Response to Reviewer 2

The edited manuscript has changes highlighted in blue, and all the line numbers referred to in our response correspond to the edited version. Thank you.

This new and valuable contribution sets out a probabilistic approach to the simulation of river meander migration that allows the generation of so-called geomorphic risk maps. The approach is potentially extremely valuable in that the derived risk maps offer a much more nuanced insight into the likelihood of different parts of the channel's floodplain being occupied. The paper is very well written and clearly argued throughout, so what follows might, for the most part, be regarded as minor queries/points of clarification rather than major critiques.

Authors' response: Thank you very much for reviewing our manuscript and for the favorable recommendation. We are very pleased to hear you find our manuscript clearly argued and grateful for your very helpful feedback and suggestions.

Reviewer comment 1: At Line 25 it is argued that there is some evidence that larger rivers (when averaged globally) migrate faster than smaller ones. However, the data on this is equivocal and it might be helpful to indicate a broader range of supporting (or conflicting) literature than just the recent analysis by Langhorst and Pavelsky. Part of the issue here is the qualitative nature of the term larger, alongside how rates of migration are actually defined. For example, an empirical data compendium assembled by Marco Van de Wiel has shown that, when normalized by their channel width, the rates of lateral migration of the largest rivers are surprisingly low (and often lower than 'smaller' rivers).

Authors' response: We agree that the jury is still out there, and there are competing hypotheses on the dependence of river migration on river width. We have now updated and qualified our sentence.

Reviewer comment 2: At Line 54, it could be useful for the reader to include some citations to highlight examples of previous risk-mapping approaches of the type referred to here.

Authors' response: Thank you. We have now included five references.

Reviewer comment 3: One of my more substantial critiques of this work concerns the introduction of the Howard-Knutson framework, which is the basis for the analysis that follows. This is initially introduced at L95, and I felt that it would be helpful to introduce here some of the limitations (including those identified in prior empirical work) of that approach, in particular examples of where the simply assumed relationship between curvature and migration breaks down. In fairness the authors do address these limitations towards the end of the work, but by deferring that discussion, the reader is left with a slightly false impression of the potential capabilities of the modelling framework. Given that one of the key advantages of a probabilistic approach is that it could potentially highlight incidences of unusual river behavior (especially behavior that is low probability but high consequence), then the exclusion of instances of channel migration that do not conform to the Howard-Knutson model, but which are known to occur in nature, is regrettable. It is, of course, very difficult to include all such instances in a single model, especially when the main aim of the paper is to highlight a new methodological framework. But I do feel that addressing this unavoidable difficulty head-on and early would be helpful to readers.

Authors' response: Thank you for pointing this out. We now make this point explicit in the introduction (L121) rephrasing concerns of the reviewers as: "For example, there are many instances when this simple assumed relationship between channel curvature and migration rate does not hold or other controls dominate the dynamics."

Additionally, we conclude by saying L541: "We see the Howard-Knutson model may not always be able to capture the first-order dynamics of the migrating river. We, therefore, suggest choosing the underlying deterministic model based on the geomorphic complexity of the case study."

Despite the limitations of this particular model, we would like to mention again that our framework is model agnostic. The $f(\theta)$, which represents a channel migration model, can be suitably chosen without loss of generality of our probabilistic framework.

L490: "As our framework to generate risk maps is model agnostic, we suggest the forecasters should first check the adequacy of their geometric models for capturing the first-order dynamics of the channel evolution."

Reviewer comment 4: Is it really the case (L117-118) that the aim is to capture only the most likely evolution and not the whole suite of possibilities/probabilities? The former feels much more limiting than the latter.

Authors' response: Thank you. We meant that's the limitation of using fixed parameter values in a deterministic modeling framework. Whereas our proposed framework explores the entire suite of possibilities. We have now changed the wording to reflect this clearly.

Additional references added to the manuscript:

Beven, K.: A manifesto for the equifinality thesis, Journal of Hydrology, 320, 18–36, https://doi.org/10.1016/j.jhydrol.2005.07.007, 2006.

Beven, K. and Lane, S.: On (in)validating environmental models. 1. Principles for formulating a Turing-like Test for determining when a model is fit-for purpose, Hydrol. Process., 36, 2022.

Borgomeo, E., Hall, J. W., Fung, F., Watts, G., Colquhoun, K., and Lambert, C.: Risk-based water resources planning: Incorporating probabilistic nonstationary climate uncertainties, Water Resources Research, 50, 6850–6873, https://doi.org/10.1002/2014wr015558, 2014.

Büchele, B., Kreibich, H., Kron, A., Thieken, A., Ihringer, J., Oberle, P., Merz, B., and Nestmann, F.: Flood-risk mapping: contributions towards an enhanced assessment of extreme events and associated risks, Natural Hazards and Earth System Sciences, 6, 485–503, https://doi.org/10.5194/nhess-6-485-2006, 2006.

Caers, J.: Modeling Uncertainty in the Earth Sciences, Wiley, https://doi.org/10.1002/9781119995920, 2011.

Donovan, M., Belmont, P., and Sylvester, Z.: Evaluating the Relationship Between Meander-Bend Curvature, Sediment Supply, and Migration Rates, Journal of Geophysical Research: Earth Surface, 126, https://doi.org/10.1029/2020jf006058, 2021.

Gaull, B. A., Michael-Leiba, M. O., and Rynn, J. M. W.: Probabilistic earthquake risk maps of Australia, Australian Journal of Earth Sciences, 169–187, https://doi.org/10.1080/08120099008727918, 1990.

Liu, Y., Freer, J., Beven, K., and Matgen, P.: Towards a limits of acceptability approach to the calibration of hydrological models: Extending observation error, Journal of Hydrology, 367, 93–103, https://doi.org/10.1016/j.jhydrol.2009.01.016, 2009.

Neal, J., Keef, C., Bates, P., Beven, K., and Leedal, D.: Probabilistic flood risk mapping including spatial dependence, Hydrological Processes, 27, 1349–1363, https://doi.org/10.1002/hyp.9572, 2012.

Reichert, P.: Towards a comprehensive uncertainty assessment in environmental research and decision support, Water Science and Technology, 81, 1588–1596, https://doi.org/10.2166/wst.20

Reichert, P., Langhans, S. D., Lienert, J., and Schuwirth, N.: The conceptual foundation of environmental decision support, Journal of Environmental Management, 154, 316–332, https://doi.org/10.1016/j.jenvman.2015.01.053, 2015.20.032, 2020.

Slingo, J. and Palmer, T.: Uncertainty in weather and climate prediction, Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 369, 4751–4767, https://doi.org/10.1098/rsta.2011.0161, 2011.

Wiel, M. J. V. D. and Darby, S. E.: A new model to analyse the impact of woody riparian vegetation on the geotechnical stability of riverbanks, Earth Surface Processes and Landforms, 32, 2185–2198, https://doi.org/10.1002/esp.1522, 2007.

Zargar, A., Sadiq, R., Naser, B., and Khan, F. I.: A review of drought indices, Environmental Reviews, 19, 333–349, https://doi.org/10.1139/a11-013, 2011.