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The mechanism linking the variability of the Antarctic sea ice extent in the Indian Ocean sector to Indian summer monsoon rainfall

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Abstract

The study investigates the mechanism of teleconnection between the variability of sea ice extent (SIE) in the Indian Ocean sector of the Southern Ocean and the variability of Indian summer monsoon rainfall. We utilized reanalysis, satellite, in-situ observation data, and model output from the coupled model intercomparison project phase 5 (CMIP5) from 1979 to 2013. The empirical orthogonal function (EOF) and correlation analysis show that the first and third modes of principal component (PC1 and PC3) of SIE in the Indian Ocean sector during April–May–June (AMJ) are significantly correlated with the second mode of principal component (PC2) of Indian summer monsoon rainfall. The reanalysis data revealed that the changes in the SIE in the Indian Ocean sector excite meridional wave train responses along the Indian Ocean for both principal component modes. Positive (negative) SIE anomalies based on first and third EOFs (EOF1 and EOF3), contribute to the strengthening (weakening) of the Polar, Ferrel, and Hadley cells, inducing stronger (weaker) convective activity over the Indian latitudes. The stronger (weaker) convective activity over the Indian region leads to more (less) rainfall over the region during high (low) ice phase years. Furthermore, a stronger (weaker) polar jet during the high (low) ice phase is also noted. The selected CMIP5 models captured certain atmospheric teleconnection features found in the reanalysis. During AMJ, the SIE simulated by the NorESM1-M model was significantly positively correlated with Indian summer monsoon rainfall, whereas the IPSL-CM54-LR model showed a negative correlation.

Keywords Antarctic sea ice extent (SIE) in the Indian Ocean sector · High ice phase · Low ice phase · Indian summer monsoon rainfall · Convective activity

1 Introduction

Sea ice extent (SIE) is a very sensitive climate variable in polar regions, and is an essential factor in the climate system. The sea ice extent variabilities influence the global climate system, encompassing the climate of both hemispheres. Since a decade ago, researchers have studied teleconnection between Antarctic sea ice and tropical climate variability extensively. Many previous studies identified the teleconnection between the variability of the Antarctic sea ice and various atmospheric-oceanic parameters and indices, including El Niño Southern Oscillation or ENSO (Simmonds et al. 1995; Schneider et al. 2012), the Southern Annual Mode or SAM (Pezza et al. 2008, 2012; Turner et al. 2015), the Southern Indian Ocean Dipole (Nuncio et al. 2015), sea surface temperature (Rai et al. 2006, 2008; Liu et al. 2011), precipitation of the tropical Pacific (Yuan and Martinson 2000) and rainfall in China (Xue et al. 2003; Liu et al. 2018; Zhou

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