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# Climate Modeling for Adaptation to Climate Change in Asia

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#### multi models



# JJA Tsa & precip change

Summer precipitation is likely to increase in northern Asia, East and South Asia and most of Southeast Asia, but it is likely to decrease in central Asia.

An increase in the frequency of intense precipitation events in parts of South Asia, and in East Asia, is very likely.

IPCC WGI AR4 Ch11

#### multi models

#### Asian monsoon precip time series



Figure 1. Time series of simulated JJA precipitation (9year running mean) in millimeters per day, averaged for  $eq.-30^{\circ}N$ ,  $60^{\circ}-100^{\circ}E$ . Dashed line denotes observed JJA rainfall from 1981 to 2000.

Increase in area-mean Asian monsoon rainfall, but with considerably different magnitude in their basic state in 1981-2000

Ueda et al. (2006) GRL

**IPCC AR4** 



# Projected changes in extremes

Intensity of precipitation events is projected to increase.

Even in areas where mean precipitation decreases, precipitation intensity is projected to increase but there would be longer periods between rainfall events.

Extremes will have more impact than changes in mean climate

## Research needs and issues to be addressed

 Better simulation of physical and biogeochemical processes sufficiently reflecting feedbacks
 Advancing climate modeling and projection

Addressing uncertainties in climate model projection
 *Quantification and reduction of uncertainty*

 Impact assessment on natural disasters by extreme events through sufficiently high resolution projection
 Application of regional projection to natural disasters Innovative Program of Climate Change Projection for the 21st century (KAKUSHIN Program)

# KAKUSHIN



#### **Program structure**



#### Participating groups and their studies

- Long-term global environmental projection with an earth system model
  - Frontier Research Center for Global Change (FRCGC) et al.
- Near-term climate prediction with a high-resolution coupled ocean-atmosphere GCM
   Center for Climate System Research (CCSR) of the University of Tokyo et al.
- Projection of changes in extremes in the future with super-high-resolution atmospheric models
- Meteorological Research Institute (MRI) et al.

http://www.kakushin21.jp/eng/index.html



Vsfc=6.7(1010-PS)0.644

MEXT Kyo-sei Project (FY2002-2006) and KAKUSHIN Program (FY2007-2011) using the Earth Simulator by MRI/JMA/AESTO

It is *likely* that future tropical cyclones will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures.

There is *less confidence* in projections of a global decrease in numbers of tropical cyclones. [IPCC AR4]

# Present-day climate validation

resolution dependencyneeds for reliable data

#### In forecast mode

the observations.

## Typhoon track and intensity: 60km vs 20km



# JJA Precipitation

Model evaluation is a <sup>20</sup> must, but there is always uncertainty in . the observations -> we need to evaluate climate models against multiple available observations



#### Performance of the Model for Reproduction of Precipitation Extremes



Simulated extremes indices are in good agreement with that of the observations

Model: 20-year mean Obs : 7-year mean from 1998 to 2003

# **Future Climate**

# 20-km & 60-km mesh model

# **Baiu (June) Precipitation**



# JJA APrecip: 60-km vs 20-km



20-km mesh model is expensive, hard to run many cases, and thus hard to say about uncertainty of the results
60-km mesh model can be used to assess statistical significance of regional climate changes

## DJF ∆Precip: 60-km vs 20-km



# Indian summer monsoon rainfall



Rajendran and Kitoh (2008) Curr Sci

# Heavy rainfall days



Rajendran and Kitoh (2008) Curr Sci

#### Sample tropical cyclone track and max surface winds

Present

#### **Future**



Wind Profile Change(at max wind speed)



Murakami and Kitoh (2008) submitted to JCLI

# Application

# **Annual Riverflow**

20-km model: Present

Future - Present



### Flood Risk Map

#### **ICHARM/PWRI**



## Potential Hazard in Global Warming Environment

Maximum surface wind

#### **Sea-level pressure** Sea-level Pressure 2096 Aug 22th 11:00 110° 120° 130° 140° 150° 160° 60° 50 50° 40° 40° 30° 30° 20° 20° 10° 10° ٥° 120° 130° 140° 150° 160° 110°









DPRI / Kyoto-Univ.

## **Cooperation activities of the MRI group**

(by **Earth Simulator** computed model outputs for adaptation studies)

Cooperation under the JICA (Japan International Cooperation Agency) funds

> Adaptation studies in agriculture in Argentina: Argentina (three, 2008)

Adaptation studies in monsoon Asia: Bangladesh, Indonesia, Philippines, Thailand, Vietnam (one each, 2008 & 2009)

#### **Cooperation under the World Bank funds**

- Adaptation study in Coastal Zones of Caribbean countries: Barbados(one, 2005), Belize (one, 2005)
- Adaptation studies in Colombian coastal areas, high mountain ecosystems: Colombia (two, 2005; two, 2009?)
- Adaptation to Climate Impacts in the Coastal Wetlands of the Gulf of Mexico: Mexico (two, 2006; two, 2009?)
- Adaptation to Rapid Glacier Retreat in the Tropical Andes: Peru (one, 2006; one, 2009?), Ecuador (one, 2006), Bolivia (one, 2006)
- > Amázon Diebaćk: Brazil (two, 2008)

Other collaborations with India, Korea, Thailand, USA, ...

#### Projection of Indonesian rainfall change at the end of the 21st century



# Other activity

- Earth system model for CO2 stabilization scenarios
- 5-km scale downscaling for Japan

# CCSR/NIES/FRCGC Earth System Model (ESM)





Also T85 without chemistry?

# Computer simulation for $CO_2$ Stabilization (1)

Projection of temperature change under stabilization scenarios using an earth system model



# Computer simulation for $CO_2$ Stabilization (2)

# Carbon Sinks and anthropogenic emission pathways under stabilization scenario



## Projection of climate change around Japan



Model

Detailed

Orographic

Effects



# Heavy rainfall in Japan in Baiu season





# Summary

- Resolution of climate models becomes finer; now we can use 60-km or even 20km mesh global climate models
- High resolution model is needed to better represent weather extremes and tropical cyclones
- Resolution and ensemble is an issue
- Capacity development for adaptation to climate change: needs for training to understand characteristics of modeling