Distinct increase in Atlantic early-season tropical cyclone activity

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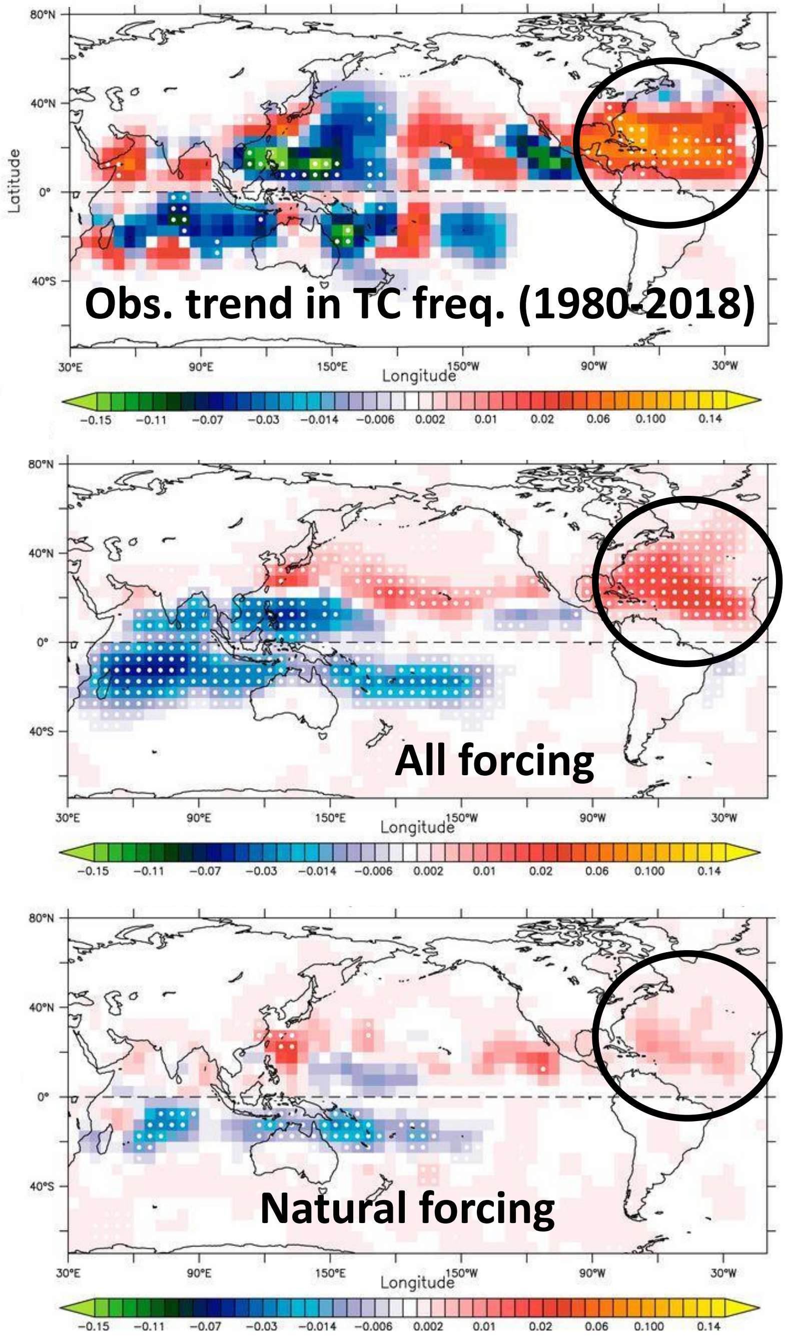
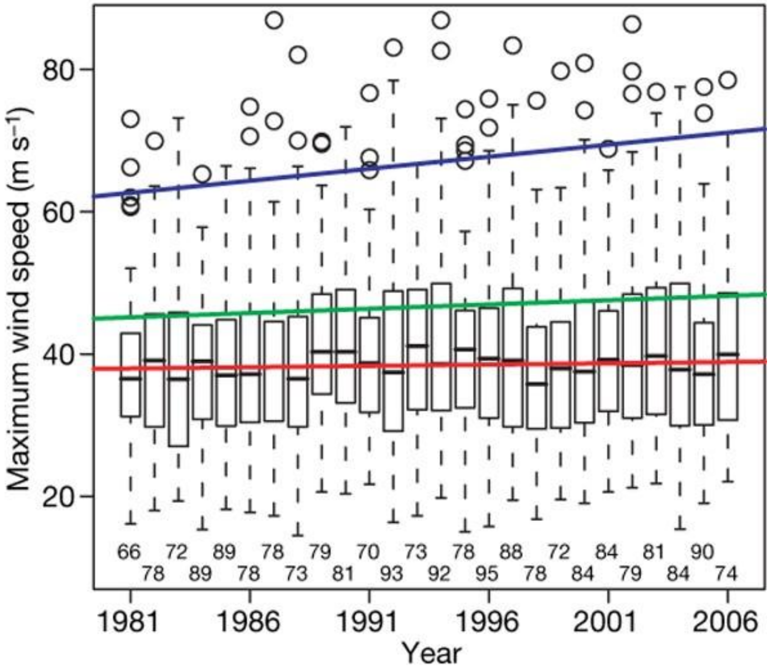
Long-term increases in tropical cyclone frequency and intensity

Large ensemble simulations using GFDL coupled models FLOR, FLOR-FA, SPEAR



Murakami et al. (2020)

Global increase in intensity of strongest storms



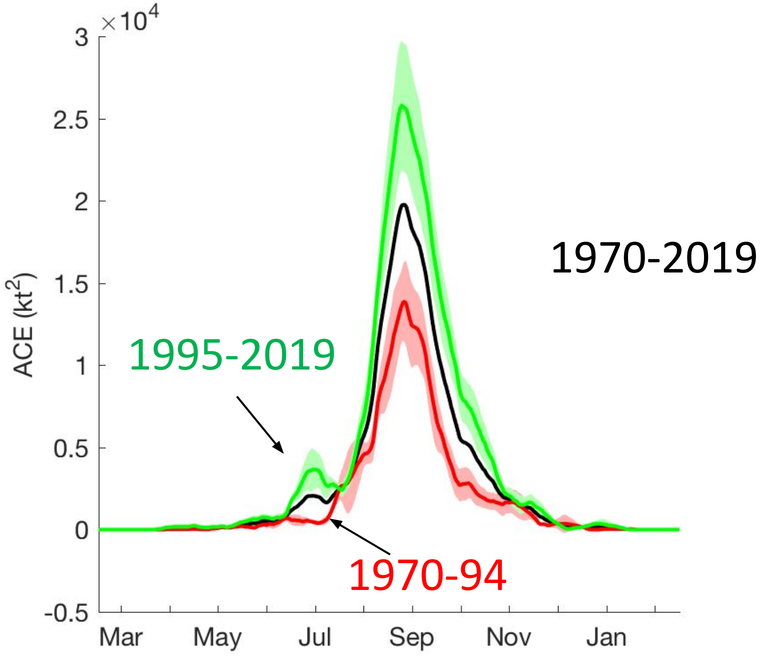
Elsner et al. (2008)

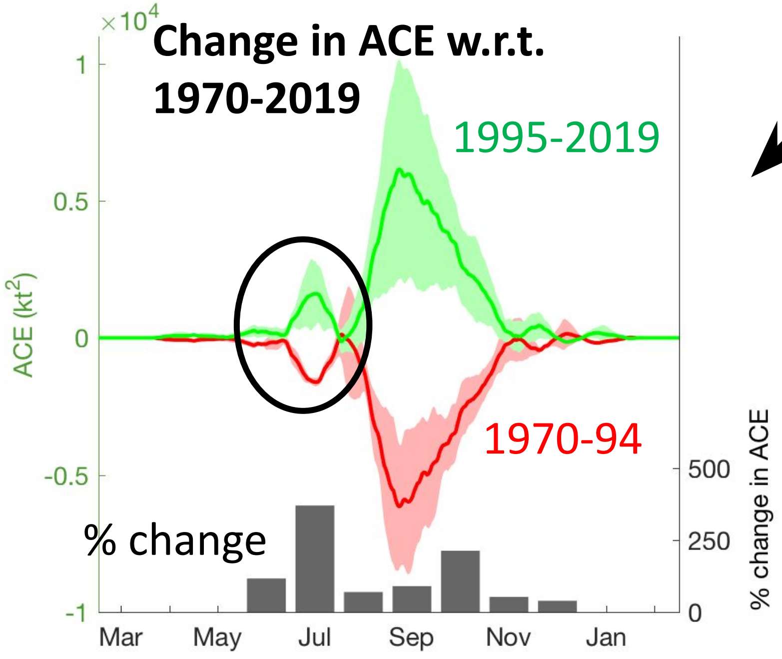
Are trends in Atlantic TC activity uniform throughout the season?

- **HURDAT2 6-hr TC locations, max. 1-min. sustained wind speed**, 1970-2019 (only TS + HU).
- **HadISST** (1979-1981), **NOAA OISST** (1982-2019), monthly.
- **ERA5 temp., humidity, wind, geopotential height,** monthly, 1979-2019.
- **Satellite OLR**, monthly, 1979-2019.
- **20CR winds** (200, 850 hPa), monthly, 1902-2015.

- **AMO index**, monthly, 1902-2015.

Seasonal distribution of TC activity





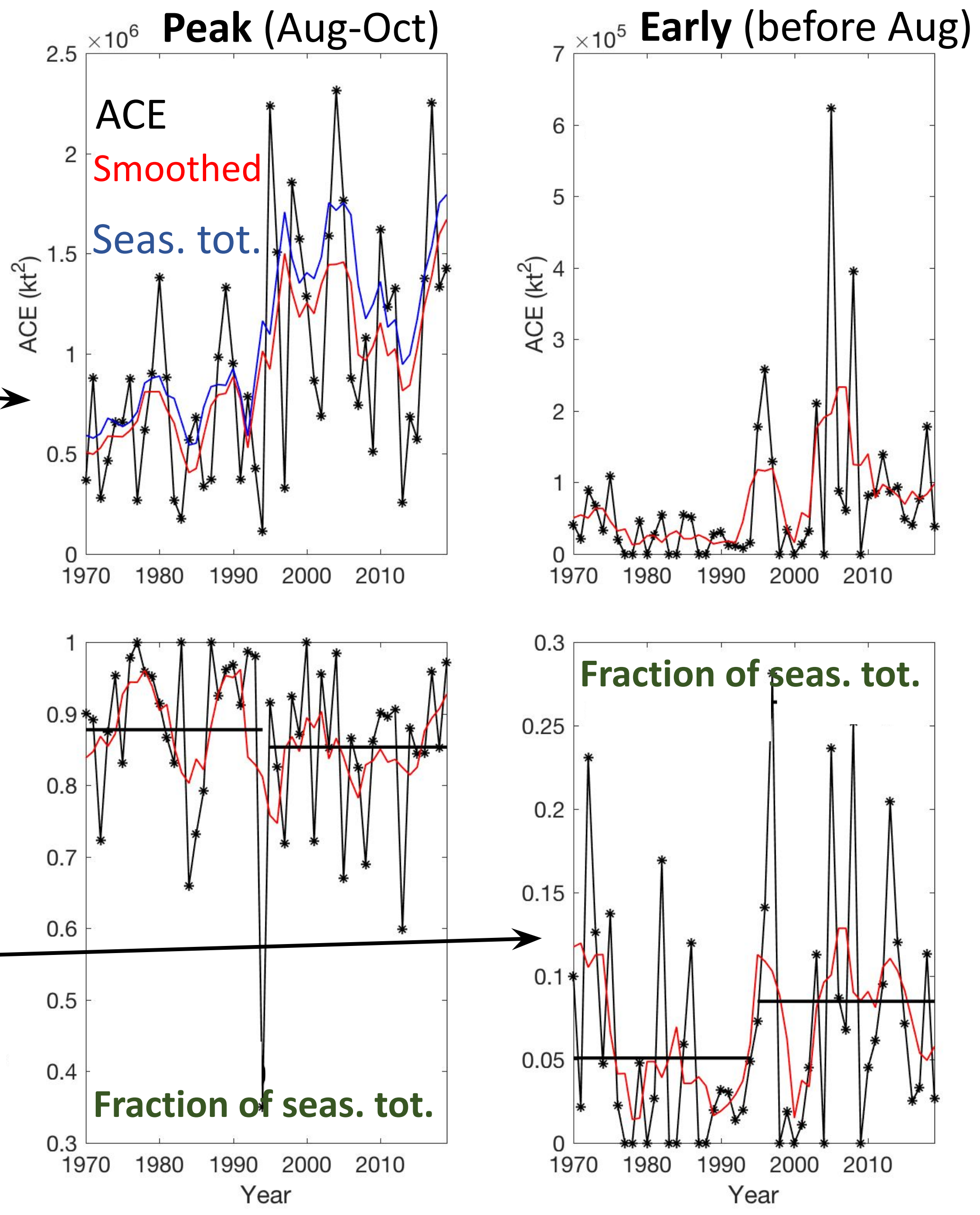
Accumulated Cyclone Energy (ACE): sum of squares of all 6-hr TC max. winds (>34 kt)

- **Early season**: concentrated closer to land (Gulf, U.S. East Coast), may be less prepared

Basinwide ACE since 1970

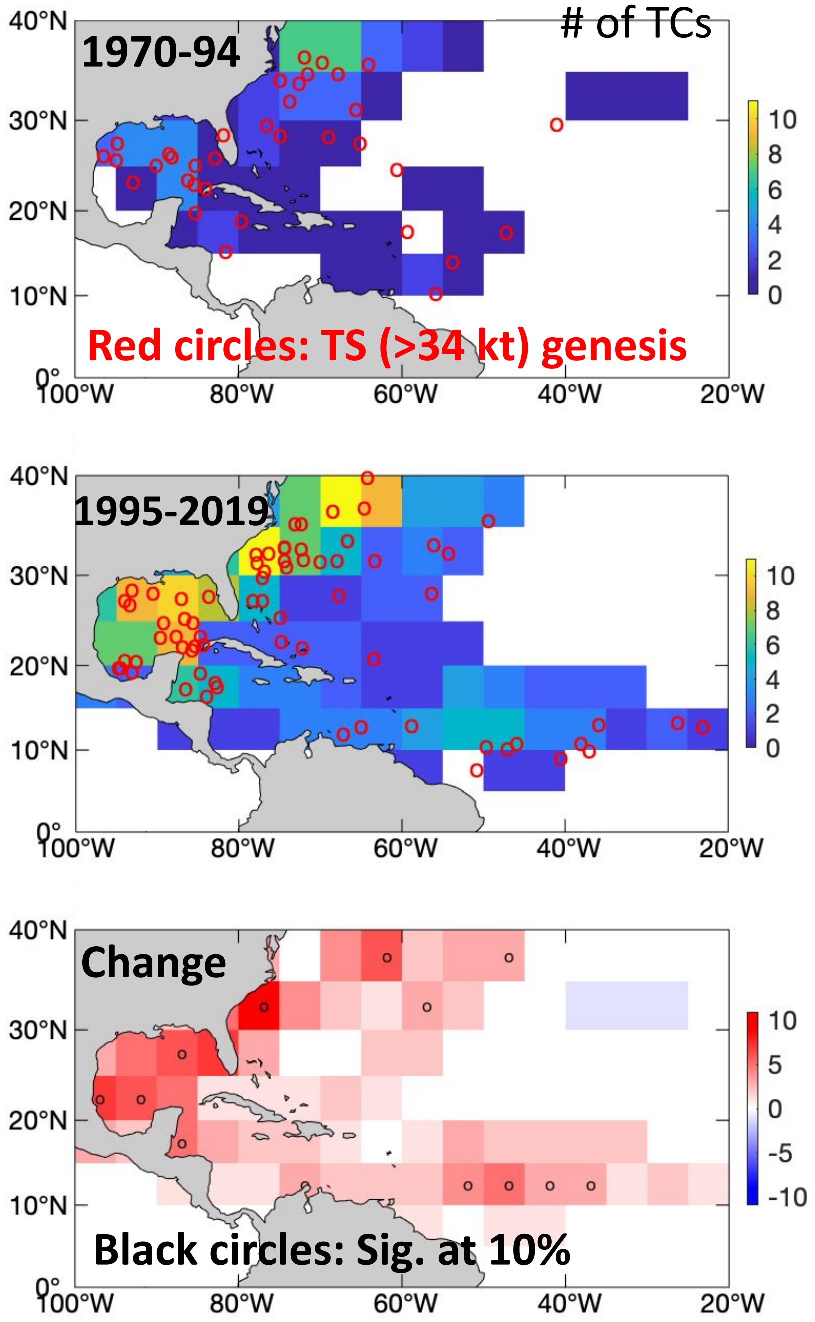
Increases in peak, early season ACE

Only early-season ACE has increased as fraction of total

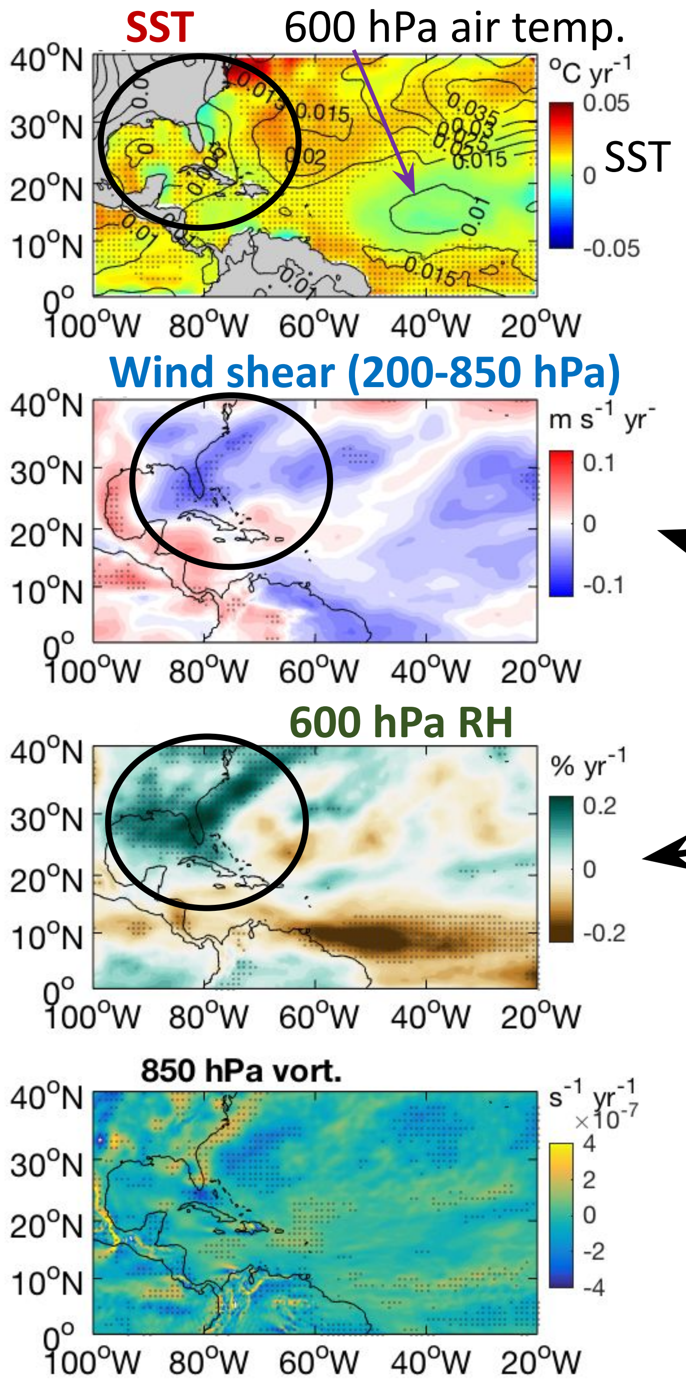


Changes in track density (pre-August)

- **80%** of track density increase, **90%** of ACE increase occurred **west of 60°W**



Linear trends (1979-2019)



Increases in SST, humidity, decrease in shear (all conducive to TC genesis/intensification)

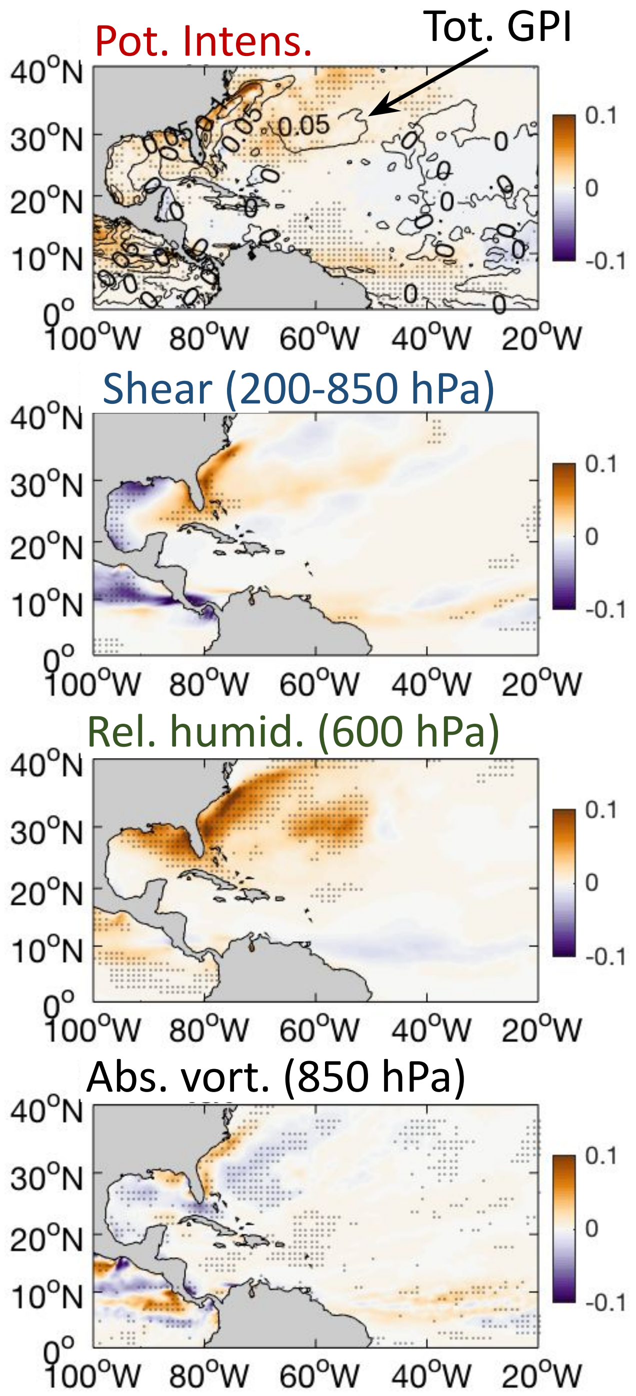
Quantification of factors driving TC activity increase

Genesis Potential Index (Camargo et al. 2007):

$$\mathrm{GPI} = |10^5\eta|^{\frac{3}{2}} \left(\frac{RH}{50}\right)^3 \left(\frac{1}{1+0.1V_{shear}}\right)^2 \left(\frac{V_{PI}}{70}\right)^3$$

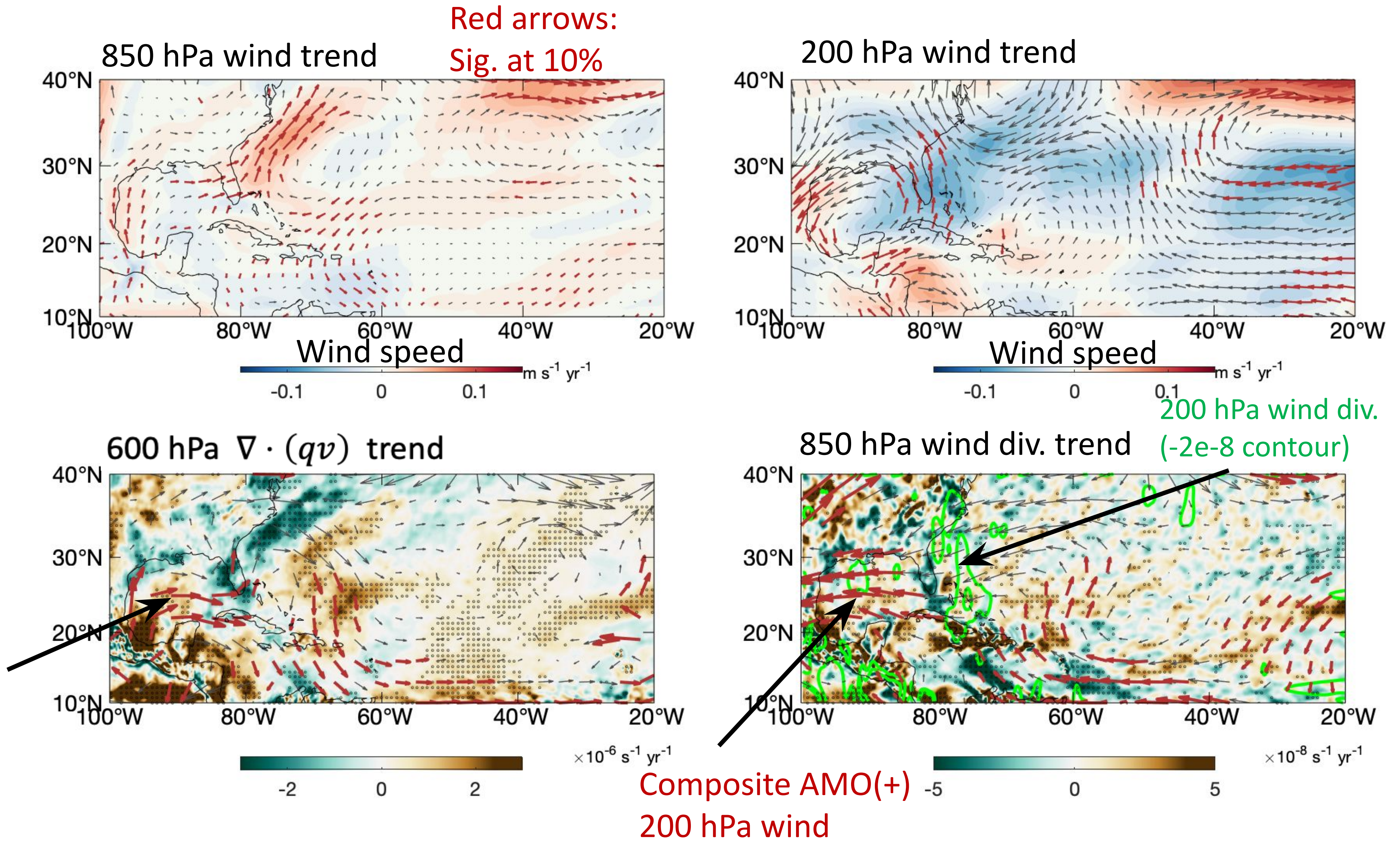
Vorticity — Humidity — Shear — Pot. Intens. (SST)

Humidity trend is most important



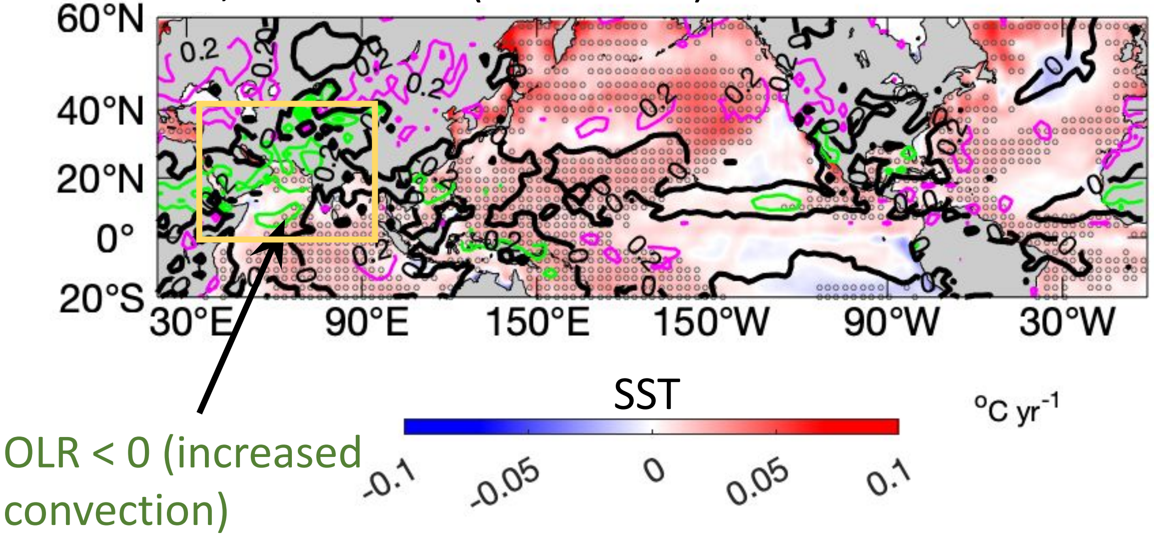
Explaining changes in shear, humidity

- Wind trends linked to N. Atl. warming
- Humidity trends driven by low-level winds

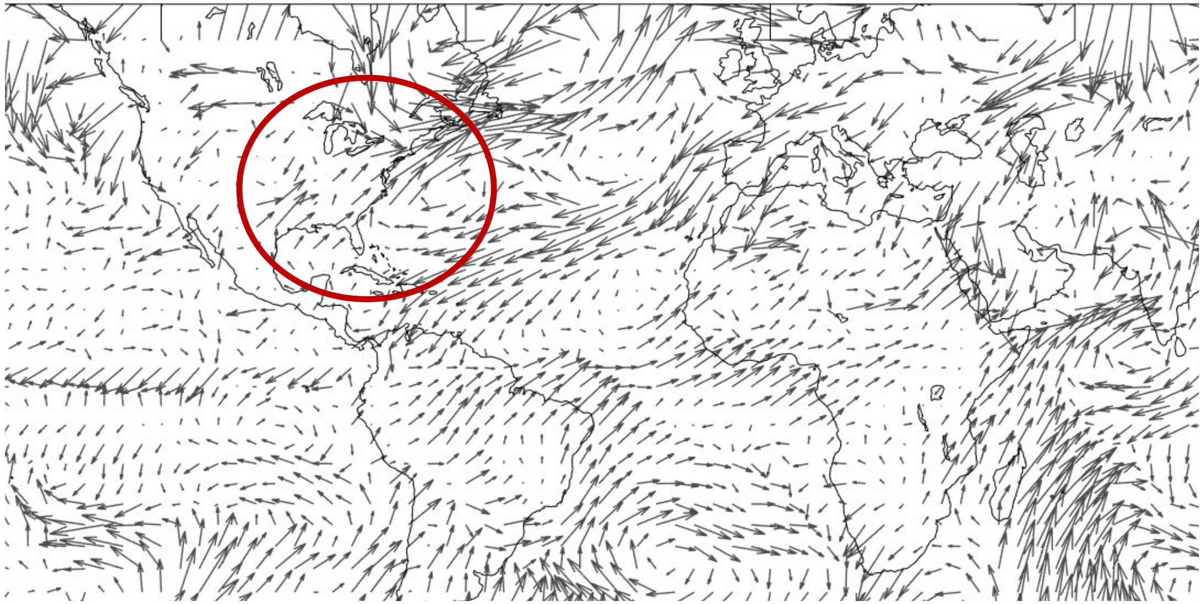


Potential forcing from Asian monsoon?

SST, OLR trends (1979-2019)



Composite 850 hPa winds for OLR(-)



- Increase in Asian monsoon convection (Latif et al. 2017, Park et al. 2020, Son et al. 2021) may also force changes in winds, shear in western Atlantic.

Summary

- Distinct increase in early-season (June-July) TC activity, concentrated mostly in Gulf of Mexico, off U.S. East Coast.

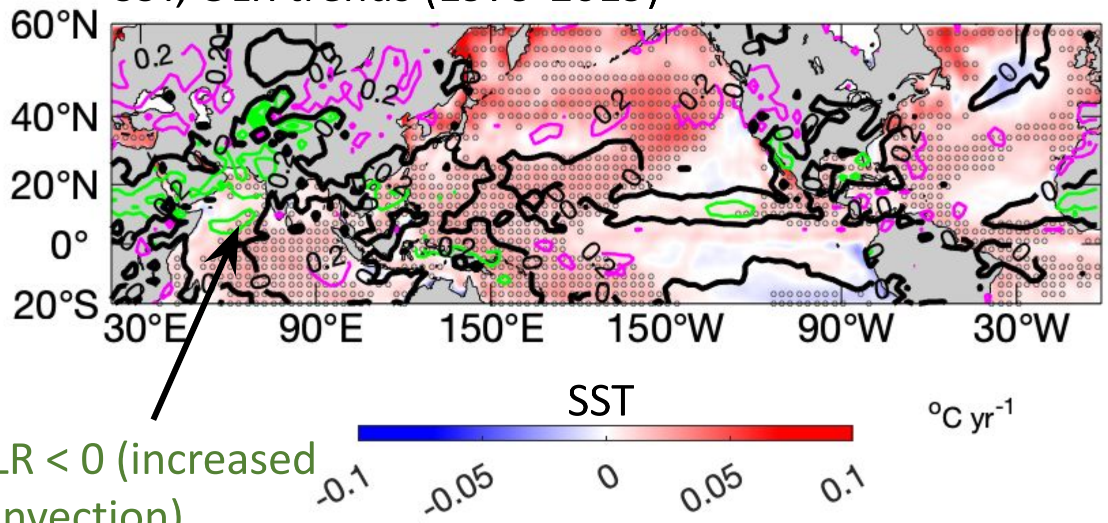
- Driven mainly by increase in mid-level humidity, decrease in shear. Both related to trends toward more westerly/southwesterly winds in lower troposphere.

- North Atlantic SST warming, Asian summer monsoon may have contributed to wind trends (more work needed). Increased frequency of atmospheric blocking events?

Potential forcing from Asian monsoon?

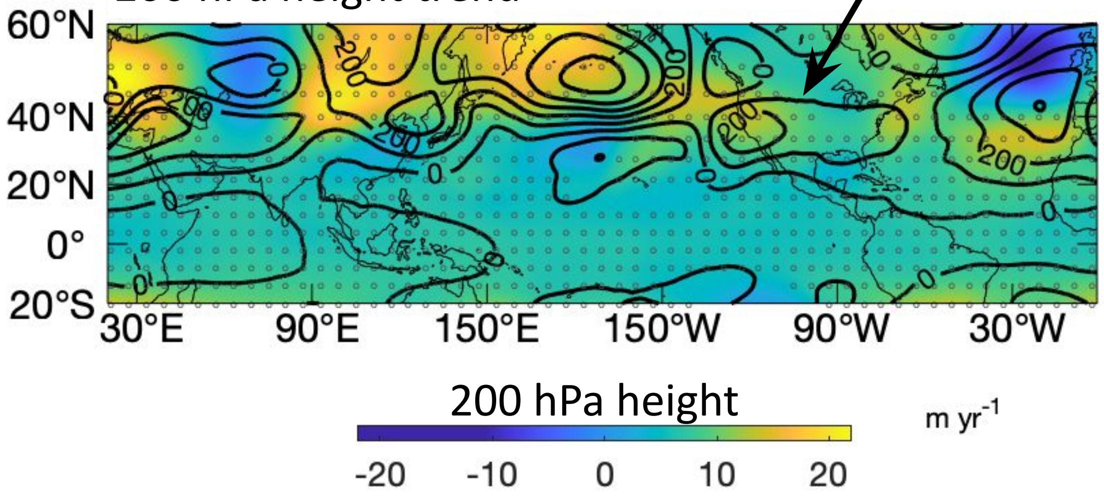
200 hPa height:
Composite strong monsoon

SST, OLR trends (1979-2019)



OLR < 0 (increased convection)

200 hPa height trend



- Increase in Asian monsoon convection (Latif et al. 2017, Park et al. 2020, Son et al. 2021) may also force changes in winds, shear in western Atlantic.