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Irreversibility of Extreme Precipitation in East Asia under Multi-Scenario to Carbon Neutrality

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Extreme precipitation refers to a bipolar climate phenomenon in which a high amount of precipitation occurs in a short period or a drought persists for a long period. In a future climate with increased CO2 concentrations, the characteristics of extreme precipitation can undergo significant variations. This study focuses on East Asia (110°-150°E, 20°-50°N) and employs six indices from the Expert Team on Climate Change Detection and Indices (ETCCDI) to assess the reversibility of extreme precipitation events. The Carbon Dioxide Removal (CDR) experiment, simulated by the National Institute of Meteorological Sciences and the Korea Meteorological Administration (NIMS-KMA) climate model, involves increasing the CO2 concentration by 1% per year from the Pre-Industrial (PI) level and decreasing it from four different carbon-neutral points: A (44 years), B (51 years), C (70 years), and D (140 years) from the initial year. The NIMS-KMA simulation proves most effective among eight models from the Coupled Model Intercomparison Project Phase 6 (CMIP6). Results indicate that extreme precipitation indices respond nonlinearly to CO2 concentration, with intensity and frequency indices showing hysteresis. Reversibility is limited, and delayed carbon neutrality leads to increased irreversibility. Notably, the R99 frequency index exhibits the highest irreversibility, ranging from 10.61% to 29.50% from point A to point D. This suggests that postponing carbon neutrality may strengthen the central Pacific warming pattern, intensify subtropical high pressure in the northwest Pacific, and increase water vapor flow into East Asia.