Project Research — **Establishment of Optimal Risk Management**

Long-term Global Warming Projection and Support for Adaptation

Background and Objective

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

In this project, we address the improvement of climate model projection, i.e., a reduction and quantification of the uncertainties. In addition, various future emission pathways are explored based upon firm scientific knowledge about climate change, reflecting the actual situation and the 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 Improvement of a Climate Change Prediction Tool Used to Propose Rational Climate Stabilization Measures

Based on a wide range of literature regarding climate sensitivity, which is an index that relates atmospheric CO_2 concentrations to a degree of warming, associated scientific knowledge and an approach to global warming mitigation measures considering uncertainties about climate sensitivity have been summarized (V11019). Among such knowledge, the quantification of uncertainties has been implemented in our climate change prediction tool (SEEPLUS) as a function for comparing multiple probability distributions of climate sensitivity (Fig. 1). In addition, useful functions for studies on long-term climate stabilization and adaptation to climate change have been incorporated into SEEPLUS, such as referring to new emissions scenarios, facilitating comparisons with different climate models, additional outputs for practical indexes including the intensity of tropical cyclones, and so on.

2 Proposal for a New CO_2 Emission Pathway for Long-term Climate Stabilization

We have proposed, in collaboration with the Japan Agency for Marine-Earth Science and Technology, a new concept for global warming mitigation in order to avoid long-term risks from climate change despite allowing increased CO_2 emissions in the next few decades. A future emission pathway, as one demonstrative example based on this concept, has been designed using SEEPLUS (Fig. 2, left). An earth system model, which simulates the earth's climate and carbon cycle in detail, has been used for the global warming projection experiment along the emission pathway of our proposal. The model projection shows a declining trend in atmospheric CO_2 concentration after the latter half of the 21^{st} century, accompanied with the gradual recovery of climate such as global mean temperature and sea ice extent (Fig. 2, right) (V11057).

3 Development of a Method to Estimate the Probability of Heavy Precipitation over River Basins

A method to estimate the probability density function (PDF) of daily precipitation over catchment areas of hydraulic dams has been developed. It computes PDFs from the outputs of climate models of coarse spatial resolution (typically 100 km). The PDFs of daily precipitation for the past 21 years have been estimated for over 20 dam basins (catchment areas are from 20 to 2,300 km^2) in the Kyushu region of Japan, where extreme rainfall events occur frequently. The results show that the present method is superior to the conventional multiple regression method in terms of the capability of representing infrequent, heavy precipitation events. It is applicable to a wide range of basin areas, and also to the month of September, in which the PDF is strongly affected by typhoons. The proposed method is useful to evaluate the impact of future changes in heavy rainfall due to global warming on hydraulic power plants (Fig. 3) (V11058).

Other reports: (V11032), (V11049), (V11064)

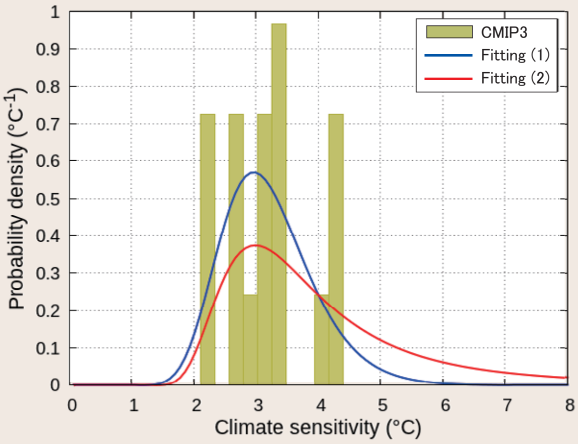

Fig. 1: Example of the probability distributions of climate sensitivity

Climate sensitivity is defined as global equilibrium surface warming due to a doubling of CO_2 concentration. The value of climate sensitivity is estimated to be about 3°C, but it involves considerable uncertainty that can be represented by a probability distribution. CMIP3 denotes the multiple climate models used in the IPCC Fourth Assessment Report in 2007. Fitting (1) is a log-normal distribution matching the CMIP3 models, and fitting (2) is one of the probability distributions devised for parameter uncertainties in a specific climate model.

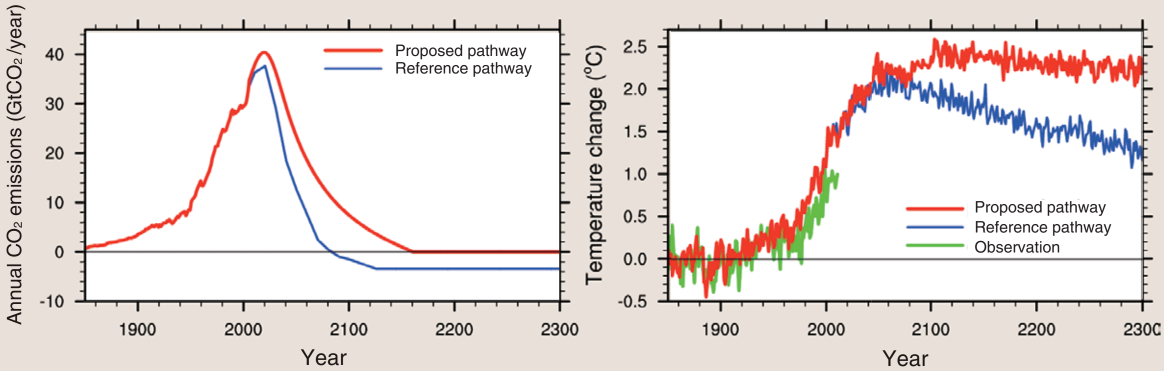

Fig. 2: CO_2 emission pathways and surface air temperature anomalies projected using an earth system model

The left figure shows the CO_2 emission pathways used in climate change projections. In our proposed pathway, CO_2 emissions are reduced to zero in the middle of the 22nd century. Thus, the atmospheric CO_2 concentration can be eventually stabilized at a lower level. The reference is one of the emission pathways for the IPCC Fifth Assessment Report. The right figure shows the surface air temperature anomaly projected by an earth system model, along with observations. In the case of the proposed pathway, the surface air temperature gradually recovers in the long term, as a consequence of declining atmospheric CO_2 concentration after the latter half of the 21st century due to CO_2 removal by terrestrial and ocean sinks.

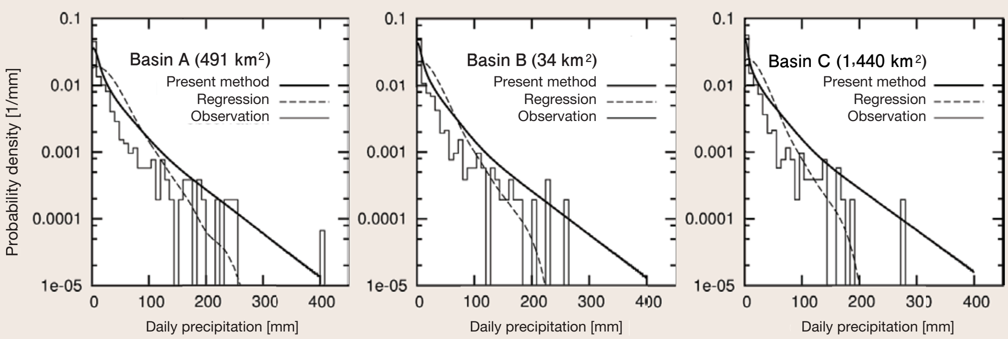

Fig. 3: Estimated climatological PDF of daily precipitation

The graphs, in order from left to right, show the estimation results for basins A (491 km^2), B (34 km^2) and C (1,440 km^2) in the same river system. The solid and dashed lines are the results using the present method and the multiple regression method, respectively, and the histogram represents the frequency of observed precipitations. The present method gives appropriate PDF estimates even in the positive tail, where the multiple regression analysis always underestimates PDFs, demonstrating the superiority of the present method in terms of the probability estimation of infrequent and heavy precipitation.