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Impacts of Urbanization on Sunshine Duration across China: The Role of Clean Air Policies

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Against the backdrop of unprecedented rapid urbanization and the continuous implementation of clean air actions in China, how sunshine duration (SSD) has changed and the extent to which it has been affected remain insufficiently understood. Based on homogenized daily SSD from 2,364 meteorological stations across China (1993-2023), this study accounts for station relocations and evaluates the urbanization effects (UE) and contribution (UC) using a dynamic urban-rural classification derived from harmonized nighttime-light-based urban extents. This study finds that SSD decreased nationwide during 1993-2013, with more pronounced declines in highly urbanized regions; first-tier and new first-tier cities exhibited positive UE because rural SSD declined more rapidly, whereas second-tier and third-tier cities showed negative UE. Following the implementation of the two phases of clean air actions during 2014-2023, a widespread national brightening emerged, and SSD recovered more rapidly in rural areas than in urban ones, while negative UE were observed across all city tiers except third-tier cities. The substantial decreases in total cloud cover (TCC), $PM_{2.5}$ and PM_{10} effectively explain the nationwide SSD recovery after 2014, highlighting the crucial role of clean air policies in promoting China's brightening trend.