

18th AP Seminar (Hanoi, Vietnam, 2-3 March 2009)

Introduction to the Earth Simulator:
Supporting Science –based Adaptation
in Developing Countries

Hiroki Kondo

Frontier Research Center for Global Change
Japan Agency for Marine-Earth Science and Technology
Yokohama, Japan

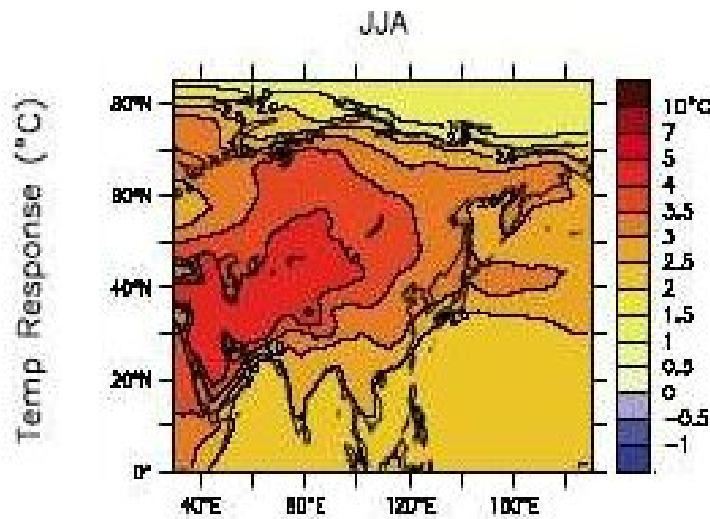
IPCC WGI AR4 Ch11:

JJA Tsa & Precip change by multi models

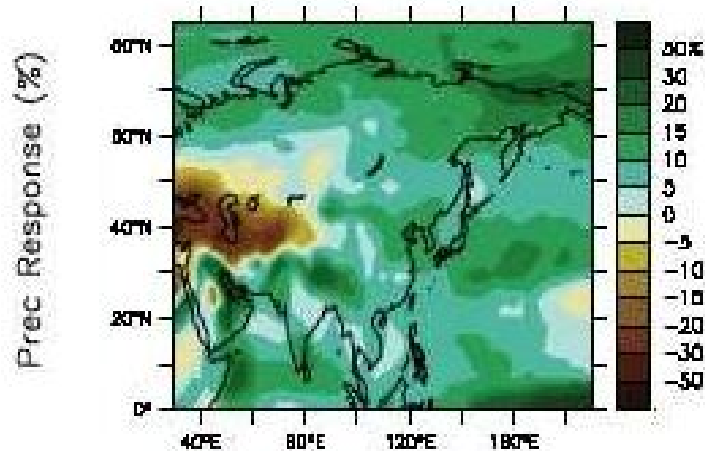
Summer precipitation is *likely* to increase in northern Asia, East and South Asia and most of Southeast Asia, but it is *likely* to decrease in central Asia.

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

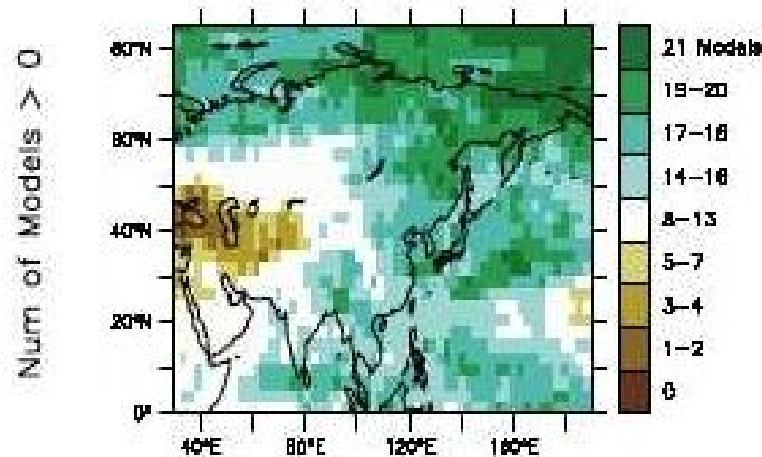
ΔT



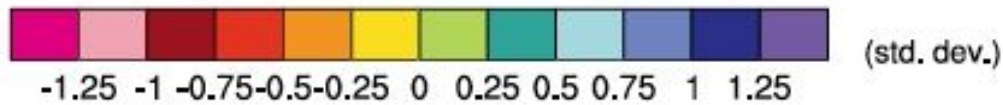
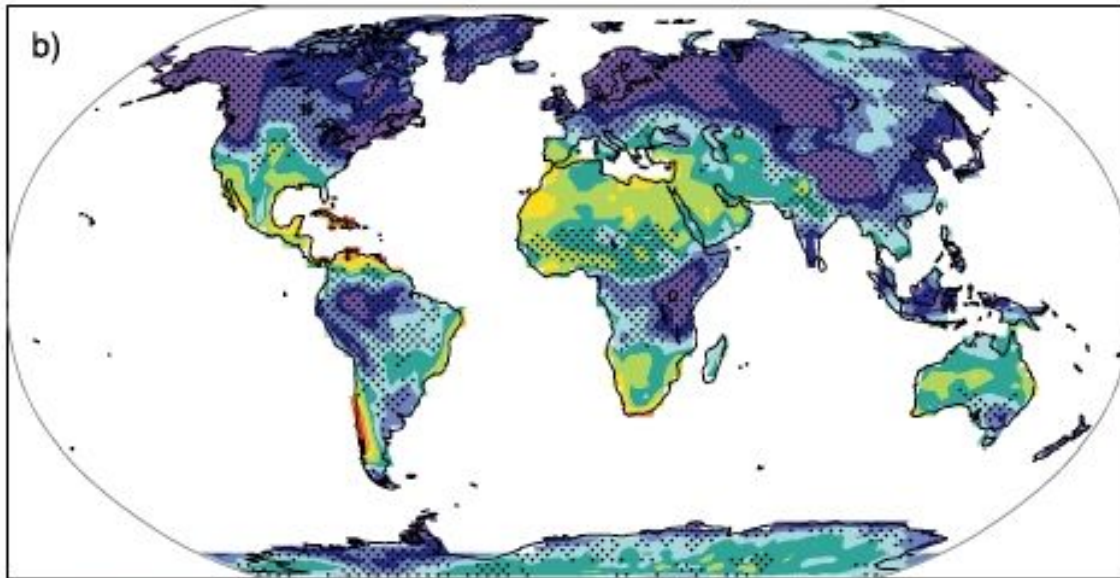
$\Delta Prec$



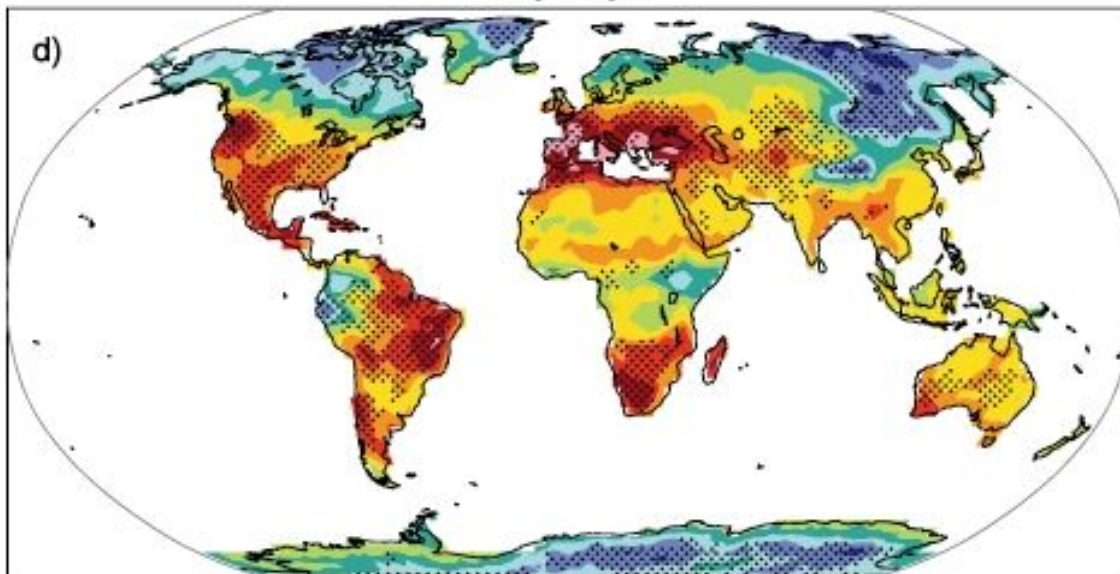
of models > 0



Precipitation intensity



Dry days



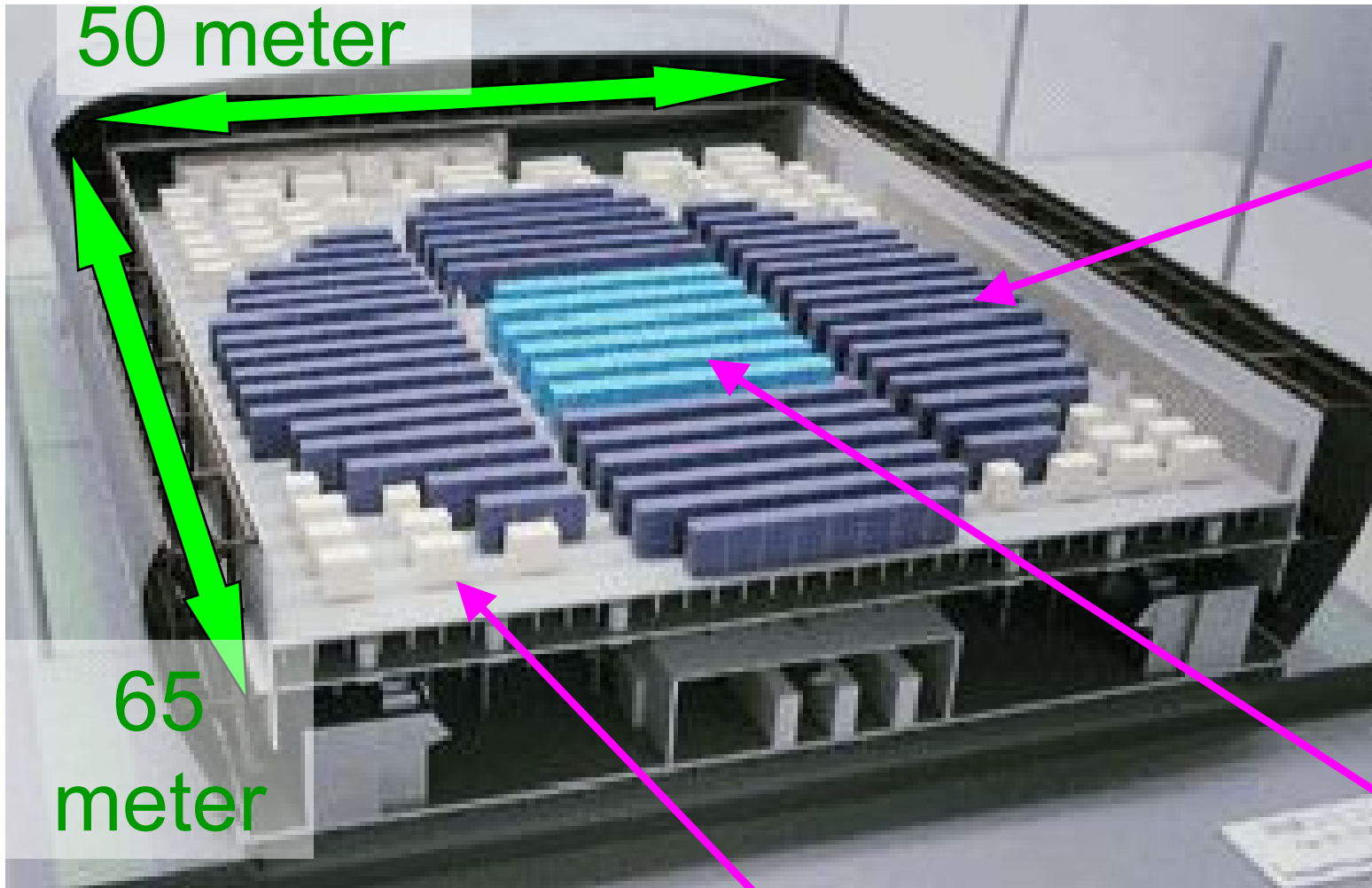
Projected changes in extremes

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

The Earth Simulator (ES)



Node (8 CPU)



Crossbar switch

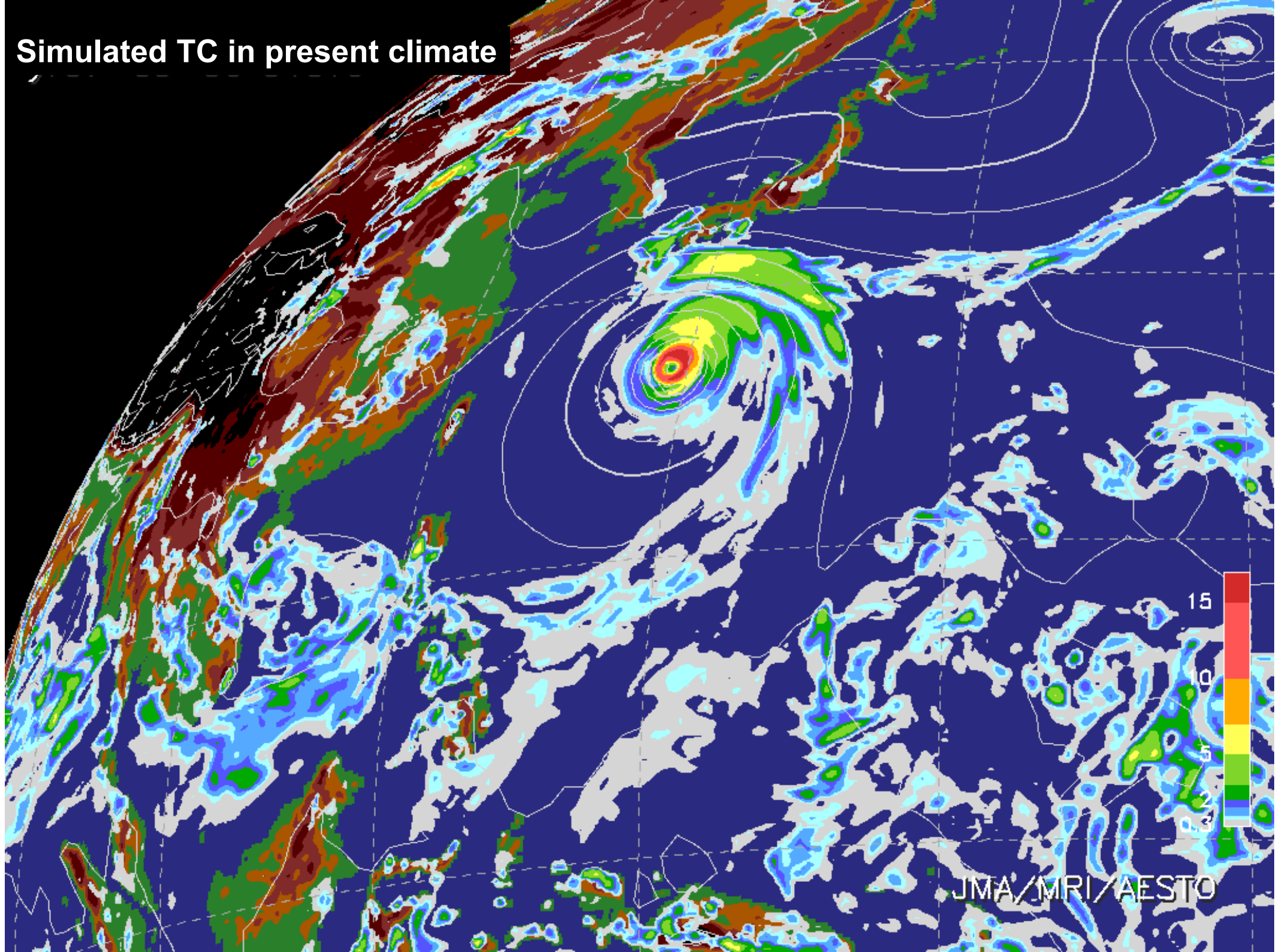
Nodes: 640, CPUs: 5120 Magnetic Disks

Peak Performance: **40 Teraflops**

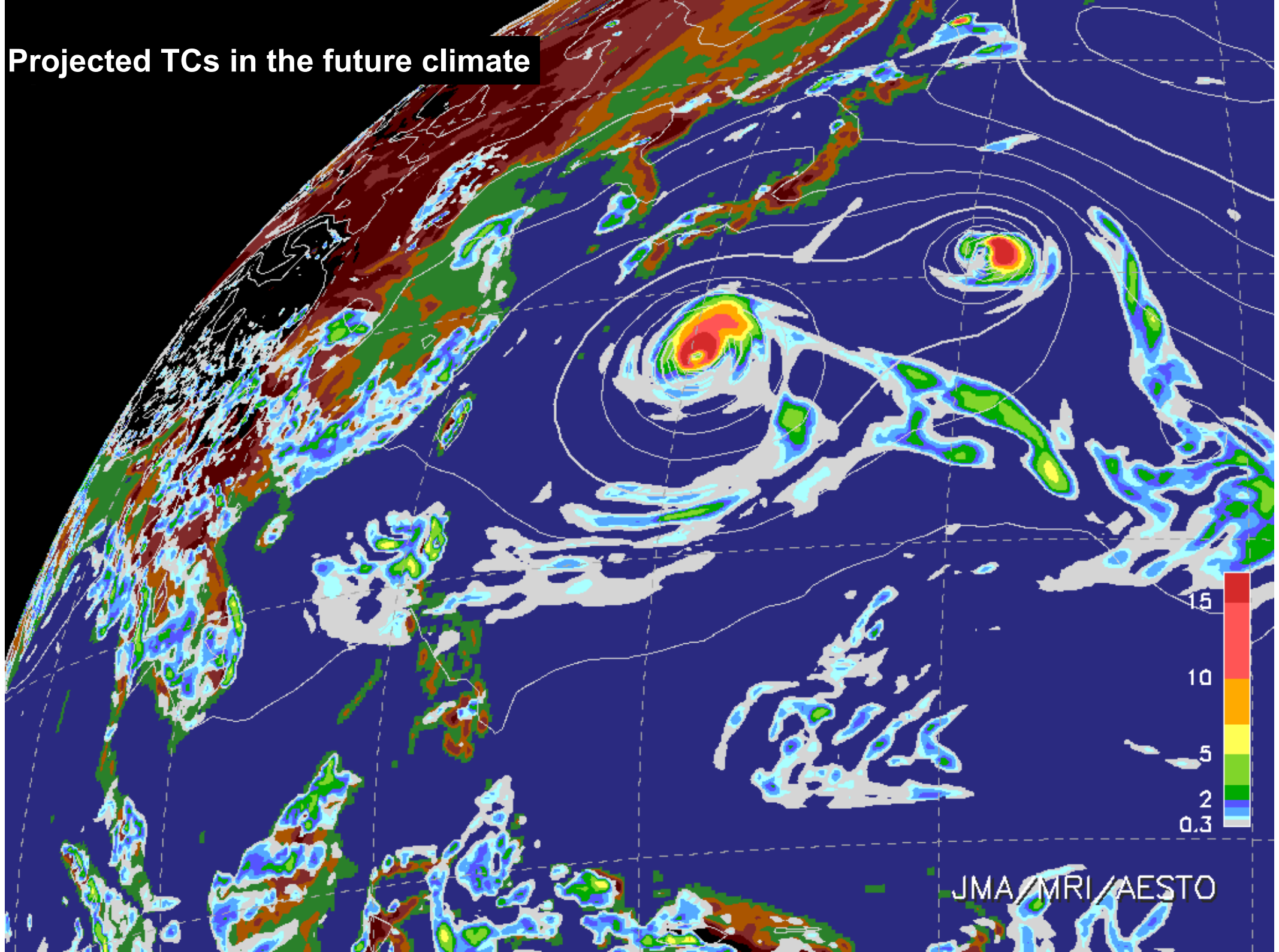


*Being updated to 130 Teraflops in **ES2***

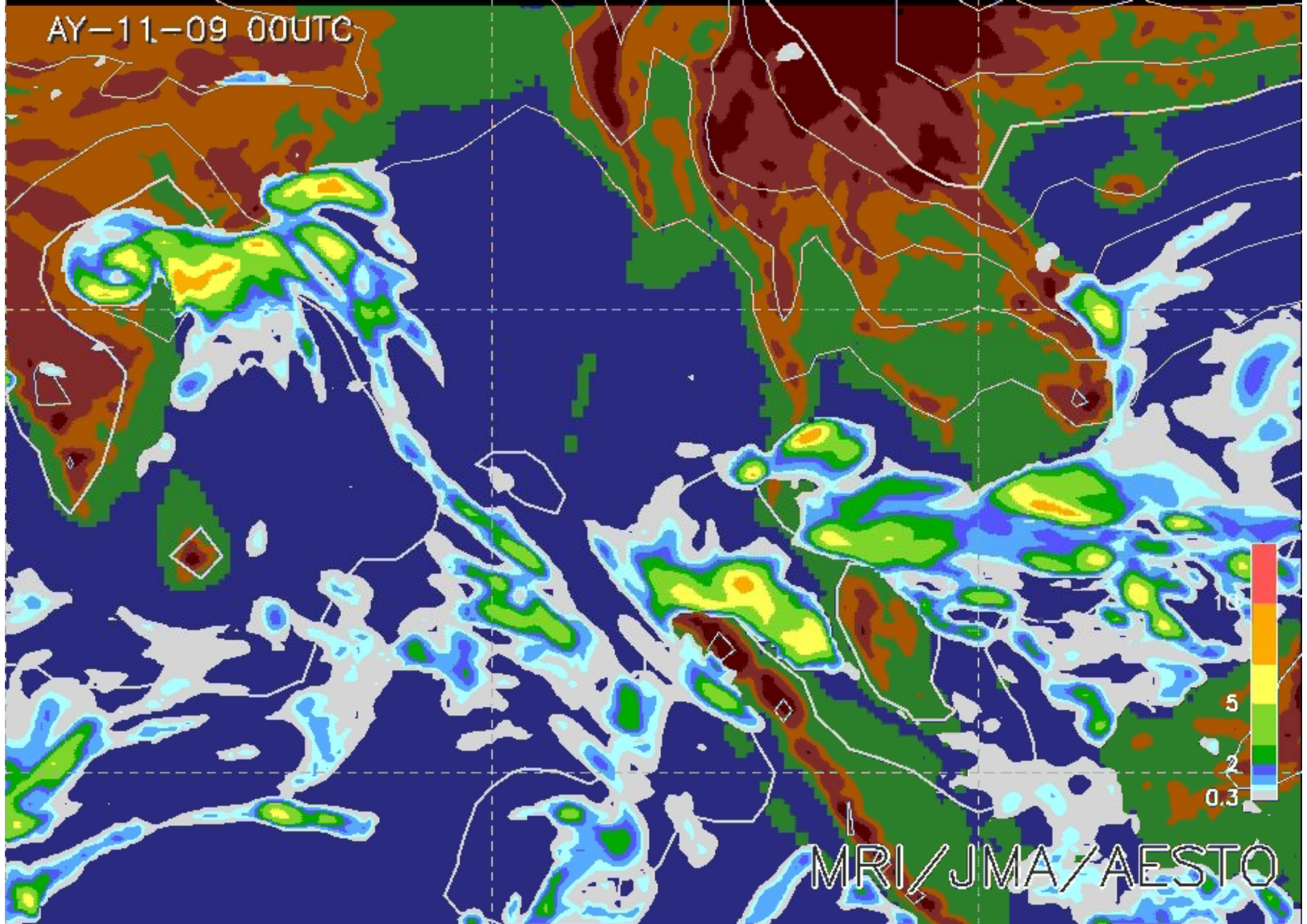
Simulated TC in present climate



Projected TCs in the future climate

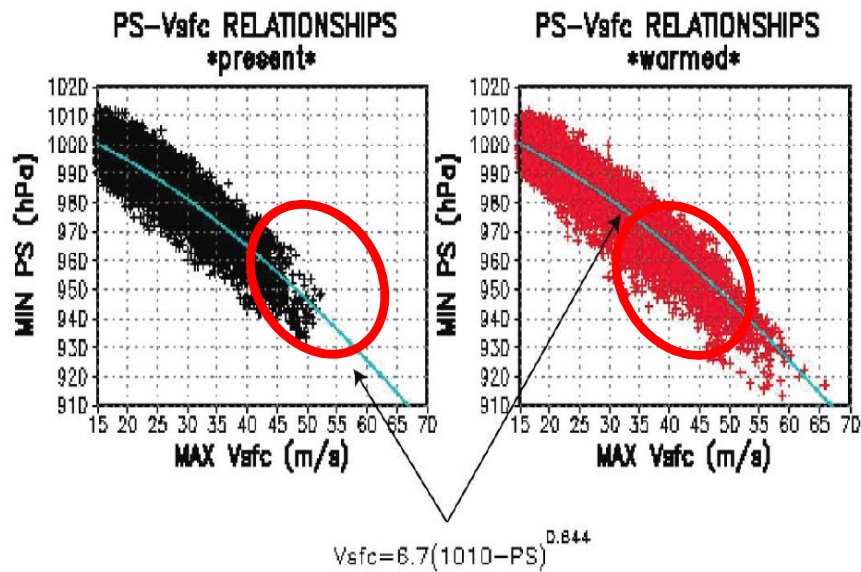


AY-11-09 00UTC



A projected case of TC in the future climate (an early stage) (MEXT/KAKUSHIN)

Tropical cyclones

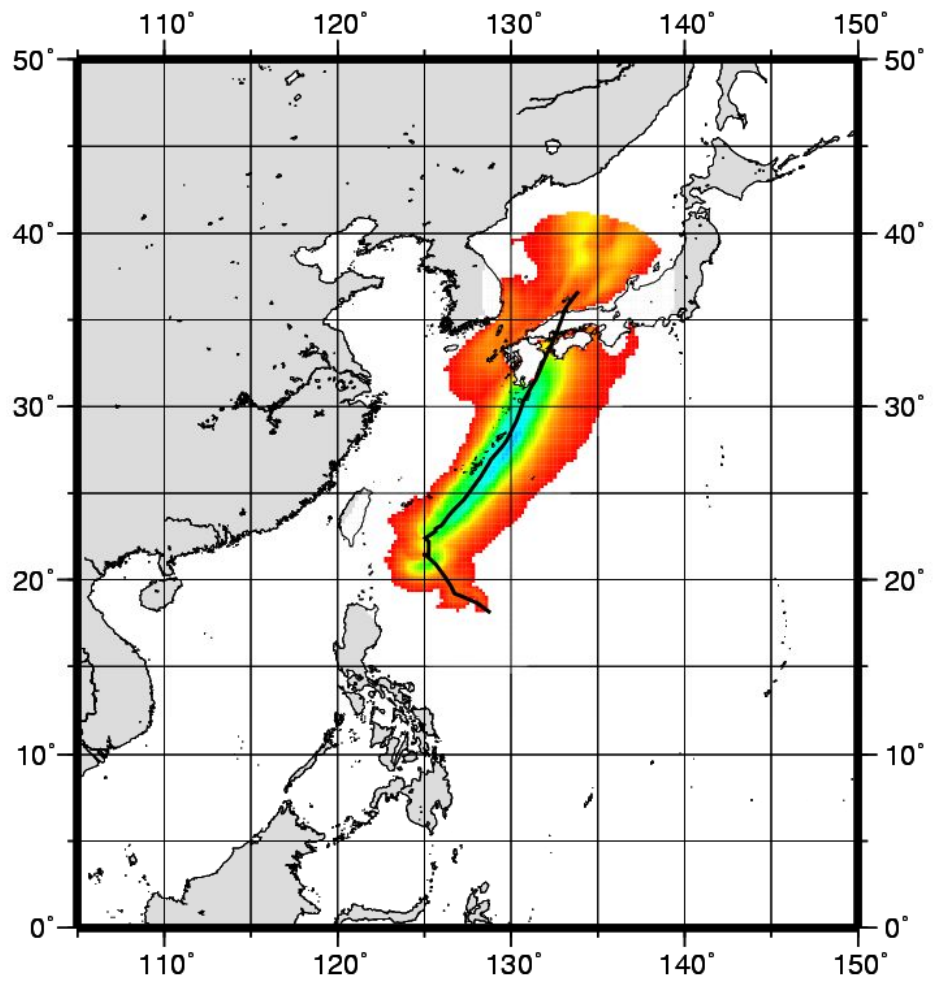


It is *likely* that future tropical cyclones will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures.

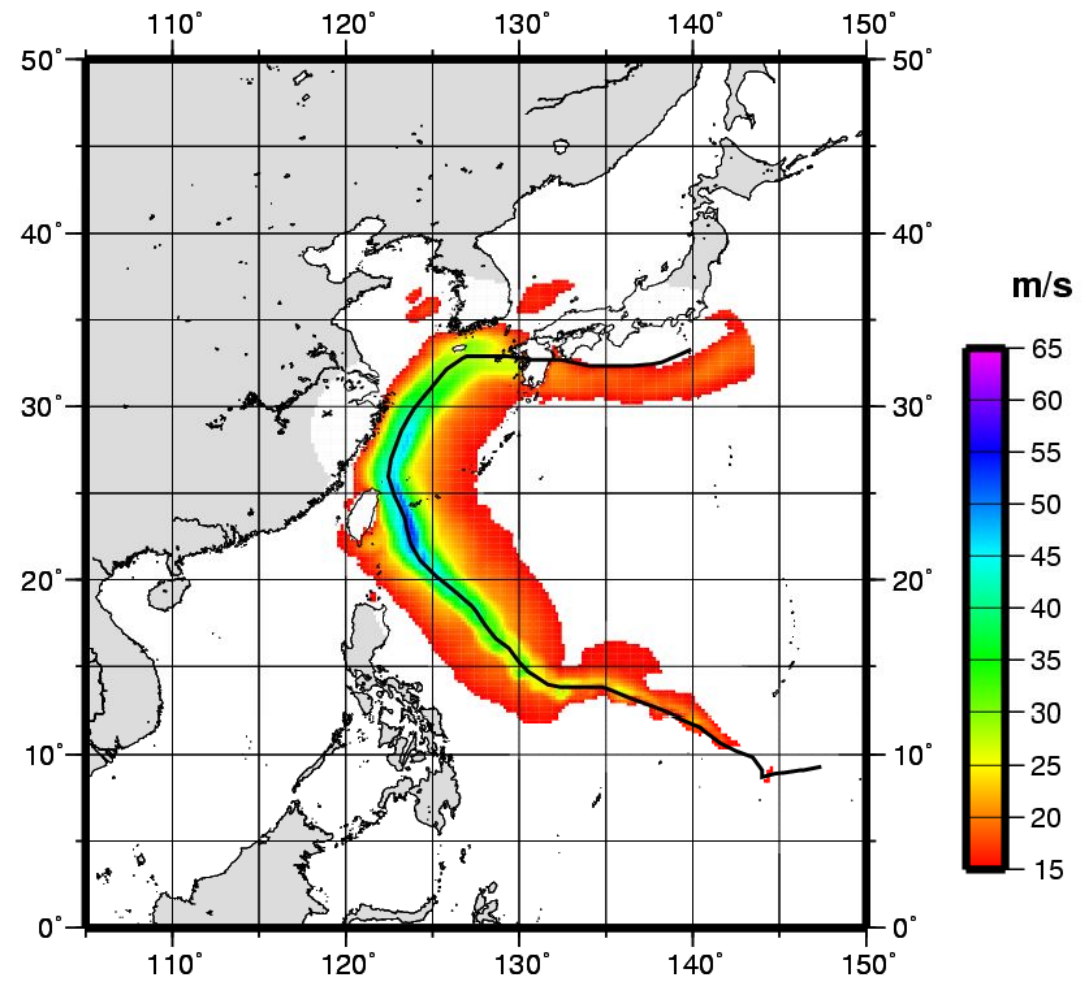
There is *less confidence* in projections of a global decrease in numbers of tropical cyclones. [IPCC AR4]

Sample tropical cyclone tracks and max surface winds

Present climate



Future climate

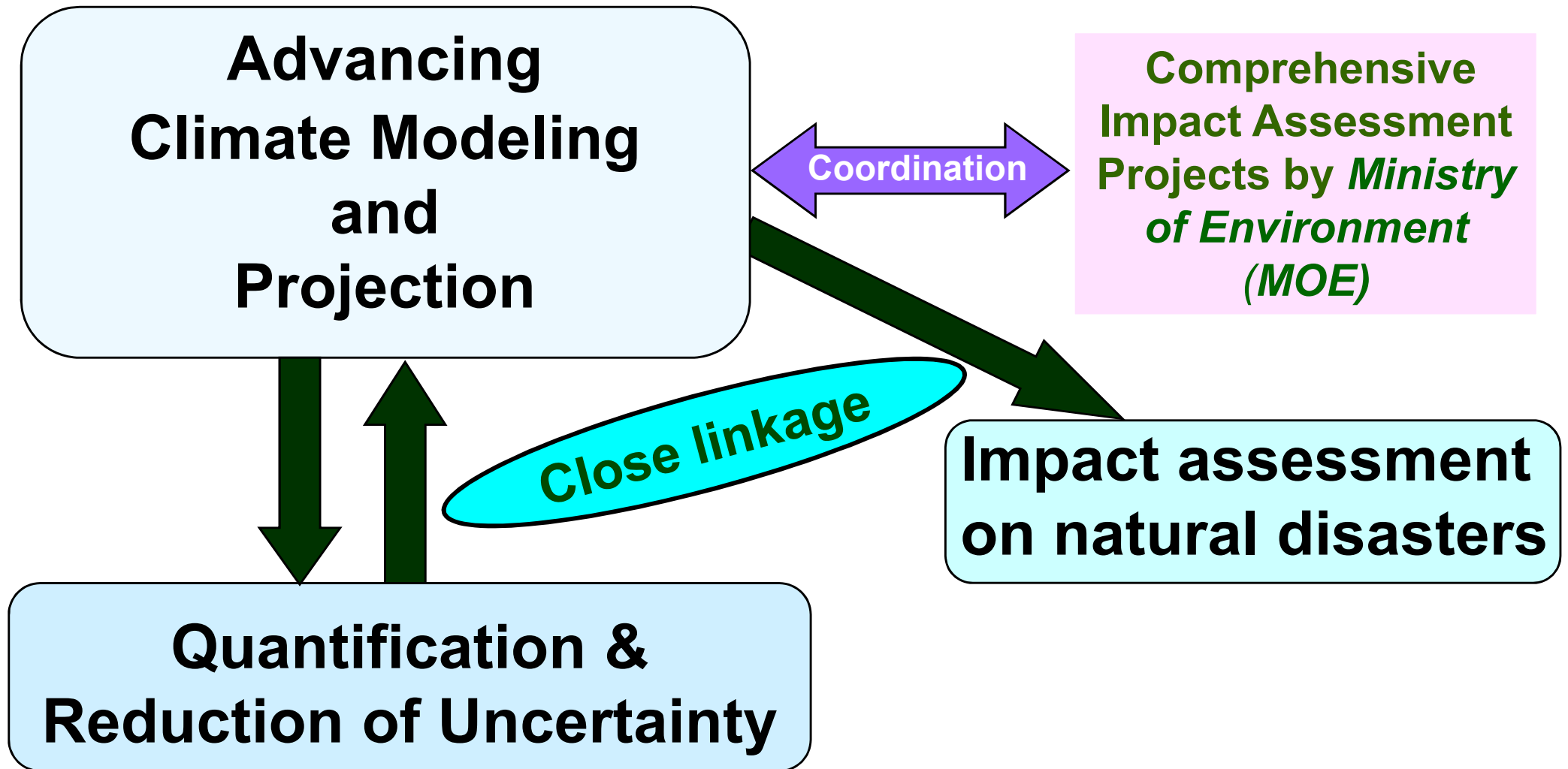


Innovative Program of Climate Change Projection for the 21st century (KAKUSHIN Program)

- ◆ **5-year initiative (FY 2007-2011)** by the **MEXT** (Ministry of Education, Culture, Sports, Science and Technology) launched in April 2007
- ◆ The Program is to follow-up and develop the **“Kyo-sei” Project (FY 2002-2006)**
- ◆ The **Earth Simulator** (being updated to ES2) be further utilized.
- ◆ The Program intends to **contribute to the AR5.**



Program structure

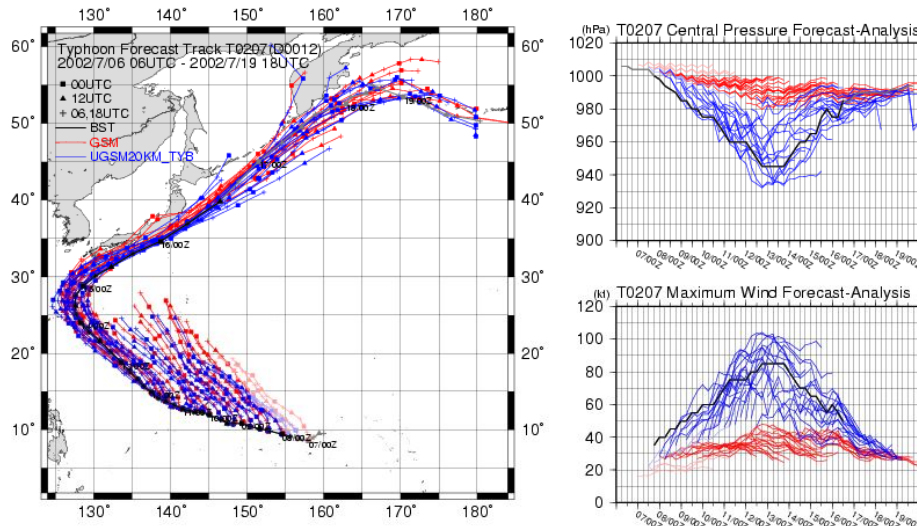


Participating groups and their studies

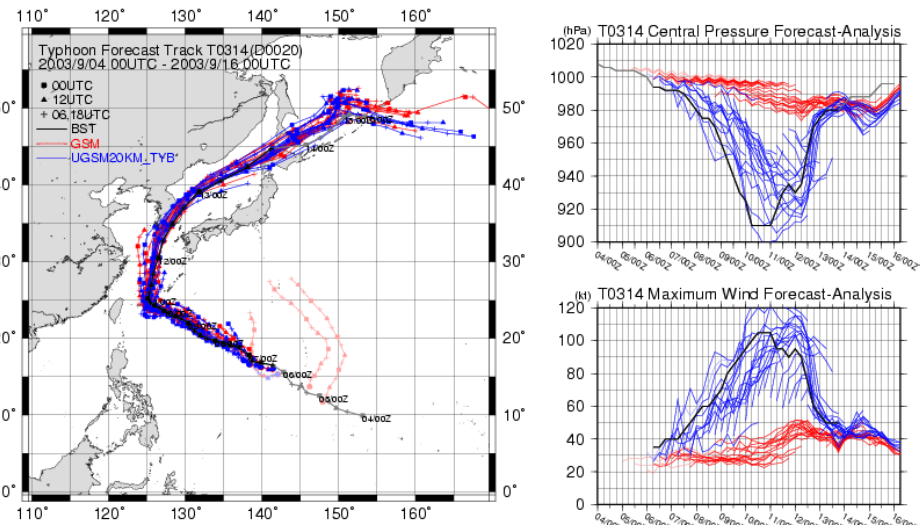
- ◆ ***Long-term global environmental projection***
with an earth system model
 - Frontier Research Center for Global Change (**FRCGC**) et. al
- ◆ ***Near-term climate prediction***
with a high-resolution coupled ocean-atmosphere GCM
 - Center for Climate System Research (**CCSR**) of the University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

Typhoon track and intensity: 60km vs 20km

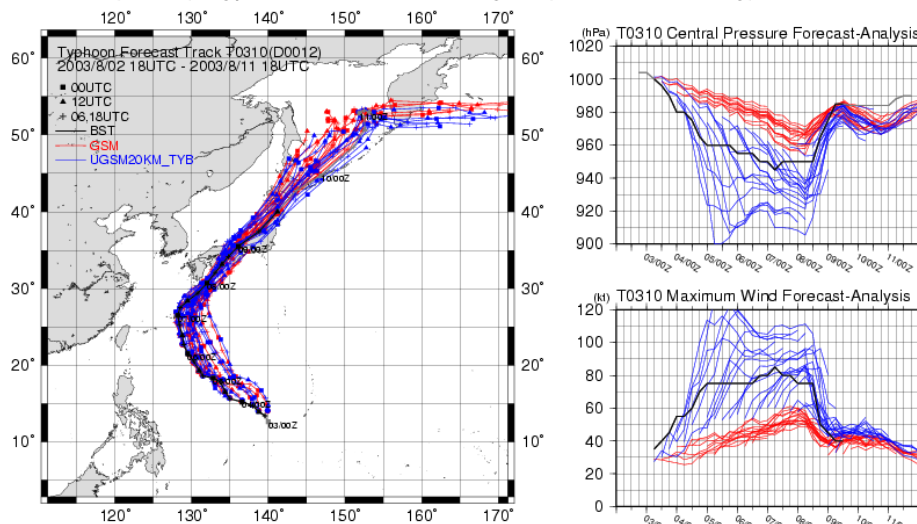
T0207(D0012) Typhoon Forecast and Analysis (Track and Intensity)



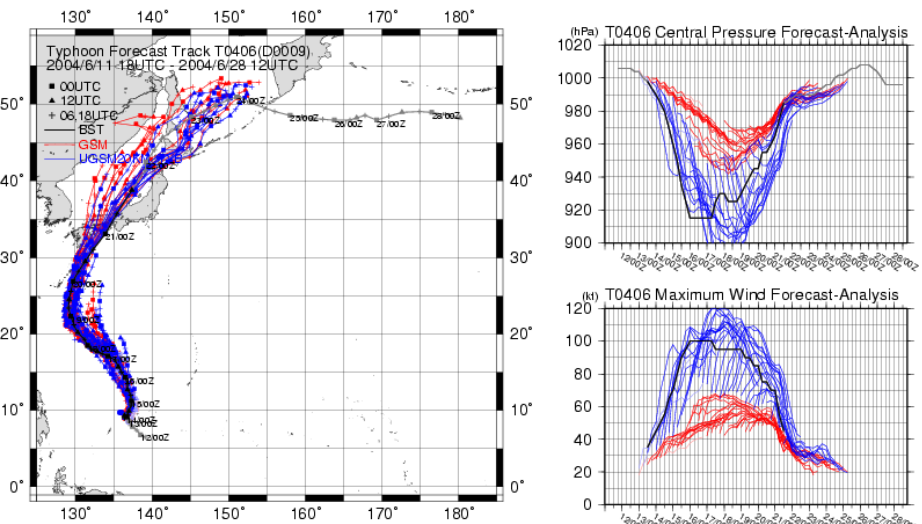
T0314(D0020) Typhoon Forecast and Analysis (Track and Intensity)



T0310(D0012) Typhoon Forecast and Analysis (Track and Intensity)



T0406(D0009) Typhoon Forecast and Analysis (Track and Intensity)



60-km model forecasts shallower central pressures and weaker maximum winds. 20-km model represents typhoon development closer to the observations.

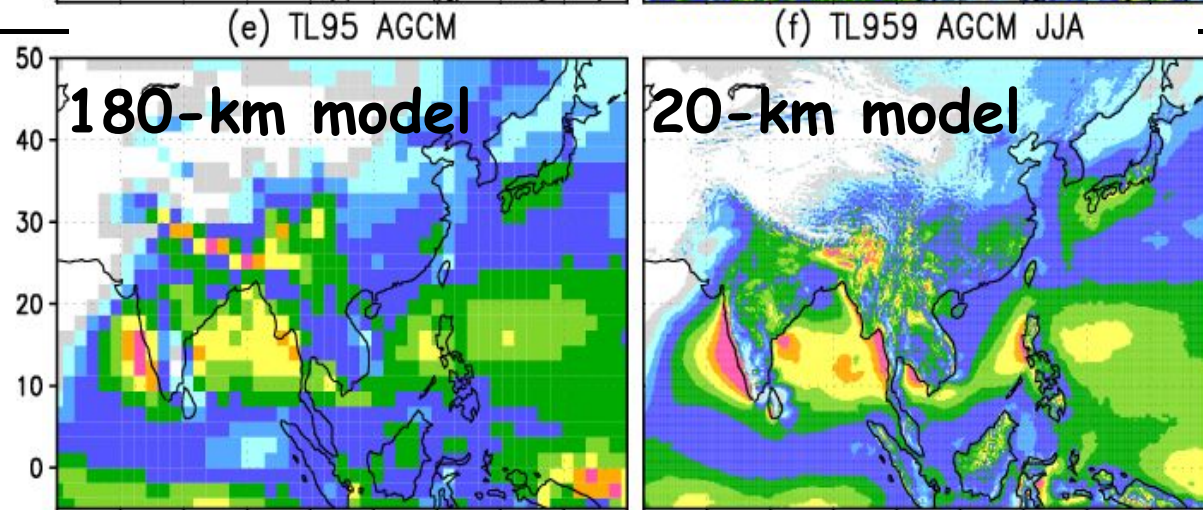
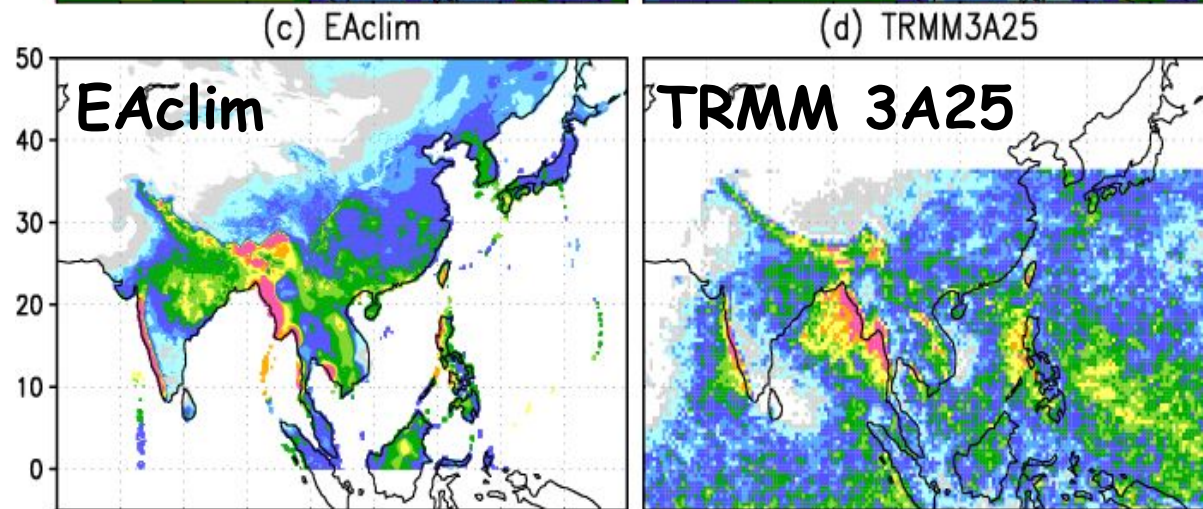
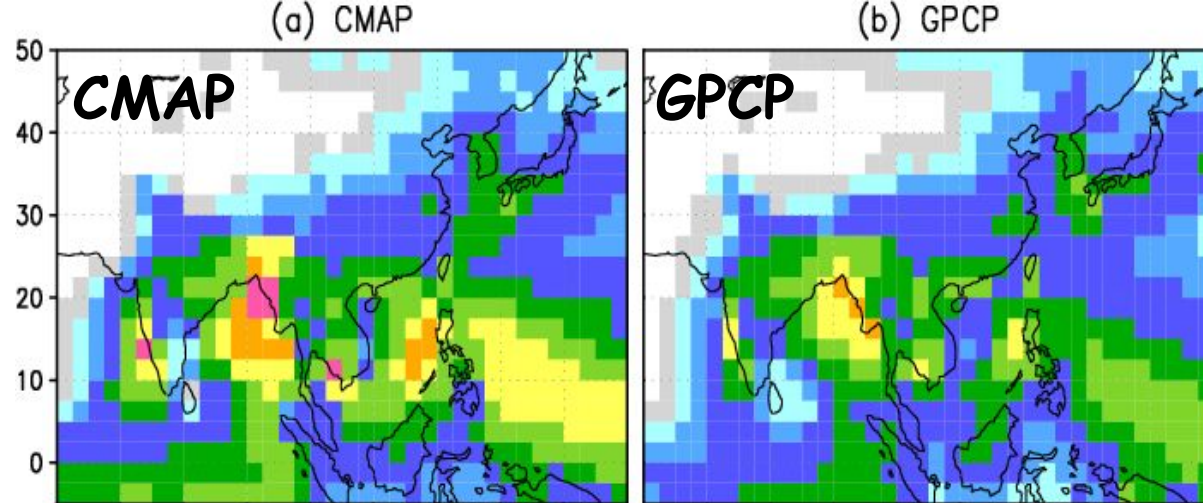
60km mesh model —
 20km mesh model —

JJA Precipitation

Model evaluation is a must, but there is always uncertainty in the observations
 → we need to evaluate climate models against multiple available observations

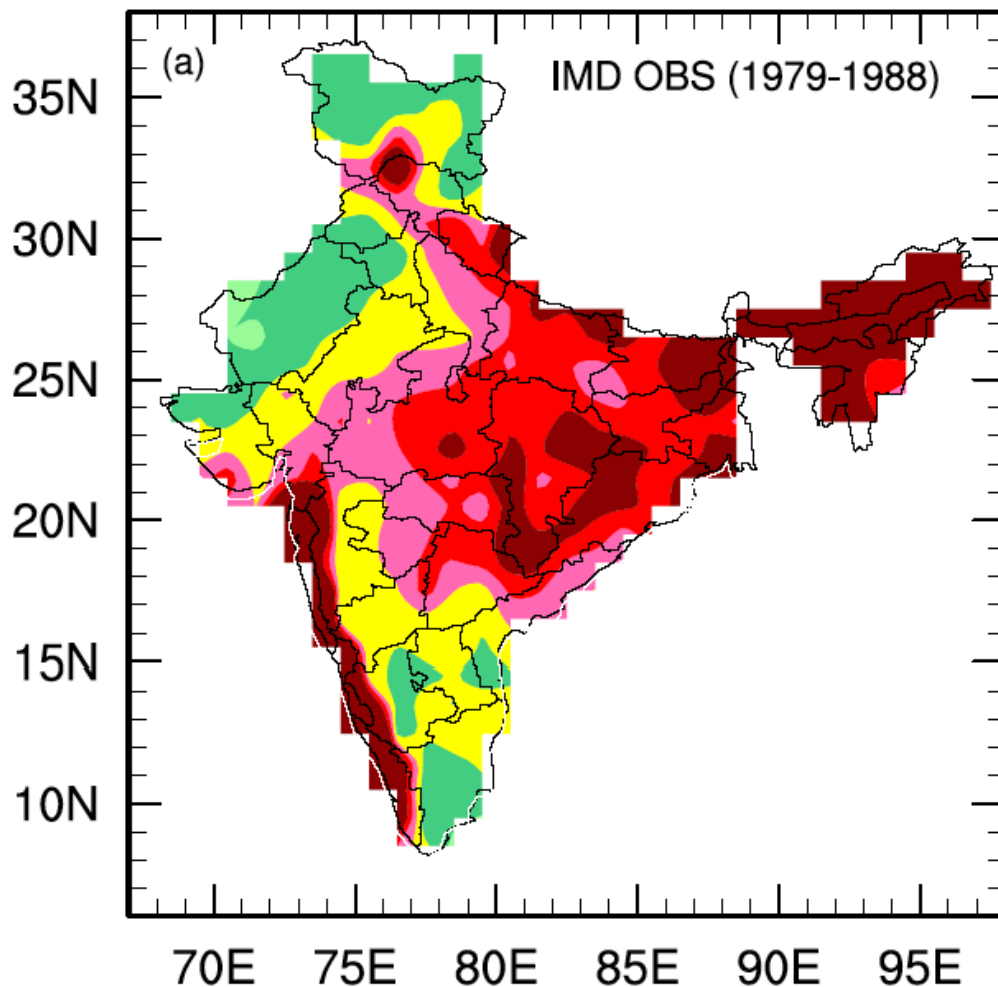
observation

model

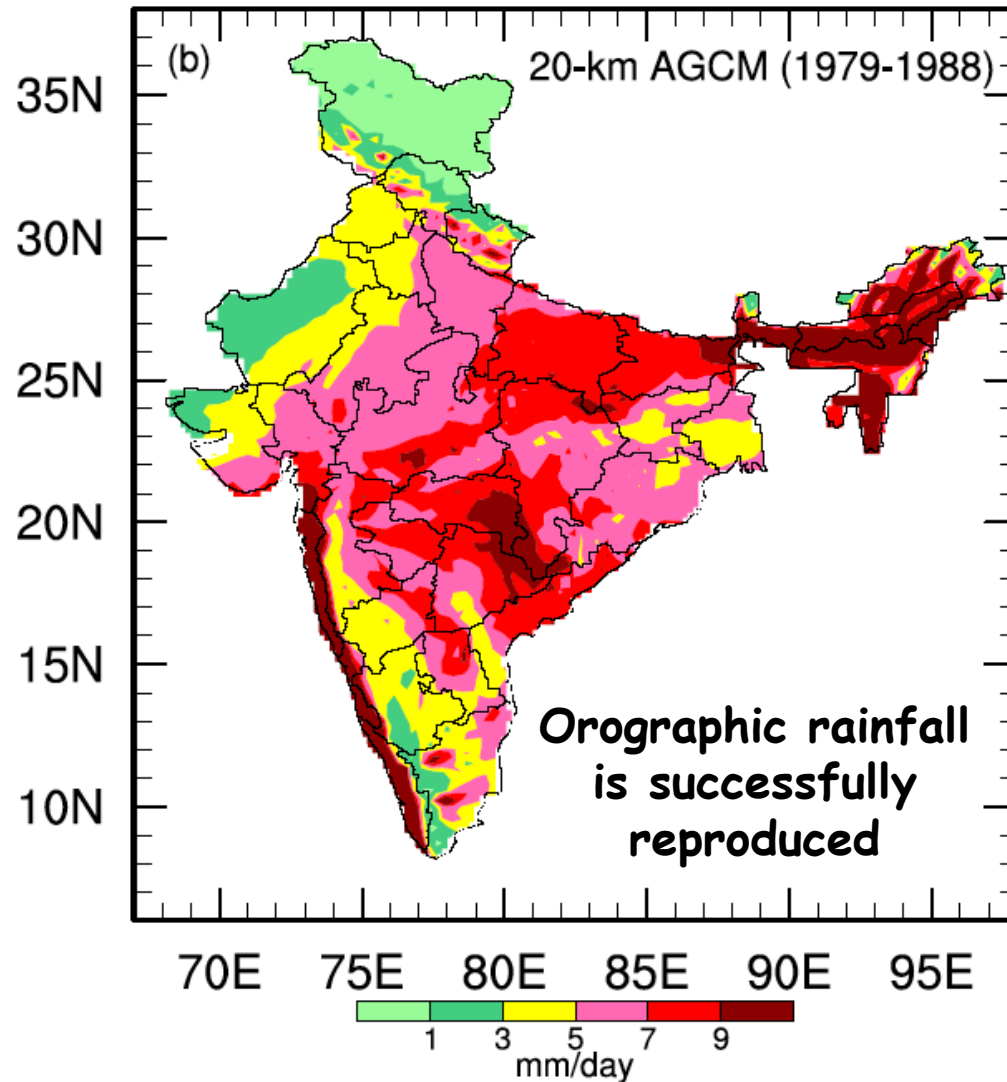


Indian summer monsoon rainfall

IMD observation



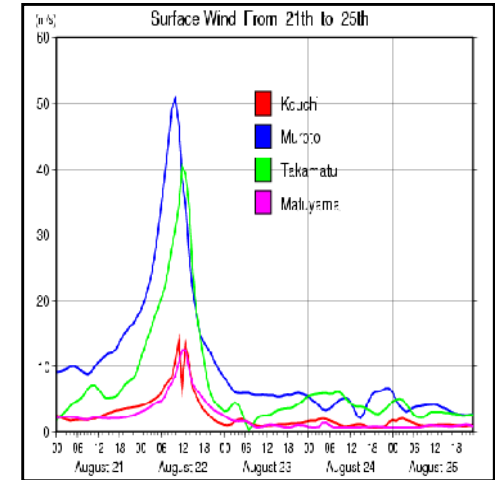
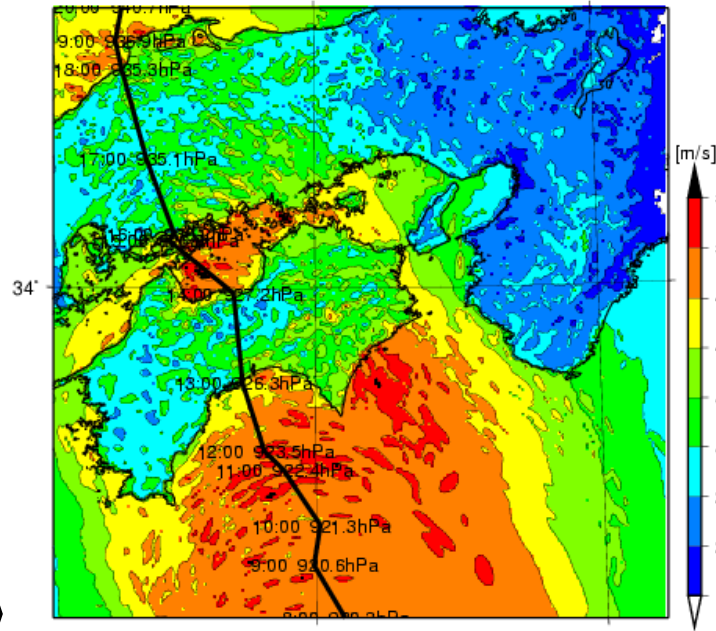
20-km model



Potential Hazard in Global Warming Environment

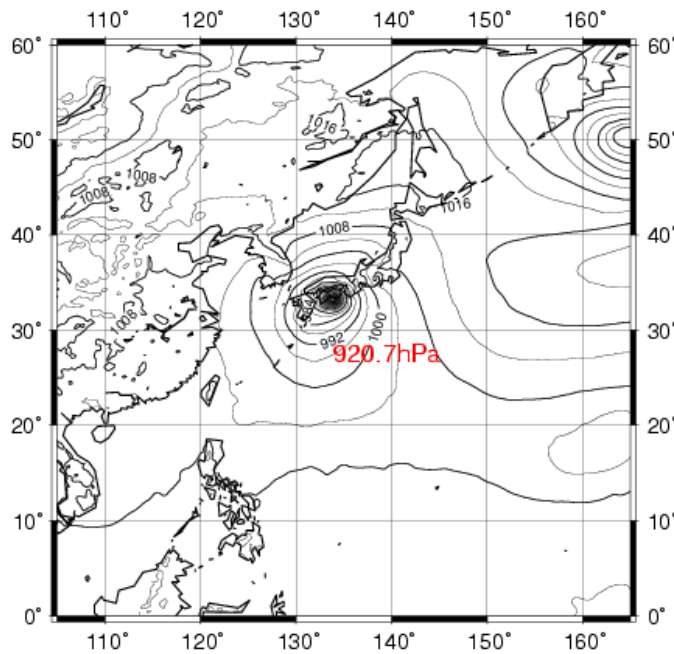
Maximum surface wind

Max wind at 10m from 2096 Aug 22th 00:10 to 23th 00:00



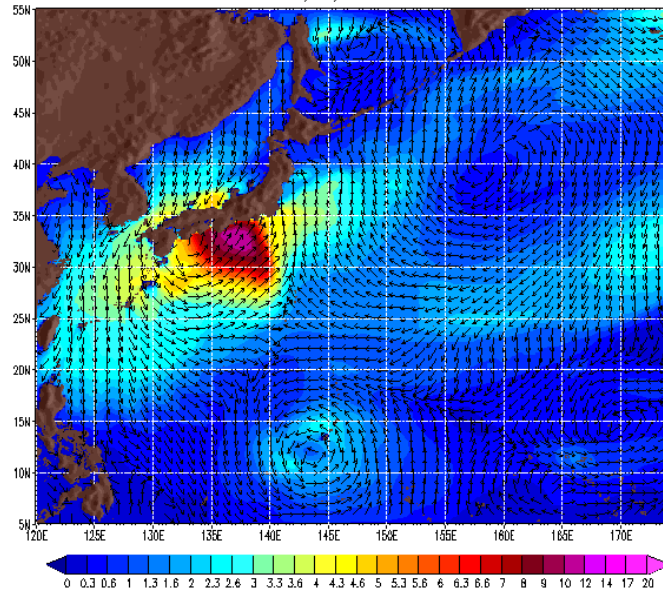
Sea-level pressure

Sea-level Pressure 2096 Aug 22th 11:00



Wave height and direction

Grid: swan 0.251x0.2513 Date: 2004/10/20 22:00 JST

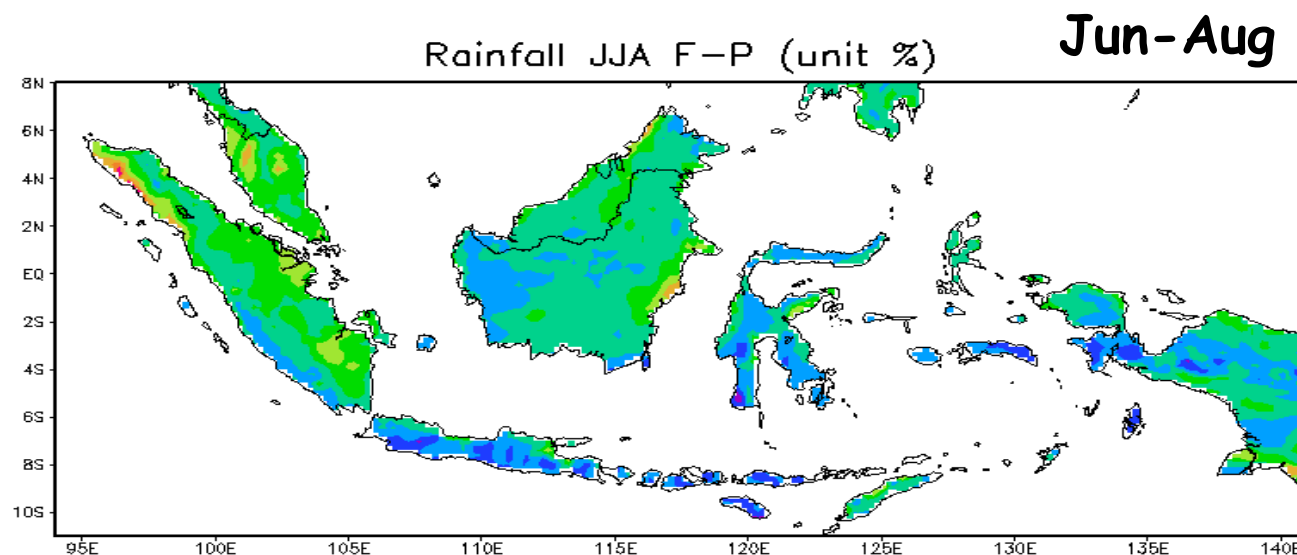
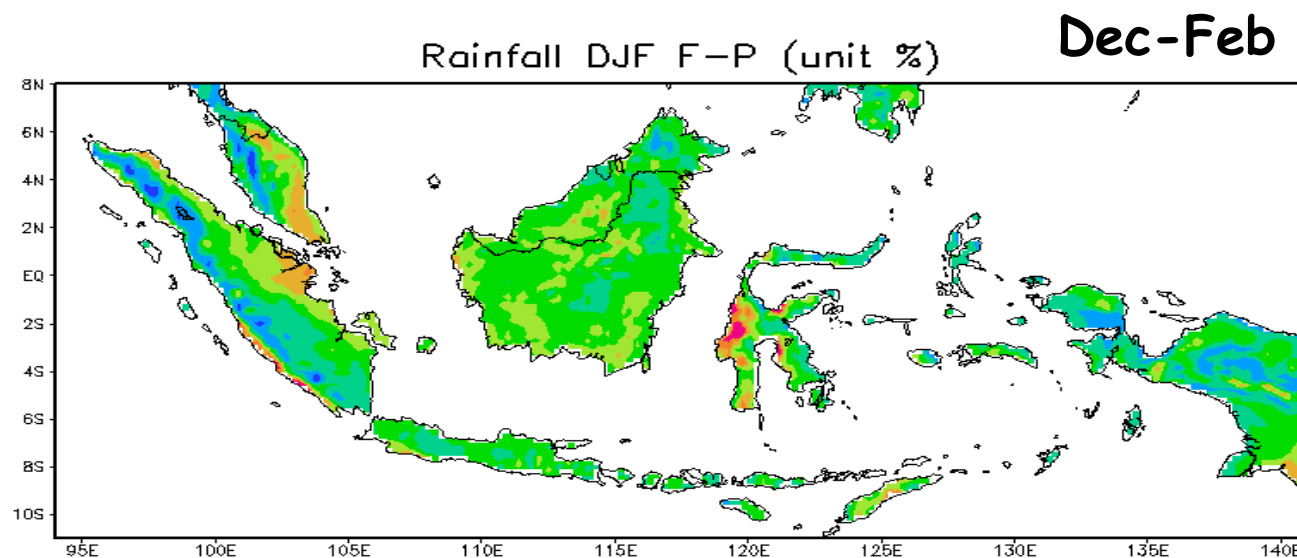


prepared by www.NAMIDENSETSU.com using SWAN, FNL(d9083.2), and GrADS.

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

Increase in rainy season
and
decrease in dry season

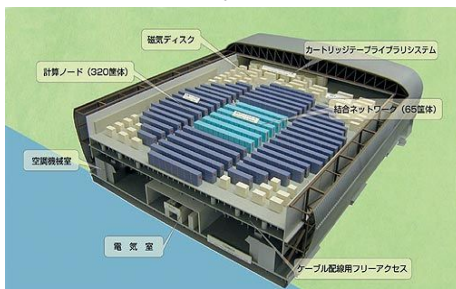
Need in adaptation of
water use for
agriculture



Regionally detail climate modelling applied to adaptation studies

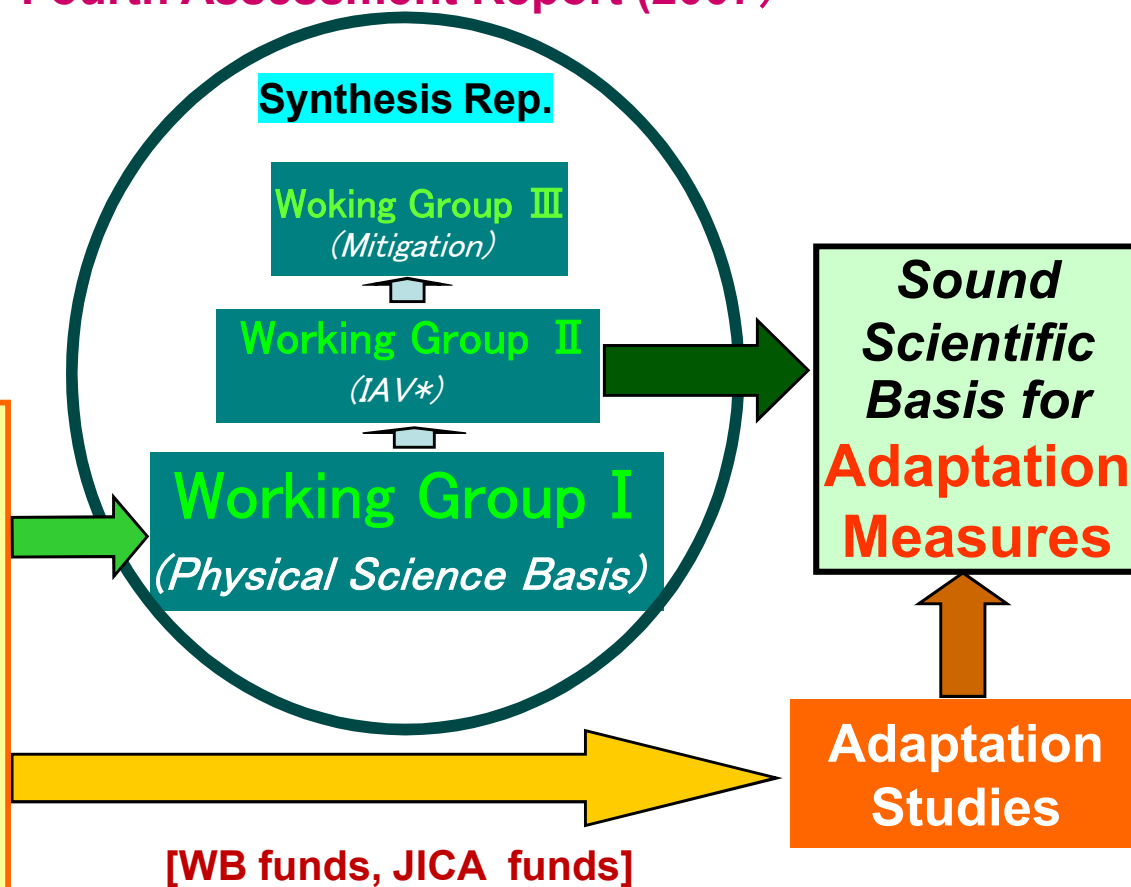
Super-high resolution (20 km)
global atmospheric modelling
<by MRI group under a MEXT project>

Earth
Simulator



IPCC
Fourth Assessment Report (2007)

- 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**



(* IAV = Impact, **Adaptation** and Vulnerability)

Cooperation activities of the MRI group

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

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)*
- ***Amazon Dieback**: Brazil (two, 2008)*

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)*

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

Summary

- Resolution of **ES** (soon **ES2**) **based climate models** has become finer; now we can use 60-km or even 20-km mesh global atmospheric models
- Higher resolution model is needed to better represent **weather extremes** including **tropical cyclones**
- Cooperation to adaptation studies in developing countries has been facilitated under the **WB** and **JICA** funds
- Capacity building for adaptation to climate change: increasing needs for training to **correctly understand characteristics of modeling** for making adequate use of model outcomes.