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Interactive comment

Interactive comment on "Development of a probabilistic ocean modelling system based on NEMO 3.5: application at eddying resolution" *by* Laurent Bessières et al.

Anonymous Referee #3

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The paper "Development of a probabilistic ocean modelling system based on NEMO 3.5: application at eddying resolution" by Bessières et al. presents an ensemble-simulation strategy in the NEMO ocean model. Results from ensemble ocean hindcasts are presented to illustrate the utility of the software. The material is a good fit for this journal and will no doubt be of wide interest. I have several 'major' criticisms, but they relate only to the way in which the broader context is discussed, and not to the specific results or to the software.

Major

- Model uncertainties can be modeled in a huge variety of ways. The discussion surrounding equation (3) tacitly suggests that the only, best, or most common way to model model uncertainty is by adding Gaussian white noise to the time tendency equation. Many other options exist; for example using non-Gaussian white noise, colored noise, or forcing with the increments of a Levy process instead of a Weiner process, to name just a few (other options exist even beyond adding terms to the equations, for example when a parameter is unknown but should not be time-dependent). The stochastic parameterizations used in NEMO in this paper (as far as I can tell) are not in the form of equation (3) because the noise terms are generated by time-correlated processes (either AR-1 or piecewise-continuous in time). (I grant that for an AR-1 noise process you can expand the definition of $\mathbf{x}$ such that the whole system is in the form (3).) In general, a stochastic model has a master equation that models the evolution of the probability density, but this master equation need not be a Fokker-Planck equation. Tying the discussion to an SDE forced by Weiner-process increments is overly restrictive and the ensemble framework described in this paper is just as useful in a broader context as it is in the restricted context.

- In a few places it is claimed that (i) an ensemble simulation provides a solution to the Fokker-Planck equation, or equivalently that (ii) the ensemble provides an approximation to the probability density function p on the model state $\mathbf{x}$ at a specific time t. I suppose that there is a sense in which this is true, but with any realistic ensemble size the approximation to p is horrendously bad. I suggest that a more accurate phrasing would be to say that an ensemble provides a set of independent, identically-distributed (iid) draws/samples/realizations from the distribution, and that these draws/samples/realizations can be used to compute a Monte-Carlo approximation to any statistic of interest, like the mean, covariance, or even the pdf itself. The accuracy of the Monte Carlo approximation depends on the number of samples (ensemble size), the distribution from which they're drawn, and the quantity of interest. For example, the ensemble mean can probably be estimated fairly well, but the full pdf $p(\mathbf{x}, t)$ almost certainly cannot.

Furthermore, the Fokker-Planck equation (or, more generally, the master equation associated with the stochastic model) only provides a pdf on the model state at a particular time, which is again overly-restrictive. The pdf at a particular time (even if you knew what it was) cannot be used to estimate things like temporal correlations, but such things *can* be estimated (using Monte-Carlo) from the ensemble, because the full time history of each ensemble member is a draw/sample/realization from the more general joint distribution of the model variables at different times.

In summary, I think it would be better to describe the ensemble system as providing a set of iid samples that can be used to compute Monte-Carlo approximations to any statistical quantity of interest.

- I think the term 'equiprobable,' frequently used to describe the ensemble members, is at best misleading. It suggests that the ensemble members are equally probable. This is usually not true. Rather, the ensemble members are independent and identically distributed (iid), and within a Monte-Carlo context they all have equal weight (perhaps the equal weights are what is meant here by equiprobable). For example, the only way to draw 'equiprobable' samples from a scalar normal distribution is for the samples to all be located an equal distance from the mean, whereas any iid set of samples – some highly improbable, others highly probable – can be used in a Monte-Carlo approximation with equal weights.

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