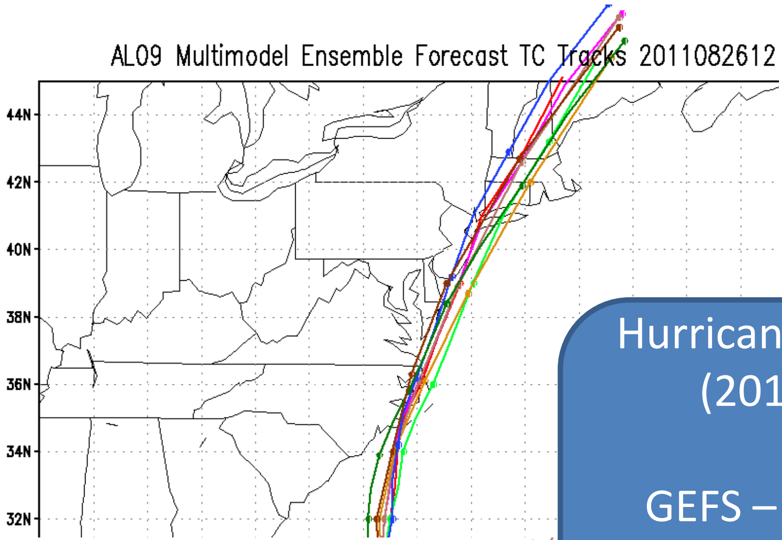
AVNO — NCEP (GFS) deterministic run (T574L64)

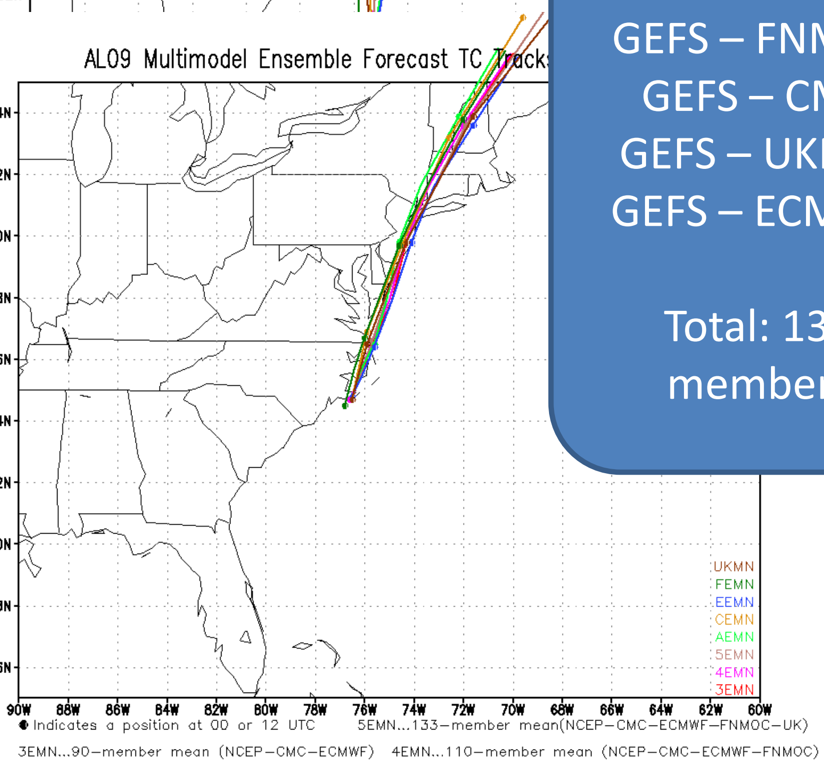
T4MN — 3EMN+(NCEP+CMC+ECMWF, three deterministic runs)

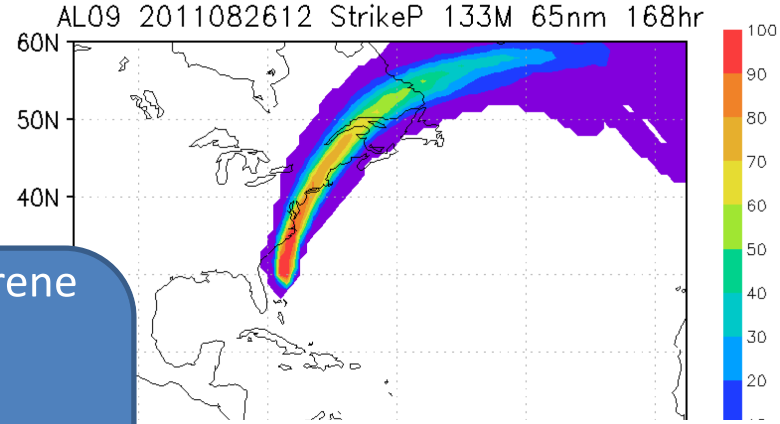
JTWC — JTWC official forecast

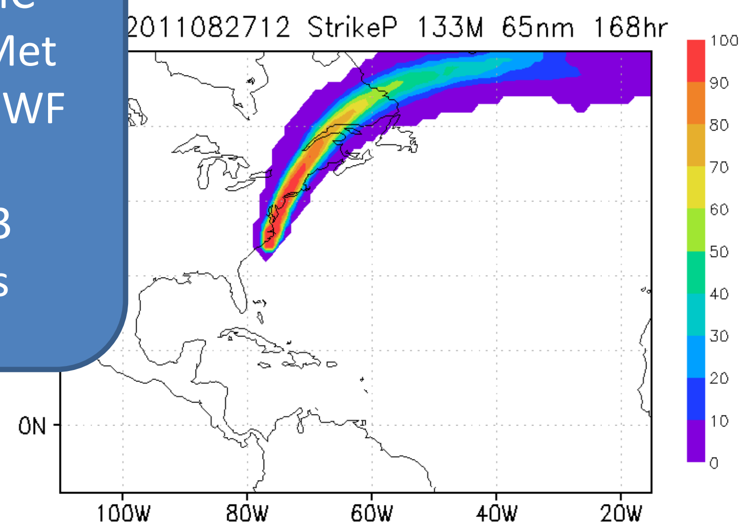
Courtesy of Jiayi Peng

Multi-model ensemble forecast









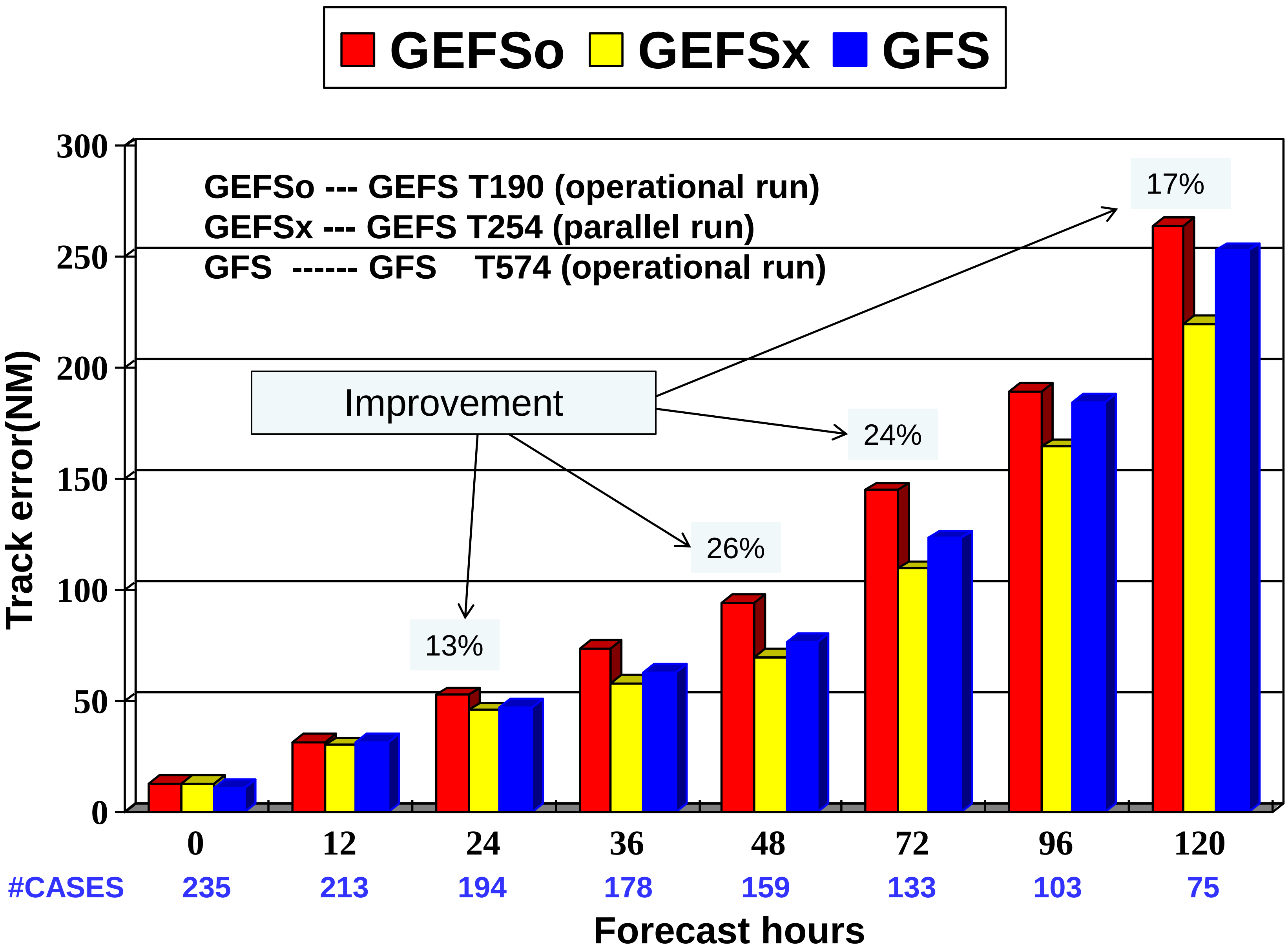
Hurricane Irene (2011):

GEFS – NCEP
GEFS – FNMOC
GEFS – CMC
GEFS – UKMet
GEFS – ECMWF

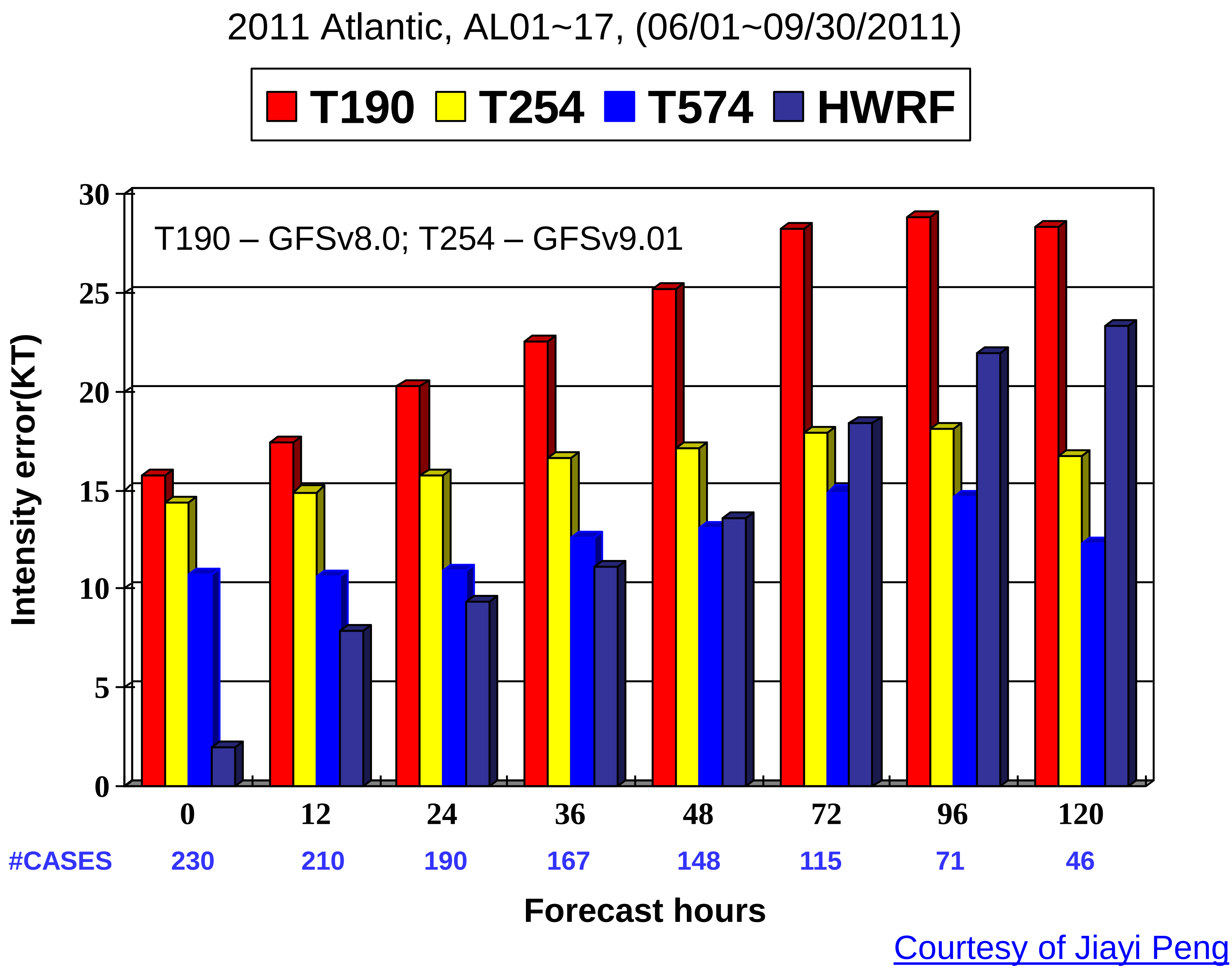
Total: 133 members

Courtesy of Jiayi Peng

Atlantic, AL01~17 (06/01~09/30/2011)



Courtesy of Jiayi Peng


2011 Atlantic, AL01~17, (06/01~09/30/2011)
T190
T254
T574
HWRF
T190 – GFSv8.0; T254 – GFSv9.01
Intensity error(KT)
30
25
20
15
10
5
0
0
12
24
36
48
72
96
120
#CASES
230
210
190
167
148
115
71
46
Forecast hours
Courtesy of Jiayi Peng

HFIP

(Hurricane Forecast Improvement Project)

HFIP Goal #1

Reduce average track error by 50% for Day1 through 5

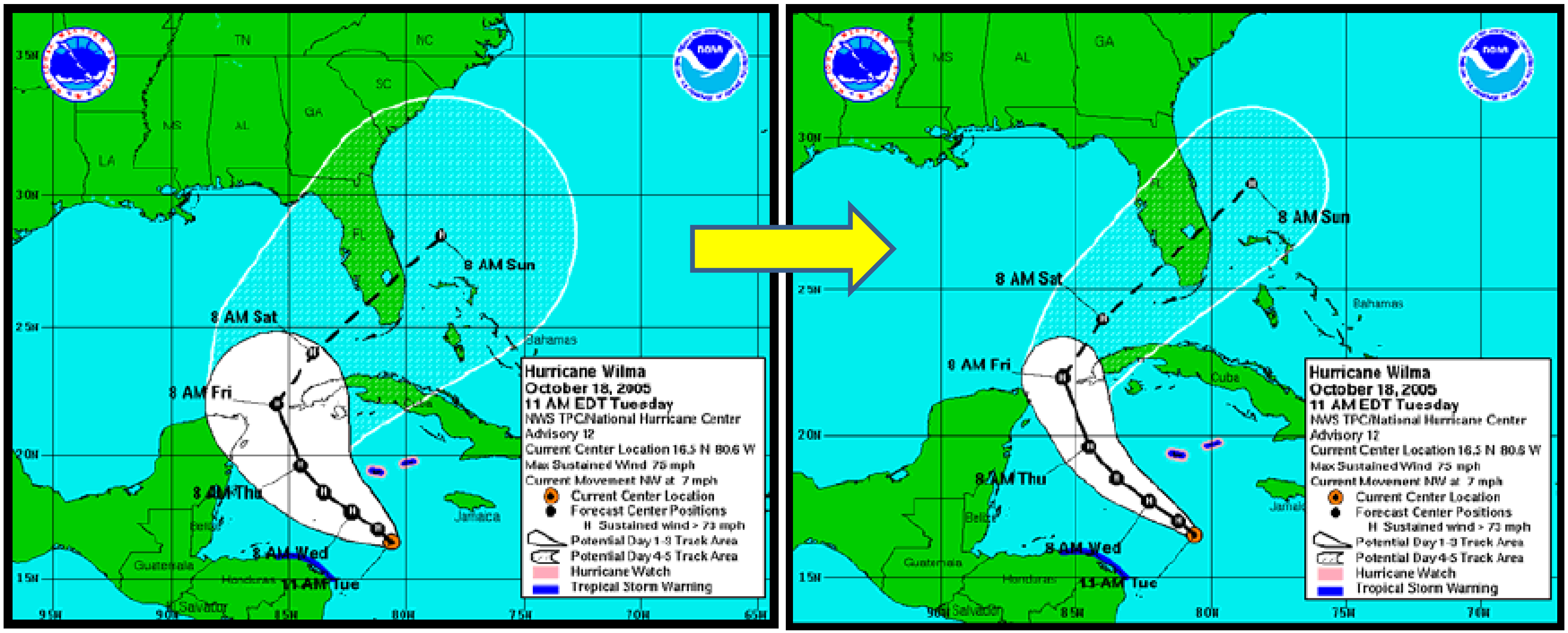


Figure 3. The panels above are examples of the NHC track forecast (cone graphic). The black line denotes the NHC forecast track for the center of the storm over a 5 day period The cone is calculated such that the center remains within it two-thirds of the time based on official forecast errors over the previous 5 years. The panel on the left shows what the NHC hurricane cone graphic would look like today. The panel of the right shows the same storm with a 50% reduction in track error, the first goal of the HFIP.

HFIP Goal #2

Reduce average intensity error by 50% for Day 1 through 5

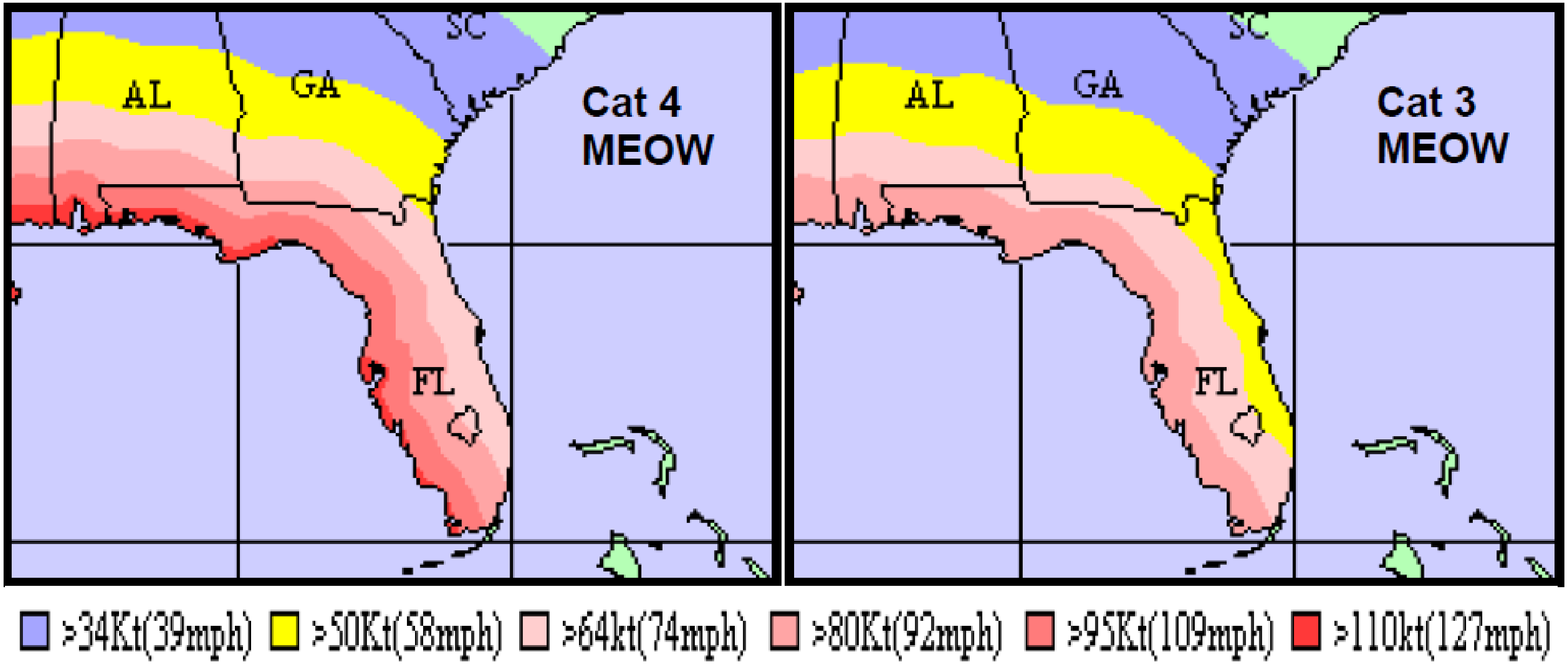


Figure 4: The Model Envelope of Winds (MEOW) shown above illustrates how far inland the winds of the hurricane will extend. The left panel shows the inland wind estimates for a Category 4 hurricane (moving at 14 mph) just prior to landfall. This is what the emergency managers would prepare for even though the official forecast calls for a Category 3 hurricane to account for the uncertainty in the intensity forecast. The success of this project would allow for emergency managers to prepare for Category 3 conditions when a Category 3 hurricane is forecast, which is represented in the panel on the right. In this example, both the east and west coast of Florida would prepare for less severe wind conditions.

HFIP Goal #2

Reduce average intensity error by 50% for Day 1 through 5

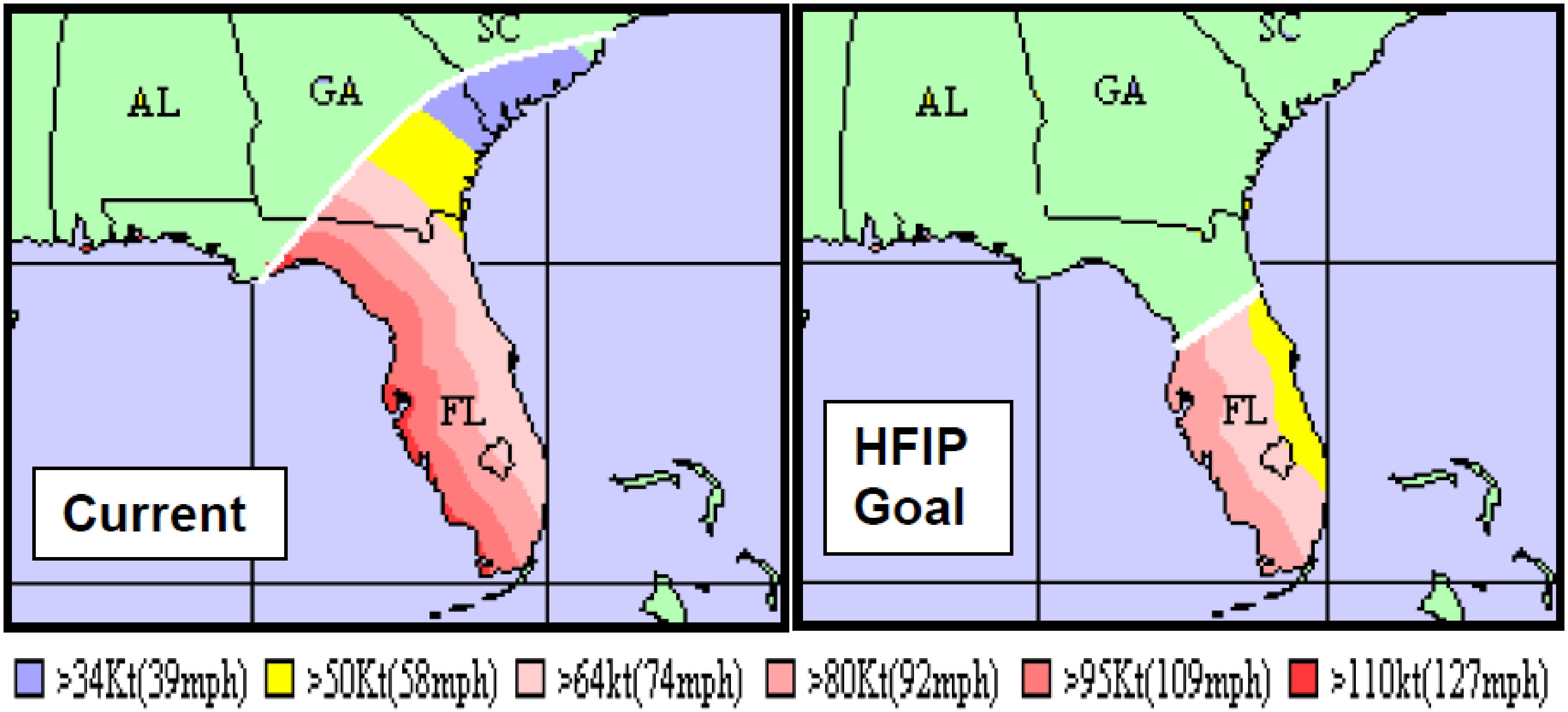
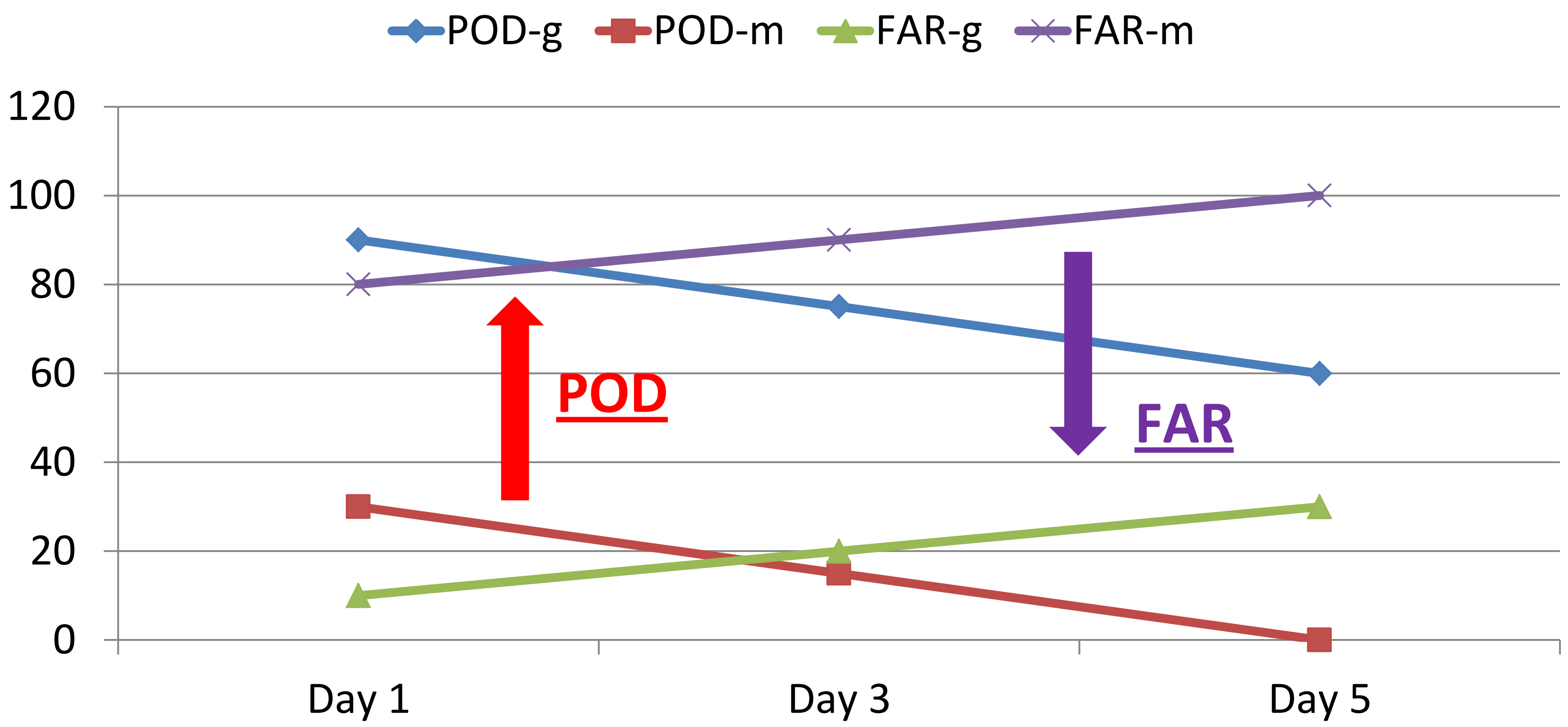


Figure 6: A depiction of a 50% improvement in intensity and track for the Gulf Coast cases shown in Figures 3 and 4. The HFIP goal (on the right) will allow a more focused effort by the emergency managers for their preparedness and evacuation activities.

HFIP Goal #3

Increase the probability of detection (POD) of RI change to 90% at Day 1 decreasing linearly to 60% at Day 5, and decrease the false alarm ration (FAR) of RI change to 10% for Day 1 increasing linearly to 30% at Day 5



HFIP Goal #4

Extend lead time for hurricane forecasts out to Day 7

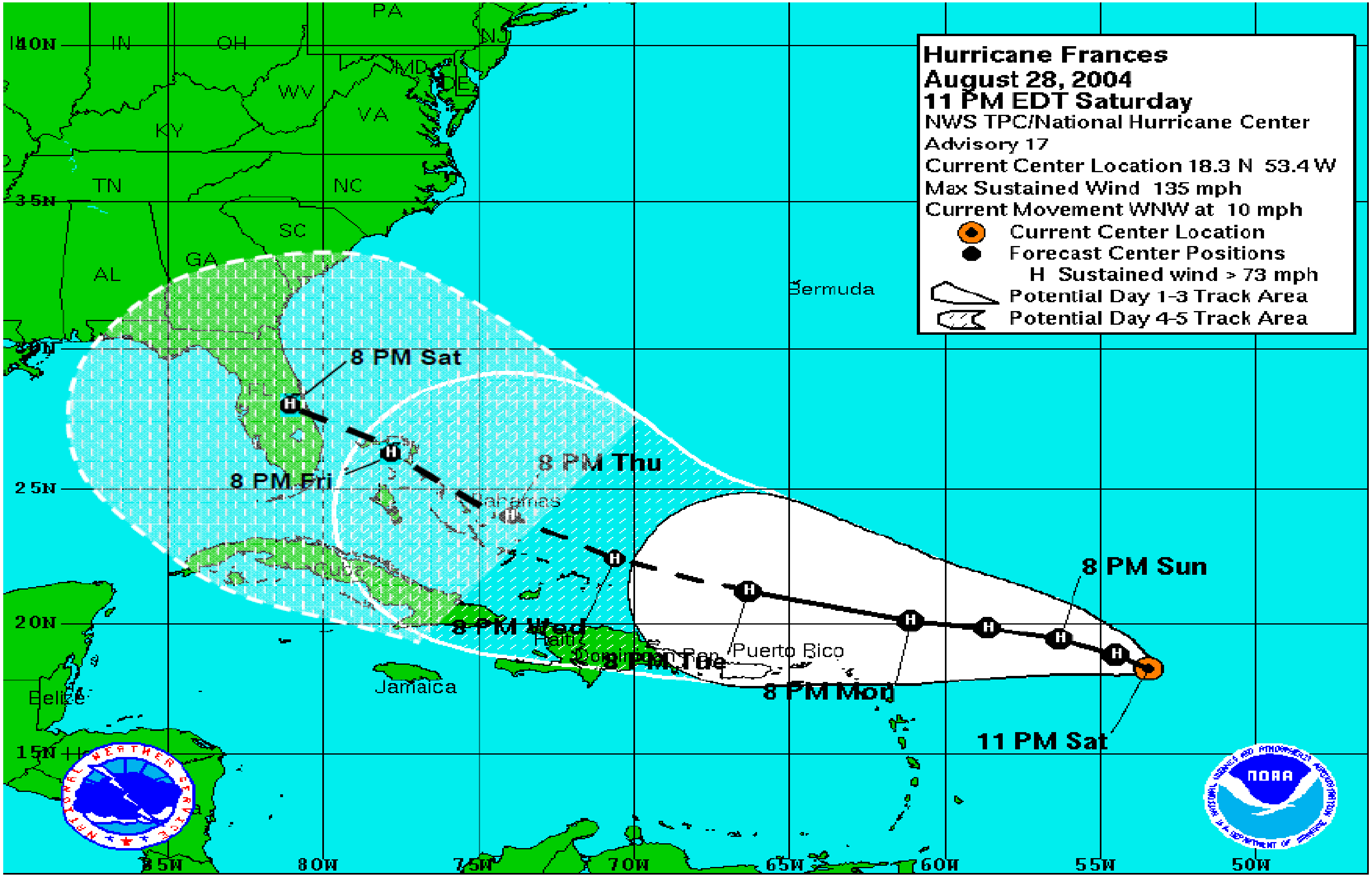


Figure 7. An example of a proposed 7-day NHC track forecast product.