Assessment of the impacts of climate change on regional blue and green water endowments: implications for food production and export potentials in Canadian Prairies

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Green water (evapotranspiration) and blue water (water yields) play a critical role in sustaining the terrestrial ecosystem and food production, especially in arid and semi-arid regions. Green and blue water resources are interlinked through numerous biogeochemical and physical processes within the soil-water-plant-atmospheric system. These processes are altered spatially and temporally either naturally or through land and water management practices. For example, projected increase of global air temperature due to global warming can enhance evapotranspiration, especially in agricultural lands, which can significantly affect the distribution and linkage between green and blue water resources and consequently can alter food production and their export to other nations. Assessment of these linkages and projection of their future changes in food exporting regions are crucial for regional and global water and food supply management. Canadian Prairies (CP) is regarded as one of the most productive agricultural regions that supply food to over 170 countries around the world. However, crop production and food export in this eco-hydro-geologically complex region is strongly dependent on variable climate and inconsistent water availability. Taking CP as an example study site, we hypothesize that response of blue and green water to changes in atmospheric composition and global warming under extreme climate events is not linear and varies by time, space, and land management practices. We tested our hypothesis in CP, which has historically been exposed to frequent droughts, e.g., 1988-1989 and 2000-2003, is regarded as a bread basket, and it has extensive data that makes it suitable study area.

In this study, we developed an agro-hydrologic model of the Nelson River Basin (NRB), a dominant agricultural watershed in CP with an area of about 1 million km^2. The process-based agro-hydrologic model was calibrated and validated using measured monthly streamflow data from 84 hydrometric stations and annual wheat yields from 50 counties in the region. Future projections were conducted from an ensemble of downscaled GCMs of the CMIP6 for SSP126, and SSP585 scenarios to analyze green and blue water anomalies based on historical (1987-2016) and future (2030-2099) projections. The model outputs can be used to elaborate on variation of green and blue water availability, their consumption, and their trade (i.e., export) in short and long term. The results can inform local-to-global stakeholders in better understanding the potential impacts on water-food security and implications to various socioeconomic sectors across regions and times.