IMPROVEMENTS TO OPERATIONAL STATISTICAL TROPICAL CYCLONE INTENSITY FORECAST MODELS

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OUTLINE

Part 1 : Modify Statistical Hurricane Intensity Prediction Scheme (**SHIPS**) and Logistic Growth Equation Model (**LGEM**) to **use daily instead of weekly SST**

Part 2: Modify SHIPS and LGEM to **use Depth Averaged Temperature (DAVT)** to account for SST cooling

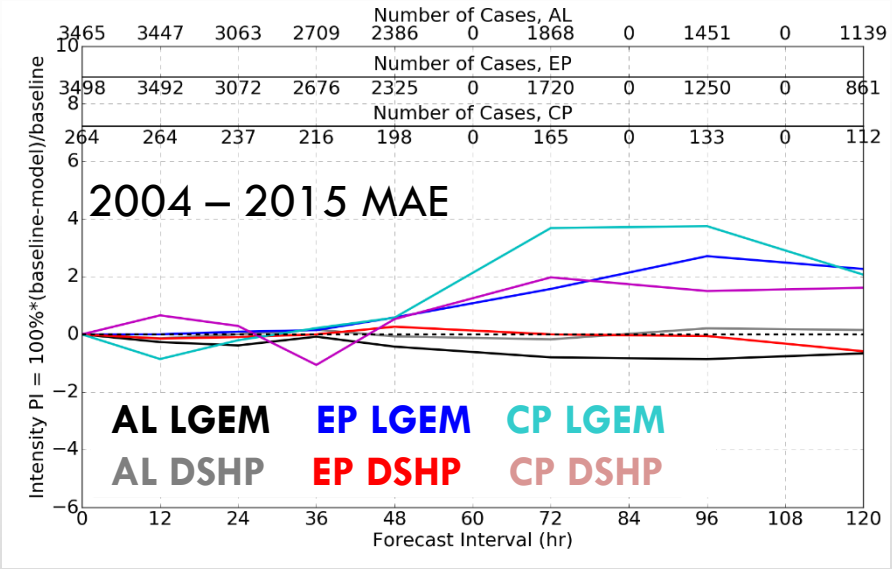
Part 3: Add TC structure forecasts to SHIPS/LGEM

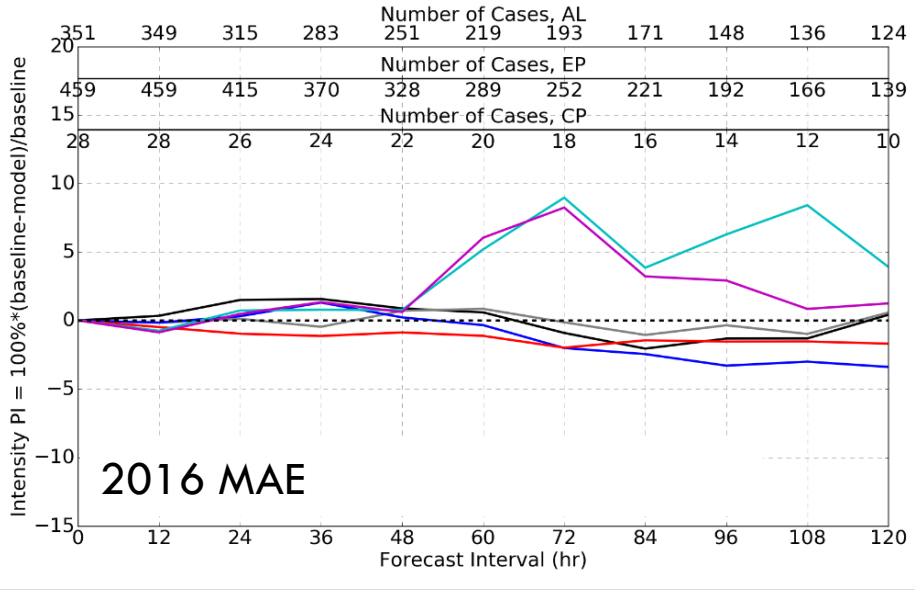
SHIPS/LGEM with DSST and DAVT

Operational SHIPS and LGEM use weekly Reynolds SST

- **SHIPS/LGEM modified to use DSST, DAVT, and/or RSST for different parts of the code**
- **DSST retrospective** (2004-2015) **and parallel** (2016) **runs and verification completed,** results similar to expected
- Adjustments made based on parallel runs:
  - Use 1 or 2 days old DSST for reruns
  - Use RSST if DSST is older than RSST
- Code and verification results for DSST provided to NHC
- SHIPS/LGEM **retrospective runs with DAVT assuming constant mixing depth completed**
- New climatology developed to include MLD, provided to NHC
- **Work continues on use of DAVT based on variable mixing depth**

SHIPS/LGEM VERIFICATION DSST VS RSST



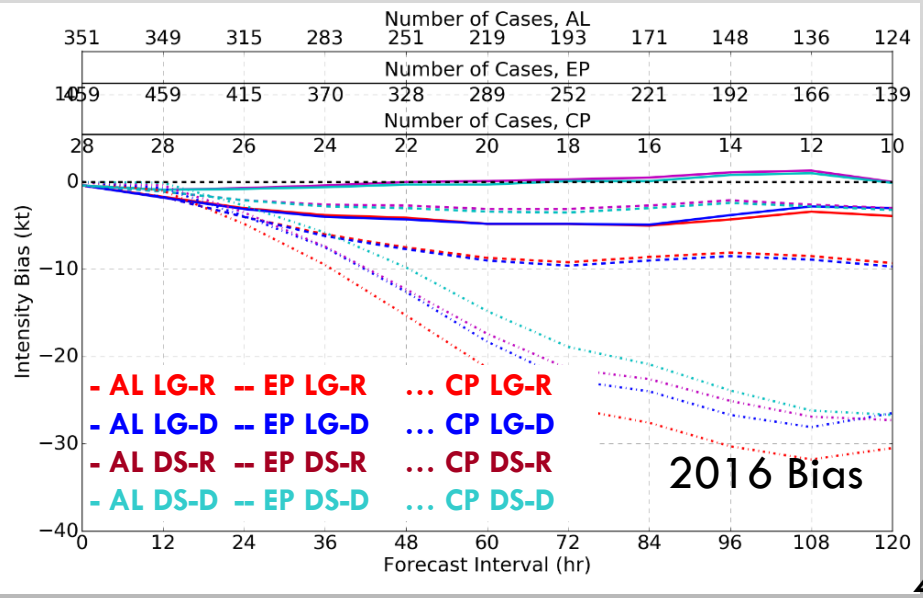


2004 - 2015 :

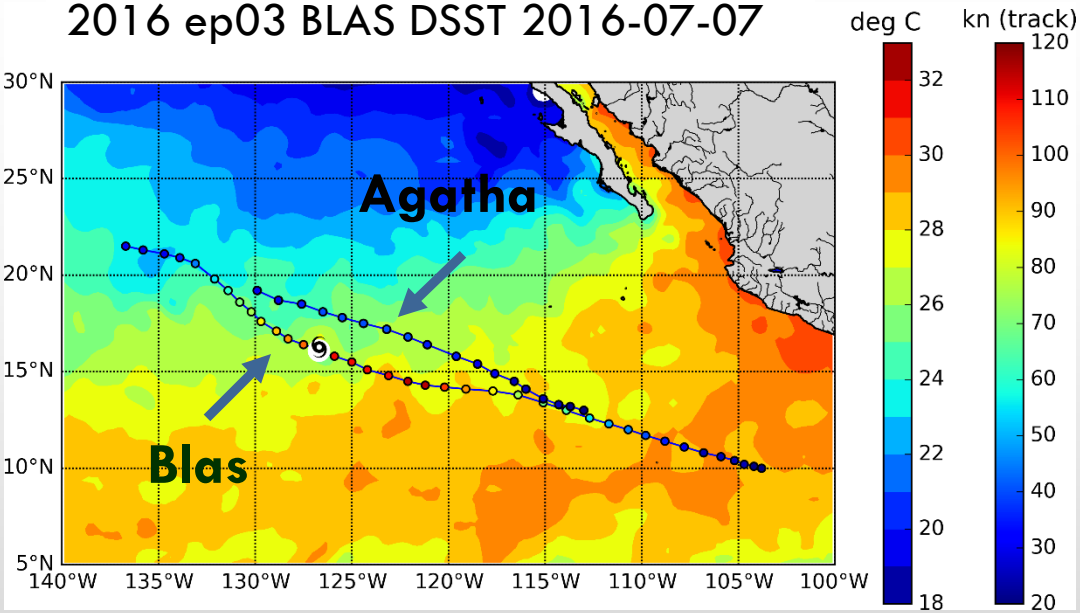
- Most improvement: LGEM EP
- Worse: DSHP AL

2016:

- Improved: LGEM AL, 0 – 60 hr
- Worse: SHIPS EP
- Biases similar to RSST
- Significant impact in some cases

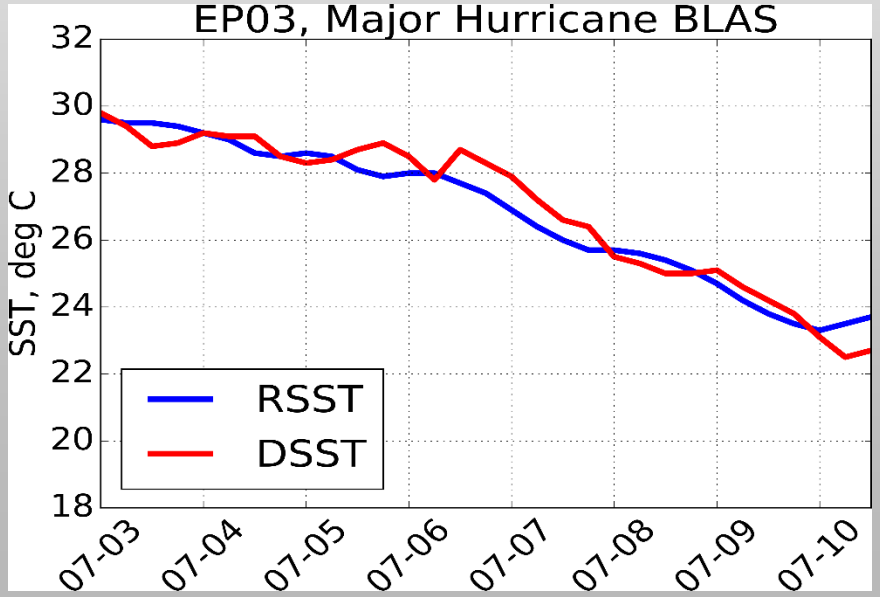


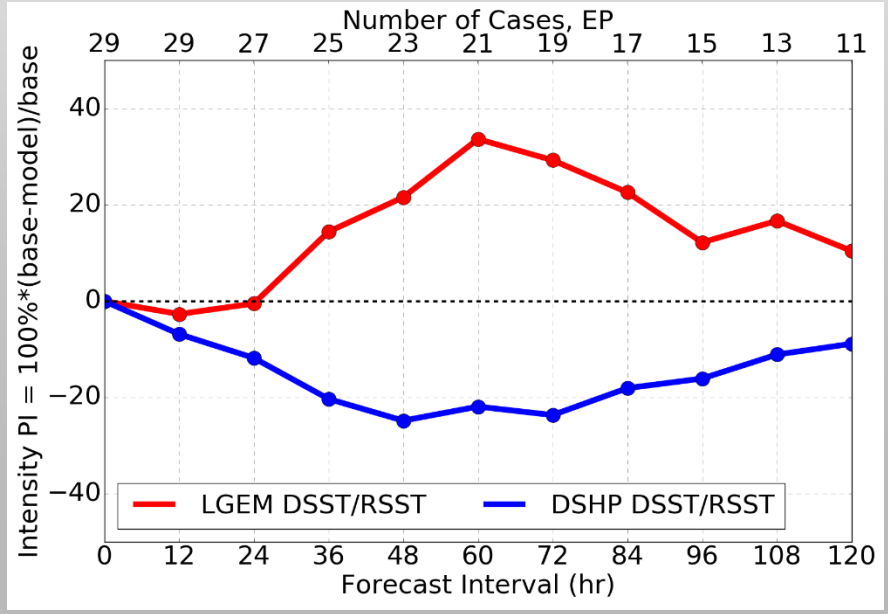
EP03 2016 Major Hurricane BLAS DSST vs RSST



- Early season storm
- Sharp SST gradient
- Cold wake of EP02 Agatha

RSST vs DSST - significant intensity forecast difference



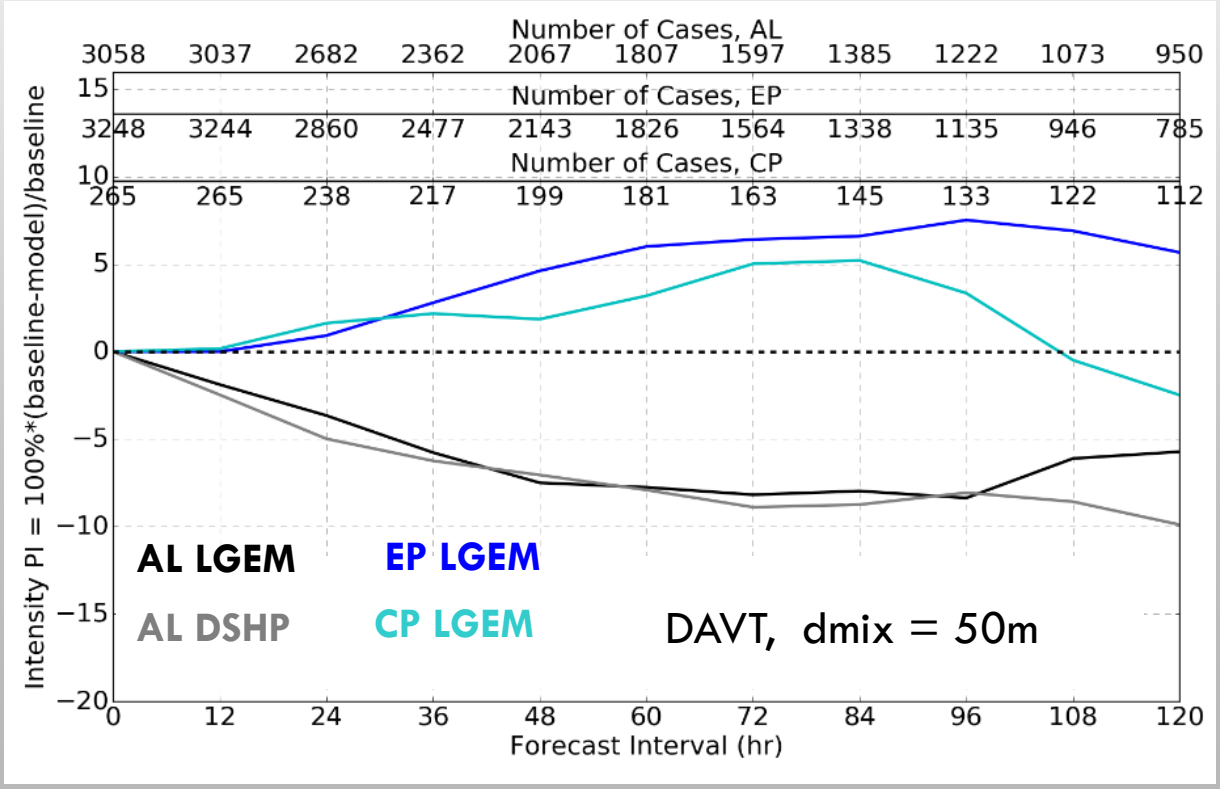


DEPTH-AVERAGED TEMPERATURE (DAVT)

Use daily SST to estimate a vertical average of the initial (pre-hurricane) ocean ***T*** *(Price, 2009)*, which is better estimate of ocean-TC interaction than OHC

$$T_{\overline{d}}(x,y) = \frac{1}{d}\int_{-d}^{0} T_i\ (x,y,z)dz,$$

d – depth of vertical mixing caused by TC



- EP – significant, up to 7% improvement for LGEM for FLT > 30 h
- AL – forecast get much worse

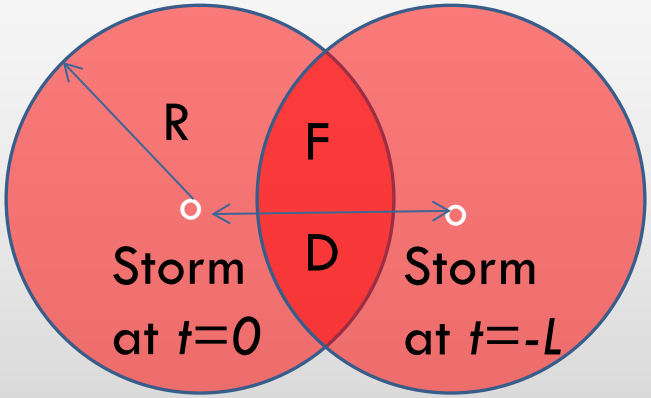
➢ Possible reasons:

- Not using MLD climatology: updated climatology developed
- Need to adjust empirical MPI
- Need to use DAVT based on variable mixing depth for the AL

DAVT ASSUMING VARIABLE MIXING DEPTH : OCEAN AGE (OA)

"Ocean Age" – a measure of the amount of time the storm area within R = 60 nmi has been over the same patch of ocean

- Average OA: AL 6.5 hours, EP 7.6 hours
- Critical Translational Speed: Ocean Age = Inertial Period

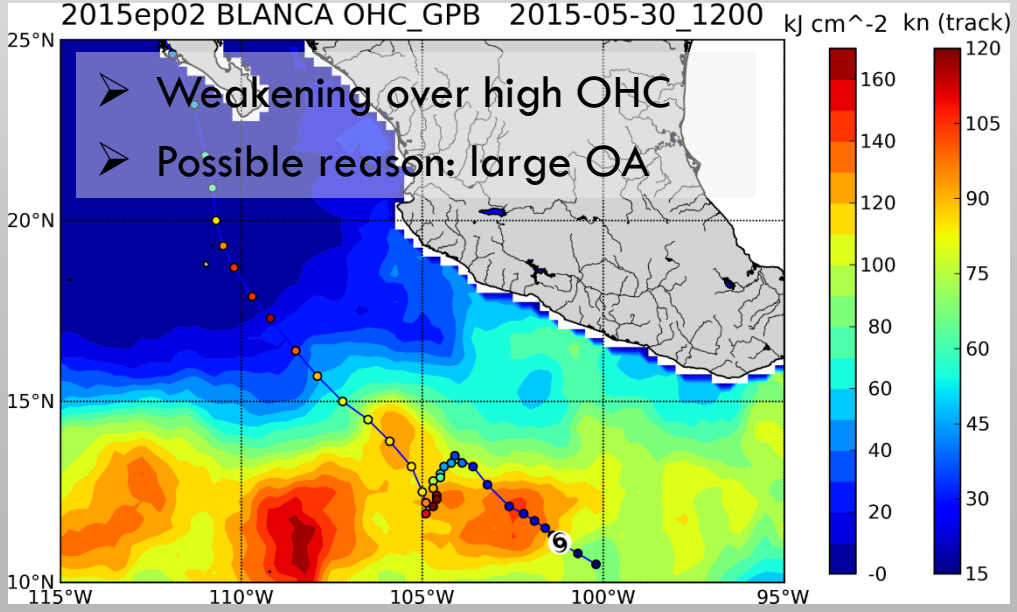


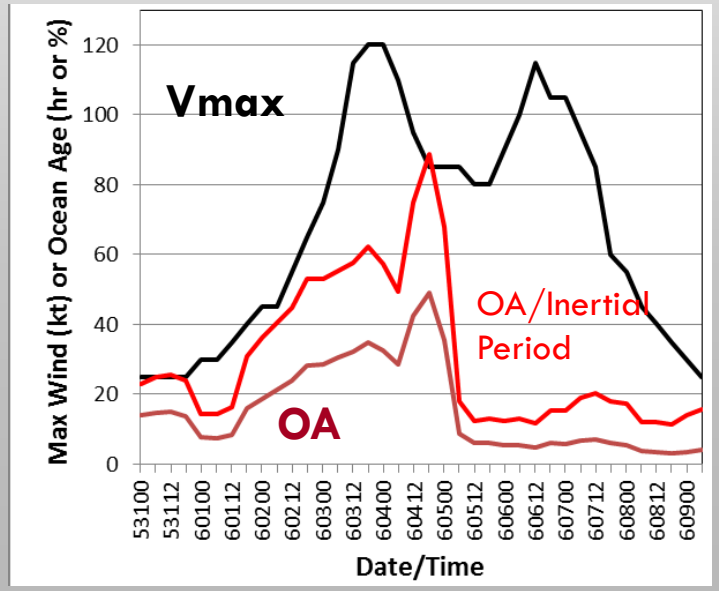
$$OA = \int_{-L_{max}}^{0} F dt$$

L_{max} = Max Tlag with $D < 2R$

$$Mixing\ Depth = a + \underbrace{b * OA}_{\text{Mixing}} + \underbrace{c(lat) * OA^2}_{\text{Upwelling}}$$

Yablonsky and Ginis (2009)





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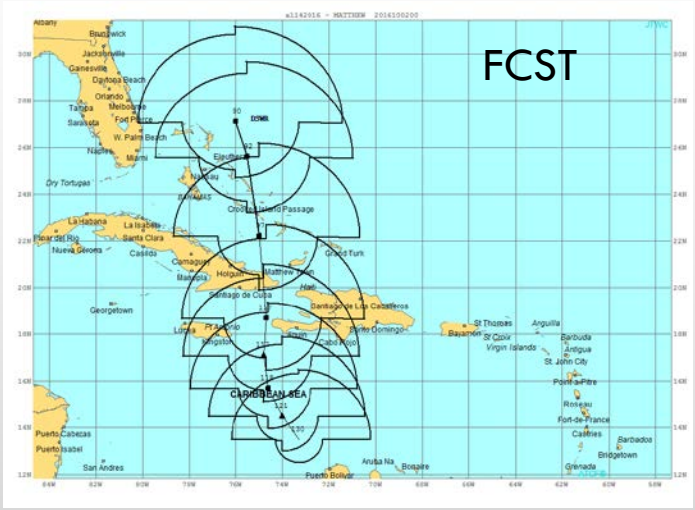
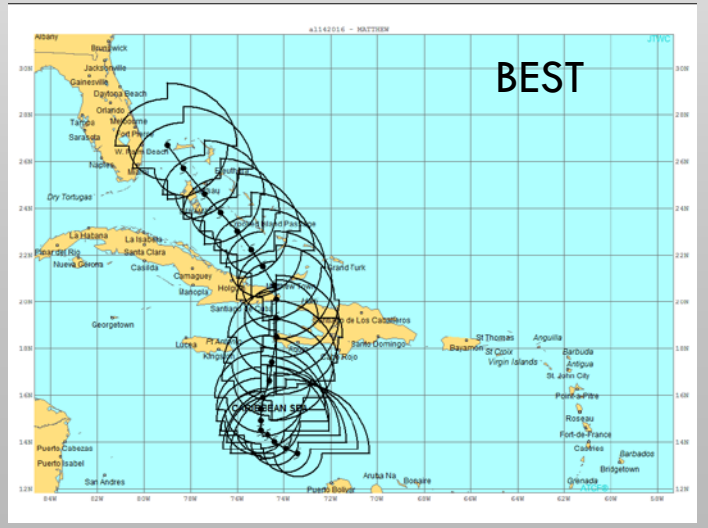
SHIPS-BASED WIND RADII FORECASTS (DSWR)

Design Principles

- Predicts TC size changes
- Multiple regression
- Environmental predictors
- Storm predictors
- Wind radii via parametric model
- MSLP is also estimated
- Contribute positively to RVCN (Sampson and Knaff (2015)
- Was run at CIRA in 2016
- Was supplied to NHC in 2016
- Published 2017

Hurricane Matthew 1 October 00 UTC



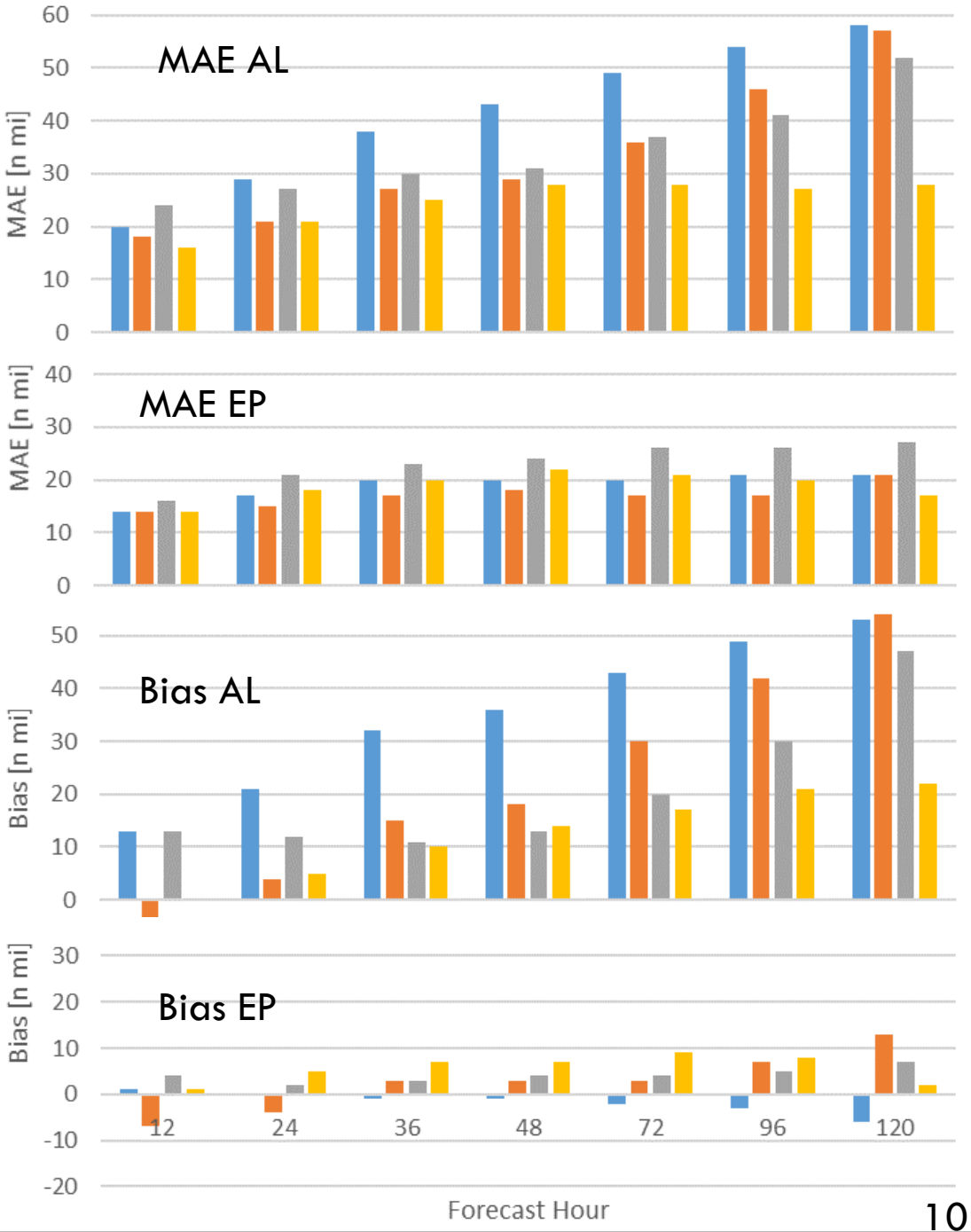


Knaff, J. A., C. R. Sampson, and G. Chirokova, 2017: A global statistical-dynamical tropical cyclone wind radii forecast scheme. Wea. Forecasting. doi: 10.1175/WAF-D-16-0168.1.

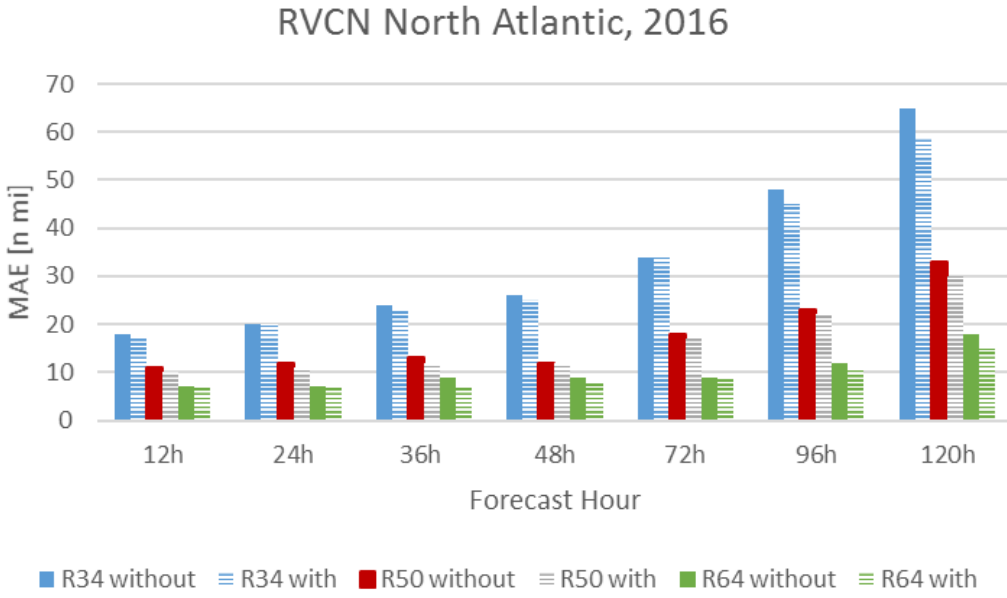
DSWR MEAN ABSOLUTE ERRORS AND BIAS (GALES/34-KT)

- AL: Large DSWR errors
- EP DSRW
  - skillful vs DRCL
  - among top performers
- 2016 – unusual AL year
- all models were high biased!
- Will look at the source of high bias
- **DSWR has near zero bias In the East (&West Pac)!**

Decay SHIPS wind radii (DSWR)
HWRF
GFDL/GFTI
Wind Radii CLIPER (DRCL)



CONSENSUS (RVCN) IMPROVEMENTS

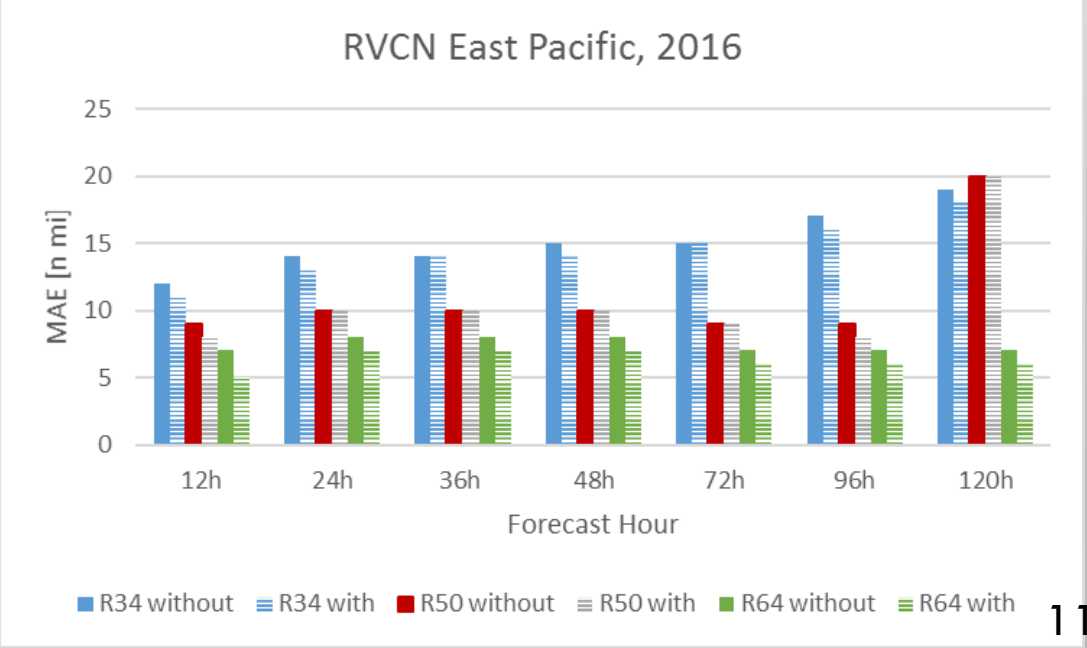


DSWR provided either improvements or **no** degradation to the multi-model wind radii consensus (RVCN) when added as a member – **all basins**

- RVCN included HWRF, GFS, GFDL
- Largest improvements with DSWR inclusion

1. R64 (0 to 28%)
2. R50 (0 to 10 %)
3. R34 (0 to 9%)

- See Sampson & Knaff (2015)



SUMMARY AND CONCLUSIONS

- SHIPS/LGEM with daily Reynolds SST:
  - Completed and verified retrospective (2004 – 2015) and parallel (2016) runs
  - Results: overall intensity forecast can get slightly better or worse with DSST, biases are reduced, DSST contribution can be very significant in some cases
  - Code and verification results provided to NHC
- SHIPS/LGEM with Depth Averaged Temperature:
  - Modified models to use RSST, DSST, DAVT in different parts
  - Completed retrospective runs for 2004 – 2015 (constant mixing depth): improvement for EP
  - Working on estimating variable mixing depth as a function of TC translation speed using OA
- TC structure forecasts:
  - A statistical-dynamical method developed to estimate wind radii and MSLP for global TCs using satellite data and SHIPS/LGEM intensities. (Based on 1996-2014 data)
  - Parallel runs and verification completed for 2016, code provided to NHC, JTWC
  - 2016 results: AL – high bias; EP - almost zero bias; improves RVCN

- Remaining work:
  - Complete tests and retrospective runs with DAVT with varying mixing depth
  - Apply changes to the global version (2017) of SHIPS/LGEM
  - Conduct parallel runs for 2017 season and respond to feedback

ADDITIONAL SLIDES

Abbreviations used:

- Statistical Hurricane Intensity Prediction Scheme (SHIPS)
- Logistic Growth Equation Model (LGEM)
- Decay SHIPS wind radii (DSWR) forecasts
- Tropical Cyclone (TC)
- Sea Surface Temperature (SST)
- Weekly Reynolds SST (RSST)
- Daily Reynolds SST (DSST)
- Depth-Averaged Temperature (DAVT)
- Maximum Potential Intensity (MPI)
- Ocean Age (OA)
- Mixed Layer Depth (MLD)