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# An Overview of the KAKUSHIN Team-3 "Projection of the Change in Future Weather Extremes using Super-High-Resolution Atmospheric Models

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# IPCC AR4 to AR5:

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)

### **Program structure**



# KAKUSHIN

### 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.

- Meteorological Research Institute (MRI) et al.

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



### Projection of the Change in Weather Extremes Using Super-High-Resolution Atmospheric Models in the KAKUSHIN Program





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#### KAKUSHIN Team 3

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



- Assessment of climate-change impacts on flood risk
  - and its reduction measures on global and local scales

深見 ational Centre for Water Hazard and Risk Management (ICHARM),

Public Works Research Institute (PWRI)

# Needs for high resolution models for adaptation studies

- representation of topography depends on resolution (land-sea distribution, mountain height, snowrain threshold, ...)
- low resolution models often fail to reproduce precipitation systems such as tropical cyclones, stationary front systems and blocking
- high resolution models have better mean climate





## JMA Numerical Analysis and Prediction System

### **Global Spectral Model**

 $T_L^{959L60}$  ( ~20km )



### MesoScale Model

5km Non-hydrostatic model



Typhoon Ensemble One-Week Ensemble  $T_L319L60$  ( ~60km ) 11members  $T_L319L60$  ( ~60km ) 51members

### 20-km mesh AGCM as the highest resolution climate model



# Indian summer monsoon rainfall



#### Rajendran and Kitoh (2008) Current Science

# Time-slice experiments: 20km/60km

- JMA : Operational global NWP model from Nov 2007
- MRI : Next generation climate model
- Resolution: TL959(20km)/TL319(60km) with 60 layers
- Time integration: Semi-Lagrangian Scheme (Yoshimura, 2004)
- Cumulus convection: Prognostic Arakawa-Schubert
- Three time periods
  - Present (1979-2003), Near future (2015-2039), Future (2075-2099)





no significance test for 20-km model



#### **Typhoon Genesis Number**



reduction in TC genesis number

### **GPI (EI Nino minus La Nina)**

#### observation



### **TC occurrence**



An eastward shift in the position of the two prevailing northward recurving TC tracks during the peak TC season (July-October) Note: El Nino like SST changes prescribed

Frequency of tropical cyclone occurrence [number per season] Murakami et al. (2010 in press) J Climate

# AGCM-60km

# 1872-2099 run 3 members

analysis is done based on one member in the following figures

# Boundary condition and Forcings

Period	1872-2000	2001-2005	2006-2099
SST Sea ice	HadISST		HadISST+CMIP3 Multi- model ensemble, A1B
See ice thickness	Observed climatology Bourke and Garrett (1987)		CMIP3 Multi-model ensemble, A1B
Greenhouse Gas	CO2,CH4,N2O,CFC Observation	CO2,CH4,N2O,CFC A1B	
Aerosol	MRI-ESM, 5-year, A1B - Volcanic eruption: Oct 1986 - Present - Before1970: 1969-1973 average - After 2097: 2092-2096 average		
Ozone O3	MRI-CCM CCMVal, 5-year, A1B - Before1960: 1959-1963 average		

Consistent with 20-km model time-slice experiment for global warming projection





20'00

20'60

90 <del>|</del> 1900



### 55 year observed precipitation in Japan



APHRO

#### Japan

## Pentad 30-year mean precipitation



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# Further downscaling

### **Kakushin Team-Extremes Time-Slice Experiments**



AGCM/NHM are climate model versions of the JMA operational NWP models

### Changes in pdf/cdf of precipitation (Jun-Oct)



Near-future: No change in daily precipitation Increase of strong hourly precipitation →increase of short-term strong rain End 21c: Increase of strong both of daily and hourly precipitation daily 40% increase for > 150mm/day hourly 60% increase for > 50mm/hour



# Summary

- Global 20-km and 60-km mesh AGCMs are used to project future changes in weather extremes
- Over South Asia, both the heavy precipitation and the length of dry season will increase at the end of the 21st century
- 5-km & 2-km mesh NHRCM is used to downscale the 20-km AGCM results
- Strong hourly precipitation will increase even in the near future
- AGCM-20km data will be submitted to CMIP5