

## ***Interactive comment on “Groundwater use for irrigation – a global inventory” by S. Siebert et al.***

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Response to Comment #2, Bridget Scanlon, Hydrol. Earth Syst. Sci. Discuss., 7, C1713–C1716, 2010

Thank you very much for providing this careful review which helped us a lot to improve the manuscript! In the following section we list a detailed response to each of the comments.

Reviewer Comment: There are a lot of acronyms used in the paper and it might be helpful to put them together in a table.

Response: This is a very good idea. We will add such a table to the appendix or as supplementary material (depending on the size of such a table).

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Reviewer Comment: The naming of regions in the paper is not internally consistent and does not follow general usage: e.g. northern America North America etc.

Response: We will ensure a consistent naming of regions for the final version of the manuscript.

Reviewer Comment: I did a check for US data. The Supplement S2-V3 lists 27,913,872 ha as the AEI for US and lists Siebert et al. (2005) as the source of the data. However, this is not an original source and the original source is not provided in the 2005 reference. The FRIS data (Farm and Ranch Irrigation Survey, not Farm and Range Irrigation Survey as in Supplement) are used to estimate the fraction that is based on groundwater. It would be best to use the same data source for the AEI, which is 22383699 ha for 2002, rather than 27,913,872 ha.

Response: The area equipped for irrigation (AEI) is not known for the United States. The 16th census of the United States, undertaken in 1940 and published in 1942 reported for the last time the so called “Area of irrigation works were capable of supplying with water” which comes close to the definition of AEI used in the manuscript. At that time this area was 28,055,248 acres while the area actually irrigated in year 1939 (called “area irrigated” in the census report) was 21,003,739 acres (75% of the AEI). Beginning with the 1950 Census of Agriculture the area actually irrigated in the year of the census survey is reported, which is similar to the area actually irrigated (AAI) used in the manuscript. The 22,383,699 ha irrigated land mentioned by the referee for year 2002 represents the AAI while the AEI is larger but not reported. Therefore, to estimate AEI, we selected for each county the maximum of AAI reported in the water use censuses of USGS for years 1995 and 2000 and in the agricultural censuses of USDA for years 1997 and 2002 and assumed that this maximum represents the equipped area (AEI). This procedure is described in Siebert et al. (2005) and in the related online resources (<http://www.fao.org/nr/water/aquastat/irrigationmap/us/index.stm>). Therefore this is also the appropriate citation for the AEI used in this inventory. A similar procedure is also used by the Natural Resources Conservation Service (NRCS) of USDA,

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who defined irrigated land as “Land that shows evidence of being irrigated during the year of the inventory or during two or more years out of the last four years” (<http://www.nrcs.usda.gov/technical/NRI/maps/meta/m5297.html>). The irrigated area computed this way by the NCRS was 67.5 million acres (27.3 million ha) for year 1997, which is very close to the AEI estimated in our inventory. However, the NRCS data were unfortunately not available at the county level.

Reviewer Comment: In the Supplement 1, the authors indicate that: We further down-scaled these statistics by using county-level data on irrigation water extraction from ground- and surface water (USGS, 2005; USGS, 1998) by assuming that the ratio between irrigated areas from ground- and surface water was similar to the ratio between groundwater use and surface water use for irrigation. The ratio between groundwater use and surface water use for irrigation based on 2000 data is 58% surface water and 42% groundwater (Hutson et al., 2004). The ratio from the data in Supplement S2-V3 is 69% groundwater, 41% surface water, almost the reverse of Hutson et al. (2004). The values of AAI for groundwater and surface water correspond to those from FRIS for 2002. The USGS and FRIS data do not seem to correspond. It would be good if the authors would comment on this. I may not be using the same data as were used in this paper but I tried to follow what was provided in the Supplementary Material.

Response: We used the statistics of the Farm and Ranch Irrigation Survey (FRIS) 2003 as the primary source of information for the United States because it is based on questionnaires filled by the irrigating farmers themselves and provides likely the most complete and detailed profiles of irrigation in the United States. According to this survey 61% of the irrigated land (AAI) was irrigated from wells and 39% from surface water sources. However, the average amount of water applied per acre varied significantly by source with lower values for wells and largest values for off-farm surface water supply. Therefore, according to the FRIS, 50% of the irrigation water application was from wells and 50% from surface water sources. Since the FRIS is only reporting statistics at the state level, we were using additionally the data collected by the USGS water census

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2000 (Hutson et al., 2004), because these data are available at county level. However, we only used the USGS-data for downscaling to represent the spatial patterns within the states, at the state level the AAI irrigated with groundwater or surface water is still consistent to the AAI reported in the FRIS. There are in fact differences between the USGS water census and the FRIS in the reported contributions of groundwater and surface water use in irrigation. One reason could be that the USGS water census reports “irrigation water withdrawals” while the FRIS reports “irrigation water application”. The difference could be in the water losses between the extraction point and the application point. These losses are larger for long distance surface water transfers in canals as compared to on farm extraction of ground water by wells. Therefore the contribution of surface water should be larger in water withdrawals as compared to water application. We will extent and improve the section in supplement S1 describing the data, references and methods used to compute irrigated areas and irrigation water use for the United States in order to avoid any misunderstanding of the terms and definitions.

Reviewer Comment: p. 3, L. 67-68, Shiklomanov et al. (2000) is generally referenced as the primary source for irrigation accounting for 70% of fresh water withdrawal and 90% of consumptive use.

Response: (In the HESSD-paper, the related section is on page 3980, lines 6-7) That’s true but the estimates in Shiklomanov et al. (2000) refer to year 1995 and the references shown in the paper use more recent and more complete data. We will add Shiklomanov et al. (2000) as additional reference.

Reviewer Comment: p. 4, L. 92- 97, It would be good to include some information on the spatial resolution of the satellite based product of Thenkabail et al. (2009). I think the percentages of surface water, groundwater and conjunctive use water for irrigation from Thenkabail should be checked. It seems that groundwater should be a much higher percentage.

Response: (In the HESSD-paper, the related section is on page 3981, lines 4-10)

That's true but we can only repeat what was written in the reference. The coarse spatial resolution of the imagery used in this study was mentioned in our manuscript as one major limitation (page 3981, line 10).

Reviewer Comment: P. 4, L. 122-123: I presume the inventory will be available on the Aquastat web site when this paper is published: : .it may be better to state that "is available" rather than "will become available".

Response: (In the HESSD-paper, the related section is on page 3982, line 7) We will change this section for the revised version of our paper.

Reviewer Comment: P. 1, L. 24-25; P. 10, L. 282: The US is discussed in many parts of the paper; however, none of the tables within the paper list the US separately. It might be helpful if they did. I understand that the data are in the supplementary material.

Response: We used in the manuscript the FAO AQUASTAT regions and sub-regions described in supplement S3 in order to be consistent to other reports available in the database. However, input data and results for the US are described in supplements S1 and S2.

Reviewer Comment: P. 11, L. 305: what is meant by "localized irrigation"? ? drip irrigation?

Response: (In the HESSD-paper, the related section is on page 3989, line 17) We use the term in agreement to the AQUASTAT glossary (<http://www.fao.org/nr/water/aquastat/data/glossary/search.html?lang=en>) for "a system where the water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it". Therefore drip irrigation, spray or micro-sprinkler irrigation and bubbler irrigation belong to this category. We will add a reference to the AQUASTAT glossary to the revised version of the manuscript.

Reviewer Comment: P. 13, L. 380: The Ogallala aquifer is part of the High Plains

aquifer. It would probably be best to indicate the High Plains aquifer, particularly in Texas and Kansas.

Response: (In the HESSD-paper, the related section is on page 3992, line 14) Accepted, this will be changed.

Reviewer Comment: P. 13, L. 393: What is meant by “from own estimates” i.e. this study?

Response: (In the HESSD-paper, the related section is on page 3993, line 1) In case of no data and no information regarding sources of irrigation water it was in a few cases required to estimate the percentage of area irrigated with groundwater by using for example data from neighbouring countries with similar conditions. However, this is reported in detail in Supplement S1.

Reviewer Comment: P. 14, L. 403-406: need more detailed references for these data beyond census source listed in figure caption.

Response: The revised version of the manuscript will contain detailed references to the data sources for figure 4.

Reviewer Comment: P. 16, L. 490 – 491: In California Central Valley, surface water is used in preference to groundwater. Faunt, C. C., Ed. (2009). Groundwater availability of the Central Valley Aquifer, California. USGS Prof. Paper 1766, 173 p.

Response: Yes, this is also shown in Figure 2. There are other regions as well where surface water is preferred although groundwater is accessible. We discuss some reasons on page 3998.

Reviewer Comment: P. 17, L. 512: “with more favourable climate conditions” should be “with more favourable climate conditions”

Response: We will change this in the revised version of our paper.

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