

43

Years of Data · 1981–2023

36

Meteorological Subdivisions

MAM & DJF

Peak Hail Season

> 250%

MAM CV in Central India

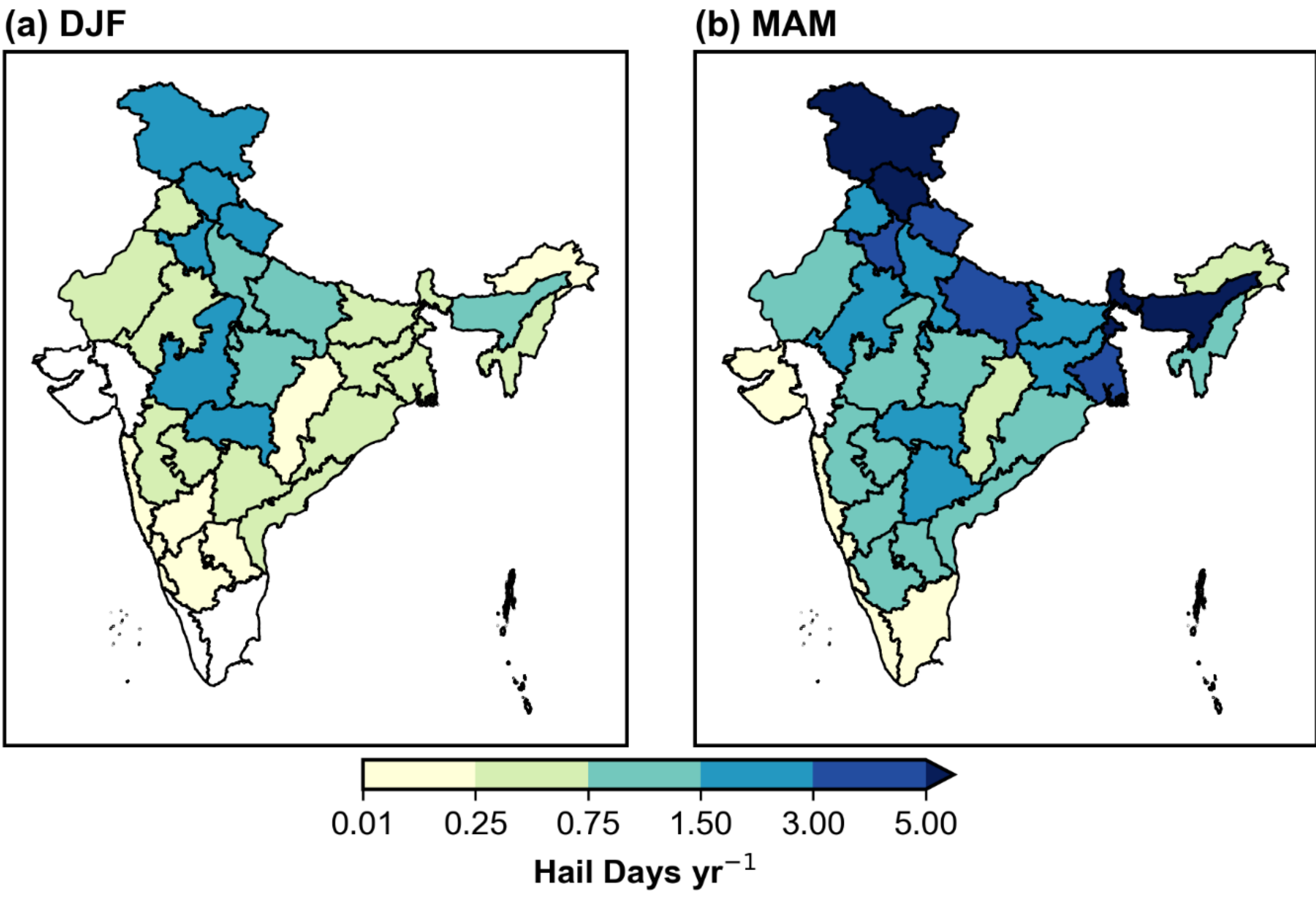
1 · Research Overview

Why this study? Hailstorms are amongst the most severe localized convective weather systems, and the scarcity of ground-based surface observations has made it difficult to establish a consistent long-term climatology. This research utilizes a merged dataset consisting of daily surface-observatory reports and the IMD Disastrous Weather Event (DWE) archive to build a 43-year (1981–2023) record across 36 meteorological subdivisions.

Methodology:

- To discuss hailstorm climatology over the Indian region across 36 subdivisions.
- To understand interannual variability, long-term trends and decadal changes over the peak months.
- To examine the synoptic evolution of various parameters around hail events.

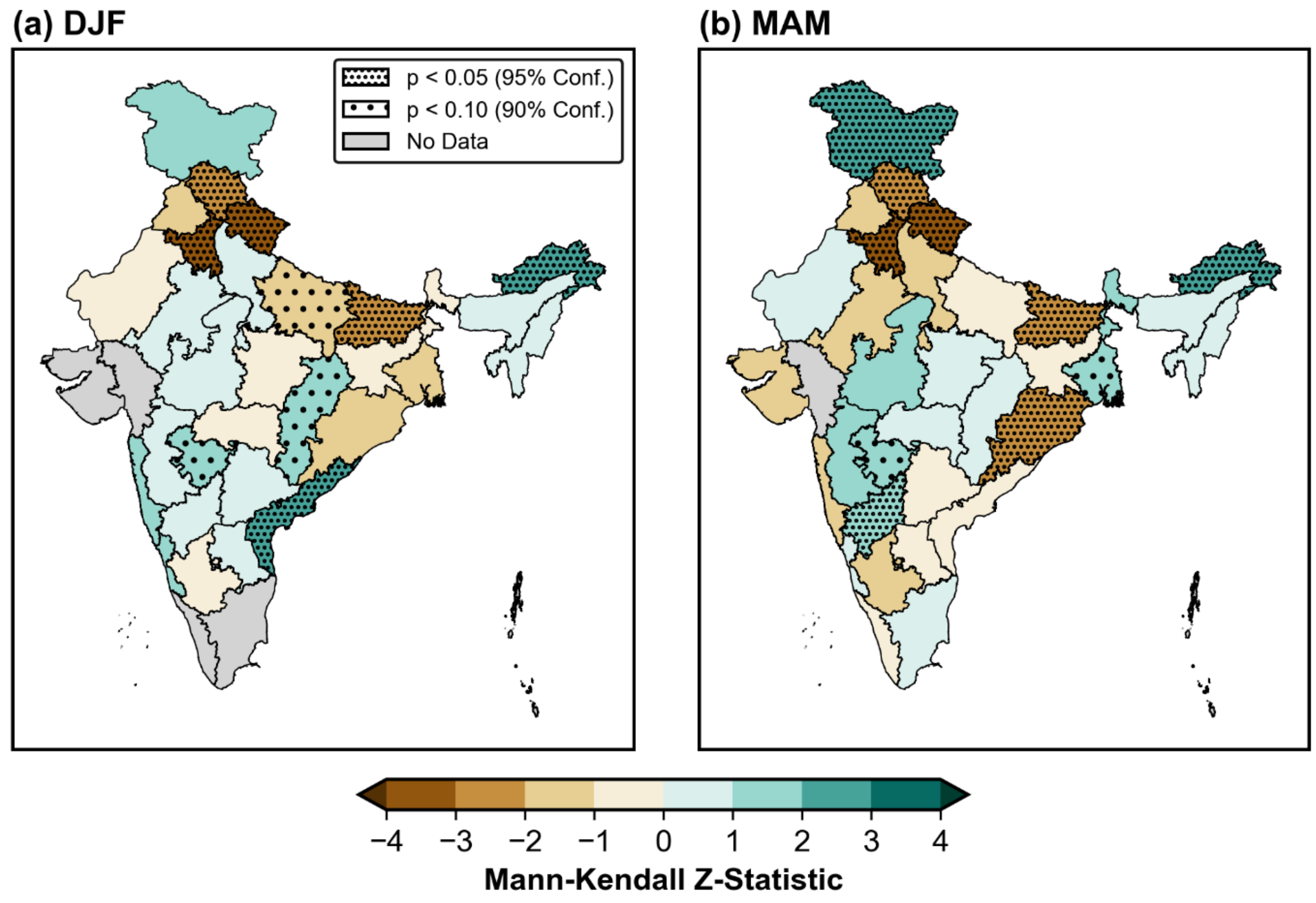
3 · Seasonal Climatology



Average hail frequency yr^{-1} by subdivision: (a) DJF and (b) MAM, 1981–2023.

- MAM is the dominant hail season across most subdivisions.
- The highest MAM hail frequencies exceed 3 days yr^{-1} in the Western Himalaya and Northeast India subdivisions, and 1 day yr^{-1} across subdivisions of Northwest and Central India.

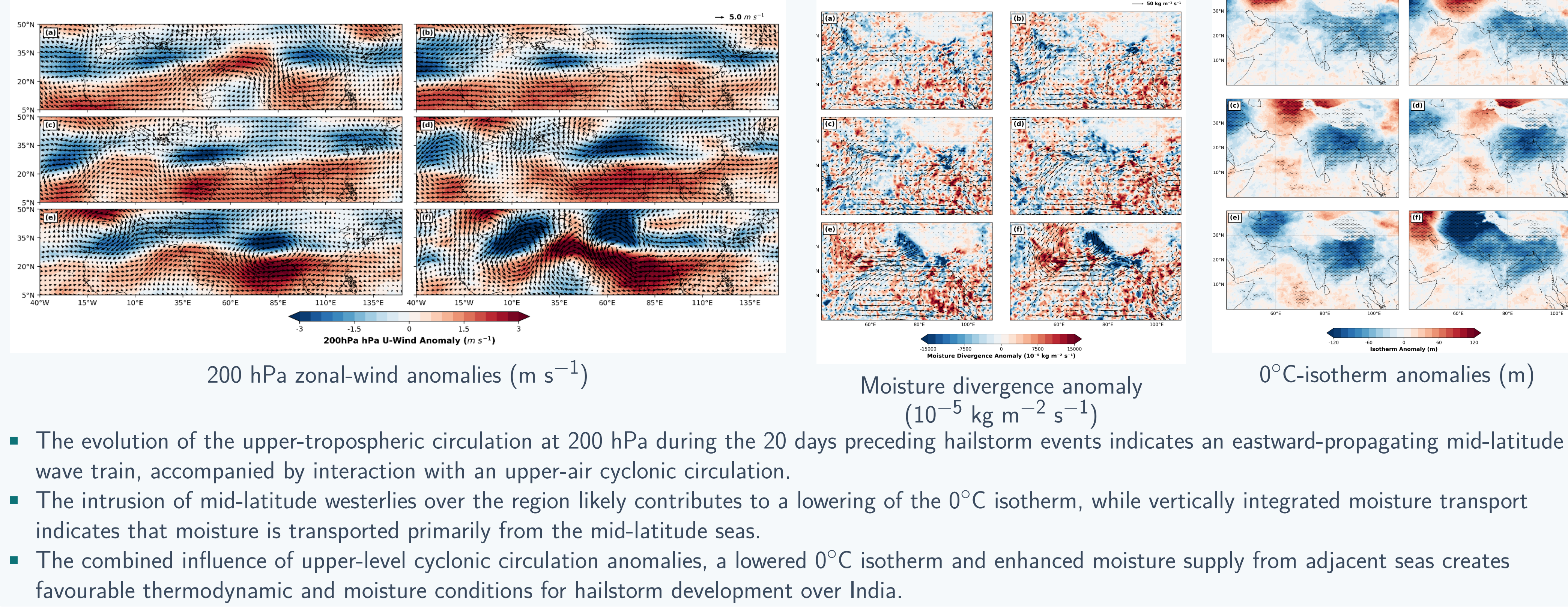
5 · Long-Term Trends



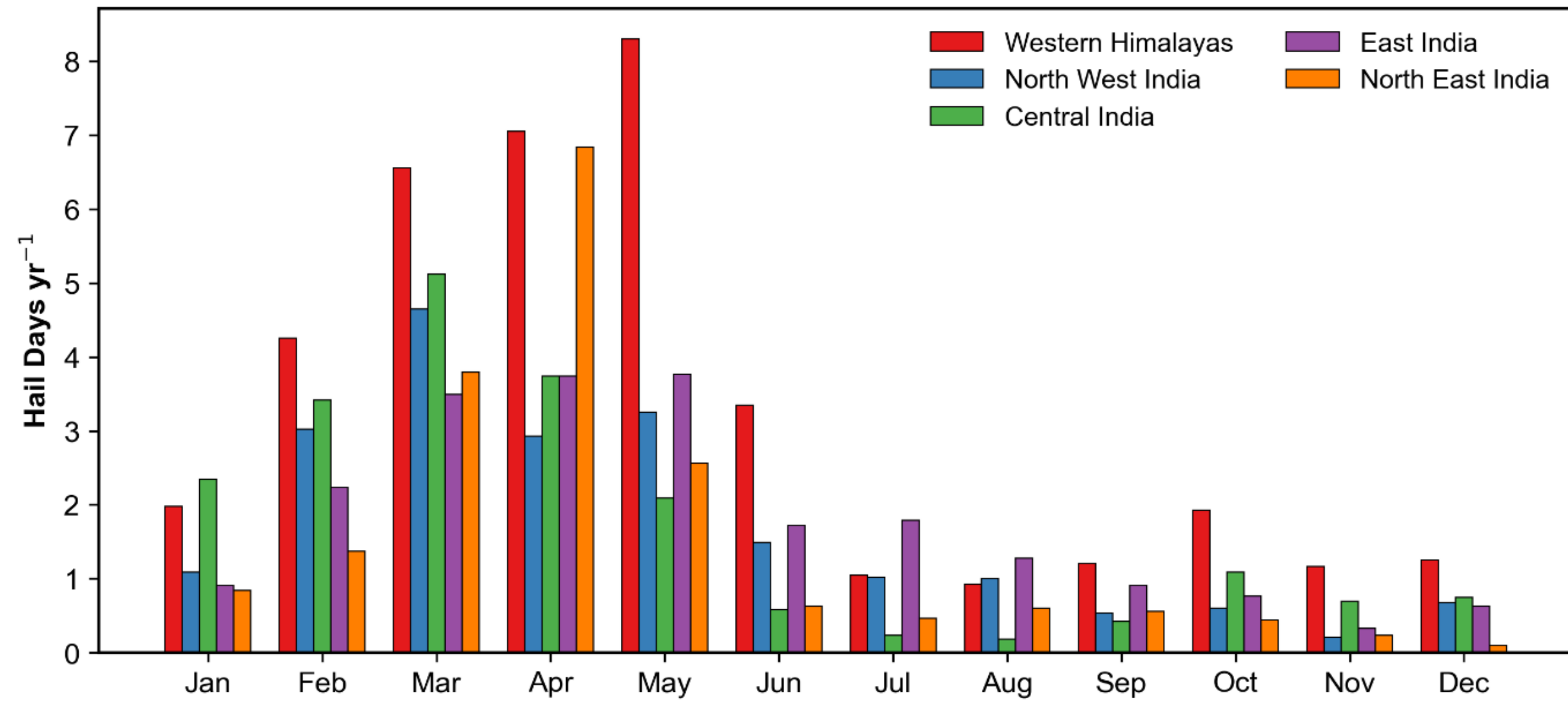
Mann-Kendall Z ; dense and sparse stippling indicate $p < 0.05$ and $p < 0.10$.

- The Western Himalayan and East India regions show significant decreasing trends in DJF, while Northwest India shows a significant decrease in MAM ($p < 0.05$).
- Significant increasing trends are observed over parts of Maharashtra, Marathwada and Vidarbha, with Mann-Kendall Z values ranging from +1.5 to +3.0.

7 · Synoptic Evolution



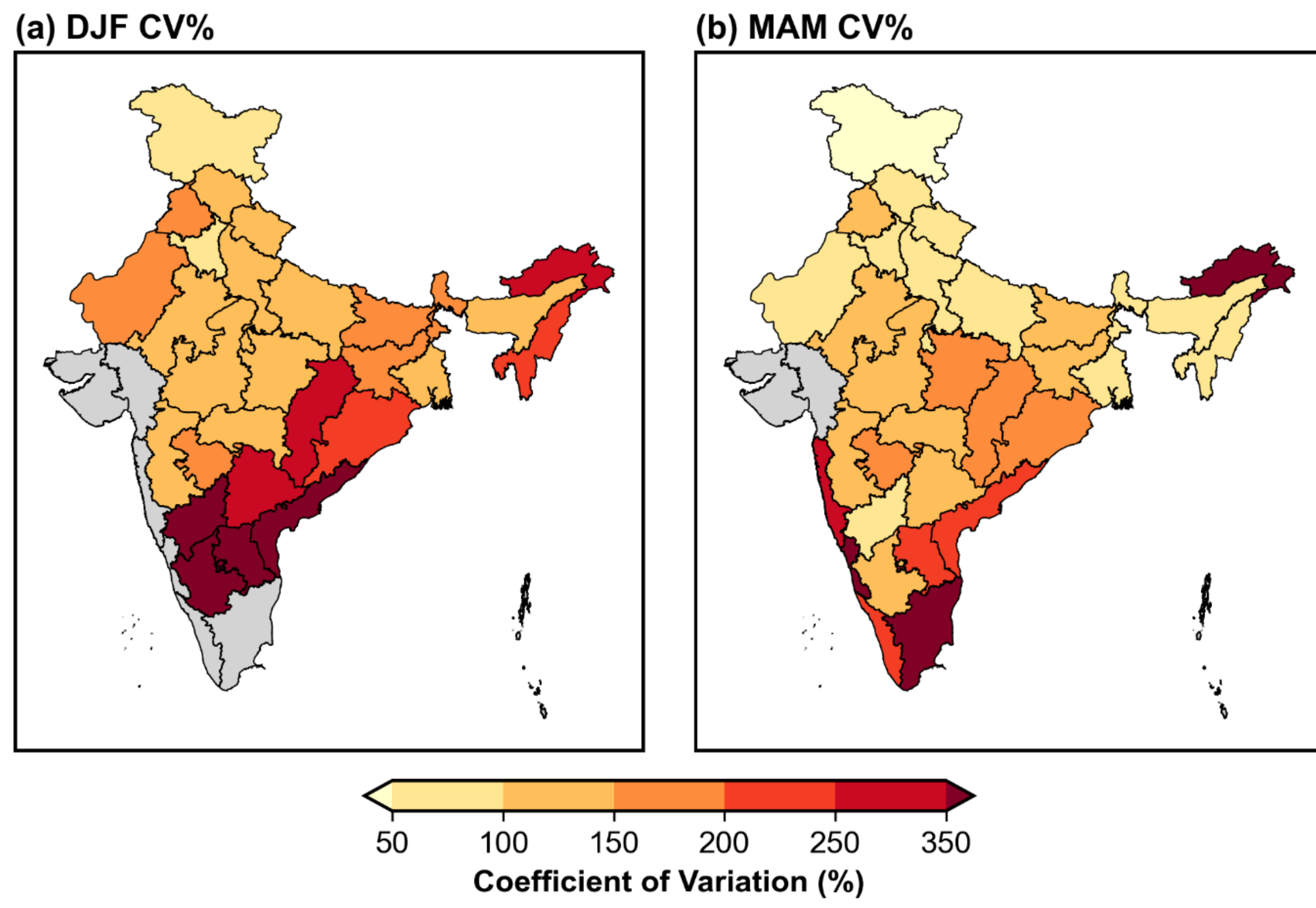
2 · Annual Climatology



Average hail frequency (hail days yr^{-1}), 1981–2023.

- Hail occurrences dominate during the pre-monsoon season (MAM) across regions of India.
- The winter season (DJF) shows a secondary, more localized peak, restricted mainly to the Western Himalaya and Northwest India.

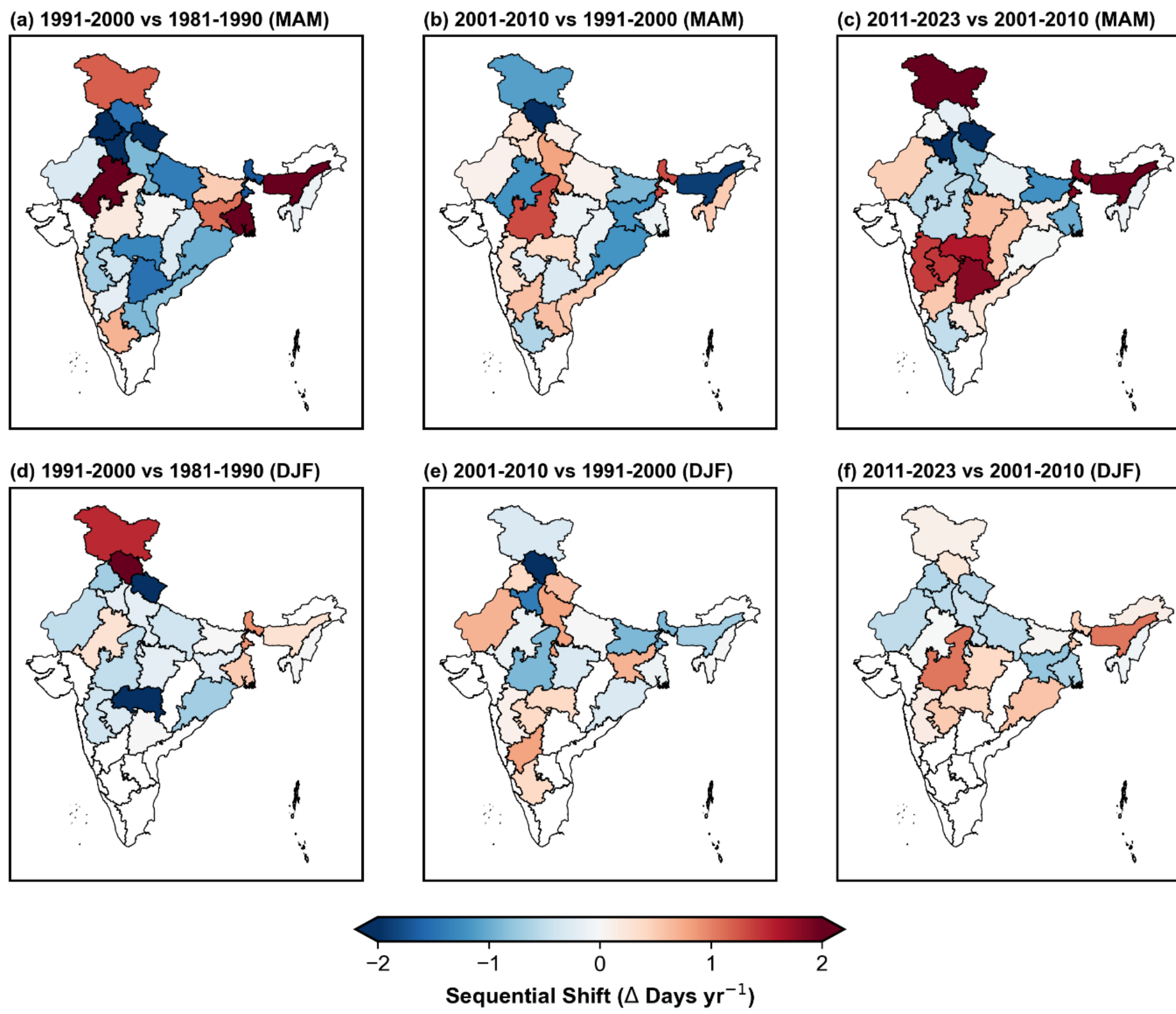
4 · Interannual Variability



CV (%) of seasonal hail frequency, DJF and MAM, 1981–2023.

- CV is comparatively low (50–100%) in the Western Himalaya and Northeast India.
- CV exceeds 250% in parts of Central India, indicating episodic events relative to the mean, not high absolute frequency.

6 · Decadal Change



Sequential Decadal Changes (days yr^{-1}): MAM (a–c), DJF (d–f)

- The strongest positive MAM shift occurs in 2011–2023 versus 2001–2010, especially across Central India.
- Marathwada and Vidarbha subdivisions approach $+2 \text{ days yr}^{-1}$.

8 · Conclusions and Discussion

- The merged sub-divisional database combines surface-observatory reports with the IMD Disastrous Weather Event archive across 43 years and 36 subdivisions, providing a more complete and spatially continuous record of hailstorm occurrence than either source alone.
- The seasonal climatology, variability and trend analyses reveal substantial regional heterogeneity rather than uniformity.
- The apparent co-occurrence of low-level moisture convergence, mid-level cold advection and upper-level divergence on Day 0 offers a potentially useful signature for operational hailstorm forecasting.

Contact



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