Evolution of wind patterns over the tropical summer monsoon region influenced by wintertime southern annular mode in the recent decades

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1. Introduction

Southern Annular Mode (SAM) (Limpasuvan and Hartmann, 1999), which is also referred to as high-latitude modes (Rogers and van Loon, 1982), is principle mode of variability in wind fields characterized by north-south vacillations over the southern polar region and the mid-latitudes. Association between SAM and the India summer monsoon rainfall (ISMR) has been examined in the recent decades 1983–2013, which indicate that February–March SAM is significantly related with the subsequent ISMR. A positive (negative) SAM during February–March is favorable (unfavorable) for the ensuing summer monsoon rainfall over the Indian sub-continent (Prabhu, et al. 2016). Further, linkages between SAM and the Korean Summer Monsoon Rainfall (JJA: KMR) based on the same data period demonstrates that the May-June SAM is positively connected with the subsequent KMR (Prabhu et al. 2017). In both these Asian summer monsoon subsystems, the sub-polar signal of SAM is relayed through the central Pacific Ocean. Considering the influence of SAM variability during late winter/early spring on the Asian summer monsoon subsystems, the evolution of wind patterns is assessed over the tropical domain (40°S to 40°N) across all the longitudes to understand its impact on the unexplored domain of African Summer monsoon along with South Asia (in particular India) and East Asia (in particular South Korea-Japan peninsula) summer monsoon regions.

2. Data

Monthly mean sea level pressure (MSLP) and winds (m/s) at 850 hPa have been obtained from National Center for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) reanalysis (Kalnay et al. 1996). Following Nan and Li (2003), SAM Index (SAMI) has been generated (SAMI = MSLP40 – MSLP70), wherein the parameters MSLP40 and MSLP70 represent normalized zonal MSLP values at 40°S and 70°S respectively. To evaluate the wind patterns generated from extreme episodes of wintertime (averaged over the months of January and February) SAM Index (SAMI), extreme positive and negative years of SAMI are identified. The years with standardized value of SAMI greater than +1 are referred as positive SAM years and less than -1 as negative SAM years. Further, simple statistical technique of composite analysis has been utilised.

3. Results

From the evolution of wind anomalies (Figure 1) from January through September at 850 hPa atmospheric low-level vector winds, following inferences have been drawn:

1) A weakened low-level (at 850 hPa) South Asian monsoon flow is evident during the negative extremes of SAM building up from May-June up to August-September, which inhibits monsoon circulation causing weakened rainfall over the Indian region, in agreement with the results shown earlier using February-March SAMI (Prabhu et al. 2016).
2) A weakened north Pacific sub-tropical high is also observed building up from May-June through July-August that constrains supply of moisture flux to East Asia, weakening its summer monsoon rainfall, in concord with study carried out earlier using May-June SAMI (Prabhu et al. 2017).
3) Further, over the African continent, the moisture laden low-level winds (May-June through August-September) from the Atlantic Ocean basin towards the western coast of Africa, which strengthens the rainfall particularly for the Sahel region, appears to have reversed, weakening its rainfall over this domain.

In summary, the high latitude SAM is significant to understand the dynamics of summer monsoon over the tropical belt. However, this is a preliminary study to understand the wintertime effect on the evolution of low-level wind patterns over the tropics encompassing important summer monsoon systems that requires thorough investigation.

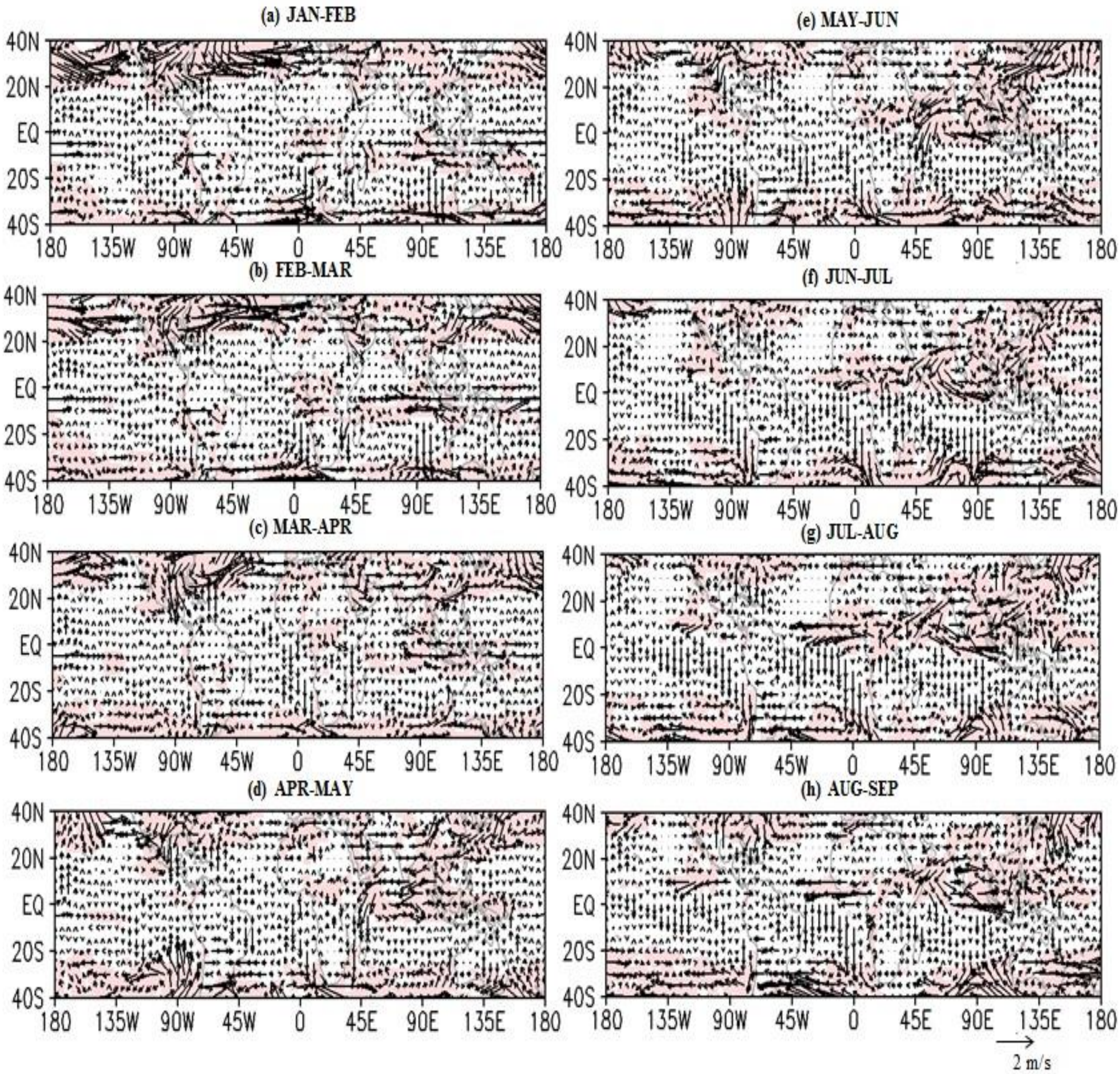

Figure 1. Winds at 850 hPa constructed from composites of 10 (Negative - Positive) modes of January-February SAMI extremes during the period 1983-2017. Significant differences at 95% confidence level in wind anomalies are shaded.

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