

## ***Interactive comment on “Estimating irrigation water use over the contiguous United States by combining satellite and reanalysis soil moisture data” by Felix Zaussinger et al.***

### **Anonymous Referee #2**

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Review of Zaussinger et al., ‘Estimating irrigation water use over the contiguous United States by combining satellite and reanalysis soil moisture data’

With great interest I have read this study trying to quantify irrigation amount from spatial remote sensing and land surface reanalysis. Manuscript is well written in good English and clear, results are well supported by figures, title and abstract reflect the work presented. It is relevant for HESS Readers. I suggest that Authors do some more bibliography as I am missing some relevant work on modelling (and even assimilation) as well as mapping of irrigated areas from the introduction. I also recommend Authors to have a careful read as e.g. many acronyms are missing. It is a very interesting study,

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stemming on previous work from e.g. Kumar et al., 2015, but yet I am not completely convinced (and Authors will have to prove me wrong), that is why my recommendation is major review. Please find below an attempt to help.

P.2, L11-13: “It influences the surface watera5\_hres010 r and energy balance through directly increasing soil moisture, which in turn modulates the partitioning of energy between sensible and latent heat (Seneviratne et al., 2010).” I find this sentence slightly simple, is the link with the reference fully appropriate? Are Seneviratne et al., 2010 clearly mentioning irrigation or are they indicating soil moisture in general?, OK soil moisture is increased on irrigated land but water has to come from somewhere else right? Sometimes it is sourced nearby, sometimes not. I think it has to be reflected in the text.

P.2, L.31: “To date, irrigation practices are typically not explicitly included in land surface, [...]” you are right, however some studies have emerged from a modelling point of view (e.g. work from Lawstone et al., 2015 over the US) and even data assimilation point of view (see recent work from Kumar et al., 2018 on the US NLDAS for irrigation intensity over CONUS). I believe it has to be acknowledge in your study.

Lawston PM, Santanello JA Jr, Zaitchik BF, Rodell M (2015) Impact of irrigation methods on land surface model spinup and initialization of WRF forecasts. *J Hydrometeorol* 16(3):1135–1154

Kumar, S. V., Jasinski, M., Mocko, D., Rodell, M., Borak, J., Li, B., Kato Beaudoin, H., and Peters-Lidard, C. D.: NCA-LDAS land analysis: Development and performance of a multisensor, multi-variate land data assimilation system for the National Climate Assessment, *J. Hydrometeor.*, <https://doi.org/10.1175/JHM-D-17-0125.1>, online first, 2018.

P.3, section 1.1 on Statistics on irrigated areas and water withdrawals, I am surprised that some more recent work from e.g. Siebert et al. is not mentioned here, please see Siebert et al., 2015 and Meier et al., 2018.

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Siebert, S., Kummu, M., Porkka, M., Döll, P., Ramankutty, N., and Scanlon, B. R.: A global data set of the extent of irrigated land from 1900 to 2005, *Hydrol. Earth Syst. Sci.*, 19, 1521-1545, <https://doi.org/10.5194/hess-19-1521-2015>, 2015.

Meier, J., Zabel, F., and Mauser, W.: A global approach to estimate irrigated areas – a comparison between different data and statistics, *Hydrol. Earth Syst. Sci.*, 22, 1119-1133, <https://doi.org/10.5194/hess-22-1119-2018>, 2018.

P.4, L.15, please rephrase and extend or remove, it can be better introduced.

P.4, L.25, please provide acronym for USGS (and later in the text CRU, DEM, ISBA, SURFEX...all acronyms have to be explained).

P.6, L.11-14, this sentence caught my interest, assuming that microwave remote sensing is sensitive to the very first cm of soil, at least at X- and C-band, could you detect all irrigation types? Is dripping/micro-irrigation leading to a sufficient change in soil moisture to be noticed from space? What about vegetation masking the ground? We all have in mind pictures of irrigated (fully developed) corn, can remote sensing see through that? Although it is mentioned in 5.1.3 maybe it could be ruled out C-band? At least for certain period of vegetation cycle. By the way, why not considering SMOS L-band mission, my understanding is that it should be more sensitive to soil moisture than the sensors you use (?). SMAP is used but in combination with SMOS (I am aware that combined products exist) it would lead to a longer period being investigated.

P.6, L.27, please add reference for SURFEX (Masson et al., 2013).

Masson, V., Le Moigne, P., Martin, E., Faroux, S., Alias, A., Alkama, R., Belamari, S., Barbu, A., Boone, A., Bouyssel, F., Brousseau, P., Brun, E., Calvet, J.-C., Carrer, D., Decharme, B., Delire, C., Donier, S., Essaouini, K., Gibelin, A.-L., Giordani, H., Habets, F., Jidane, M., Kerdraon, G., Kourzeneva, E., Lafaysse, M., Lafont, S., Lebeaupin Brossier, C., Lemonsu, A., Mahfouf, J.-F., Marguinaud, P., Mokhtari, M., Morin, S., Pigeon, G., Salgado, R., Seity, Y., Taillefer, F., Tanguy, G., Tulet, P., Vincendon, B.,

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Vionnet, V., and Voltaire, A.: The SURFEXv7.2 land and ocean surface platform for coupled or offline simulation of earth surface variables and fluxes, *Geosci. Model Dev.*, 6, 929–960, <https://doi.org/10.5194/gmd-6-929-2013>, 2013.

P.6, L.32, “[...] that SMAP soil moisture carries a clear irrigation signal from rice irrigation [...]”, could you please specify irrigation type, flooding (as it is likely to be water seeded)? Did SMAP see open-water there?

P.11, L.4, didn't you say earlier that this map was not reliable? Please clarify.

Section 3.4, then considering SMOS would make it possible investigating longer period of time.

P.11, L.18-23, please see work from Kumar et al., 2015 on the scaling issue.

P.12, sections 4.1 to 4.3, so a big assumption is that the mismatch between model and satellite soil moisture is irrigation, so the forcing is assumed to be perfect and we know that is not the case. I am also curious on the possible mismatch between what land cover the satellite is really sensing and what MERRA2 has for land cover. The same is true for soil texture, porosity and all ancillary data...could it lead to spurious irrigations/non-irrigation? And what about temporal mismatch? Do you consider the satellite soil moisture revisit time enough for such study? If it rains after the satellite has passed (but maybe it a silly thought as you consider rain free period -according to the forcing)? Please comment on this issue. You should also assess your method in areas where crops are rain-fed only to see what signal is detected when we know that no irrigation occurs (see 5.1.3!)

P.18, L.7, typo (?) “due to”

P.21, L.7-8, “Consequently, microwave soil moisture retrievals are expected to be most sensitive to flood irrigation, followed by sprinkler- and micro-irrigation [...]” are microwaves less sensitive to micro-irrigation or not at all?

Please reshape figure 6 as text is hardly readable (and label panels as much as possible

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for sack of clarity)

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2018-388>, 2018.