

Principal Research Results

Scientific Assessments of the Impacts Due to Global Warming – Increase in Precipitation Amounts and Droughts –

Background

It is widely accepted that surface air temperature will increase due to global warming. However, concerning precipitation, which means rain and snow, it seems to be contradictory that the occurrences of both floods and droughts are projected to simultaneously increase in many research results. At the stage of the IPCC Third Assessment Report (TAR, 2001), projected changes in precipitation were still uncertain, because the reliability of climate models and the performance of computers were not sufficient.

Objectives

In order to assess the changes in precipitation, we analyze in detail the large amount of output data from the climate model experiments using the world fastest class supercomputer, the Earth Simulator. For evaluating the performance of the climate model used in this study, we compare simulated regional precipitations with observations.

Principal Results

1. Outline of the datasets used for analyses

We analyzed the long-term projected data by the end of the 21st century (year 2100) based on A1B and B1 scenarios from the IPCC Special Report on Emissions Scenarios (SRES, 2001). In the medium-emission A1B scenario, the storyline is described as the world of rapid economic growth with emphasized introduction of renewable energy in Asia. In the low-emission B1 scenario, the storyline is described as the world of rapid change in economic structures with emphasized introduction of nuclear energy in Asia. These long-term data were obtained through the international research consortium with the National Center for Atmospheric Research (NCAR) and others using the atmosphere ocean coupled model (CCSM3) having resolution of about 150 km in the atmosphere model component. For comparing simulated precipitations with observations, we used the past 25-year reanalysis dataset (JRA-25) from year 1979 to year 2004 with the resolution of about 120 km. We have completed the JRA-25 dataset (Japanese Reanalysis dataset with 25years) in FY 2005 in collaboration with the Japan Meteorological Agency (JMA).

2. Features of precipitation changes

- (1) For a short period (1991-1994) without an apparent trend of climate change, we analyzed the projected data about the number of days with precipitation and compared them with the JRA-25 data (Fig.1). The projected number of days with precipitation (P) larger than 50 mm/day was extremely underestimated in comparison with the JRA-25 data. However, the projected number of days with precipitation (P) larger than 10 mm/day was in good agreement with the JRA-25 data.
- (2) In these projections, three-member ensemble projections (named b, f, and g, respectively) with slightly different initial conditions were carried out for each scenario. In some regions (e.g., central Australia), the projected precipitations showed different manner among the members (Fig.2). Therefore, by introducing the ensemble mean, which indicates averaging of three members, statistical uncertainties of the projected precipitation changes are expected to decrease.
- (3) Under both the A1B and B1 scenarios, annual precipitations are projected to increase in most regions over land (Fig.3). However, in the regions included in the so-called Mediterranean climate type, the annual total precipitations are projected to decrease and, at the same time, the index of the annual maximum of consecutive dry days (CDD), which indicates the index of drought, is projected to increase (Fig.4). In such regions included in the so-called Mediterranean climate type, it is suggested that the precipitations decrease and the droughts increase simultaneously in the future.
- (4) In the regions where annual precipitations are projected to increase, annual evapotranspirations, which mean evaporation from the land surface and forests, are also projected to increase due to the high increases of surface temperatures (Fig.5). In such regions with increased evapotranspirations, the annual mean runoff-to-precipitation ratio is projected to decrease under both the A1B and B1 scenarios (Fig.6), which might cause the shortage of water resources in the future.

Future Developments

We will investigate the methods of adapting social system to the unavoidable future climate changes and reducing the possible damages caused by global warming.

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References

- K. Maruyama et al., 2005, "FY2005 research report on the development of high-resolution atmosphere-ocean coupled model", V990601 (in Japanese)
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C. Harmonization of energy and environment

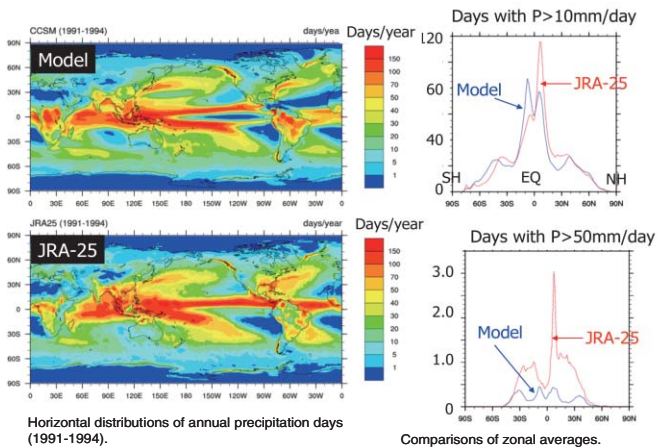


Fig.1 Comparison of the annual number of days with precipitation (P) between the model and the reanalysis data (JRA-25)

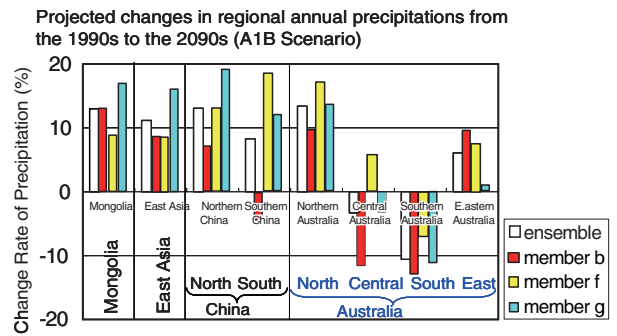


Fig.2 Changes in regional annual precipitations for each ensemble member (b, f, g)

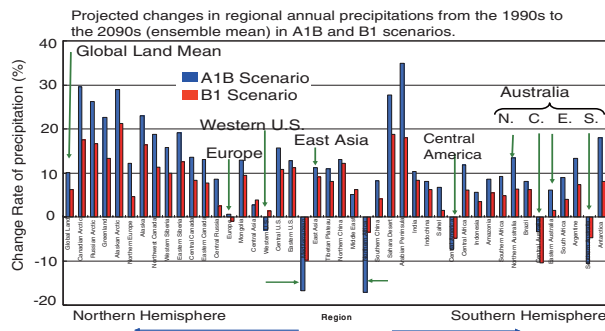


Fig.3 Changes of annual precipitations

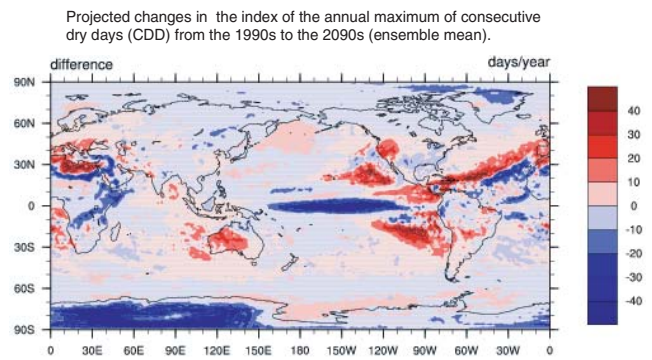


Fig.4 Change of Consecutive Dry Days (CDD)

In the regions with highlights of red, the index of CDD increases and it suggests that the drought increases in these regions.

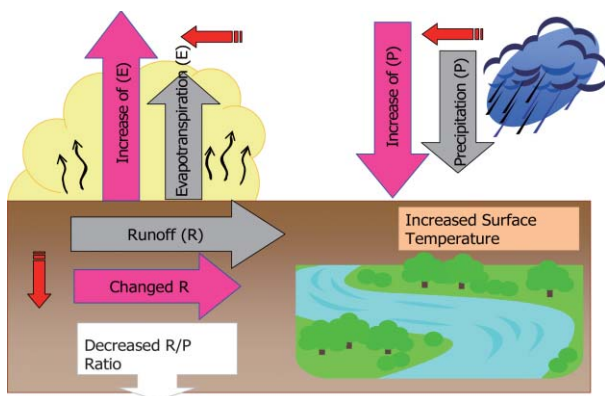


Fig.5 Schematic graph of runoff

The runoff (R) and precipitation (P) ratio decreases due to the high increase of land surface temperature.

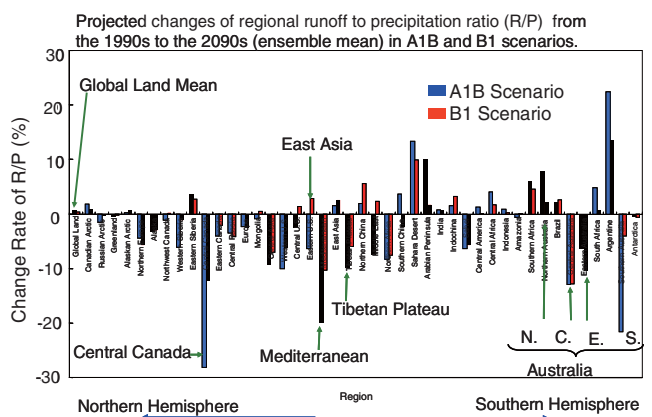


Fig.6 Decrease of the value of R/P in most regions

These results suggest shortage of water resources in the future.