Review of: Theoretical framework to estimate spatially averaged rainfalls conditional on river discharges and point rainfall measurements from a single location: an application to Western Greece

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Paper summary:

The manuscript describes a methodology to generate estimates of the basin-averaged precipitation value (or Mean Areal Precipitation, MAP hereafter) at daily scale, starting from daily rainfall records of a single gage located in the basin. In the common practice, the MAP is simply estimated as the point measurements of the gage without applying any corrections. The authors propose a statistical methodology to improve the estimation of the MAP taking into account: (i) the daily streamflow series at the basin outlet; (ii) the expected fraction of wet days in the basin, as revealed by application of concepts from multifractal theory, which, in turn, utilizes information on the physical characteristics of the rainfall storms; (iii) the spatial heterogeneity of the rainfall distribution (as those introduced by orography).

The authors present the mathematical background of the statistical framework, with an application on a study basin in Western Greece, named Glafkos basin, where daily records of three raingauges and streamflow measurements at a dam (or, more precisely, in a hydroelectric power plant downstream) are available. After describing the methodology, the authors demonstrate the model performances by comparing the statistics of the MAP simulated with their model, the observed MAP (i.e. spatial weighted averages through the Thiessen polygon method) and rainfall records at each gage.

General Comment:

This is a well-written manuscript that describes a methodology to produce reliable MAP series from observations of a single raingauge. The presence of a single gauge in a basin is a circumstance occurring very frequently in the world. The paper makes an excellent use of new and previously published statistical methodologies and applications, with a solid connection to the physical processes. All tables and figures (including the captions) are useful to illustrate the methodology and present the results.

Results of this work are useful to apply hydrological models as well as to simply refine the computation of water balances at basin scale, which is always useful to manage water resources. In the current state, the technique can be applied in medium-to-small basins with perennial stream. In the paper conclusions, the authors suggest the next steps they will pursue to generalize the procedure to larger basins, higher resolution of rainfall data, and different climates. As a result, my recommendation for this paper is: publication after minor revisions. These are described in the following points.

1. The authors presented the main results of their approach using data collected by the rain gauge located at the Hydroelectric Plant in point A of Fig. 2 (see Figs. 1, 3, 6, 9, 12, 13, 16 and 17). While they state that results are similar for other gauges, the gauge A is actually located out of their study basin (2 km downstream from the outlet). The authors should provide some explicit clarifications for this choice. It may be also better that the main results (e.g. Fig. 1, 12, 16 and 17) are presented using data from gauge B or C that are inside the basin and have an influence in the calculation of the MAP with the Thiessen polygon methodology (see page 12471, lines 3-7 and Table 3).

2. The authors should provide comments in the Introduction on the role of the basin size and climate

on the validity of the proposed methodology. Some comments are described in the paper conclusions (page 12489, lines 15-24), but I believe it's important to stress this issue from the beginning to support the physical interpretations provided in the rest of the manuscript.

3. Page 12465, line 11:
Please correct typo: "form" to "from".

4. Page 12466, lines 11-12:
I suggest eliminating the reference to Fig. 1 and Table 1, because they are described right after that paragraph. In my opinion, this allows keeping the reader's attention.

5. Page 12466, lines 15-16:
Change the sentence "To illustrate the first issue, Fig. 1 presents daily river discharges and measured precipitation depths at the hydroelectric plant at the Glafkos river basin" to "To illustrate the first issue, Fig. 1 compares the time series of daily river discharges at the outlet of the Glafkos river basin with the rainfall depths observed by a single raingauge also located at the basin outlet".
Regarding this comment, please refer also to comment 1 if the authors decide to show in Fig.1 the rainfall time series of a different gauge.

6. Page 12466, line 24:
Change "1971-1982" to "1981-1982".

7. Page 12466, line 25:
The authors state that "…the annual runoff volume is lower than that of precipitation". It's the opposite. Please, correct.

8. Page 12466, line 26:
Please change "evaportranspiration" to "evapotranspiration" throughout the manuscript.

9. Page 12468, line 2:
I suggest the authors should change the sentence "The latter exhibit a lower fraction of dry intervals relative to rainfall measurements at distinct locations inside the catchment; see above" to "As previously outlined, the latter exhibit a lower fraction of dry intervals relative to rainfall measurements at distinct locations inside the catchment".

10. Page 12470, Sections 2.1:
    - 10.1. I believe that presentation of Fig. 2 needs to be improved. First of all, it is necessary to clearly identify the boundaries of the study basin. Thus, the black boundaries are not needed (they can be plotted with a thinner grey line) and reference to "mountainous part" should be changed to "study basin", because the discharge data are referred to the dam located in B (even if measured in A). Reference to the coastal aquifer may be removed as well.
    - 10.2. It may be useful to provide some information on the physiographic properties of the basin (slope, length of main channel and estimated concentration time). This can be done in a table.
    - 10.3. Lines 14-18. It is not clear how the authors have reconstructed missing rainfall data of gauge C in years from 1-Oct-1986 to 30-Sep-1993, where they have more than 150 missing values. Please, clarify.

11. Page 12473, line 6:
Change "…positive values of ω are not feasible" to "…positive values of ω are very likely not feasible, especially in Mediterranean basins".

12. Page 12475, line 9:
The authors have previously used the symbol β to generically indicate the confidence level. Please, change here γ to β to be consistent.

13. Page 12475, line 16:
Change: "as a function of the observed change of the river discharge" to "as a function of the observed positive change of the river discharge".

14. Page 12475, lines 17-22:
The physical considerations explained in these lines are dependent on the basin size and climate (see comment 2).

15. Page 12478, line 14:
What happens to δ when considering the raingauge A that is out of the basin?

16. Pages 12480-12481:
The symbols used to describe Fig. 10 should be changed to be clearer. I would use:

- capital letters like P, M and Q to indicate the gauge location and the interceptions between the line depicting the storm direction and the basin boundaries;
- the symbol $d(\theta)$ to indicate the distance between M and Q (now B and Γ), as x is usually used as a coordinate.

17. Pages 12481, line 1:
Please, define the vector **z** before equation (13). As it is, it seems that **z** should appear in equation (13).

18. Pages 12482, line 11:
I think that the condition $\omega \leq 1$ should be $\omega \leq 0$.

19. Pages 12502:
Change "linear dimension" to "Linear dimension".

20. Pages 12507:
Correct legend for the dashed line in Fig. 3d.