

NOAA Probabilistic Rip Current Forecast Model: Evaluation and Implementation

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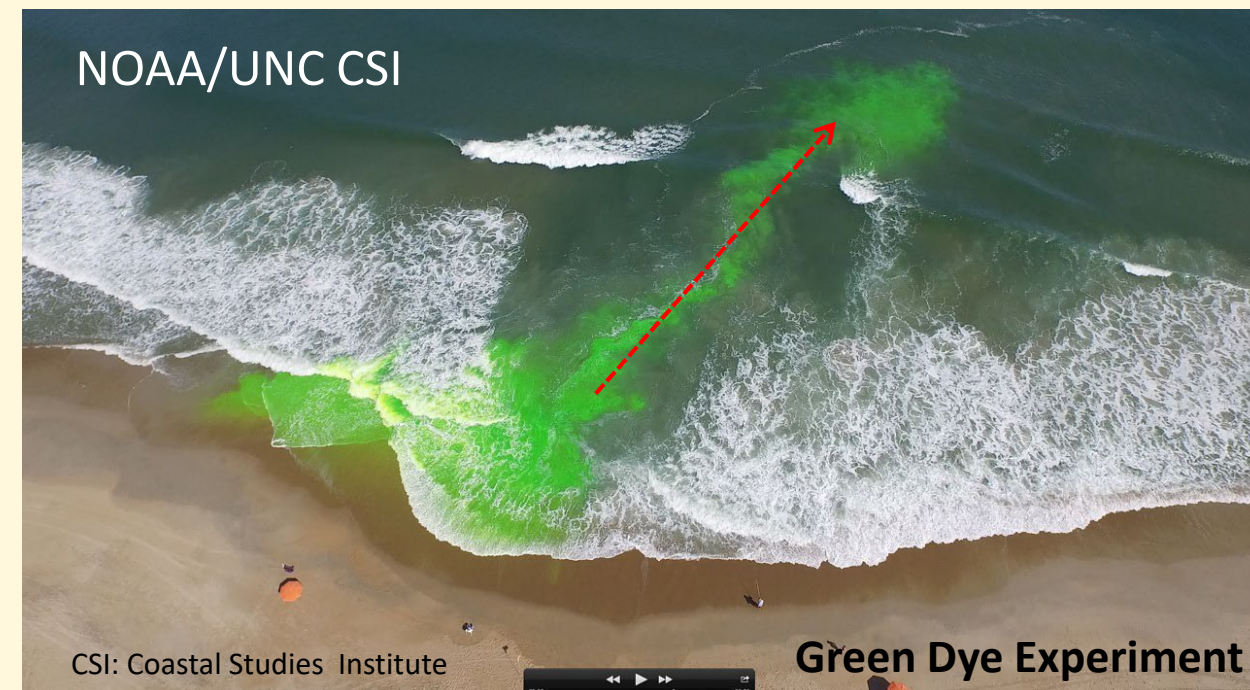
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Introduction

The National Weather Service (NWS) and the National Ocean Service (NOS) are collaboratively transitioning the NOAA probabilistic rip current forecast model (Dusek and Seim 2013) into NWS operations. This model predicts the statistical likelihood of hazardous rip currents using a logistic regression technique. In a staged implementation along the US coasts, the model is running experimentally as a component of the National Center for Environmental Prediction (NCEP)'s Nearshore Wave Prediction System (NWPS; Van der Westhuysen et al. 2013).

Rip current observation reports have been collected from lifeguards in coordination with local NWS Weather Forecast Offices (WFOs). The NWS Meteorological Development Laboratory (MDL) is using these rip current observations to evaluate the model performance at WFO pilot beaches across the US. This presentation will summarize the NOAA probabilistic rip current forecast model and verification results. We will show the model's strengths and weaknesses, the benefits of using MDL's Model Output Statistics (MOS) method to improve the performance scores, and the potential for tuning the model locally and seasonally to more effectively forecast regional and seasonal rip current behavior. The presentation will conclude with future research plans with a focus on operational implementation.

What is a Rip Current (RC)?



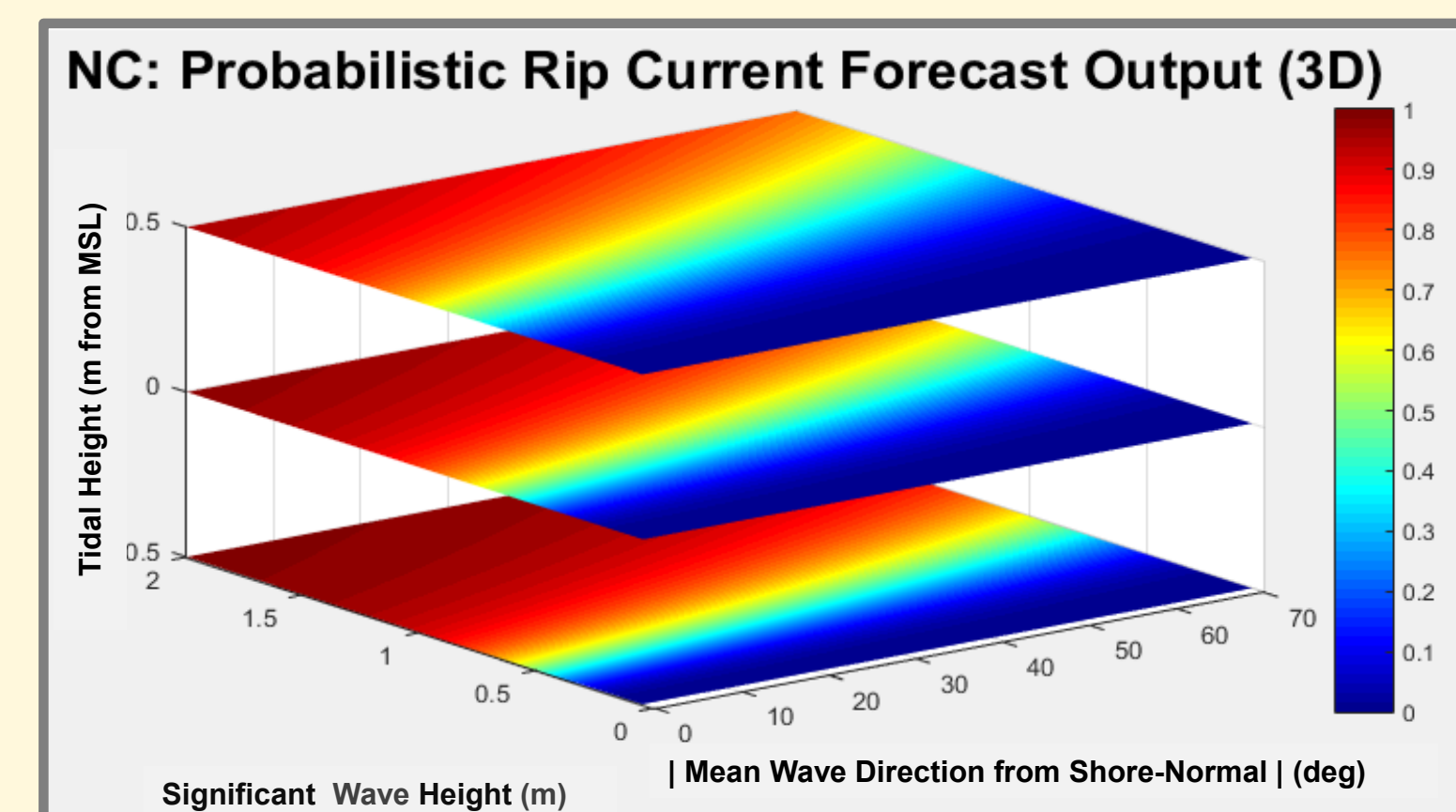
- Rapid offshore-directed jets of water that originate in the surf zone
- Mostly caused by alongshore variations in breaking waves
- Takes swimmers of all ability levels into deeper water within minutes
- **The number one public safety risk on US beaches** (<http://arc.usla.org/Statistics/view/displayAgency.asp>)

NOAA Probabilistic RC Forecast Model

- A perfect prog model developed using lifeguards' rip current observations (predictand) and predictors of the observations for

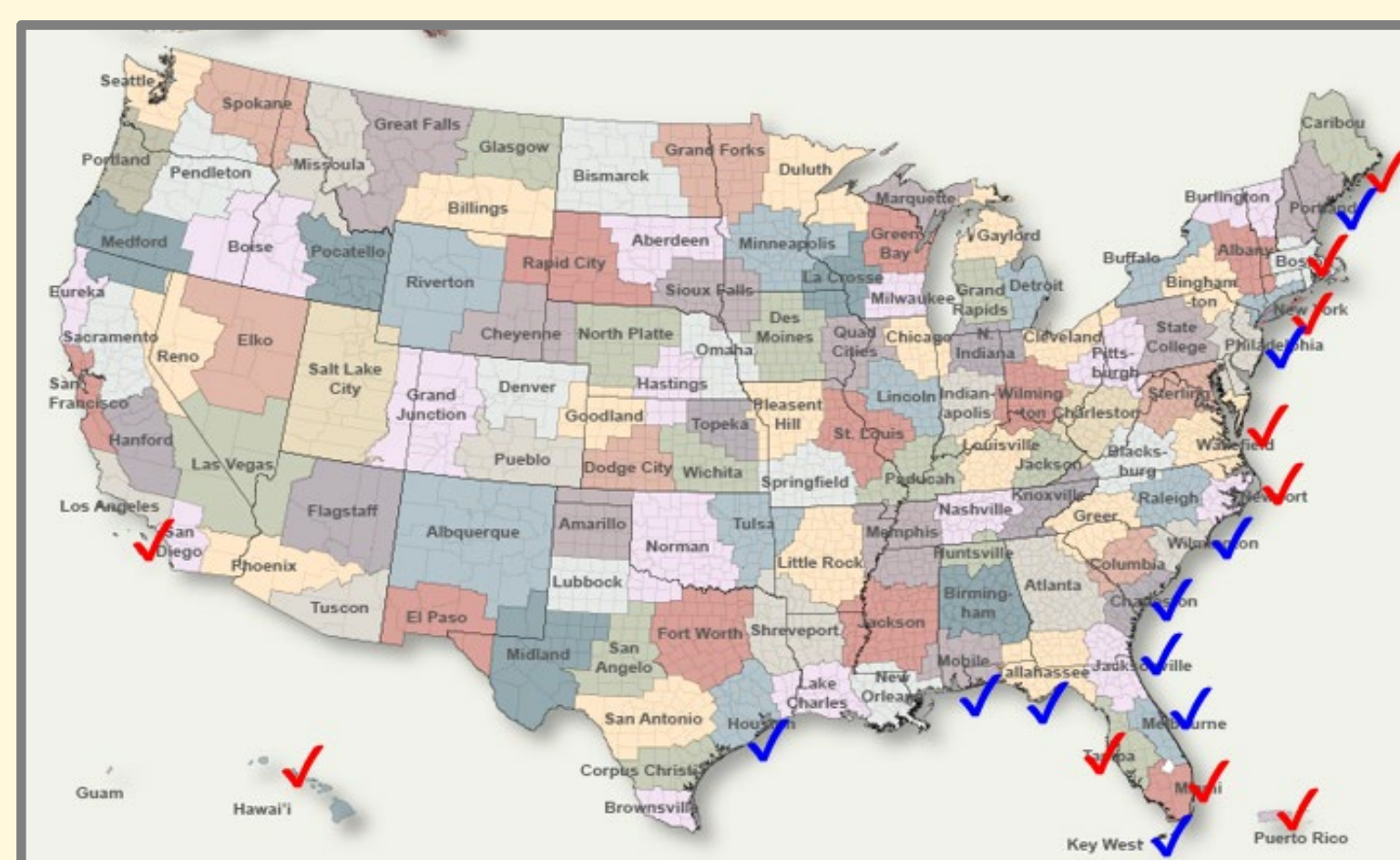
- Significant Wave Height
- Mean Wave Direction
- Tide Water Level
- Previous Wave Event (Persistence/Bathymetry Proxy)

at Kill Devil Hills, NC



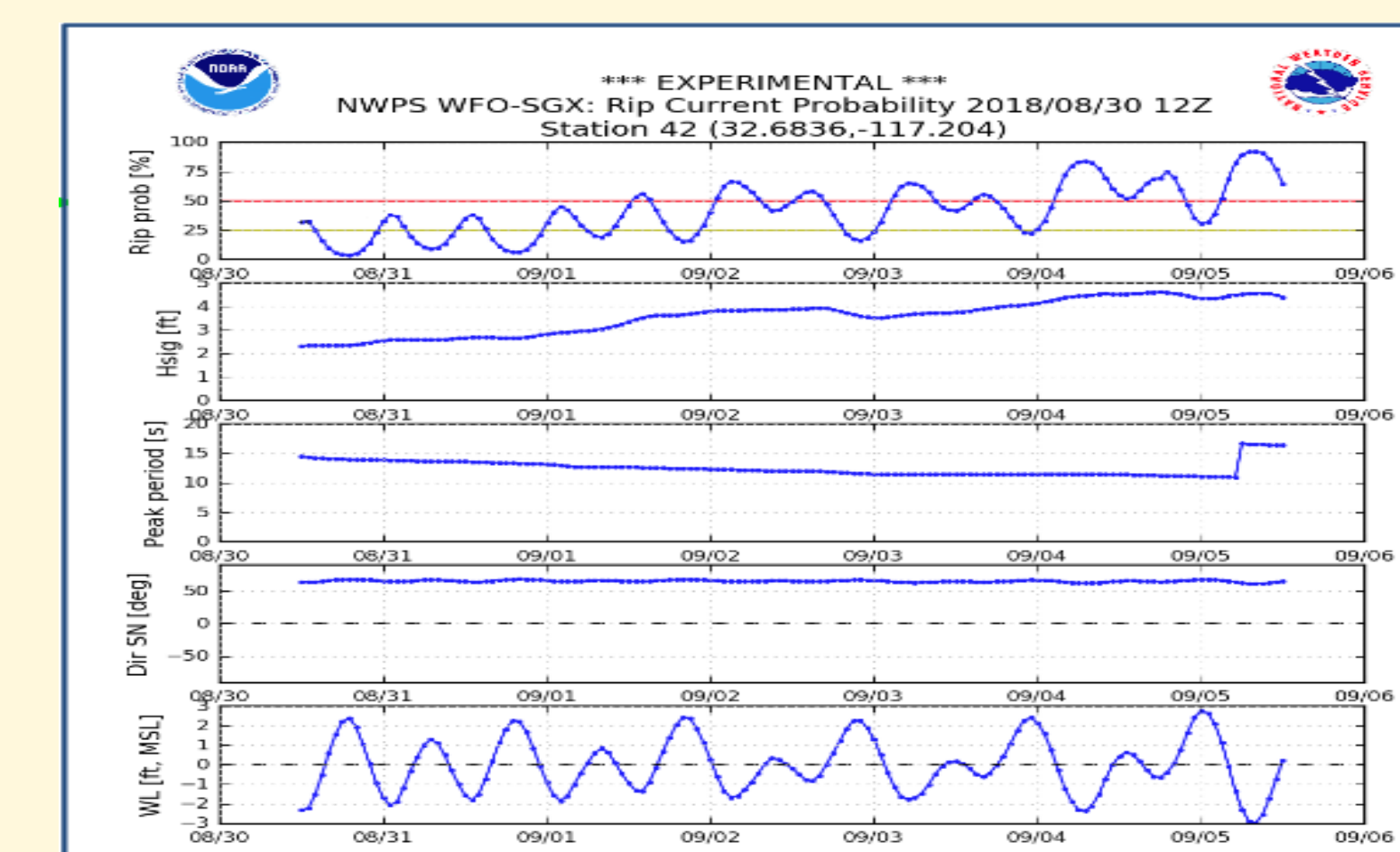
- Output: Probability of occurrence of hazardous rip current (hourly 0-144 hour forecasts)
- Computed using NWPS's wave parameter and tide water level forecasts
- Applied logistic regression coefficients developed for NC to all regions
- Running experimentally at NWS/WFOs pilot sites
- Prototype Google Map-style visualization created

Current 20 WFO Pilot Sites



✓: Recently Added

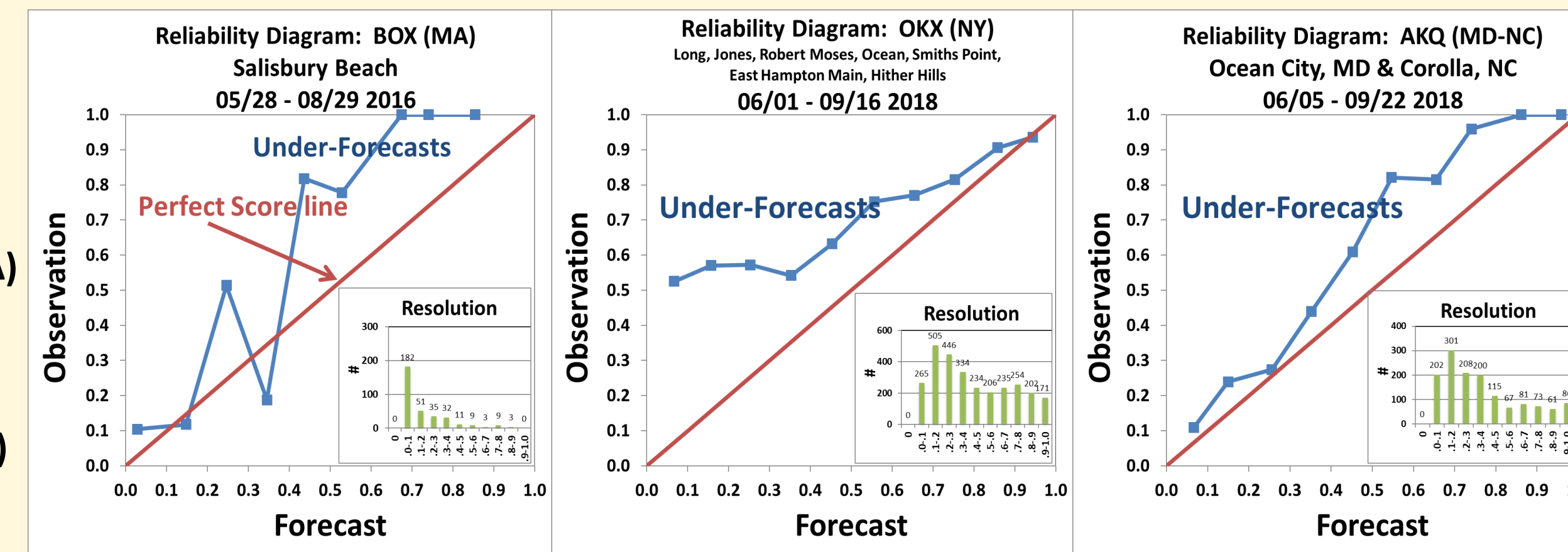
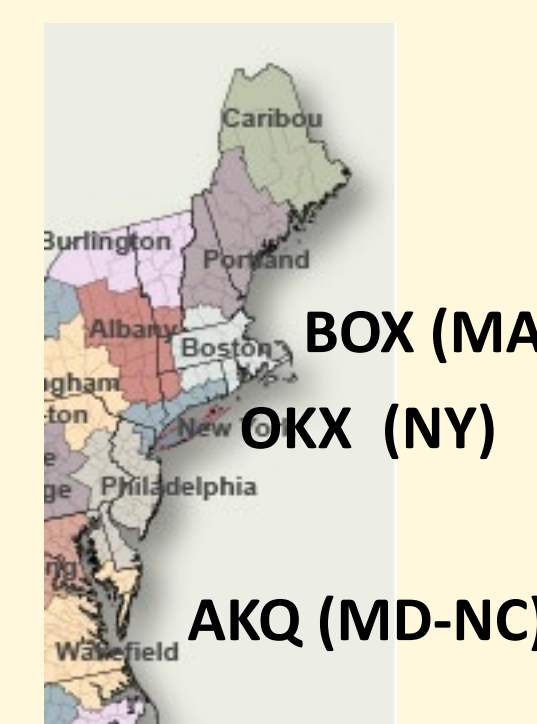
Real-Time Forecast Sample



Verification Results

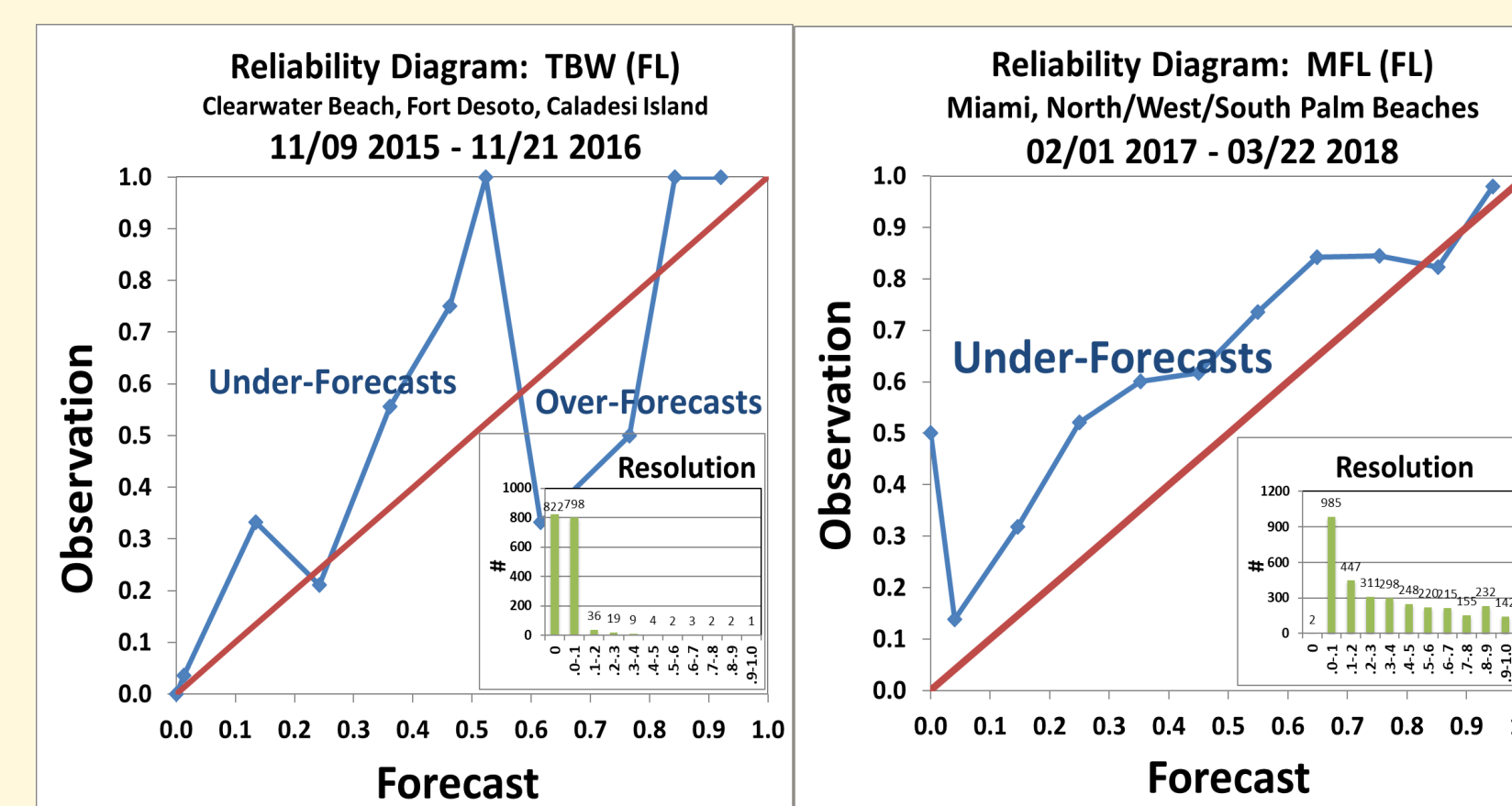
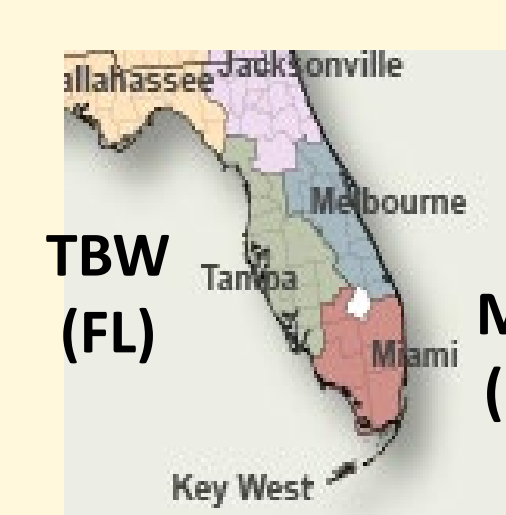
1. Eastern Region

WFO Period	BOX (MA) 05/28 - 08/29 2016				OKX (NY) 06/01 - 09/16 2018				AKQ (MD-NC) 06/05 - 09/22 2018			
	Zero	Weak	Mod	Strong	Zero	Weak	Mod	Strong	Zero	Weak	Mod	Strong
Obs Occurrence	48.9%	25.5%	17.0%	8.5%	17.0%	14.9%	52.2%	15.9%	6.1%	40.1%	35.0%	18.8%
Assumption	Hazardous* ¹				Hazardous* ¹				Hazardous* ¹			
# of Forecast Data	335				2852				1394			
Brier Score (BS)	0.139				0.280				0.168			
BS Sample Climate	0.182				0.223				0.249			
Brier Skill Score (BSS)	23.5% improvement				-25.8% (Decline)				32.4% improvement			

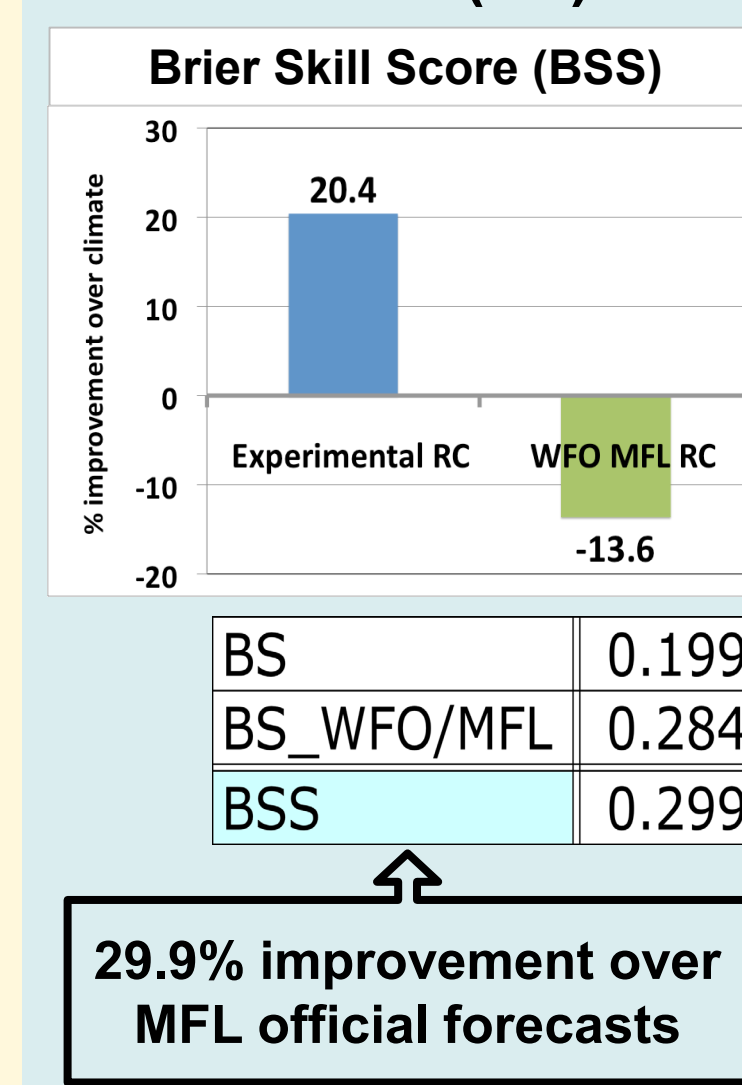


2. Southern Region

WFO Period	TBW (FL) 11/09 2015 - 11/21 2016				MFL (FL)* ² 02/01 2017 - 03/22 2018					
	No	Yes	Zero	Weak	Mod	Strong	Zero	Weak	Mod	Strong
Obs Occurrence	91.3%	8.7%	35.0%	13.0%	26.4%	25.6%				
Assumption	Hazardous				Hazardous* ¹					
# of Forecast Data	1690				3255					
Brier Score (BS)	0.027				0.195					
BS Sample Climate	0.034				0.250					
Brier Skill Score (BSS)	22.0% improvement				21.9% improvement					

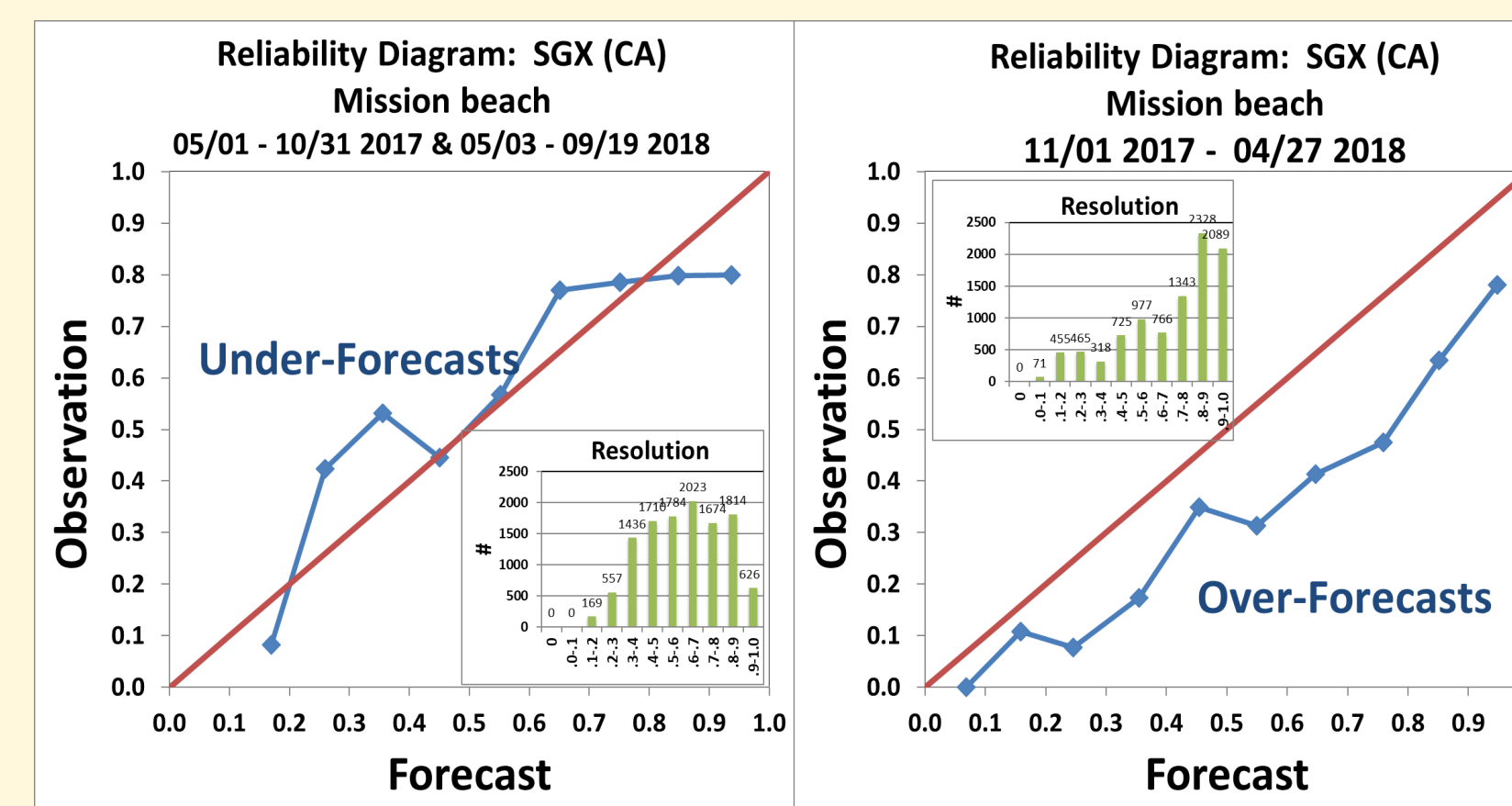


Comparisons to WFO Official Day1 Forecasts in MFL (FL)

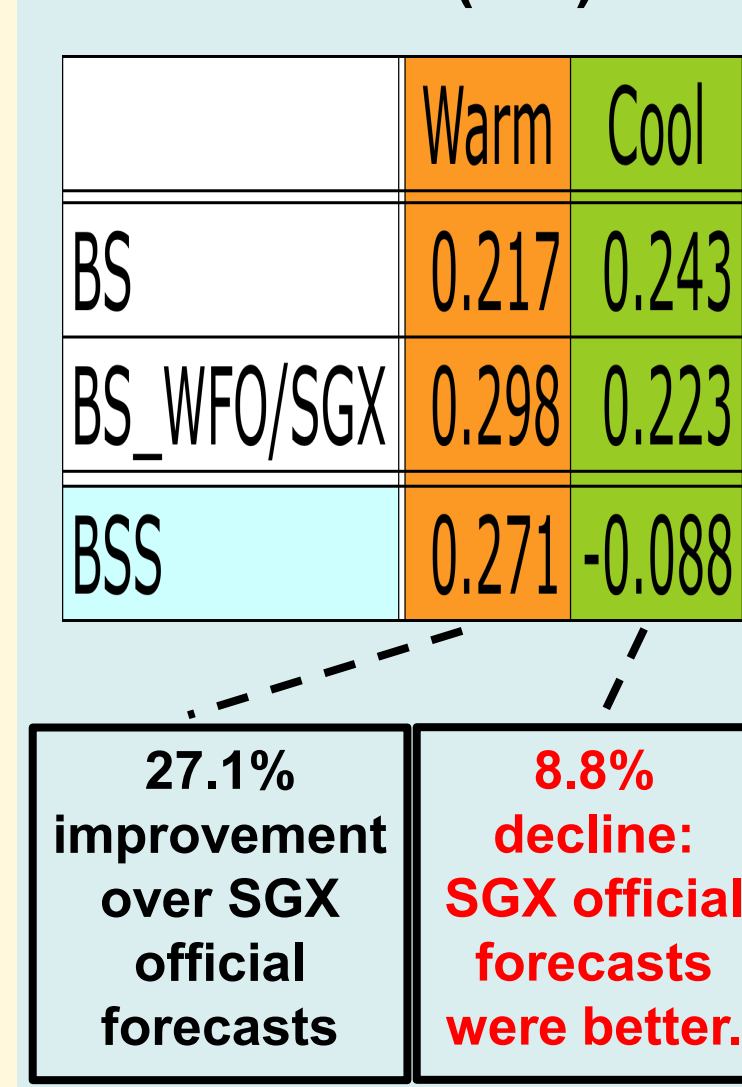


3. Western Region

WFO Period	SGX (CA): Warm Season 05/01 - 10/31 2017 & 05/03 - 09/19 2018				SGX (CA): Cool Season 11/01 2017 - 04/27 2018			
	Zero	Weak	Mod	Strong	Zero	Weak	Mod	Strong
Obs Occurrence	1.9%	33.5%	50.9%	13.7%	1.2%	49.6%	41.0%	8.2%
Assumption	Hazardous* ¹				Hazardous* ¹			
# of Forecast Data	11793				9537			
Brier Score (BS)	0.212				0.241			
BS Sample Climate	0.229				0.250			
Brier Skill Score (BSS)	7.4% improvement				3.7% improvement			



Comparisons to WFO Official Day1 Forecasts in SGX (CA)

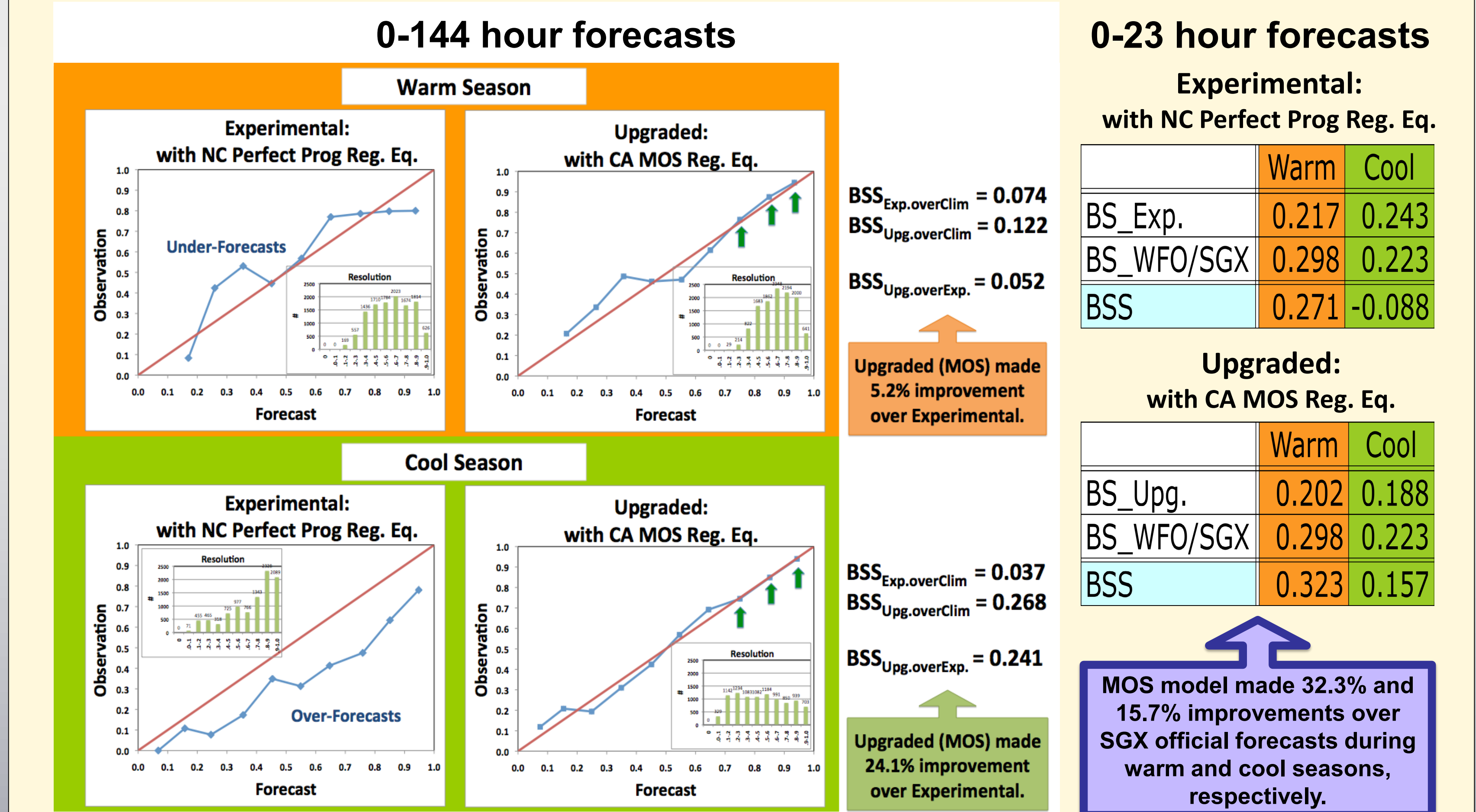


Summary, Discussion, and Future Plan

NWS is implementing a real-time forecast system for hazardous rip currents based on a statistical model developed using lifeguard observations, nearshore wave measurements, and tidal elevation.

- Goal: National implementation of the NOAA probabilistic forecast model
- Current Status: Running experimentally in NCEP's NWPS for 20 WFO pilot sites along the US coasts. Providing hourly 0-144 hour forecasts at a spatial resolution of ~1 km.
- Verification: The Brier Skill Score indicates improvements over the sample climate at beaches in WFO BOX (MA), AKQ (MD-NC), TBW (FL), MFL (FL), and SGX (CA), but there were no improvements in OKX (NY). The Reliability Diagram reveals a general tendency to under-forecast rip currents. The reasons could be that:
 - 1) the RC model is not calibrated with regard to either regional or seasonal variations, i.e., used only one regression equation developed for NC during summer season,
 - 2) the RC model is not a MOS model, but rather a perfect prog model, i.e., no corrections made for systematic biases of the NWPS model output (input to this RC model), and
 - 3) the lifeguard observations are subjective.
- To address these issues, MDL has developed new regional and seasonal MOS logistic regression equations using lifeguard observations (predictand) and NWPS forecast data (predictors) at the Mission beach, CA, for the WFO SGX area (verification statistics are below).

Improvements with MOS Model May 2017 - Sep. 2018, Mission Beach, WFO SGX, CA



- Implementation Plan: This version of the current perfect prog model is planned to be implemented operationally in 2020 and the upgraded MOS model, which consists of region, season, and NWPS model bias calibrations, will be available in the following implementations.
- More improvements are expected from obtaining more predictand data such as high-resolution digital video camera observations (Dusek et al. 2019) in addition to more lifeguards' observations.

References & Acknowledgments

Dusek, G., and Coauthors, 2019: WebCAT: Piloting the development of a web camera coastal observing network for diverse applications. *Frontiers in Marine Science*.
 Dusek, G., and H. Seim, 2013: A probabilistic rip current forecast model. *J. of Coast. Res.* 29(4): 909-925.
 Van der Westhuysen, A., and Coauthors, 2013: Development and validation of the Nearshore Wave Prediction System. 93rd AMS Annual Meeting, Amer. Meteor. Soc.

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*¹ We made the assumption that moderate or strong RCs are hazardous in this verification. Note: Some RCs identified as "weak" may be hazardous as well since there are some rescue reports during weak RC days. When we assumed all of weak, moderate or strong RCs are hazardous, we got worse verification scores.
² Meta data reported in WFO MFL does not have hourly info on obs time, so we paired the obs data with "maximum" forecast data during lifeguard work hours.