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Interactive comment on "Numerical simulations of oceanic oxygen cycling in the FAMOUS Earth-System model: FAMOUS-ES, version 1.0" *by* J. H. T. Williams et al.

Anonymous Referee #1

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Review on " Numerical simulations of oceanic oxygen cycling in the FAMOUS Earth-System model: FAMOUS-ES, version 1.0" by Williams et al.

Summary: Williams et al. describe the implementation of an OCMIP2-type oxygen cycle into the FAMOUS model. The authors show that the FAMOUS model can generally reproduce the observed surface and zonal mean depth distribution of dissolved oxygen. The model, however, overestimates the surface oxygen concentration in the Northern Hemisphere due to a general cold bias, and largely underestimates oxygen concentration in the deep Southern Ocean possibly caused by sluggish Southern Ocean ventilation.

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Evaluation: Oxygen is a sparingly soluble gas, and its scarcity in the ocean affects the welfare and behavior of marine animals in a large fraction of the ocean. Together with changes in nutrient, oxygen is also a useful diagnostic of changing ocean biogeochemistry. Climate models including ocean oxygen cycle are therefore of great value for the scientific community.

The paper provides a nice overview of the implementation of the oxygen cycle and the strengths and weaknesses of the FAMOUS model in representing steady-state oxygen distributions. The paper is nicely written and easy to follow. The corresponding code is freely available on the website and as such, the manuscript fits well the aim of GMD.

Recommendation: I recommend acceptance of this manuscript after minor to moderate revisions. Five points have to be clarified before acceptance of the manuscript.

Major Comments: 1. Highlight of results in the abstract: I recommend being more specific in the abstract. Please highlight the results. For example, the authors may include in the abstract that the FAMOUS model overestimates surface O2 concentration in the Northern Hemisphere and underestimates deep ocean oxygen concentration in the Southern Hemisphere.

2. Description of the oxygen cycling implementation: Please specify the basis of the equations, include references, and indicate the units of the variables. For example, why did the study use 138/106 as a constant of proportionally between C and O, and not 170/106 as proposed by Anderson and Sarmiento (1994)? In addition, the use of specific abbreviations such as H for Salt or S for the Schmidt number are unusual. It would be good to follow the same standard abbreviations as used in the OCMIP-2 protocols.

3. Adding an experimental design/model description paragraph to section 2: I recommend adding a paragraph in section 2 that describes the experimental setup in detail. How long was the model run? Do the figures represent equilibrated quantities? What are the atmospheric boundary conditions: Preindustrial or present-day? Etc.

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The authors may also move the small paragraph describing the resolution of the models to this new section as it currently does not well fit the validation section.

4. Use of observational-based oxygen data: The authors use surface oxygen concentration data from Helm et al. 2011. Why haven't the authors chosen the gridded oxygen data based on the World Ocean Atlas 2009 (Garcia et al. 2010), which would cover the entire surface ocean?

5. Discussion of implications of model biases for simulations of past and future climate: It would be great if the authors can add a paragraph to the discussion section outlining possible implications of the relatively large Southern Ocean oxygen biases for simulations of past and future climate change. Does the model represent O2 concentration well enough for studying oxygen changes over different timescales? What are the weaknesses/strengths?

Specific comments: p. 1454: l.11-12: This sentence is not relevant for the abstract and can be deleted. p. 1455: l.1: Does the model include an interactive land and/or ocean carbon cycle? Please specify. p. 1455: l. 7: What do the authors mean with "up to date" models? Please specify. p. 1455: l. 12: There are several recent studies that have looked at changes in oceanic oxygen under future climate change. The authors may add some of the studies: e.g. Bopp et al. 2002 or Frölicher et al. 2009. p. 1456: l. 21: What are the units for T? p. 1457: l. 12: Unclear what 'simulator label' means. p. 1457: l. 8-13: This paragraph is unclear to me. Doesn't the HadCM3 represent relatively well observations? What was the reason to compare earlier FAMOUS versions with HadCM3 and not with observations? Please specify. p. 1458: l. 18-20: Why do the authors take an 1870-1880 SST pattern from Rayner et al. 2003 with low coverage instead of a present-day SST data-set? The overall zonal and meridional gradients are similar between present-day and preindustrial and differences between present-day and preindustrial SST shouldn't be an issue for this kind of comparison. p. 1459: l. 16: What's the motivation behind the use of a 2°C threshold? Please specify. p. 1460: l. 4-6: You may add AOU patterns here. AOU may help to further explain the simulated

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oxygen biases. p. 1461: l. 12-18: What's the reason for the large NPP overestimation in the equatorial Pacific and Atlantic? Please explain. Table 1 caption: Abbreviation for Atlantic Meridional Overturning is usually AMOC. Table 1 caption: Change to 'Note the lack of an error estimate for Talley et al. (2003)' Table 1: What is the difference between the two Atlantic MOC estimates? Please also specify in the Table caption. Figure 3: Narrow the x-axis range. Reduce it to 150 to 400 umol/l or so, to highlight the important part of the oxygen range. Figure 4: Interestingly, both the HadGEM-ES and FAMOUS largely overestimate O2 concentrations from 0° and 20°N and between 100m and 1500m depth. Any ideas why this might be the case? Figure 8: This figure can be deleted.

References: Anderson et al., 1994: Redfield ratios of remineralization determined by nutrient data analysis, Global Biogeochem. Cycles, 13, 337-349. Bopp et al., 2002: Climate-induced oceanic oxygen fluxes: Implications for the contemporary carbon budget, Global Biogeochem. Cycles, 16(2), 1022. Frölicher et al. 2009, Natural variability and anthropogenic trends in oceanic oxygen in a coupled carbon cycle-climate model, Global Biogeochem. Cycles, 23, GB1003. Garcia, et al., 2010, Dissolved Oxygen, Apparent Oxygen Utilization, and Oxygen Saturation, Government Printing Office, Washington, DC, 344pp.

Interactive comment on Geosci. Model Dev. Discuss., 7, 1453, 2014.