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Extreme rainfall in Northern China in September 2021 tied to air–sea multi□factors

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The September rainfall over Northern China (NC) in 2021 was the heaviest since 1961 and had unprecedented socioeconomic impacts. Holding the hypothesis that the drivers of extreme climate events usually contain extreme factors, we firstly propose the Ranking Attribution Method (RAM) to find the possible air–sea multi-factors responsible for this rainfall event. Via the atmospheric bridges of zonal-vertical circulation and Rossby wave energy propagation, the remote factors of warm sea surface temperature anomalies (SSTA) over the tropical Atlantic, cold SSTA over the tropical Pacific, Southern Annular Mode-like pattern in the Southern Hemisphere and North Pacific Oscillation-like pattern in the Northern Hemisphere jointly strengthened the Maritime Continent (MC) convection and Indian monsoon (IM). Through meridional-vertical circulation, the intensified MC convection enhanced the subtropical high over southern China and induced ascending motion over NC. The local factor of extreme air acceleration in the east Asian upper-level jet entrance region further anchored the location of the southwest-northeast rain belt. The strengthened IM and subtropical high over southern China induced considerable moisture transport to the rain belt via two moisture channels. The combined effect of these extreme dynamic and moisture conditions formed this unprecedented rainfall event. This study suggests that the RAM can effectively reveal the factors that contributed to this extreme rainfall event, which could provide a new pathway for a better understanding of extreme climate events.