

- The Paris Agreement went into effect on 4 November 2016, which requests all parties to reduce carbon emissions to well below 2 °C and enhance adaptive capacity, and has led to enhance the importance of mitigation and adaptation measures to climate change
- From this perspective, based on the needs of the international, national and local community and private enterprises, Ministry of Education, Culture, Sports, Science and Technology – Japan (MEXT) promotes research on making accurate climate change projections and revealing the mechanism of climate change, that can be applied to domestic and international climate change measures, through the improvements of climate models as the foundation of all climate change measures
- For this purpose, MEXT has launched a new science project “Integrated research program for advancing climate models (2017-2021)”, and in the theme of “Clarification of carbon cycle, climate sensitivity and tipping points”, scientific efforts will be made to further understand the Earth system dynamics, to make climate projections, and to create knowledge on mitigation, with improvement of the Earth System Models and intensive application of the models to the simulations where strong mitigation is assumed for 1.5/2.0 °C targets.

Specific needs related to research and development

Challenges at the global scale / international level

- There is the need to illuminate insufficient scientific knowledge, such as in “carbon cycle”, “climate sensitivity”, and “tipping point”, which are essential to consider the requested GHG reduction amount to reach the GHG emission pathways to well below 2 °C and to pursue efforts to limit the temperature increase to 1.5 °C.
- There is the need to conduct experiments to project temperature rise in relation to multiple GHG emission scenarios, with consideration of the interactions of climate, carbon cycle, ecosystems, and human activities

Challenges at the regional scale / domestic level

- There is the need to produce highly accurate risk information about climate change as the basis, which can be utilized by national and local community to consider adaptation measure and also by private enterprises to make their economic activities adaptive.
- There is the need to make scientific consensus about climate change mechanism (e.g., climate sensitivity) that is a bottleneck to reduction efforts of GHG emission.

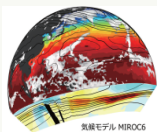
Contents of this program

Creation of highly accurate projection to clarify mechanism applicable to international and domestic climate change measures

[Contribution to climate change measures in international and domestic communities; Enhancement of Japan's presence in science and technology through IPCC]

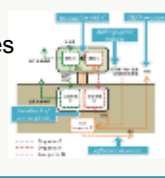
Global climate change projection:
Development of Global Climate Model as the basis for all climate change measures

Develop Global Climate Model and run experiments to project global warming at the end of this century.



Clarification of carbon cycle, climate sensitivity and tipping points:
as the basis for considering mitigation measures

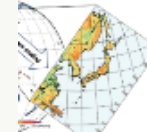
Develop the Earth System Model which can reproduce climate-carbon-nitrogen cycles and clarify climate sensitivity, tipping points, among others.



Integrated climate change projection:

as the foundation of building adaptation plans in Japan and Southeast Asia

Develop Regional Climate Model around Japan and project future climate change with high resolution.



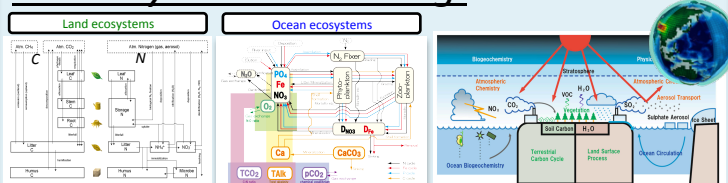
Integrated hazard projection:
Evaluation of risks and impacts of natural disasters caused by global warming

Simulate intensified natural hazards due to climate change such as typhoons and floods and estimate maximum damage and probability of occurrence.



Development of the Earth system models (ESMs) for mitigation policy

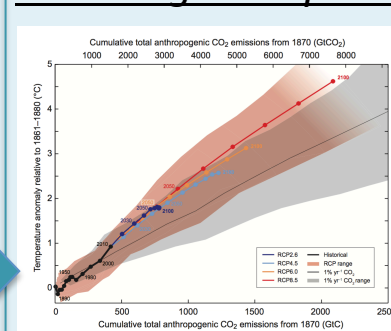
Earth system modeling



Earth system model “MIROC-ES2” (Hajima et al., in prep.)

- Earth system models: Climate models that have carbon cycle, ecosystem processes, atmospheric chemistry, etc.
- A new Earth system model has developed in the previous project: The model has explicit Global Carbon & Nitrogen cycle, and their interaction with climate processes
- The basic tool for our scientific challenges, and the model will be further improved in the new project

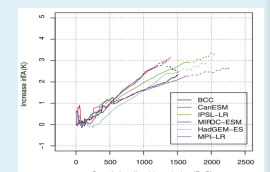
For Mitigation policy: TCRE (Transient Climate Response to cumulative Emission)



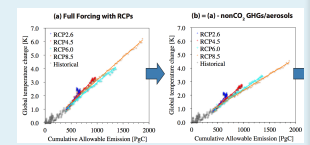
IPCC-AR5, SPM: ESMs revealed a almost linear relationship between cumulative anthropogenic CO2 emission and global warming. This enables us to estimate the future allowable emission to achieve a warming target.



- **Problem1:** the models show a large spread for the results. Need to reduce/constrain the climate and carbon cycle sensitivities. Incorporation of Nitrogen cycle into ESMs is likely to reduce the carbon cycle sensitivity
- **Problem2:** TCRE estimation is more uncertain when CO2 stabilized / reduced
- **Problem3:** Existence of non-CO2 GHGs. To achieve 1.5/2.0 °C target, these agents cannot be ignore, but most ESMs are imperfect for these processes.



Tachiiri et al., 2015, ERL: TCRE in RCP4.5 scenario: before (solid lines) and after (dotted lines) CO2 stabilization

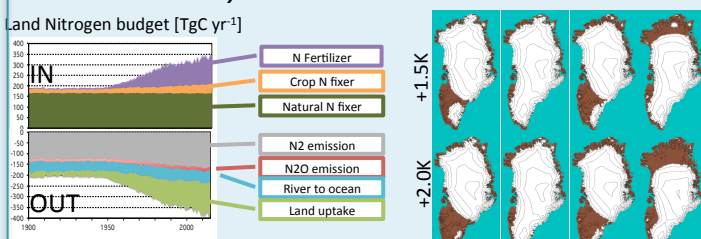


Modified from: Hajima et al., 2012, JMSI: Difference between with (left) and without (right) consideration of non-CO2 GHGs

Understanding the Earth system dynamics under mitigation scenarios

Human impact on the Earth system

Tipping elements / Paleo climate



Preliminary results by offlined Land ecosystem model: impact of land-use change on Nitrogen cycle

Demonstration of Ice sheet distribution of Greenland in the new equilibrium state s of +1.5/2.0 °C. Horizontal panels represents the simulation with different forcing data: Simulated by offlined icesheet model

Contribution to CMIP6 (WCRP)

- The ESM modeling group will join the Coupled model intercomparison project “CMIP6” by WCRP (:AerChemMIP, C4MIP, GeoMIP, ISMIP6, LUMIP, OMIP, PMIP, ScenarioMIP, VolMIP, etc), submit our simulation result, and analyze the multi-model simulations, in order to make more robust conclusions for climate projection and reduce projection uncertainty

Other challenges

- Impact of climate change on anthropogenic GHG emission and on human activities (land-use, agriculture and water resource management) will be examined, in order to understand and make projections of the comprehensive Earth system-human dynamics.

