

Contrasting Indian summer monsoon rainfall in July and August 2023

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1. Introduction

The Indian Summer Monsoon rainfall (ISMR) during June to September (JJAS) accounts for about 70-90% of annual rainfall in India (Shukla and Haung, 2016). In 2023, the ISMR was 94% of its long period average, with contrasting all India rainfall in July and August (IMD, 2023) (Table 1). Striking feature is the above normal all India rainfall (+13%) in July, followed by the deficient rainfall (-36%) in August 2023, despite the presence of El Niño-Southern oscillation (ENSO) throughout the summer monsoon season (Blunden and Boyer, 2024). The coupled ocean-atmosphere processes in the Indian and Pacific Oceans are considered as the major external forcing of ISMR variability (Gnanaseelan and Chowdary, 2019; Hrudya et al. 2021). This study examines the influence of the ENSO and Indian ocean (IO) Sea surface temperature (SST) in the contrasting ISMR during July and August 2023.

2. Data

Following monthly mean datasets for July and August 2023 from multiple sources have been used for the analysis:

(i) Monthly mean Global Precipitation Climatology Project (GPCP) data (2.5°x 2.5°) from (<https://downloads.psl.noaa.gov/Datasets/gpcp/>). (ii) Monthly mean high-resolution NOAA OISST V2 (0.25° x 0.25°) from (<https://downloads.psl.noaa.gov/Datasets/noaa.oisst.v2.highres/>). (iii) Monthly mean Vertical velocity (ω , pascal/sec) (2.5° × 2.5°) at different vertical levels has been acquired from National Centers for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) reanalysis at (<https://psl.noaa.gov/data/gridded/index.html>). (iv) Southern Oscillation Index (SOI) from (https://psl.noaa.gov/gcos_wgsp/Timeseries/SOI/) (v) Niño3 SST index from (https://psl.noaa.gov/gcos_wgsp/Timeseries/Nino3/).

3. Results

To assess the role of ENSO in the contrasting ISMR of July and August 2023, Table 1 presents the percentage departure of all India rainfall, SOI, Niño3 SST index for July and August 2023. Largest negative SOI and anomalously warmest East Pacific SST over Niño3 region in August compared to July, evidently suggests the impact of ENSO in the contrasting ISMR of July and August 2023. Further, monthly mean precipitation over large Indo-Pacific region (60°-120°E, 0-40°N) for July and August 2023 (Figure 1 (a-b)), along with corresponding anomalies (Figure 1 (c-d)), clearly reveal the large spatial variation of precipitation in both the months. Widespread positive (negative) precipitation anomalies over India in July (August) 2023 are conspicuous. Monthly mean SST anomalies over IO (Figure 1 (e-f)) delineates extensive warming over the North Indian Ocean (NIO) from 0-25°N in August, encompassing the Arabian Sea (ARB), Bay of Bengal (BOB), and the northern parts of western Pacific Ocean as well (Figure 1(f)). The equatorial and southwest IO is warm as well in August 2023. Such widespread ocean warming is absent in July 2023. Moreover, southern equatorial IO is anomalously cool in July. The latitude-pressure section of vertical velocity (ω) averaged over the Indian longitudes (75°-83°E) (shaded), from Eq-40°N (Figure 1(g)), illustrates an intensified ascending motion extending across the depth of troposphere from about 17°-28°N over India in July, corresponding to increased convection. On the contrary, weakened ascending branch limited to narrow latitudinal belt (25-28°N) up to 200hPa is observed in August (Figure 1(h)). The ascending motion over India is substantially strengthened (weakened) in July (August) (Figure 1(g-h)), due to enhanced (suppressed) convection. IO is comparatively cooler (warmer) in July (August) leading to increased (decreased) land-ocean thermal contrast and consequently enhanced (suppressed) convection over India. The descending motion around 10°-13°N in August extends deep up to the upper troposphere, while it is intense and extremely shallow (confined to 700hPa) in July. Thus, intensified (weakened) ascending branch

is in the northern position around the monsoon trough region in the July (August), when monsoon is strong (weak), in response to IO SST. The combine influence of the coupled atmosphere-ocean processes linked with the ENSO and IO SST on the contrasting ISMR in July and August 2023 is highlighted by the results.

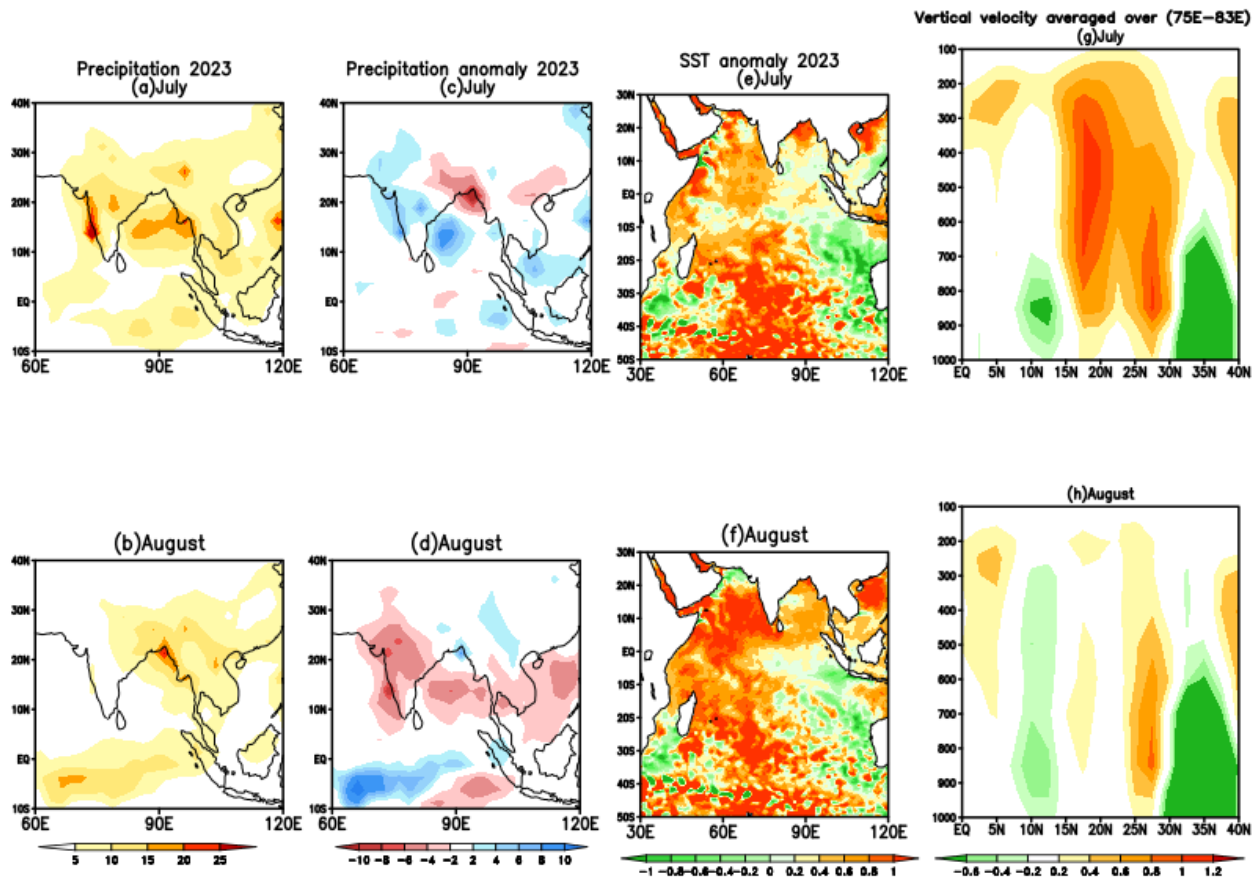


Figure 1 (a-b): Monthly mean (GPCP) precipitation for July and August 2023, respectively.
(c-d): Same as (a-b) except for monthly mean precipitation anomaly.
(e-f): Same as (c-d) except for monthly mean (NOAA OISST V2) SST anomalies.
(g-h): Latitude-pressure plot of vertical velocity (ω) averaged over Indian longitudes (75° - 83° E).

Table 1. Monthly mean percentage departure of all-India rainfall and ENSO indices

Month (2023)	All India rainfall (% departure) (IMD)	SOI	Niño3 SST Index
JULY	+13%	-0.38	1.72
AUGUST	-36%	-1.60	2.09

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