Correlation of Pennsylvania Temperature and Precipitation with Pacific Ocean Sea Surface Temperatures

Mercie Diodati, M.S. Geoscience Major
Dr. Joby Hilliker, Professor of Meteorology

WCU WEST CHESTER UNIVERSITY

Department of Earth and Space Sciences
West Chester University, West Chester, PA

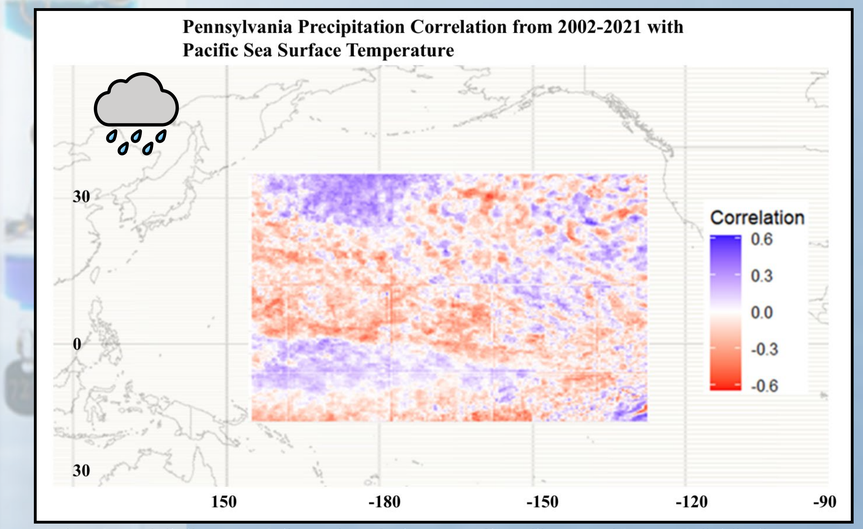
1. Introduction

- **Sea surface temperature (SST)** may have a greater influence on weather patterns than previously recognized (Guillaume-Castel and Meyssignac, 2025).
- **ENSO** alters winter rainfall in the Southeast U.S., with El Niño increasing moisture and La Niña causing weaker opposite effects (Qian et al., 2022).
- The **relationship** between Pacific SSTs, precipitation, and temperature trends in the northeastern United States remains poorly understood.
- Limited **SST** research exists, but studies show that ocean, atmosphere, land interactions drive climate variability in Pennsylvania (Zhang et al., 2021).
- **This study investigates the areal correlation (r) between Pacific Ocean SSTs and annual precipitation and temp in PA during 2002–2021.**
- Finding that **SST** variability influences regional weather patterns can **enhance** forecasting accuracy and climate-resilience strategies.

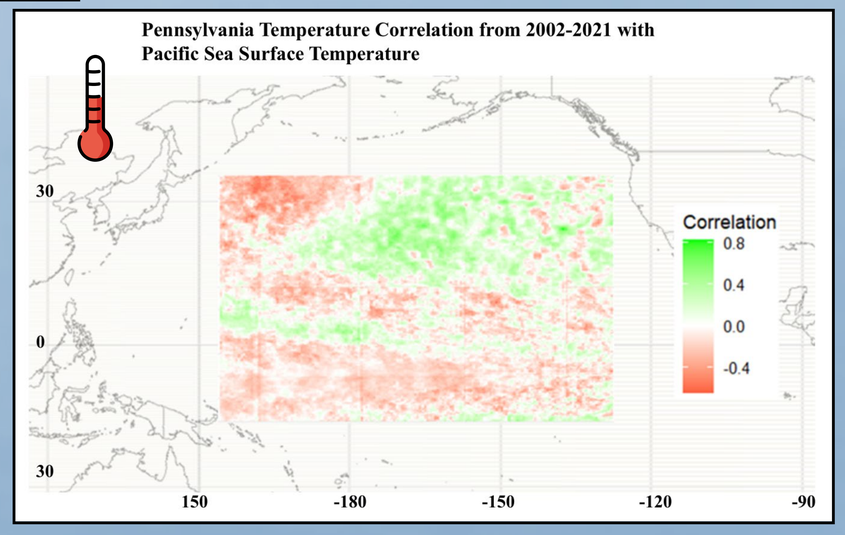
2. Data/Methodology

- 19 **Pacific SST** annual satellite images were obtained (NASA Ocean Biology Processing Group, 2025), with the study **region defined as 125°E–140°W, 10°S–45°N.**
- The data was preprocessed in Google Colab using Python 3.x with Google Earth Engine for **geospatial retrieval and computation**.
- In addition, numerical **SST** values from each **satellite image -- totaling 188,703 pixels each --** were extracted by obtaining pixel-level RGB data, mapping pixels to image coordinates with corresponding longitude and latitude, and generating Excel spreadsheets.
- Next, the numerical accuracy was verified using heat maps, and a single spreadsheet combining all **years in the database** was created**.**
- **Correlations (r)** between Pacific **SST** and Pennsylvania precipitation and temperature were calculated for each of the 188,703 pixels.
  - Review: Correlation measures the strength and direction of the relationship between two variables, ranging from −1 to 1. Positive values show variables moving together, negative values indicate opposite movement, and values near 0 suggest a weak relationship.
- *R* was used to create **heat maps** to visualize the areal correlations between SST and Pennsylvania precipitation and temperature.
- Each of the 188,703 pixels in the heat maps reveal a ~20-year average (r) between **SST** and the Pennsylvania climate.

3. Results



- Areal precipitation correlations show **heterogeneity**, with a roughly equal distribution between positive (blue) and negative (red) (r) values.
- Precipitation shows a large expense of strong negative (r) in the northwestern Pacific, with the highest correlation of −0.76 at **-160.99°W, -9.85°S.**
- The red-to-blue shift in the central Pacific hints at a dipole and changing climate patterns.



- Areal temperature correlations reveal **more** negative (red) (r) pixels than positive (greens) values.
- There is a concentrated area of **strong positive correlations** in the north Pacific, with the highest value of 0.87 at **-137.87°E, 32.96°N.**
- A broad area of moderate weak negative (r) are evident in the northwestern Pacific.

4. Discussion

- The **heat maps** reveal a clear spatial structure in the (r) between **SST** and both PA precipitation and temperature.
- Temperature correlates more with Pacific **SSTs** due to **large-scale** circulation, while local factors make precipitation signals weaker.
- **SST** variability shows potential as a predictor for annual precipitation and temp in PA -- but long-term averages **limit** its use for seasonal forecasts.
- Six major El Niño events (1895–1996) produced modest and inconsistent climate effects in PA, indicating **El Niño is not a reliable predictor for the state** (Forbes et al., 1999).
- A **Lancaster** County, PA, study found **no strong ENSO link** to average summer temperatures, but more extreme warm events during El Niño; precipitation declined in June–July, with weaker La Niña effects (Yalda et al., 2002).
- **SST** can reveal **meaningful** annual-scale statistical relationships with PA's climate, but long-term averages and weak ENSO teleconnections limit its usefulness for seasonal forecasting, supporting the need for more targeted, region-specific approaches.
- Central/eastern Pacific **SSTs** often oppose western Pacific SSTs, forming an ENSO-related dipole that explains spatial **differences** in Pennsylvania climate correlations.

5. Conclusions

- Overall, Pacific SSTs show areas of both **high positive and negative correlations** with PA precipitation and temperature.
- Both heat maps reveal **high heterogeneity** (variation) in both the magnitude and sign of correlations.
- However, there are **broad areas in the Pacific that have the same relationship (i.e., correlation sign)** between SST and PA temperature and precipitation.
- Thus, this study **suggests SSTs affect regional PA weather** and can **aid climate predictions,** particularly during ENSO.
- East-west **SST** gradients show the central/eastern Pacific Ocean is often **opposite** the western Pacific, typical of ENSO phases..
- **Future research** will expand the domain to include the Atlantic Ocean.

6. References

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