Relationship between the Preceding Boreal Winter Southern Hemisphere Annular Mode and Spring Precipitation in South China

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1. Introduction

The Southern Hemisphere annular mode (SAM) is the principal mode of atmospheric variability in Southern Hemisphere (SH) extra-tropical regions, which is a seesaw pattern in SLP between SH mid- and high-latitudes (Gong and Wang, 1998; Thompson and Wallace, 2000). Because of the zonal symmetry and hemispheric scale of SAM, its variability can impact global and regional atmospheric circulations on different time scales. Nan and Li (2003, 2005) pointed out that the boreal spring SAM is positively interrelated with summer precipitation in the Yangtze River valley, see also Wu et al. (2006). Winter monsoon in China are also closely related to preceding boreal autumn SAM as Wu et al. (2009) indicated. How does preceding boreal winter SAM affect on spring precipitation in South China (SC)? This question seems to not been discussed yet.

2. Data and Method

The main data sets employed in this study include rainfall at 160 gauge stations across China, NCEP/NCAR reanalysis data, the improved Extended Reconstructed SST Version 2 (ERSST V2) for the period of 1950/51-2007/08. The SAM Index, taken from Li and Wang (2003), is defined as the difference in the normalized monthly zonal mean SLP between 40° S and 70° S. The singular value decomposition (SVD), linear regression and composite analysis are adopted. The NCAR Community Atmospheric Model version 3 (CAM 3) is employed to investigate the possible mechanism.

3. Correlation between preceding DJF SAM and MAM rainfall in SC

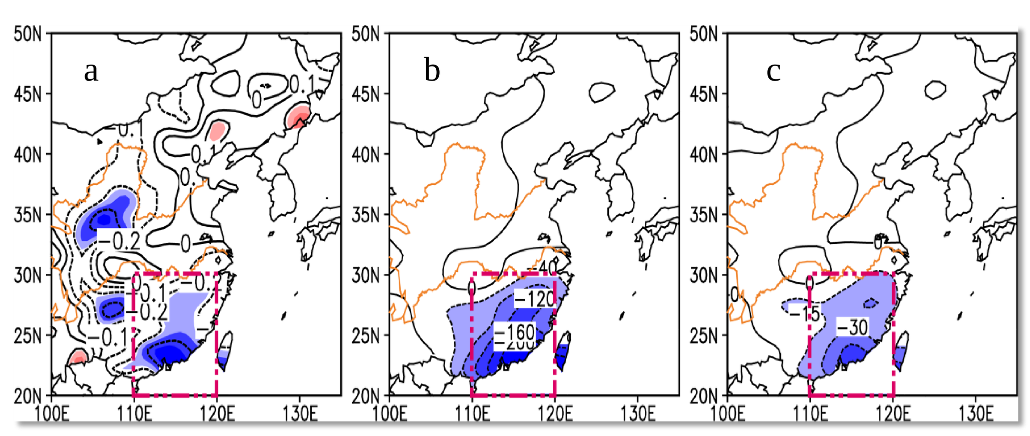


Fig.1 Relationship between preceding boreal winter SAM and spring precipitation in China. (a) correlation coefficients; (b) composite difference in precipitation between high and low DJF SAMI years; (c) precipitation linear regressed against DJF SAMI.

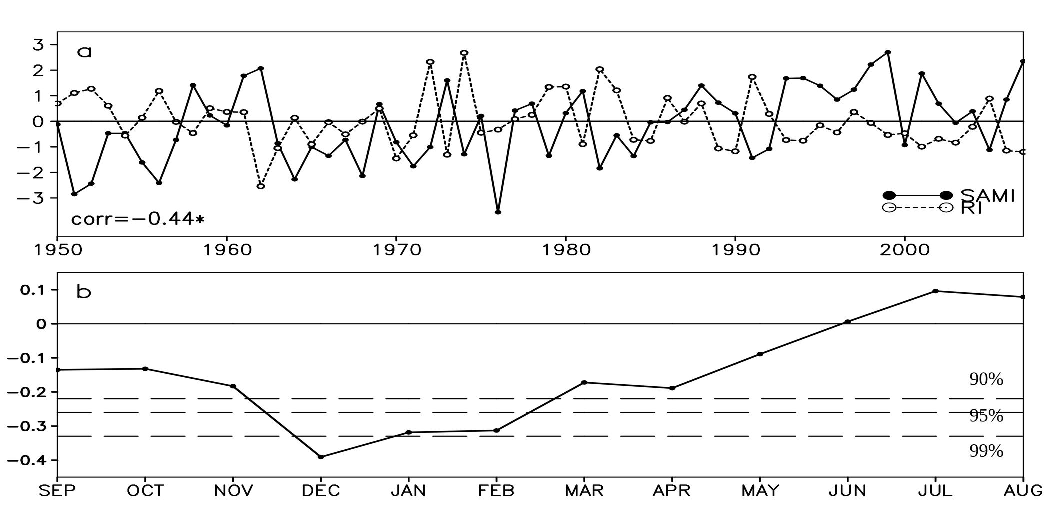


Fig.2 Normalized time series of preceding DJF SAMI and MAM SCRI (a) and lead-lag correlations between MAM SCRI and SAMI in different months (b). SCRI is defined as average rainfall of 11 stations in SC.

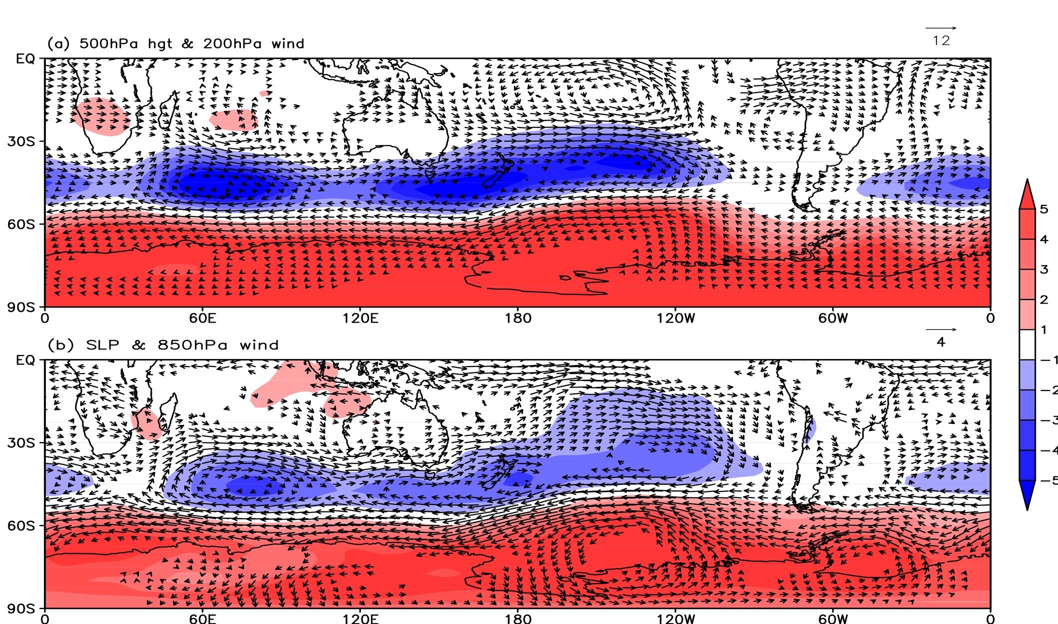


Fig.3 Composite differences in preceding DJF atmospheric circulation anomalies between high and low MAM SCRI years. (a) 500 hPa geopotential height and 200 hPa winds ; (b) SLP and 850 hPa winds.

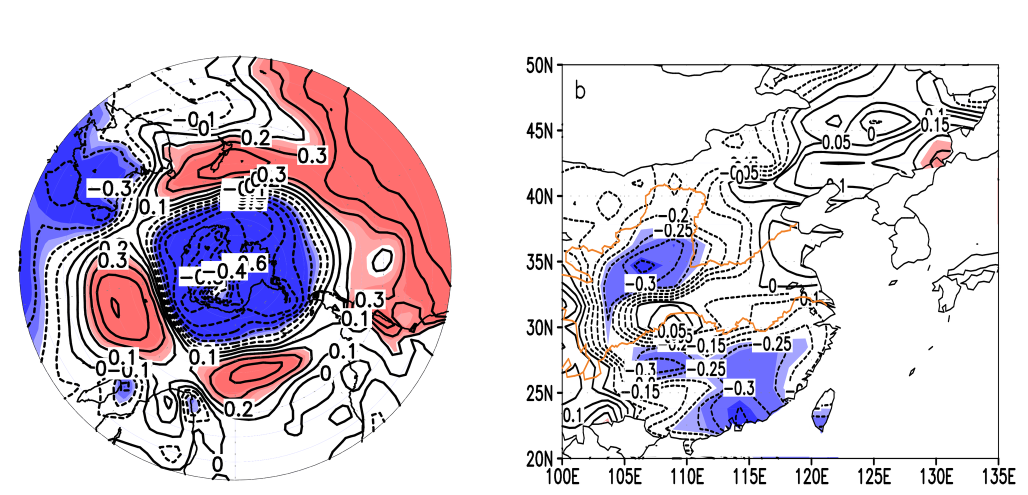


Fig.4 Leading hetero-geneous SVD mode for DJF SH SLP to the south of 10° S (left) and MAM rainfall in China (right). (Shaded areas indicate correlation coefficients beyond 95% confidence level.)

4. Atmospheric circulation anomalies associated with SAM and SC Rainfall

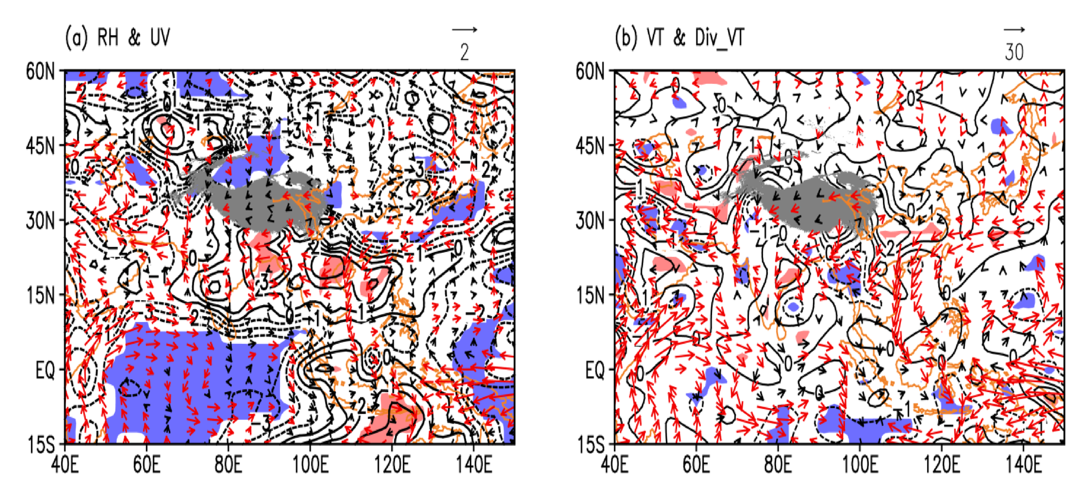


Fig.5 Composite differences between high and low DJF SAMI. (a) wind field on 850 hPa (m/s) and relative humidity on 700 hPa (%) in MAM; (b) low layer (1000-700 hPa) water vapor transport in (kg/m/s) and its water transport divergence on 850 hPa (10^{-5}kg/m^2/s) in MAM.

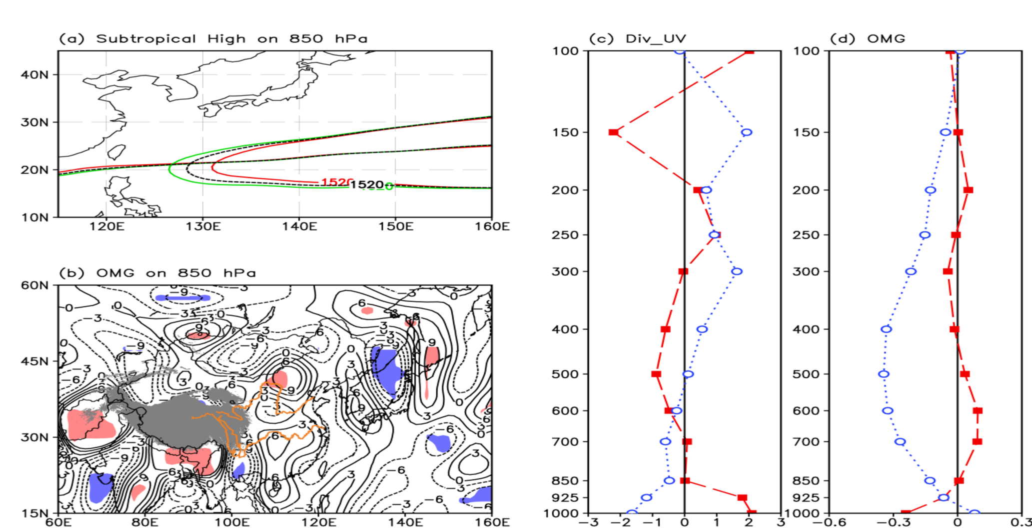


Fig.6 Same as Fig.5, but for: (a) ridge line of subtropical high on 850 hPa; (b) vertical velocity on 850 hPa (10^{-5} hPa/s); (c) regional mean of wind divergence (unit: 10^{-7}/s); (d) vertical velocity (10^{-4} hPa/s).

5. Physical Mechanism of influence of SAM on SC Rainfall

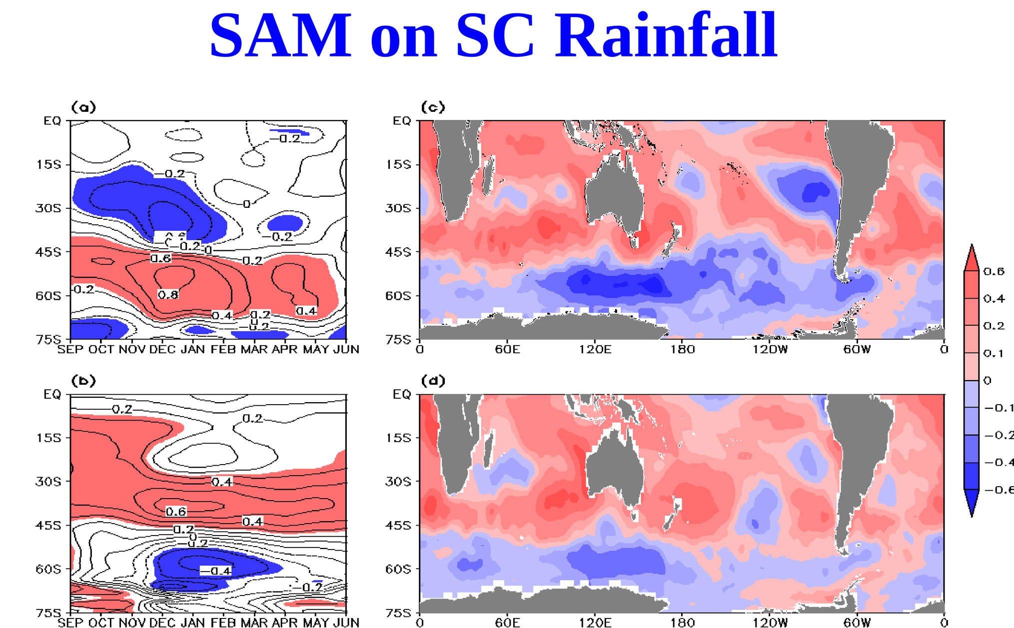


Fig.7 The lead-lag correlation between DJF SAMI and zonal mean zonal wind (a), and zonal mean SST (b), and composite differences in DJF SST (c) and MAM SST (d) between high and low DJF SAMI.

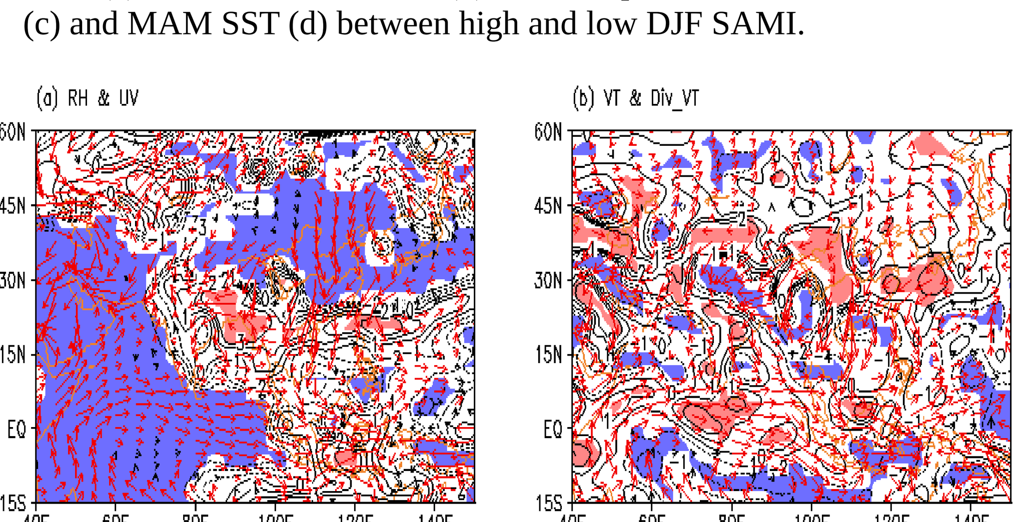


Fig.8 Same as Fig.5, but for spring ZSSTI.

ZSSTI (Zonal Mean SST Index) is defined as the difference between regional mean SST within 30°~45°S and 45°~70°S.

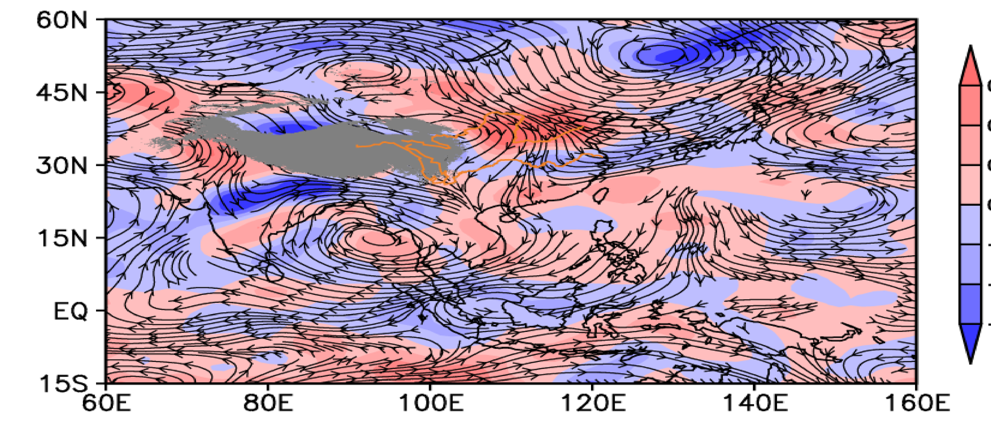


Fig.9 MAM 867 hPa wind field (stream, unit:m/s) and vertical velocity (shaded, unit:10^{-5}hPa/s) response to a high ZSSTI forcing in the CAM3.

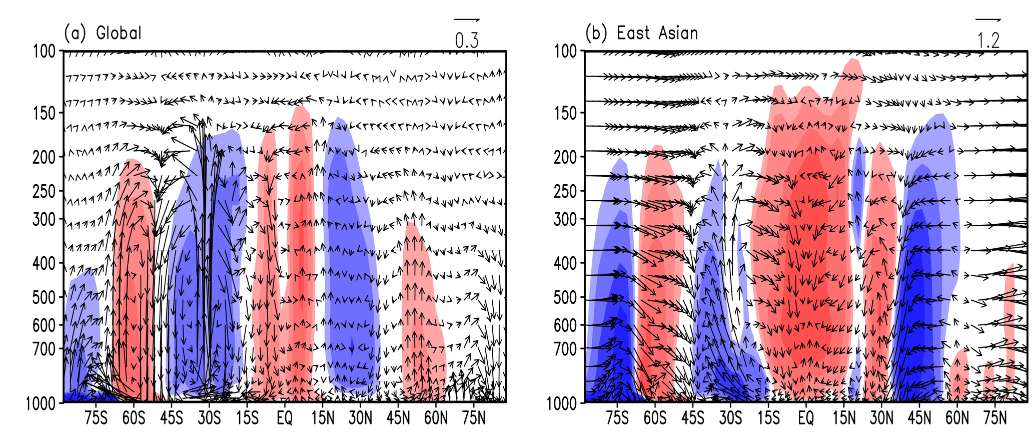
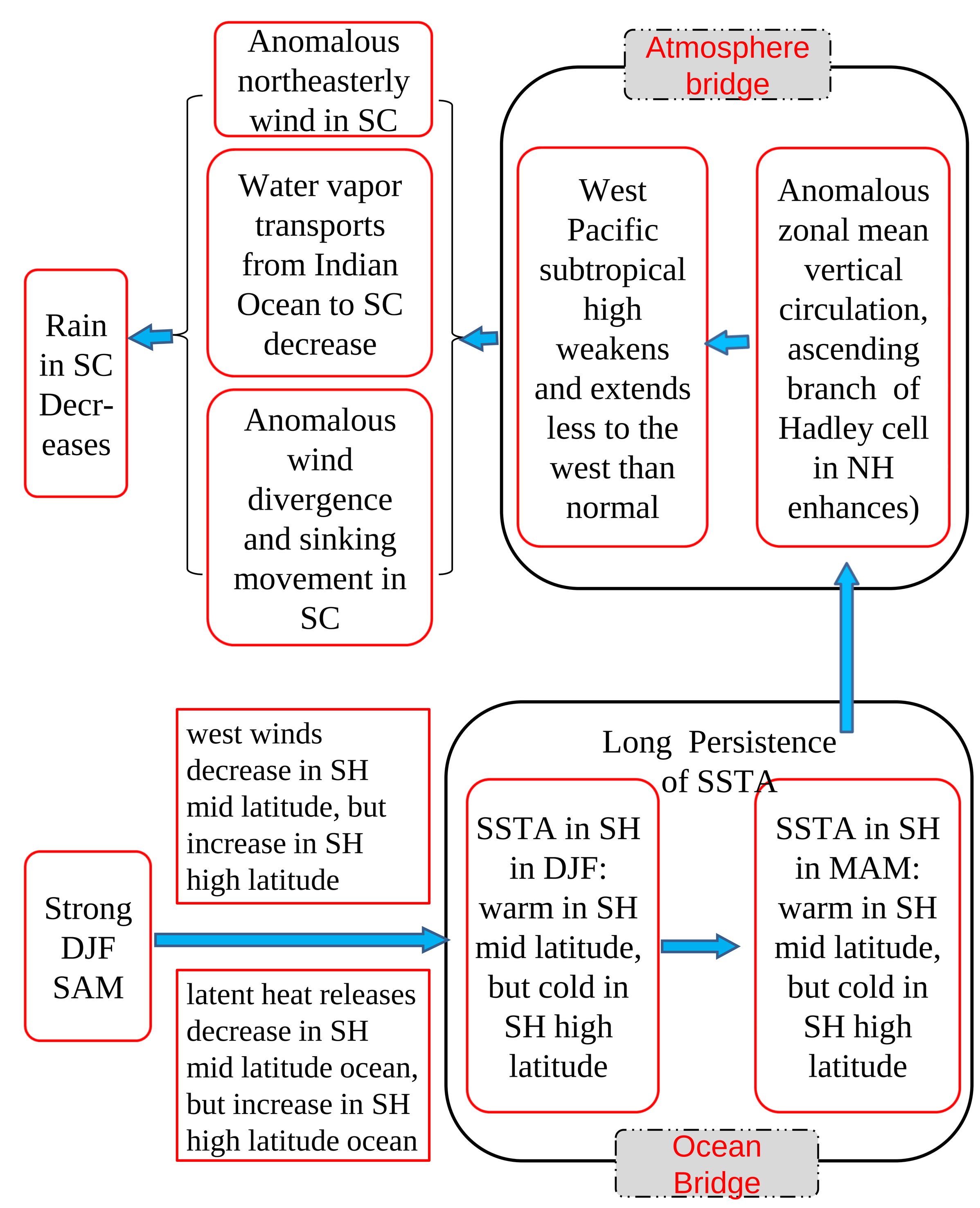


Fig.10 MAM zonal mean vertical circulation in global (a, 0° ~360° E) and in SC(b, 110° ~120° E) response to a high ZSSTI forcing in the CAM3 model. (The red (blue) shaded area indicates climatologic ascending (descending) motion)

6. Conclusion

1. There is a significant negative correlation relationship between the preceding DJF SAM and MAM precipitation in South China.

2. When the preceding DJF SAM is strong, latent heat fluxes increases/decreases because of the strengthened /weakened sea surface wind speed, thus leading to cold SSTA in 45°~70°S /(warm SSTA in 30°~45°S).



3. When the spring ZSSTI is strong, the West Pacific subtropical high weakens and extends less to west than normal years; an anomalous cyclonic circulation exists in West Pacific region; and there are anomalous northerlies in SC. All these conditions weaken water vapor transport from Indian Ocean to SC, and then lead to less rainfall in SC, and vice versa

Main References:

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