NOAA Joint Hurricane Testbed Project
Year-1 progress report
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"Updating the Secondary Eyewall Formation Probabilistic Model, Completing New Climatologies of Intensity and Structure Changes Associated with Eyewall Replacement Cycles, and Construction of New Forecast Guidance Tools based on the New Climatologies"

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Report:

Year-1 proposed milestone timeline, and progress by item:

- *Append model training/testing dataset with 2010 data.*
  - **Completed**. Table 1 shows appended dataset.

- *Perform cross-validation studies to include weighting of satellite-based features and to explore the utility of additional features (based on observed model performance during the 2010 season).*
  - **Completed**. Results shown in Table 2.

- *Adapt feature selection code (used in a regression framework) to the Bayesian framework of the model with the goal of better feature optimization and increased skill.*
  - **Completed**. Figure 1 and Table 3 show the results of the objective feature selection applied to the Bayesian probability model. The main result is that *the number of features decreased while the independent testing skill increased substantially*.

    Details: Optimal feature selection and cross-validation for the Bayesian probability model were performed for both the original dataset (1997-2006) and the expanded (1997-2010) dataset (completion noted above). An objective function, J, was defined as:

    $$J = \sum_{i=1}^{N} (f_i - o_i)^2,$$

    where f and o represent the model predicted and observed probability of secondary eyewall formation, respectively. The minimum of this function was determined using a standard sequential feature selection software package and the features selected were employed in the model for cross-validation purposes for both training datasets. The results are summarized in Table 3 and Figure 1.

    For both datasets, the features MSLP, U20C and VVAC were chosen and found to be robust. MSLP is a measure of TC intensity, U20C is a measure of zonal wind shear in the near-TC environment, and VVAC is a measure of vertical motion (i.e. a proxy for convective activity). The attributes diagrams for both datasets (Figure 1) show excellent agreement between predicted and observed probability of occurrence. The Brier skill scores for the two datasets are 0.24.

- *Write new routines to utilize logistic regression as a second model, and form a simple two-member ensemble with the Bayesian model (again with the goal of improving overall model skill). These will be added to our current suite of subroutines running within SHIPS.*
  - **Completed**. Results shown in Table 2.

- *Complete the formation of a more inclusive and relevant climatology of intensity and structure changes associated with ERCs.*
  - **Completed**. Published papers listed in bibliography.

In addition to completing a number of Year-1 milestones, we have completed the Year-2 milestone below. We were in a position to do this, and felt that this task should be completed as quickly as possible so that we can test the new models during the 2012 hurricane season.

- *Transform the new ERC climatologies into an objective forecasting tool that will provide guidance on how best to adjust the intensity forecasts in the case that an ERC occurs (the probability of an ERC is given by our existing model). An analogous tool to provide guidance on structure changes will also be constructed.*
  - **Completed**. The models constructed from the ERC climatologies are described in an Expedited Note to appear in Weather and Forecasting (Kossin and Sitkowski 2012).

Tables and Figures

Table 1: Number of North Atlantic hurricanes, major hurricanes, hurricanes that exhibited at least one secondary eyewall during their lifetime, and number of individual SEF events from 1997-2010.

	1997	1998	1999	2000	2001	2002	2003	2004
Hurricanes	3	10	8	8	9	4	7	9
Major Hurricanes	1	3	5	3	4	2	3	6
SEF Hurricanes	2	3	2	1	3	2	2	5
SEF Events	3	3	3	1	3	2	4	16
	2005	2006	2007	2008	2009	2010	Total	
Hurricanes	15	5	6	8	3	12	107	
Major Hurricanes	7	2	2	5	2	5	50	
SEF Hurricanes	5	1	2	3	2	6	39	
SEF Events	9	1	5	4	3	9	66	

Table 2: Brier skill scores from *operational* testing on the years 2008-2011 for the new Optimized Bayesian model, the logistic regression model and the unweighted two-member ensemble for all model lead times.

Operational Model Verification, 2008-2011
Brier Skill Scores

Bayes   Logistic Regression   Ensemble

Year	N(ERC)	00-12 hr	12-24 hr	24-36 hr	36-48 hr
2011	5	+22% +10% +20%	+16% +11% +17%	+13% +6% +14%	+16% +11% +18%
2010	9	+41% +25% +38%	+20% +25% +28%	+17% +15% +20%	+17% +8% +17%
2009	3	-6% +11% +7%	-8% +6% +3%	-6% +28% +17%	+6% +36% +27%
2008	4	+11% +2% +10%	+4% -7% +4%	-7% +0% +0%	-6% -4% +0%
2008-2011	21	+24% +14% +24%	+12% +12% +16%	+8% +10% +14%	+10% +8% +14%

Table 3: Features selected in the new objective procedure, and cross-validated Brier Skill Scores for the models based on the previous dataset and the expanded dataset.

Training Dataset	Features Selected	Brier Skill Score
1997-2006	MSLP, U20C, VVAC, VMFX, R000	0.24
1997-2010	MSLP, U20C, VVAC	0.24

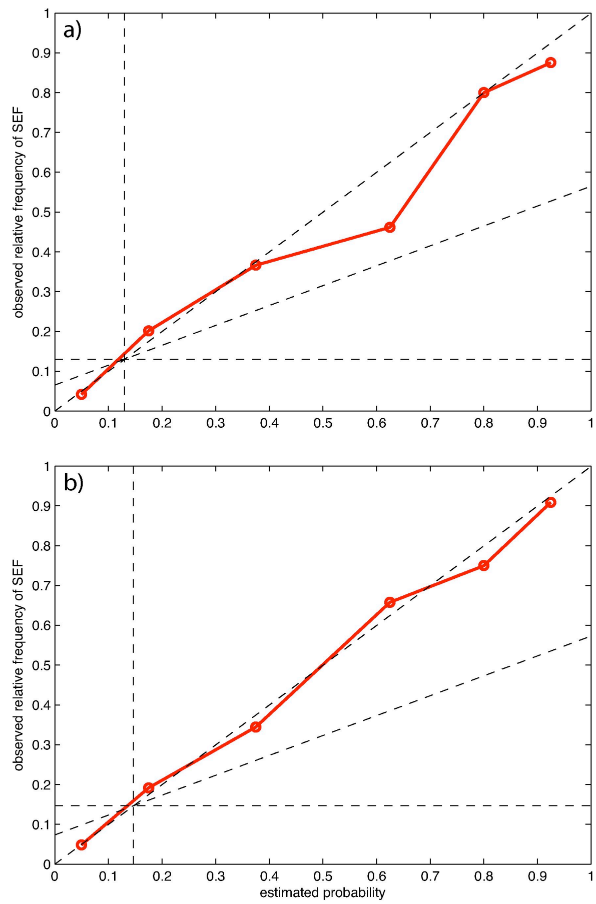

Figure 1: Attributes diagrams for the model based on the objectively chosen features using (a) the original 1997–2006 dataset and (b) the expanded 1997–2010 dataset.

Bibliography

Kossin, J. P., and M. Sitkowski, 2012: Predicting hurricane intensity and structure changes associated with eyewall replacement cycles. *Wea. Forecasting*, to appear.

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