EGU24-6888, updated on 18 Feb 2025
https://doi.org/10.5194/egusphere-egu24-6888
EGU General Assembly 2024

Mechanical and thermal forcings of Asian large-scale orography on spring cloud amount and atmospheric radiation budget over East Asia

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Asian large-scale orography profoundly influences circulation in the North Hemisphere. Considerable spring top-of-the-atmosphere (TOA) radiative cooling over Southeast China (SEC) is very likely related to upstream orography forcing. Here we investigate the mechanical and thermal forcings of Asian large-scale orography, particularly the Tibetan Plateau (TP), on downstream East Asian cloud amount and atmospheric radiation budget during March-April using the Global Monsoons Model Intercomparison Project simulations. The thermal forcing drives significant surface heating and a low-level cyclone over the TP, pumping low-level air to the middle troposphere. Ascent and water vapor convergence triggered by the thermal forcing favor air condensation, low-middle clouds, and resultant strong spring cloud radiative cooling over SEC. Moreover, the thermal forcing moves the position of cloud radiative cooling westward towards the TP. The TP's blocking role weakens low-level westerlies over SEC, but its deflecting role increases downstream high-level westerlies, dynamically favoring cloud formation over SEC and the eastward ocean. In addition, the TP can force ascent and increase cloud amounts over the western and central TP. The thermal forcing contributes to 57.1% of total cloud amount and 47.6% of TOA cloud radiative cooling induced by the combined orography forcing over SEC while the mechanical one accounts for 79.4% and 95.8% of the counterparts over the ocean to the east of SEC. Our results indicate that Asian large-scale orography shapes the contemporary geographical distribution of spring East Asian cloud amount and atmospheric radiation budget to a large extent.