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Mechanisms of reduced mid-Holocene precipitation in arid central Asia as simulated by PMIP3/4 models

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We investigated the precipitation changes in mid-latitude arid central Asia (ACA, including Central Asia and Xinjiang) and the related mechanisms in the mid-Holocene using the output from the Paleoclimate Modelling Intercomparison Project phases 3 and 4 (PMIP3/4). The annual precipitation in ACA was decreased in the mid-Holocene compared with the pre-industrial period, consistent in direction with reconstruction records. Such change was mainly due to deficient winter and spring (December–May) precipitation in the mid-Holocene. The decrease in incoming solar radiation in the mid-Holocene winter and spring caused stronger surface and tropospheric cooling in the northern low latitudes. It reduced the meridional temperature gradient in the troposphere, thereby weakening the westerly winds and related transport of water vapor. More importantly, the cooling weakened the local water cycle in ACA. Finally, the precipitation decreased over almost all of ACA. In the mid-Holocene summer (June–August), the meridional temperature gradient and related westerly winds were also reduced. It was mainly caused by stronger surface and tropospheric warming in the northern mid- to high latitudes. The stronger warming was due to increased summer incoming solar radiation in the mid-Holocene. This process differed from that occurred in winter and spring. Therefore, the water vapor transport was weakened, and the summer precipitation was deficient in northern ACA. At the same time, strengthened descending motions contributed to the decrease in summer precipitation in most Central Asia. On the contrary, intensified ascending motions increased summer precipitation in southeastern Xinjiang.