Has Intensity Forecast Guidance Improved?

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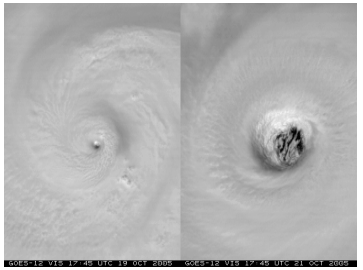
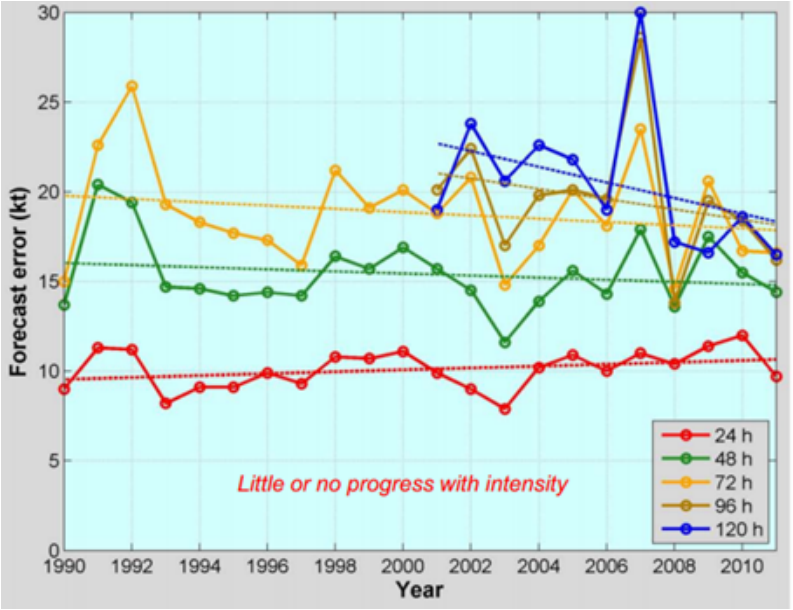
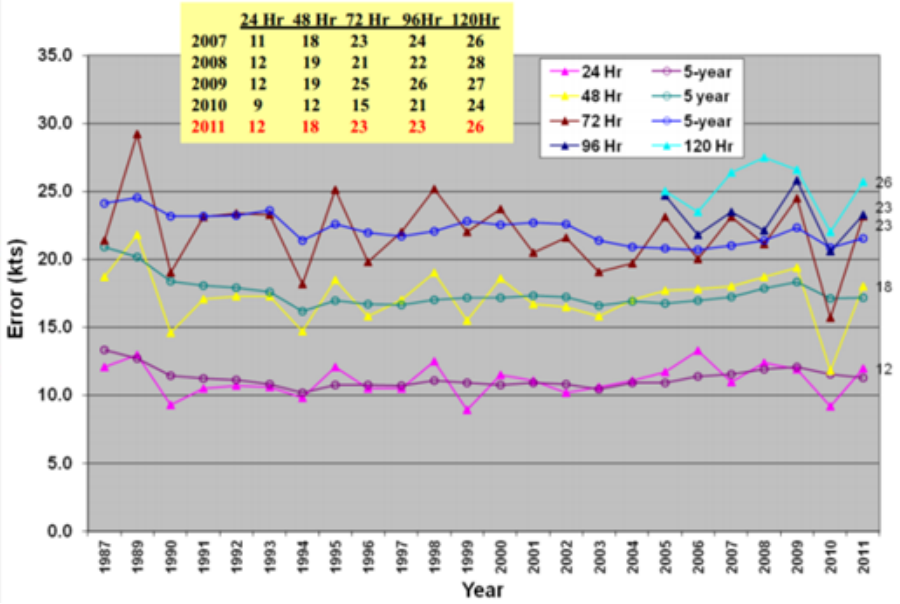


NHC and JTWC Official Intensity Error Time Series
Atlantic and Western North Pacific





NHC

JTWC

Conclusions Often Draw from the NHC and JTWC Diagrams

- Little or no progress with intensity
  - Emphasis is on 24 and 48 h even though 72, 96 and 120 h show downward trends
- The intensity guidance must not be improving since the official intensity forecasts have not improved

Evaluation of Intensity Forecast Error Trends

- Start at beginning of ATCF (1989)
- Include 2012 with working best tracks
  - 24 year sample for 12-72 h
  - 12 year sample for 96 and 120 h
- Include only “early” models in each year with forecasts for at least 1/2 of official forecasts
- Use NHC evaluation rules
  - Tropical and subtropical only
- Atlantic, eastern N. Pacific, western N. Pacific samples

Trend Analysis and Statistical Significance Testing

- Linear least squares fit to annual average errors of best model
  - $E = mt + b$
  - $t = (\text{year}-1989)$
- Trends presented in % improvement per year based on linear trend
  - $\%\ \text{Improvement} = -100(m/b)$
- Statistical significance if null hypothesis

  $m \geq 0$ can be rejected at the 95% level

Selection of “Best” Model

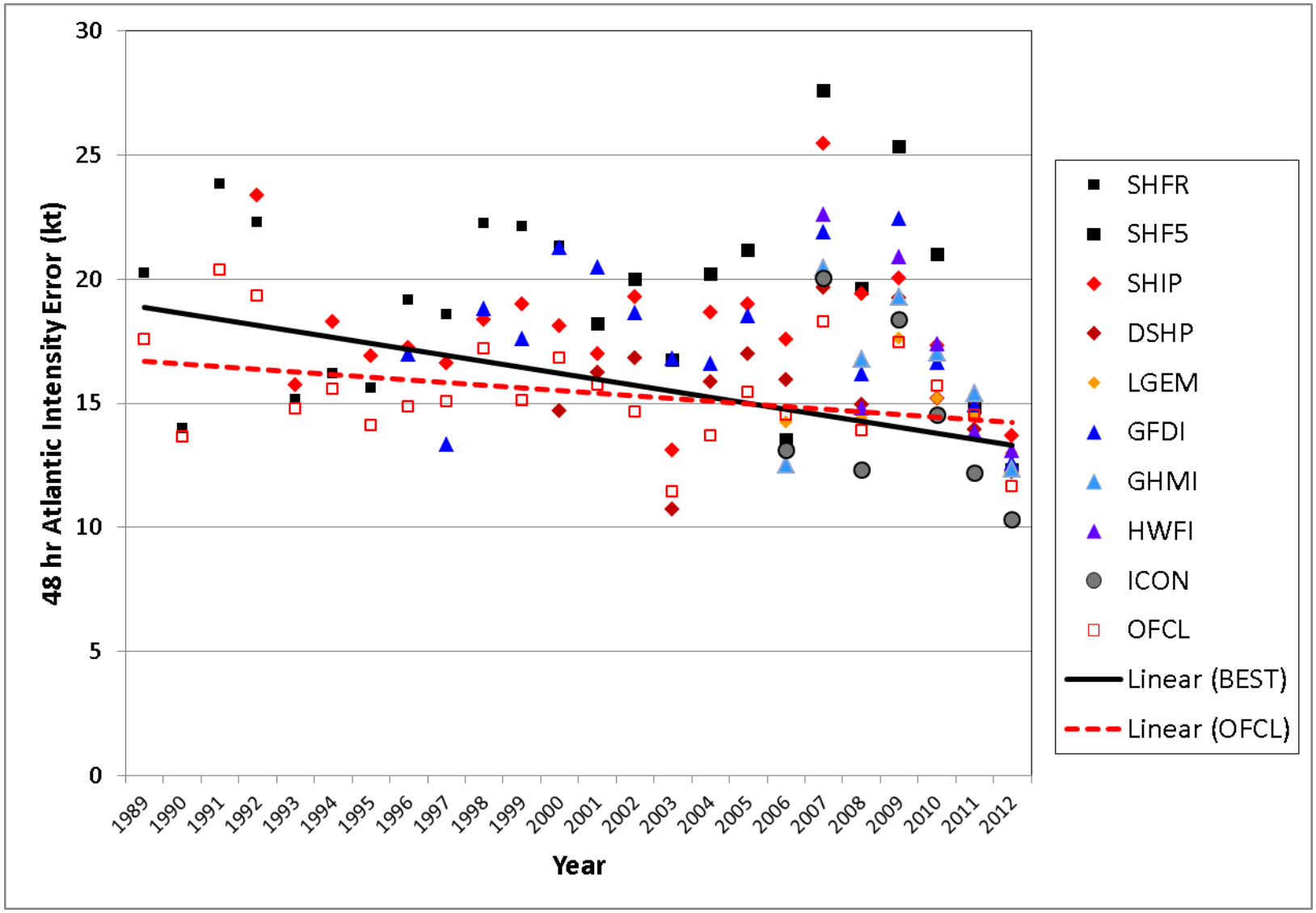
- Use 48 h errors for best model selection
- Divide 24 year period into segments where early model selection was constant
- Pick model in each segment that was best on average over that time period

Best Atlantic Models

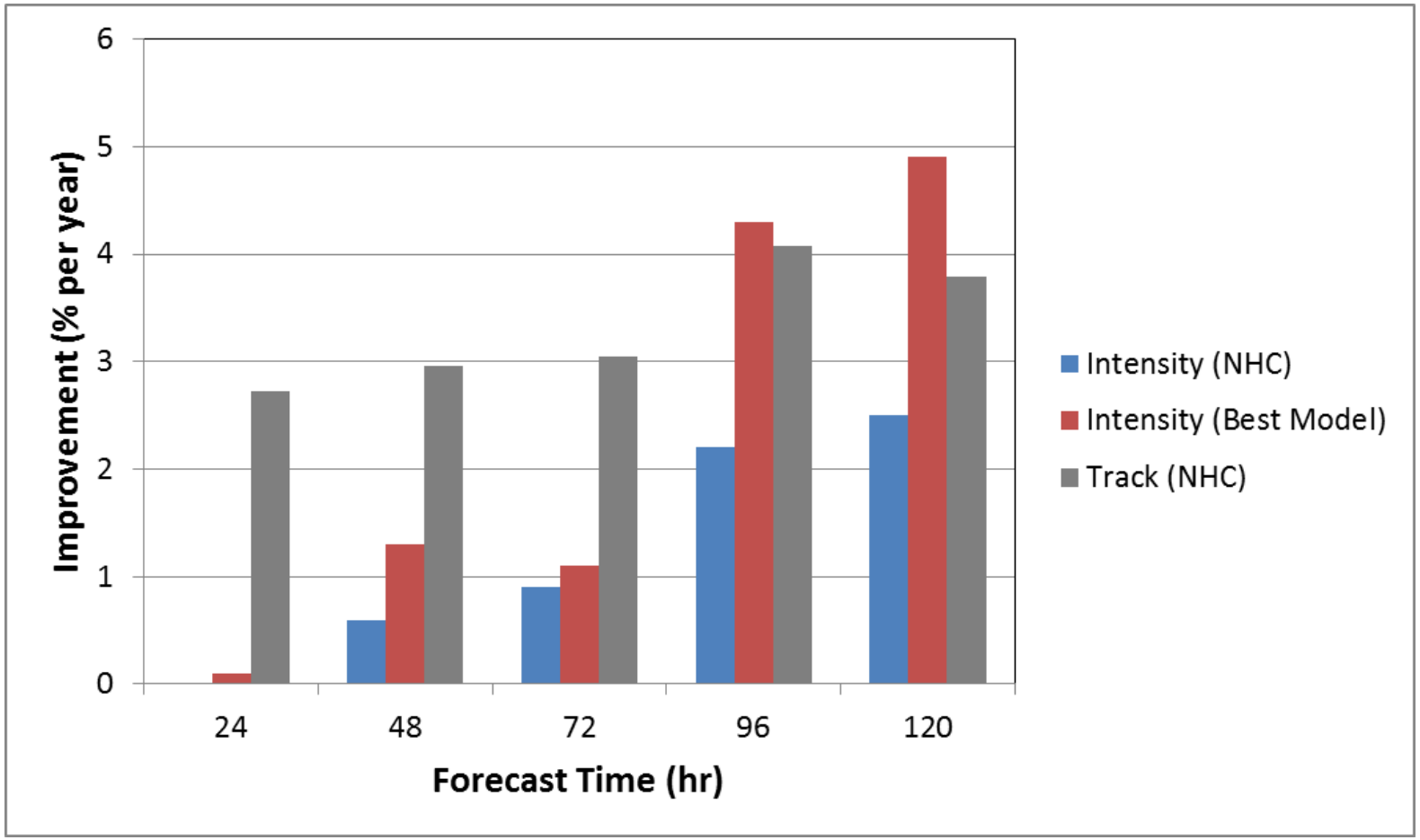
- 1989-1991 SHFR
- 1992-1995 SHFR, SHIP
- 1996-1999 GFDI, SHFR, SHIP
- 2000-2005 DSHP, GFDI, SHFR, SHIP
- 2006-2012 ICON, GFDI, SHIP, GHMI, DSHP, LGEM, HWFI (since 2007)

- GFNI not included because sample size inconsistent
- IVCN not include because of similarity to ICON

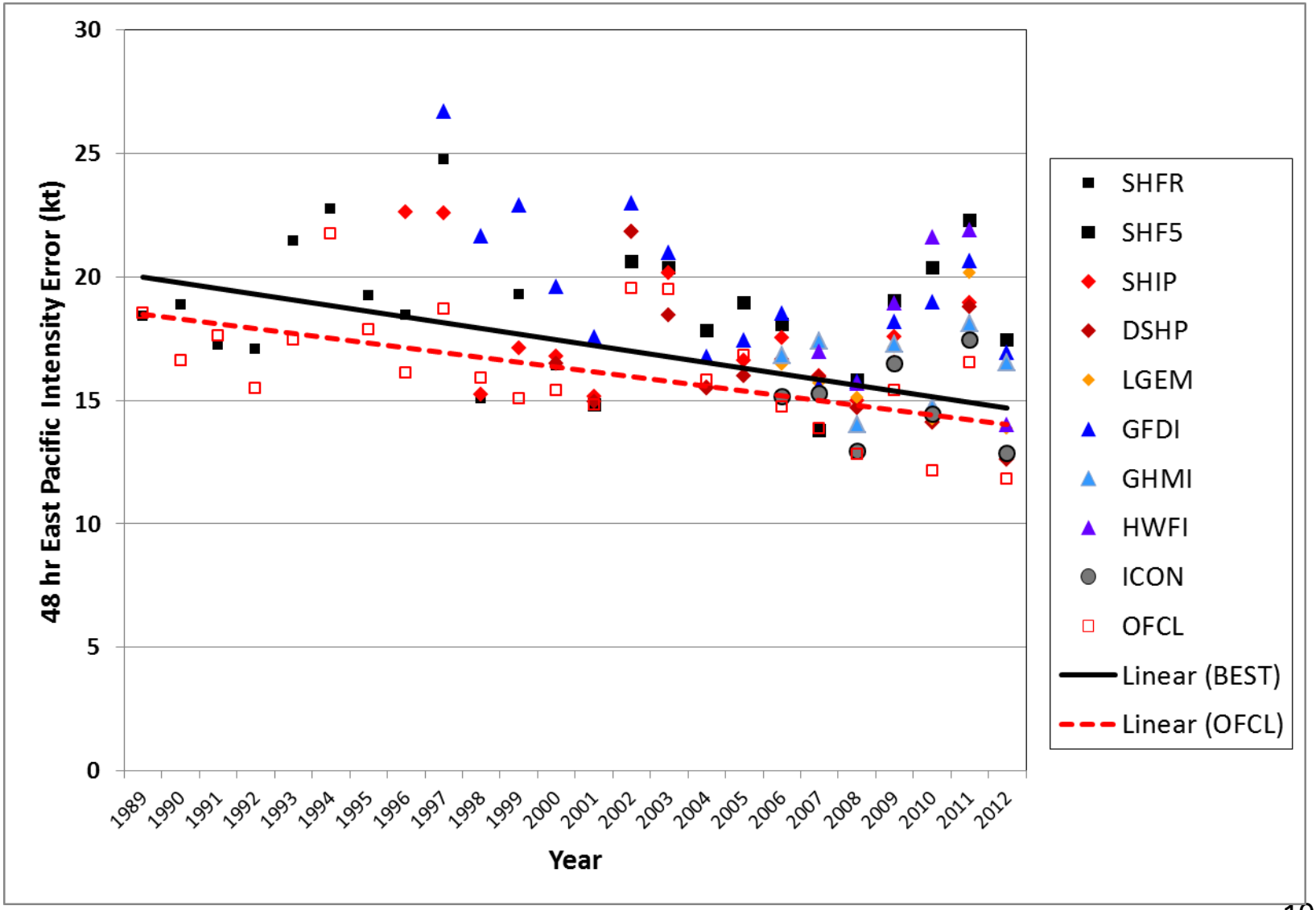
48 h Atlantic Intensity Model Errors



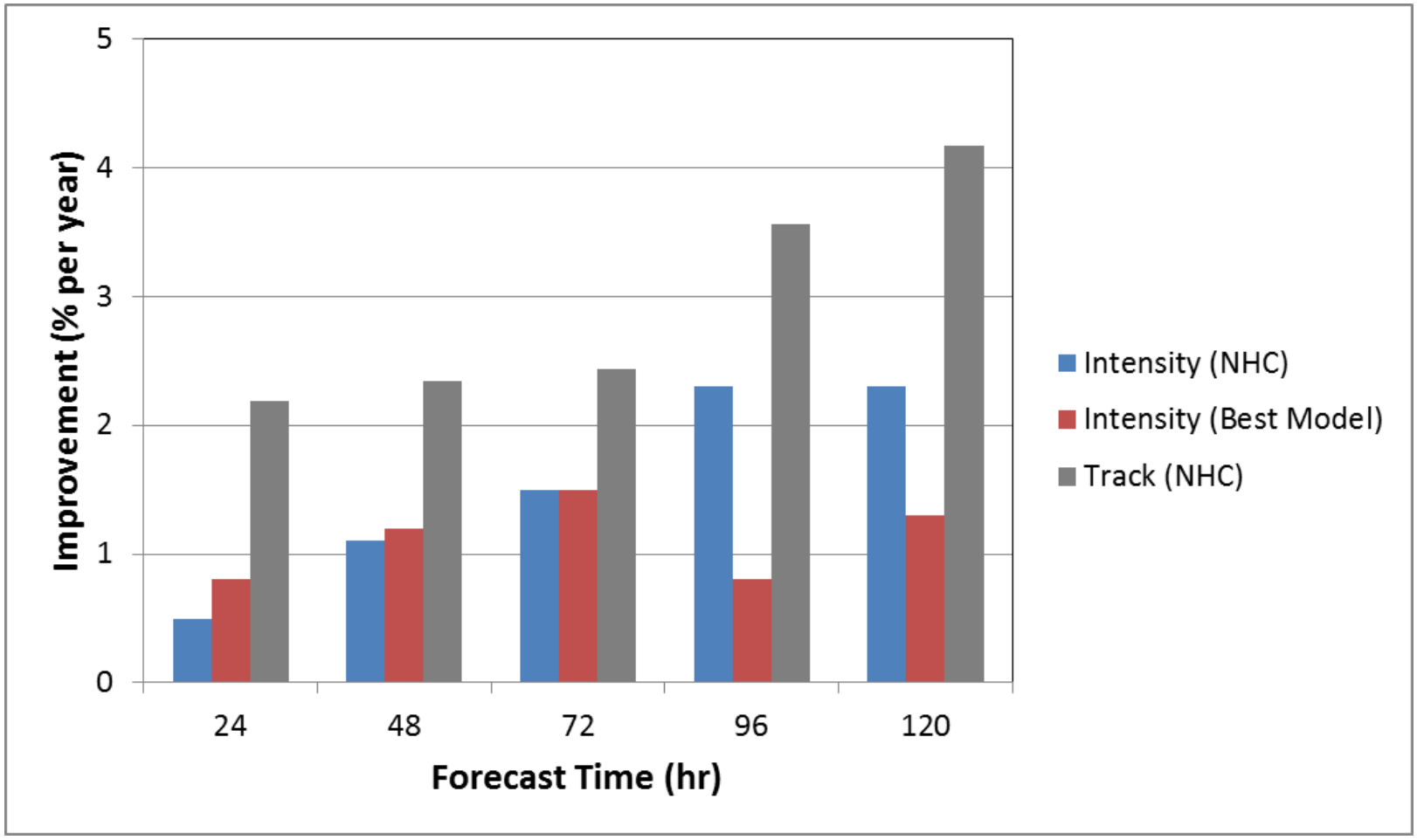
Annual Improvement Rates of Atlantic Forecasts



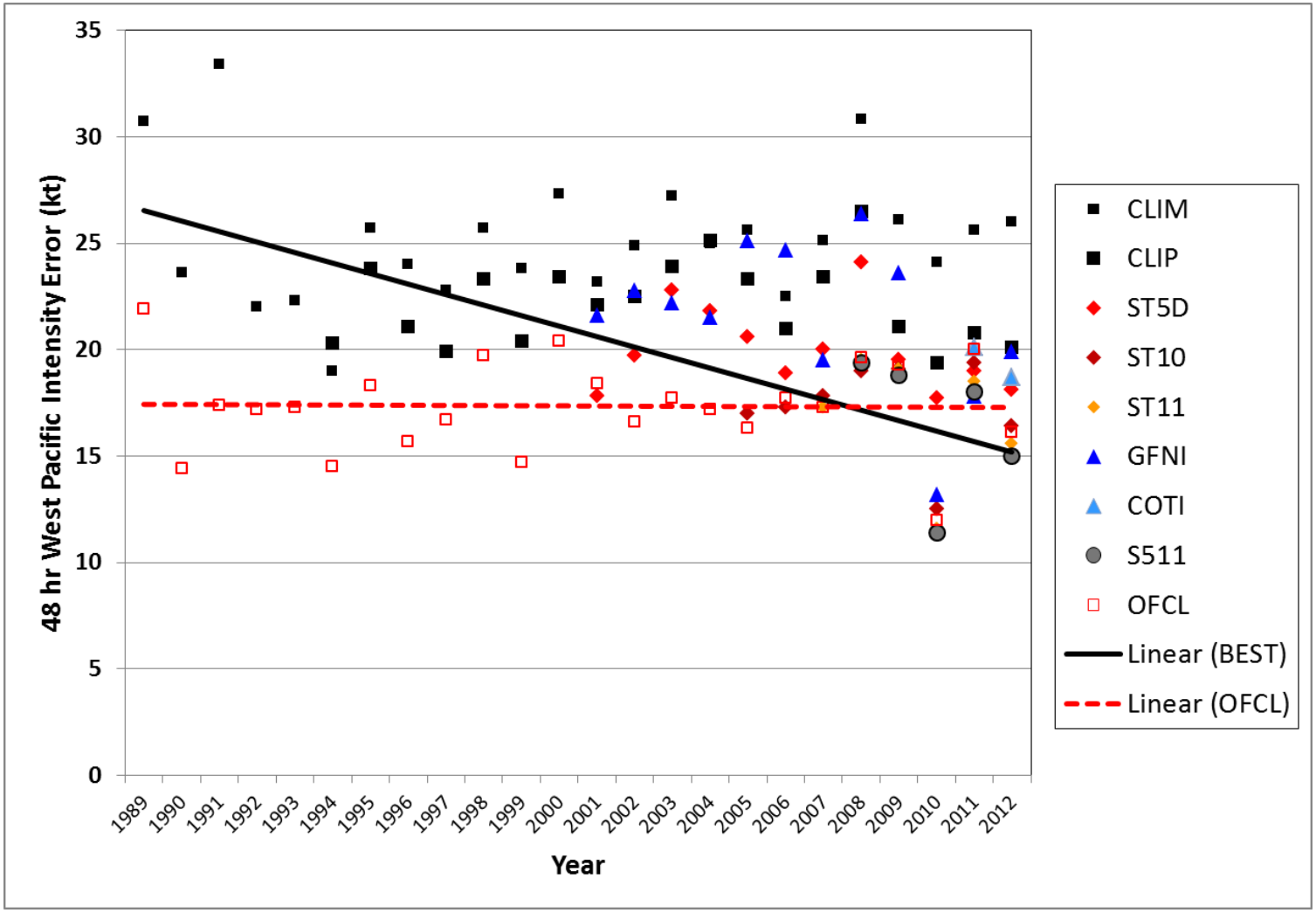
48 h East Pacific Intensity Model Errors



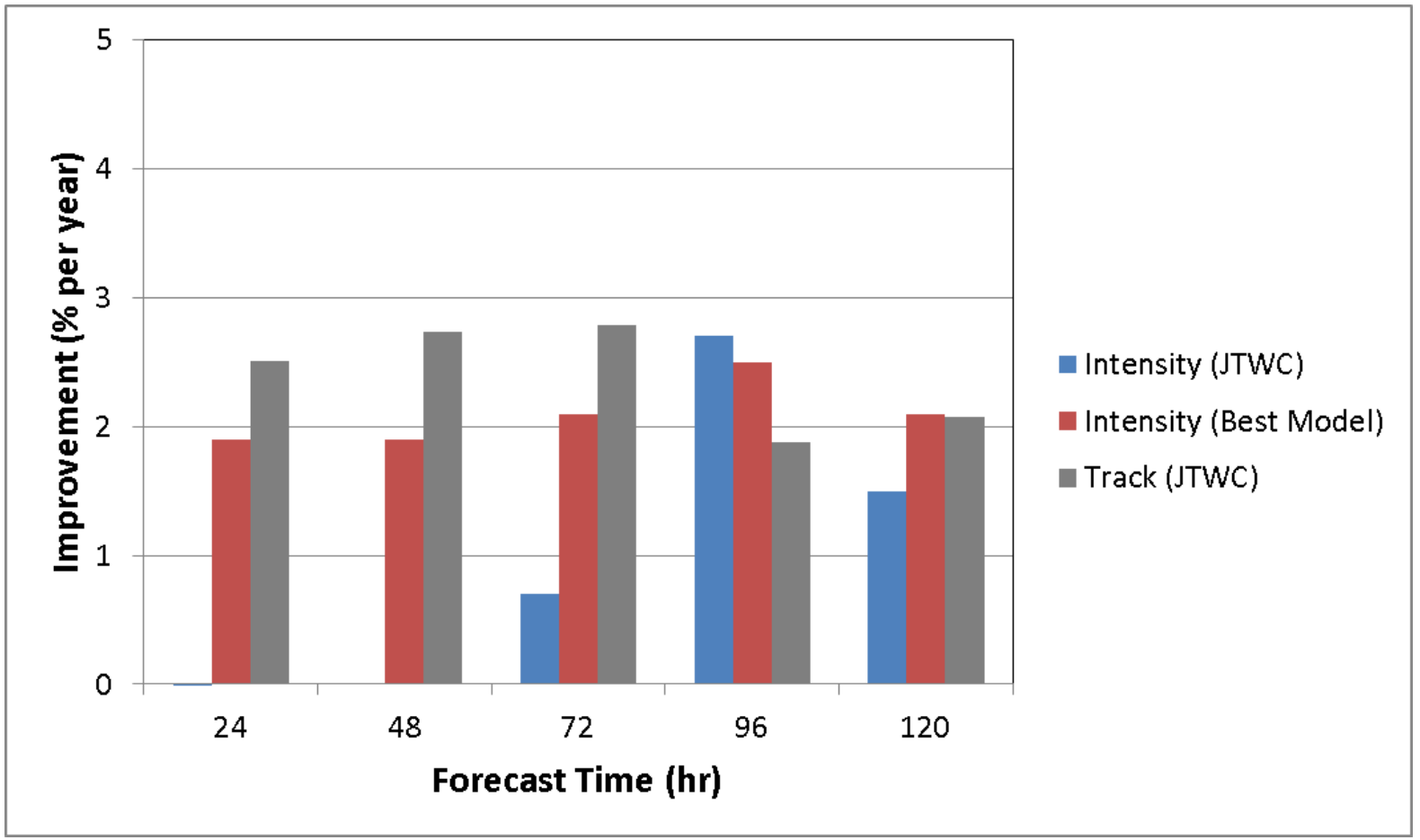
Annual Improvement Rates of East Pacific Forecasts



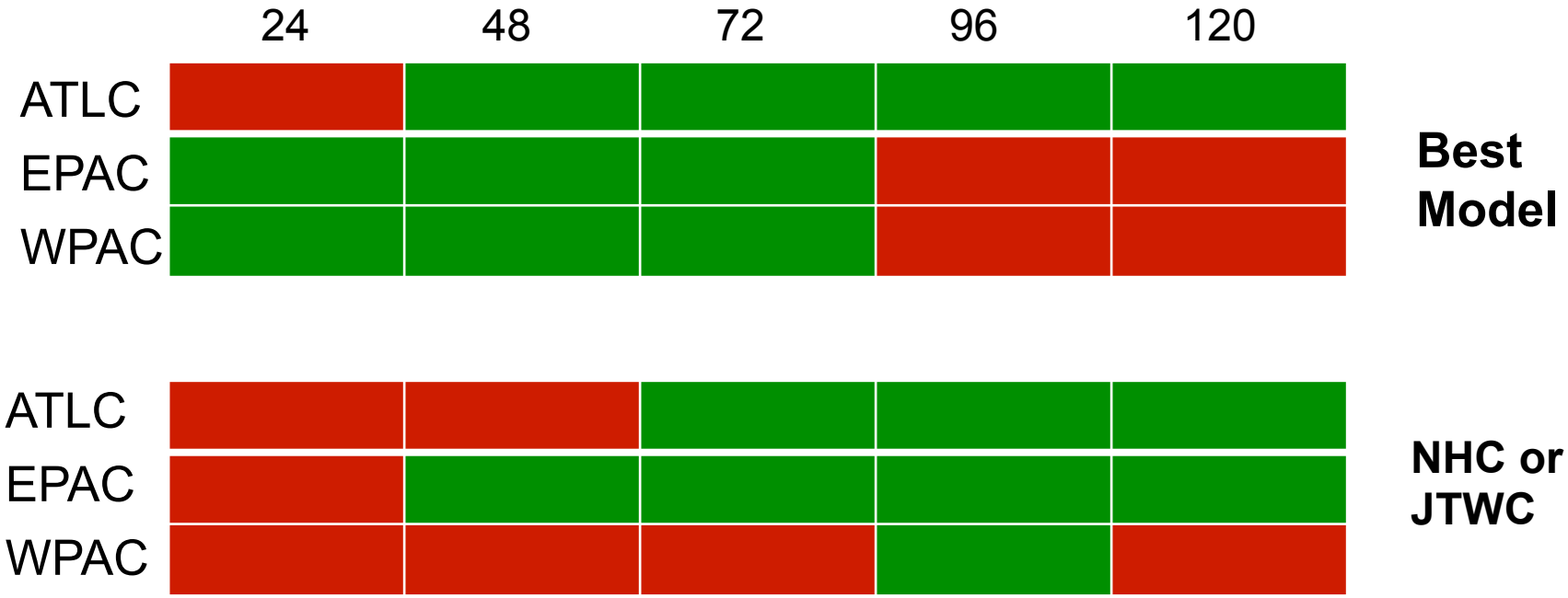
48 h West Pacific Intensity Model Errors



Annual Improvement Rates of West Pacific Forecasts



Summary of Times With Significant Intensity Forecast Improvements (Green)

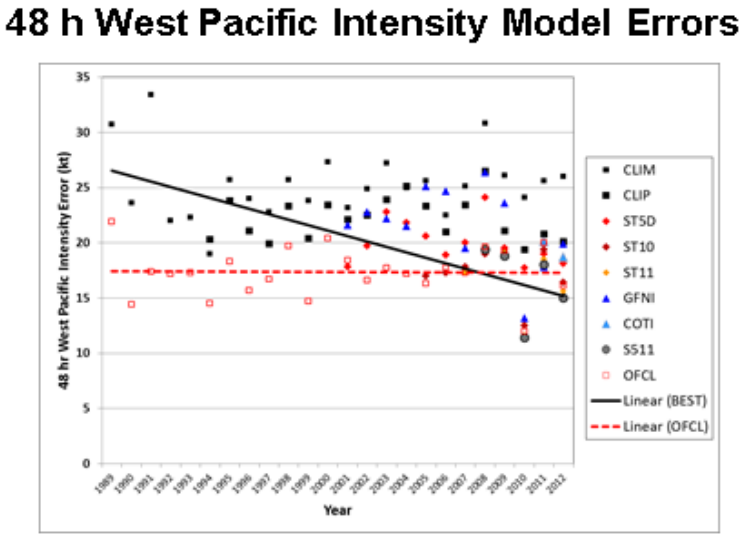


A Few Questions

1. Why have NHC and JTWC intensity forecasts generally improved slower than the guidance?
2. What are the reasons for the intensity guidance improvements?
3. What does this mean for HFIP?

Q1: Different Rates of Guidance versus OFCL Improvement

- Early part of the time series, subjective forecasts easily beat all guidance
  - Reduces slope of OFCL compared to Best Model
- Cross over point in past decade, guidance now driving OFCL forecast improvements



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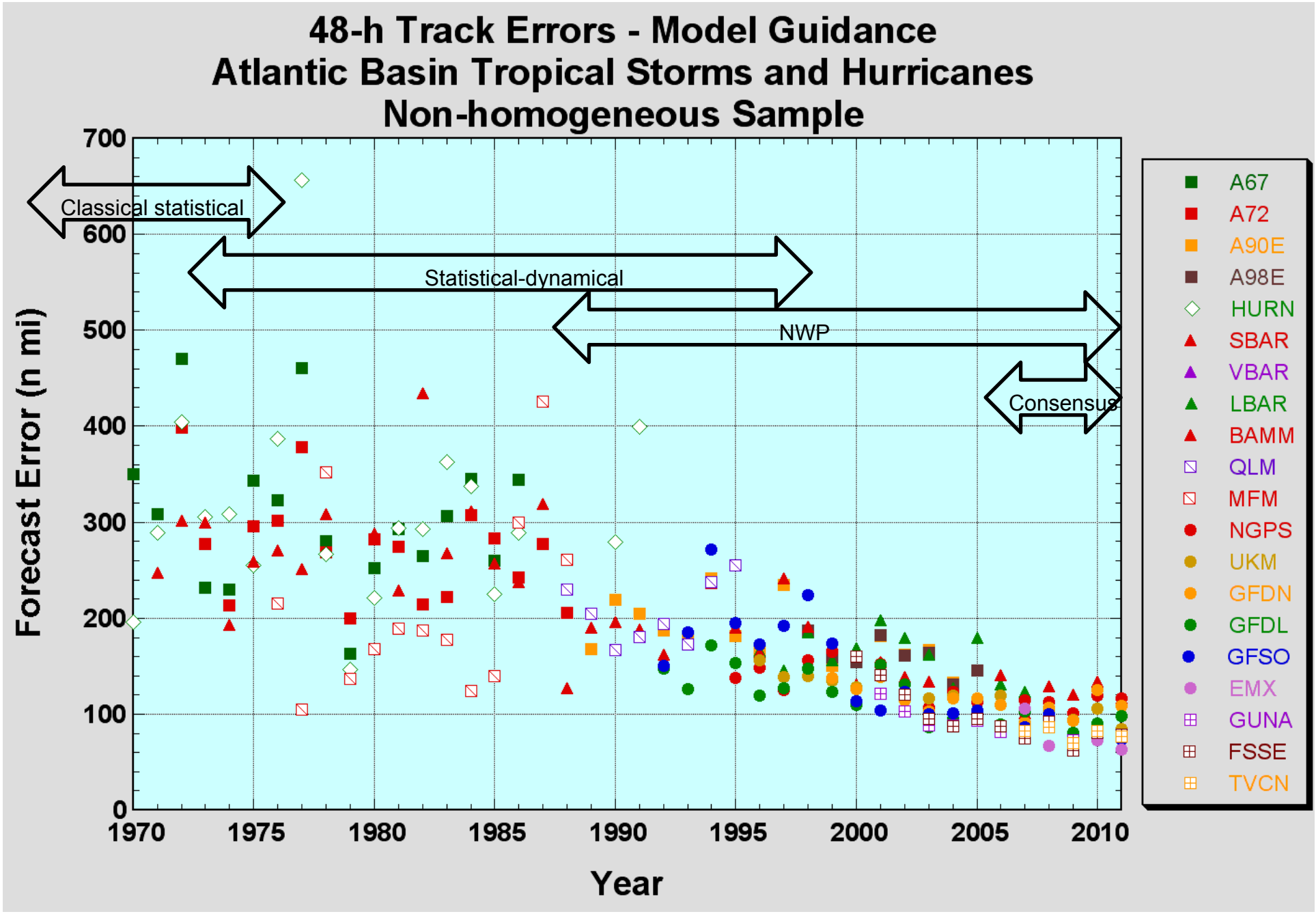
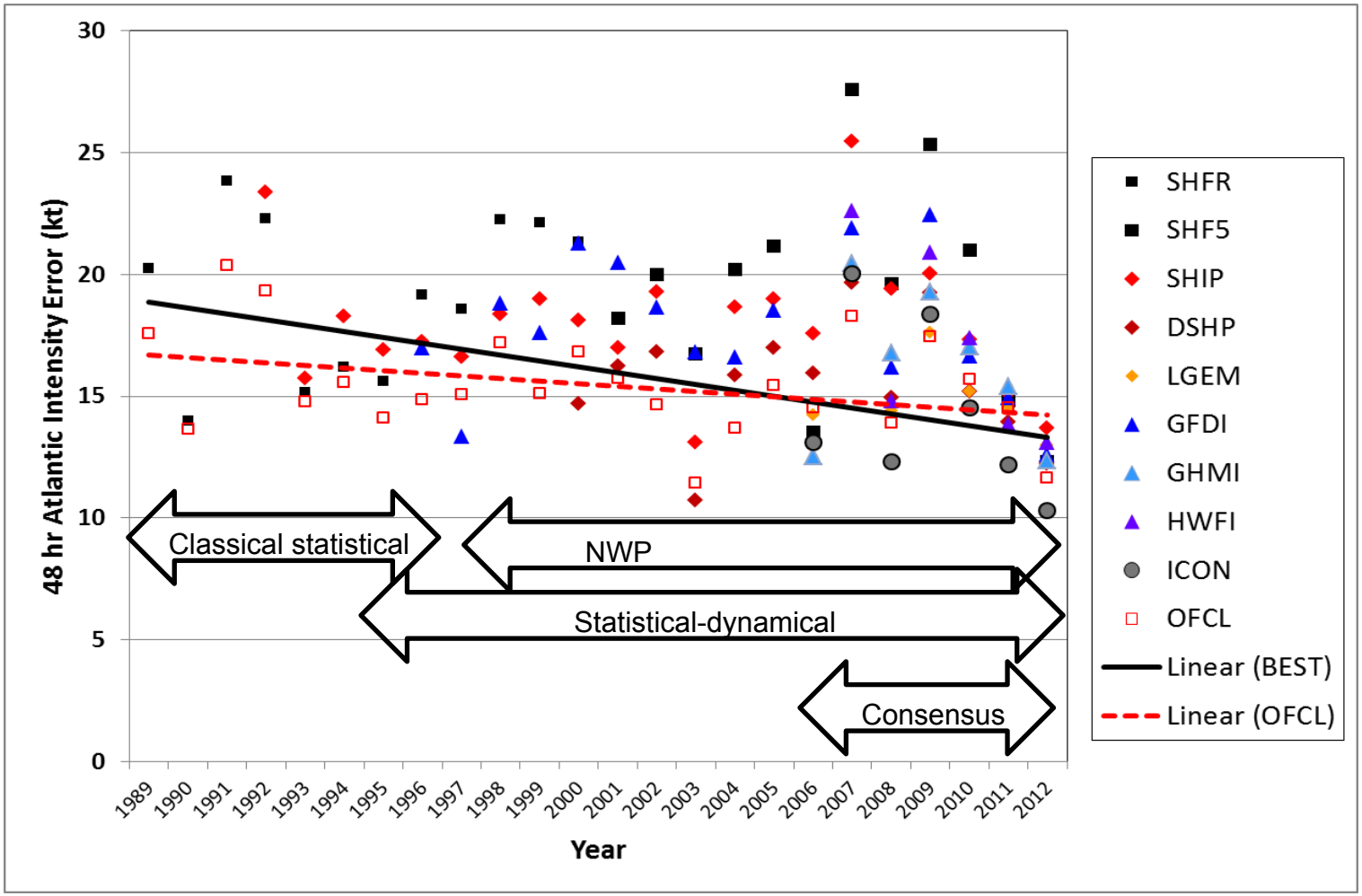
Q2: Why Has Intensity Guidance Improved?

- Improved individual models
  - Transitions from classical statistical to statistical-dynamical to dynamical models
- Implementation of consensus methods since 2006
- Better track forecasts lead to better intensity forecasts



Adapted from www.nhc.noaa.gov

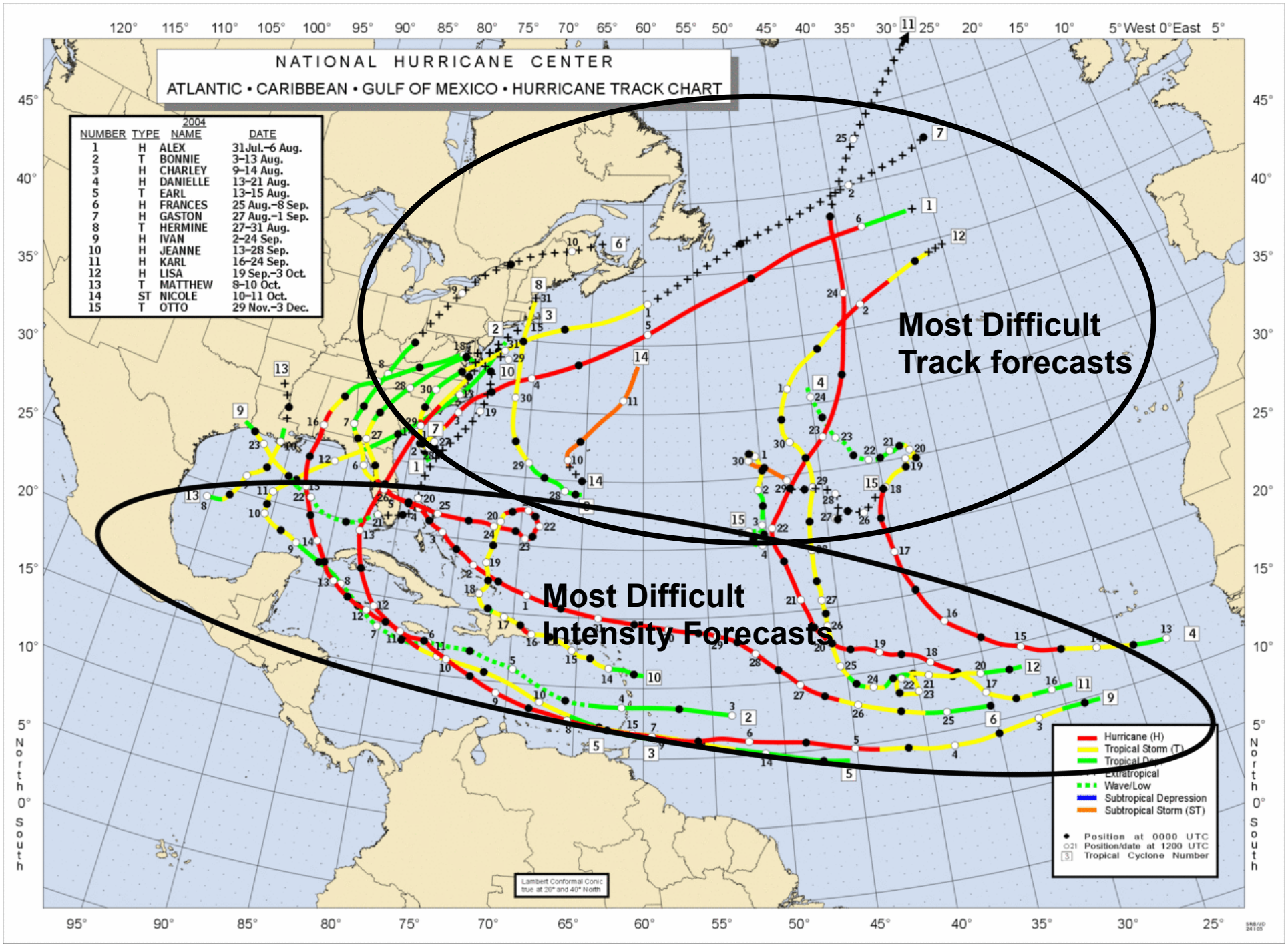
Atlantic Intensity Guidance Errors



From DeMaria et al 2013, BAMS manuscript

Methods to Evaluate the Track Error Influence on Intensity Error

- The wrong way
  - Take a large sample of forecasts and correlate track and intensity errors
    - Different geographic regions for track and intensity forecast difficulty
- A better way
  - Take a fixed sample of cases, systematically reduce track error and re-run intensity forecasts
  - Hard to do with dynamical models, easy with statistical models

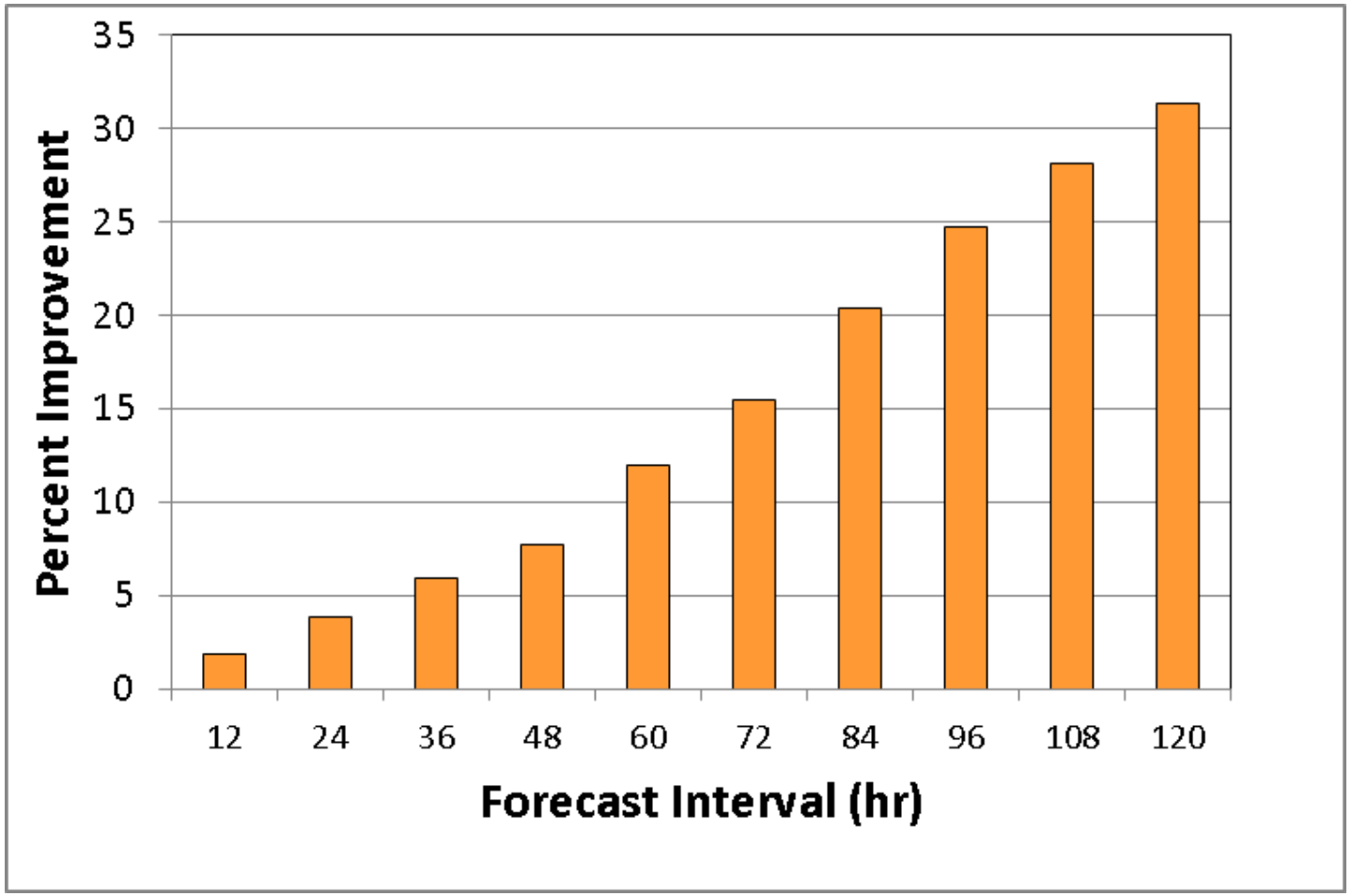

NATIONAL HURRICANE CENTER
ATLANTIC • CARIBBEAN • GULF OF MEXICO • HURRICANE TRACK CHART
2004
NUMBER TYPE NAME DATE
1 H ALEX 31Jul.–6 Aug.
2 T BONNIE 3–13 Aug.
3 H CHARLEY 9–14 Aug.
4 H DANIELLE 13–21 Aug.
5 T EARL 13–15 Aug.
6 H FRANCES 25 Aug.–8 Sep.
7 H GASTON 27 Aug.–1 Sep.
8 T HERMINE 27–31 Aug.
9 H IVAN 2–24 Sep.
10 H JEANNE 13–28 Sep.
11 H KARL 16–24 Sep.
12 H LISA 19 Sep.–3 Oct.
13 T MATTHEW 8–10 Oct.
14 ST NICOLE 10–11 Oct.
15 T OTTO 29 Nov.–3 Dec.
Most Difficult Track forecasts
Most Difficult Intensity Forecasts
Hurricane (H)
Tropical Storm (T)
Tropical Depression
Extratropical
Wave/Low
Subtropical Depression
Subtropical Storm (ST)
Position at 0000 UTC
Position/date at 1200 UTC
Tropical Cyclone Number
Lambert Conformal Conic
true at 20° and 40° North

Use of LGEM Model to Estimate Track Error Influence on Intensity Error

- Run LGEM model using operational input
  - NHC official track, GFS forecast fields, real-time GOES and ocean data
- Replace NHC Official track forecasts with final best track positions, keep everything else the same
- 2002-2009 Atlantic sample
  - 2400 cases

From 2010 AMS Tropical Conference

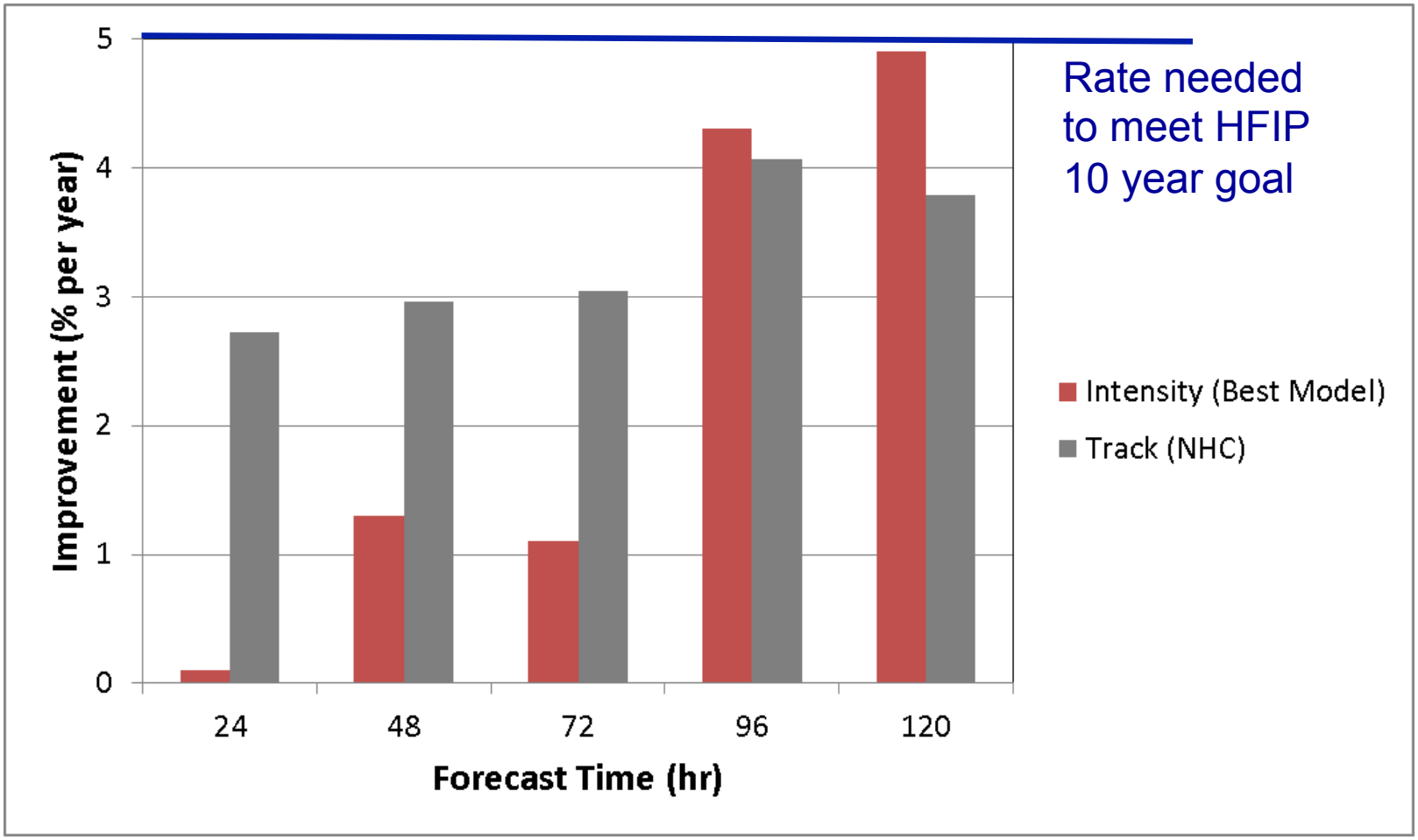
LGEM Improvements from Eliminating Track Errors



Q3: What Does This Mean for HFIP?

- Intensity forecast guidance improvements are not impossible
- Some intensity improvement comes for free if tracks continue to improve
- Need to continue improving individual models
- Utilize ensembles and consensus methods
- Considerable acceleration of improvement rates are needed, especially in the short term

1989-2012 Atlantic Intensity and Track Guidance Improvement Rates



Summary

- Focus on short-term NHC and JTWC intensity error trends led to overly-pessimistic view of improvements
- Model and official intensity forecasts have shown statistically significant improvements since 1989
  - Longer range forecasts improvement rate generally faster
  - Guidance has improved faster than official forecasts
- Intensity guidance improvement rate ~1/3 of track improvements for short range, comparable in longer range
- Intensity guidance improvements due to better track forecasts, consensus techniques that combine dynamical and statistical-dynamical models
- HFIP is on right path, but acceleration of improvement rate is needed, especially for short range