

## Response to RC2 by J. O. Skøien (Referee)

*We sincerely thank the reviewer for carefully reviewing our manuscript and for thoughtful feedbacks. We have revised our manuscript taking into account every suggestion and comment of this reviewer. Our point-to-point responses are detailed below.*

1. “This manuscript describes a coupling of the Budyko approach and hydro-stochastic interpolation. The topic is interesting, the results good, but revisions are necessary before possible publication, particularly related to the presentation.”

*Answer: We thank Dr. Skøien's suggestions. We have thoroughly revised the manuscript.*

2. “I am a bit surprised by the relatively poor performance of the application of hydro-stochastic interpolation directly. It is also interesting that two methods that both over-estimate parts of the prediction area can achieve a better result together. I tried to understand how this could be from Figure 7, but the use of different color keys makes it difficult to compare the maps. This should be the same for the three maps. I would also have liked to see the similar map for the observations, and maybe also a map of the residuals. Adding these maps would also help the authors in improving the conclusions, which is currently more like a summary of the results section. I would rather like to see some more discussion around how the combined method can be so much better than the individual methods.”

*Answer: We remade the four figures using the same color code. We also added Fig. 7d to show the observations as required by this reviewer. The improved figures clearly show spatial differences of estimated runoff by the three methods. The improved statistical results of the residuals are shown in Table 2. We also revised the conclusions and discussed additional advantages of our coupled method and its future improvements.*

3. “The methodology in Section 2.2 covers almost 5 pages, and is mainly from Sauquet et al. (2000), somewhat rewritten. It should be shortened, and the text must be more precise.”

*Answer: Complying with the reviewer's suggestion, we have revised Section 2.2 and removed the weight matrix calculation equations which can be found in Sauquet et al.*

(2000). We also revised some descriptions on water balance constraints, the theoretical covariance function and geostatistical distance.

4. “In Eqs 1-2, is only one  $\omega$  calibrated for all sub-basins, or is it calibrated separately for each sub-basin. If the second, is it then interpolated to uncalibrated locations (or for cross-validation locations)?”

*Answer: We used the mean of  $\omega$  in interpolation. The mean of  $\omega$  in Eqs. 1 and 2 is calculated at each sub-basin (Table 1), and the  $\omega$  values at the sub-basins are averaged. In validation, the mean  $\omega$  is alternatively obtained by fitting the curve of Eq. 1, i.e.,  $E/P \sim E_0/P$  ( $E = P - R$ ), from observations to minimize the mean absolute error (MAE) (refer to P8L147-153 and 312-320 in the revised manuscript).*

5. “The text needs improvement. Copy-editing is necessary, preferably from someone with knowledge about spatial interpolation. A list of necessary edits is given below, but the list is not exhaustive.”

*Answer: We have carefully improved the grammar of the text. Our responses to the suggested necessary edits are listed below, and corrections are highlighted in blue in our revised text.*

Some edits:

P2L14 I think it is better with “relationships between”

*Answer: It has been changed to “relationships between”.*

P2L19 Maybe rather “spatially interpolate runoff: : :”

*Answer: It has been changed to “spatially interpolate runoff in...”.*

P2L24 determination Coefficient?

*Answer: “The coefficient of determination” has been changed to “The determination coefficient”.*

P2L31 “accurate way in spatial interpolation: : :” something is wrong.

*Answer: This sentence has been modified as “...offers an effective and accurate way to predict mean annual runoff in river basins”*

P3L37 something is missing

*Answer: This sentence has been revised as “Runoff observed at the outlet of a basin is a crucial element for investigating the hydrological cycle of the basin. The runoff is influenced by both deterministic and stochastic processes” (refer to P3L36-38).*

P3L43 I think the authors rather want to say that “Geostatistical approaches are commonly used for spatial interpolation”.

*Answer: This sentence is used.*

P3L44-46 “similarity of a generalized stochastic field” – what is meant by this? And what is multivariate here? Rewrite sentence.

*Answer: The sentence has been rewritten (P3L45-48 in the revised manuscript).*

P3L47 remove “of values”.

*Answer: It has been deleted in the revised manuscript.*

P3L49 “kriging is the MOST popular: :” (or is A popular)

*Answer: This sentence has been rewritten as “The values obtained by geostatistical or kriging interpolation methods are the best linear unbiased estimate...” (refer to P3L50-52 in the revised manuscript).*

P3 Kriging -> kriging

*Answer: It has been changed to “kriging” in the revised manuscript.*

P4L57 remove “also suggested as”

*Answer: The Introduction has been revised thoroughly. This expression has been deleted in the revised section.*

P4L63-67 This sentence is not understandable.

*Answer: This sentence has been rewritten in P5L81-85 in the revised manuscript.*

P5L87 remove “of”

*Answer: Removed.*

P94-96 Clumsy sentence.

*Answer: This paragraph has been rewritten in P4L76-77.*

P6L103-104 I do not understand what is meant here.

*Answer: The paragraph including this sentence has been rewritten (P5L79-80 in the revised manuscript).*

P6L111 incorporate -> combine?

*Answer: The word has been changed to “combine” (refer to P6L116).*

P6L114-115 difficult to read, rewrite sentence.

*Answer: The sentence has been rewritten as “In this study, the spatial runoff from sub-basins in the HRB is separated into the deterministic trend and its residuals both of which are estimated by the Budyko framework and interpolation method.” (P6L118-120).*

P7L126 what is meant with terrestrial scale here?

*Answer: It has been changed as “a regional or global scale”.*

P7L138 popularly -> frequently?

*Answer: It has been changed to “frequently”.*

P8L152 Delete “interpolation” after Kriging and “The” before “Gottschalk’s”

*Answer: Corrected (refer to P8L157).*

P8L155-L158 The definition of basin area as specific unit should be at L155.

*Answer: The definition of basin area as a specific unit has been moved to P8L161 in the revised manuscript.*

P10L188 (Sauquet et al., 2000) (Sauquet and Gottschalk, 2000) occurs several times, missing the last author.

*Answer: We have corrected this citation in the revised manuscript.*

P14L268 has the highest population density?

*Answer: The word has been changed to “highest” (refer to P13L274).*

P14L272 more than 50% is exploited or water resources are overexploited?

*Answer: The sentence has been revised to “More than 50% of the water resources is exploited” (refer to P14L277 in the revised manuscript).*

P14L276 “increase difficulty in : : :” -> something seems wrong, revise

*Answer: The sentence has been deleted.*

P14L279 data packages or digital elevation models?

*Answer: The river system shapefiles in ArcGIS are included in the data package from the National Fundamental Geographic Information System issued by National Geomatics Center of China.*

P17L335 the EMPIRICAL covariance?

*Answer: It is correct. We described it in more detail in the Methodology section.*

P17L342-343 “to obtain the : : in sub basins A and B” is confusing and can probably be deleted.

*Answer: We revised this sentence to make it clearer (P16L341- P17L344 in the revised manuscript).*

P17L350 Maybe “This function is then used for the covariances in the covariance matrix in Eq. (17).”

*Answer: The sentence is rewritten as “This function is further used in calculation of the average theoretical covariances  $Cov(A,B)$  in Eq. (8)”(refer to P17L352-353 in the revised manuscript).*

P17L352 The sentence is clumsy. Also, as MATLAB is mentioned here, I guess it was used for all/most of the analyses? Whether yes or no, it is better to describe in general which software was used, maybe also if there were particular add-on packages.

*Answer: We revised this sentence as “Subsequently, the weight matrices are determined using our program in MATLAB” (P17L353-L354).*

P18L365 Departures (or deviations) FROM the trend.

*Answer: It has been changed to “the deviations from the trend...”.*

P19L380 What is perditiion here?

*Answer: The word should be “prediction”. It has been corrected.*