EGU24-7942, updated on 15 Feb 2025
https://doi.org/10.5194/egusphere-egu24-7942
EGU General Assembly 2024

The cooling effect induced by the Three Gorges Reservoir operation in observations and model simulations

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The Three Gorges Dam, the world's largest hydropower project, and its impoundment reservoir have notably modified land cover, with potential implications for regional hydroclimate. However, the seasonal dynamic climate feedbacks arising from variations in water body areas managed by the Three Gorges Reservoir (TGR) remains poorly understood. Based on data-driven analysis and regional climate simulations, we depict the impact of the TGR regulation activities on local land surface temperature (LST) and biophysical processes across different spatiotemporal dimensions, determine the spreading extent of this effect to external territories, and further identify the quantitative attributions between regional climate variabilities and the TGR operation. Results indicate that the TGR induces more pronounced daytime cooling from May to October, particularly in June-August (JJA) with -2.41±0.23 K. The influence of TGR on nighttime LST transitions to warming effects in most regions from November to April (NDJFMA). The significantly increased latent heat (LH) from evaporation growth dominates cooling effects, particularly during daytime, while in JJA, the effects of evaporation are constrained to some extent by abundant precipitation. Albedo exerts a comparatively significant dominance on the nighttime LST in NDJFMA. The TGR-induced surroundings LST changes are notably discernible within an approximately 10 km buffer. The simulations amplify the magnitude and extent of the TGR cooling effect. The simulation results reveal significant reductions in LST of 6.08% (-1.42 K, JJA) and 4.58% (-1.04 K, December-January-February, DJF). respectively, TGR-induced LH variations are dominant for cooling (contributions: -52.09% in JJA; -71.98% in DJF, respectively) among the diverse energy components. This study is valuable for providing scientific guidance in reservoir planning under changing climate.