General comment:

Recommendation: Moderate revision

The net irrigation over two severely water-stressed basins (Indus and Ganges) is estimated by subtracting the satellite-based actual evapotranspiration (ET) from a baseline rainfed ET estimated through hydrological modeling. This study is a follow on to a previous study by Koch et al., 2020, with one significant enhancement of using an ensemble approach in which multiple precipitations and RS-based ET data are used to create an ensemble model simulation to estimate net irrigation and its uncertainty. The results are nicely presented and the manuscript is well-written. However, I believe the authors should distinguish between consumed irrigation by the crops (what is estimated in this study) and net irrigation water use which can be significantly higher than consumptive water use (based on irrigation efficiency). I am also concerned about replacing the observed LAI with the rainfed LAI climatology to calculate the rainfed component of ET. This can potentially lead to false baseline ET estimation by removing the irrigated crop characteristics. Details on these main concerns along with some other moderate and minor comments are provided below. Addressing all these comments I suggest the acceptance of the paper.

Specific comment:

Major:

1. L44: There is an important distinction between the irrigation water consumed by crops and the net irrigation. ET is a measure of consumptive water use which is consumed irrigation water over the irrigated area. In many cases of flood or surface irrigation, a substantial portion of irrigation is lost to drainage (not consumed by the crops). This is especially important in your case studies where the irrigation efficiency is reported to be less than 52% on average (Simon et al., 2020). Please clearly mention in the manuscript that what is estimated here is consumed irrigation and not net irrigation.

   Simons, G. W. H., et al. "A novel method to quantify consumed fractions and non-consumptive use of irrigation water: Application to the Indus Basin Irrigation System of Pakistan." Agricultural Water Management 236 (2020): 106174.

2. **The problem with replacing LAI over irrigated agriculture with climatology LAI over rainfed areas:**

   The only place where the crop or land cover type is incorporated in the actual ET estimation in the hydrological model is in the downscaling of ET potential using the LAI data. Here I quote from a reference study (Demirel, et al., 2018) that is cited here for this part of the methodology: "*The DSF (vegetation dynamic coefficient) is parametrized using spatiotemporal LAI component accounting for the effect of characteristics that separate the actual vegetation from a reference grass. These characteristics include*

specific landcover, albedo and aerodynamic resistance ...," here, you are replacing the main component of crop and landcover characteristics over the irrigated area with a rainfed climatology LAI which has different characteristics (land cover, crop type, albedo, etc.). This can lead to a false baseline ET estimate and consecutively net irrigation and can be a major source of error that needs proper attention and discussion in the manuscript. Please comment on the possible impact of this replacement on the final net irrigation estimation.

3. L233: part of uncertainty can be attributed to the simplified model physics and the heterogeneity of land cover which is not mentioned in the manuscript. Please discuss these other sources of uncertainty in the manuscript as well.

Moderate:

1. 1.L34: there is also a more recent study on irrigation mapping using SMAP-Sentinel1 1kmsoil moisture data that can be cited here:

   E. Jalilvand, R. Abolafia-Rosenzweig, M. Tajrishy and N. N. Das, "Evaluation of SMAP/Sentinel 1 High-Resolution Soil Moisture Data to Detect Irrigation Over Agricultural Domain," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 14, pp. 10733-10747, 2021, doi: 10.1109/JSTARS.2021.3119228.

2. L44: some other disadvantages of using ET that are not mentioned here:
   a. Limitation of ET estimation in cloudy weather situations
   b. The ET is an estimation of consumptive water use not irrigation

3. L 62: There are many other studies on the satellite-based ET and consumptive water use estimation over the Indus and Ganges basins which can be referred to in the introduction or the discussion section of the paper. Studies such as:

   Karimi, P., Bastiaanssen, W. G. M., Molden, D., and Cheema, M. J. M.: Basin-wide water accounting based on remote sensing data: an application for the Indus Basin, Hydrol. Earth Syst. Sci., 17, 2473–2486, https://doi.org/10.5194/hess-17-2473-2013, 2013.

   Simons, G. W. H., et al. "A novel method to quantify consumed fractions and non-consumptive use of irrigation water: Application to the Indus Basin Irrigation System of Pakistan." Agricultural Water Management 236 (2020): 106174.

   Peña-Arancibia, Jorge L., Joel P. Stewart, and John M. Kirby. "Water balance trends in irrigated canal commands and its implications for sustainable water management in Pakistan: Evidence from 1981 to 2012." Agricultural Water Management 245 (2021): 106648.

4. L113-114: a more recent Modis product version (v 061) was introduced at least a year ago (late 2020) and the research community is advised to use this product due to changes and improvements in the calibration approach. It is expected that the most recent product is used in a study that is going to be published in late 2022. It would be interesting if a test analysis were conducted using the v061 data and the differences were reported in the supplementary material.

5. L127: is there any time dimension in the optimization conducted in this study or the optimization is only done in the space domain and on one image (Snapshot)? Can you comment on how different it would be if the optimization were conducted for each pixel separately and in time and why not time series based objective function is used in your optimization?

6. L207: net irrigation is a misleading phrase as explained in the major comment (1).

7. L290: please explain why the net irrigation precision is higher than the ensemble baseline rainfed ET.

8. L378: I assume here the Author meant RS-based actual ET by the reference ET which is again misleading as the reference ET has a different meaning in the evapotranspiration community. I suggest using different terminology.

Minor:

1. L19: 25 mm/season is the average of two basins? Please explicitly mention
2. L19: I think an "of" is missing after "the robustness"
3. L46: Koch et al., 2020 …
4. L261: 16th …
5. L265-266: this sentence is not clear to me please rephrase