Probabilistic Information on Climate Change in Extreme Events by High-resolution Large Ensemble Simulations

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Introduction

- Uncertainties of global warming model projections are still large, especially for extreme events (heavy rainfall, heat waves, etc.), while they can cause most significant impacts to the society.
- Large part of the sources of the uncertainties is in the variability inside the climate system. Probabilistic approach is required to obtain useful information of the change in extreme events.

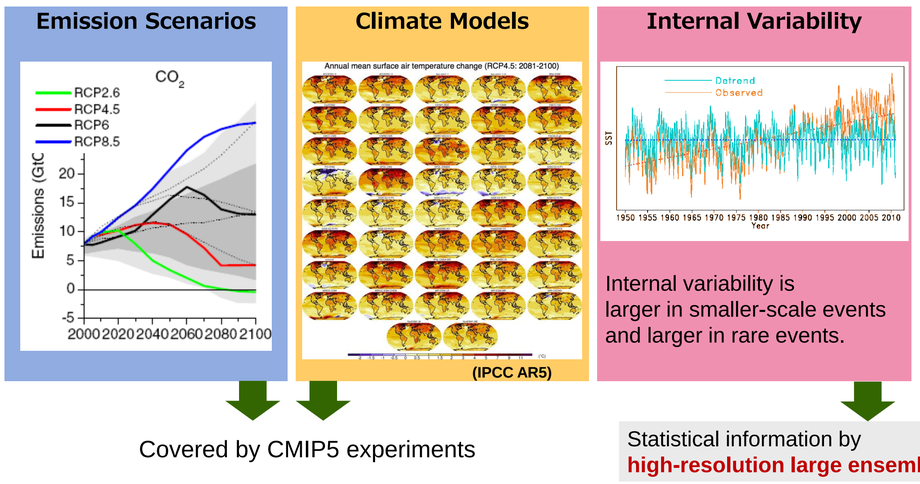
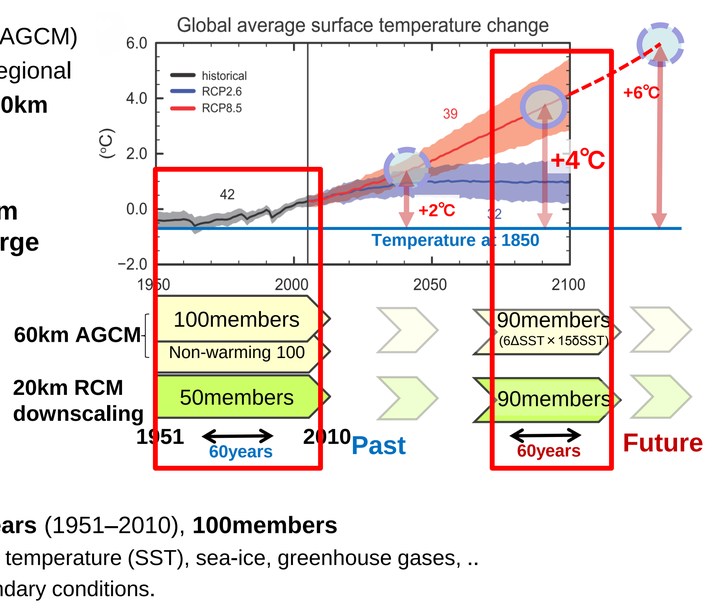


Fig.1: Sources of uncertainties of global warming model projections.

Simulations Design

- Global atmospheric model (AGCM) with **60km** resolution, and regional climate model (RCM) with **20km** resolution are used.

Fig.2: Schematic diagram of the high-resolution large ensemble simulations.



- Historical Simulations: **60years** (1951–2010), **100members**
  - Observational sea-surface temperature (SST), sea-ice, greenhouse gases, .. are prescribed as the boundary conditions.
  - 100 SST perturbations representing observational error (δSST)
- +4K Simulations: Climate when global-mean surface temperature is 4K warmer than pre-Industrial, **60years**, **90members** (6×15)
  - Future SST = detrended past SST + 6 SST warming patterns (ΔSST) from 6 CMIP5 models in RCP8.5 scenario
  - 15 SST perturbations (δSST)
  - Greenhouse gases are values in 2090 following RCP8.5 scenario

Precipitation Extremes

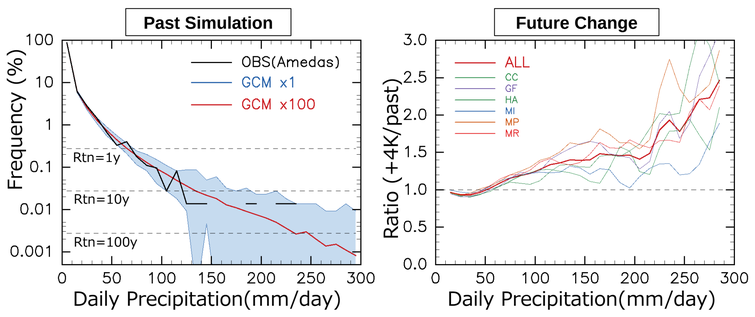


Fig.3: Frequency distribution of daily precipitation at Tokyo, (left) for the historical simulation and (right) change ratio from the past to the future.

- Frequency distribution of daily precipitation at Tokyo
  - Ensemble spread between members (Blue) is large in rare events
  - Observation (Black) is inside the ensemble spread without any bias corrections
  - Results from the total 100 members (Red) shows reasonable frequencies of extremes as low as 0.003%(=once in 100 years)
  - Increase is larger in the heavier precipitation rate

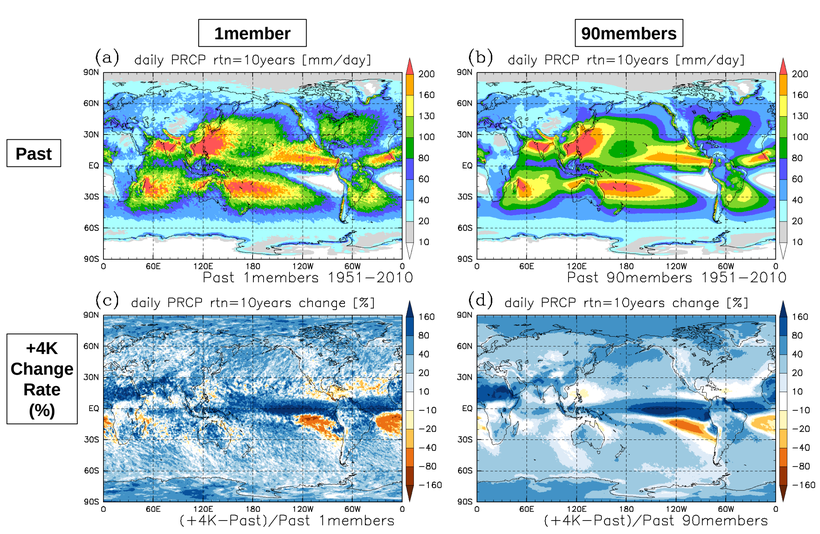
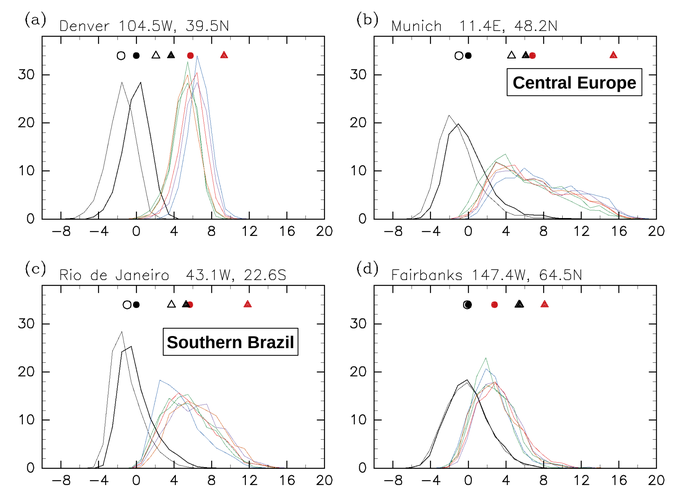


Fig.4: 10-year return value of daily precipitation (mm/day) and its change in the +4K simulation.

- 10-year return value of daily precipitation
  - Clear and smooth picture can be obtained by using large ensembles
  - Future increase is found over most of the world about 20-40 %

Temperature Extremes

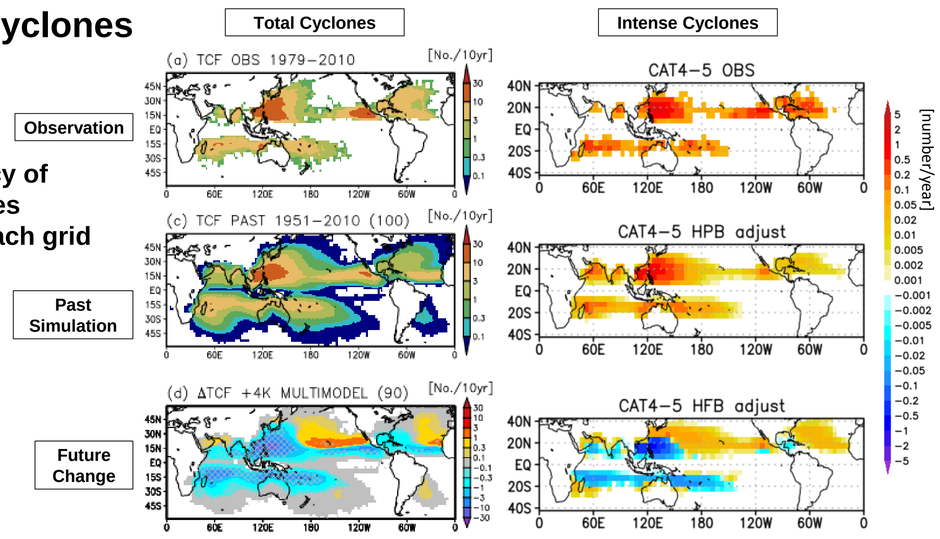
Fig.5: Frequency distributions of annual maximum temperature for four representative points



- Over the most part of the land, the change is almost the same as the mean temperature warming during hot season.
- However, extreme temperature increases more than the mean in central Europe and southern Brazil.

Tropical Cyclones

Fig.6: Frequency of tropical cyclones passing over each grid box.



- Similar, but smoother distribution compared with the observation is obtained.
- Total increase is found around E. N. Pacific, E. N. Atlantic, and decrease around the other regions.
- Although bias correction is required for intense cyclones in the 60km model, Category 4-5 cyclones increases on N. W. side of Pacific and Atlantic, as well as eastern side.

Dynamical Downscaling

- By the 20km downscaling, we can obtain more detailed spatial distribution along with small topography.

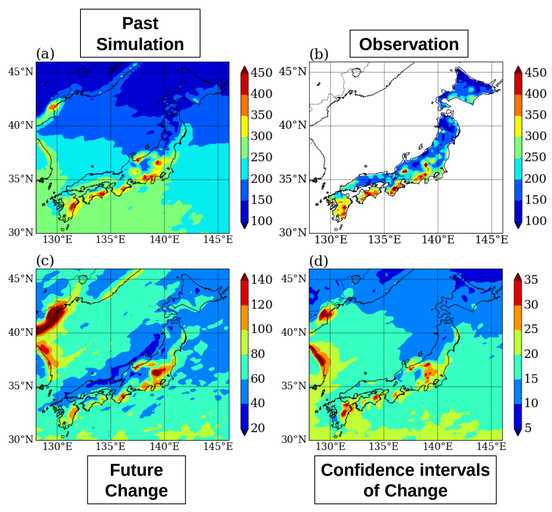


Fig.7: 50-year return value of daily precipitation around Japan.

Impact Assessments

- The simulation results are open to the public as a database, intended to be utilized for the impact assessment studies and adaptation planning to global warming.

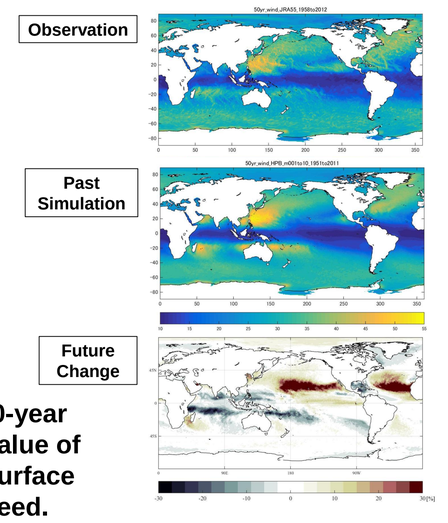


Fig.8: 50-year return value of ocean surface wind speed.

Summary

- Unprecedented large ensemble climate simulations with a 60km AGCM and 20km RCM have been performed.
- As the 60km model is capable of representing tropical cyclones, the results enable us to discuss long-term trends and future changes in localized rare events.
- By the 20km downscaling, we can obtain more detailed spatial distribution along with small topography.
- The simulation results are open to the public as a database named “d4PDF”, intended to be utilized for the impact assessment studies and adaptation planning to global warming.
  http://www.miroc-gcm.jp/~pub/d4PDF/
  http://dias-dss.tkl.iis.u-tokyo.ac.jp/ddc/viewer?ds=d4PDF_GCM&lang=en

SOUSEI Program for Risk Information on Climate Change
気候変動リスク情報創生プログラム

d4PDF: database for Policy Decision making for Future climate change

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