The authors thank the reviewer for the valuable comments and recommendations to improve our manuscript. The comments of the reviewer are in boldface, whereas our responses are in normal fonts. Italic text is quoted from the updated manuscript. Line numbers refer to the manuscript version with track changes.

Reviewer #1:

1. **The article 'Net irrigation requirement under different climate scenarios using Aquacrop over Europe' quantifies the current net irrigation and the future variations under different climate change scenarios for a single crop all over Europe. The topic has great potential, and it is particularly up to date and interesting to be analyzed, however, some hypotheses and limitations strongly affect the potential of the results here presented. The major concerns are related to the choice of a unique crop type to be simulated all around Europe. Even if a strong statistical analysis is beyond the reported calculation, it is completely missing how the choice of this crop type is significative for Europe. Are C3 the most widespread crops in Europe?**

Answer: The paper now includes a paragraph to explain that the irrigation requirement is computed independent of the irrigation area, period and exact crop type. This paragraph was added to section 2.2, it now better explains these generalizations.

L134-136:

"Climate impact assessments are subject to large uncertainties, which increase with longer temporal projections. Therefore, several assumptions are made in this study to limit the uncertainty of other factors than climate. We will present net irrigation requirement values that are independent of the irrigated area, period, infrastructure and the exact crop type."

L147-149:

"For future projections, the use of a representative field crop is supported by the current lack of detailed year- and location-specific crop maps, and by the unpredictability of changes and developments in crop type and distribution."

Regarding the choice the crop type, we have now clarified that two different crops are used in this study: (i) the general C3 crop (from de Roos et al., 2021) for the historical evaluation of the model; and (ii) a representative field crop to assess future I_{net}.

For the historical evaluation, we added a statement about the fact that C3 crops are dominant in Europe.

L173-174:

"C3 crops are dominant in Europe (Monfreda et al., 2008; Still et al., 2003)."

For the I_{net} projections, the 'modified generic C3 crop' is indeed a poor and misleading identification of the crop with which the net irrigation requirement (I_{net}) was determined. Therefore, this "unique" crop type is now referred to in the paper as a "representative field crop". It has the typical characteristics of most field crops cultivated in Europe. A table and some information about the considered crop characteristics have been added to the paper. If the crop is a C3 or C4 is indeed important when determining the crop yield. However, for determining I_{net}, only the crop characteristics that determine the evapotranspiration need to be considered, i.e. the crop transpiration coefficient, the canopy cover, and the thresholds for water and temperature stress.

Table 1. Characteristics of the representative field crop

Crop parameters	values	units
Canopy cover (during the 3 summer months)	85	% soil cover
Crop transpiration coefficient when canopy is complete	1.10	-
Maximum effective rooting depth	1.0	m
Soil water depletion at which stomata starts to close	50	%TAW
Base temperature, below which crop development does not progress	8.0	°C
Minimum growing degrees required for full crop transpiration	10.0	°C-day

The following text was added to describe this representative field crop:

L179-186:

"For the determination of I_{net}, a representative field crop is considered. The crop characteristics that determine crop transpiration and hence I_{net} are listed in Table 1. The considered crop transpiration coefficient of 1.10 is a good indicative value of the basal crop coefficient for the mid-season for a large range of field crops (Allen et al., 1998). Moreover, it is assumed that in the summer months (in which I_{net} is determined) the crop has reached its maximum canopy cover and is prior to senescence. Since I_{net} is determined by keeping the soil water content in the root zone above 50 % of the readily available water (RAW, which is 25 % of the total available water, TAW, for the representative field crop), water stress does not affect crop transpiration. Also, air temperature stress affecting crop transpiration will be small or absent in the summer months with the settings of the thresholds in Table 1."

2. **Similarly, in the method it is not clearly stated on which areas the calculation has been computed.**

Answer: The purpose of this study is to quantify irrigation amounts required for optimal crop growth, without including explicit future projections on the extent of irrigated areas (such as available through e.g., Hurtt et al., 2020). This has been clarified in the newly added paragraph of section 2.2.

L136-140:

"First, simulations are performed over all pixels of the entire study domain (i.e. the main European continent), and the irrigation estimates for the entire hypothetically irrigated agricultural domain are normalized by area to make the results independent of the actual irrigated area. This avoids the need to include estimates of future hypothetical land use (Prestele at al., 2016), and the uncertain evolution of the extent of irrigated areas (Schaldach et al., 2012; Hurtt et al., 2020)."

3. **Secondly, the spatial resolution of the analysis is coarse, since some global assessment of water for irrigation works at 10km at the equator and maps of harvested areas are available at a resolution up to 250m or even 30m.**

Answer: Our values of our irrigation estimates are generated at a 0.5° x 0.5° spatial resolution due to the spatial resolution of the meteorological forcing, and particularly the future climate scenarios. We further added the following text to highlight the distinction between our climate-based study and fine-scale agricultural studies.

L140-146:

"Second, the spatial resolution of this study matches that of the ISIMIP input data resolution. In contrast to fine-scale agricultural studies, usually assessing actual irrigation under historical conditions, future climate projections are dependent on the resolution of the driving climate models

(or downscaled output). Such studies mainly aim at estimating the irrigation requirement that is needed for crop root uptake, thereby omitting the part of irrigation that is lost to the atmosphere, or retained on the soil surface or in the soil profile. Also, state-of-the-art global and continental-scale climate impact assessments are typically performed at the same resolution (e.g., Jägermeyr et al., 2021; Lange et al., 2020; Thiery et al., 2021)."

4. **I furtherly suggest that these works are seen and cited in the article (Liu et al., 2010; Siebert and Doll, 2010, Chiarelli et al., 2020).**

Answer: These are indeed relevant studies, thank you for mentioning them. They were carefully considered and included in the paper.

5. **Third, some strong assumptions are related to crop characteristic and growing period. While only one crop has been selected, results are reported for only the three summer months, when it could be expected that in future more water is needed even outside the summer months. Furtherly, farmers can adopt different techniques, shifting to different crops or even adapting the planting and harvesting period accordingly to the new climatic condition. This latter option is not mentioned in the paper, neither discussed, while it could greatly influence the reported results.**

Answer: We agree with the reviewer on this point. As mentioned in the comment, shifts in the growing period can be expected to follow the new climatic conditions but, ultimately, this remains a decision taken by the farmer in the context of climate change adaptation, and characterized by uncertainty. Therefore, we decided to present results integrated over the summer months only (current growing periods in Europe) and to assume no climate change adaptation (crop type, growing season, fertilizer use, etc.), to make the irrigation amounts directly comparable to the baseline. We added the following text in this extra paragraph (section 2.2) to support this choice.

L149-155:

"Finally, the uncertainty and high spatial and temporal variability of the start and end of the growing season (King et al., 2018; Menzel and Fabian, 1999; Schadlach et al., 2012) restricts the modelling possibilities. Some previous studies (e.g., Elliott et al., 2014; Fader et al., 2016; Fischer et al., 2007; Konzmann et al., 2012) have used dynamic growing seasons, but the choice has been made to avoid this additional level of uncertainty for this study. Therefore, only the summer months are considered to make the future requirement directly comparable to the baseline I_{net}. On average, these are the months presenting the highest I_{net} (Siebert and Döll, 2010), and are expected to remain important months for irrigation requirements, even if growing seasons might shift in the future."

For clarity, we now also express the results in mm month^{-1} (instead of mm year^{-1}), and specify that the values are computed for the summer months only.

6. **The quite lengthy description of the statistical analyses obfuscates the main outcomes of the paper regarding the variation in the irrigation demand, potentially distracting the reader from the most interesting results. I suggest moving some of the analysis as supplementary material for better highlighting the effects of climate change scenarios in the different regions of Europe.**

Answer: We moved the SIM1 evaluation in terms of anomalies (originally in section 4.1.1) to the Appendix. Also, the comparison of SIM2 with SIM1 (section 4.1.2) was removed to have consistent comparison periods (i.e. the period of jointly available SMAP and SMOS data, from April 2015 onwards). We realize that the model evaluation constitutes an important part of the paper, but we would like to highlight the importance of the two types of evaluation. The analysis performed with

SIM1 is a short-term evaluation with reanalysis meteorology whereas SIM2 constitutes a climatological (long-term) evaluation with GCM meteorology. Both are important analyses to understand the model performance and the GCMs for historical periods. This is clarified in the text and in the new Table 2, describing the different simulations (replacing former Fig. 1).

L290-293:

"Both the time series of historical SIM1 and SIM2 SSM are compared to satellite observations through the skill metrics described in section 3.1.1 for the time period with available data for both SMOS and SMAP, i.e. from April 2015 through 2016. SIM1 is a short-term evaluation since daily SSM simulations are compared to satellite observations."

L295-298:

"For the historical SIM2 SSM simulations, the multi-year average (long-term) results driven by the five different GCMs, and the median SSM time series across the GCMs are evaluated."

Minor comments:

7. Line 110: Please, better state which can be the advantages of the results your presented in this paper.

Answer: The advantages are now clarified in the introduction.

L117-124:

"Compared to previous studies, the advantages are that the simulations are performed with (i) climate data from the latest generation of reanalyses and GCMs, (ii) the most recent set of future scenarios, and (iii) a crop model (AquaCrop), in which the dynamic interactions between water and vegetation are the main focus and where irrigation and management practices can be included with more detail than in a land surface or hydrological model. Future I_{net} projections could be used to inform on climate change adaptation strategies (e.g., climate-smart irrigation, crop type selection, water conservation). The new AquaCrop-ISIMIP3 model setup can be run at any spatial domain and resolution, providing future opportunities for further climate analysis, also including other irrigation practices and management options."

8. Line 127: 1m of soil depth is your assumption?

Answer: We understand that the description of the soil profile may have been confusing. Therefore, we added an extra sentence to clarify this.

L165-167:

"A total profile depth of 1.30 m is defined, but without the presence of a groundwater table or confining layers, the actual depth below the maximum rooting depth has no influence on the simulations."

9. Method: on which areas has the model run?

Answer: This has now been clarified by describing the hypotheses in the new paragraph of section 2.2 (see R1#2).

10. Line 194: Your hypothesis?

Answer: For optimal irrigation scheduling, irrigation water is applied when the root zone depletion is 100% RAW (timing of irrigation). The amount of water applied (amount of irrigation) will bring back the root zone to field capacity (which corresponds with 0% RAW depletion). Hence during the irrigation interval, the root zone depletion varies between 0 and 100 % RAW depletion. The 50% root zone depletion is hence the average root zone depletion in the irrigation interval.

The text has been adjusted in the manuscript.

L254-256:

"By selecting a threshold of 50% RAW depletion, which is the average depletion in an optimal irrigation interval (Smith, 1992), crop water stress affecting the canopy development and transpiration of the representative field crop is avoided, and effective rainfall (the part stored in the root system up to field capacity) is still considered."

11. Line 208: Is the volumetric content an average on the entire pixel? Is this comparable with the result of a single crop?

Answer: Indeed, soil moisture values are averages over an entire pixel. All input and AquaCrop variables are integrated over one pixel. The following sentence has been added for clarity.

L146-147:

"Third, each pixel is defined as a hypothetical homogeneous field, in which the vegetation conditions are identical."

12. Line 234: How are initial simulation conditions set?

Answer: Thank you for noticing this information was missing. Information about the spinup has now been added to the manuscript.

L241-243:

"SIM1 and SIM2 have a spin up period of four years, and only output from 2015 onwards is used for evaluation, i.e. starting when both SMOS and SMAP data are available."

L248-249:

"For the baseline simulation, the initial moisture conditions are set to field capacity while the future periods have a spin up of at least 10 years (continuous simulation from 2021 through 2100)."

13. Results: Are you referring to consumptive water use or water withdrawals?

Answer: The net irrigation requirement concept is explained in the following text.

L249-253:

"For SIM3, irrigation is introduced, using the net irrigation requirement option in AquaCrop, whereby a small amount of water (just covering the crop ET for that day) is injected into the root system on days when a certain fraction of the RAW is depleted (Raes et al., 2017). With this option, solely the amount water taken up by the roots is considered, where the wetting of the soil surface, and interval and application amount specific to a particular irrigation method are not relevant."

I_{net} could therefore not be categorized as consumptive water (since it is not equal to the total evapotranspiration), nor as water withdrawals (since the irrigation water added is not withdrawn from a system).