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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Impact of capillary rise and recirculation on crop yields" *by* Joop Kroes et al.

Joop Kroes et al.

joop.kroes@wur.nl

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Reviewer's first major concern: "such a demonstration would necessitate comparing the accuracy of yields predicted with the bucket approach versus the proposed approach, which was not properly done in this study and would imply quite substantial additions to the manuscript."

Our reply to the first major concern: The idea of the reviewer is strongly appealing and we would have done so if the measurements at the experiments were sufficient. However, the measured data sets are insufficient to calibrate and validate the soil and crop parameters in such detail that they allow proper statistical evaluation of the bucket approach and the approach with full simulation of capillary rise and recirculation. The cal-

ibration of both model approaches has too much freedom with the available datasets, which upsets a reliable validation. Therefore we used the measured data sets to illustrate that with common soil and crop input values SWAP-WOFOST yields realistic and plausible results for the crops considered in this study. Further, crop growth and soil water flow are simulated by SWAP-WOFOST with state of the art concepts. Therefore we may expect that the model itself can be used to show the effect on crop yield of different boundary conditions with respect to zero flux, recirculation and capillary rise.

Reviewer's second major concern: "description of the methods is rather incomplete, as central elements of the study are not presented" and in detail: "How is the numerical method blocking recirculation implemented? What is the domain vertical discretization? How is yield affected by water limitation in SWAP (provide at least a couple of sentences)? How were the 72 sets of Mualem – van Genuchten parameters obtained (e.g. artificial neural network, pedotransfer function, etc.)?"

Our reply to the second major concern: The numerical method to block recirculation is explained in line 252-256: "A synthetic modelling option has been implemented to stop upward flow from reaching the root zone, without inhibiting percolation. This option is implemented in the numerical solution of the Richards equation and minimizes vertical conductivity just below the root zone in situations that the model simulates upward vertical flow." However, this explanation is not very detailed and we will therefore add some user suggestions in the Supplementary Material that is part of this paper. We implemented this option in SWAP version 4 which is available online since June 2017 (www.swap.alterra.nl). Our explanation in the Supplementary Material will also serve as support to the user manual (Kroes et al., 2017). This should increase transparency and will allow future users to simulate similar conditions.

The domain of the vertical discretization is briefly summarized in line 234-250. We applied 72 different soil schematizations which is explained in line 226-237. Each soil schematization consists of one or more soil horizons, each with different soil physical/hydraulic properties. This is described in detail by Wösten et al. (2013a)

and available on internet http://www.wur.nl/nl/show/Bodemfysische-Eenhedenkaart-BOFEK2012.htm. We will add a sentence to further clarify this.

We will insert sentences to clarify how yield is affected by water limitation. In line 200 we will insert: “Oxygen and drought stress cause water limitation which directly influences yields through reduced transpiration. Drought stress in SWAP is described by the dry part of the reduction function proposed by Feddes et al. (1978). Oxygen stress with the process-based method of Bartholomeus et al. (2008).” This reference will be added to the reference list: Bartholomeus, R. P., Witte, J. P. M., van Bodegom, P. M., van Dam, J. C., and Aerts, R., (2008). Critical soil conditions for oxygen stress to plant roots: substituting the Feddes-function by a process-based model, J. Hydrol., 360, 147–165

Reviewer’s third major concern: “the quality of the yield model is not as good as suggested by the mean error indicator, which is the indicator mostly referred to throughout the results and discussion.” And “the mean error is not such a good model quality indicator. In Table 2, 4 out of 5 Nash-Sutcliffe indices for yield are below zero, which suggests that the yield model is not accurate” A negative NS index means that a the observed mean is a better predictor than the model outcome.

Our reply to the third major concern: The reviewer has a point. The simulation results could be improved. The negative NS index demonstrates that the observed mean is a better predictor than the model outcome. However, one has to bear in mind that perfect calibration is not the objective of this study. As mentioned in line 198, we used calibration values from earlier studies (Kroes et al. 2015 and Hack et al., 2016). No detailed assimilation measurements were executed on the fields and the meteorological data was not measured on site, but taken from meteorological stations sometimes more than 30km away. Furthermore, no detailed information concerning fertilizer applications and soil carbon is available, therefore we considered it constant in time. In lines 311-314 we mention that the calibration can be improved.

In this research we want to demonstrate that for crop growth modelling a proper soil modelling component that includes recirculation is important. We know from experience that WOFOST with a simple soil model underestimates water availability in the rooting zone and consequently overestimates drought stress (A regional implementation of WOFOST for calculating yield gaps of autumn-sown wheat across the European Union. Van Boogaard, H., Wolf, J., Supit, I., Niemeyer, S., Ittersum, M., 2013. Field Crops Research, vol143, March 2013, p. 130-142). The results in this study clearly demonstrates that the (simulated) yield reduction resulting from over-estimated drought stress is reduced when capillary rise and recirculation are taken into account. We will add a reference to the above mentioned paper to the reference list.

Specific comment From reviewer

Title: The title should mention that the paper presents simulated results. Our reply: “Impact of capillary rise and recirculation on simulated crop yields” is fine

Line 31 (L31): It is unclear what the unit “a” represents Our reply: the unit “a” is changed into the unit “year” or the unit “season”

Line 137: The chosen time step is one day Our reply: For crop growth WOFOST applies a time step of one day with integration of light interception during the day. However, SWAP calculates soil water flow at very small time steps ranging between a few seconds and a few hours depending on the variation in boundary conditions. The exchange of information between the 2 sub models SWAP and WOFOST occurs at the end of day and therefore does not allow impact analyses during the day. Such detailed analyses would require a different crop growth model.

Line 183: Feddes et al. (1978) stress function and Jarvis (1989) compensation function are known to be entangled Our reply: For drought stress we applied Feddes et al. (1978) combined with Jarvis (1989) compensation function using a compensation factor (ALPHACRIT) of 0.7 (see manual Kroes et al., 2017). The compensation factor will be added to the text.

Line 252 and many other places: The term “upward flow” is ambiguous as capillary rise and upward recirculation are both upward flow Our reply: you are very right that “upward flow” may have 2 meanings. It may refer both to recirculation and capillary rise. Previous reviewers indicated this and made us introduce Figure 2. We will screen the text on “upward flow” and use EITHER recirculation OR capillary rise. Capillary rise always includes recirculation. We will only speak of “upward flow” when it can refer to both “recirculation” and “capillary rise”.

Line 409-434: Please use references to support your claims. Our reply: we will use references to the Tables with simulated results.

Typos: Line 96: “ss”? Our reply: “ss” in Line 96 will be changed into “as”

References: Our reply: Thank you for the suggestions. These references are relevant and we will give them a proper place in the manuscript.

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