

## ***Interactive comment on* “Spatial Relationship between Precipitation and Runoff in Africa” by Fidele Karamage et al.**

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RC1-Anonymous Referee #1

Anonymous Referee of the HESS Journal

Dear Anonymous Referee,

Subject: Responses for your review comments posted on 18 October 2018 on our manuscript No.: hess-2018-424, entitled “Spatial Relationship between Precipitation and Runoff in Africa”

We would like to thank you for the time and effort used to review our manuscript. We have carefully reviewed the comments and have revised the manuscript accordingly.

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Our responses are given point by point below and the track-change and clean-revised manuscripts were also prepared. We thankfully acknowledge your comments, as they were valuable in improving the quality of our manuscript and are useful in our future work.

Yours sincerely,

Review comment 1

I would like to start my comments by referring to one of the authors conclusions that states 'The interpolation method of observed runoff coefficient ..... that affect the runoff generation process has improved the estimation of runoff coefficient and runoff depths in ungauged basins'. This is simply NOT TRUE for several reasons. The most obvious reason is that the paper includes no validation of the estimated runoff coefficients.

Response

We would like to apologize for the inconsistent statements, mistakes, and unwell-described concepts. Based on your comments was majorly revised and more details were provided. In the revised manuscript, this study has 2 objectives: (1) the estimation of the relationship between precipitation and runoff using the runoff discharges down-scaled from basin to grid-scale which can be reasonably utilized on the non-catchment regional studies (i.e.: Country scale), (2) prediction of runoff depths and coefficients over ungauged regions utilizing the inter-gauged and ungauged basin parameter transfer method based on spatial hydrologic similarities. This is one of the recommended approaches for hydrological predictions in ungauged basins (PUB) (Bárdossy, 2007; Blöschl, 2006; Chiew et al., 2018). This method assumes that two separate catchments can have a similar hydrological process if they have similar climatic and physical conditions. Hydrologic similarity was assessed based the key runoff controlling factors, including antecedent soil moisture condition (AMC), Natural Resources Conservation Service (NRCS) runoff curve number (CN), terrestrial water storage change (TWSC), surface temperature (T), and topographic parameters (topographic wetness

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index (TWI) and slope). Regarding the validation of the approach used to predict the data for filling the gaps indicated that the estimated and observed runoff coefficients have the goodness of fit ( $R^2$ ) ranging from 0.56 to 0.67 for the long-term monthly  $R_c$  and 0.78 for the annual mean  $R_c$  (Figure 14). These results are within permissible validity limits since an  $R^2 > 0.5$  is considered acceptable for calibration and validation in hydrological modeling (Santhi et al., 2001; Van Liew et al., 2003). It can be concluded that inter-gauged and ungauged basin parameter transfer based on hydrologic similarity is an alternative approach for gaps filling in runoff prediction and it can even perform much better if the input observed runoff discharges do not have a lot of temporal gaps.

### Review comment 2

The 2nd reason is that the runoff data set used to establish the runoff coefficient estimates is based on observed data from some basins which have huge impacts of reservoir storage, hydropower releases, irrigation abstractions (and others) all of which will affect either the annual runoff coefficient and/or the seasonal patterns of runoff coefficient.

### Response

Thank for your valuable comment about water storage changes. In our revised manuscript monthly water storage change within different parts of the continent were considered in the hydrologic similarity analysis (Figure 7) using the terrestrial water storage changes estimated from the Center for Space Research (CSR) Gravity Recovery and Climate Experiment (GRACE) RL05 mascon solutions available at 1o resolution for the period starting from April 2002 to June 2016 (Save et al., 2016). Except, the precipitation datasets available since the beginning of 20th century, even before, the other above-mentioned changing runoff controllers are available for the recent decades (i.e.: GRACE data for water storage change analysis were collected since 2002 and good quality land cover maps are available since the 1990s). Lack of these data for the earlier decades constrained us to predict the past runoff process. Again, if the ear-

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lier runoff discharges are excluded from the long-term runoff calculations, spatial gaps would be increased and bring more challenge for validation.

#### Review comment 3

The 3rd reason is that many of the observed runoff data represent very large catchments that have hugely spatially variable patterns of runoff such that an average runoff coefficient would be meaningless.

#### Response

In the revised manuscript, runoff discharges for very large catchments were replaced by the sub-catchments with the medium size. In addition, using the Natural Resources Conservation Service (NRCS) runoff curve number (CN), the basin's runoff discharge was downscaled at a grid scale which can be reasonably utilized on the non-catchment regional studies (i.e.: Country scale). Actually, runoff-related studies are often conducted at a drainage basin scale, but, hydrological studies on the grid and country scales are very useful at the country level since each government has own policies for water resource management. For instance, it has been noticed that runoff discharges are useful in water stress analysis at country scale (Ruess, 2015; Smakhtin, 2004). Integration of NRCS-CN in downscaling the runoff discharges do not alter the quantity of observed runoff at a catchment scale, but it redistributes catchment's discharged runoff volume to its grids proportionally according to their respective climate and physical conditions.

#### Review comment 4

The 4th reason is that in many parts of the continent runoff coefficients will be strongly related to topographic characteristics that might not be adequately reflected in the input variables used by the authors. This is not the first paper that attempts to apply methods at very coarse spatial scales and to suggest (without any validation what so ever) that the outputs will be useful to water resources management. Quite often these papers

(as does this one) criticize the use of 'unwell-constructed models' (page 21) that are based on non-error free data. Are the authors seriously suggesting that their data are error-free, because this is a claim that can very easily be refuted There are many people within the African continent (and from other countries) who have been using hydrological and water resources assessment models for practical water resources management and are unlikely to see the results of this study as adding anything, either from a scientific or practical perspective, to the approaches that can be applied. Apart from the points that I have already raised about the complete lack of validation, the spatial scale of the study is simply too coarse to be of any value to the type of water resources management and planning issues that confront African countries. I also found it rather interesting that the authors fail to quote any of the scientific literature that has been produced in the region on the subject of water resources estimation (see the rather condescending sentence on line 10 of page 2). In summary, this study is seriously flawed from a scientific hydrology perspective and adds nothing to either African hydrological sciences nor to the methods that can be used to manage water resources over different parts of the continent.

## Response

Thank you for your concern about the topographic factor on the hydrologic process. In the revised manuscript, the following key runoff controlling factors were utilized in the hydrologic similarity analysis: antecedent soil moisture condition (AMC), Natural Resources Conservation Service (NRCS) runoff curve number (CN), terrestrial water storage change (TWSC), surface temperature (T), and topographic parameters (topographic wetness index (TWI) and slope). We would like to apologize for the above-mentioned misstatement. You are right, there are no data with error-free. Really, several hydrological models and methods have been developed and they are very useful in water resource management in different part of the world but, they have some limitations depending on the case study either due to the lack of sufficient and reliable input dataset or their development that cannot allow easy incorporation of additional param-

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eters (Lim et al., 2006). Regarding the validation of the approach used to predict the data for filling the gaps indicated that the estimated and observed runoff coefficients have the goodness of fit ( $R^2$ ) ranging from 0.56 to 0.67 for the long-term monthly  $R_c$  and 0.78 for the annual mean  $R_c$  (Figure 14). These results are within permissible validity limits since an  $R^2 > 0.5$  is considered acceptable for calibration and validation in hydrological modeling (Santhi et al., 2001; Van Liew et al., 2003). It can be concluded that inter-gauged and ungauged basin parameter transfer based on hydrologic similarity is an alternative approach for gaps filling in runoff prediction and it can even perform much better if the input observed runoff discharges do not have a lot of temporal gaps. Actually, runoff-related studies are often conducted at a drainage basin scale, but, hydrological studies on the grid and country scales are also very useful at the country level since each government has own policies for water resource management. For instance, it has been noticed that runoff discharges are useful in water stress analysis at a country scale (Ruess, 2015; Smakhtin, 2004).

As a scientific contribution, this study highlighted step by step how the Natural Resources Conservation Service (NRCS) runoff curve number (CN) can be a prominent proxy for the basin's runoff discharge downscaling at a grid scale which can be reasonably utilized on the non-catchment regional studies (i.e.: Country scale). In addition, this study highlighted the performance of inter-gauged and ungauged basin parameter transfer based on hydrologic similarity over the large scale as the African continent. This method indicated to be is an alternative approach for gaps filling in runoff prediction and it can even perform much better if the input observed runoff discharges do not have a lot of temporal gaps.

Again, we are thankful and appreciate your valuable comments.

Please also note the supplement to this comment:

<https://www.hydrol-earth-syst-sci-discuss.net/hess-2018-424/hess-2018-424-AC4-supplement.zip>

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2018-424>, 2018.

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