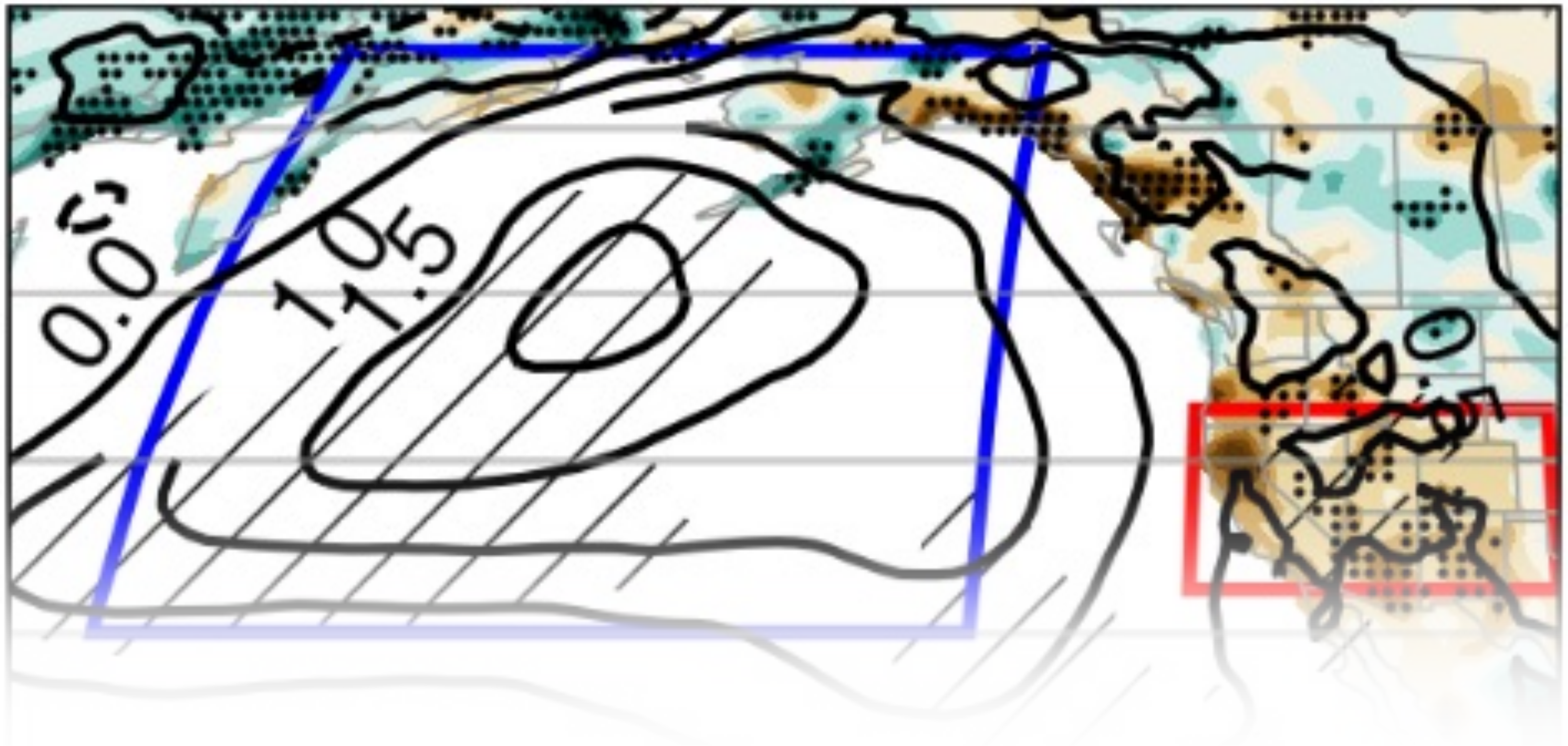
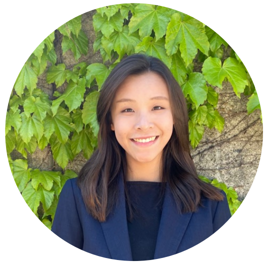
1980 – 2020 hydroclimate trend



Influences of Forced and Unforced Pacific Decadal Variability on Southwestern United States (SWUS) Precipitation



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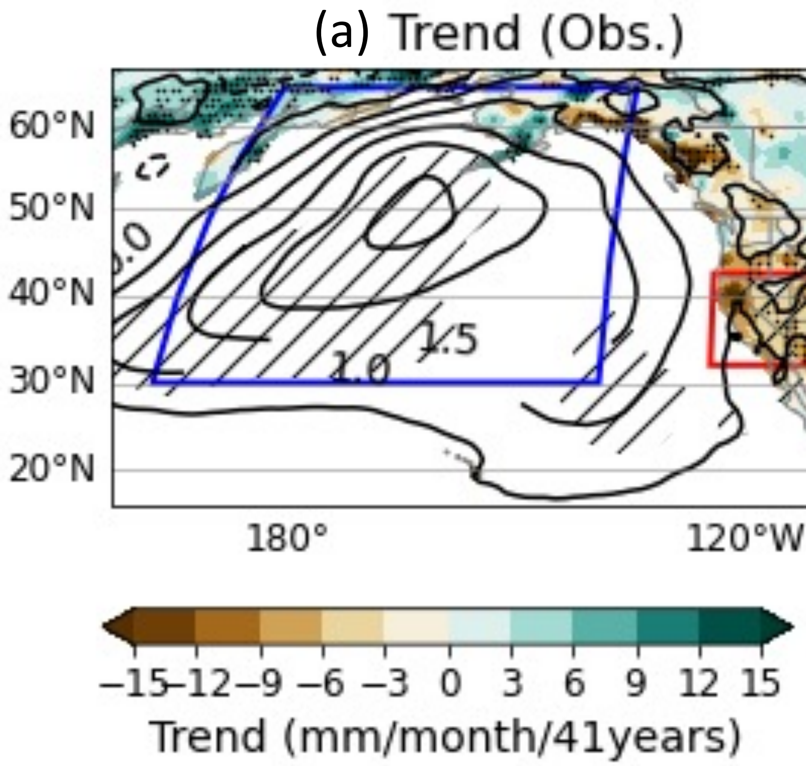
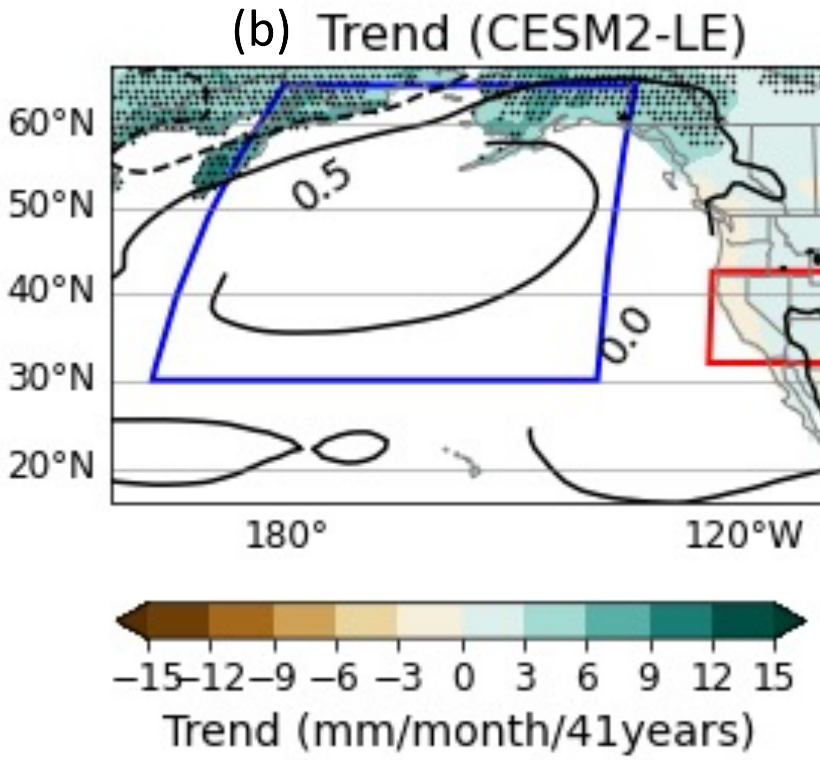
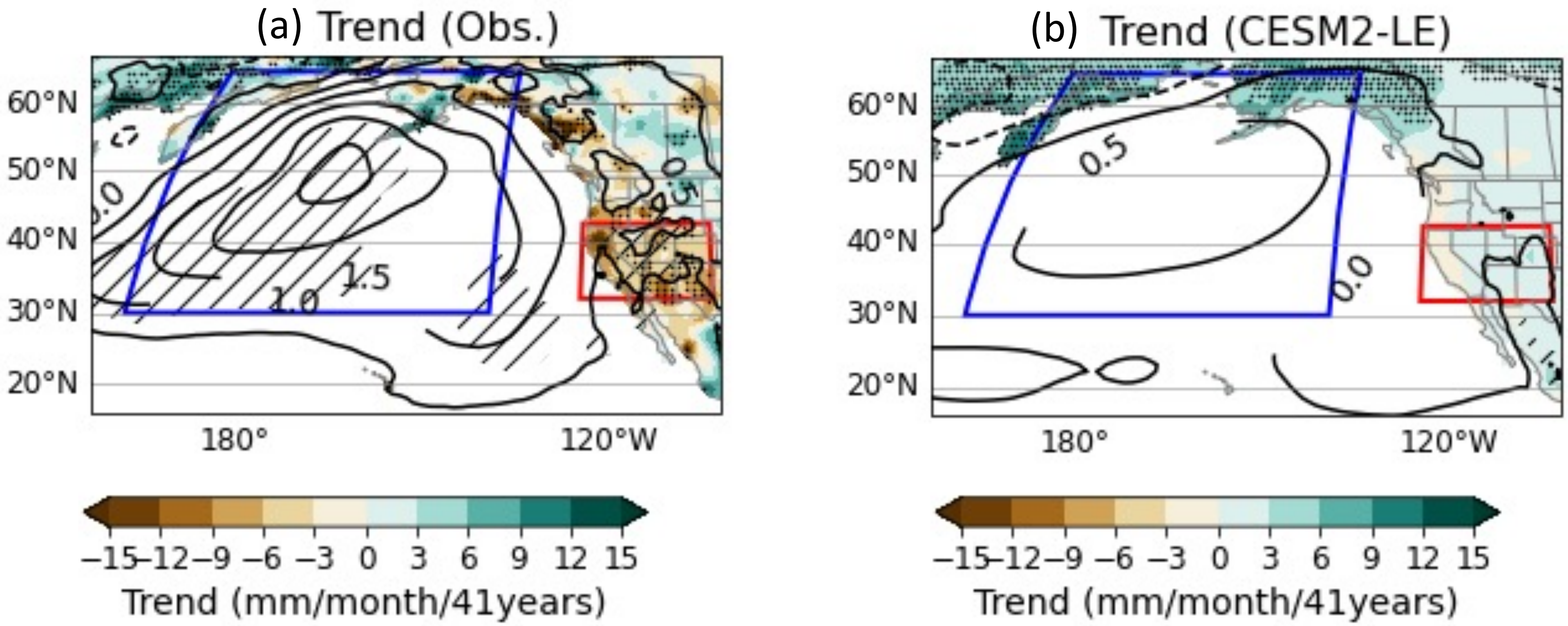
Hydroclimate trend of 1980–2020: different in observation and CESM2-LE





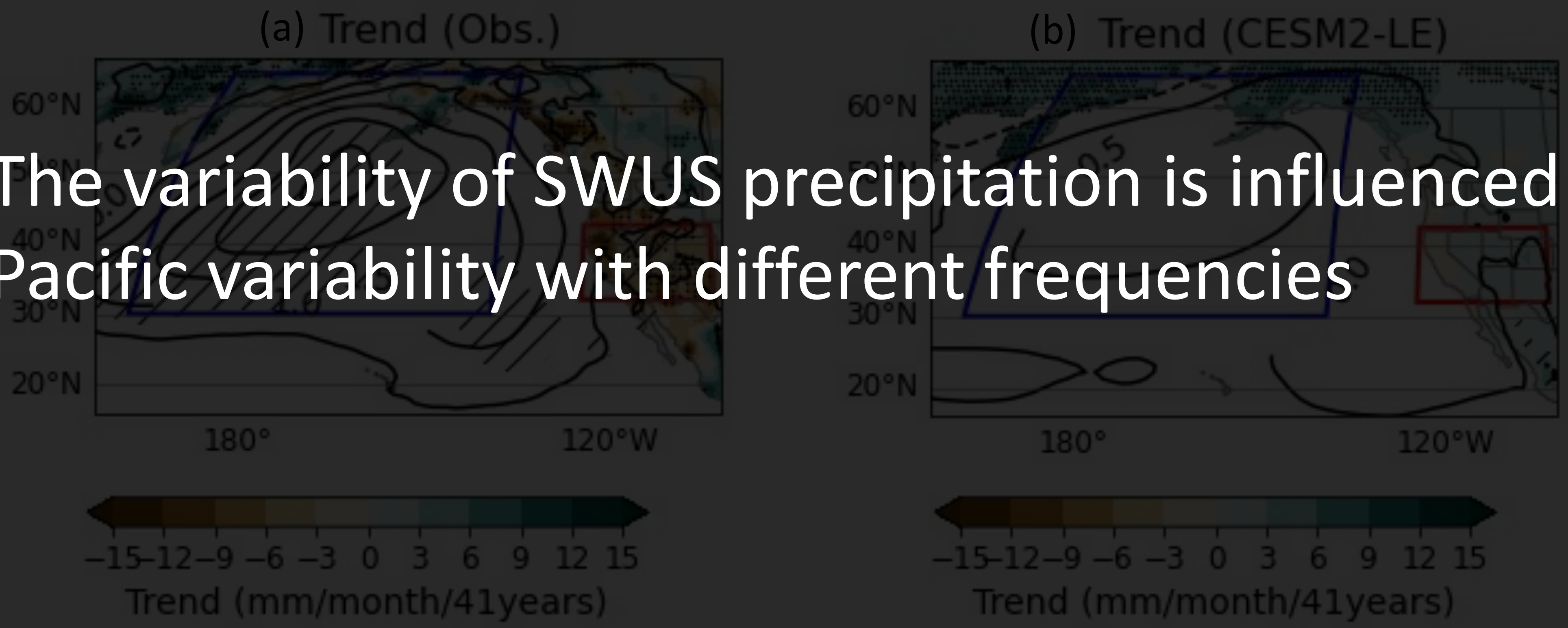
Trends in observation and CESM2-LE are **different**

Hydroclimate trend of 1980–2020: different in observation and CESM2-LE



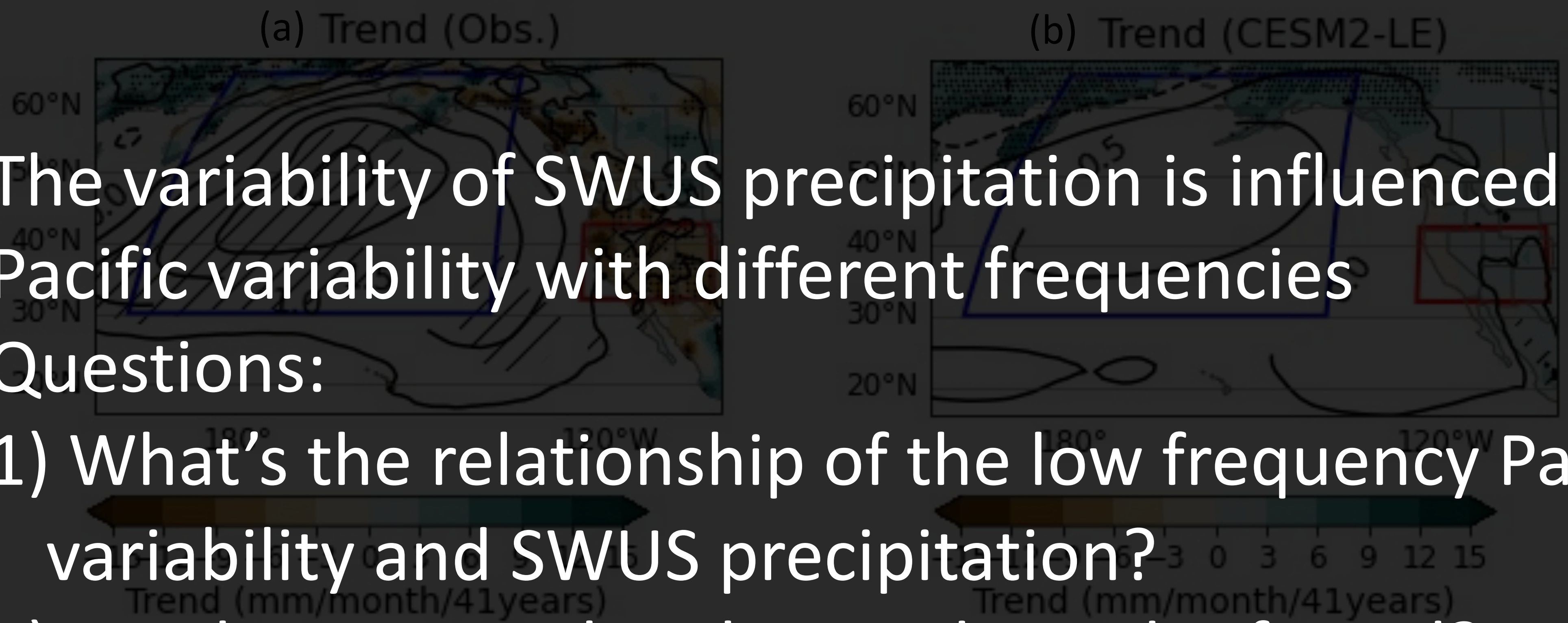
Trends in observation and CESM2-LE are **different**

The internal variability may contribute to this precipitation decline



The variability of SWUS precipitation is influenced by Pacific variability with different frequencies

Observed and CESM2-LE simulated trends show **different** magnitude in North Pacific SLP and even different signs in SWUS precipitation



The variability of SWUS precipitation is influenced by Pacific variability with different frequencies

Questions:

1) What's the relationship of the low frequency Pacific variability and SWUS precipitation?
2) To what extent the observed trend is forced?
3) Forced by what?

Observed and CESM2-LE simulated trends show **different** magnitude in North Pacific SLP and even different signs in SWUS precipitation

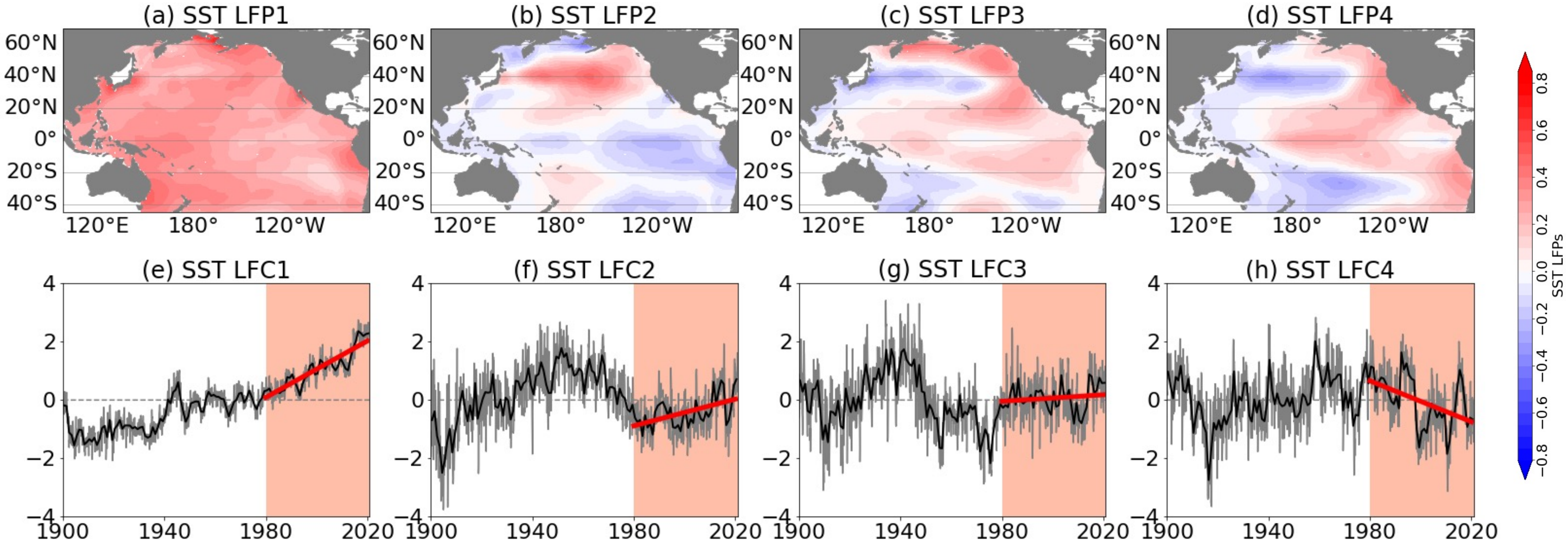
Low frequency component analysis (LFCA)

- An analogy of EOF analysis but obtains modes that the low frequency variability to total variance ratio is maximized

$$\xrightarrow{LFCA}\begin{cases} LFP: low\ frequency\ pattern\ (\Leftrightarrow EOF) \\ LFC: low\ frequency\ component\ (\Leftrightarrow PC) \end{cases}$$

Low frequency component analysis (LFCA)

- An analogy of EOF analysis but obtains modes that the low frequency variability to total variance ratio is maximized
- Apply LFCA on 1900–2020 Pacific SST (ERSSTv5): get 4 physically meaningful modes



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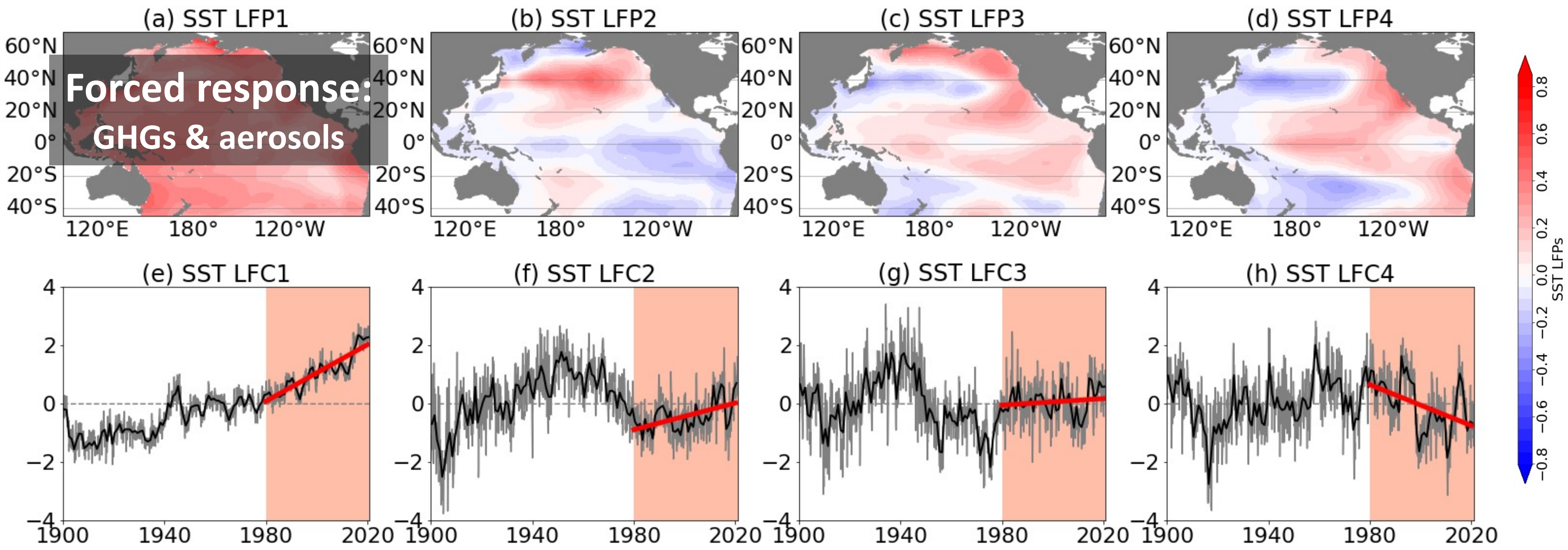

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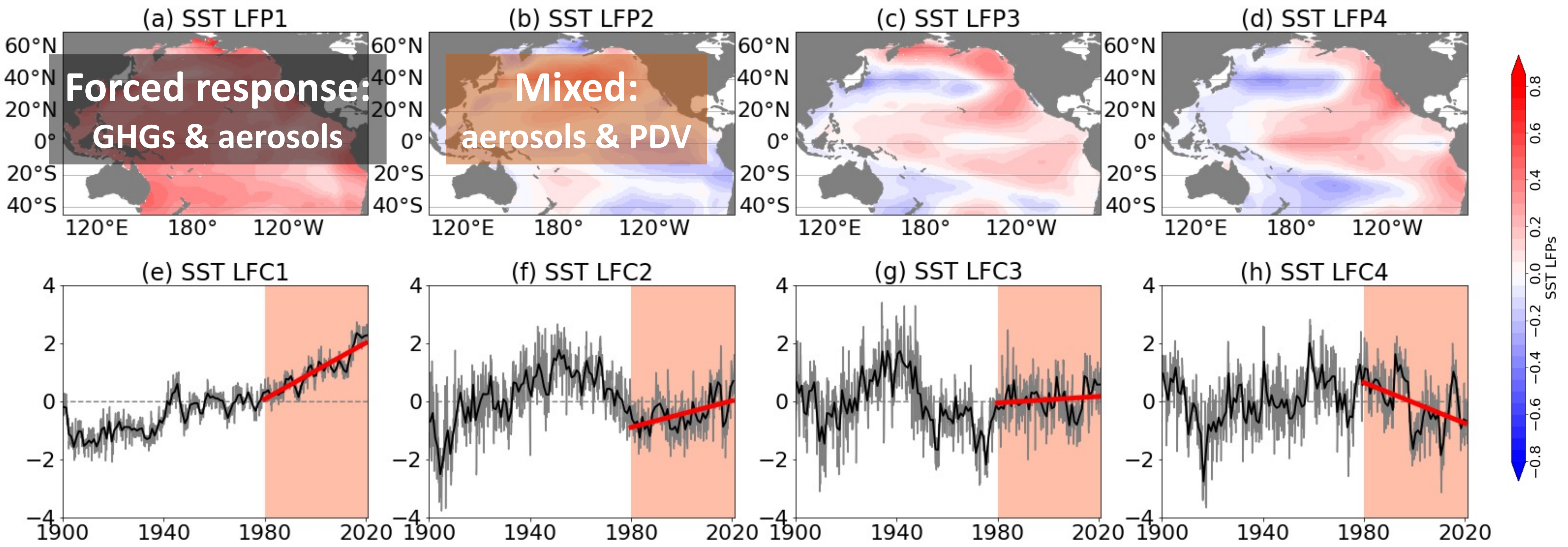

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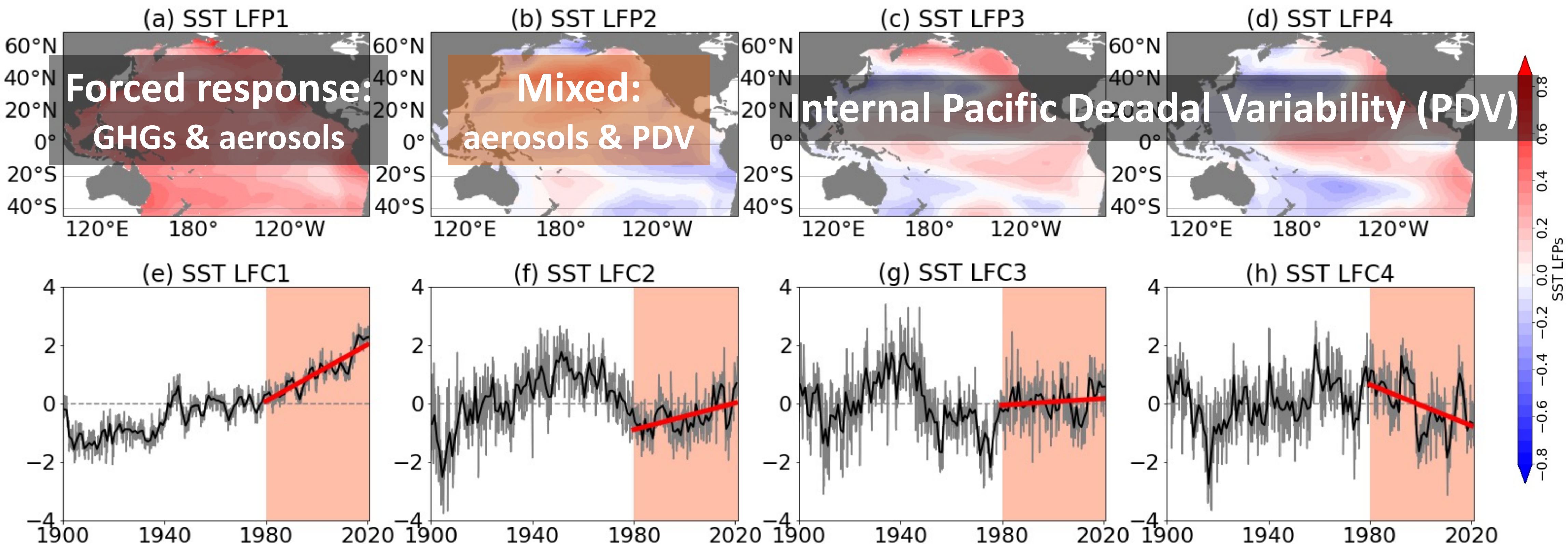
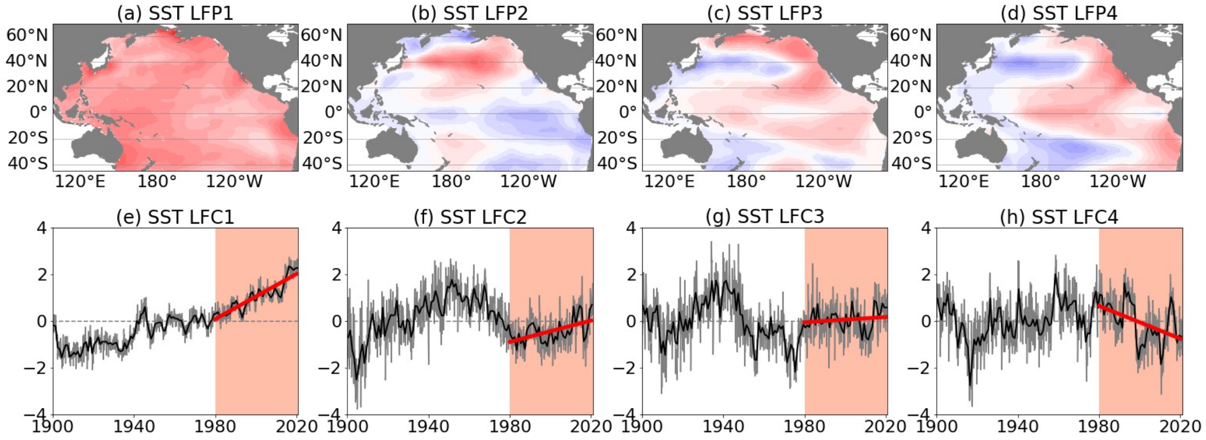


Regressing LFCs on precipitation and sea level pressure

$$\begin{matrix} PRECT(t) \\ SLP(t) \end{matrix} = \sum_{i=1}^{4} \beta_{LFC_i} LFC_i(t) + \varepsilon(t)$$



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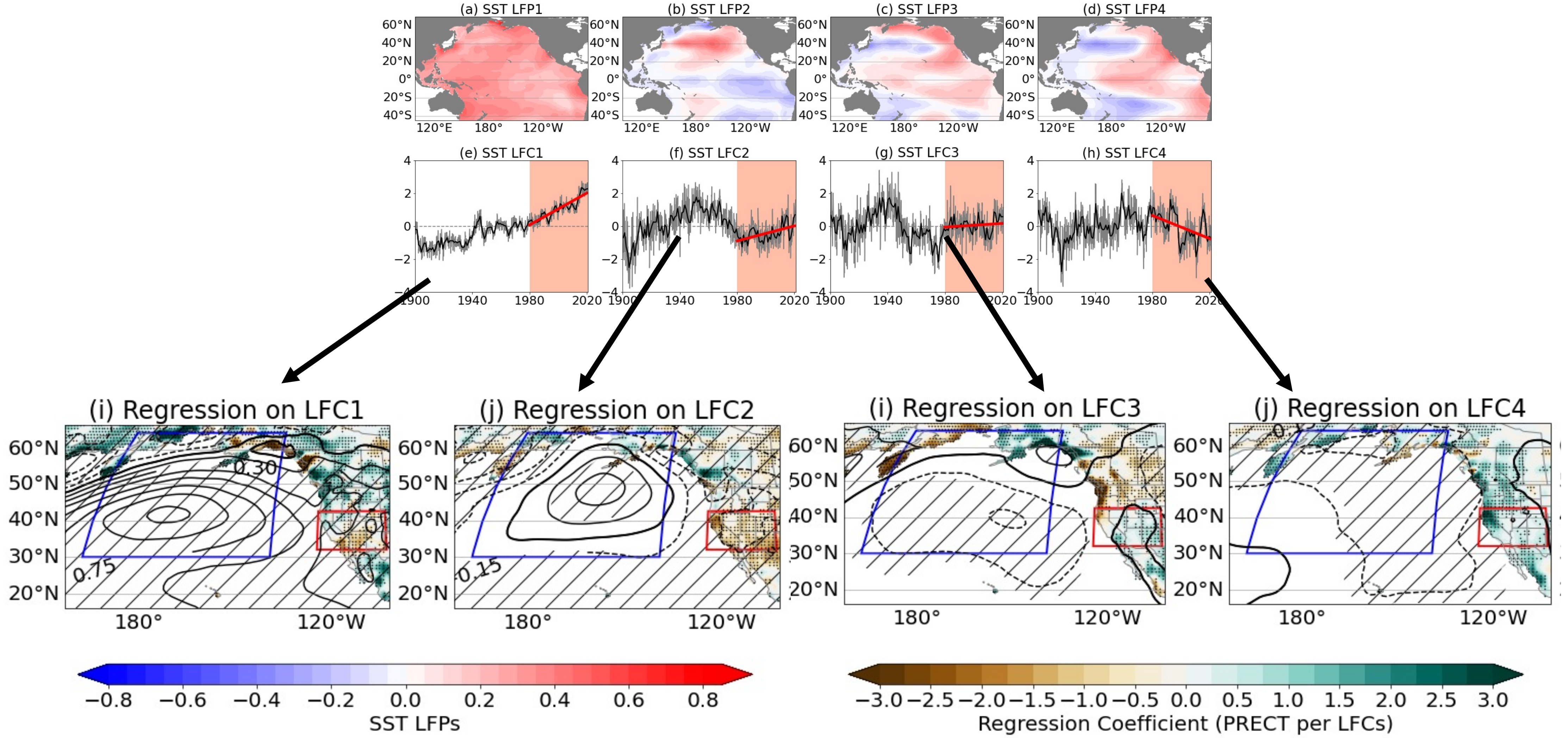

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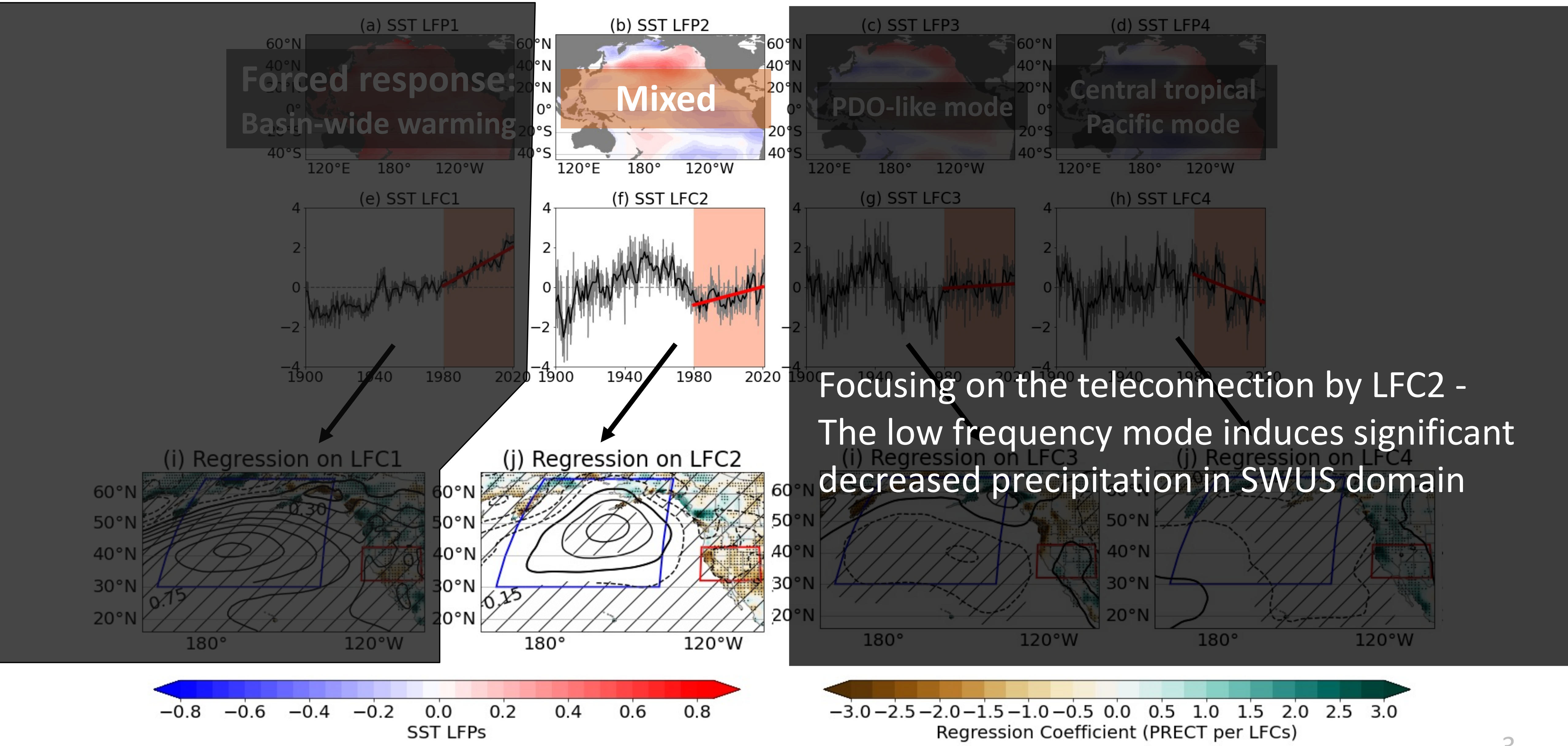
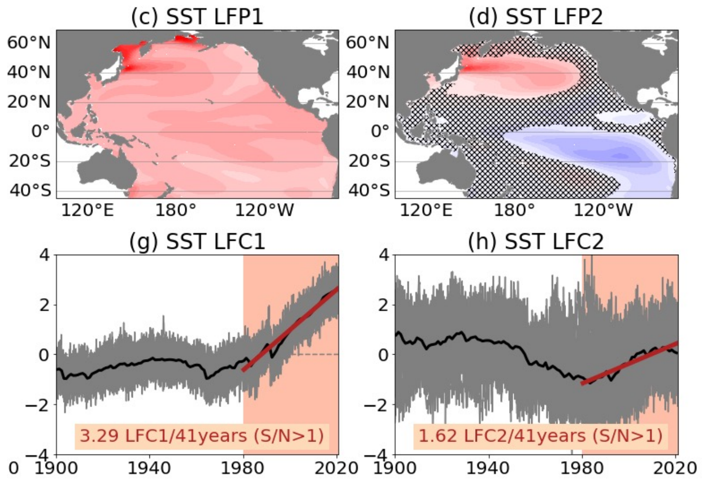


Focusing on the teleconnection by LFC2 - The low frequency mode induces significant decreased precipitation in SWUS domain

The forced signal in the LFP1/LFC1 and LFP2/LFC2

- Utilizing CESM2-LE (Rodgers et al., 2021)



CESM2-LE LFP1/LFC1 & LFP2/LFC2

The forced signal in the LFP1/LFC1 and LFP2/LFC2

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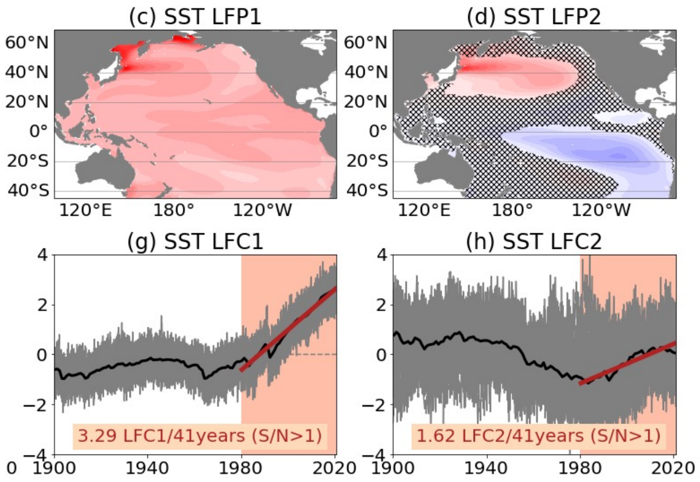

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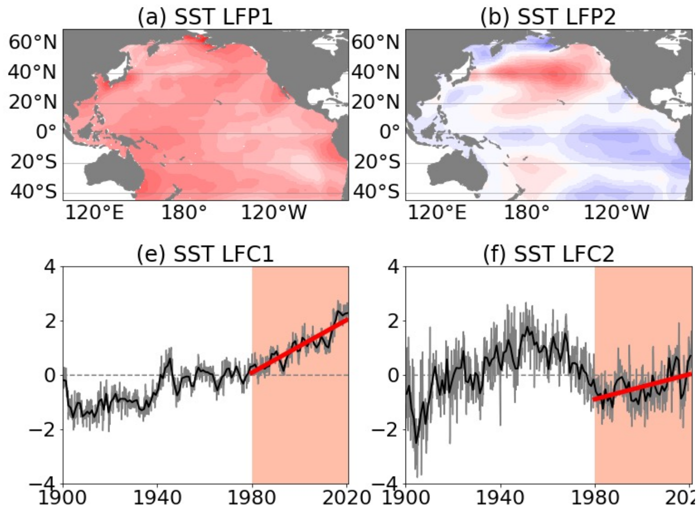
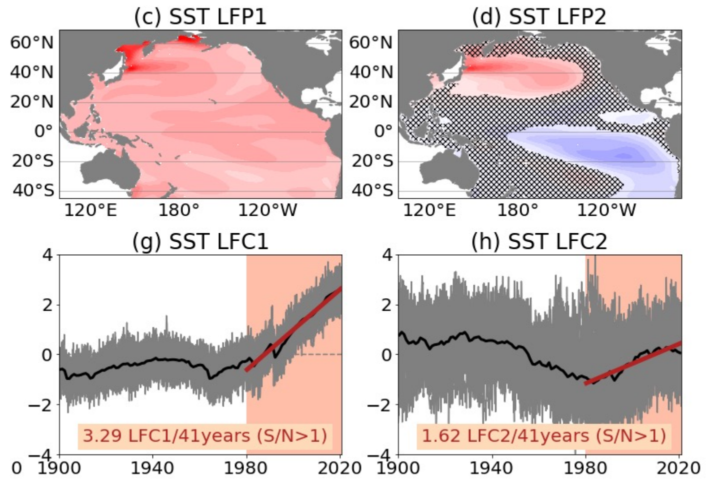
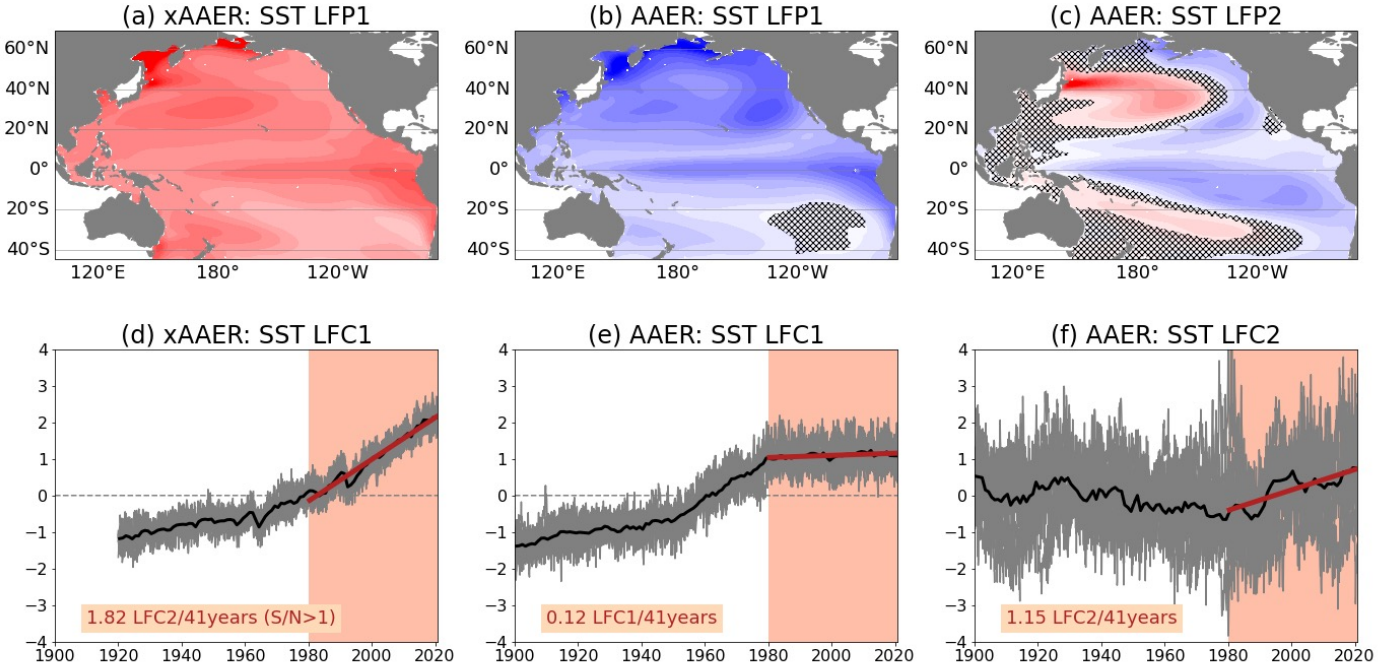


Similar to the observed LFP1/LFC2 & LFP2/LFC2

The forced signal in the LFP1/LFC1 and LFP2/LFC2

- Utilizing CESM2-LE (Rodgers et al., 2021) and two CESM2 single forcing large ensemble experiments (Simpson et al., 2022)
  1. Anthropogenic aerosols (AAER) only simulation (AAER; 15 ensemble members)
  2. Everything other than AAER simulation (xAAER; 10 ensemble members)





xAAER AAER

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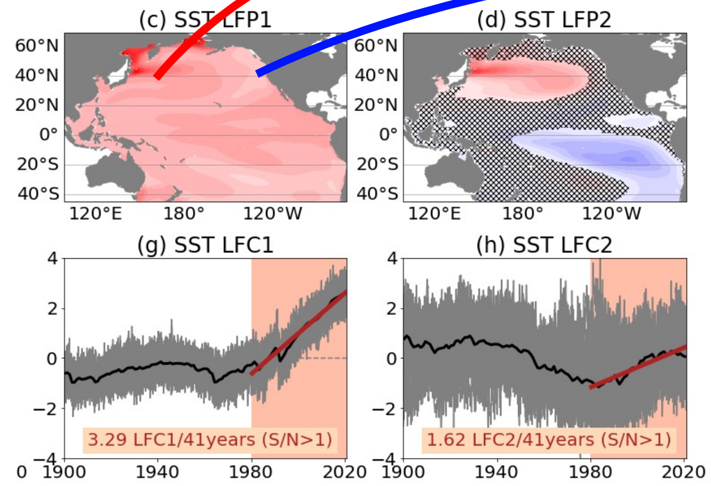

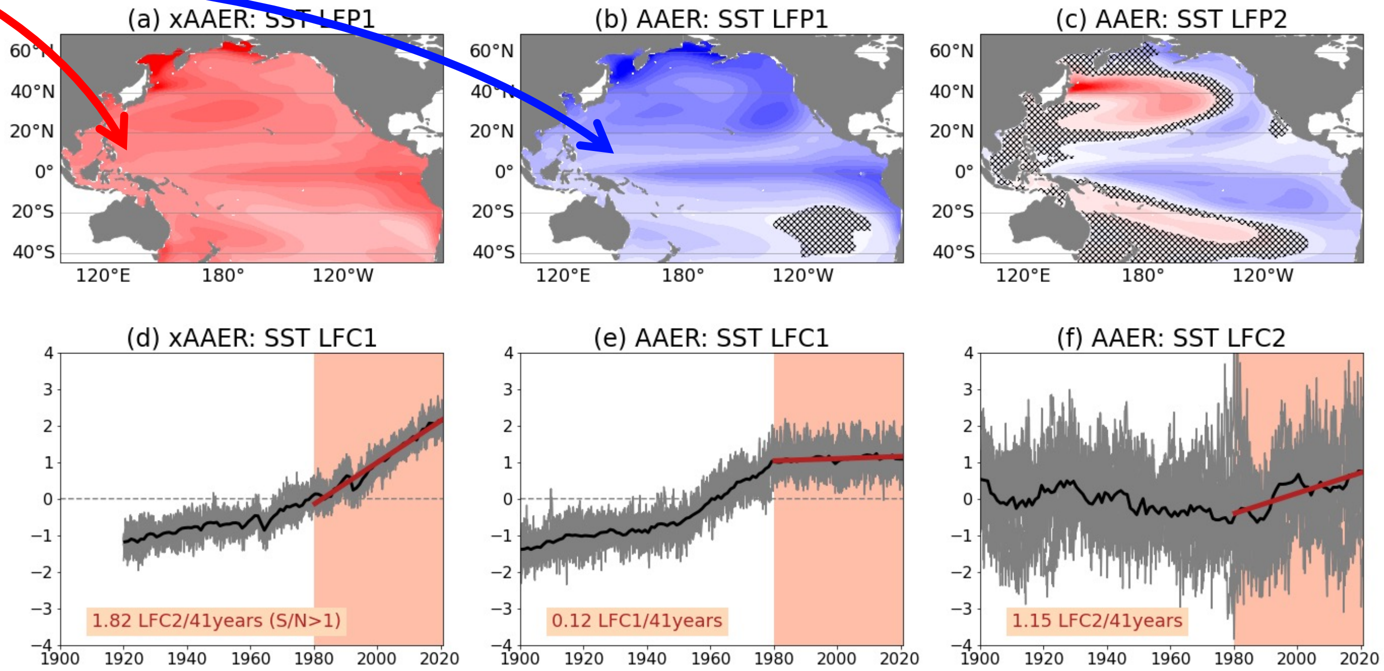

xAAER AAER

- $LFP1_{all} = LFP1_{xAAER} + LFP1_{AAER}$

The forced signal in the LFP1/LFC1 and LFP2/LFC2

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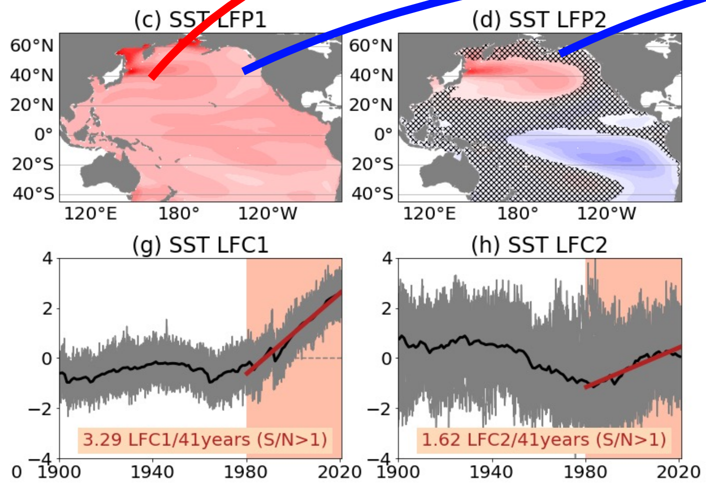

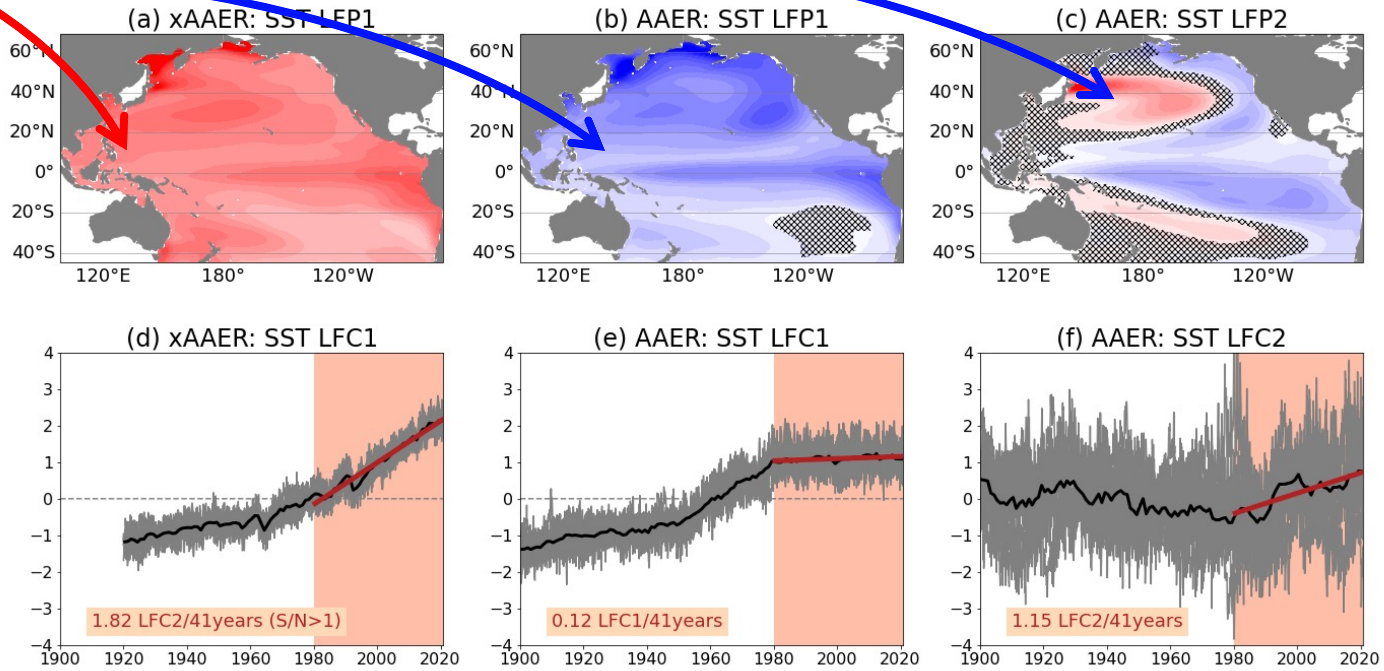

xAAER AAER

- $LFP1_{all} = LFP1_{xAAER} + LFP1_{AAER}$
- $LFP2_{all} = LFP2_{AAER}$

- Utilizing two CESM2 single forcing large ensemble experiments (Simpson et al., 2022)
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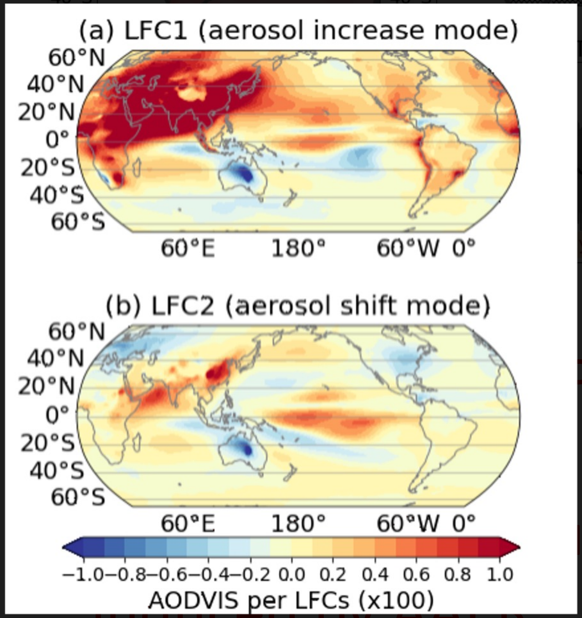
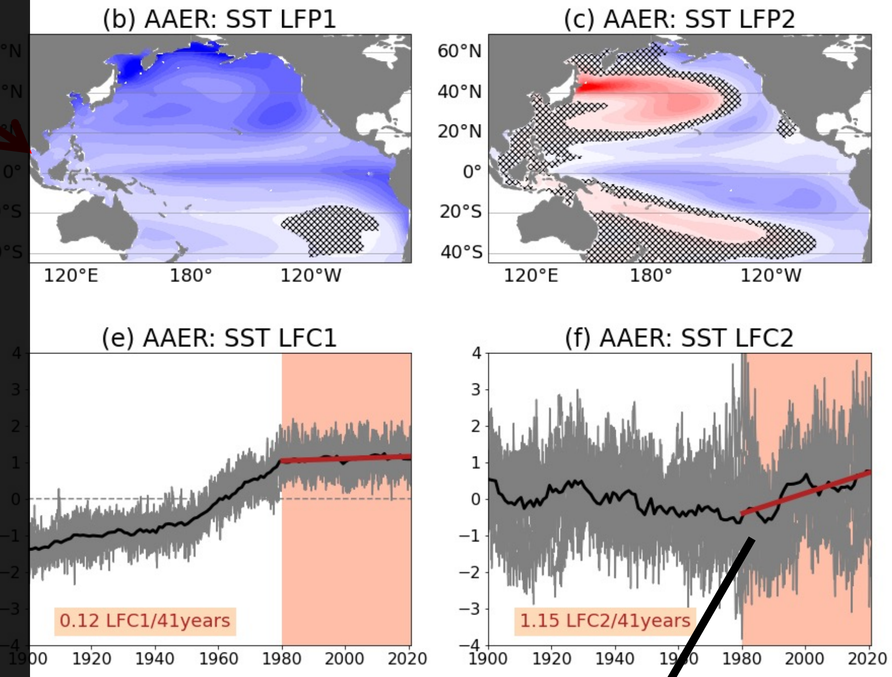
The physical meaning of the two AAER modes



Regressed $LFC1_{AAER}$ and $LFC2_{AAER}$ onto aerosol optical depth (AOD):

1. $LFC1_{AAER}$:
   Aerosol increase mode
   $LFC2_{AAER}$:
   Aerosol shift mode



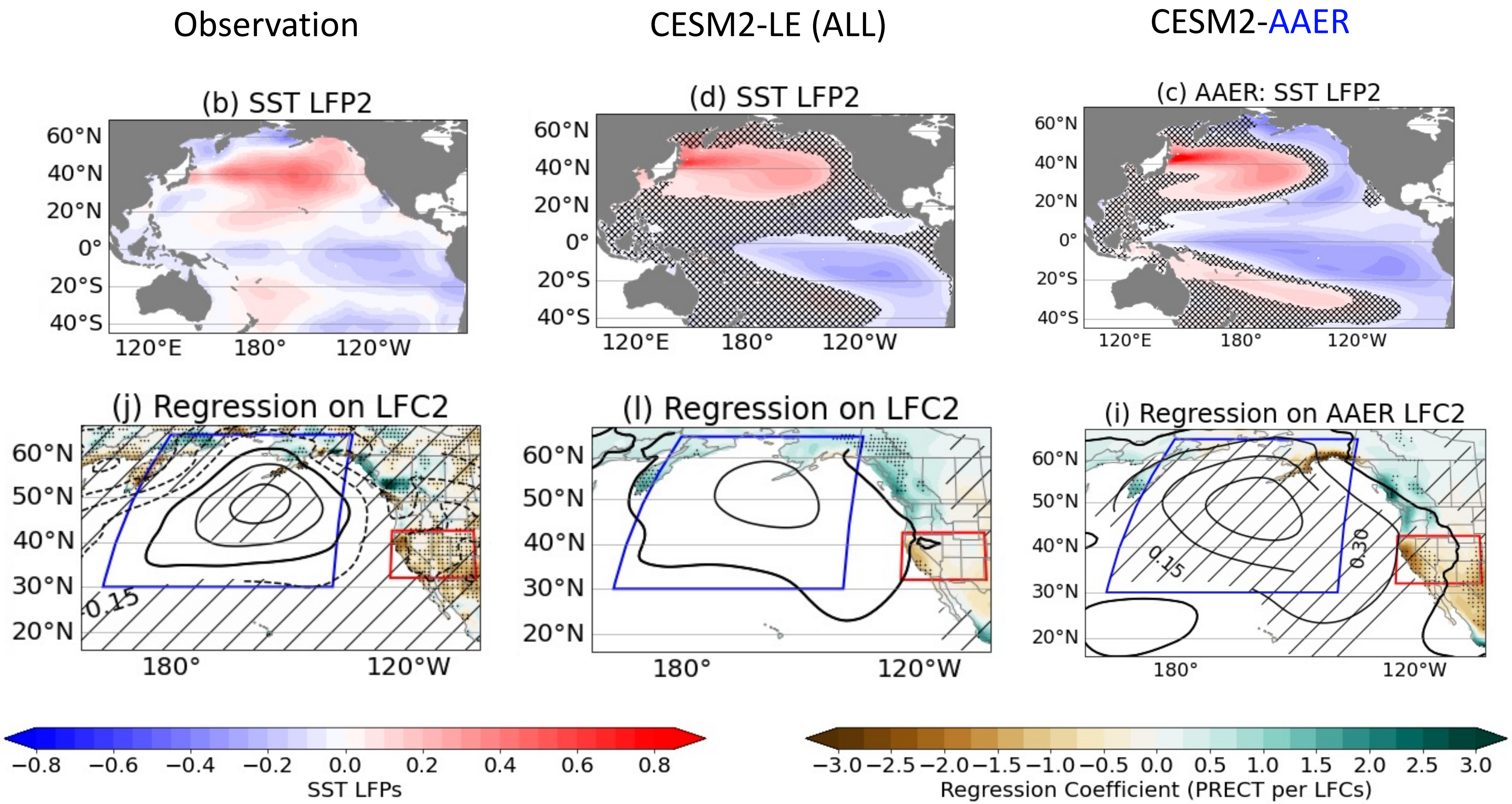
AAER

Corrcoef. 0.74
($LFC2_{AAER}$ vs $LFC2_{all}$, 1980-2020)

Results similar as Kang et al. (2021), Shi et al. (2022), Shi et al. (2023)

Compare the observed regression to CESM2-LE for LFP2/LFC2

$$LFP2_{obs} = LFP2_{all} = LFP2_{AAER}$$



Compare the observed regression to CESM2-LE for LFP2/LFC2

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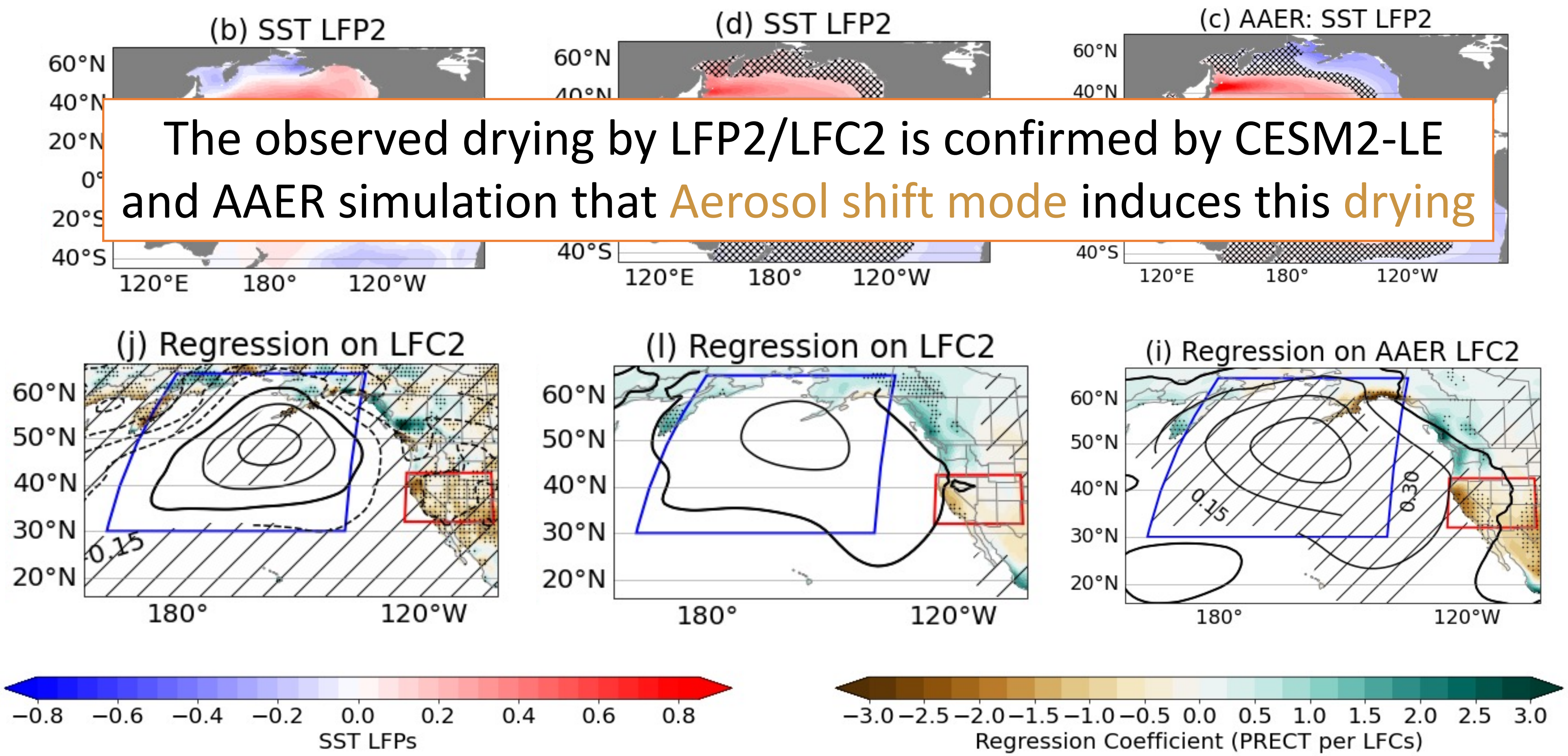
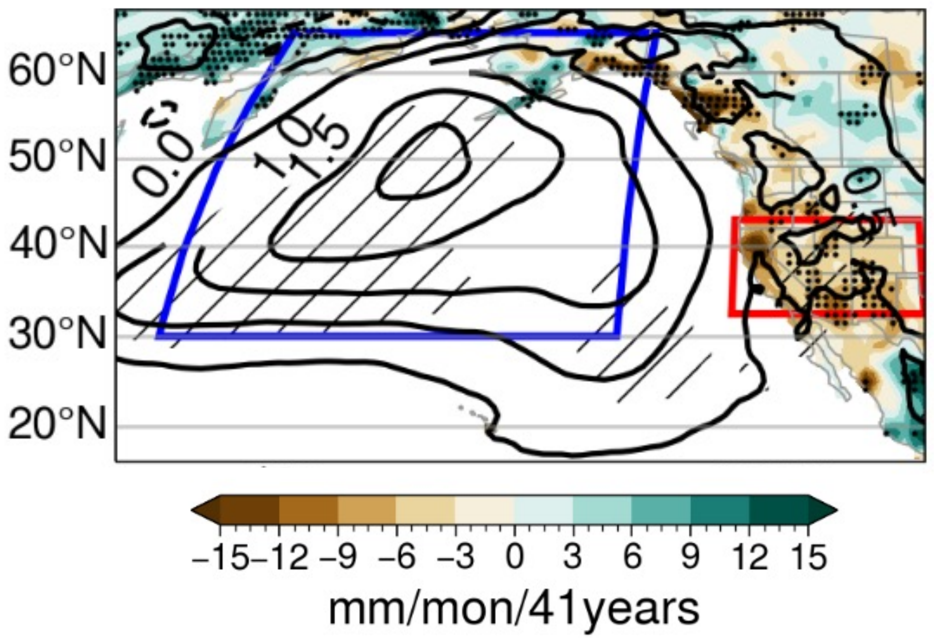
Observation | CESM2-LE (ALL) | CESM2-AAER



The observed drying by LFP2/LFC2 is confirmed by CESM2-LE and AAER simulation that Aerosol shift mode induces this drying

Key take-away

1980 – 2020 hydroclimate trend



1. Pacific decadal variability is influenced both by internal variability and anthropogenic forcings

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Key take-away

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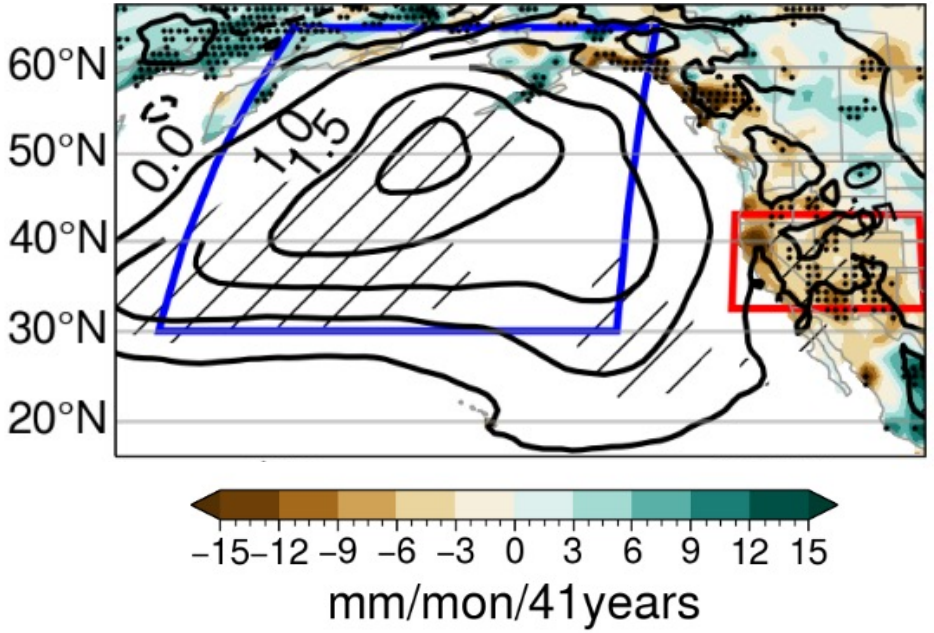

1. Pacific decadal variability is influenced both by internal variability and anthropogenic forcings
2. These modes of Pacific decadal variability influence SWUS precipitation through different teleconnection patterns

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Key take-away

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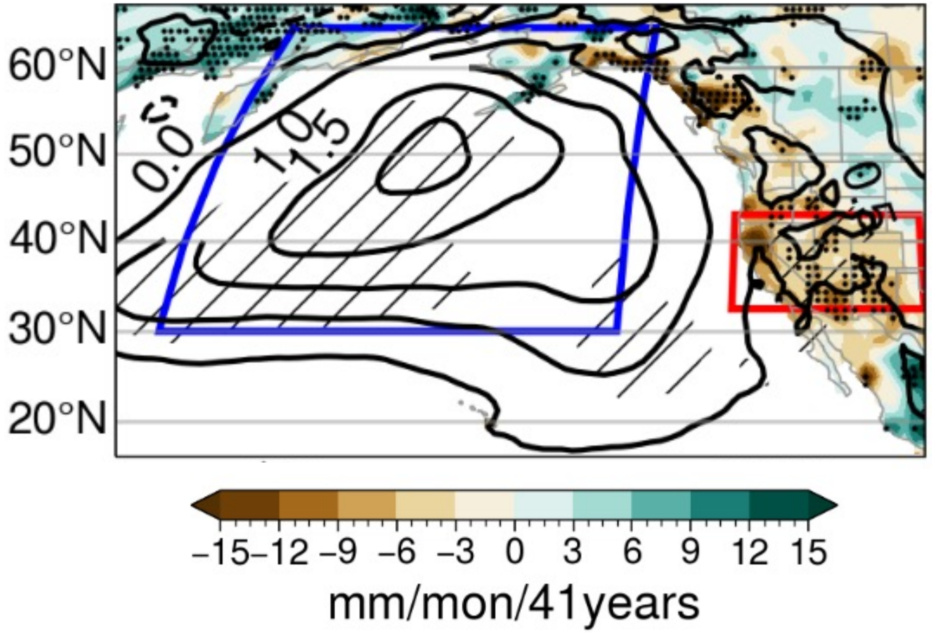

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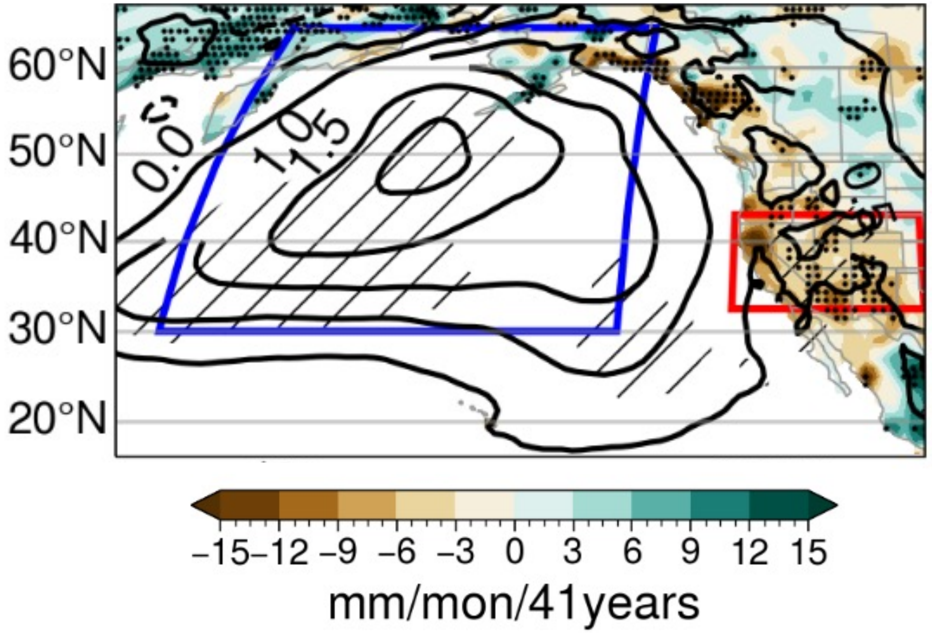

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Thank you for your attention!

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