Earth system and climate modeling activities toward IPCC AR6 in Japan: A review

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Many of AR6-related activities are supported by SOUSEI program, funded by MEXT…

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)

SOUSEI is coming to an end in March 2017. A follow-on program is likely to be established.

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

Multi-model analysis on ocean acidification in the middle layer of Ogasawara region

Possible impact of ocean acidification on precious corals

http://blog.goo.ne.jp/gpf4226/e/63d10ac376054207859508ba0bf38ab5

http://shop.plaza.rakuten.co.jp/housekisango/diary/detail/201007120000

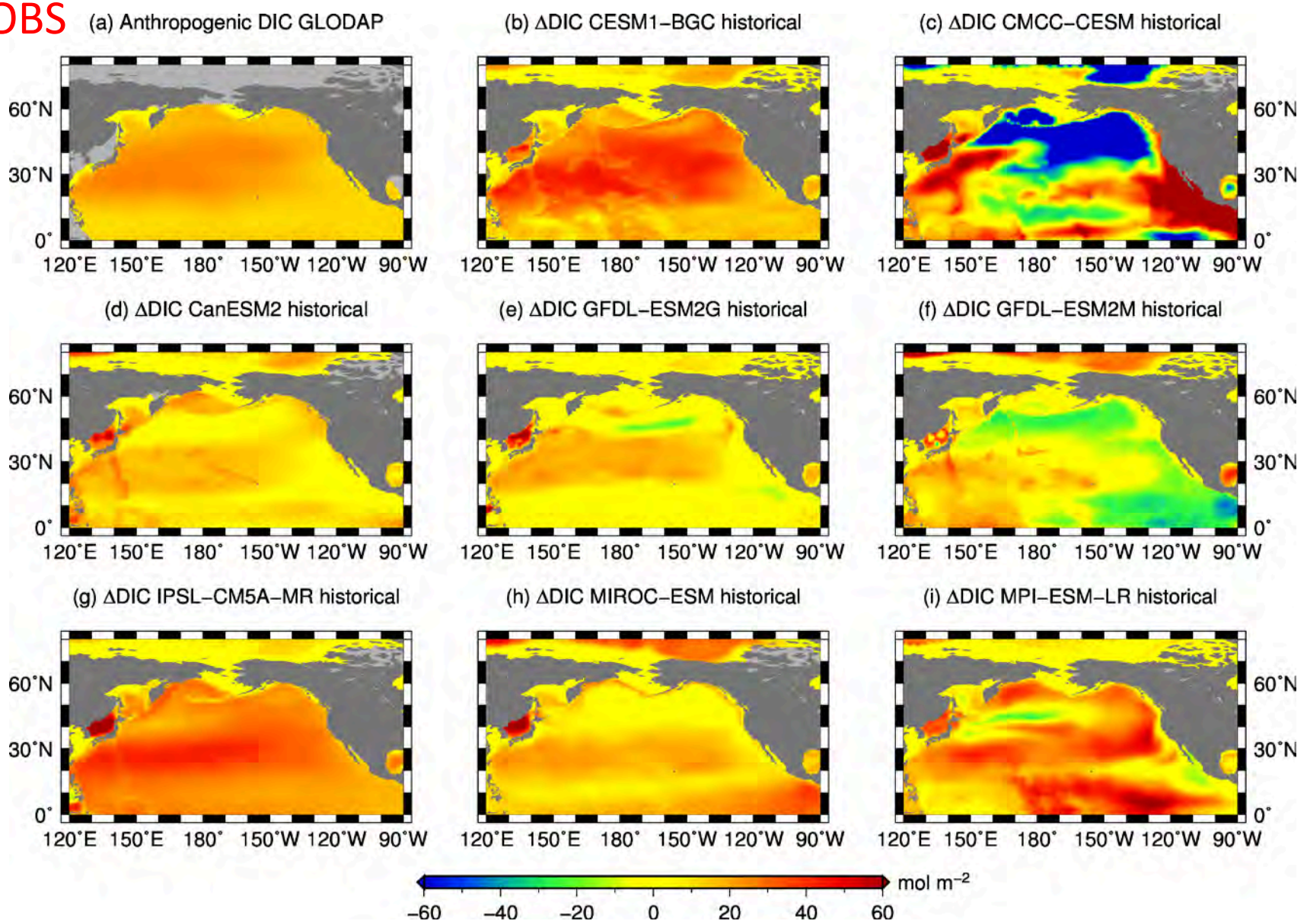
Midway
Hawaii

Mediterranean

Precious corals inhabit ocean floor with a depth of ~200m.

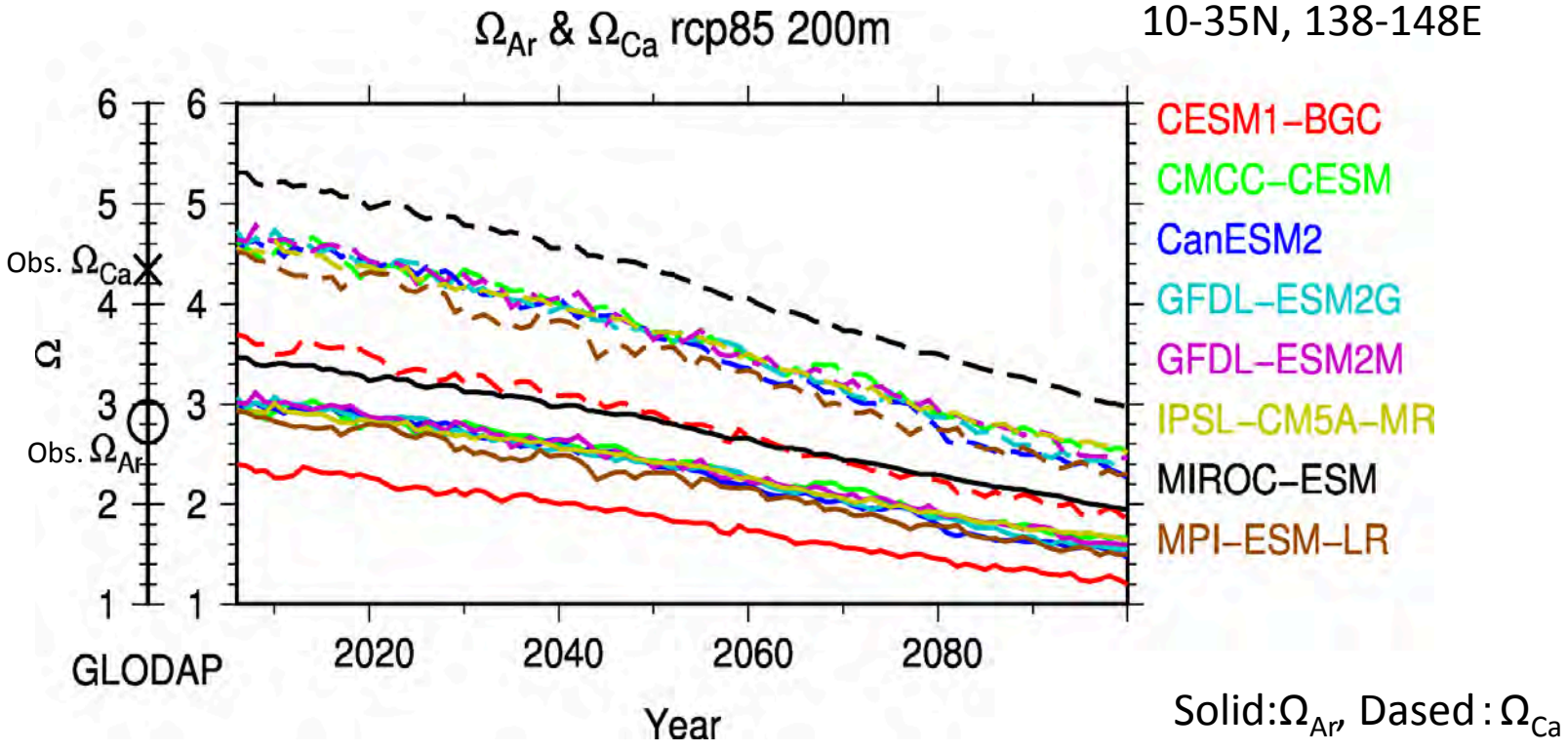
Vertically integrated DIC by CMIP5 models

historical run



Watanabe et al. (2016)

Changes in Saturation state $\Omega_{Ca,\ Ar}$



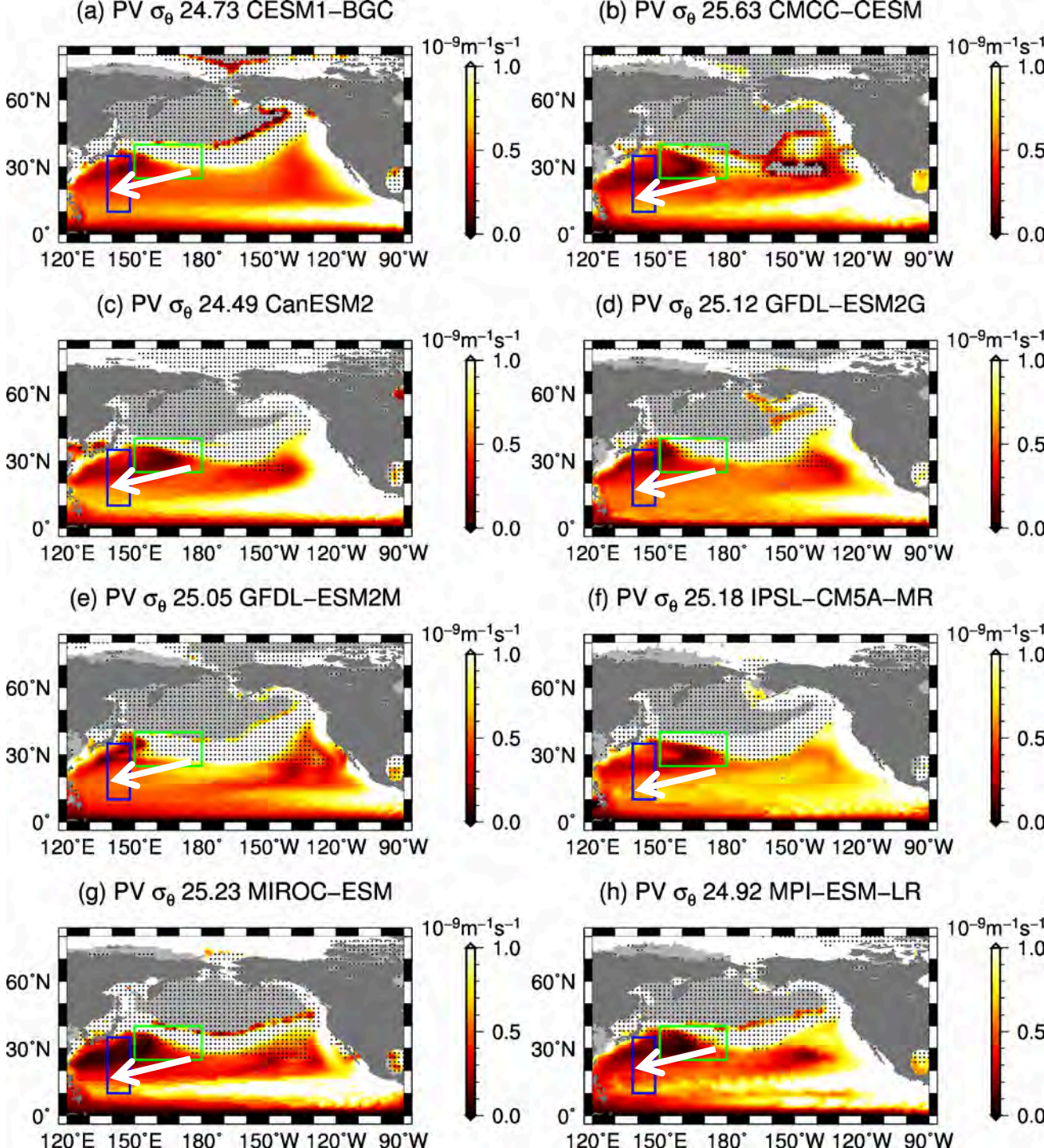
- Ω_{ca} decreases by 2.4 by the end of this century
- Ω_{Ar}=2.3 has been prposed for temperate corals (Yara et al., 2012)

Watanabe et al. (2016)

Potential Vorticity (PV) distribution on isopicnal surfaces

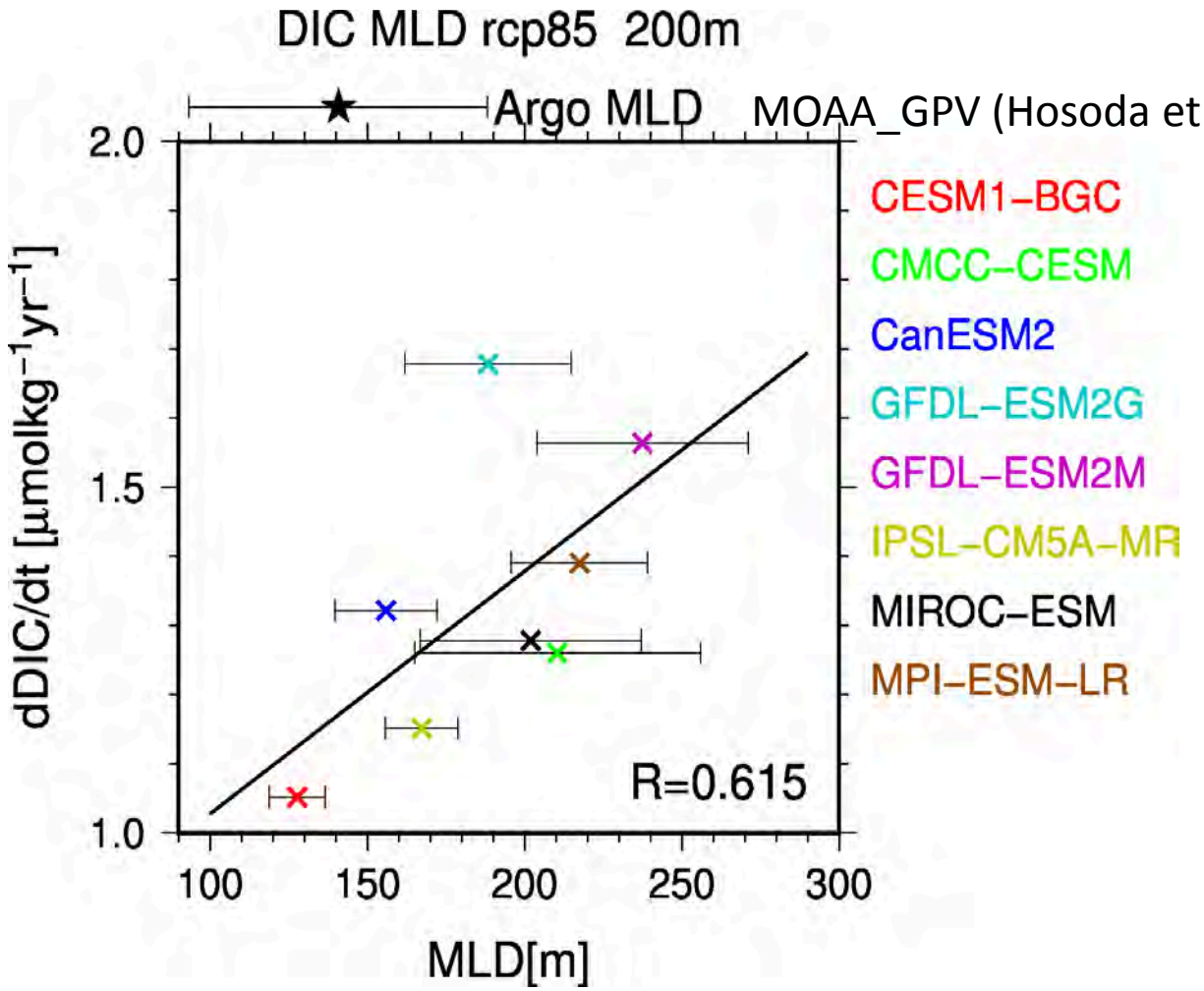
Dots indicate areas outcropping during Jun.-Mar.

Water masses with a low PV are transported from Kuroshio extension area toward the southeast



Watanabe et al. (2016)

DIC increasing rate in Izu-Ogasawara region



Winter mixed layer depth in Kuroshio extension region (2006-2015)

- Good correlation between the two variables
- Argo indicates lower values of MLD~140m

-> Importance of MLD reproducibility for impact assessments on deep corals

Watanabe et al. (2016)

Downscaling for studying changes in coral connectivity under warmer climate in East China Sea

Assessment of multiple effects of climate change on coastal ecosystem

- Quantify combined effects of global warming and ocean acidification on distribution, diversity and function of marine ecosystem and the uncertainties
- Present quantitative guidelines for conserving marine biodiversity and ecosystem services

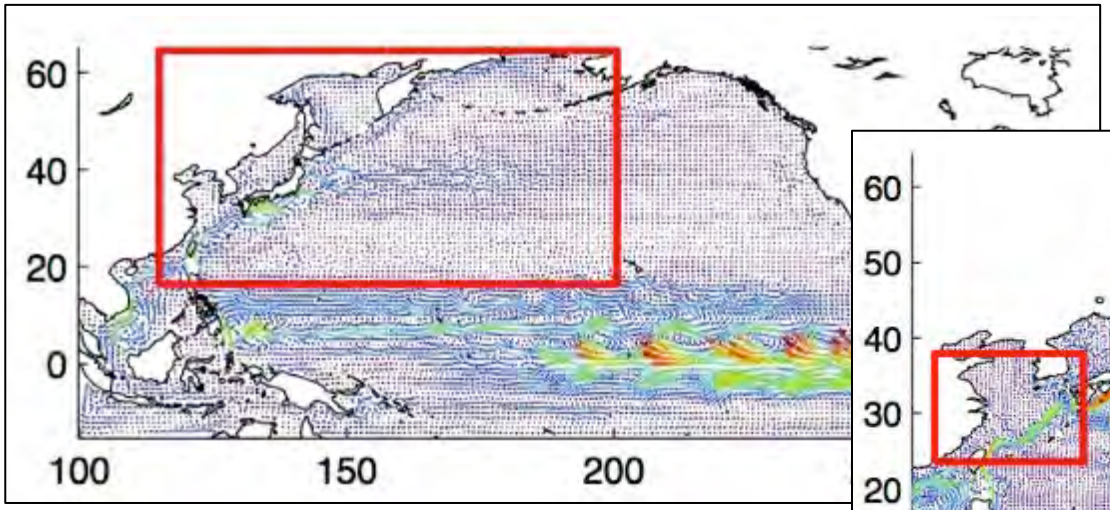
Simulation

Monitoring

Hokkaido University

National Institute for Environmental Studies

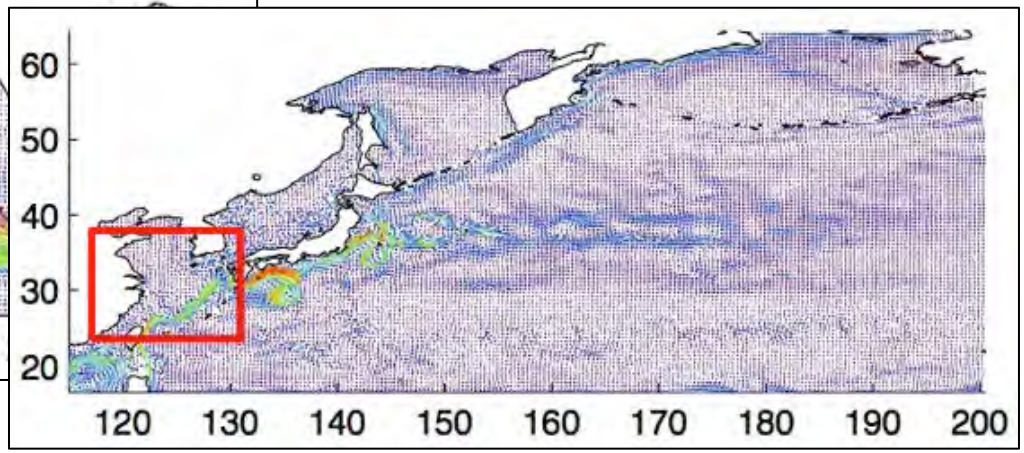
One-way, doubly-nested eddy-resolving model



(FRA-ROMS 1/2°)

Spatial current patterns

(FRA-ROMS 1/10°)



Spatial SST patterns

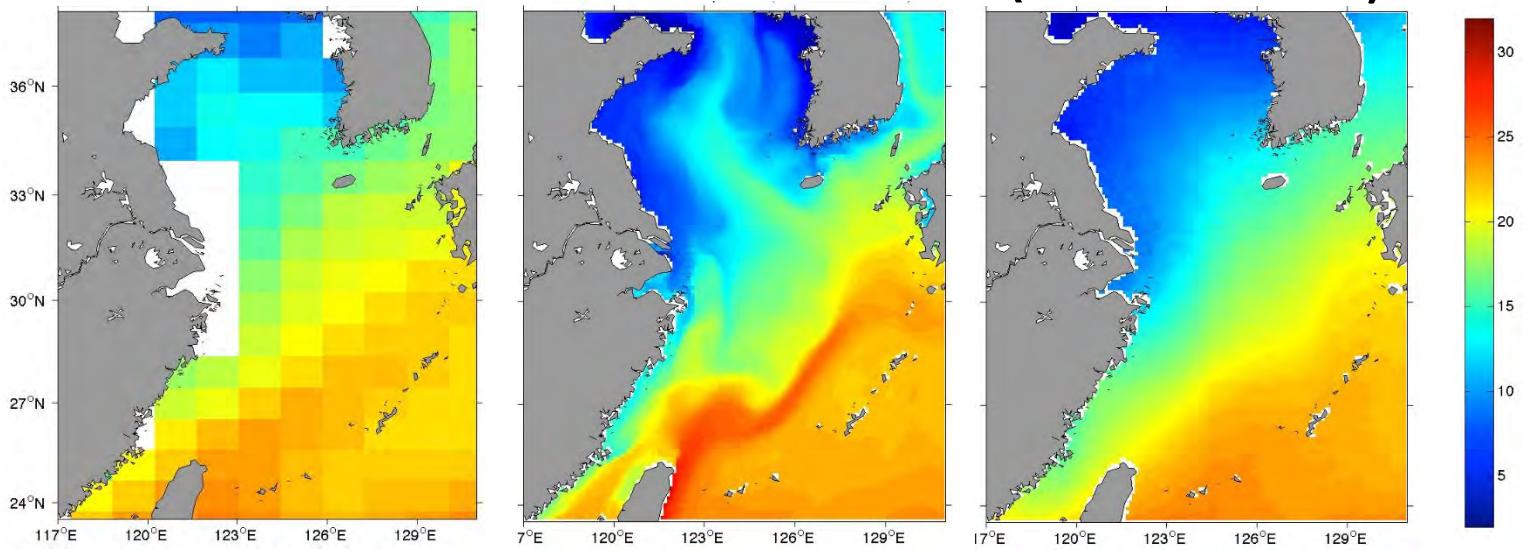
January 1996-2005 climatology

MIROC-ESM orig. (~150 km)

FRA-ROMS (10km) (Kuroda et al., 2013)

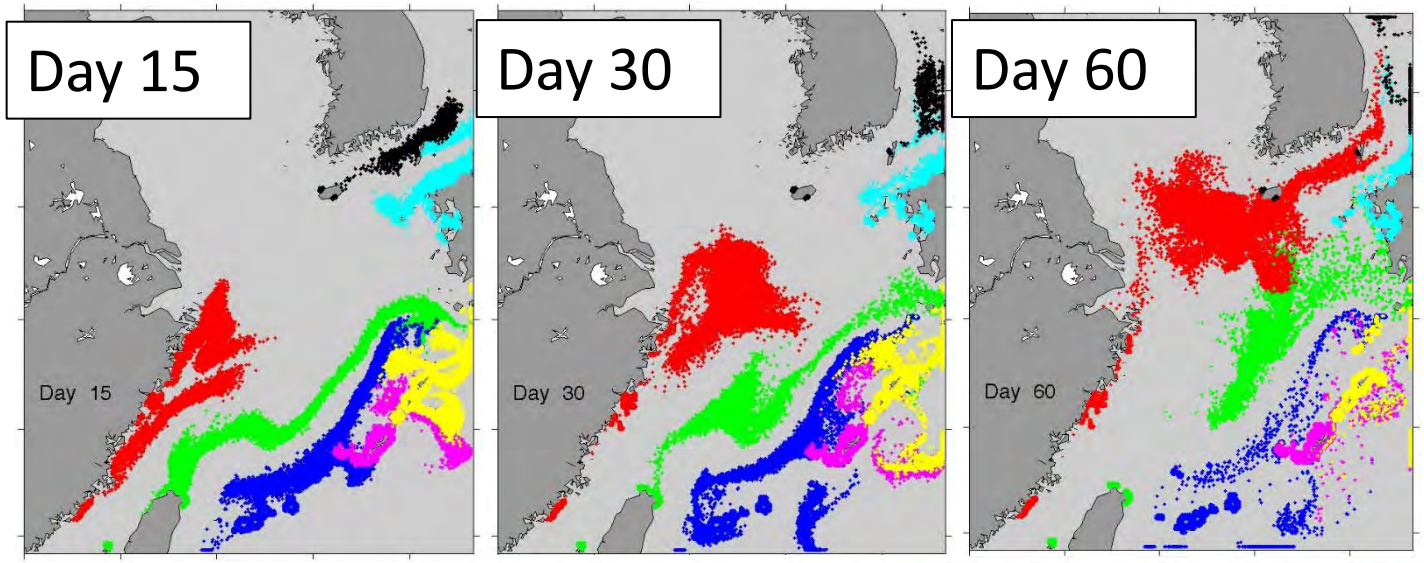
AVHRR (Satellite: 10 km)

[°C]

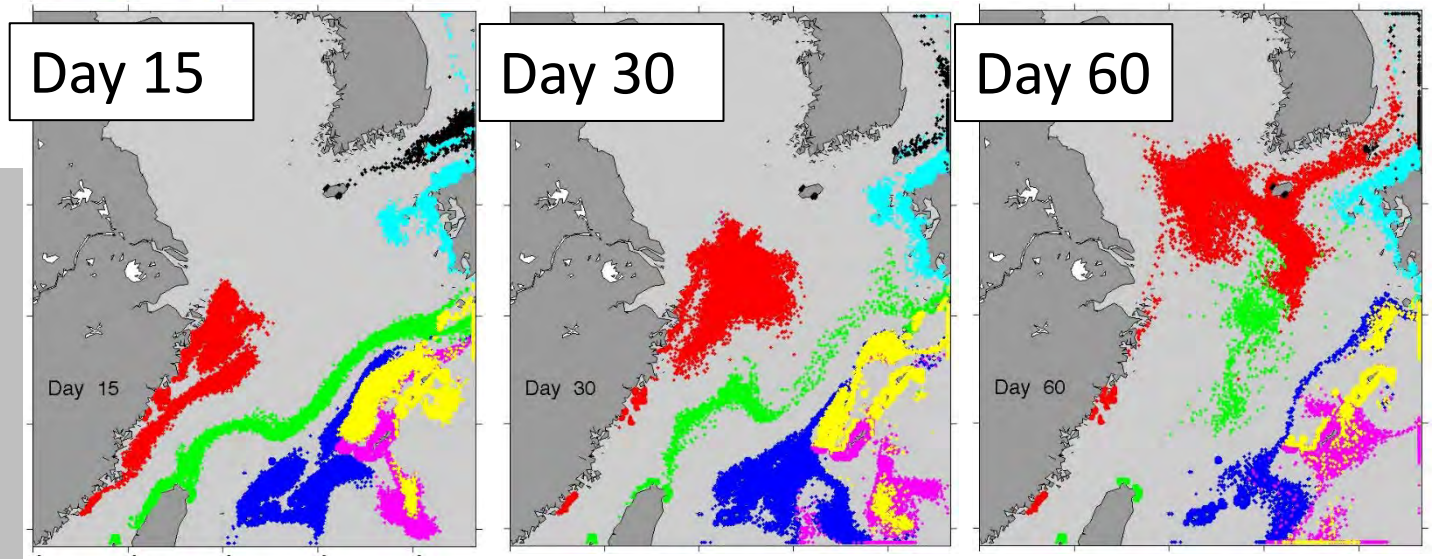


Passive tracer (as coral larvae) experiments
【Historical (1996-2005 climatology) and RCP8.5 (2086-2095)】

Historical



RCP8.5



Release points

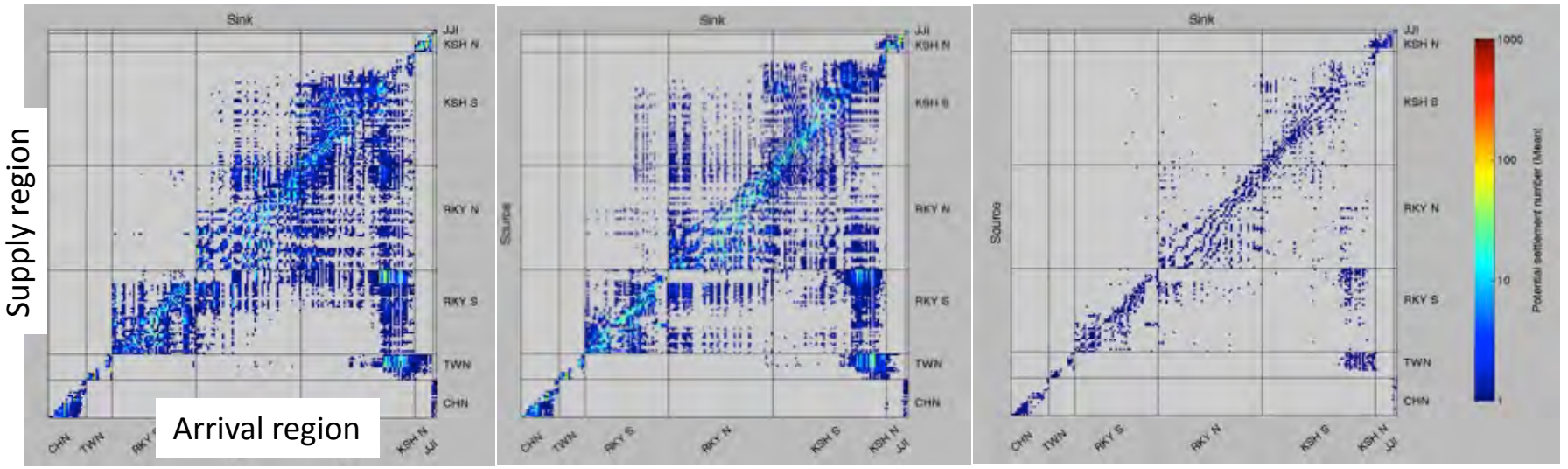
- China
- Taiwan
- Ishigaki
- Okinawa
- Amami
- Kyushu
- Tsushima

Changes in coral connectivity due to future warming and current changes in East China Sea

現在気候
（input data：climatology for 1996-2005）

Egg supply: constant
Survival & settlement rate are changed
RCP8.5
（input：climatology for 2086-2095）

Egg supply, survival & settlement rate are all changed
RCP8.5
（input data：climatology for 2086-2095）



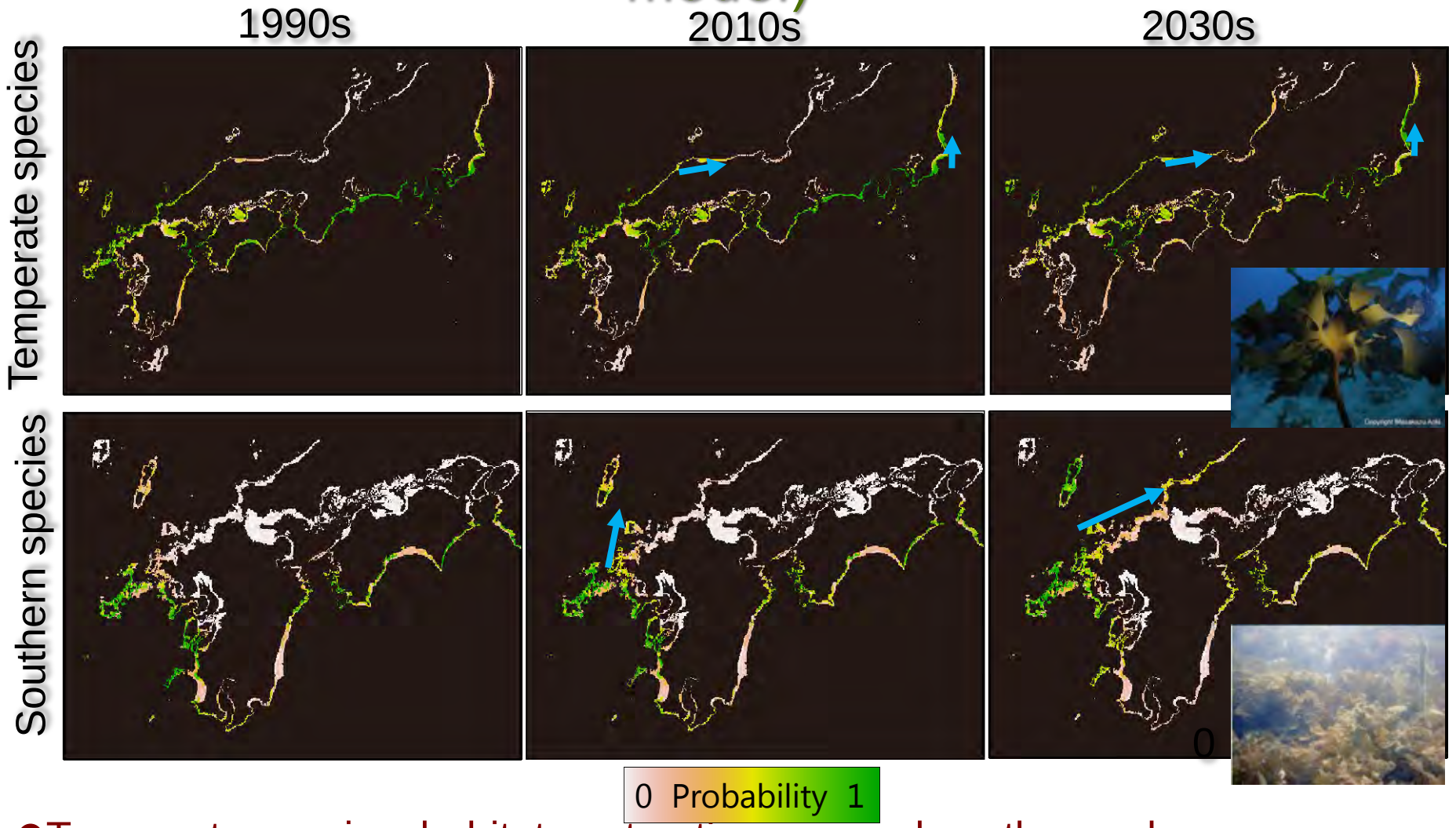
中国 台湾 石垣・宮古島 沖縄本島 奄美大島 種子島 九州本土

Connectivity changes are estimated based on the results for the last four years out of the 20-year integration for present and future.

- Settlement rate may be enhanced in the original region due to faster growth of larvae under higher temperature.
- Scatter may be increased.

- Scatter is decreased due to lower supply of spawn and enhanced settlement rate in the original region.

Prediction: past, current, and near-future (full model)



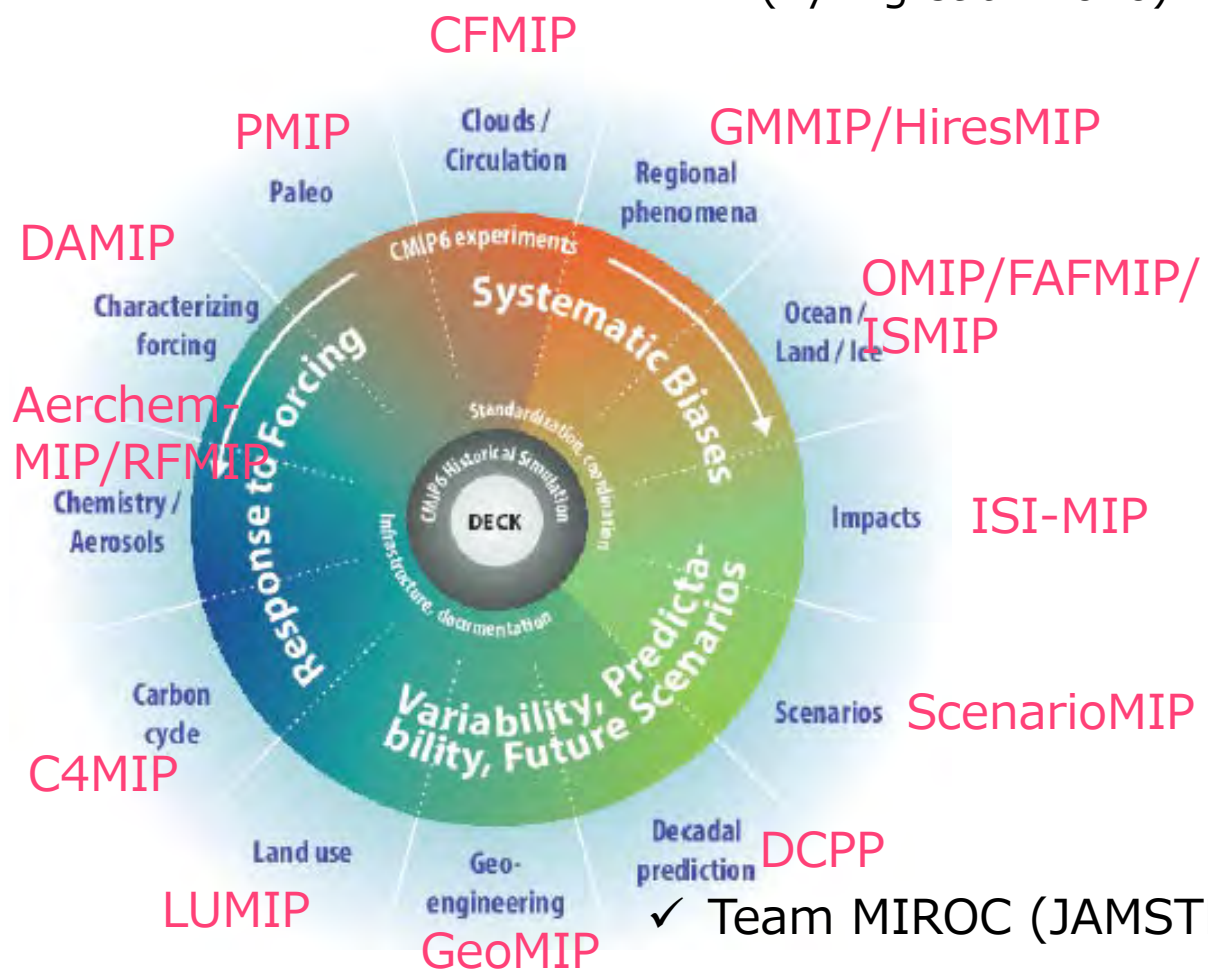
- Temperate species: habitat contractions around southern edges are remarkable
- Southern species: both of contractions and expansions

Activities in Japan toward CMIP6

DECK and Endorsed MIPs : MIROC group

Schematic of CMIP6 experimental design

(Eyring et al. 2016)



DynVAR
SIMIP
VIACS

✓ Team MIROC (JAMSTEC/AORI/NIES) are planning to participate in 16 Endorsed MIPs and 3 Diagnostic MIPs

MIROC series of models for CMIP6: Resolutions

CMIP6	MIROC6	ATM: T85(150km)L81(0.004hPa), OCN: 1°x0.5°-1°L63
	MIROC6hiresMIP	ATM: T213(60km)L??(??hPa), OCN: 0.25°x0.25°L63
	MIROC-ESM-LTE	ATM: T42(150km)L40(3hPa), OCN: 1°x0.5°-1°L63
	MIROC-ESM-FULL	ATM: T85(150km)L81(0.004hPa), OCN: 1°x0.5°-1°L63

Configuration of MIROC6 (Update from MIROC5)

AGCM (T85L81)

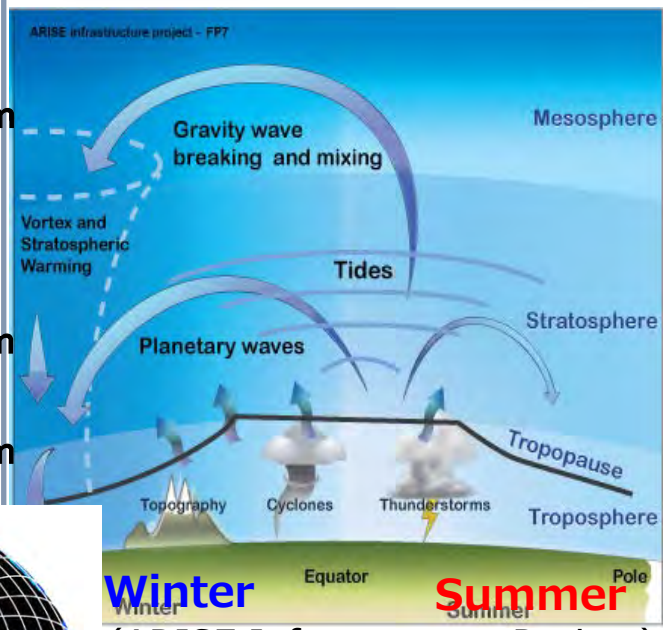
- Shallow convection
- High-Top TOA (3hPa → 0.004 hPa)
- SOA, Oceanic organic Aerosol
- Scattering by non-spherical cloud ice
- Non-orographic GWD
- modified CMT, water leak fixed, etc.

OGCM

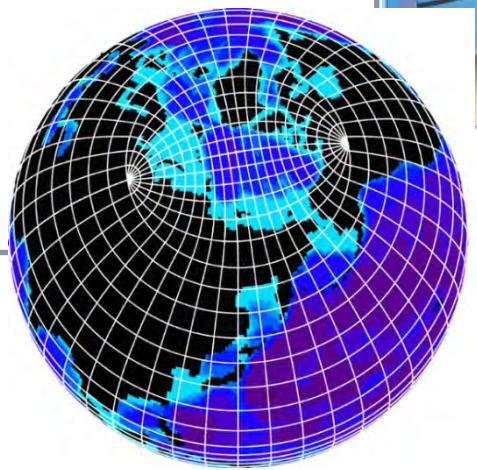
- Higher resolutions (1.4°L50 → 1°L63)
- Tripole coordinate
- Improved TKE estimate under sea-ice

Land Surface Model

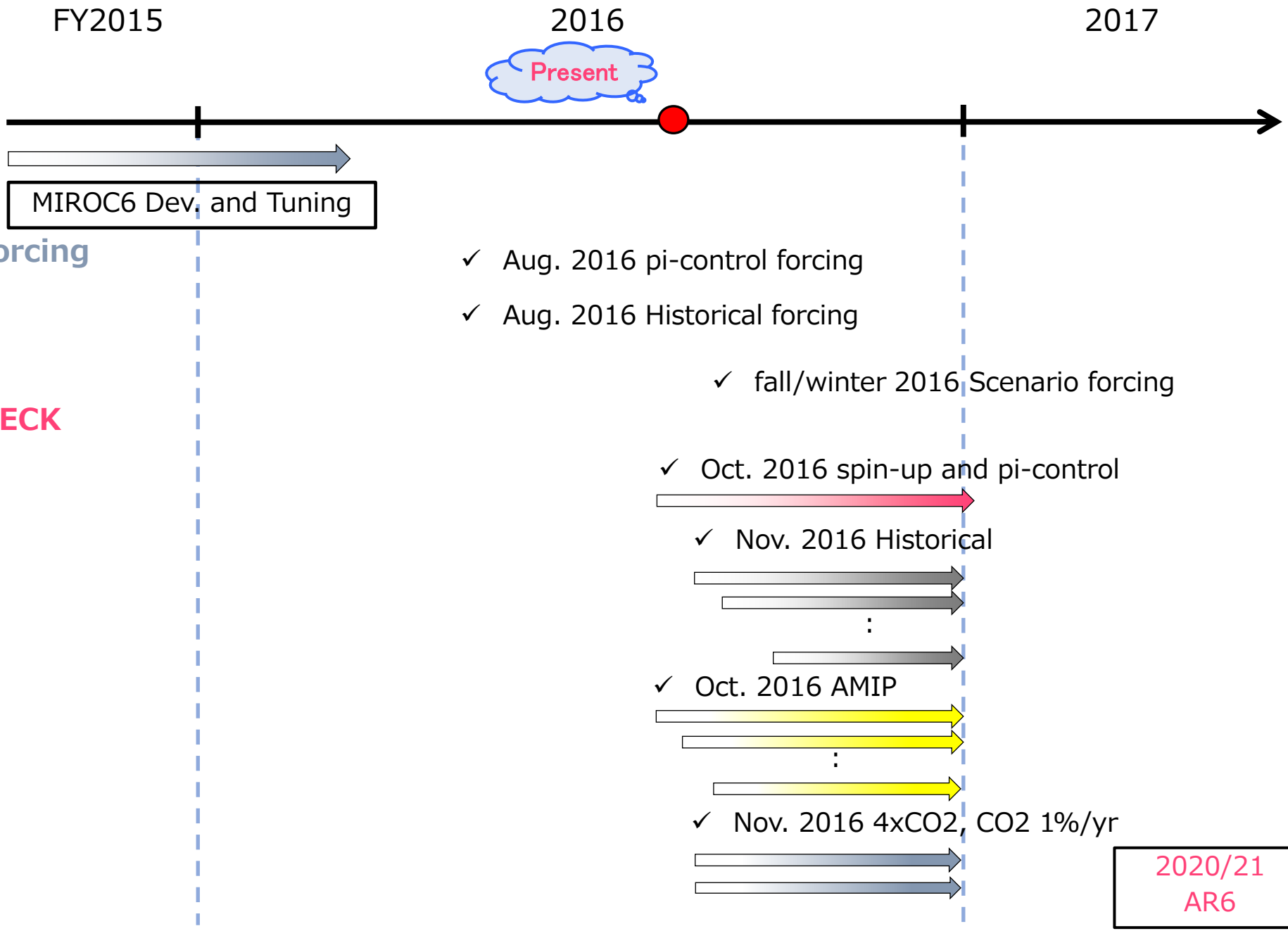
- Subgrid snow cover distribution
- Wet land due to snow melting



(ARISE Infrastructure Project)

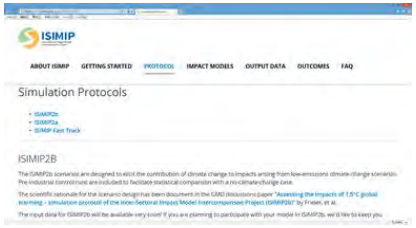


Timeline for CMIP6 experiments



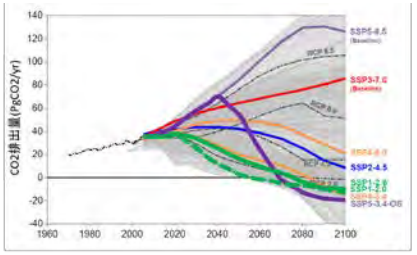
Responses for the 1.5°C trend

- HAPPI-MIP
  - Half a degree Additional warming, Prognosis and Projected Impacts
  - “Time” slice ensembles for +1.5°C and +2.0°C
  - Paricipants: MIROC5; NCAR CAM4,5; HadGEMx; CanAM4 etc.



- Extension of RCP2.6 for ISI-MIP
  - Warming projected by MIROC5 is close to 1.5°C
  - ISI-MIP asked Team MIROC, among others, to extend RCP2.6 exp.

- 1.5°C scenarios of scenarioMIP



O'Neil et al. (2016) GMDD

Summary

- Ocean acidification impact on precious corals
  - May reach a possible threshold at 2100 under RCP8.5
- Spawning and settlement of reef corals
  - More likely to settle in the original site
- Activities toward AR6
  - Team MIROC participate in most of the CMIP6 endorsed MIPs
  - 1.5^{o}C issues will also be addressed.