Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2019-20-AC1, 2019

Geoscientific Model Development Discussions

Interactive comment on "How to use mixed precision in Ocean Models" *by* Oriol Tintó Prims et al.

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Received and published: 10 May 2019

We thank the consideration that the referee had for our work and the valuable comments that helped improve the quality of our manuscript. Answers for the questions follow this lines, and the specific suggestions to improve the text have been adopted.

Referee: There is one weakness of the presentation at the moment: Results for model simulations that are using the reduced precision configuration are not presented. If these are not shown, the reader will assume that the results are not so great but I think that this is actually not the case. Can you add some figures showing results when using the reduced precision configurations? E.g. mean fields for long term simulations and differences for short term simulations in comparison to differences

that are caused by a change of the timestep?
Answer: The reason to leave the results without a figure was that the maps are virtually identical and the differences are not perceptible. Figure 1 and Figure 2 attached to this document show the sea surface temperature mean during the first month of simulation for the reference case and the loose case. It can be seen that there are no perceptible differences. A paragraph has been added to the discussion section 3.1.4 trying to empathize this.+

Referee: The English should be revised and improved throughout the paper (see some detailed comments below but there are more problems in the text).
Answer: There has been an effort to improve the quality of the text, all the mistakes pointed out by the referee have been solved and a general revision of the text has been performed.

Referee: One of the main problems for a precision reduction in ocean models is that conservation laws may get violated (mass and tracers). Can you comment on that? Or quantify mass loss/gain when running the reduced precision configurations?
Answer: The conservation of mass and tracers in our experiments has not been studied. It is in fact a good idea to consider conservation laws to be used as accuracy tests as well. Defining an accuracy test to ensure that conservation laws are fulfilled will prevent that any variable that might negatively affect conservation is set to reduced precision.

Referee: The constraints that come in via the exponent are not very well discussed.
Answer: I have added clarifications regarding this point in two different sections of the code: when we first talk about the reduced precision emulator in the introduction and when we talk about the possibility of using half-precision for ROMS simulations in section 3.2 .

Referee: You may want to cite this paper: Düben et al. 2017: "A study of reduced nu-

merical precision to make superparameterization more competitive using a hardware emulator in the OpenIFS model".It performs a precision analysis per parameter for the CRM used in superparametrisation similar to the one performed in this paper. It is also arguing that the parameter uncertainty that is found via an automated precision analysis could be used to develop stochastic parametrisation schemes. This may also add to an interesting discussion in this paper.?
Answer: A cite to this manuscript has been included in the introduction.

Referee: I do not understand IQR and how it is used.
Answer: Interquartile Range is a measure of statistical dispersion of the values of a sample. In the manuscript, it is used in the NEMO cases to normalize the RMSD minimizing the effects of outlier values. At first, it was considered because it would make it easier to combine errors from variables of different magnitudes, although in the case presented in this manuscript it might be unnecessary.

Referee: Why do you not present the results for the tight evaluation? The light cray is not visible in my printout.
Answer: The tight case was included to demonstrate that the method can work imposing different constrains. Showing the impact estimates for the tight case can mislead the reader to think that the potential reduction of memory usage is lower that what it really is. This same information has been included in the manuscript. The Figure 1 has been modified to make the two colors distinguishable in black and white.

Referee: For NEMO: Maybe I have missed this information: Do you state how many of the variables are actually used and how many are not used in standard simulations? You should also state the accuracy score when you run simulations with the combined precision reductions for the tight and loose precision configuration.
Answer: From more than 3500 variables declared through the code, our specific configuration only uses 942. These are identified during a simulation and a file that

shows which variables were actually used is generated. This information has been included in the manuscript (section 3.1.3). Our experience using the method with NEMO tells us that with a large number of variables, the final accuracy score ends up being just below the limit established. This has been empathized in the manuscript.

Referee: "AD and TL should be better targets" 4DVar experts tend to disagree with this statement since the forward TL and the backward AD need to fit to each other to guarantee convergence of the assimilation. Reduced precision can destroy this. You may want to discuss this less optimistically.
Answer: TL and AD models that are typically used in 4D-Var systems involve many approximations (e.g. different resolutions to the NL model, reduced physics, more stable numerics, etc) - nonetheless they provide useful gradient information. We see reduced precision as simply another level of approximation. As long as the TL and AD models are consistent (i.e. the AD will be the transpose of the TL to within the chosen precision), the numerical precision can be reduced. The referee was right pointing out that our previous explanation could seem too optimistic and it was clarified in the manuscript.

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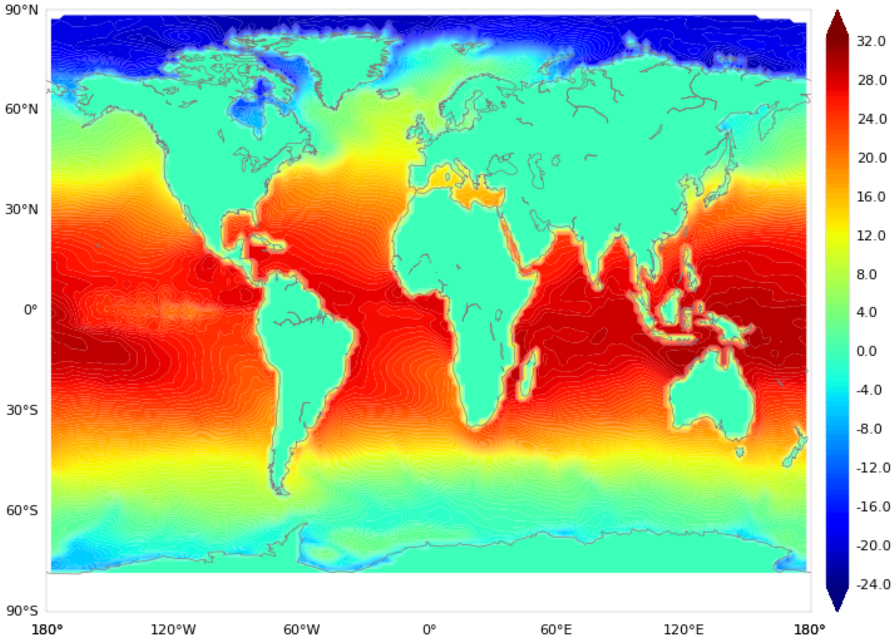

Fig. 1. Monthly mean sea-surface temperature in the first month of the reference simulation.

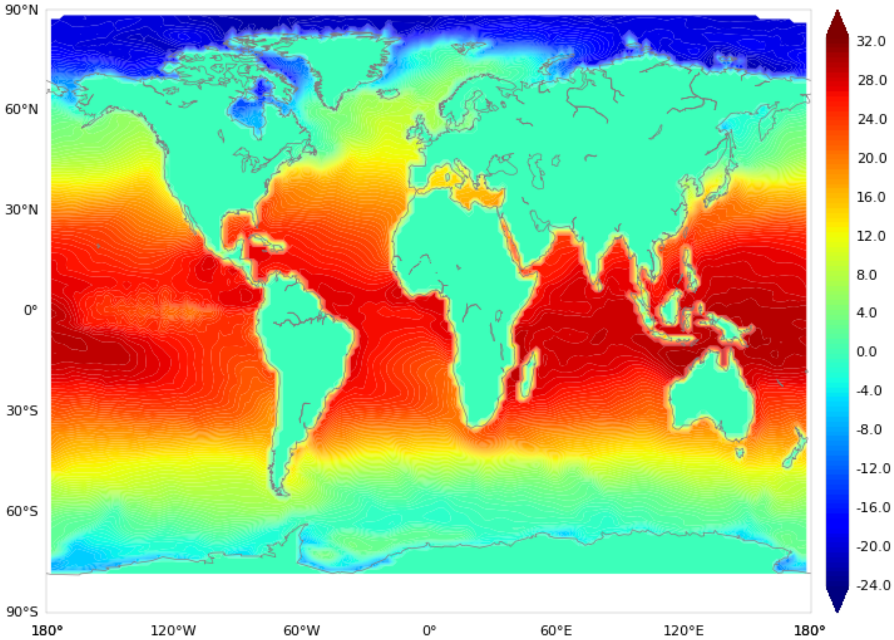

Fig. 2. Monthly mean sea-surface temperature in the first month of the loose case simulation.