Japanese modeling groups' perspectives:

MIROC, MRI, and NICAM

Masa Watanabe (Univ of Tokyo, Japan)

Snapshot from 1 km NICAM prototype simulation

Model updates after CMIP6

MIROC6 ✓
MIROC-ESM ✓

→ unified → **MIROC7-ESM**

NICAM ✓

→ expanded → **NICAM AOGCM**

Unified ocean & land models
COCO (ocean model)
ILS (land model)

MRI-ESM3 ✓

→ updated → **MRI-ESM4**

Direction: toward higher resolution, more complexity, unified framework
Timeline: will be ready for piControl in ~2yrs
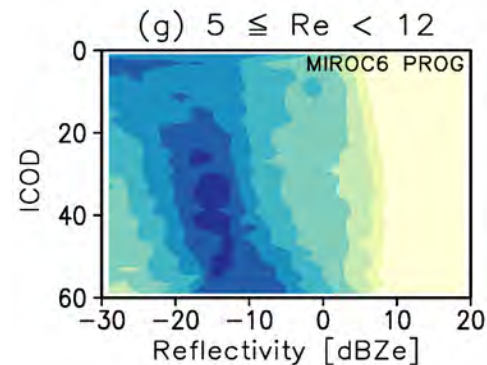
Development of **MIROC7** (climate component)

MIROC6

Strengths: realistic natural variability (MJO, ENSO, QBO & SSW) (Tatebe et al. 2019; Fasullo 2020)
Weaknesses: large error in energy budgets (Wild 2020) **& too weak cloud feedback** (Zelinka et al. 2022)
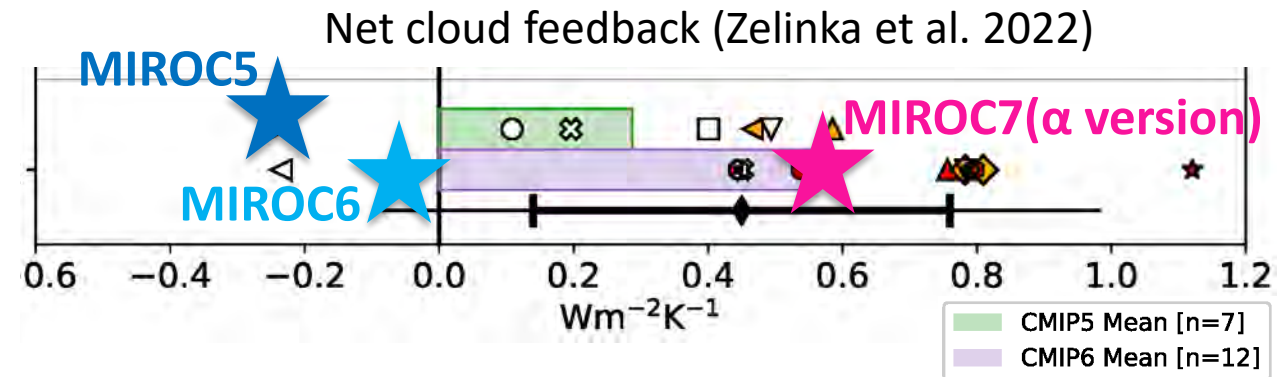
MIROC7

Improved energy budgets **with a prognostic rain/snow scheme** interacting w/ radiation

Better treatment of accretion & autoconversion of precipitating particles reduced "too fast rain problem" common to many GCMs

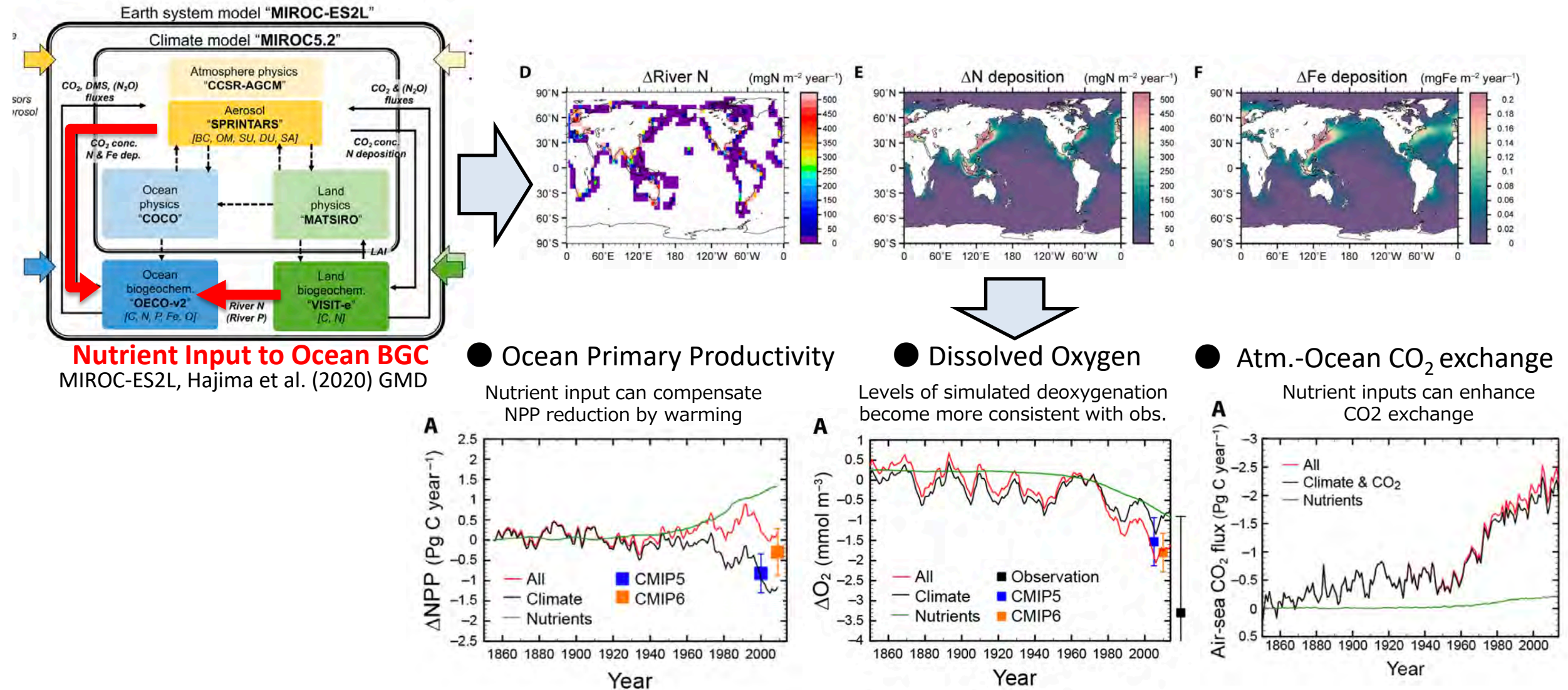Michibata & Suzuki (2020)

Net cloud feedback (Zelinka et al. 2022)

- Weak negative net cloud feedback in MIROC6 turned to positive in MIROC7α, consistent with Sherwood et al. (2020)
- Further update in radiation in progress

✓ Higher atmospheric horizontal resolution: 140km → 50km
✓ Other updates (ocean mixing processes, sea-ice treatment, etc)

Development of MIROC7 (Earth system module)

## *Nutrient inputs and the impact on ocean biogeochemistry*

Nutrient Input to Ocean BGC
MIROC-ES2L, Hajima et al. (2020) GMD

● Ocean Primary Productivity

Nutrient input can compensate NPP reduction by warming

● Dissolved Oxygen

Levels of simulated deoxygenation become more consistent with obs.

● Atm.-Ocean CO_2 exchange

Nutrient inputs can enhance CO2 exchange

Yamamoto, Hajima et al. (2022 Sci Adv)

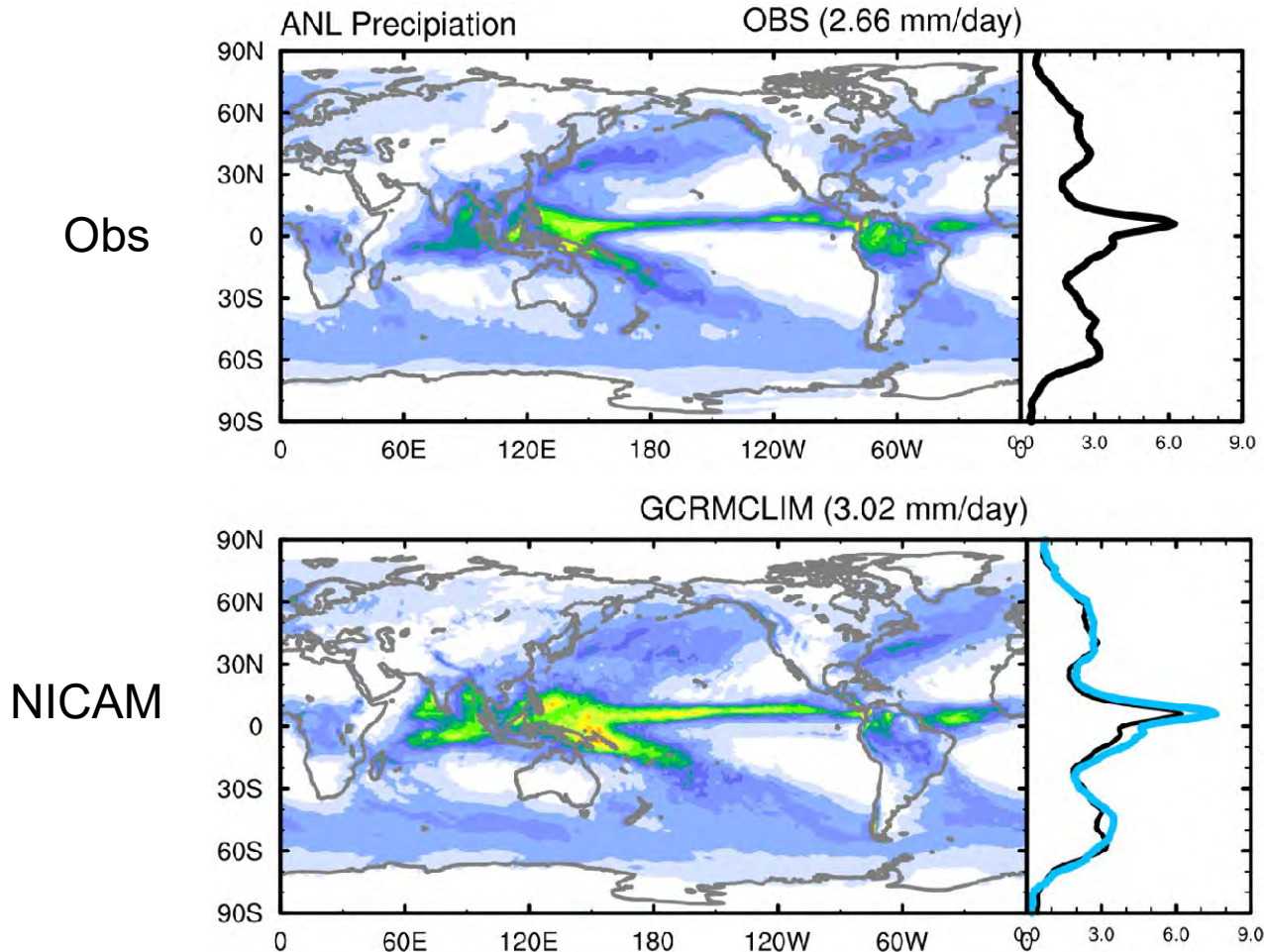# NICAM AGCM (3.5km/L78) for 10yr simulation (on-going)

Simulation period: From Jan 1, 2011; SST/ICE: OSTIA (daily; 1/20°; w/ slab); O3, Aerosol, GHG: Following HighRes MIP protocol
CPU: Use 10240 proc. (**2% node on Fugaku** [2560 nodes])
Finished 1st year

Frequency of intense rainfall
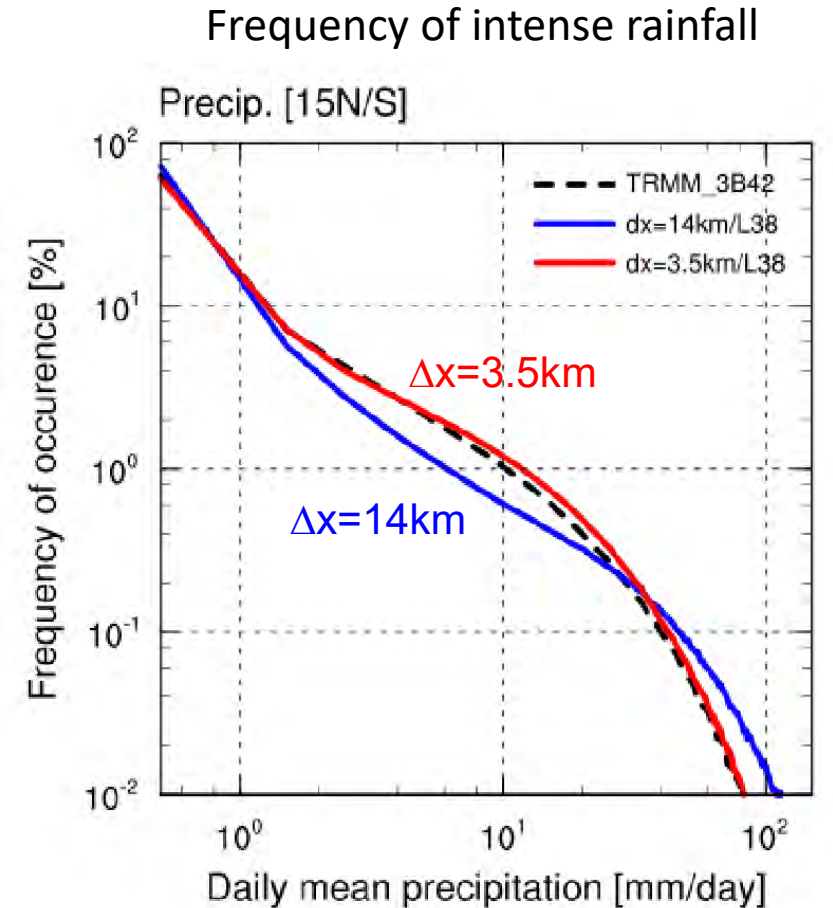
Courtesy of D Takasuka

Km simulation with NICAM

DYAMOND Phase 2

Setup: Sub-5 km mesh global models
Period: 40 days starting from Jan 20th, 2020 (EUREC4A)
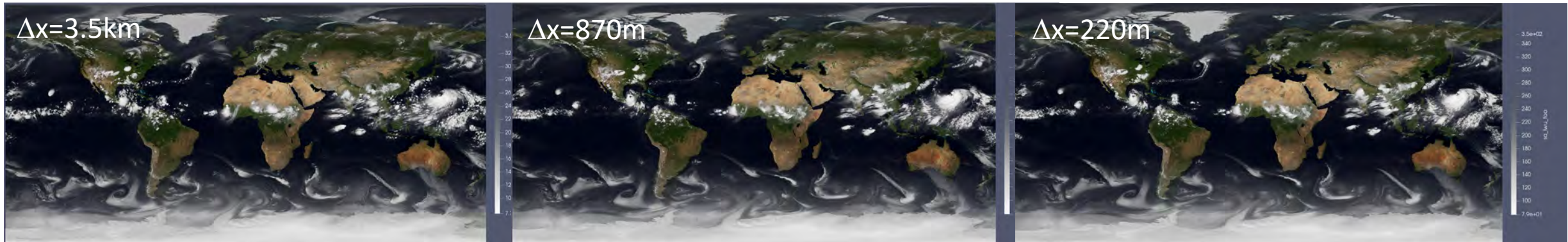Initial state: ECMWF operational forecast (or ERA5)

Courtesy of T Miyakawa, D Klocke & F Ziemen

Toward a global large-eddy simulation

CASE: Aug. 1-6, 2016: DYAMOND summer
Aug. 1-6 w/ Δx=3.5km; Aug. 4-6 w/ Δx=870m; Aug. 5 w/ Δx=220m

Courtesy of S Matsugishi, M Satoh

Integrated Land Simulator (ILS)

AGCMs
MIROC (Tatebe et al., 2019)
NICAM (Sato et al., 2014) etc.

OGCMs
COCO (Hasumi, 2006) etc.

Development of ILS (Nitta et al., 2020)

Basic concepts:
- Port the latest stand-alone models with smallest modification to codes
- Run the models with their preferred time steps and resolutions, and exchange necessary data with appropriate regridding
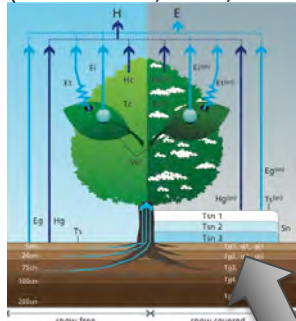
1-D Land Model MATSIRO
(Takata et al., 2003; Nitta et al., 2014; 2017)

General purpose coupler Jcup (Arakawa et al., 2020)

River Model CaMa-Flood
(Yamazaki et al., 2011; 2013)

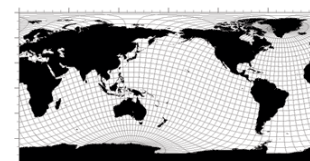**Human Impact Model H08**
(Hanasaki et al., 2008)

Peripheral / Environment:
- Spatial coordinates are controlled by mapping tables.
- Mapping table generator SPRING (Takeshima et al., in prep)
- Boundary conditions are also generated by using SPRING
- Gitlab version management
- Benchmarking with ilamb (underway)

Models to be coupled

Lake model and Hydrological Energy Transfer (Tokuda et al., 2021)

River A   Lake A   River B
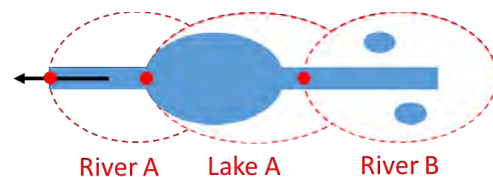
---: Boundary of unit-catchment
● : Outlet of unit-catchment

Sediment Transport
(Hatono and Yoshimura, 2020)

yield

Q_{s_out} S_s Q_{s_in} h

Q_{b_out} SSP PCP Q_{b_in}

S_d
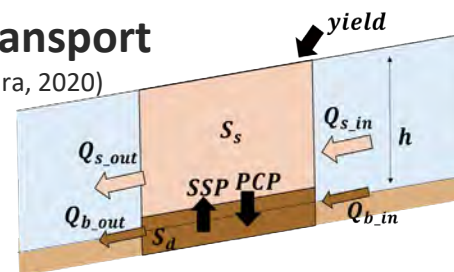
Generalized Dam Operation
(Hanazaki et al., 2022)

V_e V_f V_c

1. Surcharge pool
2. Flood control pool
3. Water supply pool (increase release)
4. Water supply pool (reduce release)

Sib-grid Hillslope Representation
(Li et al., in prep)

10 9 8 7 6 5 4 3 2 1

3D Groundwater
(Miura and Yoshimura, 2020; 2022)

MATSIRO

infiltration   runoff   CaMa-Flood

GW model   Water level
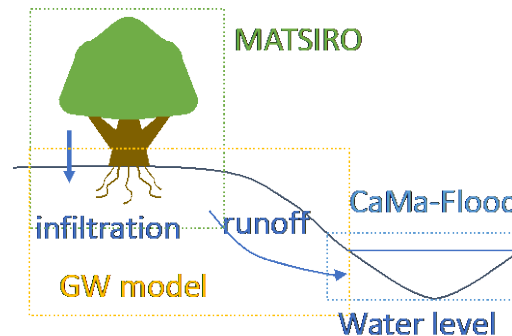
MRI-ESM related activities
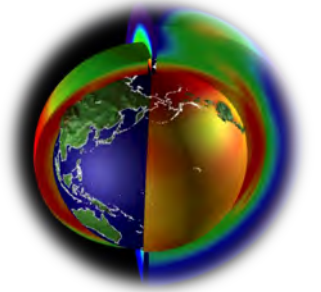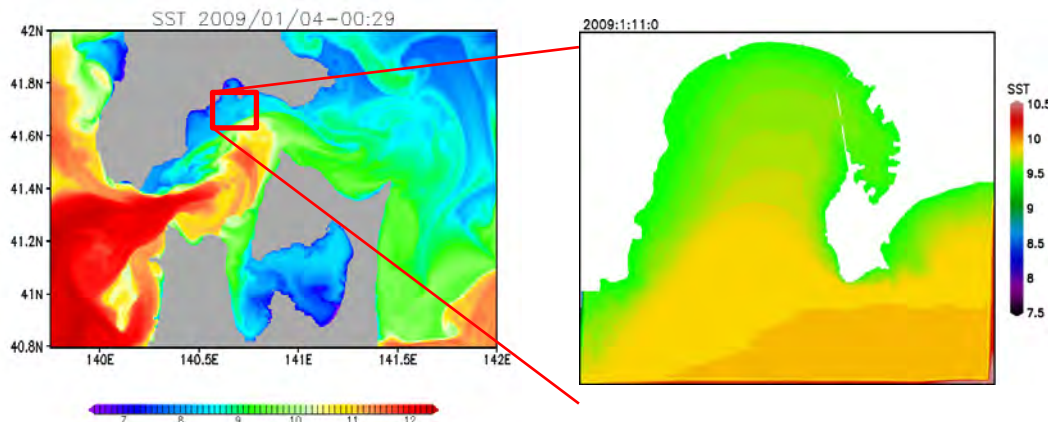

New version MRI-AGCM

Introducing the JMA operational AGCM
with many updates (available in 2023)

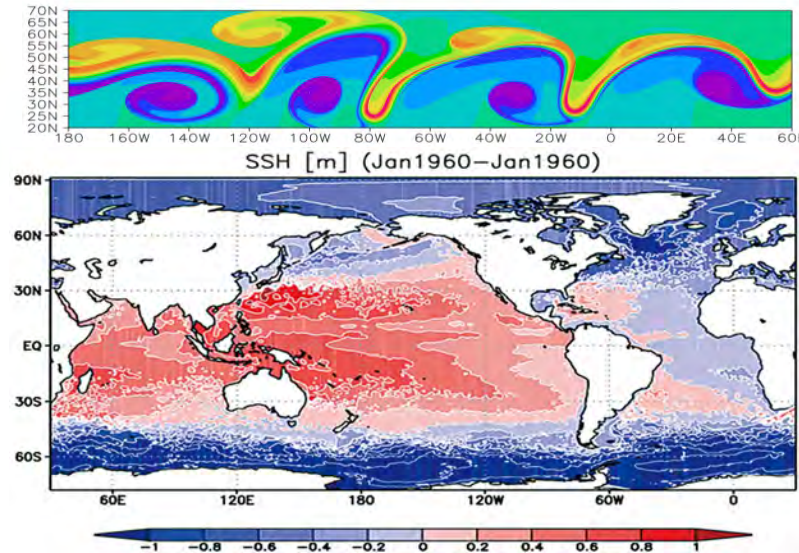(Yoshimura, Kawai, Mizuta et al.)

Updated MRI-AOGCM

Incorporation of Melt pond models into the sea Ice model
Arbitrary Lagrangian-Eulerian method (in progress)
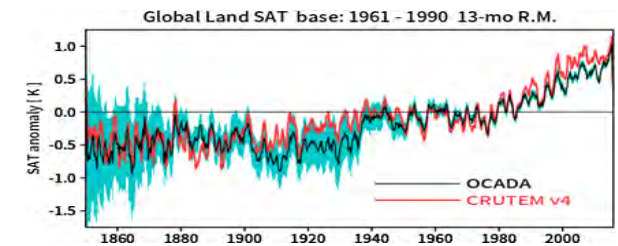Incorporation of a NPZD model

(Tsujino, Nakano, Urakawa et al.)
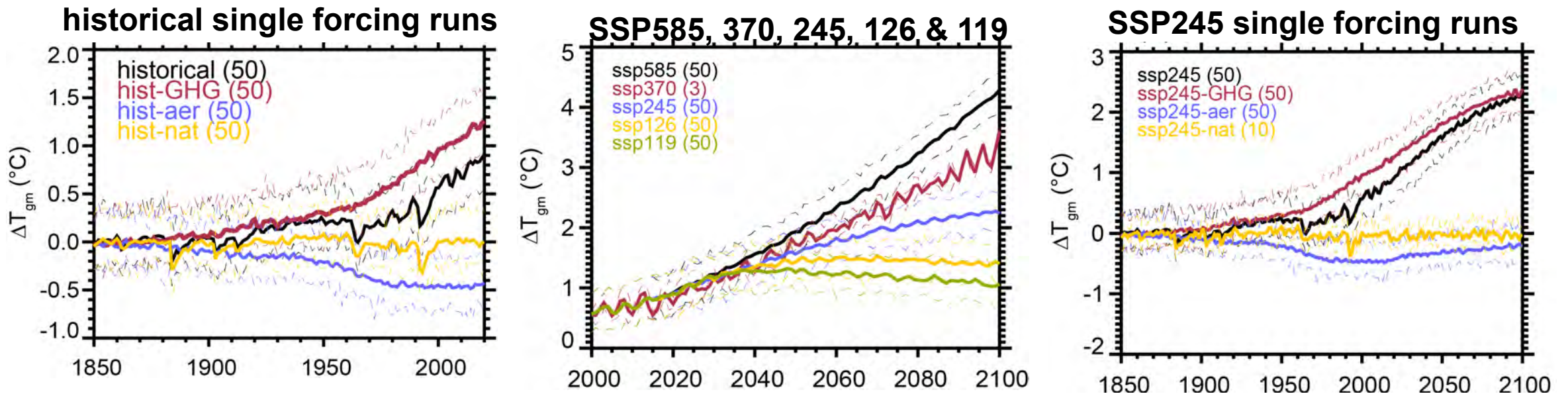
Toward high-resolution ESM

Historical atmospheric reanalysis

Atmospheric Reanalysis
from1850 to 2015 with the 60-
km MRI-AGCM + LETKF
(Ishii et al. 2022, submitted)

MIROC6 Large Ensemble (DAMIP)

Set of 50 member simulations (historical, 5 SSP scenarios, historical+SSP single forcing)

We have completed all the simulations except for the 50-member ensembles of ssp370 and ssp245-nat

Shiogama et al. (2022 in prep.)