A. Prediction and Projection of Large-Scale Climate Changes Based on Advanced Model Development MIROC6-CGCM
B. Sophisticated Earth system model for evaluating emission reductions needed MIROC-ES2L
C. Integrated Climate Change Projection
D. Integrated Hazard Prediction

MIROC: Model for Interdisciplinary Research on Climate
Description of the MIROC-ES2L Earth system model and evaluation of its climate–biogeochemical processes and feedbacks

Tomohiro Hajima, Michio Watanabe, Akitomo Yamamoto, Hiroaki Tatebe, Maki A. Noguchi, Manabu Abe, Rumi Ohgaito, Akinori Ito, Dai Yamazaki, Hideki Okajima, Akihiko Ito, Kumiko Takata, Koji Oguchi, Shingo Watanabe, Michio Kawamiya

Earth system model “MIROC-ES2L”

Climate model “MIROC5.2”

Physics “MIROC-AGCM”

Aerosol “SPRINTARS”

Physics “COCO”

Physics “MATSIRO”

Biogeochem. “OECO-v2”

Biogeochem. “VISIT-e”

(a) Land C change: By experiments

HIST
CTCL
HIST-NOLUC
HIST-BGC

(b) Ocean C change: By experiments

HIST
CTCL
HIST-NOLUC
HIST-BGC

(c) Land C change: By responses

HIST
Response to CO2
Response to Clim.
Response to LUC

(d) Ocean C change: By responses

HIST
Response to CO2
Response to Clim.
Response to LUC
MIROC-ES2L

Model

Validation

Data

GPP

Biomass

SOC

(Hajima et al., to be submitted to GMD)
LUH2 data

12 states => 5 states
3 cropland types

Forest area
Increase in SSP1
Decrease in SSP370

$ f_{LUC, PV} + f_{LUC, SV} + f_{LUC, UR} + f_{LUC, CR} + f_{LUC, PS} = 1 $
MIROC-ES2L

MATSIRO (Physics)

Non-Agriculture

Agriculture (Crop + Managed pasture)

Specific parameter file / LAI

VISIT (Ecosystem)

Primary Veg.

Secondary Veg.

Urban

Cropland

Pasture

Soil moisture/ Runoff rate

LAI / N leaching

$f_{LUC, PV} + f_{LUC, SV} + f_{LUC, UR} + f_{LUC, CR} + f_{LUC, PS} = 1$

Deforestation and abandonment

Infertile

harvest/fertilization/ N fixation /specific parameters

With higher leaf turnover

$f_{LUC, PV} + f_{LUC, SV} + f_{LUC, UR} + f_{LUC, CR} + f_{LUC, PS} = 1$
1. Transition (mass change and rebalancing)

Area fraction

Biomass per unit area etc.

Secondary

Pasture

Abandon

Mass ‘dilution’

Regrowth

CO₂ absorb

2. Harvest

Area fraction

Biomass per unit area etc.

Urban

Secondary

Harvest

Harvested mass

Transfer to product pools

CO₂ emission
1. N fertilizer

Area fraction

Biomass per unit area etc.

Secondary

Cropland

Fertilizer

2. N fix (agr.)

Secondary

N fixer

3. Urban

Secondary

Urban

CO2

4. Crop harvest

Transfer to product pools

Possible, but not introduced:
- Irrigation in cropland
- BECCS (eternally unreleased C)

CO2 emission
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### Graph

**Example: SOC (will be discussed tomorrow)**

- **Concentration-driven**
  - **pI control**
  - **Hist**
  - **Hist without**
  - 1850 years
  - 15 yrs
  - 2100 years

- **Emission-driven**
  - **pI control**
  - **Hist**
  - 1850
  - 2019
  - 2100

**Soil C, global (Pg C)**

- **Year**: 1650, 2019, 2100
- **X-axis**: 1650, 1700, 1750, 1800, 1850, 1900, 1950, 2000, 2050, 2100
- **Y-axis**: 1500, 1550, 1600, 1650, 1700, 1750, 1800, 1850, 1900, 1950, 2000, 2050, 2100

**Legend**

- **CD_hist_noLu**
- **CD_hist**
- **CD_pi**
- **ED_hist_noLu**
- **ED_hist**
- **ED_pi**
- **Experiment 1200**
- **Experiment 1285**
- **Experiment 370**
- **Experiment 126**
- **Experiment 370**
MIROC-ES2L

Done (will appear on ESGF soon)
• Historical, noLu, ssp-LU data exchange (conc.- and emission-driven)

Ongoing
• Idealized deforestation

Future
• Land-only simulations: land-hist, land-cCO2, land-cClim
• More ensembles?

Far future (CMIP7 and AR7?)
• Cropland irrigation, more cropland types (e.g., bio-fuel crop)
• Permafrost
• Re-coupling with dynamic vegetation
• Phosphorus limitation?
• Total greenhouse gas budget (CH$_4$ from paddy field, N$_2$O from croplands)