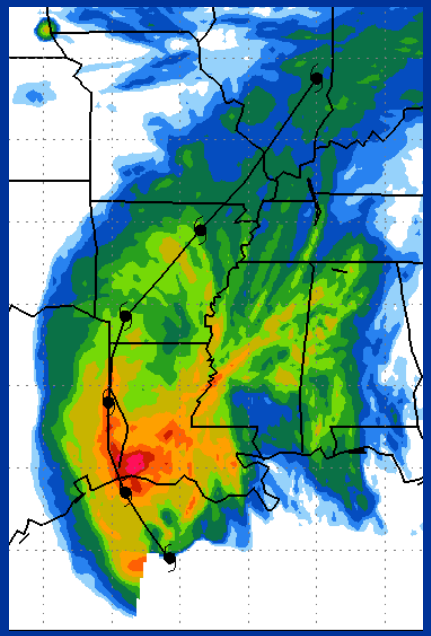
Verification of model wind structure and rainfall forecasts for 2008 Atlantic storms



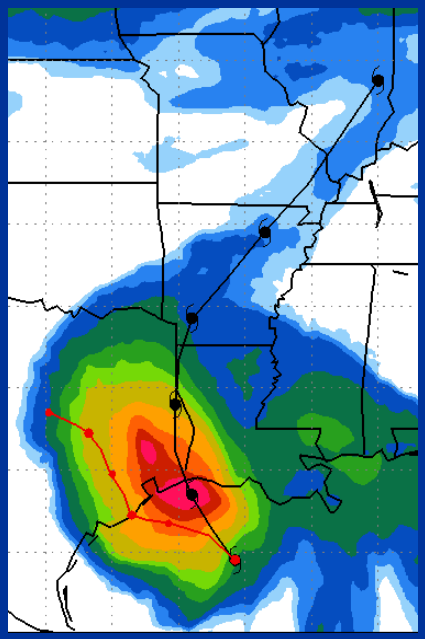
Tim Marchok

NOAA / GFDL

HFIP Hurricane Diagnostics and Verification Workshop

NHC, Miami, FL

04 May 2009



Collaborators: Rob Rogers (NOAA / AOML / HRD)

Bob Tuleya (NCEP/EMC & Old Dominion Univ.)

Mark Powell (NOAA / AOML / HRD)

Motivation

- Inland flooding from TC rainfall accounts for a significant percentage of deaths from U.S. landfalling TCs.

- Storm size / structure has a major impact on the amount of damage at landfall.

…both aspects have only recently begun to receive attention in terms of model evaluation

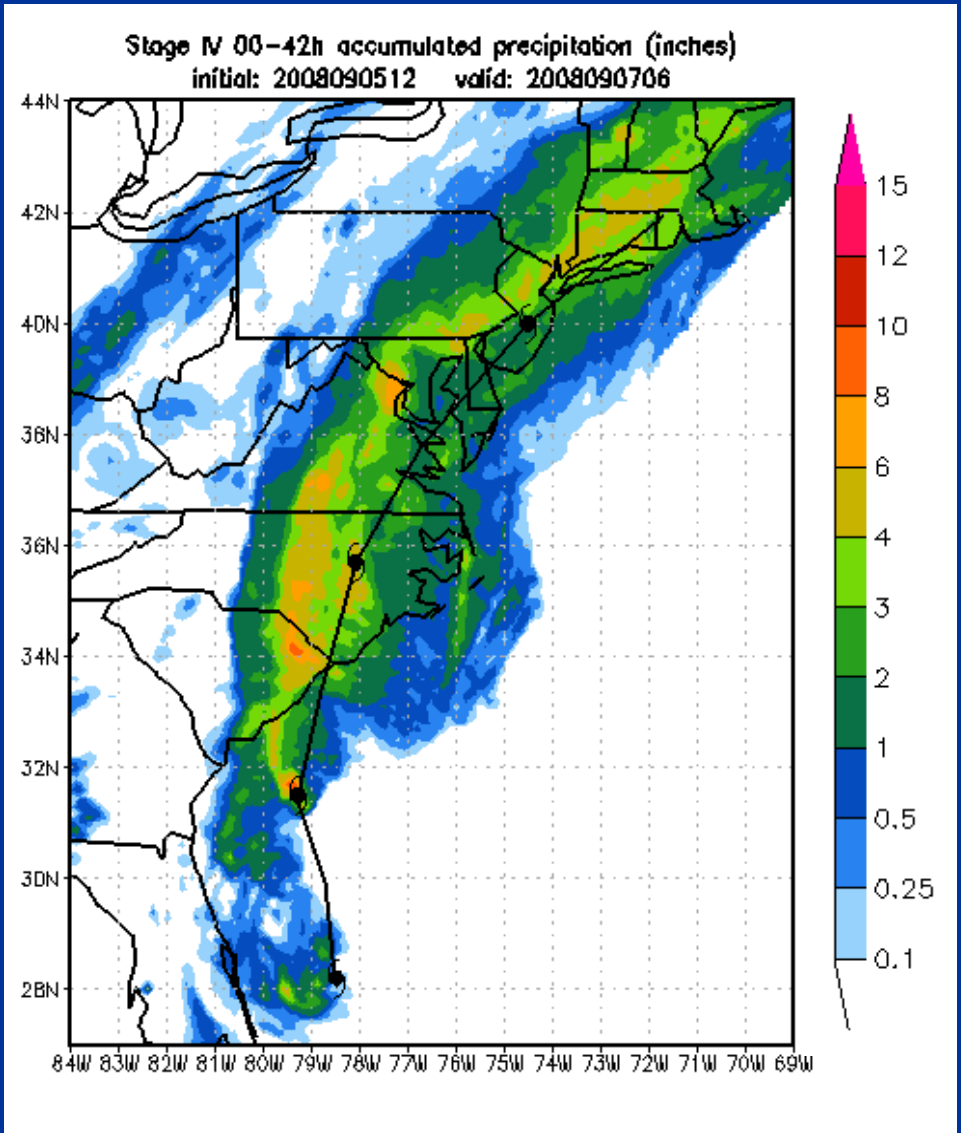
Outline

- Rainfall validation & techniques
- Application of TC QPF validation techniques to 2008 U.S. landfalling storms
- Development of model wind structure validation techniques
- Application of wind structure validation techniques to 2008 Atlantic TCs

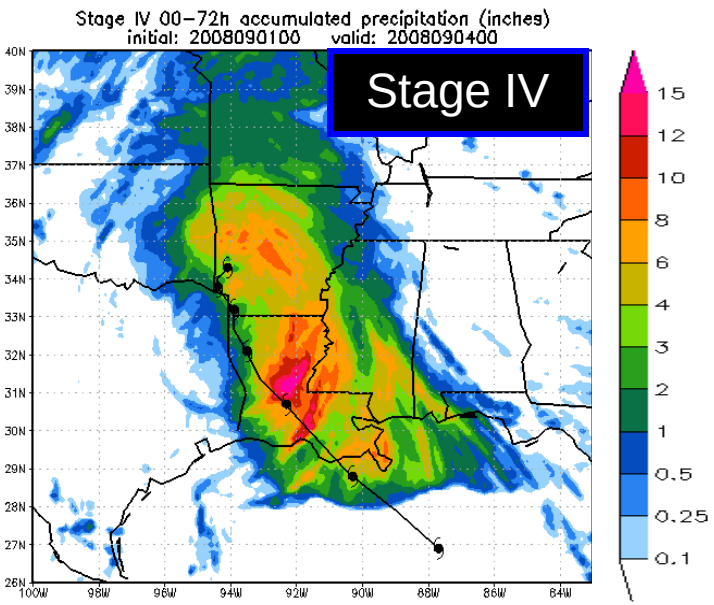
Rainfall validation: What to focus on?

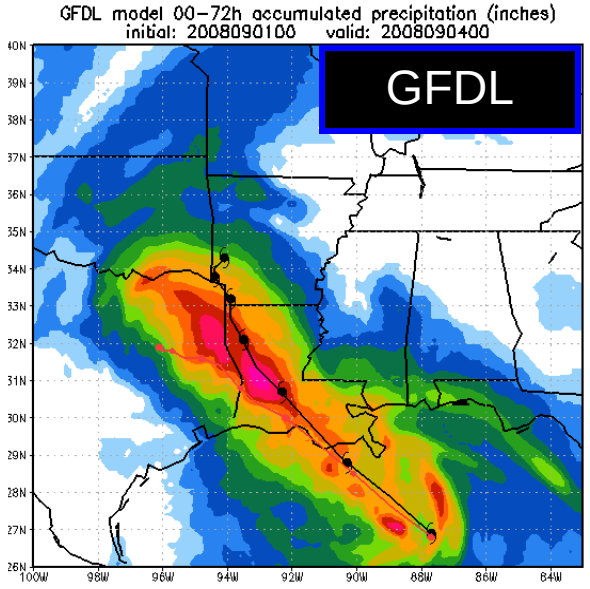
- Rainfall patterns
- Rainfall mean & volume
- Extreme amounts

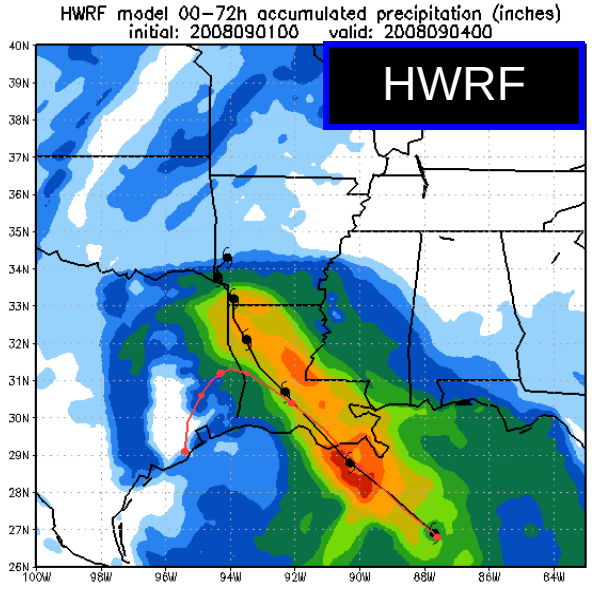
The TC track: An anchor for QPF validation

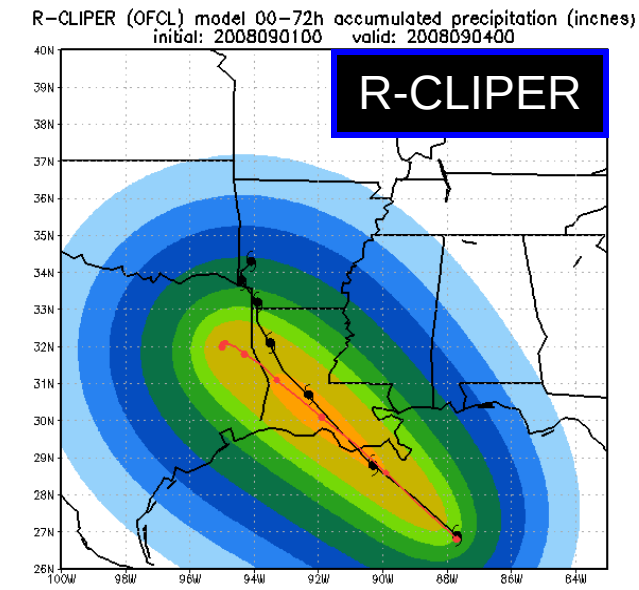


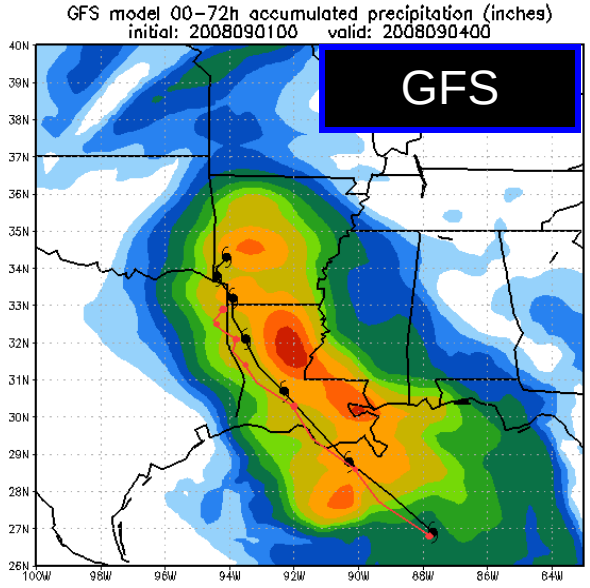
Example: Hurricane Gustav 72-h total rainfall

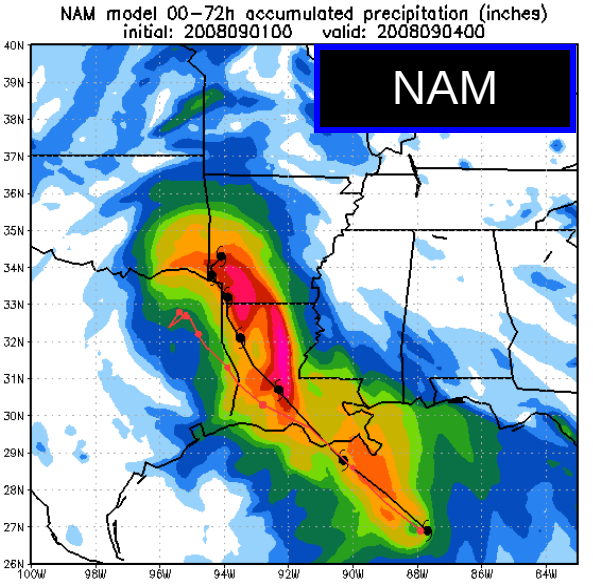




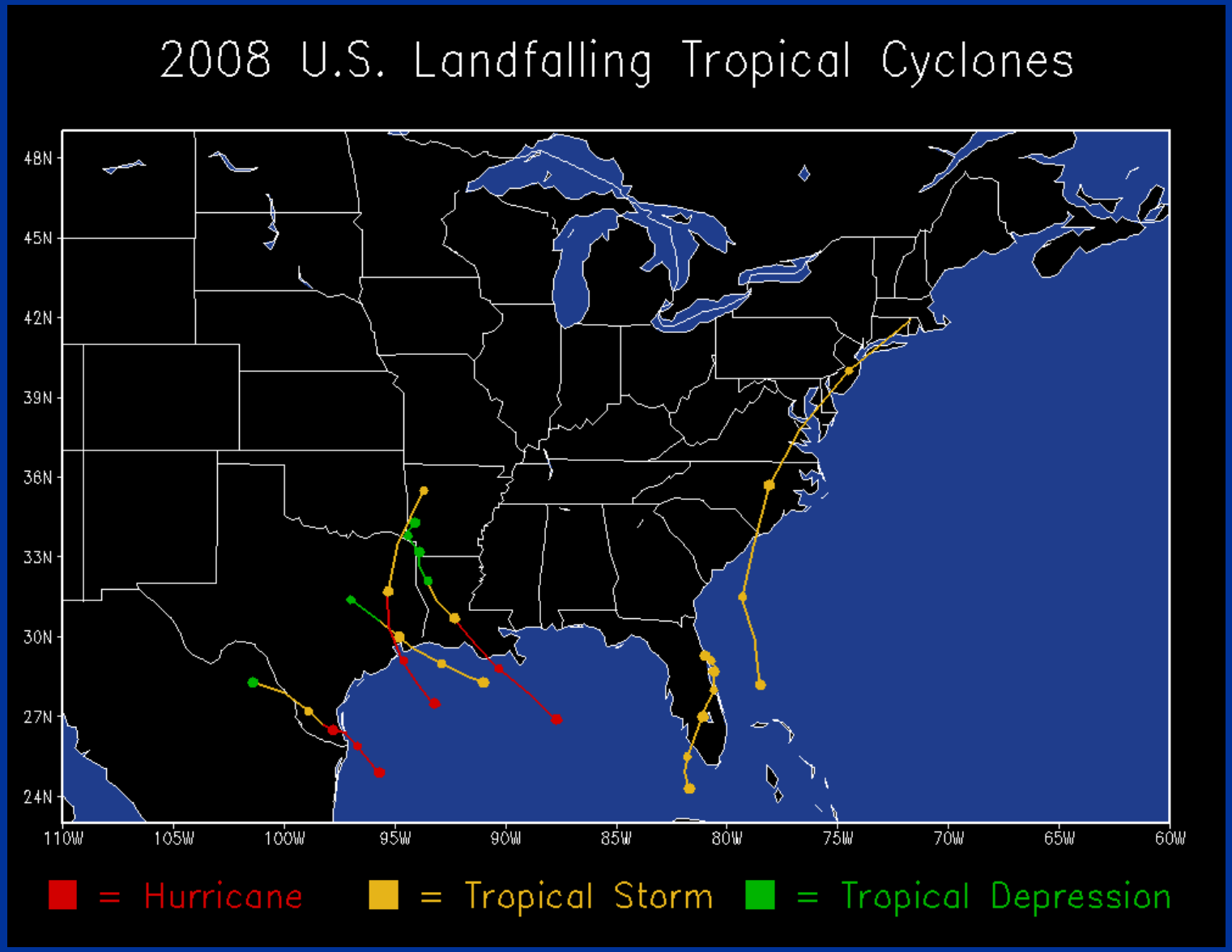








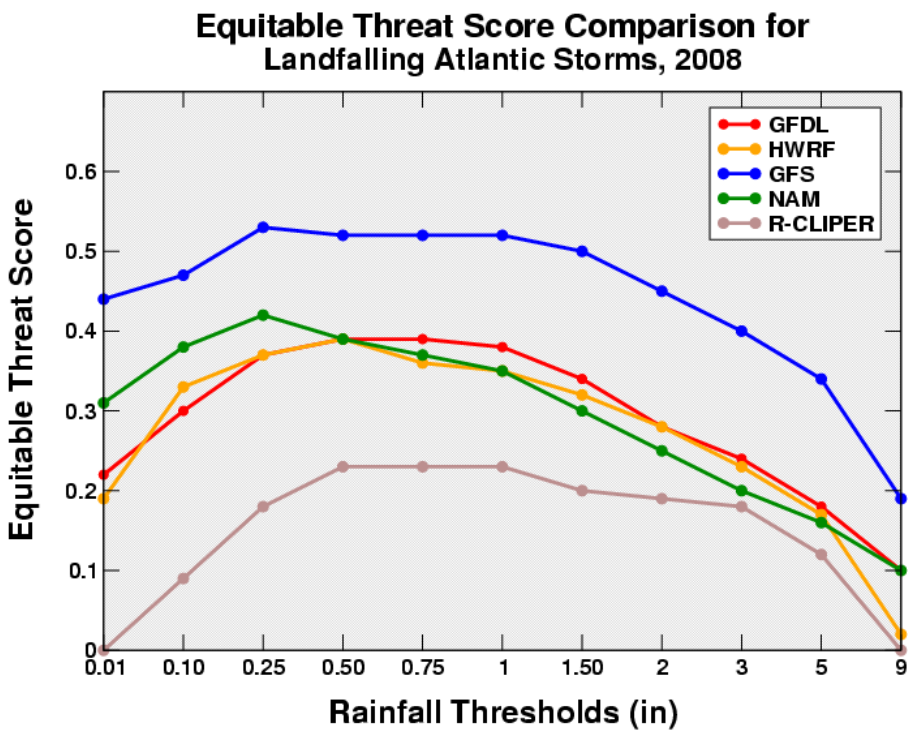
2008 Landfalling Storms



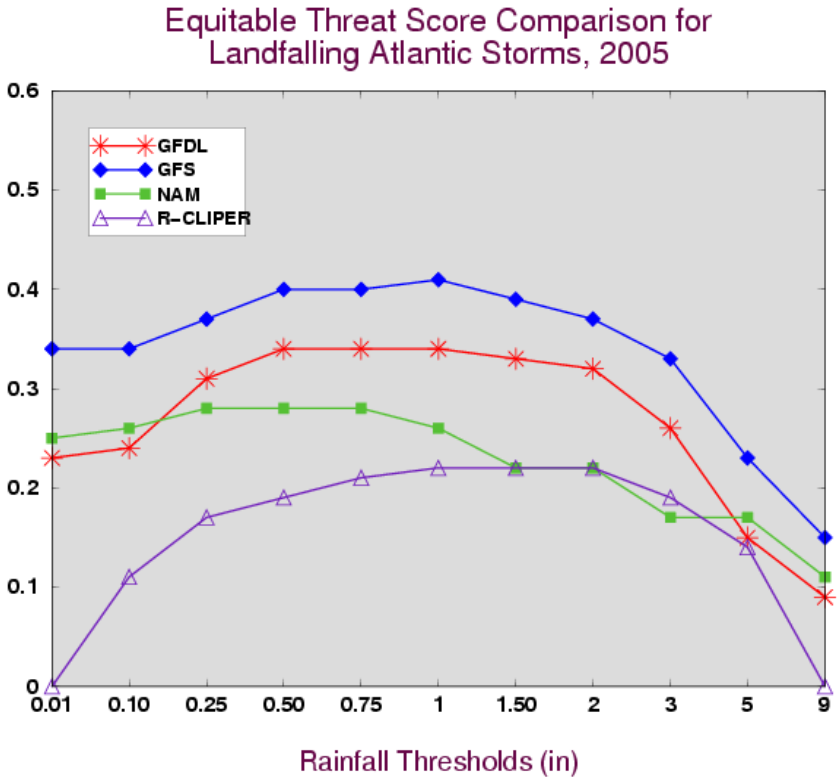
Rainfall Patterns

Equitable Threat Scores

2008



2005



Pattern Correlations: (2008)

GFS (r = 0.78)

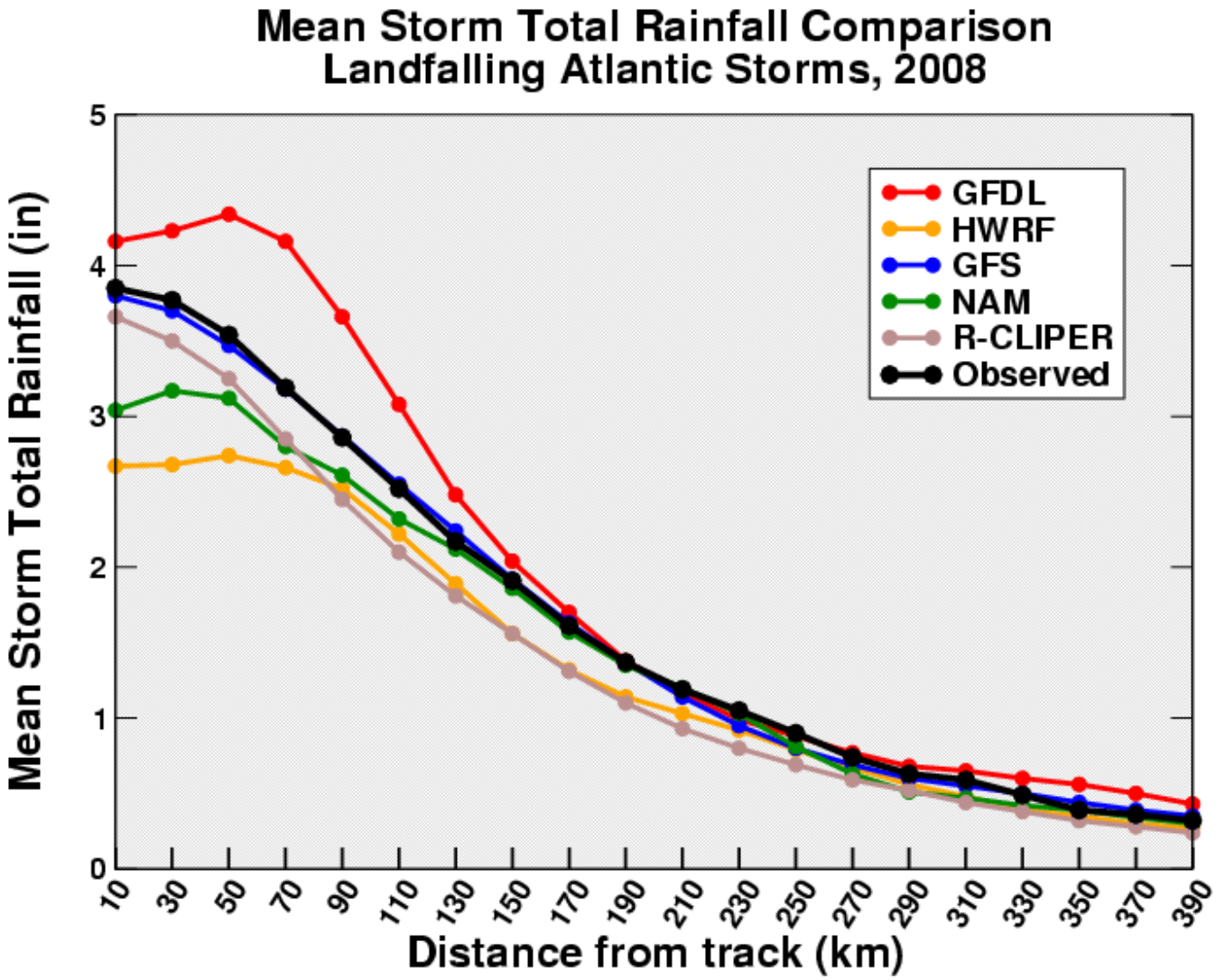
HWRF (r = 0.60)

GFDL (r = 0.53)

NAM (r = 0.52)

R-CLIPER (r = 0.51)

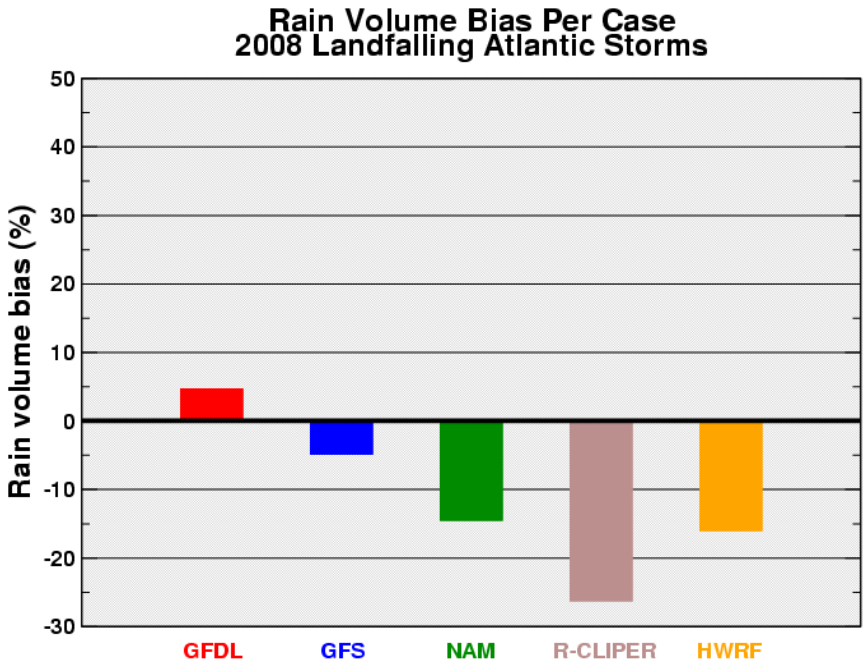
Mean Rainfall



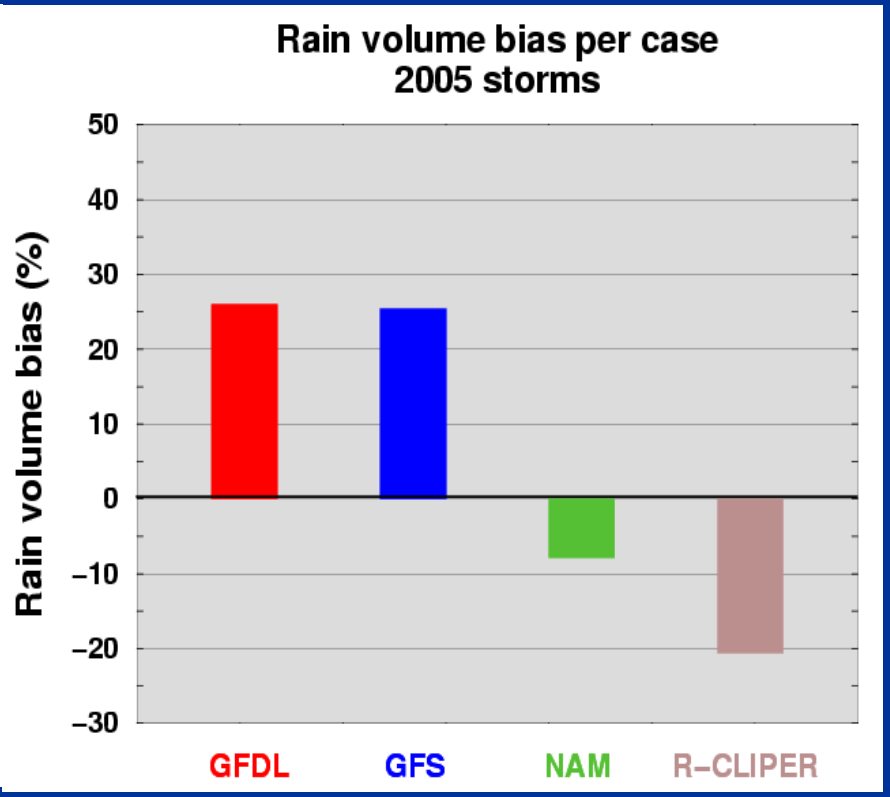
Rainfall volume

Comparison of rain volume bias by model

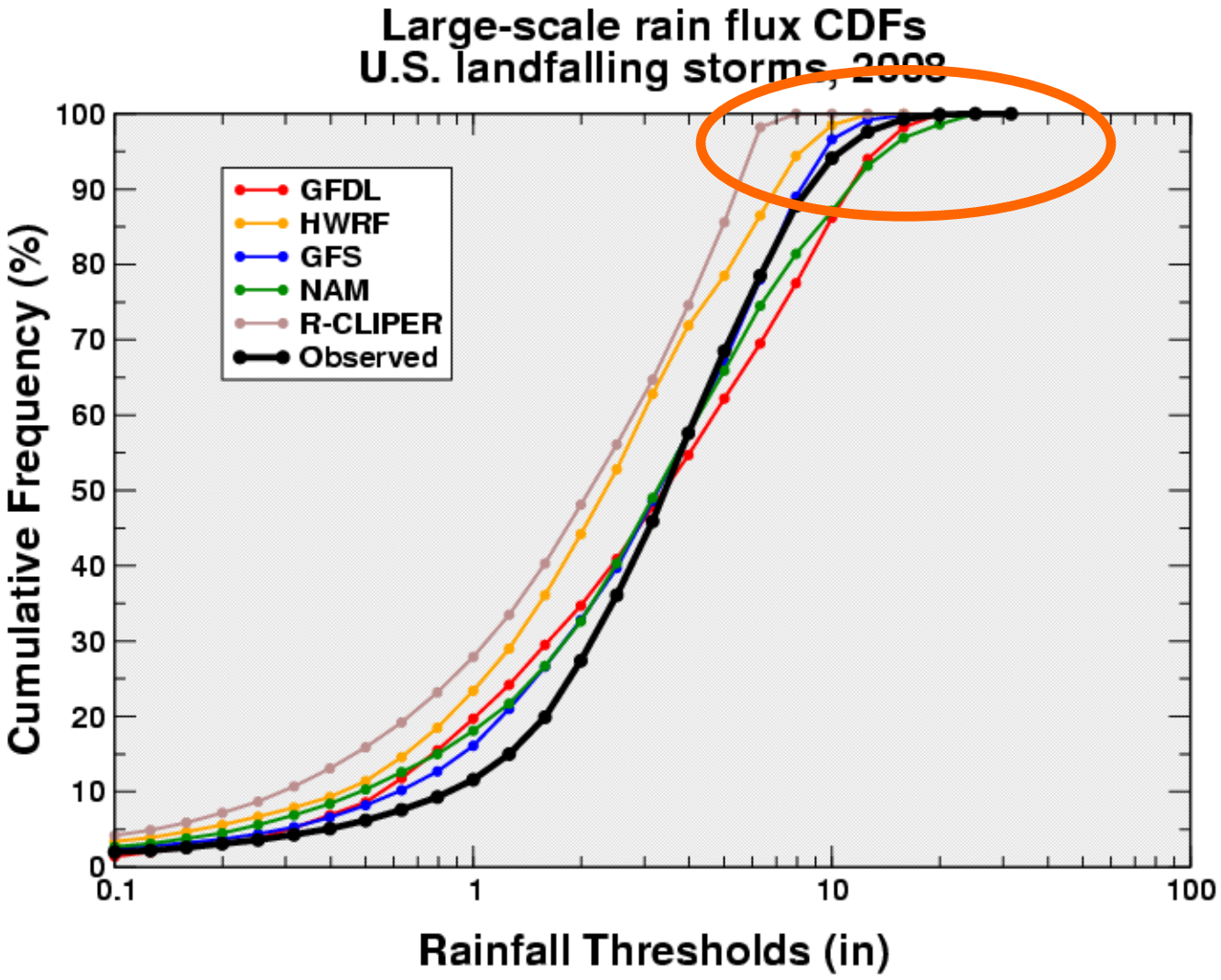
2008



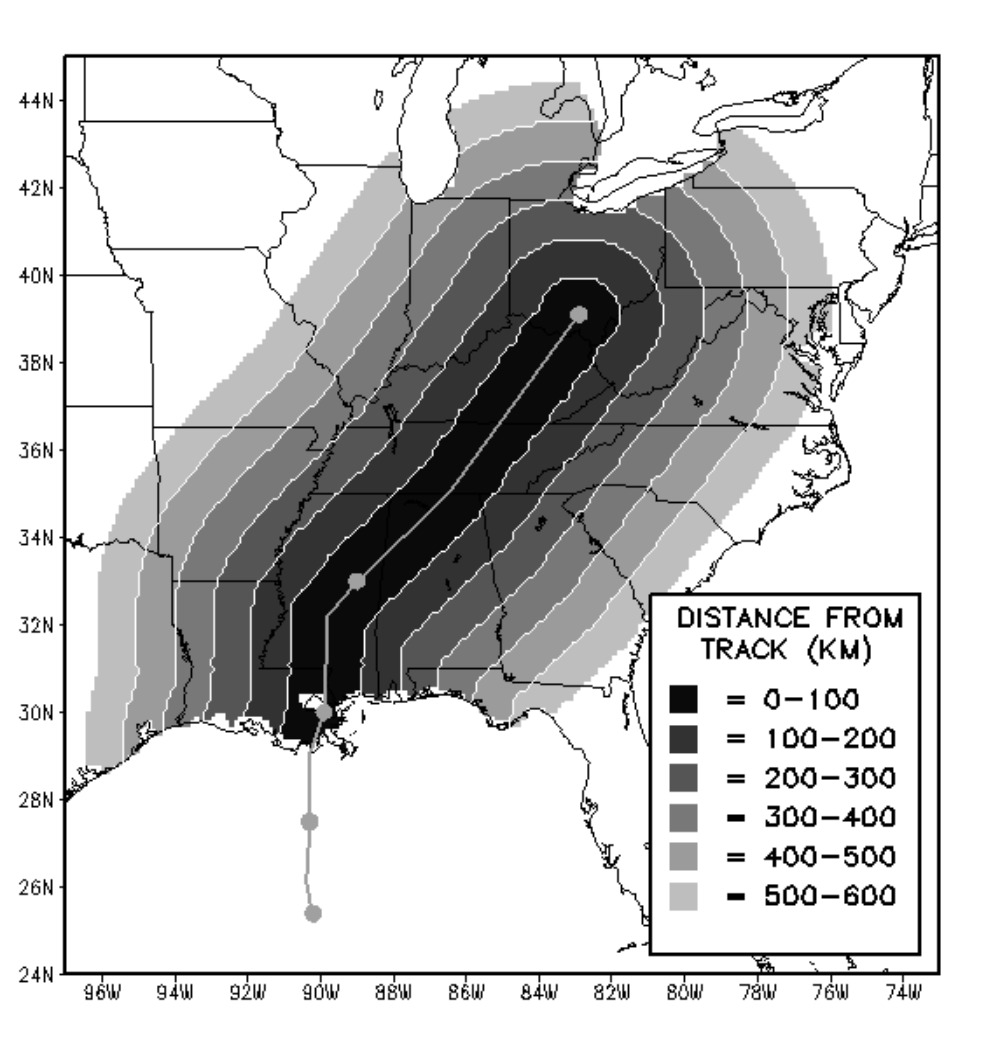
2005



2008 Landfalling Storms



Track-relative rain flux analyses

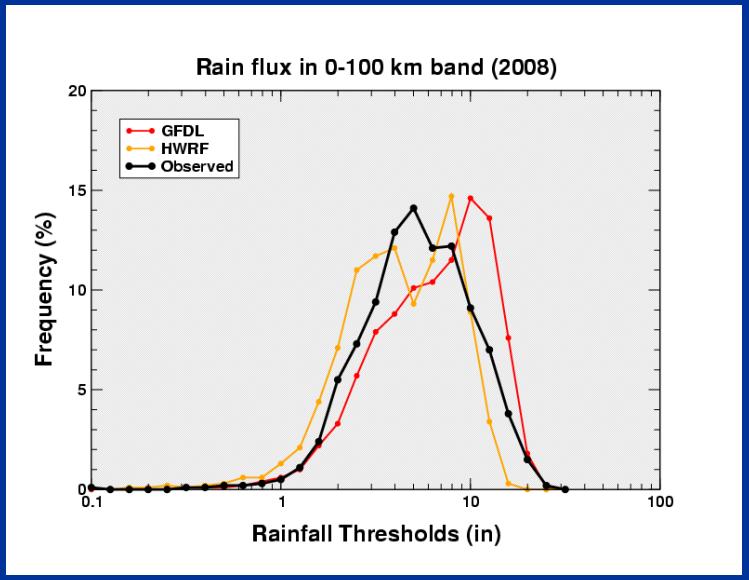


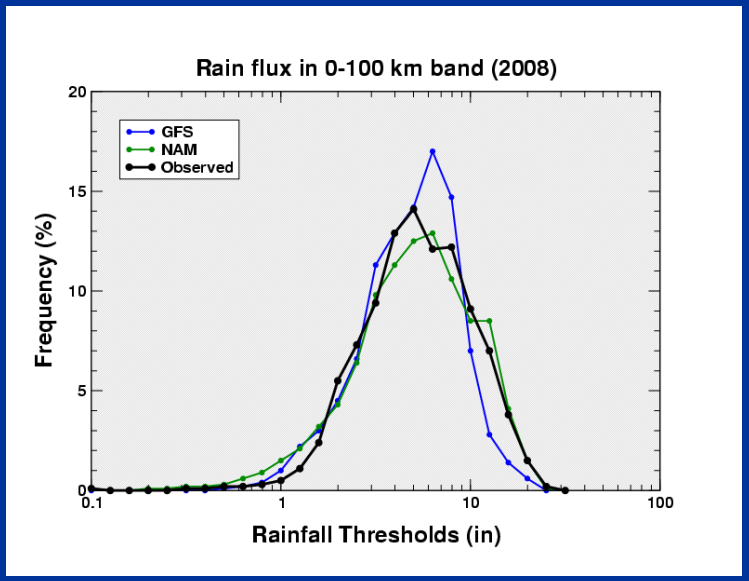
Rain volume: Rain flux in select bands

GFDL, HWRF

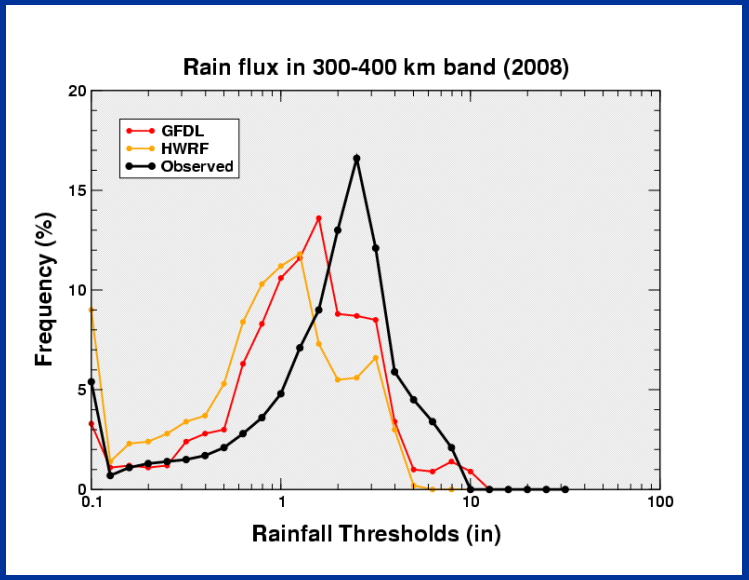
GFS, NAM

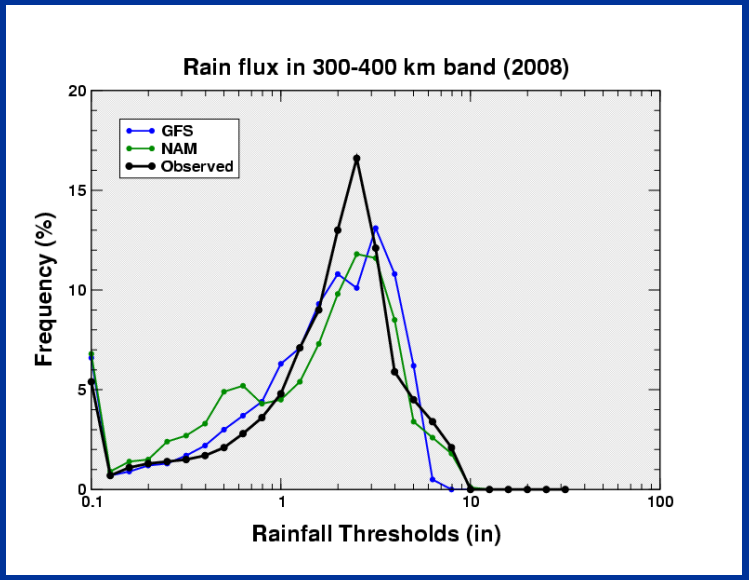
0–100 km





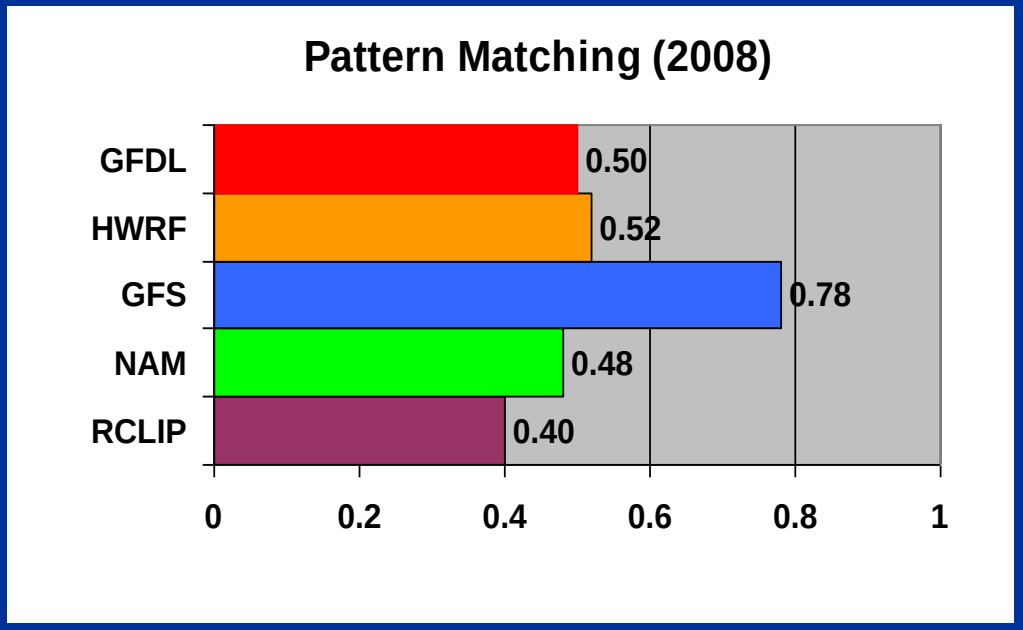
300-400 km



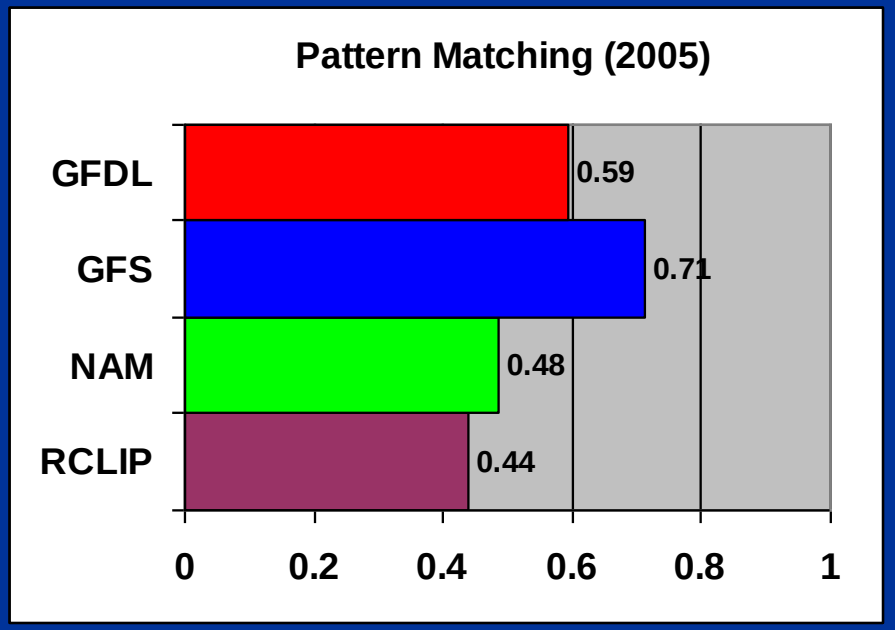


Skill Indices: Pattern Matching

2008



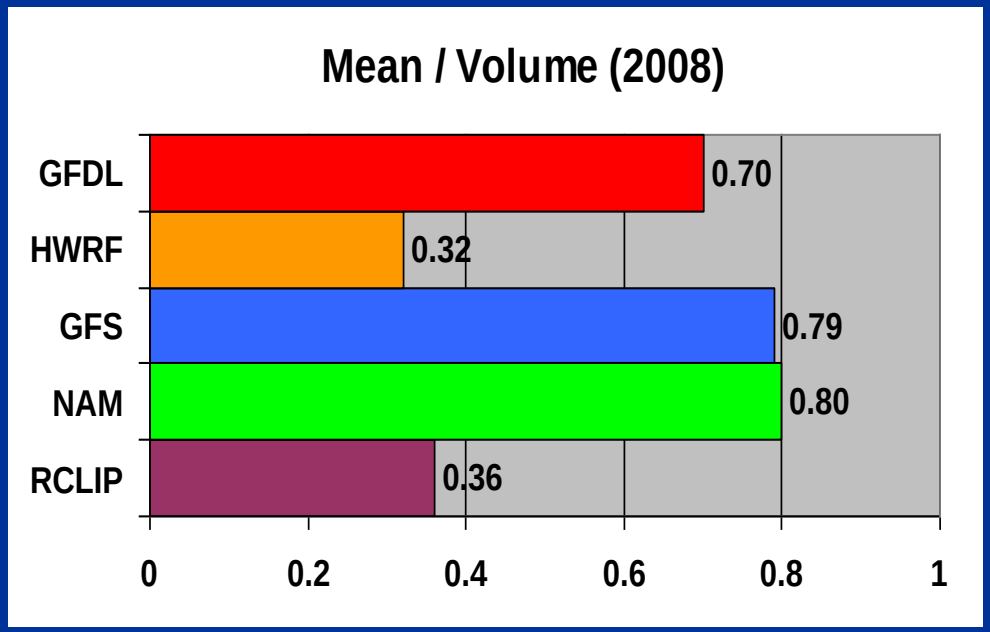
2005



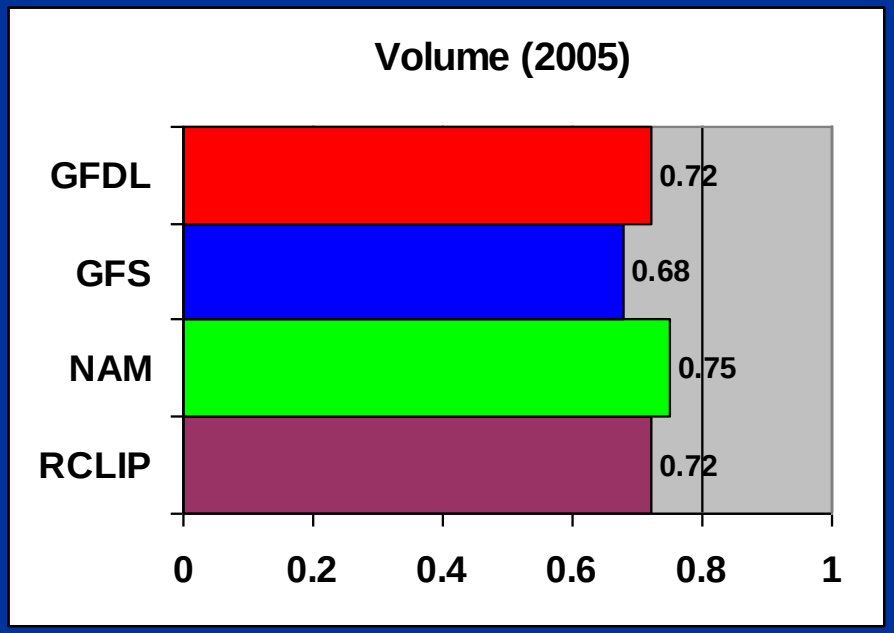
- GFS performs the best in both samples
- All models have skill relative to R-CLIPER

Skill Indices: Mean / Volume

2008

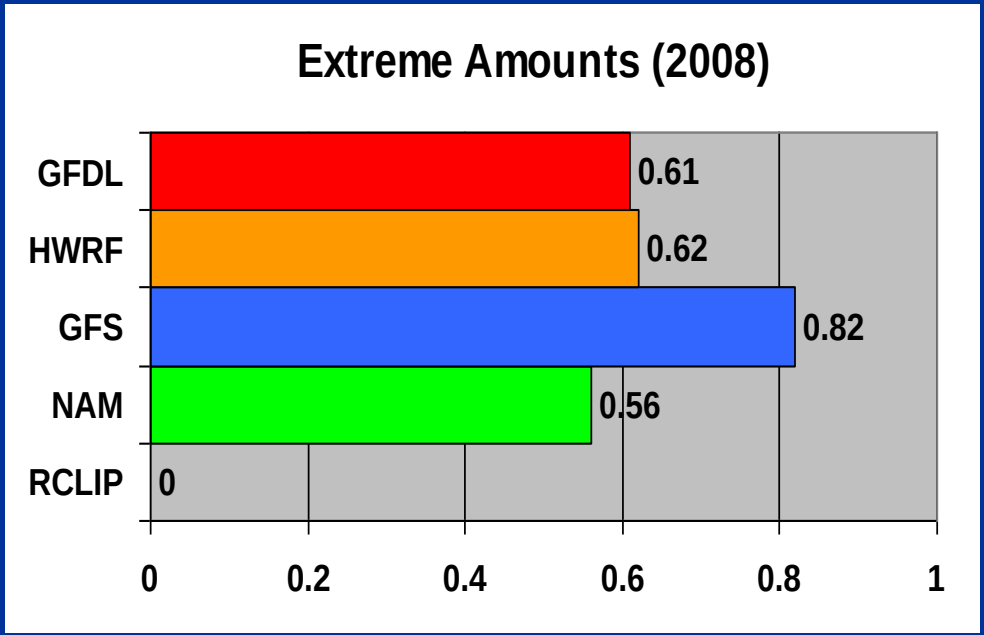


2005

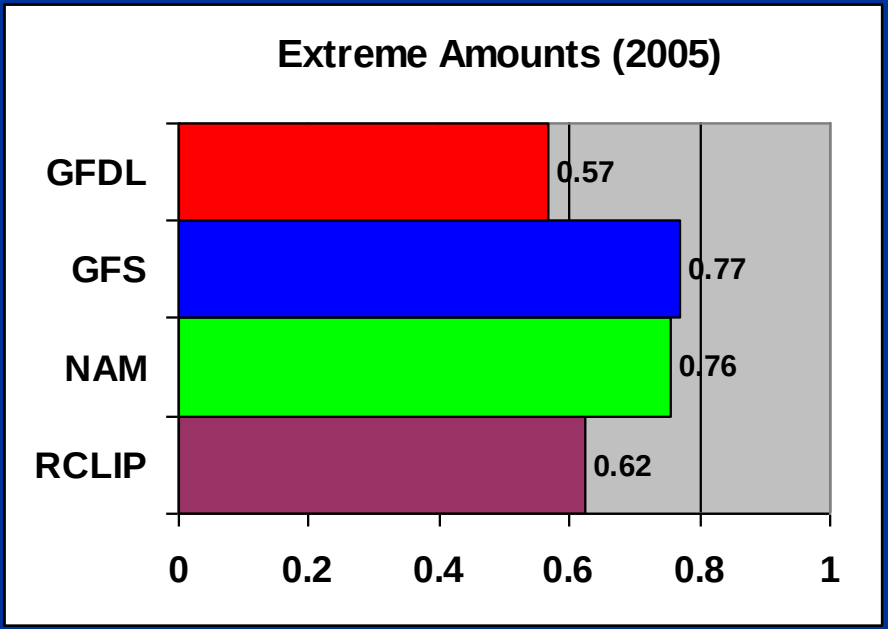


Skill Indices: Extreme Amounts

2008



2005



- GFDL overforecasts the large amounts, HWRF underforecasts them, resulting in comparable indices
- GFS performs best despite lowest resolution

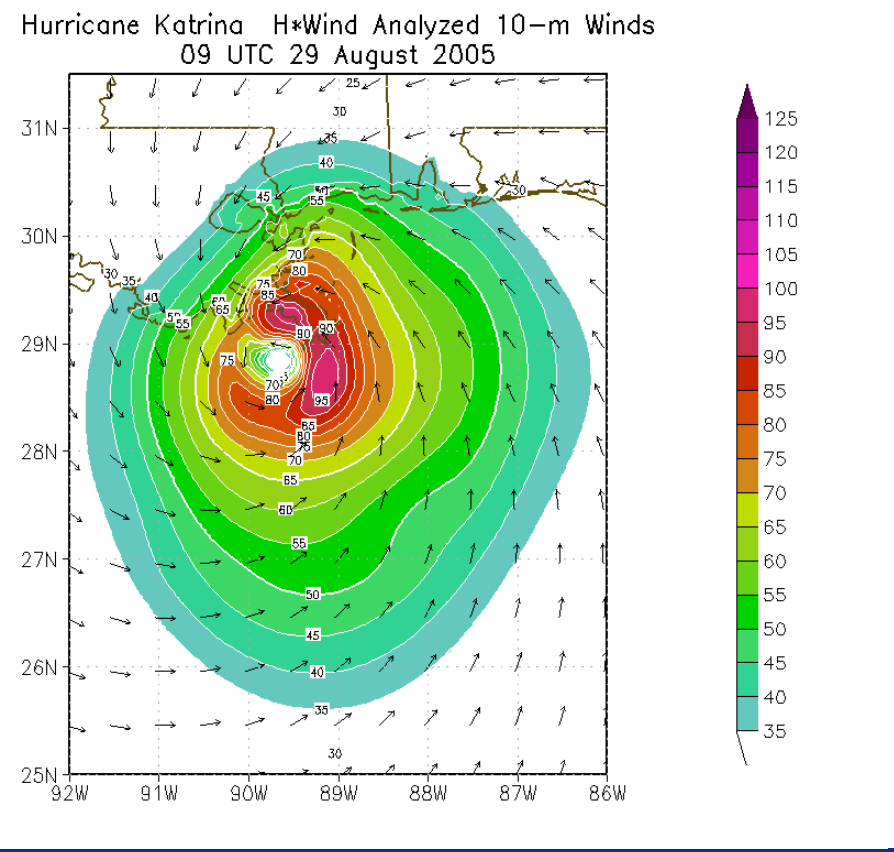
Rainfall Summary

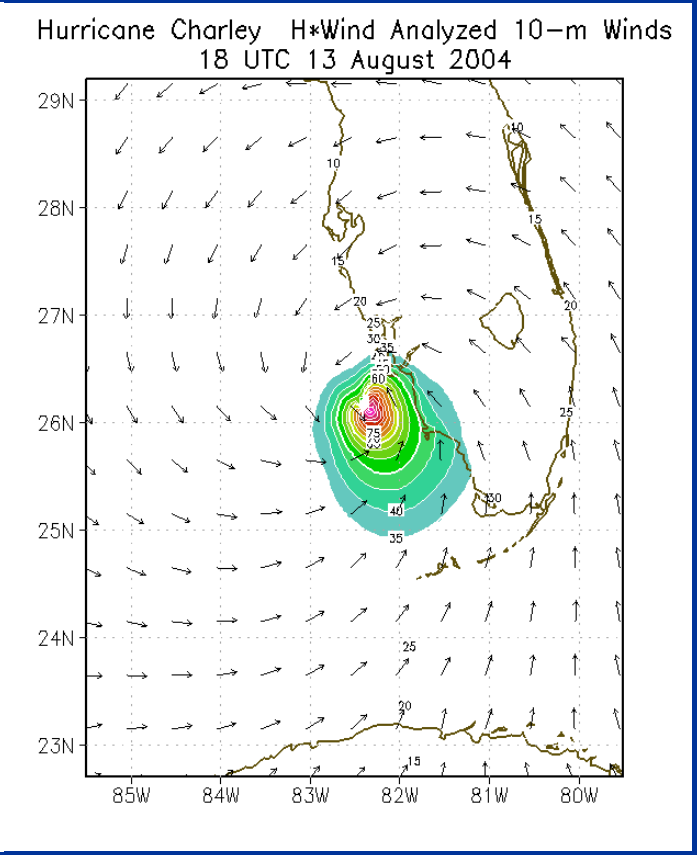
- Validation techniques address unique TC rainfall attributes:
  - Pattern matching
  - Rainfall volume
  - Extreme amounts
- TC QPF skill indices for operational forecast evaluation
- GFS most skillful in 2008 (similar to 2005)

Outline

- Rainfall validation & techniques
- Application of TC QPF validation techniques to 2008 U.S. landfalling storms
- Development of model wind structure validation techniques
- Application of wind structure validation techniques to 2008 Atlantic TCs

The importance of near-surface wind structure

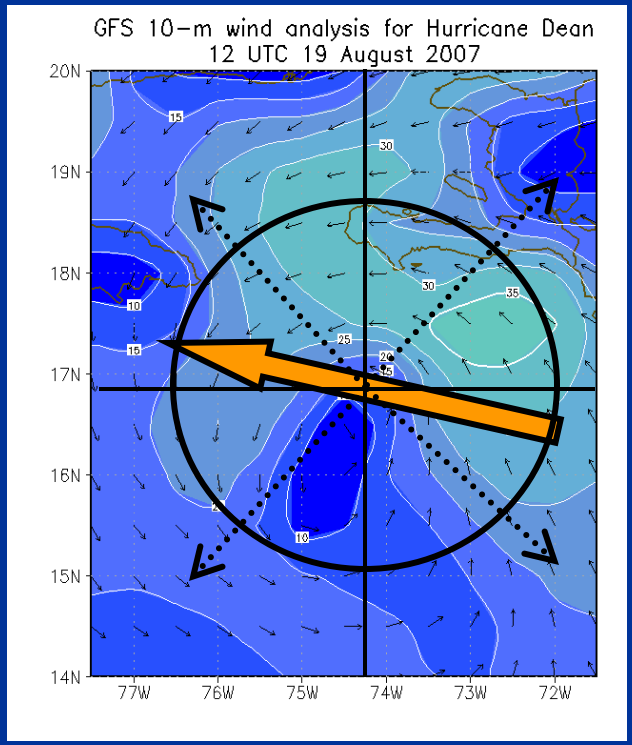




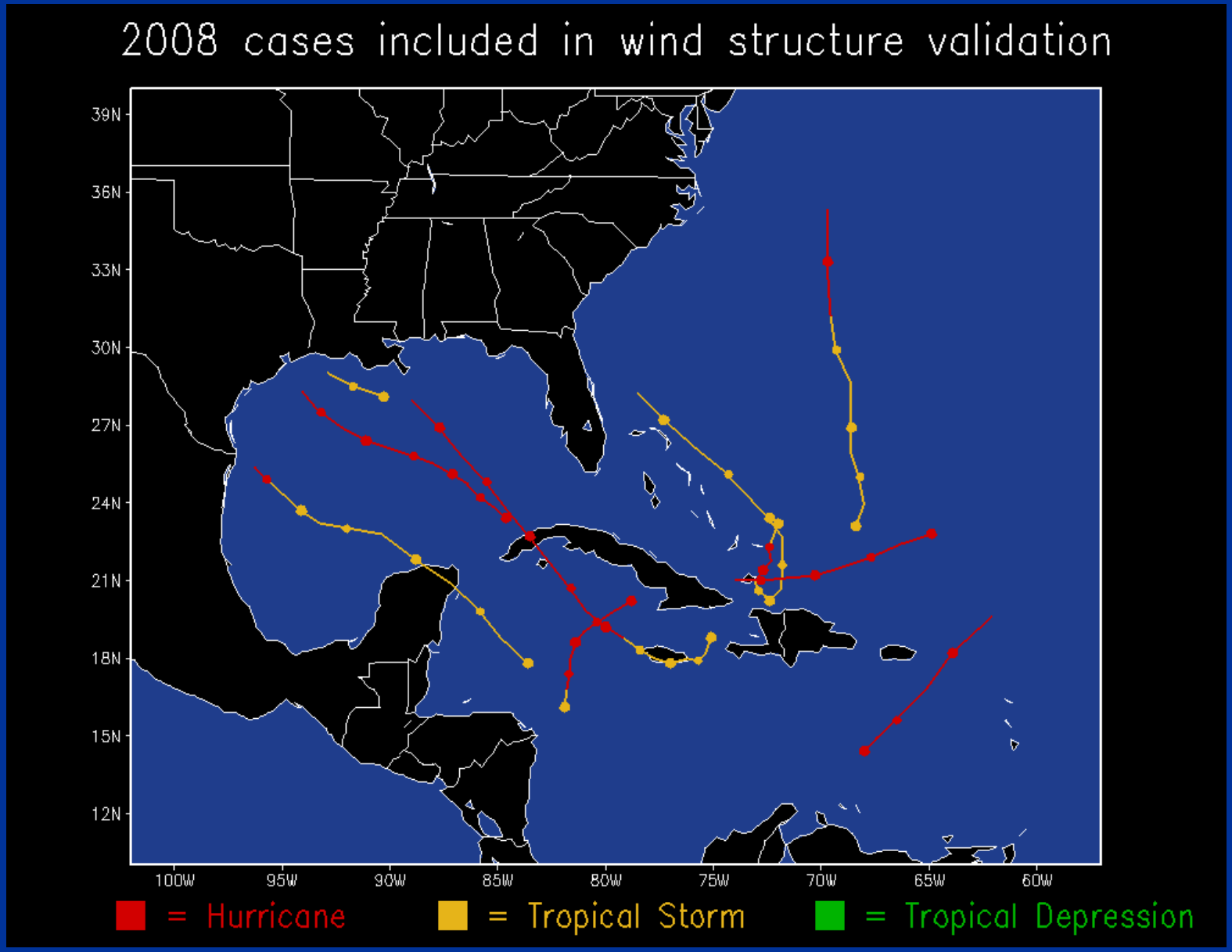
$$\frac{\text{Area\_TS}_{\text{Katrina}}}{\text{Area\_TS}_{\text{Charley}}} = \text{Factor of 9}$$

Focus is on continuous / homogeneous methods

- Distribution of Winds
  - Fractional areal coverage
  - PDFs of the winds
- Radial Structure
  - Earth-relative profiles
  - Storm motion-relative profiles
  - Radius of max winds
- Storm Destructive Potential
  - IKE, SDP, WDP (Powell and Reinhold 2007)
- Others?



Cases included in study…

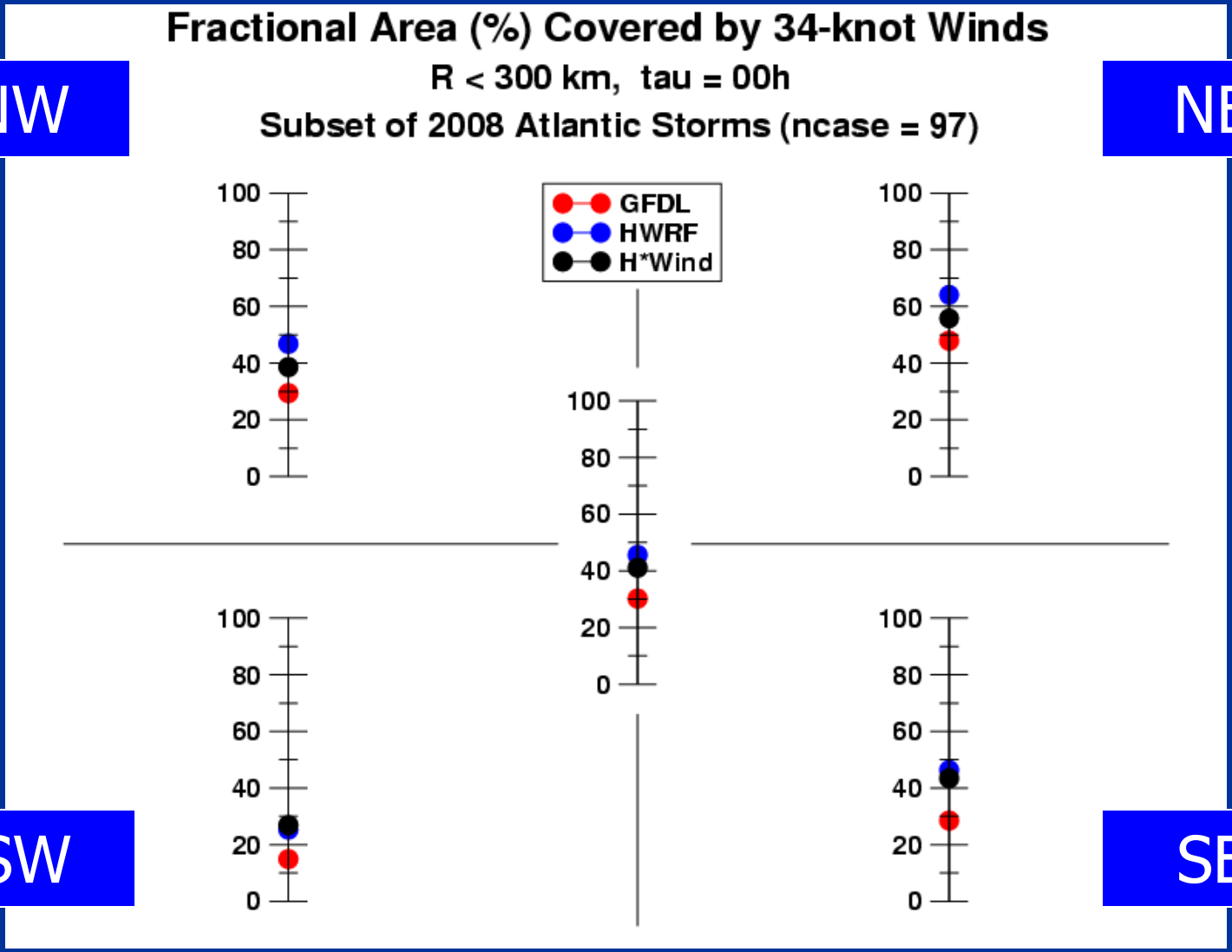


Distribution: Fractional Areal Coverage (34-kt winds)

NW

NE

Storm-sample average at tau=00h



SW

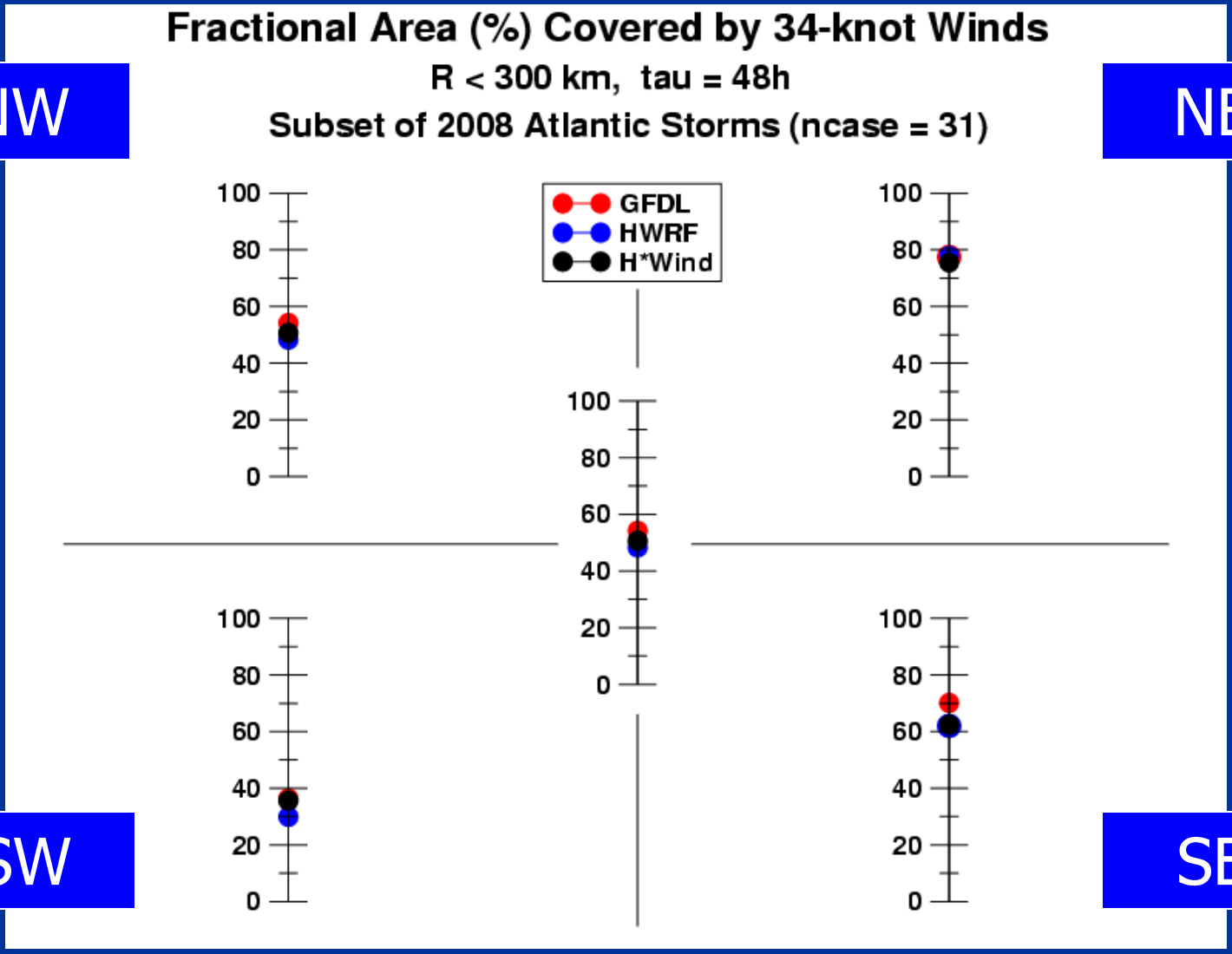
SE

Distribution: Fractional Areal Coverage (34-kt winds)

NW

NE

Storm-sample average at tau=48h



SW

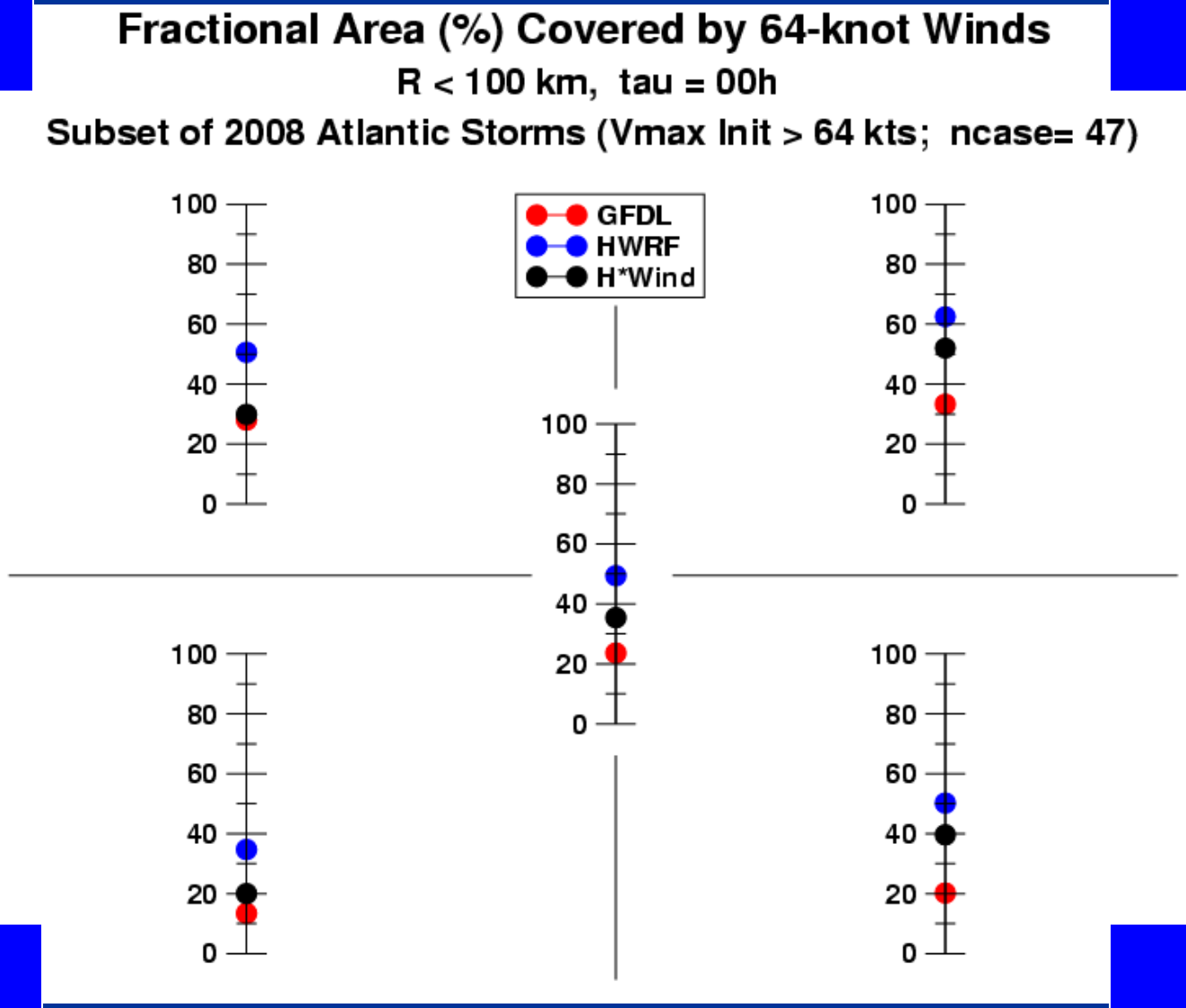
SE

Distribution: Fractional Areal Coverage (64-kt winds)

NW

NE

Storm-sample average at tau=00h



SW

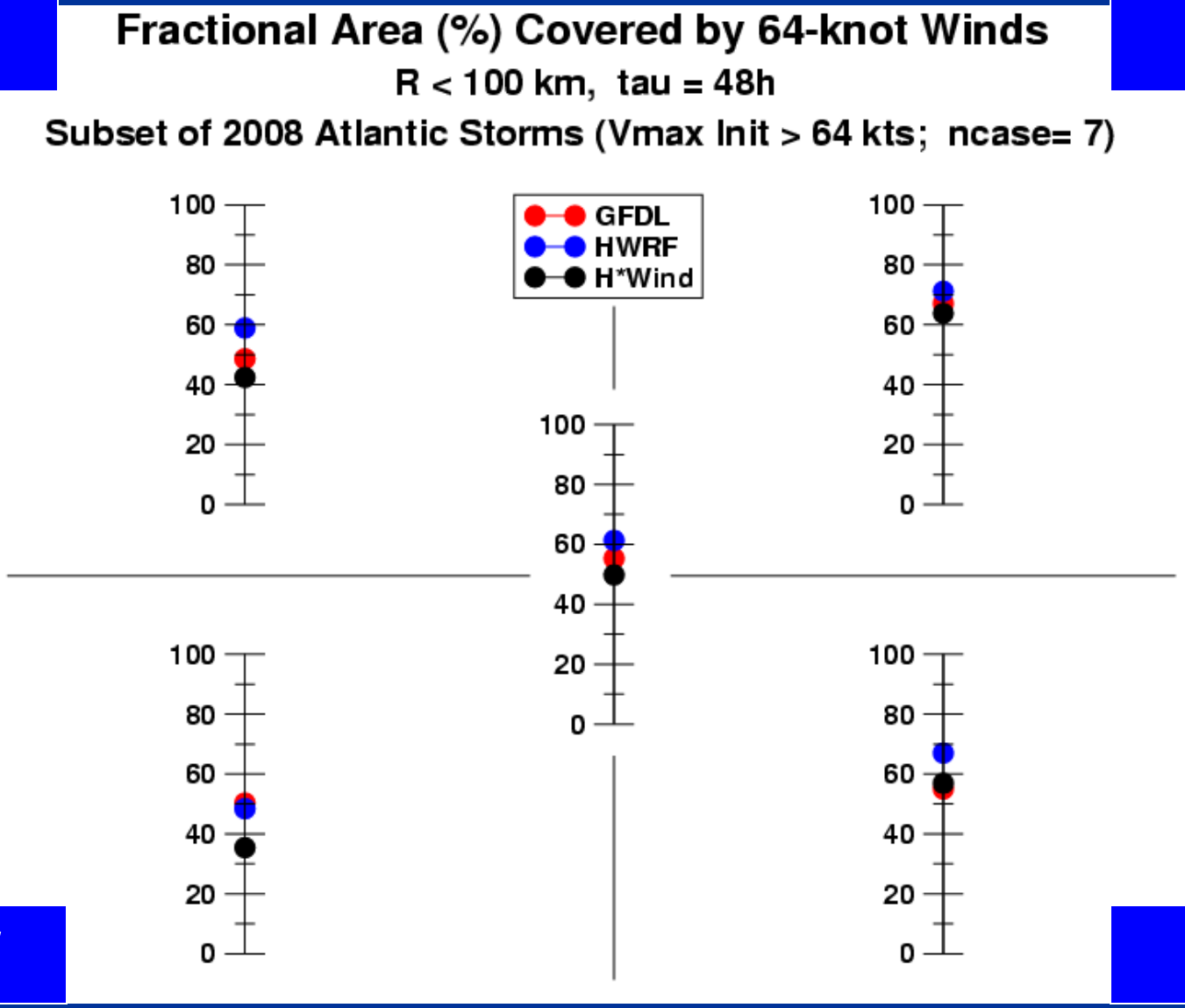
SE

Distribution: Fractional Areal Coverage (64-kt winds)

NW

NE

Storm-sample average at tau=48h



SW

SE

Radial profiles of the wind (all cases)

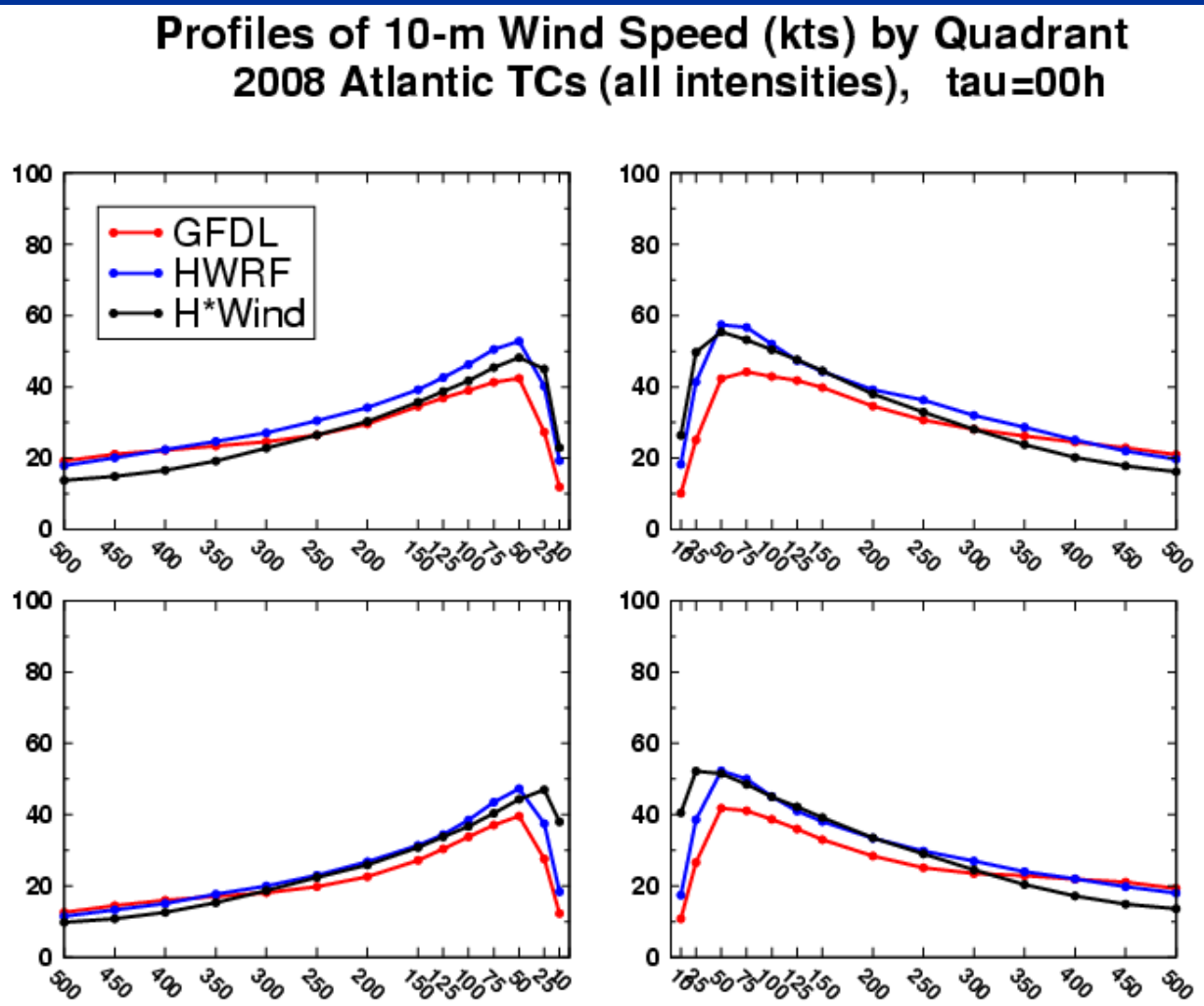
NW

NE

Tau= 00h

SW

SE

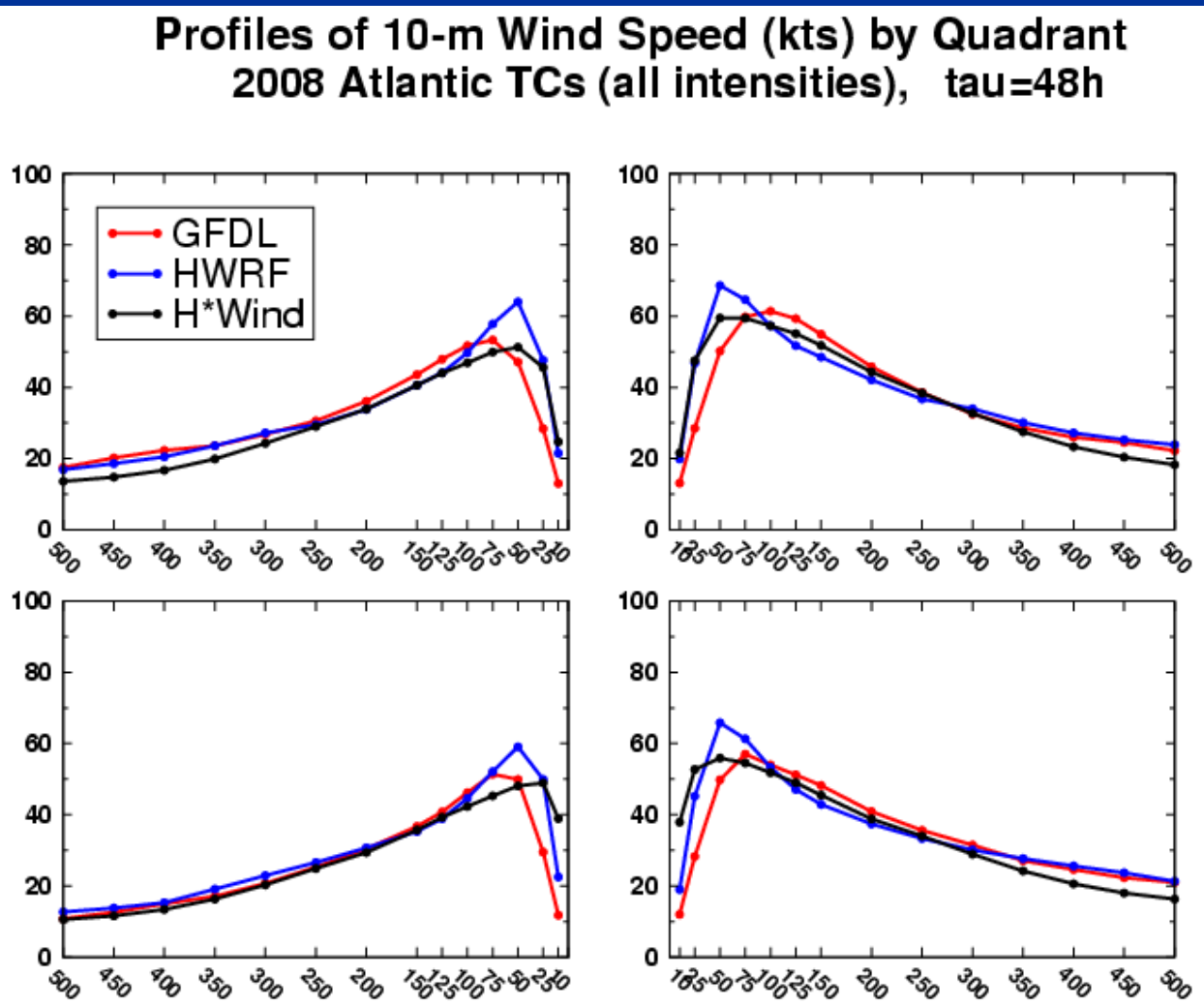


Radial profiles of the wind (all cases)

NW

NE

Tau= 48h



SW

SE

Radial profiles of the wind (Hurricanes only)

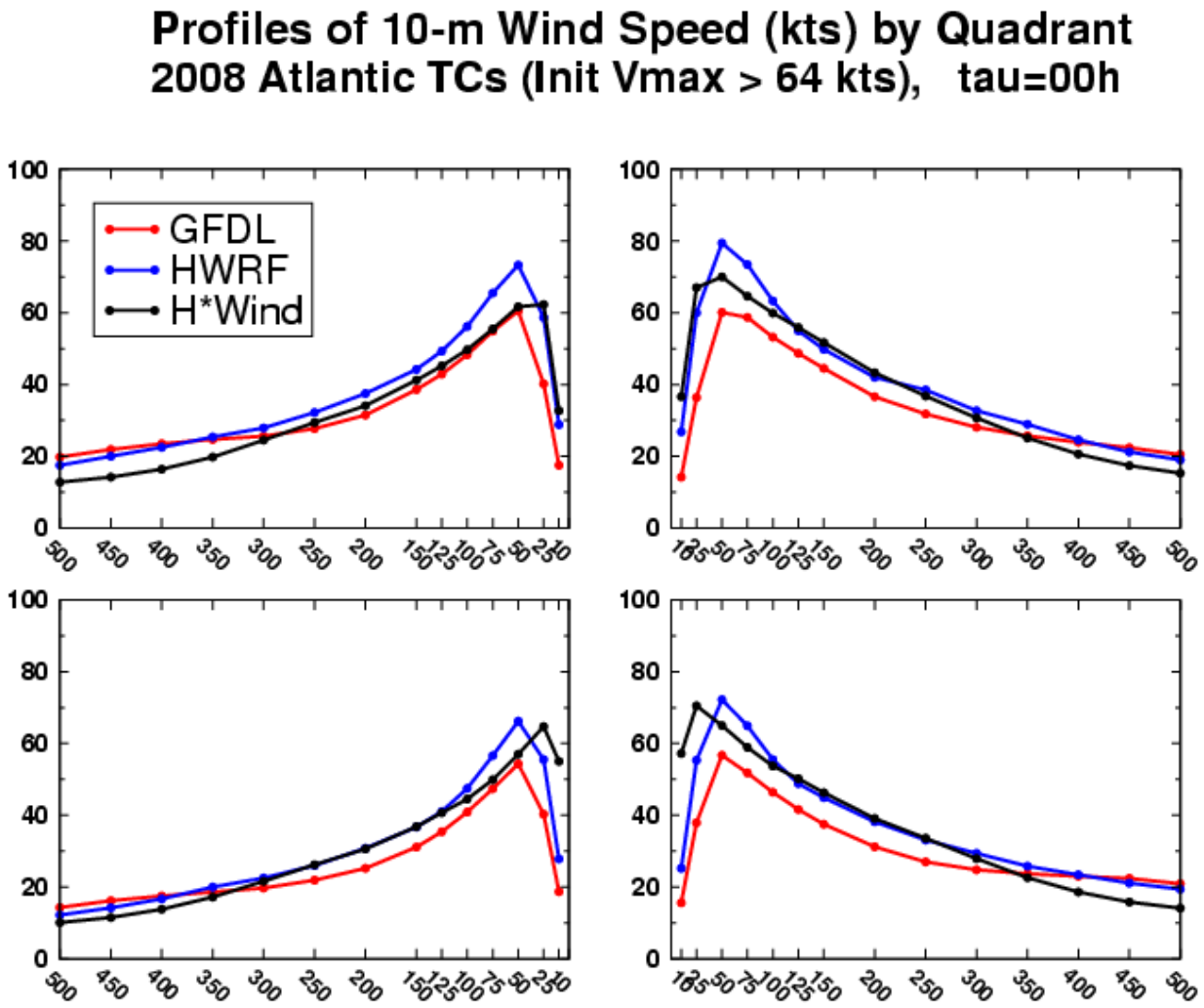
NW

NE

Tau= 00h

SW

SE

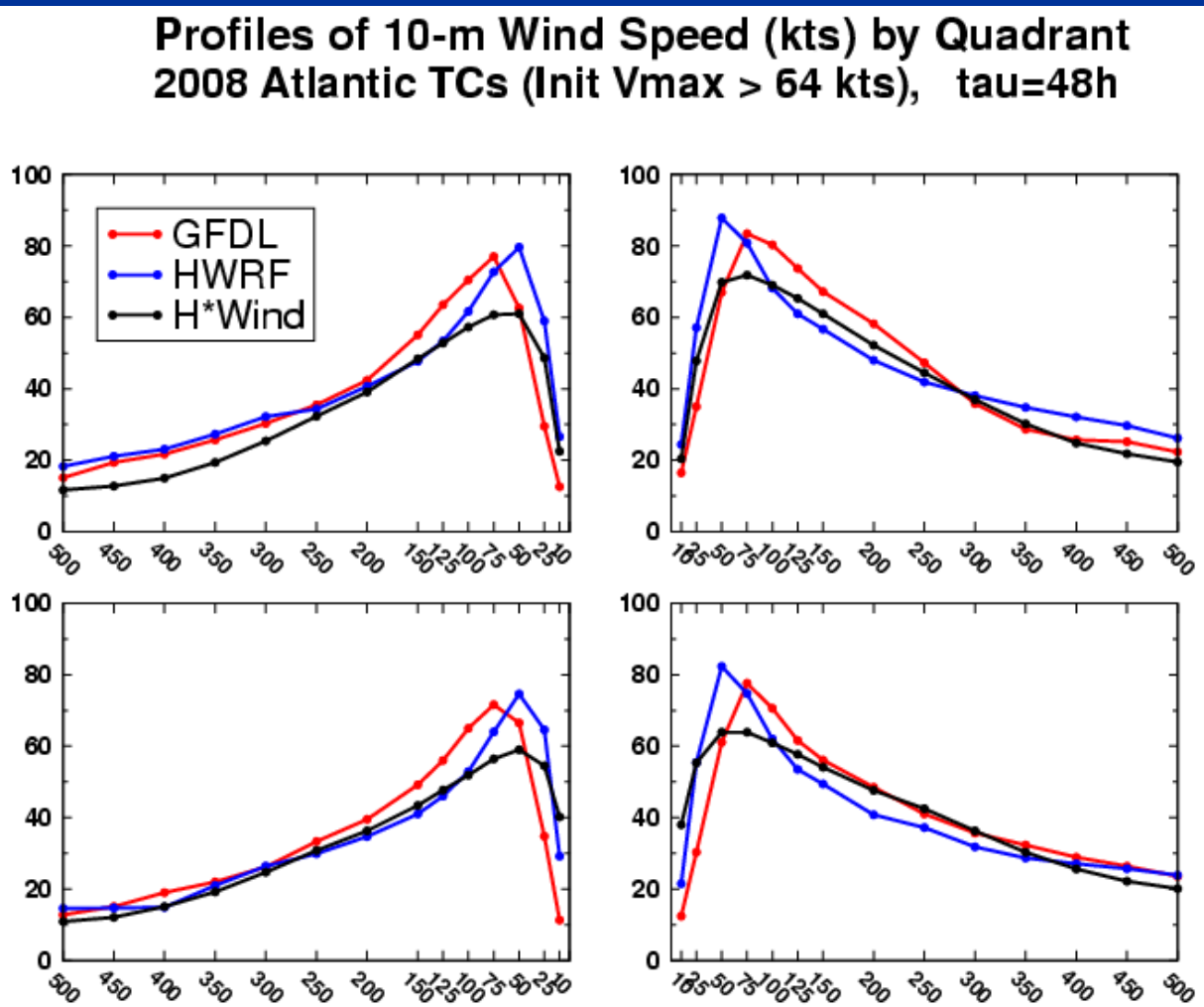


Radial profiles of the wind (Hurricanes only)

NW

NE

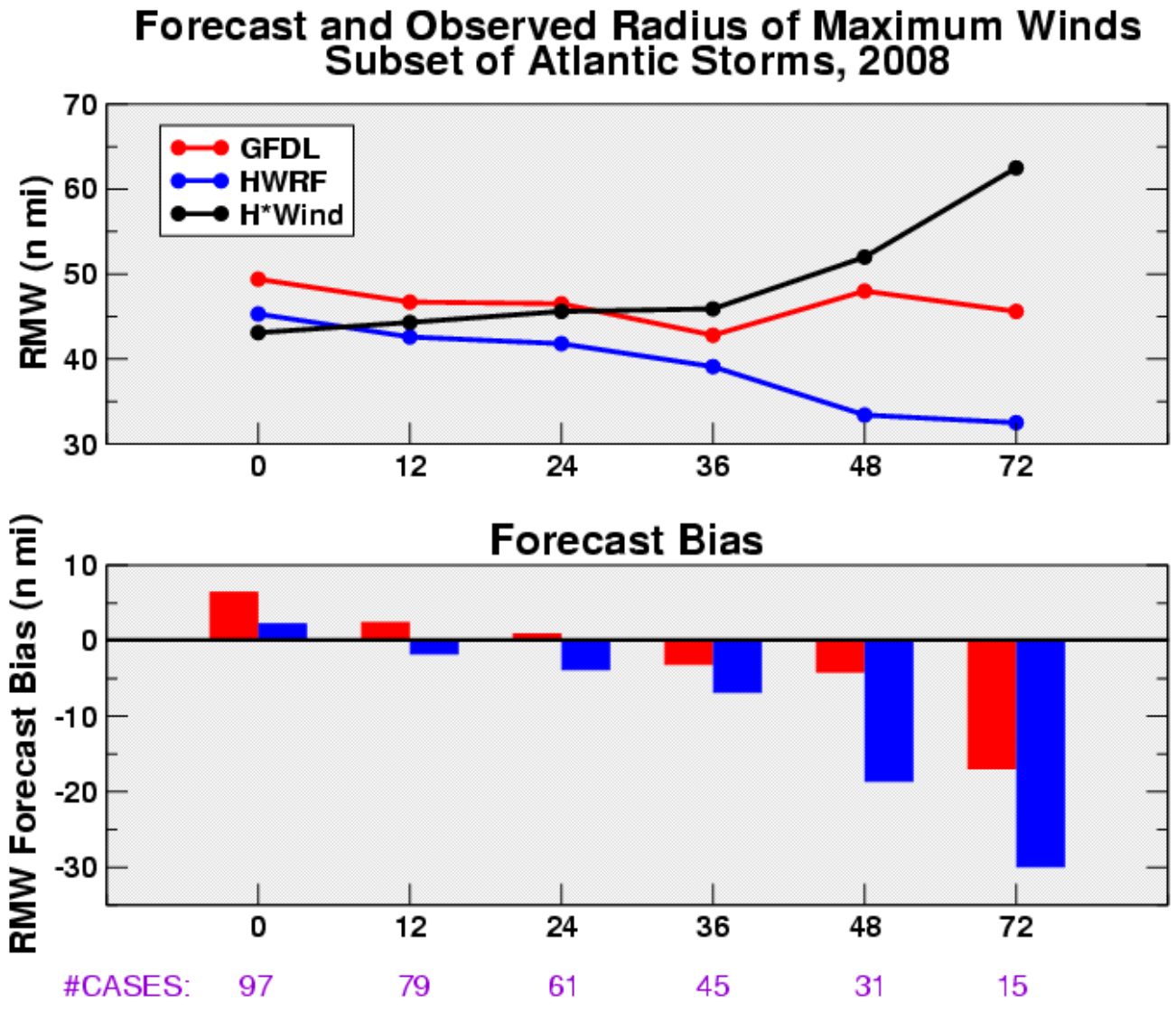
Tau= 48h



SW

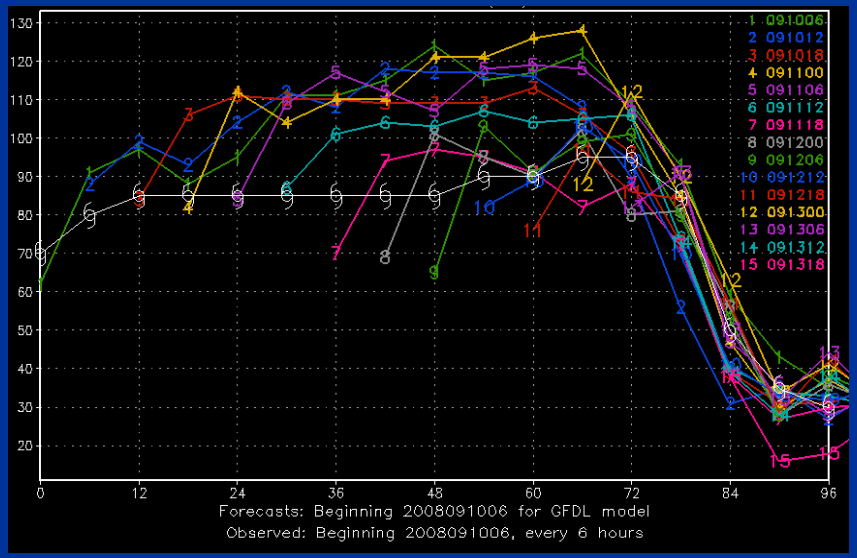
SE

Radius of Maximum Winds

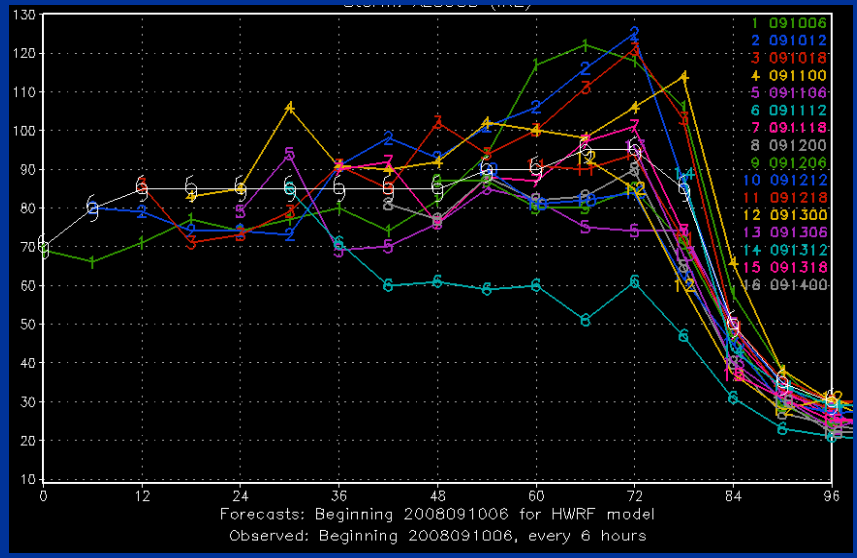


Forecasts of Integrated Kinetic Energy

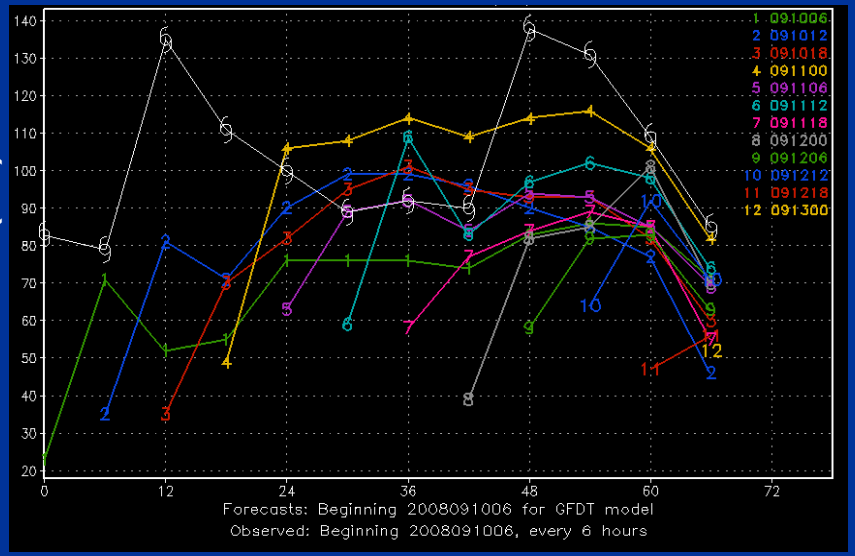
GFDL Ike Intensity Forecasts



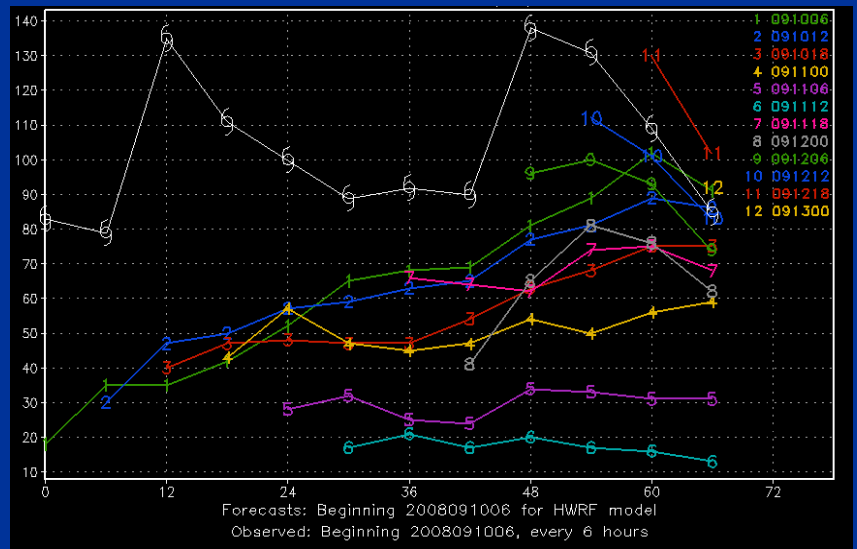
HWRF Ike Intensity Forecasts



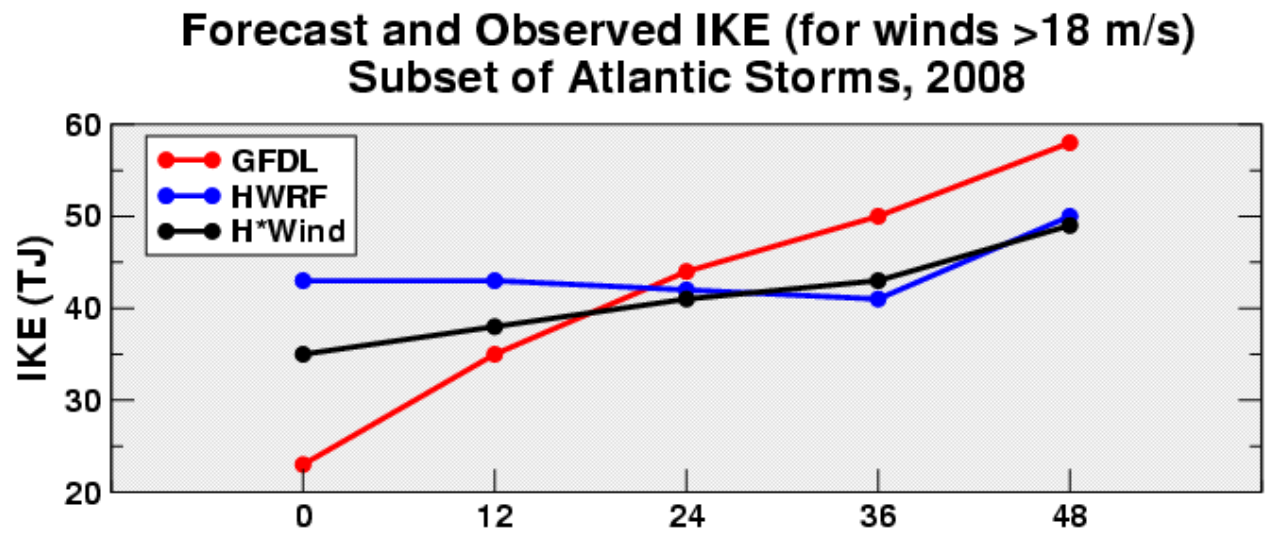
GFDL Ike IKE (V>18 m/s) Forecasts

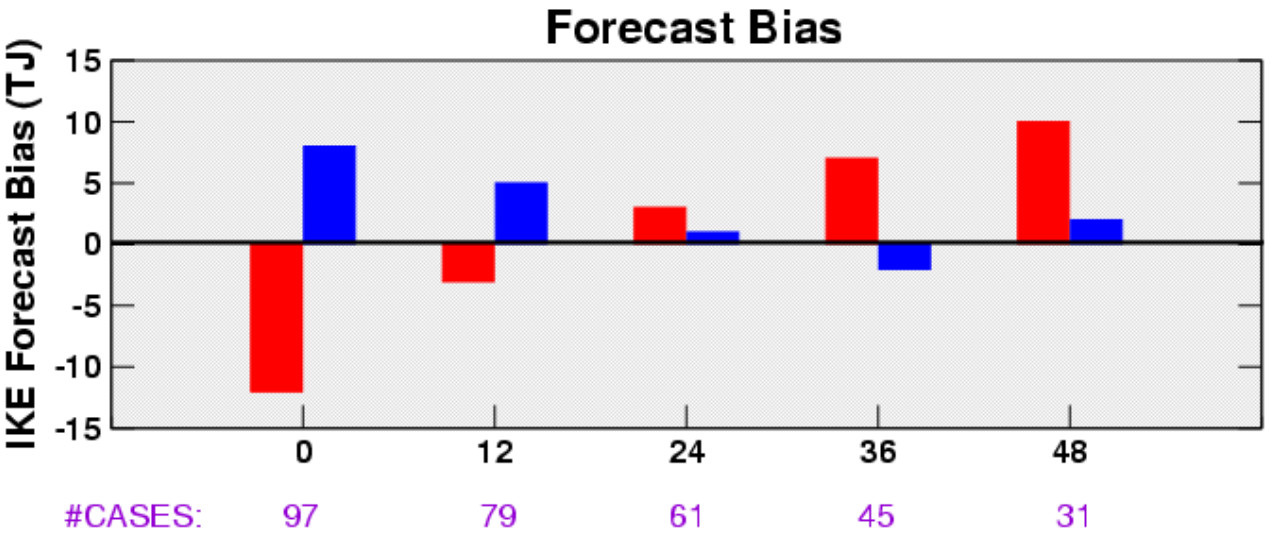


HWRF Ike IKE (V>18 m/s) Forecasts



Forecasts of Integrated Kinetic Energy





Wind Structure Summary

- Methods complementary to wind radii validation
- Focus on various aspects of wind field
  - Distribution
  - Radial structure
  - IKE / Storm destructive potential
  - Others…?
- Some biases already evident