Statistical Rapid Intensity Prediction: Implications of Recent Model Results

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Outline

- Background on the RI problem
- Analysis of RI prediction skill of recent deterministic model forecasts
- Description of the statistical RI models
- Verification of statistical RI model performance
- Overview of shear distributions of RI and non-RI cases
- Summary

Background

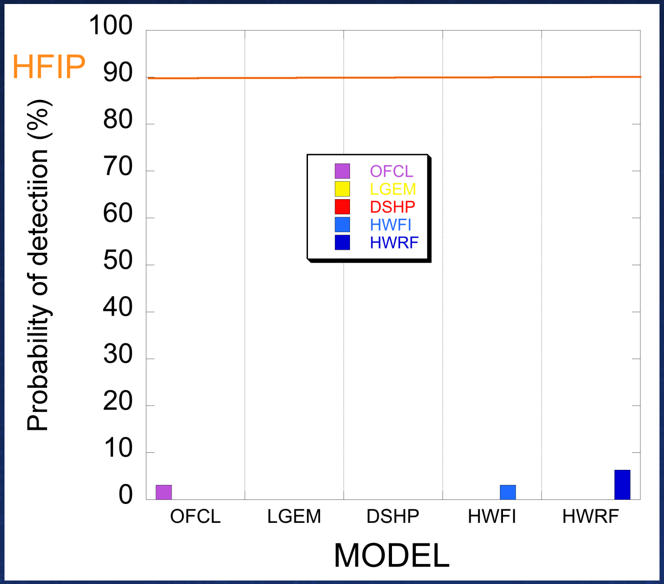
- Predicting RI using deterministic intensity prediction models has proven to be very difficult (Elsberry et al. 2007)
- ~80% of Atlantic MH undergo RI (30-kt/24-h) (Kaplan and DeMaria 2003)
- Model forecasting difficulties due to the multi-scale nature of RI:
  - Environment (e.g. Molinari and Vollaro 1989; Kaplan and DeMaria 2003)
  - Inner-core (Kossin and Schubert 2001, Kieper and Jiang 2012; Rogers et al. 2015)
  - Ocean (Shay et al. 2000)
- 2004-SHIPS-RII - Statistical model for estimating probability of RI (30-kt/24-h) using SHIPS(GFS-based) environmental predictors becomes operational (Kaplan and DeMaria 2003)
- 2008- More sophisticated versions of SHIPS-RII based upon linear discriminant analysis are developed (Kaplan et al. 2010)
- 2016- SHIPS-RII and new probabilistic Logistic regression, Bayesian, and Consensus RI models (Rozoff and Kossin 2011) developed for **12-h**, **24-h** , **36-h**, and **48-h** lead times (Kaplan et al. 2015)
- 2017 – RI models for 65kt/72-h lead-time added (HFIP)

Percentiles of over-water tropical cyclone intensity change (1995-2016)

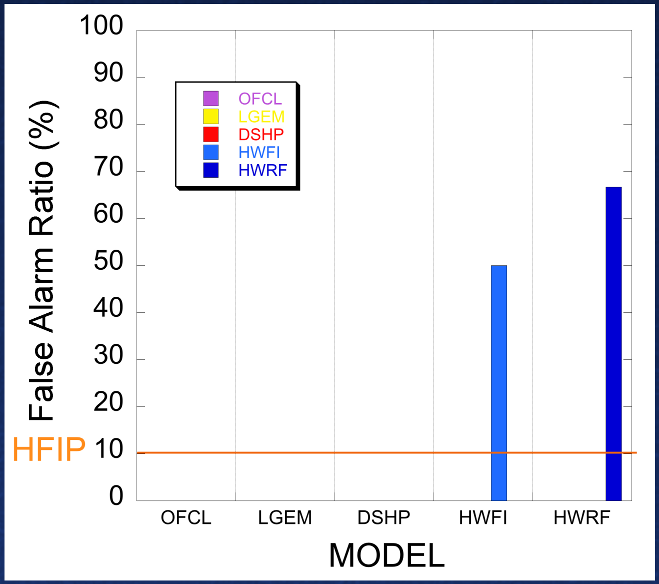
dv/dt (kt h^{-1})	Atlantic	E. Pacific
20-kt/12h	**95**	**92**
25-kt/24h	89	85
30-kt/24-h	**93**	**90**
35-kt/24-h	96	93
40-kt/24-h	97	95
45-kt/36-h	**95**	**92**
55-kt/48-h	**95**	**93**
65-kt/72-h	**94**	**94**

POD, FAR, and Frequency of RI (30-kt/24-h) of 2014-2016 Atlantic operational model forecasts (N=470, NRI=32)

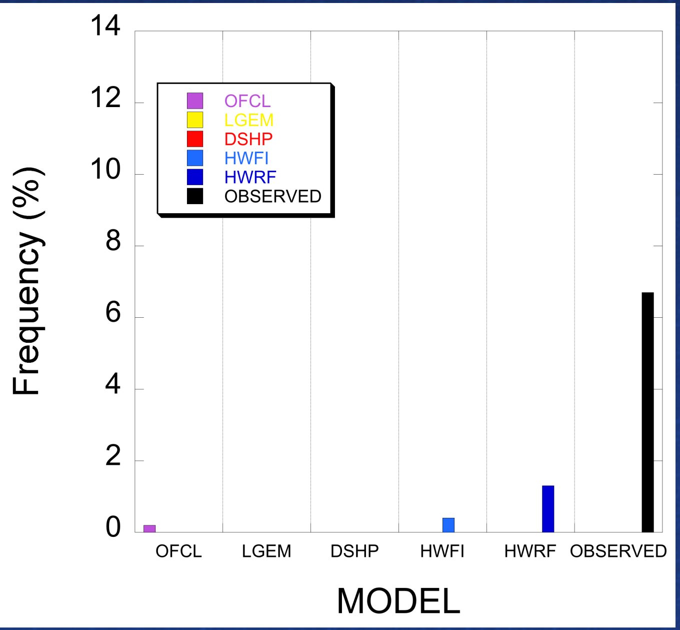
POD



FAR

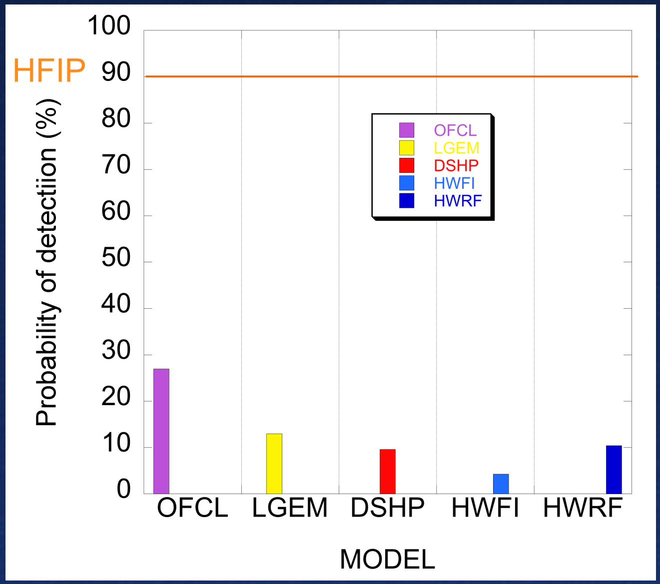


Frequency

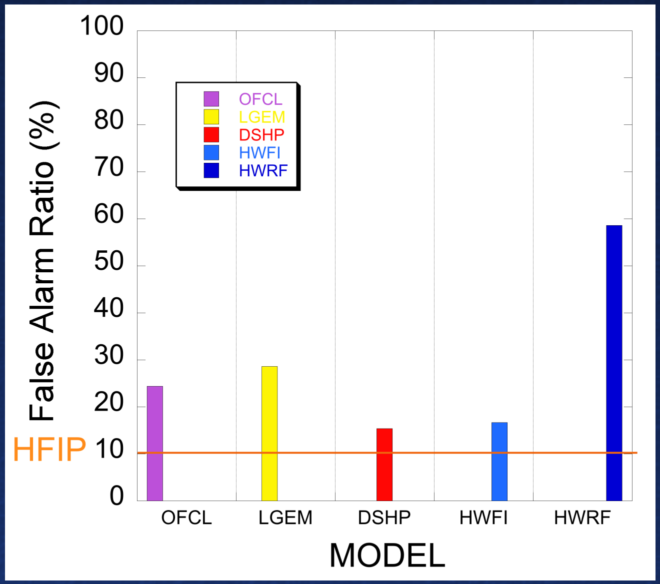


POD, FAR and Frequency of RI (30-kt/24h) of 2014-2016 E. Pacific operational model forecasts (N=929, NRI=115)

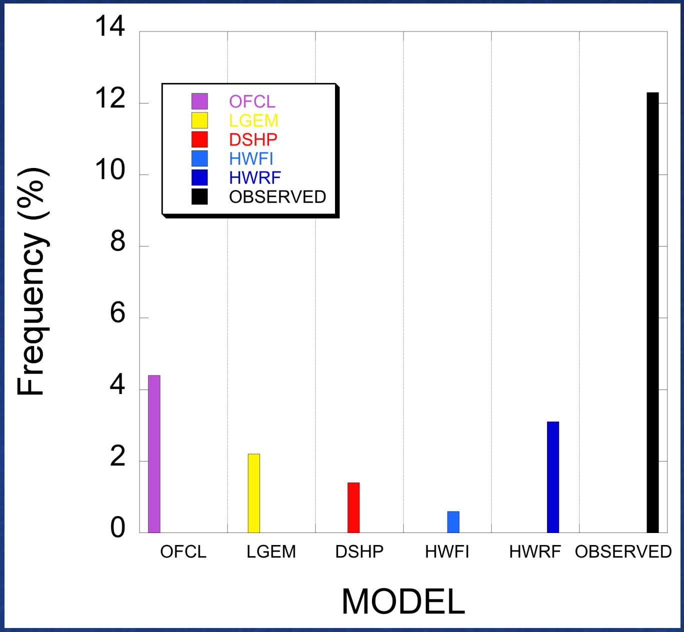
POD



FAR

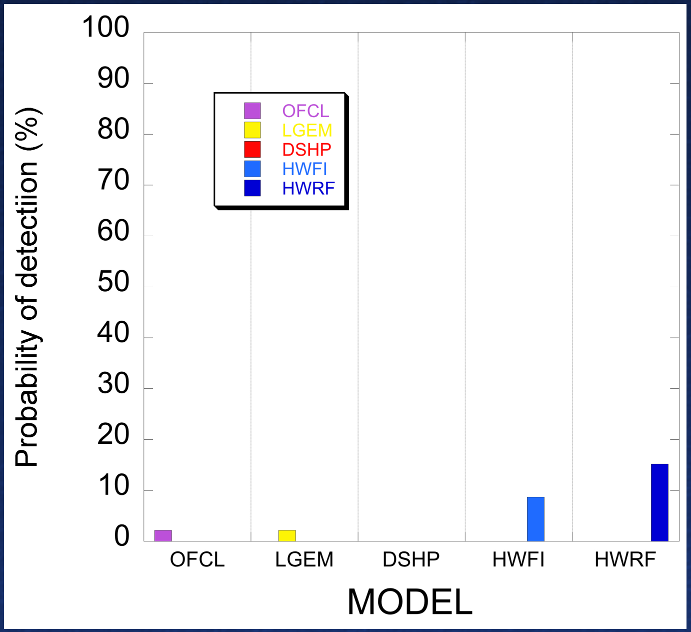


Frequency

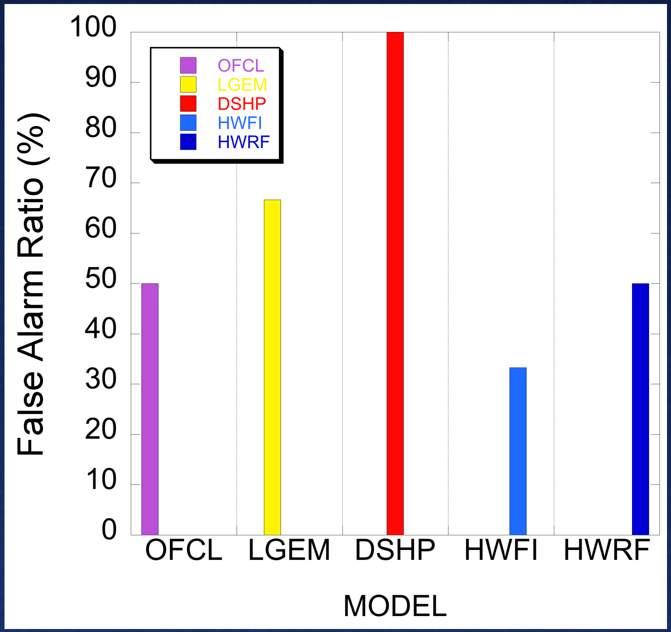


POD, FAR, and Frequency of RI (25-kt/24-h) of 2014-2016 Atlantic operational model forecasts (N=470, NRI=46)

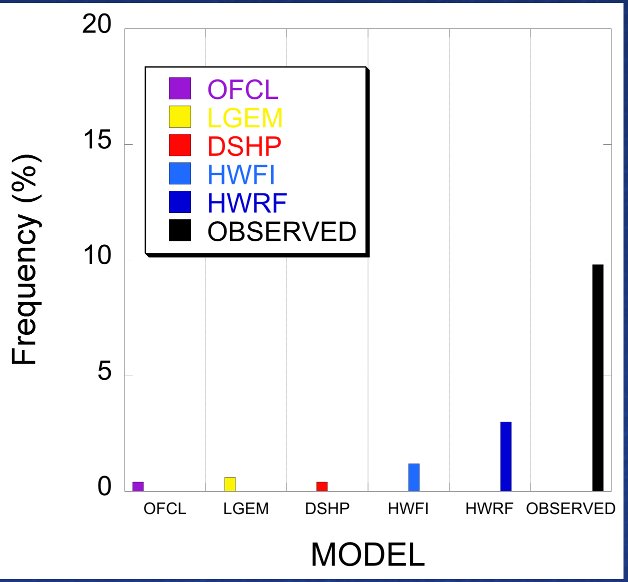
POD



FAR

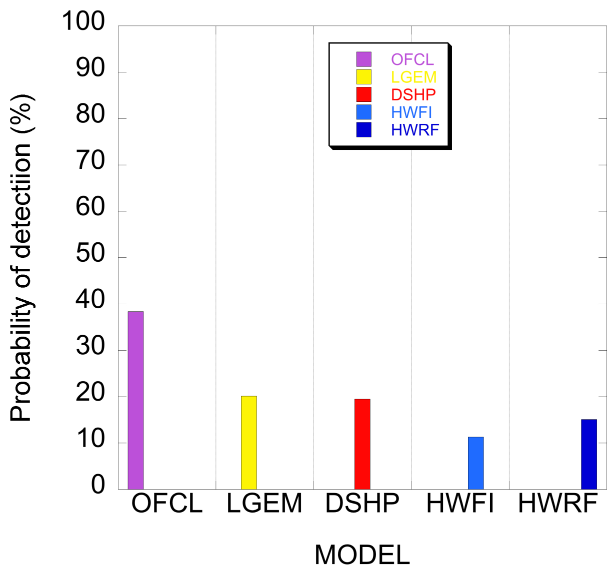


Frequency

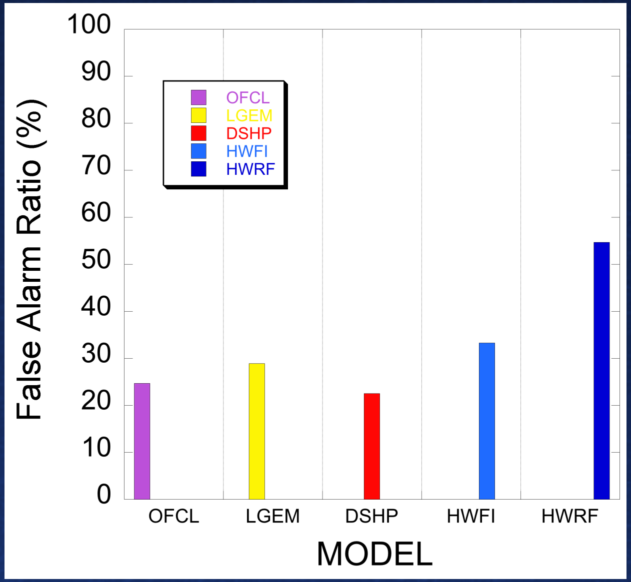


POD, FAR and Frequency of RI (25-kt/24h) of 2014-2016 E. Pacific operational model forecasts (N=929, NRI=159)

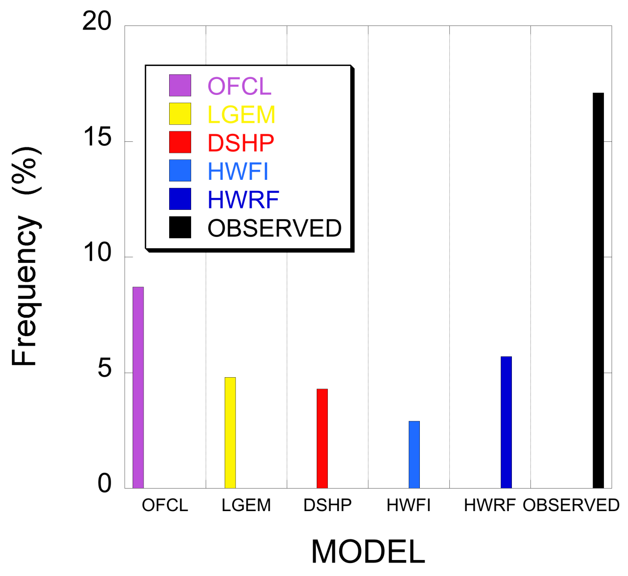
POD



FAR

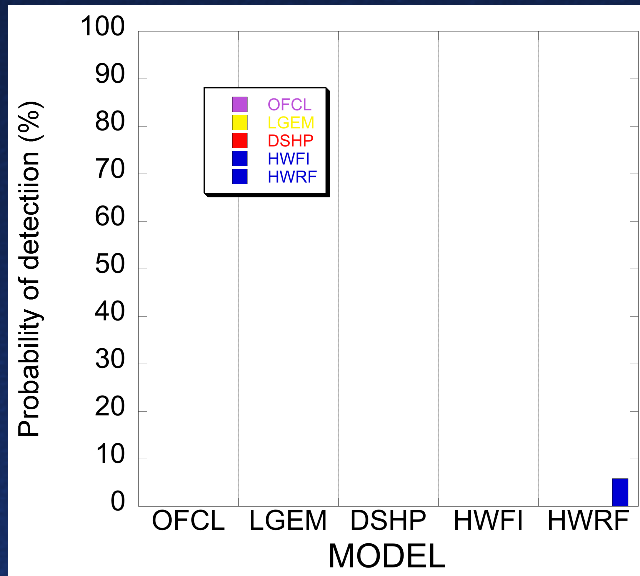


Frequency

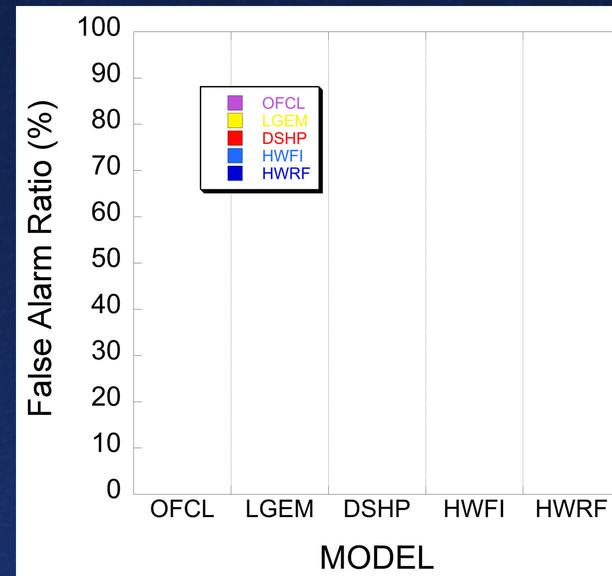


POD, FAR, and Frequency of RI (55-kt/48-h) for 2014-2016 Atlantic operational model forecasts (N=361, NRI=17)

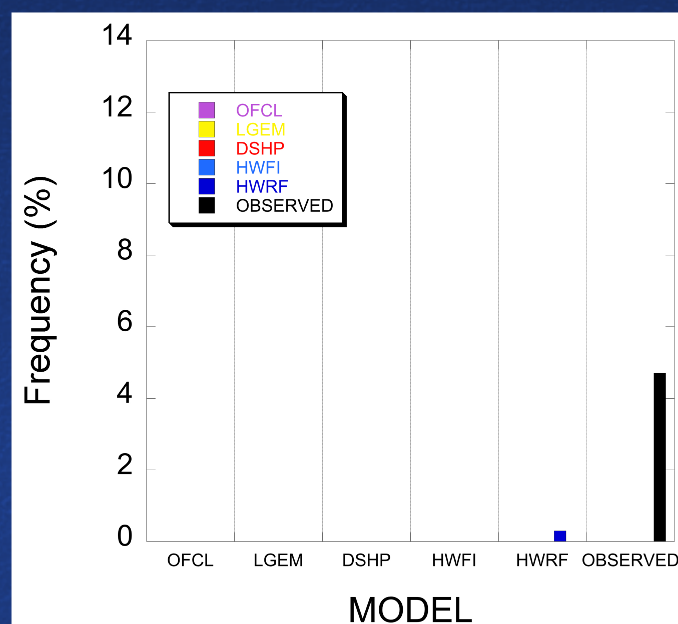
POD



FAR

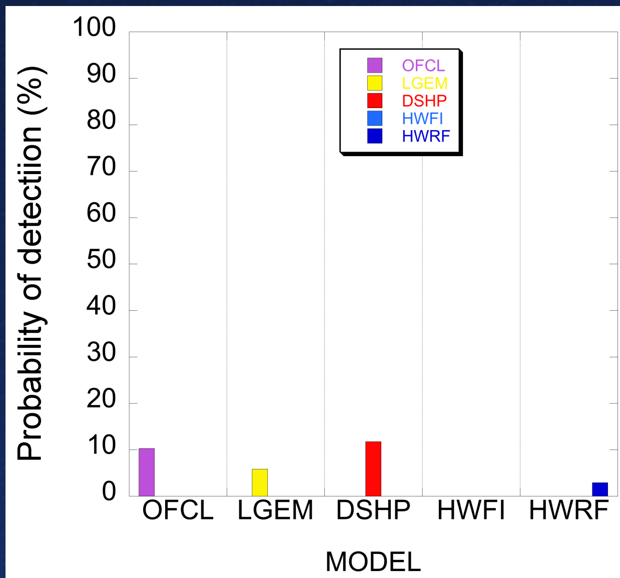


Frequency

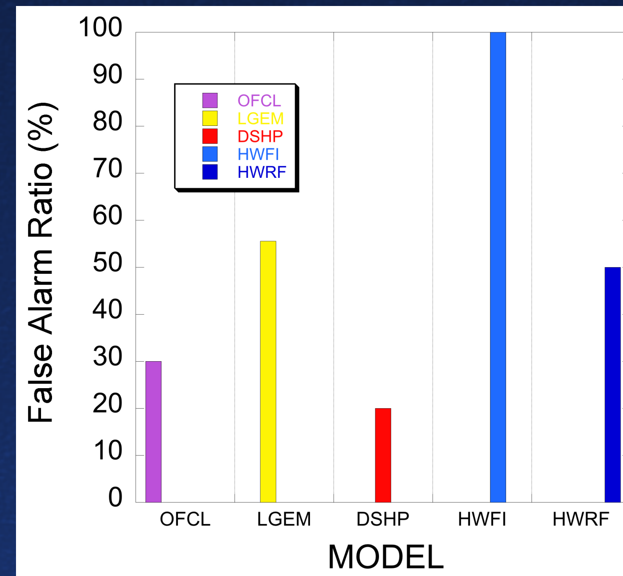


POD, FAR, and Frequency of RI (55-kt/48-h) for 2014-2016 E. Pacific operational model forecasts (N=725, NRI=68)

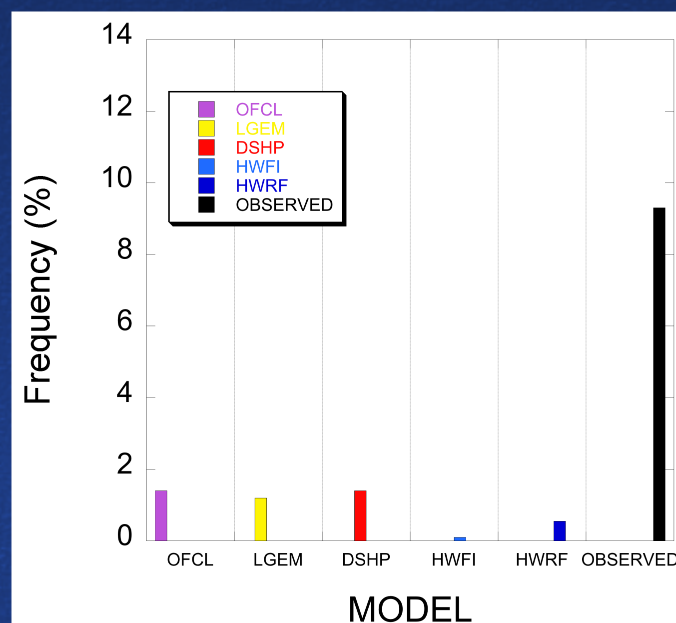
POD



FAR



Frequency



2016 Operational Statistical RI models

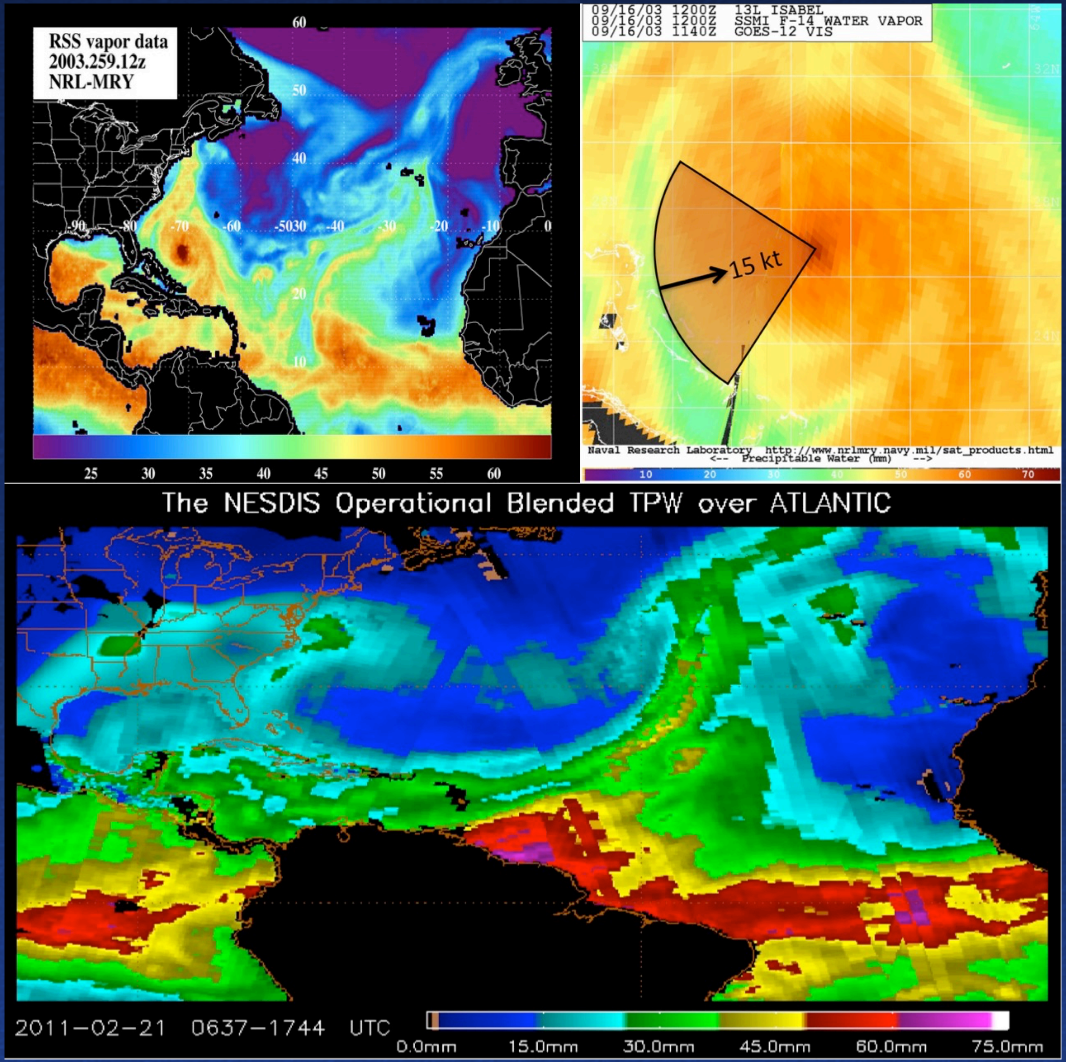
- Predict RI probability for 7 RI thresholds at 4 lead times (**20-kt/12-h**, 25-kt/24-h, **30-kt/24-h**, 35-kt/24-h, 40-kt/24-h, **45-kt/36-h** and **48-h/55-kt**) for the Atlantic and E. Pacific (Kaplan et al. 2015).

- Multi-lead time RI models developed include the following:
  - ➢ SHIPS-RII – Based upon linear discriminant analysis
    - 10 SHIPS environmental predictors utilized in both the Atlantic and E. Pacific basins (Kaplan et al. 2015)
  - ➢ Logistic regression and Bayesian RI models (Rozoff and Kossin 2011; Kaplan et al. 2015)
    - Logistic regression/Bayesian RI models employ the SHIPS predictors that maximized cross-validated model skill at each forecast lead time
  - ➢ Consensus RI model is the arithmetic average of SHIPS, Logistic, and Bayesian model forecasts

Predictors used in operational SHIPS-RII

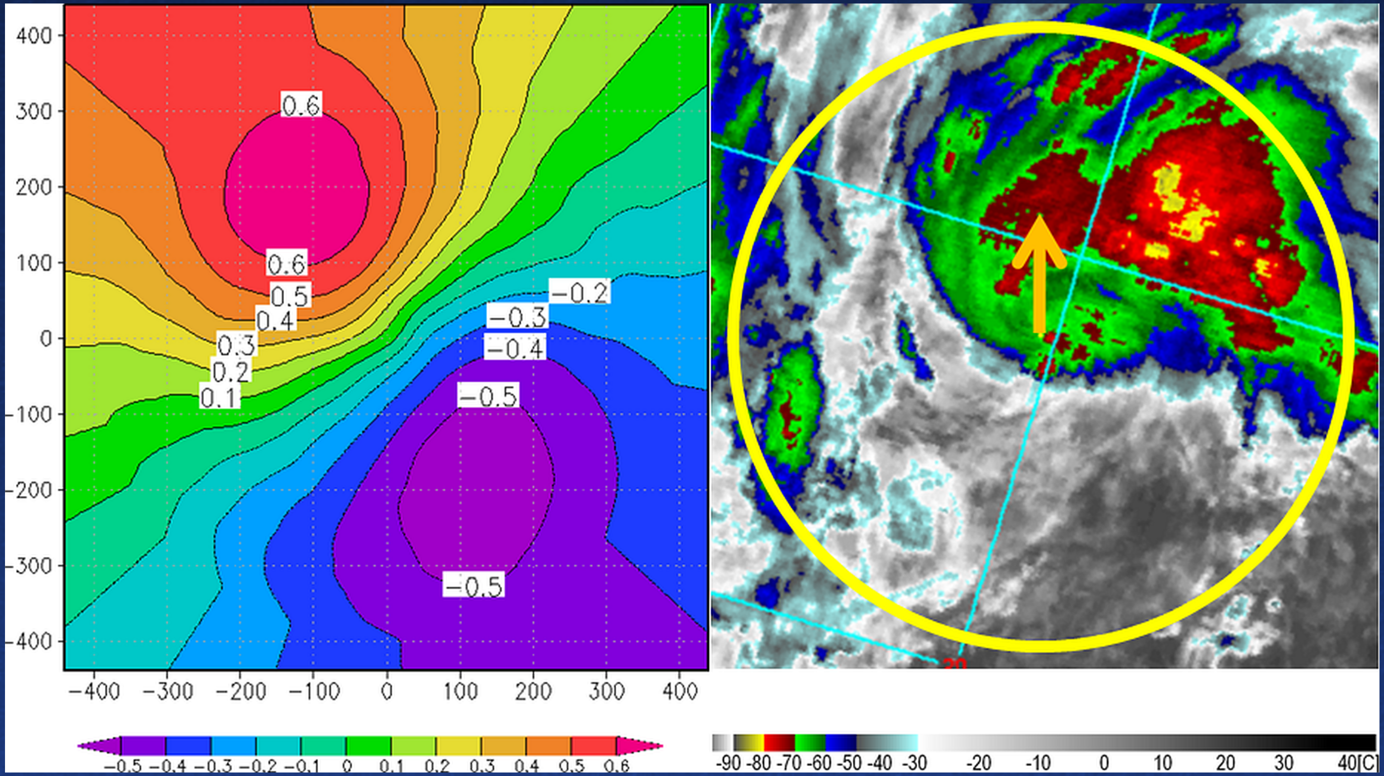
Predictor	Definition	More Favorable
PER	Previous 12-h intensity change	Larger
VMAX	Maximum sustained wind (t=0 h)	Avg. of RI sample
IRSD	Std. dev. of 50-200 km GOES-IR brightness temperatures (t= 0 h)	Smaller
IRPC	2nd principle component of GOES-IR image (0-440 km radius) (t= 0 h)	Front left quadrant
SHEAR	850-200-hPA shear 0-500 km radius (time-avg.)	Smaller
D200	200-hPA divergence from 0-1000 km radius (time-avg.)	Larger
TPW	Percent area with TPW < 45 mm within 500 km 90 deg. up-shear (t=0 h)	Smaller
CFLX	Inner-core dry-air predictor/flux (time-avg.)	Smaller
POT	Potential intensity (Current intensity – MPI) (time-avg.)	Larger
OHC	Oceanic heat content (time-avg.)	Larger

Sample TPW predictor for Hurricane Isabel (2003)



Source: Kaplan et al. 2015

Sample IRPC predictor for Hurricane Wilma (2015) at 1800 UTC on October 17



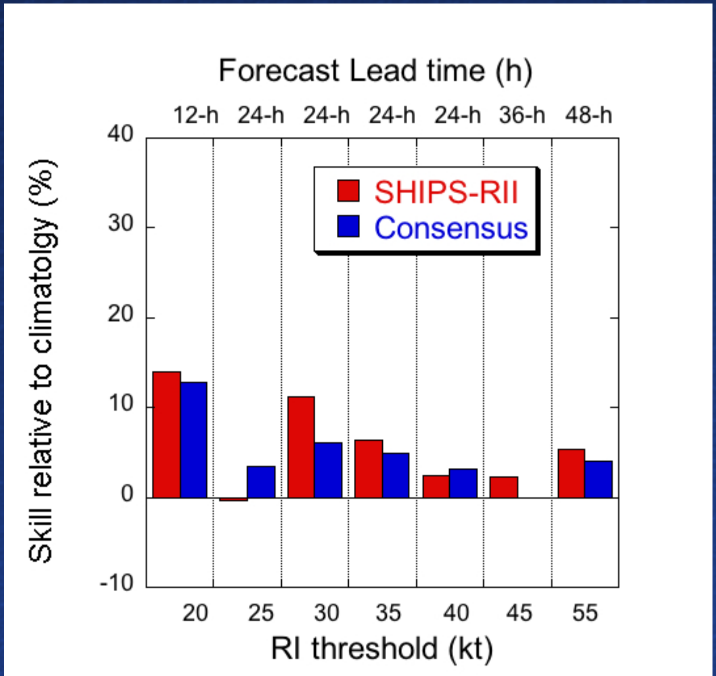
Source: Kaplan et al. 2015

Statistical operational RI model skill in 2016 Hurricane Season

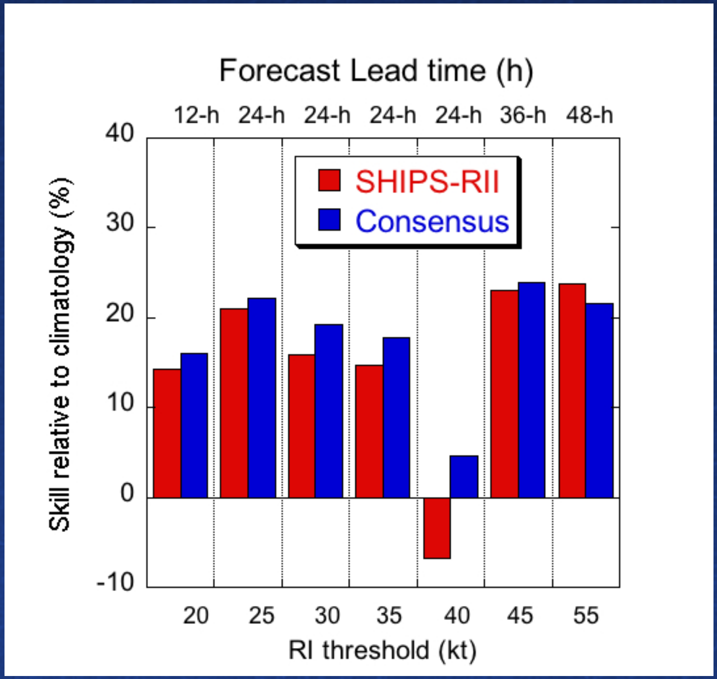
Skill evaluated for all tropical and subtropical over-water cases relative to the climatological RI probabilities based upon NHC best tracks as of Feb 2017

Consensus Model- Average of SHIPS-RII, Bayesian, and Logistic regression RI probabilistic forecasts

Atlantic



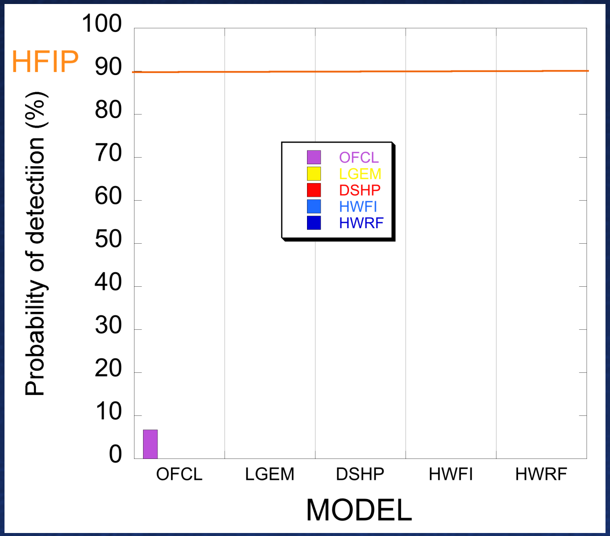
E. Pacific



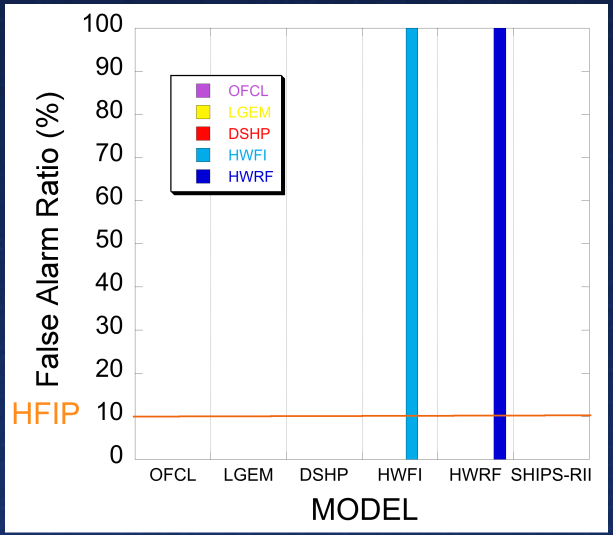
POD, FAR of RI (30-kt/24-h) of 2016 operational forecasts

Atlantic (N=206, NRI= 15)

POD

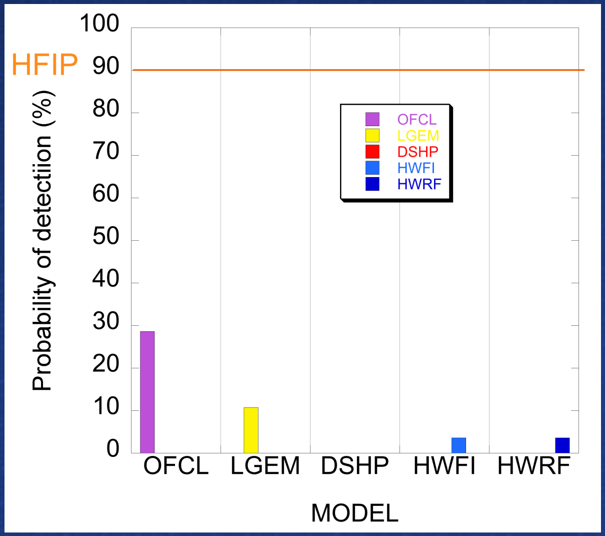


FAR

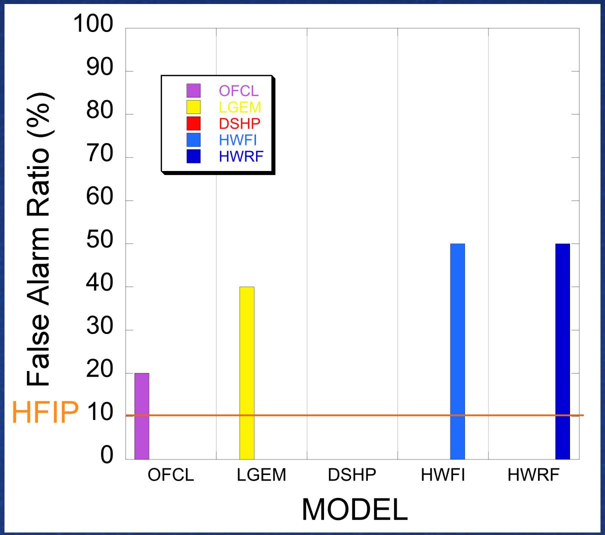


E. Pacific (N=246, NRI=28)

POD



FAR



2017 Operational RI models

-GFS model-derived TPW used in place of satellite-based values

-Slight modification to methodology used to derive GOES IR principle-component predictor

-GFS CSR reanalysis fields used in place of operational GFS analyses for cases from 1995-1999

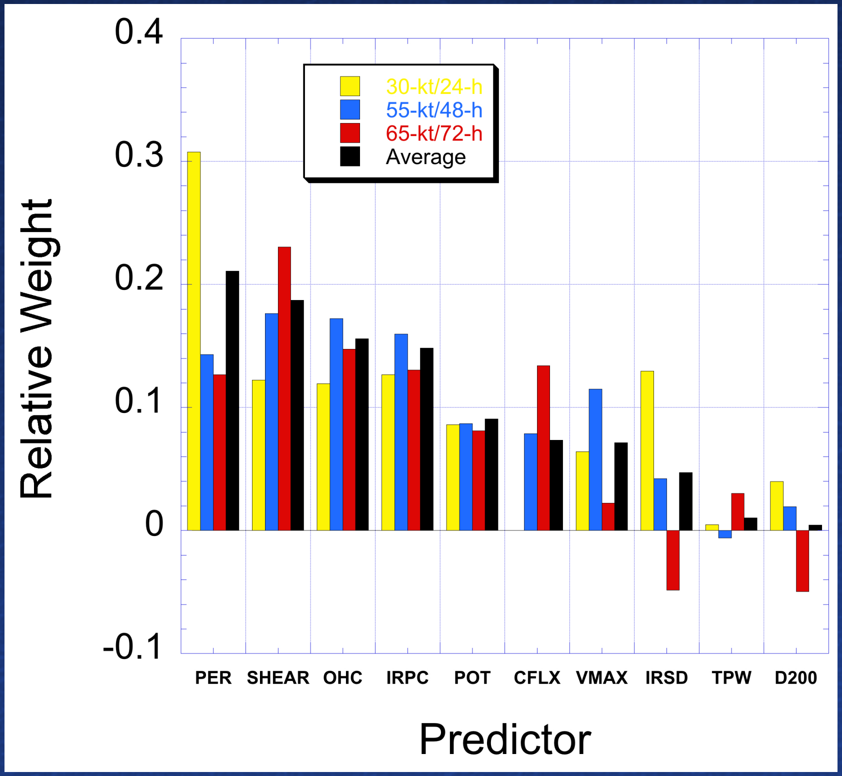
-SHIPS-RII predictors same as 2016 version but Logistic and Bayesian models predictors slightly different

-2017 RI models include RI probabilities for 72-h/65-kt threshold (HFIP)

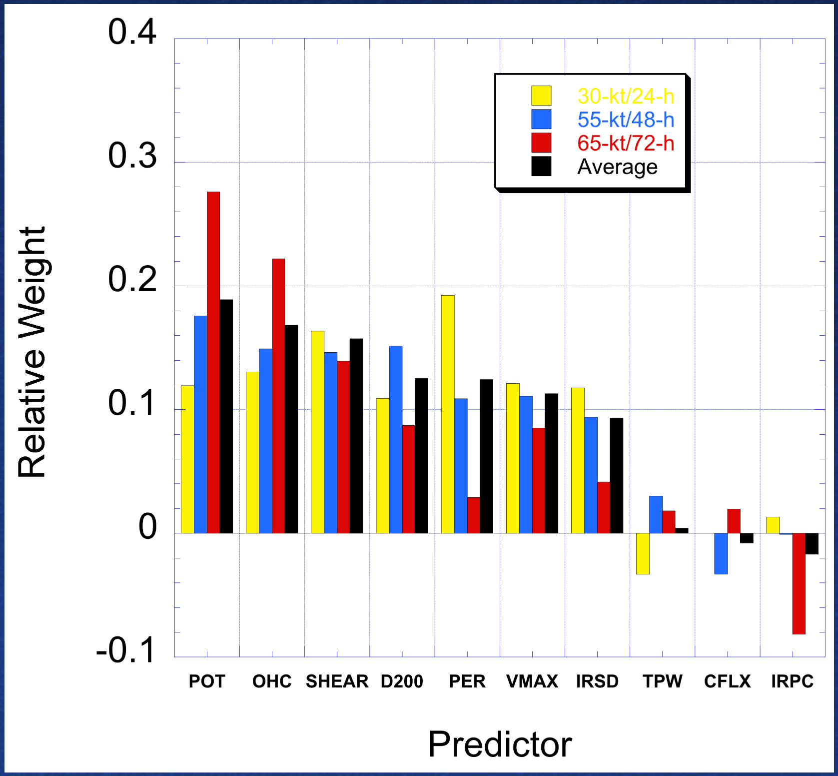
Relative weights of the 2017 SHIPS-RII

(for 24-h/30-kt, 48-h/55-kt and 72-h/65-kt RI thresholds based upon 1995-2016 developmental data)

Atlantic

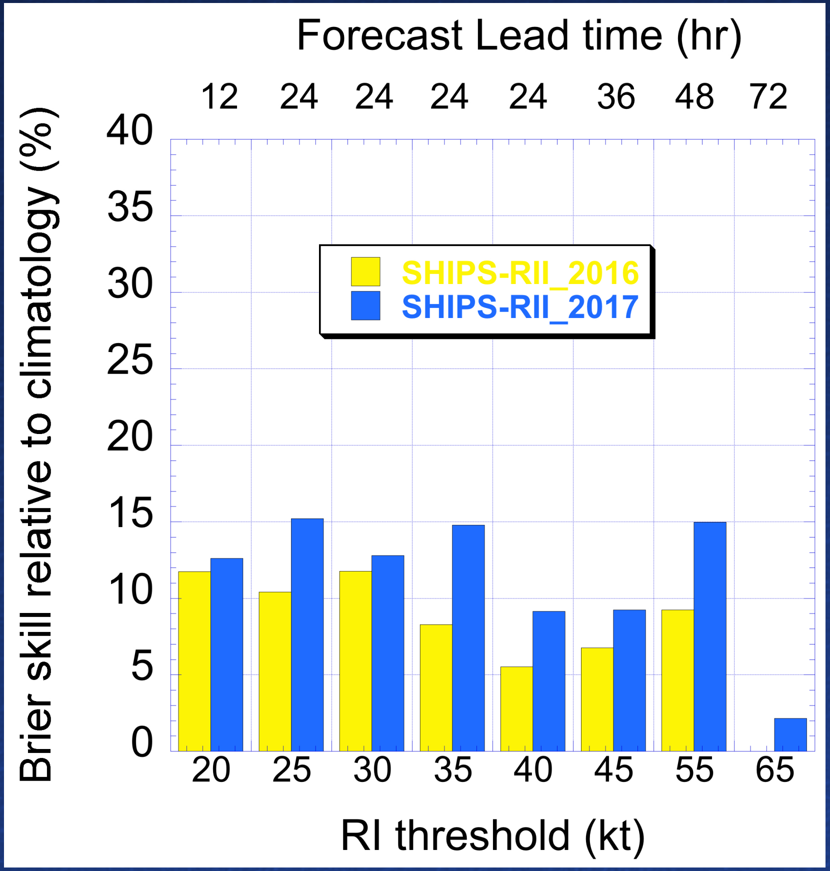


E. Pacific

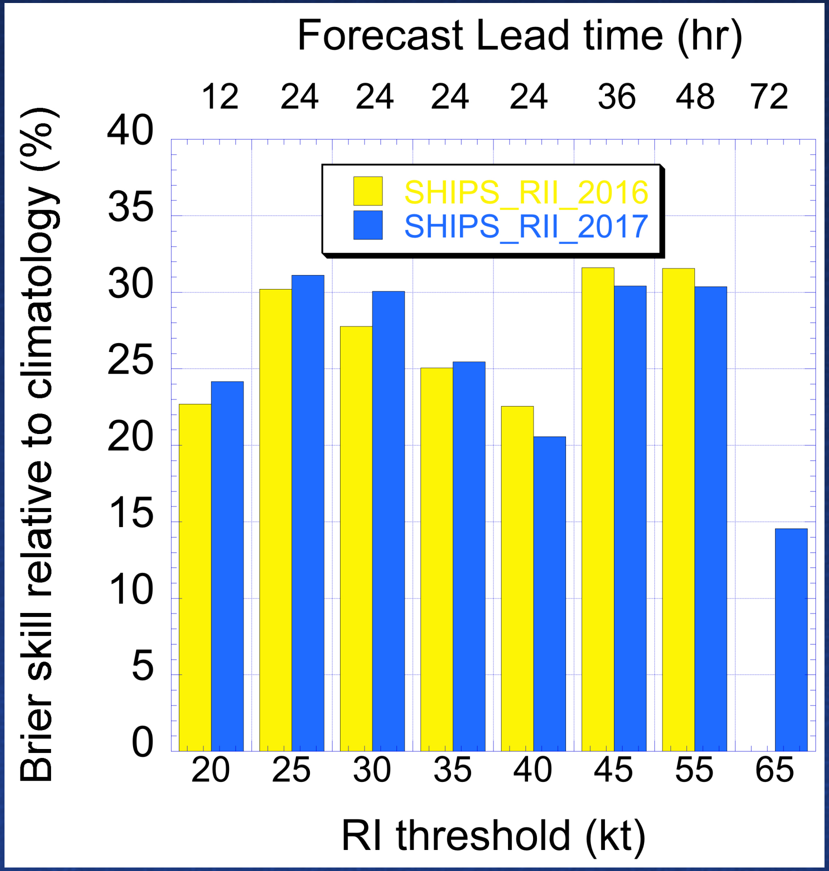


Comparison of Skill of the 2016 and 2017 SHIPS-RII for the 2014-2016 re-run forecasts

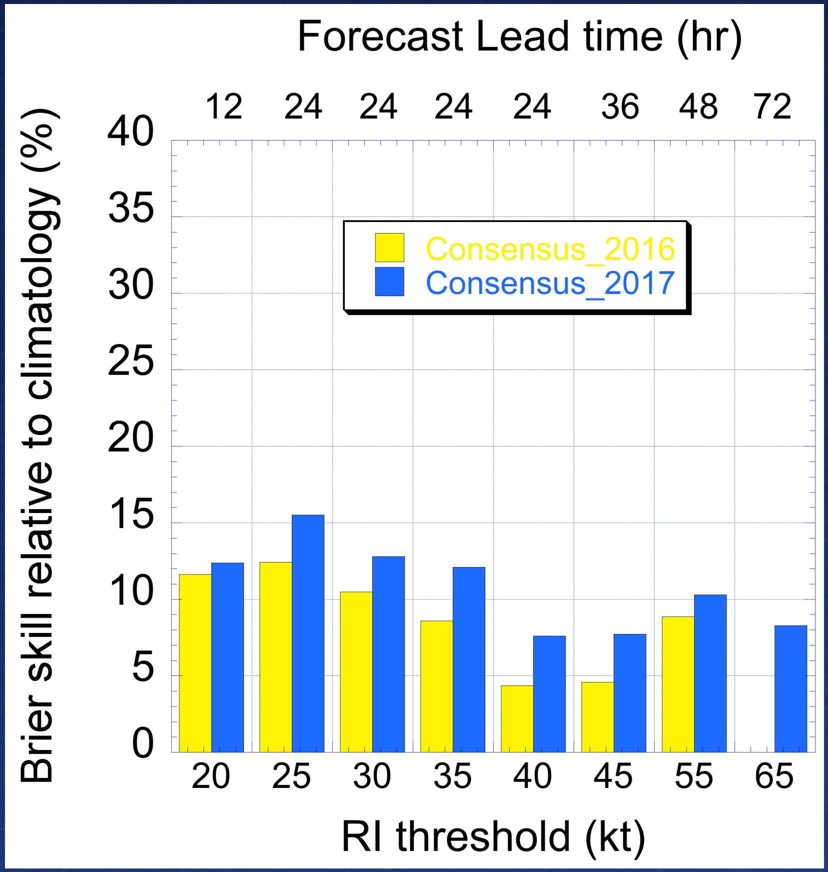
Atlantic

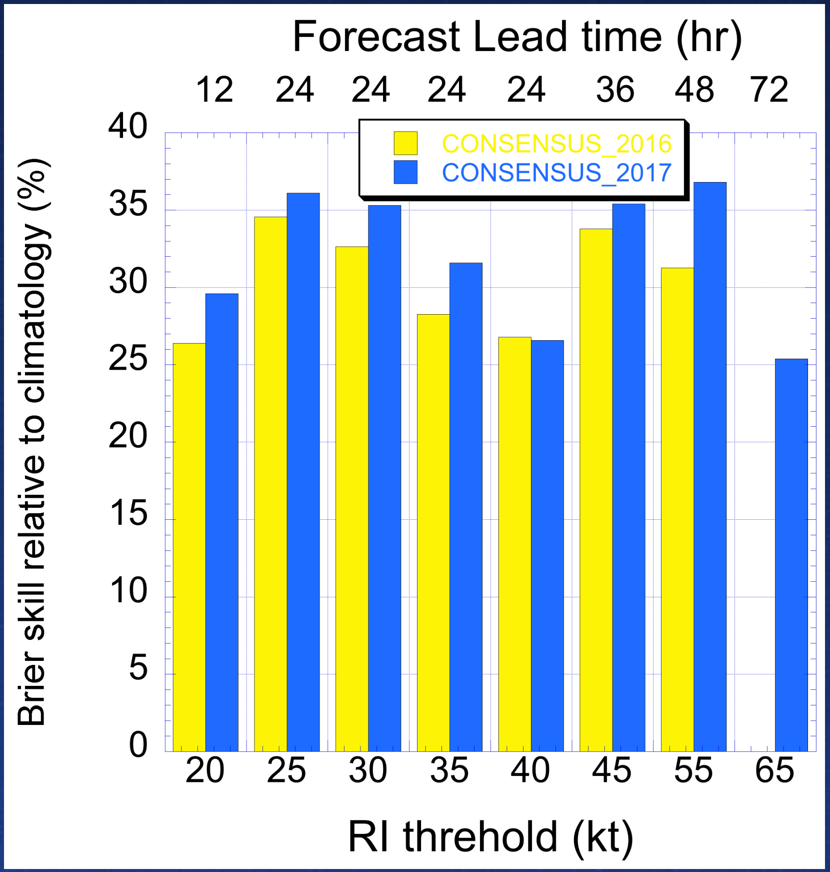


E. Pacific



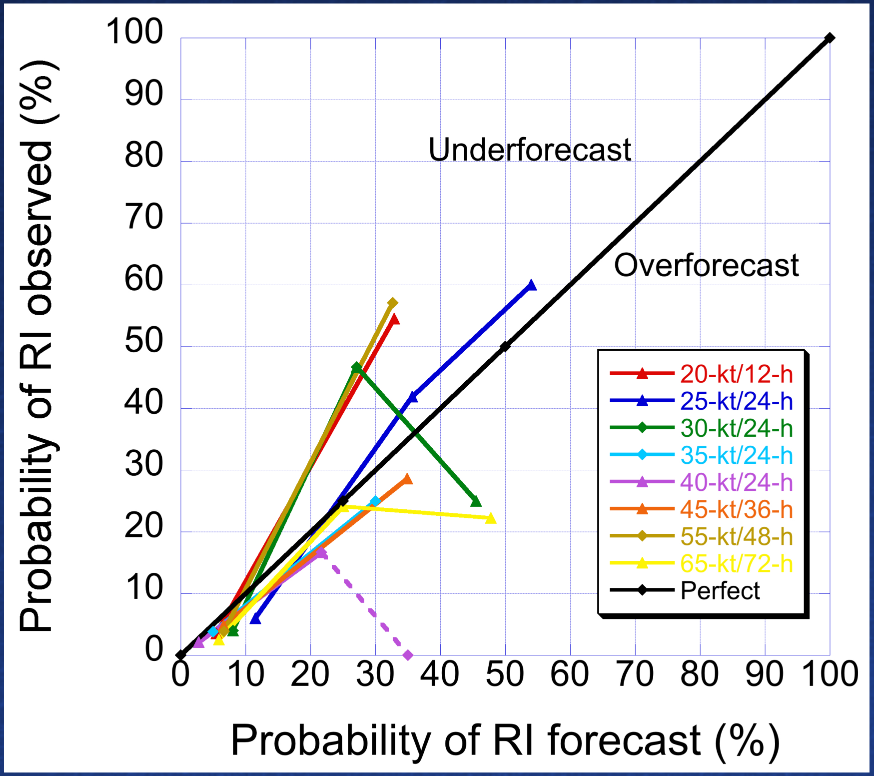
Skill of the 2016 and 2017 Consensus RI models for the 2014-2017 re-run forecasts



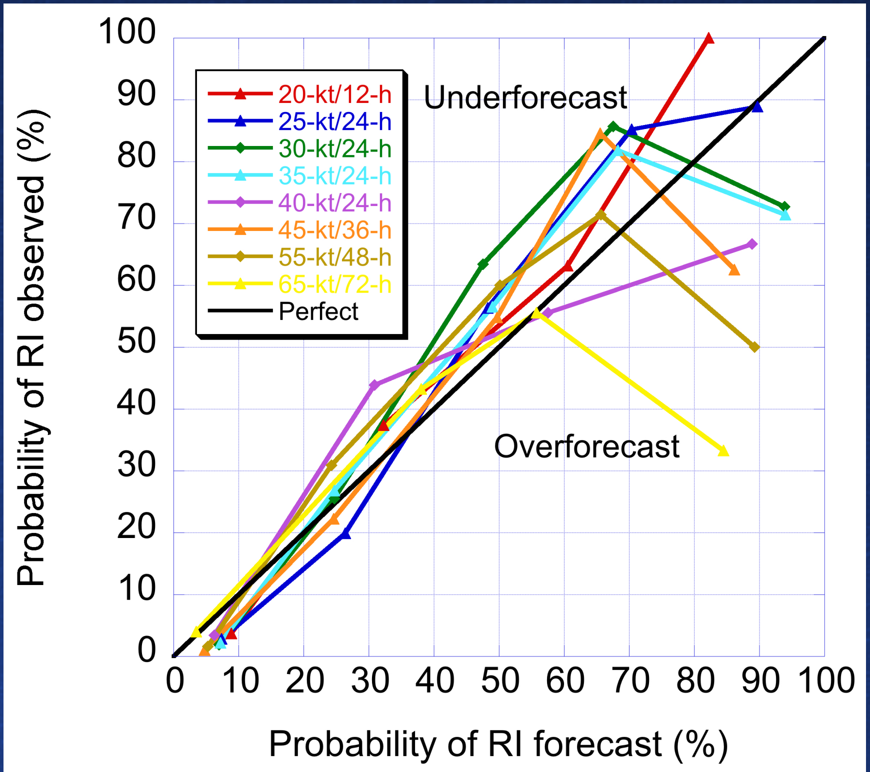


Reliability of the 2017 SHIPS-RII forecasts for the 2014-2016 rerun cases

Atlantic

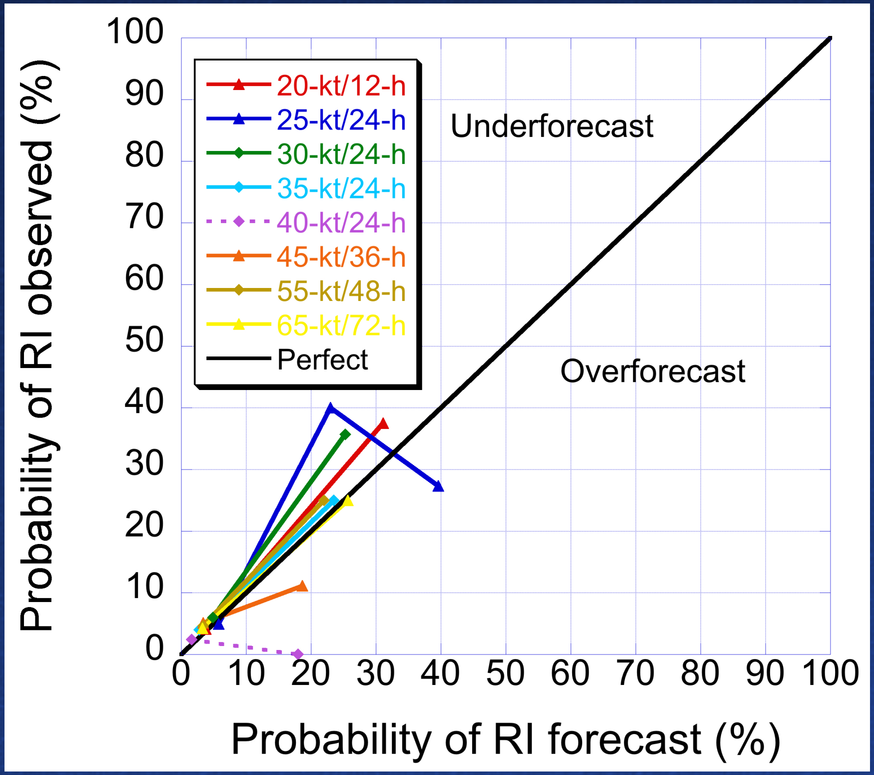


E. Pacific

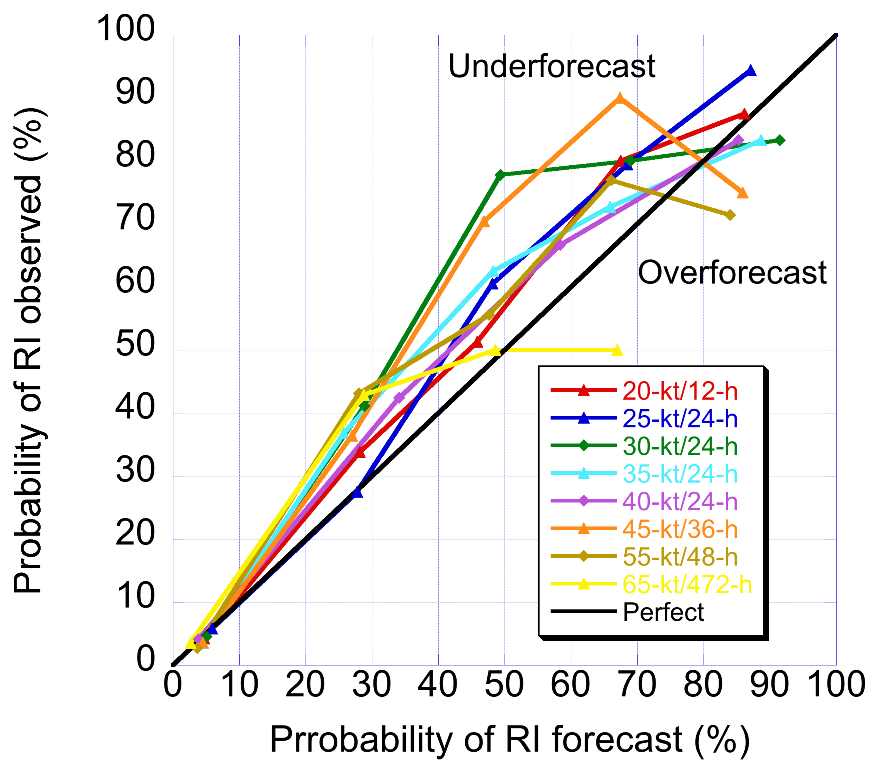


Reliability of 2017 Consensus RI model forecasts for the 2014-2016 rerun cases

Atlantic



E. Pacific

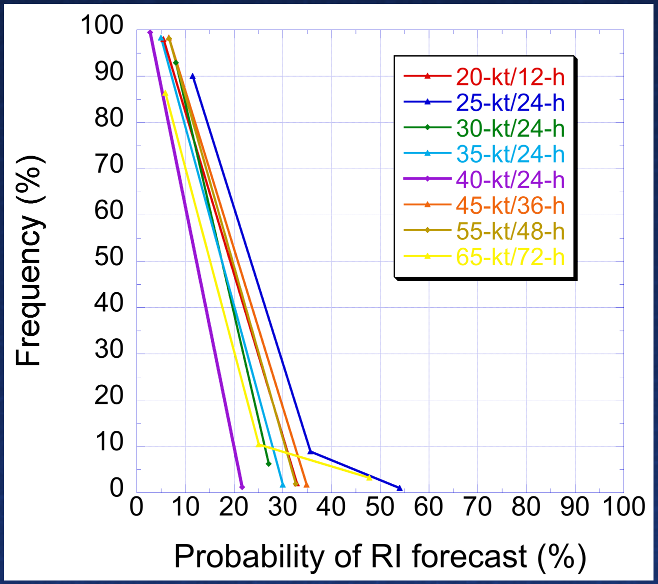


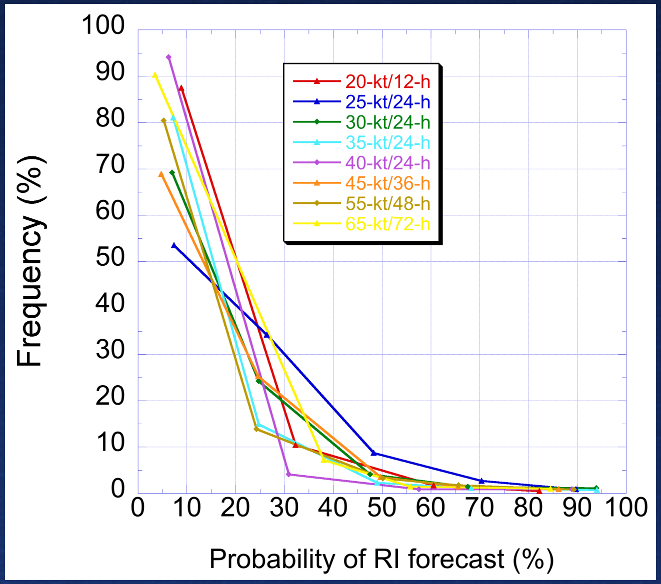
SHIPS-RII and Consensus RI model forecast frequency distributions

Atlantic

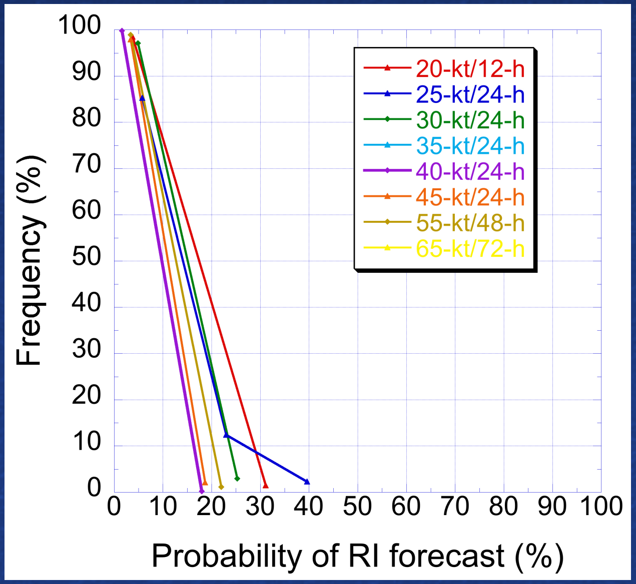
E. Pacific

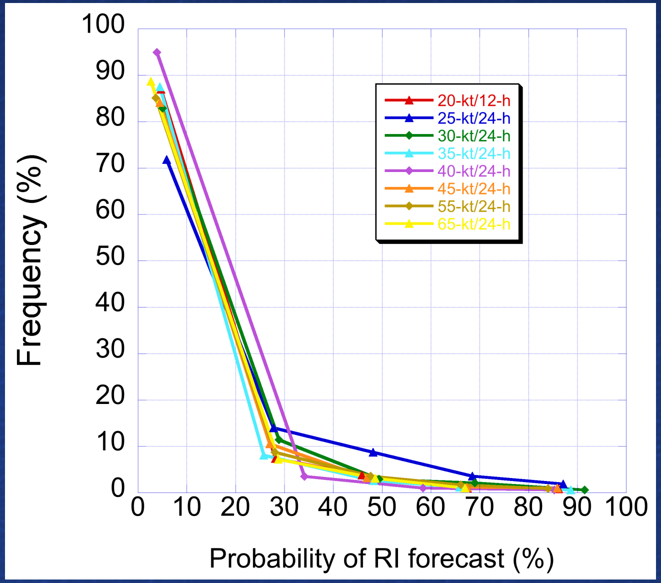
SHIPS



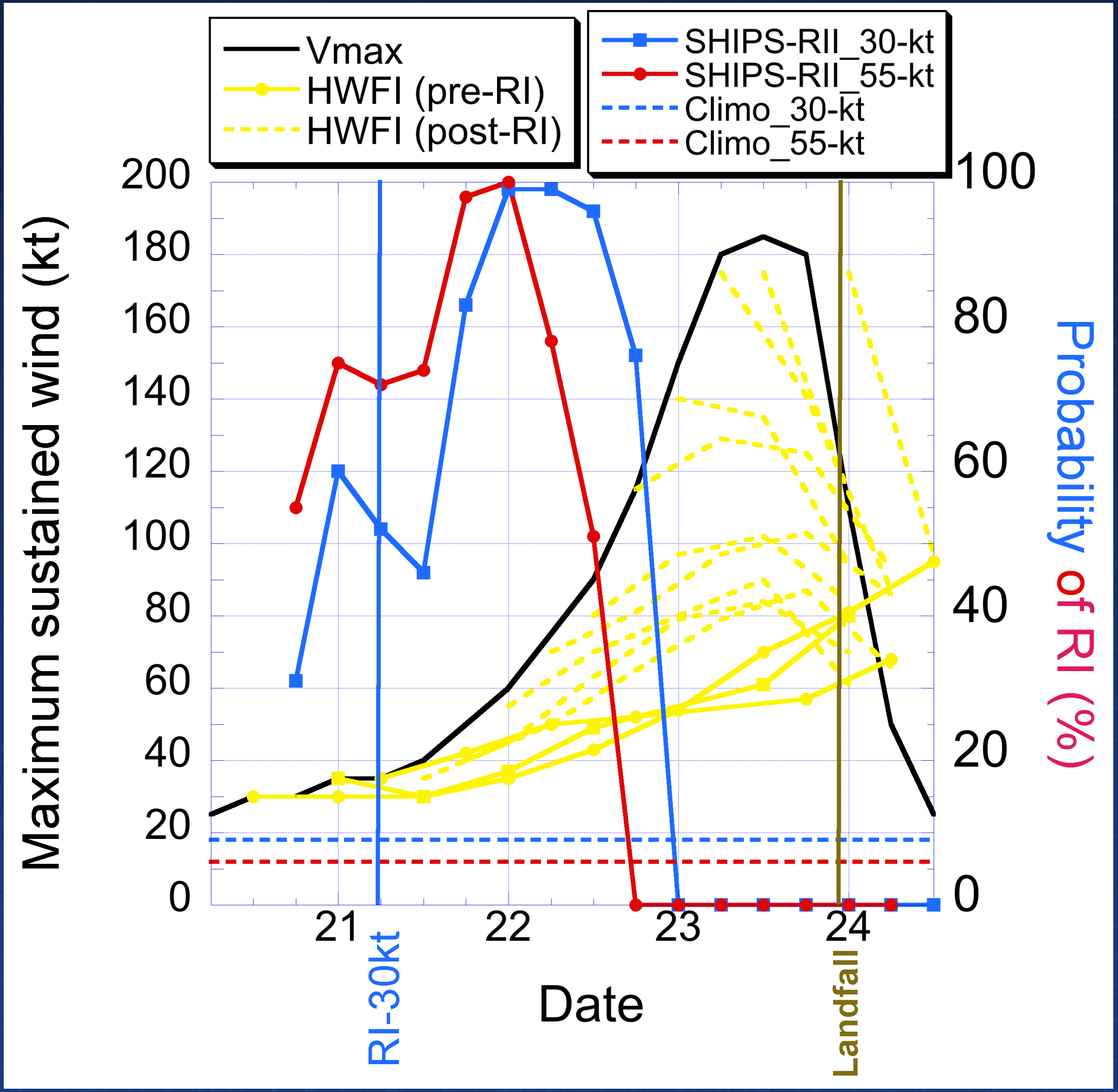


Consensus

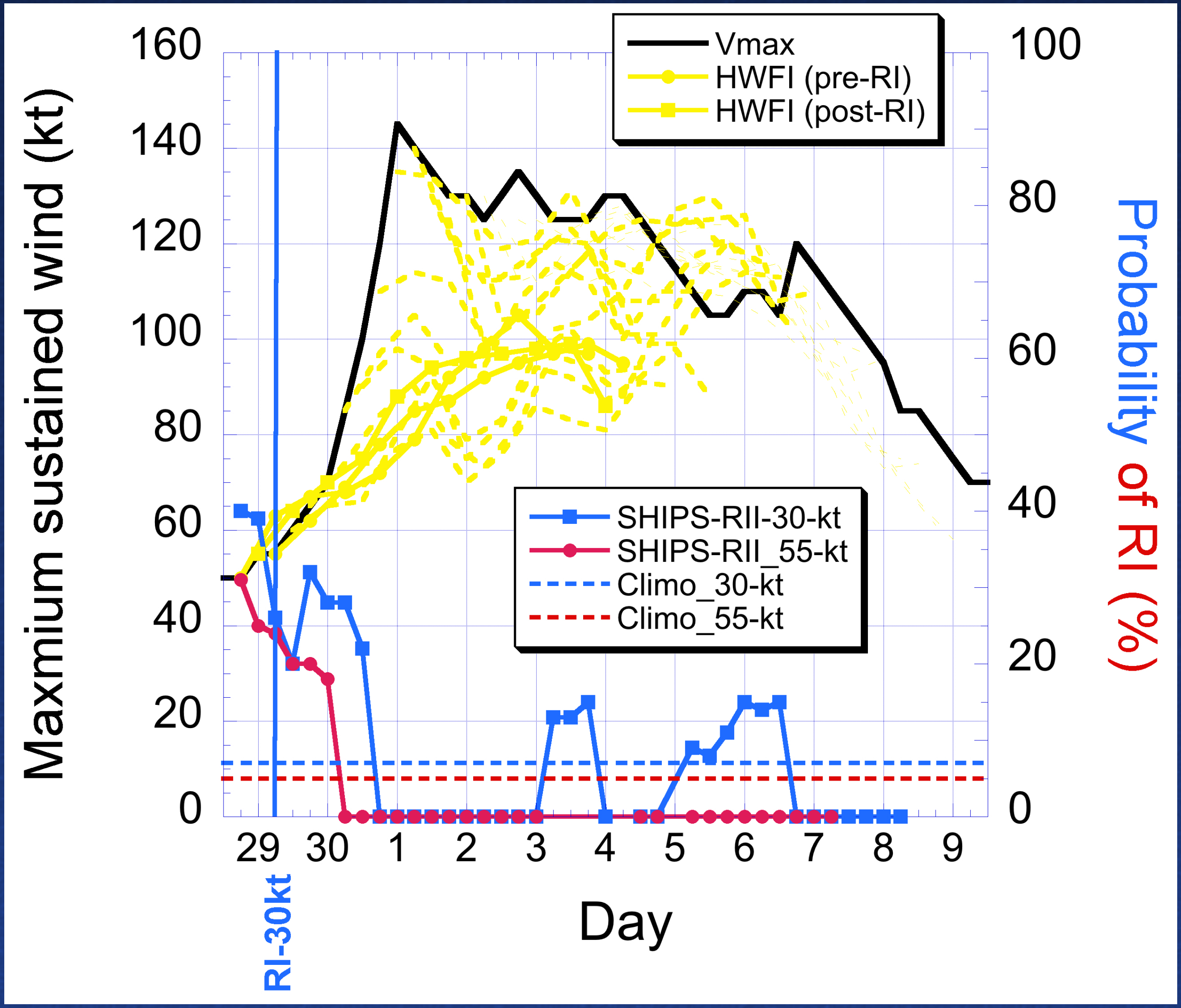




SHIPS-RII 2017 model rerun and HWFI operational forecasts for Hurricane Patricia (2015)

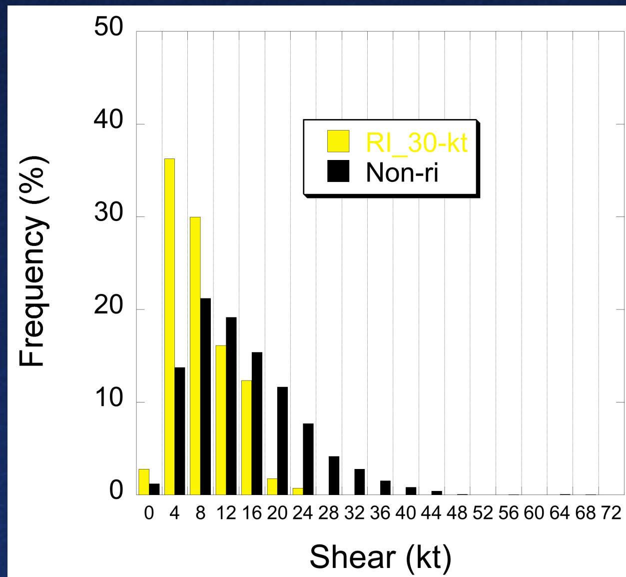


SHIPS-RII 2017 rerun and HWFI operational forecasts for Hurricane Matthew (2016)

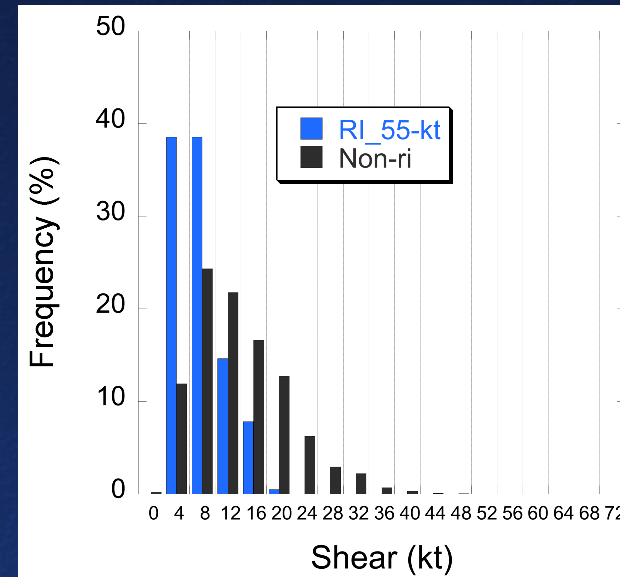


Atlantic basin 850-200 mb observed SHIPS shear distributions for the 1995-2016 developmental sample

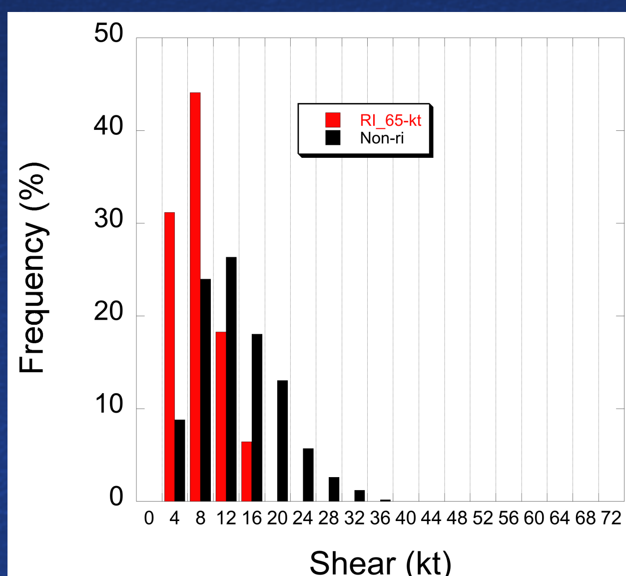
30kt/24h



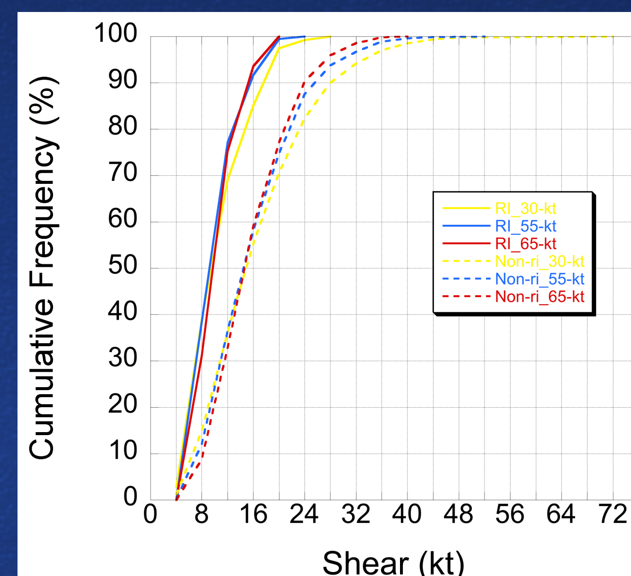
55kt/48h



65kt/72h

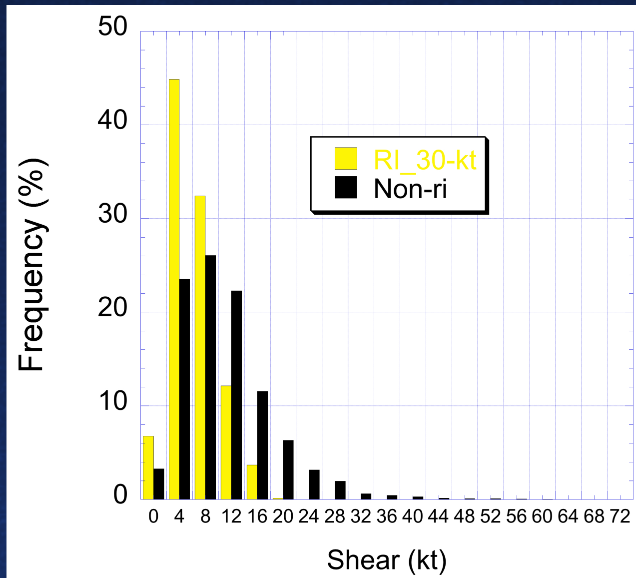


Cumulative Frequency

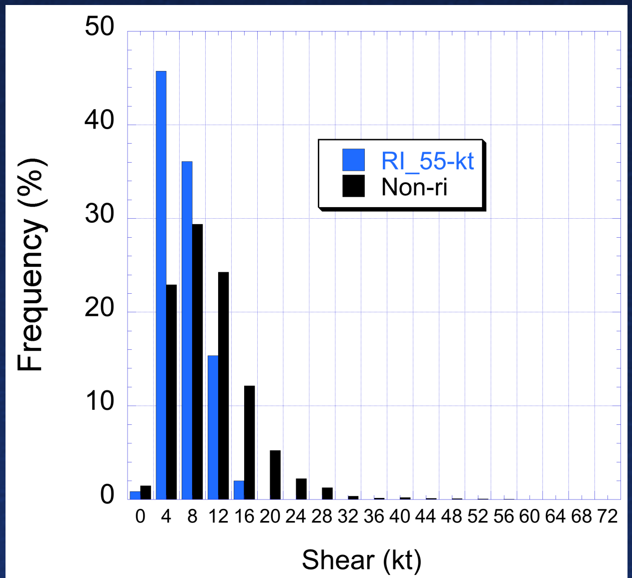


E. Pacific basin 850-200 mb observed SHIPS shear distributions for the 1995-2016 developmental sample

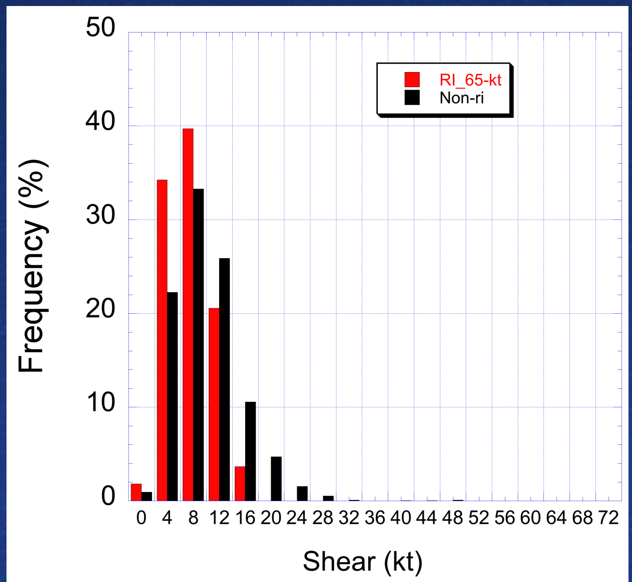
30kt/24h



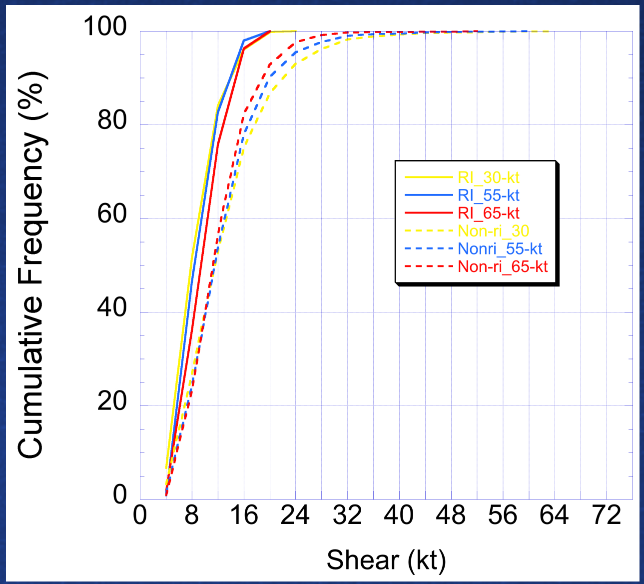
55kt/48h



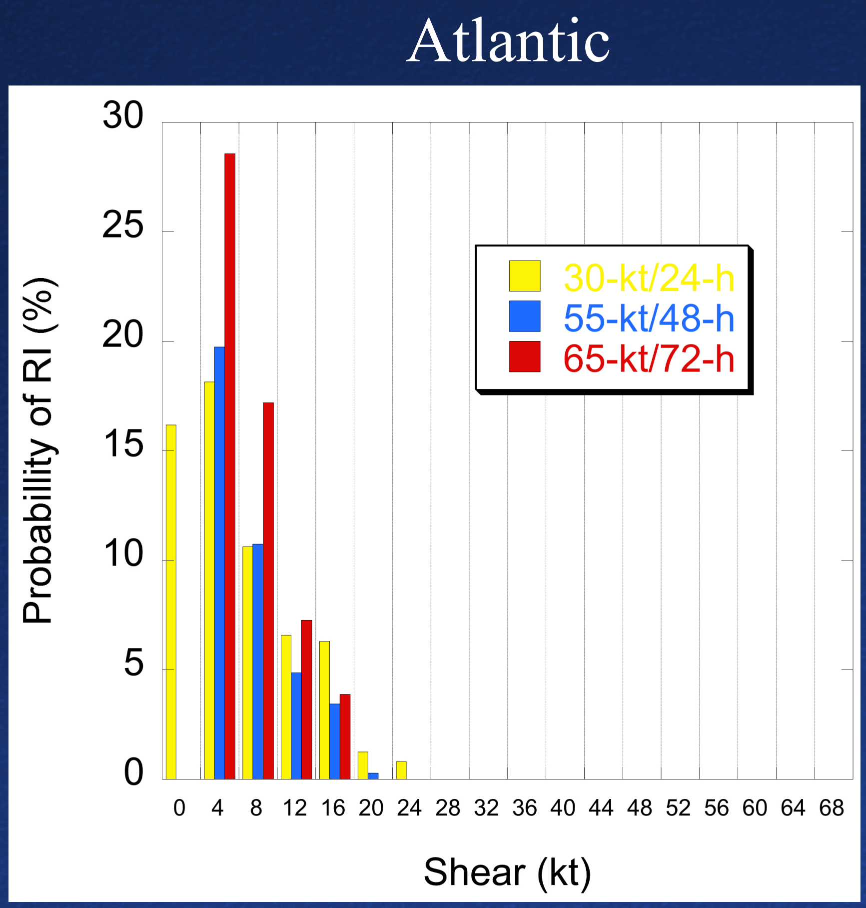
65kt/72h

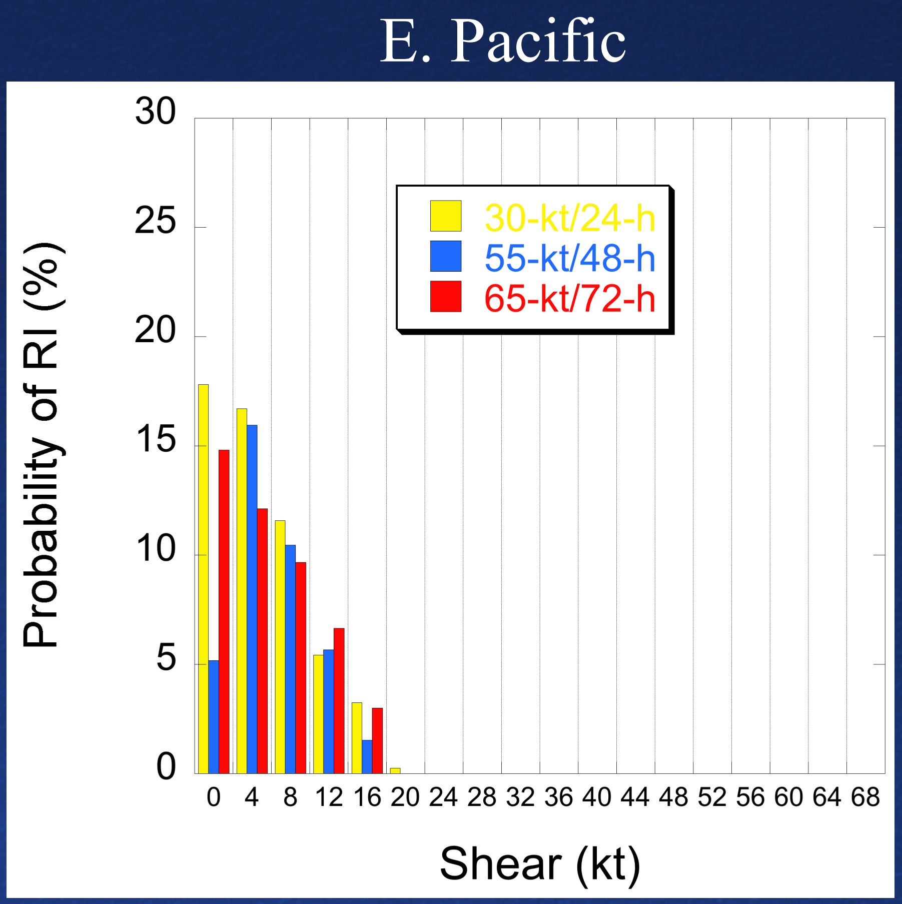


Cumulative Frequency



Probability of RI based upon 850-200mb observed SHIPS shear for the 1995-2016 developmental samples





Summary

- Deterministic model forecasts exhibited a low POD and moderate FAR for the 2014-2016 Atlantic and E. Pacific samples.
- Statistical operational RI models showed a small (modest) degree of skill in the Atlantic (E. Pacific) for the 2016 season. New 2017 RI models showed improvements over 2016 versions for the 2014-2016 reruns.
- Consensus of SHIPS, Logistic, and Bayesian RI models generally provided increased reliability and skill over SHIPS-RII for the 2014-2016 reruns forecasts (particularly in E. Pacific).
- Study results underscore the importance of accurately measuring and predicting the large-scale environment.
- Additional research is needed to better understand the processes that govern RI to ultimately improve RI prediction.