Abstract

The presence of a stationary sea surface temperature (SST) wavenumber-4 (W4) pattern over southern subtropics (20°-55°S) is revealed using empirical orthogonal function analysis. The signal over the southern subtropics is seasonally phase-locked to the austral summer and persists up to mid-autumn. Correlation analysis suggests that the W4 pattern in SST is mostly independent of other natural variabilities, such as Southern Annular Mode, Indian Ocean Dipole, as well as El Niño/Southern Oscillation. Thermodynamic coupling of the atmosphere and the upper ocean helps in generating the SST-W4 pattern, which later terminates due to the breaking of that coupled feedback. The W4 pattern in SST peaks during the austral summer season precedes a similar atmospheric pattern, which is forced by a Rossby wave with a source in the upstream region of the upper-tropospheric westerly waveguide. The vortex stretching associated with the anomalous convection in the vicinity of Tasman Sea adjacent to the westerly jet triggers the Rossby wave train around mid-November. This disturbance gets trapped in the Southern Hemisphere westerly jet waveguide and circumnavigates the globe. Around 15-25 days later (in early December), a steady atmospheric W4 pattern is established in the southern mid-latitudes.

Realistic simulation in SINTEX-F2 coupled model unfolds the detailed air-sea interaction processes and the convective activity over the Tasman Sea during the development of atmosphere- and SST-W4 patterns. Sensitivity model experiments confirm the independency of tropical and polar climates in generating these patterns, and suggesting internal dynamics of southern subtropics with a necessary convective anomaly over the Tasman Sea being responsible for it. Further, it is found that the SST-W4 pattern is generated by thermodynamic interaction between the atmosphere and the oceanic mixed layer. The atmosphere interacts with the upper ocean, causing mixed layer depth variations due to latent heat flux anomalies. Absorption of incoming solar radiation by shallower (deeper) mixed layer promotes surface warming (cooling). This leads to positive (negative) SST anomalies, developing the SST-W4 pattern. Subsequently, anomalous entrainment due to the temperature difference between the mixed layer and the entrained water below the mixed layer, anomalous latent heat flux and disappearance of the atmospheric wave forcing cause the decay of the SST-W4 pattern during austral autumn. Therefore, an accurate simulation of the atmospheric forcing and the associated atmosphere-ocean interaction is essential for the SST-W4 pattern in the coupled models.

The SST-W4 pattern also has a decadal variability, which evolves from the decadal modulation of the South Pacific Meridional Mode (SPMM) as seen in SST footprints. The SST residuals of the SPMM create a favorable environment for the frequent occurrence of positive/negative types of the SST-W4 pattern. Also, the SST and atmospheric W4 patterns are seen to have a large impact on the weather and climate, especially the continental rainfalls, of the southern subcontinents from interannual to decadal timescales.

Keywords: SST Wavenumber-4; Atmospheric Wavenumber-4; Teleconnection; Decadal Variabilty; SPMM; SINTEX-F2; Southern subtropics; Southern Mid-latitude; Australian Rainfall; South America Rainfall; South Africa Rainfall; Air-Sea Interaction; Mixed Layer Heat Budget; Rossby Wave; Rossby Wave Source; Linear Response; SST Footprints