Reviewer 1

The paper presents an important step forward to better capture crop phenology in hydrological modelling. It is well written and structured. To demonstrate its reach and inspiration for future modelling, the paper could be better positioned with regard to existing modelling advances considering crop dynamics. It would gain from a discussion of results in view of existing modelling approaches and advances, going beyond the mention of omitting these in most models. Discussing uncertainties arising from the sole focus of the most widespread crop per pixel and simulation of the 5 representative crops would also make the paper stronger.

Response: Thank you for a positive evaluation of our study and your time to provide critical comments to improve the manuscript.

A discussion of results (LAI and ET) in view of existing approaches is to be added in the revised manuscript. Uncertainties arising from sole focus on the widespread crop per pixel as compared to the simulation of the 5 representative crops is to be added under the discussion of ET simulations. This is because the heterogenous representation of crops in a pixel can have effects on the ET fluxes due to variations in the physical characteristics of vegetation such as root depth, LAI, stomata conductance, surface roughness and albedo (Burakowski et al., 2018).

Further remarks

- **The start of the introduction would be more interesting to read if it wasn't a copy of the abstract.**

Response: Yes, this is to be rectified in the revised manuscript.

- **Lines 34-35: some details of the "simplistic way"/"abstract terms" of considering crops in hydrological models and what we learn from these would provide a good start.**

Response: Lines 35 – 37 give some details of the "simplistic way/abstract terms" of considering crops in hydrological models. Specifically, by highlighting how most models neither address crop phenological development nor distinguish between different crops and the associated management practices (e.g planting, irrigation, fertilization, harvesting). We will add information in the revised manuscript about the regional model applications that have considered one uniform generic crop for agricultural land use modelling despite the wide variety of crops existing in agricultural land use.

Lines 37 – 38 gives some information about how cropland representation and the timing of applied management practices in hydrological models affects the water balance components. However, we will add more information specifically on how the efficient Evapotranspiration (ET) estimation is a challenge in agricultural dominated catchments without representation of various crops and crop types. Moreover, using a generic uniform crop for agricultural land use modelling fails to account for any variability in Leaf Area Index corresponding to real life crop scenarios.

- **Line 62: examples on current knowledge derived from the implementation of cropping dynamics in hydrological modelling would be useful (e.g. The Crop Generator: Implementing crop rotations to effectively advance eco-hydrological modelling. https://www.sciencedirect.com/science/article/abs/pii/S0308521X21001360).**

Response: Yes, examples on current knowledge about approaches on representation of crop dynamics in other eco-hydrological models is to be added in the revised manuscript to highlight what we can learn from these approaches.

- Lines 70-75: How is phenological crop development simulated in other hydrological models, e.g. SWIM? Has there been any coupling attempts with modelling of land surface processes that consider phenology, e.g. PROMET?

Response: Most hydrological models e.g SWAT+, SWIM have an integration of a hydrologic module and crop growth module (mostly EPIC, Williams and Singh, 1995) and by default, crop growth is simulated by accumulated heat units. In most applications, modelers uses a generic or a constant crop for representation of agricultural land use. As highlighted, the challenge of this representation is twofold; in tropical and subtropical regions, the use of heat units easily causes incorrect cropping seasons as these regions are primarily driven by water availability. Secondly, the use of a generic crop fails to account for any variability in existing heterogenous agricultural land use. A review of coupled hydrologic and crop growth models has been done by Siad et al., (2019).

Coupling attempts of land surface process models e.g PROMET to consider phenology have been done through an agricultural management subroutine which also initializes management actions that may be of hydrologic, climatic or agricultural consequence (Hank et al., 2015). However, just like in any eco-hydrological model, the agricultural management subroutine simulates the growing seasons through accumulated heat units (a temperature and photoperiodic day-length-dependent approach is used). To use the plant and harvest dates (preferred approach for tropical and subtropical regions), information is required on the cropping calendar and management practices e.g fertilization which highlights the methodological advances presented in this paper. i.e exploitation of the existing global phenological data sets of rainfed and irrigated croplands with the associated cropping calendar and management practices.

- 4a and c show a good improvement of LAI, also seen to some extent in Figs. 5a and c. Also erosion is reduced accordingly. But why do erosion values show strong peaks in March and May in Figs. 5b and d? In March LAI is already high.

Response: The strong peaks in March and May can be explained by the reduction of residue on the soil surface. With the second rainy season occurring with no crop cover, part of the residue generated from the first growing season is washed away. Hence with the rainy season occurring in March, we obtain erosion peaks regardless of the relatively high LAI value in the default model that uses a generic uniform crop. However, with the realistic crop representation, we obtain a slightly higher LAI that reduces the erosion peaks in the revised SWAT+ model (we notice a slight increase in the LAI magnitude having a strong impact on the erosion peaks). But with only one growing season, we still have part of the residue washed away in the second rainy season. According to Neitsch et al., (2005), a given residue percentage on the soil surface is more effective than the same percentage of canopy cover. Residue intercepts falling raindrops so near the surface that the drops regain no fall velocity. Additionally, residue obstructs runoff flow, reducing its velocity and transport capacity, [explained in lines 274 – 279]. The explanation will be better phrased in the revised manuscript for clarity.

- Line 191: The idea is clear that results are compared with reality to the extent possible. But what does ‘scientific validation’ mean? How is this different from just ‘validation’?

Biondi et al., (2012) draws a distinction between performance validation and scientific validation. Performance validation is a typical approach adopted to evaluate model performance that requires the comparison between simulated outputs on a set of observations that were not initially used for calibration. This involves the use of graphical techniques or performance metrics. A scientific validation aims at evaluating the consistency of the model thought as input-state-output system. This concept was derived from the idea that verifying the model performance by simply comparing outputs and observations does not assure that the model is correct from a scientific point of view. This validation may include and extend the performance validation and is specifically required in cases when the quality and quantity of observation data is not sufficient to allow an adequate validation. Studies such as (Haregeweyn et al., 2017) have used the term 'scientific validation' in validating their results. Just like our research, they did the validation by comparing the soil erosion model outputs with previous studies and the scant observations.

However, since the term 'scientific validation' seems to be confusing in this context, it is to be replaced with 'plausibility check' in the revised manuscript.

Lines 261-263: wouldn't this speak to an increase of ET as water is applied without limits? Please clarify.

Response: No water is applied with limits (50mm every application). The water is irrigated when the water stress is below a specified threshold of 0.7. By unlimited source (which is the deep aquifer in the model), we mean that the water is always available for irrigation when the water stress in the field during the growing season goes below the specific threshold. However in real life scenarios, the farmer may not always have water for irrigation when needed on a specific day due to different management schedules of irrigation schemes. Additionally, not all irrigation water comes from the deep aquifer on all irrigation sites. The statement will be rephrased and a clear explanation added to text in the revised manuscript.

References

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