Evaluation of Experimental Models for Tropical Cyclone Forecasting in Support of the NOAA Hurricane Forecast Improvement Project (HFIP)

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Tropical Cyclone Modeling Testbed (TCMT): HFIP Model evaluation activities

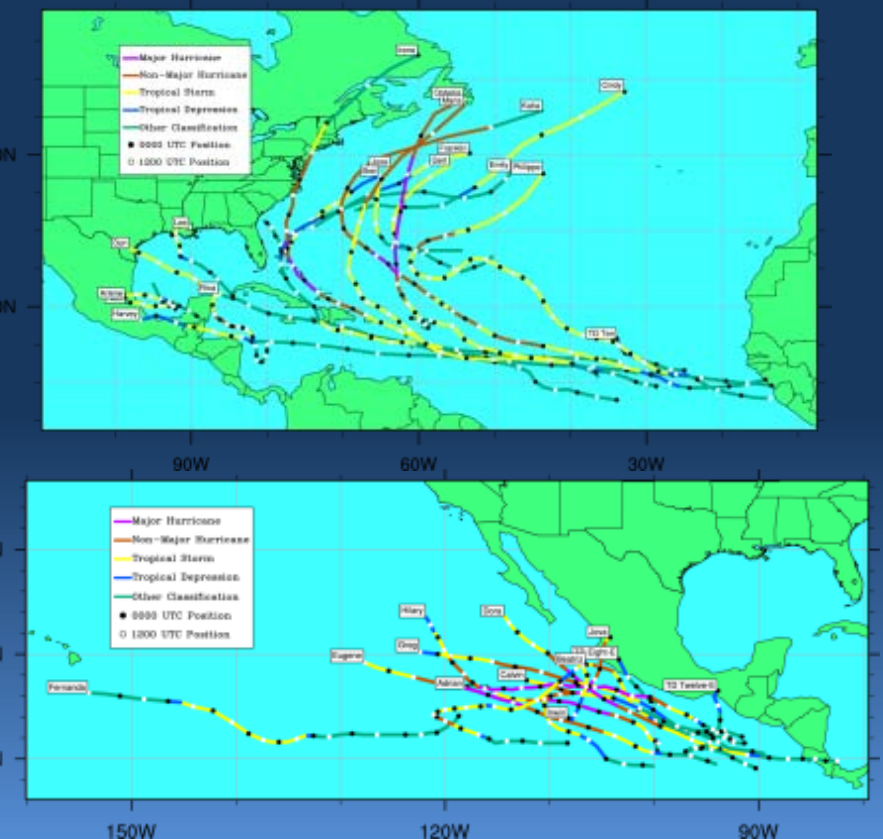
- *Main focus*: Independent diagnostic evaluation of HFIP models
- Planning and evaluation of HFIP Retrospective evaluations
  - Implementation of meaningful diagnostic verification approaches: *Focus on NHC requirements*
  - Evaluation of Stream 1.5 candidates; report to NHC and HFIP
- Real-time demonstration during Demo period (Aug-Nov)
- Evaluation of Demo models
  - Intensive evaluations of specific storms
  - Overall evaluation of forecasts for all storms
- Development of verification methods and tools

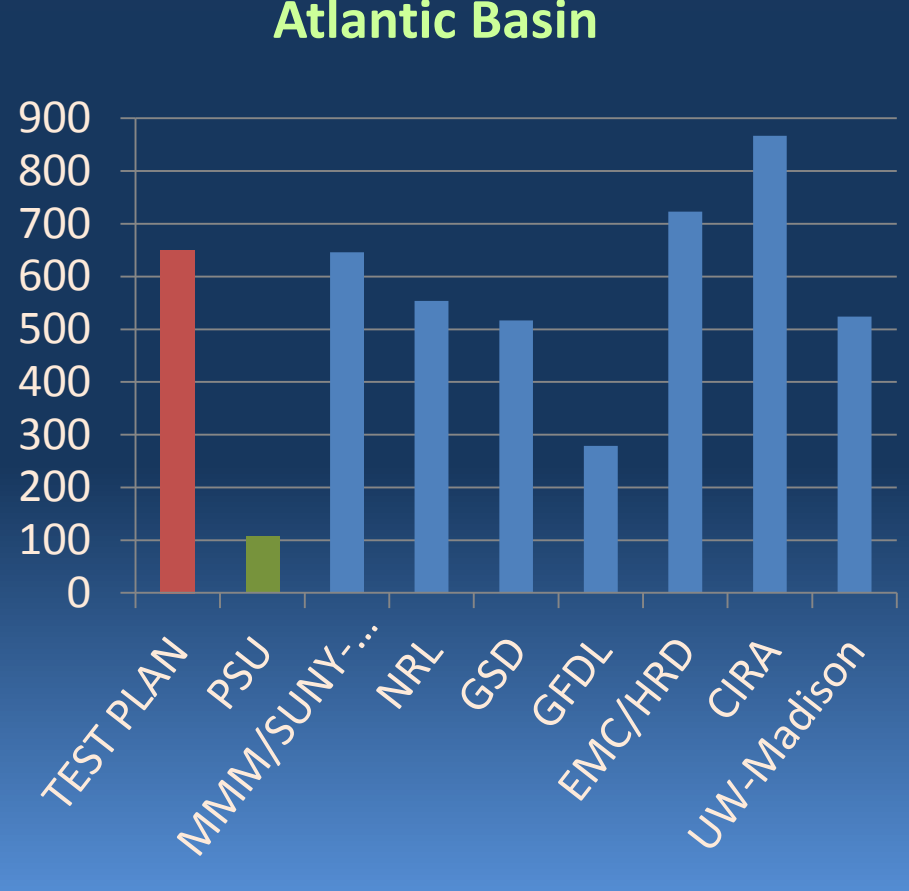
HFIP 2011 Retrospective Cases

Goal: Select Stream 1.5 models for HFIP Demo exercise

Modeling groups ran retrospective cases for more than 600 cases from 2008-2010

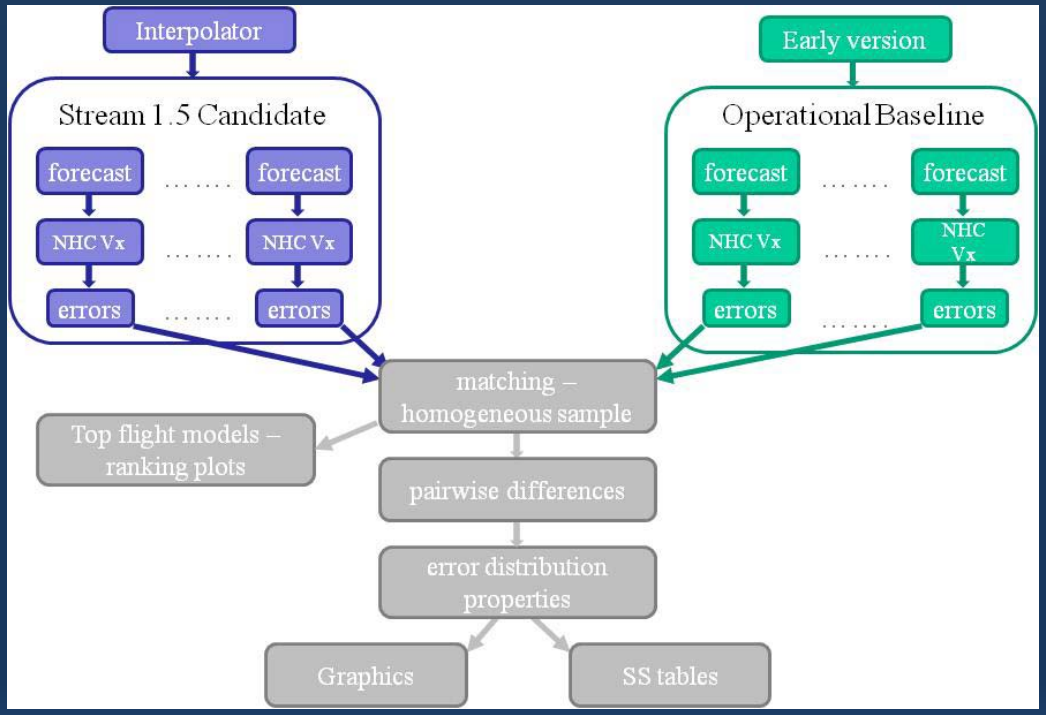
Collaboration with NHC





Retrospective evaluations

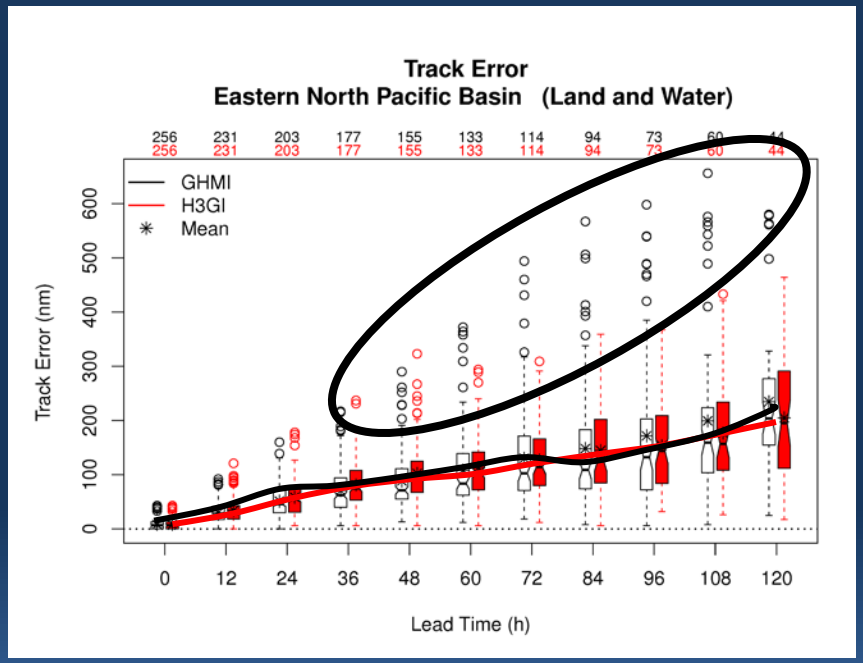
- Comparisons with baseline models
  - Significant and "practical" differences
  - Frequencies of large error differences
- Contributions to consensus forecasts
- Performance relative to "top flight" models

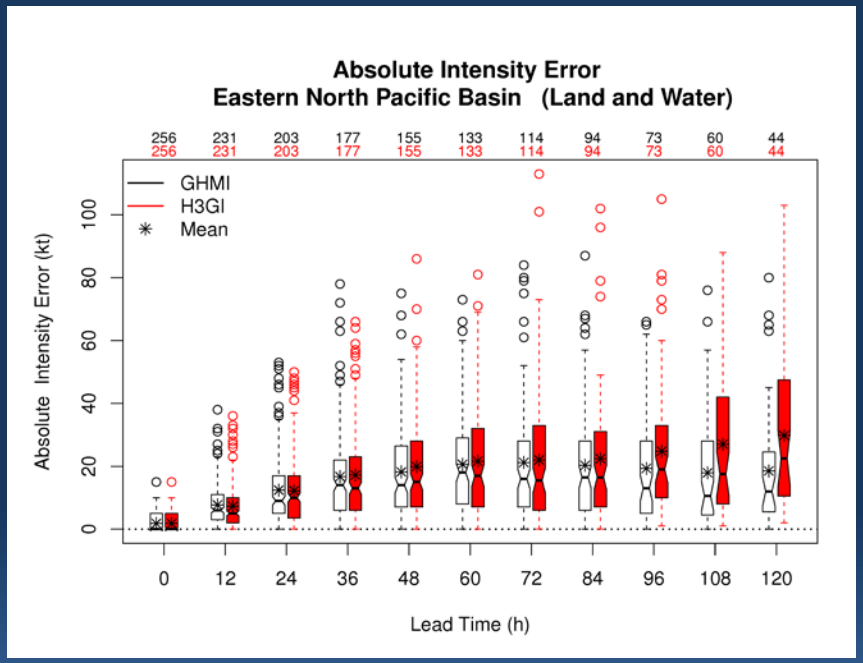


2011 Retrospective Evaluation

Example: 3 km HWRF

Error Distribution Evaluation



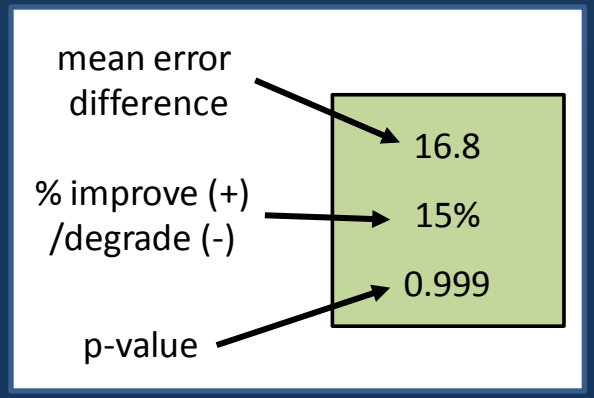


Stream 1.5 model: Fewer cases w/ large track errors
Similar or larger errors for intensity

2011 Hurricane Retrospective Evaluation - Results

Example: 3 km HWRF

Practical Significance Evaluation

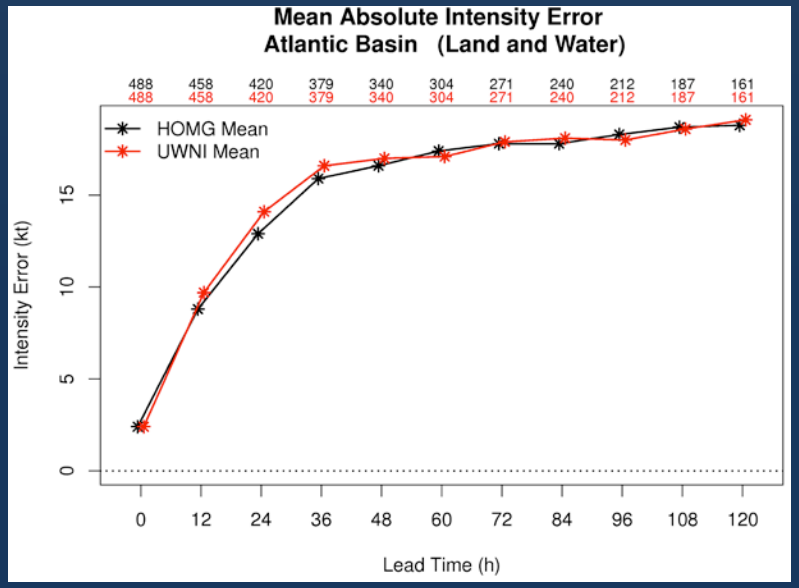


		Track	Intensity
SS differences		Δ < -20	Δ < -2
		-20 < Δ < -10	-2 < Δ < -1
		-10 < Δ< 0	-1 < Δ< 0
		0 < Δ< 10	0 < Δ < 1
		10 < Δ< 20	1 < Δ < 2
		Δ > 20	Δ> 2
Not SS		Δ< 0	Δ < 0
		Δ> 0	Δ> 0

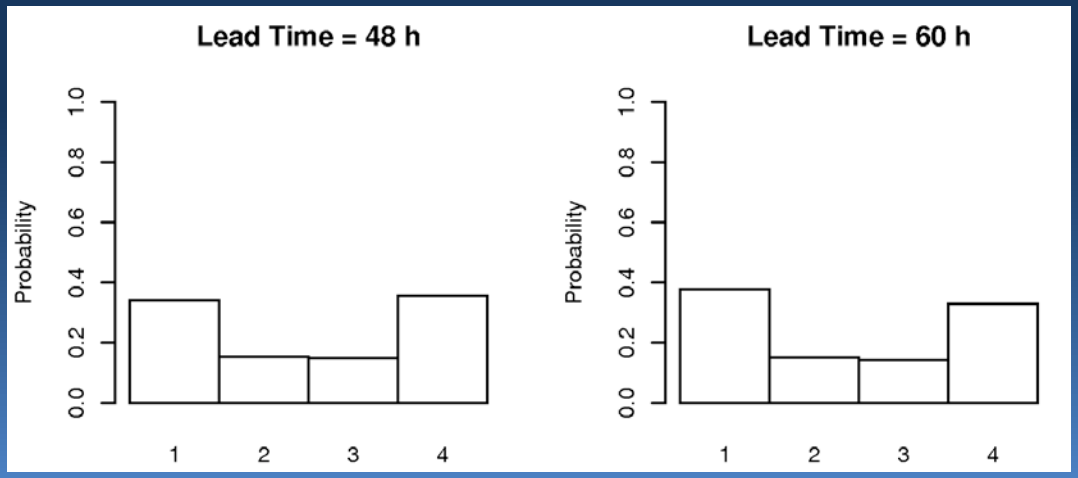
	Forecast Hour	0	12	24	36	48	60	72	84	96	108	120
Atlantic Basin	GFSI	0.0	-0.7	-4.0	-5.4	-9.1	-13.2	-16.5	-16.1	-20.5	-28.3	-44.4
	Track	0%	-2%	-8%	-8%	-10%	-12%	-12%	-10%	-11%	-13%	-19%
	(Land and Water)	–	0.618	0.987	0.986	0.961	0.936	0.819	0.837	0.876	0.929	0.969
	GHMI	0.0	1.4	0.9	1.7	-3.1	-6.2	-5.7	2.5	2.9	-1.6	-7.2
	Track	0%	4%	2%	2%	-3%	-5%	-4%	1%	1%	-1%	-3%
	(Land and Water)	–	0.880	0.426	0.540	0.682	0.667	0.420	0.201	0.185	0.083	0.307
	GHMI	0.0	0.5	1.0	2.1	1.9	1.7	0.8	0.0	-0.5	-0.6	-0.2
	Intensity	0%	6%	8%	13%	11%	9%	4%	0%	-3%	-3%	-1%
	(Land and Water)	–	0.987	0.987	0.999	0.998	0.984	0.532	0.000	0.279	0.292	0.094
	GHMI	0.0	0.5	1.3	2.4	2.1	2.4	2.8	2.9	2.0	0.7	0.5
	Intensity	0%	5%	9%	14%	11%	12%	14%	15%	10%	4%	3%
	(Water Only)	–	0.904	0.999	0.999	0.963	0.970	0.998	0.973	0.816	0.338	0.188
	LGEM	0.0	0.1	-0.2	-0.2	-1.1	-1.4	-1.5	-1.4	-1.8	-1.5	-0.9
	Intensity	0%	1%	-2%	-1%	-7%	-9%	-9%	-9%	-11%	-9%	-5%
	(Land and Water)	–	0.261	0.311	0.261	0.728	0.796	0.751	0.649	0.769	0.682	0.451
	LGEM	0.0	-0.1	-0.3	-0.4	-1.0	-0.7	-0.6	-0.6	-1.0	-0.7	-1.1
	Intensity	0%	-1%	-2%	-3%	-7%	-4%	-4%	-4%	-6%	-4%	-6%
	(Water Only)	–	0.261	0.451	0.311	0.558	0.359	0.276	0.248	0.336	0.229	0.327
Eastern North Pacific Basin	GFSI	0.0	-2.1	-3.6	-6.8	-12.9	-10.8	-12.4	-11.1	1.3	13.0	7.5
	Track	0%	-7%	-7%	-9%	-14%	-11%	-11%	-8%	1%	7%	3%
	(Land and Water)	–	0.618	0.519	0.681	0.882	0.694	0.738	0.693	0.071	0.331	0.123
	GHMI	0.0	-4.0	-7.3	-10.4	-13.9	-4.5	3.3	3.5	18.2	22.7	29.9
	Track	0%	-13%	-14%	-15%	-16%	-4%	3%	2%	11%	11%	13%
	(Land and Water)	–	0.995	0.962	0.889	0.880	0.238	0.129	0.100	0.342	0.405	0.570
	GHMI	0.0	0.4	0.1	-0.5	-1.7	-0.9	-0.8	-2.1	-5.5	-9.1	-11.3
	Intensity	0%	5%	1%	-3%	-9%	-4%	-4%	-10%	-28%	-51%	-61%
	(Land and Water)	–	0.816	0.132	0.350	0.841	0.270	0.154	0.399	0.869	0.999	0.999
	GHMI	0.0	0.3	0.2	-0.4	-2.4	-3.6	-4.7	-6.2	-9.6	-9.3	-8.4
	Intensity	0%	4%	1%	-2%	-12%	-18%	-25%	-34%	-56%	-55%	-43%
	(Water Only)	–	0.382	0.225	0.224	0.911	0.939	0.956	0.985	0.999	0.999	0.999
	LGEM	0.0	-0.1	-1.0	-2.4	-3.2	-4.7	-6.0	-6.9	-9.6	-11.9	-15.2
	Intensity	0%	-1%	-9%	-16%	-19%	-28%	-38%	-45%	-63%	-78%	-96%
	(Land and Water)	–	0.197	0.682	0.912	0.953	0.893	0.864	0.821	0.868	0.944	0.994
	LGEM	0.0	-0.1	-1.1	-2.5	-3.0	-4.5	-6.3	-7.3	-8.8	-8.7	-11.4
	Intensity	0%	-1%	-10%	-17%	-17%	-26%	-39%	-46%	-53%	-49%	-66%
	(Water Only)	–	0.197	0.727	0.903	0.920	0.838	0.845	0.804	0.780	0.774	0.968

Top Flight Model Comparison

UW-NMS Example



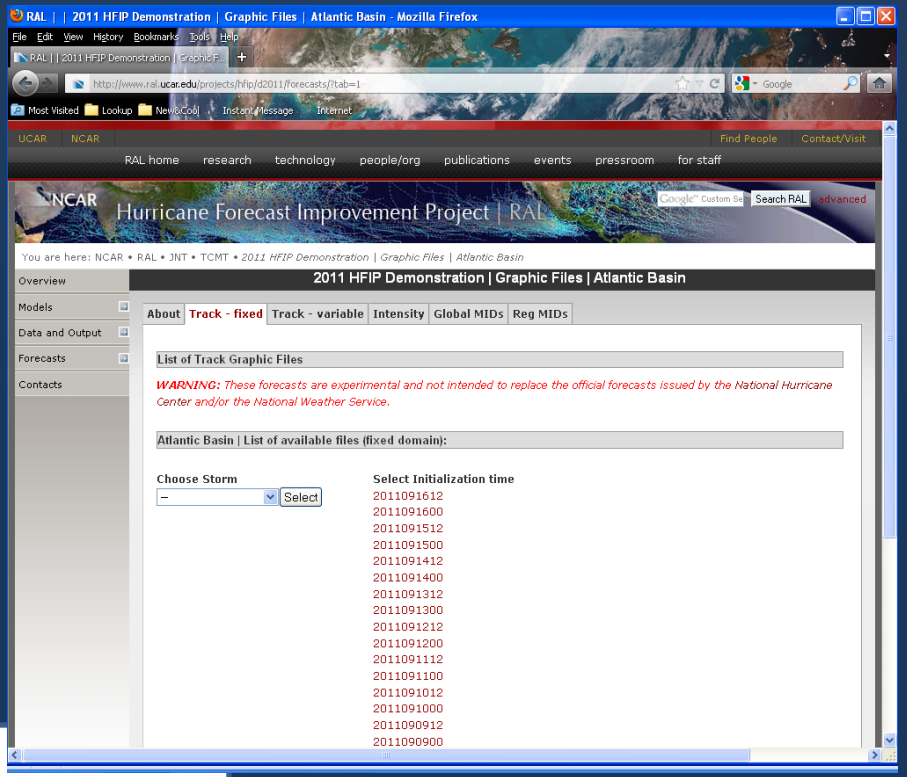
Average Errors

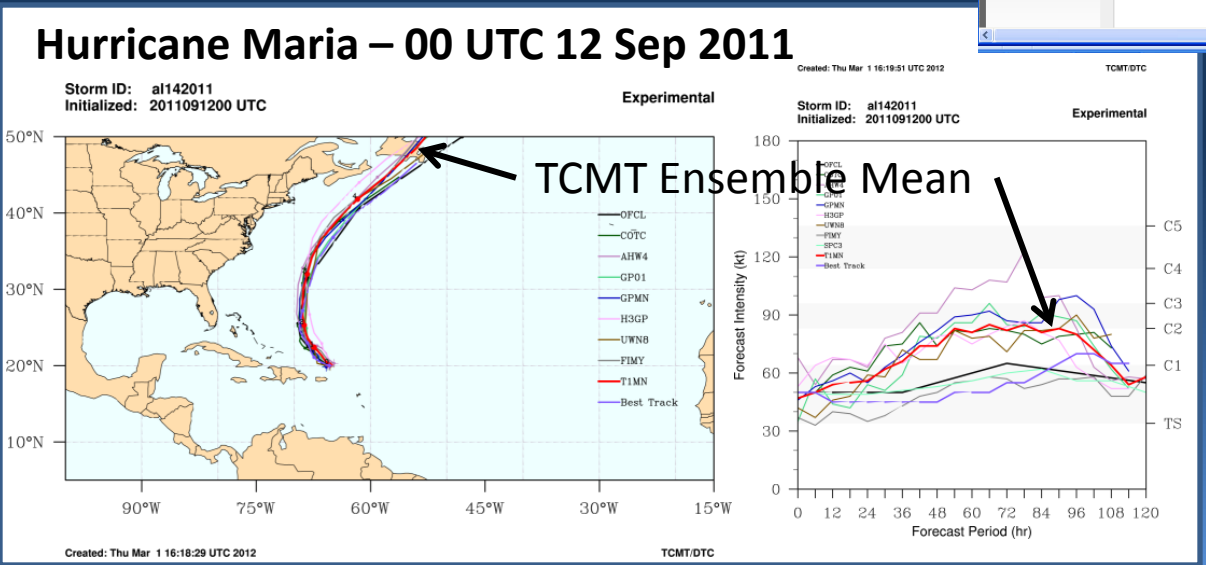


Rank

Real-Time Demonstration and Evaluation

- Operational and experimental models provided in real-time to TCMT website in support of the HFIP Demonstration
- Multi-model ensemble mean computed and displayed using the HFIP experimental models
- Track plots and verification results available on the HFIP web site
- Near real time diagnostic evaluation of individual storms (Irene, Maria)





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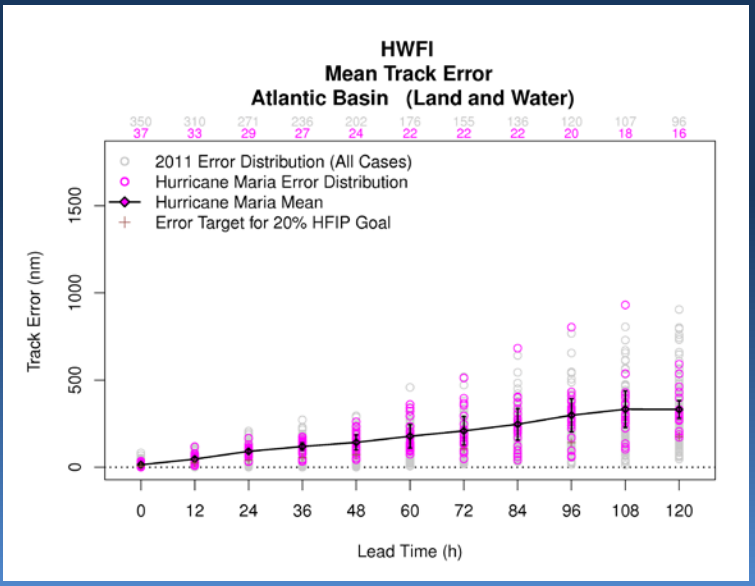
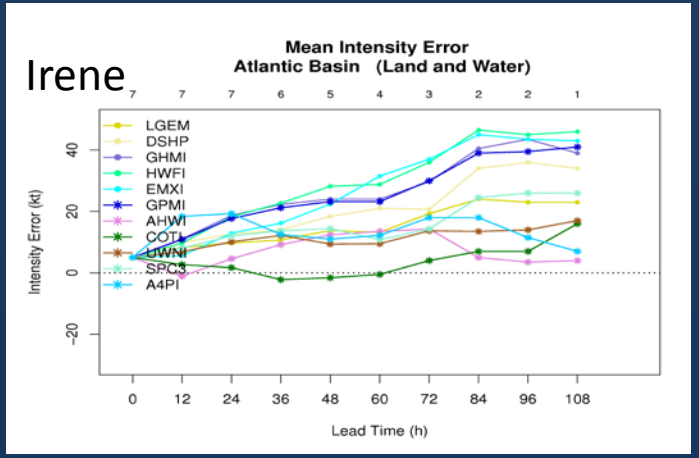
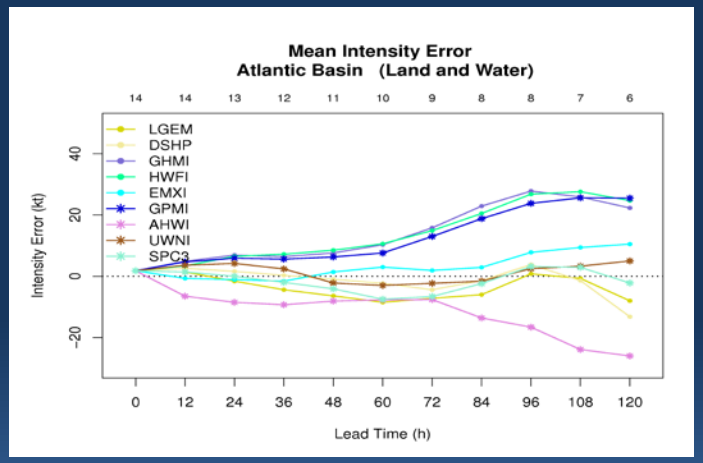


Sample Size Sensitivity





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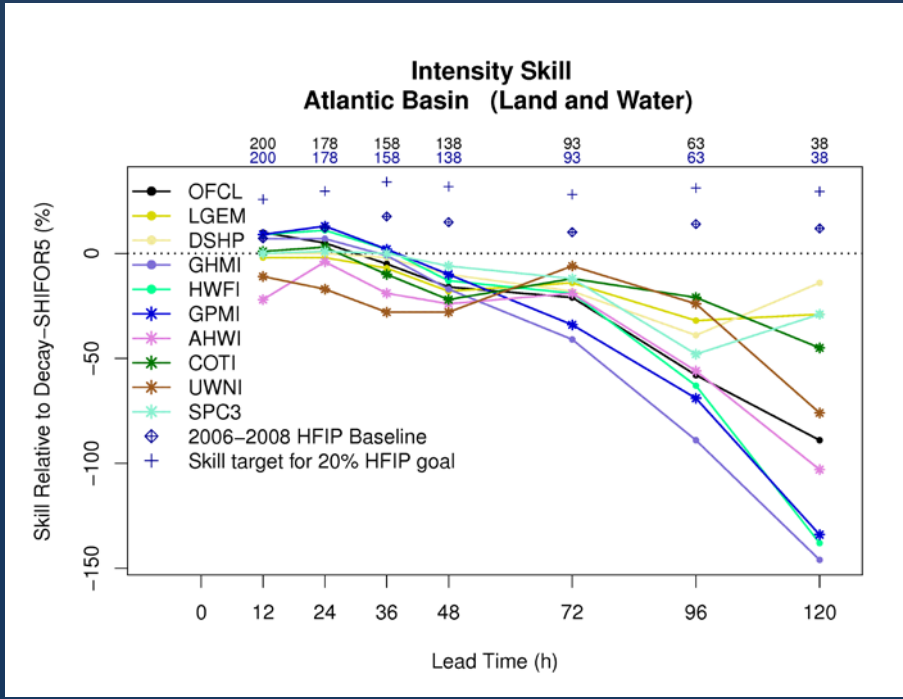
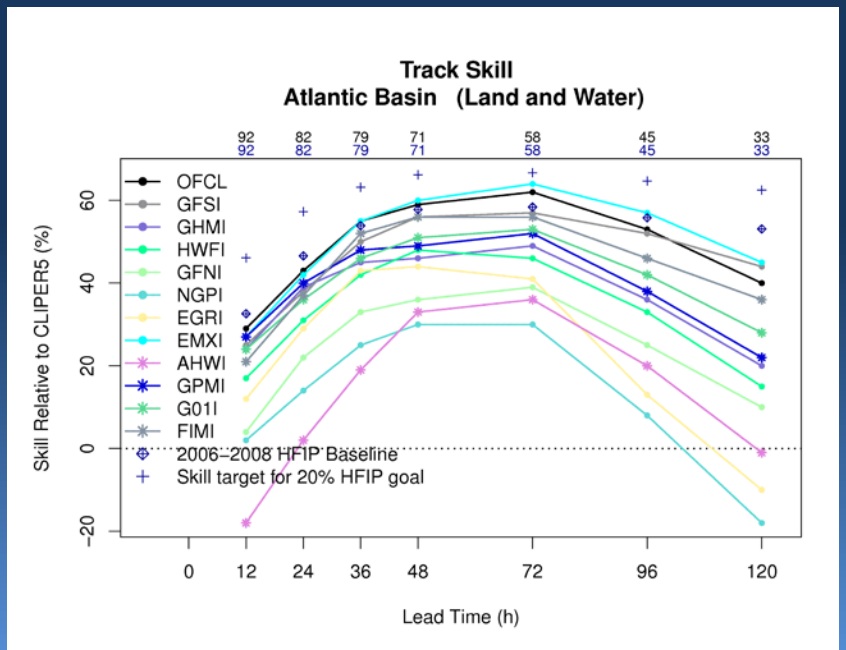


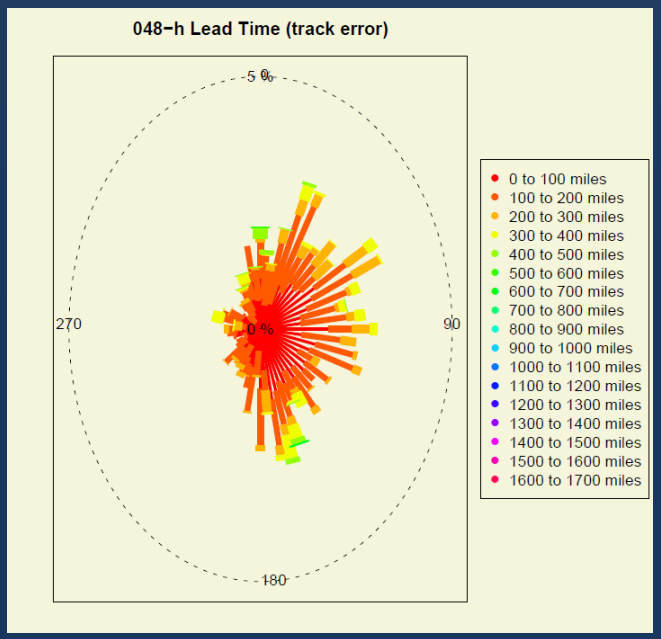


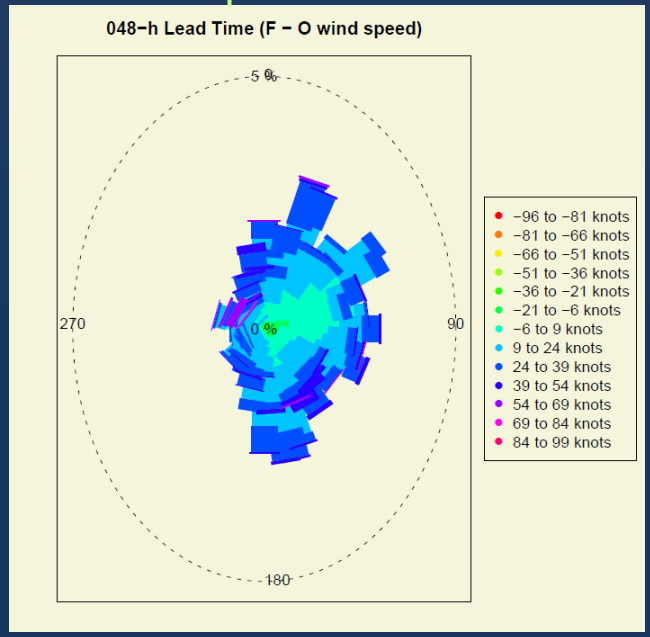
New Methods for Evaluation of TC Forecasts

Developing new methods to evaluate ensemble and multi-model forecasts

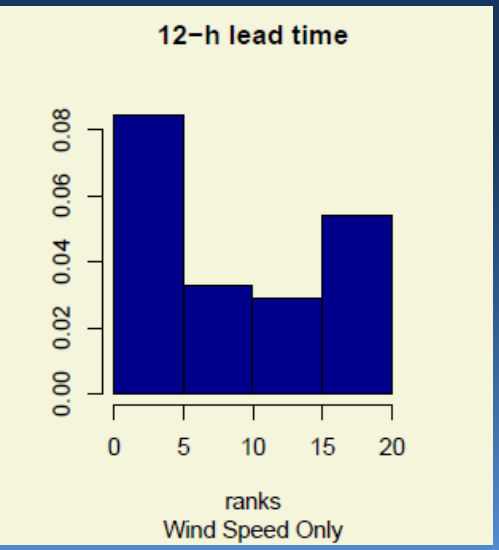
Example: GFDL 18-member Ensemble

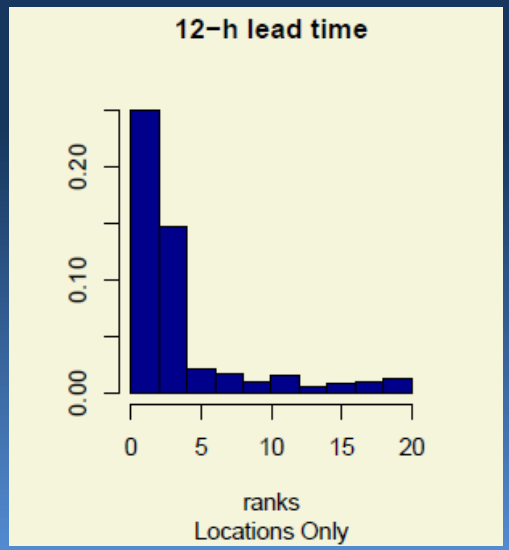
"Wind Rose" Plots for Track and Wind Speed Errors



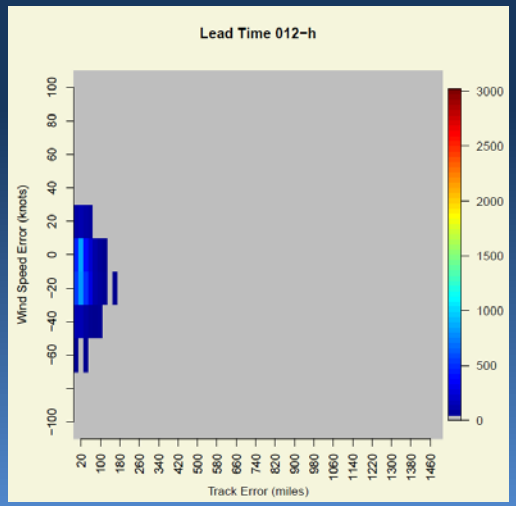


Rank Histograms





Wind Speed/ Track Error Diagrams



Summary

- TCMT supports HFIP efforts by providing independent, diagnostic, forecast verification of experimental model forecasts
- New approaches for evaluation
  - To meet needs of NHC for selecting promising models for Stream 1.5
  - To evaluate new kinds of forecasts (e.g., ensembles)
- Results available for 2009-2012 at http://www.rap.ucar.edu/jnt/tcmt/
- Currently gearing up for 2012 retrospective (Stream 1.5) evaluation