Interdecadal Variability of Regional Sea Surface Temperature and Rainfall in the Austral-Indonesian Region

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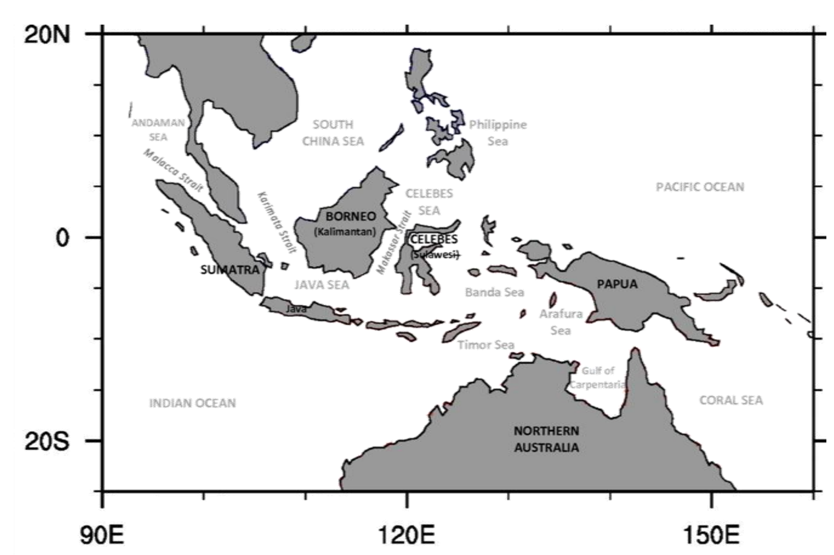
Introduction

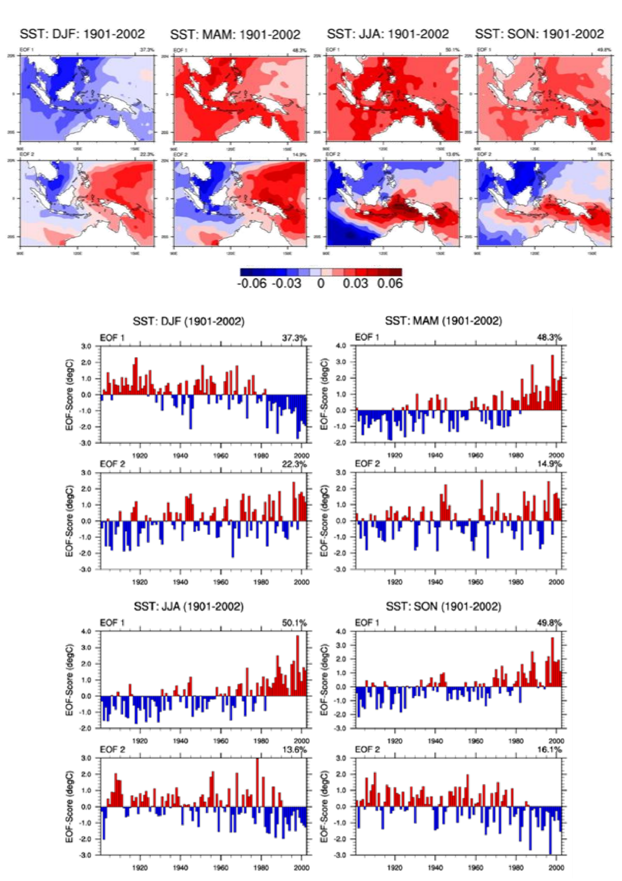
There is evidence of a link between the El Niño-Southern Oscillation (ENSO) and interdecadal rainfall variability in Indonesia (1,2,3). A better understanding of the physical processes and an improved capacity to deliver accurate rainfall projections is important for agricultural production, water resources management, food security, and disaster mitigation programs in the region (4,5,6). A similar link between ENSO and rainfall variability has been documented for Australia (7) and the large scale climate process driving this variability is referred to as the Interdecadal Pacific Oscillation (IPO) (8). The IPO is associated with changes in the intensity of ENSO cold and warm events, rainfall, surface temperature, stream flows, wheat crop yields (7) and sea surface temperature (SST) along the east coast of Australia (9). Although the impacts of low-frequency and large scale changes in ENSO on rainfall are well documented, little is known about the exact physical causes and need to be investigated further, in particular for the Austral-Indonesian region. In addition, the exact role of local processes including changes in regional SST is unclear (11,12,13,14).

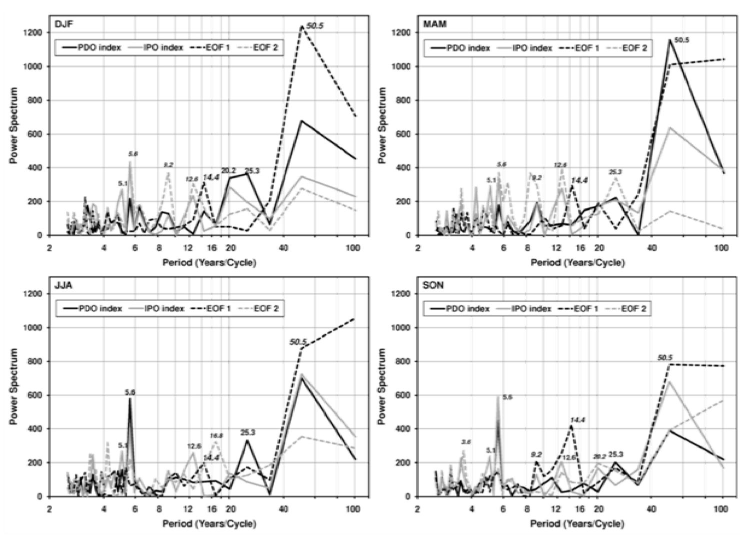
In this study, we present the analysis of seasonal SST and rainfall data to investigate interdecadal variability in the SST-rainfall relationship for the Austral-Indonesian region. Our goal is to identify the role regional SST plays in driving rainfall variability and how it contributes to the low-frequencies changes driven by large-scale atmospheric and oceanic processes such as the Pacific Decadal Oscillation (PDO) and the IPO.

The Austral-Indonesian region investigated in the study.



EOF 1 and 2 of seasonal SST over the Austral-Indonesian region





FFT Spectral analyses obtained from the first and second SST EOFs for DJF (a), MAM (b), JJA (c) and SON (d) compared with the PDO index (17), the IPO index (18). Horizontal (x) axis is transformed into logarithmic scale.

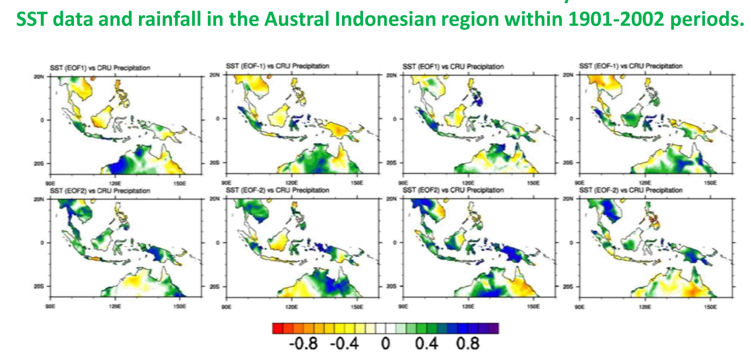
Data and Methods

We use several monthly datasets for this study. Those data are monthly SST data from the British Atmospheric Data Centre (HadISST SST Version 1.1, (16), rainfall data from the Climatic Research Unit (CRU TS2.1) (17) as well as the PDO and IPO indices (7,8, 18, 19).

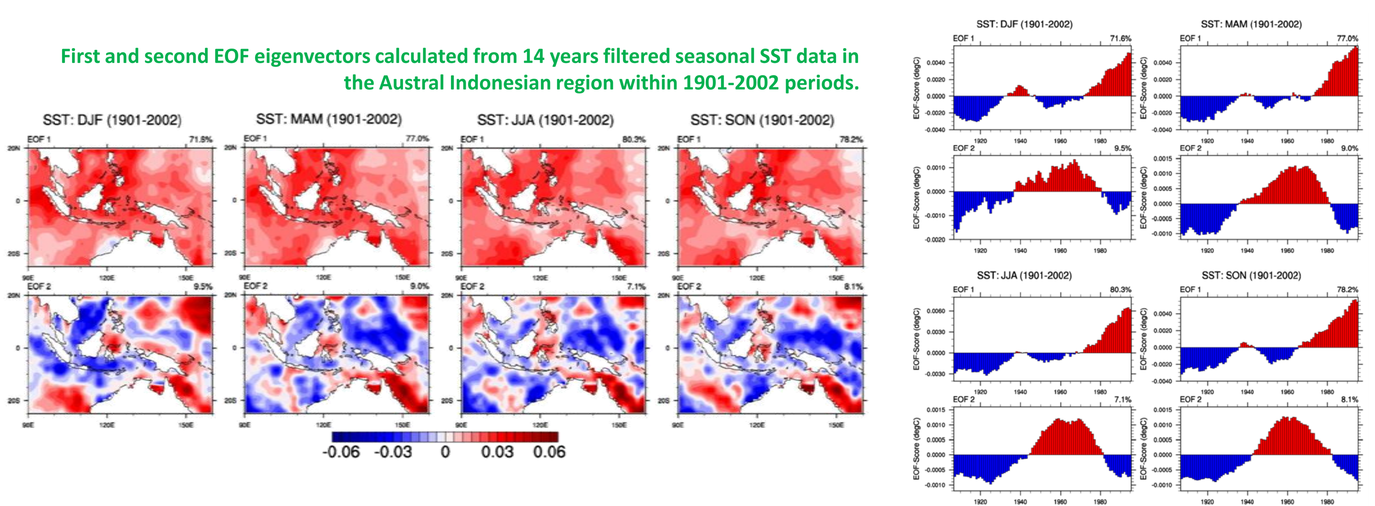
We implement Fast Fourier Transforms (FFT) for the first two leading seasonal SSTs that are obtained from EOF analysis to investigate the most dominant and consistent inter-decadal frequencies on the regional SST data. This information is used as a filter parameter to obtain the low-frequency of seasonal SST prior to do another EOF calculation. The methodology implemented by calculating the EOF on the filtered data is referred to previous study (9,20). It can be used to determine the leading spatial and temporal patterns on interdecadal timescales.

Time series analysis of the filtered seasonal SST data in some of the local seas is conducted as well as a correlation between the filtered SST Empirical Orthogonal Function (EOF) scores and rainfall. For comparison, the rainfall anomalies are calculated and referenced to the 1901-2002 climatology. The rainfall record is divided into three periods which follow the climatic shifts that are well documented through the PDO index. Those periods are 1925-46, 1947-76 and 1977-2002.

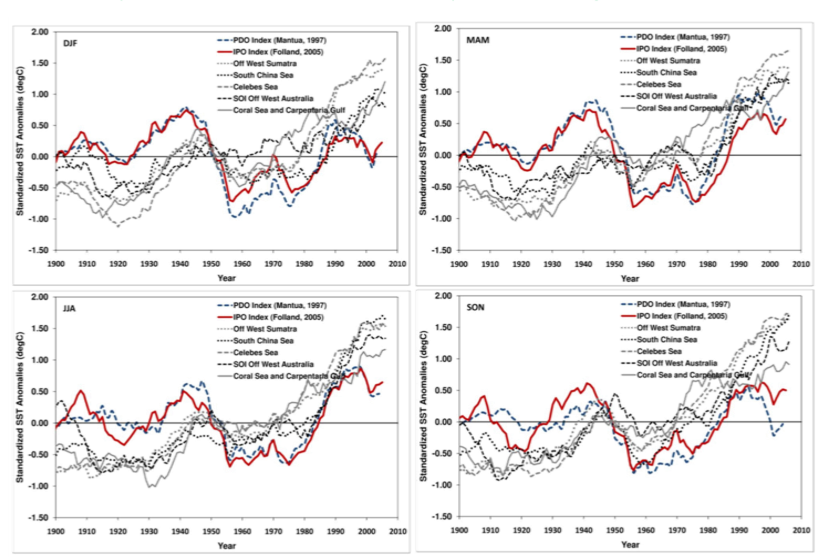
Correlations of first and second EOF scores calculated from 14 years filtered seasonal SST data and rainfall in the Austral Indonesian region within 1901-2002 periods.



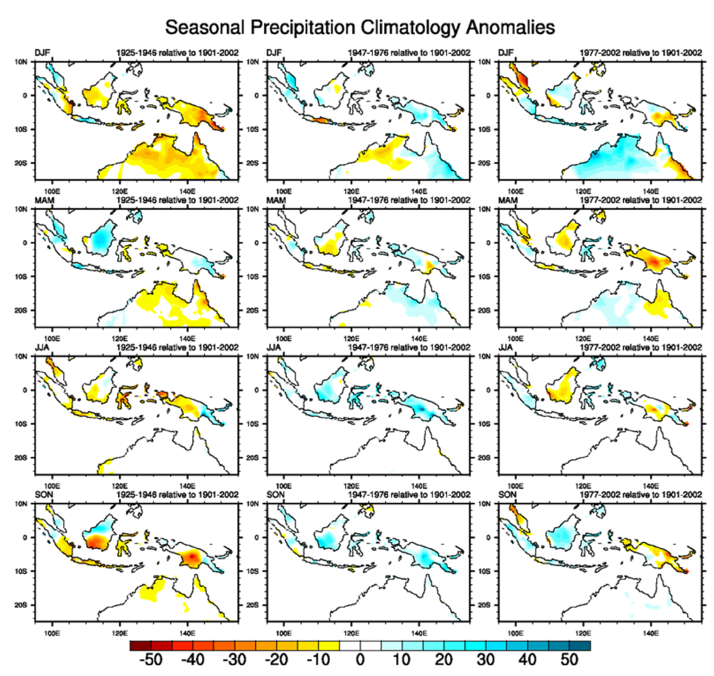
First and second EOF eigenvectors calculated from 14 years filtered seasonal SST data in the Austral Indonesian region within 1901-2002 periods.



The time series of local SST filtered using 14 years moving average. The results are compared with the IPO and PDO indices performed using the same filter.



The anomalies of seasonal rainfall climatology during different phases of interdecadal variability. All relative to 1901-2002 climatology, and c) rainfall climatology differences between strong and weak phases.



Summary

This study investigates the interdecadal SST-rainfall variability from a regional perspective. The result complements the finding of a previous study (10). The first leading seasonal SST patterns are consistently characterized by around 14 years interdecadal variability at all seasons. By using the dominant cycle as a parameter in filtering the data, the study finds that the low-frequency regional SST is locally and seasonally varying. The seasonal variations of the regional SST also influence the SST-rainfall relationship on the low-frequency timescales. The PDO and IPO are linked to low-frequency rainfall variability in the region through regulating regional SST patterns mostly through the atmospheric interaction (21). However, the influence of those large scale climate phenomena is interfered by the warming and upward trend of the regional SST. It is possible that climate change has a major role in contributing to these upward trends. The study highlights the important role local SST plays in driving rainfall variability. This needs to be considered when studying the effect of global climate phenomena such as PDO and IPO on rainfall variability in the region.

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