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Comment on hess-2020-627

Anonymous Referee #1

Referee comment on "Untangling irrigation effects on maize water and heat stress alleviation using satellite data" by Peng Zhu and Jennifer Burney, Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2020-627-RC1, 2021

This is an interesting article describing effects of high temperature and drought on maize yield and yield components in Nebraska. The authors used remote sensing to detect high temperature stress and drought stress and also tested whether four different crop models can reproduce the effects detected by remote sensing. The article is well written, good to understand and figures are of high quality. However, I cannot recommend to publish the present version of the article in HESS. My major criticisms are:

1) The major source to describe high temperature and drought stress in maize are land surface temperature and ET detected by remote sensing. I think that the temperature based indicators LST and EDD are highly determined by the ratio ET/PET which was used to describe drought impacts. Which factor different from drought can explain canopy temperature differences between well watered and rainfed maize fields? Or in other words: can differences in LST and EDD at the same location happen independently of drought stress? I don't think so. If so, for example because of different LAI, then this is likely an affect of drought in previous growth stages.

It is well understood that transpiration cooling is directly controlled by the stomata conductance and vapor pressure deficit, which are again controlled by drought. This is also the reason why canopy temperature differences are often used as indicator for drought stress or even for irrigation scheduling. Consequently I think that EDD differences or LST differences between irrigated and rainfed maize in the same region are just another manifestation of differences in drought stress between irrigated and rainfed fields. From that perspective I cannot understand why the collinearity tests performed for the variables included in equation 7-9 did not show critical values.

2) The authors showed that there are considerable differences in the growing season length of irrigated and rainfed maize and suggest that the differences are mainly an effect of cooler canopy temperature under well watered conditions (lines 322-337). Another potential reason could be the so called drought escape effect. It is known that many crops speed up their phenological development under drought to make sure that grains reach

physiological maturity before the stress becomes so strong that the crop has to die. Again, in that case it would be a drought effect and not an effect of higher temperatures. I agree that it is not so easy to find out which effect really matters. I suggest to test the GDD computed in equation 3 for years with similar canopy temperature but different drought stress (ET/PET ratio). For example, a year that is warm and wet should result in similar canopy temperatures compared to a year that is a bit cooler but dry. Important is that the test has to be made for the same location (county) to avoid that cultivar differences between warmer and cooler regions disturb the relationship. If for years with similar canopy temperature but different ET/PET ratio the GDD is similar, then the shorting of the growing period is independently of drought and the drought escape mechanism can be excluded. If GDD is, for similar canopy temperatures, positively correlated with the ET/PET ratio, then this would point to the drought escape mechanism.

Specific comments:

Line 175 (equation 3): Why was it decided to set the high temperature threshold to 30 dC? In the literature heat stress thresholds for maize are typically higher, about 34 dC (Sanchez et al., 2014).

Line 262 (equation 7): How was LST and ET/PET computed? As mean for the whole growing period? In the variable explanation (line 265) you call LST "local crop temperature stress" but shouldn't you then better use EDD here?

Lines 280-292: Any reason why delta EDD and delta ET/PET are NOT highly correlated?

Lines 363-365: "As shown in Figure 7, we found that temperature sensitivity of yield was significantly weakened from − 6.9%/â□□ to −1%/â□□ in irrigated vs. rainfed areas ..."

=> shouldn't this be vice versa (lower sensitivity in irrigated maize)?

Lines 438-442: The assimilation of satellite derived LST might in fact reduce crop model uncertainty but this helps only when LST data are available. Crop models are also often used for climate change impact analysis but for simulation of potential futures LST is not available. Another disadvantage could be that LST is sensor and satellite specific, for example due to the different overpass times. Therefore another recommendation could be to improve crop models so that they can reproduce the effects that were found in the present study and use remotely sensed LST for validation.

Figure 8: It seems that there is also considerable drought stress in irrigated maize because the ET/PET ratio is often much lower than 1. Any explanation why yield under irrigated conditions is often much higher for similar ET/PET ratios? Because irrigated maize is more often grown in cooler regions?

References:

Sanchez, B., Rasmussen, A. and Porter, J.R. (2014). Temperatures and the growth and development of maize and rice: a review. Global Change Biology 20, 408–417.