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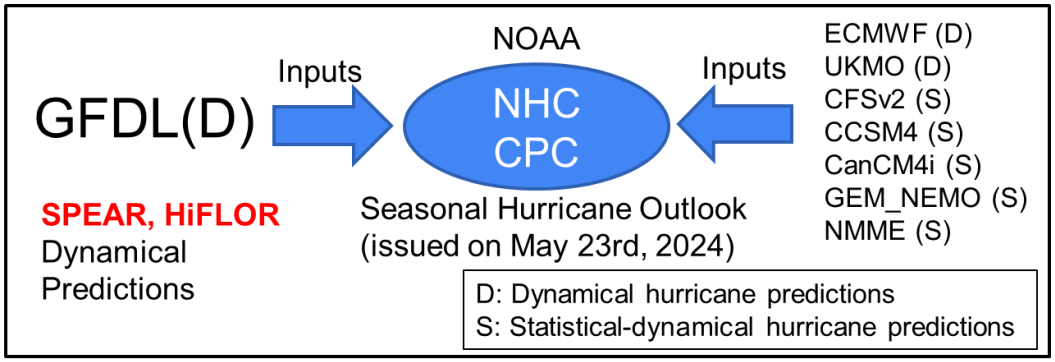
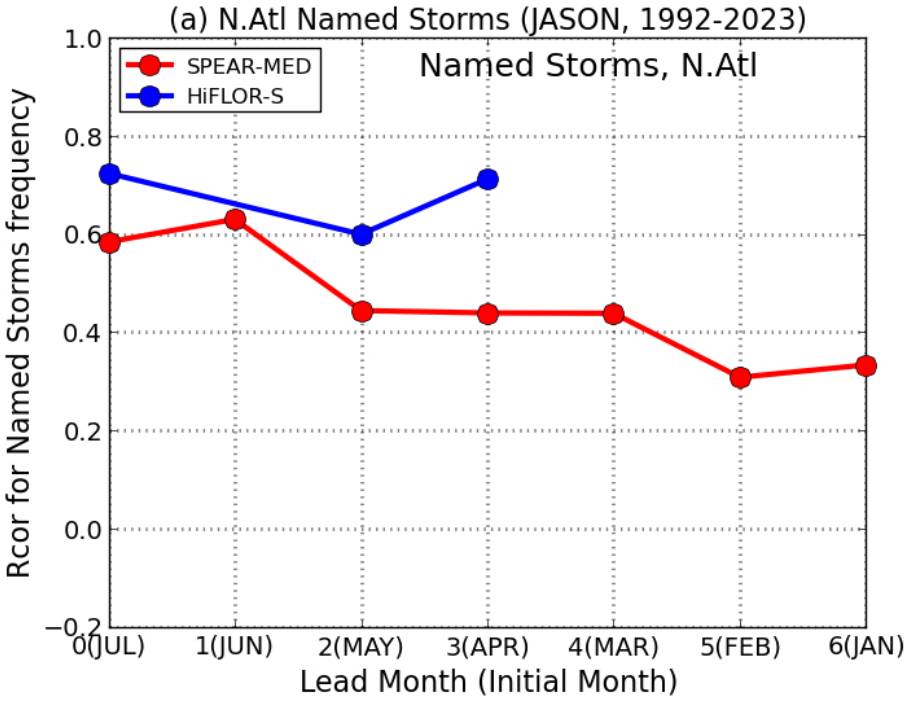
Experimental Seasonal Hurricane Predictions at NOAA's GFDL

•NOAA-GFDL has been supporting experts at the National Hurricane Center and Climate Prediction Center since 2017 for the hurricane seasonal outlook.

•NOAA-GFDL is the only U.S. institution that provides **dynamical** seasonal hurricane forecasts (**SPEAR and HiFLOR**)



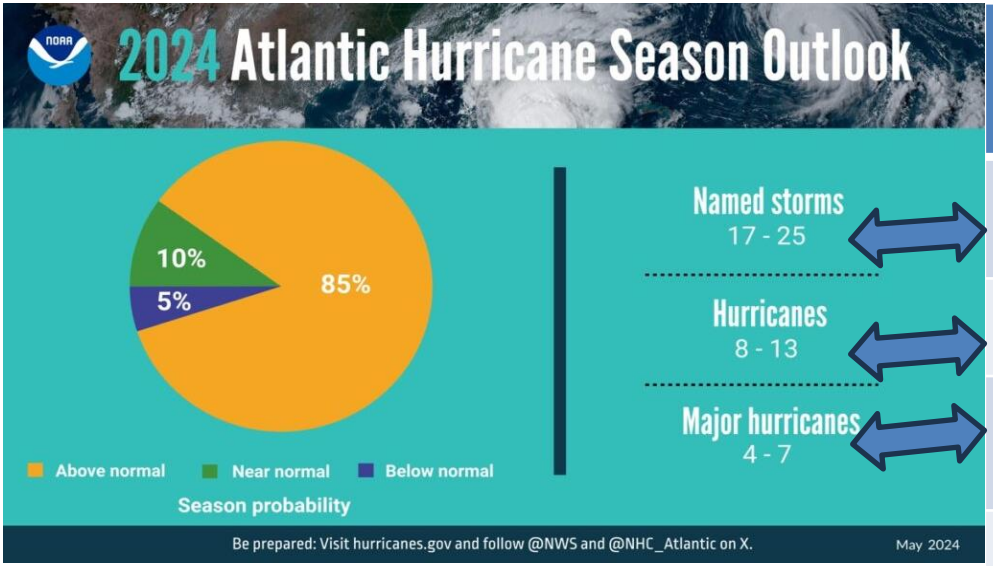


- GFDL's seasonal predictions have demonstrated high skill in forecasting tropical cyclones in the North Atlantic.
- The correlation between observed named storms and predictions from the initial July 1st forecast is +0.7.

Murakami et al. (2024, submitted)

Extremely active hurricane season is predicted for the 2024 summer in the North Atlantic

NOAA's 2024 Seasonal Hurricane Outlook



Predicted from the May 1st GFDL predictions

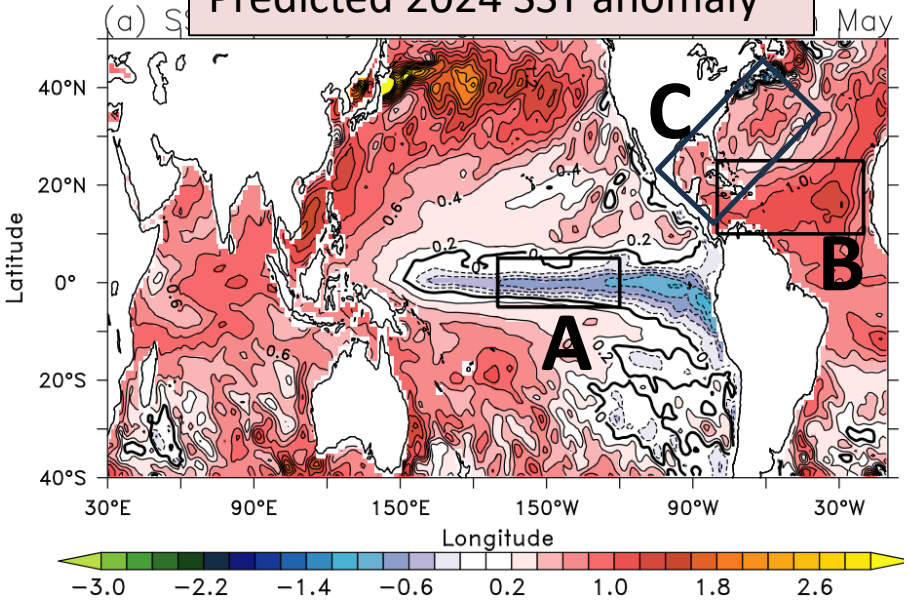
	GFDL predictions	Observed climatology	Anomaly (Standard deviation)
Named Storms	17-23	15	+1.8σ
Hurricanes	9-14	7	+2.4σ
Major Hurricanes	4-7	3	+2.3σ
ACE (10^5 m^2 s^{-2})	4-6	3.2	+1.9σ

- An extremely active hurricane season is predicted for the summer of 2024 in the North Atlantic
- The GFDL's 2024 hurricane predictions are consistent with NOAA's hurricane seasonal outlook

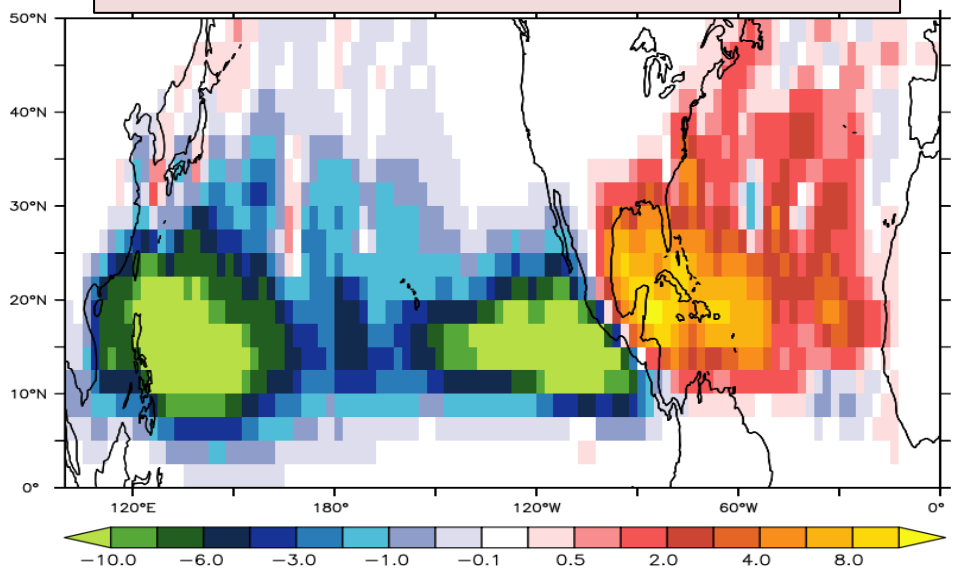
What causes the predicted active hurricane season in 2024?

The May 1st initial predictions for this summer by the GFDL-SPEAR model

Predicted 2024 SST anomaly



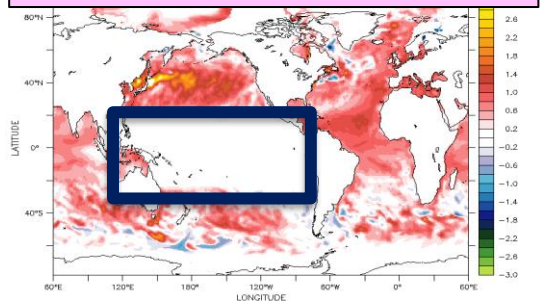
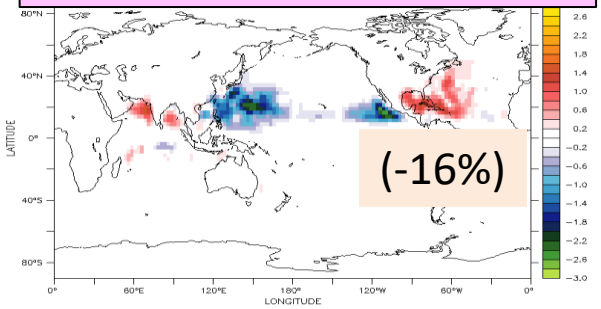
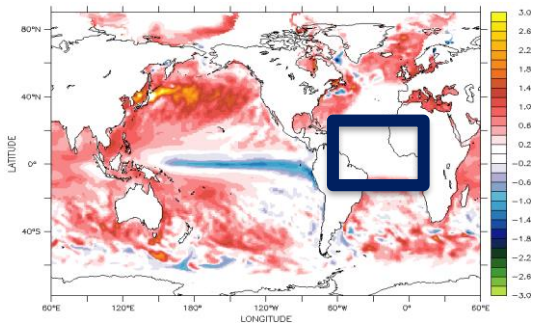
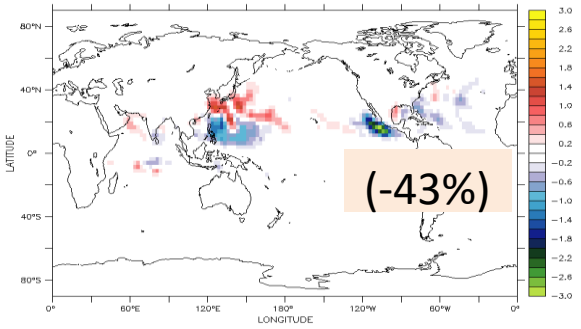
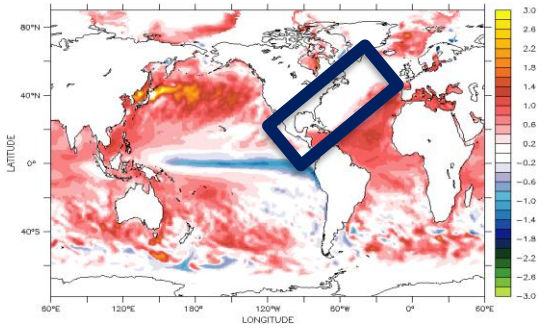
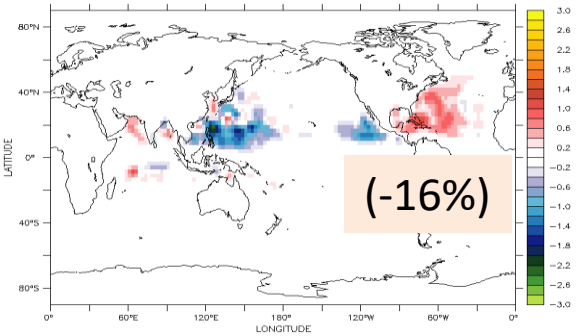
Predicted 2024 storm density anomaly



Anomaly relative to the 1992-2023 mean

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

Idealized Seasonal Prediction for the Summer of 2024 by SPEAR

Prescribed SST Anomaly	Predicted TC density Anomaly
	
The La Nina condition was removed	
	
The warmer SST anomaly in the tropical Atlantic was removed	
	
The warmer SST anomaly off the coast of the US was removed	

Detailed methodology: Murakami et al. (2018, Science)

A. La Niña?

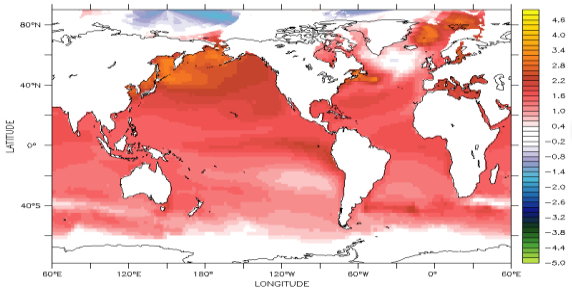
B. Warmer Tropical Atlantic?

C. Warmer off the coast of North America?

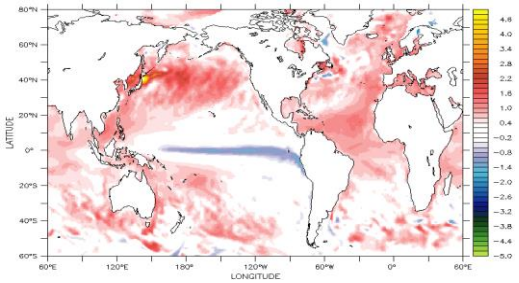
<u>The warmer tropical Atlantic could be a major contributor to the active 2024 hurricane season.</u>

What would the future look like if conditions similar to those in 2024 were to happen again?

SSP2-4.5 mean SST change (2081-2100 minus 1991-2010 by CMIP6 models)

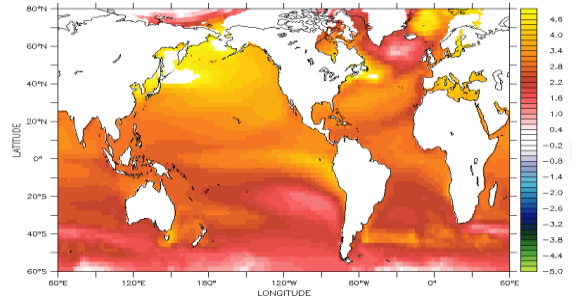


Predicted 2024 SST Anomaly

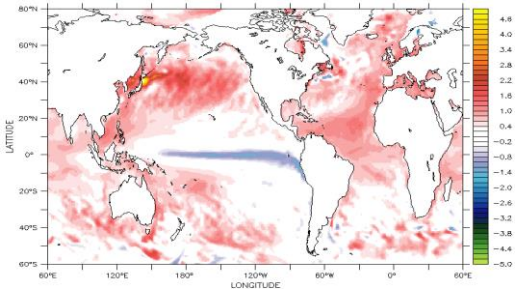


CO_2: 597 ppmv

SSP5-8.5 mean SST change (2081-2100 minus 1991-2010 by CMIP6 models)



Predicted 2024 SST Anomaly



CO_2: 998 ppmv

Will we see more active hurricane season than 2024?

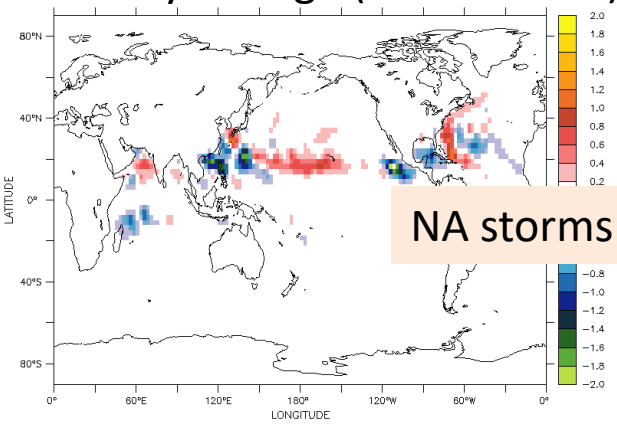
(The current CO_2 level is around 425 ppmv)

Detailed methodology: Murakami et al. (2018, Science)

What would the future look like if conditions similar to those in 2024 were to happen again?

SSP2-4.5 mean SST change (2081-2100 minus 1991-2010)

TC Density Change (2090 – 2024)

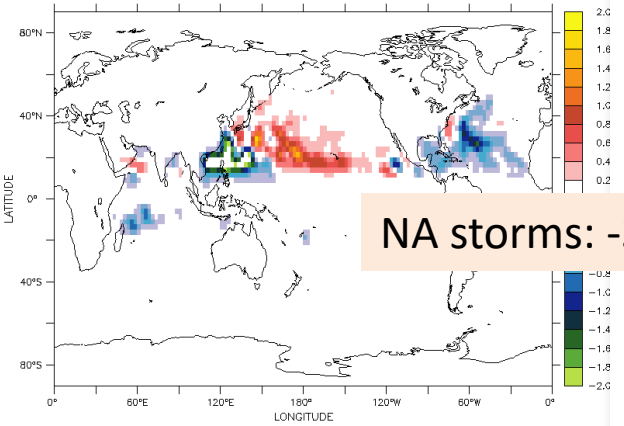


No change under the SSP2-4.5 scenario

NA storms: 0% change relative to 2024

SSP5-8.5 mean SST change (2081-2100 minus 1991-2010)

TC Density Change (2090 – 2024)

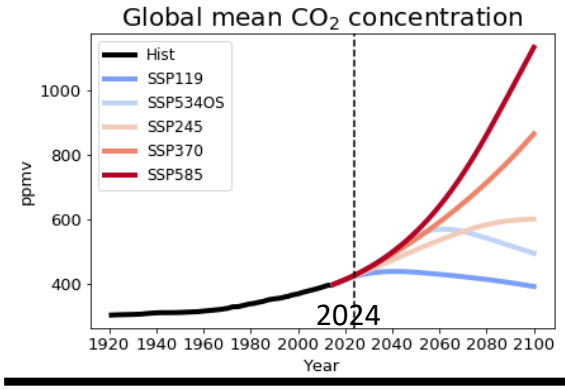


Projected decrease under the SSP2-4.5 scenario

NA storms: -30% change relative to 2024

GFDL-SPEAR tends to project decreased frequency of tropical cyclones in the North Atlantic in the future

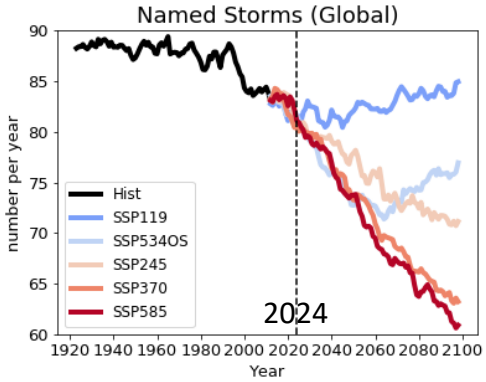
Long-term historical & future simulations by the GFDL-SPEAR model

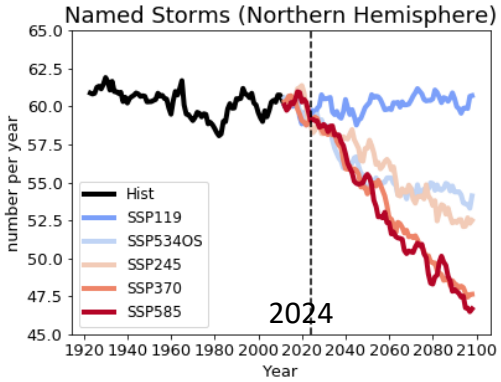


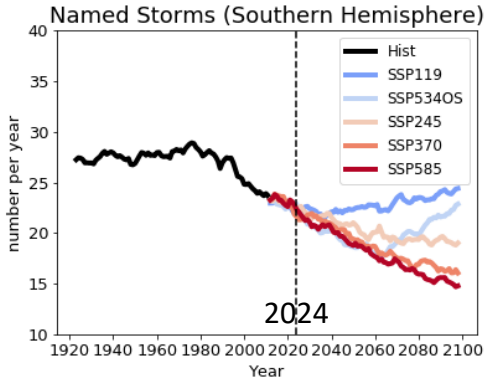
Large-ensemble simulations by the GFDL-SPEAR model

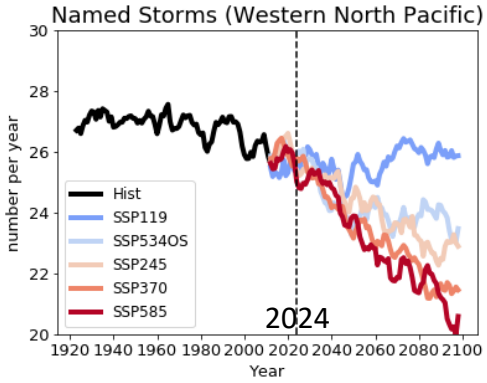
- 30 ensemble member initialized in 1921.
- 1921-2014: Historical forcing (CO_2, Aerosols, etc.)
- 2015-2100: Future forcing under the various SSP scenarios

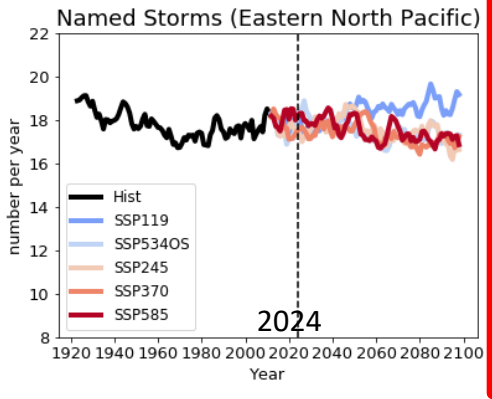
Simulated frequency of named storms (≥ 34 knots)

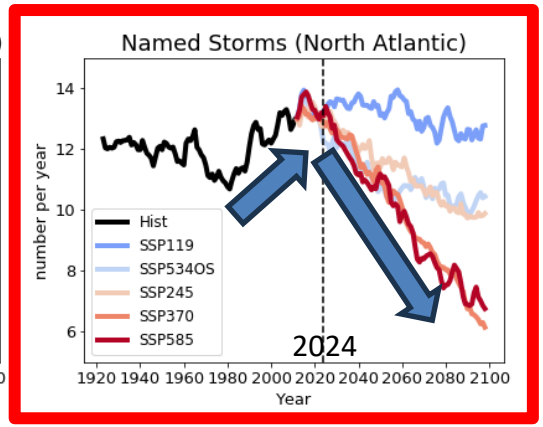








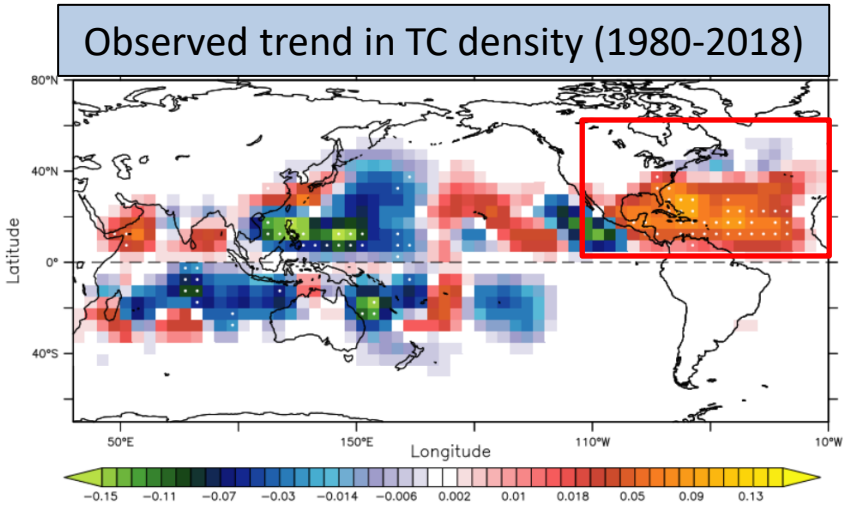


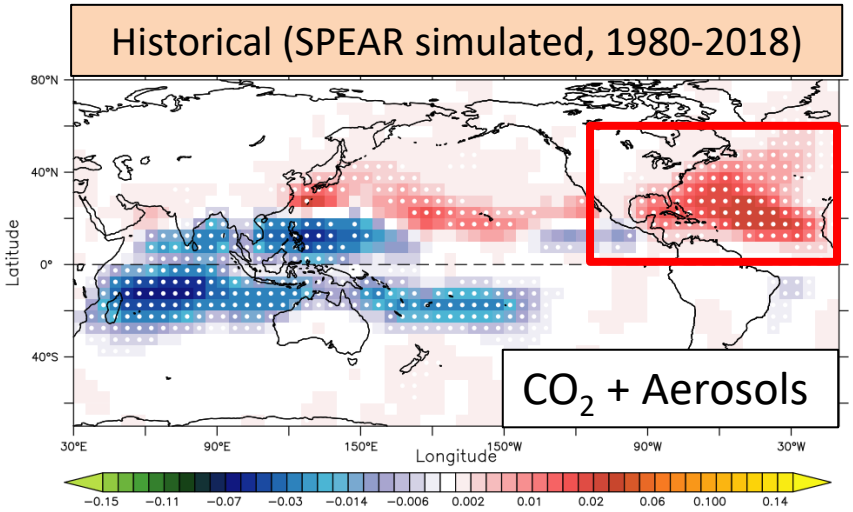


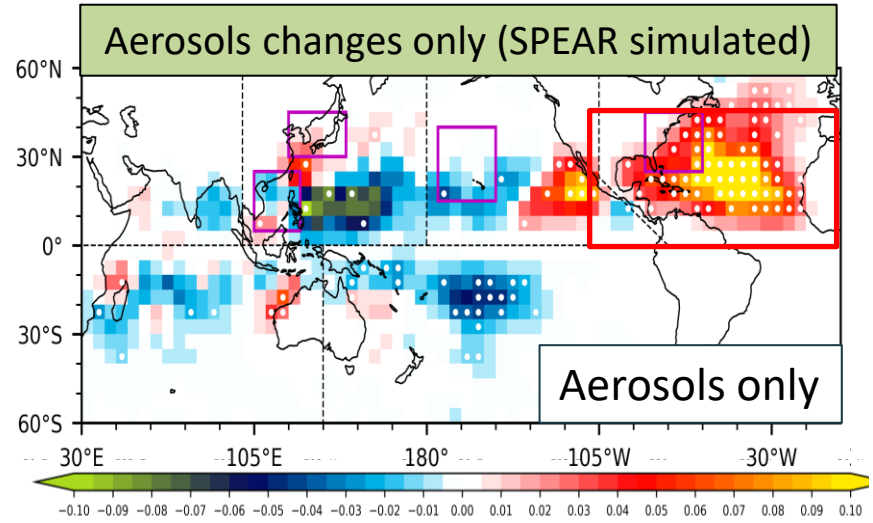
Murakami et al. (2024, submitted)

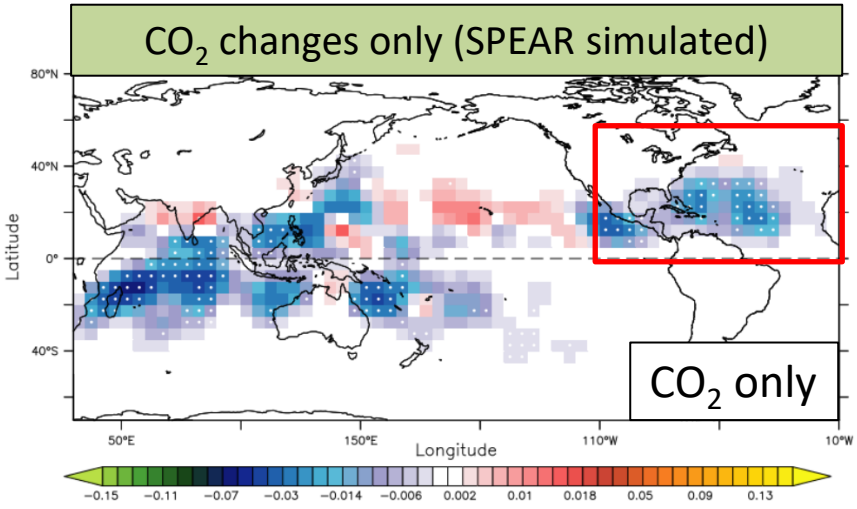
The changes observed in tropical cyclones in the past may not necessarily apply to the future.

Observed and simulated trends in storm density over the period 1980-2018



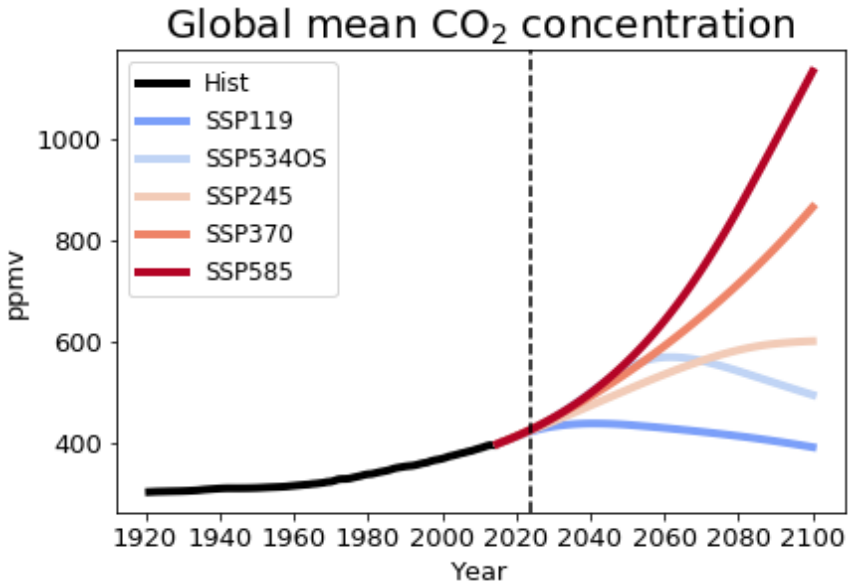


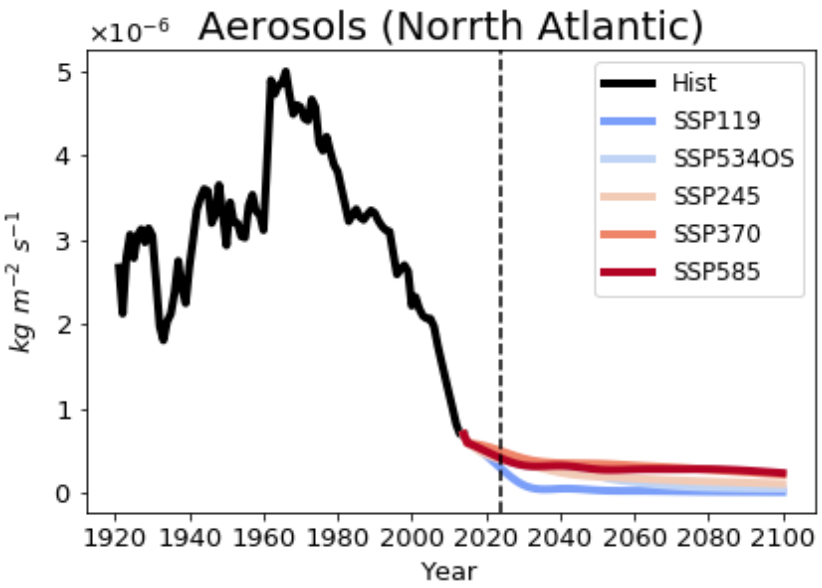




Murakami et al. (2020, PNAS), Murakami (2022, Sci. Adv.), Wang et al. (2023, npj. Clim. Atmos)

The past changes in tropical cyclones may not apply to the future





Substantial increases in CO_2 are expected, whereas anthropogenic aerosols over the North Atlantic may not change much in the future

According to the SPEAR future projections, frequency of tropical cyclones in the North Atlantic is projected to decrease due to the dominant effect of CO_2

Murakami et al. (2020, PNAS), Murakami (2022, Sci. Adv.), Murakami (2024, submitted)

Key takeaways

- GFDL-SPEAR predicts an extremely active hurricane season in the North Atlantic in 2024, consistent with NOAA's hurricane seasonal outlook.

- The predicted active 2024 hurricane season is largely attributed to the anticipated warm sea surface temperatures in the tropical Atlantic Ocean.

- A hurricane season similar to 2024 in the future climate may be less active than 2024.

- SPEAR projects a decrease in the frequency of tropical cyclones in the North Atlantic in the future, primarily due to the dominant effect of increasing CO_2 levels. This trend contrasts somewhat with the past 40 years, which have shown an increased frequency of tropical cyclones, partially attributed to decreased aerosol emissions.