

#### Motivations & Questions

- PDO has remarkable influences on Pan-Pacific marine and terrestrial ecosystems<sup>2</sup>.
- PDO is highly unpredictable<sup>3</sup>.
- Initial state can provide decadal prediction with some predictable informations<sup>4</sup>.
- An early warning signal for the PDO regime shift can be detected using **complex network** methods<sup>5</sup>.
- (1) Is the predictive skill on PDO improved in CMIP6?
- (2) Can initialization help to promote predictive skill?
- (3) Is the same warning signal exists in CMIP6 simulations?

#### Methods

- Construct climate networks:
- (1) Define nodes with monthly SSTA in the North Pacific.
- (2) Calculate correlations between nodes in Region A and B:

$$C_{i,j}^{t}(\theta) = \{ \begin{array}{l} \langle T_{i}(t-\theta)T_{j}(t)\rangle - \langle T_{i}(t-\theta)\rangle\langle T_{j}(t)\rangle \\ \overline{\sqrt{\langle (T_{i}(t-\theta) - \langle T_{i}(t-\theta)\rangle)^{2}\rangle\langle (T_{j}(t) - \langle T_{j}(t)\rangle)^{2}\rangle}} \\ \langle T_{i}(t)T_{j}(t+\theta)\rangle - \langle T_{i}(t)\rangle\langle T_{j}(t+\theta)\rangle \\ \overline{\sqrt{\langle (T_{i}(t) - \langle T_{i}(t)\rangle)^{2}\rangle\langle (T_{i}(t+\theta) - \langle T_{i}(t+\theta)\rangle)^{2}\rangle}} \end{array} \right\}$$

(3) Define link strength with the maximum  $|C_{i,j}^t(\theta)|$  within time lags  $\theta \in [-100, 100]$ .

(4) Calculate total node degree (TD) for links with  $\theta_{max} > 0$ :  $TD(t) = \sum_{i \in A, j \in B} C_{i,j}^t(\theta_{max})$ 

 Access predictive skill of warning signals: 2(ad – bc)

HSS =  $\frac{1}{(a + c)(c + d) + (a + b)(b + d)}$ 





## On the Pacific Decadal Oscillation (PDO) Simulations in CMIP6 Models: A New Test-Bed from Climate Network Analysis Yiling Ma (E-mail: mayling5@mail2.sysu.edu.cn), Naiming Yuan\*, Tianyun Dong, Wenjie Dong

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## Performance of CMIP6 Models in Simulating the PDO and Early Warning Signal



# Effect of Initialization on Hindcasts of PDO and Early Warning Signals

- hindcast of regime shifts.



- $, \theta > 0, A \rightarrow B$
- ,  $\theta < 0, B \rightarrow A$



• The initial state can improve the predictive skill of PDO index and regime shifts for a few years and contribute to the successful

• The initialization is also conducive to a successful simulation of early warning signals. Particularly, the decadal hindcast from NorCPM1 can capture the early warning signals 5–7 years in advance of the late-1970s and late-1990s regime shifts.

Fig. 5&6 The PDO index (red line) and  $TD_{A \rightarrow B}$  (solid blue line) calculated with non-initialized/initialized simulations.

However, some models can still represent the

### Next Step

Combine climate networks and machine learning for ENSO prediction.

References:<sup>1</sup> Ma Y. et al. (2022) Asia-Pacific Journal of Atmospheric Sciences; <sup>2</sup> Mochizuki T et al. (2010) *Proceedings of* the National Academy of Sciences; <sup>3</sup> Farneti R (2017) *Wiley Interdisciplinary Reviews;*<sup>4</sup> Meehl GA et al. (2009) *Bulletin* of the American Meteorological Society; <sup>5</sup> Lu Z et al. (2021) *GRL*.