

## ***Interactive comment on “Description and evaluation of NorESM1-F: A fast version of the Norwegian Earth System Model (NorESM)” by Chuncheng Guo et al.***

### **Anonymous Referee #2**

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**General comments** The manuscript by Guo et al. presents a new version of the Norwegian Earth System Model, i.e., NorESM1-F, that is designed for millennium-scale and large ensemble climate simulations. The paper describes the major developments of the model from its predecessor, NorESM1-M. These developments lead to substantial improvement of the computational efficiency, and better representations of the atmospheric and oceanic physics as well as ocean biogeochemistry. The model performance is documented by examination of the equilibrium state of a 2000 year spin-up and control run forced with pre-industrial conditions, and evaluation of the model transient climate using observations and NorESM1-M as benchmarks. In general the model shows a satisfactory equilibrium with only a slightly cooling trend in 1000 years,

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and a good agreement with the observational estimates of the present day climate state. In comparison with the NorESM1-M, the new model demonstrates comparable or reduced biases. A particular feature of the improvements lays in the much more realistic strength of the simulated meridional overturning circulation, which results in more realistic atmospheric heat transport in the Atlantic Ocean and reduction of the warm and saline bias in the deep Atlantic. The more realistic physical ocean consequently improves the simulated interior ocean biogeochemical tracers.

Overall the manuscript is well written, and clearly documents the major development and performance of the new model version of the NorESM. As large ensemble has become an important way forward in understanding climate variability and quantifying climate change projections, I believe the NorESM1-F with its computational efficiency, will make important contributions to studies of the millennium-scale climate change as well as to the Coupled Model Intercomparison project 6. I recommend publication in GMD subject to the following minor (and mostly technical) revisions.

**Specific comments** – The authors demonstrate that the simulated Atlantic meridional overturning circulation (AMOC) in NorESM1-F is improved greatly and is much more realistic in comparison with NorESM1-M. This is a very encouraging improvement. As getting a realistic AMOC is often a difficult task in climate modeling, and to my knowledge, it is also a long standing problem in NorESM models. It is thus worth to discuss which model developments lead to such an achievement. This is potentially important for future model development. **Minor comments** – Page 2, line 32-32: What is the vertical resolution of the atmosphere and ocean component of the NorESM1-F? It is not mentioned in the manuscript. These can be state here, where the horizontal resolutions are given. – Page 2, line 34-35: do you really ran the model configured with the biogeochemistry using less cores than the model with the biogeochemistry deactivated? This doesn't sound logic to me. – Page 4, line 23: here “thus” should be “that”? – Page 10, line 23: “cleanly” should be “clearly”. – Page 10, line 28: what is AABW stands for? – Page 14, line 28: “the” should be deleted. – Page

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27, figure 6: I suggest to add zero lines in the figures to increase the readability of the figures.

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