An Improved Wind Probability Program: A Joint Hurricane Testbed Project Update

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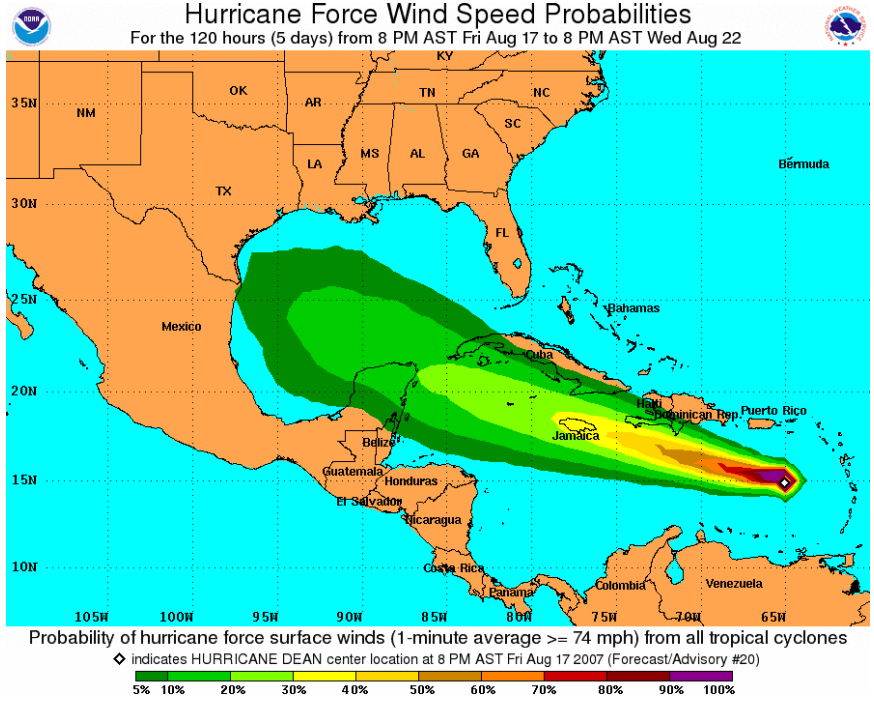
Presented at the
Interdepartmental Hurricane Conference
March 5, 2008

Monte Carlo Wind Probability Model

- 1000 track realizations from random sampling NHC *track error* distributions
  - Serial correlation and bias of errors accounted for
- Intensity of realizations from random sampling NHC *intensity error* distributions
  - Serial correlation and bias of errors accounted for
  - Special treatment near land
- Wind radii of realizations from radii CLIPER model and its *radii error* distributions
  - Serial correlation included
- Probability at a point from counting number of realizations passing within the wind radii of interest

MC Probability Example
Hurricane Dean 17 Aug 2007 18 UTC



1000 Track Realizations

64 kt 0-120 h Cumulative Probabilities

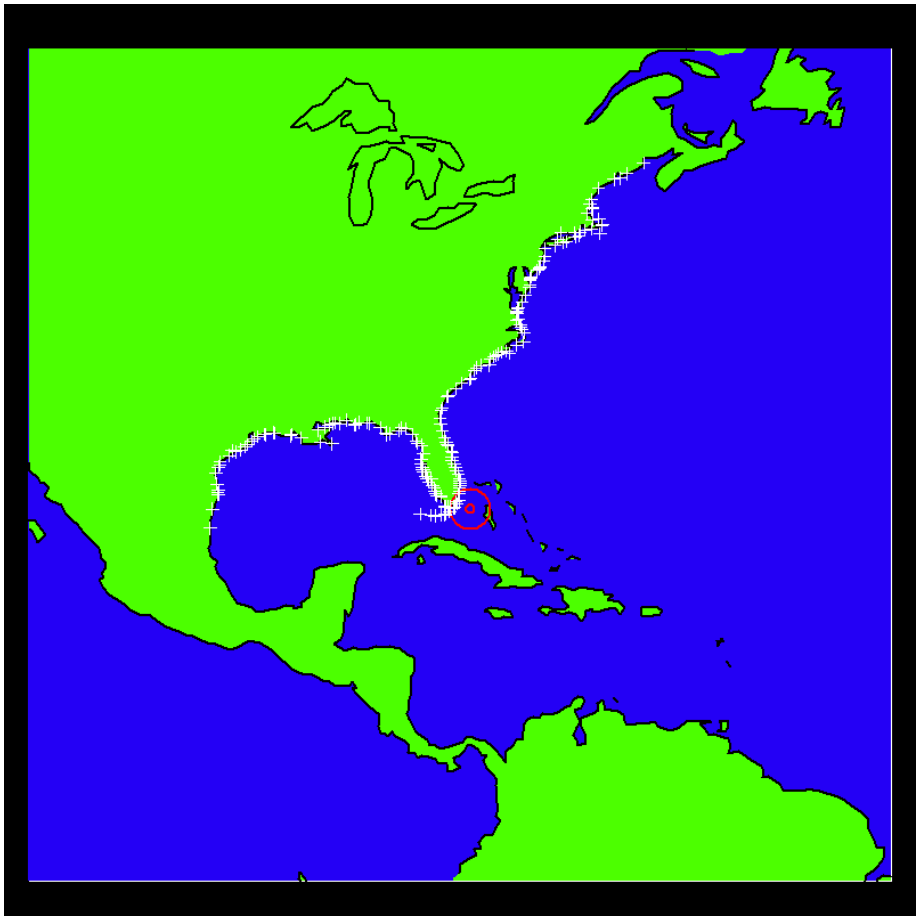
Project Tasks

1. Improved Monte Carlo wind probability program by using situation-depending track error distributions
   - Track error depends on Goerss Predicted Consensus Error (GPCE)
2. Improve timeliness by optimization of MC code
3. Update NHC wind speed probability table product
   - Extend from 3 to 5 days
   - Update probability distributions (currently based on 1988-1997)

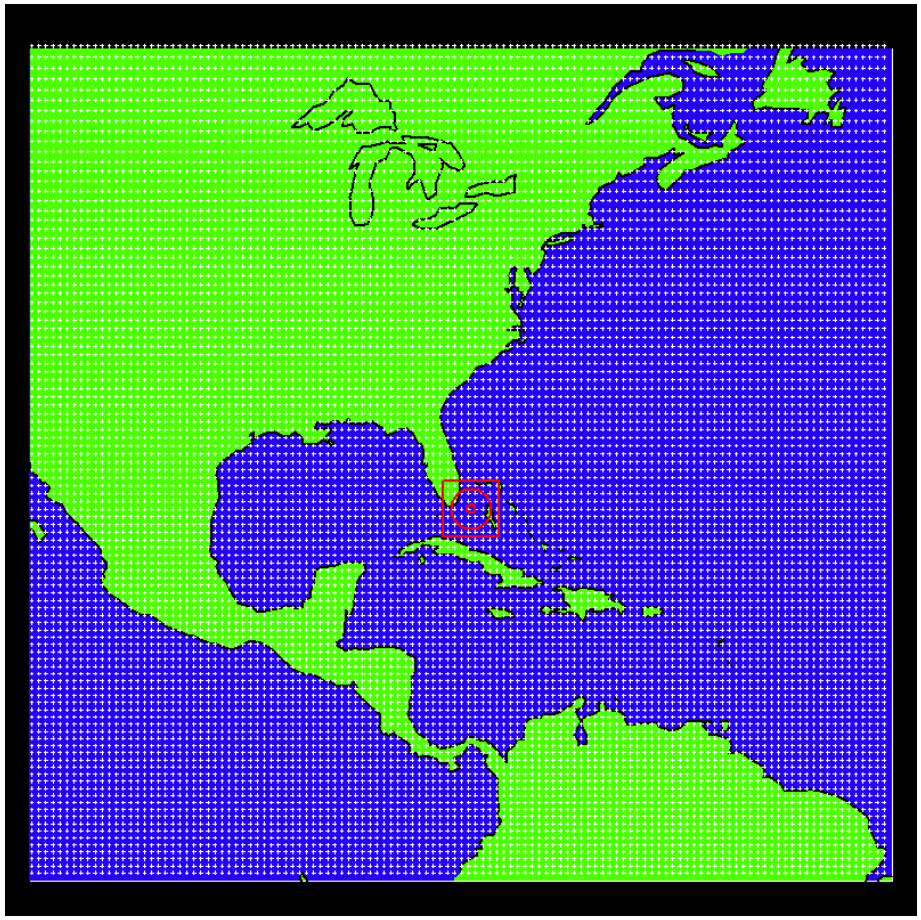
Code Optimization

- Code profiling showed ~85% of CPU in distance calculation routine
- Automated procedure added to test for regular grid
- If yes, rectangular mask added at each time step to reduce number of distance calculations
- Speed up of ~600% for large grid
  - 25 to 50% expected
- Implemented before 2007 season

Code Optimization



Text Product Grid



Graphical Product Grid

Wind Speed Probability Table

WIND SPEED FORECAST FOR DEAN
EXPRESSED AS PROBABILITY
FROM NHC ADVISORY 16
5:00 AM EDT AUG 17 2007

TIME	WIND SPEED INTERVAL IN MPH							
HOURS	DISSIPATED	TROPICAL DEPRESSION < 39	TROPICAL STORM 39 - 73	HURRICANE >= 74	HURRICANE			
					CAT. 1 74 - 95	CAT. 2 96 - 110	CAT. 3 111 - 130	CAT. 4-5 >= 131
12	<2%	<2%	<2%	>98%	30%	50%	20%	3%
24	<2%	<2%	5%	95%	40%	30%	15%	5%
36	<2%	<2%	<2%	>98%	25%	25%	35%	20%
48	<2%	<2%	<2%	>98%	10%	20%	30%	40%
72	<2%	<2%	<2%	98%	10%	25%	30%	30%

Wind Speed Probability Table

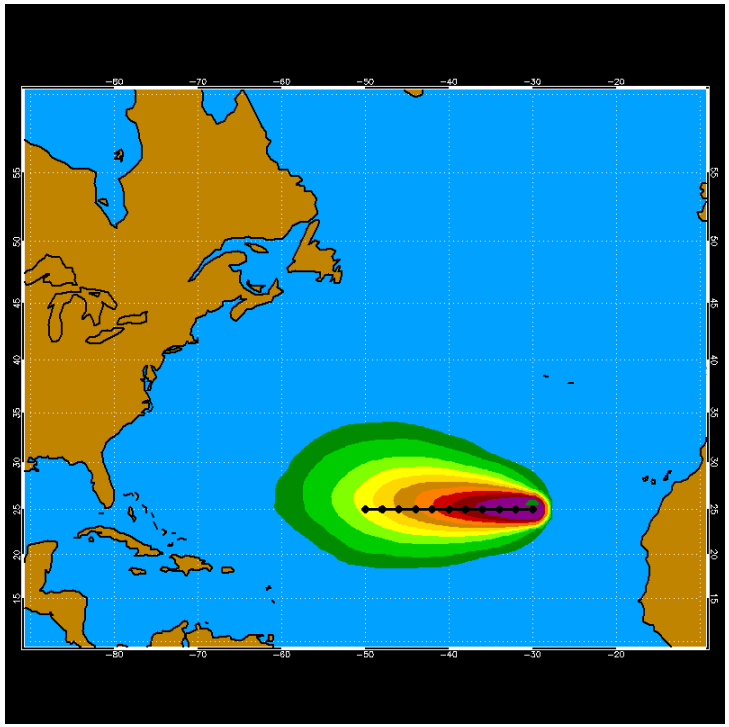
- Developed by E. Rappaport and M. DeMaria as part of original NHC graphical products
- Limitations addressed by JHT project
  - Based on 1988-1997 NHC error statistics
  - Extends only to 3 days
- Other limitations
  - Does not directly account for land interaction
  - Inconsistent with other probability products from MC model
- Rick Knabb and Dan Brown suggestion*:
  - Use output from MC model as table input
  - Addresses all of the above limitations
  - Will automatically update when MC model updates

**via Dave Thomas*

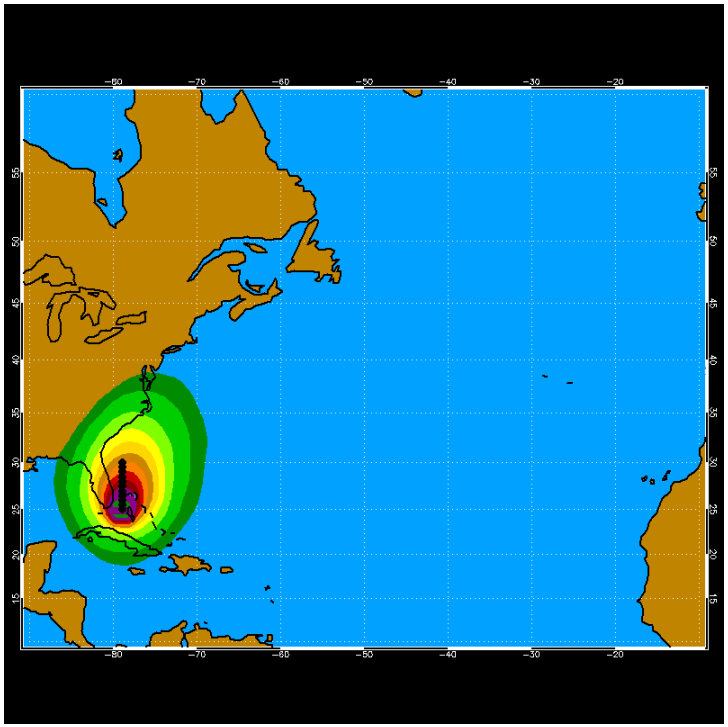
Wind Speed Probability Table
Evaluation Procedure

- Examine MC model intensity probability distributions for idealized storms
- Compare MC intensity probabilities with WSPT values for real forecasts
  - Frances 29 Aug 2004 12 UTC
  - Katrina 24 Aug 2005 18 UTC
  - Katrina 27 Aug 2005 18 UTC
  - Ernesto 29 Aug 2006 06 UTC
  - Ernesto 29 Aug 2006 18 UTC
  - Humberto 12 Sep 2007 12 UTC
  - Humberto 12 Sep 2007 18 UTC
  - Ingrid 13 Sep 2007 00 UTC

Wind Speed Probability Table
Idealized Storm Cases

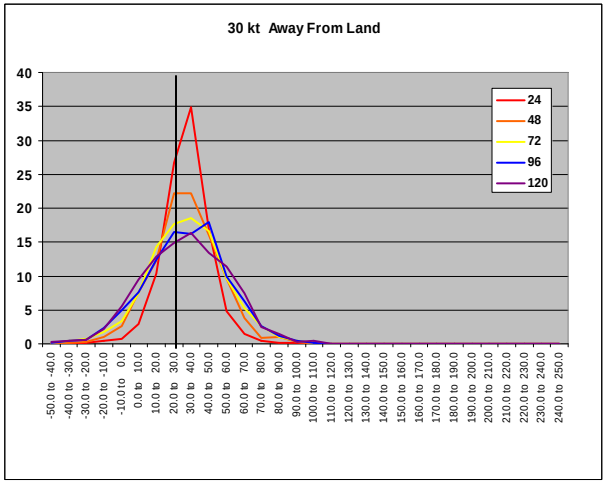


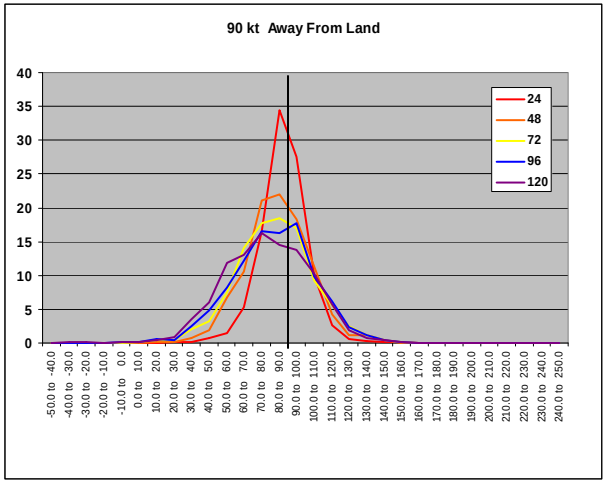
Straight west track
far from land
Three cases:
Constant max wind of
30, 90 and 150 kt

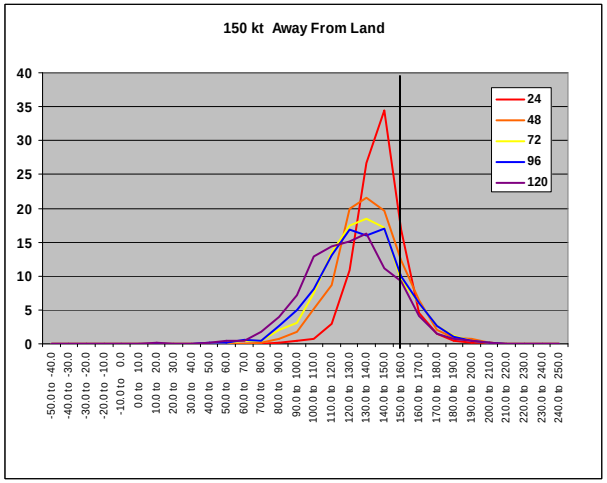


Straight north track
close to land
Three cases:
Constant max wind of
30, 90 and 150 kt

MC Intensity Distributions
Far from Land



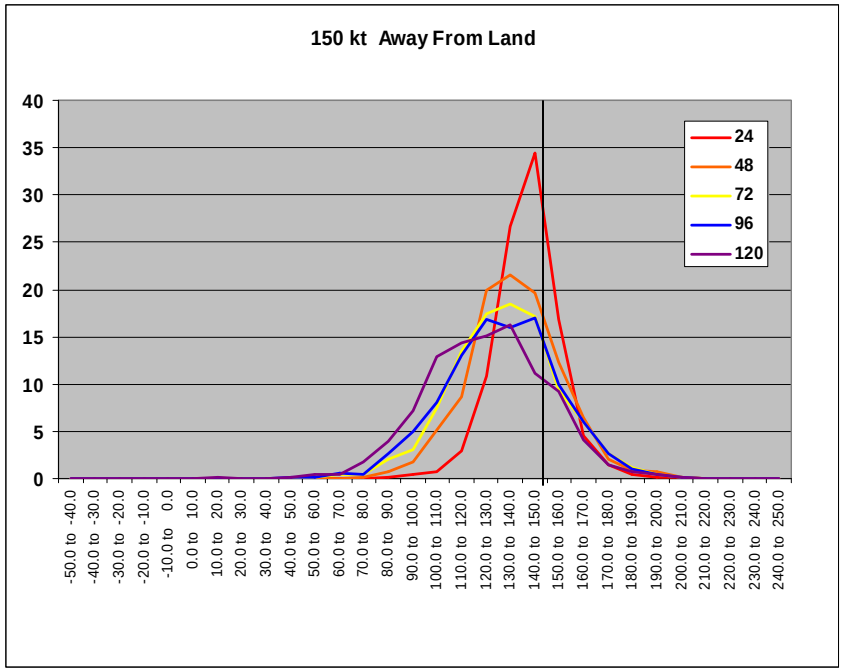




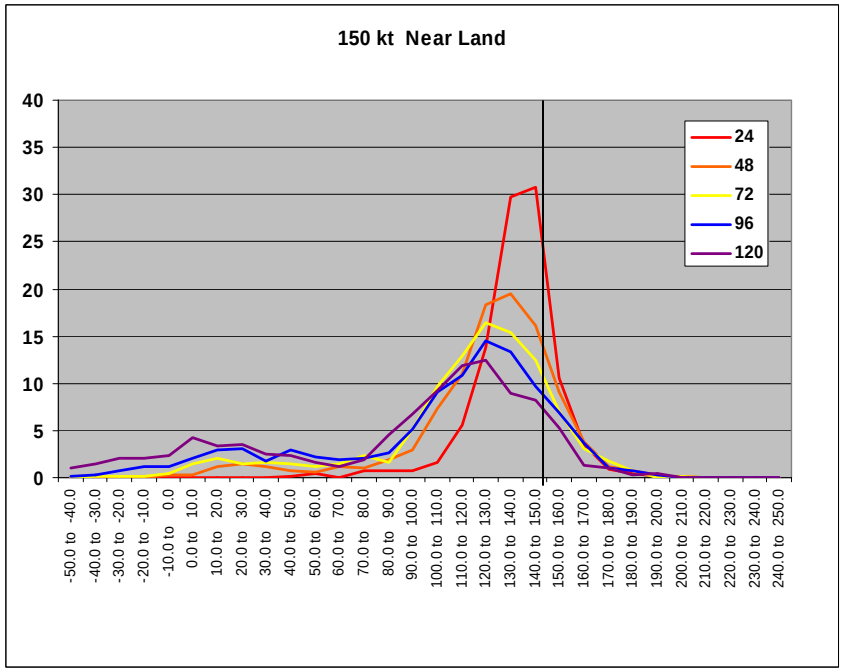
30 kt fcst **90 kt fcst** **150 kt fcst**

MC Intensity Distributions

150 kt fcst far from and near land

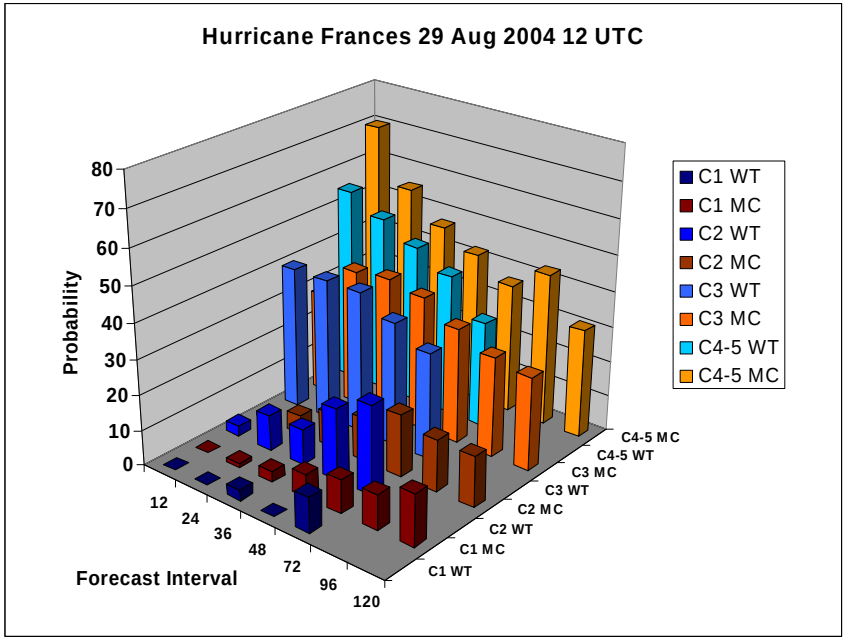


Far from land

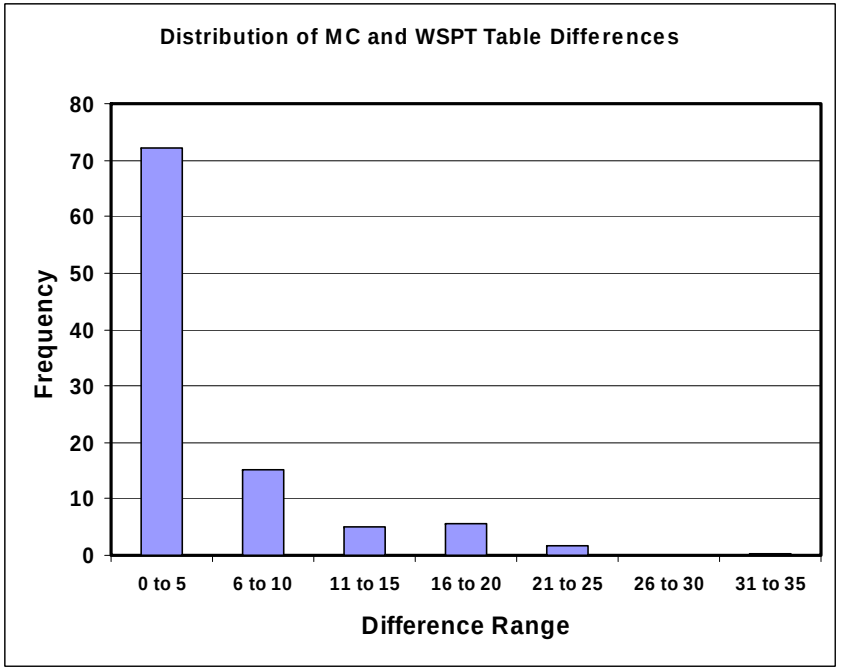


Near land

MC and Wind Speed Table Probability Comparison

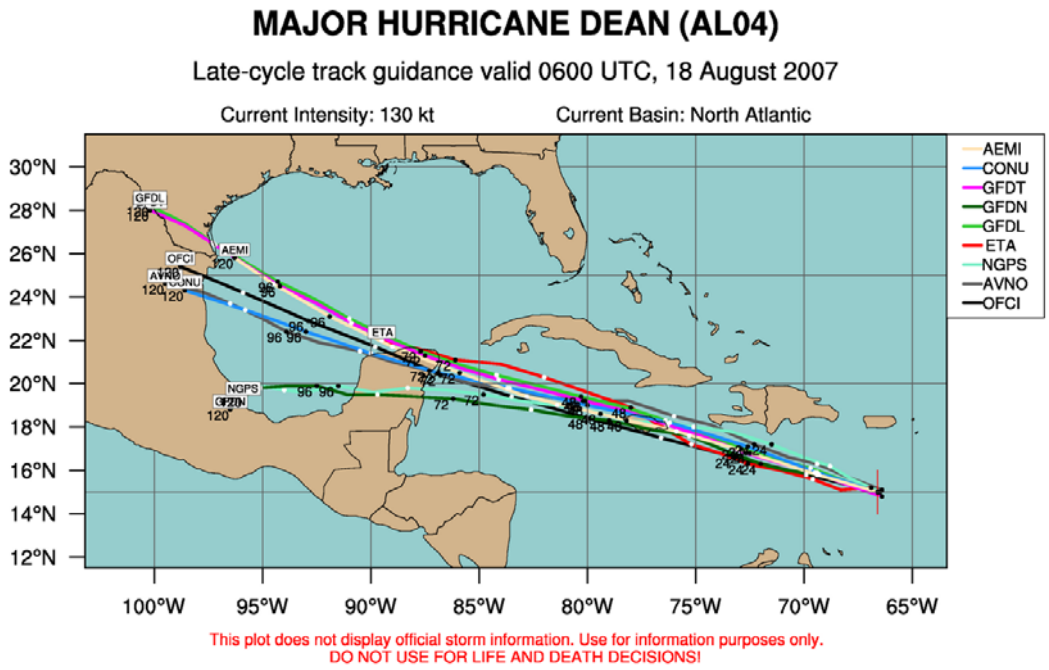


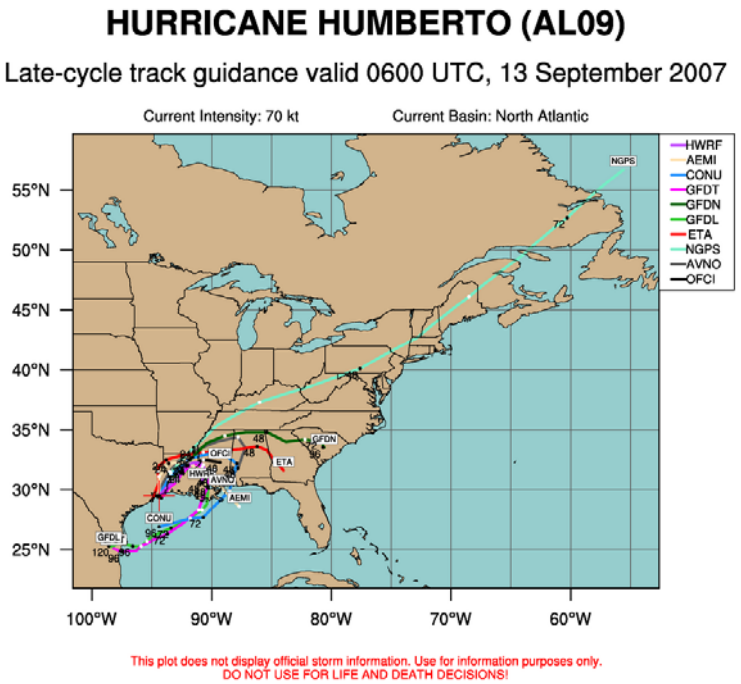
Hurricane France Example



Nine Forecast Totals

Forecast-Dependent Probabilities





- Operational MC model uses basin-wide track error distributions
- Can situation-dependent track distributions be utilized?

Track plots courtesy of J. Vigh, CSU

Goerss Predicted Consensus Error (GPCE)

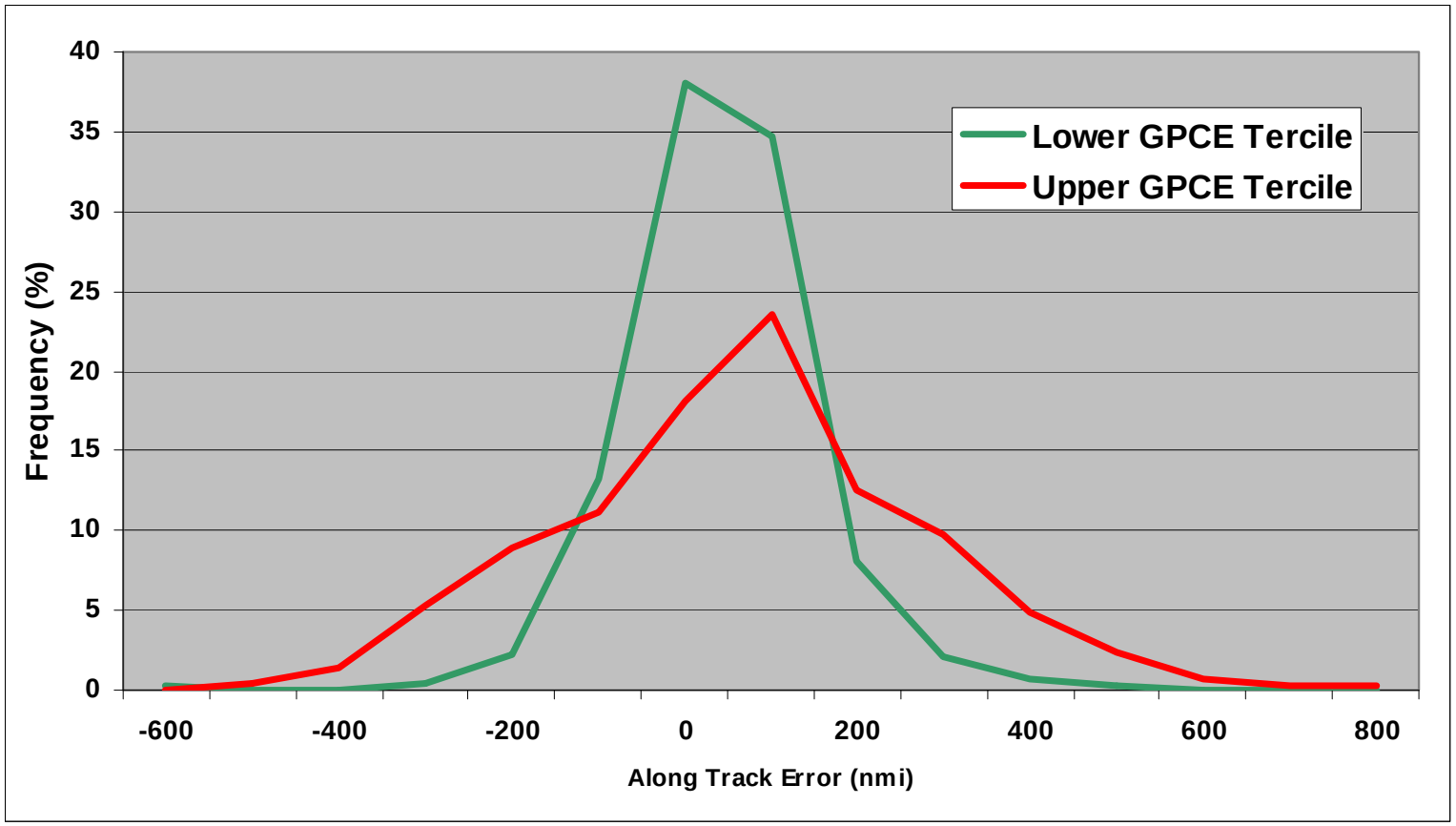
- Predicts error of CONU track forecast
  - Consensus of GFDI, AVNI, NGPI, UKMI, GFNI
- GPCE Input
  - Spread of CONU member track forecasts
  - Initial latitude
  - Initial and forecasted intensity
- Explains 15-50% of CONU track error variance
- GPCE estimates radius that contains ~70% of CONU verifying positions at each time

Use of GPCE in the MC Model

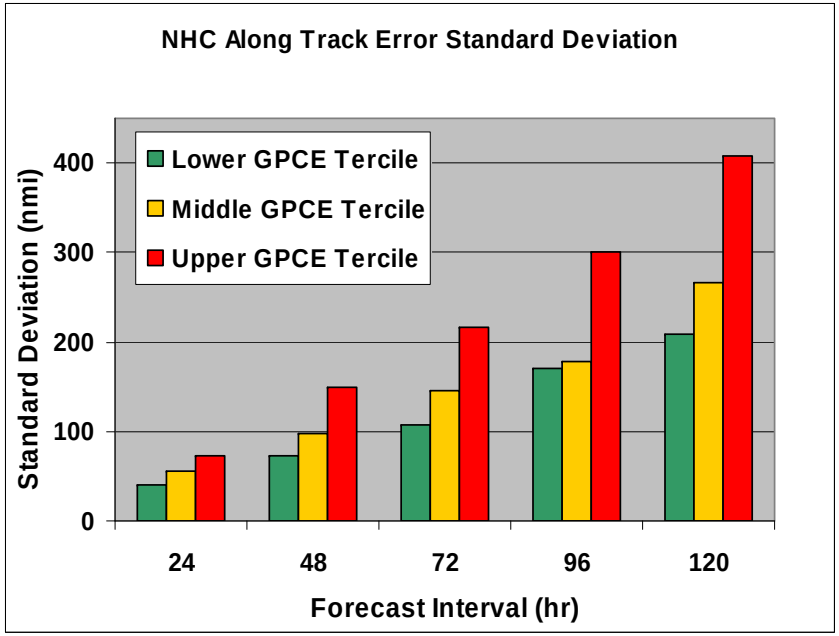
- 2002-2006 database of GPCE values created by NRL*
- Are GPCE radii correlated with NHC and JTWC track errors?
  - GPCE designed to predict CONU error
- How can GPCE values be used in the MC model?
  - MC model uses along/cross track error distributions

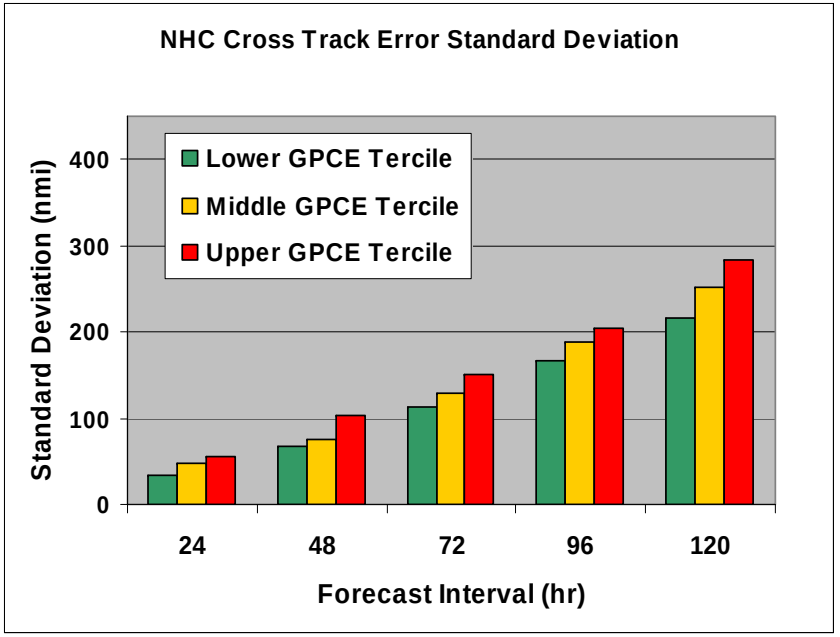
**Buck: Domestic or Imported?*

72 hr Atlantic NHC Along Track Error Distributions Stratified by GPCE (2002-2006)

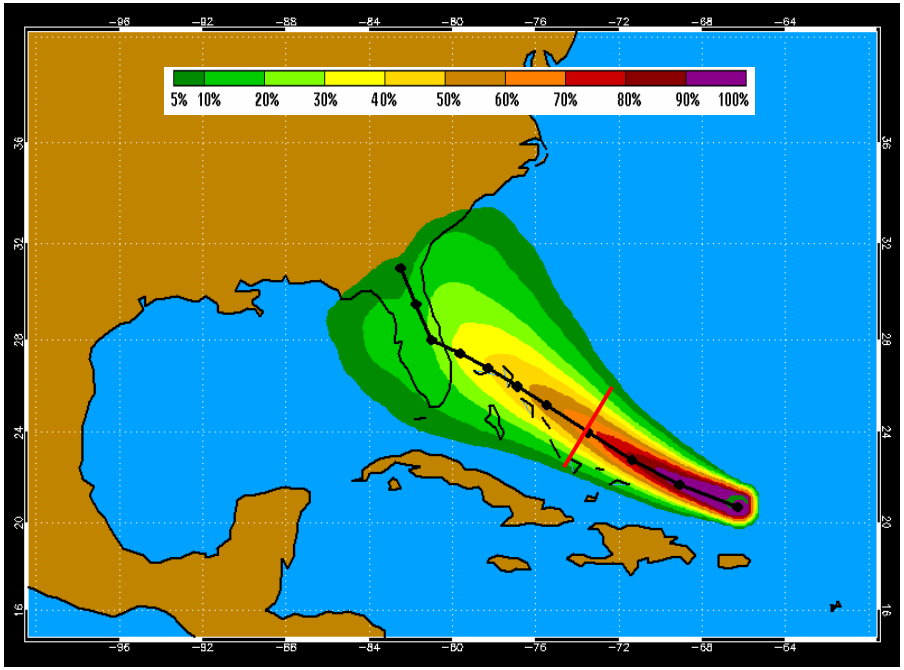


NHC Along and Cross Track Error Standard Deviations Stratified by GPCE (2002-2006 Atlantic Sample)

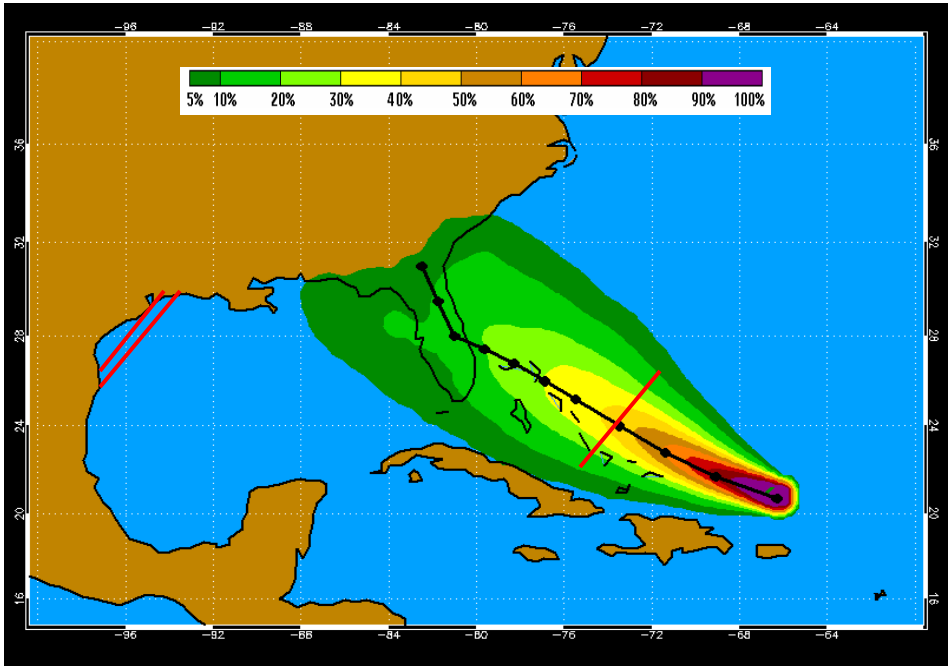




MC Model with Track Errors from Upper and Lower GPCE Terciles



Lower Tercile Distributions



Upper Tercile Distributions

Hurricane Frances 2004 01 Sept 00 UTC Example
120 hr Cumulative Probabilities for 64 kt

Remaining Questions

- How to include GPCE in MC model
  - Method 1: Sample from appropriate tercile
  - Method 2: Include GPCE input in serial correlation correction
- Behavior in other basins
- Does GPCE correction improve probability verification?
- Real time tests beginning Aug 2008

Summary

- Code optimization is complete
  - Factor of 6 speed up
- Wind speed table product input from MC model is a reasonable approach
  - Implementation in 2008
- GPCE-dependent MC model is promising
  - Further evaluation needed
  - Real time parallel runs in Aug 2008?