REVIEWER #2 COMMENTS:

OVERALL COMMENT:

This is an interesting paper that combines radar-rainfall estimation using WPMM (Window Probability Matching Method which matches raingauge and reflectivity probability distributions) and advection correction methods (which accounts for storm movement in pixel rainfall estimation over a time-interval) with distributed hydrological modelling to investigate model simulation sensitivity to rainfall time-resolution for flash floods. It also attempts to treat rainfall at different resolutions as independent ensemble members, along with taking account of uncertainty in model states and discharge measurements, in a probabilistic model calibration. I am less convinced by the utility of the latter, brings added complexity to the paper and tends to hide judgements on the plausibility of the hydrological model. However, it also has interest.

Application of WPMM has novelty, using a nonparametric Kernel density function approach (and comparison with parametric approaches) to overcome problems in the distribution tails. A clearer comparison and discussion of the two approaches is required when the results are first presented. Categorisation into rainfall types adds further complexity to the method, and brings further issues that are discussed. Application of the advection correction approach also has novelty and draws on relevant literature sources.

Choice of the RIBS model seems a reasonable one, with infiltration excess runoff probably dominating the case study Spanish catchment; but the meaning of return flow needs clarification or a change of terminology.

Overall, the paper is deserving of publication. It could be much improved through detailed attention to the English, so as to improve readability. Thus I recommend provisional acceptance subject to this being done, together with addressing other detailed comments presented below. The amended paper will need to be re-reviewed.

We thank the reviewer for her/his interesting and useful comments to improve our paper as well as for the recognition of the positive aspects of the paper.

DETAILED COMMENTS:

1. **The English needs detailed attention by a native-English speaker: examples of problems on the first page are given below.**

The whole manuscript has been checked in detail by a native English speaking corrector.

2. **7996 line 3 rainfall surface data introduced – rephrase to estimates of surface rainfall used**

The abstract has changed.

3. **Line 5 model results – model predictions**

The abstract has changed

4. **Line 6 composed radar – composite radar**

Done

5. **Line 6 6-minute**

Done

6. **Line 10 in both convective and stratiform Z/R relations – rephrase**

Done

7. **Line 22 for rainfall estimation.**

"on" was changed into "for".

8. **Line 23 on basin processes….especially for convective…**

"on a basin processes" was changed into "on basin processes". The second phrase was rewritten.

9. **Line 24 Is the Bell and Moore (2000) in the References the right one? Think it should be HESS, 4(4), 653-667, (2000).**

Yes, it should be the other. It has been changed.

10. **7998 line 4 Using 1000 km2 as the "usual basin size for flash-flood prone basins" is rather strange, and seems rather large to me.**

We thank the reviewer for pointing out this. The phrase and the paragraph were rewritten as:

> Furthermore, a more recent study has shown that distributed model simulations are statistically distinguishable from the lumped model simulations for basin areas around 1000\,km^2 \citep{carpenter2006ilv}.

11. **line 20 The literature shows many Z/R relations…to more recent ones for different climate types.**

Changed.

12. **Line 28 other methods for obtaining**

Done.

13. **8000 line 12 The sensitivity of time-resolution on distributed hydrological models is addresse in Bell and Moore (2000)**

The reference was removed from the manuscript.

14. **8002 3.1 line 6 Sempere-Torres et al, 2000;**

The reference was removed from the manuscript.

15. **Line 10 "huge sub-estimation" - rephrase – due to gross underestimation.**

Rephrased.

16. **8004 line 27 non-univocal - better to use "ambiguous" as in more common usage.**

Changed.

17. **8005 line 4 commented on previously. Subsequently, the ambiguous relation between…as two independent unambiguous datasets.**

Done.

18. **8006 line 19 where the transformed field**

Corrected.

19. **8007 "return flow" requires closer definition: is it saturation excess surface runoff?**

Return flow refers to the saturation excess surface runoff. It was amended in the manuscript.

> Two modes of runoff generation are simulated: infiltration excess runoff and saturation excess surface runoff. RIBS applies a kinematic model of infiltration to evaluate local runoff generation in grid elements and also accounts for lateral moisture flow between elements in a simplified manner.

20. **8010 line 10 GSA – define as Global Sensitivity Analysis**

We thank the reviewer for this comment. It was added to the manuscript.

21. **Line 21 Nash-Sutcliffe Efficiency (NSE) were selected…..The NSE was used**

This index has been removed from the manuscript.

22. **8011 line 4 T s better written as Ts – also occurs elsewhere**

It was changed in the whole manuscript.

23. **Line 11 of goodness-of-fit tests**

Corrected.

24. **8012 Is it better to change the terminology from BIAS to "log ratio bias" and Error to "bias" (or "mean error")?**

It has been changed to log ratio bias and mean error.

25. **Lines 3-10 Better style to introduce equations sequentially within sentence construct, and not just a list outside the sentence.**

Some equations has been removed whereas other ones has been introduce within the sentence.

26. **8013 line 9 "that are not held between the prediction intervals" – should this read "that are within the prediction intervals"?**

Authors thank this comment that improves the readability of the paper. It was corrected in the manuscript.

27. **Lines 6-15 Again, better to introduce the equations as part of the sentence construct.**

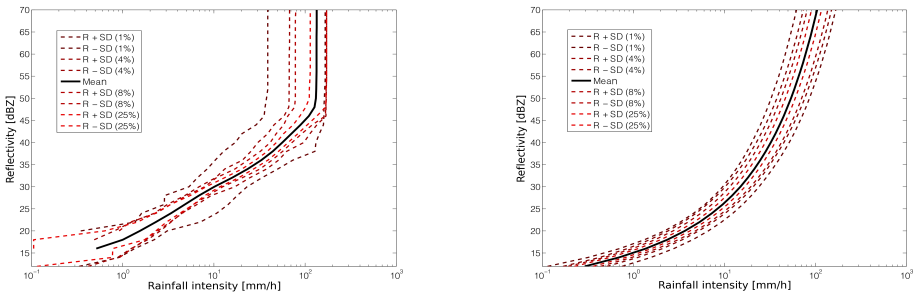
Some equations has been removed whereas other ones has been introduce within the sentence.

28. **8014 line 6 In Table 4 the eight**

It has been corrected.

29. **Line 1-15 There needs to be more discussion here on the relative merits of parametric and non-parametric approaches: this is discussed only later on page 8017.**

We thank this reviewer comment because the introduction of some figures and comments in the result section has emphasized the novelties applied in this contribution.



(a) Non-parametric (b) Parametric

Fig. 10: The new Z/R relation (solid middle line), as obtained from WPMM for the full dataset. The broken lines represent plus and minus one standard deviations from the Z/R when calculated by population from 1% to 25% sub-samples. The upper example (a) is the new Z/R relation obtained by non-parametric fitting whereas the lower one (b) correspond to the parametric fit.

30. line 13 "is own case data" – actually only 2 out of 4 cases. Comment on this case specific calibration in relation to flood forecasting application.

A figure comparing own case data against other case data has been added.

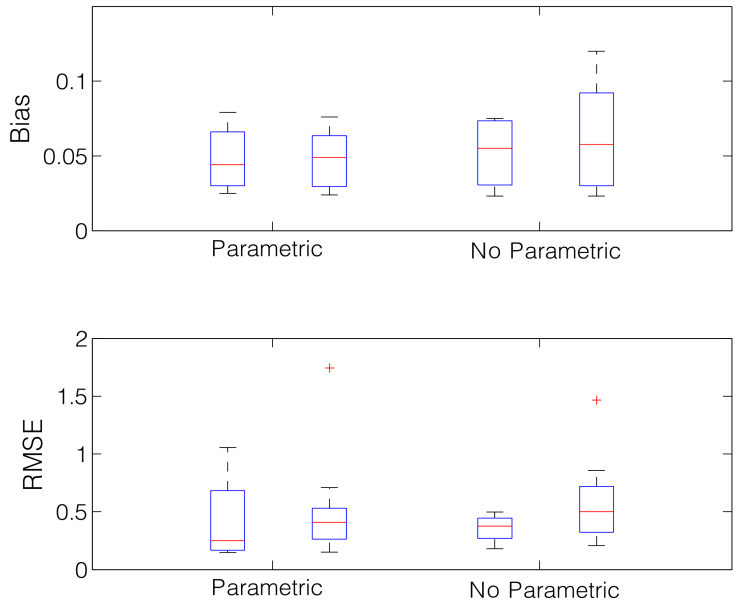


Fig. 9: Box-plot of both fitting techniques (Parametric and non-parametric) for the log ratio bias and the RMSE. The left box-plot for a given fitting methodology represents the results for the Z/R obtained for the same study case whereas the right box plot is the results obtained for the Z/R computed by the three other case studies.

31. **Line 20 Clarify why gamma function chosen rather than non-parametric kernel estimator.**

Besides the figures added, two new paragraphs have been added in the methodology section:

> Regarding the comparison of both methodologies, it can be observed that a parametric fit improves the results compared to a non-parametric fit (Fig. \ref{fig:COMP_BP}). The left box plot for a given fitting methodology represents the results for the Z/R obtained for the same study case, whereas the right box plot shows the Z/R results computed for the three other case studies. The log ratio bias and the RMSE show better results for both box plot regarding the mean and the IQ range. It could be observed that, for the most part, the most suitable data for the calibration are our own case data. Nevertheless, as the results show, the calibration could be performed by using data from other cases that achieve accurate precipitation estimations.
>
> A comparison between both methodologies shows that the parametric fit improves the range of applicability of the new Z/R relationship. It can be observed in figure \ref{fig:ZRSD} that the SD is higher for the tails of the non-parametric Z/R relation (Fig. \ref{fig:ZRSD_a}) than for the parametric Z/R relation(Fig. \ref{fig:ZRSD_b}). This is caused by the scarcity of values at the tails of the probability distribution function for the reflectivity and high intensity rainfall values. The parametric fit does not have this problem because it has only two parameters to compute, and this computation gives more weight to the central values of the distribution.

32. **8015 line 2 at six river gauging stations.**

It was corrected in the manuscript.

33. **Line 13 value for a 15 min time-interval.**

It was corrected in the manuscript as value for time resolutions of 12,15 and 18 min.

34. **8016 line 15 Because of this, an effort was made to couple radar data with a hydrological model for flash-flood cases recorded in Catalonia. This contribution provides a good example of….traditional Z/R power-law…**

It was corrected in the manuscript.

35. **Line 21 caused by the heavy precipitation**

It was changed.

36. 8017 line 1 minimum root mean square error is obtained

It was corrected in the manuscript.

37. Line 3 However, the results – not only in the lower tail of the distribution but also in the higher reflectivity tail – show…

Done.

38. Line 10 "potential form" and potential factor" – consider change of terminology

The term has been changed.

39. Line 14 of reflectivity into rainfall intensity…due to the convex shape of the WPMM function in the semilog….

The sentence has been corrected as:

> … reflectivity into rainfall intensity, which increases the quantitative precipitation estimation due to the convex shape of the WPMM function in the semilog rainfall intensity -- reflectivity axis.

40. Line 26 could be related to under-estimation of reflectivity

The sentence has been corrected as:

> The second correction made by WPMM non-parametric methodology could be related to the underestimation of the reflectivity due to the power parameter calibration or own rainfall attenuation.

41. 8018 better line 3 QPE results

It has been changed.

42. Lines 15-17 Clarify how this overall result was obtained.

The sentence has been rewritten in order to provide this information. The overall result has been obtained by comparing the new WPMM Z/R relation results with literature Z/R relation results. The new paragraph is:

> Comparing the results obtained in the literature for the Z/R relations \citep{ atencia2008nnp} with the results of the combined application of both methodologies, the RMSE has been reduced by up to 40\% and log ratio bias between 75\% and 95\%. These accurate results allow us to couple radar rainfall information across an area-weighted interpolation.

43. 8019 lines 11-12 Could link to findings and discussion of this by Bell and Moore (2000)

The finding in our work has been written as: "This work proves that the highest available rainfall time resolution does not necessarily provide the best results in terms of the predictability of peak flow while the radar system is coupled with a distributed hydrologic model."

The results obtained by Bell and Moore (2000) showed: "that the lower resolution rainfall data generally gave as good flow simulation as the higher resolution rainfall data. This result needs to be interpreted with caution in the context of the rainfall resolution requirements of a distributed rainfall-runoff model. It is cleary more appropriate for a distributed model to represent explicity the smoothing effect of the catchment on the runoff response to rainfall than for the modeller to degrade the resolution of the rainfall data to achieve the same purpose. This puts the onus on seeking improvements to the rainfall-runoff model to make best use of the higher resolution rainfall data."

The rainfall time resolution obtained by Berne (2004) formulae has no relation to spatial rainfall resolution but other formulas give the same results for the 2 km spatial resolution. Consequently, it could exist a link between the findings about spatial resolution and temporal resolution. However, the present study has been focused only on the temporal resolution and the authors would prefer not to suppose this link.

44. Line 18 "a previous analysis" – is the intended meaning "a further analysis"?

The sentence has been changed as: :

> The results for other basins could vary across the Mediterranean due to the dependence of the basin response on other characteristics not analysed in this work, such as geomorphology, geology and vegetation.

45. 8020 lines 22-24 Should this be the paper HESS, 4(4), 653-667, (2000)?

It has been changed.

46. 8029 Table 4. Validation results for the eight Z/R relationships in..

The word Z/R has been included in the caption.

47. September 06 in table

The year has been corrected.

48. 8030 "to the same rainfall estimation" – rephrase to clarify meaning

The caption has been rewritten as: "Comparison of results before and after of applying the advection correction."

49. 8031 Median R2 Efficiencies are low suggesting low model performance – does this deserve comment? There is no visibility of observed and simulated hydrographs to judge plausibility of hydrological model behaviour and performance. This is needed, and to be commented on.

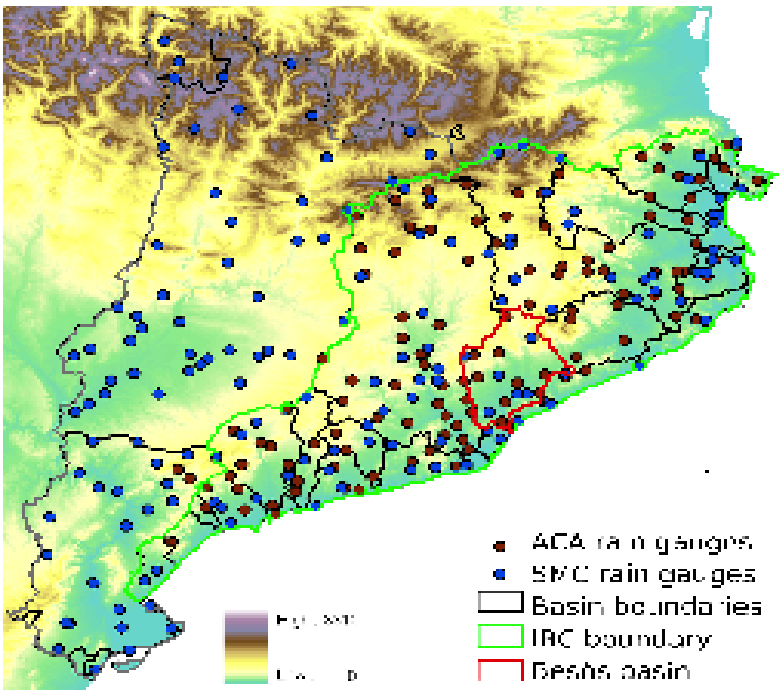
The R2 values are low because the whole event was considered and the simulated receding limbs do not fit fine the observed receding limbs. The R2 values increase if the higher part of the hydrograph were considered and the lower part were ignored. This can be seen in Figure 11 where the median of the simulated peaks are close to the observed peaks.

50. 8032 Fig 1. Boundary of Catalonia with DEM relief.

The caption has been changed.

51. On map key, contour should read boundary. Not clear if Basin boundary is Catalonia boundary. Need to get this right.

The word contour has been changed to boundary. The basin boundaries have been kept in black whereas the Catalonia boundary has been changed to grey in order to distinguish both boundaries.



52. 8033 Fig. 2. Location of river gauging stations:…

The caption has been changed.

53. 8035 Fig. 4. Examples of a

The word example has been well written.

54. 8036 for radar data window

Done

55. 8039 radar rainfall disaggregation

Done

56. 8040 Superposition of radar pixels…domain of area…

The upper-case has been changed.