

MPI-ESM in LUMIP

(as a part of the EU CRESCENDO project)

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H2020 project CRESCENDO (updated 2018): Terrestrial biogeochemical processes in CMIP6

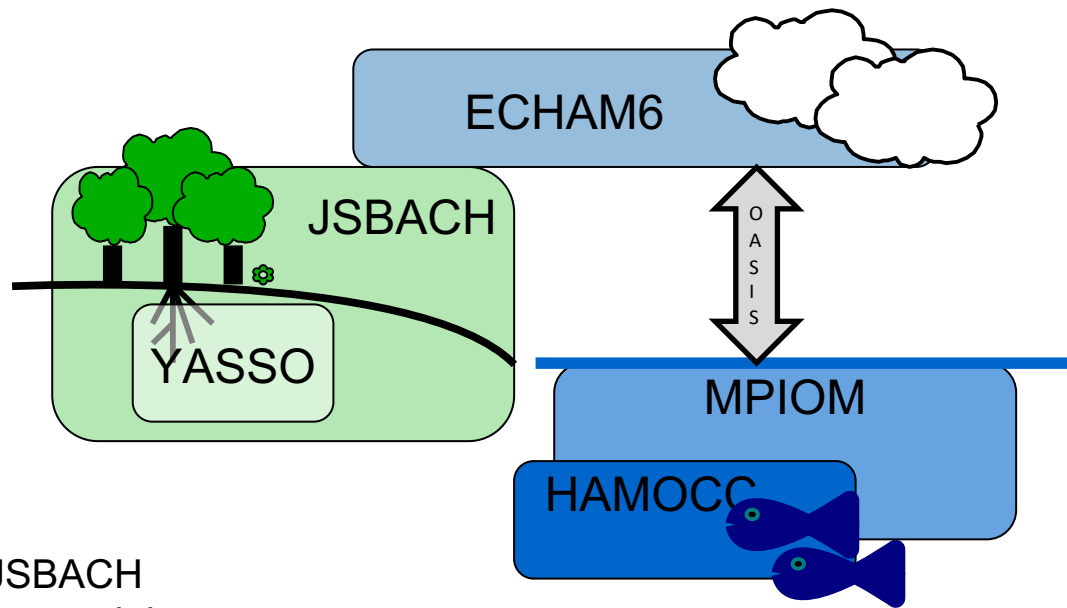
Task\Model	UKESM	MPI-ESM	IPSL-CM	NorESM	EC-Earth	CMCC ESM	CNRM-ESM
C-N interaction	on	on	On?	on	on	on	on (simple parameter.)
N ₂ O emissions	offline	offline	on	on	on	on	no
Permafrost physics	on	offline	on	on	on	no	on
Permafrost C	no	offline	offline	on	offline	no	offline
CH ₄ emissions	on	offline	offline	on	offline	offline	offline
Landuse	on	on	on	on	on	on	on
Forest structure (eg cohorts)	no	no	offline	on	on	no	no

Empty cells: component improvement has not been planned in CRESCENDO

On: in the DECK runs; offline: not in DECK, but used in the CRESCENDO evaluation



JSBACH in MPI-ESM 1.2-LR for CMIP6



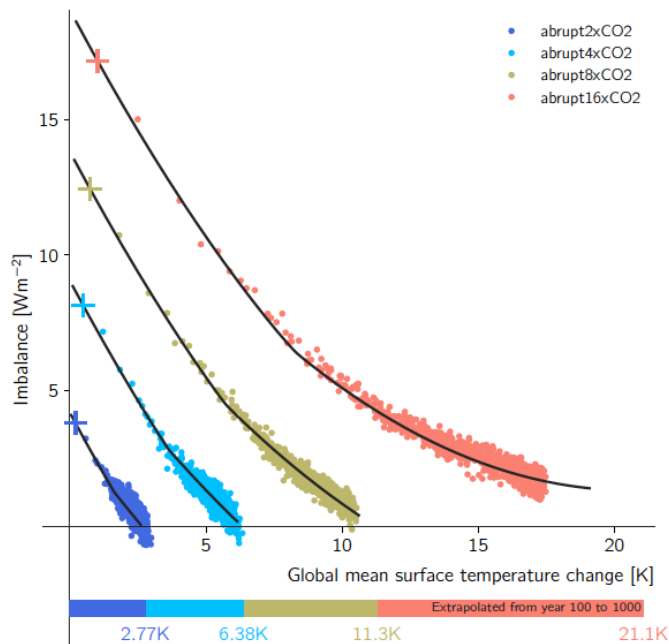
land surface model JSBACH

- dynamic vegetation model
- improved landuse
- improved 5-layer hydrology
- new soil C model YASSO
- Carbon-nitrogen coupling
- SPITFIRE

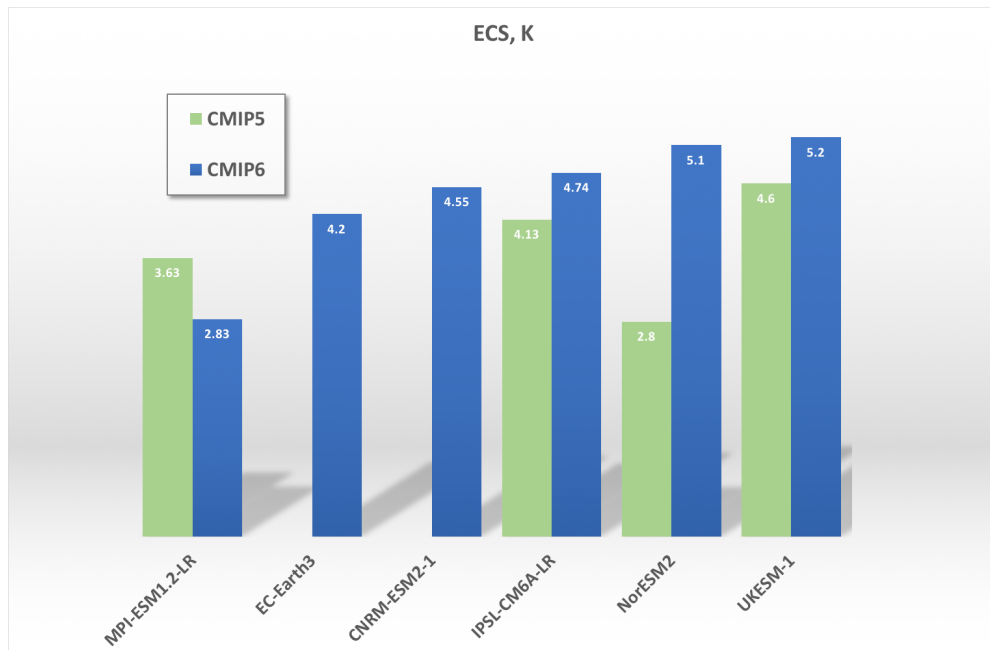
Offline JSBACH extensions

- physical permafrost model (Ekici et al., 2014)
- C in permafrost (Kleinen et al., 2018)
- wetland scheme & methane emissions

Climate sensitivity of MPI-ESM1.2 is the lowest among European ESMs

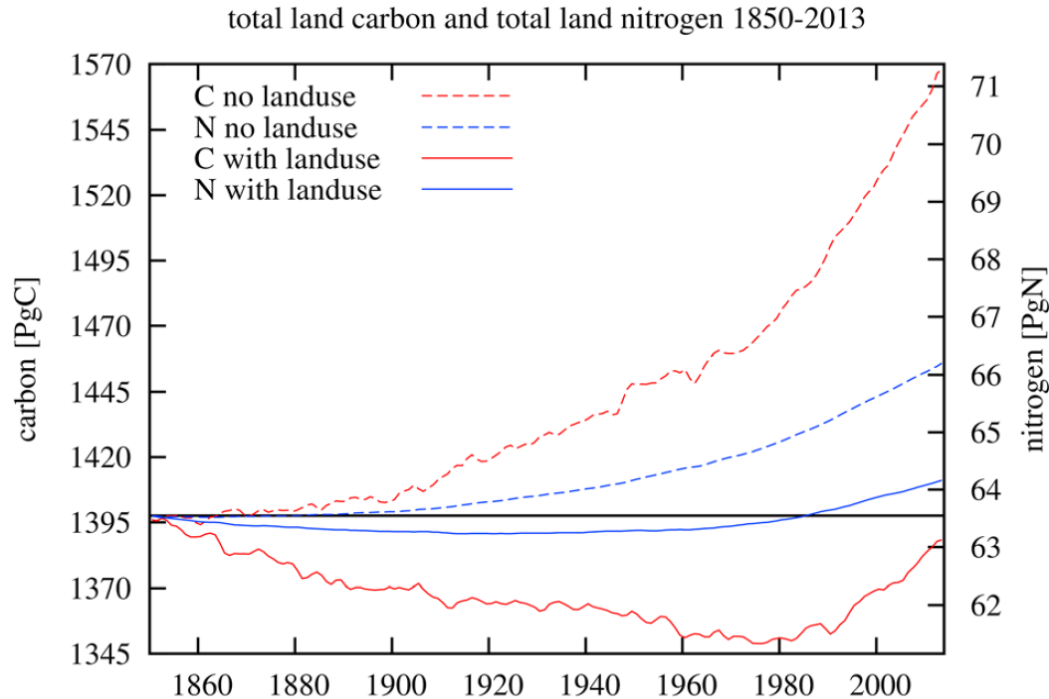


Mauritsen et al, JAMES, 2019



EU CRESCENDO project

With landuse, carbon stocks reach minimum in 1970-80s, N stocks - earlier



Historical simulations with/without landuse

Horizon 2020

H2020-SC5-2014 ADVANCED EARTH-SYSTEM MODELS

CRESCENDO

(GRANT AGREEMENT 641816)

COORDINATED RESEARCH IN EARTH SYSTEMS AND CLIMATE:
EXPERIMENTS, KNOWLEDGE, DISSEMINATION AND OUTREACH

Consolidated representation of land use in ESMs

Milestone 3 | month 24 | RT1 | WP1

Lena Boysen / Victor Brovkin / Julia Nabel (MPG)

David Warlind / Paul Miller (Uni Lund)

Altug Ekici (Uni Bergen)

Philippe Peylin (IPSL)

Roland Sérérian / Matthias Rocher (CNRM)

Eddy Robertson / Taraka Davies-Barnard (Metoffice, Uni Exeter)

Daniele Peano (CMCC)

Table 1: ESMs in CRESCENDO

ESM	LSM	Modelling Center	Primary Contact (Oct 17)
UKESM	JULES	UExe, MOHC	Eddy Robertson
MPI-ESM	JSBACH	MPG	Lena Boysen
IPSL-CM	ORCHIDEE	CNRS-IPSL	Philippe Peylin
NorESM	CLM5.0	UiBergen	Yuanchao Fan
EC-Earth	LPJ-Guess / HTESSEL	ULUND	David Warlind
CMCC ESM	CLM4.5	CMCC	Daniele Peano
CNRM-ESM	SURFEX	MF-CNRM	Matthias Rocher

Table 2 LULCC: Gross vs. net transitions

Model	Current state	Historical/ SSPs	LUMIP offline	C history
UKESM	Net	net	Net	Not tracked
MPI-ESM	Both possible	gross	Gross	Not tracked
IPSL-CM	Net	net	Both possible	Not tracked
NorESM	Both possible	Both possible	Both possible	Tracked
EC-Earth	Both possible	Gross (Net)	Gross (Net)	Tracked
CMCC ESM	Both possible	Net	net	Not tracked
CNRM-ESM	net	net	net	Not tracked

Table 3 LULCC: Crop representation

Model	#crop types	Crop representation	Distribution of C3, C4
UKESM	2C	C3, C4 as nat grass	Bioclimatic limits changing with time
MPI-ESM	2C	C3, C4 (tropical, extra tropical, winter, summer)	Time series of LUH2
IPSL-CM	2C	As pasture (possibly with winter/summer wheat)	bioclimatic
NorESM	8C	C3, C4, spring(summer) wheat, temperate/tropical corn, temperate/tropical soy, cotton, sugarcane, rice	Time series of LUH2
EC-Earth	5*2	Explicit	Time series of LUH2
CMCC ESM	1C	C3	Time series of LUH2
CNRM-ESM	3C	C3, C4 as nat grass	Time series of LUH2

Table 4 LULCC: Pasture representation

Model	pasture representation	Pasture allocation	Range land
UKESM	C3 and C4 grass	P replace grass	Nat veg
MPI-ESM	C3 and C4 grass	LUH2, P replace grass first	Nat veg or pasture
IPSL-CM	C3 and C4 grass	LUH2, proportionally allocated from grass and forest	Nat grass
NorESM	C3 and C4 grass	LUH2, proportionally allocated from grass and forest	Nat veg
EC-Earth	C3 and C4 grass	LUH2, proportionally allocated from grass and forest	Pasture (Nat veg possible)
CMCC ESM	C3 and C4 grass	LUH2, P replace grass	Nat veg
CNRM-ESM	C3 and C4 grass	LUH2, proportionally allocated from grass and forest	Nat grass

Table 5 LULCC: Management. Important for LUMIP Tier 2 experiments

Model	Crop harvest	Pasture harvest	irrigation	fertilizer	tillage	fire
UKESM	Fixed fraction of litter to atm.	No	No	No N-lim.	No	No fire (at all)
MPI-ESM	Yes, fixed fraction of storage organ to harvest pool	No (but grazing rate)	No	No (but possible)	No	Suppression on C (P burn with spitfire)
IPSL-CM	Fixed fraction of NPP to atm	No (not yet)	(Yes, with different version)	No (not yet)	No (turnover could be changed)	No (not yet)
NorESM	Fraction of harvest to food pool	Yes	Yes	Yes	No	Yes
EC-Earth	At maturity to atm	Yes (1x year)	Yes (5PFTs)	Yes	Yes	Suppr. On C&P
CMCC ESM	No	No	No	No	No	Based on demographic + econ. Conditions
CNRM-ESM	Yes _{offline}	No	No	No	No	Suppr. On C&P

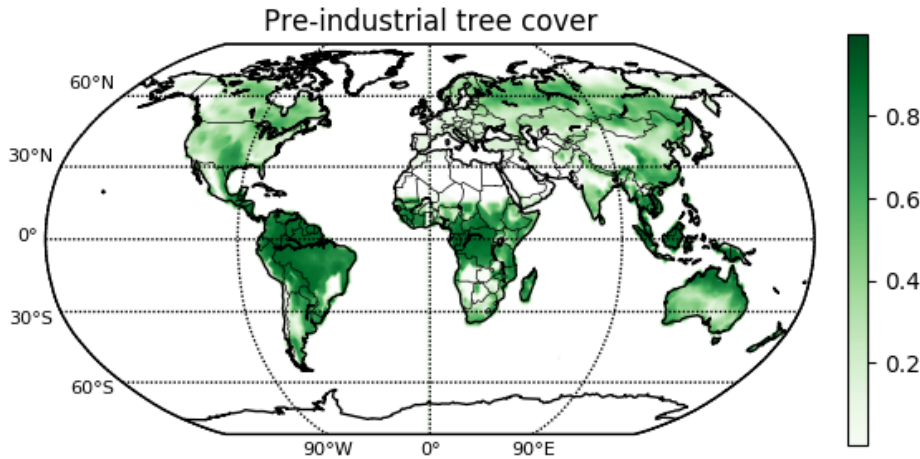
Table 6 Natural Vegetation: Dynamic vs. prescribed

Model	General	Historical/ SSPs	LUMIP offline
UKESM	dynamic	dynamic	dynamic
MPI-ESM	dynamic or prescribed	dynamic	dynamic
IPSL-CM	Prescribed (but dyn possible)	prescribed	prescribed
NorESM	dynamic	dynamic	prescribed
EC-Earth	dynamic	dynamic	dynamic
CMCC ESM	prescribed	prescribed	prescribed
CNRM-ESM	prescribed	prescribed	prescribed

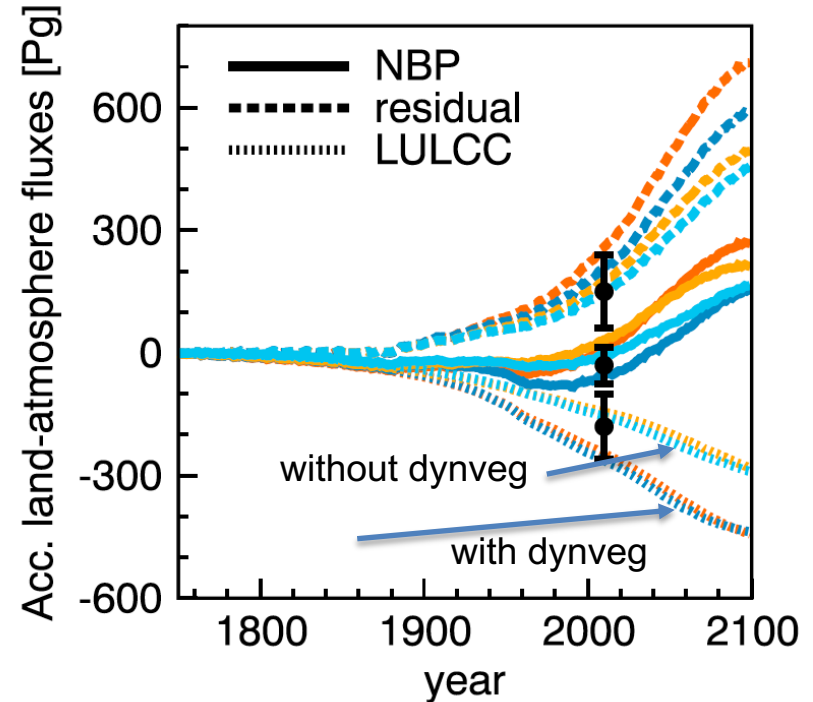
Table 7 Natural Vegetation: General characteristics

Model	#PFTs	Forest structure	Wild fires
UKESM	9	No	No
MPI-ESM	12	No	Spitfire (~fuel, ~relHum, ignition)
IPSL-CM	10	No (soon)	No (not yet)
NorESM	12	No (possible soon in the ED version)	Yes
EC-Earth	12	Dynamic	Yes (~fuel, ~vert.moisture)
CMCC ESM	15	No (2 nd phase)	Yes (~fuel, ~relHum, ~socioecon. cond.)
CNRM-ESM	16	No	Yes (~fuel, ~vert.moisture)

Dynamic vegetation tends to overestimate carbon losses due to landuse in drylands



Mauritsen et al, JAMES, 2019



Goll et al., GBC, 2015

Table 8 Natural Vegetation: Forest management

Model	Forest management	Wood harvest	Wood harvest pools
UKESM	No	Area: No; only if forest is reduced (slow pool)	Long-, medium, short-lived
MPI-ESM	No (but constant grazing)	LUH2 harvest biomass C taken from average forest; plus if forest frac is reduced (diff. rules for distribution to wood pool and litter)	Long- (construction), medium- (paper), short-(on-site) –lived
IPSL-CM	No (soon self-thinning)	LUH2 C + Area reduction only if forest is reduced	Long-, medium, short-lived ¹¹
NorESM	Prescribed PFTs	LUH2 area	Long-, medium, short-lived
EC-Earth	Self-thinning	Area: only if forest is reduced (slow pool)	Long-, medium, short-lived
CMCC ESM	Prescribed PFTs	LUH2 area	Long-, medium, short-lived
CNRM-ESM	No	Area: only if forest is reduced	Long-, medium, short-lived ¹¹

JSBACH: Details of wood harvest/allocation to pools

Table 4

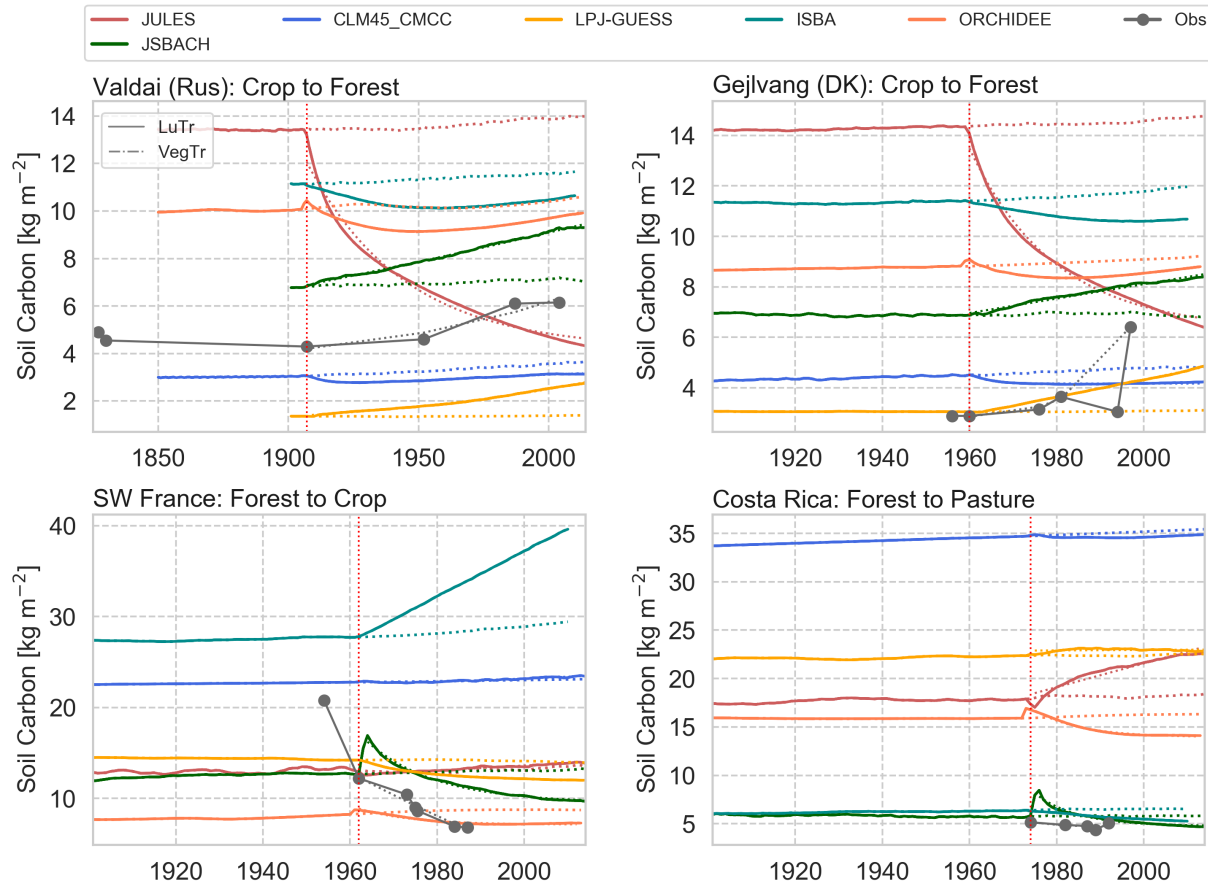
Fractions of Carbon Fluxes From Wood Harvest, ALCC, and Crop Biomass Allocated to Litter Carbon and the Seven Product Pools (3 for Wood Harvest, 3 for ALCC, and 1 for Crop Harvest)

From	To	Tropicalforest	Extra- tropical forest	Shrubland	Grassland	Crops
Wood Harvest	Litter	0.300	0.300	0.3	—	—
	Fuel	0.630	0.280	0.7	—	—
	Paper	0.028	0.168	0	—	—
	Construction	0.042	0.252	0	—	—
ALCC	Fuel wood	0.597	0.5970	0.8	1	—
	Paper	0.403	0.2985	0.2	0	—
	Construction	0	0.1045	0	0	—
Crop biomass	Litter	—	—	—	—	0.5
	Harvest	—	—	—	—	0.5

Note. ALCC = anthropogenic land cover change.

- all five LUH2v2h wood harvest categories are aggregated in the preprocessing to a single value because JSBACH does not distinguish between different types of wood harvest.

CRESCENDO: Site-level evaluation of soil carbon response to LULCC using soil chronosequences



MPI-ESM runs in CMIP6: current stand

- Historical simulations are done
 - LR-version – useful for C cycle, HR-version – not (but available on ESGF)
 - LR: In concentration-driven and emission-driven modes (an issue with too high CO2 concentration due to too high emissions?)
- Idealized deforestation experiments are done (10 ens members)
- SSP runs are in progress, but not available yet
- Offline simulations are in progress in Julia's group