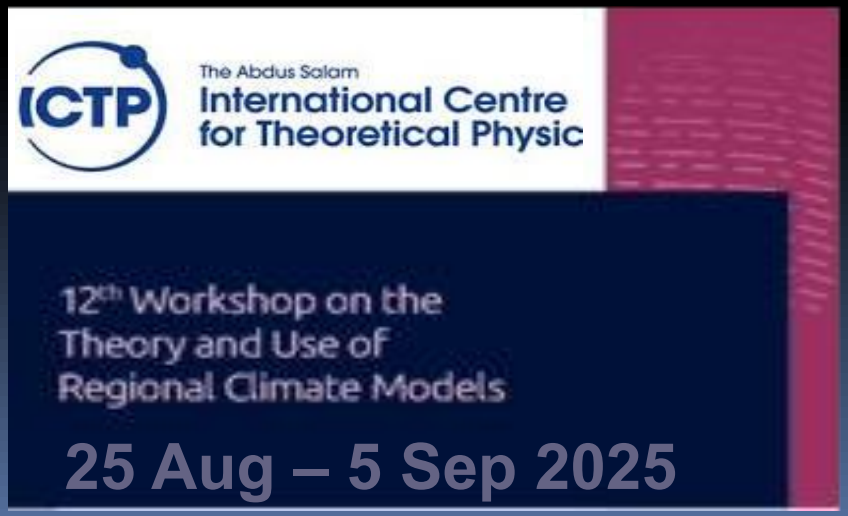
Spring 2024: Unprecedented atmospheric heatwaves in Mexico

Tereza Cavazos
Departamento de Oceanografía Física



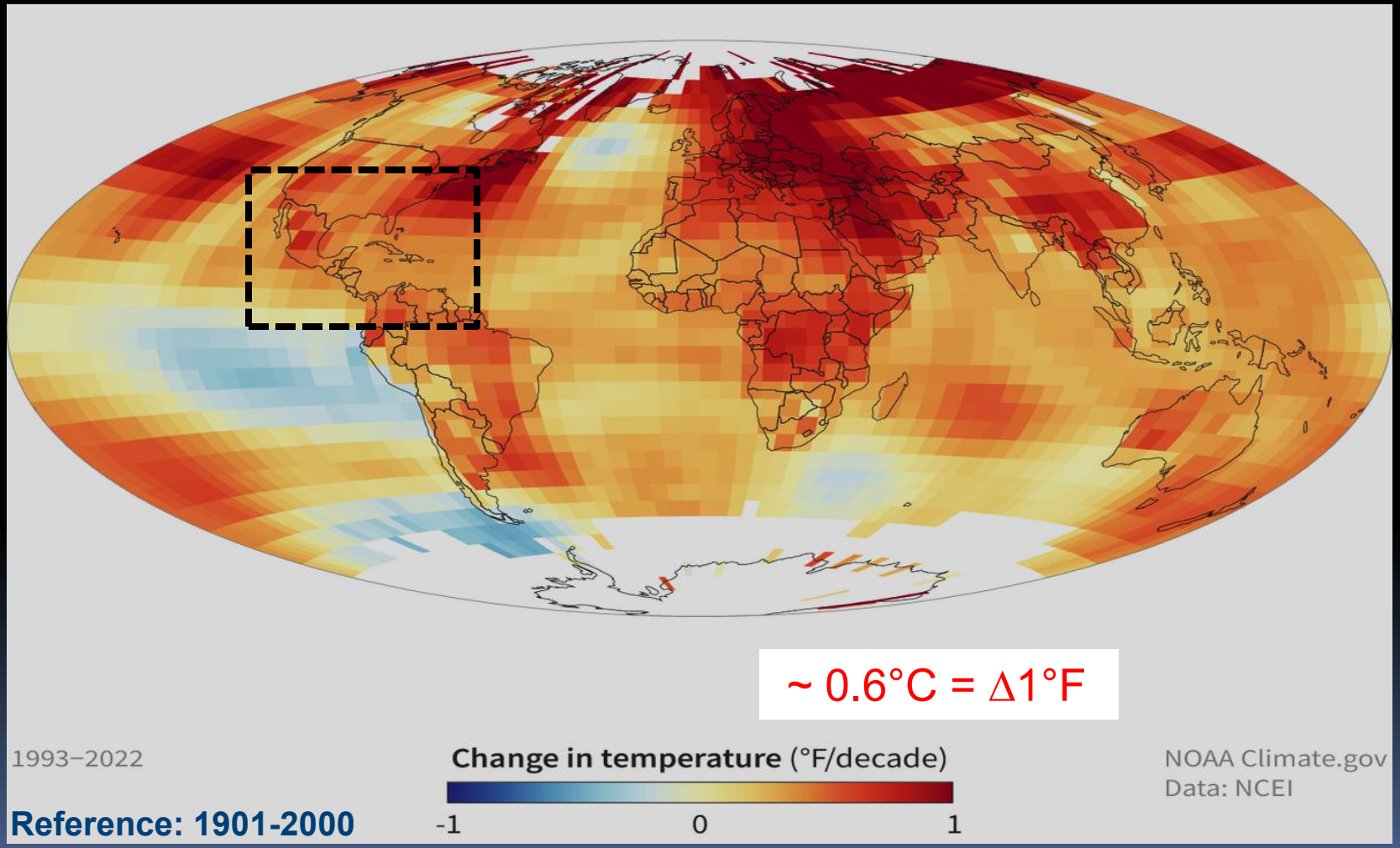
Departamento de
Oceanografía
Física

CICESE

Content

1. Recent temperature trends
2. Heatwaves of spring 2024
3. Physical mechanisms and impacts
4. Synoptic circulation
5. Discussion of climate drivers

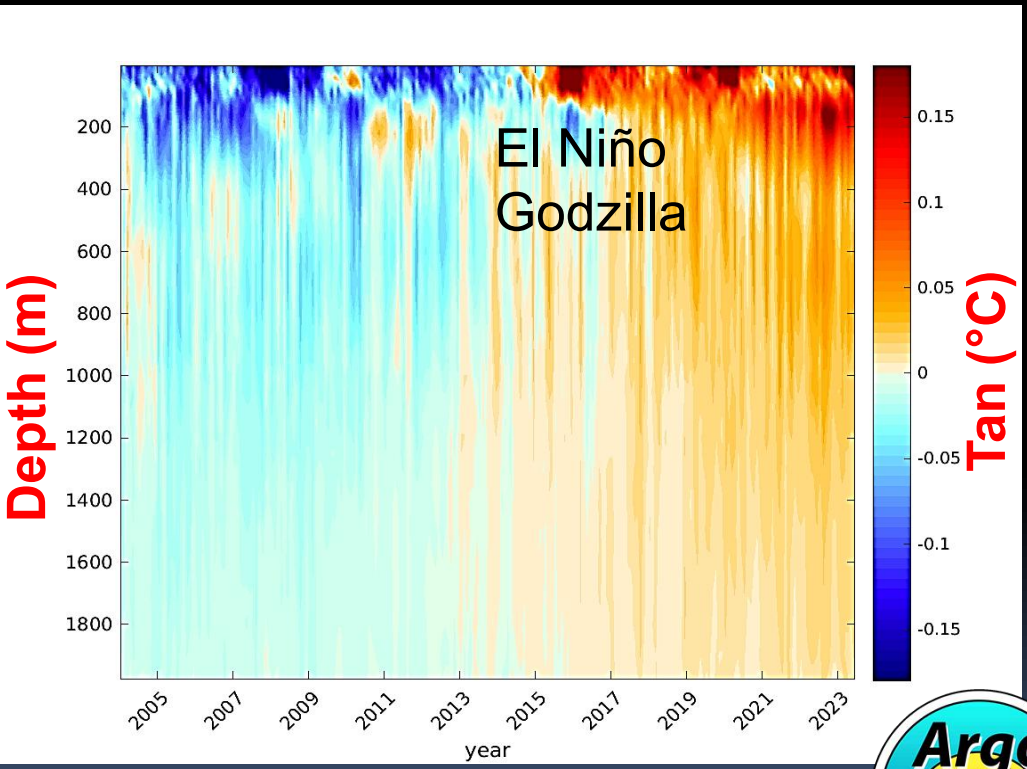
Temperature trends (°F/decade) 1993-2022
(Surface air Temp)



https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

Records of temperature and ocean heat content

Global ocean temperature anom (°C)



https://globalocean.noaa.gov/Research/Argo-Program/

Anom ocean heat content (ZJ) of the **Gulf of México** (0-2000 m)

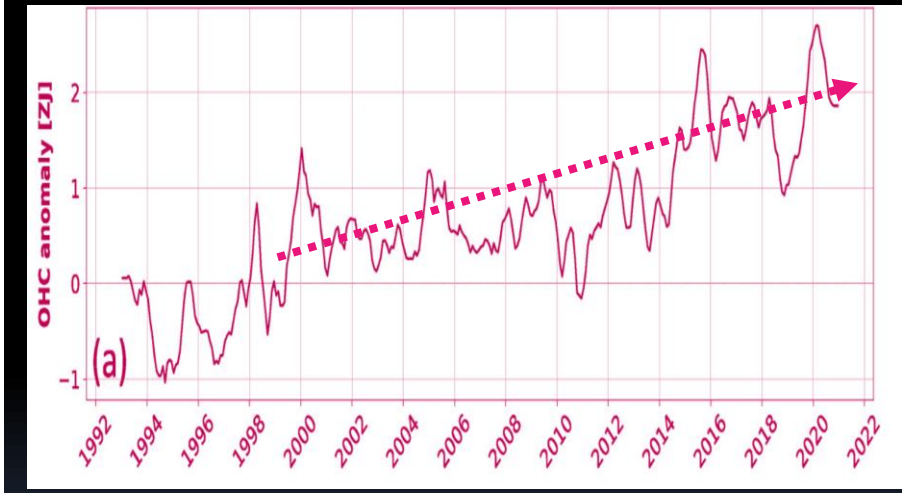
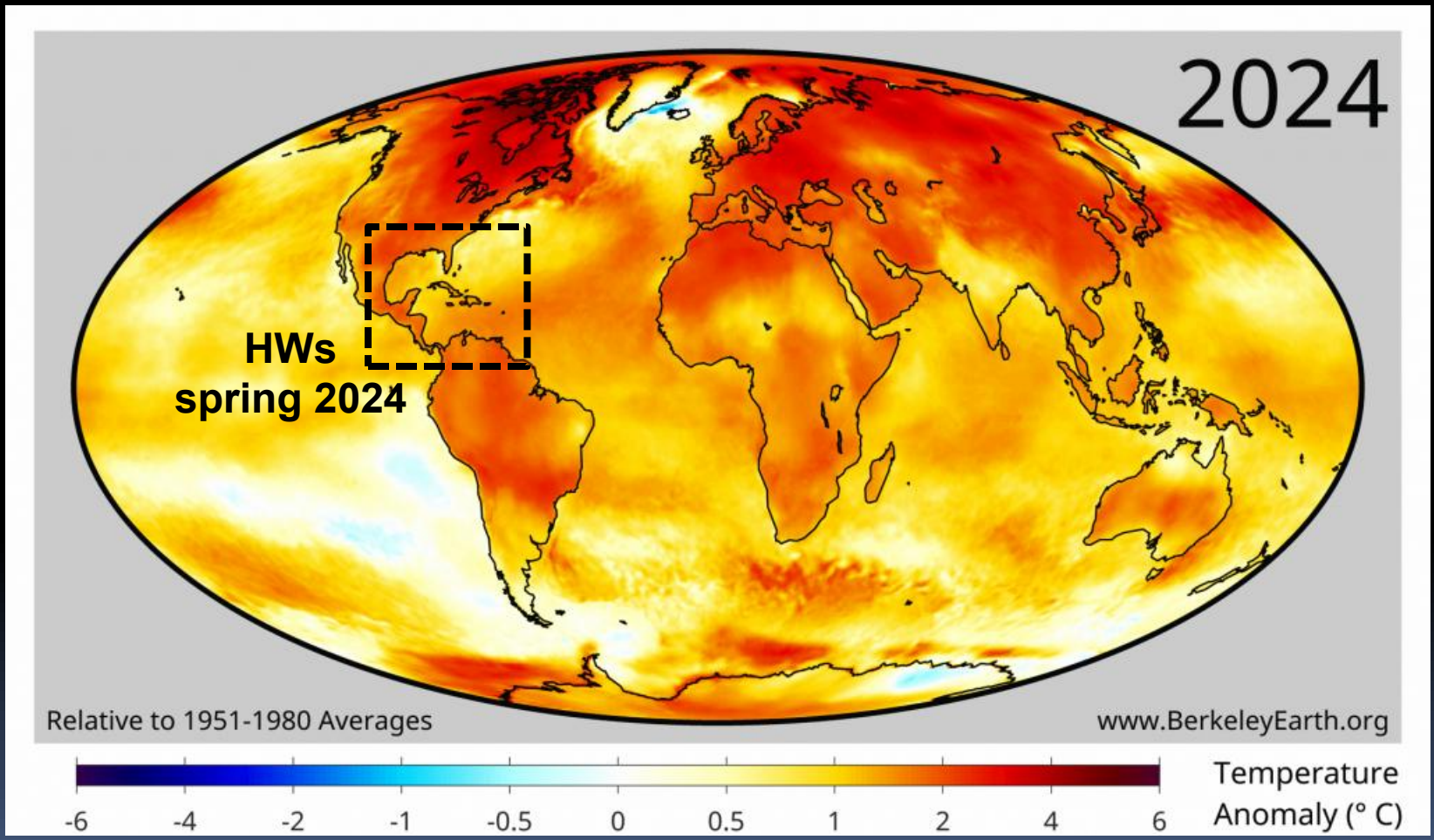


Figure 8 from Thirion et al. (2024)

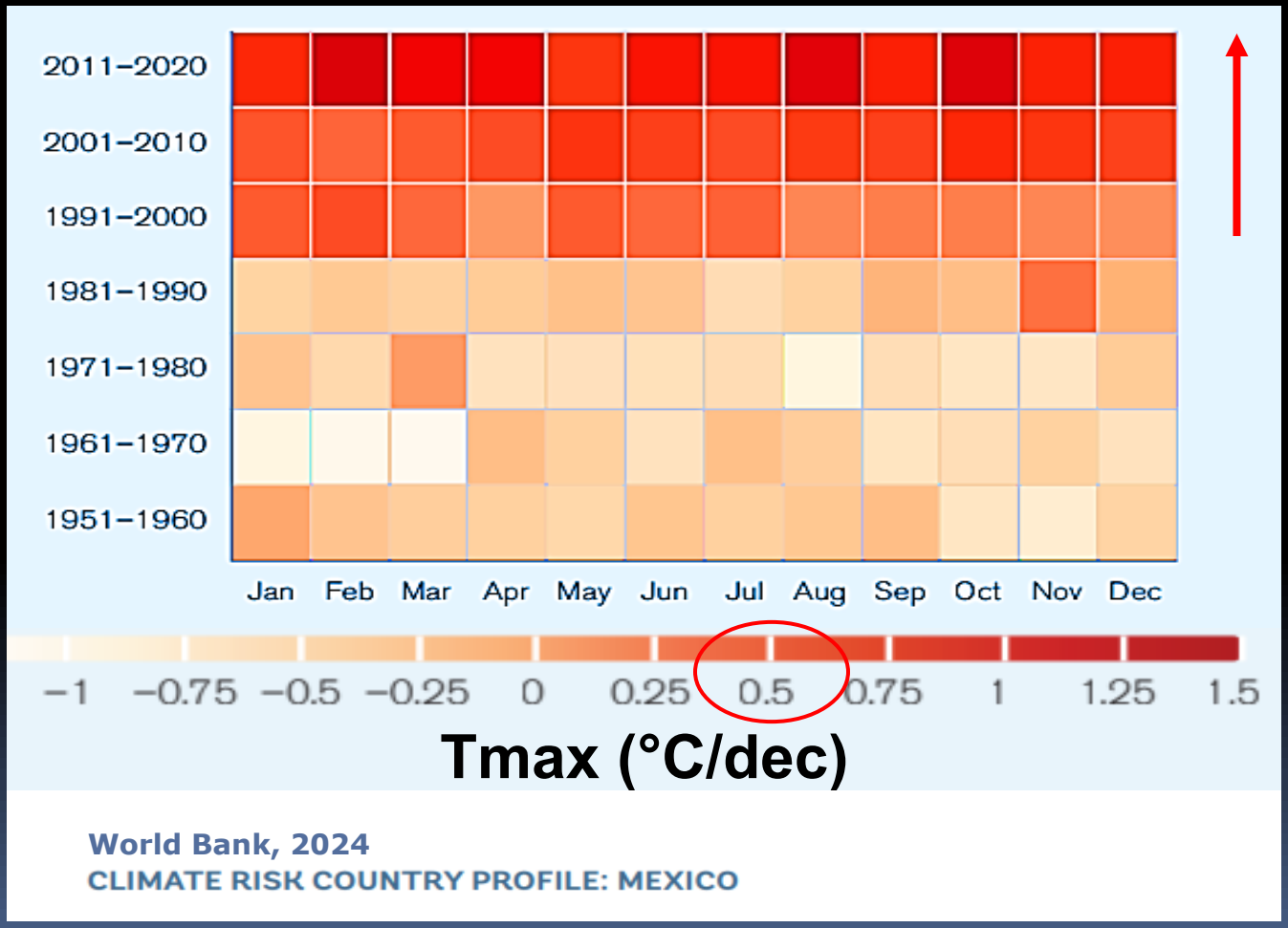
UN: 2023, 2024 – warmest years!

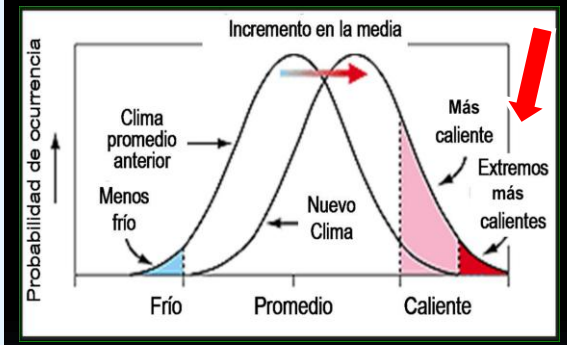
Surfce air temperature change (°C)



https://berkeleyearth.org/global-temperature-report-for-2024/

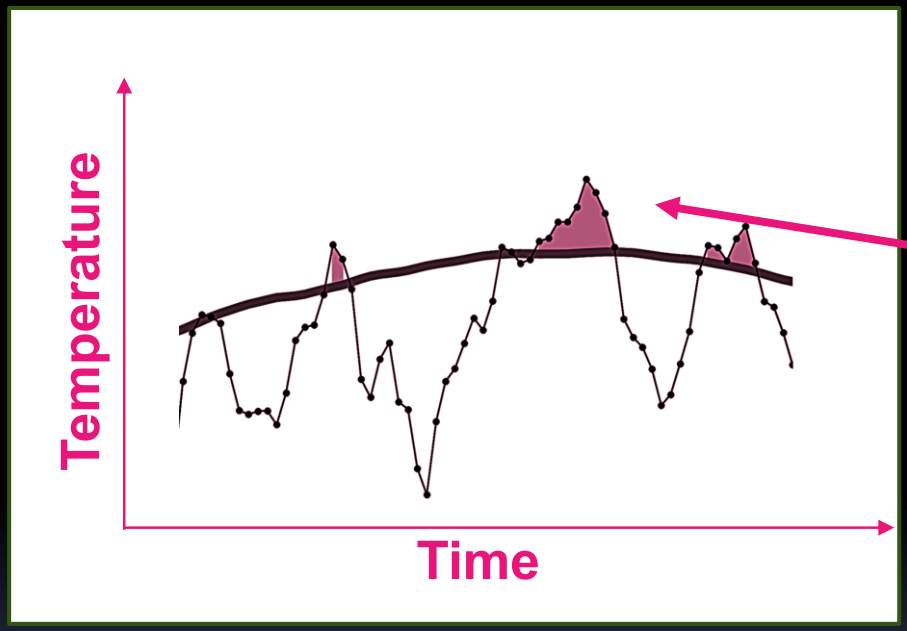
Warming in Mexico
Decadal changes of Tmax (°C)
(1951-2020)





World Bank, 2024
CLIMATE RISK COUNTRY PROFILE: MEXICO

Heatwave: Prolonged period of high T



Thresholds for each gridpoint or region

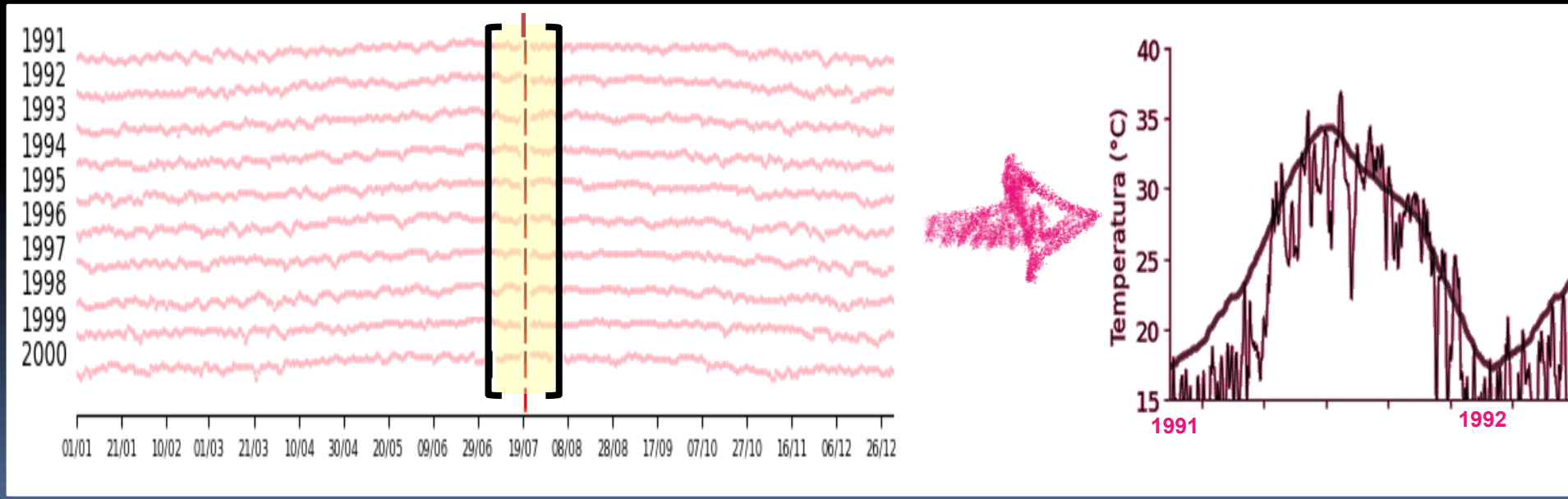
At least 3 consecutive days with:

Tmax > P95 – **daytime heatwaves**
Tmin > P95 – **nighttime heatwaves**
Twet_b > P95 – **humid heatwaves**

P95 thresholds of Tmax in each gridpoint

Calculation Example:

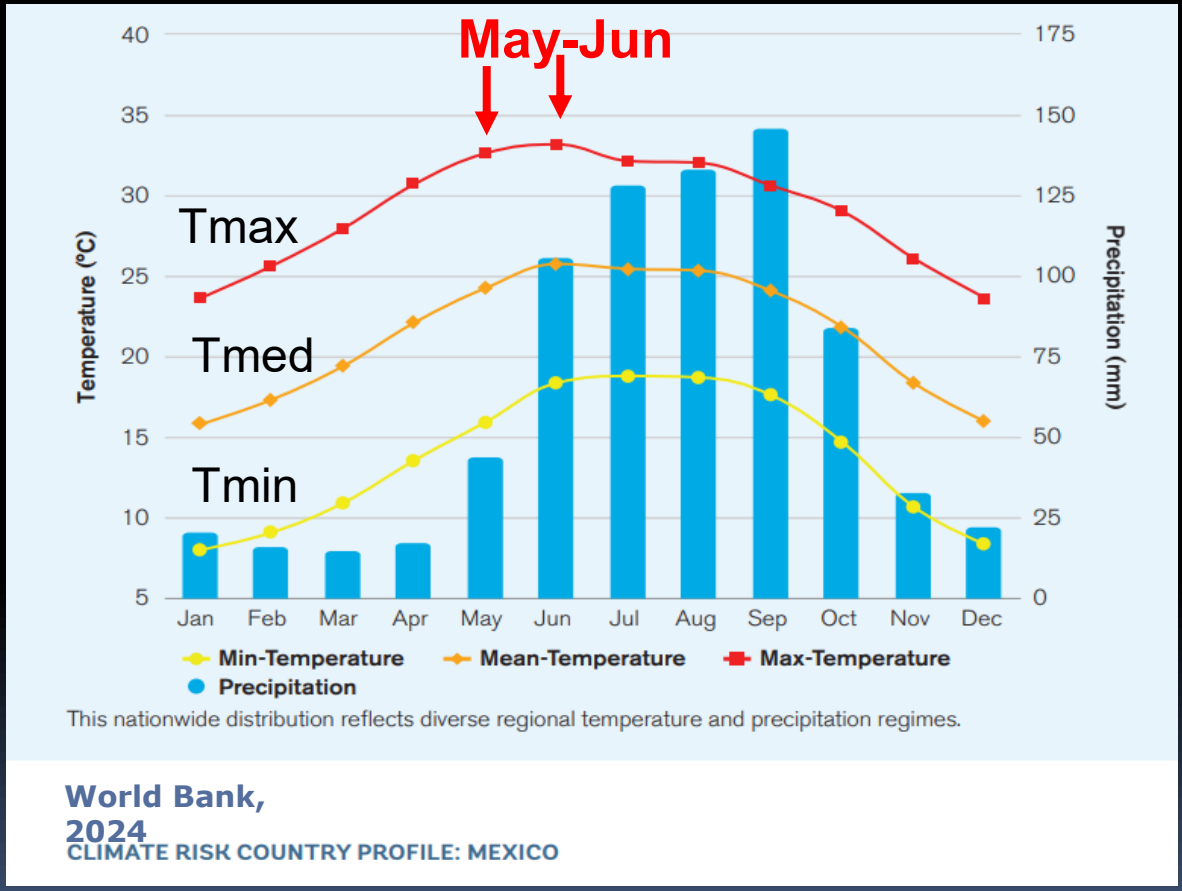
- Daily climatology of P95 of Tmax during the reference period
- P95 of Jul 19 centered in a 31-day moving average window of the period
- Do it for every day of the calendar year
- Then count the HW events > P95 that last at least 3 consecutive days every yr.



Spring 2024: Unprecedented atmospheric heatwaves in Mexico (14 Abr – 5 Jun)

Cavazos, 2024, Frontiers in Climate
https://doi.org/10.3389/fclim.2024.1449710

Spring and summer extreme Tmax in Mexico (1991-2020)



World Bank, 2024
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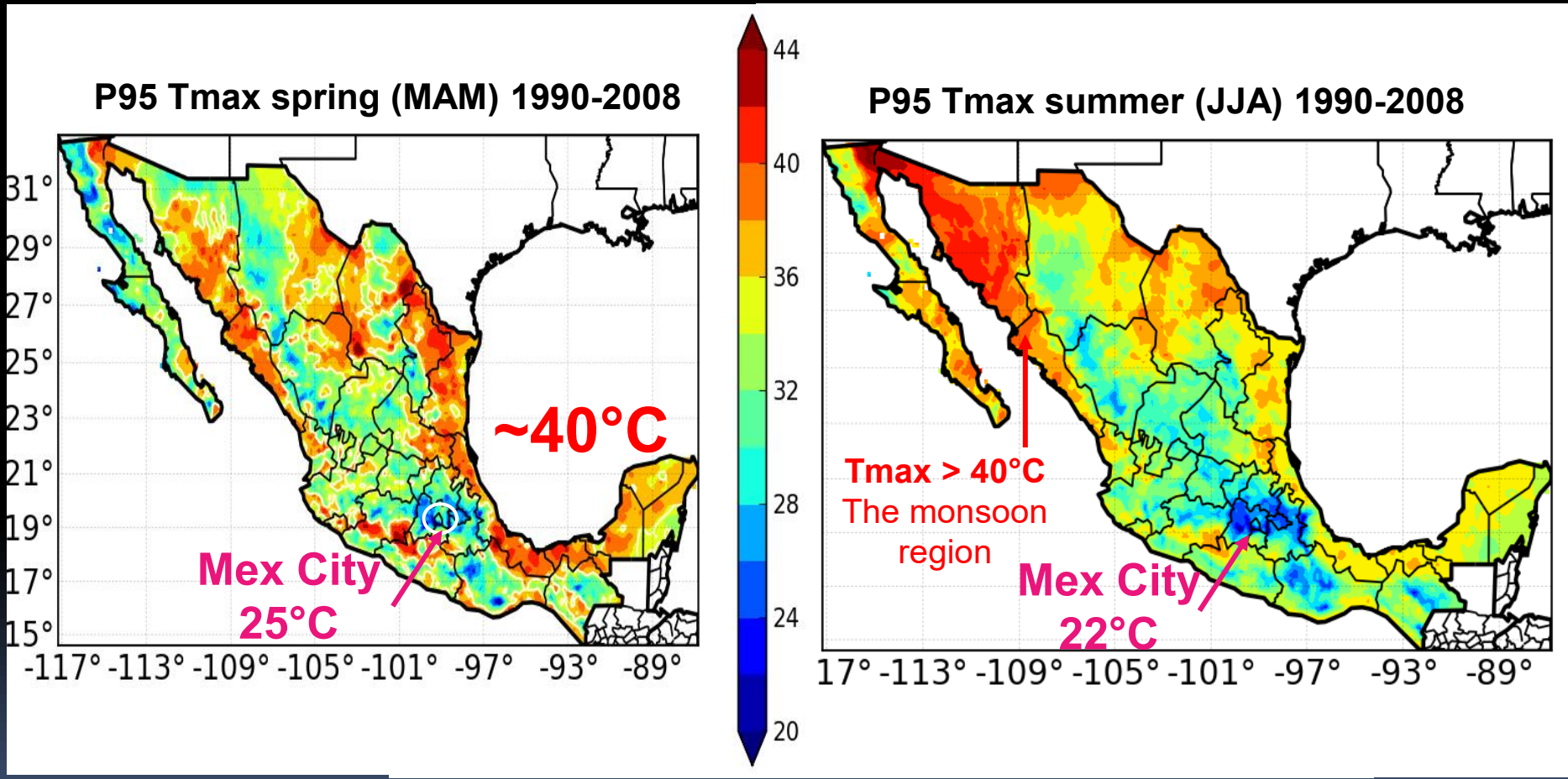
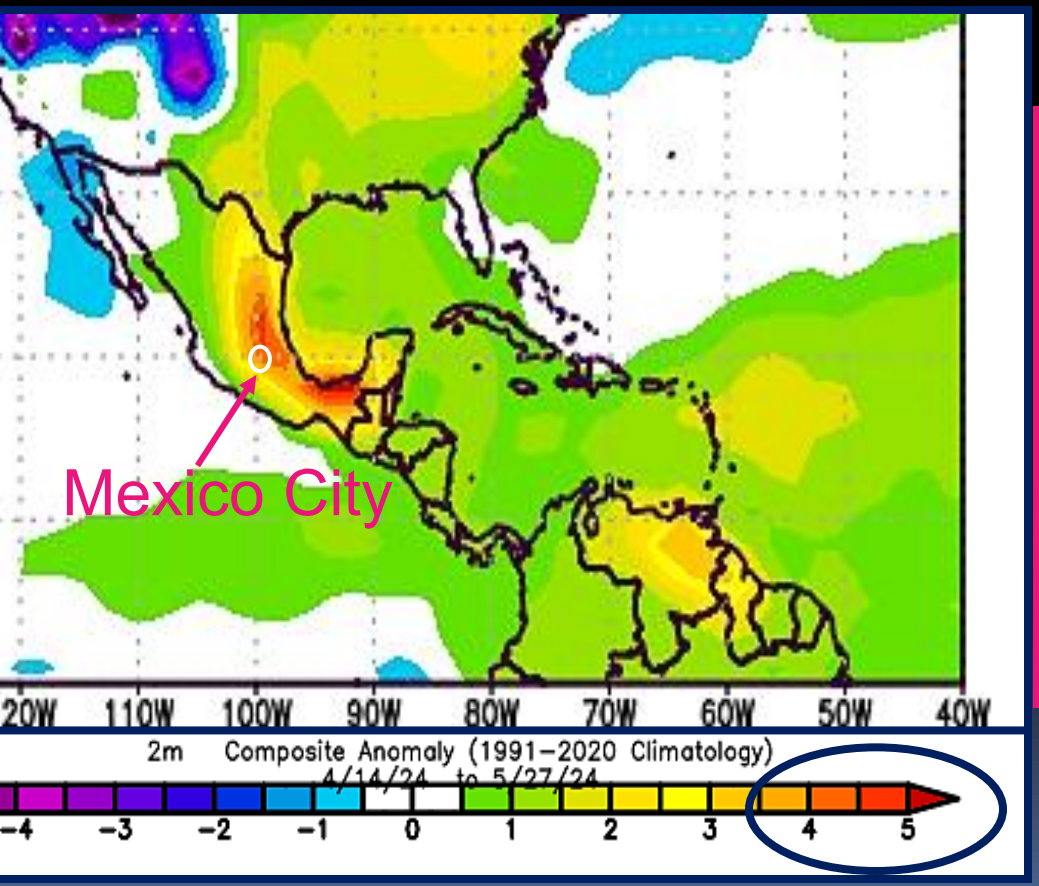
Spring and summer extreme Tmax (1991-2020)



http://clicom-mex.cicese.mx/malla/index.php

Anom conditions during the three heatwaves 14 Apr - 27 May 2024

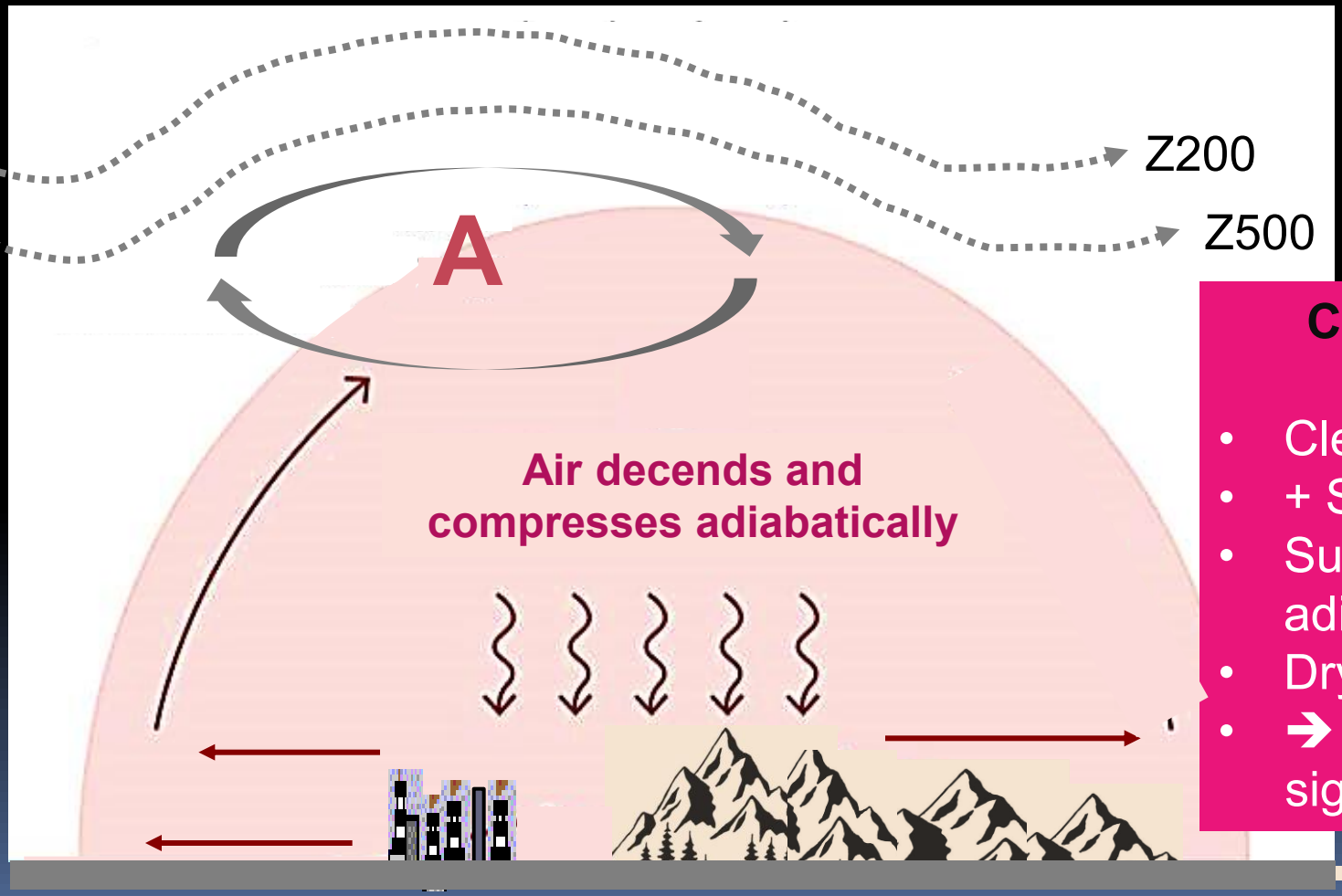
Tanom (°C) a 2 m



IMPACTS

- Record breakings: Temp (30° to 45°C).
- Deficit of water ➔ low dam levels **Sectors:** energy, agriculture, construction workers
- Health (SS, 5th of Jun): 1937 cases of dehydration, 90 human deaths due to heat stroke and death of animals at zoos.

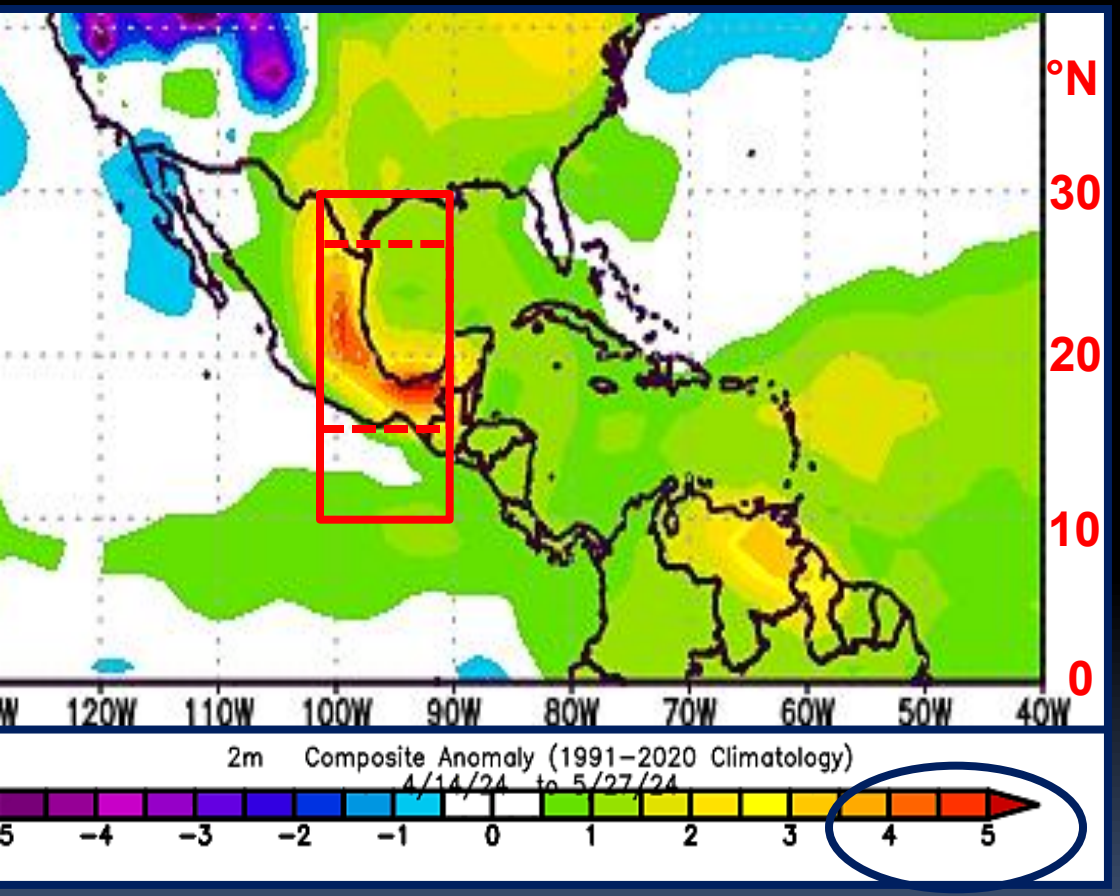
Mid-tropospheric heat dome:
Anticyclone at 500 hPa (aprox. 5500 m asl)



Consequences

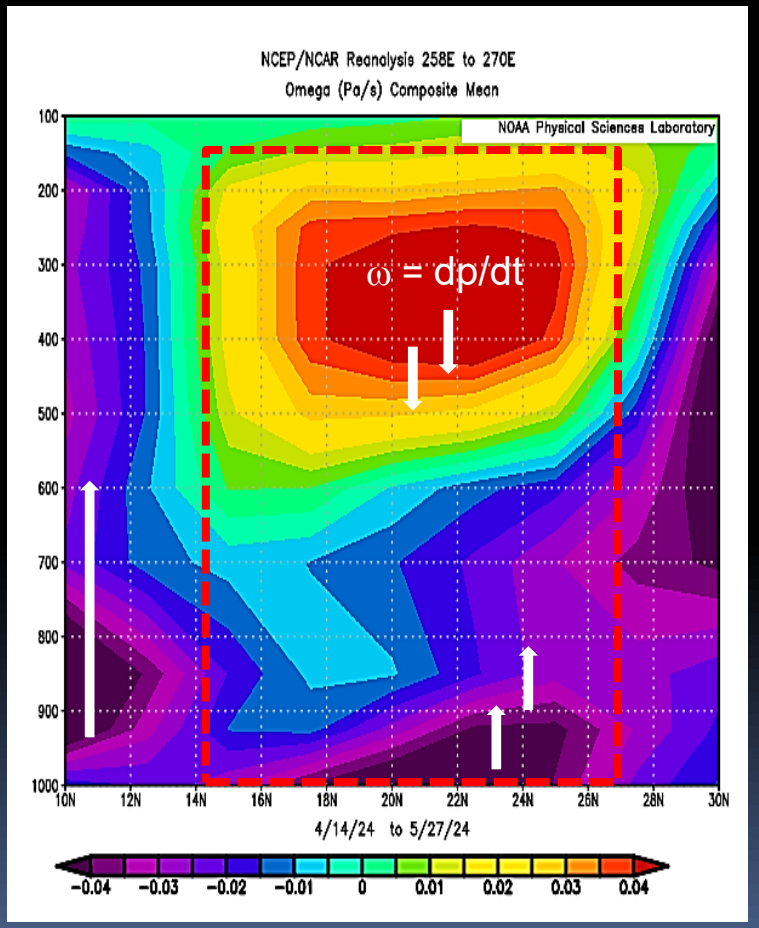
- Clear skies
- + Solar radiation
- Subsidence and adiabatic heating
- Dry soil (evap.)
- ➔ Temp increases significatively

Mexico City and other cities: Thermal inversion

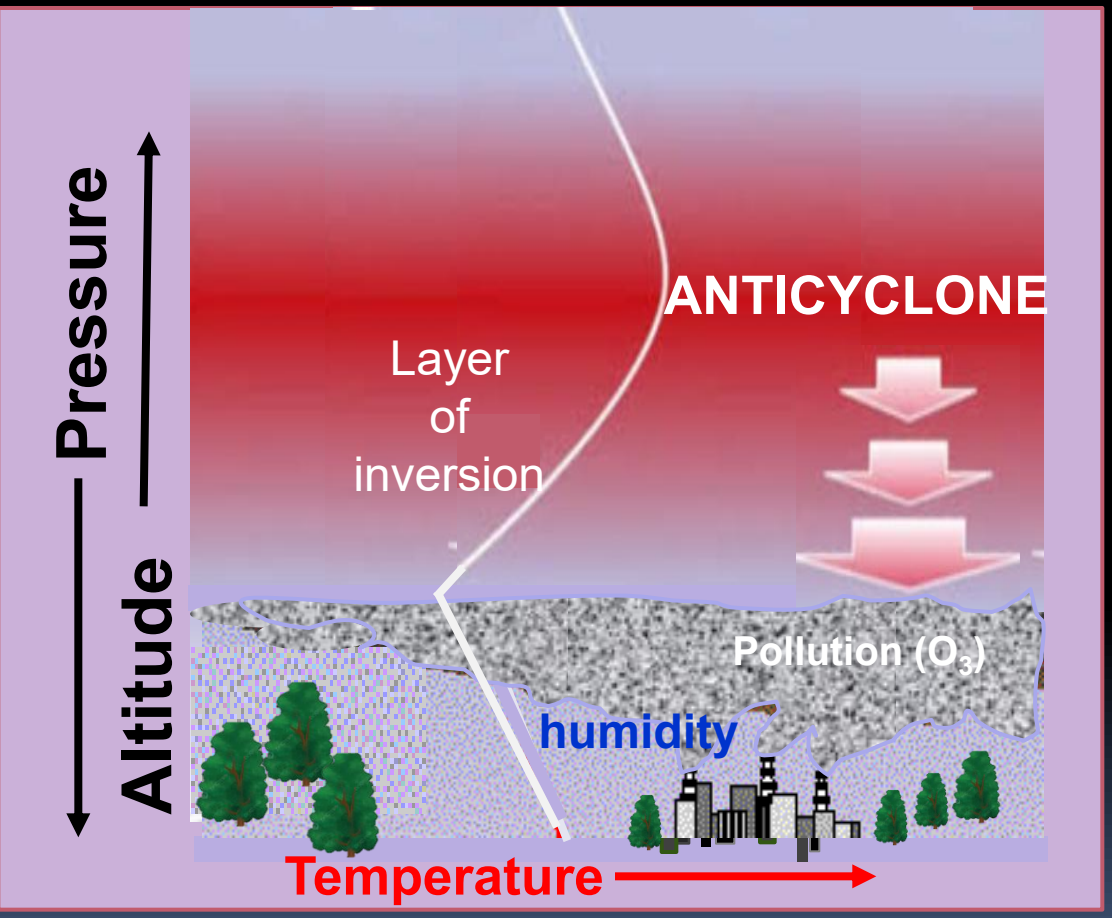


Temp Anom at 2 m (°C)

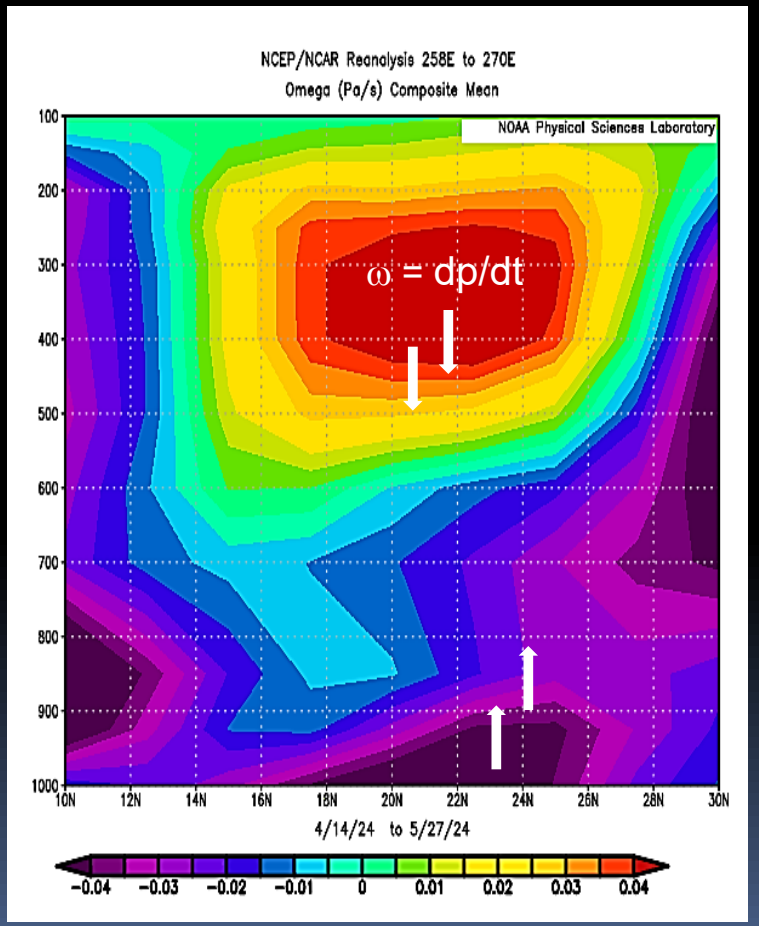
Vertical profile by Lat of ω in 102W-90W



Mexico City and other cities: Thermal inversion

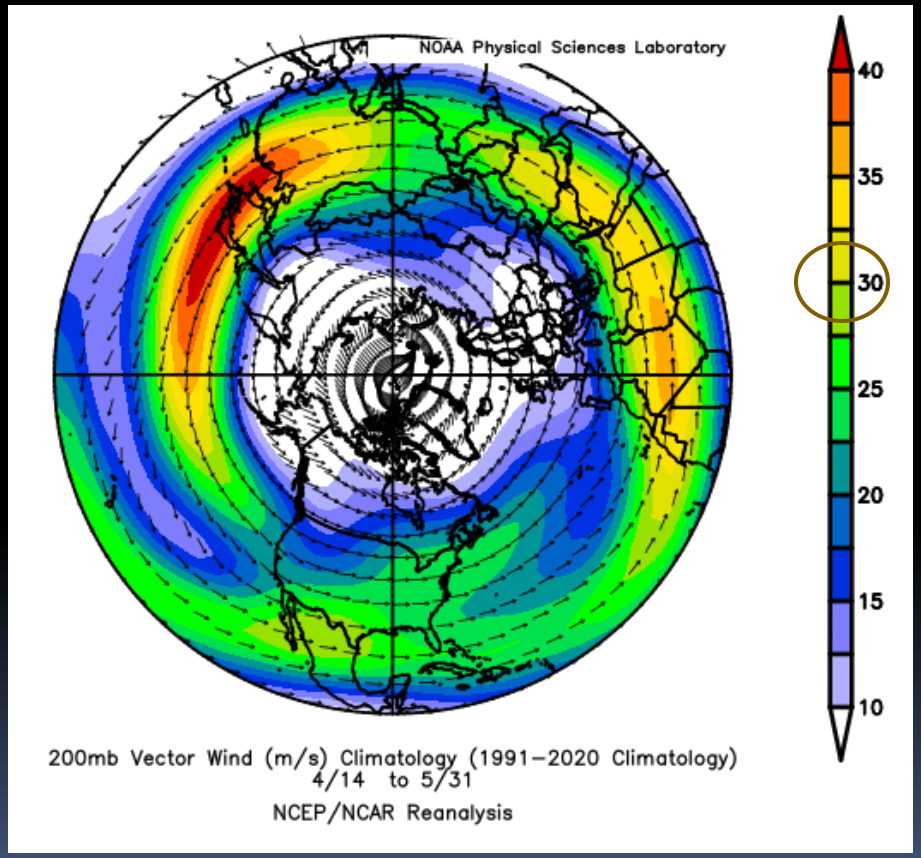


Vertical profile x Lat of ω in 102W-90W

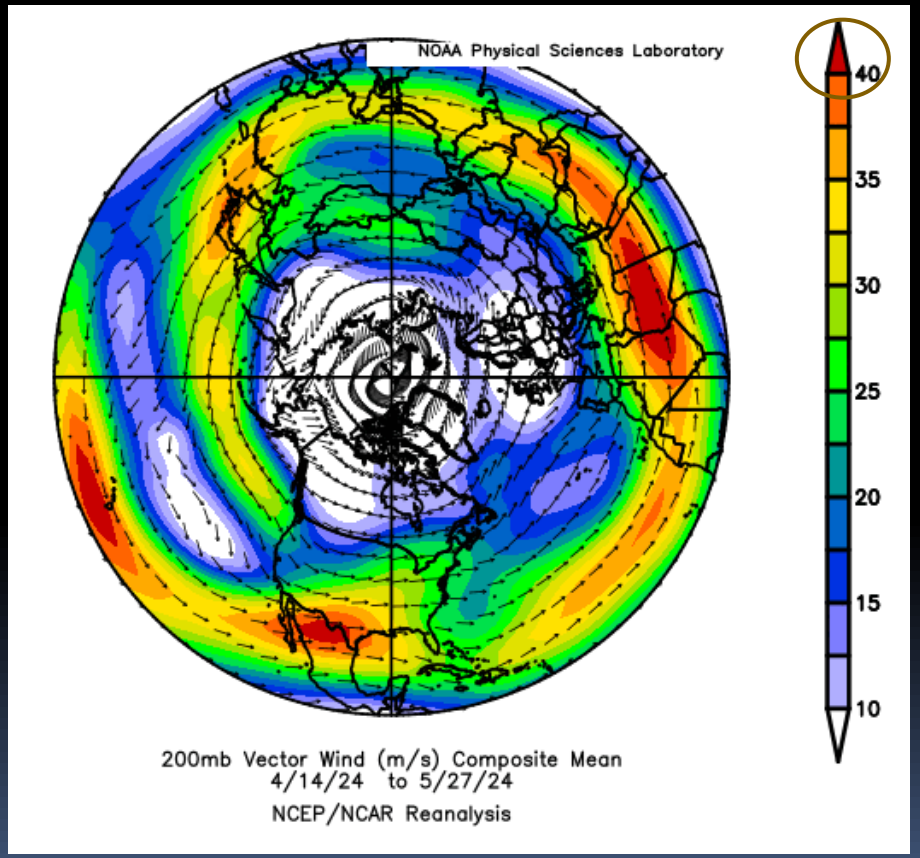


Large-scale seasonal circulation
Subtropical jet stream (UV200 hPa)

Climatology Apr-May

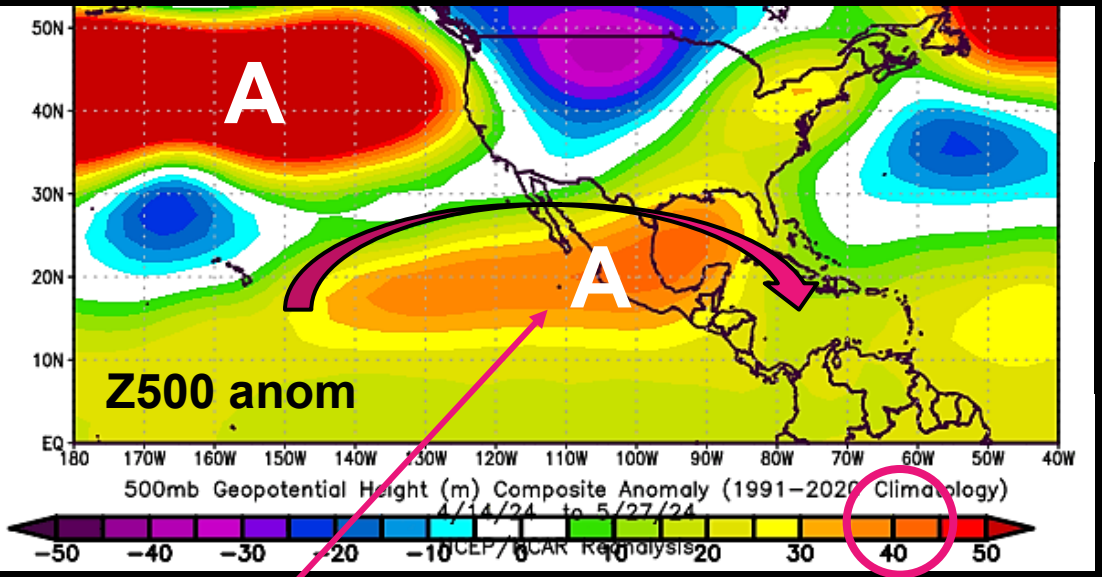


14 Apr - 27 May 2024

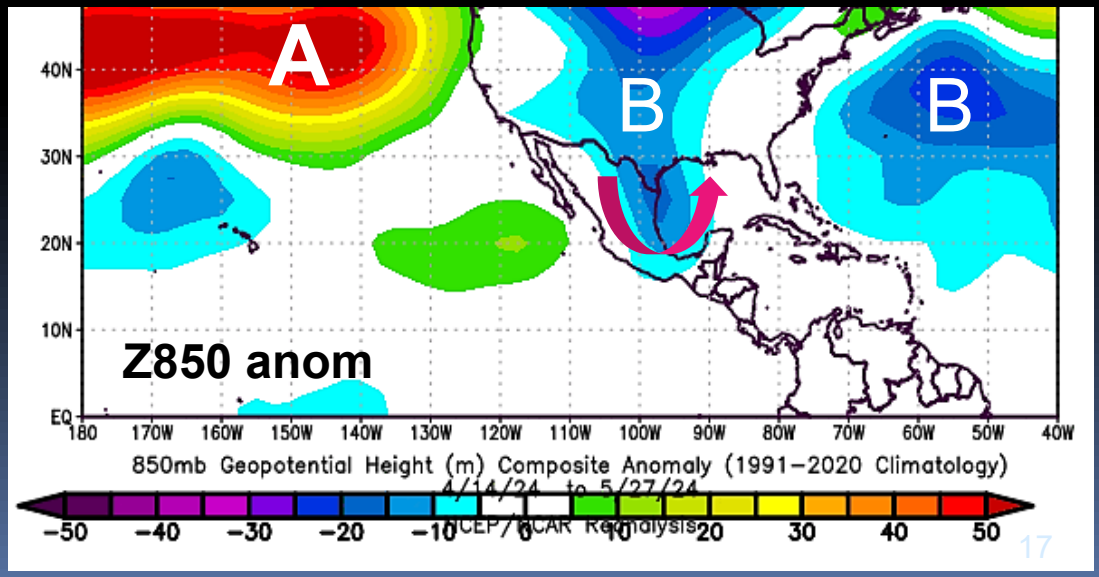


End of El Niño: Vector wind anomaly (m/s)

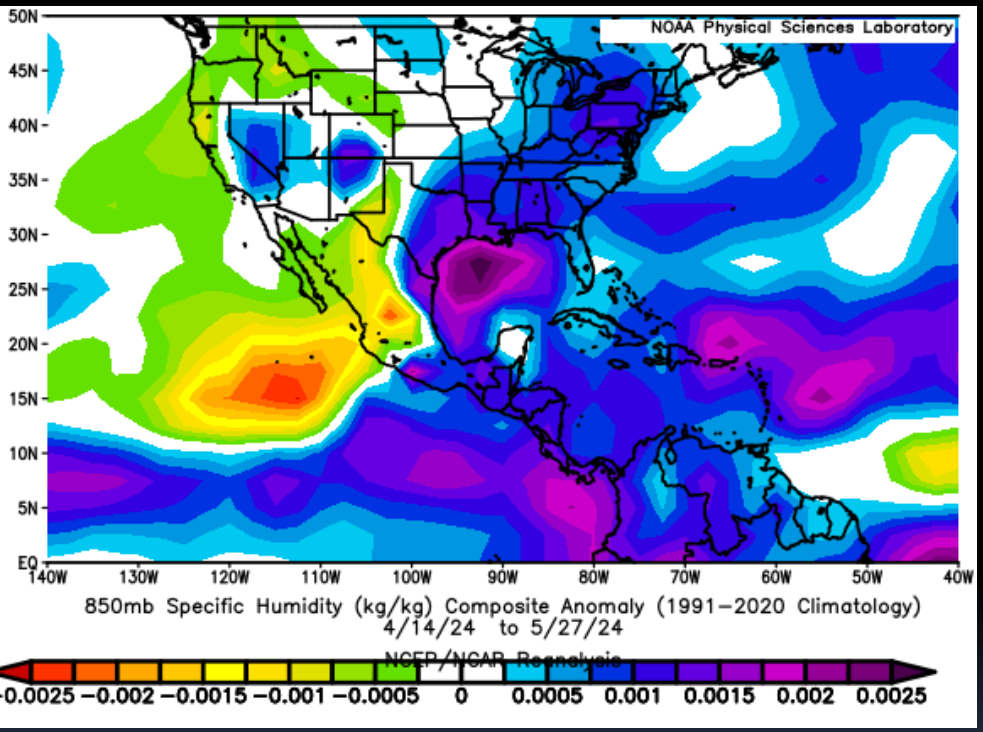
Geopotential height anomalies (Z500) over Mexico during the three heatwaves



Anticyclone over Mexico
(45 m above the mean)



Specific humidity anomalies (q850; kg/kg) during the three heatwaves

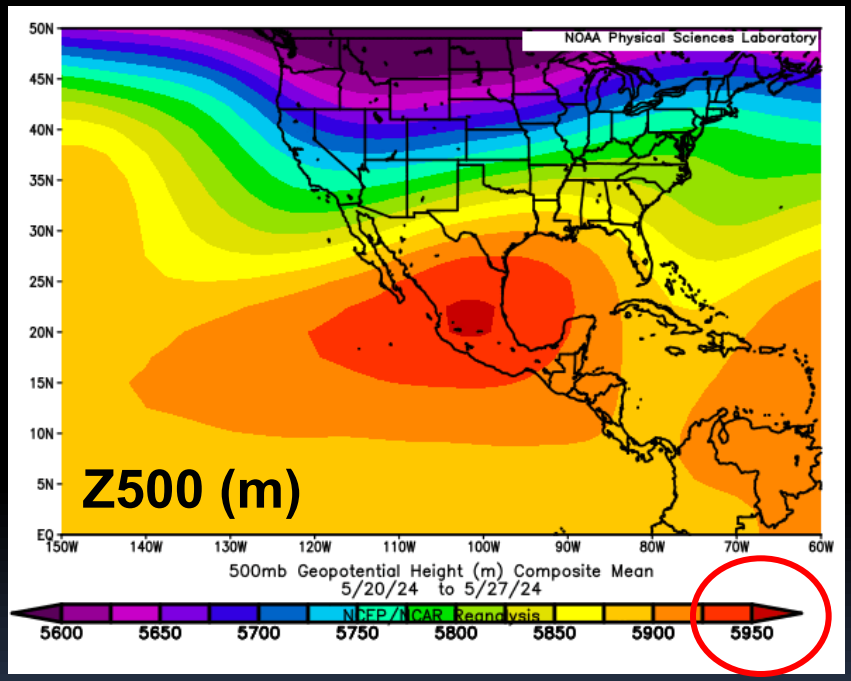


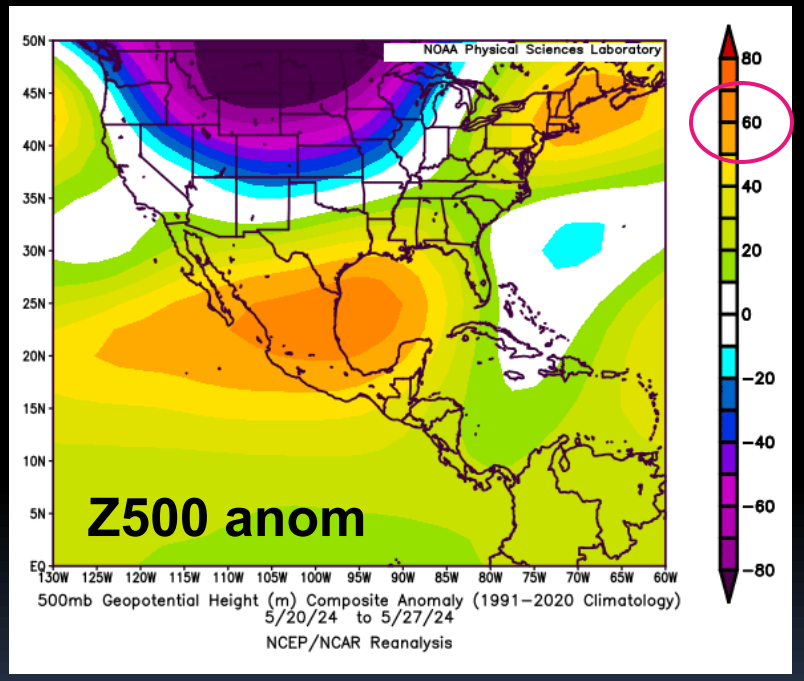
IMPACTS

- Warm and humid air in the Gulf of Mex region
- West of Mex: dry air and forest fires.
- May - driest (precip) and warmest month since 1953; Tmin y Tmax (SMN).

- Mean climatology: q850 = 8-10 g/kg in the Gulf of Mex region and & SE Mex
- During the heatwaves:
  q850 anom > 15 y 20% larger, but RH anom < -10 -15%) in almost all Mexico.

Last & most intense heatwave (20-27 May 2024)
Anticyclone height at 500 hPa (m)

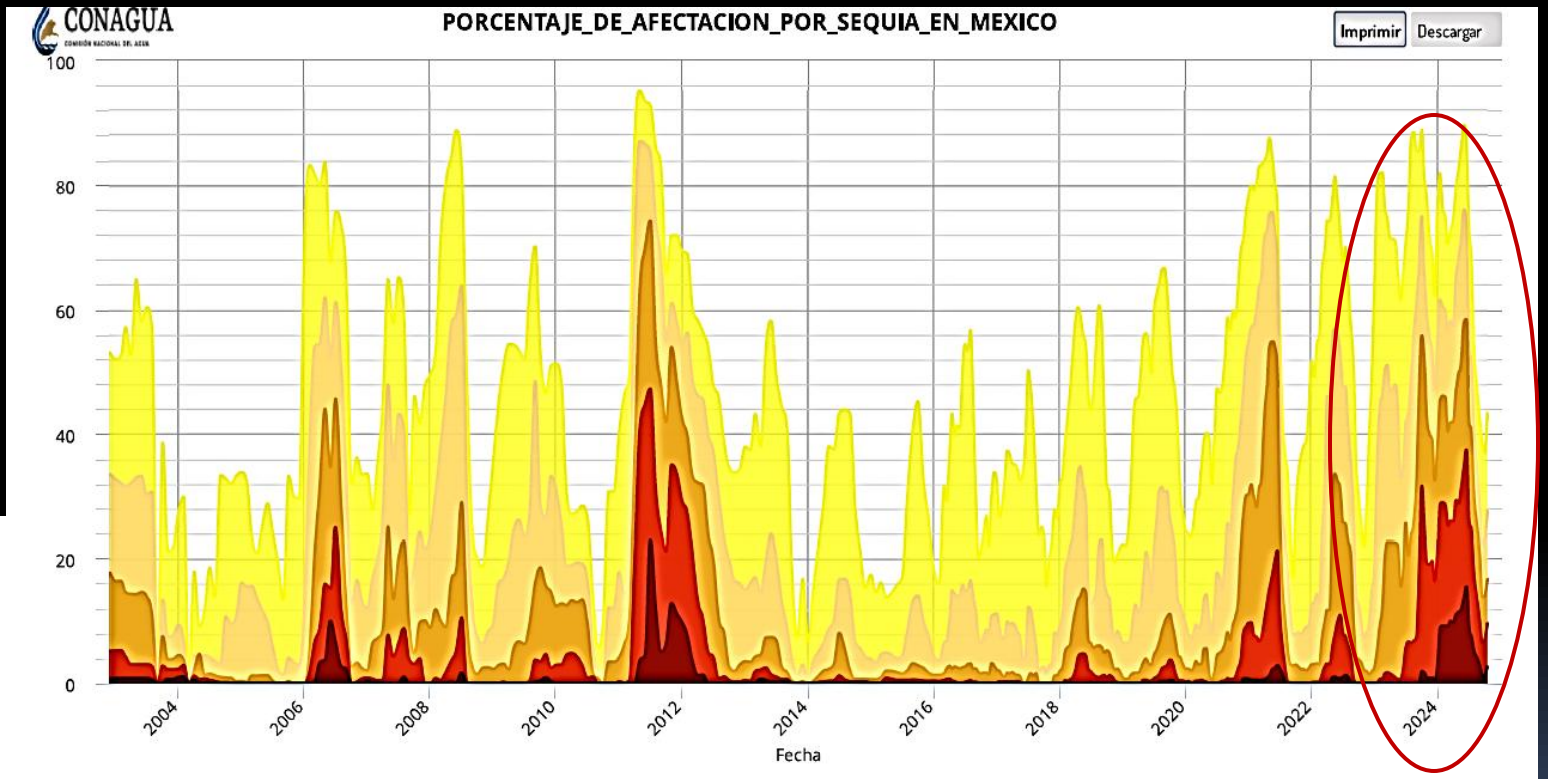




Discussion:
Natural Drivers vs Climate Change

Land antecedent condition (winter-spring 2024)

Severe to exceptional droughts in 40% of Mexico



Intensidad de sequía:

- D0 Anormalmente seco
- D1 Sequía moderada
- D2 Sequía severa
- D3 Sequía extrema
- D4 Sequía excepcional
- Sin sequía

Tipos de impacto de sequía:

~ Delimita impactos dominantes

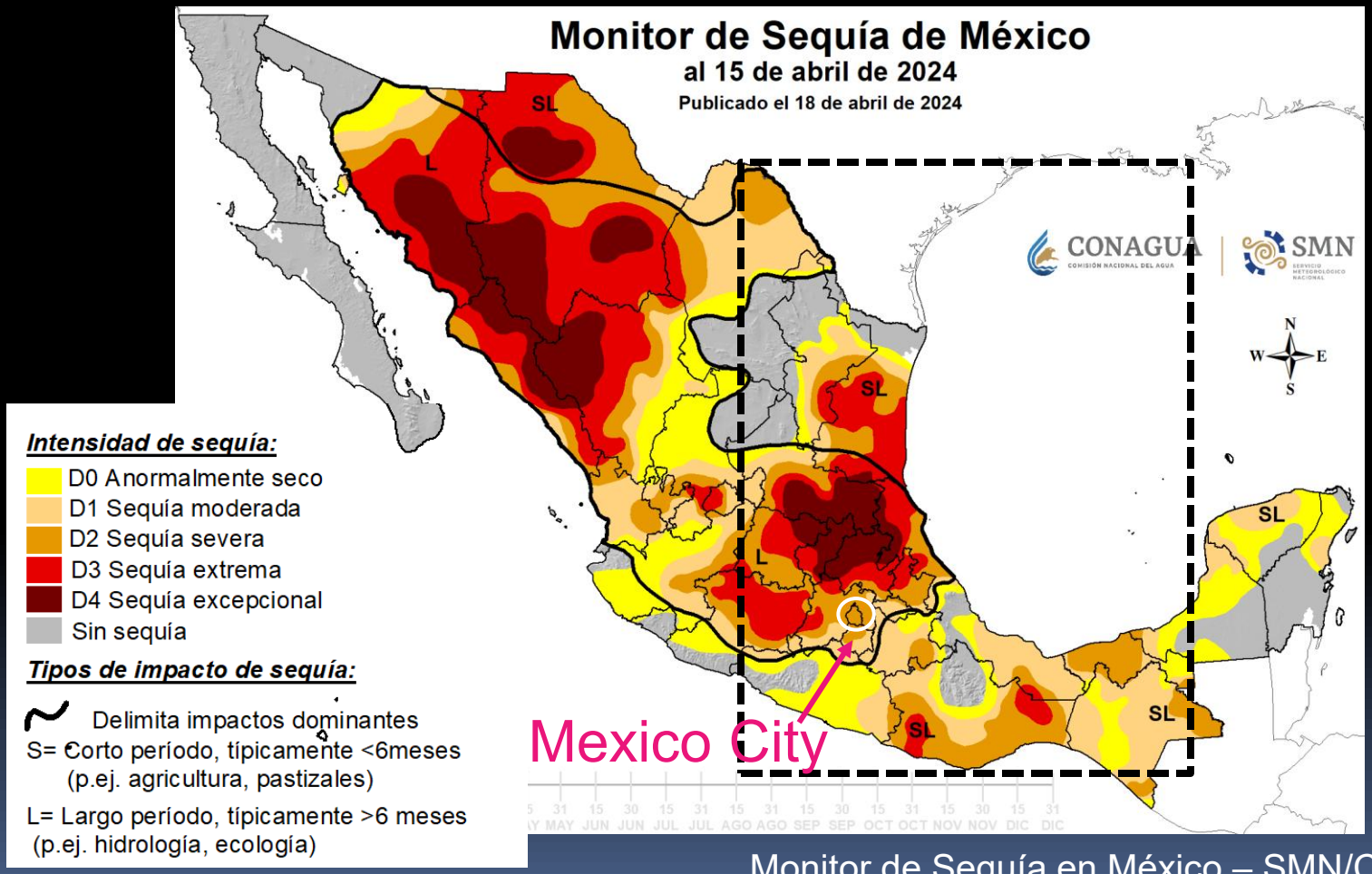
S= Corto período, típicamente <6meses (p.ej. agricultura, pastizales)

L= Largo período, típicamente >6 meses (p.ej. hidrología, ecología)

Monitor de Sequía en México – SMN/CONAGUA

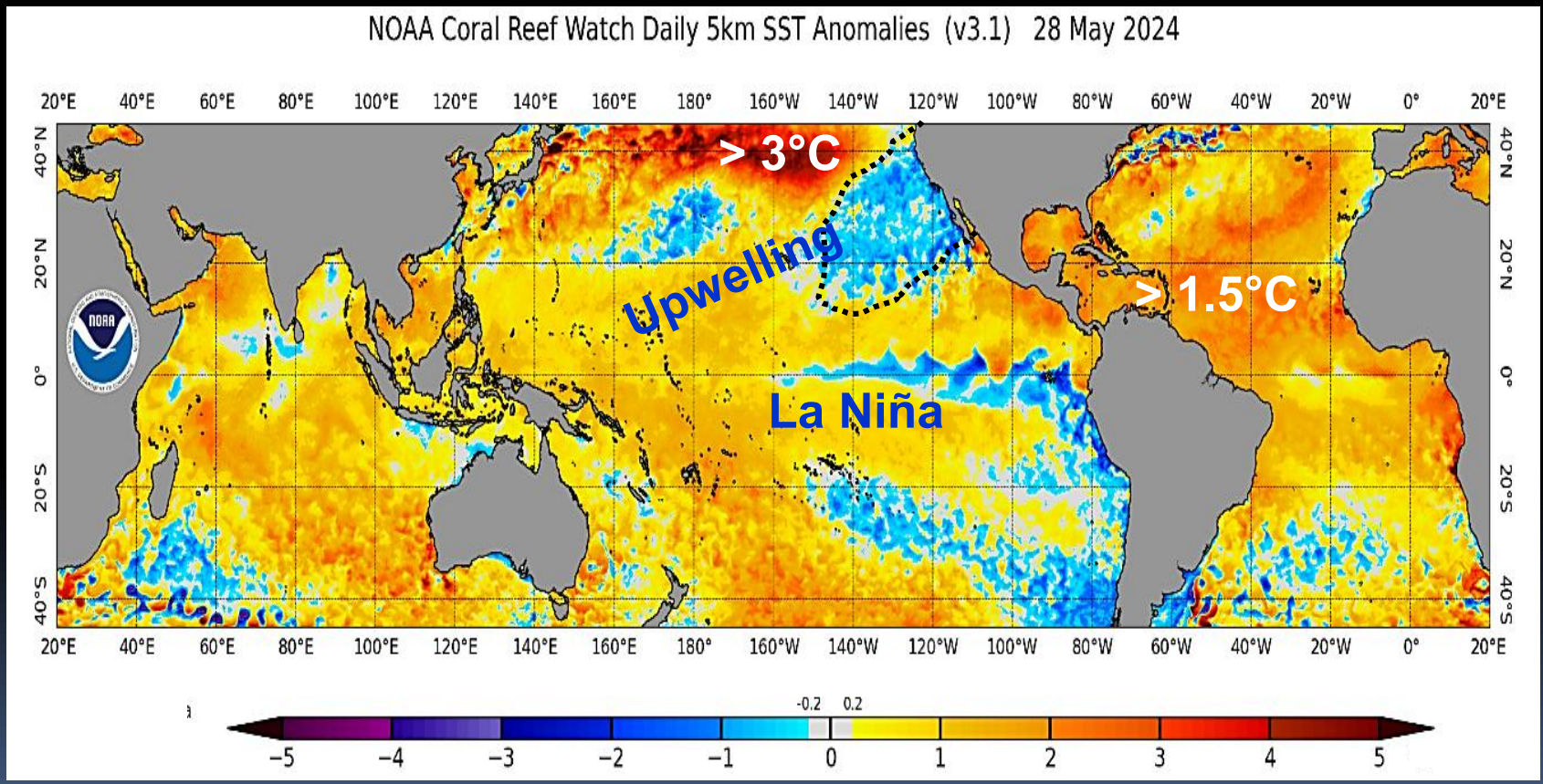
Dry winter – El Niño year

Droughts before 15 April 2024



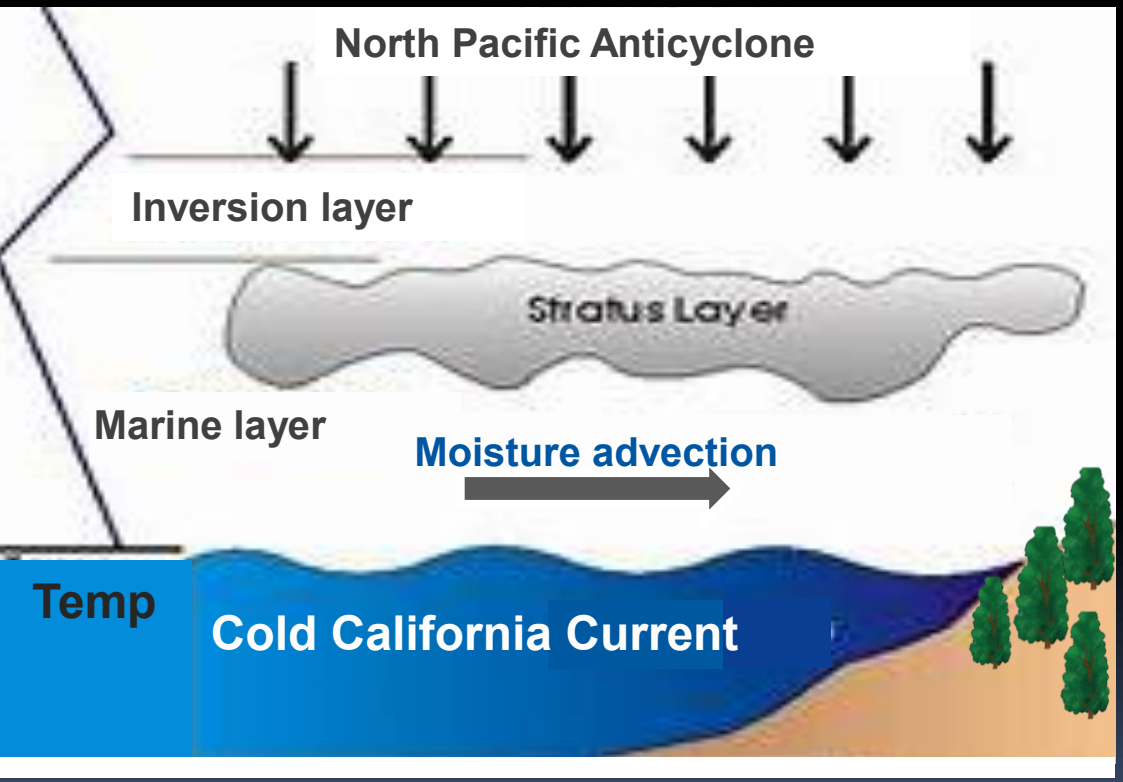
Monitor de Sequía en México – SMN/CONAGUA

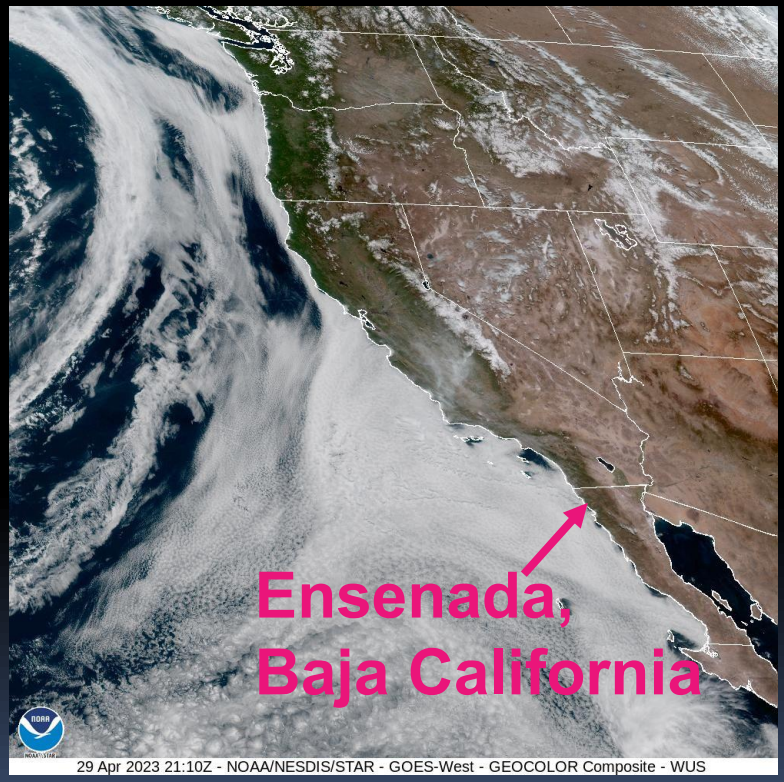
SST anomalies
Last heat wave - week of 28 May 2024



Costs of Baja California and California escaped from the heatwaves

29 April 2024

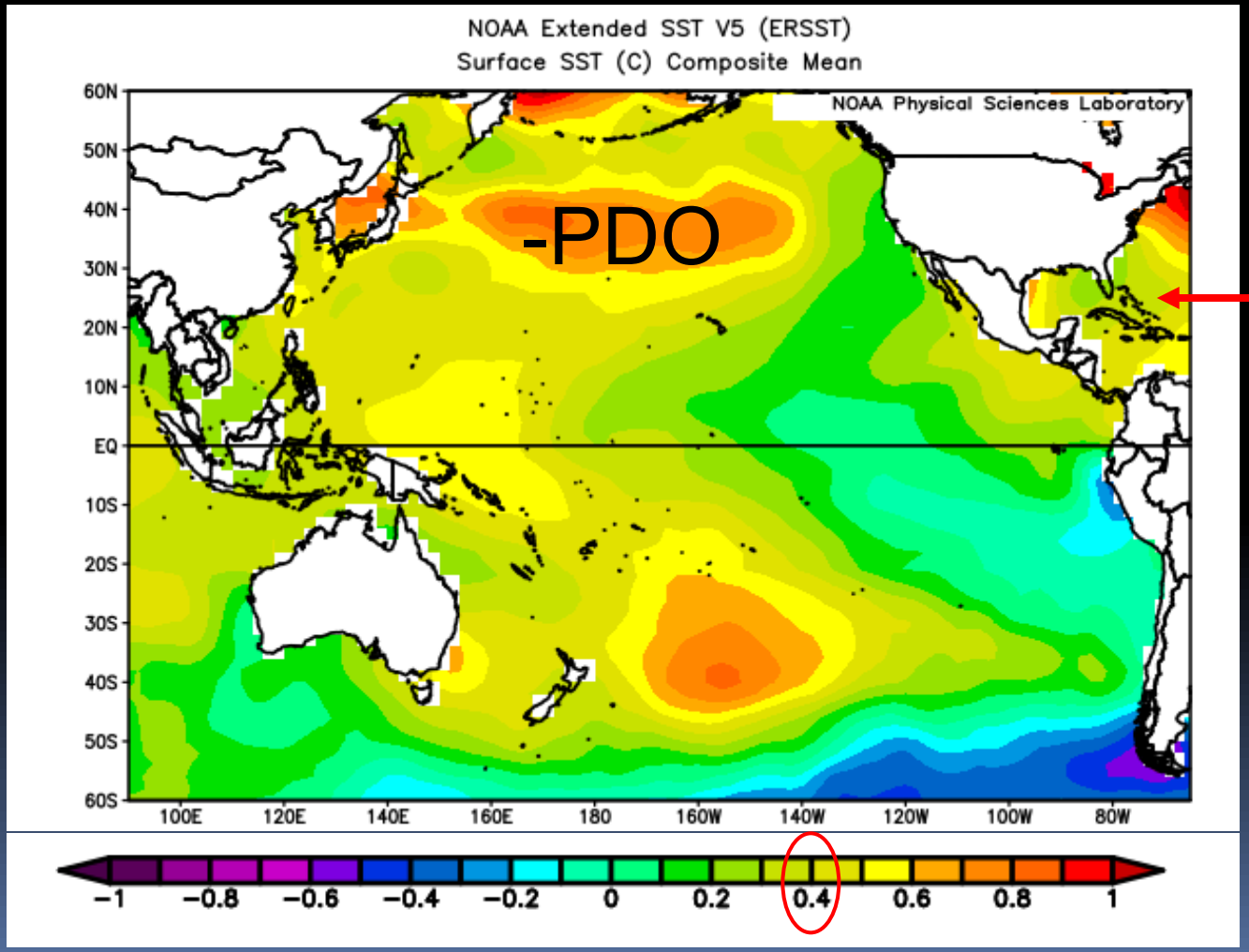




Natural teleconnections:
-PDO / -IPO, +AMO, ENSO

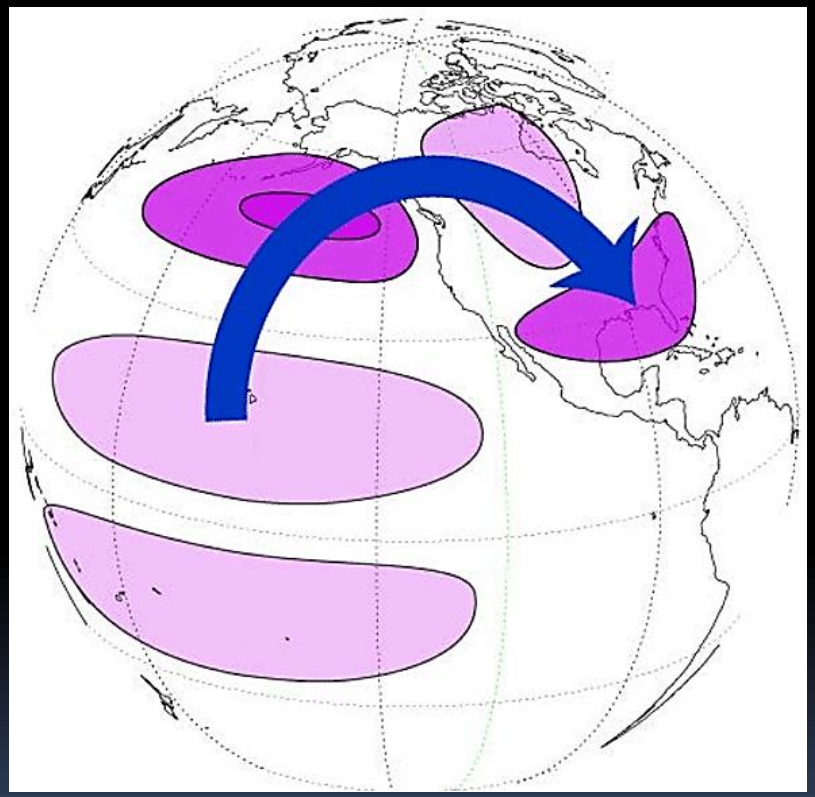
SST anom (°C) de 2001-2023 minus 1971-2000

➔ Increment 0.05°C/década en Golf Mexico and Eastern Pacífico

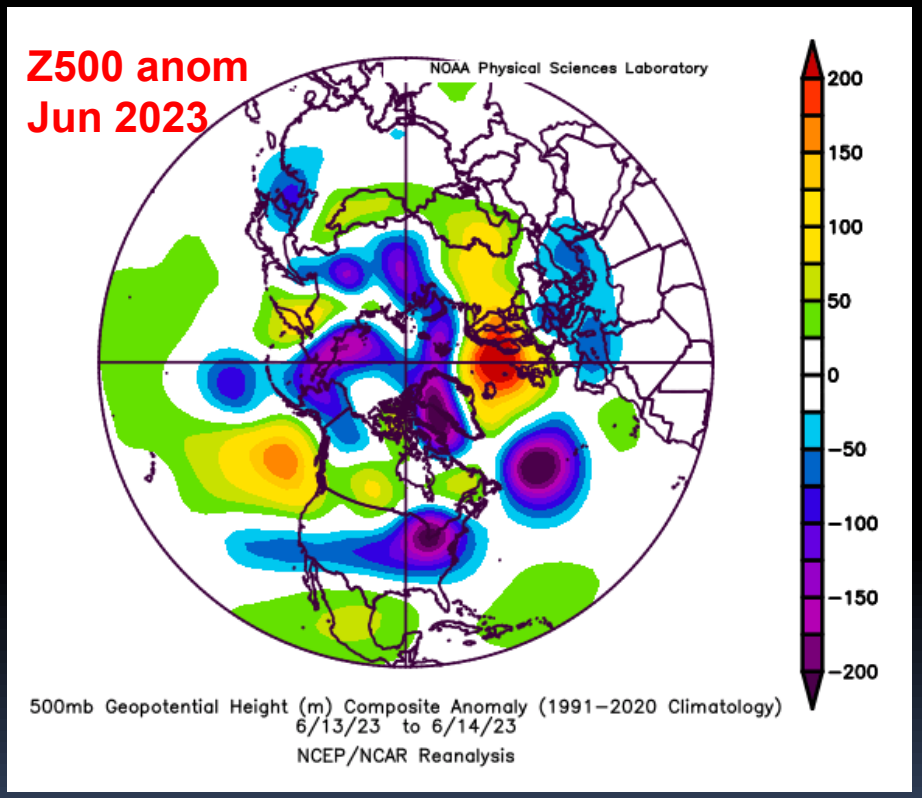


Tropical Teleconnections and Rossby waves

ENSO-PNA



Jun 2023: heatwave in Mex/US



Tropical teleconnection: Rossby waves, El Niño, and PNA pattern.

Heatwaves & teleconnections ➔ Cai et al., 2024; Nat. Comm.

HWs in the Northern Hemisphere: Arctic

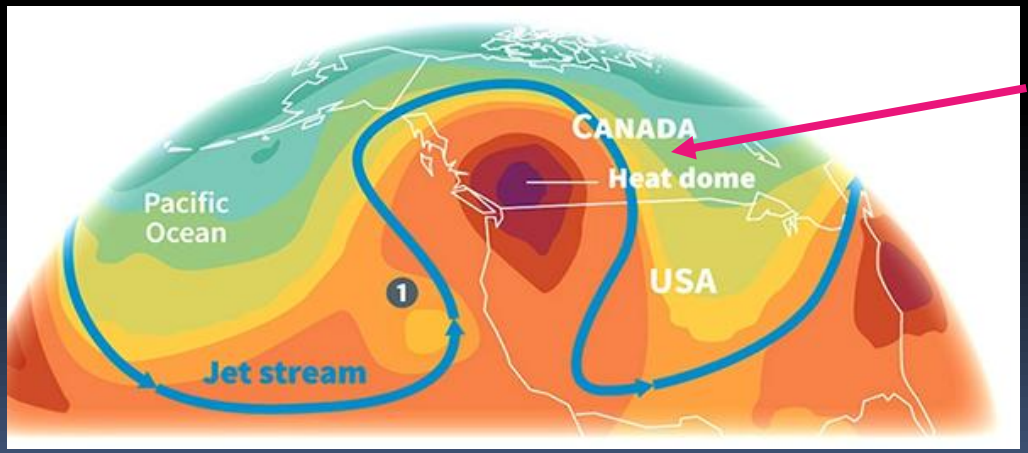
Article | Open access | Published: 18 February 2020

Increased European heat waves in recent decades in response to shrinking Arctic sea ice and Eurasian snow cover

Ruonan Zhang, Chenghu Sun, Jieshun Zhu, Renhe Zhang & Weijing Li

npj Climate and Atmospheric Science **3**, Article number: 7 (2020) | Cite this article

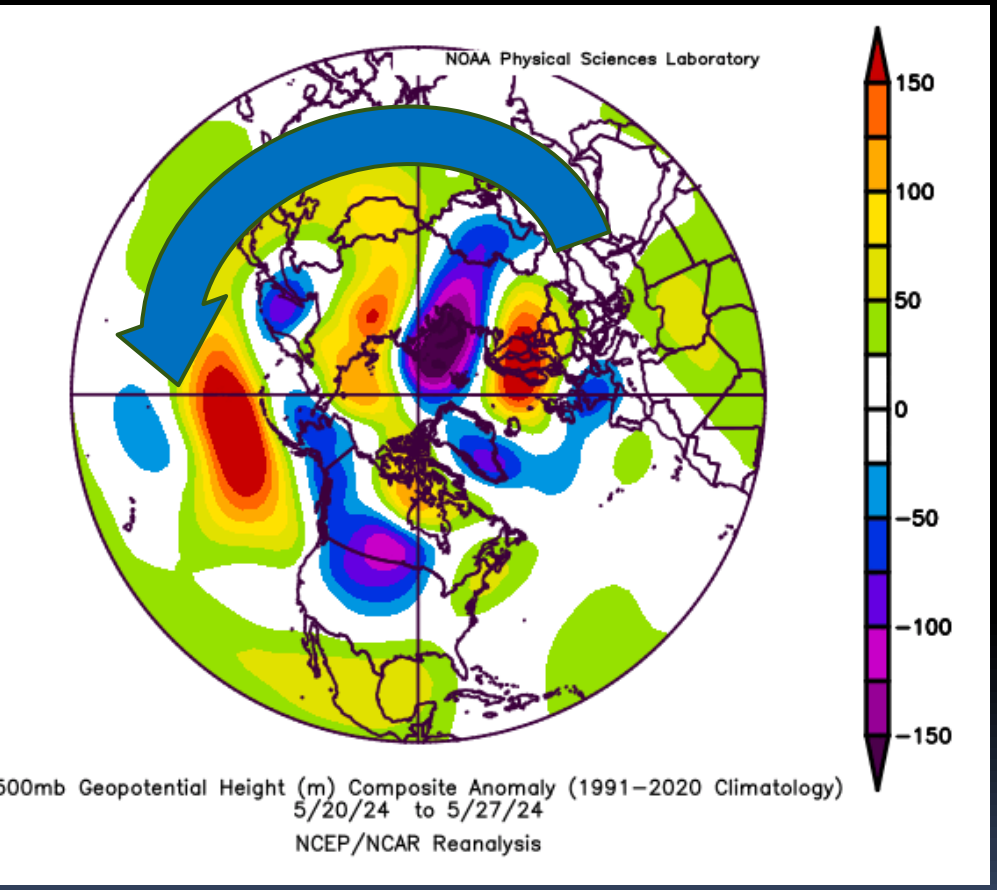
- ➔ Arctic amplification
- ➔ Polar jet stream more wavy (or meridional)
- ➔ More extreme events, why?



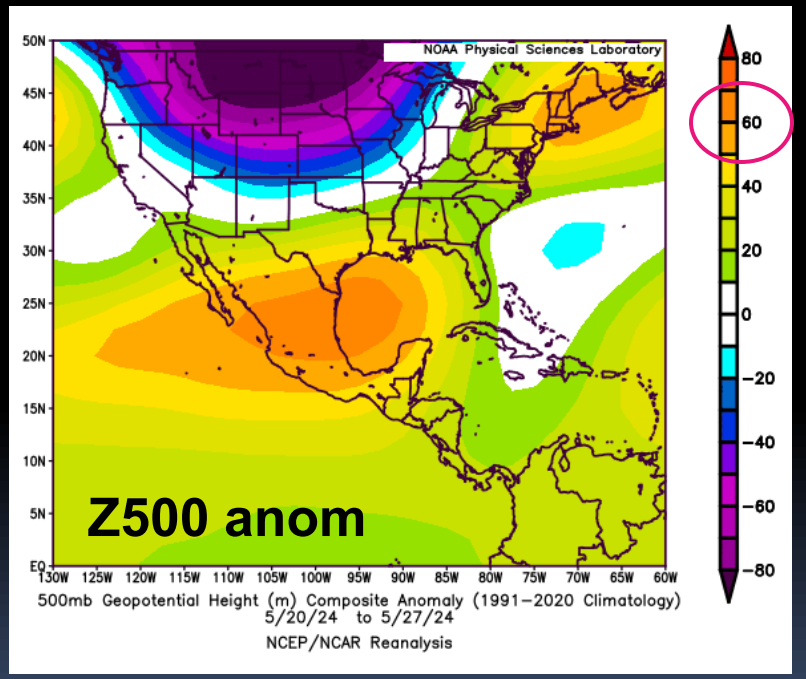
https://www.drishtiias.com/images/uploads/1626762592_image1.jpg

- ➔ Omega block: antecedent drivers?: droughts
- ➔ Positive trend in Rossby wave patterns 7-8 in NH (e.g., Guimãres et al., 2024; Nature).

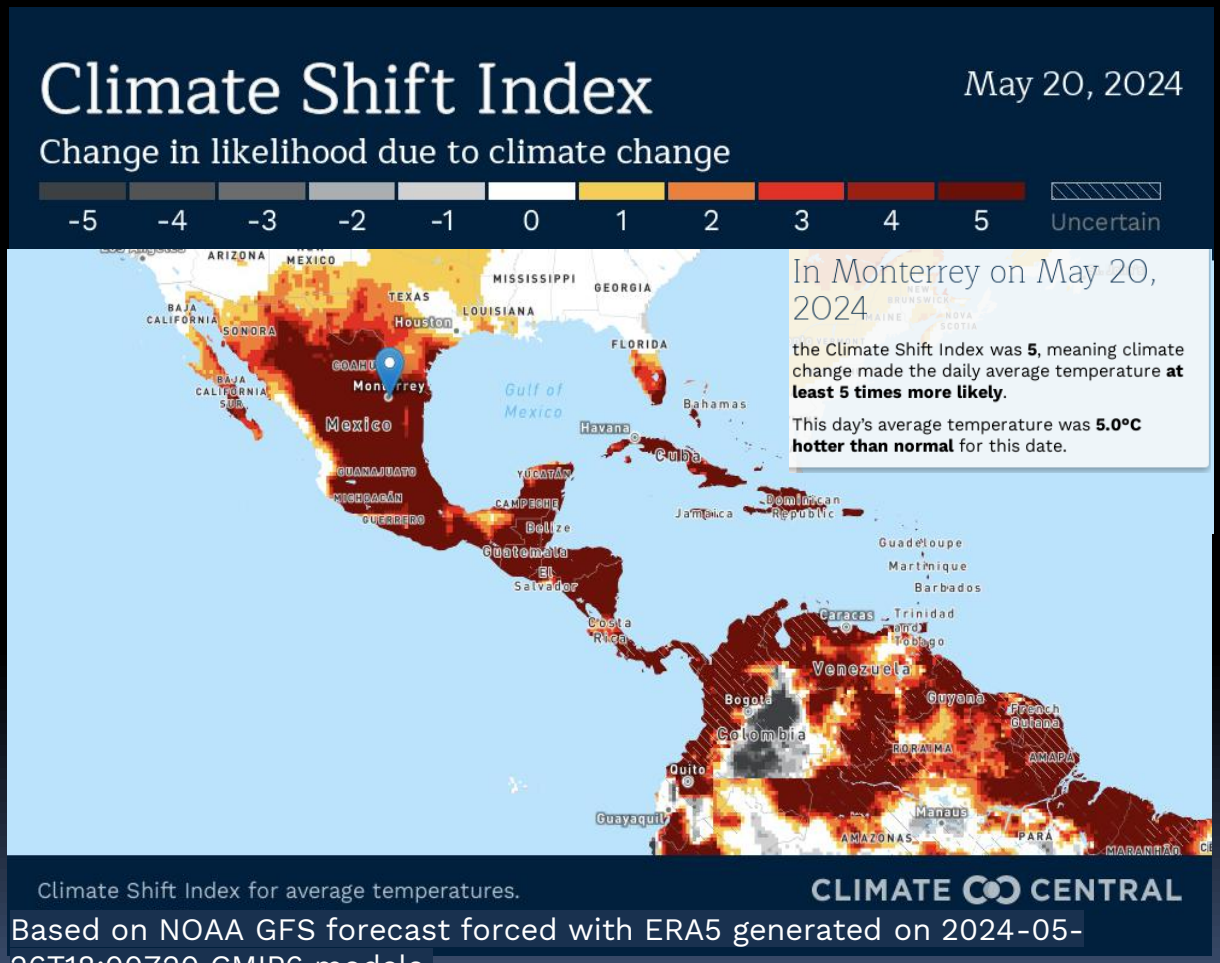
Rossby waves in the midlatitudes
Z500 anom (m)



20-27 May 2024



Attribution to Climate Change?



Based on NOAA GFS forecast forced with ERA5 generated on 2024-05-26T18:00Z20 CMIP6 models.

20-27 May 2024 heatwave

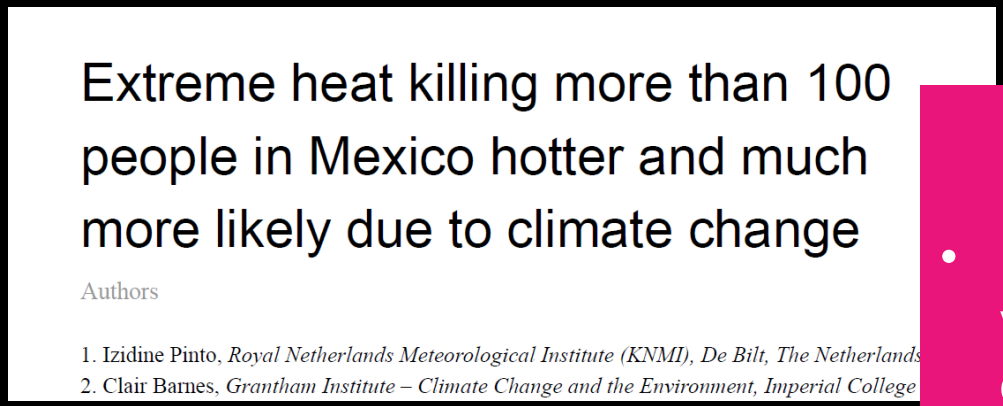
- Tanom = 3°C to 5°C
- Climate change made the daily Temp averages 5 times more likely.

https://csi.climatecentral.org/ ➔ Pershing et al., (2023)

https://www.ncdc.noaa.gov/cag/time-series/global/globe/land_ocean/ytd/5/1880-2016

Attribution to Climate Change

https://www.worldweatherattribution.org/



Extreme heat killing more than 100 people in Mexico hotter and much more likely due to climate change

Authors

1. Izidine Pinto, *Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands*
2. Clair Barnes, *Grantham Institute – Climate Change and the Environment, Imperial College*

Pinto et al., (2024)

25 May – 3 de Jun 2024

- It is expected that similar Tmax values observed in these days occur every 15 years
- At the beginning of the Century, they were expected to occur every 60 years.

Next steps: Experiments with RegCM5
Mean climate; attribution analysis; urban simulation

https://www.ncdc.noaa.gov/cag/time-series/global/globeland_ocean/ytd/6/1880-2016

Thanks!

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https://usuario.cicese.mx/~tcavazos/index.php

Pacific Decadal Oscillation