Large-scale features of active and break phases during Indian summer monsoon 2022

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1. Introduction

A substantial component of the Indian summer Monson (ISM) rainfall variability arises from the fluctuation on subseasonal scale between active and break spells. The subseasonal variation of monsoon rains over India have a strong bearing on the rainfed agriculture. Despite significant progress in understanding intraseasonal variability of ISM (Goswami, 2005), there is lack of understanding of the complex processes leading to active-break phases. The convection and circulation patterns fluctuate between active-break events, which are part of the large-scale shifts associated with monsoon intraseasonal oscillations (Annamalai and Slingo, 20001). The present study diagnoses the large-scale changes in the convection and circulation during active-break periods of contrasting rainfall conditions during ISM 2022, that are identified based on the criteria by India Meteorological Department as the periods in which the normalized anomaly of the rainfall averaged over the core monsoon zone (CMZ) (18- 28°N, 65°E-88°E) exceeds 1 or is less than −1.0 respectively, provided the criterion is satisfied for at least three consecutive days.

2. Data

Datasets used are: (a) Global Precipitation Climatology Project (GPCP) daily precipitation (mm) (1°x1°) (b) Daily wind (m/s), Geopotential height (GPH) (m) and vertical velocity (omega) (pascal/second) (2.5°×2.5°) at different vertical levels from National Center for Environmental Prediction/National Centre for Atmospheric Research (NCEP/NCAR) Reanalysis.

3. Results

To isolate the large-scale spatial structure of rainfall and circulation changes between an active (9-15th July 2022) and break (26th August – 3rd September 2022) spell, spatial plot of precipitation anomaly, wind anomaly at 850hPa, GPH at 200hPa, divergence anomaly at 200hPa and latitude-pressure section of vertical velocity (omega) averaged over the Indian longitudes (73°-82°E) depicting Hadley circulation is illustrated separately for active and break spell, along with the difference (active-break) spell in (Figure 1(a-o)) respectively. Precipitation anomalies features 'quadrupole' structure with enhanced (decreased) precipitation over central India, extending over the Bay of Bengal and equatorial west Pacific, while decreased (enhanced) precipitation over the south-eastern tropical Indian Ocean (SETIO) and northwest tropical Pacific during an active (break) phase (Figure 1(a, b)) (Annamalai and Slingo,2001). The low-level mean monsoon circulation, monsoon trough and the cross-equatorial jet over Somali is strengthened (weakened) in active (break) phase. The low-level anomalous anticyclonic circulation over head Bay of Bengal (BOB) caused reduced precipitation during break (Figure 1(d, e)).

In the upper troposphere, the local circulation associated with active phase is characterised by extended Tibetan anticyclone (TA) with two-cell structure of the core of TA (Basha et al. 2020). The extent of TA is less in break spell compared to active spell (Figure 1(g-i)). Intensified TA reinforced the strong horizontal divergence in the upper level (Figure 1j) initiating the outbreak of convection over India in an active phase. The upper-level divergence is enhanced over CMZ stretching south eastward to central and southeast BOB, Maritime continent, and equatorial west Pacific Ocean in active phase (Figure 1j), whereas it is enhanced over south peninsular India, southwest Arabian sea and SETIO during break phase (Figure 1k). Location and spatial pattern of strong positive upper-level divergence anomalies correspond well with those of increased precipitation anomalies. The intensified (weakened) lower and upper tropospheric flow over the monsoon domain corroborates that the large-scale Hadley circulation is substantially strengthened (weakened) during active (break) phase **(**Figure 1(m, n)). The enhanced low-level cyclonic (anticyclonic) circulation anomaly in the monsoon trough region during an active (break) condition (Figure 1 (d, e)) is associated with enhanced (decreased) ascending motion (Figure 1(m, n)), causing enhanced (decreased) precipitation over the monsoon trough region and decreased (enhanced) ascending motion and decreased (enhanced) precipitation over the equatorial warm waters (Figure 1(a,b)). Thus, regional Hadley circulation oscillates between northern position around the monsoon trough region and southern location over an equatorial ocean between an active (break) phase.

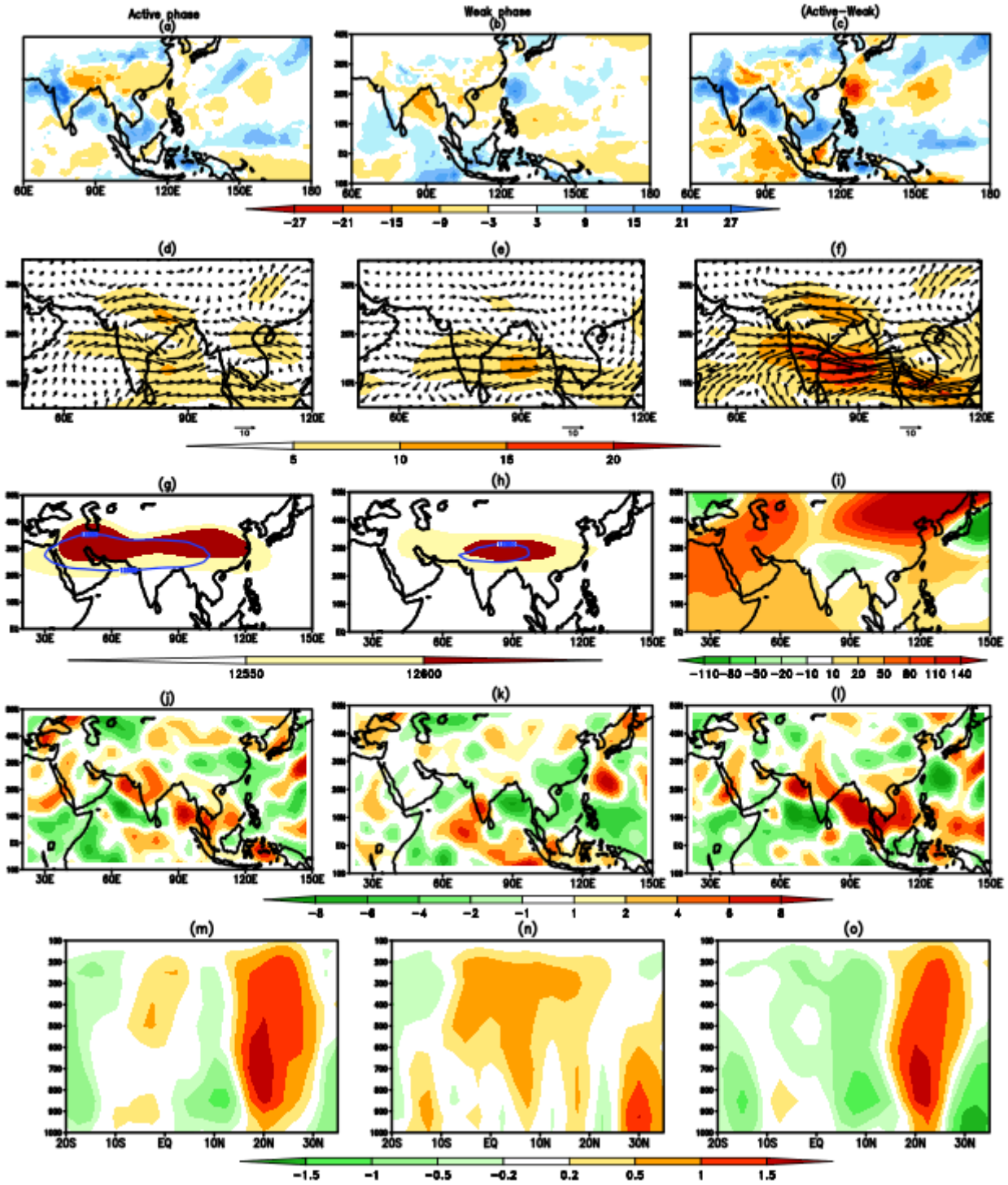

Figure 1. Spatial plot of precipitation anomaly for (a)Active spell (b)Break spell (c) Difference (Active-Break). (d, e, f) are same as (a, b, c) respectively, except wind anomaly at 850hPa. (g, h, i) are same as (a, b, c) respectively, except Geopotential height at 200hPa (shaded) overlaid by climatology (blue contour). (j, k, l) are same as (a, b, c) respectively except divergence anomaly at 200hPa ($*10^6$). (m, n, o) are latitude-pressure section of vertical velocity (omega*-10) averaged over Indian longitudes (73°-82°E) during Active spell, Break spell and difference (Active-Break) spell, respectively.

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