Report on North Pacific Sea Surface Temperature Analysis

Introduction

The objective of this analysis is to understand the temporal patterns and trends in sea surface temperature (SST) data from the North Pacific region. By applying various time series and spectral analysis techniques, we aim to identify dominant frequencies and trends, assess the spectral content, and forecast future SST values.

Data Description

The dataset used in this analysis comprises sea surface temperature (SST) measurements from the North Pacific region. The data spans multiple decades, providing a comprehensive view of SST changes over time.

Analysis Methods

Time Series Analysis

The initial step in the analysis involved plotting the SST time series to visualize the overall trend and variability. This plot revealed significant short-term and long-term fluctuations in SST values, indicating both seasonal and decadal patterns.

Spectral Analysis

To further investigate the periodic components of the SST data, Welch's method was applied for spectral analysis. This technique helps identify dominant frequencies in the data by estimating the power spectral density (PSD). The PSD plot highlighted significant recurring patterns in the SST data, with higher power at lower frequencies suggesting that long-term trends are a major component of SST variations.

Low-Pass Filtering

A Butterworth low-pass filter was designed and applied to the SST data to highlight long-term trends by removing high-frequency components. This filtering process allowed us to visualize the underlying decadal variations more clearly, providing a smoother representation of the SST time series.

Linear Regression Analysis

A linear regression model was fitted to the filtered SST data to quantify the long-term trend. The analysis revealed an estimated warming rate of 0.0040°C per year, indicating a gradual increase in SST over the analyzed period. This positive trend is consistent with global warming observations.

Forecasting

To forecast future SST values, a multi-lag linear regression model was employed. This model uses past SST values (lags) to predict future values. The model's predictions for the next decade were compared to the observed values, with the forecast indicating that the mean SST in the North Pacific will remain relatively stable with minor fluctuations.

Results

SST Time Series Plot:

The plot of the SST time series shows significant variability, with both short-term and long-term fluctuations. A graph showing the time of a wave

Description automatically generatedPower Spectral Density Plot:

The PSD plot highlights dominant frequencies, confirming the presence of significant recurring patterns in the SST data. Higher power at lower frequencies indicates the importance of long-term trends. A graph showing a number of power spectrum

Description automatically generated with medium confidence

Filtered SST Time Series:

The comparison between the original and low-pass filtered SST series demonstrates the effectiveness of filtering in highlighting long-term trends and decadal variations. A graph showing a wave of time

Description automatically generated with medium confidenceSST Forecasting:

The plot comparing observed and forecasted SST values shows that the model's predictions closely follow the observed trends. The Mean Absolute Error (MAE) of 0.10 indicates good prediction accuracy. A graph with blue and orange lines

Description automatically generated

Conclusion

The analysis of sea surface temperature (SST) data from the North Pacific reveals significant temporal patterns, including short-term seasonal fluctuations and long-term decadal variations. Spectral analysis identified dominant frequencies, highlighting significant recurring patterns in the SST data. The linear regression analysis showed a gradual warming trend, with an estimated rate of 0.0040°C per year, indicating a slow but steady increase in SST over time. Forecasting with a multi-lag linear regression model suggests that the mean SST will remain relatively stable with minor fluctuations over the next decade.