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Multi-Scale Synergistic Characteristics and Temporal Structure of Extreme Precipitation over China

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Using high-resolution hourly precipitation observations over China from 2010 to 2024, this study investigates extreme precipitation from a multi-time-scale synergistic perspective, with emphasis on its temporal structure and concentration characteristics. Extreme precipitation series at 1-, 3-, 6-, 12- and 24-hour accumulation scales were constructed to reveal regional differences in persistence and explosiveness. Results show that extreme precipitation in North China is dominated by short-duration intense rainfall, while in the northern Sichuan Basin it is mainly characterized by long-lasting events, and South China and the Yangtze-Huaihe region exhibit mixed features. Sub-daily contribution analysis indicates that, in most parts of central and eastern China, the major portion of 24-hour extreme precipitation is concentrated within the first three hours, highlighting the dominant role of short-lived mesoscale convective systems. An Extreme Concentration Index (ECI) is further proposed by integrating actual precipitation contributions with climatic background thresholds, enabling quantitative classification of temporal concentration. The spatial pattern of ECI reveals pronounced geographical differences in the temporal structure of extreme precipitation and shows strong relevance to different disaster risk types. Based on ECI classification, region-specific conceptual forecasting models and refined prediction strategies are developed, providing an effective scientific framework for improving extreme precipitation forecasting and risk prevention.