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Worldwide water constraints on attainable irrigated production for major crops

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Currently, irrigation withdrawals are resulting in groundwater exploitation and unmet ecosystem water requirements. However, to achieve worldwide food security, there is a need to focus on sustainable intensification of crop production. This requires a more sustainable use of water for irrigated croplands. Our presentation focuses on quantifying attainable wheat, maize, rice and soybean production on currently irrigated cropland under sustainable water use. Attainable production accounts for increases in nutrient application, while limiting irrigation withdrawals to renewable water availability and without compromising river ecosystem water requirements.

Attainable crop production was quantified using a newly developed two-way coupling between the VIC hydrological model (Droppers et al., 2020) and the WOFOST crop model (Wit et al., 2019). This VIC-WOFOST model framework comprehensively simulates biophysical processes related to water availability and crop growth under water and nutrient limitations. Our results indicate that worldwide crop nitrogen uptake should increase by 20%, to achieve production gap closure. However, worldwide irrigation withdrawals should decrease by more than a third in order to ensure sustainable water use. Under these constraints, decreases in attainable irrigated yields of 5% are expected (14% decrease due to water constraints, 9% increase due to increased nutrient availability). Moreover, achievable irrigated crop production in the extensively irrigated croplands of north-eastern China, Pakistan and north-western India would be reduced by up to a third.

In addition we explored the impact of atmospheric CO2 enrichment on worldwide attainable irrigated production using VIC-WOFOST. Increased atmospheric CO2 concentration increases crop assimilation and decreases crop transpiration. Initial results show that these effects may offset the unsustainable water withdrawals and increase attainable irrigated yields.

References:

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