Is equatorial Atlantic variability resurging?

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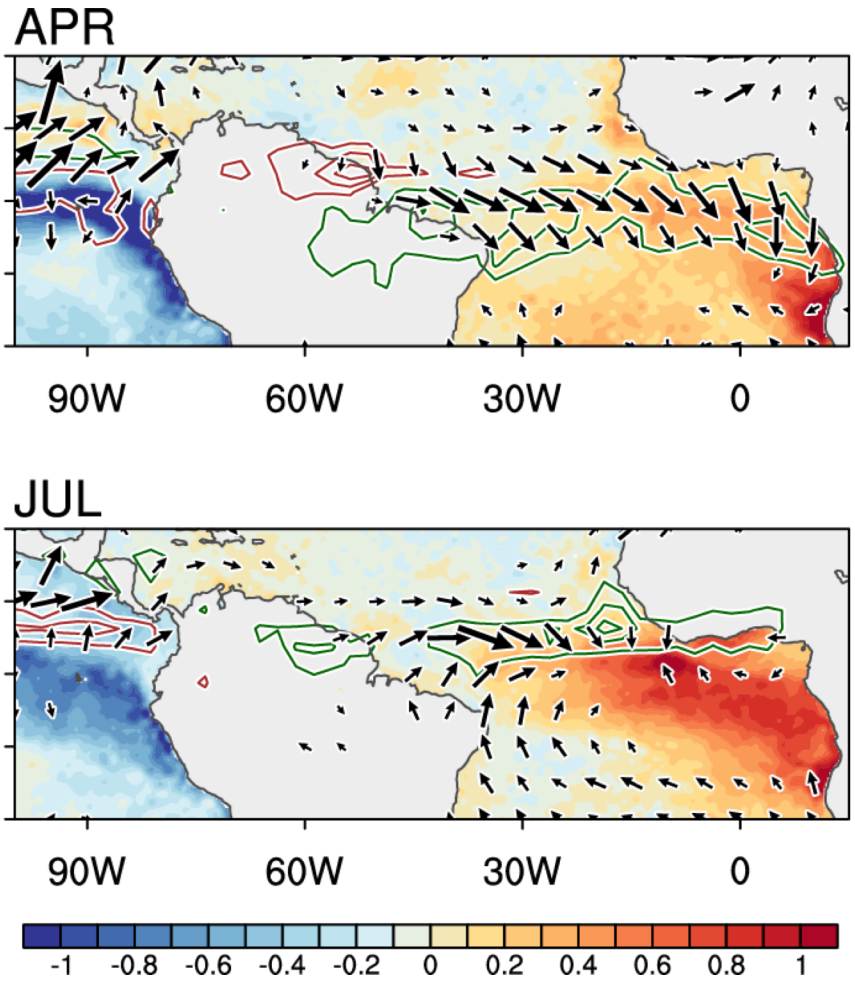
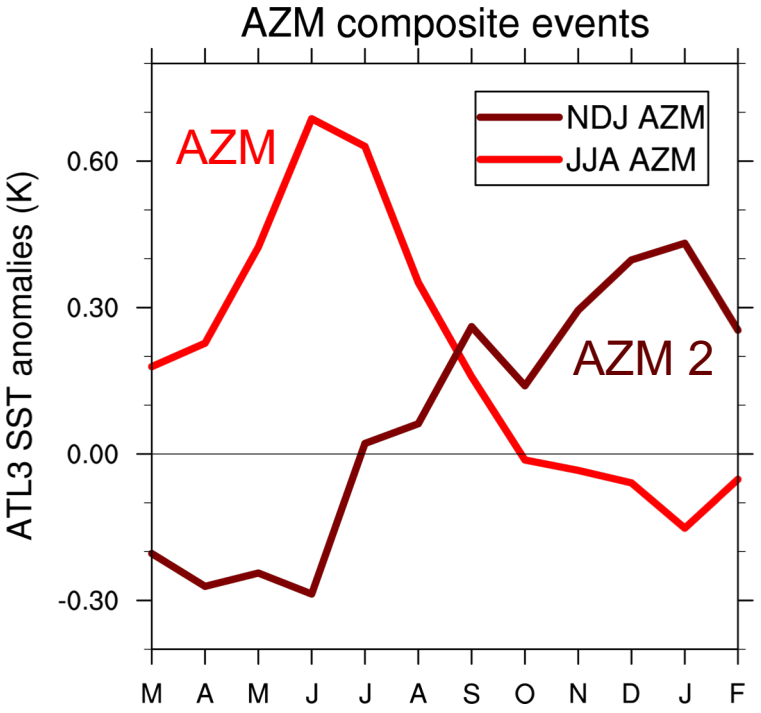
Background

Atlantic Zonal Mode
(also known as Atlantic Niño)

Composite positive AZM from ERA5

left: SST (shading), sfc wind (vectors), precip (cnt)





from Richter and Tokinaga (2021)

Background

recent decline in AZM activity

Decreasing variability in recent decades

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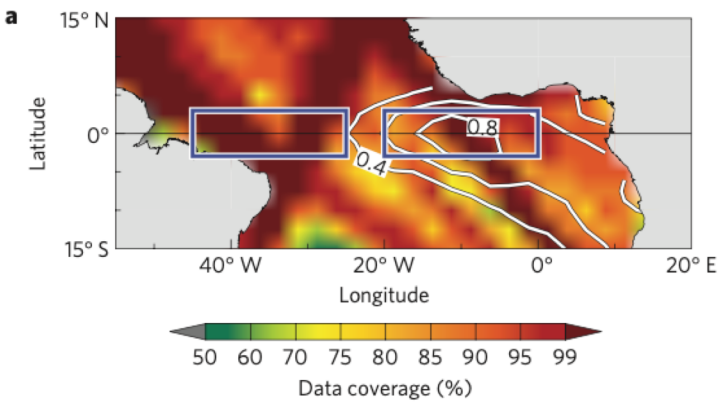
nature geoscience

Weakening of the equatorial Atlantic cold tongue over the past six decades

Hiroki Tokinaga[1]* and Shang-Ping Xie[1,2]

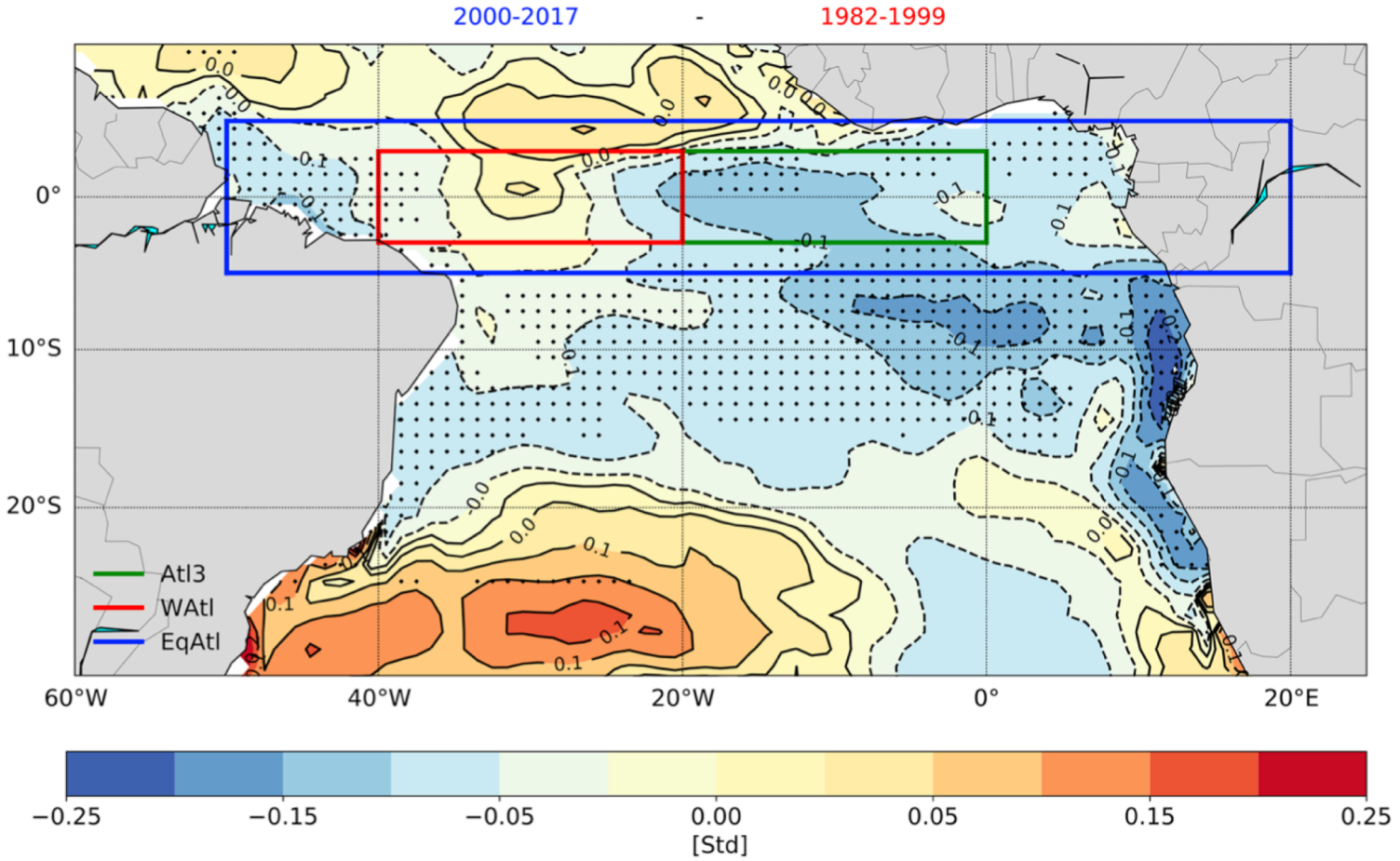
Seasonal and interannual variations of the equatorial cold tongue are defining features of the tropical Atlantic Ocean, with significant climatic[1–3] and biogeochemical[4] effects. However, its long-term changes are poorly understood owing to biases in observations and climate models[5]. Here we use a suite of bias-corrected observations, and find that cold-tongue variability has weakened during the past six decades. We find that sea surface temperature has increased across the basin, with a local enhancement over the eastern equatorial Atlantic. This warming pattern of the sea surface is most pronounced during boreal summer, reducing the annual cycle through a positive ocean–atmosphere feedback. Specifically, the eastward-intensified warming leads to enhanced atmo-



from Tokinaga and Xie 2011

Decreasing variability in recent decades

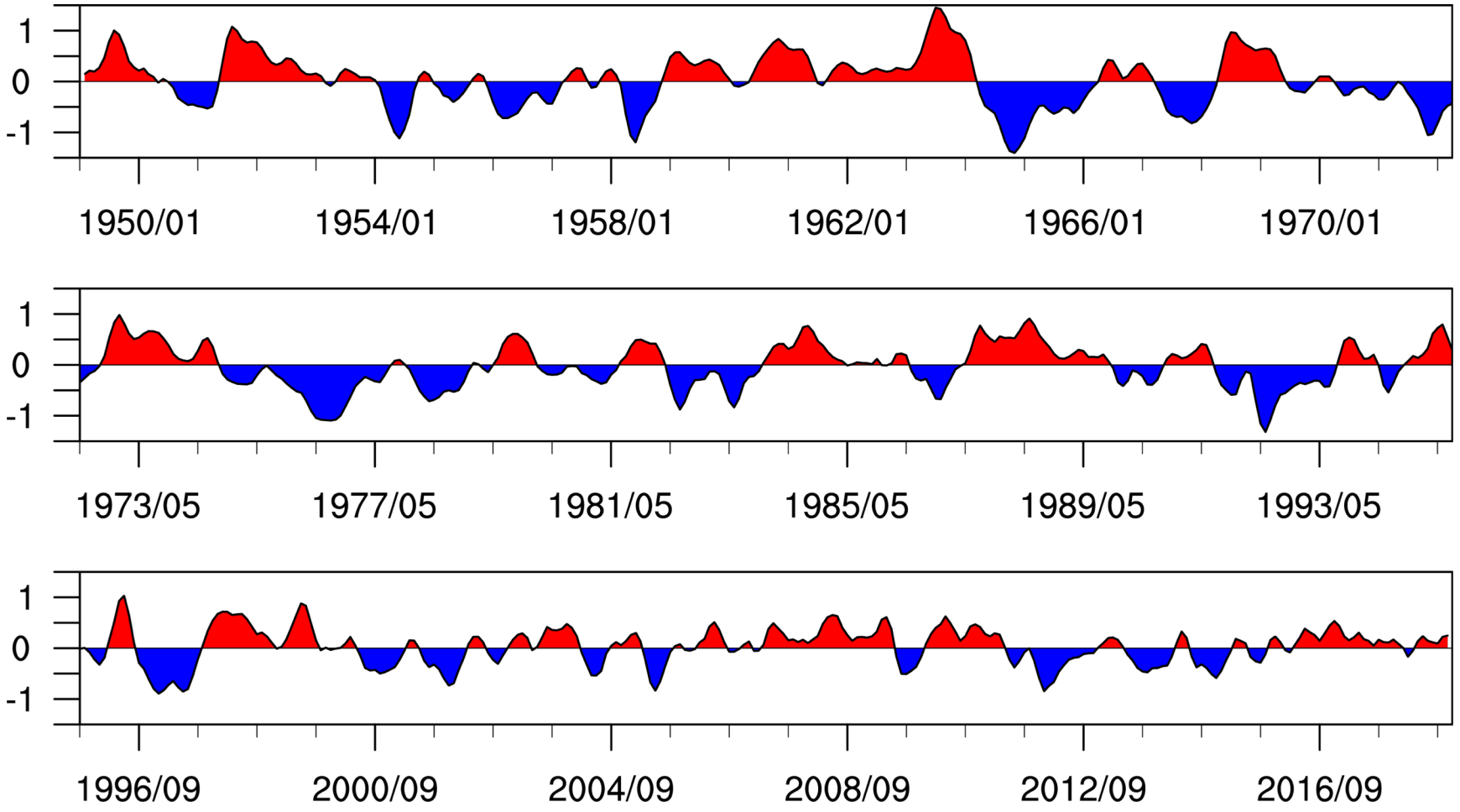
ORAS4 SST std dev (K): 2000–2017 minus 1982–1999



from Prigent et al. 2020

ATL3 time series 1948-2018

NCEP/NCAR Reanalysis



from Richter and Tokinaga (2021)

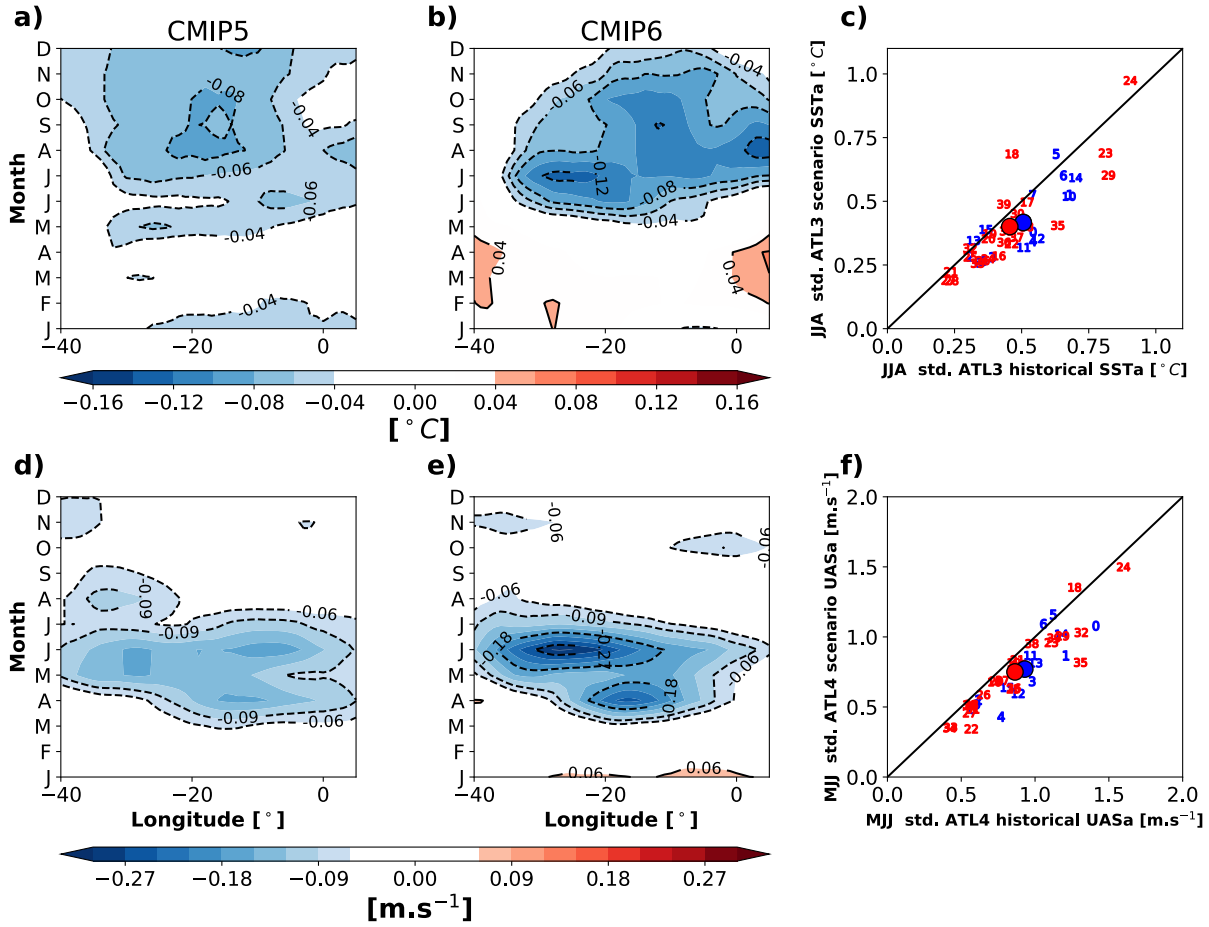
Projected decrease in eq Atl variability

std dev of SST (top) and u10 (bottom), 3S-3N

(2050-2099, ssp585) minus (1950-1999, historical)

SST variability

zonal wind variability

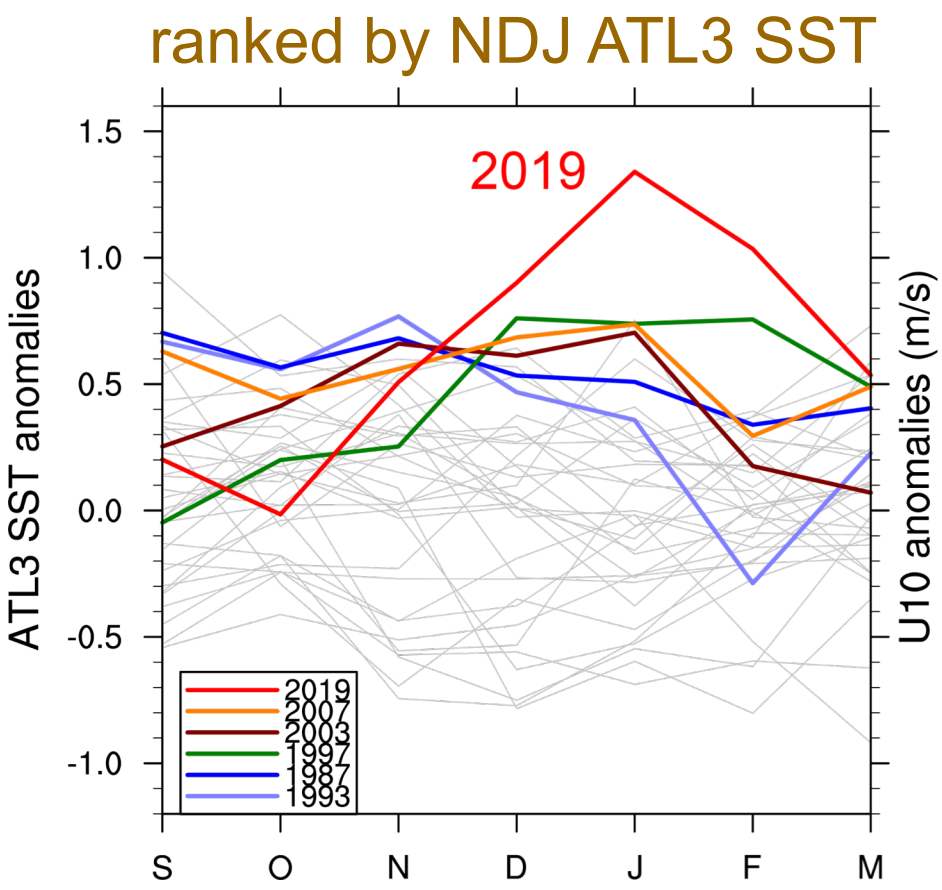


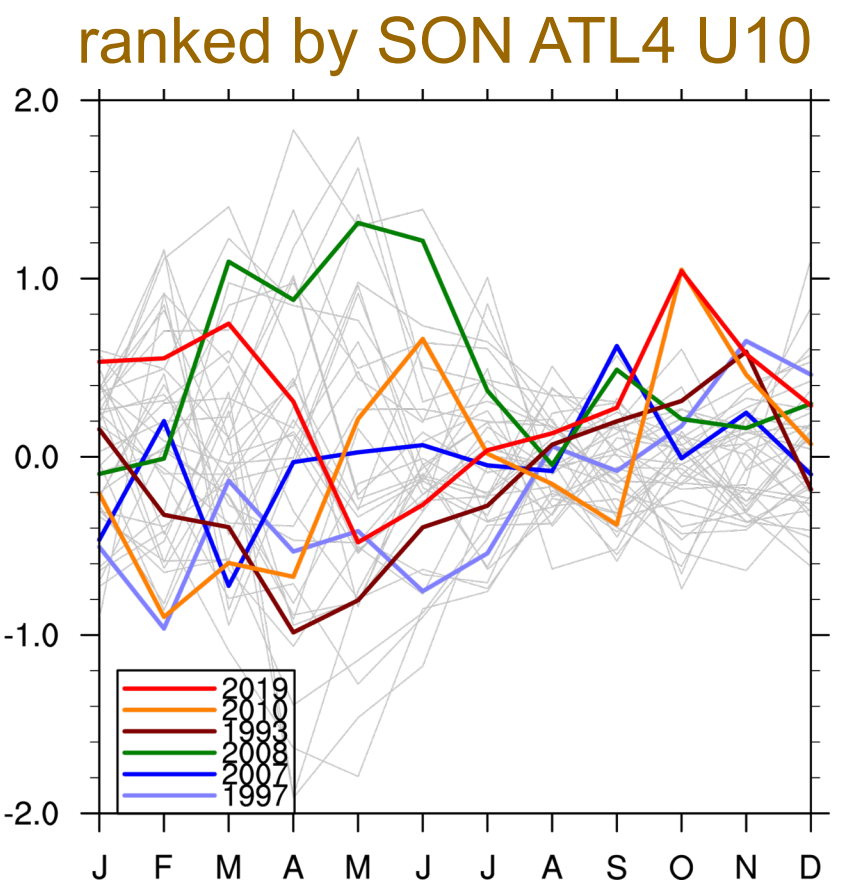
from Lander et al. (2022; under review)

The 2019/2020 and 2021 events

The 2019 event

all years in the ERA5 record (1979-2021; linearly detrended; 6 strongest events colored)

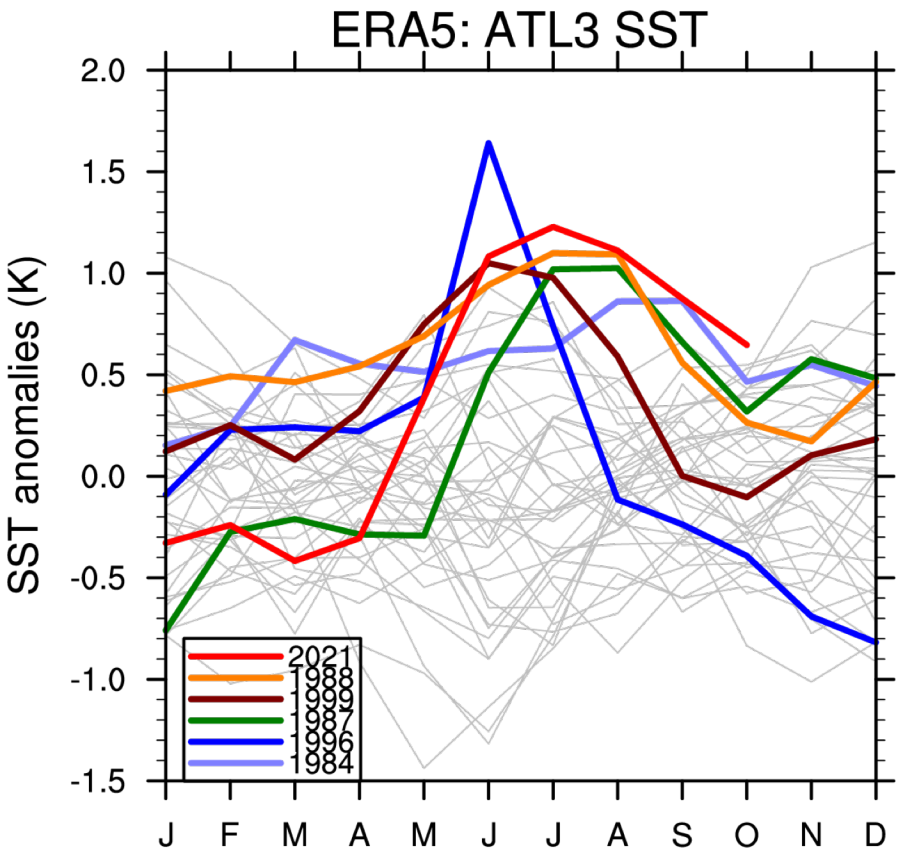




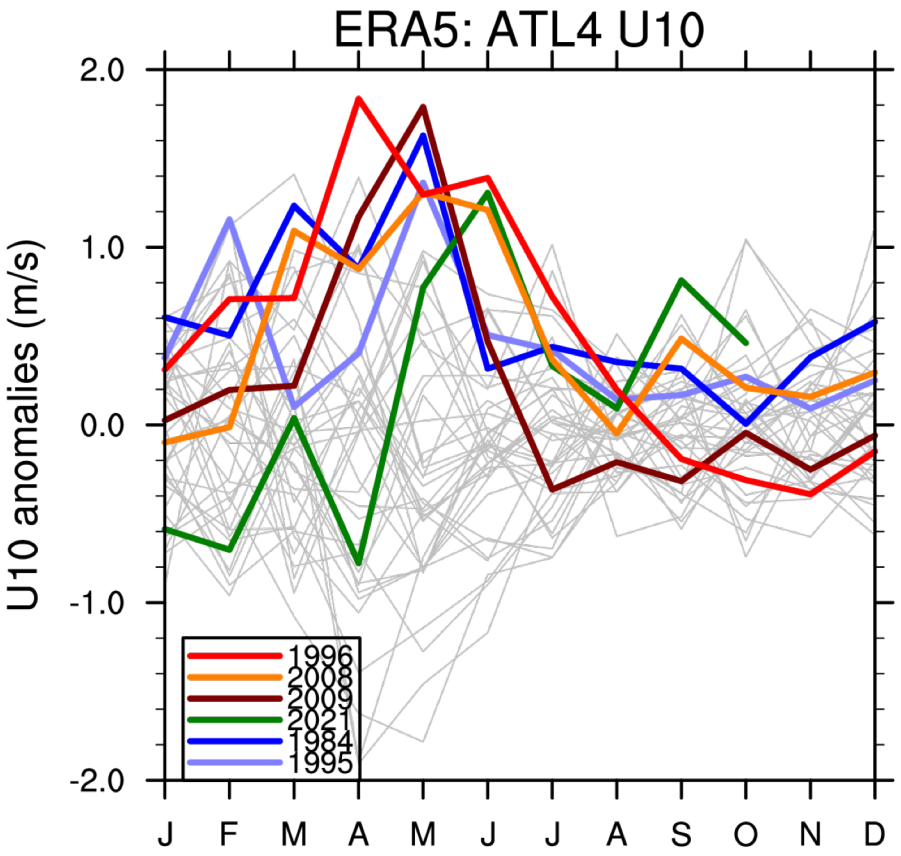
The 2021 event

all years in the ERA5 record (1979-2021; linearly detrended; 6 strongest events colored)

ranked by JJA ATL3 SST

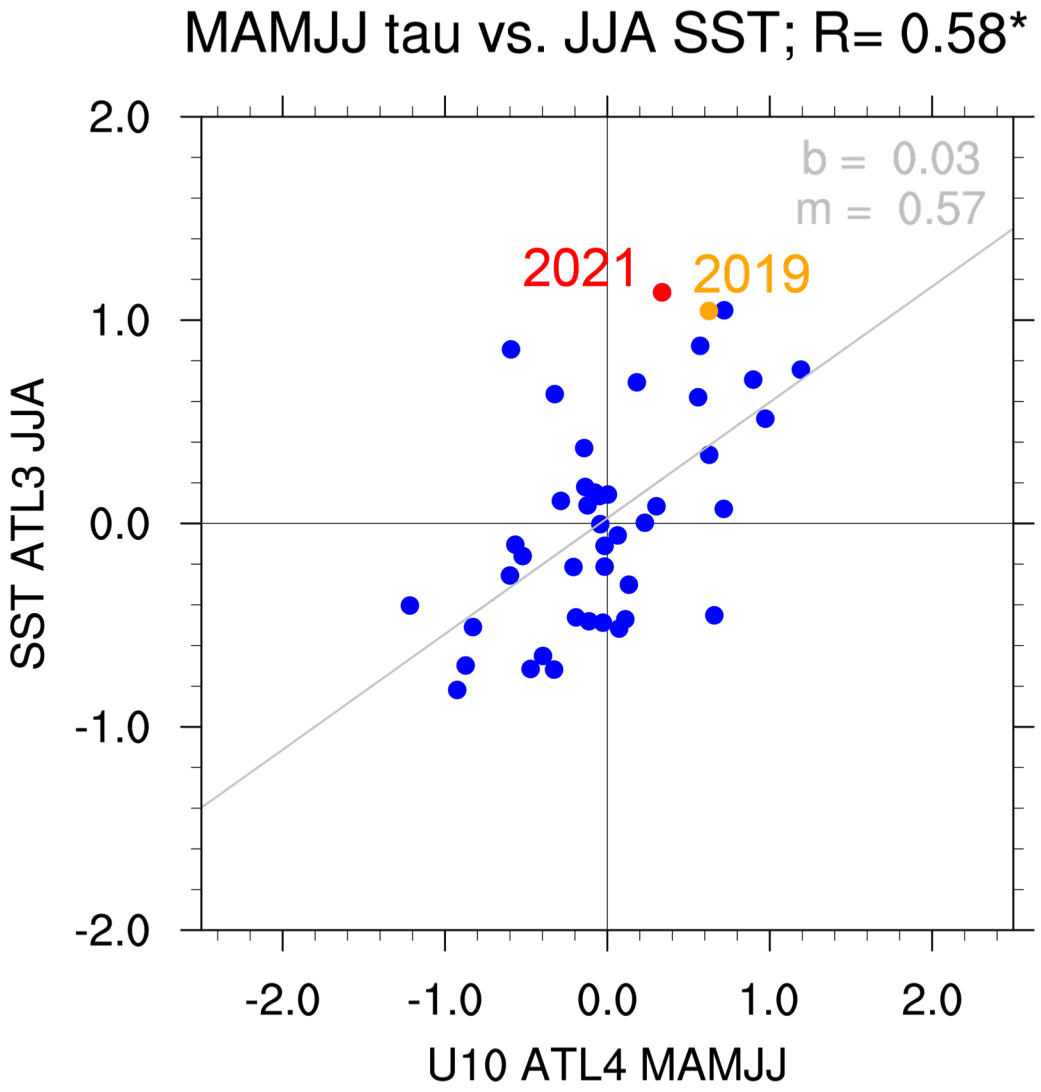


ranked by MJ ATL4 U10



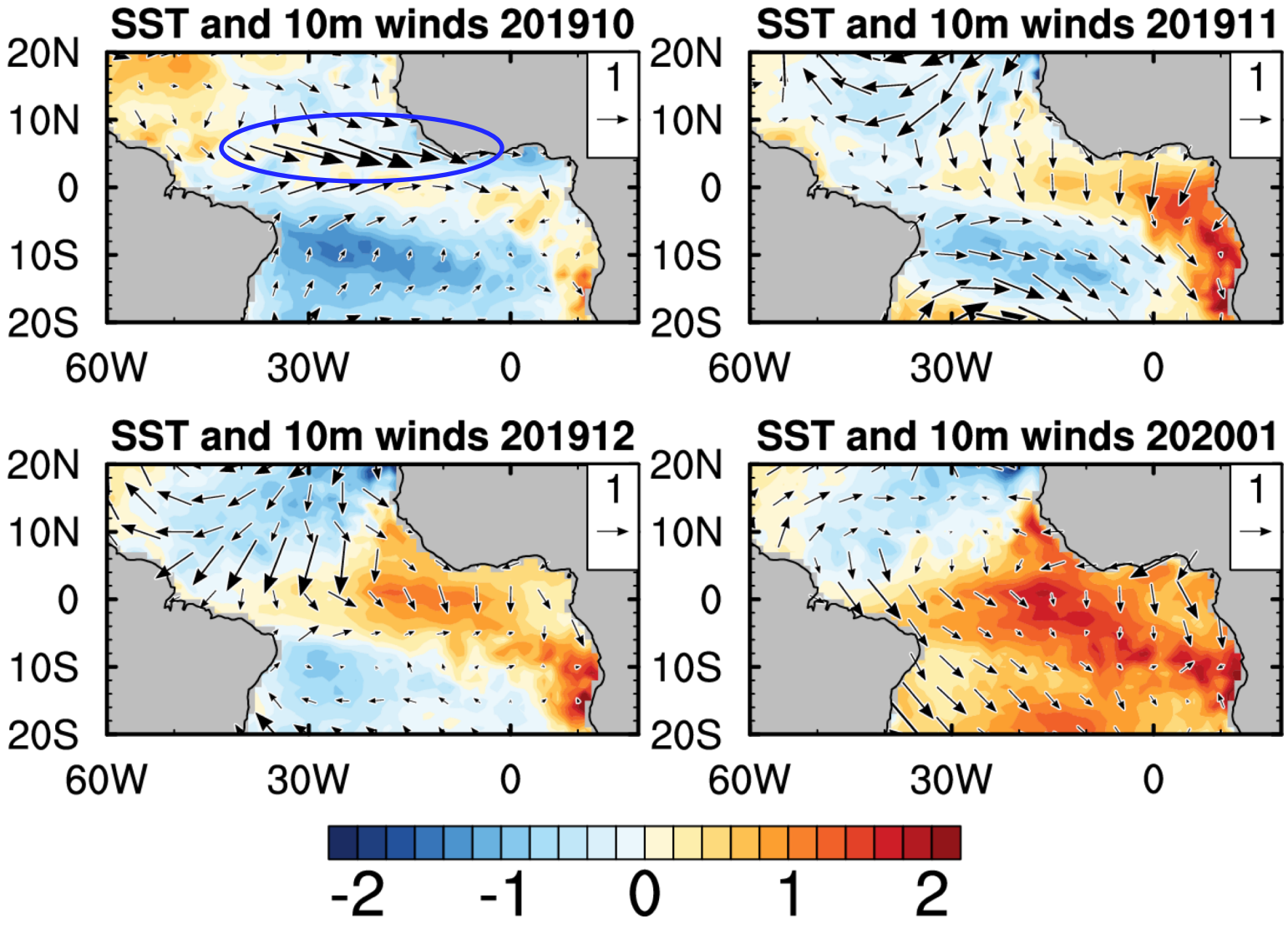
x-axis: ATL U10 anomalies MAMJJ
y-axis: ATL3 SST anomalies JJA

2019 and 2021 had disproportionally large SST anomalies, relative to the equatorial wind forcing -> other processes at play? E.g., off-equatorial wind anomalies?



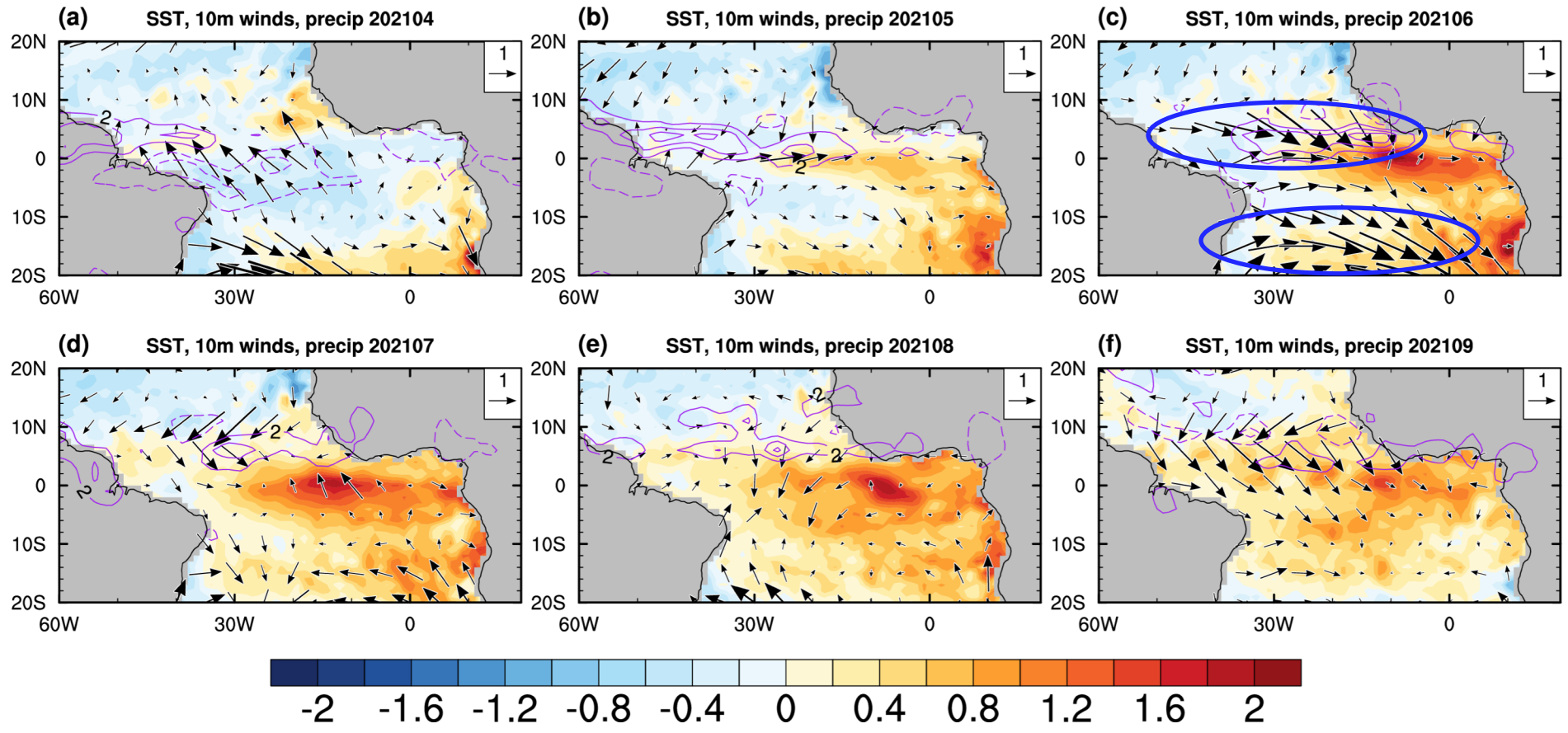
Evolution of the 2019/2020 event

SST (shd) and 10m winds (vect) in ERA-5



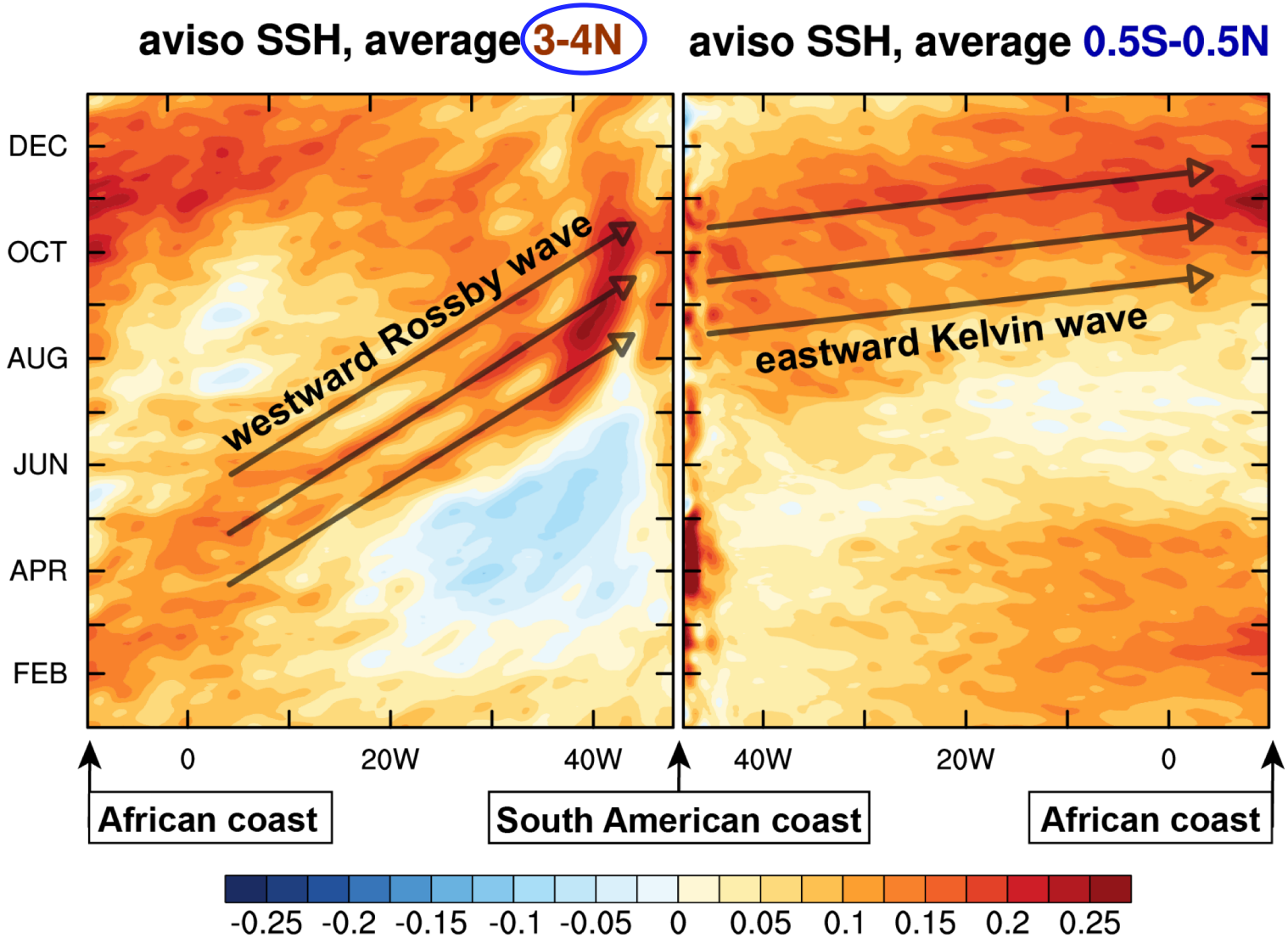
Evolution of the 2021 event

ERA5 SST (shd), 10m wind (vect); GPCP pr (cnt)



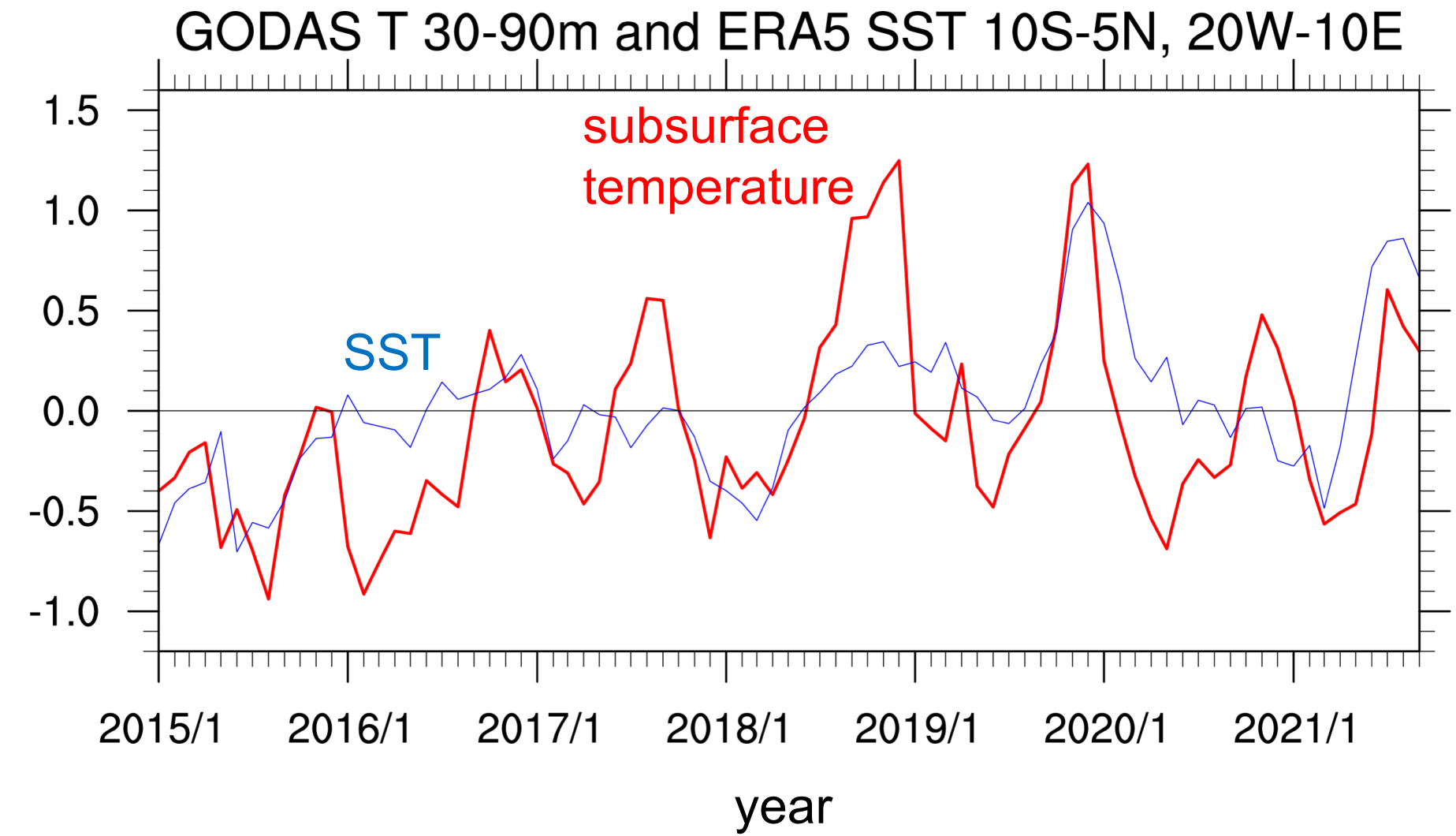
Off-equatorial influences 2019

AVISO SSH



Oceanic heat build-up

subsurface heat content gradually increased from 2015 onward; discharge in 2019, 2021?



Summary

- strong positive AZM events occurred in 2019/2020 and 2021
- this ended 20-year quiescent period
- events likely strongest in ~40 years
- event development rather canonical, but strength somewhat surprising, given wind forcing
- off-equatorial Rossby waves may have contributed
- future of AZM uncertain; continued (in-situ) monitoring crucial
- variability increase consistent with global warming projections?