

Attribution of the Extremely Active 2018 Typhoon Season in the North Pacific

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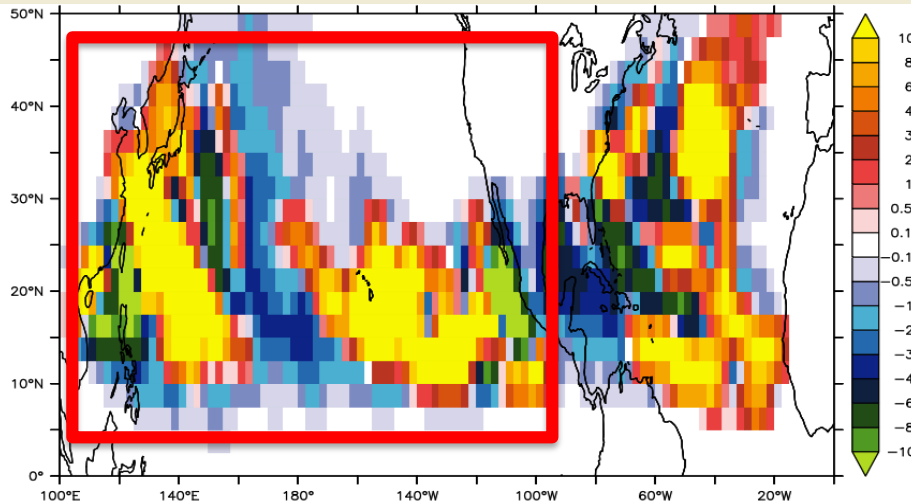
GFDL/JAMSTEC/MRI

July 12, 2019



2018 Tropical Cyclone Season

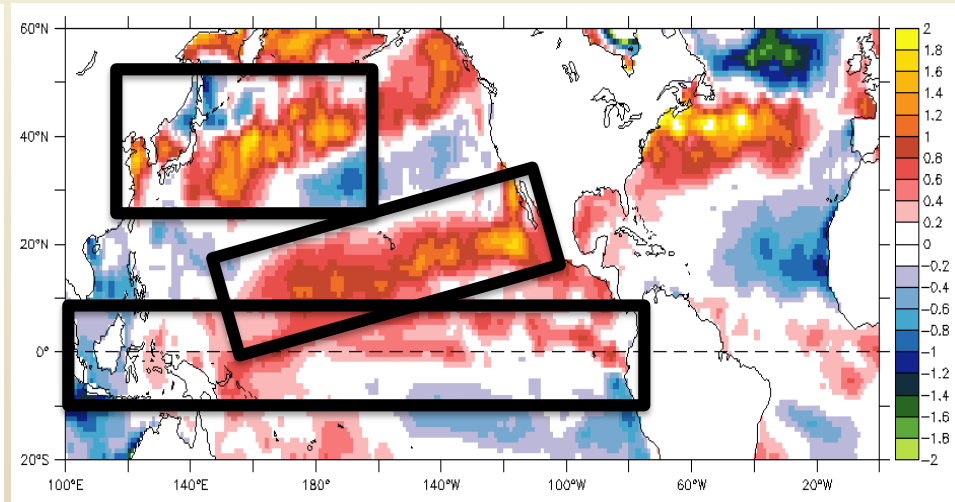
Observed Storm Density Anomaly for 2018 (Jul–Sep)



2018 Accumulated Cyclone Energy (ACE) anomaly relative to 1980–2010 mean

- +60% in the Northern Hemisphere
- +27% in the Western North Pacific
- +140% in the Eastern North Pacific

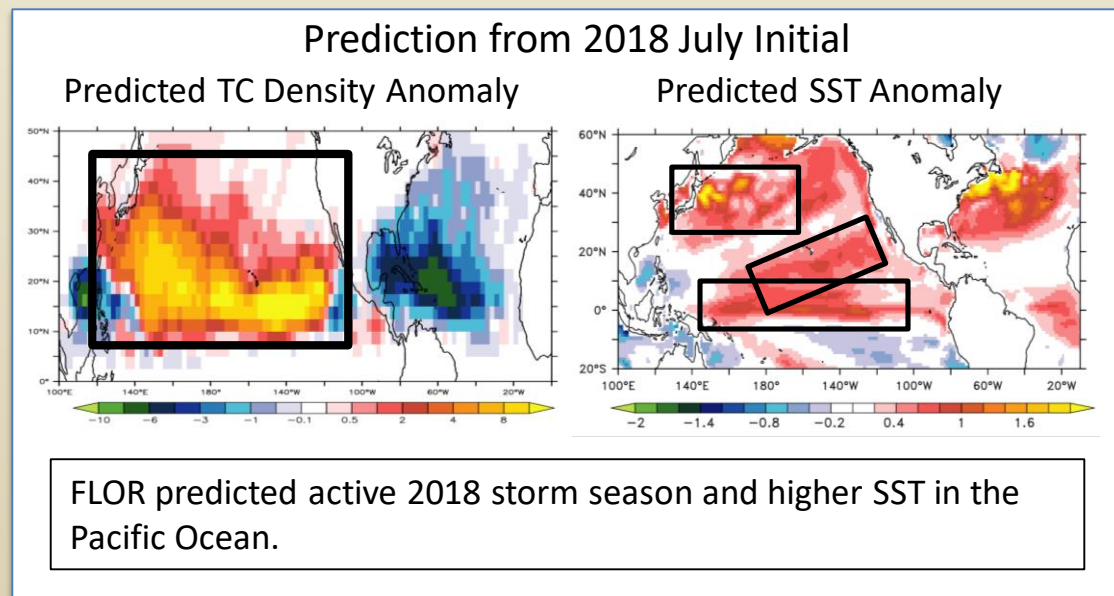
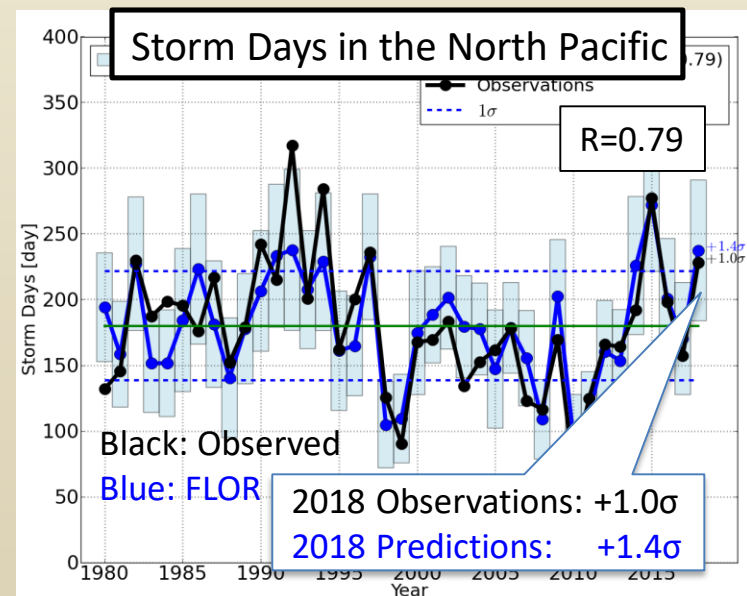
Observed SST Anomaly for 2018 (Jul–Sep)



1. El Niño (Central Pacific El Niño) Development
2. Warmer Subtropical Central Pacific (PMM+)
3. Warmer Kuroshio Current Region

Seasonal Forecasts by GFDL-FLOR

Model	GFDL-FLOR (50km Atmosphere/Land + 100 km Ocean/Ice)
Prediction Period	1-year prediction from July 1 st for each year of 1980–2018
Initialization	Ocean is initialized, but atmosphere is not initialized
# Ensembles	36 Ensemble Members (perturbed in initial conditions)



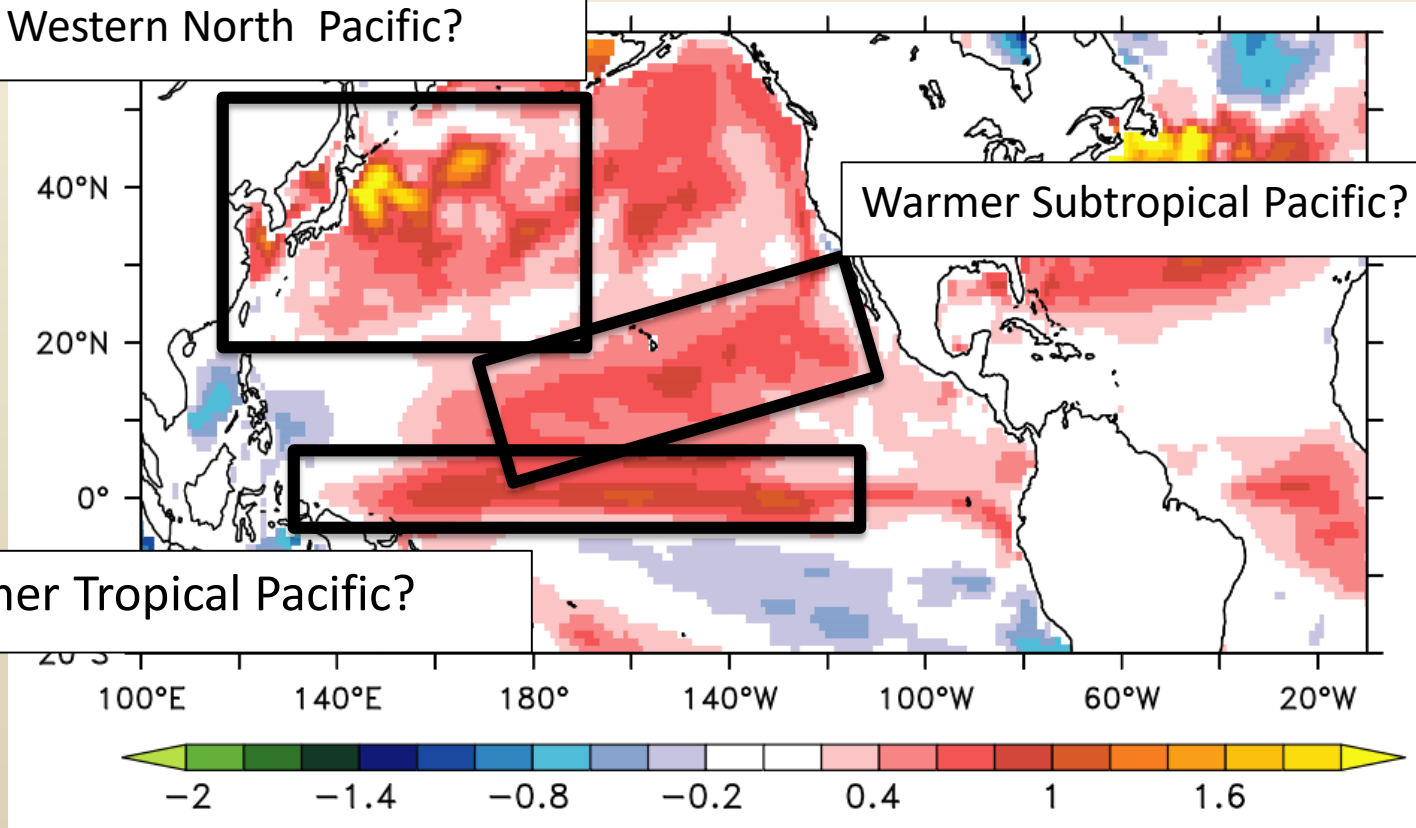
What caused the active storm season in the North Pacific?

Observed SST Anomaly in 2018

Warmer Western North Pacific?

Warmer Subtropical Pacific?

Warmer Tropical Pacific?



Idealized Seasonal Experiments

Murakami et al. (2018, *Science*)

July 1st, 2018

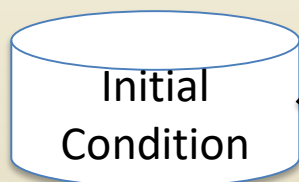
August

September

October

November

Real-time
Predictions

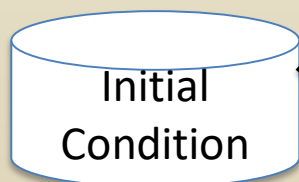


Free Coupled Model Simulation given the Initial Condition

Predicted SST



Idealized
Predictions

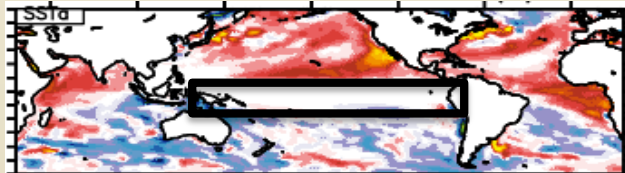
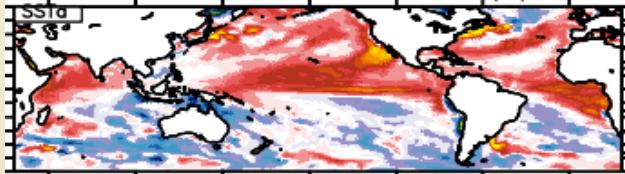


GFDL FLOR (50km)
JAMSTEC NICAM (14km)
MRI-AGCM3.2H (50km)

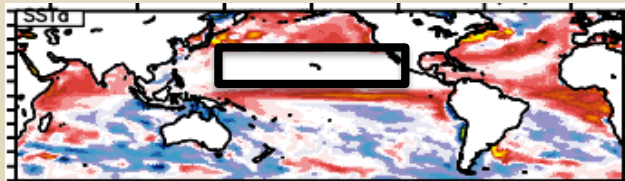
SST is tightly controlled to see impact of regional SST

Idealized SST-Prescribed Seasonal Prediction

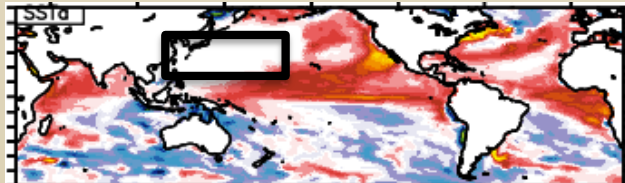
Prescribed SST Anomaly



Pacific Tropical SST anomaly was removed.

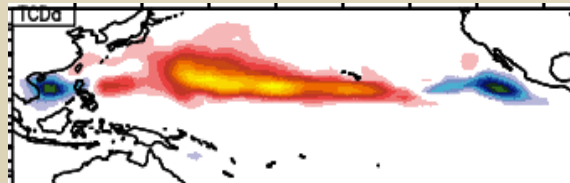
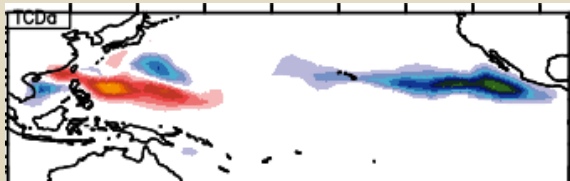
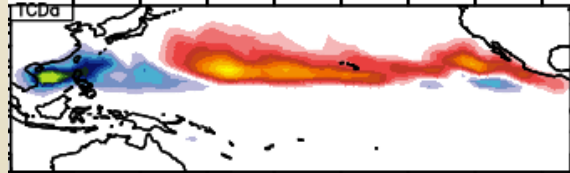
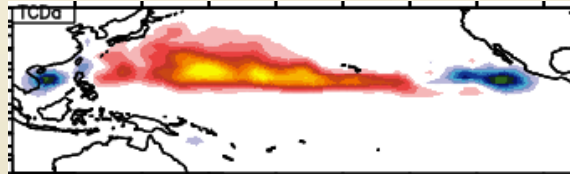


Subtropical SST anomaly was removed.



WNP SST anomaly was removed.

Predicted TC Density Anomaly



The 2018 active storm season in the North Pacific is explained mainly by the SST anomaly over the subtropical Pacific.

Moderate El Niño



Warmer Subtropical Pacific

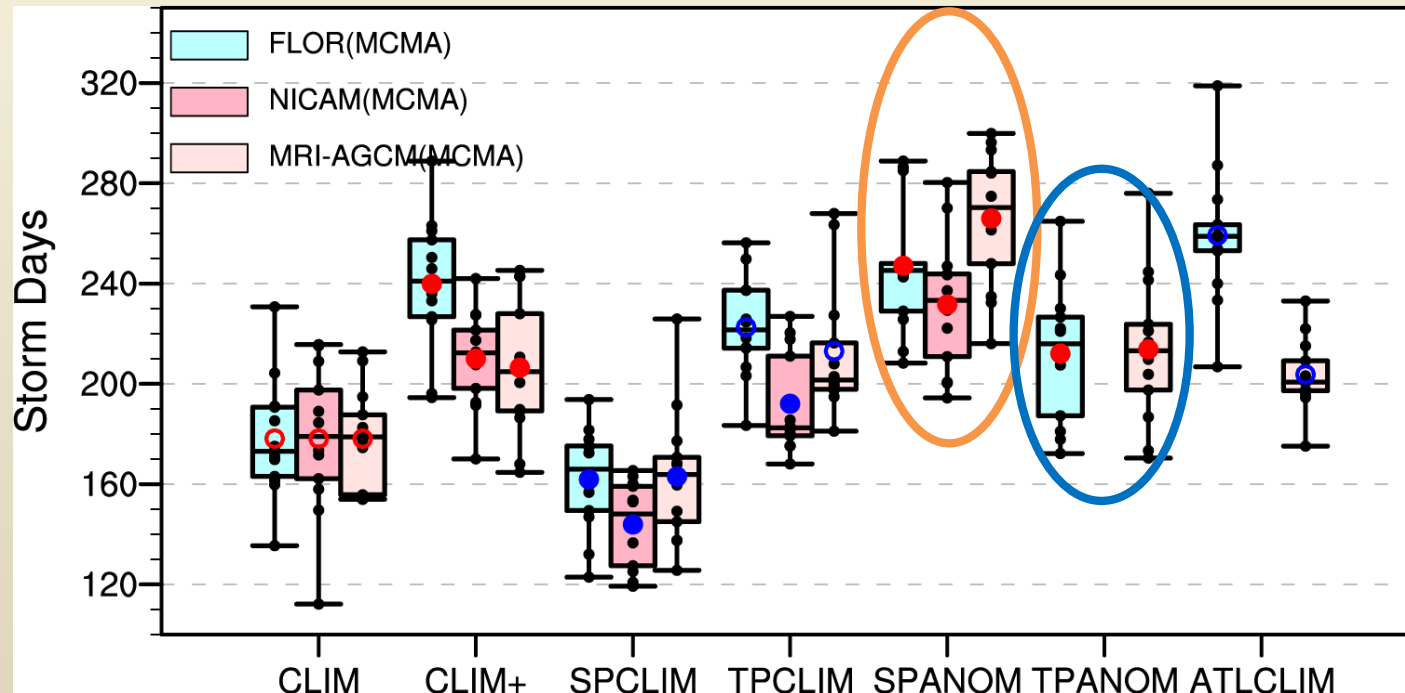


Warmer W.N. Pacific



Consistency among the models

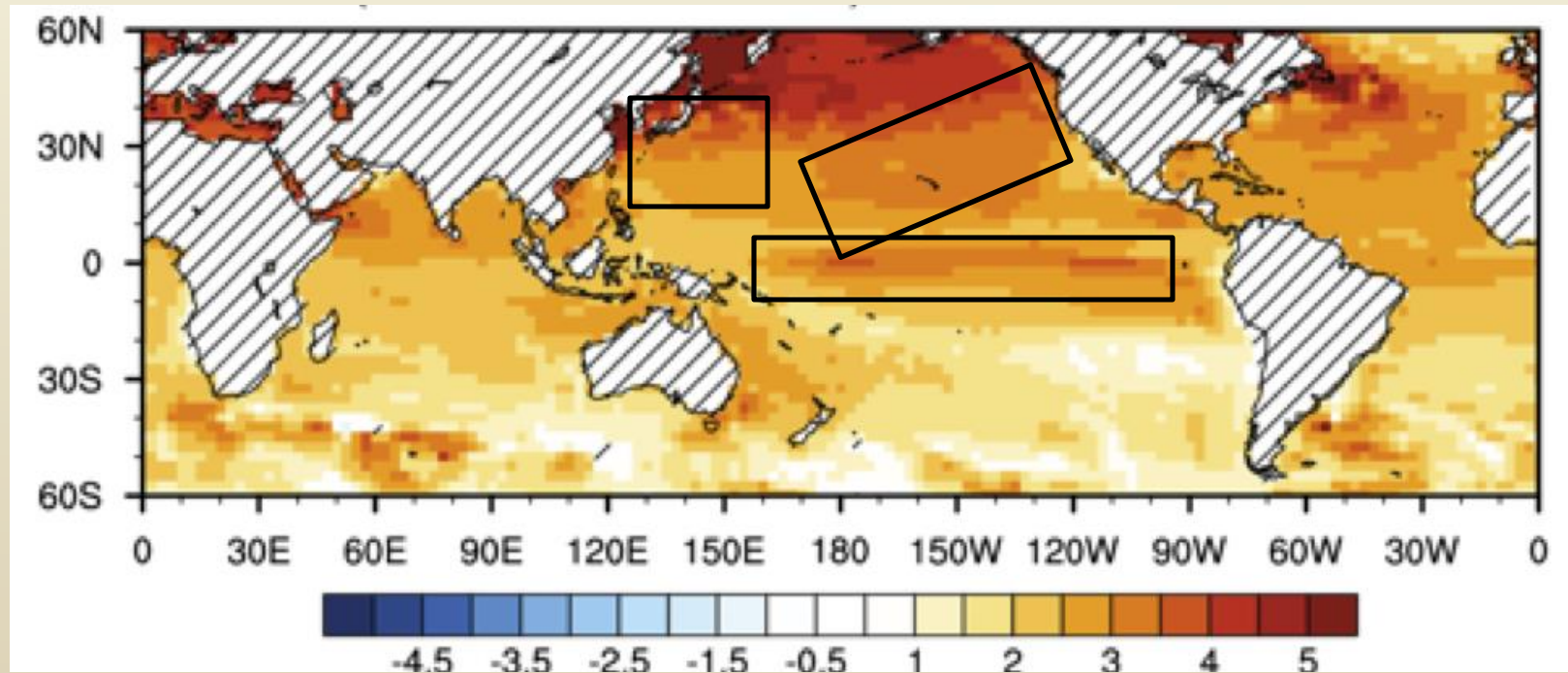
Basin-total Storm Days for each experiment and each model



The three models are qualitatively consistent among the idealized seasonal predictions.

Potential Impact of Anthropogenic Forcing on Active 2018 TC Season in North Pacific

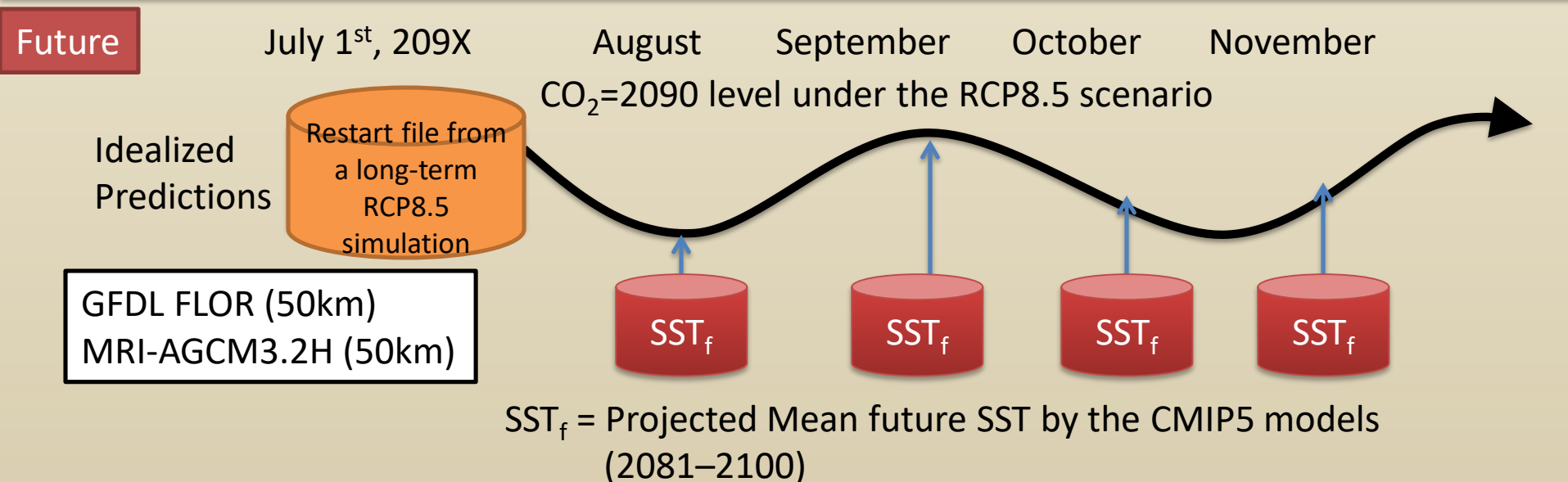
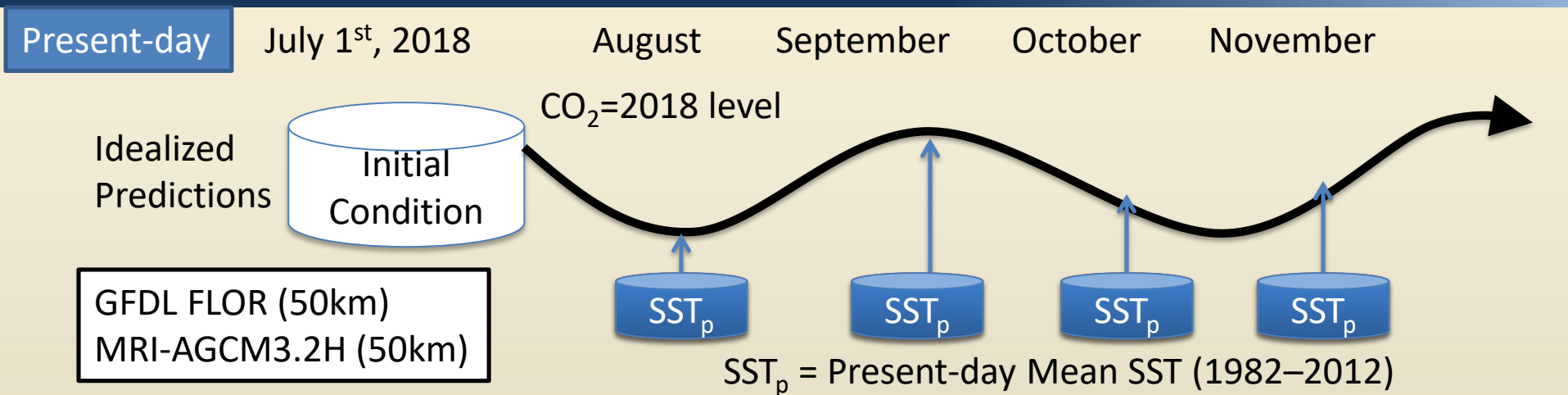
Projected Future Changes in SST by CMIP5 models
RCP8.5 (2081-2100) minus present day (1982-2012)



Similar SST changes to the 2018 SST anomaly.

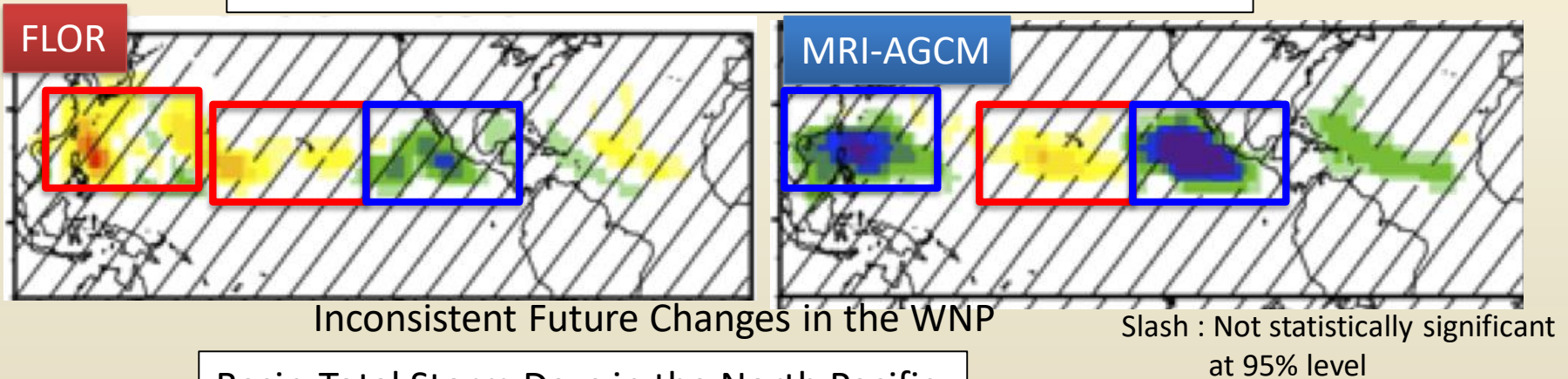
However, it is impossible to distinguish how much 2018 SST anomaly comes from increases in anthropogenic forcing.

Future Simulations

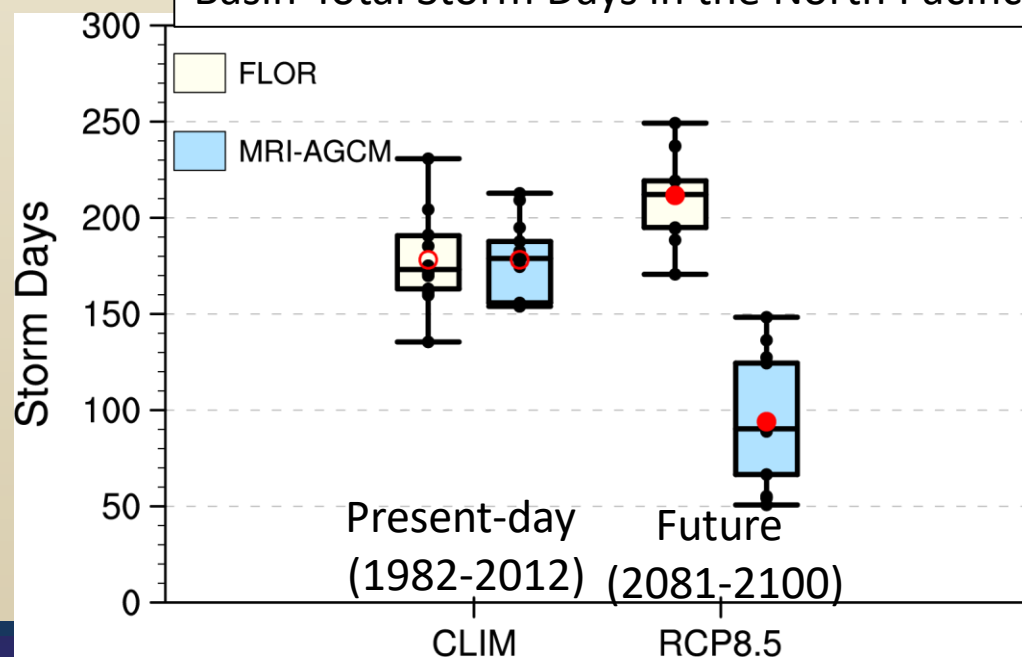


Results of Future Simulations

Projected Future Changes in TC Density (Future – Present)



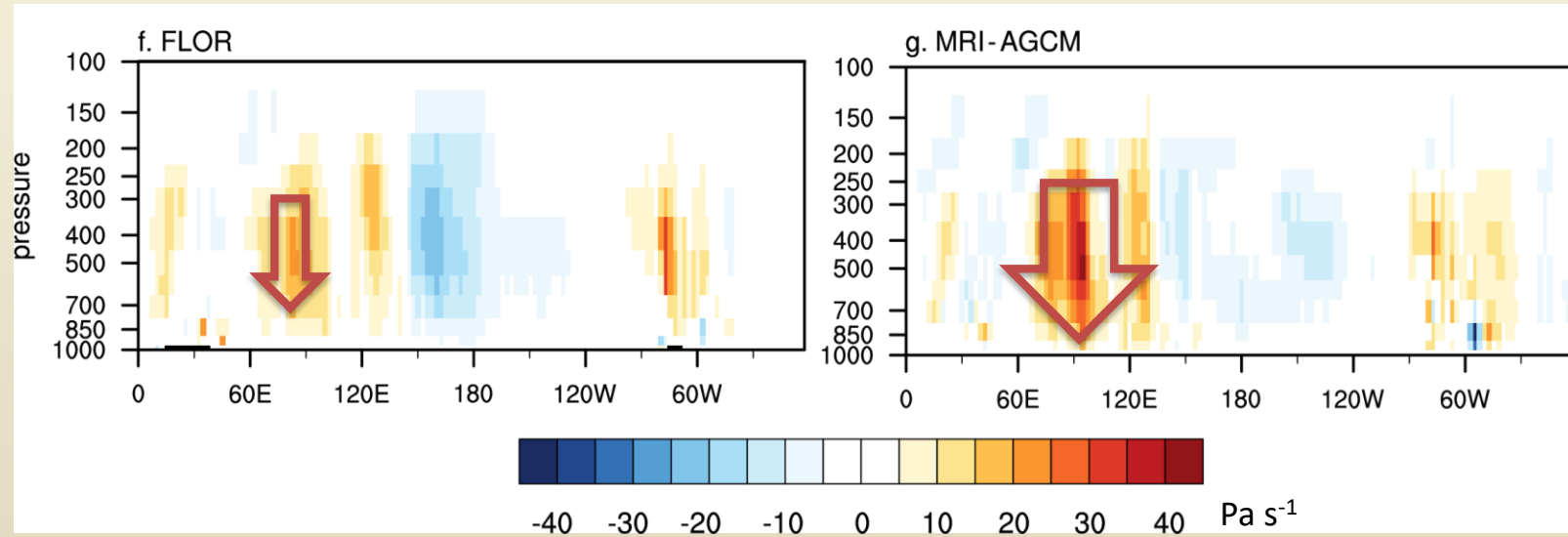
Basin-Total Storm Days in the North Pacific



FLOR projects an increase in storm days, whereas MRI-AGCM projects a decrease in storm days.

Why is the two model different in future changes?

Projected Future Changes in Vertical Motion in the Tropics



	Walker Circulation	Atmospheric Stability	TC Frequency in the western North Pacific
FLOR	Slight Weakening	Slight Increase	Slight Decrease
MRI-AGCM	Large Weakening	Large Increase	Large Decrease

Summary

- Seasonal prediction model (GFDL-FLOR) could predict active 2018 TC season in the North Pacific a few months in advance.
- **Subtropical Pacific SST anomaly** associated with positive PMM is a primary reason for the active 2018 storm season in the North Pacific.
- **Three models (FLOR, NICAM, MRI) are consistent** through the idealized seasonal predictions for the 2018 summer season.
- Two models show different sign of the future changes in TC frequency of occurrence in the WNP, resulting in **significant uncertainty in future changes** in TC activity in the North Pacific.

Real-time Seasonal Predictions for 2018

Predicted Storm Density Anomaly for **2018 July–November** from different initial months

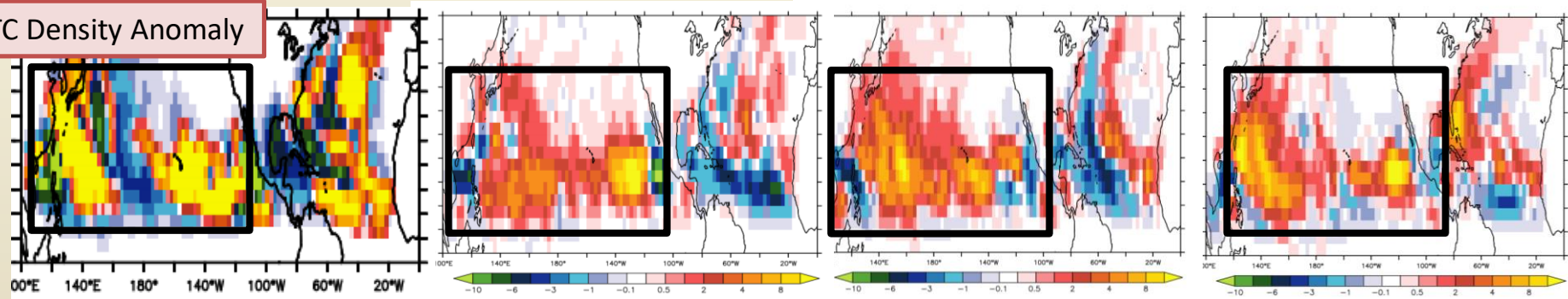
Observations (July-Sep)

April

March

February

TC Density Anomaly



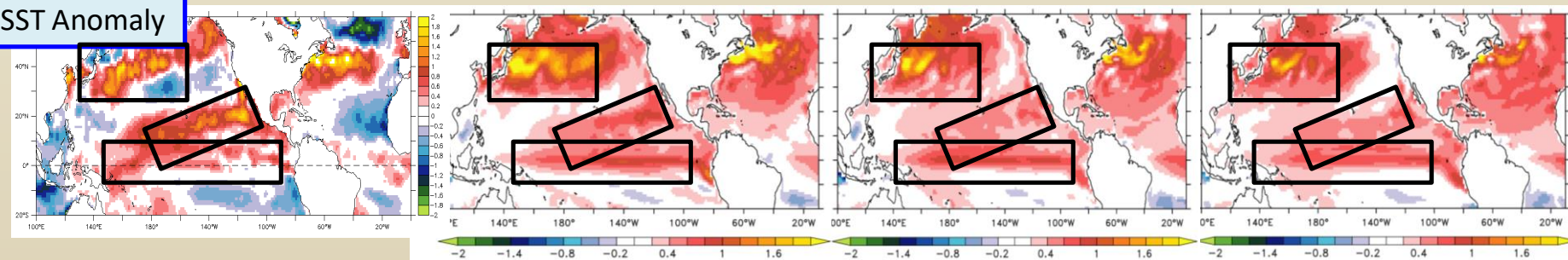
Observations (July-Sep)

April

March

February

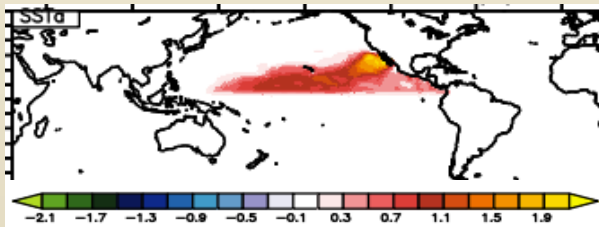
SST Anomaly



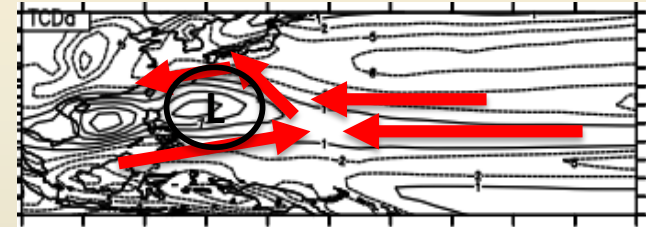
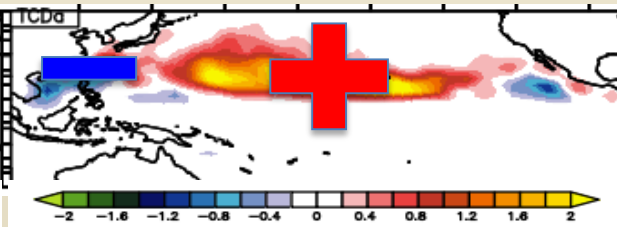
Active 2018 storm season in the Pacific as well as SST anomaly was well predicted even from Feb 2018.

Eastward Shift in Monsoon Trough

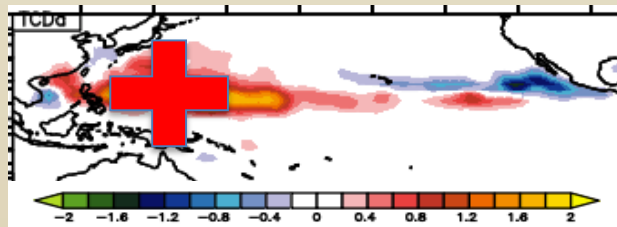
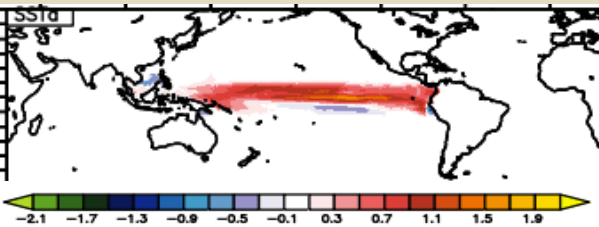
Prescribed SST Anomaly



Predicted TC Density Anomaly



Predicted Vort 850 Anomaly



Why is the two model different in future changes?

Storm Days
Large-scale parameter

Red: FLOR
Blue: MRI

