Quantitative attribution of historical anthropogenic warming on the extreme rainfall event over Henan in July 2021

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The “21·7” Henan extreme rainfall event (HNER) caused severe damage and many fatalities. The daily precipitation during this event (from 1200 UTC on July 19, 2021 to 1200 UTC on July 20, 2021) was 552.5 mm and the maximum hourly precipitation was 201.9 mm (at 0900 UTC on July 20, 2021). Previous studies have suggested that an evaluation of the role of anthropogenic climate change in extreme rainfall events is crucial in disaster prevention and mitigation under the current global climate crisis. We examined the changes in the coverage and intensity of extreme rainfall during the “21·7” HNER event under anthropogenic climate change using a set of convective permitting simulations. Our results showed that the regional-average magnitude of the 48-h accumulated rainfall during the “21·7” HNER was increased by 5.7% (95% confidence interval: 4%–11%), which is in agreement with the Clausius–Clapeyron (CC) rate, while the area of extreme rainfall (≥500 mm) increased by 29.9% (95% confidence interval: 21%–40%) as a result of anthropogenic climate change over the Henan region during the late 20th century. Anthropogenic climate change has led to a warm moist tongue over the target region, which has increased the column-integrated water vapor content and induced an anomalous cyclone–anticyclone pair. Anthropogenic warming has caused stronger southerly and southeasterly winds, leading to stronger convergence in the lower troposphere, stronger updrafts in the mid-troposphere and stronger divergent winds in the upper levels. These effects have all contributed to the increase in rainfall. These results enhance our understanding of the dynamic effects of anthropogenic warming on the “21·7” HNER and provide additional evidence that anthropogenic warming increased the magnitude of the “21·7” HNER in China.