[Reviewer comments in normal font; *Author replies in itialic*]

- The manuscript provides a novel and useful evaluation of a technique to estimate net irrigation over a global irrigation hotspot (the Indus and Ganges basins). Overall, the results are impressive, with quantification of net irrigation from an ensemble of unique realization having strong agreement in most cases. I recommend publishing the manuscript after addressing the below comments and expect this will be a widely used study by the remote sensing, hydrology, and agricultural science communities.

Reply: *We thank the reviewer for the overall positive and constructive feedback that will help us to further improve our work. Below, we outline how we consider responding to the issues pointed out by the reviewer in the revision.*

General comments

- Is the transferability of calibrated parameters evaluated in space and time (i.e., to non-calibrated areas and times?). It seems the accuracy of the methodology relies on these calibrated parameters being transferable from non-irrigated places or times to irrigated areas. It would be valuable to estimate irrigation from non-irrigated areas following the same method used to estimate irrigation over the irrigated areas to provide an estimation of the method's potential systematic biases. Similarly, it would be valuable to show an ET bias time series for the calibrated model over non-irrigated times and irrigated times, respectively (which could be a supplemental figure). It would be helpful to include more detail about the calibration procedure as well. Namely, for irrigated pixels, is the model calibrated during non-irrigated periods or are calibrations from rainfed areas transferred to irrigated areas? In either case, there needs to be an evaluation the parameter transferability.

Reply: *Thanks for raising this point. We believe that the manuscript will benefit from a better presentation of the calibration results. In the initial submission, the model is only validated in time (calibration period: 2003-2007, validation period: 2008-2012). To validate the parameter transfer in space we plan to provide model performance for a parameter transfer from rainfed to irrigated areas for a model calibrated against ERA5-Land. ERA5-land does not include irrigation and could therefore be used to validate the spatial transferability of rainfed parameters.*
Plan for revision: *Include a validation of parameter transferability in space and time and report cal/val performance of the applied metrics (SPAEF and MAE). Include supplemental figures of rainfed ET bias timeseries and maps.*

- Please include how data and code can be accessed.

Reply: *This is a relevant point. Thank you for bringing this up. The ensemble estimates of the quantified net irrigation, and uncertainty will be made publicly available via an online*

repository. And code and model setup will be shared upon personal request.
Plan for revision: *The data acknowledgment section will be extended accordingly and the online data repository will be created.*

- Please provide a thorough grammatical edit of the manuscript before re-submission.

Reply: *Thanks, for carefully reading or manuscript. We will try to correct grammatical mistakes to the best of our abilities.*

Specific comments

- Line 12: “an novel” should be “a novel”.
- Line 45: “led” should be “lead”.
- Line 46: Should this be Koch et al. (2020) instead of 2000?
- Line 64: I believe 1960 should be “1960s”.
- Line 329: “reliably” instead of “reliable”
- Figure 7 caption: misspelling of “charts” and “decomposition”

Plan for revision: *Thank you very much for these careful observations. All will be changed in the manuscript.*

- Lines 101-114: What are the sources of uncertainty in the calculations of PET & ET from this model?

Reply: *The second reviewer stated their concern about an introduced uncertainty of our ET estimate by lowering the LAI over irrigated areas to rainfed conditions. By replacing the main component of crop and landcover characteristics over the irrigated area with a rainfed climatology LAI we will probably underestimate the rainfed ET baseline, thus potentially overestimating the net irrigation. Based on the reviewers’ careful observations, we have reached the conclusion that we want to change our methodology in the manuscript, as we want to subtract rainfed ET from a managed scenario (this will result in higher ET baselines, lower net irrigation) and not subtract rainfed ET from a non-managed scenario (what we are during now).*
Plan for revision: *We will run all the models without the LAI correction to estimate rainfed ET in a managed scenario. We expect this to decrease our net irrigation estimates. The two approaches will be briefly discussed in the discussion section of the revision.*

- Line 101: Please include some more information on the ET calculation (e.g., an equation or equations to show the ET calculation). Is there a soil water module involved in the hydrologic model?

Reply: *We agree that specifics about mHM's ET calculations may be of interest to some readers. Since we are applying a well-documented mode, i.e. mHM, we have not included any detailed information regarding the ET module in the manuscript. The scope of the manuscript is the sole application of mHM to quantify the precision of the ET-based irrigation approach, which, in our opinion, does not require the specifics on ET calculations. In short, mHM calculate ET by reducing PET by fraction of roots and a soil water stress factor, in our study, Fedde's equation from the defined soil layers.*
Plan for revision: *We will add a few more lines on the ET and soil water modules in mHM, but these will not be described by equations.*

- Line 110: Please explain the choice of why FAO-56 PM was used to compute PET.

Reply: *Our choice of FAO-56 PM is based on its documented ability to estimate PET for use in irrigation management and studies evaluating FAO-56 PM against other PET estimation methods.*

Allen, R. G., Jensen, M. E., Wright, J. L., and Burman, R. D. (1989). "Operational estimates of evapotranspiration." Agron. J., 81(4), 650-662.

Jensen, M.E., Burman, R.D. and Allen, R.G. (ed). 1990. Evapotranspiration and Irrigation Water Requirements. ASCE Manuals and Reports on Engineering Practices No. 70., Am. Soc. Civil Engrs., New York, 360p

Martin, D. L., Gilley, J. R., Carmack, W. J., and Hardy, L. A. (1993). SCS methods for determining irrigation water requirements." Management of irrigation and drainage systems: Integrated perspectives, R. G. Allen, ed., ASCE, New York, 1031-1038

Plan for revision: *Will be further documented our choice in the manuscript and substantiate our choice with the abovementioned references.*

- Line 119: in the supplementary information, can you please provide the list of parameters that were calibrated?

Plan for revision: *List will be provided in supplementary material, with parameters, initial values and parameter bounds.*

- Eq. (3): This definition of net irrigation assumes that 100% of applied irrigation is returned to the atmosphere via ET within the month it is applied. In some instances, this may not be the case. I suggest changing the title to "The precision of satellite-based net irrigation quantification in the Indus and Ganges basins"

Reply: *We agree that the title can be misleading without specifying that it is not total irrigation we are trying to quantify with this approach, but only the evapotranspirated part.*
Plan for revision: *We will change the title of the manuscript as suggested by the reviewer. And clarify what part of total irrigation our term net irrigation cover.*

- Fig. 2b & 2d: please constrain the axes limits to the temporal domain of the study, which looks to be constrained by the ET data.

Plan for revision: *The axes limits will be constrained to the temporal domain of the study.*

- Fig. 4: Please clean up this figure. Some labels on the left are cut off and the dots are awkwardly overlapping. The color scheme could also benefit from a change.

Plan for revision: *Figure will be edited.*

- Line 265: To support that the baseline models can accurately simulate reference ET products, please include a time series comparison over the calibration period. A low MAE can result from large random biases, rather than accurate estimation of ET, thus the MAE is limited in information.

Reply: *The mean absolute error (MAE) is expected to capture large biases independent of their sign. We chose the MAE as objective function in the calibration to get the right magnitude of rainfed ET. Opposed, the mean error (ME) may be incentive to random biases if they are evenly distributed in positive and negative direction. However, we agree that a timeseries of the monthly MAE could be a good addition to the supplementary analysis.*
Plan for revision: *We will include time series comparisons from the calibration in supplementary material.*

- Figure 5: Why is the month of February chosen here? The spatial maps only show a single snap shot (in Feb.) of an instance that helps illustrate the points made in lines 272-285, but presentation of more data is needed to know that this snapshot is not a special case. Perhaps creating a boxplot for differences in ET (ref-baseline) of irrigated lands (across all periods of analysis) for all ET products would be beneficial here to show these results are generalizable, and maintain this snap shot to help illustrate the point through this single example.

Reply: *Yes, the figure shows a single timestep that help to illustrate the overall approach. We would argue that the results from our irrigation ensemble estimates due confirm that*

this is not just a single case but a good representation of the irrigation patterns. In the month of February, we expect the deviation between ET reference and ET baseline to be largest since irrigation activities peak during this month. The sole purpose of this Figure is to present our approach visually and not to quantify the ET differences. However, we agree that additional information on the differences in ET may be of interest to the readers.
Plan for revision: *The differences in ET (ref-baseline) at monthly timescale will be prepared for all 15 models.*

- Figure 6: does this ensemble include ERA5-Land. I expect it does not because the prior plot just illustrated that irrigation is not present in this data set. Either way, please clarify this in the manuscript text. (Similar comment also applies to Figure 7). If ERA5-Land is included, shouldn't the estimated irrigation for that ensemble member be close to 0 resulting in a large reduction of the precision?

Reply: *You are right, ERA5-Land is not included in the ensemble.*
Plan for revision: *This will be clarified.*

- Line 290: Please note the ratio of the standard deviation to the mean irrigation to give a quantification of how large the ensemble uncertainty is relative to the magnitude of irrigation.

Reply: *This value is reported in line 309.*
Plan for revision: *Clarify*

- Line 309: Why is precision much lower in arid regions?

Reply: *The precision is lower in the arid regions because of evident errors in FLUXCOM and PML ET datasets. During the wet season both FLUXCOM and PML have almost no spatial variation in ET within the arid zone and so, ET is characterized by having a very high, uniform ET rate. NTSG and our hydrological models on the other hand show a distinct spatial variation within the arid zone, which follows variability in vegetation, soil and climate. This is why the precision is lower in the arid zone when we compare irrigation estimates from the three ET products.*
Plan for revision: *We will try to clarify this in the manuscript.*

- Lines 322-325: This statement claims lower precision is expected during the wet period because irrigation is lower during this time of year. However, Figure 7 estimates a peak in irrigation occurs during the wet part of the year in the arid and semi-arid regions. Please reconcile this.

Reply: *This peak relates to the comment before. Errors in FLUXCOM and PML in the arid zone during the wet period yield high mean irrigation ensemble estimates. NTSG estimates of irrigation is much lower and so the precision is also very low.*
Plan for revision: *We will make an effort to better explain this in the revised manuscript.*