Response to the comments of Anonymous Referee #2 published on January 5, 2018 concerning the manuscript with reference number: hess-2017-394.

We would like to thank Referee #2 for his/her insightful feedback. Our responses to the specific points raised by the referee are provided below. Please note that the referee's comments will be presented in italics, preceded by a "**C**", while the corresponding authors' responses will be presented in normal typeface with a blue font, preceded by an "**R**". For some responses, text which was changed or added to the manuscript (based on suggestions from the referee comments) is quoted and placed under "Specific author changes". Please note that the pages and line numbers provided in this document are from the original version of the manuscript.

C1: *The authors present a novel way of using the Fokker–Planck Equation (FPE) to derive directly (one simulation) the probability distributions of velocity and depth resulting from uncertain roughness in a hypothetical unsteady open-channel flow problem. Although the efficiency gain over Monte Carlo simulation for the particular case presented seems limited, improving direct ways for probabilistic modelling is a relevant contribution.*

R1: We would like to thank the referee for this review.

C2: *The paper is well-written and well-structured, with sometimes a bit too many reminders of the story-line and mentioning in an early stage already the main conclusions (e.g. P.2 l.28).*

R2: We thank the referee for the positive comment. We would like to note that we worked on adjusting the manuscript to remove any repetitions and obvious statements, including those specified by the referee in the Detailed Comments below.

Main Comments

C3: *The title is confusing because of the "Ensemble modeling", whereas the main objective of the authors is to present a single simulation solution for providing a pdf. I suggest changing the title of this paper and the companion paper, taking out the term "Ensemble". (e.g. into something like "Fokker-Planck modelling of stochastic open-channel flow in term..", or "Deterministic modelling of..")*

R3: We thank the referee for his suggestion and we understand the confusion regarding the title. We will certainly consider the referee's suggestion of improving the title for both papers.

C4: *I would suggest to continue reporting and discussing the results for velocity and depth also in the latter part of the Results section (even if only in text, because with figures it would become too long), rather than only discussing discharge results. For velocity and depth, differences are likely to be larger and may lead to better understanding of what are the causes, because in discharge differences in velocity and depth may be cancelled out.*

R4: We thank the referee for his suggestion. Following the referee's recommendation in the above comment, as well as in **C14** and **C16** below, we have added a paragraph to the manuscript to briefly

discuss the results of the standard deviation for the velocity and depth. We do not include their figures as to not lengthen the manuscript as mentioned by the referee, but we describe their behavior and provide ranges for their values and some relative differences as suggested by the referee in **C16**.

Specific author changes

A paragraph that addresses the referee's comment is added prior to Page 11: Line 32, and reads as shown below. Note that due to an additional figure, which became denoted as Figure 8 (see Referee #1 **C5**), all figure numbers starting from 8 and above (in the original manuscript) have been increased by one for the revised manuscript. The numbers in the below paragraph refer to the new figure numbers.

> *" Concerning the standard deviation of the velocity and depth, it is important to note that their behavior over position is somewhat different from that of the flow discharge. In fact, the standard deviations of the velocity at the same four time positions of Fig. 9 seem to be relatively constant at each time position, having a value between 0.015 and 0.02 $m^3 s^{-1}$. On the other hand, the standard deviation of the depth showed a greater range of values at each time position, as a function of location, with values ranging between 0.15 and 0.5 m. When looking at the standard deviations as a function of time at the same four locations of Fig. 10, both standard deviations seem to show that their values increase to reach a maximum and then decrease to levels similar to original levels, not unlike their corresponding ensemble average plots over time. Again, the range of change in the standard deviation of the velocity is much smaller (0.015 to 0.02 $m^3 s^{-1}$) than that of the depth (0.15 to 0.5 m). Note that the relative differences of the FPE results when compared to the MC results reach up to 23% and 29% for velocity and depth, respectively."*

C5: *Please include a sensitivity analysis of the MC results with respect to the number of iterations. It would be interesting to check if with more simulations the results go nearer to the FPE result or further away (or no difference), and if with fewer simulations the same result is achieved. This is relevant for the claim on computational efficiency, as also pointed out by Referee#1 (fifth specific comment).*

R5: We kindly refer the referee to our reply to **C6** of Referee #1. In our reply, we present a sensitivity analysis showing how the number of realizations of the MC simulations affects the results of the ensemble average and standard deviation of the flow discharge, thus explaining in greater detail the choice of 1000 simulations in this study. We also mention that we believe that including such a long discussion and sensitivity analysis in the manuscript may cause a digression from the main idea of the manuscript, which is mainly to gauge the performance of the FPE methodology. Therefore, we believe that it would be preferable not to add such an analysis to the manuscript. Nonetheless, we include some text in the manuscript to clarify our choice of 1000 simulations to the reader, and we briefly mention the lower accuracy occurring at lower MC realizations (please see "Specific author changes" in our response to **C6** of Referee #1).

C6: *The analysis and discussion on computational time needs to be more detailed (including computational times, hardware used, etc.) and expanded. In particular with whether the FPE approach is suitable for parallelisation, if not, the MC analysis, for the case study presented, can be easily made more efficient. The authors could perhaps also include their expectations on the applicability and computational efficiency of their FPE method for larger systems. Would the gain with respect to MC increase or not?*

R6: More details have been given in the revised manuscript for the discussion of computational time needs as suggested by the referee. Moreover, a short discussion regarding the parallelization of the FPE as well as the greater advantage of the computational efficiency of the FPE methodology for systems with greater numbers of uncertainties is also added to the manuscript. These additions will be detailed below. The referee is also kindly referred to our replies to Referee #1, especially regarding **C6** (last two paragraphs) and **C9.**

Specific author changes

Technical information has been added directly before Section 3.1 (on Page 6: Line 14):

> *"Note that all simulations for the MC approach and the FPE methodology were run on a computer having 16 GB of RAM and an Intel i7 processor with four cores, each core having a base frequency of 2.40 GHz and a maximum frequency of 3.40 GHz."*

Two paragraphs were added to the end of the Discussion section, and read as follows:

> *" Moreover, it should be noted that these FPE results required a significantly less amount of time for computation as opposed to the MC results. Recall that the 1000 MC simulations were parallelized and run over all four cores (with no hyperthreading), thus noticeably reducing the computational time as compared to an un-parallelized run. With such parallelization, the MC simulations ran for over 2 days. On the other hand, the results of the FPE methodology, which was not parallelized, were obtained in about 7 hours.*
>
> *If we observe the computational times of the implicit numerical solution of the FPE methodology, the portion of the simulation requiring the greatest time is filling out the coefficient matrix, especially for small α and β discretizations. Parallelizing this portion over the four cores would allow one to considerably reduce the time to fill out the coefficient matrix, thus reducing the total computational time of this method. Without the parallelization of the FPE methodology, its one simulation may still not seem to provide an immense advantage when only one uncertain parameter is involved, especially with the possibility of parallelizing the MC simulations among a much larger number of cores. Nonetheless, when the problem being solved involves a greater number of uncertain parameters and boundary conditions, or even a larger system, such an advantage may prove to be crucial. In fact, the computational expense of the MC simulations for such a case would be expected to increase exponentially due to the higher number of simulations needed to maintain the desired accuracy in the results, thus significantly increasing the computational time regardless of parallelization. On the other hand, such additional uncertainties can be easily implemented into the FPE methodology by making simple changes and additions that will be reflected in Eq. (5), after which the FPE would be solved following similar steps as discussed for this study, with minimal implications on the computational expense."*

C7: *The gain in computational efficiency, as presently described, seems limited. Hence, the claimed contribution there, in Abstract and Conclusions, should be down-sized or contextualised.*

R7: The referee's point is acknowledged, and adjustments have been made to the corresponding text in the Abstract and the Conclusion as detailed below.

Specific author changes

In the Abstract, Page 1: Line 16-17 was adjusted as follows:

> *"Moreover, the total computational time of the FPE methodology is smaller than that of the MC approach, which could prove to be a particularly crucial advantage in systems with a large number of uncertain parameters."*

In the Conclusion, Page 13: Lines 12-13 now read as follows:

> *"Moreover, the FPE methodology results were obtained by running only one simulation, as opposed to the large number of simulations performed by the MC approach. Such an advantage becomes prominent with a greater number of uncertain parameters and boundary conditions, in which case the computational expense of the MC simulations that is needed to preserve the desired accuracy would exponentially increase. On the other hand, only simple adjustments would be required for the FPE, which could then be solved as was done in this study, with minor implications on its computational expense."*

Detailed Comments

C8: *P.2 l.28: "..producing the complete ensemble model results.." is not correct, because, if I understand correctly, the method does not reproduce the individual traces (ensemble members). Therefore, this should be something like "..producing the statistical properties.."*

R8: The sentence has been adjusted following the referee's comment.

C9: *P.7 l.14-15: Explain the choice of 1000 simulations. Report the sensitivity of the statistical characteristics to the number of simulations in the MC.*

R9: We kindly refer the referee to our reply to **C6** of Referee #1 which expands on this topic and explains in greater detail the choice of 1000 simulations.

C10: *P.8 l.27-28: Repetition. There is already a sentence connecting Sections 3 and 4 in lines 23-25. Consider leaving out one of the two.*

R10: Following the referee's comment, the sentence at the end of Section 3 has been removed to reduce the repetition.

C11: *P.9 l.18: Repetition. Delete ".., with very minimal differences among the two"*

R11: As suggested by the referee, the phrase "with very minimal difference among the two" was deleted.

C12: *P.9 l.32-33: However, ... ,but... Consider reformulating.*

R12: As suggested by the referee, the sentence was reformulated as detailed below.

Specific author changes
The reformulated sentence now reads as follows:

> *"Similarly to Fig. 4, a slight overestimation can be noticed from the FPE methodology especially around the peak depths, but with a maximum relative difference of only around 7.5%."*

C13: *P.10 l.13-17: Reformulate removing redundancies. (Or consider leaving out, because it reads perhaps too much as general conclusions, while this is in the middle of presenting and discussing results)*

R13: The sentences noted by the referee have been left out.

C14: *P.10 l.20: Why do the authors continue only with Discharge? Differences in velocity and depth may be cancelling each other in the resulting discharge. Also when thinking of flood risk management applications, it may be more interesting to look at velocity and depth variance.*

R14: As suggested previously by the referee, we provide additional text in the manuscript to briefly discuss the results for the standard deviations of the velocity and depth. We kindly refer the referee to our reply to **C4** for our full response.

C15: *P.10 l.18-23: Too much repetition. Suggest to shorten and merge with next paragraph where actually the presentation of variability results starts.*

R15: As suggested by the referee, the noted paragraph was shortened to one and merged with the following paragraph as follows:

> *"In a similar manner to the ensemble averages, the relative performance of the FPE methodology in predicting the system's variability was examined, this time by checking the standard deviations."*

C16: *P.10 l.33: "relatively small" Suggest to add some of the differences in %. Also provide differences in standard deviation for velocity and depth. P.11 l.15-21: The results for velocity and depth may help in understanding the causes of differences in variability.*

R16: The phrase structure for the sentence of Page 10: Line 33 has been changed due to changes from other comments. The percent relative differences have been added for the standard deviation for velocity and depth as suggested by the referee. Again, we kindly refer the referee to our reply to **C4** for our full response.

C17: *P.11 l.27-31: As described in main comments above, please expand the analysis and discussion of computational efficiency, and make it a separate paragraph.*

R17: We kindly refer the referee to our reply to **C6** above for the full response regarding this matter.

C18: *P.12 l.18: General sentence. Consider deleting.*

R18: As suggested by the referee, the sentence has been deleted.