The decomposition of wind-forced upwelling variability in the North Pacific though the application of cyclostationary empirical orthogonal functions

Lev B. Looney[1], Benjamin D. Hamlington[2], and Ryan R. Rykaczewski[1,3]

[1]Marine Science Program, University of South Carolina, Columbia, SC (llooney@email.sc.edu)
[2] NASA Jet Propulsion Laboratory (JPL), Pasadena, CA
[3]Department of Biological Sciences, University of South Carolina, Columbia, SC

Motivation:

- Upwelling regions are some of the most biologically productive ecosystems in the world's oceans.
- Coastal upwelling is caused by equatorward, alongshore winds, as a result of large-scale atmospheric pressure gradients across the coastline.
- By bringing cold, nutrient-rich waters from the deep towards the surface and stimulating primary production, the upwelling process impacts the entire food chain through bottom-up influencing.
- Understanding the relationship between recognized climate modes (e.g., seasonal climatology, ENSO, NPGO, and PDO) and upwelling-favorable winds could potentially improve ecosystem forecasting ability.

Methods:

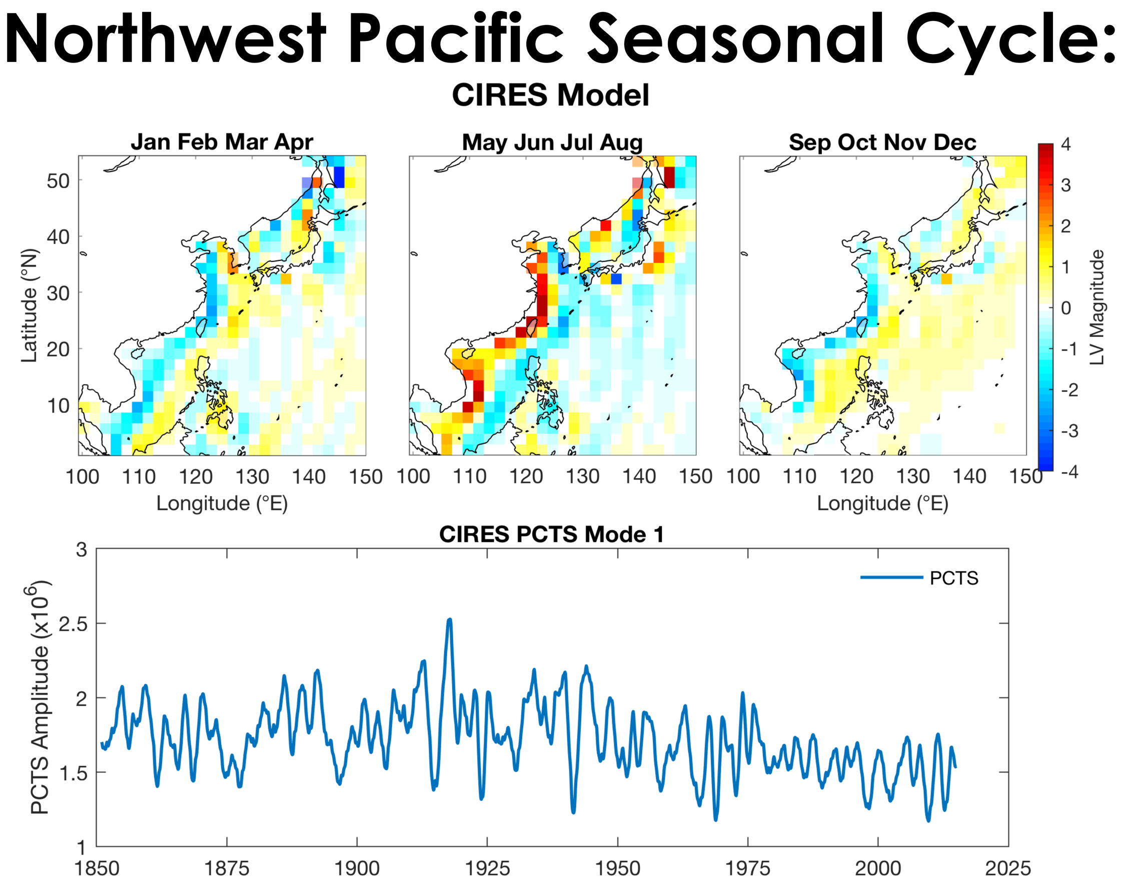
- Cyclostationary Empirical Orthogonal Functions (CSEOFs) were applied to wind-stress curl derived from global climate models subset to each region.
- CSEOFs are a modification of the more well-known Empirical Orthogonal Functions (EOFs), which are a complete model decomposition, separating the variability into different modes.
- Each mode consists of a loading vector (LV) and a principal component (PC) time series.
- Therefore, CSEOFS are defined as:

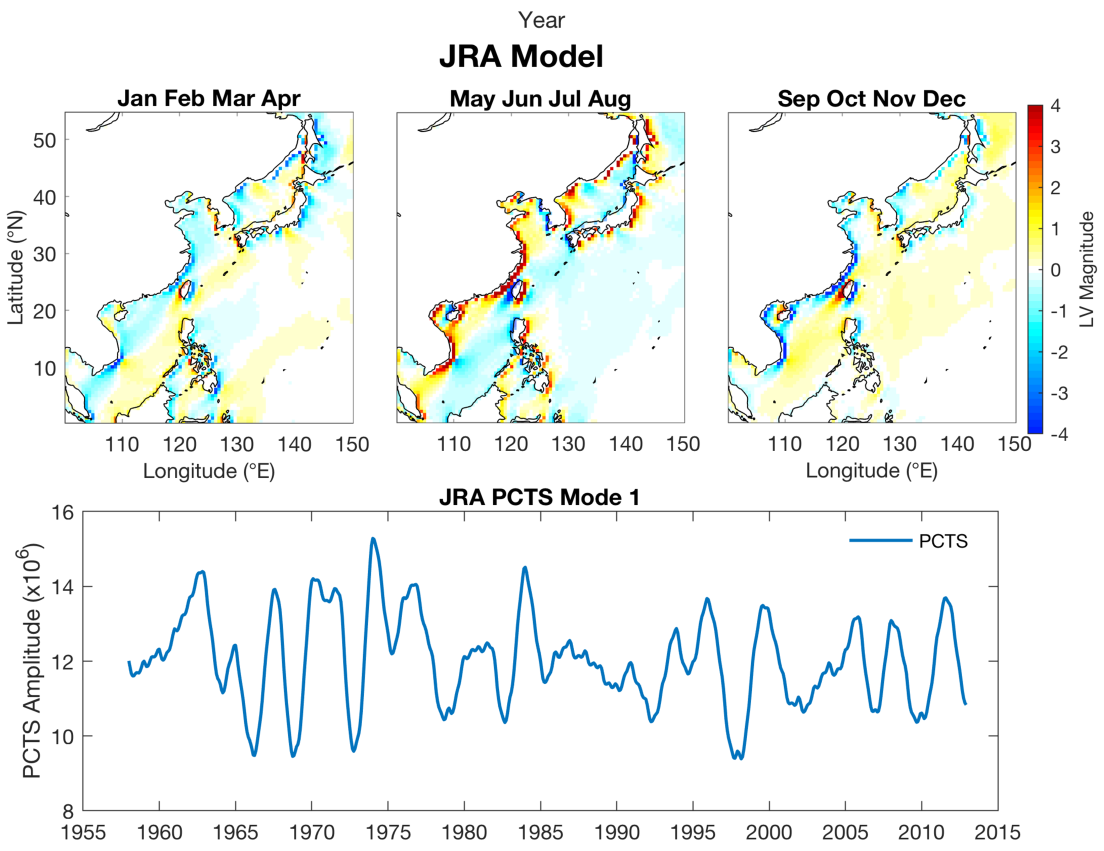
$$T(r,t) = \sum_i LV_i(r,t)PC_i(t)$$

$$LV(r,t) = LV(r,t+d)$$

- Loading vectors describe the temporal progression of the spatial pattern of inherent physical processes.
- Principal component time series display the amplitude of the pattern of variability through time.

Northwest Pacific Seasonal Cycle:





These figures show the loading vectors and principal component time series of the seasonal cycle

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- This work and travel was supported by the South Carolina Honor's College; the School of Earth, Ocean, and Environment; and the Office of Undergraduate Research.

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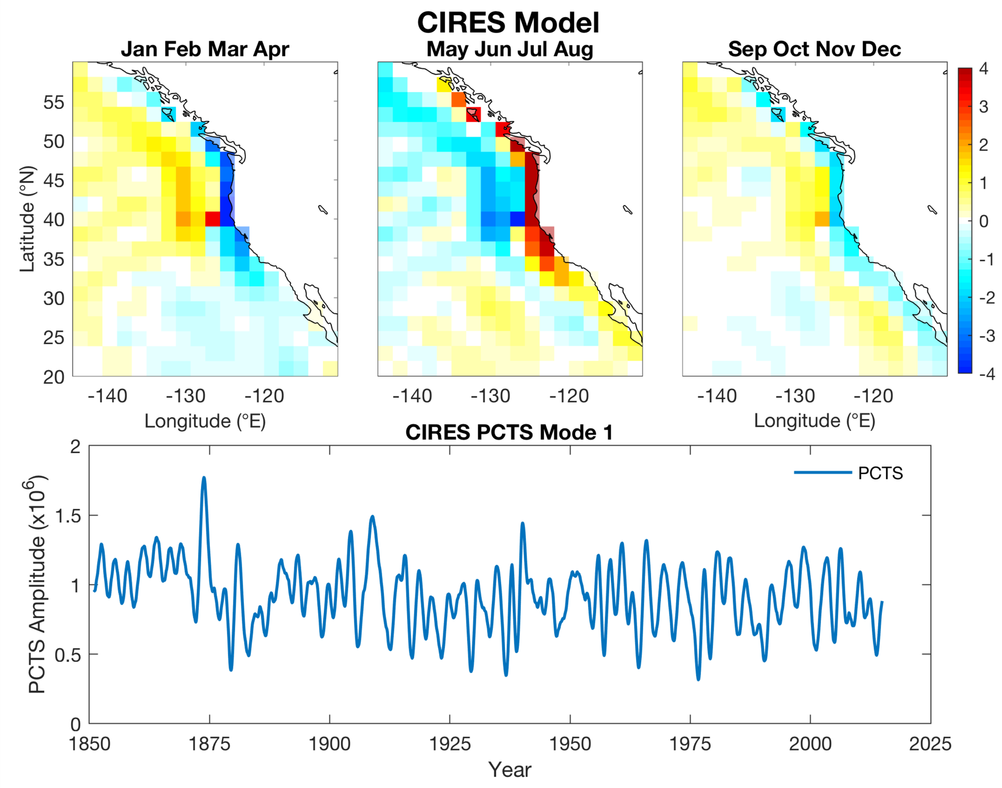
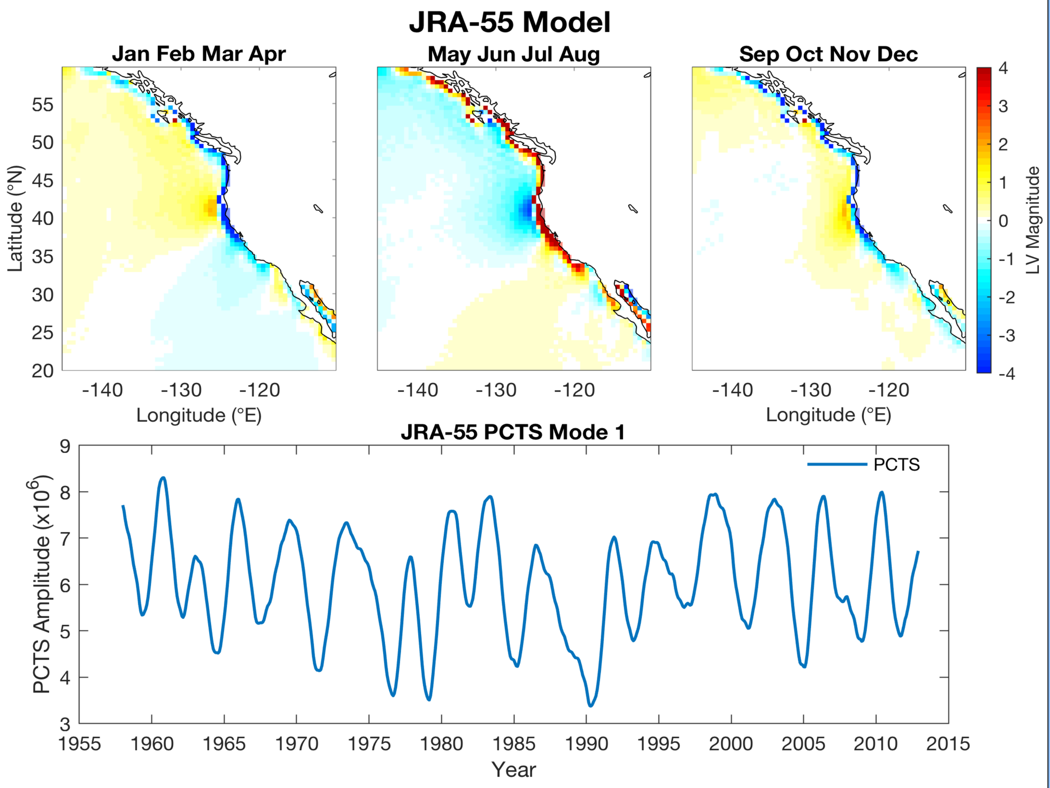
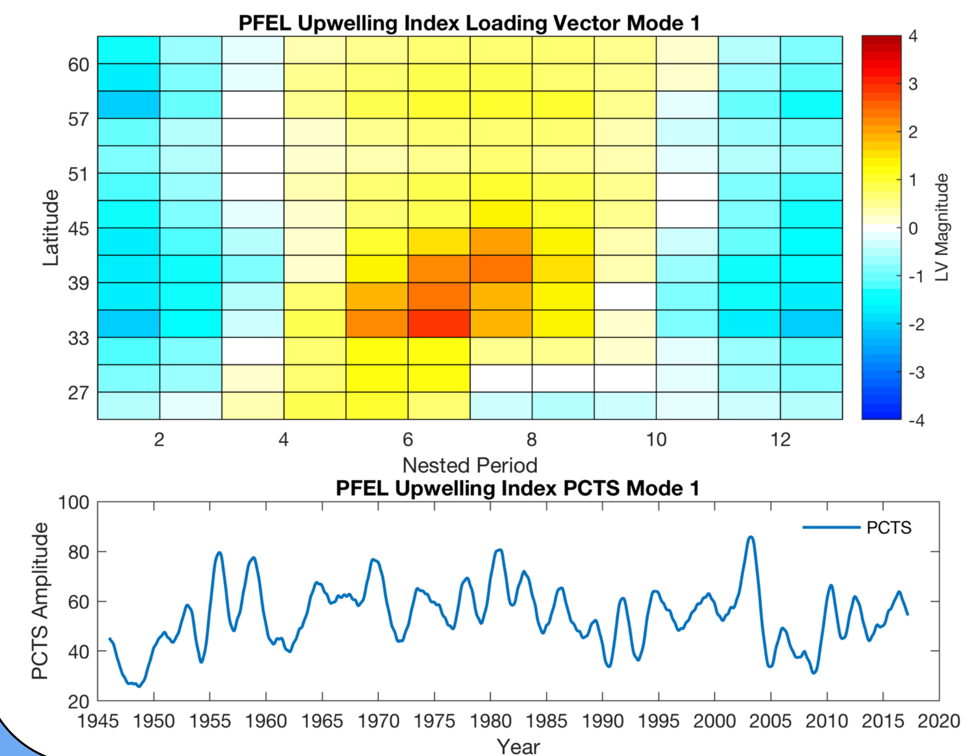


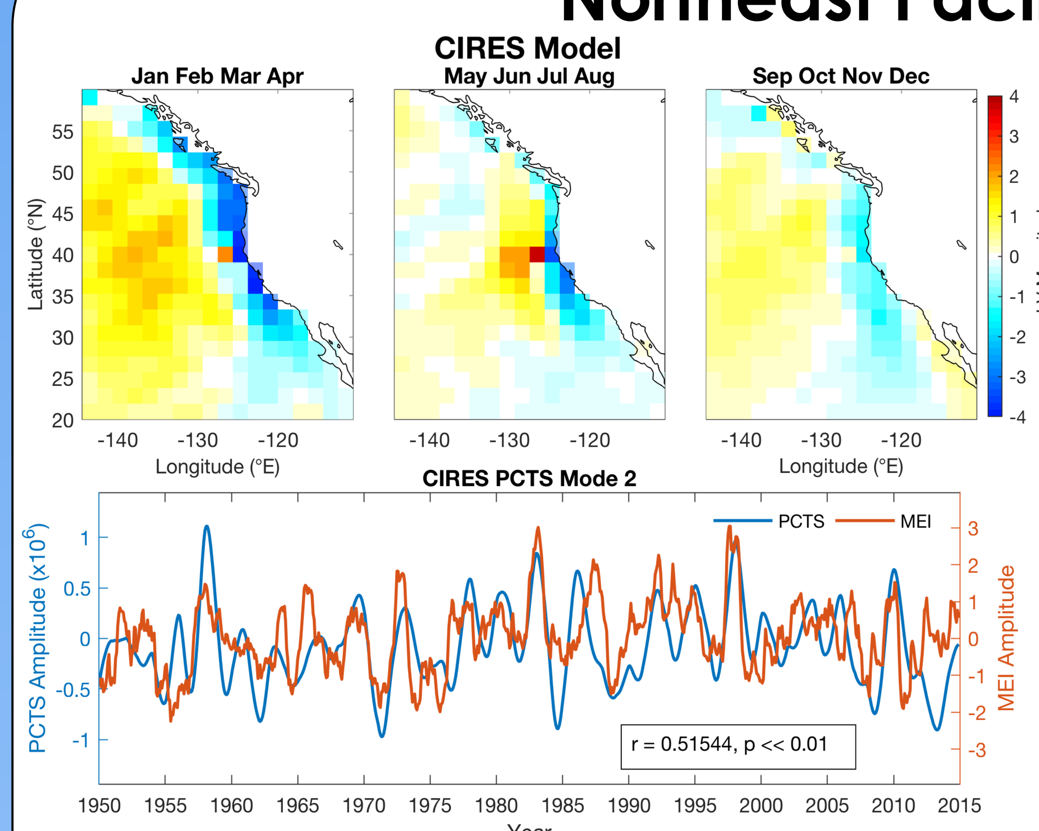


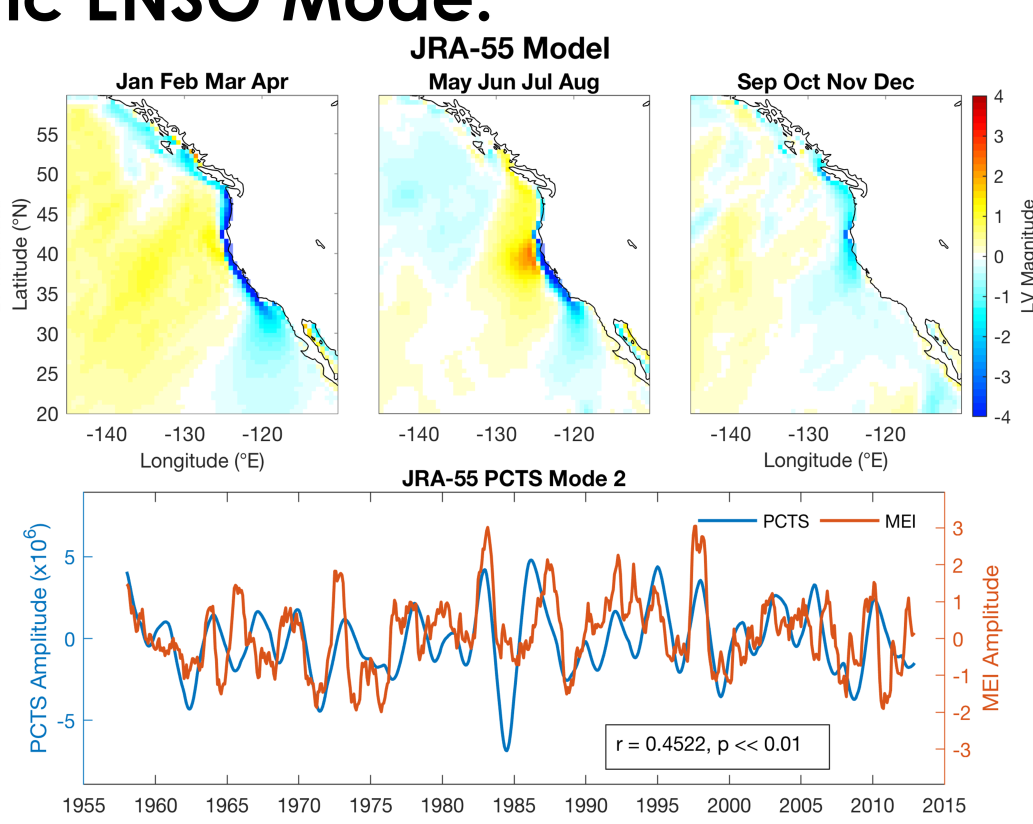


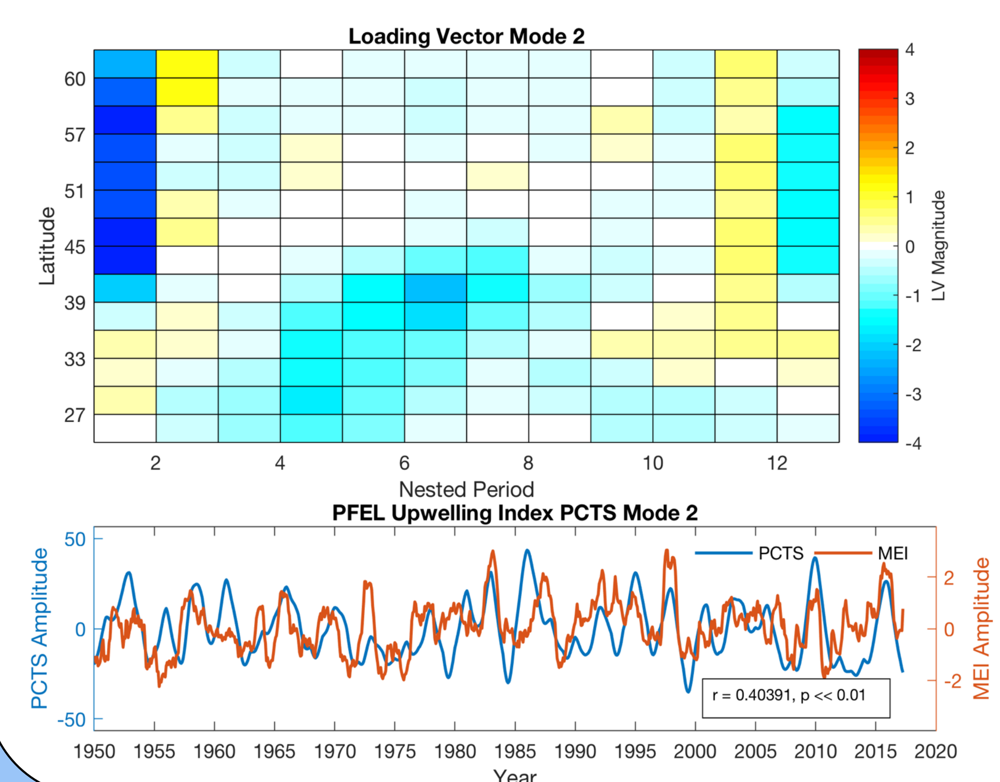
These figures show the loading vectors and principal component time series of the seasonal cycle

- Throughout all the models, there is a distinct seasonal cycle, with downwelling in the wintertime and upwelling in the summertime along the California coast.
- There is a cross-shelf gradient in wind-stress curl throughout the year.

Northeast Pacific ENSO Mode:







These figures show the loading vectors and principal component time series (blue) of the ENSO mode correlated with the Multivariate ENSO Index (orange)

- The loading vectors of the ENSO mode exhibit a decrease in upwelling along the coast in the early winter months during El Niño events, then a gradual transition back to normal conditions.
- An offshore gradient in wind-stress curl anomaly is associated with the ENSO mode.

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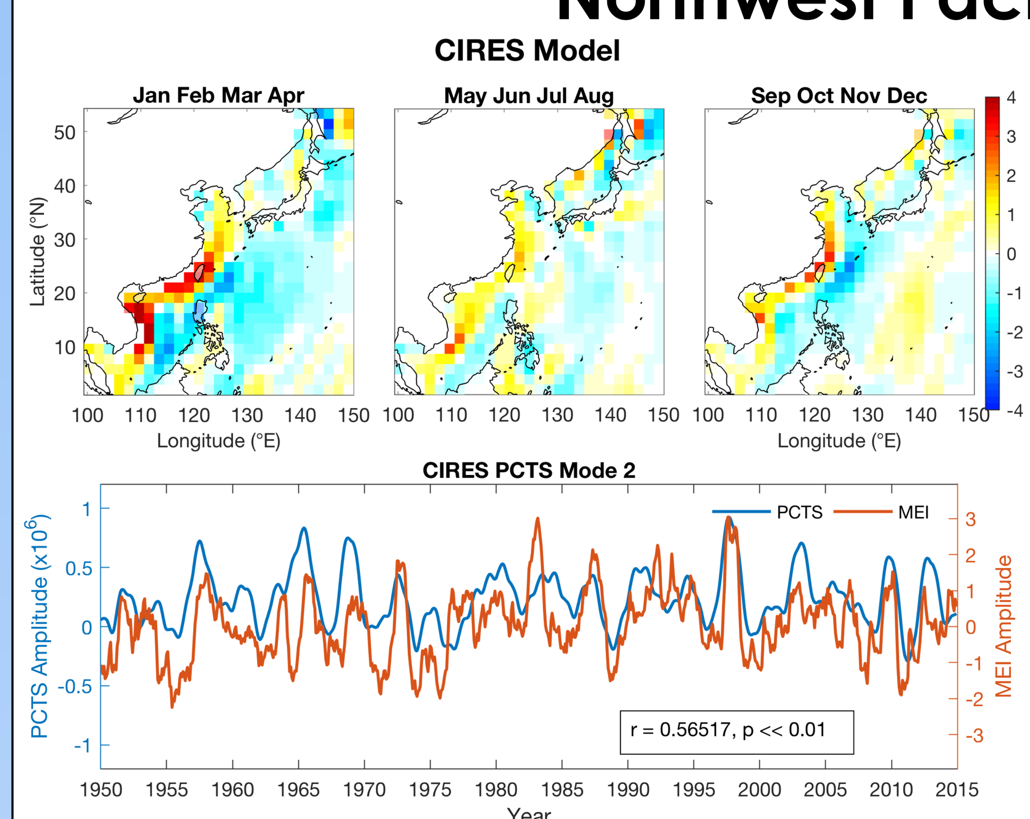

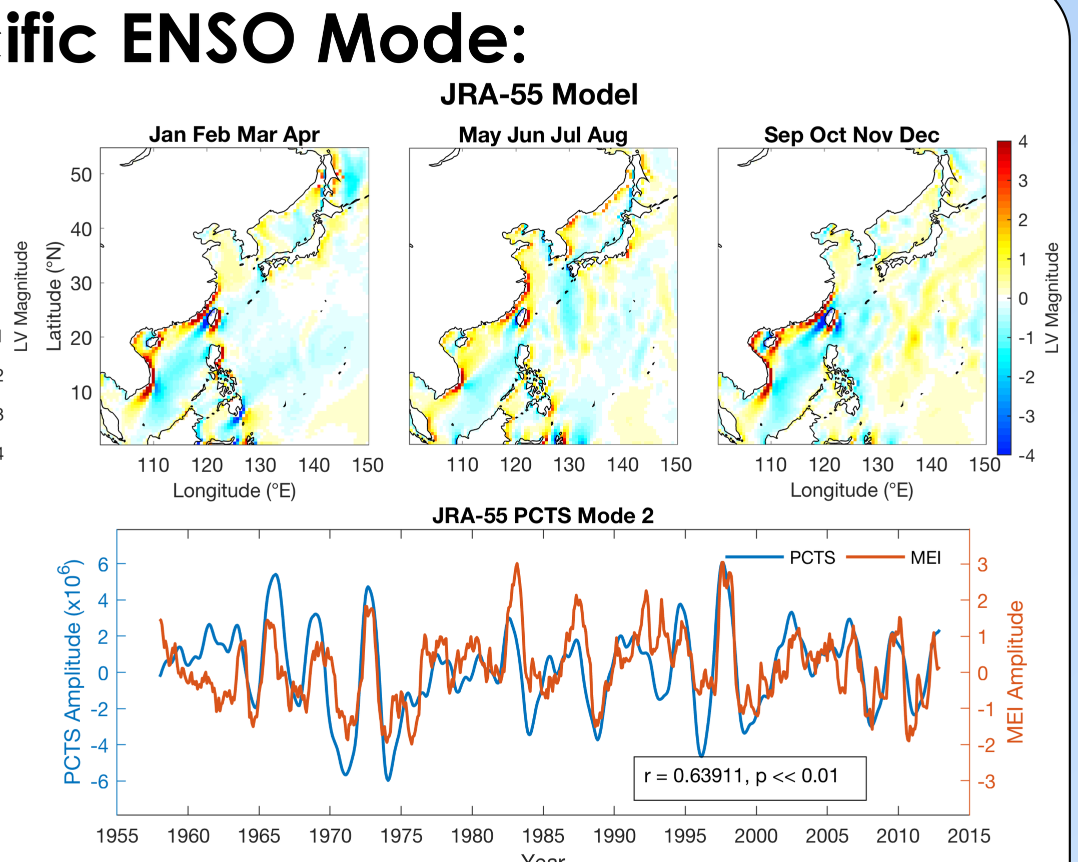

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RYKACZEWSKI LAB
Ecosystem Oceanography and Climate Change

気象庁
Japan Meteorological Agency

OLD DOMINION UNIVERSITY

Ocean Remote Sensing Group