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Interactive comment on "Propagation of biases in humidity in the estimation of global irrigational water" *by* Y. Masaki et al.

Anonymous Referee #2

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Masaki et al. address in their manuscript entitled "Propagation of biases in humidity in the estimation of global irrigational water" a timely and important topic. It is relevant for hydrological and vegetation/crop models that use humidity as input (other models use different approaches) for estimation of potential evapotranspiration (Epot). Nevertheless, it is crucial and timely to increase our understanding of uncertainties associated with estimates of global irrigation water requirements.

Masaki et al. use climate scenarios from 5 GCMs that are bias-corrected for all variables but humidity (ISI-MIP setup) to investigate the effect of the remaining humidity bias on global estimates of irrigation water abstractions under current and future climates, based on simulations with the global hydrological model H08. In addition, they carry out a sensitivity analysis employing artificial humidity perturbations. Moreover,

they perform another simulation using a bias-corrected humidity product, and they are able to show that such corrections can contribute to reducing uncertainty in global estimates from ensemble GCM simulations.

In general, the study setup is well designed and aims at on open research question suitable to be published in ESD. However, the conceptual design involves some drawbacks and, to my regards, some mistakes, that are not discussed in the manuscript and might affect the overall study results. First, I present some general concerns, thereafter I relate to more detailed comments and questions. I suggest a major revision to address these points.

- Simulated irrigation water demand is only based on Epot, soil moisture and precipitation is not accounted for. Furthermore, it is assumed that actual evapotranspiration (Eact) always equals Epot. I do not agree with this assumption, but one could argue that it holds true for the IWD scenario (potential irrigation water demand). However, the study also relies on this assumption for the IWAR scenario (actual irrigation water abstraction), which is constrained by local water scarcity and thus Epot cannot equal Eact by definition. Accordingly, Eact is likely to be less dependent on humidity and thus the bias effect on irrigation water demand might be overestimated here.

- Moreover, why is it important to study bias impacts on potential withdrawal amounts? Since it is an artificial value (in this study: 3129km3/yr, ensemble mean, year 1971-2000) the impact of humidity bias might be much smaller in reality. I assume it might be more relevant to investigate the bias effect on actual water consumption, since much of abstracted water returns to the riverine system.

- It is unclear from the manuscript how irrigation water abstraction is derived, how it is calculated, and how irrigation efficiencies are incorporated. There is a conceptual error with the definition of IWAR (defined here as water abstraction, diverted from rivers, section 2.2) but it is later argued that IWAR is in line with irrigation water consumption from other studies (p. 94 l. 25). This indicates that actual irrigation water abstractions simulated here (1269 km3/yr ensemble mean, year 1971-2000) are substantially below competing studies (irrigation water water withdrawal/abstraction estimates are generally ∼2200-2500 km3/yr, and consumption ∼1100-1400 km3/yr; e.g. Wada and Bierkens, (2014), Döll et al., (2014)). More generally, in the manuscript target variables need to be defined more clearly and transparently in respect of recent literature (withdrawn/diverted irrigation water vs. consumed/depleted irrigation water, role of returnflow, irrigation water losses (beneficial and non-beneficial) etc.). As it is correctly cited in the introduction from Vörösmarty et al. (2005).

- The study lacks a quantification to what extend bias-corrected GCM simulations of precipitation still affect IWD/IWAR estimates. It is concluded that bias in humidity is the only factor explaining the range in irrigation water demand across GCM outputs during the reference period, but also in future climate scenarios. For the reference period the precipitation effect might indeed be small, but it needs to be shown, as it is done for air temperature. For future time periods this assumption might not hold true, since GCMs develop individual precipitation patterns, which strongly affect irrigation water demands (at least in other studies).

- Stylistic language editing of the manuscript might straighten some unclear or imprecise formulations.

More detailed comments:

- It is not common to use the term “irrigational water” or “irrigated water”, as it is used here it is sometimes arbitrary. I suggest to use more precise terms that are commonly used, e.g. “irrigation water demand/consumption/withdrawal” etc.

- Check consistency of tense in manuscript

p 82 line 11: unclear formulation, meteorological data sets relate to GCM outputs?

p 83 line 7: irrigation water is not “lost” through evapotranspiration, it is depleted or consumed, but only water that is non-beneficially consumed, i.e. “lost” during conveyance

or irrigation application (soil evaporation etc.) con be considered losses.

p 84 line 3: In addition to model parameter estimates and issues with input data, irrigation systems itself are in most models not sufficiently represented and only rough indicative estimates for irrigation efficiency are employed.

p83 line 20: references needed here

p 86 p5: Please give a reason why you don’t use the reservoir module, I assume abstraction rates would be more realistic using it?

p 86 line 12: “The human impacts of irrigational, municipal and industrial water abstraction from rivers for consumptive use were determined.” How were they determined?

p 86 line 18: Which crops/crop types are simulated by H08?

p 86 line 19: “The soil water of cropland is lost through evapotranspiration and runoff.” better use depleted instead of lost.

p 86 line 20: Please clarify why evapotranspiration estimates are not linked to soil water content.

p 86 line 23: There are more recent publications on the extent of irrigated cropland. Please clarify why you do not use e.g. Siebert et al. 2014: A global dataset of the extent of irrigated land from 1900 to 2005.

p 86 line 25: Double-cropping information is based on what kind of data?

p 86 line 27: Mosaic 4, what “other” uses does it represent? It is not shown along with the other mosaics in Figure 1, it is not mentioned in any Table or Figure. If not important, consider to skip.

p 87 line 4: Why is irrigation water consumption consequently not shown in this study? I’d assume it is very important to show the effect of humidity bias on depleted water, maybe even more important than diverted water, since half of it returns to the riverine system.

p 87 line 5: "...irrigational water demand (IWD) and simulated irrigation water abstraction..." IWD not simulated?

p 87 line 6: Please elaborate how IWD and IWAR are derived. How are efficiencies from Döll and Siebert et al. (2002) incorporated?

p 87 line 10: Water is not only lost through conveyance, irrigation efficiencies also account for losses during water application to the plant. But it is important to separate consumptive losses from return-flow, which might be recoverable for downstream users. Please clarify how you incorporate indicative values for water use efficiency by Döll and Siebert (2002). These values do not reflect that a substantial amount of "lost" water remains in the system.

p 88 lin 19: This is one of the more important critique points. Eact = Epot can only hold true for IWD, right? In IWAR simulations, W might fall below 0.75 in case of local surface water scarcity. More generally, I do not agree that Eact is not constrained by soil water content. In this regard the irrigation type is very important, even when using surface irrigation systems, the surface soil layer might not be saturated anymore soon after the irrigation event, while the root zone is still well watered. In this case soil evaporation is reduced and Eact does not equal Epot. Using drip system further decreases soil evaporation.

p 89 line 12: "(crop type, crop calendar, etc.)" In my opinion, most important are irrigation management and irrigation technique.

p 92 line 15: Although soil moisture is not considered for calculating irrigation water demand, what is the contribution of different precipitation regimes, even though bias-corrected?

p 93 line 12: "That is, small humidity biases over irrigated cropland are beneficial for suppressing their effects on irrigational water." Unclear formulation

p 94 line 25: This is wrong! You compare water withdrawal/abstraction from your study with water consumption from other studies. Please clarify. Please elaborate why you arrive at withdrawal amounts way below competing studies. Roughly speaking, agricultural consumption is generally assumed to amount to ∼1100-1400 km3/yr and agricultural water withdrawal to ∼2200-2500 km3/yr.

p 98 line 18: This is wrong! Bias in GCM precipitation is small during reference period (needs to be shown!), but GCMs develop individual precipitation patterns in future scenarios. These individual patterns strongly affect irrigation water demands.

p 124: show Figure 5 also for precipitation

p 125: why IWAR only for MOSAIC0? not clear from Methods section.

p 129: Why only HadGEM shown? What is the reason to select HadGEM? Why only June and August? Monthly sums might be more informative.

References Döll, P., Schmied, H., Schuh, C., Portmann, F., and Eicker, A.: Global-scale assessment of groundwater depletion and related groundwater abstractions: Combining hydrologi- calmodeling with information from well observations and GRACE satellites, Water Resources Research, 50, 5698–5720, doi:10.1002/2014WR015595.Received, 2014.

Wada, Y. and Bierkens, M. F. P.: Sustainability of global water use: past reconstruction and future projections, Environmental Re- search Letters, 9, 104 003, doi:10.1088/1748-9326/9/10/104003, http://stacks.iop.org/1748-9326/9/i=10/a=104003?key=crossref. 5e9e54a6dcd7140e8f70e367028e1217, 2014.

Interactive comment on Earth Syst. Dynam. Discuss., 6, 81, 2015.