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南インド洋における東西ダイポール型の長周期海面水温変動
Low-frequency variations of the zonal dipole sea surface temperature pattern in the South Indian Ocean

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Temporal variations of monthly sea surface temperature (SST) anomalies from 1951 to 2012 are investigated using observational dataset (ERSST: Smith et al., 2008). To explore large-scale SST patterns, we perform an empirical orthogonal function (EOF) analysis in the South Indian Ocean [20E-120E, 55S-Equator]. The first EOF mode (35%) represents an increasing tendency and the second EOF mode (13%) presents the Indian Ocean subtropical dipole (IOSD) pattern, as shown by Behera and Yamagata (2003). The third EOF mode (9%) has an east-west seesaw pattern, whose boundary lies at 90E: the centers of action are located around [70E, 30S] in the positive area and [110E, 30S] in the negative area. The time coefficient tends to have low-frequency variations: positive phases in the 1970s and 2000s, and negative phases in the 1960s and 1990s.

We specifically focus on the third EOF mode. We propose an zonal dipole index (ZDI) showing an activity of the third EOF mode based on the SST anomalies: the ZDI is defined as the SST anomalies averaged within the central South Indian Ocean [65E-75E, 35S-25S] minus SST anomalies averaged within the eastern side of the basin [110E-120E, 35S-25S], and then the ZDI is normalized using a standard deviation. Because the correlation coefficient between the ZDI and the time coefficient of the third EOF mode is 0.80, results obtained using the ZDI are not substantially different. We investigate temporal feature of the ZDI by applying a power spectral analysis. Result shows that the dipole SST pattern has a low-frequency variation on decadal (about 15 years) timescale. In addition, we investigate monthly dependence of the zonal SST pattern using the root mean square. Result shows that the SST pattern is dominant during austral summer (January to March).

We investigate causes of the zonal dipole SST pattern by applying a correlation analysis for various variables such as SST, sea level pressure (SLP), sea surface wind, and vertical velocity through the troposphere. Here, we use the JFM mean values. The correlation analysis with the ZDI shows existence of positive SLP anomaly with the downward anomaly located around [90E, 20S]. Therefore, we can point out that the zonal dipole SST pattern results from changes in surface wind related to the SLP variations. Interestingly, the ZDI shows significant correlations in the western equatorial Pacific: positive SST pattern, negative SLP pattern, and upward anomaly throughout the troposphere. The SST spatial structure resembles the El-Nino Modoki: an obtained coefficient between the ZDI and the Modoki index is 0.30 (0.54 of 1981-2012). Therefore, we expect that changes in zonal atmospheric circulation, that is, Walker circulation, associated with the western equatorial Pacific SST variations can form the zonal dipole SST pattern in the South Indian Ocean.

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