Final Author response to Interactive comments on "Coupled Climate–Economy–Biosphere (CoCEB) model – Part 1: Abatement share and investment in low-carbon technologies" *by* K. B. Z. Ogutu et al.

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We thank the two Referees for their constructive comments and respond to them herewith. In the following, each referee's comments are in italics, our responses are in Roman, and the changes to be made in the manuscript are in bold. Unless otherwise stated, sections, equations, figures, page numbers, and line numbers referred to are those of the original manuscript.

Referees #1:

1. *The paper is unclear about the main innovation and the main new findings. The paper states: "Figure 1e is the key result" (p. 838. L. 4). However, this is a well published and also seems to be an intuitively obvious effect. Abatement in a DICE type setup causes near-term costs and long-term benefits.*

To remove any ambiguity, the abstract is rewritten as:

The Coupled Climate–Economy–Biosphere (CoCEB) model described herein takes an integrated assessment approach to simulating global change. By using an endogenous economic growth module with physical and human capital accumulation, this paper considers the sustainability of economic growth, as economic activity intensifies greenhouse gas emissions that in turn cause economic damage due to climate change. Different types of fossil fuels and different technologies produce different volumes of carbon dioxide in combustion. The shares of different fuels and their future evolution are not known. We assume that the dynamics of hydrocarbon-based energy share and their replacement with renewable energy sources in the global energy balance can be modeled into the 21st century by use of logistic functions. Various climate change mitigation policy measures are considered. While many integrated assessment models treat abatement costs merely as an unproductive loss of income, **CoCEB innovates in (i) making emissions depend on economic growth; and (ii) treating investment in abatement not as a pure loss but as a way to increase the overall energy efficiency of the economy and decrease the overall carbon intensity of the energy system.** The paper shows that **mitigation costs do slow down economic growth over the next few decades, but only up to the mid-21st century or even earlier, while this growth reduction is compensated later on by having avoided negative impacts of climate change on the economy.**

Also we rewrite the paragraph in lines 23-29 on page 824 as:

Various climate change mitigation policy measures have been considered heretofore. Many IAMs, though, treat abatement costs merely as an unproductive loss of income (e.g. Nordhaus and Boyer, 2000; Nordhaus, 2007, 2008, 2010, 2013b; see also Stoknes, 2015, p. 59). Our CoCEB model innovates in (i) making emissions depend on economic growth; and (ii) treating investment in abatement not as a pure loss but as a way to increase the overall energy efficiency of the economy and decrease the overall carbon intensity of the energy system.

As will be shown below, the paper's main result is that, over the next few decades, up to or even earlier than the mid-21st century, mitigation costs do interfere with economic growth, but that this growth reduction is compensated later on by having avoided negative impacts of climate change on the economy; see also Stern (2007, p. 35, Fig. 2.3), Guest (2010, Fig. 1) and Kovalevsky and Hasselmann (2014, Fig. 2). This result, as shown in the sensitivity analysis of Section 4.1, is due to an increase with time in climate-related damages (see also, Ackerman et al., 2009) that in turn has the effect of anticipating the crossover time, i.e. the time at which the abatement-related costs start paying off in terms of increased per capita gross domestic product (GDP) growth.

This result calls for urgent, all-inclusive local and global solutions to the climate change challenge (see also, Stoknes, 2015, Ch. 8). Such a now-and-not-later conclusion contradicts, for example that of the DICE model, in which abatement benefits are realized way beyond the year 2100, due to low climate-related damages (Kaufmann, 1997;

Nordhaus and Boyer, 2000; Greiner, 2004; Greiner and Semmler, 2008, p. 68; Ackerman et al., 2009; Stoknes, 2015, p. 62). Analyses based on DICE and similar models usually call, therefore, for less immediate solutions to the challenge of climate change (Kaufmann, 1997; Stoknes, 2015, p. 62).

Also line 4, p. 838 is rewritten as: **Figure 1*e* is a key result of our study: …**

In the sensitivity analysis Section 4.1, p. 840, the following paragraph is inserted:

Considering the damage function of Eq. (20), the choice of $m_1 > 0$ and $\chi > 0$ in the literature is ad hoc and based on "informed guesses" (Peck and Teisberg, 1994). According to these authors, χ is more important than m_1. Because the shape of the damage function varies from linear to cubic, $1 \le \chi \le 3$ (Tol, 1996; see also Tol, 2002; Ackerman et al., 2009) while $0.0022 \le m_1 \le 0.0231$, cf. Roughgarden and Schneider (1999) and Labriet and Loulou (2003).

We modify the values of the parameters m_1 and χ by +50 and –50% from their respective values of $m_1 = 0.0067$ and $\chi = 2.43$ in Tables 1–4 above, **so as to get their ranges into fair agreement with the ones in the literature**, and examine how that affects model results for year 2100. In Table 5 are listed the per annum CO_2 emissions, CO_2 concentrations, SAT, damages, and growth rate of per capita GDP. All parameter values are as in Table 1, including $\alpha_\tau = 1.8$.

Furthermore, the following is added on page 841, after line 4:

We also observe that the 2100 climate change damages before and after abatement range between 1.9–41.6%. Our damage figures thus agree fairly well with those in the literature; see, for instance, Creedy and Guest (2008), Ackerman (2009), and Chen et al. (2012, p. 5; and references therein).

Also, the following references have been added to the Bibliography:

Ackerman, F., Stanton, E. A., Hope, C., and Alberth, S.: Did the Stern Review underestimate US and global climate damages? Energ. Policy, 37, 2717–2721, 2009.

Kaufmann, R. K.: Assessing the DICE model: uncertainty associated with the emission and retention of greenhouse gases, Climatic Change, 35, 435–448, 1997.

Peck, S. C. and Teisberg, T. J.: Optimal carbon emissions trajectories when damages depend on the rate or level of global warming, Climatic Change, 28, 289–314, 1994.

Stoknes, P. E.: What We Think About When We Try Not To Think About Global Warming: Toward a New Psychology of Climate Action, Chelsea Green Publishing, USA, 2015.

Tol, R. S. J.: The damage costs of climate change towards a dynamic representation, Ecol. Econ., 19, 67–90, 1996.

Tol, R. S. J.: Estimates of the damage costs of climate change – Part 2: dynamic estimates, Environ. Resource Econ., 21, 35–160, 2002.

Weinstein, M. P., Turner, R. E., and Ibáñez, C.: The global sustainability transition: it is more than changing light bulbs, Sustainability: Science, Practice, and Policy, 9, 4–15, 2013.

2. *The introduction of the paper sets out to explain limitations of models such as DICE. It then, seemingly, expands the complexity of the considered processes. What is missing is a careful comparison of the new model with the closest approximation (one may assume DICE to be this models) in terms of the number of parameters, the number of equations, the number of decision variables, and the considered processes. Having the code available in an appendix would also simplify the discussion and the ability to reproduce the results.*

In Section 5.2, we replace the first paragraph (page 843, lines 10-19) with the following:

In the decadal time step ran Dynamic Integrated model of Climate and the Economy (DICE), the economic costs associated with addressing and coping with climate warming are quantified by coupling a system of economic equations to an intermediate-complexity climate model. The DICE model makes aggregate regionally-based assessments of the economics of production, investment, consumption, welfare, discount rates, population and rates of technological change (Nordhaus, 2007, pp. 39–41). These economic functions are coupled to functions for atmospheric temperature and climate damage. The decision variables that are available to the world economy are the rate of investment in physical capital and the rate of emissions reductions of GHGs. Given a variable-and-parameter space of order 18 x 65, the model outcome is an optimized trajectory for long-term societal welfare to which policy measures can be compared (Nordhaus and Boyer, 2000, pp. 181–187; Nordhaus, 2008, pp. 205–208; Nordhaus, 2013b, p. 1109; see also Garrett, 2012).

The annual time step ran CoCEB model has a considerably smaller number of variables and parameters — equal to 5 and 38, respectively — and it builds upon previous work on coupled models of global climate–economy interactions, starting from the pioneering work of Nordhaus (1994a), as extended by Greiner (2004) with the inclusion of endogenous growth. Greiner (2004) treated industrial CO_2 emissions as constant over time, while excluding the particular case of no-abatement activities (BAU); in fact, his model only applies for a minimum level of abatement. The present paper takes into account, more generally, emissions that depend on economic growth and vary over time, while including the case of abatement equal to zero, i.e. BAU. To do so, we used logistic functions (Sahal, 1981) in formulating equations for the evolution of energy intensity and carbon intensity of energy throughout the whole 21st century (Akaev, 2012). CoCEB's damage function specification allows abatement benefits to be realized earlier than the mid-21st century as compared to DICE, while the latter shows that abatement benefits are only feasible way beyond the 21st century.

The following paragraph (page 843, lines 20) is also modified as:

The CoCEB model, as developed in this first part of a two-part study, is sufficiently simple as to be transparent, to allow a range of sensitivity analyses, and to be available for a number of further extensions. The current model version analyzes the carbon policy problem in a single-region global model with the aim to understand theoretically the dynamic effects of using the abatement share as a climate change mitigation strategy. To be able to draw more concrete, quantitative policy recommendations is it important to account for regional disparities, an essential development left to future research.

The code can be made available upon request. We would be quite happy to put it on the website if the editors think it is necessary, and in agreement with the journal's policies. We added the following under Acknowledgements (page 845): **The CoCEB model code is available from the authors upon request.**

Also, the following reference has been added to the reference list:

Garrett, T. J.: No way out? The double-bind in seeking global prosperity alongside mitigated climate change, Earth Syst. Dynam., 3, 1–17, doi:10.5194/esd-3-1-2012, 2012.

3. *Several assumptions are difficult to understand. For example, why does only governmental spending on abatement affect production possibilities (p. 828, L. 13)?*

As to why only governmental spending on abatement affects the size of per capita GDP, we note that as economic activity intensifies greenhouse gas emissions that in turn cause economic damage due to climate change; the government in our economy uses resources for abatement activities G_{E} (Eq. 5) that reduce emissions of CO_2. On the one hand, an increase in abatement activities, implying a higher value of the abatement share $\tau_{\mathrm{b}} > 0$, makes the difference $1-\left[\tau\left(1+\tau_{\mathrm{b}}\right)+c\left(1-\tau\right)\right]$ in Eqs. (9) and (10) smaller and hence decreases both production factors: (a) per capita physical capital, and (b) per capita human capital; hence production, in turn, decreases. On the other hand, a reduction in CO_2 emissions, due to the government's spending on abatement activities, lessens the damage to the economy due to climate change and hence improves per capita GDP.

To make things clearer, the above explanation is now inserted to replace the sentence starting in line 12 and ending in line 13 on page 828 in the original manuscript.

4. *The paper contains several claims that are not substantiated by / easily accessible from the provided evidence. Examples include:*

a. Motivation of IAMs (p. 822, L. 25-27).

We tried to make the text clearer and more self contained. Lines 25-29 on page 822 and lines 1-5 on page 823 now read:

Our model explicitly includes the causal links between economic growth and the climate change–related damages via the increase of CO_2 emissions. In particular, the model can show how to alter this relationship by the use of various mitigation measures geared toward reduction of CO_2 emissions (Metz et al., 2007; Hannart et al., 2013). We will use the abatement share to invest in the increase of overall energy efficiency of the economy and decrease of overall carbon intensity of the energy system; see Equation (14) below and Diesendorf (2014, p. 143).

b. Does (UNFCCC, 1992) really call for a two degree C limit? In which article?

No, UNFCCC (1992) doesn't really call for a 2^{o} C limit, however, the framework stated, "The ultimate objective … is to achieve … stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (United Nations, 2009; see also Nordhaus 2013b). At the recommendation of leading world climatologists, in 1996 the European Council made the decision that the "average global temperature of the pre-industrial level should not be exceeded by more than 2^{o} C; therefore, global efforts for restricting or reducing the emissions must be oriented at an atmospheric concentration of CO_2 of no more than 958.5–1171.5 GtC" (Akaev, 2012; see also Rozenberg et al., 2015). The warming limit of 2^{o} C was confirmed by the United Nations in the Declaration adopted at the 2009 United Nations Conference on Climate Change (Copenhagen Summit) (Akaev, 2012; Nordhaus 2013b).

In view of the above, we have changed lines 1-4 on page 839 to:

Now, according to the United Nations Framework Convention on Climate Change (UNFCCC, 2009), the average global SAT should not exceed its pre industrial level by more than 2^o C; see also UNFCCC (1992), European Council (2005), Yakovets et al. (2009), Akaev (2012), Nordhaus (2013b), Kuckshinrichs and Hake (2015, pp. 1 and 289) and Rozenberg et al. (2015). This SAT target means that global efforts to restrict or reduce CO_2 emissions must aim at an atmospheric CO_2 concentration of no more than **958.5–1171.5 GtC (Akaev, 2012); see also Rozenberg et al. (2015).**

We also added the following before the sentence beginning in line 21 on page 839:

see also Held et al. (2009) whose study suggests that stringent mitigation strategies cannot guarantee a very high probability of limiting warming to 2 °C since preindustrial time under current uncertainty about climate sensitivity and climate response time scale.

The following references were also added to the Bibliography:

European Council: Presidency conclusions, European Council, Brussels, 2005.

Held, H., Kriegler, E., Lessmann, K., and Edenhofer, O.: Efficient climate policies under technology and climate uncertainty, Energ. Econ., 31, S50–S61, 2009.

UN – United Nations: Copenhagen Accord, United Nations, New York, 2009.

Kuckshinrichs, W. and Hake, J-F.: Carbon Capture, Storage and Use: Technical, Economic, Environmental and Societal Perspectives, Springer International Publishing, Switzerland, 2015.

Rozenberg, J., Davis, S. J., Narloch, U., and Hallegatte, S.: Climate constraints on the carbon intensity of economic growth, Environ. Res. Lett., 10, 1–9, 2015.

c. Is this really a "win-win situation" (p. 843, L. 4). Figure 1e suggests that current generations may loose something.

Yes, in the longer run, it is a win-win situation in the following sense: subject to the assumption that anthropogenic GHGs are the result of economic activities, one would expect high economic growth to be accompanied by high GHG emissions, that is, you win economic-growth–wise but loose in terms of climate deterioration via emitting more GHGs into the atmosphere. But upon investing in abatement measures, the results (see Figures 1*a* and 1*e*) show that higher annual economic growth rates, on average, of per capita GDP can go hand-in-hand with a decrease in GHG emissions, that is, you win economic-growth–wise and also win by emitting less GHGs into the atmosphere. In other words, "increases in abatement spending yield a win-win situation" means "a rise in abatement activities both reduces greenhouse gas emissions and raises economic growth" (see also, Greiner, 2004; Greiner and Semmler, 2008, pp. 95 and 120). Of course, the result that a win-win situation or double dividend may be observed crucially depends on the specification of the functional relation between the economic damage and climate change; see also Greiner (2004) and Greiner and Semmler (2008, p. 120).

As shown in Table 3, the losses from mitigation in the near future are outweighed by the later gains in averted damage.

Of course mitigation costs do hinder economic growth over the next few decades, up to the mid-21st century, at the latest, but this growth reduction is compensated later on by having avoided negative impacts of climate change on the economy. To the contrary, as the CoCEB model shows, taking no abatement measures to reduce GHGs leads eventually to a slowdown in economic growth implying that future generations will be less able to invest in emissions control or adapt to the detrimental impacts of climate change.

To clarify things, we replaced the sentence starting in line 2 and ending in line 8 on page 843, with the following:

The great flexibility and transparency of the CoCEB model has helped us demonstrate that an increase in the abatement share of investments yields a win-win situation: higher annual economic growth rates, on average, of per capita GDP can go hand-in-hand with a decrease in GHG emissions and, as a consequence, to a decrease in average global SATs and in the ensuing damages; see also Greiner (2004) and Greiner and Semmler (2008, pp. 95 and 120). These results hold when considering the entire transition path from now to 2100, as a whole. Of course, the result that a win-win situation or double dividend may be observed crucially depends on the specification of the functional relation between the economic damage and climate change; see also Greiner (2004) and Greiner and Semmler (2008, p. 120).

5. *What is the logic behind the mapping of the 2 degree target to a single atmospheric CO2 concentration (p. 839)? What about an overshoot?*

Of course, the prudent thing would have been to map the 2^o C target to a given range of atmospheric CO_2 concentrations. However, we got this value of atmospheric CO_2 concentration from Akaev (2012), although he later says that "the specified value of CO_2 concentration in the atmosphere that should not be exceeded became 958.5–1171.5 GtC …" We are thus led to believe that an overshoot of atmospheric CO_2 concentration is not compatible with achieving, eventually, the 2^o C target; instead, the excess global average surface temperatures above pre-industrial would surpass 2^o C for good and trigger, therewith, major Earth instabilities and tipping points; see, for instance, Nordhaus (2003b, pp. 200–204). However, we have not found any scientific evidence in the literature to support this belief (*idem*, p. 200).

To remove any ambiguity in using a single value of atmospheric CO_2 concentration, we modify the text by using the range:

958.5–1171.5 GtC (Akaev, 2012); see also Rozenberg et al. (2015).

6. *The language needs a careful round of editing to address issues with word choices, grammar, and style.*

We have done so, to the best of our ability.

7. *The wording is often ambiguous. For example:*

a. How is a "best approach" defined (p. 824, L. 21)?

To remove any ambiguity, we have rewritten the sentence beginning in line 17 and ending in line 22 on page 824, as:

This shortcoming can be remedied by including endogenous technological change in IAMs either through direct price-induced, **research-and-development–induced**, or **through** learning-induced approaches (see Popp et al., 2010 for details), **but** there is no **agreement** in the climate change mitigation literature **as to which single approach to utilize** (Grubb et al., 2002; Popp et al., 2010**, p. 925**).

b. What does it mean when future values are "not known" (p. 824. L. 2)? Does this not apply to all other projected numbers?

Yes it does. We just chose to repeat this here because it is one of the novelties of our model and it is good, therefore, to emphasize it.

c. What does it mean to "enhance the quality of life for all" (p. 843. L. 2) in the framework of this model?

Indeed, this is too general, thank you. We replaced "enhance the quality of life for all" with "**enhance economic growth and hence wealth**".

8. *The citations are imprecise. For example, on which chapter and page in "(IPCC, 2013)" should the reader look to see the support for the claims on page 837?*

To remove the lack of precision, we rephrased the reference in line 19 on page 837, as: **(IPCC, 2013, p. 23, Table SPM.2)**.

We also inserted in line 25 the following reference: **(IPCC, 2013, p. 27, Table SPM.3)**

9. *What is the relevance of the discussion on the "finite-horizon optimal climate change control solution" (p. 843)?*

Like every other model, CoCEB has its own limitations and simplifications. The "finite-horizon optimal climate change control solution" discussion, among other discussions in Subsection 5.2, outlines a possible extension to the CoCEB model to address its current limitations. We modified the text to make this clearer. We took the sentence "The determination of an optimal abatement path along the lines above will be the object of future work." and moved it to the beginning of the paragraph, with the necessary changes. Now the paragraph reads:

The determination of an optimal abatement path being the object of future work, a finite-horizon optimal climate change control solution can be gotten by assuming that the government takes per capita consumption and the annual tax rate as given and sets abatement such that welfare is maximized. **The usual approach to welfare in the macroeconomic literature is to assume it to be given** by the discounted stream of per capita utility times the number of individuals over a finite time horizon**; cf. Nordhaus and Boyer (2000), Nordhaus (2008); see also Greiner et al. (2010) and Maurer et al. (2013) and the references therein.** ….

We also add the following reference in the reference list:

Greiner, A., Gruene, L., and Semmler, W.: Growth and climate change: threshold and multiple equilibria, in: Dynamic Systems, Economic Growth, and the Environment, edited by: Crespo Cuaresma, J, Palokangas, T., and Tarasyev, A., Springer, New York, USA, pp. 63–78, 2010.

Referees #2:

The climate module

I am not an expert on climate models, but it appears to me that the authors should seriously consider to use a more recent version. For example, the carbon cycle comprises the parameter β_2 *that equals 0.49. This means that 51% of all emissions in a year are immediately removed and do not contribute to the accumulation of carbon in the atmosphere. This problem has been discussed with respect to the DICE model in the literature (Kaufmann, 1997).*

We appreciate the reviewer's concerns and presume that by suggesting that we use "a more recent version of the climate model", s/he means "a more detailed version", for example, replacing the carbon cycle in Eq. (2) with three equations where a three-reservoir model is calibrated to current scientific carbon-cycle models, as in Nordhaus and Boyer (2000) or using a pulse response function, i.e. a Green's function (e.g., Hasselmann et al., 1996; Joos et al., 1996; Siegenthaler and Oeschger, 1978), or utilizing a time- or, more generally, a state-dependent rate of carbon removal (Traeger, 2014). Of course, doing so might mitigate the possibility that our model's solutions, like those of the original DICE (see Nordhaus, 1994), understate carbon retention because a constant decay of atmospheric excess carbon is assumed. The reviewer's concerns suggest a worthwhile line of future work.

However, the DICE model – and hence the CoCEB model – is a typical climate–economic model where the essence of particular relationships is examined to try to further the understanding of key elements within a complex and interrelated environment. The DICE model interacts with the economy through only one variable, temperature. Therefore, a complex model that provides dynamic estimates for carbon-dioxide is not needed; see Hof et al. (2012) for a summary of the various representation of the carbon cycle in IAMs. In any case the climate module of the DICE model is calibrated against a more complex climate model and follows the results of the more complex model very closely (Nordhaus and Boyer, 2000; see also Sanderson, 2002).

In our case, a more detailed representation of the carbon-cycle, akin to the three-reservoir model used by Nordhaus and Boyer (2000) (see also, Van Vuuren et al., 2011; Glotter et al., 2014 and the references therein), would not allow the coupling of biomass and the related exchanges of CO_2 into the climate model as done in paper 2 (see Ogutu et al., 2015).

Furthermore, Hof et al. (2012) showed that in the longer term, beyond 2100, most IAM parameterizations of the carbon cycle imply lower CO_2 concentrations compared to a model that captures IPCC Fourth Assessment Report (AR4) knowledge more closely, e.g. the carbon-cycle climate Model for the Assessment of Greenhouse-gas Induced Climate Change (MAGICC) 6. This result of Hof et al. (2012) combined with the fact that in this study we confine our investigations to the transition path for the next 110 years from the baseline year 1990 renders our results useful (see also, Gerlagh and Van der Zwaan, 2003; Traeger, 2014).

We have therefore added the following sentence before line 12 on page 826:

There is some discussion on the representation of the carbon cycle in IAMs (see Hasselmann et al., 1996; Janssen, 1996; Joos et al., 1996; Kaufmann, 1997; Siegenthaler and Oeschger, 1978; Nordhaus and Boyer, 2000; Van Vuuren et al., 2011; Hof et al., 2012; Glotter, et al., 2014; Traeger, 2014).

The following references are also added in the reference list:

Glotter, M. J., Pierrehumbert, R. T., Elliott, J. W., Matteson, N. J., and Moyer, E. J.: A simple carbon cycle representation for economic and policy analyses, Climatic Change, 126, 319–335, 2014.

Hasselmann, K., Hasselmann, S., Giering, R., Ocana, V., and Van Storch, H.: Optimization of CO_2 emissions using coupled integral climate response and simplified cost models: a sensitivity study, Max-Planck Institut für Meteorologie, Report No 192, Hamburg Germany, 1996.

Hof, A. F., Hope, C. W., Jason, L., Mastrandrea, M. D., Malte, M., and Van Vuuren D. P.: The benefits of climate change mitigation in integrated assessment models: the role of the carbon cycle and climate component, Climatic Change 113, 897–917, 2012.

Janssen, M. A.: Meeting Targets: Tools to Support Integrated Assessment Modelling of Global Change, Cip-Genevens Koninklijke Bibliotheek, Den Haag, 1996.

Joos, F., Bruno, M., Fink, R., Stocker, T. F., Siegenthaler, U., LeQuere, C., and Sarmiento, J. L.: An efficient and accurate representation of complex oceanic and biospheric models of anthropogenic carbon uptake, Tellus B, 48, 397-417, 1996.

Siegenthaler, U. and Oeschger, H.: Predicting future atmospheric carbon dioxide levels, Science, 199, 388–395, 1978.

Traeger, C. P.: A 4-Stated DICE: quantitatively addressing uncertainty effects in climate change, Environ. Resource Econ., 59:1–37, 2014.

Van Vuuren, D. P., Lowe, J., Stehfest, E., Gohar, L., Hof, A., Hope, C., Warren, R., Meinshausen, M., and Plattner, G.: How well do integrated assessment models simulate climate change? Climatic Change, 104, 255–285, 2011.

Now, according to IPCC, β_2 = 0.49 for the time period 1990 to 1999 for CO_2 emissions (IPCC, 2001, p. 39). Furthermore, the fraction of carbon dioxide found in the atmosphere is currently around 50% of the total anthropogenic emissions, with a slight upward trend (Raupach et al., 2008; Hüsler and Sornette, 2014). We therefore strongly feel β_2 = 0.49 is reasonable to use in our case (see also, Greiner and Semmler, 2008, p. 62).

We have also added the following references after line 21 on page 826:

(see IPCC, 2001, p. 39; Greiner and Semmler, 2008, p. 62; Raupach et al., 2008; Hüsler and Sornette, 2014)

The following references have been added to the Bibliography:

Hüsler, A. D. and Sornette, D.: Human population and atmospheric carbon dioxide growth dynamics: Diagnostics for the future, Eur. Phys. J. Special Topics, 223, 2065–2085, doi:10.1140/epjst/e2014-02250-7, 2014.

Raupach, M. R., Canadell, J. G., and Le Quéré, C.: Anthropogenic and biophysical contributions to increasing atmospheric CO_2 growth rate and airborne fraction, Biogeosciences Discussions, 5, 2867–2896, 2008.

The economic module

The economic module deviates from the original DICE model because (i) it assumes a fixed savings, (ii) technological progress in form of increasing human capital H is an externality that depends on investments into macro-economic capital and (iii) abatement activities are a government activity that is financed from income tax that is fixed share of individual incomes. The variable parameter is the share τ_b of the tax revenue that is allocated to abatement activities. This is the policy parameter. It is worth to mention that the model does not consider carbon pricing (e.g. via a tax on emissions). It is also worth to mention that the macroeconomic production function only considers per capita capital and per capita human capital as inputs. Note that the present model, like DICE, does not consider energy as an input to the production function. This is a common assumption in models that have a focus on the energy sector.

The CoCEB model is a highly simplified representation of the complex climate and economic realities. One example of simplification is the use of a constant global tax rate and thus ignores the structure of the tax system. This is particularly important for energy and capital taxes, which have large effects on energy use and on the rates of return used in making long-term decisions in the energy sector. The structure of tax systems is particularly important for estimation of the optimal level of carbon pricing or taxation because of the need to consider the interaction of carbon pricing with the structure of pre-existing tax and regulatory distortions; see, in particular, the several important studies collected in Goulder, 2002; see also Nordhaus, 2013b).

The purpose of the CoCEB model, as clearly stated in Section 1 and Section 5.1, is not to exactly replicate real-world processes, but to provide overall insights into the effect of abatement policies or their absence on economic welfare and climate preservation. Hence we feel that the greater detail needed to capture the international and sectoral reactions to changes, say in tax policies, would not contribute much to achieving this paper's purpose.

We thank the reviewer for his/her observations and good advice; we have added the following after line 11 on page 828:

Our model's macroeconomic production function only considers per capita physical capital and per capita human capital as inputs, and like in the DICE model, does not consider energy as an input to the production function. It is also worth to note that the CoCEB model does not consider carbon pricing (e.g. via a tax on emissions).

Equation 8 describes the population growth rate. Equation 18 describes the population development. What is the relationship between Equation 8 and 18 , and why are these two equations not treated together?

The human population growth rate *n* as given in Eq. (8) does not depend on human population size *L*, which is exogenous. However the evolution of human population is precomputed using Eqs. (18) and (8). As for treating them together, *n* is introduced first because it is used in the per capita physical capital Eq. (7) and in subsequent equations, while *L* is only used later in getting per capita GDP from aggregate GDP; see line 10–15 on page 829 of the original manuscript.

Emissions module

The paper basically builds on the Kaya identity. The approach is to use logistic curves that mimic the introduction of non-fossil technologies as well as changes in the carbon intensity of the fossil fuels in order to derive the relevant CO_2 emissions. It appears to me that his dynamic is driven fully time driven. However, the authors say that emissions depend on τ_b, but I was not able to find it in the equations of this section. Therefore, the reader is left with some confusion. It seems to me that the authors have introduced simply another way to calibrate and tune the *trajectory for the emissions per unit of GDP. The development of this parameter seems to be completely time driven.*

The abatement share τ_b is the ratio of abatement spending to the tax revenue, cf. Eq. (5), and it is used here as a policy tool. This share is used in the energy intensity e_c, cf. Eq. (13); the carbon intensity of energy c_c, cf. Eq. (14); the carbon intensity σ, cf. Eq. (15); and the de-carbonization of the economy (Eq. 16). The abatement share τ_b enters into all of these equations via the parameter $\psi = \psi_0 \left[1/\left(1 - \alpha_\tau \tau_b\right) \right]$, where $\alpha_\tau > 0$ is an abatement efficiency parameter. By considering various values of the abatement share, τ_b, the overall energy efficiency of the economy increases and the overall carbon intensity of the energy system decreases depending on whether the abatement share is increasing, say from $\tau_b = 0$ to 0.145.

To remove any confusion on the reader's part, we have rearranged line 19 on p. 830 so that the parameter $\psi = \psi_0 \left[1/\left(1 - \alpha_\tau \tau_b\right) \right]$ is now labeled as Eq. (14) and the numbering of the subsequent equations has been modified accordingly.

Of course, as the reviewer rightly observes, the de-carbonization of the economy, i.e. the declining growth rate of the carbon intensity σ in Eq. (16), apart from its depending on the specific value of the abatement share τ_b, is also assumed to be time-dependent, to be able to account for a gradual de-carbonization process. Fossil-fuel consumption has been subject to such a process since the early times of industrialization, by a transition—in chronological order—from the use of wood to coal, from coal to oil, and in the most recent past from coal and oil to natural gas (see also, Gerlagh and Van der Zwaan, 2003).

We captured this observation after line 13 on page 831.

The following references have been added to the Bibliography:

Gerlagh, R. and Van der Zwaan, B.: Gross world product and consumption in a global warming model with endogenous technological change, Resour. Energ. Econ., 25, 35–57, 2003.

Abatement share

It appears to me that the relationship between the costs (percentage reduction of BAU GDP) and the emission reduction (percent deviation from BAU) is quite similar to what Nordhaus did. The calibration is done given a broad range of studies summarized by IPCC. However, it is not clear what they really did. Also it is not clear to me what the trigger for the choice of the abatement activity (climate policy) is. I guess that it is simply set exogenously.

Our choice of the abatement share, which is the key policy tool in our CoCEB model, was explained already in the original version of the paper, Section 2.6. The remark of the referee points to a lack of clarity on our part. To make things clearer we add the following at the beginning of this section:

In this section, we determine the abatement share, τ_b, which is the ratio of abatement spending to the tax revenue (see Equation 5) and is being used here as a policy tool. The abatement share is used in the de-carbonization of the economy, cf. Eq. (16), through the parameter $\psi = \psi_0 \left[1/\left(1-\alpha_\tau \tau_b\right) \right]$; see also Eq. (14).

Assessment of the model set up

It appears to me that the authors have transformed the DICE model from a CBA analysis tool based on a Ramsey growth model into a policy evaluation tool based on a Solow model with a spill-over from physical investment to human capital formation. This also means that the authors have substituted the endogenous policy by an exogenous one. Moreover, I cannot see where the novelty is that the authors indicate in the title of the paper ("…investment in low-carbon Technologies"). As far as I can understand the model set-up there is no endogenous investment in any particular technology.

The abatement share τ_b is the ratio of abatement spending to the tax revenue, cf. Eq. (5), and it is used here as a policy tool. This share is used in the energy intensity e_c, cf. Eq. (13); the carbon intensity of energy c_c, cf. Eq. (14); the carbon intensity σ, cf. Eq. (15); and the de-carbonization of the economy (Eq. 16). The abatement share τ_b enters into all of these equations via the parameter $\psi = \psi_0 \left[1/\left(1-\alpha_\tau \tau_b\right) \right]$, where $\alpha_\tau > 0$ is an abatement efficiency parameter. By considering various values of the abatement share, τ_b, the overall energy efficiency of the economy increases and the overall carbon intensity of the energy system decreases depending on whether the abatement share is increasing, say from $\tau_b = 0$ to 0.145.

The endogenous growth part would be interesting to analyze in an integrated climate-economy model, if the investment rate can be adjusted, but here the investment rate is given. The point would be to ask whether the direct cost of climate change are smaller or larger than the full economic impact, when the second order effects via the macro-economy are considered.

As the referee observes in the "The economic module" section, abatement activities are a government activity that is financed from income tax that is a fixed share of individual incomes. The *variable* parameter is the abatement share τ_b of the tax revenue that is allocated to abatement activities. This is the policy parameter. As we responded under the "Emissions module" section, we reiterate that by considering various values of the abatement share τ_b in the parameter $\psi = \psi_0 \left[1/\left(1-\alpha_\tau \tau_b\right) \right]$, the overall energy efficiency of the economy increases and the overall carbon intensity of the energy system decreases depending on whether the abatement share is increasing from $\tau_b = 0$ to 0.145.

Now, the per capita abatement costs $G_E = \tau_b X = \tau_b \tau Y$ from Eq. (5) and the damage costs $\left(1-D\right)Y$ from Eq. (19) for the various emission reduction paths are given in Table 3 for the year 2100. From the table we notice that, generally, the more one invests in abatement, the more emissions are reduced relative to baseline and the less the cost of damages from climate change.

Also, I do not understand the reason for having the term Biosphere in the model acronym. I have not found the bio-sphere in the model description.

This article is based on a new integrated assessment model; its structure is extended in a subsequent twin article by the same authors; this article is under consideration by the same journal as ESDD-6-865-2015/esd-2015-14. The term Biosphere as used in the acronym is for the purpose of anticipating the coupling of biomass and the related exchanges of CO_2 into the climate model as done in Paper 2 (see Ogutu et al., 2015). The intent of extending the model, by the inclusion of the "Biosphere", in paper 2 is clearly indicated in line 19 on page 822, line 6 on page 823, and line 1 on page 845. We added a further clarification on p. 3, lines. 85–86 of the revised manuscript, as follows:

The model's biosphere component is added in Part 2. The resulting CoCEB model is still a reduced-complexity model that tries to incorporate the climate–economy–biosphere interactions and feedbacks with the minimum amount of variables and equations needed.

It is true that one could have combined Paper 1 and 2 into a single paper and put much of the technical details into an appendix. However, the results of Paper 1 require merely a simpler version of the model, while for the results of Paper 2 the inclusion of 2 extra equations is needed. Dividing the material into two allows us to keep Paper 1 self-consistent, as well as short and readable; moreover, it only increases the complexity of the model when it is needed, i.e. in Paper 2. Furthermore, we feel that the methodological aspect, i.e. the construction of a simplified model, is one of the main points of this work, and that relegating it to an appendix would fail giving it its due importance.

Results

There are two major problems with the results.

The emission trajectory peaks in 2060 at 48GtC/yr. Starting with CO2 emissions in 2015 of 35GtCO2/yr (which is a high expectation) the implied growth rate is 3.7%/yr. This is very, very *high and has not been observed in the past. Also the emission growth rate is higher than the economic growth rate, which has also not been observed in the past. After the peak the model reverts back to the CO2 emissions of the RCP8.5 scenario by 2100 at emissions below 30GtC/yr. This emission pathway has been assumed to be very high. The authors report the result for 2100, but not for the remarkable peak. They do not give a reason why the baseline emissions trajectory is that high.*

The results presented here should be viewed as only suggestive and illustrative. They come from a single model and modeling perspective, and most of the relationships are subject to large uncertainties (see also, Petersen, 2012; Hannart et al., 2013; Wesselink et al., 2015 and the references therein for an insightful uncertainty assessment). However, we can confidently say that our BAU per annum growth rate of CO_2 emissions by 2050 agrees quite well with the Edmonds and Reilly (1983) study which asserts that the CO_2 emissions growth rate will increase to over 3% per year by 2050 (see also, Kuper, 2011). Actually, it has been noted that the global CO_2 emission rate has not only grown along a "business-as-usual" (BAU) trajectory, but has in fact slightly exceeded it (Raupach et al., 2007; Peters et al., 2013; see also Garrett, 2015), in spite of a series of international accords aimed at achieving the opposite (Nordhaus, 2010).

Our baseline emissions trajectory is assumed to be high because, as Garrett (2012) states, the IPCC Special Report on Emission Scenarios (SRES) — which can be mapped onto the Representative Concentration Pathways (RCPs), cf. Van Vuuren and Carter (2014) — underestimates the energy consumption in economic activities and hence CO_2 emissions; see also Pielke Jr. et al. (2008), Hay (2013, pp. 903–904). Therefore our BAU scenario's energy technology is assumed constant at its 1990 level contrary to the IPCC BAU and similar scenarios which assume two thirds or more built-in emissions reducing technological change; see also Edmonds et al. (2004, p. 77) and Pielke Jr. et al. (2008). Our BAU CO_2 emissions is fairly similar to the scenarios given in the literature; see, for instance, Edmonds et al. (2004, p. 78, Figure 4.1) and Nakićenović (2004, p. 227, Figure 11.1).

Considering Eq. (12) and dividing through by carbon emissions E_Y and on subtracting the per capita GDP growth rate g_Y from both sides, we get

$$\frac{1}{E_Y}\frac{\mathrm{d}E_Y}{\mathrm{d}t} - g_Y = g_\sigma + n + g_{ccs}. \qquad \text{(C.1)}$$

The left-hand side of Eq. (C.1) is positive at the beginning of the 1990–2100 study period, and negative later during this period; this means that g_Y is less than and later greater than the growth rate of E_Y. Actually, the right-hand side of Eq. (C.1) is bounded between -0.0545 and 0.0145. In this study, we assumed 1990 as the time when the use of renewable energy sources (biomass and wastes, hydropower, geothermal energy, wind energy, and solar energy) and biofuels became significant in the global energy balance (GEB). As we responded under the “emissions” section to Reviewer #2, the de-carbonization of the economy — i.e. the declining growth rate of the carbon intensity σ, as seen in Eq. (16) — apart from it depending on the specific value of the abatement share τ_b, is also assumed to be time-dependent, in order to be able to account for a gradual de-carbonization process.

Through the CoCEB model, we were able to demonstrate that an increase in the abatement share of investments yields a win-win situation: higher annual economic growth rates, on average, of per capita GDP can go hand-in-hand with a decrease in carbon emissions (as well as the growth rate of carbon emissions) and, as a consequence, to a decrease in average global SATs and the ensuing damages (see also, Greiner, 2004; Greiner and Semmler, 2008, pp. 95 and 120).

Now, Global fossil fuel CO2 emissions increased by 3.3% yr^{-1} on average during the decade 2000–2009 compared to 1.3% yr^{-1} in the 1990s and 1.9% yr^{-1} in the 1980s (see e.g., Canadell et al., 2007). The global financial crisis in 2008–2009 induced only a short-lived drop in global emissions in 2009 (–0.3%), with the return to high annual growth rates of 5.1% and 3.0% in 2010 and 2011, respectively (IPCC, 2013, p. 489); see also Albanese and Steinberg (1980). Therefore a high CO_2 emissions growth rate— actually higher in comparison to the per capita GDP growth of the same time (see Guest and McDonald, 2007, Table 2; Yakovets et al., 2009, Fig. 8, Tables 2, 10 and 14) — has been observed in the past.

To clarify the issue raised by the reviewer, we add the following paragraph after line 17 on page 838:

We also observe from Figure 1a that the BAU emission trajectory peaks in 2064 at 48.2 $GtCyr^{-1}$ and then reverts back to the CO_2 emissions of the RCP8.5 scenario by 2100, at an emissions level of 29.3 $GtCyr^{-1}$. Our baseline emissions trajectory is assumed to be high

because, as Garrett (2012) states, the IPCC Special Report on Emission Scenarios (SRES) — which can be mapped onto the RCPs, cf. Van Vuuren and Carter (2014) — underestimates the energy consumption in economic activities and hence CO_2 emissions; see also Hay (2013, pp. 903–904). Therefore our BAU scenario's energy technology is assumed constant at its 1990 level contrary to the IPCC BAU and similar scenarios which assume two thirds or more built-in emissions reducing technological change; see also Edmonds et al. (2004, p. 77) and Pielke Jr. et al. (2008). Our BAU CO_2 emissions is fairly similar to the scenarios given in the literature; see, for instance, Edmonds et al. (2004, p. 78, Figure 4.1), Nakićenović (2004, p. 227, Figure 11.1) and Moss et al. (2010, Figure 5b).

We also add the following references in the reference list:

Edmonds, J., Joos, F., Nakićenović, N., Richels, R. G., and Sarmiento, J. L.: Scenarios, Targets, Gaps, and Costs, in: The Global Carbon Cycle: Integrating Humans, Climate, and the Natural World, edited by Field, C. B. and Raupach, M. R., Scientific Committee on Problems of the Environment (SCOPE) 62, Island Press, Paris, France, 2004.

Garrett, T. J.: No way out? The double-bind in seeking global prosperity alongside mitigated climate change, Earth Syst. Dynam., 3, 1–17, doi:10.5194/esd-3-1-2012, 2012.

Hay, W. W.: Experimenting on a Small Planet, Springer Verlag, Berlin, Heidelberg, doi:10.1007/978-3-642-28560-8_5, 2013.

Moss, R. H., Edmonds, J. A., Hibbard, K. A., Manning, M. R., Rose, S K., Van Vuuren, D. P., Carter, T. R., Emori, S., Kainuma, M., Kram, T., Meehl, G. A., Mitchell, J. F. B., Nakićenović, N., Riahi, K., Smith, S. J., Stouffer, R. J., Thomson, A. M., Weyant, J. P., and Wilbanks, T. J.: The next generation of scenarios for climate change research and assessment, Nature, 463, 747–756, doi:10.1038/nature08823, 2010.

Nakićenović, N.: Socioeconomic driving forces of emissions scenarios, in: The Global Carbon Cycle: Integrating Humans, Climate, and the Natural World, edited by Field, C. B.

and Raupach, M. R., Scientific Committee on Problems of the Environment (SCOPE) 62, Island Press, Paris, France, 2004.

Pielke Jr., R. A., Wigley, T., and Green, C.: Dangerous assumptions, Nature, 452, 531–532, 2008.

Van Vuuren, D P. and Carter, T. R..: Climate and socio-economic scenarios for climate change research and assessment: Reconciling the new with the old, Climatic Change, 122, 415–429, doi:10.1007/s10584-013-0974-2, 2014.

Second, 1990 is the year for the model calibration and the first year for the policy analysis. This is a quarter of a century before today. Consequently, there is large variation by the year 2010. This can be seen in the emission trajectories as well is in the economic growth rates. In my opinion this is a flawed result. It is common practice for existing models to use 2005 or 2010 as a calibration year, but not 1990 and then let the model start with deviating results from 1990 onwards.

We don't think that the variation between our BAU and non-BAU scenarios with the RCPs is as large by year 2010 as the referee claims (see Table 4). However the existing variation could be minimal if, as Garrett (2012) states, the SRES scenarios which can be mapped onto the RCPs, did not underestimate the CO_2 emissions.

The primary need and rationale of CoCEB is not to provide the best simulation fit to the truth, but CoCEB is a formal framework in which it is possible to represent in a simple way several components of the coupled system and their interactions. While we strive for CoCEB to be a well performing model, we do not think it is necessary for CoCEB to outperform more complex models (see also, Nordhaus, 2013a, b). The revision version of the manuscript makes this point clearer (see also our first response to referee #1 on the main innovation and the main new findings of CoCEB).

The standard way to evaluate the accuracy of a model is to do hindcasts. The hindcast of the model described here is illustrated in Fig. 1, Table 4 and discussed in Section 3. Effectively the model is initialized with current conditions in 1990 and the hindcast made for the 24 year period between 1990 and 2014. What we show is that the model reproduces fairly well, albeit with little deviations, both the timing and magnitude of observed changes in CO_2 emissions per year and the atmospheric concentrations in the transition path up to year 2100. The implication is that, even though the model that is used is extremely simple, it is nonetheless able to produce accurate enough annual results for CO_2 emissions and concentration, temperature, damage and capita gross domestic product (GDP) growth.

Smaller issues

Page 822, line15: the industrial emissions are assumed constant, but those from fossil fuel combustion are variable right?

The industrial emissions are due to combustion of fossil fuels.

To make things clearer, we add:

Since anthropogenic GHGs are the result of economic activities, the main shortcoming in Greiner's (2004) approach is that of treating industrial CO_2 emissions, **due to combustion of fossil fuels,** as constant over time.

Page 822, line 17: what means "zero abatement activities"? is this zero cost or zero emission? Please clarify.

"Zero abatement activities" mean "a total absence of abatement activities". In fact, in the paper, abatement equal to zero corresponds to Business As Usual (BAU). To clarify things, we write as:

Another problematic aspect of Greiner's emissions formulation is its inability to allow for **a total absence of abatement activities: in** fact, his formulation only holds for a minimum level of abatement.

822, line 25: I guess it is better to substitute analytically by quantitatively.

Lines 25-29 on page 822 and lines 1-5 on page 823 are now rewritten and hopefully more clear:

Our model explicitly includes the causal links between economic growth and the climate change–related damages via the increase of CO_2 emissions. In particular, the model can show how to alter this relationship by the use of various mitigation measures geared toward reduction of CO_2 emissions (Metz et al., 2007; Hannart et al., 2013). We will use the abatement share to invest in the increase of overall energy efficiency of the economy and decrease of overall carbon intensity of the energy system; see Equation (14) below and Diesendorf (2014, p. 143).

Page 833, line 24ff: it is unclear to me how the choice of the parameter χ (the exponent in the damage function in Equation 19) can have any influence on the emissions in the Business as Usual scenario.

The influence of the parameter χ on the per annum CO_2 emissions, CO_2 concentrations, global mean surface air temperature (SAT), damages and growth rate of per capita GDP is well explained in Section 4.1.

We therefore modify the lines 24-27 on page 833 as:

On the other hand, we calibrated the nonlinearity parameter $\chi = 2.43$ so that our model's BAU emissions of $CO_2 yr^{-1}$ and concentrations by 2100 mimic the Representative Concentration Pathway (RCP) 8.5 (Riahi et al., 2007; IPCC, 2013, **p. 27, Table SPM.3); see Sect. 4.1 for details on our calibration of χ.**

822, line 26: IN my perception the term adaptation rather than mitigation is appropriate, if the relationship between climate change and economic growth shall be influenced. Mitigation means to limit climate change to avoid impacts on the economy.

In our understanding the current definitions are the following. Mitigation: consists of actions to reduce emissions and atmospheric concentrations of CO_2 and other greenhouse gases (GHGs); Adaptation: involves learning to cope with a warmer world rather than trying to prevent it; Suffering: adverse impacts that are not avoided by either mitigation or adaptation.

In this paper and in paper 2, we consider the broad range of options available, reducing CO_2 emissions, i.e. for mitigation according to the above definitions. These include: increasing energy efficiency, increasing non-fossil fuel-based energy production, the use of carbon capture and storage (CCS), and deforestation control.

822, line 28ff: I do not understand what it means to use the "abatement share to invest in the increase of overall energy efficiency of the economy and decrease of overall carbon intensity of the energy system". It is simply not clear what abatement share means and how it relates to the investment. To me it seems like a typical allocation problem.

The abatement share τ_b is the ratio of abatement spending to the tax revenue, cf. Eq. (5), and it is used here as a policy tool. This share is used in the energy intensity e_c, cf. Eq. (13); the carbon intensity of energy c_c, cf. Eq. (14); the carbon intensity σ, cf. Eq. (15); and the de-carbonization of the economy (Eq. 16). The abatement share τ_b enters into all of these equations via the parameter $\psi = \psi_0 \left[1/\left(1-\alpha_\tau \tau_b\right) \right]$, where $\alpha_\tau > 0$ is an abatement efficiency parameter. By considering various values of the abatement share, τ_b, the overall energy efficiency of the economy increases and the overall carbon intensity of the energy system decreases depending on whether the abatement share is increasing, say from $\tau_b = 0$ to 0.145.

To make things more clear, we add "**see Equation (14) below**" in the paragraph contained in lines 25-29 on page 822 and lines 1-5 on page 823.

Section 2.3: Section 2.3: the first paragraph can be deleted. It does not really add to the content of the model. It only discusses an approach that is not followed.

Right, we will do exactly that. The following paragraph has been written as:

Here, in order to formulate emissions E_Y so that they may vary over time and to allow abatement to be zero, we specifically utilize the Kaya–Bauer identity (Kaya, 1990; Bauer, 2005) that breaks down CO_2 emissions E_Y (in $GtCyr^{-1}$) into a product of five components: emissions per unit of energy consumed (carbon intensity of energy), energy use per unit of aggregate GDP (energy intensity), per capita GDP, human population, and carbon emission intensity, as shown below:

We finally would like to add the following in the acknowledgements: **We also would like to thank the editor and two anonymous reviewers for constructive comments.**

Once more, we would like to thank the two referees for their thoughtful and critical reviews which have been extremely helpful at refining the manuscript. We are greatly appreciative of the effort that went into it and hope that our answers are satisfying. If there are still things unclear or incomplete, we are happy to receive further comments.

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