Long-term Global Warming Projection and Support for Adaptation

Background and Objective

There have been growing concerns about global warming since IPCC Fourth Assessment Report in 2007. However, many uncertainties remain regarding future projections of climate change, thus reliability of future climate information needs to be improved in order for planning mitigation and adaptation measures against global warming.

In this project, we address improvement of climate model projection, i.e. reduction and quantification of its uncertainties. In addition, various future emission pathways are explored based upon firm scientific knowledge about climate change, reflecting the actual situation and future prospects of energy supply. Furthermore, the impacts of global warming on power supply systems are being investigated based on regional scale climate change information downscaled from global scale projections.

Main results

1. Synthesis of a climate model and an economy-energy model

With the aim of appropriately reflecting scientific knowledge about climate prediction on action plans for measures against global warming, we have publicized the simple climate model (SEEPLUS) developed in FY2009 as a web application on the Internet. Besides, to investigate greenhouse gas emission pathways toward the realization of low-carbon society, we have developed the integrated assessment model, BET, which manipulates variables of energy, environment, and economy in a common framework (Fig. 1) [V10013]. The BET incorporates the climate computing scheme used in SEEPLUS. This scheme realistically deals with natural carbon cycle processes, likely leading to a better assessment for emission pathways compared to the one used in a conventional integrated assessment model.

2. Assessment of typhoon changes due to global warming

We have developed a theoretical scheme to evaluate global warming-induced changes in strong winds and torrential rains associated with typhoons on the basis of SEEPLUS output [V10014]. This scheme provides potential changes and their uncertainty ranges for a past severe typhoon event as functions of global surface temperature anomalies. A case study for Typhoon Flo (1990) has shown that the intensity, measured by a central pressure drop at sea level, and peak precipitation will increase by 6.5% and 9.3%, respectively, under a globally one-degree warmed environment. These changes are expected around the year 2040, and differences among emission scenarios become evident in long-term changes (Fig. 2).

3. Classification of anomalous summer climate around Japan

Anomalous climate around Japan shows complicated behavior due to interaction between various large-scale phenomena. To evaluate the long-term change in the anomalous summer climate, we introduced a nonlinear classification technique [V10026] by using “Self-Organizing Map” (SOM). During past 32 years (1979-2010), the SOM analysis well captures the feature of anomalous summer climate in relation to extreme high- and low-temperature events around Japan. The results exhibited that the frequency of cool summer patterns gradually decreases and conversely that of hot summer significantly increases during the period (Fig. 3).

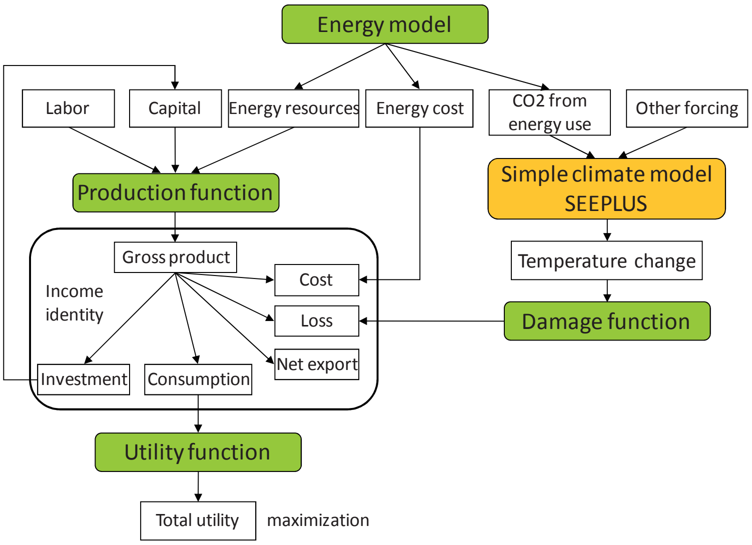

Fig. 1 Components of the integrated assessment model (BET) and the role of SEEPLUS

The gross product is allocated to the consumption and investment to maximize the total utility. The energy cost includes emission reduction costs. The climate-induced loss is evaluated as reduction of the production. Inter- dependency between energy-economy and climate is subject to CO_2 emissions from energy use and economic losses due to climate change.

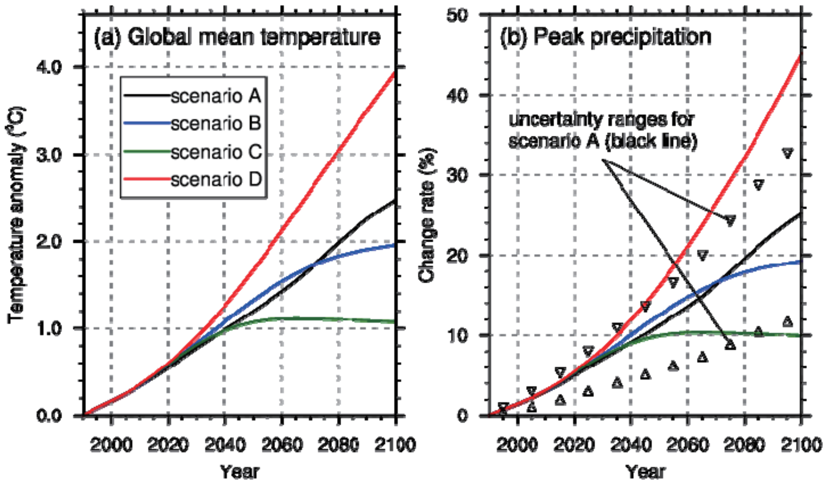

Fig. 2 Typhoon changes due to global warming

Assessment of potential changes for a typical severe event, assuming Typhoon Flo (1990), in the four different scenarios provided for the IPCC Fifth Assessment Report. The temperature change (panel a) shows the anomaly from the 1990 level, calculated by SEEPLUS with the climate sensitivity, defined as the equilibrium response of global mean temperature to doubling CO_2 concentration, of three Celsius degrees. Uncertainty ranges are indicated by triangle markers for scenario A only. This scheme allows evaluating change rates of typhoon intensity for many scenarios at low computation cost.

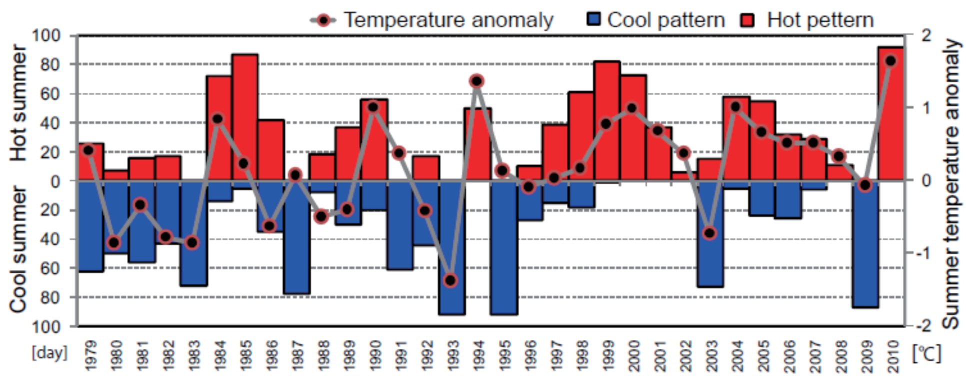

Fig. 3 Frequency of the extreme hot- and cool-summer patterns

Long-term change in the frequency of extreme hot- and cool-summer patterns derived from atmospheric re-analysis data through the SOM technique. Solid line represents a surface temperature anomaly in Japan averaged in the boreal summer (June-July-August). The frequency of extreme hot-summer patterns is about 1.5 times greater in the second half of the period than in the first half, whereas that of extreme cool-summer is about half.