Earth System
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Interactive comment on "Climate model emulation in an integrated assessment framework: a case study for mitigation policies in the electricity sector" *by* A. M. Foley et al.

Anonymous Referee #1

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GENERAL COMMENTS This paper discusses an important topic relevant to Earth System Dynamics, that is the relationship between global greenhouse gas emissions and global warming and the potential for humans to mitigate that warming. It presents a novel tool for examining this relationship suitable for use in integrated assessment models (IAMs). Whilst high complexity, high resolution climate models have examined this relationship, IAMs are required to actually explore the outcomes of potential policy interventions, since these types of climate models are computationally extremely expensive. For this reason, simpler mechanistic climate models are often used in IAMs. These suffer from the drawback that they many not represent processes such as feedbacks and non-linear dynamics as well as the complex models. Statistical emulators of

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complex models can provide a solution to this drawback, and this paper is one of the first to demonstrate the use of such an emulator, capable of better representing this type of dynamics, in an IAM. This IAM is created by coupling the emulator to an economic model, which is then run to provide an illustration of its use. The paper therefore presents a novel tool. The scientific methods and assumptions are valid and certainly clearly outlined. The results are sufficient to support the conclusions. The description of the method is unusually clear and the authors have done a very good job of explaining their mathematical methods to those not familiar with this particular tradition of mathematics. [However, fellow scientists could not of course reproduce the results without access to the codes, several of which have been published elsewhere, but given the code they would be able to do so]. The presentation and structure are very clear, the language is fluent, mathematical symbols, formulae and abbreviations are correctly defined and used, and the paper is easy to read. I don't recommend that any parts of the paper should be reduced, combined or eliminated. The results are novel in that new results from the IAM created by linking the GENIE_em and PLASIM_ENTSem models with the E3MG_FTT model are presented, focusing on the role of the electricity sector only in climate change mitigation: most published studies consider all sectors together, so this research is novel. Whilst the paper places its methods in the context of other literature, highlighting why this new research is needed, the paper does fail to adequately place its conclusions (i.e. the finding of the use of this much needed new method) in the context of the larger body of literature on mitigation. Below, suggestions are made about how to approach that. I believe that this can easily be rectified and therefore recommend the paper for publication. The title and the abstract clearly reflect the content of the paper, but the abstract needs to be modified to incorporate a statement or two to put the conclusions in the context of other literature (i.e. to reflect my suggested amendments below). The supplementary information describes the modelling of the economic and technological substitution processes. The description is of good quality, clear and correctly cited. It is appropriate that this material appears here. SPECIFIC COMMENTS In section 3.1 where the PLASIM_ENTSem is discussed, it

would be useful to know how the relationship between CO2 concentrations and global temperature rise compares with the CMIP5 simulations reported in IPCC AR5 WGI The Physical Science Basis (IPCC 2013). The earlier part of the paper demonstrates that the relationship between emissions and concentrations is very similar to that of the relationships found in VanVuuren et al. 2011. Hence it would useful also to have this analogous information about PLASIM_ENTSem. In section 3.2, at the end on page 1291 the authors need to provide information about the baseline scenario in the main text – in particular whether its emissions are similar to those which others have published as consistent with RCP8.5, or are they higher or lower? Do they grow more/less rapidly at different times during the 21st century? When it comes to the results, text making comparison of the trends in CO2 concentrations and temperatures with the RCPs would be useful – so that one can relate the outcomes of the scenarios being explored to these. In the conclusion, the authors need to put their results in context of existing work on mitigation policy by: - detailing the latest IPCC AR5 figures estimating the contribution that the electricity sector makes to the total CO2 emissions; and also the total GHG emissions. This is a key factor in assessing the significance or otherwise of the results in terms of global mitigation policy considerations and in determining the extent to which these results might suggest more pessimistic outcomes for mitigation (in terms of reducing warming) than IPCC AR5 WGIII (IPCC 2014, Mitigation of Climate Change). - discussing how their results compare with the IAM model ensemble database of IPCC AR5 WGIII. These are mainly outputs of IAMs which use simple climate model emulators, MAGICC6 or others. Obviously the IAM database mitigation scenarios represent mitigation in many sectors not just the electricity sector, but comparison could still be made in terms of the level of GtC removed, to see if the relationship between emissions, concentration and temperature in the WGIII database differs from that in this paper. It would be useful to specify precisely which feedback mechanism is responsible for the difference. - making a comparison with the level of decarbonisation in the electricity sector in the IPCC AR5 WGIII database: are you simulating similar levels of decarbonisation by similar to dates to many of these scenarios,

or do your scenarios examine greater rates of decarbonisation than are explored in this database? - if a rigorous comparison with the database is extremely time consuming and thus beyond the scope of the paper, statements along these lines could instead be made by making approximations based on reading from Figures in the IPCC AR5 assessment report, and by expert judgement. - please make clearer if the policy relevance of the paper lies rather in pointing out the inadequacy of policies that focus on the electricity sector alone in reaching the 2C target; rather than in suggesting that mitigation policy will be less effective than as stated in IPCC 2014 because of the inclusion of non-linear dynamics that the IAMs underpinning the database don't include. It would be very helpful to understand which of these points you are trying to make - either or both. - It would be useful to add some background about whether there is some possibility or not that real world policies might be in danger of focusing on the electricity sector whilst leaving the other sectors to their own devices. You could discuss whether mitigation in this sector cheaper than in the other sectors for example.

Detailed comments Page 1285 lines 5-7 Note that the RCPs are not emission scenarios but concentration pathways – suggest that you edit the the phrase 'RCP emission scenarios' to read 'emissions consistent with the RCP pathways that are reported in VanVuuren et al 2011' or similar. Page 1285 lines 6-7 and 14-16 Justify the choice of values for E1, E2 and E3 – how do I go from Moss et all or Van Vuuren et al. to derive these? Similarly for R1, R2, R3. Page 1287 lines 1-9. Link this to the IPCC AR5 treatment of uncertainty in the terrestrial carbon sink, as Holden et al 2013a presumably is not based on IPCC AR5? Page 1288 lines 5-10. Should there be illustrations or tables to support statements about how the simulated ensemble mean and the emulated ensemble mean compare in section 2.5 in the SM? Page 1288-9. Impressive performance of the emulator! Page 1289 lines 6-20. I very much like the explanation of the discrepancy for RCP2.6 Page 1291 line 4. Please detail the baseline assumptions here and how does the scenario compare with other analysts' emissions for RCP8.5? Page 1292 line 11. This paragraph refers to 'the' mitigation scenario – aren't there several? In which is there 90% decarbonisation? Page 1295. Line 5 suggest insert

'86' before 'ensemble members' to clarify Page 1295 line 23. Suggest reword. The statistical performance of the pattern scaling seems to be generally quite good really, so I would rephrase this to say that assumptions of pattern scaling may perform less well, rather than saying 'especially likely to break down', or say what % error you think there might be that your method can improve upon. Page 1296. See my comments about what is missing from the conclusion. If the journal allows you may want to insert a separate discussion prior to the conclusion where this comparison is made.

Please note that in previewing this document I noticed that all the formatting is lost once it is uploaded to the website, so I am attaching the same document as a pdf so that it is easier to read.

Please also note the supplement to this comment:
http://www.earth-syst-dynam-discuss.net/6/C501/2015/esdd-6-C501-2015-supplement.pdf

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