Projection Outcomes from KAKUSHIN towards IPCC/AR5

Japan Agency for Marine-Earth Science and Technology
Hiroki Kondo

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Innovative Program of Climate Change Projection for the 21st Century

KAKUSHIN Program *and AR5 schedule*

April 2006: Third Basic Plan for Science and Technology (FY2006-FY2010) started

Feb. 2007: *IPCC/WG1/AR4 completed*

April ------: *KAKUSHIN Program was launched*

Sept. 2008: *New IPCC Bureau elected for AR5*

July 2009: **Scoping meeting**（Drafting *AR5*）

Nov. ------: **Each WG plenary and IPCC Plenary** → *Basic AR5 structure fixed*

KAKUSHIN —— *Substantial projection experiments*

July 2010: *AR5 Writing team*（CLAs、LAs、REs) *for each WG be selected*

Nov. 2010: **First meeting of WG1/LAs**   *Informal Review*

—— *Output analysis, paper submission and acceptance*

July 2011: **Second meeting of WG1/LAs**

Expert Review

Mar. 2012: *End of KAKUSHIN Program*

April 2012: **Third meeting of WG1/LAs**

Government/Expert Review

Jan. 2013: **Fourth meeting of WG1/LAs**

Government Review

Sept. 2013: *WG1 and IPCC plenary* → *Completion of WG1/AR 5*

Sept. 2014: *IPCC Plenary* → *Completion of the whole AR5*

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Innovative Program of Climate Change Projection for the 21st Century

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using the **Earth Simulator** (ES)

- **Long-Term Global Change Projection (~2300)**
- **Near-Term Climate Prediction (20~30 years prediction)**
- **Extreme Event Projection** (Typhoons, Hurricanes, Heavy rain, etc.)
- **Cloud Resolvable Modeling**
- **Parameterization of Marine Microphysics**

Advancing Climate Modeling and Projection

Quantification and reduction of uncertainty

Application of Regional Projections to Natural Disasters

Close Coordination

Impact Assessment Studies

Model output

Contribute to IPCC AR5
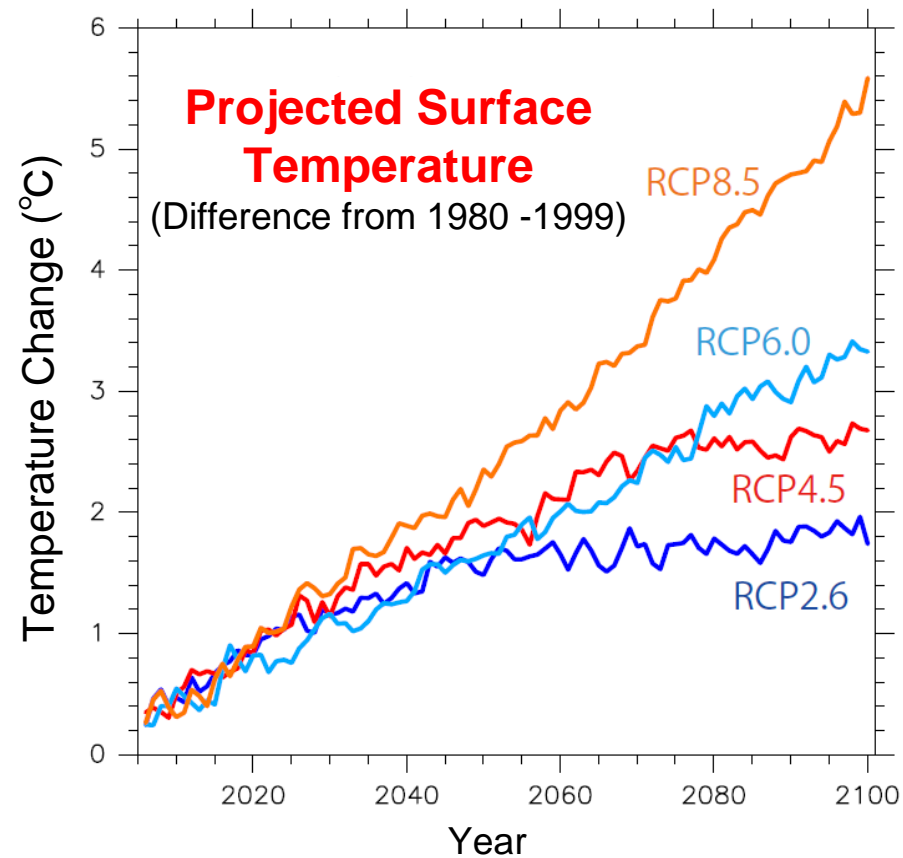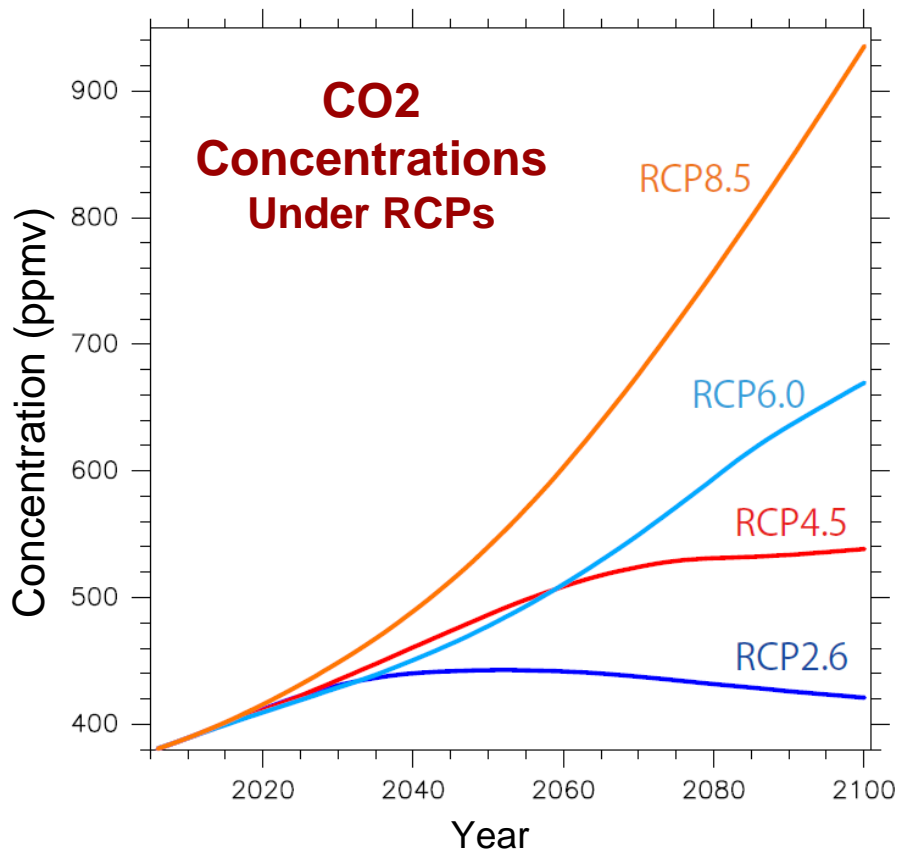**Scientific Basis for Policymakers**

Adaptation Studies

Long-Term Global Change Projection
By the Earth System Model (MIROC-ESM)

- An **Earth System Model (ESM)** has been developed by **integrating bio-geochemical process models** into a climate model (**MIROC**) and is referred to as **MIROC-ESM**.

- The **MIROC-ESM** includes, in particular, a **dynamic vegetation model** (SEIB-DGVM), where **species of vegetation compete** each other under a given climate to attain a balanced distribution.
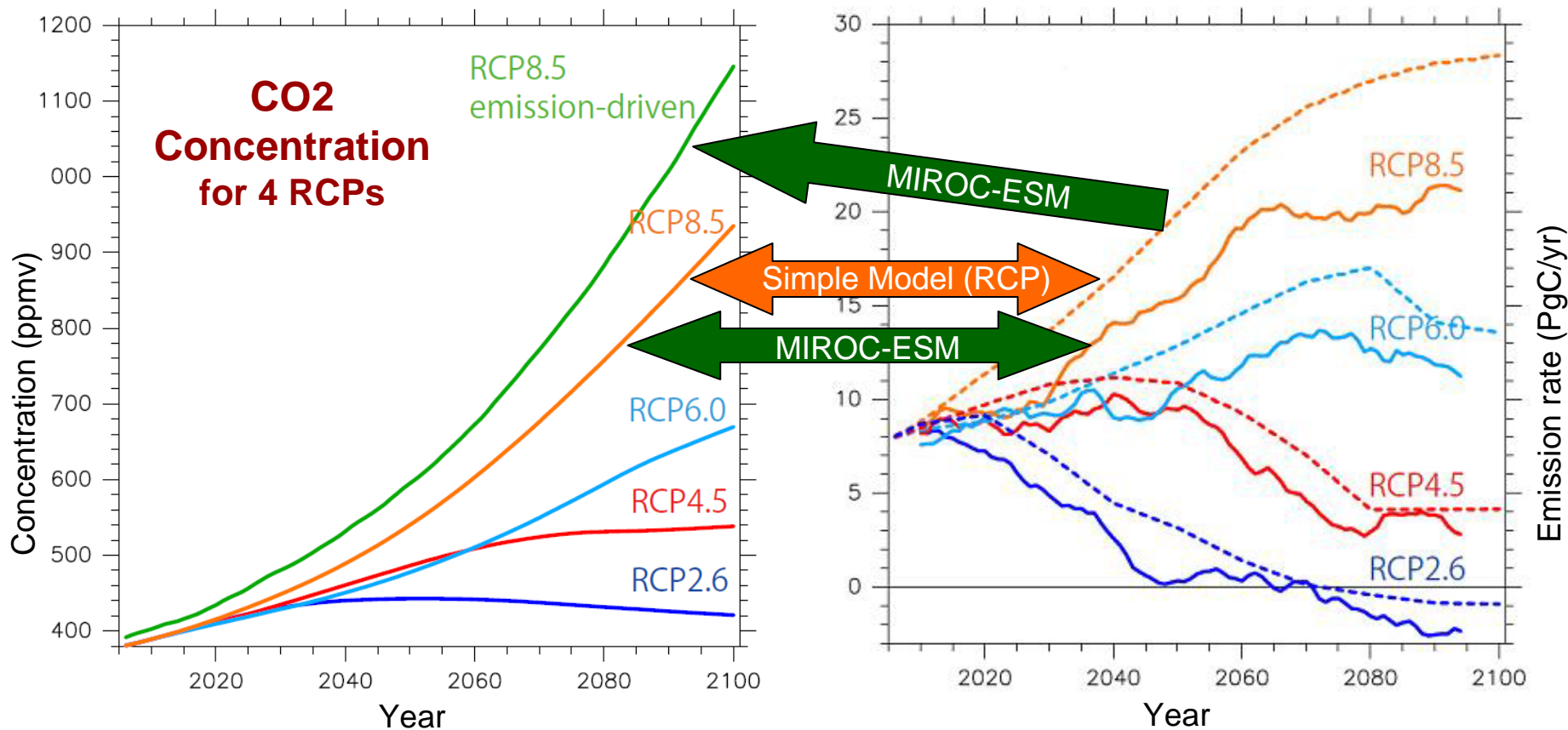
Structure of the Earth System Model (MIROC-ESM)

Bio-geochemical processes

Physical processes

Stratosphere

Atmospheric Chemistry Model

VOC H_2O

Atmospheric Model

Aerosol Model

CO_2

NOx

SO_2

Ice Sheet

Organic Compound

H_2O

Run-off

Ocean Chemistry - Ecosystem Model

Land Surface Carbon Cycle Model

Land Surface Heat – Water Circulation Model

Ocean Circulation Model

（JAMSTEC/AORI/NIES/MEXT）

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Innovative Pro
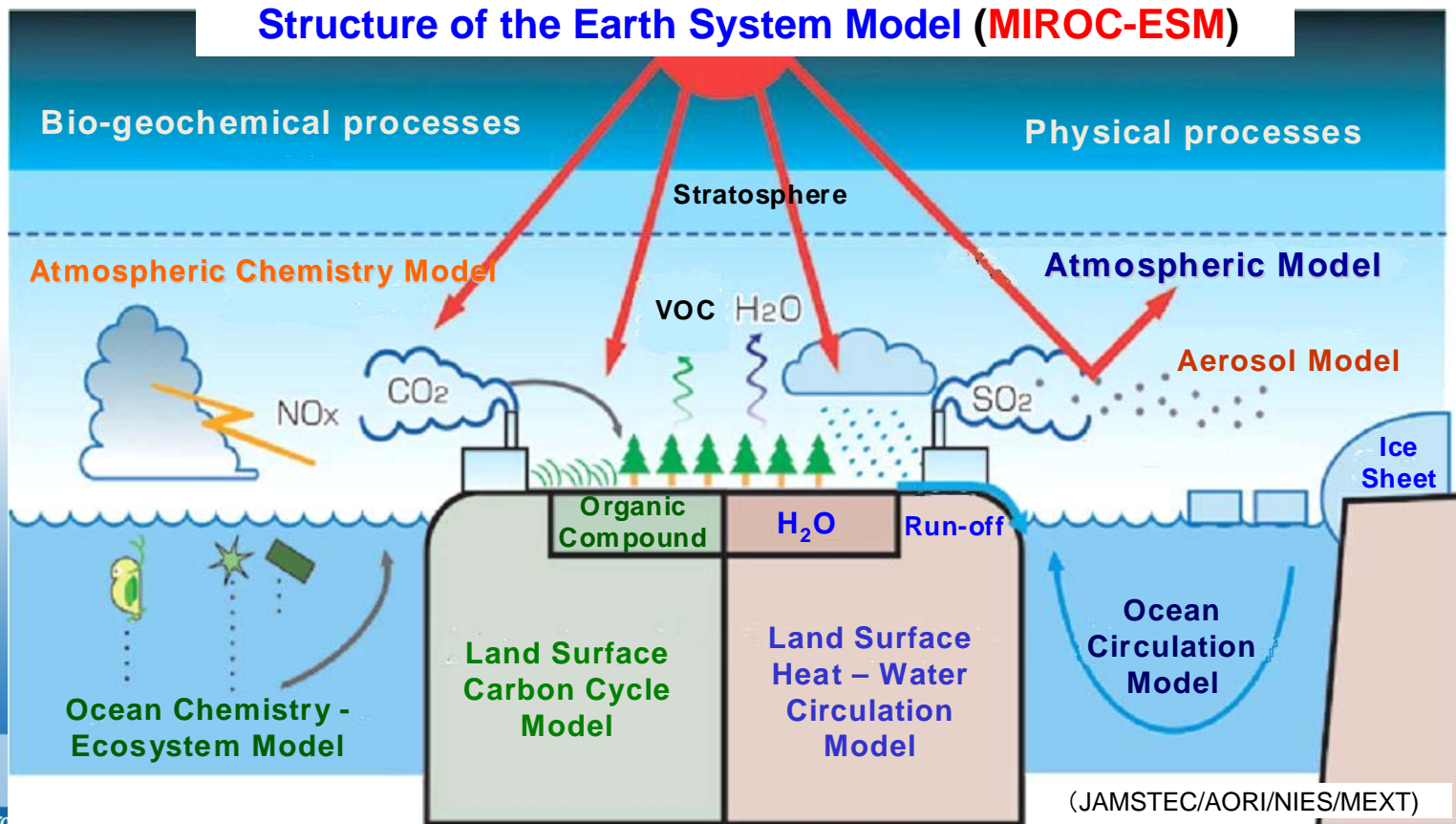
Projected **Surface Temperature Change** under RCP (MIROC-ESM)

(JAMSTEC/AORI/NIES/MEXT)

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CO₂ Emission rate from fossil fuel
estimated by MIROC-ESM as necessary to Cause RCP Concentrations

（JAMSTEC/AORI/NIES/MEXT）

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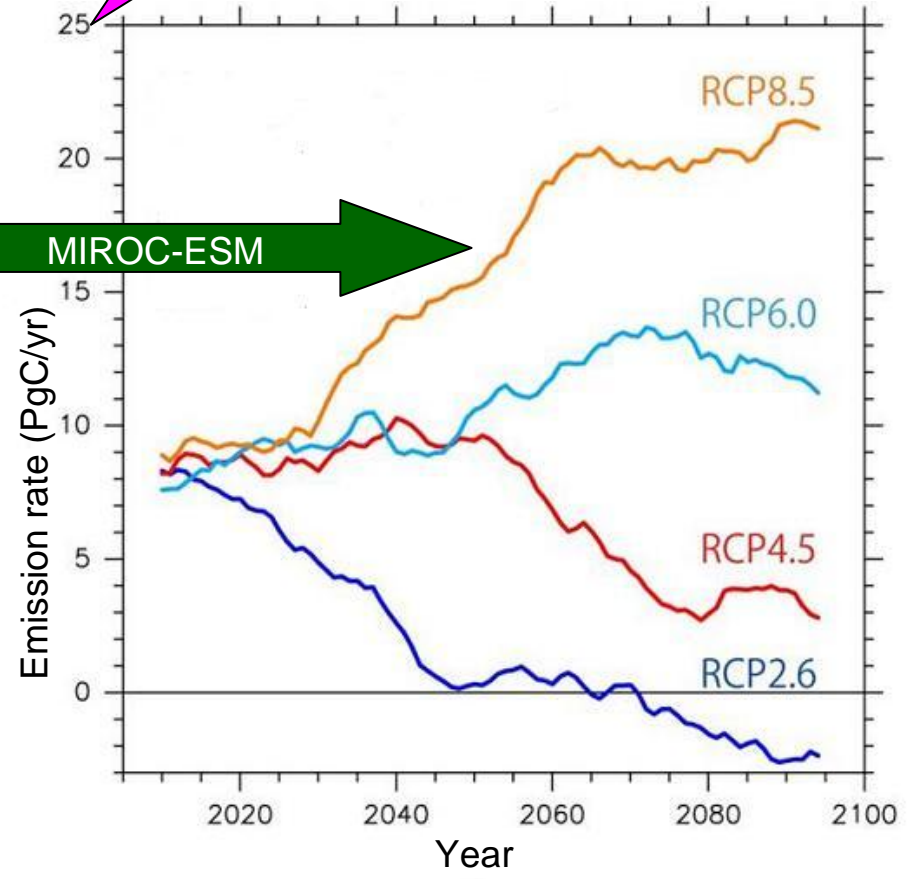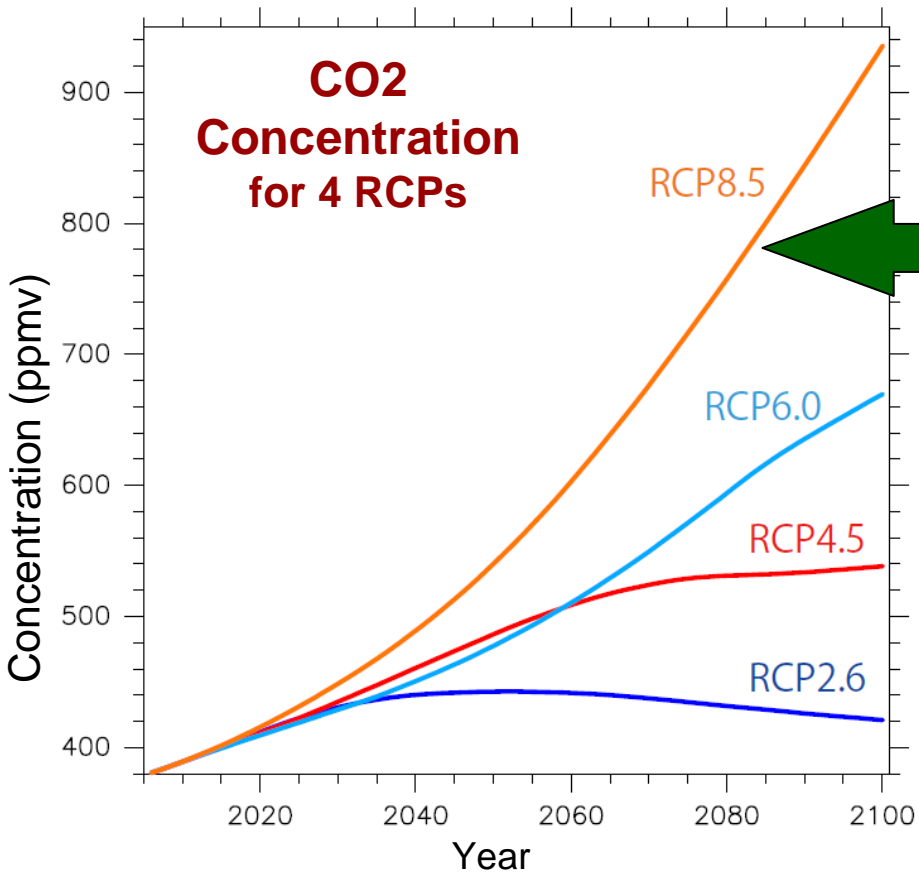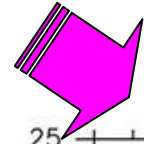
MIROC-ESM shows some different outcomes from the simple carbon cycle model for RCP with implications

CO2 Concentration for 4 RCPs

RCP8.5 emission-driven
RCP8.5
RCP6.0
RCP4.5
RCP2.6

Concentration (ppmv)

Year

MIROC-ESM

Simple Model (RCP)

MIROC-ESM

RCP8.5
RCP6.0
RCP4.5
RCP2.6

Emission rate (PgC/yr)

Year

（JAMSTEC/AORI/NIES/MEXT）

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Innovative Program of Climate Change Projection for the 21st Century

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

CO2 Concentration

RCP4.5

Projected Global Average Surface Temperature Change

Temperature difference from 1980-1999

RCP8.5

RCP6.0

RCP4.5

RCP2.6

Year

（JAMSTEC/AORI/NIES/MEXT)

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Innovative Program of Climate Change Projection for the 21st Century
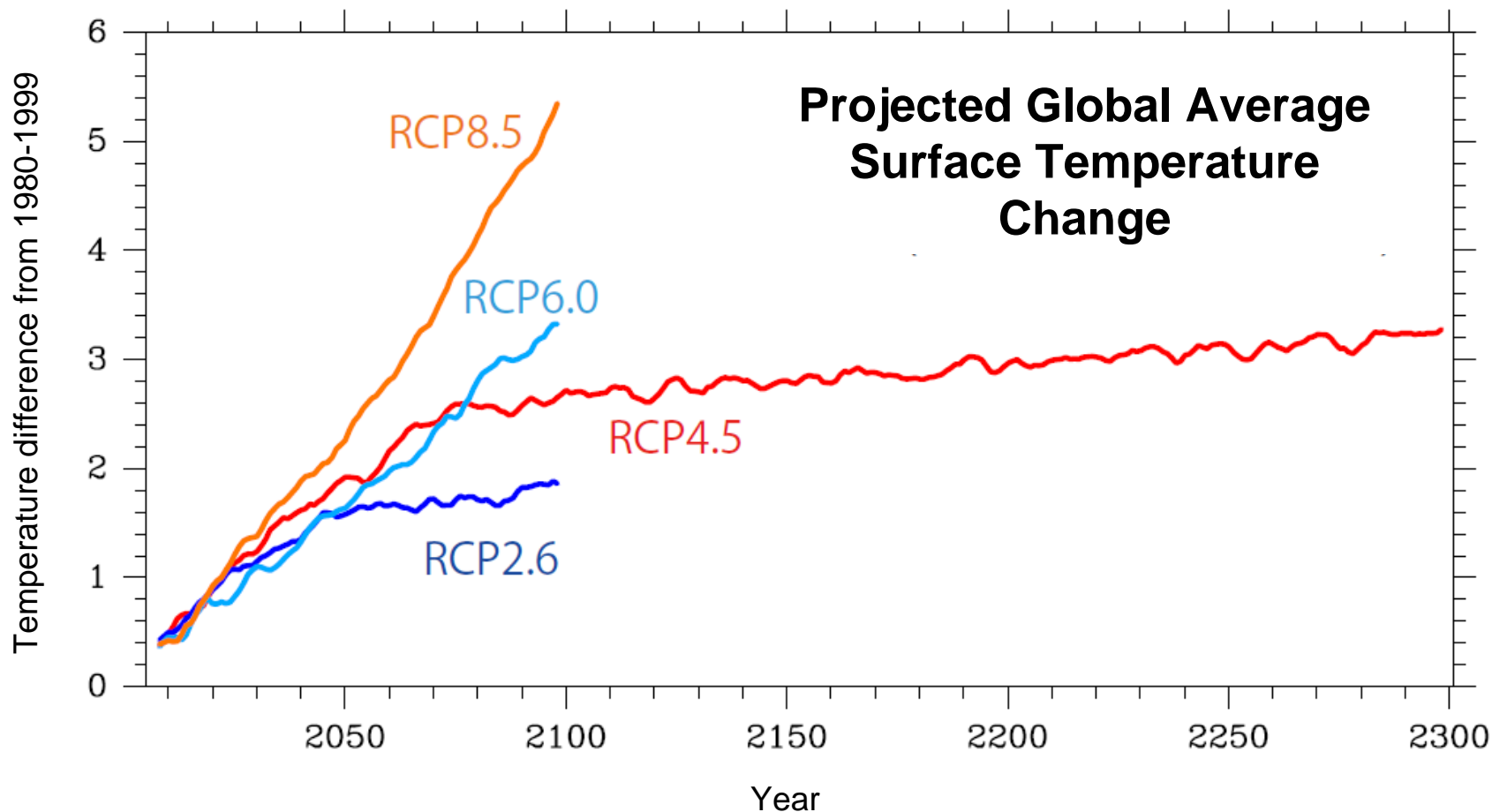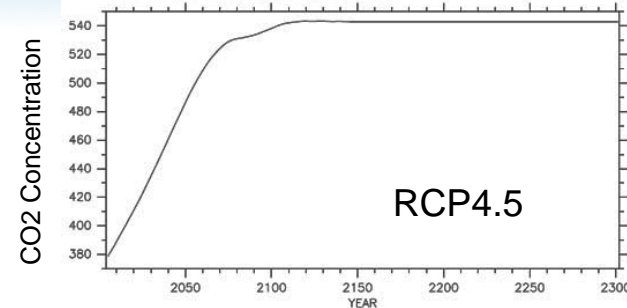
0 year

Observed vegetation distribution
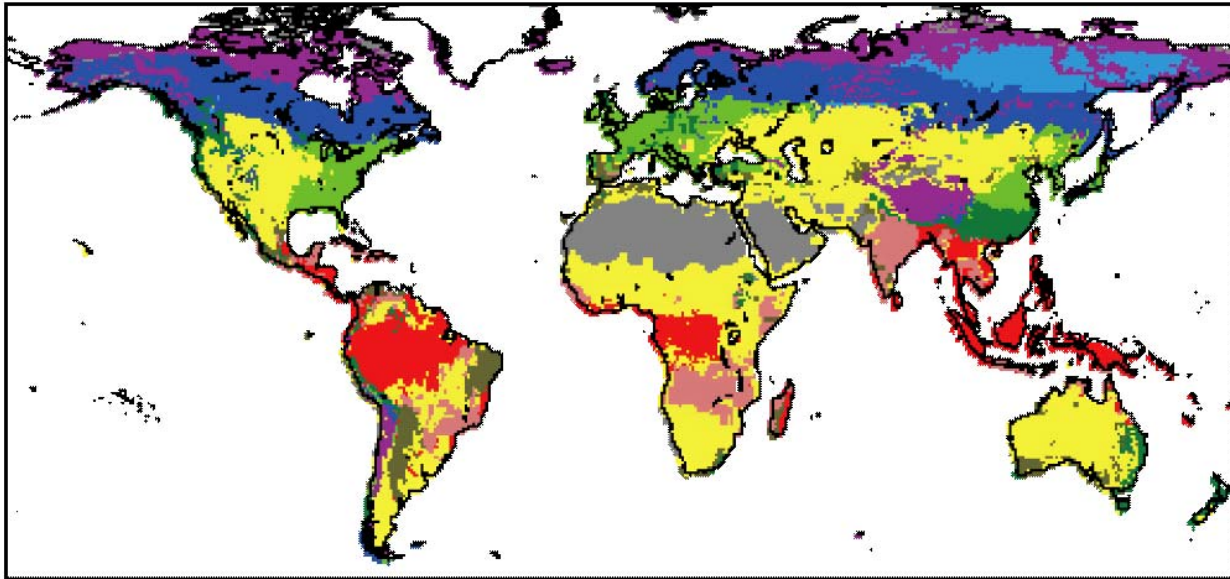
Simulated vegetation distribution

- Desert
- Tundra
- Xeric woodland/scrub
- Glassland/Savannas/Steppe
- Borealdeciduous forest
- Boreal evergreen forest
- Temperate deciduous forest
- Temperate evergreen forest
- Tropical deciduous forest
- Tropical evergreen forest
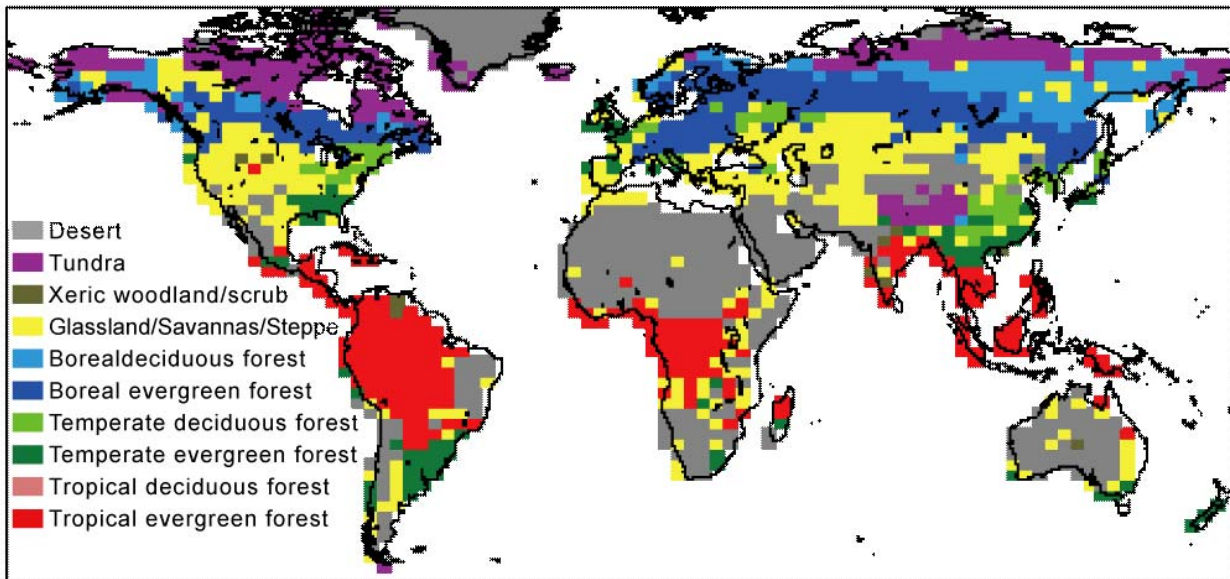
（JAMSTEC）

Projected Vegetation under RCP4.5
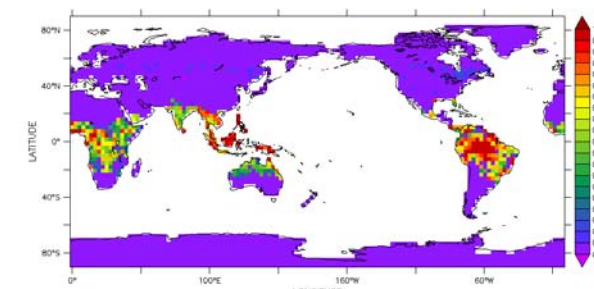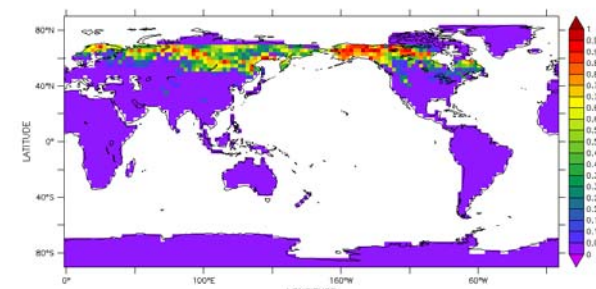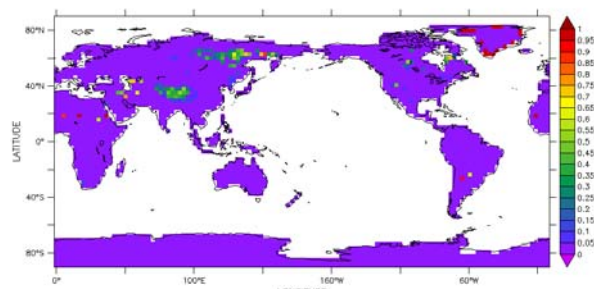
(JAMSTEC/AORI/NIES/MEXT)

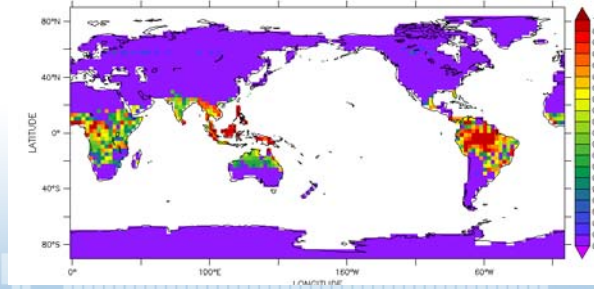| Boreal-Deciduous Forest | Boreal-Evergreen Forest | Tropical Forest |
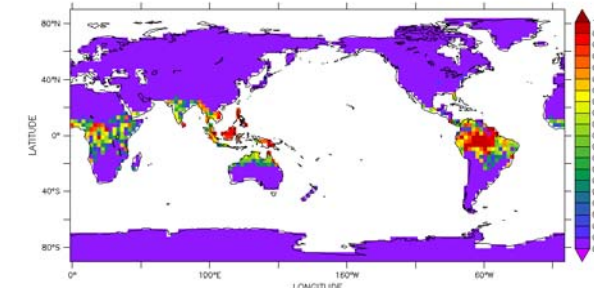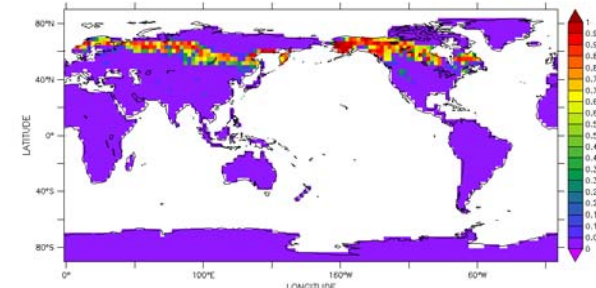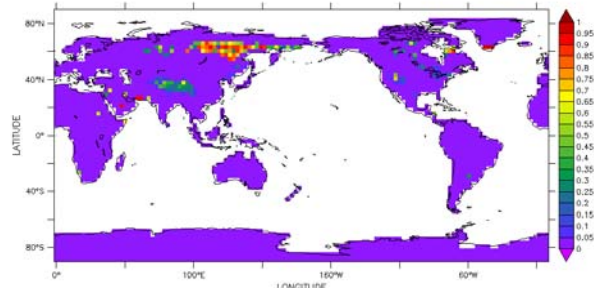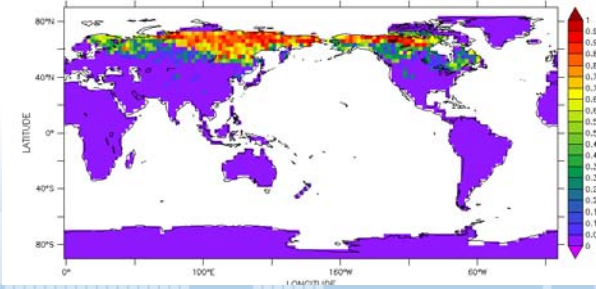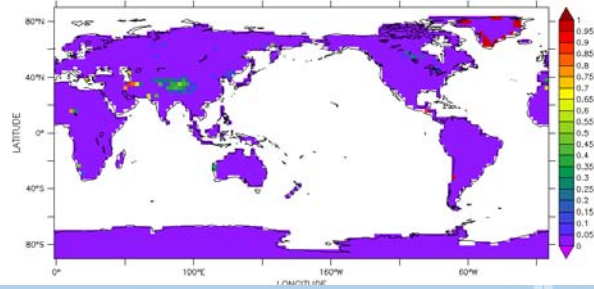
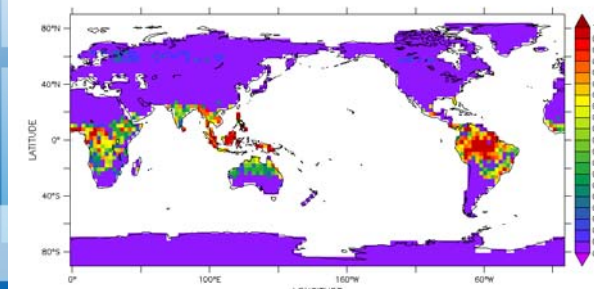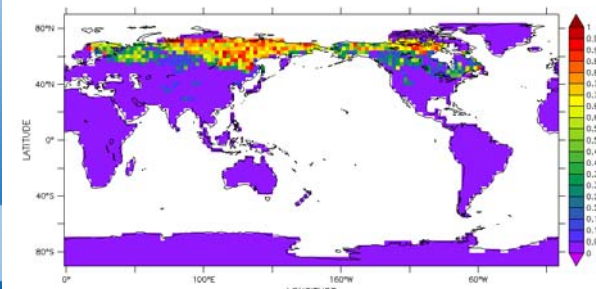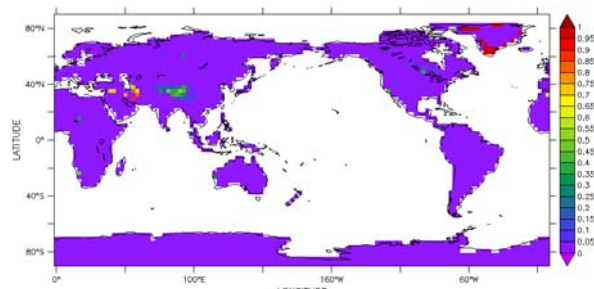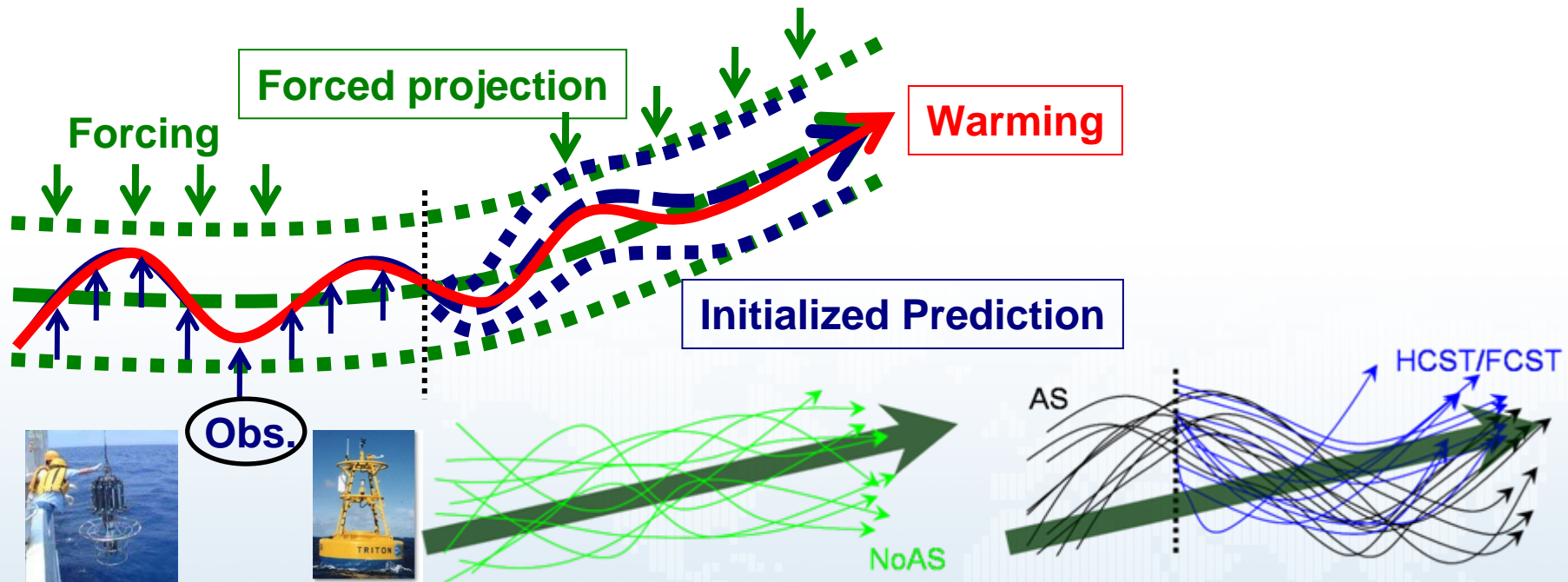# Near-term climate prediction

Near-term climate prediction experiments focused on the climate change induced by anthropogenic and natural climate variability
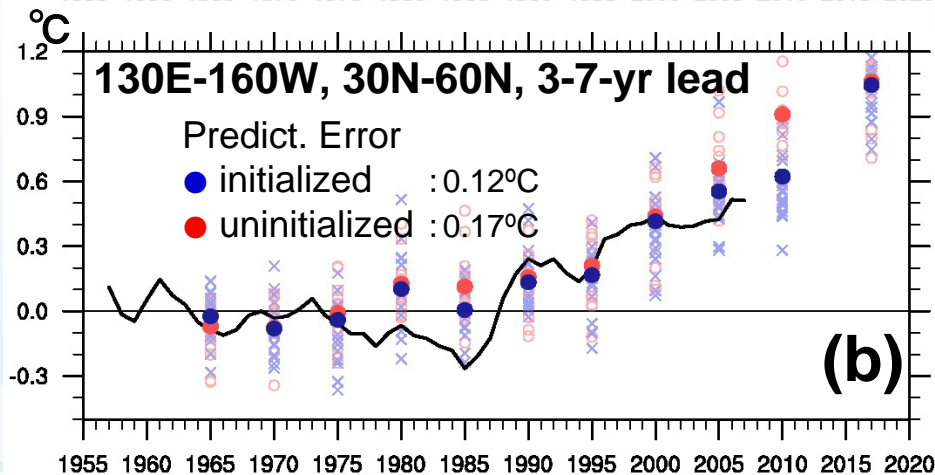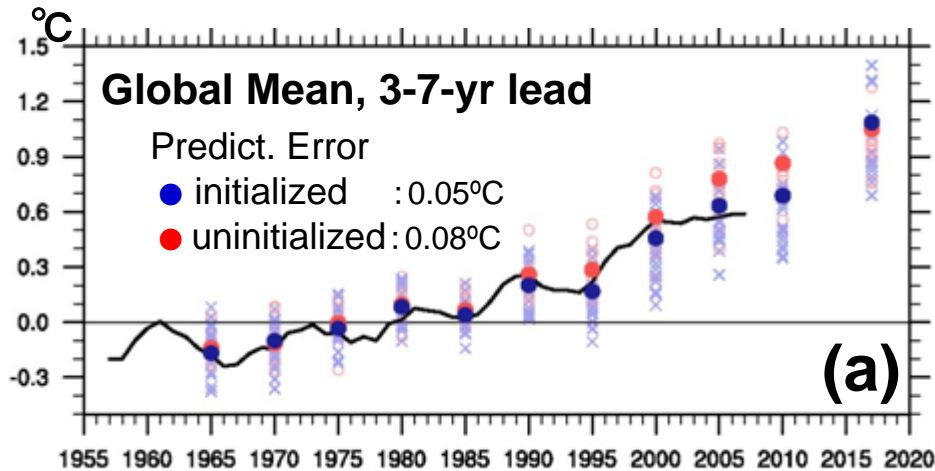
- We built a state-of-the-art **high-resolution atmosphere-ocean coupled general circulation model**, in which not only GHGs but also many climate change factors such as all kinds of aerosols are taken into account.

- An **initialization method** for the model to take into account the **observed climate variability** and an **ensemble prediction scheme** have been developed.
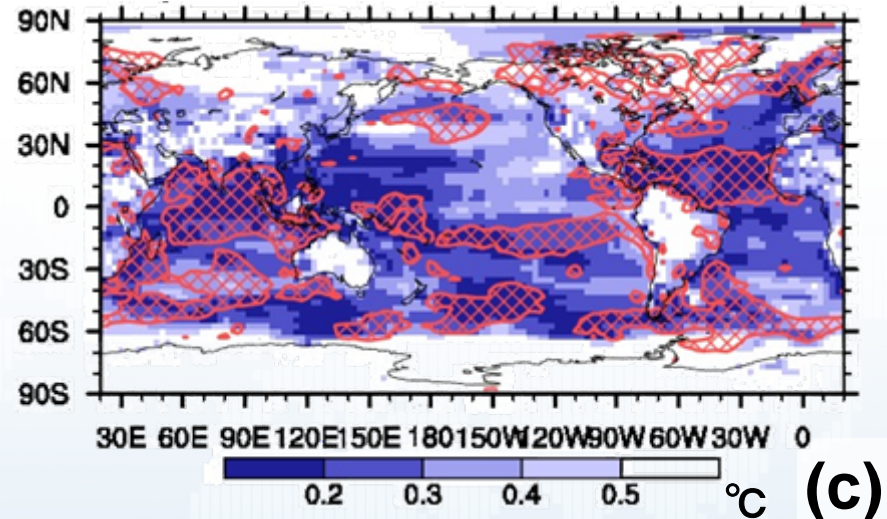
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Near-term climate prediction

The predictability in decadal climate changes

- With various prediction experiments, we found that some of decadal climate changes are **predictable for lead time more than 5 years**.

- It is indicated that **the global surface temperature will begin to increase again in coming decade**.
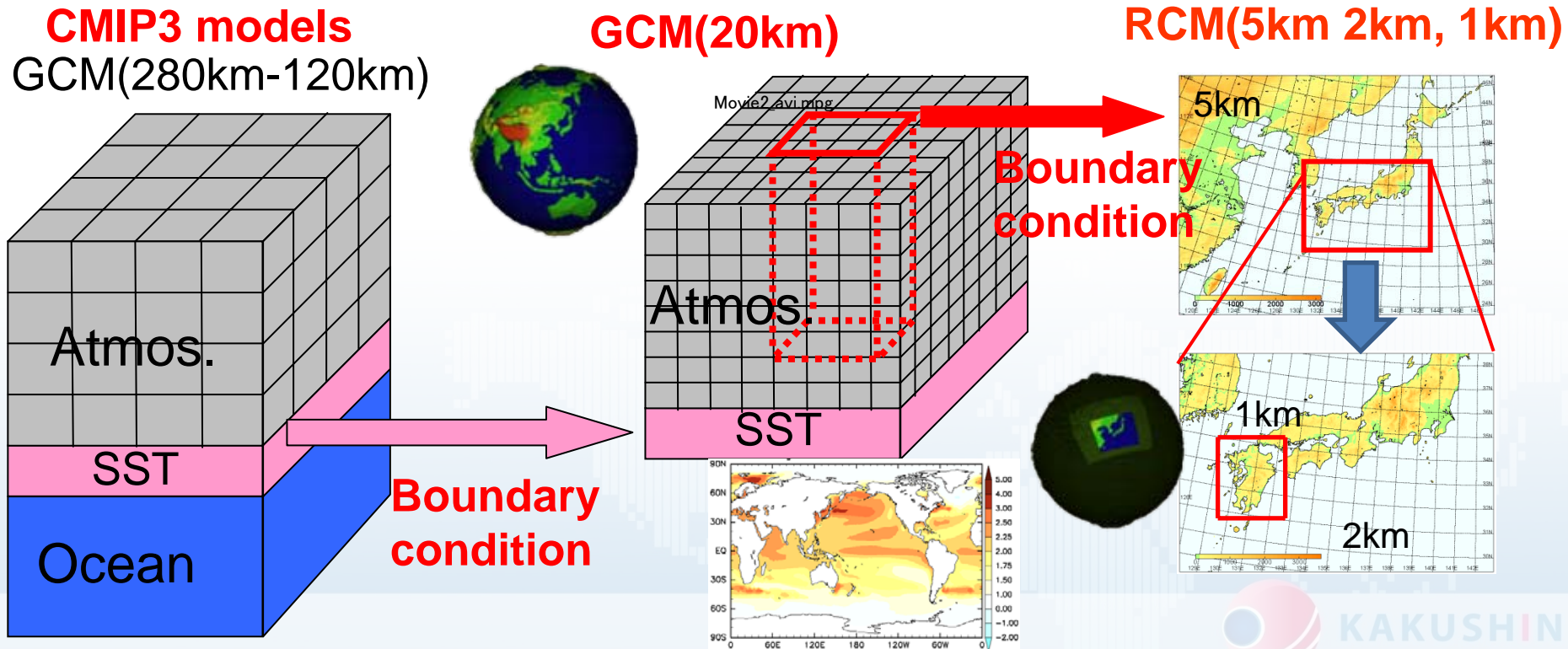

(a) Global Mean, 3-7-yr lead
Predict. Error
- initialized : 0.05°C
- uninitialized : 0.08°C

(b) 130E-160W, 30N-60N, 3-7-yr lead
Predict. Error
- initialized : 0.12°C
- uninitialized : 0.17°C

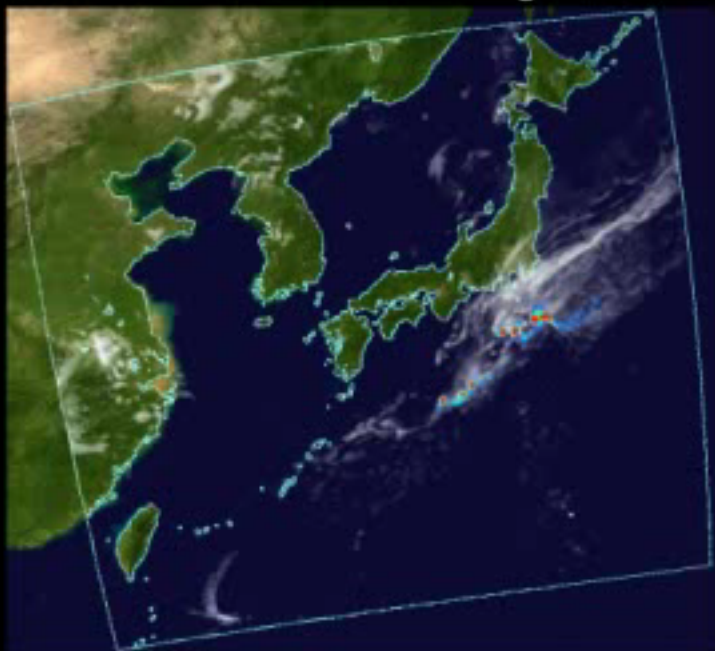(c) RMS errors of 3-7-yr-lead prediction

Extreme Event Projection

Projection of the change in future weather extremes using super-high-resolution atmospheric models
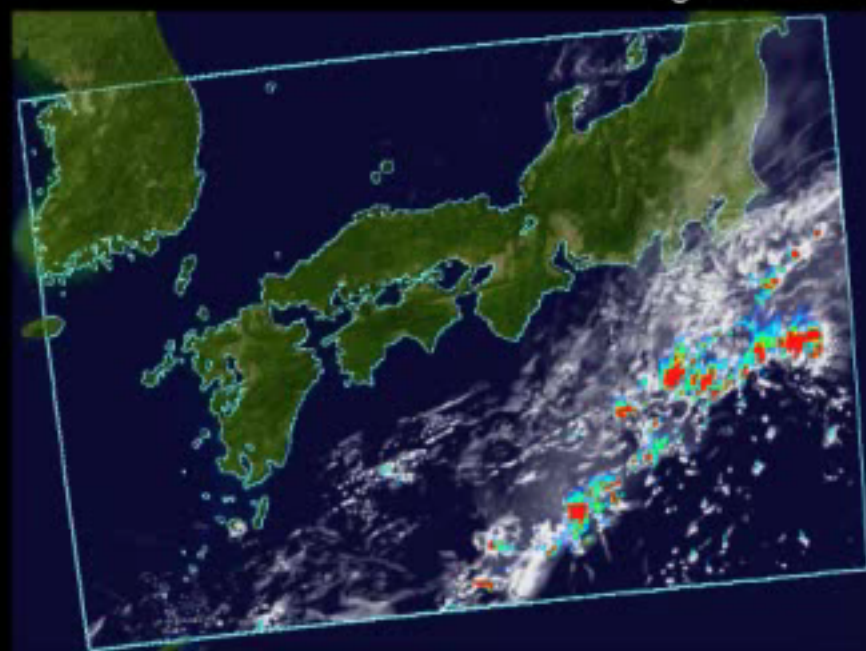
- The multi-model ensemble of sea surface temperatures (SSTs) projected by atmosphere-ocean general circulation models used in the IPCC AR4 will be input to the **global 20-km mesh atmospheric model** to obtain the future climate projection (**time-slice experiment**).

- 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**.

CMIP3 models
GCM(280km-120km)

GCM(20km)

RCM(5km 2km, 1km)

Atmos.

SST

Ocean

Boundary condition

Movie2.avi.mpg

Atmos.

SST

Boundary condition

5km

Boundary condition

1km

2km

5km Regional Model

2km Regional Model

20 km Global Model

05 Sep
208X
00 UTC

mm/hour

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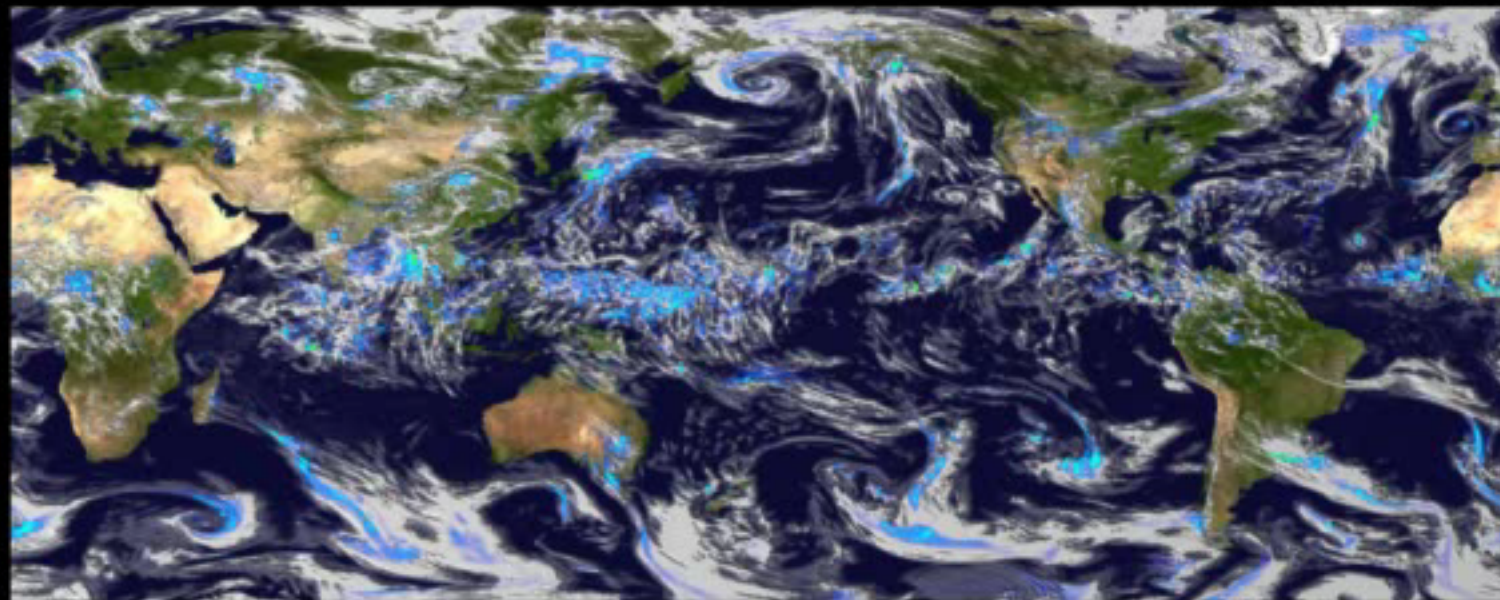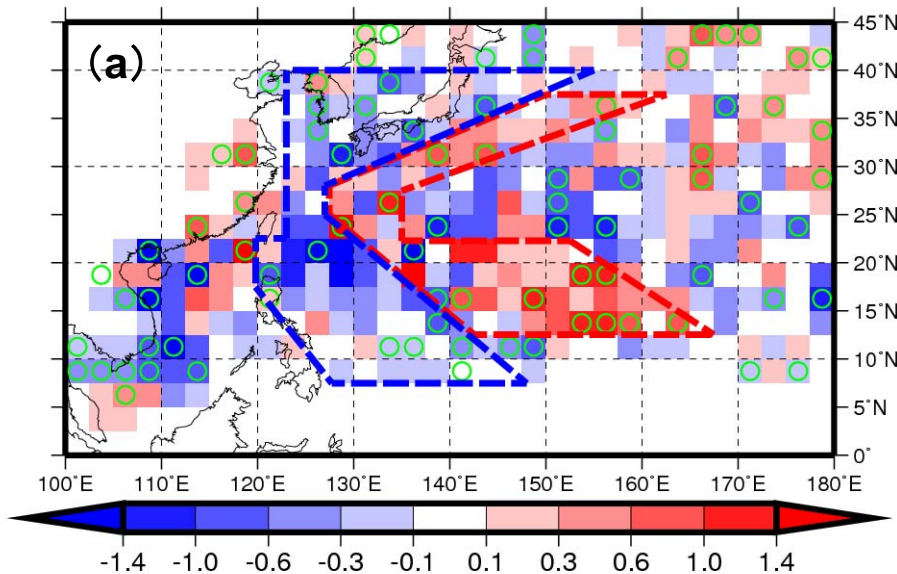
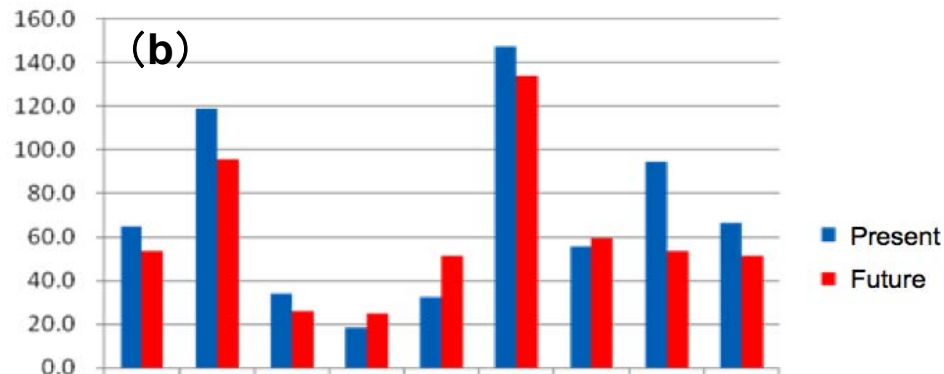# Extreme Event Projection

Typhoons approaching land

- An **eastward shift** in the positions of the two prevailing recurring TC tracks.
- Significant **increase in TC maximum** surface wind approaching coastal regions.
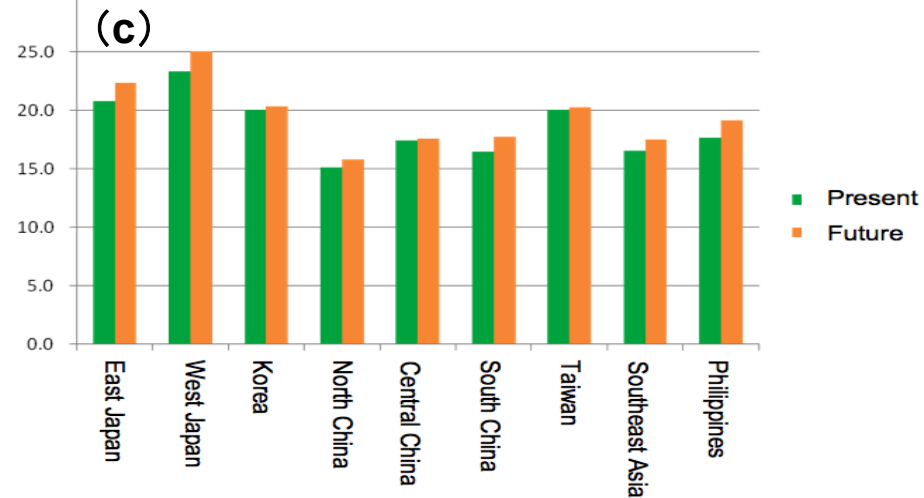
Change in TC frequency of occurrence during JASO

【2075-2099 vs 1979-2003】

Accumulated TC storm days

Maximum wind velocity

Summary(1):
Model Experiment Outcomes

- **Long-Term Climate Prediction**：
  - *CO_2 Emission rate from fossil fuel estimated by **MIROC-ESM** as necessary to cause a RCP concentration scenario is smaller that that estimated in the RCP simple model and is almost zero at the middle of the 21st century.*
  - *Most **boreal-deciduous forests** transform into **boreal-evergreen forests** in 300 years under RCP4.5, while most tropical forests remain the same.*

- **Near-Term Climate Prediction**：
  - *According to various prediction experiments, some of **decadal climate changes** have been found to be predictable for lead time of more than 5 years.*

- **Extreme Event Projection**：
  - *An eastward shift of **typhoon tracks** and an increase in maximum surface wind velocity approaching coastal regions are projected for the future.*
  - *The regional model simulates more **realistic structure of heavy rainfall** and provide detail information applicable to regional impact and adaptation studies*

- **Contribution to CMIP5**：
  - *Experiment results following the **CMIP5** protocol will be distributed through the CMIP5 servers.*

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Summary (2)

Some Implications (emerging challenges) of KAKUSHIN Outcomes

- **New findings** could provides scientific basis for both adaptation and mitigation.

- **Risk management** against **climate extremes** needs **substantial dialogue** between research communities and policy makers.

- **Further quantitative studies** are needed to contribute to stability issues, particularly for low carbon society.

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