IMPROVEMENTS TO OPERATIONAL STATISTICAL TROPICAL CYCLONE INTENSITY FORECAST MODELS USING WIND STRUCTURE AND EYE PREDICTORS

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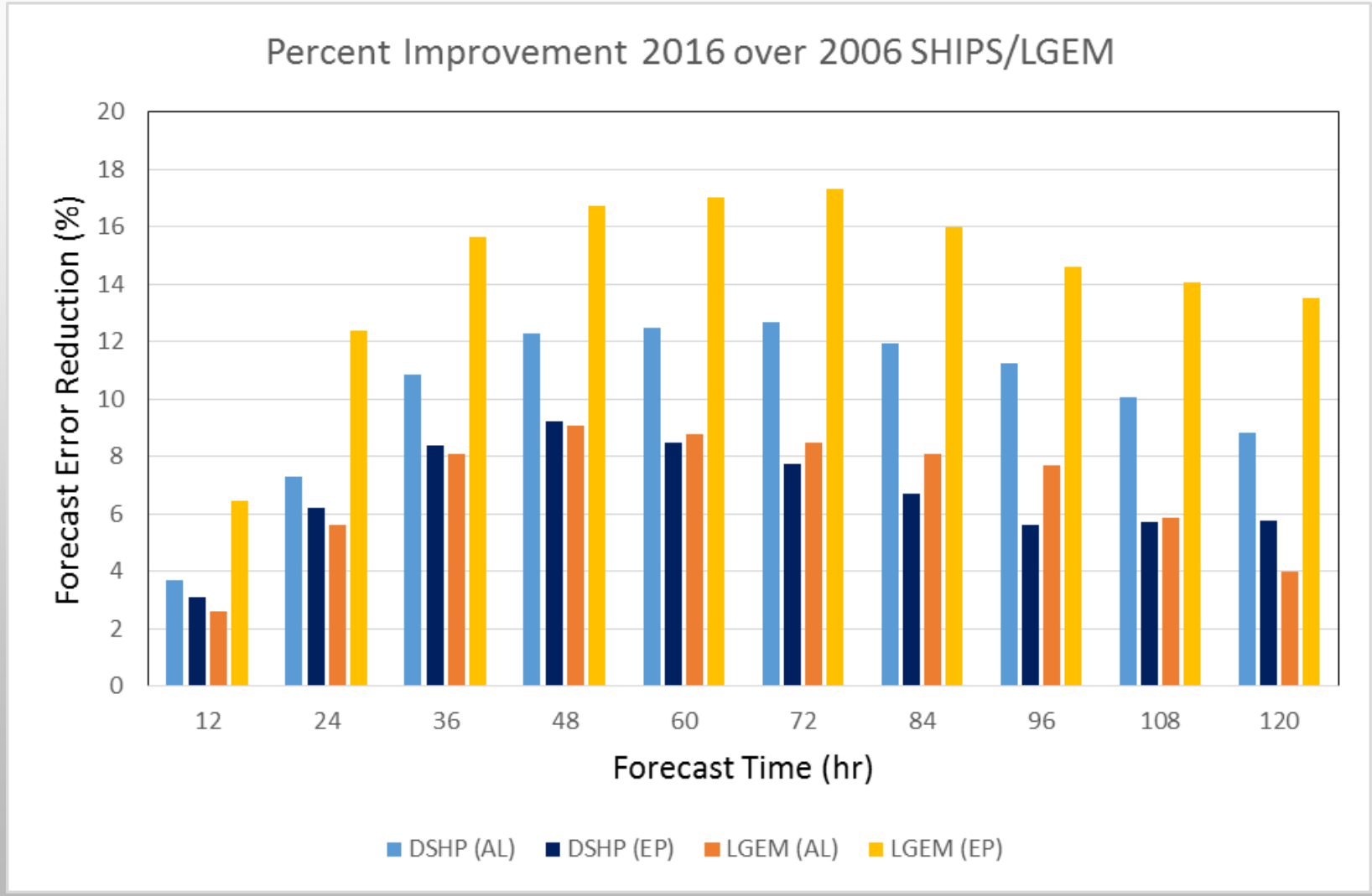
OUTLINE

1. Add to Statistical Hurricane Intensity Prediction Scheme (SHIPS) and Logistic Growth Equation Model (LGEM) and Rapid Intensification Index (RII) predictors
   - related TC structure
   - related to the probability of eye-existence
2. Upgrade SHIPS, LGEM, and RIIs using the best combination of structure and eye-based predictors

SHIPS, LGEM Improvements 2006 - 2016



From DeMaria et al, 2016

MODIFYING SHIPS/LGEM TO USE TC STRUCTURE BASED PREDICTORS: PROJECT PROGRESS

1. Created database of R34A, RMW, R5, FR5 ~1988 - 2017:
2. Created database of climatological values for all structure predictors
3. Completed dependent sample tests for SHIPS, LGEM, and RIIs. Overall, the combined use of R34, RMW, and FR5 or Latitude consistently produces the best results for all models
4. Modified models to use new structure predictors
5. Updated coefficients for SHIPS, LGEM, RII versions with new size predictors
6. Working on retrospective runs using best combination of structure predictors

TC SIZE AND INTENSIFICATION

Multiple studies show that TC size is important for TC intensification (Carrasco et al. 2014, Knaff et al. 2014, Xu and Wang 2015)

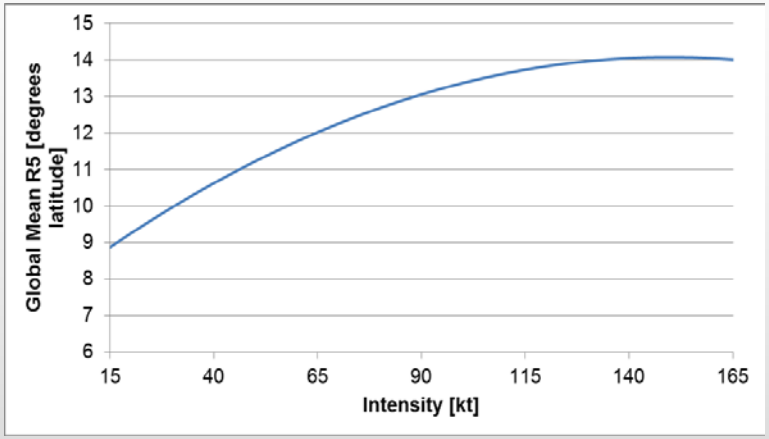
Both TC Intensification and the likelihood of undergoing RI are related to storm size

- Smaller storms found to be more likely to intensify
- Wind structure parameters are strongly negatively correlated with the rate of change of intensity.
  - radius of maximum winds (RMW)
  - average radius of gale-force winds (R34),
  - objective size parameter (R5, Knaff et al, 2014a)

NEW STRUCTURE BASED PREDICTORS

Developed a database of

- **R34A**: non-zero averaged R34
- **RMWB**: B-deck RMW
- **R5** and **FR5** (IR-based TC size, Knaff et al 2014)



Used data from ATCF best track and extended best track

$$R5 = f(Vmax, Lat) \qquad F_{R5} = \frac{R5}{R5_c}$$

	R34A	RMW	R5
Atlantic	1988 - 2017	1988 - 2017	1988 -2017
East Pacific	2001 – 2017*	1990-2017	1998 - 2017

* Will expand to use all available R34 data for east Pacific from 1990

MODIFYING SHIPS/LGEM TO USE TC STRUCTURE BASED PREDICTORS

SHIPS and LGEM need to run at all forecast times: need to fill in missing values:

- RMW climatology = f(Vmax, Lat), following Willougby and Rahn (2004)

$$RMW = 51.6 \exp(-0.0223 Vmax + 0.0.281\ \varphi),$$

- R34 climatology: use modified Rankine vortex, assuming there are no asymmetries (Knaff et al 2007)

$$V(r) = Vmax \left(\frac{r_m}{r}\right)^x,$$

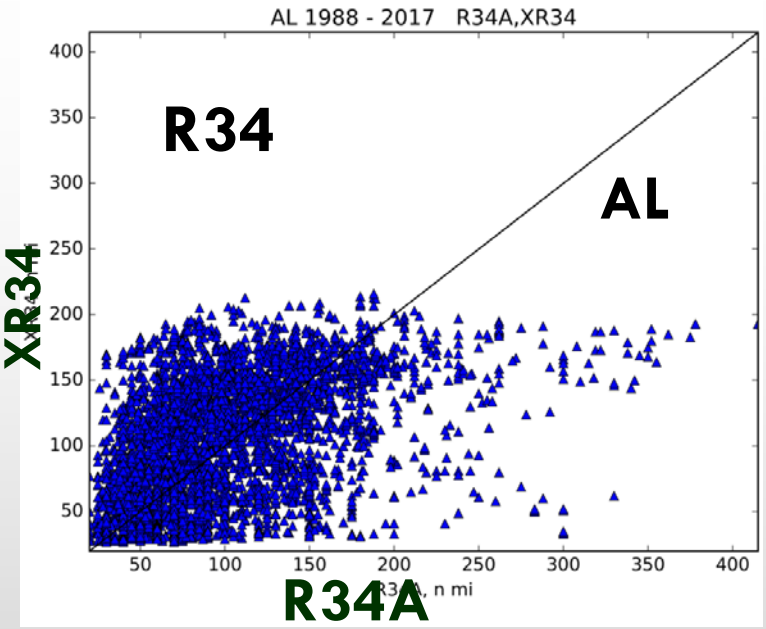
Vmax - maximum wind speed

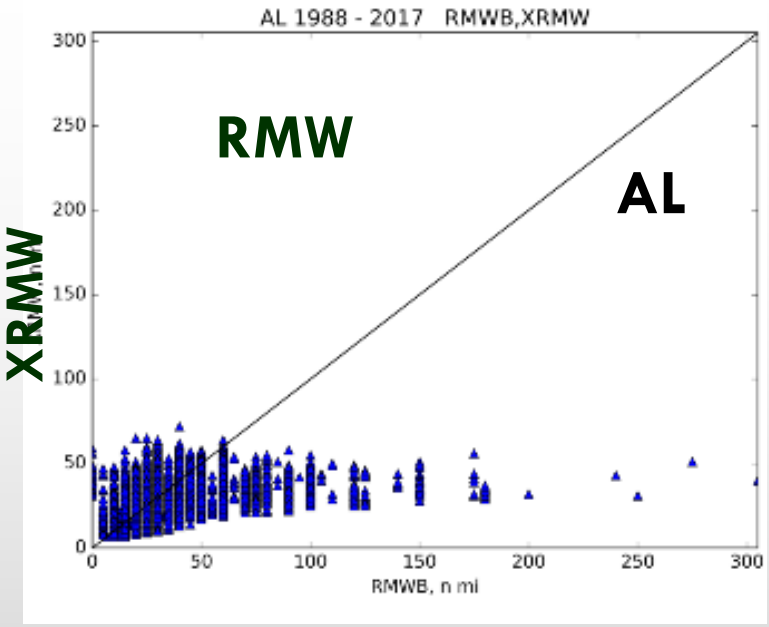
m, x = f(Vmax, Lat) (Knaff et al. 2007)

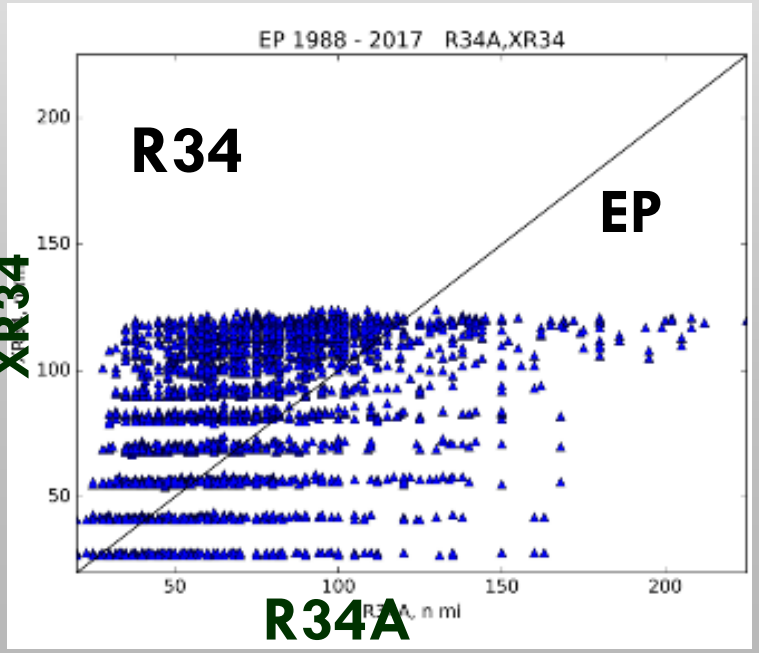
- R5 climatology (Knaff et al 2014)

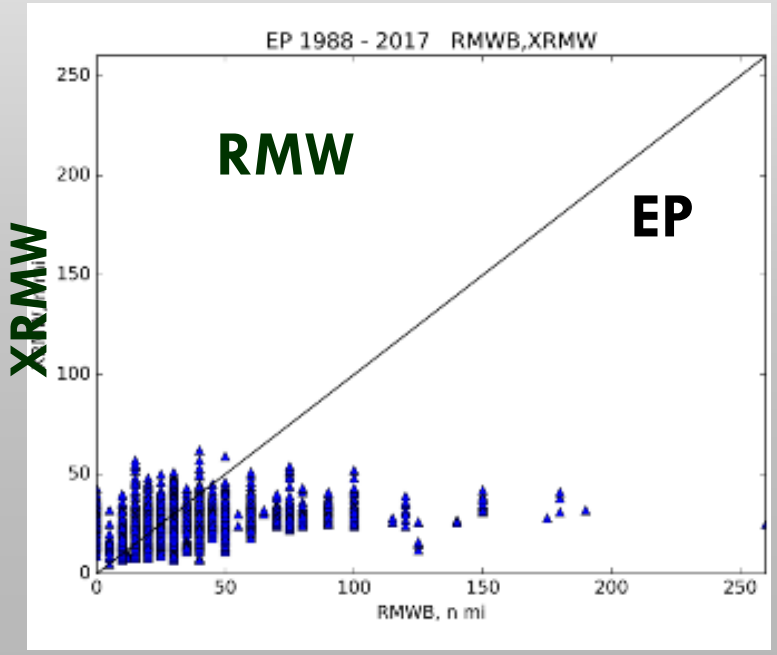
$$R5_c = 7.653 + \left(\frac{Vm}{11.651}\right) - \left(\frac{Vm}{59.067}\right)^2$$

R34, RMW CLIMATOLOGY



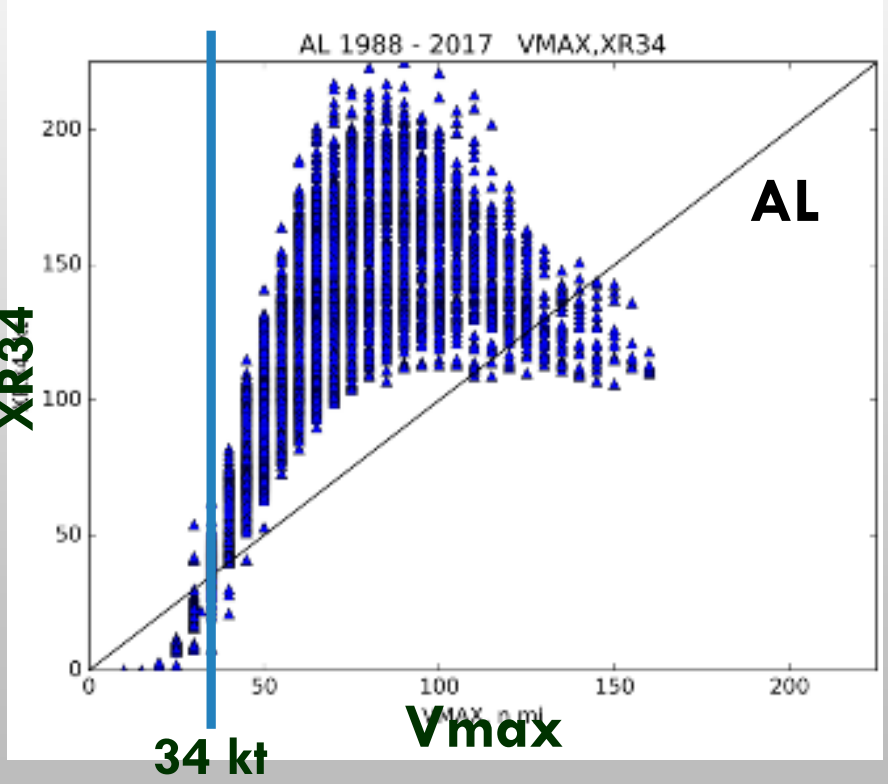


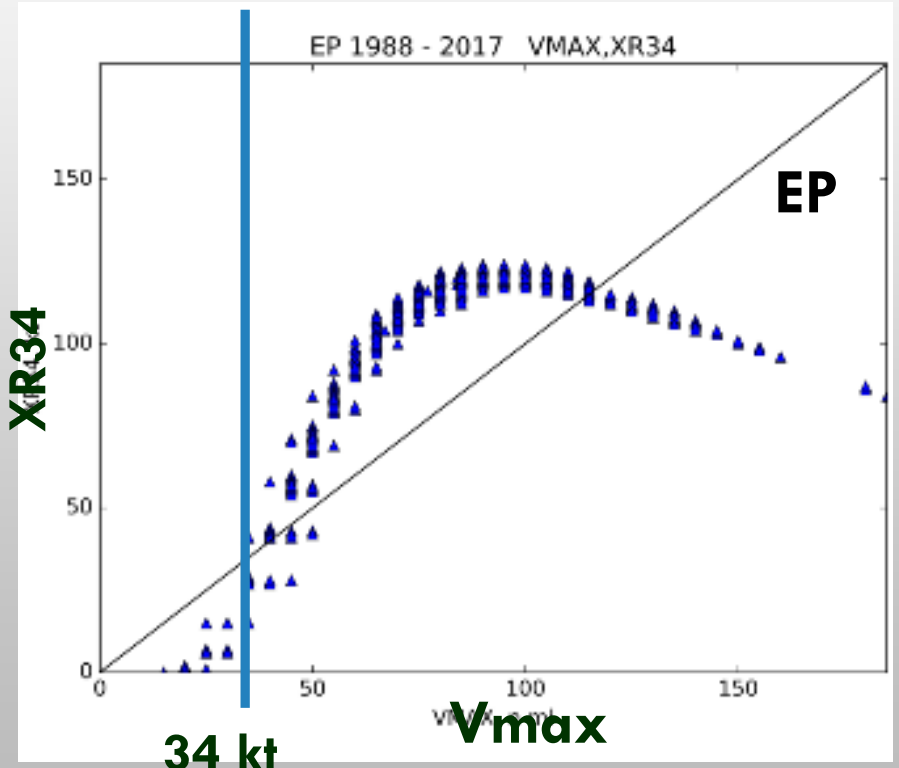




R34, RMW CLIMATOLOGY

How to use new predictors when Vmax < 34 kt ?





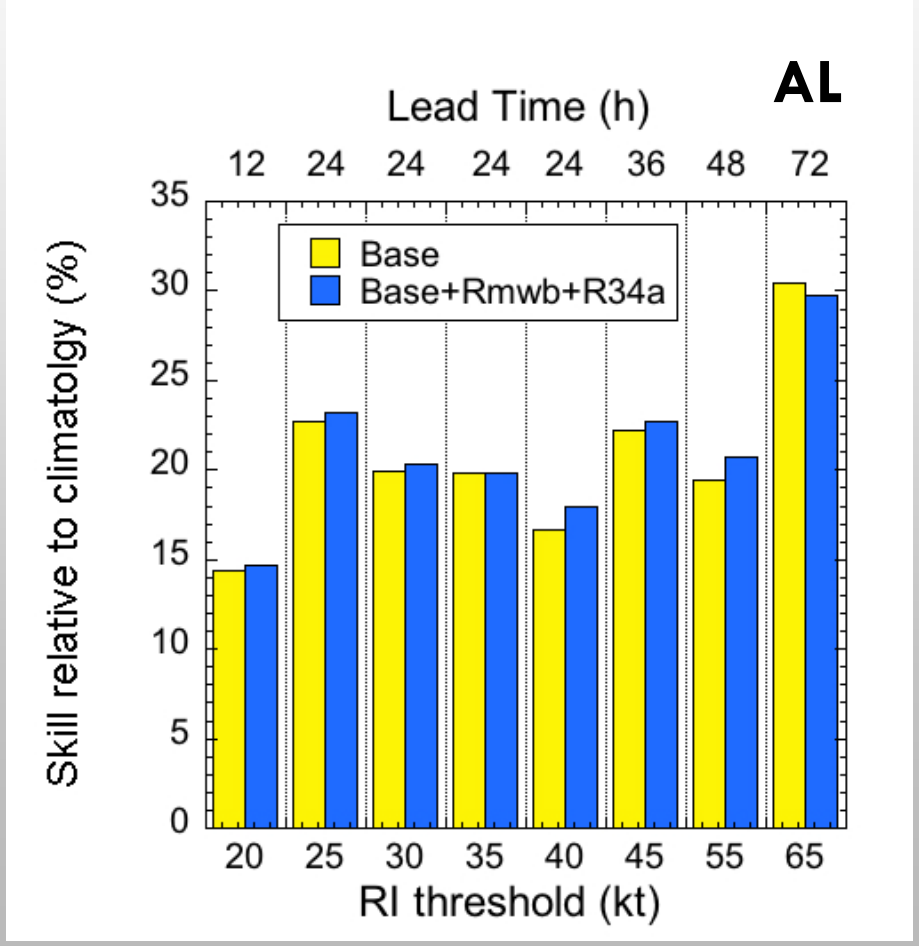
RAPID INTENSIFICATION INDEX

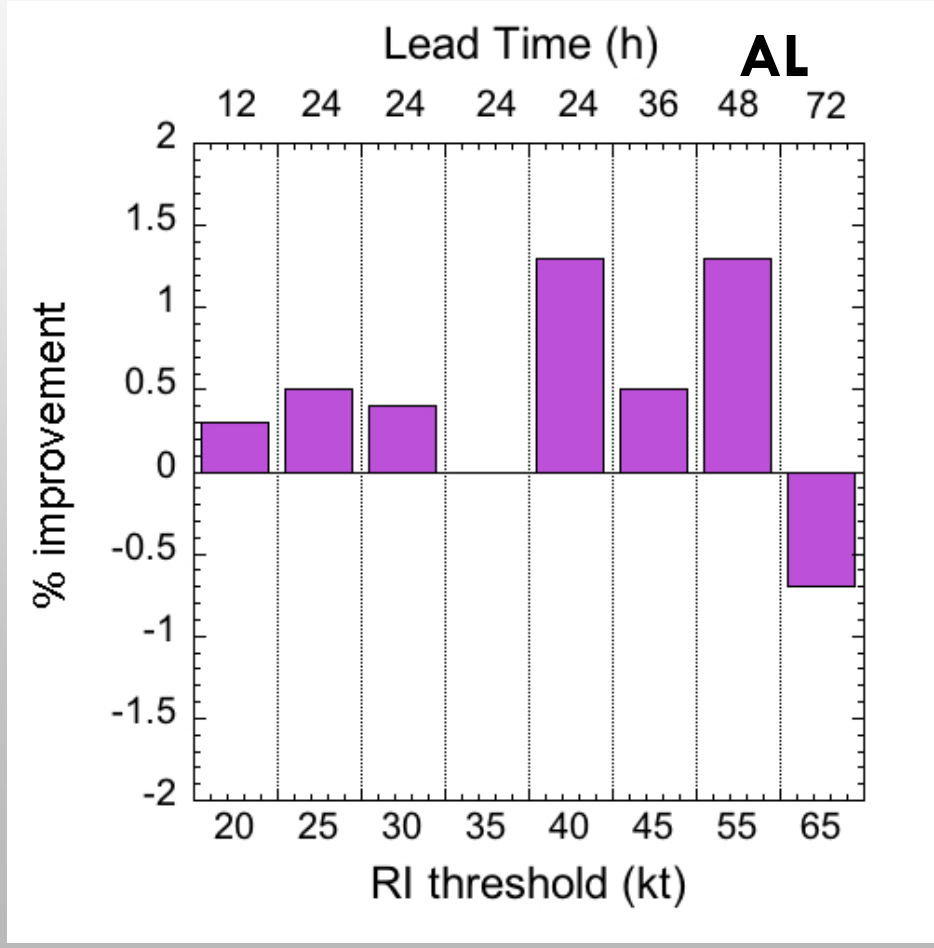
- MLTRII (SHIPS-RII)
  - Linear discriminant analysis model
  - utilizes 10 mostly environmental + a few GOES-IR predictors (Kaplan et al. 2015)
  - Provides probability of RI estimates for both the Atlantic and east Pacific basins for 8 RI thresholds (20-kt/12h,25-kt/24h,30-kt/24h,35-kt/24-h,40-kt/24h, 45-kt/36-h, 55-kt/48-h, 65-kt/72-h)
  - Performance typically much better in E. Pacific than Atlantic

- GRII
  - Linear discriminant analysis model
  - Provides probability of RI estimates for global TC basins for 55-kt/48h
  - GRII forecast is used as predictor in LGEM

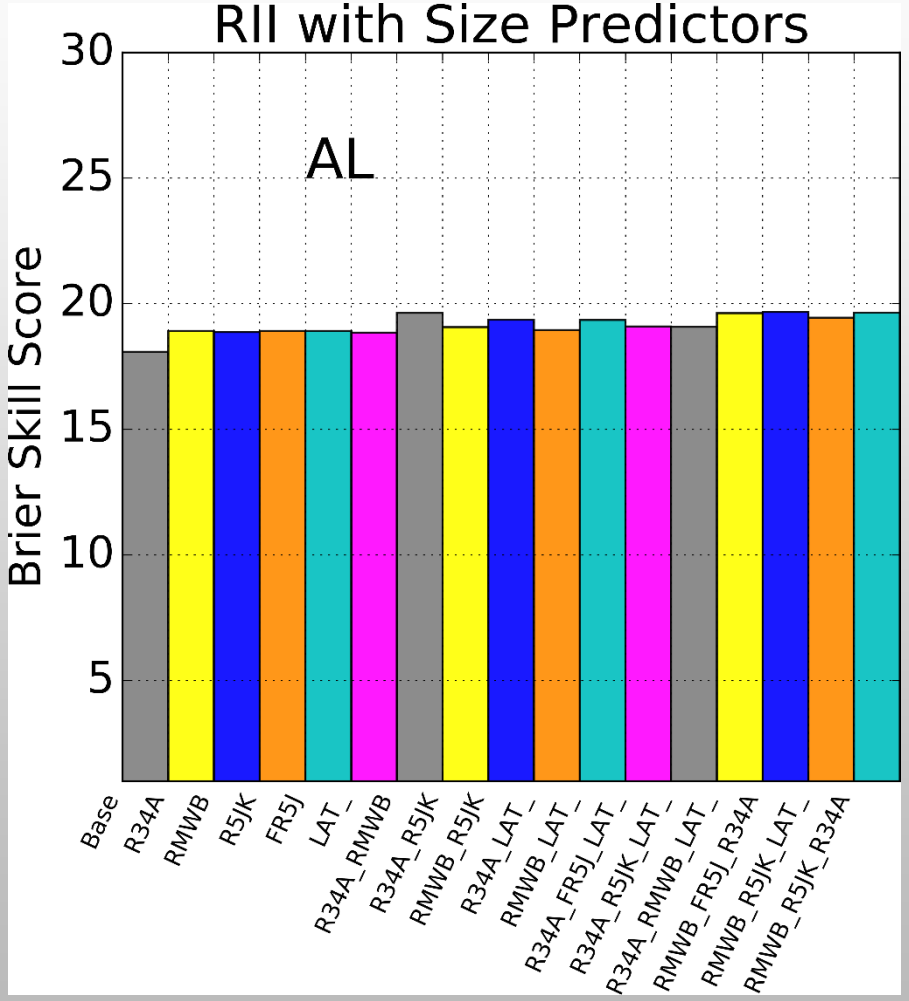
DEPENDENT SAMPLE TESTS – **MLTRII**

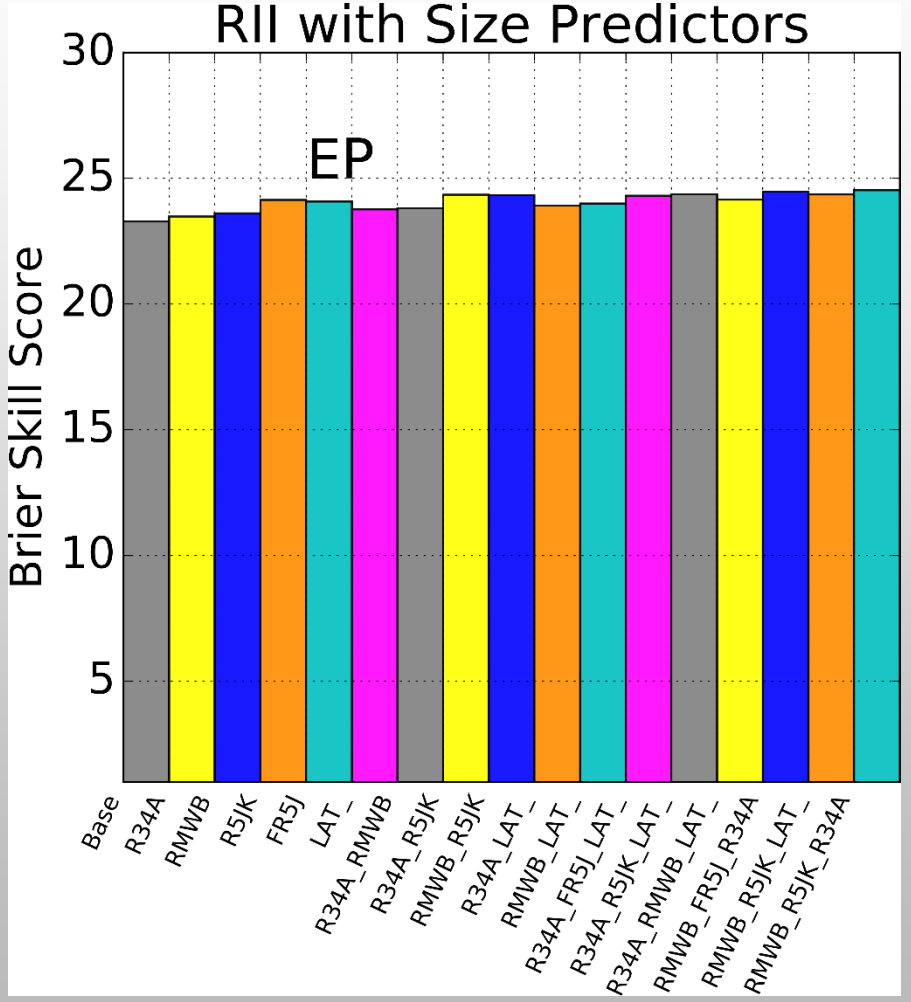
Smaller RMWB and R34A found more favorable for RI



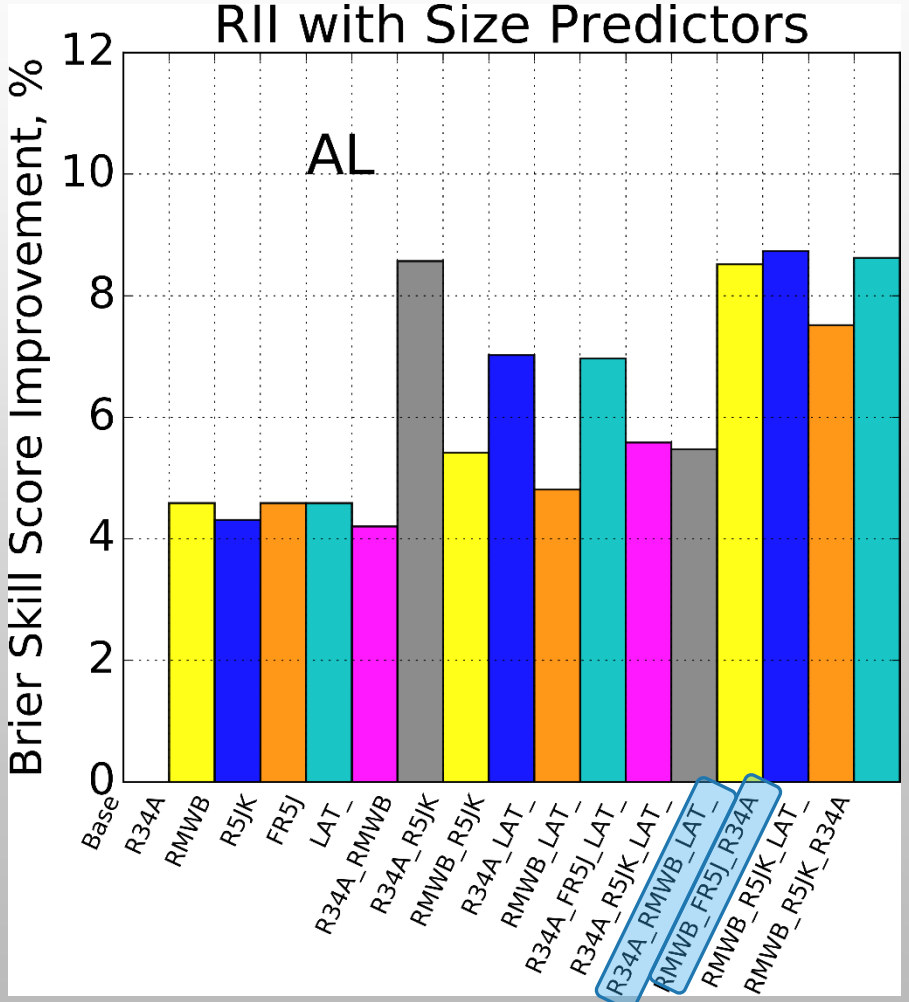


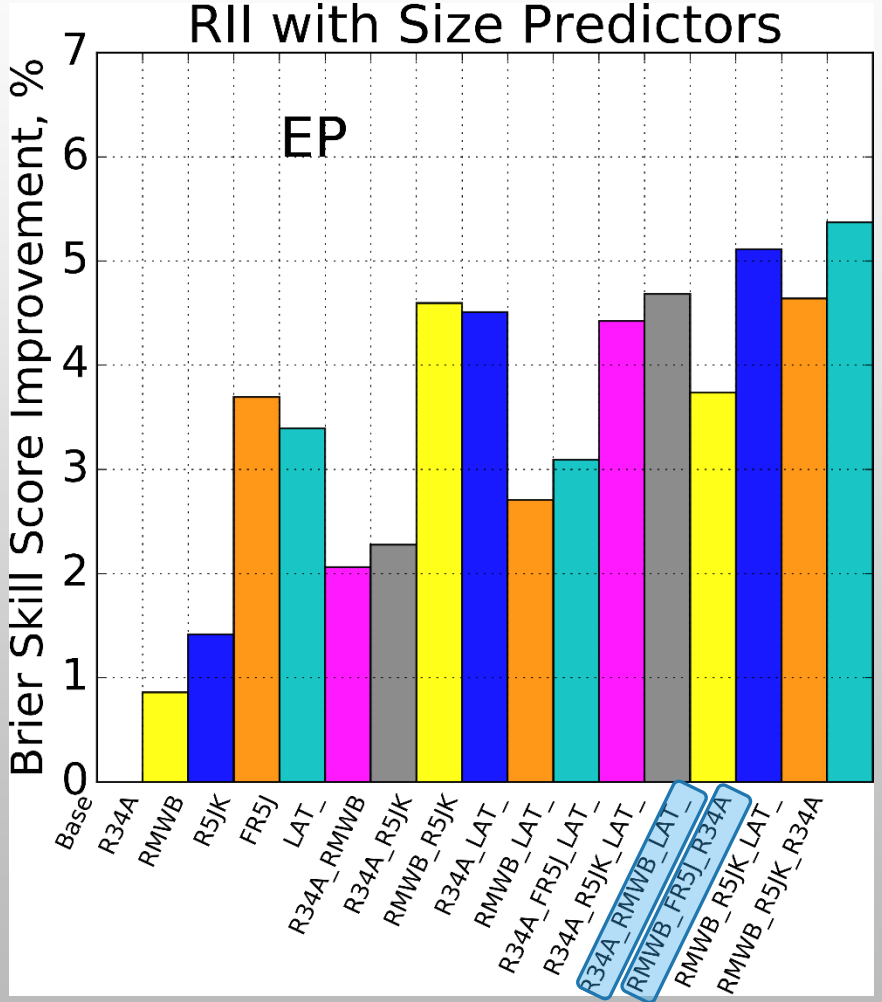
DEPENDENT SAMPLE TESTS - GRII



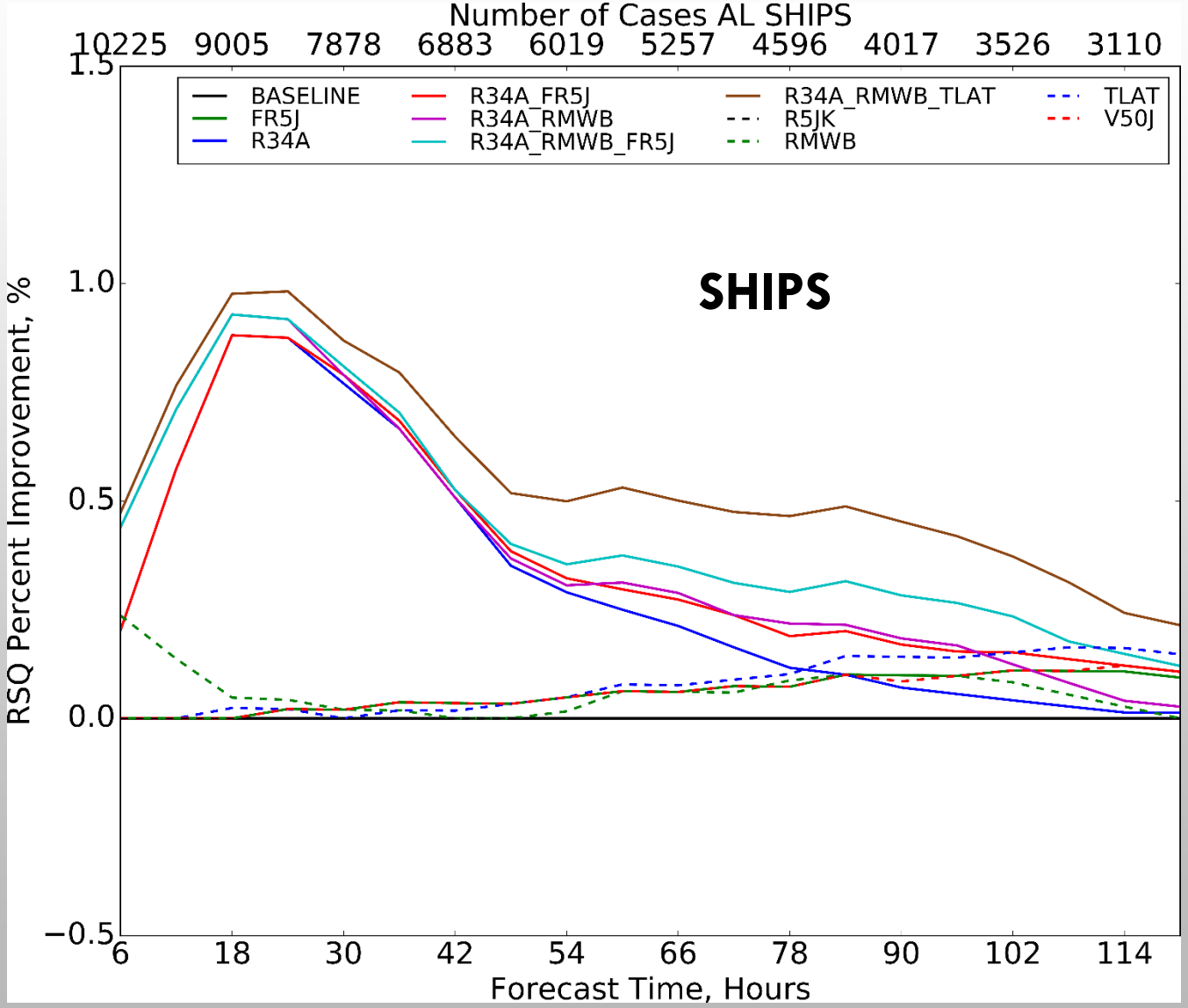


DEPENDENT SAMPLE TESTS - GRII



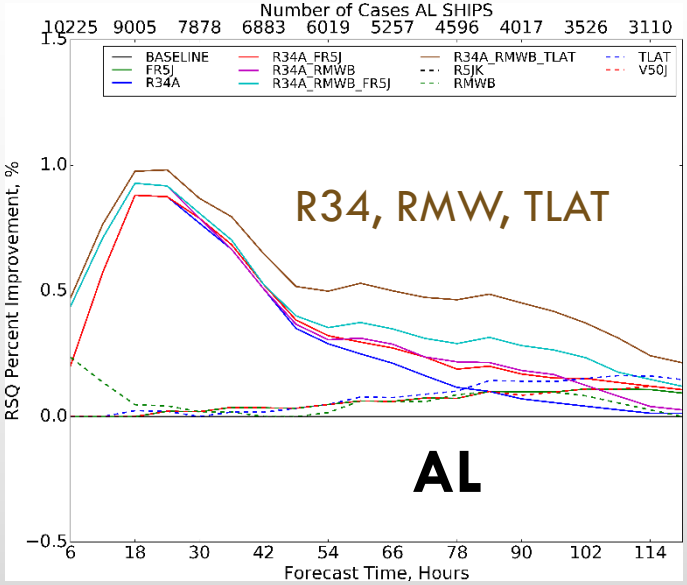


DEPENDENT SAMPLE TESTS - SHIPS

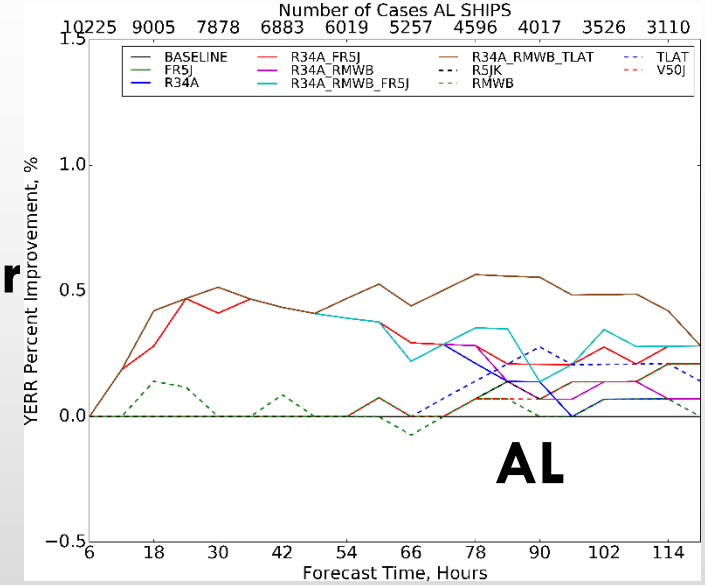


DEPENDENT SAMPLE TESTS - **SHIPS**

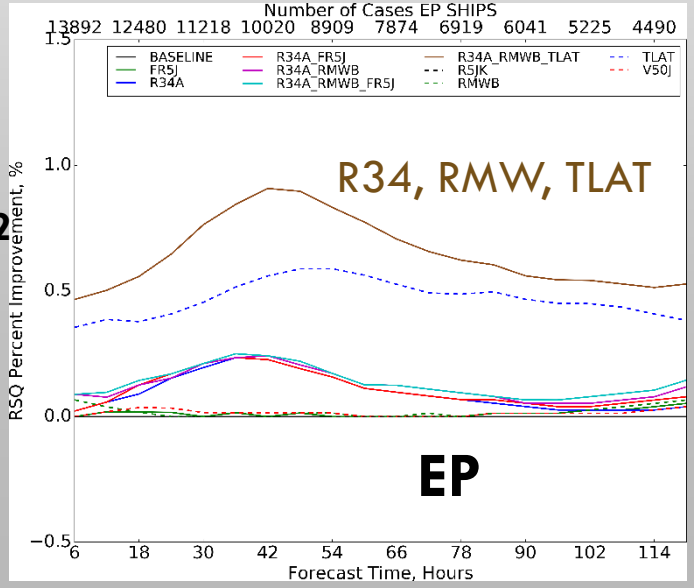
R^2 PI



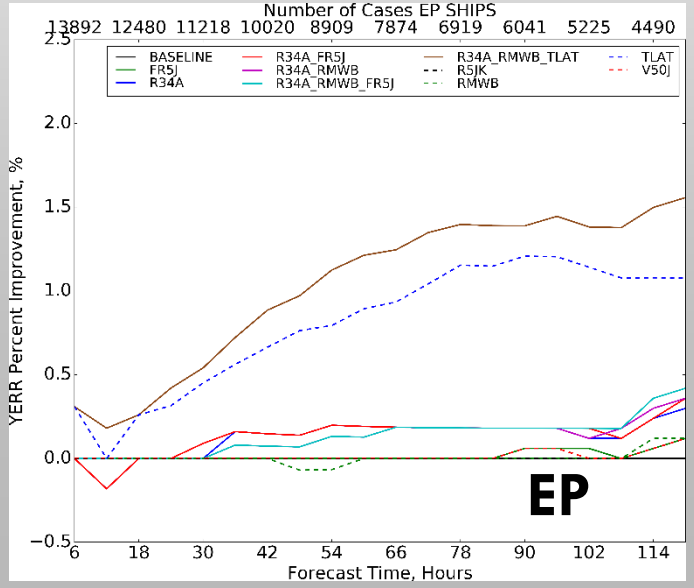
Yerr PI



R^2 PI



Yerr PI



DEPENDENT SAMPLE TESTS – **LGEM**

For SHIPS and LGEM adding 3 new predictors consistently produces best results

- R34A
- RMWB
- TLAT

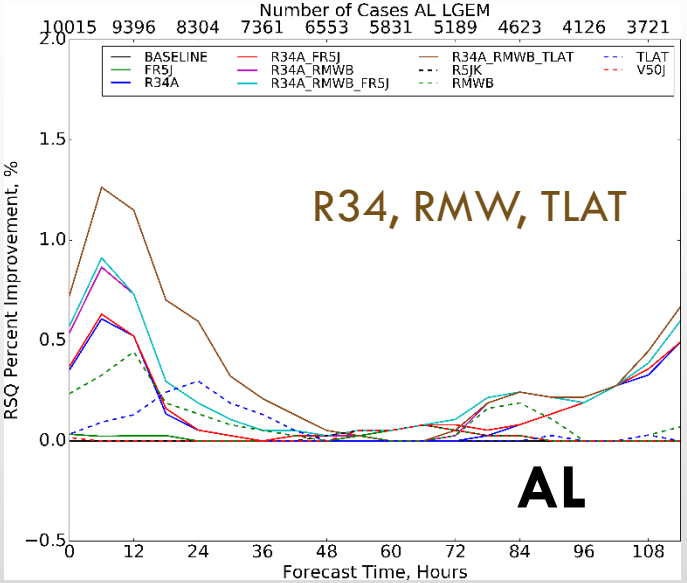
R34A – improves short-term forecst

6 – 48 hours

RMWB – improves longer term forecast

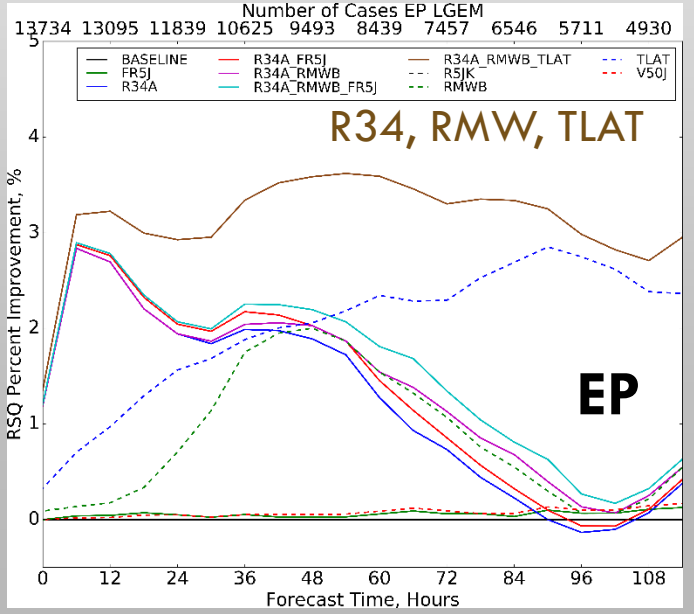
R^2

PI



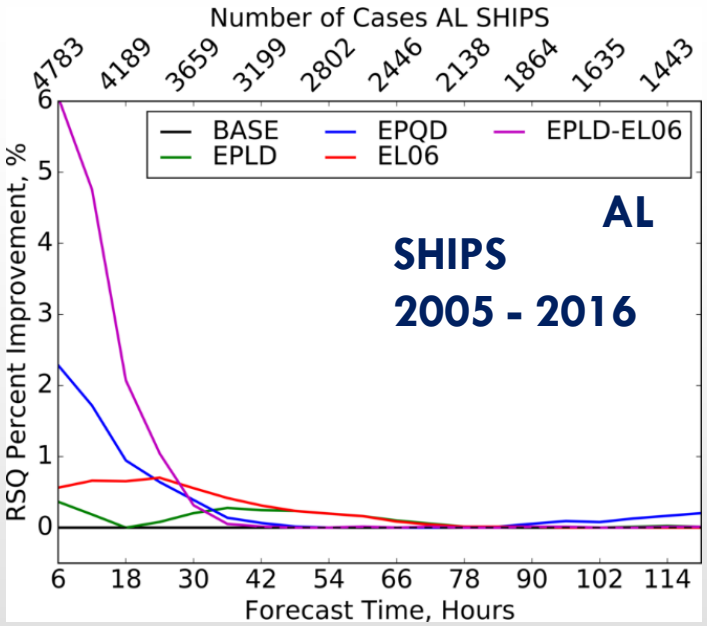
R^2

PI

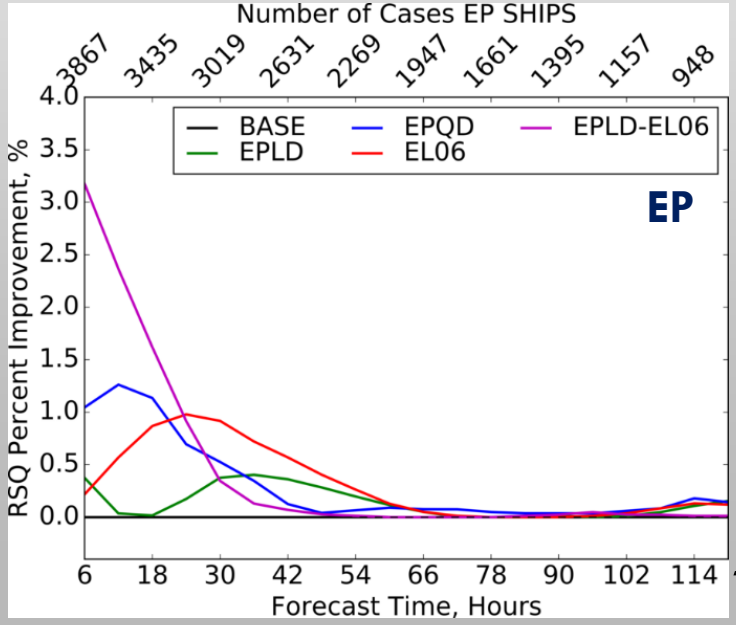


FURTHER STEPS:

1) Add predictors based on the probability of the eye-existence determined by CIRA Eye Detection Routine (SEDR)
2) Run SHIPS, LGEM, GRII, MLTRII with added structural predictors for 2018 season at CIRA
3) Possibly: run SEDR in quasi-production at NHC for 2018 season



Best: P(t = 0 hr) – P(T = -6 hr)



SUMMARY AND CONCLUSIONS

- Created database of storm structure predictors:
  - R34, RMW, R5, FR5 using all available data for 1988 – 2017
  - Created database of climatological values for R34, RMW, R5, FR5
- Completed dependent statistical tests using 1982 – 2017 data for SHIPS, LGEM , GRII, and MLTRII, derived new regression coefficients for models.
- Best results:
  - GRII: RMWB + R34A + FR5
  - MLTRII: RMWB + R34A
    - Smaller storms are more likely to rapidly intensify
  - SHIPS. LGEM: RMWB+R34A + time-averaged Latitude
- Modified models to use new structure predictors
- Further steps:
  - Complete retrospective runs
  - Run modified models in parallel for 2018 Atlantic season at CIRA
  - Possibly run SEDR in quasi-prod at WCOSS at NHC for 2018

UPDATE ON PREVIOUS JHT PROJECT: IMPROVING SHIPS AND LGEM WITH DAILY SST AND DEPTH-AVERAGED TEMPERATURE

- Re-derived global (AL, EP, WP, IO, SH) OHC and sub-surface ocean data (was requested by NHC)
- Updated OHC provides improvement to SHIPS and LGEM
- Updated subsurface data, d32 – d16, mixed layer depth
  - improved estimates of depth-averaged temperature (DAVT)
  - improved SHIPS, LGEM forecasts with DAVT
- Transitioned to operations at NHC for 2018 SHIPS and LGEM:
  - Daily SST, averaged over 50 km around the storm center
  - New OHC data
- Transitioned to operations at JTWC:
  - SHIPS Wind Radii Forecast (DSWR, Knaff et al 2017)
- Run in quasi-prod at NHC in 2018:
  - SHIPS, LGEM with depth-averaged temperature using re-derived ocean data
  - DSRW