Hydrol. Earth Syst. Sci. Discuss., 8, C3971–C3974, 2011
www.hydrol-earth-syst-sci-discuss.net/8/C3971/2011/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Modelling global water stress of the recent past: on the relative importance of trends in water demand and climate variability" *by* Y. Wada et al.

Anonymous Referee #2

Received and published: 12 September 2011

The manuscript "Modelling global water stress of the recent past: on the relative importance of trends in water demand and climate variability" by Wada et al. attempts to highlight the role of human water use and climate variability on global water stress. The paper emphasizes that the increase in human water use, particularly for irrigation, largely increased global population living in water stressed regions from 1960 to 2000. Overall, the results presented are interesting, the paper is well written, and is suitable for HESS readership. However, there are a number of issues the authors should address before the manuscript can be accepted for publication. Some unnecessary tables could be removed and more discussion could be added, for example, to high-

light the role of desalinated water and groundwater use in reducing water scarcity. My detailed comments are as follows:

Major comments:

(1) The methodology section (2) is rather lengthy and could be shortened. For example, section 2.6.2 can be shortened, and only the updates over Wada et al. (2010) can be highlighted.

(2) Eq. 1, section 3.4, and Table 9: you compare your results with Kummu et al., (2010) which, as you have indicated, is the only study assessing the past development of water scarcity. However, there are numerous studies on water stress around the year 2000 or the mid-1990s, e.g., Vorosmarty et al., (2000), Oki and Kanae (2006), Hanasaki et al. (2008b), Alcamo et al. (2007), all listed in the references. As you account for desalinated water and groundwater abstractions in calculating water stress (Eq. 1), I would expect your estimates of population living in water-stressed areas would lie on the lower limit of these previous estimates. However, your value of 2.6 billion (43%) is well above the most previous estimates. Please compare your results for the year 2000 with the above listed studies in section 3.4, and also add discussion in the final section.

(3) Section 2.5 and Table 3: it would be interesting to see how the use of desalinated water affected your WSI, particularly in countries using huge amounts of desalinated water such as the Saudi Arabia.

(4) Section 2.6.1: what is the unit of RIrr? In Eq. 7, why do you multiply the latter term by Tirr,i? I wouldn't know but the first term here is a flux (per day) and the latter one is given in terms of total volume for the cropping period. Please make sure that it is correct. I would suggest using 'irrigation return flow' rather than 'artificial recharge' because apparently only irrigation is considered here. Also, P7415,L1: irrigation water infiltrates at a rate of unsaturated hydraulic conductivity of the top soil layer, but recharge to the groundwater storage (gravity drainage) would be equal the unsatu-

rated hydraulic conductivity of the bottom soil layer, am I right? Going back to P. 7410, L20: how do you consider the domestic/industrial return flows? Are they directly added to surface runoff?

(5) Table 8: what are the differences here with the previous estimates (Wada et al, 2010)?

(6) Section 3.5 and 3.6: in these sections, you highlight the climate- and anthropogenically-driven water scarcities and discuss the historical drought events. As you have pointed out, in many emerging economies, and also globally, irrigation water demand is the major cause of heightened water stress. Irrigation demand simulated by your model is largely dependent on precipitation received during irrigation period. In that sense, the anthropogenic cause here is not totally independent of the climatic causes. Please note this limitation with some discussion. Also, specify the definition of drought in your study.

Minor issues:

(1) P. 7401, L2: why (e.g., dams)?: can't reservoirs and dams be used synonymously?

(2) P. 7401, L8: withdrawal: is it same as the 'gross demand' defined in pp. 7403 L.2? They have been slightly touched upon in Fig. 2, but clarification in the text would be appreciated. In Fig. 2, what does 'actually available to satisfy requirements' mean? Only from surface sources or including desalination and groundwater?

(3) P7407, L1: please confirm that all values from previous studies in Table 2 are correctly listed.

(4) P7415, L1-2: 'groundwater abstraction is somewhat uncertain' contradicts with 'Estimated groundwater abstraction is subject to large uncertainties' in P7428,L20. I think groundwater abstraction is largely uncertain. Here, You may also want to compare your results (Table 4) with the recent statistical and model-based estimates by Konikow (2011) and Pokhrel et al. (2011), respectively.

(5) Fig. 3: I would not know if it is printing issue, but the symbols denoting different years are hard to differentiate. Also, adding 1:1 line in each panel would be appreciated.

(6) P7419, L16: Why is your irrigation demand lower?

(7) P7420, L2: does it mean that 420 km3 (out of the net irrigation water use of 1376 km3 in Table 6) returns to the groundwater systems? In other words, (1376-420) km3 is lost as consumptive use? Please clarify.

References:

Konikow, L.F., 2011 : Contribution of Global Groundwater Depletion Since 1900 to Sea-Level Rise, GEOPHYSICAL RESEARCH LETTERS, VOL. 38, L17401, doi:10.1029/2011GL048604

Pokhrel et al., 2011: Incorporating anthropogenic water regulation modules into a land surface model, J. Hydrometeorology, doi: 10.1175/JHM-D-11-013.1

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 7399, 2011.