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Hydrology and Earth System Sciences Discussions

Interactive comment on "Correcting the radar rainfall forcing of a hydrological model with data assimilation: application to flood forecasting in the Lez Catchment in Southern France" *by* E. Harader et al.

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Response reviewer #1

The authors would like to thank reviewer #1 for his or her careful review of the paper. The questions are re-copied below followed by our responses.

1. There seems to be a contradiction: you consider a "medium sized basin" of 114 Km2 (see Page 3532 line 23), whereas in Page 3537 line 23 you say that the simplification

0.2S is for SMALL rural watersheds and in line 10 you say that for watersheds less wide than 8 Km2. Is it because you implement the SCS-CN method in every (independent) cell (whose width is definitively smaller than 8 Km2)? Please let this point be clear in the text.

The SCS method using an initial abstraction of 0.2S is a well-tested and popular method in hydrology. Two recent examples of this method for medium-sized basins are Abon et al., 2011 and Han et al., 2012. The application of this method is not limited by the size of the grid cell selected. For example, in the case of Abon et al., 2011, the basin was distributed into sub-basins between 11 and 30.25 km2, which exceed the size of the 8 km2 for which the model was originally designed. The two references mentioned above have been added to the section. Also, the text describing the derivation of the SCS method for small rural watersheds has been removed, since this method has already been validated for larger catchments in other literature.

2. You speak about the presence of a subsurface poorly known process that may intensify the flood severity (Page 3534 line 7/10), and about the Mosson tributary (Page 3533, line 1). Can the error of flood prediction in some events be also due to these factors?

Model errors result from simplifications in the model structure compared to reality, the subsurface influence of the Karst and the upstream tributaries, the Lirou, Yorgues and Terrieu. The Mosson, however, is downstream of the Lavalette measuring station and will not have an impact on measured flood intensity. The Mosson will be removed from the paper as suggested by reviewer #2 to clarify this issue.

3. I think that working on independent grid cells is a strong simplification. I think that this must be acknowledged, furthermore, more references must be put to other works in Literature using independent cells. Any particular reason for the use of a linear reservoir elementary hydrograph? Can the model work also with Nash elementary hydrographs with more than one reservoirs in cascade?

The use of independent grid cells with a Lag and Route transfer function was selected because it does not require prior knowledge of the hydrodynamic features of the catchment such as roughness coefficients or hydraulic conductivity and has relatively few parameters to calibrate. Independent grid cells may be a strong simplification; however, runoff is rapidly concentrated, leading to little or no infiltration or storage during flow routing. For example, L'homme et al., 2004 showed that differences between the Lag and Route method and a kinematic wave approach may be negligible.New references will be added to this section (Olivera & Maidment, 1999; Maidment et al., 1998; Tramblay et al., 2011). The model could be adapted to work with Nash elementary hydrographs, but would require the calibration of additional parameters (e.g. n, the number of reservoirs, and K, the storage coefficient).

4. The whole procedure does not work very well for some events, but the reason for this are not merely due to the radar rainfall assimilation procedure, but also to the poorly known karstic system and to the rainfall-runoff model containing some important simplifications . I think that this must be acknowledged.

Yes, some of the error is related to simplifications of the physical system in the model, poor knowledge of the karstic system and the linear hydrograph method. This will be added to the conclusions. Further analysis of the model limitations for data assimilation is the subject of on-going research.

4. Page 3549 line15, why isn't the model able to reproduce multiple peaks in succession?

Reviewer #2, question #3 had the same concerns. The classical SCS methods have been adapted to better reproduce multiple peaks in succession through the introduction of the drainage coefficient, ds. However, this parameter may not be sufficient to account for the effects of intermittent rainfall. The karst is also thought to have a role in sustaining the discharge during the recession limb (Coustau et al., 2012). In addition to model errors, the radar rainfall error may differ between peaks (e.g. modifications in the

raindrop granulometry). Because of these factors, the model has difficulty representing the state of the catchment at the start of the second peak (stoc(t), Pb(t)).

5. I think that in the Summary and Conclusion section some should be said about the comparison between reanalysis and forecast modes

The authors agree that a comparison of reanalysis and pseudo-forecast modes should be included in the conclusion. One of the main interests of comparing these two modes is to estimate the error that results from the initialisation of S using catchment wetness state indicators and the error that results from an incomplete knowledge of the episode. This has been added to the conclusion.

6. Page 3548 line 6 to end of section. I think that you should give some explanation to the value assigned to the parameter.

Scal is the parameter described in Eq.(3), p.3537 calibrated for each event. The equation reference has been added to the text.

General comments on the text

1. Be careful with the (ab)use of commas. In many cases there are commas where they are not needed at all. I can do only some examples: Page 3535 line 22, after "location"; Page 3544 line 1, after "function"; Page 3546 line 7/8 after "reanalysis" and after "forecast".

The excess commas will be removed.

2. In general, there are too much equations in the whole manuscript, some of them are not strictly necessary, and some of them can be incorporated each other. Please, consider reducing the number of equations and write only equations that you recall in the text.

Sections 2 and 3 will be simplified to include more reference to previous literature and fewer equations. Equations (3), (4), (6), (8), (12), (13), (14), (20), (22), (23), (24) and

(26) have been removed.

Minor issues.

1. Abstract: line 9 – Replace “Because it depends on geographical features and cloud structures : : :” with “Depending on geographical features and cloud structures: : :”

This sentence has been changed to clarify was ’it’ was referring to: "Because the radar rainfall input to the model depends on geographical features and cloud structures, it is particularly uncertain and results in significant errors in the simulated discharges."

2. Page 3528, consider replacing “complex” with “complicated”, see http://larrycuban.wordpress.com/2010/06/08/the-difference-between-complicatedand-complex-matters/ , physical and space explicit models are full of rules, step-by step algorithms and of cause-effect relationships and, for this reason, complicated.

Changed.

3. Page 3531, line 6: Consider replacing “approaches to implementing the Kalman Filter algorithm” to “approaches to the implementation of the Kalman Filter Algorithm”.

Changed.

4.Page 3531, line 18: Personally I don’t like “the simplified version of the version of the Kalman Filter: : :”, please restate the sentence.

This sentence has been shorted and the second "of the version" removed.

5. Note of page 3533, insert a space after “Cretaceous”

Changed.

6.Page 3533 line 21: What reference level is +65 referred to (please, specify in the text)?

This is +65m NGF (nivellement général de la France). The datum is based on the sea level measured in Marseille. (The sentence containing "+65m" has been removed in

order to reduce the contents of Sect. 2.1.1, as suggested by reviewer #2.)

7. Page 3533 line 21/22: Restate the sentence “Several smaller seasonal springs drain the same system; these are discussed in greater detail in : : :”, maybe in “There are several seasonal springs, described in more detail in : : :, draining the same system”.

This sentence has been removed in order to reduce Sect. 2.1.1, as suggested by reviewer #2.

8. Beginning of Section 2.1.2, I think it is better to speak not only in terms of season but give also the information in terms of months.

The main recharge period for the karst is September through January. However, this sentence was removed in order to reduce the karst section..

9. Page 3537 line14: consider condensing the sentences “For predicting the instantaneous runoff rate during an event, a derived version of the SCS equation is necessary. The derivation of the SCS function is shown below.” In one sentence, like “For the prediction of instantaneous runoff rate during an event, we derived a version of SCS method as shown below.”

This sentence was combined with the two following sentences.

10. Paragraph 2.2.1 Are you sure that equation (3) is necessary? I think that the section is efficient only with equation (4) and (5), the reference (Gaume et al, (2004)) is enough and the question Ia = 0.2S can be explained in the text.

Equations (3) and (4) have been removed. The explanation of the initial abstraction was removed since this is a common feature of the SCS method.

11. It is good that thetime derivative of the SCS method reminds to the rational method, but in my opinion, itis not worthy to insert 3 equations for this comparison. While the comparison to Rational Method should be reduced, more words should be spent on the cumulative rainfall reservoir and the soil reservoir: (a) which is their physical meaning?

(b) why ds can be calculated from the slope of the descending limb of the hydrograph?

Equations (5) and (6) have been combined and the section on the rational method shortened.

The following explanations have been added to Sect. 2.2.1:

(a)The cumulative rainfall reservoir represents the total amount of rainfall received and is used to calculate the portion of the incident rainfall contributing to runoff during the event. The soil reservoir represents the amount of rainfall stored in the soil. A portion of the water lost by this reservoir becomes delayed runoff.

(b) When the rainfall rate is zero, discharge consists entirely of delayed runoff and stoc(t) becomes a decaying exponential with a coefficient of ds. The coefficient ds can then be estimated by creating a semi-log plot of the observed hydrograph and calculating the slope during the recession limb as done in Coustau et al., 2012.

12. In equations (9)and (10) the dot between ds and Pb(t) and between ds and stoc(t) is too low and can be confused with something else.

Unfortunately, this was the notation selected for the model validation (Coustau et al., 2012). While we acknowledge that it may be difficult to read, we would like to remain consistent with the previous literature.

13. Below equation (11), after defining w, define also,with a parallel sentence, S.

This has been added.

14. Page 3541 line 3/7: why do you use brackets for explainingthe meanings of Im, V0 and K0. I think it would work better using commas.

The parentheses seemed easier to read. They have been changed to commas.

15. Page 3542 line 21: I think that the sentence would work better replacing “The” with “Such a”

We prefer "The" since the goal is not to highlight the degree of nonlinearity in the relation, but to offer an explanation of why it might occur.

16. Below equation (19), please adjust the sentence describing the equation itself..“ J expresses the sum between two terms: the first one is: : :. And the second one is: : :.”

This has been changed.

17. Page 3544line 8: put comma after xa , put “respectively” between “are” and “the”, and why do you introduce new symbols (epsilonb, epsilona, and epsilon0) if they are not used in the following?

The comma was intentionally left out since we decided not to use the Oxford comma for this paper. The symbols were included for completeness, but have been removed since they are not used later.

18. Page 3546 line 7. It is “forecast” or “pseudo-forecast”? see Page 3548 line 25. Please use a unique definition.

This was changed to pseudo-forecast everywhere. The term was used in order to clarify that pseudo-forecast uses a known future rainfall, while a real forecast would not have this information.

19. Page 3546 line 23. Unify the style: in the text, numbers are expressed in letter or in numbers? (i.e., 2 or two)?

2 was changed to two.

20. Figure 3 is not somuch clear in my opinion, formulas should be cut off and, for example, say that the lineis the ground level. What is w in this figure? Please, show it .

The formulas have been removed and w was added to the figure.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 3527, 2012.