



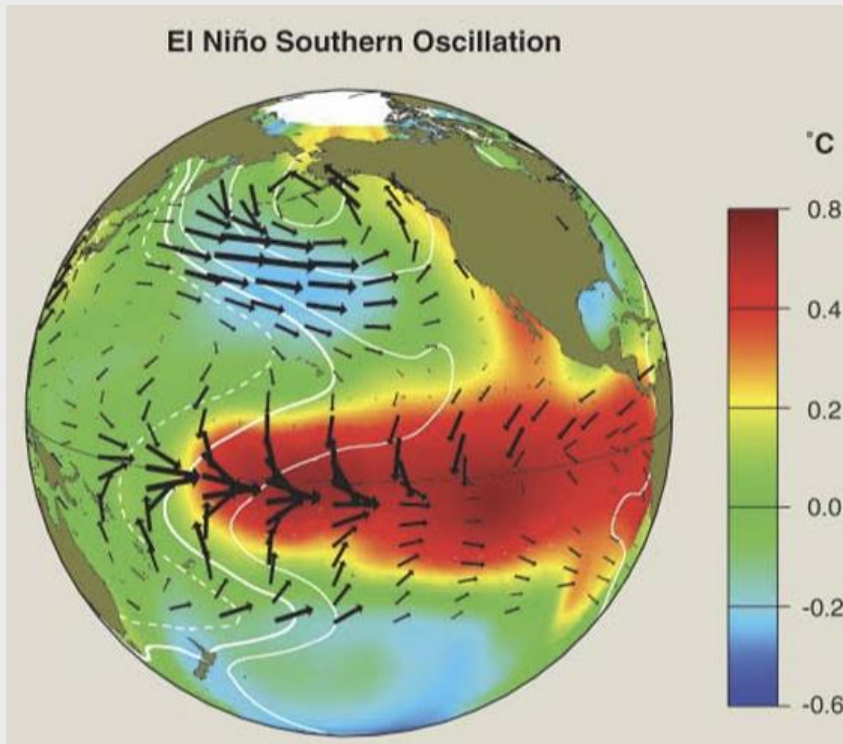
Asia-Pacific
Economic Cooperation

Towards a better understanding of ENSO and its impacts

Sang-Wook Yeh, Hanyang University, South Korea

August, 13, 2024

REVIEW



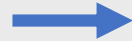
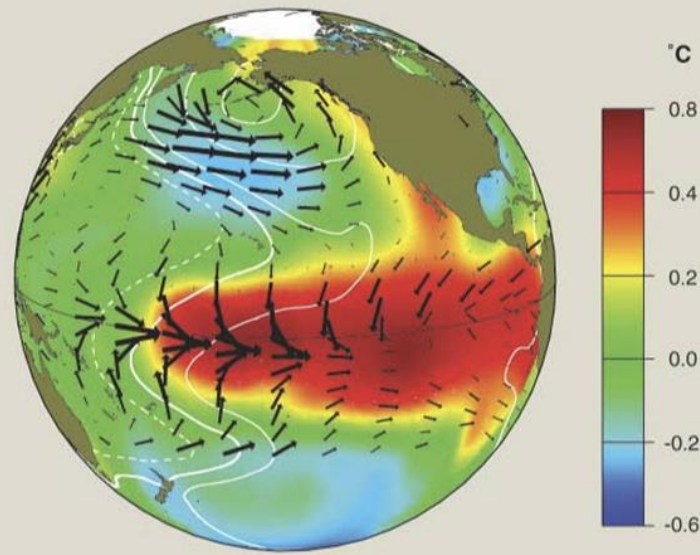
ENSO as an Integrating Concept in Earth Science

Michael J. McPhaden,^{1*} Stephen E. Zebiak,² Michael H. Glantz³

The El Niño–Southern Oscillation (ENSO) cycle of alternating warm El Niño and cold La Niña events is the dominant year-to-year climate signal on Earth. ENSO originates in the tropical Pacific through interactions between the ocean and the atmosphere, but its environmental and socioeconomic impacts are felt worldwide. Spurred on by the powerful 1997–1998 El Niño, efforts to understand the causes and consequences of ENSO have greatly expanded in the past few years. These efforts reveal the breadth of ENSO’s influence on the Earth system and the potential to exploit its predictability for societal benefit. However, many intertwined issues regarding ENSO dynamics, impacts, forecasting, and applications remain unresolved. Research to address these issues will not only lead to progress across a broad range of scientific disciplines but also provide an opportunity to educate the public and policy makers about the importance of climate variability and change in the modern world.

Science (2006)

El Niño Southern Oscillation



Hydrological
cycles

Extreme
Weathers
(heatwaves,
flooding,
drought and
cold spells)



Goddard and Gershuniv (2020), Soden (2000), Hobbrook et al. (2020)

Figure. ENSO influence on winter mean precipitation during 1950/1951–2009/2010.

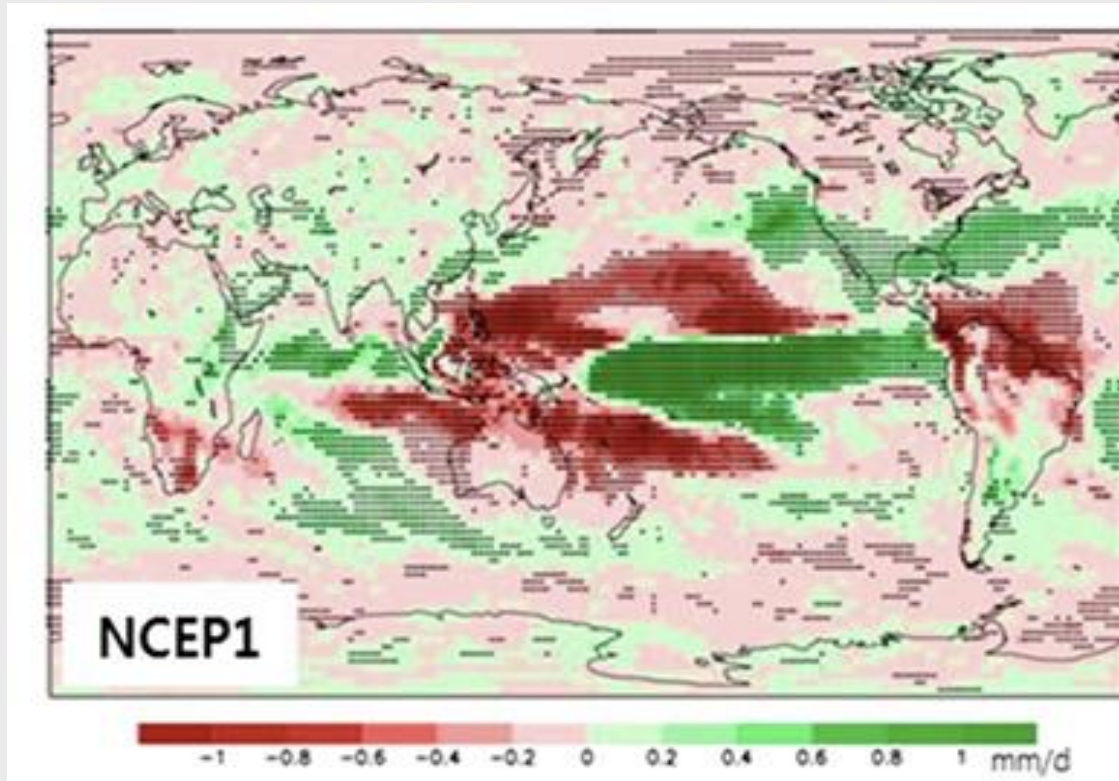
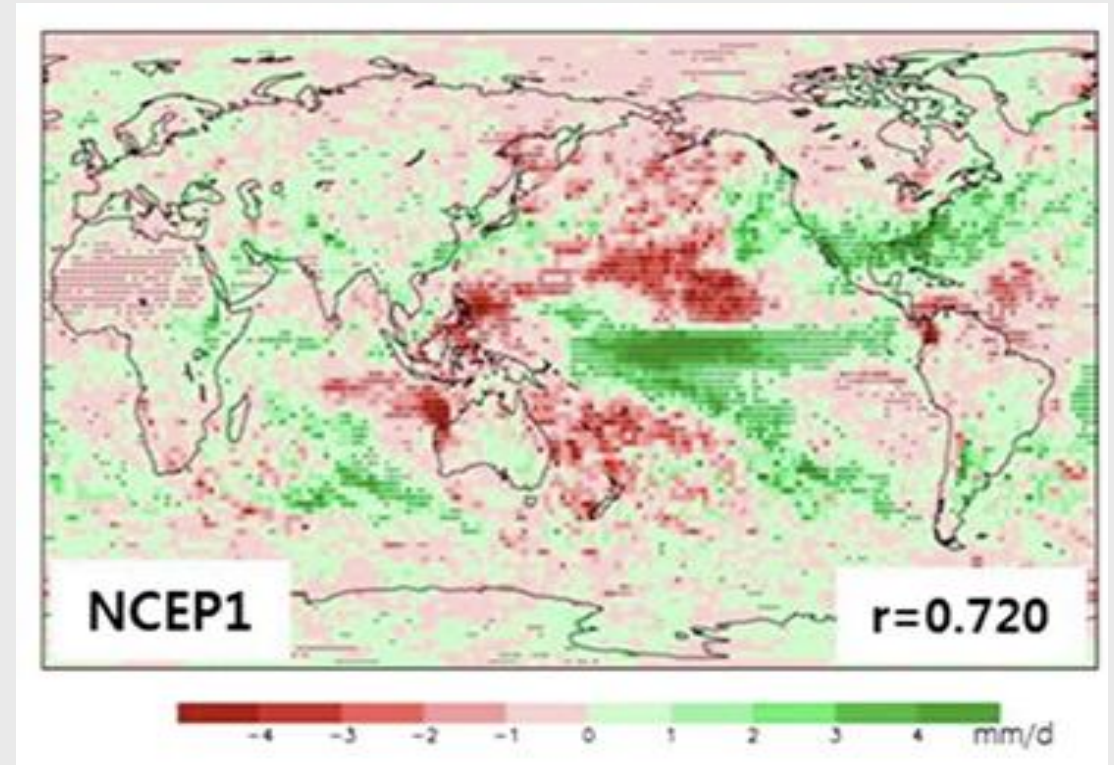
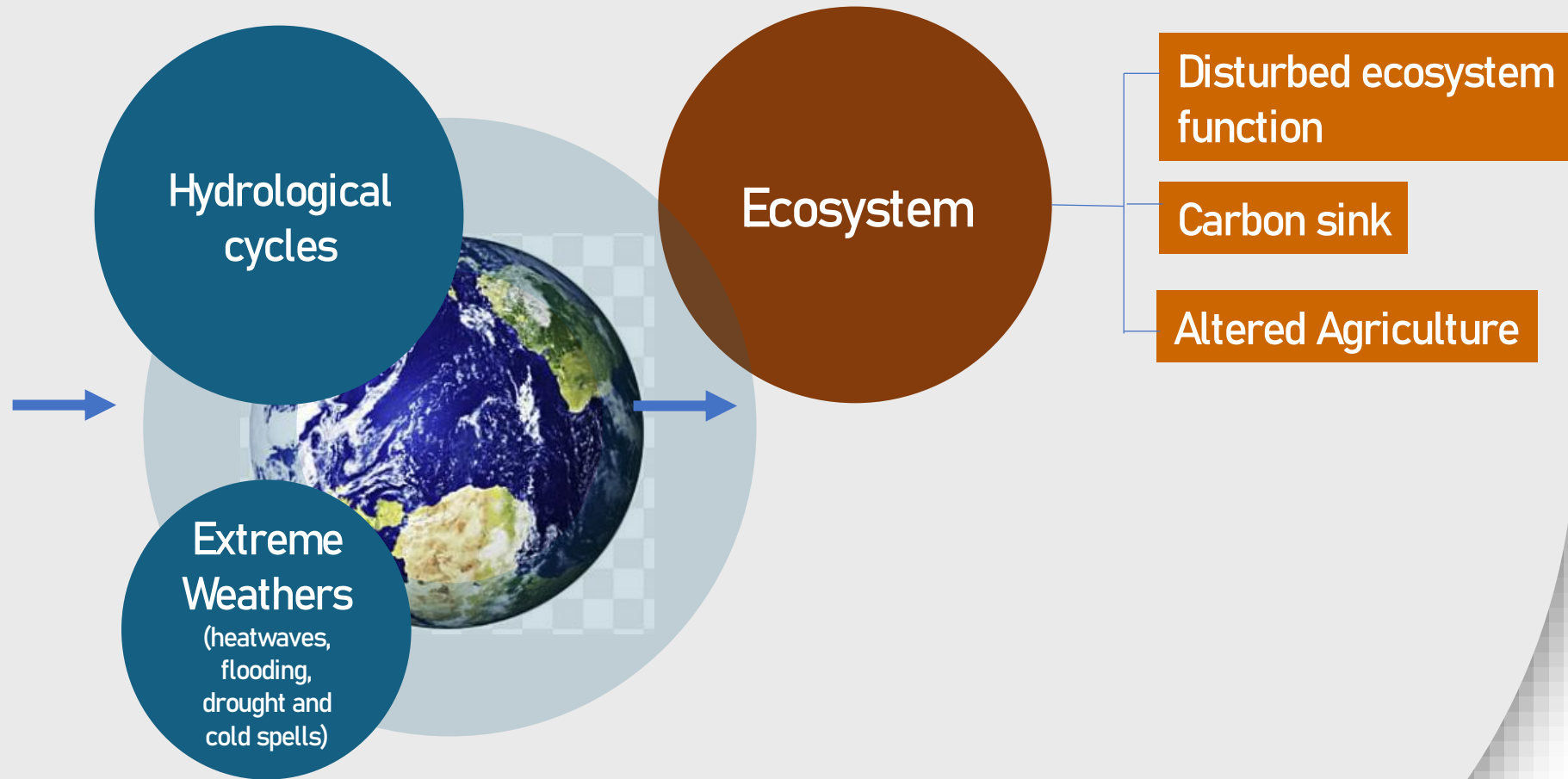
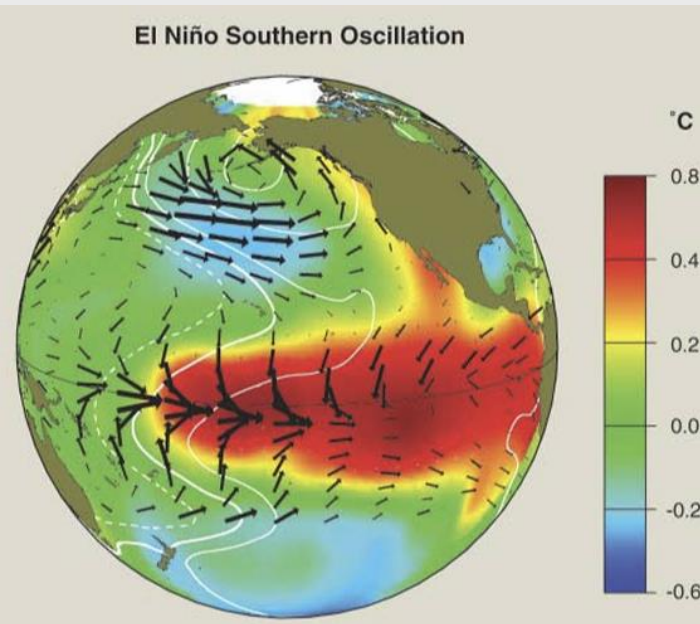
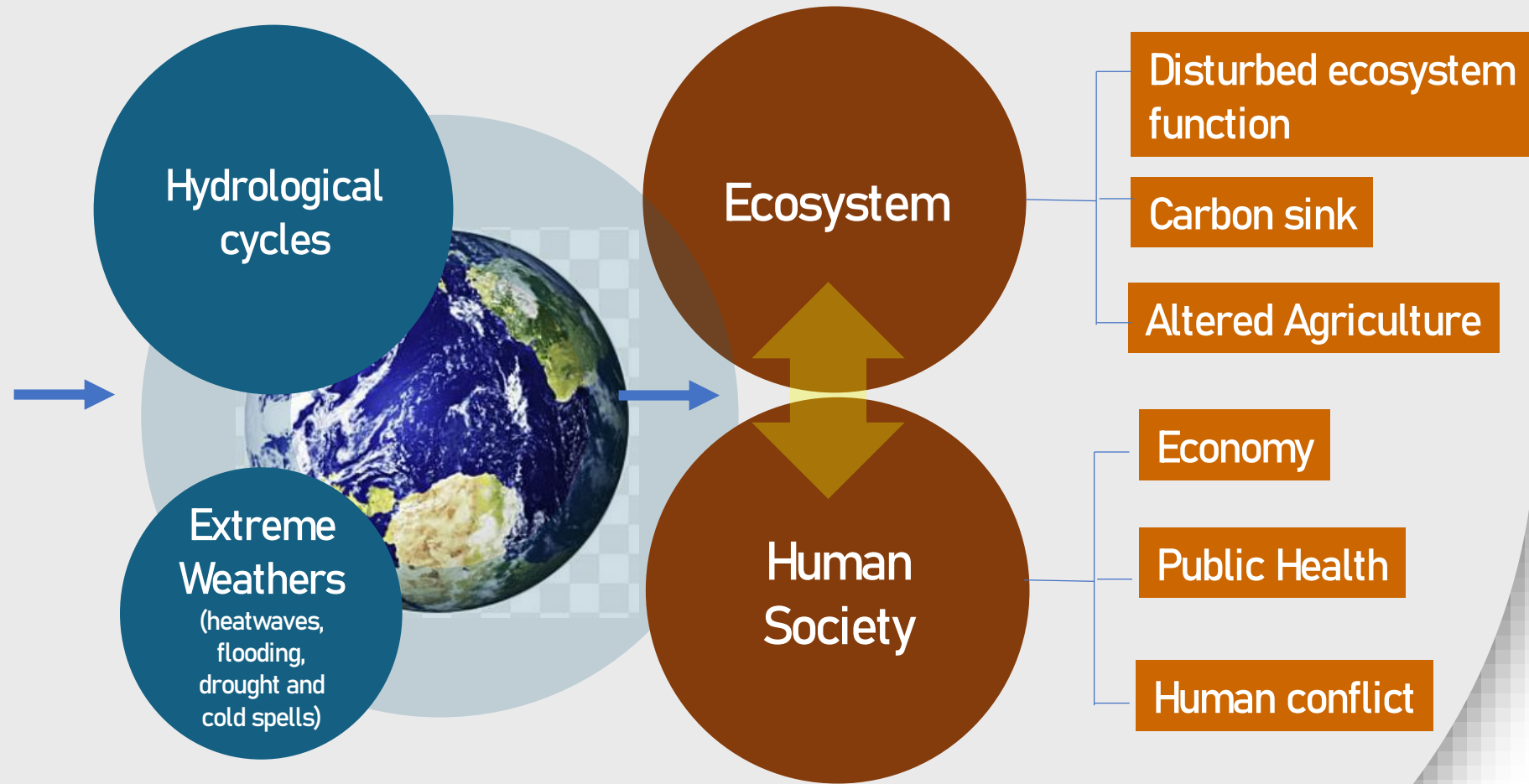
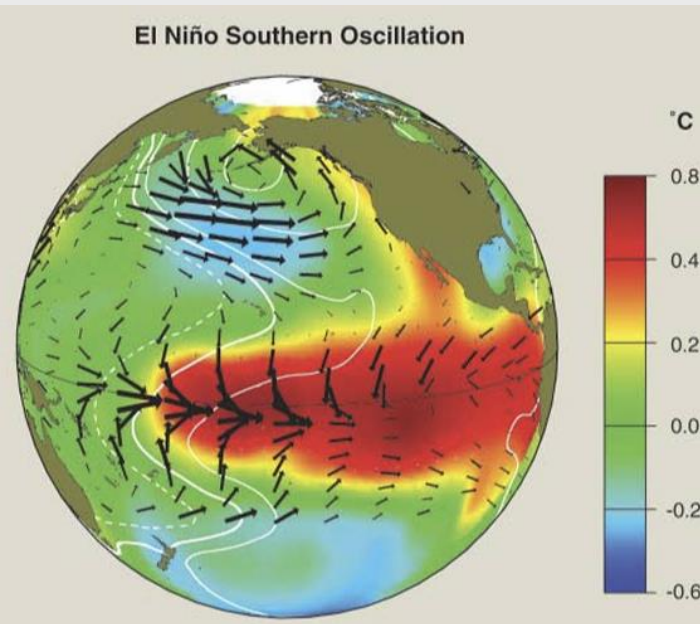


Figure. ENSO influence on winter maxima of daily precipitation (RX1day) during 1950/1951–2009/2010.





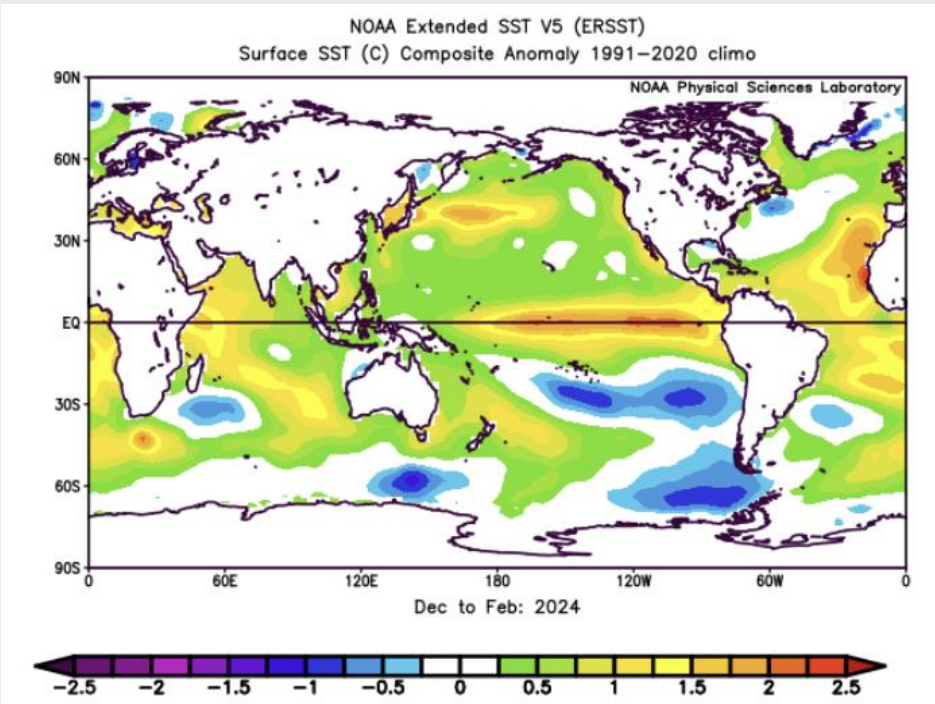
Goddard and Gershuniv (2020), Soden (2000), Hobbrook et al. (2020), Adams et al. (1999), Callahan and Mankin (2022)



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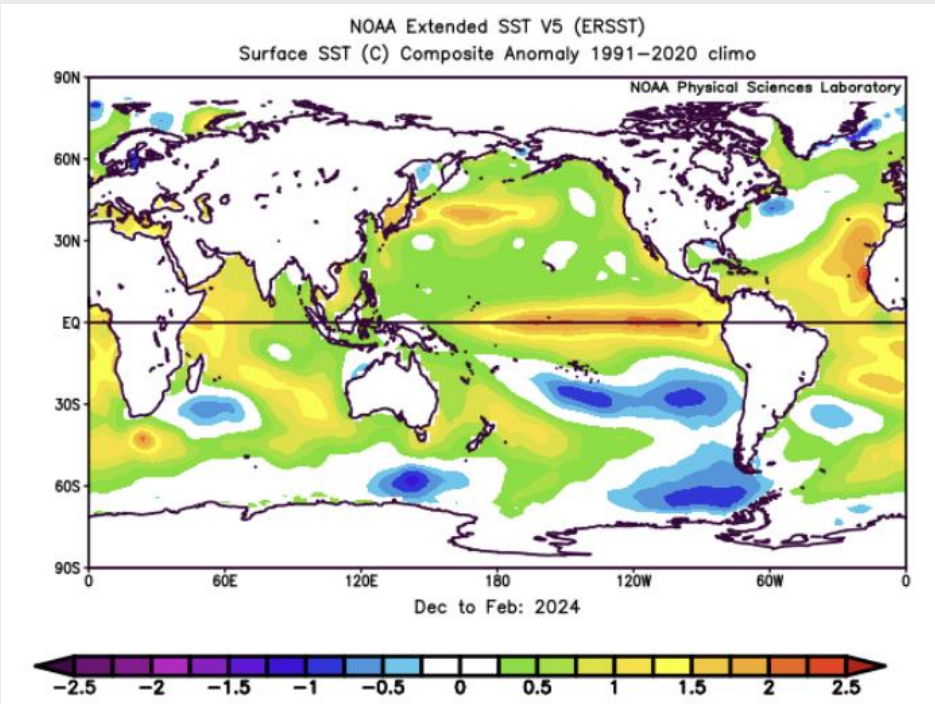
Q] How local and regional communities can better respond to and sustainably manage ENSO events and impacts ?

2023 D 2024 JF SST anomaly



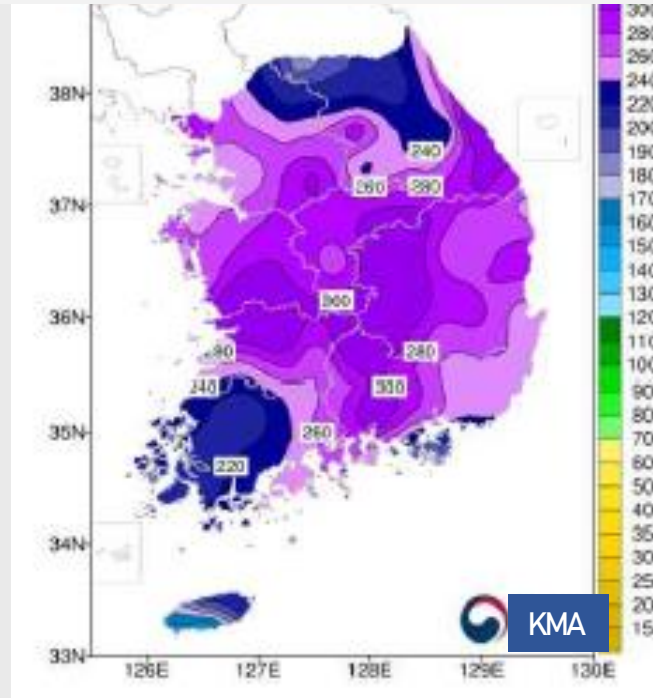
DJF: December-January-February
SST: Sea Surface Temperature

2023 D 2024 JF SST anomaly



2023 D 2024JF Precipitation.

Precipitation increasing ratio compared to normal (270.8%) Record High in Korea since the mid 1970s



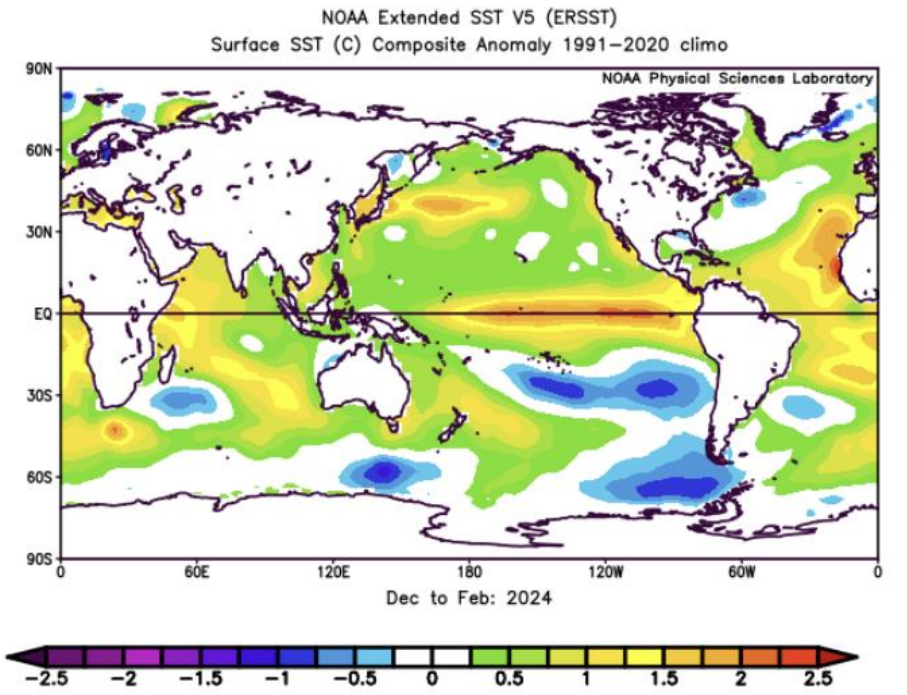
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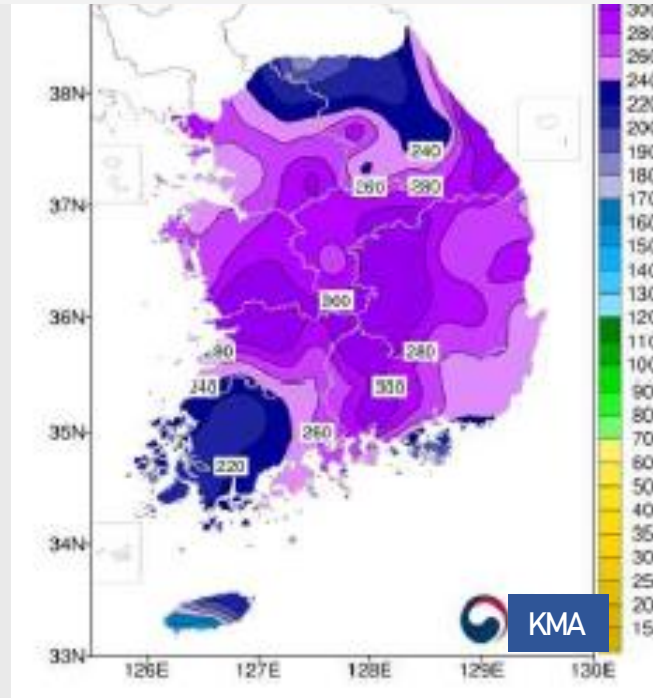
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2023 D 2024 JF SST anomaly



2023 D 2024JF Precipitation.

Precipitation increasing ratio compared to normal (270.8%) Record High in Korea since the mid 1970s



20% of planted area in Jeonnam damaged 'Leaf blight' in Muan, Hampyeong, etc. Fears of supply disruption due to reduced shipments Provinces "recognize the disaster" to the government






DJF: December-January-February
SST: Sea Surface Temperature



Rapid rise of vegetable prices...food price 'emergency'

KMA's winter Probability forecasting

	December	January	February
Precipitation	 20% 40% 40% B/ N/ A	 20% 50% 30% B/ N/ A	 20% 50% 30% B/ N/ A
Normal range	19.8~28.6mm	17.4~26.8mm	27.5~44.9mm

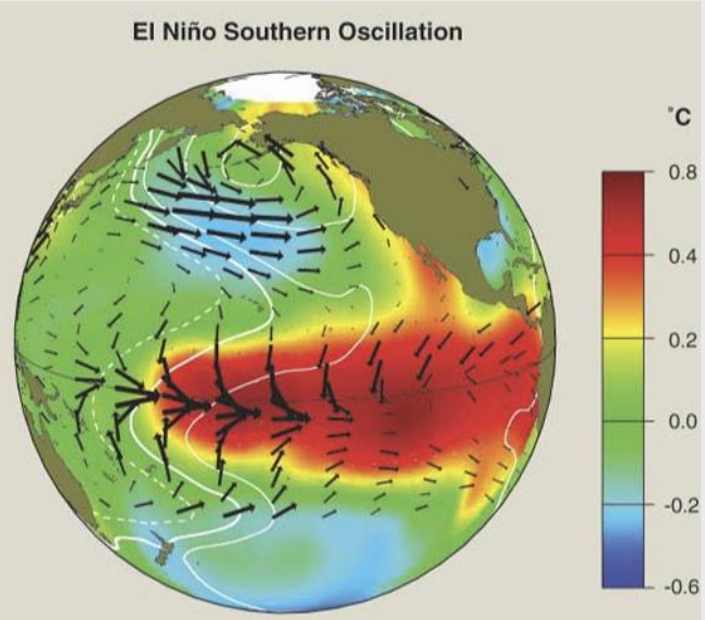
[Nov. 2023, KMA]

KMA: Korea Meteorological Administration
 B/N/A: Below Normal/Normal/Above Normal

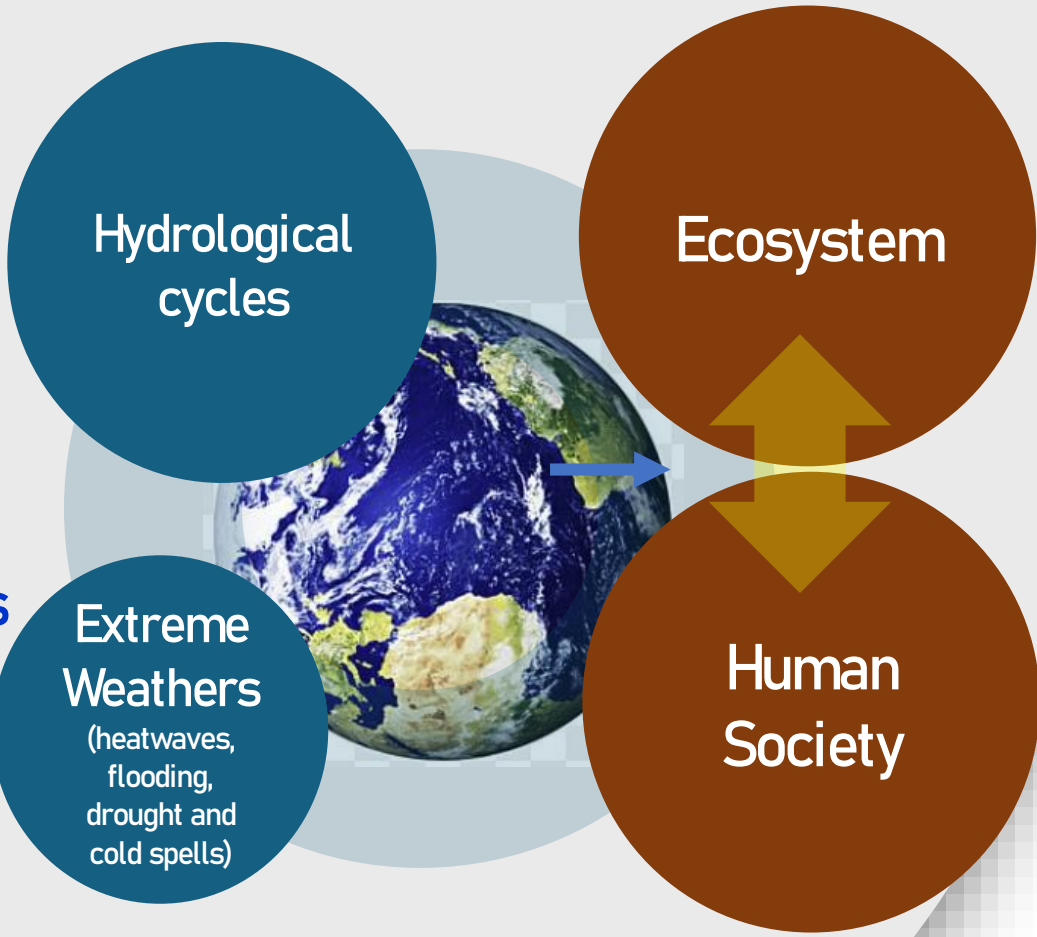
Q] How local and regional communities can better respond to and sustainably manage ENSO events and impacts ?

- Further understanding ENSO climate teleconnection (i.e., extreme weather) and its change
- Need to understand the relationship between ENSO's impact (ex, Agriculture) and Human community/Ecosystem from the present climate to future climate

- Further understanding ENSO climate teleconnection and its change



Atmospheric teleconnections



What are Teleconnections?

ENSO & Local weather and
climate

Teleconnections are significant relationships or links between **weather/climate phenomena** at widely separated locations on earth.

ENSO Teleconnection Mechanisms

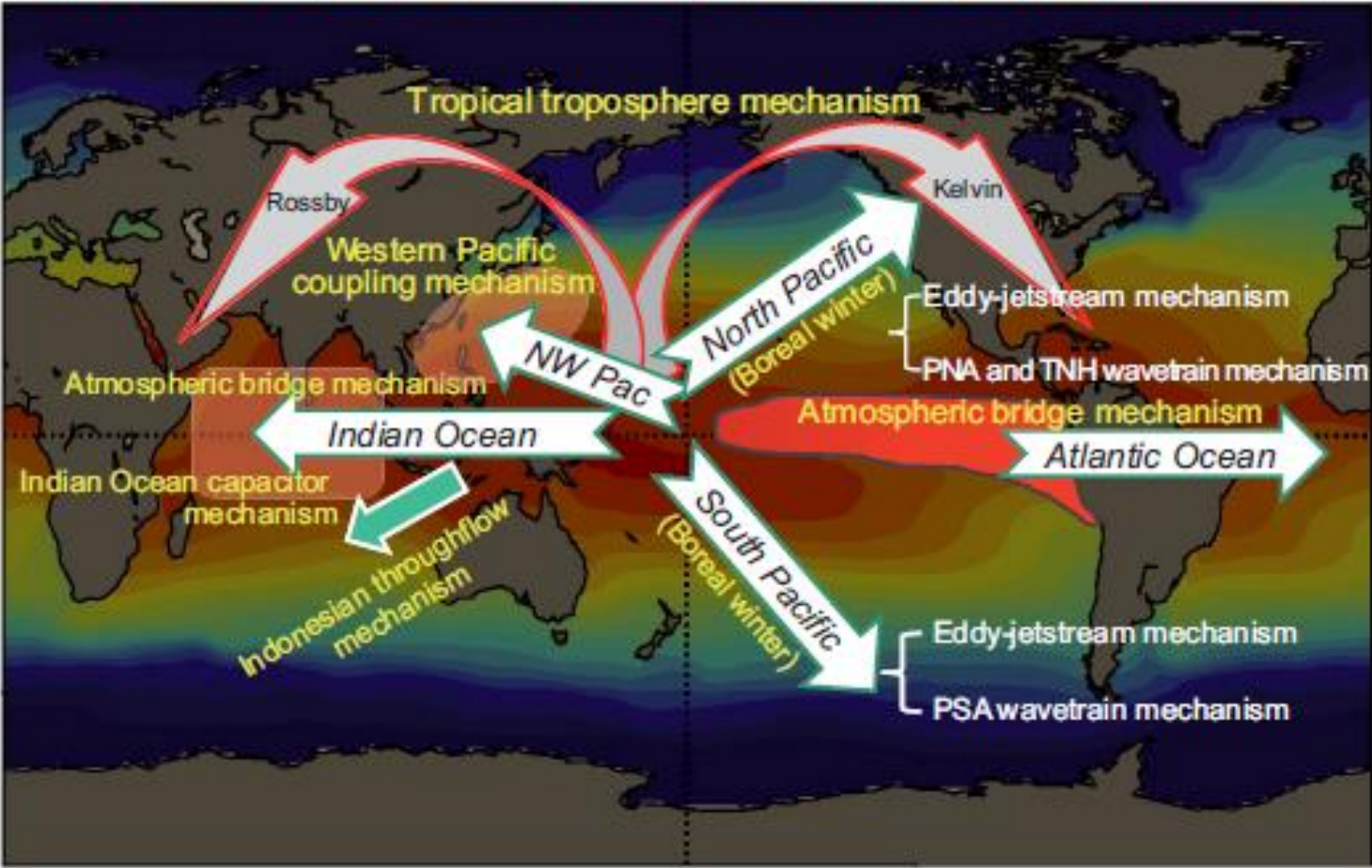


Figure 2. A schematic illustrating the major teleconnection mechanisms through which ENSO affects the global climate.

Yang et al. (2018, National Science Review)

ENSO Teleconnection Mechanisms

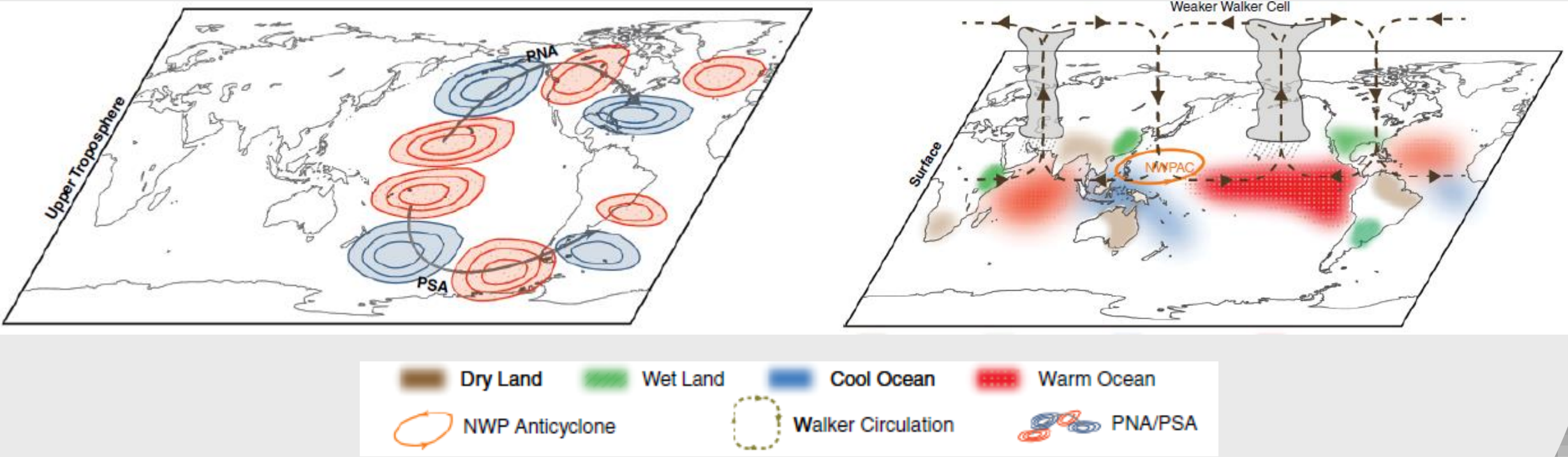
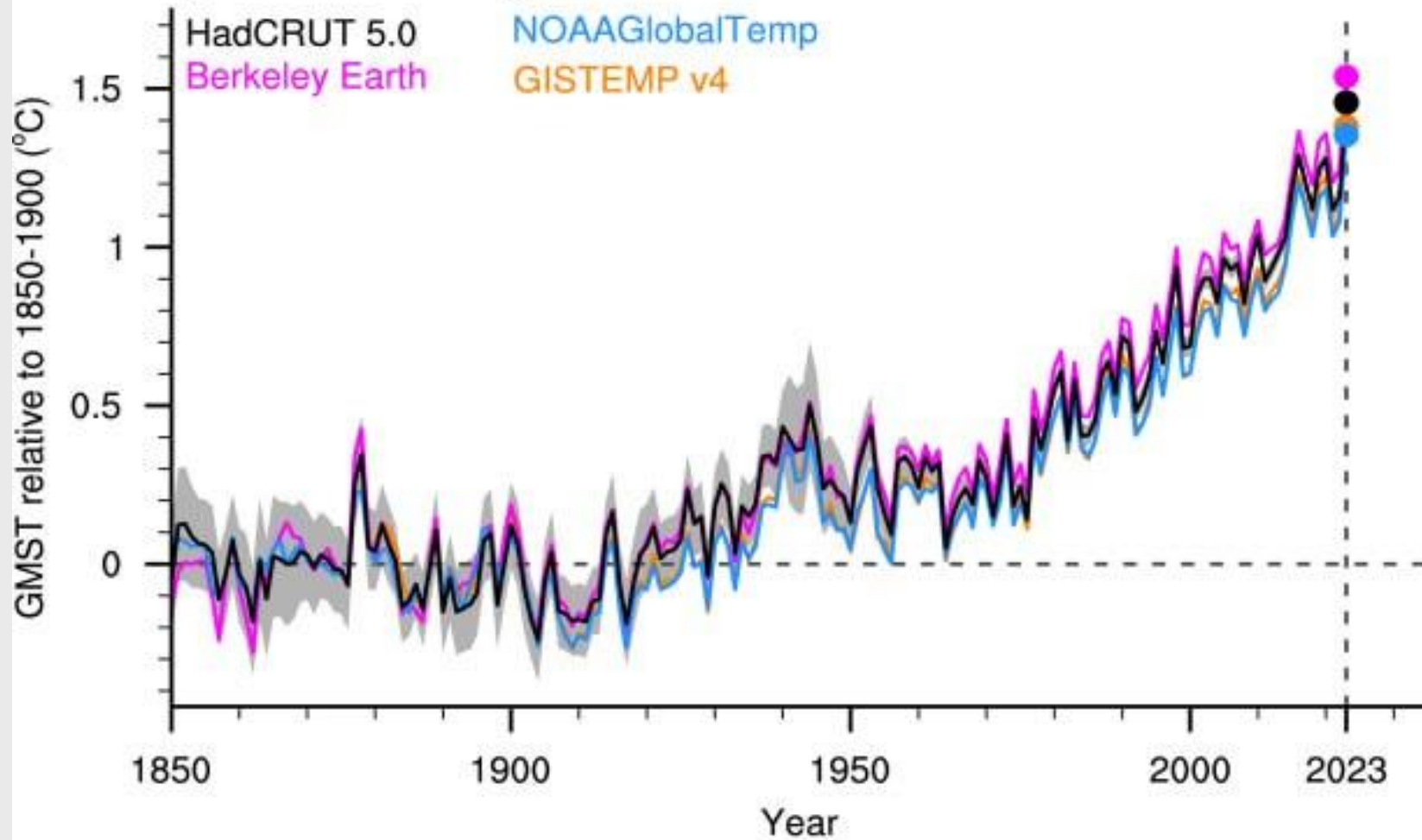
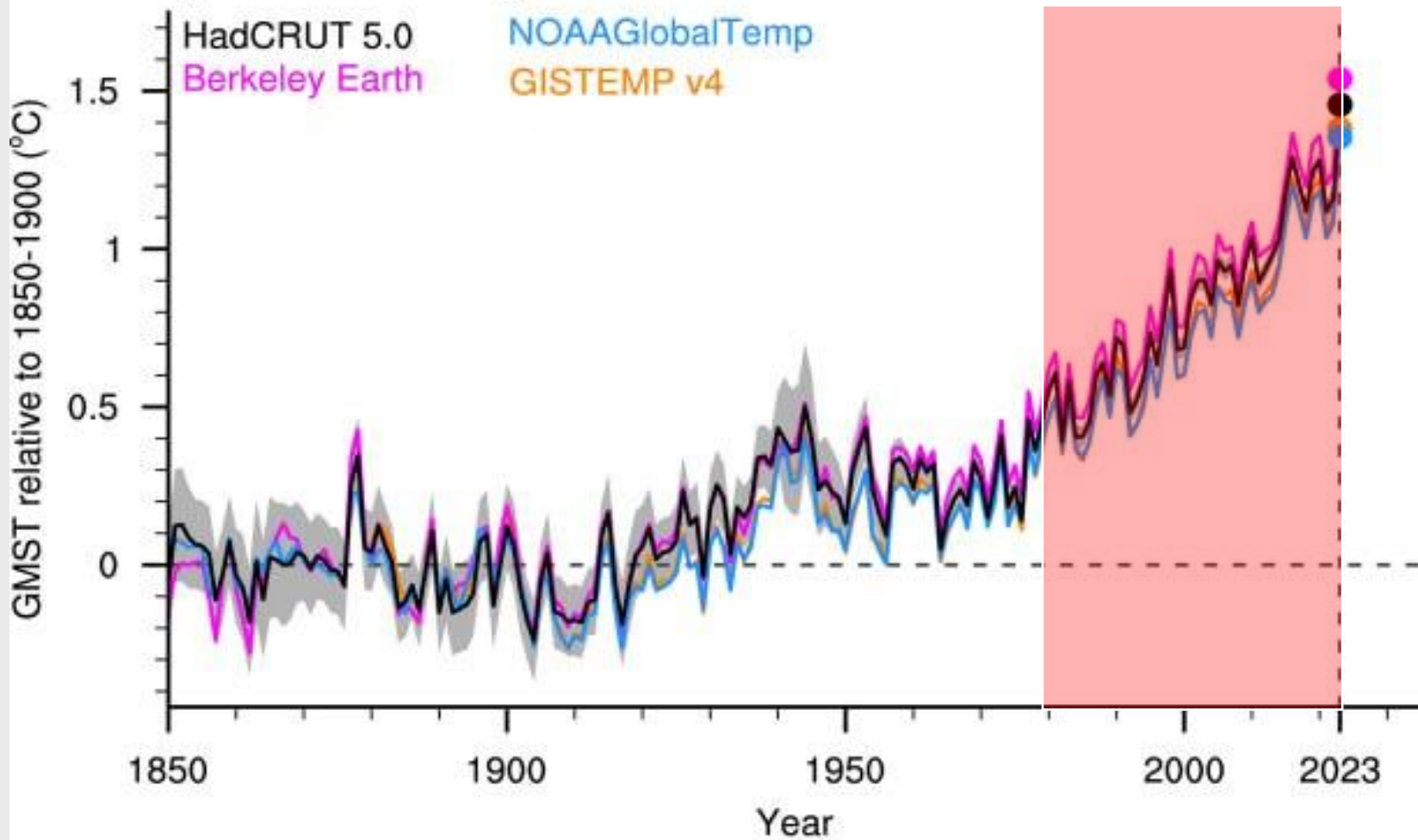


Figure 14.1 ENSO atmospheric teleconnections: Schematic of global circulation changes during El Niño. Top: Upper troposphere. Centers of geopotential height representing the Pacific North American (PNA) and Pacific South American (PSA) patterns. Red contours: positive geopotential anomaly. Blue contours: negative geopotential anomaly. Grey arching arrows represent typical PNA and PSA paths. Bottom: surface. Sea surface temperature anomalies (shading), Walker Circulation anomalies (brown dashed arrows), Northwest Pacific Anticyclone (orange contour), and precipitation anomalies (shading over land). Brown: dry. Green: wet. Red: warm. Blue: cool conditions.

Global mean surface temperature anomaly



Global mean surface temperature anomaly



Reviews of Geophysics



REVIEW ARTICLE

10.1002/2017RG000568

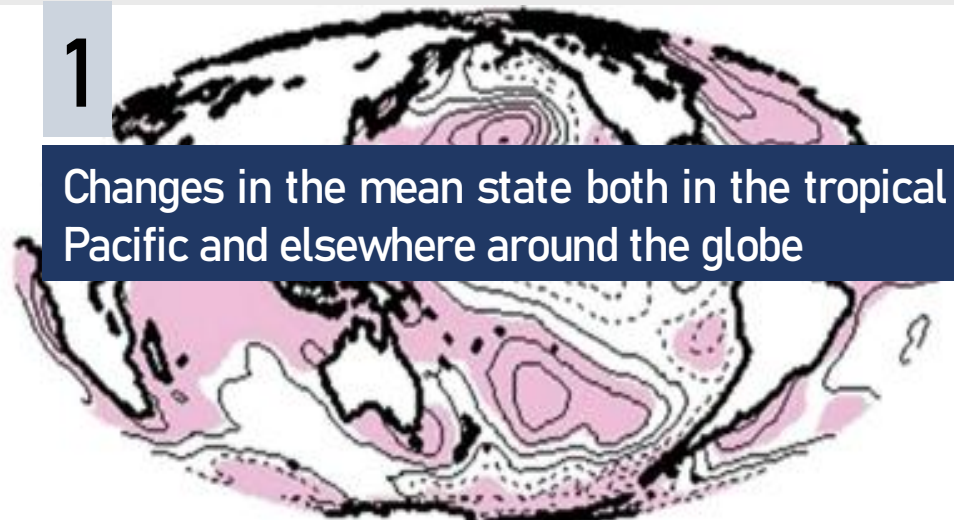
ENSO Atmospheric Teleconnections and Their Response to Greenhouse Gas Forcing

Yeh et al. (2018)

Key Points:

- The character of ENSO as well as the ocean mean state has changed since the 1990s, resulting in changes in ENSO atmospheric teleconnections

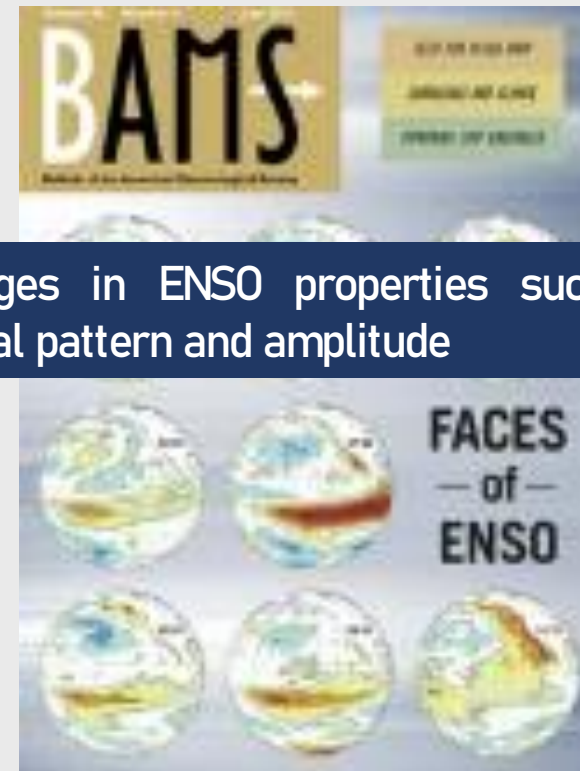
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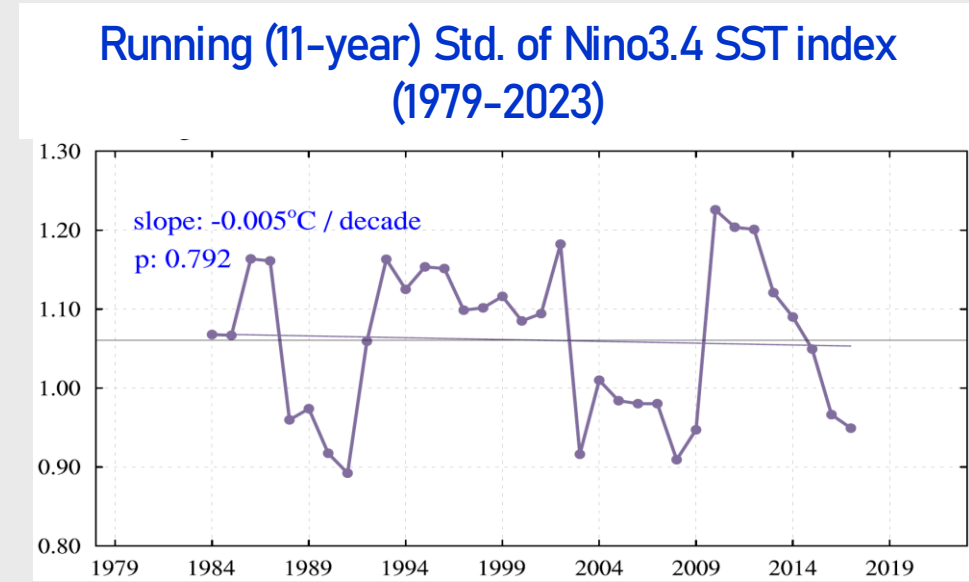
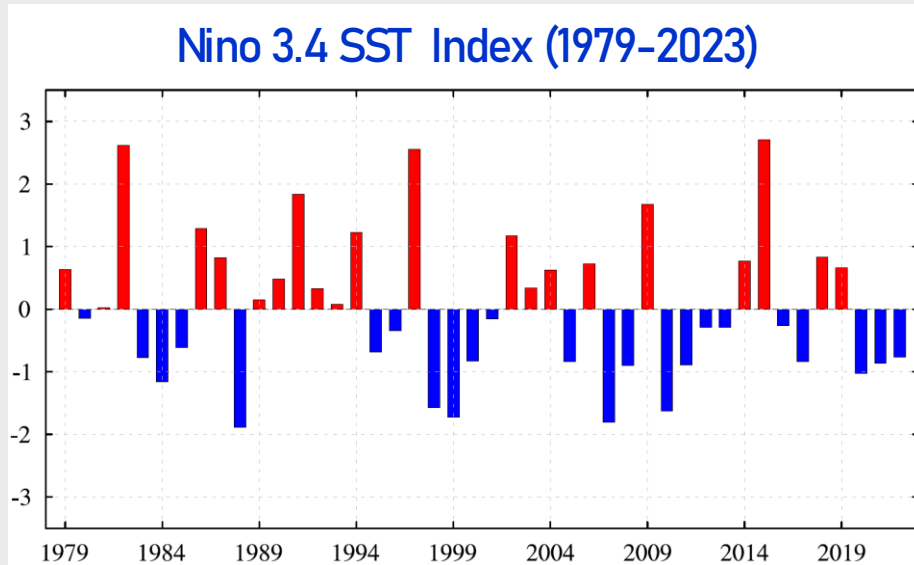
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&

Changes in ENSO properties such as its spatial pattern and amplitude

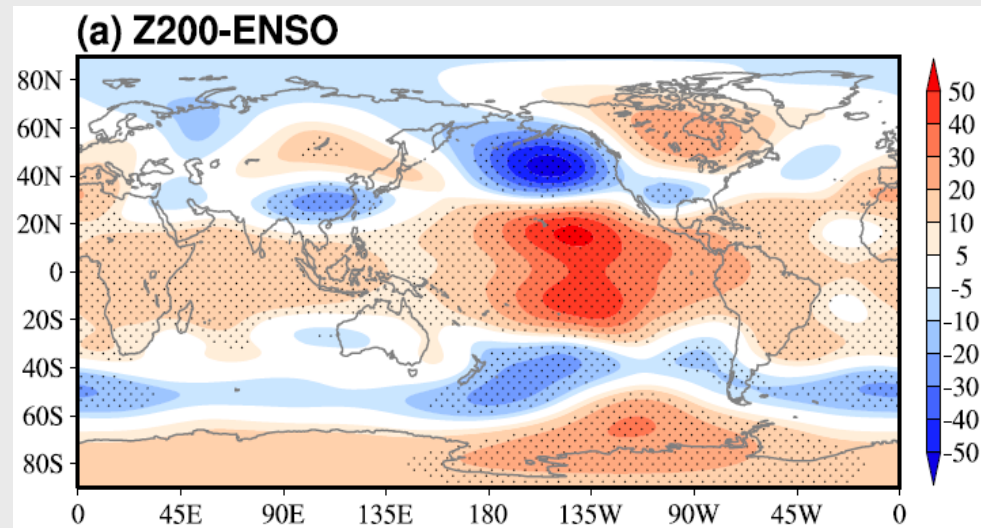


Changes in ENSO atmospheric teleconnection since 1979 (Boreal winter, Dec.-Jan.-Feb)



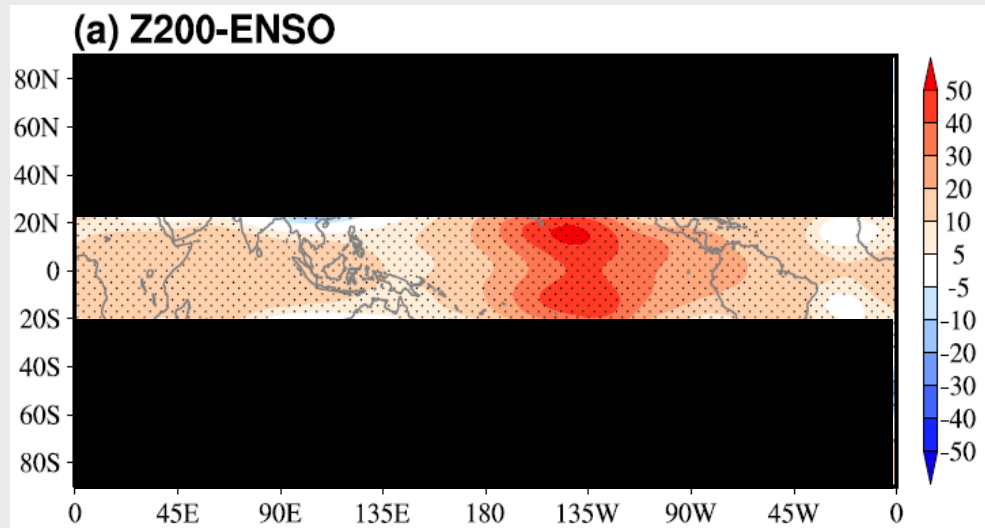
Nino 3.4 SST Index: Averaged SST anomaly
In the NIN03.4 region (170W-120W, 5N-5S)

Typical ENSO response:



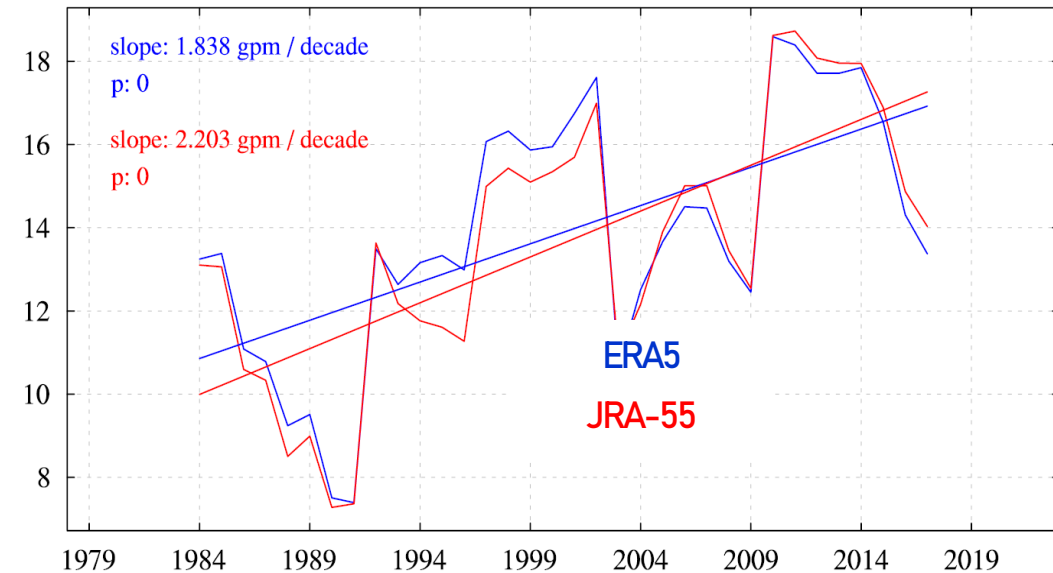
Changes in ENSO atmospheric teleconnection since 1979 (Boreal winter, Dec.-Jan.-Feb)

Typical ENSO response:



Tropical mean (20°S-20°N) ENSO-response with a 11-year window & Line (Trend):

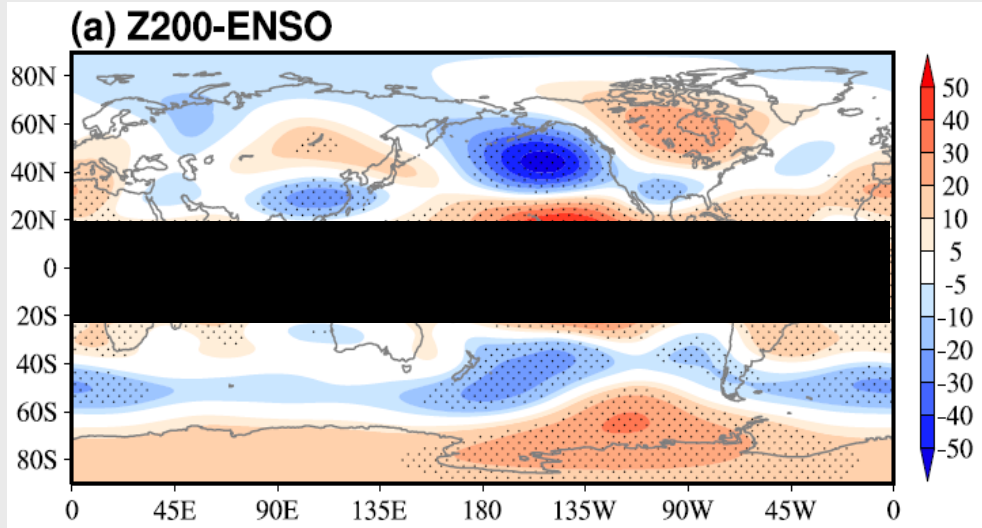
Trend of tropical mean Z200-ENSO



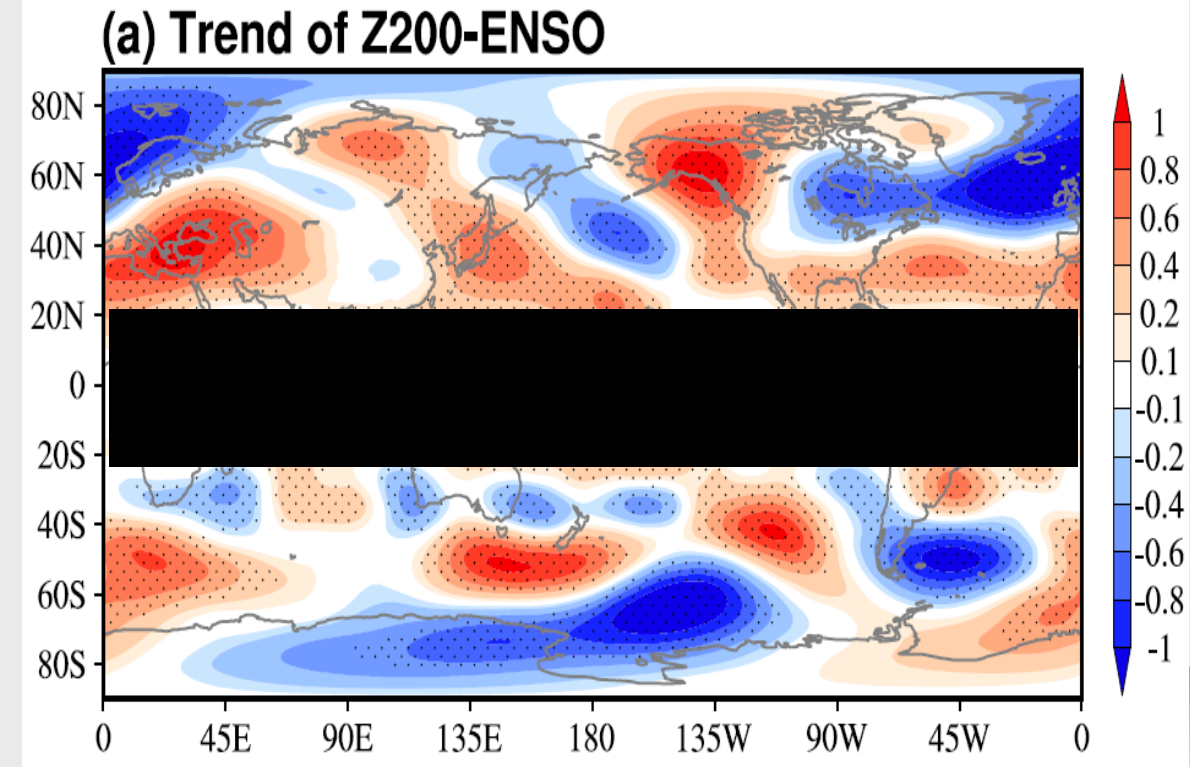
Tropics: The ENSO-induced atmospheric anomalies significantly increase

Changes in ENSO atmospheric teleconnection since 1979 (Boreal winter, Dec.-Jan.-Feb)

Typical ENSO response:



Trend of ENSO response (1979-2023)

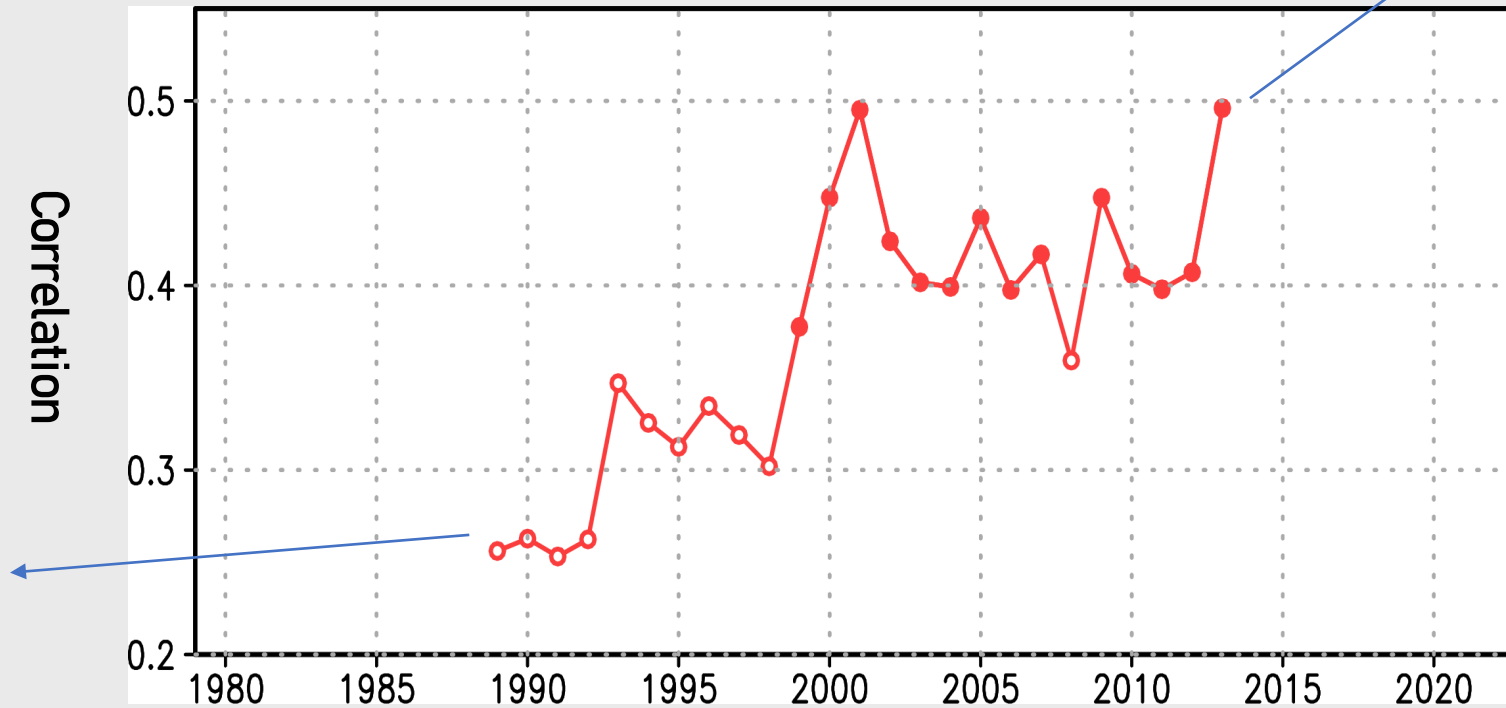


- Extratropics: Shift of El Nino-induced atmospheric anomalies

Example: South Korea Temp & ENSO

Moving (21-year) correlation
[ENSO & South Korean winter Temp]

2003-2023
C.C.:0.49



1979-1999
C.C.:0.26

Need to understand the relationship between ENSO's impact and Human community/Ecosystem from the present climate to future climate

nature communications



Article

<https://doi.org/10.1038/s41467-023-41551-9>

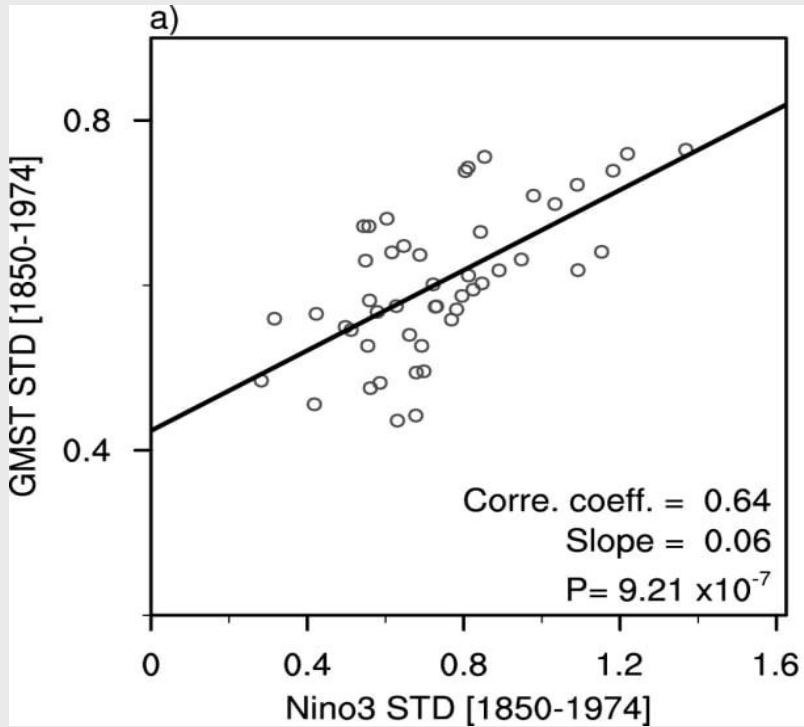
Nonlinear El Niño impacts on the global economy under climate change

Liu et al. (2023)

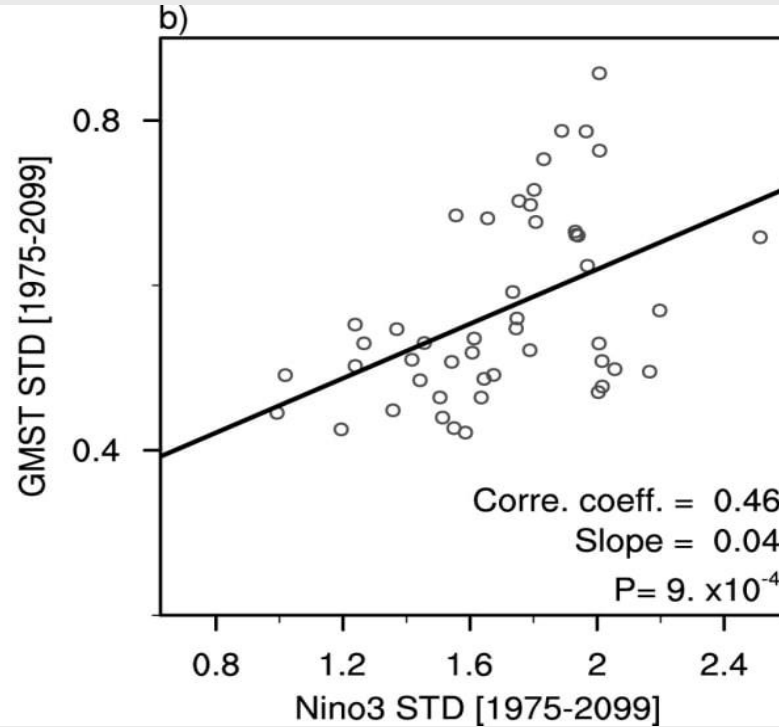
...Under climate change, economic loss grows exponentially with increased ENSO variability. Under a high-emission scenario, increased ENSO variability causes an additional median loss of US\$33 T to the global economy.....

Need to understand the relationship between ENSO's impact and Human community/Ecosystem from the present climate to future climate

125 years [1850-1974]



125 years [1975-2099]



Under climate change,
ENSO variability ↑
Global mean surface temp. Variability ↑
Extreme Weather & Hydrological cycle ↑



ENSO's impact ↑

• 48 CMIP6 Earth System Models (SSP585)

- ENSO climate teleconnection is changing.
- ENSO's impact might increase if ENSO's variability increases under global warming



Collaboration & Sharing Information in regional communities

Example: KMA & ENSO





Asia-Pacific
Economic Cooperation

Thank you