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Rainfall and sea level variability in the face of changing El Niño: Evidence from the US-Affiliated Pacific Islands

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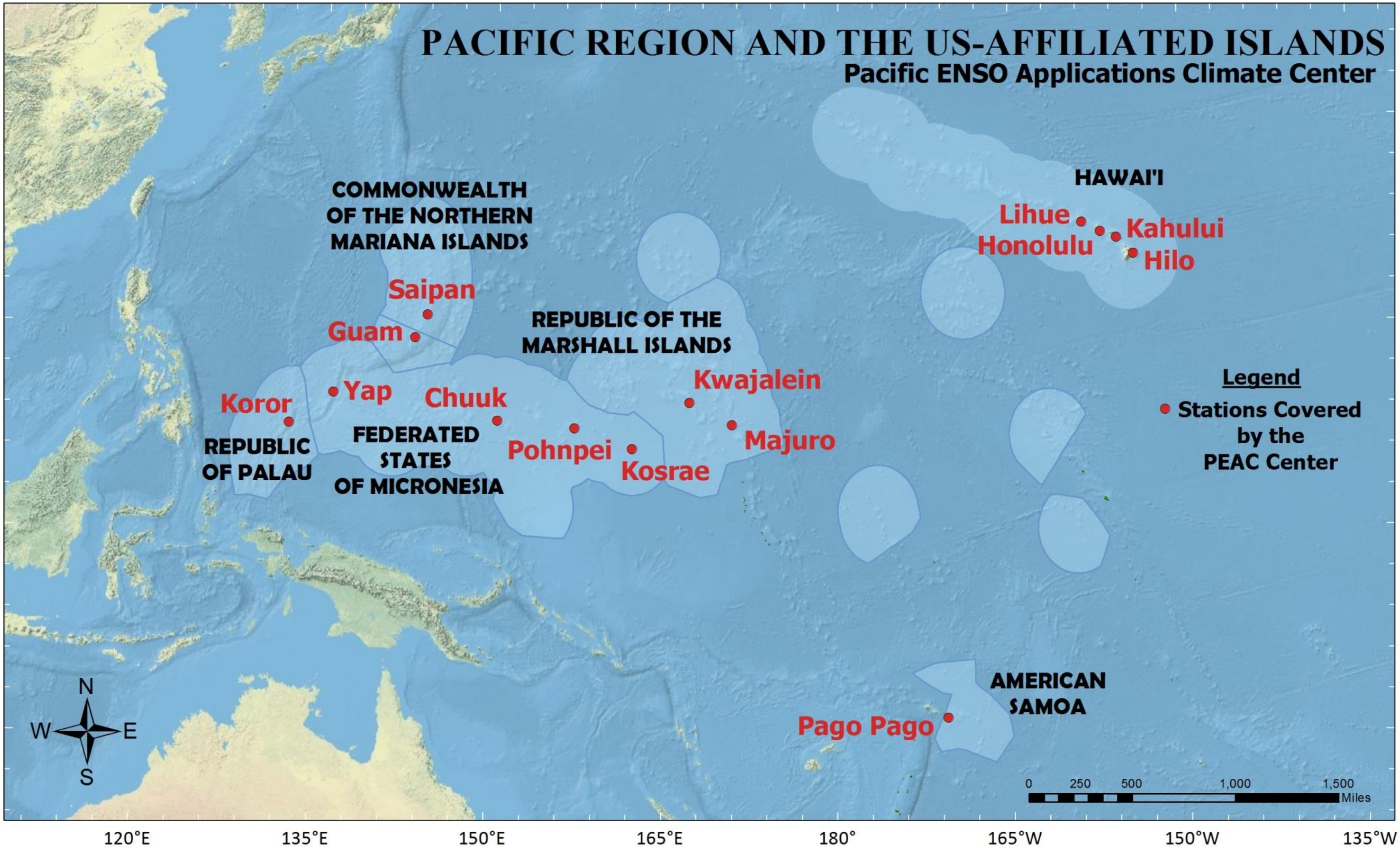
Background and objectives

- **The USAPI region is ENSO sensitive;**
- **The CMIP5 model-based study provides a strong message about the higher risk of extreme El Niño;**
  - **Wenju et al. (2014): super El Niño events could double and occur every 10 years instead of 20.**
  - **Guojian et al. (2017)—frequency of extreme El Niño events doubles under the 1.5° C Paris target;**
  - **ENSO-driven SST anomalies and background global warming (Power et al., 2013; Brown et al., 2013).**

- **Future disruptions in the USAPI region are centered on the consequences of increasing frequency of ENSO;**
  - **Much larger in 21st century than it was during the 20th century (Cai et al., 2014; Cai et a1., 2015a; Cai et al., 2015b).**

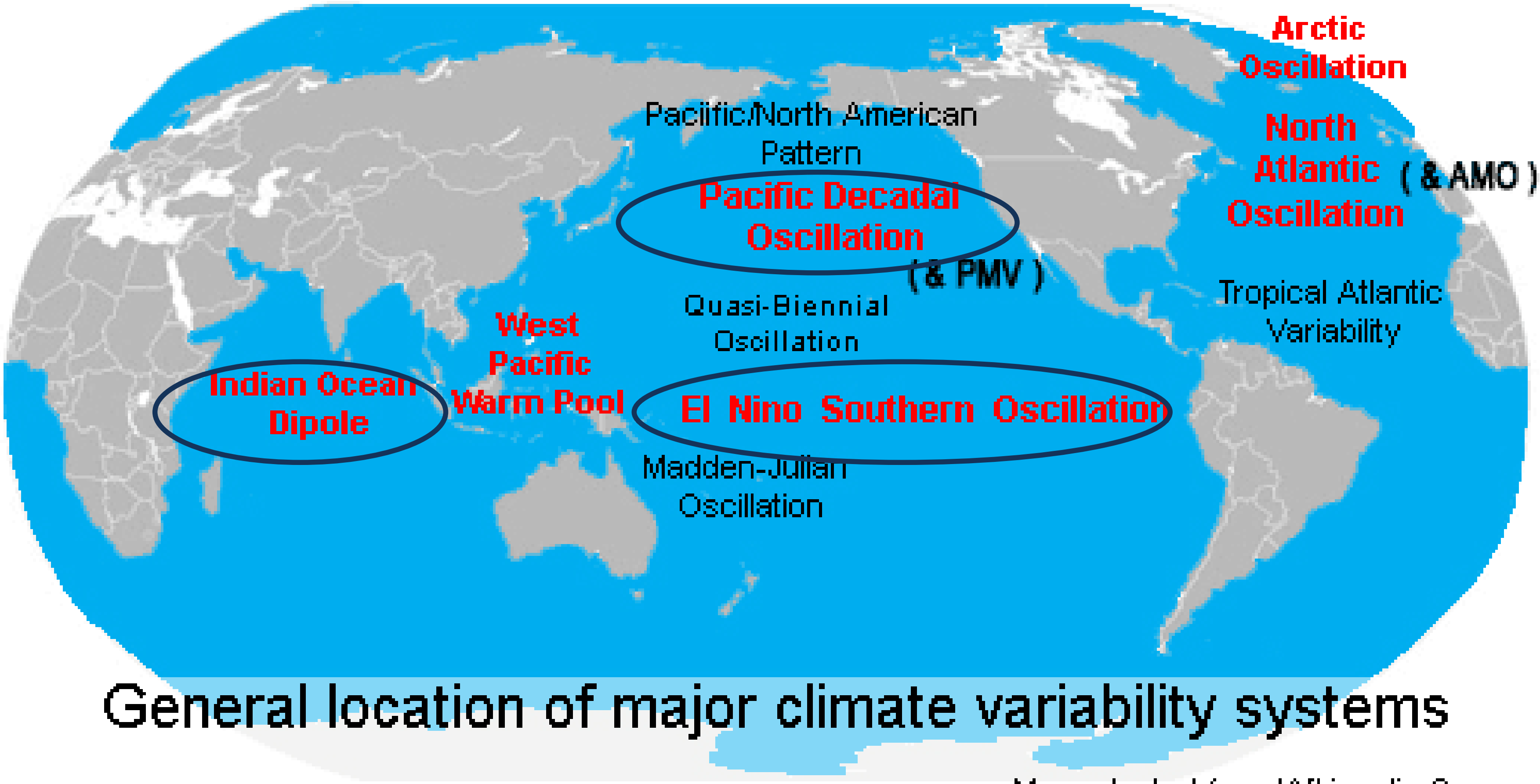
- **Freund et al. (2019): El Niño events differ in their impacts on the location (NINO-3/ NINO-4) & intensity of temp;**
  - **The objective is to provide three types of El Niño information and related RF/SLA for better disaster preparedness and planning.**

USAPI Region



General Location of Major Climate Variability System

IOD: 201805: neutral, 1997: +ve,1998: -ve



Map adapted from Wikimedia Commons

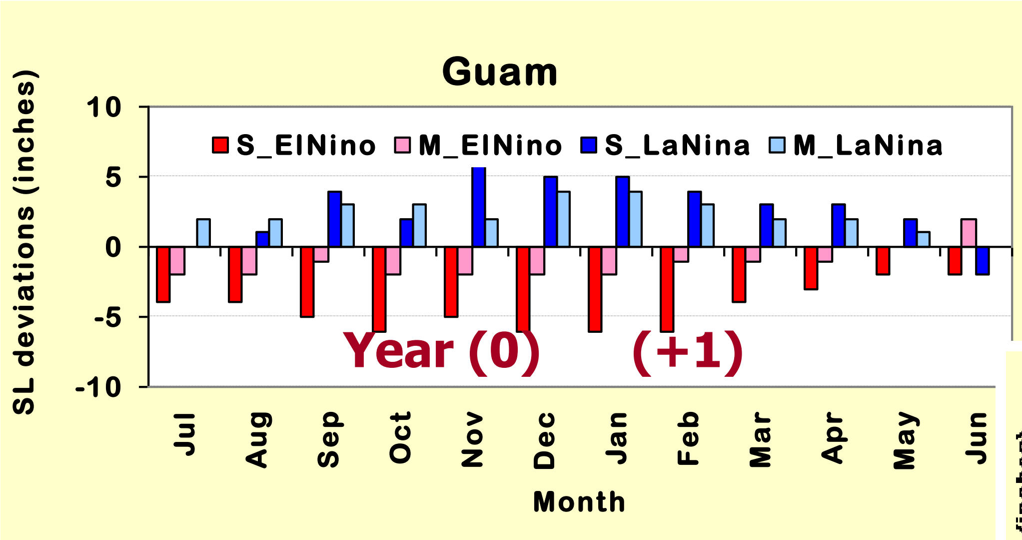
PDO: 201805: -0.61, 199710: +1.72,199810: -2.23

COLD: 1890-1924;1947-76….WARM: 1925-46; 1977-97

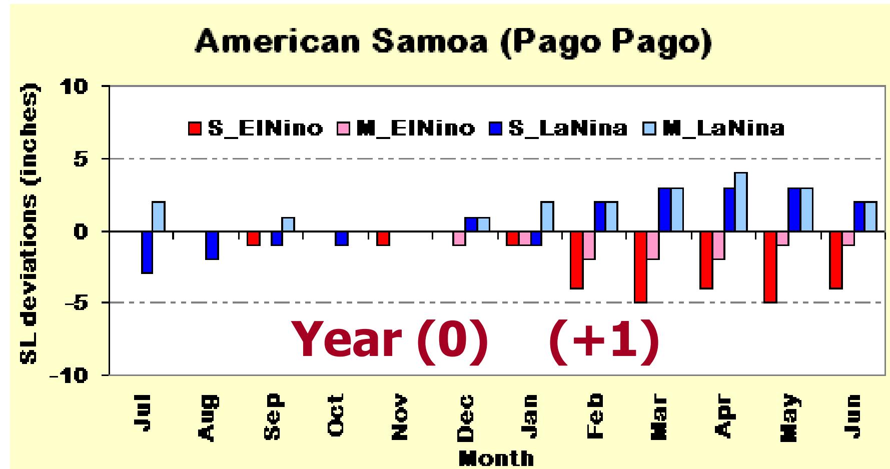
Seasonal rainfall variations (%) during El Niño/La Niña years

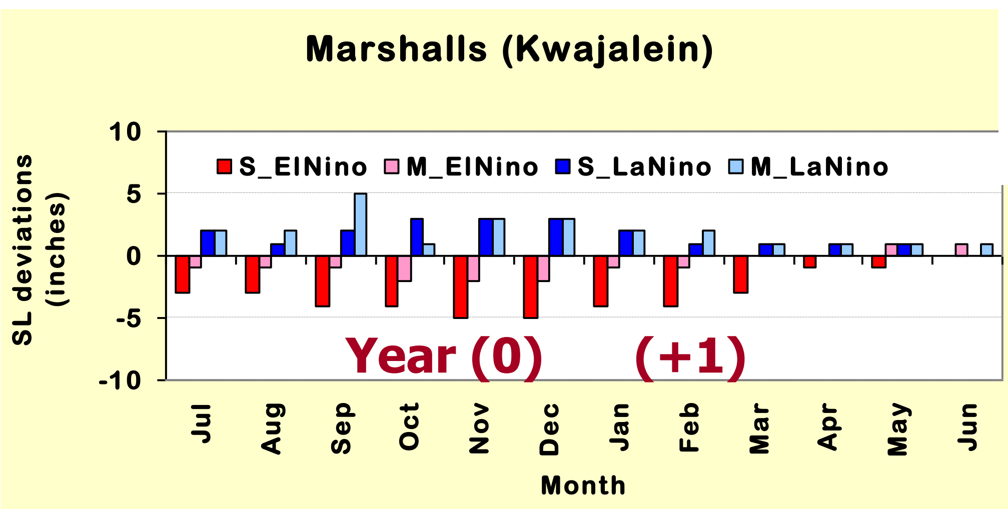
		El Niño (0)		El Niño (+1)		La Niña (0)		La Niña (+1)	
		JJA	SON	DJF	MAM	JJA	SON	DJF	MAM
	Guam	93	100	70	50	102	87	108	174
	Saipan	84	104	73	63	106	104	135	182
	Palau	102	79	88	82	92	122	128	111
FSM	Yap	99	91	75	72	82	111	124	149
FSM	Chuuk	97	82	71	74	88	107	115	123
FSM	Kosrae	98	105	90	84	91	101	107	122
FSM	Pohnpei	100	95	77	80	83	96	114	119
	Marshalls	102	100	99	74	100	97	95	135
	A Samoa*	110	114	109	107	94	90	99	86

ENSO and sea level variability



S El Niño: 1951, 58, 72, 82, & 97/ (Yr,0)
S La Niña: 1964, 73, 75, 88, 98 (Yr, 0)
M El Niño: 1963, 65, 69, 74, & 87
M La Niña: 1956, 70, 71, 84, 99

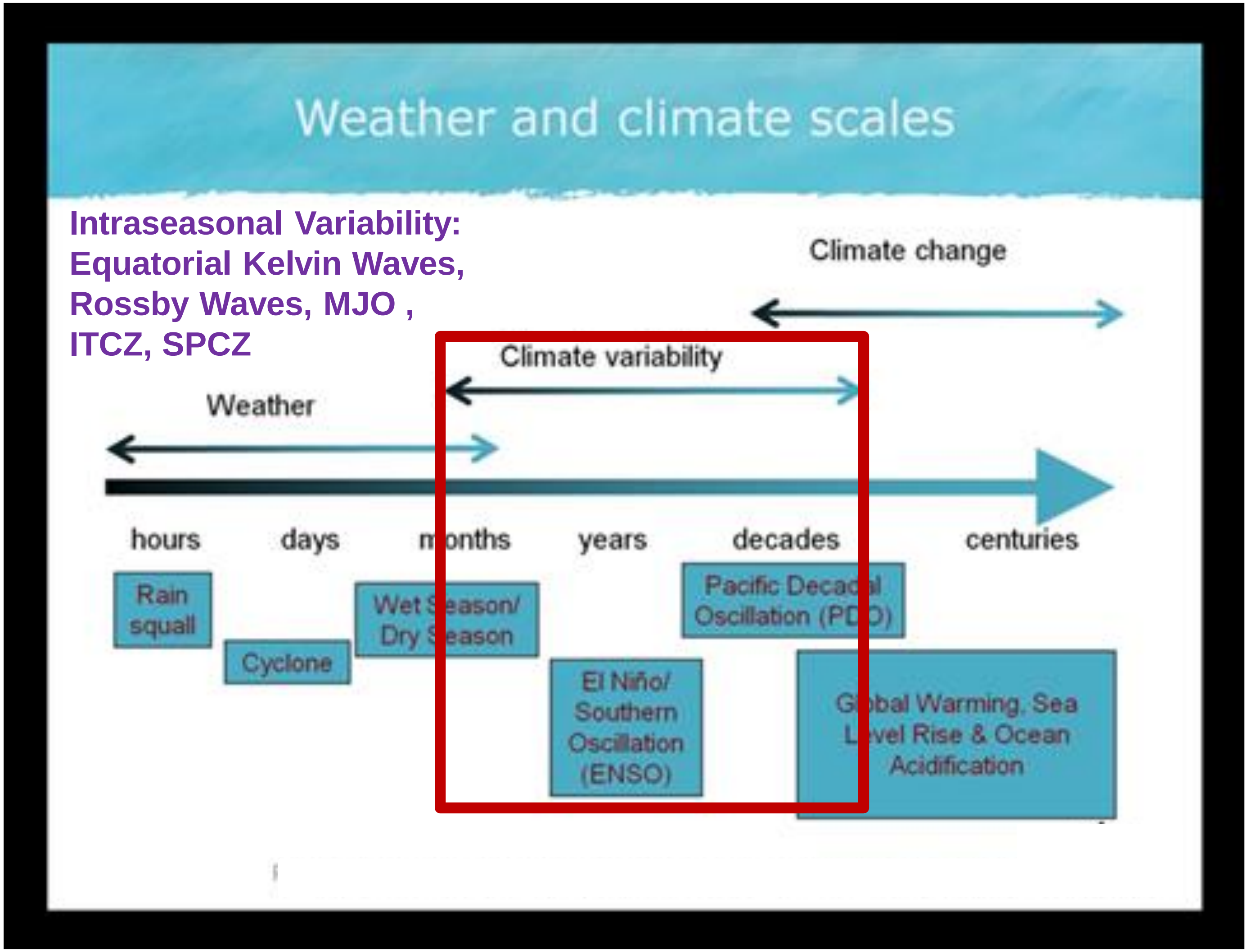




Composites of monthly Sea-level deviations in El Niño /La Niño years

Source: Chowdhury et al., 2006

Understanding Climate Variability/Change



- **Long-term decadal variations in climate are understood, but our ability to predict such changes in an operational context is somewhat difficult;**
- **In contrast, ENSO's interannual time-scale variability are more effective for the USAPI region--*global nature, strong signal, interannual time scale, and inherent lag relationships.***

Applications Research

ENSO sensitive climate variability

- **Demand for ENSO-based season-to-interannual climate forecasts for disaster preparedness planning for the island communities (USAPIs).**

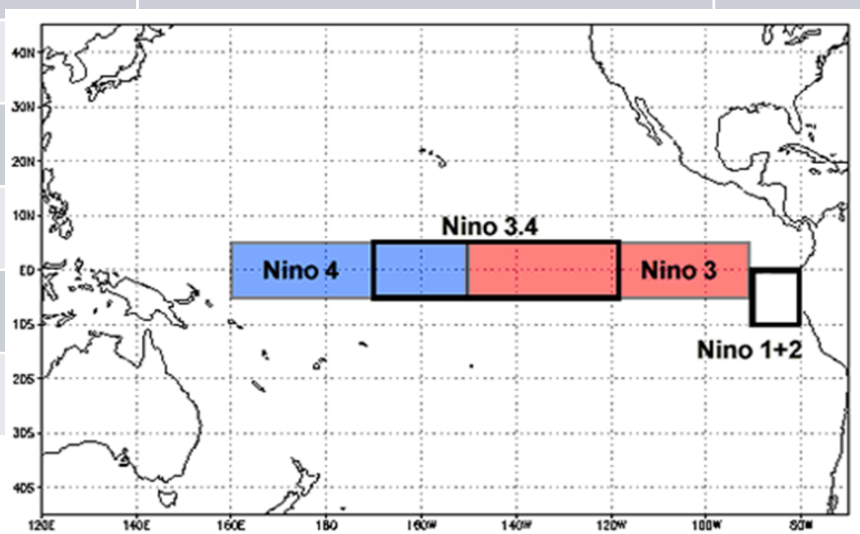
- **Fang and Mu (2018) mentions that, while the simple zonal two-region framework can accurately manifest the traditional EPE, it cannot fully depict the variations of the CPE, because of the difference in locations of the major warming centers;**

Three types of EL Niño

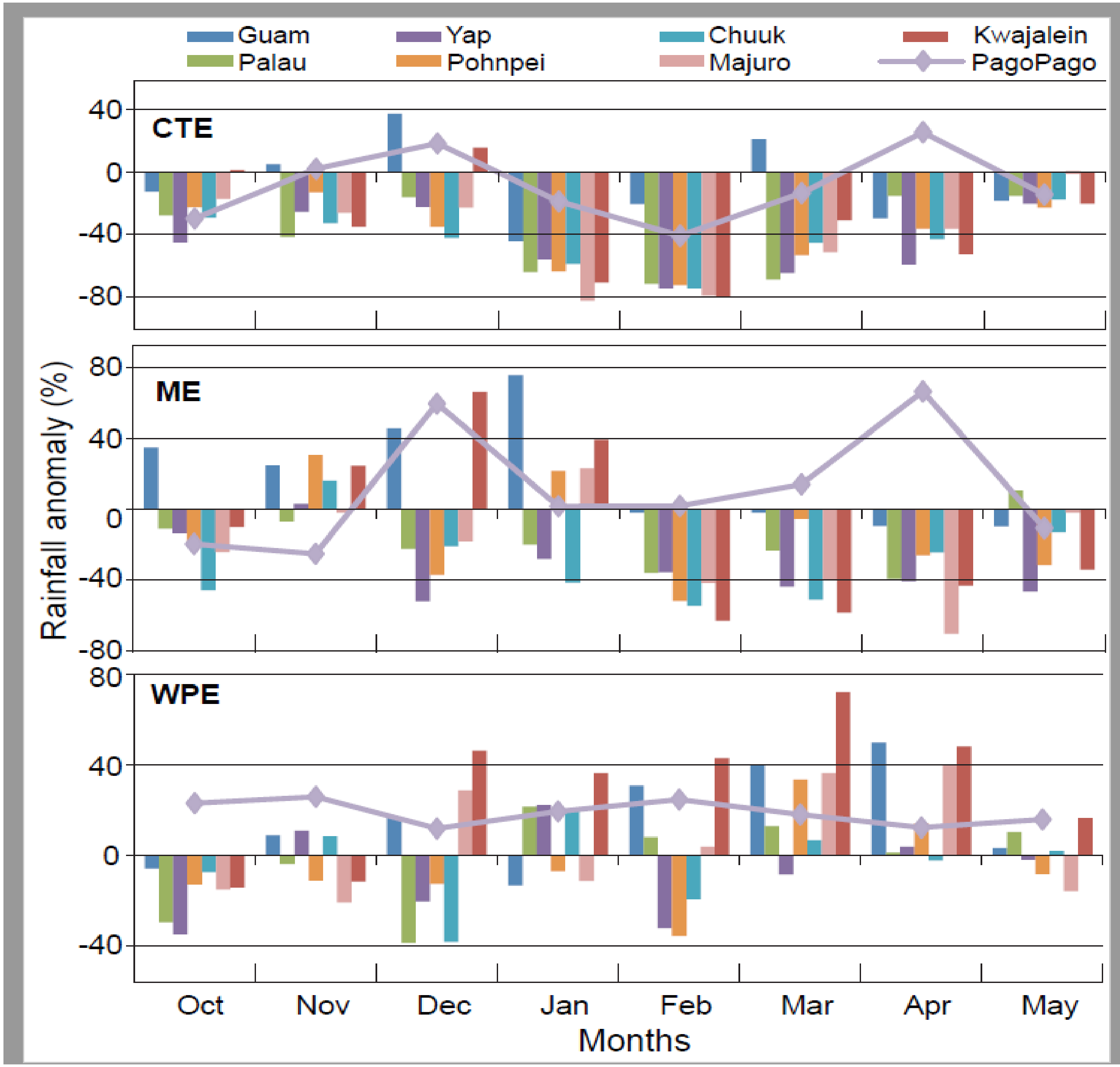
EPE, ME, and CPE events

differ in their impacts on the location and intensity of temperature

Easter Pacific El Niño Niño- 3 region (5°S–5°N, 90-150°W)	Mixed El Niño (Niño-3.4 region) (5°S–5°N, 170-120°W)	Central Pacific El Niño (Niño-4 region) 5°S–5°N, 160°E–150°W
1972-73	1986-87	1977-78
1976-77	1987-88	1990-91
1982-83	1991-92	1994-95
1997-98		2002-03
2015-16		2004-05
		2009-10
		2018-19?
		2020-21?



Monthly (observed) mean rainfall anomaly (1975-2019)



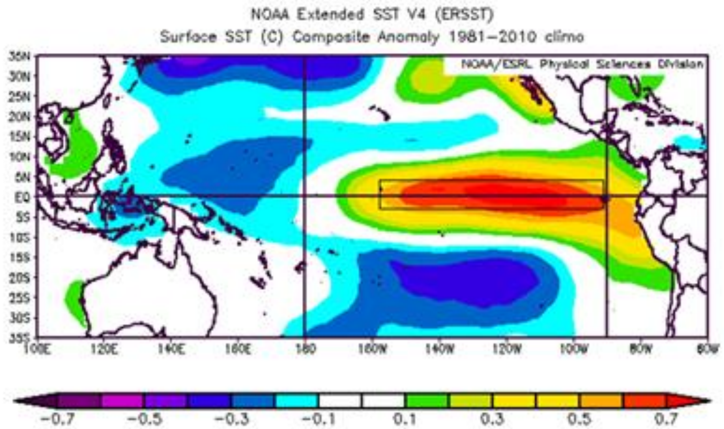
EPE: lower RF

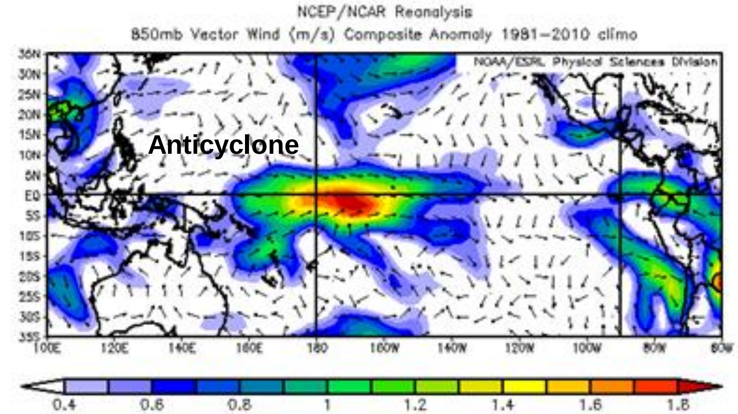
ME: lower RF

CPE: scattered/wet Jan-Apr (+1)

Data source: PEAC Conf. call / NWS

Average SST (L) and Wind (R) anomalies: Sept-Feb



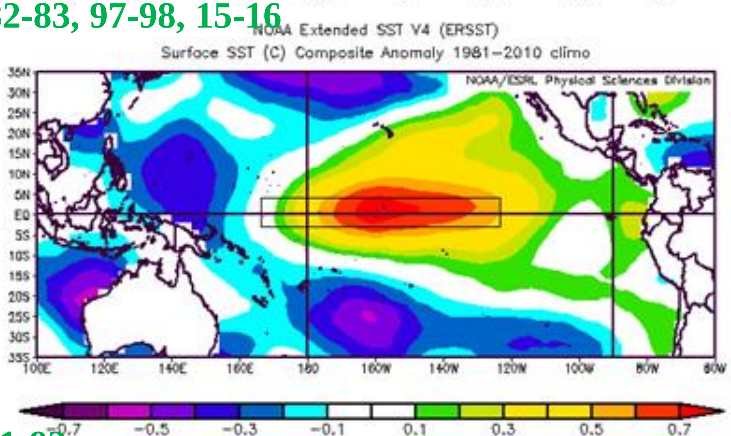


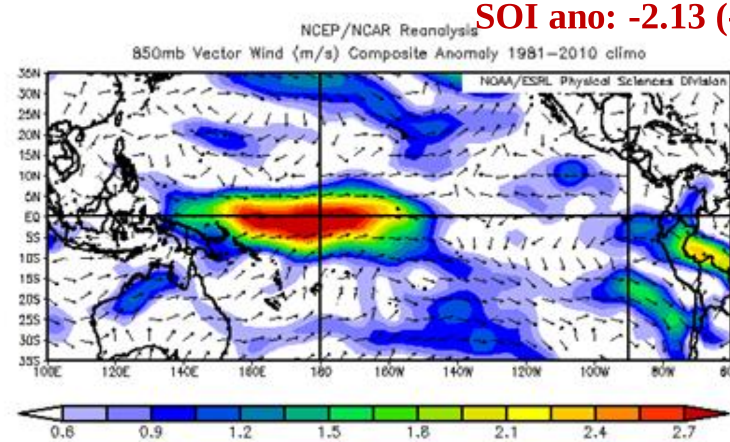
EPE /CTE

(Niño-3)

1972-73, 76-77, 82-83, 97-98, 15-16

SOI ano: -2.13 (-1.29)



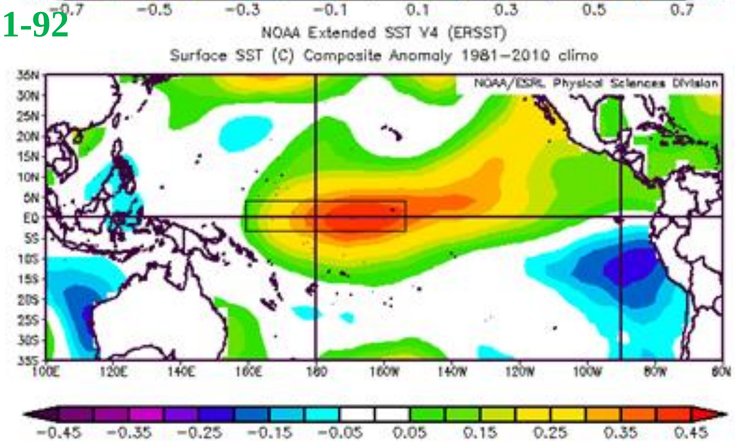


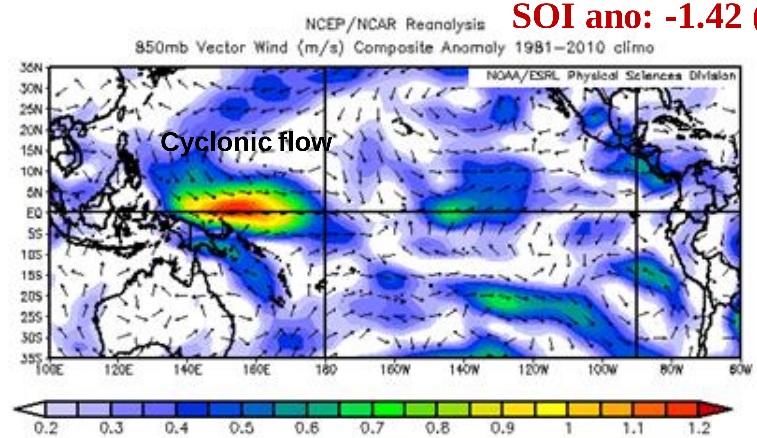
ME

(Niño-3.4)

1986-87, 87-88, 91-92

SOI ano: -1.42 (-0.87)





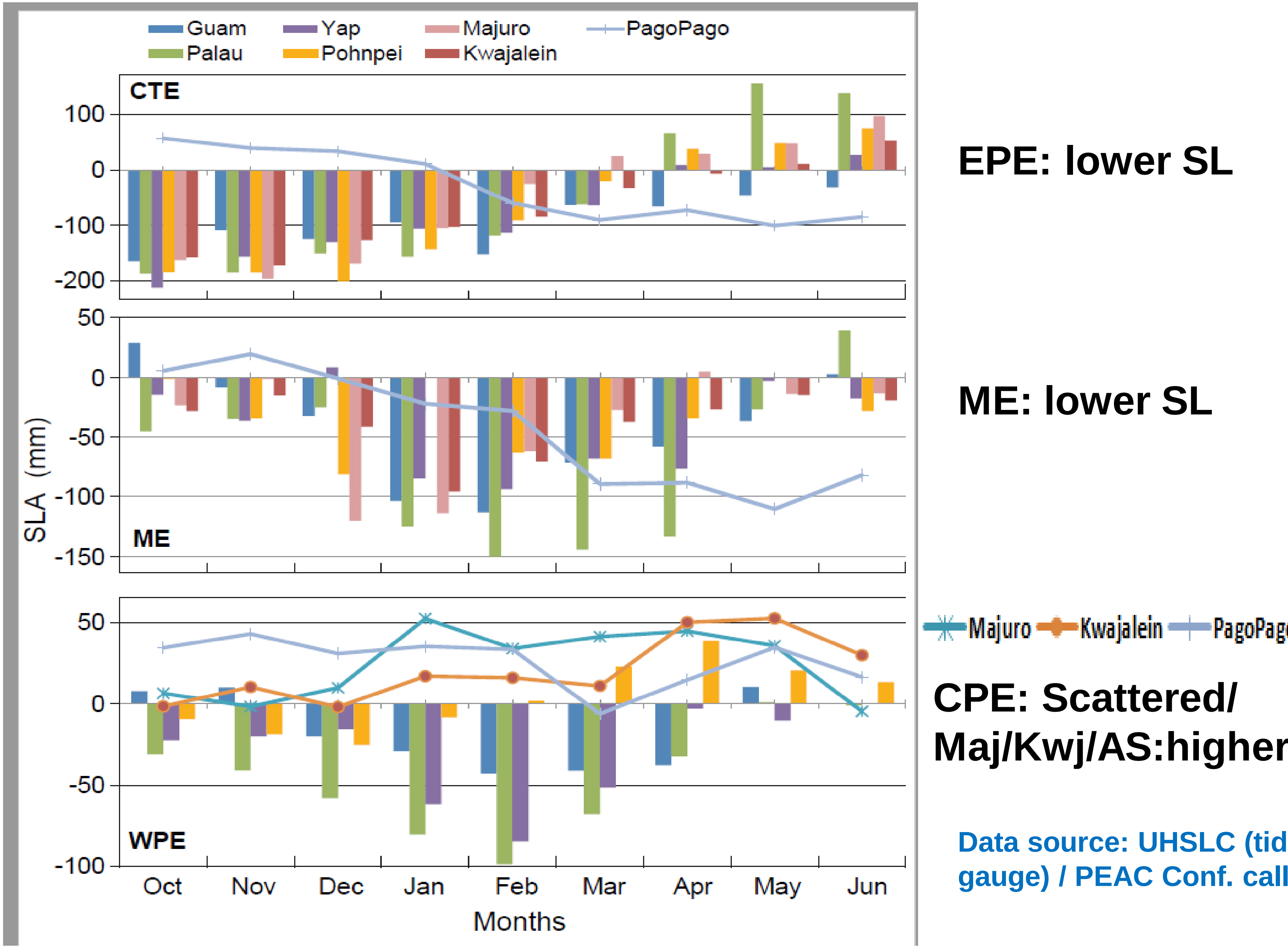
CPE/WPE

(Niño-4)

1977-78, 90-91, 94-95, 2002-03, 04-05

SOI ano: -1.0 (-0.63)

Monthly mean sea level anomaly (1975-2019)



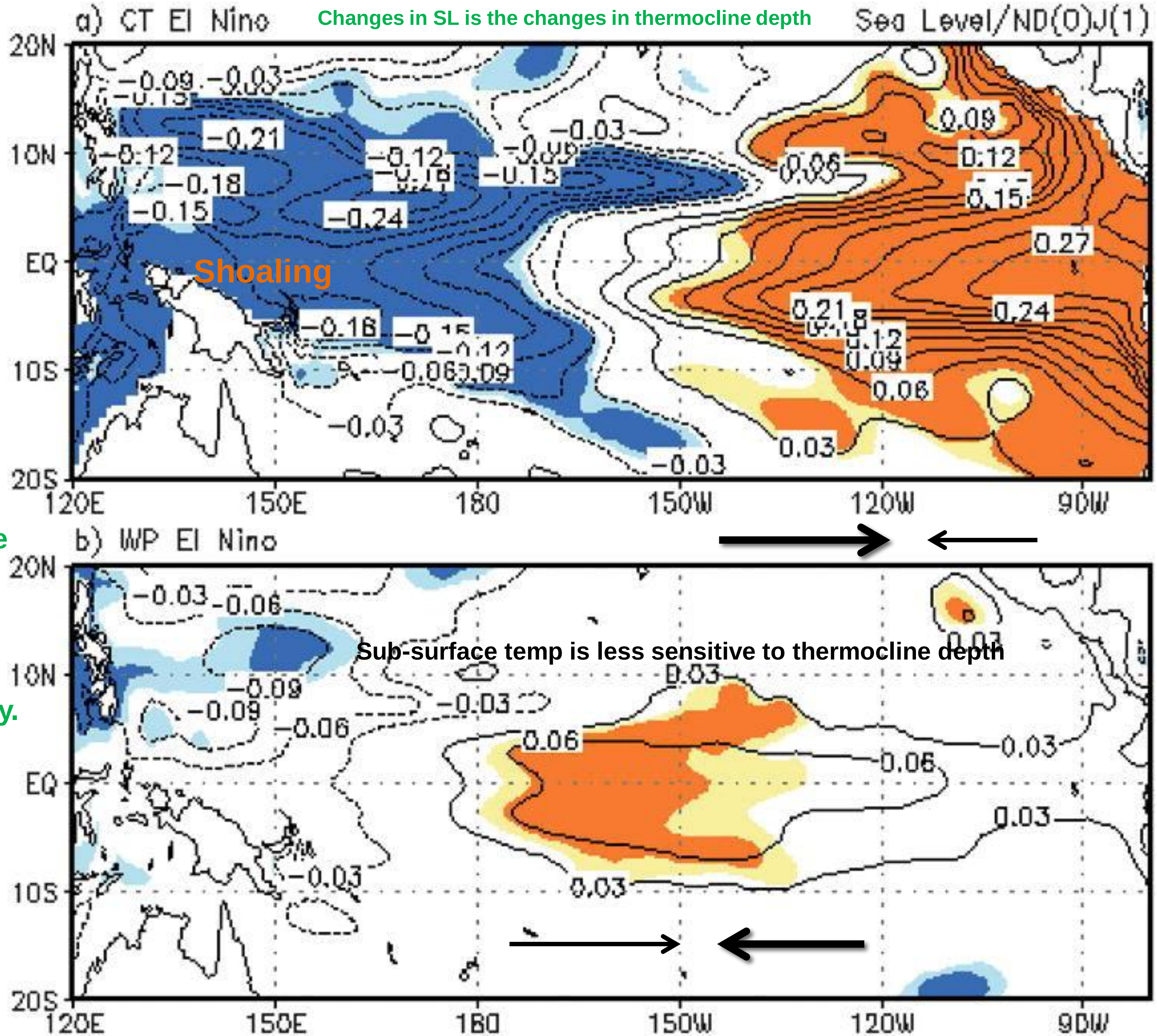
EPE: lower SL

ME: lower SL

CPE: Scattered/ Maj/Kwj/AS:higher SL

Data source: UHSLC (tide-gauge) / PEAC Conf. call

Sea level (cm) composites of (a) CT El Niño and (b) WP El Niño



deepens; vertical advection upwelling large area SST

Light and dark shadings indicate the 90% and 95% confidence levels, respectively.

Summary

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a) **Extreme El Niño events (i.e., 1982-83, 1997-98, and 2015-16) doubles under the 1.5°C and could occur roughly every 10 years instead of every 20;**

b) **The EPE and ME events are associated with dry conditions for the entire USAPIs, but the CPE events are linked to scattered wet conditions.**

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a) **The combined impact of increasing temperature and future El Niño will cause serious drought for water-scarce FSM and RMIs;**

b) **Rising sea levels and wave-driven flooding in La Niña will cause damage to infrastructure and contaminate freshwater resources (Recent study—uninhabitable by mid-century 2050s).**

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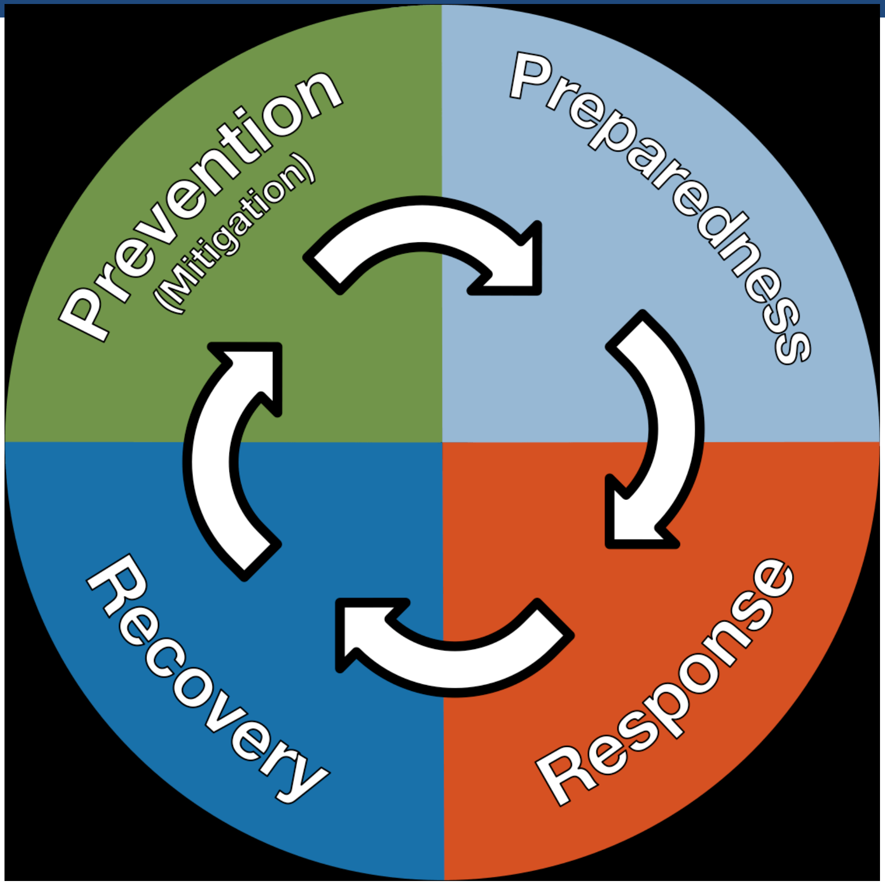
a) **Our ability to predict long-term decadal variations is limited, but ENSO's interannual time-scale variability are more effective;**

b) **Information related to three different types of El Niño and related island-specific climate anomalies can provide an improved perspective for disaster preparedness planning.**

Conclusions

Disaster Management Cycle



- **Preparedness -** Planning how to respond. Examples: preparedness plans; emergency exercises/training; **warning systems**.
- **Response** - Efforts to minimize the hazards created by a disaster. Examples: search and rescue; **emergency relief**.
- **Recovery** - Returning the community to normal. Examples: temporary housing; medical care.
- **Mitigation** - Minimizing the effects of disaster. Examples: building codes and zoning; vulnerability analyses; public education.

Photo courtesy:
Lt. Charlene Felkley