National Hurricane Center Forecast Verification: Quantifying Forecast Uncertainty

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Acknowledgement to James Franklin and John Cangialosi

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NHC Forecast Verification

- NHC verifies all official tropical cyclone track and intensity forecasts each year

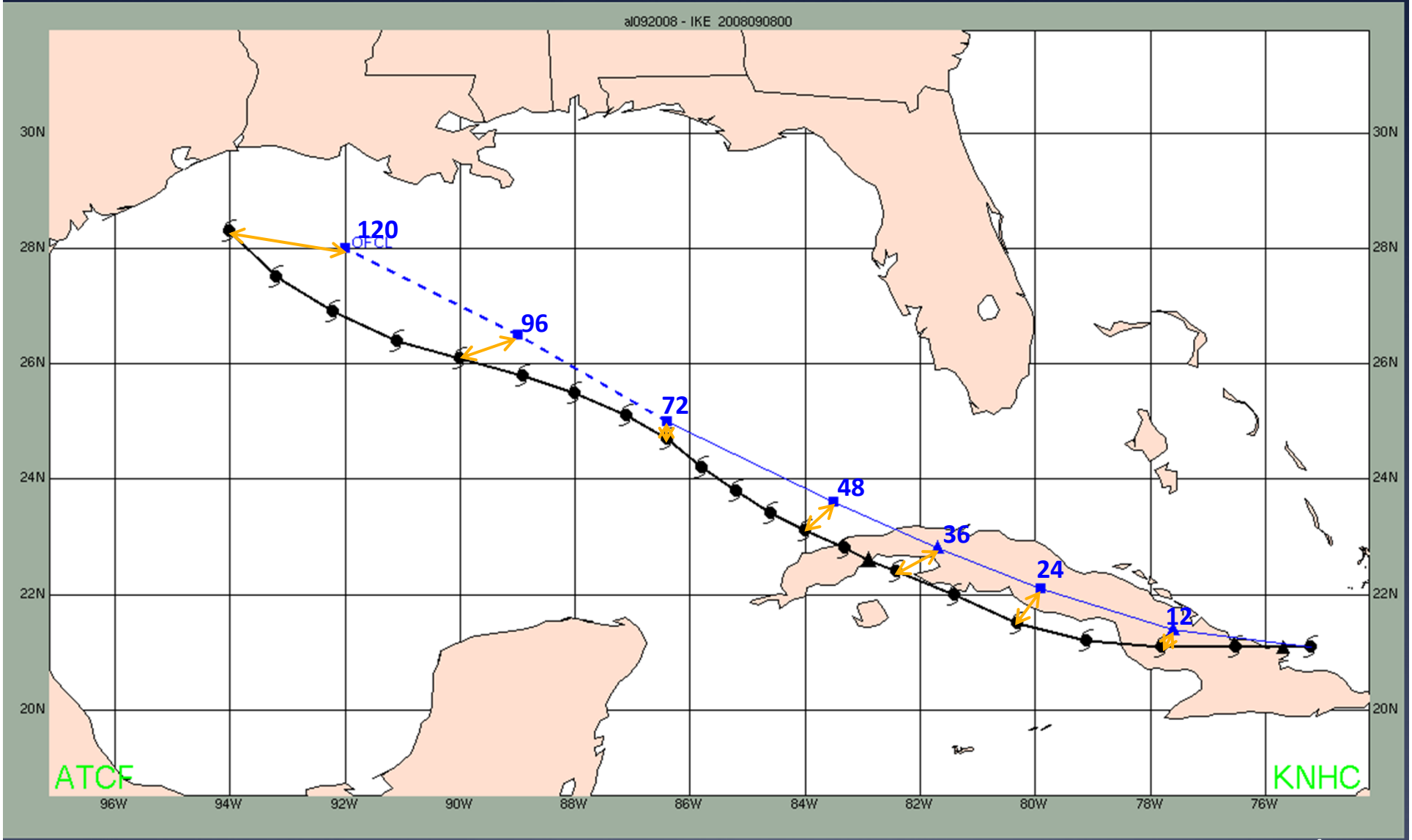
- Why verify forecasts?

1. We have to monitor performance and progress
   - Government Performance and Results Act (GPRA)
2. Understanding forecast errors help forecasters and modelers to reduce them
3. Identify critical issues for the research community
4. Basis for the development of certain products
   - Wind speed and storm surge probabilities
5. Helps decision makers use NHC products more effectively

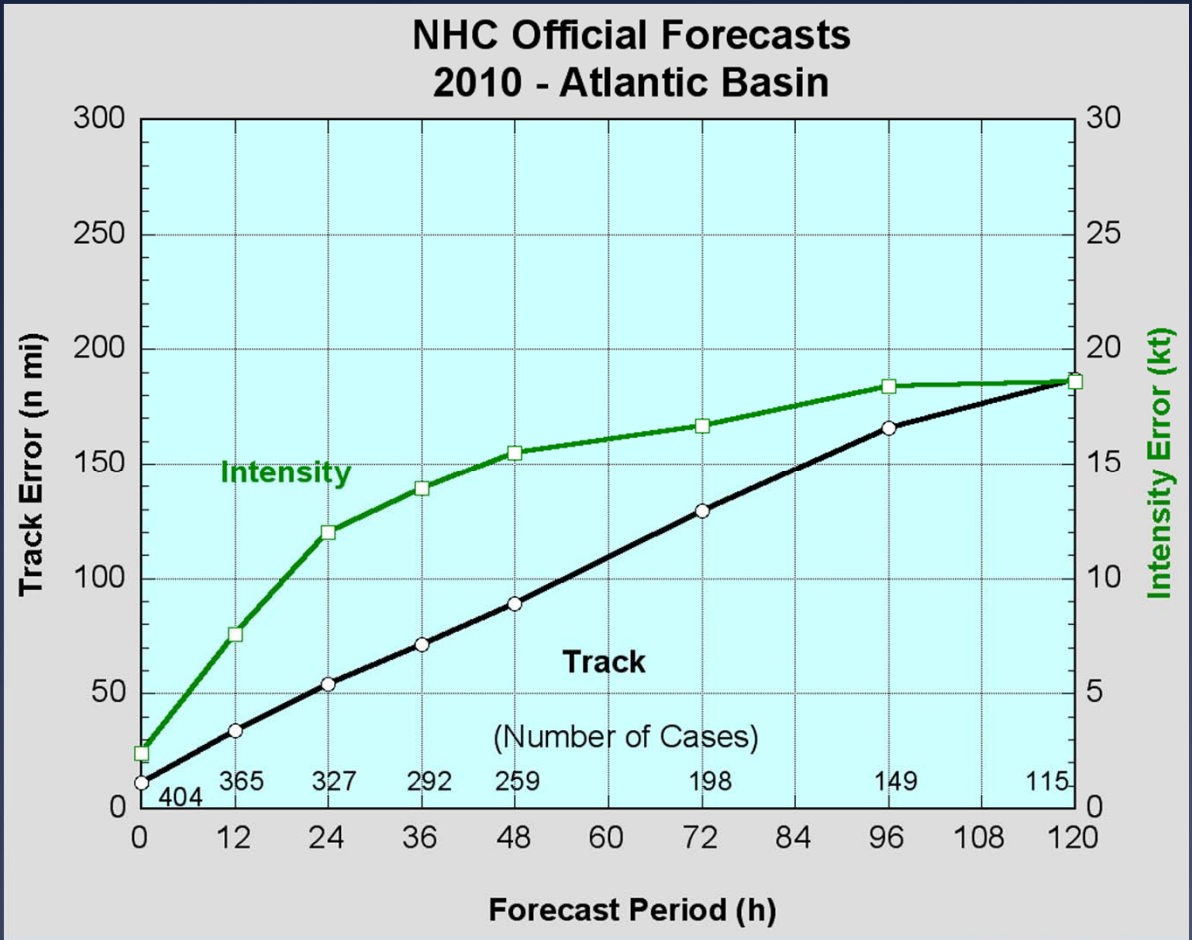
NHC Forecast Verification

- System must be a tropical or subtropical cyclone at both forecast initial time **and** verification time
- Special advisories ignored (original advisory is verified instead)
- Definitions:
  - Track error: great-circle distance between the forecast location and the actual location of the storm center (n mi)
  - Intensity error: 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



2010 Atlantic Verification



VT (h)	NT	TRACK (n mi)	INT (kt)
000	404	11.2	2.4
012	365	34.2	7.6
024	327	54.2	12.0
036	292	71.6	13.9
048	259	89.1	15.5
072	198	129.4	16.7
096	149	166.0	18.4
120	115	186.7	18.6

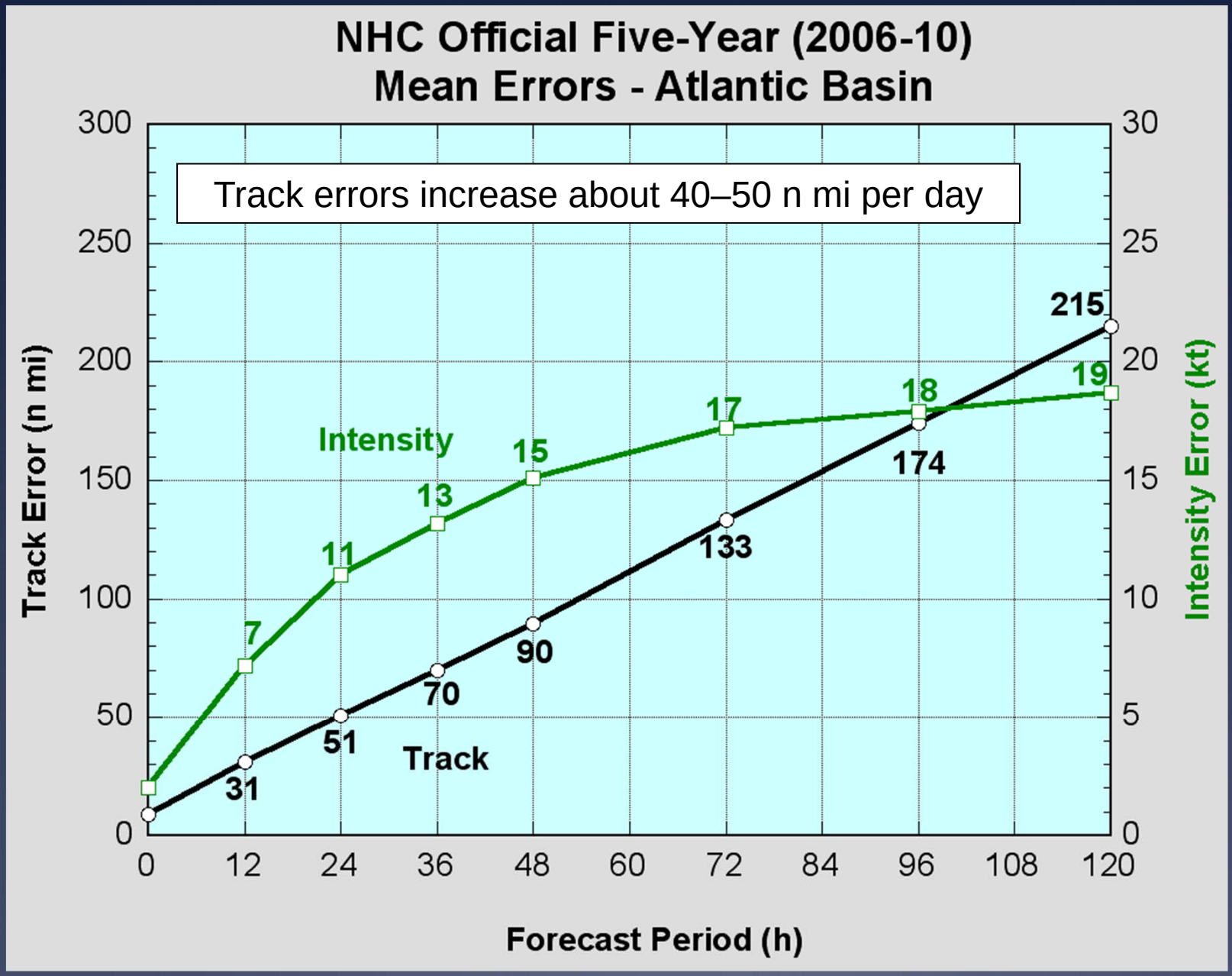
Values in red exceed all-time records

Only one record set for track, but 48-h track error below 90 n mi

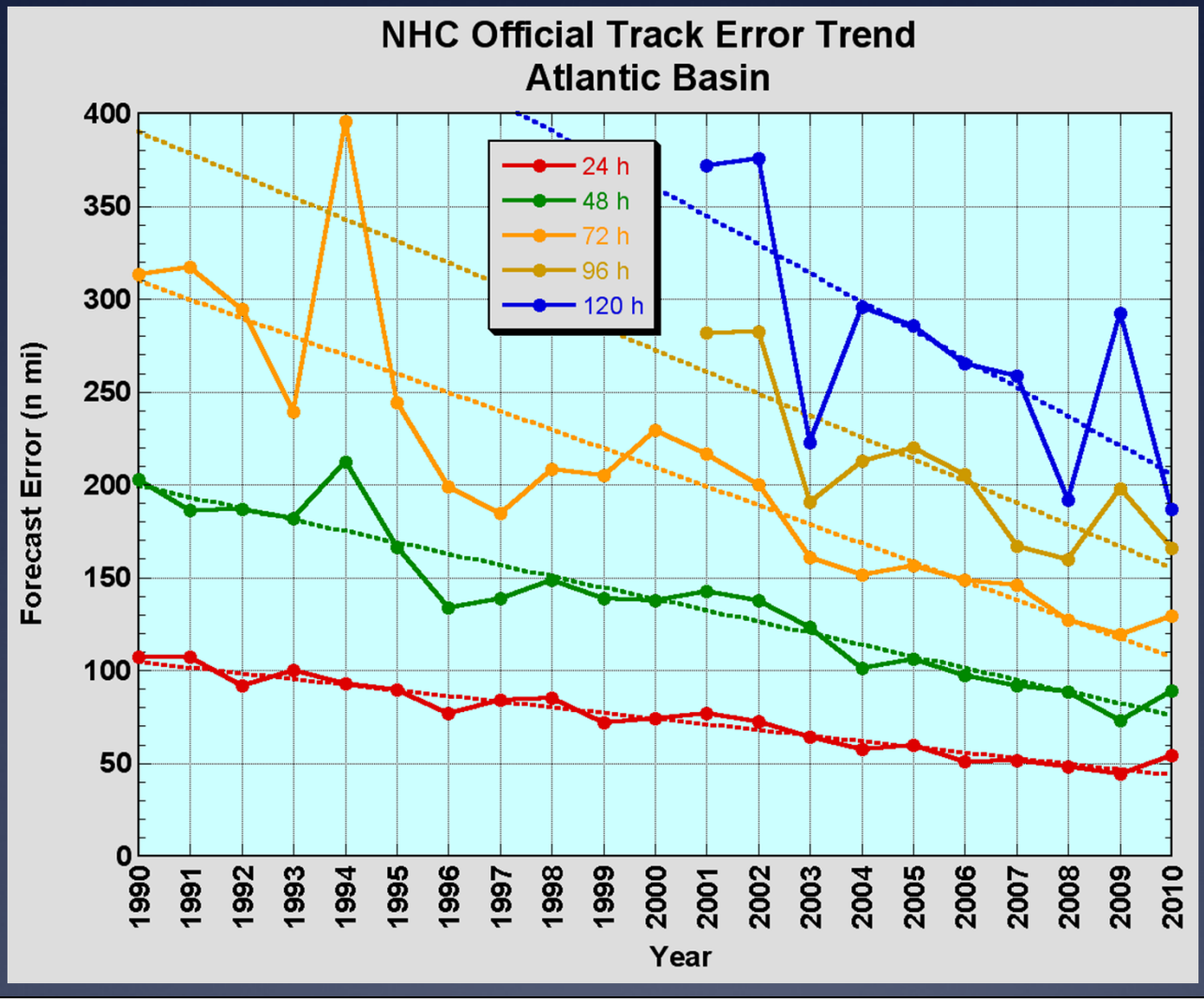
No change in intensity error, still grows quickly through 2-3 days and levels off

Much larger sample than 2009, especially at days 4 and 5

Atlantic 5-Year Mean Track Errors



Atlantic Track Error Trends (1990-2010)

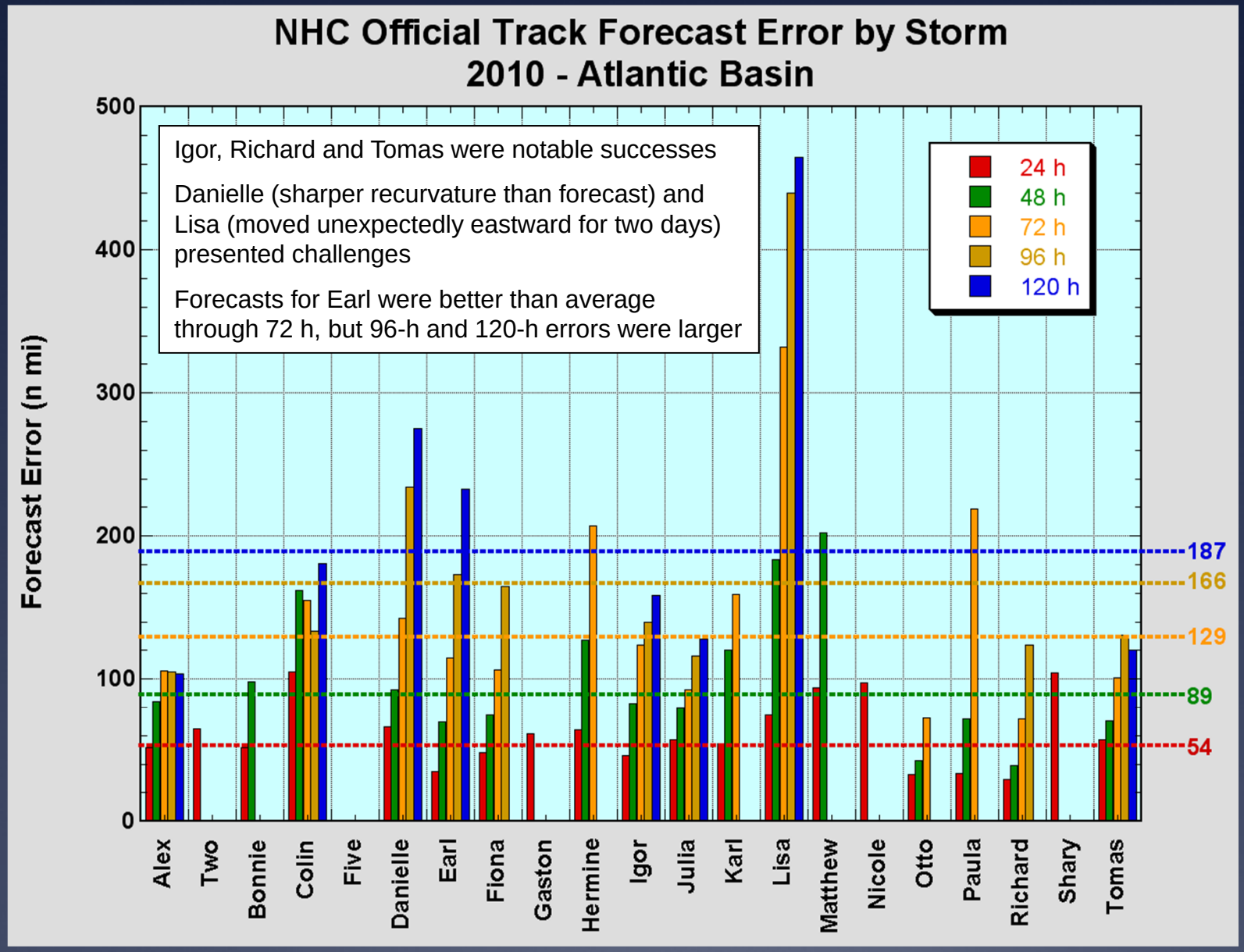


Track errors have decreased by about 60% since 1990

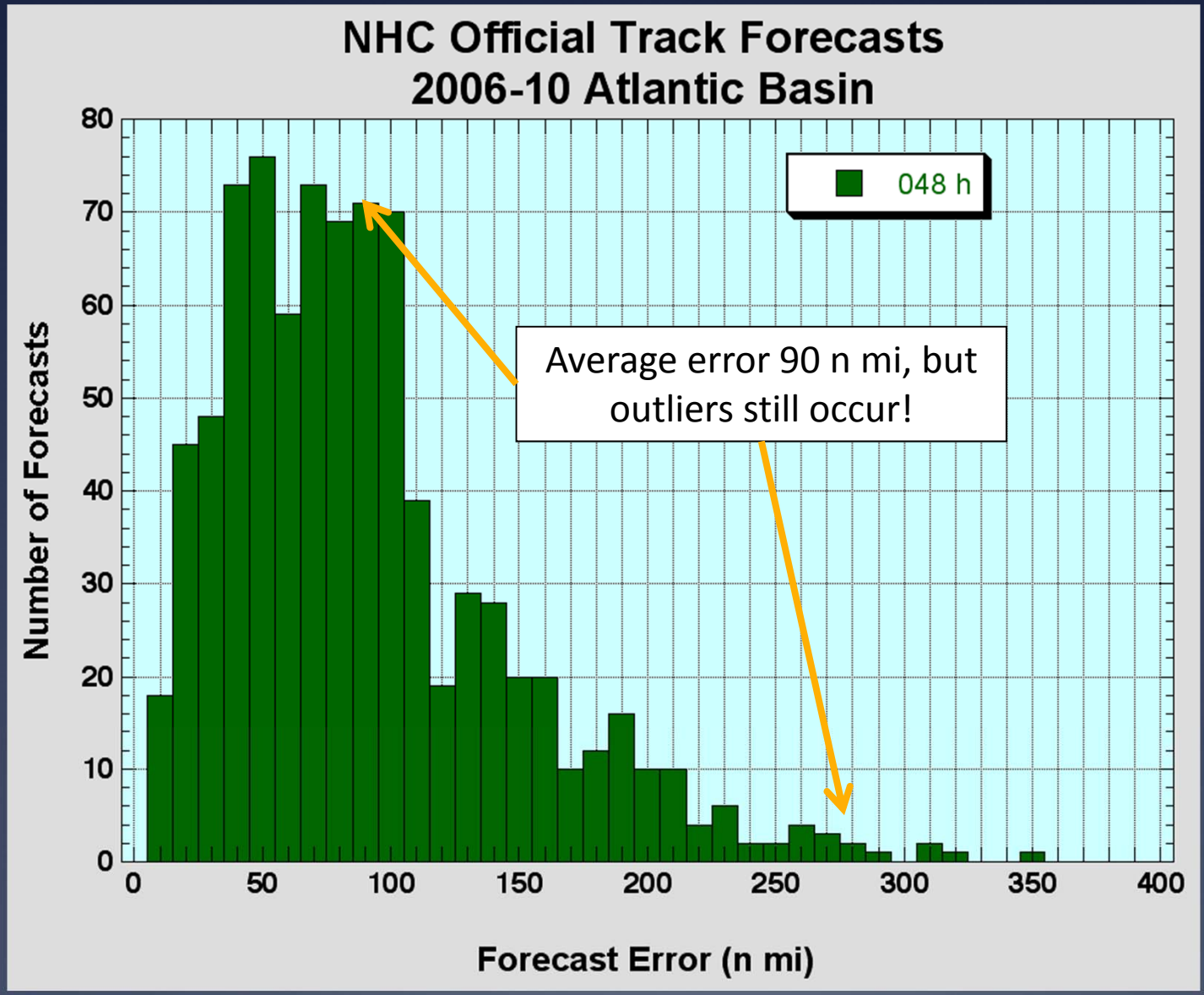
Current 5-day forecast is as accurate as the 3-day forecast was just 10 years ago

Long-term trend distinctly downward through day 5

2010 Atlantic Track Errors by Storm

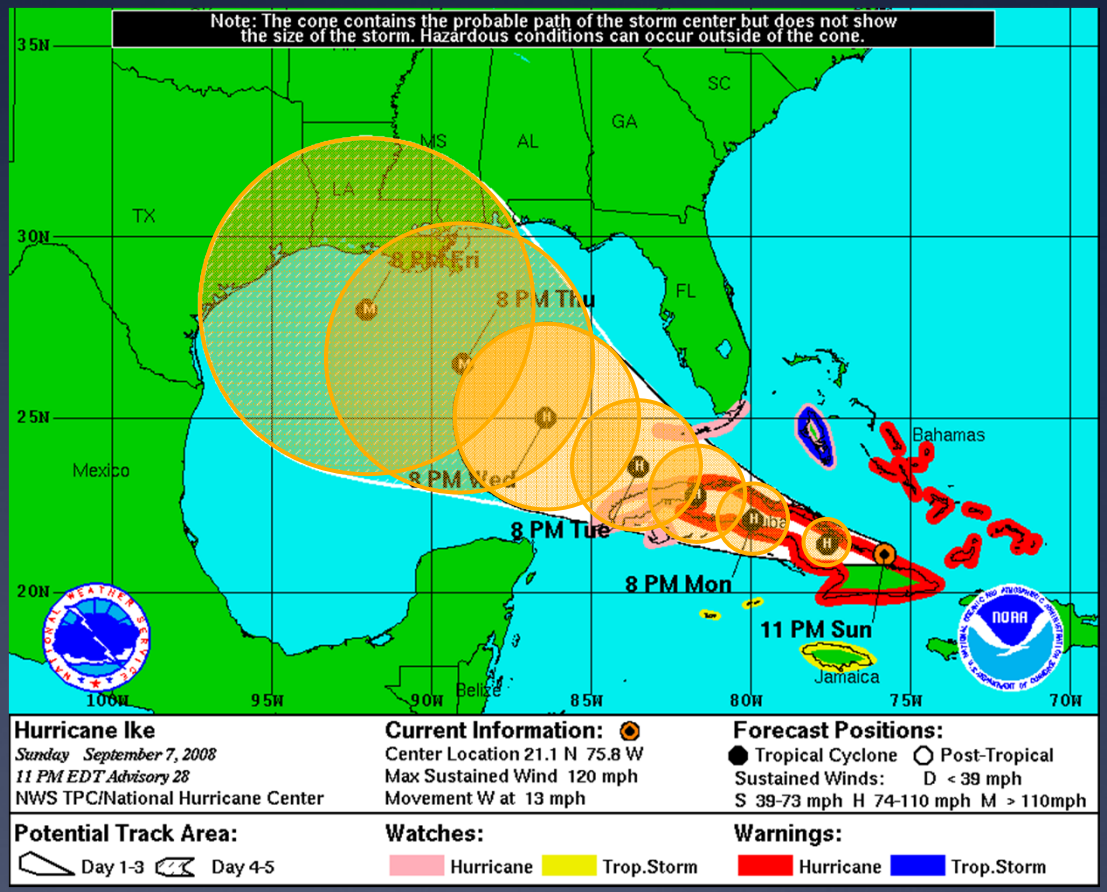


Atlantic Track Error Distribution (48 h)

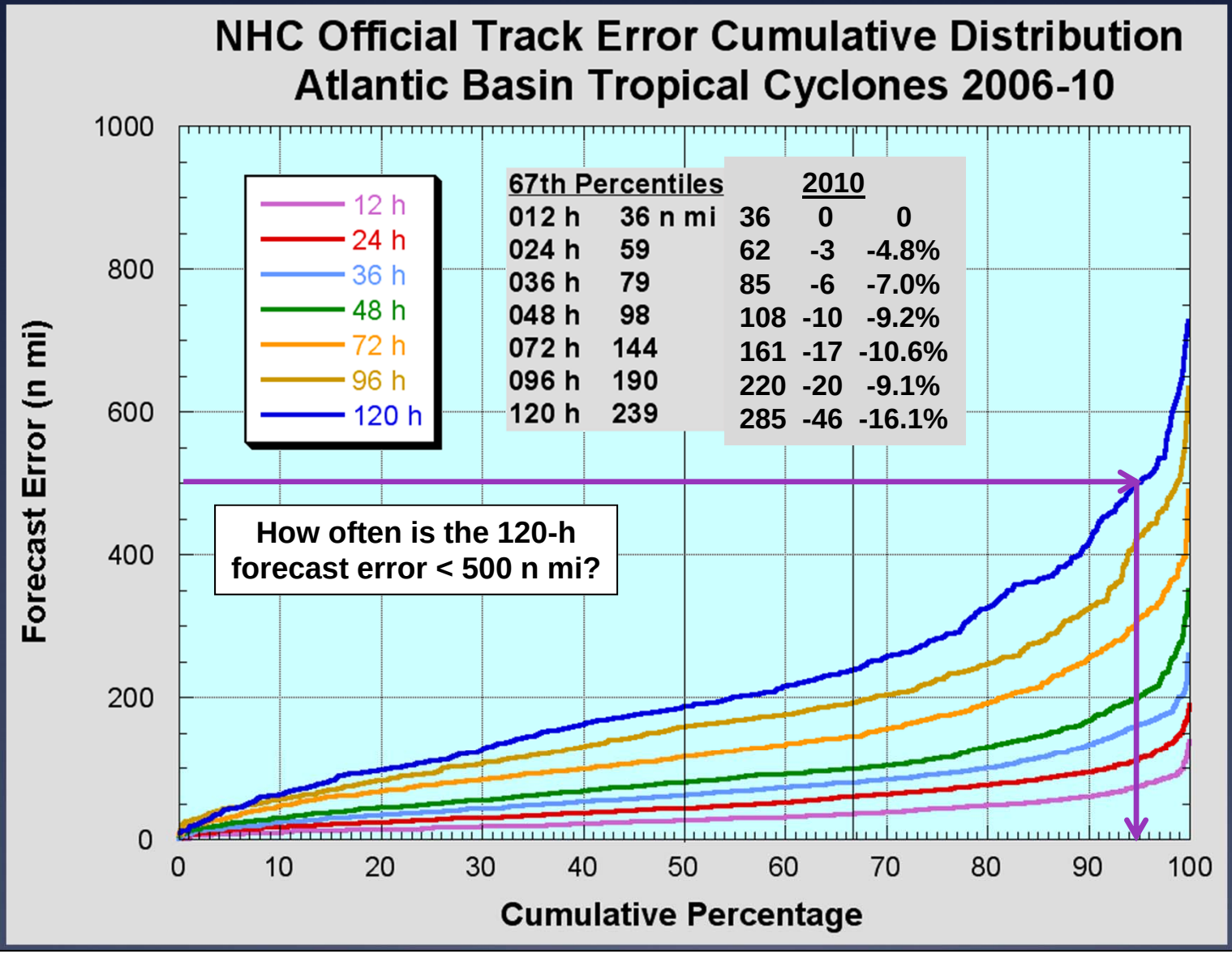


NHC Forecast Cone

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

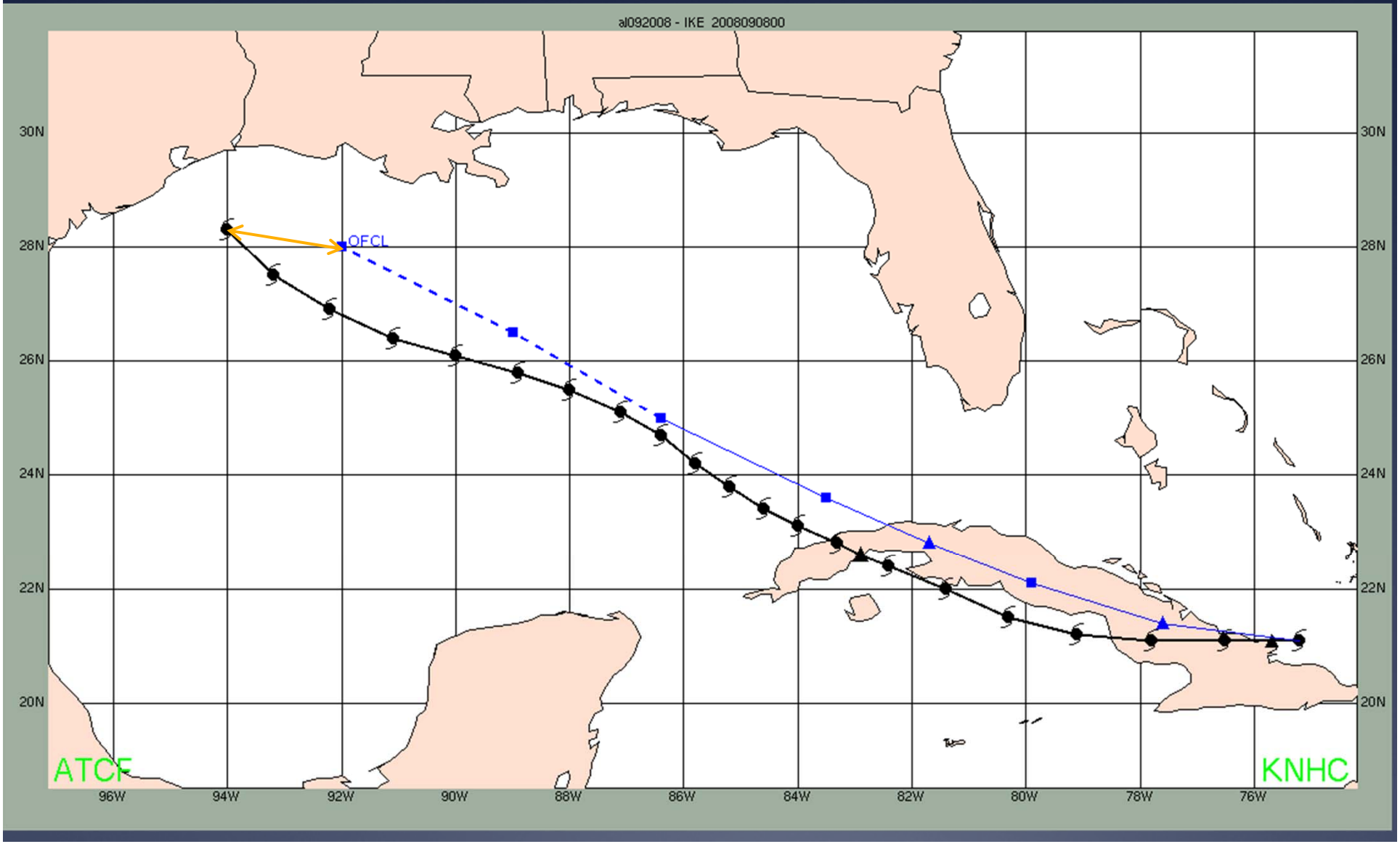


Forecast Error Distributions and Cone Radii

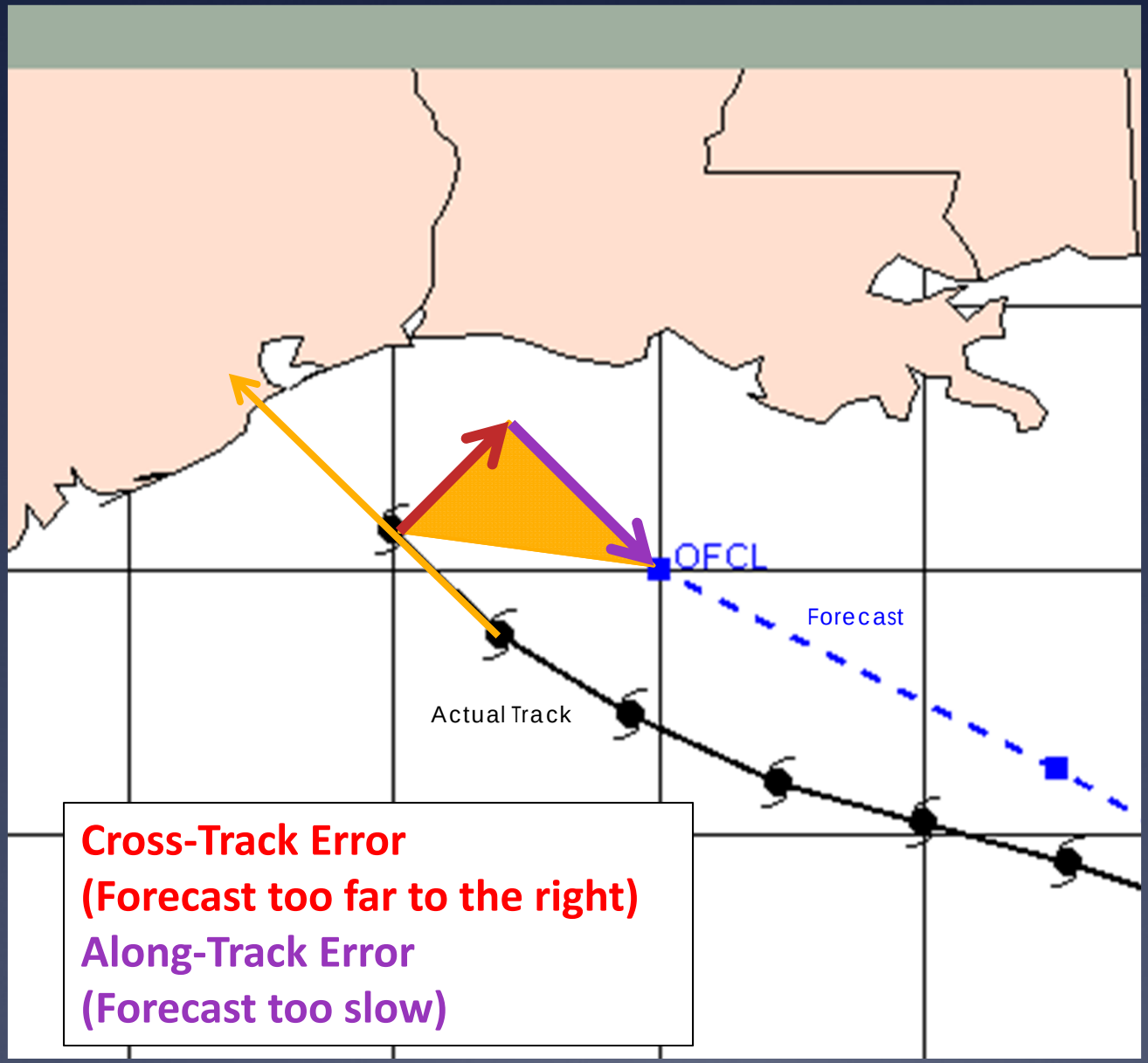


Substantial reduction in track cone size for 2011 due to 2005 season dropping out of the sample

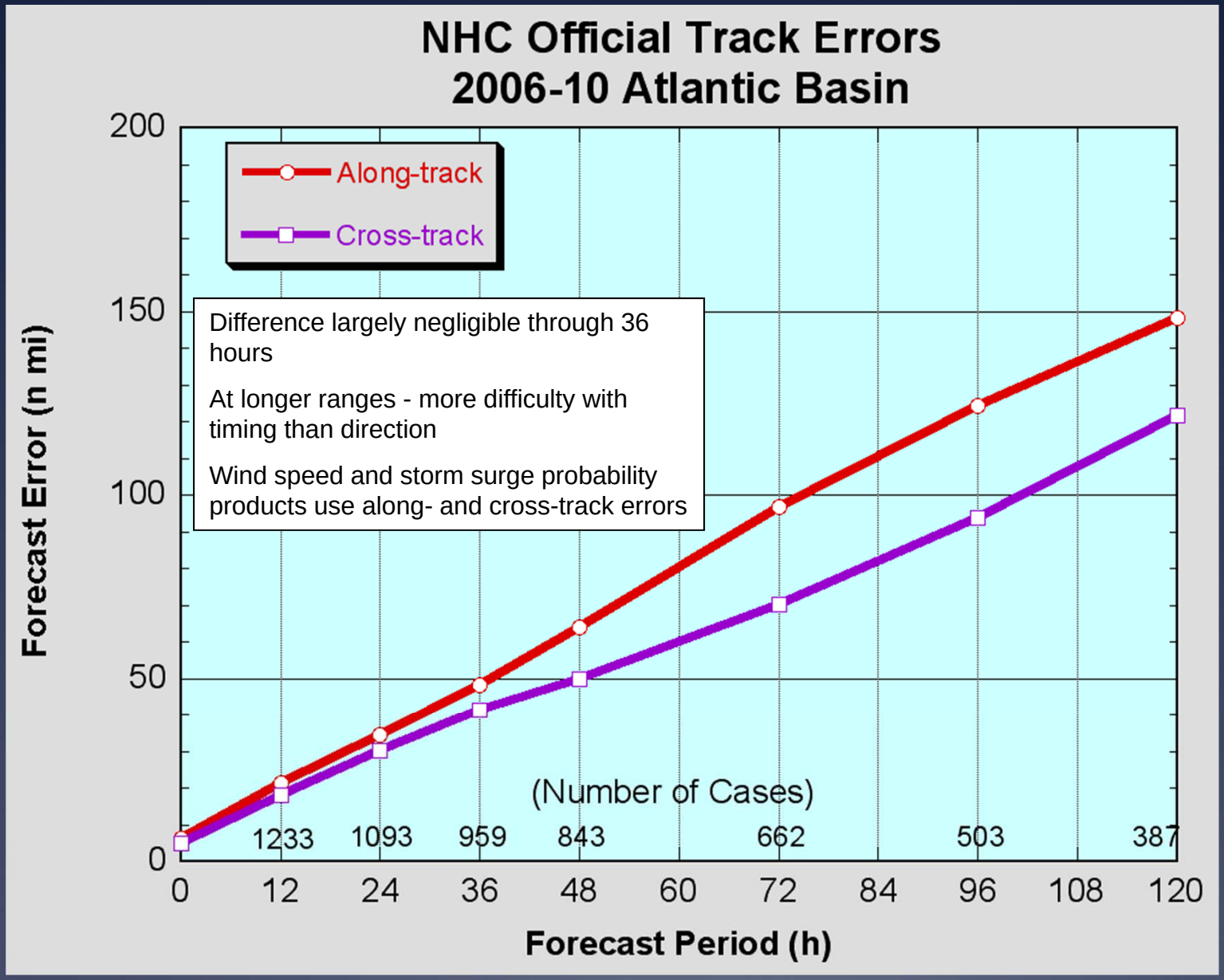
Along- and Cross-Track Errors (Timing vs. Location)



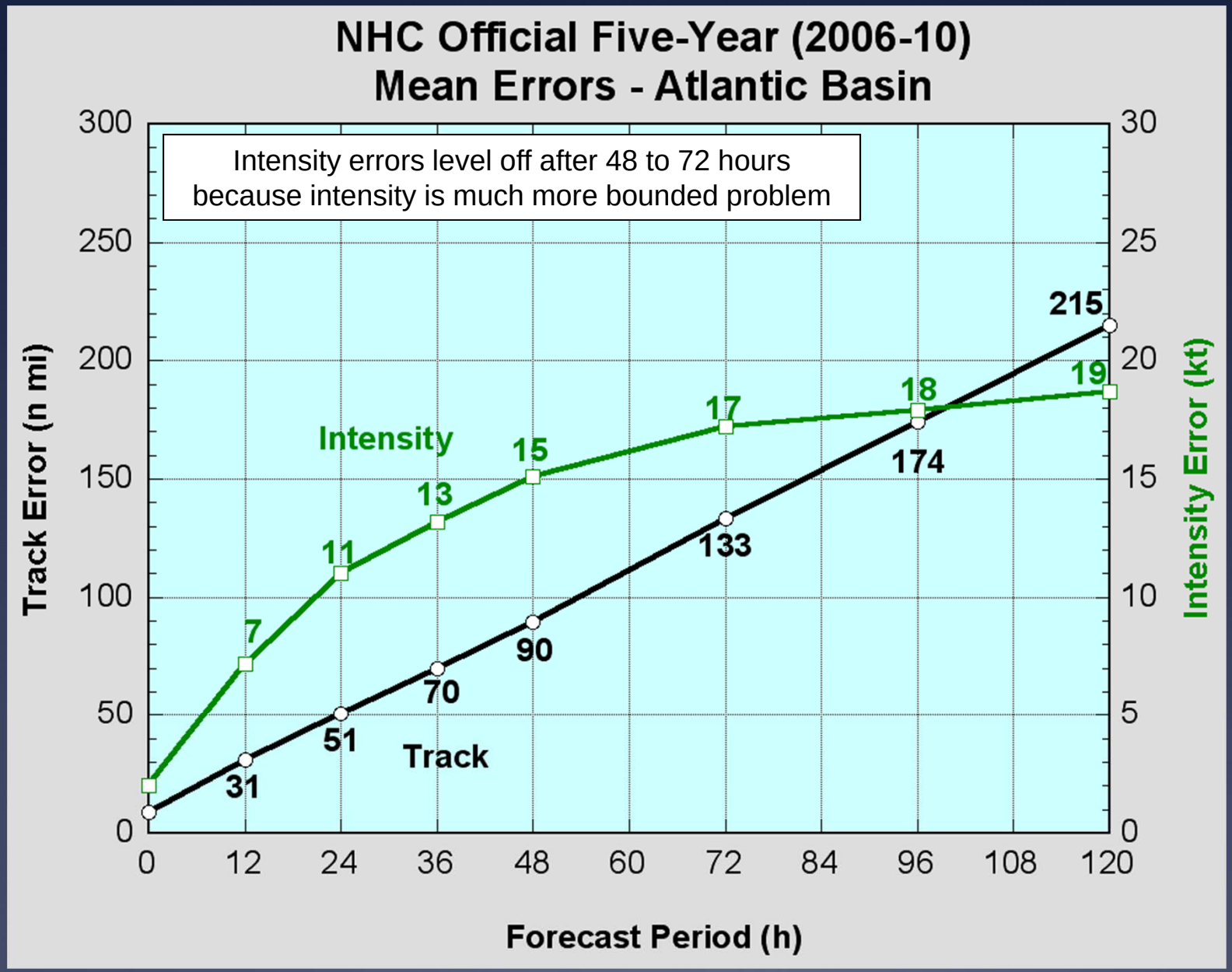
Along- and Cross-Track Errors



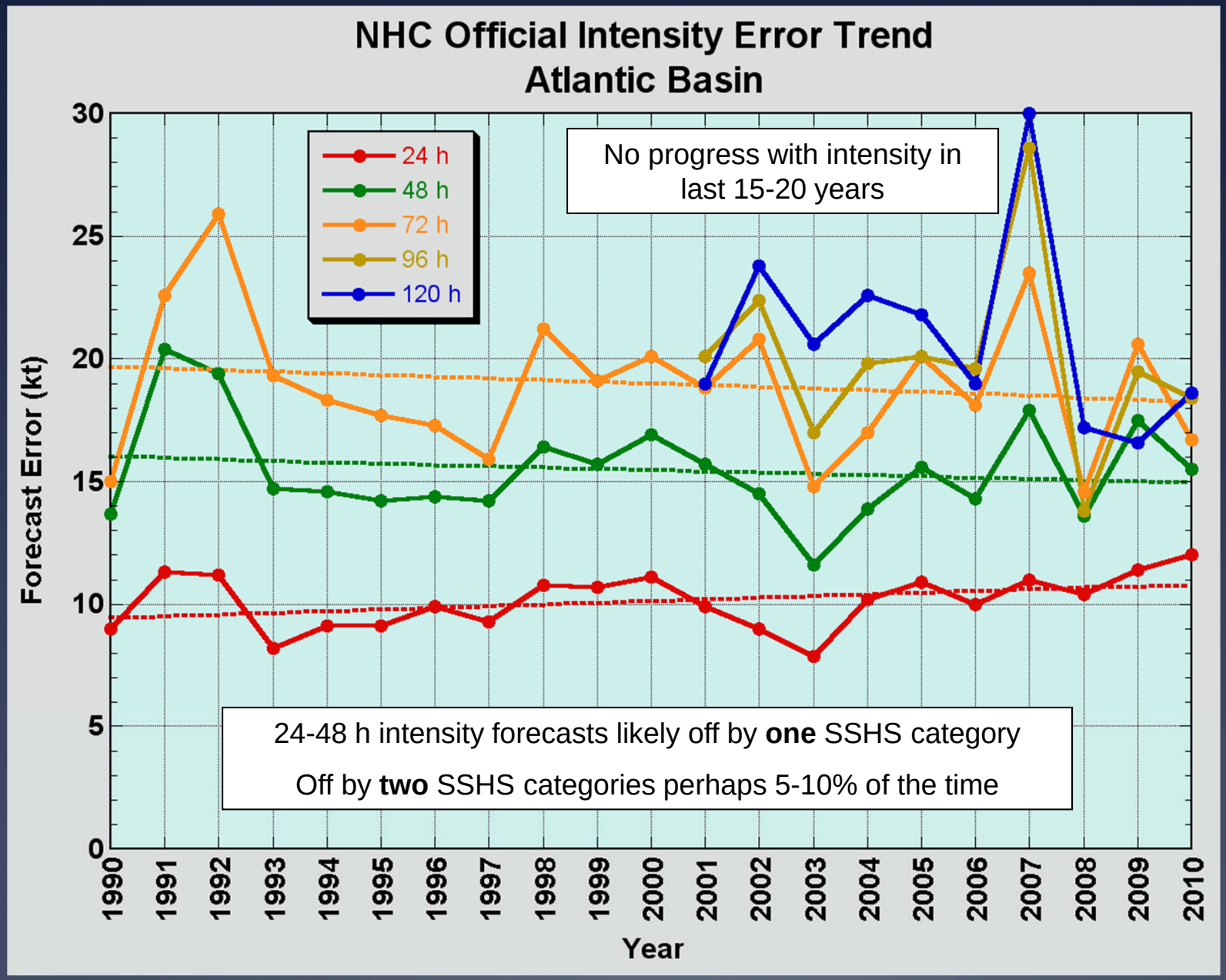
Along- and Cross-Track Errors



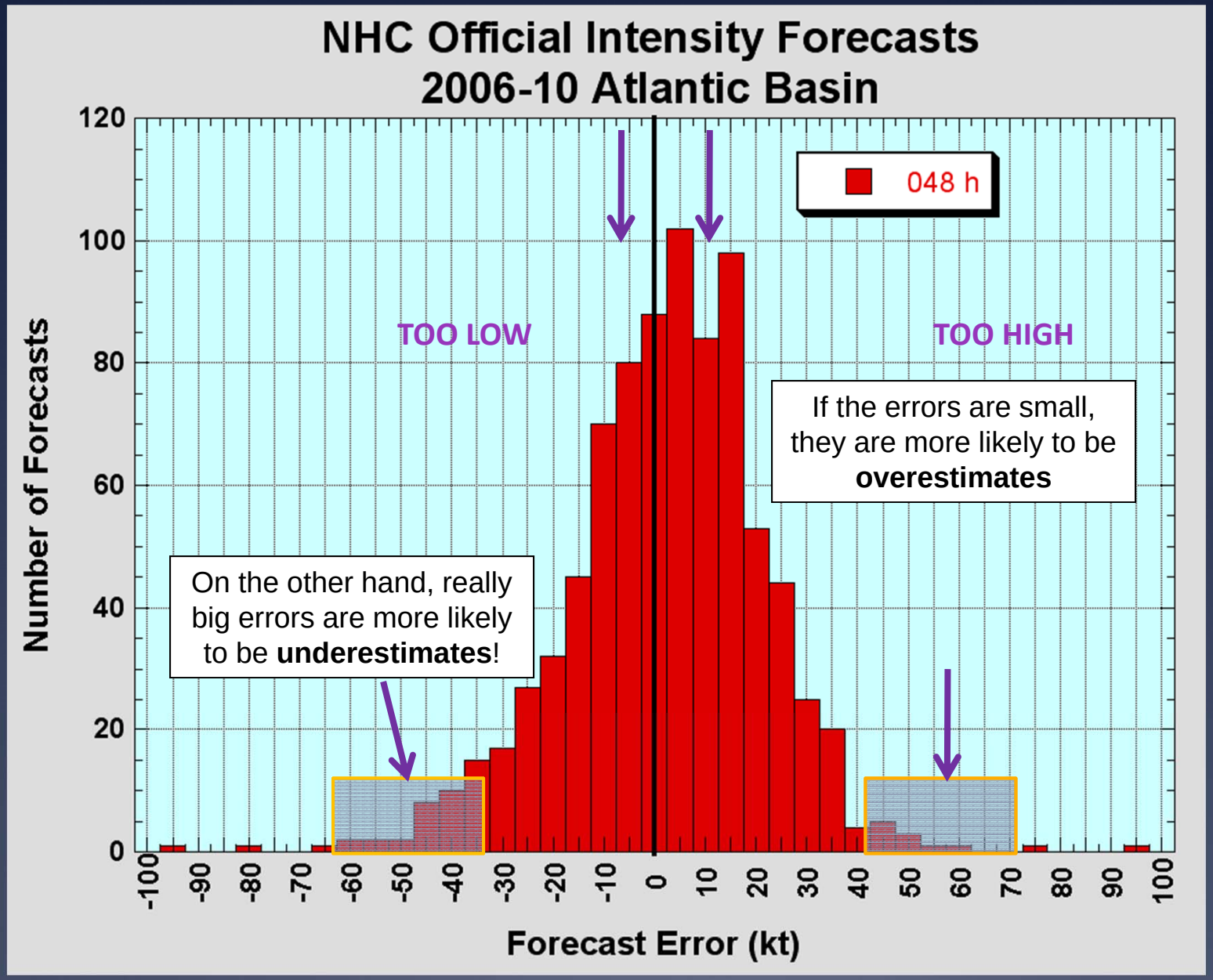
Atlantic 5-Year Mean Errors



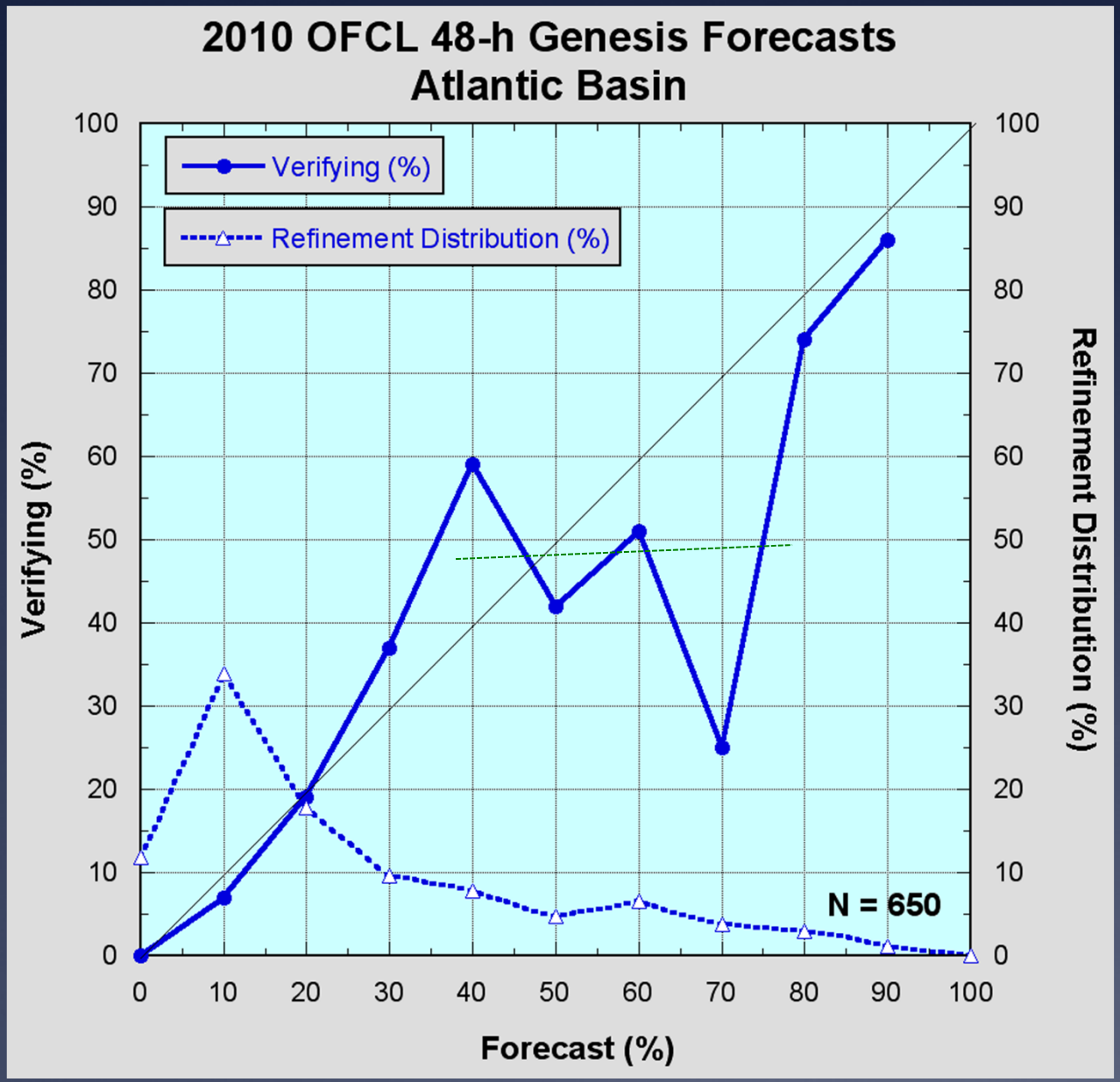
Atlantic Intensity Error Trends (1990-2010)



Intensity Error Distribution (48 h)



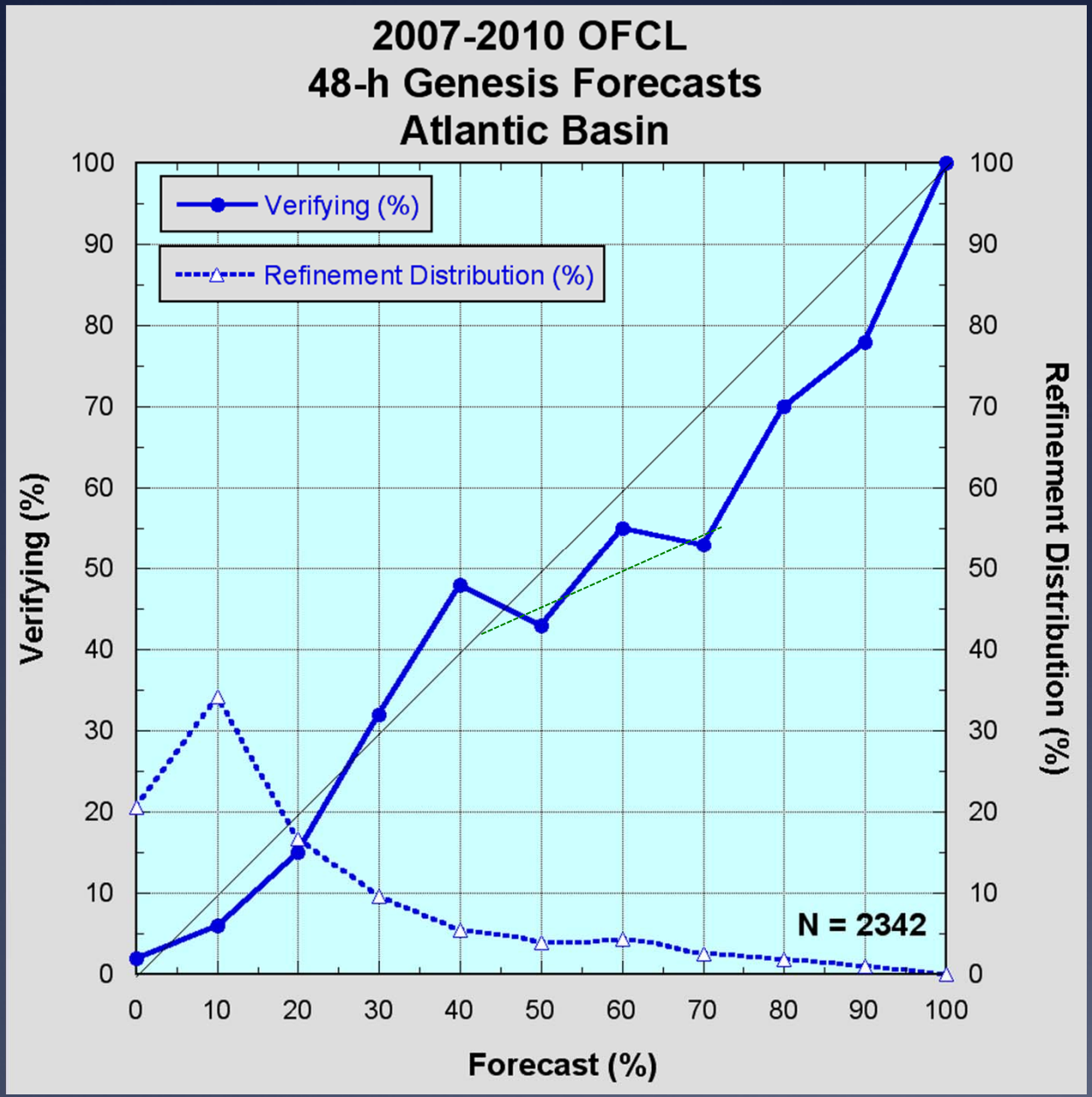
Atlantic Genesis Forecasts



Forecasts at the high end and low end were very well calibrated (reliable) with minimal bias

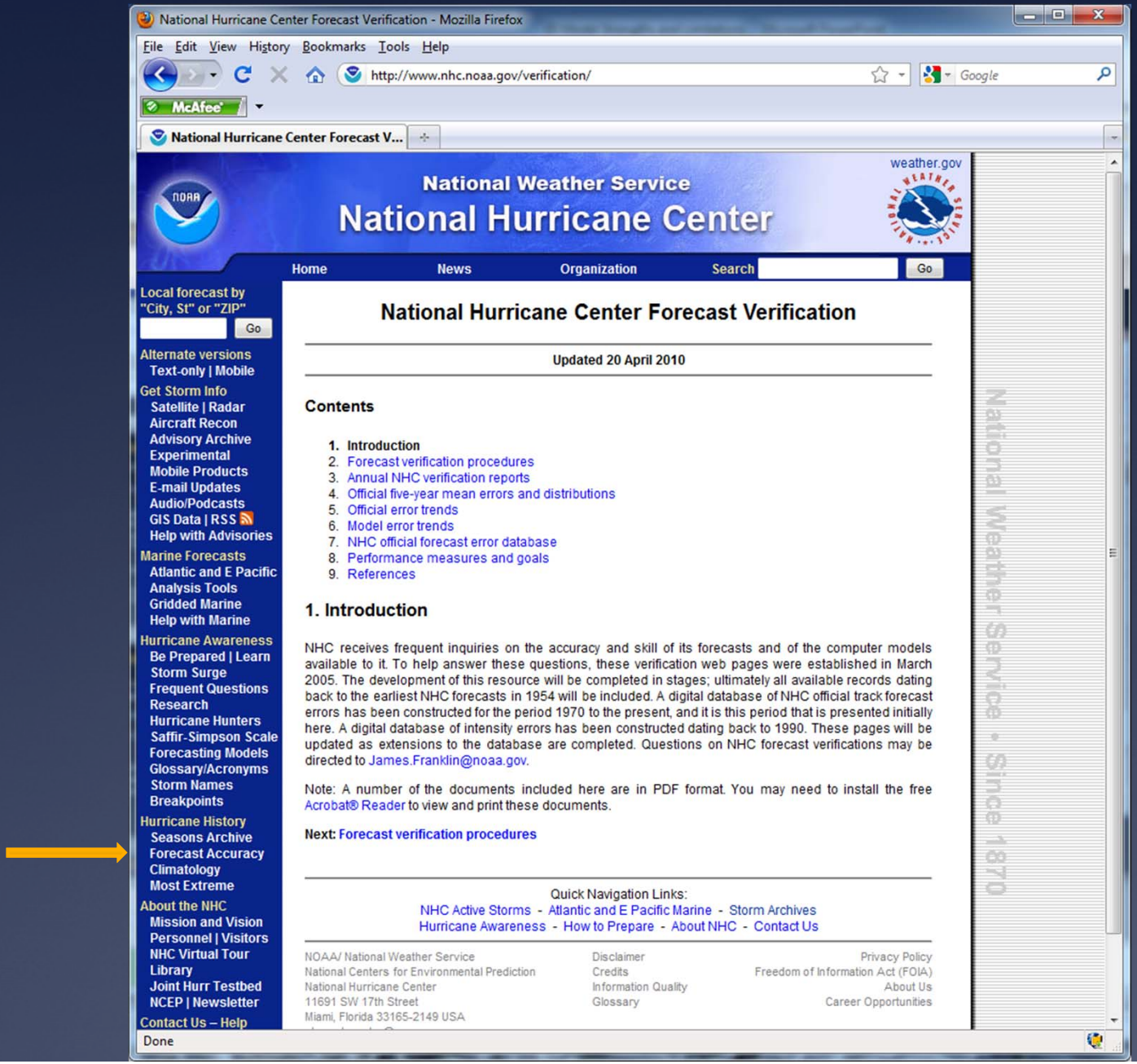
However, this year's forecasts could not distinguish gradations in likelihood between 30% and 70%

Atlantic Genesis Forecasts



Results for the 2007-2010 sample show some ability in the mid-range, but it's clearly an area that could be improved

Verification Web Page



Summary

- Atlantic basin track errors increase by 40–50 n mi per day
  - Forecasts have been steadily getting better over the past two decades (and longer)
- NHC uncertainty cone made up of circles that enclose actual storm position about two-thirds of the time
  - Error cone will be substantially smaller in 2011, especially at days 4 and 5, due to 2005 season statistics dropping out of the sample
- Actual track forecast errors aren’t quite circular about the forecast point
  - Along-track (timing) errors tend to be larger than the cross-track (directional) errors at 48 h and beyond

Summary

- Intensity errors 24-48 h in advance are regularly off by one Saffir-Simpson category
- Intensity errors begin to level off around 72 h
- No appreciable change in intensity forecast error over the past two decades
- 48-h genesis forecasts show ability to distinguish between systems that clearly will or will not develop, but struggle with marginal systems in the 30-70% probability ranges