Improvements in Statistical Tropical Cyclone Forecast Models:
A Year 1 Joint Hurricane Testbed Project Update
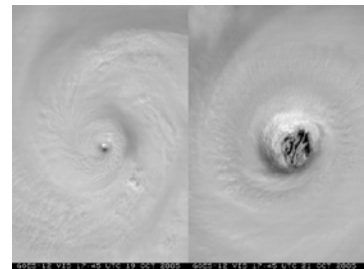
Mark DeMaria[1], Andrea Schumacher[2],
John A. Knaff[1] and Renate Brummer[2]
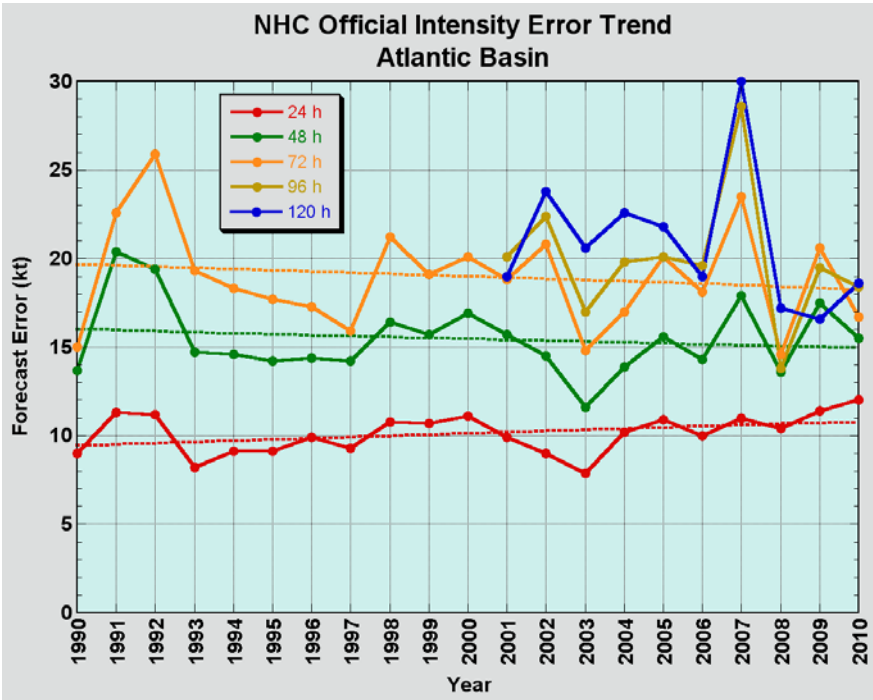
[1]NOAA/NESDIS, Fort Collins, CO
[2]CIRA, Colorado State University, Fort Collins, CO

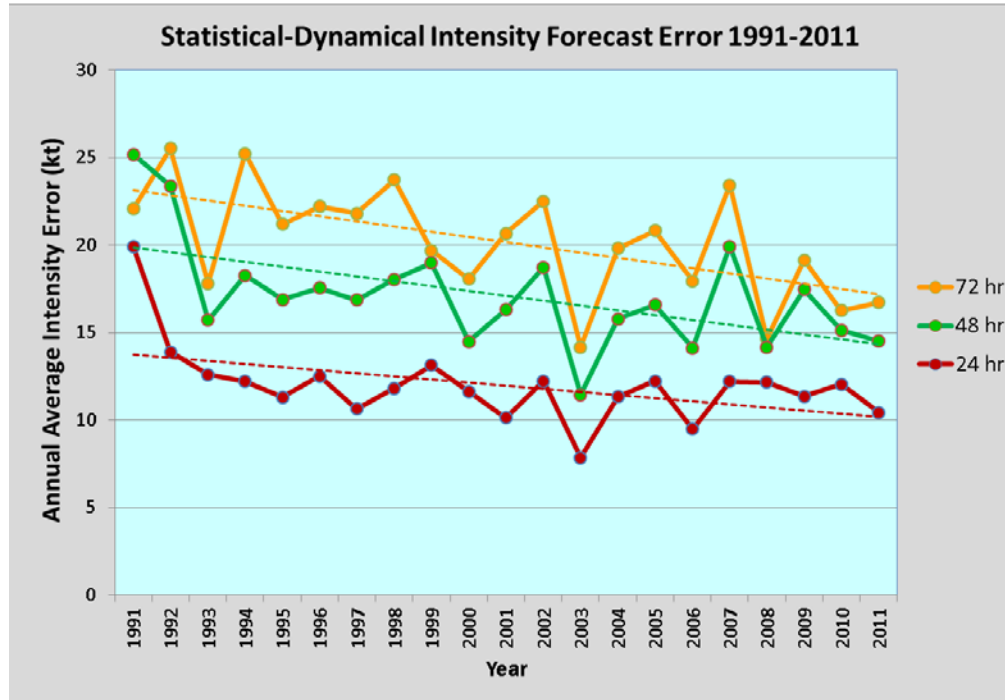*NHC POC: Lixion Avila, Robbie Berg, Chris Landsea*

Interdepartmental Hurricane Conference
March 2012

Atlantic Intensity Error Trends

NHC Official
1990-2010

Statistical-Dynamical Models
1991-2011

1991-2000 SHIPS
2000-2005 D-SHIPS
2006-2011 LGEM

Outline

- Project Tasks
  1. Extended range baseline models for track and intensity
  2. Update of SHIPS/LGEM databases using new NCEP Climate Re-analysis
  3. Extending LGEM to 7 days
  4. SHIPS/LGEM specific for the Gulf of Mexico
- Progress so far (mostly topic 1)
- Plans for 2012 season and Year 2

Baseline Forecast Models

- CLIPER and SHIFOR used as baseline for measuring track and intensity forecast skill
- Errors provide estimate of forecast difficulty
- Input
  - t = 0 h max wind, lat, lon, motion vector
  - t =-12h max wind, lat, lon, motion vector
  - Julian Day
- Output
  - 5-day forecast of lat, lon, max wind

Current Approach for Baseline Models
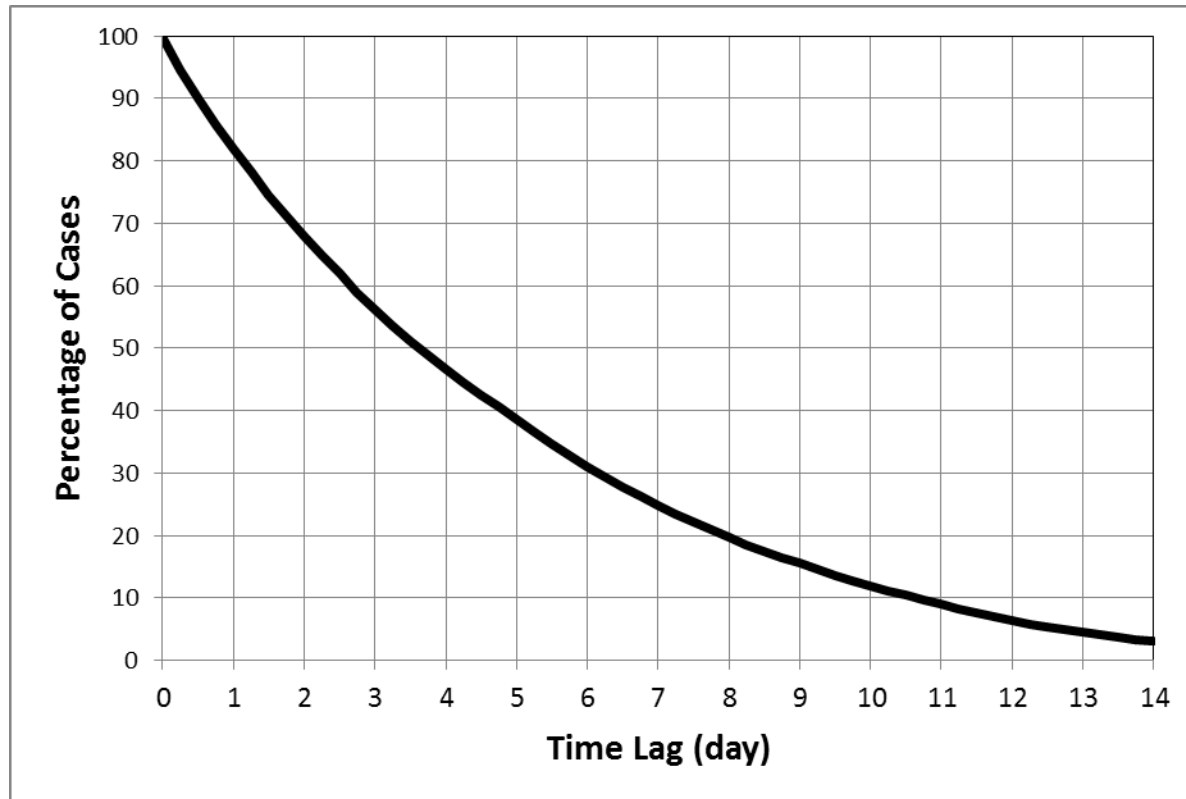
$$dx/dt = u$$

$$\int dx = \int u\,dt$$

$$x(t_n) - x(0) = \int_0^{t_n} u\,dt$$

$$t_n = 12, 24, \ldots, 120 \text{ h}$$

$$F(t_n) = \int_0^{t_n} u\,dt \quad \text{estimated from multiple regression}$$

$$\text{with climatology/persistence input}$$

Percent of Atlantic Best Track Point Pairs versus Time Lag

1982-2011, Tropical, Subtropical only, unnamed depressions 1989-2011

Trajectory Approach for Baseline Models (T-CLIPER)

$$dx/dt = u \qquad dy/dt = v$$

- Estimate u,v from climatological wind field and persistence, integrate to desired time

- 1st try: Use monthly mean deep layer mean for u,v (BAM approach)

  - Failed because early, late season storms form only when there are significant u,v anomalies

- 2nd try: Estimate u,v from long term average storm motion field
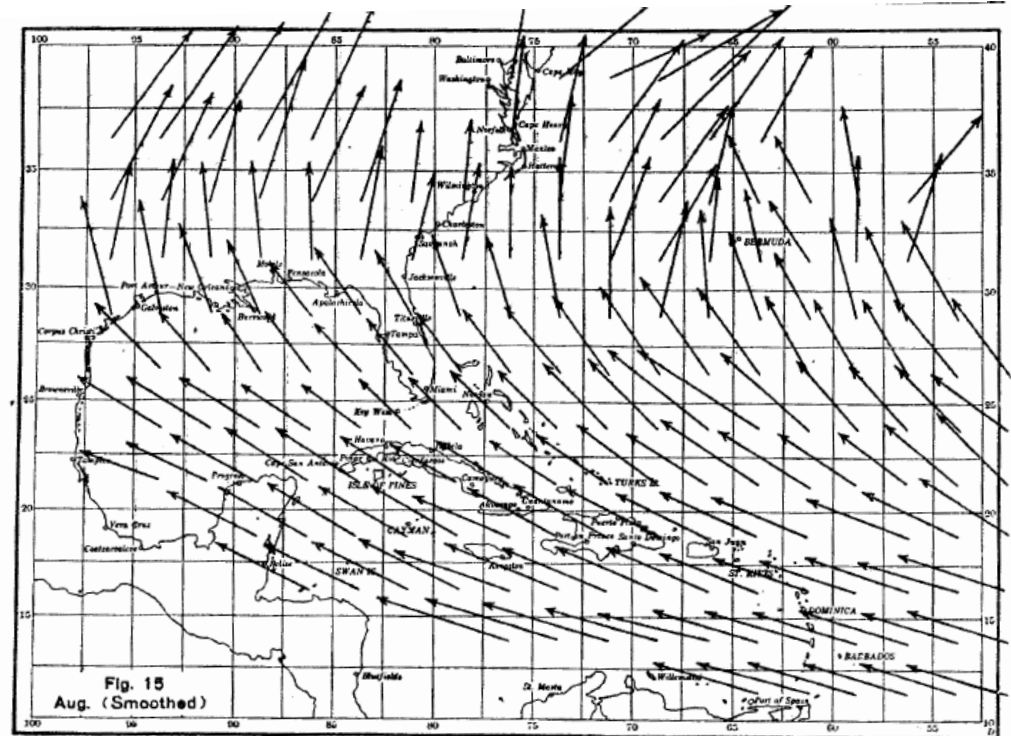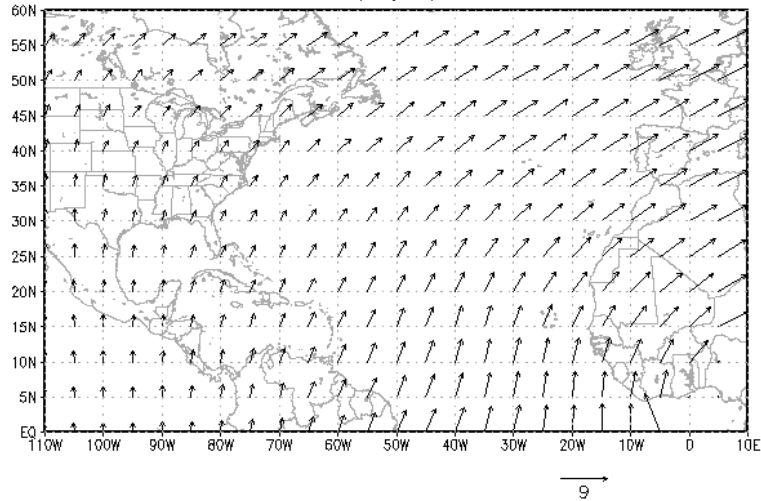
Mitchell (1924) Trajectory "Model"
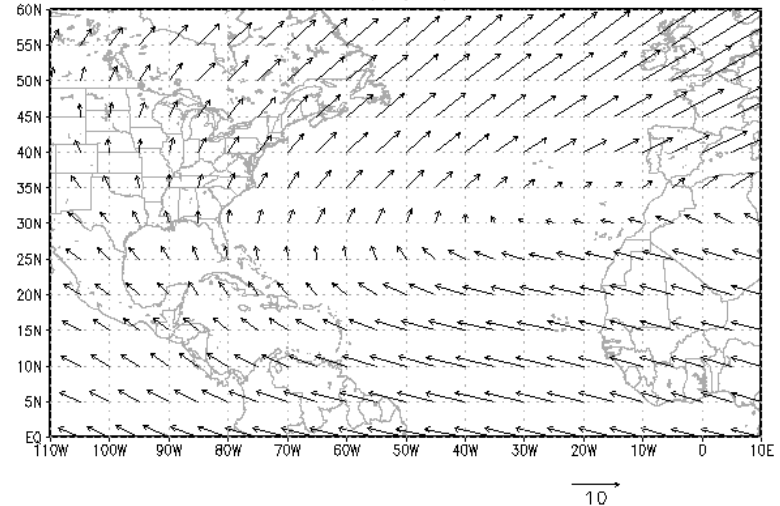
Climatological Motion Fields

- 1982-2011 cases
  - Includes unnamed depressions 1989-2011
- Supplemented with all off-season storms 1946-1981
- All storm stages
- Monthly mean fields
  - Jan-Apr combined for Atlantic
- Barnes analysis with r_e=1500 km
- 0 to 60°N, 110 ^{o}W to 10 ^{o}E
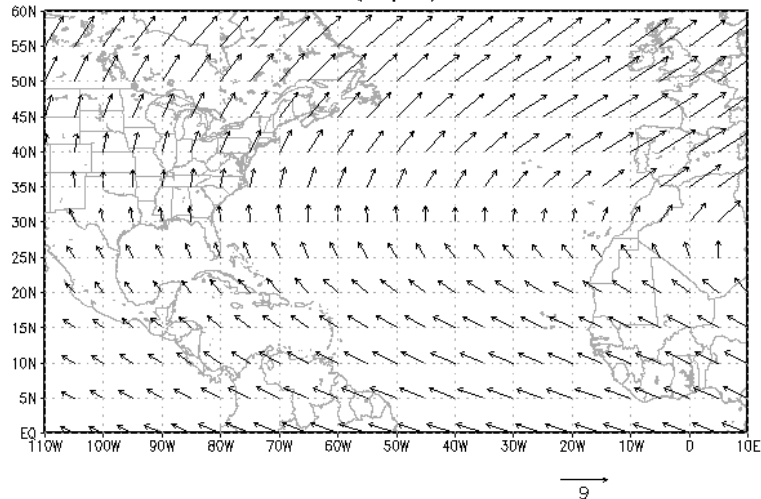
Mean Storm Motion Fields
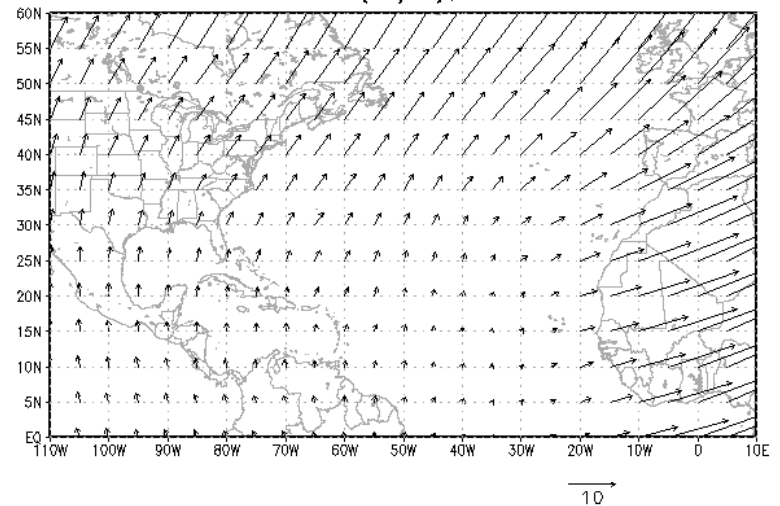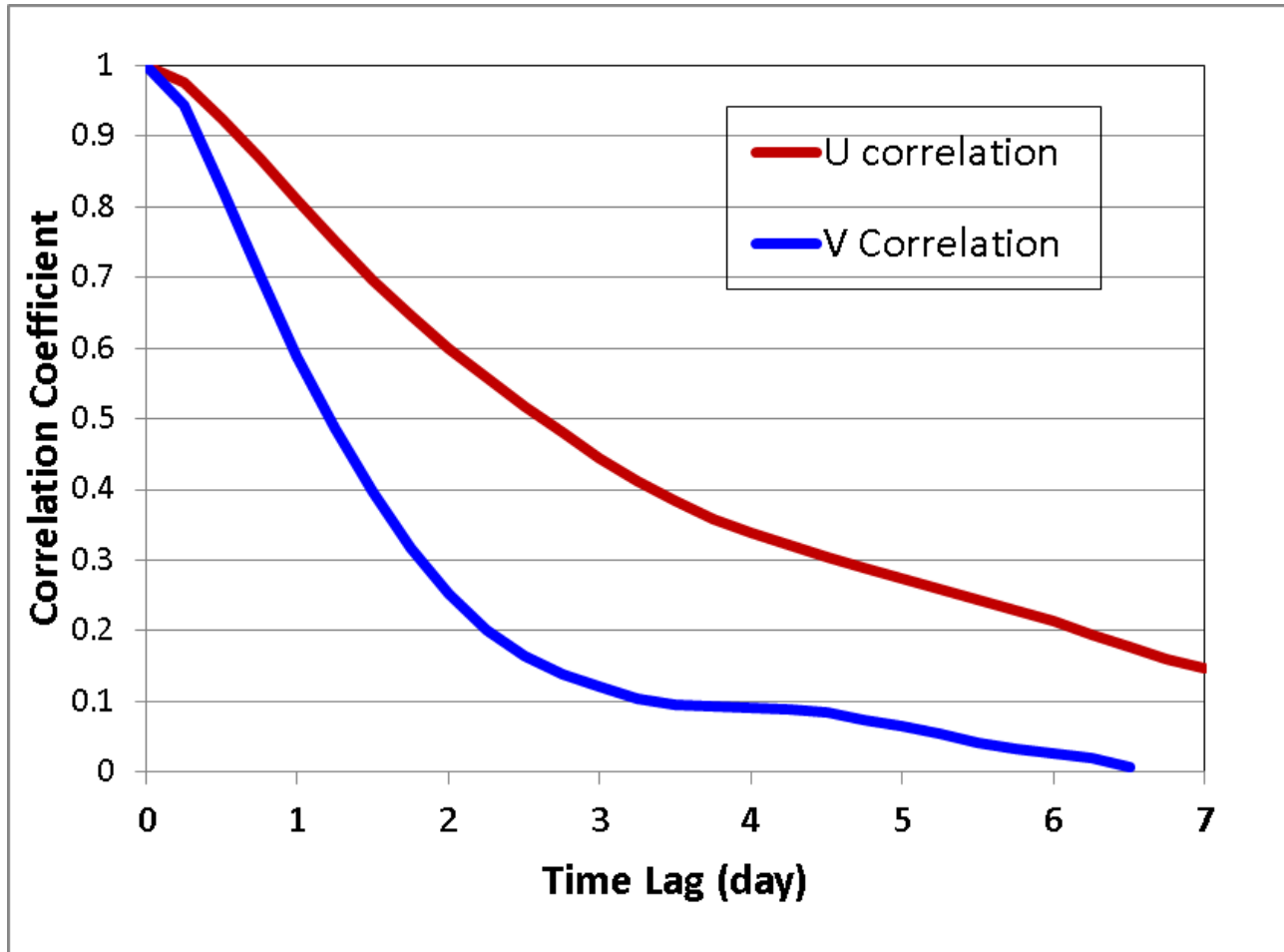

Wind (m/s), MAY

Wind (m/s), JUL

Wind (m/s), SEP

Wind (m/s), NOV

Inclusion of Persistence

Time lag correlations for u and v storm motion components

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Inclusion of Persistence
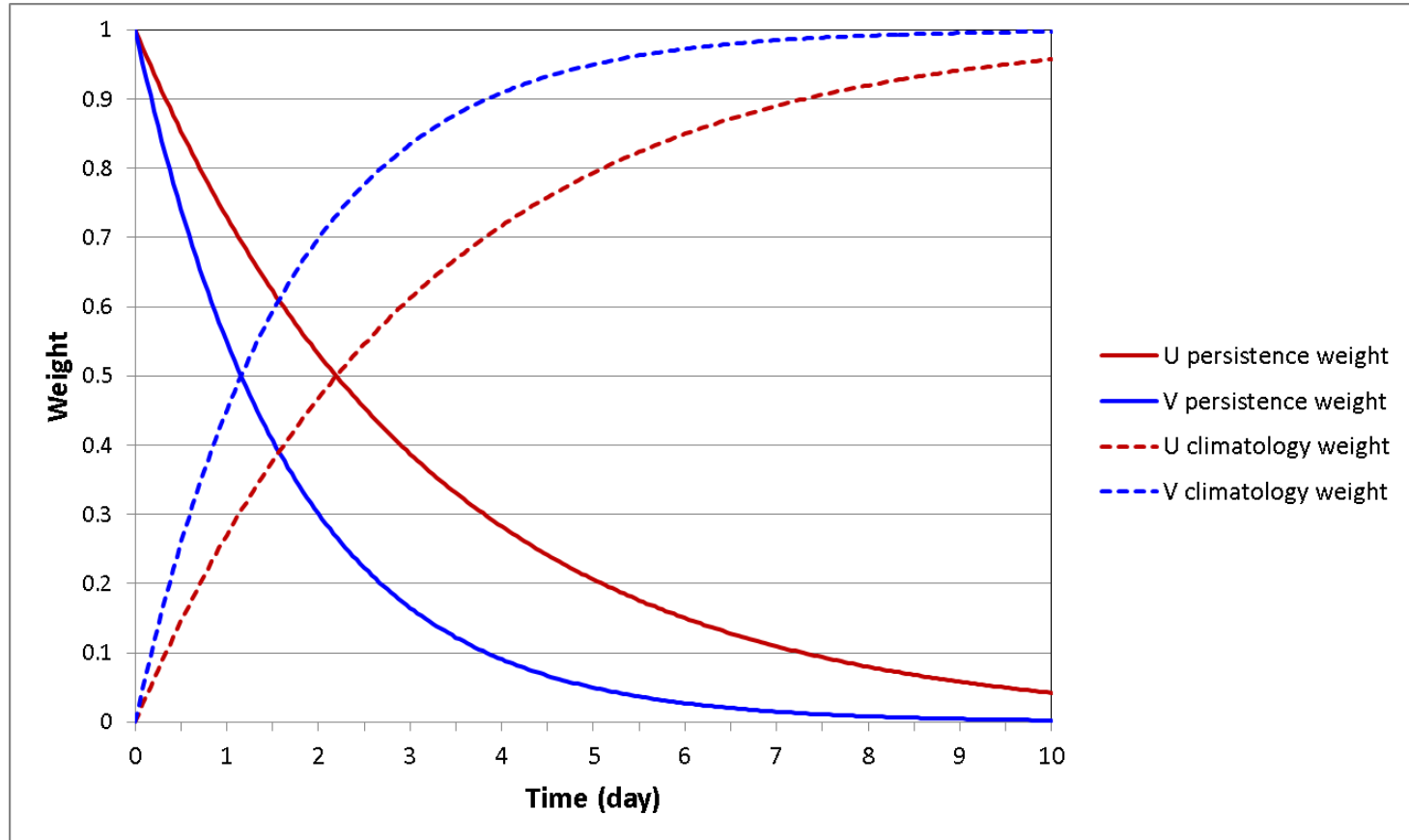
$$u(t) = w_{uc}u_c + w_{up}u_p$$

$$v(t) = w_{vc}v_c + w_{vp}v_p$$

$(u_p , v_p) = $ initial motion vector

$$w_{up} = e^{-\alpha_u t} \qquad w_{vp} = e^{-\alpha_v t}$$

$$w_{uc} = (1 - w_{up}) \qquad w_{vc} = (1 - w_{vp})$$

Climatology and Persistence Weights vs. Time

Based on best fit to 7 day forecasts, 2007-2011

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Trajectory Intensity Model (SHIFOR alternative)

- Use with LGEM equation with input from climatology and persistence input

$$dV/dt = \kappa V - \beta(V/V_{mpi})^n V$$

$$n = 2.5, \; 1/\beta = 24 \text{ hr}$$

- Estimate V_{mpi} from climatological SST along T-CLIPER track

- $\kappa = w_p \kappa_p + w_c \kappa_c \quad w_p = e^{-\alpha t}, \;\; w_c = 1 - w_p$

- κ_p from previous 12 hr intensity change

- κ_c from climatological LGEM growth rate

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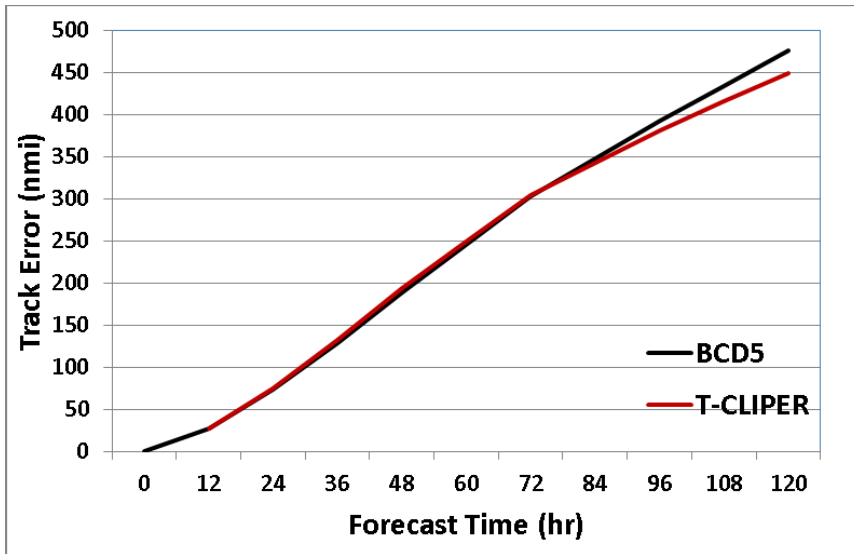# Intensity Climatology and Persistence Weights Compared to Track
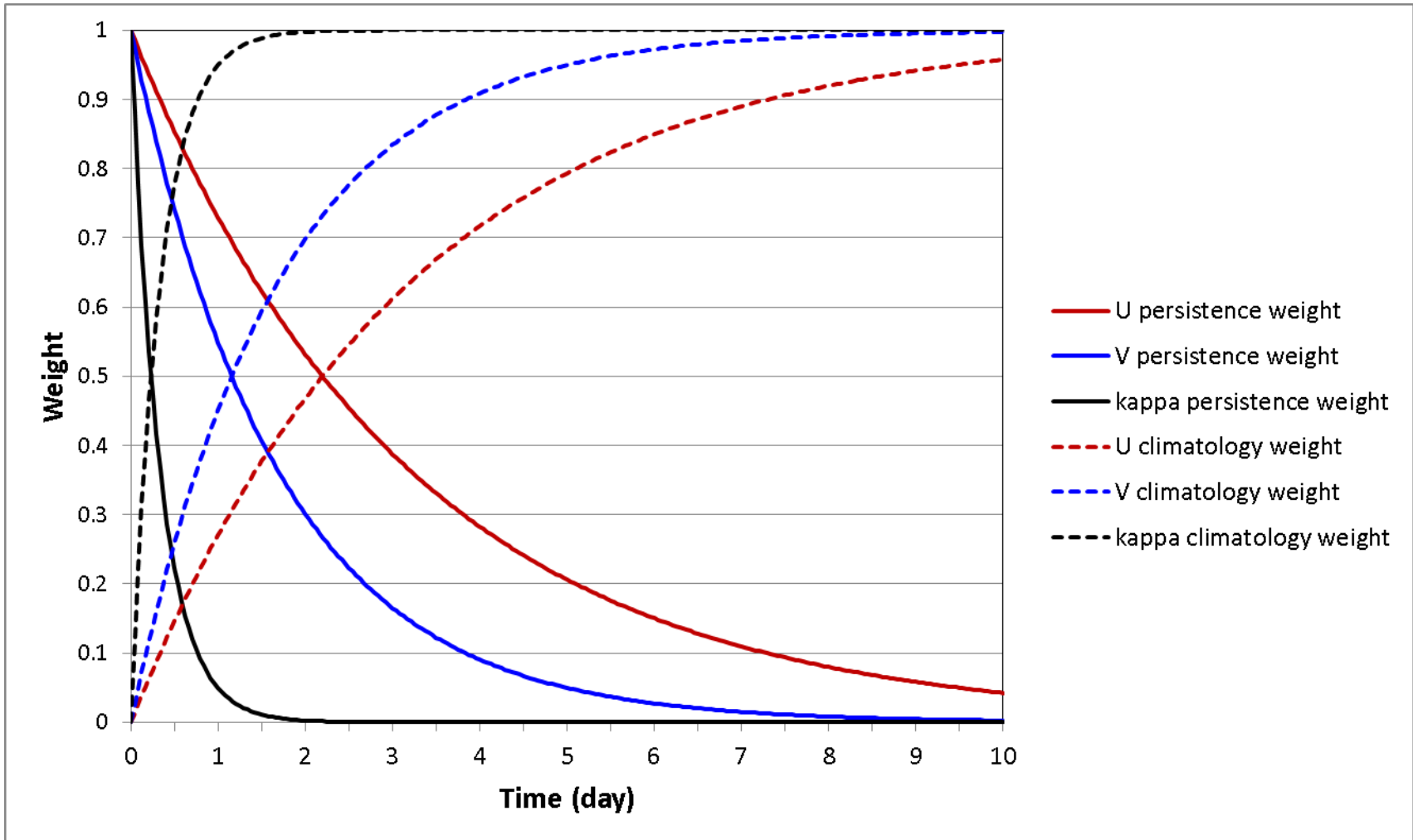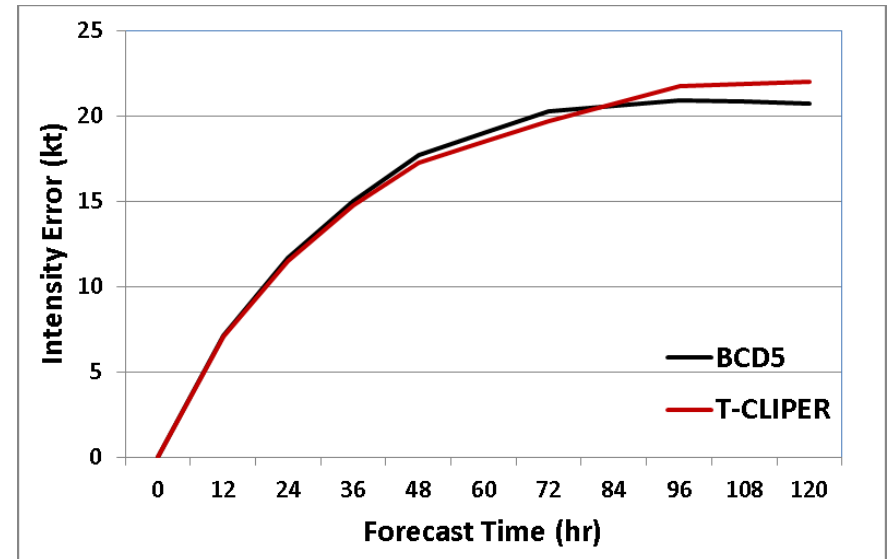
Initial T-CLIPER Tests

- All Atlantic cases 2007-2011
- Compare with BCD5 errors
  - 5 year averages
  - 1 year averages
  - Individual cases
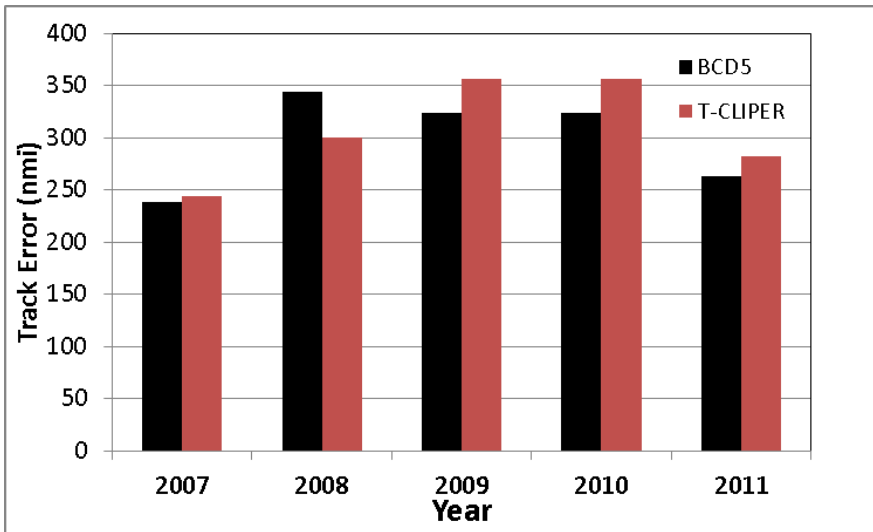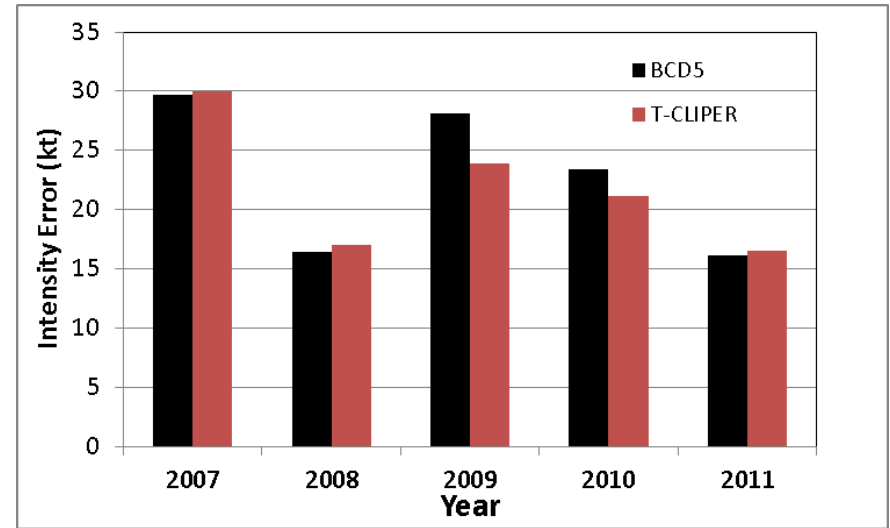- Error characteristics of10 day forecasts

5-Year Average Errors
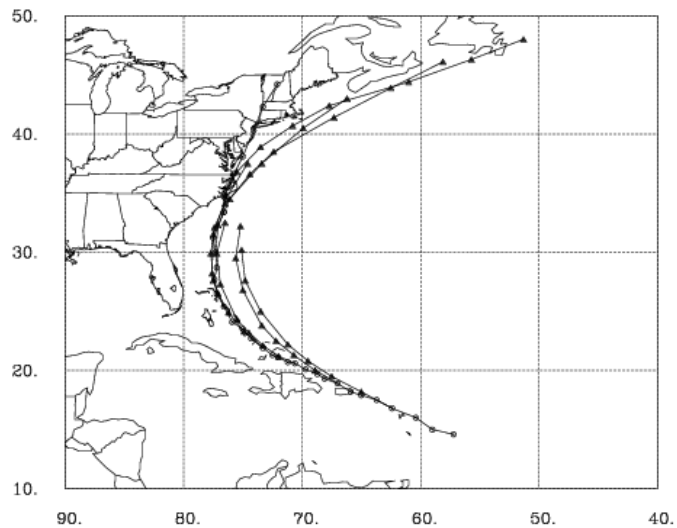

Track
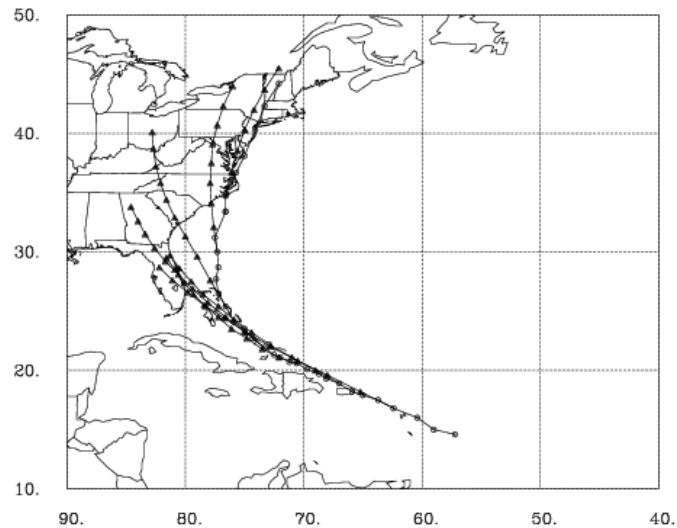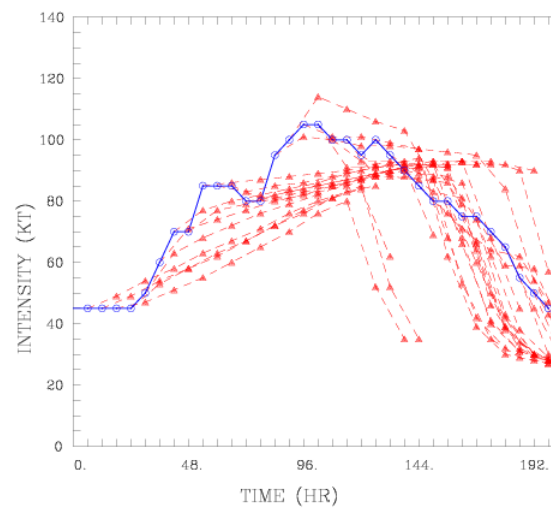
Intensity

Annual 72 hr T-CLIPER Errors

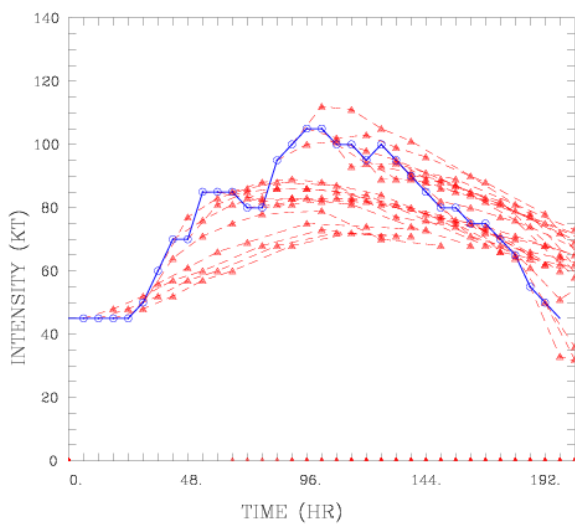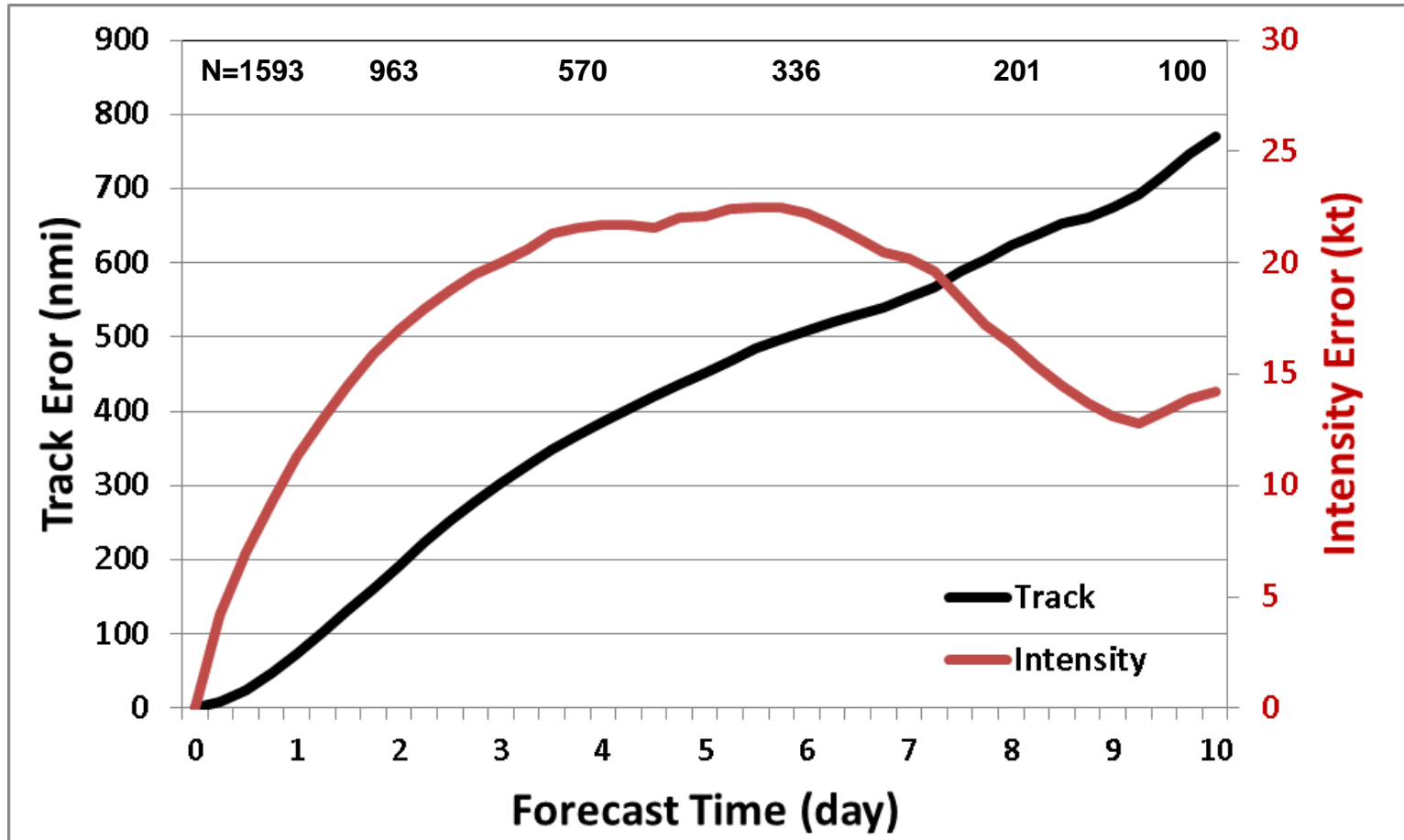Track

Intensity

BCD5 and T-CLIPER Forecasts for Irene 2011

BCD5

T-CLIPER

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10 Day T-CLIPER Errors 2007-2011

Future Plans

- Complete development of baseline models
  - Test in 2012
- Test impact of climate reanalysis and higher resolution on SHIPS database
- Extend SHIPS database to 7 days
- Develop adjoint version of LGEM to separate persistence from other variables
  - Extend LGEM to 7 days
- Gulf of Mexico SHIPS/LGEM
  - Year 2 task

Acknowledgments and Related Activities

- This NOAA Joint Hurricane Testbed project was funded by the US Weather Research Program in NOAA/OAR's Office of Weather and Air Quality

- Other statistical intensity model improvement activities

  - HFIP/NOPP: WPAC SHIPS/LGEM/RII, Ensembles

  - GOES-R3: Lightning and other new data sources

  - GIMPAP: Combining Rapid Intensification Index and SHIPS/LGEM