El Nino and its global influence in a warming climate

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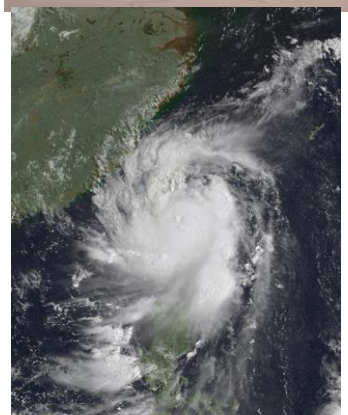
- El Nino
- Global impacts (Peru, N America, Asia)
- 2023-24 anomalies
- Warming climate

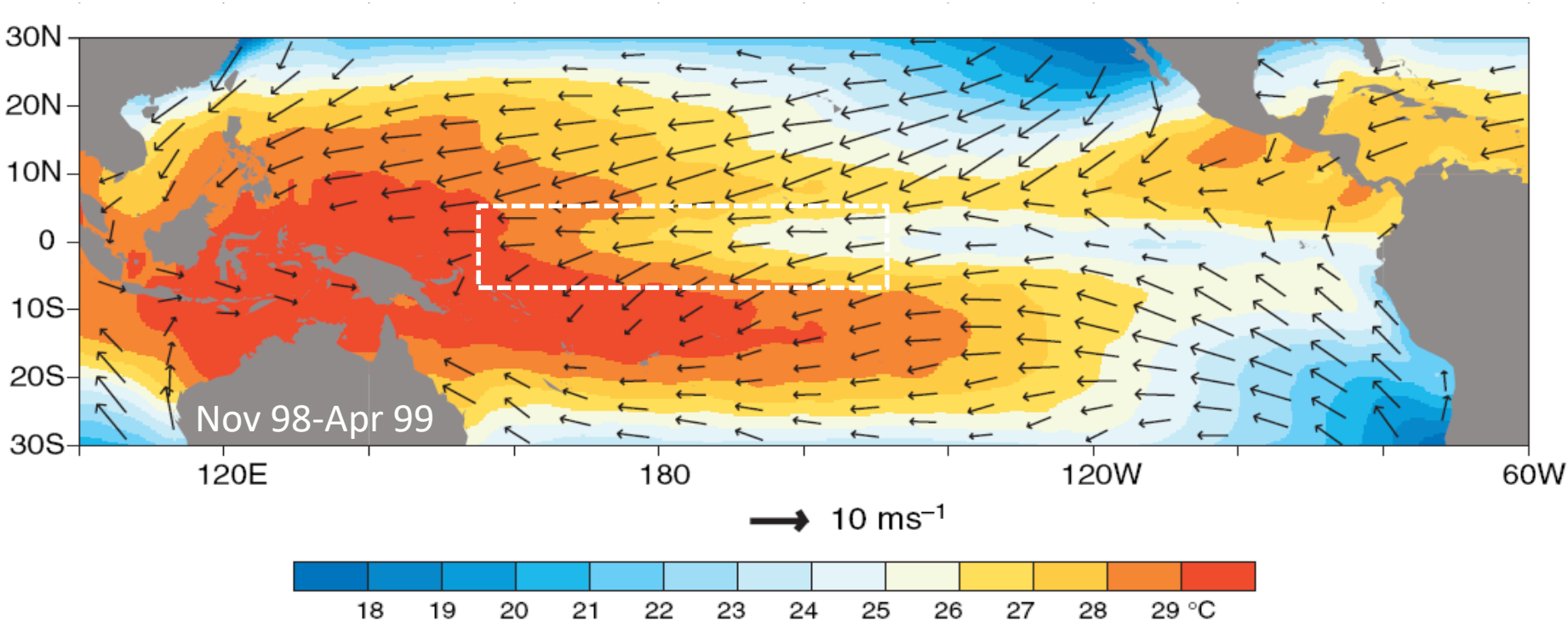
Jul-Aug 1998, Yangtze River flooding



3 Aug 1998, late onset of typhoon season

Time

Weather disasters Sept 1997-Aug 1998, all induced by El Nino in remote eq Pacific



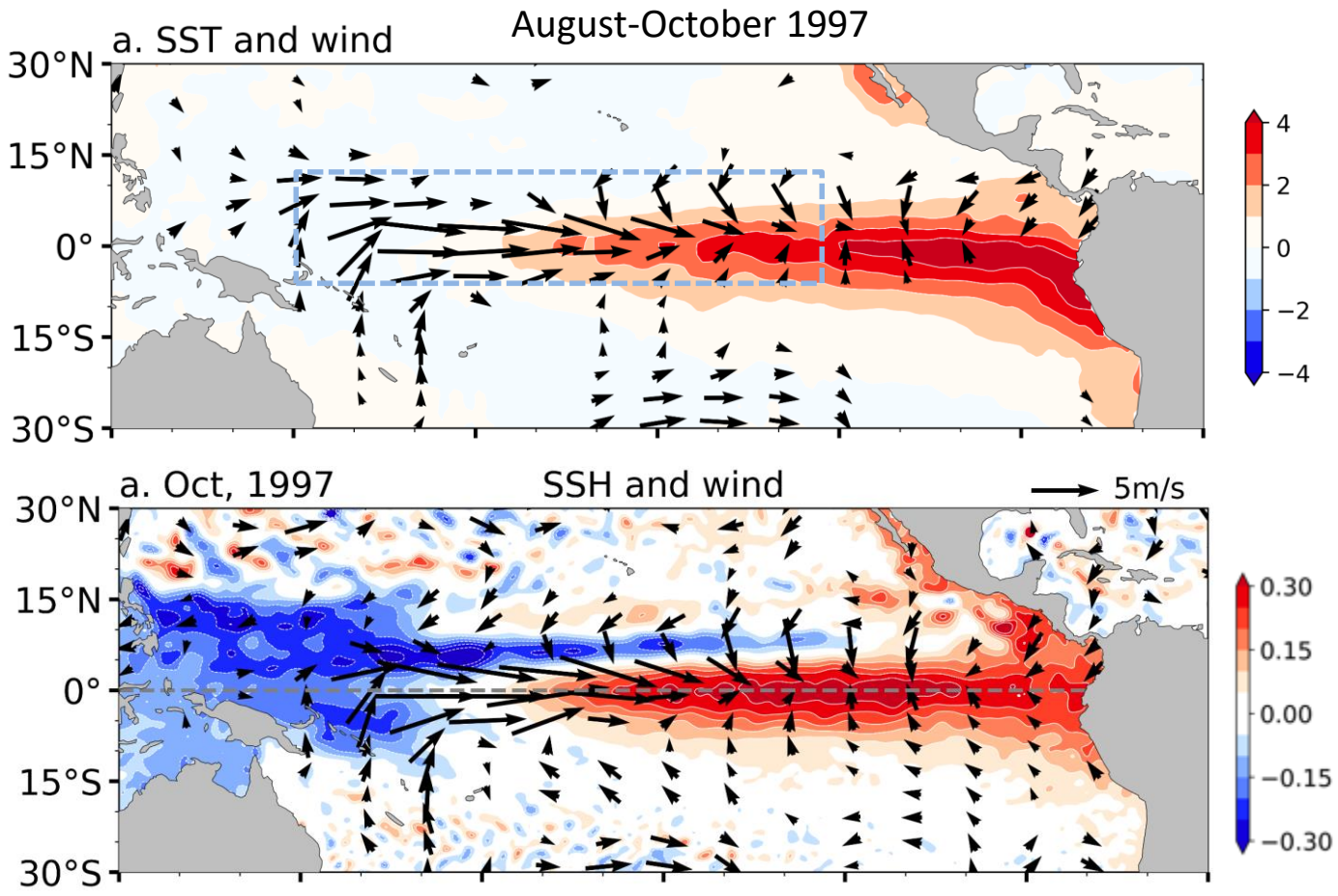
SST and surface winds during November-April of 1997-98, and 1998-99.

Fig. 9.4

El Nino: An anomaly view

El Nino

Relaxed trades/Southern Oscillation

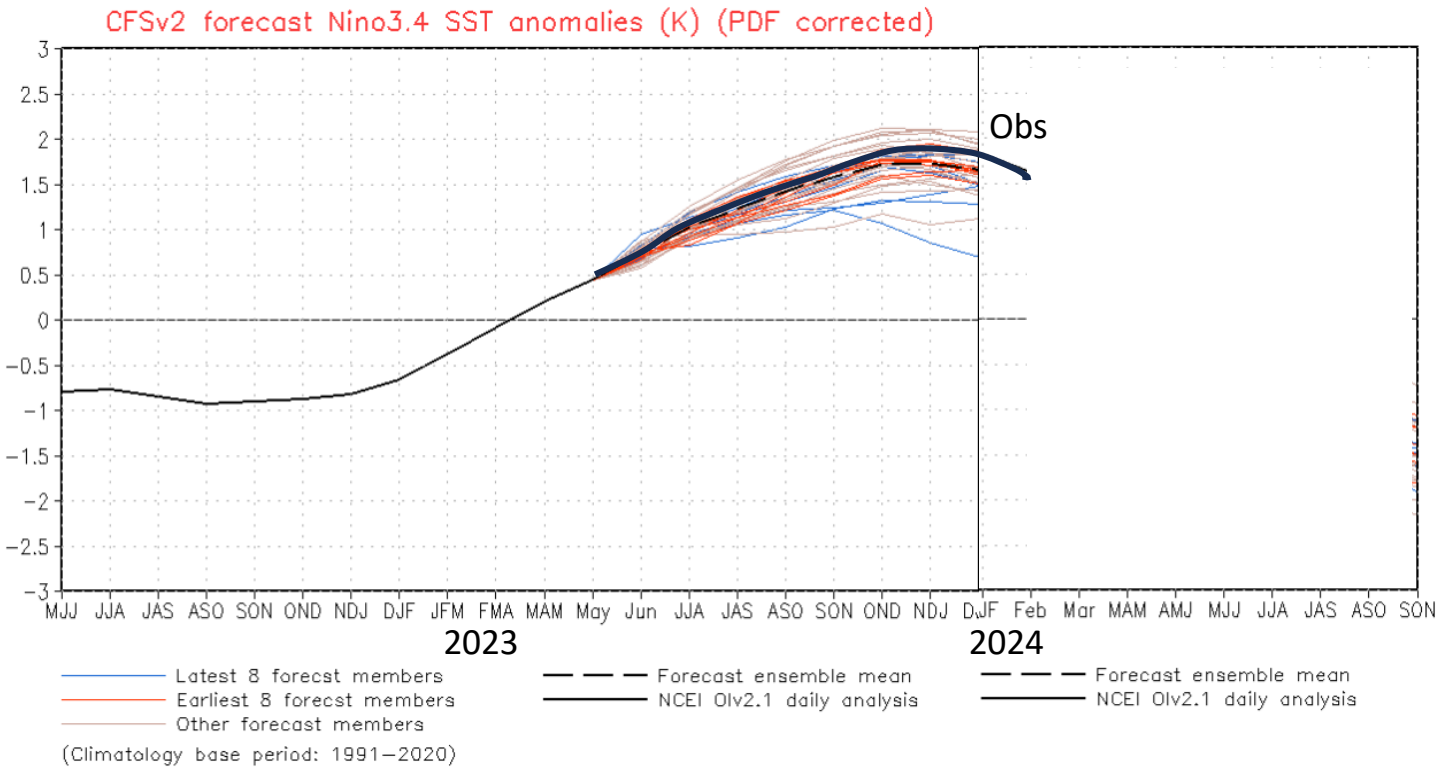


Westerly wind anomalies deepen the thermocline in the eastern eq Pacific while lifting the thermocline in the western Pacific off the equator.

Initializing ocean allows prediction of ENSO and other seasonal mean statistics

NCEP CFS.v2 Forecast Issued: 22 May 2023

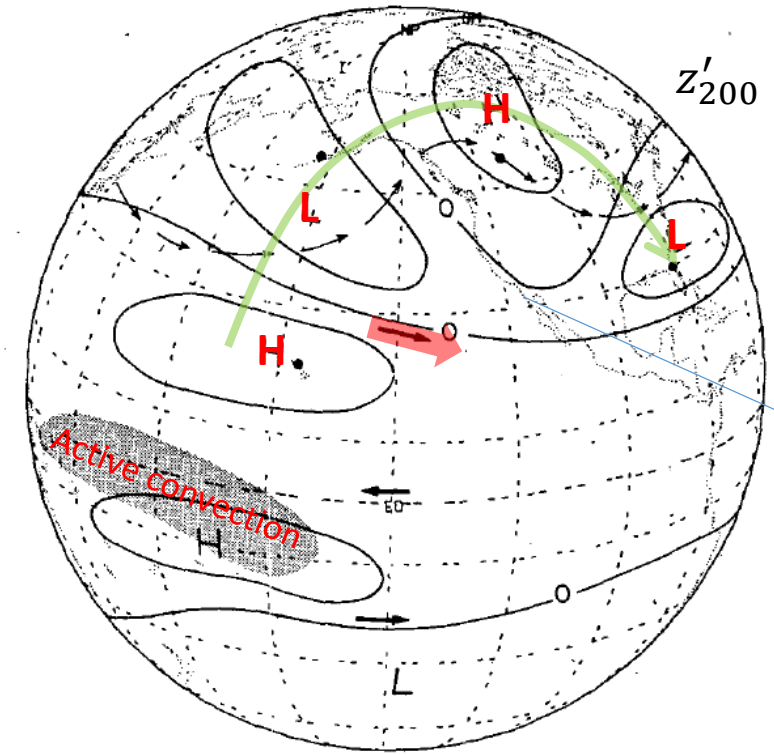
The ensemble mean (black dashed) favors a strong El Niño in winter 2023-24.



Pacific-North American pattern

Teleconnection out of tropics during El Nino winter

- Intensified Pacific westerly jet that extends closer to N America.
- Steers storms towards California with increased rainfall and high surfs.



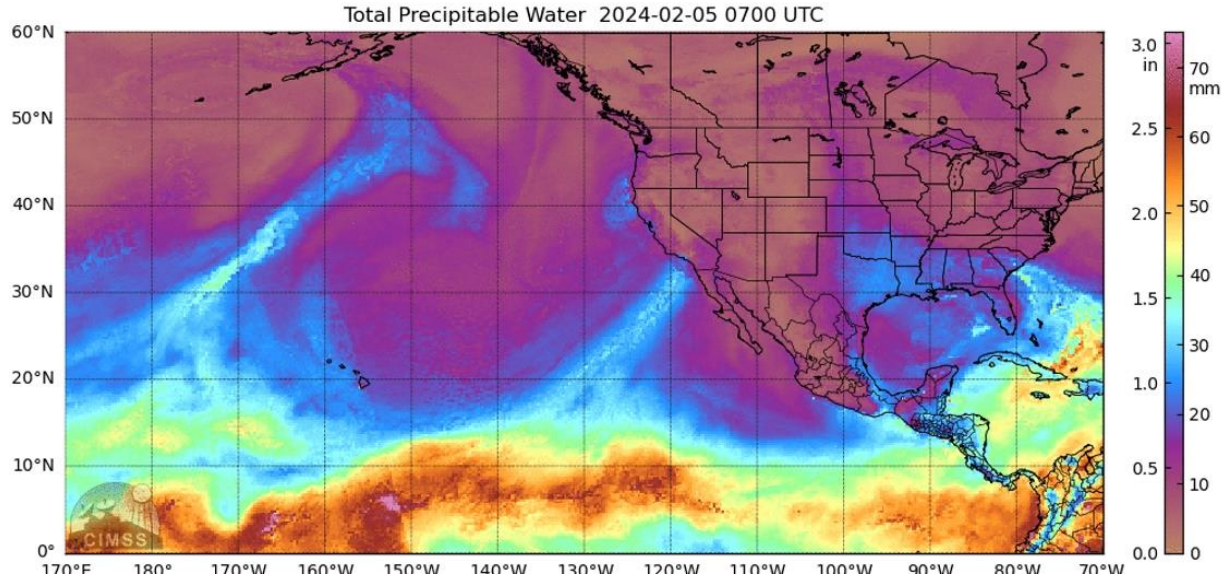
An SUV sits buried by a mudslide, Feb. 5, 2024, in Beverly Crest, LA. (AP Photo/Marcio Jose Sanchez)

San Diego, Jan 24, 2024

Atmospheric River

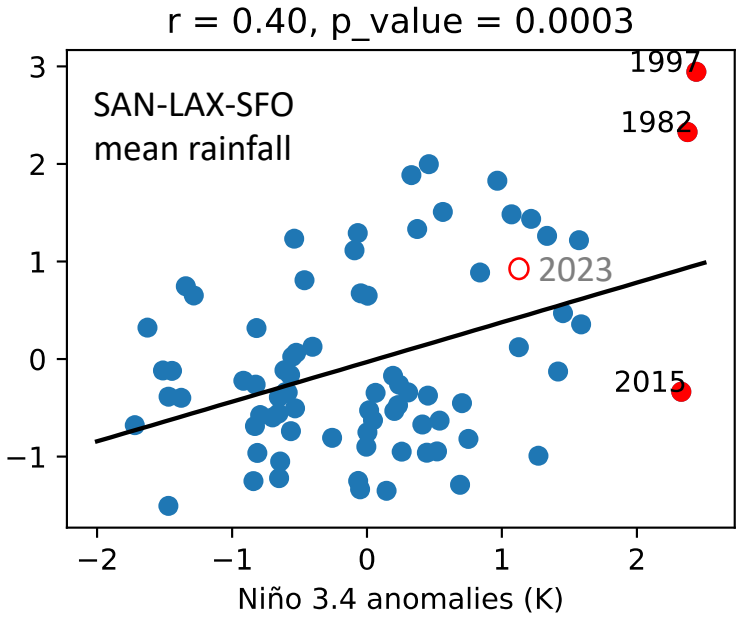
3-day (2/4-6) airport rainfall totals (inches)

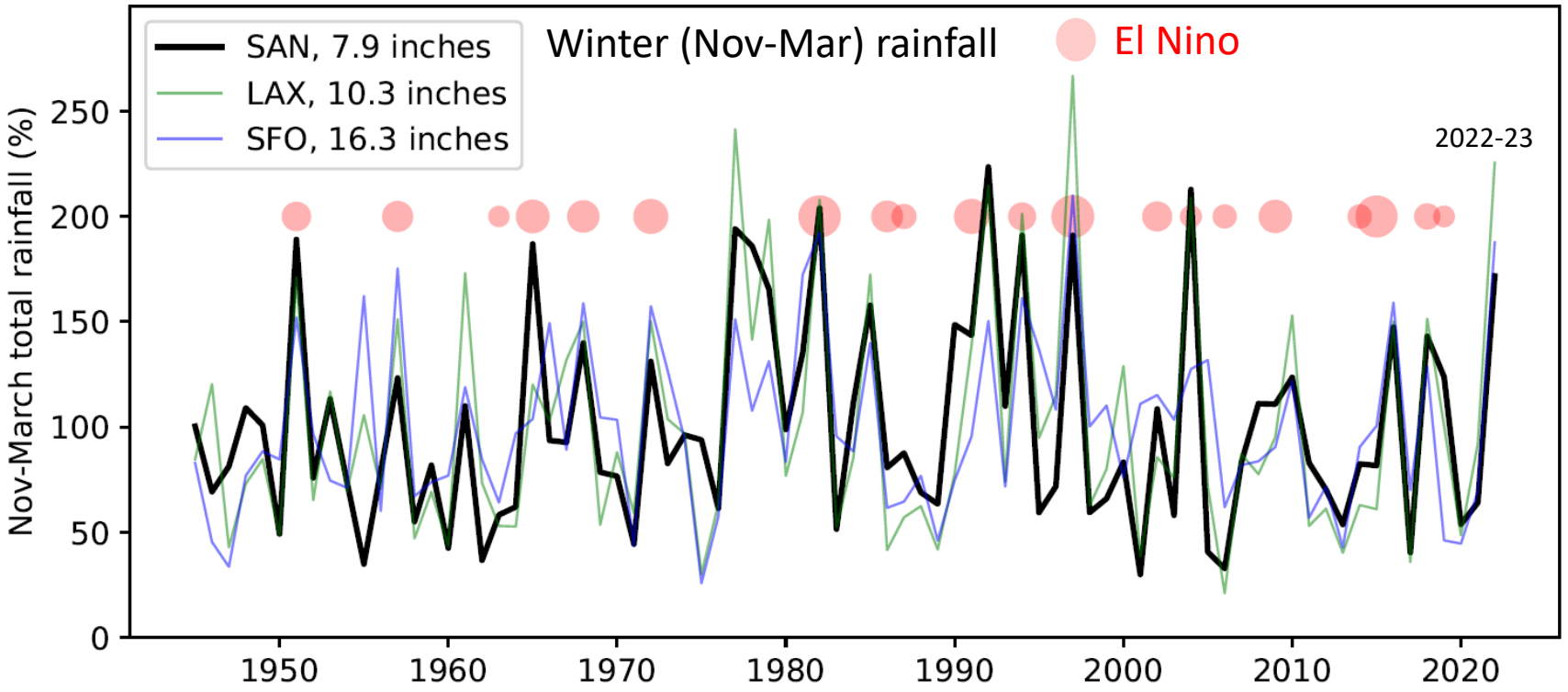
- LAX 5.41
- Riverside 3.93
- John Wayne 3.77
- San Diego 1.92



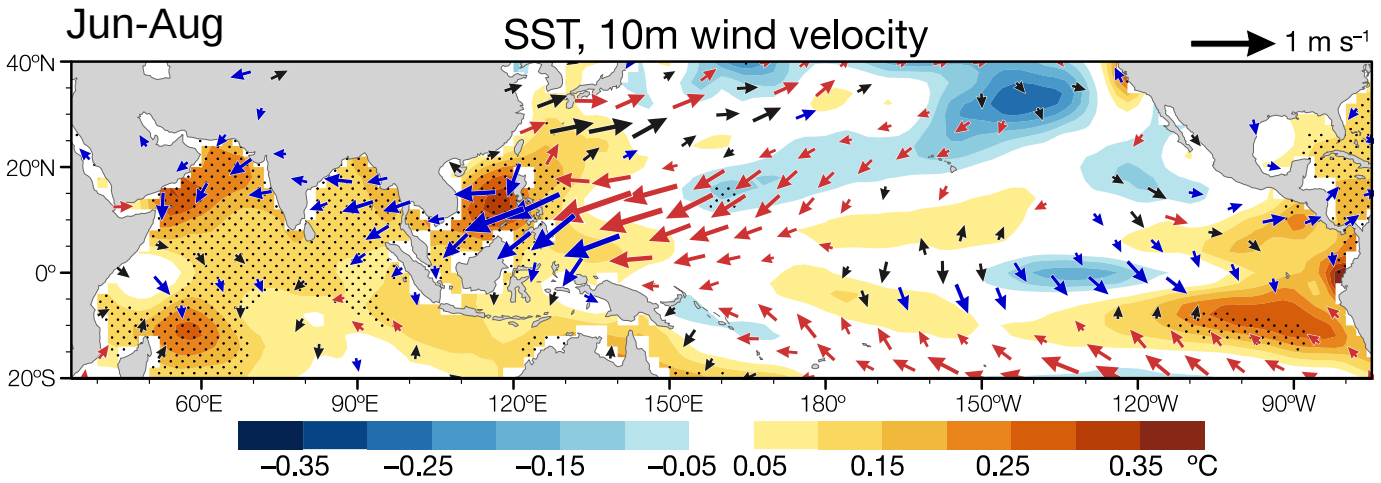
ENSO modulates odds of wet/dry winter.

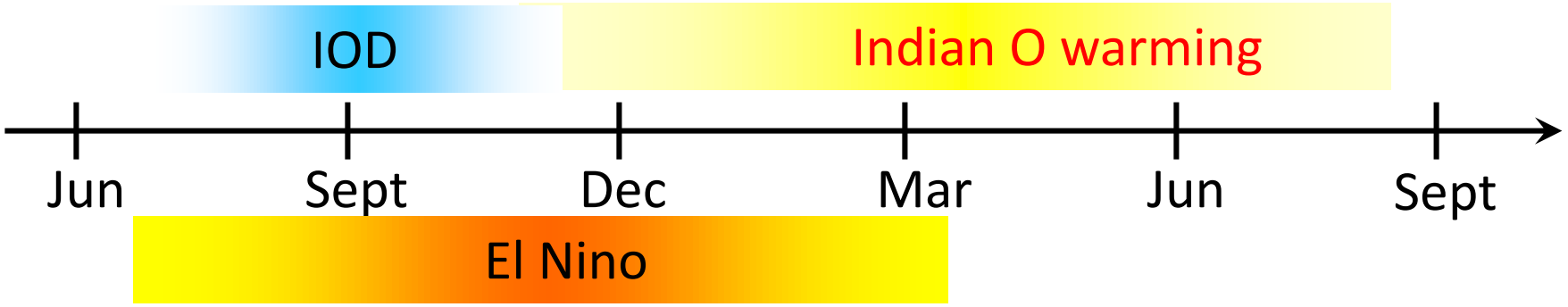
- SAN/LAX/SFO co-vary.
- Significant correlation b/w ENSO and Cal winter rainfall.
- Non-ENSO variability is quite large, limiting predictability.

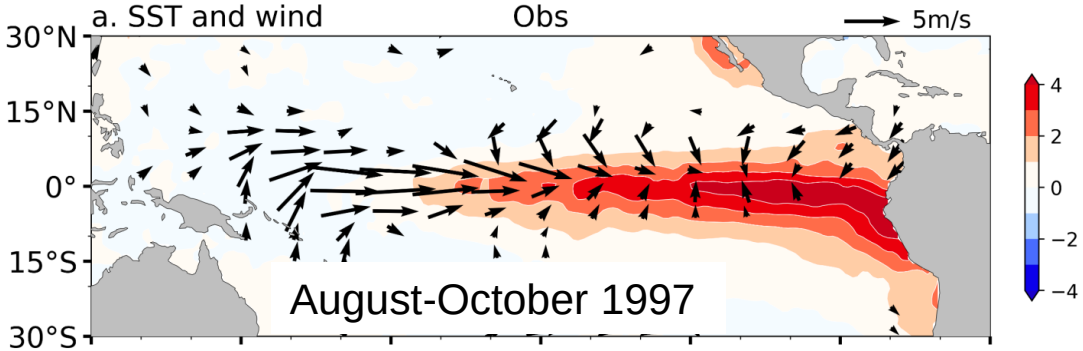




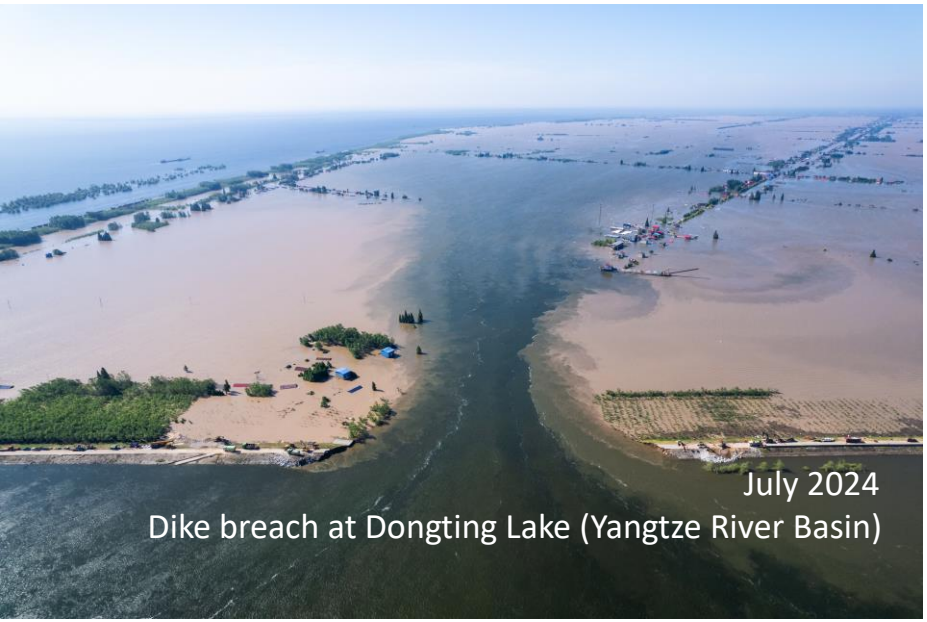
Post El Nino summer: Indian Ocean warming w/ anticyclonic wind



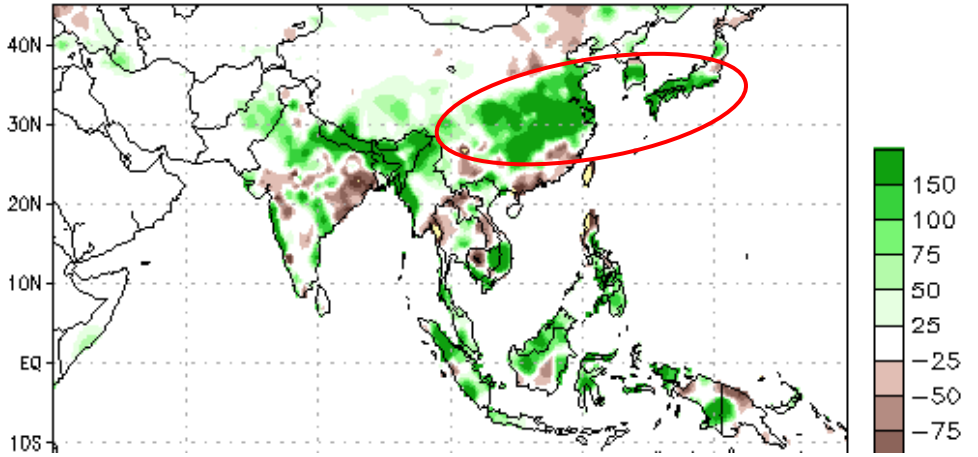




Post El Nino effect: heavy rainfall along Yangtze River

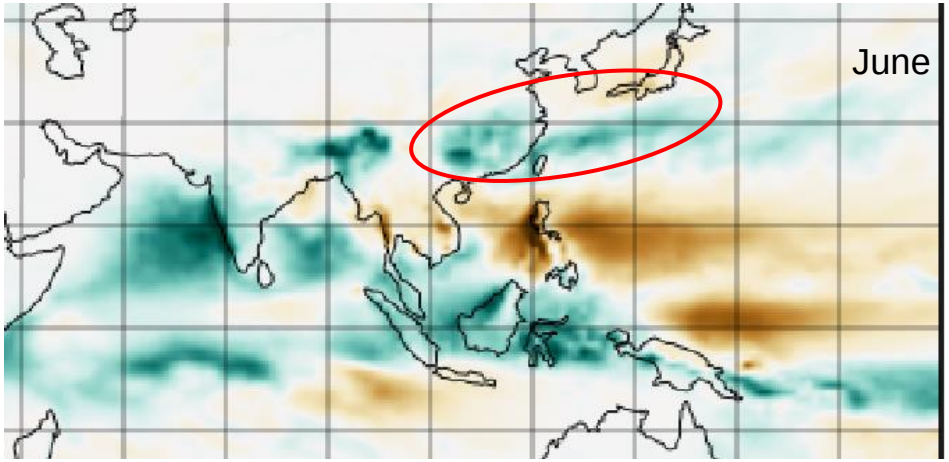


Observed (6/15-7/14/2024)

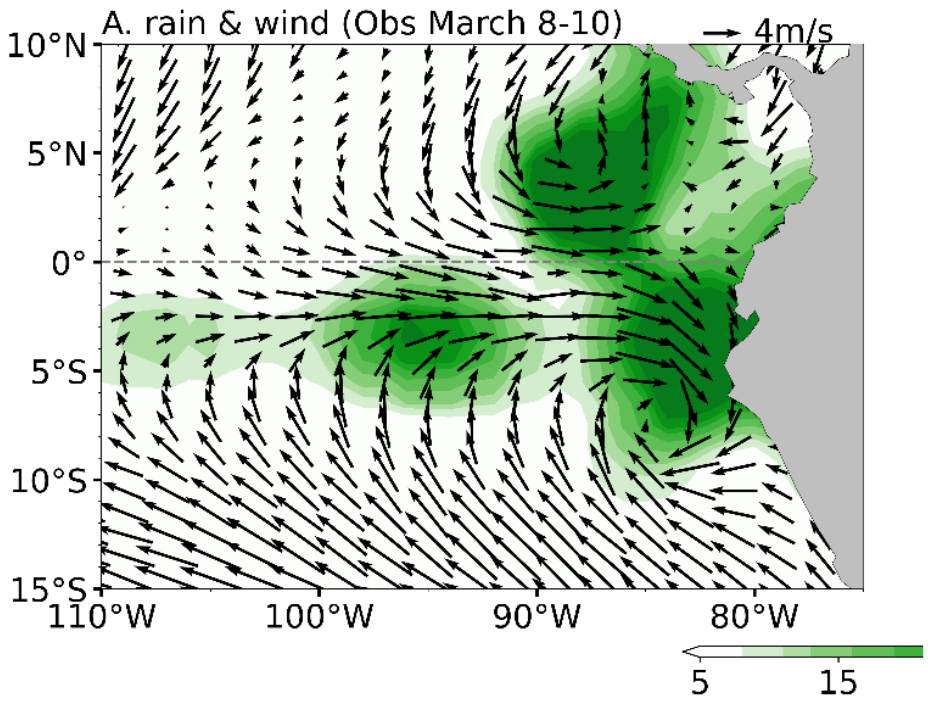


Rainfall anomalies of Asian summer monsoon

ECMWF prediction issued in Mar 2024

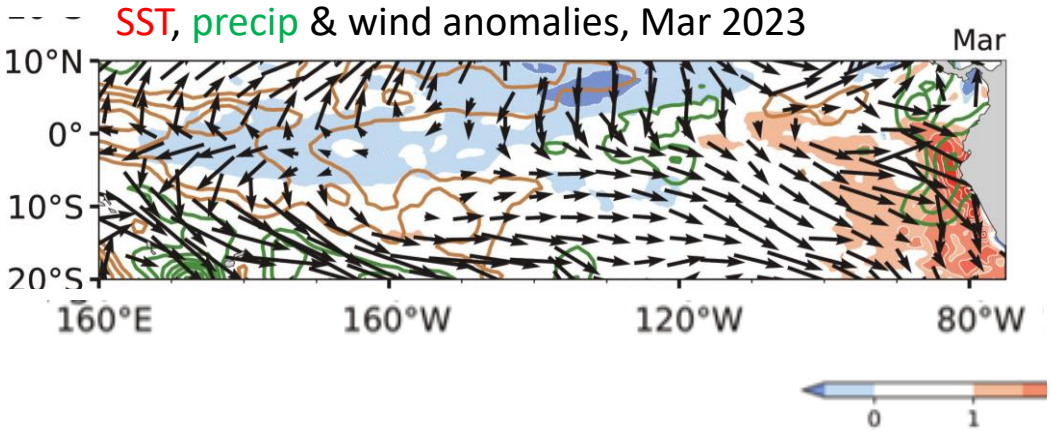


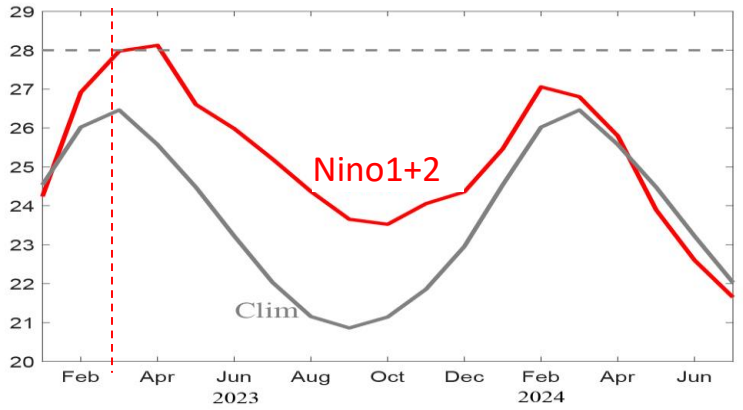
7/23/2024, Gaem was typhoon #2 of the year.



Cyclone Yaku of 10 March 2023

- Madden Julian Oscillation, blocked at low levels by the Andes
- **Coastal El Nino**





Q. Penget al., 2024: The 2023 extreme coastal El Niño: Atmospheric and air-sea coupling mechanisms. *Sci. Adv.*, 10, eadk8646.

Summary

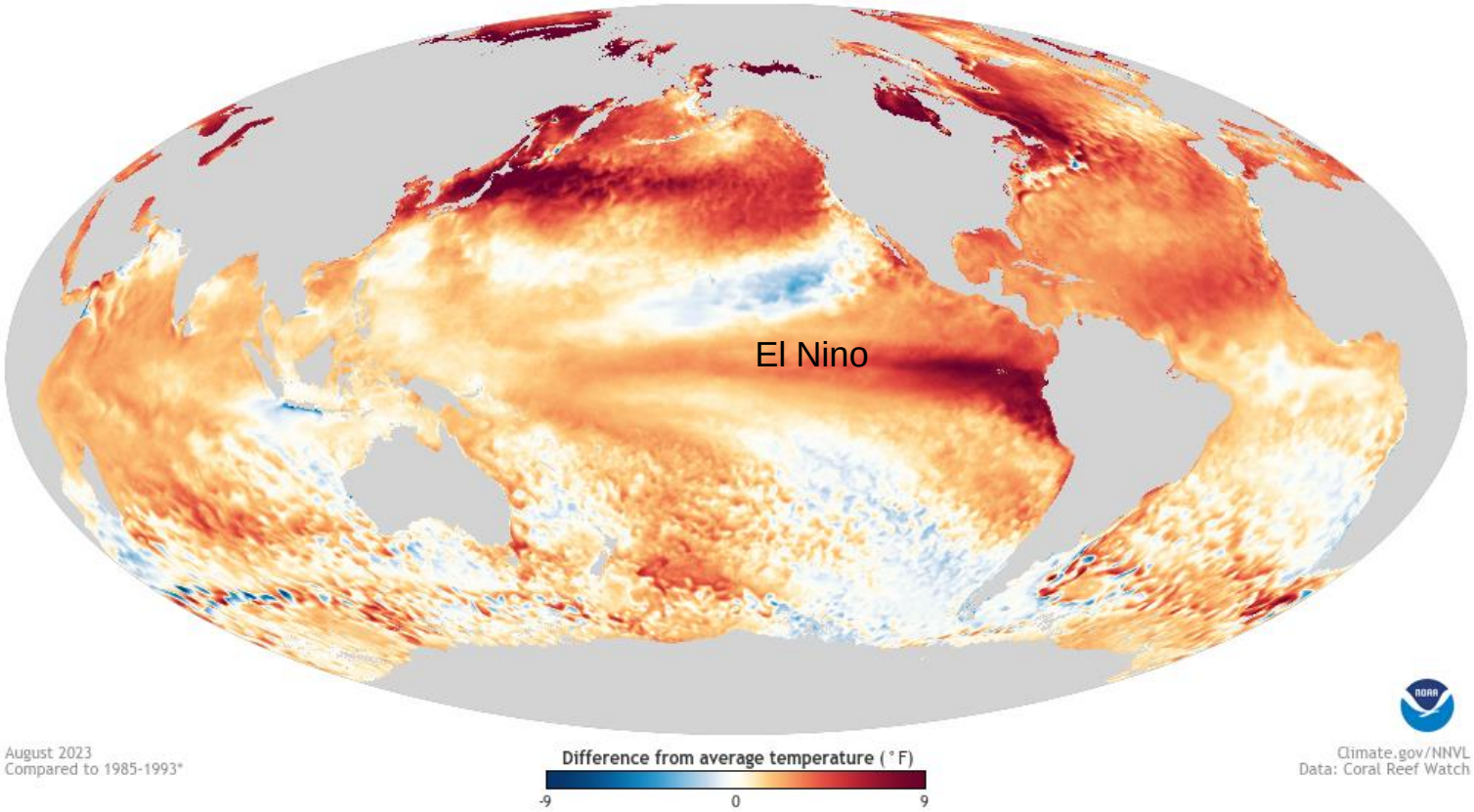
- El Nino: from Peruvian coast to a basin-wide phenomenon
- El Nino is of global impacts.
- ENSO is the main predictor for seasonal forecast.

Tropical sea surface temp anomalies Aug 2023 feature ***much more than*** El Nino:

- N Atlantic warming
- Indian Ocean warming
- NE Pacific cooling southwest of California
- Multi-decadal warming trend

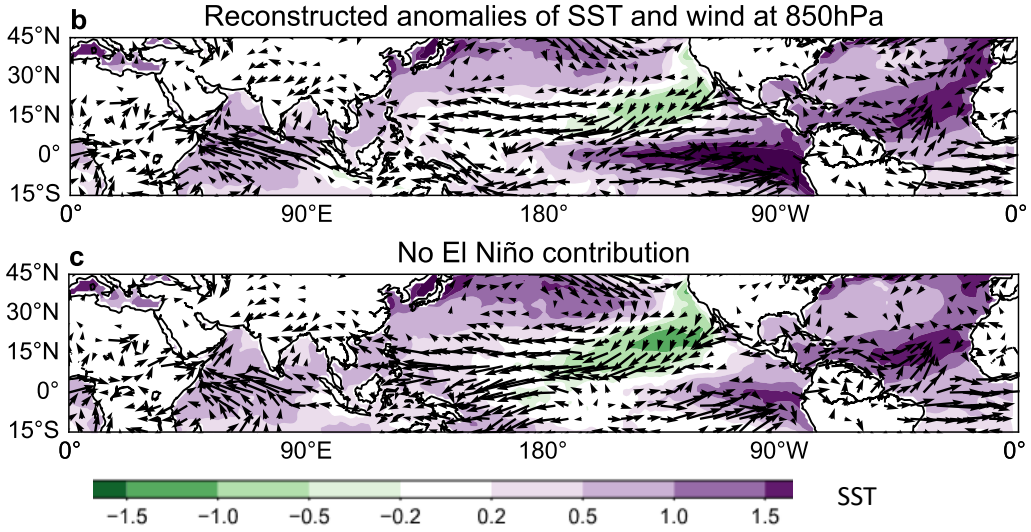
Jun-Nov trop cyclone counts

	Atlantic	WN Pacific
Climatology	13.1	21.6
2023	20	13

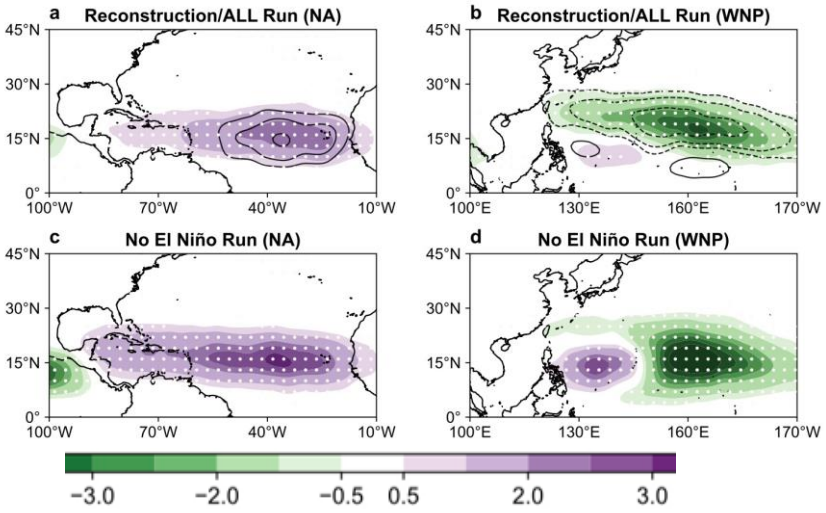


Non-ENSO effect is as large as El Nino

- Multi-decadal warming trend
- Extremely warm tropical N Atlantic …



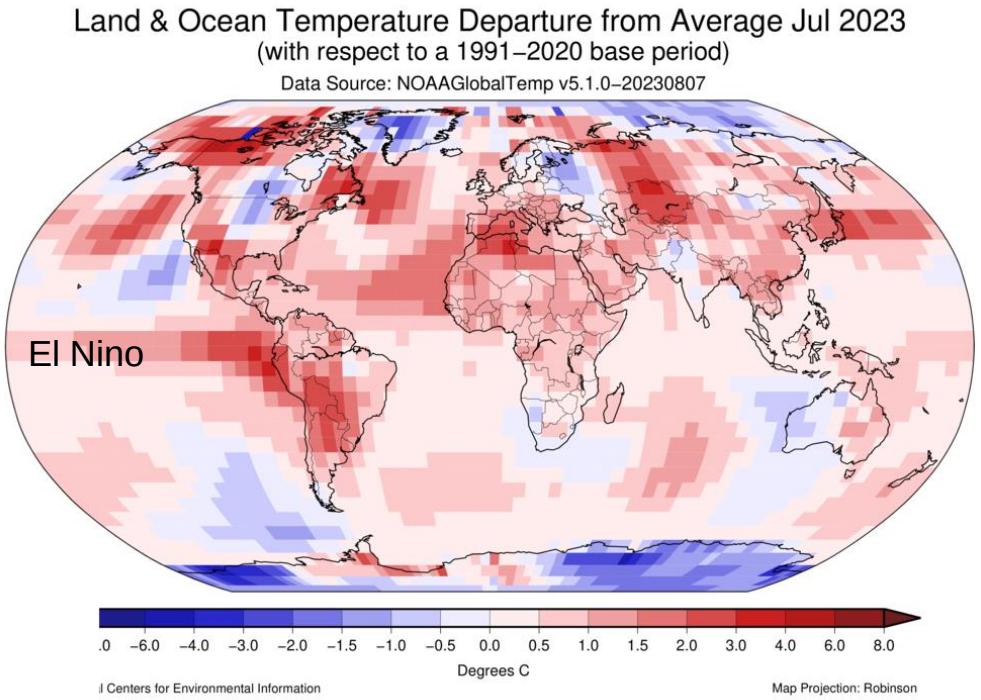
Atmospheric GCM

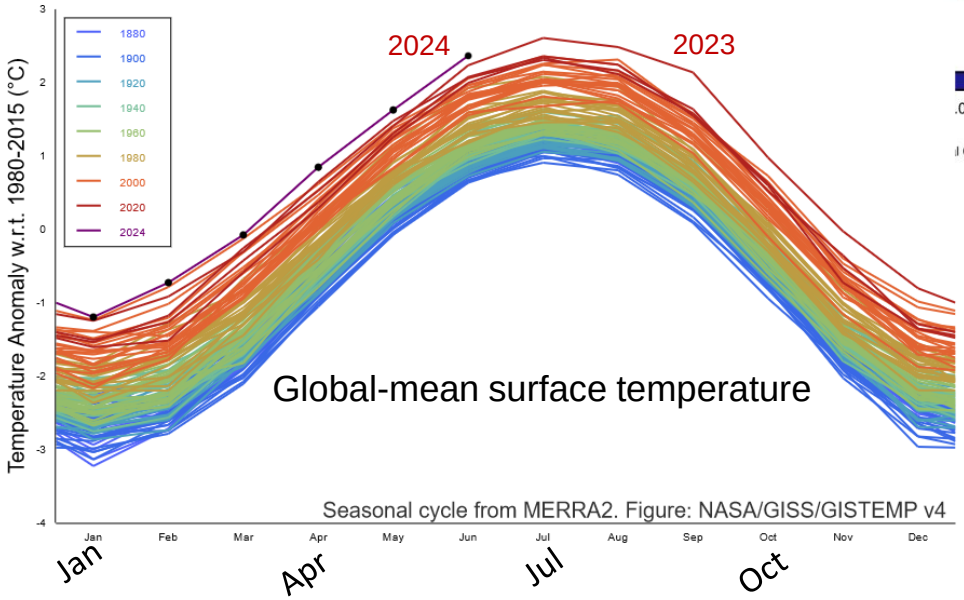


Tropical cyclone genesis frequency

J. Zhao et al., 2024: Lapsed El Niño impact on Atlantic and Northwest Pacific tropical cyclone activity in 2023. *Nature Commun.*

Record high temperatures in many parts of the world during 2023-24





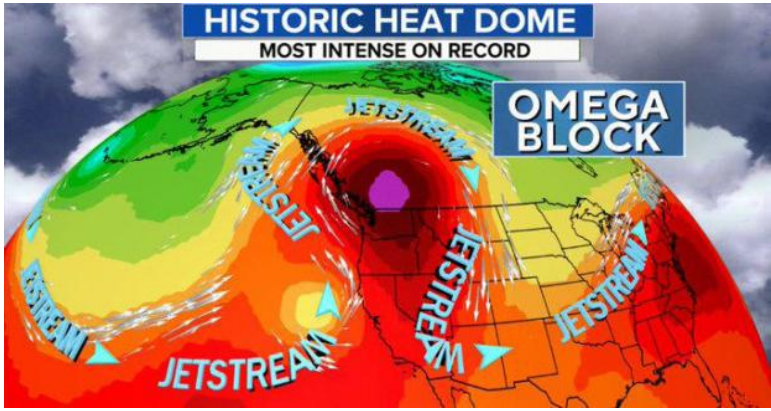
Without climate change, record Pacific Northwest heat wave would have been near impossible, researchers say

July 7, 2021 at 3:00 pm | *Updated July 7, 2021 at 5:28 pm*

The Seattle Times

Seattle exceeded its previous highest temperature mark by five degrees on June 28 — reaching 108 °F. …Temperature records were shattered throughout British Columbia, where the municipality of Lytton set a new national record for high temperature at 121 degrees.

Scientists pegged the heat wave — throughout the Pacific Northwest — as a 1-in-1,000-year event in today's climate.

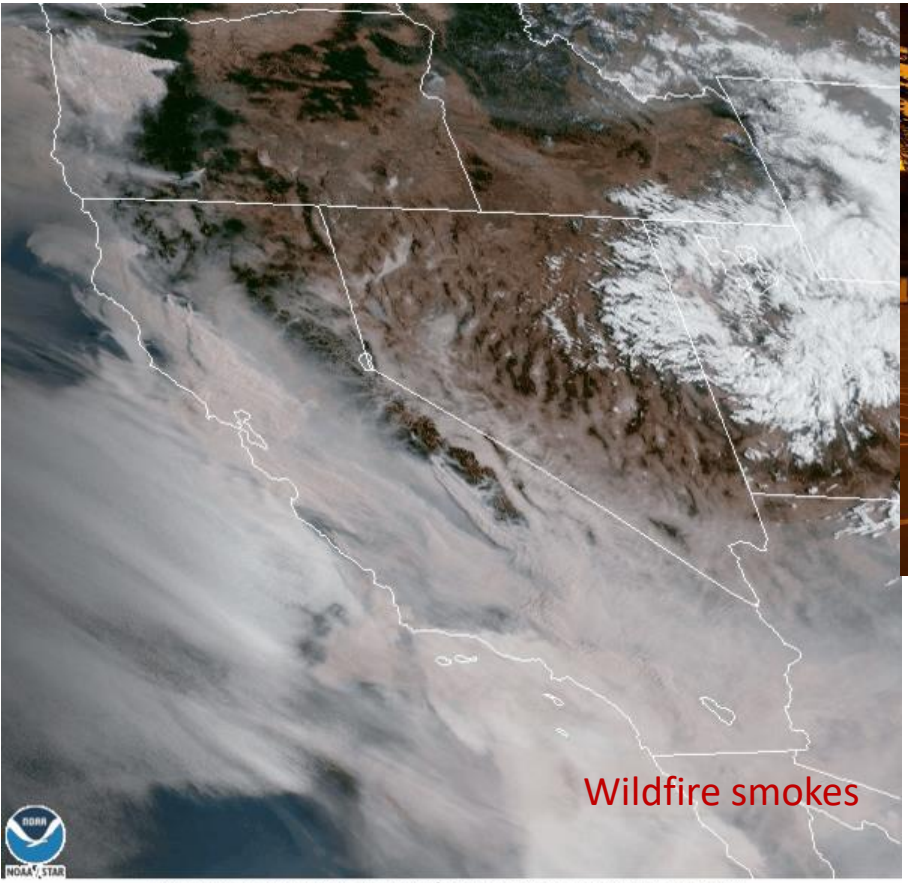


Global warming effects

Global warming effects

Climate change in action: *Increased risks for wildfires*

- High temp & drier soil
- Smaller, early-melting snowpack

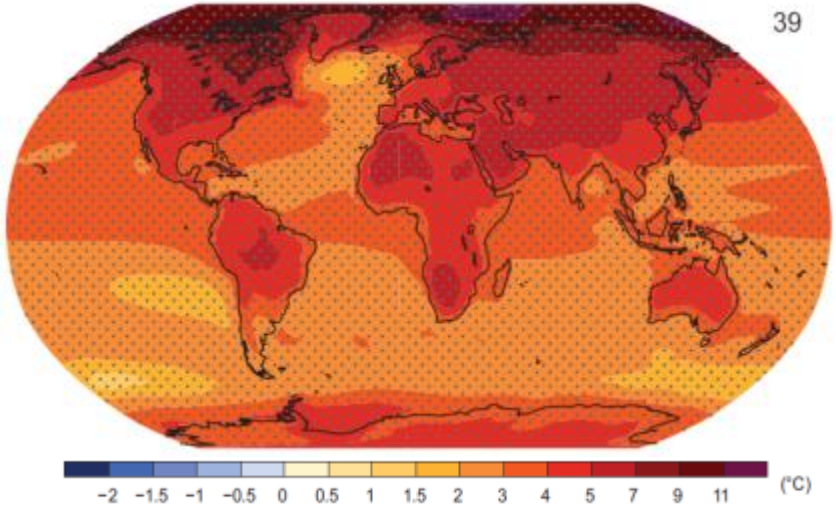


Bay Area looks like Mars during the wildfires
https://www.cnn.com/2020/09/09/weather/california-orange-skies-wildfires-photos-trnd/index.html

Precipitation change is spatially variable

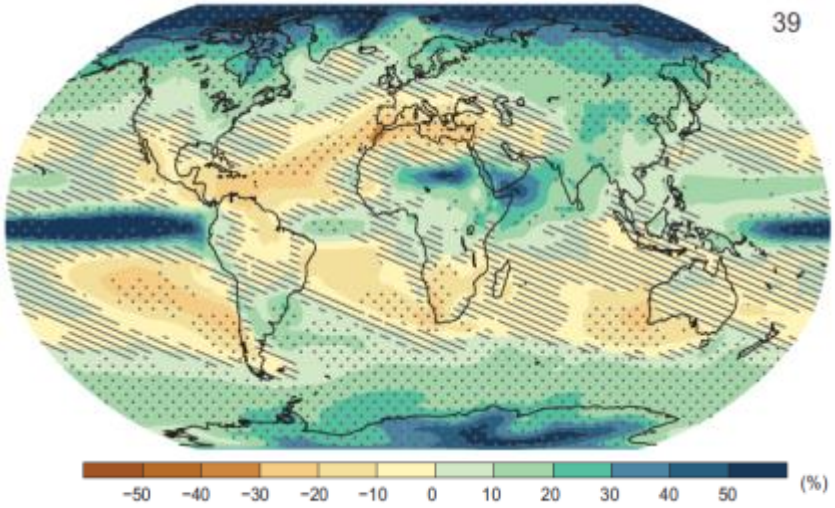
Uneven ocean warming is important for regional patterns of rainfall change

Climate change (1986–2005 to 2081–2100), Business as usual (RCP8.5); IPCC AR5



Temperature

- Larger on land than ocean;
- Arctic amplification
- Warming hole in subpolar N Atlantic



precipitation

- Increase in midlat-polar regions
- Drying in subtropics
- Increase in eq Pacific

Fig
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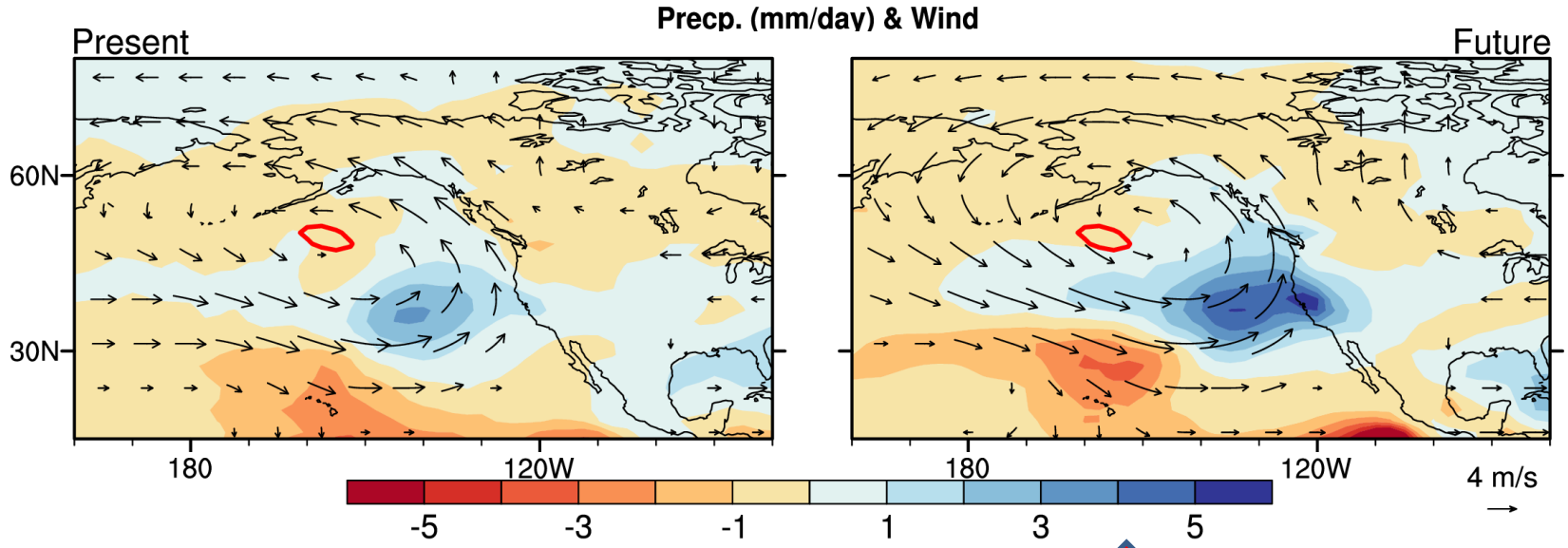
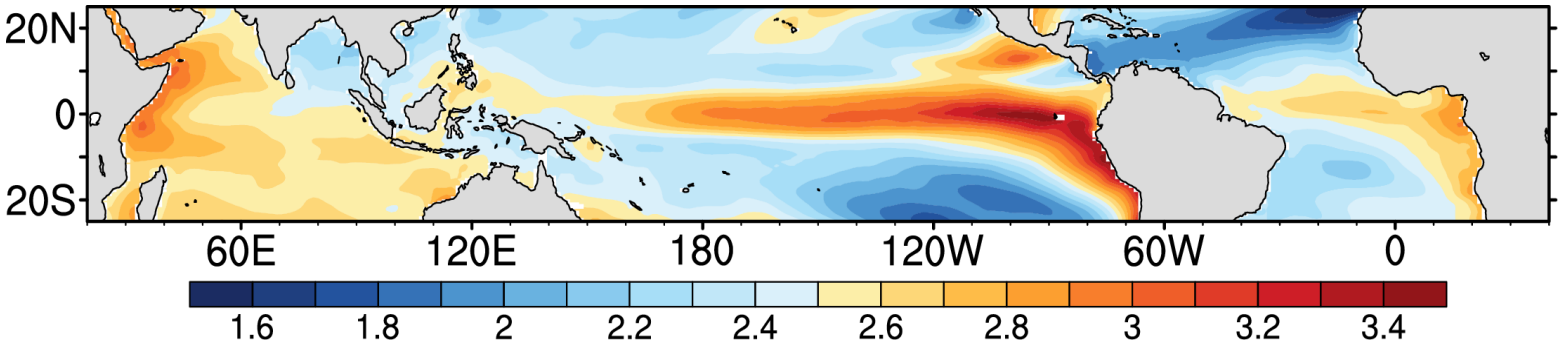
Increased rainfall & storminess in El Nino winter on U.S. west coast in warmer climate.

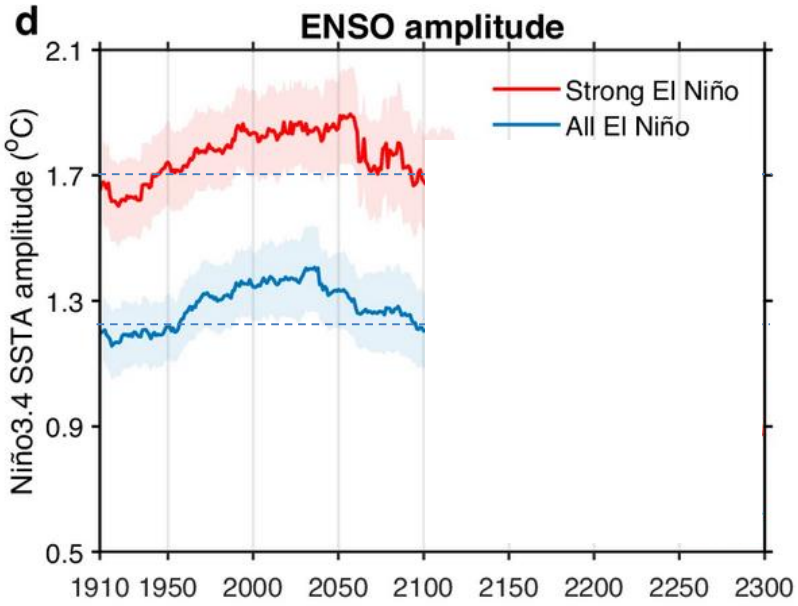


Intensified ocean warming in eastern Pacific

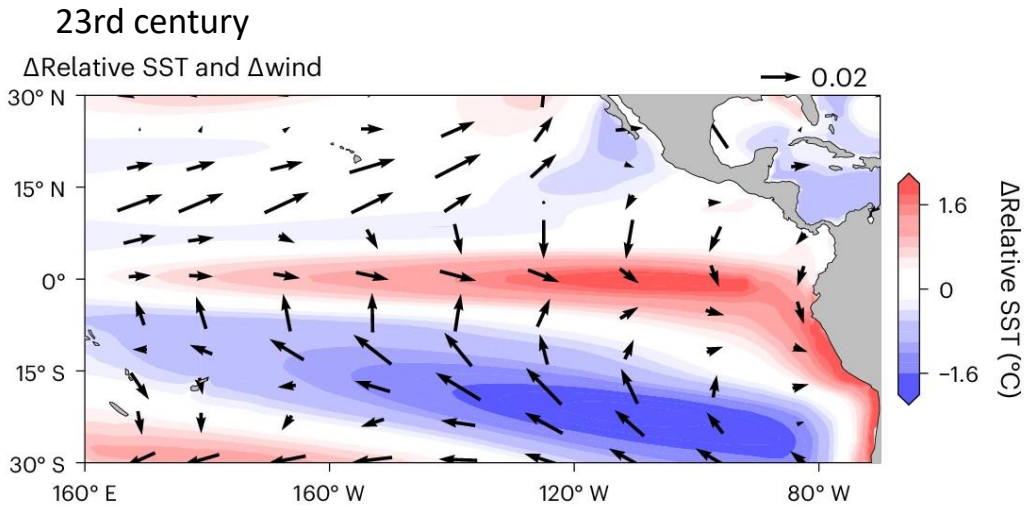


Z. Zhou et al. (2014, JC)

ENSO amplitude change may not be monotonical, decreasing at large warming.

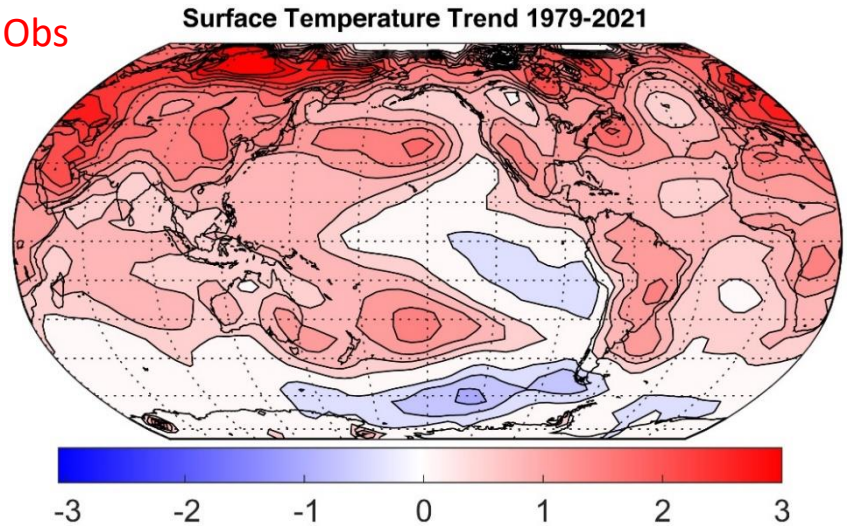


T. Geng *et al.* 2024, *Nat Commun*

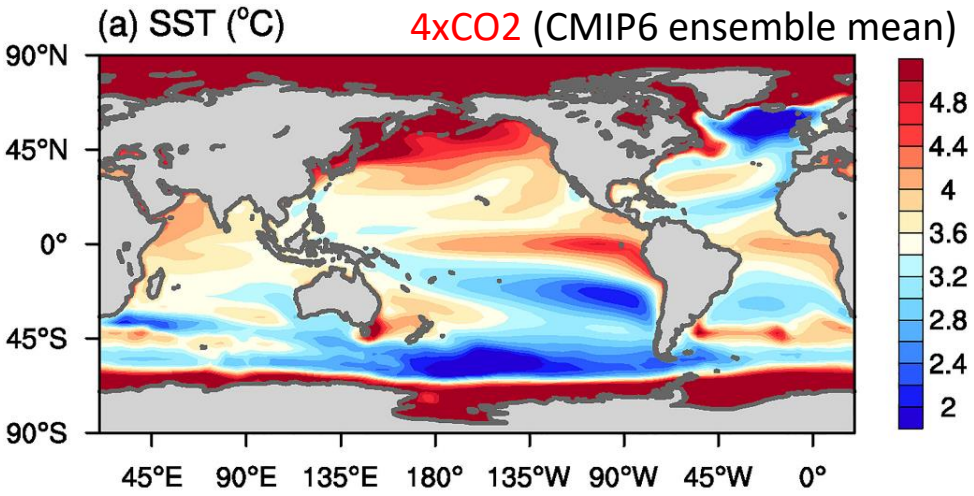


Q. Peng et al., 2024: Collapsed upwelling projected to weaken ENSO under sustained warming beyond the 21th century. *Nature Clim. Change*

Obs



Hartmann (2022 *PNAS*); Dong et al. (2022 *JC*)



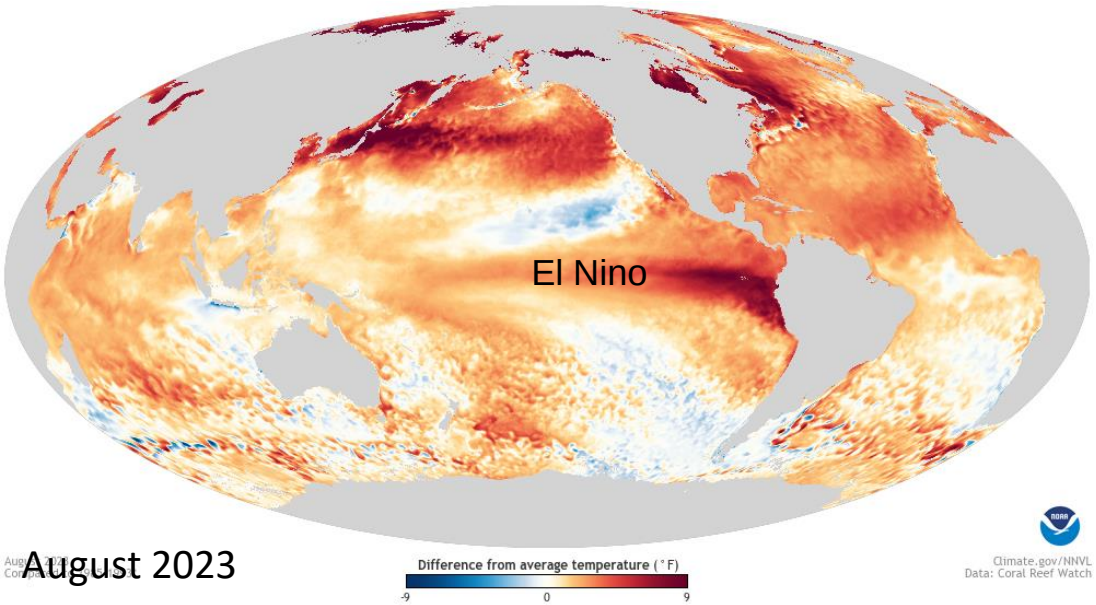
4xCO2 (CMIP6 ensemble mean)

Xie (2020, *AGU Adv*)

Major discrepancies in Eq. Pacific:
Obs. cooling vs. enhanced warming in models

Discussion

- El Nino is a global phenomenon.
- ENSO is the main predictor for seasonal forecast.
- Other SST modes (tropical Atlantic, Indian Ocean, subtropical Pacific) are promising sources of predictability, directly and indirectly by modulating ENSO.
- Pan tropical approach to extracting additional predictability ← better models guided by physical understanding
- Innovative case studies for deeper insights into predictability in warming climate.

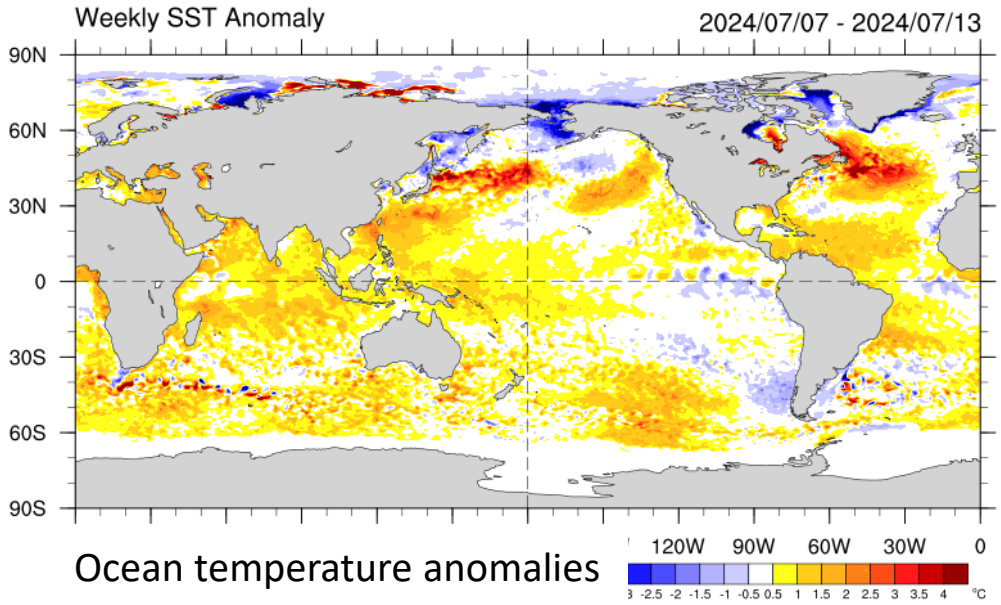


Global warming effects

Atlantic Hurricane Beryl reaches cat. 5 on 7/1/2024, the earliest such storm in recorded history.

Ocean warming fuels tropical cyclones to greater intensity (higher wind, rainfall, storm surge)

- Regional change depends on warming magnitude relative to the tropical average.
- Storm surge worsen by sea level rise



Ocean temperature anomalies

Key words

- El Nino and Southern Oscillation are a coupled ocean-atmosphere phenomenon
- Ocean: SST warming, retreating cold tongue, deepened thermocline, phase-locking
- Atmosphere: eastward shift of convection, SLP seesaw between Darwin and Tahiti, westerly anomalies near the Dateline
- Bjerknes feedback, coupled instability, effect of Earth rotation
- Role of ocean Kelvin wave, zonal displacement between maximum zonal wind anomalies and peak SST warming on the equator, coastal Kelvin wave observed at tide gauges,
- Thermocline feedback confined to eastern Eq. Pacific ← shallow mean thermocline & persisting southeast trades
- Oscillation b/w El Nino and La Nina, delayed negative feedback due to slow ocean wave propagation, preference for large basin