Two examples of advanced global climate change impact assessment on water and agricultural sectors

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It is essential to international climate policy to project climate change impact globally on various sectors in the future. In the fiscal year 2011, the AIM Climate Change Impact Assessment Team has conducted two advanced global assessments on water and agricultural sectors.

(1) Global water resources assessment at a sub-annual timescale: Application to climate change impact assessment

Several reports have assessed water scarcity globally using the widely accepted withdrawal-to-water resources ratio (hereafter WWR). This index is defined as the ratio of annual withdrawal to the annual renewable water resources (runoff). The index has also been used widely to assess the impact of climate change on global water resources. Here, we ask whether it is appropriate to use the WWR to assess the impact of climate change. Global warming is projected to increase the mean annual runoff in many parts of the world. Therefore, in these regions, the WWR decreases, by definition. However, water scarcity may not always be alleviated in these regions. Global warming is also projected to increase the temporal and spatial variability of precipitation, decrease snowfall, and change the timing of snowmelt. These phenomena may increase the temporal gap between water availability and water demand, which might worsen local water scarcity, even if the mean annual runoff is increased. To assess the impact of climate change on global water resources incorporating subannual time-scale phenomena, this study applies a new water scarcity index, the cumulative withdrawal-to-demand ratio (hereafter CWD). This index is defined as the ratio of the accumulation of daily water withdrawal from local water resources to the accumulation of daily water demand. To estimate daily water withdrawal and water demand, we used the state-of-the-art H08 global water resources model. Our results indicated that global warming increased the mean annual runoff in 52% of the total land area globally (GCM: MIROC3.2 medres; Emission scenario: A2). However, in 42% of the area where runoff increased, the CWD showed increased water stress. Those regions included India, northern China, and northern Europe. For India, the increase in water stress was attributed to the seasonal gap between runoff increase and water demand. The increased runoff was concentrated in a few months, while the high water demand months differed and were much longer. For Europe, the change was attributed to the shift in the timing of snowmelt, which occurred approximately 1 month earlier than at present, causing water shortages in early summer.

(2) Impact assessment of climate change on maize productivity using GAEZ model

The crop productivity depends not only on the climate characteristics such as temperature, precipitation and radiation but also on the environmental factors such as the atmospheric CO_2 concentration and soil fertility. The IPCC's Fourth Assessment Report (AR4) predicted that the average temperature rise due to anthropogenic greenhouse gas emissions has a large impacts on crop`s productivity. Maize is now one of the world's three basic staple crops, being in third place after wheat and rice. The prediction of global change in maize productivity is extremely important to foresee the world's cereal supply and demand under the climate change and global population growth in the future. A number of earlier studies assessed climate change impact on agriculture using several future climate projections developed by General Circulation Models (GCMs). However, their results were significantly varied, and their agricultural simulation results were heavily dependent on climate projections they used. We considered the uncertainty in maize productivity by inputting the future climate projections under the IPCC-SRES emission scenarios (18 GCMs for A1B, 14 GCMs for A2, and 17 GCMs for B1) into the Global Agro-Ecological Zones (GAEZ) model. The GAEZ model was developed by FAO/IIASA and estimates the potential productivity of crops for each grid-cell at 2.5′latitude/longitude using the biophysical information such as climate conditions, soil types, and atmospheric CO_2 concentration, and the agricultural management information such as water management, cultivation system, and input level. The simulation periods were the 1990s (1991-2000), 2020s (2021-2030), 2050s (2051-2060), and 2080s (2081-2090); the 1990s served as the base period for the comparison. In the 2020s, the average productivity of the main maize production countries (U.S.A., China, Brazil, Indonesia, France, South Africa) in each continent decreased for all emission scenarios in comparison with 1990s (A1B: -8.8%, A2: -6.8%, B1: -7.5%). The average productivity in the 2050s decreased for all scenarios in comparison with 2020s (A1B: -12.0%, A2: -12.4%, B1: -9.1%). The average productivity in the 2080s further decreased in comparison with other periods especially A2 scenario (A1B: -16.2%, A2: -22.0%, B1: -10.2%). The uncertainty of average change in production of each GCM varied by 37% (Max: 12%, Min: -26%) for A2 scenario in the 2020s, 52% (Max: 12%, Min: -40%) for A1B scenario in the 2050s, and 62% (Max: 10%, Min: -50%) for A2 scenario in the 2080s.