Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-598-AC1, 2017

Hydrology and Earth System Sciences
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Discussions

Interactive comment on "Capillary rise affecting crop yields under different environmental conditions" *by* Joop Kroes et al.

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Received and published: 6 February 2017

Comment on 3 major issues: 1) how the simulations were carried out based on the authors definition of capillary rise, 2) the lack of partitioning capillary rise into the various fates (flux into the plant root, loss via soil surface evaporation, change in soil water storage, subsequent loss to deep drainage), and 3) novelty with regards to new scientific insights on capillary rise in soil.

Our reply to Major issue 1) We will adapt the text and introduce a Figure to explain hydrological conditions in the model simulations. Part of this has been done in our comments to Referee #1. However we will elaborate on it more in the section 'Modelling approach' and include relevant equations. We will limit our definition of capillary rise and more strictly define the term "recirculation" for the fluxes across the dynamic

boundary of root zone and subsoil. We prefer to keep both names (capillary rise and recirculation) intact to be able to distinguish the different processes. The term capillary rise will be defined as "Phenomenon that occurs when small pores which reduce the water potential are in contact with free water." (SSA. (2008). Glossary of Soil Science Terms 2008. Soil Science Society of America. Soil Science). The term "capillary fringe" will not be used because it is defined as "Zone immediately above the water table where the soil is saturated but under sub-atmospheric pressure" (SSA, 2008) and will cause confusion because we extend our model experiments towards soil parts above this zone.

Our reply to Major issue 2) We will extend table 4 (Figure 2 of comment-version to Referee #1) with water balance terms that demonstrates partitioning of capillary rise (actual crop transpiration, soil evaporation.

Our reply to Major issue 3) We think that the quantification of capillary rise on yield is a novelty, especially with respect to recirculation which is generally valid even without groundwater level.

Specific Comments Major Issue 1a) : The authors define capillary rise as "the upward flux across the root zone which can be either caused by upward flow from deeper soil layers or from soil water recirculation near the bottom of the root zone". This definition is a vague and incomplete. Capillary rise is associated with waters within a water-tables capillary fringe. Therefore, the author's justification for including unsaturated soil water redistribution (which is a function of soil water matric and gravitational potential energies) in the upward direction at a somewhat arbitrary depth is not clear. Precipitation or irrigation waters that infiltrate into the soil and then taken up by the plant roots are always governed by soil water potential energy gradients. Therefore, what is the benefit of lumping unsaturated soil water redistribution with soil water held in the capillary fringe?

Our reply to Specific Comments Major Issue 1a): We did not lump the unsaturated soil water redistribution with soil water held in the capillary fringe. We introduce a separate numerical modelling experiment (hydrological condition a, Figure 2 of comment-version to Referee #1) to be able to make this distinction without lumping the 2 zones.

Specific Comments Major Issue 1b): Additionally, by restricting their estimates to water fluxes across a somewhat arbitrary boundary, the soil water redistribution in the upward direction within the developing root zone is excluded. I encourage the authors to ask themselves, what is the benefit or usefulness of separating upward water fluxes in these two zones?

Our reply to Specific Comments Major Issue 1b): The benefit of this separation is that it allows us to quantify the contribution of the different water fluxes on crop yields. The reason is that we want to demonstrate that a tipping bucket approach as applied in various crop models is, even in the absence of a groundwater level, too simple because it neglects recirculation.

Specific Comments Major Issue 1c): Based on the authors new diagram (Figure 2 in the authors reply to reviewer 1's comments), the bottom of the root zone appears to be held constant in regards to where upward water fluxes are calculated even though the depth of the plant root zone is a function of time. Finally, this definition also excludes soil water that is held within a water table's capillary fringe that may not have previously crossed below the root zones lower most boundary; therefore also excluded from the calculation.

Our reply to Specific Comments Major Issue 1c): We calculated fluxes across a dynamic plane (bottom root zone which varies in time) and therefore our calculation does not exclude fluxes, such as would have happened if we used a static plane. Water held in the capillary fringe does not fall within our definition of capillary rise as given above, and we thus intentionally did not include it.

Specific Comments Major Issue 2): The authors estimate the upward flux of water across the lower-most plant root boundary. However, it is not clear how the authors

then partition how much of this upward water flux is then used by the crop, is lost via evaporation at the soil surface, contributes to changes in the soil water storage component, or is subsequently redistributed below the lower-most plant root boundary. This partitioning is essential to gain a mechanistic understanding of upward water flux effects on crop grown. For instance, does the upward water flux mostly contribute directly to the amount of water taken up by the crop or mostly to changes in soil heat fluxes/thermal regimes and thus influence on microbial nutrient cycling?

Our reply to Specific Comments Major Issue 2): We will extend table 4 (Figure 2 of comment-version to Referee #1) with water balance terms that demonstrates partitioning of capillary rise (actual crop transpiration, soil evaporation. This extension will be used to explain understanding of mechanisms of upward water flow. Upward water flux does not change soil heat fluxes in our modelling approach. We assume that it can be neglected with respect to other processes. We will explain this in more detail in the section "Modelling approach".

Specific Comments Major Issue 3) Major Issue 3) Soil water redistribution in any direction is already incorporated into physics based soil-plant-atmosphere models since this is governed by gradients in soil water potential energies. The authors do not state what is new or useful by intentionally altering the model code to restrict upward water flow when a soil water potential energy gradient exist. Such artificial restrictions do not represent physical reality.

Our reply to Specific Comments Major Issue 3): Adjustment of the code was necessary to carry out the model experiment (no recirculation) and to demonstrate (quantitatively) the added value of simulating more detailed water fluxes in the soil profile in comparison to simple bucket approaches that inherently include the mentioned "artificial restriction". When crop models are used for yield forecasting these detailed processes play an important role; neglecting them generally may cause large error. We want to improve our understanding of processes in the soil-crop continuum and thereby minimizing errors.

Specific Comments Additionally: The authors reference many studies in the manuscripts introduction that already quantify capillary rise and the contributions to crop yields and deep drainage. These studies already provide data and evidence to address the author's research questions stated in line 116 and 117. Therefore, the novelty of a model simulation based study to contribute to the already vast literature on capillary rise appears to be minimal. I suggest the authors rework this manuscript to focus it on research questions pertaining to hydrologic modeling approaches and submit the work to a more specialized journal.

Our reply to Specific Comments Additionally: We think that the quantification of capillary rise on yield is a novelty, especially with respect to the interaction between recirculation and crop growth, which represents a huge economic value in the Dutch Delta and in other deltas in general. Another aspect which cannot be found in the referenced studies is the lack of a quantification of the impact of capillary rise and recirculation on crop yields. Correct quantification of the water fluxes contributes to the understanding of crop production and will help the institutions in charge of yield forecasting.

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