Subject: esdd-6-819-2015

The manuscript is based on a model that requires substantial improvements to comply the scientific standards. Therefore, the manuscripts – in its current state – cannot be recommended for publication.

I went through the individual parts of the model introduction and found serious reasons for concern. Also the results are subject to serious problems.

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.[1]

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.

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?

Emissions module

The paper basically builts 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 CO2 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.

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.

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 endogenous growth part would be interesting to analyze in a 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.

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.

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.

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.

Smaller issues

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

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

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

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.

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.

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.

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.

References

1. Kaufmann, R. K. ASSESSING THE DICE MODEL: UNCERTAINTY ASSOCIATED WITH THE EMISSION

    AND RETENTION OF GREENHOUSE GASES. *Clim. Change* **35,** 435–448 (1997).