HydroClimatology Group
at Department of Atmospheric Sciences, National Taiwan University

Exploring the Impact of Multiple La Niña Phenomenon on East Asia Agricultural Economy

- Yu-Hsuan Chang[1], Min-Hui Lo[1,2]

School
National Taiwan University (NTU), Taipei, Taiwan
International Degree Program in Climate Change and Sustainable Development (IPCS)[1] / Department of Atmospheric Sciences[2]

Email
r12247004@ntu.edu.tw

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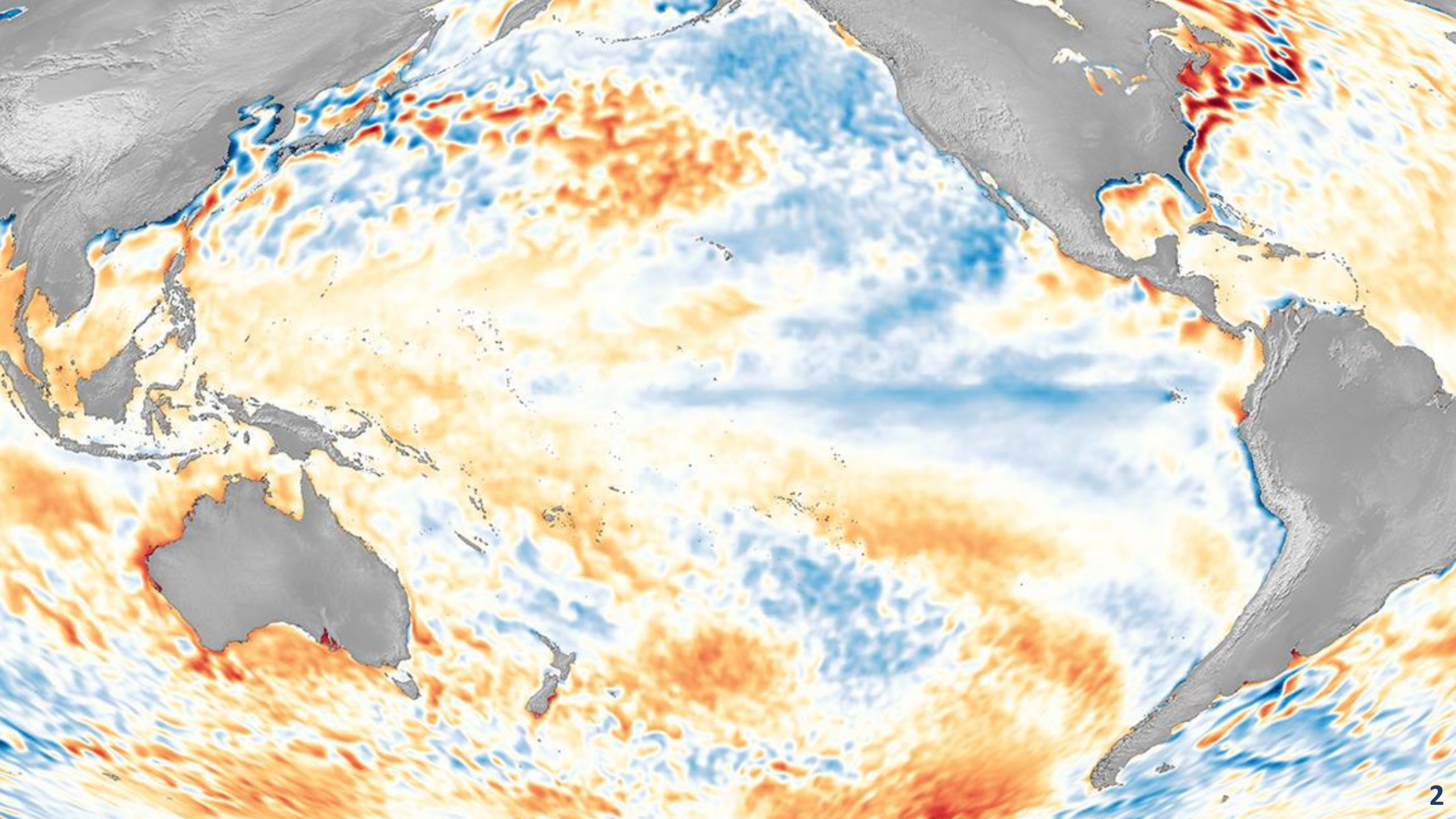
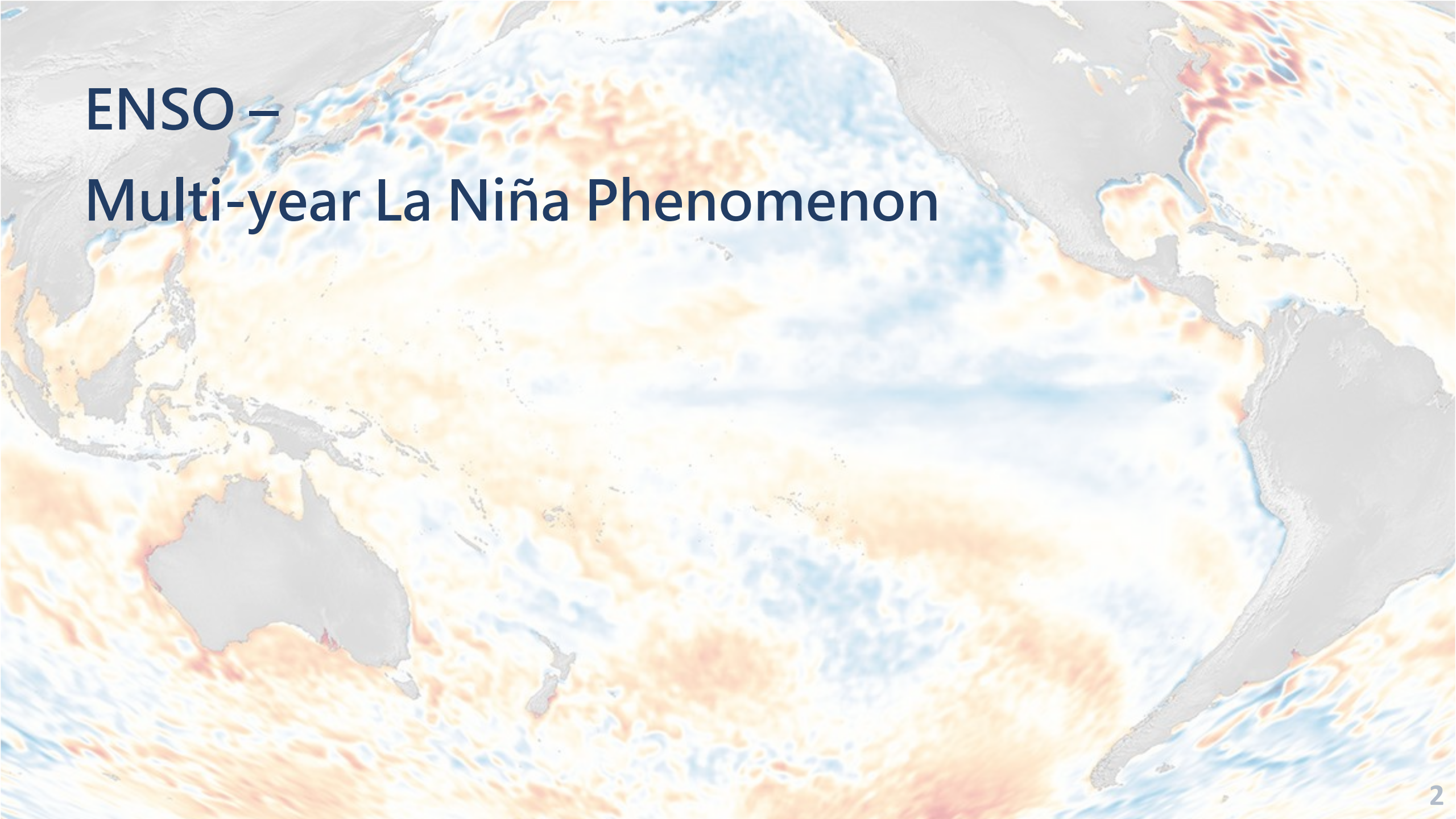


ENSO –
Multi-year La Niña Phenomenon



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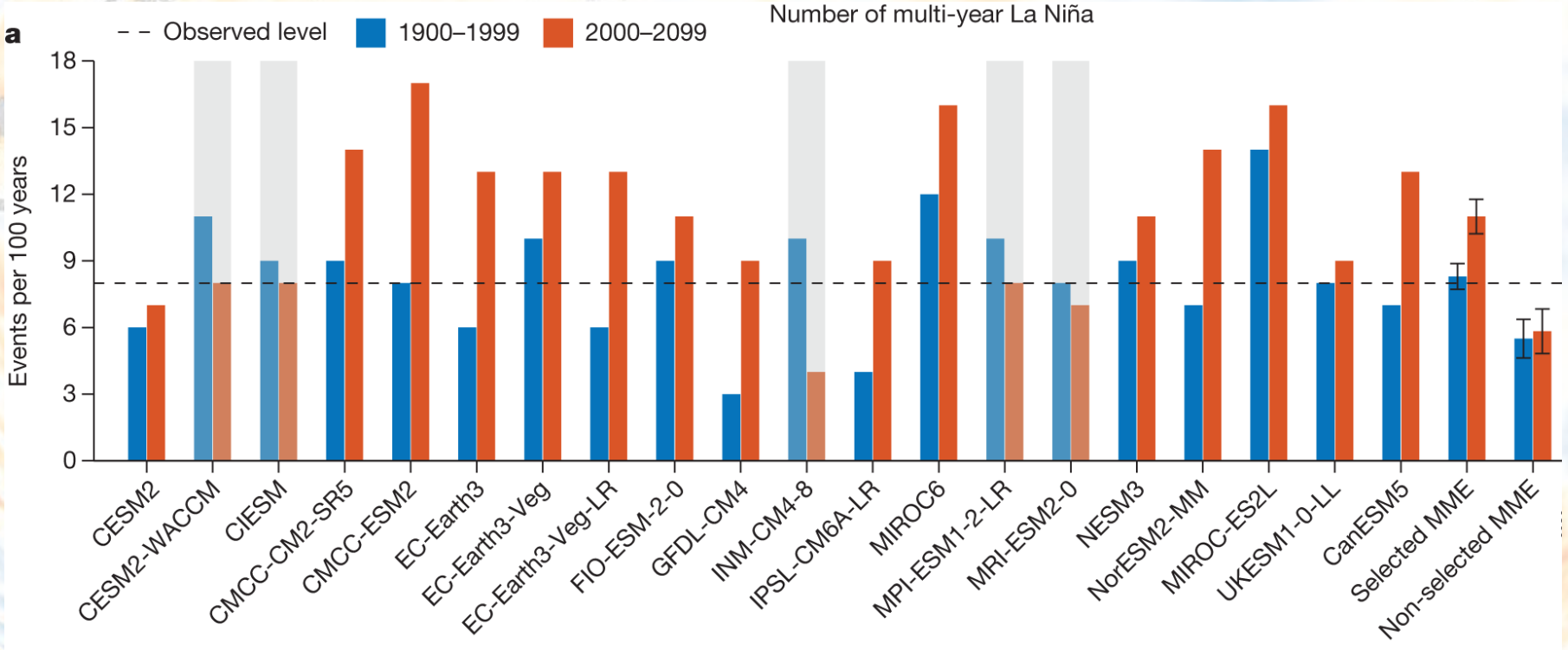
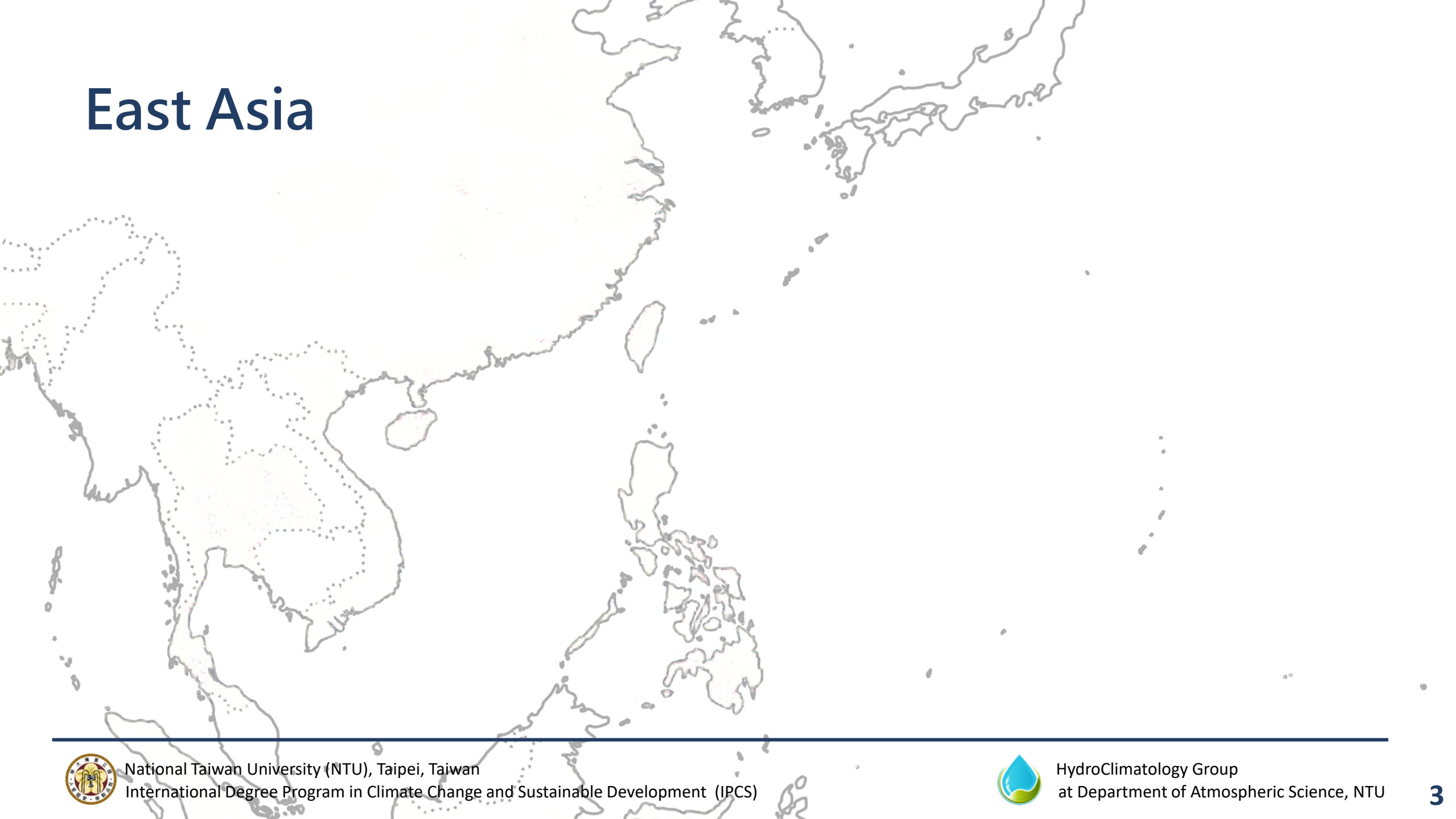
Multi-year La Niña Phenomenon

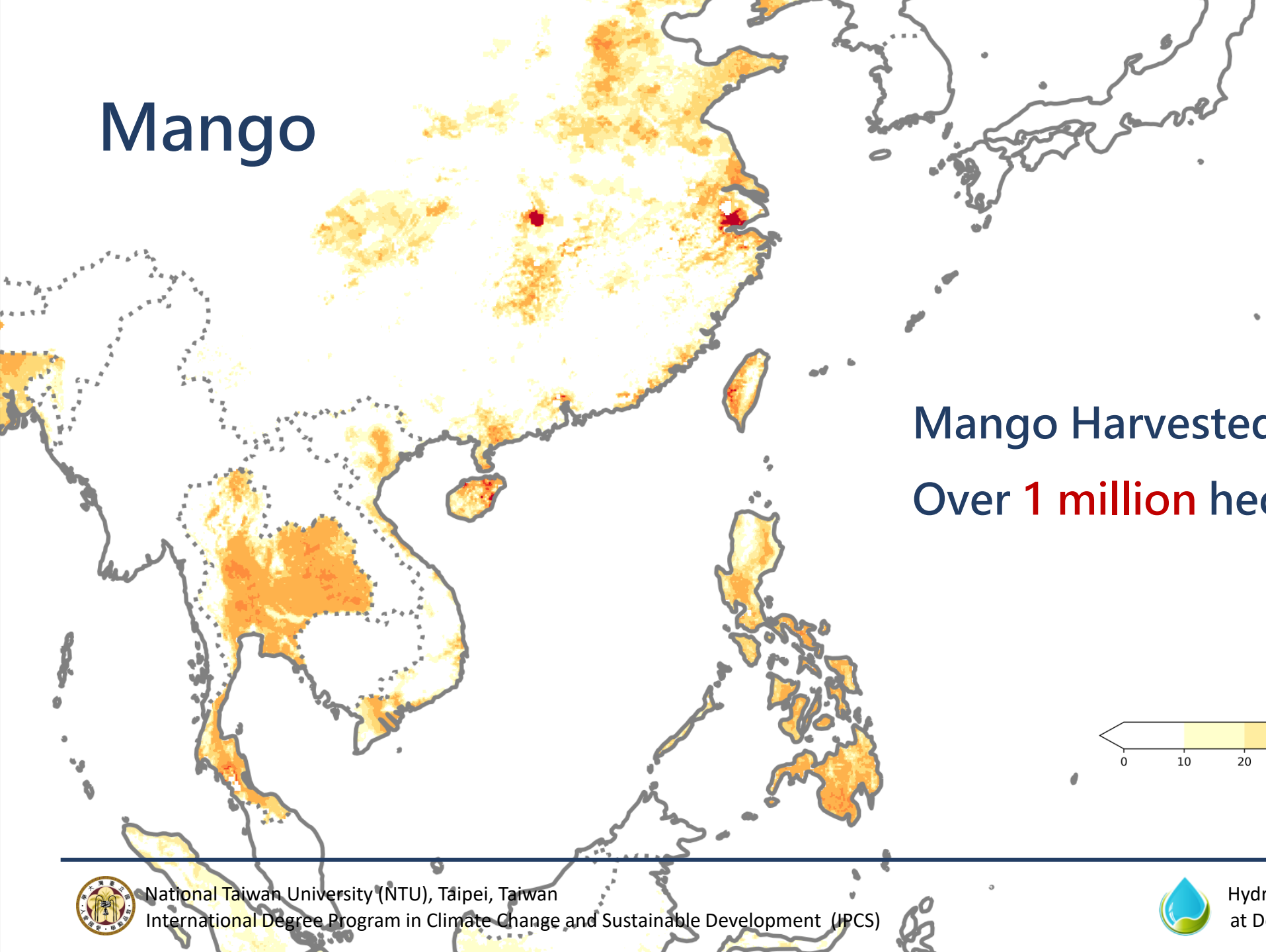


(Tao Geng et al., 2023)

East Asia

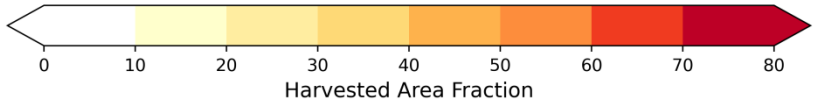


Mango



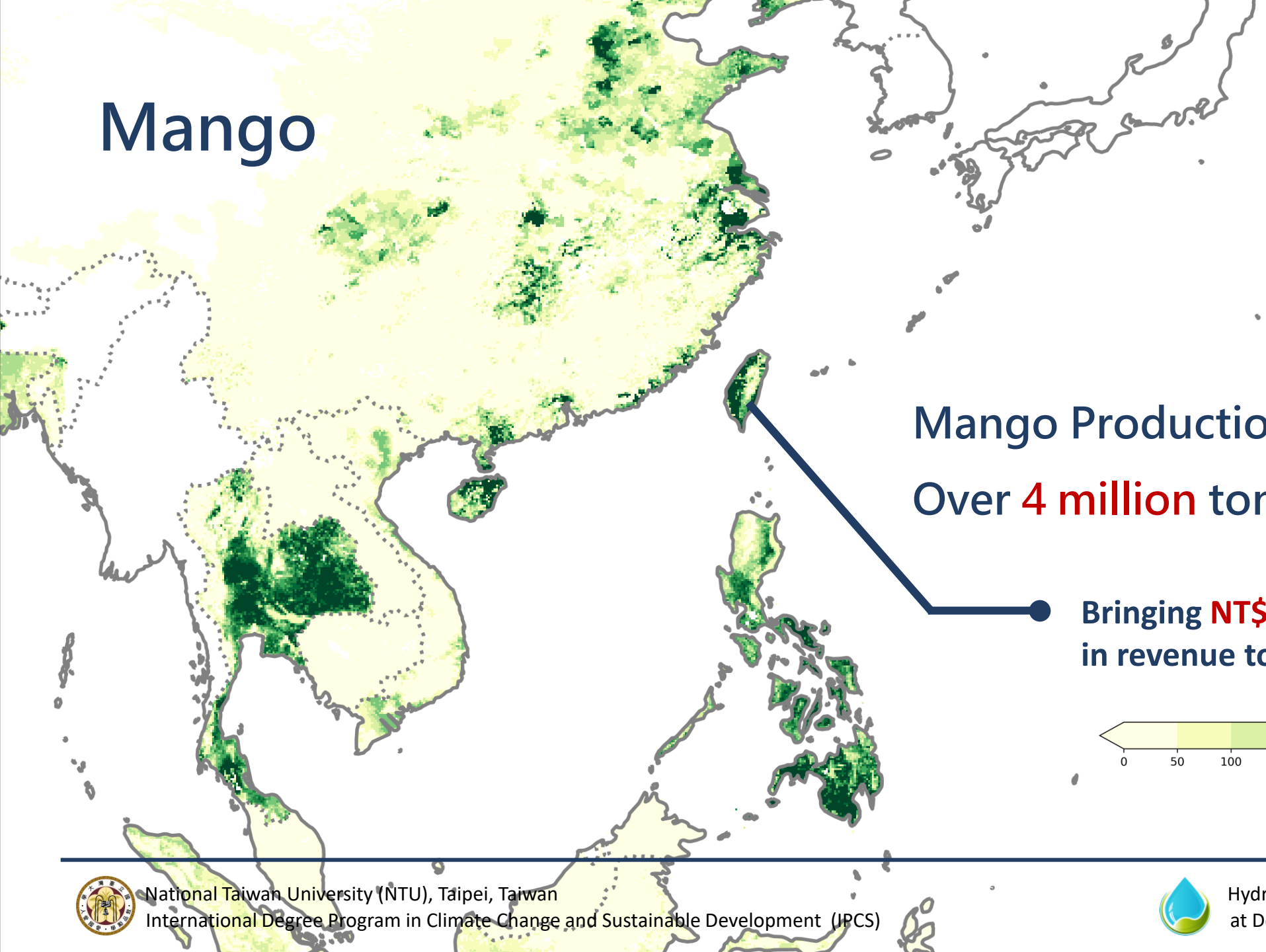
Mango Harvested Area Hectares

Over 1 million hectares



(Monfreda et al., 2008)

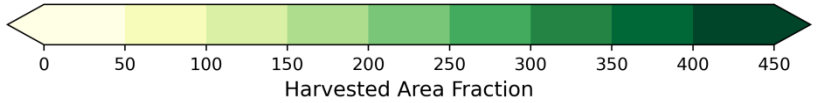
Mango



Mango Production

Over 4 million tons

Bringing NT$12 billion in revenue to Taiwan (2023)



(Monfreda et al., 2008)

Mango Growth Stage

Month	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
Growth Stage	Shoot Growth Period											
				Dormancy Period								
						Flower Bud Differentiation						
								Flowering Period				
									Fruit Setting			
										Fruit Development Period		
	Harvest Period										Harvest Period	

(Ministry of Agriculture)

(Monfreda et al., 2008)

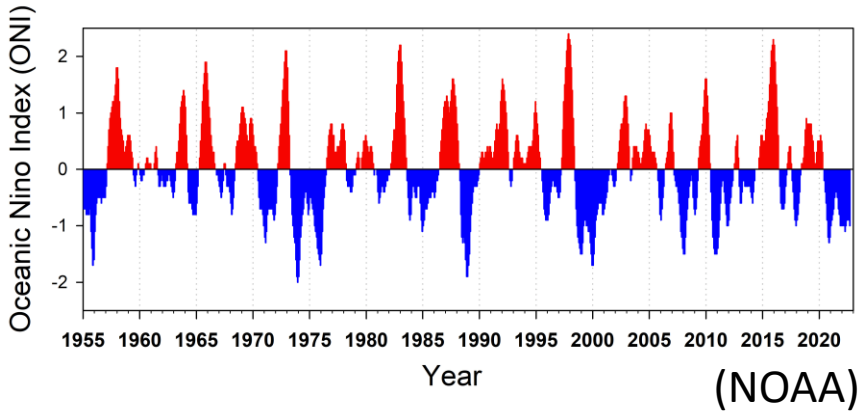
Dataset

Data set	Variables	resolution	Citation	time
GPCC	Total precipitation (mm/day)	0.5°×0.5°	Rustemeier, E. et al. (2022)	1950-2022
ERA5-Land monthly averaged data		0.1°×0.1°	Muñoz Sabater, J. (2019)	
	T2M (K)			
ERA5 monthly averaged data	850 hPa U-component of wind, V-component of wind	0.25° x 0.25°	Hersbach, H. et al. (2023)	
	Specific humidity (kg/kg)			
NOAA	Niño3.4 index	every 3 months	NOAA. (2024)	1960-2022
Ministry of Agriculture	Mango unit production (kg)	17 cities (Taiwan)	Ministry of Agriculture(2024)	1997-2023
DATA.GOV.TW	Municipality and County/City Boundaries (TWD97 Latitude and Longitude)		Data.gov.tw (2024)	2024

NOAA Oceanic Niño Index (ONI)

Definition of Singe La Niña events：

ONI is below -0.75 between October (Year 0) and February (Year +1).



(NOAA)

Definition of Multi-year La Niña events：

ONI is below -0.75 in any month from October (Year 0) to February (Year +1), and below -0.5 in any month from October (Year +1) to February (Year +2).
Here, Year 0 is the starting year of La Niña, and Year +1 and +2 refer to the two years after it begins.

(Okumura et al., 2017)

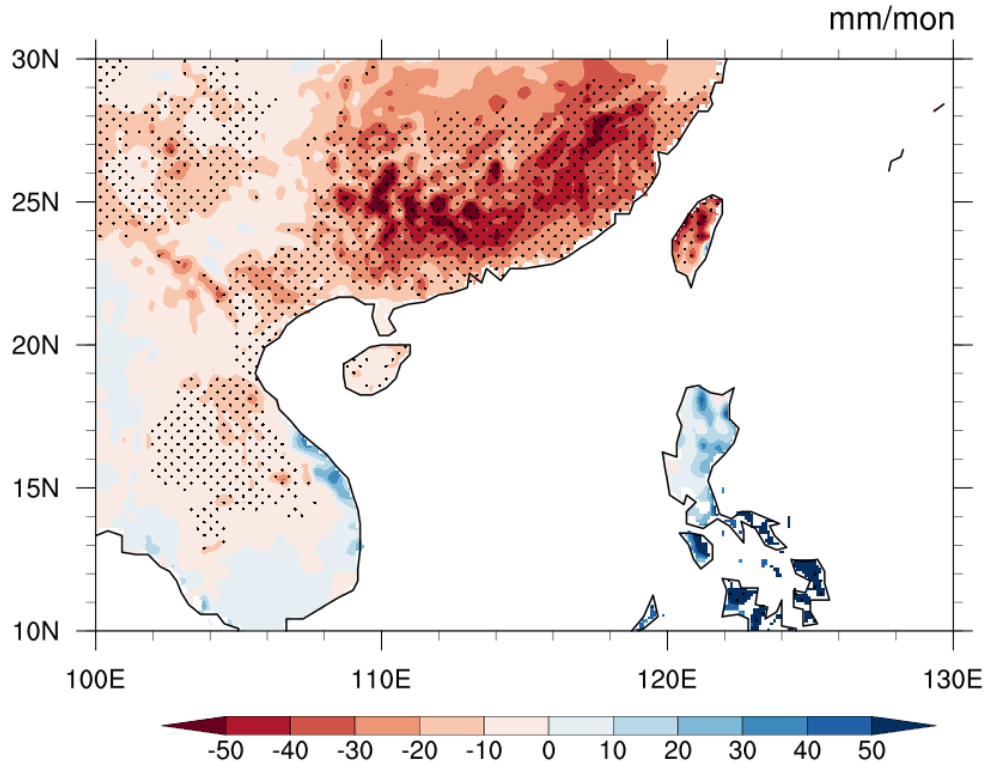
Multi La Niña Events (9)

Nine identified multi-year La Niña events

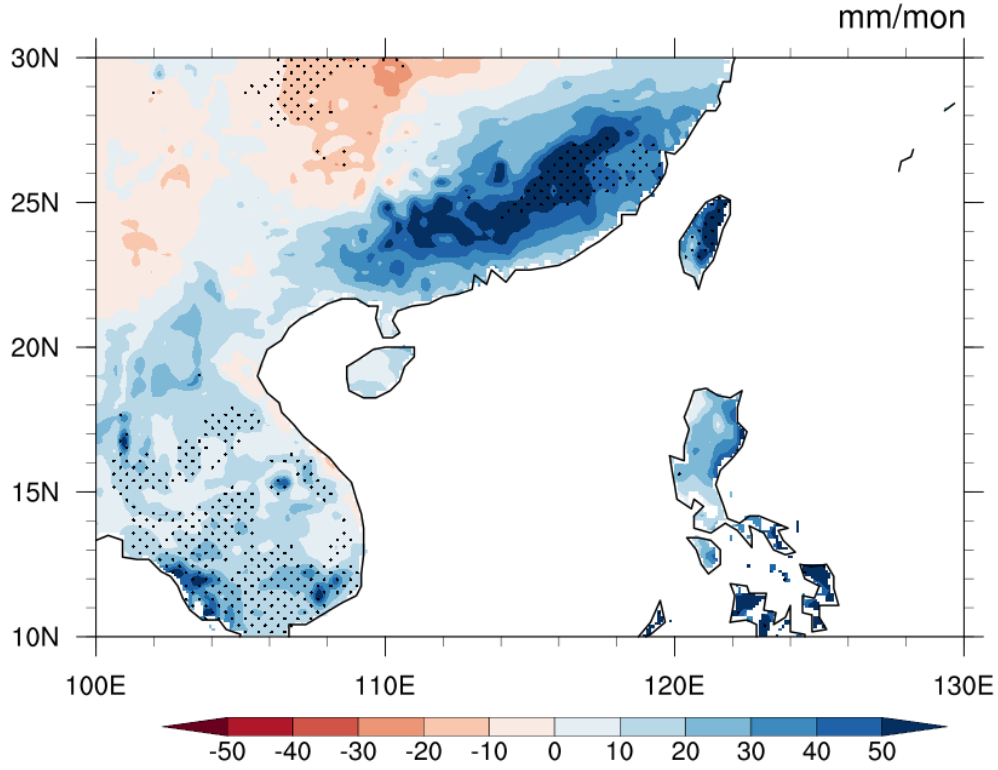
	1	2	3	4	5	6	7	8	9
Multi - La Niña (+1)	1955	1971	1974	1984	1999	2008	2011	2017	2021
Multi - La Niña (+2)	1956	1972	1975	1985	2000	2009	2012	2018	2022

February Average Precipitation Anomalies

Multi - La Niña (+1)

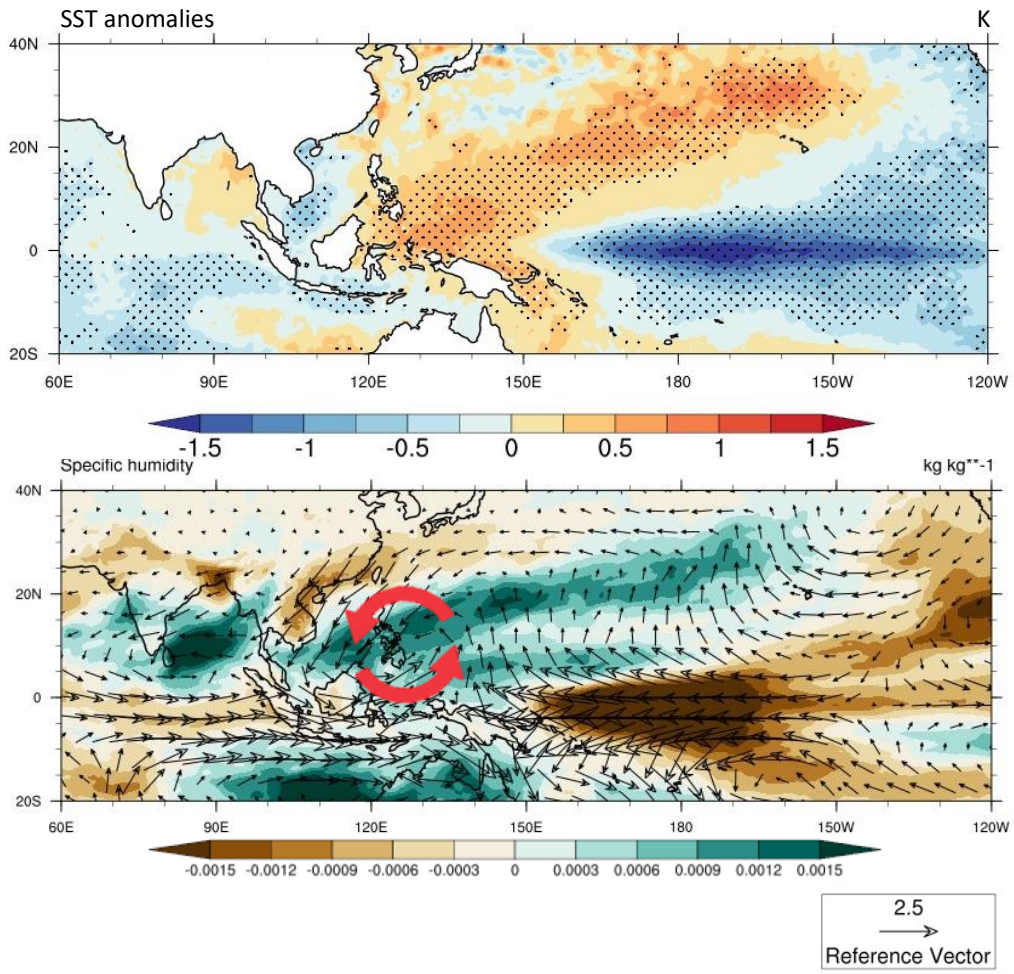


Multi - La Niña (+2)

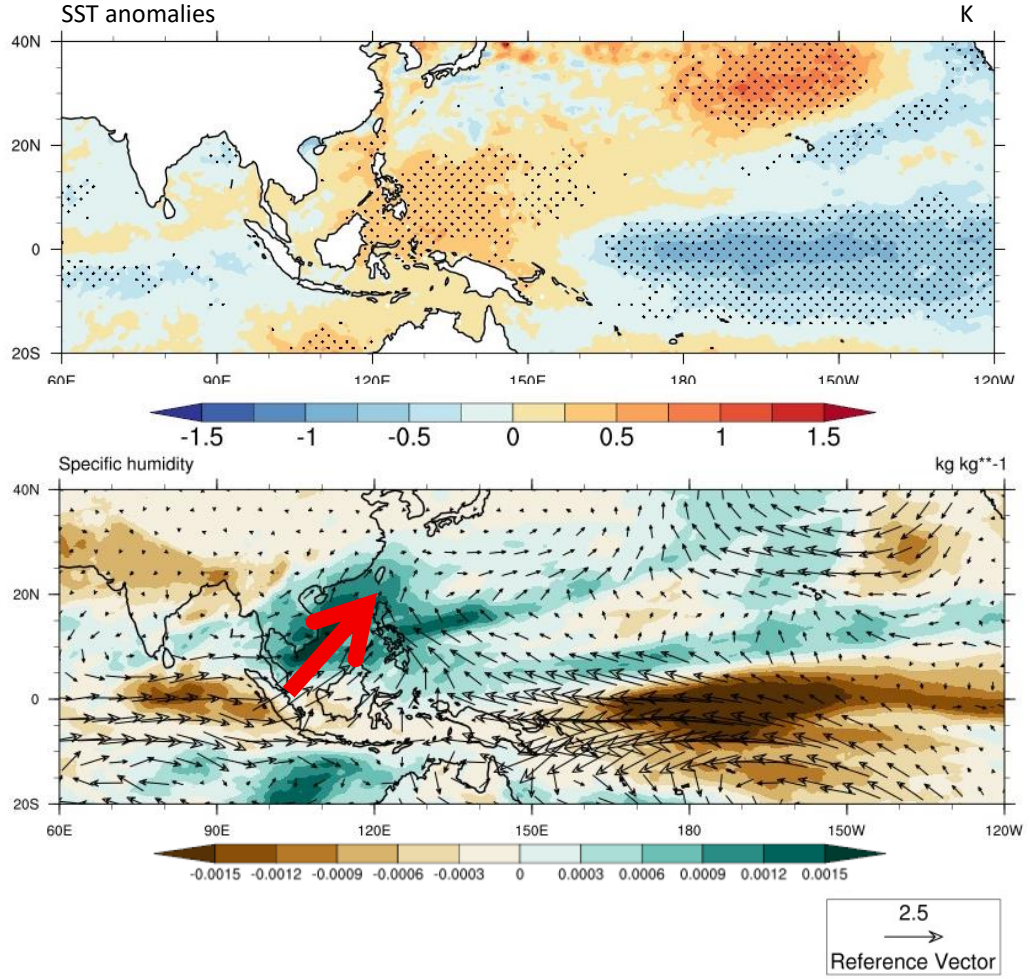


Local Sea Surface Temperature Impact

Multi - La Niña (+1)

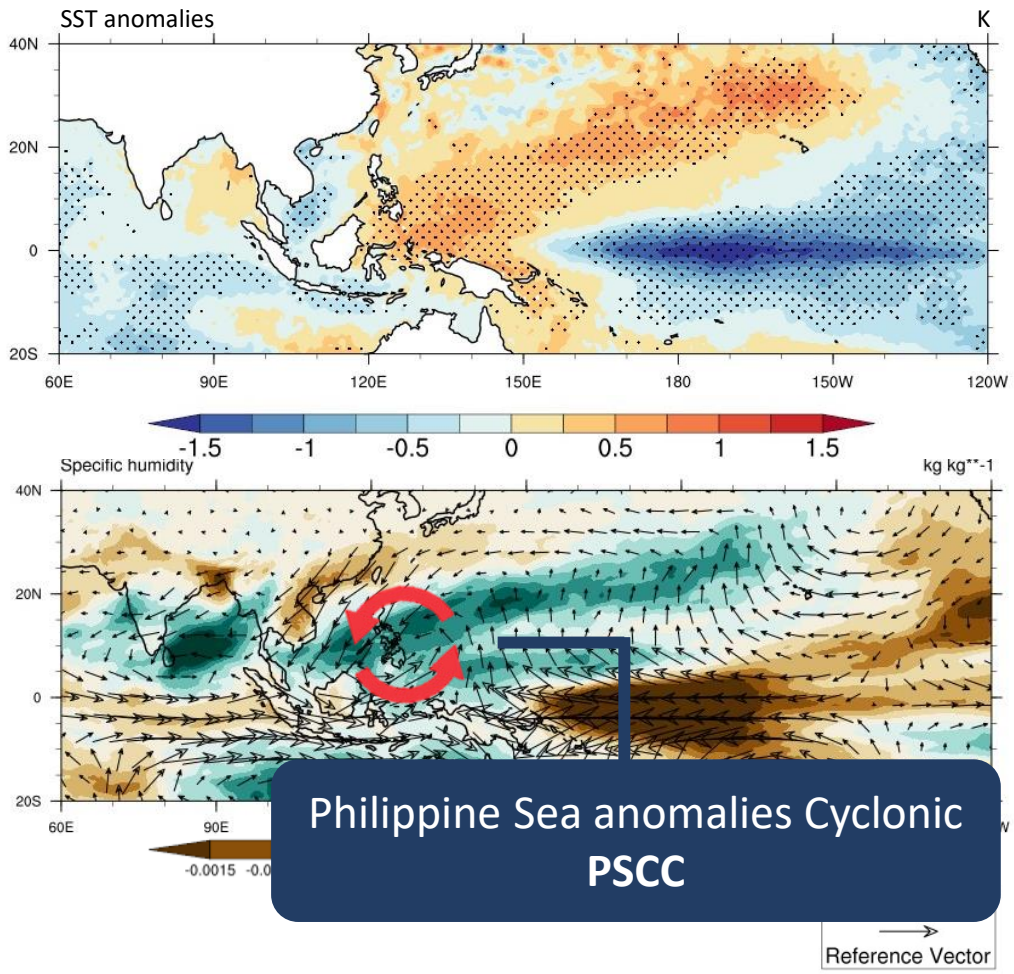


Multi - La Niña (+2)

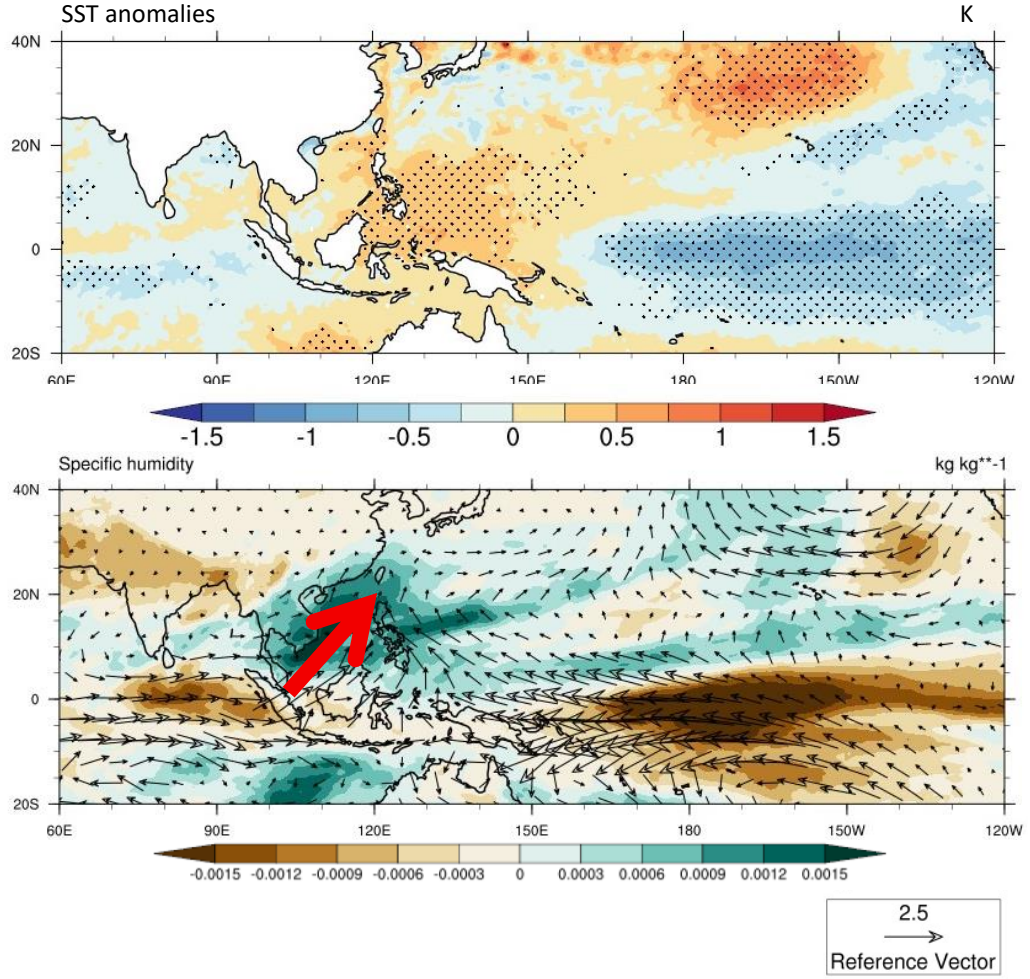


Local SST Impact

Multi - La Niña (+1)

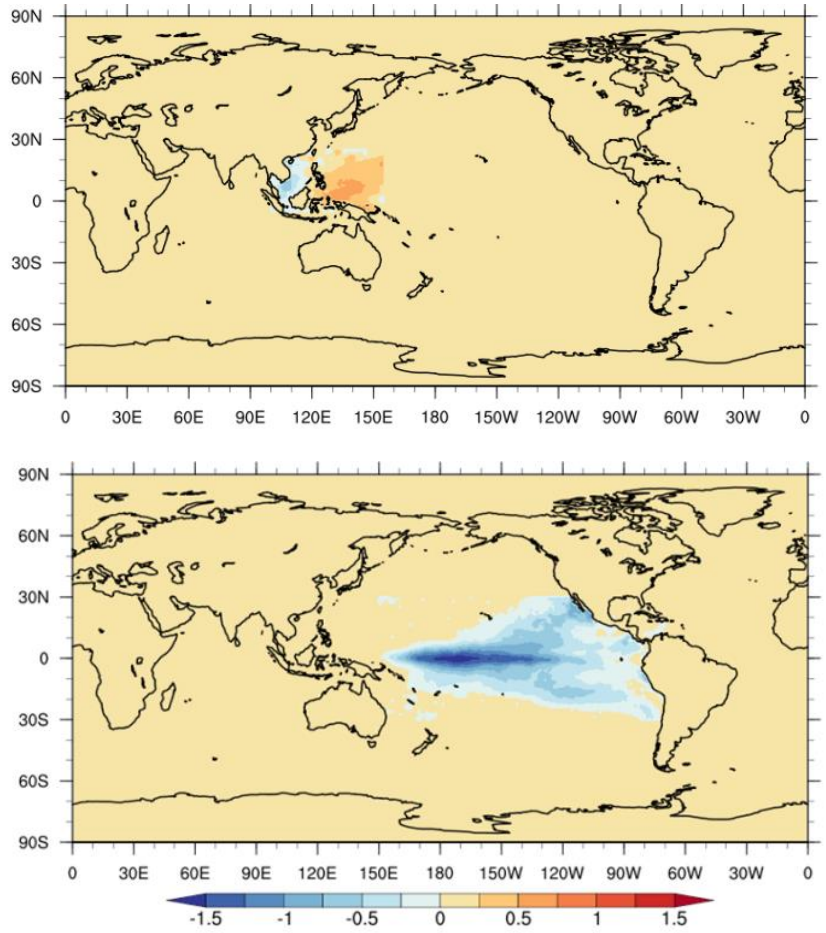


Multi - La Niña (+2)



CESM2 Climate Model

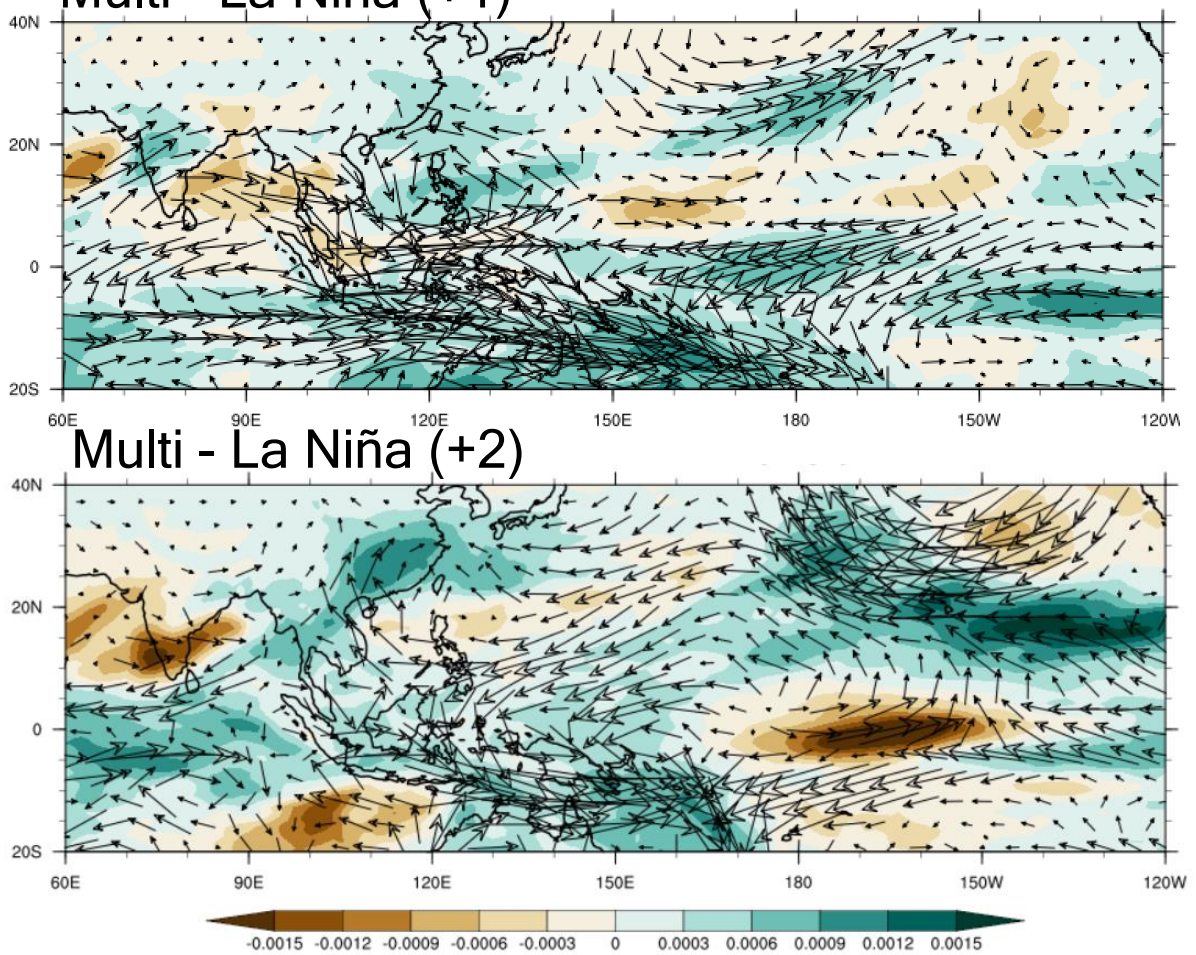
Input



Output

Multi - La Niña (+1)

Multi - La Niña (+2)



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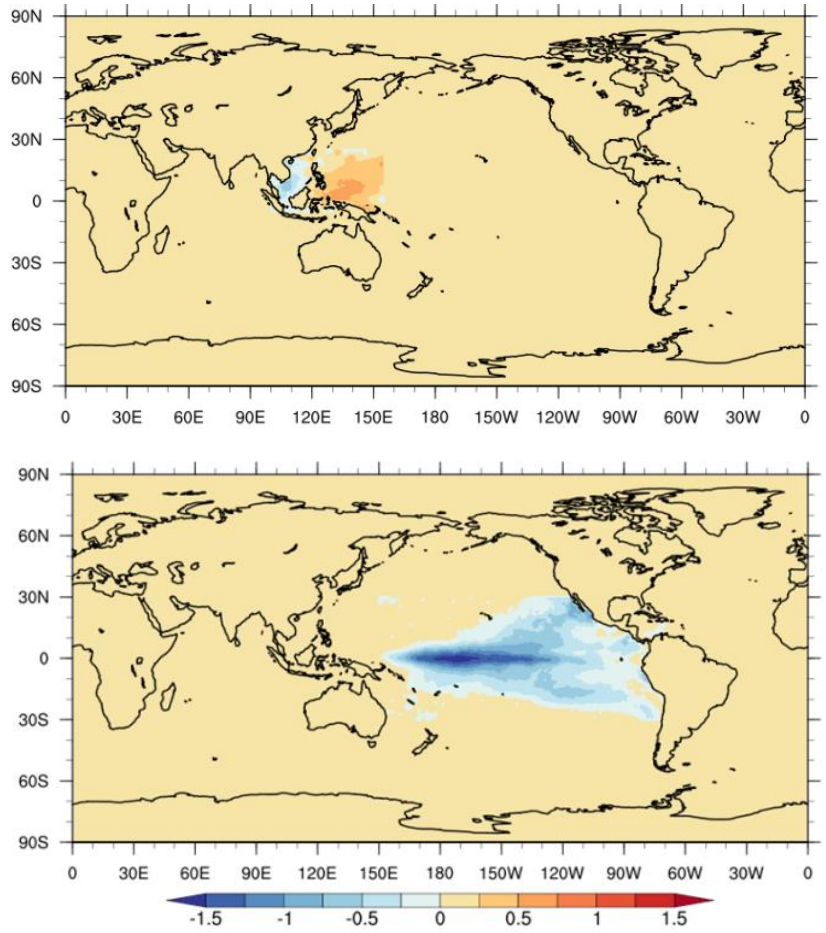
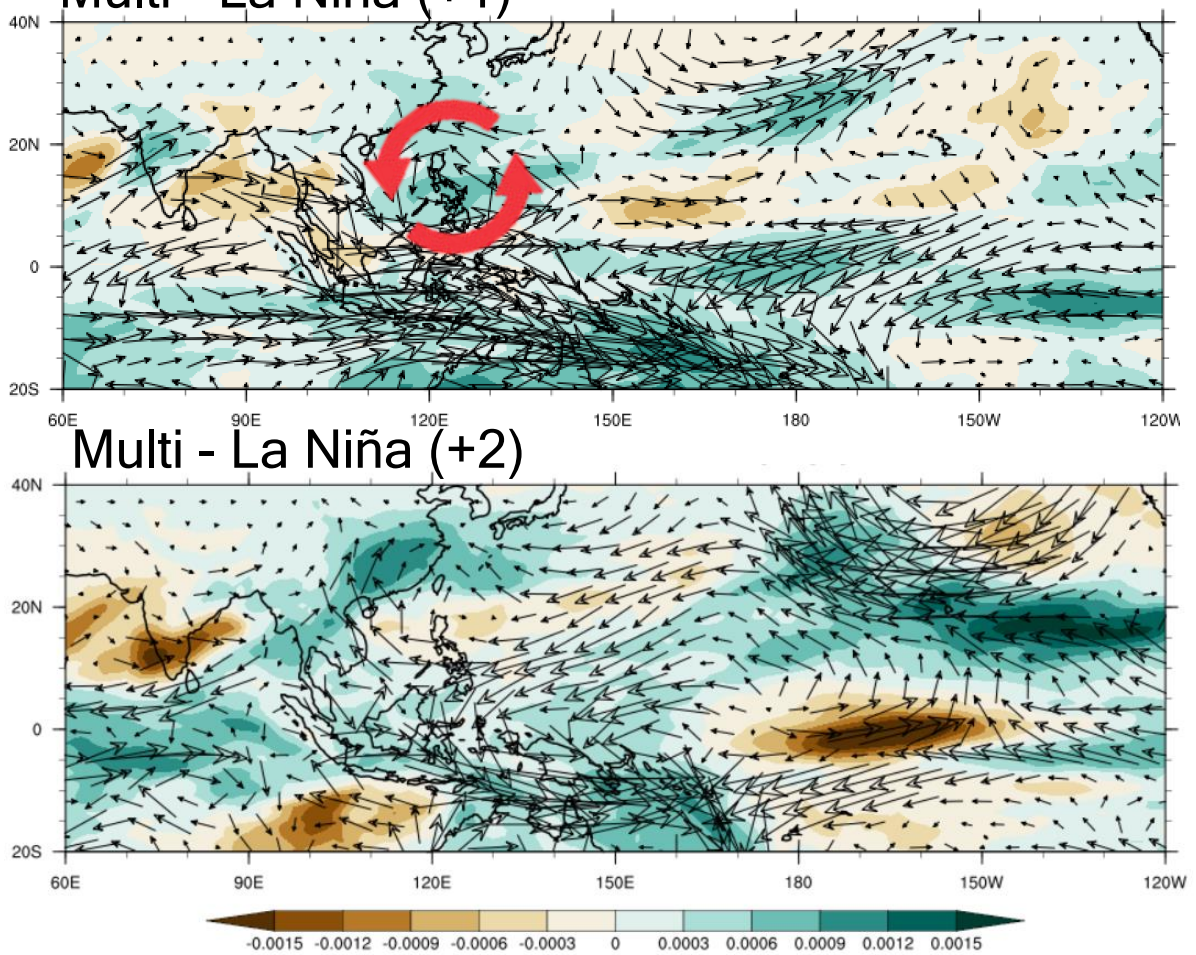


Output

Multi - La Niña (+1)

Multi - La Niña (+2)



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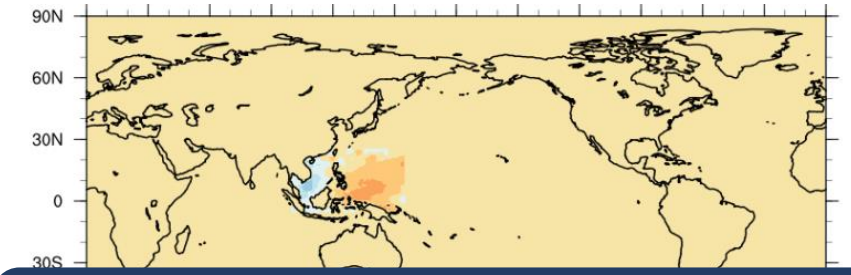
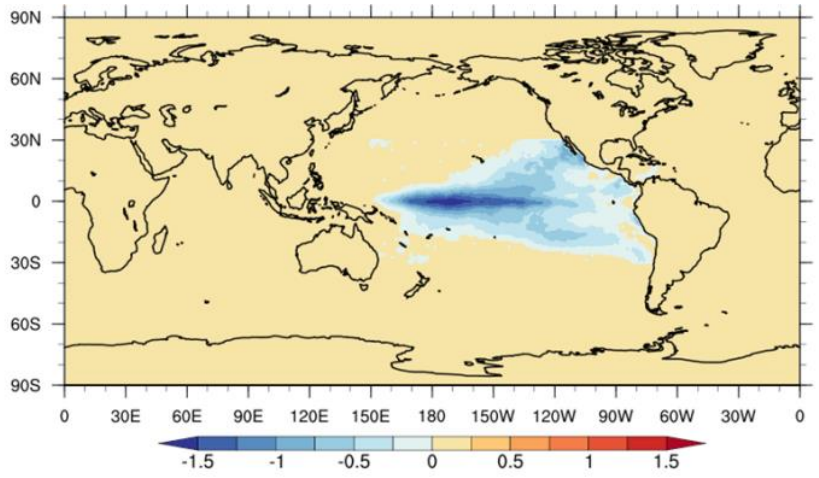
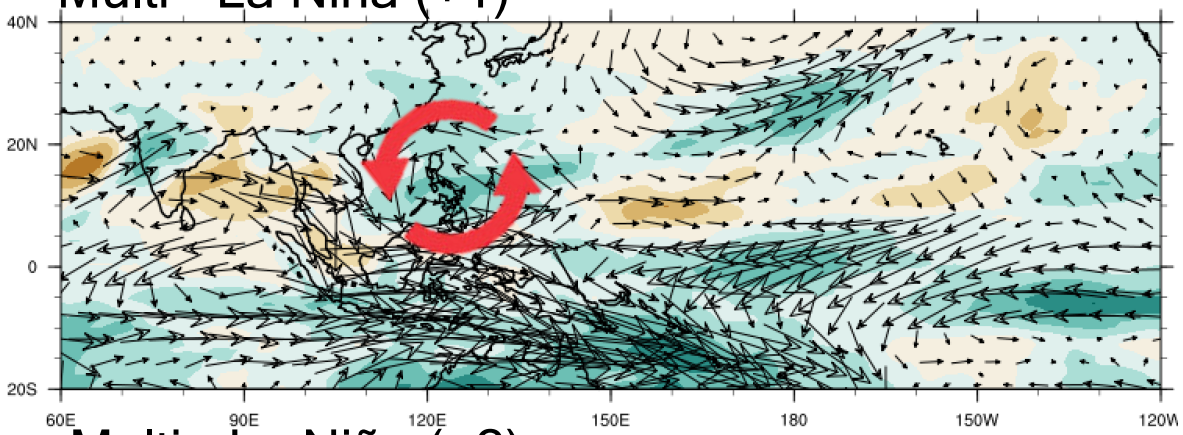


Local SST difference plays an important role in the formation of the PSCC.

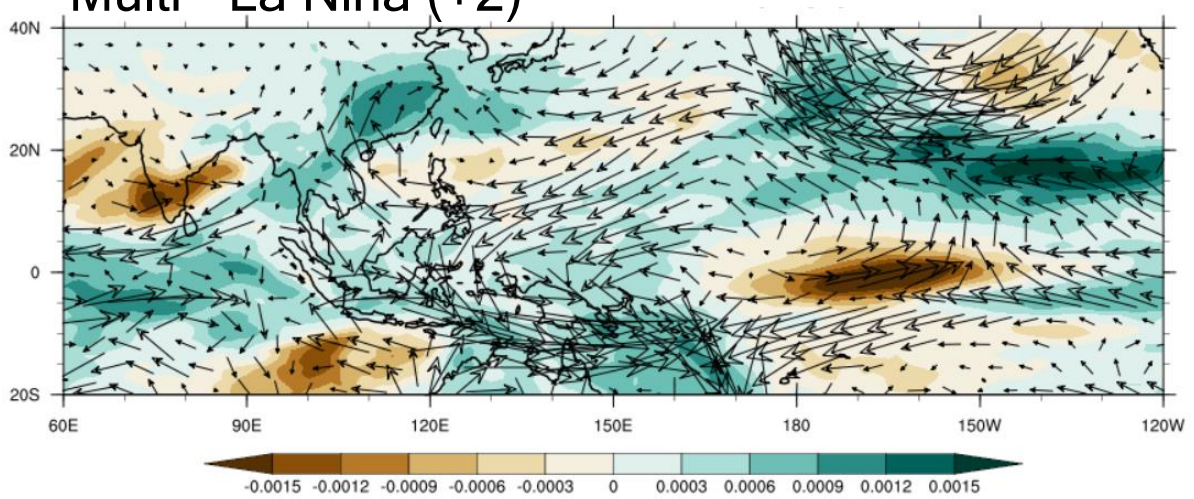


Output

Multi - La Niña (+1)



Multi - La Niña (+2)



CESM2 Climate Model

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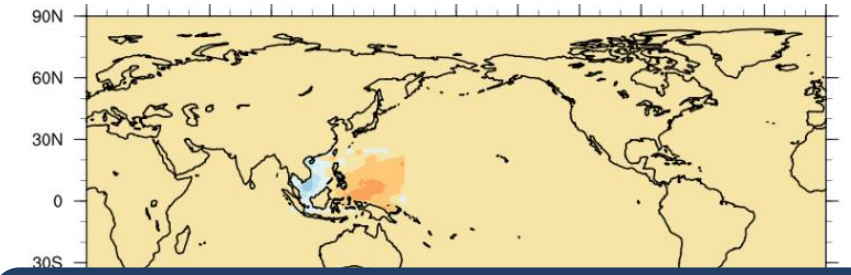

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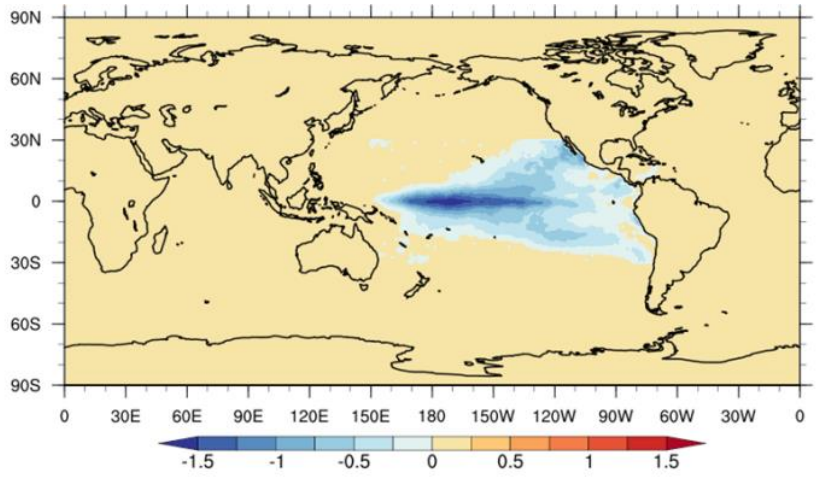
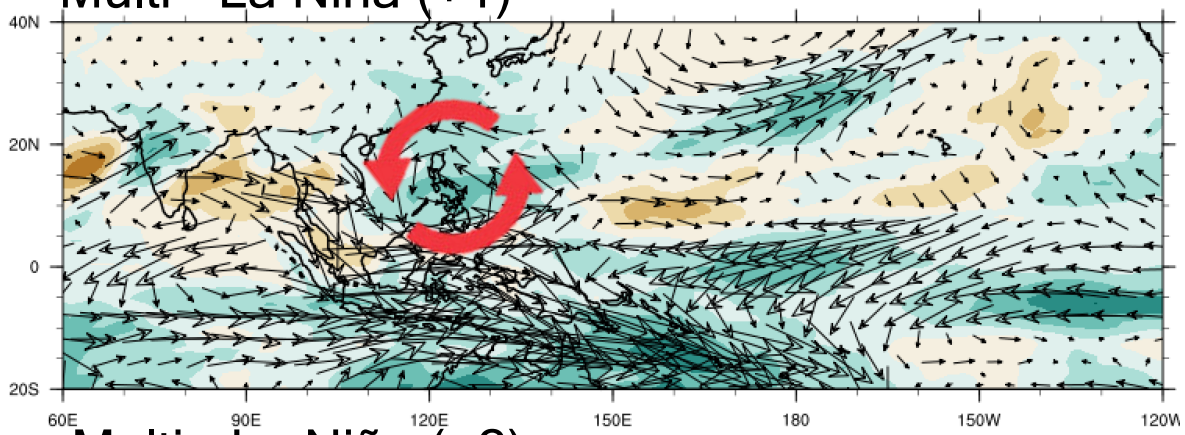
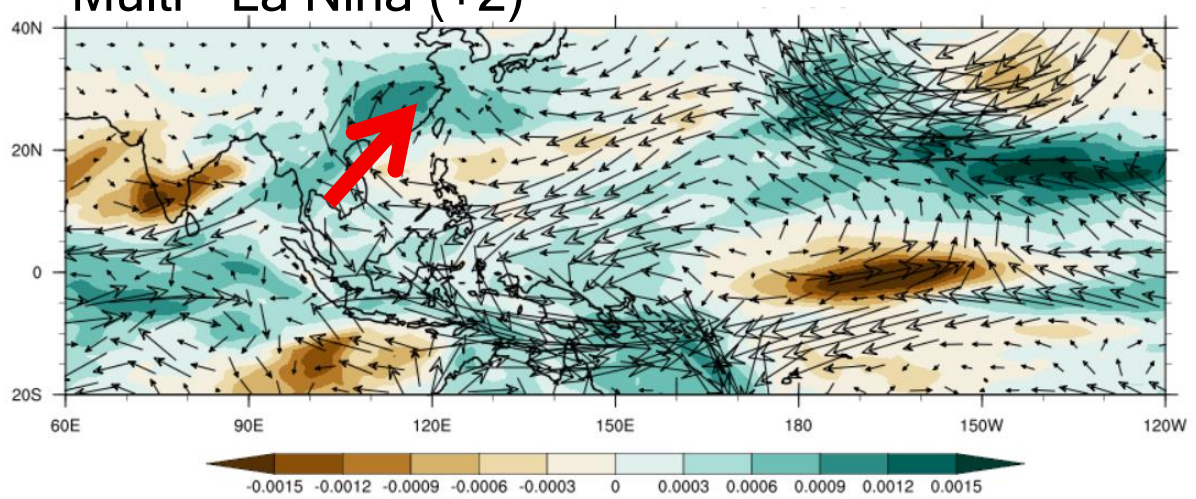


Output

Multi - La Niña (+1)



Multi - La Niña (+2)



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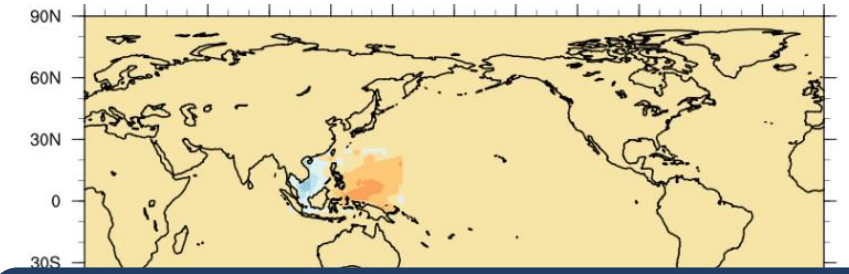

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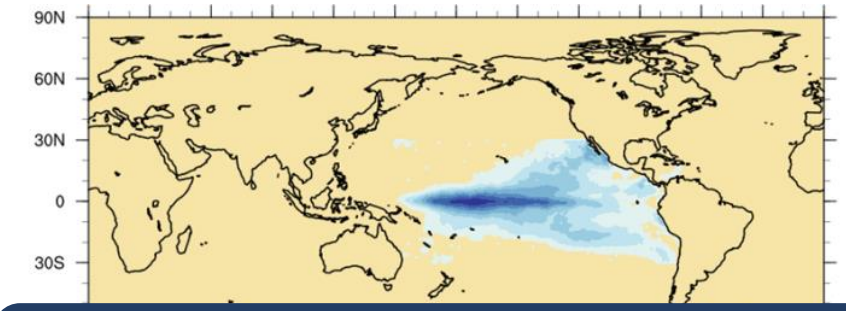
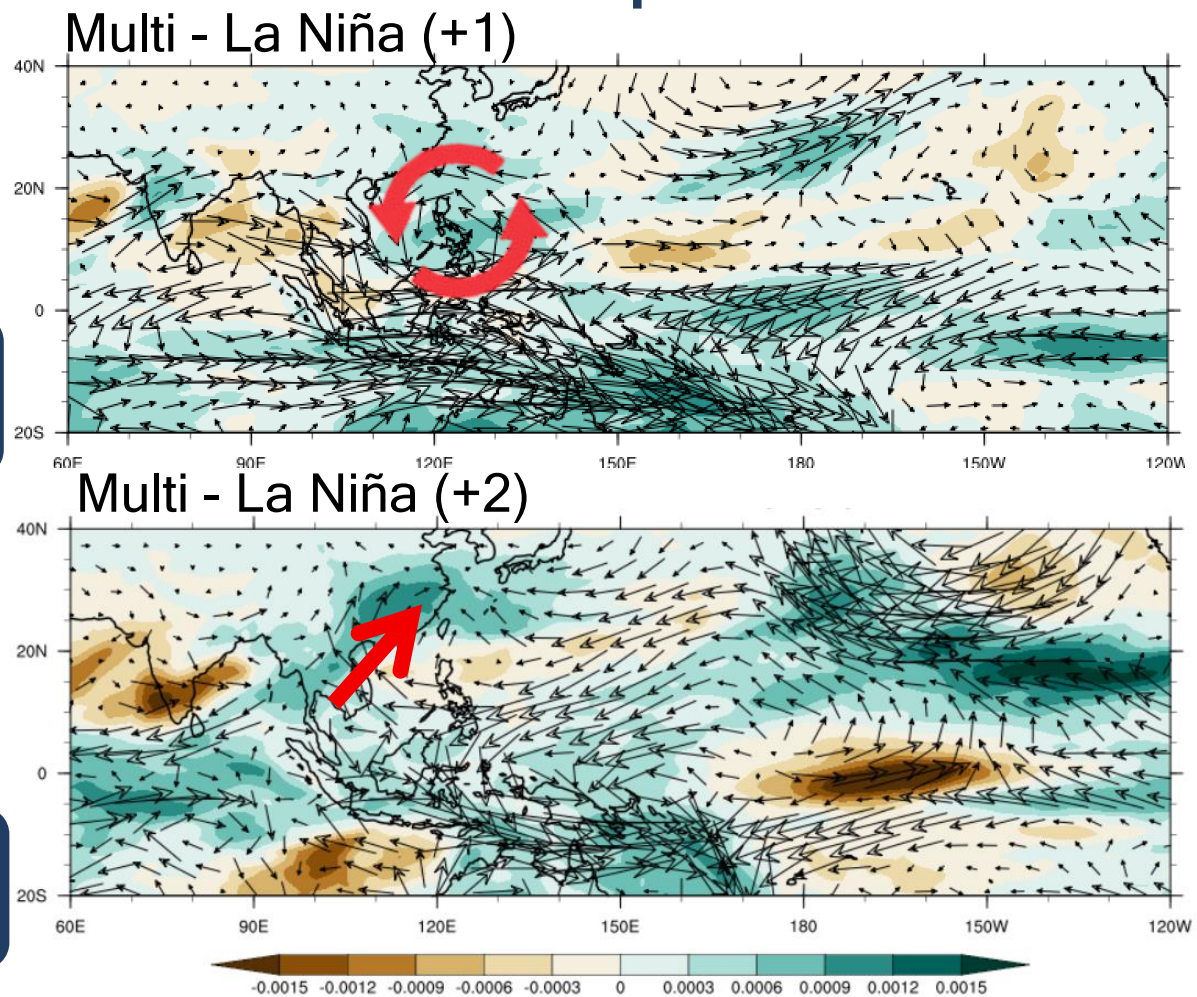
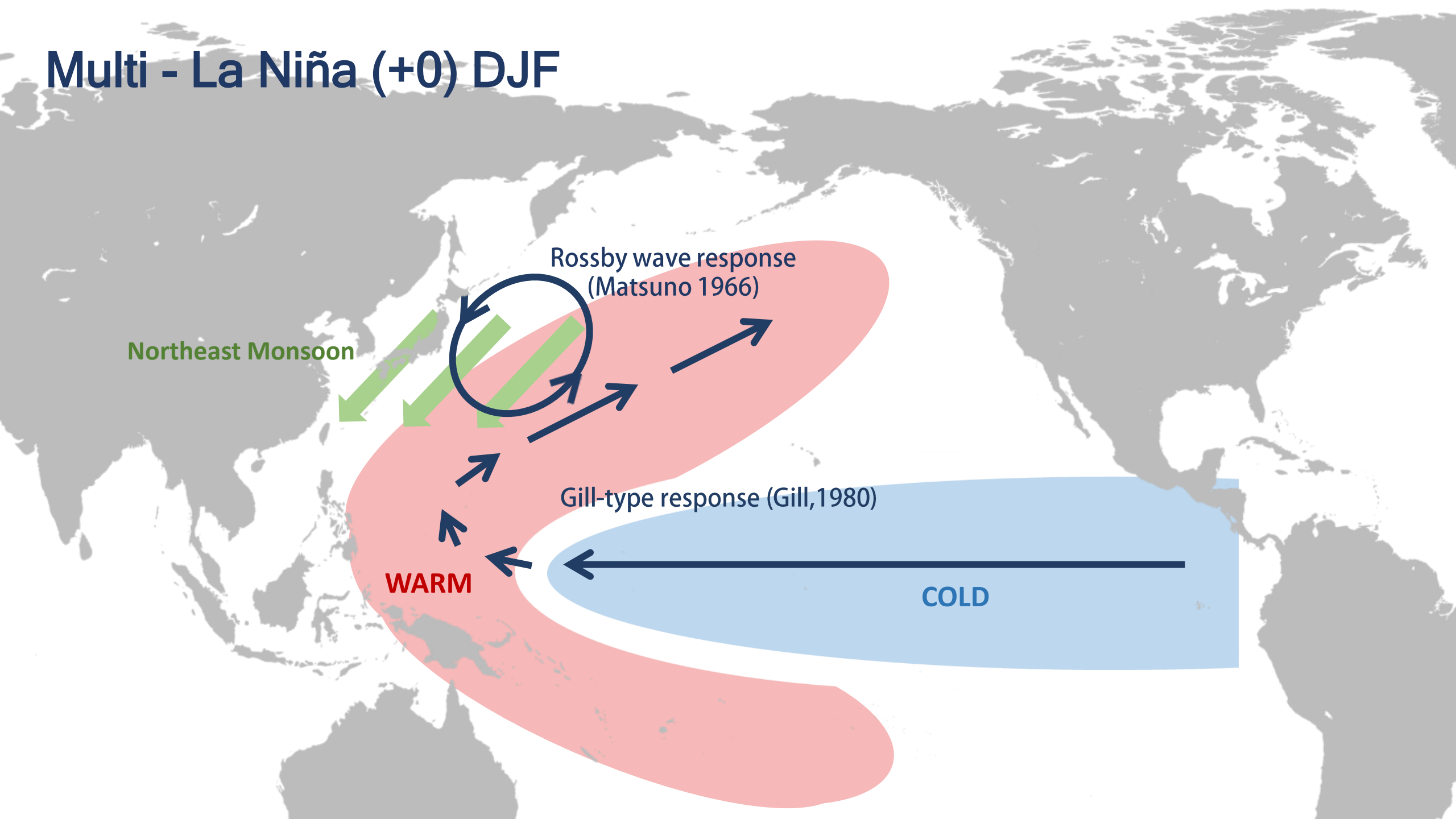


Central Pacific cooling plays an important role in southwesterly winds.

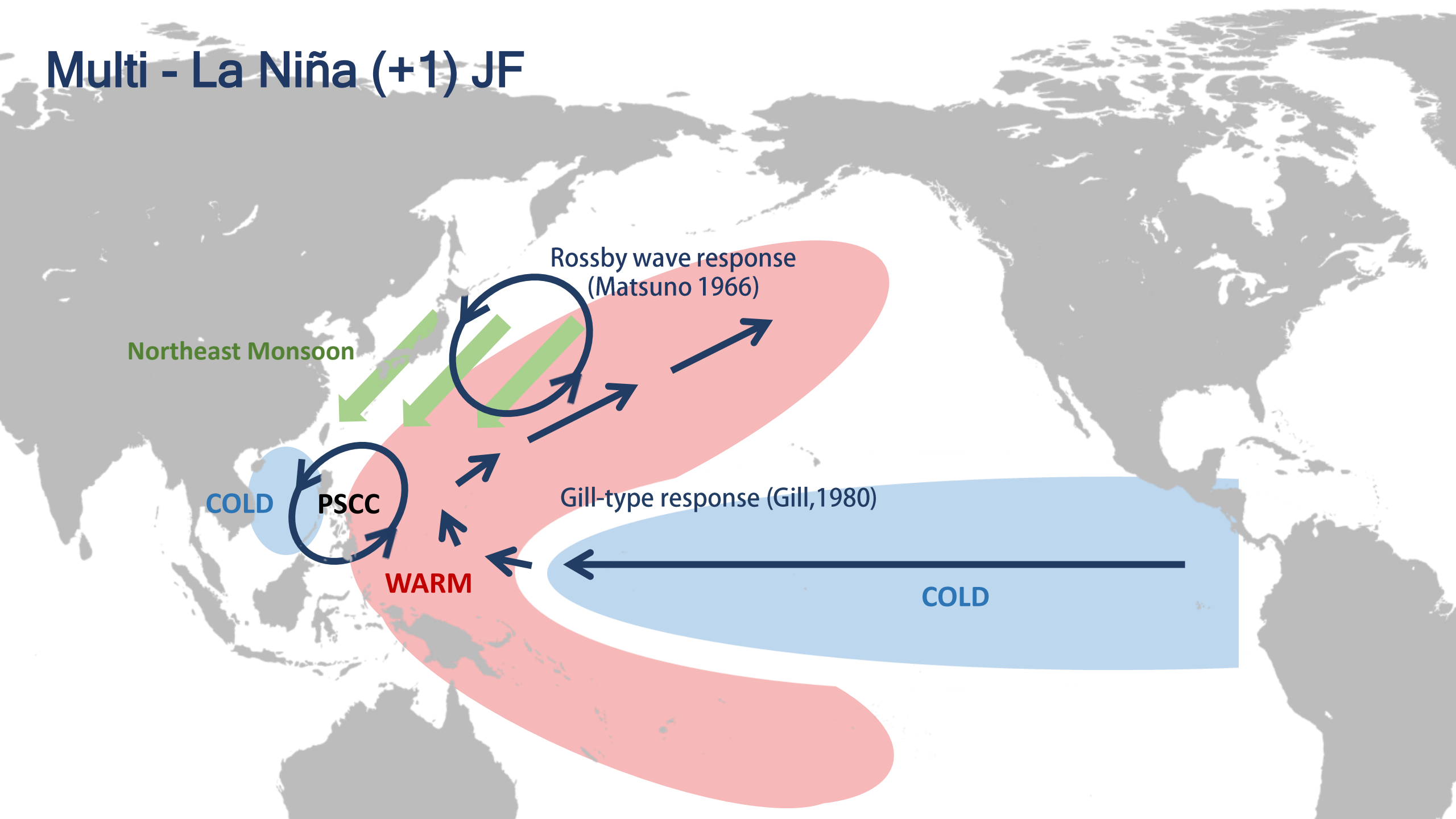
Output



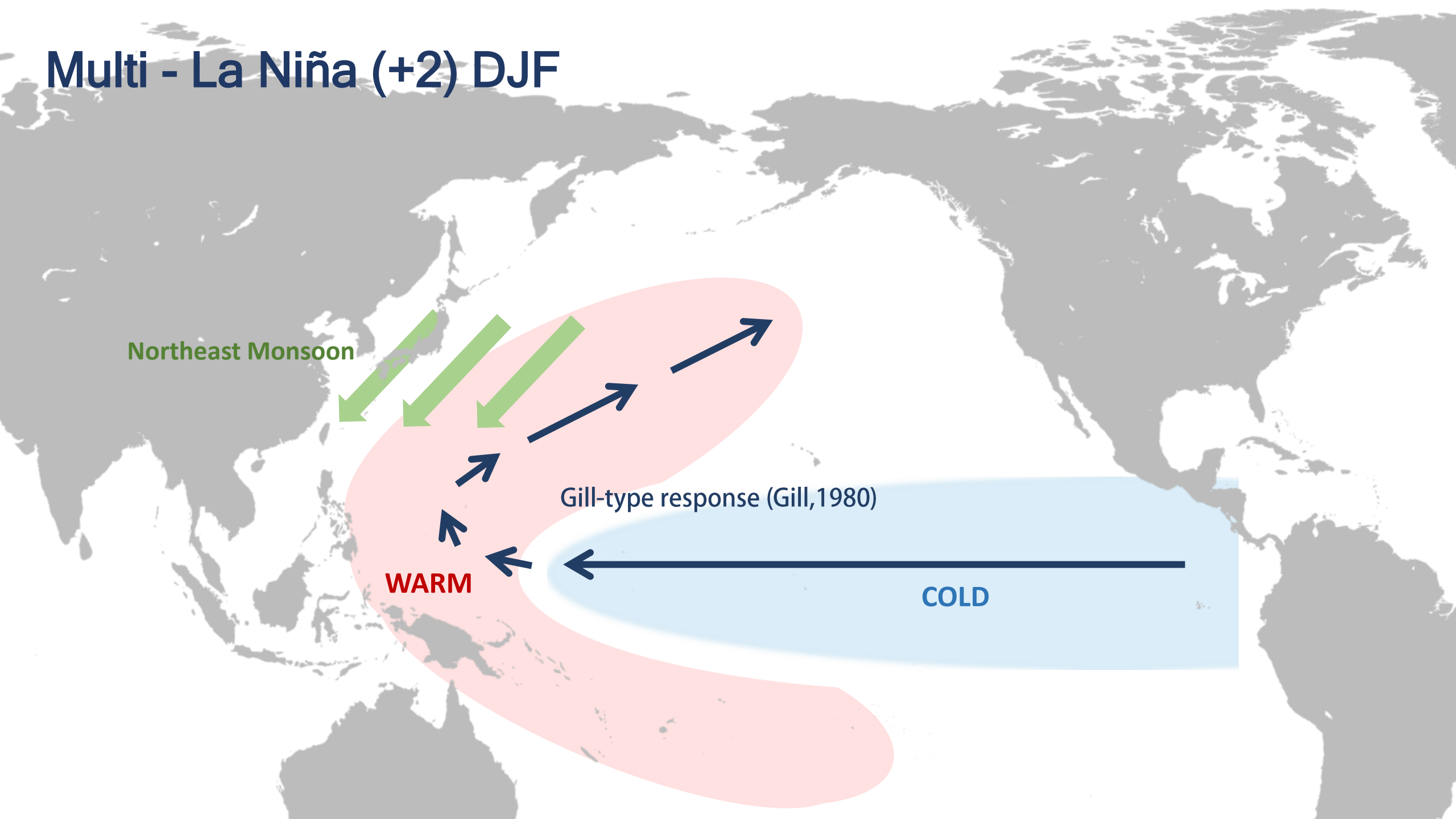
Multi - La Niña (+0) DJF



Multi - La Niña (+1) JF



Multi - La Niña (+2) DJF



Panel Data Model

$$y_{it} = \alpha_{it} + \sum_{k=1}^{k} \beta_k x_{kit} + \varepsilon_{it}$$

- Control unobservable individual differences
- Capture dynamic changes
- Allow more flexible model design

k：1, 2, …, K, The k-th explaining the variables

i：1, 2, …, n, The i-th observer (cross section)

t：1, 2, …, T , The t-th observation time (time series)

y_{it}: Dependent variable for entity i at time t.

α_{it}: Intercept term, capturing individual and time-specific effects.

β_k: Coefficient for the k-th independent variable, indicating its effect on y_{it}

x_{kit}:$k-$ th independent variable for entity i at time t.

ε_{it}: Error term for entity i at time t, capturing unobserved factors.

(Baltagi, B. H. 2008)

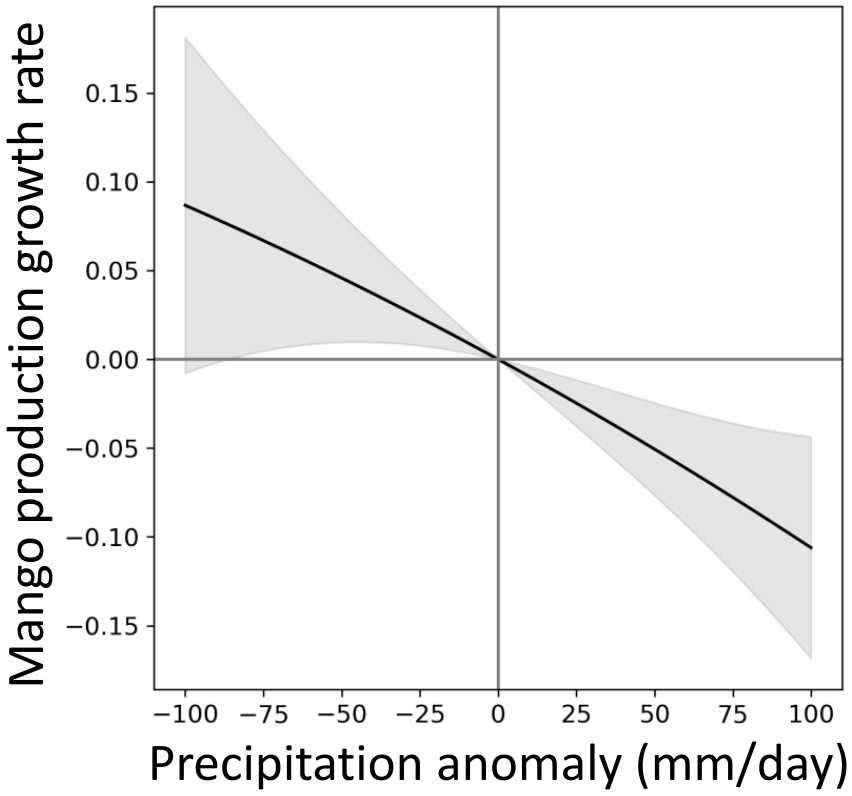
Taiwan's Mango Production Growth Rate

Temperature Precipitation

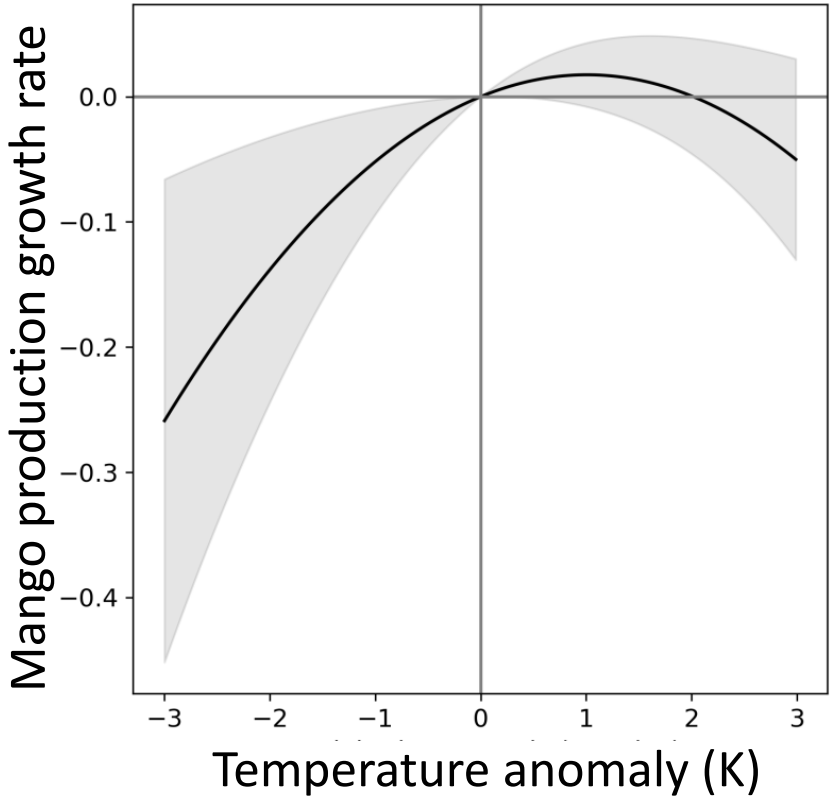
$$\Delta \log(y_{it}) = \sum_{l=0}^{n} \{ \beta_{1,l} T_{it-l} + \beta_{2,l} T_{it-l}^2 + \lambda_{1,l} P_{it-l} + \lambda_{2,l} P_{it-l}^2 \} + \mu_i + \theta_{1i} t + \theta_{1i} t^2 + \varepsilon_{it}$$

$\boldsymbol{Mango\ production_{it}}$ for each city (17) for each year (1997-2022)

Precipitation



Temperature



Conclusion and Future Work

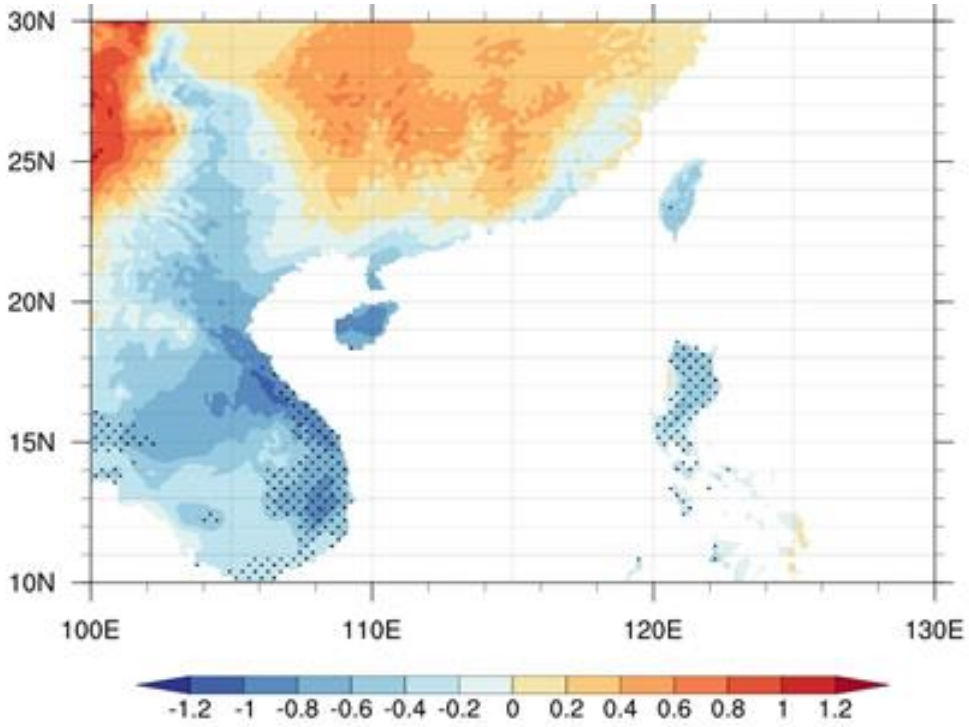
	Multi - La Niña (+1)	Multi - La Niña (+2)
Sea Surface Temperature	Strong local SST gradient	Insufficient cooling in the Central Pacific
PSCC	Present	Absent
Wind Direction	Northeasterly winds	Southwesterly winds
FEB Precipitation	Decrease	Increase
Mango Production	Increase	Decrease

Objective: Acquire extended records of mango production data to strengthen the reliability of this study.

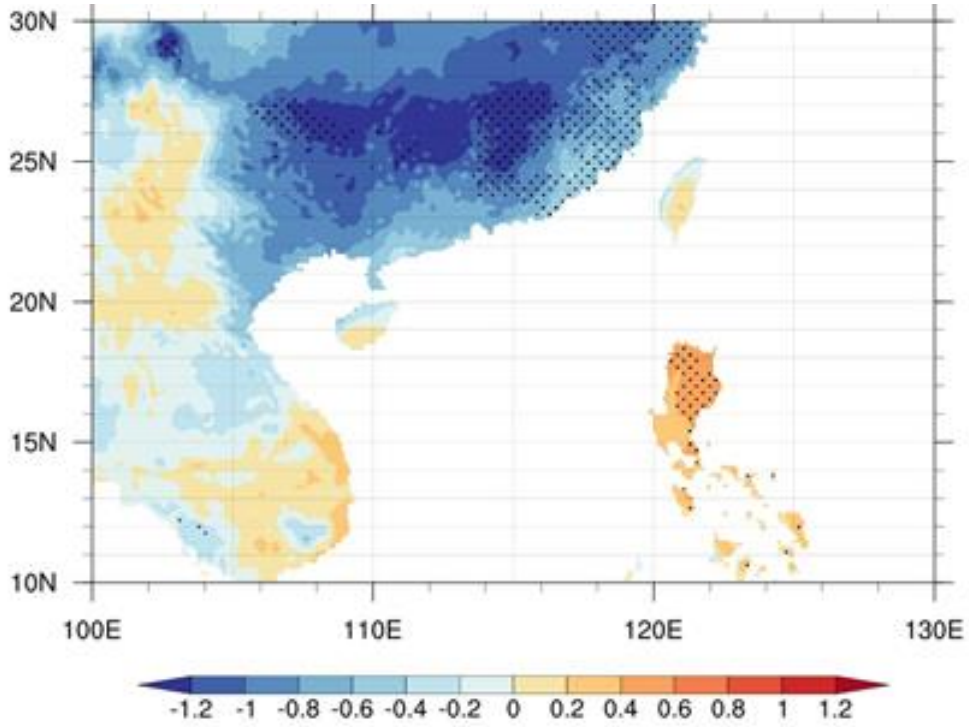
Future Analysis: Utilize downscaled data from CMIP6 to evaluate the potential impact of rainfall during future multi-year La Niña events on mango production.

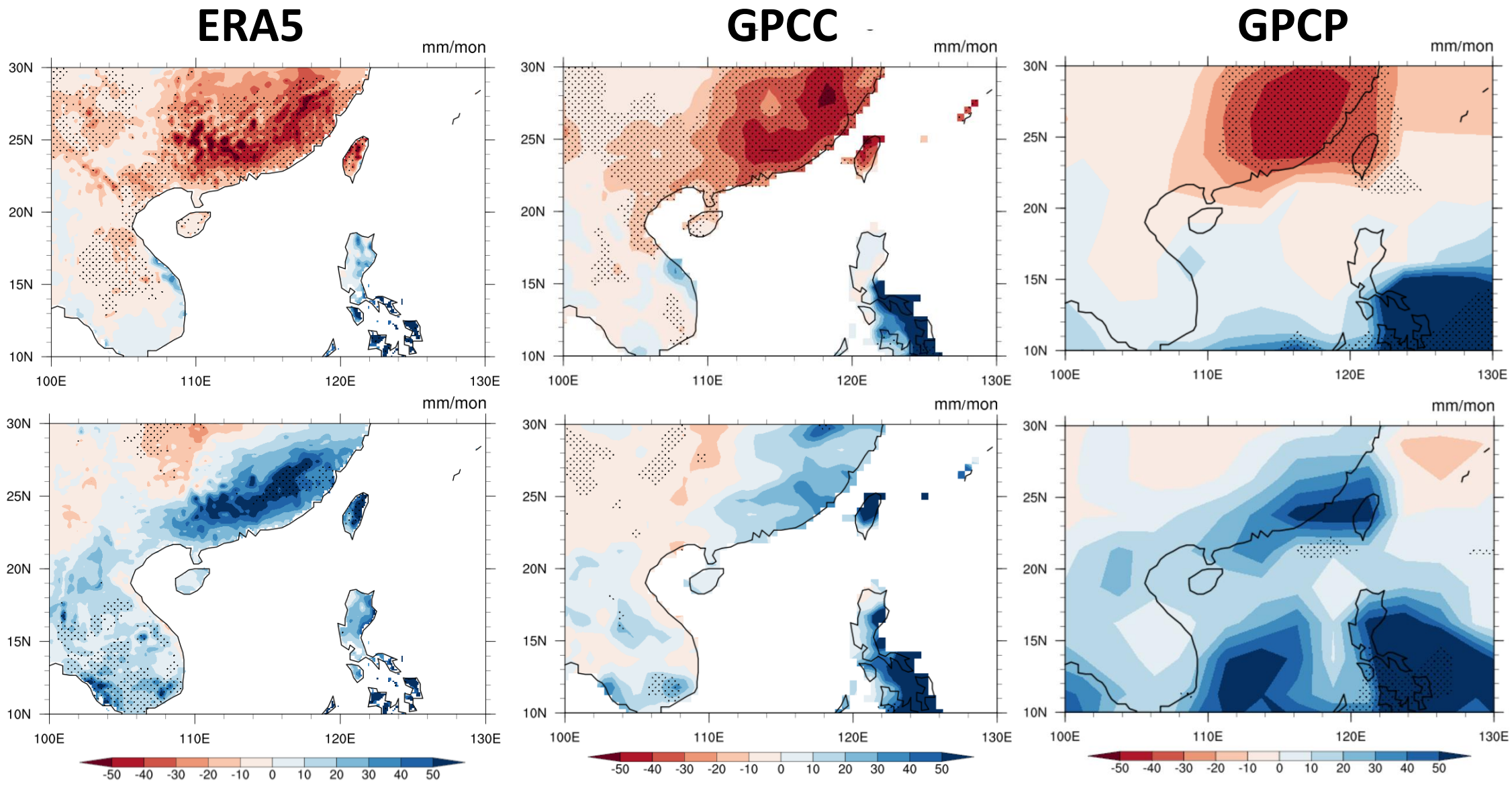
February Average Temperature Anomalies

Multi - La Niña (+1)



Multi - La Niña (+2)




ERA5
GPCC
GPCP
mm/mon
30N
25N
20N
15N
10N
100E
110E
120E
130E
-50 -40 -30 -20 -10 0 10 20 30 40 50