Review of "*Adjoint-Based Simultaneous State and Parameter Estimation in an Arctic Sea Ice-Ocean Model using MITgcm (c63m) »*

by François Massonnet (UCLouvain). I did not look at the other reviewer's comment before submitting mine.

In this study, Lyu and colleagues employ the MITgcm and an adjoint method to jointly estimate the state and parameters of the ocean-sea ice model. They assimilate satellite and in-situ observations and compare the results of the CTRL run (no assimilation), adjoint-SE (state estimation only) and adjoint-SPE (state and parameter estimation) to independent observations. Most of the improvements come from the state estimation but further improvements are noted with the parameter estimation.

The study is interesting and the attempt to estimate parameters and state together has some future, I believe, especially in the context of prediction where model drift can be an issue.

My main remark on the paper is that the authors do the analysis on one year, and in fact on a very particular year : 2012. Why this choice ? Is there a risk that the outcome of the paper could be drastically different for other years? I am asking because 2012 is such a special year, with a strong cyclone (not something that is model-dependent) that may bias the results.

Related to that, I am not sure what is the overall implication of this work. Are the authors willing to recommend new parameter values for the MITGcm community? If so, I would like that they test whether the state is improved on a year without assimilation (e.g., running 2017 from the normal initial conditions but using parameters obtained for the 2012 estimation) and show the improvement.

The English could be improved at places, as suggested below.

- Line 18 : tunned → tuned (many other instances in the text)
- Line 19 : of AN Arctic
- Line 27 : applied to perform/produce (not reproduce) ?
- Line 33 : not sure that the processes themselves undergo changes : processes remain (e.g. heat conduction, ice melting), but it is the state of the system (affected by these processes) that changes
- Line 34 : To me, parameters stemming from parameterizations cannot be measured by construction. Nature ignores what a parameterization is.
- Line 35 : is assumed, not are assumed

- Line 42 : I would use the past tense as in the previous sentence. In general, please keep consistency of the tenses.
- Line 44 : budgetS
- Line 48 : sensitive
- Line 60 : likely TO improve
- Line 112 : The authors justify that assuming B^(-2) to be diagonal is a consequence of the fact that they rely on the adjoint model to project the model-data misfits on the control variables. First, I do not understand what the two sentences have to do with each other. Second, I am surprised to read that B is assumed to be diagonal. In general, one can assume the observation error R to be diagonal (i.e., uncorrelated observational errors) but for the background model state, this seems to be a very strong assumption! Indeed model background errors are certainly correlated. Can the authors provide justification for the diagonal nature of B ?
- Line 119 : uncertainties are set to 20% ; please be more specific : I assume this is the standard deviation of the error distribution (assumed Gaussian) ?
- Table 1 : could the authors justify where the ranges of parameters come from ?
- Line 141 : please specify what « uncertainty » means here.
- Line 156-158 : why multiplying here ?
- Line 161 : this is not very clear, especially when it is said that SIT is SIT x SIC. I would use another symbol, maybe SIT_floe for the in-situ and SIT for the effective. Also, I assume that the "gridded SIT" means the model SIT?
- Line 202: "*Firstly, the parameter changes within the range of uncertainties have considerable impacts on the model simulation*. » is presented as «a prerequisite » but it is not. Did the authors mean « a hypothesis » maybe ? But then I am confused by the sentence after that. Maybe they meant « requirement » ?
- Line 207 « perturb by 10% » could mean many things : is that the range, the standard deviation, with perturbation statistical model ?
- Line 291 : this ocean heat
- Line 295 : a much
- Line 296. Starting a sentence with « While, « is strange
- Fig. 8 the colormap is not adapted for colorblind people, can you please choose a colorblind-friendly one?