

Geosci. Model Dev. Discuss., author comment AC5
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Reply on RC2

Stefania Camici et al.

Author comment on "Synergy between satellite observations of soil moisture and water storage anomalies for global runoff estimation" by Stefania Camici et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2020-399-AC5>, 2021

RC2: This paper presents a simple data-driven model, call STREAM, to estimate global runoff using satellite observations of precipitation, soil moisture, and total water storage anomalies (TWSA). The structure of the model is simple but clear — precipitation and soil moisture are used to estimate surface quick flow while TWSA is used to compute underground slow flow. It is shown that the model can be used to estimate runoff at a basin scale after careful calibrations, which is evidenced by the validation over five calibrated sections in Figure 4.

AC: The authors are thankful to the reviewer for their assessment of our paper. We have provided a point-by-point reply to each of the comments in the sequel.

RC2: However, I doubt very much whether the model can be used for the global runoff estimation since 8 parameters need to be well calibrated based on observed river discharge, which will, to a large extent, limit its application on a global scale.

AC: The intent of the paper is to describe a model that could be used for the estimation of river flow (and runoff) worldwide. However, as correctly stated by the reviewer, the model results are only shown for the Mississippi River basin and the "Global" in the title may not be appropriate. Consistent with the reviewer's assertion, the article and model should be evaluated for their ability to estimate river flow and runoff in the Mississippi River Basin, not globally. In the revised version of the manuscript, the term "Global" from the title will be removed.

The possibility to regionalize the model parameters for the estimation of river discharge at global scale is a topic beyond the scope of this article. However, the authors are working on the regionalization of the model parameters. Preliminary results, which will be shown at the next EGU 2021 conference, demonstrate the possibility to link model parameter values to the basin characteristics, still obtaining satisfactory results.

RC2: For example, the validation results over the gauged sections not used in the calibration phase do not show very good performance of the model as the difference between simulations and observed river discharge may go beyond 1000 m³/s in most sections. The authors attribute this difference to the presence of dams, but this may also happen in sections without dams such as sections 3 and 7.

AC: As any hydrological model calibrated against observed data, it is expected that the best performances of STREAM model can be obtained over the calibrated gauging sections whereas the performances will decrease over the gauging sections not used for the calibration. However, gauging section 3 and section 7 cannot be taken as reference to understand if the STREAM model is suitable for reproducing river discharge over not calibrated sections as they are affected by local characteristics (section 7 is located over the Rock river (near Joslin), a tributary of Mississippi river) and by the presence of an important dam (section 3).

Moreover, we underline that a decrease in the model performance is obtained for all hydrological models. We are preparing a second paper showing the comparison between STREAM and other global hydrological model performances, and STREAM model is working similarly (and even better) than other models (much more complex and with a much larger number of parameters). Preliminary results have been shown at EGU conference in 2020 (<https://doi.org/10.5194/egusphere-egu2020-13718>).

RC2: On the other hand, this paper highlights the use of three satellite observations of precipitation, soil moisture, and TWSA. However, these three components are highly correlated with each other. For example, soil moisture can be used to estimate rainfall through the SM2RAIN algorithm [1]. Another example is that, on a regional scale, TWSA is very synchronous with soil moisture [2]. Accordingly, the synergy between precipitation, soil moisture, and TWSA, to me, shall be very limited.

AC: The reviewer is right that precipitation, soil moisture and TWSA are in some way correlated but this does not represent a problem for our approach. The proposed STREAM model is a conceptual hydrological model where the inputs contribute to the different runoff components according to specific laws. Specifically, soil moisture and precipitation contribute to the quick component of runoff (daily time scale) while TWSA contributes to the slow component (monthly scale). The differences in the temporal (and spatial) scale of the input data allow us to use the different input consistently and to optimize their synergy for runoff estimation.

Likely, the misunderstanding could have been generated as in the text the STREAM model is defined as a "data-driven model" to indicate that the model is mainly based on the contribution of the input data rather than of complex equations and processes.

RC2: For these reasons, I suggest rejecting this paper as is.

AC: We hope that with these new explanations the reviewer might reconsider their decision.

RC2: [1] Luca Brocca et al (2015). Rainfall estimation from in situ soil moisture observations at several sites in Europe: an evaluation of the SM2RAIN algorithm. HESS. [2] A Geruo et al (2017). Satellite-observed changes in vegetation sensitivities to surface soil moisture and total water storage variations since the 2011 Texas drought. ERL.

Minor comments:

- *As the experiments are only conducted over the Mississippi river basin, the word "GLOBAL" used in the title may not be suitable.*
- *In line 122, please add necessary references regarding SMAP and GPM.*
- *Please add some necessary references to Eqs. 1 and 4.*
- *The statements in lines 295-296 are slightly in conflict with the statements in lines 306-308. As I know, TWSA can partly include information on soil moisture.*
- *In line 303, what are the ranges of beta and m values?*
- *In line 344, the meaning of the Horton-Strahler order is not clear.*

- *In lines 444-445, the authors mention that the performance of model in section 3 is not bad. However, as I checked from Figure 5, the difference between simulated and observed discharge can go beyond 8000 m³/s.*

AC: The minor comments will be addressed in the revised version of the manuscript.