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Assessing the Irrigation Impact in North China Plain Using Regional Climate Models with Dynamic Vegetation and Groundwater Pumping

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Intensive irrigation in the North China Plain (NCP) has raised significant environmental concerns. Recent research highlights the bidirectional and regional-dependent feedback between irrigation and climate, prompting studies that utilize regional climate models to assess these impacts in mesoscale. However, inconsistencies in results persist across current modeling efforts, particularly regarding summer precipitation and extreme heat. These discrepancies may arise from diverse model choices and inherent limitations in existing regional climate models, such as the lack of dynamic vegetation simulations, neglect of double cropping rotation, omission of groundwater pumping, and inappropriate parameter selection for the NCP.

To address these challenges, we selected two widely used regional climate models: the Weather Research and Forecasting model version 4 with Noah-MP land surface model (WRF4 with Noah-MP) and the Regional Climate Model version 5 with Community Land Model (RegCM5 with CLM). We enhanced these two models to better simulate large-scale irrigation practices in the NCP by incorporating dynamic double-cropping vegetation, interactive irrigation, and groundwater pumping. Parameters were recalibrated using local data, and validation was conducted across hydrological, agricultural, and atmospheric sectors. The improved models allow for a comprehensive examination of the mutual feedback between irrigated crops and the atmosphere.

By comparing the outputs of these two enhanced models, we gain greater confidence in our conclusions regarding the irrigation impact on the NCP and its surrounding areas, particularly concerning the alterations to the hydrological cycle, groundwater depletion, and extreme weather events. Additionally, the differences in model results will elucidate the extent to which irrigation impacts are model-dependent and provide insights into the reasons for inconsistencies found in previous studies. Overall, our study enhances land representation and its coupling with regional climate models, offering valuable implications for future model development.

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