Continued Development of Tropical Cyclone Wind Probability Products

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Outline

- Training Activities
- Verification Activities
- Results/insights from examination of hurricane warning break points

Training Activities

- Mark DeMaria coordinated with Rick Knabb to provide feedback on a TPC/NHC training session.
- Several cases rerun for 2004 and 2005
  - For Pablo Santos, Miami WFO for an experimental algorithm that uses the probabilities.
  - Web page with examples and a product description http://rammb.cira.colostate.edu/projects/tc_wind_prob

Experimental Tropical Cyclone Wind Probabilities - Microsoft Internet Explorer

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Experimental Tropical Cyclone Wind Probabilities

2004 Florida Hurricane Landfall Case Studies

and 2005 Katrina and Rita Landfall Case Studies

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Verification: Current Status

- Developed:
  - Input data handling (GRIB, ATCF….)
  - Statistical Methods
    - Scalar measures of skill, accuracy, confidence
    - Conditional measures
  - Methods to assess deterministic forecasts
- Remaining
  - Treatment of the OFCL forecast & wind radii through 5 days.
  - Integrating the pieces.
  - How to Interpret the statistics and optimize use.

Statistical methods: Probability Bias

- Mean Forecast Probabilities (F_i) minus the Mean Observed Frequencies (E_i) = 1 or 0

Determines if the probabilities over/under forecast the outcome.

$$Bias = \frac{\sum_{k=1}^{N} F_k}{\sum_{k=1}^{N} E_k}$$

Statistical Methods: Brier Score

- Mean of square of the Forecast Probabilities (F_i) minus the Observed Frequencies (E_i) = 1 or 0

Measures the Mean Square Errors (Accuracy) associated with a probabilistic forecast

$$BS = \frac{1}{N} \sum_{k=1}^{n} \left(F_k - E_k \right)^2$$

Statistical Methods: Brier Skill Score

- A scalar skill score comparing a given Brier Score with the Brier Score of a reference forecasts (OFCL, CLIPER etc.).

Assess relative accuracy (skill) of a probabilistic forecast with respect to a reference forecast.

$$BSS = 1 - \frac{BS}{BS_{ref}}$$

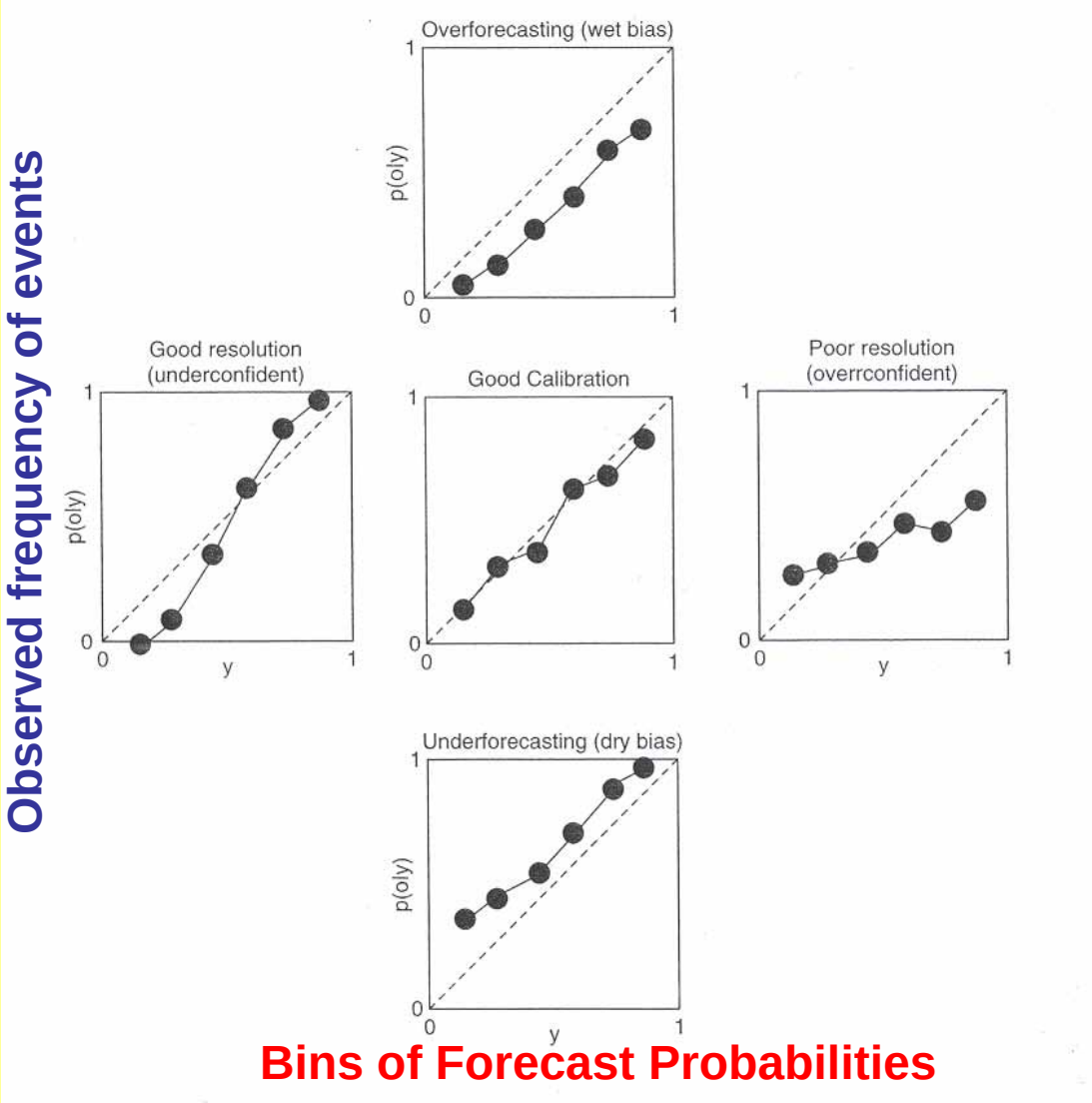
Statistical methods: Discrimination Distance

- Distance between the mean forecast probability (*F*) for all event (*E*) and all non-events (*E*').

Measures the ability of a forecast scheme to discriminate events.

$$d = \left| m_{F|E} - m_{F|E'} \right|$$

Statistical Methods: Conditional Distributions



Statistical Methods: Relative Operating Characteristics

A series of 2x2 contingency tables, which are conditional on a range of forecast probabilities are constructed.

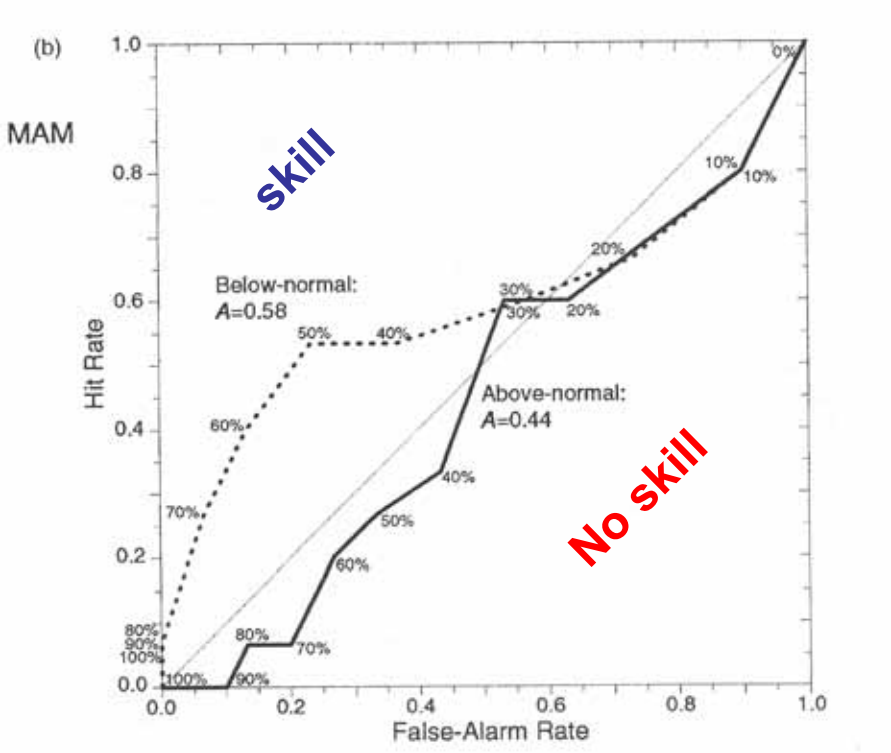
For instance a warning would be issued if the probability exceeded 1,2,3,4,…100 %

	Forecasts (contingent on the forecast probability)		
Observation	**Warning (*W*)**	**No Warning (*W'*)**	**Total**
Event (*E*)	*h*	*m*	*E*
Nonevent (*E'*)	*f*	*c*	*E'*
Total	*w*	*w'*	*N*

The results of the contingency tables can be quantified in terms of hit rate (***hr***) = *h/(h+m)* and false-alarm rate (***far***)=*f/(f+c)*

A plot of far vs. hr can be created and a skill score created from the area under the curve.

Statistical Methods: ROC diagram & Skill Score



ROC Skill Score

$$SS_{ROC} = 2A - 1$$

,where *A* is the area under the curve

Mason and Graham (1999)

Verification Procedure: Test Dataset

- Dataset
  - 5-day cumulative 64-kt wind probabilities were generated for 342 coastal break points (195 official breakpoints + 147 additional points)
  - These were analyzed when warnings were issued for the 14 storms to the right
  - N=128250 points

Storm Name	Year
Alex	2004
Charley	2004
Frances	2004
Gaston	2004
Ivan	2004
Jeanne	2004
Arlene	2005
Cindy	2005
Dennis	2005
Emily	2005
Katrina	2005
Ophelia	2005
Rita	2005
Wilma	2005

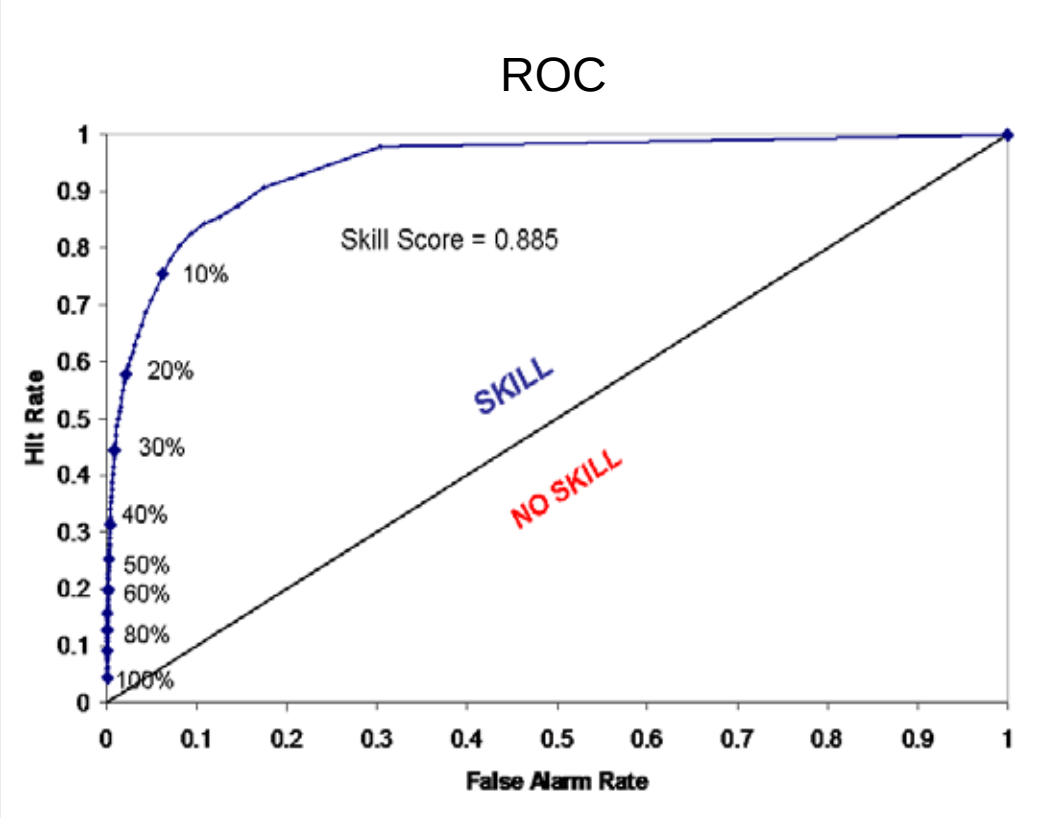
TROPICAL CYCLONE BREAKPOINTS

Verification Procedure: Summary Skill Measures

Bias = 0.893 (under forecasts)
BS = 0.0248
BS_{OFCL} = 0.0346
BS_{zero} = 0.0392

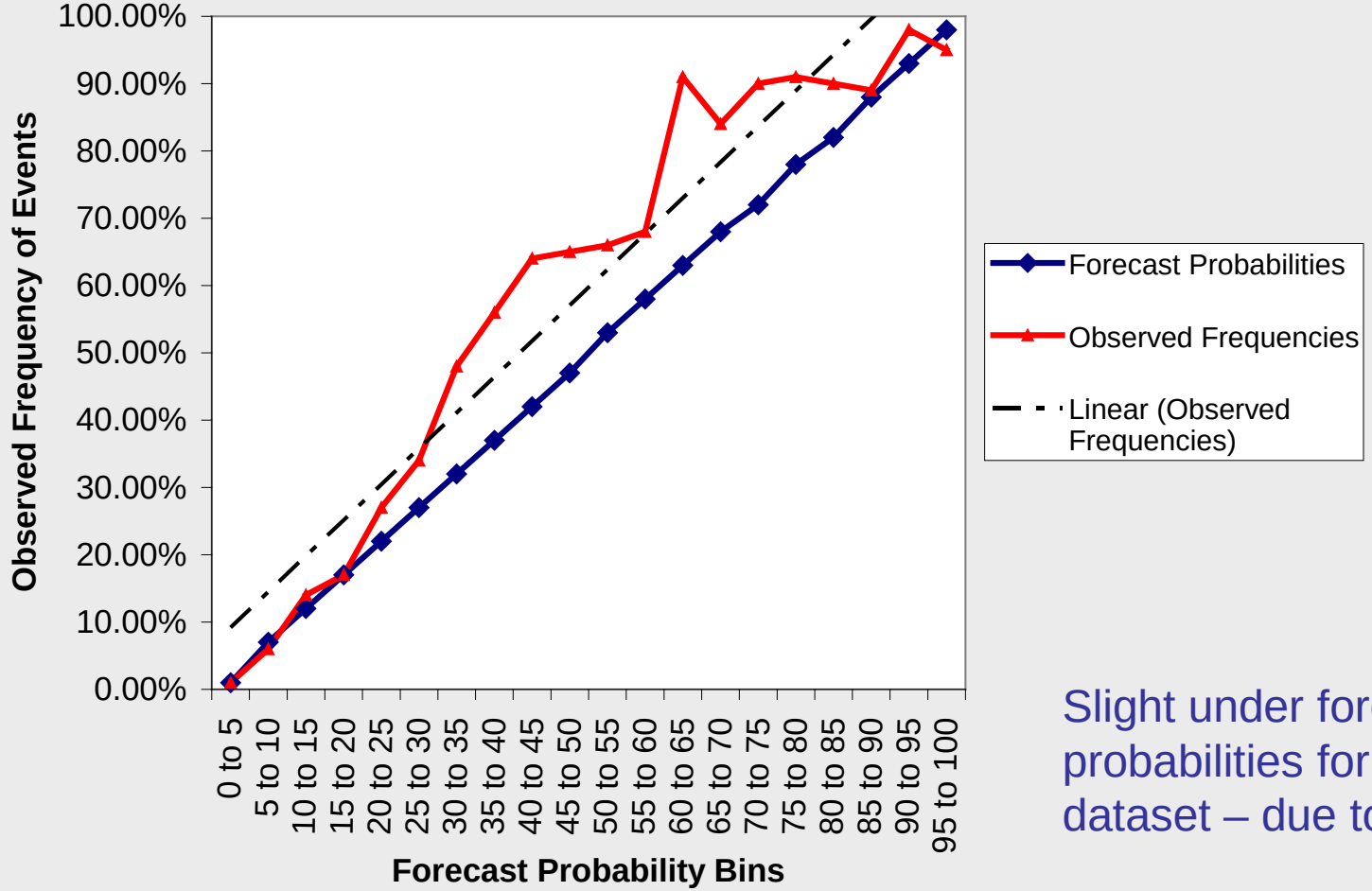
BSS_{OFCL} = 28.30%

BSS_{zero} = 36.75%



Relative Operating Characteristics 5-d Cummulative Probabilities for Landfalling Atlantic TC 2004-2005

Verification Procedure: Conditional Distribution of Break Point Probabilities



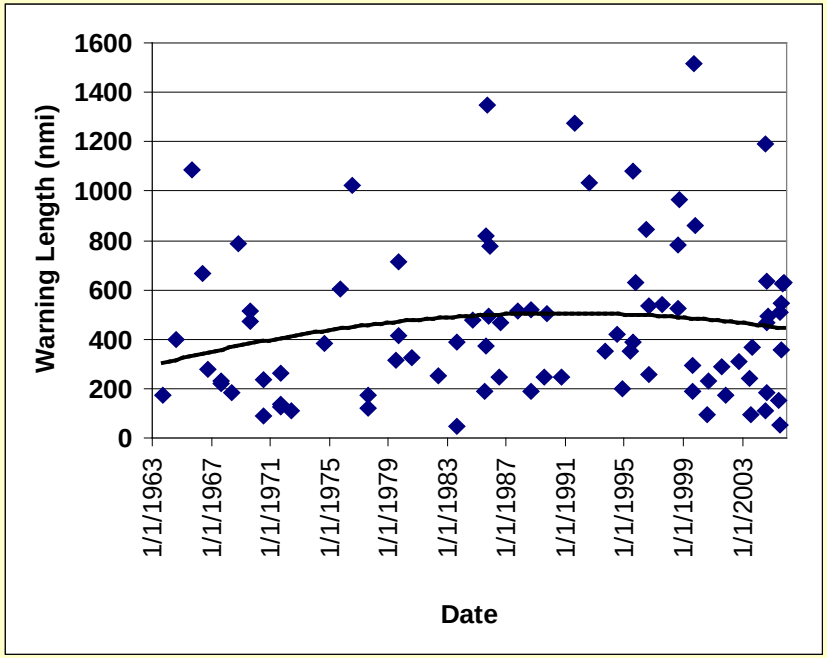
Slight under forecast of probabilities for this dataset – due to Wilma

Verification Procedure: Summary

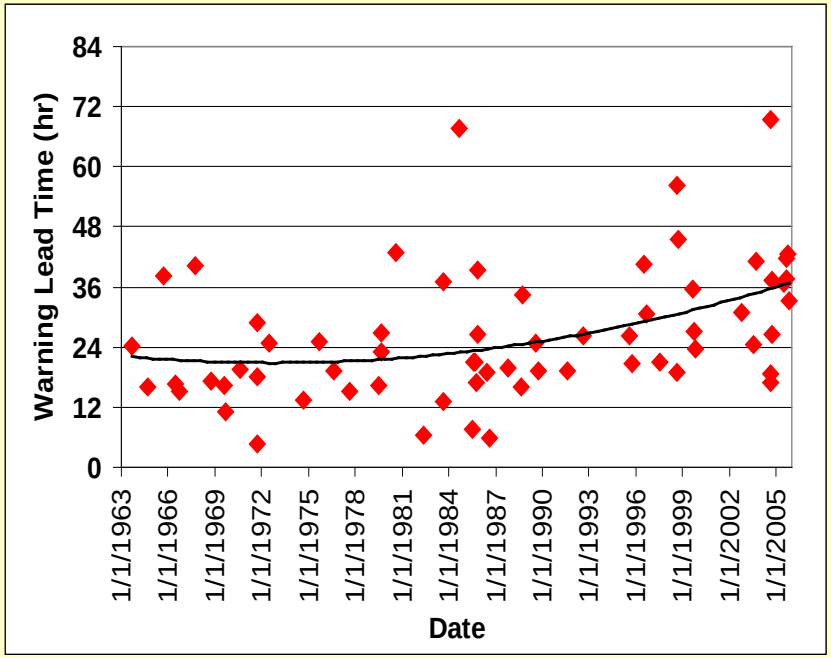
- The probabilities are skillful
  - Brier Skill Score 28% more accurate than the OFCL deterministic forecast
    - Note 50% of the OFCL forecasts verified
  - ROC Skill Score 88%
  - The discrimination distance *d=26%* is large
  - Probabilities slightly under forecast and are well calibrated for this limited dataset

Can the wind speed probabilities be used do decrease the area warned or increase lead time?

Probability Model for NHC Hurricane Warnings



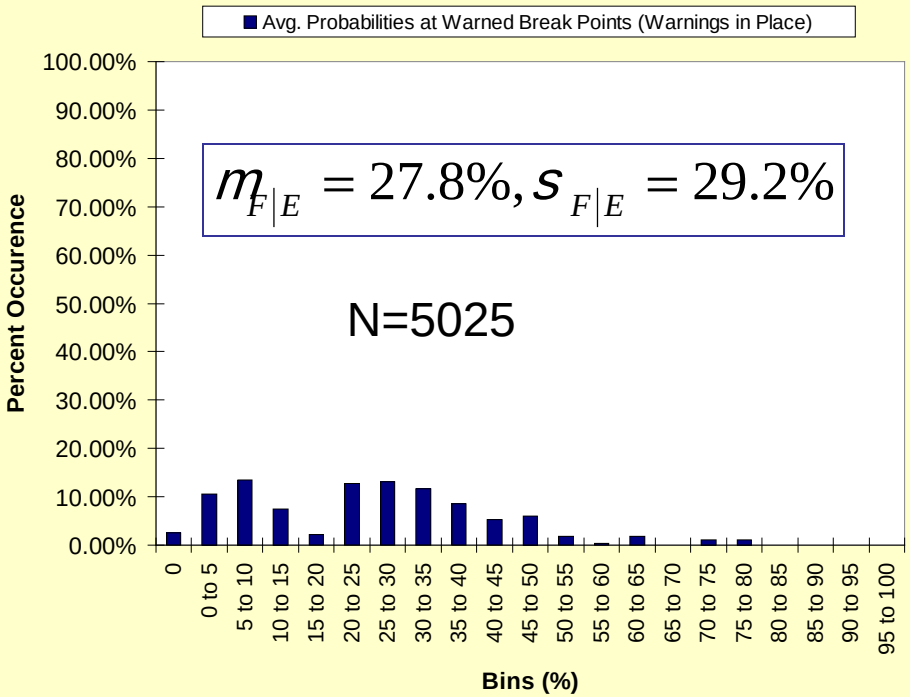
NHC storm total hurricane warning lengths 1963-2005



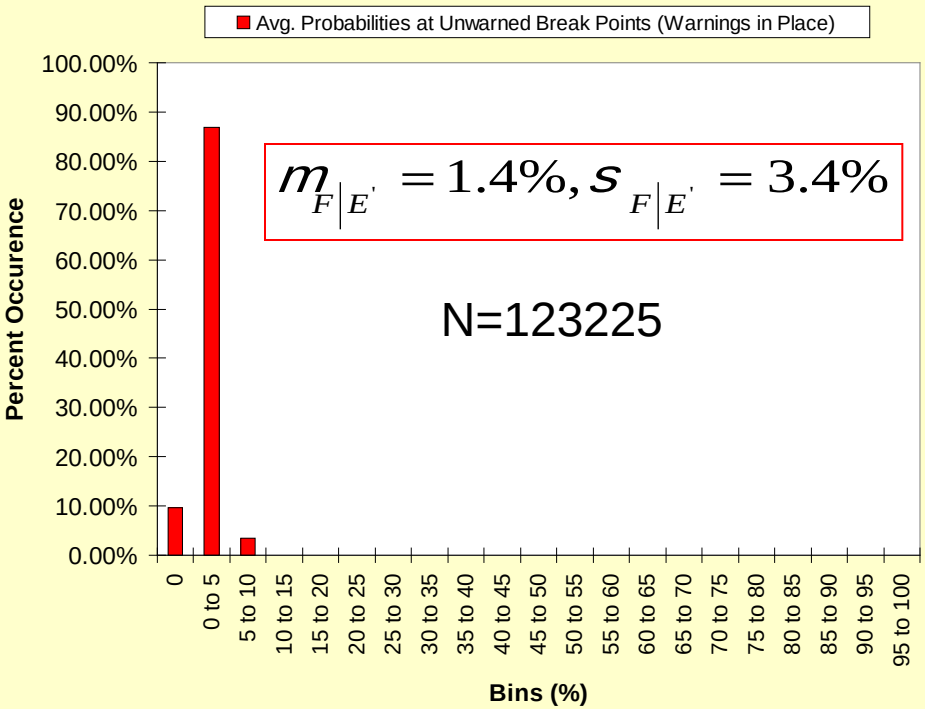
NHC storm average hurricane warning lead times 1963-2005

Since 2000 warning areas have decreased and lead times increased.

Discrimination Distance



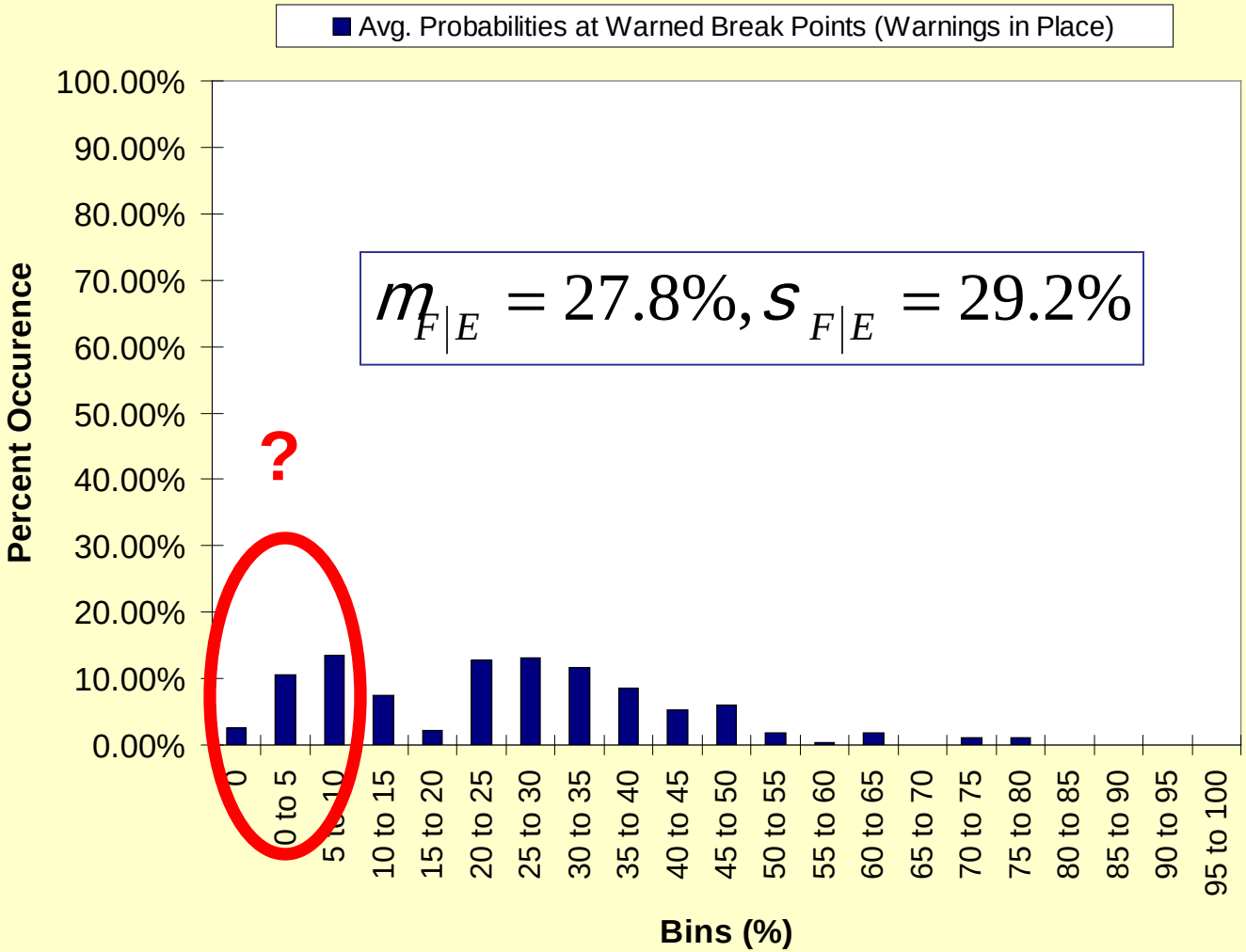
Warned Break Points (Warnings in Place)



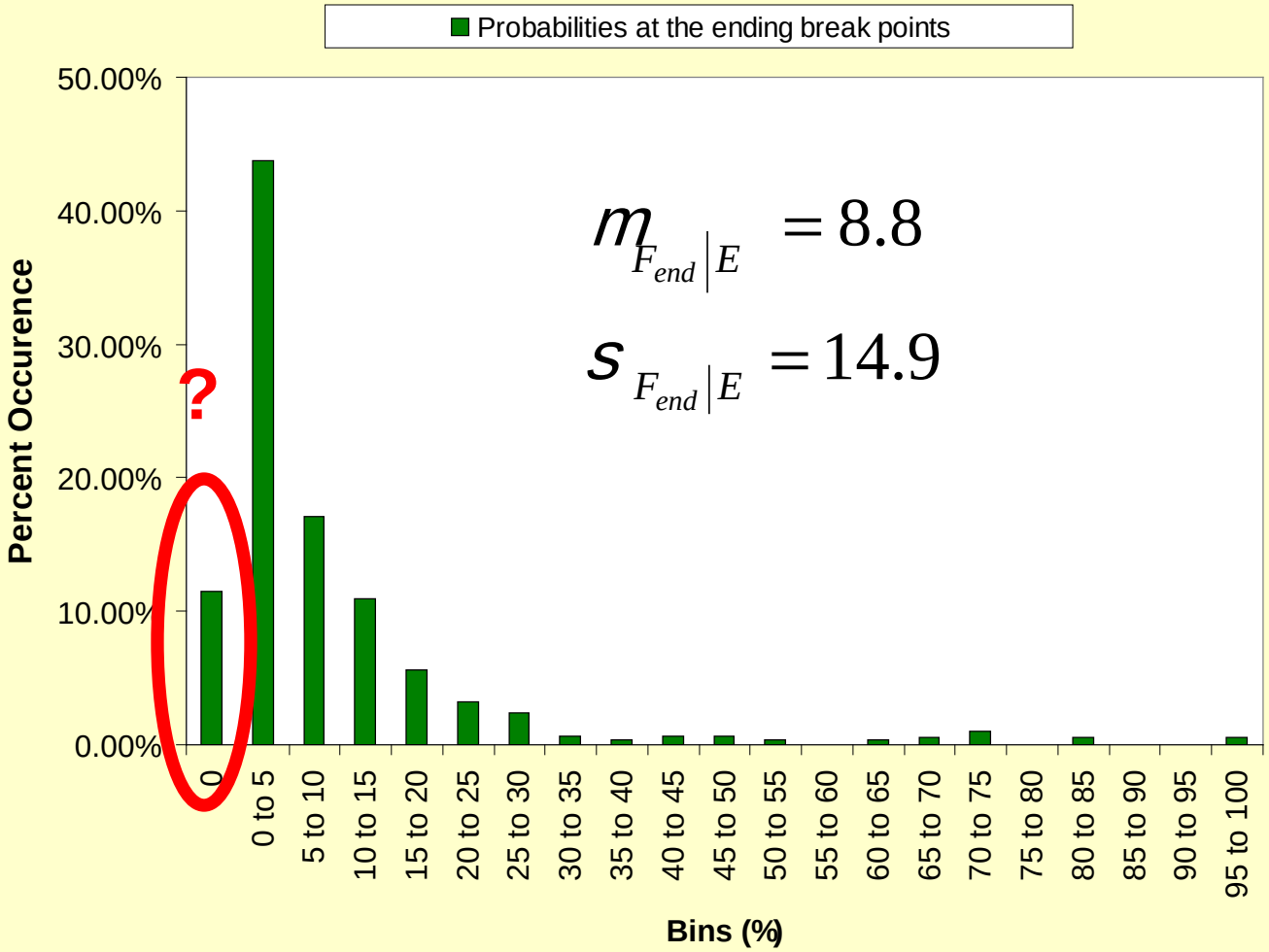
Unwarned Break Points (Warnings in Place)

$$d = 26.4\%$$

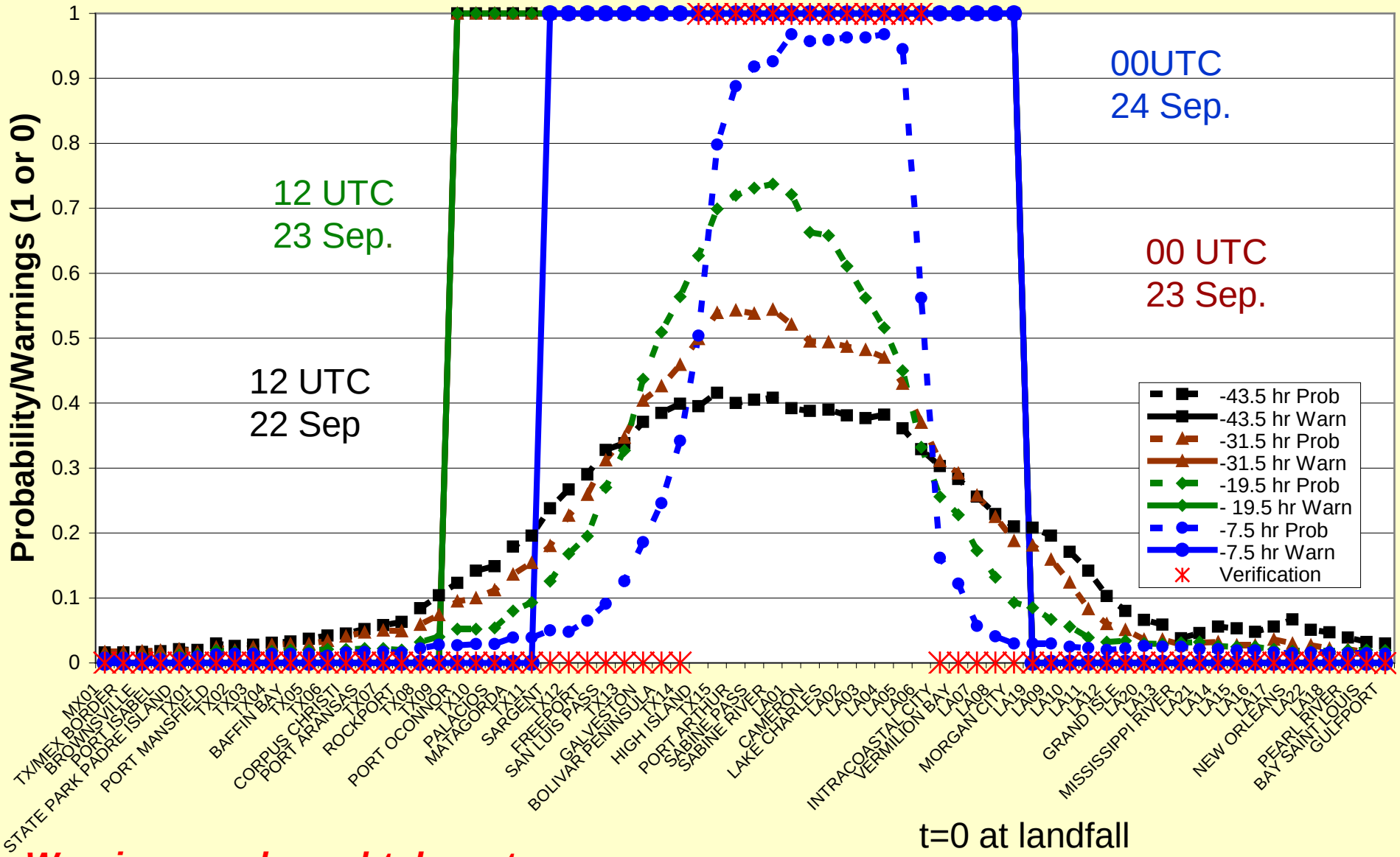
Why are there so many low probabilities at the break points?



Distribution of Probabilities at the Ending Break Points



Example: Hurricane Rita



Warnings are brought down too slowly in this case.

Summary of Warning Break Points

- Probabilities are useful in the watch/warning process.
  - Objectively assign of the warnings at fixed lead time?
  - Average at warnings = 28%
  - Average at end points of the Warnings = 9%
- It appears that warnings can be dropped sooner, thus decreasing the area warned area.

Future Plans

- Seasonal Verification Code
- See what we can learn from the verification.
- Report to this audience

Questions?