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Integration of climate and economic modeling studies

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So far, there have not been many studies which integrate climate modeling and economic modeling research. The purpose of this presentation is to show one way to integrate climate and economic studies with regard to climate change issues. Here, we present an example of the integration of these two areas, which analyzes socioeconomic impact of achieving a specific radiative forcing level considering the uncertainties of Earth system models using a computable general equilibrium (CGE) model.

Although much uncertainty exists in climate system and simulations of future climate profiles with Earth system models (ESMs), it has not been evaluated in relation to socioeconomic aspects. In this study, we analyze the socioeconomic impact (including that on energy) of three emission pathways, all of which possibly achieve 4.5 W/m^2 of radiative forcing in the year 2100 within uncertainties estimated by an ESM of intermediate complexity (EMIC) tuned for full ESMs using a CGE model, a type of economic models. The model used here is a multi-regional and multi-sectoral recursive dynamic CGE model on a global scale, with energy and environmental components. Thus, the model is also called an integrated assessment model or IAM.

The emission pathways considered in this study are allowable emission pathways obtained by using an EMIC with the Representative Concentration Pathway 4.5 scenario. Here, we analyze the emission pathways of the 5th (lower bound), 50th (mean), and 95th (upper bound) percentiles of the weighted ensemble members in the parameter perturbation experiment. Different pathways are derived from different physical and biogeochemical properties. The global CO_2 emissions in 2100 and the cumulative CO_2 emissions in this century in the upper bound case are 5.1 GtC/yr and 917.6 GtC, while those in the mean case are 3.0 GtC/yr and 764.9 GtC respectively, and those in the lower bound case are 0.91 GtC/yr and 619.7 GtC respectively.

The results indicate that the socioeconomic impacts are larger in the lower bound emission pathway to achieve 4.5 W/m^2 as expected, although the economy and energy demand (both primary and final energy demand) increase continuously in this century. For example, the global gross domestic product (GDP) in each emission pathway is $212 trillion in the lower bound case, $217 trillion in the mean case, and $221 trillion in the upper bound case in 2100 ($30 trillion in 2001), which are 4.2 – 8.1% smaller than that of the reference scenario ($230 trillion in 2100). On the other hand, the global primary energy demand in 2100 in the lower bound case is slightly larger than in the mean case; this can be interpreted because biomass energy with carbon capture and storage technology is enhanced to achieve very low carbon dioxide emissions in the lower bound case. In a comparison between the upper bound and lower bound emission pathways, the carbon price of the latter is approximately three times higher in 2100. The GDP in the latter is 4.1% smaller than that in the former in 2100, which is equivalent to only a 0.042% decrease in the annual GDP growth rate. Thus, the socioeconomic impacts caused by ESM uncertainties, here evaluated by GDP and energy demand, are not insignificant but are smaller than the differences in the emission pathways to achieve 4.5 W/m^2.

Keywords: earth system model, computable general equilibrium model, climate change