SOCIO-ECONOMIC IMPLICATIONS OF CLIMATE STABILIZATION SCENARIOS FROM MIROC EARTH SYSTEM MODEL

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Overview

Stabilization of climate in the long-term requires significant reductions in greenhouse gas (GHG) emissions at global scale. This involves important transformations in the drivers of human-induced GHG emissions, namely energy consumption and production, as well as land use change. Moreover, the cost for achieving climate stabilization may be considerable, thus, requiring an optimal allocation of efforts that minimizes the economic impact (Clarke et al., 2014). This study presents the socio-economic implications of emission scenarios aiming at long-term climate stabilization, estimated with an integrated assessment model (IAM). Emission scenarios are obtained from the earth system model (ESM) Model for Interdisciplinary Research on Climate (MIROC-ESM). The outcomes on supply and demand of energy, land use, and mitigation costs are presented.

Methods

The Global Change Assessment Model (GCAM) is applied to assess emissions scenarios leading to stabilization of global temperatures in the long term (Kim et al., 2006; Clarke et al., 2007). The assessment covers changes in energy, land use and emissions throughout the 21st century. GCAM is an IAM based on a partial equilibrium approach with a detailed representation of the energy, land use and agricultural sectors. The emissions scenarios considered have been obtained from MIROC-ESM, and are consistent with the representative concentration pathways (RCP) that aim at a global radiative forcing by 2100 of around 4.5 W/m^2 (RCP4.5) and 2.6 W/m^2 (RCP2.6) (van Vuuren et al., 2011). Compared to other models, MIROC-ESM has a higher climate sensitivity and a stronger feedback between climate and the carbon cycle, which results in more stringent emission scenarios for a given concentration path (Watanabe et al., 2011).

Results

Achieving an intermediate stabilization target, indicated by the RCP4.5 scenario, required a progressive increase in carbon prices to around 850 USD/tC in 2100. This scenario involved reductions in energy intensity in the first decades, with values up to 10% smaller compared to the Reference case. Also, electricity became more important as it changed from less than 25% of TPES in 2100 in the Reference scenario to around 34% of TPES. The share of fossil fuels decreased to less than 50% of TPES, while renewables grew to 40% of the TPES, and power technologies with CCS covered 30% the electricity mix. Major land use changes were dominated by the expansion of biomass, croplands and forest plantations, over unmanaged lands (mainly arable land, pastures, grasslands and natural forests). Compared to the Reference scenario, expansion of land for bioenergy crops and food was larger, while the area of pastures and natural forests decreased considerably in the long-term. The achievement of an ambitious target, indicated by the RCP2.6 scenario, increased mitigation costs sharply, especially in the first half of the century. Carbon prices in this period reached values 2 to 3 times larger than those required for an intermediate stabilization target, and converged towards a similar value by 2100 (around 970 USD/tC). Changes in the energy supply were more severe, especially in the first half of the century. For example, in 2050 the share of fossil fuels in TPES dropped to 50% in 2050, while CCS share in electricity supply peaked at 36%. These trends also reflected in the use of land. Bioenergy by 2050 took 50% more area compared to the scenario with an intermediate target.

Conclusions

Stabilization scenarios indicated that society can still rely on fossil fuels to a large extent, provided that CCS and low-carbon technologies are largely deployed. In addition to decarbonisation of the energy supply, lower energy intensity and increased energy efficiency resulting from the higher penetration of electricity as energy carrier, were important components of stabilization scenarios. They induced important land use changes, in particular the expansion of land for bioenergy over unmanaged lands and natural forests. Achieving a more stringent stabilization target required larger costs and sharper changes in energy and land use in the first half of the century. Compared to the standard RCPs, the emission scenarios from MIROC-ESM presented lower levels of allowable anthropogenic CO_2 emissions for the same climate target. As a consequence, the changes in the energy and land systems are more drastic, while the cost of mitigations is higher. These differences were clear in the second half of the century for the intermediate stabilization target, and occurred earlier for the stringent stabilization target.

References

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