

## ***Interactive comment on “Formulation of an ocean model for global climate simulations” by S. M. Griffies et al.***

**S. M. Griffies et al.**

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We thank Reviewer 2 (David Webb) for his provocative comments concerning the scientific judgement of the new GFDL climate model. Please accept the following discussion, along with the earlier one from Anand Gnanadesikan, as our response to these comments.

The evaluation of a high-end climate model is a nontrivial process that requires years of analysis by numerous scientists. The present manuscript is but a small part at the beginning of that process for the most recent GFDL climate model. This manuscript is insufficient to allow a full scientific judgement of the model's merit. For global ocean climate modelling, no single journal article can fulfill this role. Furthermore, we have noted in the manuscript where further studies and analysis are warranted, and thus where the present manuscript falls short in achieving its stated goals. Nonetheless, we feel that this manuscript does achieve much to remove model opacity that often

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presents a barrier to non-specialists and students when aiming to understand, interpret, analyze, and/or run ocean climate models.

We believe that it is critical for modellers to document in a peer reviewed manner their model fundamentals. Doing so provides a basis from which to judge the scientific integrity of a simulation. There are numerous examples in climate modelling where simulations agree reasonably well with observations, yet employ unphysical parameterizations or unsound numerics. Anand Gnanadesikan's response illustrates but a few. We believe that sound physical processes and parameterizations, along with robust numerical methods, form a necessary part in judging the scientific integrity of a climate model. Such is just as important as computer power in determining a model's utility.

The present manuscript candidly exposes fundamental elements of the most recent GFDL ocean climate model. We have endeavoured to compare and contrast these formulations with older approaches, many of which were used in earlier GFDL models and which are far less physically based and often numerically unsound. From this perspective, we have argued that the new model is superior physically and numerically from the previous GFDL climate model documented by [Delworth et al.(2002)]. In addition to highlighting improvements in model fundamentals over earlier efforts, we aimed to expose shortcomings of this new model in hopes that smarter people will take on the challenge of improving our work. This candid discussion is often absent in other treatments.

Absent this manuscript, the new GFDL ocean climate model would remain a virtual *black box* with just a few developers understanding its inner workings. That situation has been the norm in ocean climate modelling during the past decades, and it is very unhealthy for climate science. In particular, it presents an unfortunate and unnecessary barrier to students and researchers outside the *inner circle* who aim to contribute to the field. It also presents a barrier to other developers aiming to reproduce elements of this model. Hence, we sincerely believe that this manuscript (1) helps the scientific

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community judge the model's simulations, (2) describes improvements in model fundamentals over earlier efforts, and (3) contributes to the evolution of ocean science by guiding efforts to realize improved models in the future.

Other parts to the *GFDL climate model story* are being filled by a growing number of studies that aim to thoroughly assess its simulations. Below is a sample of manuscripts available from GFDL web sites documenting some of these studies. Many pieces of these efforts illustrate simulation improvements over those of earlier GFDL climate models.

- [[Delworth et al.\(2005\)](#)]: This paper presents the full climate model and illustrates some of its characteristic simulation properties.
- [[Wittenberg et al.\(2005\)](#)]: This paper focuses on the tropical simulation in the climate model, with particular focus on ENSO.
- [[Stouffer et al.\(2005\)](#)]: This paper discusses idealized climate response in the climate model due to changes in greenhouse gas concentrations.
- [[Griffies et al.\(2005\)](#)]: This is the present manuscript submitted to Ocean Science.
- [[Gnanadesikan et al.\(2005\)](#)]: This paper presents a preliminary analysis of the ocean simulations within the coupled climate model, and describes biases and potential origins of these biases.
- [[Russell et al.\(2005a\)](#)]: This paper compares the Southern Ocean simulations in the control simulations from a suite of IPCC climate models, including the GFDL model.
- [[Russell et al.\(2005b\)](#)]: This paper compares the Southern Ocean simulations in the CO<sub>2</sub> doubling simulations from a suite of IPCC climate models, including the GFDL model.

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