Nearshore Wave Prediction System Model Output Statistics (NWPS MOS):

Improvement upon the NOAA Probabilistic Rip Current Forecast Model

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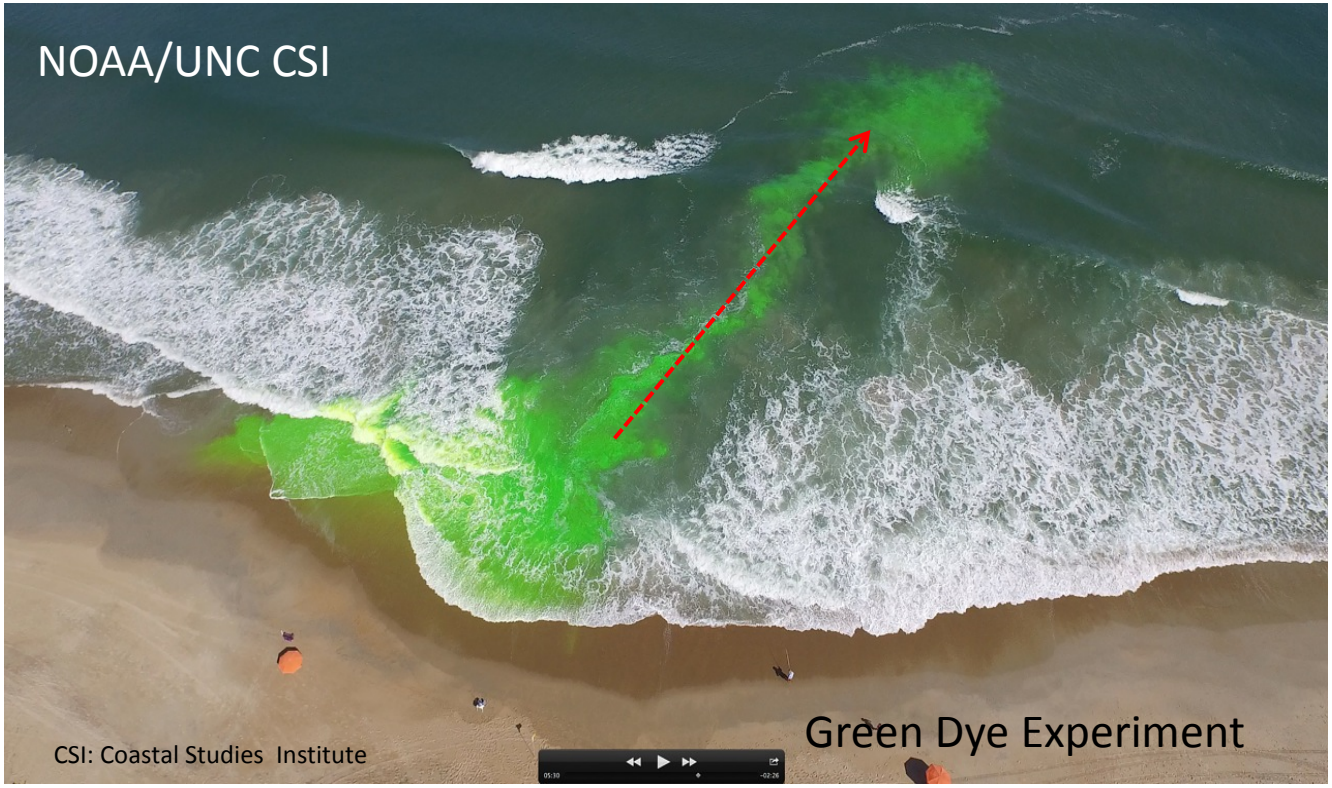
What is a Rip Current (RC)?



- **Rapid offshore-directed jets of water that originate in the surf zone.**
- **Mostly caused by alongshore variations in breaking waves.**
- **RCs are the number one public safety risk at the beach.**

Current Status of NOAA RC Forecast Model

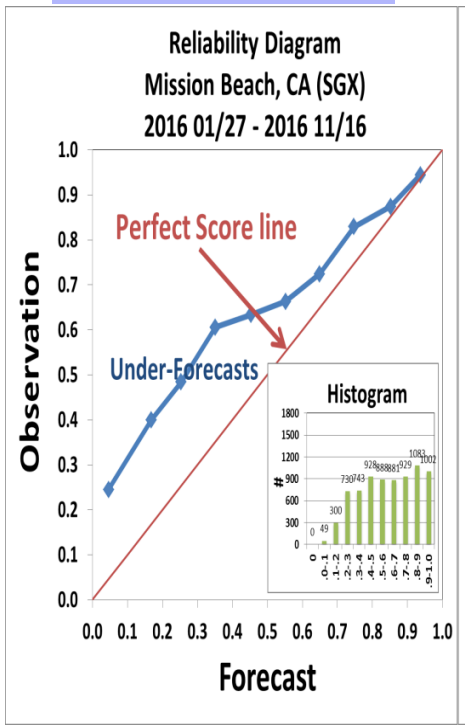
NWS is implementing a real-time short-range forecast system for hazardous RCs based on a statistical model developed using lifeguard observations, nearshore wave measurements, and tidal elevation.

- **Goal: National implementation of the NOAA probabilistic forecast model**
- **Current Status: Running experimentally in NCEP's NWPS for Weather Forecast Office (WFO) pilot sites along the US coasts. However,**
  - ✓ **1) Uses one regression equation developed at Kill Devil Hills (KDH), NC**
  - ✓ **2) Implicitly assumes the NWPS forecasts are perfect**

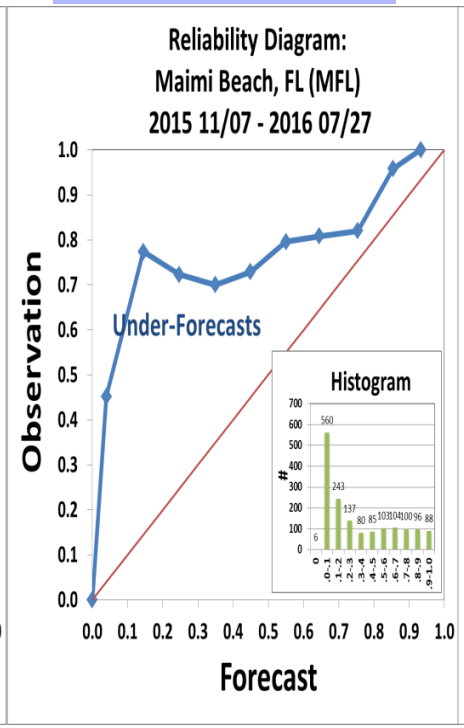
Evaluation Results Applied to Different Beaches with Different Rip Current Characteristics

- **For 0-102 hrs forecasts:**

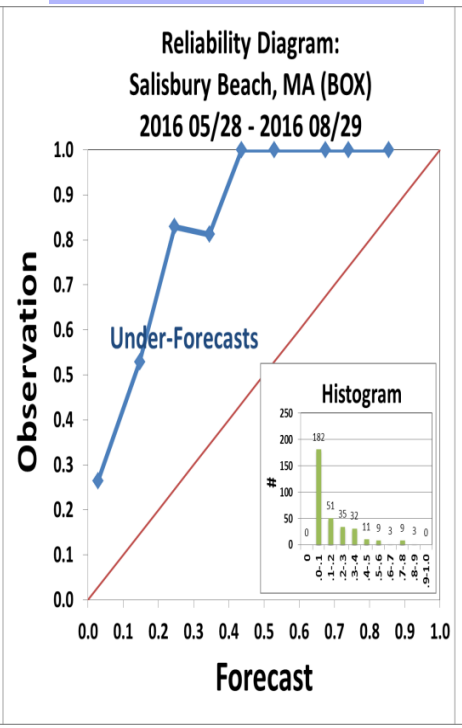
San Diego, CA



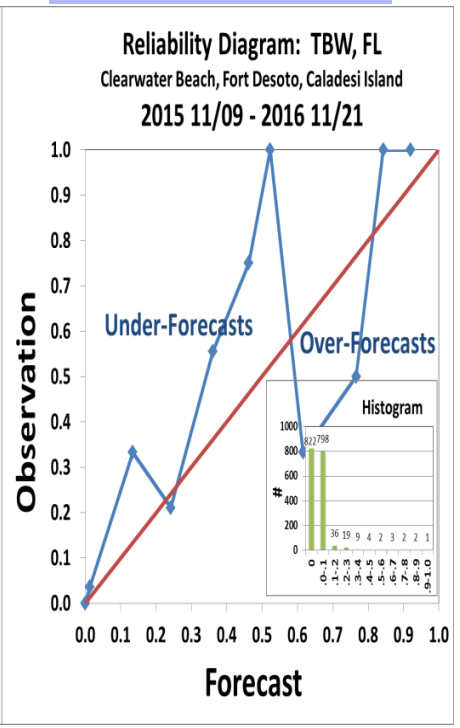
Miami, FL



near Boston, MA



Tampa Bay, FL



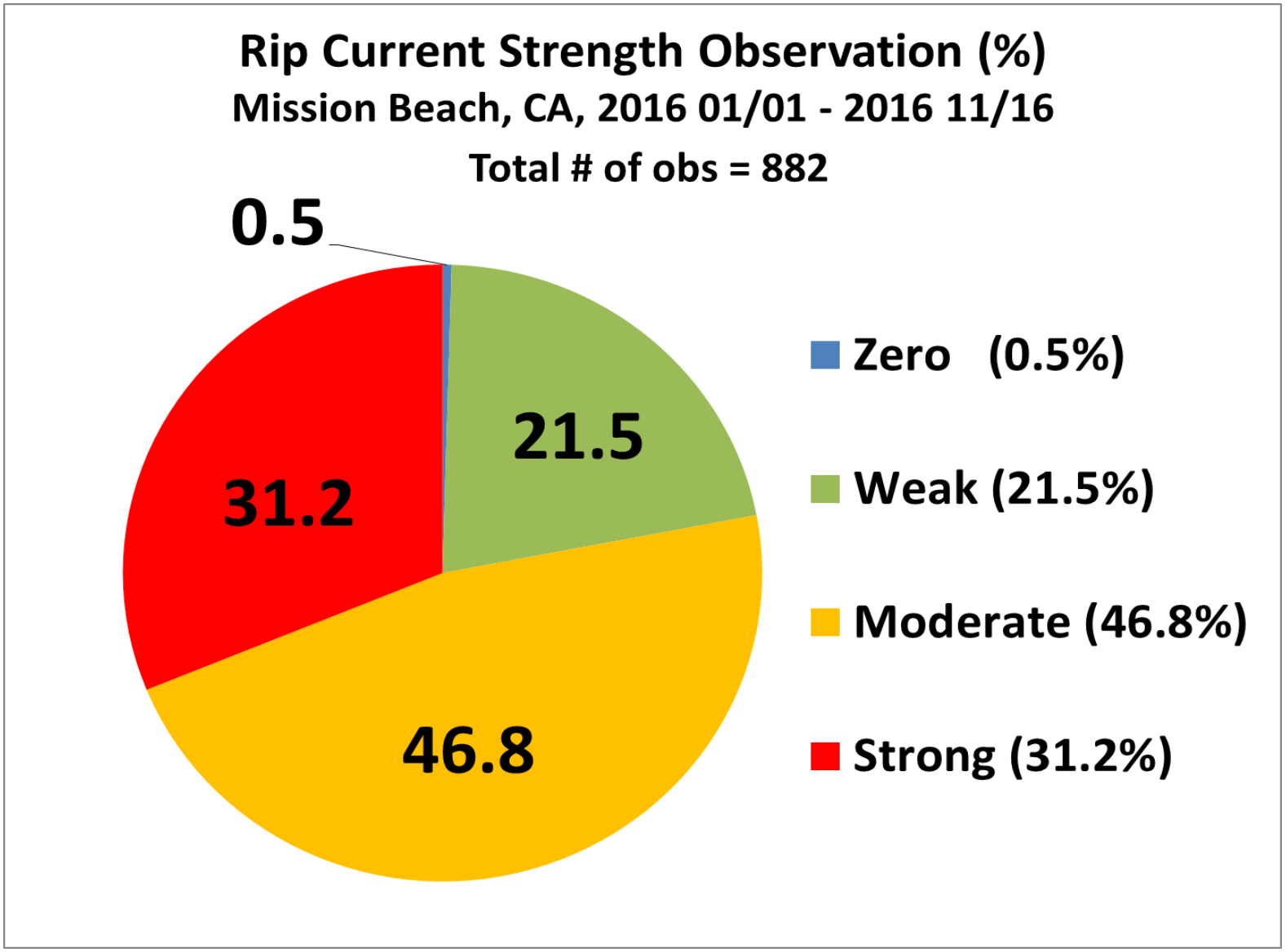
Reliability Diagrams indicate “under-forecast skill” in general.

Current Work

- **To address these issues:**
  - **NWPS Model Output Statistics (MOS) approach applied, which directly computes the regression between NWPS model forecasts (predictors) and RC obs (predictand).**
  - **Regionally-calibrated threshold probabilities were developed to provide forecast users with deterministic high/moderate/low RC risks.**

***MOS:** **Fits statistical model between Numerical Weather Prediction output at a given time frame (i.e., forecast projection) and subsequent observations at that time, and thus can correct for biases of the NWPS model.**

NWPS MOS Development using Logistic Regression Model at Mission Beach, CA for NWS San Diego area forecasts



Note: # of rescues increases significantly going from weak to moderate rip current strength.

Predictand:

Rip Current Strength

(as observed by lifeguards)

Predictors:

-Significant Wave Height

-Mean Wave Direction

-Wave Peak Period

-Previous Wave Event

-Tide Water Level

(as forecast by NWPS)

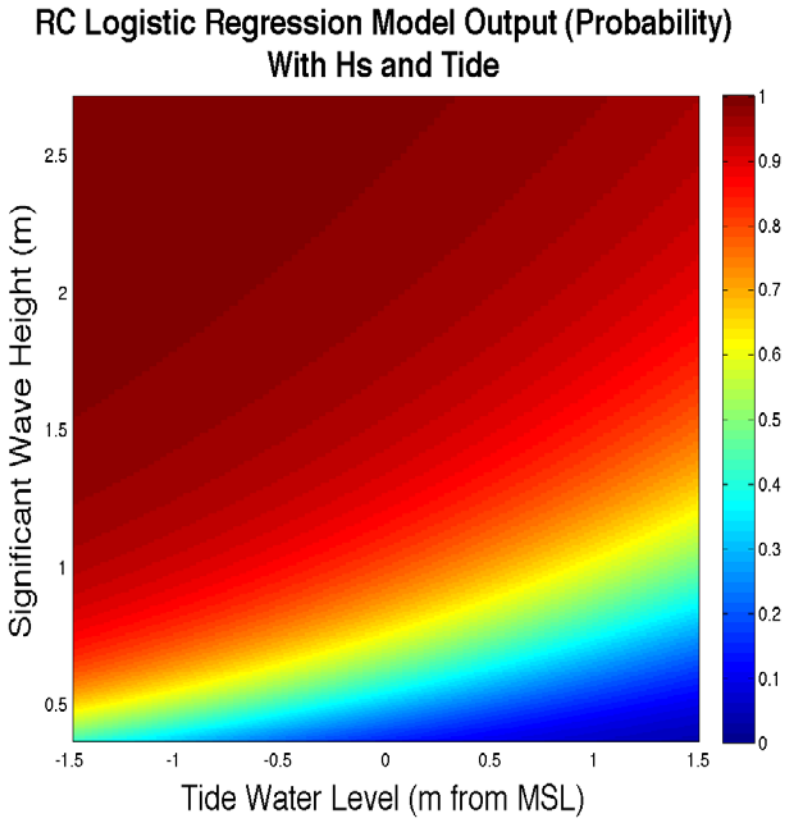
Multivariate Logistic Regression Model Formulation

Probabilistic RC forecast Model

after checking reductions of variance & collinearity of predictors

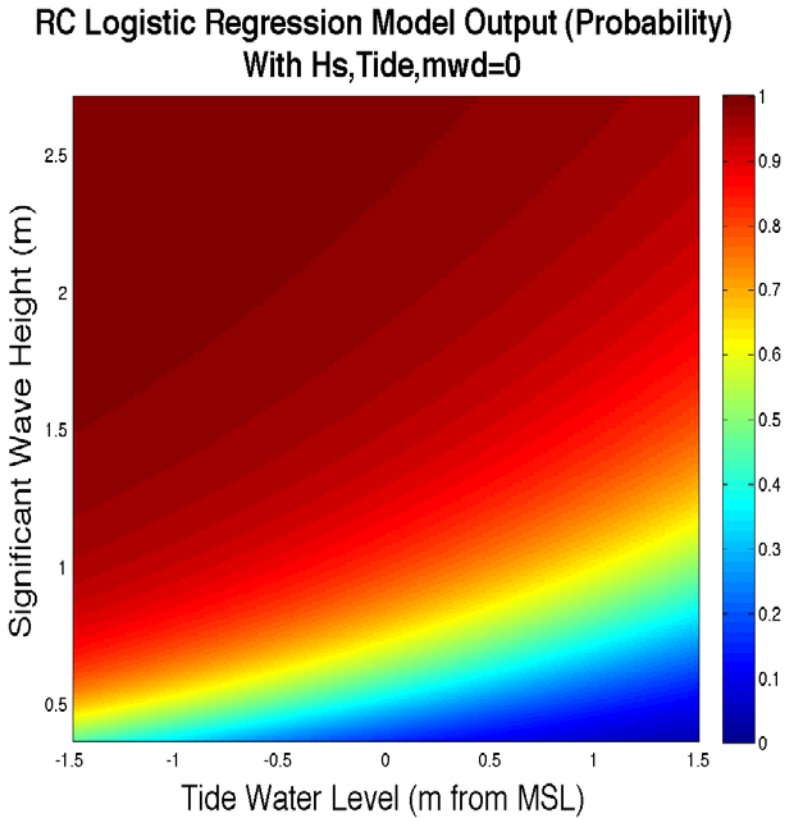
Logit with 2 Variables

1.36 + 3.13 ln (Hs) – 0.96 Tide

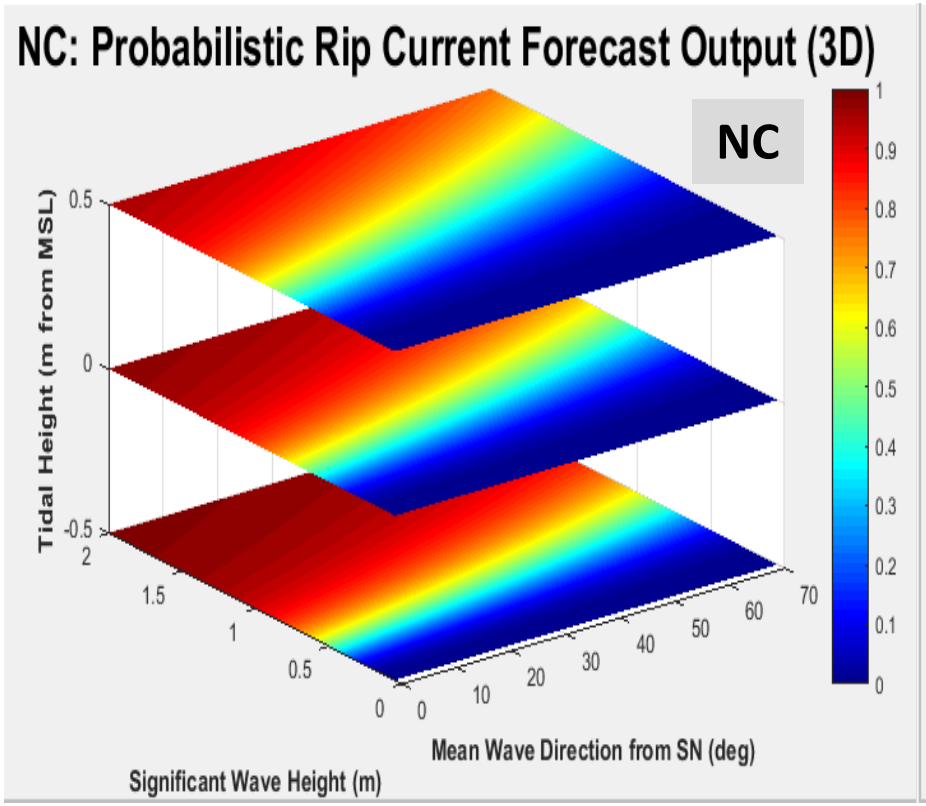


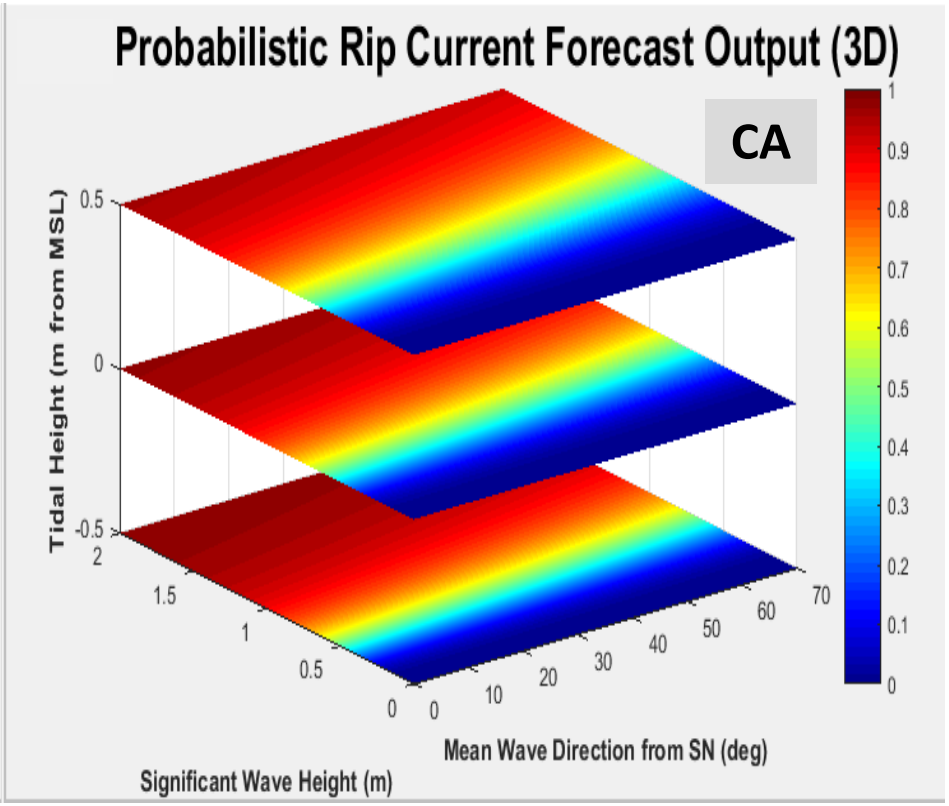
Logit with 3 Variables

1.46 + 3.13 ln (Hs) – 0.97 Tide – 0.01 |MWD|



Comparison of NC and CA





*Note: Just used NC scales for comparison

Logit of NC model (Dusek and Seim, 2013)

1.05 + 3.51 ln (Hs) – 0.027 |MWD| + 0.42 Ep – 1.70 Tide

***Note: Ep = 1 was used for the above figure.**

Logit of CA model

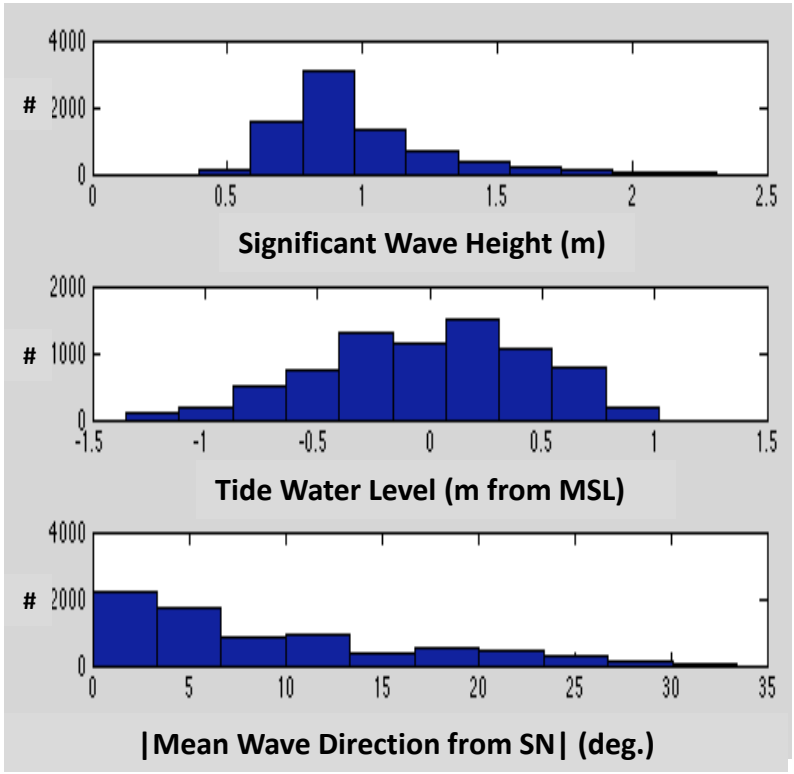
1.46 + 3.13 ln (Hs) – 0.011 |MWD| – 0.97 Tide

Selected Predictors are different than NC's.

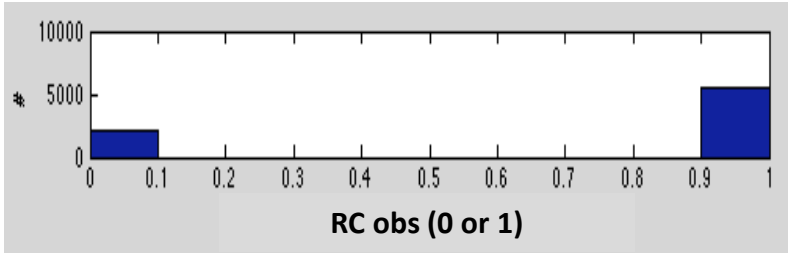
Probabilistic RC forecast output

with NWPS predictor data ranges forecasted during Jan – Nov 2016

Histogram of Predictors from NWPS

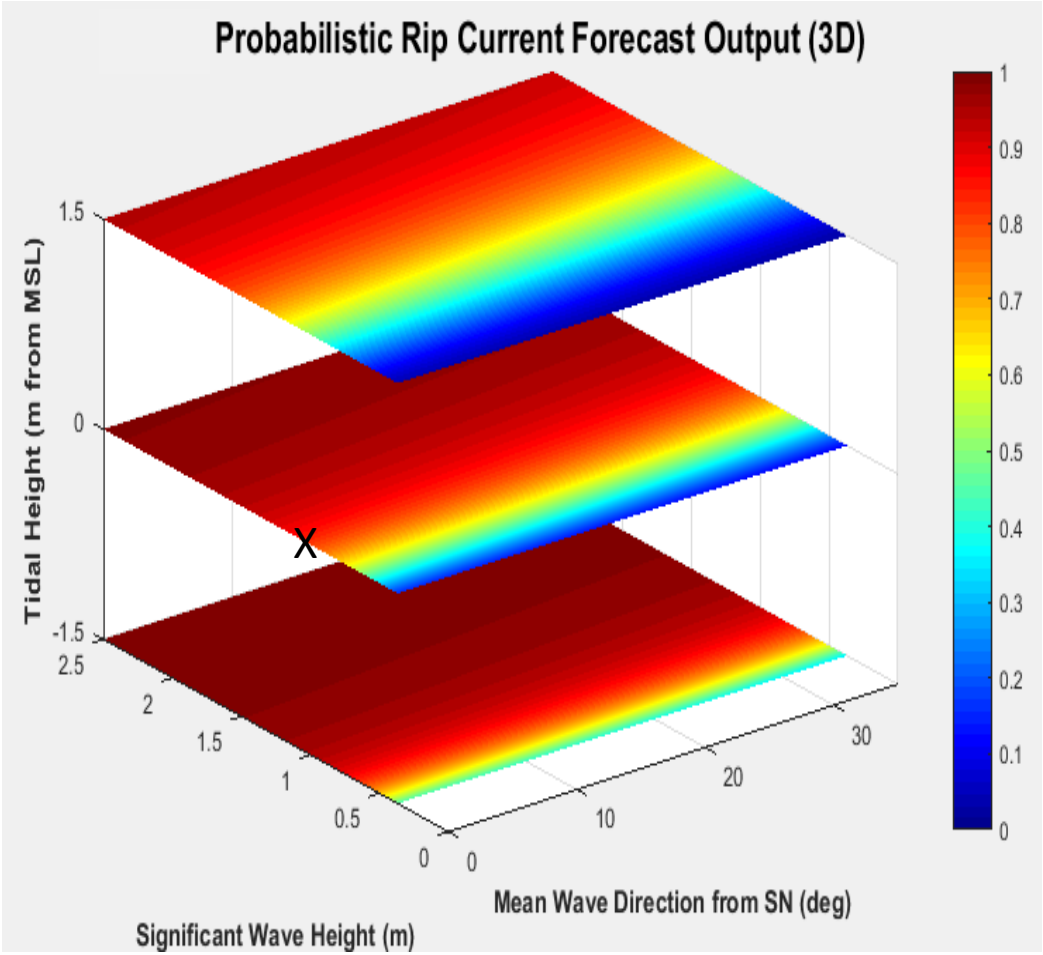


Histogram of Predictand

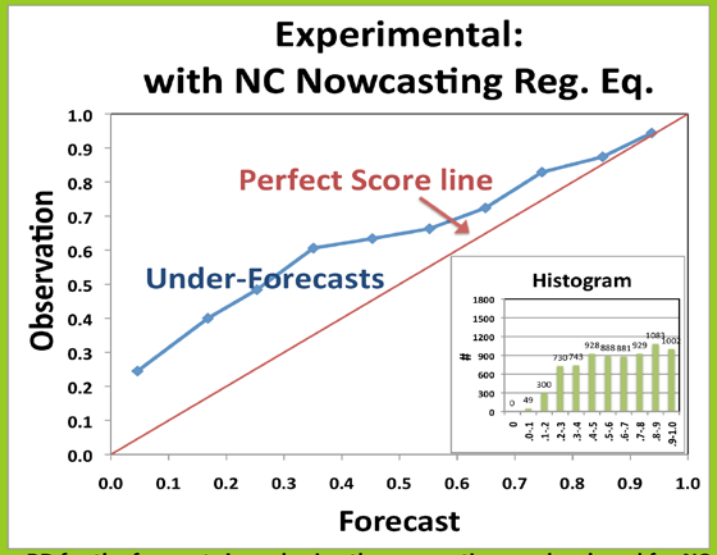


Logit of CA model

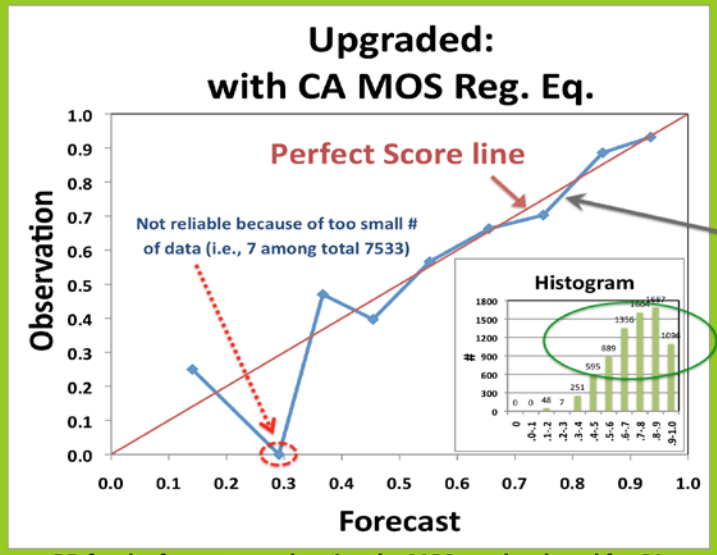
1.46 + 3.13 ln (Hs) – 0.97 Tide – 0.011 |MWD|



Verification: Reliability Diagram



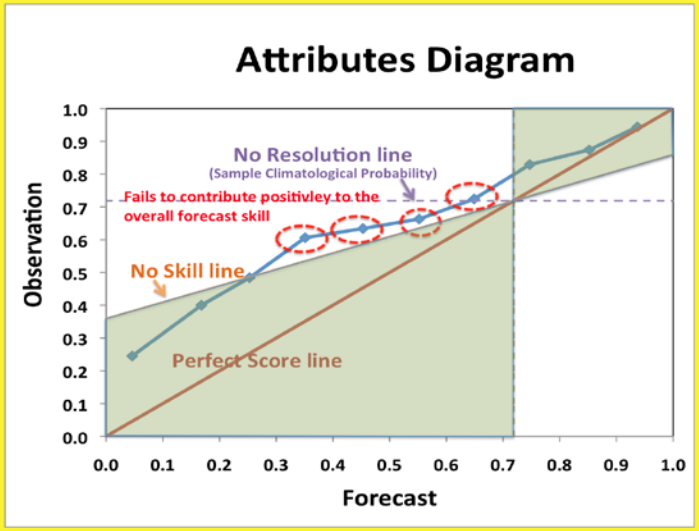
RD for the forecasts issued using the nowcasting eq. developed for NC

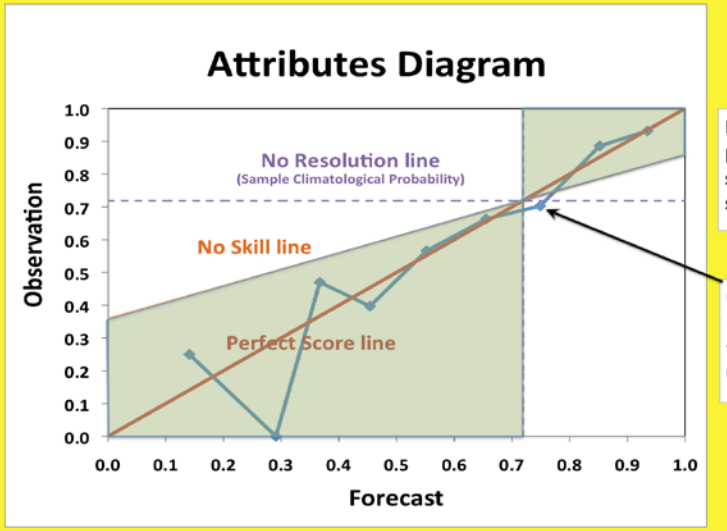


RD for the forecasts made using the MOS eq. developed for CA

Improvements over all forecast ranges especially 0.4-1.0. One exception is in 0.2-0.3, but this is not reliable due to too small # of data

Improvements based on the fact of "Probability of Hazardous RC event occurence from climatology = 0.719"

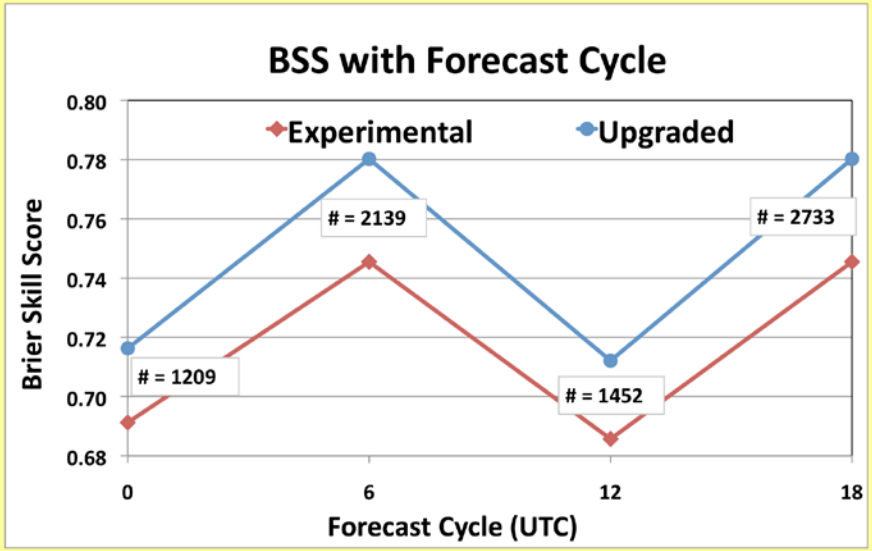


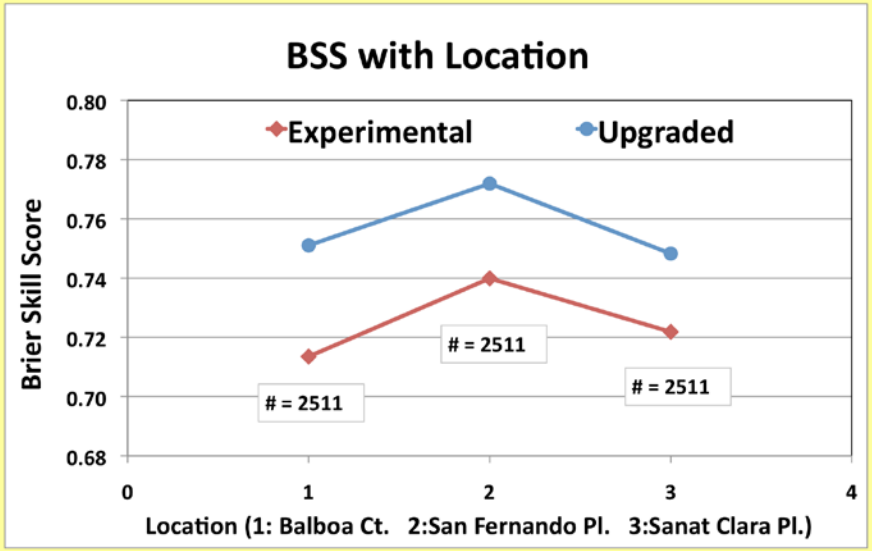


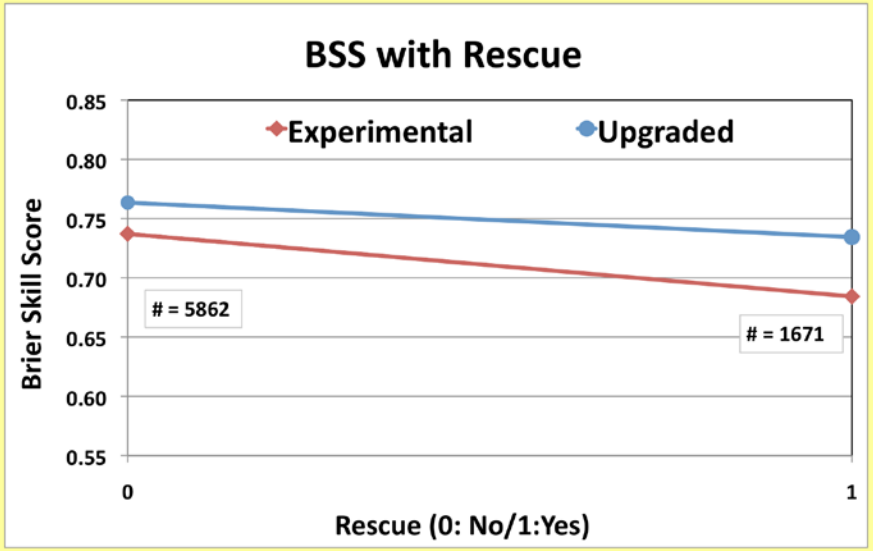
Most probablity bins contribute positively to the overall forecast skill (measured against the sample climatology).

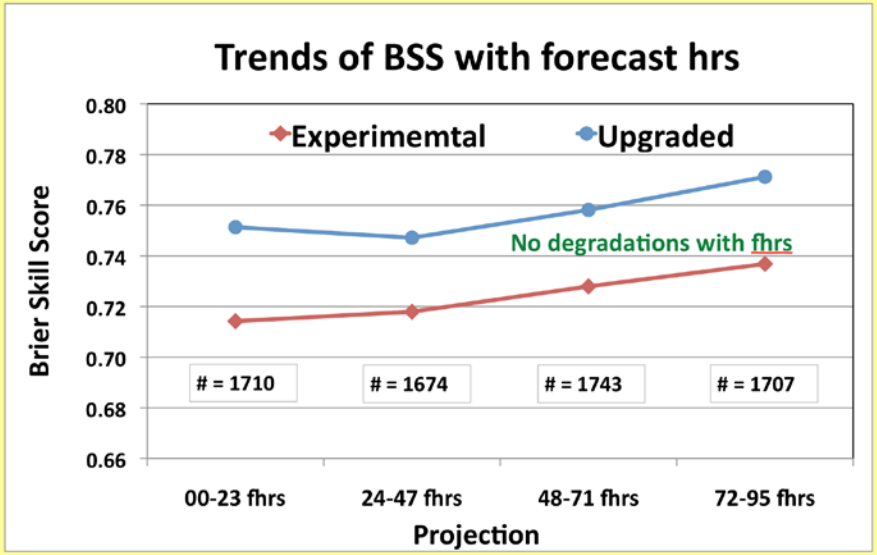
One exception, of course, is the bin of 0.7-0.8, which is close to the sample climatology of 0.719.

Verification: Brier Skill Score









Conversion from a probabilistic to a deterministic forecast (high/moderate/low RC risk)

2x2 Contingency Table (Wilks, 2011)

Observation

Forecast	Yes	No
Yes	a hit	b false alarm
No	c miss	d correct negative

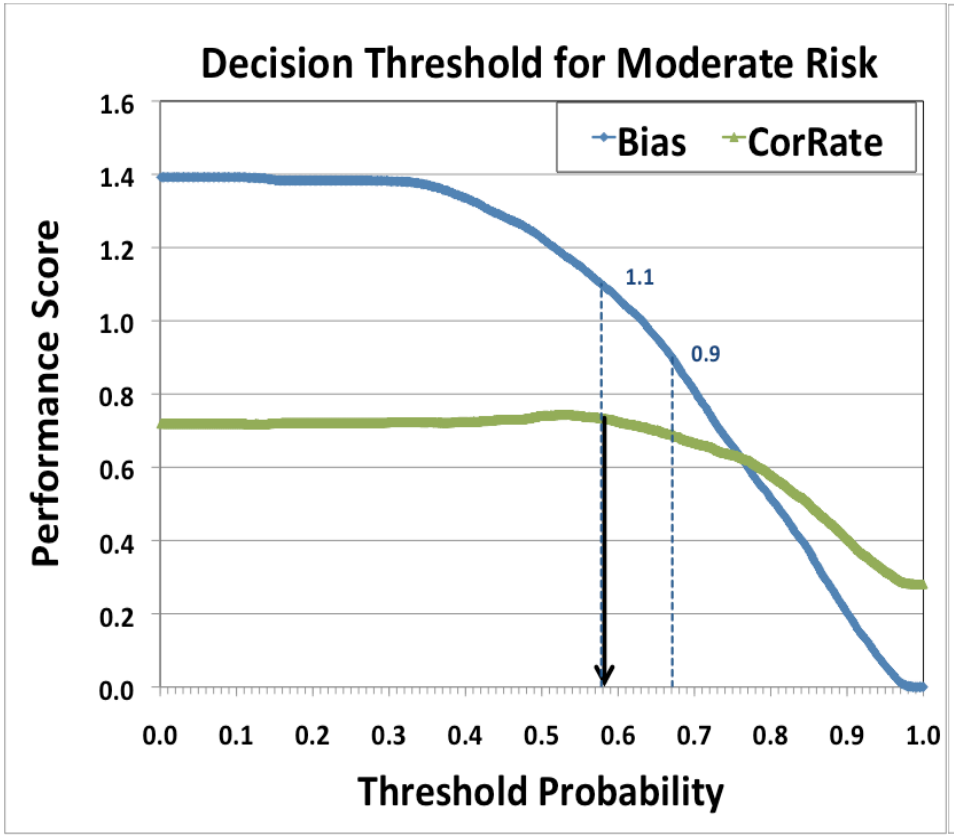
Performance Score

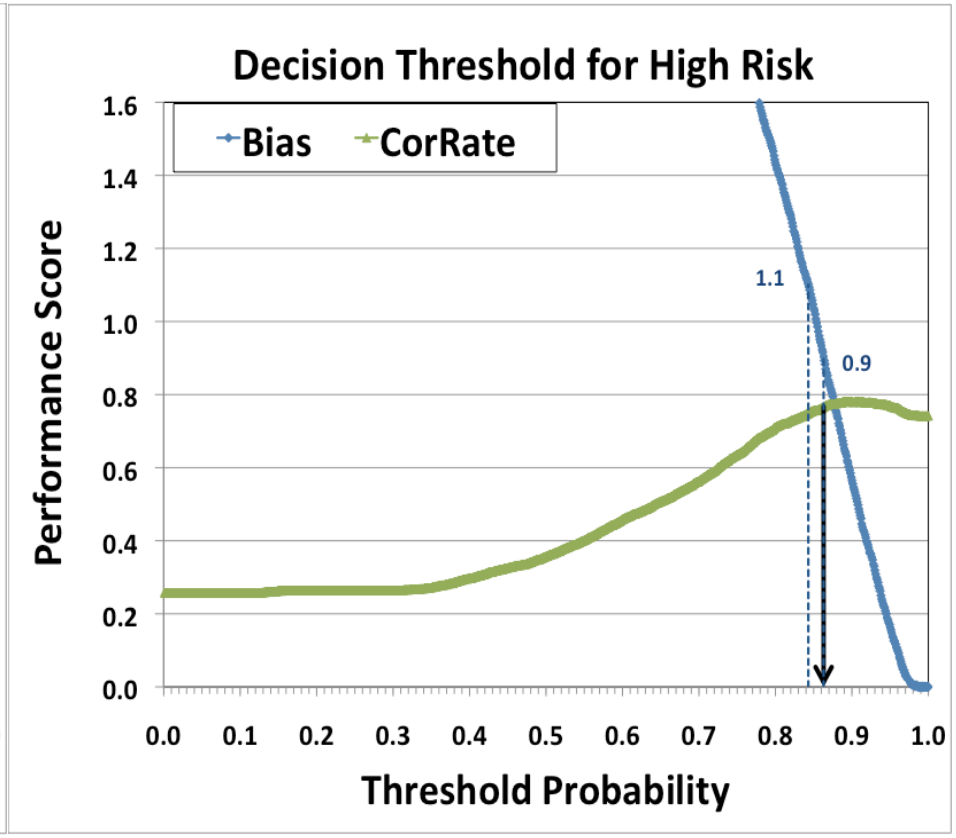
POD=a/(a+c)
FARatio=b/(a+b)
FARate=b/(b+d)
Bias=(a+b)/(a+c)
CorrectRate=(a+d)/(a+b+c+d)
TS=a/(a+b+c)
HSS=2(ad-bc)/((a+c)(c+d)+(a+b)(b+d))
PSS=(ad-bc)/((a+c)(b+d))

- Requires selection of a threshold P, above which the forecast will be "yes" and below which the forecast will be "no."
- The two methods for choosing the threshold P that are most often used in operations are TS* and Bias which are commonly used for rare events.
- RC occurrences at Mission beach are not rare events, thus we decided to use Correct Rate* and Bias.
- Found threshold P to maximize the Correct Rate within allowable Bias range (1 +/- 0.1).

*: Threat Score gives credits only a, but Correct Rate gives credits d as well as a.

Regionally calibrated decision thresholds





0.582

0.863

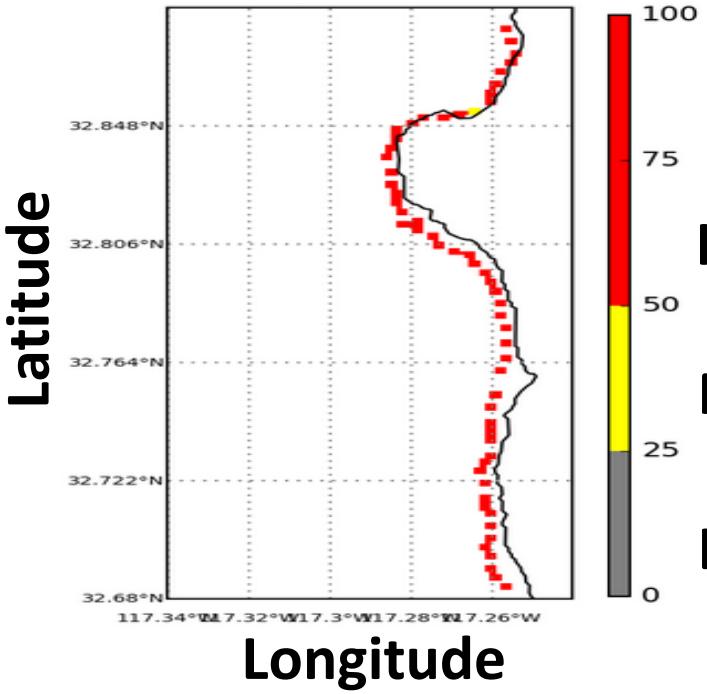
***Note: Using TS and Bias method also selected similar threshold probabilities.**

Decision thresholds: Experimental => Upgraded

San Diego, CA

** EXPERIMENTAL **
NWPS Hazardous Rip Current Probability (%)

http://polar.ncep.noaa.gov/nwps/para/nwpsloop.php?site=SGX&loop=rip&cg=2



Upgraded

Locally Calibrated Decision

High Risk: 50 – 100% => 86.3 – 100%

Mod Risk: 25 – 50% => 58.2 – 86.3%

Low Risk: 0 – 25% => 0 – 58.2%

For High Risk	Bias	POD	CorRate	TS	FARatio	FARate	HSS	PSS
Exp: ThreshP=0.500	2.48	0.81	0.52	0.30	0.67	0.58	0.16	0.23
UpG: ThreshP=0.863	0.90	0.50	0.77	0.36	0.45	0.14	0.37	0.36

*POD: Not a surprising result because POD and TS are only considering "hit."

Summary

1) NWPS MOS products developed for Mission beach
2) Developed regionally-calibrated threshold probabilities to provide forecast users with deterministic high/moderate/low rip current risks
3) Verification with dependent data indicated improvements over the current experimental products.

Future work:

NWPS is now transitioning from structured to unstructured mesh grids and extending to 144 hours. Once training data are available, regression equations/threshold probabilities for each regional domain, warm/cool seasons, cycles, and projections will need to be developed.

Acknowledgements

Special thanks to

- Steve Harrison and Noel Isla (NWS SGX, San Diego, CA)
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Questions?

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