Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., author comment AC6
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Reply on RC3

Stefania Camici et al.

Author comment on "Synergy between satellite observations of soil moisture and water storage anomalies for runoff estimation" by Stefania Camici et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2020-399-AC6, 2021

RC3: The authors present a model 'STREAM' that is used to derive river discharge and runoff. The STREAM model is conceptually and computationally simple, and uses inputs of precipitation, total water storage, soil moisture as well as air temperature to provide estimates of global runoff. The results are tested for the Mississippi River basin in the United States and indicate good agreement. Enhancing the ability to model distributed runoff has important applications for hydrology. However, further justification of the methods used and applicability to other climate regimes and regions is needed.

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. Additional details and justifications of the method used will be added in the revised version of the manuscript.

RC3: For example, the authors should comment on the sensitivity of the model to the hydrological inputs of precipitation, soil moisture and total water storage anomaly. The authors should comment on the contribution of using these inputs, and whether results are improved or not by using all three. Otherwise it is not immediately clear to the reader the contribution of each to the estimation of runoff.

AC: In a preliminary analysis, we have tested the sensitivity of STREAM model to the different hydrological inputs of precipitation, soil moisture and total water storage anomaly (not shown for brevity). In particular, by running the STREAM model with different input configurations (e.g., by using TRMM3B42 or CPC data for precipitation, ESA CCI or ASCAT data for soil moisture, GRACE or soil moisture data to simulate the slow-flow river discharge component), we found that STREAM results are more sensitive to soil moisture data rather than to precipitation input. In addition, by running STREAM model with soil moisture data as input to simulate the slow-flow river discharge component (i.e. without using GRACE data) we found a deterioration of the model results.

A sentence to explain the contribution of the hydrological inputs to the STREAM results will be added in the revised version of the manuscript

RC3: The authors also only test their model in the Mississippi River basin, however it would be interesting and informative to address the performance of this model in different regions including more arid basins, snow-dominated, lots of topography, heavily managed,

etc. The study indicates it is a ‘global’ model so more discussion of its applicability worldwide is needed.

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 even if the model could be applied at global scale, the "Global" in the title may not be appropriate for this manuscript. For that, in the revised version of the manuscript, “Global” in the title will be removed.

Concerning the applicability of the model to other climate regimes and regions, the authors are preparing a new manuscript where STREAM model has been tested on 5 pilot basins (Mississippi, Amazon, Niger, Danube and Murray-Darling) across the world with good model performances. Preliminary results have been shown at EGU conference in 2020 (https://meetingorganizer.copernicus.org/EGU2020/EGU2020-13718.html) and 2021 (https://meetingorganizer.copernicus.org/EGU21/EGU21-14175.html).

Specific comments:

RC3: Line 208 - Can the authors provide the depth of the soil moisture used in this study.

AC: Satellite soil moisture observations obtained by the ESA CCI soil moisture product refer to first centimeters of soil (2-3 cm). However, in the STREAM formulation we used a root-zone soil moisture product derived by the surface ESA CCI satellite soil moisture product, by applying the exponential filtering approach in its recursive formulation as in Albergel et al. (2009). For that, the root zone soil moisture used in the STREAM model is referred to the first layer of the model, whose depth varies approximatively from 5 to 20 cm.

RC3: Line 262 - Given that the authors only validate in the Mississippi basin, can they comment on how different climate regimes could impact the accuracy of the modeled runoff in particular more snow-dominated basins. Can the authors comment on the validation of the snow module.

AC: The Mississippi basin contains different climatic regimes, particularly if we consider the differences between the eastern and western parts of the basin. As anticipated before, the authors are preparing a new manuscript where STREAM model has been tested on 4 additional basins (Amazon, Niger, Danube and Murray-Darling) thus exploring a larger variability of climatic regimes, as well as soil and land use characteristics.

In the revised paper we will add specific comments about the model performances in snow-dominated basins. The detailed testing of the snow module is also under investigation, but it is beyond the purpose of this paper.

RC3: Line 300 - Can the authors provide additional information on how they resolve the differences in spatial and temporal scale between the various input data sets provided. In particular, the coarser scale of the GRACE data.

AC: Concerning the spatial scale, air temperature, soil moisture, precipitation and GRACE data have been resampled over the precipitation spatial grid at 0.25° resolution through a bilinear interpolation. For the temporal scale, air temperature soil moisture and precipitation data are available at daily time step, while monthly GRACE data have been linearly interpolated at daily time step. Major details on how the differences in spatial and temporal scale between the various input data sets is resolved will be added in the revised

version of the manuscript.

RC3: Line 462 - can the model be run with same input precipitation as GRUN for the validation purposes? Or can the authors comment on precipitation differences between either product .

AC: The STREAM model could be run with the same input precipitation as GRUN to compare the runoff maps obtained by the two approaches. However, as it is beyond the purpose of the paper, the authors will add only comment in the revised version of the manuscript to underline the differences between the two precipitation products and the related runoff estimates.

RC3: Line 520 - Does using GRACE data for water storage (which captures both human and natural processes) address this? GRACE can indicate human activity and water extraction practices, which I think could help improve purely 'natural' estimates of runoff.

AC: The added value of satellite observations in the STREAM model is the possibility to capture processes and human activities not modelled but directly observed by satellite. However, we think that GRACE could not be appropriate for capturing reservoir management and for that, in the current development of STREAM model, we are including additional modules for simulating the presence of reservoirs and diversions along the river that can be relevant in several basins/regions.