The Effect of a Pacific Meridional Overturning Circulation in the Mid-Latitudinal Pacific Ocean on Pacific Decadal Oscillation

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Aspiring Scientists' Summer Internship Program

Introduction and Purpose

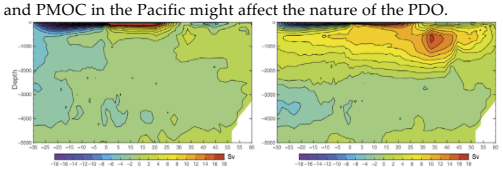
The Pacific Decadal Oscillation (PDO) describes the sea surface temperature variability and anomalies that persist for over 10 years in the North Pacific Ocean.

The PDO bears great significance to the environment because it:

1. Changes the path of atmospheric jet streams in the north hemisphere
2. Alters ecosystems of marine life in the northeast Pacific and Atlantic
3. Affects hurricane activity, droughts, and flooding around the Pacific basin.

The Pliocene plot shown below illustrates a Pacific Meridional Overturning Circulation (PMOC) while the PreIndustrial plot elucidates how the Pacific looks without this phenomenon. The Atlantic currently has a similar circulation called the Atlantic Meridional Overturning circulation (AMOC), which is thought to play an important role in the PDO counterpart for the Atlantic basin know as the "Atlantic Multidecadal Variability" (AMV), and was used for comparison in this project along with observed data from 1854 to 2018.

The central aim of this study is to evaluate how the presence of winter deep water formations and PMOC in the Pacific might affect the nature of the PDO.



PreIndustrial (Control) Pliocene

Methods

1. A PDO index was constructed from an observed data set.
2. Using simulated data from the Pliocene and PreIndustrial simulations in a CCSM model, a time series was produced from sea surface temperature data from 1854 to 2018.
3. A 10 year running mean of the time series was calculated from from the last 164 years of each simulation to compare with the observed data spanning 1854 to 2018 in order to produce some of the plots displayed in the Results section
4. The running mean plots were detrended to ensure accurate results.
5. The relationship between the PDO and each grid cell was determined by calculating correlations and mapping them on a grid to form regression plots.

Major Citations/Acknowledgements

Clement, A., Bellomo, K., Murphy, L. N., Cane, M. A., Mauritsen, T., Radel, G., & Stevens, B. (2015). The Atlantic Multidecadal Oscillation without a role for ocean circulation. *Science,350*(6258), 320-324. doi:10.1126/science.aab3980

N. J. Burls, A. V. Fedorov, D. M. Sigman, S. L. Jaccard, R. Tiedemann, G. H. Haug, Active Pacific meridional overturning circulation (PMOC) during the warm Pliocene. Sci. Adv. 3, e1700156 (2017).

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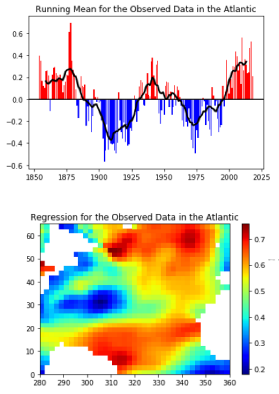
Results

Figure 1: Observed

Atlantic



Pacific

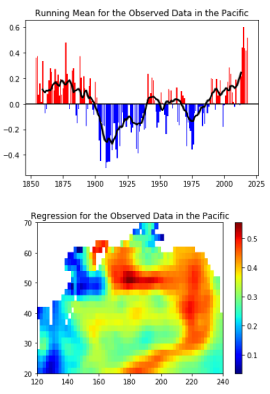
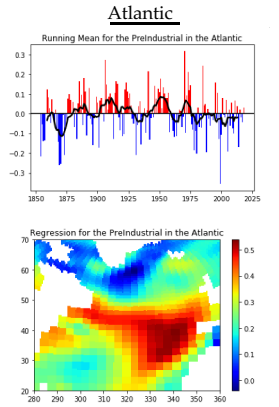
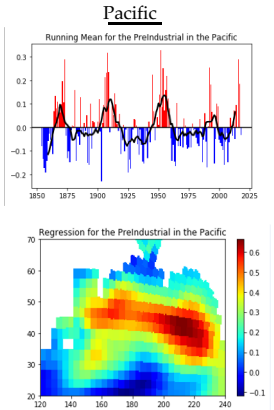


Figure 2: PreIndustrial Model

Atlantic



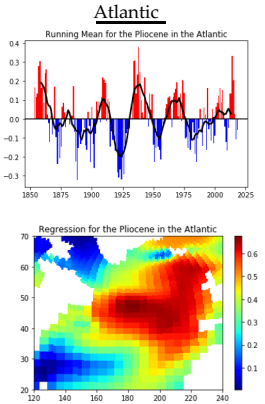
Pacific



Results

Figure 3: Pliocene Model

Atlantic



Pacific

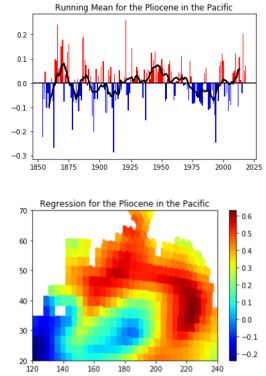


Table 1: Statistics

	Atlantic Std. Dev.	Atlantic Variance	Pacific Std. Dev.	Pacific Variance
Observed	0.148	0.020	0.085	0.007
PreIndustrial	0.041	0.002	0.052	0.003
Pliocene	0.088	0.007	0.035	0.001

Conclusions

- The frequency of oscillations in the model is approximately double of that in the observed
- The control displays weaker decadal to multi-decadal variance for both the Atlantic and the Pacific relative to observations (Fig. 1 vs 2, top panels & Table 1). The spatial correlations generally resemble observations with the exception of the subarctic Atlantic and subtropical Pacific (Fig. 1 vs 2, bottom panels)
- In the Pliocene simulation, the Pacific displays decreased variability likely due to a stronger PMOC (Fig. 1 vs 2, top panels & Table 1) that shifts the variability to the northern extratropical region and forms a horseshoe pattern (Fig. 1 vs 2, bottom panels)
- Future research into this topic will include determining the implications of these variance oscillations and comparing the results from this study with different 150 year time intervals in the model data.