EGU General Assembly 2023

EGU23-7555, updated on 29 Mar 2024
https://doi.org/10.5194/egusphere-egu23-7555
EGU General Assembly 2023

Feedback between Water Availability and Crop Growth using a Coupled Hydrological – Crop Production Model

Sneha Chevuru[1], Michelle T.H van Vliet[1], Rens L.P.H van Beek[1], Bram Droppers[1], Jerom P.M. Aerts[2,3], and Marc F.P. Bierkens[1,4]

[1]Department of Physical Geography, Utrecht University, The Netherlands (s.chevuru@uu.nl, m.t.h.vanvliet@uu.nl, R.vanBeek@uu.nl, bram.droppers@uu.nl,M.F.P.Bierkens@uu.nl)

[2]Water Resources Section, Faculty of Civil Engineering and Geosciences, Delft University of Technology, The Netherlands (J.P.M.Aerts@tudelft.nl)

[3]Department of Hydraulic Engineering, Faculty of Civil Engineering and Geosciences, Delft University of Technology, The Netherlands (J.P.M.Aerts@tudelft.nl)

[4]Unit Subsurface & Groundwater Systems, Deltares, Utrecht, The Netherlands (M.F.P.Bierkens@uu.nl)

Climate change and increases in extremes, such as heatwaves and droughts, threaten crop production and food security in various regions worldwide. Irrigation is increasingly used to secure stable yields, increasing the competition for available water resources with other sectors. To assess the vulnerability of crop production under present and future drought and heatwave events, the two-sided interactions between crop growth and hydrology should be represented by a coupled model system, combining the strength of both a crop model and a global water resource model.

Our main objective, therefore, is to quantify the mutual feedback between crop production and hydrology under climate extremes (i.e., droughts and heatwaves) in various regions globally over the historical period 1990-2019. To this end, we have developed a coupled hydrological-crop model framework, coupling the PCR-GLOBWB2 water resources model to the WOFOST crop model. The coupled model framework operates on high spatiotemporal resolution (daily time step up to 5 arc minutes) to assess the two-way interaction between hydrology and crop production (maize, wheat, rice, and soybean) for irrigated and rainfed agriculture. We first established a one-way coupling to evaluate the effect of the simulated water availability in terms of soil moisture of PCR-GLOBWB2 on crop production in WOFOST. Next, we established a two-way coupling in which the vegetation dynamics of WOFOST determine the evapotranspiration, which is fed back into PCR-GLOBWB2 and affects the soil moisture status. The individual WOFOST and PCR-GLOBWB2 runs and the coupled one-way and two-way model runs were compared in terms of crop production, dynamic vegetation growth, and hydrological response. The results of our simulations will be corroborated with reported yield statistics, observed discharge data, soil moisture, evaporation data obtained from satellite remote sensing, and reported annual irrigation withdrawals to assess their validity. In addition, we will evaluate the additional variance that can be explained by the more complete process description in the coupled hydrological – crop production model framework. For example, we hypothesize that the one-way coupling overestimates the crop yields

under drought-heatwave events.