Are Atlantic basin tropical cyclone intensity forecasts improving?

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HFIP call

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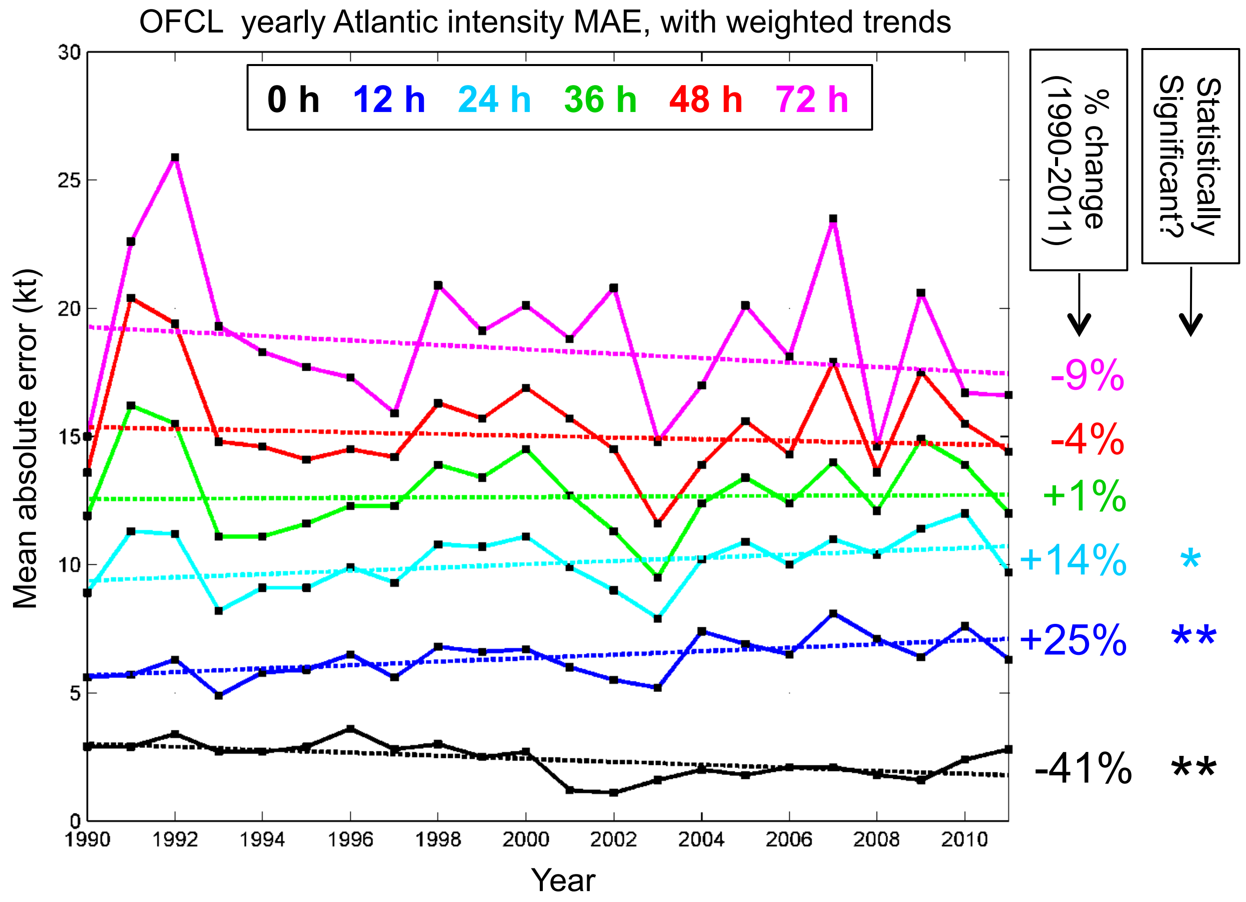
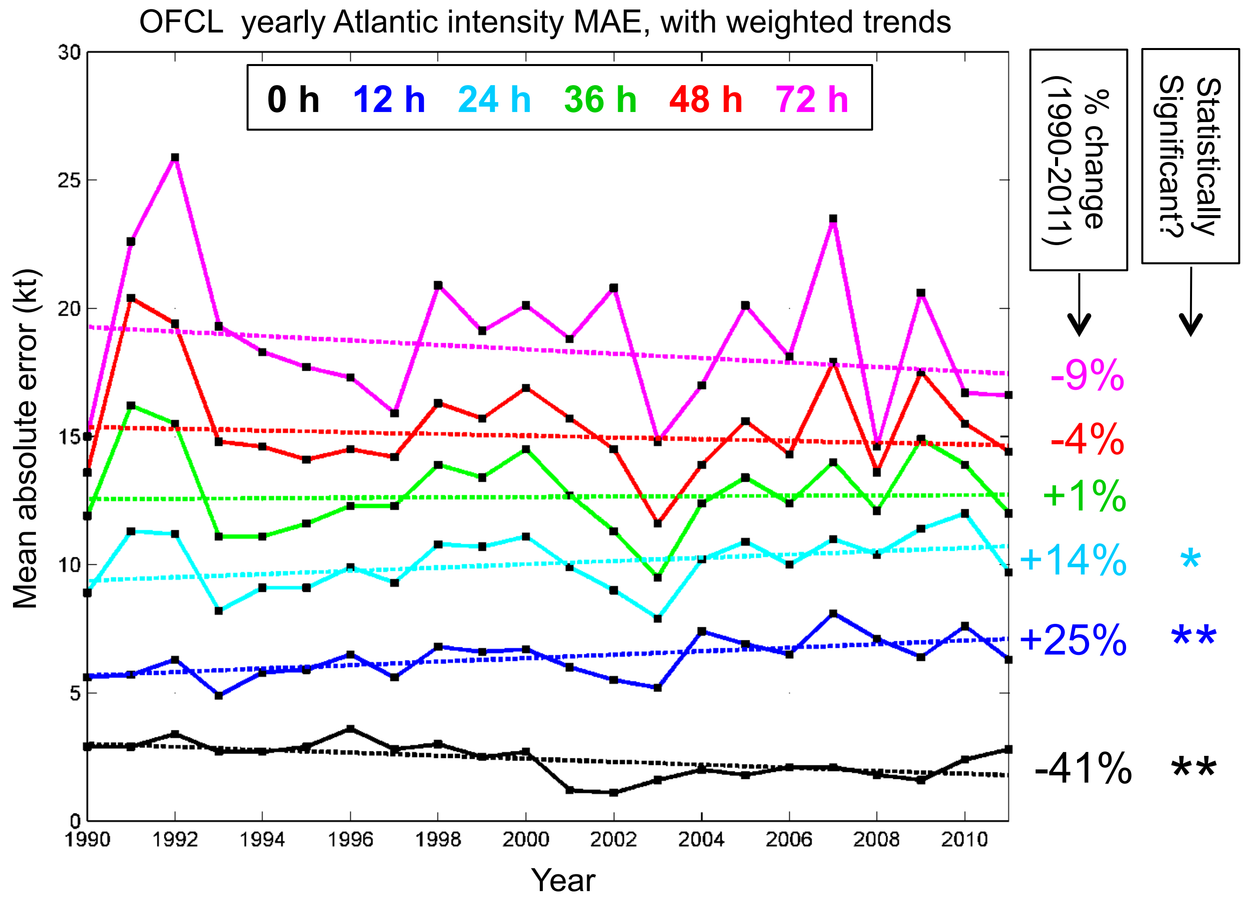


Introduction

In order to understand the OFCL intensity MAE trends, it is necessary to consider how **both** the statistics of the forecasts and the statistics of the best track analyses have changed over the years.



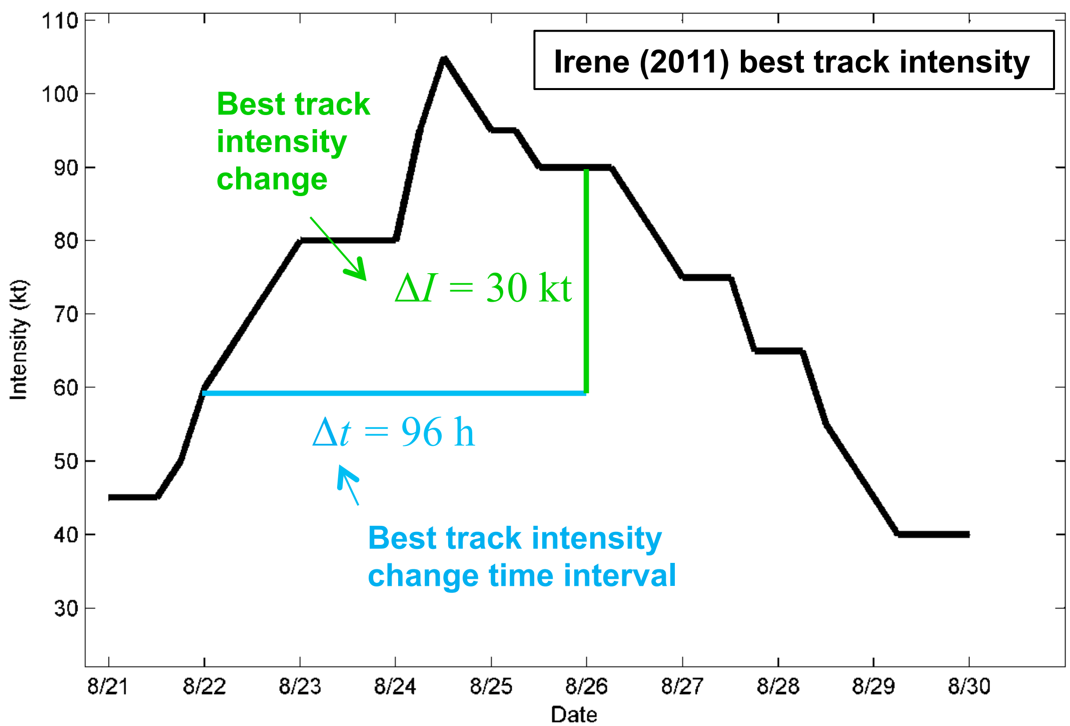
Objective

(1) Investigate best track intensities over the 1990-2011 period in order to discern if significant changes to the statistics of the verifying analyses have taken place

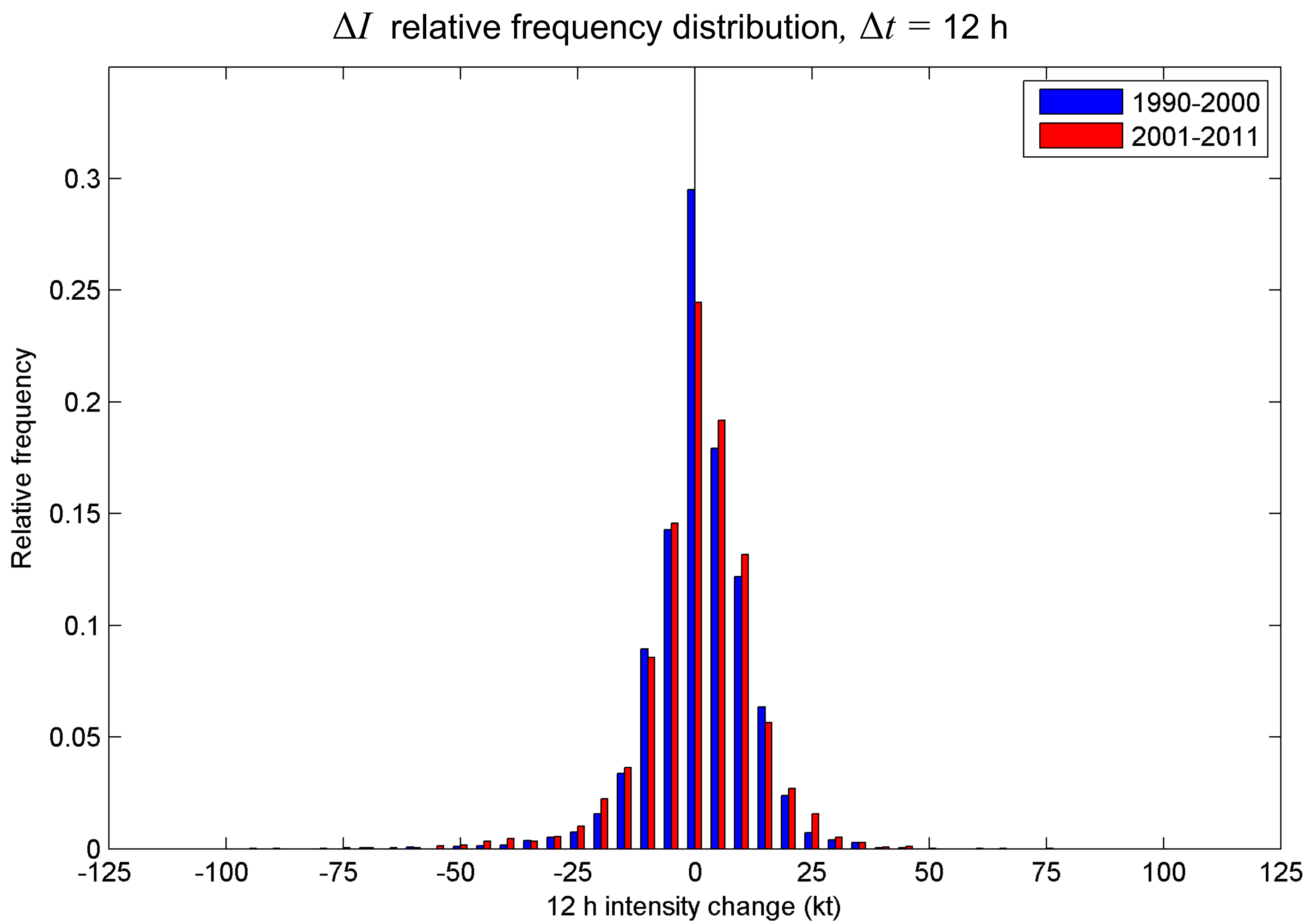
(2) Evaluate the implications of the evolution of the best track intensity statistics over the years for the interpretation of the OFCL intensity MAE trends

<u>Data</u>: ATCF a-decks and b-decks

<u>Intensity change:</u>



Best track intensity change:
1990-2000 vs. 2001-2011



- *Lower* relative frequency of *small-magnitude* intensity changes for 2001-2011 than for 1990-2000
- *Higher* relative frequency of *large-magnitude* intensity changes for 2001-2011 than for 1990-2000

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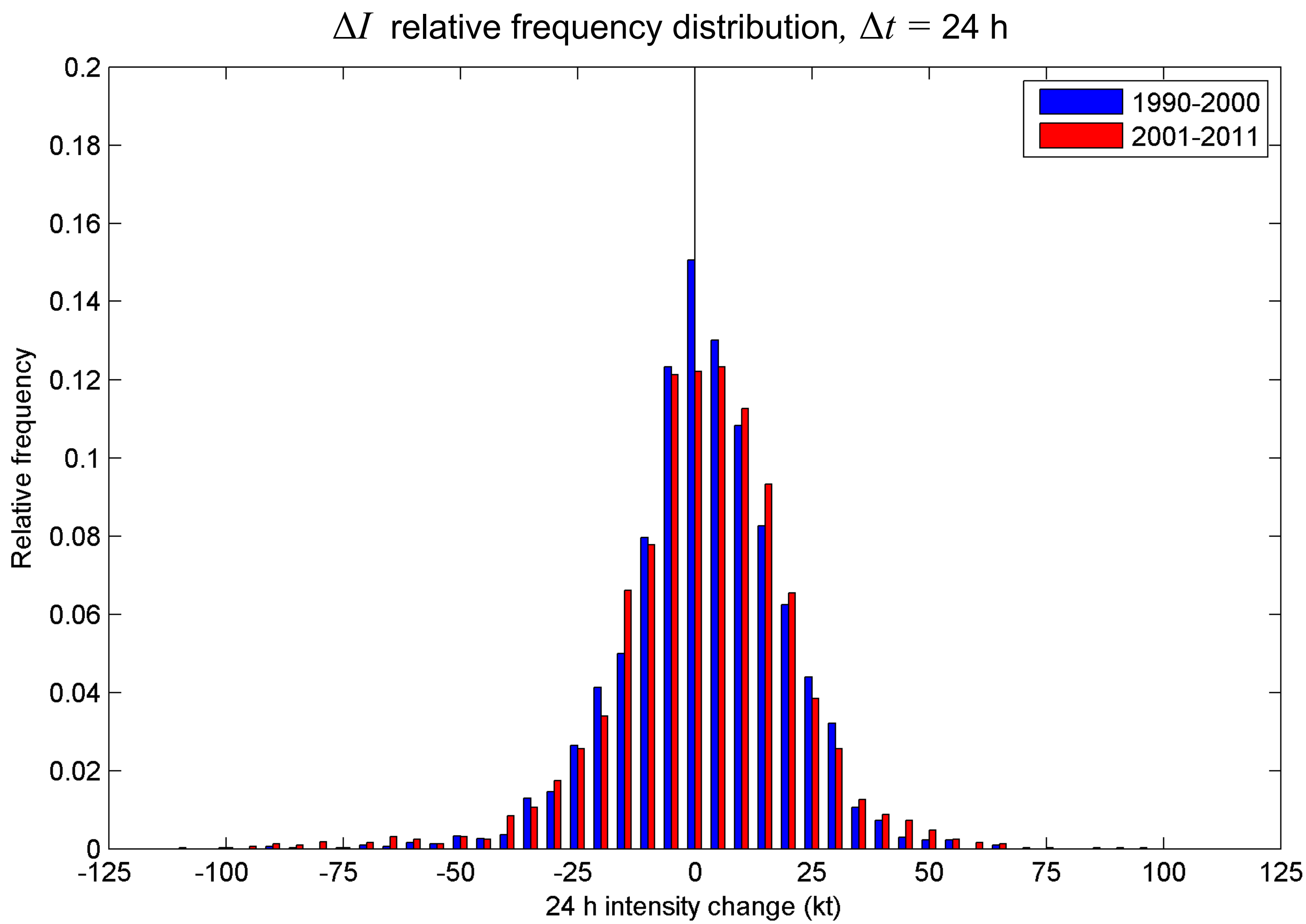
1990-2000 vs. 2001-2011



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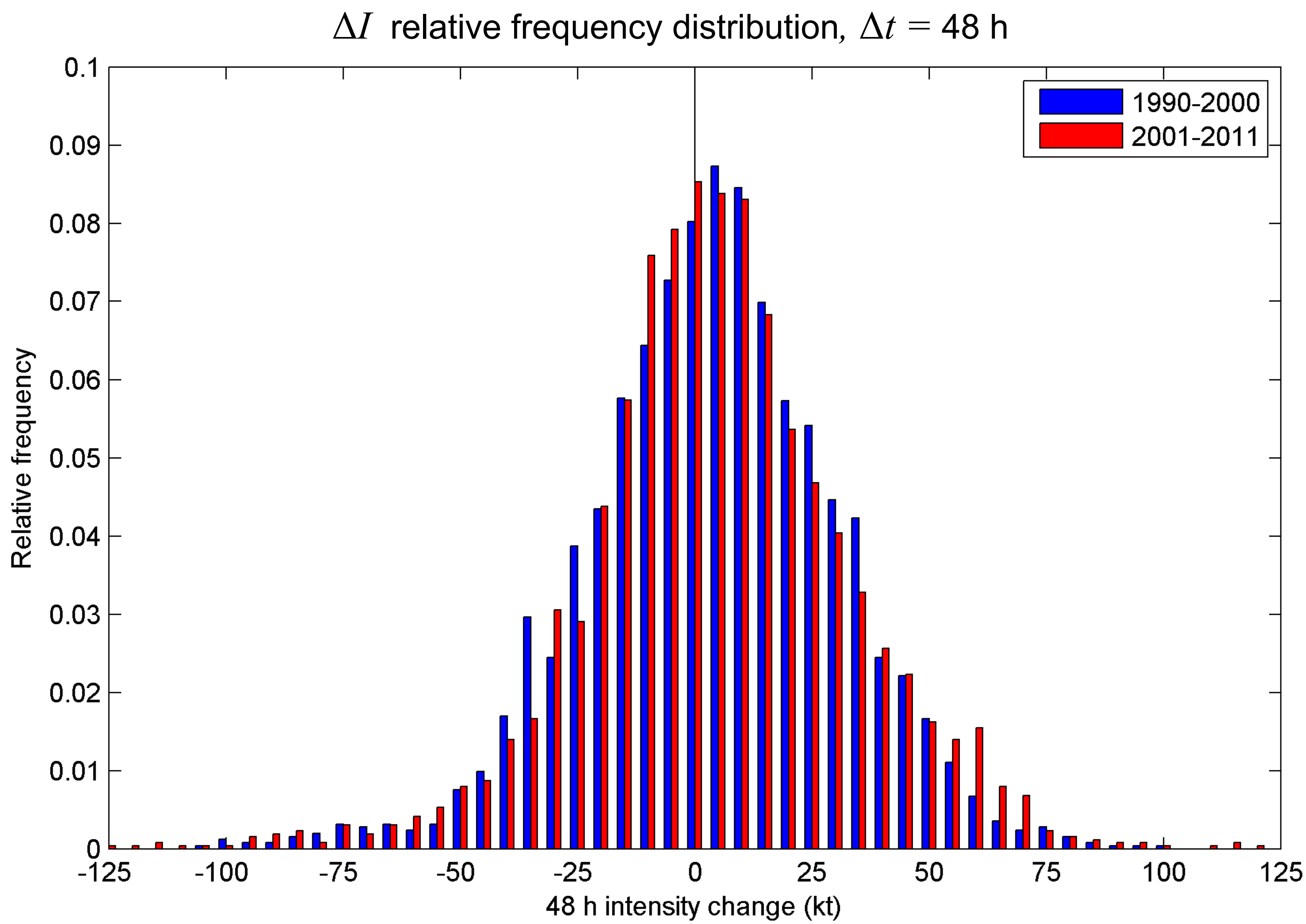

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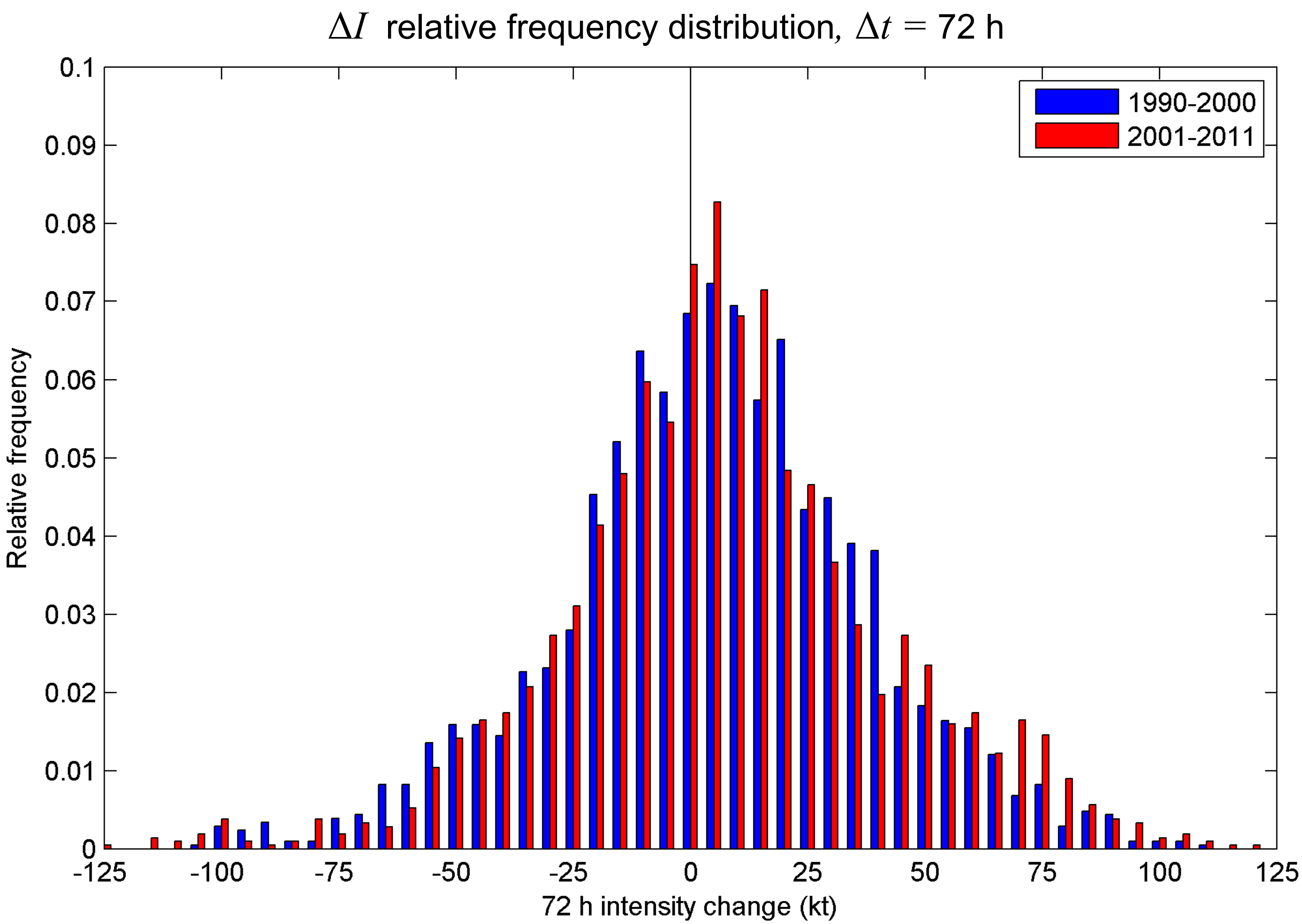

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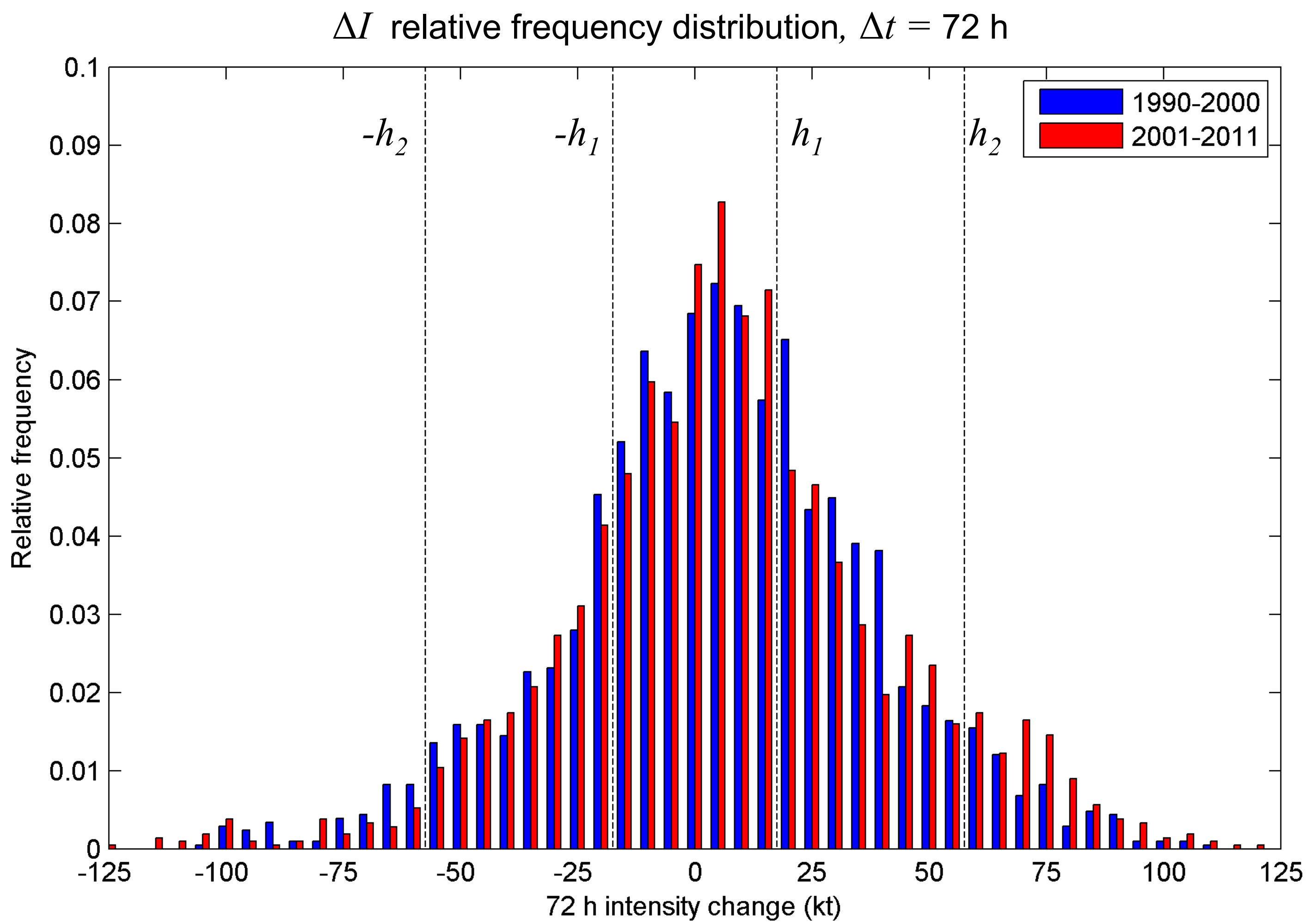
Best track intensity change: 1990-2000 vs. 2001-2011



RF_S = Relative frequency of small-magnitude intensity change, $|\Delta I| \leq h_1$
RF_L = Relative frequency of large-magnitude intensity change, $|\Delta I| \geq h_2$

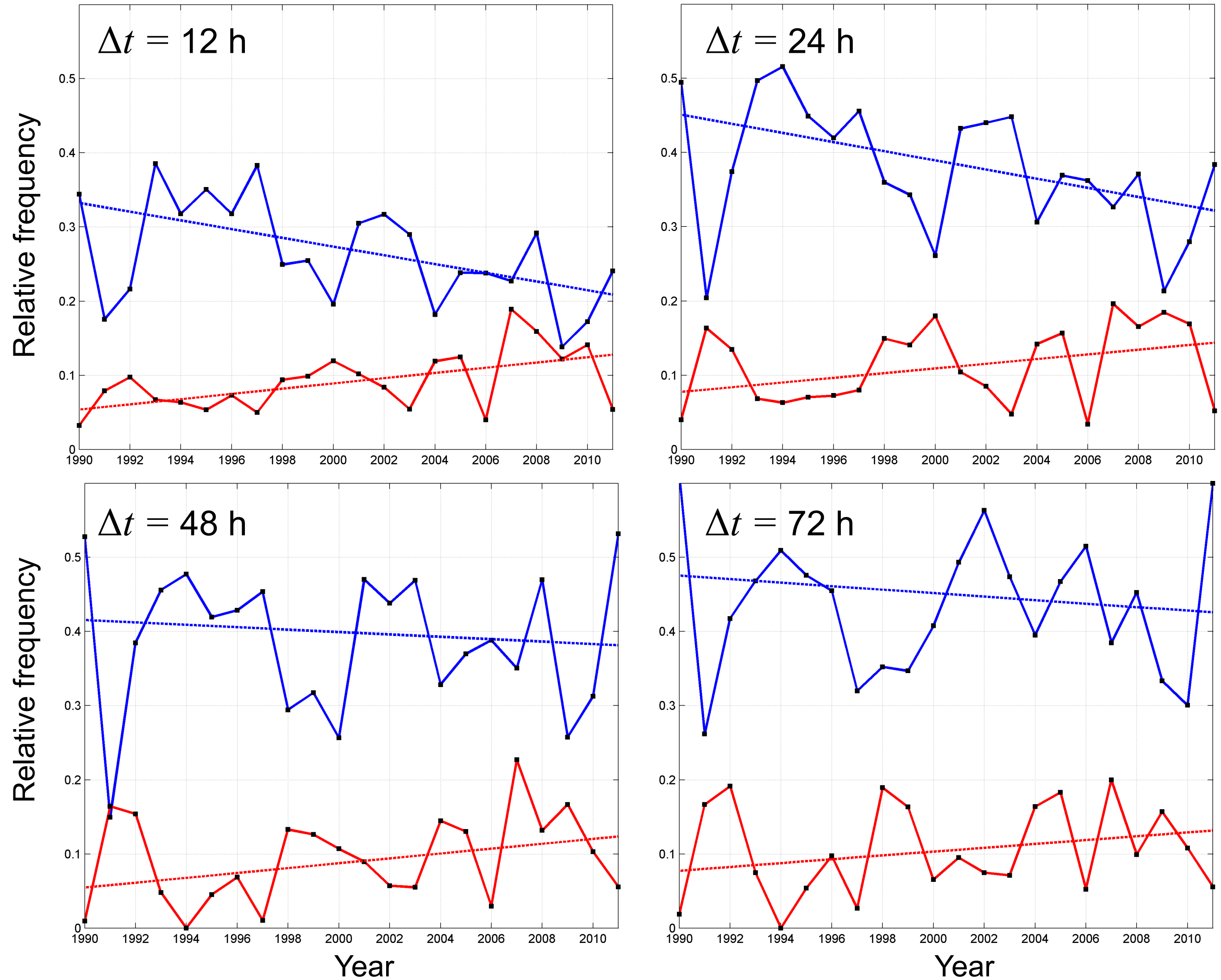
Best track intensity change: Trends in yearly samples

Relative frequency of small-magnitude intensity change (RF_S)

Relative frequency of large-magnitude intensity change (RF_L)

% change (1990-2011)

Δt	RF_S	RF_L
6 h	-23**	90*
12 h	-37**	138*
24 h	-29**	86*
36 h	-17	117*
48 h	-8	126*
72 h	-10	70
96 h	-18	78
120 h	-10	93

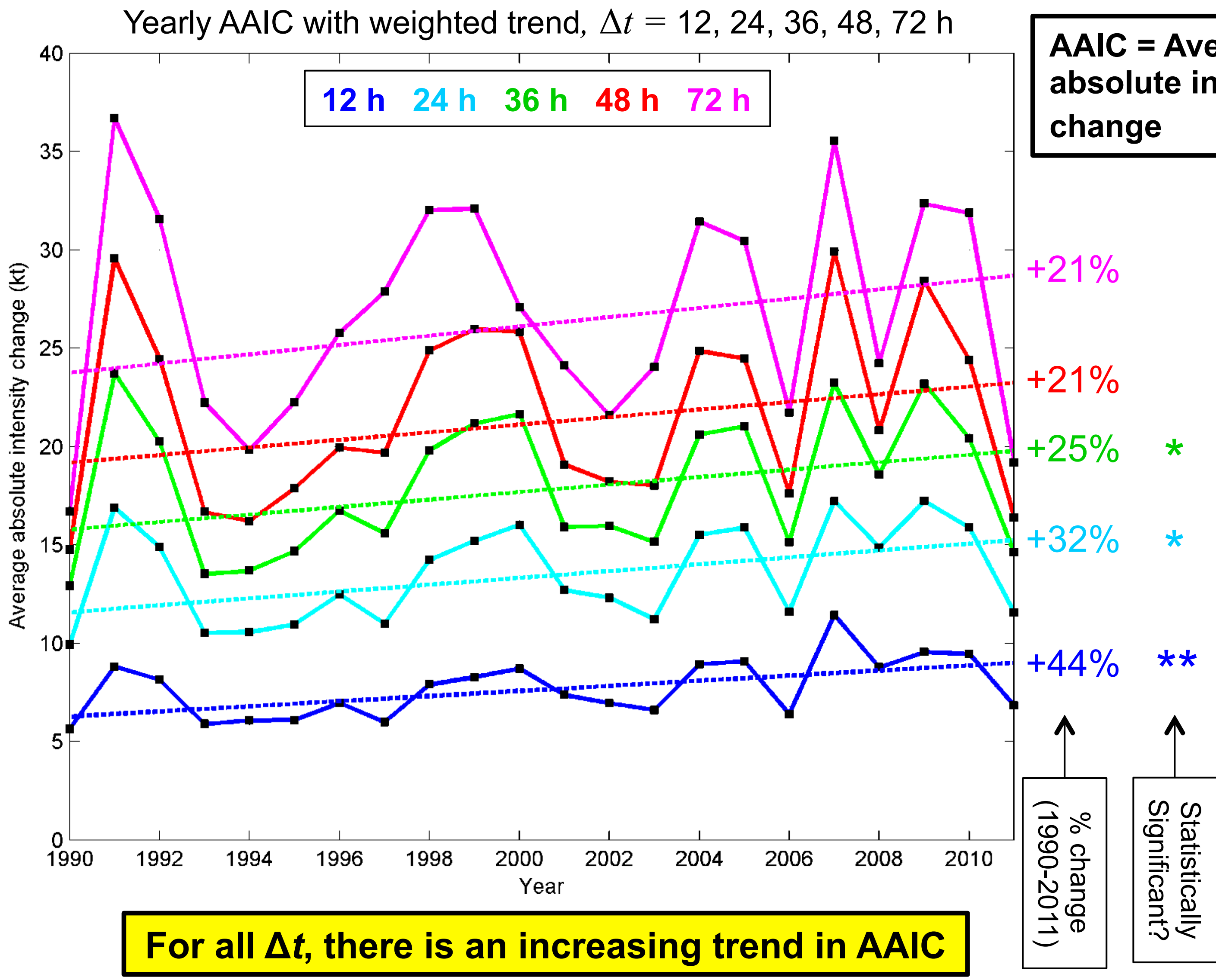


For all Δ*t*, the trend indicates decreasing relative frequency of small-magnitude intensity changes and increasing relative frequency of large-magnitude intensity changes

Best track intensity change: Trends in yearly samples

% change (1990-2011)

Δt	AAIC
6 h	46**
12 h	44**
24 h	32*
36 h	25*
48 h	21
72 h	21
96 h	23
120 h	19

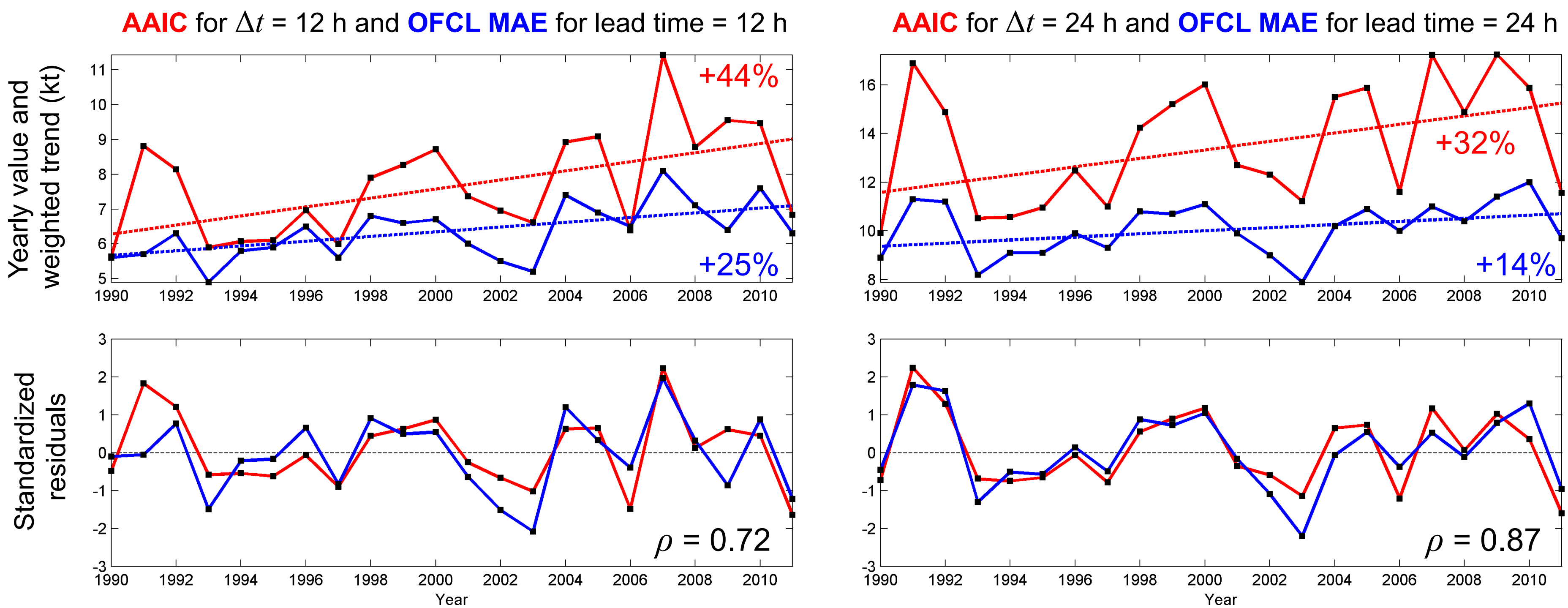


AAIC = Average absolute intensity change

For all Δ*t*, there is an increasing trend in AAIC

Best track intensity change: Relationship with OFCL intensity MAE

- AAIC can be interpreted as a measure of forecast difficulty
- AAIC = MAE of persistence intensity forecasts
- How does AAIC compare to OFCL intensity MAE?

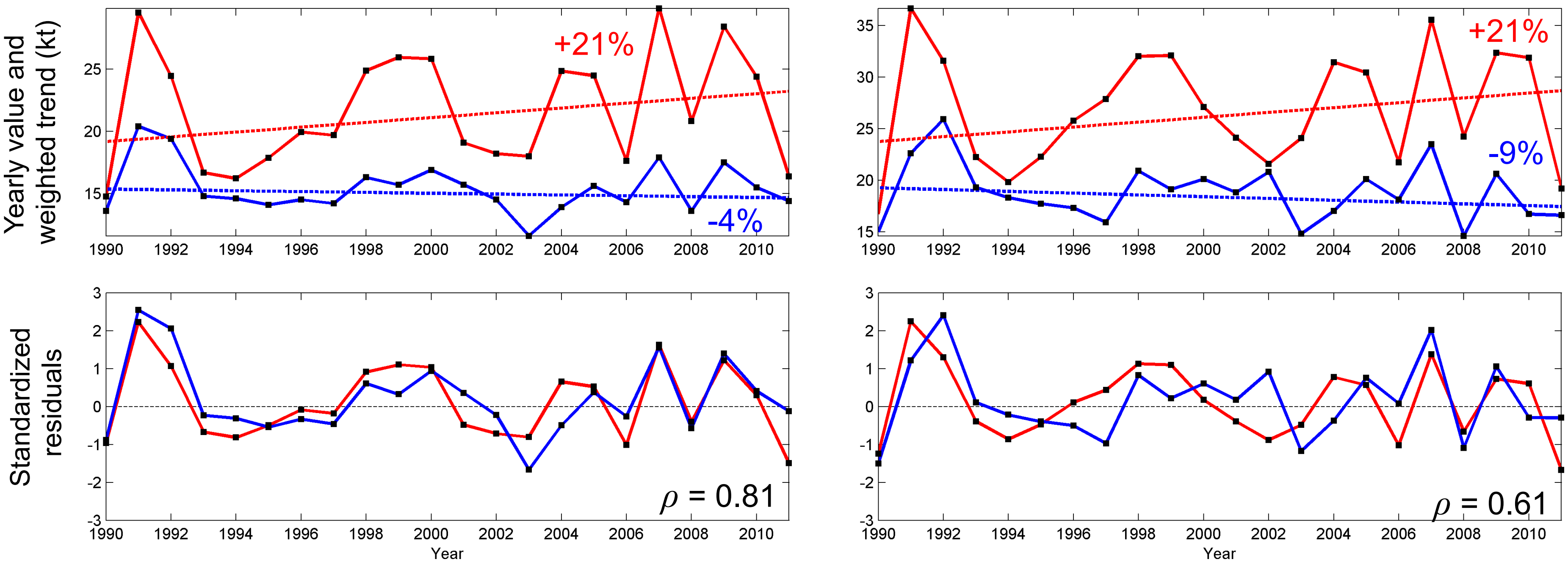


Best track intensity change:
Relationship with OFCL intensity MAE

- AAIC can be interpreted as a measure of forecast difficulty
- AAIC = MAE of persistence intensity forecasts
- How does AAIC compare to OFCL intensity MAE?

AAIC for Δt = 48 h and **OFCL MAE** for lead time = 48 h

AAIC for Δt = 72 h and **OFCL MAE** for lead time = 72 h

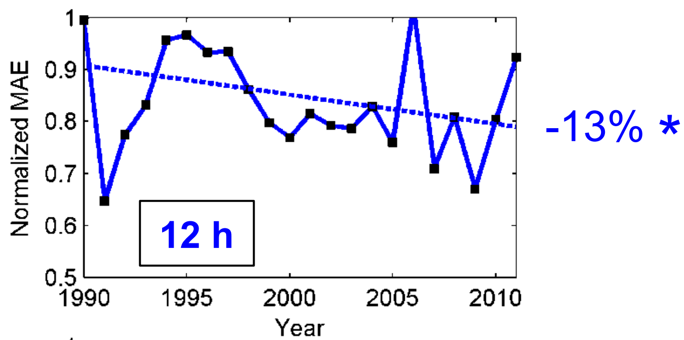


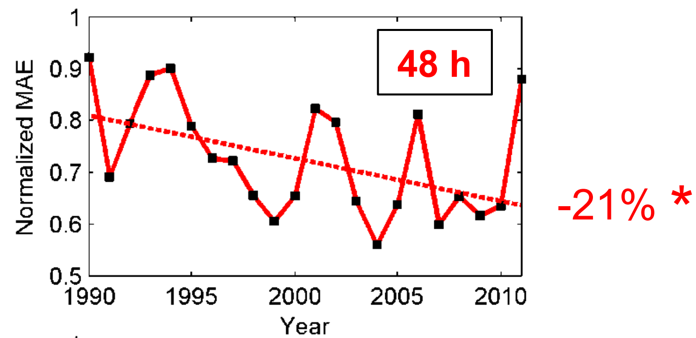
On the decadal time scale, AAIC (forecast difficulty) and OFCL MAE have different trends. The slope of AAIC trend > slope of OFCL MAE trend.

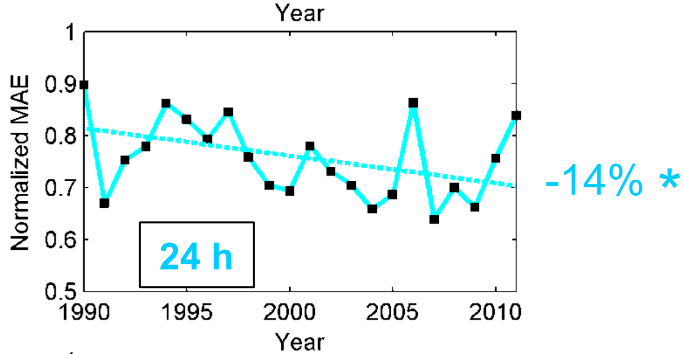
Year-to-year departures from the trend lines are highly correlated, suggesting the AAIC departure controls the OFCL MAE departure.

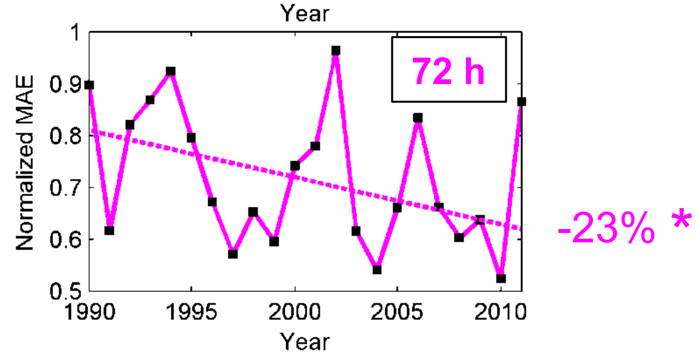
Best track intensity change: Relationship with OFCL intensity MAE

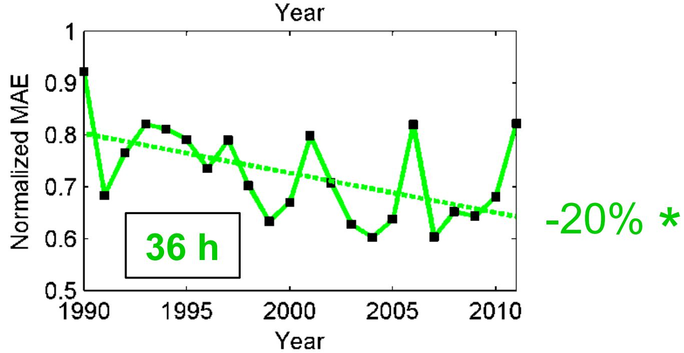
- **Normalized MAE = OFCL MAE / AAIC**
- **Accounts for forecast difficulty, as measured by AAIC**











For all lead times, there is a statistically significant decreasing trend in normalized MAE

Summary and conclusions

Analysis of Atlantic best track intensities during the 1990-2011 period shows:

- Decreasing trend in relative frequency of small-magnitude intensity changes (RF_S)
- Increasing trend in relative frequency of large-magnitude intensity changes (RF_L)
- Increasing trend in average absolute intensity change (AAIC)

Trends in OFCL intensity MAE should be interpreted in context of the AAIC, to account for evolution in the statistics of the best track intensities on the decadal time scale

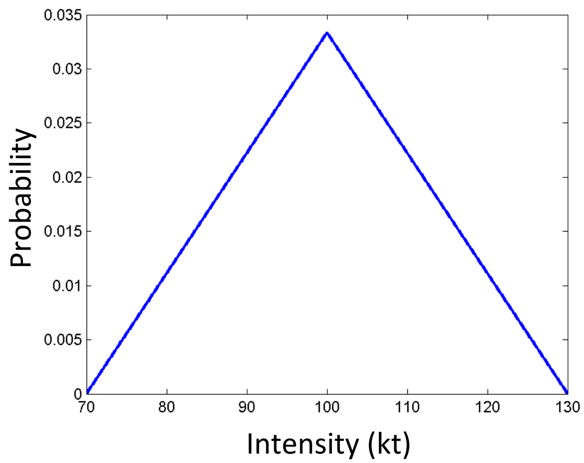
- AAIC can be interpreted as a measure of forecast difficulty
- After normalizing by AAIC, OFCL intensity MAE shows statistically significant decreasing trends at 12, 24, 36, 48, and 72 h

Question for future research: Why are there trends in AAIC, RF_S, and RF_L?

Incorporating best-track uncertainty in intensity forecast verification

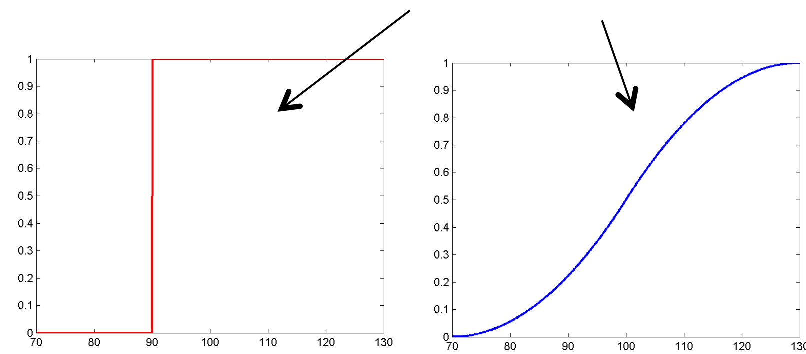
(1) Observation probability distribution

Example probability distribution for best track value of 100 kt and observation uncertainty of 10 kt.



(2) Probabilistic verification: CRPS

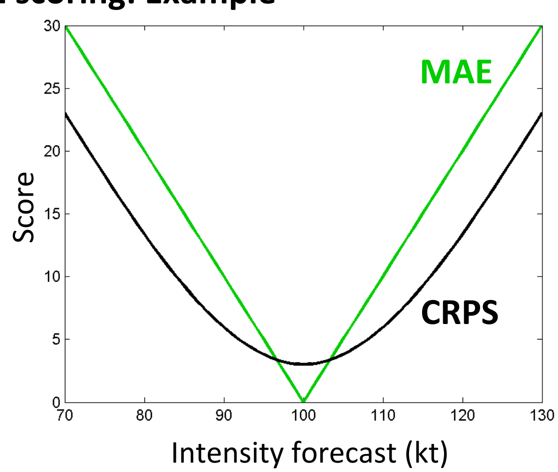
$$CRPS = \int_{I} (F(I) - O(I))^2 \, dI$$



(3) CRPS vs MAE scoring: Example

Best track = 100 kt

Observation Uncertainty = 10 kt



(4) Summary

- CRPS incorporates observation uncertainty in forecast verification
- Different observation probability distributions could be used for different cases
- Broadly speaking, CRPS gives the forecast ‘credit’ for being with the range of the observation uncertainty.
- CRPS = MAE for deterministic observation