

Recent Progress and Outcomes of
the **Earth Simulator** based
Climate Change Projection Research
in Japan under the MEXT*
by H. Kondo

*: *MEXT = Ministry of Education, Culture, Sports, Science and Technology*

- Project for the Sustainable Coexistence of Humans, Nature and the Earth (“**KYOSEI Project**”): *Global warming projection.*

FY2002- FY2007 ⇒ IPCC/AR4

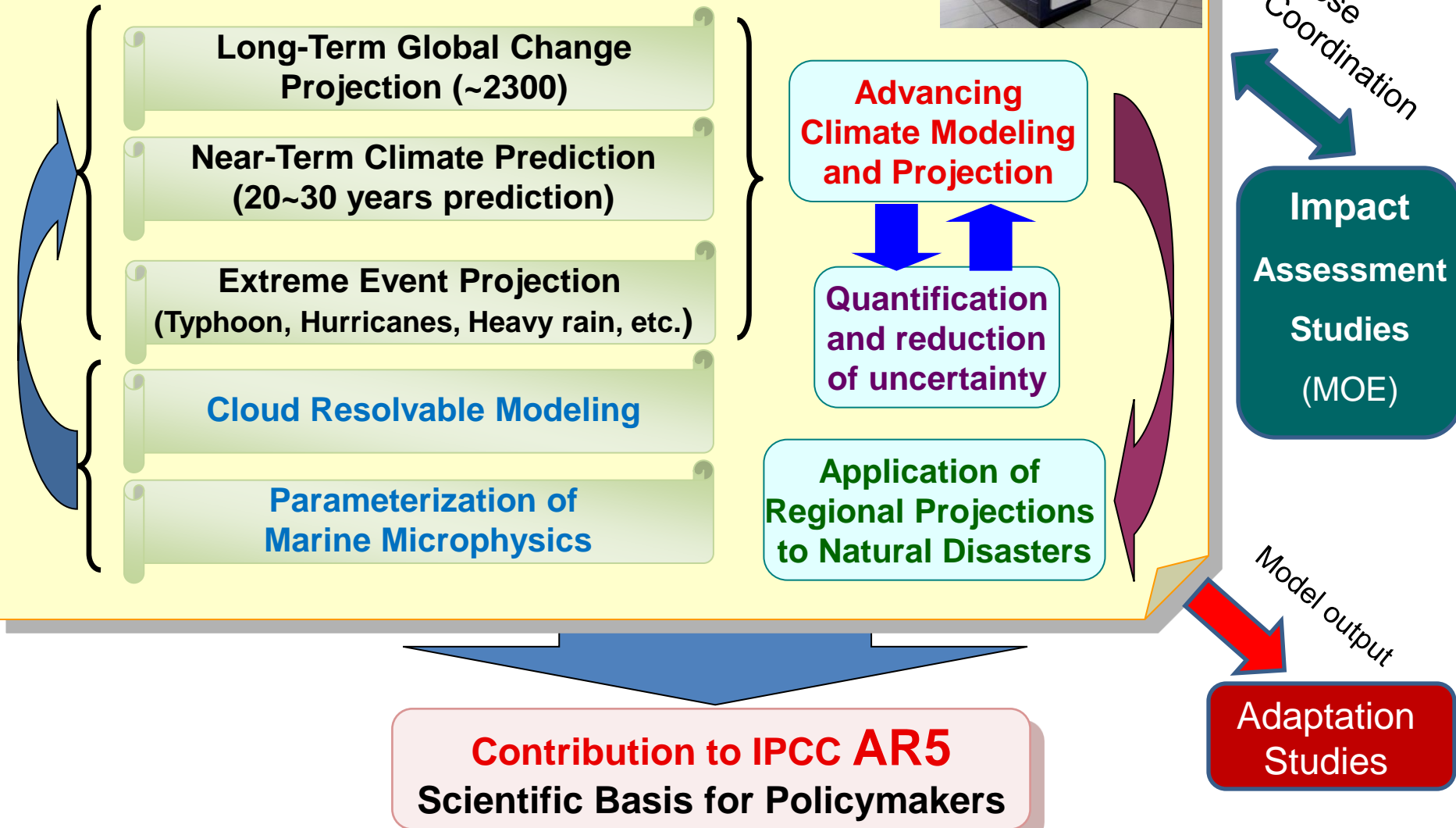
- *Innovative Program of Climate Change Projection for the 21st Century (“**KAKUSHIN Program**”): Projection and its application to impact assessment*

FY2007 – FY2011 ⇒ IPCC/AR5

- *Program for Risk Information on Climate Change (“**SOUSEI Program**”): Findings from model studies as foundation for planning policy measures for global warming*

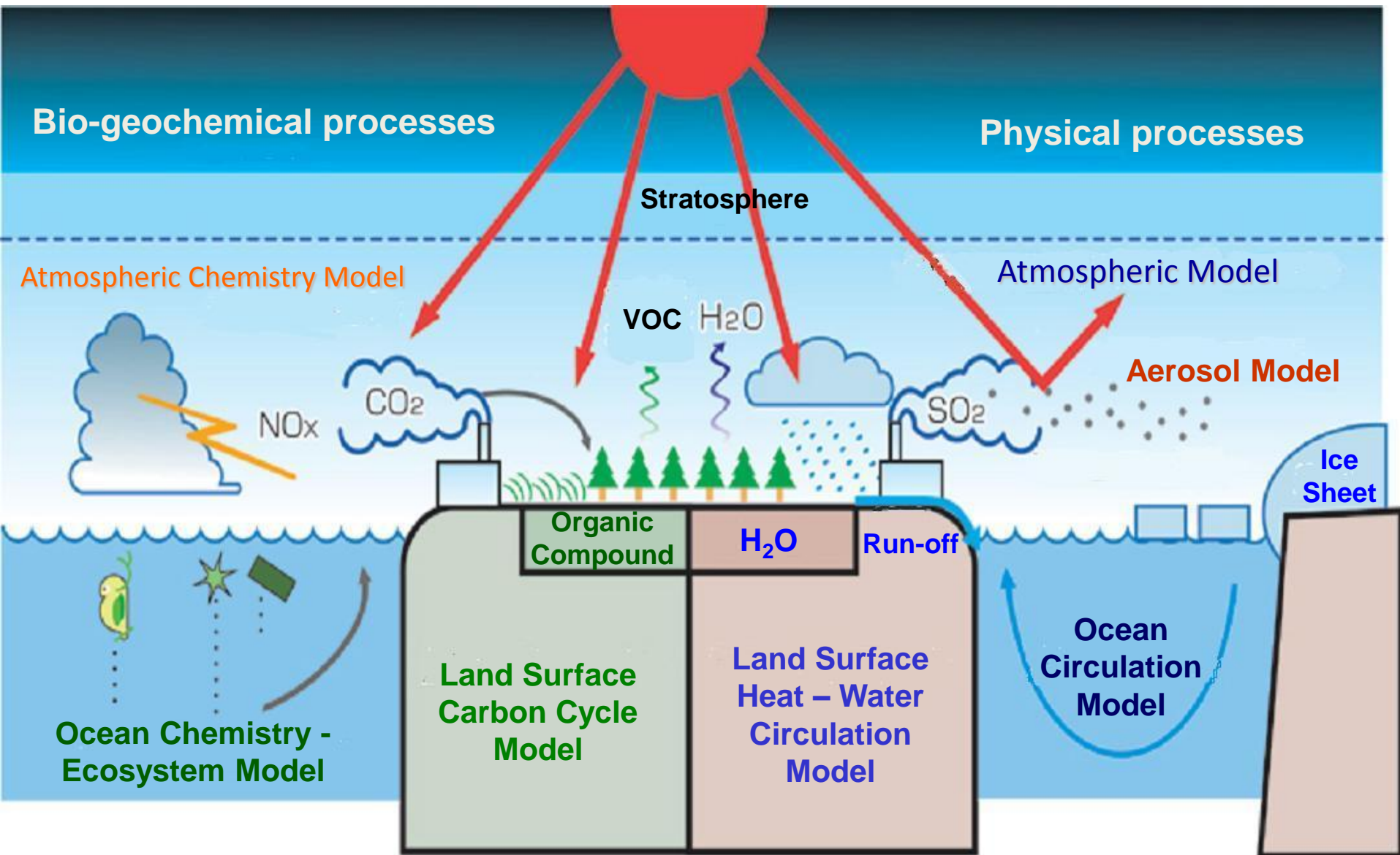
FY2012 – FY2016 ⇒ Future IPCC Assessment

Climate change projection using the *Earth Simulator* (ES)



Contribution to IPCC AR5
Scientific Basis for Policymakers

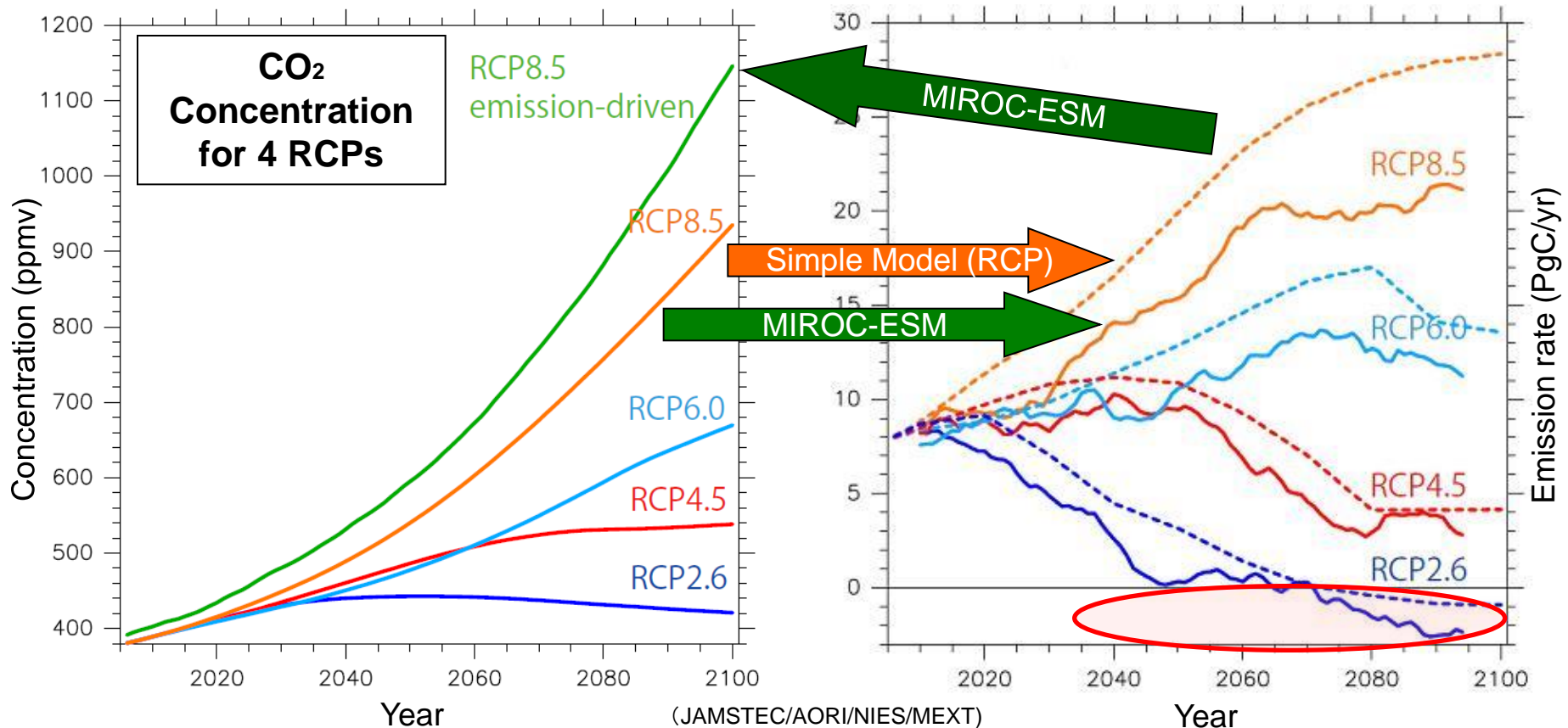
Structure of the Earth System Model (MIROC-ESM)



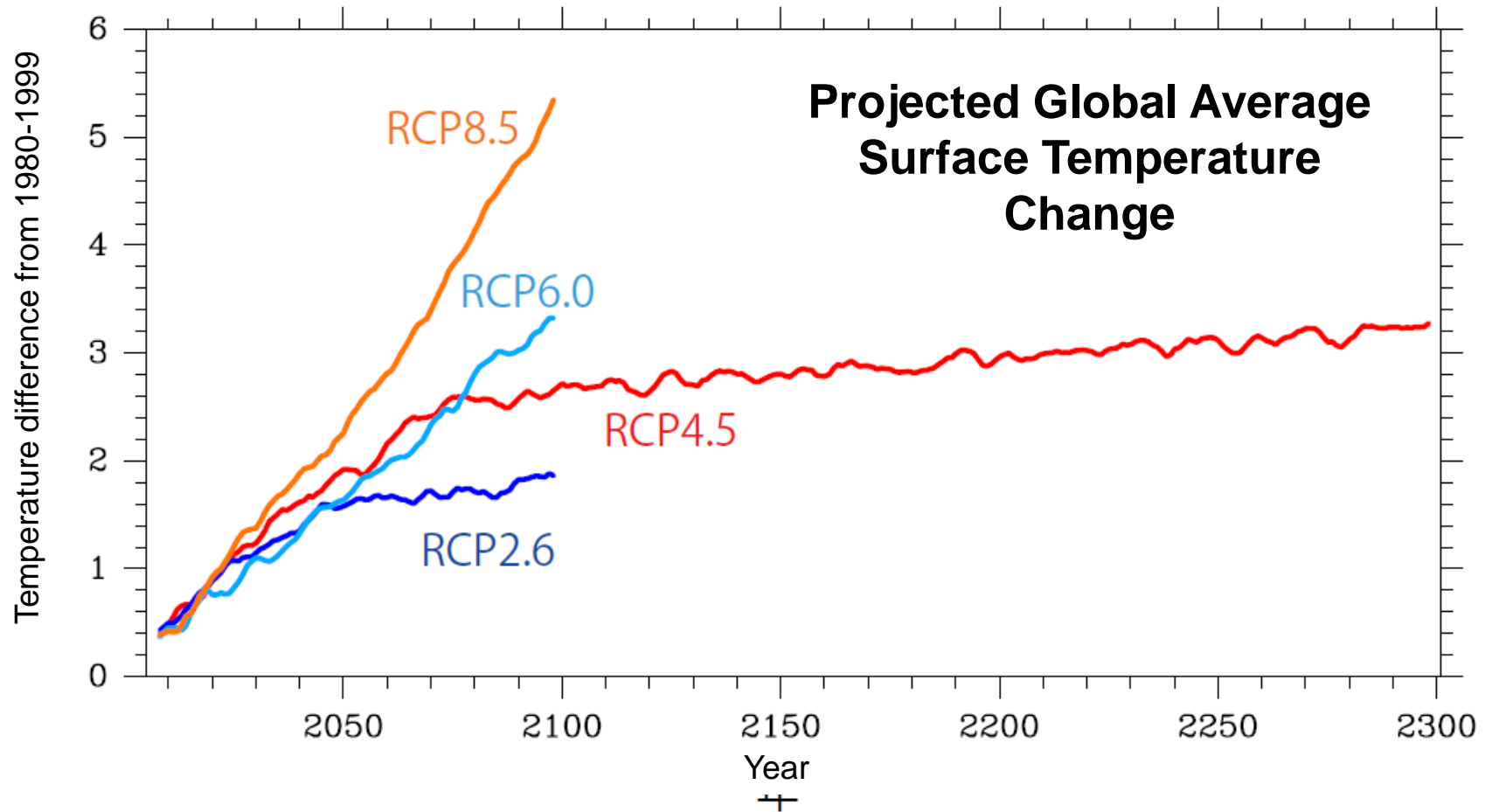
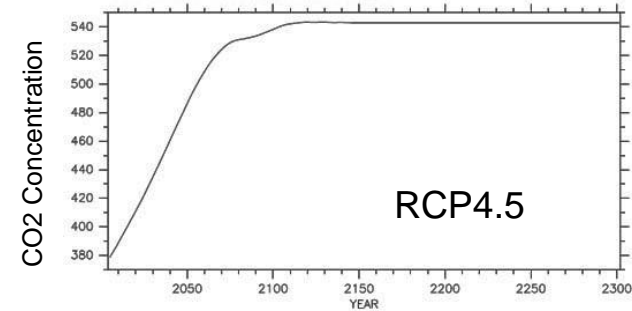
Long-Term Global Change Projection

MIROC-ESM shows some different outcomes from the simple carbon cycle model for RCP with implications

- **CO₂ Emission rate from fossil fuel** estimated as necessary to cause a RCP concentration scenario is almost **zero at the middle of the 21st century**.
- CO₂ concentration caused by **MIROC-ESM** from a RCP emission rate is, in response, **larger than the respective RCP concentration**.



Long-term Projection of Surface Temperature Change up to 2300 (under RCP4.5)



SEIB-DGVM @ Larch forest

Location (East-Siberia)

Latitude : 62°15'N
Longitude : 129°37'E
Altitude : 220m

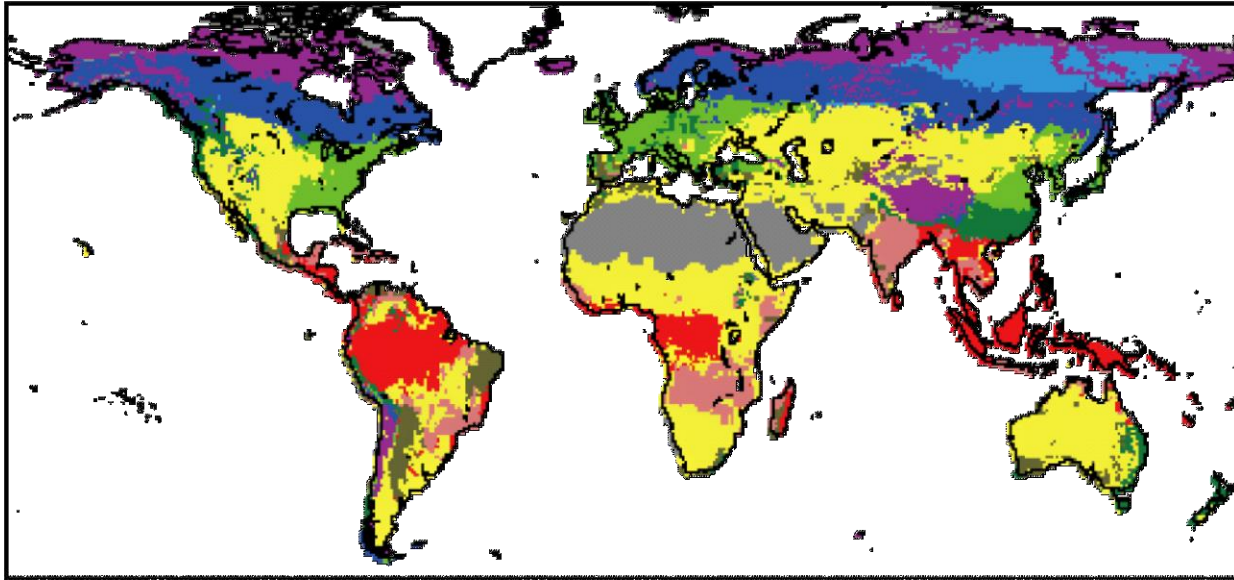
Annual mean climate

Air temp. : -9.9C°
Precipitation : 257mm

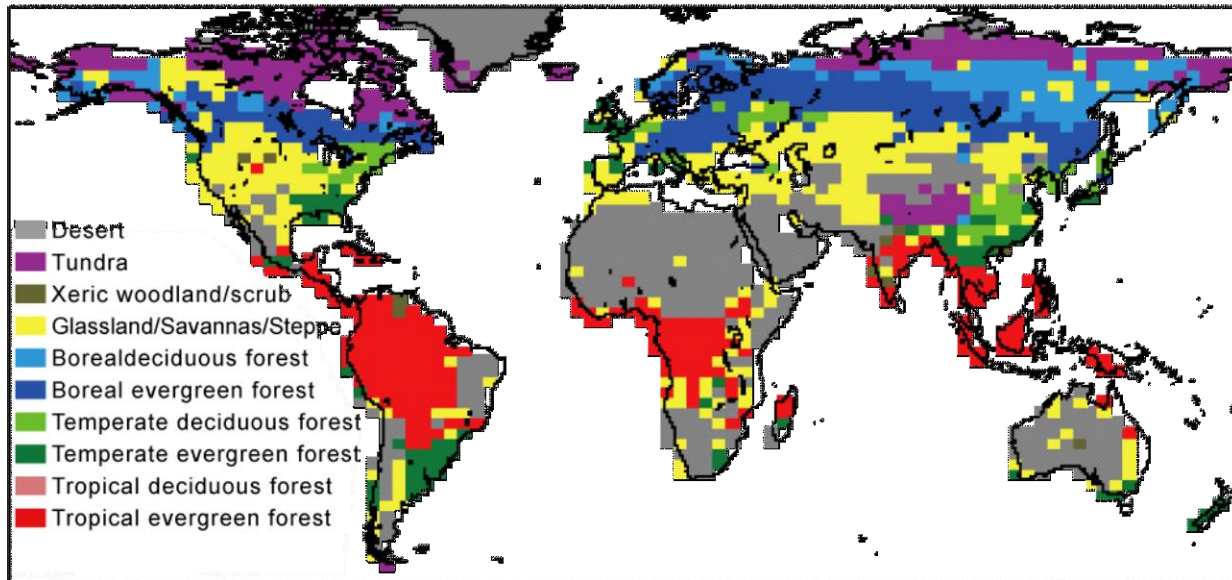
Size of virtual forest: 100m × 100m

Grass PFTs are not visualized

Observed vegetation distribution



Simulated vegetation distribution



(JAMSTEC/MEXT)

Projected Vegetation under RCP4.5

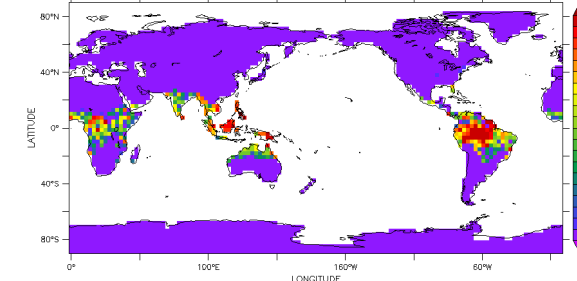
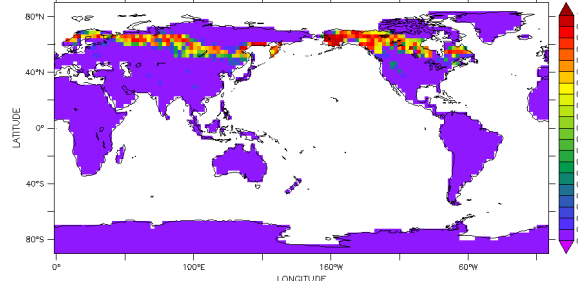
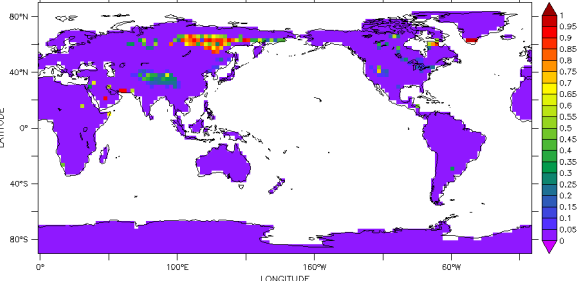
(JAMSTEC/AORI/NIES/MEXT)

Boreal-Deciduous Forest

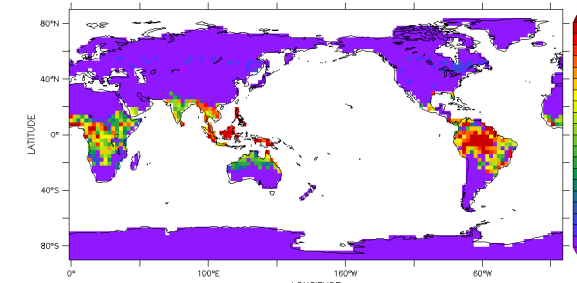
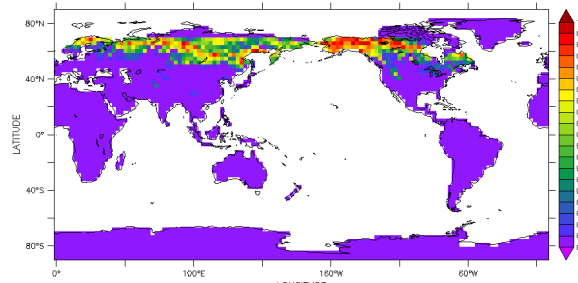
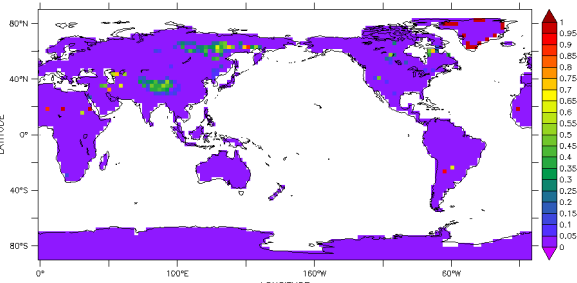
Boreal-Evergreen Forest

Tropical Forest

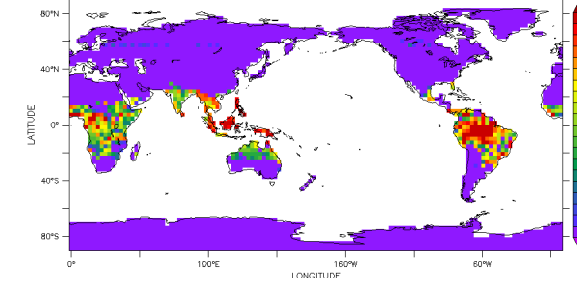
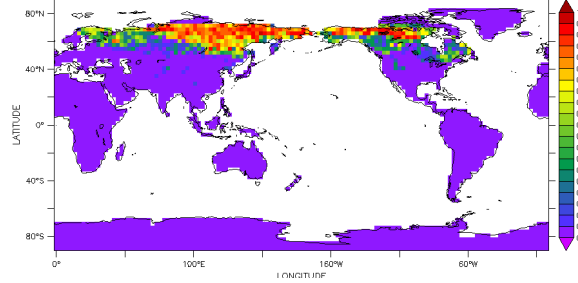
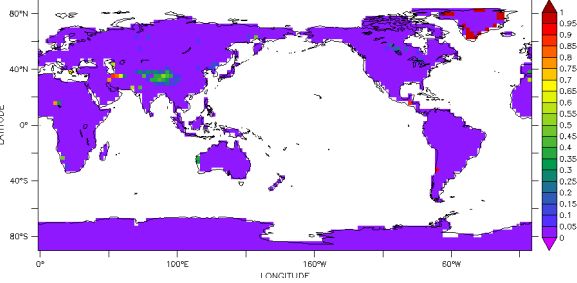
2007



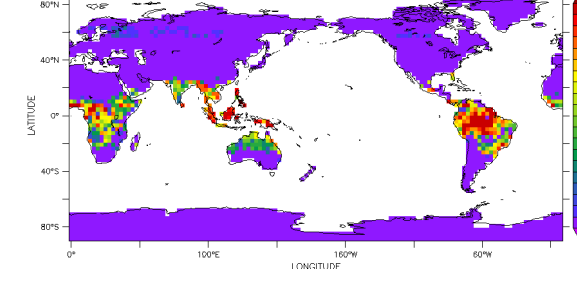
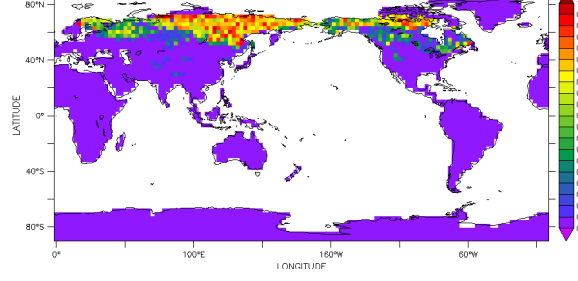
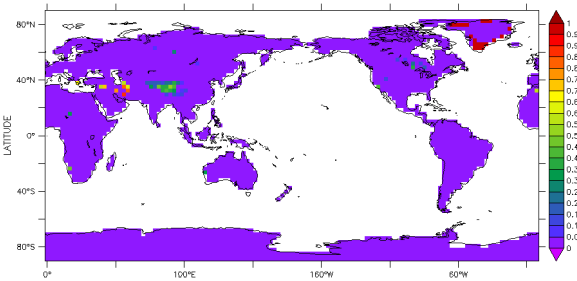
2100



2200



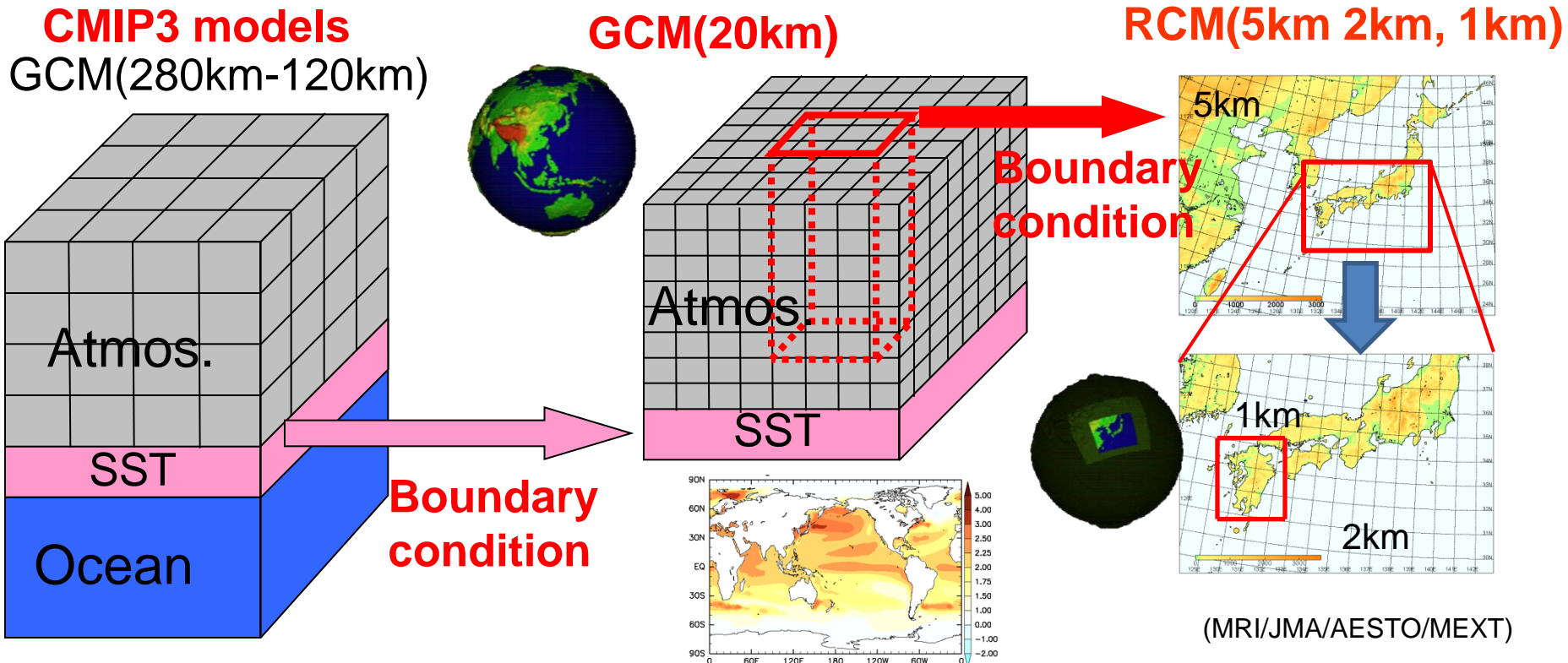
2300



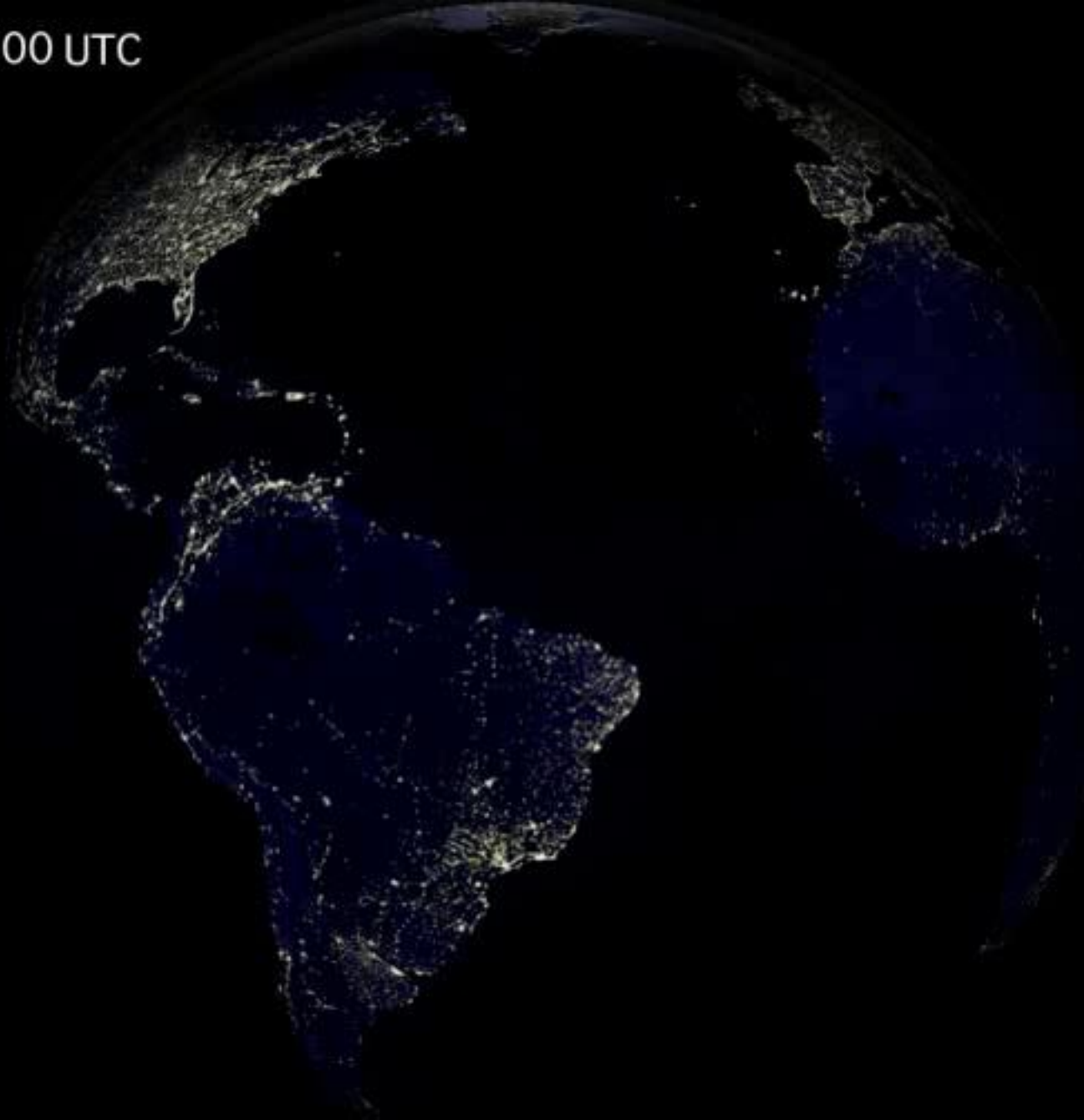
Extreme Event Projection

Projection of the change in future weather extremes using super-high-resolution atmospheric models

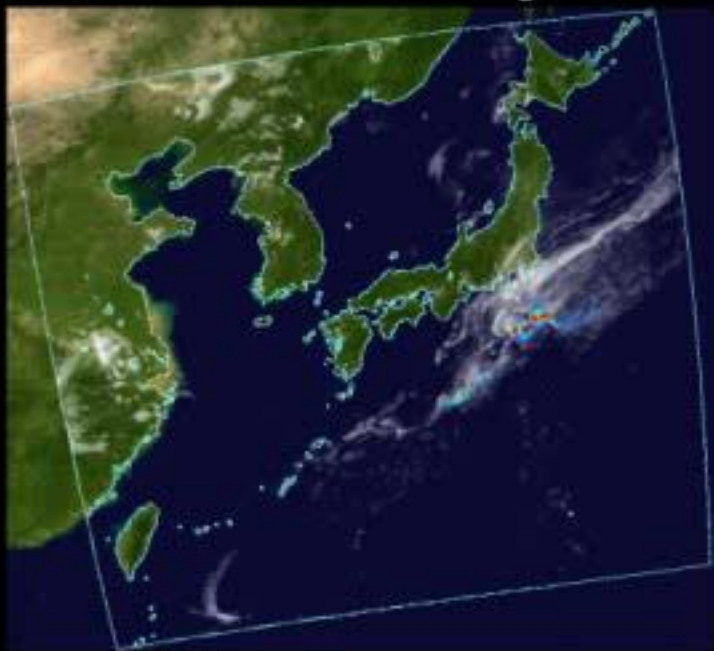
- The multi-model ensemble of sea surface temperatures (SSTs) projected by atmosphere-ocean general circulation models used in the IPCC AR4 will be input to the global 20-km mesh atmospheric model to obtain the future climate projection (**time-slice experiment**).
- In a focus on **local climate change over Japan**, **regional atmospheric models** embedded in the global model is used to investigate changes in **heavy precipitation**.



01 Sep 208X 00 UTC



5km Regional Model

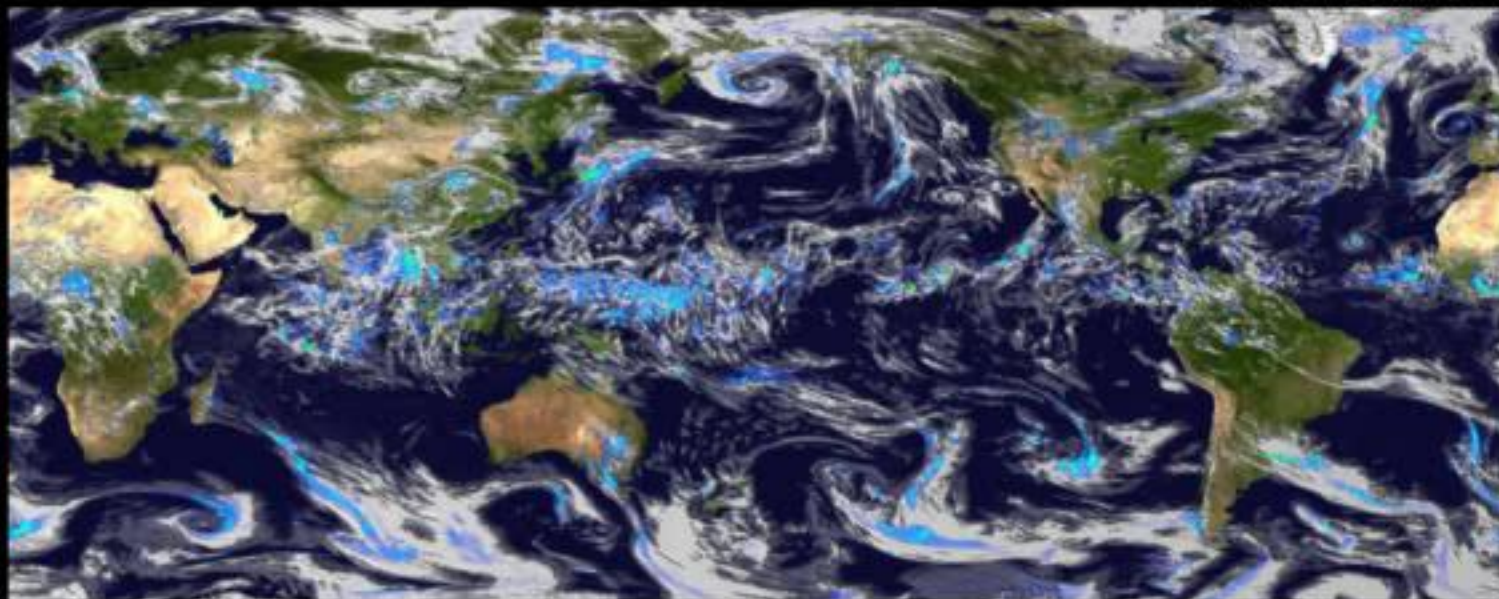


2km Regional Model



20 km Global Model

05 Sep
208X
00 UTC



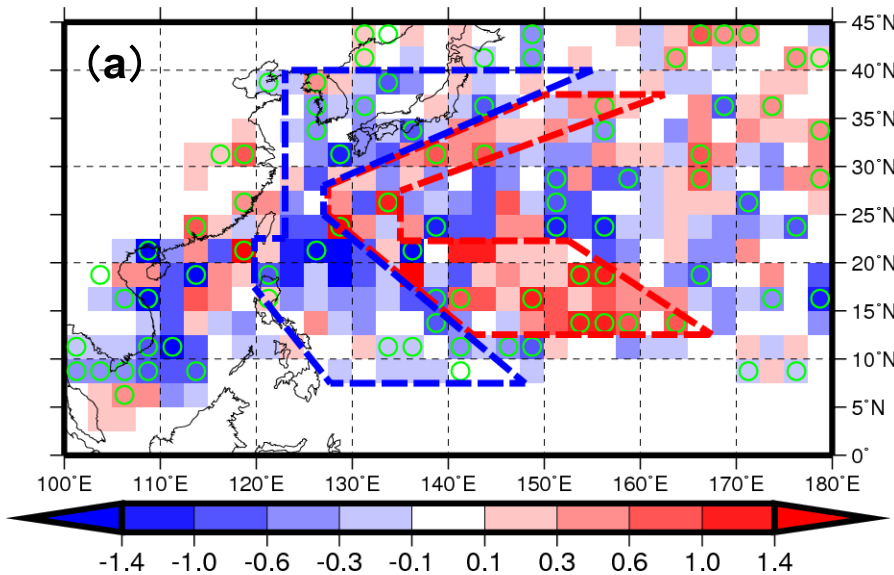
Extreme Event Projection

Typhoons approaching land

- An **eastward shift** in the positions of the two prevailing recurving TC tracks.
- Significant **increase in TC maximum** surface wind approaching coastal regions.

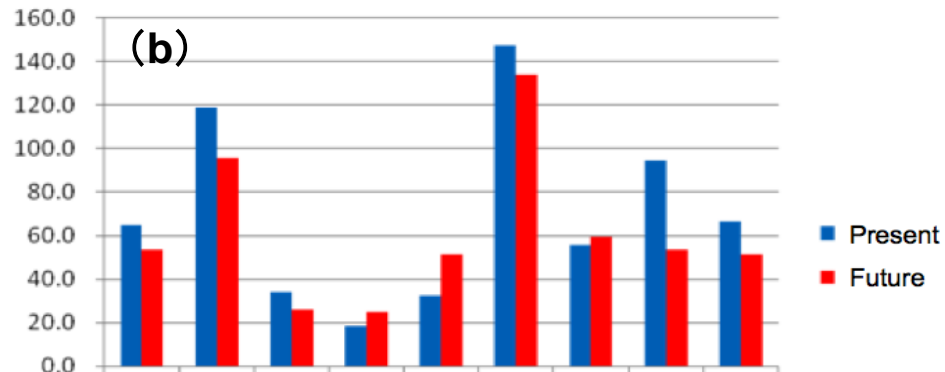
Change in TC frequency of occurrence during JASO

[2075-2099 vs 1979-2003]

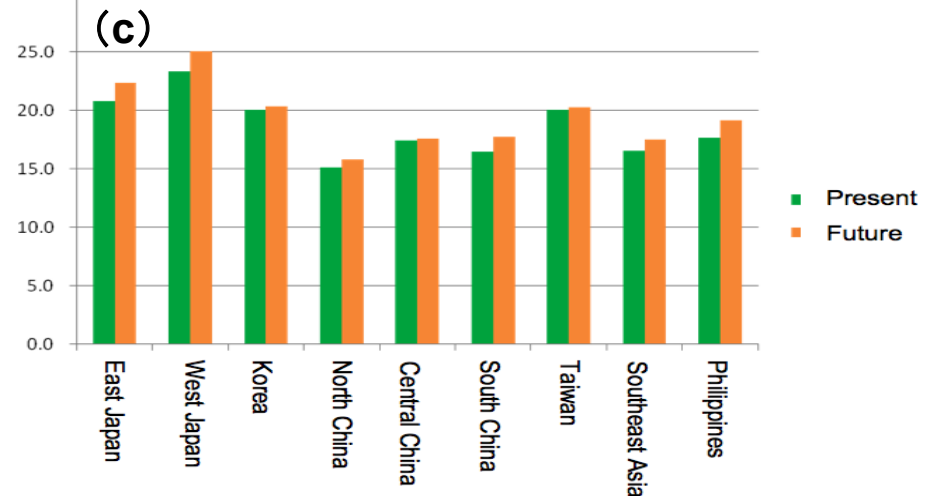


(MRI/JMA/AESTO/MEXT)

Accumulated TC storm days



Maximum wind velocity



Regionally detail climate modelling applied to adaptation studies

Super-high resolution (20 km)
global atmospheric modelling
<by MRI group under a MEXT project>

Earth
Simulator
(ES2)



Some of major outcomes

- ◆ Projection of **increased strength** of Typhoons & Hurricanes (new finding)
- ◆ Projection of **regionally detail extreme events** (heat waves, droughts, etc.) under sufficient regional geographic effects
- ◆ Projection of temporally detail behaviour such as **diurnal precipitation change**

IPCC

Assessment Reports (AR4 & AR5)

Synthesis Rep.

Working Group III
(Mitigation)

Working Group II
(IAV*)

Working Group I
(Physical Science Basis)

Sound
Scientific
Basis for
Adaptation
Measures

Adaptation
Studies

[WB funds, JICA funds]

(* IAV = Impact, Adaptation and Vulnerability)

“SOUSEI” Program

*(Program for Risk Information on Climate Change,
based on advanced projection outcomes*

Launched in 2012 to further develop
climate change research based upon
outcomes from the “KAKUSHIN” Program

Four Main Themes of “SOUSEI”

- ◆ **A: Prediction and diagnosis of imminent global climate change**
- ◆ **B: Climate change projection contributing to stabilization target setting**
- ◆ **C: Development of basic technology for risk information on climate change**
- ◆ **D: Precise impact assessments on climate change**

Theme B: Climate change projection contributing to stabilization target setting

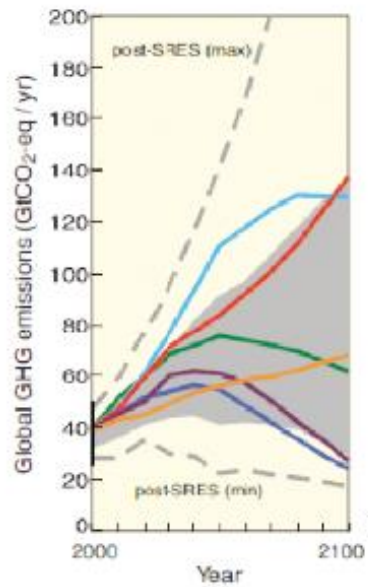
- To aim to contribute to the setting of target levels to stabilize the climate and the building of more reliable socio-economic scenarios, by further advancing a climate system model (Earth System Model <ESM>) that incorporates biological activities such as photosynthesis and environmental biogeochemical cycles for carbon dioxide and methane, etc., on a global scale.

Theme C: Development of basic technology for risk information on climate change

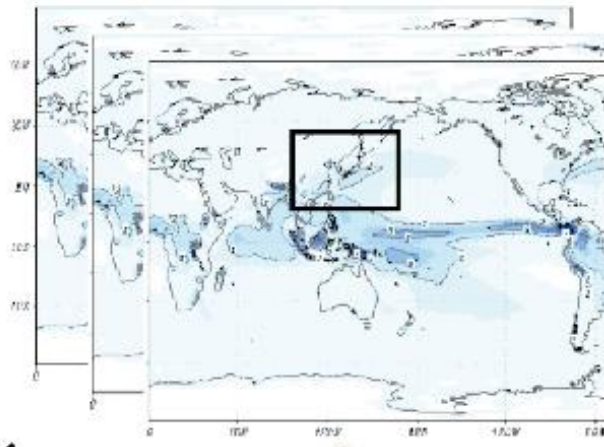
- To develop **statistical methods** for analyzing and evaluating, for instance, the **inter-annual variability of seasonal changes** which affects the timing of the **northward movement of the cherry blossom front** (“Sakura-Zensen”) or the southward movement of the autumnal-colored front (“Kouyou-Zensen”), or **extremely rare weather phenomena** such as the Isewan Typhoon (Typhoon Vera).
- To create a picture of the “**conceivable scenarios**,” including the probability of a particular scenario occurring. The research results will be useful when devising **countermeasures for future disasters**, etc., of the nation and municipalities.

Theme C

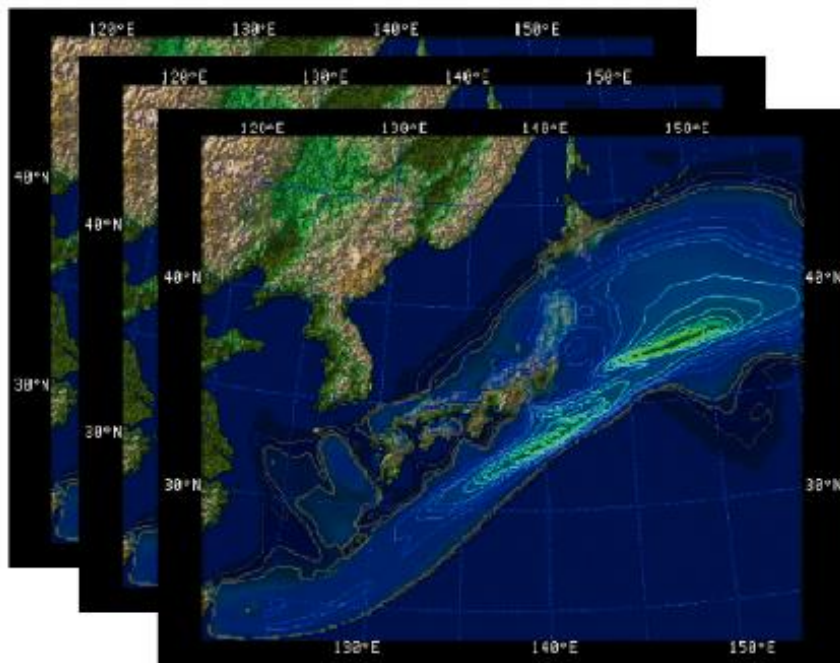
Socio-economic scenario



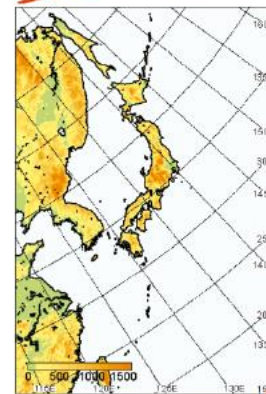
Global climate model



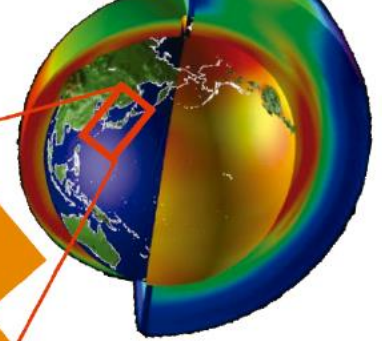
Regional climate model



MRI-NHRCM (5km-mesh)

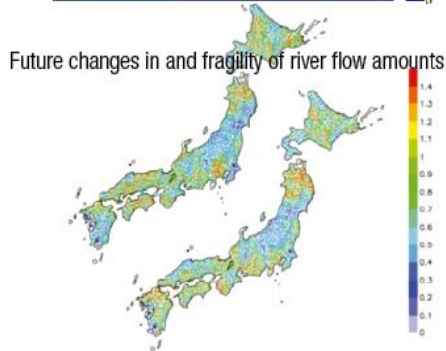
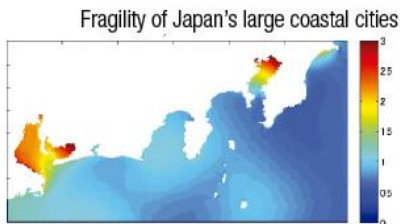


20kmAGCM

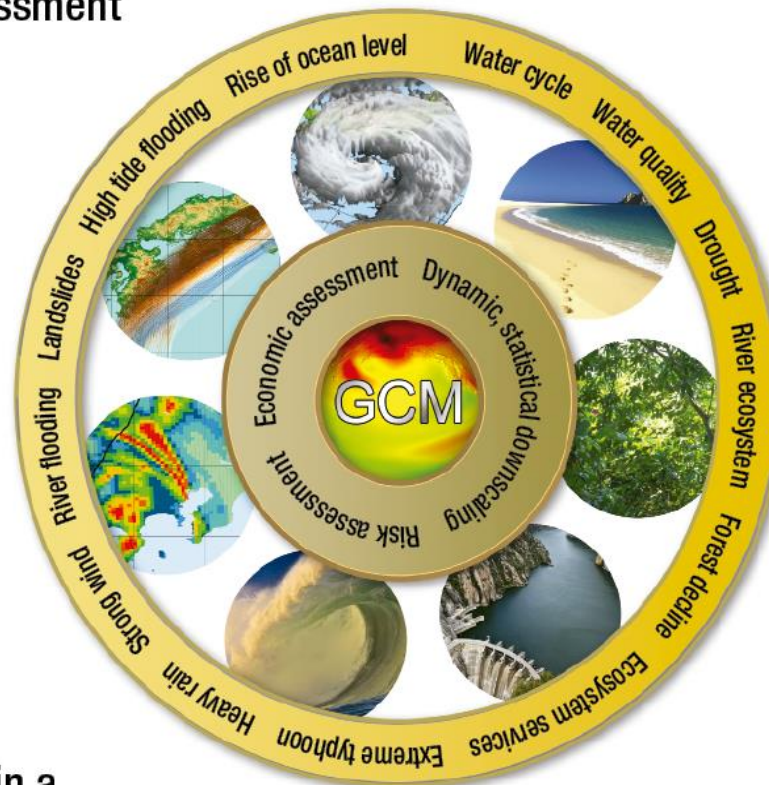


Theme D: Precise impact assessments on climate change

Prediction of changes in natural hazards and uncertainty assessment
Socio-economic assessment

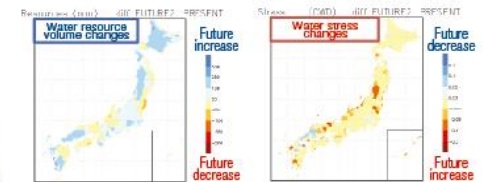


Socio-economic assessment
Prediction of natural hazards in a worst-case scenario

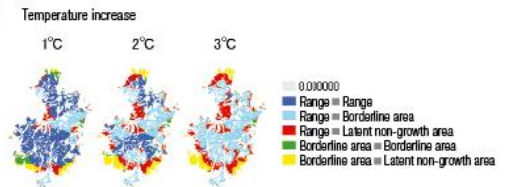


Climate change risks on water resources

Future changes in Japan's water resource volume



Temperature impact on Maries' fir tree (*Abies mariesii*)



Climate change impacts on ecosystem and biodiversity

Conclusions

- Research in climate change modeling using the **Earth Simulator** has progressed substantially through “**KYOSEI**” Project, and “**KAKUSHIN**” Program contributing to AR4 and AR5 respectively. The latter included impact assessment on natural disasters.
- “**SOUSEI**” Program just launched in 2012 and now targeting **the risk assessment** also based upon projection outcomes towards future IPCC assessments.