Improving the Validation and Prediction of Tropical Cyclone Rainfall

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Funded by NOAA Joint Hurricane Testbed

Rainfall forecasts from landfalling TC's

standard forecasting tools

- Kraft rule of thumb
- numerical model guidance
- R-CLIPER

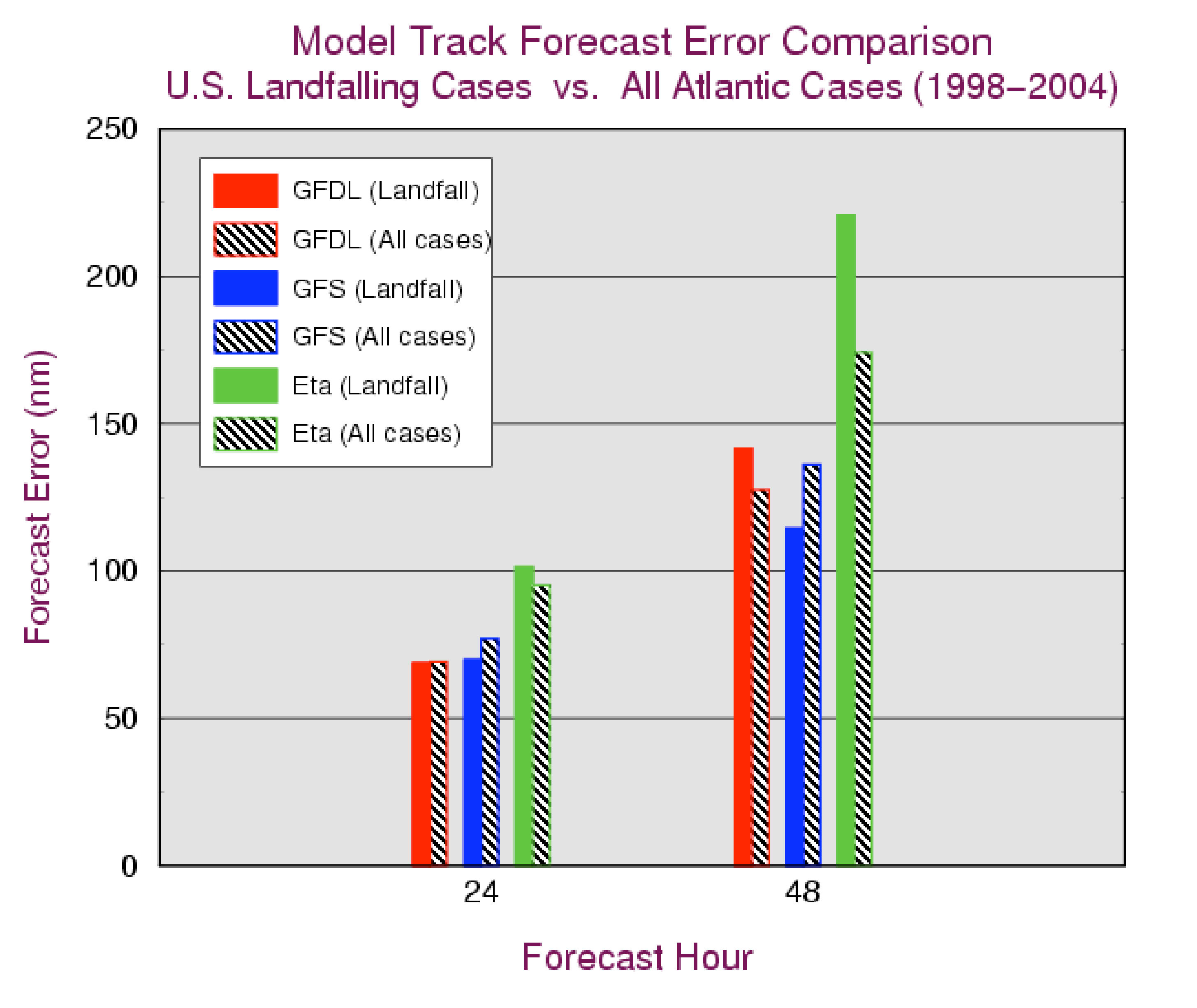
standard validation tools

- bias score
- equitable threat score
- pattern correlation

Factors impacting rainfall distributions in landfalling TC's

- storm track
- topography
- interaction with synoptic-scale features
- storm intensity
- land-surface boundary

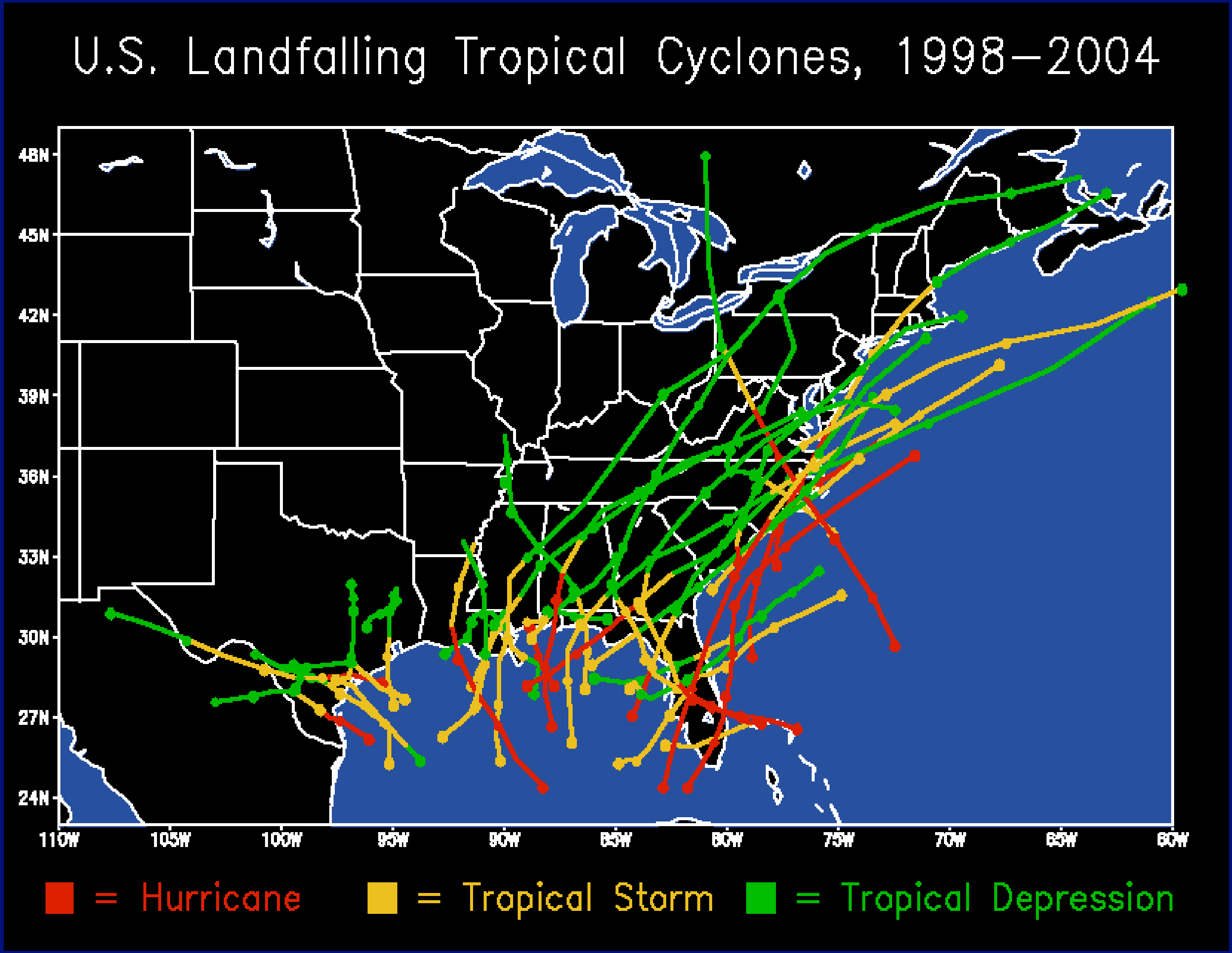
Track errors for all Atlantic and U.S. landfalling cases



U.S. Landfalling Cases for Model Evaluation

1998	1999	2000	2001	2002	2003	2004
Bonnie 95	Bret 100	Gordon 55	Allison 45	Bertha 35	Bill 50	Bonnie 45
Charley 40	Dennis 60	Helene 65	Barry 60	Edouard 35	Claudette 75	Charley 125
Earl 70	Floyd 90		Gabrielle 60	Fay 50	Grace 35	Frances 95
Frances 45	Harvey 50			Hanna 45	Henri 30	Gaston 65
Georges 90	Irene 70			Isidore 55	Isabel 90	Ivan 110
Hermine 35				Kyle 35		Jeanne 105
				Lili 85		Matthew 40

Storms Included in this study



Models included in this study

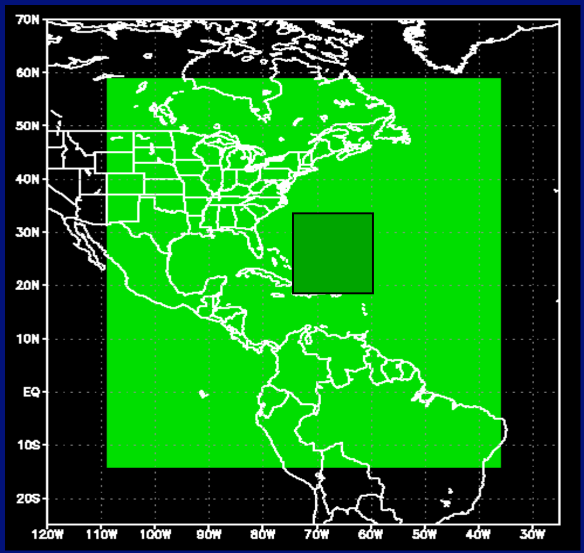
GFDL

Regional

1/2°, 1/6° (2-nest)

42 levels

2003 version

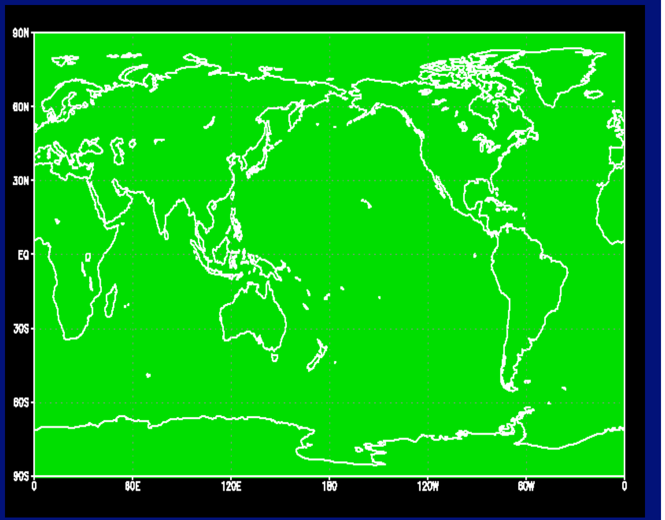


NCEP/GFS

Global

T254 (~0.6°)

64 levels

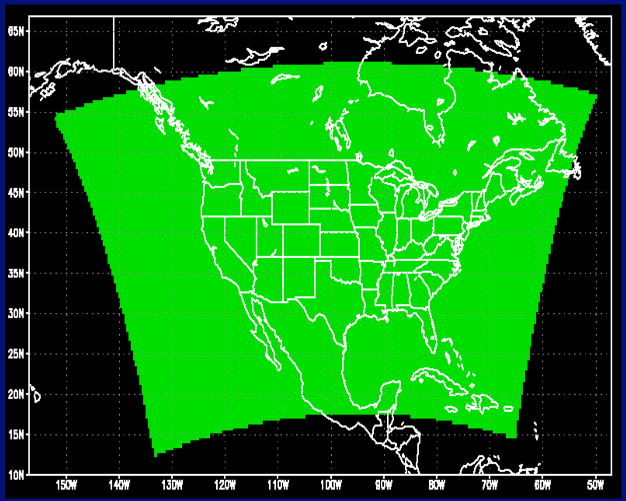


NCEP/Eta

Regional

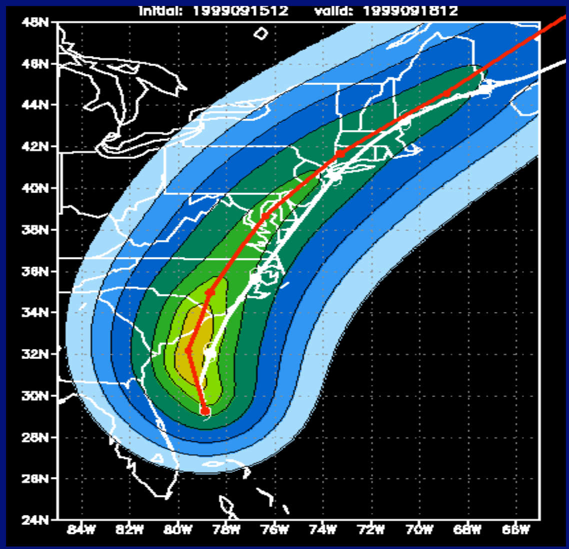
12 km

60 levels

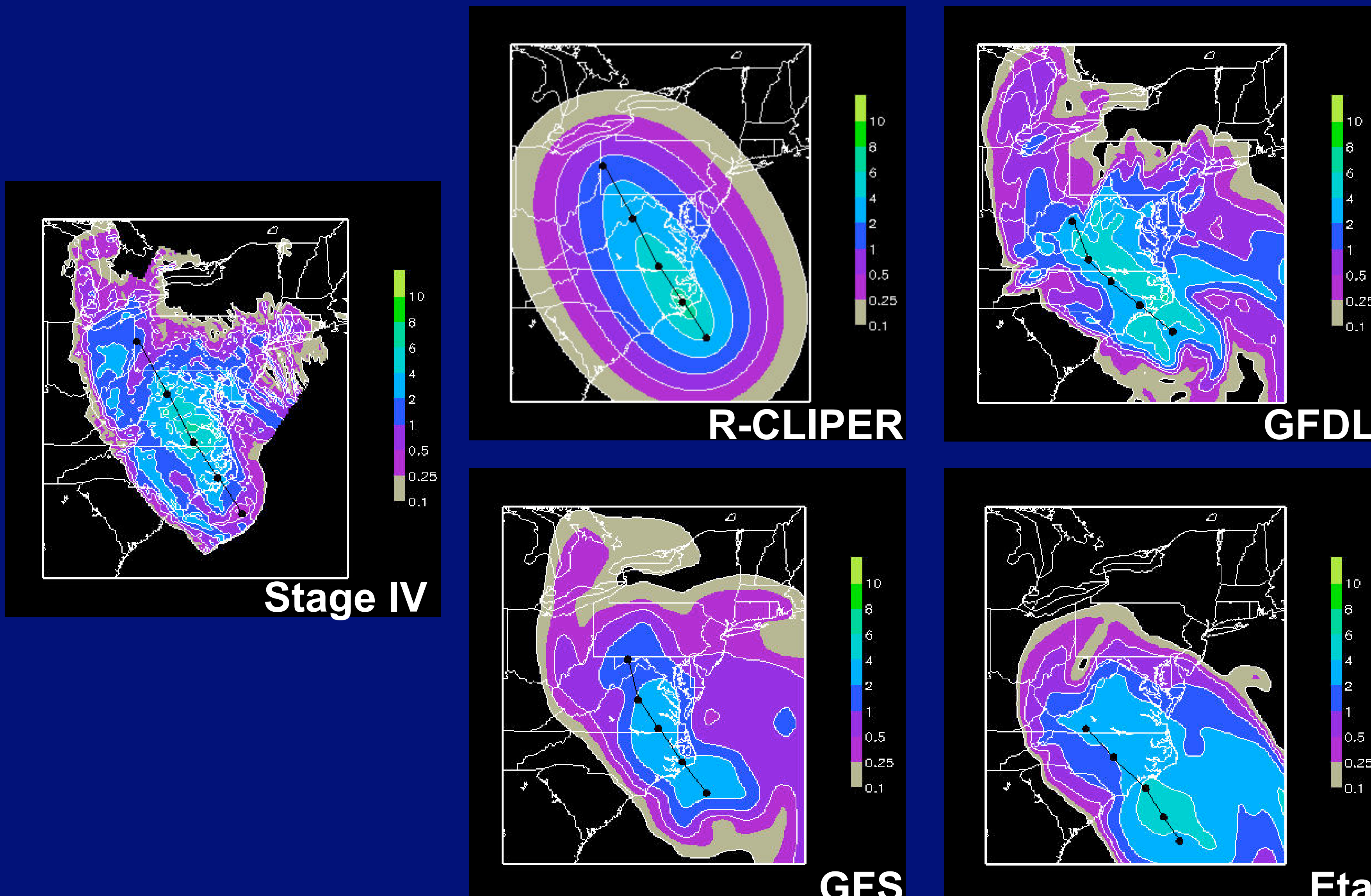


Rainfall-CLIPER

Climatology-based parametric model



Isabel 24-hr rain from 12 UTC 18 to 12 UTC 19 September 2003 (12 UTC 17 forecasts)



Parameters describing skill of TC QPF forecasts

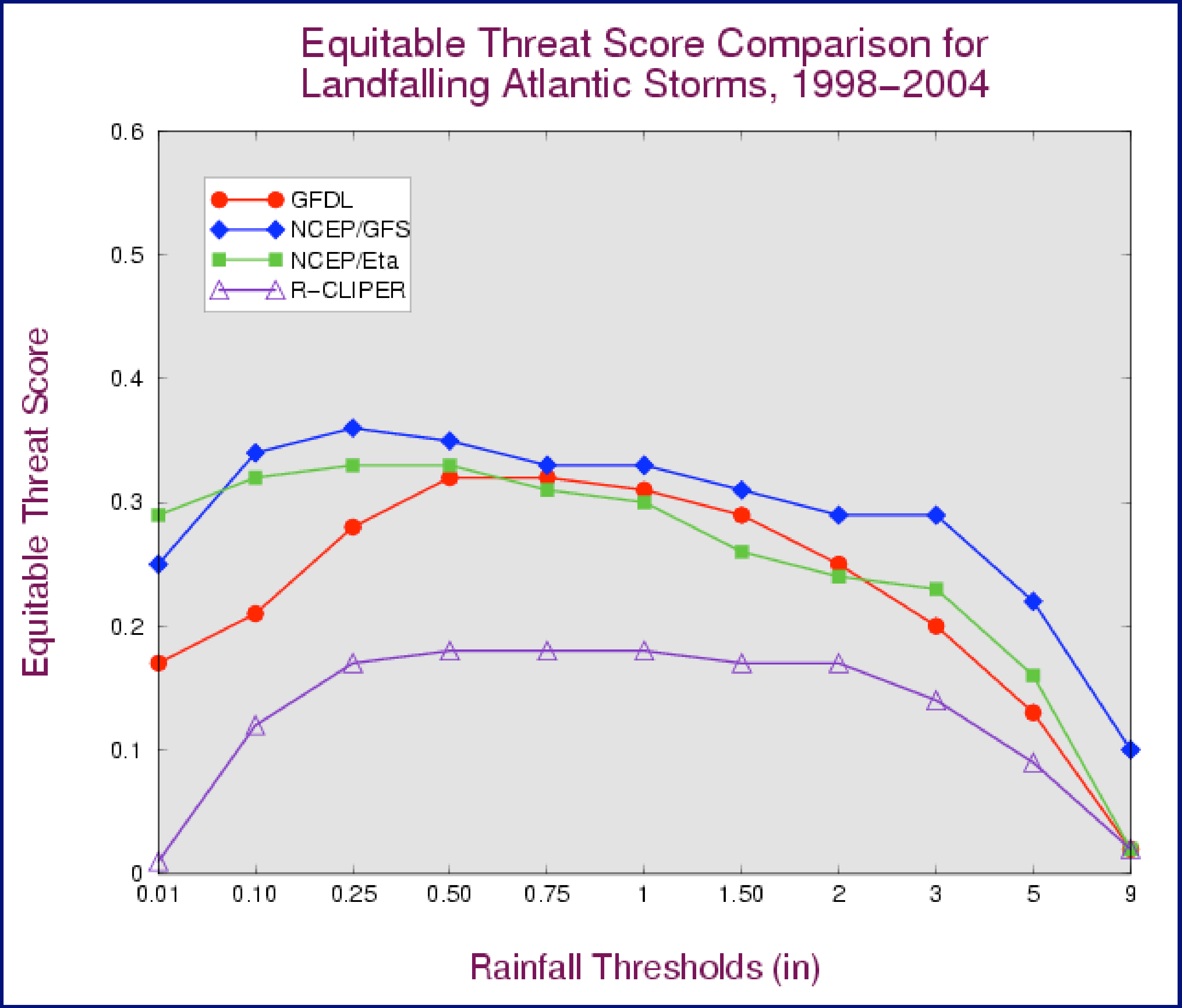
- Pattern
- Volume
- Extreme amounts
- Sensitivity to track errors

Matrix of TC QPF Metrics

Index	Dependence on Track Error		Primary QPF attribute described			
	Dependent	Independent	Pattern	Volume	Maximum	Impact of Track Error
Large Scale ETS	?		✍			
Pattern Correlation	?		✍			
Mean Rainfall Error Index		?	✍	✍		
Large-Scale CDF Median Value		?		✍		
Large-Scale CDF % in 95th percentile		?			✍	
Track-Relative CDF % in 95th percentile		?			✍	
Grid-Shifted Pattern Correlation		?				✍
Grid-Shifted ETS		?				✍

Pattern

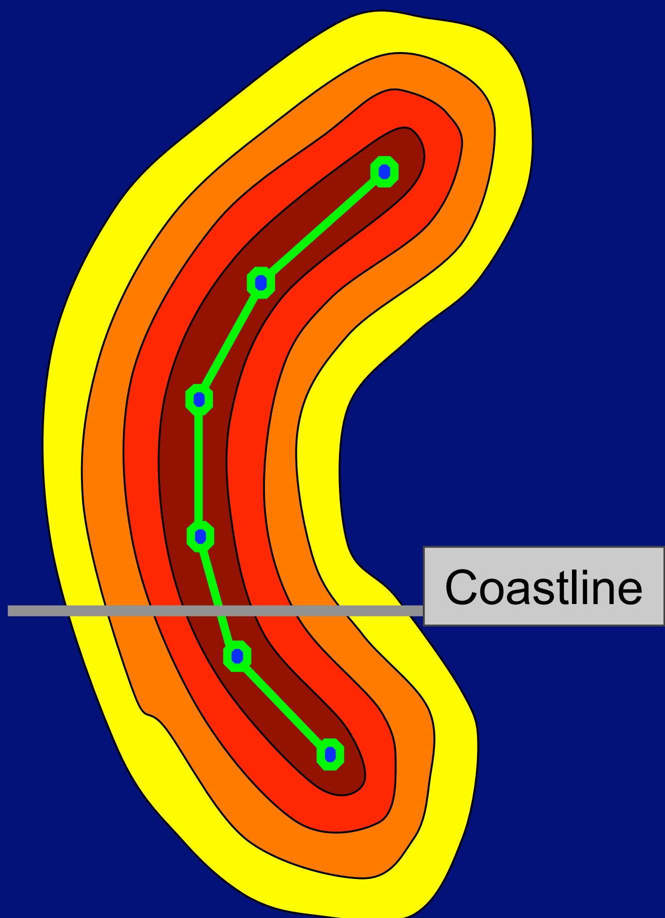
Pattern comparisons for U.S. landfalling storms



Equitable Threat Score

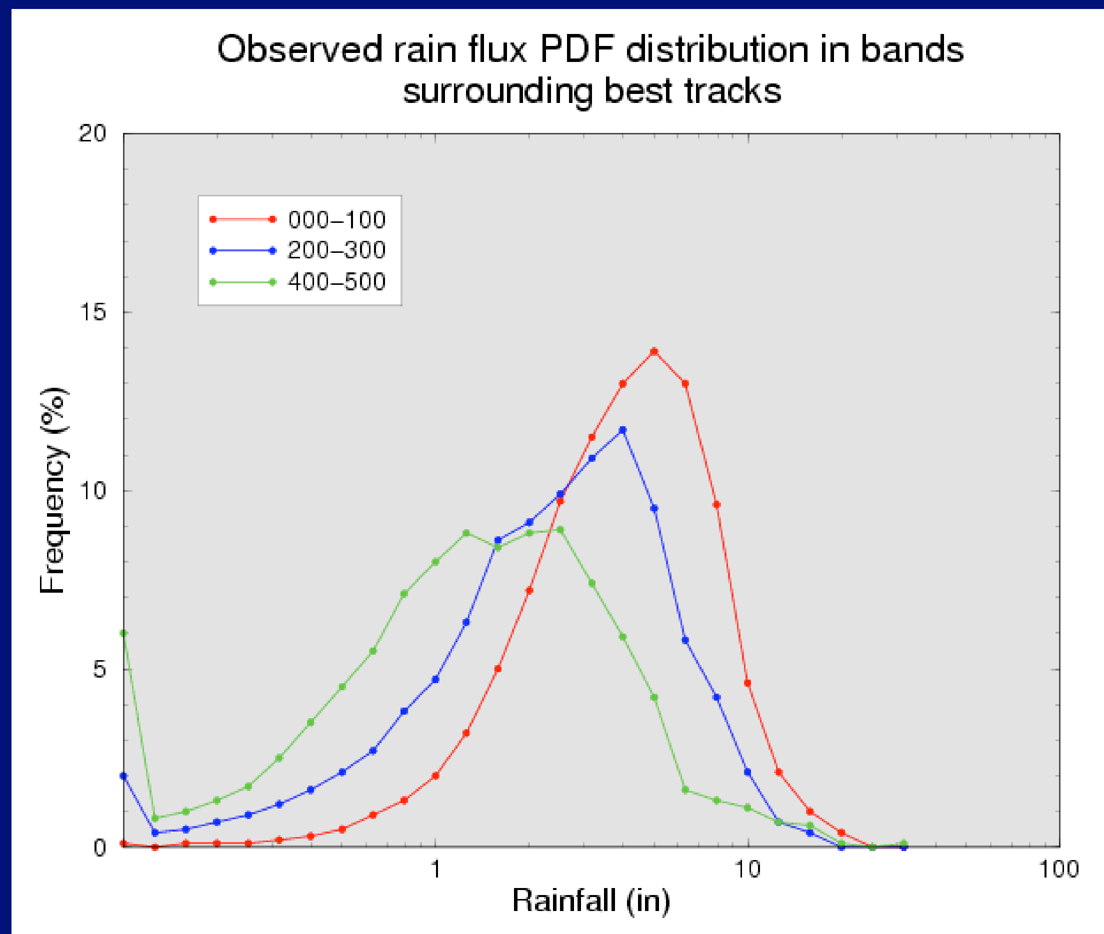
Volume

Distributions of rain flux in bands surrounding storm track



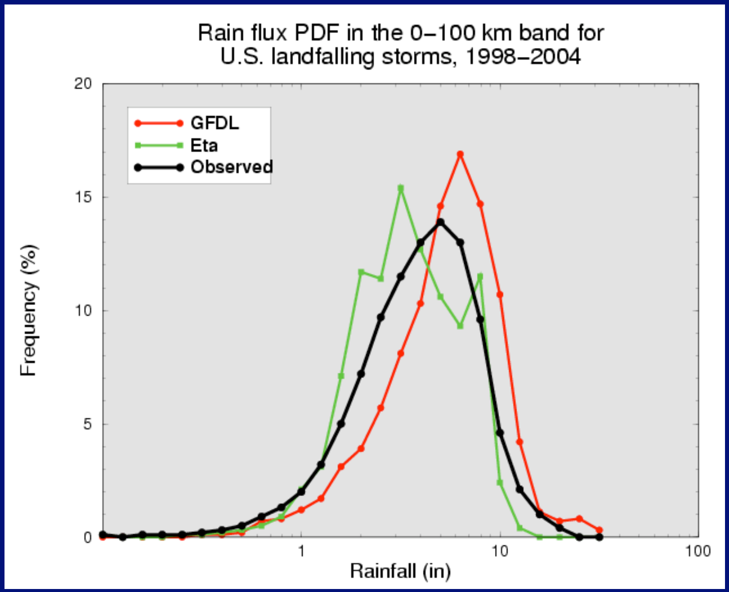
= 0-100 km from track
= 100-200 km from track
= 200-300 km from track
= 300-400 km from track

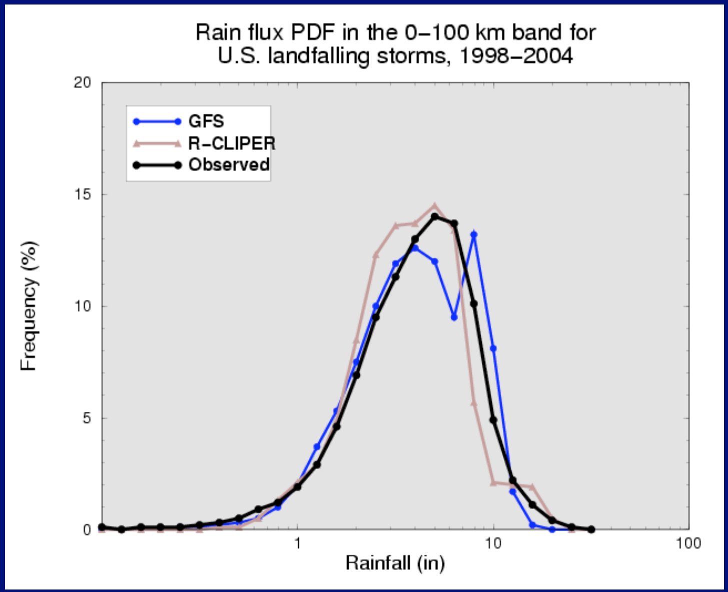
Observed PDF for all storms in selected bands



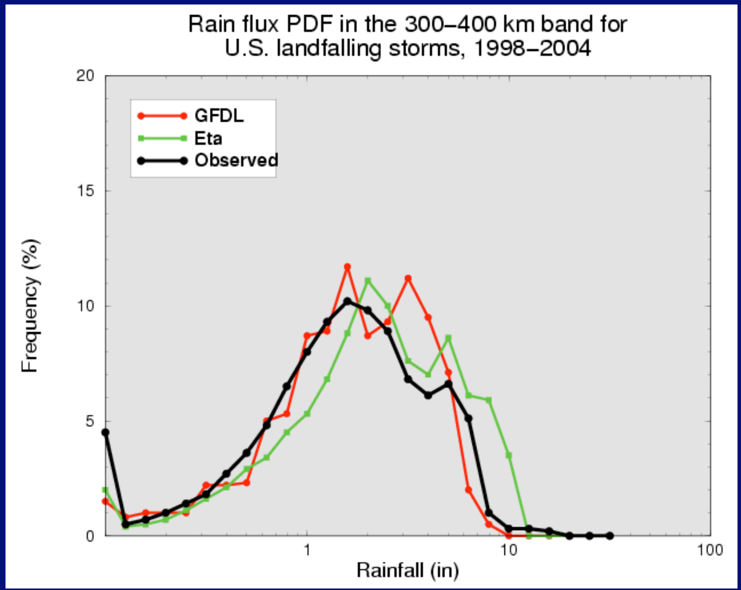
Distributions of model rain flux in bands surrounding forecasted storm track

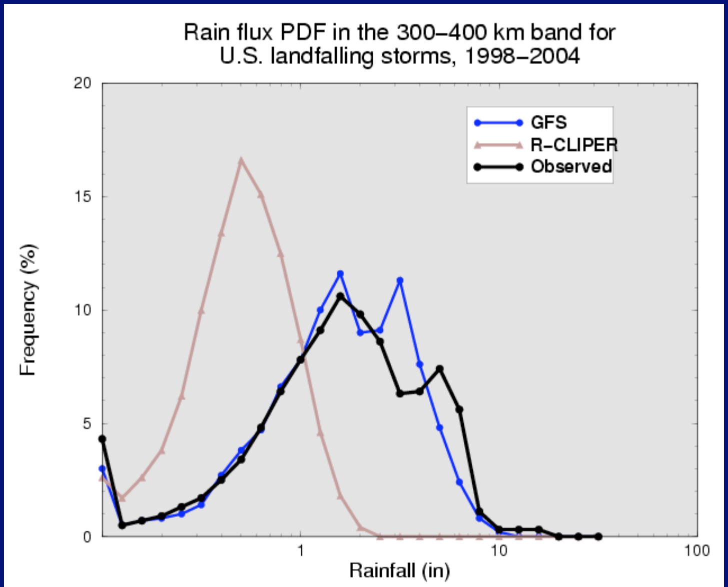
0-100 km





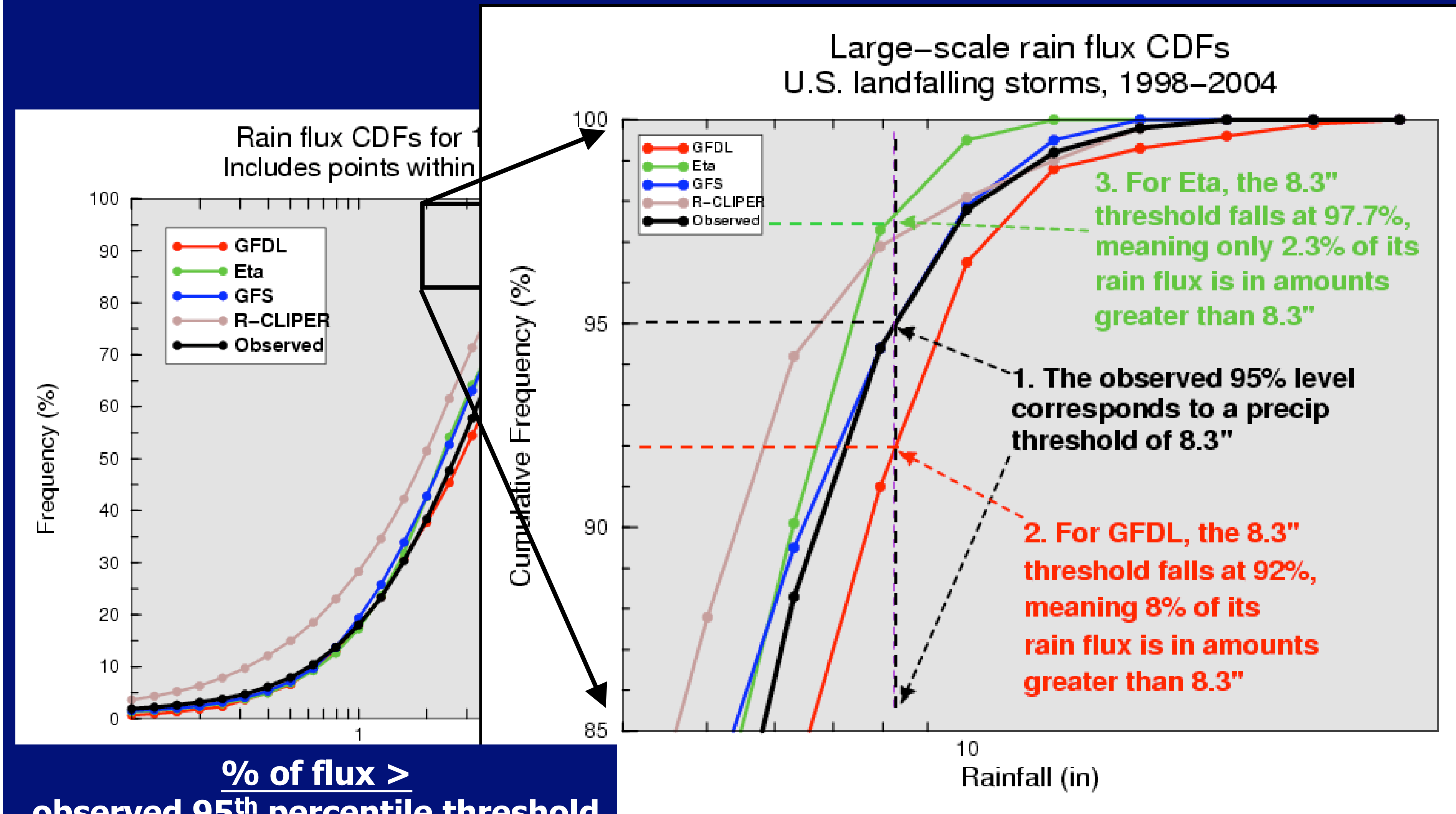
300-400 km





Extreme amounts

Top 5% of rain flux comparisons



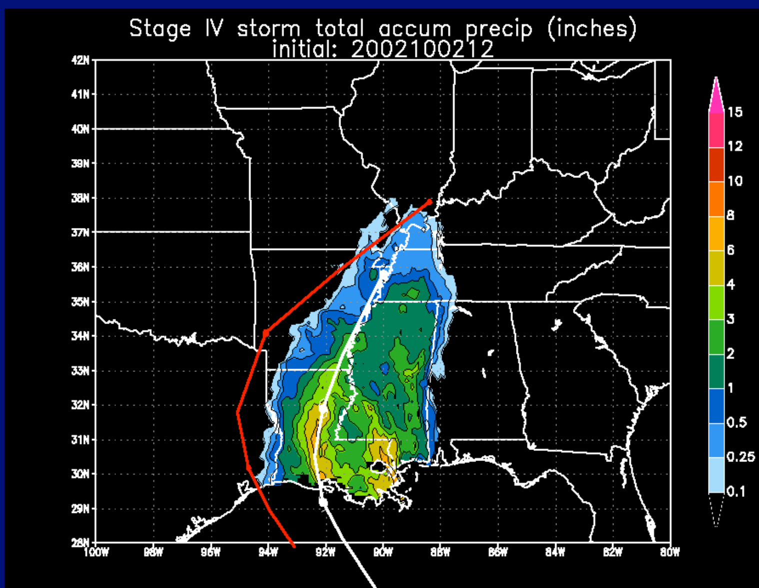
<u>% of flux ></u>
<u>observed 95th percentile threshold</u>

GFDL: 8%
Eta: 2.3%
R-CLIPER: 3%
GFS: 5%

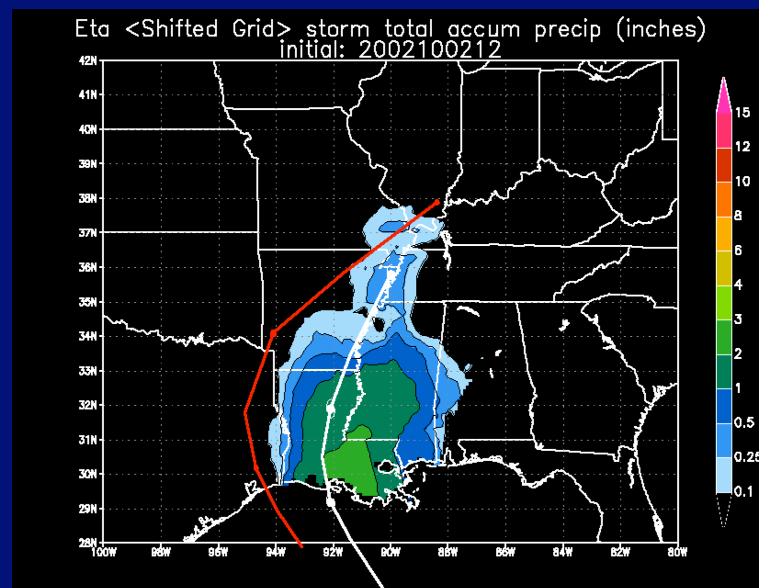
Sensitivity to track error

Example of grid-shifting of rain field

Lili Stage IV

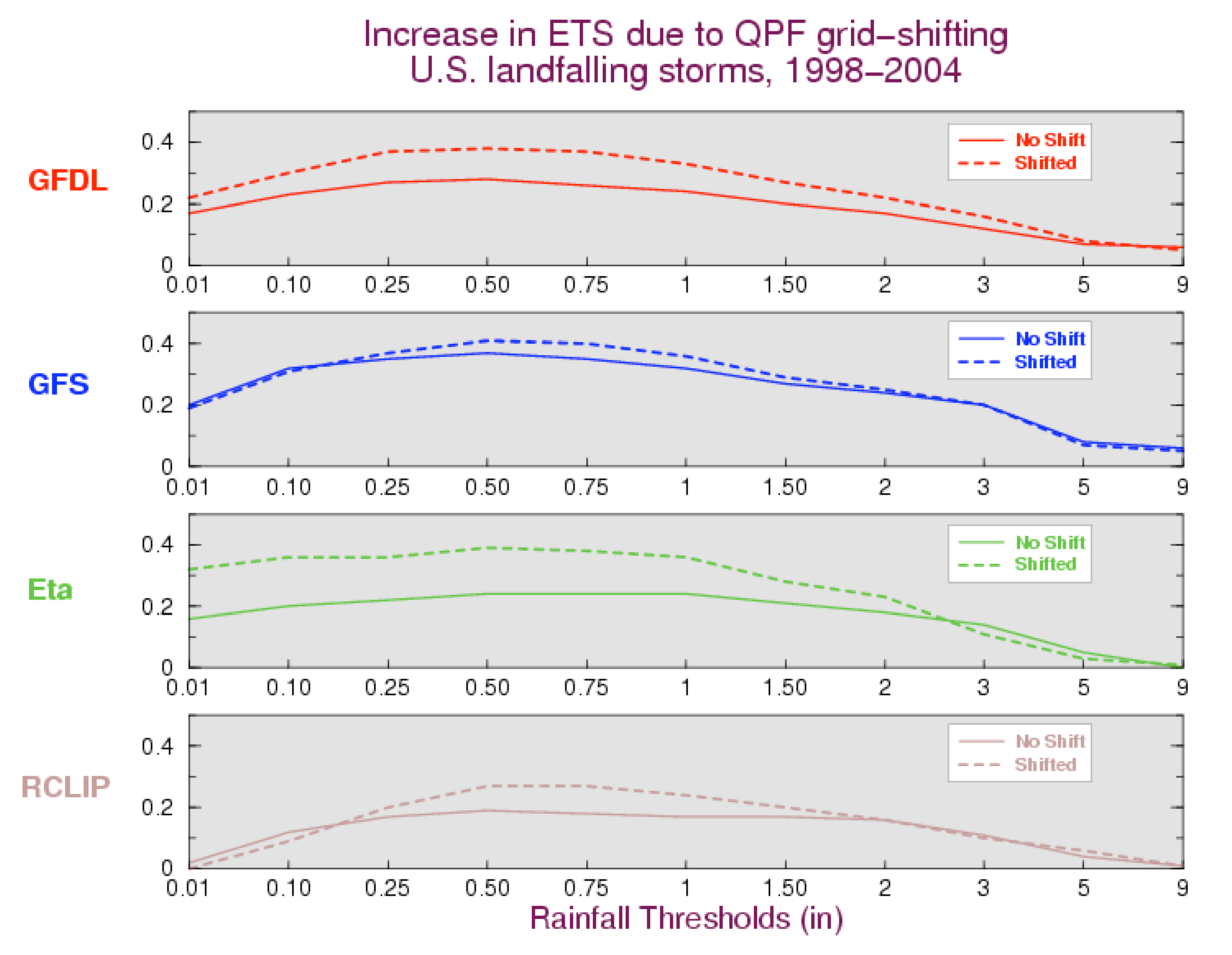


Eta shifted



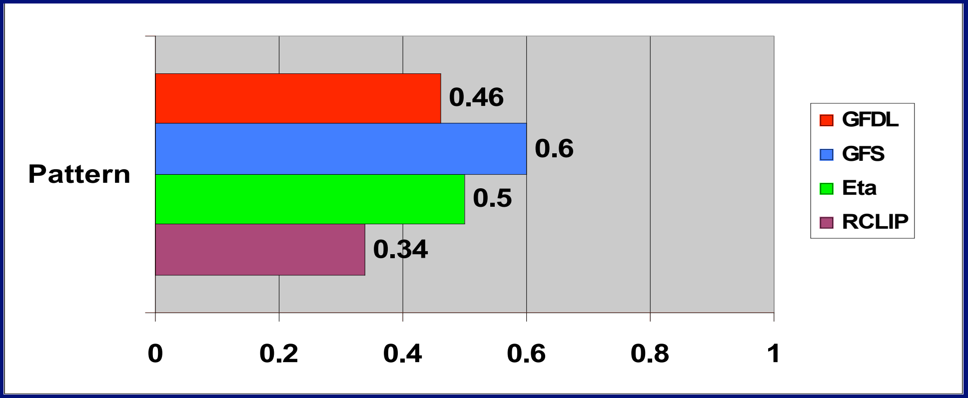
r increased from 0.36 (unshifted) to 0.85 (shifted)

ETS improvements due to grid shifting



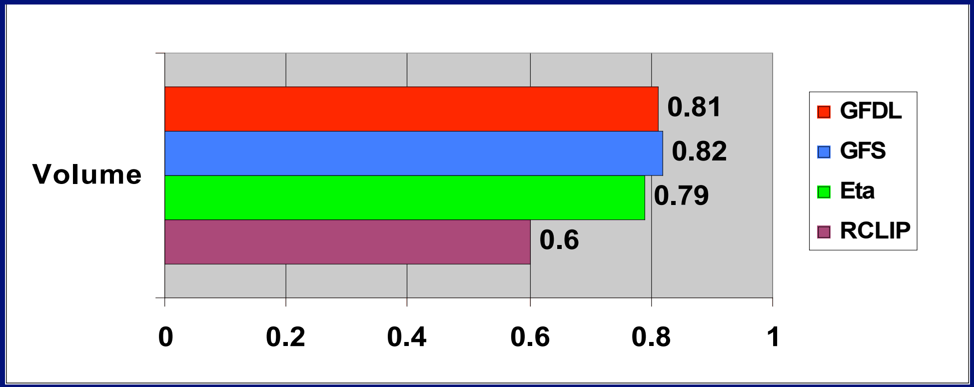
Summary comparison for all models

Pattern



- GFS performs best
- all models show skill relative to R-CLIPER
- GFDL worst among numerical models

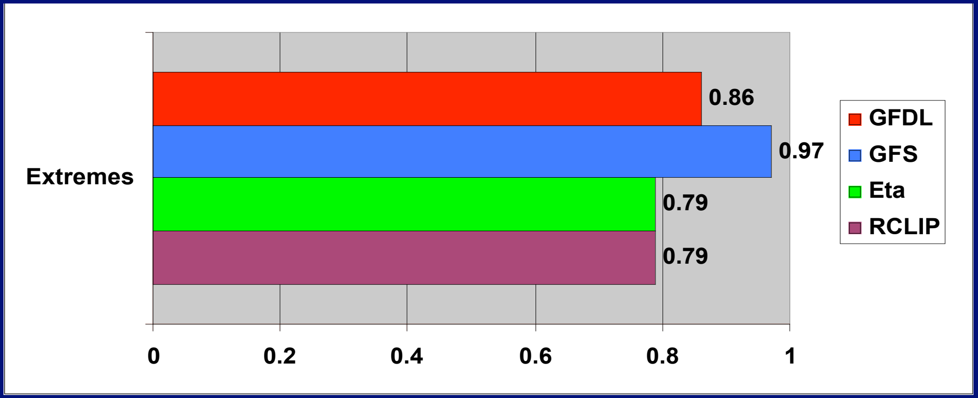
Volume



- All models essentially equivalent
- GFS slightly better
- all show skill over R-CLIPER

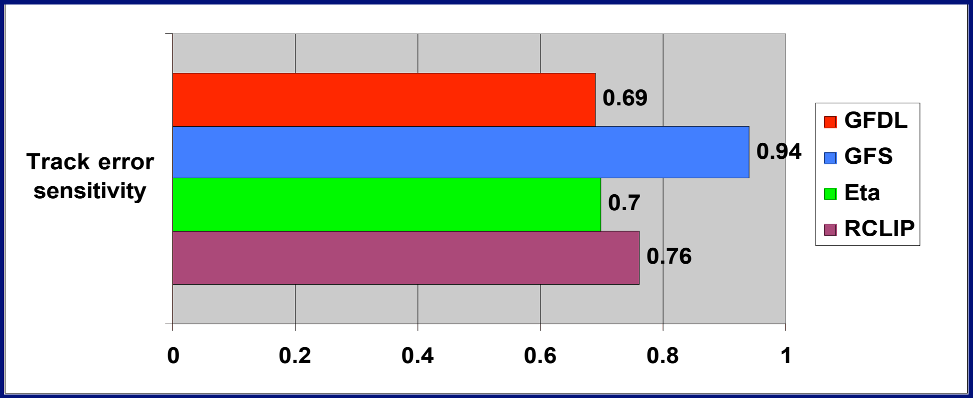
Summary comparison for all models (cont.)

Extremes



- GFS best
- GFDL produces too much of heaviest rain
- both show skill over R-CLIPER
- Eta shows no skill over R-CLIPER

Sensitivity to track error



- GFS least sensitive to track error
- GFDL, Eta more sensitive to track error than R-CLIPER

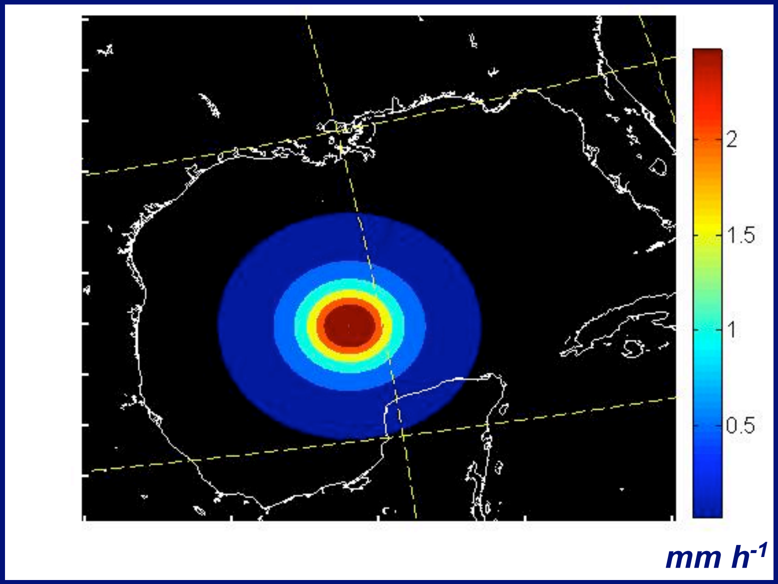
Future work

- finish development of a set of metrics that synthesizes various aspects of TC QPF
- determine way of picking out other contributors to rainfall variability other than track (e.g., topography) in validation scheme
- develop parametric rainfall model that accounts for vertical shear; validate this model using same metrics
- add other sources of variability to new parametric model (e.g., topography, synoptic environment)

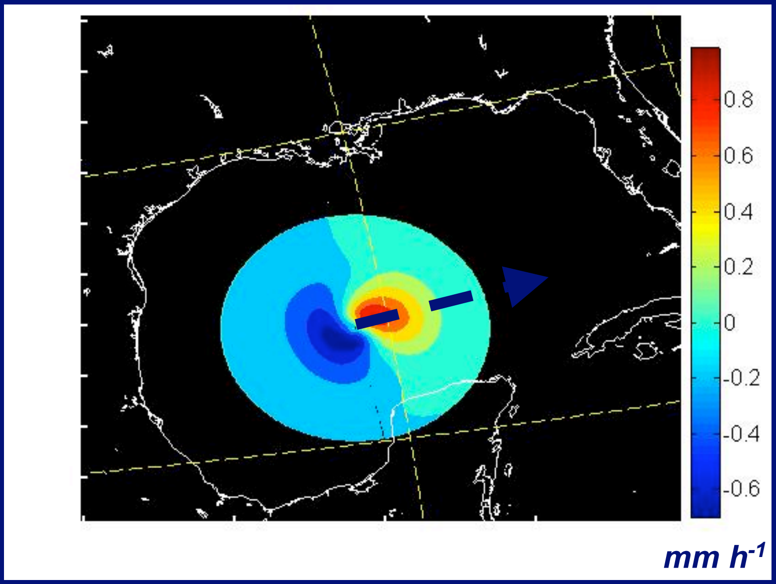
New forecasting tools for TC rainfall

Example of footprint: Hurricane Ivan

a) Wavenumber 0



b) Wavenumber 1,2

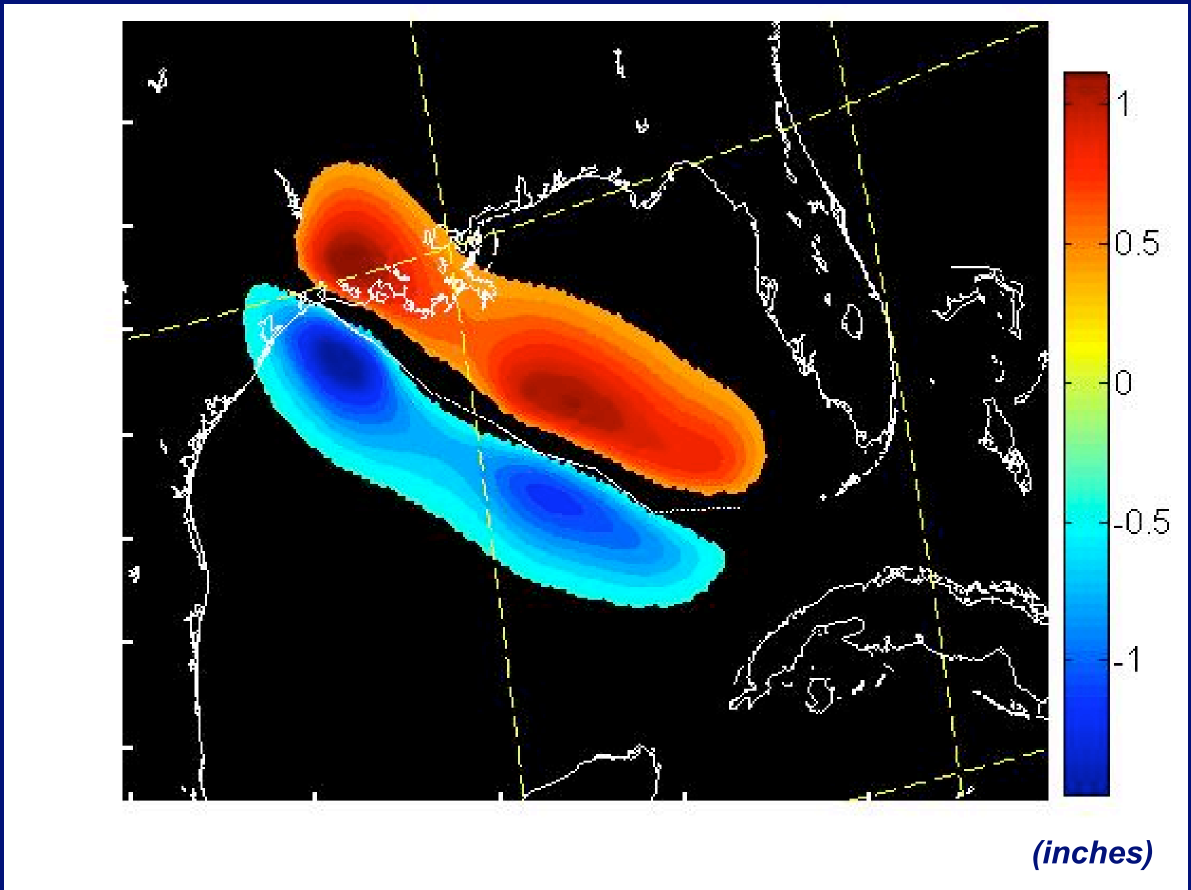


06 UTC 09/23/2004

The Footprint is “stamped” on a lon/lat grid every 15 minutes, providing a storm total accumulation

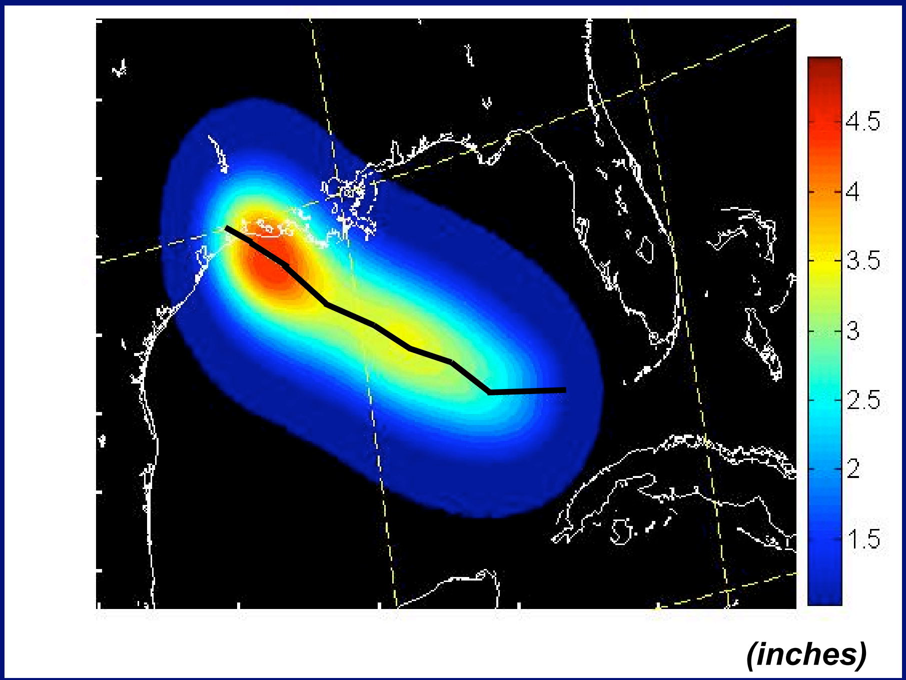
Impact of shear on accumulated rain

Only Wave numbers 1,2 included

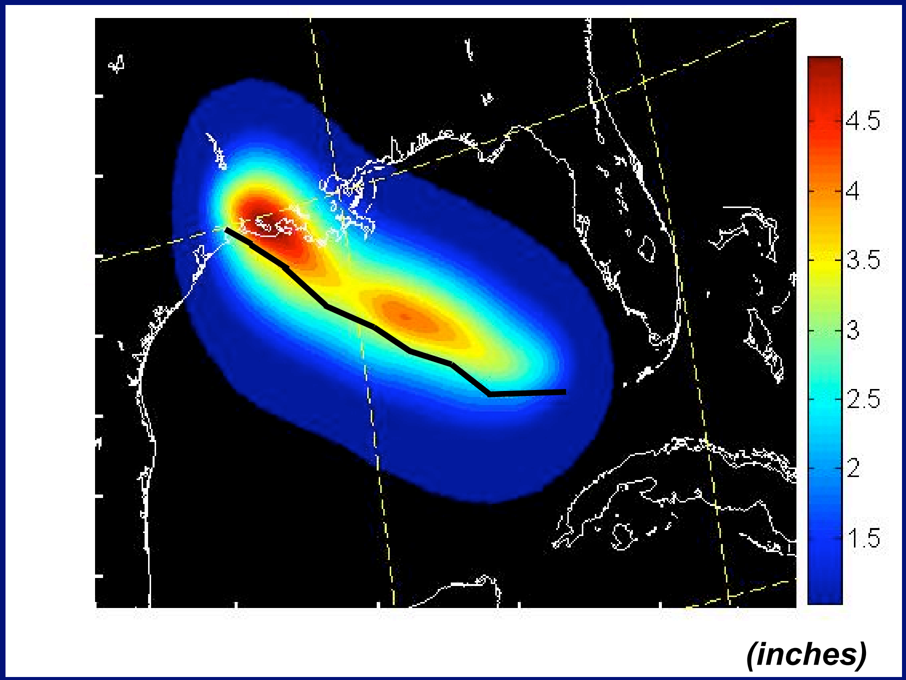


Impact of shear on total accumulated rain

Ivan – R-CLIPER control run



Ivan – R-CLIPER run including shear



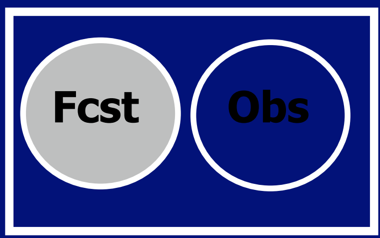
QPF Equitable Threat Score

$$ETS = \frac{H - \textit{chance}}{F + O - H - \textit{chance}}$$

Where H = "Hit" area

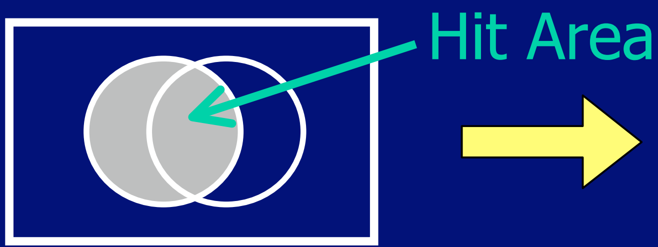
F = Forecast rain area

O = Observed rain area



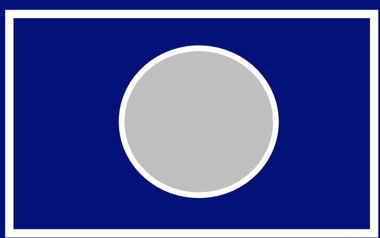
No overlap: Hit area = 0

ETS ~ 0



Hit area = _ Forecast area

ETS ~ 0.33



Hit area = Forecast area

ETS = 1.0