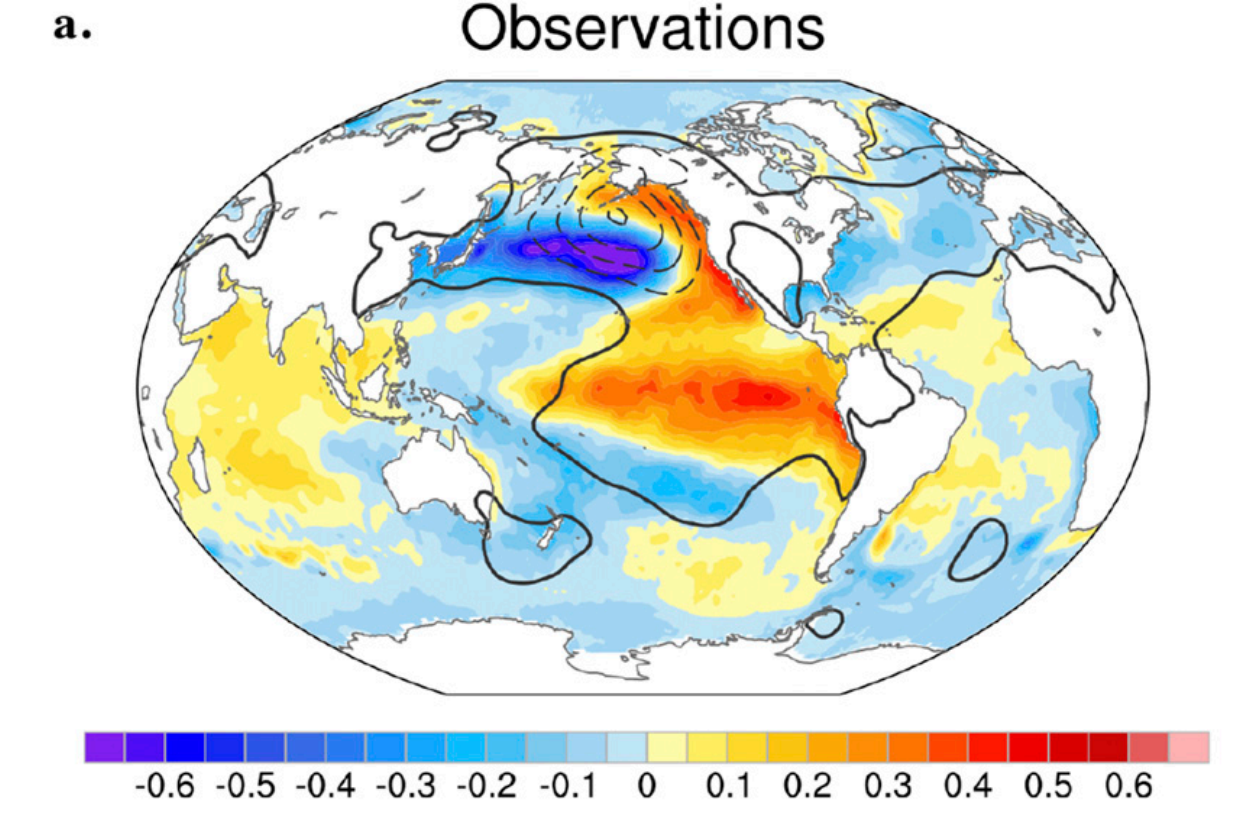
Pacific Decadal Oscillation (PDO)

Outline

- What is the PDO? (spatial pattern, time scale, index)
- What are the impacts of the PDO?
- How predictable is the PDO?

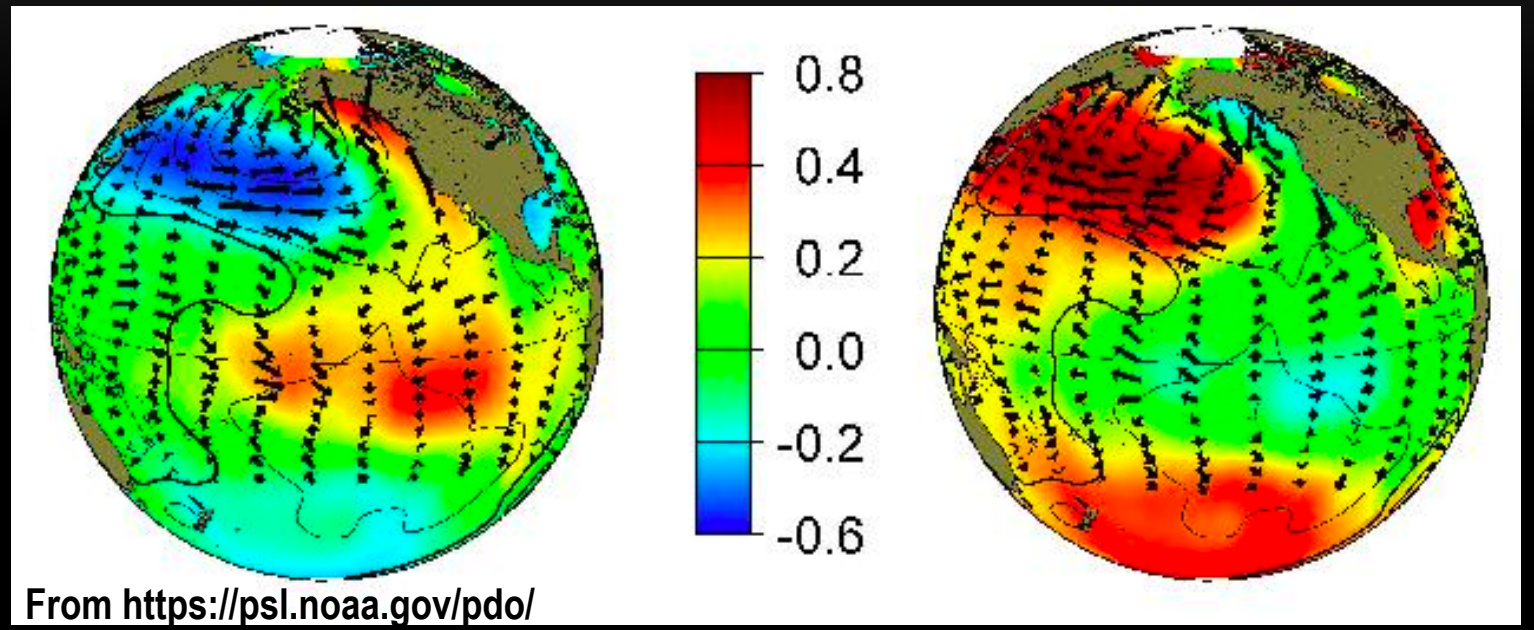
What is the PDO?



Regression of global monthly SST (shading; interval is 0.058C) and DJF SLP (contours; interval is 1 hPa) anomalies onto the PDO time series from the HadISST dataset. From Newman et al. 2016 © American Meteorological Society. Used with permission

- The PDO is the leading EOF mode of the North Pacific (20–70N) monthly averaged SST anomalies (Mantua et al. 1997).
- The PDO is associated with variability outside the North Pacific, including the Atlantic.
- The SST pattern of the PDO is similar to that of the ENSO. Different from the ENSO, the PDO includes a strong connection between the North Pacific and the tropical Pacific.

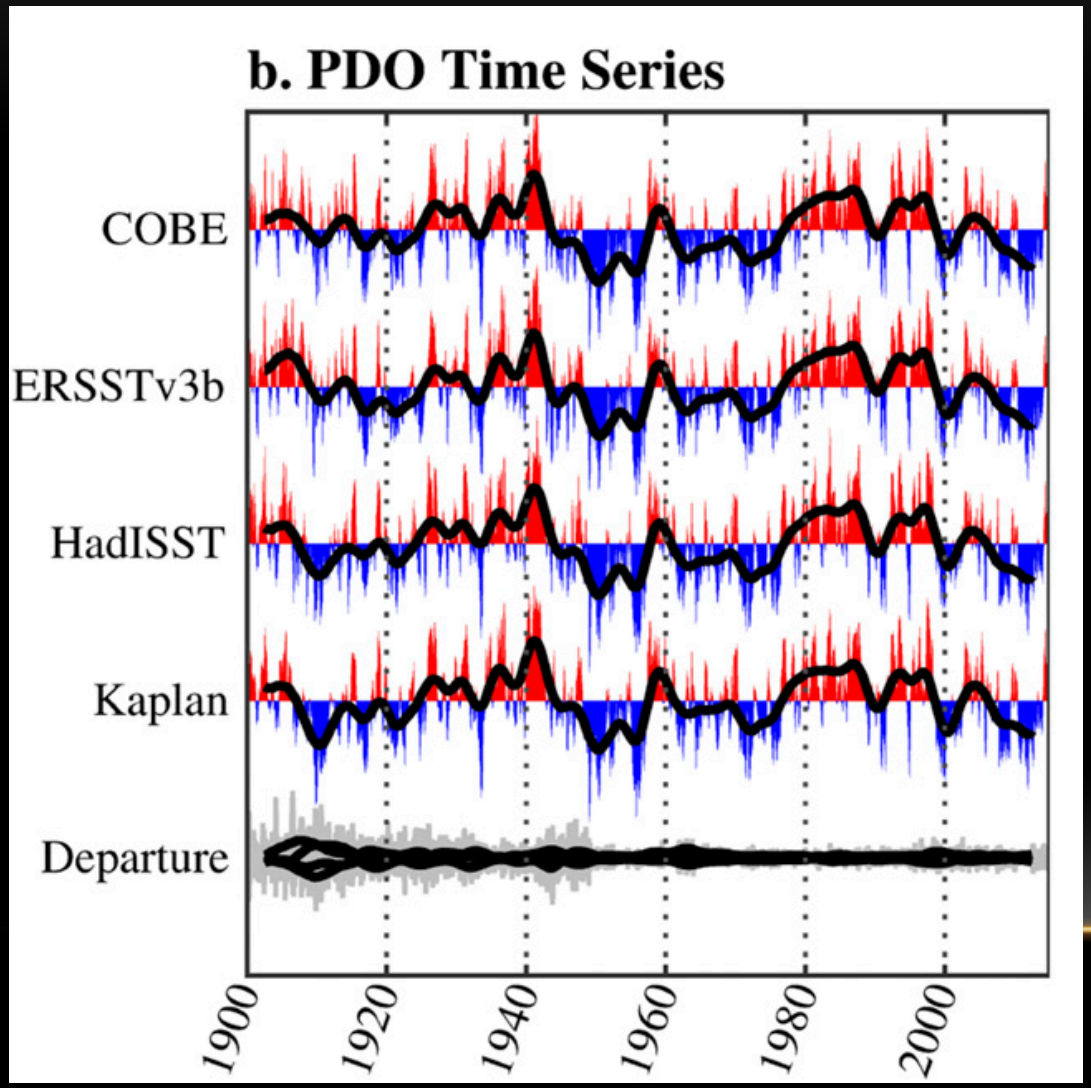
PDO Phases



From https://psl.noaa.gov/pdo/

- The PDO phases (either warm or cold) are defined by SST anomalies in the northeast and tropical Pacific Ocean.
- PDO Warm Phase: SSTs are anomalously cool in the interior North Pacific and warm along the Pacific coast and tropical Pacific Ocean, and sea level pressures are below average over the North Pacific.
- PDO Cold Phase: the climate anomaly patterns are reversed; above average sea level pressures over the North Pacific.

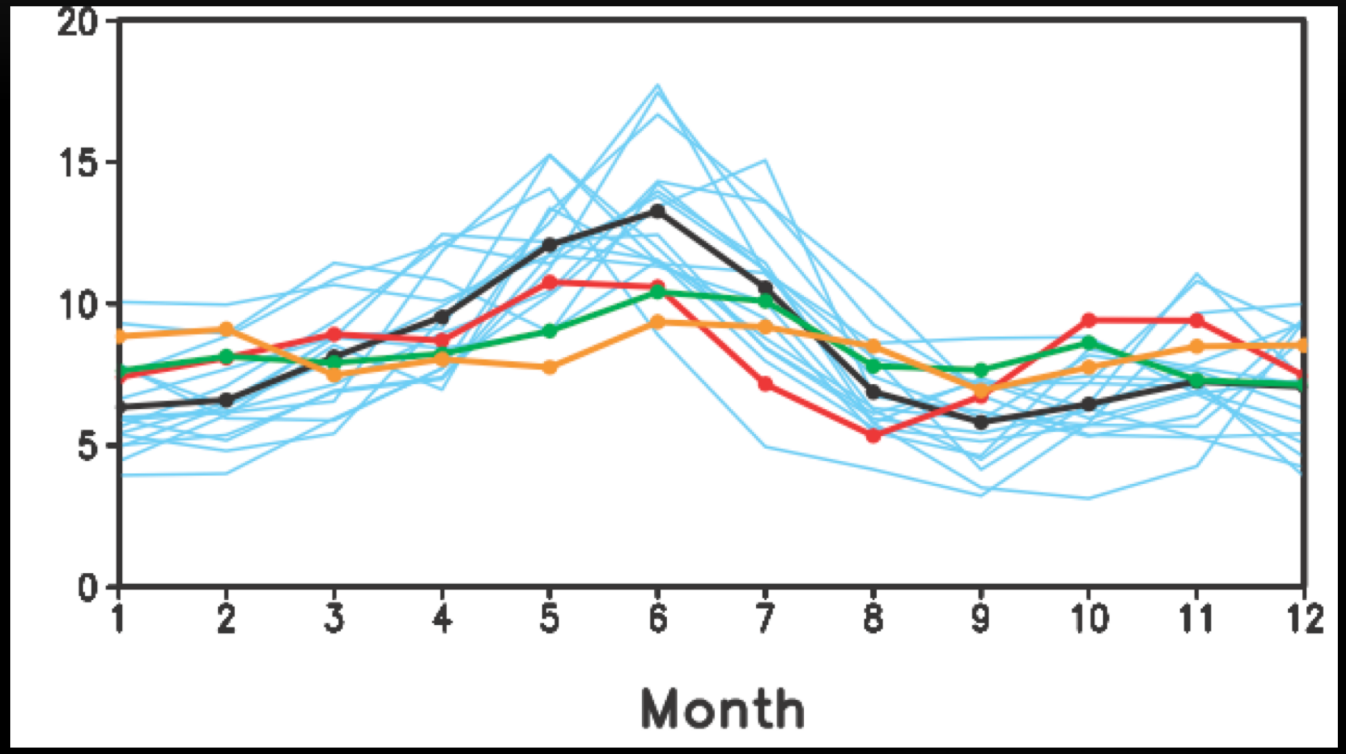
Low-frequency Nature of the PDO



The PDO time series clearly has a low-frequency component, with episodic changes of sign, hence "decadal oscillation."

PDO index time series determined from different SST datasets. The thick black line in each panel shows the smoothed (6-yr lowpass) time series. The last series shows the departure of each time series from the mean of all four time series. From Newman et al. 2016 © American Meteorological Society. Used with permission

Seasonal Cycle



The PDO has the greatest amplitude from November through June and a pronounced late summer–early fall minimum

Seasonality of the PDO in terms of the EOF percentage variance. Different colors represent different data sources. From Wang et al. 2012

PDO: Internal variability vs. external forcing

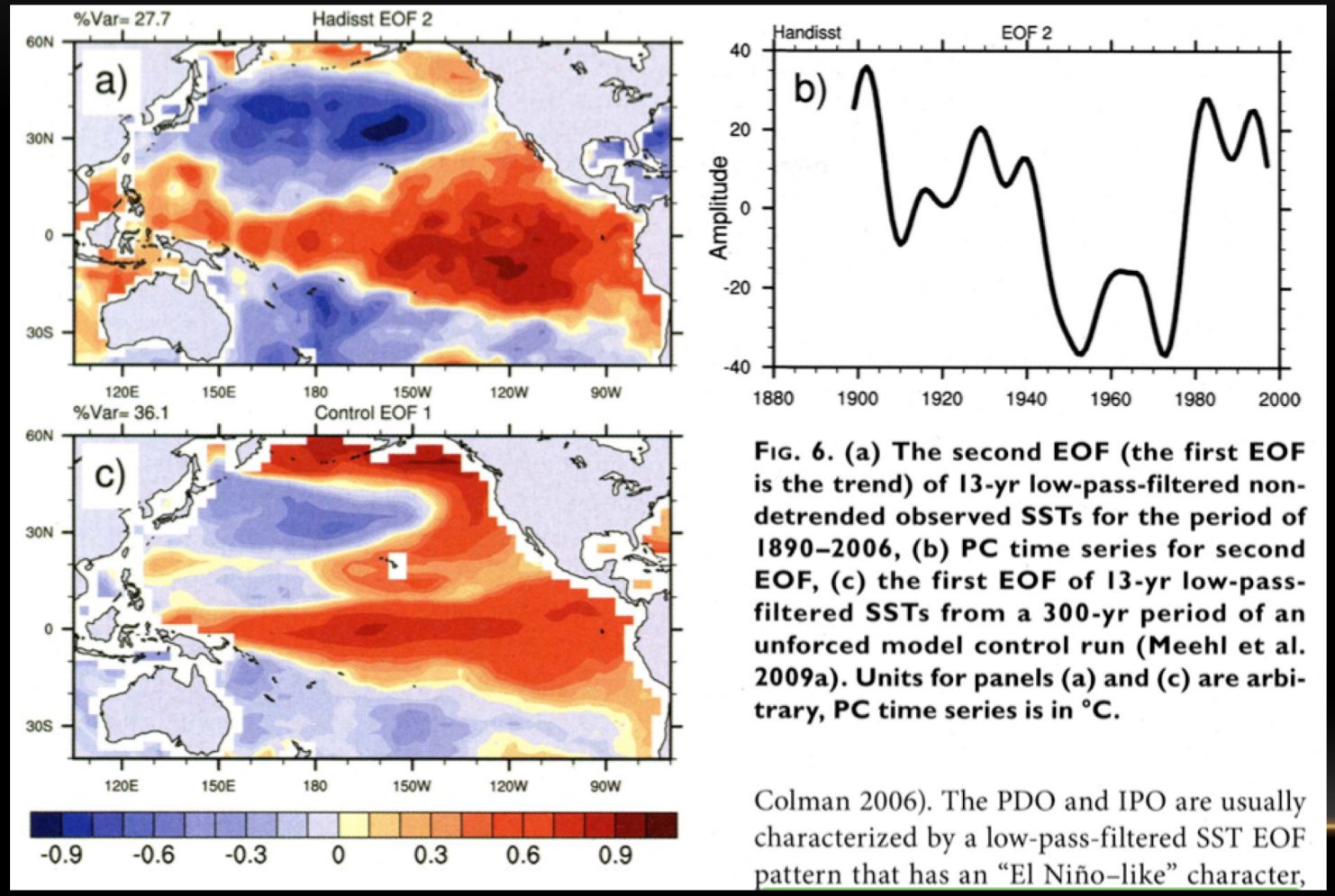


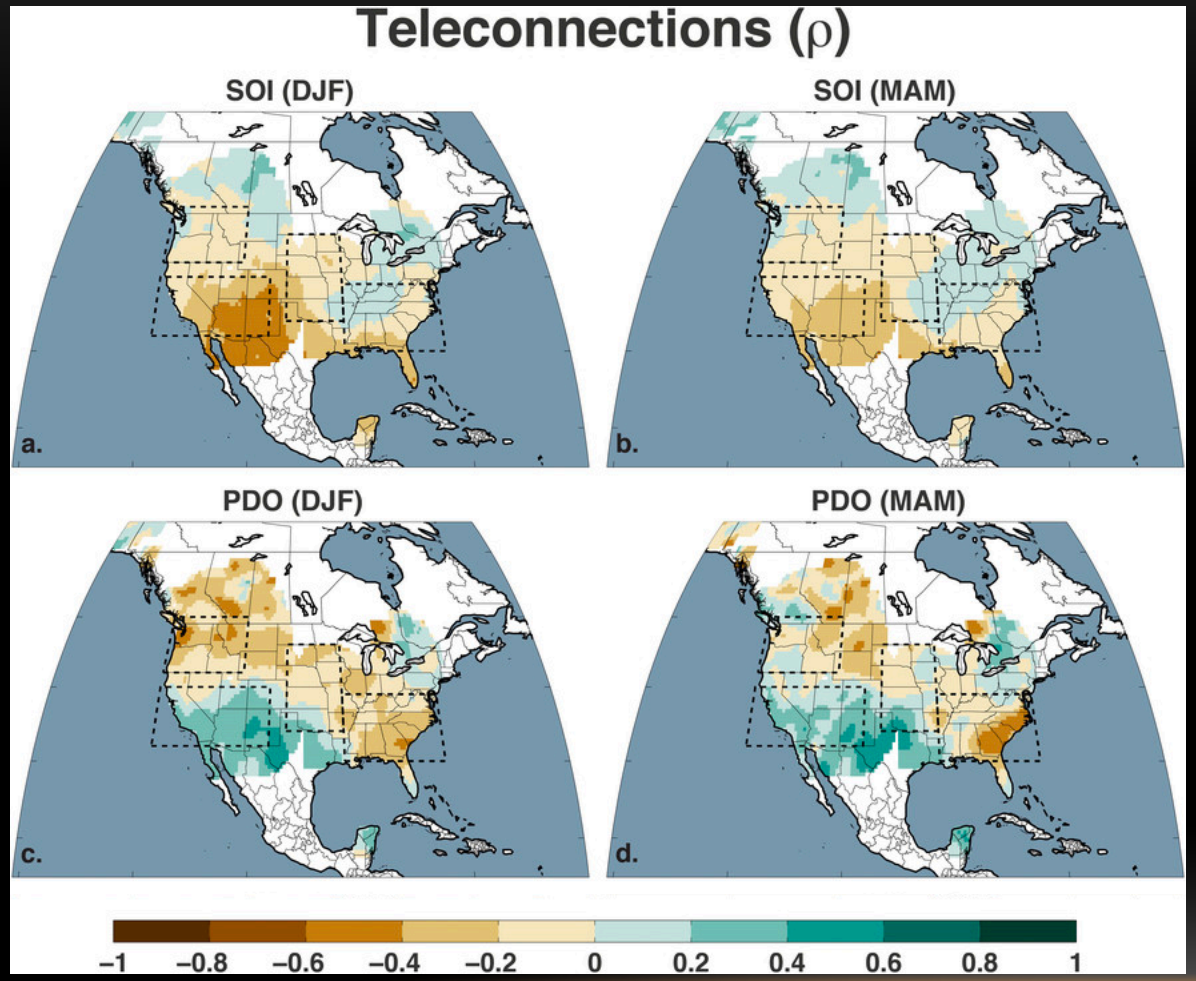
FIG. 6. (a) The second EOF (the first EOF is the trend) of 13-yr low-pass-filtered non-detrended observed SSTs for the period of 1890–2006, (b) PC time series for second EOF, (c) the first EOF of 13-yr low-pass-filtered SSTs from a 300-yr period of an unforced model control run (Meehl et al. 2009a). Units for panels (a) and (c) are arbitrary, PC time series is in °C.

Colman 2006). The PDO and IPO are usually characterized by a low-pass-filtered SST EOF pattern that has an "El Niño–like" character,

- Although external forcing can contribute to the PDO, global coupled models without eternal forcing can produce decadal variability very similar to the observed PDO, suggesting that the PDO is an internal mode (Meehl et al. 2009).
- It was also suggested that the Atlantic multidecadal variability contributes to the PDO (Zhang et al. 2019)
- Studies suggested that external forcing, such as greenhouse gases, could contribute to the phase transition of the PDO like the one in mid-1970s (Meehl et al. 2009).

From Meehl et al. 2009 © American Meteorological Society. Used with permission

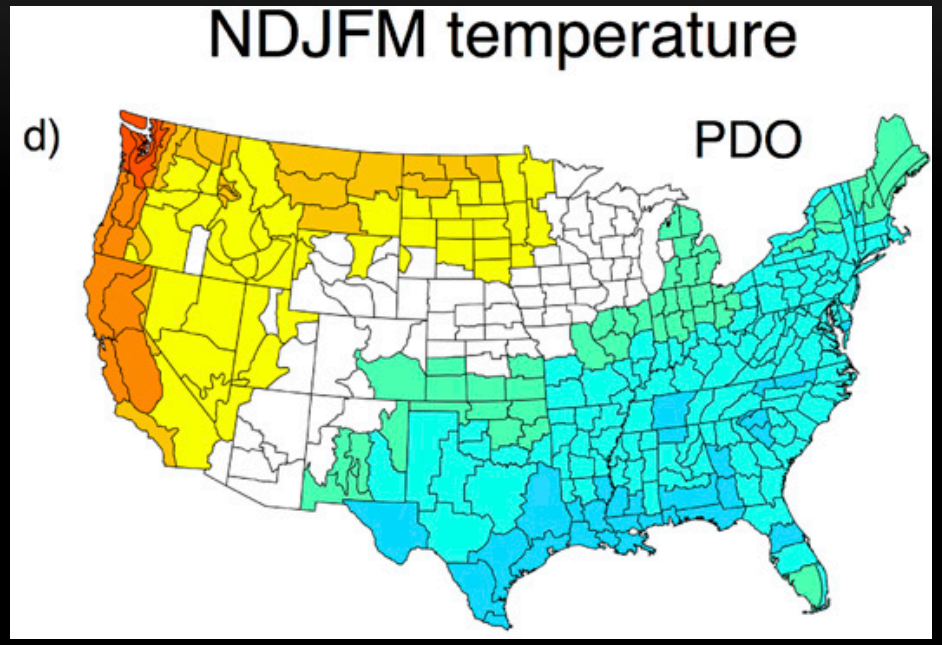
PDO and US Precipitation (PDSI)

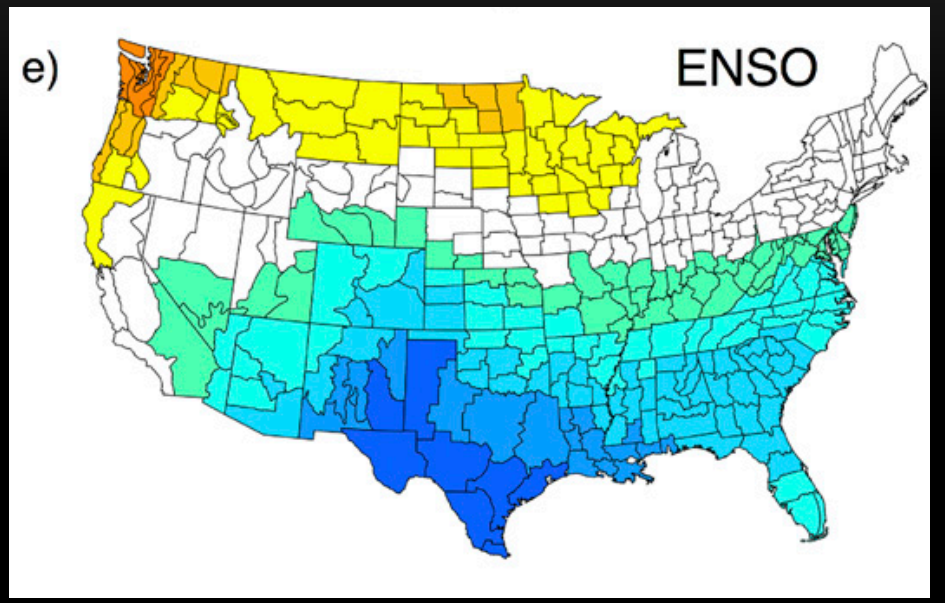


- The influence of the ENSO weakens with the transition from winter to spring.
- Positive values of the PDO in winter and spring correlate strongly with droughts in the NW and SE and pluvial conditions in the SW .
- Despite some similarities to the ENSO impacts, there are noticeable differences between the ENSO and PDO correlation maps.

This figure shows the correlations between Palmer drought severity index (PDSI) over the US and: SOI, PDO and AMO in (left) DJF and (right) MAM (from Cook et al. 2014 © American Meteorological Society. Used with permission)

PDO and US Temperature





NDJFM U.S. temperature anomalies correlated with (d) the PDO index, (e) the ENSO index during 1901-2014 (from Newman et al. 2016 © American Meteorological Society. Used with permission)

- Despite some similarities to the ENSO impacts, the major centers of strong correlation differ between the ENSO and PDO correlation maps.

PDO and ENSO Diversity

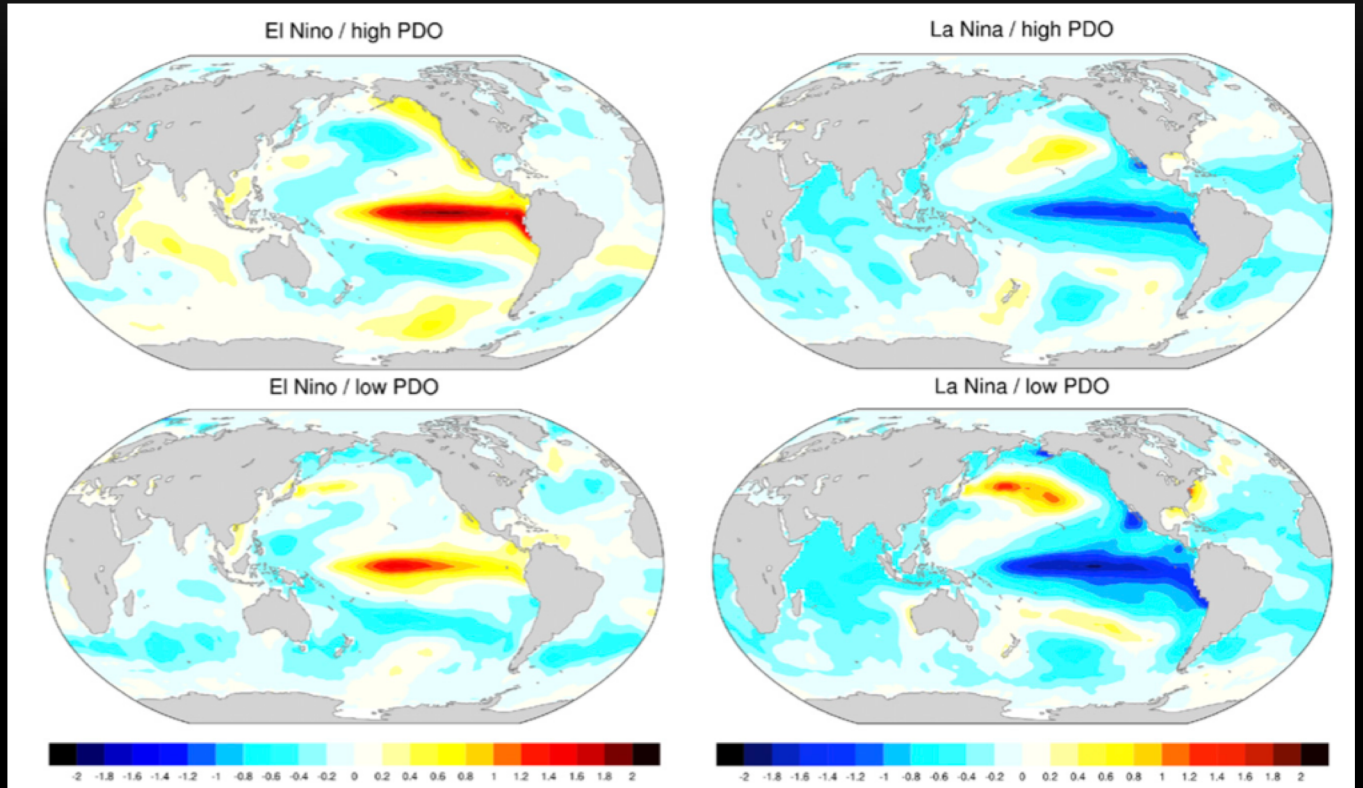
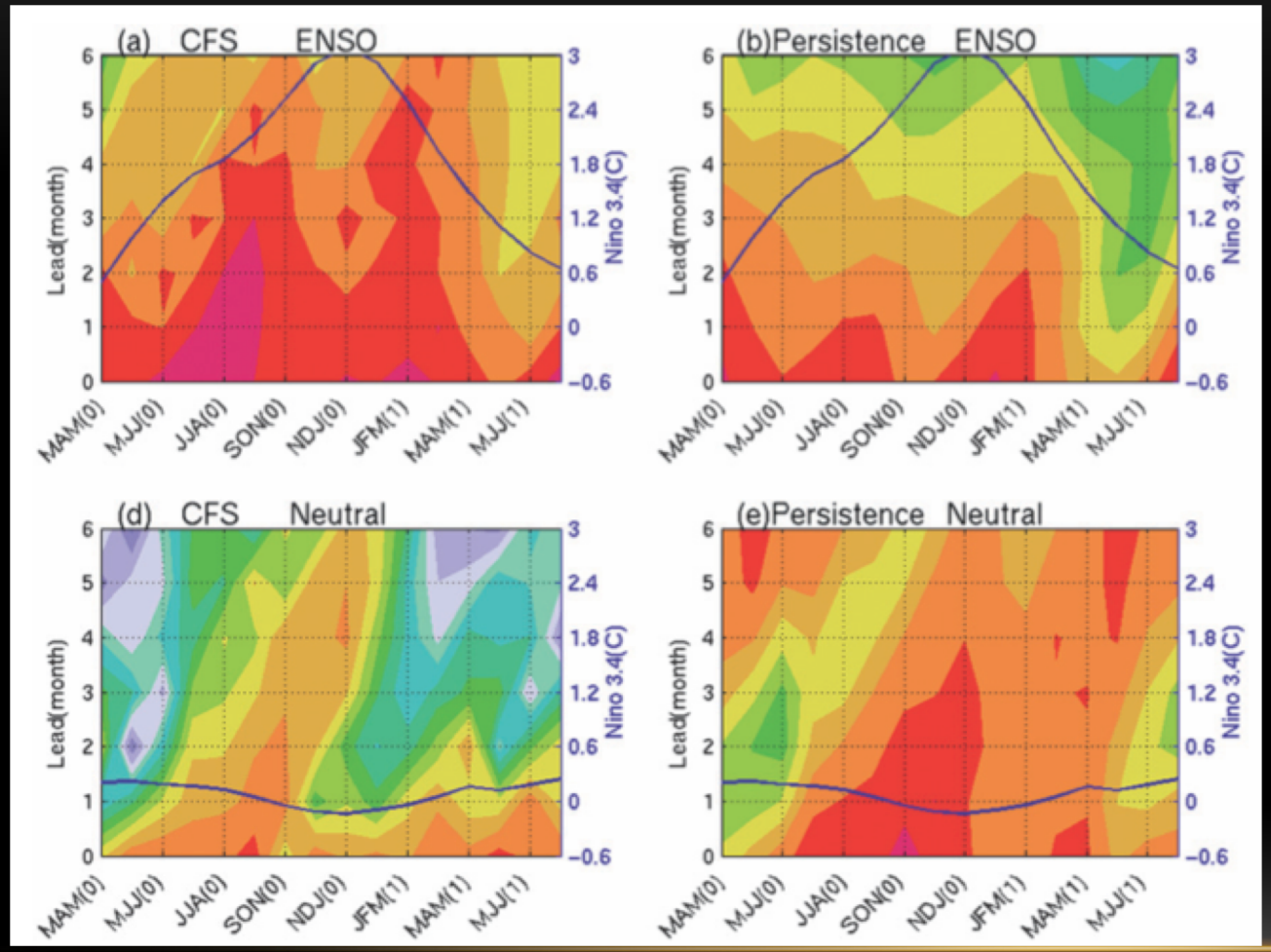


FIG. 13. NDJFM SST ENSO composites separated by high and low PDO values, determined over the years 1948–2008 from the ERSST.v3b SST dataset. Shown are composites of the top quintile (El Niño) of the ENSO index segregated by the (top left) top and (bottom left) the bottom halves of the PDO indices for the 12 cases, and the bottom quintile (La Niña) of the ENSO index segregated by the (top right) top and (bottom right) the bottom halves of the PDO indices for the 12 cases. Each half of the quintile is determined by ranking the PDO values of the quintile years. Contour interval is 0.2°C.

- ENSO diversity is evident between the high and low PDO years.
- Newman et al. (2016) suggested that the ENSO diversity between the PDO warm and cold phases may reflect the impacts of ENSO diversity on both PDO and ENSO teleconnections, rather than PDO impacts on ENSO teleconnections.

Seasonal Prediction of PDO in the NCEP CFS Hindcasts



The CFS prediction is shown in the left column and the persistence prediction in the right column.

- The PDO prediction skill strongly depends on the ENSO phase.
- The CFS prediction of the PDO is more skillful than persistence perdiction at all lead times during ENSO years but less skillful during ENSO-neutral conditions

Variation of correlation coefficient of the PDO index between forecasts and observation with respect to lead time from MAM (0) to JJA (1) during ENSO years and ENSO-neutral years. The blue line is the composite Niñ o-3.4 anomalies (right y axis) during ENSO years and neutral years (From Wen et al. 2012 © American Meteorological Society. Used with permission)

References

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