

Hydrol. Earth Syst. Sci. Discuss., referee comment RC3  
<https://doi.org/10.5194/hess-2021-156-RC3>, 2021  
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## Comment on hess-2021-156

Elena Toth (Referee)

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Referee comment on "On the selection of precipitation products for the regionalisation of hydrological model parameters" by Oscar M. Baez-Villanueva et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2021-156-RC3>, 2021

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The manuscript presents the results of a certainly massive amount of work, aiming at analysing the performances of a set of gridded rainfall products when regionalising the parameters of a rainfall-runoff model, to be used at ungauged river sections in a data-scarce region. It addresses therefore a very interesting, and novel topic, with important practical impacts and potential for improving predictions in ungauged basins (PUB) in many regions of the world.

On the other hand, the topic is complex and the aim of the work is perhaps a bit too ambitious for a single paper.

Given the main final focus of the work, the paper requires first of all a more thorough analysis and comparison of the rainfall products, that should be carried out at catchment scale and over the different seasons (see, for example, Tarek et al, HESS 2020). The interpretation of such comparison should be based on the knowledge of the differences among the rainfall products, considering and explaining in particular the differences among their sources, first and foremost the availability and use of raingauges (that I personally, as a hydrologist, still find the most reliable information on actual rainfall). Such analysis is currently only partial in the paper and it is probably its weakest point.

Following such analysis, a more detailed presentation of the performances of the streamflow simulations when the model is "regularly" calibrated (not regionalised) may allow to understand if the products are indeed equally suitable to reproduce the rainfall fields over the catchment in a "reasonable" way, through the simulation of the rainfall-runoff transformation processes. I totally agree with the authors that the parameters may compensate for the differences in the rainfall fields, up to a given extent, and such analysis is therefore very interesting, especially for a data-scarce region. Some of the interpretations in the discussion and conclusions (see reference to Fig. 5 in Sect 5.1) on the compensation are referred to the regionalisation results, while they should be demonstrated through the analysis of the results of the "calibrated" simulations.

Such first two steps would be enough for a paper of its own, without considering the regionalisation that is built on top of them. The importance of the rainfall estimates is certainly crucial also for model regionalisation purposes, but I think this is mainly due to an indirect impact of their reliability on the different climatic areas, extremely diversified

in the Chilean region, and not directly to the regionalisation approaches: for this reason, a deeper understanding of such reliability is mandatory.

In an already very complex framework, the authors have added a second, complicated objective function (AOF), which would be justifiable only if the study focussed much more on the analysis of the simulation of the different parts of the hydrograph (low flows, flow duration curves, baseflow...), which is not instead the focus of the present work, and the issue is only partially addressed, and only late, in the discussion section on the hydrological signatures. As it is, the second OF lengthens and complicates the paper, and I would suggest to remove it.

Another analysis that I think may be removed or restructured is the comparison of the regionalisation performances over the different hydrological regimes. This is very interesting issue to study per se, but i) the rationale for the separation of the basins into such groups ("visual screening"?) has not been explained (and the hydrological regimes seem to overlap only partially with the identified climatic regions, which I find a bit puzzling) and ii) the results of section 4.2 are not particularly significant: the rainfall products do not show any clear pattern and the differences are probably more due to the more pronounced rainfall errors or difficulties of the model in reproducing the streamflow over the different regimes, independently of the regionalisation procedure. In order for such section to be useful, it should be preceded by an analysis - over the catchments belonging to such regimes - of the reliability of the rainfall maps and of the model performances when the model is not regionalised but calibrated (other analyses to be added in the first two steps...)

#### SPECIFIC COMMENTS

##### **II 68-74 and Section 3.1.1:**

As I wrote above, the main limitation of the study is the lack of a detailed description of the rainfall products: the main difference is in their sources, whereas it is not a matter of being gridded and probably also the spatial scale is less relevant than how much they rely on ground measurements. The ERA5 is probably the product with less dependence on raingages, since reanalyses assimilate a number of both measured and remotely sensed information within the numerical models, but mainly atmospheric and ocean measures and not ground data, I think. But all the other products you use are, on the basis of your description, based on a merging of reanalysis (ERA5) and ground-based data (CR2MET and RF-MEP), and for MSWEP including also use of satellite data. For all such products some information on the location and temporal coverage of the raingages data is needed, in order to understand their differences. It is written that RF-MEP uses 331 gauges, but not if CR2MET uses the same data. And MSWEP is based on 77000 gauges globally, but how many are in Chile? (and are they the same used in the other products?). Adding a map with the locations of such gauges would also help to interpret the reliability of the products over the different parts of the country.

In addition, it would be useful to know if one of these products (CR2MET?) is considered, or it has been demonstrated in previous studies, to be more reliable or if it is the 'reference' product for the Chilean meteorological or hydrological offices (which one is included as meteorological driver into CAMELS-CL?)

As written above, I would suggest adding more information on the comparison of the rainfall fields, that should be carried not only over the mean annual values (Fig. 2), but over the different years (so to differentiate also the "near normal", and "dry" periods cited when identifying the verification periods in Sect 3.3), over the different seasons, and, especially important, at catchment scale, in order to preserve the consistency among the rainfall forcing and the corresponding streamflow (see, for example, Tarek et al, HESS

2020). For each product, it may be shown, for example the yearly time-series of the box-plots representing the Mean Areal Precipitation for the catchments)

Section 3.3: the fact that the first 10 years (1990-1999) are used both as warm-up period and as verification period is a bit confusing: ten years of warm-up period is not necessary, and in this way there seems to be no warm-up for Verification 1 period? At least one year of warm-up would be needed... This point may be clarified.

pag. 11: as written above, I would remove the AOF objective function.

Section 4.1.1: more information should be given on the performances of the models when not regionalised: first of all distinguishing the performances over the different climatic regions and interpreting the efficiencies in relation to the possible lack of reliability of the rainfall forcing in specific catchments/regions. In addition, looking at the entire boxes and whiskers (and not at the median values only) in Fig. 3, I do not agree that ERA5 is equally (or better) performing than the other products: perhaps more details on local performances may help to better understand.

Section 4.2.2: as above written, if this section is preserved, there should be a similar analysis for the 'at-site parameterised', not regionalised simulations (and more information on how the regimes have been identified).

#### TECHNICAL COMMENTS

I.1: I suggest to clarify in the abstract that what is regionalised are the parameters of a rainfall-runoff model.

Fig. 2: I would use a linear scale for the legenda, since the current colours do not clearly distinguish the regional differences in the rainfall values among the products.

I.323: I do not agree that the spatial proximity and feature similarity results are so close: adding an x-axis grid in Fig. 4 would highlight that Feature similarity performs better, looking at the entire boxes.

II 340-344: actually, not only RF-MEP but all products (a part from ERA5) are a merging of reanalysis and ground-based observations, from what I understood.

lines 349-354 (and bottom panel of Fig. 5) are more related to the results presented in Section 4.2.1 (and in Fig. 6) and may be moved there?

Section 4.2.1: maybe at least a first comment on the differences among the rainfall products shown by Fig, 6 should be added/moved here.