Dominant Effect of Relative Tropical Atlantic Warming on Major Hurricane Occurrence in the North Atlantic: 2017 and Future

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Murakami et al. 2018, *Science*, **362,** 794-799

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Motivation

- Tropical cyclones (TCs) have large societal and economic impacts on the United States (and many other countries)

Disaster Type	Number of Events	Percent Frequency	CPI-adjusted Losses ($ billions)	Percent of Total Loss	Average Event Cost ($ billions)
Drought	21	12.4	199	19.1	9.5
Flooding	19	11.2	86	8.3	4.5
Freeze	7	4.1	25	2.4	3.6
Severe Storm	65	38.2	143	13.7	2.2
Tropical Cyclone	34	20.0	530	50.9	15.6
Wildfire	12	7.1	26	2.5	2.2
Winter Storm	12	7.1	35	3.4	2.9

Table: Damage cost from U.S. Billion-dollar disaster events (1980–2013)

Smith and Matthes (2015, Natural Hazards)

- About **85%** of the total TC damage has been caused by major hurricanes

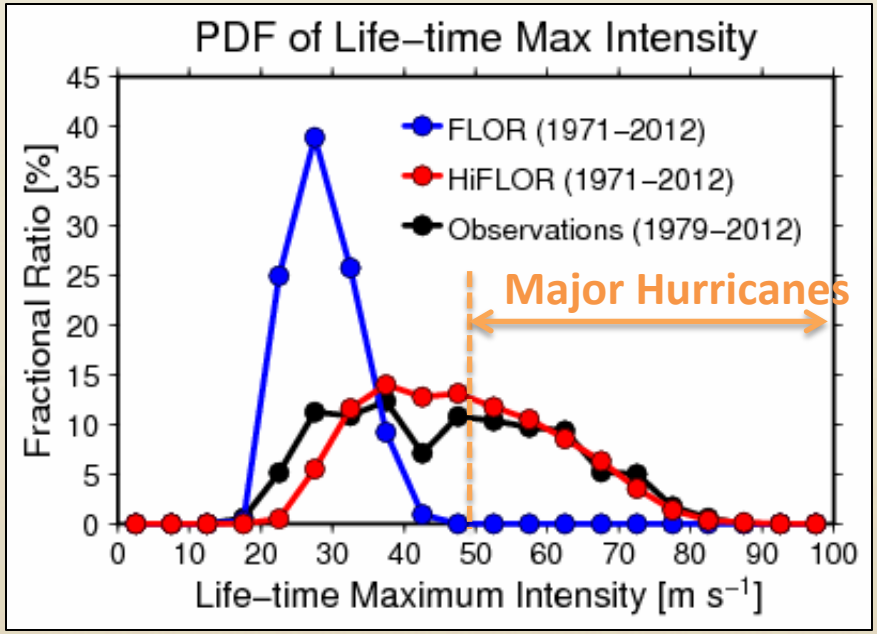
Major Hurricane: Hurricane with lifetime maximum surface wind ≥50 m/s (96kt)

HiFLOR (Seasonal Forecast Model Developed at GFDL; Hi-Resolution Version of FLOR)

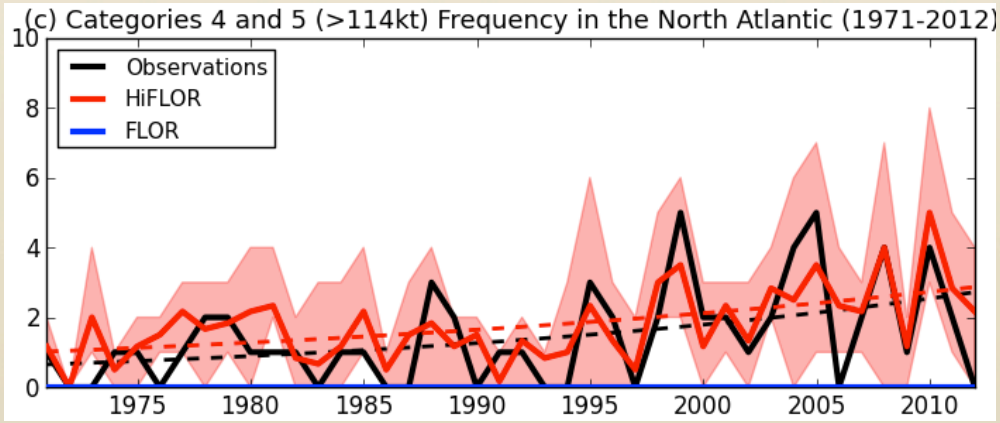
Model	Resolution
FLOR	Atmosphere : **50 km**, L32 Ocean: 100 km, L50
HiFLOR	Atmosphere : **25 km**, L32 Ocean: 100 km, L50

FLOR : One of the NMME models.

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



Interannual variaiton of Categories 4-5 Hurricanes

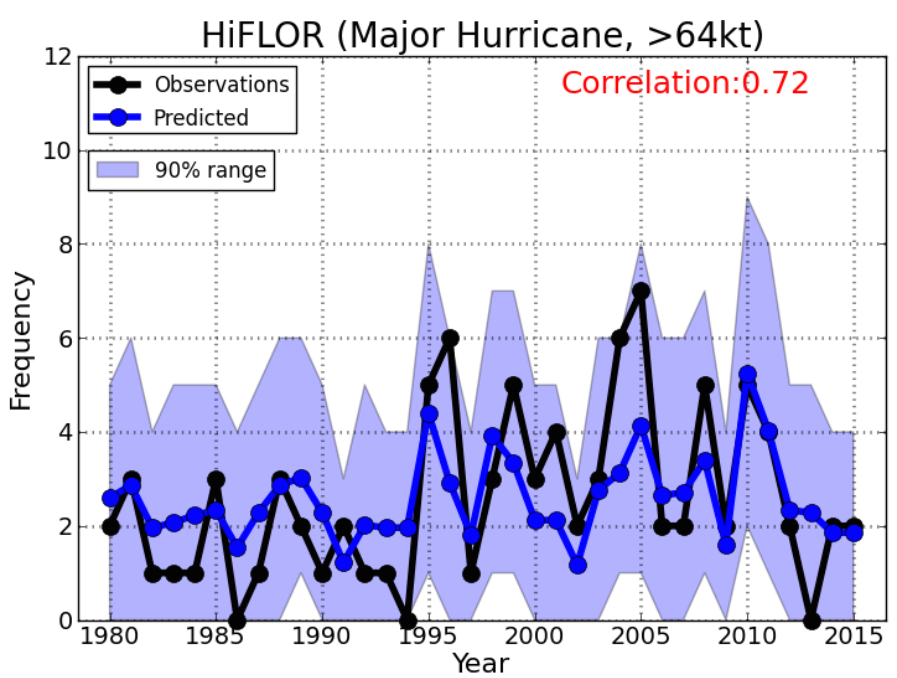


Murakami et al. (2015, *J. Climate*)

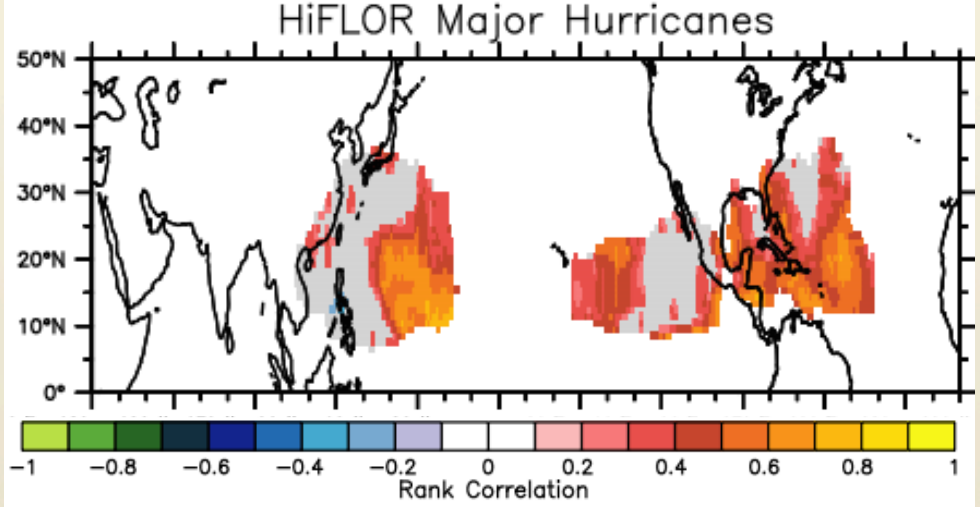
HiFLOR can simulate intensity and interannual variation of MHs as observed.

Retrospective Seasonal Forecasts
(July Initial Forecasts, July-November Predictions Lead Month=0–4)

MH Frequency in the North Atlantic



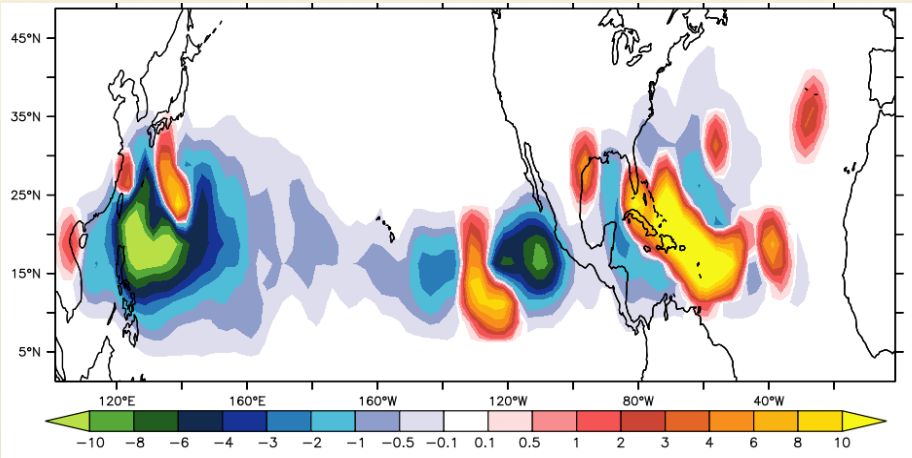
Skill in Predicting MH Density



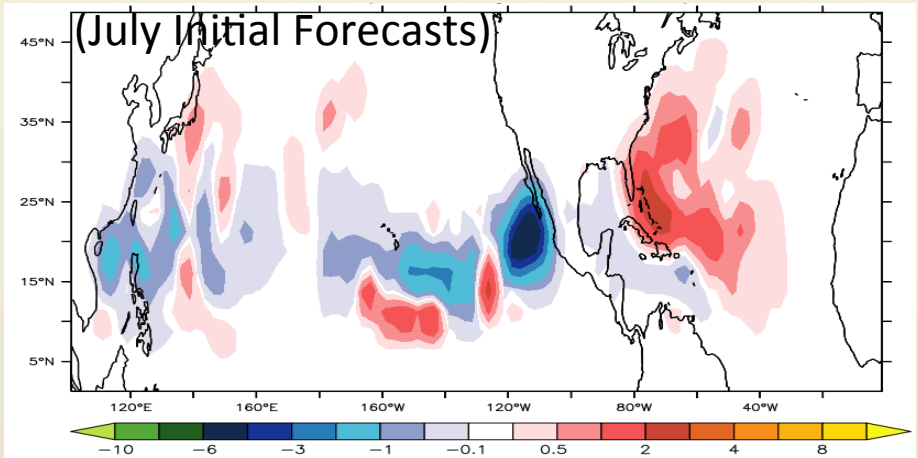
- HiFLOR shows skillful prediction for frequency of major hurricanes a few months in advance (r=0.72).
- HiFLOR has skill in predicting major hurricanes at regional scale.

Real-Time Prediction for the 2017 Summer Season

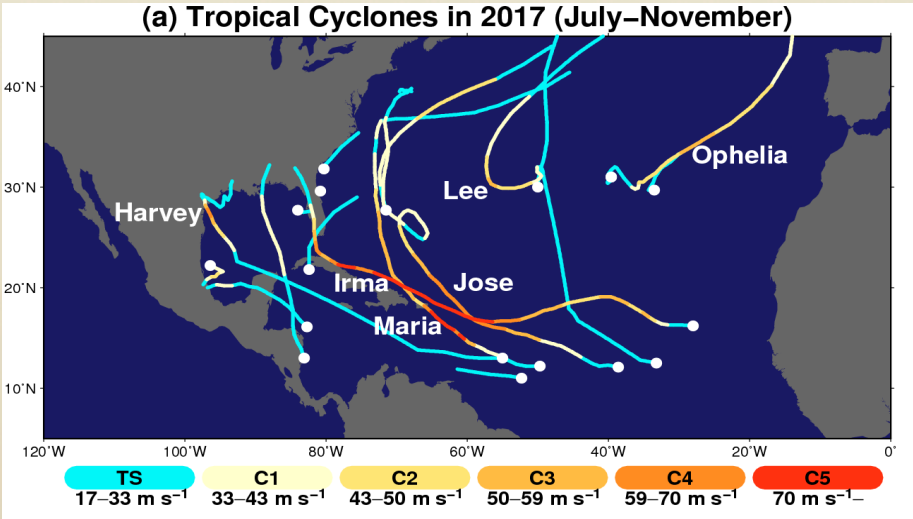
Observed MH Density Anomaly in 2017



Predicted MH Density Anomaly in 2017 (July Initial Forecasts)



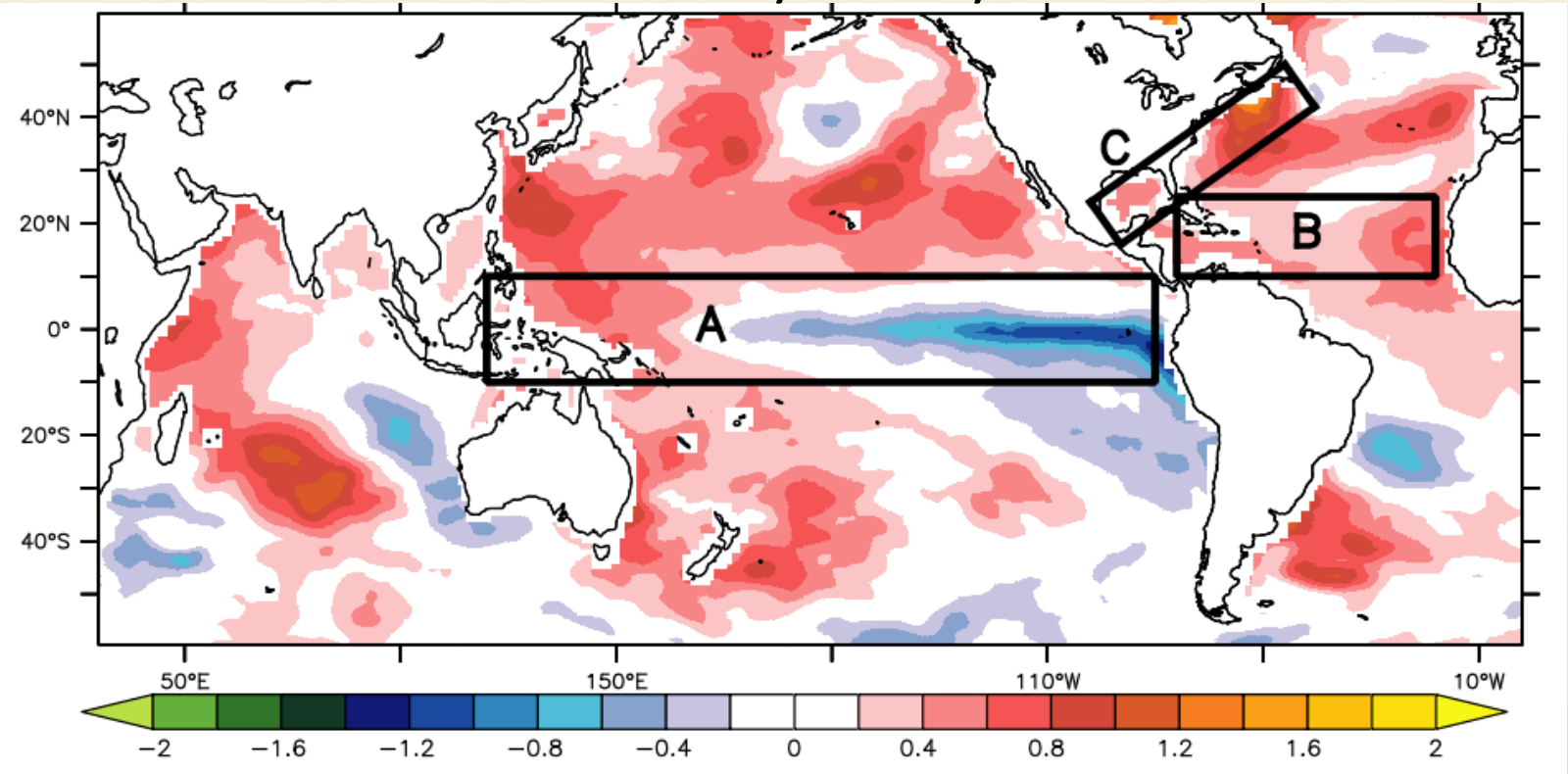
Observed Storm Tracks in 2017



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

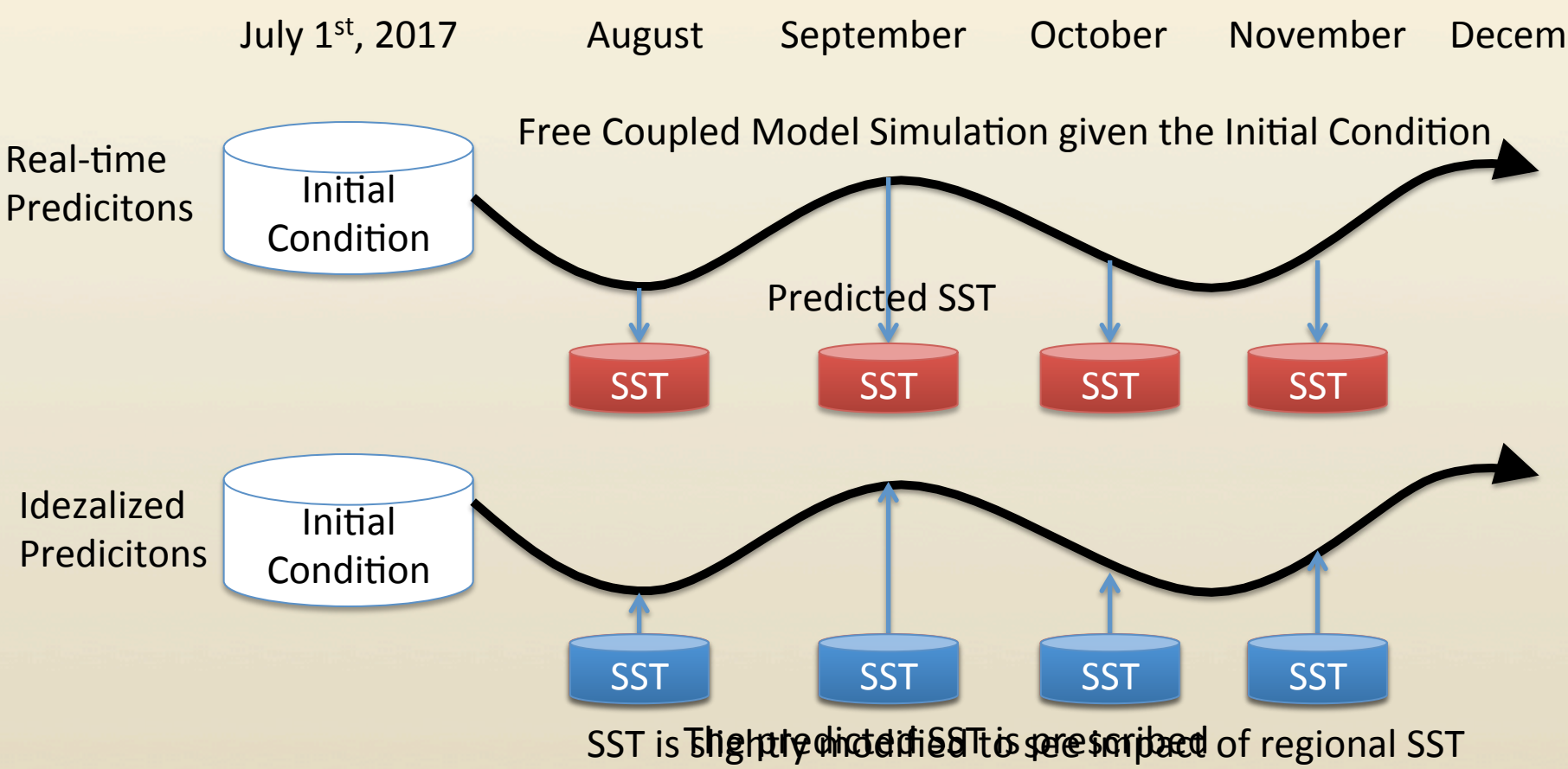
What caused the active 2017 MH season?

Observed SST Anomaly for July–November in 2017



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

Idealized Seasonal Predictions

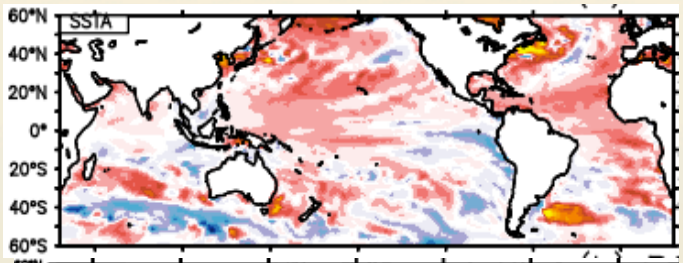


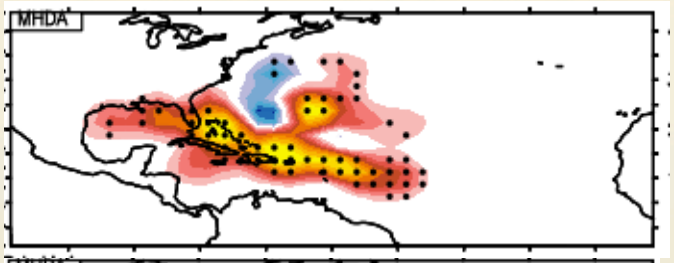
We call this type of experiments as “real-time attribution” because we can examine causes for active hurricane season even as hurricane season is underway.

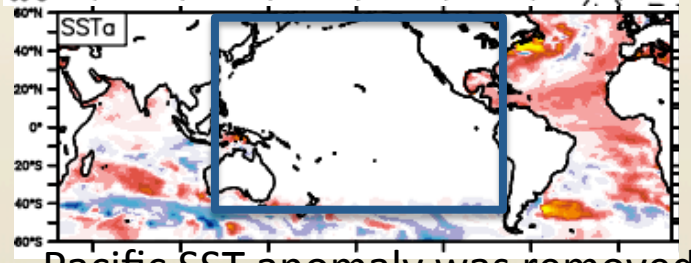
Idealized Seasonal Predictions

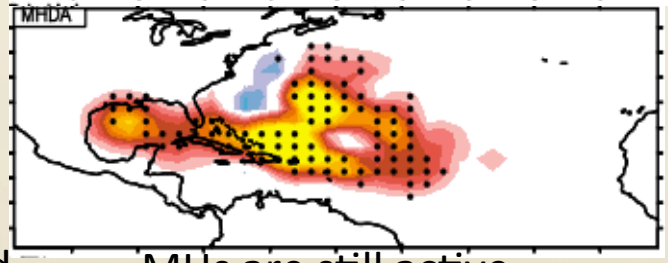
Prescribed SST Anomaly

Predicted Major Hurricane Density Anomaly





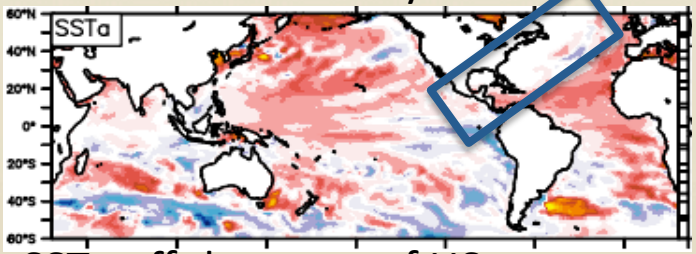


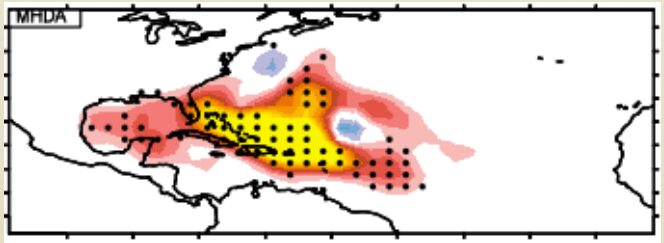


A. Moderate La Niña? ✗

Pacific SST anomaly was removed.

MHs are still active.

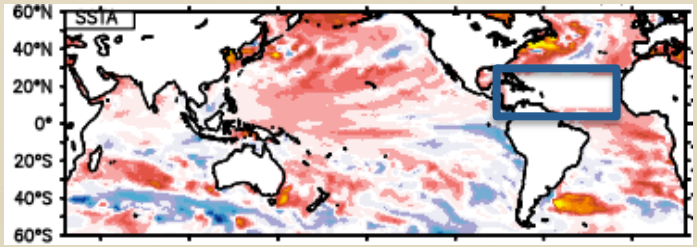


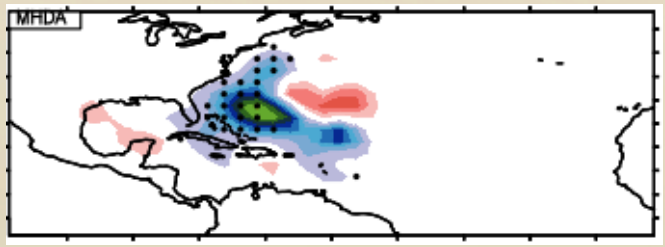


C. Warmer off the coast of North America? ✗

SSTa off the coast of US was removed.

MHs are still active.





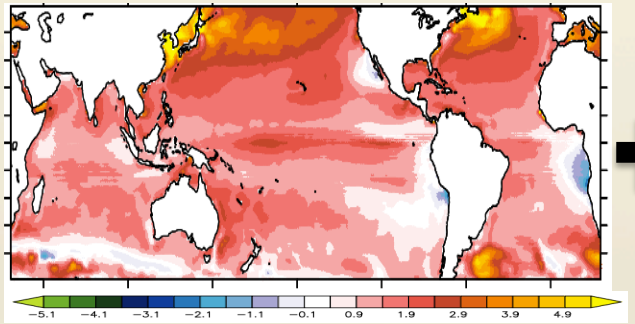
B. Warmer Tropical Atlantic? ✓

SSTa in the tropical Atlantic was removed. MHs reduced.

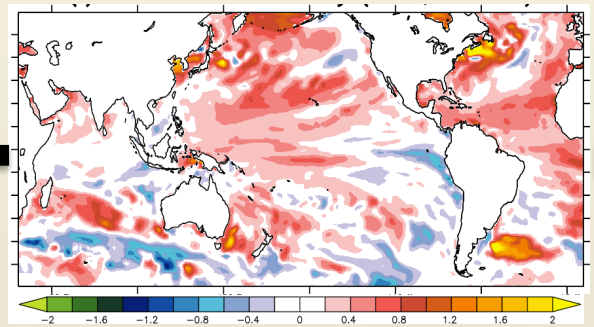
Idealized Seasonal Predictions for the Future

RCP4.5

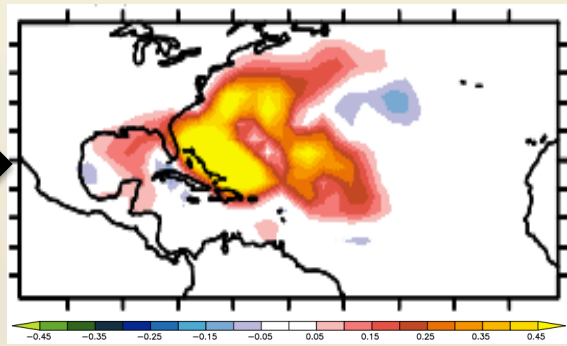
(2080-2099 minus 2015-2025)



2017 SST Anomaly

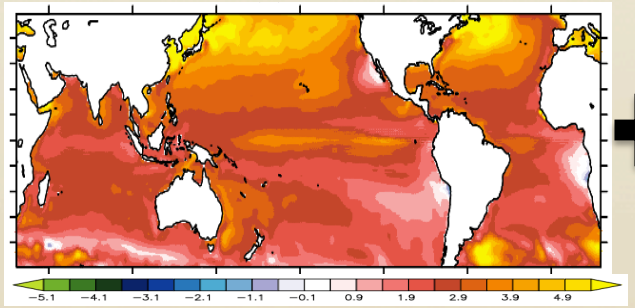


Projected MH Density Anomaly

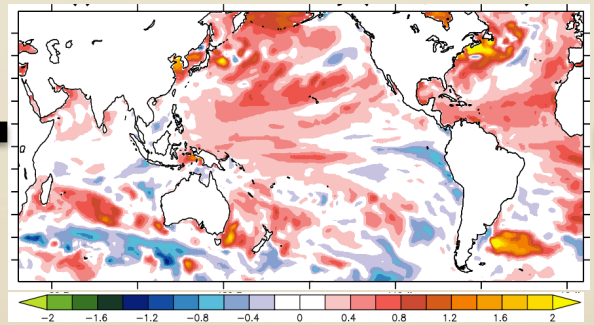


RCP8.5

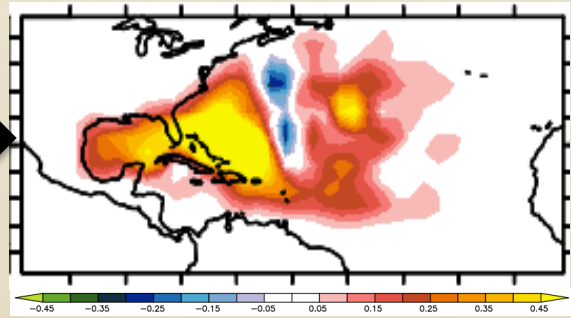
(2080-2099 minus 2015-2025).



2017 SST Anomaly



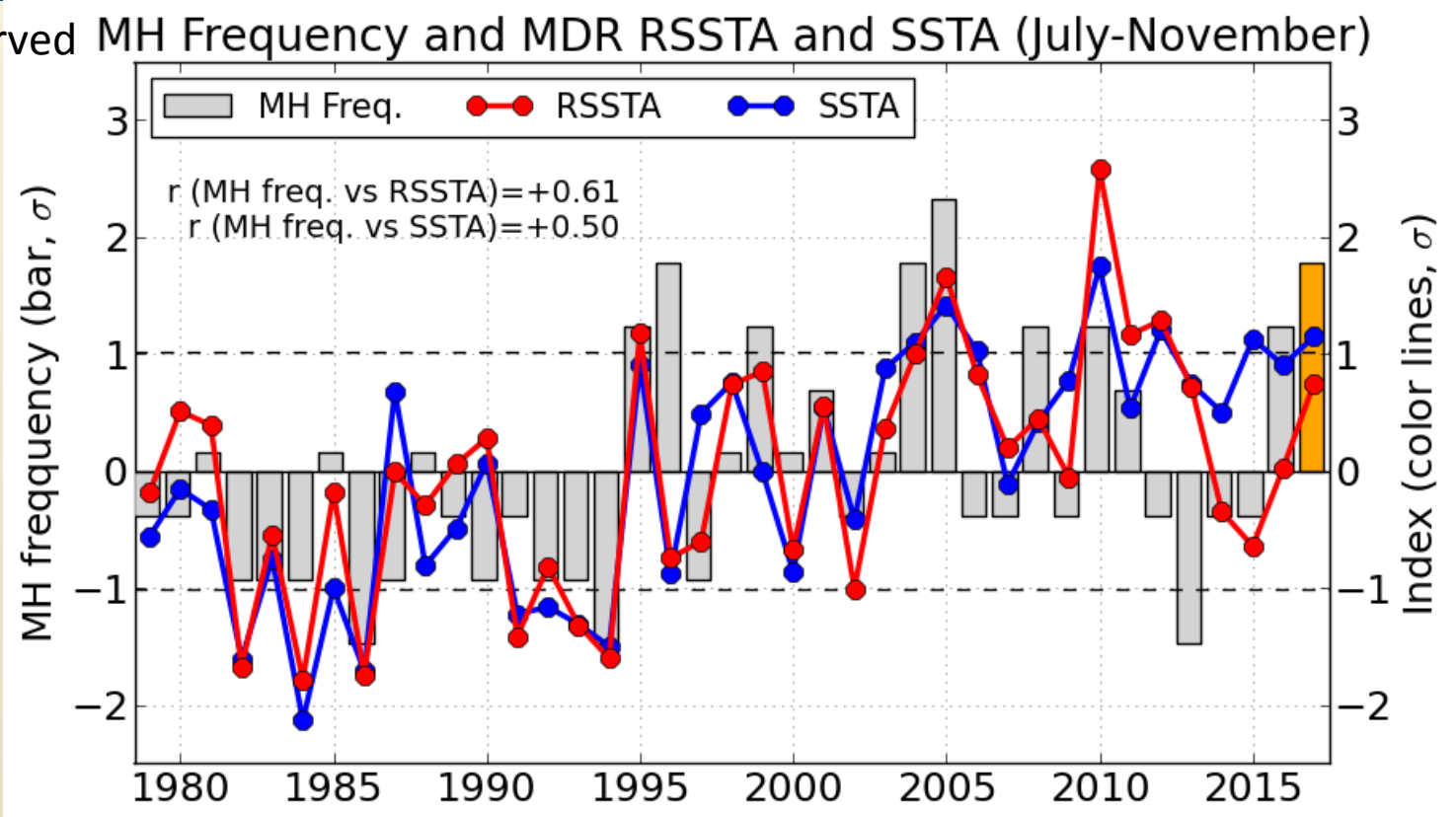
Projected MH Density Anomaly



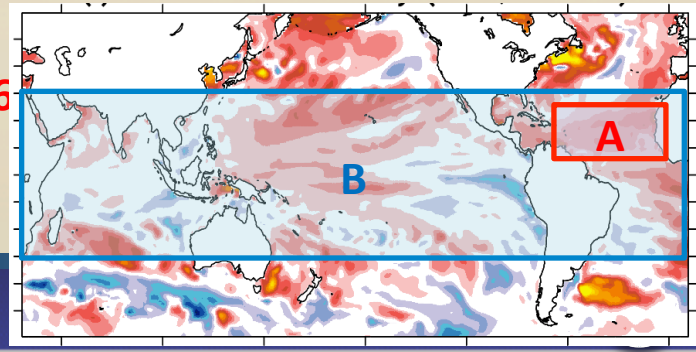
More active MH season than the 2017 summer is projected in the future even with the same spatial patterns of 2017 SST anomaly, resulting in **amplifying the risk of MHs**.

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

Observed



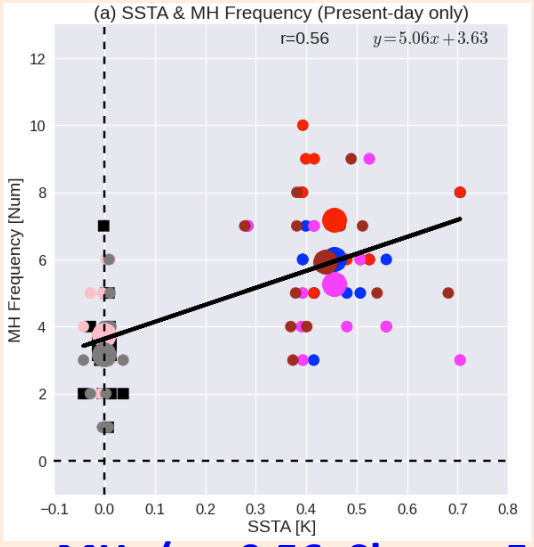
Observed number of MHs (gray bars) is correlated with both
tropical SST anomaly (SSTA, r=+0.50) and
tropical SST anomaly relative to tropical mean (RSSTA, r=+0.6

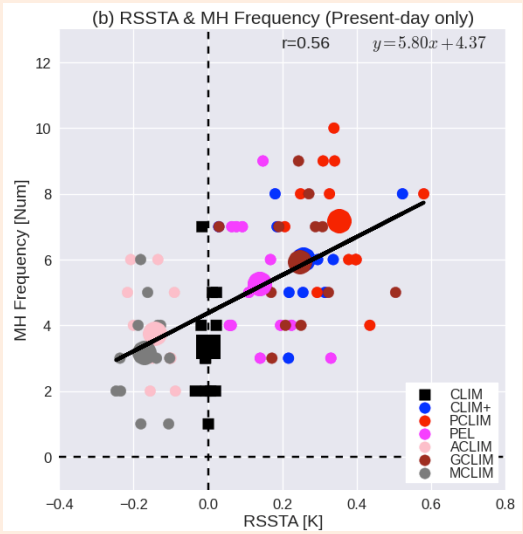


Which of local SST anomaly or relative SST anomaly is important for frequency of MHs in the North Atlantic?

Model

2017 Experiments only

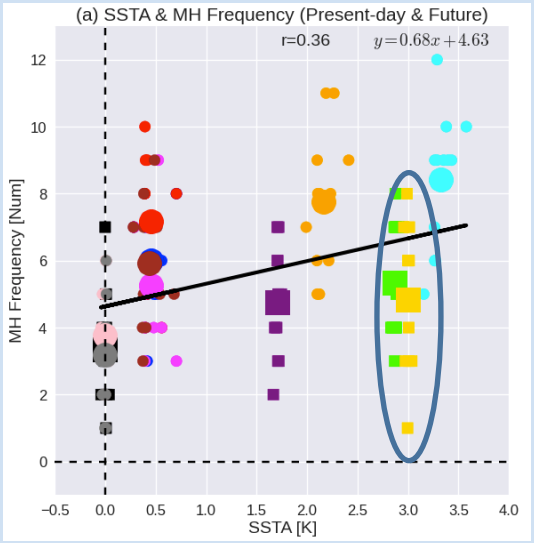


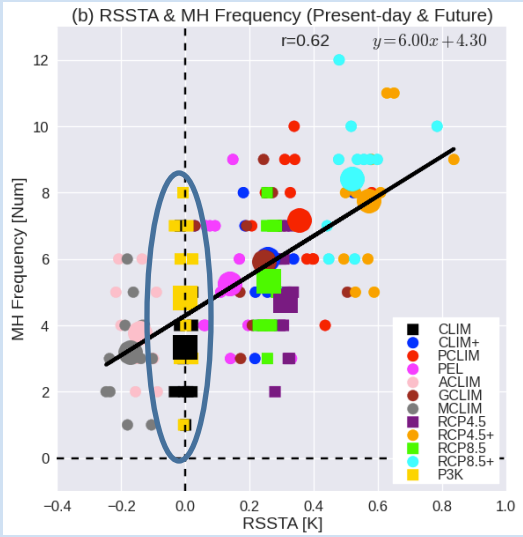


SSTA vs MHs (r=+0.56, Slope=+5.1)

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

2017 Experiments & Future Experiments





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

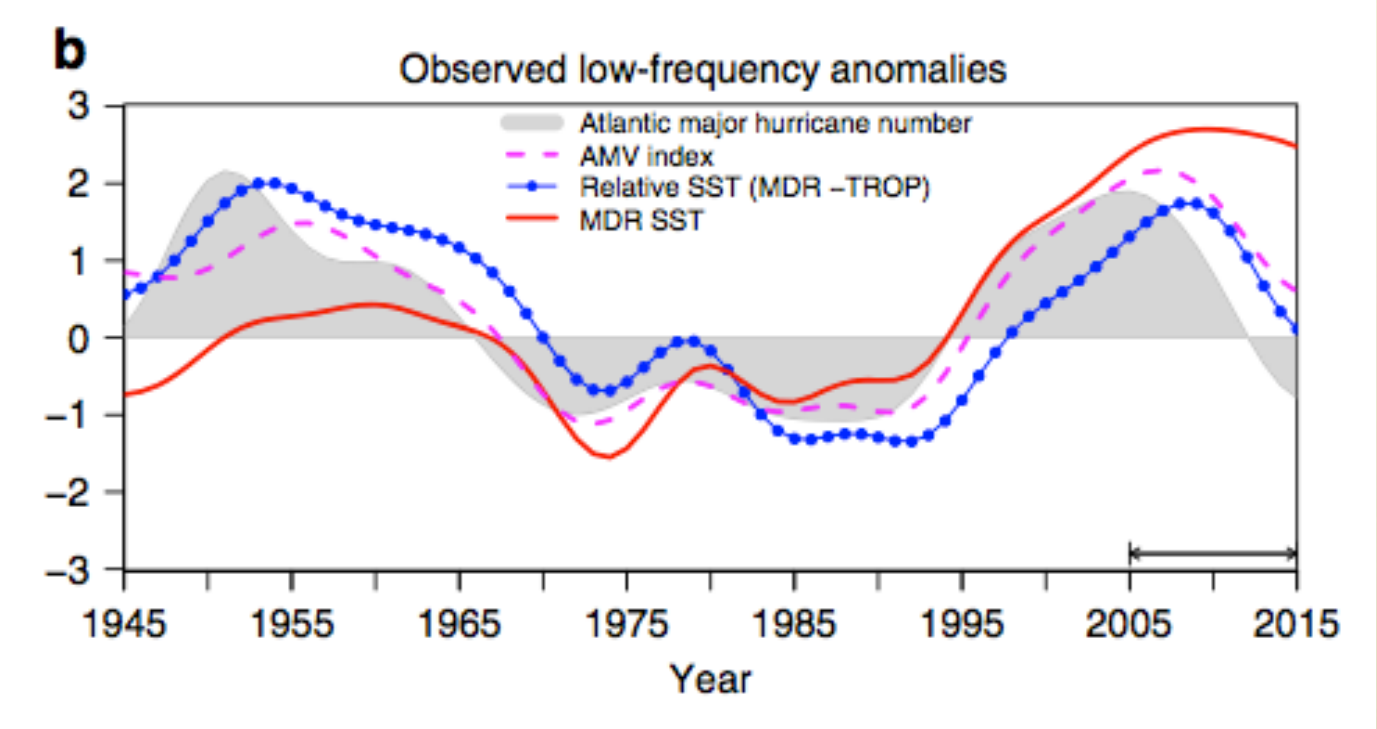
RSSTA vs MHs (r=+0.62, Slope=+6.0)

Summary

- We developed a new high-resolution coupled model, HiFLOR that can simulate/predict major hurricanes (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.

What will happen in the next decades?

Yan et al. (2017, *Nat. Comm.*)



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.