Decadal variaility of Sea Surface Temperature wavenumber-4 pattern in the Southern Hemisphere

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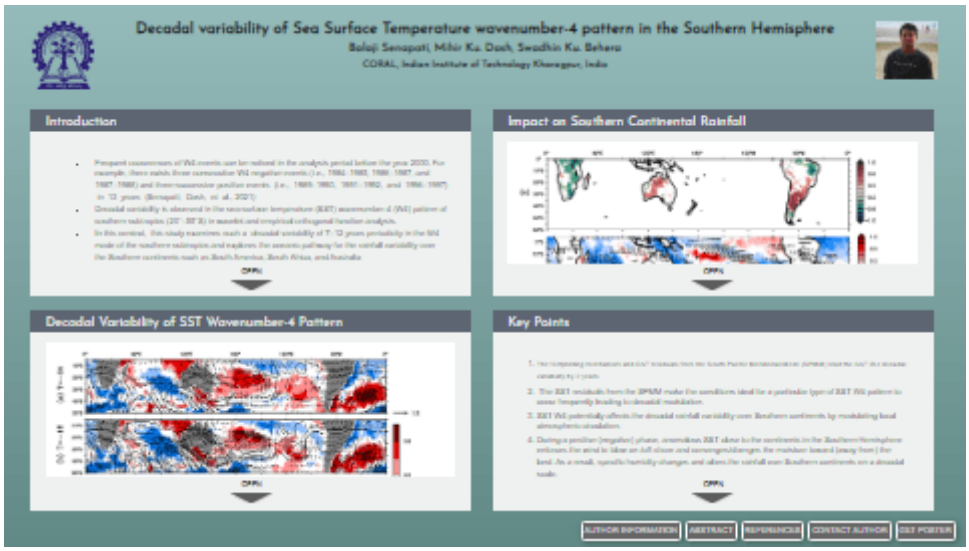

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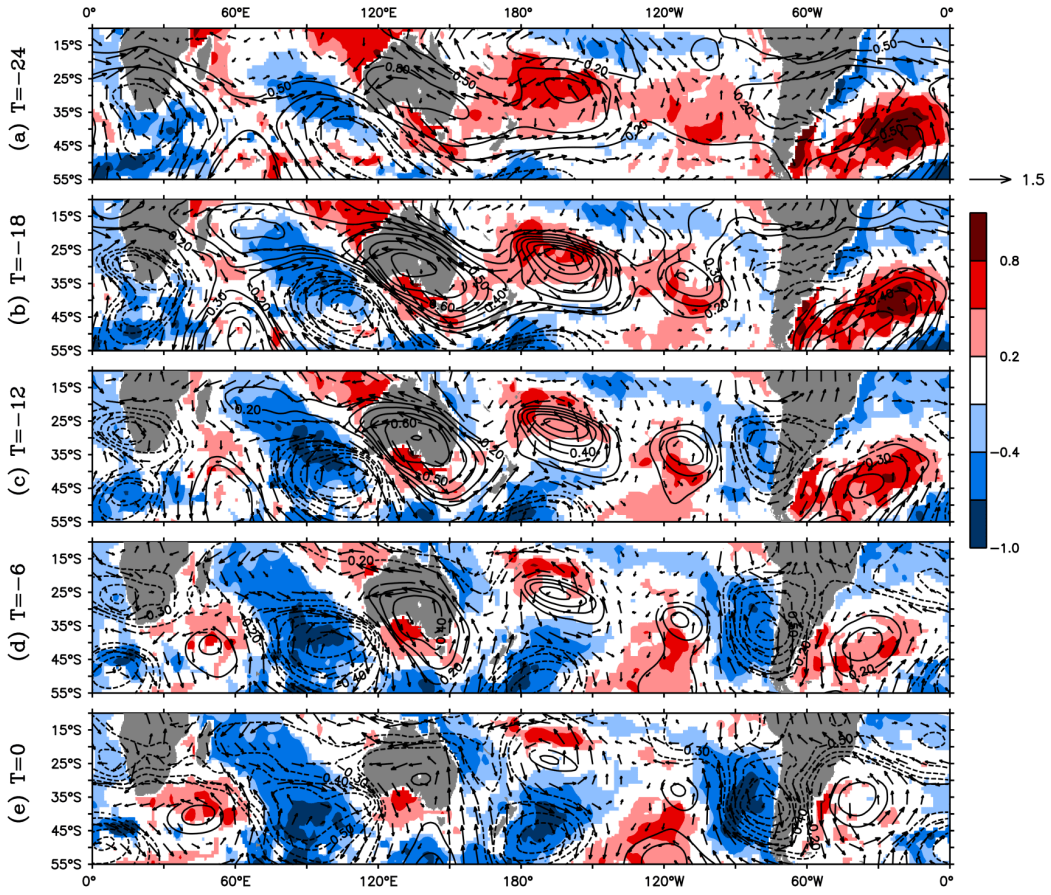
INTRODUCTION

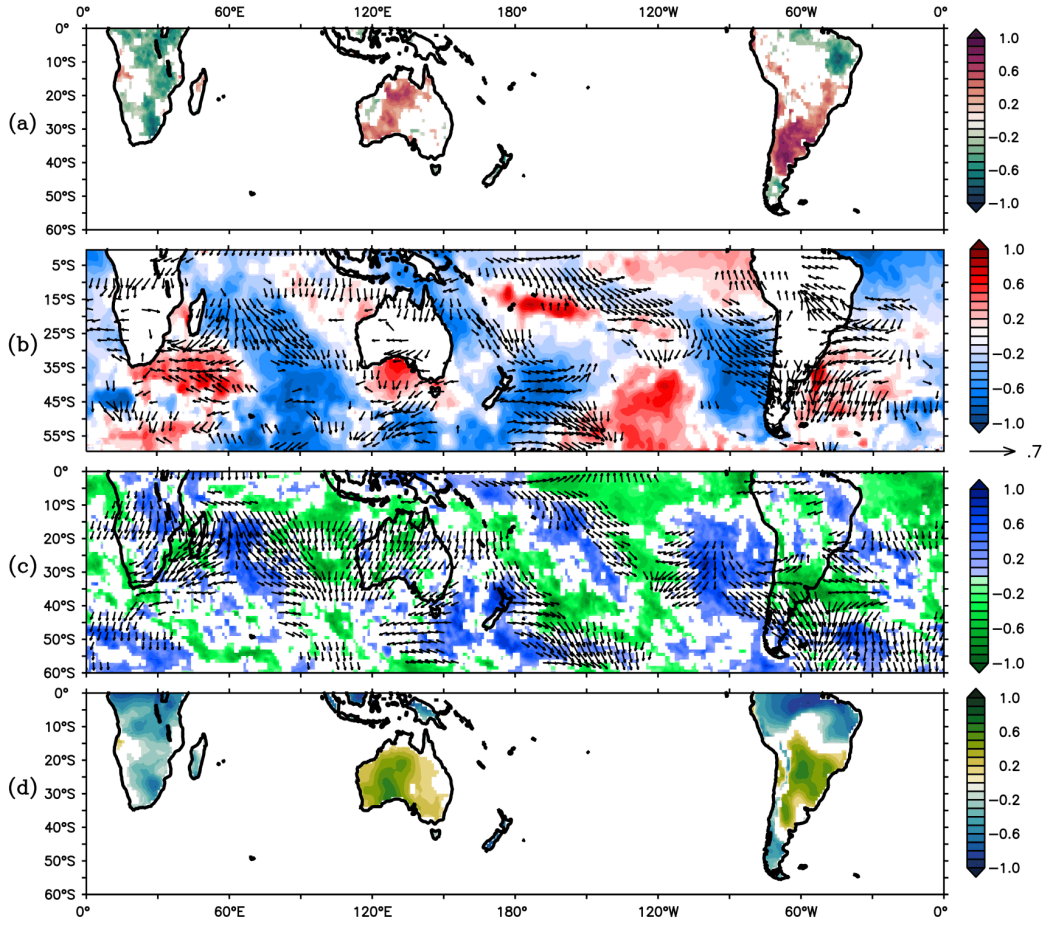
- Frequent occurrences of W4 events are noticed in the analysis period of wavenumber-4 (W4) before the year 2000. For example, there exists three consecutive W4 negative events (i.e., 1984–1985, 1986–1987, and 1987–1988) and three successive positive events (i.e., 1989–1990, 1991–1992, and 1996–1997) in 13 years (Senapati, Dash, et al., 2021)
- Decadal variability is also observed in the sea surface temperature (SST) W4 pattern of southern subtropics (20°–55°S) in wavelet and empirical orthogonal function analysis.
- In this context, this study examines such a decadal variability of 7–12 years periodicity in the W4 mode of the southern subtropics and explores the oceanic pathway for the rainfall variability over the Southern continents such as South America, South Africa, and Australia
- This examination might also help understand the source of decadal variability in the western subtropical Indian Ocean SST and associated anomalous pressure, wind, and moisture divergence over South Africa that impacts South African Summer Rainfall

DECADAL VARIABILITY OF SST WAVENUMBER-4 PATTERN



Correlation field between filtered maximum covariance analysis sea surface temperature (SST) time series and 7–12 years filtered anomalous SST (shaded), 250 hPa geopotential height (contour), and 250 hPa wind (vector) at lag (a) 24-month, (b) 18-month, (c) 12-month, (d) 6-month, and (e) 0-month. Here, the SST W4 pattern is lagged by other variables. Values not satisfying a 99% significance level of the correlation coefficients are suppressed.

IMPACT ON SOUTHERN CONTINENTAL RAINFALL



(a) Correlation field between filtered maximum covariance analysis sea surface temperature (SST) time series (black line in Figure 1e) and 7–12 years filtered anomalous (a) rainfall, (b) SST (shaded) and 850 hPa divergent wind (vector), (c) vertically integrated moisture divergence (shaded) and moisture transport (vector), and (d) vertically integrated specific humidity. Values less than 99% significance level of correlation coefficients are suppressed.

KEY POINTS

1. The footprinting mechanism and SST residuals from the South Pacific Meridional Mode (SPMM) lead the SST W4 decadal variability by 2 years.
2. The SST residuals from the SPMM make the conditions ideal for a particular type of SST W4 pattern to occur frequently leading to decadal modulation.
3. SST W4 potentially affects the decadal rainfall variability over Southern continents by modulating local atmospheric circulation.
4. During a positive (negative) phase, anomalous SST close to the continents in the Southern Hemisphere enforces the wind to blow on-/off-shore and converges/diverges the moisture toward (away from) the land. As a result, specific humidity changes and alters the rainfall over Southern continents on a decadal scale.
5. The weakening of the W4 pattern post-2000 is directly related to the waning of the SPMM.
6. The limitation in data length makes it difficult to quantify the independent role of the W4 pattern on the Southern continental rainfall apart from the influence of Atlantic and Pacific tropical climates.
7. A coupled model simulation study is opened as a future work given the potential importance of decadal variability of the W4 SST pattern and limited observational records.

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ABSTRACT

The Southern subtropical (20°S-55°S) sea surface temperature (SST) wavenumber-4 (W4) pattern exhibits a decadal variability as revealed in the wavelet and EOF analysis. Involved physical processes and its impact are discussed. It is found that the decadal variability of the SST W4 pattern is the decadal modulation of its interannual variability. The decadal modulation of the SST W4 pattern is mainly linked with the SST footprints from the South Pacific Meridional Mode (SPMM). The SST residuals of the SPMM create a favourable environment for the frequent occurrence of positive/negative type of the SST W4 pattern. Also, the SST W4 pattern has the potential to impact the rainfall variability over the Southern continents on a decadal scale. It modulates the local atmospheric circulation by enforcing the wind to go on/offshore and converging/diverging the moisture into/out of the landmass. As a result, specific humidity changes and alters the rainfall over Southern continents on a decadal scale.

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