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WHY DO WE PREFER BELOW 2 DEGREE WARMING WORLD AND HOW DO WE ACT IN THE DIFFERENT CONDITIONS?

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Overview

Since COP21 followed by Paris Agreement, the world agree to set the climate targert of the global average temeprature rise to be less than 2 Celsius degree in the end of this century. Although IPCC-AR5-WG3 states that the economic loss under the 450ppmv stabilization constraint compared to BAU is around 5% in 2100, it ranges from 1.5% to 15% depending on the various model assumptions (IPCC, 2013). It should be also pointed out that the current global climate models still intrinsically include various uncertainties. For instance, the climate sensitivity spreads from 1.5 Celsius degree to 4.5 Celsius degree. Thus, the 2 Celsius degree target fails to determine the concrete GHG emission policy. Conversely we always have to consider the strategies for the cases where the observations stray off the presumptions of the initial climate policies. In this case, one may well raise the following two question: (1) what assumptions do we have when we agree with the two degree warming world, and (2) how should we shift the climate target according to the changes in the presumptions? Many existing studies have focused on the energy strategies including CCS and BECCS under the given GHG emission pathway or GHG concentration scenario. However, the appropriate future behavior changes which are consistent with the 2 Celsius degree target under the different presumptions have not been discusssed.

This study focusing on this point consists of two steps: first, the author expand the integrated assessment model MARIA, Multiregional Approach for Resource and Industry Allocation (Mori, 2013), to represent the 2 Celsius degree target world as BAU as well as the parameters under the certain conditions. Second, through the various sensitivity analysis, extended MARIA shows how the climate target should be modified under the different assumptions. The comparison of economic losses between „flexible target“ and „strict 2 Celcius degree target“ is also shown.

Method

Since the DICE model is developed, the economic loss caused by the climate changes has often been internally formulated in the inter-temporal optimization model(Nordhaus, 1994, 2013). However, the solution which represents the Pareto optimum of cost and benefits policy tends to allow relatively high GHG emission.This study proposes an alternative formulation, where the utility is discounted by the climate changes in addition to the economic losses. The latest version of DICE, DICE-2013R (Nordhaus, 2013), gives near 2.0 Celsius degree solution as BAU when 0.1% per year discount rate (Stern case).

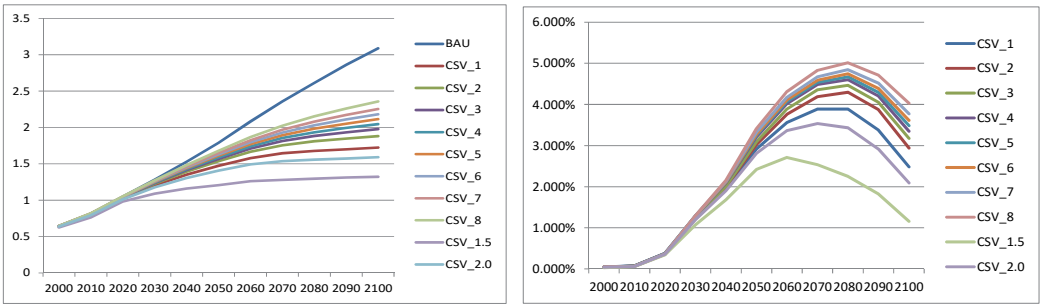
In this study, the author expands the objective utility function of MARIA as follows:

$$U(C,T) = u(C)/\{1+\delta(T)\}, \quad u(C) = L\frac{\left(C/L\right)^{1-\gamma}}{1-\gamma}, \quad \delta(T) = \phi\left(\frac{T-T_0}{T^*-T_0}\right)^{\theta} \qquad \theta = 2,\ T^* = 3.0,\quad T_0 = T_{1990} \qquad (1)$$

Where C, T, T_0 and T^* represent consumption, global atmospheric temperature, initial value of T, and normalized value of T, respectively. Through sensitivity analysis, one can find the ϕ value to represent the 2.0 Celsius degree world as BAU solution.

Results

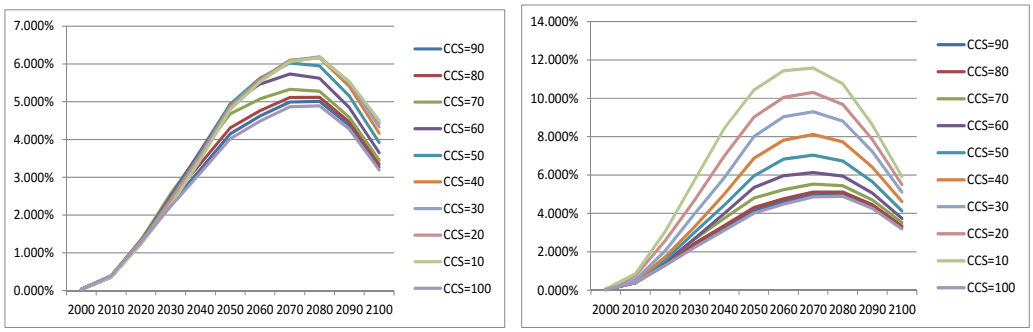
Since MARIA employs economic damage function similar to DICE model, the author set ϕ by changing multiplying factor DM under climate sensitivity (CSV)=3.0. Based on the results, the author employs ϕ =4.5 suggesting that people prefer 2 Celsius degree world when utility loss at 3 degree world is around 6%-7% , energy conservation is optimistic, and 80% of non-carbon GHG radiative forcing can be reduced at 2.5% of GDP. Figure 1 (a) and (b) show how the different climate sensitivity affects the optimal solution. If CSV are different from presumptions, climate target should be adapted in the future.



(a) Atmospheric temperature changes (b) GDP losses from BAU

Figure 1 Atmospheric temperature rise and GDP loss under different climate sensitivity: CSV_1:2.29, CSV_2:2.67, CSV_3:2.94, CSV_4:3.17, CSV_5:3.42, CSV_6:3.67, CSV_7:4.06, CSV_8:4.72. CSV=1.5 and 2.0 are also shown.

Figure 2 exhibits the effects on the economic losses caused by the changes in the availability of carbon capture and storage (CCS), where CCS=xx represents the limit of CCS availability at xx% of optimal implementation.



(a) Without strict 2.0 Celsius degree policy (b) With strict 2.0 Celsius degree policy

Figure 2 GDP loss changes with respect to the carbon capture and storage availability in with and without strict 2 Celsius degree constraint

It should be noted that the atmospheric temperature rise in Figure 2(a), without strict temperature limit, ranges still from 1.98 degree to 2.17 degree, suggesting that the marginal cost to keep 2.0 Celsius degree increases rapidly and sensitive to the assumption changes. Figure 2(a) and (b) also suggest why the IPCC-model comparison results on the economic loss spread broadly.

Conclusion

In this study the author proposes an expansion of existing IAM so as to represent the below 2.0 Celsius degree warming world as BAU. The simulation results demonstrate that (1) in which condition people prefer the 2.0 Celsius degree warming world, and (2) how people would behave when the presumptions change. Needless to say, the above findings are derived from the MARIA model assumptions. The multi model comparison will clarify that to what extent the above observation holds.

Acknowledgement

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