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• Editorial Notes •

Preface to the Special Collection on the July 2021 Zhengzhou, Henan Extreme Rainfall Event※

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A period of extreme rainfall occurred from 17 to 22 July 2021 in Henan Province of China where the accumulated precipitation in the 6-day period exceeded 1000 mm, which is more than the mean annual precipitation in the region. The rainfall was particularly intense on 20 July 2021, especially over Zhengzhou City, the capital of Henan Province and home to more than 10 million people. Hourly rainfall of 201.9 mm was measured at a station in Zhengzhou, breaking the station hourly rainfall record for all of mainland China. Major urban flooding occurred in Zhengzhou, leading to submerged subway trains and city road tunnels.

Towards the goal of understanding the dynamic, thermodynamic, microphysical, and land surface and boundary layer processes and conditions leading to this extreme event, and to understand the large-scale influence and control on the regional processes, a special collection of six articles that investigate some of the above questions is published in this issue. The predictability of such extreme events from seasonal down to short-range forecasting scales is also examined. These articles are briefly introduced below.

In Zhang et al. (2023), large-scale and mesoscale features and processes for the Zhengzhou extreme rainfall event are investigated based on station observations and reanalysis data. The study suggests that planetary-scale wave disturbances, potential vorticity (PV) streamers, and two typhoons played important roles in providing the critical moisture and instability conditions for this event, and a meso-β-scale vortex helped maintain the extreme rainfall.

More local processes leading to the record-breaking hourly rainfall over Zhengzhou in the late afternoon of 20 July are investigated in Wei et al. (2023). Their convection-allowing simulation results show that the extreme rainfall takes place in an environment similar to that of warm-sector heavy rainfall, with abundant warm moist air transported from the ocean by an abnormally northward-displaced western Pacific subtropical high (WPSH) and typhoon In-Fa (2021). A quasi-stationary storm is supported by and held in place over Zhengzhou by low-level converging flows from east, south, and north of the city. The barrier effect of the Taihang Mountain to the north, in which easterly flow is deflected towards the south and converges with the flow from the south over Zhengzhou, is highlighted. Strong low-level easterly flow containing rich moisture further prevents eastward propagation of rain-induced cold outflow, causing the sustained intense rainfall over Zhengzhou that breaks the hourly rainfall record.

Luo and Du (2023) focus on the possible roles of low-level jets (LLJs) over the extreme rainfall period. Both synoptic-scale LLJs (SLLJs) and boundary-layer jets (BLJs) are identified as playing important roles. The study finds that the meridional shifts of rainfall correspond well to the varying directions of LLJs, and the precipitation maximum during 20–21 July occurs as the LLJs strengthen and expand vertically into double LLJs, including a SLLJ at 850–700 hPa and a BLJ at ~950 hPa. The coupling of the LLJs provides favorable convergence-divergence forcing for heavy precipitation. The formation mechanisms of the two types of LLJs are also discussed.

The large-scale precipitation efficiency (LSPE) and cloud microphysical precipitation efficiency (CMPE) of the Zhengzhou extreme rainfall event are analyzed based on a model simulation in Yin et al. (2023). Strong low-level moisture flux convergence is identified as a key factor influencing LSPE. Moisture transported by the flow between typhoon In-Fa (2021) and the WPSH, and the southerly flow of typhoon Cempaka, converge in Zhengzhou due to the blocking by the Taihang Mountains to the north and the Funiu Mountains to the west, leading to high LSPE in Zhengzhou. The main microphysical

※ This paper is a contribution to the special collection on the July 2021 Zhengzhou, Henan Extreme Rainfall Event.

processes leading to high CMPE are analyzed through microphysical budget analyses. The intrusion of cold and dry air at the middle and upper levels is suggested to also play a role in enhancing the precipitation.

The potential influence of urbanization effects on the extreme precipitation in Zhengzhou is investigated in Luo et al. (2023) through two sets of ensemble forecasts with the real land cover and with cities within the innermost 1-km domain removed, respectively. The cities to the south through east sides of Zhengzhou are found to reduce precipitation in Zhengzhou by reducing evapotranspiration in the boundary layer and slowing down the boundary layer flows towards Zhengzhou.

Lastly, the predictability at the seasonal scale of the background circulation of the extreme rainfall event is investigated in Hu et al. (2023) through ensemble forecasts initialized at the end of June 2021. The extremely heavy rainfall is associated with the northward shift of the WPSH, which corresponds to a meridional dipole pattern of the 850-hPa geopotential height to the east of China; the amplitude of the northward shift of the low-level component of the WPSH is found to be the strongest since 1979. The predictable and unpredictable components of the meridional dipole pattern are investigated in the ensemble predictions. The predictable component is found to be driven by positive precipitation anomalies over the tropical western Pacific associated with the concurrent La Niña event, while the main unpredictable component is associated with the atmospheric internal intraseasonal oscillations, which are not initialized in the predictions.

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