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Hydrology and Earth System Sciences Discussions

HESSD

Interactive comment

Interactive comment on "Estimation of water yield in the hydrographic basins of southern Ecuador" *by* Saula Minga-León et al.

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Dear reviewer: We are thankful for the time taken to review our manuscript, and we consider that the questions and comments are appropriate.

1) Comment: My main concern with this work is on the author's use of the Budyko framework for estimating water yield based on the functional form of one parameter Budyko model (Fu's equation; ω) without any proper validation. A recent study by Padron et al., 2017 (https://doi.org/10.1002/ 2017WR021215) provides a comprehensive picture on control of ω – relationships of which to catchment geo-physical attributes are not very clear (i.e., they appears to be location/climate specific). Therefore before resorting to any sort of the functional relationship (for ω), it needs to be properly vali-

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dated. The authors must show some sort of validations through e.g., split sampling test in time and space. Besides, it is not clear to me why the authors do not directly estimate the ω values through calibration. Such procedure is very common in literature (see the references given in Padron et al. 2017; https://doi.org/10.1002/2015GL066363; https://doi.org/10.1002/2015GL066363). I would like to see more discussion on this topic and especially the rational of author's selection (for the Budyko form).

Response: Yes, we agree with you. Calibration and validation must be done, and in fact, have been done. We will explain bellow. The present study used the Water Yield model from InVEST, for the estimation of water yield, which is based on the hydrological framework of Budyko adapted by Fu (1981) and Zhang et al. (2004). The first incorporates a catchment parameter (w) and the second an empirical parameter (Z). It′s important to mention that the Water Yield model of InVest is designed to model long term averages. As a rule of thumb, a 10-year period should be used to capture some climate variability, according to Sharp et al. (2018).Due to the lack of continuity and sample size of observed runoff of some hydrometrics stations, the available data allowed only making calibration and validation of the model at the following gauges; Alamor (H0616), Puyango (H0591), Arenillas (H0574), Jubones (H0530) and Zamora (H0889), in Table 1. Regarding hydrometric stations that have few observed data such as Macará (H0626), Catamayo (HB32), Chaguana (H0508) and Mayo (H0966) only calibration was performed. To standardize and summarize the information, it was decided to show only the global results over the whole period of available data.

Why not estimate directly the w factor?

The InVEST user's guide (Sharp 2018), between one of the prosed methods is to calibrate the parameter Z of the model which varies from 1 to 30 which will allow simultaneously to calculate w (equation 4). This method was evaluated and recommended by Hamel and Guswa (2015) and has been applied in studies such as Pessacg et al. (2015) and Redhead et al. (2016).

2) Comment: Another major concern, I have with this study is the achieved overall modeling results. Considering even the functional relationship of ω (and Z to estimate) based on the outflows of 9 basins, results shown in Table 4 rather indicate very poor model fits in 4 basins; and other 2 have unreasonably low Z values (less than 5) and one at the border line of Z = 5. The authors then left with 2 basins in which the Z parameter can be reliably estimated; and based on this I do not see how you come up with the conclusion that "The modeling of water yield in the majority of hydrographic basins was satisfactory". Besides there is no information provided in the manuscript on how the Z parameters estimated in limited number of (sub-) basins are applied to the entire (hydrographic) region – or even at the pixel level (Figures 5 & 6)? How did you treat the bad preforming basins (in terms of it and unreasonable Z values)?.

Response: Indeed, in the conclusions we stated that the results are satisfactory in most basins. This statement is supported (without mentioning it in the manuscript) by the classification of Moriasi et. al (2007). Indeed, according to these authors, the simulation results based on the relative error (PBIAS) are very good when PBIAS is $<\pm10\%$, good between 10 and $\pm15\%$, satisfactory between ±15 and $\pm25\%$ and unsatisfactory $>\pm25\%$. Water Yield Model is a relatively simple model (with one parameter). The unsatisfactory results in some basins can be explained only for two reasons, 1) whether the model does not adequately describe the studied phenomenon and/or 2) that the input data are not enough to describe the phenomenon or of poor quality (non-optimal meteorological network, no consideration of change of land use, observed flows of doubtful quality).

3) Comment: Page 7: It is not entirely true that "Data on the root restriction layer were unavailable" as authors, stated. Specifically in the HWSD database, which the authors are using – there is information on the root restrictions in so-called, attribute "ROOTS" (http://www.fao.org/docrep/018/aq361e/aq361e.pdf). Please double check. Also I think there is some mismatch between the authors plotted soil-depth (in Figure 3) and ones given in information of the HWSD database. In the manual of the HWSD,

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the REF_DEPTH attribute is defined as: Reference soil depth of all soil units are set at 100 cm, except for Rendzinas and Rankers of FAO-74 and Leptosols of FAO-90, where the reference soil depth is set at 30 cm, and for Lithosols of FAO-74 and Lithic Leptosols of FAO-90, where it is set at 10 cm. An approximation of actual soil depth can be derived through accounting for relevant depth limiting soil phases, obstacles to roots and occurrence of impermeable layers (the latter two refer to ESDB only). Besides it is not clear that how the authors use the information of the soil depth (from HWSD) and the Root depth (in Table 1) in estimating the Z parameter (or in AWC). Please clarify these points.

Response: We agree. The HWSD database manage an attribute named “Obstacles to Roots”, however this data are not available to most of the countries and specifically to the study area (Figure 1). That is the reason why we decided to use the soil depth as recommended by Sharp et al. (2018) as an approximation to the depth of restriction of the roots. The data of depth of soil and depth of rooting of the vegetation are used in the estimation of PAWC, variable requested by the Water Yield model. AWC values (mm) were obtained from the HWSD database, and these values were divided by the minimum value of the root restriction depth or rooting depth of vegetation (mm) with the goal of obtaining the required fraction (PAWC) by the model. According to Sharp et al. (2018) “the model determines the minimum of root restricting layer depth and rooting depth for an accessible soil profile for water storage”. The PAWC values are dimensionless (0 to 1) and are basically obtained by solving equation 5 in the document. PAWC=AWC/(Min (Rest.layer.depth,root.depth))

4) Comment: Table 3: Are the (irrigation) flow estimates being constant over the study period?

Response: Local water transfers (irrigation) were considered only in the Catamayo and Macará basins in the calibration process. The calibration depended on the availability of data for each hydrometric station.

New reference

Moriasi, D., Arnold, J. and Liew, M. W. Van: Model Evaluation Guidelines for Systematic Quantification of Accuracy in Watershed Simulations, Trans. ASABE, 50(3), 885–900, doi:10.13031/2013.23153, 2007.

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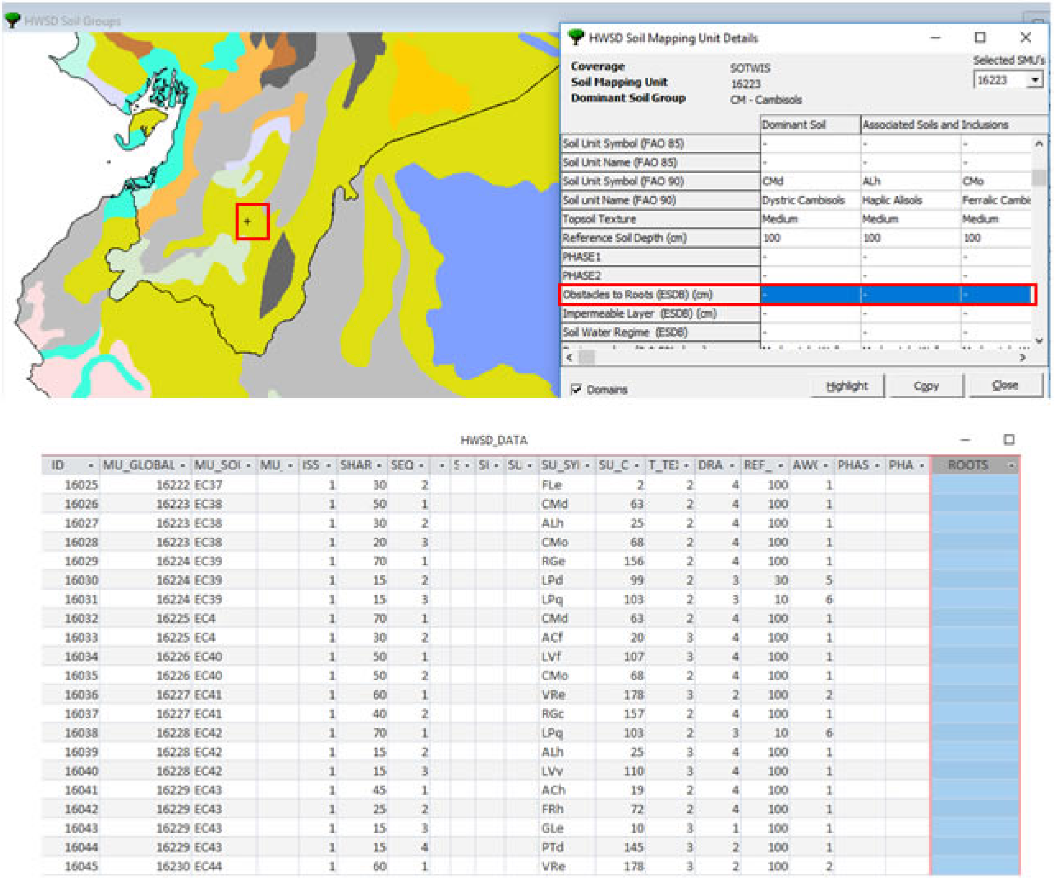

ID	MU_GLOBAL	MU_SOI	MU_	ISS	SHAR	SEQ		S	SI	SU	SU_SYI	SU_C	T_TE	DRA	REF_	AWC	PHAS	PHA	ROOTS
16025	16222	EC37		1	30	2					FLe	2	2	4	100	1			
16026	16223	EC38		1	50	1					CMd	63	2	4	100	1			
16027	16223	EC38		1	30	2					ALh	25	2	4	100	1			
16028	16223	EC38		1	20	3					CMo	68	2	4	100	1			
16029	16224	EC39		1	70	1					RGe	156	2	4	100	1			
16030	16224	EC39		1	15	2					LPd	99	2	3	30	5			
16031	16224	EC39		1	15	3					LPq	103	2	3	10	6			
16032	16225	EC4		1	70	1					CMd	63	2	4	100	1			
16033	16225	EC4		1	30	2					ACf	20	3	4	100	1			
16034	16226	EC40		1	50	1					LVf	107	3	4	100	1			
16035	16226	EC40		1	50	2					CMo	68	2	4	100	1			
16036	16227	EC41		1	60	1					VRe	178	3	2	100	2			
16037	16227	EC41		1	40	2					RGc	157	2	4	100	1			
16038	16228	EC42		1	70	1					LPq	103	2	3	10	6			
16039	16228	EC42		1	15	2					ALh	25	3	4	100	1			
16040	16228	EC42		1	15	3					LVv	110	3	4	100	1			
16041	16229	EC43		1	45	1					ACh	19	2	4	100	1			
16042	16229	EC43		1	25	2					FRh	72	2	4	100	1			
16043	16229	EC43		1	15	3					GLe	10	3	1	100	1			
16044	16229	EC43		1	15	4					PTd	145	3	2	100	1			
16045	16230	EC44		1	60	1					VRe	178	3	2	100	2			

Fig. 1. The HWSD database

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Table 1. Calibration and validation

Station code	Hydrometric station	Area (Km²)	Process	Calibration period	Excluded years	Observed water yield	Estimated water yield	Z	Error relativo
H0616	Alamor at Saucillo (Dj Celica)	585	Calibration	1970-1999		405	407	13	0.58
			Validation	2000-2011		357	325	13	-8.90
H0591	Puyango at Cpto. Militar (Pte. Carretera)	2728	Calibration	1970-1999		1017	769	1	-24.31
			Validation	2000-2011		1094	832	1	-23.96
H0574	Arenillas at Arenillas	493	Validation	1970-1983	1984-1990	538	570	3	5.87
			Calibration	1991-2011	1984-1990	415	423	3	1.85
H0530	Jubones at Ushcurrumi	3636	Validation	1970-1980		472	377	4	-20.11
			Calibration	1981-2011		406	438	4	8.01
H0889	Zamora DJ Sabanilla (at Zamora)	1422	Calibration	1982-2000	1985	1660	828	1	-50.09
			Validation	2001-2011	2002	1841	1156	1	-37.17

Fig. 2. Table 1. Calibration and validation

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