Authors' responses to interactive comment on Paiva et al. *"Assimilating in situ and radar altimetry data into a large-scale hydrologic-hydrodynamic model for streamflow forecast in the Amazon"* by Anonymous Referee #1
Hydrol. Earth Syst. Sci. Discuss., 10, C1364-C1366, 2013.

The authors are please to respond to the comments and suggestions by Reviewer in the following text, in which Reviewers' comments are shown in **bold** typeface, and the authors' replies in *italic*.

Authors' responses to comments by Anonymous Referee #1.

Reviewer's general comment:
Review of the paper by R. Paiva et al 'Assimilating in situ and radar altimetry data a large-scale hydrologic-hydrodynamic model for streamflow forecast in the Amazon'

The paper presents assimilation of water levels and discharge from gauges and altimeter derived into a hydrologic hydraulic model for improving streamflow forecast.

This is a very timely research topic since (1) the field of assimilation of hydraulic variables is not well advanced but research in this area is picking up quickly and (2), as noted by the authors as well, the potential NASA/CNES SWOT mission and also other altimetry missions could benefit from assimilation approaches that make use of river hydraulic parameters.

The paper is well written and follows a clear structure. The technical description and equations are sound and the results are encouraging and in my opinion this paper is worth publishing after some major concerns are addressed.

These relate primarily to the setup of the design, including the use of the EnKF, to estimate Q. In particular I have some concerns regarding the following points:

Authors' response: *The authors are grateful for the Reviewer's opinion about the paper and for the comments that helped us to improve the manuscript. We have made our best efforts to address all the suggested corrections.*

Reviewer's specific comment: In the introduction the authors should mention other research on assimilation of water level data in hydrodynamic or coupled hydrology-hydrodynamic models that use variational techniques (Hostache, 2010) or particle filter methods (Matgen et al, Giustarini et al.):

Hostache et al, JoH, 2010, Assimilation of spatially distributed water levels into a shallow-water flood model. Part II: Use of a remote sensing image of Mosel River

Matgen et al, HESS, 2010, Towards the sequential assimilation of SAR-derived water stages into hydraulic models using the Particle Filter: proof of concept

Giustarini et al, HESS, 2011, Assimilating SAR-derived water level data into a hydraulic model: a case study

Hostache et al., SPIE Proc. Remote Sens. for Agric. and Ecosys., 2011, Tracking, sensing and predicting flood wave propagation using nomadic satellite communication systems and hydrodynamic models

Authors' response: *We reviewed and included these references in the "Introduction" section of the corrected manuscript as suggested by the Reviewer.*

<u>Reviewer's specific comment</u>: Also there should be an explanation why the EnKF is preferred over VAR or Particle-based assimilation

<u>Authors' response:</u> *We included the following comment at the end of section 2.2:*

"Also, the advantage of the EnKF is that it can be easily implemented in any mathematical model, e.g. it does not require the development of a particular adjoint model as the variational methods, and it usually requires smaller ensemble sizes, and consequently less computational effort, if compared to particle filter methods [Liu et al., 2012]."

<u>Reviewer's specific comment</u>: In section 2, what's the effect of log-transforming Q and levels before assimilation vs. using the untransformed data?

<u>Authors' response:</u> *According to the results, using the log transformation improves the DA scheme performance, as discussed at the end of section 4.1, possibly due to (i) non-linear relation between streamflow and model states [Clark et al.,* 2008*] and (ii) its ability to deal with very discharges with different order of magnitude (different spatial scales or floods and droughts).*

<u>Reviewer's specific comment</u>: The experimental design seems appropriate to me. Although I'm not an assimilation expert, I assume the main reason that results (particularly in terms of Q) are improving is that the authors have used perturbations in precip. to get ensembles of Q through their hydrology model which makes the ensemble mean quite different from the 'truth', both in timing and magnitude. This is absolutely fine but I wonder if Q estimates of an ensemble were slightly better, maybe the degradation in Q when assimilating water levels would have been much larger and maybe not even show minor improvements in some places at all.

I say this since I imagine Q is correlated with water depth, which cannot be assimilated since it is not known but Q has much lower correlations with h, esp. in space

<u>Authors' response:</u> *We understand that the Q derived from a simple simulation and from the ensemble mean can be slight different due to the non-linear nature of the hydrological model. However, the comparisons were always made between assimilation results and outputs from the simple simulation as a reference (with no perturbation on precipitation). Consequently, our analyses show the improvement or degradation of results when data assimilation is used in comparison with the case where no data assimilation is used.*

<u>Reviewer's specific comment</u>: I think the improvements in results make a lot of sense but some aspect could do with more explanation. For example assimilating h to retrieve h, or Q to retrieve Q can be expected to work but assimilating h to get Q is a very different problem as illustrated well by your results since h for Q only gives very minor improvements and in most cases degradation.

So, in this respect, there should be some suggestions how this retrieval of Q with just levels (h) might be improved; maybe another assimilation technique is required or an extension or simultaneous assimilation of different variables and including both space and time is an option that could be explored.

Although the authors discuss some possible alternative to solve this problem (e.g. subbasin scale based assimilation), it would be useful to have a more elaborate discussion on this 'Q issue'.

Authors' response: *We included the following discussion in section 3.2.*
"The minor improvement of discharge estimates when water levels are assimilated may related by the fact that water level errors are not only related to stream flow or precipitation errors, but also to river-floodplain geometry parameters, as discussed by Paiva et al. [2013]. But this kind of model uncertainty was not considered by the DA scheme. Consequently, at river reaches where the model already provided accurate discharge estimates but wrong water level results, the assimilation of altimetry data correct water levels but can degrade discharges. Some possible alternatives to improve model discharge results from altimetry assimilation could be: (i) the simultaneous assimilation of discharge and water level data; (ii) the assimilation of altimetry-based discharge data (tested in Section 4.3); (iii) representing the uncertainty of model parameters (e.g. river-floodplain geometry) in the DA scheme; (iv) assimilation of altimetry data to first retrieve better river-floodplain geometry parameters [e.g. Durand et al., 2008; Durand et al., 2010b]; or (v) assimilation future SWOT data [Durand et al., 2010a], that will provide additional information such as water surface slope."

Reviewer's technical comment: Figures are of good quality

Authors' response: *OK.*

Reviewer's technical comment: Please update the reference by Alfieri et al

Authors' response: *Done.*