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| Word | Definition | Source |
| Quiescence | Dormancy | Oxford dictionary |
| Pacific cold tongue | A patch of cold water in the Pacific created by ENSO | Wikipedia |
| Conceptual model | A model of the earth’s atmosphere based on interacting equations | Article/Wikipedia |
| Spring Persistence barrier | Reduction in predictability depending on time of calculation | Article |
| Bjerknes instability index | Equation to determine ENSO stability | Article |
| Autocorrelation | Measuring correlation of a dataset with an offset version of itself | Wikipedia |
| Stochastic | Random | Oxford dictionary |
| Recharge oscillator | Equation that models ENSO activity | Burgers, G., Jin, F.‐F., and van Oldenborgh, G. J. ( 2005), The simplest ENSO recharge oscillator, *Geophys. Res. Lett.*, 32, L13706, doi:[10.1029/2005GL022951](https://doi.org/10.1029/2005GL022951). |
| Red noise | Noise created with higher amplitude at lower frequencies | Wikipedia |

Levine, A. F. Z., M. J. McPhaden, and D. M. W.Frierson (2017), The impact of the AMO on multidecadal ENSO variability, Geophys. Res. Lett., 44, 3877–3886, doi:10.1002/ 2017GL072524.

Introduction:

ENSO (El Niño Southern Oscillation) has been shown to vary on multidecadal timescales. The leading explanation for this change in activity is that ENSO is affected by the AMO (Atlantic Multidecadal Oscillation). However, there is some uncertainty around this hypothesis, as given the long timescale of the AMO cycle, few cycles have been observed in precollected data. Consequently, a few studies have proven that the observed multidecadal variability in ENSO activity could be simply random. Some of the recent changes observed in ENSO activity are a recent reduction in average ENSO strength and frequency. Another change observed is a cooling of the Pacific cold tongue. The Pacific cold tongue is a pool of cold water formed in the eastern Pacific by upwelling. One viable way that an Atlantic multidecadal cycle could impact ENSO is though strengthening trade winds. Given the shored timespan of observed SST (sea surface temperature) data compared to the length of the AMO cycle, this study will support the relationship between the AMO and ENSO through a conceptual model of interacting equations and a computer climate simulation, as opposed to looking for statistical patterns in observed data.

2. Data and methods:

The study used many different data sources. They used an SST reconstruction from NOAA’s ICOADS project, an ocean reanalysis providing data for water temperature at certain depths. Additionally, they used SST data from certain islands to check the results of the reanalysis datasets. Their study is based on 2 different ways to measure the impact that AMO has on ENS), the spring persistence barrier and the Bjerknes Instability Index. The spring persistence barrier is a measurement of how predictable ENSO is at different times of year, given by comparing the autocorrelation of Pacific SST data at different lag-times. The Bjerknes Instability Index measures ENSO strength by using an equation that accounts for wind speed, temperature, and thermocline depth. Finally, they used a high-resolution coupled-model simulation with the AMO SST pattern as an input, along with a control simulation. They observed the development of SST as the model ran.

3. The tropical pacific annual cycle and ENSO

First, the researchers learned how to use the SPB (Spring Persistence Barrier) strength to measure ENSO strength. They observed a strong correlation between the value of the SBP and the standard deviation of the Nino 3.4 index (SST in a box in the central Pacific, an accurate metric for ENSO strength), and that weaker SBP is associated with stronger El Nino. To study the role of the SPB in ENSO multidecadal variability, the researchers used a recharge oscillator, an equation that models ENSO behavior, with an added equation that changes certain parameters to simulate the effect of the AMO. They systematically altered the values of 2 parameters in the equation, the annual mean growth rate, and the annual cycle of the growth rate. They found that these 2 parameters must be inversely related to accurately simulate the observed relationship between ENSO strength and SPB strength. They found that altering the shape of the AMO variability does not significantly affect the relationship between ENSO strength and SPB strength. Given this information, there are only 2 possible hypotheses for why ENSO varies multidecadally, that multidecadal variation naturally occurs in ENSO, or that factors outside the Pacific Ocean affect ENSO by changing the value of ENSO amplitude and the SPB strength in opposite ways.

4. The tropical Atlantic relationship with ENSO

Next, the researchers examined the correlation between AMO state and ENSO intensity in precollected data. Their results indicated that ENSO magnitude is inversely correlated with AMO magnitude. They checked this observation against accurate time series data from certain locations, and showed that while the inverse relationship between ENSO and AMO is not significant above 95% confidence, it is still appropriate to run coupled model simulations to test their relationship over timespans greater than that available in the precollected data.

5. Challenges in the Tropical Pacific Annual Cycle and Their ENSO Impact:

They used the Bjerknes Instability Index to observe the impact that the AMO has on ENSO. They modified the equation for the index to accurately account for multidecadal variability. Their calculations revealed that certain aspects of ENSO very greatly over the course of the year and have little impact on the yearly mean stability, while others to not greatly impact seasonality, but do impact mean stability. They calculated the difference in these 2 measurements of ENSO activity (seasonality and mean stability) over the course of different parts of the AMO cycle. Their values support their conclusions drawn from the conceptual model experiments. The significance of their values and their agreement with previous experiments supports the hypothesis that the AMO affects the correlation between ENSO magnitude and SPB strength.

6. Pacemaker Experiments

They additionally supported their hypothesis with a coupled model experiment, with the AMO SST pattern as an input, and with a control simulation without the AMO forcing. The AMO-forced experiment had a significant increase in the relationship between ENSO magnitude and SPB strength from the control simulation. The results of the model simulation indicated an overly large effect of the thermocline element of the Bjerknes instability index. This is due to a bias in the coupled model. However, the thermocline feedback varies greatly over the course of the year but has a smaller impact on the yearly mean stability. They conducted further calculations involving the correlation between the AMO index and the Bjerknes instability index. Their research showed that the AMO affects 2 distinct aspects of ENSO variability, the overall stability and the seasonal stability. The change in these variables is responsible for the observed inverse relationship between the SPB strength and ENSO magnitude.

7. Conclusions

The researchers concluded that the Atlantic Multidecadal Oscillation affects ENSO by causing an inverse relationship between ENSO predictability and magnitude. They observed that the Atlantic Multidecadal Oscillation facilitated this change by altering the strength of the trade winds, which then affect the seasonal variability Pacific cold tongue. These changes in the Pacific cold tongue variability alter ENSO growth rate differently at different months, giving rise to modulations in the value of the SPB.

Questions

1. What are the implications of your results for ENSO prediction?
2. What methods did you use to determine the functioning of the atmospheric bridge connecting the AMO to ENSO?
3. How do you know that your results are statistically significant enough to rule out other possible explanations for the inverse relationship between the spring persistence barrier and ENSO magnitude?