

Dear Dan Crisan,

we are thankful for the constructive criticism and the suggestions made about the manuscript. In the following you find detailed answers to the points that were raised.

Reviewer's comments and author's answers:

The authors use a particle filter for parameter estimation in a visco-elastic model of the lithosphere and mantle. The goal here is to find a set of parameters in a model that leads to a solution consistent with a set of observations. In this work the unknown parameters are the viscosities of the lower and upper mantle. The authors study the effect of different parameter initializations and observation uncertainty on the performance of the filter with clearly stated results and conclusions.

The paper is well organized and well-presented. I recommend publication but suggest that the authors address the following niggles:

Line 78 I don't get this sentence "the ensemble members did not mix they were called particles"

*A: The intention of this sentence was to explain the name particle filter. Since it was also unclear to other reviewers it was removed.*

Line 85 This is also a very good review paper:

PJ Van Leeuwen, HR Künsch, L Nerger, R Potthast, S Reich, Particle filters for high-dimensional geoscience applications: A review, Quarterly Journal of the Royal Meteorological Society 145 (723), 2335-2365, 2019

*A: Actually, we had also consulted this paper. It was added here as a reference.*

To find more generic references on particle filters, I suggest that the authors look at:

Doucet, A.; Johansen, A. M. A tutorial on particle filtering and smoothing: fifteen years later. The Oxford handbook of nonlinear filtering, 656–704, Oxford Univ. Press, Oxford, 2011.

*A: Thank you for this hint.*

Line 110 An alternative method to update the parameter set is to use jittering. For details:

Crisan, Dan; Míguez, Joaquín Nested particle filters for online parameter estimation in discrete-time state-space Markov models. Bernoulli 24 (2018), no. 4A, 3039–3086.

*A: The jittering method has been added in the manuscript as another possibility to update the parameters.*

Line 138 In section 4.2 It would be good to explain what the observations are, the choice of the distribution for observation noise (the observation uncertainty parameter is stated at line 165 but not the distribution) , and give the expression for the parameter likelihood function.

Finally, perhaps you can put the VILMA equations in an appendix.

*A: The complete set of equations that are solved can be found in the references given in the respective parts of the manuscript. However, we have added the most basic equations in the appendix.*