Nonlinear Processes in Geophysics Discussions

Nonlin. Processes Geophys. Discuss., referee comment RC2
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# Comment on npg-2021-22

Peter Jan van Leeuwen (Referee)

Referee comment on "An approach for constraining mantle viscosities through assimilation of paleo sea level data into a glacial isostatic adjustment model" by Reyko Schachtschneider et al., Nonlin. Processes Geophys. Discuss., https://doi.org/10.5194/npg-2021-22-RC2, 2021

The manuscript discusses the estimation of mantel viscocities using sea-level observation in a particle filter. The manuscript is well written, and the results are interesting even though the set-up is highly simplified. I suggest publication after the following minor comments are taken into account.

Line 78: Strange sentence, not sure what the authors want to convey.

Line 79: Note that the output of the filter is the weighted posterior ensemble, from which a weighted mean can be calculated. This mean can be a poor estimate of the posterior pdf if that pdf is strongly non-Gaussian. Please add a small discussion of these facts.

Line 102: Resampling hardly changes the ensemble variance of the weighted ensemble, which is the relevant ensemble in this case. The weighting itself reduces the variance in the ensemble.

Line 105: It would be good to mention that of the three methods the second is the correct methods, and the 1st and 3rd are approximations.

Line 111: I assume the authors mean N(0,a \sigma^U,L). Note that it is common to have the (co)variance of the distribution as the second argument of N(..,..) and not the standard deviation.

Line 114: Setting a=0.5 \sigma is a large value to perturb each viscocity with. However, it is perhaps good to mention that the standard deviation of the ensemble as a whole only increases by a factor 1.12 (= sqrt(1 + 0.25)) through this procedure.

Line 115: Probabilistic resampling means that one has to draw N random numbers, where N is the ensemble size. A more accurate resampling method is Stochastic Universal Resampling, in which only one random number is drawn, and it is also faster! This could be mentioned. Since after resampling relatively large random perturbations are added to the particles the difference will be minor in this case.

Line 165: mu

Line 174-175: Please remove this sentence, it is just a repetition of what was said before.

Since the variance in the initial ensemble is chosen as large as the mean many initial particles will have negative viscocities. What is done when a negative viscocity is drawn? A similar question for later in the run, what is done if the 'jittering' after resampling produces negative viscocities? Related to this, the figures show different mean viscocities than the table 2. Please correct the one that is incorrect.

It would be good to show the effective ensemble size, defined as $N_{eff} = 1/\sum_i (w_i^2)$ in which the $w_i$ are the normalized weights, such that $\sum_i w_i = 1$. This allows the readers to judge the quality of the ensemble. My suspicion is that $N_{eff}$ is rather low, as low as 2-5 members at time, which is close to degeneracy.

Fig 10: caption, change left and right to top and bottom.

Line 309: I don't understand this sentence, please clarify.

Section 2: I'm not an expert in this field and would suggest providing the set of equations being solved to gain an idea of the complexity of the problem at hand.

Section 7: It would be good to also include a discussion of the accuracy of the underlying ice model and its expected influence on the results.