

Earth system/climate modelling activities in Japan

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Lineup of Japanese models for CMIP6

	MIROC6– CGCM	MIROC– ESM	NICAM	MRI– ESM1.2	MRI– AGCM3.2	NHRCM
Resolution (Atm.)	140km or finer	140km– 280km	14km– 56km	120km	< 20km	O(5km)
Resolution (Ocean)	1deg. X 1deg.	1deg. X 1deg.	n.a.	1deg. X 0.3– 0.5deg.	n.a.	n.a.
High Top	Yes	Yes	Yes	Yes	Yes	
Biogeo– chemistry	No	Yes	No	Yes	No	No
Institutions	AORI/UT, JAMSTEC,	JAMSTEC, AORI/UT, AORI/UT,	JAMSTEC , RIKEN	MRI	MRI	MRI

Participation in endorsed MIPs

	Short name of MIP	MIROC6-CGCM	MIROC-ESM	NICAM	MRI-ESM1.2	MRI-AGCM3.2	NHRCM
1	AerChemMIP	0	1	0	1	0	0
2	C4MIP	0	1	0	1	0	0
3	CFMIP	1	0	1	1	0	0
4	DAMIP	1	0	0	1	0	0
5	DCPP	1	0	0	1	0	0
6	FAFMIP	1	0	0	1	0	0
7	GeoMIP	0	1	0	1	0	0
8	GMMIP	1	0	0	0	0	0
9	HighResMIP	1	0	1	1	1	0
10	ISMIP6	0	1	0	1	0	0
11	LS3MIP	1	0	0	1	0	0
12	LUMIP	0	1	0	0	0	0
13	OMIP	1	1	0	1	0	0
14	PMIP	0	1	0	1	0	0
15	RFMIP	1	0	0	0	0	0
16	ScenarioMIP	1	1	0	1	0	0
17	VolMIP	0	1	0	1	0	0
18	CORDEX	0	0	0	1	0	1
19	DynVar	1	1	1	1	0	0
20	SIMIP	1	0	0	1	0	0
21	VIAAB	1	1	0	0	0	0

13

11

3

17

1

1

Earth Simulator for most of the CMIP6 experiments

	Total Peak Performance (Pflops)	Total main memory (Tbyte)	Peak Performance / CPU (Gflops)	Total number of CPUs
Earth Simulator (JAMSTEC)	1.31	328	256 (4 cores)	5120
K Computer (Riken)	10.6	1,260	128 (16x8cores)	88,128



Earth Simulator: “medium” size simulations such as CMIP6 experiments. Operation started in March, 2015.



K Computer: ambitious, gigantic size simulations such as global cloud resolving runs with 870m mesh



SOUSEI Program for Risk Information
on Climate Change

気候変動リスク情報創生プログラム

FY 2012-2016

Budget: ~6m\$/y

**A. Prediction and diagnosis of imminent global climate change (PI:
M. Kimoto, U. of Tokyo)**

D/A, E/A, Seamless Prediction, Climate Sensitivity, Data Assimilation

**B. Climate change projection contributing to stabilization target
setting (PI: M. Kawamiya, JAMSTEC)**

Climate Scenario, Earth System Model, Tipping Element, Geo-engineering

**C. Development of basic technology for risk information on climate
change (PI: I. Takayabu, MRI)**

Dynamical and Statistical Downscaling, High-res GCM

**D. Precise impact assessments on climate change (PI: E. Nakakita,
Kyoto U.)**

Weather, Water, Coastal Disasters, Water Resource, ecosystem ...

**E. Promotion office for climate change research and linkage
coordination (PI: M. Kawamiya, JAMSTEC)**

Supported by MEXT  文部科学省
MINISTRY OF EDUCATION,
CULTURE, SPORTS,
SCIENCE AND TECHNOLOGY-JAPAN

SOUSEI is coming to an end in March 2017. A forum involving both scientists and the funding agency (MEXT) has been set up for establishing a follow-on project.

The K(京) Computer Project



- **SPIRE (Strategic Program for Innovation Research, 2011-2015)**

Five fields are specified to be strategically promoted

- Field 1 [Life science and medicine](#)
- Field 2 [Materials and energy](#)
- Field 3 [Natural disaster](#)
- Field 4 [Manufacturing technology](#)
- Field 5 [The origin of universe](#)

- **Field 3: Advanced Prediction Researches for Natural Disaster Prevention and Reduction**

- Coordinated by JAMSTEC, in collaboration with other national labs and universities
- Meteorology
 - Tropical cyclones under global warming
 - Prediction of torrential rain
- Seismology
 - Earthquake hazard maps
 - Tsunami warning accuracy

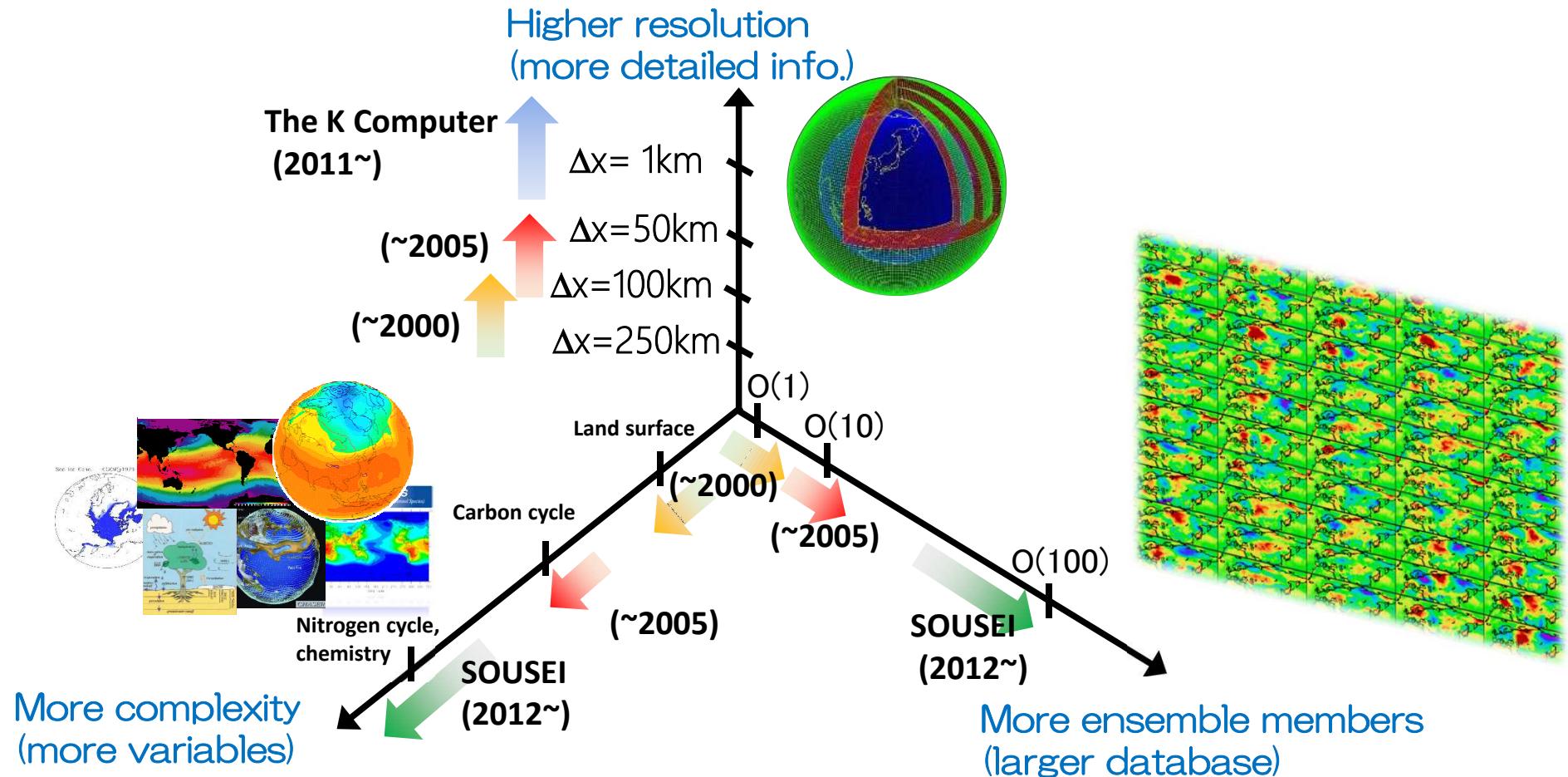
A follow-on project has been established, which is now in a feasibility study phase.



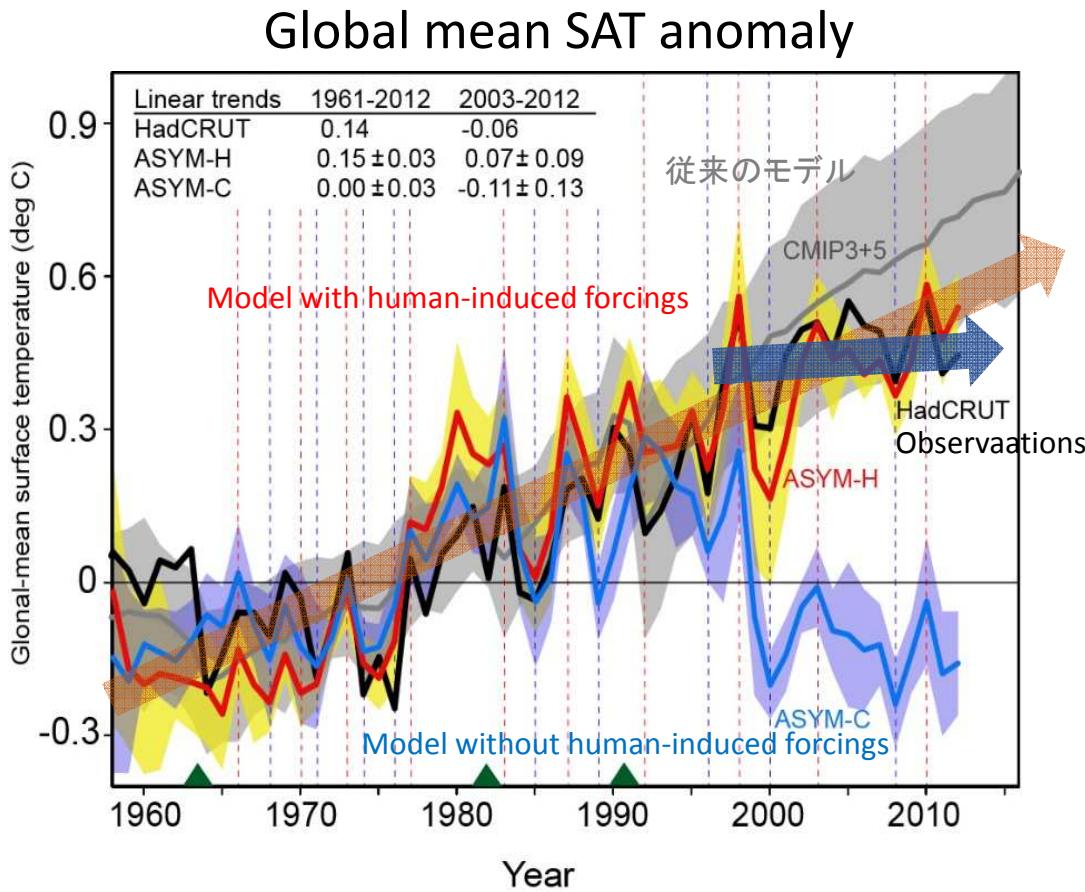
SOUSEI Program for Risk Information
on Climate Change

気候変動リスク情報創生プログラム

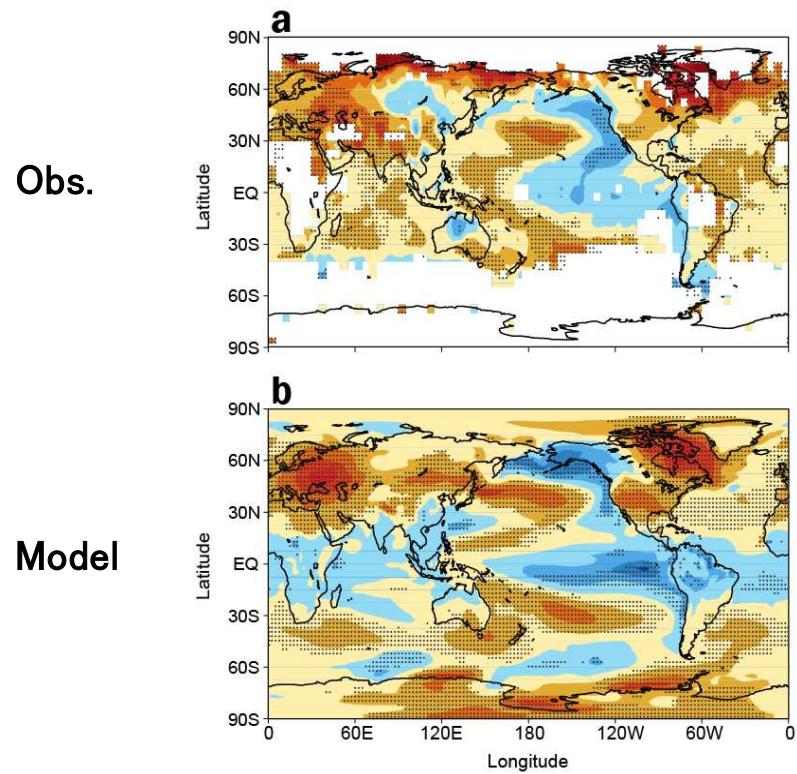
What do we do with the limited computer resource?



“Detection & attribution” exp. for hiatus

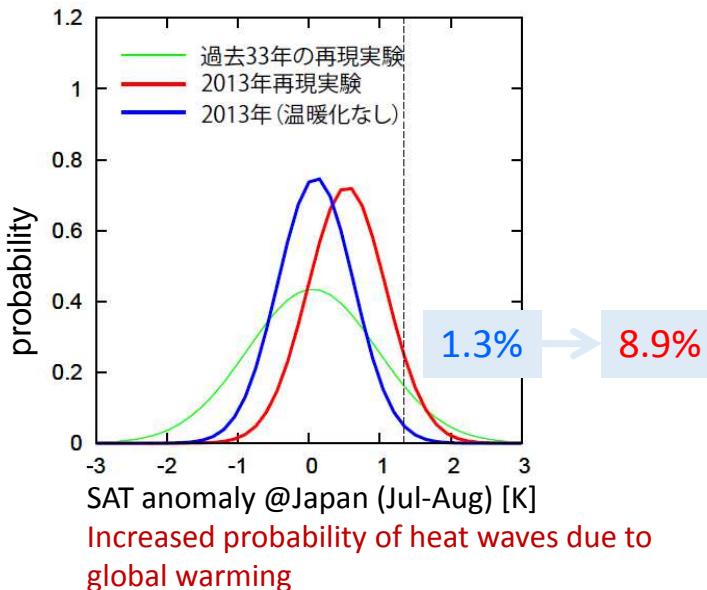
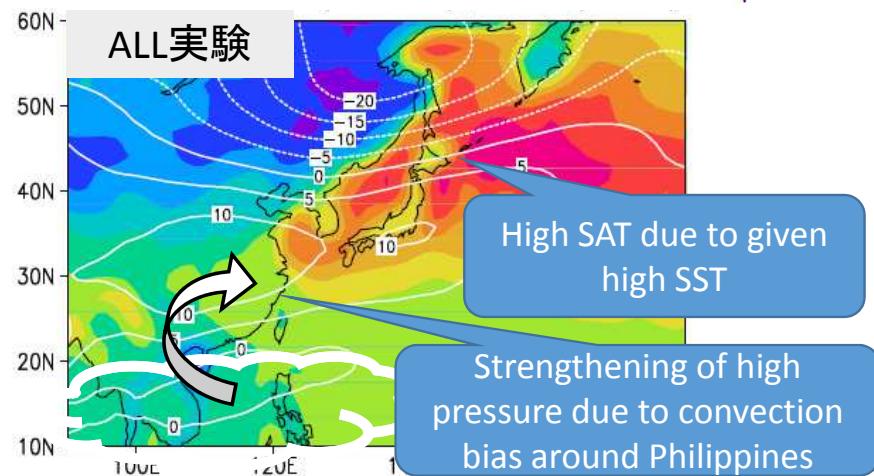
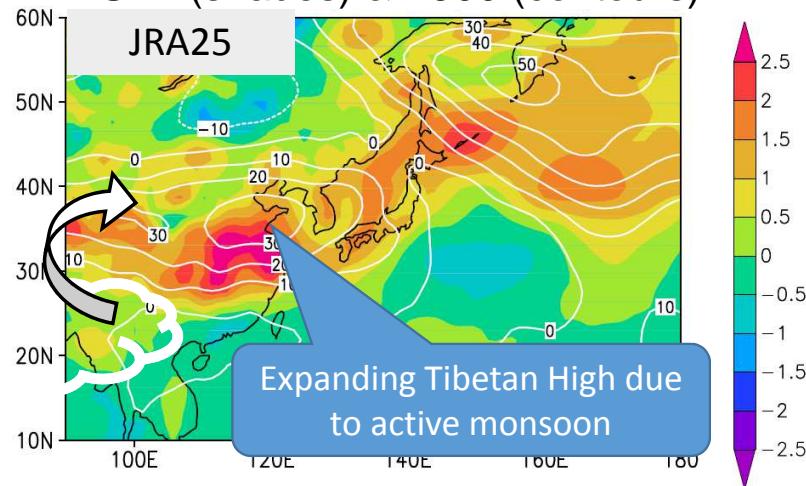


SAT Changes (1990–1999⇒2001–2012)

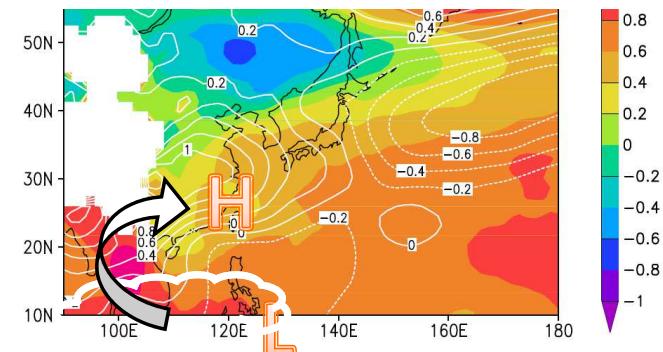


Event attribution study: heat wave in Japan, 2013

Anomaly for Jul.-Aug., 2013
SAT (shades) & Z500 (contours)



Contribution of global warming (ALL-NAT)



Imada et al.
(2014, BAMS)

Update from MIROC5 to MIROC6

AGCM (T85L81)

- Shallow convection
- Higher TOA ($3\text{hPa} \rightarrow 0.004 \text{ hPa}$)
- Non-orographic gravity wave drag
- Improved cumulus momentum transfer
- Non-spherical cloud ice scattering
- Secondary organic aerosol, Organic aerosol from the ocean

OGCM

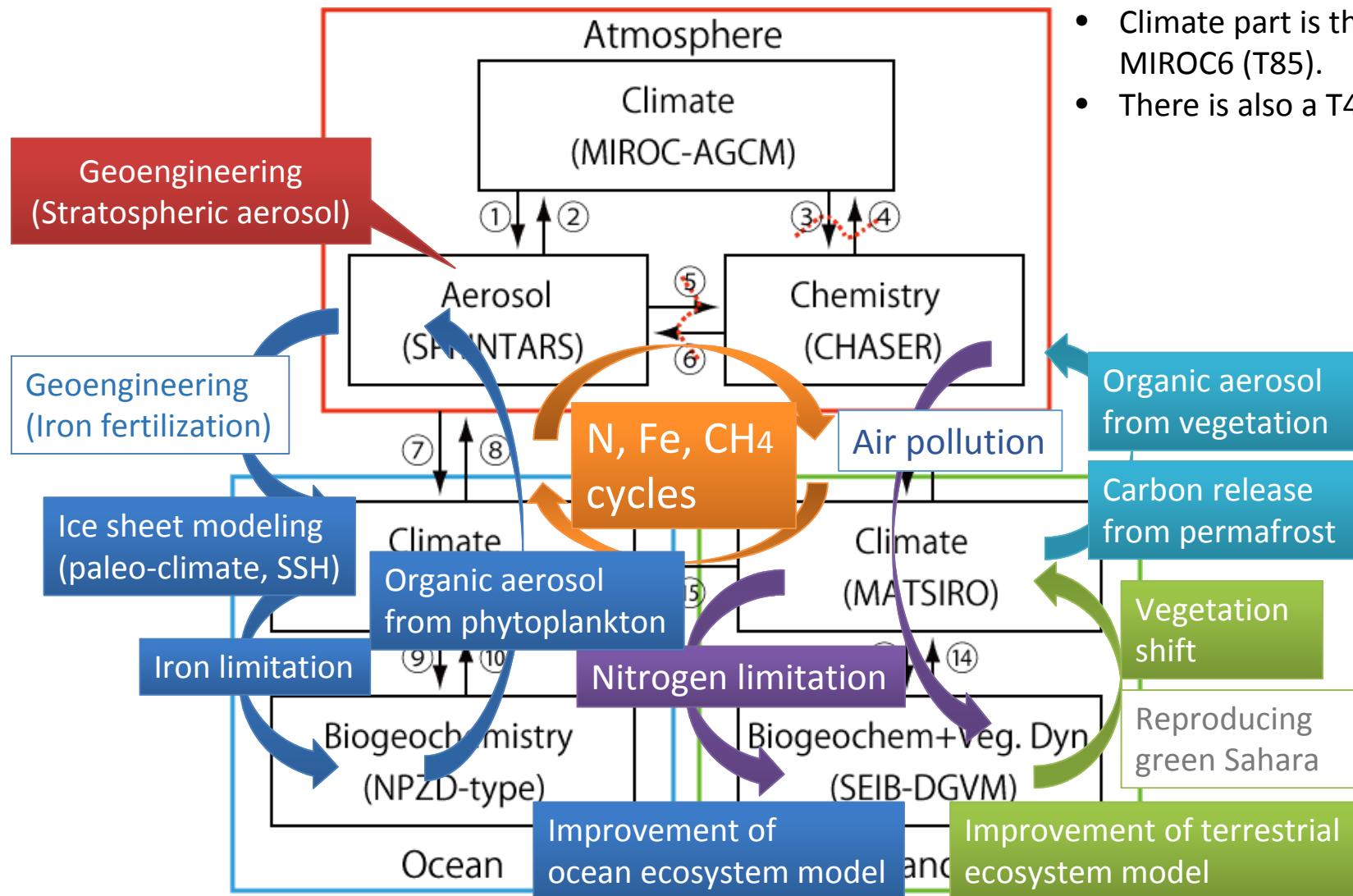
- Higher resolutions ($1.4^\circ \times 1.4^\circ \times L50 \rightarrow 1^\circ \times 1^\circ \times L63$)
- Tripolar horizontal coordinate
- Improved TKE input under sea ice
- Thermal vent at ocean floor, and vertical mixing due to tidal energy

(optional)

Land Surface Model

- Subgrid snow cover parameterization
- Representation of wet land due to snow-melting

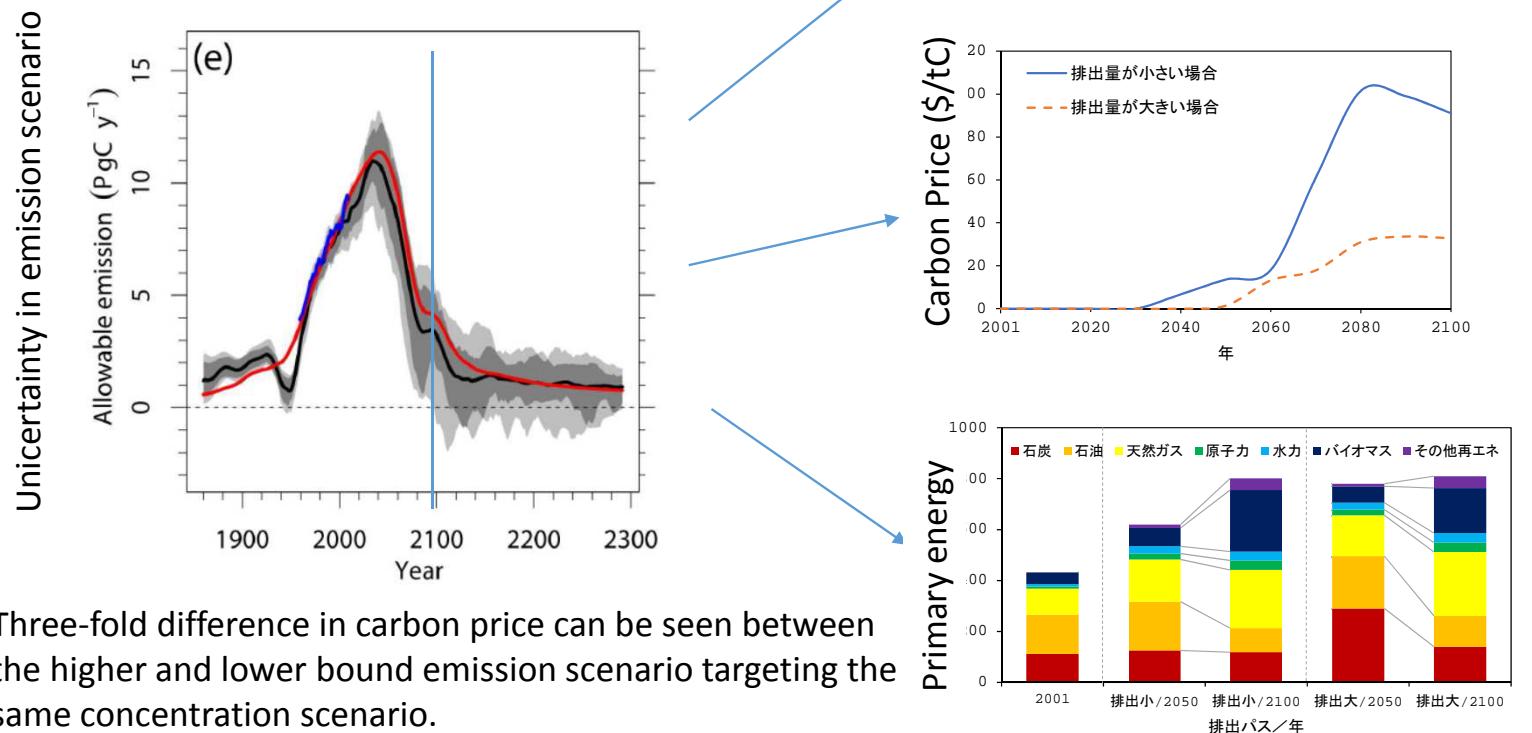
Model update plan & particular interests



- Climate part is the same as MIROC6 (T85).
- There is also a T42 version.

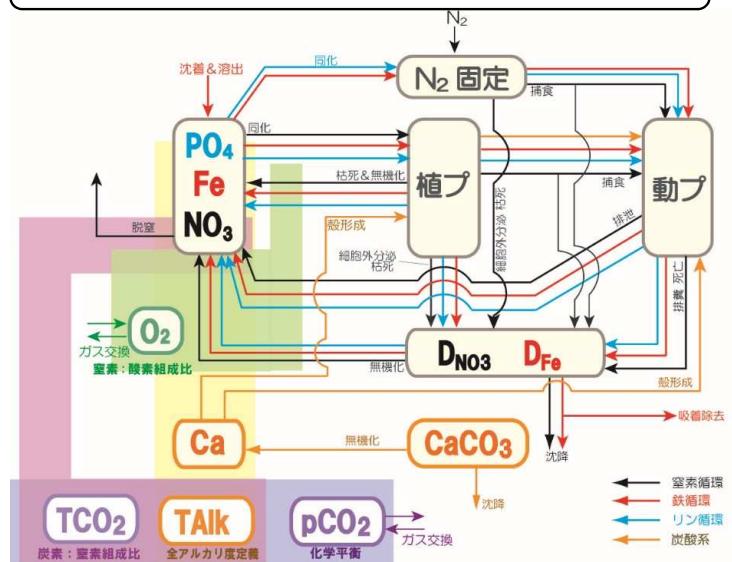
Socioeconomic impact of earth system uncertainty

Matsumoto, K., Tachiiri, K., Kawamiya, M (2015):
Impact of climate model uncertainties on
socioeconomics: a case study with a medium
mitigation scenario, Computers & Operations
Research.



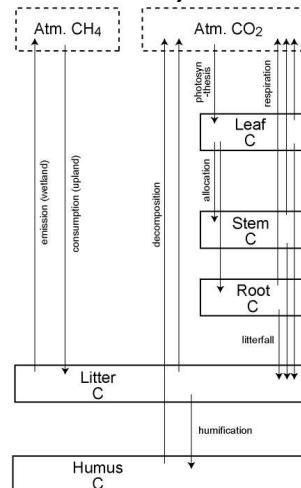
Components in LTE: Ocean and Land

Ocean Ecosystem/Biogeochemistry

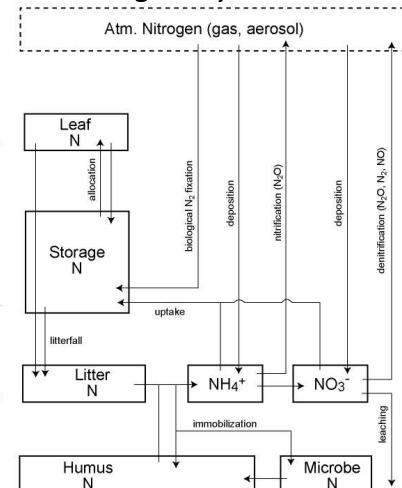


Land Ecosystem/Biogeochemistry

Carbon-cycle



Nitrogen-cycle



資料提供:野口様

資料提供:伊藤様

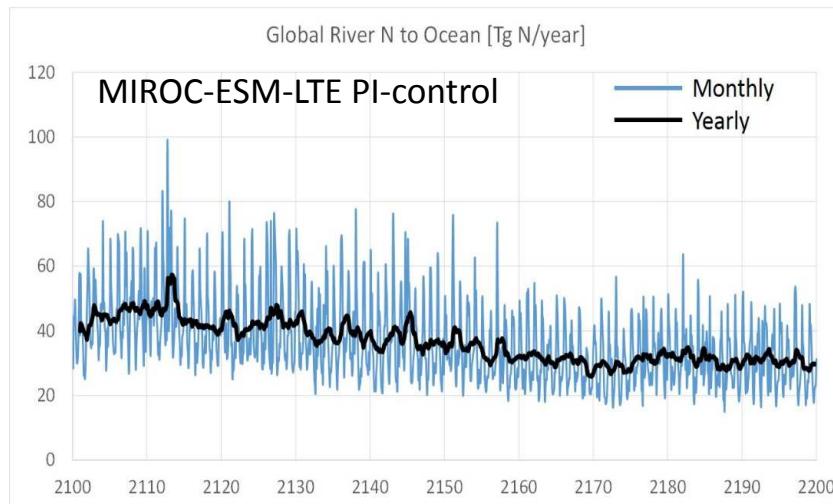
- C and N cycle (NPZD type)
 - N fix and Denitrification
- Fe cycle
 - Bioavailable Fe deposition
 - Fe reaching/inactivation
- O₂ cycle
 - O₂ dissolution
- P cycle (ocean-closed)
- C cycle
- N cycle
- From Atm: T₂, T_{soil}, Prec, Rad, etc
- To Atm: LAI, CO₂ flux, N₂O emission, etc
- To River: N mineral
- Land-use change (5 categories)

Nutrient transport from land to ocean through rivers

[Recent Research Activity]

(1) River tracer scheme in MIROC-ESM

- Code developed & implemented in MIROC-ESM.



Basin-total N:

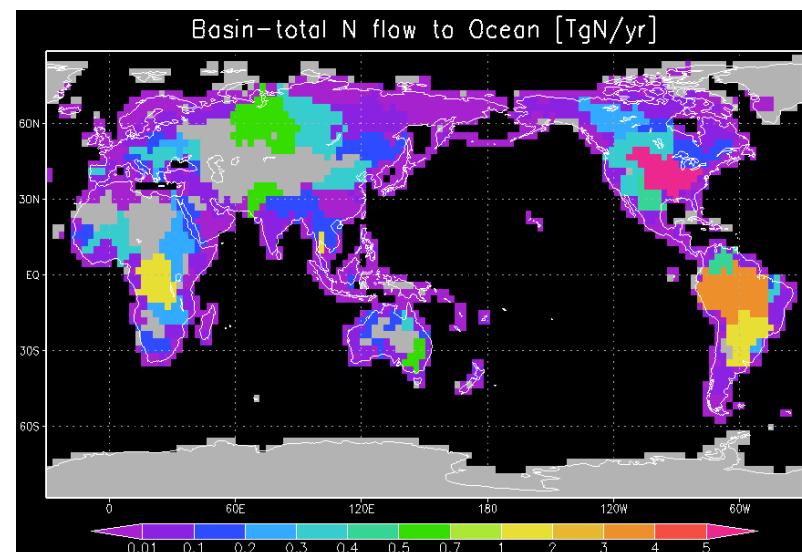
N runoff in endorheic basins is redistributed to coastal river mouths for closing global N cycle.

Global Estimate:

30TgN/year (PI Natural systems)

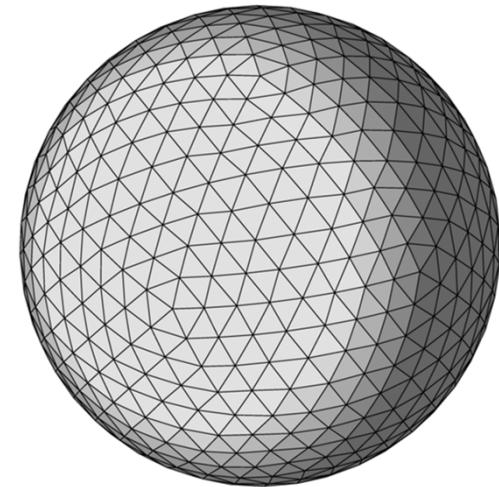
+50 TgN/year (Human systems)

[Gruber & Galloway, 2008, Nature]



NICAM activity for CMIP6

- MIPs to join
 - HighResMIP: Tier I
 - dx=56km, 28km, *14km (* for short-term)
 - CFMIP: at least Tier I
 - amip4K, amip4xCO2, amipFuture
 - aquaControl, aqua4xCO2, aqua4K
 - DynVAR (diagnostic MIPs)
- Preparations (by JAMSTEC, U. Tokyo, RIKEN AICS)
 - Currently, a series of sensitivity experiments are performed in parallel with intensive model development (next slide).
 - NICAM.16 (NICAM for CMIP6) including well-tuned parameters and full CMOR support will be appeared in the middle of 2016.



NICAM Activity for CMIP6: development and key experiments

Cloud microphysics scheme

- Double moment (Seiki et al. 2015a).
- Modified single moment (Roh and Satoh 2014).
- Updated auto-conversion from cloud water to rain.

Coupling with aerosol model

- Coupling with aerosol transport model (SPRINTARS) is being tested.

Climate simulation

- $dx=14\text{km}$, 30-year present and future climate simulations (Kodama et al. 2015; Satoh et al, 2015)

Vertical resolution

- L46 - L158 are being tested.
- $dz = 400 - 100\text{ m}$ experiments to simulate cirrus (Seiki et al. 2015b).

Model top height

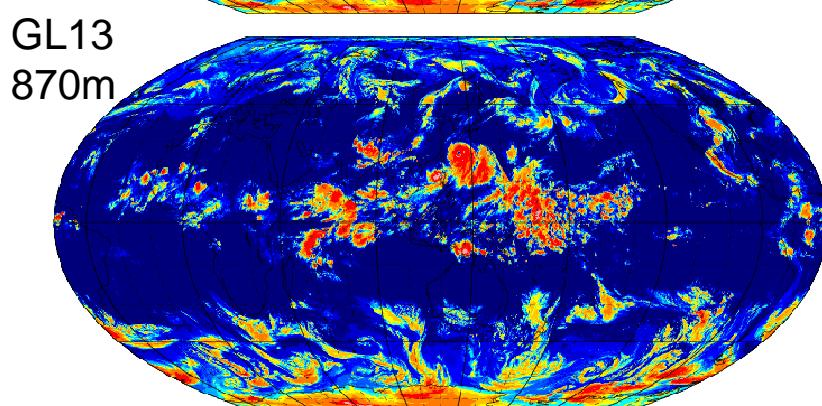
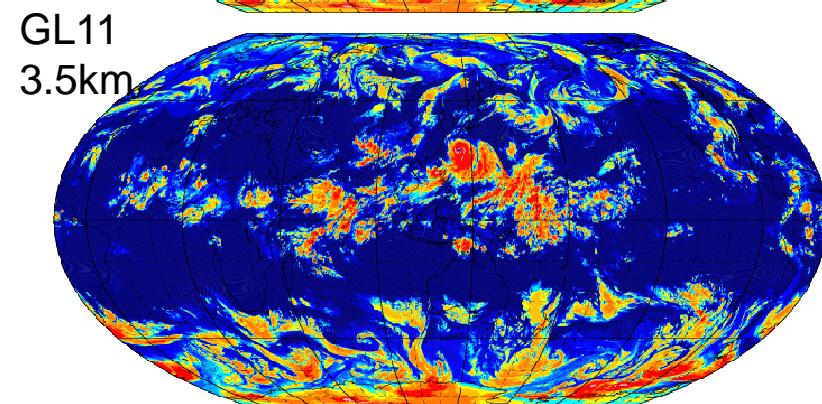
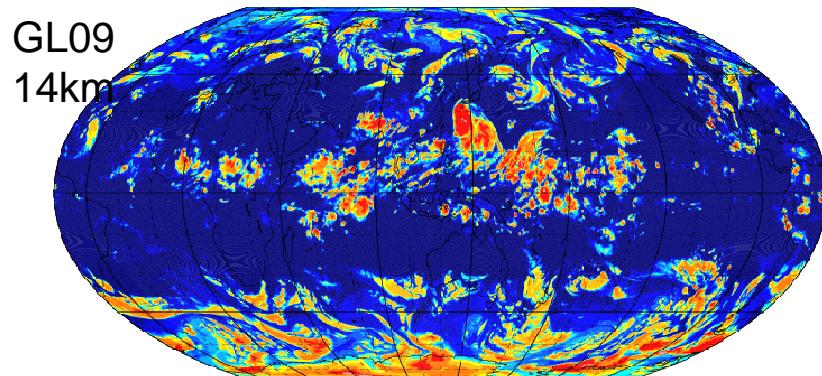
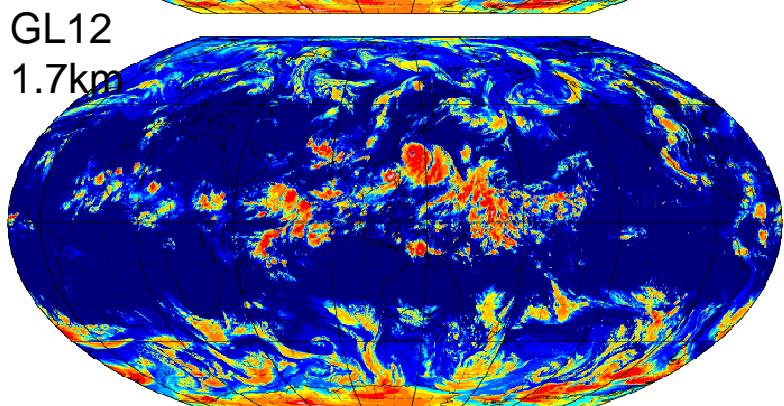
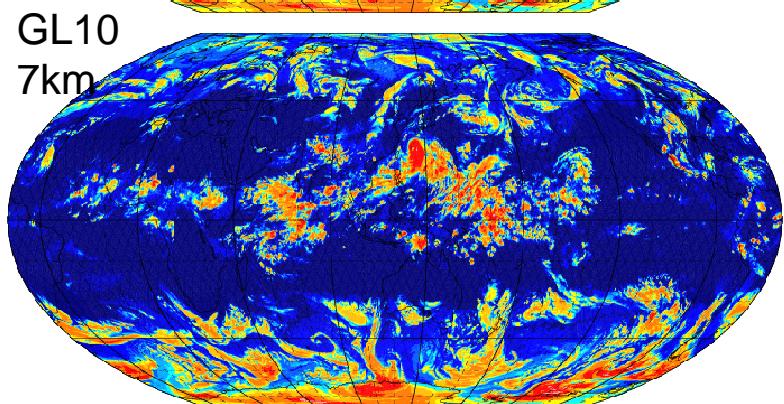
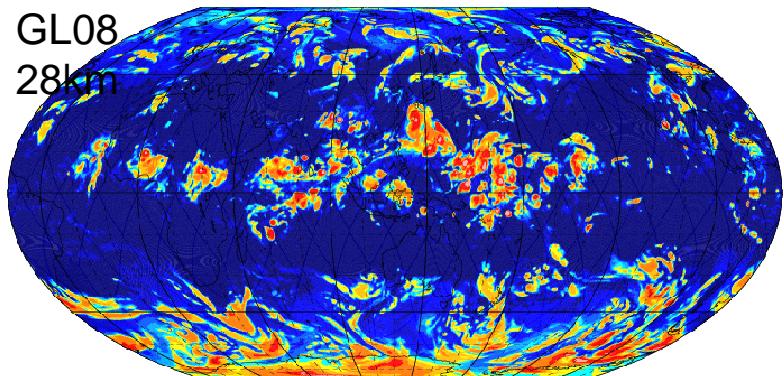
- $40\text{km} \rightarrow 80\text{ km}$ model top height (Satoh et al. 2014).

Horizontal resolution

- $dx = 14 - 3.5\text{ km}$ annual experiments.

Coupling with ocean model

- NICAM-COCO 10-yr stable run with $dx=220\text{ km}$ (by H. Yashiro).



6UTC, 25 Aug. 2012

160 180 200 220 240 260 280

K-computer by Y. Miyamoto (AICS, RIKEN)

160 180 200 220 240 260 280

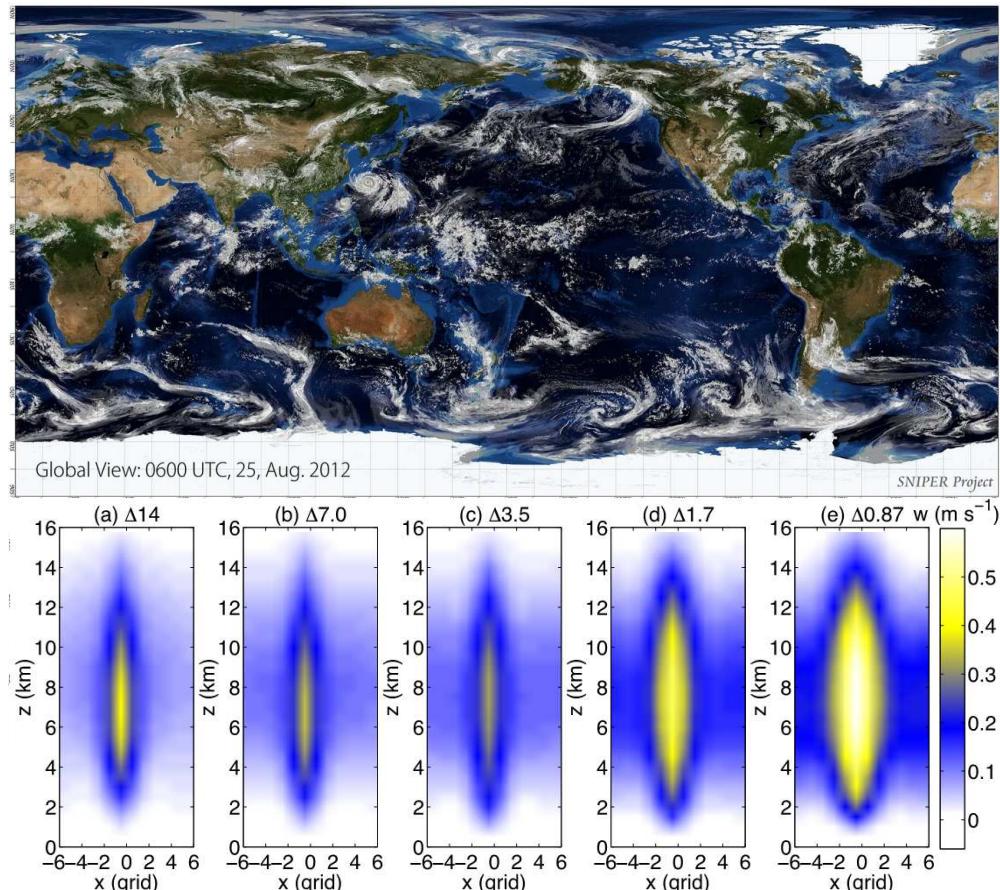
NICAM 870m-mesh simulation

Miyamoto et al. (2013, GRL) using the K computer

$dx=870\text{ m}$



$dx=3.5\text{ m}$



Radius-height cross sections for composites of vertical velocity w

JpGU-AGU joint session for earth system modelling section

- Background: JpGU (Japan Geoscience Union) and AGU are holding many joint sessions at 2016 JpGU meeting, as a preparation for full joint meetings in and after 2017.
- Session Title: Development and application of land and ocean biogeochemistry components of Earth system models
- Date: May 22-26, 2016
- Venue: Makuhari Messe, Chiba, Japan (30min. from Tokyo)
- Conveners: M. Kawamiya, V. Arora, K. Tachiiri and T. Hajima
- Abstract submission: Jan. 7 – Feb. 18, 2016
- Keywords: Earth system model, Biogeochemistry, CMIP6, C4MIP, ...
- URL: http://www.jpgu.org/meeting_e2016/

Summary

- Japanese models for CMIP6
 - MIROC family (MIROC6, MIROC-ESM), NICAM, MRI models
 - With all the Japanese models combined, the endorsed MIPs are fully covered.
 - Computer resource: The Earth Simulator (1.3PFlops) run by JAMSTEC, plus MRI supercomputer
- Large ensemble experiments: MIROC6, MRI-ESM
 - Hiatus issue due to internal variation,
 - Event attribution for heat wave in Japan
- Earth system type of experiments: MIROC-ESM, MRI-ESM
 - Impact on earth system uncertainty on future socio-economics
 - Rivers connect land and ocean
- High resolution experiments: NICAM, MRI-AGCM
 - NICAM for HighresMIP, CFMIP & Dynvar, MRI-AGCM for HighresMIP
 - NICAM runs at 870m resolution on the K computer
 - Complex structure of vertical flow is only resolved at resolutions finer than ~1.7km