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Interactive comment on "The software architecture of climate models: a graphical comparison of CMIP5 and EMICAR5 configurations" *by* K. Alexander and S. M. Easterbrook

Anonymous Referee #1

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"The software architecture of climate models: a graphical comparison of CMIP5 and EMICAR5 configurations" investigates six CMIP5 model configurations and two EMICAR5 configurations. The paper is based on ideas presented by the authors at the AGU conference in 2011. The authors introduce a set of diagrams to visualise the dependencies between model components in the selected Earth system models. All contributing model versions are analysed following the same principles which allows for an immediate intercomparison of software architecture. The additional information about the relative size in terms of source code of the different model model components makes these 8 diagrams a felicitous representation of the general software design. The idea is worth to be published and the diagrams have the potential to become a standard ingredient for every model description paper. Some statements made by the authors require some more proof (for details see below). Some paragraphs would benefit from being rewritten as the reasoning and relevance for this paper is not obvious. Conclusions are too vague.

Specific comments

P354, l 16ff: Many individual modelling groups have tried to find simple graphical representations of their own code (HadGEM2-ES see Fig 3 in Collins et al., 2011, MPI-ESM-LR see Fig. 1 in Giorgetta et al., 2012, for CESM1 see Fig 2 in Hurrell et al., 2013). Are these in your terminology examples of Bretherton diagrams? It needs to be worked out more clearly what modelling groups have done so far and why the approach taken by the authors is a better one (standardised view, provides relevant information rather than dressed up pictures). Already from the three examples provided above one may guess that some figures are more self-explanatory than others in terms of architectural design.

P 354,l 20: some reference could be added to explain what a Bretherton diagram is: Figure 2b in Earth System Science Overview: A Program for Global Change, NASA Advisory Council. Earth System Sciences Committee, 1986?

P 354, l 25: I claim that models can be architecturally similar but be still divers in terms of geoscience aspects. HadGEM2-ES, IPSL-CM5A-LR, and MPI-ESM-LR are very similar in architecture but still quite divers in terms of science as they do not share many (if any) components. See also my comment for P364, l2 ff.

P 354, l 27 ff: While the authors put forward geoscientific arguments in the previous paragraphs, here they make a short detour into the development of coupler software. While there is nothing wrong about the idea of sharing and reusing model infrastructure (not only for coupling) I do not see the relevance of this statement for this paper. Using coupler A versus coupler B does not have a direct impact on the quality of science that we get out of an Earth system model. I understand Randall (2011) the way that he is

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addressing the coupling algorithms but not coupling software.

P 355, l 9 ff: As already stated in the introduction I appreciate the way how the authors address the general architecture of a given Earth system model, and I have no objection against the statement made in the last sentence of this para, the demand for a comparative analysis. However, I cannot follow the logics that lead to this statement. The text raises the expectation that the authors will now present a top-down analysis, but then the authors only present a top analysis and do not go down deep into the code as it would be necessary for an investigation, comparison and revision e.g. of a coupling algorithm (not coupling software).

P 355, l 23: Selection criteria are missing. Why do the authors select those six out of 45 model configurations, why three models from a single country (USA) but none from Asia or Australia?

P 359, l 26: If components share the same grid the nesting of those components is probably also more efficient performance wise (as MPI messages are saved) and it eliminates the problem of load balancing between those nested components or enhances the problem of load balancing as there is less freedom in distributing processes.

P 361, l 15ff: Line count may correlate with code complexity. But I can have numerous physical or dynamical processes implemented in my model code like different advection schemes or radiation code while only one scheme is selected via Fortran-if at run time. The software stack can become incredibly complex (even after the preprocessing step) while the really active model code can still remain remarkably simple. Can the authors comment on this? Is the finding of Herraiz et al. (2007) applicable to Earth system model code?

P362, l 1 ff: What is the knowledge we gain from this paragraph. The more source code a component has the more complex it is? What is the benefit of including poorly understood processes? Does a more complex model deliver a better climate? Is there any insight this analysis can provide about scientific quality of model components, model systems and model results?

P 363, l 20 ff: The logics of this paragraph is not clear to me. It starts with “organized collaborations between institutions”, moves to the OASIS coupler which is built in Toulouse (at CERFACS, to my knowledge with only financial support by CNRS). Is this really a good example for a multi-institutional effort? MPI-ESM-LR is given as an example which uses OASIS. HadGEM(2-ES) is highlighted as a model which “consists almost entirely of in-house components (except for the UKCA atmospheric chemistry)”. How does this compare to the MPI-ESM-LR whose components are almost entirely developed in-house but for the coupler? The message (if any) of this paragraph is more confusing than helpful.

P 364, l 16: The factor of 20 one probably gets when comparing EMICs with a full ESM? Is this a fair comparison? A simple box model is likely to be even smaller. But what is the message here, that adding more processes to the model system increases the number of lines of code? Hm.

P 364, l 20: The authors state that similarities in architecture lead to a similarity in the simulated climate. I cannot deduce such from Masson and Kutti (2011). On the contrary, IPSL-CM5A-LR and MPI-ESM are similar in architecture but differ in the simulated climate. Can the authors give some evidence for their believe and hypothesis?

P 365, l 2 ff: Even though the diagrams do help very much to get an overview of the general design (which is useful and helpful) I am not convinced that the diagrams help to understand the inner workings of climate models. Statements made by the authors are perfectly right. Then the authors speculate about potential usage of their approach. At conferences the authors have communicated their idea about how to visualise those internal structures of Earth system models for some years now. Thus, I would have been glad to read about concrete examples where their approach has already brought some light into the dark mystery of source code and how this has already helped climate scientists to understand each others source code.

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P 366 Appendix: Could the list be completed with links to all models? A reference for each Earth system model would be helpful if one wants to learn more about the inner workings of the respective models.

Technical remarks:

p360, l 17: . . . the the . . .

additional citations:

Collins et al. (2011): Development and evaluation of an Earth-System model – HadGEM2, Geosci. Model Dev., 4, 1051-1075, doi:10.5194/gmd-4-1051-2011.

Giorgetta, M. A., et al. (2013), Climate and carbon cycle changes from 1850 to 2100 in MPI-ESM simulations for the Coupled Model Intercomparison Project phase 5, J. Adv. Model. Earth Syst., 5, 572–597, doi:10.1002/jame.20038.

Hurrell et al., 2013: The Community Earth System Model: A Framework for Collaborative Research. Bull. Amer. Meteor. Soc., 94, 1339–1360. doi: http://dx.doi.org/10.1175/BAMS-D-12-00121.1

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