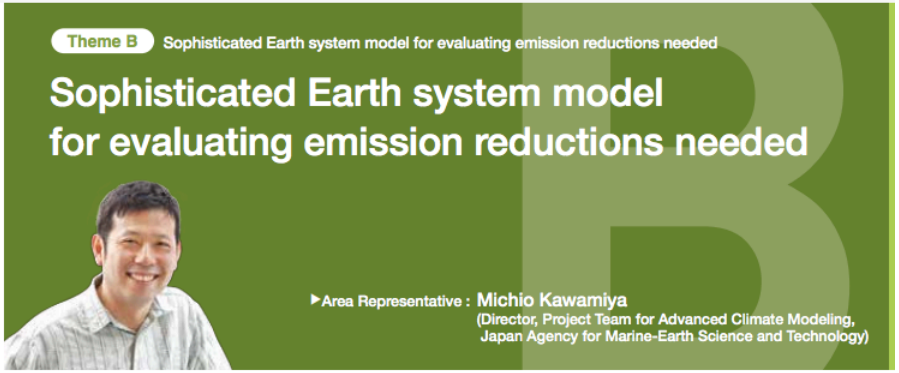
MIROC-ES2L

TOUGOU | Integrated Research Program for Advancing Climate Models

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



The IPCC's Fifth Assessment Report (2013) revealed the temperature rise due to global warming to be in good proportion with the cumulative emission of anthropogenic carbon dioxide. This relationship can be used to estimate total acceptable emissions if society is to achieve the 2°C target. About two thirds have already been emitted of total emissions thus estimated. This leads to the understanding that achieving the 2°C target or the 1.5°C target mentioned in the Paris Agreement will not be easy at all, however, the uncertainty involved in the estimate is also quite large. The exact value of the estimate can lead to huge differences in the cost of global change mitigation and thus drastic changes in what future society will be like in terms of energy production and consumption.

The "Earth System Model" (ESM), a climate model that utilizes biological and chemical processes, is used in computing total overall acceptable emissions and examining all the associated uncertainties. Theme B involves further development of ESM via the introduction of the new biogeochemical processes that are needed in more sophisticated global change projections, for example nitrogen and methane cycling, improving the physical processes involved with the atmosphere and oceans in thereby enabling the performance of more elaborate evaluations, and taking into account the interaction between human activities and the Earth system. We will also work on simulation studies for use in evaluating the effectiveness of artificial control of the climate such as scattering sunlight by distributing fine particles throughout the atmosphere in order to slow down the global change. In addition, keeping an eye on abrupt changes in the Earth system, for example the collapse of the Antarctic ice sheets, with which the probability may be low but the damage gigantic, will be necessary. Through these activities Theme B aims to contribute to international efforts to establish a pathway to mitigating global change, including the Climate Change Framework Convention, which entered a new phase with the Paris Agreement.

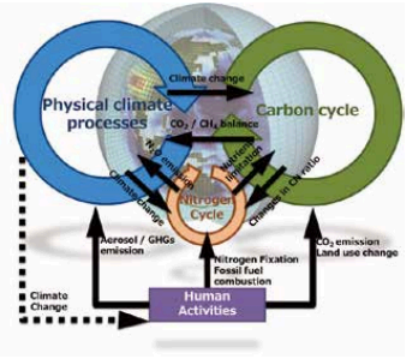


Fig. 1: Conceptual diagram of global change projection via an Earth System Model that incorporates nitrogen circulation
Anthropogenic emissions of greenhouse gasses and artificial nitrogen fixation (process wherein nitrogen in the atmosphere is transformed into a biologically reactive form) are increasing, and are critical factors with future global environment projections. Comprehensive projections that take into consideration the interactions between the carbon and nitrogen cycles and the physical climate change are very important.

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<u>Description</u> of the MIROC-ES2L Earth system model and evaluation of its climate–biogeochemical processes and feedbacks

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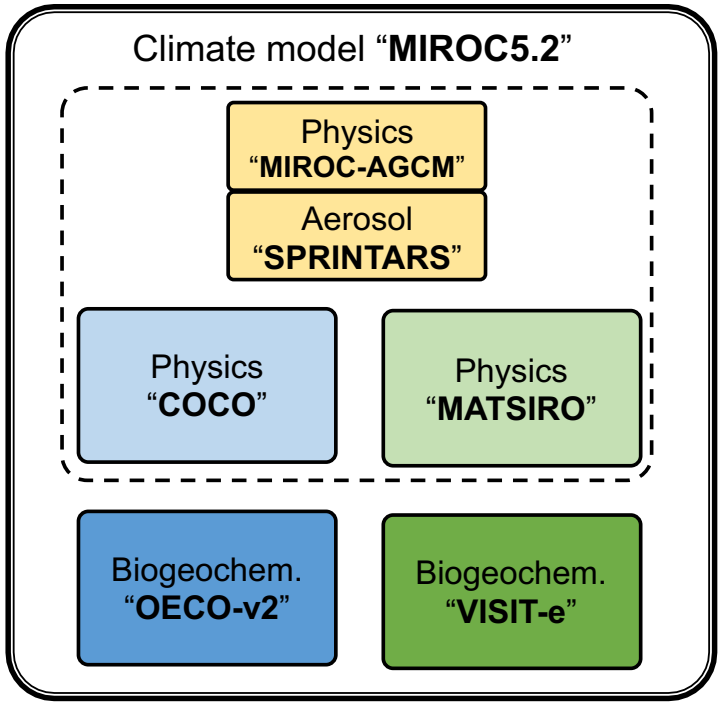
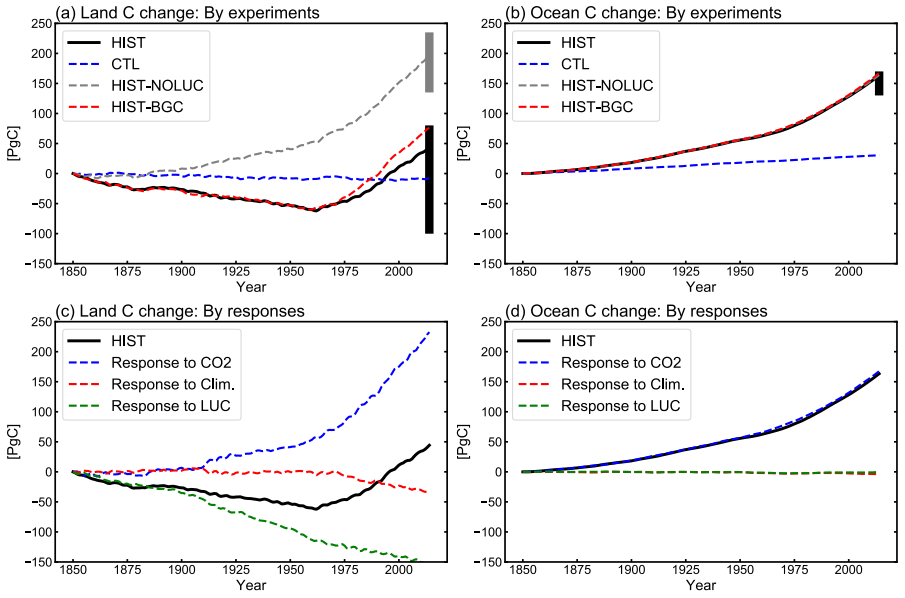
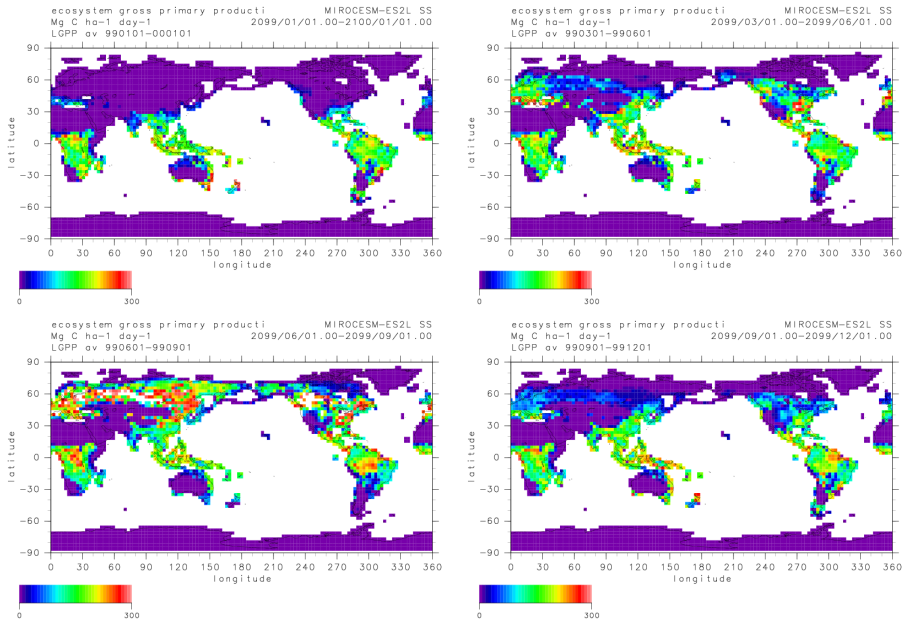
Earth system model "**MIROC-ES2L**"







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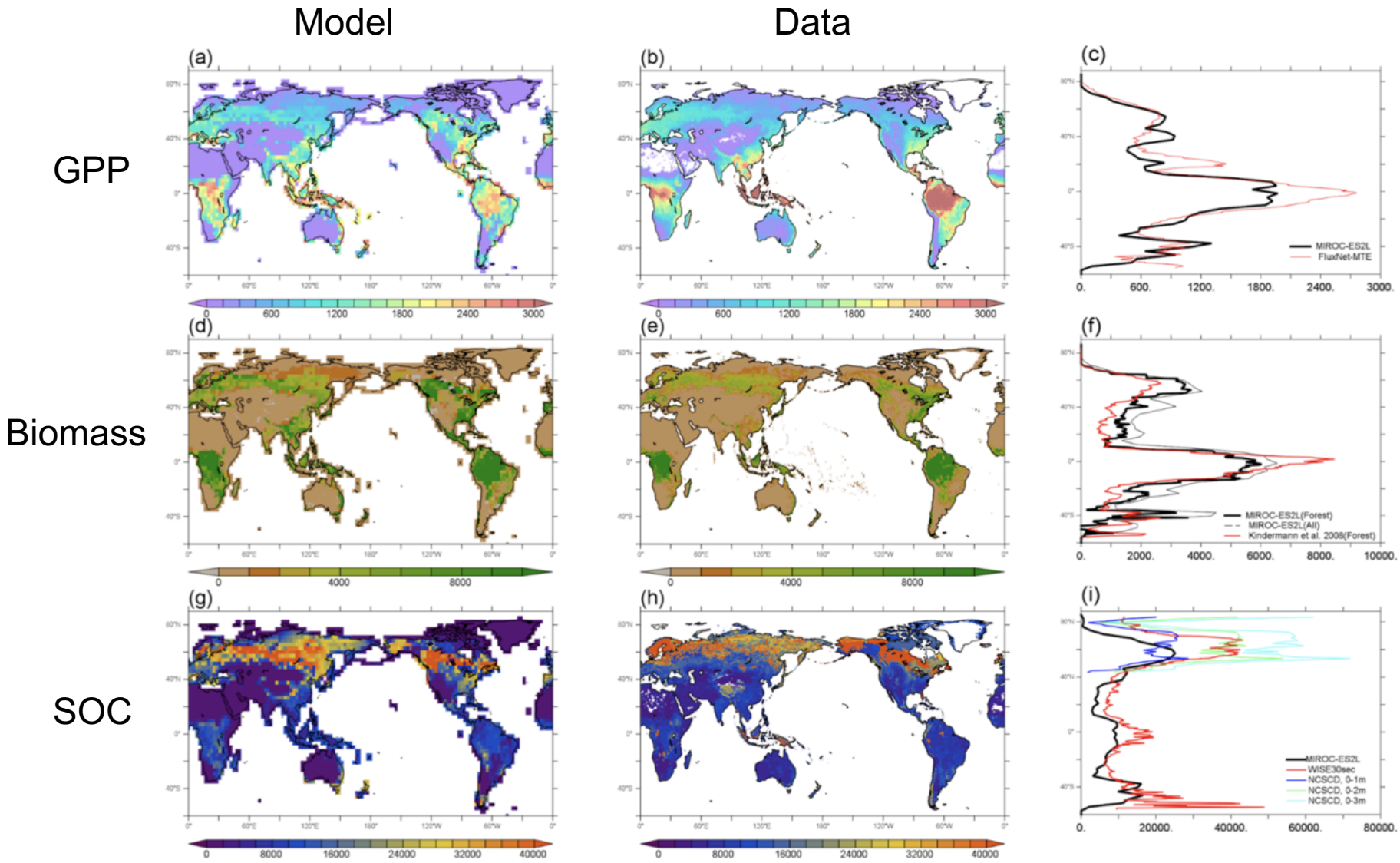
Validation



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

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LUH2 data

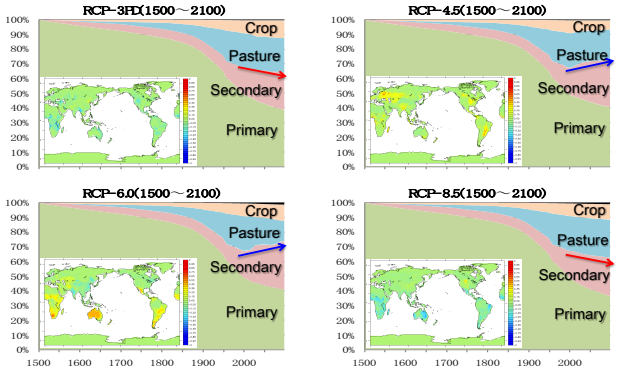
$$f_{LUC,\,PV} + f_{LUC,\,SV} + f_{LUC,\,UR} + f_{LUC,\,CR} + f_{LUC,\,PS} = 1$$

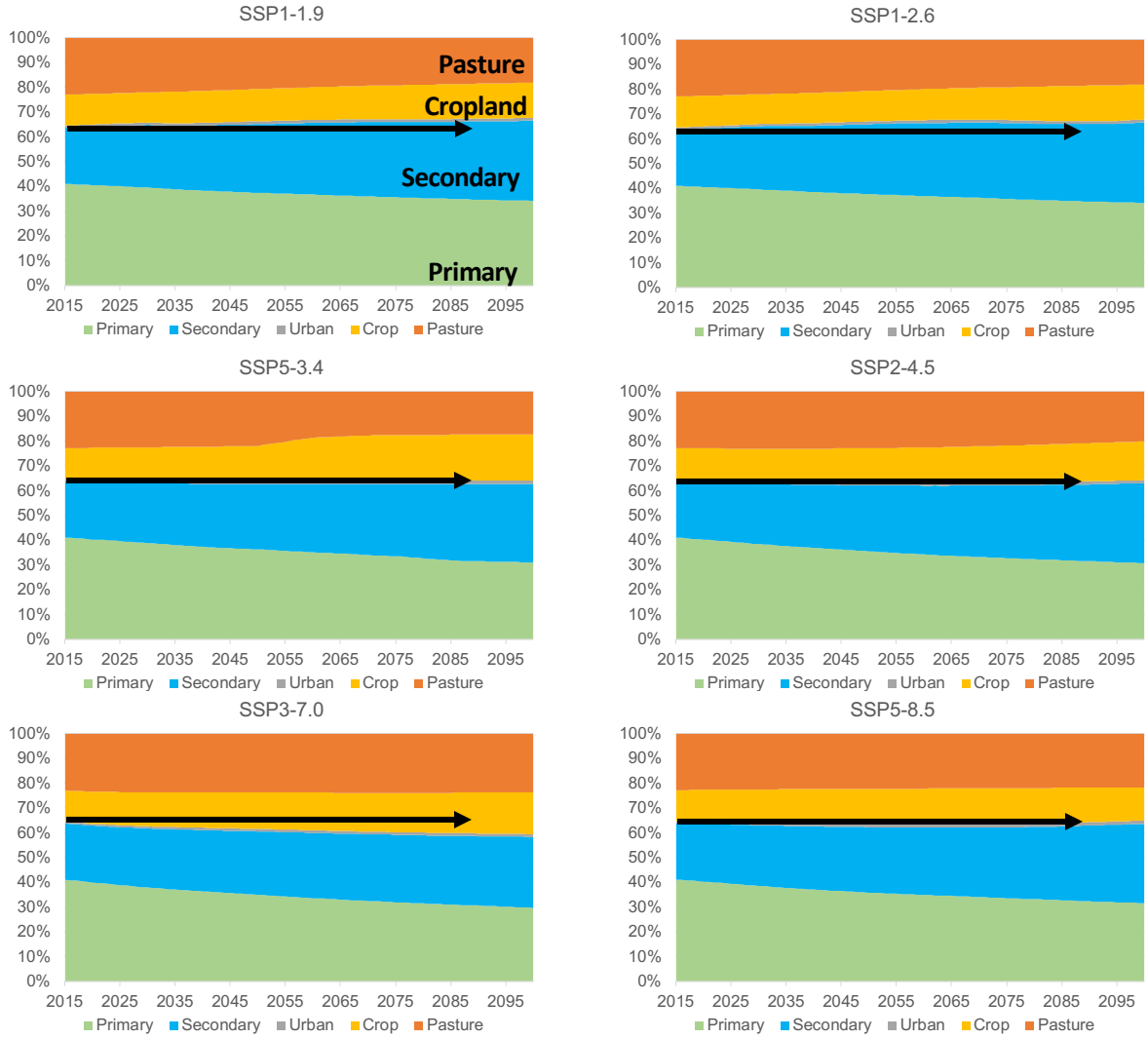
12 states => 5 states
3 cropland types

Forest area
Increase in SSP1
Decrease in SSP370

Crop + Pasture

Prim + Secon





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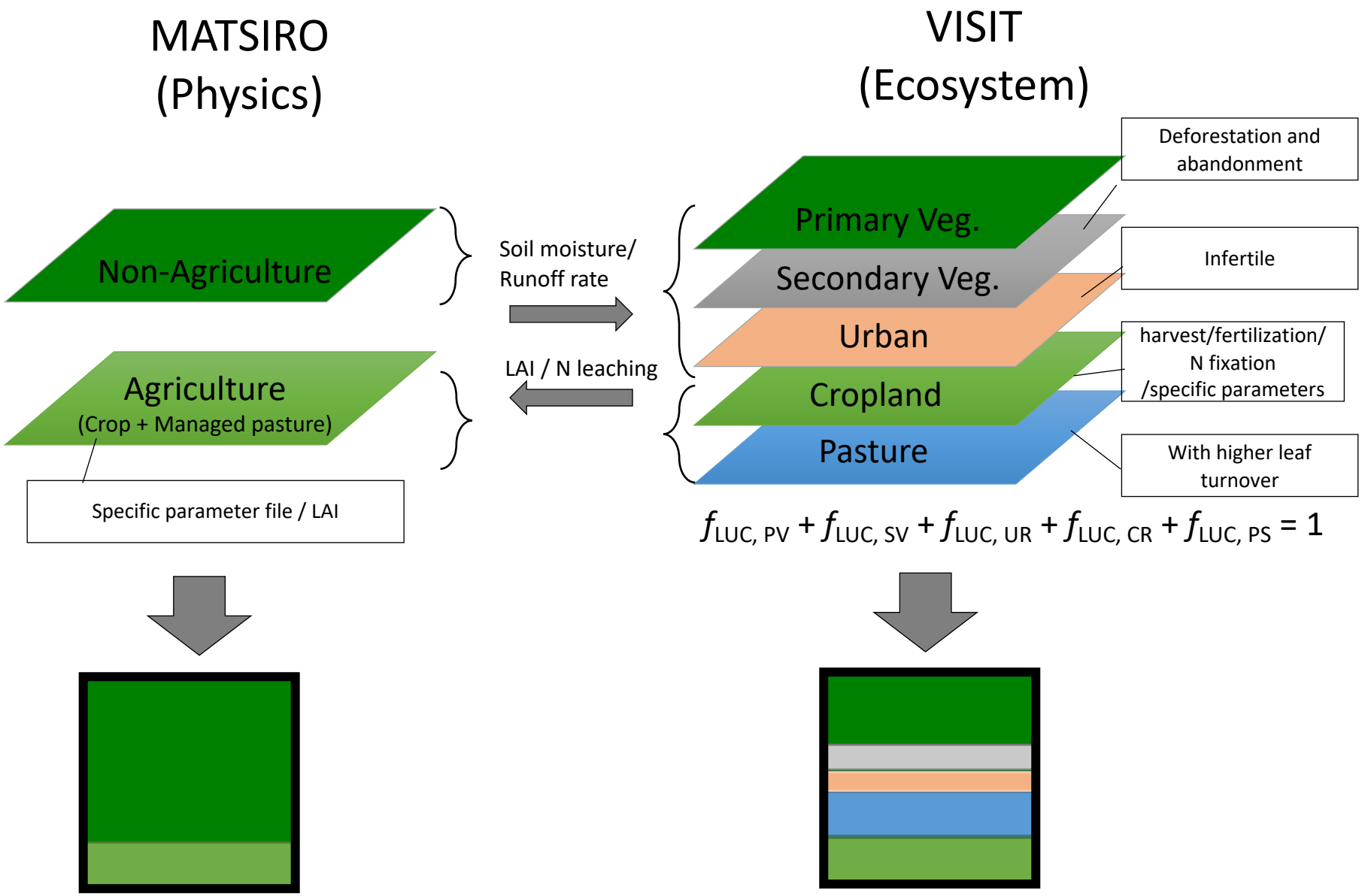
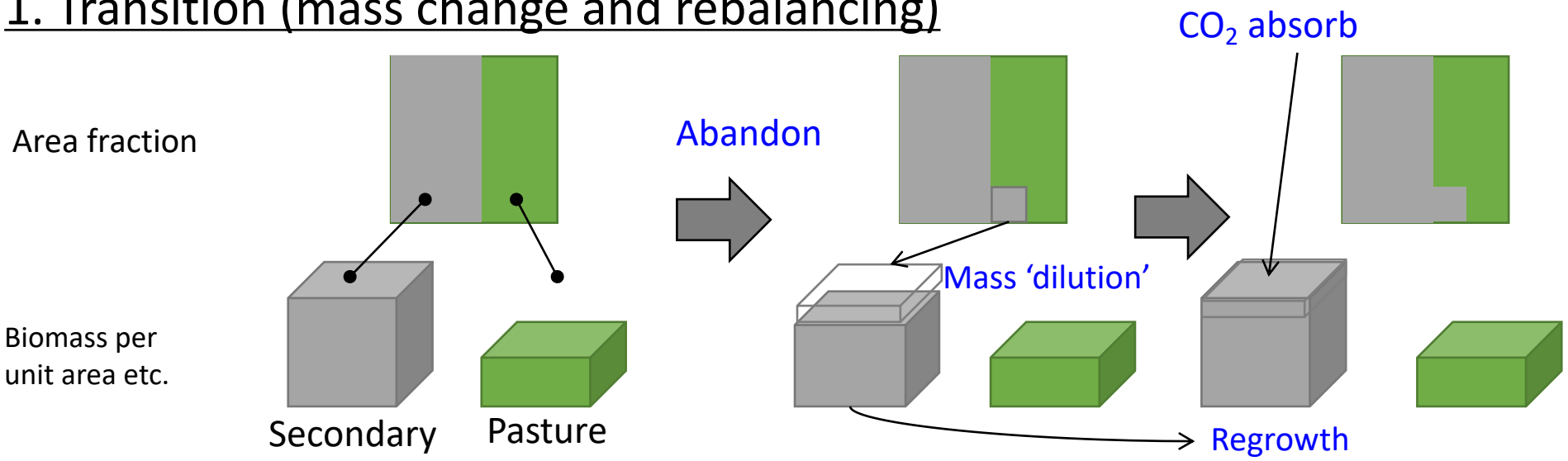
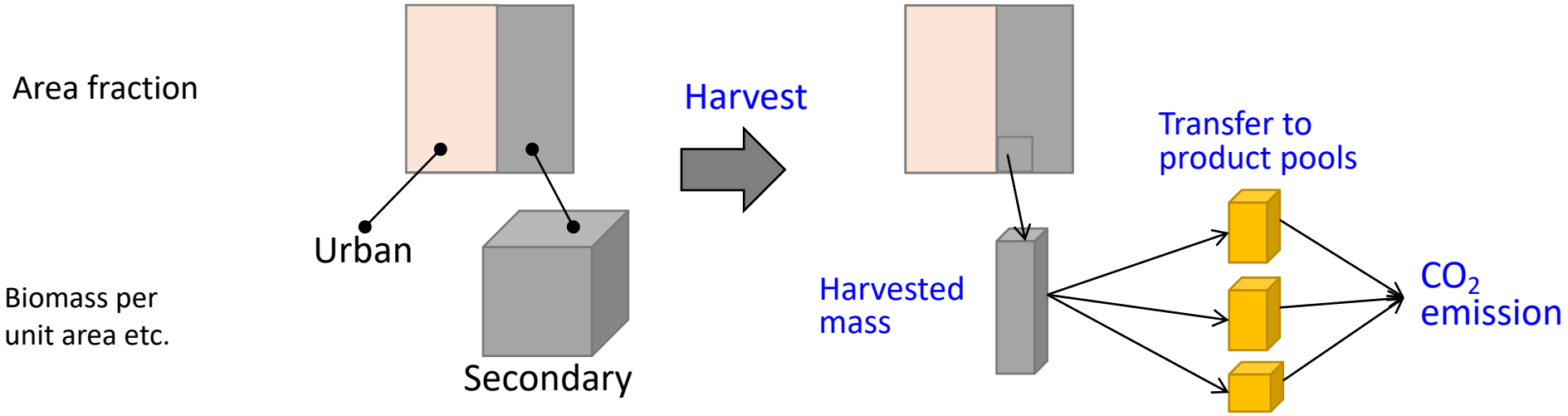

MATSIRO
(Physics)
VISIT
(Ecosystem)
Non-Agriculture
Agriculture
(Crop + Managed pasture)
Specific parameter file / LAI
Soil moisture/
Runoff rate
LAI / N leaching
Primary Veg.
Secondary Veg.
Urban
Cropland
Pasture
Deforestation and
abandonment
Infertile
harvest/fertilization/
N fixation
/specific parameters
With higher leaf
turnover
$f_{LUC,\,PV} + f_{LUC,\,SV} + f_{LUC,\,UR} + f_{LUC,\,CR} + f_{LUC,\,PS} = 1$

MIROC-ES2L

1. Transition (mass change and rebalancing)



2. Harvest



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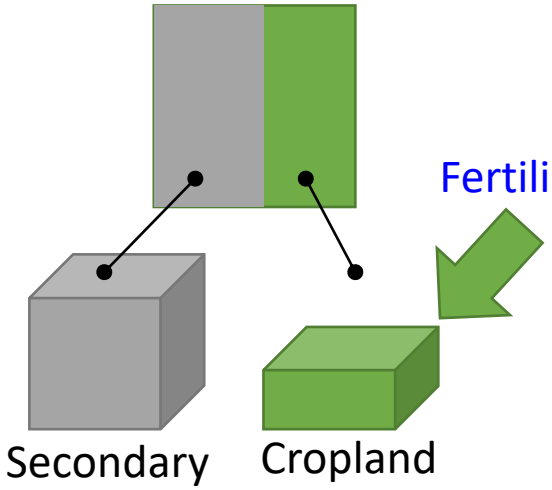
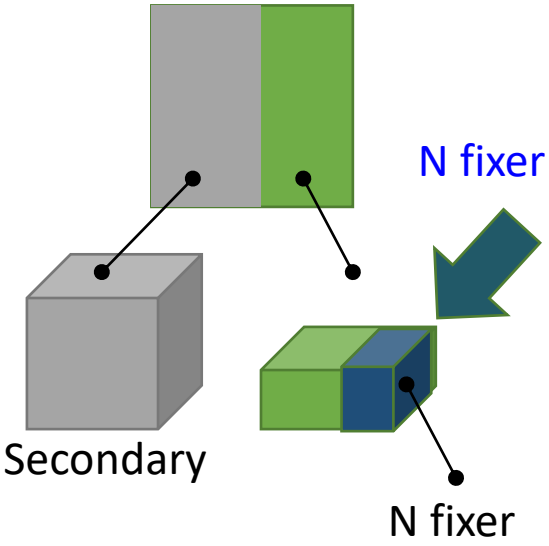
1. N fertilizer

Area fraction

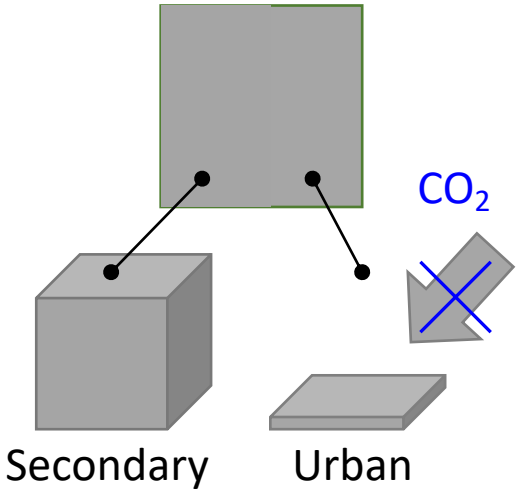
Biomass per unit area etc.



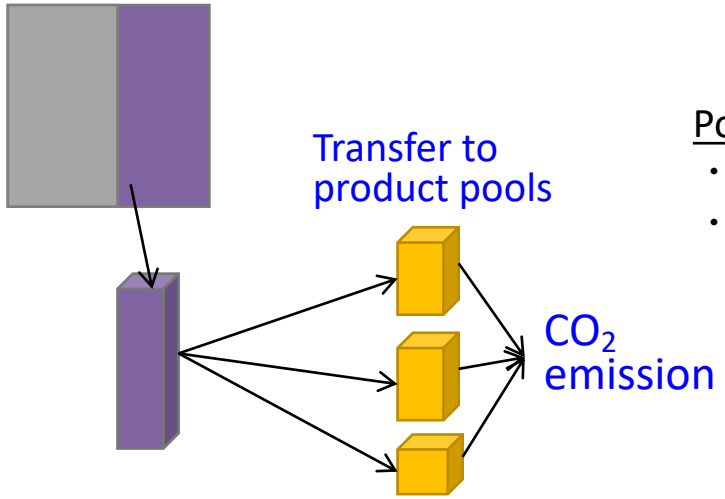
2. N fix (agr.)



3. Urban



4. Crop harvest



Possible, but not introduced:

- Irrigation in cropland
- BECCS (eternally unreleased C)

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model	# of activities	AerChemMIP	C4MIP	CDRMIP	CFMIP	CMIP	DAMIP	DCPP	FAFMIP	GMMIP	GeoMIP	HighResMIP	LS3MIP	LUMIP	OMIP	PAMIP	PMIP	RFMIP	ScenarioMIP	VolMIP
# of models	167	15	7	3	10	29	9	4	2	8	4	20	5	8	8	2	3	9	20	1
AWI-CM-1-1-MR	3	50				960													50	
BCC-CSM2-MR	8		514		844	2161	1481			413			41	858					884	
BCC-ESM1	2	2988				1631														
CAMS-CSM1-0	3	66				648													330	
CESM2	12		890	134	1126	14659	1380			291			265	3574	1546	46400		742	5492	
CESM2-WACCM	4	2149				7143					678								5357	
CMCC-CM2-HR4	1											70								
CMCC-CM2-VHR4	1											70								
CNRM-CM6-1	12	1931			2944	7052	5161	20919		832		674	153	153	7			580	5457	
CNRM-CM6-1-HR	1											410								
CNRM-ESM2-1	10	12401	2422			9190				181	2038		229	897	136			1278	15481	
CanESM5	15	6945	1558	2393	1817	23084	34019	199878	1713	2150	1028			700		64800		2962	32254	2490
E3SM-1-0	1					874														
EC-Earth3	3	1125				2466													4794	
EC-Earth3-Veg	3	234				997													1175	
ECMWF-IFS-HR	1											303								
ECMWF-IFS-LR	1											307								
FGOALS-f3-L	2					12									5					
FIO-ESM-2-0	1					12														
GFDL-AM4	1					69														
GFDL-CM4	5				402	2015									52			46	644	
GFDL-CM4C192	1											167								
GFDL-ESM4	4		107	55		1387													589	
GFDL-OM4p5B	1														21					
GISS-E2-1-G	6		810		588	7487	4025							805			161			
GISS-E2-1-G-CC	1					550														
GISS-E2-1-H	2				138	1803														
HadGEM3-GC31-HM	1											435								
HadGEM3-GC31-LL	4					4060	2242					340							712	
HadGEM3-GC31-LM	1											172								
HadGEM3-GC31-MM	1											496								
IITM-ESM	1					1														
IPSL-CM6A-ATM-HR	1											250								
IPSL-CM6A-LR	14	9667			3621	37495	19638	116604		558	1161	271	176	3433	642		2177	5897	15219	
MIROC-ES2L	3	259				1585													1295	
MIROC6	10	4185			420	2905	2205	49000	545	450					38			1652	1864	
MPI-ESM1-2-HR	3	517										74							2068	
MPI-ESM1-2-XR	1											75								
MRI-AGCM3-2-H	1											125								
MRI-AGCM3-2-S	1											125								
MRI-ESM2-0	7	1157			812	4005	1884			246								774	2005	
NESM3	3					1527											65		875	
NICAM16-7S	1											79								
NICAM16-8S	1											79								
NICAM16-9S	1											79								
SAM0-UNICON	1					832														
UKESM1-0-LL	6	3932	766			6042								178				373	8479	

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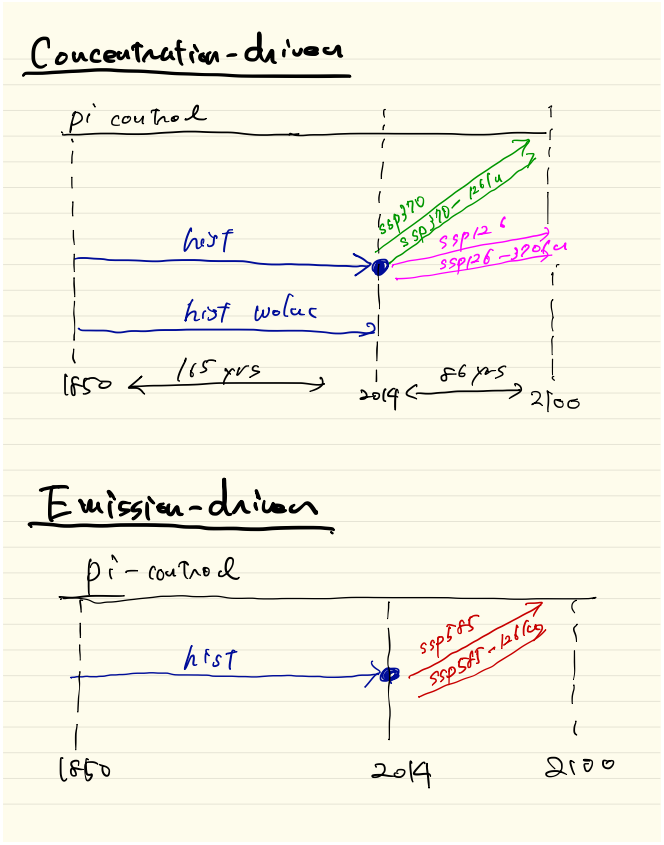
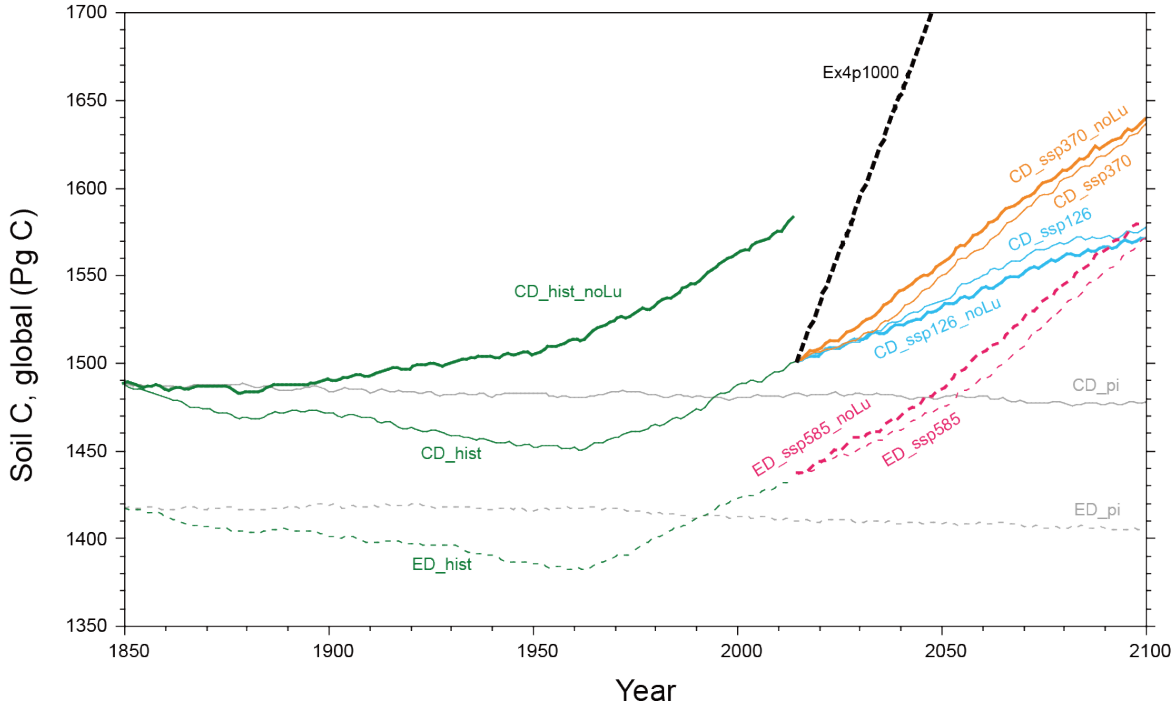
model	# of experiments	deforest-globe	esm-ssp585-ssp126Lu	hist-noLu	land-cCO2	land-cClim	land-crop-noFert	land-hist	land-hist-altStartYear	land-noFire	land-noLu	ssp126-ssp370Lu	ssp370-ssp126Lu
# of models	31	5	3	4	1	1	1	5	1	1	2	3	4
BCC-CSM2-MR	7	156	157	157				41			41	151	155
CESM2	11	370	179	1298	172	172	172		24	172	161	427	427
CNRM-CM6-1	1							153					
CNRM-ESM2-1	3	334		334				229					
CanESM5	4	342	342									8	8
GISS-E2-1-G	1							805					
IPSL-CM6A-LR	3	1369		1888				176					
UKESM1-0-LL	1												178
		Coming	Done	Done				(Done)				Done	Done



Example: SOC (will be discussed tomorrow)



MIROC-ES2L

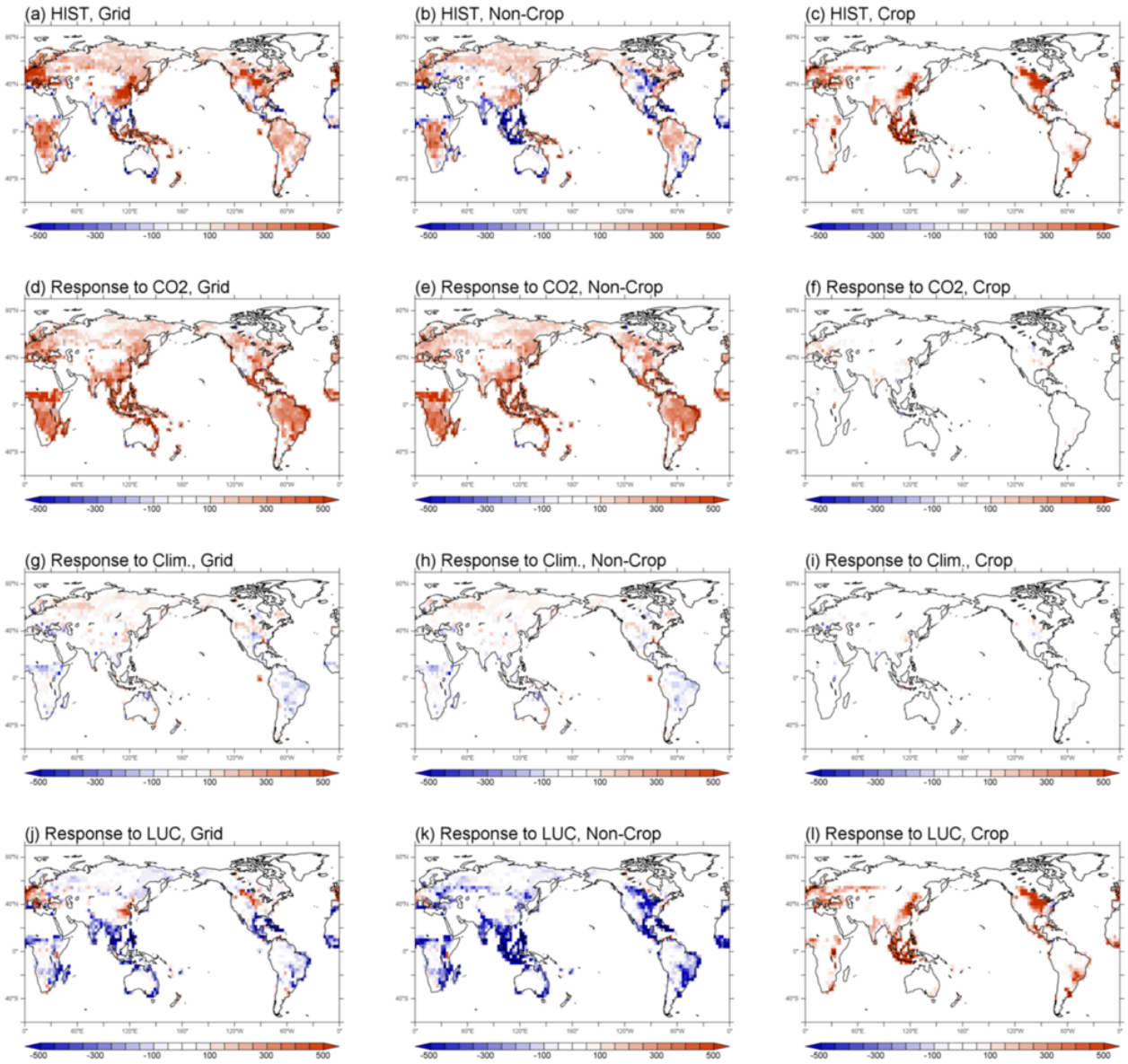
Done (will appear on ESGF soon)
• Historical, noLu, ssp-LU data exchange (conc.- and emission-driven)

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_2O from croplands)

MIROC-ES2L



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