Attribution Study for Extreme Tropical Cyclone Seasons Using a High-Resolution Global Coupled Model - 2017 Active Major Hurricane Season-

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Murakami, H., G. A. Vecchi, G. Villarini, T. L. Delworth, R. Gudgel, S. Underwood, X. Yang, W. Zhang, and S. Lin, 2016: Seasonal forecasts of major hurricanes and landfalling tropical cyclones using a high-resolution GFDL coupled climate model. *J. Climate*, **29**, 7977-7989.

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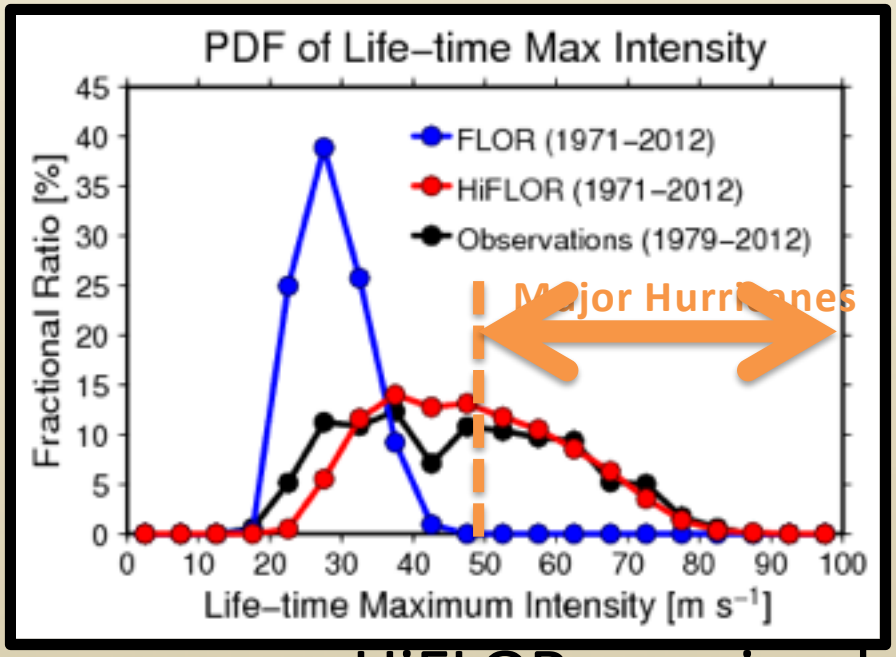
HiFLOR (Hi-Resolution version of FLOR)

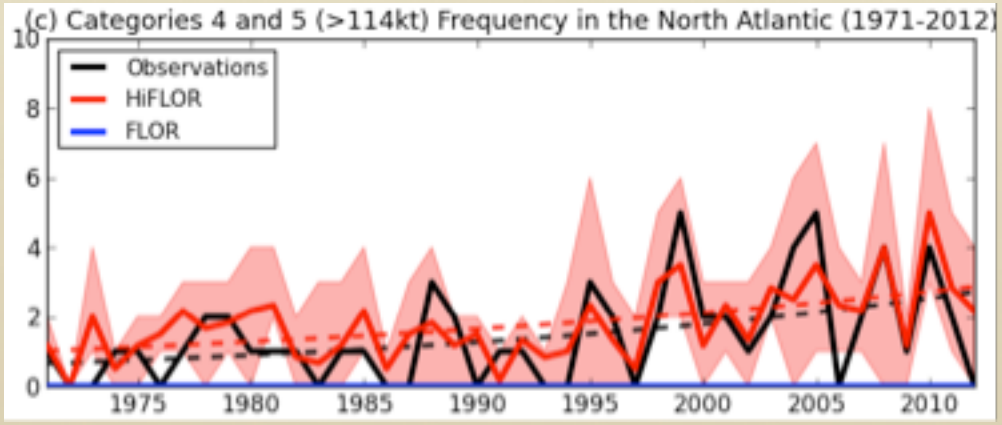
Model	Resolution
FLOR	Atmosphere : **50 km**, L32 Ocean: 100 km, L50
HiFLOR	Atmosphere : **25 km**, L32 Ocean: 100 km, L50

FLOR : One of the NMME models.

We developed a new high-resolution coupled model, **HiFLOR** to improve prediction of MHs.



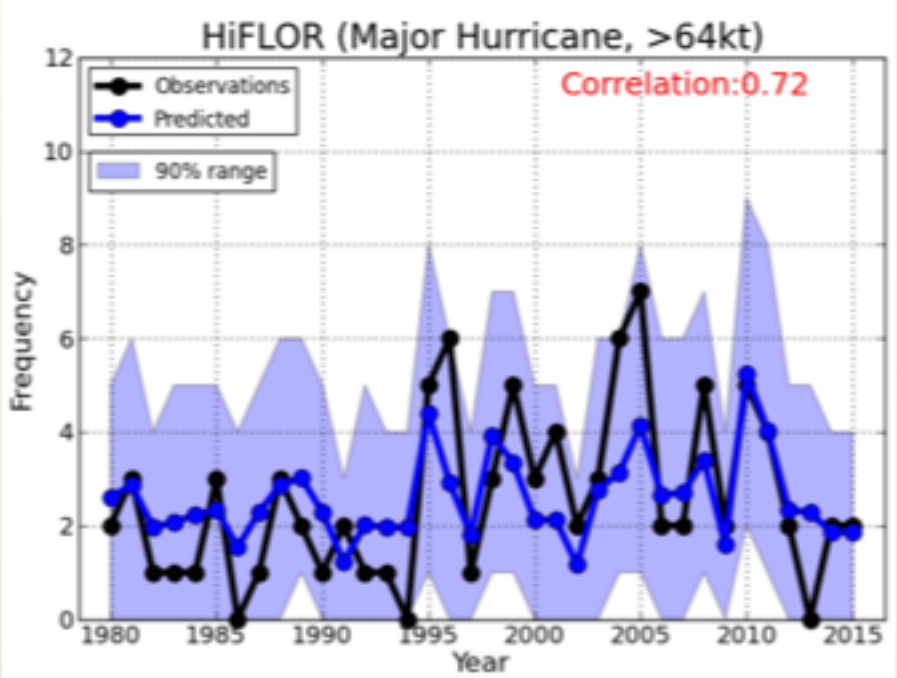
Interannual variaiton of C45 Hurricanes



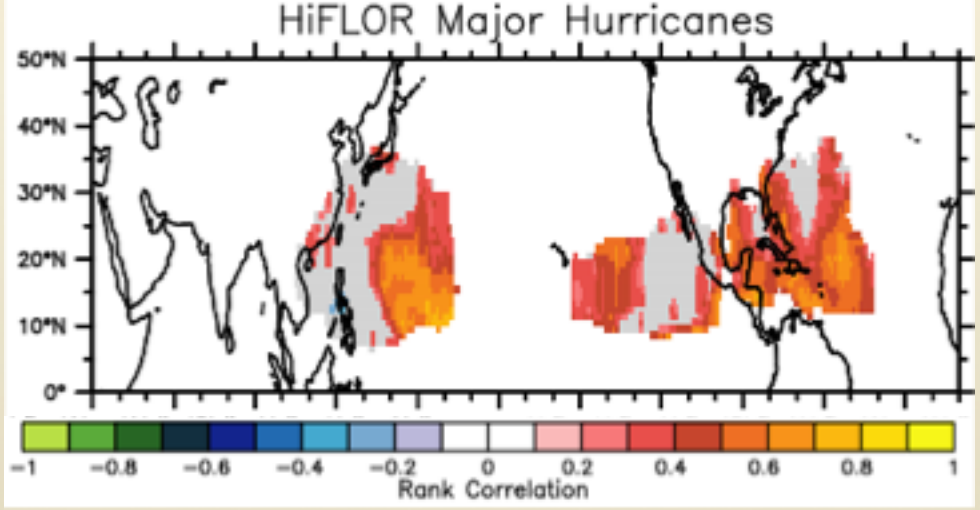
- HiFLOR can simulate MHs as observed.

Retrospective Seasonal Forecasts (Lead Month=0–4)

MH Frequency in the North Atlantic



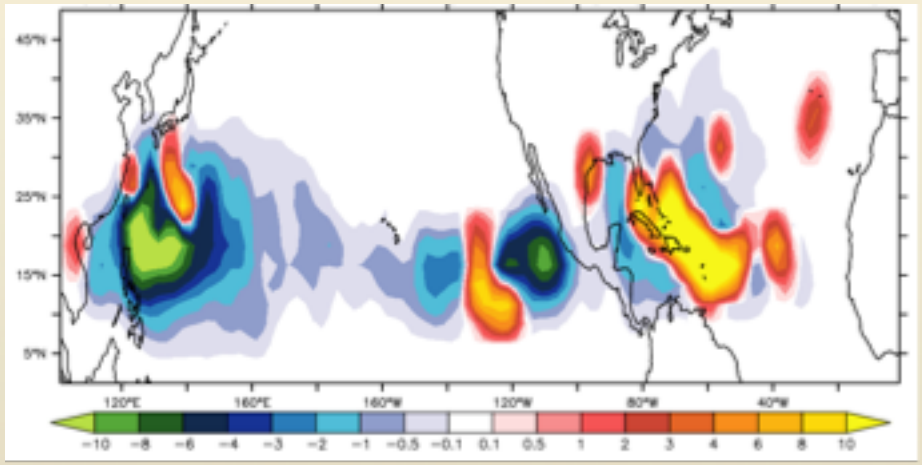
Skill in Predicting MH Density



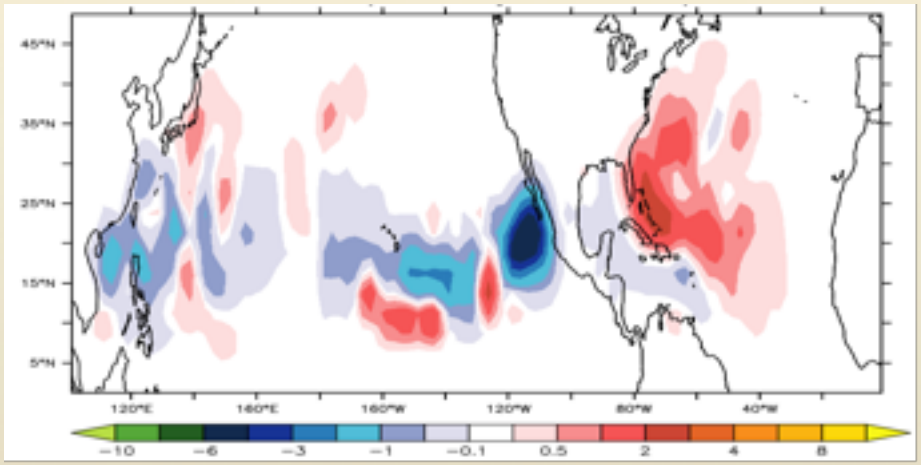
- HiFLOR shows skillful prediction for frequency of major hurricanes a few months in advance (r=0.72).
- HiFLOR has skill in predicting major hurricanes at regional scale.

Real-Time Prediction for the 2017 Summer Season

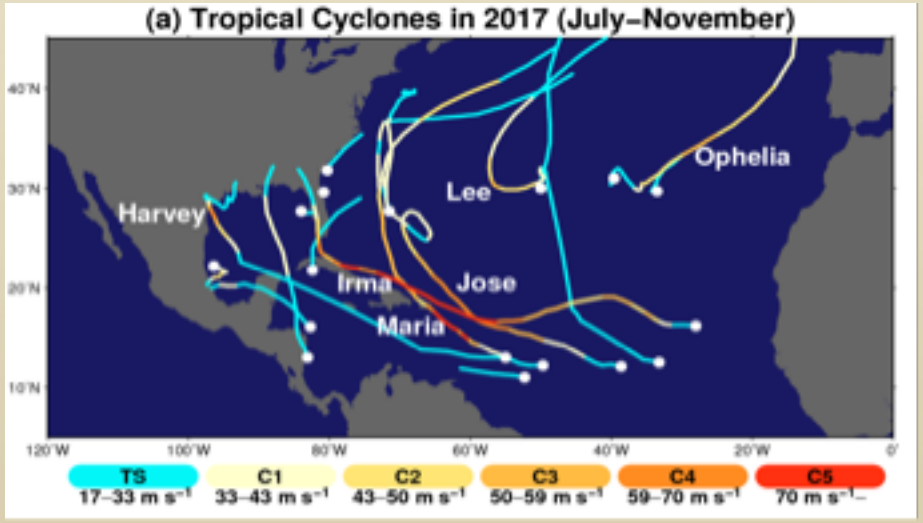
Observed MH Density Anomaly in 2017



Predicted MH Density Anomaly in 2017



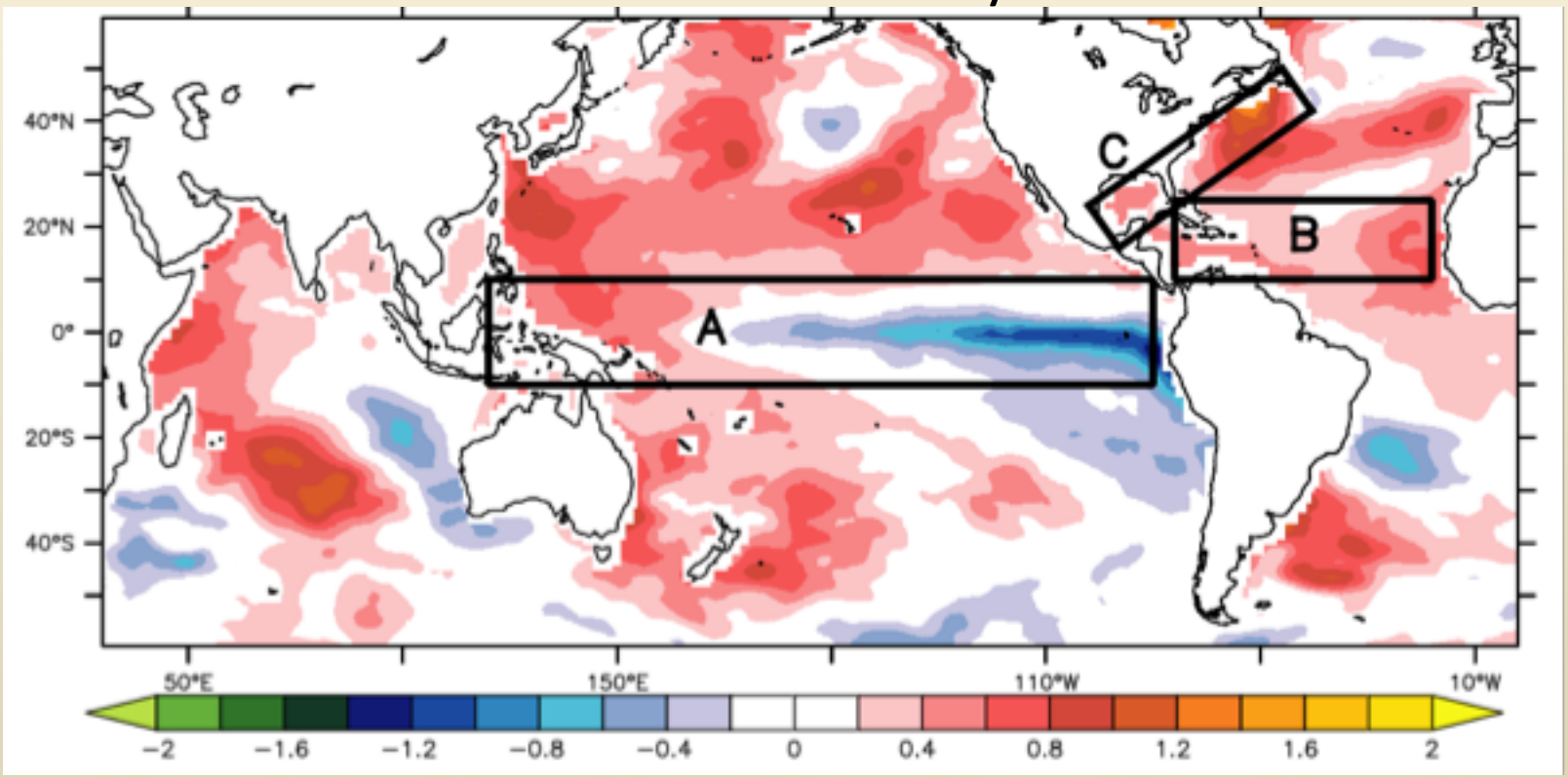
Observed Storm Tracks in 2017



HiFLOR could predict the locations of MHs a few months in advance for the 2017 summer.

What caused the active 2017 MH season?

Observed SST Anomaly in 2017

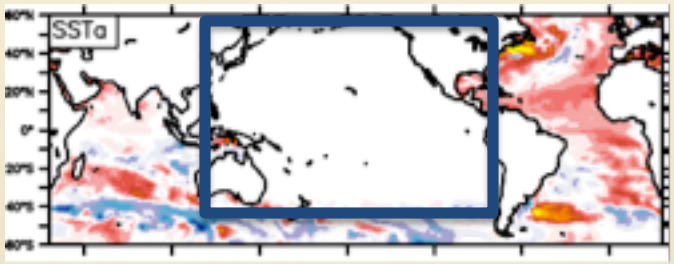


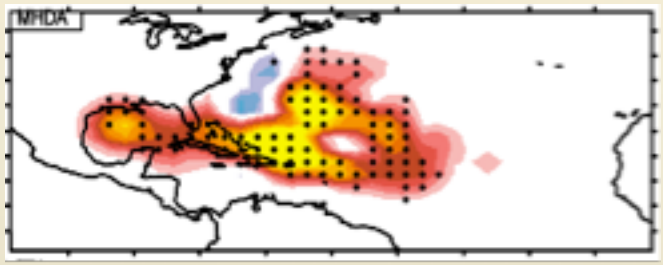
A. Moderate La Niña?
B. Warmer Tropical Atlantic?
C. Warmer off the coast of North America?

Idealized SST-Prescribed Seasonal Prediction

Prescribed SST Anomaly

Predicted MH Density Anomaly

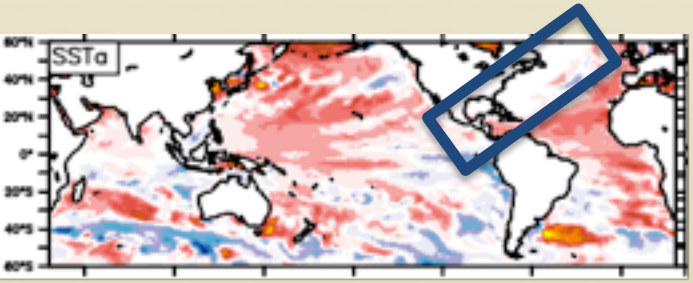


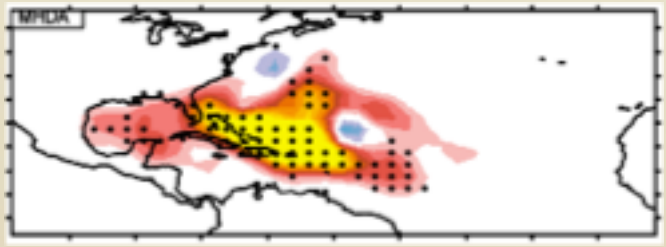


A. Moderate La Niña?

Pacific SST anomaly was removed.

MHs are still active.

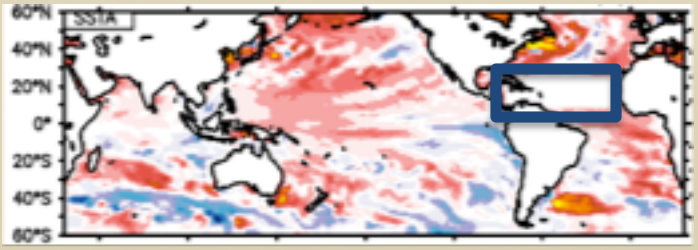


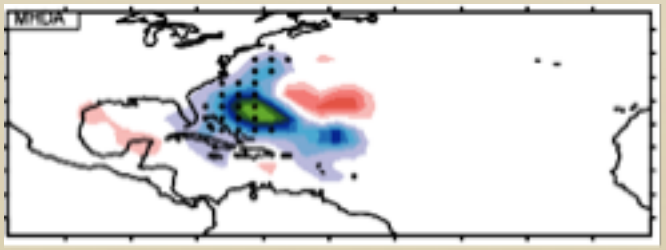


C. Warmer off the coast of North America?

SSTa off the coast of US was removed.

MHs are still active.





B. Warmer Tropical Atlantic?

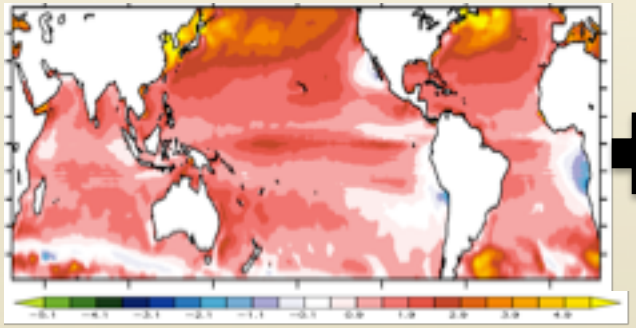
SSTa in the tropical Atlantic was removed.

MHs reduced.

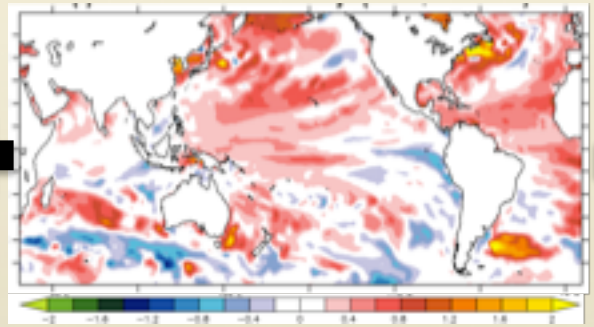
Idealized Prescribed SST Experiments in the Future

RCP4.5

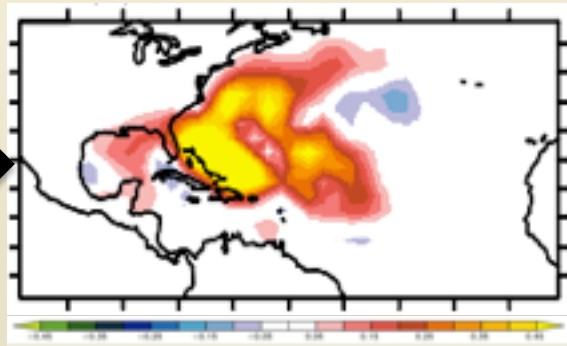
(2080-2099 minus 2015-2025)



2017 SST Anomaly

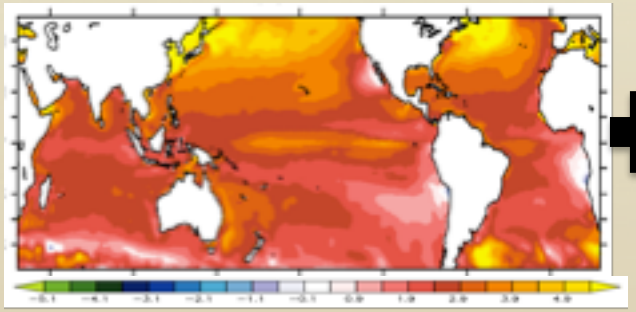


Projected MH Density Anomaly

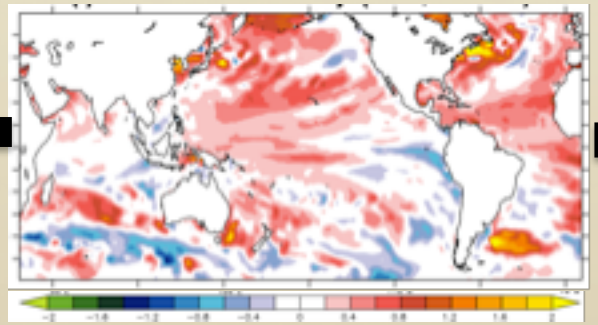


RCP8.5

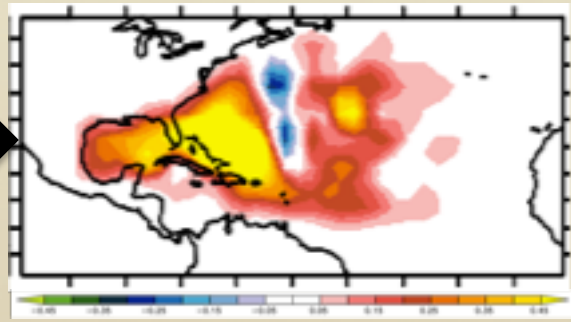
(2080-2099 minus 2015-2025).



2017 SST Anomaly



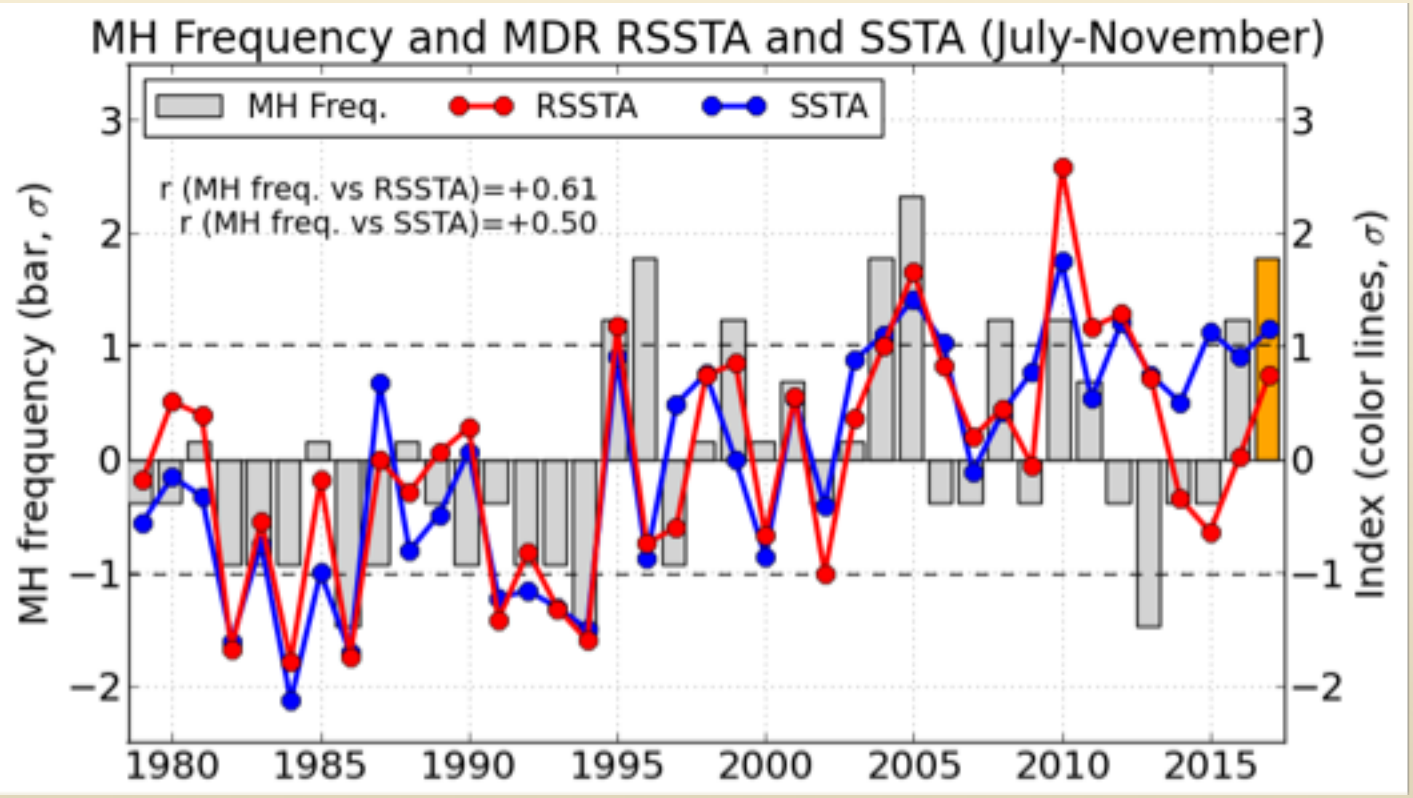
Projected MH Density Anomaly



More active MH season than the 2017 summer is projected in the future even with the same spatial patterns of 2017 SST anomaly, resulting in **amplifying the risk of MHs**.

Which of local SST anomaly or relative SST anomaly is important for frequency of MHs in the North Atlantic?

Observations

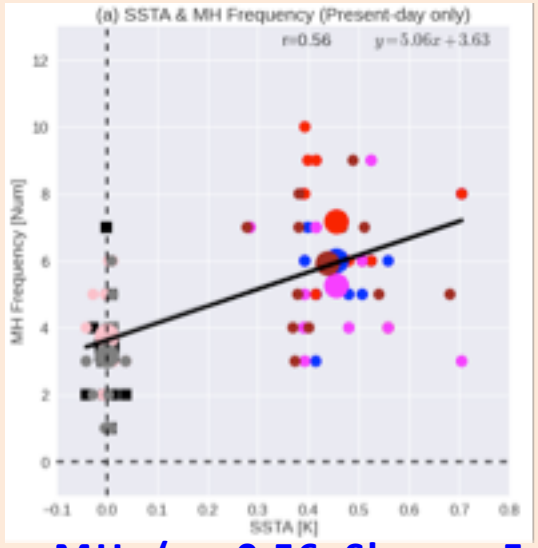


Observed number of MHs (gray bars) is correlated with both **tropical SST anomaly (SSTA, r=+0.50)** and **tropical SST anomaly relative to tropical mean (RSSTA, r=+0.61)**

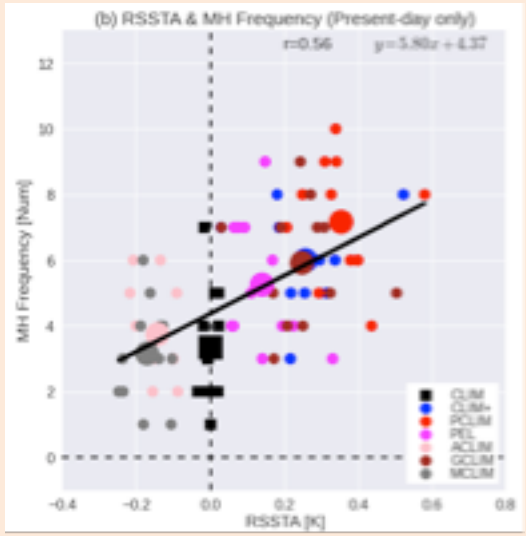
Which of local SST anomaly or relative SST anomaly is important for frequency of MHs in the North Atlantic?

Model

2017 Experiments only

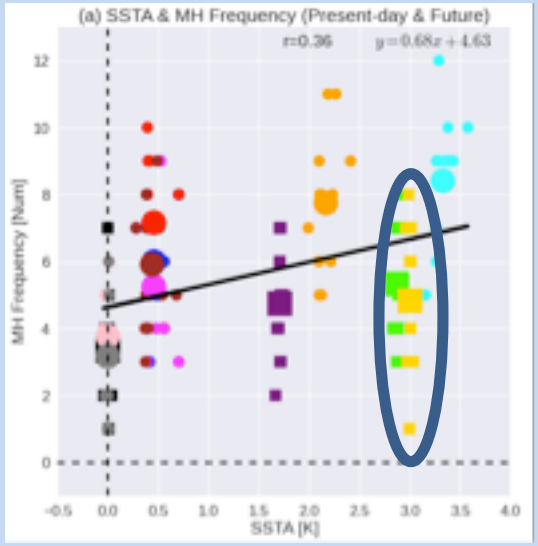


SSTA vs MHs (r=+0.56, Slope=+5.1)

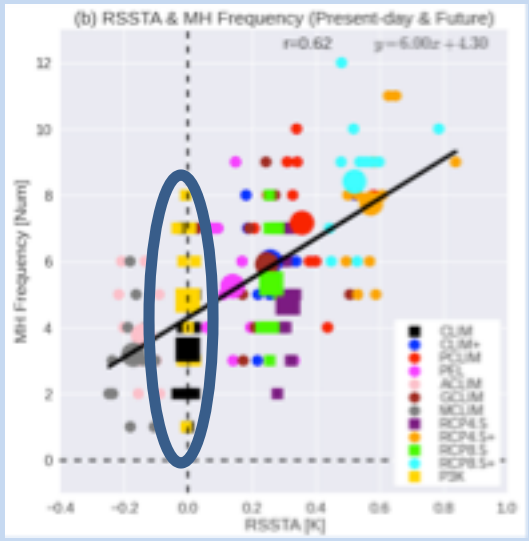


RSSTA vs MHs (r=+0.56, Slope=+5.8)

2017 Experiments & Future Experiments

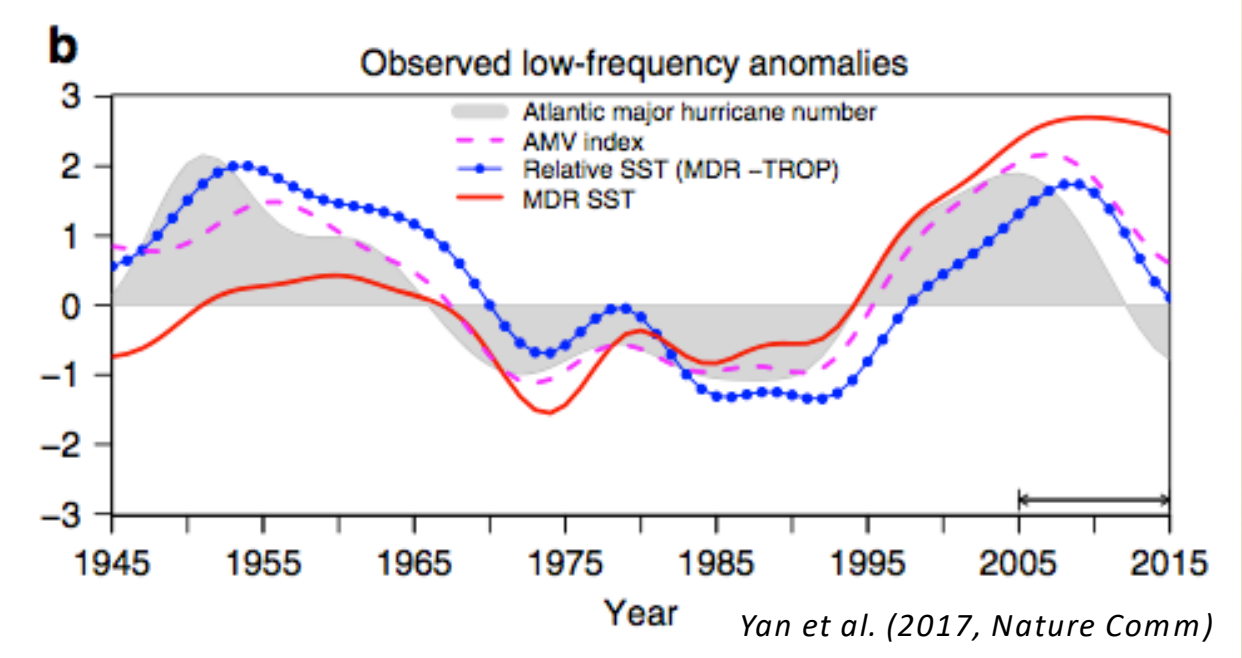


SSTA vs MHs (r=+0.36, Slope=+0.7)



RSSTA vs MHs (r=+0.62, Slope=+6.0)

What will happen in the next decades?



AMO (or AMV) index is going to negative?

=> Decrease in major hurricanes in next decades?

Monitoring or predicting natural variability (AMO, AMOC) is a key to predict frequency of major hurricanes in the next decades.

Summary

- We developed a new high-resolution coupled model, HiFLOR that can simulate/predict MHs.
- HiFLOR has skill (r=0.7) in predicting frequency of MHs in the North Atlantic a few months in advance.
- HiFLOR predicted observed locations of MHs very well for the 2017 summer.
- The active 2017 major hurricanes were controlled by the tropical ocean surface warming in the North Atlantic.
- In the end of 21st century, even given the similar SST anomaly patterns like the 2017 summer, MH could be more active than the 2017 summer season.
- Relative SST anomaly associated with AMO and AMOC is a key for prediction of MHs in the near future.