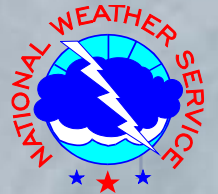


# National Hurricane Center Forecast Verification: Quantifying Forecast Uncertainty (or "Lies, Damned Lies, and Statistics")

James L. Franklin  
Branch Chief, Hurricane Specialist Unit  
National Hurricane Center

2010 Florida Governor's Hurricane Conference



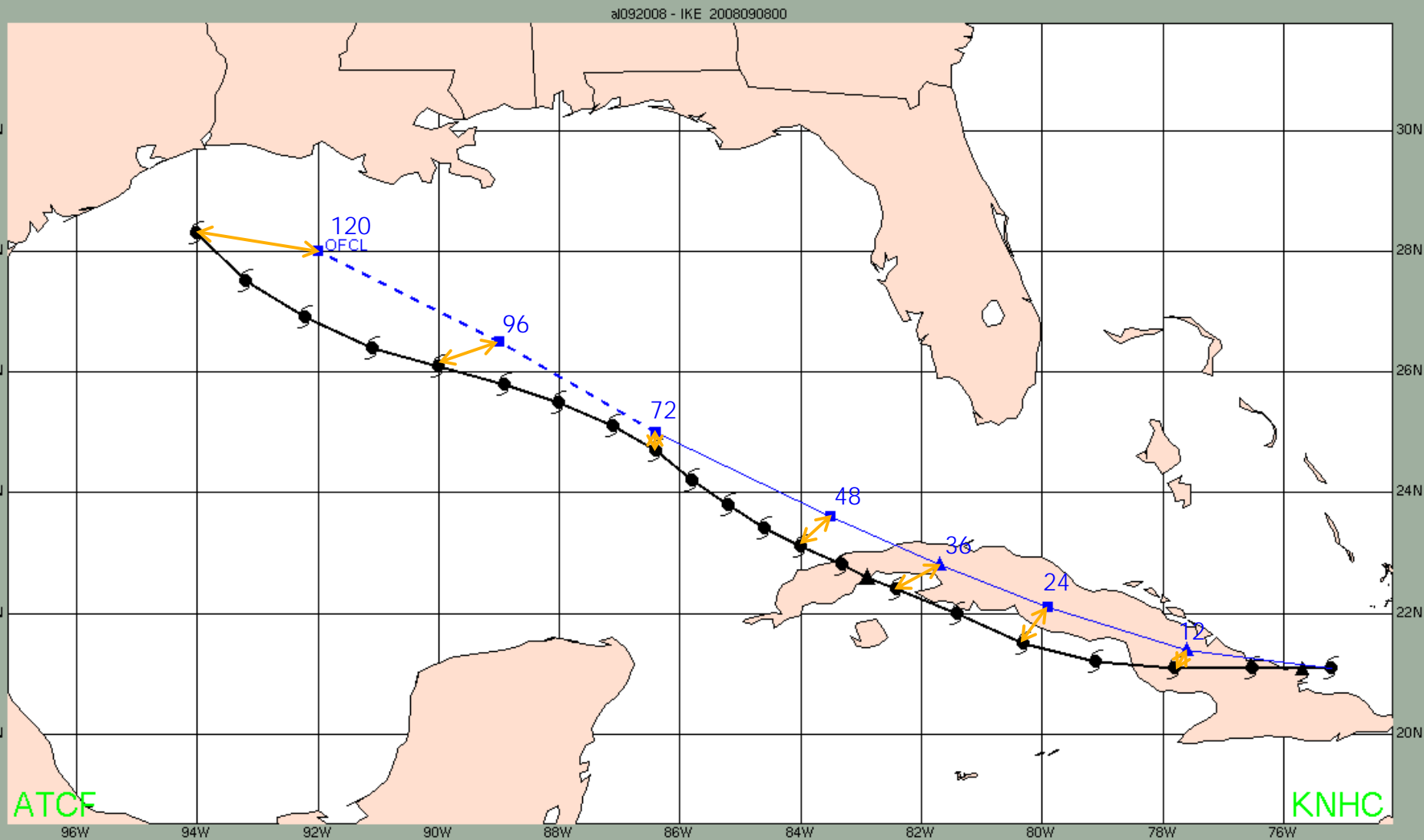
# NHC Forecast Verification

- \* NHC verifies all its official tropical cyclone track and intensity forecasts each year.
- \* Why do a forecast verification?
  - \* We have to (Government Performance and Results Act [GPRA]). Monitor performance and progress.
  - \* Understanding forecast errors help forecasters (and modelers) to reduce them.
  - \* Identify critical issues for the research community.
  - \* Basis for the development of certain products (e.g., the wind speed probabilities, storm surge probabilities).
  - \* Helps decision makers use NHC products more effectively.

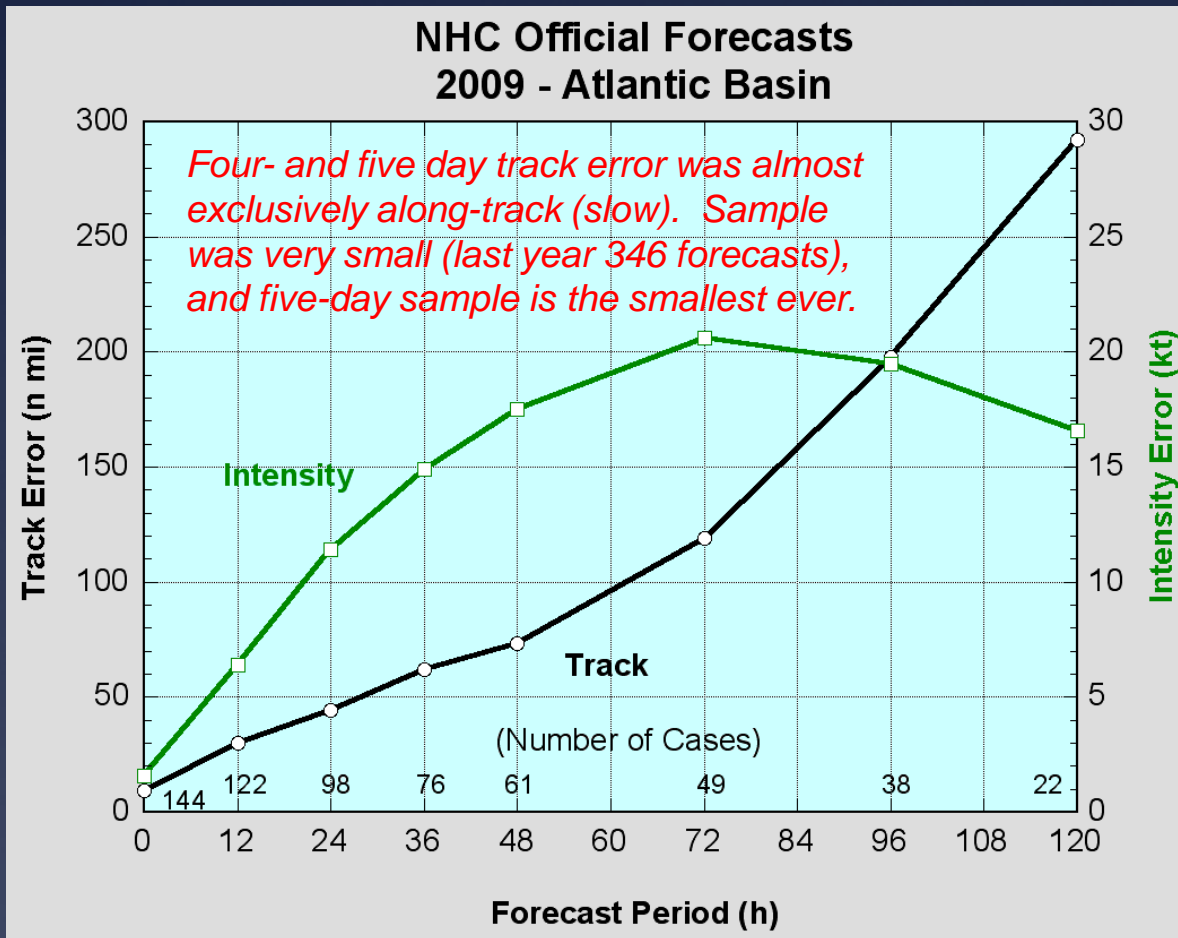
# NHC Forecast Verification

- \* System must be a tropical or subtropical cyclone at both forecast initial time and verification time.
- \* Special advisories ignored (original advisory is verified).
- \* Definitions:
  - \* Track error is the great-circle distance between the forecast location and the actual location of the storm center (n mi).
  - \* Intensity error is the difference between the forecast and actual intensity (kt).
  - \* Forecast SKILL is computed by comparing forecast error to the error from a Climatology-Persistence model (CLIPER, Decay-SHIFOR).

# Track Error Definition



# 2009 Atlantic Verification



VT (h)	NT	TRACK (n mi)	INT (kt)
000	144	9.6	1.6
012	120	30.1	6.4
024	96	44.5	11.4
036	75	61.8	14.9
048	61	73.2	17.5
072	49	119.2	20.6
096	38	197.9	19.5
120	22	292.3	16.6

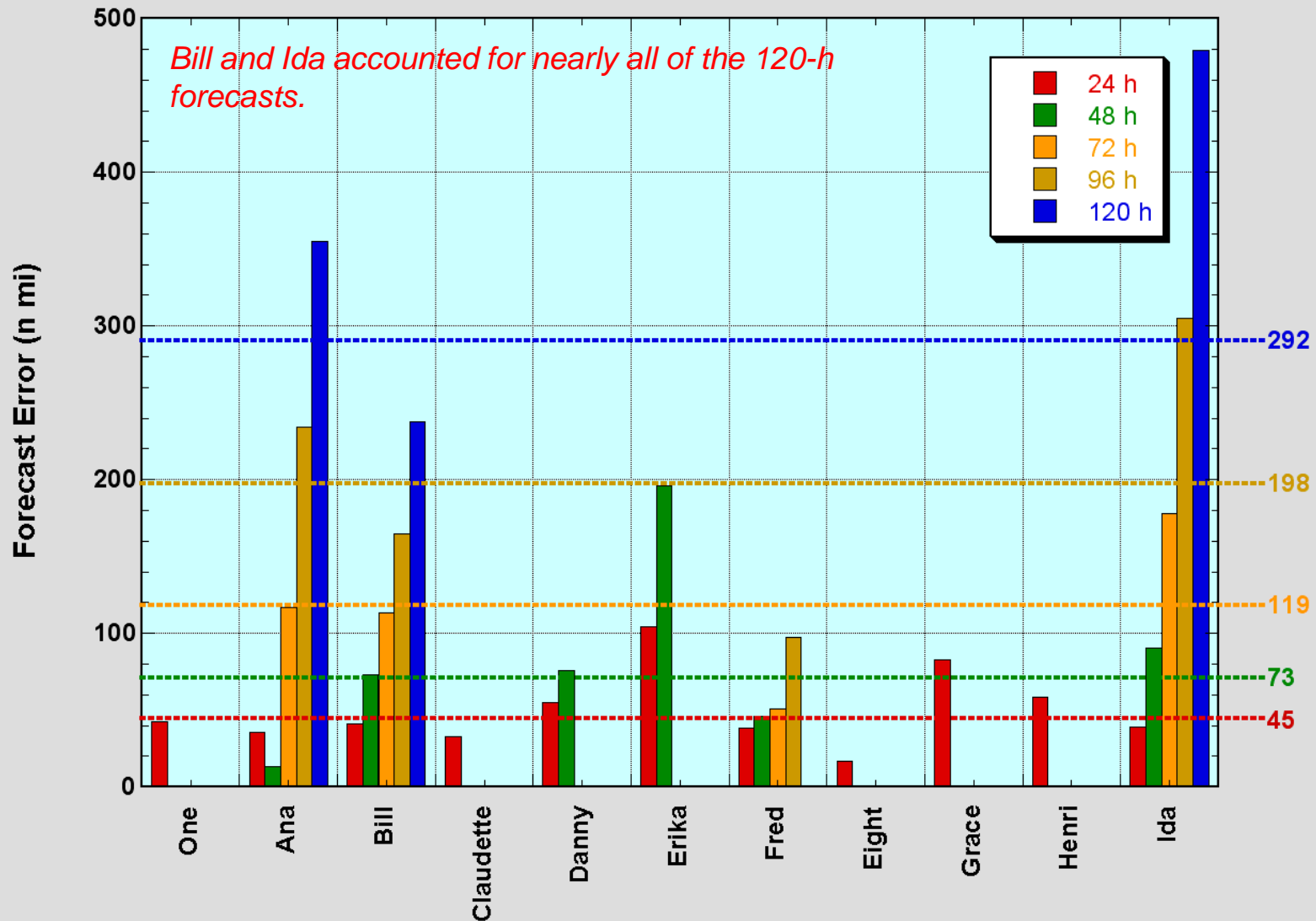
Values in green exceed all-time records.

•GPRA track measure (48 h error for TS/H only) was 70.1 n mi, well below previous record of 86.2 and goal of 108 n mi.

•GPRA intensity measure (48 h error for all TCs) was 17.5 kt, well above goal of 13 kt.

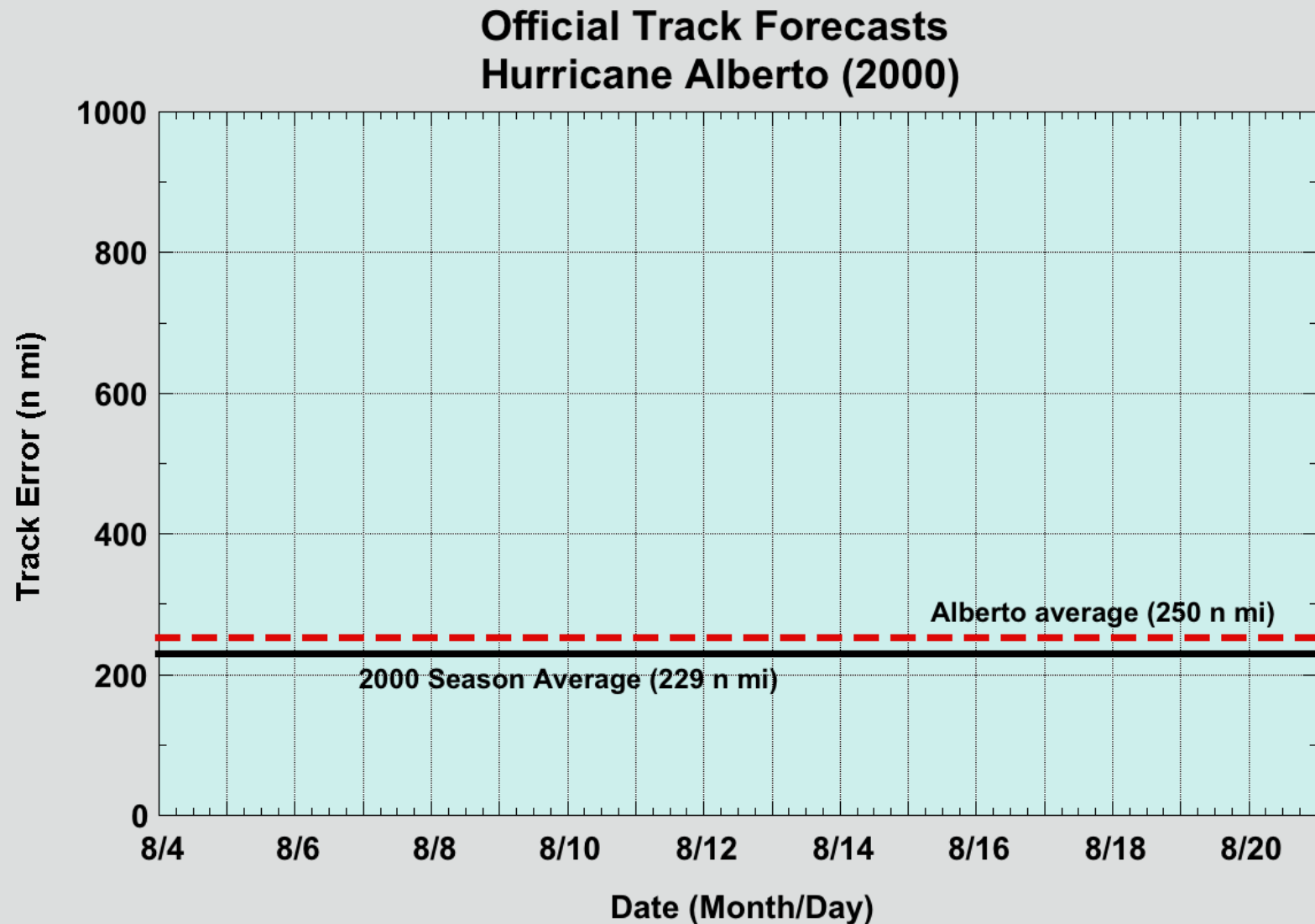
# Atlantic Track Errors by Storm

NHC Official Track Forecast Error by Storm  
2009 - Atlantic Basin



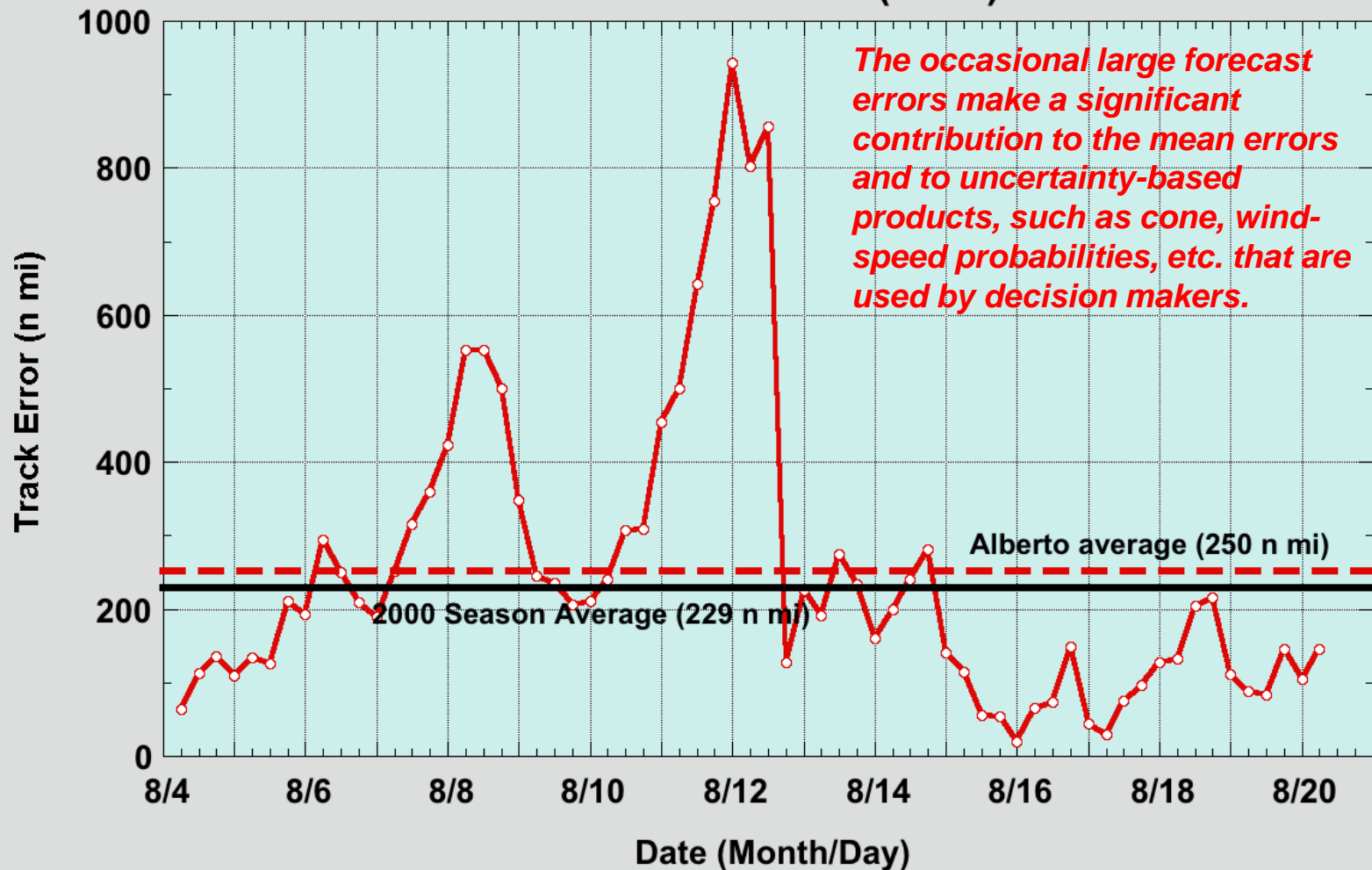


# Forecast Variability



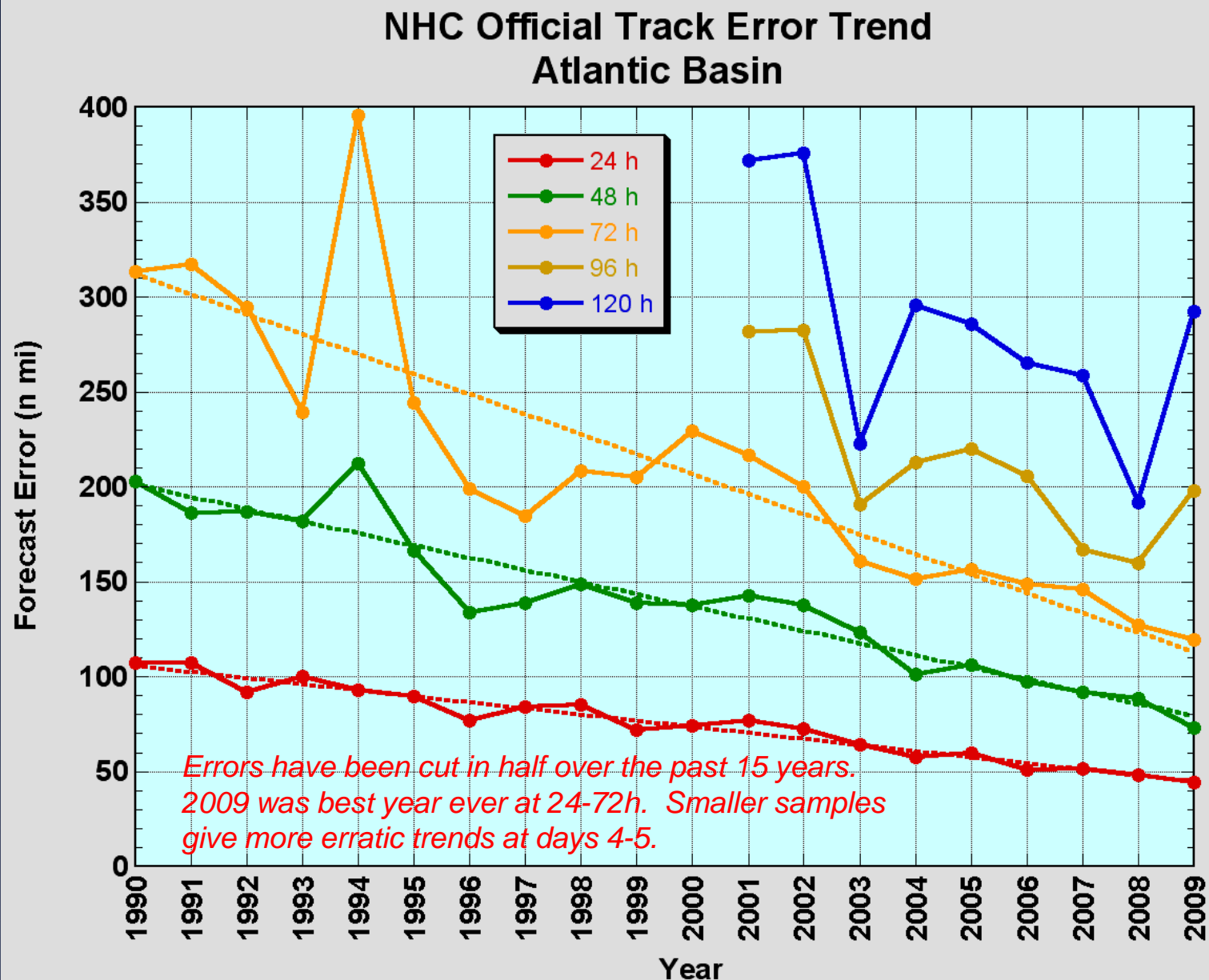
# Forecast Variability

## Official Track Forecasts Hurricane Alberto (2000)



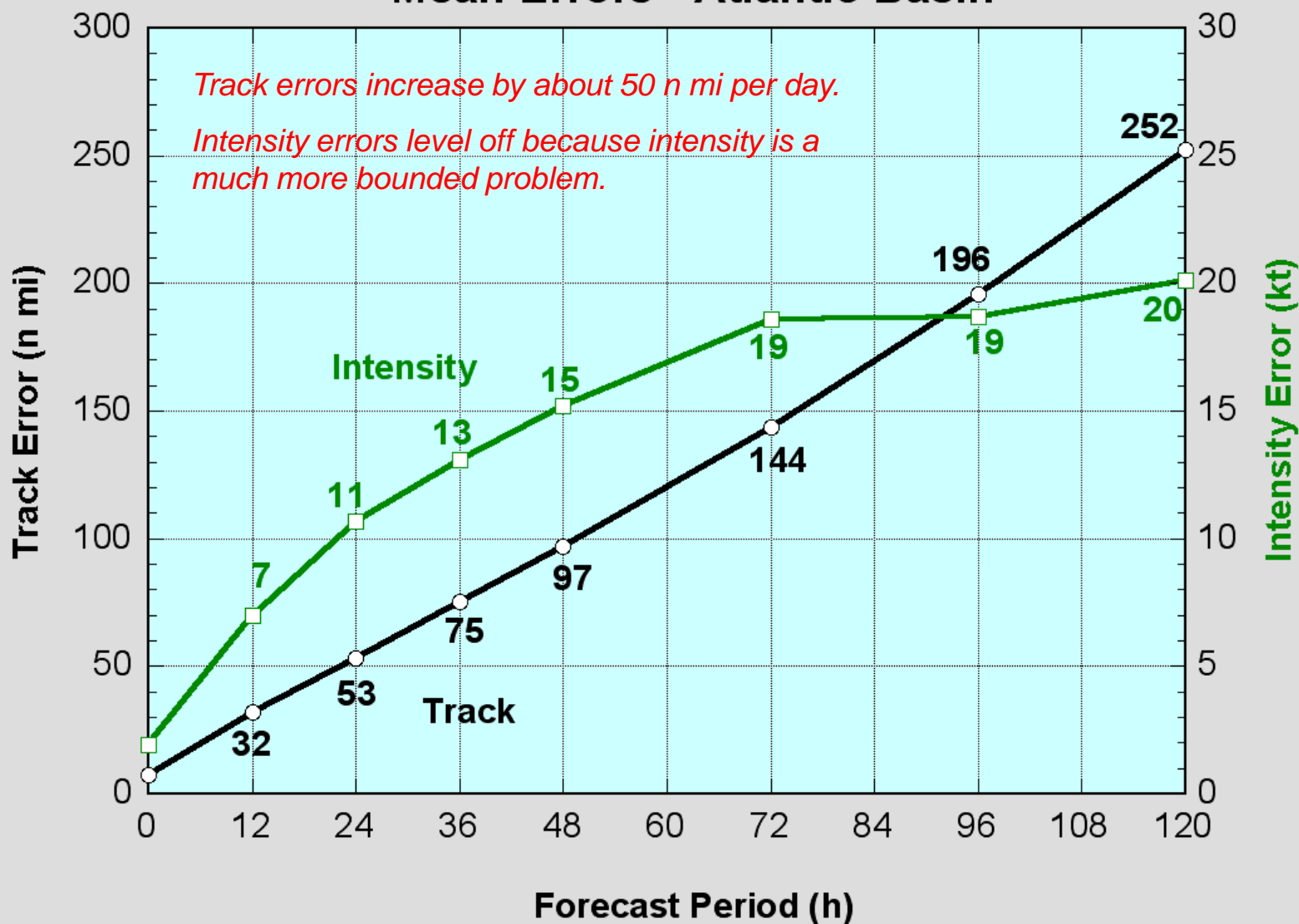


# Atlantic Track Error Trends

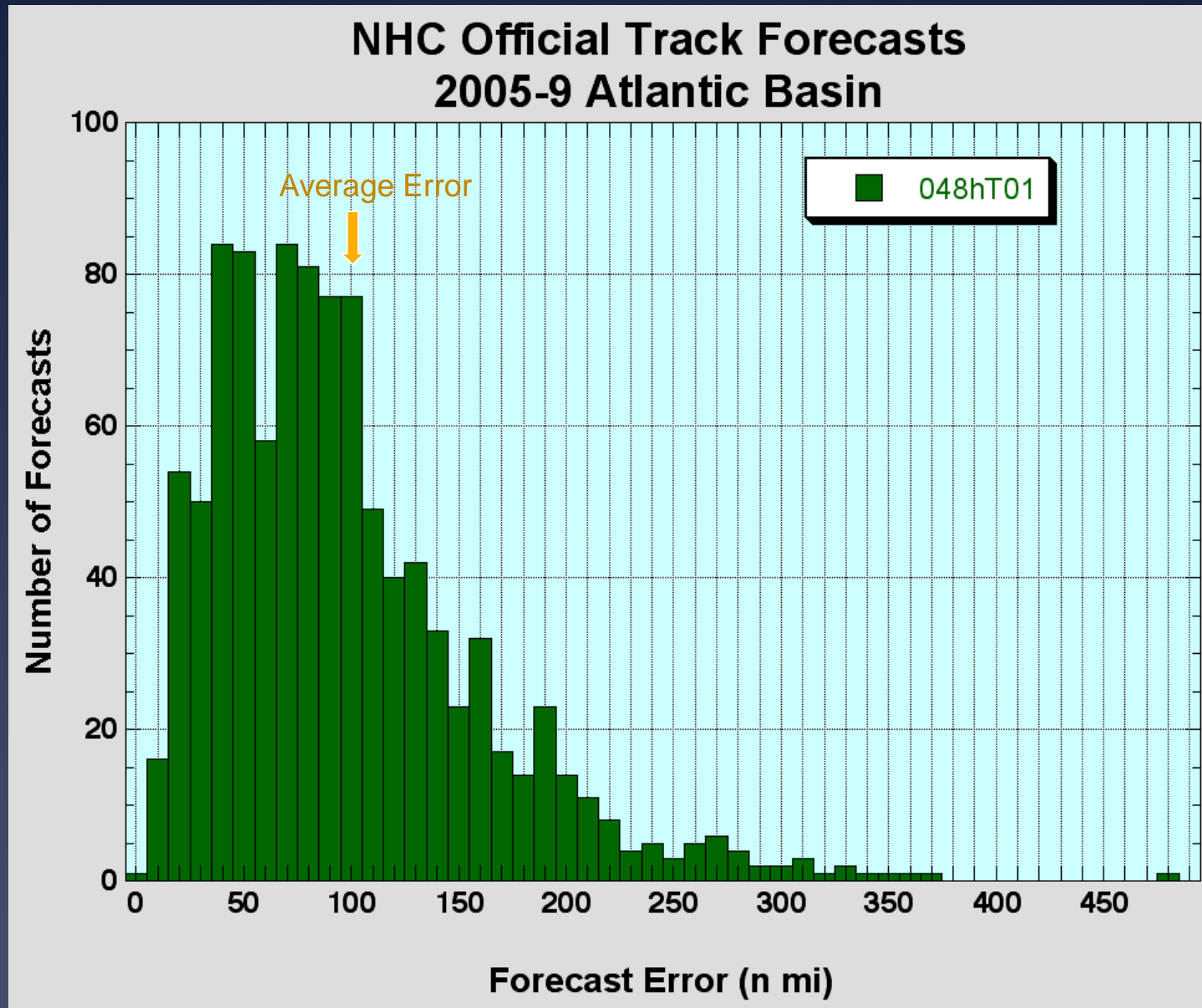


# Atlantic 5-Year Mean Errors

NHC Official Five-Year (2005-9)  
Mean Errors - Atlantic Basin

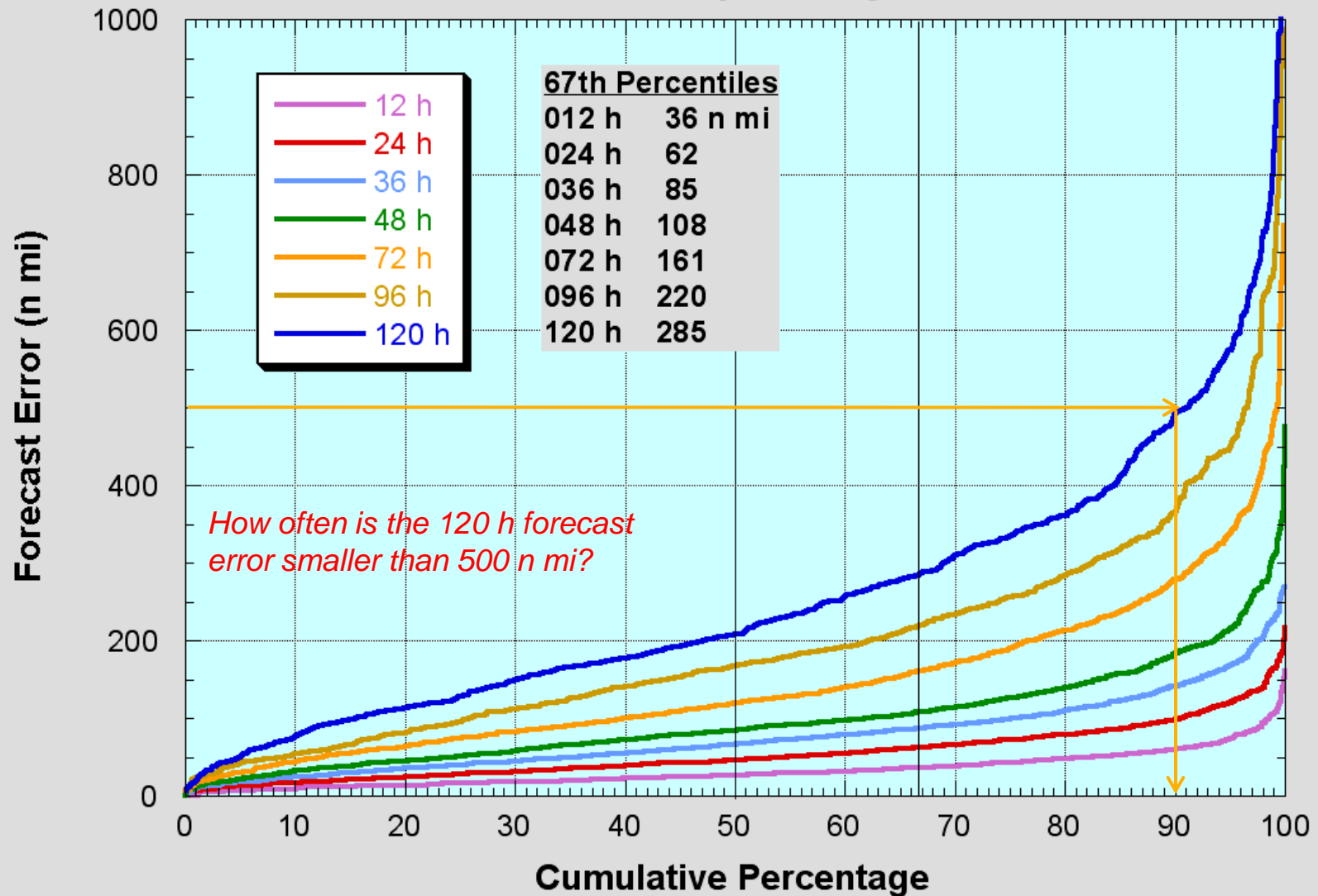


# Atlantic Track Error Distribution



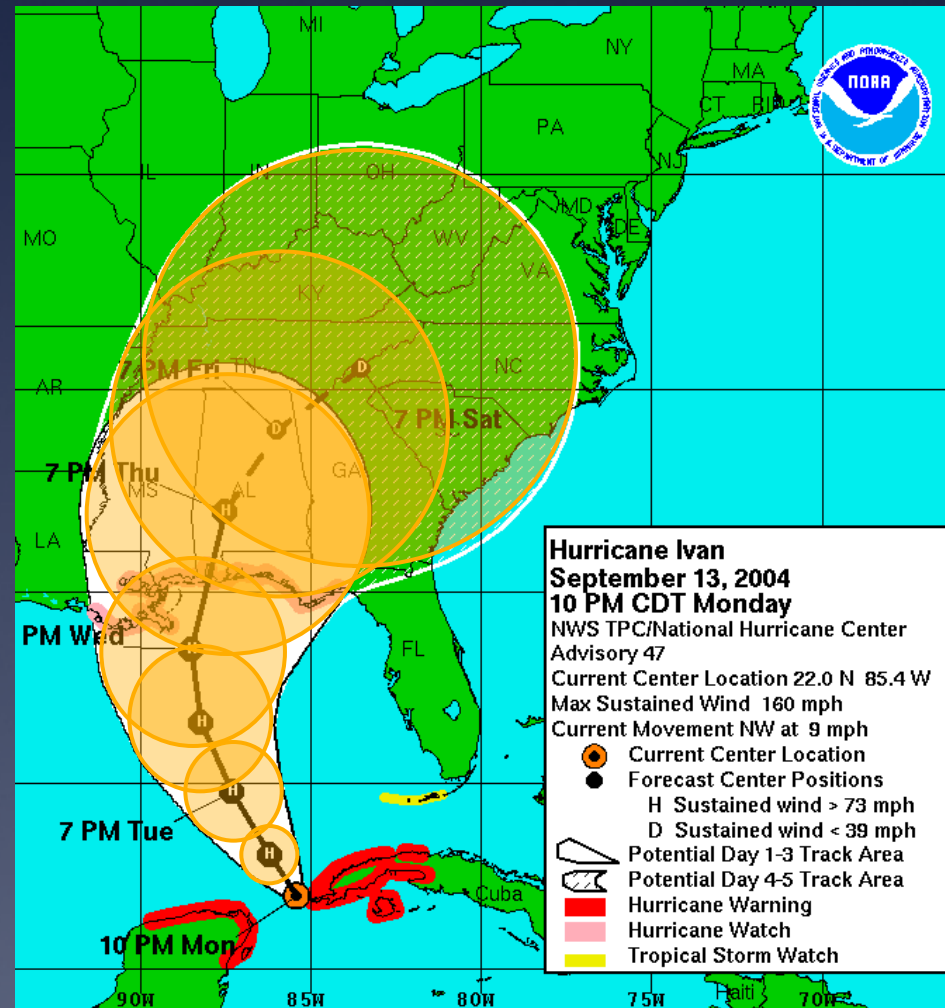
# OFCL Error Distributions and Cone Radii

## NHC Official Track Error Cumulative Distribution Atlantic Basin Tropical Cyclones 2005-9



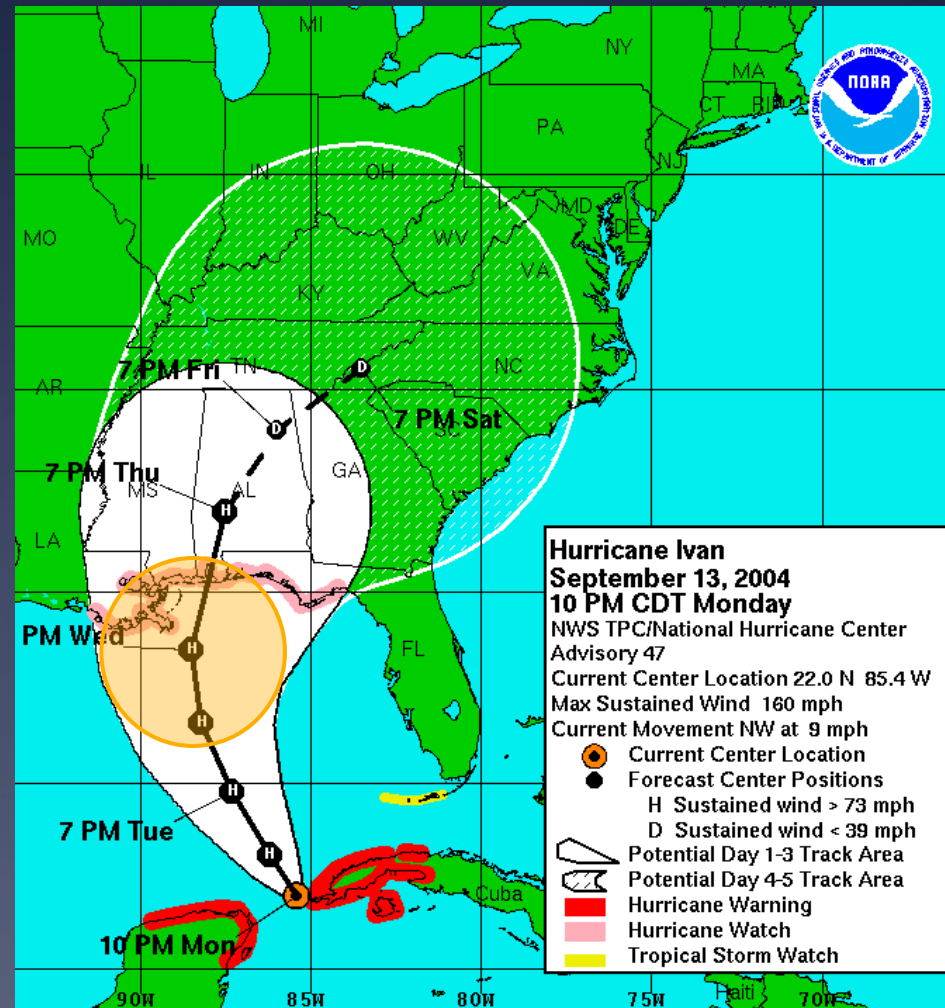
# NHC Forecast Cone

- \* 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.



# NHC Forecast Cone

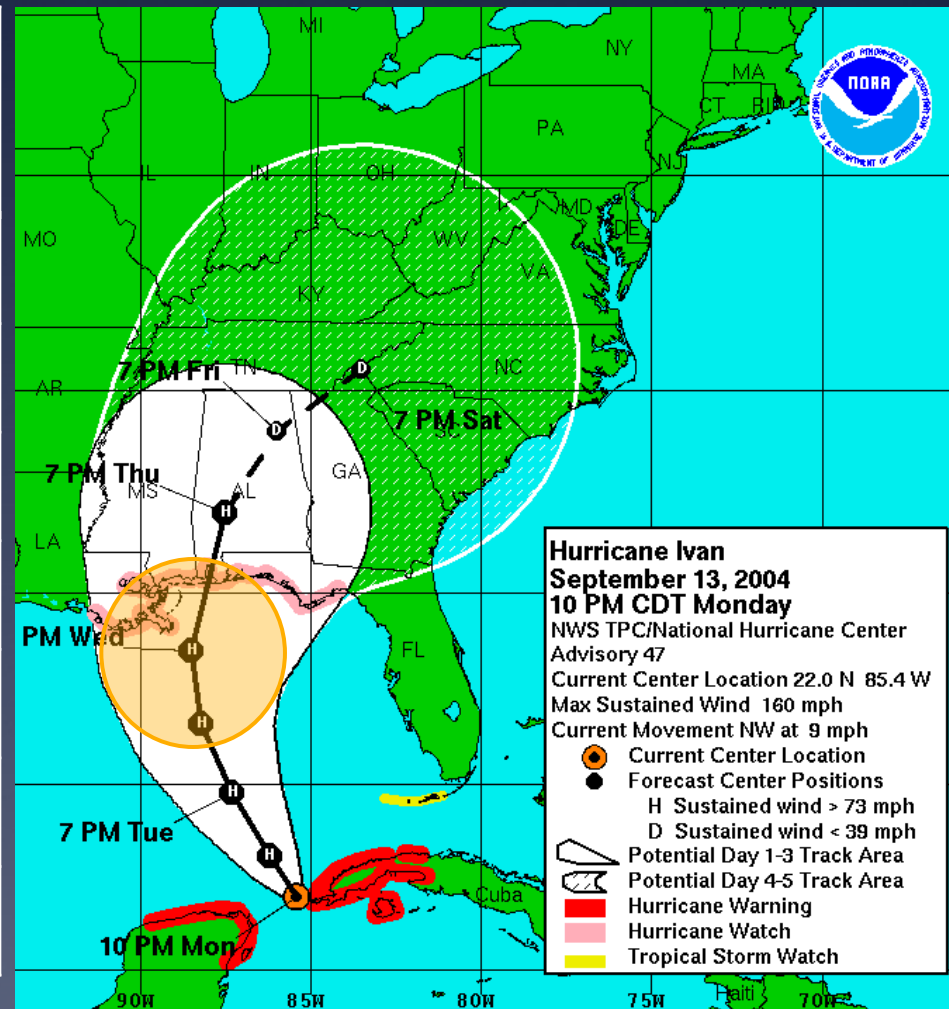
- \* Represents the probable track of the center of the tropical cyclone.
- \* Formed by connecting circles centered on each forecast point (at 12, 24, 36 h, etc.)
- \* Size of the circles determined so that, say, the actual storm position at 48 h will be within the 48-h circle 67% of the time.



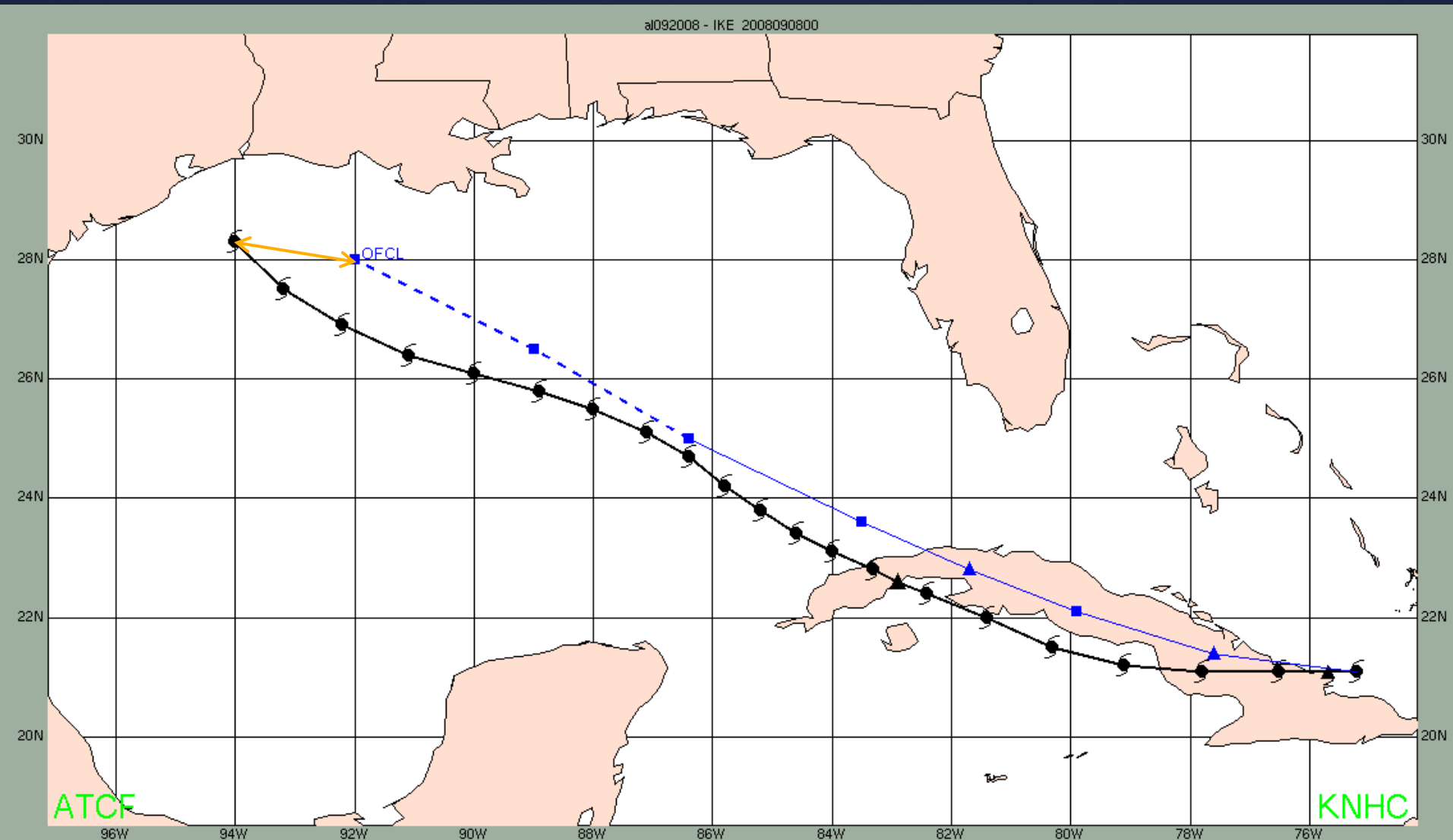


# NHC Forecast Cone

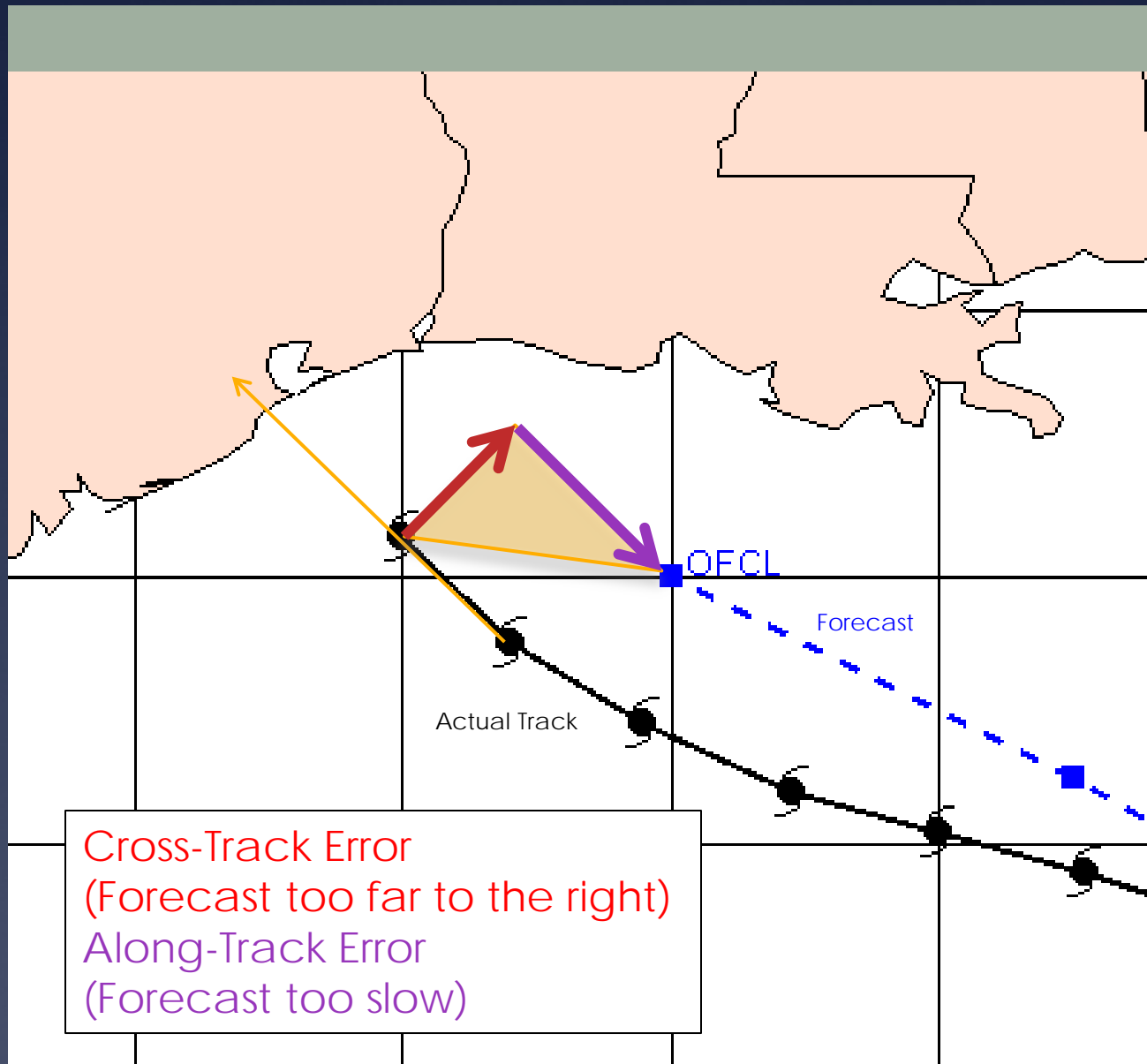
Forecast Period (h)	2009 Circle Radius (n mi) ('04 – '08 errors)	2010 Circle Radius (n mi) ('05 – '09 errors)
12	36	36
24	62	62
36	89	85
48	111	108
72	167	161
96	230	220
120	302	285



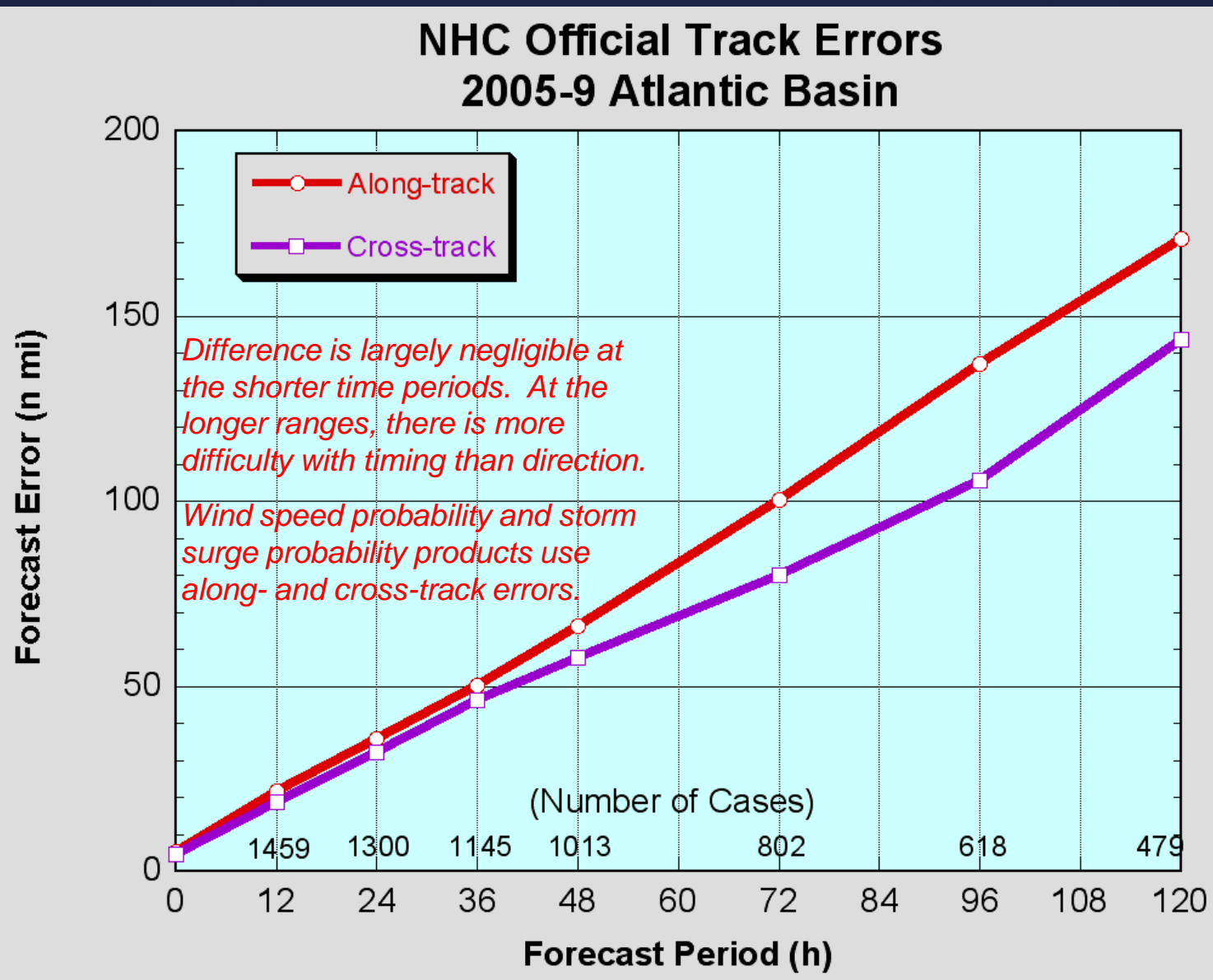
# Along- and Cross-Track Errors (Timing vs. Location)



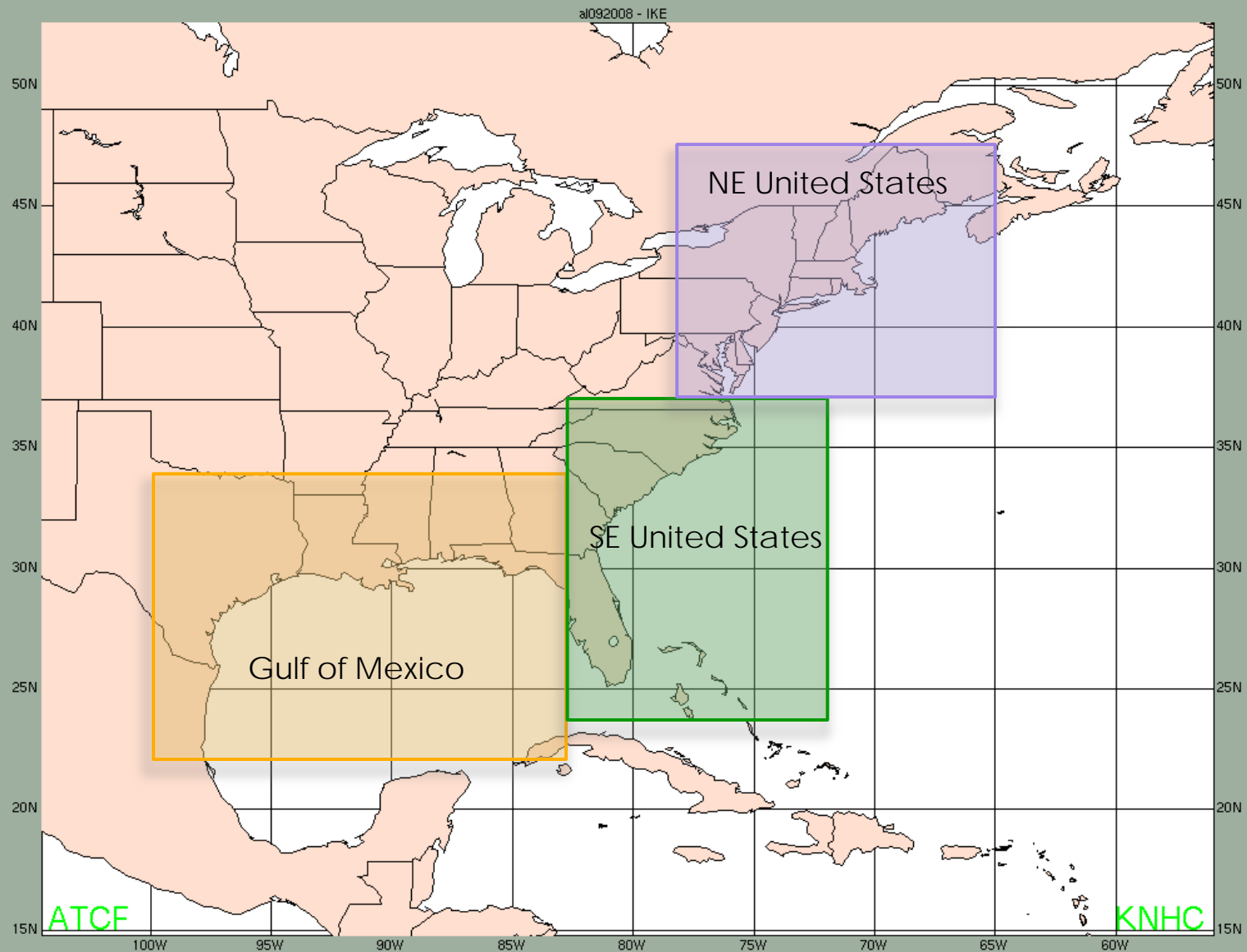
# Along- and Cross-Track Errors



# Along- and Cross-Track Errors



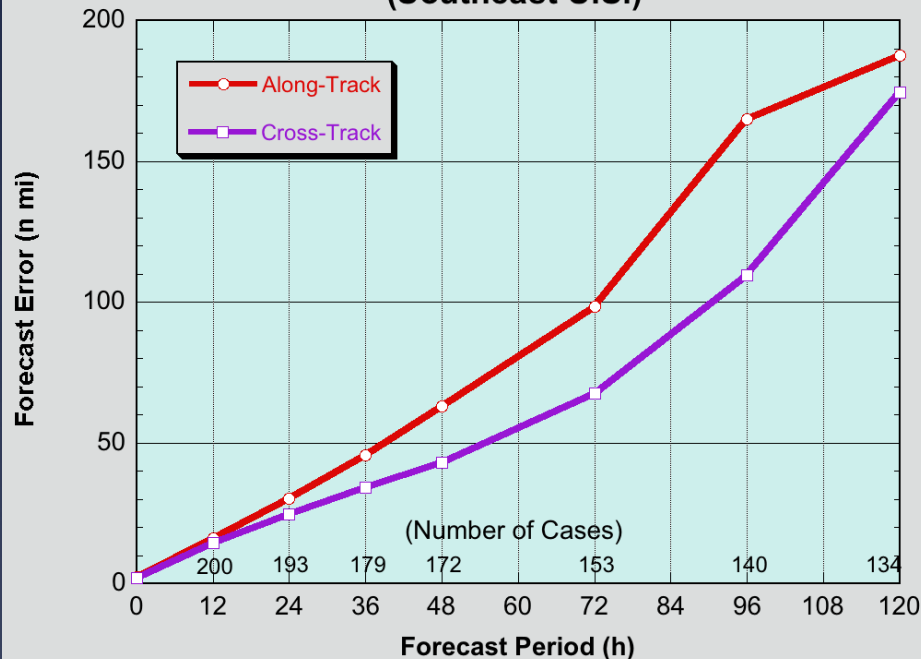
# Geographical Domains



# Southeast United States

## Along/Cross Errors

NHC Official Track Errors 2004-8  
Forecasts Verifying from 24-37N, 72-83W  
(Southeast U.S.)

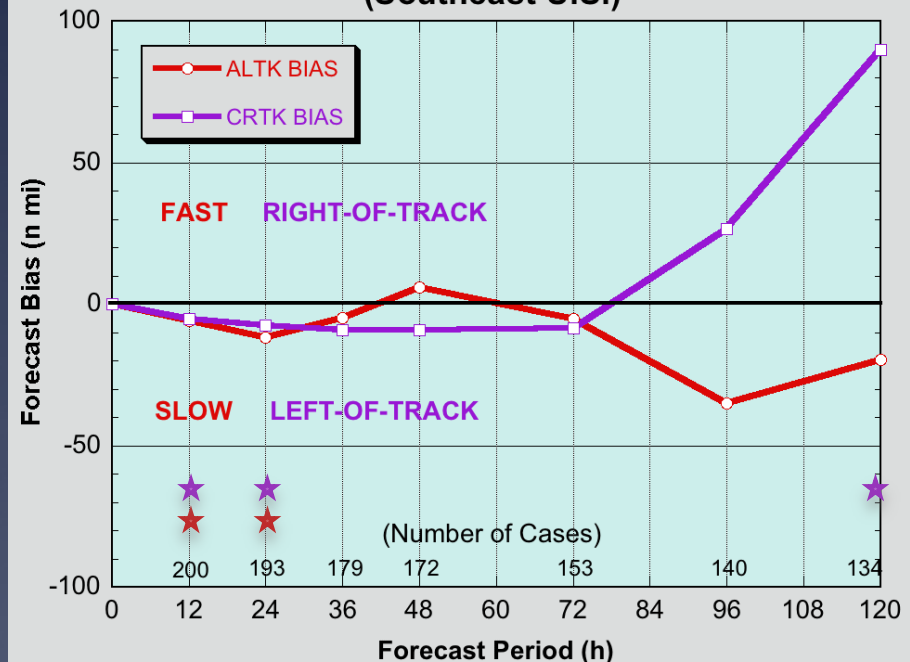


In this region, cross-track errors are significantly smaller than the along-track errors.

Mean forward speed = 9 kt.

## Along/Cross Biases

NHC Official Track Errors 2004-8  
Forecasts Verifying from 24-37N, 72-83W  
(Southeast U.S.)



Biases are minimal through Day 3. Interesting rightward bias develops by Day 5.

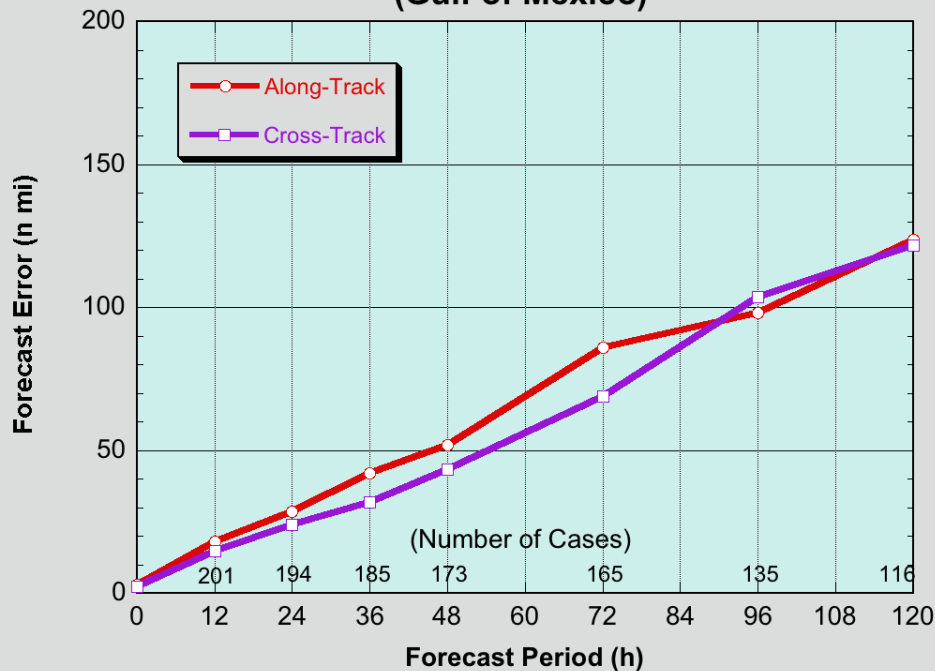
★ = Statistically significant biases (95%)



# Gulf of Mexico

## Along/Cross Errors

NHC Official Track Errors 2004-8  
Forecasts Verifying from 22-33N, 83-100W  
(Gulf of Mexico)

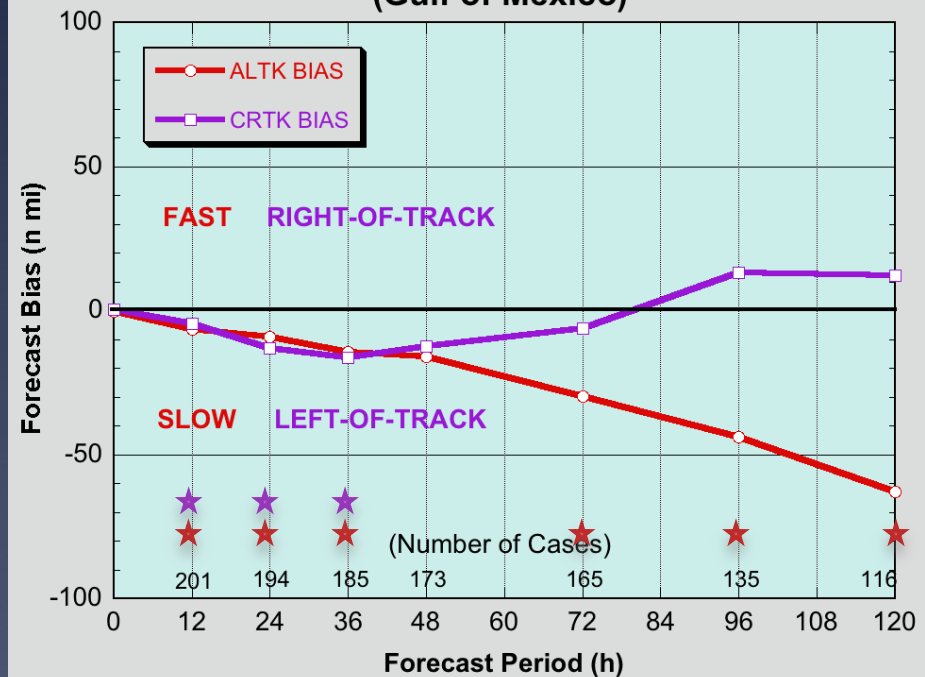


Along- and cross-track errors are about equal.

Mean forward speed = 10 kt.

## Along/Cross Biases

NHC Official Track Errors 2004-8  
Forecasts Verifying from 22-33N, 83-100W  
(Gulf of Mexico)



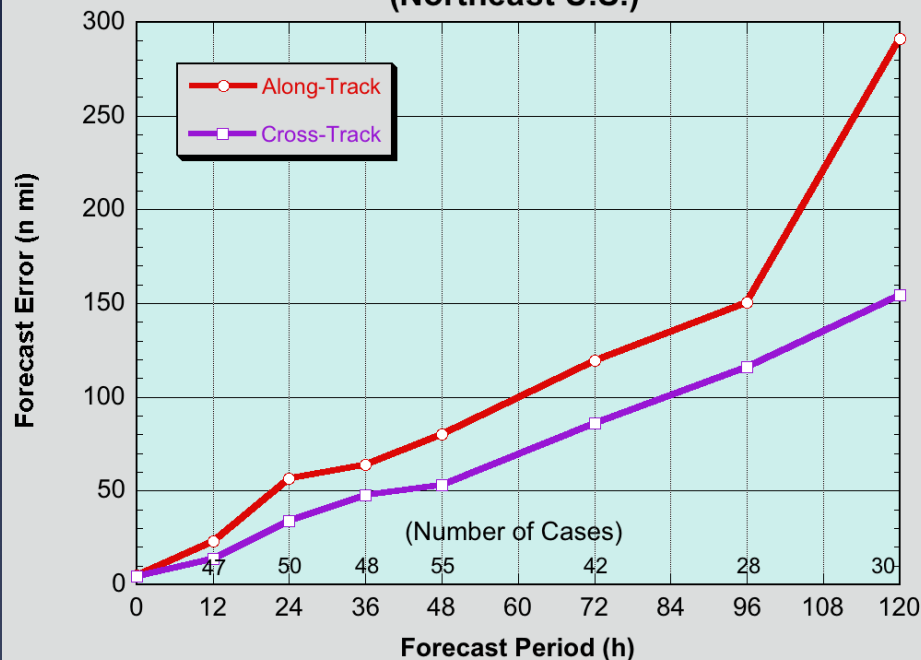
Left biases through 48 h, while (mostly) significant, are still less than ~15 n mi.  
Slow bias in W/W phase is 1-2 h.

★ = Statistically significant biases (95%)

# Northeast United States

## Along/Cross Errors

NHC Official Track Errors 1999-2008  
Forecasts Verifying from 37-47N, 65-78W  
(Northeast U.S.)

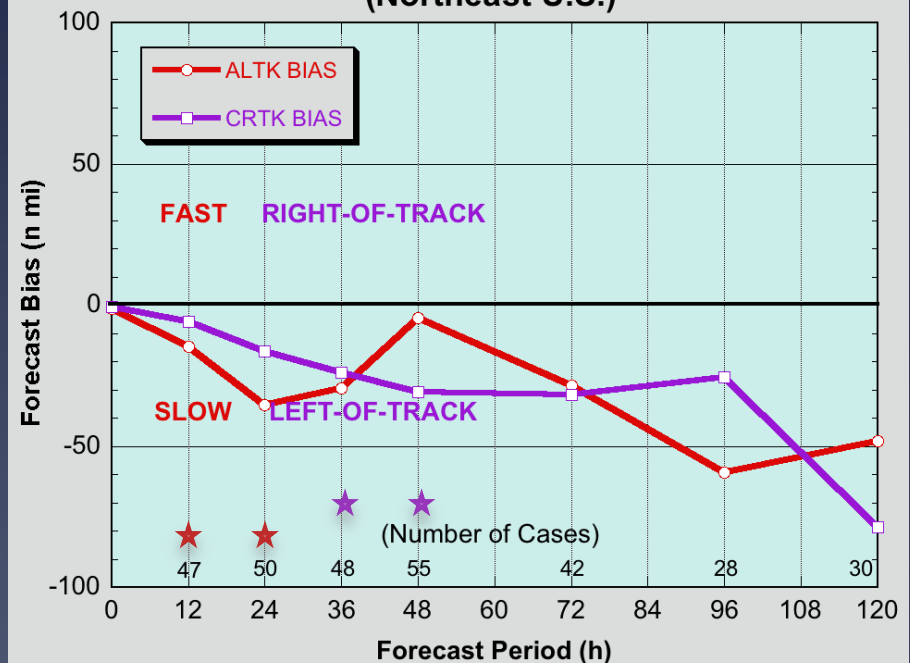


In this region, cross-track errors are significantly smaller than the along-track errors. Timing is especially difficult at 5 days.

Mean forward speed = 18 kt.

## Along/Cross Biases

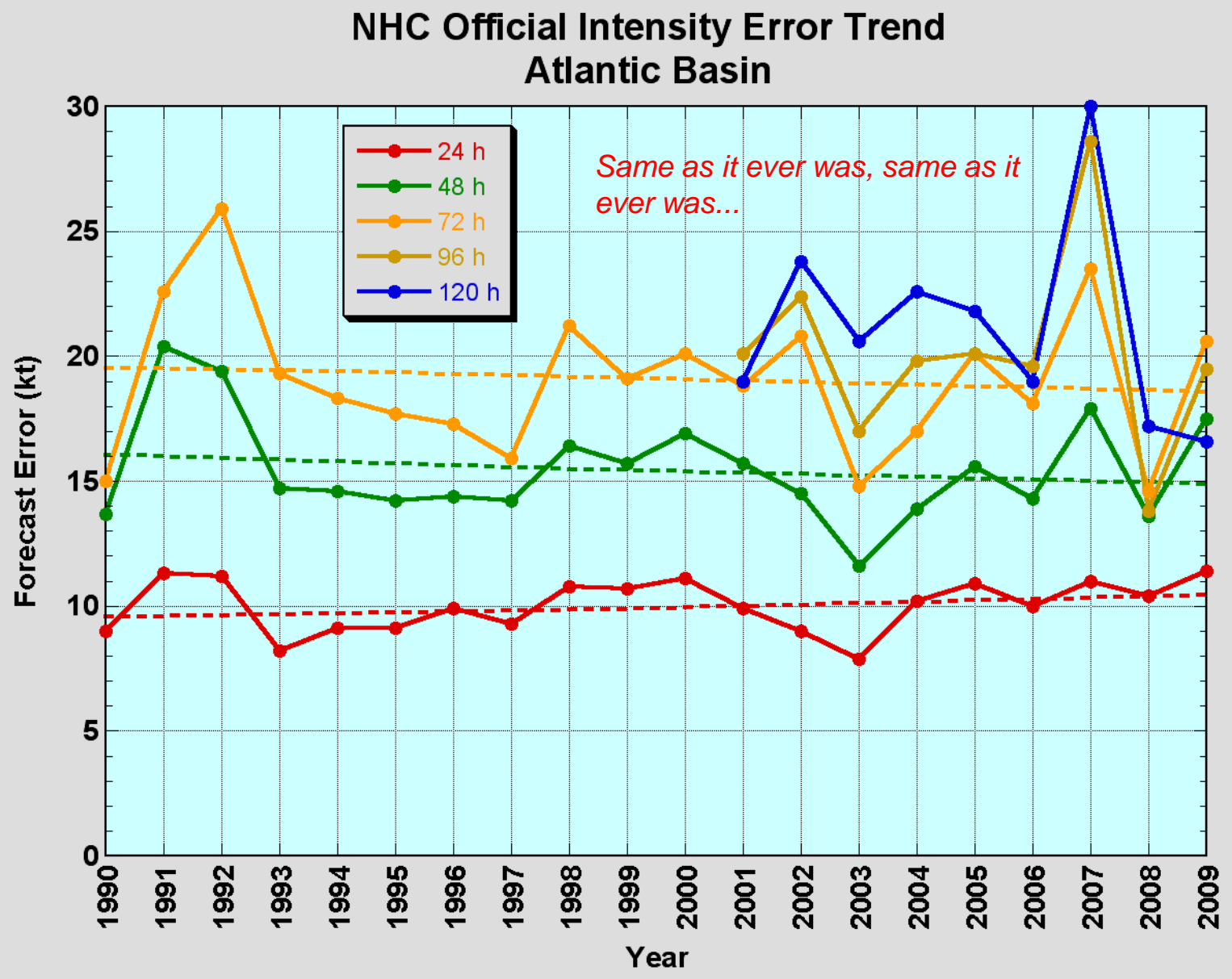
NHC Official Track Errors 1999-2008  
Forecasts Verifying from 37-47N, 65-78W  
(Northeast U.S.)



Forecast tracks tend to be too far to the left and too slow (~2 hr at 24-36 h).

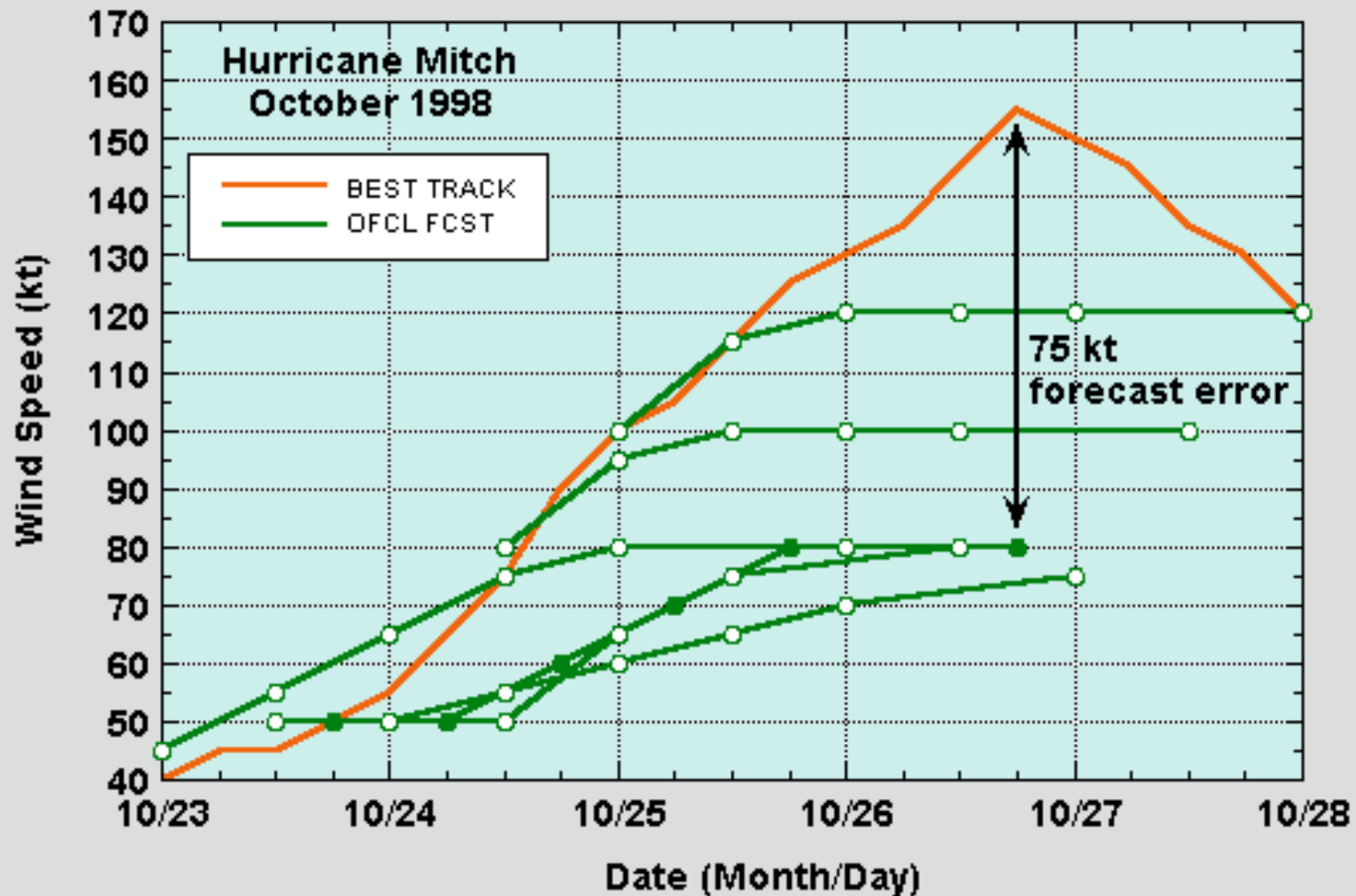
★ = Statistically significant biases (95%)

# Atlantic Intensity Error Trends



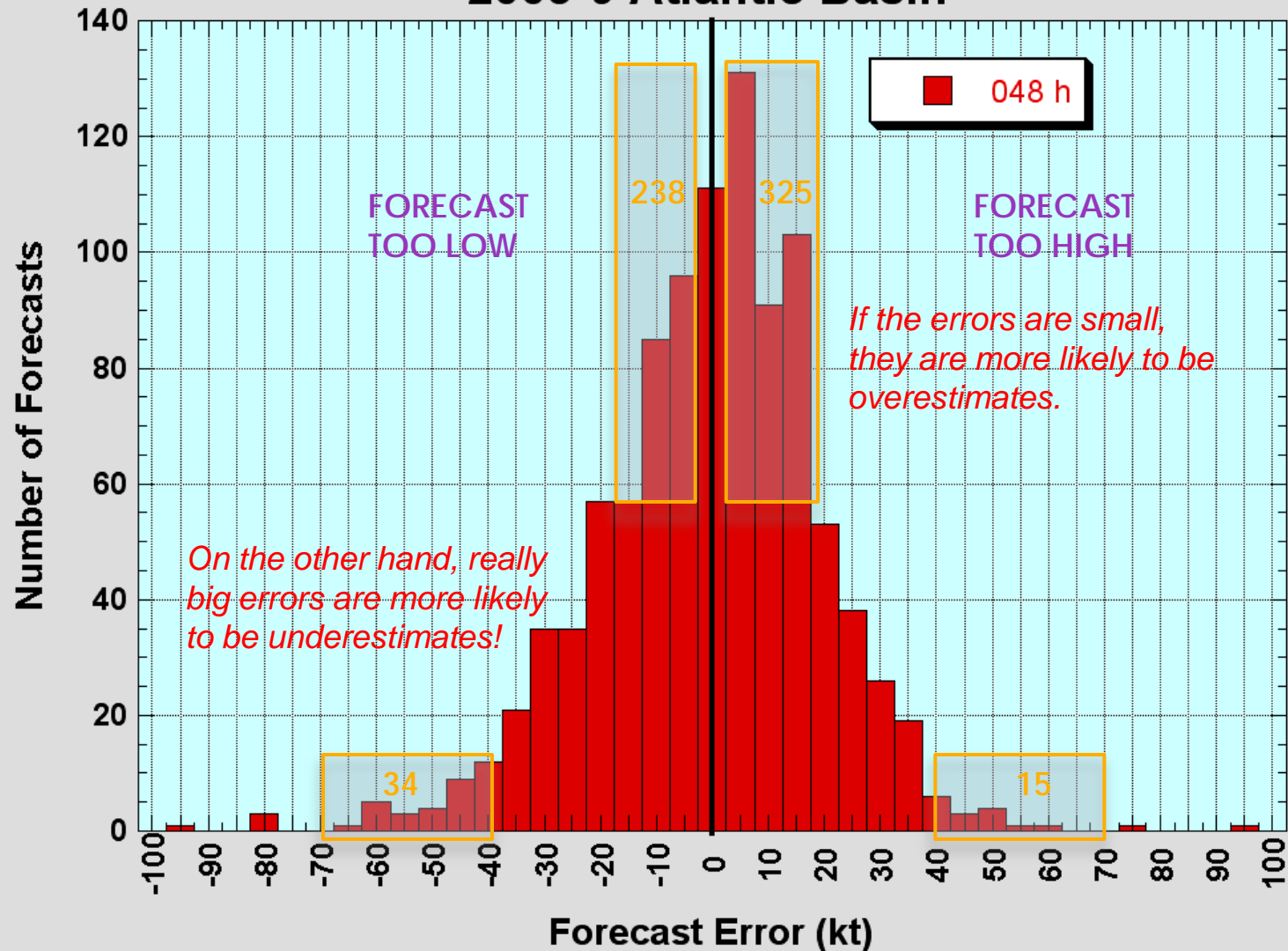
[illegible]

# Challenge: Rapid Intensification



# Intensity Error Distribution

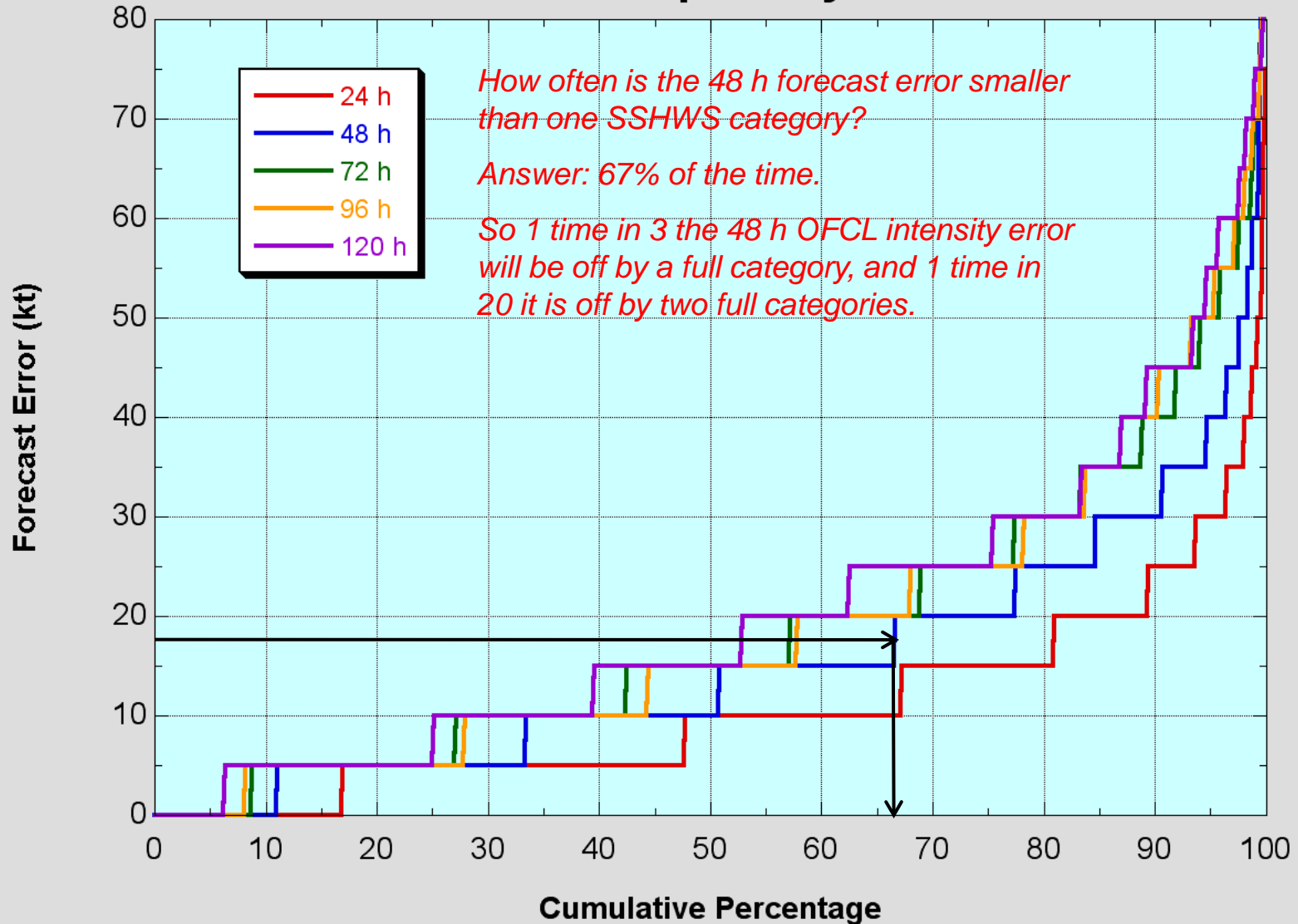
## NHC Official Intensity Forecasts 2005-9 Atlantic Basin





# OFCL Intensity Error Distributions

## NHC Official Intensity Error Cumulative Distribution Atlantic Basin Tropical Cyclones 2005-9



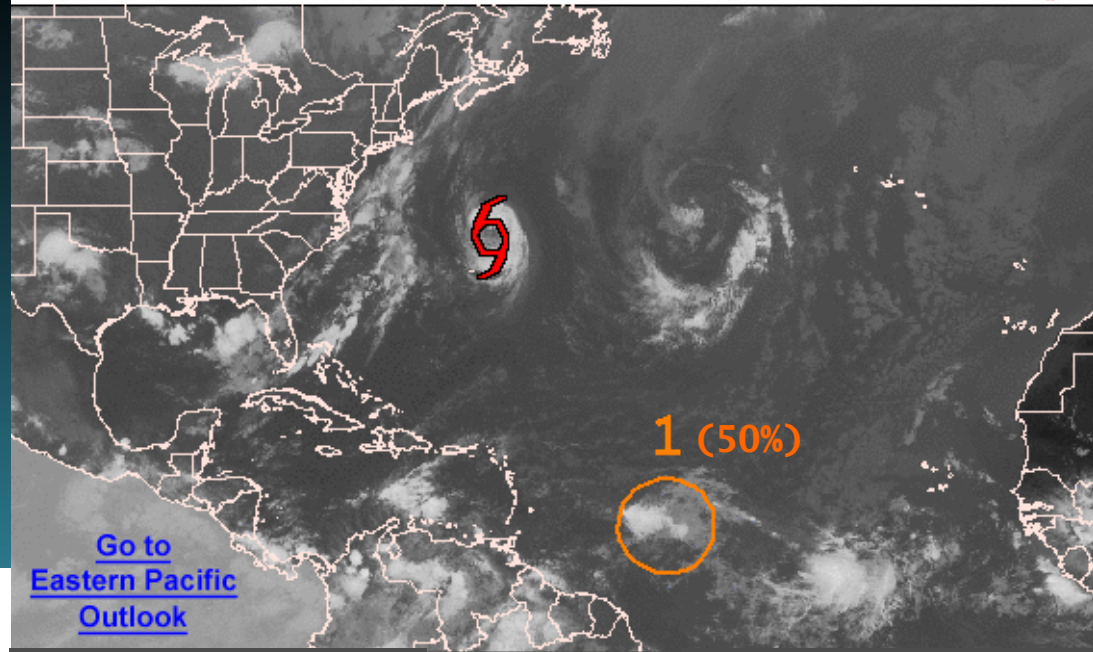


# Graphical Tropical Weather Outlook

National Hurricane Center Miami, Florida



## Addition of explicit probability in Tropical Weather Outlook



200 PM TUE SEP 2 2008

Satellite Image: 122 PM

Outlined areas denote current position of systems discussed in the Tropical Weather Outlook. Color indicates probability of tropical cyclone formation within 48 hours.

Low <20%

Medium 20-50%

High >50%

TROPICAL WEATHER OUTLOOK

NWS NATIONAL HURRICANE CENTER MIAMI, FL

200 PM EDT TUE SEP 2 2008

FOR THE NORTH ATLANTIC...CARIBBEAN SEA...AND THE G

THE NATIONAL HURRICANE CENTER IS ISSUING ADVISORIES ON TROPICAL STORM BERTHA...LOCATED ABOUT 190 MILES NORTH-NORTHEAST OF BERMUDA.

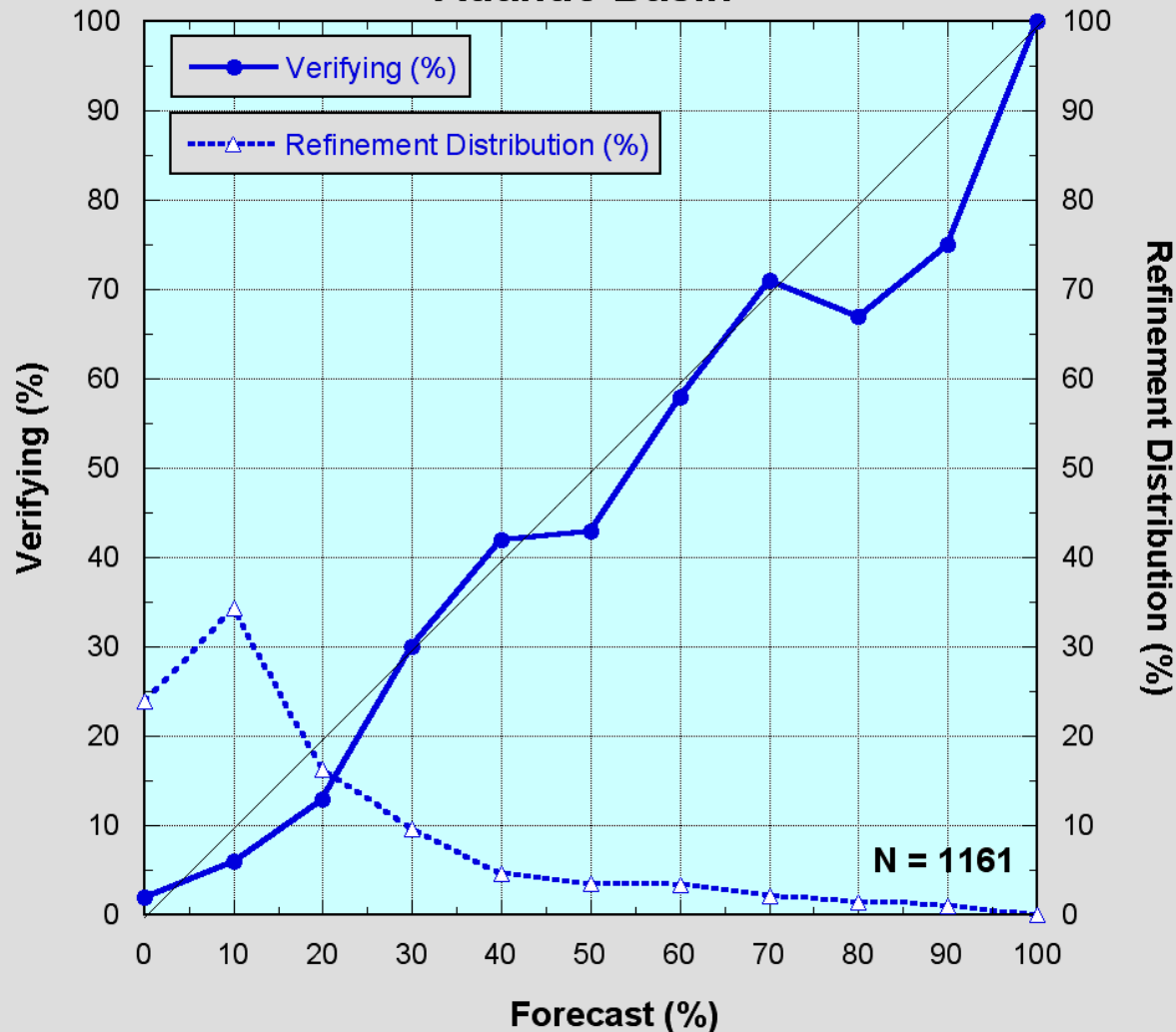
THE AREA OF LOW PRESSURE LOCATED ABOUT 950 MILES EAST OF THE LESSER ANTILLES HAS CHANGED LITTLE IN ORGANIZATION THIS MORNING. ENVIRONMENTAL CONDITIONS APPEAR FAVORABLE FOR DEVELOPMENT AND THIS SYSTEM COULD BECOME A TROPICAL DEPRESSION DURING THE NEXT DAY OR SO. THERE IS A MEDIUM CHANCE...**50 PERCENT**...OF THIS SYSTEM BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS.

\$\$

FORECASTER BROWN

# Genesis Forecasts

## 2007-9 OFCL Experimental 48-h Genesis Forecasts Atlantic Basin



*Forecasts over three years were very well calibrated (reliable) with minimal bias.*

*Refinement distribution shows how often the forecasts deviated from (perceived) climatology. Sharp peaks at climatology indicate low confidence; maxima at the extremes indicate high confidence. Current distribution indicates intermediate confidence.*

# Verification Web Page

National Hurricane Center

http://www.nhc.noaa.gov/

NHC HP C309a Mifi XM Online MobileMe Login NOAA WebCalendar NOAA WebMail BellStH WebMail Chase Log In Smith Barney TIAA-CREF News >>

National Weather Service  
National Hurricane Center

Home News Organization Search Go

Local forecast by "City, St" or "ZIP" Go

Alternate versions  
Text-only | PDA | Cell

Get Storm Info  
Satellite | Radar  
Aircraft Recon  
Advisory Archive  
Experimental  
Mobile Products  
E-mail Updates  
Audio/Podcasts  
GIS Data | RSS  
Help with Advisories

Marine Forecasts  
Atlantic and E Pacific  
Analysis Tools  
Help with Marine

Hurricane Awareness  
Be Prepared | Learn  
Frequent Questions  
AOML Research  
Hurricane Hunters  
Saffir-Simpson Scale  
Forecasting Models  
Eyewall Wind Profiles  
Glossary/Acronyms  
Storm Names  
Breakpoints

Hurricane History  
Seasons Archive  
Forecast Accuracy  
Climatology  
Most Extreme

About the NHC  
Mission and Vision  
Personnel | Visitors  
NHC Virtual Tour  
Library  
Joint Hurr Testbed  
The NCEP Centers  
Contact Us - Help

USA.gov

Top News of the Day.....view past news Last update Tue, 4 May 2010 11:10:06 UTC

- Changes to NHC products for the 2010 hurricane season.....view a summary (pdf)
- NOAA's National Weather Service to Use New Hurricane Wind Scale
- Q & A for NHC.....a new monthly series about NHC professionals. [Read the May issue](#)

Eastern Pacific Atlantic

Atlantic Marine Forecasts

Gulf of Mexico Caribbean Atlantic High Seas

Click Region for Current Marine Forecast

Graphical Tropical Weather Outlook | Active Storms | Marine Forecasts

Atlantic - Caribbean Sea - Gulf of Mexico

Tropical Weather Outlook (en Español\*) Tropical Weather Discussion  
700 PM EST MON NOV 30 2009 805 AM EDT TUE MAY 04 2010

There are no tropical cyclones at this time.

Eastern Pacific (out to 140°W)

Tropical Weather Outlook Tropical Weather Discussion  
1000 PM PST MON NOV 30 2009 1005 UTC TUE MAY 04 2010

There are no tropical cyclones at this time.

\*Spanish translations courtesy of the NWS San Juan Weather Forecast Office

Hurricane Preparedness

Learn about hurricane hazards and what you can do to help protect yourself, your family, and your property.

Tropical Cyclone Centers Worldwide

- Central Pacific Hurricane Center
- Joint Typhoon Warning Center
- Canadian Hurricane Centre
- WMO Severe Weather Info Centre

National Weather Service - Since 1870