

1981-2021年中国骤发干旱加剧 The intensification of flash droughts across China from 1981 to 2021

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What is the flash drought?

- Flash drought, compared with traditional climate drought, has the characteristics of sudden occurrence, rapid development, and heavy damage, accompanied by rapid loss of soil moisture, possible high temperatures, and even heat wave events (Otkin et al. 2013, 2018; Wang et al. 2016).
- In Yuan's definition (Wang and Yuan 2022), flash drought events are considered based on the pentad scale (5 days).
 - If the pentad-mean soil moisture percentile in the root zone decreases from above 40th to 20th with an average decline rate of no less than 5% in percentile per pentad, a flash drought event starts.
 - The event ends when the soil moisture rises above the 20th percentile with a duration of more than 4 pentads.
- To avoid unreasonable implications for ecohydrological management, we added an absolute soil moisture variation criterion to the established criteria.
- The soil moisture percentile dropping from 40th to 20th simultaneously with an absolute soil moisture variation larger than $0.01 \text{ m}^3 \text{ m}^{-3}$.

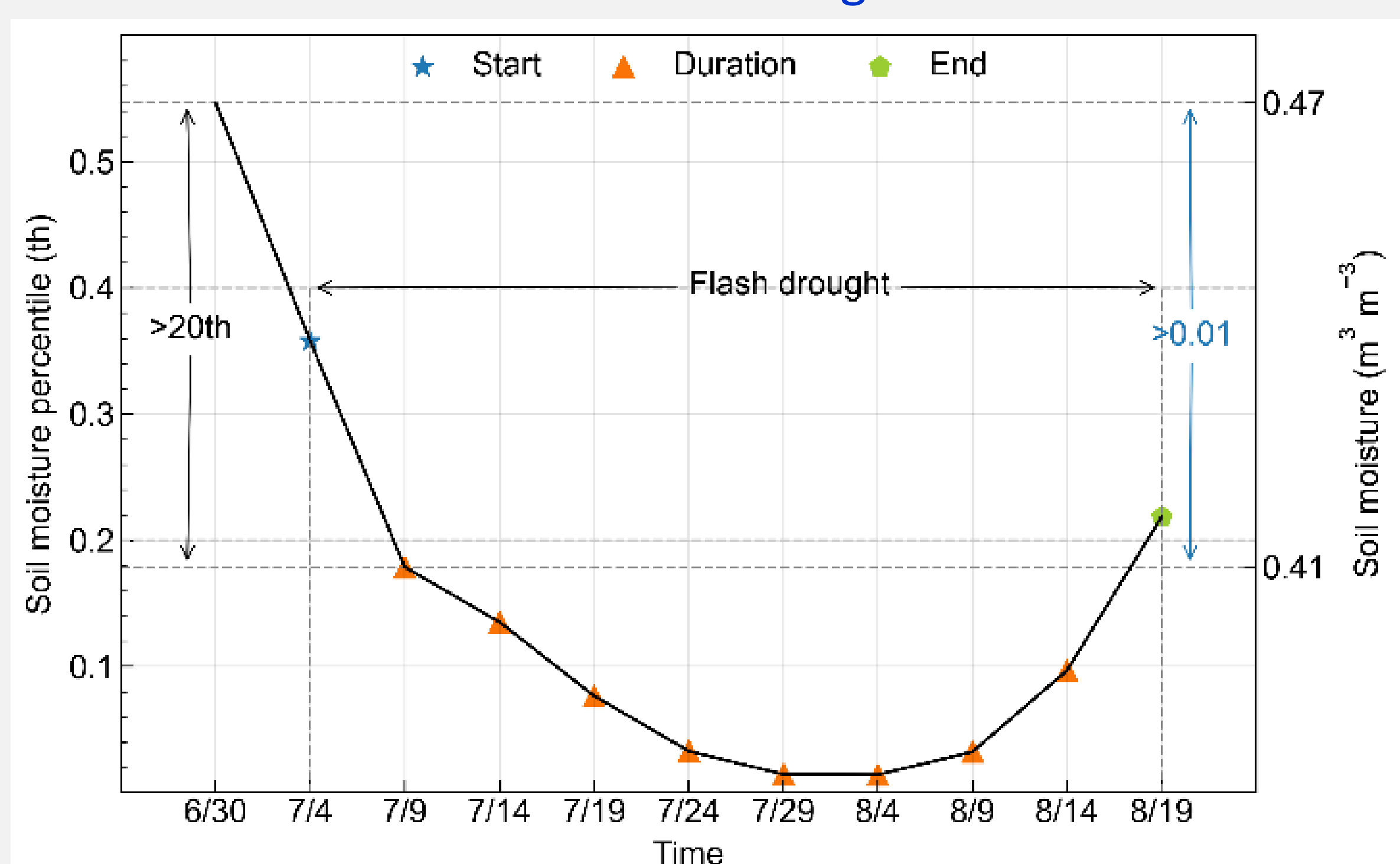


Fig. 1 Schematic diagram for a flash drought event. The solid black line presents the pentad mean soil moisture percentile on a grid point (25°N , 112°E) during the 2007 flash drought

Temporal characteristics of flash droughts

- In North China, Northwest China, the Yangtze-Han River, and the Yangtze-Huaihe River basins, upward trends were significant.
- Decreasing trends were observed in the peripheral regions of the Tibetan Plateau and parts of the arid zone.

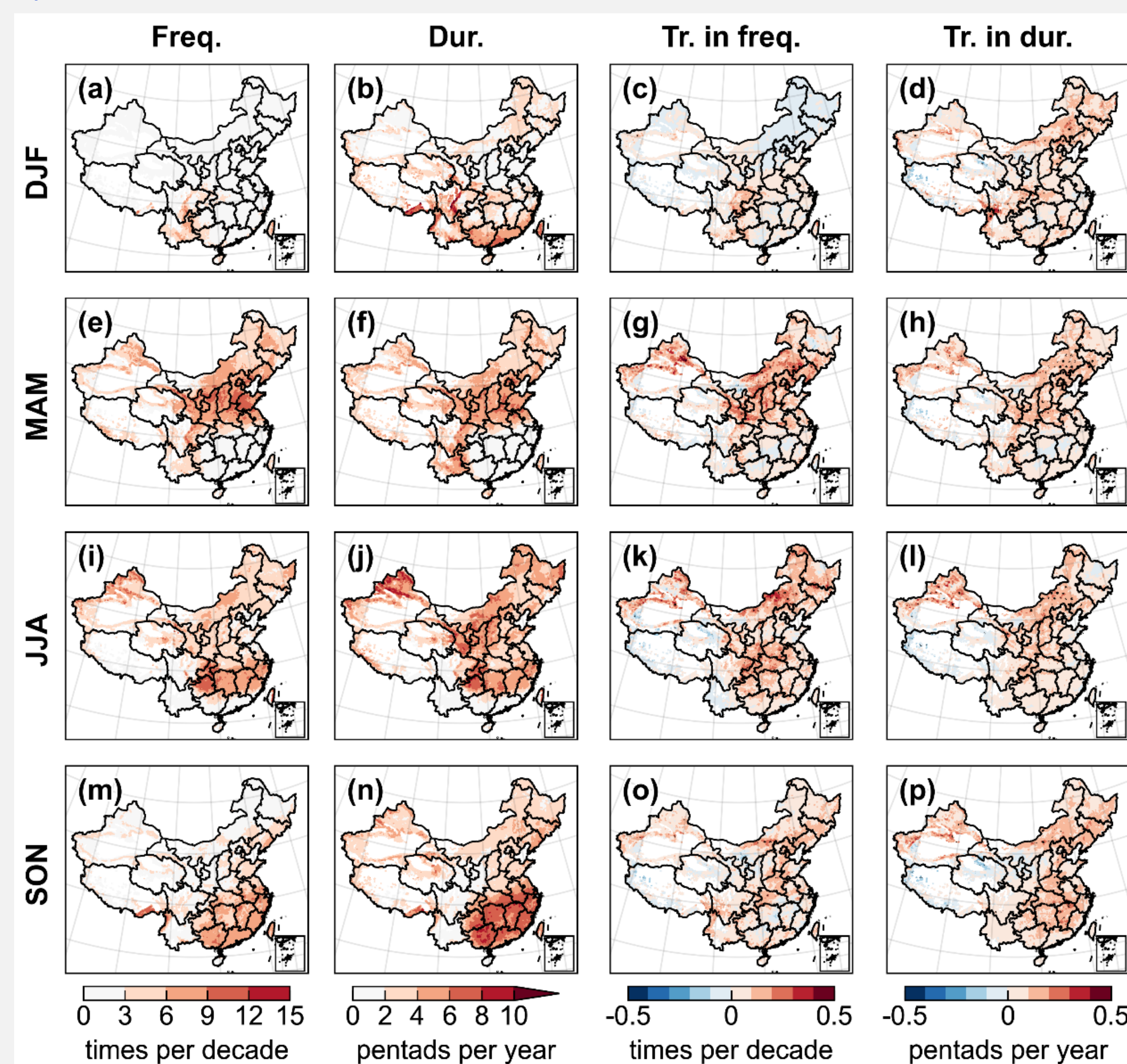


Fig. 4 Spatial distribution of seasonal changes in the frequencies, total durations, and their trends ($p < 0.01$) for flash droughts in China from 1981 to 2021

Spatial characteristics of flash droughts

- Flash drought hotspot regions were mainly located in North China and the Yangtze River Basin.
- Long-lasting flash drought events were prone to appear in Northeast and South China.
- The mountainous regions were prone to high-frequency flash droughts.

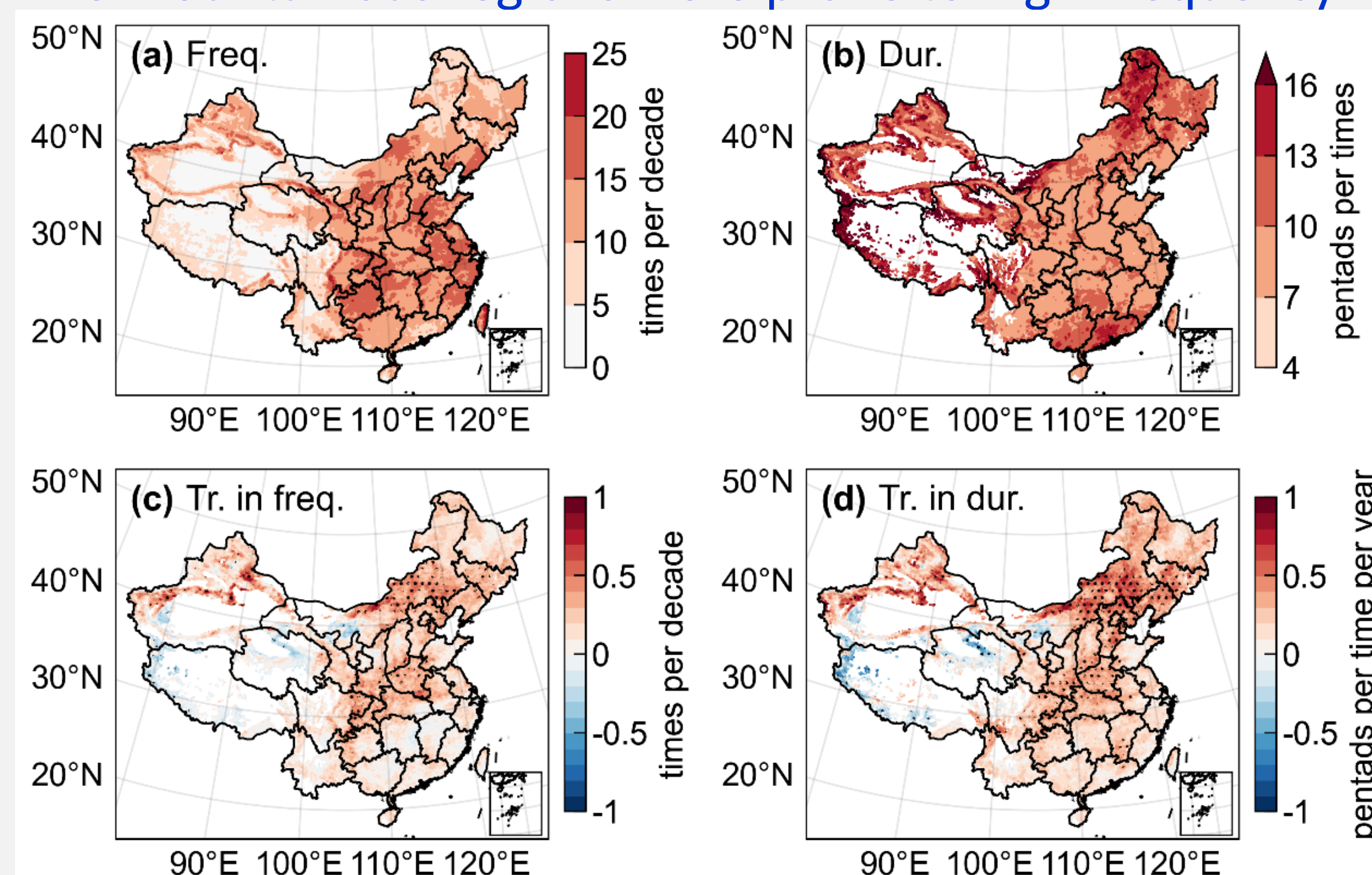


Fig. 2 Spatial distribution of the frequencies (a), mean durations (b), and trends of the two characteristic variables (c, d, $p < 0.01$) of flash droughts in China from 1981 to 2021. Areas with less than 5 events per decade were excluded.

Flash droughts response to surface water balance

- Hotspot regions emerging from North China to the Yangtze River Basin to South China were in turn changeably dominated by soil moisture gain and loss processes, which were driven by the regime of surface water and solar radiation balances across various climate zones.

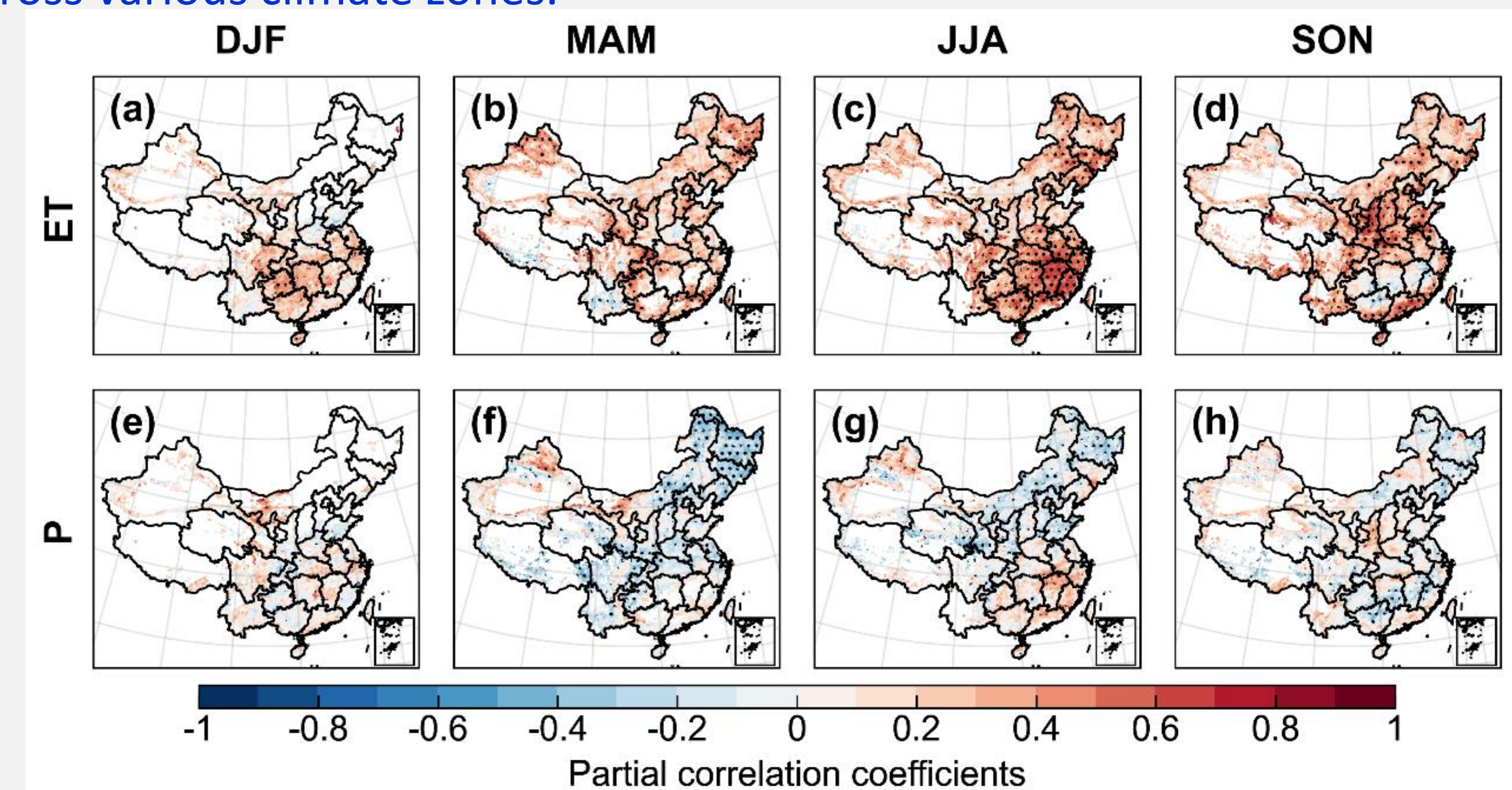


Fig. 5 Spatial distribution of seasonal changes in partial correlation coefficients ($p < 0.05$) between frequencies of flash droughts and evapotranspiration (a-d) and precipitation (e-h) anomalies in China from 1981 to 2021

Temporal characteristics of flash droughts

- Flash drought frequencies and durations overall increased, in terms of both mean and extremely high values, from the 1980s to the 2010s.
- The probability density functions of the surface atmospheric aridity index (AI) showed a slight increase in dryness. The soil tends to amplify the atmospheric dry anomalies forced by land-atmosphere feedback with climate change over the past 41 years.

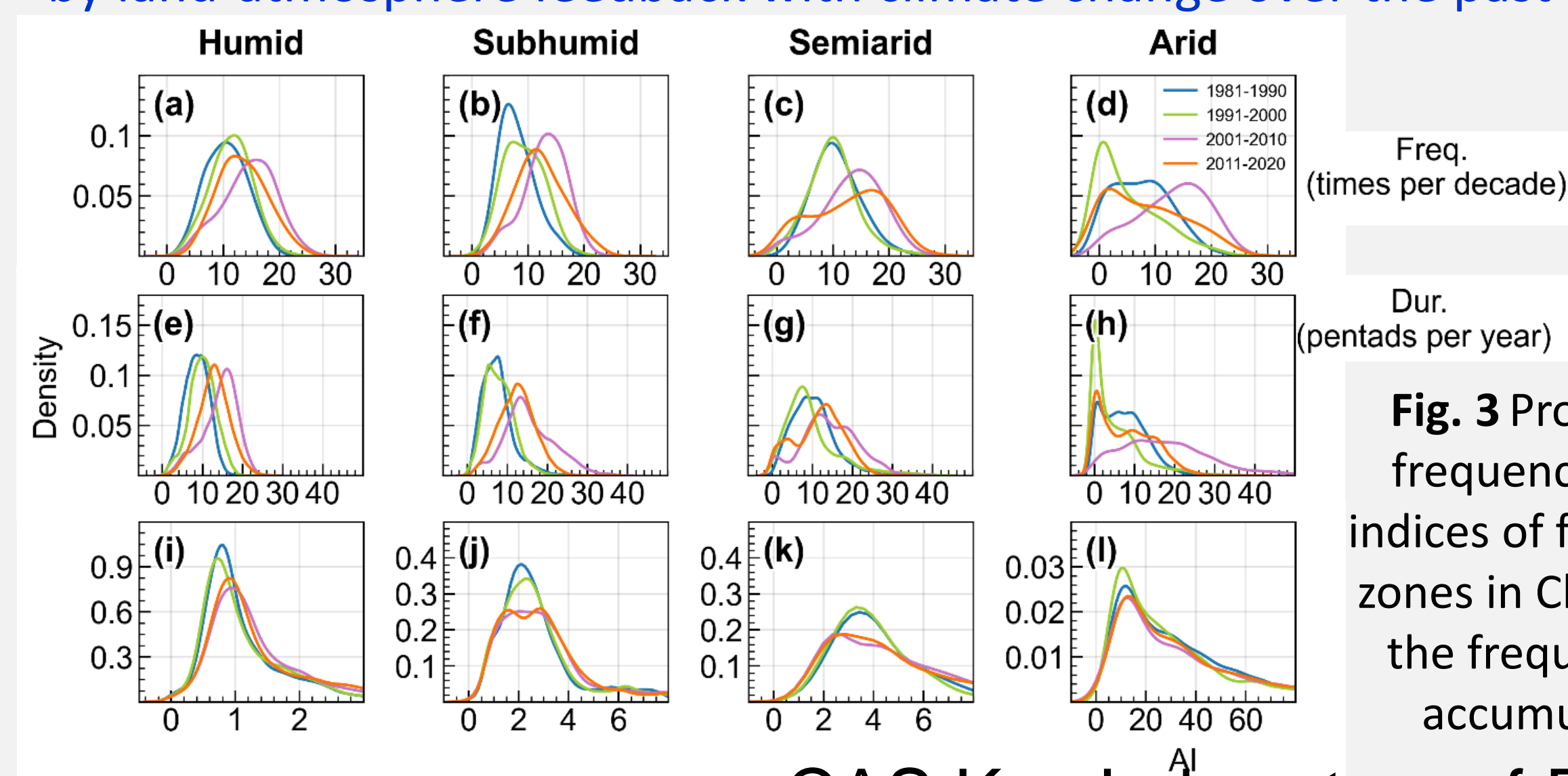


Fig. 3 Probability distribution of the frequencies, total durations, and AI indices of flash droughts in four climate zones in China from 1981 to 2020, and the frequencies and durations were accumulated on a monthly scale

Summary

We detected flash drought events across China during 1981-2021 and characterized their frequency, duration, and affected area changes, using soil moisture data from ERA5-Land. Results show that:

- Flash drought hotspots appeared in North China and the Yangtze River Basin.
- During 1981-2021, the hotspots, even nationwide, underwent significant increases in frequencies, durations, and affected areas of flash droughts. Especially, North China saw the most extensive and rapid increases.
- Seasonally, flash drought frequencies and durations intensified more during spring and autumn, and seasonal hotspots in eastern China shifted in phase with spatial patterns of soil moisture loss balanced by precipitation and evapotranspiration. Thus, flash droughts tended to amplify atmospheric aridity.

Zhang S., Li M.*, Ma Z., Jian D., Lv M., Yang Q., Duan Y., Amin D., 2023: The intensification of flash droughts across China from 1981 to 2021. *Climate Dynamics* (under review)

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