Answers to comments by anonymous referee #1 RC C2527

B. J. Snow, I. Moulitsas, A. J. Kolios, M. De Dominicis

We would like to thank you, anonymous referee #1, for treating our article with invaluable care and for giving us detailed and constructive feedback towards the improvement of the manuscript. Please find below our comments on your suggestions.

General Comments

We accepted most of the suggestions as they improve the clarity and readability of the article. We accepted to reorganise and restructure the paper and further clarify points that were deemed vague. Below we only discuss the comments that we do not fully agree.

1. On page C2527, item 1, you pose the question on the advantage of the proposed method. *"What is the advantage of doing this? For example: Medslik II is designed to run on small desktop PCs, but probably could be run even hundreds of times per day, depending on the problem and model set up and CPUs available. Thousands of calculations can be done using CranSLIK (Monte Carlo) but how is this expected to be used in practice?"*

   The main advantage of the proposed approach is in the fact that it allows consideration of stochastic inputs in the problem assigning confidence intervals on the measured output quantities. Considering that the problem at hand is governed by highly stochastic variables, the authors strongly believe that this approach becomes pertinent.

   Furthermore, the proposed approach is far quicker. As you mention, MEDSLIK II could be run hundreds of times a day. However CranSLIK can run thousands of times a second. This allows for real-time Monte Carlo simulation. At any time the wind and current velocities are known. However their behaviour over the next time period is not. Therefore these values are predicted using the various meteorological models. What CranSLIK allows for is the input of a distribution for the current and wind velocities leading to all possible destinations for the oil spill to be considered. From this, a region can be created in which contains, for example, 95% of all possible destinations. In other words, the suggested approach of employing approximation methods and coupling them with stochastic (i.e. Monte Carlo Simulations) or analytical methods (i.e. First Order Reliability Methods/FORM) reduces computational time significantly, especially when the complexity of systems/cases increases. Text will be added highlighting further the novelty of the approach.

2. On page C2528, item 1, you state that *A richer set of test cases should be used to convince the reader of the validity and usefulness of the method.*

   This paper focuses on the methodology establishment of combining deterministic simulations of MEDSLIK II, approximation methods and probabilistic analysis methods for the probabilistic prediction of oil spills transport and fate under stochastic inputs.

3. On page C2528, item 1, you wonder about the events that can be handled. *"For example, in real transport phenomena, surface patches are often twisted and drawn out into long filaments before being eventually fully mixed. Can this model handle such an event?"*

   The small scale processes (for example filaments) can not be reproduced using low resolution ocean model (such as MFS) and they are not connected with the oil spill model used (in MEDSLIK II to start with, and therefore in CranSLIK either). CranSLIK, the probabilistic model, can only be as good as the deterministic model used, i.e., MEDSLIK II. Therefore, if a phenomenon is captured by the deterministic model, then this capability is passed to the probabilistic model too.

Specific Comments

As stated previously, we accepted most of the suggestions as they improve the clarity and readability of the article. We accepted to reorganise and restructure the paper and provide clarifications where requested. Below we only discuss the comments that we do not fully agree

1. On page C2528, item 2, you are concerned about the definition of terms. *"In section 1, terms are used but not defined adequately: apply sampling, Hypercube"*

   Sampling: Since the variables are continuous, it is not possible to try all of the values. Therefore samples of each variable must be taken to reduce the continuous variables to sets of discrete values. This is known as sampling, which we consider to be a common term. Several types of sampling are discussed in the paper, the aim being to create a set of discrete values which are representative of the continuous variable.

Hypercube: A hypercube is simply an n-dimensional shape. Here it refers to the design of the simulations. For example, if there were only two variables, the design would be a 2-dimensional hypercube, i.e. a square. Hypercube is a a term commonly used in this respect. If necessary we can provide references.

2. On page C2528, item 2, you wonder about the spreading.

   Full description of the formulas and all related references on the spreading appear in the Part 1: Theory, GMD paper of MEDSLIK II. If necessary, we could add more information in this manuscript, but we tend to feel that this would be beyond its aim and scope.

3. On pages C2528-C2529, item 2, you wonder about the way the technique is presented. *"-Uncertainty: how does it affect the forecast values of wind speed, -How is the hourly value related to the distributions discussed (is a value taken from the forecast model, then a distribution assumed, or are many forecast runs completed as an ensemble?), and -What is meant by apply sampling? line 13 p 7055 -Where do values of wind come from? Which meteorological model? Reference?"*

   Quantities such as wind speed is by definition stochastic as they cannot be deterministically predicted, especially considering their time dependence. Due to this presence of uncertainty we refer to forecasting, which is a prediction of the expected value and its distribution rather than absolute calculation, in order to estimate high or low percentiles for deterministic analysis. This new approach takes into consideration a full statistical distribution (of any type) avoiding any subjective decision making. When developing the model a distribution was assumed and then sampled to give a discrete set of velocities. In other words, in CranSLIK an input distribution can be used as an input but how this is obtained is not specific. Assuming a distribution centred on the forecast model is probably the most simple way to do this.

4. On page C2529, item 2, you state that you would like to see the equations used for regression.

   We cannot think of a neat way of including the equation (polynomial) information in the manuscript. We also do not see why the presentation of the polynomial pertinent to the test case is a valuable addition to the manuscript. Instead, we suggest to include this information as a separate file in the repository where the code for the model, along with the test case data and output, can be downloaded from. If our alternative suggestion is not acceptable, we will happily include the polynomial in the manuscript.

5. On page C2529, item 2, you state *"Section 5.4 needs to be enriched with some further, detailed discussion of the benefits and limitations of this model: can it produce the results needed, and under what circumstances?"*

   CranSLIK can be used to provide a likely region for the oil spill by considering thousands of possible values for wind and current velocities. An approximate distribution is required for this however this can be a distribution centred on the values predicted from meteorological models. This will allow for consideration of errors in the predicted velocities. By considering more advanced approximation methods, we can achieve better accuracy, obviously at the expense of computation time.

6. On page C2530, item 3, you state *"It is not clear if the simplification of the oil spill fate model is novel"*

   The novelty of this work lies in the fact that the oil spill transport and fate is assessed through a probabilistic perspective, taking into account the state of the art deterministic tool MEDSLIK II. This is a particularly important addition as the parameters influencing the phenomenon are highly stochastic.

7. On page C2531 you state *"methodology too vague"*

   Methodology should be clear as far as the sequence of steps, please see also Fig. 3. Components of the methodology will be enhanced for clarity.

8. On page C2531 you state *"No mention of related work, is the first such attempt?"*

   To the best of our knowledge, this is the first time approximation methods have been used to approximate oil spill fate and transport.