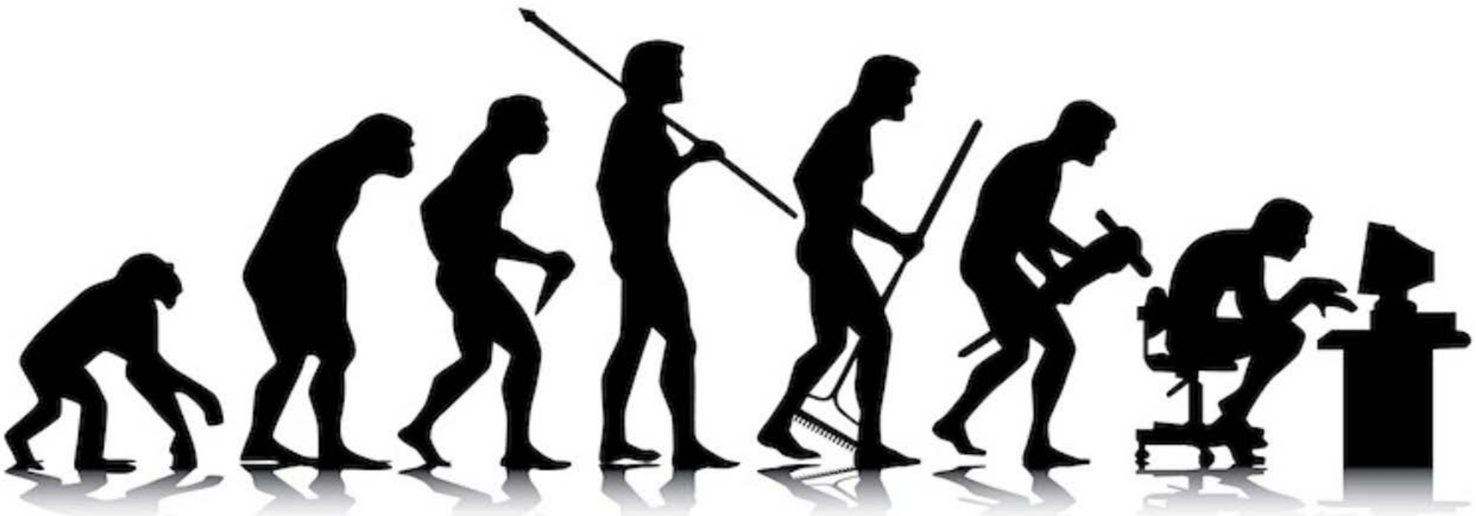
USING EVOLUTIONARY PROGRAMMING TO GENERATE IMPROVED TROPICAL CYCLONE INTENSITY FORECASTS



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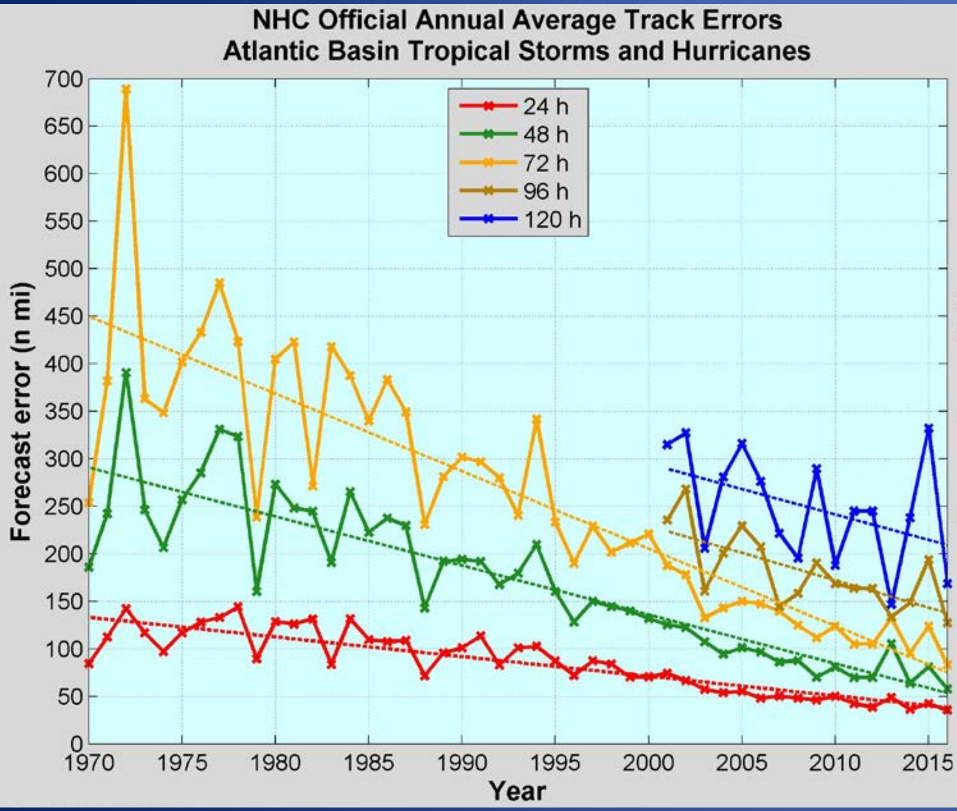
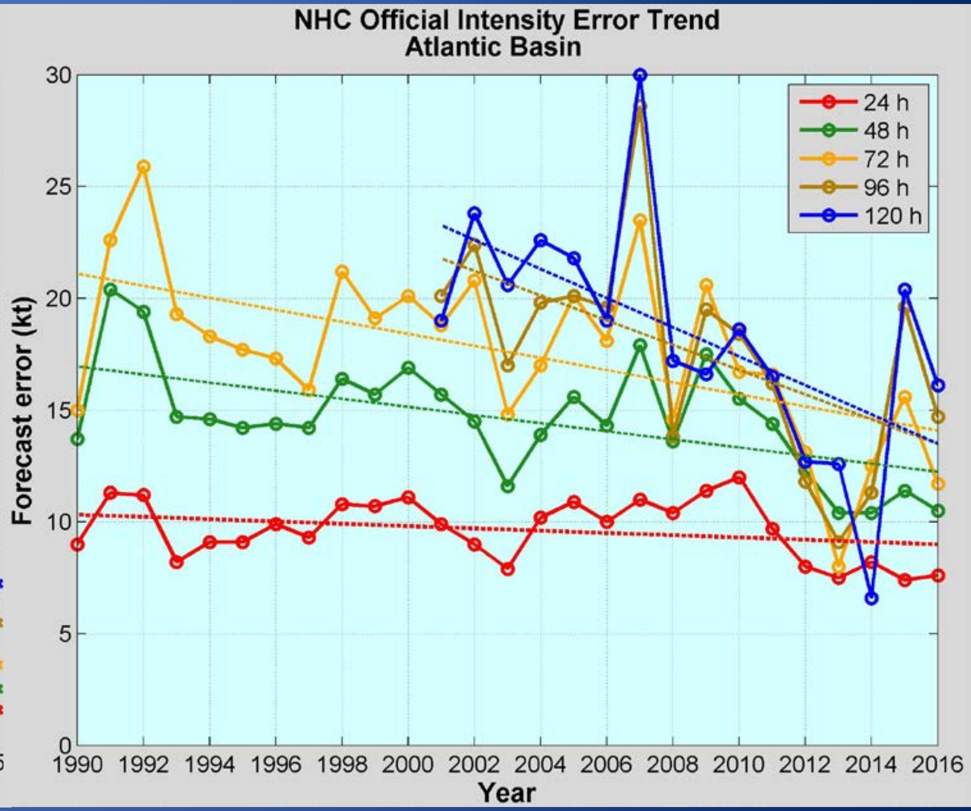
Motivation





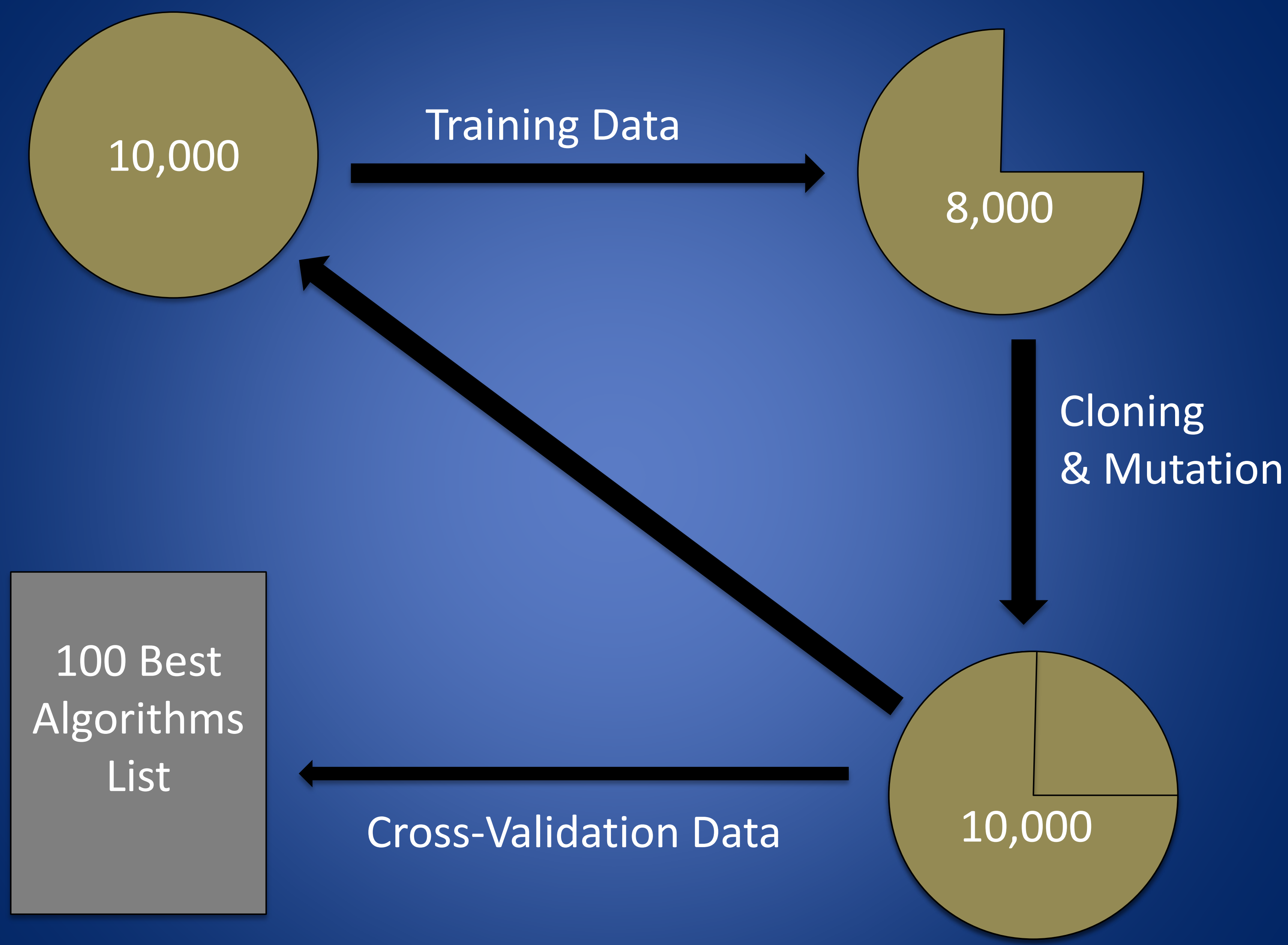
https://www.nhc.noaa.gov/verification/verify5.shtml?

Model Overview / Goals

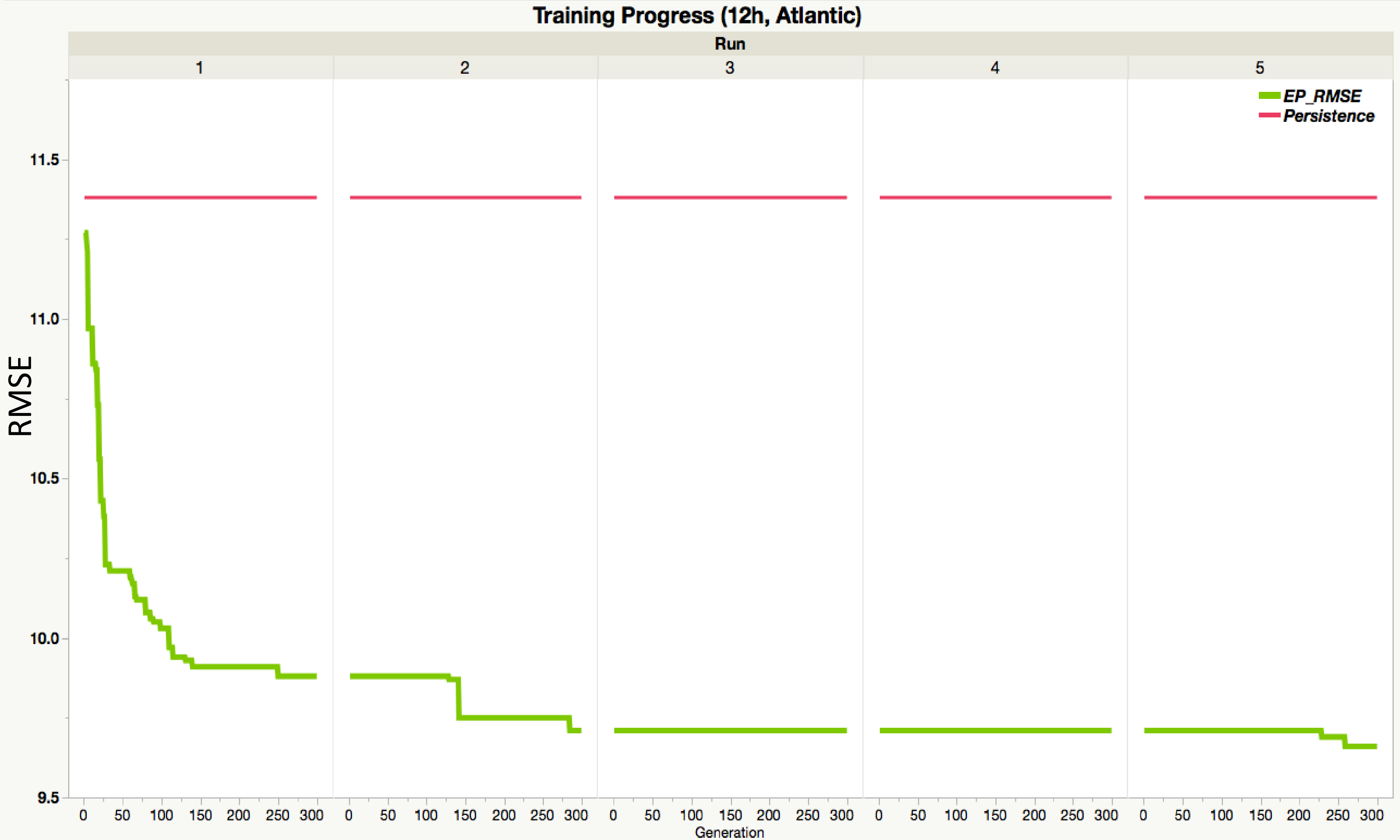
- Develop a Statistical-Dynamical Model using EP to generate improve TC intensity forecasts
- Separate model for the Atlantic and East Pacific Basins
- Deterministic and probabilistic TC intensity forecasts every 12h out to 120h
- Probabilistic forecasts for rapid intensification and rapid weakening every 12h out to 72h

Data

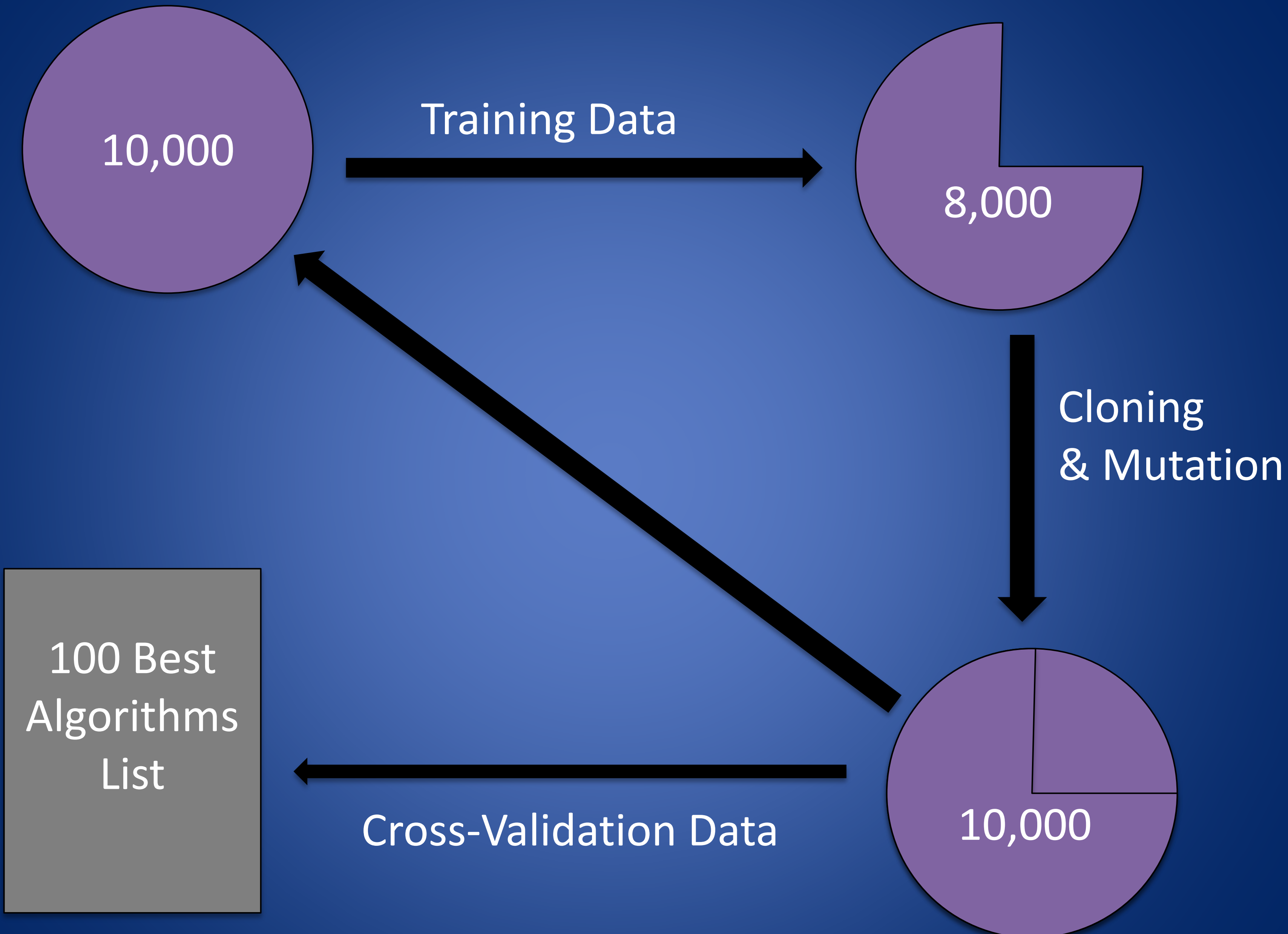
- Utilized SHIPS developmental data for all TCs in the respective basin from 2000-2015 (includes 46 variables converted to standard anomaly, plus a constant)
- TC cases were separated into three categories: TSs, Weak Hurricanes, Major Hurricanes
- Pulled storms evenly from each category to form Training, Cross-Validation, and Testing data sets



10,000
Training Data
8,000
Cloning
& Mutation
10,000
Cross-Validation Data
100 Best
Algorithms
List



Training Progress (12h, Atlantic)
Run
1
2
3
4
5
EP_RMSE
Persistence
RMSE
11.5
11.0
10.5
10.0
9.5
0 50 100 150 200 250 300
Generation


10,000
Training Data
8,000
Cloning
& Mutation
10,000
100 Best
Algorithms
List
Cross-Validation Data

Algorithm Structure

Each algorithm has five IF-THEN statements that provide an adjustment to a persistence forecast

1	IF	RHMD	<=	RHMD	THEN	0.29	*	INCV	+	-0.51	*	LON	*	0.18	*	RSST
2	IF	T150	<=	10	THEN	0.29	*	MSLP	+	-0.95	*	10	*	-0.01	*	V850
3	IF	RD26	>	SHDC	THEN	-0.13	*	Z000	*	0.71	*	RHCN	+	-0.3	*	SHDC
4	IF	D200	>	IR00_2	THEN	0.11	*	RD20	+	0.02	*	10	*	-0.61	*	MTPW_2
5	IF	RHMD	>	IR00_2	THEN	0.14	*	SDDC	+	-0.12	*	PSLV_5	*	0.39	*	T200

- Blue highlights lines where the if-statement is always true and thus the following adjustment will always be performed.

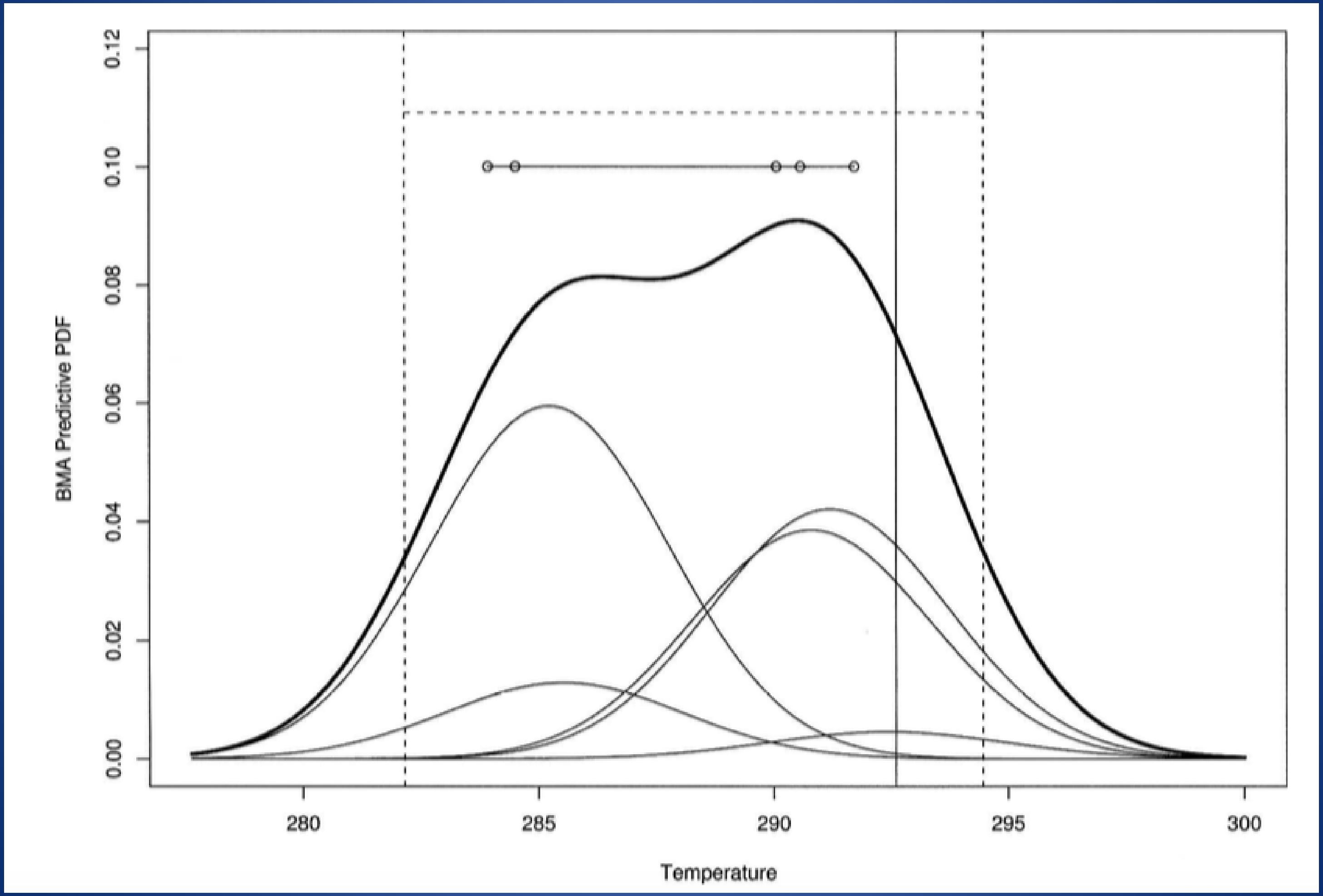
Mutation

Each algorithm has five IF-THEN statements that provide an adjustment to a persistence forecast

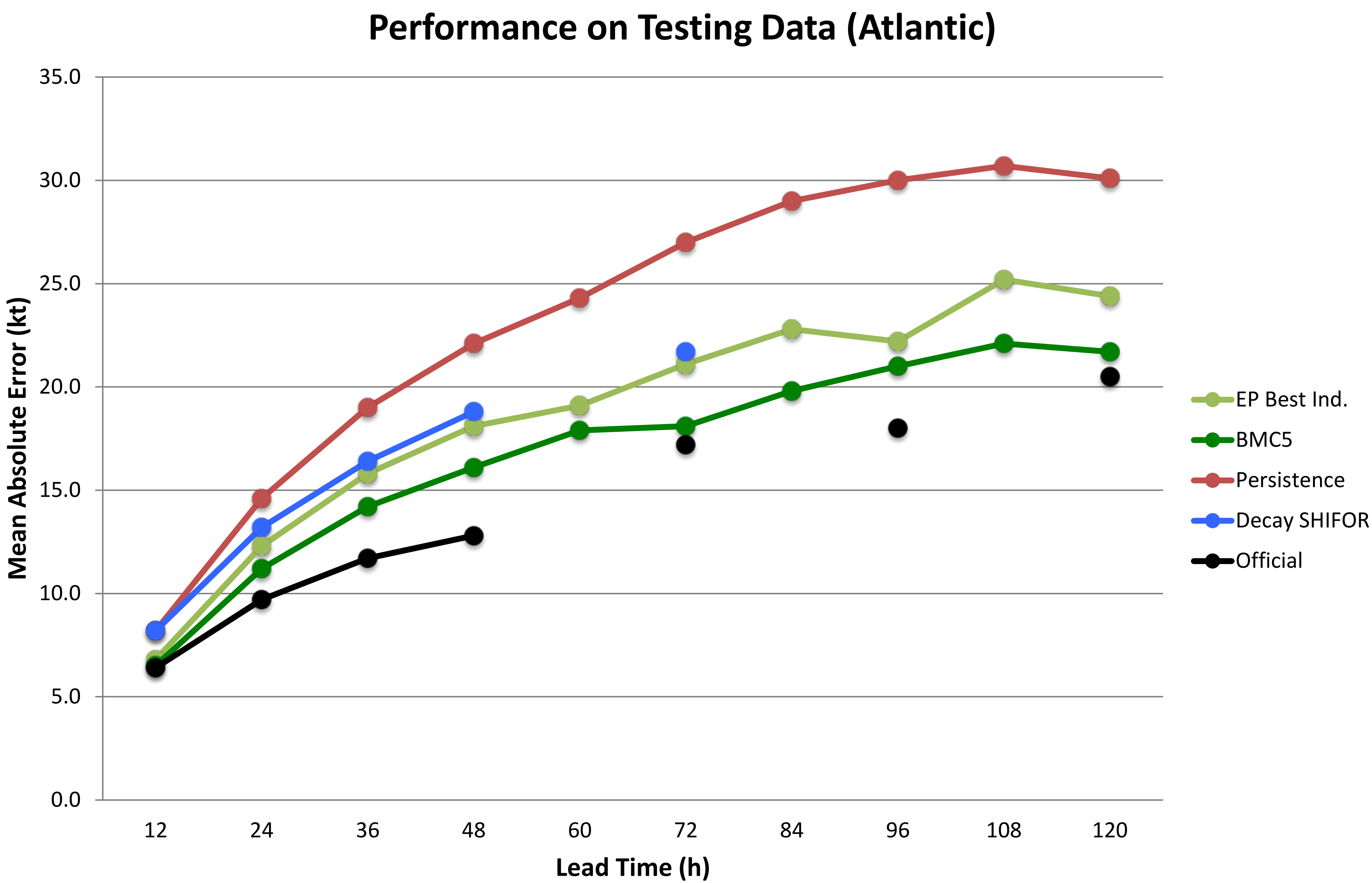
1	IF	RHMD	>	RHMD	THEN	0.29	*	INCV	+	-0.51	*	LON	*	0.18	*	RSST
2	IF	T150	<=	10	THEN	0.29	*	MSLP	+	-0.95	*	10	*	-0.01	*	V850
3	IF	RD26	>	SHDC	THEN	-0.13	*	Z000	*	0.71	*	RHCN	+	-0.3	*	SHDC
4	IF	D200	>	IR00_2	THEN	0.11	*	RD20	+	0.02	*	10	*	-0.61	*	MTPW_2
5	IF	RHMD	>	IR00_2	THEN	0.14	*	SDDC	+	-0.12	*	PSLV_5	*	0.39	*	T200

- Blue highlights lines where the if-statement is always true and thus the following adjustment will always be performed.
- Red highlights lines where the if-statement is always false and thus the following adjustment will never be performed.

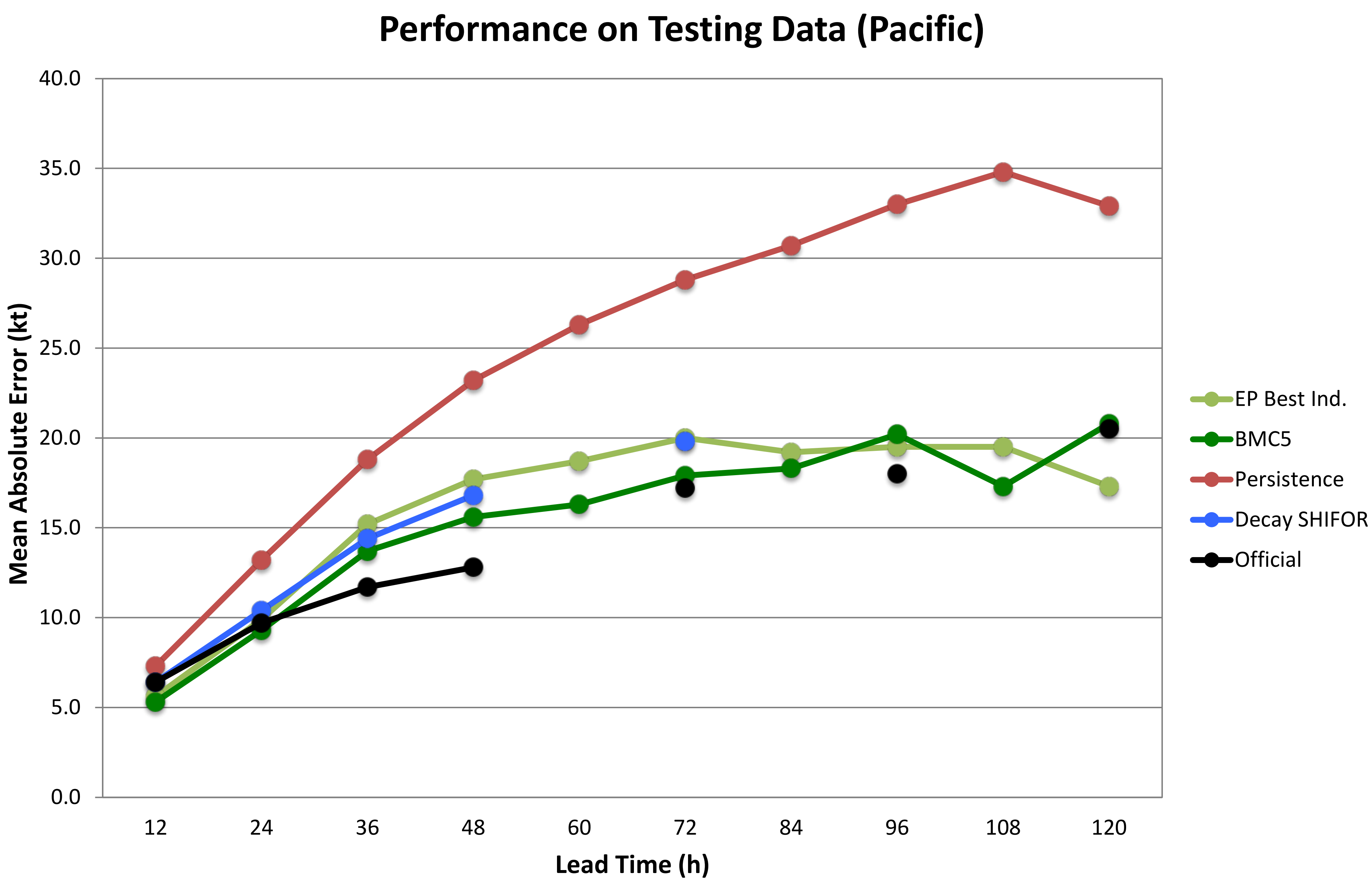
Bayesian Model Combination

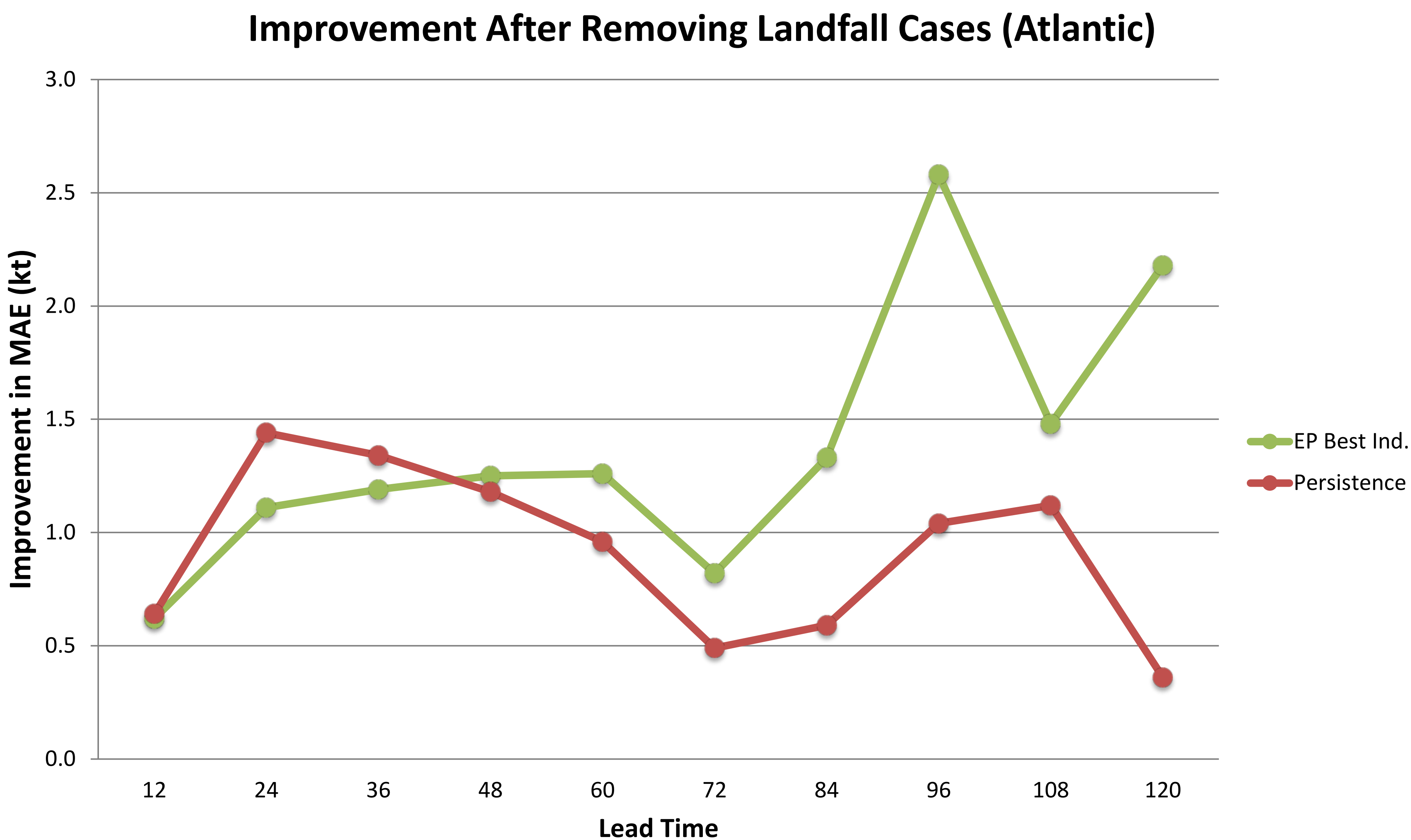


Raftery, A. E., T. Gneiting, F. Balabdaoui, and M. Polakowski, 2005: Using Bayesian model averaging to calibrate forecast ensembles. Mon. Wea. Rev., 133, 1155–1174, doi:10.1175/ MWR2906.1.



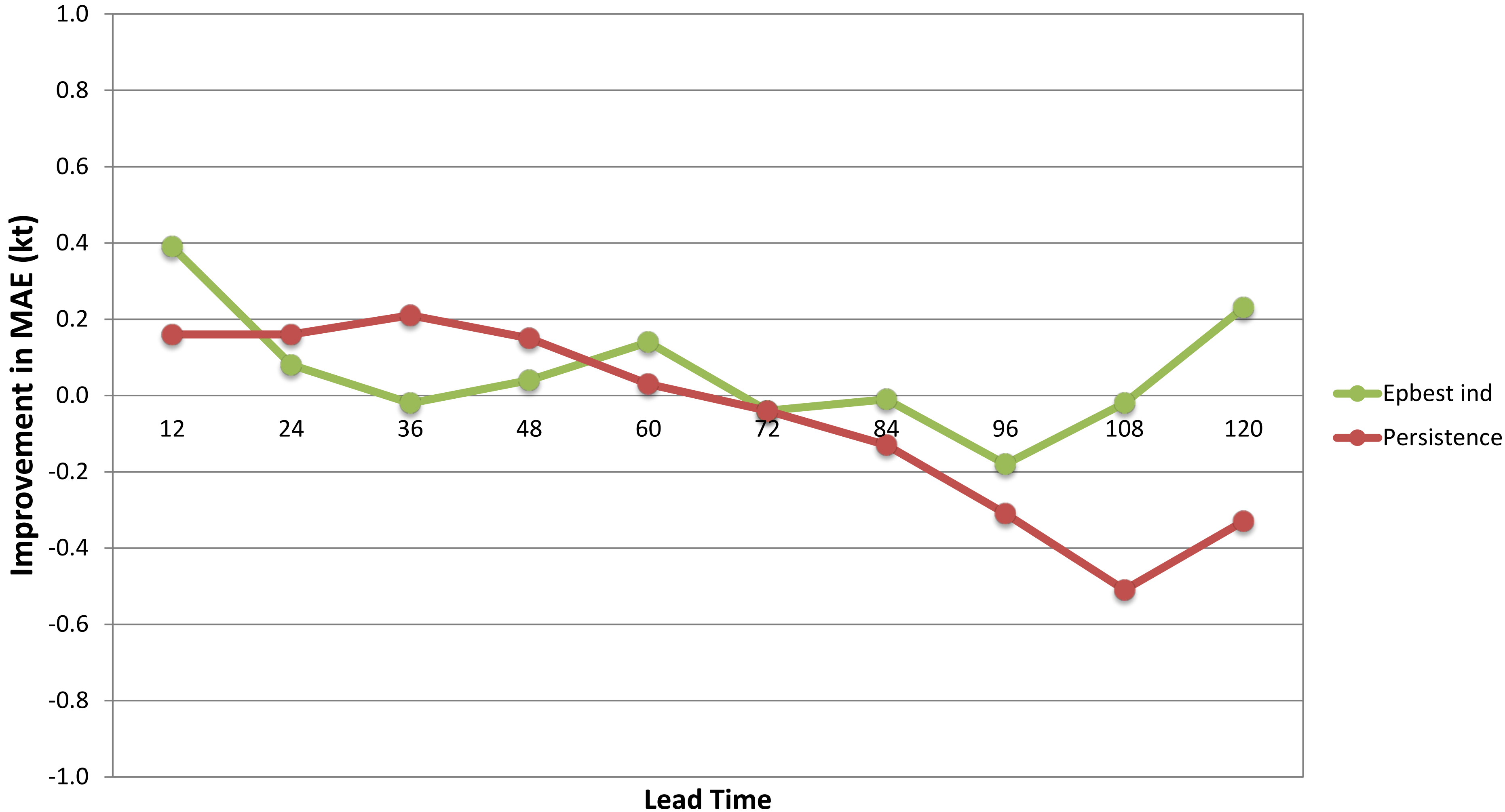
Performance on Testing Data (Atlantic)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Mean Absolute Error (kt)
12
24
36
48
60
72
84
96
108
120
Lead Time (h)
EP Best Ind.
BMC5
Persistence
Decay SHIFOR
Official


Performance on Testing Data (Pacific)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Mean Absolute Error (kt)
12
24
36
48
60
72
84
96
108
120
Lead Time (h)
EP Best Ind.
BMC5
Persistence
Decay SHIFOR
Official



Lead Time	12	24	36	48	60	72	84	96	108	120
Total Cases	632	564	499	437	375	336	293	256	225	193
Landfall	5.2%	8.0%	9.0%	10.1%	11.4%	12.2%	10.9%	9.8%	9.3%	10.4%

Improvement After Removing Landfall Cases (Pacific)



Lead Time	12	24	36	48	60	72	84	96	108	120
Total Cases	362	318	273	231	194	163	136	108	85	71
Landfall	1.4%	1.5%	1.8%	2.1%	2.0%	1.8%	2.2%	2.7%	3.4%	4.1%

Conclusion

- EP can successfully be used to forecast TC intensity and it shows promise in generating improved forecasts

Future Work

- Real time testing during the 2018 season
- Modification of model to handle landfalling cases
- Evaluation of RI and RW probabilistic forecasts
- Case Specific Examinations

Acknowledgments

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Questions?