Global warming projection based on high-emission scenarios assuming expanding use of coals in developing countries

Background

More rigorous scientific knowledge about global warming impacts and effect of greenhouse gas (GHG) concentrations under various future GHG emission scenarios is required for building a post-Kyoto international framework for reduction of GHG emissions. For this purpose, we have conducted global warming projections based on IPCC (Intergovernmental Panel on Climate Change) SRES (Special Report on Emissions Scenarios) A1B and B1 scenarios that are, respectively, medium- and low-emission scenarios.

Objectives

To enhance scientific knowledge about dangerous anthropogenic interference with climate system, global warming projection experiments are conducted based on SRES A2, the high-emission scenario.

Principal Results

1. GHG concentration scenarios employed in the global warming projection experiments

The IPCC SRES A2 scenario is a typical high-emission scenario that assumes expanding use of coals, especially, in developing countries, as well as high population growth. The use of coals is assumed to account for about 50% of primary energy supply in year 2100. GHG stabilization and overshoot scenario experiments are conducted based on this A2 scenario. In the stabilization case, GHG concentrations are assumed to be fixed at the year 2100 level in the A2 scenario, while linear reduction of GHG concentrations from year 2150 is assumed in the overshoot scenario cases as depicted in Fig.1.

2. Results

(1) Though the projected geographical pattern of surface warming under the A2 scenario is very similar to that in lower-emission scenarios such as the A1B, its magnitude is much more significant in the A2 case. Even if the GHG concentrations were to be stabilized, the surface air temperature of the globe keeps rising for hundreds of years and it takes very long time for the climate system to reach equilibrium (Fig.2).

(2) If the GHG concentration in atmosphere is stabilized at the SRES A2 level, sea ice in the Northern Hemisphere disappears for six months of the year. The reduction of Arctic sea ice in winter is also noteworthy (Fig.3).

(3) The North Atlantic Meridional Overturning Circulation (MOC) is more weakened than under the SRES A1B scenario. The GHG stabilization, however, limits further reduction of the MOC. Its shutdown and a resulting large abrupt transition of climate are very unlikely to occur (Fig.4).

(4) Most of the elements of climate system such as surface temperature, precipitation, sea ice, MOC do not show measurable hysteresis behavior. An exception is sea level: it does not recover to the B1 level as shown in Fig.5.

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Future Developments

To develop an earth system model, that employs biogeochemical processes such as carbon cycle and ecosystem, in order to evaluate impacts to and feedbacks from such biogeochemical processes.

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Reference

Y. Yoshida, et.al., 2006, "Global warming projections based on SRES A2 scenario," in FY2006 Report of the Project for Sustainable Coexistence of Human, Nature and the Earth. CRIEPI Report V990601 (in Japanese)

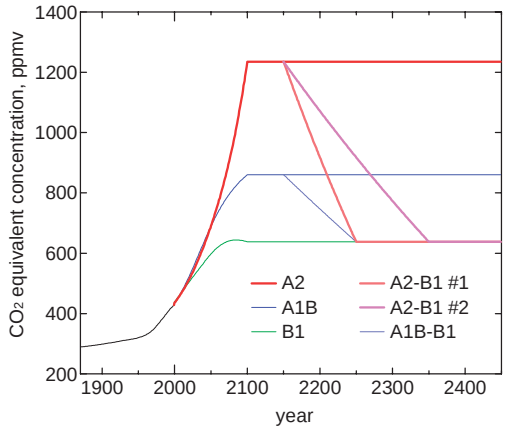

Fig.1 GHG concentration scenarios for the projections

Three experiments denoted by thick lines (A2, A2-B1#1, A2-B1#2) were performed in FY2006. The GHG stabilization scenario assumes that GHG concentrations are stabilized in 2100. Two overshoot scenarios assume linear reduction of GHG concentrations from 2150, with 100- and 200-year periods of GHG decline phase.

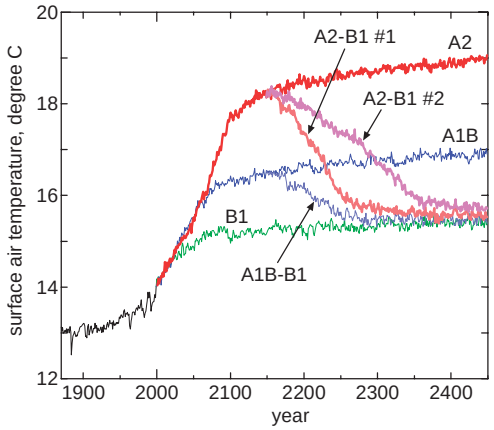

Fig.2 Global annual mean surface air temperature

Projected temperature rise during the 21st century is 3.7, 2.5, and 1.5˚C, respectively, under A2, A1B and B1 scenarios.After the GHG stabilization at 2100, surface warming will continue for hundreds of years. The surface temperature will recover to the B1 level under the overshoot scenarios.

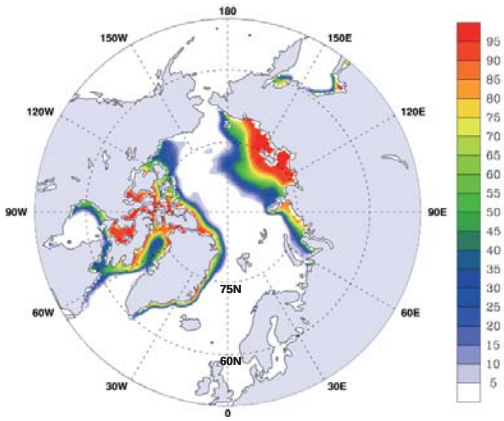

Fig.3 Sea ice concentration in Northern Hemisphere under the A2 scenario (years 2390-2399, March)

A drastic reduction of Arctic sea ice is projected under the A2 scenario: Sea ice will completely disappear in summer and substantial reduction will take place even in winter.

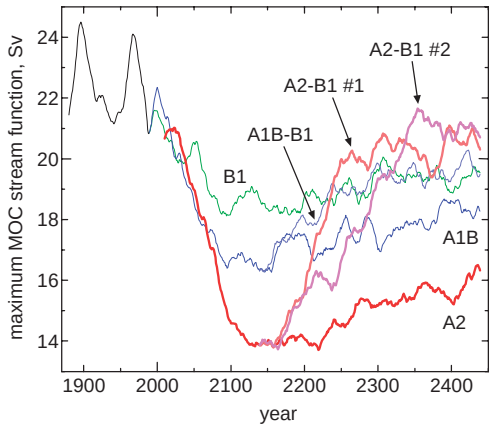

Fig.4 Projected change in North Atlantic MOC

Changes in North Atlantic MOC are of great concern from the viewpoint of abrupt climate change. Projected results show that the MOC will slow down during the 21st century. However, the GHG stabilization will limit reduction of MOC and its shutdown is unlikely to occur.

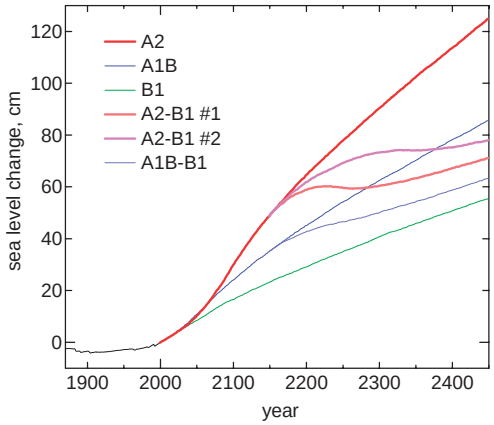

Fig.5 Sea level rise due to thermal expansion of seawater

The effect of GHG stabilization is limited and the sea level keeps rising for centuries even after the GHG stabilization at 2100. In the cases of overshoot scenarios, the sea level shows measurable hysteresis effect. Even if GHG concentrations were to be lowered, the sea level will not completely recover to the B1 level.