25th International Congress on Modelling and Simulation, Darwin, NT, Australia, 9 to 14 July 2023
mssanz.org.au/modsim2023

Greening of vegetation and climate change promote an increase in evapotranspiration and transpiration fraction in the Yellow River Basin, China

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Abstract: In recent years, the vegetation cover has been significantly improved, and the water and soil loss have been effectively controlled due to the carried out of the Grain for Green project in the Yellow River Basin (YRB) of China (Cao et al. 2022). However, the improper selection of restoration species in large-scale vegetation restoration and reconstruction also caused new ecological problems. For example, introducing high water-consuming species for high-density planting neglects the balance between vegetation growth and the hydrological cycle, thus increasing soil water consumption (Shao et al. 2019; Liang et al. 2020; Yang et al. 2022). Obviously, in arid areas such as the YRB, in order to maintain the sustainability of vegetation restoration and ensure the stability of available water resources, it is necessary to fully comprehend the impact of regional vegetation evolution on the evapotranspiration process, and then construct vegetation restoration strategies with the goal of sustainable water resources. Meanwhile, the YRB has shown a significant warming trend in recent years. Under the influence of climate change, changes in vegetation patterns will lead to significant uncertainty in the regional evapotranspiration process, as there is a synergistic effect between climate change and vegetation evolution on the evapotranspiration process. Ignoring the synergistic effects of climate and vegetation evolution will increase the uncertainty in understanding the response relationship between vegetation evolution and regional evapotranspiration processes.

In order to quantify the relative impact of climate change and vegetation restoration on regional evapotranspiration processes, we used an optimized Priestley-Taylor Jet Propulsion Laboratory (PT-JPL) model to simulate evapotranspiration (ET), transpiration (T) and transpiration fractions (T/ET). Partial correlation analysis, multiple regression analysis, and structural equation modelling were used to elucidate the response mechanism of evapotranspiration processes to climate change and vegetation greening. Model evaluation showed that the PT-JPL model performs well in the simulation of ET and T. During the study period of 1982 to 2015, the average annual ET, T, and TF increased at a rate of 3.20 mm/a, 0.77 mm/a and 0.003/a, respectively. Vegetation greening was proved to be the primary driver for the increase of ET, T and TF, which enhanced ET, T, and TF at a rate of 0.81 mm/a, 0.26 mm/a and 0.54/a, respectively. Radiation and temperature jointly dominated ET changes in the upper reaches of the YRB, as well as the T and TF changes in the southern part of the basin, while the relative humidity and temperature jointly dominated the T change in the upper reaches of the basin. The findings were helpful for regional water resources management and formulating water resources-sustainable vegetation restoration strategies.

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Keywords: *Climate change, evapotranspiration, transpiration fraction, revegetation, Priestley-Taylor Jet Propulsion Laboratory model*