Japanese modeling groups’ perspectives:

MIROC, MRI, and NICAM

Masa Watanabe (Univ of Tokyo, Japan)
Model updates after CMIP6

- MIROC6
- MIROC-ESM
- NICAM
- MRI-ESM3

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

- Weak negative net cloud feedback in MIROC6 turned to positive in MIROC7α, consistent with Sherwood et al. (2020)
- Further update in radiation in progress
Nutrient Input to Ocean BGC MIROC-ES2L, Hajima et al. (2020) GMD

Nutrient inputs and the impact on ocean biogeochemistry

● Ocean Primary Productivity
Nutrient input can compensate NPP reduction by warming

● Dissolved Oxygen
Levels of simulated deoxygenation become more consistent with obs.

● Atm.-Ocean CO₂ 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

# ANL Precipitation
# OBS (2.66 mm/day)
# GCRMCLIM (3.02 mm/day)

Frequency of intense rainfall

Δx=3.5km
Δx=14km

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)

Toward a global large-eddy simulation

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

Courtesy of S Matsugishi, M Satoh

Courtesy of T Miyakawa, D Klocke & F Ziemen

Courtesy of S Matsugishi, M Satoh
Integrated Land Simulator (ILS)

**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)

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

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

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

**Models to be coupled**

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

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

**Sediment Transport**
(Hatono and Yoshimura, 2020)

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

**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)
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 from 1850 to 2015 with the 60-km MRI-AGCM + LETKF
(Ishii et al. 2022, submitted)
Set of 50 member simulations (historical, 5 SSP scenarios, historical+SSP single forcing)

MIROC6 Large Ensemble (DAMIP)

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

Shiogama et al. (2022 in prep.)