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Hydrology and Earth System Sciences Discussions

Interactive comment on "Reconstructing 20th century global hydrography: a contribution to the Global Terrestrial Network- Hydrology (GTN-H)" *by* D. Wisser et al.

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General Comments:

The authors apply a spatially-distributed water balance model to separate-out the natural versus human-induced changes to streamflow over continents and large river basins. The model accounts for changes in precipitation and temperature as well as human-induced changes due to reservoir operations and irrigation. The model includes explicit treatment of snowmelt dynamics, crop water use, reservoir operations, river routing, and irrigation. There is no explicit treatment for deep groundwater dynamics, a common shortcoming among large-scale hydrology models. The model runs at a daily

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time-step at a spatial resolution of 30 minutes.

The main issue that I have with this paper is that many of the assumptions are not adequately defended, and there is no basis given for the selection of numerous parameters and equations. Furthermore, there is no sensitivity analysis for many of these processes and parameters showing how important they are for the paper results and conclusions. Below, I list some specific examples:

1. Equation 1: the snowmelt equation comes from where? A regression based on empirical data? Was a physically-based method not used because with a daily time-step, snowmelt dynamics cannot be properly simulated?

2. 2685, 7: Why was 5 degrees C used? Is there a reference?

3. 2685, 10: the growing season starts 1 month before month with max rainfall that year. What is the basis for this assumption? How reasonable is it?

4. Section 2.3: How are beta and gamma parameterized? Empirically? From the literature? Are the results sensitive to these values?

5. Section 2.5.1: You need to somehow demonstrate that not using an objective function specific to the purpose of the dam is not significantly affecting your results. If it is, by how much? Actually, I think it would be possible to increase the sophistication of this model by assigning a purpose to each of the major dams, as the ICOLD database generally includes purpose. Reservoirs that have 2 or more purposes are not a problem, as a multi-criteria objective function can be created for these. However, if doing this does not impact your results, this is not important at this time. Later, this sophistication should probably be added to the model, as you and/or others may want to use the model to start understanding processes at finer temporal and spatial scales. Furthermore, why is reservoir evaporation neglected? If the water balance model is already simulating evaporation, it should be straight forward to include reservoir evaporation, which can be significant in drier, warmer climates.

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6. Section 2.5.2: How is h = 2m chosen?

7. Section 2.6: In allowing irrigation, there is no treatment of water laws, regulations, and policies (e.g. water rights system in the western US). Although a rigorous treatment would be way beyond the scope of the project, this point should at least be mentioned, and there should be some kind of sensitivity analysis to determine whether or not some kind of a water rights system might impact the results (e.g., all perennial-growers have senior rights versus field-crop growers all having junior rights – as a very simplistic assumption that can be explored for the Columbia River Basin, for example). However, with the current model configuration, the crops never experience any kind of water shortages as all of the shortages are met with deep groundwater resources. This should also be subjected to a sensitivity analysis by letting some or all crops experience water shortage during dry years, which is much more realistic.

8. Section 3.2: An assumption is being made that the change in irrigated areas is spatially uniform across each country.

9. Section 3.2: crops were aggregated into 4 groups: perennial, vegetables, rice, and others) – what is the rational for this grouping? For example, field crops like wheat, barley, and alfalfa will be placed in the "others" generic category. Does this make sense for such a wide-spread group of crops?

Specific Comments:

1. 2680, 12: "variations in the volume of water entering the oceans" – at what time-scale?

2. 2681, 10: "for example in the temperate zone" – why? Because water is unfrozen?

3. Section 2.2.2: What other models use this approach? This might help defend your use of it.

4. 2684, 22-24: How is this different from how the model handles infiltration elsewhere over the land surface?

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5. A coupled crop model over the large domain is fairly novel. This point should perhaps be emphasized with a sentence or 2 discussing how other largescale models deal with crops.

6. 2685, 7-10: How did you differentiate between areas that are limited by precipitation versus temperature?

7. 2685, 17: To clarify things, state at this point that deep groundwater dynamics are not included.

8. 2689, 3-4: "but their combined storage capacity. . ." – is this from the McCully paper? If so, clarify.

9. 2689, 13-15: It is not completely clear exactly what mu is from this description. Should "can" be replaced with "should"? Also, "reservoirs" is misspelled.

10. 2689, 19-21: This is unclear. Either clarify with words or show it in equation form.

11. 2689, 23-25: Use "E" not "ET" for reservoir evaporation, as an open water surface has zero transpiration. Also, why not use the model's evaporation algorithm rather than a coefficient that is constant?

12. 2690, 19-22: from this sentence, it looks like this comparison has been performed. It would be interesting to either show this figure or give quantitative estimate of differences between the two.

13. 2690, 21-22: under-representation of precipitation at higher elevations: this can occur anywhere in the globe where there are mountains, not just in the high latitudes

14. Why were gauge-corrected data not used for this study? These data do exist on a global scale. Rather than discuss the shortcomings of not using the data, it would make much more sense to go ahead and use them.

15. 2691, 1: Precipitation trends can also be affected by gauge undercatch biases (the bias changes in time as the fraction of precipitation that is snow changes), as well as

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changing station networks used for gridding (Rawlins et al. 2006).

16. 2691, 24-25: I do not think it is defensible using the2002 daily sequencing (within months) for all of the months in the historical record. The least that could be done is sampling from random months from the GPCP period – this would remove the biases that you would have from using the same daily sequencing. This method is used by Wood et al. (2002) in downscaling monthly GCM data – the daily sequencing is taken from random from the historical period. (Wood, A.W., Maurer, E.P., Kumar, A. and D.P. Lettenmaier, 2002, Long range experimental hydrologic forecasting for the eastern U.S. J. Geophys. Res., 107(D20), 4429, doi:10.1029/2001JD000659.) This method has been tested. An alternative, of course, is to use global reanalysis data.

17. 2691, 27: "differences in model predictions were small" – at what spatial and time scales? Show results.

18. 2692, 12: "Adequately reflects. . ." – how do you know? Did you perform some sort of evaluation?

19. 2695, 9: "<4% on observed runoff" – over what time-scale? Annual average?

20. Section 5.1: How many of the observed stations are for regulated basins? How much does adding in reservoirs and irrigation improve the simulations (in comparison to observed) over the naturalized simulation?

21. Equation 21: What is the purpose of j? Is the "2" in the denominator also supposed to be "j"?

22. 2698, 3-5: Only 0.2% of groundwater stocks are utilized, but it this is not the same as the percentage of readily available groundwater stocks. For example, areas needing additional GW may not be the same areas with plentiful GW.

23. 2698, 13-15: So this sentence would suggest that evaporation over all of the land areas is primarily water-limited. Is this defensible?

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24. 2698, 24: “predicted natural runoff”

25. Section 5.4: Introduce this section with a description of what it could mean if runoff is changing: changing precipitation, changing ET, or change in delS/delT because of reservoir storage or groundwater pumping.

26. 2699, 23: what are the values from the earlier estimates? (or range of values)

27. “natural” and “pristine” are used interchangeably. Perhaps it would be better to stick to just one of these consistently.

28. 2701, 10: so the reservoirs were constructed in the early 1980s?

29. 2702, 3: Cite literature demonstrating that this is realistic for those areas, if it is.

30. 2703. 2: but climate has nearly as large an impact – they both decrease together.

31. 2703, 17: percentages not given for each basin, independently.

32. 2704, 1: also, glacier and permafrost melt was not considered

33. 2708, 6-9: where was this shown, just in figure 8 for 6 basins?

34. 2708, 21: What is dramatic?

35. Table 2: Do the Fekete 2002 data indicate observed? They are not mentioned in the caption. Also what period are these for?

36. Figure 3 caption: change runoff to ET

37. Figure 6: mention in the caption what “land” represents

38. Figure 7: add observed to these plots

Technical Corrections:

1. 2681, 19: “emission of trace gas emissions”

2. 2687, 15: “at-asite” – use “in situ”

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3. 2688, 13-15: this sentence is awkward: “for” instead of “from”?

4. 2689, 23: “is computed as”

5. Throughout the manuscript, there is a problem with referencing. For example, you would not say “provided by (AQUASTAT, 2008)” – you would say “provided by AQUASTAT (2008)”

6. 2696, 21-23: This sentence is awkward. Also, “the the” is a typo.

7. 2699, 20: have not yet introduced figs 5 or 6, before introducing fig 7.

8. 2701, 7: 2000

9. 2702, 12: negligible small

10. 2703, 11: as with discharge

11. 2704, 12: data were

12. 2704, 19: selected gauging stations

13. 2704, 22: the most the most

14. 2704, 27: two reservoir were

15. 2705, 28: station The

16. 2706, 19: in of the

17. 2706, 21: capacity, and sediment

18. 2707, 8: estimates days

19. 2707, 13: as increased

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 2679, 2009.