Evaluation of Forecasting Techniques for the Radius of Maximum Wind (RMW)

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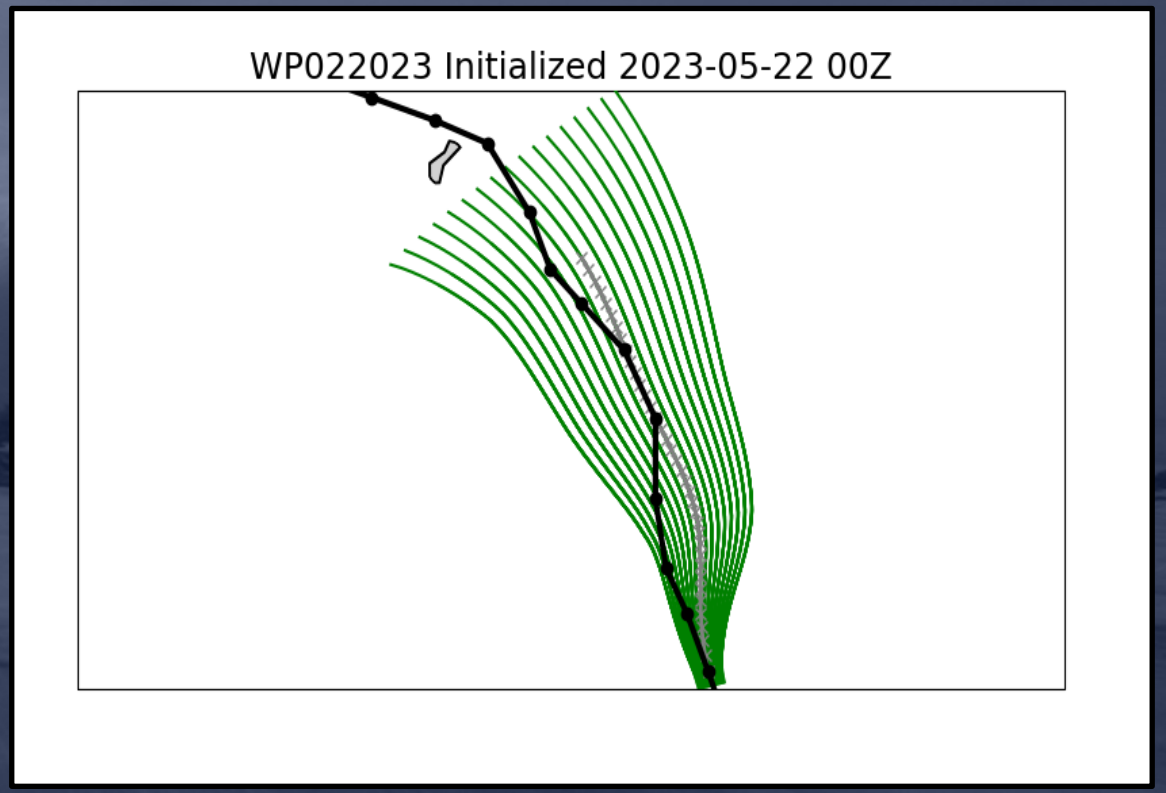
Introduction to Probabilistic Storm Surge

- P-Surge is an ensemble of Sea, Lake, and Overland Surge from Hurricane (SLOSH) model runs that incorporates uncertainty using a statistical method based on NHC historical errors of:
  - Cross track (landfall location, # members varies) attempts to encompass 90% of cross track uncertainty
  - Along track (forward speed, 7 members)
  - Intensity (3 members)
  - Storm size (RMW, 3 members)
- RMW error distributions not from OFCL

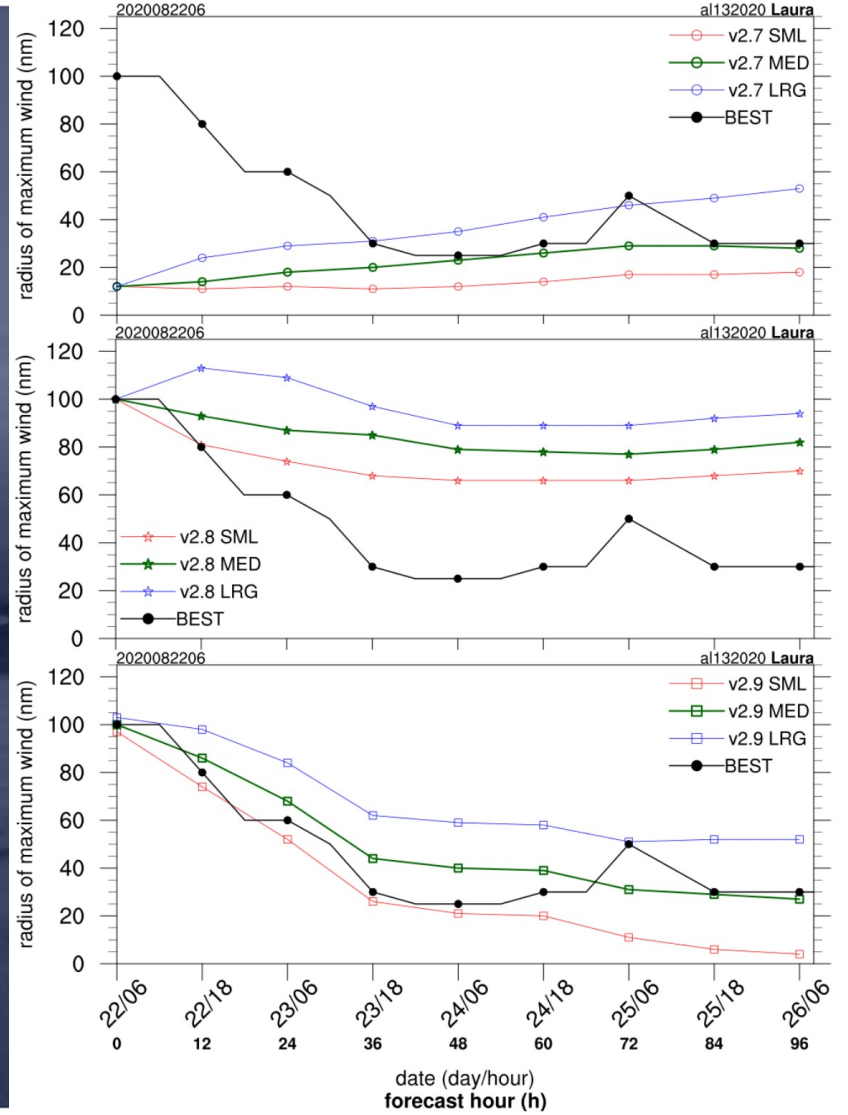
Mawar (WP022023) P-Surge 36-h ensemble tracks



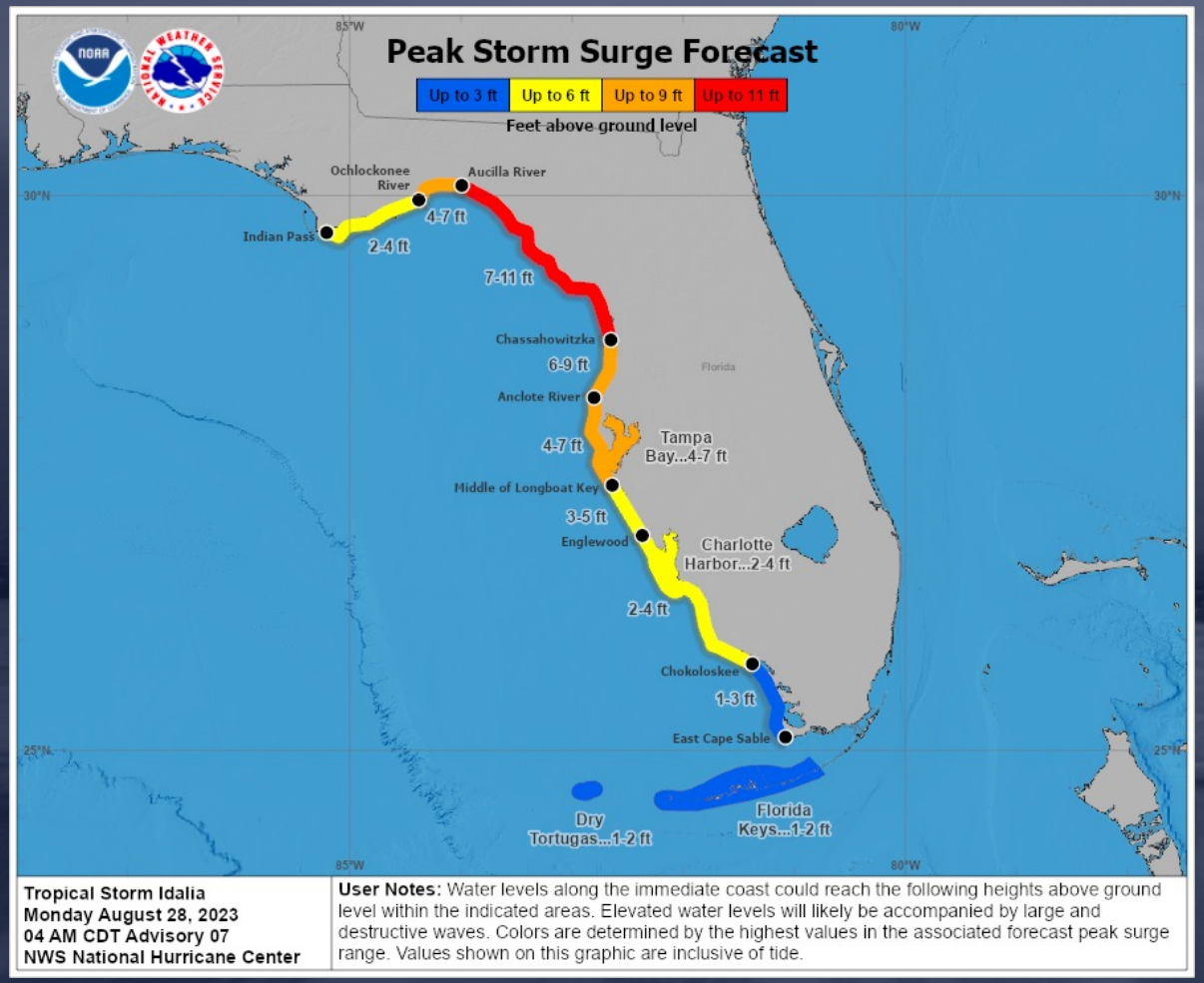
RMW Prediction within P-Surge

- P-Surge v2.7 (2018) used a derived pressure-wind-RMW relationship to with error perturbations to create RMW forecast
- P-Surge v2.8 (2020) used error perturbations for RMW forecast but with the estimated RMW at initialization from b-decks
- P-Surge v2.9 (2021) uses a multivariate linear regression technique to forecast RMW based on OFCL
- Spread in P-Surge RMW forecasts is then based on errors of the regression model

See Penny et al. (2023) for details

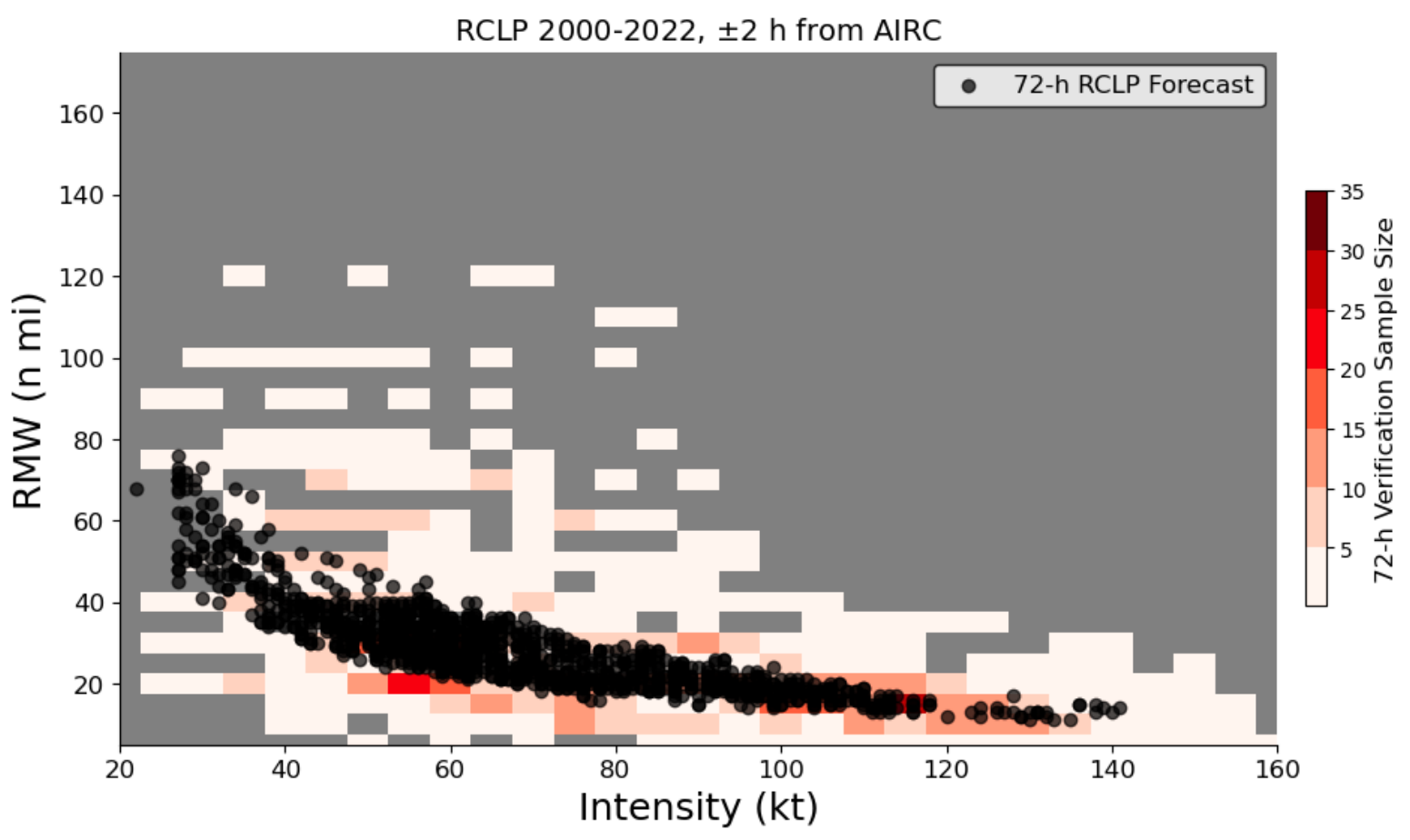


How good are RMW Forecasts?



- Are P-Surge forecasts of the RMW skillful?
- How well do Hurricane Analysis and Forecast System (HAFS) models perform relative to the statistical RMW forecasts created for P-Surge and would they be considered skillful?
- Could we eventually use HAFS wind forcing to improve storm surge forecasts?

A Climatological Baseline using OCD5 Input

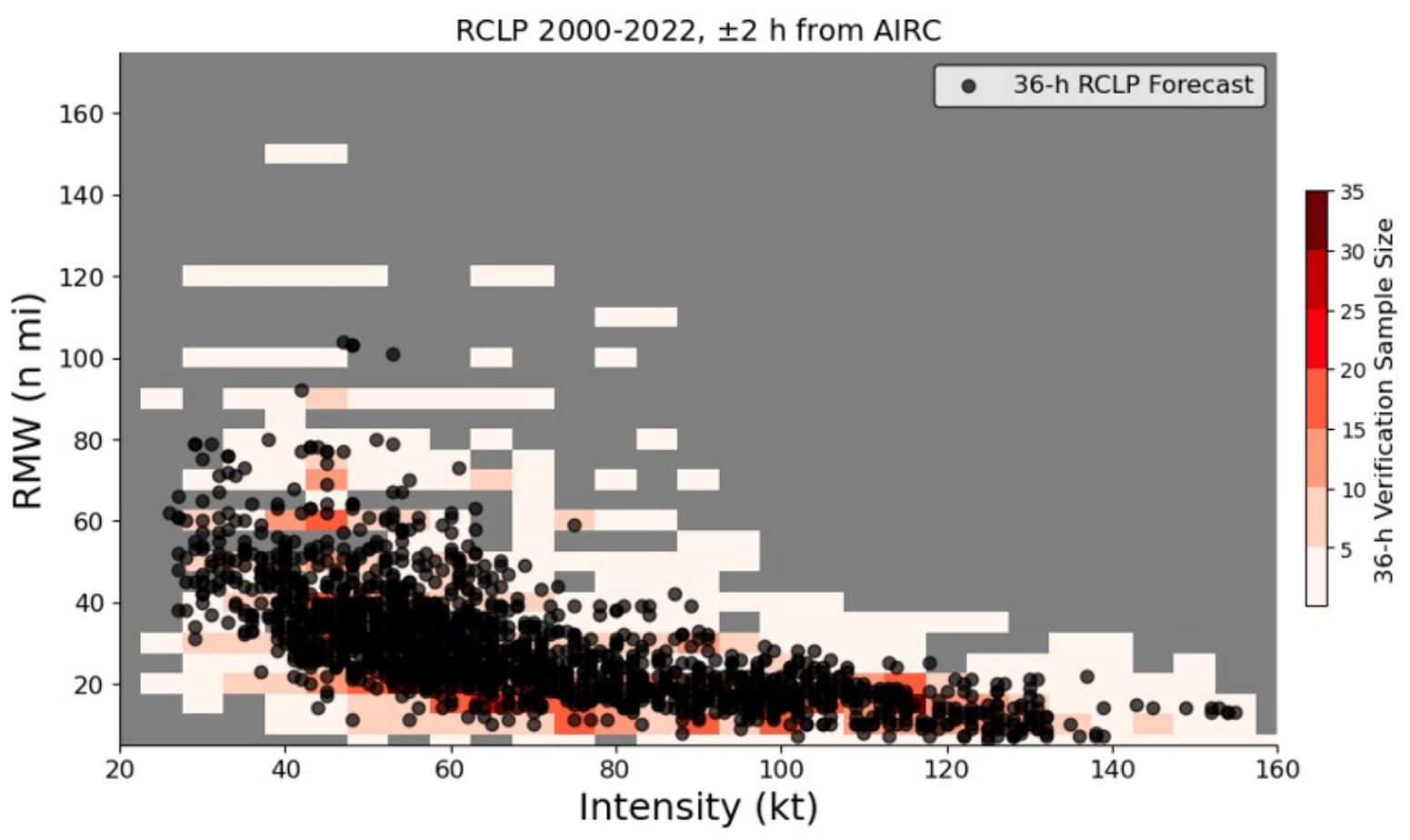


- RMW Climatology and Persistence Model (RCLP) created using similar equations to Vickery et al. (2000), Willoughby and Rahn (2004), Willoughby et al. (2006), and Penny et al. (2023)

$$RMW = \alpha V_{max}{}^{\beta} e^{\gamma\phi}$$

$\alpha = 760.0619$
$\gamma = 0.0242$
$\beta = -0.9516$
V_{max} = Intensity (kt)
ϕ = Latitude (degrees)

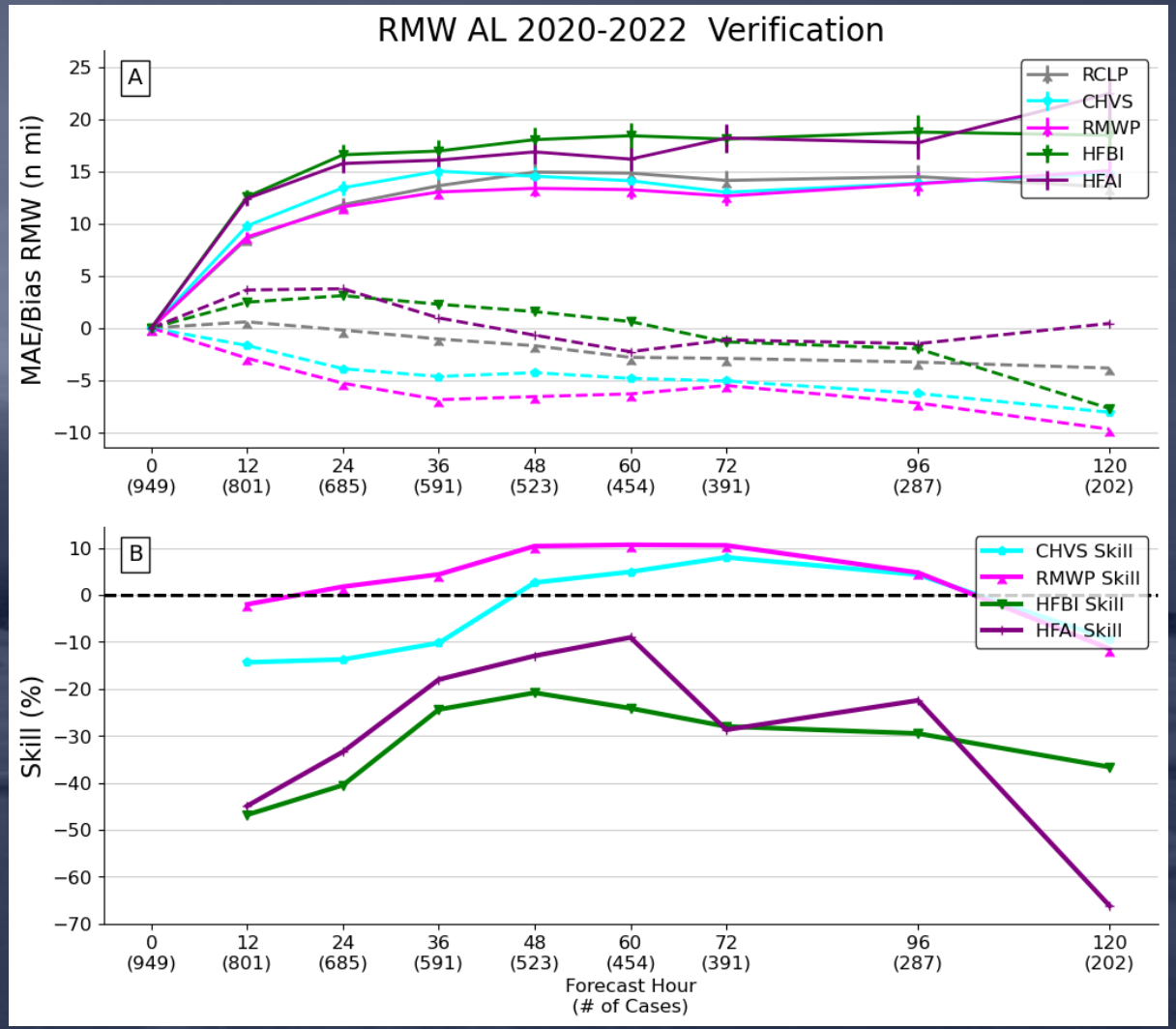
A Climatological Baseline with Persistence



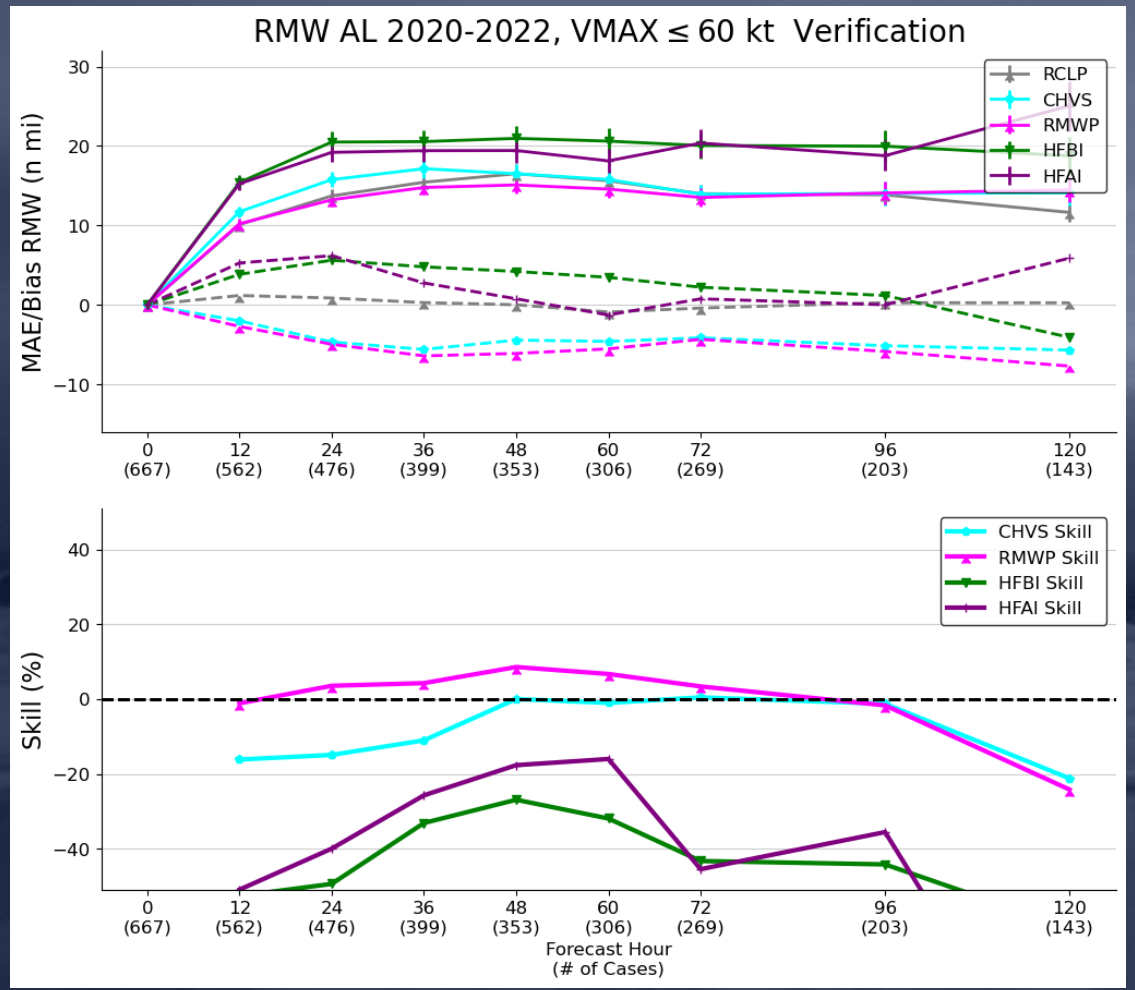
- RMW Climatology and Persistence Model (RCLP) created
- Persistence applied using initial offset that was linearly reduced to zero at 60 h
- Latitude and intensity forecasts come from climatology and persistence model (OCD5)

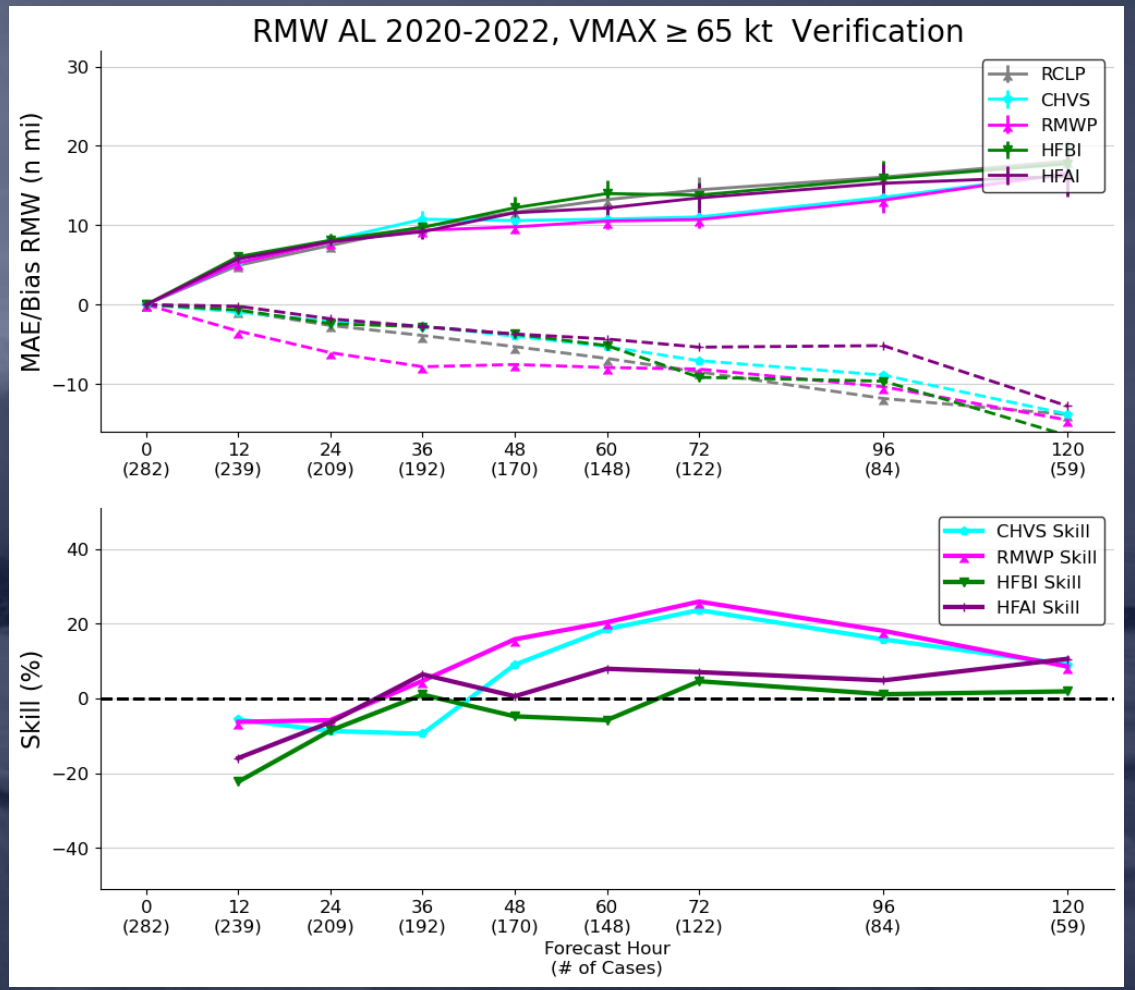
Performance of RMW Forecasts (2020-2022)

- Using all over-ocean forecasts from 2020-2022 in the Atlantic (retrospective runs)
- Using standard NHC verification rules (except depressions are not included)
- Chavas and Knaff (2022) method applied to OFCL (CHVS)
- The HAFS models have a short term large bias while statistical models have small bias
- HAFS models are not skillful in forecasting RMW over full dataset

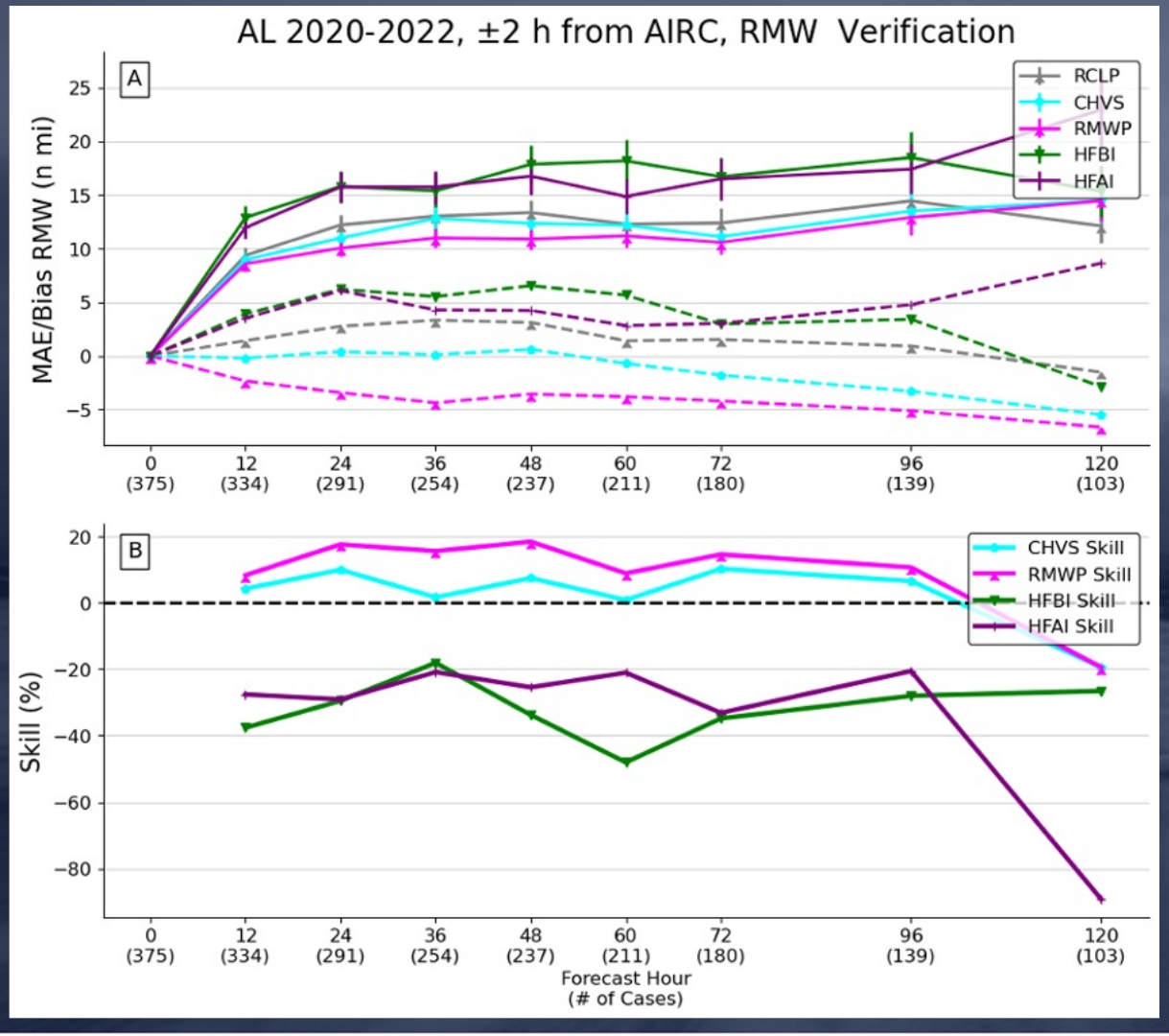


Performance on Weak vs. Strong TCs





Performance with Aircraft Observations



- Using only over-ocean forecasts constrained to within 2 hours of aircraft reconnaissance
- Statistical models have a consistent negative bias
- Over entire sample, statistical models are skillful at most forecast lead times
- The RMW forecasts from HFAI and HFBI are not skillful relative to RCLP at any forecast hour
- Competing biases suggests an RMW consensus could help improve forecasts

Summary and Next Steps

- The use of a statistical model to predict the radius of maximum wind for P-Surge has motivated further guidance on prediction of the RMW
- We have created a simple climatology and persistence model and shown that RMW forecasts in P-Surge are skillful
- The statistical models do a better job at forecasting over-ocean RMW (which they are trained on) compared to the HAFS models
- Other complicating factors such as track errors, vortex tracker methods, and observational biases are important to consider and will be examined in the future
- Need for additional guidance on storm structure to improve surge forecasts

Forecasting the RMW at NHC

Questions?
Feedback?

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Max Olsen, Hurricane Ian (2022)

This work is currently under review at GRL